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Inventory of Juvenile Coho Salmon and Off-road Vehicle Trail Distribution in the Knik River Public Use Area, Alaska, 2012

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Abstract

The Matanuska and Susitna (Mat-Su) river watersheds support the freshwater life history needs of all five species of Pacific salmon *Oncorhynchus* spp. as well as resident populations of rainbow trout *O. mykiss*, and Dolly Varden *Salvelinus malma*. The Mat-Su Borough is one of the most rapidly developing areas in Alaska and extensive recreational use in the Knik River Public Use Area (KRPUA) may pose a potential threat to freshwater fish habitat. Fisheries and land managers have concerns that intense recreational use in wetland complexes and streams in this area could impact salmon production. The goal of this project was to map the spatial distribution of off-road vehicle (ORV) trails within the KRPUA, develop a simple method to assess ORV trails at stream crossings that is focused on anadromous fish habitat, and complete fish sampling in this area to update the Anadromous Waters Catalog (AWC). The spatial distribution of ORV trails and locations where ORV trails intersected with salmon bearing waters were assessed using satellite imagery, aerial photography, and on-the-ground surveys mapped with GPS. At each ORV stream crossing, characteristics of the stream crossing were collected using evaluation methods, a data dictionary, and weighted rankings developed by modifying existing methods for trail condition assessments. Seven attributes of the trail stream crossing (ORV track type, stream bank impact width, trail impact width, trail surface/substrate, rutting, mud/muck, and trail grade) were recorded and assigned a rank and used to determine the relative level of degradation. Over 200 km of ORV trails were mapped in the Knik River area in 2012. Thirteen ORV trail stream crossings were assessed for degradation level and ranked, and seven nominations were made to update the AWC. All stream crossings were degraded, and most ranked as extremely degraded. Results of the trail mapping and stream crossing assessments will provide local land managers with data documenting areas where ORV trails intersect with anadromous waters, and where levels of degradation due to ORV use are highest within the Knik River area. It will provide information that may be used to prioritize areas of concern, inform trail management decisions, and identify or prioritize habitat restoration projects. Methodology developed during this project may be applicable elsewhere in Southcentral Alaska where ORV use has degraded fish habitat.

Introduction

The human population of the Matanuska-Susitna (Mat-Su) Borough is one of the fastest growing in the U.S., with a growth rate of 50% from 2000 to 2010 (Matanuska-Susitna Borough 2011). Population growth, associated development, and increased recreational trail use in the Knik River Public Use Area (KRPUA) continues to challenge the ability of fisheries and land managers to balance fish habitat conservation with these changes over time. Maintaining healthy

fish habitat, including water quality and quantity, is critical to preserving healthy fish populations in the Mat-Su basin.

Concerns about how to effectively protect and restore salmon production in the face of rapid development led to the formation of the Mat-Su Basin Salmon Habitat Partnership (Partnership) under the National Fish Habitat Action Plan (NFHAP). NFHAP is a national effort to protect and restore the nation's waterways and fisheries through science-based partnerships of affected stakeholders. The Partnership has developed a Strategic Action Plan, which identifies objectives, actions, and research necessary to protect salmon and their habitat in the Mat-Su basin (Mat-Su Basin Salmon Habitat Partnership 2008).

Fish habitat protection authorities and planning processes in Alaska are constrained by the extent of current knowledge of fish distributions and their habitats. Some protections provided under AS 16.05.871 only apply to waters specified in the *Catalog of Waters Important for the Spawning, Rearing or Migration of Anadromous Fishes* (Anadromous Waters Catalog (AWC); Johnson and Blanche 2010). Currently, the AWC contains only 4,200 miles of the more than 23,900 miles of streams that have been mapped in the Mat-Su basin. Management and regulatory tools cannot be applied to their full extent until the remaining streams are surveyed for anadromous fish habitat.

The Anchorage Fish and Wildlife Field Office initiated this project in 2007 to support the Partnership's Strategic Action Plan and NFHAP by increasing coverage of the AWC for Mat-Su basin water bodies. Sampling 2007–2009 centered on increasing the known upper extent of anadromy in lotic systems. Sampling in 2010 and 2011 focused on the lake and wetland complexes of the KRPUA based on consultations with Alaska Department of Fish and Game (ADF&G) as a first step in understanding the use of these complexes by juvenile salmon. Use of off-channel habitats such as ponds, log jams, swamps, side channels, and beaver ponds is recognized as important to juvenile coho salmon survival and growth (Tschaplinski and Harman 1983; Swales et al. 1986; Ebersole et al. 2006) as is the use of lakes for rearing juvenile sockeye (Groot and Margolis 1991). Numerous ORV trails were observed in these areas during fish sampling efforts in 2010 and 2011, and the potential impacts to salmon habitat from changes in flow, increased sedimentation, or damages to soils and vegetation are unknown.

The overall goal of this project is to provide information for the protection and management of freshwater habitats that support Alaska's anadromous and freshwater fish, and to document the spatial distribution of ORV trails to develop a framework to identify locations where potential conflicts between salmon habitat and human use exist. The specific project objectives are to: (1) assess the spatial distribution of, and create a Geographic Information System (GIS) layer to document current locations of ORV trail use, (2) develop a simple method to assess ORV trails at stream crossings that is focused on anadromous fish habitat and, (3) complete AWC inventory work in KRPUA to maximize the known spatial distribution of anadromous fish habitat.

Study Area

The Matanuska and Susitna rivers watersheds encompass about 24,500 square miles in Southcentral Alaska, ranging in elevation from the highest point in North America (Mount McKinley 20,320 ft) to sea level at Cook Inlet. The watersheds meet freshwater life history needs for Chinook *Oncorhynchus tshawytscha*, chum *O. keta*, coho *O. kisutch*, pink *O.*

gorbuscha, and sockeye *O. nerka* salmon. Other fishes common to Mat-Su water bodies include Arctic grayling *Thymallus arcticus*, rainbow trout *O. mykiss*, Dolly Varden *Salvelinus malma*, burbot *Lota lota*, eulachon *Thaleichthys pacificus*, longnose sucker *Catostomus catostomus*, threespine *Gasterosteus aculeatus*, and ninespine *Pungitius puntitius* stickleback, as well as several species of whitefish (*Coregonus* spp. and *Prosopium* spp.), lamprey *Lampetra* spp., and sculpin *Cottus* spp. Northern pike *Esox lucius* are also common in numerous lakes and streams, although they are not native to Mat-Su basin water bodies (Mecklenburg et al. 2002).

Areas specified for priority sampling included anadromous waters north of the Knik River, which are part of the KRPUA and include Jim Creek, McRoberts Creek, Metal Creek, and other unnamed bodies of water near Wolf Point (Figure 1). The KRPUA is a legislatively designated area (AS 41.23.180-230) managed by the Alaska Department of Natural Resources (ADNR), Division of Mining, Land, and Water, Southcentral Regional Office. Within the boundary of KRPUA are approximately 200,000 acres of state-owned land, 60,000 acres of federally owned land, and 1,000 acres of privately owned land. The KRPUA was established to "preserve and perpetuate public recreation and the traditional use and enjoyment of fish and wildlife resources" (Alaska Department of Natural Resources 2012).

Coho salmon returning to Jim Creek annually support one of the largest recreational fisheries in Knik Arm. Since 2004, annual fishing effort has averaged approximately 22,687 angler-days with recreational harvests averaging 14,106 coho salmon and 5,834 sockeye salmon (Oslund and Ivey 2011). The lakes and wetlands of KRPUA provide important rearing habitat for juvenile coho salmon (ADNR 1985; Sweet et al. 2004; Benolkin 2011), breeding and nesting habitat for waterfowl (Moore et al. 2007), and are popular among outdoor recreationalists who enjoy activities such as riding off-road vehicles (ORV), hunting, bird watching, hiking, and boating. Data gaps and concerns about potential threats to fish habitat from intense recreational use in the KRPUA prompted this project.

Methods

Fish and habitat information were collected at the intersections of ORV trails and lotic water bodies, herein referred to as stream crossings. Due to the extent of ORV use and stream crossings, surveys were only conducted on streams with a confirmed presence of fish but not included in the AWC. Inclusion into the AWC affords specific protections under State of Alaska law (Johnson and Blanche 2010). As such, we targeted streams that were currently excluded protection due to a lack of nomination into the AWC. Information was collected in the following order; spatial distribution of ORV trails, fish assessment, stream habitat assessment, stream crossing assessments, and a determination of the habitat impact using a weighted rank metric known as a "condition category assessment". This prescription was repeatable, efficient, and minimized the time spent at a particular site while maximizing the number of sites visited during the field season.

Spatial Distribution of ORV Trails

Satellite imagery, aerial photos, and on-the-ground surveys were used to assess the spatial extent of ORV trails within the KRPUA. Flights of the survey area were conducted in spring to photograph and evaluate current conditions and to locate ORV trails and stream crossings for surveying. Ground surveys were conducted to delineate trails (along the centerline) using a GPS

(Garmin GPS Map62sct) and to identify ORV stream crossing locations. These stream crossings were identified and named by geographic area.

Fish Assessment

Streams identified intersecting at ORV trails were sampled for the presence of fish. Fish sampling was conducted using Gee® brand 6 mm galvanized minnow traps. Traps were baited with 4 g of cured salmon roe, placed in a predrilled film canister and soaked for a minimum of one hour. Minnow traps were deployed in areas of preferred salmon habitat such as low velocity water or areas that provide cover (Peterson 1982; Taylor 1988; Magnus et al. 2006). All fish sampling was conducted within a 200 m stream reach, which was measured 100 m upstream and downstream of the ORV crossing by walking the centerline of the stream channel with a hip chain. If multiple ORV crossings were present, the stream reach was delineated using the most upstream and most downstream crossing. In instances where the stream had jumped from its original channel and flowed onto the trail, the stream reach was delineated 100 m upstream of where the stream flowed onto the trail and 100 m downstream of where the stream moved back into the original channel. Minnow trapping began at the downstream end of a stream reach and continued upstream until the upper extent of anadromous fish presence had been determined for that stream. If fish were not captured at the lower end of the stream reach, sampling continued upstream until the presence of fish was determined.

Trap locations were recorded as a GPS waypoint and start, end, and total soak time were also recorded. Captured fish were placed in 5 gallon buckets filled approximately half full with stream water. Fish were counted and identified to species (Pollard et al. 1997). Fork length (mm) was recorded for all juvenile salmonids (coho salmon, sockeye salmon, and Dolly Varden). All fish were kept in the bucket to recover after handling and released into slack water areas within the stream reach.

The presence of adult salmon was noted during field surveys, and locations were documented with a handheld GPS. Detailed field notes and photographs were collected to describe the species, number of fish captured, and behavior of salmon observed. Photos and GPS coordinates were collected in North American Datum of 1983 (NAD 83) geographic coordinate system.

On several occasions, opportunistic AWC surveys were conducted outside of established stream crossing survey locations, including locations close to, but outside of the KRPUA, when stream crossing surveys were not feasible or when locations were inaccessible.

Stream Habitat Assessment

At each stream crossing, a suite of habitat parameters were collected within the stream reach to characterize the stream habitat at, above, and below the stream crossing (Ouren et al. 2007). Flagging was used to mark upstream and downstream extents at habitat unit breaks (transitions between pool, riffles, runs, cascades, or complex). Within stream reaches, habitat types were classified as pools, riffles, runs, cascades, or complex (Bisson 1982; Helm 1985; Frissell et al. 1986; Hawkins et al. 1993), starting at the downstream extent and working to the upstream extent. In addition, a continuous stream-wide approach, adapted from the Basinwide Visual Estimation Technique (Hankin and Reeves 1988; Dolloff et al. 1993), was used to describe each stream reach. For each stream reach, wetted width (m), mean stream width (m), mean and

maximum stream depth (m), dominant and subdominant substrate, stream slope (%), length of undercut banks (m), and water quality parameters; temperature (^{o}C), pH, conductivity (µS/cm), and dissolved oxygen (mg/L) were recorded.

Wetted width was recorded to the nearest centimeter at multiple locations perpendicular to the stream thalweg along each habitat unit using a stadia rod. Stream depths of each habitat unit were recorded to the nearest centimeter at 10 to 20 points and the maximum and mean depths were calculated.

Dominant and subdominant substrate were categorized visually and assigned to one of five categories described by Wentworth (1922) and Cummins (1962) (Table 1). Dominant substrate was defined as the particles of a given size which occupy >50% of the total substrate area.

Stream slope (%) for each stream habitat unit was estimated with a handheld clinometer following Gordon et al. (1992). Slope was measured at multiple locations along the greatest line-of-site distances throughout the stream reach, and a mean slope was calculated for each stream reach.

Length of undercut bank (m) was estimated to the nearest meter on along both stream banks, then added together for a total length for each reach.

Stream Crossing Assessments and Ranking

At each ORV stream crossing, basic characteristics of the crossing were recorded based on evaluation methods, a data dictionary, and weighted rankings developed by Kevin Meyer and Blain Anderson, USDI National Park Service (Kevin Meyer, USDI NPS, personal communication). These methods were modified for trail condition assessments to focus on stream crossings. A waypoint marking the intersection of an ORV trail and stream was mapped and used to identify each survey site. The following seven attributes of the trail at the stream crossing were measured at each site to describe the section of trail which impacted the stream, potential fish habitat, or both.

1) ORV track type
2) Stream bank impact width
3) Trail impact width
4) Trail Surface Substrate
5) Rutting
6) Muddiness of the trail
7) Trail grade

Each attribute was assigned a weighted ranking based on the descriptions and values detailed in Tables 2–7. Measurements for both stream bank impact and trail impact widths were categorized using the definitions listed in Table 3. Stream bank impact width was measured as the width of the surface impact along each stream bank, measured perpendicular to direction of travel. Trail impact width was measured as the width of the surface impact associated with the trail measured perpendicular to direction of travel, approximately 10 m from the water's edge. For trails where the stream was flowing on the trail, stream bank impact and trail impact width

measurements were collected from points where the stream flow began and ended on and off the trail.

Trail surface was used to characterize the natural or altered soil or substrate of the trail treads through the stream crossing. The trail surface substrate type descriptions and weighted rankings are given in Table 4.

Rutting was categorized by the extent of surface damage in the form of ruts, erosion, or soil compaction below the original terrain surface (if constructed or graded), or below the original tread surface (if not constructed). Measurements were collected at the deepest part of the rutting from the level of surface terrain adjacent to the surface level of compacted vegetation at the stream impact area. Rutting was measured on each side of the stream bank within the area of impact (up to ~2 m on each side). Descriptions of rutting depths (cm) and ranking weights are given in Table 5.

Muddiness of the trail was categorized by the level of muddiness on the trail tread during typical use periods and during seasonal wet conditions. Muddiness was measured where the trail entered and exited the stream. Descriptions of muddiness values and ranking weights are given in Table 6.

Trail grade identifies the slope (%) of the trail for each point of entry into the stream. Slope was measured from the water's edge to a point 10 m up the trail from the water's edge using a hand-held clinometer (Gordon et al. 1992). Descriptions of percent grade of the slope and ranking weights are given in Table 7.

The overall condition of the trail crossing was defined using a scoring index based on the level of degradation (Kevin Meyer, USDI NPS, personal communication). The sum of all stream crossing characteristic weighted ranking values resulted in an overall metric that categorized the trail crossing into one of five condition categories called the "condition category assignment" (Table 8). The metric indicates the level of degradation, where higher ranking values correspond to more severe degradation. In instances where multiple trail crossings existed in one stream, each point of entry into the stream was evaluated and ranked, and the resulting condition category assignment was based on the cumulative ranking values for each point of entry.

Results

Spatial Distribution of ORV Trails

A total of 211 km of ORV trails were delineated on the ground and mapped with GIS within the KRPUA, and 13 stream crossings were assessed in 2012 (Figure 2). Possible ORV and stream intersections were surveyed within seven general geographic locations and grouped broadly as: 1) Plumley-Maud, 2) Rippy Trail, 3) Outlet of Jim Creek, 4) Knik River Flats, 5) Friday Creek, 6) Wolf Point, and 7) Metal Creek (Figure 3). Three stream crossings were assessed within the Plumley-Maud area, six stream crossings within the Rippy area, and four stream crossings were assessed within the Wolf Point area (Figures 4–6). No stream crossings were assessed within the other four general geographic areas because they did not contain stream crossings or access was not feasible or safe due to high flow water.

Fish Assessment

Fish were sampled at all 13 stream crossings. Salmon were captured at four stream crossing sites within two general geographic areas (Plumley-Maud and Wolf Point) (Table 9; Figures 2 and 3–6). No salmon were captured at stream crossings within the Rippy area (Figure 5). Juvenile coho salmon were captured at Plumley-Maud 2 (n = 5; Figure 4), Wolf Point 1 (n = 14; Figure 6), and Wolf Point 4 (n = 9; Figure 6). One juvenile sockeye salmon was captured at Wolf Point 2 (Figure 6; Table 9). Other fish species captured stream crossings were Dolly Varden (n =14), stickleback spp. (n = 2842) and sculpin spp. (n = 42); Table 9).

Several locations were opportunistically sampled for juvenile fish to update the AWC, or when surveys sites were inaccessible (Table 10; Figure 7). Three sites within the Friday Creek area, one at the inlet of Chain Lake, one at an unnamed creek near the Palmer wastewater treatment plant outflow (Matanuska River drainage outside of the KRPUA), and two within the Wolf Point area were sampled for fish in 2012 (Table 10; Figure 7). Juvenile coho salmon (n = 38) were captured at five sites (Friday Creek 1, Chain Lake inlet, the unnamed creek near the Palmer wastewater treatment plant, Wolf Point 5, and Wolf Point 6), and juvenile sockeye salmon (n = 29) were captured in the unnamed creek near the Palmer wastewater treatment plant and at Wolf Point sites 5 and 6. Other species captured during opportunistic or AWC sampling included Dolly Varden (n = 10), stickleback spp. (n =194), sculpin spp. (n = 1), and Alaska blackfish (n = 1).

Seven nominations were submitted to update the AWC in 2012 (Table 11). There were five nominations (for sites Friday Creek 1, Wolf Point 1, 2, 4, and 6) made to add new water bodies not documented in the AWC, and two nominations made to extend the upper extent of juvenile coho and sockeye salmon distribution within Wolf Point 5 and the unnamed creek near the Palmer wastewater treatment plant.

Approximately 400 adult sockeye salmon and 200 adult chum salmon were observed in Jim Creek, near Wolf Point 1, and in the unnamed creek near the Palmer wastewater plant treatment outflow. These areas were already included in the AWC; however, additional notation, photos, and observations were submitted to the AWC to serve as supporting documentation.

Stream Habitat Assessments

Habitat type, stream width, stream depth, dominant substrate, stream slope, and undercut bank length were collected at the 13 stream crossings during stream habitat assessments (Table 12). All sites had riffle or run habitat, except for four stream crossings on Rippy trail, which were cascades (Table 12). Mean stream width ranged from 1.57 to 6.43 m and the widest streams (Plumley-Maud 2, Wolf Point 1, and Wolf Point 4) had salmon present. Mean stream depths ranged from 0.11 to 0.39 m. Salmon were captured at the site with the highest mean and maximum depth (Plumley-Maud 2) and at 3 other sites at Wolf Point (Table 12). No salmon were captured in sites where stream depth was <0.19 m. Dominant substrate varied within and among general geographic areas, and ranged from silt/sand to boulder/cobbles. Salmon were generally captured at sites that had smaller (silt to gravel) size substrates. Stream slopes ranged from 1.23% to 6.41% in run/riffle habitats and from 6.75% to 9.24% in cascade habitats. All salmon were captured at sites with the lowest stream slopes (1.23%–1.56%), with the exception

of a single sockeye salmon captured at Wolf Point 2, which had a stream slope of 6.41%. Length of undercut banks ranged from 2 to 196 m.

Stream Crossing Assessments and Ranking

Thirteen stream crossing were assessed for level of degradation and ranked based on seven trail attributes at the stream crossing: ORV track type, stream bank impact width, trail impact width, trail surface substrate, rutting, muddiness of the trail, and trail grade (Tables 13-14; Figures 2-6). All stream crossings were degraded and most ranked as *extremely degraded* (total ranking weight >75; Table 14; Figure 8).

Because the ranking system was cumulative, stream crossings with more than one entry point or altered channels were assigned higher rankings weight values, resulting in condition categories indicative of higher degradation. Eight sites were simple crossings which had two entry (or exit) points (Plumley-Maud 2, Plumley-Maud 3, Rippy 1, Rippy 2, Rippy 3, Rippy 5, Wolf Point 2, and Wolf Point 3; Table 14). Five sites were more complex or braided with 3 to 15 entry points (Table 14; Figures 9-11). At three stream crossing s (Plumley-Maud 1, Rippy 4, and Wolf Point 3), the stream had been diverted from its original channel and was flowing in the ORV trail path (Figures 12-14). The three stream crossings where juvenile salmon were captured (Plumley-Maud 2, Wolf Point 1, and Wolf Point 4) had total ranking values of 159, 791, and 1,406, respectively, and were all categorized as "extremely degraded".

The three sites with the lowest total ranking values were dominated by larger substrates (boulder/cobble). All other sites ranked as "extremely degraded", and were dominated by gravel or silt substrates, except site Rippy 1. Although larger cobble substrates were observed at site Rippy 1, it had a relatively high trail impact width ranking weight due to braided trails, which elevated the total ranking. Wolf Point 1 and 4 had multiple trail exit and entry points, resulting in the highest rankings.

Discussion

Over 200 km of ORV trails were mapped in the Knik River area in 2012. Thirteen ORV trail stream crossings were assessed for degradation level and ranked, and seven nominations were made to the AWC. All stream crossings were degraded to some degree, and most ranked as "extremely degraded". Since 2010, the U.S. Fish and Wildlife Service has surveyed all accessible lowland water bodies within the KRPUA for presence/absence of anadromous fish (approximately 875 hectares of lakes/wetlands and 10 km of streams). In all years, 24 nominations were made to update the AWC to document juvenile and adult coho and sockeye salmon in the KRPUA (Benolkin 2011, Benolkin and Sethi 2012). Juvenile coho salmon were the most common anadromous fish captured by minnow traps in all years and were found in most lakes and wetland areas sampled. Adult salmon (coho, sockeye, and chum salmon) were documented in all years, primarily in Jim Creek, and spawning fish were observed on the north end of Jim Lake. Project results from 2012 will complement the fish presence information, allowing land managers and others to overlay locations of ORV trails to determine where important fish habitat and recreational use overlap, and where fish habitat may be prioritized for conservation, protection, or restoration.

The stream crossing methodology provided a simple and efficient assessment of ORV trail impacts at stream crossings where crossings were simple (2 entry points). Because the ranking system was cumulative, sites with complex or braided trails, or those in soft soils (wetland areas) had relatively elevated rankings. Nearly all sites (regardless of the number of entry points into the stream) were categorized as "extremely degraded". For example, although sites Wolf Point 1 and Wolf Point 4 had the highest number or entry points (6 and 15, respectively) and also had the highest total rankings (791 and 1,406; Table 14; Figures 10-11); site Rippy 4 with a total ranking weight of 97 also ranked as "extremely degraded". This was likely the result of a relatively high "rutting" value at this site (50, indicative of rutting or erosion between 22 and 41 cm; Table 13).

Of the three sites not categorized as "extremely degraded", the total weighted rankings ranged from 31 to 51 (Table 14) and were all located on the Rippy trail which is upland of the other survey sites located near wetland complexes. These sites each had only two points of entry and no rutting or mud. In contrast, site Wolf Point 4 which was located near wetland complexes had 15 entry points, each of which was assigned individual values for rutting (841 total points) and mud (56 total points; Tables 14 and 15). These elevated ranking values and thus high degradation levels may be misleading, or in this case not allow sites to be distinguishable, based on category condition alone. Therefore, this ranking system will be further evaluated to determine whether improvements can be made for application to complex stream crossing sites (e.g., braided trail networks often found in wet or soft soils). Continued investigations will provide information to determine how these stream crossing assessment methodologies may be applicable in effectively prioritizing future habitat restoration projects.

Results this project provide valuable baseline information and GIS maps describing existing fish presence and the extent of ORV trails within a heavily used recreational area. This project will provide useful data to support other fish or habitat efforts in the area, such as recent efforts to quantify the impacts of ORV stream crossings in the KRPUA (Graziano, APU Master's thesis, in prep). Graziano's study examined how ORV crossings impacted turbidity levels, and if turbidity levels pose a potential threat to juvenile salmon health, which will be an important complement to the data provided in our study. Results of both may also be useful for land managers in prioritizing habitat protection efforts in light of anticipated future land use or to inform future trail management decisions. For instance, results indicate crossings over boulder/cobble streambeds were not as highly degraded as those in gravel and silt streambeds, and may be more suitable sites for mechanized recreational use. Survey data and GIS fish and trail maps will support future study efforts, and stream crossing methodology developed during this project may be applicable elsewhere in Southcentral Alaska where ORV use overlaps with fish habitat.

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Table 1. Substrate size class categories.

Size Class		Particle Diameter (mm)
1	Boulder	>256
2	Cobble	64–256
3	Gravel	2–64
4	Sand	0.062–2.000
5	Silt	<0.062

Table 2.Description and weighted rankings of ORV track types.

Track type	Description	Ranking weight
Single track	A single track, typically a narrow foot or cycle path.	NV[1]
Double wheel track	One set of parallel wheel tracks, with mostly vegetated center hump (>75% vegetated).	2
Wide track	A wide stripped travel track mostly stripped of vegetation (<25% vegetated).	6
Multi-braid 2 to 4	Between 2 and 4 sets of tracks- single tracks, double tire tracks, or wide tracks.	25
Multi-braid 5 to 10	Between 5 and 10 sets of tracks- single tracks, double tire tracks, or wide tracks.	50
Multi-braid >10	More than 10 sets of tracks- single tracks, a whole lot of tracks affecting a very large area.	75

[1]NV indicates that the attribute has no assigned ranking weight value. If a value was not mapped during the survey, it was coded as “not indicated.”

Table 3. Descriptions used to categorize stream bank and trail impact width, and corresponding ranking weights for each category.

Impact width (m)	Description	Ranking weight
<0.50	Surface impact is less than 0.5 m wide, typical of well-defined single track.	NV[1]
0.50–1.0	Surface impact is .50 to 1 m wide, typical of well- defined social trail.	NV
1.1–2.0	Surface impact is 1.1 to 2.0 m wide, typical of well-defined ATV trail.	NV
2.1–4.0	Surface impact is 2.1 to 4.0 m wide, typical of well-used ATV trail, wide or braided segment.	8
4.1–5.5	Surface impact is 4.1 to 5.5 m wide, typical of well-used ATV trail, wide or braided segment.	20
5.6–7.5	Surface impact is 5.6 to 7.5 m wide, typical of well-used ATV trail, wide or braided segment.	25
7.6–12.0	Surface impact is 7.6 to 12.0 m wide, typical of braided impact area.	50
>12.1	Surface impact more than 12.1 m wide, typical of braided impact area.	75

[1]NV indicates that the attribute has no assigned ranking weight value. If a value was not mapped during the survey, it was coded as "not indicated."

Table 4. Description and ranking weights for the trail surface and the in-stream substrate.

Trail surface/substrate	Description	Ranking weight
Wetland vegetation	Trail surface is directly on wetland plant species, typically wet sites.	20
Floating vegetation	Trail surface directly on vegetated floating bog	20
Water crossing over fines	Trail fords river, stream, lake or impoundment over a silt or clay bottom.	20
Water crossing over sand	Trail fords river, stream, lake or impoundment over a sandy bottom.	10
Water crossing over course material	Trail fords river, stream, lake or impoundment over gravel or cobble bottom.	5

Table 5. Description and ranking weights for trail rutting.

Rutting (cm)	Description	Ranking weight
None	No erosion or ruts are evident, typical of a very lightly used trail or hard surface.	NV[1]
<5	Erosion or rut depth is less than 5 cm below surrounding soil surface.	8
5–21	Erosion or rut depth is 5 to 21 cm below surrounding soil surface.	25
22–41	Erosion or rut depth is 22 to 41 cm below surrounding soil surface.	50
42–81	Erosion or rut depth is 42 to 81 cm below surrounding soil surface.	75
>81	Erosion or rut depth is more than 81 cm below surrounding soil surface.	75

[1]NV indicates that the attribute has no assigned ranking weight value. If a value was not mapped during the survey, it was coded as "not indicated."

Table 6. Description and ranking weights for the muddiness of the trail surface.

Muddiness Value	Description	Ranking Weight
None	Tread surface is not muddy under typical moisture conditions.	NV[1]
Muddy	Trail surface is typically muddy during wet periods but ruts are not typically formed.	8
Extremely Muddy	Trail surface develops a thick layer of mud during wet periods and ruts more than 2.5 cm deep form easily.	20
Muck hole	A single, solitary large deep water and/or mud- filled hole along the tread alignment.	35
Multimuck holes	A nearly continuous series of muck holes.	60
Seasonally impassable	Degraded conditions- typically multiple muck holes that limit passage during wet periods.	25
Impassable all times	Degraded conditions- typically multiple muck holes that make the trail totally unusable.	75
Churned organics <6”	Trail crosses organic soil. Surface materials have been churned shallower than 15.2 cm.	15
Churned organics <6”	Trail crosses organic soil. Surface materials have been churned deeper than 15.2 cm.	35

[1]NV indicates that the attribute has no assigned ranking weight value. If a value was not mapped during the survey, it was coded as “not indicated.”

Table 7. Description and ranking weights for trail grade (slope %).

Percent	Description	Ranking Weight
0%–3%	Trail grade is essentially flat, between 0 and 3 %.	4
4%–8%	Trail grade is between 4 and 8%	0
9%–11%.	Trail grade is between 9 and 11%	0
12%–15%.	Trail grade is between 12 and 15%	4
16%–20%.	Trail grade is between 16 and 20%	8
21%–30%.	Trail grade is between 21 and 30%	10
31%–40%.	Trail grade is between 31 and 40%	15
41%–60%.	Trail grade is between 41 and 60%	20

Table 8. Category condition assignments; based on cumulative ranking values. The total ranking weight values were used to allocate each ORV trail crossing segment into one of the five condition categories.

Total ranking weight	Condition category assignment	Code
Less than 10	Good	G
10 to 24	Fair	F
25 to 49	Degraded	D
50 to 75	Very Degraded	VD
More than 75	Extremely Degraded	XD

Table 9. Fish captured in minnow traps at stream crossing locations in the Knik River Public Use Area, Alaska 2012.

Stream name	Date(s)	Species	Count
Plumley-Maud 1	6/26		0
Plumley-Maud 2	7/9	Coho salmon	5
Plumley-Maud 2	7/9	Dolly Varden	3
Plumley-Maud 3	7/26	Dolly Varden	1
Rippy 1	7/6	Dolly Varden	1
Rippy 2	6/22		0
Rippy 3	6/25		0
Rippy 4	6/27	Dolly Varden	1
Rippy 5	6/27		0
Rippy 6	7/6	Dolly Varden	2
Wolf Point 1	7/11, 7/16, 7/30, 8/8, 8/14	Coho salmon	14
Wolf Point 1	7/11	Dolly Varden	3
Wolf Point 1	7/11, 7/30, 8/14	Sculpin spp.	41
Wolf Point 1	7/16, 7/30, 8/8, 8/14	Stickleback spp.	2,839
Wolf Point 2	8/2	Sockeye salmon	1
Wolf Point 2	8/7	Sculpin spp.	1
Wolf Point 3	7/17		0
Wolf Point 4	7/17, 8/2	Coho salmon	9
Wolf Point 4	7/17, 8/2, 8/15	Dolly Varden	3
Wolf Point 4	8/15	Stickleback spp.	3

Table 10. Location, date, species, and number of fish captured in minnow traps during opportunistic or AWC sampling in the Knik River Public Use Area and in an unnamed creek near the Palmer wastewater treatment plant, Alaska 2012.

Site Name	Date	Species	Count
Friday Creek 1	8/16	Coho salmon	7
Friday Creek 1	8/16	Dolly Varden	1
Friday Creek 2	7/13	Alaska blackfish	1
Friday Creek 3	8/4	Stickleback spp.	4
Chain Lake Inlet	7/2	Coho salmon	6
Chain Lake Inlet	7/2	Stickleback spp.	87
Palmer Wastewater	8/1	Chum salmon	1
Palmer Wastewater	8/1	Coho salmon	8
Palmer Wastewater	8/1	Sockeye Salmon	13
Wolf Point 5	7/31, 8/9	Coho salmon	14
Wolf Point 5	8/9, 8/13	Sockeye salmon	10
Wolf Point 5	8/9, 7/31	Dolly Varden	2
Wolf Point 5	7/31, 8/2, 8/9	Stickleback spp.	103
Wolf Point 6	8/21	Coho salmon	3
Wolf Point 6	8/21	Dolly Varden	7
Wolf Point 6	8/21	Sockeye salmon	6
Wolf Point 6	8/21	Sculpin spp.	1

Table 11. Summary of nominations submitted for inclusion in the Anadromous Waters Catalog from the Knik River drainage, Alaska 2012. Species codes are CO = coho salmon, S = sockeye salmon. Life stage codes are: r = rearing, p = present, s = spawning. Backup information was provided for 2 sites that were previously cataloged to extend the species distribution or provide additional survey data for the species listed.

Site Name	AWC Nomination #	AWC Waterway #	USGS Quad	New or Extended Water Body	New Species	Backup Information
Friday Creek 1	12-535	247-50-10200-	Anchorage B-5	Yes	COr	
Wolf Point 1	12-536	247-50-10200-	Anchorage B-5	Yes	COr	
Wolf Point 2	12-539	247-50-10200-	Anchorage B-5	Yes	Sr	
Wolf Point 4	12-538	247-50-10200-	Anchorage B-5	Yes	COr	
Wolf Point 5	12-541	247-50-10200-2155-	Anchorage B-5	Yes	Sr, COr	Sp, Sr, COr
Wolf Point 6	12-534	247-50-10200-	Anchorage B-5	Yes	Sr, COr	
Palmer Wastewater	12-533	247-50-10220-2037	Anchorage C-6	Yes	COr	Sp, Sr, COr, CHp

Table 12. Summary of stream habitat characteristics collected at each stream crossing assessment site, KRPUA, 2012.

Site Name	Dominant Habitat Type	Mean Stream Width (m)	Mean (Max) Stream Depth (m)	Dominant (Subdominant) Substrate	Stream Slope (%)	Undercut Bank Length (m)	Salmon Present (Y/N)
Plumley-Maud 1	Run	1.57	0.14 (0.26)	Silt (Boulder)	3.99	84	N
Plumley-Maud 2	Riffle	4.99	0.39 (0.64)	Gravel (Sand)	1.56	191	Y
Plumley-Maud 3	Run	2.07	0.11 (0.17)	Silt (Sand)	2.14	17	N
Rippy 1	Cascade	2.80	0.18 (0.37)	Cobble (Gravel)	6.75	10	N
Rippy 2	Cascade	2.16	0.18 (0.41)	Boulder (Cobble)	9.02	19	N
Rippy 3	Cascade	2.91	0.14 (0.33)	Boulder (Cobble)	8.12	12	N
Rippy 4	Riffle	1.78	0.17 (0.22)	Gravel (Cobble)	4.12	17	N
Rippy 5	Cascade	3.95	0.18 (0.34)	Boulder (Gravel)	9.24	31	N
Rippy 6	Riffle	3.07	0.37 (0.61)	Gravel (Boulder)	3.27	196	N
Wolf Point 1	Run	5.31	0.18 (0.30)	Silt (Sand)	1.23	30	Y
Wolf Point 2	Riffle	2.13	0.08 (0.19)	Gravel (Cobble)	6.41	2	Y
Wolf Point 3	Riffle	2.70	0.19 (0.20)	Gravel (Sand)	5.14	15	N
Wolf Point 4	Run	6.43	0.20 (0.43)	Silt (Sand)	1.53	50	Y

Table 13. Ranking weight values for each point of entry into the stream, KRPUA, 2012.

Site name	Track type	Track surface	Impact width	Track width	Rutting	Mud	Trail grade
Plumley-Maud 1	2	20	0	0	50	0	0
Plumley-Maud 1	2	20	0	0	75	8	4
Plumley-Maud 2	6	5	8	8	75	0	4
Plumley-Maud 2	6	5	50	8	50	0	4
Plumley-Maud 3	6	20	8	8	25	8	4
Plumley-Maud 3	6	20	8	8	50	8	4
Rippy 1	6	5	8	8	0	0	4
Rippy 1	6	5	25	50	75	0	4
Rippy 2	6	5	8	8	0	0	0
Rippy 2	6	5	8	8	0	0	8
Rippy 3	6	5	8	0	0	0	4
Rippy 3	6	5	0	8	0	0	0
Rippy 4	6	5	8	8	50	0	0
Rippy 4	6	5	8	8	0	0	4
Rippy 5	6	5	8	0	0	0	0
Rippy 5	6	5	20	8	0	0	0
Rippy 6	6	5	8	8	75	0	8
Rippy 6	6	5	8	8	50	0	4
Rippy 6	6	5	0	8	75	0	8
Wolf Point 1	6	20	50	20	75	8	0
Wolf Point 1	6	20	8	8	75	8	4
Wolf Point 1	6	20	8	8	75	75	4
Wolf Point 1	6	20	25	50	75	8	4
Wolf Point 1	6	20	8	8	75	8	4
Wolf Point 1	6	20	25	0	25	20	4
Wolf Point 2	6	5	20	8	50	0	0
Wolf Point 2	6	5	20	20	75	0	4
Wolf Point 3	6	5	8	8	25	8	4
Wolf Point 3	6	5	25	50	75	0	4
Wolf Point 4	2	20	0	0	8	8	4
Wolf Point 4	6	20	25	20	50	0	0
Wolf Point 4	6	20	8	8	50	8	4
Wolf Point 4	6	5	50	8	75	0	0
Wolf Point 4	6	5	0	0	75	8	0
Wolf Point 4	2	5	0	0	75	8	4
Wolf Point 4	2	20	0	0	8	8	4
Wolf Point 4	6	20	50	25	25	0	0
Wolf Point 4	6	20	8	50	50	0	4
Wolf Point 4	6	20	8	8	50	0	4
Wolf Point 4	6	5	8	8	75	0	4
Wolf Point 4	6	5	20	50	75	0	4
Wolf Point 4	6	5	0	8	75	0	4
Wolf Point 4	2	5	0	0	75	8	4
Wolf Point 4	2	5	0	0	75	8	4

Table 14. Summary for each site of the ranking weights and the ranking totals used to assign a condition category. Condition category assignments based on cumulative rankings are XD = extremely degraded, VD = very degraded, and D = degraded.

Site Name	# of entry points	Track type	Track surface	Impact width	Track width	Rutting	Mud	Trail grade	Total rank Weight	Condition category
Plumley-Maud 1	2	2	20	0	0	125	8	4	159	XD
Plumley-Maud 2	2	6	5	58	16	125	0	8	218	XD
Plumley-Maud 3	2	6	20	16	16	75	16	8	157	XD
Rippy 1	2	6	5	33	58	75	0	8	185	XD
Rippy 2	2	6	5	16	16	0	0	8	51	VD
Rippy 3	2	6	5	8	8	0	0	4	31	D
Rippy 4	2	6	5	16	16	50	0	4	97	XD
Rippy 5	2	6	5	28	8	0	0	0	47	VD
Rippy 6	3	6	5	16	24	200	0	20	271	XD
Wolf Point 1	6	6	20	124	94	400	127	20	791	XD
Wolf Point 2	2	6	5	40	28	125	0	4	208	XD
Wolf Point 3	2	6	5	33	58	100	8	8	218	XD
Wolf Point 4	15	28	75	177	185	841	56	44	1,406	XD

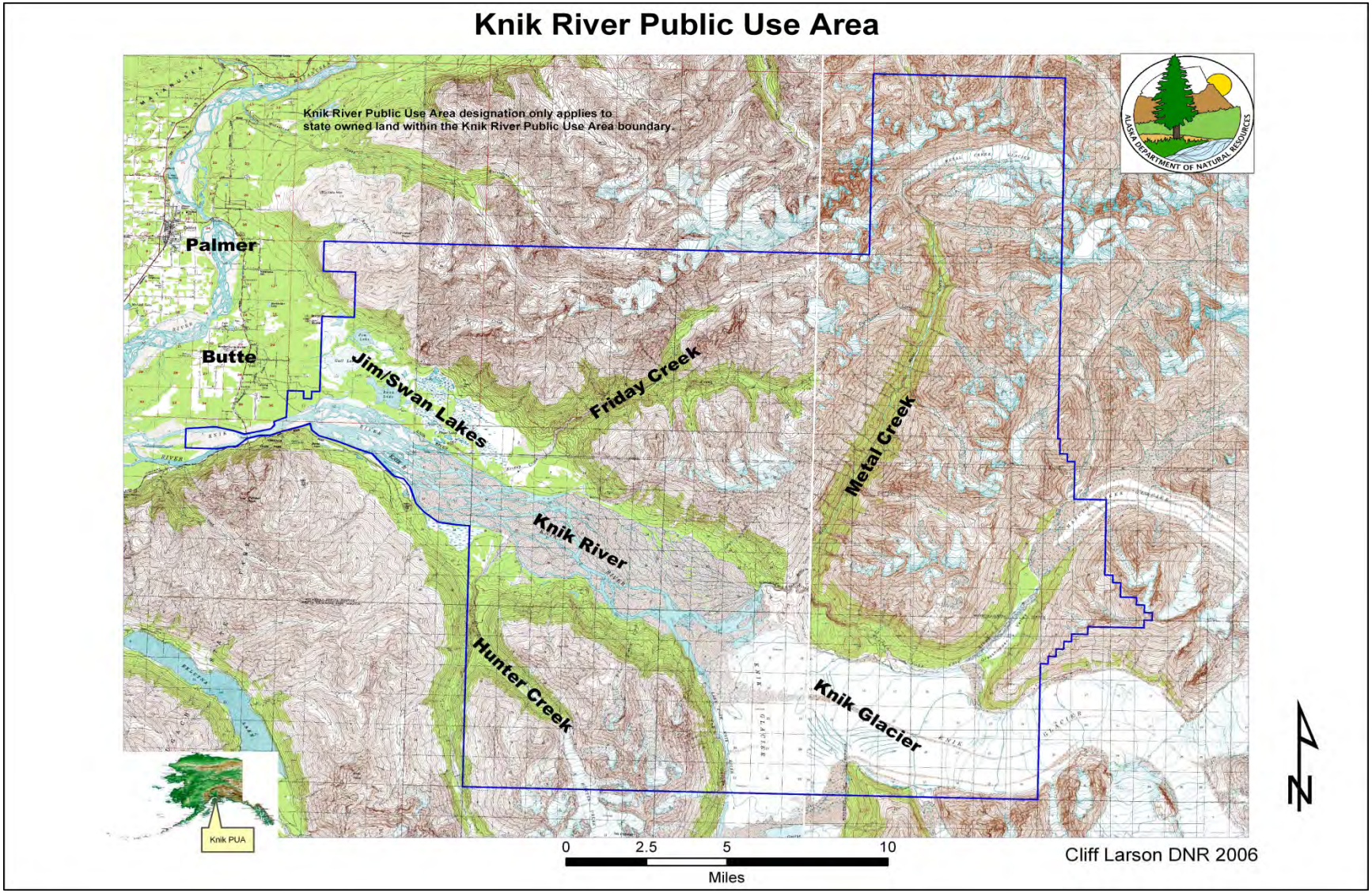

Figure 1. Map of the Knik River Public Use Area (from http://dnr.alaska.gov/mlw/krpua/pdf/Knik_PUA_map.pdf). (Accessed April 2012).

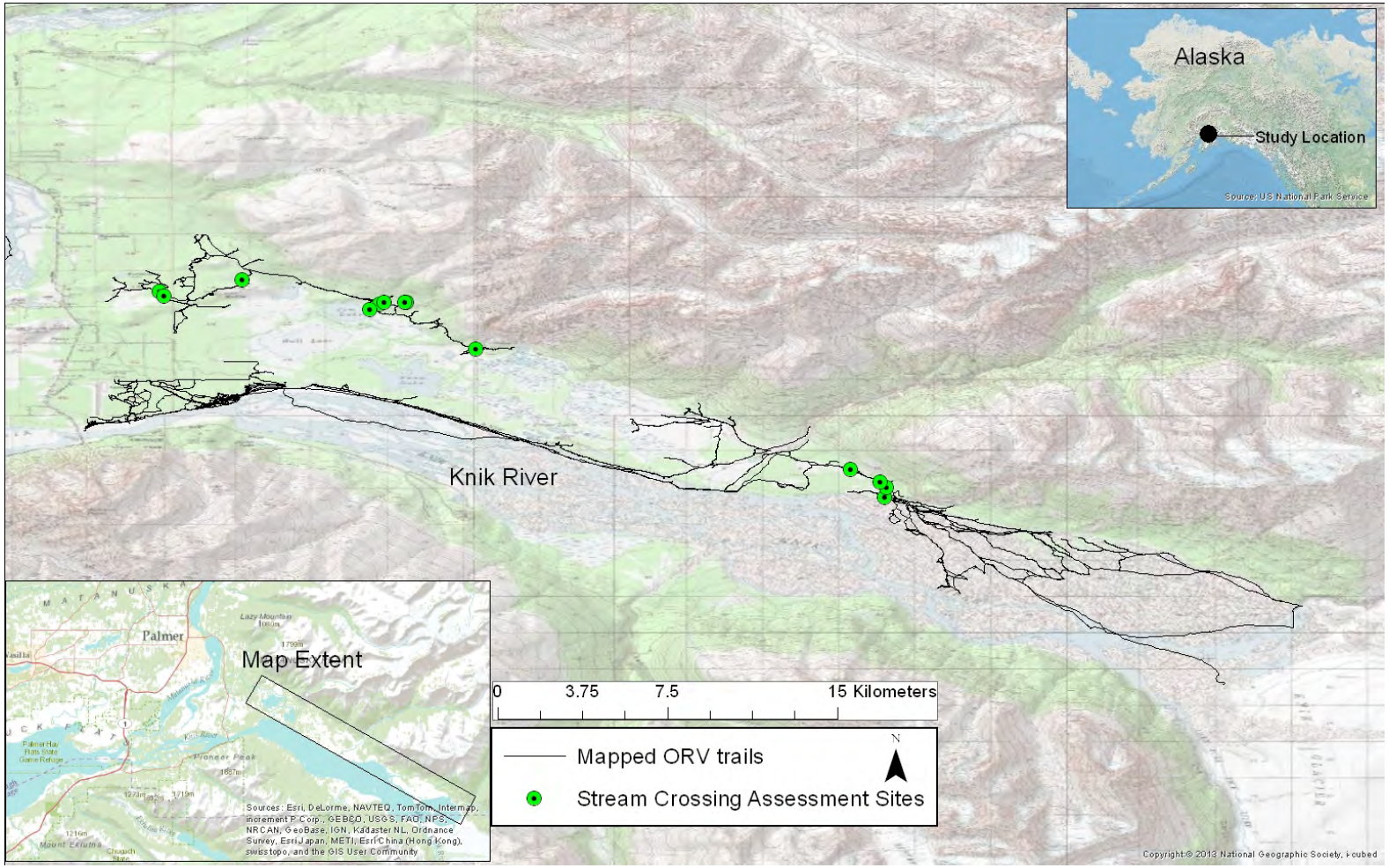

Figure 2. Study locations of mapped ORV trails (211 km) and 13 stream crossing assessment sites within the Knik River Public Use Area, 2012.

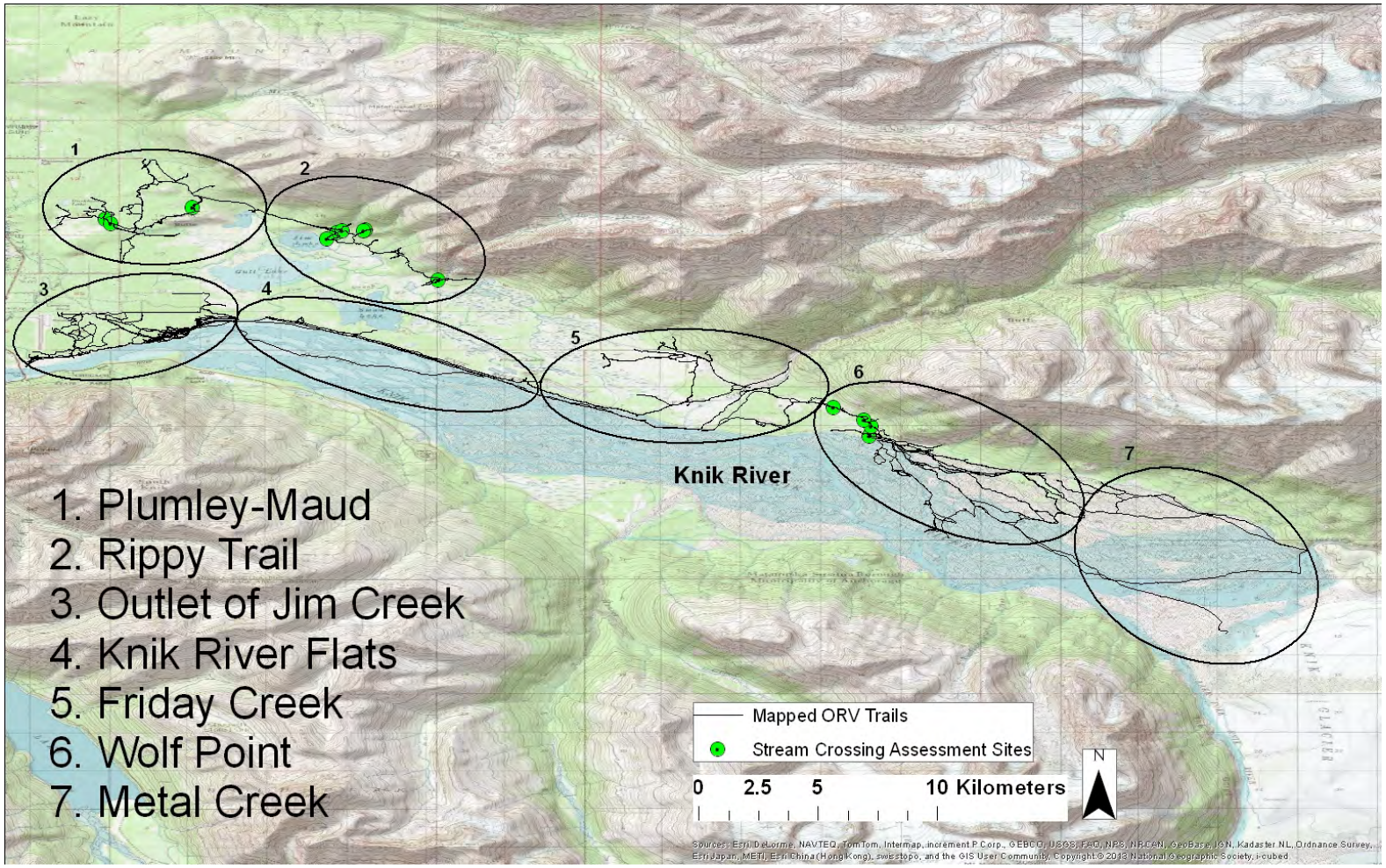

Figure 3. Map showing the general geographic locations of ORV mapping and stream crossing assessments within the Knik River Public Use Area, 2012. The numbers next to the ovals correspond to the numbers shown in the list of location names in the lower left-hand corner of the map, and to stream crossing assessment site names.

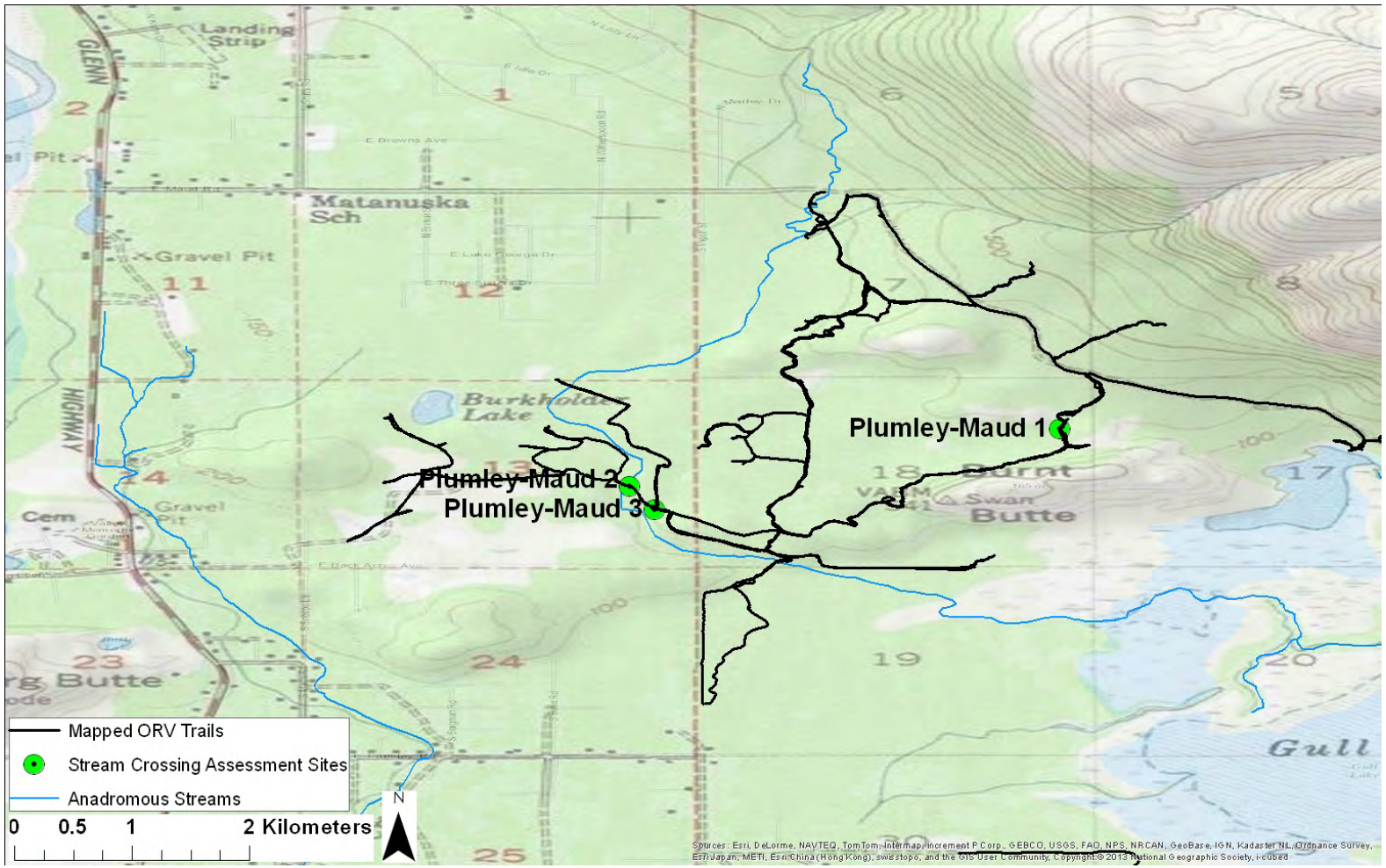

Figure 4. Map of the Plumley-Maud area showing locations of mapped ORV trails (black line), locations of stream crossing assessment sites (circles), and waters in the AWC prior to this study (blue line). Coho salmon (n = 5) were captured at site 2 during surveys, and Dolly Varden were captured at sites 2 and 3. No fish were captured at site 1.

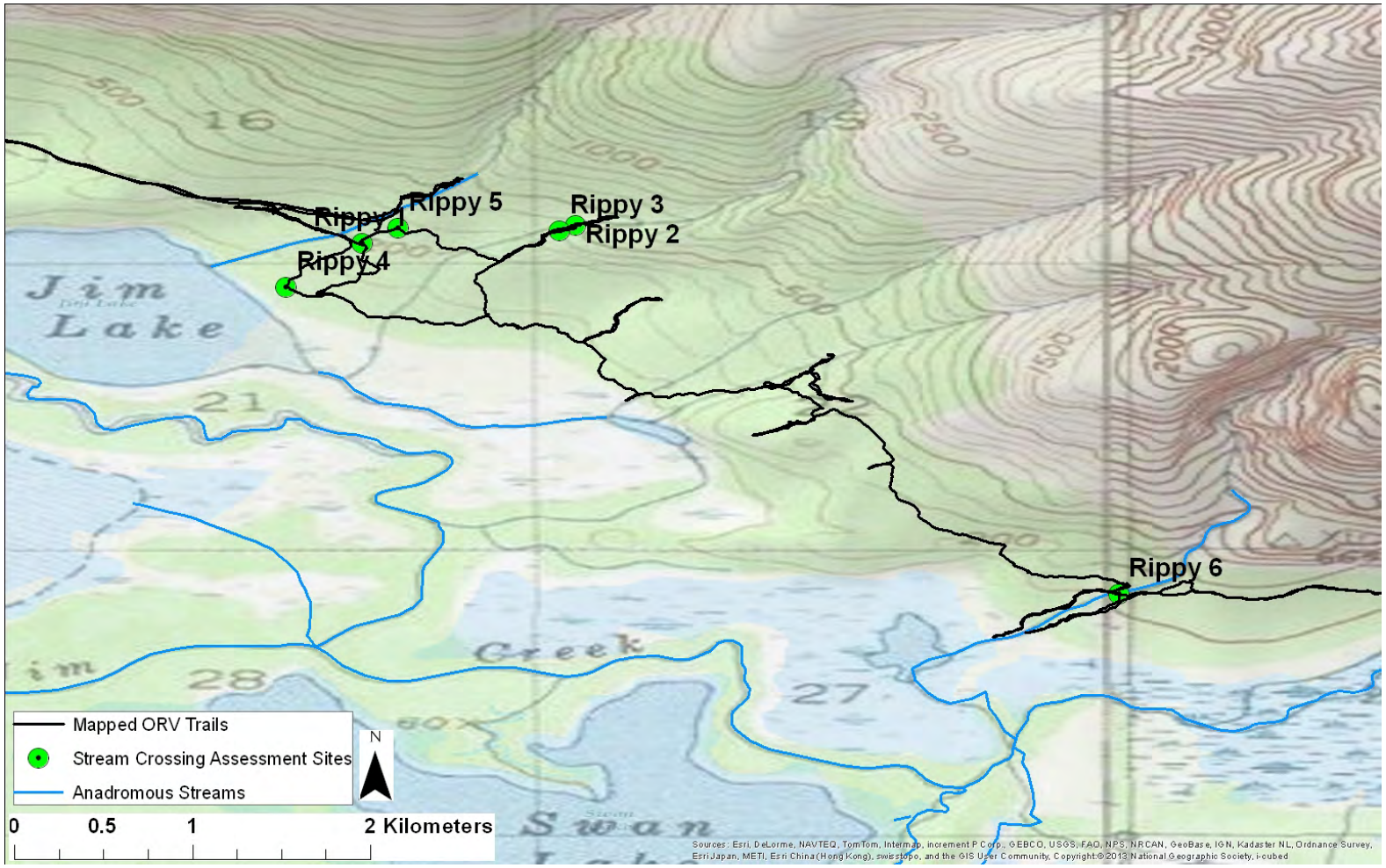

Figure 5. Map of the Rippy Trail area showing locations of mapped ORV trails (black line), locations of stream crossing assessment sites (circles), and waters in the AWC prior to this study (blue line). No salmon were captured at any Rippy sites. One Dolly Varden each was captured at sites 1 and 4, and two Dolly Varden were captured at site 6.

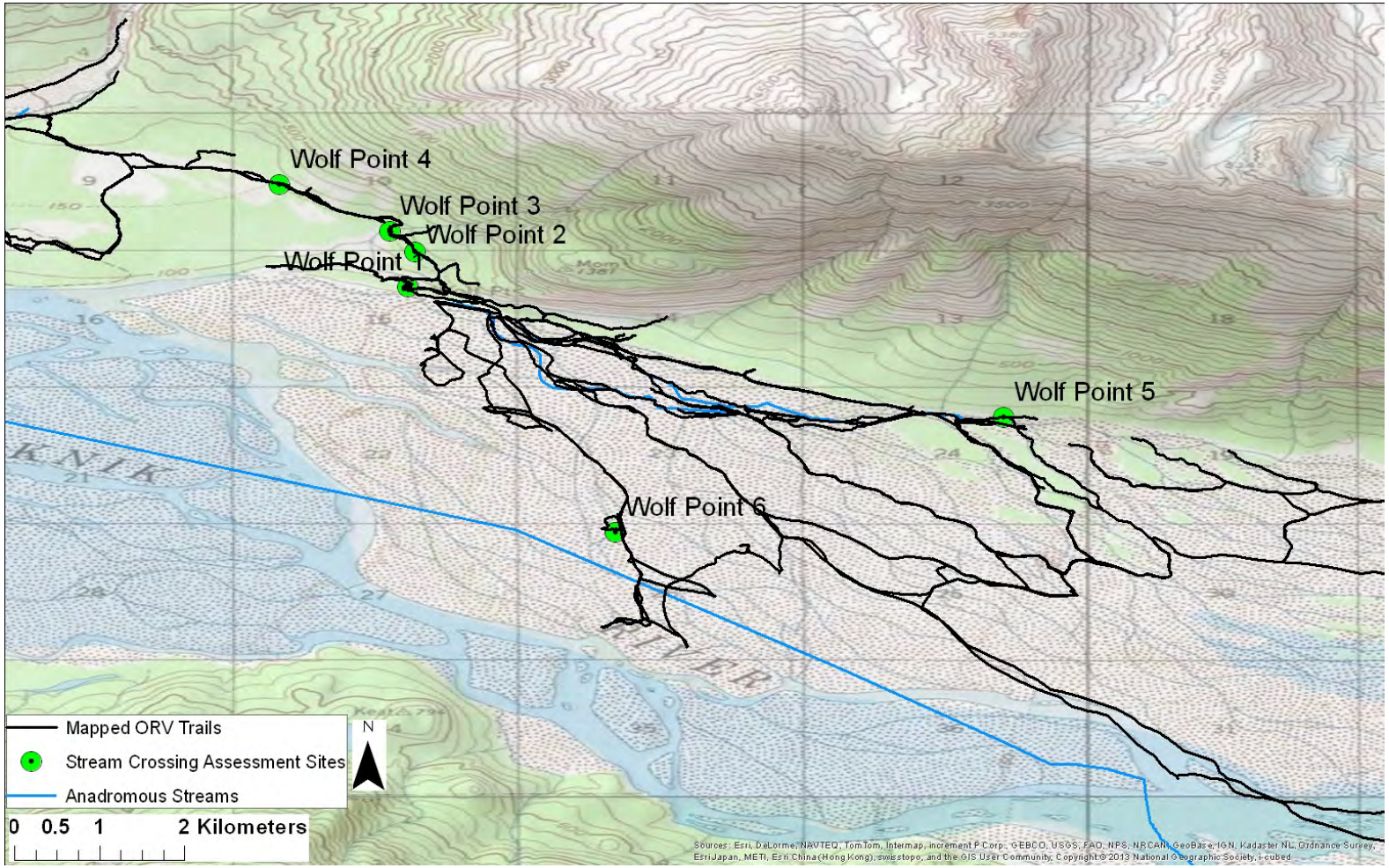

Figure 6. Map of the Wolf Point area showing locations of mapped ORV trails (black line), locations of stream crossing assessment sites (circles), and waters in the AWC prior to this study (blue line). Coho and sockeye salmon were captured in this area (14 coho salmon at site 1, 9 coho at site 4, and 1 sockeye at site 2). Other species captured here were Dolly Varden (n = 14), stickleback spp. (n = 2842), and sculpin spp. (n = 42). This area had the 2 highest degradation rankings (sites 1 and 4), both of which had multiple entry points or complex braided trails.

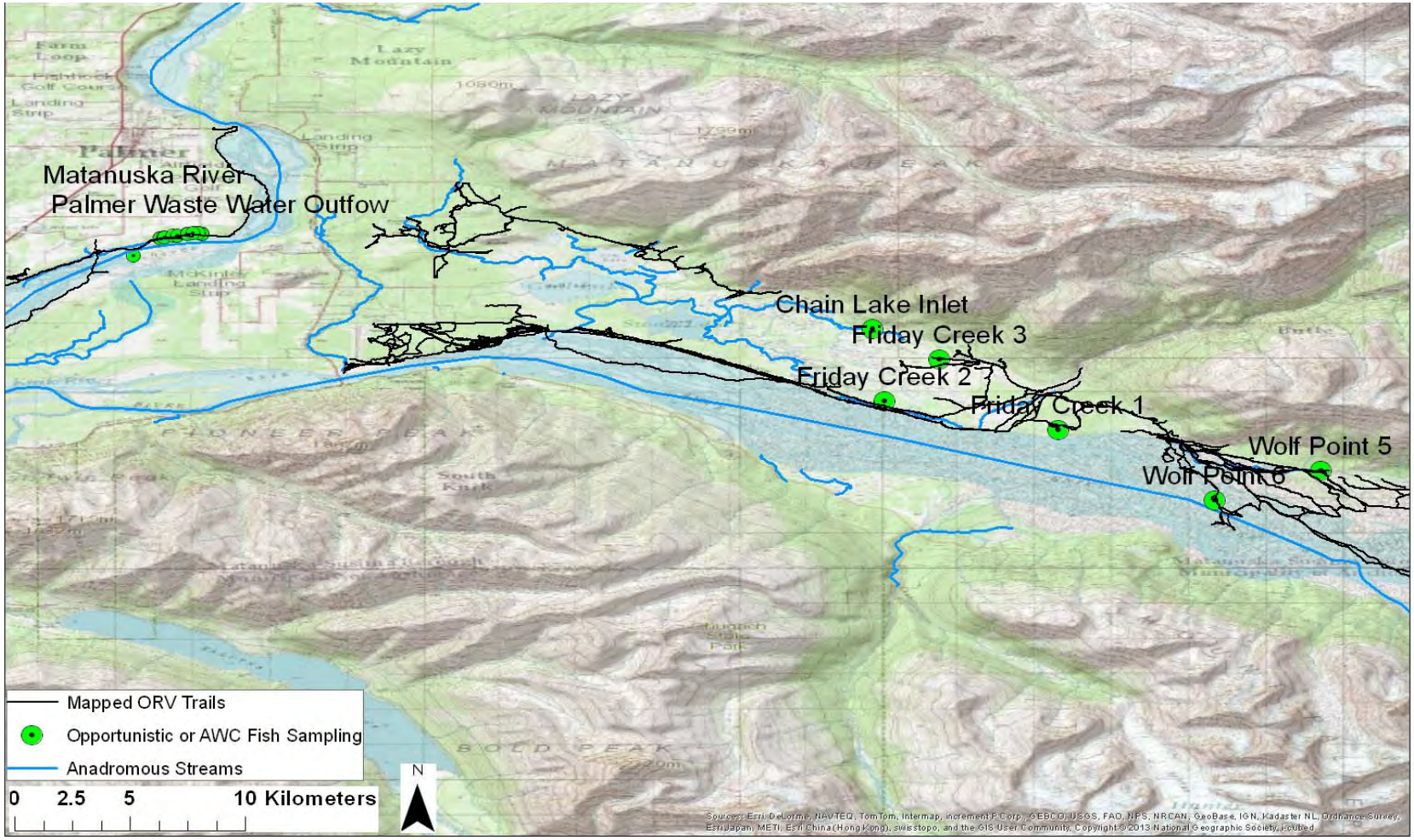

Figure 7. Locations of opportunistic or AWC fish sampling near the Palmer waste waterwater treatment outflow area near Palmer, and in the KRPUA at Chain Lake Inlet, Friday Creek, and Wolf Point. Coho salmon (n = 38) were captured in all of the four areas and sockeye salmon (n = 29) were captured at the Palmer wastewater treatment site, and Wolf Point 5 and 6.

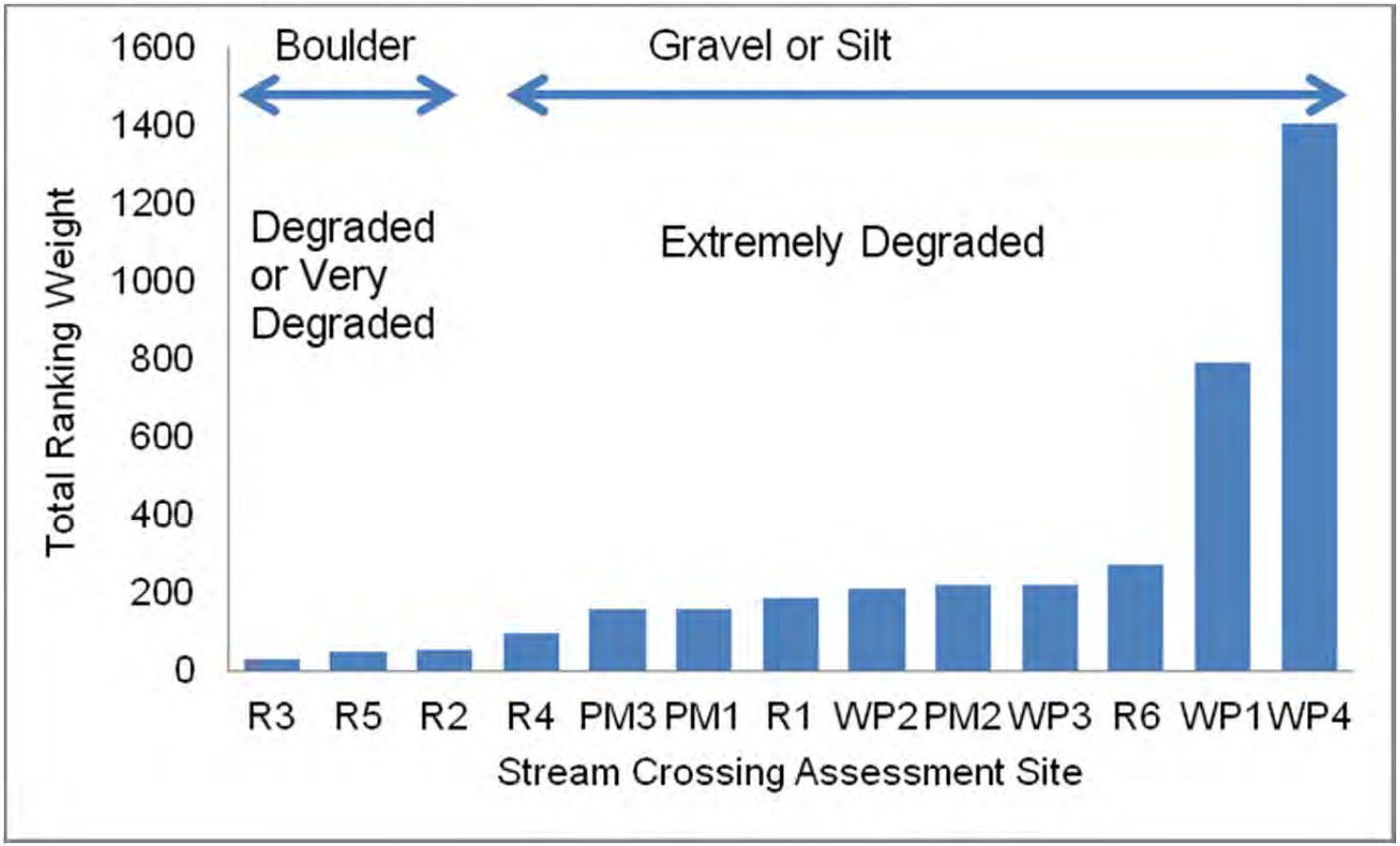

Figure 8. Graph showing 13 stream crossing assessment sites within the KRPUA ranked in ascending order by degradation. Abbreviations correspond to general geographic areas outlined in the text above, where R = Rippy, PM = Plumley-Maud, and WP = Wolf Point. Sites with total rankings >75 were categorized as "extremely degraded".

Figure 9. Example of "extremely degraded" crossing at Rippy 6, which had three points of entry, one on the right bank and two on the left bank. Total ranking at this site was 271.

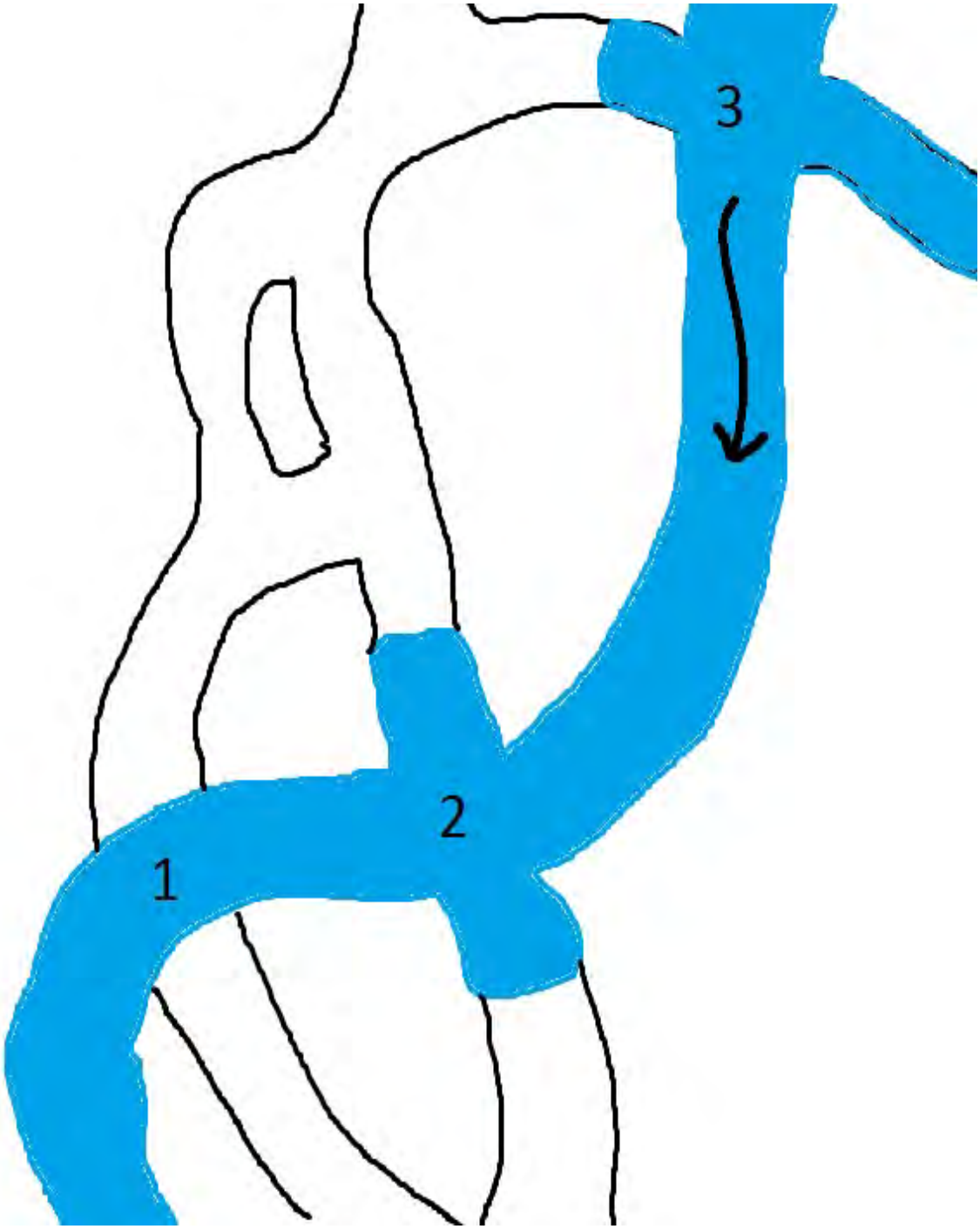

Figure 10. Depiction of "extremely degraded" crossings at Wolf Point 1. Blue indicates location of stream, arrow indicates stream flow, and numbers indicate three distinct trail crossings. This site had 6 points of entry into the stream, with a total ranking of 271.

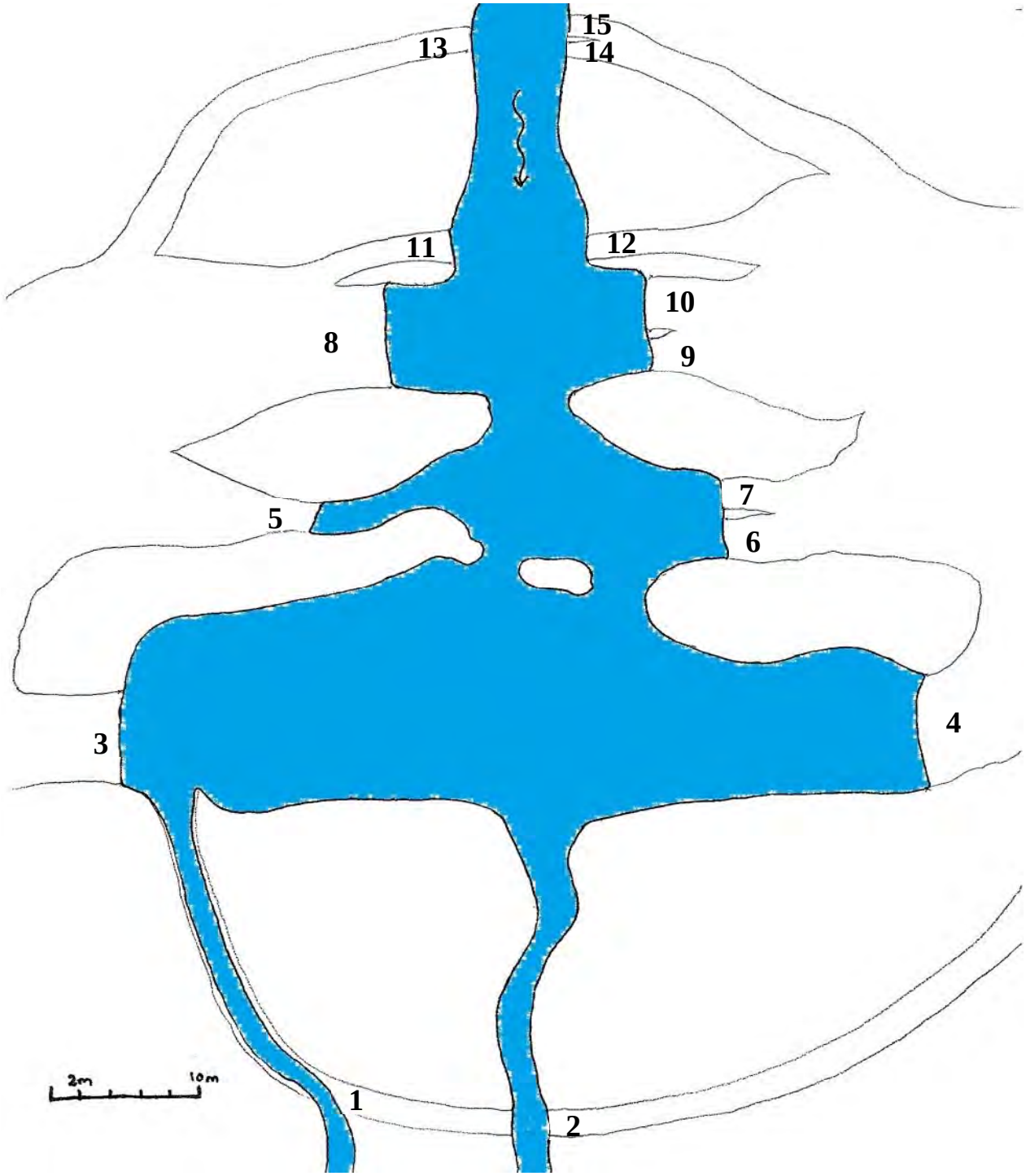

Figure 11. Depiction of an "extremely degraded" complex crossing at Wolf Point 4, which had 15 distinct points of entry into the stream. Blue indicates stream location, arrow indicates stream flow direction, numbers show individual entry points where stream assessments were conducted. This site had the highest total ranking of 1406.

Figure 12. Example of an "extremely degraded" stream crossing at Plumley-Maud 1 looking upstream. The stream was diverted from its original channel and in this section flowed along the path of the ORV trail for 58.2 meters before returning back into its original channel. This site had a total ranking of 159.

Figure 13. Example of an "extremely degraded" stream crossing at Rippy 4 looking downstream. Photo shows where the stream was diverted from its original channel and was flowing along the path of the ORV trail for 40.0 meters before returning back into its channel. This site had a total ranking of 97.

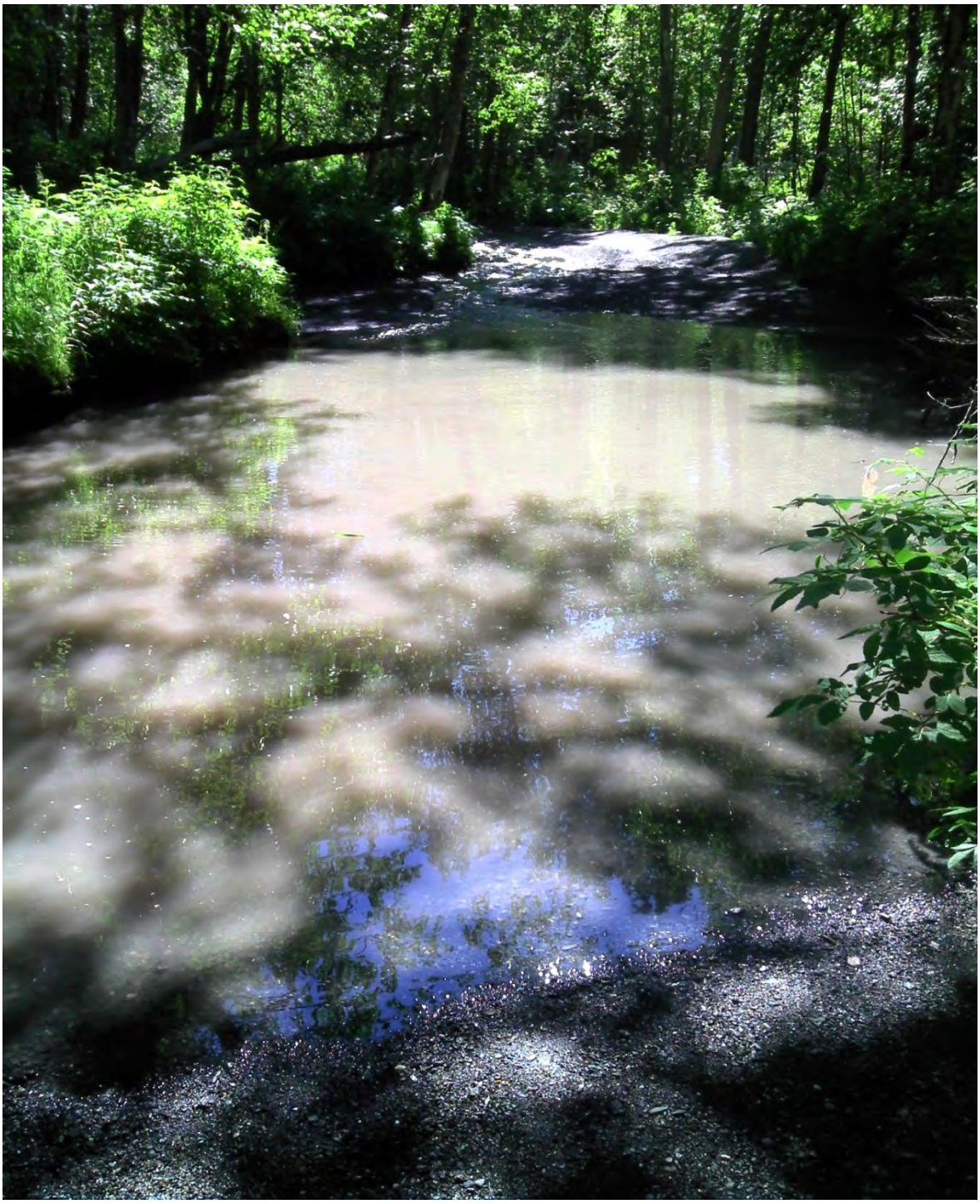

Figure 14. Example of an "extremely degraded" stream crossing at Wolf Point 3 looking upstream. The stream was diverted from its original channel and was flowing along the path of the ORV trail for 53.7 meters. Photo shows where stream was pooling on the trail as seen in the foregorund before flowing back into the woods. This site had a total ranking of 218.