North Platte River Environmental Restoration Master Plan – Phase I

City of Casper Public Services Department
Casper, Wyoming

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May 21, 2012

Executive Summary

The North Platte River and its tributaries are an integral part of the community, and the history and founding of the City of Casper (Balloffet and Associates, 2000). The North Platte River provides Casper, Wyoming its water resources, riparian habitats, scenic beauty, and a countless number of recreational opportunities. In addition, the North Platte watershed provides this urban area and surrounding communities with a number of ecosystem services that are not as easily identifiable, which include water regulation, water supply, soil retention and formation, nutrient regulation, fish nursery function, and science and education (Holmes, et al., 2004; Soman, et al., 2007). It is essential that the City of Casper continue to preserve and protect this invaluable resource.

At the request of the City of Casper Wyoming, Stantec Consulting Services Inc. and SWCA Environmental (Stantec Team) has prepared the North Platte River Master Plan. The purpose of the project is to provide an assessment of the existing condition of, and to propose restoration strategies for, the North Platte River in a 13.5-mile stretch that flows through the City of Casper, the Town of Mills, and Natrona County.

The Stantec team gathered data on the North Platte River to assess the current conditions of the river. Several stream assessment tools were used to evaluate the condition of the streams, including Rosgen Stream Classification, geomorphic cross-sections, geomorphic profiles, Bank Erosion Hazard Index and Near Bank Stress, and the Channel Evolution Model. Additionally, a cultural resources survey and vegetation inventory survey was conducted along the project study area.

Though much of the project reach was observed to be over widened, the majority of the North Platte River was observed to be relatively stable along the 13.5-mile project area. However, areas of mass bank wasting were observed in areas where the river has over widened resulting in divided/braided stream flow. In these braided sections local areas of high shear stress have resulted in accelerated bank erosion. Additionally, long sections of the river in the project area lack riffle pool complexes resulting in reduced fish habitat.

Though much of the river banks are populated with mature woody vegetation, much of the vegetation is the invasive Russian olive tree (*Elaeagnus angustifolia)*. Mature Russian olive stands have come to dominate the bank zone and the transition to the terrace zone in many parts of the project area. Natural resources specialists of the Team surveyed nearly 70 acres of riparian cover, and Russian olive percent cover ranged from 2.5 percent total cover to nearly 50 percent total cover with an average of 20 percent of total cover. Any revegetation plan for the river will require addressing the presence of this invasive species.

Based on the results of the surveys, the Stantec team has developed a Master Plan that focuses on preserving the ecosystem services provided by the North Platte River, primarily through stabilizing the riverbank and enhancing riparian vegetation. Riverbank stabilization will help reduce sedimentation from soil erosion, and maintain the natural riparian hydrology. Riparian vegetation enhancements, including the removal of nonnative vegetation and establishment of wetlands, will help filter sediments from runoff, stabilize the river bank, maintain the natural riparian hydrology, and provide native riparian habitat for wildlife. Overall, the Master Plan will help preserve the natural beauty of the river and enhance the natural resources available to the City of Casper and the surrounding communities.

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1.0 Introduction

The North Platte River and its tributaries are an integral part of the community and the history and founding of the City of Casper (Balloffet and Associates 2000). The North Platte River provides Casper, Wyoming its water resources, riparian habitats, scenic beauty, and a countless number of recreational opportunities. In addition, the North Platte watershed provides this urban area and surrounding communities with a number of ecosystem services including water regulation, water supply, soil retention and formation, nutrient regulation, and fish nursery function (Holmes, et al., 2004; Soman, et al., 2007). It is essential that the City of Casper continue to preserve and protect this invaluable resource.

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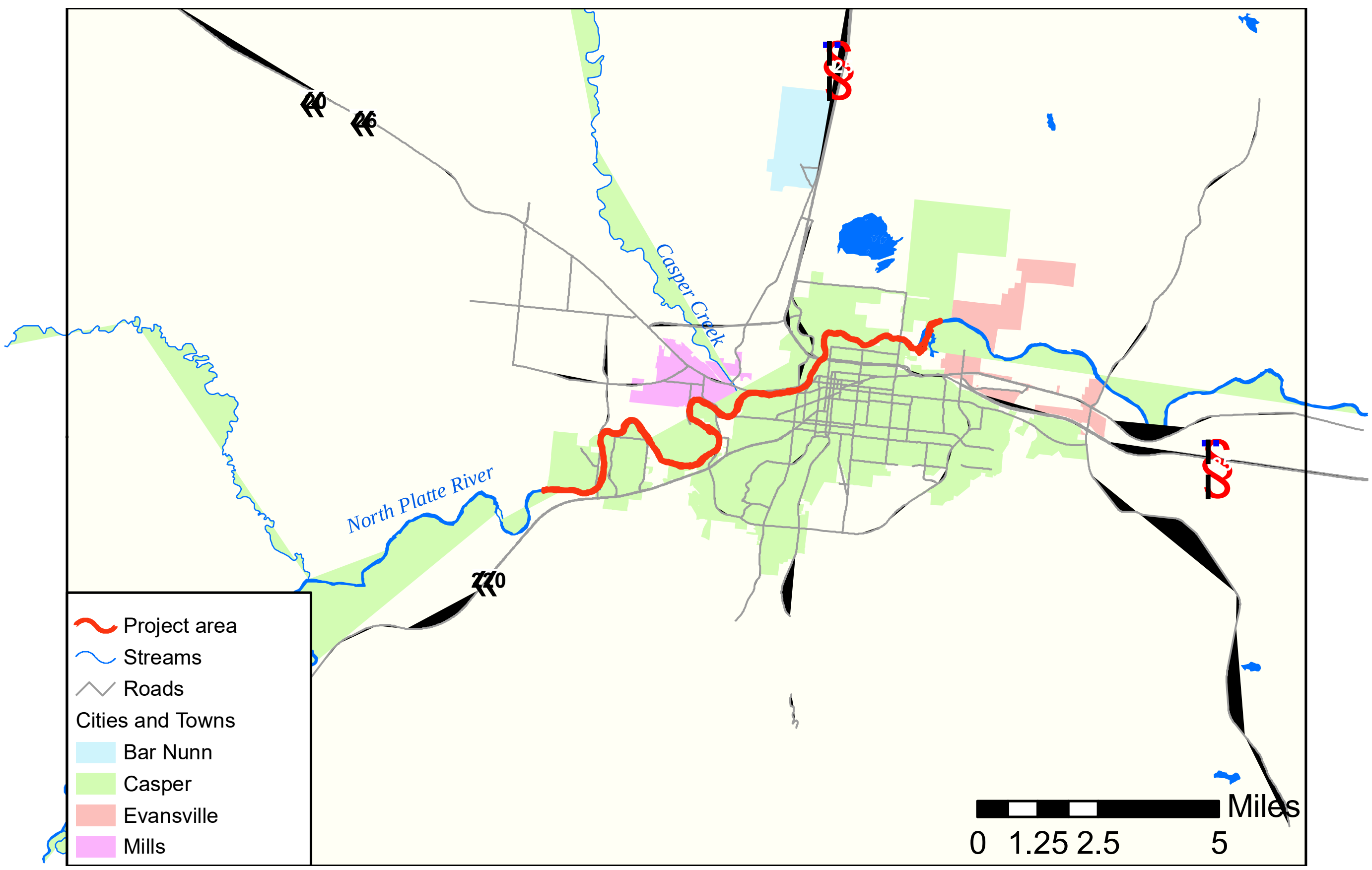

Figure 1. Project vicinity map

2.0 Summary of Previous Studies

The Stantec team request and reviewed all publically available data, prior studies, and reports focused on the North Platte River through the City of Casper. These studies included: The Casper Area Walkability Study; Casper Area Comprehensive Plan; Highway 20/26 Enhancement Plan; Baby Boomer Study; Platte River Parkway Trust Master Plan; and the Stormwater Master Plan. Our review also included any corrective actions being conducted under Wyoming Department of Environmental Quality (WYDEQ) jurisdiction, such as with the former BP refinery, the Texaco refinery, and the Sinclair Casper refinery.

Additionally, requests for data, studies, and projects within the Project area were submitted to the Bureau of Land Management (BLM), the Natural Resource Conservation Service (NRCS), Wyoming State Forestry Division, Bureau of Reclamation, WYDEQ TMDL program, and Natrona County Conservation District. The BLM, NRCS, Wyoming State Forestry Division, BOR, and WYDEQ TMDL did not have any relevant information to provide for the Master Plan.

2.1 Summaries of relevant information was summarized and provided below. This data was used to guide planning efforts and to avoid disturbance of any existing or proposed remediation systems or projects. Platte River Parkway Trust Master Plan

In 1982, the City of Casper developed a Master Plan document which would serve as the basis for the development of a recreation and green space corridor along the North Platte River (CH2MHill, 1982). The Platte River Parkway was developed during the 1990s and now travels approximately 11-miles from Paradise Valley Park to the North Casper Soccer Complex at the Bryan Stock Trail. The parkway serves as a link between the riparian corridor and the City of Casper. The parkway provides a variety of recreation opportunities including walking, jogging, biking, canoeing, kayaking and white water rafting access, fishing, wildlife watching, and picnicking.

2.1.1 Casper Area Comprehensive Land Use Plan

The Casper Area Comprehensive Land Use Plan (Balloffet and Associates 2000) was developed to guide long-term future development, redevelopment, and preservation of the Casper Metropolitan area. Included within the plan are visions and goals for a system of open space connections, and a plan to protect scenic view corridors, including Casper Mountain. The North Platte River and its tributaries were identified as an integral part of the community, and the history and founding of Casper. Connectivity between the North Platte River to the community was proposed through a system of trails and parkways along each tributary to the North Platte River. The development of a new riverfront park in downtown Casper was also identified as an integral focal point for the community. The plan developed the following guidelines for reconnecting the community with the North Platte River and its tributaries: 1) beautifying the waterfront landscape; 2) creating gathering places at strategic points along the water's edge; 3) overcoming the barriers that separate downtown from the water; 4) creating a strong visual connection to the river and its tributary drainages at street crossings that establish the river and tributaries as prominent features; 5) establishing more pedestrian connections to the river and its tributaries that draw people to the water; and 6) repeating the image of the river when possible throughout the downtown with shallow pools, fountains, reservoirs, and channels along pedestrian paths.

2.1.2 The Casper Walkability Study

The Casper Area's vision is to create a walkable community where pedestrians can easily walk to activity areas, schools, and parks. The Casper Walkability Study (CAMPO 2008) identified priority pedestrian improvement areas located within a ¼-mile walking distance of high activity use areas. These high activity use areas include parks, transit routes, schools, shopping areas and hotel clusters, and business parks and office areas. Based on priority rankings, specific areas were identified that would benefit from improvements, connectivity, or installation of sidewalks and pedestrian facilities. The three highest priority areas were identified as the Events Center South, CY Avenue/Southwest Wyoming Boulevard, and Mills. Guidelines and specific proposed improvement projects were also presented in the study.

2.1.3 Highway 20/26 Enhancement Plan;

The Highway 20/26 corridor is the major highway running east-west into the City of Casper, serving between 11 and 14,900 vehicles per day. The Highway 20/26 Enhancement Study (SEH 2008) was developed to guide the improvement of the visual character and functionality of the highway right-of-way on private and public lands. A framework plan for design treatments was established to a central enhancement theme within the designated Urban Transition, Urban District, and Rural District. The plan defined transportation, landscape, and urban design enhancements. Integrated design standards included incorporation of gateway location and opportunities, trail connections to the Platte River Parkway System, native plantings in right-of-ways, decorative lighting improvements, park enhancement areas, and living snow fence installation locations.

2.1.4 Baby Boomer Study

In 2008, the Baby Boomer Study (University of Wyoming 2008) was completed to identify an action plan to address the projected changes in the demographic composition within the community. The study identified six primary action plan categories. One of these action items was to provide and promote a variety of leisure activities to develop and enhance social networking opportunities for seniors. As part of this action plan, the need to establish a forum for collaboration between community recreation service providers and facility operators was highlighted. The Community Recreation Foundation was tasked with defining opportunities for enhancement of existing programs and facilities, including the accessibility of trails, parks, and interpretive areas.

2.1.5 Stormwater Master Plan

A plan was prepared in 1981 to provide design procedures and techniques for the management of urban stormwater. The plan identified need, and set priorities for storm drainage improvements. Results of this plan identified the Garden Creek and Eastdale Creek as having major problem areas due to road crossings obstructing flow, encroachment into the floodplain, lack of detention cells, infilling of the natural channel, and a lack of large detention sites. The plan recommended prohibiting filling natural channels, restricting development in the floodplain, and special prohibitions on development at road crossings to minimize damage from major flood events. A list of priority drainage improvements was developed. The list was prioritized based on risk to existing improvements and flood hazards associated with the 100-year flood.

2.1.6 Wyoming Game and Fisheries Resources

The North Platte River through the City of Casper is rated as a blue ribbon trout fishery, meaning it as over 600 pounds of trout per mile. In 2007, this fishery was estimated to contain 901 trout per mile, consisting of rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and Snake River cutthroat trout (*Oncorhynchus clarki behnkei*) (WYGFD 2007). Rainbow trout were the predominate species present, and accounted for 875 fish/mile. The trout were found to range in length from 6.0 to 21.3 inches (mean = 12.4 inches). Winter stream flow was identified as being a limiting factor for this population, accounting for 66% of the variation in the estimated population of trout. In 2011, this fishery was estimated to contain 957 trout per mile. Rainbwo trout again were the predominate species present, and accounted for 897 fish/mile (WGFD 2012).

2.1.7 Wyoming Department of Environmental Quality

The North Platte River may be subject to several point and nonpoint source pollution sources as it enters the City of Casper. Nonpoint source pollution sources can be controlled by implementing best management practices (BMPs) for urban areas (WDEQ 1999). The federal Clean Water Act provides that the discharge of any pollutants from a point source into surface water of the United States must be regulated under the Wyoming Pollutant Discharge Elimination System (WYPDES) Program (WDEQ 2011). Many point source pollution sources have been eliminated and/or controlled with the closures of the Radex, Paradise Valley, and Mills sewage facilities, construction of the Sam Hobbs Regional Wastewater Treatment Plant, and the closure of the Amoco Refinery.

British Petroleum (BP) Amoco Refinery

The former Amoco Refinery, located in Casper, is bordered to the north by the North Platte River and to the east by Popular Avenue. The refinery operated from 1912 to 1991, and processed crude oil, treated lube oils and finished waxes, and removed sulfur odor from gasoline. In the final year of operation, output from the refinery included fuel gas, liquid propane gas, motor/aviation gasoline, fluid cracking unit coke, heavy fuel oil, kerosene and distillates, asphalt, and residuum (BP, 2011).

Hydrocarbon and metals contamination from refinery operations have been identified in the soils and ground water in and around the former refinery. The refinery also discharged process water to the Soda Lake inlet basin from 1957 to 1990. Soda Lake is located approximately three miles northeast of the refinery property. In 2002 a remedy agreement was signed, and BP began the implementation of cleanup requirements. As part of this agreement, a six thousand-foot long steel sheet pile (subsurface) barrier wall and hydraulic well system was installed to contain and remove subsurface contaminants that had the potential to migrate and impact the North Platte River. Potential sources of free phase hydrocarbons were removed, including removal of the subsurface pipe, waste units, and soils. A Corrective Action Management Unit (CAMU) was constructed as a permanent engineered containment system for remediation wastes. A groundwater restoration system, including a water treatment system that uses wetlands to remove contaminants, was installed. These remediation activities have been initiated and completed in the North Properties Area, South Properties Area, and in the Soda Lake Area (BP, 2011).

In addition, BP integrated cleanup systems and remediation requirements with reuse. Examples of this integration include a kayak course in the North Platte River that bolsters the hydraulic containment system on the Refinery Property, the construction of wetlands and treatment ponds as water features on an 18 hole golf course, and property development in the Platte River Commons and Salt Creek Business Park (BP, 2011).

Texaco Refinery

The former Texaco Refinery is a 200-acre refinery site located approximately three miles east-northeast of the City of Casper. The refinery is bordered to the north by the North Platte River, to the west by the town of Evansville, and to the east by the Sinclair Refinery. The refinery processed crude oil from local sources into gasoline, diesel, and other motor fuels from 1923 to 1982. Texaco began decommissioning the refinery in 1996 and has removed all inactive underground piping, concrete foundations, and other subsurface structures. From 1997 to 2005 petroleum contaminated soils and refinery wastes were excavated, removed, and treated. The site was graded and seeded in 2001 (CESC, 2011).

Between 1993 and 1997 Texaco installed 21 full time groundwater restoration systems, including 3,650 linear feet of interceptor trenches, 12 hydrocarbon recovery wells, and two large soil vapor extraction systems. The groundwater interceptor trenches run along the south bank of the North Platte River to contain and remove subsurface contaminants that exhibited potential to adversely influence surface water quality in the river. Texaco installed a Waterloo Barrier in mid-1997 to provide an added measure of protection for the river, while maintaining operation of the interceptor trenches (CESC, 2011).

Sinclair Casper Refinery

The Sinclair Casper Refinery is located east of Evansville, approximately one-quarter mile south of the North Platte River. Since 1968, Sinclair has operated the refinery as an active fuels-type refinery. Since 1999, the Sinclair Casper Refinery has followed a corrective action plan of boundary control of light non-aqueous phase liquid (LNAPL) and dissolved-phase hydrocarbons, including source stabilization where necessary to meet boundary controls. The boundary control system consists of an interceptor trench, an interceptor drain, and a low permeability barrier (LPB) which protects the northern border of the refinery and the North Platte River. The interceptor trench was constructed in the early 1980s and consists of an open ditch located been the refinery and the North Platte River, and graded toward the east where fluid could be extracted and sent to a wastewater treatment system. The trench was extended in 1994. The interceptor drain system began operating in 1985 and consisted of two horizontal collection drains running to a single sump. In 1994, the drain system was extended and now consists of slotted, 6-inch diameter PVC horizontal drains and risers graded to a sump and above ground pump hose. The interceptor drain was designed to intercept LNAPL by altering groundwater flow adjacent to the drain. In 2004, the LPB was installed west of the interceptor drain system and river pump house following the edge of the North Platte River. The LPB is 142 feet long, 18 feet deep, extends 2 feet into bedrock, and consists of a 5% bentonite/soil mixture. The refinery continues to monitor the effectiveness of these systems to ensure that ground and surface water contamination is not occurring (Pearson, 2008).

2.1.8 Natrona County Conservation District

The Wyoming Department of Environmental Quality (WDEQ) implemented an assessment project to develop selenium Total Maximum Daily Loads (TMDLs) for impaired waterbodies in the North Platte River Watershed. The purpose of the assessment was to analyze existing data, characterize water quality problems, assess sources, allocate loads, calculate TMDLs, and define management measures for selenium in the watershed. In 2012, the Natrona County Conservation District received three years of funding from WDEQ to restore beneficial uses on the North Platte River and its tributaries by 2024 through implementing the recommended best management practices (BMPs) from the TMDL. The objectives of this initial phase of the project are to implement BMPs on irrigated and non-irrigated lands to achieve selenium reduction, increase BMP public adoption and build upon past public outreach efforts to residents and landowners in the watershed, track BMP implementation progress toward achieving the goals of the TMDL, and monitor water quality and BMP effectiveness to document implementation progress.

3.0 Site Analysis

The Stantec team developed and conducted a desktop evaluation for natural and cultural resources that may be found within four miles of the proposed project area to identify those areas and specific resources that have the potential to occur in the survey area and potential to constrain construction of the project through either timing of construction activities or surface occupancy restrictions. All data gathered was provided to the City of Casper in the Master Plan Geodatabase.

Zoning and land use, property ownership, stormwater outfalls, floodways and floodplains, utilities, municipal boundaries data, transportation/ circulation systems, above and below ground infrastructure, existing reclamation or beautification projects was identified using data provided by the City

3.1 Biological Resources Desktop Analysis

Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) vegetative cover data and the Wyoming Natural Diversity Database (WYNDD) to identify areas where sensitive species are likely to be concentrated or have potential habitat within and surrounding the project area. For wildlife and plant species, up-to-date monitoring information from the Wyoming Game and Fish Department (WYGFD), Wyoming Observation System (WOS), the WYNDD, and BLM-Casper field office was obtained. Potential waters of the U.S., soil types, known noxious weed distribution were also identified.

3.1.1 Jurisdiction

A number of legal designations of the North Platte River apply to the river and the riverbank; Bureau of Reclamation (BOR) operates the control of dams; the U.S. Army Corp of Engineers (USACE) regulates changes to the riverbed and waterway; and the State of Wyoming has jurisdiction over the water within the river (CH2MHill, 1982). A variety of federal, state, local government, and private individuals have ownership of the land associated with the river. Ownership of the land may extend to both sides of the river or, in the case of different ownership on each river bank, the center of the river denotes the property line.

The North Platte River is regulated by the Bureau of Reclamation, primarily to supply the irrigation needs of the surrounding rural areas during the arid summer months. Flows are lowest in winter months when water is being stored and highest in July and August when water is released for irrigation. The river through the city is naturally fast-flowing, dropping approximately 40 feet over a 12-mile reach. Upstream control of the river since the early 1900s for the Pathfinder, Alcova, and Seminoe Reservoirs has generated conditions allowing development to occur along the river and within the floodplain in Casper (CH2MHill, 1982).

3.1.2 Watershed

The North Platte River is a major tributary of the Platte River and is approximately 716 miles in length. The 13.5-mile project area of the North Platte River is located in the 8-digit Hydrologic Unit Code (HUC8) 10180007. The drainage area at the upstream portion of the project area is 10,442 square miles (sq mi). At the downstream end of the project area, the total drainage area is 11,282 sq mi. One major tributary enters the North Platte River within the 13.5-mile project area: Casper Creek enters the North Platte River from the north, approximately 8 miles from the upstream end of the project area.

According to the 2006 National Land Cover Dataset (MRLC, 2006), land cover within the upper and lower watersheds is primarily comprised of scrub/shrub, with areas of forest and grassland. Less than one percent of the watershed is urban development, and less than two percent of the watershed is developed for agriculture. A watershed and land cover map is presented in Figure 2, and land cover within the watershed is summarized in Table 1 below.

Table 1. Land cover percentages in the North Platte River watershed

Land cover/land use	Upper watershed	Upper and Lower watershed
Scrub/shrub	70.1%	69.2%
Grassland	12.7%	14.0%
Forest	12.1%	11.4%
Wetlands	2.2%	2.2%
Agriculture	1.6%	1.7%
Open space	<1%	<1%
Low density development	<1%	<1%
Medium density development	<1%	<1%
High density development	<1%	<1%
Barren	<1%	<1%
Water	<1%	<1%

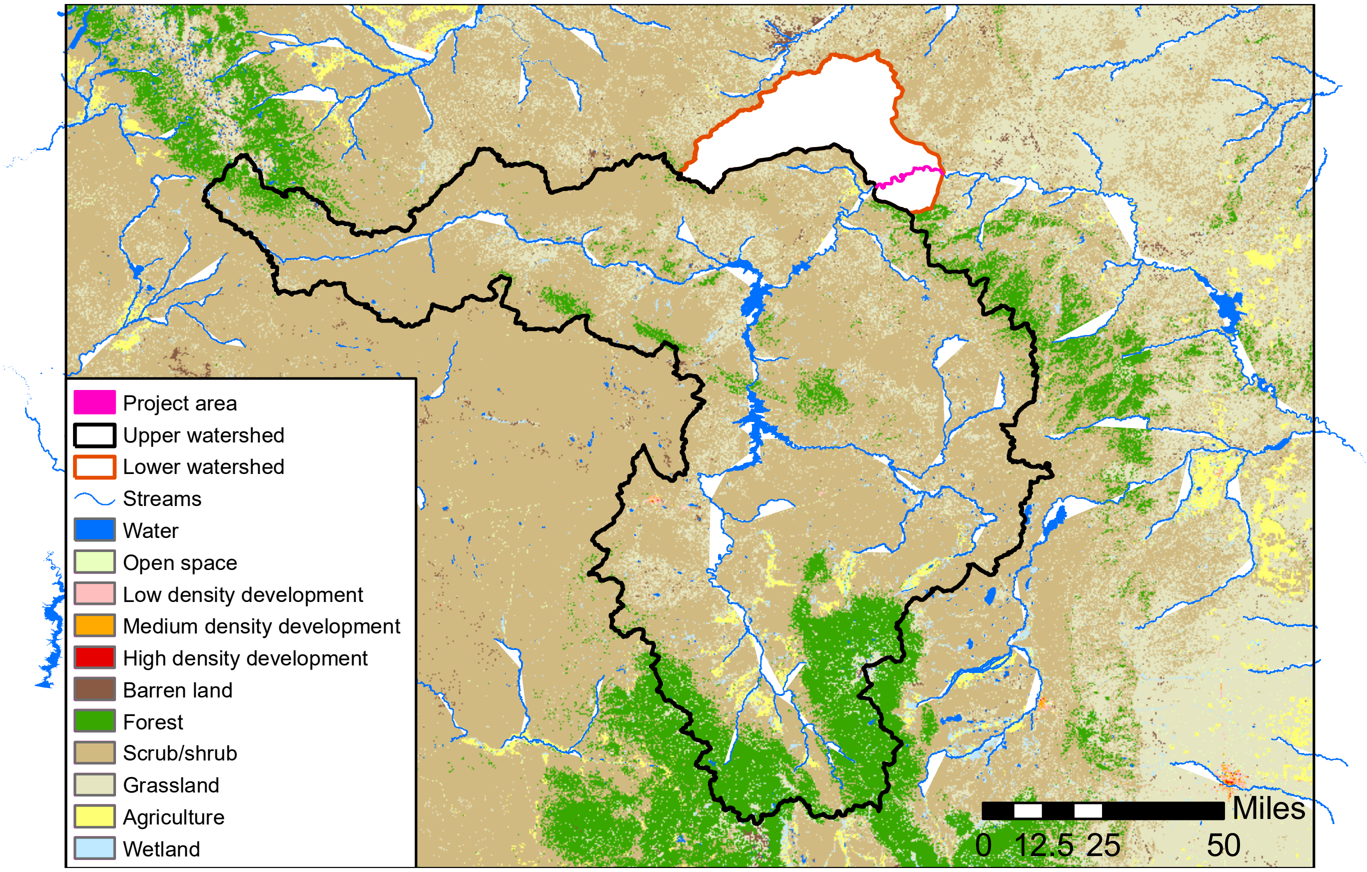

Figure 2. Land cover of the North Platte River watershed (MRLC, 2006).

3.1.3 Soils

Soils in the project area are predominantly alluvial soils developed in flood plains, drainageways, and stream terraces (Table 2) (NRCS 2012). Soils of flood plains, drainageways, and terraces account for 631.3 acres (60.2 % of Project area) of the 100 year flood plain within the Project area. Other soils include urban lands and developed areas (300.1 acres – 28.6 % of Project area); backslopes, hills, and ridges (13.1 acres – 1.2 % of Project area); and, alluvial fans (4.3 acres – less than 1.0 % of Project area). Soils within the 100 flood plain of the Project area include soils of backslopes, hills, and ridges that transition from flood plains and terraces to uplands on steeper backslopes and hillslopes (greater than 5 percent slope) but often include riparian habitat. In addition, the Project area is located within an urban-riparian interface and includes soil classes that have been developed as urban land or for salable minerals.

The most dominant soil class within the Project area is soils of flood plains, drainageways, and terraces. Soil components within this morphological class include Clarkelen, Draknab, Haverdad, Anvil, and Rivra soil components (Figure 3). These deep, alluvial soils developed on relatively flat terrain (0 to 6 percent slope) from parent material derived from igneous, metamorphic, and sedimentary rock. Haverdad, Anvil, and Rivra soil components are hydric soils that are frequently inundated during peak growing season. The sandy loam soils derived from alluvium often contain large fragments and coarse material that general increase erodibility and limit reclamation potential (Table 2). Erosion hazard within this soil class range from slight to moderate; however, soils become more susceptible to erosion as slope increases in coarser soil types. Overall, this soil class on flat terrain is generally not limited by susceptibility to erosion.

Erosion hazard increases in soils of backslopes, hills, and ridges. As slopes increases, these soils generally become shallower, less developed, and easily detachable. In addition, these fine-textured soils typically developed from residuum of sedimentary rock or aeolian deposits and become highly susceptible to wind and water erosion.

Table 2. Soil classes within the project area

Landform	Erosion Hazard	Limitation	Acreage	% Area
Alluvial fans	Moderate	Slope/erodibility	4.3	< 1.0
Backslopes, hills, and ridges	Moderate-Severe	Slope/erodibility	13.1	1.2
Developed	Not Rated	Not Rated	300.1	28.6
Flood plains, drainageways, and terraces	Slight-Moderate	Slope/erodibility	631.3	60.2
Water	Not Rated	Not Rated	100.0	9.5
		Total	**1,048.8**	**100.0**

3.1.4 Wetlands

Wetlands, including riparian areas, perennial streams, and lakes, are considered to be transition zones between terrestrial and aquatic systems where soils are at least periodically saturated with water (Cowardin, et al., 1979). Because of their proximity to available surface and subsurface water, plant species, soils, and topography of riparian and wetland areas differ considerably from those of adjacent uplands. These areas often have highly productive soils that promote a lush and diverse vegetative community composition, which is important for wildlife and ecosystem health.

Under the federal definition of wetlands, areas must meet three criteria to be classified as a wetland: wetland hydrology, hydrophytic vegetation, and hydric soils. Wetlands that meet these three criteria are subject to regulation by the U.S. Army Corps of Engineers (USACE) under Section 404 of the CWA (33 CFR 1251 et seq.) and Executive Order 11990. The regulatory status of jurisdictional wetlands and other waters of the U.S. are determined by the USACE and EPA using this most recent guidance.

Wetlands are classified by the USACE, with general wetland surveys maintained in a National Wetland Inventory (NWI) maintained by the U.S. Fish and Wildlife Service (USFWS). These wetland classifications are based on desktop analysis by the USFWS and would need to be field verified prior to project implementation. Common wetland types found the Project Area include riverine (83%), freshwater forested/shrub (12%), and freshwater emergent wetlands (5%). Riverine wetlands include all wetlands and deepwater habitats contained within the North Platte River channel (Figure 4; USFWS, 2012a). The freshwater forested wetland class is characterized by woody vegetation that is at least 19 feet tall and is found along hydrologic features such as rivers and streams in mountainous areas that support distinct plant compositions that are dependent on saturated soils. The freshwater scrub/shrub wetland class is typically dominated by woody vegetation less than 20 feet tall, such as shrubs, saplings, or small and stunted trees (Cowardin, et al., 1979).

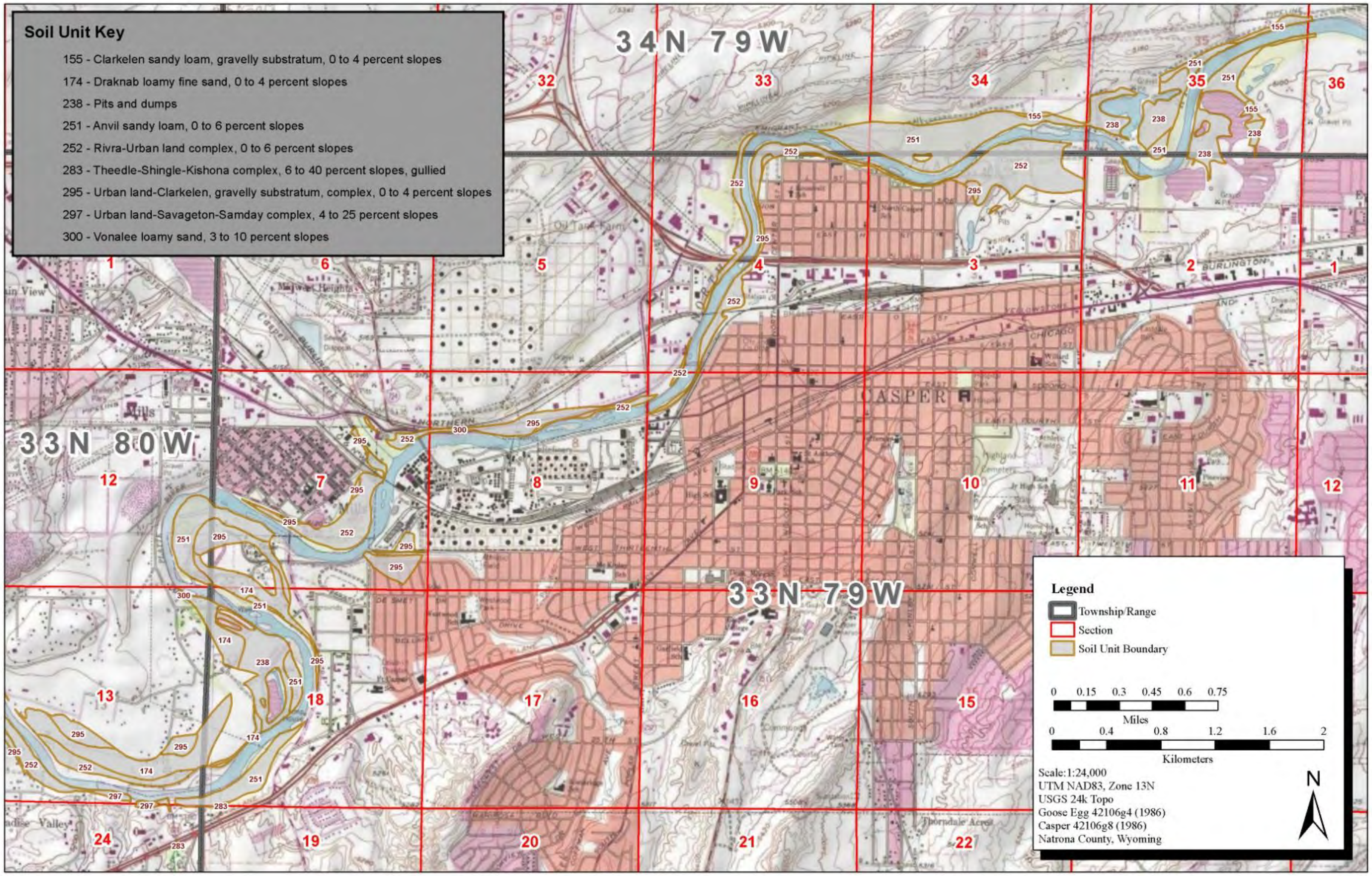

Figure 3. Soil class within the Project area (NRCS 2012).

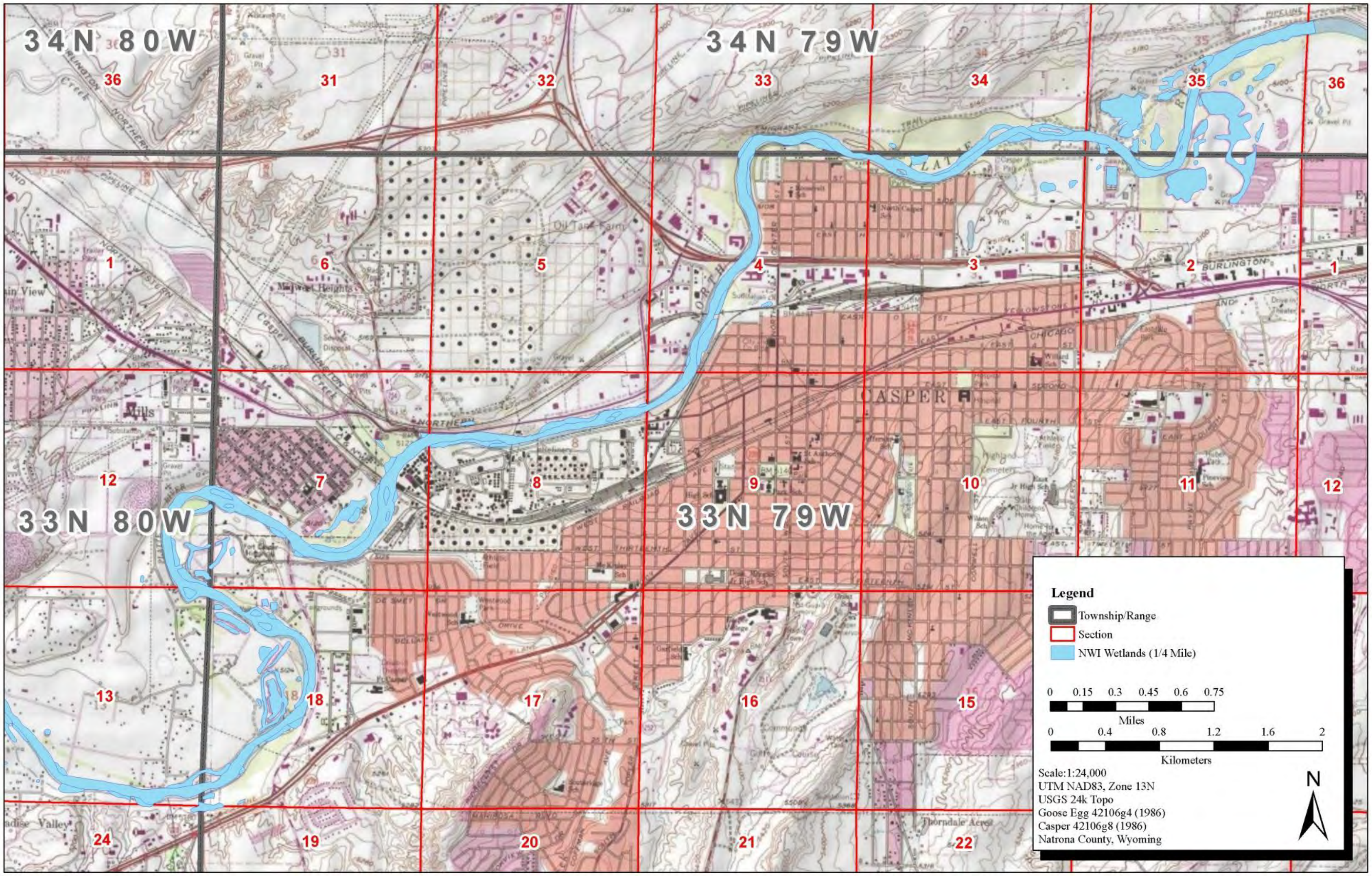

Figure 4. NWI-identified wetlands within the Project area (USFWS 2012a).

3.1.5 Vegetation

Riparian habitat surrounding the North Platte River can be described in four habitat zones: toe zone, splash zone, bank zone, and terrace zone. The toe zone in the areas surveyed fluctuates with flow levels and is an actively scoured area with exposed coarse, often cobbly alluvium. Vegetation is characterized primarily by sandbar willow (*Salix exigua*) and reed canarygrass (*Phalaris arundinacea*). The splash zone is an occasionally flooded area that is interspersed with wetlands. Vegetation in the splash and bank zones is typical of a riparian canopy especially along the transitions between zones. These areas are dominated by plains cottonwood (*Populus deltoides*), narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negundo*), Russian olive (*Elaeagnus angustifolia*) and willows (*Salix* spp.). Wetlands are dominated by wet grasses, sedges (*Carex* spp.), and rushes (*Juncus* spp.). The bank and terrace zones are infrequently inundated; soils and vegetation are more indicative of uplands. Canopy is dominated by Russian olive and old growth cottonwood with an understory of western snowberry (*Symphoricarpos occidentalis*), western wheatgrass (*Pascopyrum smithii*), alkali sacaton (*Sporobolus airoides*), and scratchgrass (*Muhlenbergia asperifolia*). The upland zone is out of the floodplain and typically devoid of a tree canopy. These areas are dominated by midgrass prairie grasses, rabbitbrush (*Chrysothamnus* spp.), and sagebrush (*Artemisia* spp.).

3.1.6 Invasive Vegetation

Invasive vegetation potentially occurring along the North Platte River includes cheatgrass (*Bromus tectorum*), leafy spurge (*Euphorbia esula*), reed canary grass (*Phalaris arundinacea*), common reed (*Phragmites australis*), Canada thistle (*Cirsium arvense*), kochia (*Kochia scoparia*), and Russian olive (*Elaeagnus angustifolia*). Russian olive is the dominant canopy species found along the North Platte River.

Russian olive is a small deciduous tree or a large multi-stemmed shrub native to southern Europe and to central and eastern Asia (Stannard, et al., 2002). It has distinctive silvery-gray leaves and reddish, shredding bark. Russian olives produce a large number of fruits annually that are typically bird-dispersed during fall and winter, although the species has an inherently slow rate of spatial spread (Katz and Shafroth, 2003). Russian olive has both negative and positive ecosystem influences, but the negative impacts (e.g., monotypic stands, nutrient cycling, and soil hydrology) exceedingly outweigh the benefits (e.g., soil stabilization, wildlife habitat).

Russian olive was introduced to western North America in the early 1900s as wind breaks, for erosion control, and wildlife habitat. Since that time, they have become a dominant non-native riparian tree species throughout western river drainages (Katz and Shafroth, 2003). This rapidly adaptable species was a popular shrub source for windbreaks and shelterbelts in semi-arid and saline environments (Stannard, et al., 2002). This species currently occupies and/or dominates a number of riverbank habitats along the North Platte River, creating dense monotypic stands that are out-competing native species, altering ecosystem functions, eliminating diverse wildlife habitats, and ultimately reducing the aesthetic and natural value of the riparian viewshed.

3.1.7 Wildlife Resources

The North Platte River and its riverbank provide critical riparian habitat for a number of fish and wildlife species (Table 3) (BLM-CFO 2011; WOS 2011; WYNDD 2011). Vegetated riverbanks provide shade and cover for fish species, while providing food sources (i.e., insects) and a buffer from activities upland (CH2MHill, 1982). Riparian vegetation also supports wildlife species by providing shelter and cover, food, and a movement corridor up and down the river.

Table 3. Wildlife species known to historically or currently occupy habitats around the North Platte River near Casper

Common Name	Scientific Name
Birds	
American Avocet	*Recurvirostra americana*
American Dipper	*Cinclus mexicanus*
American Peregrine Falcon	*Falco peregrinus anatum*
American Three-toed Woodpecker	*Picoides dorsalis*
American White Pelican	*Pelecanus erythrorhynchos*
Bald Eagle	*Haliaeetus leucocephalus*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Black-rosy Finch	*Leucosticte atrata*
Bufflehead	*Bucephala albeola*
Burrowing Owl	*Athene cunicularia*
Bushtit	*Psaltriparus minimus*
California Gull (Breeding Colonies)	*Larus californicus*
Canyon Wren	*Catherpes mexicanus*
Caspian Tern	*Sterna caspia*
Chukar Partridge	*Alectoris chukar*
Common Goldeneye	*Bucephala clangula*
Common Grackle	*Quiscalus quiscula*
Common Loon	*Gavia immer*
Common Nighthawk	*Chordeiles minor*
European Starling	*Sturnus vulgaris*
Ferruginous Hawk	*Buteo regalis*
Golden Eagle	*Aquila chrysaetos*
Golden-crowned Kinglet	*Regulus satrapa*
Great Blue Heron	*Ardea herodias*
Great Horned Owl	*Bubo virginianus*
Greater Sage Grouse	*Centrocercus urophasianus*
Greater Sandhill Crane	*Grus canadensis tabida*
Killdeer	*Charadrius vociferus*
Lark Bunting	*Calamospiza melanocorys*
Lewis' Woodpecker	*Melanerpes lewis*
Loggerhead Shrike	*Lanius ludovicianus*
Mallard Duck	*Anas platyrhynchos*
Merlin	*Falco columbarius*

Common Name	Scientific Name
Mourning Dove	*Zenaida macroura*
Northern Goshawk	*Accipiter gentilis*
Osprey	*Pandion haliaetus*
Plain Pocketbook	*Lampsilis cardium*
Prairie Falcon	*Falco mexicanus*
Pygmy Nuthatch	*Sitta pygmaea*
Red-tailed Hawk	*Buteo jamaicensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Ring-billed Gull	*Larus delawarensis*
Ring-necked Duck	*Aythya collaris*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Rough-legged Hawk	*Buteo lagopus*
Short-eared Owl	*Asio flammeus*
Snowy Egret	*Egretta thula*
Tundra Swan	*Cygnus columbianus*
Virginia Rail	*Rallus limicola*
Western Scrub-Jay	*Aphelocoma californica*
White-winged Junco	*Junco hyemalis aikeni*
Winter Wren	*Troglodytes troglodytes*
Yellow-billed Cuckoo	*Coccyzus americanus*
Mammals	
American Badger	*Taxidea taxus*
Black Bear	*Ursus americanus*
Black-footed Ferret	*Mustela nigripes*
Black-tailed Prairie Dog	*Cynomys ludovicianus*
Bobcat	*Lynx rufus*
Common Gray Fox	*Urocyon cinereoargenteus*
Coyote	*Canis latrans*
Eastern Cottontail	*Sylvilagus floridanus*
Gray Wolf	*Canis lupus*
Mountain Lion	*Puma concolor*
Mule Deer	*Odocoileus hemionus*
Northern Raccoon	*Procyon lotor*
Pronghorn	*Antilocapra americana*
Striped Skunk	*Mephitis mephitis*
Swift Fox	*Vulpes velox*
Reptiles	
Eastern Yellow-bellied Racer	*Coluber constrictor flaviventris*

Common Name	Scientific Name
Wandering Garter Snake	*Thamnophis elegans vagrans*
Fish	
Brown Trout	*Salmo trutta*
Rainbow Trout	*Oncorhynchus mykiss*
Snake River cutthroat trout	*Oncorhynchus clarki behnkei*

Source: BLM-CFO 2011; WOS 2011; WYNDD 2011

3.2 Special Status Species Occurrence and Habitat

Several wildlife species that may exist in Natrona county (USFWS 2012) are listed as threatened or endangered under the Endangered Species Act (ESA) (16 USC 1531 et seq.). According to the USFWS, listed species with habitat in Natrona County include black-footed ferret (*Mustela nigripes*), blowout penstemon (*Penstemon haydenii*), Ute Ladies'-tresses (*Spiranthes diluvialis*), and greater sage-grouse (*Centrocercus urophasianus*). Four other species have riverine habitat downstream of Wyoming in the Platte River system, including least tern (*Sterna antillarum*), pallid sturgeon (*Scaphirhynchus albus*), piping plover (*Charadrius melodus*), Western prairie fringed orchid (*Platanthera praeclara*), and whooping crane (*Grus americana*). None of these species are known to occur within the project area. Potential habitat for Ute Ladies'-tresses does occur within the project area. Prior to ground disturbing activities surveys for this species would need to be conducted within suitable habitats.

In addition to the ESA, the Bald and Golden Eagle Protection Act (16 USC 668–668d, 54 Sta. 250) and the Migratory Bird Treaty Act of 1918 (916 USC 703–711) protect nesting migratory bird species. Migratory birds are known to nest within the project area. Bald and golden eagles are also known to use the project area for nesting and feeding. Bald eagle winter foraging habitat, as designated by the Bureau of Land Management Casper Field Office (BLM-CFO), overlaps with the project area, upstream of stationing 100+00 which is located near Paradise Valley.

The project area also contains nesting habitat for various raptor species, including some that are designated as special status species by the BLM-CFO. Raptor species designated by the BLM-CFO as special status species include red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk (*Buteo swainsoni*), American kestrel (*Falco sparverius*), osprey (*Pandion haliaetus*), great horned owl (*Bubo virginianus*), long-eared owl (*Asio otus*), northern saw-whet owl (*Aegolius acadicus*), common barn owl (*Tyto alba*), and western screech owl (*Megascops kennicotti*). BLM seasonal wildlife timing limitation stipulations would be applied to projects occurring on BLM lands near raptor nests to conserve these special status species and minimize impacts to habitats. These timing limitation stipulations for raptor nesting would include no surface-disturbing activity within a 0.5-mile radius of an active nest February 1 to July 31, or until young birds have fledged. All known current and historic nests have been included within the geodatabase for planning purposes. Surveys for raptor nests would be recommended within all project areas prior to initiation to ensure that raptor nests are not disturbed.

4.0 Site Reconnaissance

Following the detailed desktop analysis, the Stantec Team performed site reconnaissance to observe and verify field conditions. This included documentation and photographing of habitat availability and types, sensitive species occurrence, verification of soil types and condition in high priority restoration sites, wetland habitat mapping, scenic view corridors, and tree inventory.

The Stantec Team also documented above and below ground infrastructure, land and water uses, existing zoning, extents of project boundary, topographic and hydrologic features, manmade structures, above ground infrastructure, transportation/circulation systems, stormwater outfalls and project constraints pertinent to the project area.

All photos and locations information collected during the site reconnaissance was provided to the City of Casper as part of the Master Plan documentation.

4.1 Vegetation Restoration Investigation

Based on the desktop analysis, four priority areas were identified that would benefit from ecological and habitat enhancement: the North Platte River Park vegetation restoration priority area, the Morad Park vegetation restoration priority area, and properties owned by Western Oil Tool & Manufacturing Company Inc. (Westech.), and the Izaak Walton League of America (Izaak Walton). Each potential vegetation restoration site was evaluated based on ecological parameters, land ownership and access, public use and benefit, and overall aesthetic potential. Ecological parameters included, but are were not limited to, native to nonnative tree occurrence, riparian habitat zones and hydrology, established native vegetation, wetlands occurrence, and evidence of flooding and scouring.

The Stantec team performed site reconnaissance between October 5, 2011 and October 7, 2011 to verify habitat types and site conditions, stand characteristics and species occurrences, and presence of nonnative and invasive plant species (with an emphasis on Russian olive) within the four priority vegetation areas. During the site reconnaissance, 12 priority vegetation restoration project sites were identified (Figure 5; Appendix A).

At each potential vegetation restoration site, habitat types were identified and characterized by the following metrics:

- Species diversity;
- Stand age demographics;
- Cover and height estimates; and,
- Number of nonnative and invasive species.

Line intercept transects were used to determine species occurrences and cover estimates at each of the 12 vegetation restoration sites (Table 4). Vegetation species observed throughout the project area was recorded (Table 5). These sites were then each assigned a priority ranking based on the methods described above. High priority sites include Site 2, 6, 8 and 11. Medium priority sites include Site 3, 4, 5 and 12, and low priority sites include Site 1, 7, 9 and 10. Site maps of each vegetation project site are provided in Appendix A.

It should be noted that Russian olive (*Elaeagnus angustifolia*) infestation in the project area is a concern. Mature Russian olive stands have come to dominate the bank zone and the transition to the terrace zone in many parts of the project area. Natural resources specialists of the project Team surveyed nearly 70 acres of riparian cover, and Russian olive percent cover ranged from 2.5 percent total cover to nearly 50 percent total cover with an average of 20 percent of total cover. These percentages are for all riparian zones, not just in the zones where Russian olive occurs. Although survey efforts on private lands was limited during this project, control of Russian olives needs to be undertaken within the watershed to ultimately eliminate the seed sources from upstream. Within the City of Casper project area boundaries, future efforts to control Russian olives on private lands will benefit publically accessible areas downstream by eliminating the seed source thus reducing reinfestation rates in reclamation areas and reducing maintenance costs.

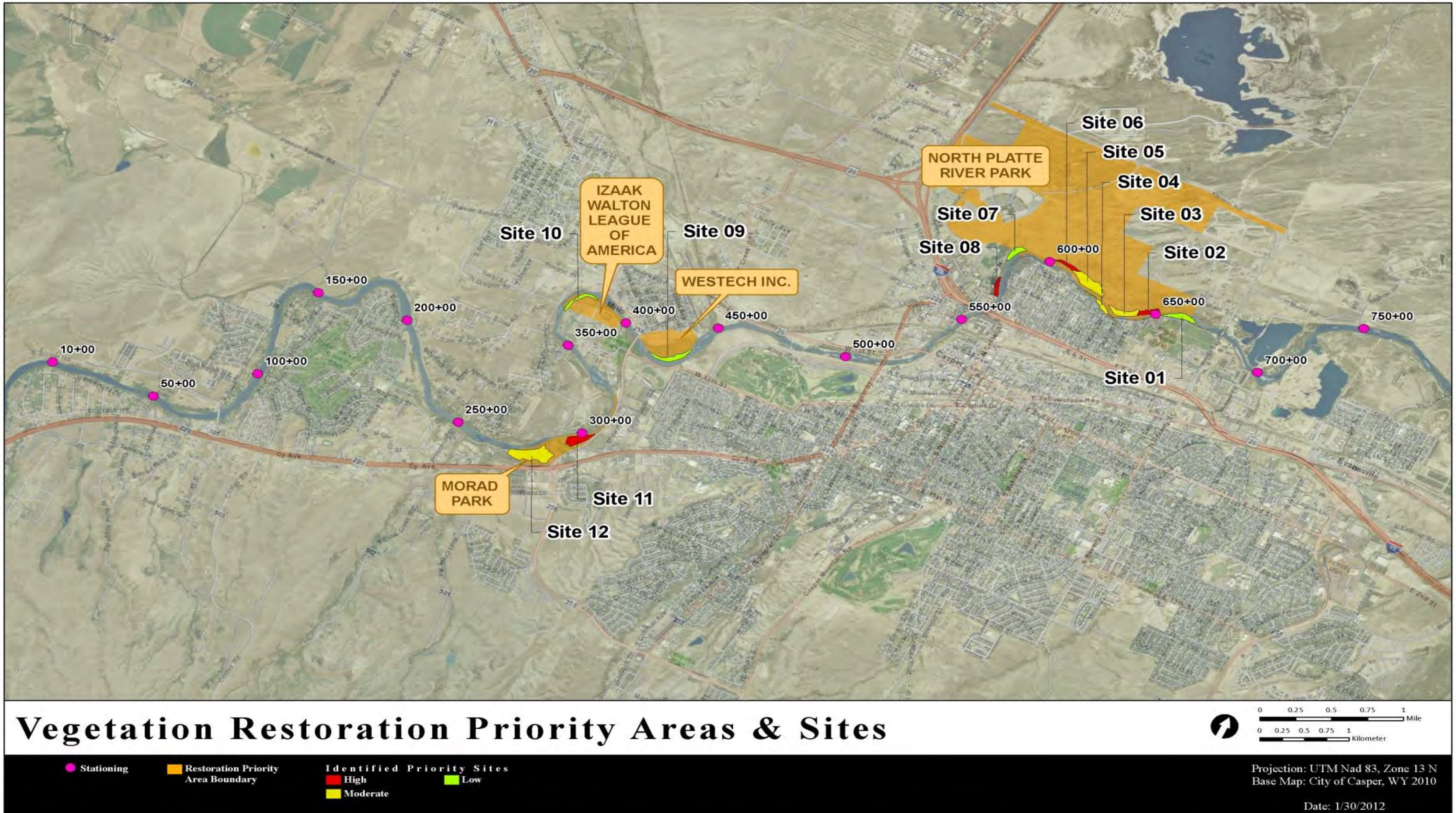

Figure 5. Vegetation restoration priority areas and sites

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Table 4. Species cover estimates at each vegetation restoration site

Priority Area	Site	Acres	Transect	Line Intercept Transect (% Cover)									
				Russian Olive	Cottonwood	Willow	Other Tree/ Shrubs	Native Grass	Nonnative Grass	Forbs	Wetland monocots	Bare/ Developed	TOTAL
North Platte River Park	1	5.81	Site 1-T1	28.6	18.4	22.4	-	2	-	-	-	28.6	100
	2	3.07	Site 2-T1	16.7	12.3	13.3	-	26.6	11.1	-	-	20	100
	3	5.21	Site 3-T1	33.3	25	25	-	13.9	-	-	-	2.8	100
	4	2.85	Site 4-T1	2.5	2.5	20	-	7.5	32.5	-	-	35	100
			Site 4-T2	13	-	34.8	-	13	13	4.3	-	21.9	100
	5	9.5	Site 5-T1	22.1	17.9	-	3.2	23.2	5.3	4.3	-	24	100
			Site 5-T2	4	13.4	0.5	-	67.7	8	-	1.5	4.9	100
	6	2.68	Site 6-T1	18.3	35	-	-	-	43.3	-	-	3.4	100
	7	4.55	Site 7-T1	-	19.1	-	-	24.9	35.3	-	-	20.7	100
			Site 7-T2	3.1	15.3	-	-	42.8	32.7	-	4	2.1	100
	8	2.54	Site 8-T1	26.5	38.2	-	-	26.4	-	2.9	-	6	100
Westtech	9	3.52	Site 9-T1	38.1	40.5	-	9.5	2.4	-	-	-	9.5	100
Izaak Walton	10	5.54	Site 10-T1	27	18.9	24.3	-	18.9	-	-	2.7	8.2	100
Morad Park	11	6.61	Site 11-T1	48.7	19.8	7.9	2.7	7.9	-	5.3	-	7.7	100
	12	14.31	Site 12-T1	3.6	17.3	5.5	10.9	28.1	18.2	11.8	-	4.6	100

Table 5. Species observed within the project area

Common Name	Scientific Name
Trees	
Boxelder	*Acer negundo*
Crack willow	*Salix fragilis*
Eastern cottonwood	*Populus deltoides*
Hawthorn	*Crataegus spp.*
Narrowleaf cottonwood	*Populus angustifolia*
Plains cottonwood	*Populus deltoides ssp. monilifera*
Russian olive	*Elaeagnus angustifolia*
Siberian elm	*Ulmus pumila*
Grasses/Monocots	
Alkali sacaton	*Sporobolus airoides*
Cheatgrass	*Bromus tectorum*
Common reed	*Phragmites communis*
Crested wheatgrass	*Agropyron cristatum*
Kentucky bluegrass	*Poa pratensis*
Narrowleaf cattail	*Typha angustifolia*
Reed canarygrass	*Phalaris arundinacea*
Rush	*Juncus spp.*
Scratchgrass	*Muhlenbergia asperifolia*
Sedge	*Carex spp.*
Tall wheatgrass	*Thinopyrum ponticum*
Western wheatgrass	*Pascopyrum smithii*
Shrubs	
Prairie rose	*Rosa arkansana*
Rabbitbrush	*Chrysothamnus spp.*
Redosier dogwood	*Cornus sericea*
Sandbar willow	*Salix exigua*
Western snowberry	*Symphoricarpos occidentalis*
Forbs	
Canada goldenrod	*Solidago canadensis*
Canada thistle	*Cirsium arvense*
Curly dock	*Rumex crispus*
Curlytop gumweed	*Grindelia squarrosa*
Kochia	*Bassia scoparia*
Pennycress	*Thlaspi arvense*
Prairie sagewort	*Artemisia frigida*
Showy milkweed	*Asclepias speciosa*

4.1.1 High Priority Vegetation Restoration Sites

High priority vegetation restoration sites are areas that are publicly owned parcels located within the boundaries of the North Platte River Park and Morad Park restoration priority areas. These sites also have well-establish (mature trees and high-density) Russian olive and native tree stands, wetlands and natural hydrological properties, and high wildlife habitat value and aesthetic appeal. High priority sites would meet the requirements for other riverbank and riverbed restoration projects (i.e., riverbank stabilization). These areas would also have the highest potential for success with tree removal and establishment of native riparian vegetation.

Site 2

This site is located in the North Platte River Park vegetation restoration priority area (Figure A2). This site is predominantly within the lower terrace zone that is frequently inundated with well-established wetlands. Mature Russian olive is established along the riverbank and saplings are well-established on side channel features and frequently flooded areas (Photopoint 1). Other wpecies observed at this site included reed canarygrass, sandbar willow, scratchgrass, alkali sacaton, fringed sagewort, carex sp., showy milkweed, eastern cottonwood, narrowleaf cottonwood, Canada goldenrod, and sandbar willow.

This site is high priority around the floodplain features. Russian olive saplings could be eradicated through spot treatments. In addition, this area supports the hydrology necessary to establish wetland vegetation. Riverbank enhancements along with side channel improvements and wetland reconstruction would be successful based on river dynamics, hydrology, and established native and wetland vegetation.

Photopoint 1. Mature Russian olive established along the riverbank at Site 2.

Site 6

This site is located in the North Platte River Park vegetation restoration priority area (Figure A6). This site has lower and upper terrace zones from the river to the uplands. The majority of trees and shrubs are located in the lower terrace zone (Photopoint 2). Severe bank collapse is occurring along the entire riverbank at this site. Russian olive cover is predominately located along the riverbank. This area provides a substantial Russian olive seed source for less invaded areas downstream. Cheatgrass is the dominant groundcover in the upper terrace zone and upland zone. Other species observed at this site included eastern cottonwood, crested wheatgrass, western snowberry, Kentucky bluegrass, scratchgrass, and western wheatgrass

Russian olive treatment potential is high if prevention of further establishment downstream is a priority. Russian olive is the dominant cover on the riverbank and may be exacerbating the bank collapse at this site with lack of native vegetation and development of high banks for undercutting. Immediate bank stabilization would be necessary if vegetation were to be removed.

Photopoint 2. Riparian vegetation on lower terrace zone at Site 6.

Site 8

This site is located in the North Platte River Park vegetation restoration priority area (Figure A8). Russian olive is well-established in mature stands along the riverbank (Photopoint 3). A variety of reclamation seed mix grasses, such as western wheatgrass and crested wheatgrass, are common in the understory. The density of Russian olive is high, with dominant canopy cover near the riverbank. This site is a potential seed source for Russian olive spread to nearby Lansing Park, which has very low Russian olive densities. Although there are mature eastern cottonwoods in the area, there are no occurrences of seedlings or saplings observed. Some cottonwoods have visible beaver (*Castor canadensis*) damage and at least one cottonwood tree was felled. Sandbar willows are well established along the riverbank where Russian olive is not present. Other species observed included eastern cottonwood, plains cottonwood, narrowleaf cottonwood, box elder, curlycup gumweed, kochia, cheatgrass, tall wheatgrass, reed canary, western snowberry, and green rabbitbrush.

Russian olive removal would be difficult and costly due to density and age of the stand; however, the potential seed source of Russian olive from this site and proximity of healthy riparian habitats downstream increases the appeal of treatment at this site. Cutting of Russian olive with concurrent and recurrent stump applications of herbicide would allow the root system to maintain bank stability while willow plantings establish.

Photopoint 3. Dense stand of mature Russian olive on riverbank at Site 8.

Site 11

This site is located in the Morad Park vegetation restoration priority area (Figure A11). This area is frequently disturbed and was recently flooded. Russian olive and crack willow (*Salix fragilis*) are co-dominant canopy species (Photopoint 4). Russian olive is well-established but the sandbar willow stands are more dominant in sandier soils along the riverbank and in areas that are more recently scoured. Mature cottonwoods are present although sparse. This area includes a high occurrence of large woody debris and refuse from recent flooding, providing ideal riparian habitat for a variety of wildlife species. Other species observed at this site included sandbar willow, carex sp., reed canarygrass, narrowleaf cottonwood, box elder, red-osier dogwood, western snowberry, crested wheatgrass, and curly dock.

Although Russian olive is co-dominant at this site, riparian willow stands provide a good source for cuttings in areas where Russian olive would be removed. The majority of the riverbank has well-established sandbar willow stands and Russian olive removal would not compromise bank stability. This area is actively flooded and supports natural riparian hydrology, which would help reduce future Russian olive establishment and support native riparian vegetation.

Photopoint 4. Russian olive and crack willow co-dominant canopy at Site 11.

4.1.2 Moderate Priority Vegetation Restoration Sites

Moderate priority vegetation restoration sites are areas that are publicly owned parcels located within the boundaries of the vegetation restoration priority areas (North Platte River Park or Morad Park) that may not have current Russian olive stands and/or saplings, but are located downstream of well-established Russian olive stands (i.e., high seed source). These areas typically have high aesthetic value with well-established native vegetation and uninterrupted hydrological processes, but are highly susceptible to future Russian olive establishment based on channel morphology and river features.

Site 3

This site is located in the North Platte River Park vegetation restoration priority area (Figure A3). This area supports a sandbar zone, lower terrace zone, and upper terrace zone (Photopoint 5). The area does not have any side channel features and/or flooding features as compared to the downstream site 2. Russian olive is concentrated at the riverbank and is limited in distribution in the upper terrace zone. Other species observed at this site included reed canarygrass, sandbar willow, scratchgrass, alkali sacaton, fringed sagewort, carex sp., showy milkweed, eastern cottonwood, narrowleaf cottonwood, Canada goldenrod, and sandbar willow.

Russian olive eradication along the riverbank would be critical to support downstream restoration and revegetation efforts. However, the removal of Russian olive would compromise bank stability and increase erosion potential. Measures would need to be implemented to support bank stability and reduce sedimentation and erosion.

Photopoint 5. Riparian vegetation with Russian olive in the upper terrace zone at Site 3.

Site 4

This site is located in the North Platte River Park vegetation restoration priority area (Figure A4). This area is positioned in a heavily flooded reach with significant beaver damage to native cottonwoods. A sandbar zone supports a healthy stand of sandbar willow and reed canarygrass. Russian olive is well established throughout this site and actively establishing within erosional areas as a result of the 2011 flood events (Photopoint 6). Additional species observed at this site included eastern cottonwood, crack willow, sandbar willow, plains cottonwood, reed canarygrass, and curly dock.

This area is highly accessible and may potentially have high recreational use. The majority of mature cottonwoods will need to be removed as a result of beaver damage. Russian olive densities at this site are high and removal and restoration efforts would require complete removal of Russian olives, followed by revegetation with native species and a monitoring and maintenance plan to keep reestablishment of Russian olives at a minimum. Removal and maintenance costs may be high at this site, however this site has high recreational use potential and could serve as a seed source for downstream areas.

Photopoint 6. Russian olive establishment upland of the sandbar zone at Site 4.

<u>Site 5</u>

This site is located in the North Platte River Park vegetation restoration priority area (Figure A5). This area is entirely within the lower terrace zone and downstream of high priority site 6. Russian olive is established in this area, but is mostly mature stands along the riverbank (Photopoint **7**). Russian olive saplings are established along the many frequently flooded swale wetlands that were naturally blocked-off side channels. There are several mature cottonwoods interspersed throughout the grassy upper terrace zone, where cheatgrass is typically the dominant cover. Additional species observed at this site included eastern cottonwood, western wheatgrass, crested wheatgrass, reed canarygrass, scratchgrass, western snowberry, narrowleaf cottonwood, Kentucky bluegrass, alkali sacaton, and sandbar willow.

Russian olive saplings could potentially be eradicated from the swale wetland areas and further wetland development could occur at this site. Russian olive removal along the riverbank could be labor intensive with potential bank stabilization issues.

Photopoint 7. Russian olive interspersed under a cottonwood gallery at Site 5.

Site 12

This site is located in the Morad Park vegetation restoration priority area (Figure A12). This area supports several relic side channels and depressions from prior flooding events and channel migration (Photopoint 8). This site is located within the upper terrace zone and supports localized depression swales and wetlands. Russian olive establishment is limited and there are very few large, mature Russian olive trees. Additional species observed at this site included sandbar willow, reed canarygrass, kochia, crested wheatgrass, narrowleaf cottonwood, alkali sacaton, western wheatgrass, western snowberry, prairie rose, Kentucky bluegrass, curly dock, cheatgrass, pennycress, and box elder. The presence of western wheat grass, cheatgrass, and Kentucky bluegrass indicates that non-native grasses have established at this site.

Although Russian olive densities are low in this area, restoration potential is moderate due to the opportunity to establish native riparian vegetation and enhance and develop existing wetland areas. Increasing wetlands in this heavily used area would increase the aesthetic appeal of Morad Park and provide a runoff and sediment trap to reduce sedimentation to the North Platte River.

Photopoint 8. Densely vegetated side channel in the upper terrace zone at Site 12.

4.1.3 Low Priority Vegetation Restoration Sites

Low priority vegetation restoration sites are areas that are either not publicly owned parcels that are located outside of the boundaries of the vegetation restoration priority areas or have low densities of Russian olives or other factors which may reduce their immediate priority need for restoration. These areas typically include well-established Russian olive stands, but management of these areas would be determined in part by the land owner, which could potentially limit restoration success. In addition, these areas may not align with additional riverbank and riverbed restoration efforts. Low priority vegetation restoration sites are identified because they may have high potential with the appropriate permissions from private land owners and are areas with limited public access, which may increase invasibility and/or limit restoration.

Site 1

This site is located in the North Platte River Park vegetation restoration priority area (Figure A1). This area has a prominent sandbar zone that is frequently flooded and scoured (Photopoint 9). Cottonwoods on the lower and upper terrace zones are mature and healthy. Russian olive is established but not dominant. A municipal drainage from a large athletic field complex to the south exits into this site. Additional species observed at this site included sandbar willow, carex sp., cheatgrass, reed canarygrass, western wheatgrass, crested wheatgrass, kochia, and crackwillow.

Restoration potential in this area may be limited due to the frequency of disturbance from flooding and irregular drainage patterns from the athletic field complex. Russian olive removal and eradication would increase the natural landscape and reduce the seed source. Development of a wetland catchment near the drainage would control the outflow from the drainage and reduce sedimentation from runoff.

Photopoint 9. Gravel and cobbly riverbed and scoured sandbar along riverbank at Site 1.

Site 7

This site is located in the North Platte River Park vegetation restoration priority area (Figure A7). This area is immediately downstream from Site 8, which supports a high density of Russian olive and a potentially large seed source. Mature cottonwoods are well established with a native grass understory (Photopoint 10). The lower terrace zone is well vegetated but contains very few shrub and/or tree species. Cheatgrass is beginning to gain dominance in sparsely covered areas. This upper terrace zone is heavily used recreationally which may facilitate the additional spread of invasive species. Established cottonwood and willow saplings were not observed in high densities. Additional species observed at this site included reed canarygrass, western wheatgrass, cheatgrass, crested wheatgrass, plains cottonwood, eastern cottonwood, crack willow, Kentucky bluegrass, narrowleaf cottonwood, kochia, black willow common reed, and timothy.

Russian olive densities are low at this site; however, this area has high invasibility potential based on its proximity and downstream location to Site 8 that has high Russian olive densities. Cheatgrass may potentially be controlled in the upper terrace with spot treatments, recreation use control, and overseeding of native grass species. Riverbank enhancements and the reestablishment of local hydrological patterns may increase sandbar willow and cottonwood establishment, further reducing the likelihood of Russian olive establishment and spread.

Photopoint 10. Mature cottonwoods with native grass understory at Site 7.

Site 9

This site is located on Westech property that includes a portion of riverfront along the North Platte River trail corridor (Figure A9). The area near the river includes a sandbar zone and lower terrace zone. These areas are frequently flooded and have an active side channel separating the sandbar zone from the lower terrace zone (Photopoint 11). Mature cottonwoods are interspersed throughout a well-developed canopy. There are well established stands of sandbar willow; however, the riverbank is predominantly Russian olive. Other species observed at this site included carex sp., sandbar willow, reed canarygrass, narrowleaf cottonwood, eastern cottonwood, scratchgrass, western wheatgrass, crested wheatgrass, showy milkweed, plains cottonwood, downey hawthorn, common reed, and cheatgrass.

This area has well-established sandbar willow stands that will continue to thrive with existing flow dynamics and hydrology. Russian olive may potentially become stressed with frequent flooding events and the spread of native vegetation. Access to the riverbank would be limited due to the active side channel and densely distributed sandbar willow. In addition, the long term management of this area may be limited due to private ownership.

Photopoint 11. Sandbar zone with native riparian vegetation and an established Russian olive stand at Site 9.

Site 10

This site is located on Izaak Walton League of America property that includes a portion of riverfront along the North Platte River (Figure A10). This area is divided by a human-constructed levee that separates the upper terrace zone from the lower terrace zone and sandbar zones. The upper terrace zone is a mature, open understory cottonwood gallery with very little understory vegetation. The lower terrace zone supports a dense cover of Russian olive (planted as a windbreak) (Photopoint 12). The sandbar zone is frequently flooded and recently scoured, with portions entirely devoid of vegetation. Sandbar willow and reed canarygrass are well-established throughout these zones. Other species observed at this site included eastern cottonwood, hawthorn, cheatgrass, sandbar willow, plains cottonwood, Kentucky bluegrass, narrowleaf cottonwood, prairie rose, western snowberry, and downy hawthorn.

This portion of the riverfront is part of the Izaak Walton League Nature Trail and is not associated with the North Platte River trail corridor. Public access is limited and the aesthetic benefits from any restoration may not be recognized by the public. However, the Russian olive stands are a potential seed source for future downstream establishment and are located away from a stabilized riverbank. Removal of Russian olive would potentially eliminate an upstream seed source.

Photopoint 12. Well established Russian olive stand and seedlings along the lower terrace zone at Site 10.

4.2 Scenic View Corridors

Visual resources represent the aesthetic quality of the environment as perceived through the visual sense only. As such, many people have differing definitions of what constitutes an aesthetically pleasing environment. The existing landscape viewed from the project area generally consists of urban development in the foreground with rolling hills and open space in the middleground, and mountainous terrain in the background view to the south, southeast, and southwest. The view is dominated by a mountain-sky horizon, with several contrasting elements in the landscape, such as rocks and outcrops, variable trees, and other contrasting vegetation. Existing features include open land vegetated with low-growing sagebrush on rolling hills giving way to rugged mountainous terrain with dark, conifer vegetation. There are not currently any industrial structures, such as windmills or oil fields, visible along the horizon to the south. However, industrial structures associated with wind farms are visible to the southeast. The addition of industrial structures to the south of Casper would greatly alter the open space view and aesthetic quality of the views from the Project Area and the City of Casper.

The view from the project area to the north consists of urban development in the foreground with rolling hills and open space in the background. In general the view of urban development to the north is reduced to specific areas throughout the project, refer to Figure 3.

Within the foreground of the project area, primarily within the riparian zones, the vegetative community is dominated to varying degrees by Russian olive infestation. As a result the riparian areas currently have a different visual appeal based on color variety, canopy composition, and structure than historically experienced or experienced within healthy native vegetative communities.

4.3 Fish Habitat

The North Platte River through the City of Casper is rated as a blue ribbon trout fishery. While the fishery is high quality based on the number of fish per mile, the fishery is known to fluctuate in density and size of trout based primarily on winter flow conditions. The habitat in North Platte River through Casper currently consists of large runs with limited availability of riffle and pool complexes. High quality trout habitat is complex; consisting of an array of rapid flowing riffles, deep pools, submerged or semi-submerged wood, boulders or rock piles, undercut banks with overhanging riparian vegetation, and aquatic vegetation. These habitat features provide food sources for trout, shelter, and overwintering habitat. These features also provide areas that concentrate fish density, thus improving angler success and satisfaction.

The entire 13.5-mile project length was floated with a local fishing guide (Luke Keil, Wyoming Anglers) to gain a better understanding of the quality of the fishery within the project area. Mr. Keil noted areas of either poor or good fishing along the project reach. When compared with data obtained during the geomorphic assessment (see Section 4.4), the areas of the poorest fishing correlated with the areas of the most geomorphic instability. This information was used to help identify potential project locations for restoration activities. The addition of physical structure can influence the development of scour holes, pools, narrowed stream channels, and increased water velocity of the stream. Additions of wood or boulders and planting of riparian vegetation can expedite an increase in overhanging bank cover and submerged habitat components that provide spawning, feeding, and cover for trout.

4.4 Stream Survey

4.4.1 Rosgen Classification

Broad, alluvial valleys with wide floodplains and gentle relief are the dominant valley type in the landscape of the North Platte River. Stable "E" and "C" stream types based on the Rosgen Classification System (Rosgen, 1994) with meandering, gently sloping channels are typically found in this valley type (refer to Appendix B for further information on the Rosgen Classification System). Valley type information can be used to predict stream type because erosional and depositional processes that influence morphological characteristics of dimension, pattern, profile, slope, and channel materials vary with valley type. For example, "C" stream type channels are wide, meandering, gently sloping channels typically found in broad valleys with wide floodplains and gentle relief. Steep, narrow, confined "G" stream type channels can be found in V-shaped, confined valleys with high elevation relief. Valley type information can also be used to assess stream stability. For example, gullies found in broad, alluvial valleys are usually highly unstable streams that have evolved from the stable "C" stream type to the "G" stream type due to changes in dimension, pattern, profile, slope, sediment supply, flow, or vegetation. Valley type is also a consideration in river restoration, as a reference reach of the same stream type and valley type is typically used as a "blueprint" for natural channel design.

The entire 13.5-mile reach was floated several times, and observations were made about the general morphology of the stream channel. Observations included stream bank conditions, fish habitat, channel pattern, proximity of manmade structures, sediment conveyance, stream cross-section, and potential restoration opportunities.

In general the stream is over widened for most of the project area. Several areas exhibited divided flow or completely braided cross-sections. The divided flow or braided cross-section occurs when a channel becomes sufficiently over widened, such that the depth decreases. As a result, shear stress in the stream decreases to a point where the incoming sediment cannot be transported and is subsequently deposited, forming sediment bars. Areas where divided or braided stream flow were observed are outlined in Table 6.

Table 6. Stationing of observed divided or braided stream flow

Divided or Braided Stream Flow	
Starting Station	Ending Station
89+00	92+25
145+00	146+00
170+00	173+10
191+00	192+50
211+00	212+50
259+50	260+70
329+50	340+00
382+00	400+00
439+00	440+00
491+00	496+00
502+00	509+00
610+50	612+00
684+00	694+00
700+00	732+00

4.4.2 Channel Evolution

Stream instability is triggered by a disturbance to the morphology of the channel, the flow regime, and/or the sediment supply rates to the channel. Once in an unstable state, streams will naturally work towards reaching a new stable state; however, the process can take 10's or 100's of years, with severe bank erosion occurring during the process. In order to determine whether stream restoration activities are necessary, or whether natural stream processes are sufficient for restoring a stream to a natural stable state, it is important to determine where along the channel evolution trajectory the stream currently lies. There are six proposed restoration reaches in the project area (see Section 5). All of these restoration reaches are currently at an intermediate point along their channel evolution, with varying degrees of horizontal and/or vertical instability. Three succession scenarios, as defined by Rosgen (2008), are present on-site. These scenarios are graphically depicted below in Figure 5. These succession scenarios represent the central tendencies of an eroding and unstable reach to transition from a stable state on the left to a new stable state on the right, with unstable transitional states in between.

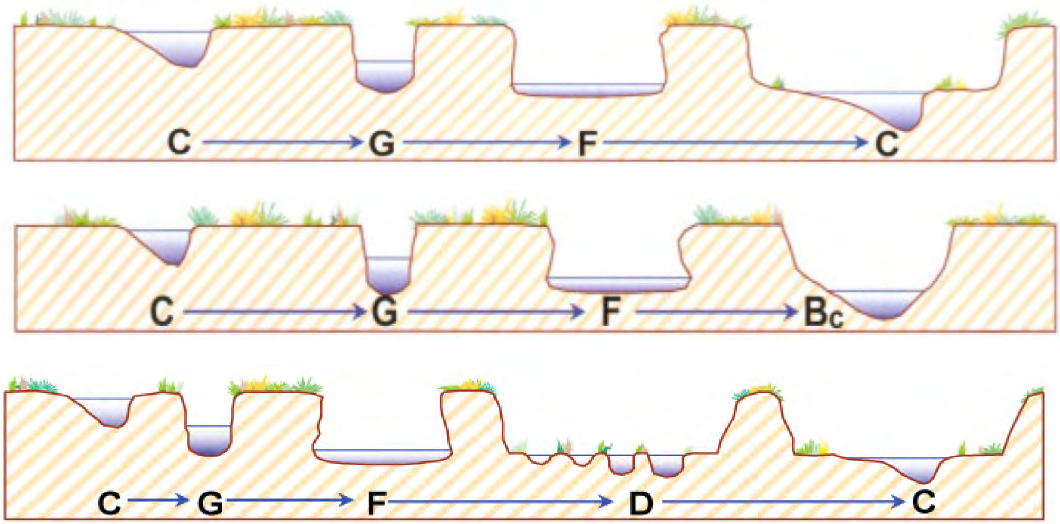

Figure 6. Three channel evolution scenarios applicable to the North Platte River project area (source: Rosgen 2006)

4.4.3 Manmade Structures

A detailed survey of manmade structures along the North Platte River was completed in the project area. There are numerous manmade structures along the river. These include docks, boat ramps, concrete, manholes, stairs, retaining walls, riprap, tire toe protection, stormdrain pipes, bridges, roadways, kayak structures, and building infrastructure. A graphic illustration of the results of this survey is included on the Existing Conditions plan sheets in Appendix C. A photo log of the observed structures is also included in this appendix. The presence of the smaller manmade structures such as the docks, boat ramps, and stairs has had little impact of the morphology. However, other larger structures have influenced the stream morphology. This includes SW Wyoming Blvd., located between stations 304+00 and 320+00. The right river bank is covered in riprap and concrete in order to protect the roadway. Additionally, the kayak structures located at stations 479+00 to 522+00 have directed flows towards stream banks, causing bank erosion. The kayak structures have also generated an over-widened cross-section resulting in sediment bar formation in those locations. Numerous other locations were observed where rip rap has been placed on stream banks, resulting in impaired fish habitat and aesthetics

4.4.4 Geomorphic Assessment

A detailed geomorphic field survey was conducted on two representative river sections (reaches) within the project area. These reaches were chosen based on their representativeness of the basic geomorphologies found in the project area, and due to their potential for future restoration projects. The detailed survey included the collection of channel cross-section data and longitudinal surveys.

For a channel cross-section survey, geometric data for the dimensions of a stream is collected across a stream channel, from one bank to another, perpendicular to the direction of stream flow. The cross-section survey includes locating the top of bank, bankfull indicators, water surface, thalweg (deepest part of the channel with active flow), and other topographic features in sufficient detail to capture the channel geometry. The longitudinal profile includes a survey of water surface, and thalweg along an entire reach, in the same direction as stream flow. This data is then plotted to determine the slope and relative slope of the different features.

The first reach was located in the Morad Park area, and was approximately 5000 feet in length, extending from station 250+00 to station 300+00. Six cross-section surveys were completed within this reach. This included two cross-sections in riffles four cross-sections located in pools in the reach. The average slope through the reach was found to be 0.08 percent, and the Rosgen classification was determined to be an F3 channel type. The second reach, approximately 8300 feet in length, began at approximate station 570+00 and ended at approximate station 653+00. Five cross-section surveys were completed within this reach. This included two riffle cross-sections and three pool cross-sections. The average slope through the reach was found to be 0.1 percent, and the Rosgen classification was determined to be an F3 channel type. F type channels can be described as deeply incised, with very high width-to-depth ratios and accelerated channel aggradation and/or degradation. The ‘3’ refers to a cobble bed channel. F type channels are inherently unstable due to the high width-to-depth ratios and inherent incision.

4.4.5 Bank Stability and Erosion Estimates

Additionally, a stream bank survey was conducted along the entire 13.5-mile study area. The survey involved Near Bank Stress (NBS) and Bank Erosion Hazard Index (BEHI) analyses. NBS is an evaluation of the stress exerted by stream flow on the stream banks. In a BEHI analysis data on the physical characteristics of the stream banks are examined to determine the susceptibility of the banks to erode. These characteristics include vegetation rooting depth, vegetation rooting density, bank angle, surface protection, bank height to bankfull height ratio, bank material, and bank stratification. The rating categories for NBS and BEHI indices rate from very low, low, moderate, high, very high, to extreme. These values indicate the banks’ susceptibility to erosion and the potential of the flow pattern to cause erosion on the banks. A rating category was assigned to sections of bank within the project area according to observed characteristics. The visual assessment indicated a low to moderate rating for the majority of the project area, and a few isolated areas with severe potential for erosion. A graphic illustration of the results is included on the BEHI plan sheets in Appendix D.

The stream bank erosion rates for the study area were predicted using the “Bank Assessment for Non-point source Consequence of Sediment” (BANCS) method. This method utilizes the results from the BEHI and NBS study, as well as a sediment rating curve to estimate bank erosion rate. For this analysis, a sediment rating curve developed by Dave Rosgen for the State of Colorado was used (Rosgen, 2006). Results from the BANCS method were then used to estimate of annual sediment loss by multiplying the bank erosion rates by the bank height and bank length along individual reaches with the same BEHI and NBS scores. The results of this analysis indicate that approximately 5,900 tons of sediment is lost per year from the stream banks within the project area. A graphic illustration of these results is provided in the sheets titled North Platte River Existing Erosion Rates in Appendix E.

4.4.6 Bankfull Velocity and Discharge Estimates

Bankfull flow is defined as the channel-forming flow, or that flow which moves the most sediment over time, thus having the greatest impact on sediment distribution and channel geometry. The bankfull elevation is determined through in-situ identification of geomorphic markers of the effective water surface elevation during past bankfull flow events. The area below that elevation represents the bankfull cross-sectional area. Bankfull velocity, bankfull discharge, and bankfull cross-sectional area are mathematically related. Bankfull cross-sectional area can be measured in the field, and the associated velocity and discharge are then calculated. On average, bankfull discharge is the flow associated with the 1.5-year storm event (Rosgen 1996). The 1.5-year storm is defined as the 24-hour rainfall event with a statistical likelihood of occurring once every 1.5 years.

During the stream survey, some bankfull indicators were located within the project area. The bankfull cross-sectional area was found to be approximately 1,400 square feet (sf). Using the bankfull cross-sectional area and Manning's Equation (with a roughness factor determined by stream type (Rosgen 1996)), bankfull velocity and discharge were calculated to be 4.34 feet per second (ft/s) and 6,000 cubic feet per second (cfs), respectively. It is important to note that a more defined bankfull cross-sectional area is needed for final design. This will involve the survey of more cross-sections in the project area, as well as upstream and downstream of the project area to confirm the bankfull cross-sectional area.

Additionally, a gage analysis was completed for the project. Five gages were analyzed: USGS 06630000 (N Platte River Seminoe Reservoir, NR Sinclair, WY), USGS 06642000 (North Platte River Alcova, WY), USGS 06645000 (North Platte River Below Casper, WY), USGS 06652000 (North Platte River Orin, WY) and Bureau of Reclamation Hydromet System for the North Platte River at Casper. The Bureau of Reclamation gage has a period of record dating back only to 2006 and only has daily average flows, therefore it was not useful for examining 1.5 year return intervals. When examining the USGS gages the discharge, velocity and bankfull cross-sectional area estimates for the project reach seem in line with gage data near the project area (Table 7).

Table 7. Gage analysis

Gage	Contributing Drainage Area (sq. mi.)	Location in Relation to Casper, WY	Discharge for 1.5 Year Return Interval (cfs)	Velocity Corresponding to 1.5 Year Return Interval (ft/s)	Cross-sectional Area Corresponding to the 1.5 Year Return Interval (sf)
06630000 Sinclair, WY	4,061	Est. 131 river miles upstream	5,910	4.67	1200
06642000 Alcova, WY	10,112	Est. 60 river miles upstream	3,620	2.89	1130
06645000 Below Casper, WY	11,743	Est. 60 river miles downstream	5,740	NA	NA
06652000 Orin, WY	13,822	Est. 117 river miles downstream	4,210	3.48	1220

4.5 Cultural Resources

A desktop analysis and evaluation of cultural resources was conducted within the proposed stream restoration project areas (refer to Sections 4.1 and 5.1). These areas are located in Sections 2-4, 7 and 18 in Township 33 North (T33N), Range 79 West (R79W); Sections 12 and 13 in T33N, R80W and Sections 33-35 in T34N, R79W of the North Platte River Valley This analysis was conducted to facilitate project design tactics related to avoiding eligible cultural resources, and to provide a general assessment of cultural resources located within the proposed restoration project areas. Based on this analysis, five cultural resources sites were identified within the restoration area. These sites include segments of the Oregon Trail, the Mormon Ferry Crossing, the North Casper Clubhouse, and the Historic Pump House. A full report on the cultural resource findings is included in Appendix A.

It is recommended that all eligible cultural resources be considered during the final design process in order to eliminate any impacts to these sites. Further work would need to be conducted to identify the historic footprint of the trail segments within the project area and to accurately provide an adequate buffer around eligible sites. A formal Class III cultural inventory of the project area would need to be conducted prior to initiation of ground disturbing activities.

5.0 North Platte River Master Plan

5.1 Stream Restoration Concept Design

Restoration is part of a broad, watershed-based approach for the re-establishment of physical, chemical, and biological components of an aquatic ecosystem. The restoration of the North Platte River will improve physical, chemical and biological components of the North Platte River and downstream waters.

Restoration designs utilize reaches of stable channel morphology and natural stable riparian zones and floodplains as references for design. These reference reaches provide natural channel design dimensionless ratios that are based on quantitative morphological relationships.

The objective of a Priority I project is to replace the incised channel with a new, stable stream at a higher elevation. This is accomplished by excavating a new channel with the appropriate dimension, pattern and profile (based on reference-reach data) to fit the watershed and valley type (NCSRI 2004). The reconnection of the channel to its original floodplain will raise the water table at the site and likely restore hydrology to wetland areas.

The objective of a Priority II project is to create a new, stable stream and floodplain at the existing channel-bed elevation. This is accomplished by excavating a new floodplain and stream channel at the elevation of the existing incised stream. The new channel is designed with the appropriate dimension, pattern and profile (based on reference reach data) to fit the floodplain (NCSRI 2004).

The North Platte River has been broken up into seven proposed project areas for the purposes of this conceptual level design (Figure 6). These reaches were determined based on existing primary stream stressors, proximity to publically owned land, river access, and potential for increasing fish habitat. Examples of existing stream stressors include active braided flow sections, base level shift, buffer disturbance, high sear stress/eroding banks, and high sediment load.

The river reaches in the North Platte River proposed restoration areas are currently somewhat incised with varying degrees of horizontal and/or vertical instability. The streams are slowly working towards recovery, but are currently experiencing bank erosion and contributing sediment loads to the system as a result. Without restoration, it will be decades to a century before the streams will reach a stable endpoint. During this time sediment will continue to degrade water quality and habitat. Therefore, restoration would improve water quality both within the restoration sites and downstream of the project area, and improve aquatic habitat.

The proposed restoration projects will provide numerous ecological and water quality benefits within the North Platte River. While many of these benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Restoration of the stream channels and riparian buffers using the principles of natural channel design will greatly benefit the stream system by improving biological integrity, increasing dissolved oxygen, and moderating water temperature.

The conceptual design is intended to restore reaches and create stable channel morphology appropriate for the existing flood flows in the system. The conceptual design will also significantly reduce sediment loads in the restoration reaches by reducing shear stress on the stream banks. Additionally, several different types of in-stream structures will be used in the design to significantly improve fish and benthic habitat throughout the project area.

The conceptual design for the proposed river restoration sites were developed using Rosgen's Natural Channel Design Methodology (NCSRI 2004). Bankfull cross-sectional areas observed in the field were used as the basis for the design. Bed roughness was assumed to be equal for all reaches within the design process. Manning's equation was utilized to calculate mean velocities and then multiplied by channel area to estimate design discharges for the restoration reaches.

Priority II (PII) restoration techniques are proposed for the restoration reaches in order to work within existing valley confinements, in addition to optimizing cut/fill requirements and reducing construction costs. The Priority II restoration approach consists of replacing the existing incised channel with a new stream of stable dimension, pattern, and profile at the existing channel bed elevation. Additionally, a new floodplain is excavated at the bankfull elevation of the new channel. The new channel, (usually an E or C stream type) in some cases can be constructed in dry conditions, allowing flow through the existing channel until it is stabilized with structures and vegetation. Flooding does not increase, and may be decreased using this option. A Priority II restoration may be more expensive and complex than a Priority I restoration, depending on valley conditions, but still can produce a long-term, stable stream system if properly designed and constructed.

The proposed Priority II channels will be C3 type channels, with slopes less than 2 percent, moderate width to depth ratios, and entrenchment ratios greater than 2.2. The entrenchment ratio is defined as the channel width at a height two times the bankfull width, divided by the channel width at bankfull. High entrenchment ratios correspond to channels that are not incised. C3 channel types occur in broad alluvial and glaciated valleys and the substrate is predominantly comprised of cobble with lesser amounts of gravel and sand (Rosgen, 1996). These reaches will require specific meander lengths and beltwidths for energy dissipation, and to maintain stable stream geometry.

For this concept design, "Rules of Thumb" (observations made by Stantec senior water resource engineers for channels of similar stream and valley type) were used to determine the new channels' pattern and profile in sections were applicable. The dimension was determined as described above under the Bankfull Velocity and Discharge section (Section 4.4.6). To develop a full design, reference reach data and regional curve data will be needed to determine the appropriate dimension, pattern, and profile of the restoration reaches. Regional curves provide a graphical representation of the relationship between bankfull discharge and drainage area, and are specific to particular regions of the country. The development of a local regional curve may provide more accurate information on this relationship, specific to the area surrounding Casper.

It is important to note that as the North Platte Restoration moves forward it will be imperative to consider shear stress and stream power as design constraints, i.e. flow velocity will need to be set to a determined maximum. Typical morphological characteristics from stable reference reaches will also need to be used in determining design dimension, pattern, and profile parameters. Additionally, all design reach parameters (geomorphology, slopes, etc.) will need to be determined with cut/fill balance in mind, and then verified with hydraulic analysis for shear stress, stream power, and flood hydraulics.

Structures are included in the conceptual design to provide grade control, bank stability, redirection of flows, and stream habitat improvement. Primary structures include woody debris toe protection, constructed rock riffles, wing deflectors, and J-hooks. The structures are simple, easy to build, and can often be constructed with local materials. Structure quantity can be adjusted according to the availability of materials. The purpose of each structure and example photos are included below.


Woody debris toe sod mats

Woody debris toe protection is an innovative structure that can incorporate readily available onsite materials that would otherwise be sent offsite for disposal. Woody debris toe sod mats will be used for both temporary and permanent bank stabilization on the outside of meanders. The woody debris toe sod mats will be planted with live stakes, bare roots, and transplants. Large woody debris will be placed under the sod mats at an elevation such that they remain submerged, providing important fish habitat and a carbon source for the streams.


Constructed riffle

Constructed riffles will be designed to improve fish and benthic habitat. The d100 (largest sediment material found in the channel) will be based on the available materials (i.e. boulders) for grade control within the riffles. Low flow channels will be designed to have a slight meander capable of passing some gravel, but leaving the larger base materials used to construct the riffle. The result is a natural looking system with a wide range of depths and velocities. The micropools created by the constructed riffles will provide valuable fish and benthic habitat.


J-hook

J-hooks will be used in some reaches for energy dissipation, to hydraullically turn flows, provide vertical grade control and bank protection, and create downstream bed scour. These structures will also help to create a large range of velocity and depth combinations throughout the project site, increasing biodiversity.

Where the stream is over-widened, wing deflectors will be used to create areas of deposition, causing the channel too narrow to an appropriate width to depth ratio.

Several areas were targeted for restoration based on a series of specific factors including morphological condition of the river, accessibility, proximity to publically owned lands, and aesthetics. In all, six potential restoration sites were determined to be viable. These sites are outlined in Table 8 below, and their concept designs are included in Appendix F. The general location of these proposed projects is depicted below in Figure 6.

Table 8. Proposed restoration projects

Site Number	Starting Station	Ending Station	Restoration Actions/Rational
1	270+00	296+00	Placing in-stream structures, correcting stream cross section, stabilizing banks, planting native vegetation. Located in Morad Park
2	300+00	330+00	Moving stream channel away from SW Wyoming Blvd, creating floodplain on right bank, removing existing riprap/concrete on right bank, planting native vegetation
3	328+00	340+00	Removing mid channel bars, placing in-stream structures, creating riparian wetlands, planting native vegetation
4	377+00	400+00	Stabilizing banks, placing in-stream structures, removing mid channel bars, creating riparian wetlands, planting native vegetation
5	570+00	670+00	Bank stabilization, fish habitat structures, removing riprap/concrete bank protection
6	700+00	740+00	Removing mid channel bars, placing in-stream structures, creating riparian wetlands, planting native vegetation
7	514+60	534+60	Stabilizing banks, planting native vegetation, removing existing riprap/concrete on banks

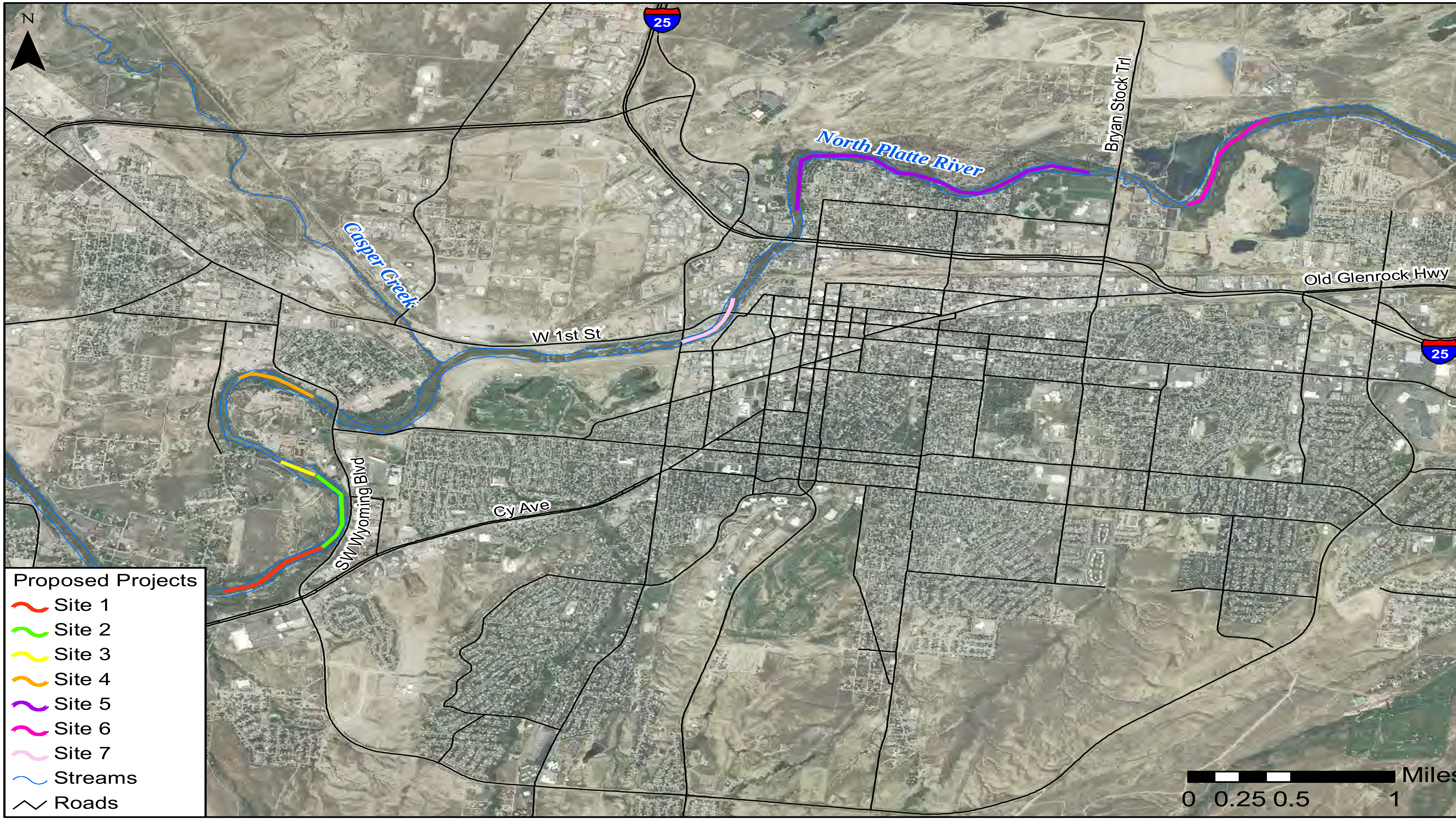

Figure 7. Proposed stream restoration project locations

5.2 Vegetation Plan

The purpose of this project is to enhance and restore riparian vegetation and wetland habitats by creating representative examples of historical riparian wetland and riparian communities to the greatest extent possible under the current hydrologic regime constraints. Project goals include:

1. Removing and/or controlling non-native phreatophytes (especially Russian olive)
2. Stabilizing the riparian bank to reduce erosion and in-stream sedimentation; and
3. Create and/or restore examples of North Platte River riparian wetlands

Two sets of general revegetation approaches are described below to achieve these project goals:

1. Non-native phreatophyte removal and revegetation in areas where river restoration work will not be taking place
2. Revegetation options in areas where large-scale river restoration will be taking place

5.2.1 Removal and Control of Non-Native Phreatophytes

The primary non-native of concern in the project area is Russian olive. There are several effective methods to treat Russian olive invasion and most other undesirable woody vegetation (Shafroth, et al., 2010). However, not all methods are appropriate for all situations. Brief descriptions of the most appropriate treatment methods for the North Platte River Project Area are provided below. Cost estimates associated with each treatment method are provided in Table 10 in Section 5.4.

Hand Cutting

Live Russian olive is a relatively soft wood and can be easily cut with hand saws or chainsaws. Cutting can take place any time of year but as with all control methods, care should be taken to avoid cutting down trees with viable fruit that could be spread through the removal process. If follow-up treatment with herbicide is planned, the air temperature should be above freezing. Cut trees can be chipped on site or stacked for later disposal. Long-term storage of cut trees is not advisable because Russian olive cuttings do have the capacity to root and resprout. Hand cutting is a relatively cost effective removal method, but if this technique is used alone Russian olive trees will resprout quickly.

Chemical Treatment

Herbicidal application, such as triclopyr (Garlon 3a. or Garlon 4) to the foliage, to the phloem through the cut-bark method, or to cut-stumps to prevent resprout are all effective methods of Russian olive control. In an aquatic environment such as the North Platte River, chemical foliar herbicidal treatment is not recommended because of the risk of aquatic contamination, and non-target species impacts. Herbicidal treatment is relatively cost effective and adjacent desirable vegetation can be maintained with careful application, but it is a relatively time-consuming process as follow-up treatment is often required to completely kill a tree. Used alone, herbicide treatment leaves unattractive standing dead vegetation.

Below-Ground Mechanical Treatment

Using a large-tracked excavator equipped with a root plow can remove the entire plant from the site, eliminating the need to do follow-up herbicide treatments. This method can be very effective, but mature tree roots will often break off during root plowing and resprout later. Also this method severely disturbs the soil and follow-up planting of desirable cover may be necessary.

Mechanical Mulching

Using a large-tracked excavator with a mulching attachment reduces the entire above-ground portion of the tree to mulch that falls on the site. This method is effective at quickly removing large stands or Russian olive, but as with the hand cutting method above, if this technique is used alone, Russian olive trees will resprout quickly and need to be re-cut in a few years.

Combining Treatments

As is often the case in invasive species management, combining treatment methods is usually the most effective way to control Russian olive. In a project area as large as the North Platte, some treatments may be more effective at some sites, and not advised at others. As planning for the project area progresses, proposed treatment sites should be evaluated individually for treatment options.

Every method of Russian olive control has advantages for certain situations, but the combination treatments are the most effective at long term control. Mechanical or hand removal followed by an herbicide treatment to stumps can greatly increase the likelihood of successful suppression. In addition, cutting trees down rather than uprooting them minimizes soil disturbance and revegetation requirements. In a riverine landscape like the North Platte River, with so many possible vectors for reinfestation (floating seed, animal waste deposits of seed, etc.) it is essential to put a long-term monitoring and retreatment plan in place after the initial treatments have been completed.

The efficacy of the treatment options described above depends on the condition of the riverbank and the desired result of treatment. Using the correct treatment option is essential to not only to prevent the spread of undesired/noxious species, but also to foster the growth of desired species as quickly as possible. Without final river engineering plans in place, it is difficult to discern where low-intensity treatments should be prescribed, however there are some assumptions that can be made. As stated above, to minimize ground disturbance of established desirable vegetation, hand cutting of Russian olive is the best method of treatment in all situations. Follow up herbicide treatment is essential in hand removal situations. It can be assumed then, that the "best" treatment option for areas where river engineering is not taking place, and ground disturbance minimization is desired would be the combination hand removal/herbicide method. Specific treatment prescriptions are expected to be part of the next phase of the North Platte Restoration project.

5.2.2 Revegetation Options by Riparian Elevation Zone

Whether ground disturbance is minimal as in the case of individual tree removal or large-scale earth moving during river restoration projects, revegetation of a project site after the treatments are complete will be necessary. Below are some options for site revegetation. This is not an exhaustive list and should not be considered a prescription for site revegetation. Revegetation plans should be tailored to individual site plans and may vary widely throughout the project area.

Since final areas for the project are not known, a "per acre" preliminary density and cost estimate is provided in Table 11 in Section 5.4.

Toe Zone

As previously stated, the toe zone is the most hydrologically unstable riparian zone. Revegetation options are limited in the toe zone and often are combined with some hard-structure bank stabilization methods. In relatively low-slope bank areas that have been disturbed, coir (coconut fiber) mats can provide short-term stabilization near the water's edge and provide an excellent medium to promote plant growth (Hoag, 1991; Hoag and Fripp, 1992). In these areas, a riparian seed mix containing site-appropriate species such as tufted hairgrass (*Deschampsia cespitosa*), Canada wildrye (*Elymus canadensis*), alkali sacaton and various rushes can be planted along with coir mat installation (Carlson, 1992). Coyote willow live stakes can also be installed with coir matting in some areas of the toe zone. Live stakes are cuttings harvested from local willow stands and driven into the water table trough the bank. Willows, cottonwoods and some other flood-adapted species will readily root from cuttings. Live staking is an extremely effective method of propagating willows and provides excellent bank stabilization once established. As the coir matting biodegrades, the root structure of the planted vegetation will become the primary bank stabilizing element.

Splash Zone

As the splash zone is relatively close to water table, many of the same techniques used in the toe zone can be used here. Riparian and transitional flood tolerant seed mixes containing species such as tufted hairgrass, Canada wildrye, switchgrass (*Panicum virgatum*), prairie cord grass and meadow sedge (*Carex praegracilis*) can be used with bank stabilizing coir matting, and willow live stakes will establish well in this zone, provided they can be driven to the depth of the midsummer water table. For areas where the water table is lower, harvesting larger willow posts for deeper planting is possible, but individual cavities for planting must be dug and cost increases rapidly. Other flood tolerant shrubs that can be planted in the splash zone with some success include thinleaf alder (*Alnus incana*), and red osier dogwood.

Bank Zone

The bank zone may be exposed to considerable flooding or wave action. In areas where expected wave action and water current are low, sodding with flood tolerant grasses like reed canarygrass, switchgrass, and buffalo grass (*Buchloe dactyloides*) can provide rapid bank stabilization. Normally, bank zone sod would have to be help in place with wire mesh or a biodegradable mesh like a low-gauge coir mesh netting to allow for root establishment. Coir matting can not only stabilize soils and prevent erosion, but also hold moisture well and can be used in the bank zone for both purposes (Platts and Rinne, 1985). Transitional flood tolerant seed mixes containing species such as tufted hairgrass, Canada wildrye, switchgrass, prairie cordgrass, meadow sedge, alkali sacaton and little bluestem can be used in the bank zone. Cottonwood pole plantings can be useful to establish native cottonwood stands in the bank zone. Pole planting, like live staking consists of harvesting live poles, ideally from a local source of cottonwood trees, and placing them in the bank deep enough to have access to the midsummer water table. Alders, dogwoods and some birch trees (*Betula* spp.) may also be planted in the bank zone (Briggs and Munda, 1992).

Terrace Zone

During river restoration work, the terrace zone should experience the least amount of disturbance. This zone also experiences the least amount of erosional pressure from the river.

Vegetation reestablishment in the terrace zone is not so much for stabilization as it is for long-term aesthetic appeal and habitat enhancement. Depending on the severity of the disturbance during river restoration or Russian olive removal activities, revegetation may be as simple as seeding the site with upland meadow seed mixes containing species such as western wheatgrass, crested wheatgrass, squirreltail (*Elymus elymoides*) and Indian ricegrass (*Achnatherum hymenoides*). If large stands of Russian olive have been removed or more severe soil disturbance has taken place, seeding along with tree planting may be prescribed (Fenchel et al, 1988). If the water table is accessible, cottonwood pole planting as described above, along with planting of container-stock trees appropriate to the landscape may be appropriate. Land use consideration such as the amount of traffic sites receive and grazing pressure from wildlife are important when deciding what types of vegetation is desired in the transitional upland areas of the Terrace zone (Swenson and Mullins, 1985).

Establishing Vegetation in Created Wetlands

River restoration work is likely to include the creation or enhancement of riparian wetlands. All of these sites will be located in the toe or splash zone of the river. Vegetating these areas will depend on the amount of flow the wetlands are expected to receive. In low flow areas, a wetland seed mix that includes species such as Canada wildrye, switchgrass, alkali bulrush (*Scirpus maritimus*), prairie cordgrass, Nebraska sedge (*Carex nebrascencis*), soft stem bulrush (*Scirpus validus*) and meadow sedge would be appropriate. In areas where higher flow is expected, a similar seed mix with the addition a mat-forming grass like reed canarygrass, with the addition of willow live stake plantings would be appropriate.

5.2.3 Long Term Monitoring and Management and Treatment Sites

Vegetation restoration projects need to be monitored closely for the first three to five years to quickly identify maintenance needs when they arise. Items to be aware of along with some options for monitoring protocols are listed below. Since access is relatively easy and the majority of the project is expected to take place on property owned by the City of Casper, it is likely that City employees can be trained to perform most of the maintenance and monitoring.

Russian Olive

Russian olive vigorously resprouts when cut. Whether or not post-cutting treatment with herbicide is applied, monitoring of formerly infested sites will be essential to maintain a low-density landscape of Russian olive. Yearly herbicide reapplications for the first 3-5 years after treatment will be necessary to treat resprouts. Herbicide applications should consist of basal bark applications or small-scale foliar treatment with a hand or backpack sprayer. These low-impact treatments will assure the minimization of non-target species collateral damage. If Russian olives become reestablished it may become necessary to repeat the initial treatment, therefore commitment to a long-term maintenance strategy will be necessary.

Herbaceous Plantings

Grass and forb plantings in high-erosion areas must be monitored not only to assess vegetation establishment, but also so that any bank erosion is caught early on in the process. Visual observance of treatment sites should be performed at least monthly and after every major storm event for the first two years after planting. Observers should note changes in plant growth over time and any erosional situations that arise. In case drought conditions manifest, a contingency plan should be in place to water the treatment areas if needed. After the first two years, quarterly inspections of the treatment areas are necessary to ensure large precipitation or high-flow events have not damaged treatment areas.

<u>Shrub and Tree Plantings</u>

Monitoring of planted trees will include noting growth and herbivore damage. If watering is called for, it can be accomplished using an ATV or small truck with a water tank installed. Shrub and tree monitoring activity can be combined with other monitoring for efficiency.

5.3 Visual Resources

The proposed landscape changes discussed within this document may impact the various user groups to different degrees. Generally, most residents are expected to be highly sensitive to changes in the landscape that can be viewed from their homes and neighborhoods. Recreational users utilizing the bike path trails and park systems would be moderately sensitive to changes in the landscape depending on the focus of their recreational activity. Travelers driving near the project area would have temporary views of the project area. Passengers in moving vehicles would have greater opportunities for off-road views of the Project than would drivers.

In general, removal of invasive vegetation and implementation of river restoration projects can have a large impact on the appearance of the landscape to residents and recreational users. In areas where Russian olives dominate the vegetative community, such as in the North Platte River Park, the removal of this vegetative community is expected to have a large impact on the visual appeal to recreational users. The long-term restoration of native landscapes will have great aesthetic values; however in the short-term recreational users can perceive the changes negatively because of the large impacts to visual appearance. As a result, in areas of high recreational use, the revegetation plan may need to include a variety of sizes of vegetation to ensure that the aesthetic quality of the environment is maintained while the native vegetation communities mature.

The proposed river restoration projects will also have a large impact on the appearance of the landscape. Removal of unnatural materials from the river banks and riparian area will greatly improve the aesthetic appeal of riparian area and increase habitats available to wildlife and fisheries species. Because the project area receives high amounts of water and land recreational use, river restoration projects throughout the project area will greatly improve the aesthetic quality of the environment.

In project areas where both revegetation and river restoration work is planned, implementation of the two project components in phases should also be considered. In many project areas, the implementation of phased vegetation work in areas that will be undisturbed by construction activities can improve the aesthetic quality of the project area. Thick stands of non-native vegetation occurring in upland areas or outside of construction and access corridors could be removed and replanted with native vegetation prior to river channel restoration. This phased approach would result phased landscape changes and allow for native vegetation to mature and recover outside of restoration areas.

5.4 Permitting

The information provided in this section is intended as a general guide for permits that may be required as part of the implementation process associated with the North Platte Mater Plan. A more detailed assessment of the permit requirements and timelines would have to be determined during the final design and planning stages of project implementation.

Implementation of river restoration projects including the creation and/or fill of waters of the U.S. would require consultation with the U.S. Army Corp of Engineering (USACE) under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. Pre-application consultation with the USACE is encouraged to determine the type of permits that would be required. Depending on the size and scope of the project, a nationwide, a regional, or an individual permit would be required. A nationwide permit is a form of general permit which pre-authorizes a category of activities throughout the nation, assuming all permit conditions are met. Nationwide Permit (13) Bank Stabilization and Nationwide Permit (27) Stream and Wetland Restoration Activities expired in March 2012 and are in the process of being updated and revised. The nationwide permitting process can take up to 90 days for processing.

The individual permit process may require preparation of an environmental assessment (EA) under the National Environmental Policy Act of 1969 (NEPA), as amended. Under this process, the USACE would be the lead agency reviewing and making a final decision on the EA. The full process would involve analysis of alternatives, assessment of potential environmental, social and economic impacts of the project, and a public scoping period. Individual permits that do not require a public hearing and EA can take from 60 to 120 days for processing.

Projects that may result in a fill or discharge into waters of the U.S. also require review and water quality certification from the Wyoming Department of Environmental Quality (WDEQ) under Section 401 of the Clean Water Act. The WDEQ has categorically certified many Nationwide and Regional General Permits from the USACE with the condition that applicants must comply with the terms and conditions of the permit, including regional conditions, for the certification to be valid. If a project is determined to be applicable for a nationwide or regional permit from the USACE, then the USACE verification letter would include standard conditions imposed by WDEQ on all certifications. If an individual permit is required from USACE, then the application package would be sent to WDEQ for review and a final water quality certification decision.

5.5 Estimated Cost and Project Prioritization

This section provides a cost estimate for the restoration activities described in Sections 5.1 and 5.2. Table 9 outlines the cost per linear foot and total cost for stream restoration activities, including construction, engineering, and construction observation. All costs presented are based on previous projects of a similar nature and scale. The costs presented in Table 10 and Table 11 summarizes the costs associated with the removal of invasive species and the re-planting of native vegetation. Since final areas for the project are not known, a “per acre” preliminary density and cost estimate is provided.

Table 9. Estimated cost of proposed stream restoration projects

Site Number	Starting Station	Ending Station	Project Type	Approximate Cost/Linear Foot	Approximate Total Cost
1	273+50	300+00	Fish Habitat Improvements	$215 to $305	$569,750 - $808,250
2	300+00	324+00	Channel Realignment	$460 to $550	$1,104,000 - $1,320,000
3	324+00	344+20	Channel Realignment	$460 to $550	$929,200 - $1,111,000
4	367+85	400+00	Bank Stabilization, Channel Realignment	$460 to $550	$1,478,900 - $1,575,350
5	569+50	677+20	Fish Habitat Improvements	$215 to $305	$2,315,550 - $3,284,850
6	695+75	747+40	Channel Realignment	$460 to $550	$2,375,900 - $2,840,750
7	514+60	534+60	Bank Stabilization	$215 to $305	$428,000.00 - $612,000.00

Table 10. Estimated treatment costs associated with Russian olive invasion

Treatment	Low-end cost/acre	High-end cost/acre	Other considerations
Hand Removal (chainsaw)	$1,500.00	$5,000.00	Disposal/chipping, spreading mulch Resprouting trees
Mechanical Removal (root plow)	$900.00	$900.00	Soil disturbance / groundcover replanting
Herbicide (hand application)	$400.00	$850.00	Removal of dead trees after treatment
Hand Removal (chainsaw) + Herbicide (cut-stump hand application)	$2,000.00	$5,000.00	Disposal/chipping, spreading mulch
Mechanical Removal (mulcher) + Herbicide (cut-stump hand application)	$500.00	$1,500.00	Disposal/spreading mulch

Source: (Shafroth, et al., 2010; and personal communication)

Table 11. Potential costs, application rate, and labor required to implement each vegetation treatment by zone of application

Treatment	Zone of Application	Application Rate	Unit cost/acre	Labor hours/acre
Willow/cottonwood live stake planting	Toe, Splash	200 stakes/acre	$2,000.00	12.0
Willow/cottonwood live pole planting	Splash, Bank	100 poles/acre	$700.00	20.0
Wetland seed mix	Toe, Splash	20 lbs./acre	$900.00	20 .0
Riparian seed mix	Splash, Bank	40 lbs./acre	$600.00	20.0
Upland seed mix	Terrace	45 lbs./acre	$550.00	20.0
Live tree plantings	Terrace	varies with land use considerations	$2,500.00	70.0

Source: (Shafroth et al, 2010; Allen and Leach 1997; and personal communication)

Labor hours/acre presented, because volunteer labor may be used to reduce the unit cost/acre.

In an effort to prioritize the proposed stream restoration projects, the approximate cost was compared to the current sediment loss along the proposed project length. This comparison was used to assess the most cost-effective projects for reducing sediment loss. It should be noted that restoration will not eliminate sediment loss completely, as all streams have a natural erosion rate. However, this natural erosion rate which will be achieved post-restoration should be constant across all projects. The ranking of the projects is presented in Table 12 below.

Table 12. Proposed stream restoration project prioritization

Site Number	Rank	Project Type	Approximate Cost/Existing Tons of Soil Loss/Year	Approximate Total Cost
1	5	Fish Habitat Improvements	$3,432.00 to $4,869.00	$569,750.00 to $808,250.00
2	7	Channel Realignment	$14,153.00 to $16,923.00	$1,104,000.00 to $1,320,000.00
3	6	Channel Realignment	$4,093.00 to $4,894.00	$929,200.00 to $1,111,000.00

4	3	Bank Stabilization, Channel Realignment	$3,146.00 to $3,351.00	$1,478,900.00 to $1,575,350.00
5	2	Fish Habitat Improvements	$2,097.00 to $2,975.00	$2,315,550.00 to $3,284,850.00
6	4	Channel Realignment	$3,314.00 to $3,962.00	$2,375,900.00 to $2,840,750.00
7	1	Bank Stabilization	$1902.00 to $2720.00	$428,000.00 to $612,000.00

5.6 Funding

This section presents potential funding sources for the restoration projects. It is important to consider that the pursuit of any outside funding can result in additional investment of effort and increased costs for some project elements. Additionally, the acceptance of outside funding may result in additional requirements or obligations. These constraints should be considered and understood when seeking outside funding.

5.6.1 U.S. Army Corps of Engineers

Water Resources Development Act – Section 206

Federal funding is available from the US Army Corps of Engineers (USACE) for aquatic ecosystem restoration projects under Section 206 of the Water Resources Development Act of 1996. Section 206 allows USACE to fund restoration projects up to $5 million in collaboration with a non-federal sponsor. Projects must be considered cost effective and in the public interest. The City of Casper is eligible to apply for Section 206 funding for the development and implementation of the North Platte River Restoration Master Plan.

To apply for Section 206 funding, the City of Casper would first submit a request for assistance to the USACE. Then, when funding is available, USACE will conduct a feasibility study, including a scope, cost estimate, and alternatives analysis for the project. The feasibility study will determine if the project is in the public interest and whether USACE will move forward with funding project implementation. USACE will pay 100% of feasibility study costs up to $100,000, and 50% beyond $100,000. If the feasibility study results in a recommendation for implementation of the project, USACE will prepare plans, obtain the required federal permits, and manage the project construction using a private contractor. USACE will pay for 65% of the design and construction costs, and the City of Casper will be required to pay the remaining 35% of costs. The value of land, easements, rights-of-way, and work-in-kind can be credited toward the non-federal portion of costs through a Project Partnership Agreement. Post-construction operation and maintenance will be entirely the responsibility of the City of Casper.

The City of Casper and the North Platte River are located in the Omaha District of USACE. The Omaha District is currently overseeing two Section 206 projects located in Colorado. Feasibility studies for both projects were completed in 2011. The availability of Section 206 funds will depend on the Omaha District's ability and willingness to take on cost-sharing for the project.

Once the City of Casper submits a funding request with a brief description of the project and its objectives, the Omaha District will indicate whether the USACE is interested in funding the project and whether Section 206 funds are currently available.

5.6.2 U.S. Environmental Protection Agency (EPA)

5 Star Restoration Program

The EPA supports the Five-Star Restoration Program by providing funds to the National Fish and Wildlife Foundation and its partners, the National Association of Counties, NOAA's Community-based Restoration Program and the Wildlife Habitat Council. These groups then make subgrants to support community-based wetland and riparian restoration projects. Competitive projects will have a strong on-the-ground habitat restoration component that provides long-term ecological, educational, and/or socioeconomic benefits to the people and their community. Preference will be given to projects that are part of a larger watershed or community stewardship effort and include a description of long-term management activities. Projects must involve contributions from multiple and diverse partners, including citizen volunteer organizations, corporations, private landowners, local conservation organizations, youth groups, charitable foundations, and other federal, state, and tribal agencies and local governments. Each project would ideally involve at least five partners who are expected to contribute funding, land, technical assistance, workforce support, or other in-kind services that are equivalent to the federal contribution. Approximately $300,000 is available annually for this program, with typical award amounts ranging from $5-20,000. Applications are due in February and funds are made available in July. Further information about this program is available on-line at http://www.epa.gov/owow/wetlands/restore/5star/.

5.6.3 National Fish and Wildlife Foundation

A variety of grant opportunities are available through the National Fish and Wildlife Foundation for projects that sustain, restore, and enhance our Nation's fish, wildlife, and plants and their habitats. The most applicable grants for the North Platte are summarized below. Full grant opportunity details are available on-line at http://www.nfwf.org.

The Native Plant Conservation Initiative

The Native Plant Conservation Initiative supports on-the-ground conservation projects that protect, enhance, and/or restore native plant communities on public and private land. Projects typically fall into one of three categories and may contain elements of each: protection and restoration, information and education, and inventory and assessment. Applicants are encouraged, when appropriate, to include a pollinator component in their project. This program is funded by the Bureau of Land Management, Forest Service, Fish and Wildlife Service, and National Park Service. Approximately $450,000 is available annually for this program, with typical award amounts ranging from $50-100,000. Applications are due June 30 of each year.

5.6.4 U.S. Fish and Wildlife Service

North American Wetlands Conservation Act Grants Program

The U.S. Fish and Wildlife Service's Division of Bird Habitat Conservation administers this matching grants program to carry out wetlands and associated uplands conservation projects in the United States, Canada, and Mexico. Grant requests must be matched by a partnership with nonfederal funds at a minimum 1:1 ratio. Conservation activities supported by the Act in the United States and Canada include habitat protection, restoration, and enhancement.

Approximately $48 million is available annually for this program, with typical award amounts ranging from $50,000 to $1 million. Full grant opportunity details are available on-line at http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm.

Partners for Fish and Wildlife Program

The Partners for Fish and Wildlife Program provides technical and financial assistance to private landowners to restore fish and wildlife habitats on their lands. Since 1987, the program has partnered with more than 37,700 landowners to restore 765,400 acres of wetlands; over 1.9 million acres of grasslands and other upland habitats; and 6,560 miles of in-stream and streamside habitat. In addition, the program has reopened stream habitat for fish and other aquatic species by removing barriers to passage. Approximately $50 million is available annually for this program, with typical award amounts ranging up to $25,000. There is no application deadline for this grant. Full grant opportunity details are available on-line at http://www.fws.gov/partners/.

5.6.5 U.S. Forest Service

Urban and Community Forestry Challenge Cost-Share Grant

The U.S. Forest Service's Urban and Community Forestry Challenge Cost-Share Grant Program seeks to establish sustainable urban and community forests by encouraging communities to manage and protect their natural resources. The program works to achieve a number of goals, including (1) effectively communicating information about the social, economic, and ecological values of urban and community forests; (2) involving diverse resource professionals in urban and community forestry issues; and (3) supporting a holistic view of urban and community forestry. In particular, the program supports an ecosystem approach to managing urban forests for their benefits to air quality, stormwater runoff, wildlife and fish habitat, and other related ecosystem concerns. The Forest Service awards these grants based on recommendations made by The National Urban and Community Forestry Advisory Council, a 15-member advisory council created by the 1990 Farm Bill to provide advice to the Secretary of Agriculture on urban and community forestry. Approximately $850,000 is available annually for this program, with typical award amounts ranging up to $250,000. Full grant opportunity details are available on-line at http://www.fs.fed.us/ucf/nucfac.

5.6.6 State of Wyoming

The North Platte Corridor, from Seminoe Reservoir downstream to the Dave Johnston Power Plant dam is designated by the Wyoming Game and Fish Department (WGFD) as a Strategic habitat priority. This designation was assigned because the North Platte River is a distinctive, productive and economically significant fishery resource in the Casper Region. Efforts to maintain or enhance this popular resource will benefit extensive stream and riparian communities and the people who enjoy them. The cottonwood gallery forests and riparian wetlands that occur along the corridor are important to a host of species and yet are a rare and declining resource.

Wyoming Wildlife Natural Resource Trust

The Wyoming Wildlife and Natural Resource Trust (WWNRT) was created by the Wyoming Legislature in 2005 to fund projects that are designed to improve wildlife habitat or natural resource values. Funds are available to both non-profit and governmental agencies, with approximately one million dollars. WWNRT funds large and small projects twice annually, with funds made available for approved projects in July and January. Deadlines for funding periods are March 31 (for July allocations) and September 30 (for January allocations). Projects should have a specific timeline for initiation and completion, with tangible benefits.

In 2009, the City of Casper was awarded this grant to help develop the hydrologic design for restoration of the North Platte River system. Implementation of the restoration design both for revegetation and geomorphology designs would qualify for additional funding from the WWNRT. Full grant details are located online at http://wwnrt.state.wy.us/application.htm.

Wyoming Game and Fish Department Trust Fund

The Wyoming Game and Fish Department (WGFD) Trust Fund is a matching grants program for riparian or upland habitat improvement, water development, and industrial water projects. The annual funding available is based on the interest generated from the WGFD Trust Fund, with up to one million dollars available annually. Funds can be used for acquisition, maintenance or improvement of wildlife habitat; or for the promotion of human understanding and enjoyment of the fish and wildlife resource (habitat or information & education projects). Funds can be used for internal (WGFD) projects or paid as grants to an outside entity with a WGFD sponsor. To apply for this funding, the City of Casper would team with the WGFD and the WGFD regional habitat biologist would submit the application for funding. Grant applications are due in January of each year.

5.6.7 Trout Unlimited

Funding and partnering opportunities are available through the Wyoming Chapter of Trout Unlimited (TU). The funding opportunities outlined below require partnership with the local and state chapters of Trout Unlimited. The City of Casper would need to contact the state and local chapter of Trout Unlimited to pursue partnership opportunities and to submit applications for these grants.

Embrace-A-Stream Program

Embrace-A-Stream (EAS) is a matching grant program administered by TU that awards funds to TU chapters and councils for coldwater fisheries conservation. The EAS is designed to fund on-the-ground restoration, protection, or conservation efforts that benefit trout and salmon fisheries and their habitats. The EAS grant program supports the conservation projects of TU chapters and councils. A TU chapter or council must be the primary applicant, but government agencies, non-profits, and other groups are strongly encouraged to partner with TU. There must be significant TU involvement in the planning and execution of the project to warrant funding.

TU chapters and councils are asked to submit proposals for projects that best address the needs of native and wild trout following TU's Protect, Reconnect, Restore, and Sustain conservation model. Projects will be evaluated based on the following criteria: Conservation Impact, Strengthening TU Impact, Public Education and Outreach, and Technical Merit. The maximum grant awarded for EAS projects is $10,000 and the applicants must match, on a one-to-one basis, the EAS grant request. Matching sources can include cash gifts, in-kind donations of materials, and/or volunteer labor. Once the grant is awarded, applicants have two years to complete a proposed project. EAS grant applications are due in December of each year and awards are made in March of the following year. The City of Casper should contact the Wyoming Trout Unlimited Office to discuss application and partnering details. Full grant details are located online at http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative/embrace-a-stream.

Wyoming Home Waters Initiative

The Wyoming Home Waters Initiative through Wyoming TU is intended to help restore watersheds within Wyoming to proper functioning condition and to encourage community involvement, interest in the outdoors, and conservation of natural resources. The program was designed to provide up to $10,000 to assist in fisheries habitat enhancement or fish passage projects that will improve local fisheries. The Wyoming Council of TU has not reapproved this grant since 2010; however the funding for the grant will be reapproved in the future. To apply for this funding opportunity, the City of Casper would team with the local chapter of TU in Casper. Applications are ranked by the conservation need of the project, the importance to the local fishery and the community.

5.6.8 Pulling Together Initiative

The Pulling Together Initiative (PTI) provides a means for federal agencies to partner with state and local agencies, private landowners, and other interested parties to develop long-term weed management projects within the scope of an integrated pest management strategy. The goals of PTI are: (1) to prevent, manage, or eradicate invasive and noxious plants through a coordinated program of public/private partnerships; and (2) to increase public awareness of the adverse impacts of invasive and noxious plants. PTI provides support on a competitive basis for the formation of local weed management area (WMA) partnerships, allowing them to demonstrate successful collaborative efforts and develop permanent funding sources for the maintenance of WMAs from the involved parties. Successful projects will serve to increase public awareness and interest in future partnership projects.

5.7 Future Work

To progress the plan for improvements along the North Platte River through the City of Casper, further work will be needed. Additional work required will include a complete design of the proposed concept design in this master plan. To produce a final design, more detailed survey efforts will be required so that accurate existing ground surfaces can be created, accurate grading quantities can be calculated, flood modeling can be completed, and utility and structure locations can be identified. Additionally, detailed calculations will be needed to size boulders for structures, determine exact locations for structure placements, determine bankfull channel and floodplain interaction, perform floodplain modeling, and calculate bankfull cross-sectional area and other design morphological parameters. It may be necessary to create a local regional curve to more accurately determine bankfull cross-sectional area for the final design. This will be accomplished by surveying reference streams in the Casper area. Typical morphological characteristics from stable reference reaches will also be used in determining dimension, pattern, and profile parameters for the final design of the North Platte River Project sites.

Prior to project implementation the following studies may be also required as part of the project planning and permitting process with the USACE: wetland delineations, Class III cultural inventories, and surveys for Ute’s-ladies tresses habitats. If projects are not planned outside of nesting seasons for migratory birds and raptor species, surveys should be done for these species to ensure compliance with the Migratory Bird Treaty Act and the Bald and Golden Eagle Act.

6.0 Summary

Based on the results of the surveys, the Stantec team has developed a Master Plan that focuses on preserving the ecosystem services provided by the North Platte River, primarily through stabilizing the riverbank and enhancing riparian vegetation. Riverbank stabilization will help reduce sedimentation from soil erosion and maintain the natural riparian hydrology. Riparian vegetation enhancements, including the removal of nonnative vegetation and establishment of wetlands, will help filter sediments from runoff, stabilize the river bank, maintain the natural riparian hydrology, and provide native riparian habitat for wildlife. Overall, the Master Plan will help preserve the natural beauty of the river and enhance the natural resources available to the City of Casper and the surrounding communities.

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8.0 Appendices

Appendix A – Revegetation Priority Site Maps

Appendix B – Rosgen Classification Chart

Appendix C – Structures Location Maps and Photo Log

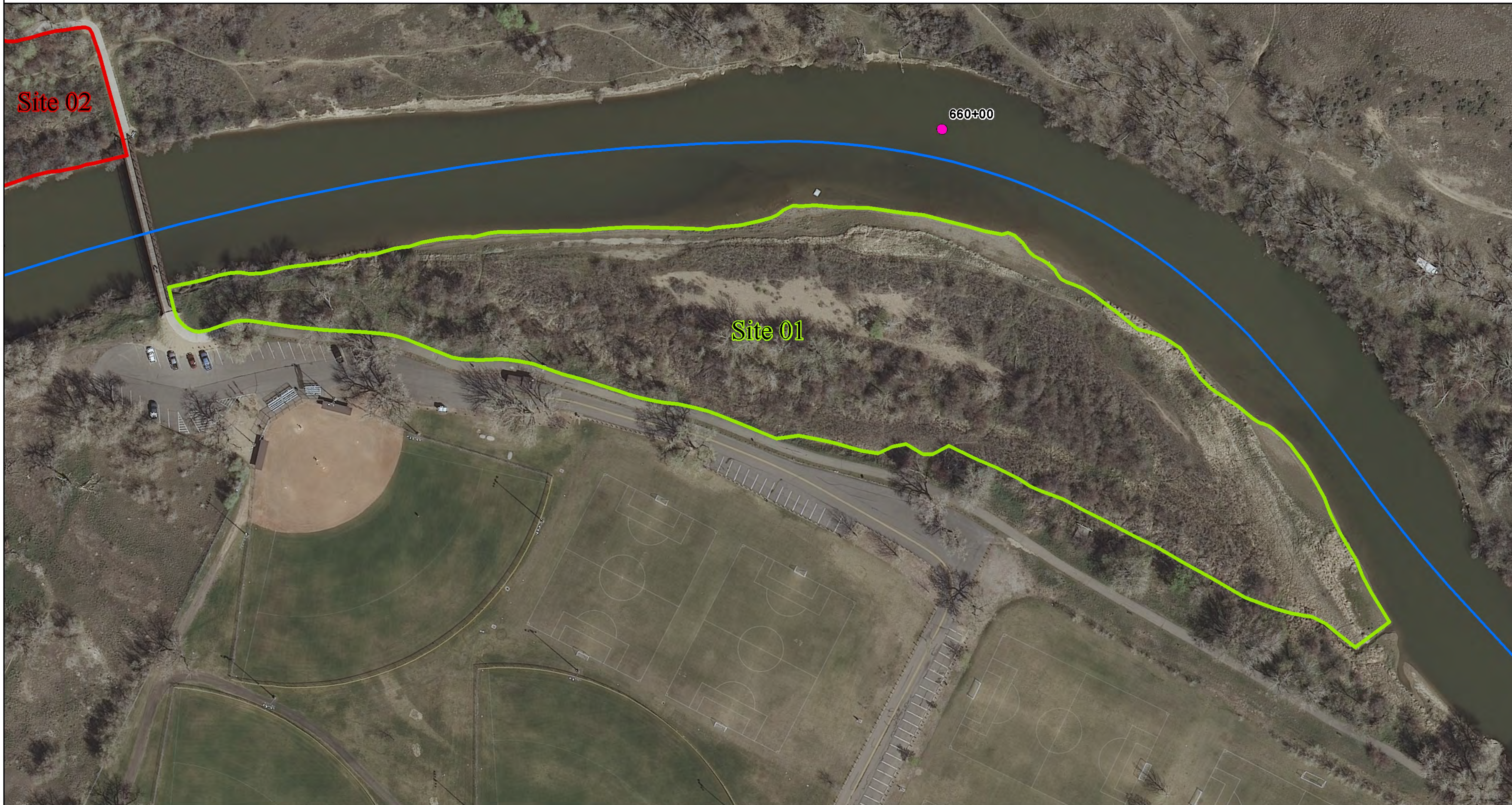
Appendix D – BEHI Survey Maps

Appendix E – Sediment Erosion Estimates

Appendix F – Stream Restoration Concept Design

Appendix A. Revegetation Priority Site Maps

Vegetation Restoration Site 01: Priority Area-North Platte River Park



Station
Priority Areas

Identified Priority Sites
High
Moderate
Low

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 02: Priority Area-North Platte River Park

0 20 40 60 Meters
0 100 200 300 Feet

Station
Priority Areas

Identified Priority Sites
High
Low
Moderate

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

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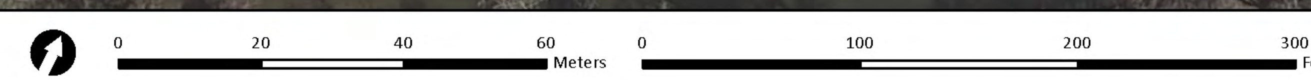
Vegetation Restoration Site 03: Priority Area-North Platte River Park



Station

Priority Areas

Identified Priority Sites

High

Moderate

Low

Projection: UTM Nad 83, Zone 13 N

Base Map: City of Casper, WY 2010

Date: 1/30/2012

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Vegetation Restoration Site 04: Priority Area-North Platte River Park

Station
Priority Areas

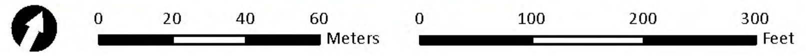
Identified Priority Sites
High
Low
Moderate

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 05: Priority Area-North Platte River Park



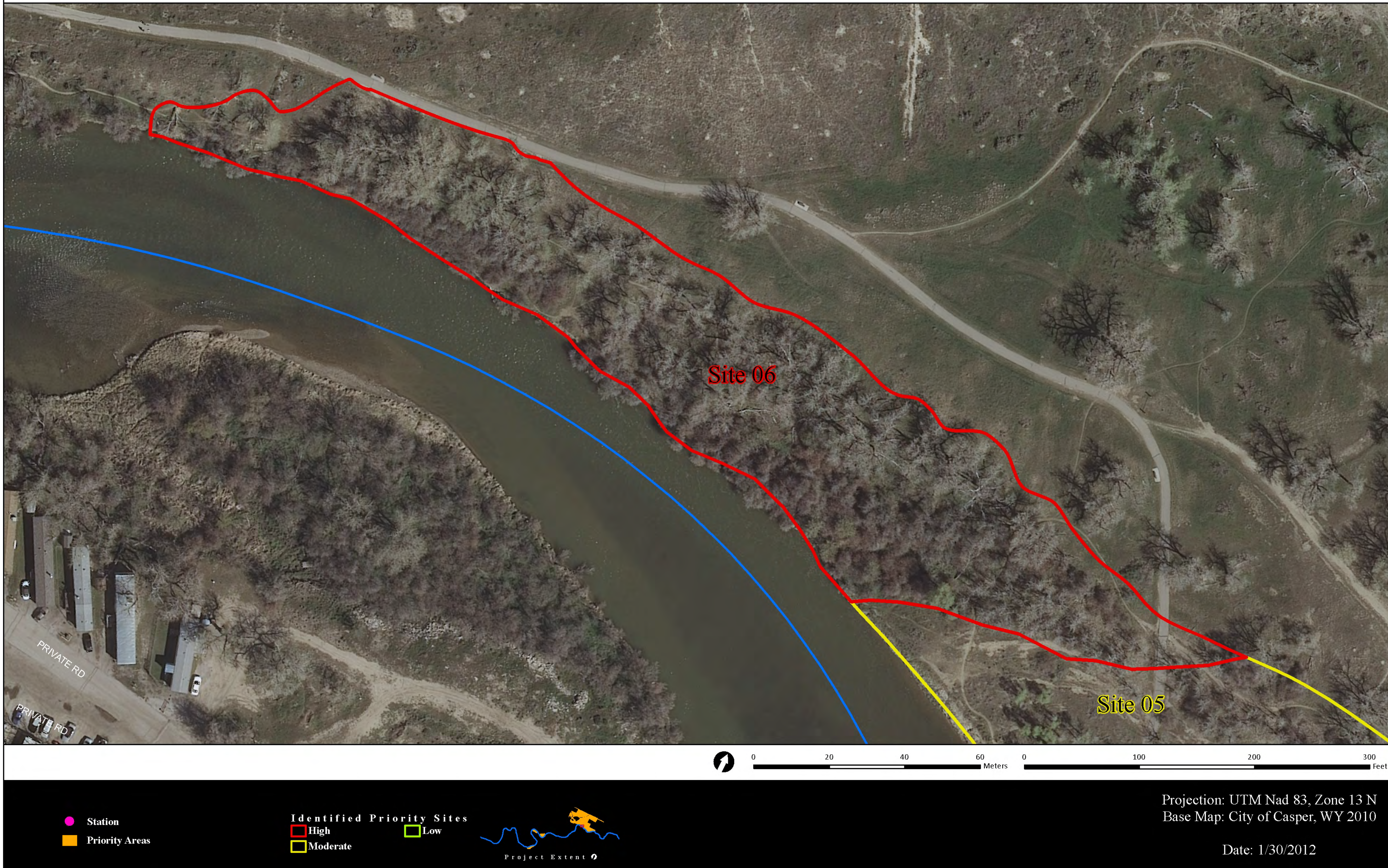
Station
Priority Areas

Identified Priority Sites
High
Low
Moderate

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 06: Priority Area-North Platte River Park



Vegetation Restoration Site 07: Priority Area-North Platte River Park

0 20 40 60 Meters

0 100 200 300 Feet

Station

Priority Areas

Identified Priority Sites

High

Moderate

Low

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Path: G:\Projects\20000-20999\20449_North_Platte_Environmental_Restoration\MXD\Report\Biological\North_Platte_Priority_Areas_FinalVersion.mxd

Vegetation Restoration Site 08: Priority Area-North Platte River Park

Station
Priority Areas

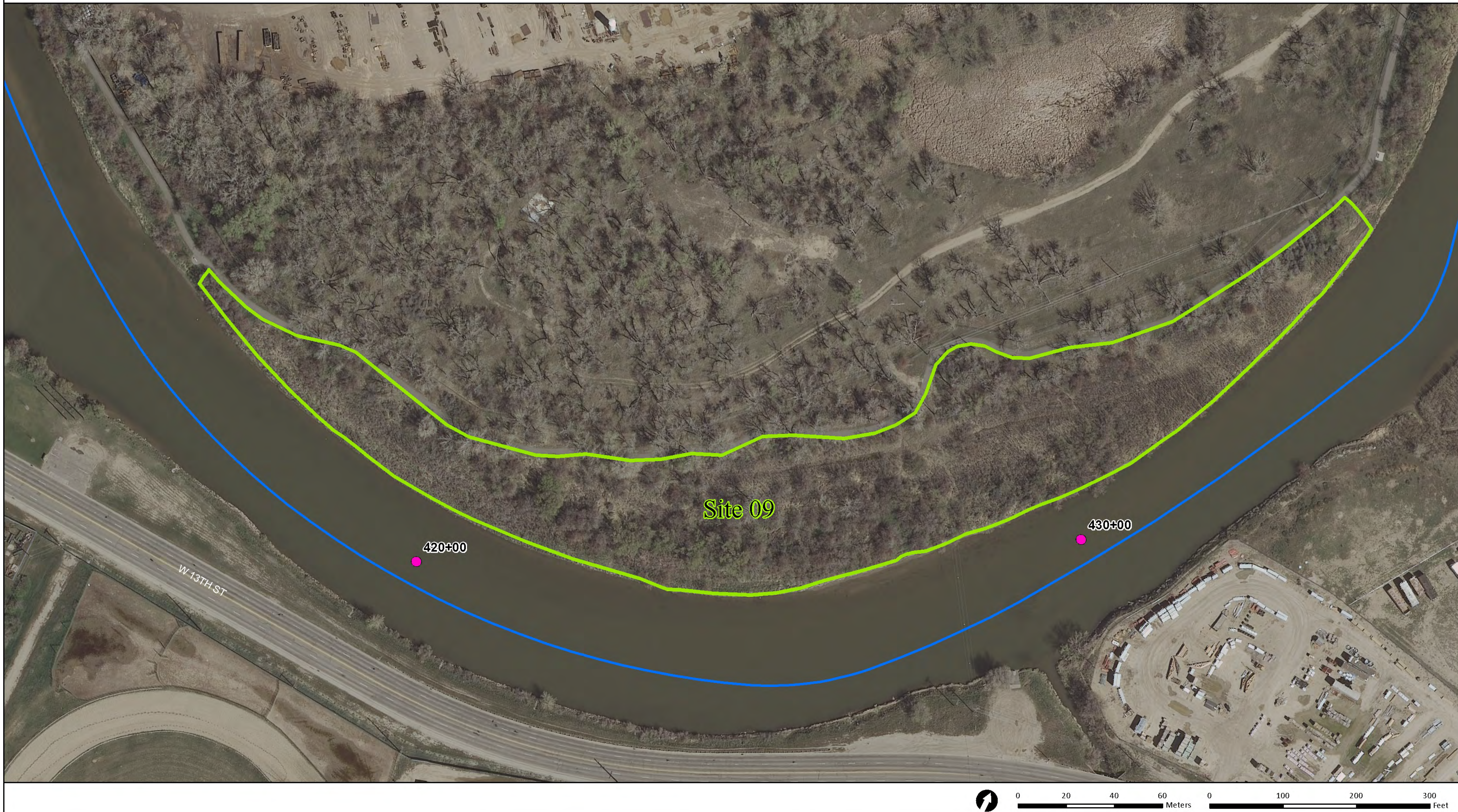
Identified Priority Sites
High
Low
Moderate

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 09: Priority Area-Westech Inc.



Station
Priority Areas

Identified Priority Sites
High
Moderate
Low

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 10: Priority Area-Izaak Walton League of America

- Station
- Priority Areas

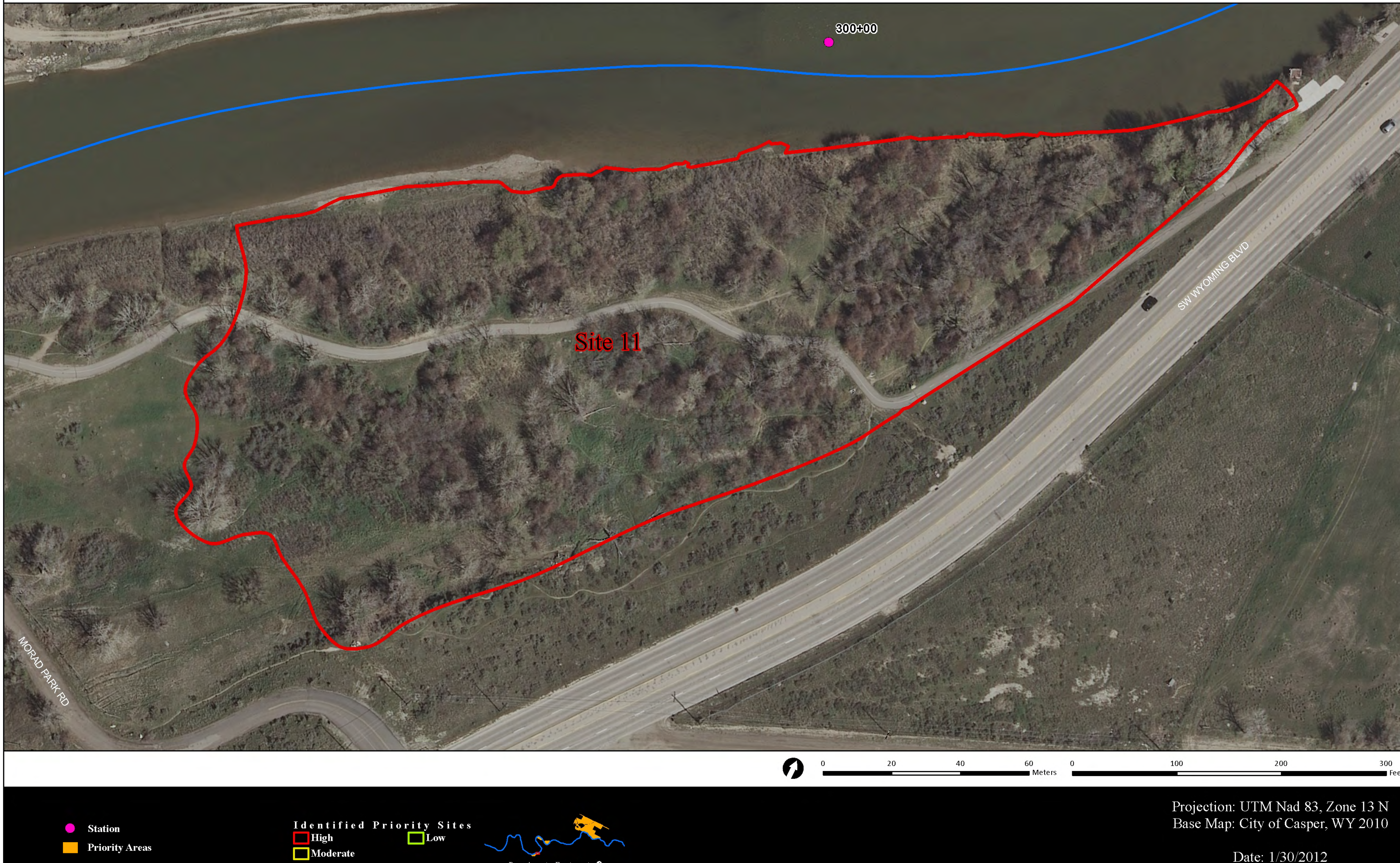
Identified Priority Sites
- High
- Moderate
- Low

Project Extent

Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 11: Priority Area-Morad Park



Projection: UTM Nad 83, Zone 13 N
Base Map: City of Casper, WY 2010

Date: 1/30/2012

Vegetation Restoration Site 12: Priority Area-Morad Park

Station

Priority Areas

Identified Priority Sites

High

Low

Moderate

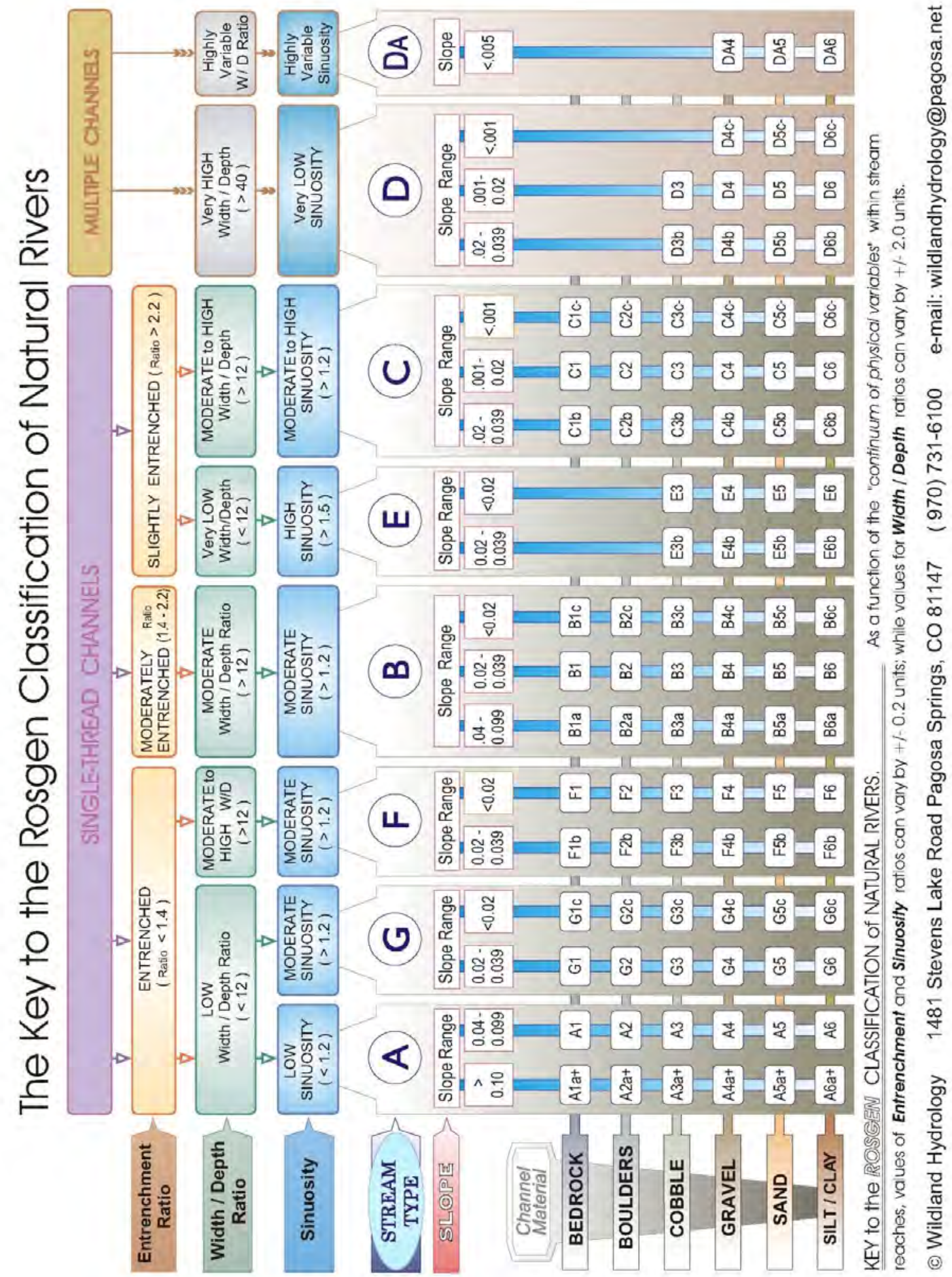
Project Extent

Projection: UTM Nad 83, Zone 13 N

Base Map: City of Casper, WY 2010

Date: 1/30/2012

Appendix B. Rosgen Classification Chart


The Key to the Rosgen Classification of Natural Rivers
SINGLE-THREAD CHANNELS
MULTIPLE CHANNELS
Entrenchment Ratio
Width / Depth Ratio
Sinuosity
STREAM TYPE
SLOPE
Channel Material
ENTRENCHED (Ratio < 1.4)
MODERATELY ENTRENCHED (Ratio 1.4 - 2.2)
SLIGHTLY ENTRENCHED (Ratio > 2.2)
LOW Width / Depth Ratio (< 12)
MODERATE to HIGH W/D (>12)
MODERATE Width / Depth Ratio (> 12)
Very LOW Width/Depth (< 12)
MODERATE to HIGH Width / Depth (> 12)
Very HIGH Width / Depth (> 40)
Highly Variable W/ D Ratio
LOW SINUOSITY (< 1.2)
MODERATE SINUOSITY (> 1.2)
HIGH SINUOSITY (> 1.5)
MODERATE to HIGH SINUOSITY (> 1.2)
Very LOW SINUOSITY
Highly Variable Sinuosity
A G F B E C D DA
Slope Range
> 0.10
0.04 - 0.099
0.02 - 0.039
<0.02
.04 - 0.099
.02 - 0.039
.001- 0.02
<.001
Slope
<.005
BEDROCK
BOULDERS
COBBLE
GRAVEL
SAND
SILT / CLAY
A1a+ A1 G1 G1c F1b F1 B1a B1 B1c C1b C1 C1c-
A2a+ A2 G2 G2c F2b F2 B2a B2 B2c C2b C2 C2c-
A3a+ A3 G3 G3c F3b F3 B3a B3 B3c E3b E3 C3b C3 C3c- D3b D3
A4a+ A4 G4 G4c F4b F4 B4a B4 B4c E4b E4 C4b C4 C4c- D4b D4 D4c- DA4
A5a+ A5 G5 G5c F5b F5 B5a B5 B5c E5b E5 C5b C5 C5c- D5b D5 D5c- DA5
A6a+ A6 G6 G6c F6b F6 B6a B6 B6c E6b E6 C6b C6 C6c- D6b D6 D6c- DA6
KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by +/- 0.2 units; while values for Width / Depth ratios can vary by +/- 2.0 units.
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Appendix C. Structures Location Maps and Photo Log

Stantec Consulting, Ltd..

Photo Log

Structures Located along North Platte River, Casper, WY

Nate Jean, Mike Geenen and Glenn Taylor
11/17/2011

Rock Toe Map-1-001

Boat Ramp Map-1-002

Rock Toe Map-1-003

Rock Toe-Pipe Map-1-004

Rock Toe-Pipe Map-1-005

Rock Toe Map-1-006

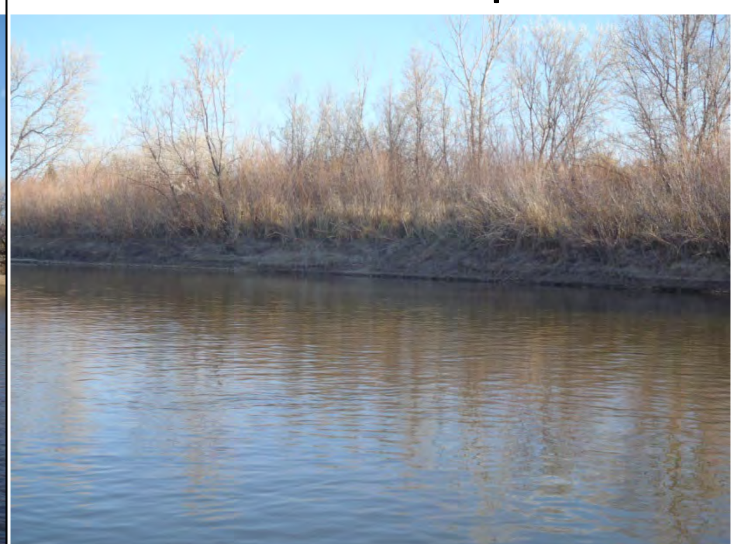
Retaining Wall Map-1-007

Rock Toe Map-1-010

Rock Toe-Dock Map-1-008

Rock Toe-Stairs Map-1-011

Rock Toe-Dock Map-1-009



Rock Toe Map-2-012

Rock Toe-Dock Map-2-013

Rock Toe-Dock Map-2-014

Stairs Map-2-015

Rock Toe-Dock Map-2-016

Rip-Rap Map-2-017

Retaining Wall-Dock Map-2-018

Stairs-Dock Map-2-019

Rock Toe-Pipe Map-2-020

Rip-Rap-Rock Toe Map-2-021

No Photograph Taken

Pipe Map-2-022

Boat Ramp Map-2-023

36 IN Invert Pipe Map-2-024

No Photograph Taken

60 IN Invert Pipe-Map-2-025

Retaining Wall Map-2-026

No Photograph Taken

36 IN Invert Pipe- Map-2-027

Rock Toe Map-2-028

36-18 IN Invert Pipes Map-2-029

Gas Pipe Map-2-030

No Photograph Taken

Retaining Wall Map-3-31

Dock-Retaining Wall Map-3-034

Dock-Retaining Wall Map-3-032

42X66-48 Pipe Inv-Retain Wall-Map-3-035

Dock Map-3-033

Dock Map-3-036

Dock Map-4-037

Tire Toe Map-4-040

Dock Map-4-038

48-60 IN Pipe Invert Map-4-041

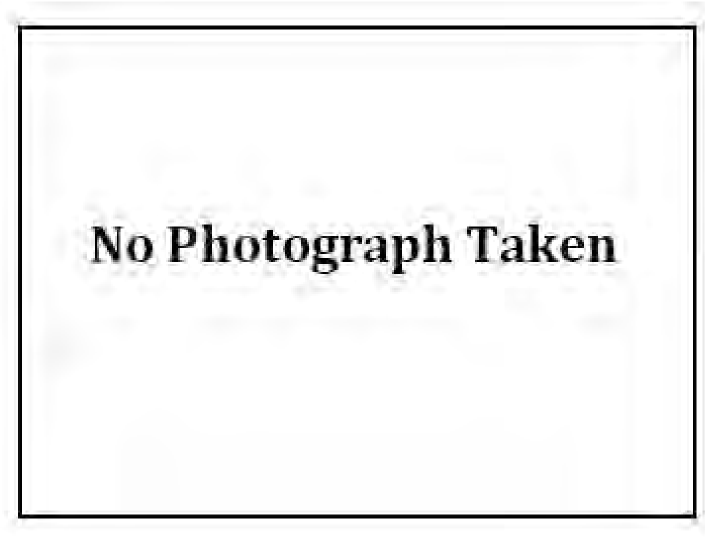
Retaining Wall Map-4-039

Retaining Wall Map-5-042

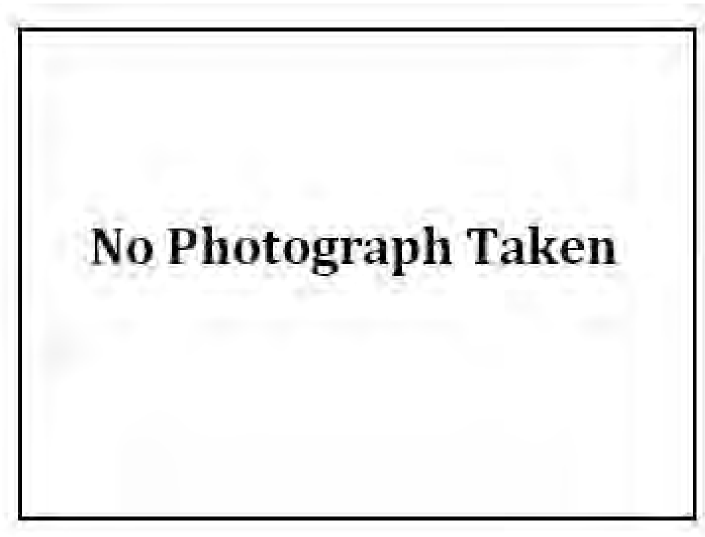
Retaining Wall Map-5-043

Storm Drain-24 IN Invert Map-5-044

Retaining Wall Map-5-045



Pipe Map-6- 046



Retaining Wall Map-6-047

Retaining Wall-Dock Map-6-048

Retaining Wall-Dock Map-6-049

Gazebo Map-6-052

Retaining Wall-Dock Map-6-050

Concrete Flow Box Map-6 053

Dock Map-6-051

Dock Map-6-054


Retaining Wall Map-6-055


Rock Toe Map-6-056


Dock-Retaining Wall Map-6-057


Retaining Wall-Dock Map-6-058


Rip-Rap-Retaining Wall Map-6-059


Rock Toe Map-6-060

Concrete Round-Left Bank Map-6-061

Boat Ramp Map-6-064

Dock Map-6-062

Rock Wall-Rip-Rap Map-7-065

Dock Map-6-063

Rock Toe Map-8-066

Rock Toe-Rip-Rap Map-8-067

Dock Map-8-070

Rock Toe-Dock Map-8-068

Retaining Wall-Dock Map-8-071

Rock Toe Map-8-069

24 IN Invert Drain Map-8-072

No Photograph Taken

Boat Ramp Map-9-073

No Photograph Taken

Drain Pipe Map-9-074

Rock Toe Map-10-075

Concrete Pump Station Map-10-076

Storm Drain Map-10-077

Retaining Wall Map-10-078

24 IN Invert-Retain Wall Map-10-079

Retaining Wall-Deflector Map-10-080

Rock Toe-Rip-Rap Map-10-081

48 IN Invert Pipe Map-10-082

Rock Wall-24 IN Inv Pipe Map-10-083

24 IN Invert Pipe Map-10-084

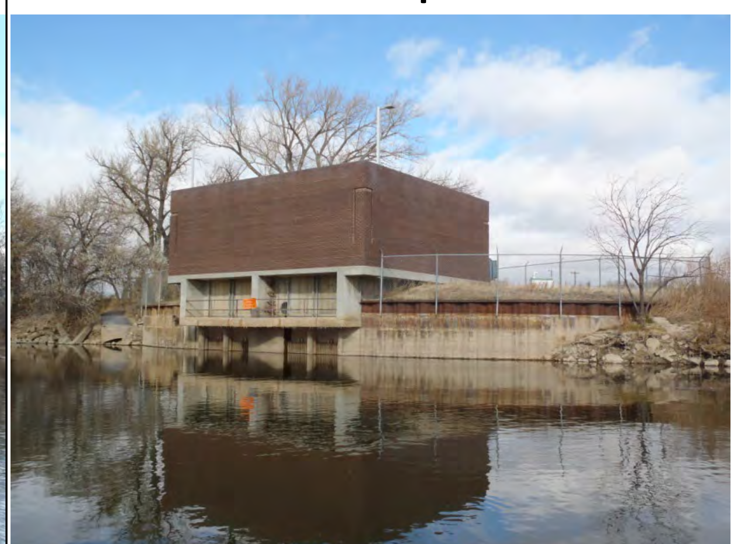
24 IN Invert Pipe Map-10-085

Concrete Intake Map-10-088

Rock Wall Map-10-086

Rock Toe Map-10-089

Rock Toe Map-10-087



Utility Building Map-10-090

Rock Toe Map-10-091

Gabion Wall Map-10-094

Steel Storm Drain Pipe Map-10-092

Rock Toe-Wall Map-10-095

Stairs Map-10-093

Rock Wall Map-11-096

Rock Toe Map-12-097

30 IN Invert Pipe Map-12-098

Rock Toe-Rip-Rap Map-12-099

Storm Drain-Left Bank Map-12-100

Rock Wall Map-13-101

18 IN Invert Pipe Map-13-101A

18 IN Invert Pipe_Map-13-101B

24 IN Invert Pipe Map-13-101E

12 IN Invert Pipe Map-13-101C

12 IN Invert Pipe_Map-13-101F

12 IN Invert Pipe Map-13-101D

12 IN Invert Pipe Map-13-101G

9 IN Invert Pipe Map-13-101H

36 IN Invert Pipe Map-13-104

Rock Wall Map-13-102

36 IN Invert Pipe Map-13-105

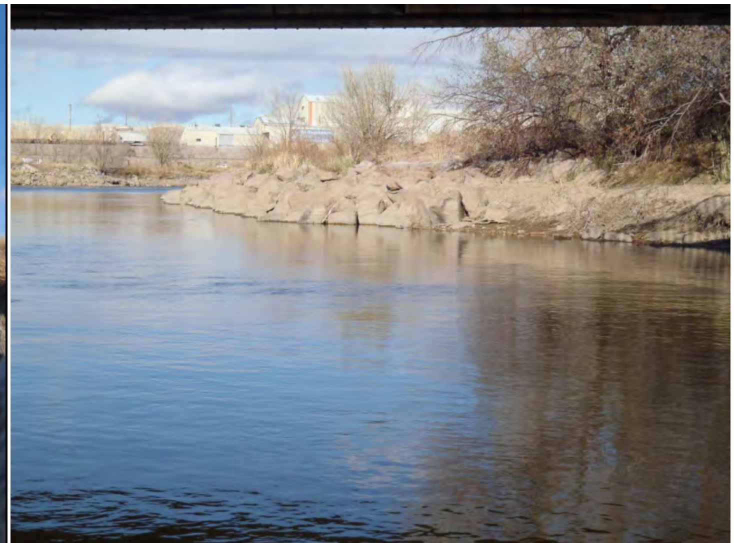
Rock Wall Map-13-103

Rock Wall Map-13-106

Rock Wall Map-13-107

Water Plant-Stairs Map-13-108

Rock Toe Map-13-109



Rock Toe Map-14-110

Rock Toe Map-14-111

Rock Wall-Left Bank Map-14-112

Tributary Entry Map-14-113

Rock Toe Map-14-114

12 IN Invert Pipes 2 ECP Map-14-115

Rock Toe Map-14-116

Rock Toe Map-14-117

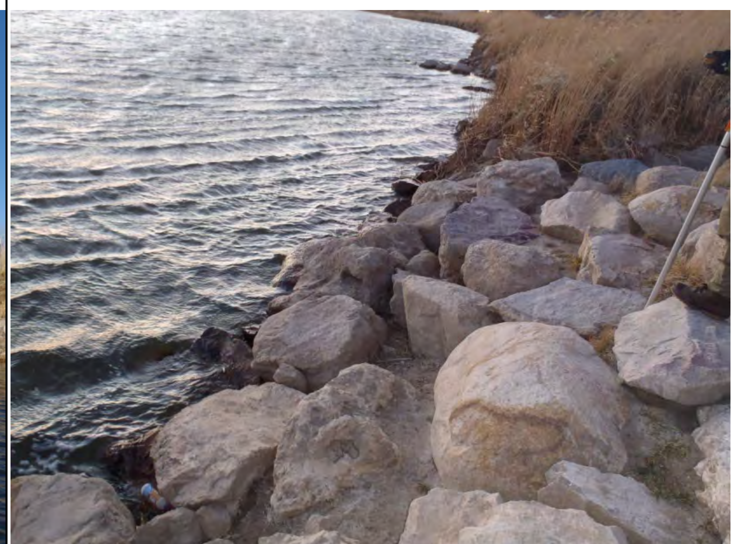
Rock Toe Map-14-118

18 IN Invert Pipes 2 ECP Map-14-119

Rock Toe Map-14-120

Pump In Pond Map-14-121

Boat Ramp Map-14-122

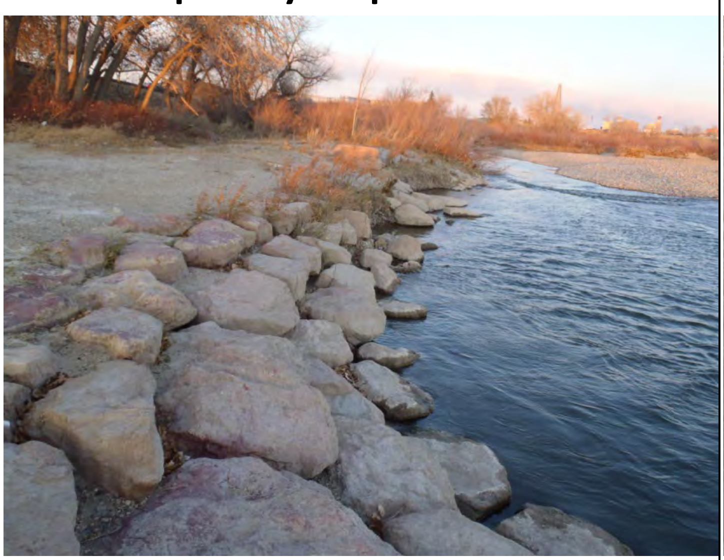


Rock Toe Map-14-123

Walking Bridge Map-14-124

Kay St Kayak Pk Structure Map-14-125

Spillway Map-15-126



Rock Toe Map-15-127

Kay St Kayak Pk Structure Map-15-128

2X6 Box Culvert Map-15-129

Rock Toe Map-15-130

Rock Toe Map-15-131

Kay St Kayak Pk Structure Map-15-132

24 IN Invert Pipe Map-15-133

36 IN Invert Pipe Map-15-134

36 IN Invert Pipe Map-15-135

24 IN Invert Pipe Map-15-136


Walkway Map-15-137


84 IN Invert Pipe Map-15-138


Rock Toe Map-15-139


12 IN Invert Pipe Map-15-140


12 IN Invert Pipe Map-15-141


24 IN Invert Pipe Map-15-142

Rock Toe Map-16-143

48 IN Invert Pipe Map-16-144

Rock Toe Map-16-145

Rock Toe Map-16-146

Walkway Map-16-147

Rock Toe Map-16-148

Rock Toe Map-16-149

Island Map-16-152

24 IN Invert Pipe Map-16-150

Gauge Map-17-153

Rock Wall Map-16-151

No Photograph Taken

Drain Map-17-154

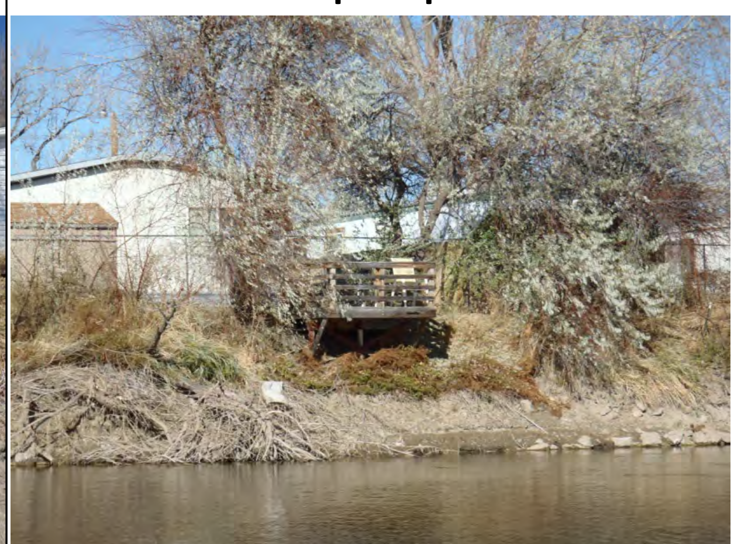
18 IN Invert Pipe Map-17-155

Dock Map-17-156

Retaining Wall Map-17-157

Rock Toe Map-17-158

Boat Ramp Map-17-159



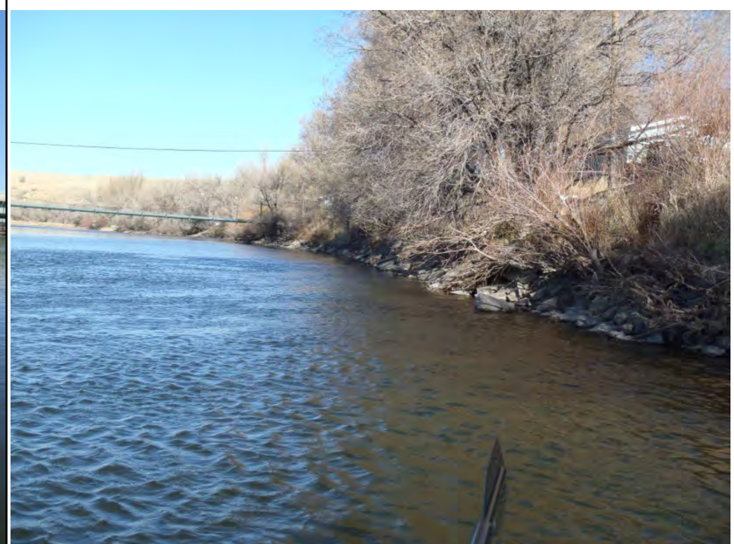
Dock Map-17-160

Rock Toe-Old Pipe Map-17-161

Rock Wall Map-17-162

Dock Map-17-163

Walkway Map-17-164



Rock Toe Map-17-165

Overhead Pipe Map-18-166

Dock Map-18-167

Dock Map-19-168

Rock Wall Map-19-169

36 IN Invert Pipe Map-19-170

Rock Wall Map-19-171

Rock Wall Map-19-172

102 IN Invert Pipe Map-20-173

No Photograph Taken

UT- Pipe Map-20-174

36 IN Invert Pipe Map-20-175

Rock Toe Map-20-176

Stairs Map-20-177

Walking Bridge Map-20-178

12 IN Invert Pipe Map-21-179

No Photograph Taken

12 IN Invert Pipe Map-21-180

Rock Wall Map-21-181

Boat Ramp Map-21-182

24 IN Invert Pipe Map-21-183

Intake Map-21-184

Pump Station Map-21-185

42 IN Invert Pipe Map-21-188

Rock Wall Map-21-186

42 IN Invert Pipe Map-21-189

42 IN Invert Pipe Map-21-187

Spillway Map-21-190

48 IN Invert Pipe Map-22-191

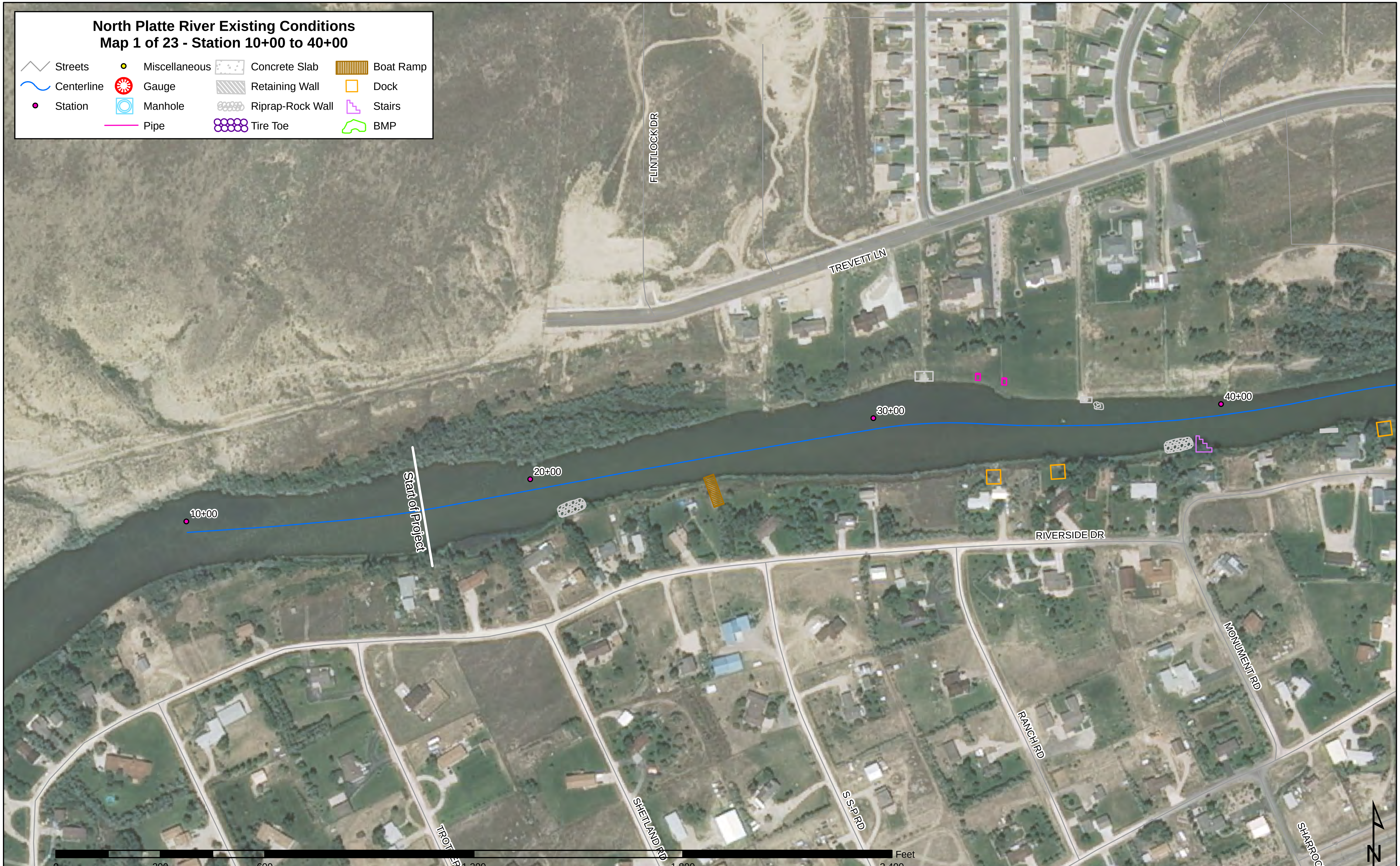
Rock Wall Map-22-192

Rock Wall Map-22-193

Conveyor Belt Map-22-194

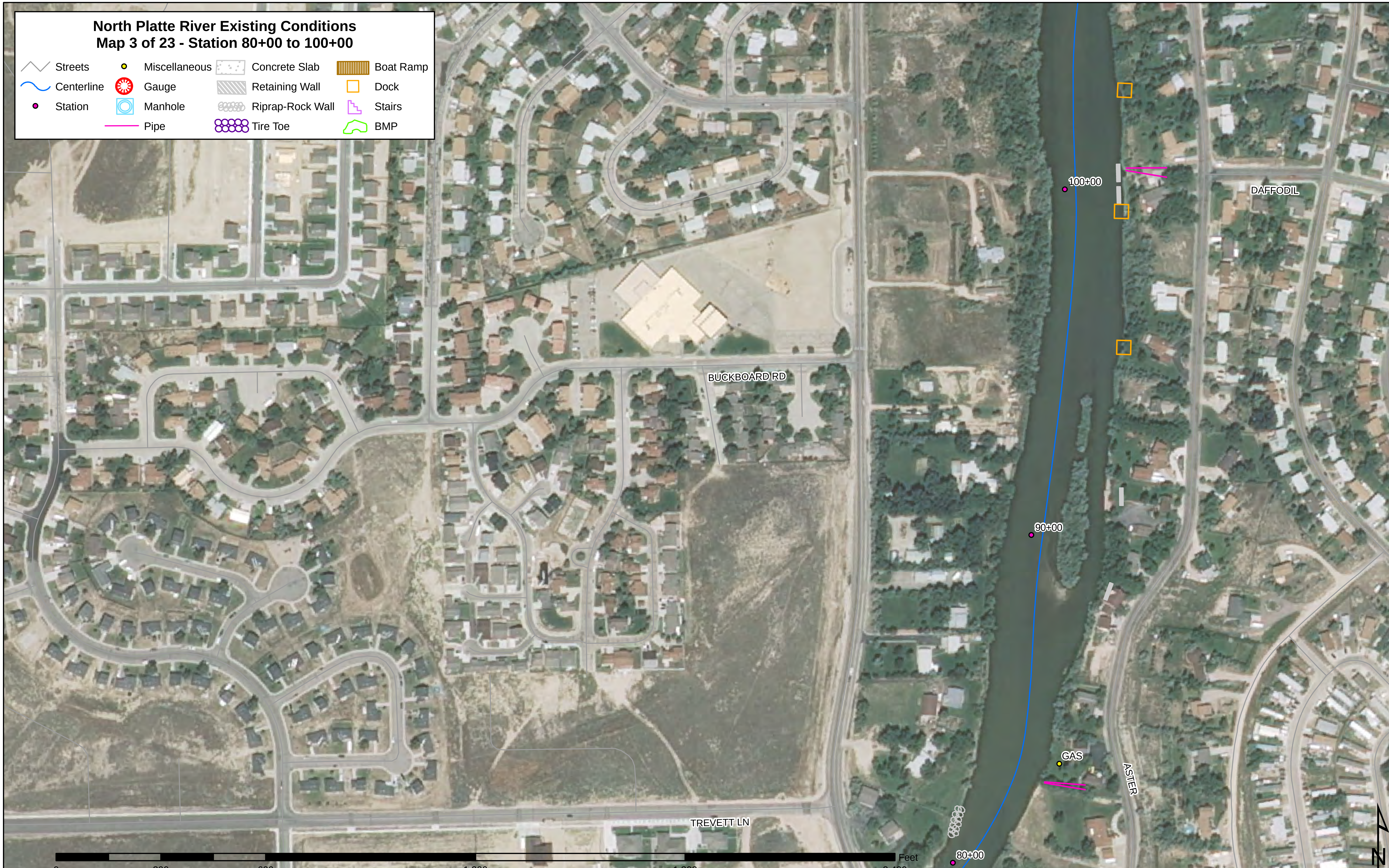
Concrete Blocks Map-22-195

24 IN Invert Pipe Map-23-196

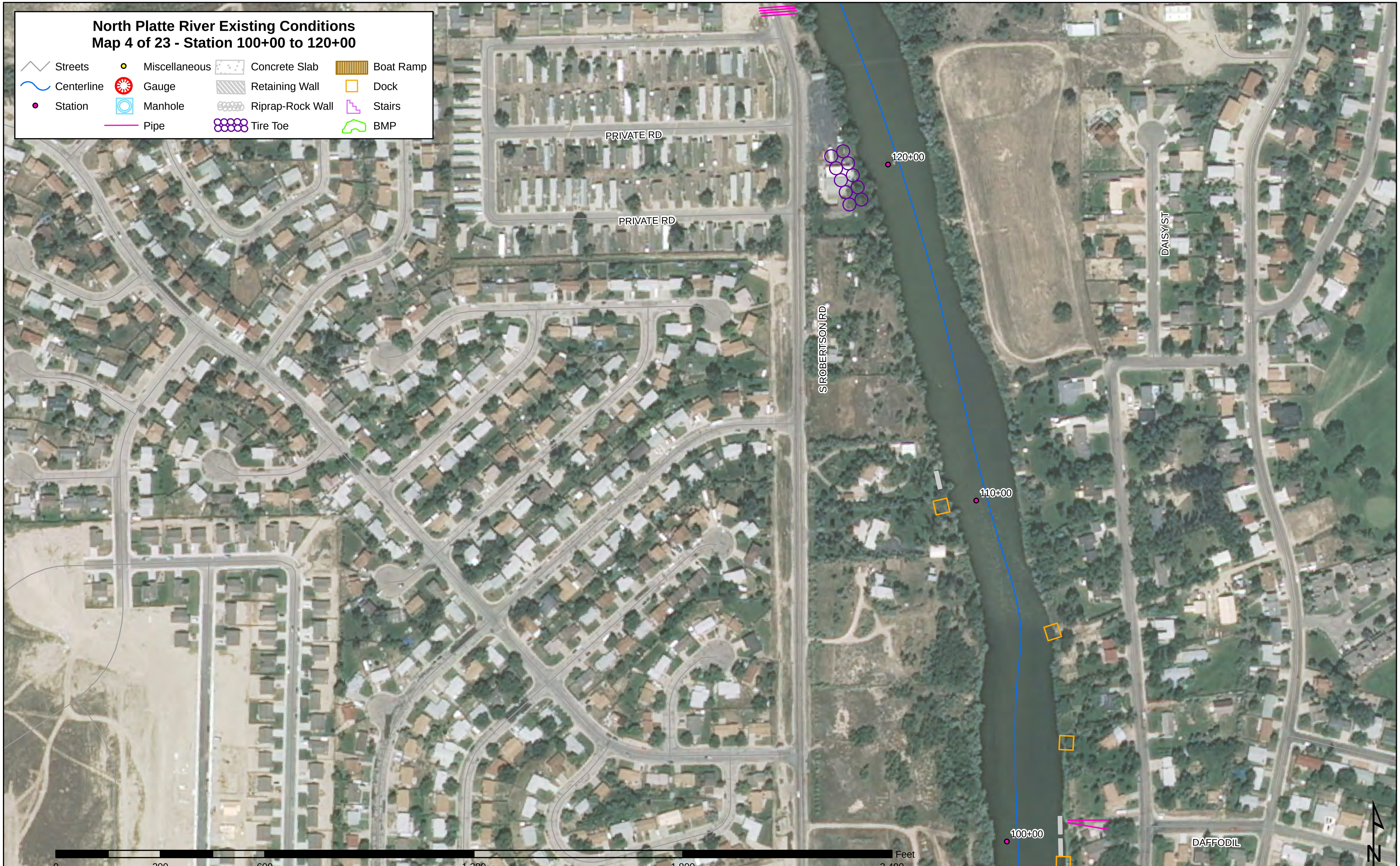


North Platte River Existing Conditions
Map 1 of 23 - Station 10+00 to 40+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
FLINTLOCK DR
TREVETT LN
RIVERSIDE DR
MONUMENT RD
RANCH RD
S S-P RD
SHETLAND RD
SHARROCK
Start of Project
10+00
20+00
30+00
40+00
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River Existing Conditions
Map 2 of 23 - Station 40+00 to 80+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
TREVETT LN
WHISPERING SPRINGS RD
40+00
50+00
60+00
70+00
80+00
S ROBERTSON RD
RIVERSIDE TER
RAVINE LN
RAVINE RD
RIVERSIDE DR
MONUMENT RD
SHARROCK RD
Feet
0
300
600
1,200
1,800
2,400
N



North Platte River Existing Conditions
Map 3 of 23 - Station 80+00 to 100+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
100+00
DAFFODIL
BUCKBOARD RD
90+00
GAS
ASTER
TREVETT LN
80+00
0
300
600
1,200
1,800
2,400
Feet
N



North Platte River Existing Conditions
Map 4 of 23 - Station 100+00 to 120+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
PRIVATE RD
PRIVATE RD
S ROBERTSON RD
DAISY ST
DAFFODIL
120+00
110+00
100+00
Feet
0
300
600
1,200
1,800
2,400
N


North Platte River Existing Conditions
Map 5 of 23 - Station 120+00 to 150+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
150+00
140+00
130+00
120+00
SQUASH BLOSSOM RD
CHIEF WASHAKIE RD
LITTLE MOON TRL
PAINTED HORSE TRL
PRIVATE RD
LARKSPUR
INDIAN PAINTBRUSH
Feet
0
300
600
1,200
1,800
2,400
N


North Platte River Existing Conditions
Map 6 of 23 - Station 150+00 to 200+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
PRIVATE DR
150+00
160+00
170+00
180+00
190+00
200+00
BEGONIA
LILAC
BEGONIA
BEGONIA
SUNFLOWER
BUFFALO
PATHFINDER
RIVERBEND RD
RIVERBEND RD
Feet
0
300
600
1,200
1,800
2,400
N

North Platte River Existing Conditions
Map 7 of 23 - Station 200+00 to 230+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
200+00
210+00
220+00
230+00
BUFFALO
PATHFINDER
RIVERBEND RD
WHITLOCK RD
BEGONIA
CALYPSO
PARADISE DR
0
300
600
1,200
1,800
2,400
Feet
N

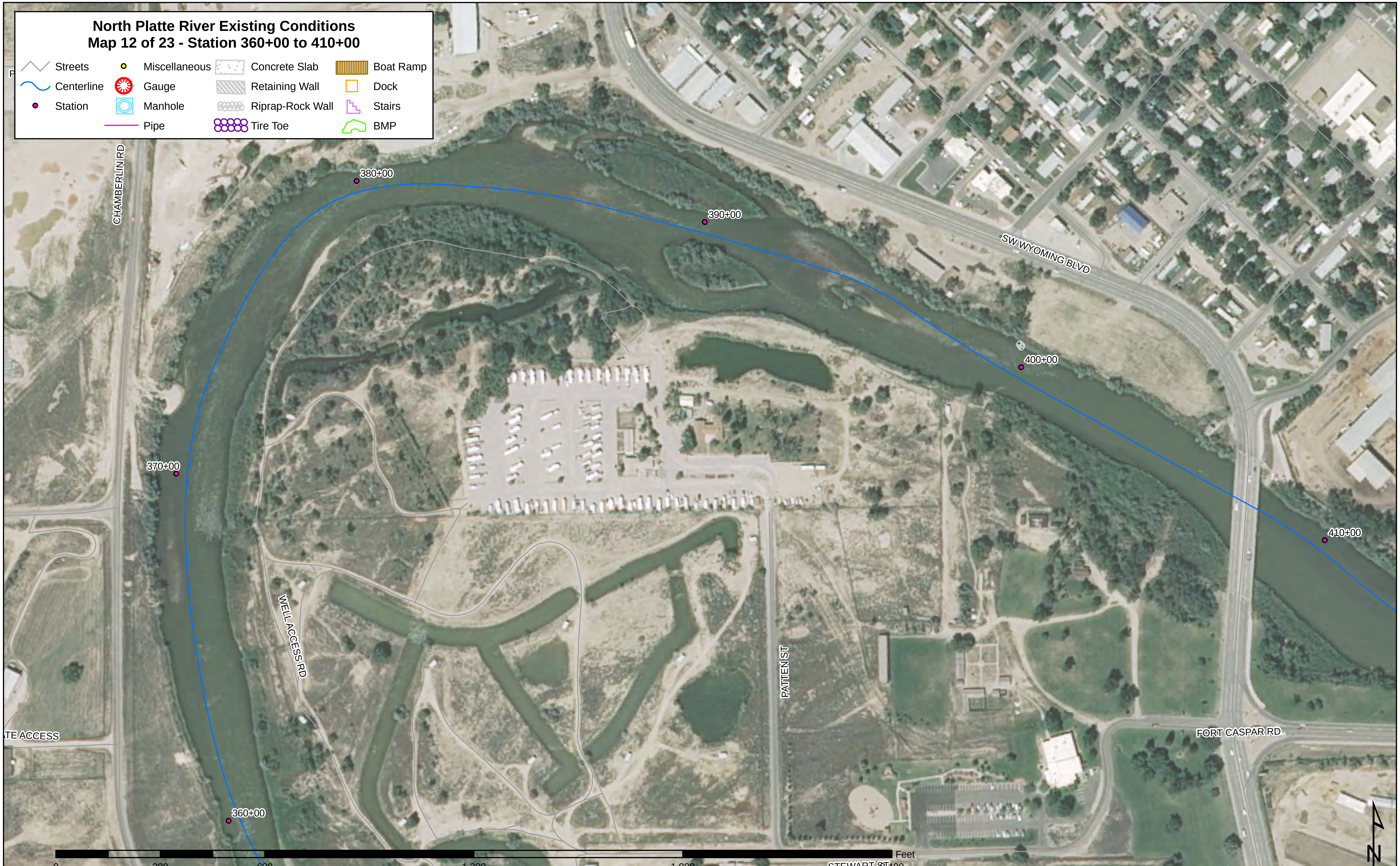
North Platte River Existing Conditions
Map 8 of 23 - Station 230+00 to 270+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
FITZHUGH RD
RIVER MEADOWS RD
BUSH LN
PRIVATE ACCESS
PRIVATE ACCESS
RIVERSIDE ST
230+00
240+00
250+00
260+00
270+00
0
300
600
1,200
1,800
2,400
Feet
N

North Platte River Existing Conditions
Map 9 of 23 - Station 270+00 to 300+00


North Platte River Existing Conditions
Map 10 of 23 - Station 300+00 to 330+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
330+00
PUMP
320+00
310+00
300+00
CHAMBERLIN RD
UNNAMED RD
SW WYOMING BLVD
FAIR
PRIVATE ACCESS
PRIVATE ACCESS
PRIVATE ACCESS
Feet
0
300
600
1,200
1,800
2,400
N

North Platte River Existing Conditions
Map 11 of 23 - Station 330+00 to 360+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
PRIVATE ACCESS
MEIER RD
HIDEAWAY LN
PATTEN ST
STEWART ST
MILLER ST
FORT CASPAR
UNNAMED RD
PUMP
360+00
350+00
340+00
330+00
Feet
0
300
600
1,200
1,800
2,400
N

North Platte River Existing Conditions
Map 12 of 23 - Station 360+00 to 410+00

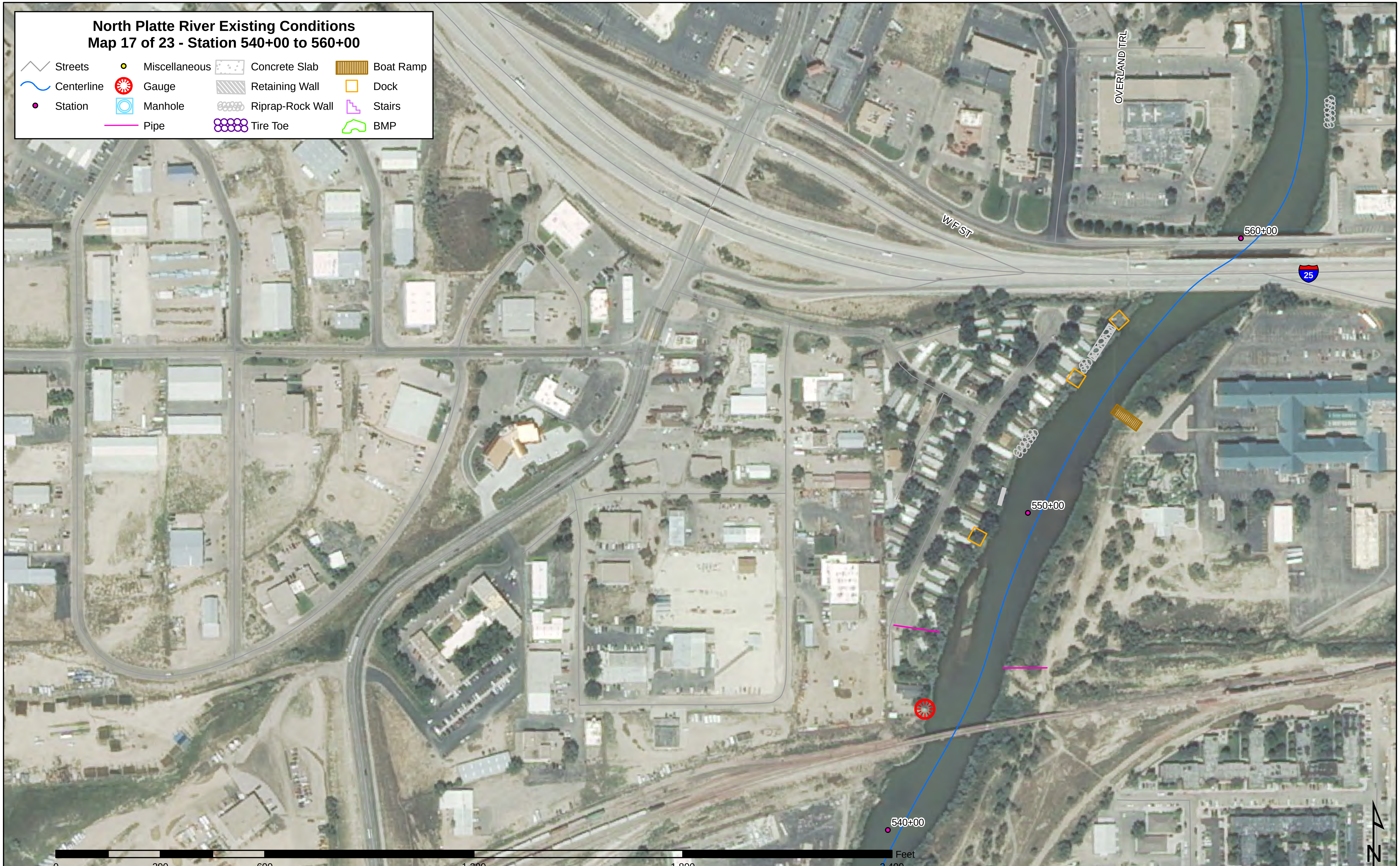


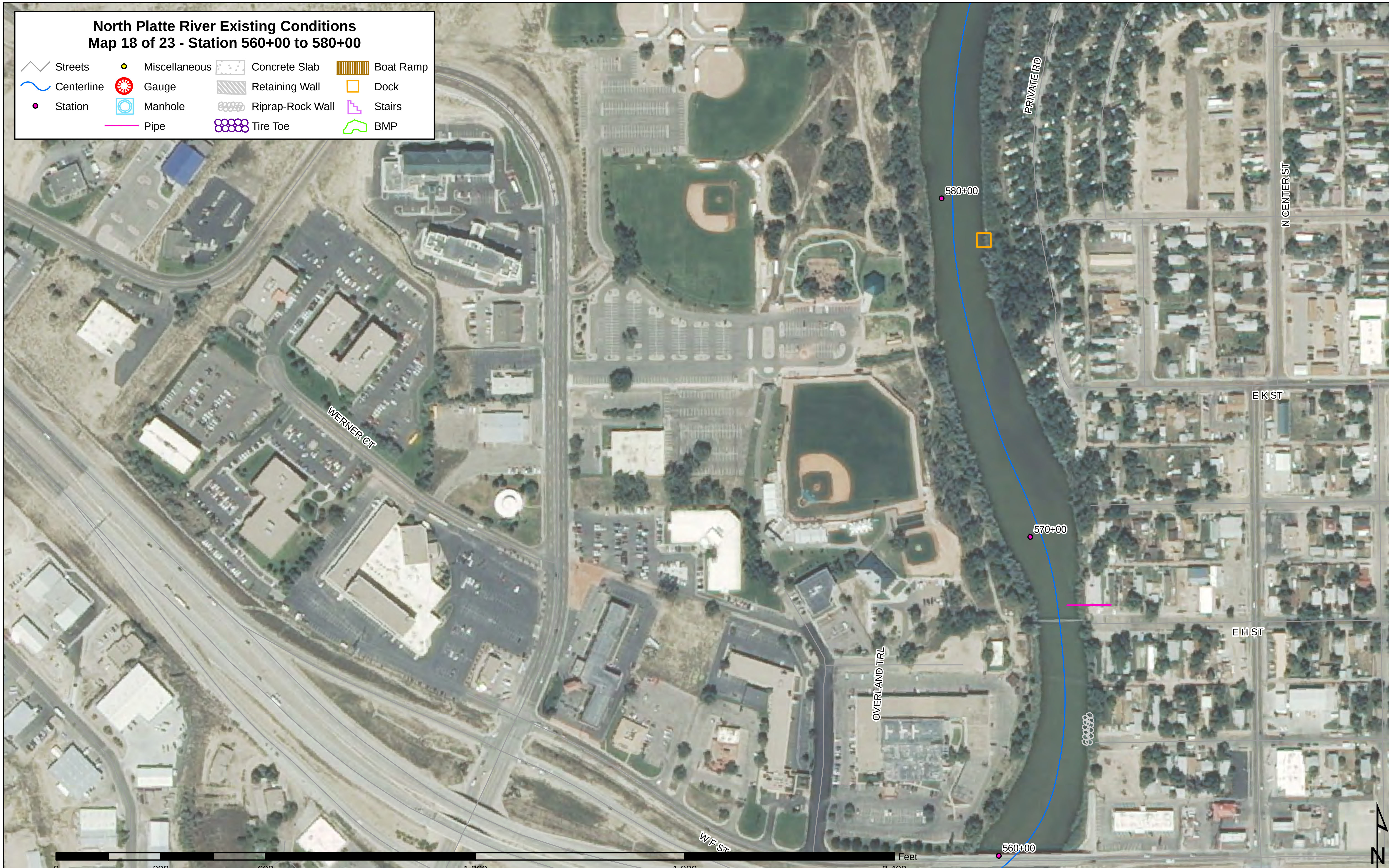

North Plattte River Existing Conditions
Map 13 of 23 - Station 410+00 to 440+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
FIRST ST
SPAWN AVE
KING BLVD
W 13TH ST
COULTER DR
410+00
420+00
430+00
440+00
0
300
600
1,200
1,800
2,400
Feet
N

North Platte River Existing Conditions
Map 14 of 23 - Station 440+00 to 480+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
440+00
450+00
460+00
470+00
480+00
KING BLVD
Feet
0
300
600
1,200
1,800
2,400
N


North Plate River Existing Conditions
Map 15 of 23 - Station 480+00 to 520+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
W 1ST ST
RED CLOUD RD
REFINEMENT WAY
STAR LN
KING BLVD
2X6 BOX
SPILLWAY
480+00
490+00
500+00
510+00
520+00
Feet
0
300
600
1,200
1,800
2,400
N


North Platte River Existing Conditions
Map 16 of 23 - Station 520+00 to 540+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
540+00
530+00
520+00
ANTLER DR
N POPLAR ST
PRONGHORN ST
N NICHOLS AVE
W 1ST ST
STAR LN
REFINEMENT W
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River Existing Conditions
Map 17 of 23 - Station 540+00 to 560+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
OVERLAND TRL
W F ST
560+00
25
550+00
540+00
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River Existing Conditions
Map 18 of 23 - Station 560+00 to 580+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
PRIVATE RD
N CENTER ST
E K ST
E H ST
WERNER CT
OVERLAND TRL
W F ST
580+00
570+00
560+00
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River Existing Conditions
Map 19 of 23 - Station 580+00 to 620+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
580+00
590+00
600+00
610+00
620+00
PRIVATE RD
N CENTER ST
E M ST
E M ST
E M ST
E L ST
N GRANT ST
LENARM ST
0
300
600
1,200
1,800
2,400
Feet
N

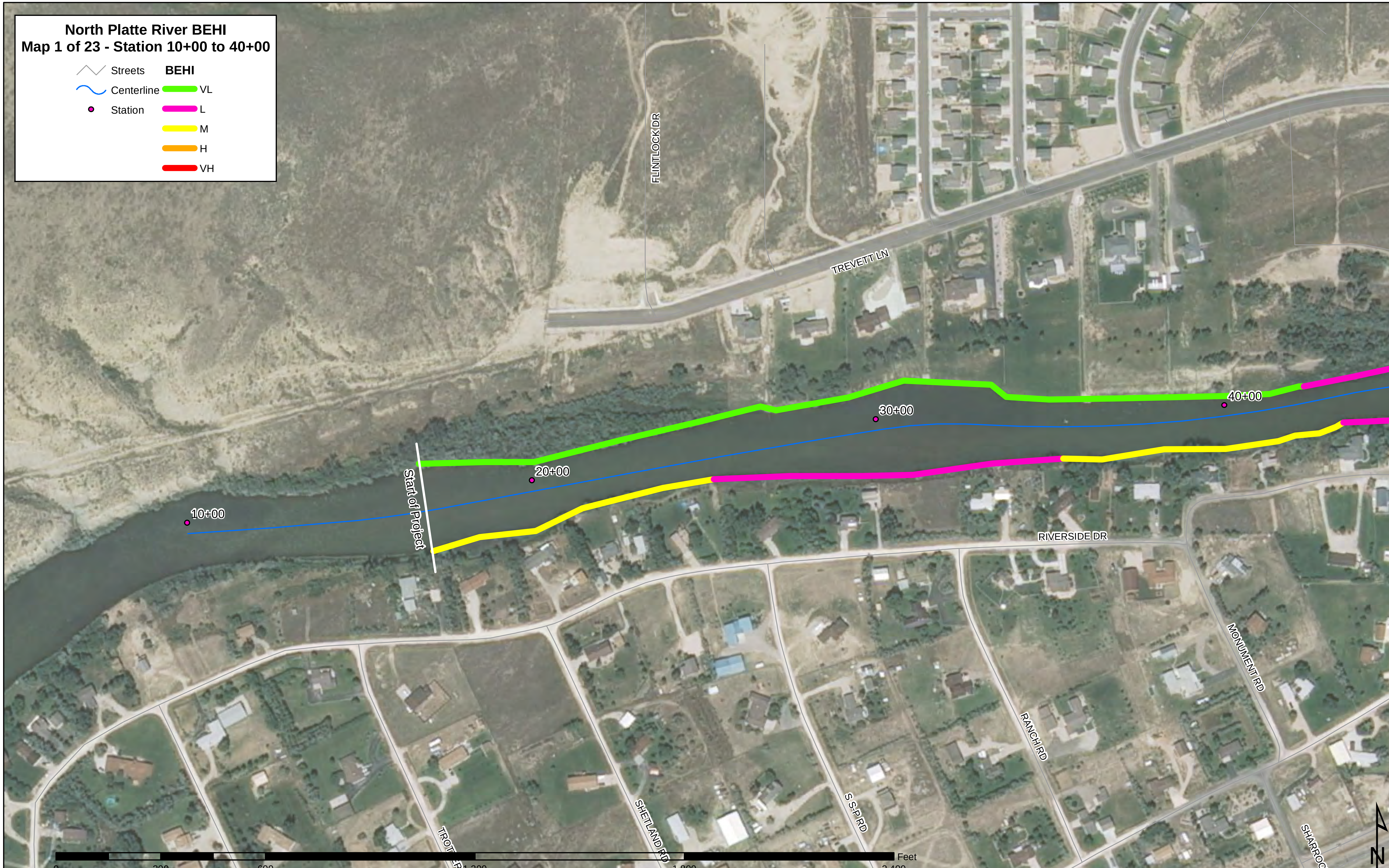

North Platte River Existing Conditions
Map 20 of 23 - Station 620+00 to 660+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
620+00
630+00
640+00
650+00
660+00
UNNAMED RD
E M ST
E M ST
E M ST
E L ST
GLENARM ST
N LINCOLN ST
N JEFFERSON ST
ST MARY ST
JACKSON ST
0
300
600
1,200
1,800
2,400
Feet
N

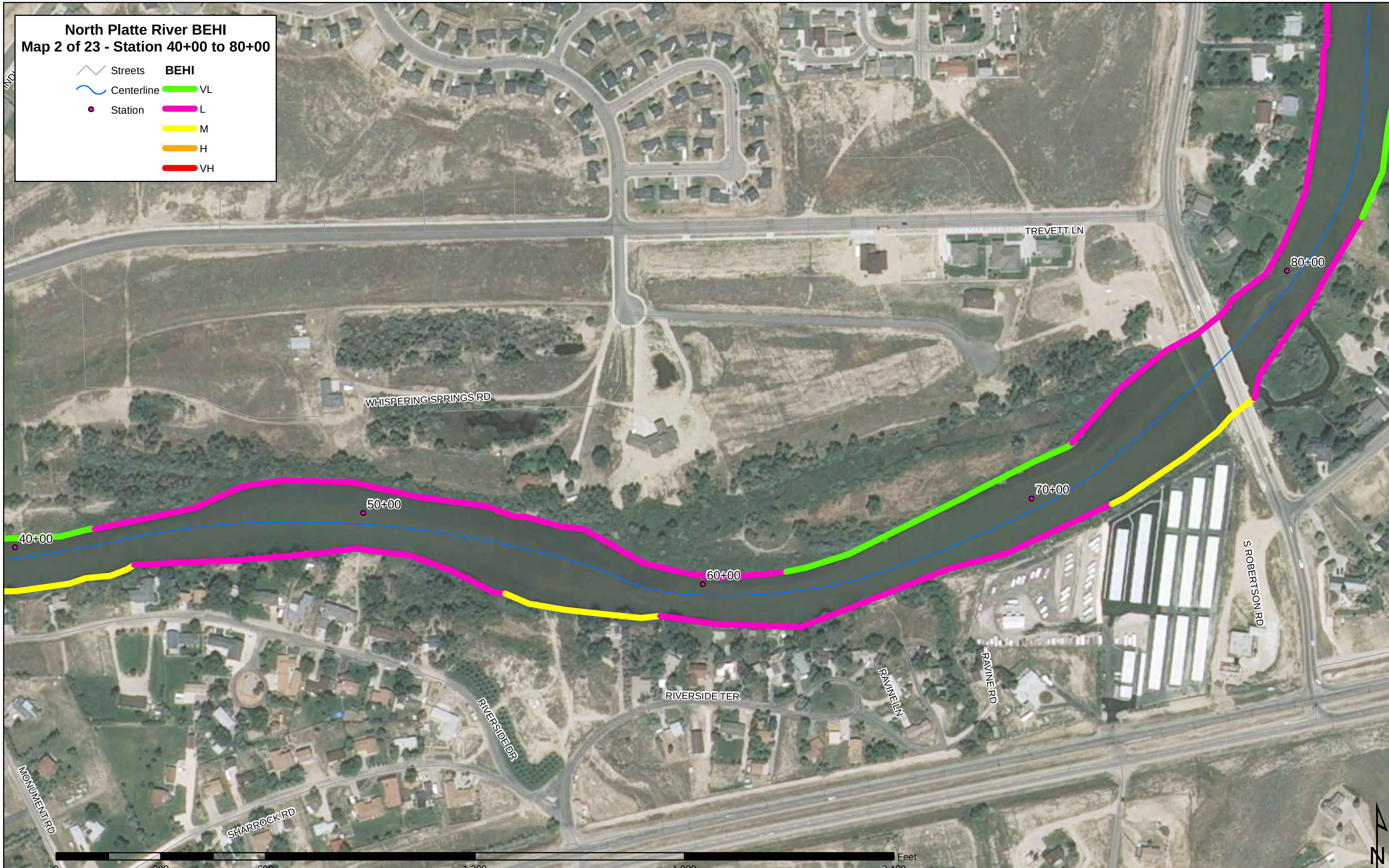

North Platte River Existing Conditions
Map 21 of 23 - Station 660+00 to 700+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
PRIVATE ACCESS
UNNAMED RD
PUMP STATION
SPILLWAY
660+00
670+00
680+00
690+00
700+00
0
300
600
1,200
1,800
2,400
Feet
N

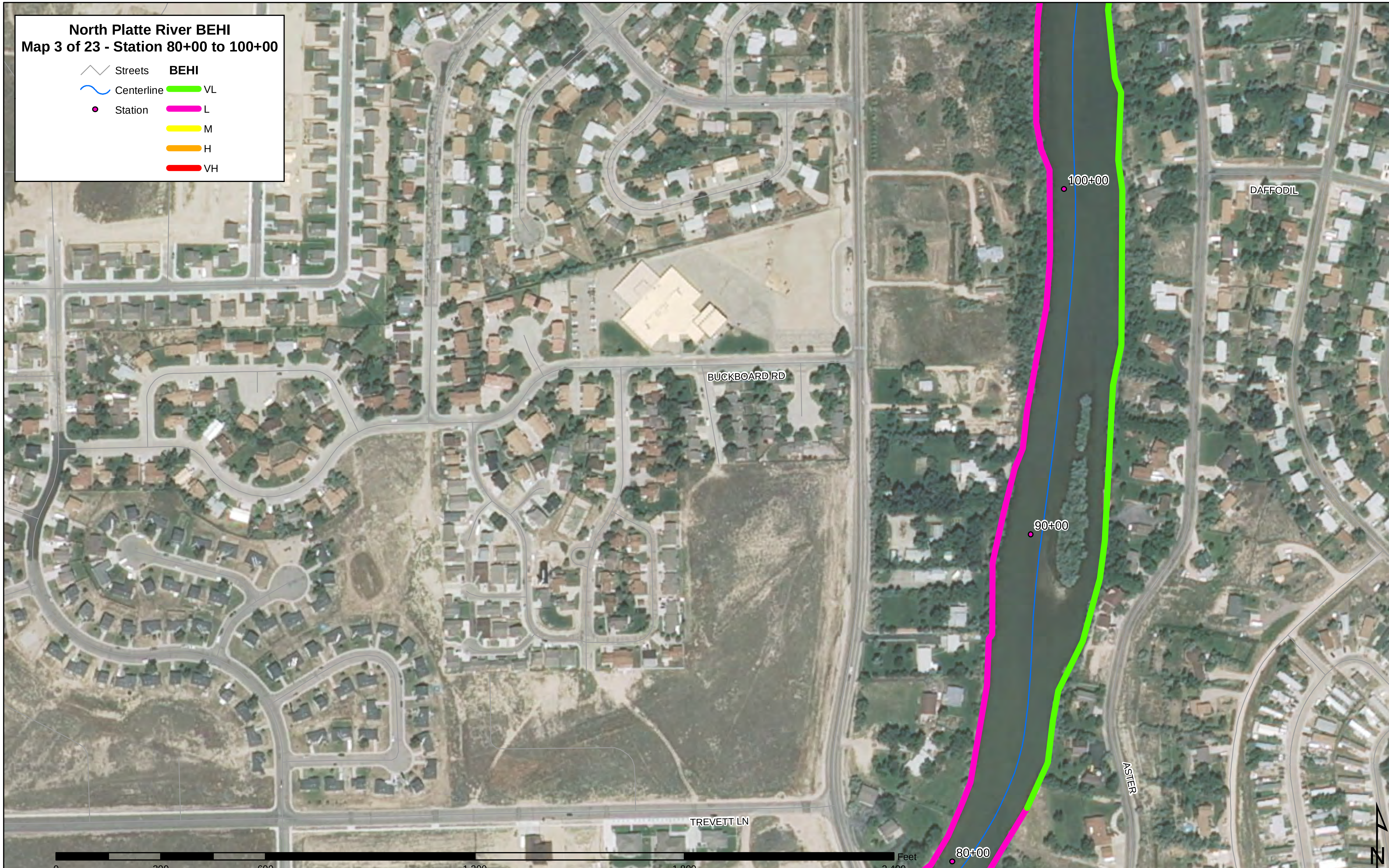
North Platte River Existing Conditions
Map 22 of 23 - Station 700+00 to 720+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
720+00
710+00
700+00
SPILLWAY
0
300
600
1,200
1,800
2,400
Feet
N

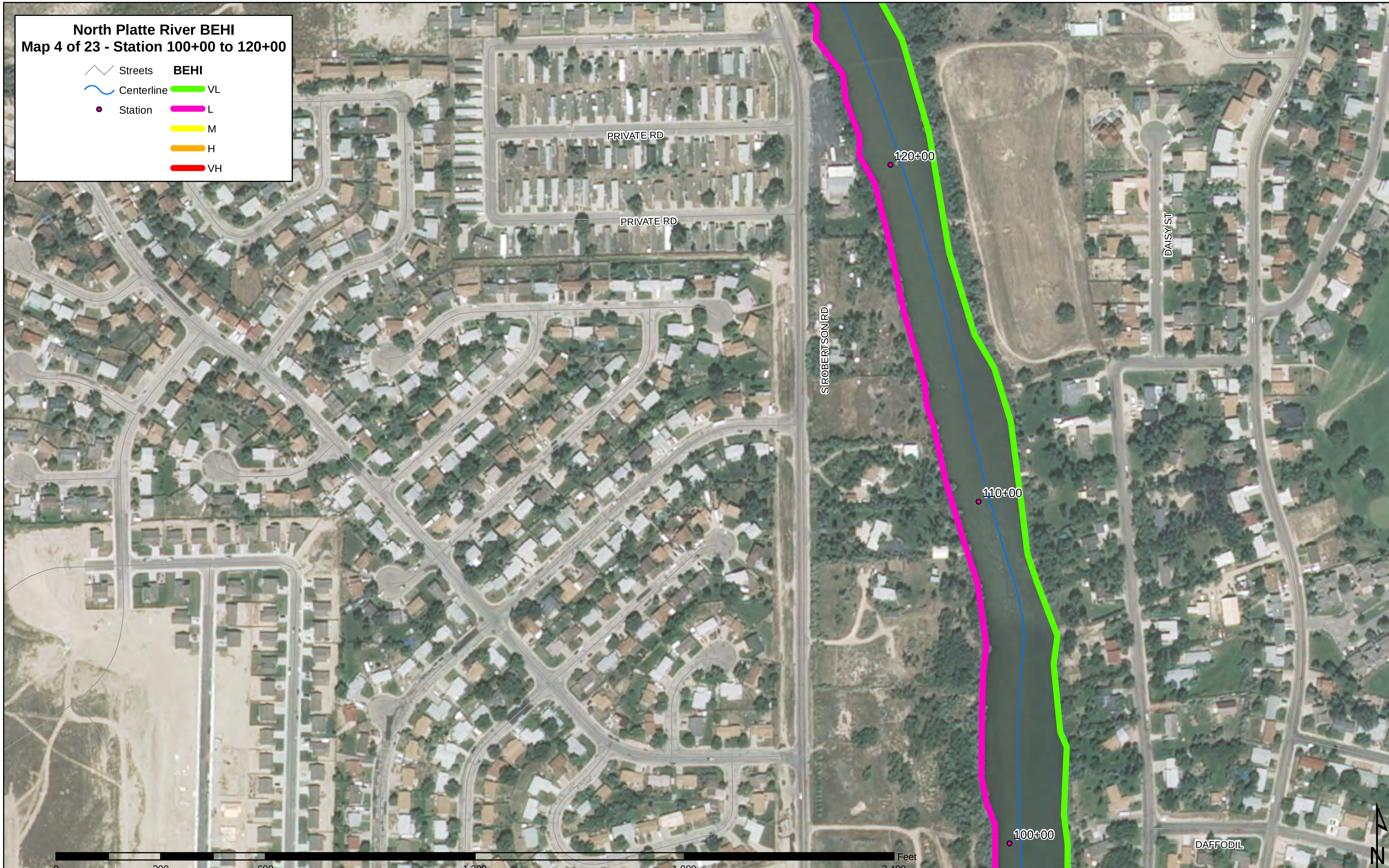

North Platte River Existing Conditions
Map 23 of 23 - Station 720+00 to 760+00
Streets
Centerline
Station
Miscellaneous
Gauge
Manhole
Pipe
Concrete Slab
Retaining Wall
Riprap-Rock Wall
Tire Toe
Boat Ramp
Dock
Stairs
BMP
METRO RD
760+00
750+00
740+00
730+00
720+00
End of Project
PLATTE PARK RD
Feet
0
300
600
1,200
1,800
2,400
N

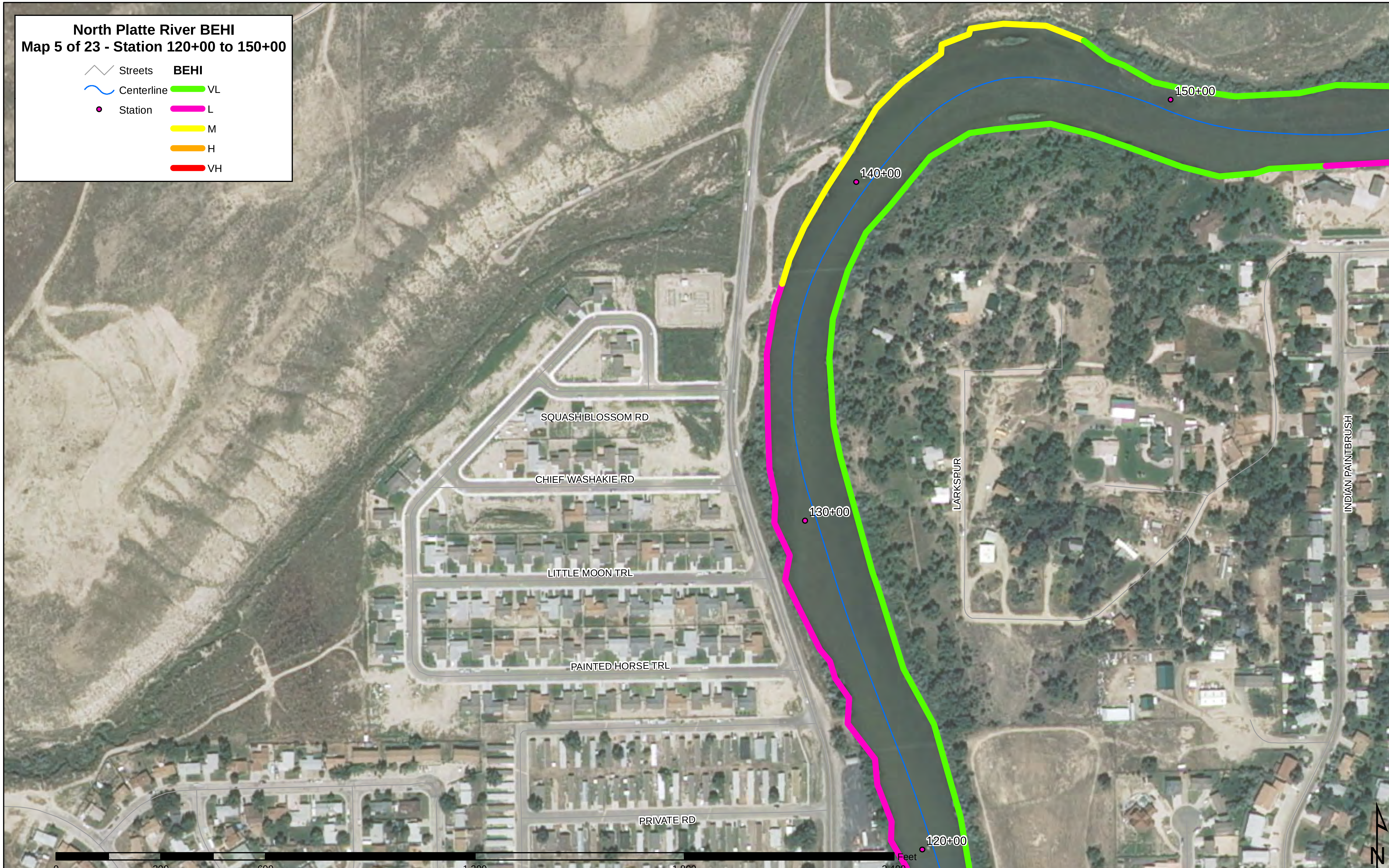
Appendix D. BEHI Survey Maps

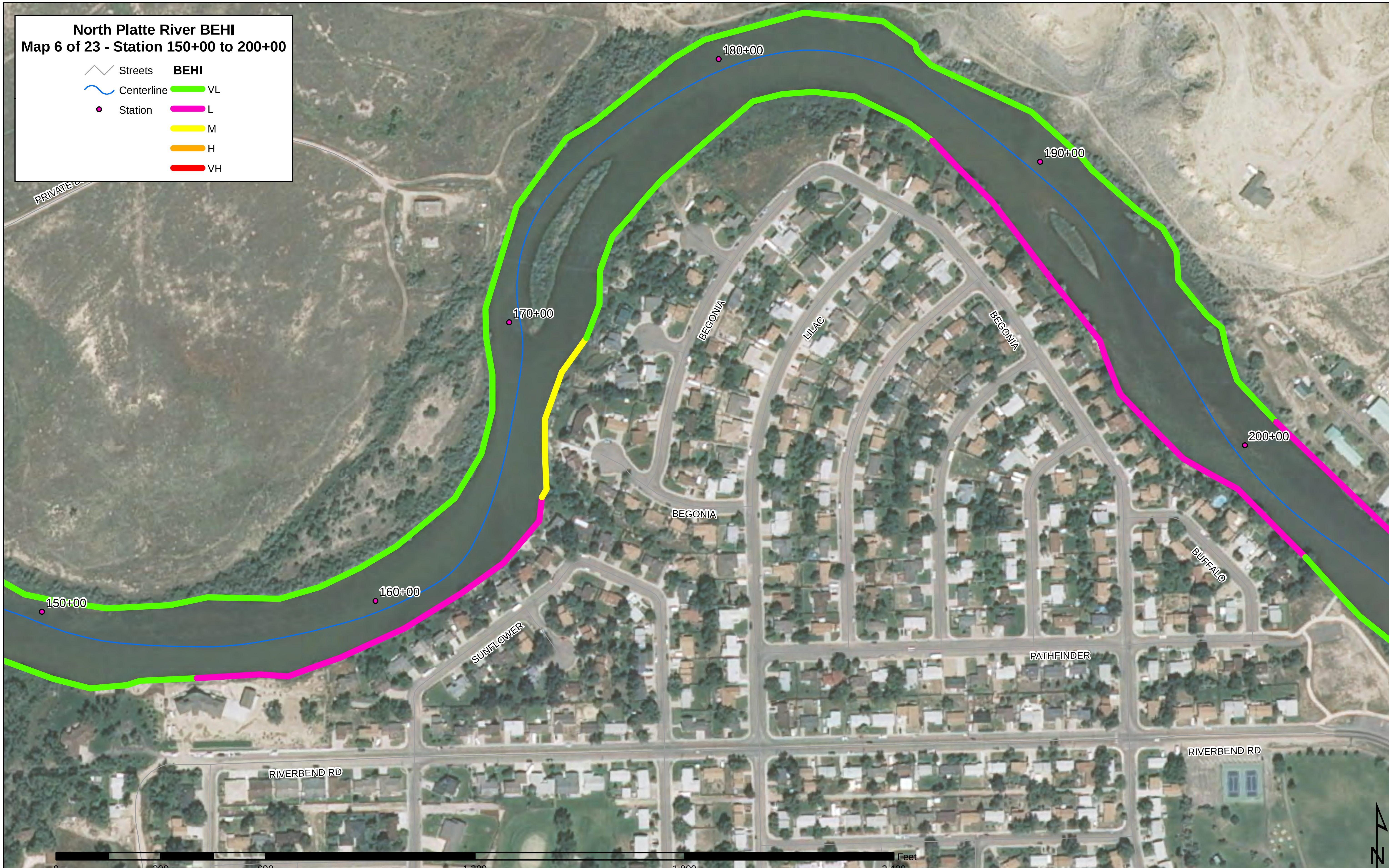

North Platte River BEHI
Map 1 of 23 - Station 10+00 to 40+00
Streets
BEHI
Centerline
VL
Station
L
M
H
VH
FLINTLOCK DR
TREVETT LN
RIVERSIDE DR
MONUMENT RD
RANCH RD
S S-P RD
SHETLAND RD
SHARROCK
Start of Project
10+00
20+00
30+00
40+00
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River BEHI
Map 2 of 23 - Station 40+00 to 80+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
40+00
50+00
60+00
70+00
80+00
TREVETT LN
WHISPERING SPRINGS RD
RIVERSIDE TER
RIVERSIDE DR
RAVINE LN
RAVINE RD
S ROBERTSON RD
MONUMENT RD
SHARROCK RD
Feet
0
300
600
1,200
1,800
2,400
N


North Platte River BEHI
Map 3 of 23 - Station 80+00 to 100+00
Streets
BEHI
Centerline
VL
Station
L
M
H
VH
100+00
90+00
80+00
DAFFODIL
BUCKBOARD RD
TREVETT LN
ASTER
Feet
0
300
600
1,200
1,800
2,400
N

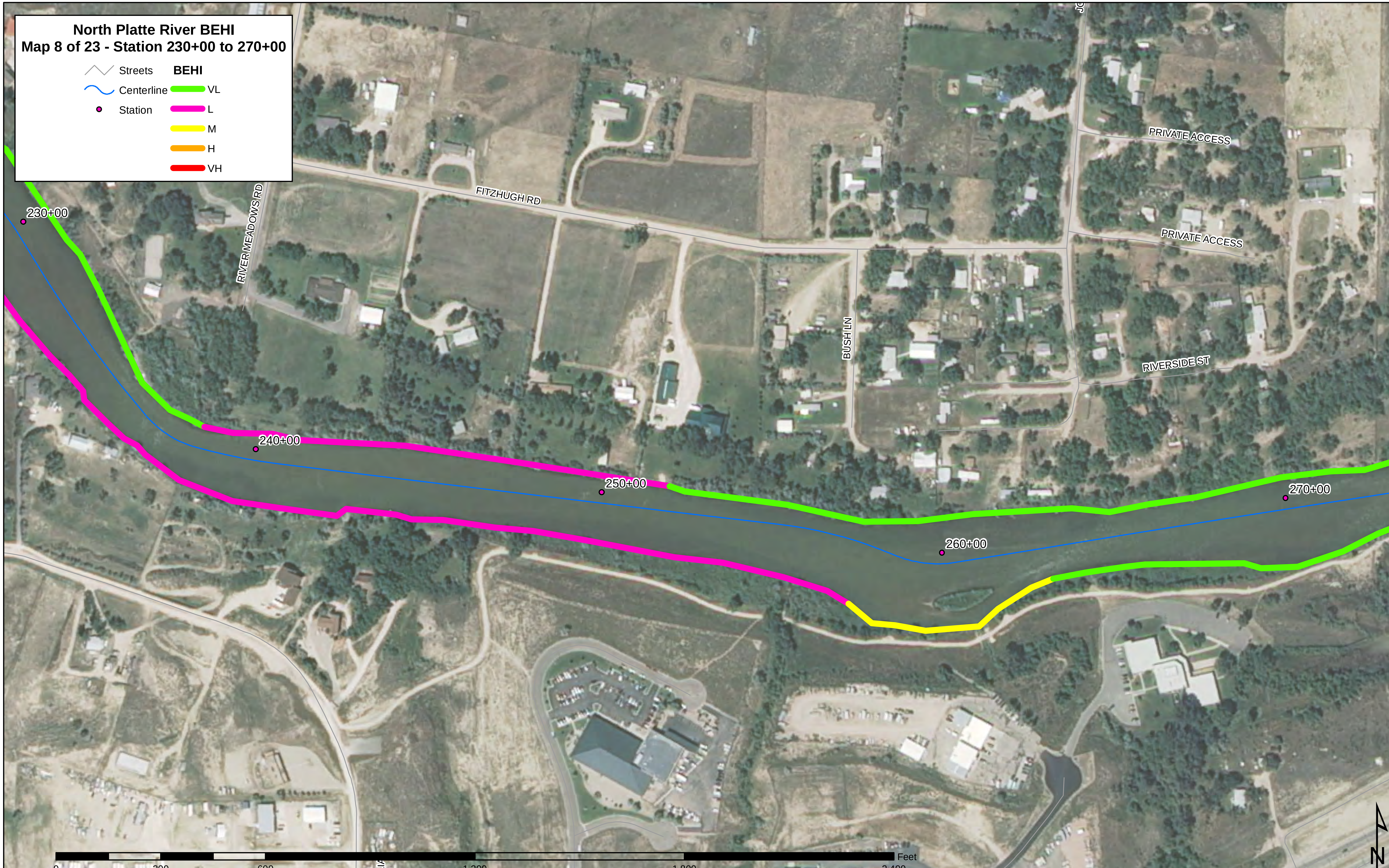

North Platte River BEHI
Map 4 of 23 - Station 100+00 to 120+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
PRIVATE RD
PRIVATE RD
S ROBERTSON RD
DAISY ST
DAFFODIL
120+00
110+00
100+00
0
300
600
1,200
1,800
2,400
Feet
N

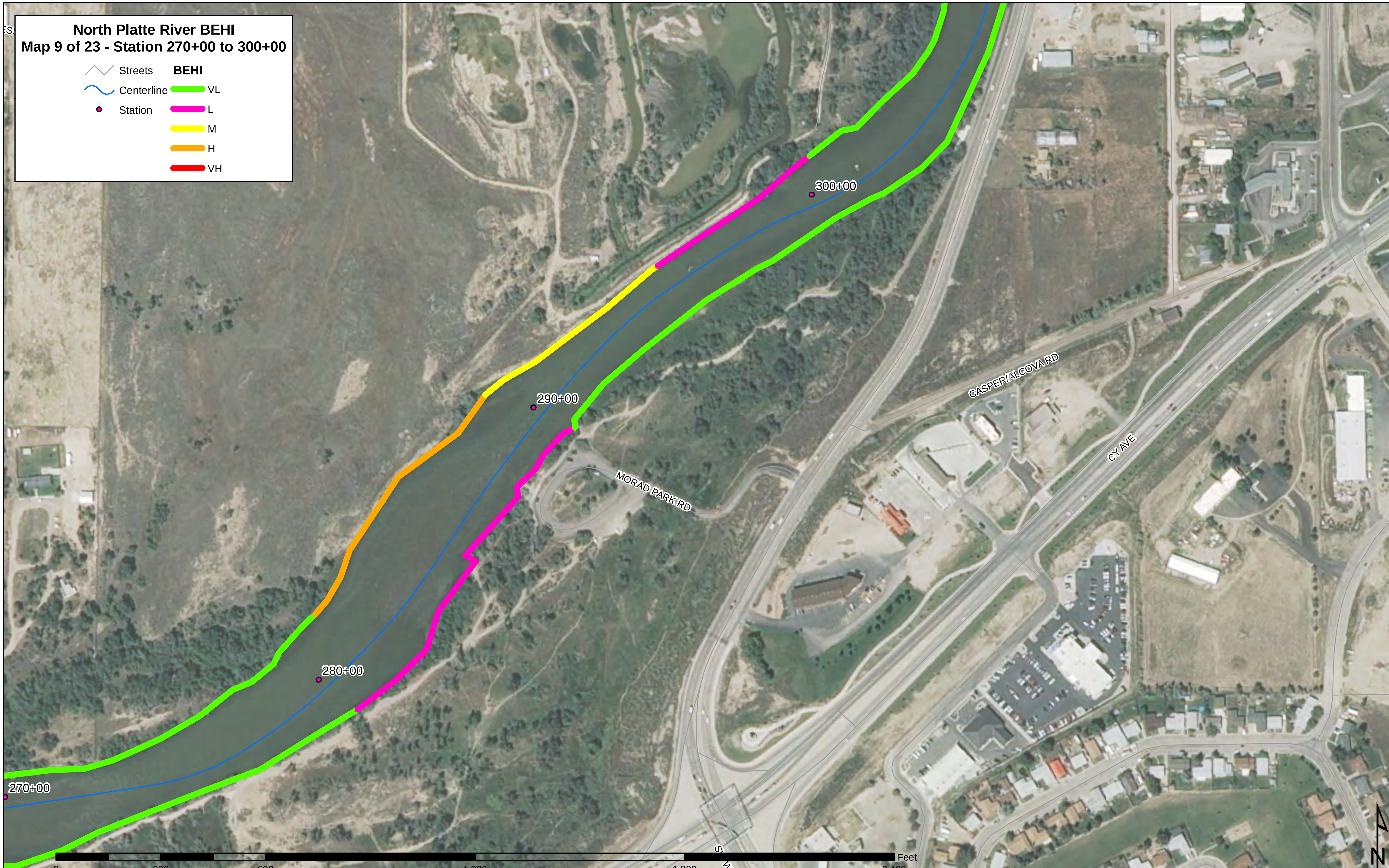

North Platte River BEHI
Map 5 of 23 - Station 120+00 to 150+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
150+00
140+00
130+00
120+00
SQUASH BLOSSOM RD
CHIEF WASHAKIE RD
LITTLE MOON TRL
PAINTED HORSE TRL
PRIVATE RD
LARKSPUR
INDIAN PAINTBRUSH
0
300
600
1,200
1,800
2,400
Feet
N



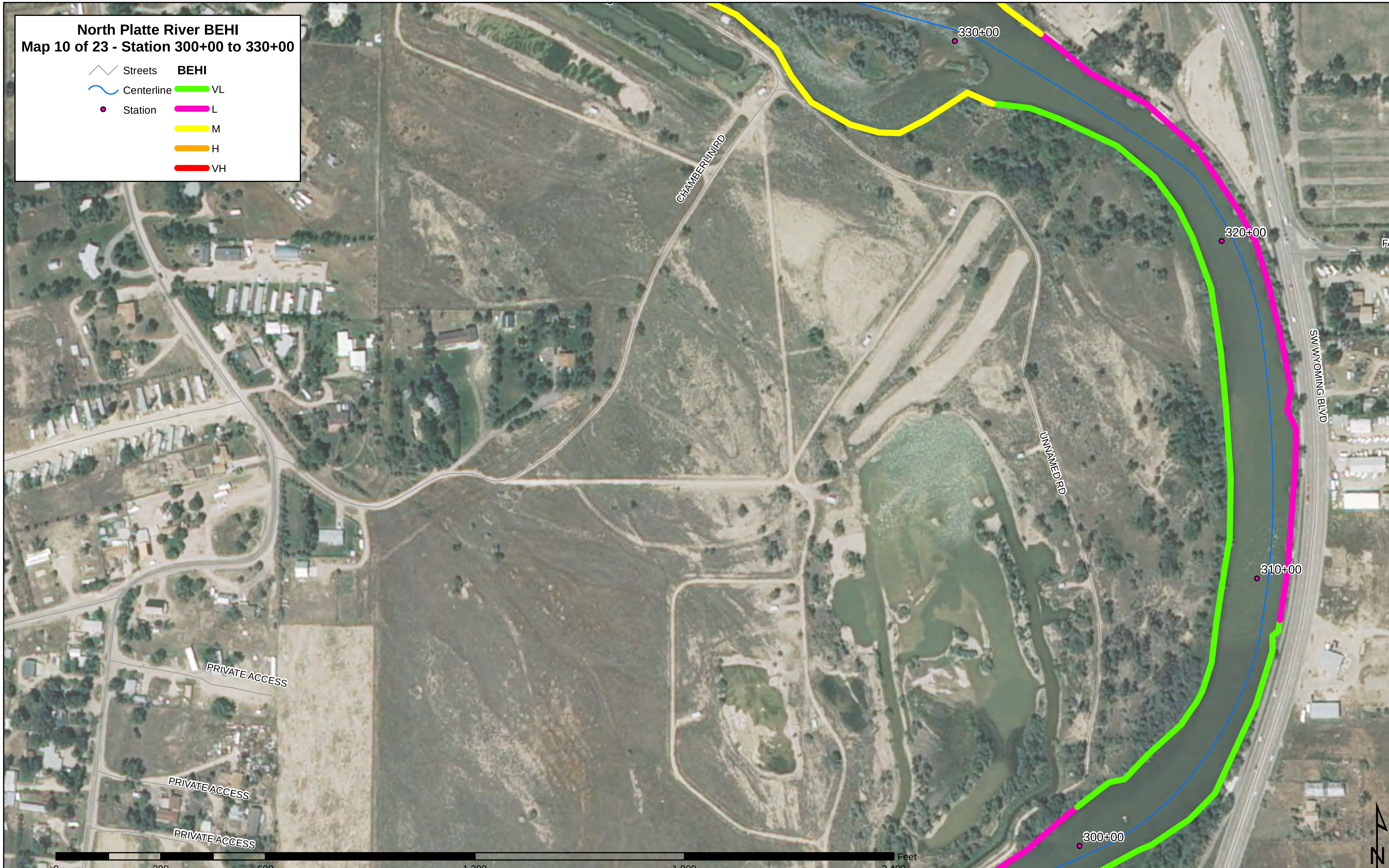
North Platte River BEHI
Map 6 of 23 - Station 150+00 to 200+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
150+00
160+00
170+00
180+00
190+00
200+00
BEGONIA
LILAC
SUNFLOWER
BUFFALO
PATHFINDER
RIVERBEND RD
Feet
0
300
600
1,200
1,800
2,400
N

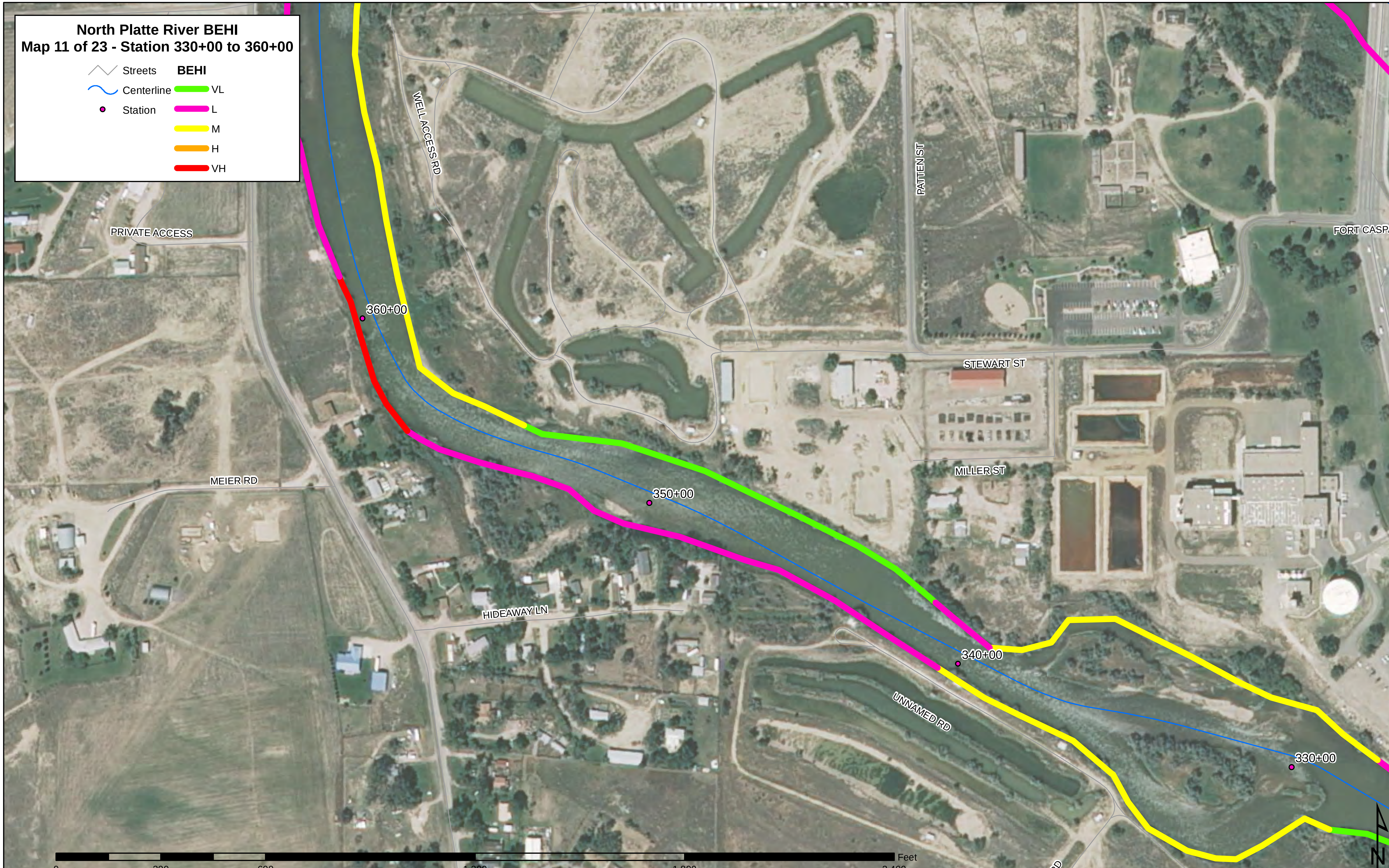
North Platte River BEHI
Map 7 of 23 - Station 200+00 to 230+00
Streets
BEHI
Centerline
VL
Station
L
M
H
VH
200+00
210+00
220+00
230+00
BUFFALO
PATHFINDER
RIVERBEND RD
WHITLOCK RD
BEGONIA
CALYPSO
PARADISE DR
Feet
0
300
600
1,200
1,800
2,400
N

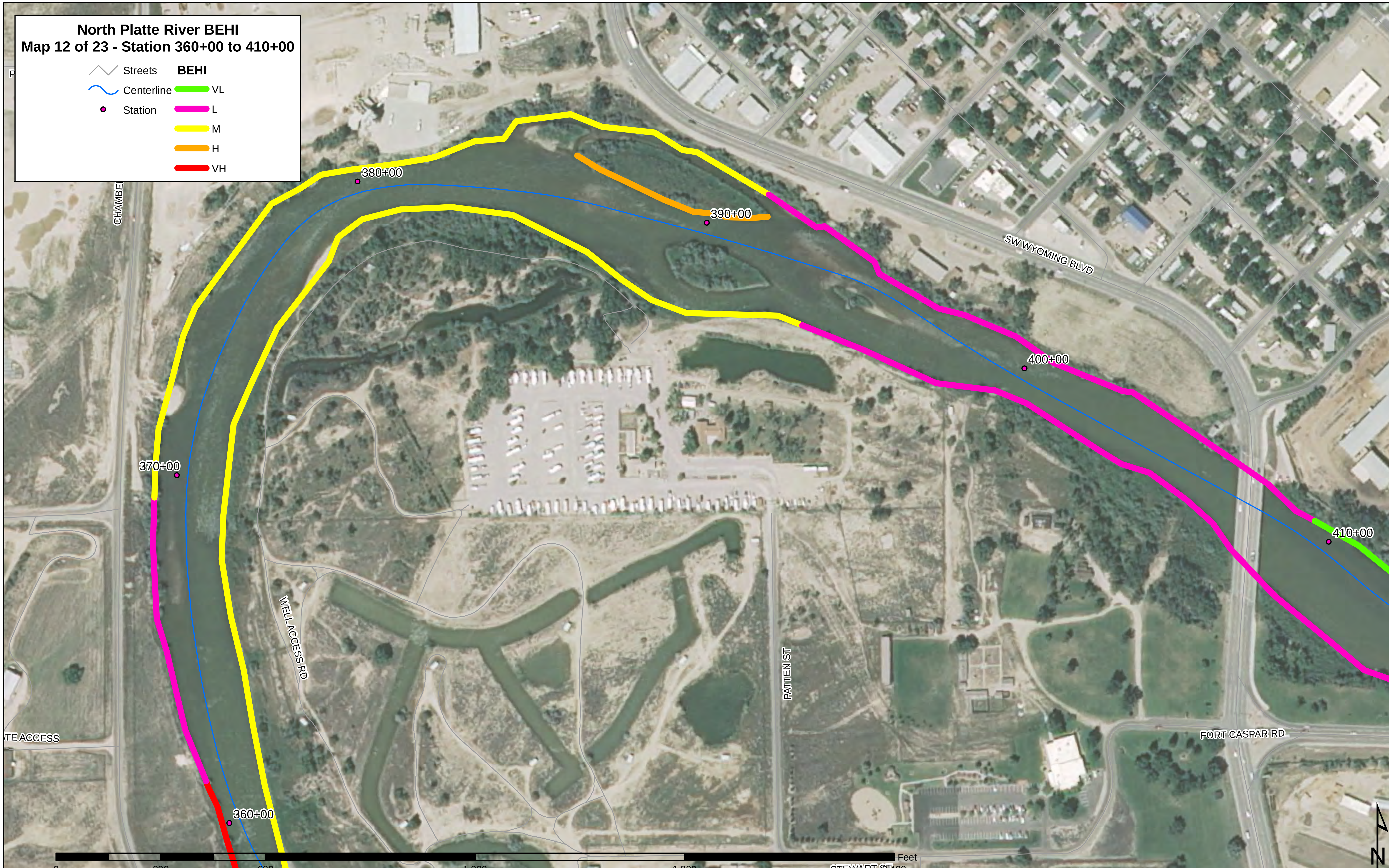

North Platte River BEHI
Map 8 of 23 - Station 230+00 to 270+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
230+00
240+00
250+00
260+00
270+00
FITZHUGH RD
RIVER MEADOWS RD
BUSH LN
PRIVATE ACCESS
PRIVATE ACCESS
RIVERSIDE ST
0
300
600
1,200
1,800
2,400
Feet
N

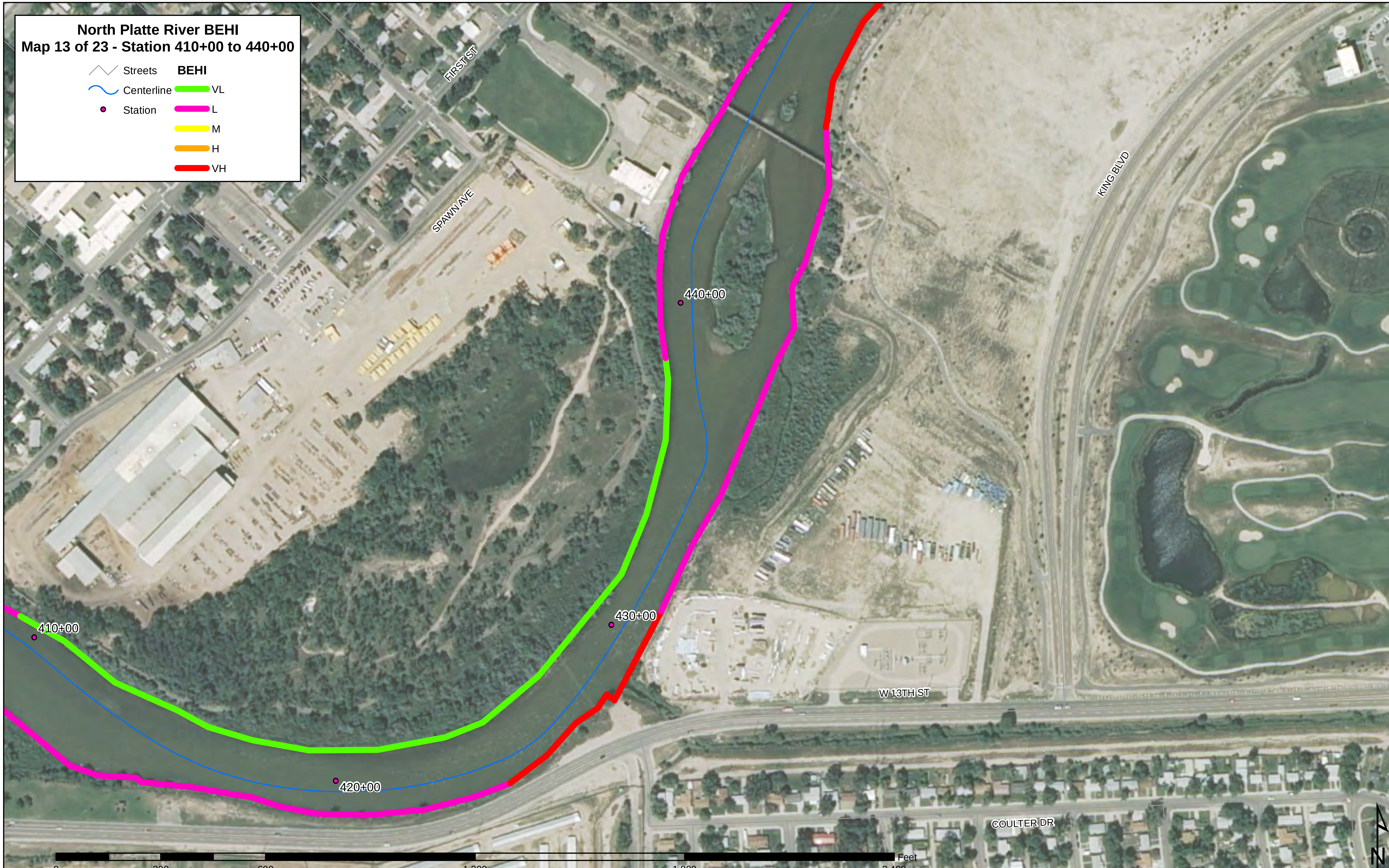


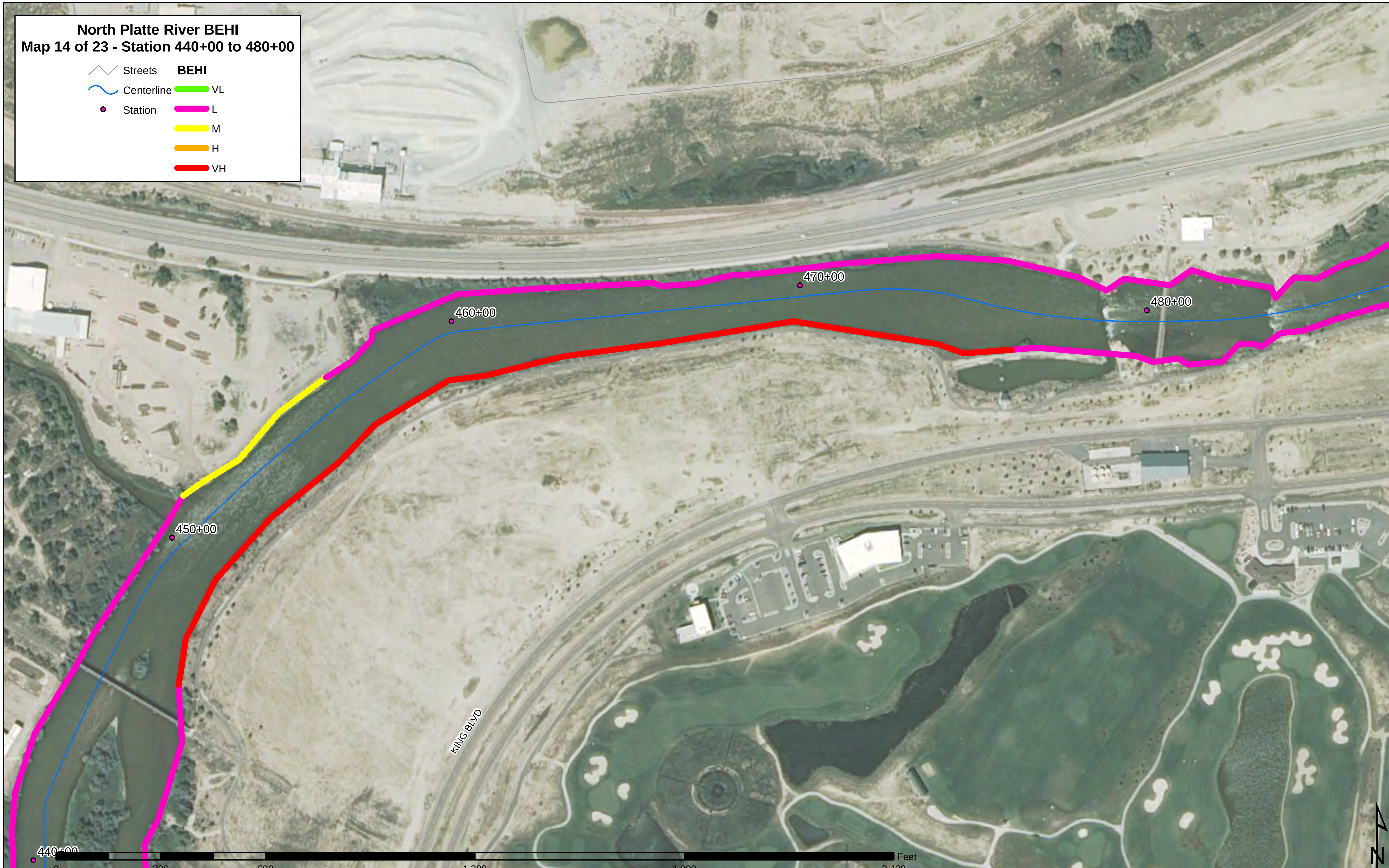
North Platte River BEHI
Map 9 of 23 - Station 270+00 to 300+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
270+00
280+00
290+00
300+00
MORAD PARK RD
CASPER/ALCOVA RD
CY AVE
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River BEHI
Map 10 of 23 - Station 300+00 to 330+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
330+00
320+00
310+00
300+00
CHAMBERLIN RD
UNNAMED RD
SW WYOMING BLVD
FAIR
PRIVATE ACCESS
PRIVATE ACCESS
PRIVATE ACCESS
0
300
600
1,200
1,800
2,400
Feet
N

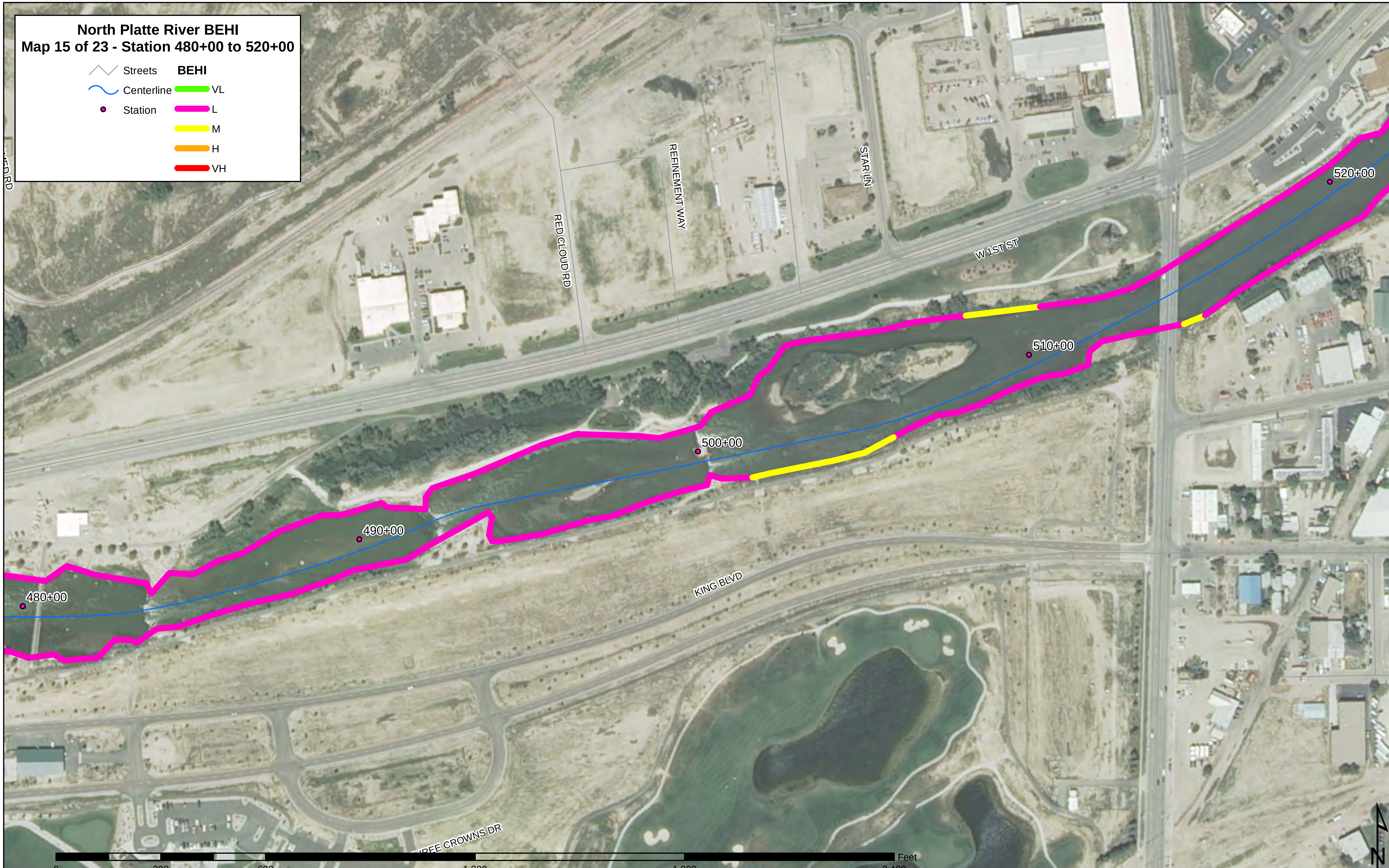

North Platte River BEHI
Map 11 of 23 - Station 330+00 to 360+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
PRIVATE ACCESS
WELL ACCESS RD
PATTEN ST
FORT CASPAR
STEWART ST
MILLER ST
MEIER RD
HIDEAWAY LN
UNNAMED RD
360+00
350+00
340+00
330+00
N
0
300
600
1,200
1,800
2,400
Feet

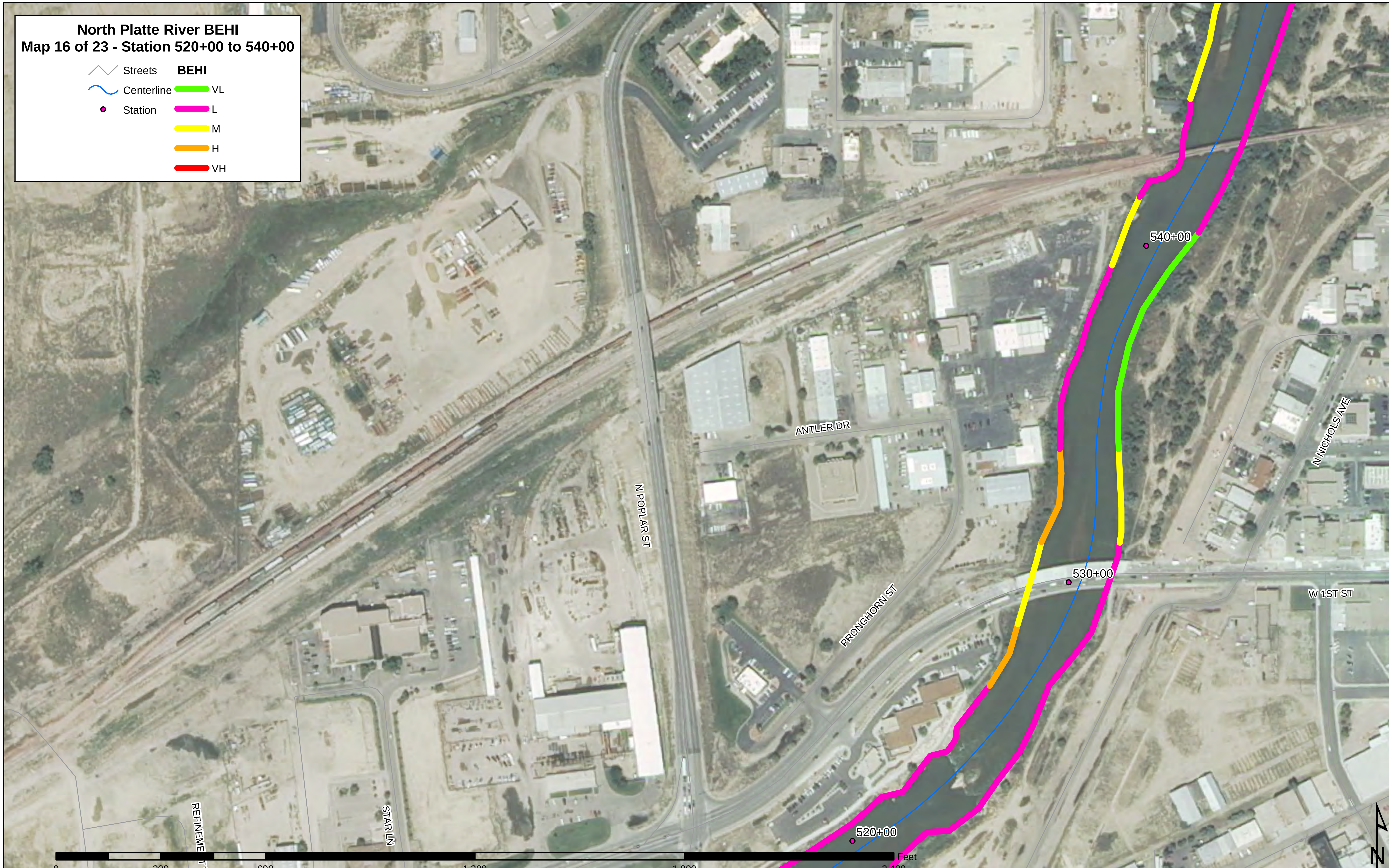

North Platte River BEHI
Map 12 of 23 - Station 360+00 to 410+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
360+00
370+00
380+00
390+00
400+00
410+00
SW WYOMING BLVD
WELL ACCESS RD
PATTEN ST
FORT CASPAR RD
STEWART ST
ATE ACCESS
CHAMBE
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River BEHI
Map 13 of 23 - Station 410+00 to 440+00
Streets
BEHI
Centerline
VL
Station
L
M
H
VH
FIRST ST
SPAWN AVE
KING BLVD
W 13TH ST
COULTER DR
410+00
420+00
430+00
440+00
0
300
600
1,200
1,800
2,400
Feet
N

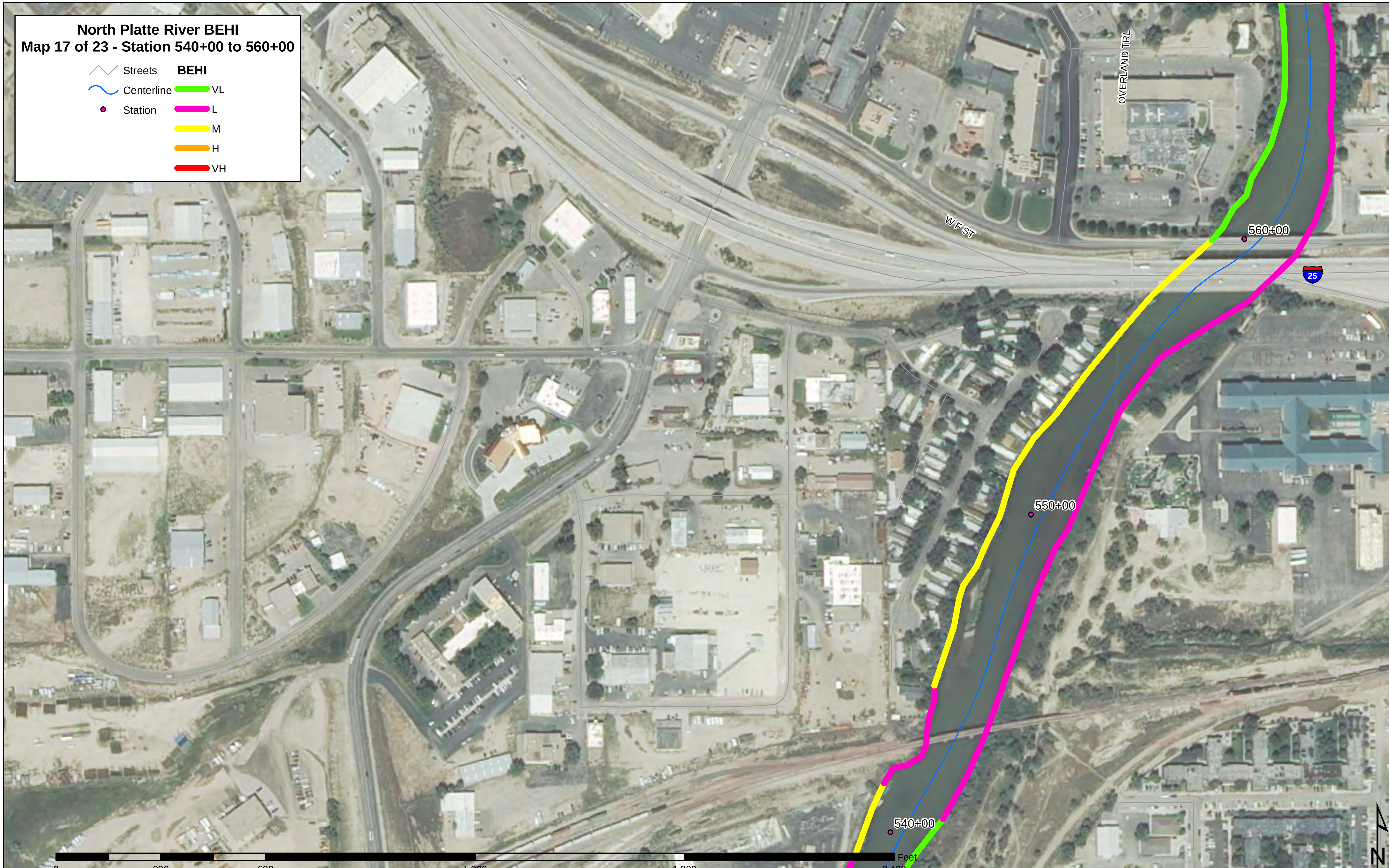


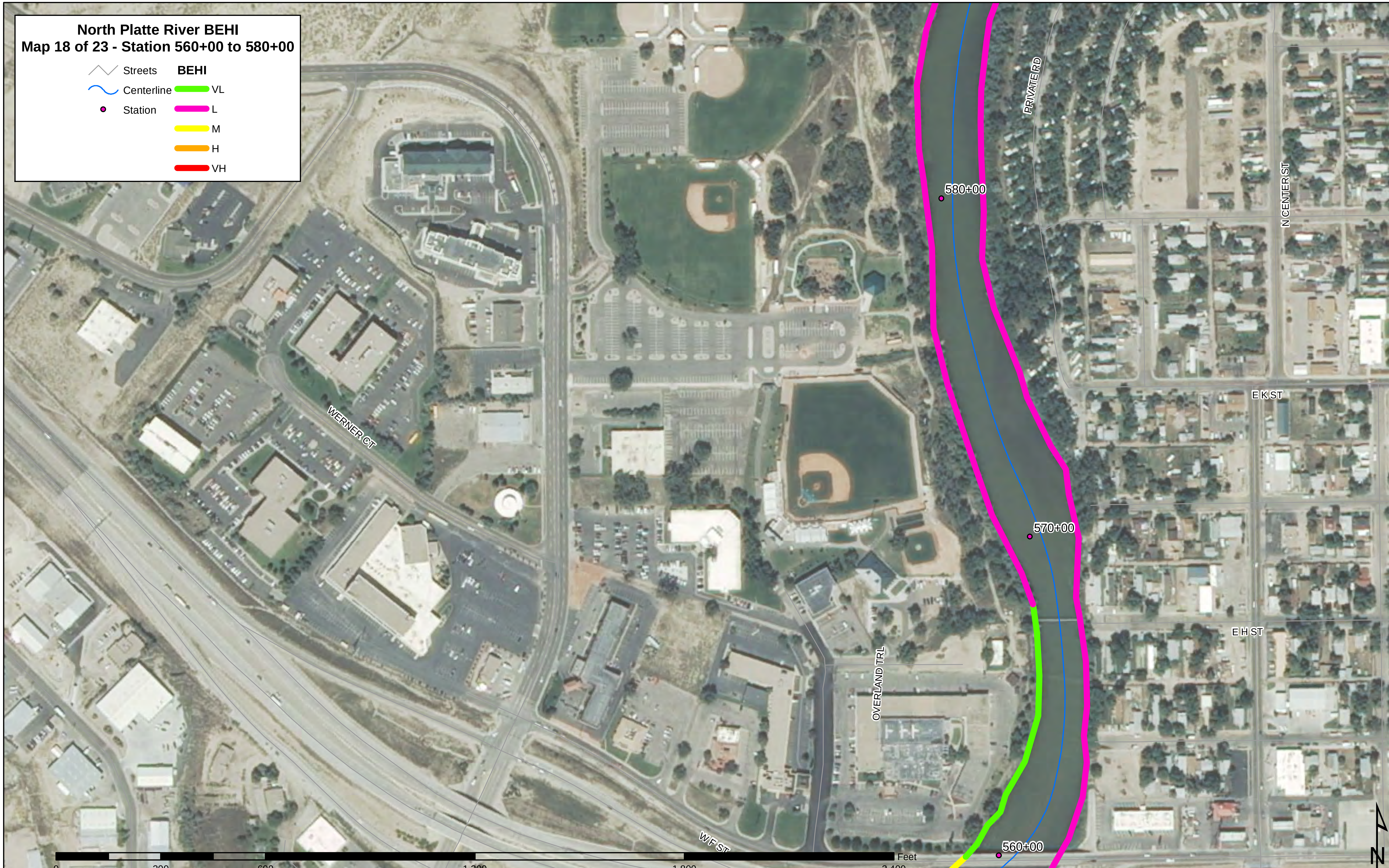
North Platte River BEHI
Map 14 of 23 - Station 440+00 to 480+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
440+00
450+00
460+00
470+00
480+00
KING BLVD
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River BEHI
Map 15 of 23 - Station 480+00 to 520+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
RED CLOUD RD
REFINEMENT WAY
STAR LN
W 1ST ST
KING BLVD
THREE CROWNS DR
480+00
490+00
500+00
510+00
520+00
0
300
600
1,200
1,800
2,400
Feet
N

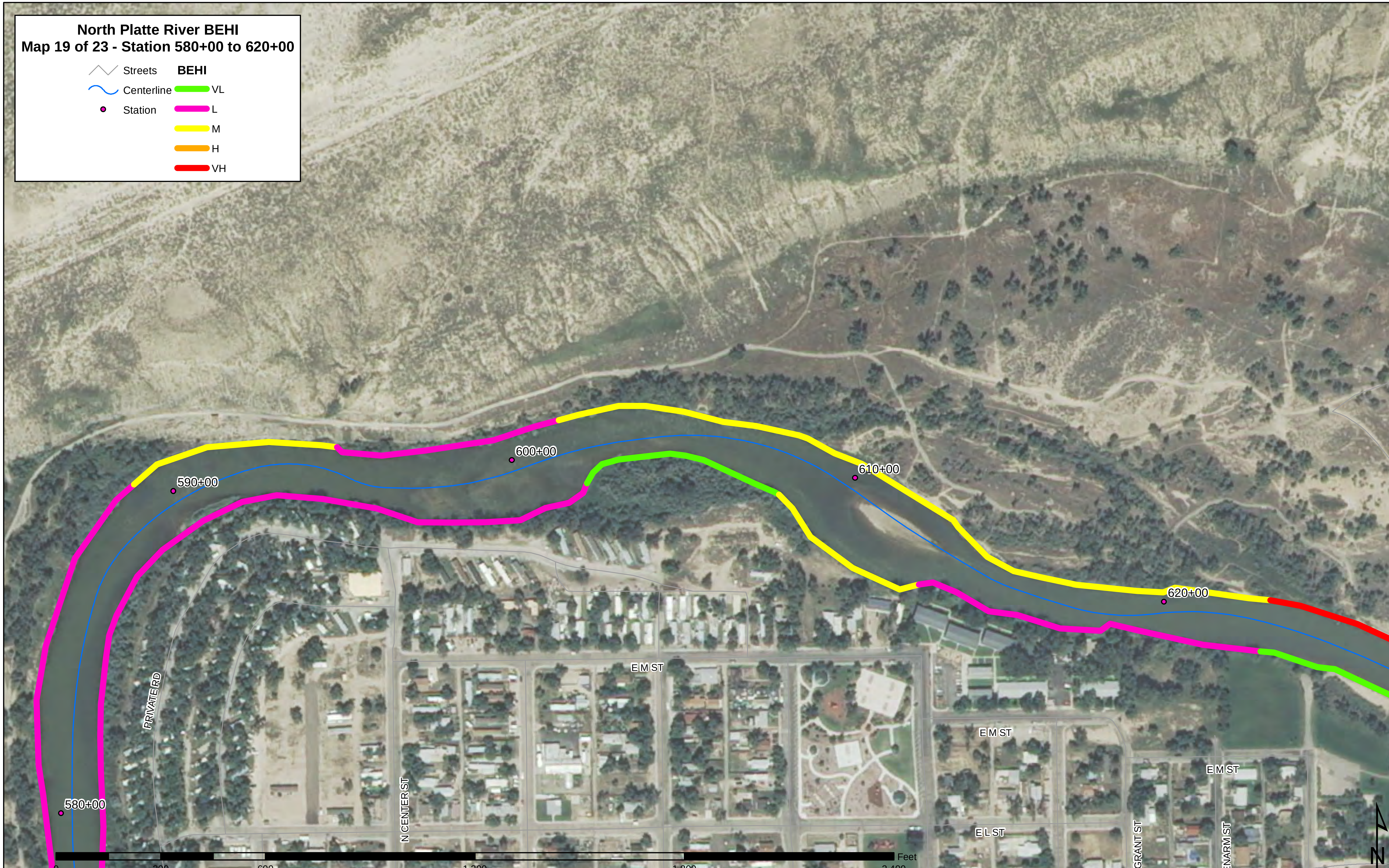


North Platte River BEHI
Map 16 of 23 - Station 520+00 to 540+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
540+00
530+00
520+00
ANTLER DR
N POPLAR ST
N NICHOLS AVE
W 1ST ST
PRONGHORN ST
REFINEMENT W
STAR LN
0
300
600
1,200
1,800
2,400
Feet
N

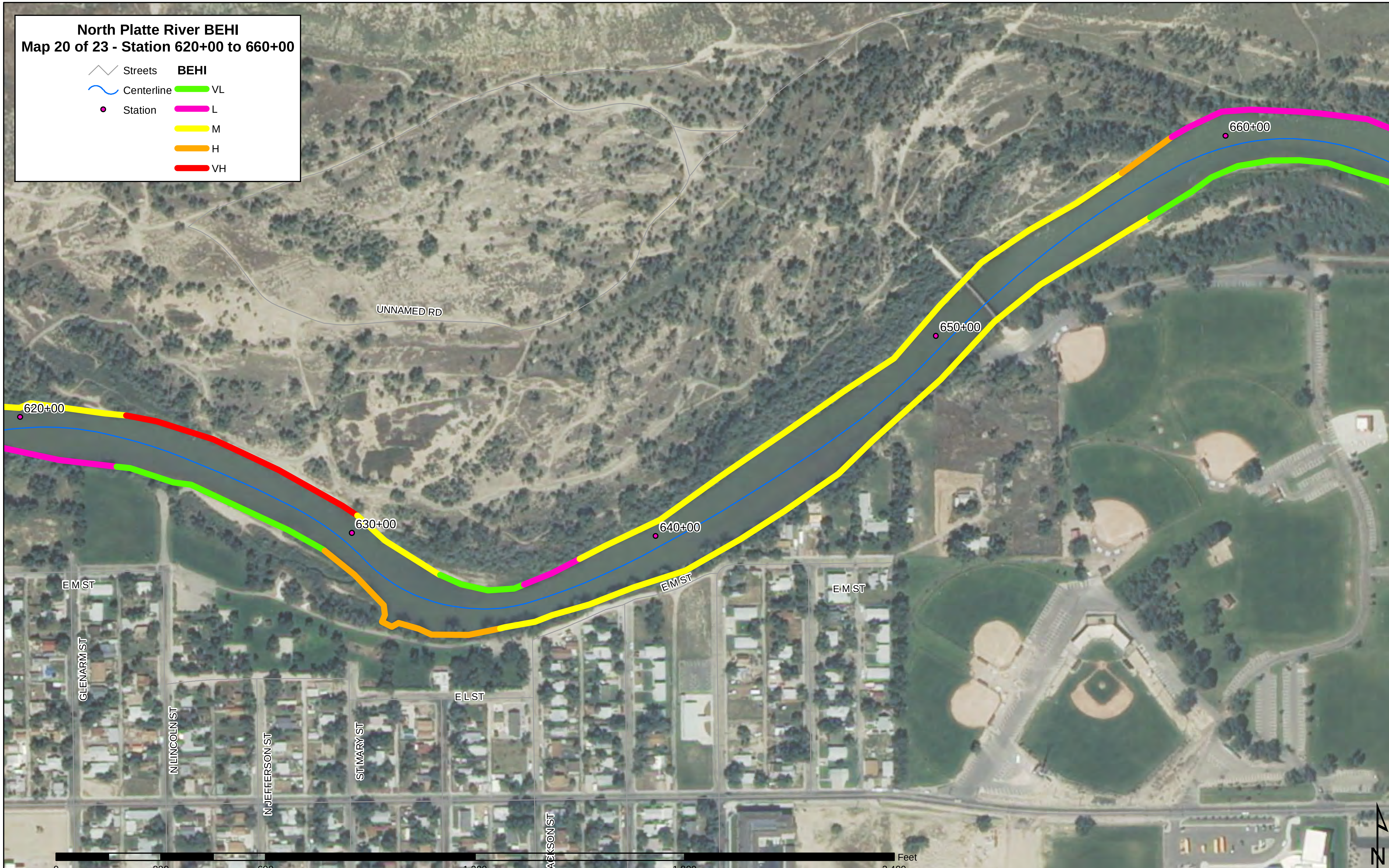

North Platte River BEHI
Map 17 of 23 - Station 540+00 to 560+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
OVERLAND TRL
W F ST
560+00
550+00
540+00
25
0
300
600
1,200
1,800
2,400
Feet
N

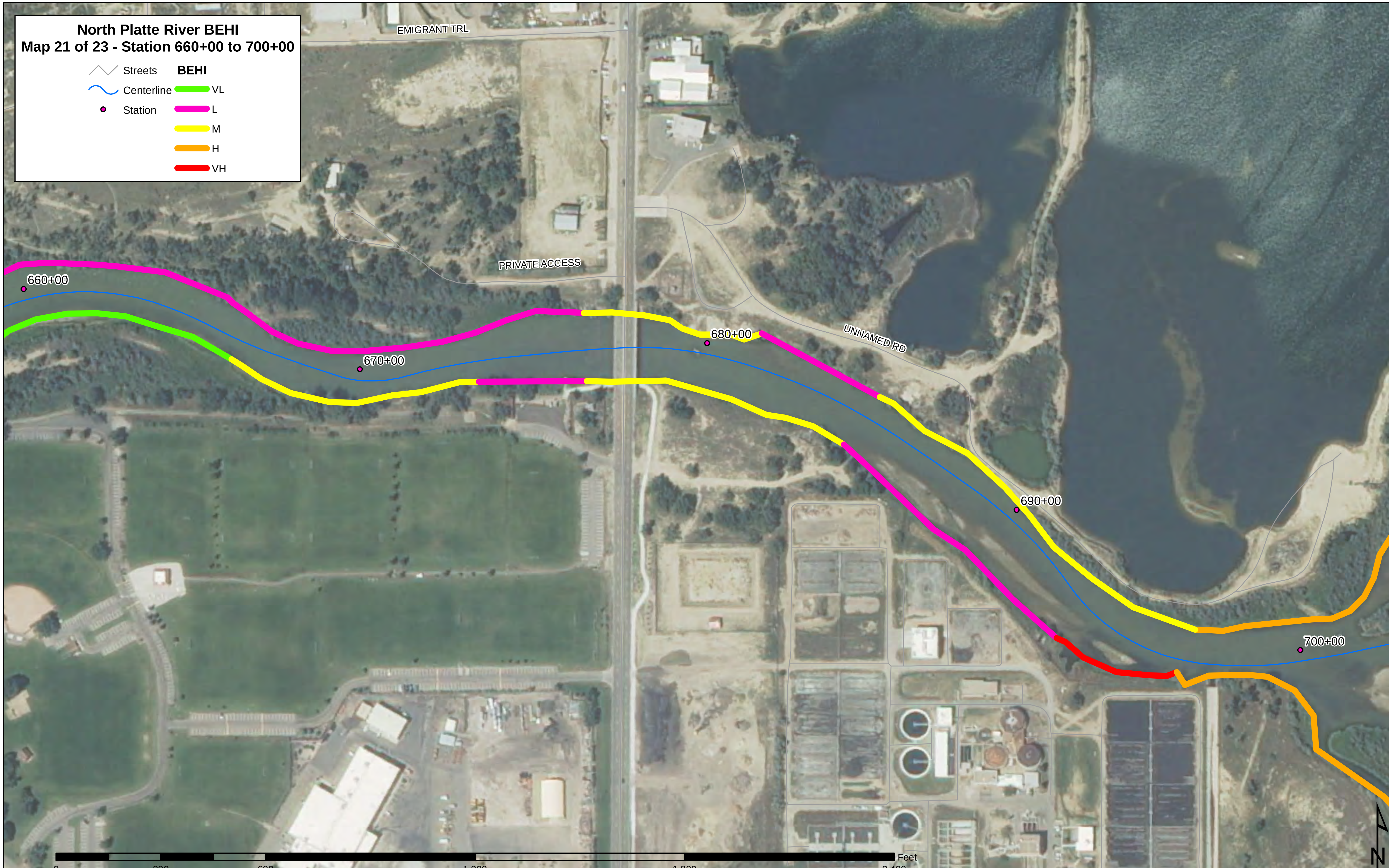


North Platte River BEHI
Map 18 of 23 - Station 560+00 to 580+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
580+00
570+00
560+00
PRIVATE RD
N CENTER ST
E K ST
E H ST
WERNER CT
OVERLAND TRL
W F ST
0
300
600
1,200
1,800
2,400
Feet
N

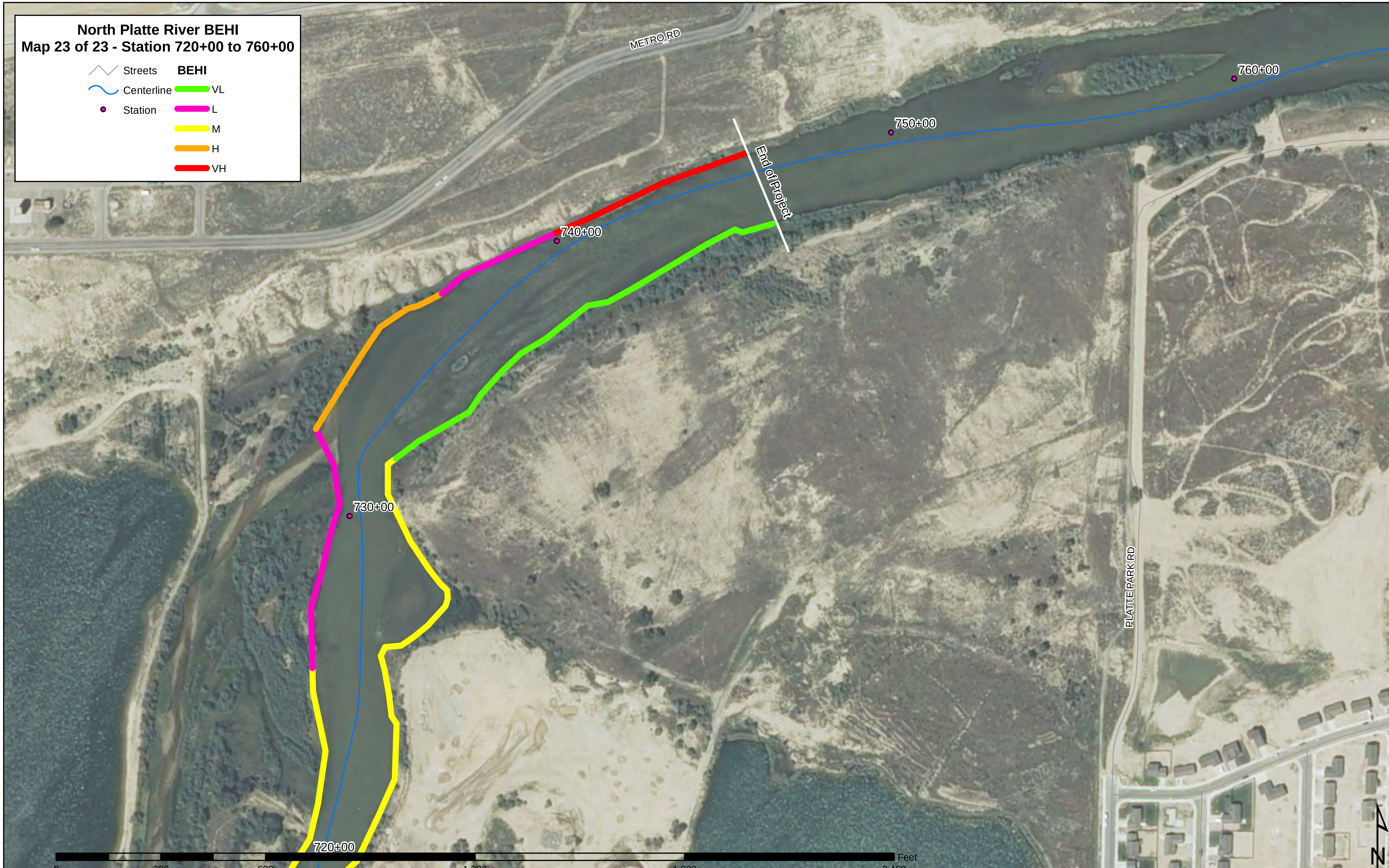


North Platte River BEHI
Map 19 of 23 - Station 580+00 to 620+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
580+00
590+00
600+00
610+00
620+00
PRIVATE RD
N CENTER ST
E M ST
E L ST
N GRANT ST
E NARM ST
0
300
600
1,200
1,800
2,400
Feet
N

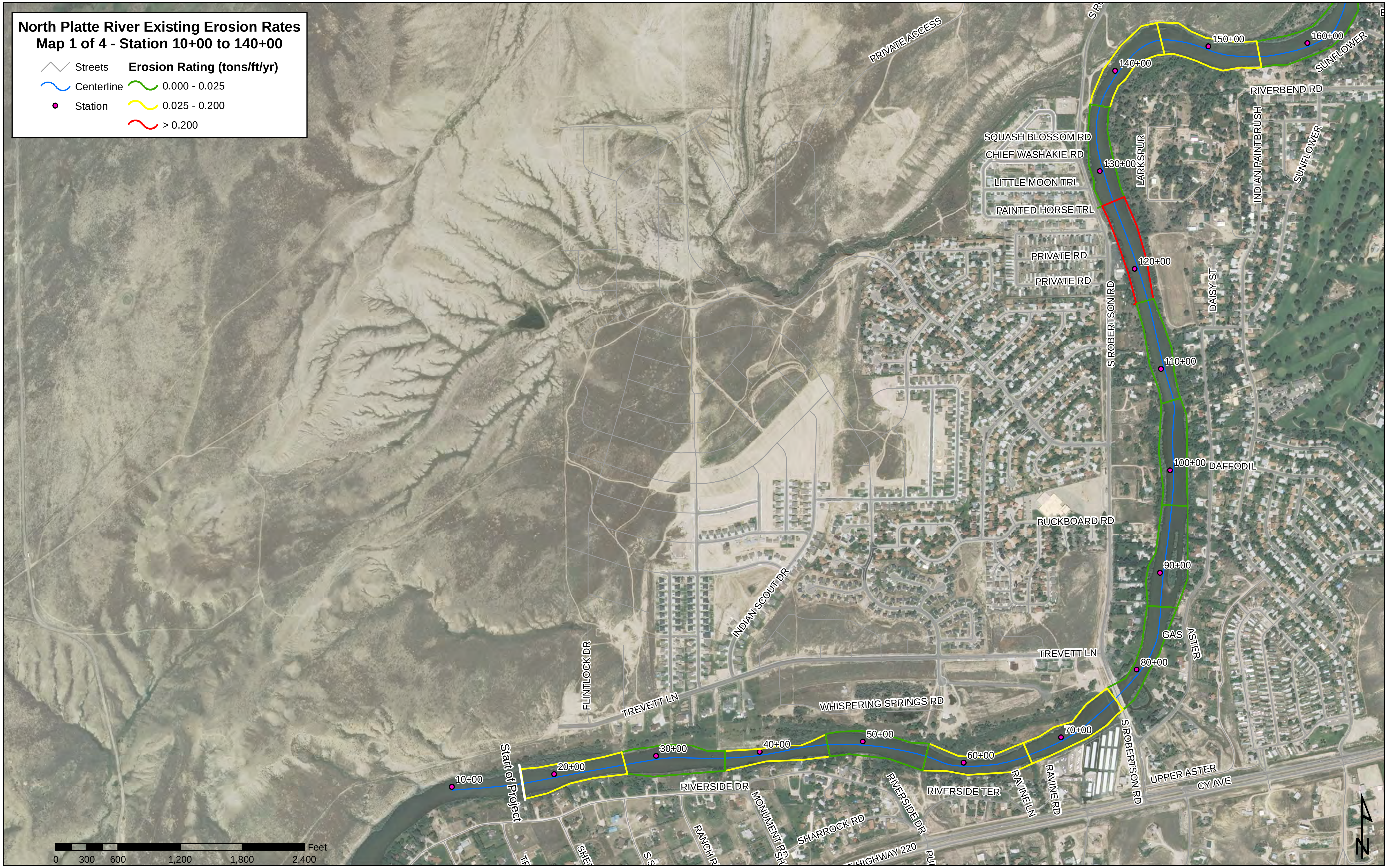

North Platte River BEHI
Map 20 of 23 - Station 620+00 to 660+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
620+00
630+00
640+00
650+00
660+00
UNNAMED RD
E M ST
E M ST
E M ST
E L ST
GLENARM ST
N LINCOLN ST
N JEFFERSON ST
ST MARY ST
JACKSON ST
Feet
0
300
600
1,200
1,800
2,400
N

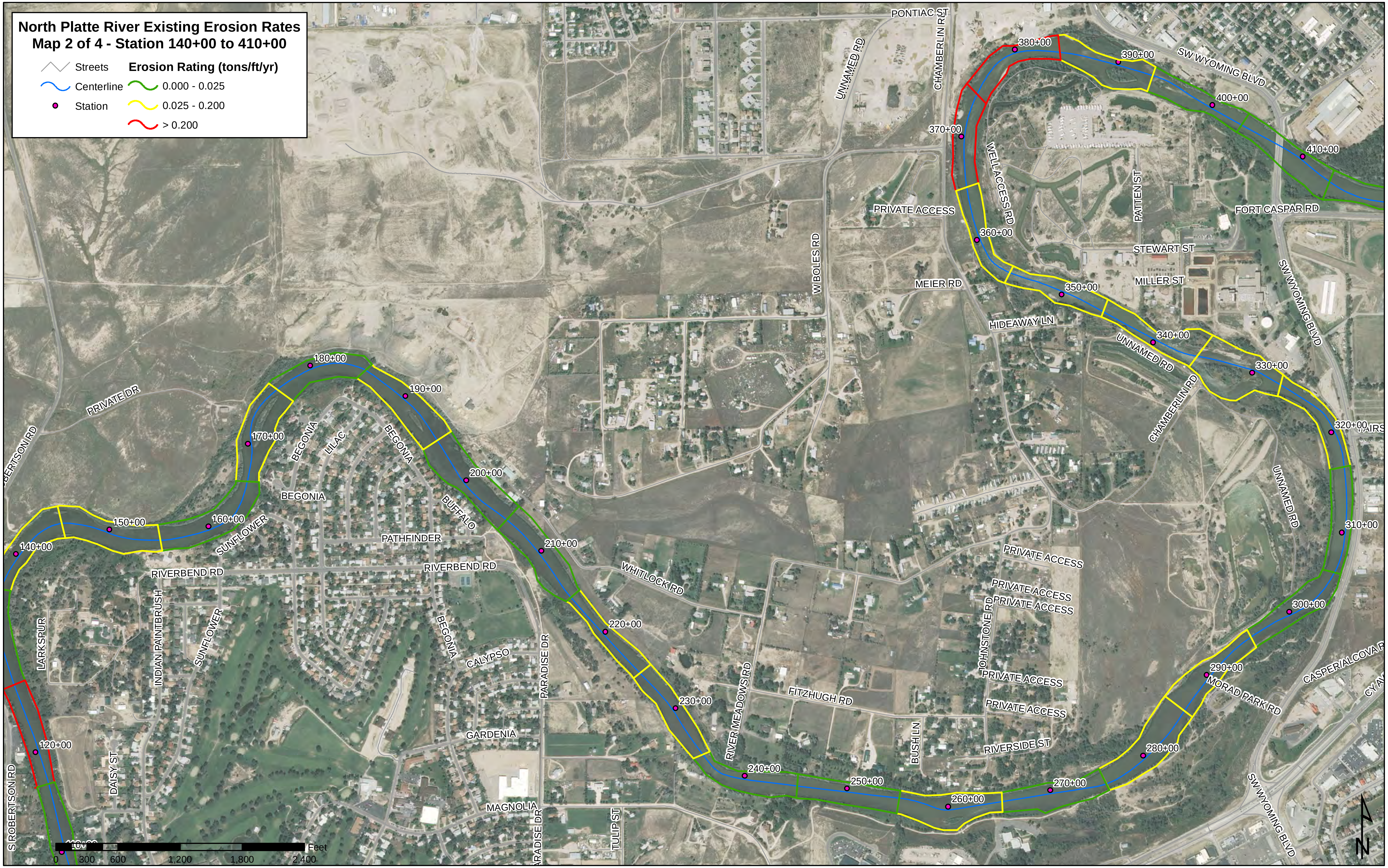

North Platte River BEHI
Map 21 of 23 - Station 660+00 to 700+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
EMIGRANT TRL
PRIVATE ACCESS
UNNAMED RD
660+00
670+00
680+00
690+00
700+00
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River BEHI
Map 22 of 23 - Station 700+00 to 720+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
720+00
710+00
700+00
Feet
0
300
600
1,200
1,800
2,400
N


North Platte River BEHI
Map 23 of 23 - Station 720+00 to 760+00
Streets
Centerline
Station
BEHI
VL
L
M
H
VH
METRO RD
PLATTE PARK RD
End of Project
720+00
730+00
740+00
750+00
760+00
Feet
0
300
600
1,200
1,800
2,400
N

Appendix E. Sediment Erosion Estimates


North Platte River Existing Erosion Rates
Map 1 of 4 - Station 10+00 to 140+00
Streets
Centerline
Station
Erosion Rating (tons/ft/yr)
0.000 - 0.025
0.025 - 0.200
> 0.200
10+00
20+00
30+00
40+00
50+00
60+00
70+00
80+00
90+00
100+00
110+00
120+00
130+00
140+00
150+00
160+00
Start of Project
PRIVATE ACCESS
SUNFLOWER
RIVERBEND RD
SQUASH BLOSSOM RD
CHIEF WASHAKIE RD
LITTLE MOON TRL
PAINTED HORSE TRL
PRIVATE RD
PRIVATE RD
LARKSPUR
INDIAN PAINTBRUSH
SUNFLOWER
DAISY ST
S ROBERTSON RD
DAFFODIL
BUCKBOARD RD
GAS
ASTER
TREVETT LN
INDIAN SCOUT DR
FLINTLOCK DR
TREVETT LN
WHISPERING SPRINGS RD
RIVERSIDE DR
MONUMENT
RANCH R
SHARROCK RD
RIVERSIDE DR
RIVERSIDE TER
RAVINE LN
RAVINE RD
S ROBERTSON RD
UPPER ASTER
CY AVE
HIGHWAY 220
Feet
0
300
600
1,200
1,800
2,400
N

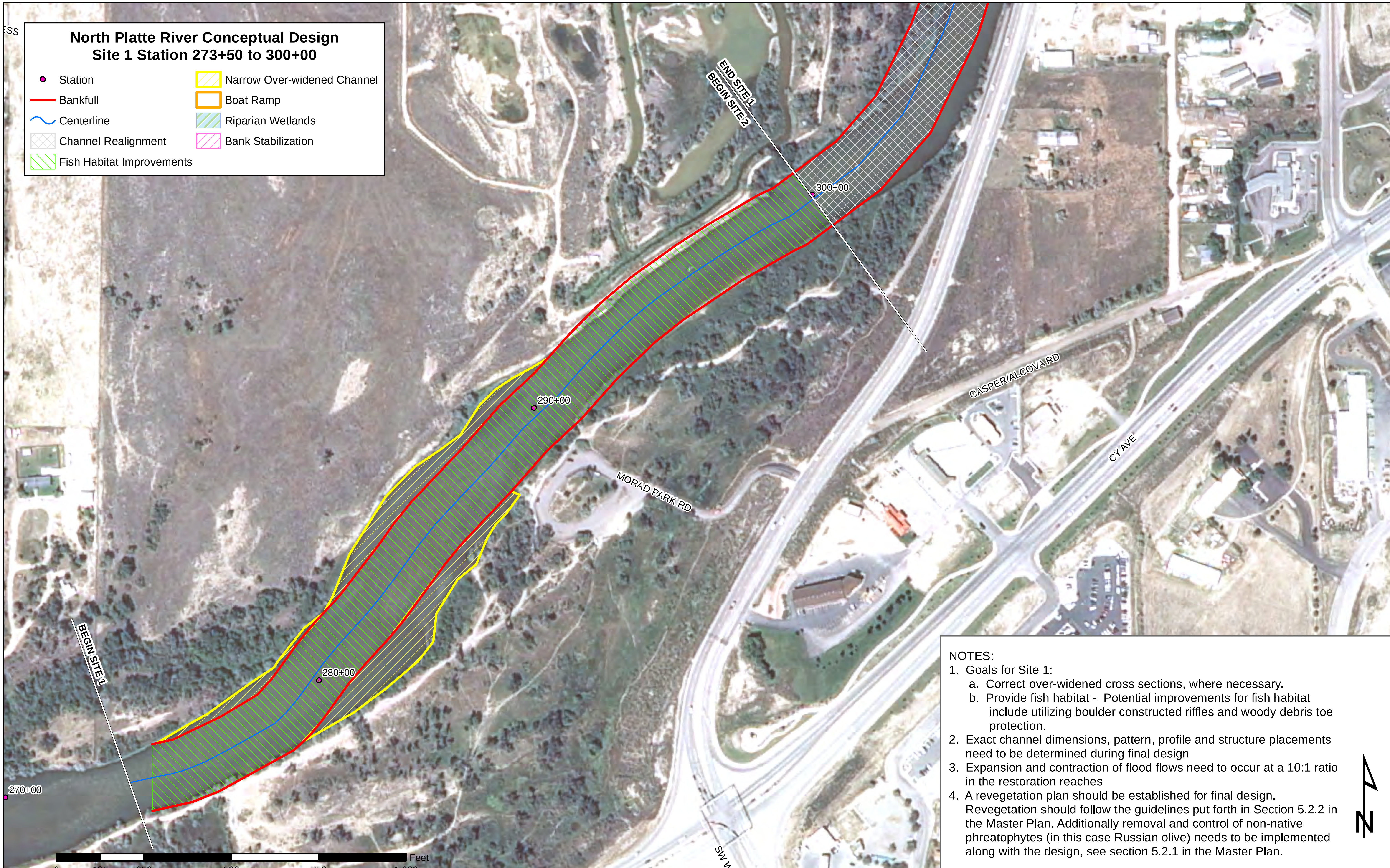

North Platte River Existing Erosion Rates
Map 2 of 4 - Station 140+00 to 410+00
Streets
Centerline
Station
Erosion Rating (tons/ft/yr)
0.000 - 0.025
0.025 - 0.200
> 0.200
120+00
140+00
150+00
160+00
170+00
180+00
190+00
200+00
210+00
220+00
230+00
240+00
250+00
260+00
270+00
280+00
290+00
300+00
310+00
320+00
330+00
340+00
350+00
360+00
370+00
380+00
390+00
400+00
410+00
PONTIAC ST
CHAMBERLIN RD
UNNAMED RD
W BOLES RD
PRIVATE ACCESS
MEIER RD
HIDEAWAY LN
WELL ACCESS RD
PATTEN ST
STEWART ST
MILLER ST
FORT CASPAR RD
SW WYOMING BLVD
UNNAMED RD
CHAMBERLIN RD
PRIVATE DR
BEGONIA
LILAC
BUFFALO
SUNFLOWER
PATHFINDER
RIVERBEND RD
WHITLOCK RD
PRIVATE ACCESS
JOHNSTONE RD
FITZHUGH RD
RIVER MEADOWS RD
BUSH LN
RIVERSIDE ST
MORAD PARK RD
CASPER/ALCOVA RD
LARKSPUR
INDIAN PAINTBRUSH
DAISY ST
CALYPSO
GARDENIA
MAGNOLIA
PARADISE DR
TULIP ST
S ROBERTSON RD
Feet
0 300 600 1,200 1,800 2,400
N


North Platte River Existing Erosion Rates
Map 3 of 4 - Station 410+00 to 560+00
Streets
Centerline
Station
Erosion Rating (tons/ft/yr)
0.000 - 0.025
0.025 - 0.200
> 0.200
410+00
420+00
430+00
440+00
450+00
460+00
470+00
480+00
490+00
500+00
510+00
520+00
530+00
540+00
550+00
560+00
W YELLOWSTONE HWY
VAN HORN AVE
NORTHWESTERN AVE
FIRST ST
SPAWN AVE
KING BLVD
THREE CROWNS DR
W COLLINS DR
W 13TH ST
COULTER DR
W 15TH ST
BRIGHAM
SPAR RD
UNNAMED RD
RED CLOUD RD
REFINEMENT WAY
STAR LN
W 1ST ST
N POPLAR ST
ANTLER DR
PRONGHORN ST
N NICHOLS AVE
W B ST
N CENTER ST
W F ST
W MIDWEST AVE
25
0
300
600
1,200
1,800
2,400
Feet
N


North Platte River Existing Erosion Rates
Map 4 of 4 - Station 560+00 to 750+00
Streets
Centerline
Station
Erosion Rating (tons/ft/yr)
0.000 - 0.025
0.025 - 0.200
> 0.200
560+00
570+00
580+00
590+00
600+00
610+00
620+00
630+00
640+00
650+00
660+00
670+00
680+00
690+00
700+00
710+00
720+00
730+00
740+00
End of Project
E SUNLIGHT DR
METRO RD
BRYAN STOCK TRL
EMIGRANT TRL
PRIVATE ACCESS
UNNAMED RD
PUMP STATION
UNNAMED RD
UNNAMED RD
PRIVATE RD
E M ST
E L ST
E K ST
E H ST
N CENTER ST
N GRANT ST
GLENARM ST
N LINCOLN ST
N JEFFERSON ST
ST MARY ST
N JACKSON ST
N WASHINGTON ST
N ELM ST
N MCKINLEY ST
OVERLAND TRL
25
Feet
0 300 600 1,200 1,800 2,400
N

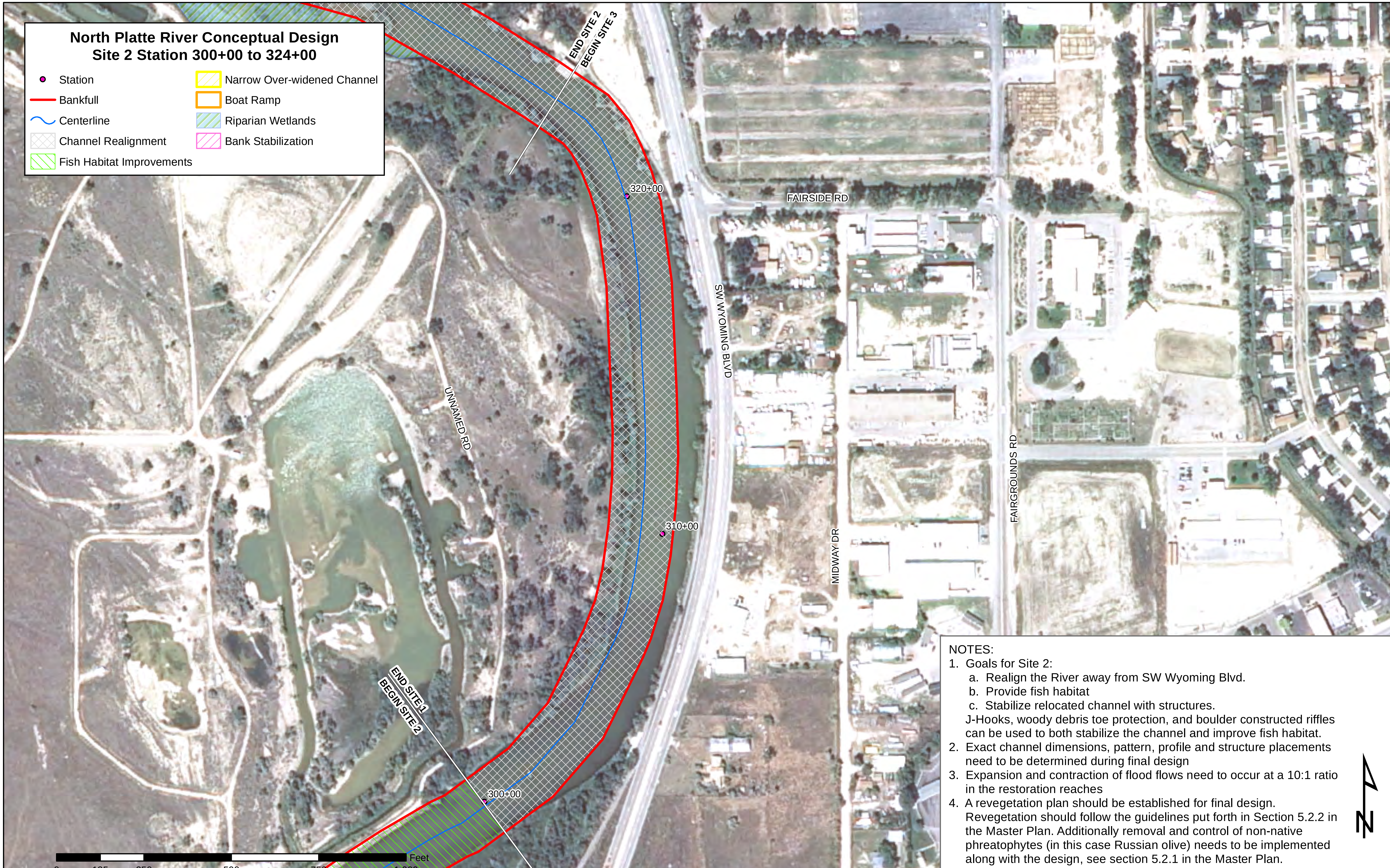
Appendix F. Stream Restoration Concept Design

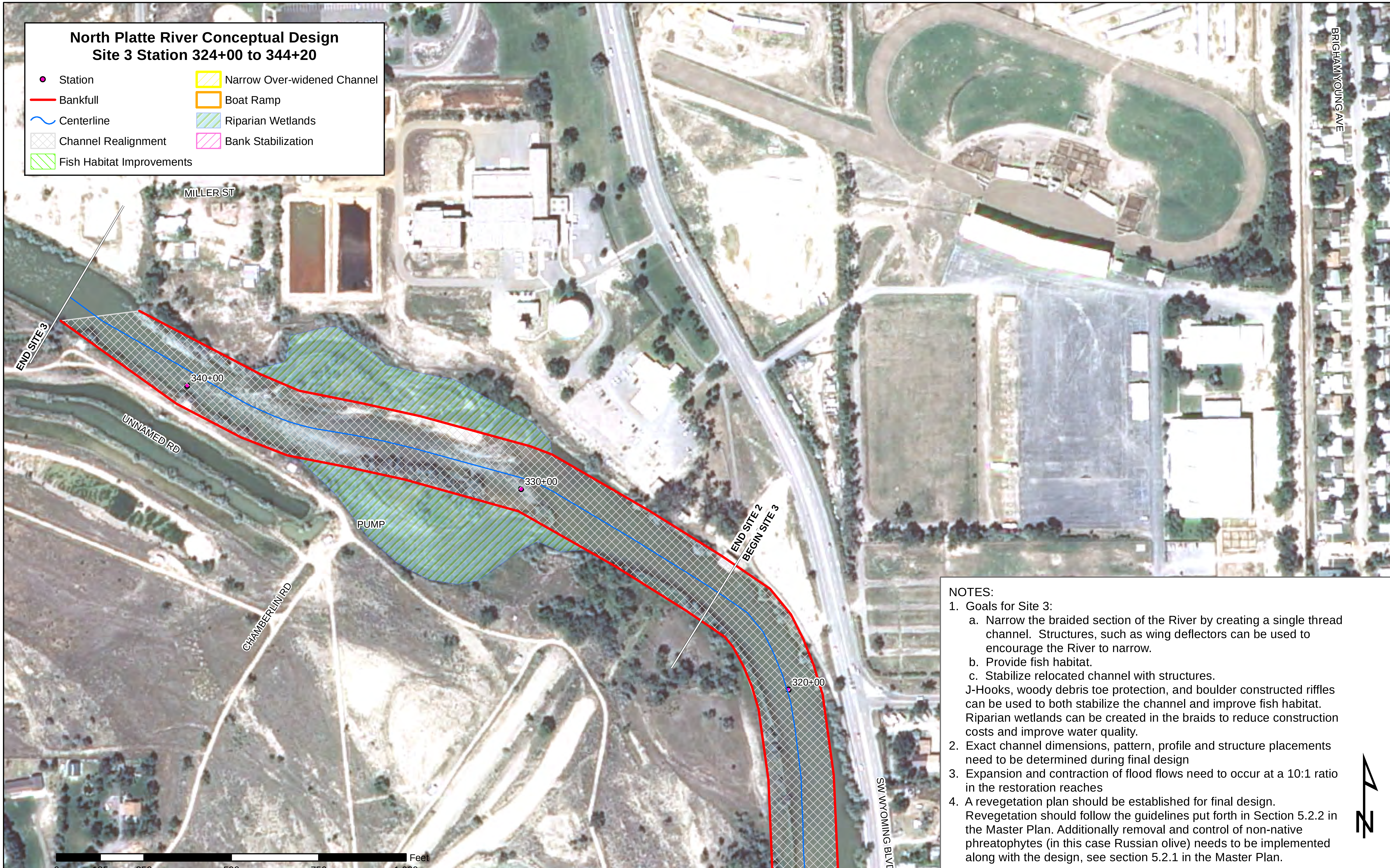
North Platte River Conceptual Design
Site 1 Station 273+50 to 300+00



NOTES:

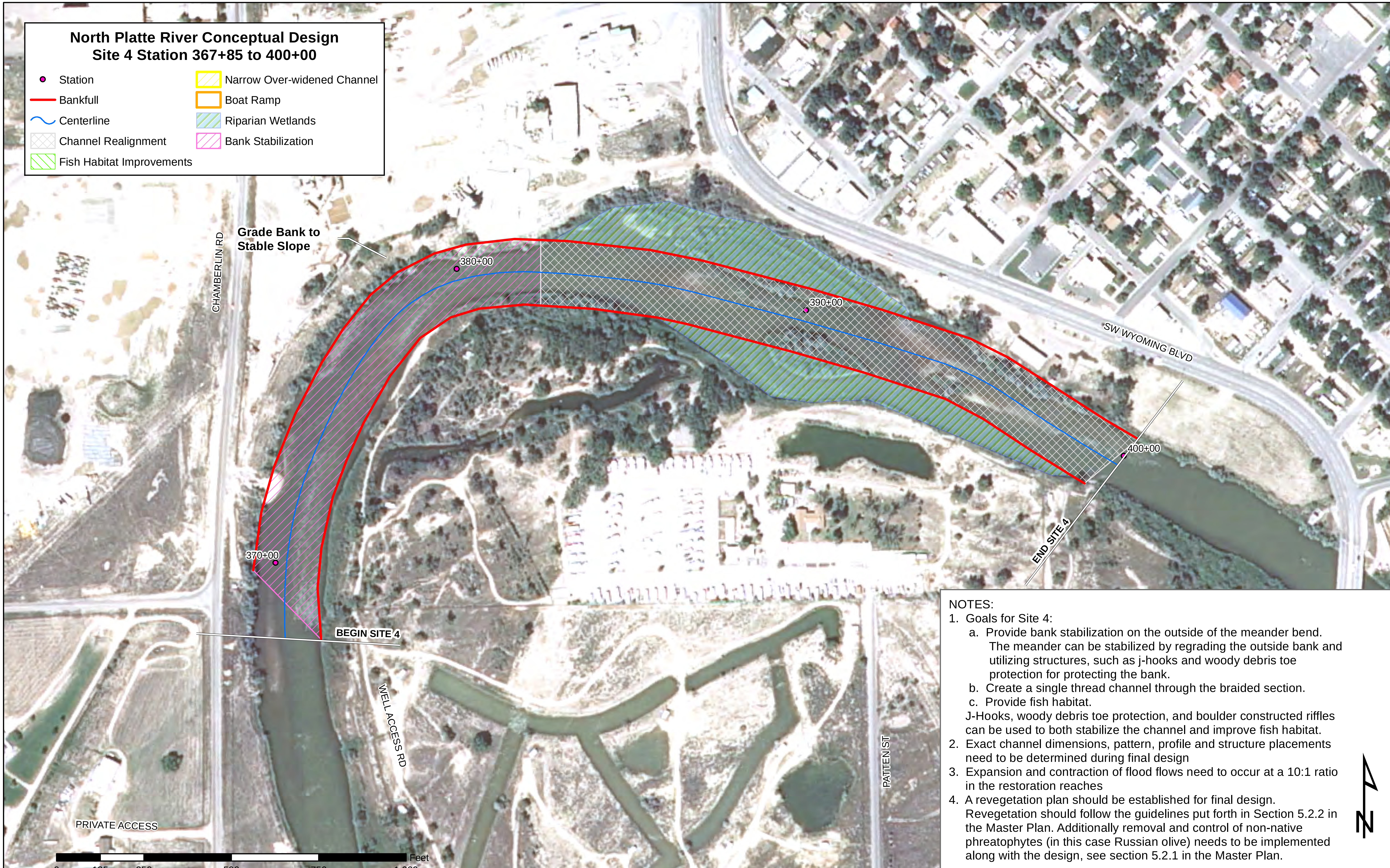
1. Goals for Site 1:
   a. Correct over-widened cross sections, where necessary.
   b. Provide fish habitat - Potential improvements for fish habitat include utilizing boulder constructed riffles and woody debris toe protection.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.


North Platte River Conceptual Design
Site 2 Station 300+00 to 324+00
Station
Bankfull
Centerline
Channel Realignment
Fish Habitat Improvements
Narrow Over-widened Channel
Boat Ramp
Riparian Wetlands
Bank Stabilization
END SITE 2
BEGIN SITE 3
320+00
FAIRSIDE RD
SW WYOMING BLVD
UNNAMED RD
310+00
MIDWAY DR
FAIRGROUNDS RD
END SITE 1
BEGIN SITE 2
300+00
0
125
250
500
750
1,000
Feet
NOTES:
1. Goals for Site 2:
a. Realign the River away from SW Wyoming Blvd.
b. Provide fish habitat
c. Stabilize relocated channel with structures.
J-Hooks, woody debris toe protection, and boulder constructed riffles can be used to both stabilize the channel and improve fish habitat.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.
N



North Platte River Conceptual Design
Site 3 Station 324+00 to 344+20
Station
Bankfull
Centerline
Channel Realignment
Fish Habitat Improvements
Narrow Over-widened Channel
Boat Ramp
Riparian Wetlands
Bank Stabilization
MILLER ST
BRIGHAM YOUNG AVE
END SITE 3
340+00
UNNAMED RD
330+00
PUMP
END SITE 2
BEGIN SITE 3
CHAMBERLIN RD
320+00
SW WYOMING BLVD
0
125
250
500
750
1,000
Feet
NOTES:
1. Goals for Site 3:
a. Narrow the braided section of the River by creating a single thread channel. Structures, such as wing deflectors can be used to encourage the River to narrow.
b. Provide fish habitat.
c. Stabilize relocated channel with structures.
J-Hooks, woody debris toe protection, and boulder constructed riffles can be used to both stabilize the channel and improve fish habitat. Riparian wetlands can be created in the braids to reduce construction costs and improve water quality.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.
N

North Platte River Conceptual Design
Site 4 Station 367+85 to 400+00

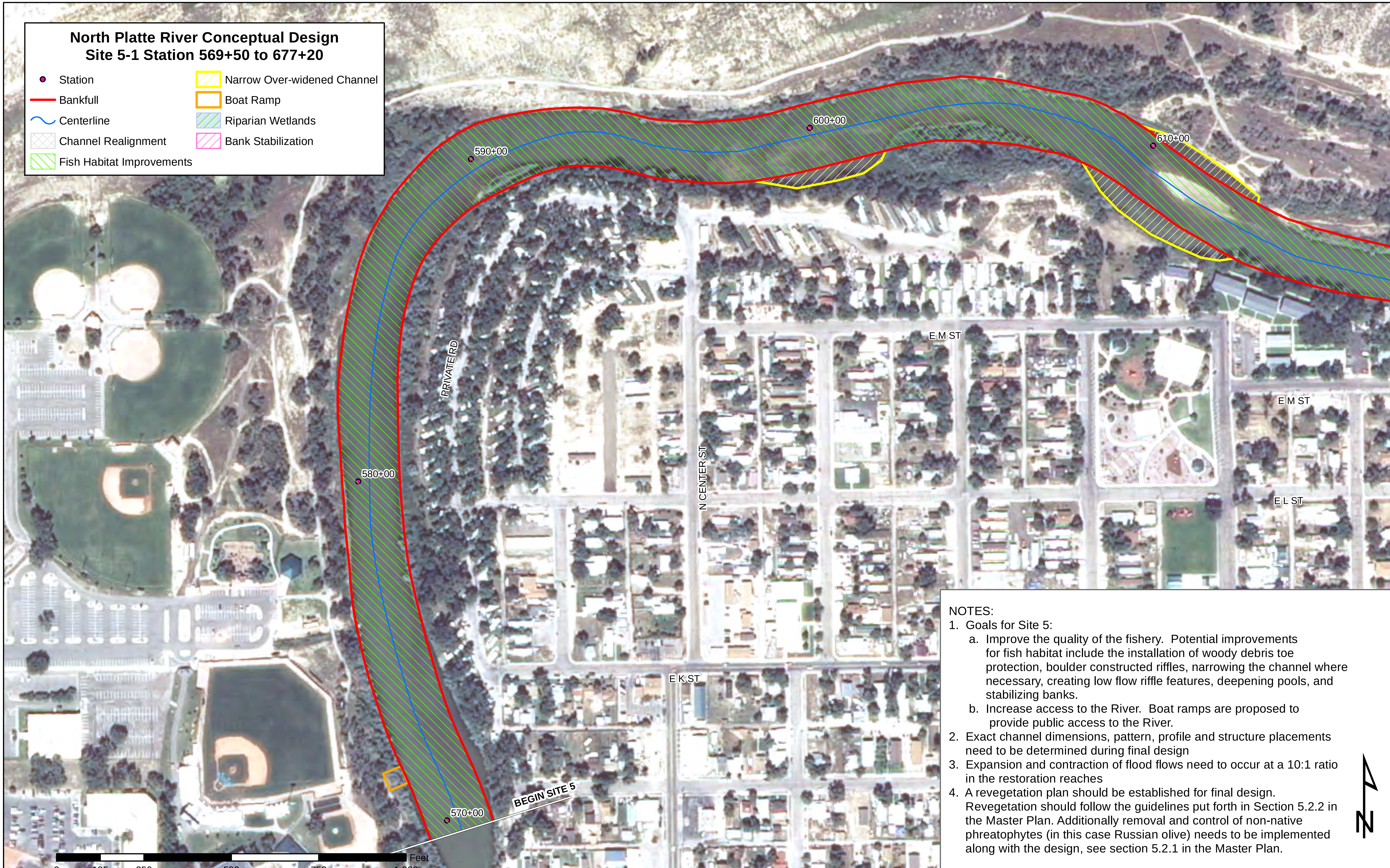


NOTES:

1. Goals for Site 4:
   a. Provide bank stabilization on the outside of the meander bend. The meander can be stabilized by regrading the outside bank and utilizing structures, such as j-hooks and woody debris toe protection for protecting the bank.
   b. Create a single thread channel through the braided section.
   c. Provide fish habitat.

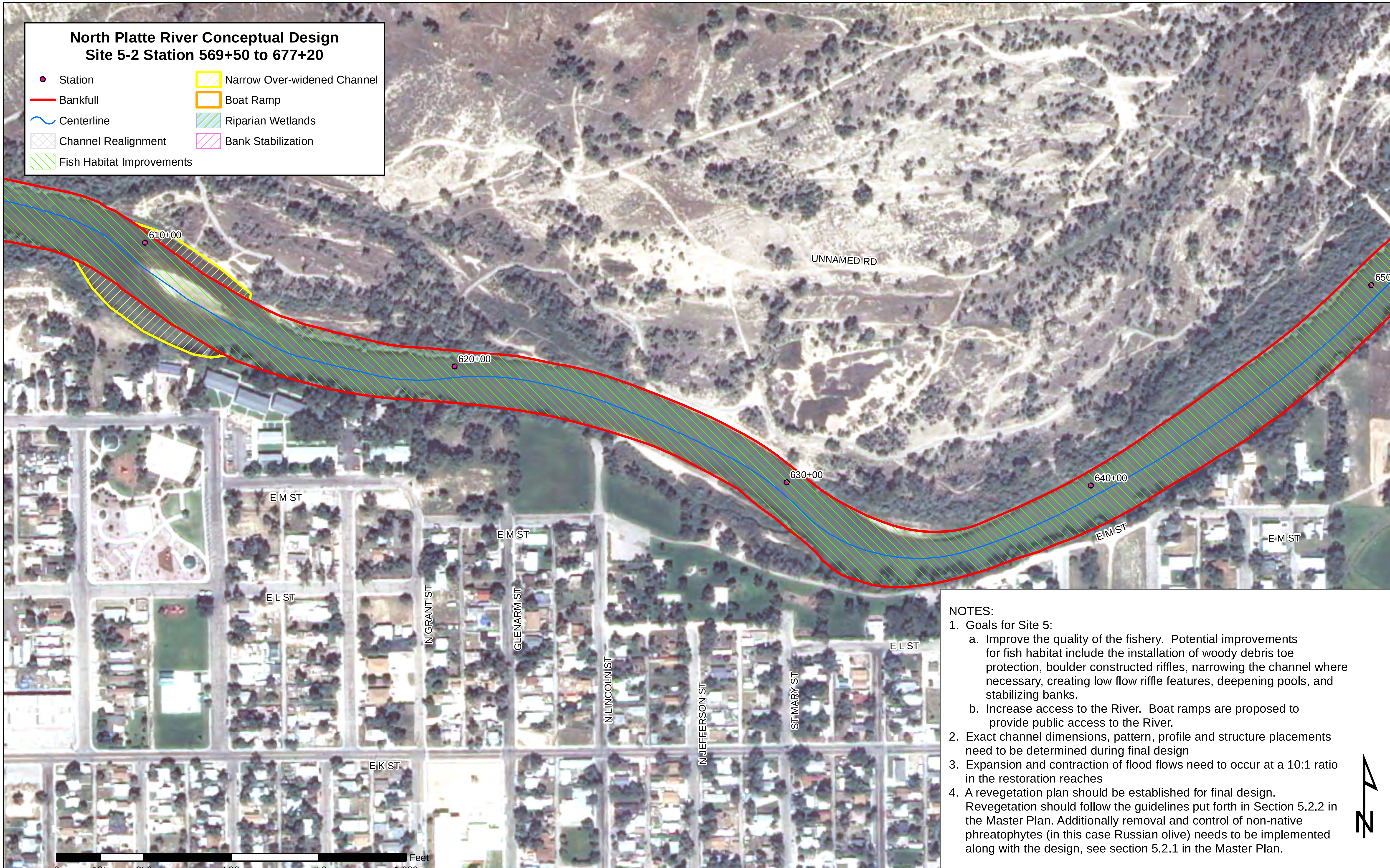
   J-Hooks, woody debris toe protection, and boulder constructed riffles can be used to both stabilize the channel and improve fish habitat.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.

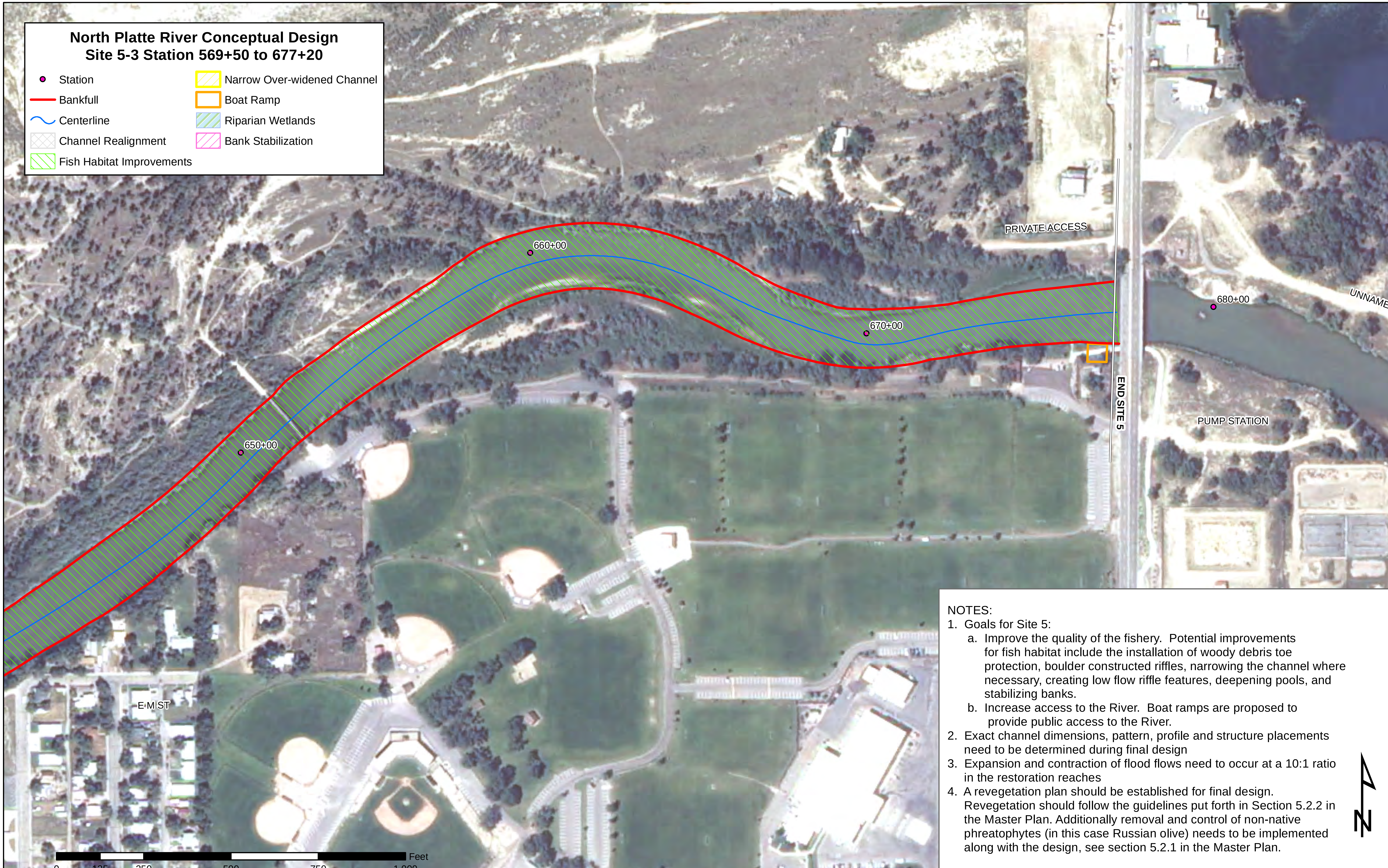
North Platte River Conceptual Design
Site 5-1 Station 569+50 to 677+20



NOTES:

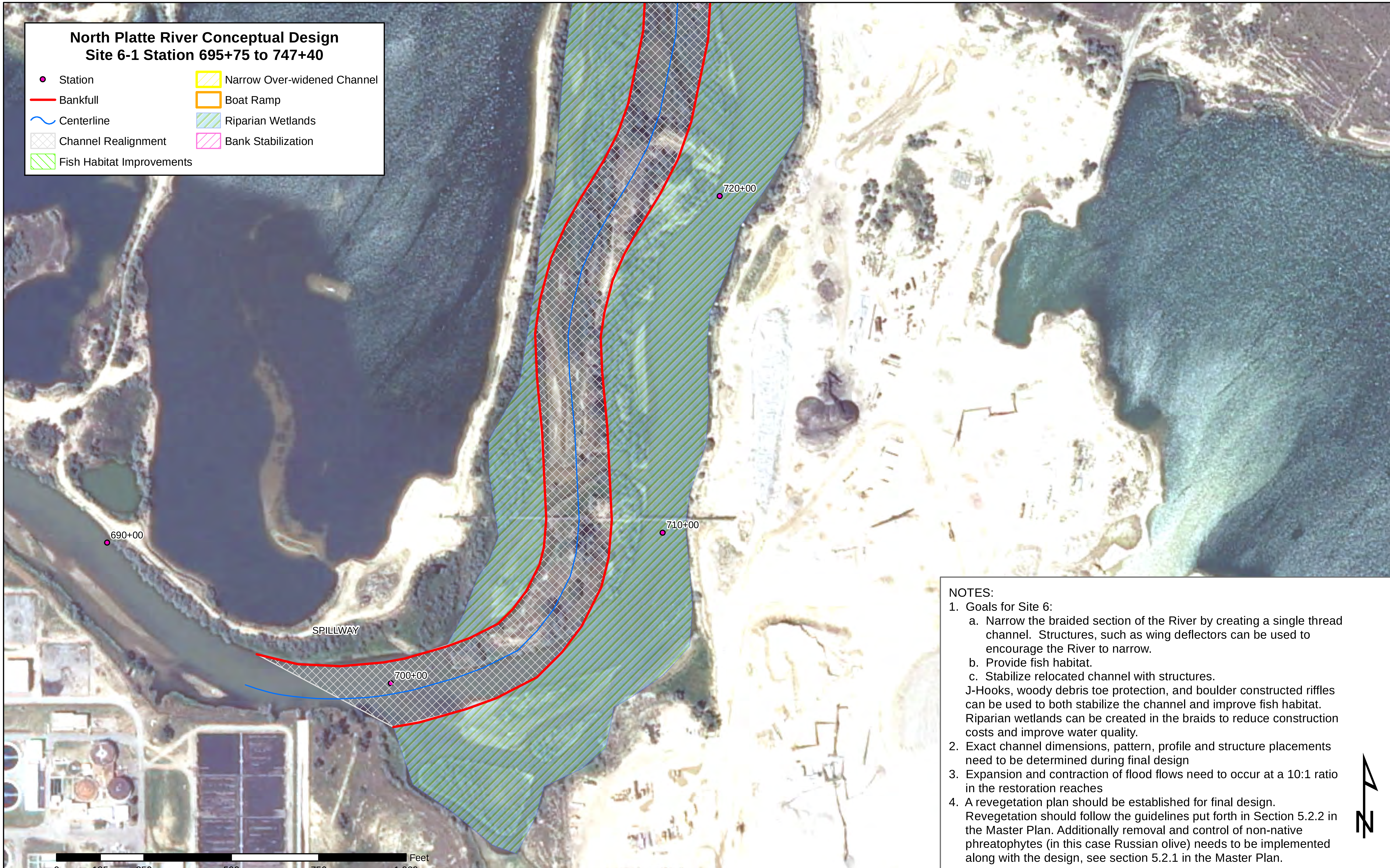
1. Goals for Site 5:
   a. Improve the quality of the fishery. Potential improvements for fish habitat include the installation of woody debris toe protection, boulder constructed riffles, narrowing the channel where necessary, creating low flow riffle features, deepening pools, and stabilizing banks.
   b. Increase access to the River. Boat ramps are proposed to provide public access to the River.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.


North Platte River Conceptual Design
Site 5-2 Station 569+50 to 677+20
Station
Bankfull
Centerline
Channel Realignment
Fish Habitat Improvements
Narrow Over-widened Channel
Boat Ramp
Riparian Wetlands
Bank Stabilization
610+00
620+00
630+00
640+00
650+0
UNNAMED RD
E M ST
E M ST
E M ST
E M ST
E L ST
E L ST
E K ST
N GRANT ST
GLENARM ST
N LINCOLN ST
N JEFFERSON ST
ST MARY ST
NOTES:
1. Goals for Site 5:
a. Improve the quality of the fishery. Potential improvements for fish habitat include the installation of woody debris toe protection, boulder constructed riffles, narrowing the channel where necessary, creating low flow riffle features, deepening pools, and stabilizing banks.
b. Increase access to the River. Boat ramps are proposed to provide public access to the River.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.
N
0
125
250
500
750
1,000
Feet



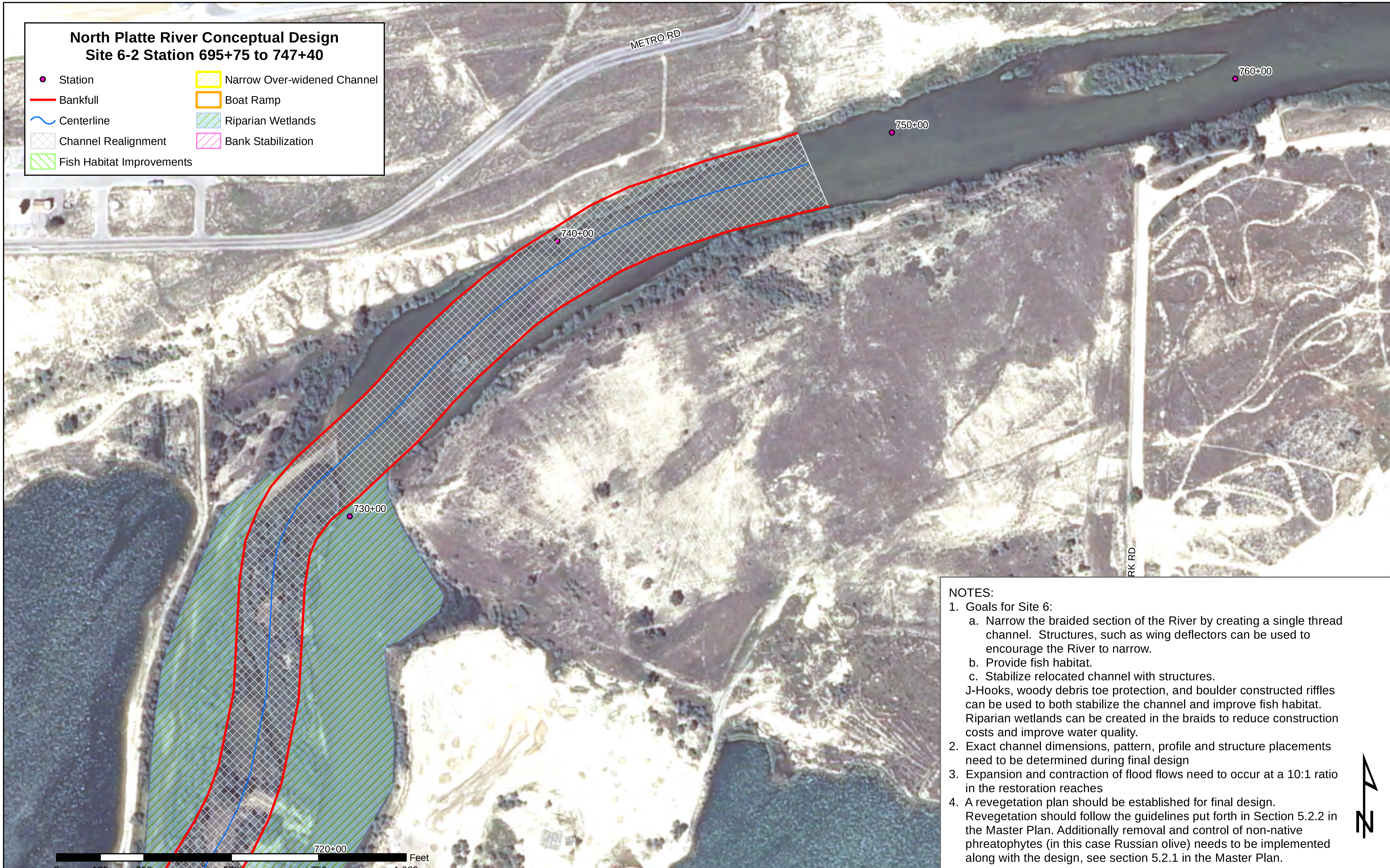
NOTES:

1. Goals for Site 5:
   a. Improve the quality of the fishery. Potential improvements for fish habitat include the installation of woody debris toe protection, boulder constructed riffles, narrowing the channel where necessary, creating low flow riffle features, deepening pools, and stabilizing banks.
   b. Increase access to the River. Boat ramps are proposed to provide public access to the River.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.



North Platte River Conceptual Design
Site 6-1 Station 695+75 to 747+40
Station
Bankfull
Centerline
Channel Realignment
Fish Habitat Improvements
Narrow Over-widened Channel
Boat Ramp
Riparian Wetlands
Bank Stabilization
720+00
710+00
690+00
700+00
SPILLWAY
Feet
0
125
250
500
750
1,000
N
NOTES:
1. Goals for Site 6:
a. Narrow the braided section of the River by creating a single thread channel. Structures, such as wing deflectors can be used to encourage the River to narrow.
b. Provide fish habitat.
c. Stabilize relocated channel with structures.
J-Hooks, woody debris toe protection, and boulder constructed riffles can be used to both stabilize the channel and improve fish habitat. Riparian wetlands can be created in the braids to reduce construction costs and improve water quality.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.

North Platte River Conceptual Design
Site 6-2 Station 695+75 to 747+40

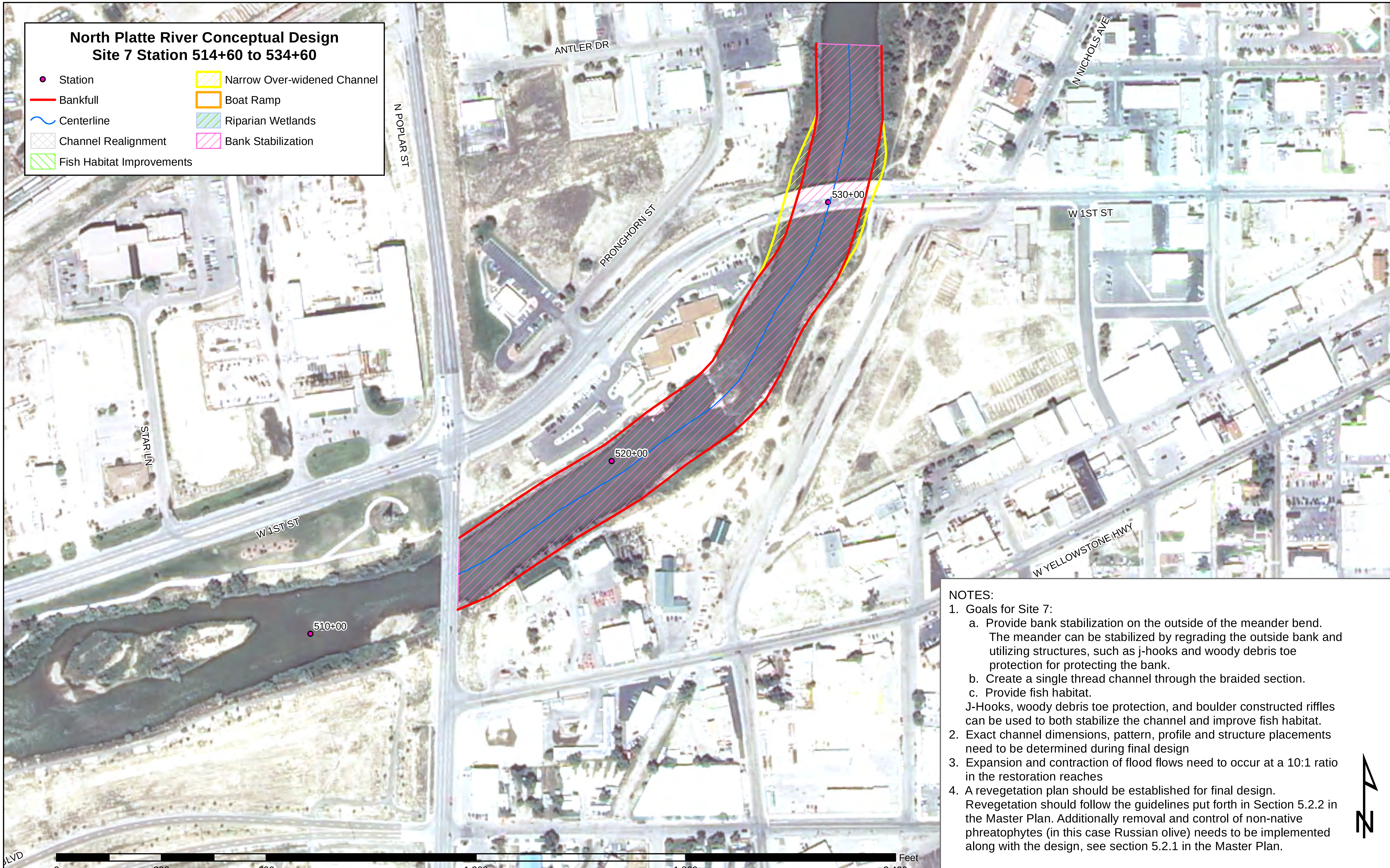


NOTES:

1. Goals for Site 6:
   a. Narrow the braided section of the River by creating a single thread channel. Structures, such as wing deflectors can be used to encourage the River to narrow.
   b. Provide fish habitat.
   c. Stabilize relocated channel with structures.

   J-Hooks, woody debris toe protection, and boulder constructed riffles can be used to both stabilize the channel and improve fish habitat. Riparian wetlands can be created in the braids to reduce construction costs and improve water quality.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.

North Platte River Conceptual Design
Site 7 Station 514+60 to 534+60



NOTES:

1. Goals for Site 7:
   a. Provide bank stabilization on the outside of the meander bend. The meander can be stabilized by regrading the outside bank and utilizing structures, such as j-hooks and woody debris toe protection for protecting the bank.
   b. Create a single thread channel through the braided section.
   c. Provide fish habitat.

   J-Hooks, woody debris toe protection, and boulder constructed riffles can be used to both stabilize the channel and improve fish habitat.
2. Exact channel dimensions, pattern, profile and structure placements need to be determined during final design
3. Expansion and contraction of flood flows need to occur at a 10:1 ratio in the restoration reaches
4. A revegetation plan should be established for final design. Revegetation should follow the guidelines put forth in Section 5.2.2 in the Master Plan. Additionally removal and control of non-native phreatophytes (in this case Russian olive) needs to be implemented along with the design, see section 5.2.1 in the Master Plan.