# APPENDIX 6.3.1-E

## Fish Habitat Quantification Report

# SHORE GOLD STAR-ORION SOUTH DIAMOND PROJECT FISH HABITAT QUANTIFICATION REPORT

*Draft Report*

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# 1.0 INTRODUCTION

## 1.1 Background

The proposed Star-Orion South Diamond Project (the Project) includes the development of two open pit mines at the Star Kimberlite and Orion South sites, as well as the construction of processing facilities and associated infrastructure to commercially extract diamonds from the kimberlite. The potential development site is located in the Fort à la Corne Provincial Forest (FalC), approximately 65 kilometres east of Prince Albert, Saskatchewan (Figure 1). The Project footprint in the FalC will be approximately 4,000 hectares (3.0% of the forest).

Shore Gold Inc., the major proponent of the Project, is currently in the process of completing revisions to the Project's Environmental Impact Statement (EIS). Part of this process includes addressing potential impacts of the Project on fish habitat in the local study area with Fisheries and Oceans Canada (DFO).

## 1.2 Regulatory Context

It is assumed that construction and operation of the Project will result in the harmful alteration, disruption, or destruction (HADD) of fish habitat in the local watershed. A HADD of fish habitat is defined as "any change in fish habitat that reduces its capacity to support one or more life processes of fish" (DFO 1998). An implicit assumption in the application of this definition to habitat compensation planning is that any reduction in the capacity of the habitat to support the life processes of fish will also reduce the capacity of the habitat to produce fish (DFO 1998). Thus, a link is made between a HADD of fish habitat, which is dealt with explicitly in the *Fisheries Act*, and the habitat's productive capacity, which underlies DFO's guiding principle for the management of fish habitat in Canada. Mitigation measures are being incorporated into the Project to minimize these losses and are explained below, however, residual impacts to fish habitat in tributaries of the Saskatchewan River are unavoidable. The federal *Fisheries Act* prohibits the HADD of fish habitat in Canada. However, Section 35(2) of the *Fisheries Act* allows DFO to authorize the HADD of fish habitat if DFO is satisfied that all HADDs can be compensated such that there is "no-net-loss of productive capacity" (NNL) of fish habitat.

Section 34 of the *Fisheries Act* defines fish habitat as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes." By this definition, fish habitat includes areas that currently produce fish, or that could potentially produce fish, or areas that provide the nutrients, water, or food supply to fish-bearing habitat downstream. Because the Project will result in a HADD, it requires compensation in order to achieve NNL of productive capacity. The amount of compensation must be determined based on the residual net loss of productive capacity after relocation, redesign, and mitigation are accounted for.

In order to move ahead with the Project, Shore Gold Inc. must negotiate a Fish Habitat Compensation Agreement with DFO and secure federal approvals. According to Section 35(2) of the *Fisheries Act*, the development of a Fish Habitat Compensation Agreement must include a quantitative assessment of the fish habitat that would be lost due to the proposed development footprint of the Project.

### 1.3 Potential Impacts on Fish Habitat

From 2006 to 2008, extensive aquatic baseline studies were conducted in the Project Local Study Area (LSA). Within the Project LSA, there are nine tributaries that drain into the Saskatchewan River (Figure 2), all of which were predicted to be impacted by the development either directly or indirectly. Some of these tributaries are fish-bearing and are therefore considered fish habitat, therefore the aquatic baseline studies included fish habitat assessments in each of the nine tributaries. The study areas included the lower reach of each tributary (from the mouth to approximately 500 m upstream of the Saskatchewan River), as well as areas that were predicted to be directly lost due to development of the Project. This included the following:

- the upper reach of 101 Ravine was to be lost due to the Overburden and Rock Storage Area (ORSA);
- the upper reaches of West and East ravines were to be lost due to the Star Pit (SP);
- Duke Ravine was to be lost due to the Processed Kimberlite Containment Facility (PKCF), the Water Reservoir (WR), and treated process water discharge; and,
- the upper reach of Wapiti Ravine was to be lost due to the Coarse Processed Kimberlite pile (CPK).

At the time the aquatic baseline studies were completed, the proposed location of the WR was in the upper reaches of East Ravine, thus this area was assessed and the area of Duke Ravine that will now be occupied by the WR was not assessed.

In order to mitigate impacts to fish habitat, a number of ground developments have been moved and/or redesigned to avoid directly impacting nearby tributaries (Figure 3). The ORSA has been moved to the west of 101 Ravine so that only a small portion of three feeder tributaries to the main channel will be lost. East Ravine will be directly impacted by the site access road, Orion South Pit (OSP), and the SP. The site access road will cross through East Ravine with a substantial embankment and culvert. Mining of the SP will result in the removal of a portion of East Ravine, from which flows will be temporarily diverted to flow to its natural outlet. As mining of the SP progresses, this natural outlet will be blocked and water from the upper reaches of East Ravine will be diverted to a polishing pond and used for site activities (i.e., dust suppression) or to supplement flows in local drainages affected by pit dewatering. At closure the middle reaches of East Ravine will be re-established so that catchment water flows into the SP which in turn discharges into the undisturbed lower reaches of East Ravine, and eventually flows into the Saskatchewan River. The PKCF has also been moved so that it no longer impacts Duke Ravine; however, it will receive discharges from the sewage lagoon.

### 1.4 Scope of Report

The purpose of this report is to determine the quantity of fish habitat within the Project local study area that will be lost as a result of the Project development. Report objectives include:

- classifying habitat types within each tributary potentially impacted by the Project;
- quantifying the available habitat; and,
- analysis of the accuracy of the desktop approach by comparing the results of the desktop approach to field information collected in the Project study area in 2007 and 2008.

## 2.0 CHARACTERIZATION OF TRIBUTARIES

The purpose of this section is to provide site characterization information on the fish communities, fish spawning, and fish habitat present in the tributaries potentially impacted by the Project, which were assessed during baseline investigations conducted in 2007 and 2008 (CanNorth 2010).

### 2.1 Aquatic Habitat Characterization

The assessment of potential critical fish habitat was modified after the Habitat Evaluation Procedure (HEP) developed by the U.S. Fish and Wildlife Service (Cowardin et al. 1979; Busch and Sly 1992) and guidance documents (e.g. DFO and BC Ministry of Environment and Parks 1987; Orth 1989; Ontario MNR 1989; Plafkin et al. 1989; Langhorne et al. 2001) recommended in the Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring (Environment Canada 2002). An overview of the results of the habitat assessments is provided below. Representative photographs of the aquatic habitat present within each study reach are provided in Appendix A.

#### 2.1.1 East Ravine

A detailed assessment of the quantity and quality of critical fish habitat in East Ravine within 500 m of the Saskatchewan River was conducted in August 2007. Habitat assessments were also conducted for the portion of East Ravine within the Star Open Pit area and the previous location of the water reservoir area in the summer of 2008.

Throughout the downstream portion of the lower reach of East Ravine, the riparian zone was predominantly forested with steep and slightly unstable slopes that were vegetated with shrubs and/or trees. Substrate in this reach of the stream contained varying proportions of sand, gravel, cobble, and boulder, with very little silt/clay and no organic matter. Cover was provided by sparse to dense quantities of large woody debris and overhanging vegetation, sparse undercut banks, or boulder. The habitat type was dominated by riffles and runs, and obstructions (waterfalls, chutes, log jams, and beaver dams) were present throughout the lower reach. There was almost a complete lack of aquatic vegetation throughout this section of East Ravine. Mean wetted width ranged from 1.0 m to 2.1 m and maximum depth ranged between 0.22 m and 0.54 m. A wetland was present in the upstream half of the assessed area, and was vegetated by grasses, sedges, shrubs, and trees. The substrate here and nearest to the Saskatchewan River was mostly or completely sand.

The middle reach of East Ravine contained three major sections: west and east branches of the creek and the section downstream from the confluence of these branches. Wetlands with stable or slightly unstable banks vegetated with shrubs, grasses, and sedges dominated the eastern branch of the creek upstream of the confluence. The shorter western branch had forest or transitional vegetation (shrubs, grasses, and sedges) on its gentle to moderate slopes, with the forested banks being stable and the banks with transitional vegetation being highly unstable. Downstream of the confluence, the riparian zone was forested, with predominantly steep, slightly unstable slopes vegetated with trees, shrubs, grasses, and sedges. In all three major sections, the substrate consisted of sand and silt/clay, generally lacked gravel and organic matter, and completely lacked boulders. Large woody debris, aquatic vegetation, overhanging vegetation, and/or undercut banks provided fish cover in the majority of this reach. Aquatic vegetation was dominated by sparse distributions of emergent species, but sparse to dense patches of floating leaf vegetation, submergent vegetation, and moss/algae were also present. Habitat type was variable, with riffles and pools dominating the west branch; runs, pools, and glides dominating the east branch; and the downstream section featuring riffles, runs, pools, and glides. Obstacles to fish passage, such as beaver dams and log jams, were found throughout this reach of East Ravine. In all three sections, the presence of beaver dams was correlated with pools and flooded areas with mean wetted widths ranging from 15 m to 60 m. In non-flooded sections, mean wetted width varied between 0.5 m and 1.8 m.

The upper reach of East Ravine was predominantly wetland with stable slopes vegetated with shrubs, grasses, and sedges. A third of the stream was forested with moderate to steep slopes and slightly unstable banks. The substrate was quite consistent throughout, consisting of silt/clay and organic matter, with some sand. Fish cover was available throughout this reach, mostly from moderate to dense distributions of aquatic vegetation, which was supplemented by large woody debris and overhanging vegetation. Aquatic vegetation, which was dominated by emergent vegetation, was observed throughout. Submergent vegetation, floating leaf vegetation, and algae/moss were also present in many areas. The habitat type varied considerably throughout the area assessed, but pools and glides were the most common habitat types observed. Pools had wetted mean widths ranging from 15 m to 80 m, and they either contained a beaver dam or were adjacent to an area that contained a beaver dam.

### 2.1.2 Caution Creek

A detailed assessment of the quantity and quality of critical fish habitat in Caution Creek within 500 m of the Saskatchewan River was conducted in August 2007.

The upland region along the portion of Caution Creek within 500 m of the Saskatchewan River consisted of mature, mixed (i.e., consists of both coniferous and deciduous trees) forest. The riparian zone was described, for the most part, as forest to bank with steep and slightly unstable slopes that were vegetated by trees and shrubs. At the riverbank and at the inland end of the habitat assessment, however, the upland slope became gentler and the tributary banks were vegetated by only grasses and sedges.

In terms of substrate composition, the tributary bed varied considerably throughout the reach surveyed, although there was a consistent lack of organic material. Substrate types included cobble and boulder mix, silt/clay mix, sand, and gravel. Although the substrate composition varied, there was a consistent absence of aquatic vegetation. The habitat type was variable throughout Caution Creek; however, riffles and runs were dominant. Another prevalent feature throughout were obstructions, as they were present throughout the reach surveyed. Mean wetted width varied between 2.0 m and 3.0 m and maximum depth was approximately 0.54 m. Fish passage from the Saskatchewan River was somewhat limited by fast flow and small obstructions such as boulders.

### 2.1.3 101 Ravine

A detailed assessment of the quantity and quality of critical fish habitat in 101 Ravine within 500 m of the Saskatchewan River was conducted in August 2007. Habitat assessments were also conducted for the portion of 101 Ravine within the former Overburden Disposal (OD) area in the summer of 2008.

The upland region of 101 Ravine within 500 m of the Saskatchewan River consisted of mature, mixed forest. Overall, the riparian zone was described as forest to bank with steep and slightly unstable slopes that were vegetated with trees and shrubs, except for at the riverbank and at the uppermost extent of the survey area, where the tributary banks were only vegetated by grasses and sedges. The substrate composition varied; however, there was a consistent lack of silt/clay and organic material. The substrate near the downstream extent of the survey was composed predominantly of boulder with some gravel and cobble; which then transitioned to mostly sand interspersed with sections of gravel, cobble, and boulder. There was a general absence of aquatic vegetation, except an area towards the upstream extent of the survey where a sparse amount of horsetail was observed. Habitat type was dominated by riffles and runs, and the channel's wetted width and maximum depths ranged from 0.95 m to 2.60 m and 0.20 m to 0.42 m, respectively. Another prevalent feature throughout were obstructions. Near the mouth of the tributary, a large waterfall/log jam was observed that would limit fish passage from the river into the stream in all but high water levels. It should be noted that this dam was present throughout all the surveys conducted in 101 Ravine.

The habitat in the middle reaches of 101 Ravine was also assessed. The upland region of this reach of 101 Ravine consisted of mature, mixed forest. The riparian zone was determined to be, for the most part, wetland with moderate to gentle sloped stable banks vegetated by shrubs, grasses, and sedges. However, there was a transitional area located between the two flooded wetlands that was vegetated with shrubs, grasses, sedges, and trees. In terms of the substrate, the tributary bed was predominantly composed of organic material with some silt/clay. The aquatic vegetation in this reach of 101 Ravine was much more prevalent and diverse as compared to the portion of the tributary within the vicinity of the river. Emergent vegetation (cattail (*Typha* sp.), sedge (*Carex* sp.), and rush (*Juncus* sp.)), floating leaf vegetation (yellow pond lily (*Nuphar* sp.)), and submergent vegetation (pondweed, and milfoil (*Myriophyllum sibericum*)) were present throughout the reach assessed. Furthermore, aquatic moss (feather moss (*Fontinalis* sp.)) was also quite prevalent. Aquatic vegetation, therefore, was determined to be dense to moderately dense. Throughout the reach assessed, the habitat type was classified as pool. These pool complexes were most likely the result of several beaver dams that created the formation of two large wetland complexes (mean wetted width ≥40 m), which were joined together by a stretch of narrower stream channel (mean wetted width ≤1 m).

### 2.1.4 West Perimeter Ravine

A detailed assessment of the quantity and quality of critical fish habitat in West Perimeter Ravine within 500 m of the Saskatchewan River was conducted in August 2007.

The upland region of West Perimeter Ravine consisted of mature, mixed forest. The riparian zone was categorized as grass to bank with steep and unstable slopes that were vegetated with shrubs, grasses, and sedges. The only exception was near the riverbank, where only grasses and sedges were present. In terms of substrate composition, there was a consistent lack of organic material and an overall absence of silt/clay. Most areas contained a mix of cobble, sand, and gravel. Although the substrate composition was variable, there was a general lack of aquatic vegetation, except for near the tributary mouth where a sparse amount of algae (Division Chlorophyta) was observed. The habitat type throughout the tributary was dominated by riffles and runs. Mean wetted width ranged between 0.5 m and 15.0 m and maximum depth varied between 0.05 m and 0.3 m. Another prevalent feature was logjams, a number of which were present throughout this portion of West Perimeter Ravine, except at the riverbank. Fish passage from the Saskatchewan River into West Perimeter Ravine is likely hindered due to a large log/rock jam near the mouth, creating a steep gradient below which water flow was minimal (depth = 0.03 m).

### 2.1.5 West Ravine

A detailed assessment of the quantity and quality of critical fish habitat in West Ravine within 500 m of the Saskatchewan River was conducted in August 2007. A Habitat assessment was also conducted for the portion of West Ravine within the former POP in the summer of 2008.

The upland region of West Ravine within 500 m of the river consisted of mature, mixed forest. With the exception of the riverbank, the riparian zone was categorized as forest to bank with steep and slightly unstable banks that were vegetated by trees and/or shrubs. At the riverbank, the tributary banks were vegetated by grasses and sedges. In terms of substrate composition, there was a complete absence of organic material and an overall lack of silt/clay, except at the riverbank where some silt/clay was noted. The substrate composition for the most part was dominated by sand, except in two areas where the substrate consisted of boulder and boulder with some gravel and cobble. Throughout the study reach, there was a complete absence of aquatic vegetation and the habitat type was dominated by riffles and runs. Mean wetted width ranged from 0.38 m to 1.00 m and maximum depth varied between 0.14 m and 0.37 m. Other prevalent features were obstructions. West Ravine runs underground for approximately 7 m at a location approximately 100 m upstream from the mouth of the Saskatchewan River. This subsurface flow likely prevents fish passage further upstream.

Within the upper reach of West Ravine, the upland region consisted mostly of mature, mixed forest. The riparian zone in the majority of the area assessed consisted of forest to bank with moderately steep and slightly unstable banks that were vegetated with shrubs, grasses, and sedges. However, the study reach was interspersed with a few wetland areas, which featured gently sloping banks that were vegetated with shrubs, grasses, and sedges. The substrate composition throughout the area assessed was depositional, consisting of a complex of sand, silt, clay, and organic material. Aquatic vegetation was consistently absent throughout the lower part of the study reach, but transitioned from a sparse amount of emergent vegetation (sedges) to dense amounts, mostly emergent sedges and mare's tail (*Hippurus vulgaris*), submergent pondweeds and stonewort (*Chara vulgaris*), and algae.

The habitat type varied throughout the upper reach, as there were areas dominated by riffle, run, glide, or pool habitat. In addition to having less vegetation and overall more riffles and run habitat, the lower section was much narrower (mean wetted width ≤1 m) as compared to the upper sections. The greater width appears to be associated with pooling because of beaver dams, which were present throughout the upper reach surveyed.

### 2.1.6 Duke Ravine

A detailed assessment of the quantity and quality of critical fish habitat in Duke Ravine within 500 m of the Saskatchewan River was conducted in August 2007. A habitat assessment was also conducted for the portion of Duke Ravine within the former PKCF in the summer of 2008.

For the most part, the upland region of the portion of Duke Ravine within 500 m of the river was determined to be mature, mixed forest, except for the part of the tributary at the riverbank where the tributary entered a grassy area. Upstream from the riverbank, the tributary entered a transitional area where the riparian zone became a forested area with steep stable slopes vegetated by trees, shrubs, grasses, and sedges. The substrate throughout the study reach was quite variable, except for a complete lack of organic material and general absence of silt/clay. Substrates consisted of a mixture of sand, cobble, gravel, and boulder. Overall, aquatic vegetation was not prevalent throughout the study reach, as only sparse amounts of emergent vegetation (sedges) were observed in some areas, along with a sparse amount of algae in an area just upstream of the tributary mouth. The habitat type was dominated by riffles, except at the upstream extent of the habitat assessment where glide became the dominant habitat type. Mean wetted width ranged from 0.1 m to 4.0 m and maximum depth was <0.25 m. Obstructions (logjams and small waterfalls) were observed in a number of areas. Steep gradient and shallow depths (0.1 m) near the tributary mouth make fish passage from the river into Duke Ravine unlikely.

For the upper reach of Duke Ravine, the upland region consisted mostly of mature, mixed forest. The riparian zone was consistently described as forest to bank with stable slopes vegetated by trees, shrubs, grasses, and sedges. The substrate within the area assessed was quite consistent, as there was a complete absence of gravel, cobble, and boulder. Aquatic vegetation was not prevalent throughout the habitat assessed. Only a sparse amount of aquatic vegetation was found throughout the study reach, including sedges, floating pondweeds, common duckweed (*Lemma minor*), feather moss, and algae. A number of areas in this study reach were comprised solely of pool habitat, were wide (≥40 m), and were separated by beaver dams. These pool complexes were interspersed with glide type habitats.

### 2.1.7 FalC Ravine

A detailed assessment of the quantity and quality of critical fish habitat in FalC Ravine within 500 m of the Saskatchewan River was conducted in the summer of 2008.

The upland region of the portion of FalC Ravine at the bank of the Saskatchewan River contained stable gentle slopes vegetated with grasses and sedges, while steeper slopes vegetated by trees and shrubs characterized the remainder of the habitat assessment. The mature forest was composed solely of deciduous species near the river, but coniferous species were also present further upstream. In terms of substrate, the tributary bed was variable throughout the area assessed, with areas dominated by gravel, cobble, sand, and/or silt/clay. Although the substrate was observed to vary considerably throughout the area, there was a consistent lack of aquatic vegetation. Habitat type was seen to vary considerably, except for a complete absent of the pool habitat type throughout. Mean wetted width ranged from 0.2 m to 1.0 m, but was usually <0.4 m. Maximum depth was generally <0.05 m. Obstructions were prevalent, with waterfalls, logjams, or subsurface flow being common. Due to the steep gradient, shallow depths, and obstructions, fish passage from the Saskatchewan River into FALC Ravine is likely not possible.

### 2.1.8 Wapiti Ravine

A detailed assessment of the quantity and quality of critical fish habitat in Wapiti Ravine within 500 m of the Saskatchewan River was conducted in August 2008.

The upland region of the portion of Wapiti Ravine within 500 m of the river consisted of mature, mixed forest, except for the upstream end of the study reach where the tributary flowed through a grassland area. The riparian zone was mostly described as forest to bank with steep stable slopes vegetated by trees and shrubs. After the forested area, the now moderately sloped banks were vegetated with grasses and sedges. Substrate composition varied considerably, except for a complete lack of organic material and a generally low contribution of silt/clay. Habitat type, for the most part, consisted of glide/run and riffle. Mean wetted width was usually <0.6 m and maximum depths ranged from 0.03 m to 0.4 m. A number of logjams were observed in the study reach. Similar to Duke and FALC ravines, the mouth of Wapiti Ravine featured a narrow, shallow channel with a steep gradient which presented a barrier to fish movement upstream.

#### 2.1.9 English Creek

A detailed assessment of the quantity and quality of critical fish habitat in English Creek within 500 m of the Saskatchewan River was conducted in August 2007. A habitat assessment was also conducted for the portion of English Creek within the former CPK in the summer of 2008.

The upland region of the portion of English Creek within 500 m of the river consisted of mature, mixed forest. The riparian zone was described as forest to bank with steep slightly unstable slopes that were vegetated by trees and/or shrubs, except for at the riverbank and at the upstream extent of the study reach. In terms of substrate composition, the tributary bed was observed to vary considerably throughout, although there was a consistent lack of organic material. There was an overall lack of aquatic vegetation, except for a sparse amount of algae in some areas. The habitat type was predominantly riffles and runs, but glides were also prevalent. Obstructions were also noted throughout the study reach. Fish passage from the Saskatchewan River into English Creek is possible in the lower reach of the tributary; however, the presence of some larger beaver dams located further upstream would likely hinder migration potential under most flow conditions.

For the upper reach of English Creek, the upland region consisted of regenerating, mixed forest. The riparian zone was described mostly as a transitional zone with gently sloping stable banks vegetated with trees, shrubs, grasses, and sedges, although one wetland area was noted as well. The substrate was predominantly composed of organic material with a significant contribution of silt/clay. Aquatic vegetation was dense throughout the study reach. Emergent vegetation (cattail, sedge, and rush) was present throughout the study reach, with floating vegetation such as Leiberg's water lily (*Nymphaea leibergii*) and Gmelin's crowfoot (*Ranunculus gmelinii*) noted in nearly all areas of the study reach. Submergent vegetation (pondweed, stonewort, and bladderwort (*Utricularia vulgaris*)) was also noted throughout the study reach, as were algae and feather moss. Pools were the dominant habitat type due to a number of beaver dams in this study reach.

### 2.2 Fish Community and Spawning Surveys

#### 2.2.1 East Ravine

Fish community surveys were completed in the lower reach of East Ravine in August 2007, and within the areas of East Ravine proposed for development of the Star Open Pit and water reservoir in 2008. Spring and fall spawning surveys were completed in the lower reach of East Ravine in May and November 2007.

In the lower section of East Ravine (from the Saskatchewan River to approximately 500 m upstream), 8 hoop nets set overnight at the mouth of the tributary during the spring of 2007 resulted in the capture of 11 white sucker (*Catostomus commersoni*) and 3 walleye (*Sander* *vitreus*). The white sucker captured were adults in ripe condition (four females), running ripe condition (one female and five males), and spent condition (one female). White sucker spawning habitat was located approximately 50 m upstream of the Saskatchewan River during the spring spawning survey (Appendix A, Photo 3) and adult white sucker were observed at this site. All three of the walleye captured in the hoop net at East Ravine were in unknown spawning condition. Kick netting was conducted in areas of the creek during the spring and fall spawning surveys, however, no fish eggs were located.

In the summer of 2007, 2 sets of 7 minnow traps were set overnight in lower East Ravine resulting in the capture of 38 fish, including 18 lake chub (*Couesius plumbeus*), 17 white sucker, 2 emerald shiner (*Notropis atherinoides*), and 1 burbot (*Lota lota*). The white sucker captured were all juveniles and the lengths ranged from 4.2 to 9.7 cm. Additionally, 2,509 s of backpack electrofishing resulted in the capture of 24 fish, including 16 lake chub, 7 white sucker, and 1 burbot. The lengths of the white sucker ranged from 5.9 to 15.0 cm.

Fish community surveys were completed in the summer of 2008 in the middle reaches of East Ravine that will likely be lost due to development of the Star Pit. A total of 1,487 s of backpack electrofishing resulted in the capture of 26 fish, including 14 lake chub, 10 white sucker, and 2 northern redbelly dace (*Phoenix eos*). The white sucker ranged in length from 4.1 to 10.5 cm. In addition, 126.1 hrs of minnow trap sets resulted in the capture of 433 fish, which included 232 lake chub, 192 northern redbelly dace, 4 pearl dace (*Semotilus margarita*), 2 river shiner (*Notropis blennius*), and 3 white sucker (ranging in length from 10.9 to 11.9 cm).

In the summer of 2008, a fish community survey was conducted in the upper reaches of East Ravine that was going to be lost due to the development of the water reservoir; however, as mentioned previously, the location of the water reservoir has subsequently been moved to Duke Ravine. A total of 917 s of backpack electrofishing effort resulted in the capture of 37 fish, including 36 northern redbelly dace and 1 white sucker (10.5 cm in length). All of these fish were caught in the lower section of this area. A total of 277.2 hrs of minnow trapping resulted in the capture of 416 northern redbelly dace, 6 lake chub, and 7 white sucker 8.8 to 13.4 cm in length.

### 2.2.2 Caution Creek

In the Caution Creek tributary, no effort was made to capture fish in the spring of 2007 because a spawning survey had already been completed in 2006 during which no fish were captured (Golder 2006). In the summer of 2007, 2 sets of 9 minnow traps were set overnight (total effort 366.0 hr) resulting in the capture of 2 brook stickleback, while 1,575 s of backpack electrofishing effort resulted in the capture of no fish. Furthermore, in the fall of 2007, 629 s of backpack electrofishing effort and 21.5 hr of hoop netting resulted in the capture of no fish.

### 2.2.3 101 Ravine

In the lower portion of 101 Ravine, no effort was made to capture fish in the spring or fall of 2007 due to the size of the tributary mouth (i.e., inability to set a hoop net). However, in the summer, 2 sets of 9 minnow traps were set overnight (total effort 468 hr) resulting in the capture of 40 lake chub. An additional 1,494 s of backpack electrofishing effort resulted in the captured of 2 more lake chub (CPUE: 4.82 fish/hr).

In the summer of 2008, within the portion of 101 Ravine in the former OD area, 2,280 s of backpack electrofishing resulted in the capture of 29 northern redbelly dace (CUPE: 45.79 fish/hr) and 10 overnight minnow traps (total effort of 219.2 hr) resulted in the capture of 671 fish: 450 northern redbelly dace, 217 lake chub, and 4 fathead minnow. Furthermore, one location deep and wide enough to allow for a spawning net was accessed and a total effort of 27.9 hr resulted in the capture of no fish.

### 2.2.4 West Perimeter Ravine

No fish were captured during the fish spawning and community surveys completed in 2007.

### 2.2.5 West Ravine

In the portion of West Ravine within 500 m of the Saskatchewan River, 8 overnight hoop net sets were conducted in the spring of 2007 (total effort 190.08 hr) at the mouth of the tributary resulting in the capture of no fish. Furthermore, in the summer of 2007, 15 minnow traps were set overnight (total effort 306.33 hr) resulting in the capture of no fish. However, 1063 s of backpacking electrofishing during the summer survey did result in the capture of 1 lake chub (CPUE: 3.39 fish/hr).

In the portion of West Ravine within the former Star Pit area, summer fish community surveys were also completed and a backpack electrofishing effort of 1035 s, in addition to 102 hr of minnow trapping effort, resulted in the capture of no fish.

### 2.2.6 Duke Ravine

The proposed future site of effluent discharge will be Duke Ravine. The 2008 spring spawning survey in the portion of Duke Ravine within 500 m of the Saskatchewan River included a series of four trap nets and this effort (total effort 117 hr) resulted in the capture of no fish. In the summer of 2008, in the initial two survey sections, 919 s of backpack electrofishing effort was conducted resulting in the capture of 22 fish: 10 juvenile white sucker, 6 northern redbelly dace, 5 fathead minnow, and 1 longnose dace (CPUE: 39.17, 23.50, 19.59, and 3.52 fish/hr, respectively). Furthermore, the summer survey also included a series of nine minnow traps that were set overnight for two consecutive days, followed by an additional set of five traps set overnight for three consecutive days. The total effort of 616.9 hr resulted in the capture of 69 fish: 38 juvenile white sucker, 18 fathead minnow, 8 longnose dace, 3 lake chub, and 2 northern redbelly dace.

In the portion of Duke Ravine within the former PKCF, 445 s of backpack electrofishing resulted in the capture of 12 fathead minnow and 1 longnose dace (CPUE: 77.08 and 8.09 fish/hr, respectively). An additional, 109.8 hr of minnow trapping resulted in the capture of 246 fish: 195 northern redbelly dace, 36 fathead minnow, 10 longnose dace, and 5 lake chub.

### 2.2.7 FalC Ravine

No fish were captured during the 2008 fish spawning and community surveys.

### 2.2.8 Wapiti Ravine

No fish were captured during the 2008 fish spawning and community surveys.

### 2.2.9 English Creek

In the portion of English Creek within 500 m of the Saskatchewan River, seven overnight hoop net/trap net sets were conducted in the spring of 2007. The total effort of 166.0 hr resulted in the capture of two juvenile white sucker. During the 2006 spring spawning survey, a short-length gill net set in English Creek resulted in the capture of two adult white sucker (Golder 2006).

In the summer, 16 minnow traps were set overnight and the 365.36 hr effort resulted in the capture of 37 fish, including 19 white sucker, 11 lake chub, and 7 brook stickleback. An additional 4816 s of backpack electrofishing resulted in the capture of 110 fish, including 55 lake chub (CPUE: 41.11 fish/hr), 26 white sucker (CPUE: 19.44 fish/hr), 17 brook stickleback (CPUE: 12.71 fish/hr), 7 emerald shiner (CPUE: 5.23 fish/hr), 2 fathead minnow (CPUE 1.50 fish/hr), 2 walleye (CPUE: 1.50 fish/hr), and 1 longnose sucker (CPUE: 0.75 fish/hr). However, in the fall 514 s of backpack electrofishing resulted in the capture of no fish. In the portion of English Creek within the CPK, a total backpack electrofishing effort of 162 s resulted in the capture of 70 fish, including 42 fathead minnow, 25 northern redbelly dace, and 3 brook stickleback (CPUE: 933.33, 555.56, and 66.67 fish/hr, respectively). All white sucker captured during the summer community surveys were juveniles (<15 cm in length).

## 3.0 METHODS

### 3.1 Background

To calculate the quantity and quality of fish habitat in a study area, ideally a field habitat assessment would be completed on all areas being impacted by the Project. As discussed in Section 2.0, detailed aquatic habitat assessments were conducted in portions of each tributary anticipated to be impacted by the Project, however, considering the size of the study area, the difficult terrain, and the complex habitat types, completing field habitat assessments on all areas of the tributaries that will be impacted by the Project was not deemed practical. Thus, a desktop approach that incorporates the use of LiDAR (Light Detection and Ranging) imagery (taken in 2005), aerial photography (taken in 2007), and field information (obtained during surveys completed in 2007, 2008, and 2011) is being utilized in order to quantify potential habitat losses due to the Project.

The approach classifies tributaries potentially impacted by the Project into different habitat types (pool, riffle, and run habitats) based on stream gradient slope differences using LiDAR imagery and aerial photography. Detailed information on the use of LiDAR imagery, aerial photography, and field data to calculate the quantity of each habitat type identified in the tributaries potentially impacted by the Project is provided below.

### 3.2 Stream Habitat Classification

Stream gradient is a useful guide for identifying and classifying stream reaches because it links hydrological processes, channel form and substrate materials. These processes and features result in a range of fish habitats with varying abilities to support fish. Differing habitat types (pool, run, and riffle) can be used to describe use by fish species, however, identification of pools, runs, and riffles has long been a problem as many researchers identify a habitat type without stating the criteria (Jowett 1993). Specific criteria have been proposed, including definitions based on stream bed topography, as pools and riffles have been defined as undulations in stream bed topography (O'Neill and Abrahams 1984).

Jowett (1993) compared hydraulic characteristics of stream habitats to derive a classification criterion that can be used to assess whether biological sampling locations are typical of the habitat types they represent, and found that slope was positively related to substrate size and negatively related to depth and relative roughness. Velocity/depth ratio and velocity were highly correlated, with the velocity/depth ratio most closely related to habitat type. Hydraulically, water surface slope must be the prime determinant of habitat type (Jowett 1993). Pools occur only where the local stream gradient is low and riffles in areas where the gradient is high. Slope determines both the water depth and velocity, which in turn are used in most definitions of pools, runs, and riffles (Henderson 1966).

Using information from the literature, as well as site-specific information collected during the habitat assessments, the following criteria were used to determine habitat types in the tributaries potentially impacted by the Project:

| Habitat | Definition |
|---|---|
| **Riffle** | Stream sections with steep gradient (>3º), fast water velocities (up to 0.5 m/sec), shallow depth (<0.5 m), and partially to total submerged gravel, cobble, or boulder substrates with turbulent flow. |

| Habitat | Definition |
|---|---|
| **Run** | Stream sections with moderate gradient (1 to 3º), deeper depths (0.5 to 0.75 m), and slower water velocities (<0.5 m/sec) than riffles. Some accumulations of silt/clay/sand on and between gravel and cobble substrates. No surface turbulence. |
| **Pool** | Stream sections with a low gradient (<1º), water depths often greater than 1 m, with water velocities less than 0.2 m/sec. Accumulations of silt, clay, sand, and/or fine organic material overtop of gravel, cobble, or boulder substrates. |

### 3.2.1 Defining Habitat Types Using LiDAR

LiDAR is an optical remote sensing technology that measures properties of scattered light to find range and/or other information of a distant target. LiDAR instruments can measure the location of objects in x, y, z space when an emitted laser pulse strikes a target surface and returns a portion of that laser energy to the sensor. The laser wavelength employed in a particular LiDAR instrument largely determined its interaction (or lack thereof) with various surface types, and therefore dictates how the 3D structure of potential habitat is recorded by the sensor. Using this technology, the differing slope found in the study area can be delineated, in turn defining habitat types throughout the stream as pool, run, or riffle using slope as the defining criteria.

Habitat types (pool, riffle, and run) were classified and mapped for the tributaries potentially impacted by the Project using the hydrology tools within ESRI ArcGIS 9.3, together with a LiDAR derived digital elevation model (DEM) and an orthorectifed digital aerial photograph of the area. Below is a detailed description of the procedures used to classify each tributary into pool, run, and riffle habitat types.

#### 3.2.1.1 Stream Channel Definition

**ArcGIS Hydrology Tools**

The location of the stream channel was defined from an analysis of a high resolution (1 m accuracy) LiDAR-derived DEM using the hydrology toolset in ArcGIS. First, the DEM was clipped to the region of interest, which included the main drainage area of the tributary and adjacent uplands draining towards the stream, but excluded neighbouring ravines. Using the *fill* tool, any sinks or areas of internal drainage within the DEM were identified and filled to remove small imperfections in the data. Based on the modified DEM created from the fill tool, a raster of flow direction from each cell to its steepest downslope neighbour was created using the *flow direction* tool. The *flow accumulation* tool was used to create a raster of accumulated flow to each cell by accumulating the weight for all cells that flow into each downslope cell. To define the stream channels, a threshold of $6.0 \times 10^4$ cells (each 1 $m^2$ in area) was applied to this raster, where values greater than this threshold were assigned a value of 1 and those less the threshold were classified as 'NoData.' This seemed to represent an appropriate limit to define the channels, which approximately corresponded in length with those defined in the National Topographic Database stream vectors. Finally, the *StreamShape* tool was used to convert the grid representing the raster linear stream network into a shapefile.

**Manual Editing**

To check the accuracy of the above method for predicting the channel locations, a comparison was made with the aerial photography available for this region. In areas where the stream network was clearly visible within the imagery, the stream network was overlain on the imagery to assess how well the predicted channel locations corresponded with the actual locations. The comparison showed that for the most part, this approach produced a close correspondence with the actual channel locations. In a few selected areas where it was clear that the approach failed to place the stream in the correct locations within the ravine, the line was manually edited to correct the position.

A number of beaver ponds were apparent in the aerial photography which could not be represented as part of the stream network using the hydrology tools as described above. To define these areas, a separate shapefile was created and polygons were manually digitized around the boundaries of these ponds.

#### 3.2.1.2 Extracting Slope Profiles and Defining Habitat

Habitat classification was performed by analyzing the longitudinal channel gradient. To extract the channel profile, a series of nodes was placed along the line network representing the stream channel at a 10-m interval. At each of the nodes, the value of the DEM was extracted. These elevation values were plotted graphically against distance from the stream mouth at the Saskatchewan River to analyze the channel profile gradient.

Habitat types were defined from a classification of the channel gradient. Slopes greater than 3° were defined as riffle habitat, those with a value between 1 and 3° were defined as run habitat, and those less than 1° were defined as pool habitat.

First, the slope values were determined for each of the 10-m channel reaches between nodes to determine the slope at this scale, and the habitat classification was based on these values. Another approach was to identify and classify the habitat sections manually based on the channel profile graph. In this case, the same slope criteria were used to distinguish the different habitat types. Sections of channel habitat were identified between nodes and over greater distance where the slope was relatively constant. These sections were then used to split the linear channel network in ArcGIS, and the lengths of each section were defined.

The lengths of each habitat type classified using the stream network shapefile were used to calculate the total area potentially impacted by the construction and operation of the Project (Table 1). This approach was recommended in Faux et al. (2009) as the best way to represent the actual stream slope. It is a more realistic representation of the true stream surface slope than taking the GIS calculated point scale values of slope along the channel, or average slope over larger areas that might include some of the adjacent banks and floodplain area.

### 3.2.2 Calculation of Areal Quantity of Habitat

The average widths of the tributaries assessed were calculated using the wetted widths of riffle and run type habitats measured during field assessments of aquatic habitat undertaken in 2007 and 2008 (Table 1). The resulting average was applied to all habitat types. The quantity of habitat was calculated by multiplying the average width of each tributary by the length of each habitat type, as determined using the procedure described above. In addition, the areal quantity of pool habitat within beaver ponds was represented by summing the area within individual shapefiles created to delineate the boundaries of these ponds (Table 2). The resulting number represents the areal amount of each habitat type (in $m^2$).

## 4.0 RESULTS

### 4.1 Calculation of Areal Quantity of Habitat

The areal quantity of each habitat type delineated for each tributary is presented in Table 3, and habitat types in each tributary are shown in Figures 4 to 12. A total of 948,946 $m^2$ of pool habitat, 40,384 $m^2$ of run habitat, and 8,065 $m^2$ of riffle habitat were available throughout the tributaries potentially impacted by the Project. In general, pools were the most common habitat type throughout the study area, followed by runs and riffles.

#### 4.1.1 East Ravine

A total 71,156 $m^2$ of pool habitat, 3,740 $m^2$ of run habitat, and 1,207 $m^2$ of riffle habitat were available in the East Ravine study area (Table 3; Figure 7). Slow flowing pool habitat accounted for 93.5% of the total habitat available in East Ravine, while intermediate runs accounted for 4.9%, and faster flowing riffle habitat accounted for 1.6% of the total habitat assessed.

#### 4.1.2 Caution Creek

In Caution Creek, a total of 180,481 $m^2$ of pool habitat, 10,738 $m^2$ of run habitat, and 1,378 $m^2$ of riffle habitat were delineated (Table 3; Figure 5). Pools were the most common habitat type within the tributary, accounting for 93.7% of the areal quantity of habitat, followed by run (5.6%) and riffle (0.7%) habitat types.

#### 4.1.3 101 Ravine

A total of $121{,}978^2$ of pool habitat, 4,830 $m^2$ of run habitat, and 1,378 $m^2$ of riffle habitat were available in 101 Ravine, accounting for 95.7%, 3.8%, and 0.5% of the total available habitat within the tributary, respectively (Table 3; Figure 6).

#### 4.1.4 West Perimeter Ravine

In West Perimeter Ravine, a total of 20,726 $m^2$ of pool habitat, 4,320$m^2$ of run habitat, and 1,024 $m^2$ of riffle habitat were delineated (Table 3; Figure 7). Of the total quantity of habitat available in the tributary, pool habitat accounted for 79.5%, run habitat accounted for 16.6%, and riffle habitat accounted for 3.9%.

#### 4.1.5 West Ravine

A total of 4,383 $m^2$ of pool habitat, 492 $m^2$ of run habitat, and 186 $m^2$ of riffle habitat were delineated in West Ravine (Table 3; Figure 8). Pools were the most common habitat type within the tributary, accounting for 86.6% of the habitat assessed, followed by run (9.7%) and riffle (3.7%) habitat types.

#### 4.1.6 Duke Ravine

A total of 41,129 $m^2$ of pool type habitat, 2,190 $m^2$ of run habitat, and 480 $m^2$ of riffle habitat were delineated in Duke Ravine (Table 3; Figure 9). Similar to the other tributaries assessed, Duke Ravine was dominated by pools, which accounted for 94.6% of the available habitat in the tributary, followed by runs, which accounted for 4.4% of the habitat assessed, and riffles, which accounted for 1.0% of the total habitat assessed.

#### 4.1.7 FALC Ravine

In FALC Ravine, a total of 340 $m^2$ of pool habitat, 196 $m^2$ of run habitat, and 160 $m^2$ of riffle habitat were delineated (Table 3; Figure 10). Pools were the most common habitat type within the tributary, accounting for 48.9% of the areal quantity of habitat, followed by run (28.2%) and riffle (23.0%) habitat types.

#### 4.1.8 Wapiti Ravine

A total of 21,180 $m^2$ of pool type habitat, 744 $m^2$ of run habitat, and 312 $m^2$ of riffle habitat were delineated in Wapiti Ravine (Table 3; Figure 11). The predominant habitat type in Wapiti Ravine was pool, which accounted for 95.3% of the available habitat in the tributary, followed by runs, which accounted for 3.3% of the habitat assessed, and riffles, which accounted for 1.4% of the total habitat assessed.

#### 4.1.9 English Creek

A total of 481,573 $m^2$ of pool habitat, 13,134 $m^2$ of run habitat, and 2,673 $m^2$ of riffle habitat were delineated in English Creek (Table 3; Figure 12). Pools were the most common habitat type within the tributary, accounting for 96.8% of the habitat assessed, followed by run (2.6%) and riffle (0.5%) habitat types.

## 5.0 METHODOLOGY COMPARISON

In order to determine the validity of the desktop modelling approach used to quantify habitat losses in the tributaries potentially impacted by the Project, the results of the aquatic habitat assessment (as determined by the desktop approach) were compared to field measurements collected during aquatic habitat assessments in 2007 and 2008. The comparison was completed using field observations recorded during habitat assessments of three sections of East Ravine (within 500 m of the Saskatchewan River, within the POP, and within the WRCO) in August 2007 and August 2008.

### 5.1 Statistical Analyses

The percentage of riffle, run, and pool habitat in each habitat section delineated by field surveys was compared directly to the results produced by the desktop modelling approach by using a Spearman correlation coefficient. The following table presents the results of the statistical analyses.

| Habitat Type | Spearman Coefficient | n | P (1-tailed) |
|---|---|---|---|
| **East Ravine within 500 m of the Saskatchewan River** | | | |
| riffle | 0.519 | 9 | >0.05 |
| run | 0.366 | 9 | >0.10 |
| pool | - | 9 | 1 |
| **East Ravine within the POP** | | | |
| riffle | -0.16 | 25 | >0.50 |
| run | 0.032 | 25 | >0.25 |
| pool | 0.037 | 25 | >0.25 |
| **East Ravine within the WRCO** | | | |
| riffle | -0.254 | 19 | >0.50 |
| run | 0.317 | 19 | >0.05 |
| pool | 0.152 | 19 | >0.25 |

The results of the statistical analyses shown above found that there was no significant correlation between field observations and model predictions. However, a direct comparison of field measurements and the modelling approach is somewhat difficult due to a number of constraints, including temporal variability between the collection of field measurements, aerial photography, and the LiDAR derived DEM, variability between observers during field habitat assessments, and the inability of the model to predict the locations of beaver dams, which have caused large impoundments in tributaries throughout the study area.

### 5.2 Limitations of the Desktop Modelling Approach

#### 5.2.1 Temporal Variability

The desktop modelling approach is based on the topography of the stream channel and surrounding watershed produced using a LiDAR derived DEM and aerial photography. However, the LiDAR imagery utilized during this study was obtained in 2005, while the aerial photography was obtained in 2007, and the field habitat assessments were completed in 2007 and 2008. Many of the tributaries that will be potentially impacted by the Project displayed a high degree of seasonal variability during the aquatic baseline studies (CanNorth 2009), and thus each set of results represents a different snapshot in time that reflects this seasonal variability.

### 5.2.2 Observer Variability

Pools, runs, and riffles are not discrete units, but instead form a continuum for which any classification is arbitrary. Consequently there will be some overlap in any subjective method of assessment. Jowett (1993) found that habitat assessments made by a field observer were influenced by the habitat type of the surrounding water. For example, locations with no measurable velocity, which should be defined as pool habitat, were assessed instead as run habitat, presumably because the surrounding region was assessed as run habitat (Jowett 1993). Similarly, locations affected by local acceleration around boulders or small log jams tended to be classified according to the surrounding region rather than the local conditions. In general, Jowett (1993) found that pool and riffle habitat types were relatively easy to distinguish from each other, but that run habitats were more difficult to distinguish from riffle habitats, likely in part due to the reasons explained above.

### 5.2.3 Ability of the Model to Predict Beaver Impoundments

In general, the model was somewhat successful in predicting the location of pool type habitat, however, it was not able to discern between the three different habitat types in areas where beaver activity resulted in small or large impoundments, such as in the middle and upper reaches of East Ravine. Beaver ponds are usually categorized as one of two types: stream channel, which are long, narrow, and less than 0.4 ha; and flood plain, which are larger impoundments and may cover several hectares of land (Pullen 1971). Although beavers appear to prefer the relatively flat terrain of fertile valleys, they can occupy streams with steeper gradients (Wing 1951; Schulte and Schneider 1989; Zurowski 1989; Müller-Schwarze 1992). However, densities at sites with steep gradients generally do not reach the same levels as at preferred sites (Zurowski 1992). Stream channel ponds are typically short lived, but flood plain ponds may persist for many years (Collen and Gibson 2001).

In the lower reach of East Ravine, where signs of beaver activity were generally rare compared to the middle and upper reaches, the model was fairly good at distinguishing between the three different habitat types. On average, riffles and pools were overestimated by 10% and 11%, respectively, while runs were underestimated 20% by the model. In contrast, in the middle and upper reaches of the tributary, riffles and runs were underestimated by the model, while pools were overestimated. This may be in part due to the presence of runs and/or riffles created by dams at the outlets of impoundments constructed by beavers in the flood plains of the middle and upper reaches of East Ravine.

## 6.0 SUMMARY AND DISCUSSION

Shore Gold Inc. is the major proponent of the proposed Star-Orion South Diamond Project, located approximately 65 kilometres east of Prince Albert, Saskatchewan in the Fort à la Corne Provincial Forest. The footprint of the Project will directly affect a number of tributaries which discharge into the Saskatchewan River, some of which are fish-bearing and are therefore considered fish habitat. Because the Project will result in a HADD, it requires compensation in order to achieve NNL of productive capacity.

The main objective of this report was to quantify fish habitat that will be potentially lost or altered due to the proposed Project. This is a particularly difficult task for this study area due to the nature of the tributaries being assessed. Habitat types within the tributaries changed frequently both spatially and temporally, and the total length of the tributaries assessed was over 145 km. The approach utilized to quantify the habitat was a simplified approach considering the complex habitat it was used to describe. The LiDAR imagery used was from 2005 and the field information was from 2007 and 2008, thus the results represent a snapshot in time. Overall, considering the limitations and issues that would be identified for any approach used to quantify fish habitat in the Project local study area, the approach proposed is considered the most effective and practical option for providing DFO a concrete number on which to base fish habitat compensation.

The most common habitat type delineated by the model during the desktop survey was pool, which accounted for 122.5 km of the habitat assessed by length and 948,946 $m^2$ by area (including beaver impoundments). This habitat type accounted for over 95% of the aquatic habitat available in the study area. In contrast, run habitat accounted for 18.58 km of the habitat assessed by length and 40,384 $m^2$ by area, equalling approximately 4.05% of the habitat assessed. Riffle habitat was the least common habitat type throughout the study area; accounting for 4.22 km of the habitat assessed by length and covering an area of 8,065 $m^2$ or less than 1% of the habitat assessed.

Pools, runs, and riffles each have a different significance in terms of their importance as habitat for various species and life stages of fish. Pool habitats provide important feeding and rearing areas for both sport fish and forage fish. Deeper pools may also provide cover for juvenile sport fish and forage fish and refuge from higher water temperatures and water velocities. Pools also act as vital overwintering habitats in areas where water depths and dissolved oxygen concentrations are sufficient to support fish during the winter. In contrast to pool habitats, riffles are typically shallow, fast flow-flowing sections with clean, coarse substrates and provide important critical spawning and nursery habitat for large-bodied fish species such as walleye and white sucker. Run habitat is intermediate between pools and riffles.

Although statistical analyses comparing the habitat assessment results as determined by the desktop modelling approach to field based observations found that there was no significant correlation between the two sets of results, the differences can be explained by a number of factors, including temporal variability between the collection of field measurements, aerial photography, and the LiDAR derived DEM, variability between observers during field habitat assessments, and the inability of the model to predict the locations of beaver dams. In order to overcome some of these discrepancies, Shore Gold Inc. is proposing to update LiDAR imagery, aerial photography, and ground truthing information immediately prior to the development of the Project to ensure that the model produces an accurate picture of fish habitat losses in the tributaries impacted by the Project.

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# TABLES

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## TABLE 1

Summary of the length and width of tributaries potentially impacted by the Star-Orion South Diamond Project.

| Stream | Average Width (m) | Total Length Incl. Tributaries (km) | Length of Habitat (km) | | |
|---|---|---|---|---|---|
| | | | Pool | Run | Riffle |
| East Ravine | 1.7 | 13.86 | 10.95 | 2.2 | 0.71 |
| Caution Creek | 2.6 | 42.2 | 37.54 | 4.13 | 0.53 |
| 101 Ravine | 1.5 | 19.98 | 16.33 | 3.22 | 0.43 |
| West Perimeter Ravine | 3.2 | 4.43 | 2.76 | 1.35 | 0.32 |
| West Ravine | 0.6 | 2.98 | 1.85 | 0.82 | 0.31 |
| Duke Ravine | 1.5 | 8.38 | 6.6 | 1.46 | 0.32 |
| FALC Ravine | 0.4 | 1.74 | 0.85 | 0.49 | 0.4 |
| Wapiti Ravine | 0.8 | 5.64 | 4.32 | 0.93 | 0.39 |
| English Creek | 3.3 | 46.11 | 41.32 | 3.98 | 0.81 |
| **Total** | | **145.32** | **122.52** | **18.58** | **4.22** |

## TABLE 2

Summary of the quantity of additional pool habitat in tributaries potentially impacted by the Star-Orion South Diamond Project.

| Stream | Areal Quantity of Additional Pool Habitat ($m^2$) |
|---|---|
| East Ravine | 52,541 |
| Caution Creek | 82,877 |
| 101 Ravine | 97,483 |
| West Perimeter Ravine | 11,894 |
| West Ravine | 3,273 |
| Duke Ravine | 37,229 |
| FALC Ravine | 0 |
| Wapiti Ravine | 17,724 |
| English Creek | 345,217 |
| **Total** | **648,238** |

## TABLE 3

Summary of the quantity of pool, run, and riffle habitat types in tributaries potentially impacted by the Star-Orion South Diamond Project.

| Stream | Percent Habitat by Area (%) | | | Areal Quantity of Habitat ($m^2$) | | |
|---|---|---|---|---|---|---|
| | Pool | Run | Riffle | Pool | Run | Riffle |
| East Ravine | 93.5 | 4.9 | 1.6 | 71,156 | 3,740 | 1,207 |
| Caution Creek | 93.7 | 5.6 | 0.7 | 180,481 | 10,738 | 1,378 |
| 101 Ravine | 95.7 | 3.8 | 0.5 | 121,978 | 4,830 | 645 |
| West Perimeter Ravine | 79.5 | 16.6 | 3.9 | 20,726 | 4,320 | 1,024 |
| West Ravine | 86.6 | 9.7 | 3.7 | 4,383 | 492 | 186 |
| Duke Ravine | 94.6 | 4.4 | 1.0 | 47,129 | 2,190 | 480 |
| FALC Ravine | 48.9 | 28.2 | 23.0 | 340 | 196 | 160 |
| Wapiti Ravine | 95.3 | 3.3 | 1.4 | 21,180 | 744 | 312 |
| English Creek | 96.8 | 2.6 | 0.5 | 481,573 | 13,134 | 2,673 |
| **Total** | **95.14** | **4.05** | **0.81** | **948,946** | **40,384** | **8,065** |

# FIGURES

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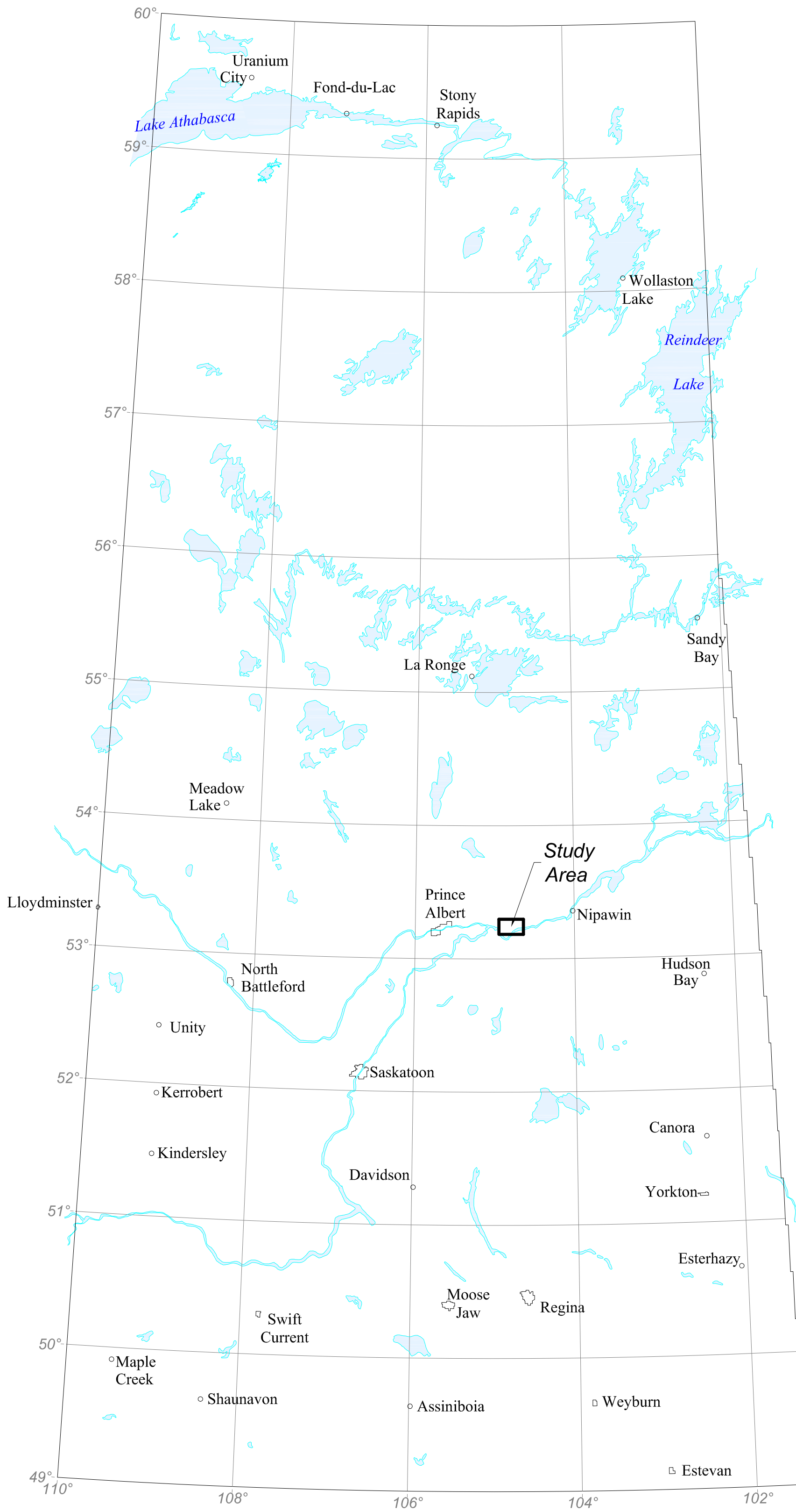


Figure 1 Study location.

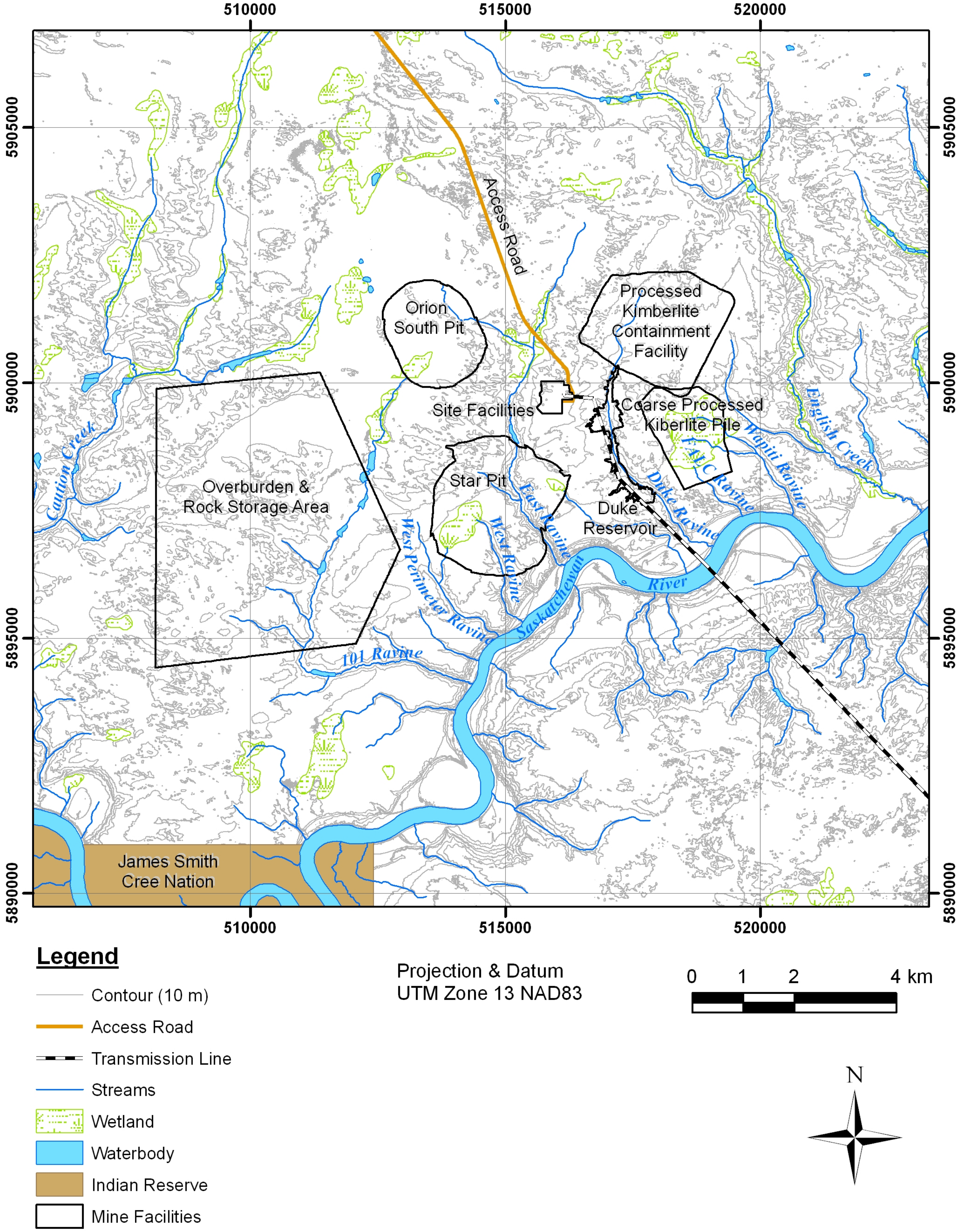


Figure 2. Locations of the site facilities and tributaries in the local study area of the Shore Gold Star-Orion South diamond project.

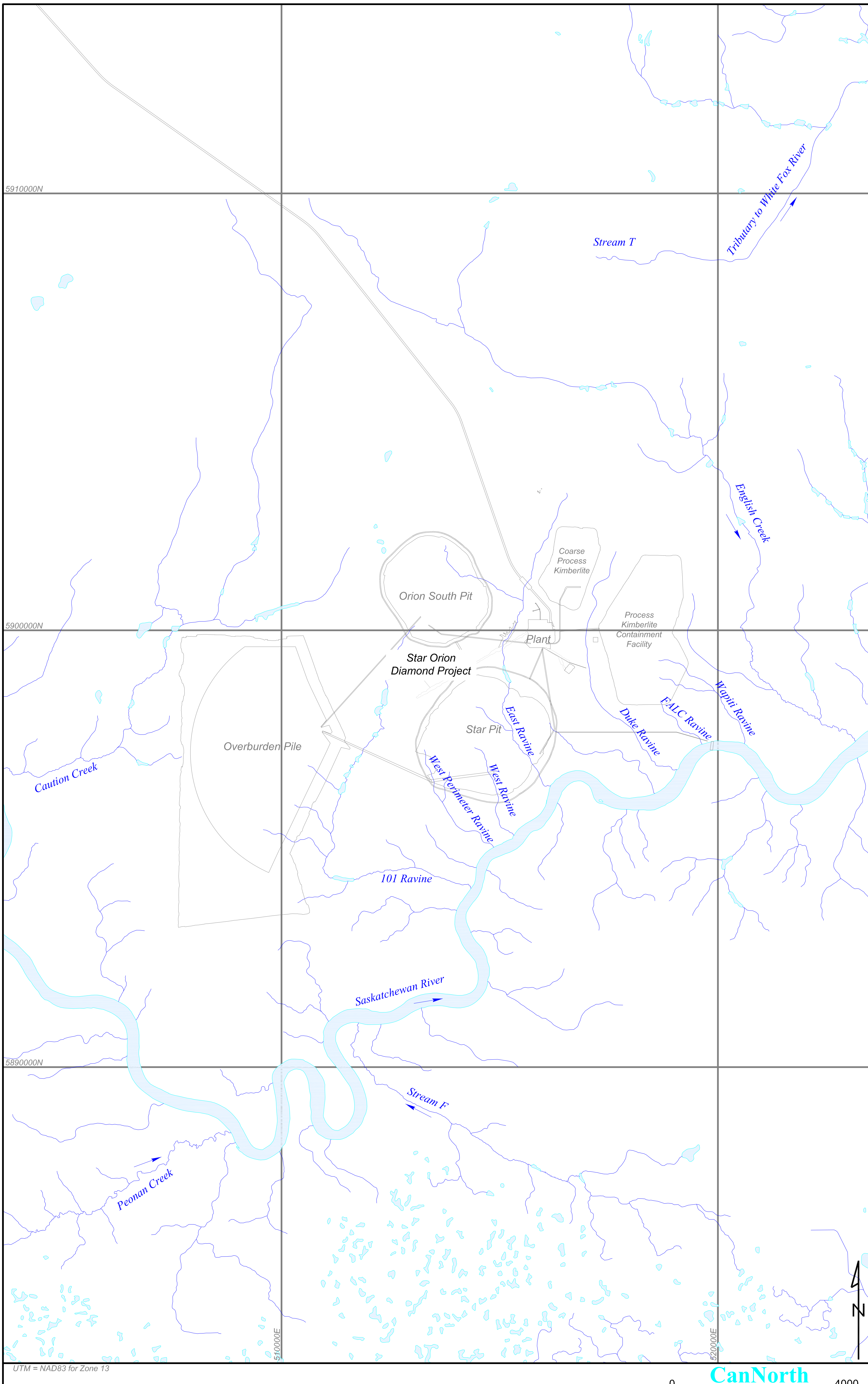


Figure 3
Final locations of the site facilities and tributaries in the local study area of the Shore Gold Star-Orion South diamond project.

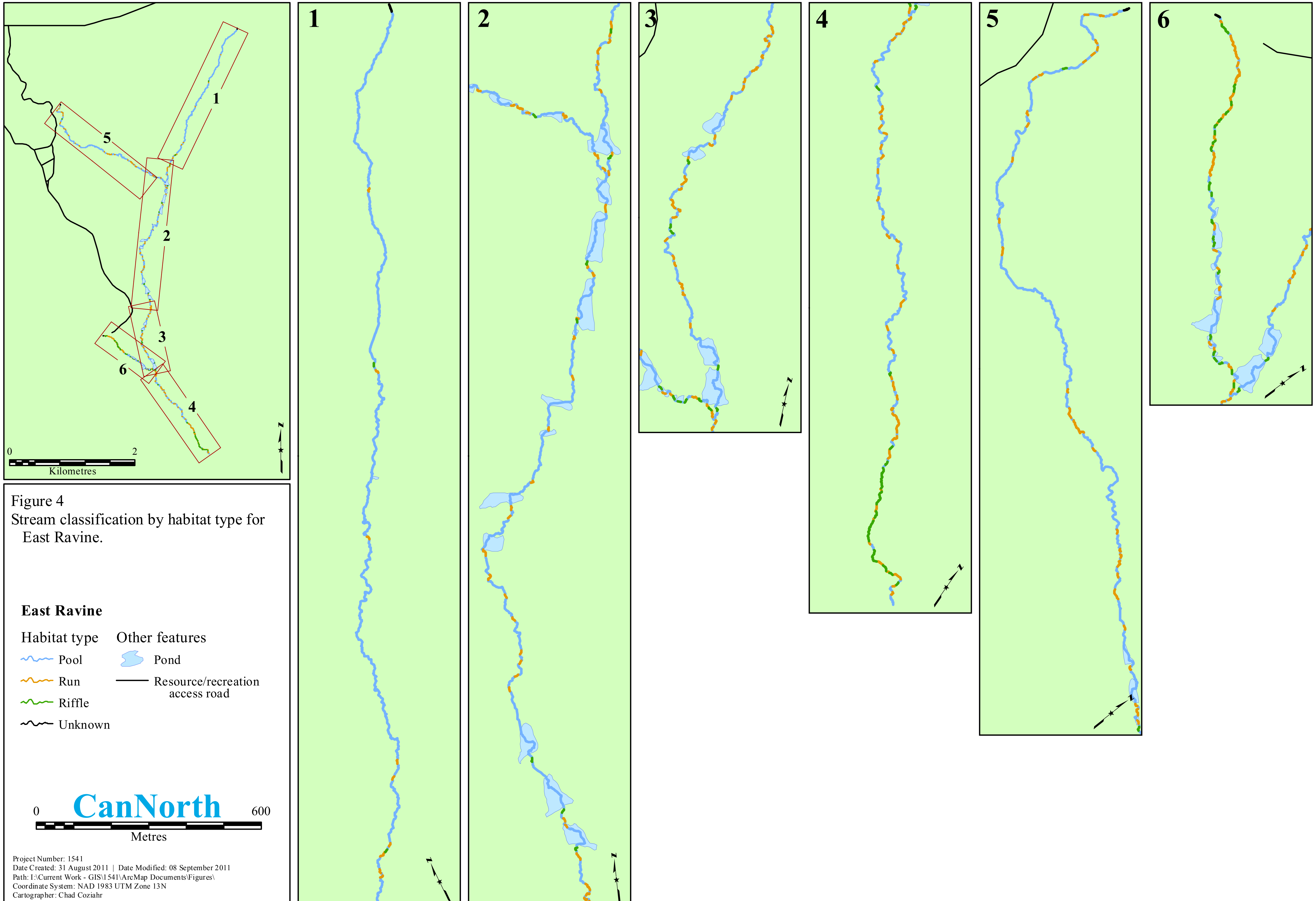


Figure 4
Stream classification by habitat type for East Ravine.

CanNorth

Project Number: 1541
Date Created: 31 August 2011 | Date Modified: 08 September 2011
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Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr

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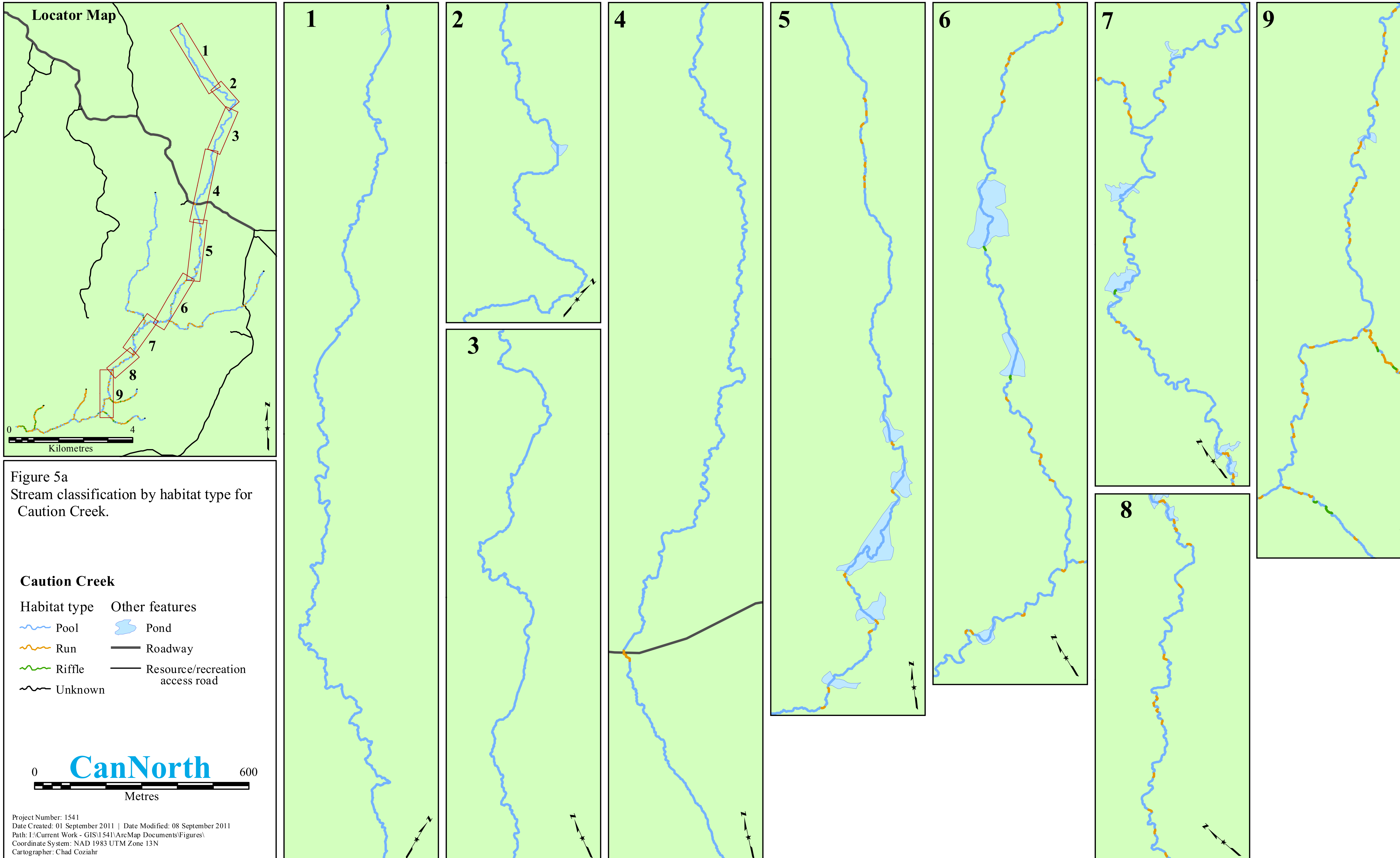


Figure 5a
Stream classification by habitat type for Caution Creek.

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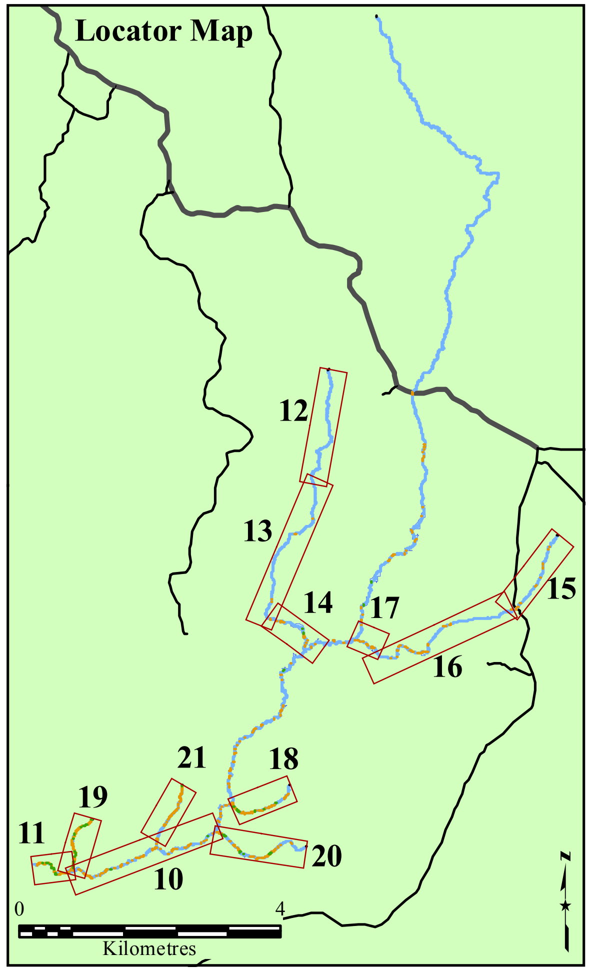


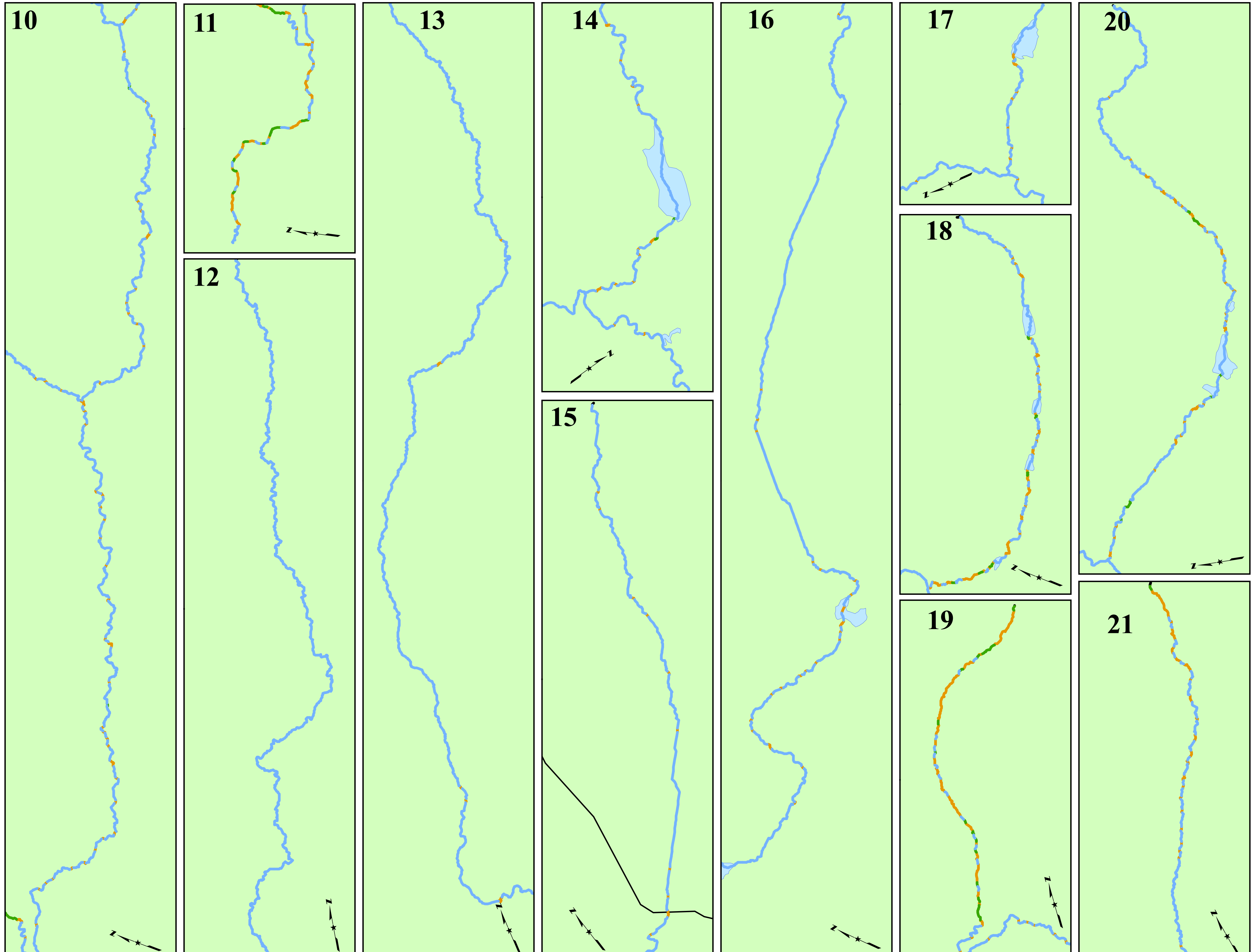


Figure 5b
Stream classification by habitat type for Caution Creek.

**Caution Creek**

| Habitat type | Other features |
| --- | --- |
| Pool | Pond |
| Run | Roadway |
| Riffle | Resource/recreation access road |
| Unknown | |

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 01 September 2011 | Date Modified: 08 September 2011
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Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr

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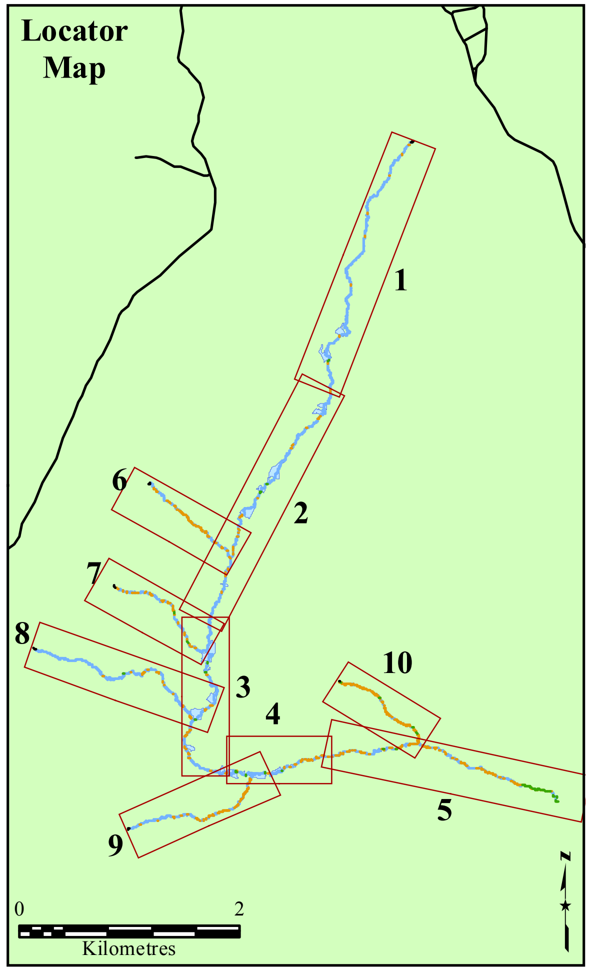


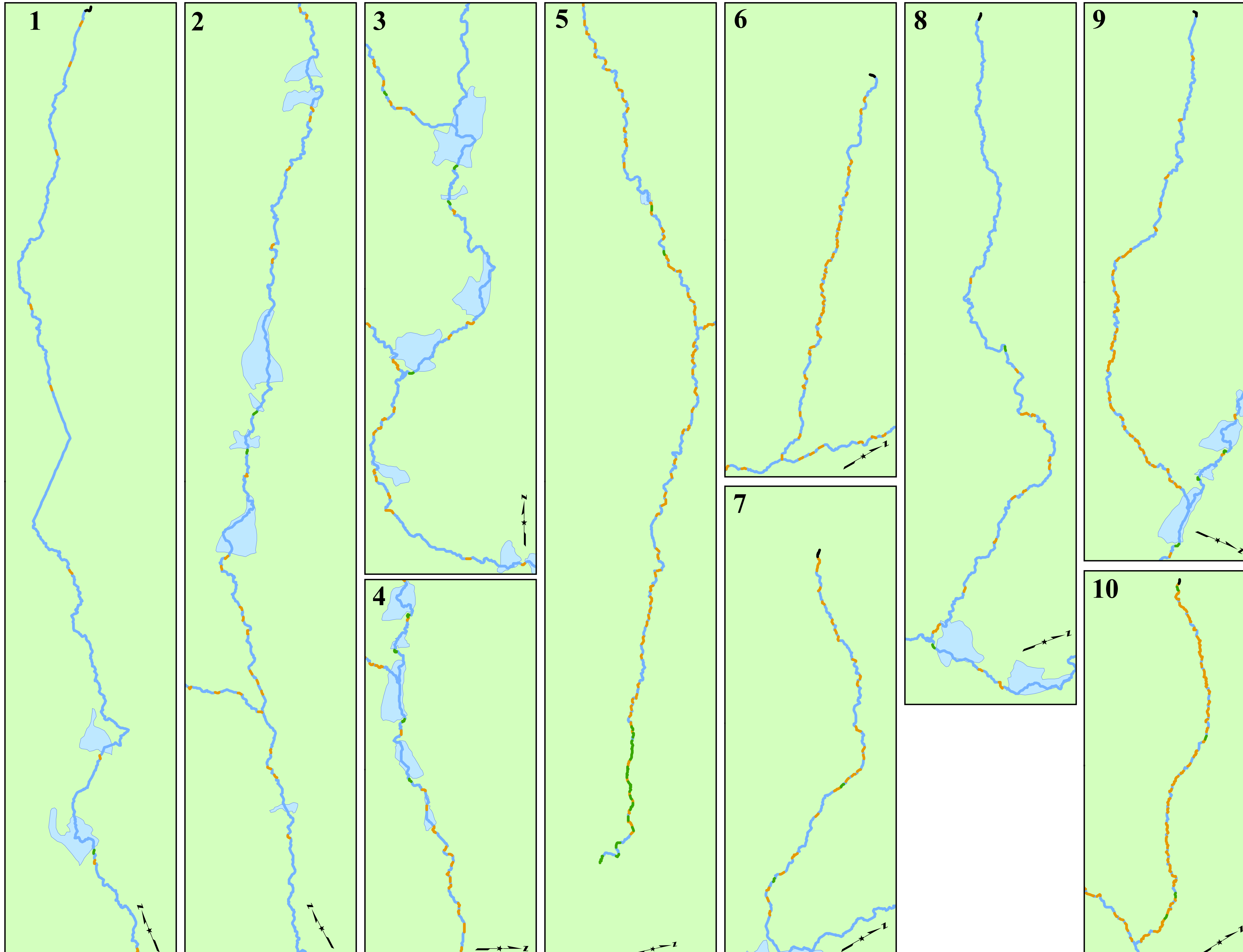


Figure 6
Stream classification by habitat type for 101 Ravine.

**101 Ravine**

Habitat type
- Pool
- Run
- Riffle
- Unknown

Other features
- Pond
- Resource/recreation access road

0 — 600
Metres

CanNorth

Project Number: 1541
Date Created: 02 September 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr

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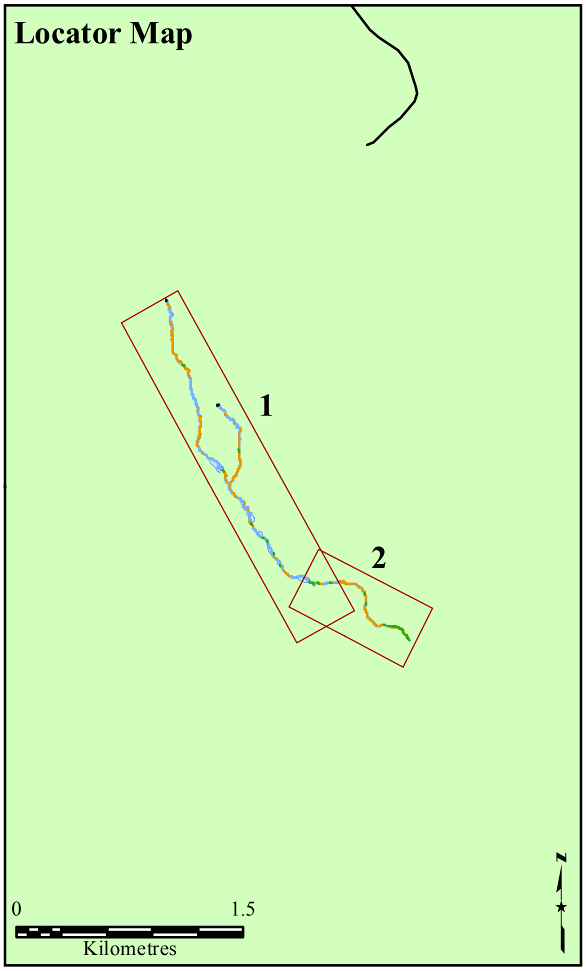
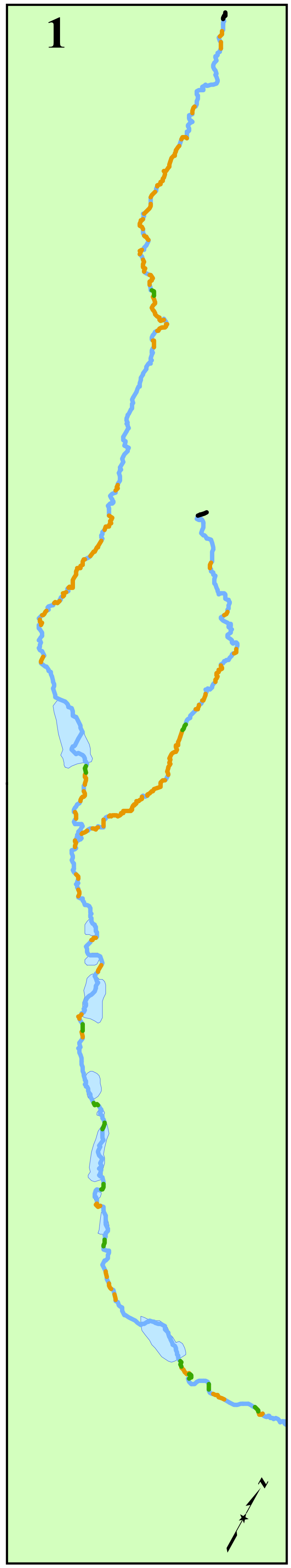


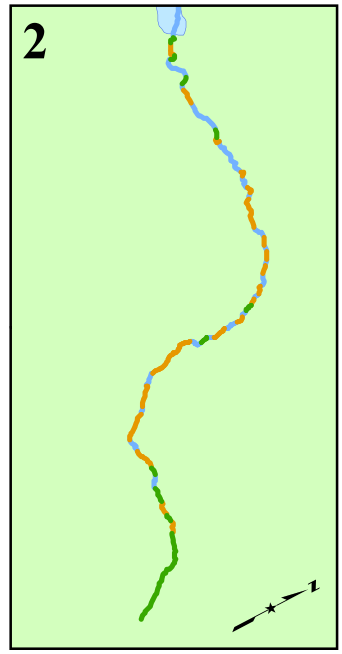




Figure 7
Stream classification by habitat type for West Perimeter Ravine.

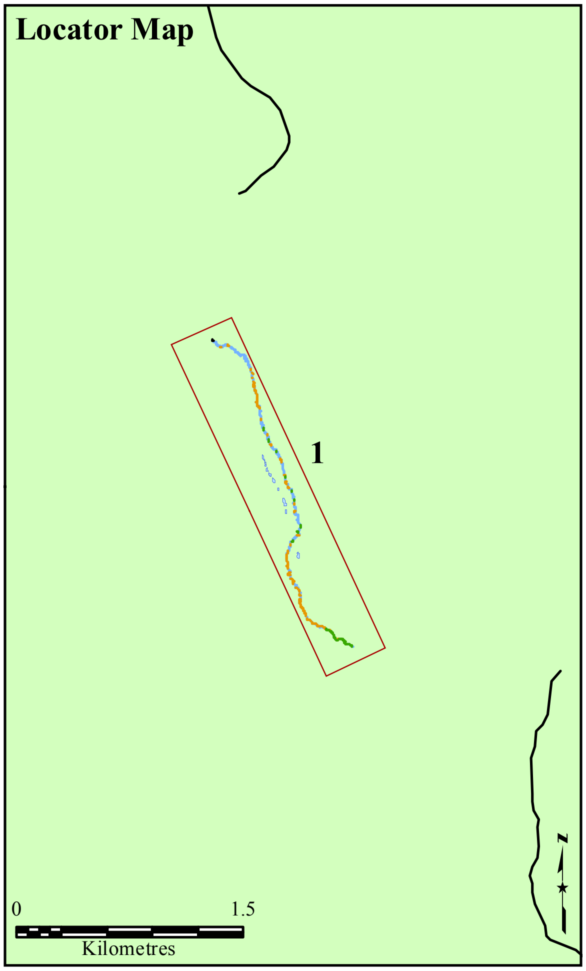
**West Perimeter Ravine**

| Habitat type | Other features |
|---|---|
| Pool | Pond |
| Run | Resource/recreation access road |
| Riffle | |
| Unknown | |

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 06 September 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr



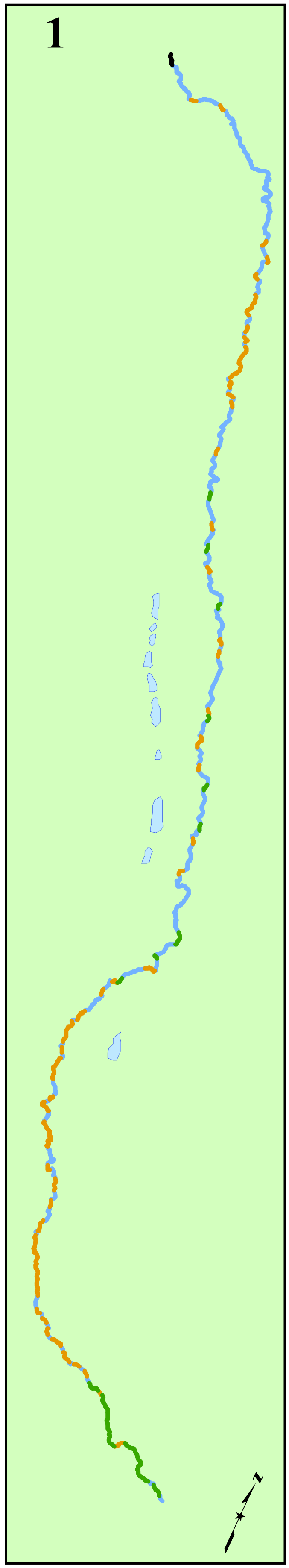




Figure 8
Stream classification by habitat type for West Ravine.

**West Ravine**

| Habitat type | Other features |
| --- | --- |
| Pool | Pond |
| Run | Roadway |
| Riffle | Resource/recreation access road |
| Unknown | |

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 06 September 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
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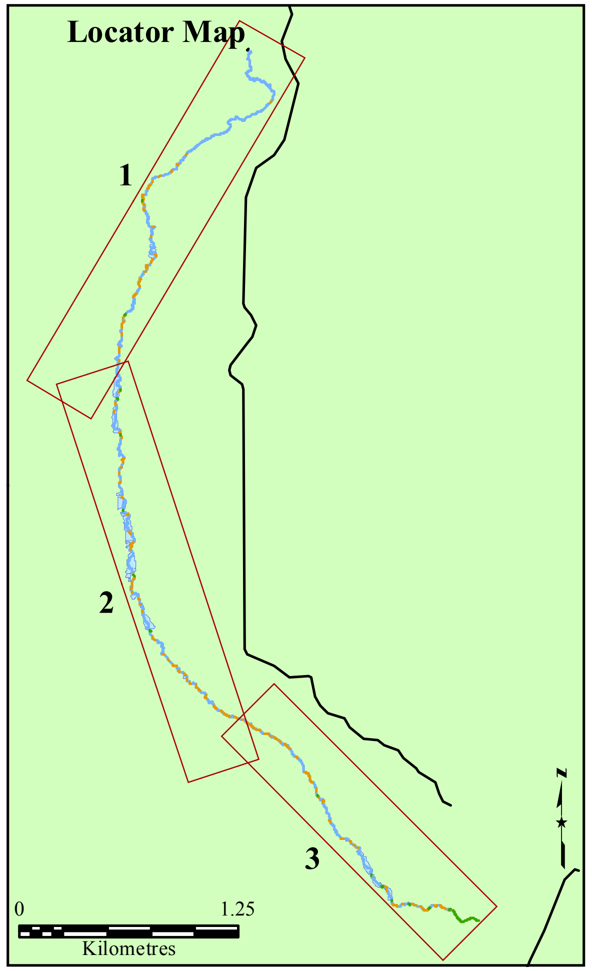


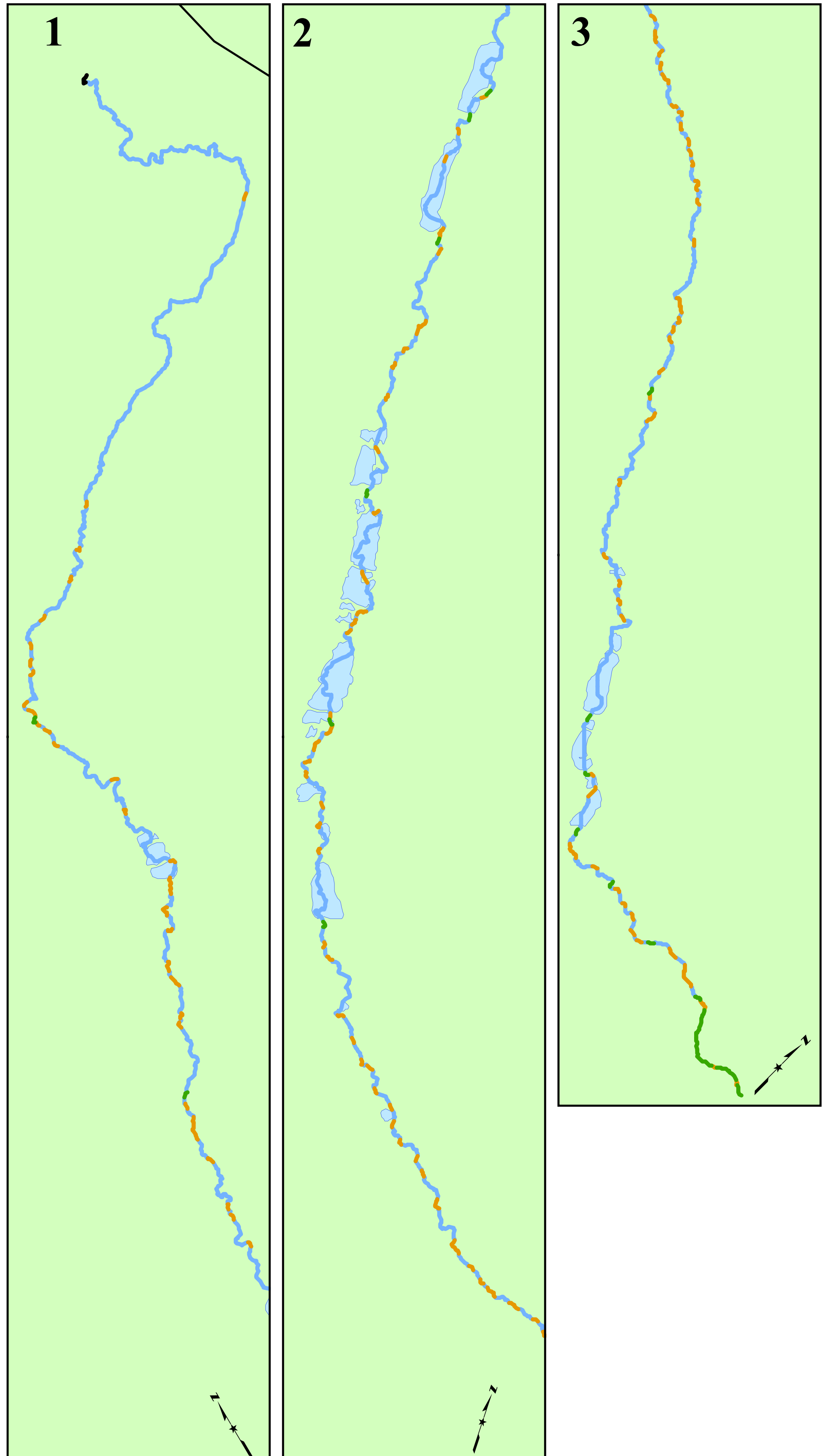


Figure 9
Stream classification by habitat type for Duke Ravine.

**Caution Creek**

Habitat type
- Pool
- Run
- Riffle
- Unknown

Other features
- Pond
- Resource/recreation access road

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 06 September 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
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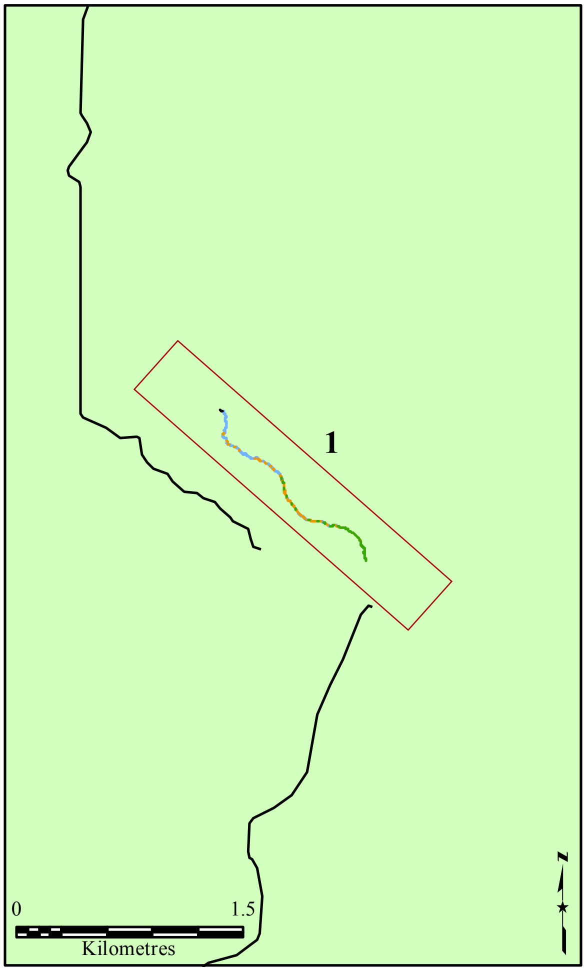


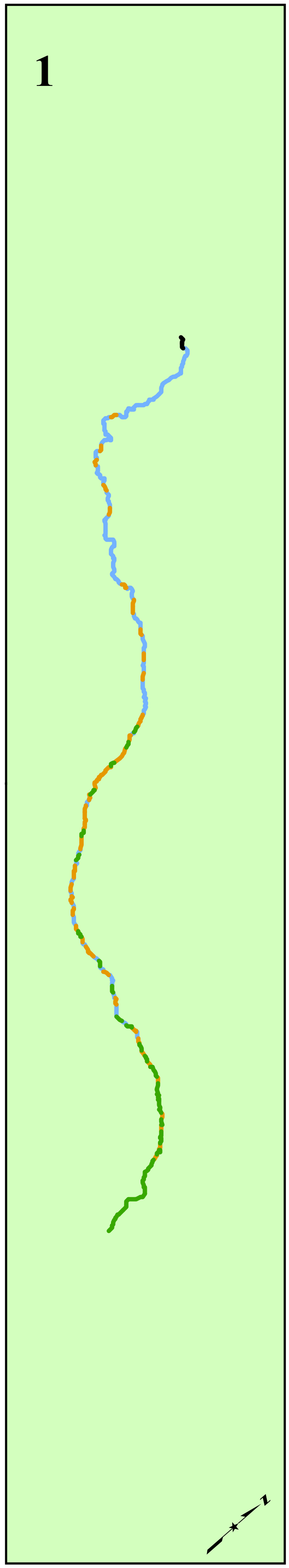




Figure 10
Stream classification by habitat type for FalC Ravine.

**FalC Ravine**

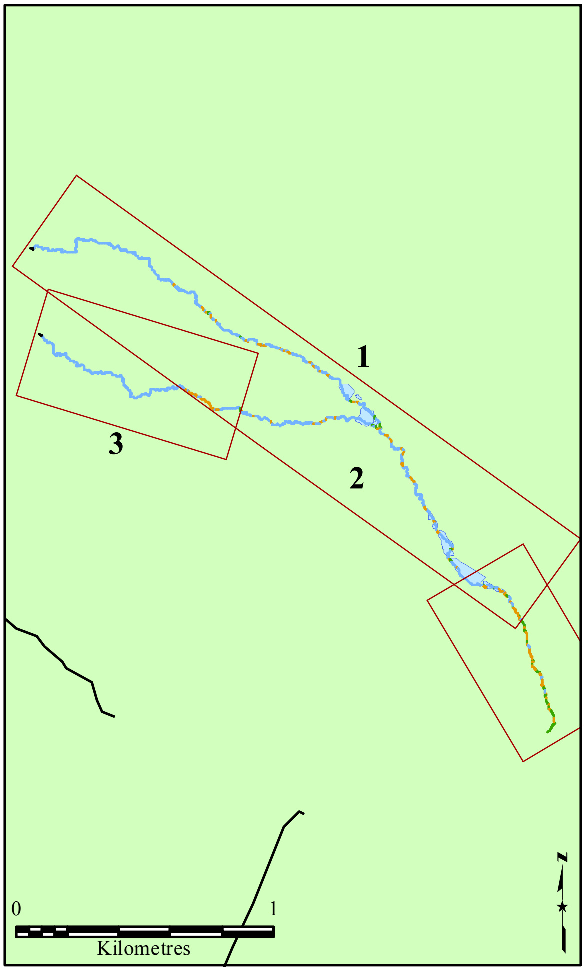
Habitat type
- Pool
- Run
- Riffle
- Unknown

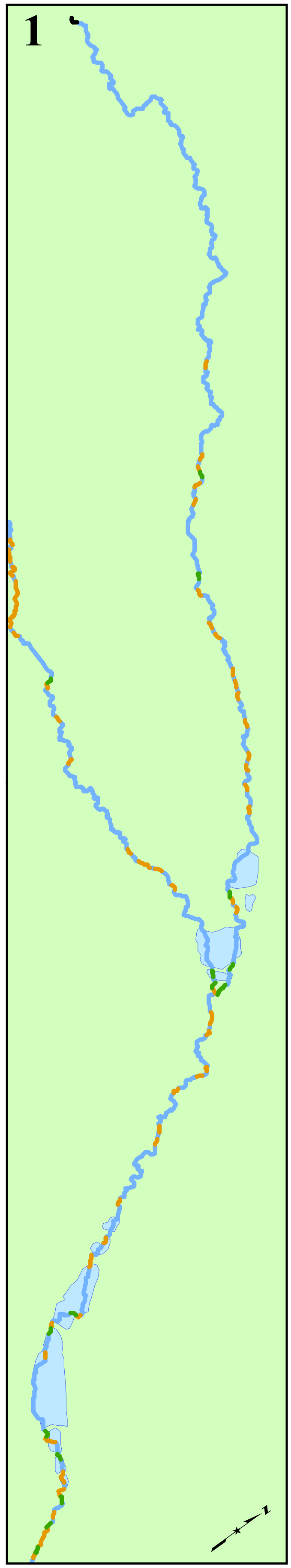
Other features
- Resource/recreation access road

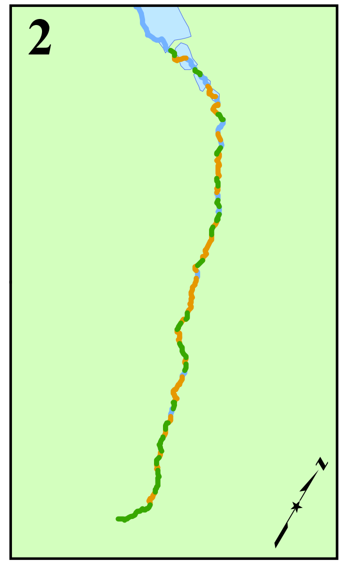
CanNorth

0 600
Metres

Project Number: 1541
Date Created: 06 September 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr



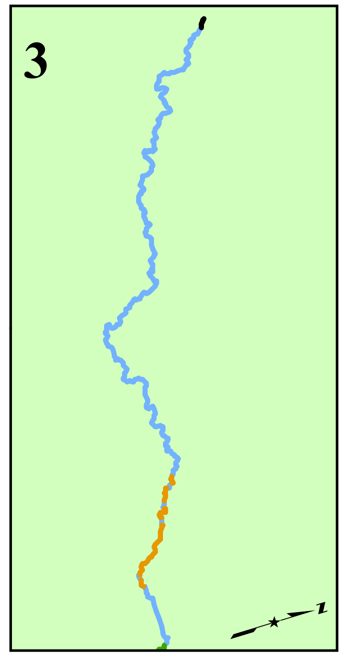




Figure 11
Stream classification by habitat type for Wapiti Ravine.

**Wapiti Ravine**

Habitat type
- Pool
- Run
- Riffle
- Unknown

Other features
- Other features
- Resource/recreation access road

CanNorth

0 600
Metres

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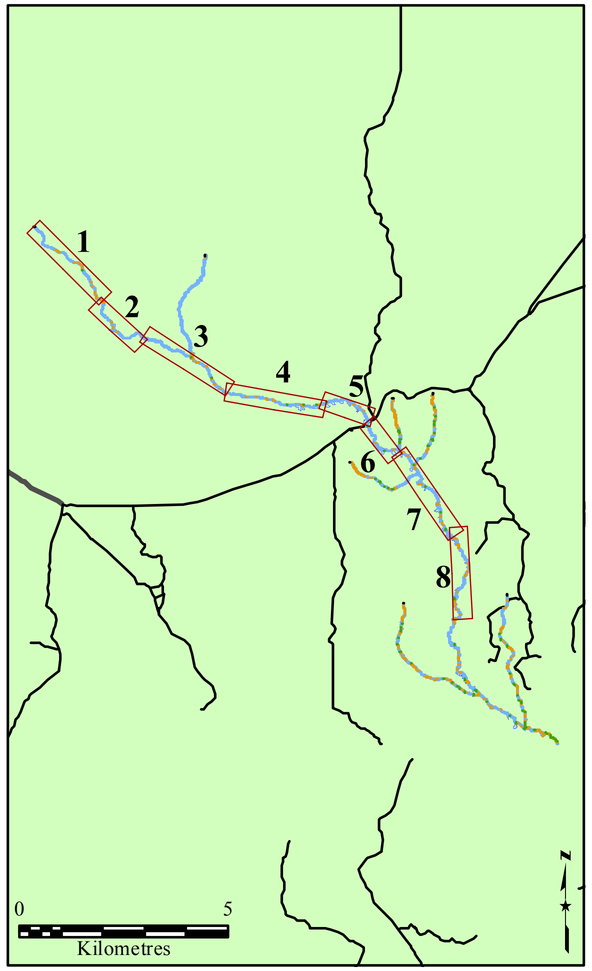


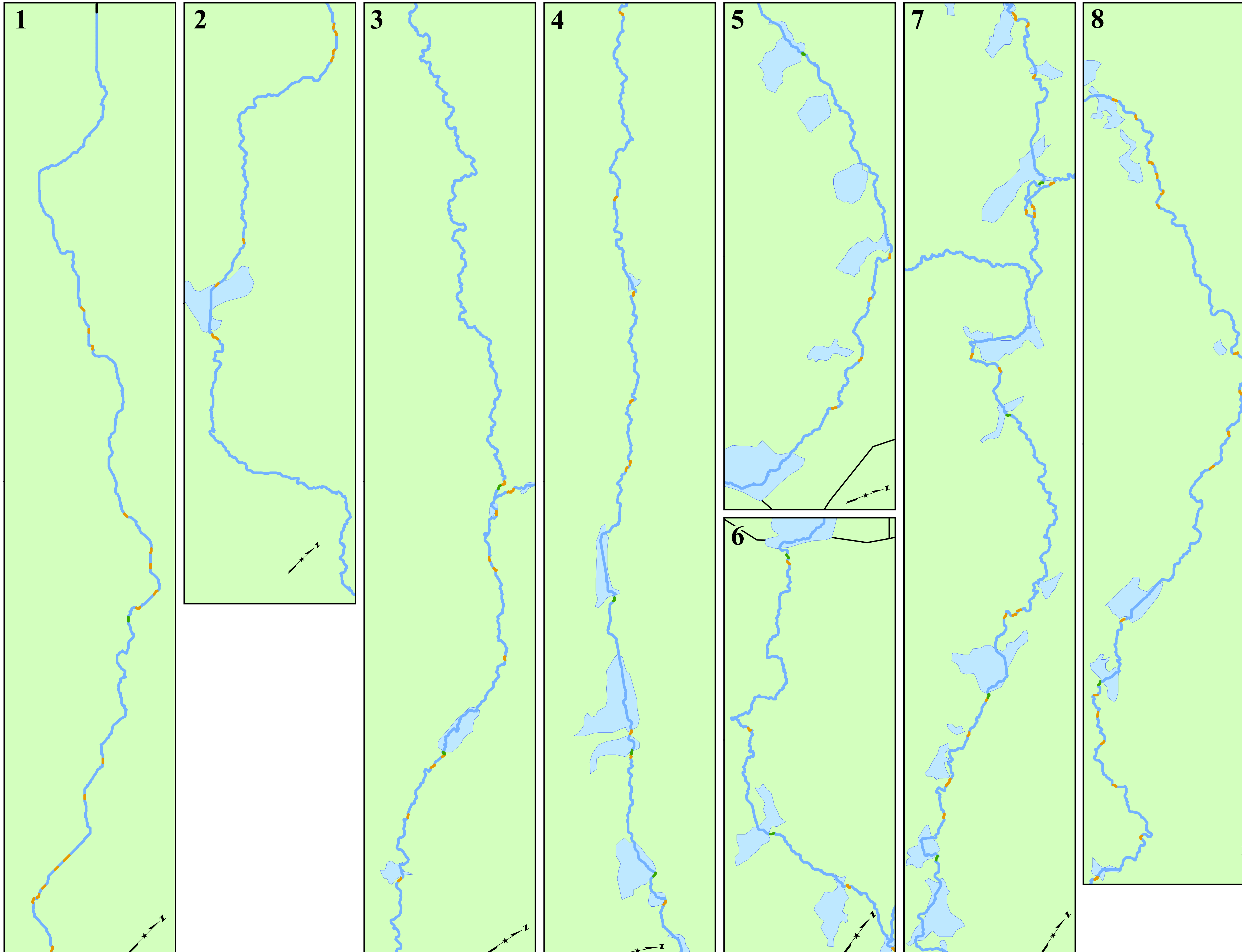


Figure 12a
Stream classification by habitat type for English Creek.

**English Creek**

Habitat type
- Pool
- Run
- Riffle
- Unknown

Other features
- Other features
- Roadway
- Resource/recreation access road

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 06 September 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
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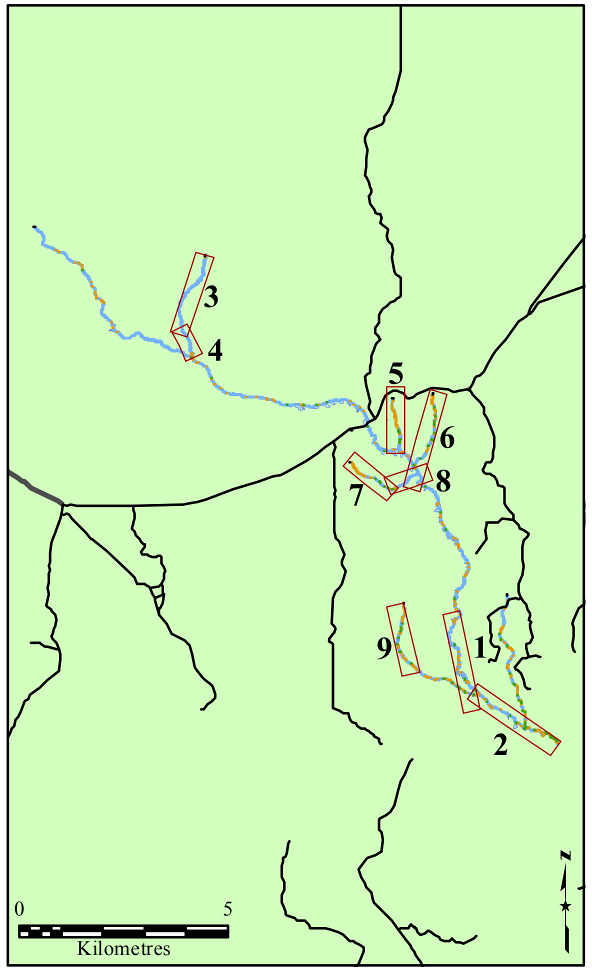



Figure 12b
Stream classification by habitat type for English Creek.

**English Creek**

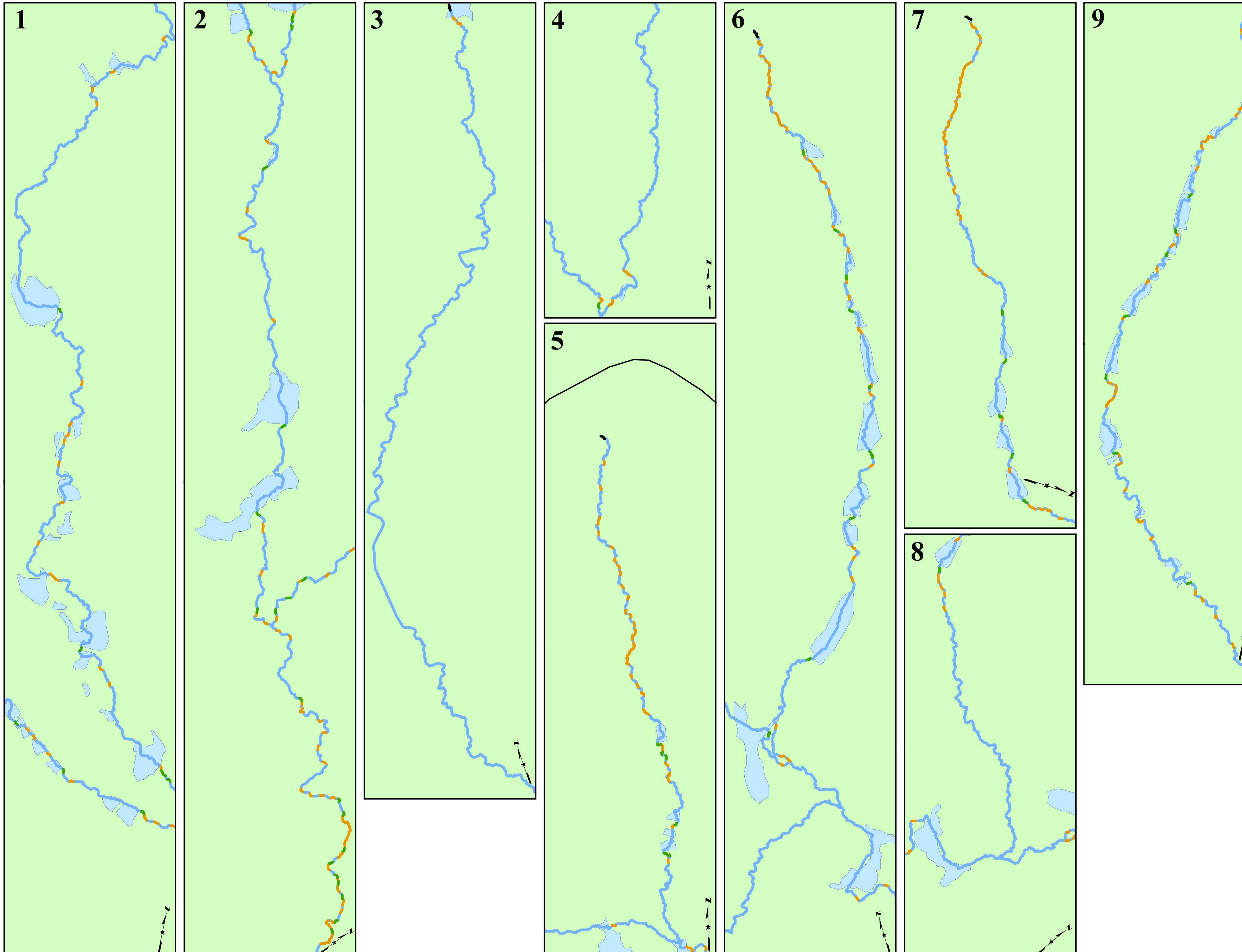
Habitat type
- Pool
- Run
- Riffle
- Unknown

Other features
- Other features
- Roadway
- Resource/recreation access road

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 21 August 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr

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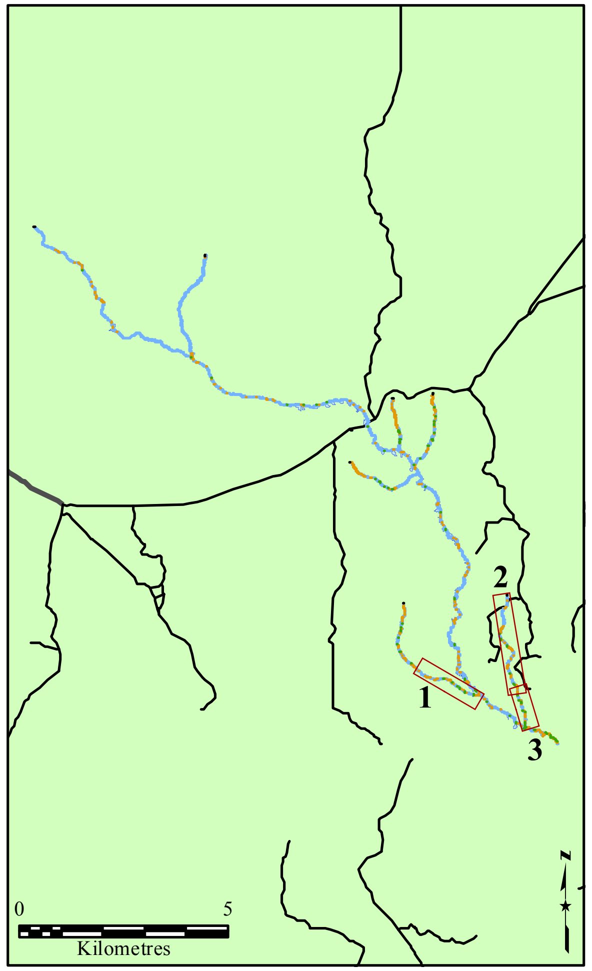


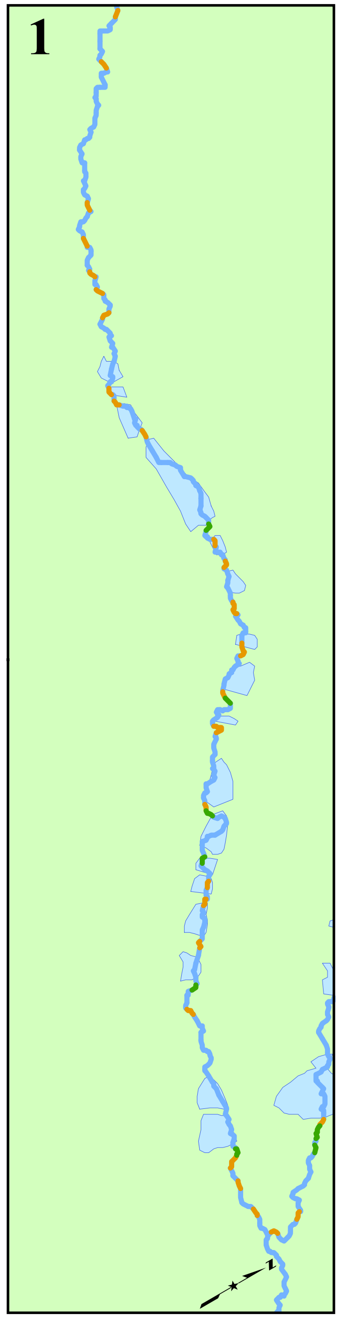


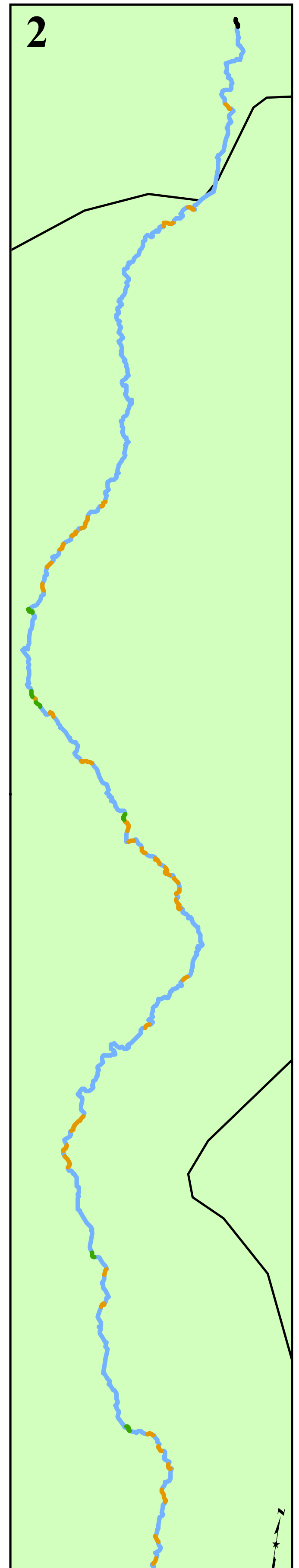


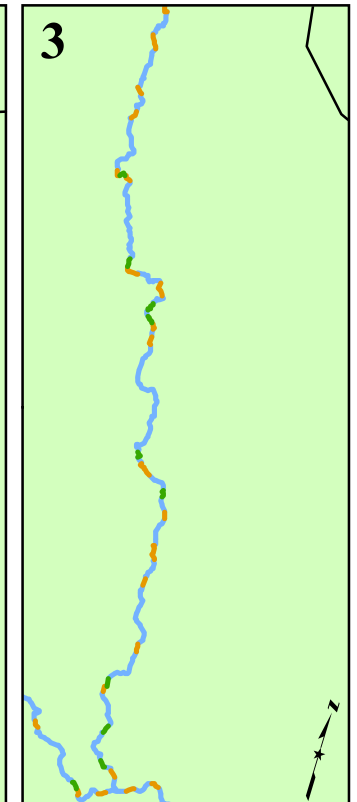


Figure 12c
Stream classification by habitat type for English Creek.

**English Creek**

| Habitat type | Other features |
|---|---|
| Pool | Other features |
| Run | Roadway |
| Riffle | Resource/recreation access road |
| Unknown | |

CanNorth

0 600
Metres

Project Number: 1541
Date Created: 21 August 2011 | Date Modified: 08 September 2011
Path: I:\Current Work - GIS\1541\ArcMap Documents\Figures\
Coordinate System: NAD 1983 UTM Zone 13N
Cartographer: Chad Coziahr

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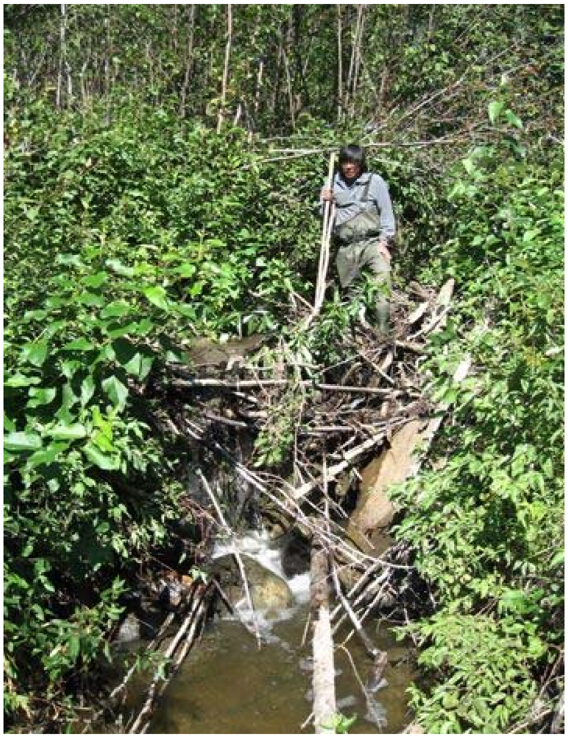
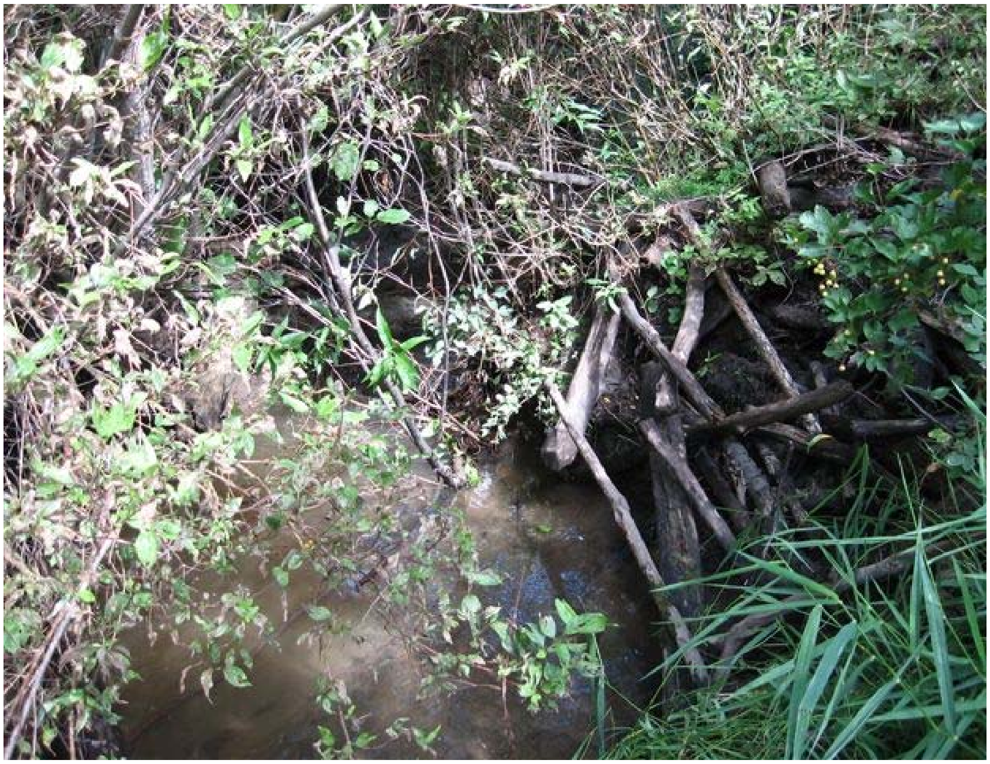


Photo 25.  101 Ravine within 500 m of the Saskatchewan River, August 2007.

Photo 26.  101 Ravine within 500 m of the Saskatchewan River, August 2007.



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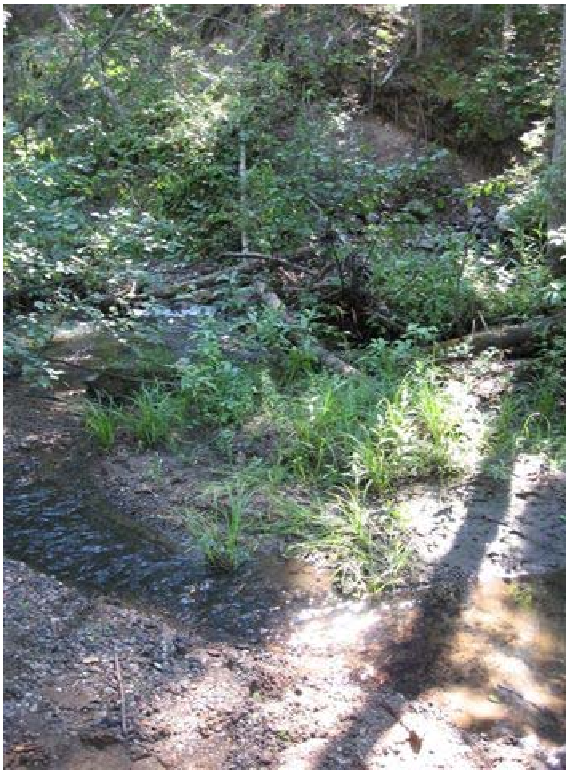

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