Peace River Project Water Use Plan

Peace Spill Protocol

Reference: GMSMON-3

Peace River Fish Stranding Survey Summary Report

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GMSMON-3: Peace River Fish Stranding
Stranding Survey Summary Report

Report submitted to:

BC Hydro
Water License Requirements
Burnaby, BC

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Cover photo: Peace River side channel and isolated pool near Transect 58, approximately 30 km downstream of the Halfway River confluence. Photo © A. MacInnis, Cooper Beauchesne and Associates Ltd.

EXECUTIVE SUMMARY

Fish stranding has been acknowledged as one of the expected outcomes of a spill event on the Peace River. However, the magnitude of stranding is unknown and the Peace River Fish Stranding Survey is one of several monitoring programs to be implemented under the Peace Spill Protocol. The fish stranding survey is intended to quantify the impact of spills on fish populations in the Peace River and to determine if the magnitude of these impacts is significant to individual fish populations.

This report presents the results of a fish stranding survey completed on July 14, 2012 following a spill in the Peace River downstream of the Peace Canyon Dam (PCN) and includes the process used to identify potential stranding areas and select survey sites. The survey was conducted under the Peace Spill Protocol to provide additional information on what fish species and life stages are most affected by a spill and to identify areas with the highest risk of stranding.

The general approach to completion of the fish stranding survey consisted of two components. The first component was a desktop review of available data to identify stranding survey sites. Site selection from the desktop review was confirmed by aerial and ground reconnaissance of identified survey sites. A total of 77 transect and 41 pool sites across the three survey strata (PCN to Lynx Creek, Lynx Creek to Halfway River, Halfway River to Pine River) were identified through the desktop review. The selected sites in each of the strata were assigned a priority ranking for the field survey.

The second component was the fish stranding survey at selected sites on July 14, 2012 following completion of the spill on July 11. The spill duration was 16 days with an average discharge close to 2700 m^3/s at PCN. A total of 30 of the pre-selected survey sites were visited during the stranding survey by the three field crews, including 12 pool sites and 18 transects. In stratum 1 (Peace Canyon to Lynx Creek), two pool and seven transects sites were surveyed. In stratum 2 (Lynx Creek to Halfway River), five pool sites and six transect sites were surveyed. In stratum 3 (Halfway River to Pine River), six pool sites and six transect sites were surveyed.

No stranded fish were observed on any surveyed transects. A single beached whitefish was observed on the river bank while travelling between transects 59 and 61. The remaining fish observed during the survey were all located in pools and the majority of pools were not isolated. The majority of fish observed were juveniles and too small to be identified. Few stranded fish were observed during the stranding survey and the majority were observed incidentally in pools while travelling on foot between identified survey sites. Incidental observations and an anecdotal report indicated that higher numbers of stranded fish may be encountered in some locations.

Fish stranding during this survey was primarily associated with isolated pools but was considered to be low in magnitude and biologically insignificant based on the results from this survey. Recommendations to assist in future surveys are related to the timing of the survey and confirming selection of the survey sites.

ACKNOWLEDGEMENTS

A number of people have contributed to the GMSMON 3 project to date. BC Hydro WLR sponsored the project. Substantial guidance and ongoing support was provided by Mike McArthur. Darrell Ratzlaff assisted with the flight plan.

Reconnaissance surveys were completed by CBA Ltd staff Andrew MacInnis with assistance from Karl Bachmann. Andrew MacInnis (CBA Senior Fisheries Biologist) was Project Manager with assistance from John Cooper the Project Advisor. The stranding surveys were led by Andrew MacInnis with assistance from Monica Stewardson, Lance Stewardson, Vicki Prigmore, Ryan Gill, and Laura Kennedy.

Helicopter services for the stranding survey were provided by Canadian Helicopters in Fort St. John.

The report was prepared by Andrew MacInnis. Ryan Gill conducted GIS analyses and prepared maps for the report. John Cooper provided a review of the report.

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1 INTRODUCTION

Fish stranding has been acknowledged as one of the expected outcomes of a spill event on the Peace River. However, the magnitude of stranding is unknown and was identified as a knowledge gap during the water use planning process (Anon. 2003). The Peace River Fish Stranding Survey is one of several monitoring programs to be implemented under the Peace Spill Protocol. The Peace Spill Protocol is one of the management plans being implemented under the Peace Water Use Plan where there was insufficient information to make informed decisions about the water management regime. The fish stranding survey is intended to quantify the impact of spills on fish populations in the Peace River and to determine if the magnitude of these impacts is significant to individual fish populations.

A total of 29 fish species have been identified as potentially occurring in the British Columbia portion of the Peace River downstream of the Peace Canyon Dam (PCN), including some species of conservation concern (Table 1). The table is based on a list of species recorded in the Peace River (P&E Environmental Consultants Ltd. 2002)[1] and updated to include any additional species identified through the Peace River Fish Community Indexing Program (P&E Environmental Consultants Ltd. and W.J. Gazey Research 2003, Mainstream Aquatics Ltd. and W.J. Gazey Research 2004, 2005, 2006, 2007, 2008, 2009) and in Mainstream (2009). An FISS (2009) search for fish distributions in the lower Peace River Watershed identified two additional species: northern pearl dace (*Margariscus margarita nachtriebi*) and brook stickleback (*Culaea inconstans*). The locations in the FISS database for these species were not in the main stem of the Peace River and they were not collected in any of the studies identified above.

The majority of studies of fish stranding focus on the variable flows associated with normal operations of hydro–peaking facilities (e.g., Woodin 1984, Halleraker et al. 1999, Nugent et al. 2001, Saltveit et al. 2001, Irvine et al. 2009) with few addressing fish stranding associated with releases that are in excess of normal flow variability (e.g., Higgins and Bradford 1996, Chamberlain 2003).

Fish stranding can occur either as entrapment in isolated pools or beaching but it can be difficult to distinguish between the two forms (Hunter 1992). Beaching is generally considered stranding on gravel and cobble bars with shallow slopes. A previous stranding assessment conducted following a spill on the Peace River identified the highest risk areas for stranding were areas with shallow slopes and gravel bar areas associated with braided channels (BC Hydro 1997). This is consistent with the factors associated with greater stranding risk described by Hunter (1992). A few incidences of stranding associated with normal river operations were also noted during the field reconnaissance in 2010. These included a single sculpin stranded interstitially in a depression on a cobble bar, a single beached kokanee, and a few schools of young-of-the-year (YOY) whitefish in isolated pools. The isolated pools appeared to have some subsurface flow and were likely connected at higher flows within the daily variation in river level.

The stranding survey conducted in association with the 1996 spill event was conducted in two parts (BC Hydro 1997). The first assessment was conducted during a rampdown event on August 2 – 4, 1996 to identify the highest risk stranding sites. A total of 75 sites were surveyed and 352 fish were stranded (beached or isolated in pools). A second survey of the 20 highest risk sites was completed on August 17, 1996 and resulted in the identification of 35 stranded fish (20 were salvaged). Stranded fish identified during the surveys included mountain whitefish, suckers, sculpins, dace, northern pike, stickleback, young-of-the-year cyprinids, burbot, arctic

[1] Table 3.1; based on (Pattenden et al. 1990, 1991, RL&L Environmental Services Ltd. 2001)

Table 1. Fish species occurring in the Peace River, downstream of the Peace Canyon Dam.

Family	Species[1]	Common Name	Sportfish	Provincial List Status
Hiodontidae	*Hiodon alosoides*	Goldeye	X	Blue
Cyprinidae	*Couesius plumbeus*	Lake chub		
	Mylocheilus caurinus	Peamouth		
	Notropis hudsonius	Spottail shiner		Red[2]
	Phoxinus neogaeus	Finescale dace		
	Platygobio gracilis	Flathead chub		
	Ptychocheilus oregonensis	Northern pikeminnow		
	Rhinichthys cataractae	Longnose dace		
	Richardsonius balteatus	Redside shiner		
Catostomidae	*Catostomus catostomus*	Longnose sucker		
	Catostomus commersoni	White sucker		
	Catostomus macrocheilus	Largescale sucker		
Esocidae	*Esox lucius*	Northern pike	X	
Salmonidae	*Oncorhynchus mykiss*	Rainbow trout	X	
	Oncorhynchus nerka	Kokanee	X	
	Salvelinus confluentus	Bull trout	X	Blue
	Salvelinus fontinalis	Brook trout	X	
	Salvelinus namaycush	Lake trout	X	
	Coregonus clupeaformis	Lake whitefish	X	
	Prosopium coulterii	Pygmy whitefish		
	Prosopium williamsoni	Mountain whitefish	X	
	Thymallus arcticus	Arctic grayling	X	
Percopsidae	*Percopsis omiscomaycus*	Trout-perch		
Gadidae	*Lota lota*	Burbot	X	
Cottidae	*Cottus asper*	Prickly sculpin		
	Cottus cognatus	Slimy sculpin		
	Cottus ricei	Spoonhead sculpin		
Percidae	*Perca flavescens*	Yellow perch	X	
	Sander vitreus	Walleye	X	

[1] Nomenclature based on McPhail (2007)
[2] Red list is for a native and disjunct population in Maxhamish Lake. The Peace population is introduced (McPhail 2007).

grayling, rainbow trout, chub, northern pikeminnow, and trout-perch. These were similar to the species collected during the Peace River Fish Community Indexing Program (e.g., Mainstream Aquatics Ltd. and W.J. Gazey Research 2006, 2009). Key findings from the stranding assessment included:

- There appeared to be no correlation between the number of fish stranded and the distance downstream from the Peace Canyon Dam,
- Fish salvage for future spill events was not recommended due to the low number of fish stranded and the difficulty in capturing fish in large, silt bottom pools, and

- It was recommended that a stranding assessment based on the methods and areas surveyed in 1996 be completed following significant reductions in flow.

This report presents the results of a fish stranding survey completed in July 2012 following a spill in the Peace River downstream of the PCN and includes the process used to identify potential stranding areas and select survey sites. The survey was conducted under the Peace Spill Protocol and was intended to provide additional information on what fish species and life stages are most affected by a spill and identify areas with the highest risk of stranding. This fish stranding survey is one of a number of environmental monitoring programs under the Peace Spill Protocol that are intended to quantify the effects of spills on fish, wildlife, and riparian habitats.

2 OBJECTIVES AND MANAGEMENT HYPOTHESES

The monitoring objectives and hypotheses for GMSMON-3 were stated in the Terms of Reference for the project (BC Hydro 2008). These are restated below with a brief summary of the approach to answering the management questions and hypothesis testing in this study.

To address the extent of fish stranding resulting from spill events and the potential impacts on Peace River fish populations the management questions to be addressed by this monitoring program are:

1) What is the magnitude of entrapment/stranding along the Peace River after a spill?

2) Which species and life stages are affected by stranding and is the level of stranding biologically significant to fish populations in the Peace River?

3) What areas of the Peace River have the highest risk of stranding?

The primary objective of the fish stranding survey is to address the above management questions through a field survey designed to collect information on the extent and magnitude of fish stranding resulting from spill events with a discharge of 2000 m^3/s from the Peace Canyon Dam for two days or longer.

Based on the above management questions and objectives, the study was designed to test the following management hypotheses stated in the Terms of Reference:

H_{01}: Fish are not isolated in pools after dam operations return to normal operating levels after a spill event.

H_{02}: Fish are not stranded interstitially in gravel and on bars (e.g., gravel, cobble bars) once dam operations return to normal operating levels after a spill event.

H_{03}: The magnitude of stranding is not biologically significant to the population abundance of a given fish species.

Water use decisions that will potentially be affected by the results of this monitoring program are future spill strategies and the use of pulses of water to maintain side-channel habitat for fish downstream of the Peace Canyon dam. The basic question is whether or not spills and/or flood pulses result in benefits to fish overall by maintaining and creating habitat or are detrimental and cause significant population impacts through stranding.

The general approach to completion of the fish stranding survey consisted of two components. The first component was a map review and an aerial and ground reconnaissance to confirm site selection for the stranding survey. The second component was the fish stranding survey at selected sites following spill event of the required magnitude. The expected outcome of the study is a summary of the magnitude of stranding due to spill events and the implications for fish populations in the Peace River.

3 METHODS

3.1 Study Area

The study area was the Peace River from the PCN downstream to the confluence of the Pine River (Figure 1). Below the Pine River confluence, the potential impacts of a spill are considered to be reduced due to flow attenuation from tributary inflows. This study area was further divided using the strata identified in the previous stranding survey (BC Hydro 1997) (Table 2). These strata were originally selected based on river length to be covered, number of high risk stranding sites suspected from aerial observations and map review, and professional expertise (BC Hydro 1997). The study area for the stranding survey was further defined in the Terms of Reference (BC Hydro 2008) to include only the area above the river channel elevation at 70,000 cfs (1982 m^3/s), which is generally defined by the edge of terrestrial vegetation.

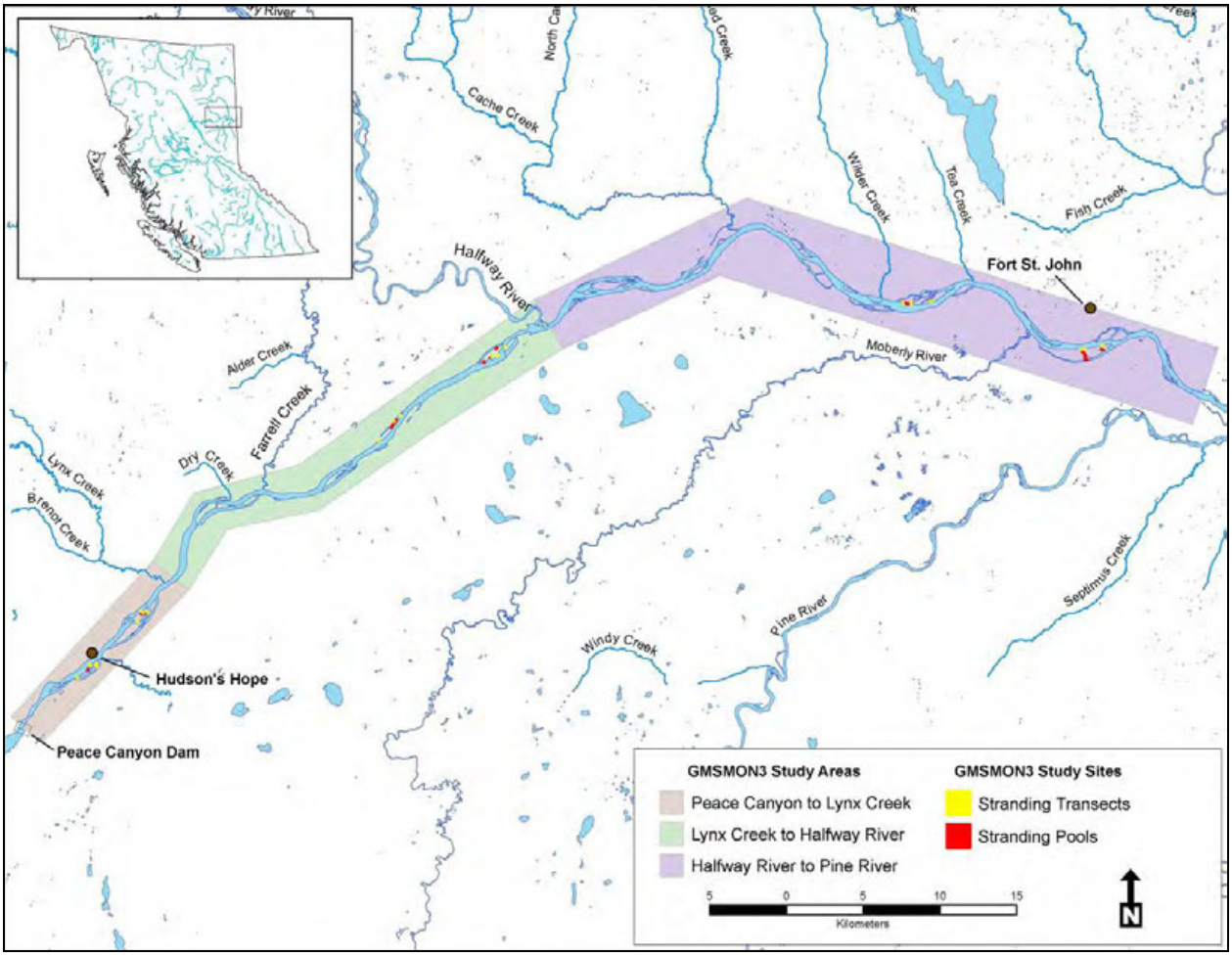

Figure 1. Peace River fish stranding survey area, strata, and survey sites.

Table 2. Peace River fish stranding survey strata.

Stratum	Description	Length (km)
1	Peace Canyon Dam to Lynx Creek	14
2	Lynx Creek to Halfway River	31
3	Halfway River to Pine River	57

3.2 Site Selection

The Terms of Reference (BC Hydro 2008) stated that a minimum of three index sites were to be surveyed in each stratum (Table 2). It was recognized that the number of sites selected in each stratum would depend on the variability within each stratum and the characteristics of selected index sites to sufficiently represent stranding potential.

Aerial photos (1:5,000, and 1:40,000) and a digital elevation model of the study region provided by BC Hydro were the primary tools used for identifying potential sites for the stranding survey. Google Earth imagery was also used occasionally as an additional source of information to confirm site selection. Sites surveyed in association with the 1996 spill, particularly sites where stranded fish were observed, were also reviewed on the air photos to assist in identifying appropriate survey sites.

The Terms of Reference (BC Hydro 2008) stated that the index sites selected for the stranding survey were to have some of the following characteristics:

1. Shallow slope;
2. Large area of small to medium sized porous substrate;
3. Undercut bank or pothole;
4. Overbank cover;
5. Large boulder or debris cover; and/or
6. Side channel

Based on the results of the air photo and the aerial and ground reconnaissance, the use of some of the above characteristics for selection of index sites were not appropriate for the section of the Peace River to be surveyed. In particular, areas with undercut banks and/or potholes, overbank cover, or large boulder or debris cover were either not present or extremely limited in extent. The selection of index sites with multiple characteristics would also make it more challenging to quantify spill associated stranding and identify the highest risk stranding areas in the Peace River.

To address these issues, an alternative approach to selecting sites was developed based on the literature review of the characteristics of stranding sites, characteristics of sites where stranded fish were observed following the 1996 spill, and the characteristics observed during the field reconnaissance in May 2010. From this information, the selection of survey sites was further stratified into pools and transects. All selected survey sites were assigned a unique identifier.

Characteristics considered when selecting pools for the survey included 1) the likelihood of being flooded during a spill, 2) unlikely to contain an existing fish population, and 3) small enough to be easily sampled using a beach seine or electrofishing. The 1996 stranding survey found that large, isolated pools (particularly downstream of the Halfway River) were difficult to sample effectively. For this reason (confirmed during the aerial overview and ground reconnaissance), large pools associated with side channels or historic side channels were

excluded from consideration as stranding survey sites. Additionally, it is expected that a number of these large pools may support existing fish populations that would confound estimates of stranding rates. It is expected that temporary pools may occur in areas of shallow slope with uneven terrain. However, it is not possible to predict the locations of these pools from the air photo analysis and depending on the river level at the time of the stranding survey they may not longer contain water due to a porous substrate.

The primary characteristic used in identifying areas to be surveyed with transects was the presence of a relatively large area with a low gradient beginning at the water's edge. These areas were associated with large bars that typically have gravel and cobble substrates (based on observations during the ground reconnaissance) and varying amounts of vegetation. The location of the bars varied and included locations on both banks of the river, the upstream and downstream ends of islands, the sides of islands, and side channels. Transects generally were perpendicular to the mainstem of the river and went from the waters edge up to higher ground. At some sites, transects are located on side channels and are oriented perpendicular to the direction of flow in the side channel.

An aerial survey and ground reconnaissance of some sites in each of the three strata was completed on May 28-30, 2010. The purpose of ground truthing was to confirm that the survey sites selected from air photo interpretation had characteristics associated with fish stranding based on the characteristics of stranding sites in the 1996 spill and as described in the literature. For transect survey sites the primary criteria was a shallow slope and association with an area of braided channels. For pool survey sites the primary criteria was the presence of standing water with no apparent connection to the river under normal operational flows. River discharge ranged from 601–1028 m^3/s during the reconnaissance survey (Peace River above Pine River [07FA004], Water Survey of Canada Real-time Data). Water levels at this station had fluctuated over a similar range since late April 2010. The normal high water level was estimated by the presence of a debris line or vegetation that was flattened in a uniform, downstream direction. Prior to ground truthing, the coordinates of each site were uploaded to a hand held GPS (Garmin 76CSx) and representative sites were visited following an over flight of the study area.

Flow mapping for a discharge of 1,982 m^3/s was not available to assist in site selection. The fish stranding survey is only to include river channel elevations above this discharge (BC Hydro 2008). In the absence of flow mapping, the location of stranding survey sites (transects and pools) in relation to this elevation was estimated based on the edge of terrestrial vegetation (as described in the Terms of Reference). However, from the air photo review and field reconnaissance this boundary was not always clearly defined and may be variable depending on the time of year. Flows are generally lower during the growing season and terrestrial vegetation may be able extend below the 1,982 m^3/s level. At sites where there was little or no vegetation to mark a clear boundary, the extent of the transect was estimated. As flow mapping was not available prior to the spill, the start elevation for transects was estimated by the field crews. The survey results can be modified where required, if and when flow mapping becomes available.

3.3 Field Surveys

As required under the Peace Spill Protocol (BC Hydro 2003), stranding surveys were completed on July 14, 2012 following a spill event where the discharge (Q_{out}) from the Peace Canyon Dam (PCN) was ≥2,000 m^3/s (≥70,629 ft^3/s) for more than two days. The spill began on June 27, 2012 and ended on July 11, 2012. Notification of the end of the spill was received after the spill had already been completed. Field crews were mobilised within two days to complete the stranding survey as soon as possible after the return to normal operation.

The fish stranding surveys were completed in a single day by three teams of two people. One field crew was assigned to each of strata identified in Table 2. Each field crew was assigned a minimum of three sites in each stratum, consisting of one pool and two transect sites. Sites were generally surveyed based on the identified priorities. Based on the level of effort used for the August 17, 1996 fish stranding survey (2 crews of 2 people surveyed 20 sites) (BC Hydro 1997), it was expected that more than the minimum number of sites could be surveyed. The total number of sites surveyed is also dependant on the number of stranded fish observed at each site (higher numbers of fish increase the amount of time required per site) and the size of the spill (higher river stage will increase the length and area of transect that needs to be surveyed). As there is little or no public road access to the Peace River in the study area and many of the survey sites were located on islands, field crews accessed sites by helicopter. In some locations, multiple survey sites were located within one kilometre and accessed on foot.

Transects ranged in width from 2 – 4 metres depending on the conditions at a given site. Transects with little or no vegetation and highly embedded substrates required less effort to search than transects with dense vegetation and/or less embedded substrates. A single transect was surveyed at each site to allow for the greatest number of sites to be sampled in a single stratum. With the size of each stratum, this approach was expected to provide a better estimate of fish stranding in the study area than surveying multiple transects at only a few sites

Transects were generally searched from the end closest to the main channel up to the flood level. In locations where a transect straddled an island or other feature that was not entirely submerged, the sections that were not flooded were identified as unsearched quadrants. The distance along a transect was measured in metres, beginning from the start, and was used to record the location of any stranded fish. It was expected that some transects might contain small, isolated pools due to localised poor drainage. This type of pool was considered part of a transect, provided it was at least partially located within the boundaries of the transect. The dimensions of each of these pools were noted and any stranded fish recorded.

Each field crew was provided detailed maps of all the sites within their assigned stratum and the survey priority of each site. If there was no evidence of flooding at a designated site, no survey was completed and the crew moved to the next site. Evidence of flooding included sediment deposition, scouring, disturbance to vegetation (e.g., grass all bent in one direction), or rafted debris. Survey priorities were adjusted in the field to maximize the number of sites surveyed. Lower priority sites were surveyed when located near the first priority sites and time was available prior to the next helicopter transfer. Surveying of lower priority sites was at the discretion of the lead biologist on each field crew. Opportunistic surveys of additional stranding sites were also conducted when identified in the field. Information from each survey site was recorded on standardized forms (Appendix 1).

Due to delays in application processing in the Peace Region, a scientific fish collection permit had not been received at the time of the survey, no handling of live fish occurred. Isolated pools were surveyed visually only. Dead fish were identified to species and the length recorded. Live fish were identified to species where a positive identification could be made, the length estimated, and the number of individuals recorded.

3.4 Data Entry and Analysis

All data was entered into a Microsoft Excel spreadsheet and reviewed for accuracy. Field data sheets and field notes were scanned to create an additional electronic copy of the data. Maps of each stranding site were developed to summarize site locations and descriptions based on field notes and GPS data.

The original intent was to quantify stranding risk using the number of fish stranded/ isolated per meter of habitat dewatered as the main reporting metric (MacInnis 2011). However, due to the few stranded fish observed during the surveys analysis of the results will be limited to qualitative discussion. Also, the limited number of stranded fish observed did not allow for estimates of stranding losses to be calculated or extrapolate stranding estimates to unsurveyed sites.

4 RESULTS

4.1 Site Selection

A total of 77 transect and 41 pool stranding survey sites were identified from the map review and confirmed during the field reconnaissance. The number of sites identified in each stratum varied due to the different lengths of the strata. The number of selected transect and pool survey sites and their relative frequency are shown in Table 3. The frequency of transect sites is similar for all three strata but the frequency of pools increases from the upstream to downstream strata. This may be related to the decreasing slope of the river beginning approximately 30 km downstream of the PCN (Northwest Hydraulic Consultants Ltd. 2010). This table only shows the frequency of selected stranding survey sites and is not an indication of relative stranding risk or the total number of potential stranding sites in the study area.

Table 3. Number and frequency of stranding survey sites by stratum on the Peace River.

Stratum	Name	Length (km)	No. of Pools	Pool Frequency	No. of Transects	Transect Frequency
1	PCN to Lynx Creek	14	2	0.14/km	12	0.85/km
2	Lynx Creek to Halfway River	31	7	0.22/km	23	0.74/km
3	Halfway River to Pine River	57	32	0.56/km	42	0.73/km

For all strata, there were more pools and transects identified than could be sampled due to the number and size of field crews and the need to complete the survey in a single day. Additionally, due to the size of the study area, not all potential stranding sites were identified. The emphasis was on sites considered to have the highest stranding potential and located on Crown land to facilitate access. Therefore, all transects and pools in each stratum were assigned a sampling priority based on considerations for obtaining a representative sample from each stratum and sampling logistics. Sites were prioritized to ensure that both pools and transects were sampled along the length of each of the strata. To simplify the logistics of transporting three field crews, areas where multiple sample sites (transects and pools) were located within a short distance (<1.5 km) were given a higher priority than areas containing a single site. Priority rankings are relative and the number of categories reflects the number of sites within a stratum. The locations of all selected survey sites are shown in Appendix 2. The coordinates and survey priorities for the pools and transects are included in Appendix 3 and Appendix 4, respectively.

4.2 Field Surveys

Field surveys for stranded fish were completed in a single day on July 14, 2012 following the end of the spill on July 11, 2012.

4.2.1 Environmental conditions

Weather conditions during the stranding survey were clear and dry with above average temperatures. Air temperatures were average during the first half of the spill and above average during the second half of the spill (Figure 2). Air temperatures also remained above average for the remainder of July following the stranding survey (Figure 2). Precipitation was above the 20 year average for values recorded in June and below average in July in the region (Table 4). At the Mackenzie weather station precipitation was approximately 50% above normal in June and

below normal in July (Table 4). At the Fort St. John weather station, precipitation was above average in June and well below normal in July (Table 4).

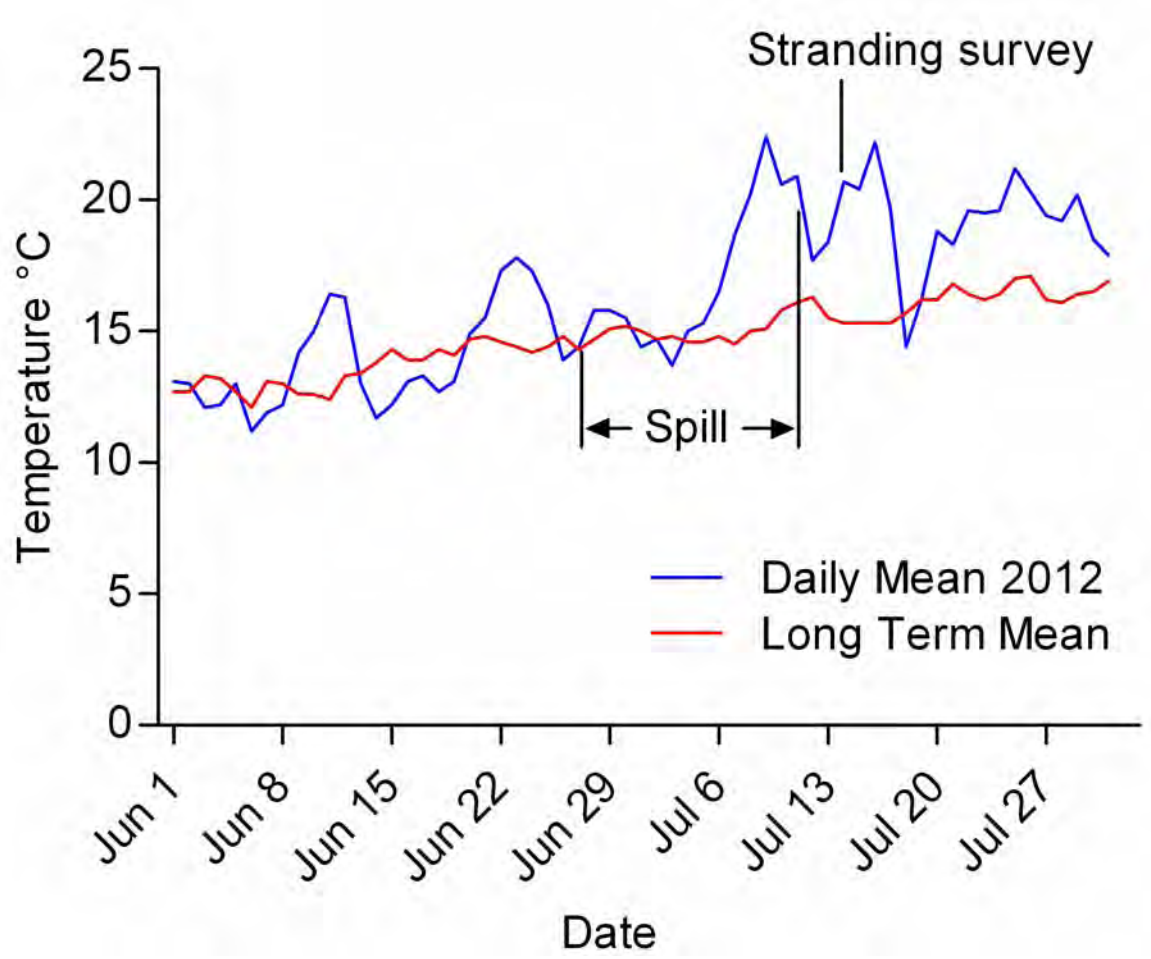

Figure 2. Daily mean temperature for June and July 2012 and the long term means in the study region. Data from Environment Canada and observed at the Fort St. John Airport weather station (Station name: Fort St. John A).

Table 4. Regional mean monthly and 2012 precipitation totals. Data from Environment Canada and observed at the Mackenzie and Fort St. John airport weather stations.

Station Name	June		July	
	Mean	2012	Mean	2012
Mackenzie A	63.2	97.5	61.5	53.5
Fort St John A	71.4	84.5	83.2	22.1

4.2.2 Spill data

The spill began on the morning of June 27 when the discharge from the PCN first exceeded 2,000 m^3/s and continued until the morning of July 11, 2012, a total of 15 days (BC Hydro). The requirement under the Peace Spill Protocol to conduct the stranding survey was not triggered until June 29 when the PCN discharge had exceeded 2,000 m^3/s for two days. Ramping rates at the beginning and end of the spill were consistent with the Peace Spill Protocol licensed rates of +0.15 m/hr and -0.10 m/hr change observed at Hudson's Hope (Figure 3 and 4). Increases in water occurred over a period of three days while flow was decreased over the course of a single day. The discharge from PCN during the spill ranged from 2,005 m^3/s to 3,289 m^3/s. The highest and lowest values occurred early in the spill with the discharge at PCN being consistently close to 2,700 m^3/s (median 2678 m^3/s) for most of the spill duration (BC Hydro). This was reflected in the discharge and water levels observed at the downstream Water Survey of Canada hydrometric stations at Hudson's Hope (Peace River at Hudson Hope [07EF001 and 07EFX01]) (Figure 5) and above the Pine River (Peace River above Pine River [07FA004]) (Figure 6).

Water levels in the Peace River at Hudson's Hope during the spill ranged from 5.14 – 6.35 m with an average level of 5.88 m (median 5.93 m) (Figure 5). Water levels at this station ranged from 3.09 – 5.38 m after the spill with a mean level of 4.61 m (median 4.81 m) (Figure 5). Water levels at the downstream end of the study area (Peace River above Pine River [07FA004]) during the spill ranged from 2.91 – 4.20 m with and average level of 3.63 m (median 3.66) (Figure 6). At the time of the stranding survey flows had returned to within normal values but without the fluctuation typical of normal operations (Figure 5 and 6). Discharge ranged from 1,408 – 1,450 m^3/s at Hudson's Hope and 1,037- 1,663 m^3/s above the Pine River during the fish stranding survey. The water levels during the stranding survey ranged from 4.89 – 4.94 m at Hudson's Hope and 1.39 – 2.19 m above the Pine River. Water and spill levels observed during the stranding survey were consistent with these values with the spill level estimated to be one to two meters above the water level at the time of the survey, depending on the location.

A high flow event in early June, prior to the spill was also recorded at the station above the Pine River (Figure 6). The peak flow associated with this event was 3,955 m^3/s and occurred on June 8, 2012. This event is associated with a flood event on the Halfway River with a peak flow of 2,039 m^3/s on June 8 (Figure 7). The peak flow from this event was the third highest value recorded in June for the period of record (1984 – 2010) at this station (Halfway River near Farrell Creek [07FA006]). The highest daily values from this station are 2,790 and 2,480 m^3/s, recorded on June 12 and 13, 2001. The next highest daily value for the period of record was 2,000 m^3/s on June 2, 1990.

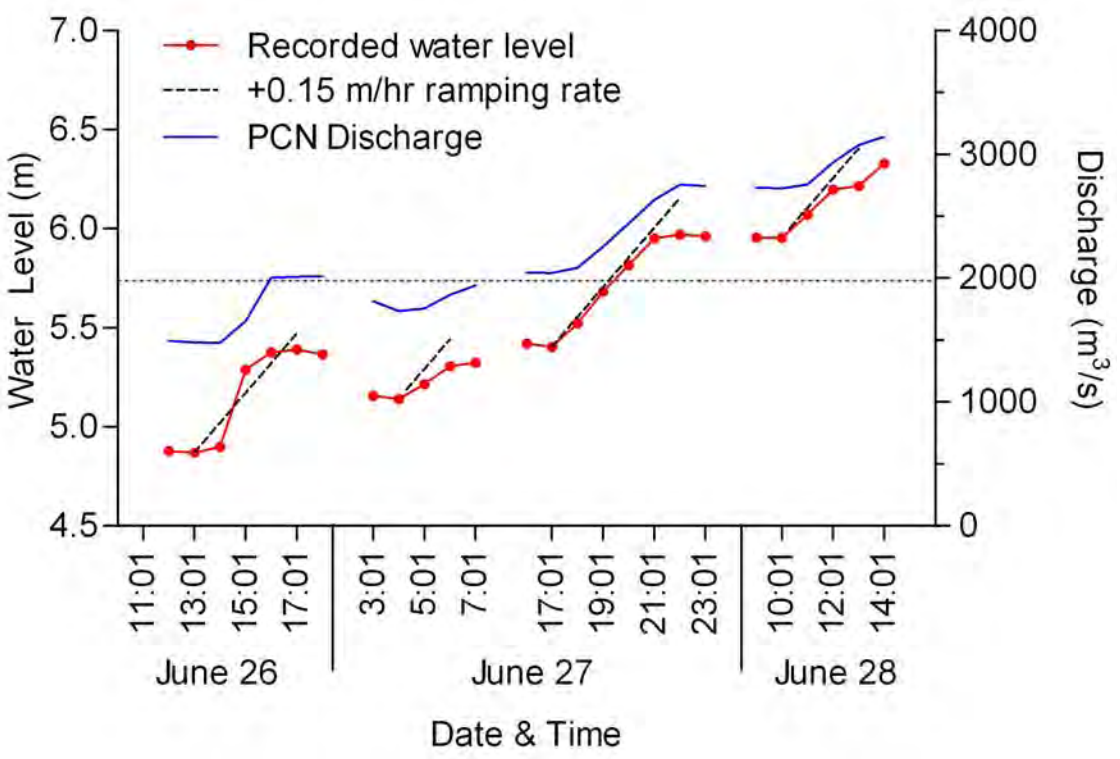

Figure 3. Water level increases observed at Hudson's Hope at the start of the spill. The black lines represent the spill ramping rate of +0.15 m/hr. Only periods with large increase in water level are shown. The horizontal line indicates the maximum normal discharge of 1982 m^3/s. Data from the Water Survey of Canada stations 07EF001 and 07EFX01.

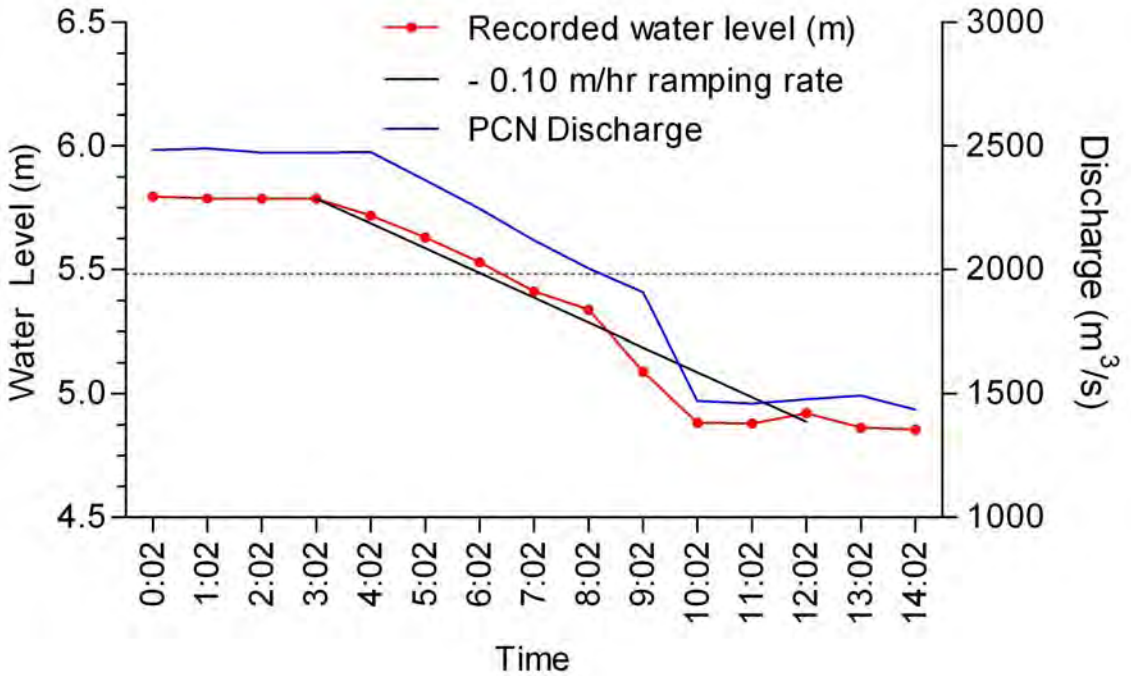

Figure 4. Water level decreases observed at Hudson's Hope at the end of the spill on July 11, 2012. The black line represents the spill ramping rate of -0.10 m/hr. The horizontal line indicates the maximum normal discharge of 1982 m^3/s. Data from the Water Survey of Canada stations 07EF001 and 07EFX01.

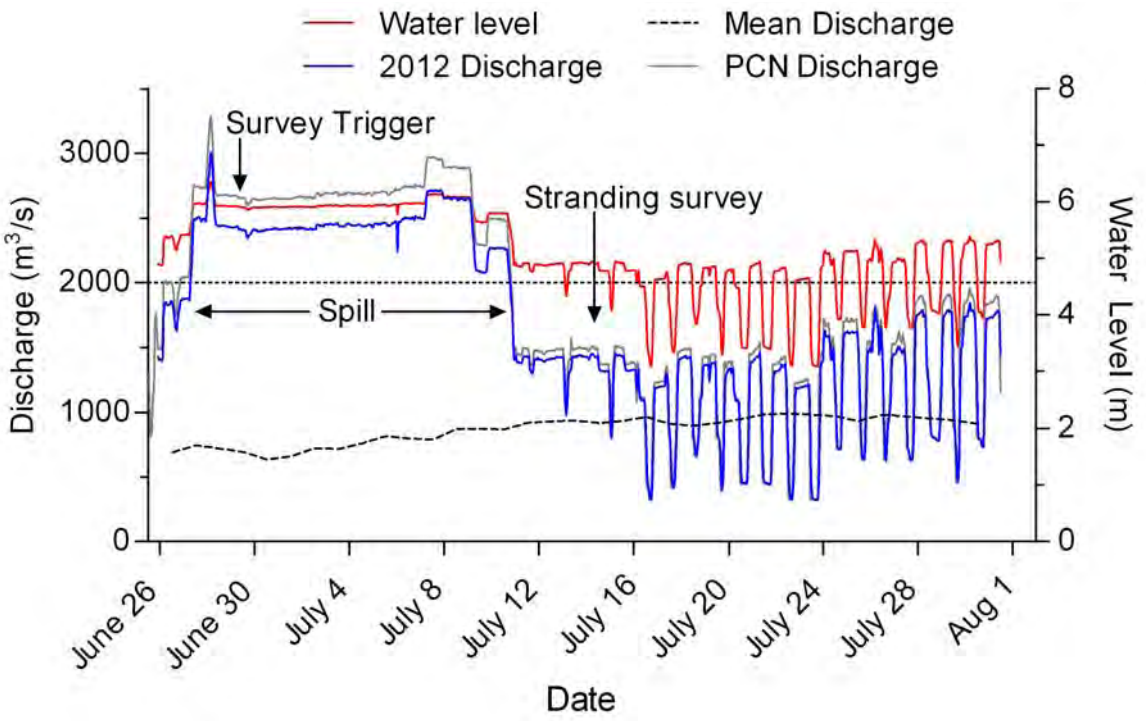

Figure 5. Discharge and water level in the Peace River at Hudson's Hope during and after the spill including the average discharge for this period and PCN discharge. Data are from the Water Survey of Canada stations 07EF001 and 07EFX01 and BC Hydro. Water level and 2012 discharge are hourly values. The mean discharge is the mean daily discharge from 1980 – 2010 (1996 excluded). No June 2012 data was available for these stations for the period prior to the spill.

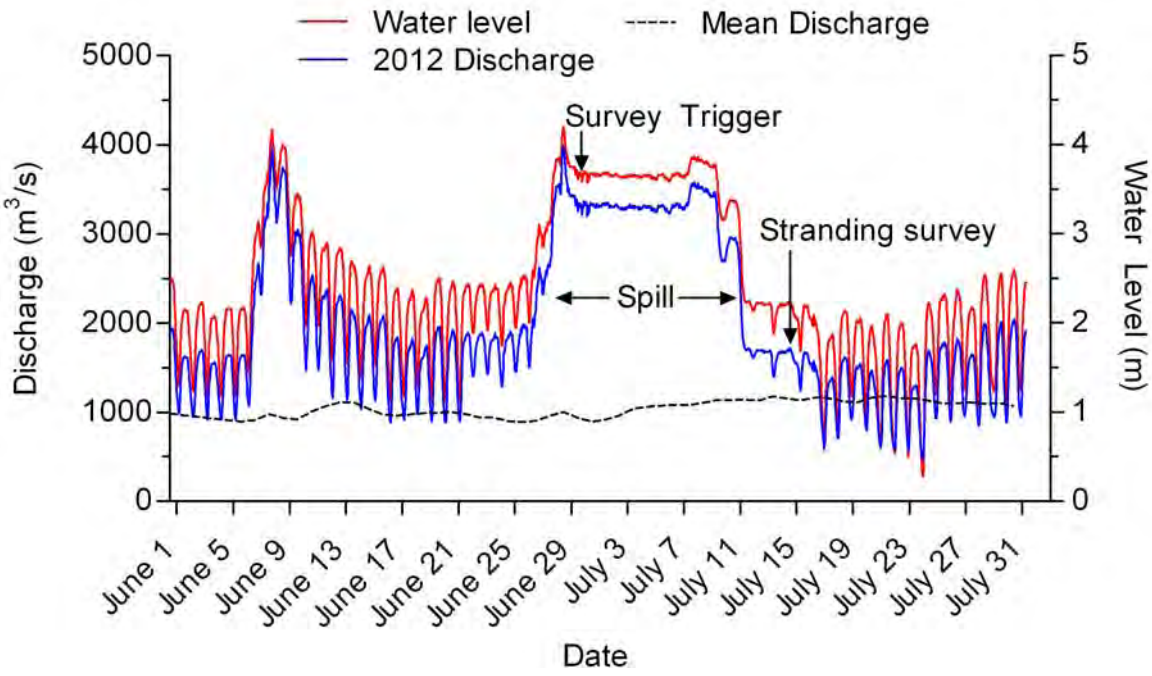

Figure 6. Discharge and water level in the Peace River above the Pine River before, during, and after the spill including the average discharge for this period. Water level and 2012 discharge are hourly values. The mean discharge is the mean daily discharge from 1980 – 2010 (1996 excluded). Data is from the Water Survey of Canada station 07FA004.

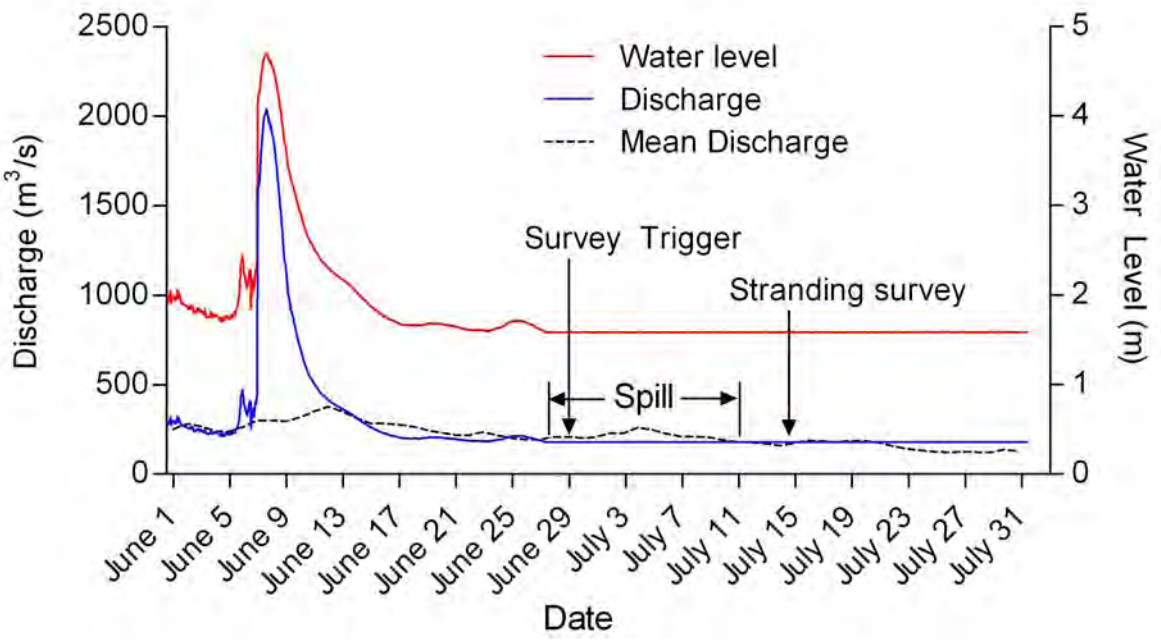

Figure 7. Discharge and water level in the Halfway River for June and July 2012. Water level and 2012 discharge are hourly values. The mean discharge is the mean daily discharge from 1984 – 2010. Data is from the Water Survey of Canada station 07FA006.

4.2.3 Flood Sign Observed

The flood signs observed in all three strata during the stranding survey included rafted debris (leaves, vegetation and small woody debris), bent vegetation, and uniform deposition of a sediment film on the substrate and vegetation (Appendix 5). In stratum 3, downstream of the Halfway River, additional flood signs included areas with extensive sediment deposition and large woody debris (LWD) jams. The LWD jams were a combination of new debris and a remobilization of existing LWD. Some of the observed LWD may have originated from the Halfway and Moberly Rivers during high flows in early June. High flows in the Halfway and Moberly Rivers are also the likely source of the large sediment deposits observed in Stratum 3 that were not present in either Strata 1 or 2, located upstream of the Halfway River.

4.2.4 Stranding Sites Surveyed

A total of 30 sites were visited during the stranding survey, including 12 pool sites and 18 transects. In stratum 1 (Peace Canyon to Lynx Creek), two pool and seven transects sites were surveyed. All of the sites designated as the first priority were surveyed in stratum 1. In stratum 2 (Lynx Creek to Halfway River), five pool sites and six transect sites were surveyed. In stratum 3 (Halfway River to Pine River), six pool sites and six transect sites were surveyed. The sites surveyed in strata 2 and 3 were a mixture of priority 1 and 2 sites. The emphasis was on priority 1 sites but priority 2 sites were also included when they were located in close proximity to priority 1 sites and time was available prior to the next helicopter transfer.

All sites were visually searched for fish generally from the end closest to the main channel up to the flood level. The search width on all transects was two metres except for transect 24 where a search width of four metres was used. The two meter width allowed for an effective search by

the two person field crews on all transects including searching under debris, vegetation, and substrate. The total area surveyed was 18,307.7 m^2, consisting of a surveyed pool area of 15,111.9 m^2 and a surveyed transect area of 3,195.8 m^2. The majority of the pool sites visited were not isolated at the river levels observed at the time of the survey and therefore and extensive search was not always completed. However, a visual inspection was completed to determine fish presence/ absence at each site even if the pool was not isolated.

A summary of sites surveyed or visited during the July 14 stranding survey by stratum is provided in Table 5 including the area searched, search effort, and fish presence. Maps of each survey site and representative site photos are included in Appendix 6 and Appendix 7, respectively.

Table 5. Stranding sites visited and area surveyed on July 14, 2012.

Stratum	Name	Site	Priority	Area Surveyed (m^2)	Search Effort (time)	Fish Presence	Comment
1	Peace Canyon to Lynx Creek	Pool A	1	-	-	N	Not isolated, not surveyed.
		Pool B	1	11,333	0:55	Y	Not isolated.
		Transect 3	1	160.6	0:16	N	
		Transect 4	1	221.2	0:32	N	
		Transect 5	1	284	0:10	N	Not flooded.
		Transect 6	1	262.6	0:30	N	
		Transect 10	1	187.8	0:27	N	
		Transect 11	1	408.8	0:45	N	
		Transect 12	1	-	-	-	Not flooded, not surveyed.
2	Lynx Creek to Halfway River	Pool E	1	1032	0:09	Y	Not isolated.
		Pool F	1	-	-	-	No pool, flowing side channel.
		Pool G	1	312	0:16	N	Not isolated.
		Pool H	1	2110	0:08	Y	Not isolated.
		Incidental 1	-	198			Isolated pool stranding
		Transect 24	2	50.4	0:10	N	
		Transect 25a	1	59.8	0:16	N	
		Transect 25b	1	69.2	0:24	N	
		Transect 26	1	236.4	0:17	N	
		Transect 31	1	165.4	0:20	N	
		Transect 32	1	298.4	0:16	N	
		Transect 33	1	204	0:20	N	
3	Halfway River to Pine River	Pool T	1	-	-	-	Not isolated, not surveyed.
		Pool DD	1	-	-	-	Not isolated, not surveyed.
		Pool FF	1	-	-	-	Not isolated, not surveyed.
		Pool II	2	-	-	-	Not isolated, not surveyed.
		Incidental 2	-	53.2	0:05	Y	Isolated pool stranding
		Incidental 3	-	73.7	0:05	Y	Isolated pool stranding
		Transect 58	1	41.2	0:10	N	
		Transect 59	1	188	1:00	N	
		Transect 61	2	-	-	-	Flooded, not surveyed.
		Transect 69	1	120	0:26	N	
		Transect 70	1	238	0:36	N	

4.2.5 Stranded fish

No stranded fish were observed on any surveyed transects. A single beached whitefish was observed on the river bank while travelling between transects 59 and 61. The remaining fish observed during the survey were all located in pools and the majority of pools were not isolated. The majority of fish observed were juveniles and too small to be identified. Few stranded fish were observed during the stranding survey and the majority were observed incidentally in pools while travelling on foot between identified survey sites. A summary of all fish observed during the surveys is in included in Table 6.

Table 6. Summary of all fish observed during the July 14, 2012 stranding survey.

Stratum ID	Site	Species	Length (mm)[1]	Condition	Stranding Type	Notes
1	Pool B	mountain whitefish	150-200	live		>20 individuals
2	Incidental 1	kokanee	172	dead	pool	
	Pool E	unknown	40	live		
	Pool G	unknown	15	live		12 small fish observed in pool
	Pool H	unknown	35-40	live		7 small, unknown fish observed
3	Pool DD	unknown		live		many small fish observed
	Pool II	unknown		live		many small fish observed
	Incidental 2	mountain whitefish	180	live	pool	
	Incidental 3	kokanee	200	dead/ injured	pool	missing upper rays of tail
		mountain whitefish	60	live		
		unknown	20	live	pool	5 unidentified fry

[1] – length estimated for live fish

4.2.6 Scavenger activity

Limited evidence of scavenger activity was observed during the stranding surveys. Two Bald Eagles were observed near pool H and a coyote (*Canis latrans*) was observed travelling (possibly foraging) along the edge of pools EE and FF. Numerous large fish scales (likely mountain whitefish) were observed at the edge of a pool near transect 61 that were assumed to be the result of predation or scavenging of one or more fish. No bird or mammal tracks were observed in association with the scales. No tracks or other signs of scavenging activity were observed at any of the pool sites surveyed. The ability to detect any tracks did vary among sites depending on the extent of vegetation, type of substrate, and amount of sediment deposition. During and immediately after the spill, higher than normal numbers of eagles and birds were observed in the area, particularly upstream of the Halfway River by field crews (R. Pattenden, pers. comm. to M. McArthur, BC Hydro).

4.2.7 Anecdotal Stranding information

Anecdotal observations by field crews conducting fish sampling in the area during and immediately after the spill did not observe large numbers of stranded or dead fish but, as noted above, higher than normal numbers of Bald Eagles were encountered upstream of the Halfway River. Fish sampling results indicated that fish were concentrated in low velocity areas in shallow water and that some of the captured fish were exhibiting signs of gas bubble trauma and/or had poorer than normal recovery rates from electrofishing (R. Pattenden, pers. comm. to M.

McArthur, BC Hydro). This anecdotal evidence suggests that predation and scavenging of fish affected by gas bubble trauma may be a more important effect of a spill than stranding.

Field crews conducting bird and amphibian surveys for GMSMON-12 encountered a number of stranded fish at two locations on July 19 and July 22, respectively. The fish were observed at GMSMON-12 survey sites 5 (July 19) and 3 (July 22). At site 5, nine dead and decomposing whitefish were observed along with a dead and decomposing rainbow trout. A single bull trout was also observed behind a beaver dam at this site. The bull trout appeared to be in poor condition due to elevated water temperatures and associated low dissolved oxygen. This site is located upstream of the Halfway River and the majority of stranded fish at this site were observed near stranding survey site Pool E. A single unidentified fish (~40mm TL) was observed at this site during the stranding survey. However, due to the size and depth of the pool only a 2m strip around the edge was searched for fish.

At site 3, a total of 22 dead and decomposing whitefish were observed in a back bay with several more live fish stranded in the remaining shallow water. A stranded sucker and sculpin were also observed at this site. No fish stranding survey sites were identified in the vicinity of this observation. The nearest fish stranding survey site identified was 1.5 km to the northwest.

At both GMSMON-12 sites 3 and 5, the dead fish observed were in various states of decomposition making it difficult to identify any obvious signs of physical trauma. While the wildlife field crews did not inspect these fish for signs of gas bubble trauma, the length of time since the end of the spill makes it unlikely that any field observable signs would still be present.

An additional report of fish stranding associated with the spill was included as a submitted opinion in the August 23, 2012 edition of the Northeast News. The author of the opinion was a landowner along the Peace River and reported observing multiple instances of fish stranding. The reported fish stranding observations included fry being regularly stranded in shallow pools that dewatered from river level fluctuations during normal operations and adult fish stranded in the same locations following the spill when water levels returned to normal levels.

5 DISCUSSION

While few stranded fish were observed during the July 2012 stranding survey, the post spill stranding survey did result in observations that provide additional information the extent and magnitude of fish stranding associated with spill events in the Peace River. The observations during the stranding survey, incidental and anecdotal observations, and the reconnaissance survey all provided relevant information and are discussed in relation to the project management questions and hypotheses.

The management questions and hypotheses for this project can be into two general categories. The first category addresses the magnitude and significance of stranding following a spill and the second category addresses the locations of stranding following a spill. For the first category, the management questions and hypothesis that address the magnitude and significance of fish stranding are:

- What is the magnitude of entrapment/stranding along the Peace River after a spill?
- Which species and life stages are affected by stranding and is the level of stranding biologically significant to fish populations in the Peace River?

H_{03}: The magnitude of stranding is not biologically significant to the population abundance of a given fish species.

The magnitude of entrapment/stranding along the Peace River following a spill appears to be relatively low but some locations may have a higher incidence of stranding than other locations. Few stranded fish were observed during the stranding surveys and the majority were in pools that were not isolated at the time of the survey. A number of dead whitefish were observed at two locations during the wildlife stranding surveys completed five and eight days following the stranding survey. Water was still present at both of these locations and the high than average air temperatures during this period may have been a contributing factor in the mortalities. A submitted opinion to a local paper also identified another location where stranding was observed following the spill. The few observations of fish stranding suggest that while stranding does occur following a spill, it appears to be restricted to selected locations, is of low magnitude, and the extent of mortalities may also be influenced by environmental conditions.

Based on the few observations of stranded fish during the survey and anecdotal observations during the post spill wildlife surveys, the numbers of fish stranded appear to be proportional to their relative abundance in the Peace River. Mountain whitefish were the most commonly observed stranded fish that could be conclusively identified. They are also the most common fish captured during the Peace River Fish Indexing surveys (e.g., Mainstream Aquatics Ltd. and W.J. Gazey Research 2009). Individuals of a few other species were also observed including kokanee, rainbow trout, bull trout, and longnose sucker. The few stranded fish observed during the surveys and the isolated locations suggest that the level of stranding is not biologically significant to fish populations in the Peace River. Therefore the null hypothesis (H_{03}) is provisionally accepted.

For the second category, the management question and hypotheses that address the locations of fish stranding are:

- What areas of the Peace River have the highest risk of stranding?

H_{01}: Fish are not isolated in pools after dam operations return to normal operating levels after a spill event.
H_{02}: Fish are not stranded interstitially in gravel and on bars (e.g., gravel, cobble bars) once dam operations return to normal operating levels after a spill event.

Fish were observed in all three survey strata and there did not appear to be any difference in the extent of stranding between areas. However, the observed strandings were associated with isolated pools, side channels, and back water areas. These features are more common further downstream in strata 2 and 3 so the relative risk of stranding would be considered to be higher in these strata than compared to stratum 1.

The majority of pools surveyed were not isolated at the time of the survey, so any fish observed were not considered to be stranded. While not isolated at the time of the survey, these pools may isolate periodically as water levels fluctuate during normal operations. A few stranded fish were also observed incidentally in small pools. These were in locations that where either not readily identifiable from the orthophotos or would have been too small and shallow to be discernible on the orthophotos. The observations of fish in side channel pools, backwater areas, and isolated pools suggest that this is the primary stranding mechanism associated with spills on the Peace River. This null hypothesis (H_{01}) is rejected.

It is possible that the numbers of fish present in some of the non-isolated pools was higher than would typically occur under normal operating conditions. The high water flows during the spill may have allowed for easier access to some of these areas than would occur under normal operating conditions. If fish use of these areas was higher as a result of the spill, this may have resulted in some indirect mortality due to the hotter than average weather that occurred following the spill. While not physically isolated, these areas may have been effectively isolated under most flow levels during normal operations. These areas trapped fish in relatively shallow water with limited or no flow resulting in high water temperatures and low dissolved oxygen saturation. This is supported by the observations of dead fish at two locations during the post-spill wildlife surveys.

At the sites surveyed during this stranding survey, there was no evidence of fish being stranded interstitially or on gravel bars following a return to normal operating levels. The relatively small size of the substrate (cobble) and high degree of embeddedness limits the potential for any interstitial stranding to occur within the study area. Observations during the stranding survey and reconnaissance survey suggest that there may be local areas where conditions allow for interstitial stranding particularly when associated with local depressions. However, these areas are small in area and appear to be uncommon in the study area. Therefore they are unlikely to be an important factor in fish stranding in the Peace River. Additionally, no fish stranding on gravel bars was observed during the stranding survey. Gravel bars were primarily encountered on survey sites in stratum 1 (PCN to Lynx Creek). This null hypothesis (H_{02}) is provisionally accepted based on the data from this survey.

5.1 Conclusions

This fish stranding survey did identify some fish stranding through a search of 30 sites along the Peace River from the Peace Canyon Dam to the Pine River. Fish stranding was primarily associated with isolated pools but was considered to be low in magnitude and biologically insignificant at the population level based on the results from this survey. There is some uncertainty in this conclusion some survey sites were located entirely (most pools and portions

of transects) within areas that are periodically flooded under normal operating conditions. The extent of fish use of these areas under normal operating conditions is unknown. Additionally, incidental and anecdotal observations of dead fish indicate that higher rates of stranding may occur in some locations. Another fish stranding survey incorporating the recommendations below should occur following the next spill on the Peace River.

With respect to the management hypotheses for this project, the following null hypotheses are provisionally accepted based on the data collected during this survey:

H_{02}: Fish are not stranded interstitially in gravel and on bars (e.g., gravel, cobble bars) once dam operations return to normal operating levels after a spill event.
H_{03}: The magnitude of stranding is not biologically significant to the population abundance of a given fish species.

The other management hypothesis for this project is rejected based on the data collected during this survey:

H_{01}: Fish are not isolated in pools after dam operations return to normal operating levels after a spill event.

6 RECOMMENDATIONS

No major issues were identified during completion of the fish stranding surveys in 2012. The recommendations presented below are intended to improve any future stranding surveys conducted under the Peace Spill Protocol. Some of the recommendations are updated versions of those presented in the survey protocol report (MacInnis 2011).

- Notification of the end of the spill as early as possible (preferably prior to the end of the spill) to allow for mobilisation of field crews and completion of the stranding surveys as soon as water levels return to normal.
- While few stranded fish were observed during this survey, an application for a scientific fish collection permit should be submitted as early as possible in any year a spill is forecast. This will allow for capture, positive identification, and salvage of any live fish encountered during the stranding survey.
- Complete a desktop review of existing stranding survey sites using the 1,982 m^3/s discharge orthophotos, 2012 peak spill and post spill orthophotos, and flow mapping to confirm the extent and location of stranding survey transects and pools. The post-spill orthophotos may also allow for the identification isolated pools that were not otherwise identifiable. This information was not available during the original selection of sites and it was recommended that this review be completed when the information became available (MacInnis 2011).
- Based on the results of the desktop review and the results of the 2012 stranding survey, update the list of survey sites and the survey priority. As the desktop review will be completed using information that was not available during the initial selection of the sites, it is expected that there will be some survey sites added and others removed.
- The stranding survey methods (MacInnis 2011) identified a number of pool sites that appeared to have relatively permanent water levels and could potentially contain fish. It was recommended that these pools be sampled prior to a spill event to confirm the presence or absence of fish. Pending the outcome of the desktop review, any pools

that are identified as high priority and appear to have relatively permanent water levels but no defined inlet or outlet to the river should be sampled to confirm the presence or absence of fish prior to a spill. This survey would be completed in a single day prior to a spill.

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Appendix 1. Stranding survey data sheets.

FISH STRANDING SURVEY - Site and Gear Information

Crew:		Date:		Stratum ID:			Site ID:		Photos:
Time Start:		Time End:			Total Survey Area:				
Weather:					Operating Conditions:				
Air Temp:		Mainstem Temp:			Isolated Pool Temp:		Total # Pools:		
Transect/Pool Length:			Transect/Pool Width:				Transect/Pool Area:		
Quadrant No.	Distance on Transect (m)	Pool Area (L x W)	Substrate	Vegetation Type	% Cover by Layer	Slope	Fish Presence	Gear Type	Gear Summary	Notes
Notes:										

Page ____ of ____

FISH STRANDING SURVEY - Fish Summary

Crew:		Date:			Stratum ID:			Site ID:	
Quadrant No.	Distance on Transect (m)	Species	Life Stage	Length (mm)	Fish Condition	Salvaged (Y/N)	Stranding Type	Gear Type	Notes
Notes:									

Page ____ of ____

Fish Stranding Survey - Data Sheet Instructions

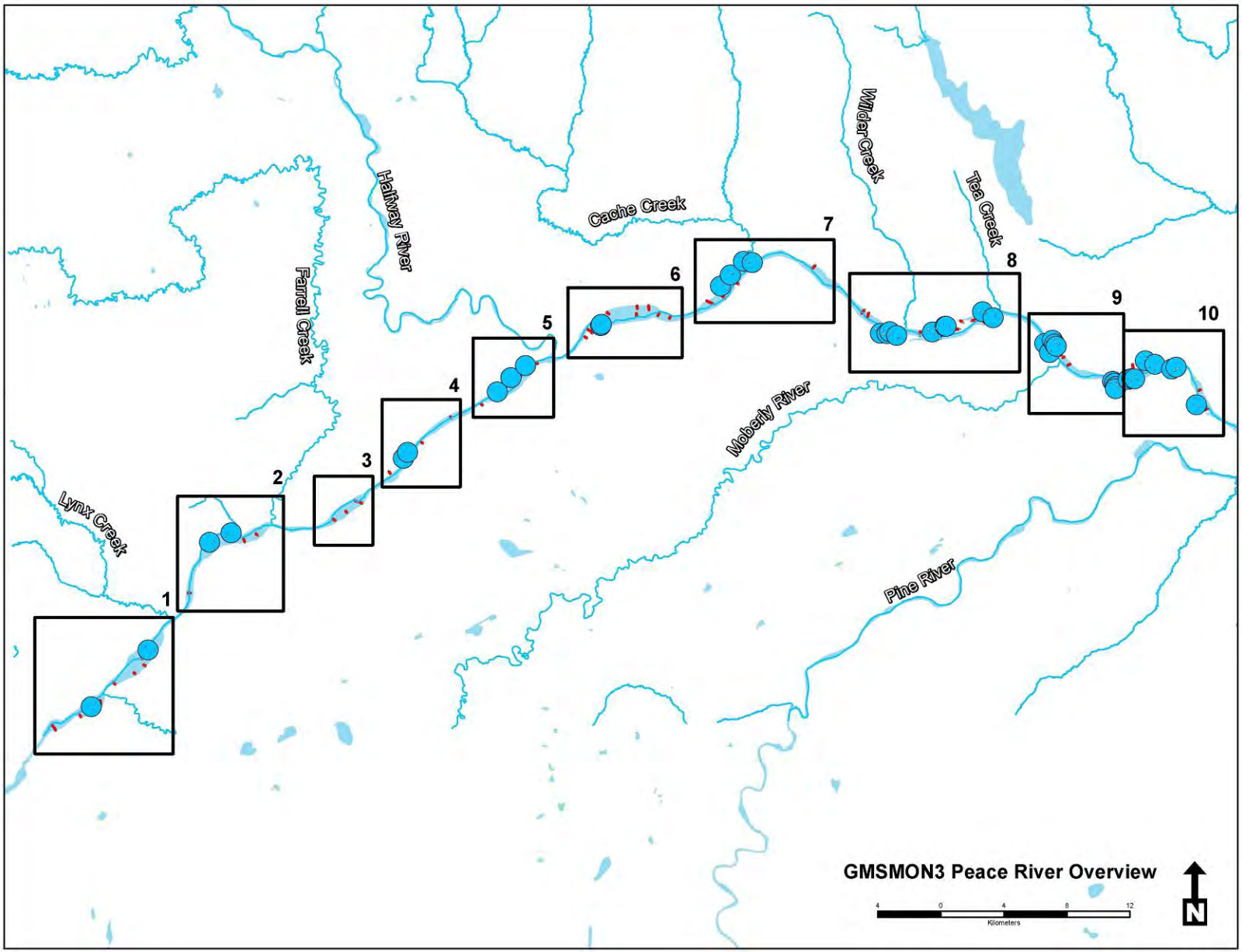
Site and Gear Summary

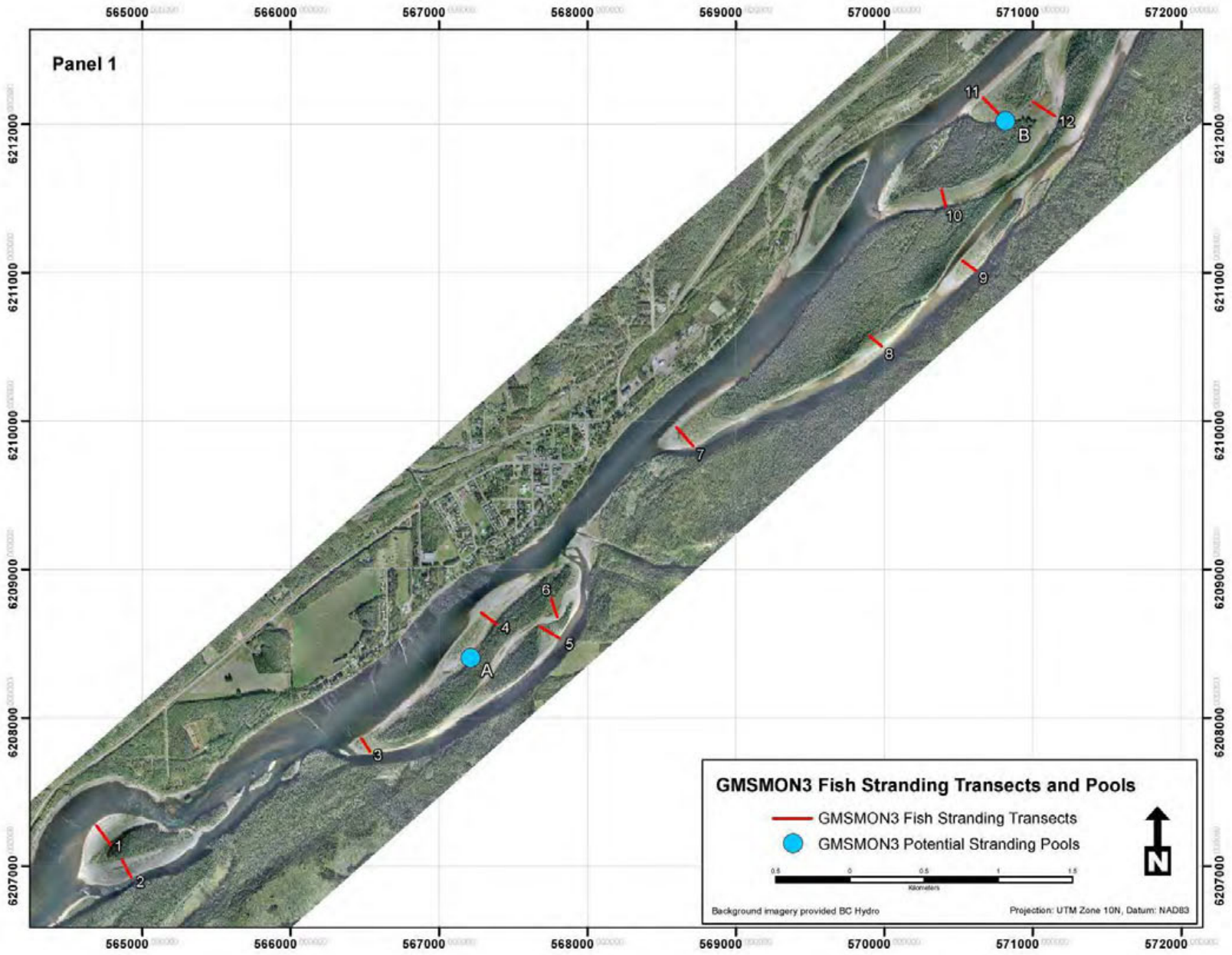
Crew:	Crew member initials
Date:	dd/mm/yy
Stratum ID:	Upper (Peace Canyon Dam to Lynx Creek), Middle (Lynx Creek to Halfway River), Lower (Halfway River to Pine River)
Site ID:	Record the identifying number (transects) or letter (pools) from the map.
Photos:	Record photo numbers from the camera display fo reach site
Time Start:	The time searching for stranded fish was started
Time End:	The time searching for stranded fish was ended
Total Area:	Calculated or total estimated area searched for stranded fish
Weather:	cloud cover, wind, precipitation
Operating conditions:	discharge, rampdown schedule, river stage (collected from BC Hydro)
Air temp:	Record in degrees Celcius
Mainstem Temp:	river temperature in degrees Celcius
Isolated Pool Temp:	Temperature of the isolated pool for pool survey sites
Transect/Pool Length:	Length of transect searched or length of pool
Transect/Pool Width:	Width of transect searched or width of pool
Transect/Pool Area:	Calculated area of transect or pool
Quadrant No:	Divide each transect into quadrants based on changes in slope, substrate, or vegetation. Begin numbering from start of transect.
Distance on Transect:	Distance in metres from the start of the transect to the beginning of the quadrant.
Pool Area (L x W):	Dimensions of any isolated pools that are included in the transect
Substrate:	Dominant substrate in each unvegetated or partially vegetated quadrant (boulder, cobble, pebble, gravel, sand, silt and clay)
Vegetation Type:	Description of vegetation type in each quadrant (e.g., grass, sedge, shrub species)
% Cover by Layer	Estimate % cover for the herb, shrub, and tree layers in each quadrant.
Slope:	Slope of quadrant measured with a clinometer
Fish Presence:	Are there stranded fish in the quadrant? Y/ N
Gear Type:	Sampling gear used in the quadrant - EF (electrofishing), SN (seine), DN (dipnet), VS (visual search)
Gear Summary:	EF - seconds, voltage, Hz, duty cycle, SN - mesh size, area swept, DN - area searched, time
Notes:	Record any signs of scavenger use or anything else of note in the quadrant.

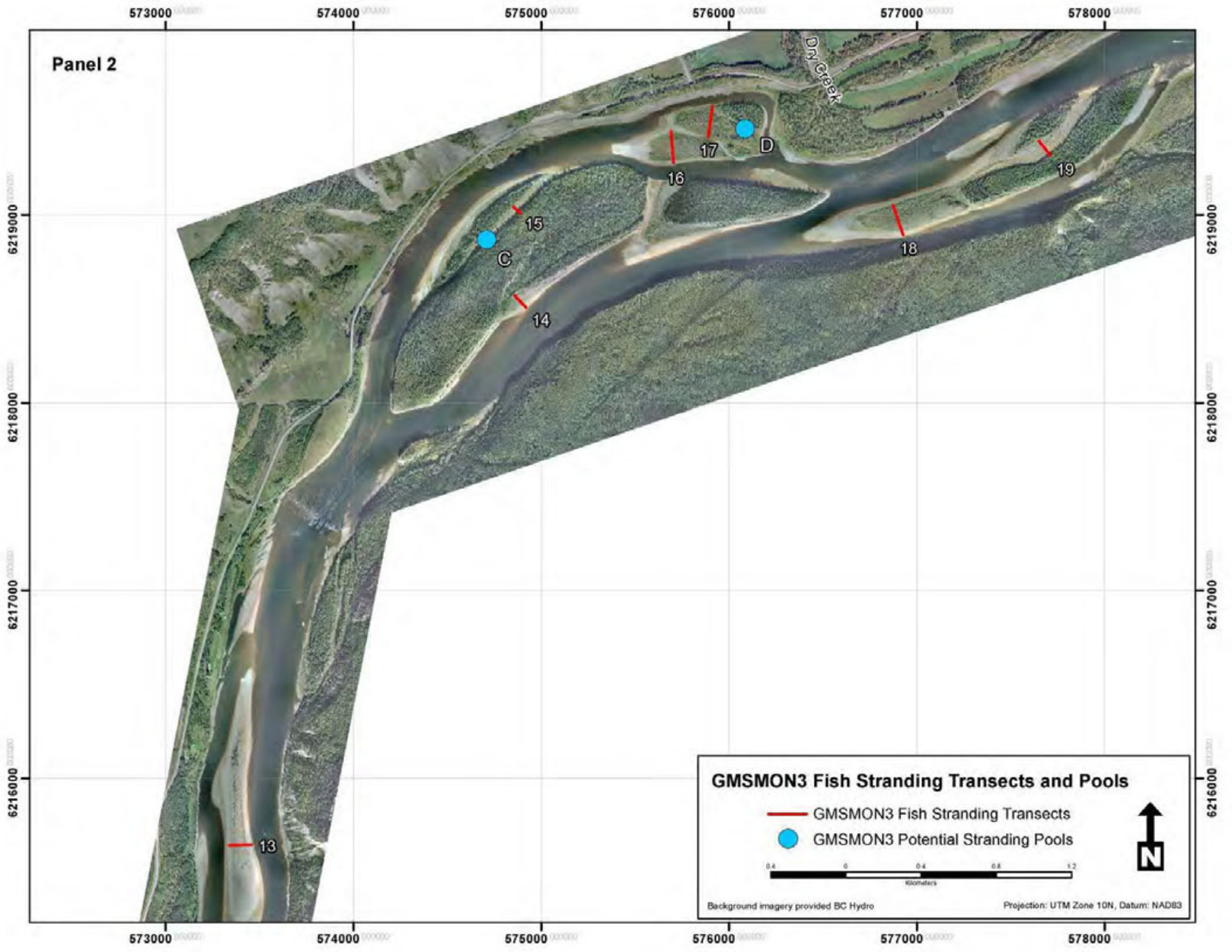
Fish Summary

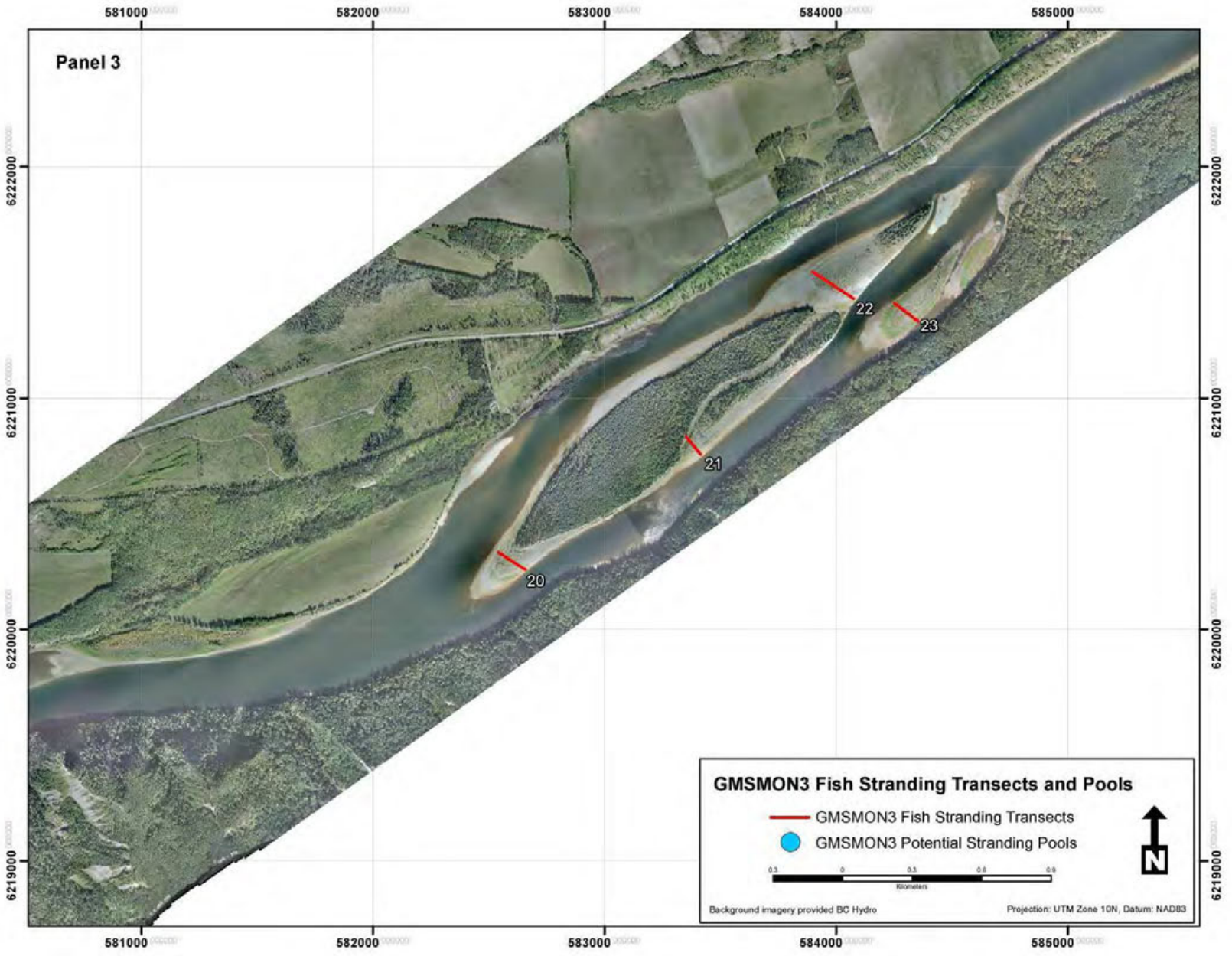
Crew:	Crew member initials
Date:	dd/mm/yy
Stratum ID:	Upper (Peace Canyon Dam to Lynx Creek), Middle (Lynx Creek to Halfway River), Lower (Halfway River to Pine River)
Site ID:	Record the identifying number (transects) or letter (pools) from the map.
Quadrant No.:	Divide each transect into quadrants based on changes in slope, substrate, or vegetation. Begin numbering from start of transect.
Distance on Transect:	Distance in metres from the start of the transect to the beginning of the quadrant.
Species:	Record the species code
Life Stage:	Life stage of the fish based on level of maturity (F = fry, J = juvenile, P = parr, A = adult, NS = not specified)
Length:	Fork length or total length in mm.
Fish Condition:	L = live, LI = live injured, D = dead, DI = dead injured
Salvaged:	Y/N, all live fish will be salvaged and returned to the river
Stranding Type:	B = beached, all fish found on top of the substrate or vegetation; I = interstitial, fish found in the substrate (under rocks); P = pool, fish srtanded in isolated pools
Gear Type:	Sampling gear used in the quadrant - EF (electrofishing), SN (seine), DN (dipnet), VS (visual search)
Notes:	Record any relevant information for individual fish such as injuries or photo numbers.

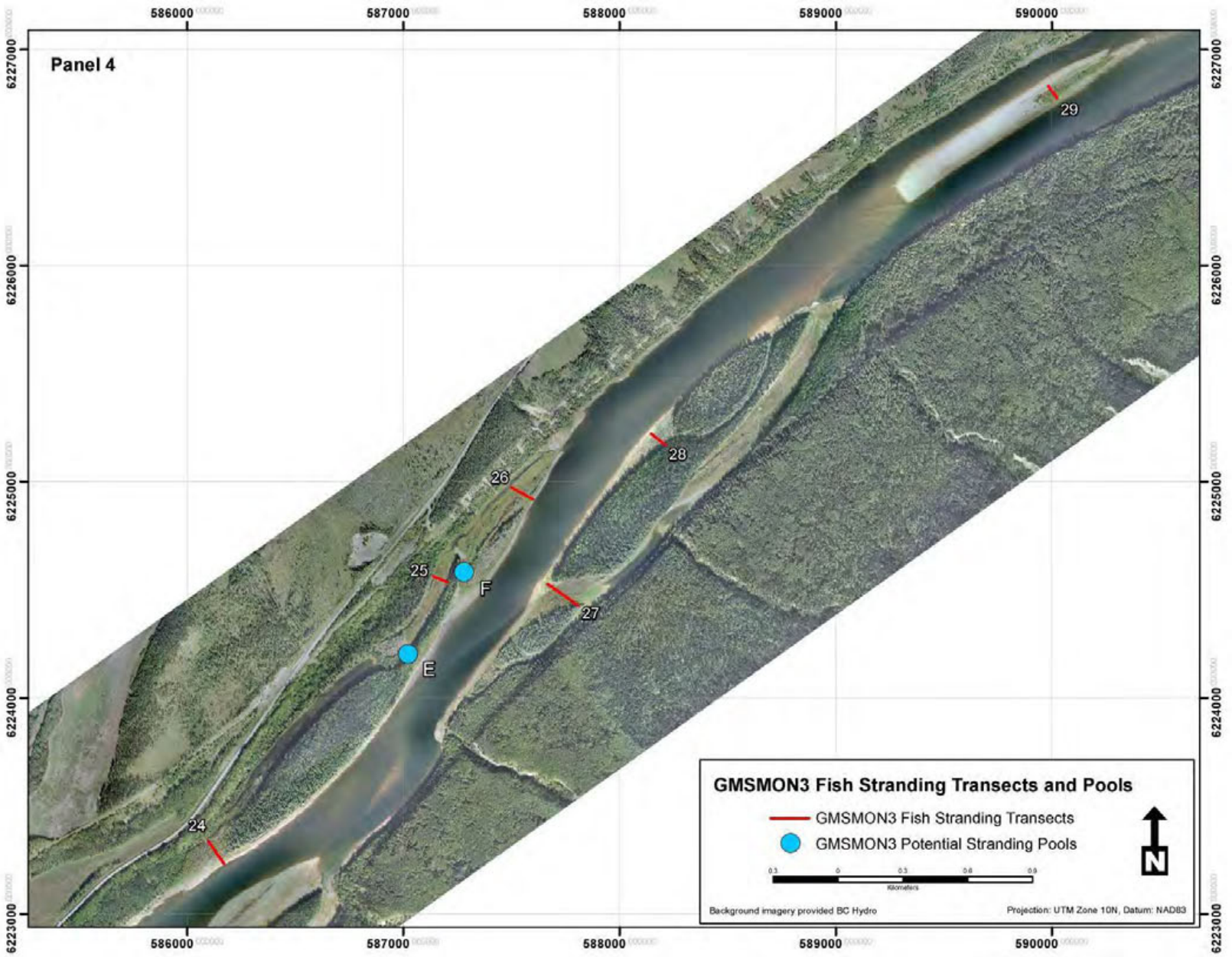
Appendix 2. Locations of stranding survey transects and pools.


Halfway River
Cache Creek
Wilder Creek
Tea Creek
Farrell Creek
Lynx Creek
Moberly River
Pine River
1
2
3
4
5
6
7
8
9
10
GMSMON3 Peace River Overview
4 0 4 8 12
Kilometers
N


Panel 1
565000
566000
567000
568000
569000
570000
571000
572000
6212000
6211000
6210000
6209000
6208000
6207000
1
2
3
4
5
6
7
8
9
10
11
12
A
B
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83

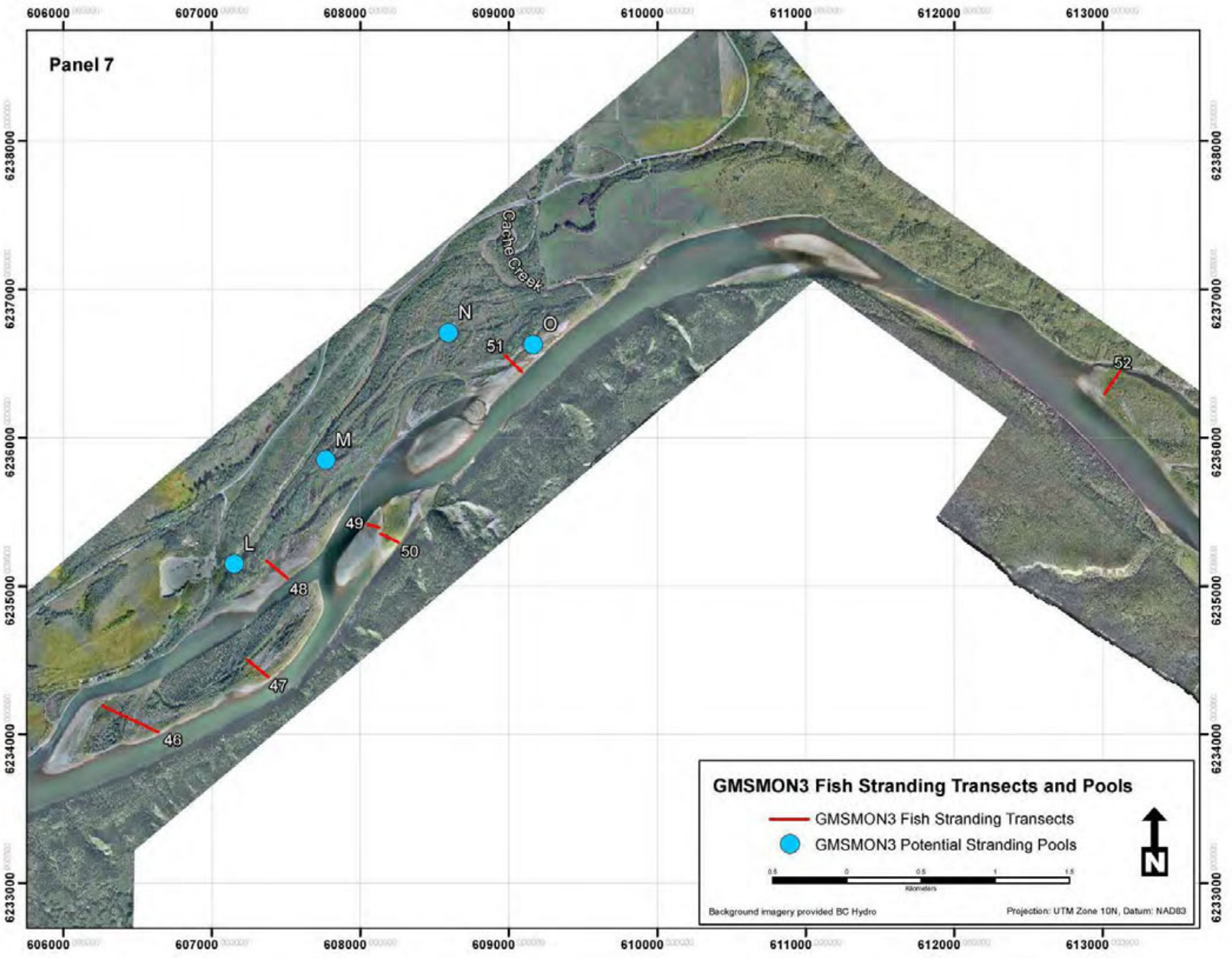

Panel 2
573000
574000
575000
576000
577000
578000
6219000
6218000
6217000
6216000
Dry Creek
13
14
15
16
17
18
19
C
D
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83

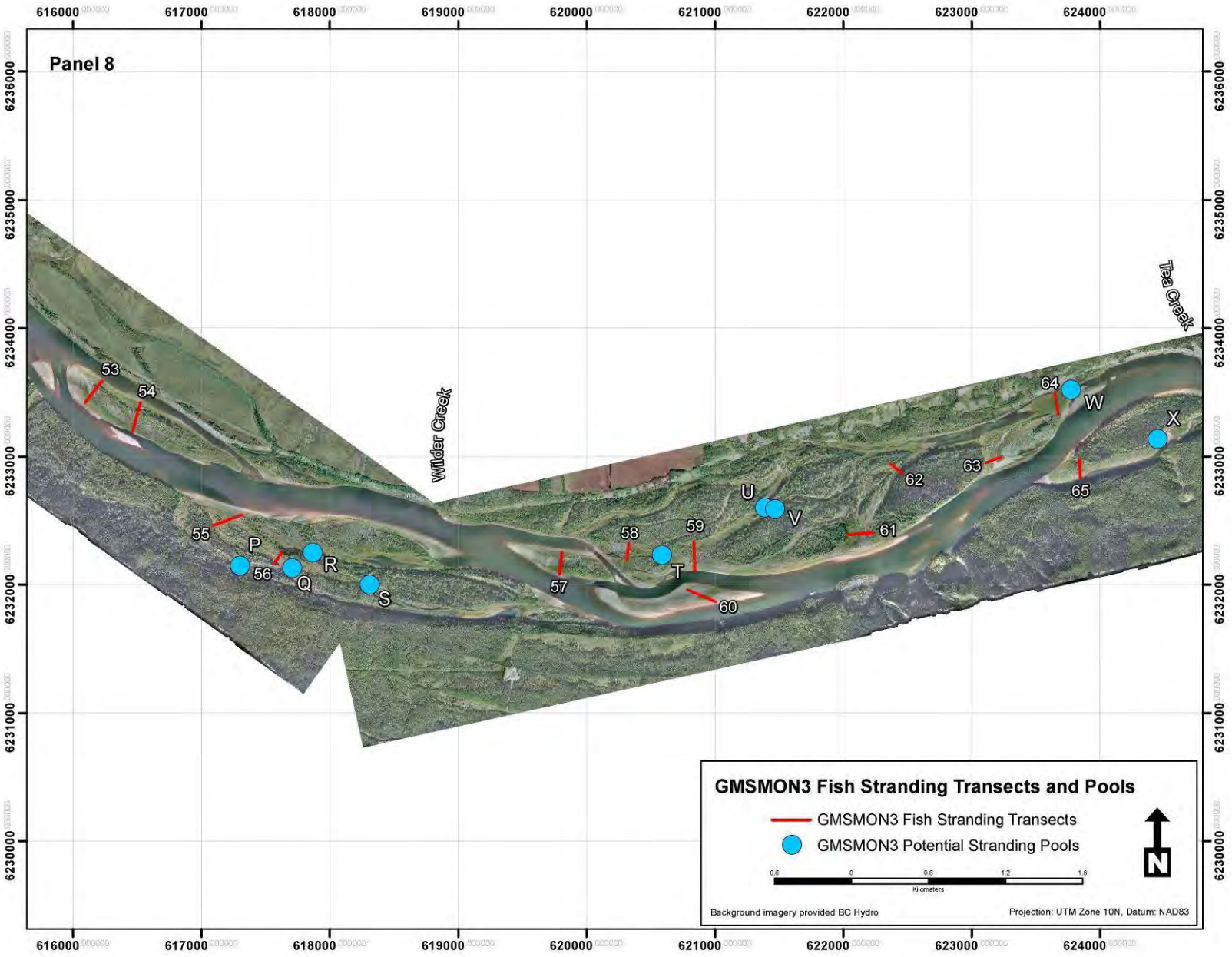

Panel 3
581000
582000
583000
584000
585000
6222000
6221000
6220000
6219000
22
23
21
20
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83


Panel 4
586000
587000
588000
589000
590000
6227000
6226000
6225000
6224000
6223000
29
28
26
25
F
27
E
24
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83


Panel 5
592000
593000
594000
595000
6230000
6229000
6228000
I
34
35
H
33
32
31
G
30
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83


Panel 6
599000
600000
601000
602000
603000
6235000
6234000
6233000
6232000
42
43
41
40
44
K
J
39
37
38
36
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83


Panel 7
606000
607000
608000
609000
610000
611000
612000
613000
6238000
6237000
6236000
6235000
6234000
6233000
Cache Creek
N
O
M
L
51
52
49
50
48
47
46
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
Kilometers
N
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83


Panel 8
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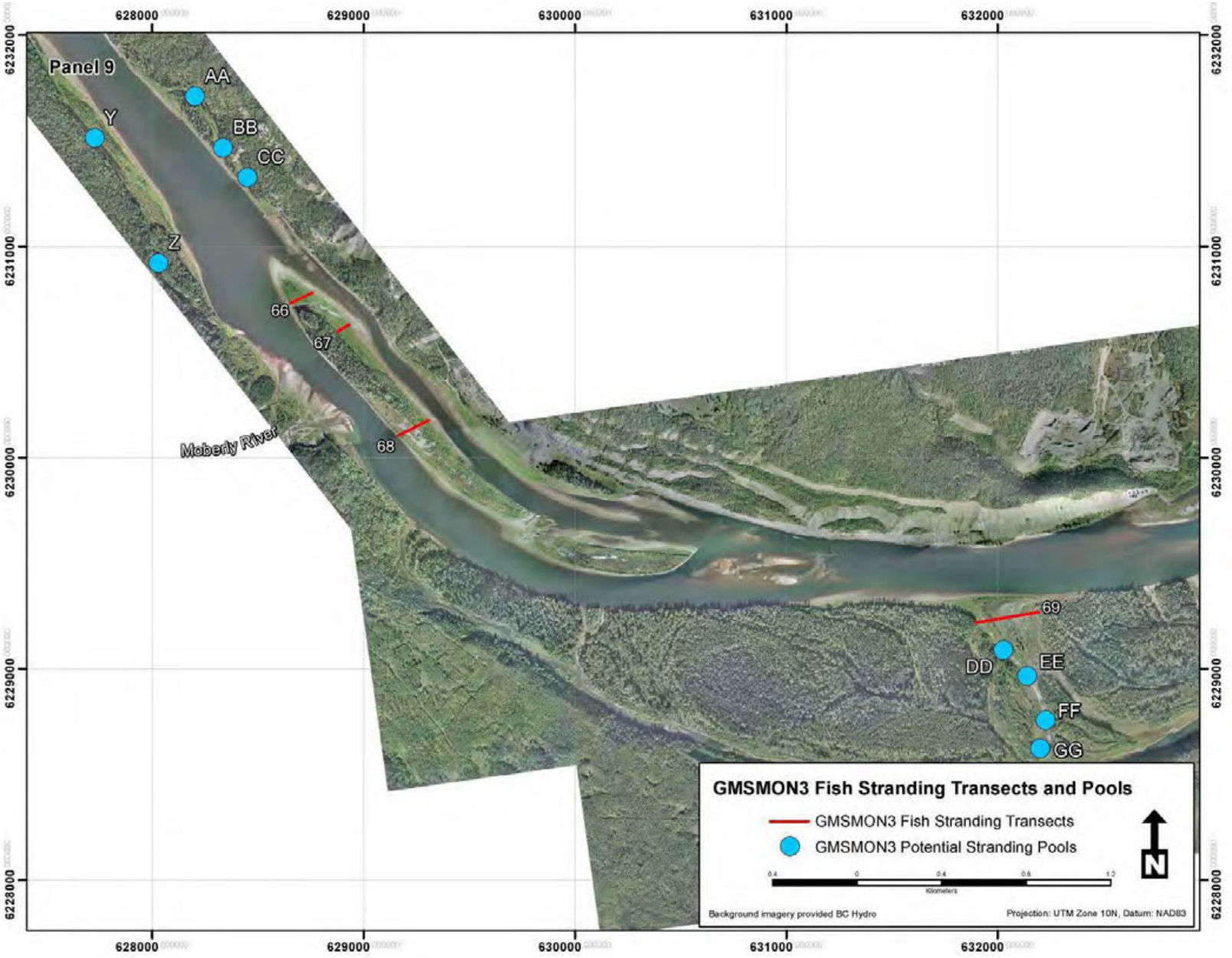
617000
618000
619000
620000
621000
622000
623000
624000
6236000
6235000
6234000
6233000
6232000
6231000
6230000
Wilder Creek
Tea Creek
53
54
55
56
57
58
59
60
61
62
63
64
65
P
Q
R
S
T
U
V
W
X
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
0.6
0
0.6
1.2
1.8
Kilometers
N
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83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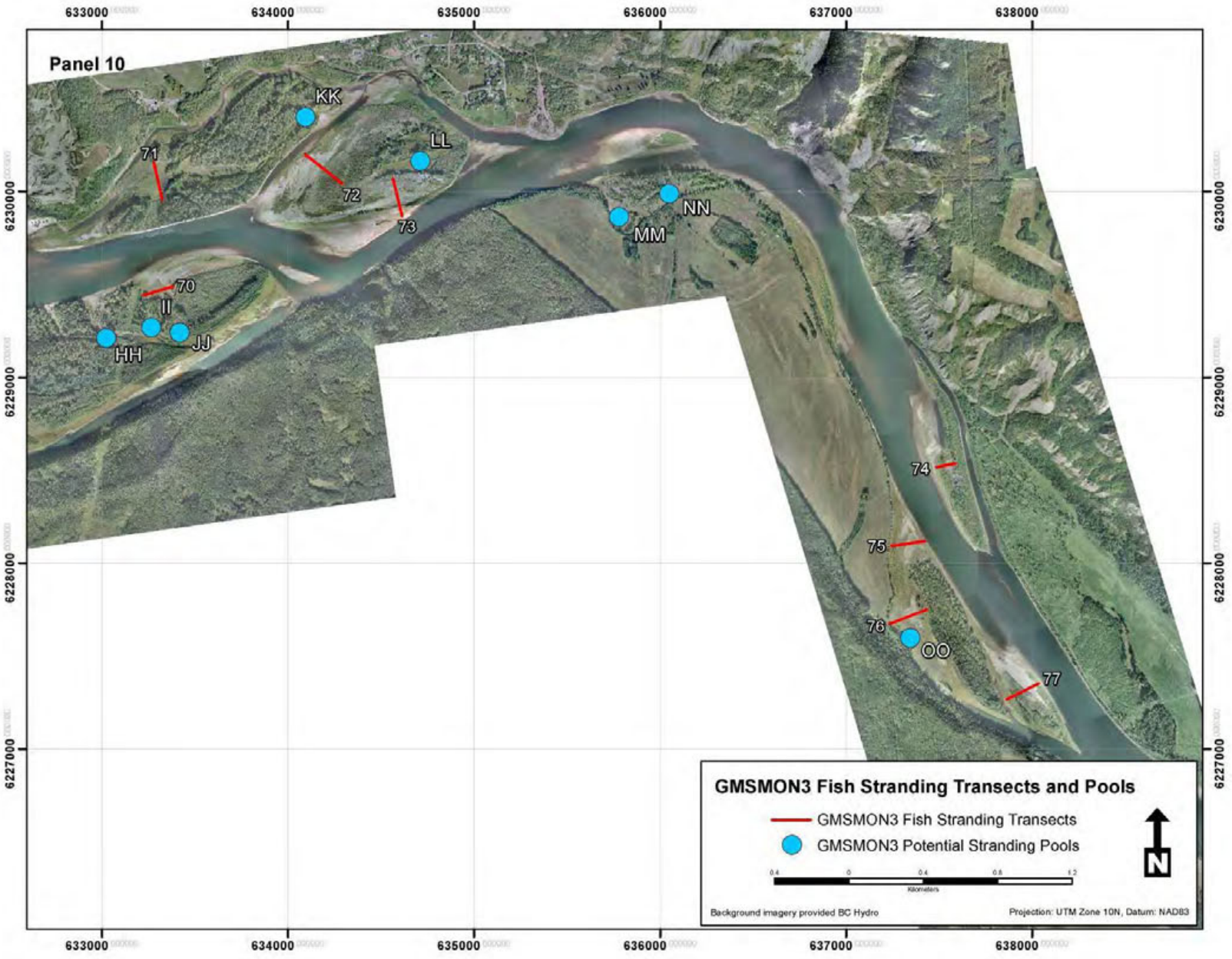
629000
630000
631000
632000
6232000
6231000
6230000
6229000
6228000
Panel 9
AA
BB
CC
Y
Z
66
67
68
69
Moberly River
DD
EE
FF
GG
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83


Panel 10
633000
634000
635000
636000
637000
638000
6230000
6229000
6228000
6227000
KK
LL
MM
NN
HH
II
JJ
OO
70
71
72
73
74
75
76
77
GMSMON3 Fish Stranding Transects and Pools
GMSMON3 Fish Stranding Transects
GMSMON3 Potential Stranding Pools
N
Kilometers
Background imagery provided BC Hydro
Projection: UTM Zone 10N, Datum: NAD83

Appendix 3. Coordinates and survey priority of stranding survey pools.

Stratum 1: PCN to Lynx Creek

Name	Location	Priority
Pool A	10 V 567211 6208404	1
Pool B	10 V 570814 6212022	1

Stratum 2: Lynx Creek to Halfway River

Name	Location	Priority
Pool C	10 V 574708 6218871	2
Pool D	10 V 576085 6219461	2
Pool E	10 V 587020 6224204	1
Pool F	10 V 587280 6224583	1
Pool G	10 V 592978 6228433	1
Pool H	10 V 593834 6229349	1
Pool I	10 V 594754 6230070	2

Stratum 3: Halfway River to Pine River

Name	Location	Priority
Pool J	10 V 599530 6232638	1
Pool K	10 V 599582 6232710	5
Pool L	10 V 607148 6235149	4
Pool M	10 V 607766 6235850	4
Pool N	10 V 608591 6236708	3
Pool O	10 V 609163 6236629	2
Pool P	10 V 617300 6232149	4
Pool Q	10 V 617706 6232130	4
Pool R	10 V 617867 6232250	4
Pool S	10 V 618310 6232000	4
Pool T	10 V 620587 6232231	1
Pool U	10 V 621389 6232601	2
Pool V	10 V 621467 6232589	1
Pool W	10 V 623775 6233519	2
Pool X	10 V 624447 6233137	5
Pool Y	10 V 627726 6231514	5
Pool Z	10 V 628028 6230922	5
Pool AA	10 V 628201 6231711	5
Pool BB	10 V 628334 6231467	5
Pool CC	10 V 628449 6231327	5
Pool DD	10 V 632024 6229090	1
Pool EE	10 V 632138 6228966	2
Pool FF	10 V 632225 6228758	1
Pool GG	10 V 632198 6228624	2
Pool HH	10 V 633021 6229213	2
Pool II	10 V 633263 6229270	2
Pool JJ	10 V 633417 6229242	3
Pool KK	10 V 634092 6230402	4
Pool LL	10 V 634710 6230166	4
Pool MM	10 V 635779 6229865	5
Pool NN	10 V 636048 6229989	4
Pool OO	10 V 637343 6227599	3

Appendix 4. Coordinates and survey priority of stranding survey transects.

Stratum 1: PCN to Lynx Creek

Name	Start	End	Priority
Transect 1	10 V 564691 6207274	10 V 564785 6207144	2
Transect 2	10 V 564863 6207042	10 V 564925 6206924	2
Transect 3	10 V 566476 6207859	10 V 566533 6207775	1
Transect 4	10 V 567282 6208709	10 V 567384 6208632	1
Transect 5	10 V 567678 6208615	10 V 567808 6208539	1
Transect 6	10 V 567755 6208800	10 V 567795 6208679	1
Transect 7	10 V 568597 6209958	10 V 568710 6209832	2
Transect 8	10 V 569895 6210573	10 V 569980 6210504	2
Transect 9	10 V 570524 6211080	10 V 570617 6211013	3
Transect 10	10 V 570383 6211557	10 V 570410 6211451	1
Transect 11	10 V 570663 6212179	10 V 570808 6212028	1
Transect 12	10 V 570996 6212153	10 V 571147 6212055	1

Stratum 2: Lynx Creek to Halfway River

Name	Start	End	Priority
Transect 13	10 V 573336 6215642	10 V 573456 6215645	4
Transect 14	10 V 574856 6218572	10 V 574917 6218507	2
Transect 15	10 V 574851 6219044	10 V 574888 6219009	2
Transect 16	10 V 575690 6219448	10 V 575703 6219279	2
Transect 17	10 V 575910 6219580	10 V 575888 6219418	2
Transect 18	10 V 576871 6219053	10 V 576925 6218895	3
Transect 19	10 V 577648 6219395	10 V 577710 6219318	3
Transect 20	10 V 582538 6220335	10 V 582656 6220259	3
Transect 21	10 V 583351 6220833	10 V 583413 6220756	3
Transect 22	10 V 583895 6221546	10 V 584074 6221429	3
Transect 23	10 V 584249 6221409	10 V 584352 6221332	4
Transect 24	10 V 586096 6223336	10 V 586169 6223233	2
Transect 25	10 V 587137 6224564	10 V 587203 6224537	1
Transect 26	10 V 587501 6224972	10 V 587596 6224920	1
Transect 27	10 V 587667 6224527	10 V 587807 6224428	3
Transect 28	10 V 588145 6225222	10 V 588212 6225171	3
Transect 29	10 V 589981 6226831	10 V 590021 6226776	4
Transect 30	10 V 591925 6227688	10 V 592006 6227578	4
Transect 31	10 V 593439 6228836	10 V 593513 6228786	1
Transect 32	10 V 593836 6228837	10 V 593934 6228894	1
Transect 33	10 V 594329 6229450	10 V 594432 6229405	1
Transect 34	10 V 594881 6230203	10 V 594980 6230180	2
Transect 35	10 V 595460 6230313	10 V 595511 6230221	4

Stratum 3: Halfway River to Pine River

Name	Start	End	Priority
Transect 36	10 V 598497 6231920	10 V 598625 6231838	2
Transect 37	10 V 598717 6232386	10 V 598790 6232327	2
Transect 38	10 V 598902 6232255	10 V 598997 6232164	1
Transect 39	10 V 599023 6232552	10 V 599134 6232644	1
Transect 40	10 V 599930 6233485	10 V 600040 6233371	4
Transect 41	10 V 601778 6233390	10 V 601798 6233217	3
Transect 42	10 V 601835 6233886	10 V 601840 6233726	3
Transect 43	10 V 602558 6233893	10 V 602591 6233646	3
Transect 44	10 V 603221 6233406	10 V 603164 6233280	4
Transect 45	10 V 603934 6233200	10 V 603883 6233098	4
Transect 46	10 V 606258 6234195	10 V 606636 6234016	4
Transect 47	10 V 607235 6234504	10 V 607381 6234386	4
Transect 48	10 V 607366 6235169	10 V 607506 6235053	4
Transect 49	10 V 608045 6235416	10 V 608127 6235394	3
Transect 50	10 V 608131 6235353	10 V 608254 6235295	3
Transect 51	10 V 608971 6236556	10 V 609084 6236446	2
Transect 52	10 V 613114 6236448	10 V 613011 6236295	5
Transect 53	10 V 616224 6233589	10 V 616093 6233422	4
Transect 54	10 V 616523 6233418	10 V 616460 6233192	4
Transect 55	10 V 617310 6232541	10 V 617089 6232462	4
Transect 56	10 V 617625 6232255	10 V 617561 6232161	4
Transect 57	10 V 619808 6232251	10 V 619788 6232083	5
Transect 58	10 V 620328 6232320	10 V 620311 6232197	1
Transect 59	10 V 620834 6232333	10 V 620840 6232109	1
Transect 60	10 V 620785 6231960	10 V 621003 6231866	5
Transect 61	10 V 622039 6232389	10 V 622231 6232406	2
Transect 62	10 V 622368 6232941	10 V 622457 6232869	2
Transect 63	10 V 623109 6232950	10 V 623234 6232998	2
Transect 64	10 V 623647 6233489	10 V 623673 6233330	2
Transect 65	10 V 623837 6232978	10 V 623845 6232833	5
Transect 66	10 V 628755 6230781	10 V 628652 6230731	3
Transect 67	10 V 628873 6230597	10 V 628928 6230629	3
Transect 68	10 V 629164 6230106	10 V 629306 6230178	3
Transect 69	10 V 631895 6229220	10 V 632192 6229269	1
Transect 70	10 V 633217 6229442	10 V 633380 6229490	1
Transect 71	10 V 633276 6230158	10 V 633321 6229956	5
Transect 72	10 V 634090 6230201	10 V 634287 6230043	3
Transect 73	10 V 634562 6230072	10 V 634611 6229869	3
Transect 74	10 V 637586 6228537	10 V 637482 6228516	5
Transect 75	10 V 637241 6228093	10 V 637420 6228118	4
Transect 76	10 V 637229 6227674	10 V 637431 6227751	4
Transect 77	10 V 637863 6227269	10 V 638032 6227354	4

Appendix 5. Examples of flood sign observed during the July 14, 2012 stranding survey.

Photo 1. Rafted debris near Pool A, Stratum 1.

Photo 2. Rafted debris on Transect 31, Stratum 2.

Photo 3. Bent vegetation in a flooded side channel on Transect 59, Stratum 3.

Photo 4. Sediment film on sedges at Transect 25, Stratum 2.

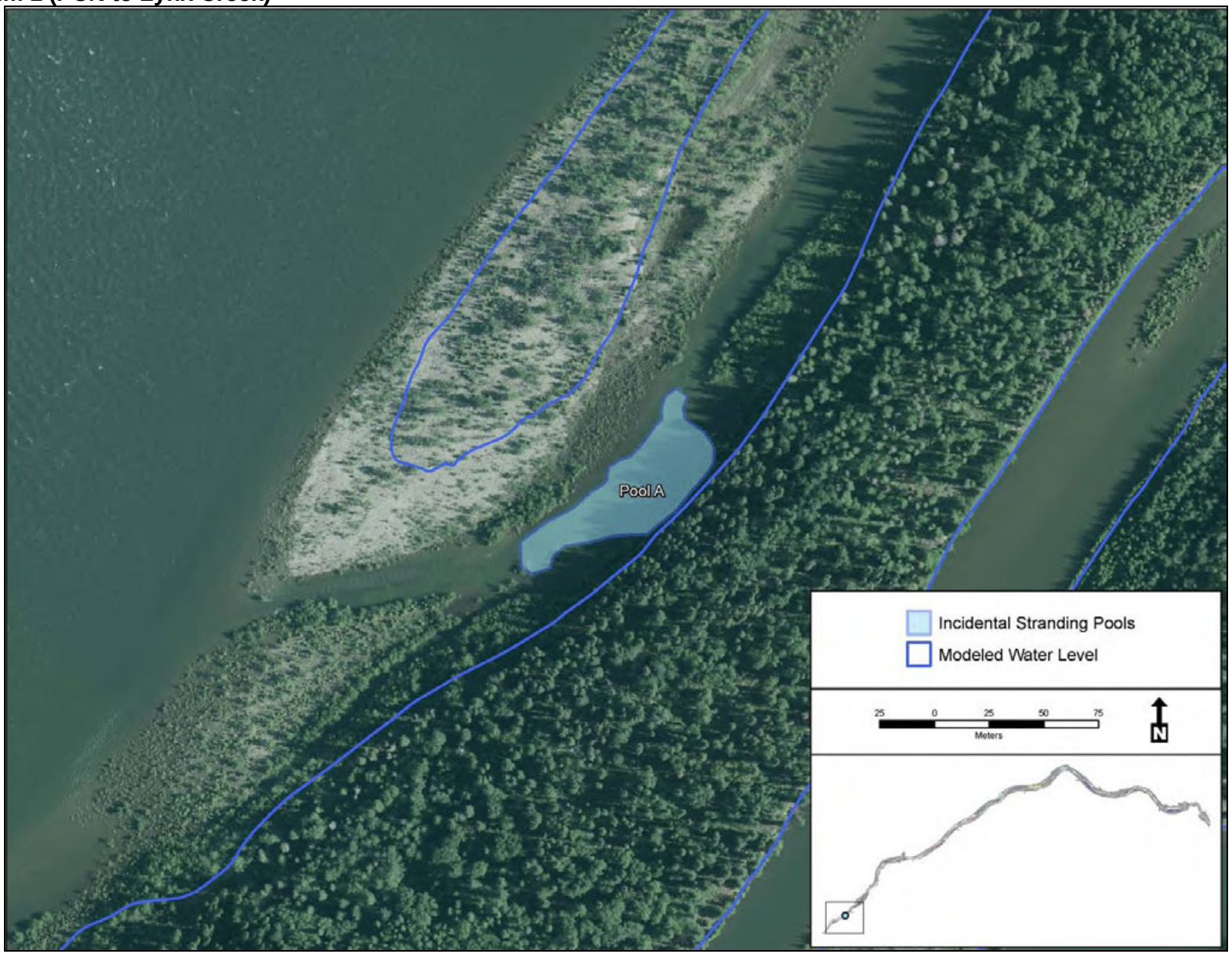
Photo 5. Sediment deposition on Transect 69, Stratum 3.

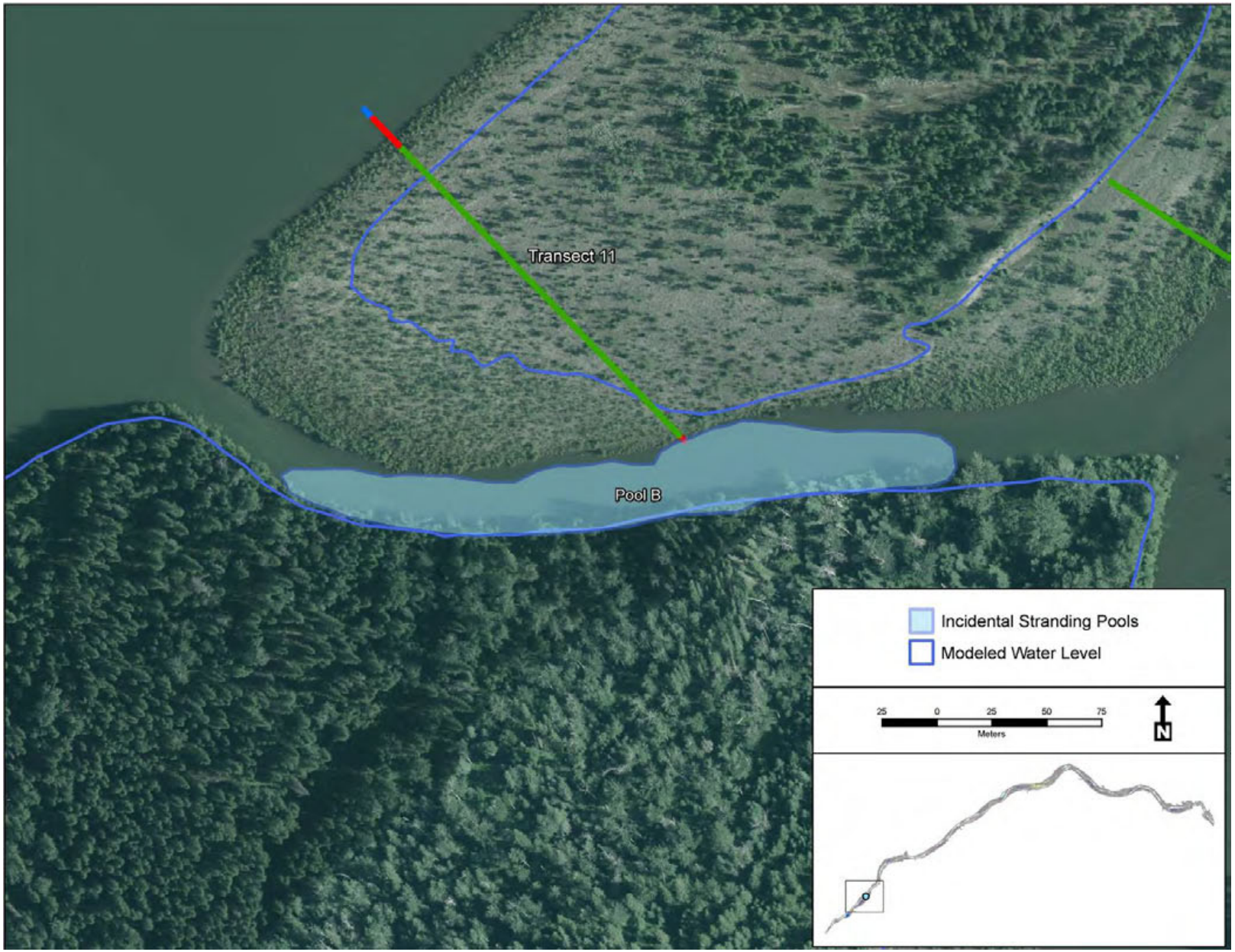
Photo 6. Sediment deposition and LWD near Transect 70, Stratum 3.

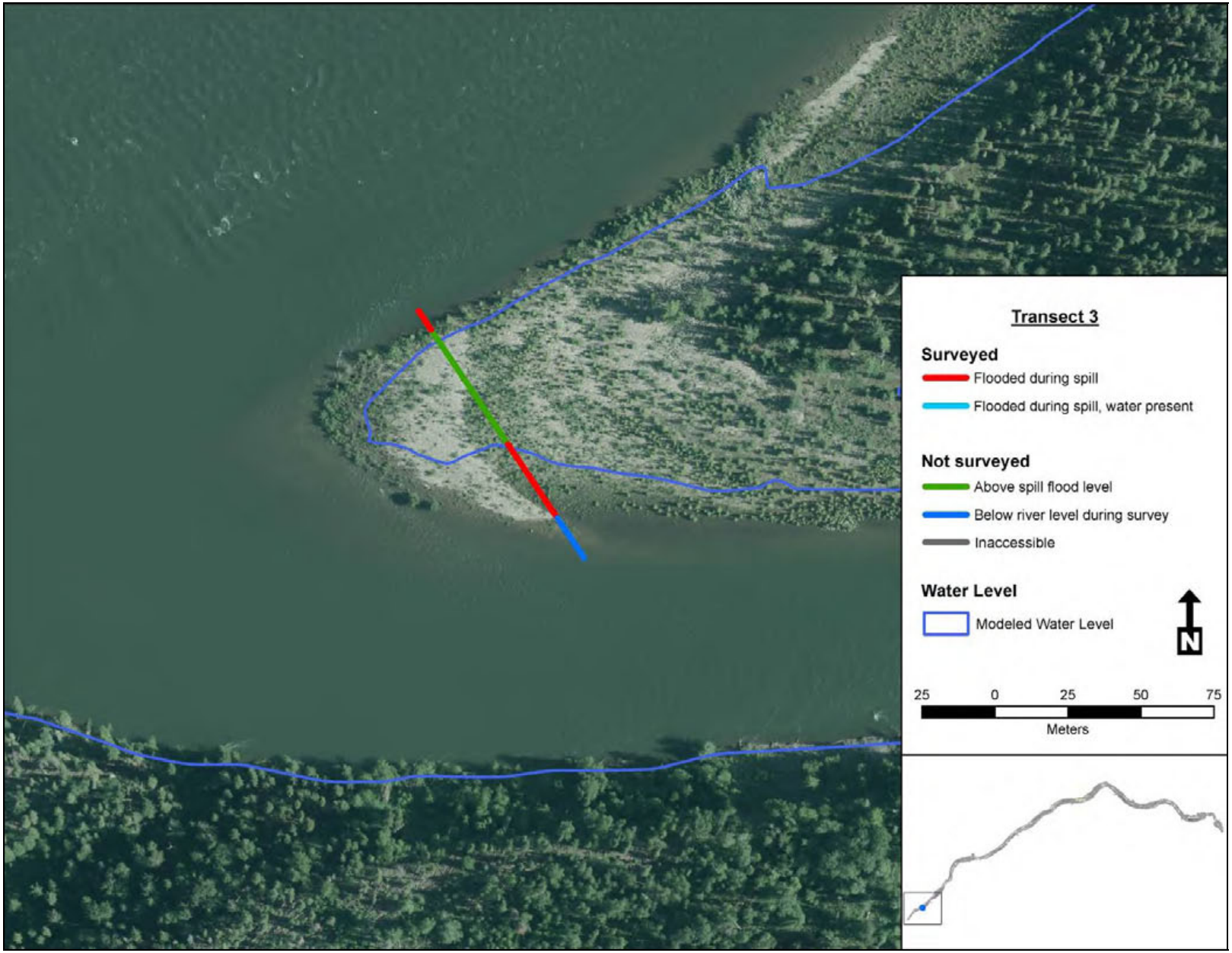
Photo 7. Recently deposited LWD near Transect 61, Stratum 3.

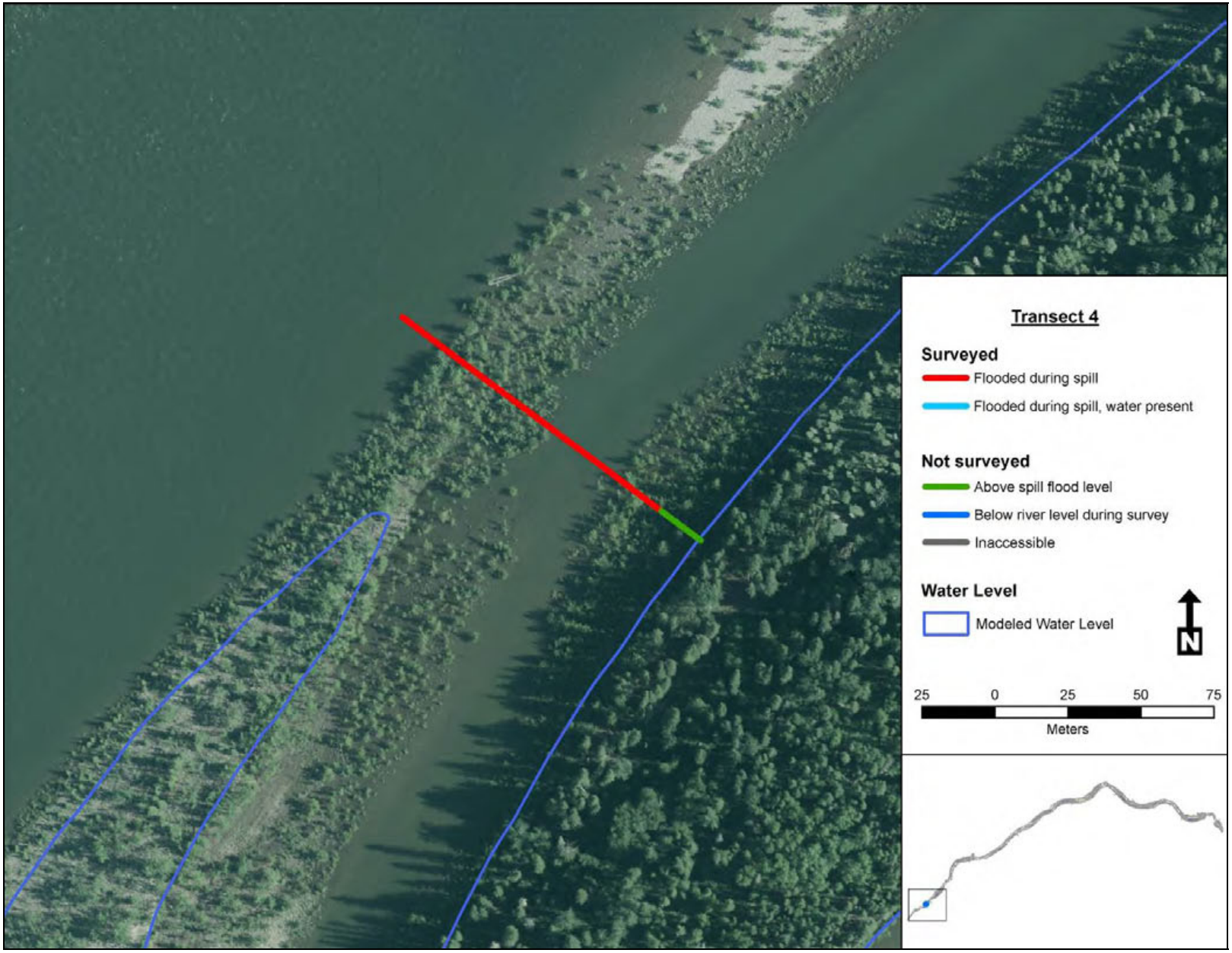
Appendix 6. Maps of sites surveyed on July 14, 2012.

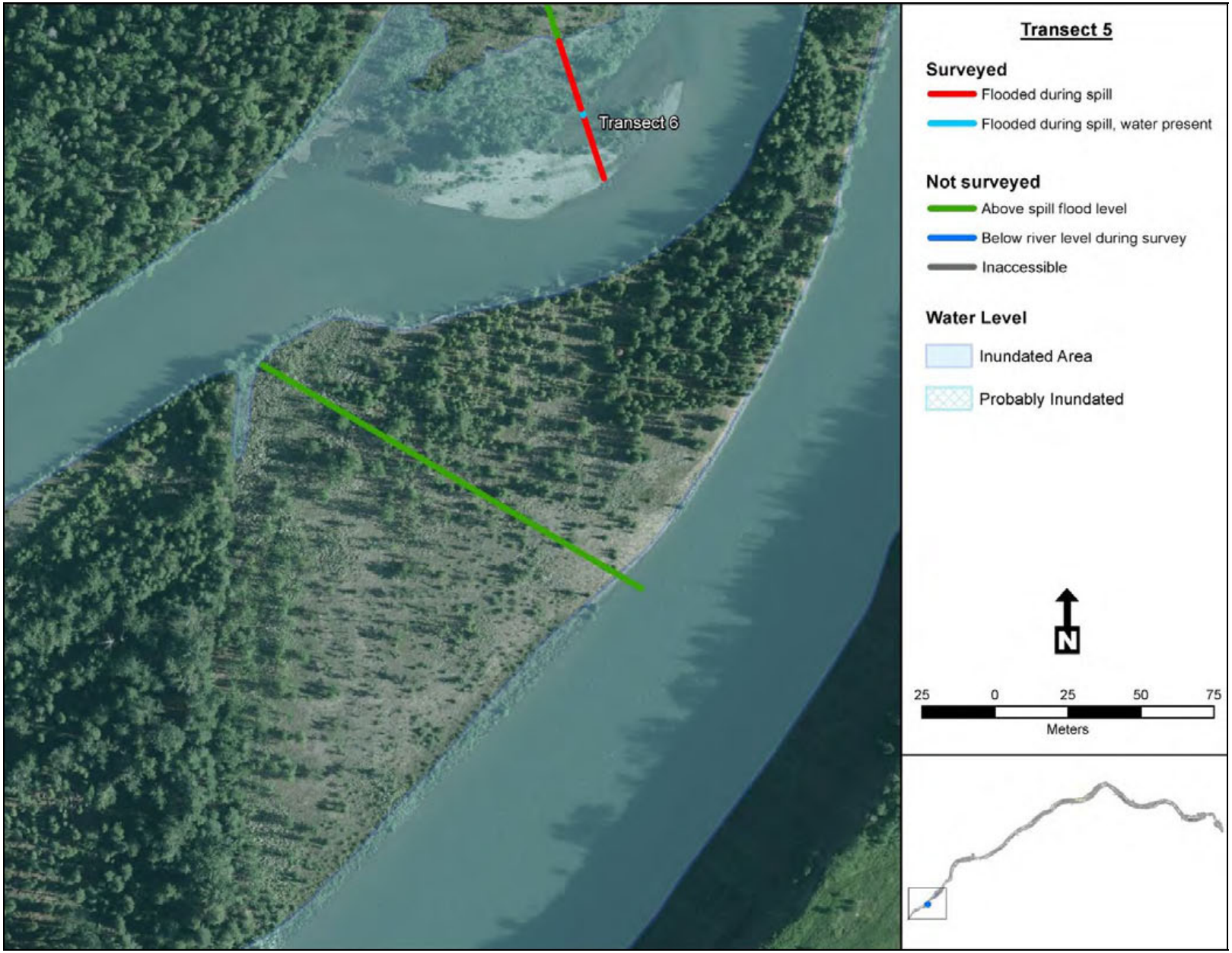
Stratum 1 (PCN to Lynx Creek)

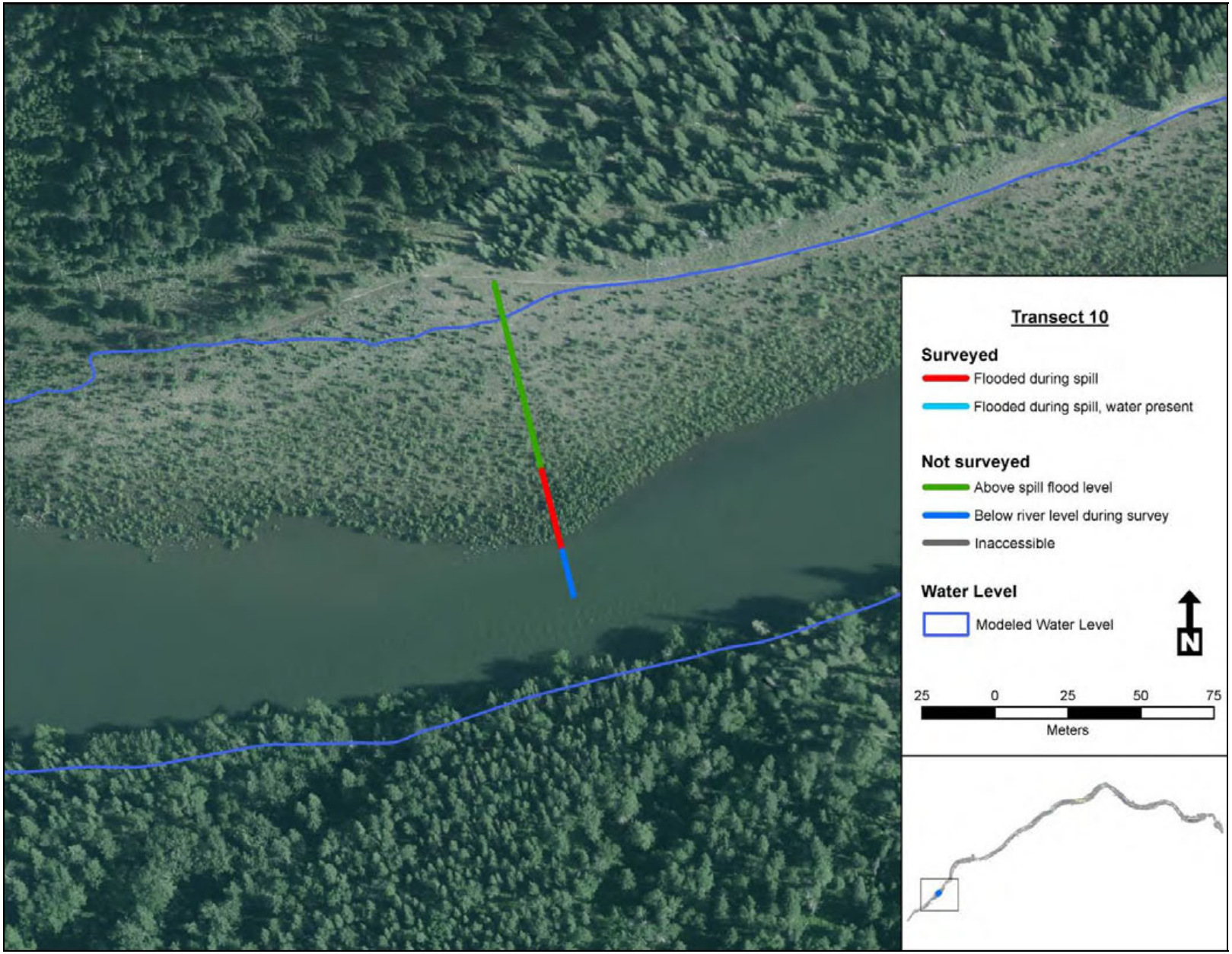


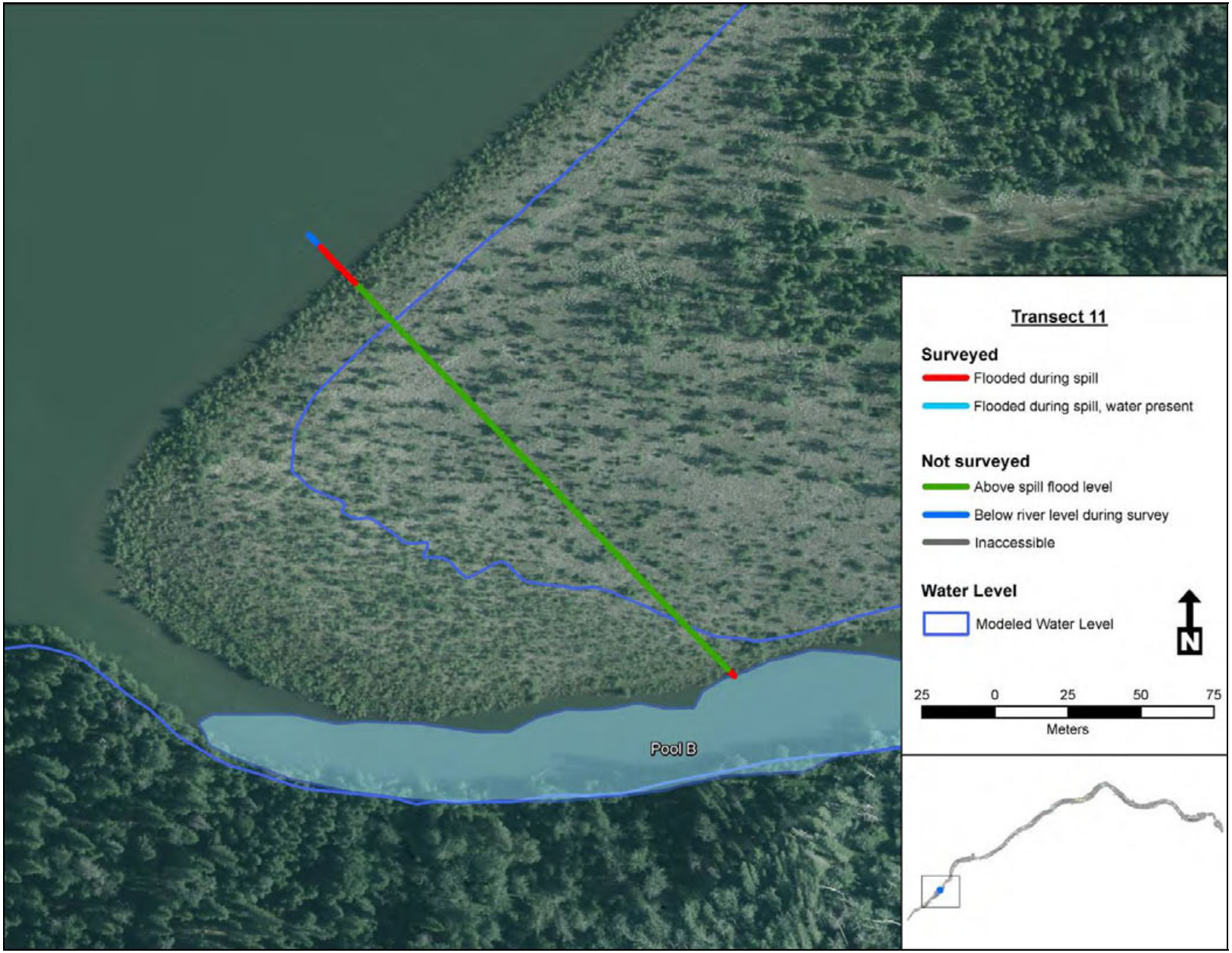

Transect 11
Pool B
Incidental Stranding Pools
Modeled Water Level
25 0 25 50 75
Meters
N

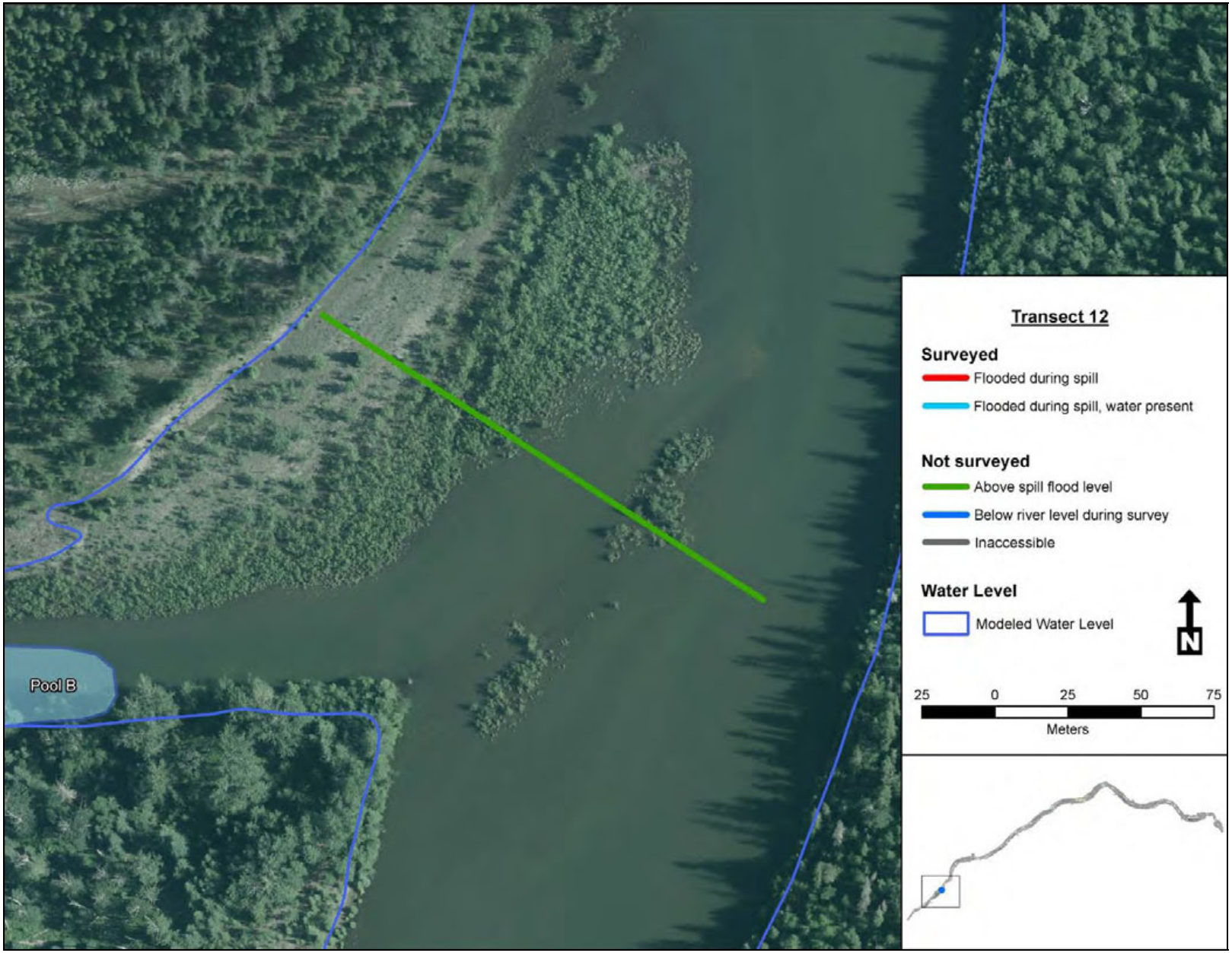

Transect 3
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters


Transect 4
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

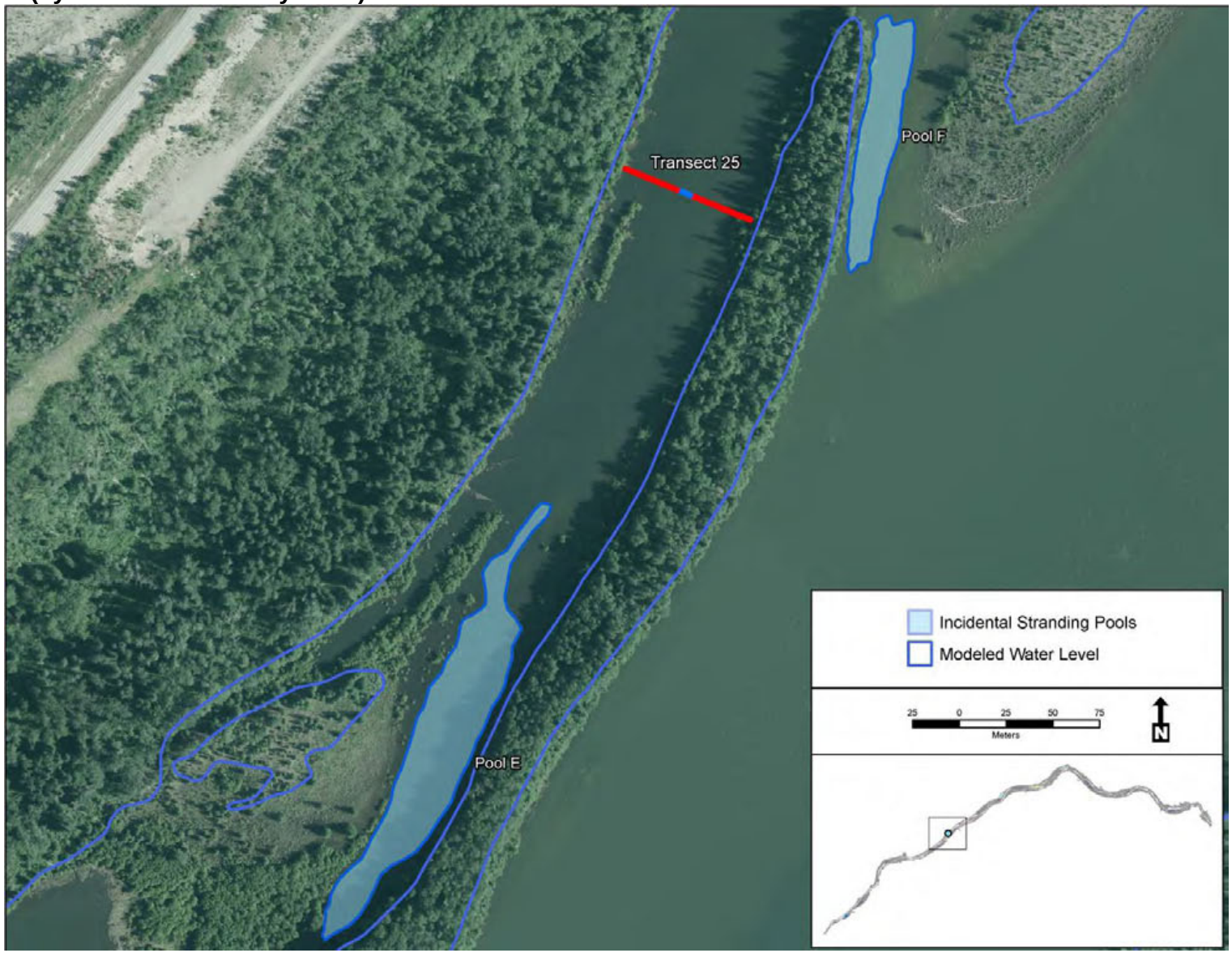

Transect 6
Transect 5
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Inundated Area
Probably Inundated
N
25 0 25 50 75
Meters

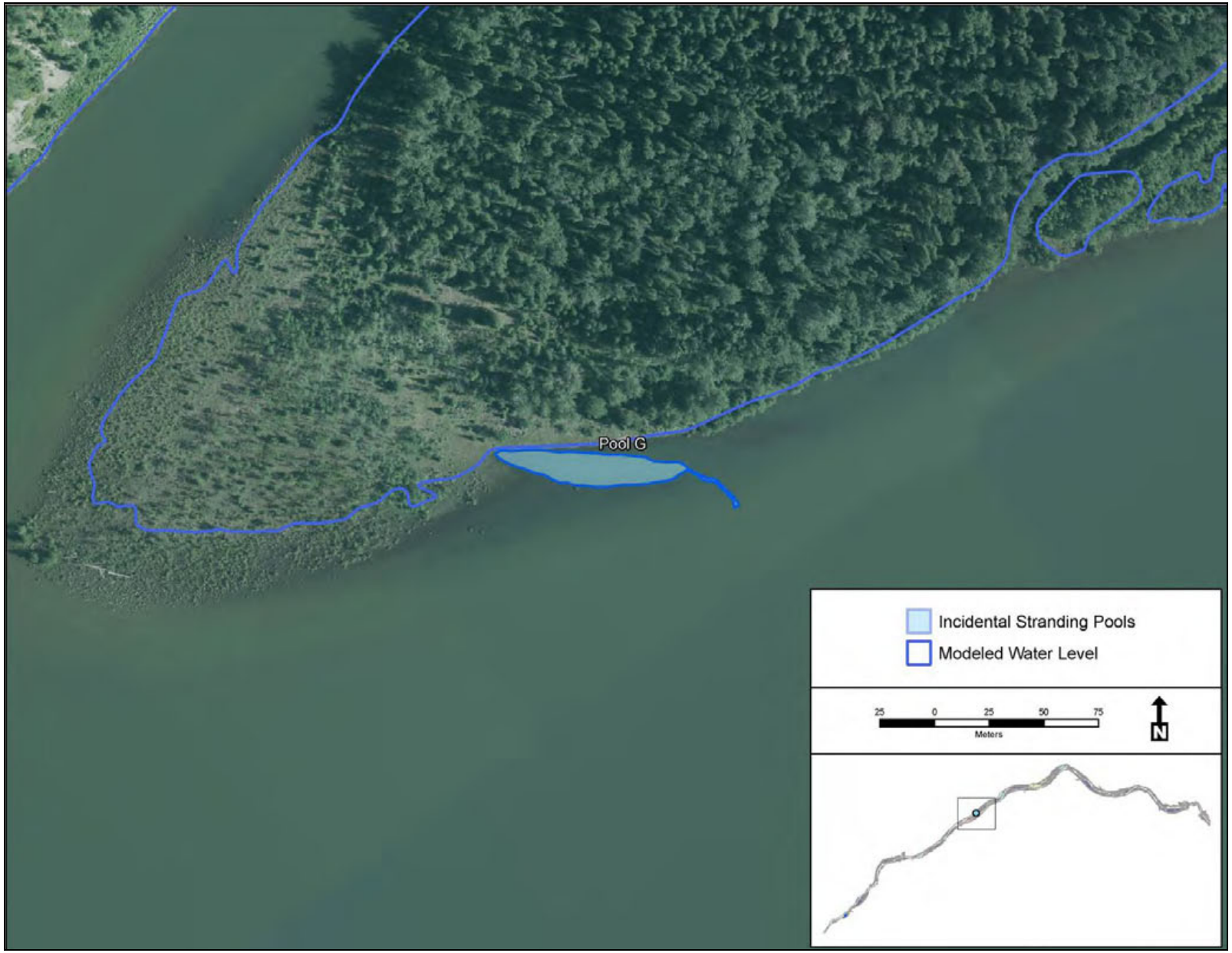

Transect 10
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

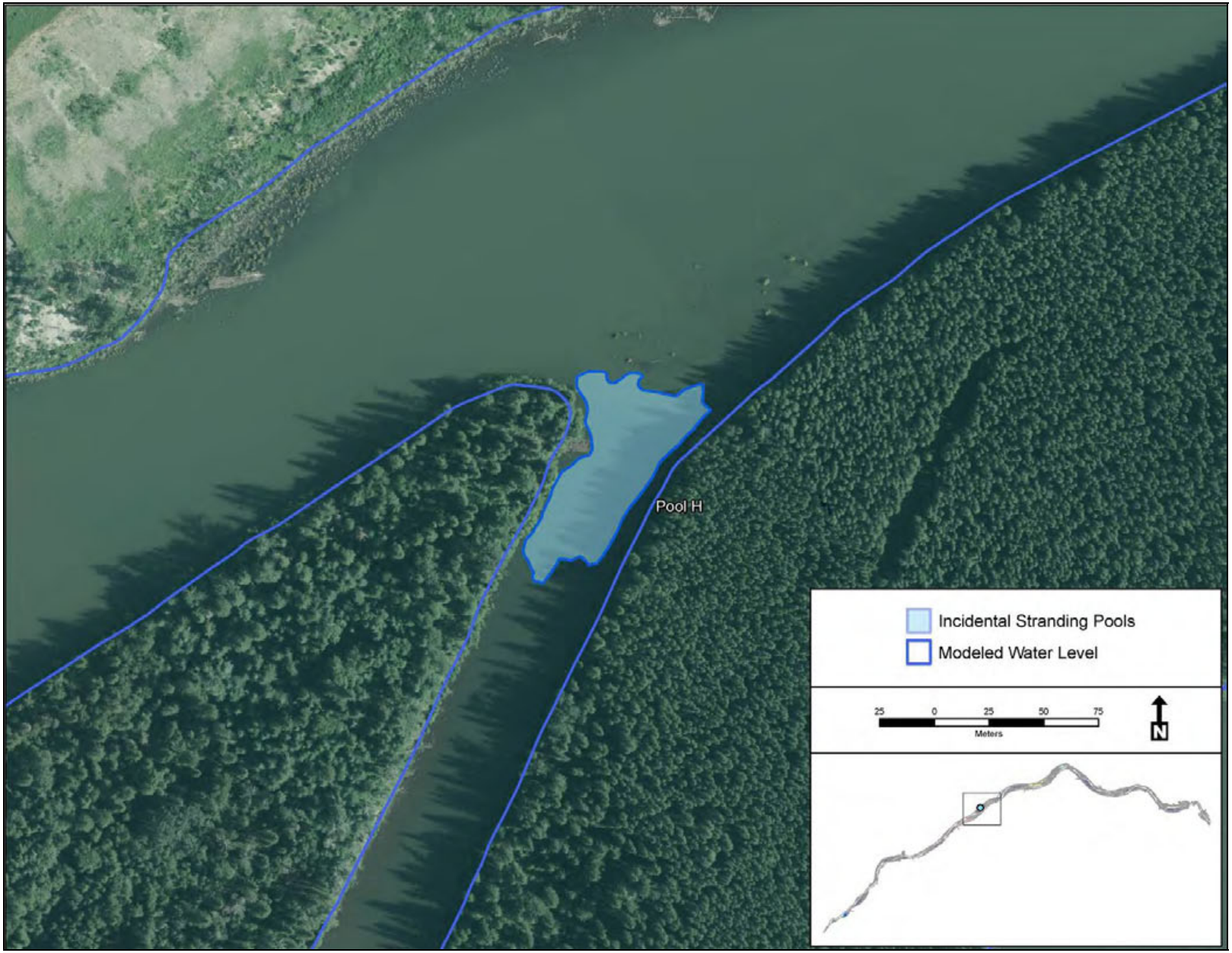

Transect 11
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters
Pool B

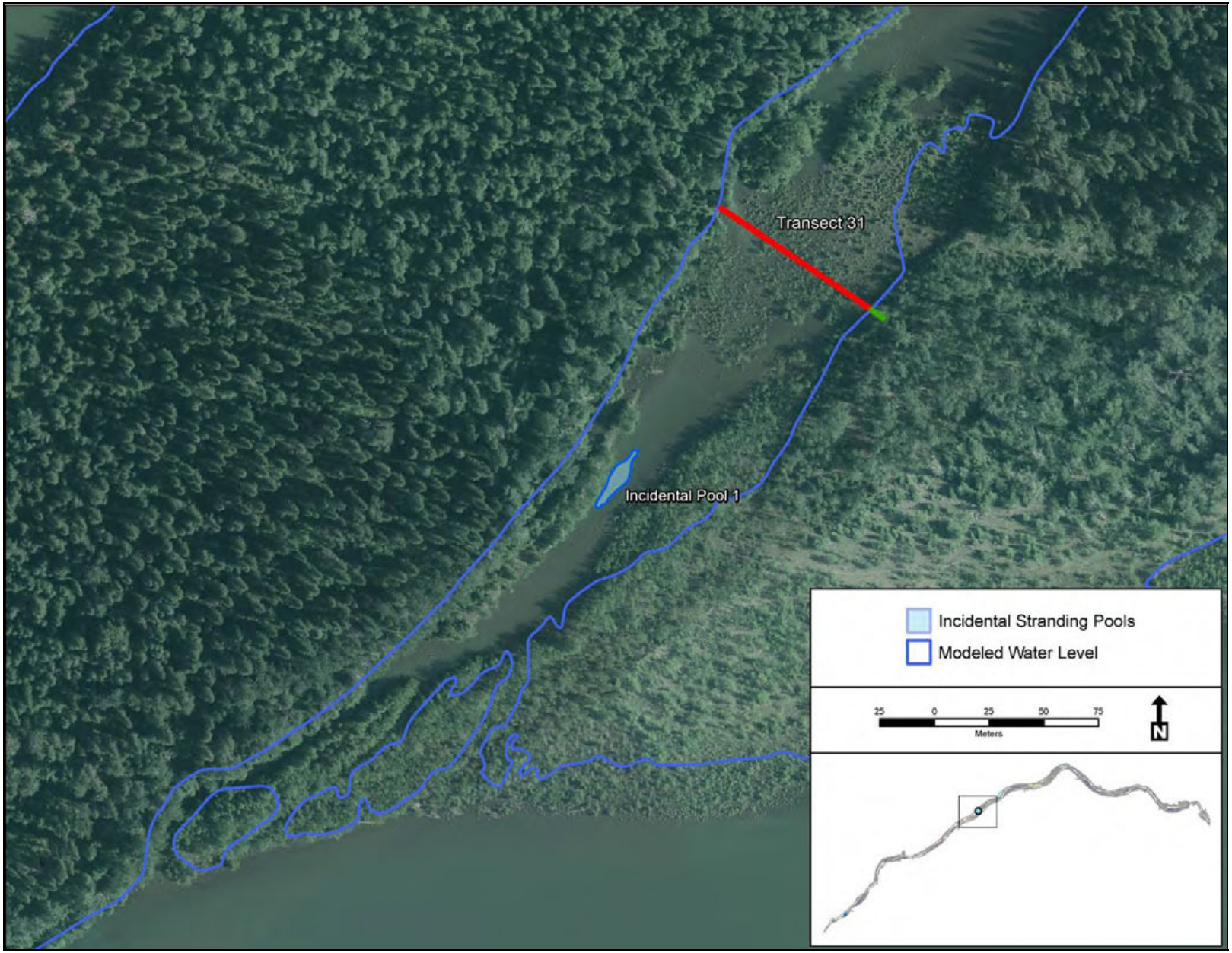

Transect 12
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters
Pool B

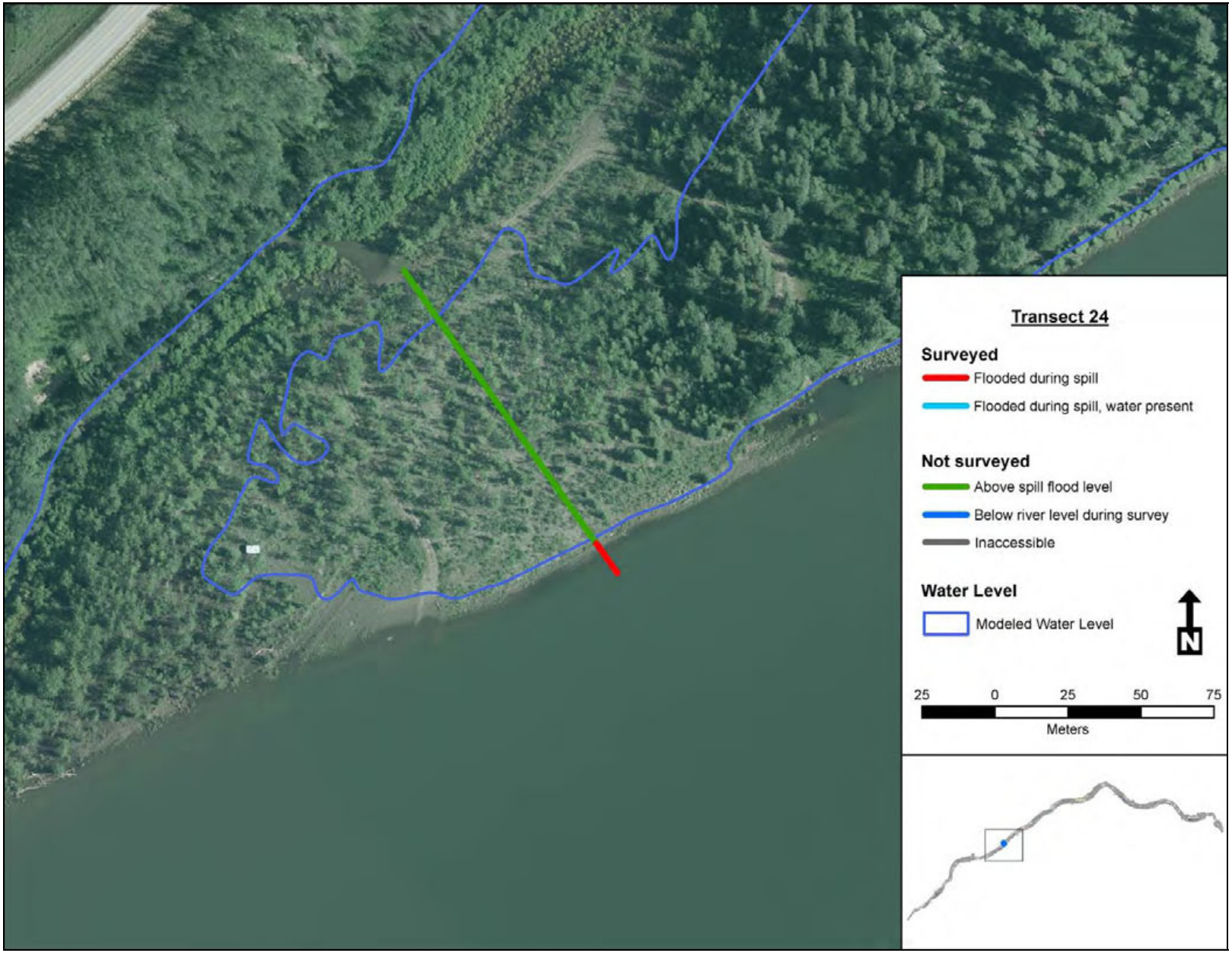
Stratum 2 (Lynx Creek to Halfway River)

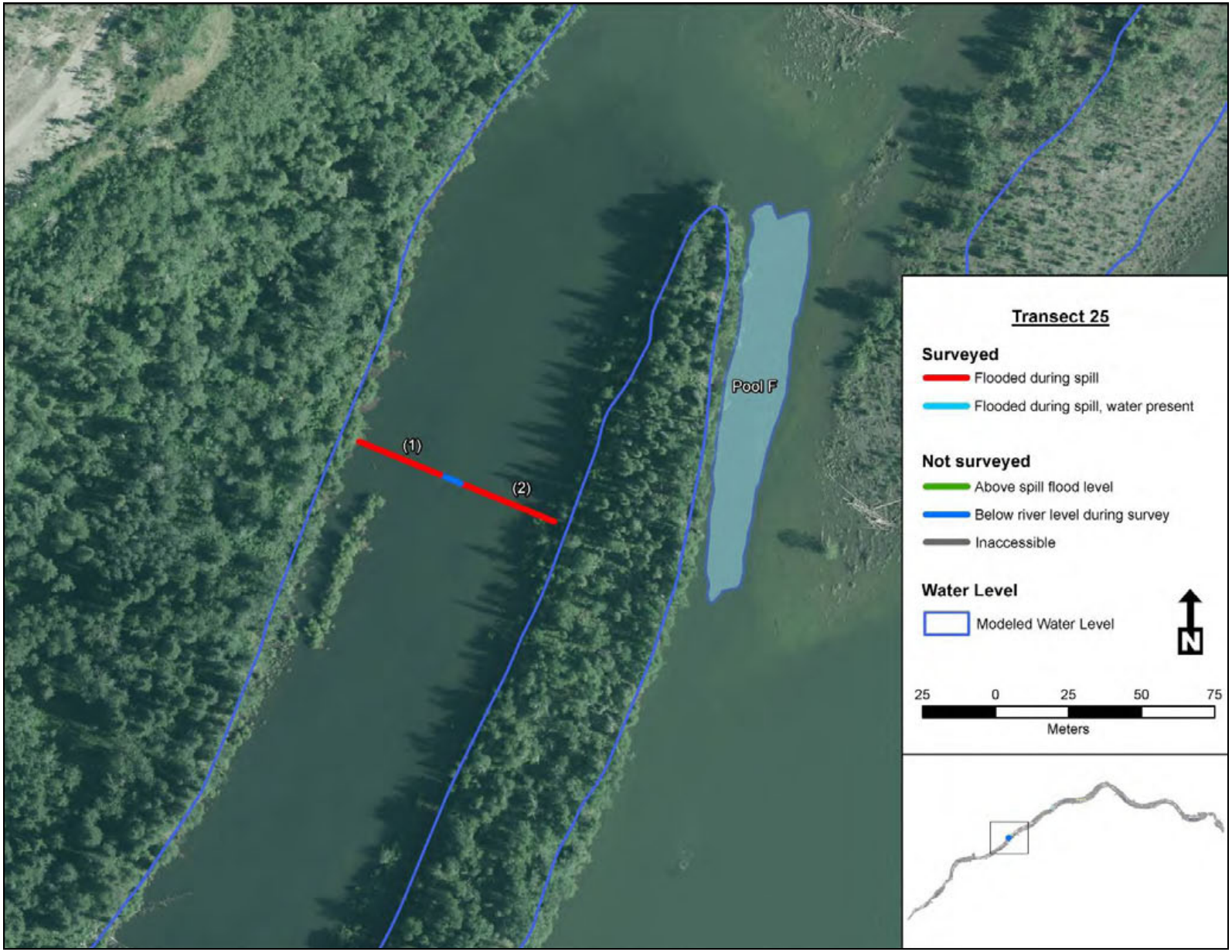


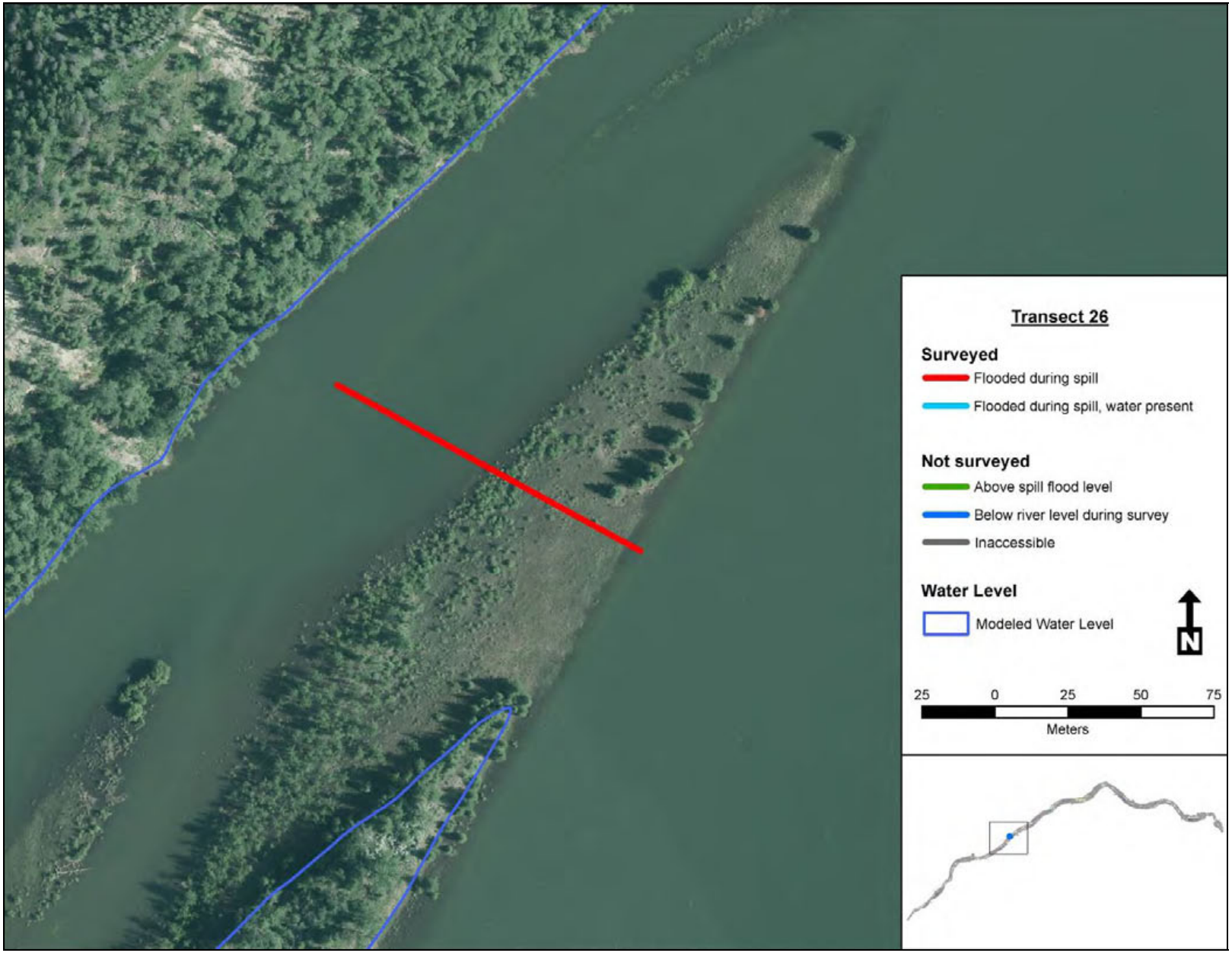

Pool G
Incidental Stranding Pools
Modeled Water Level
25 0 25 50 75
Meters
N

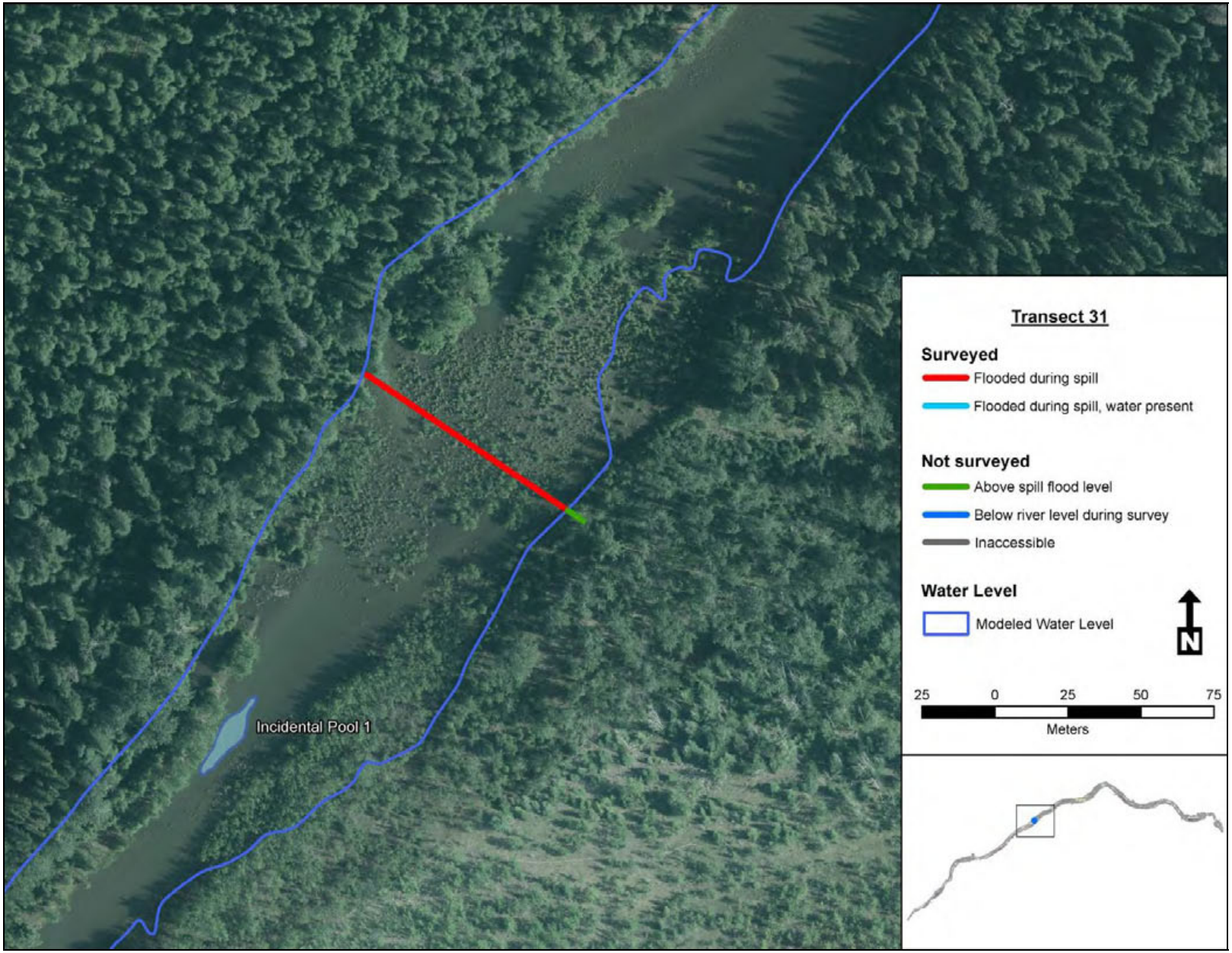

Pool H
Incidental Stranding Pools
Modeled Water Level
25 0 25 50 75
Meters
N

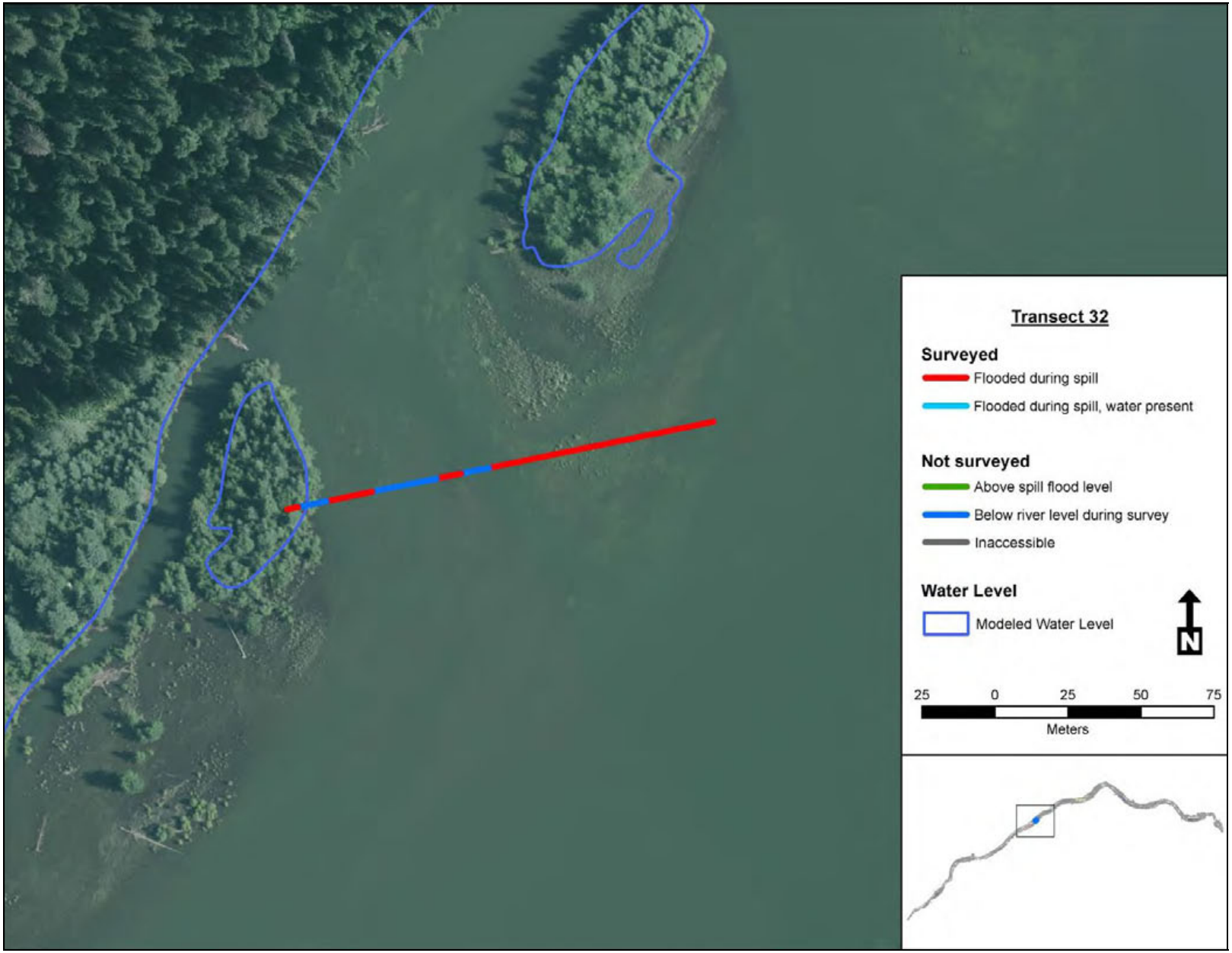

Transect 31
Incidental Pool 1
Incidental Stranding Pools
Modeled Water Level
25 0 25 50 75
Meters
N

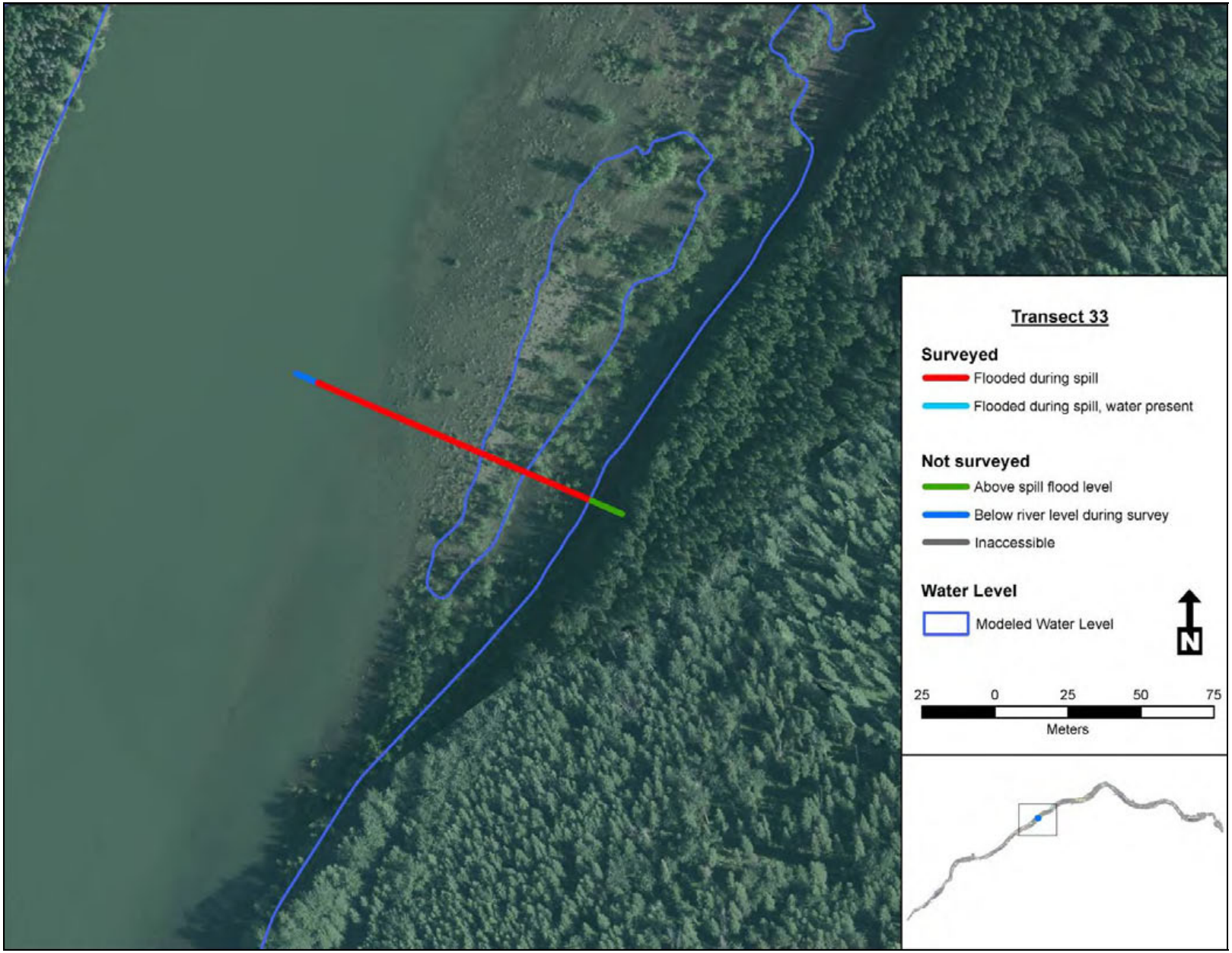

Transect 24
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters


Pool F
(1)
(2)
Transect 25
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

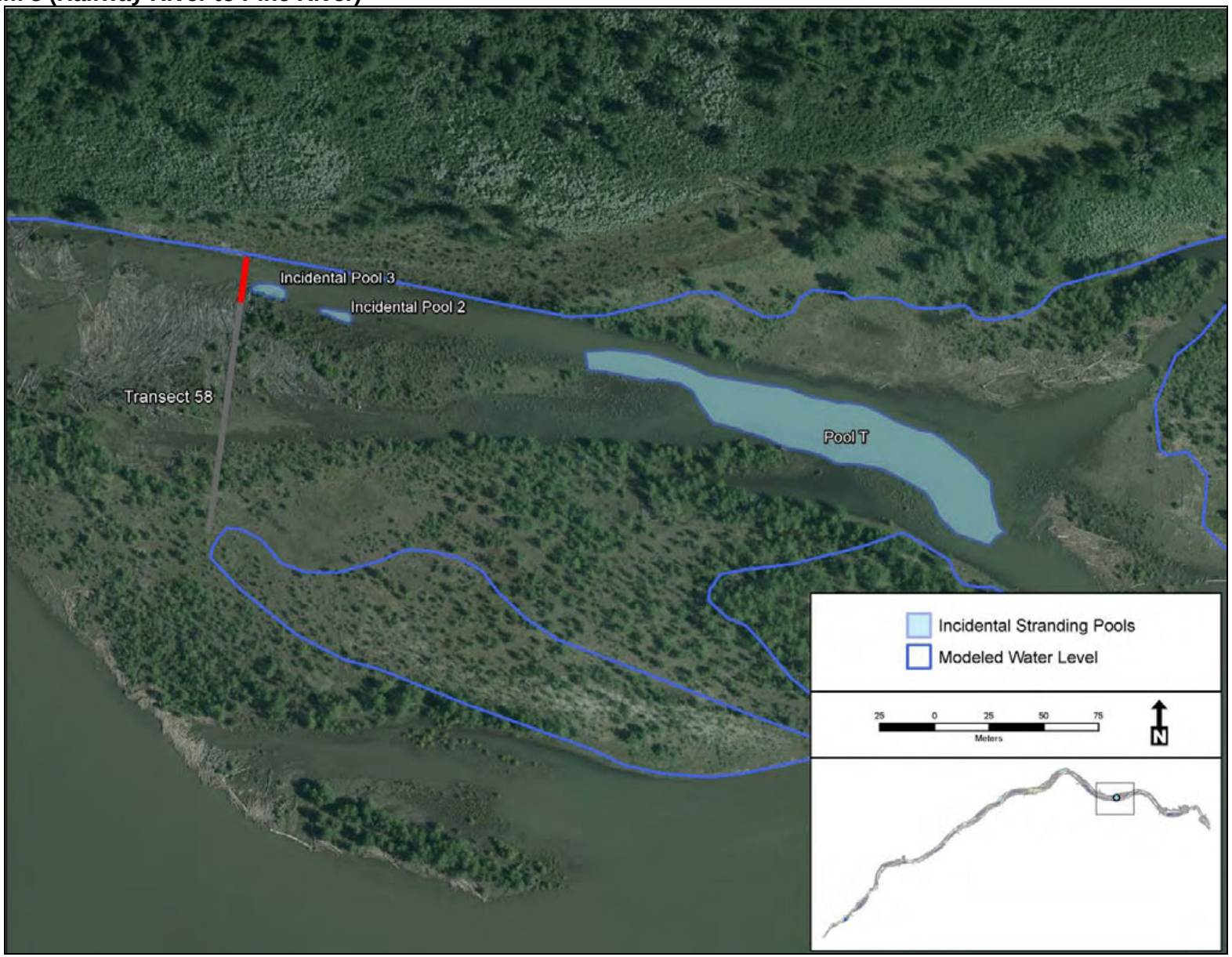

Transect 26
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

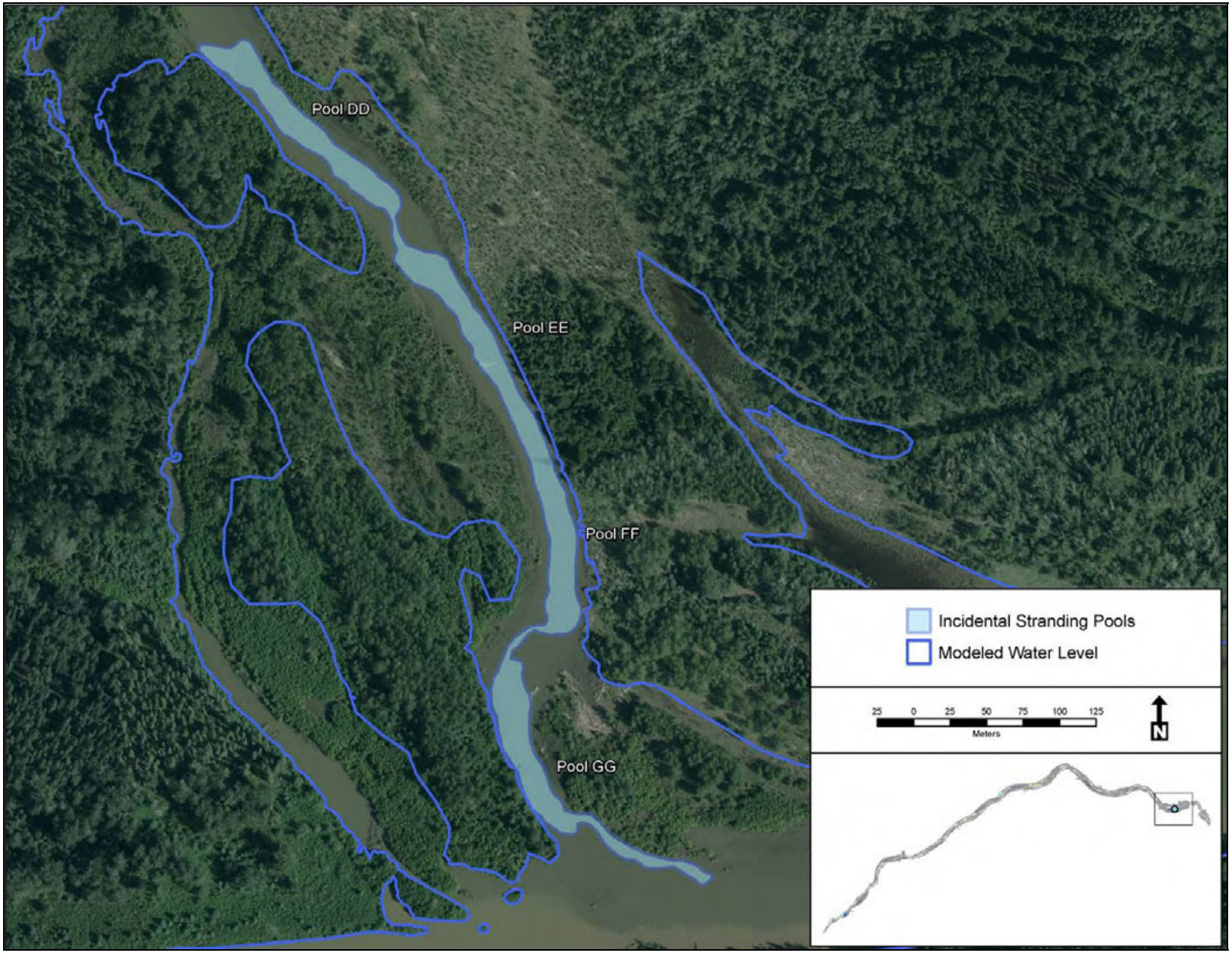

Transect 31
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters
Incidental Pool 1

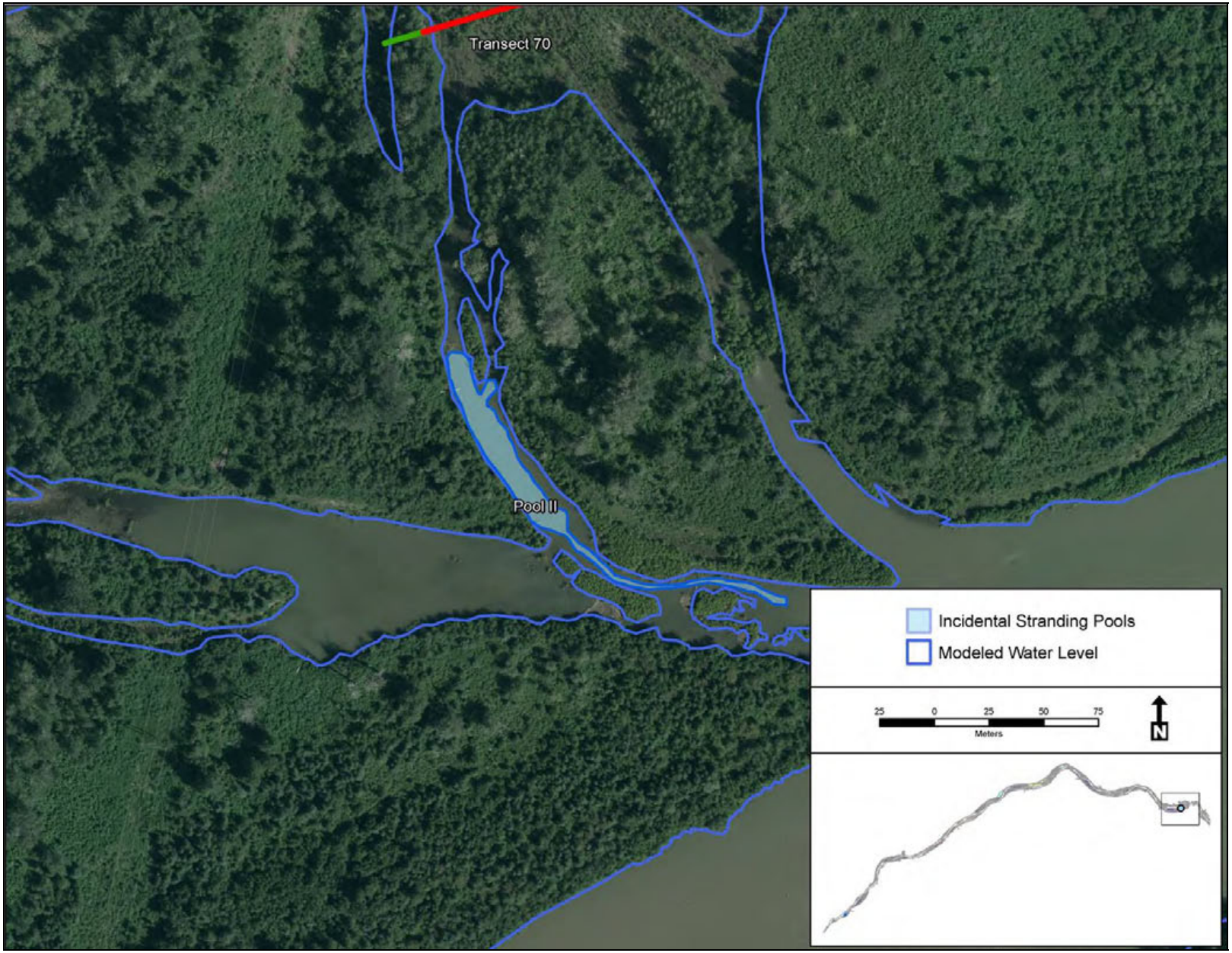

Transect 32
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

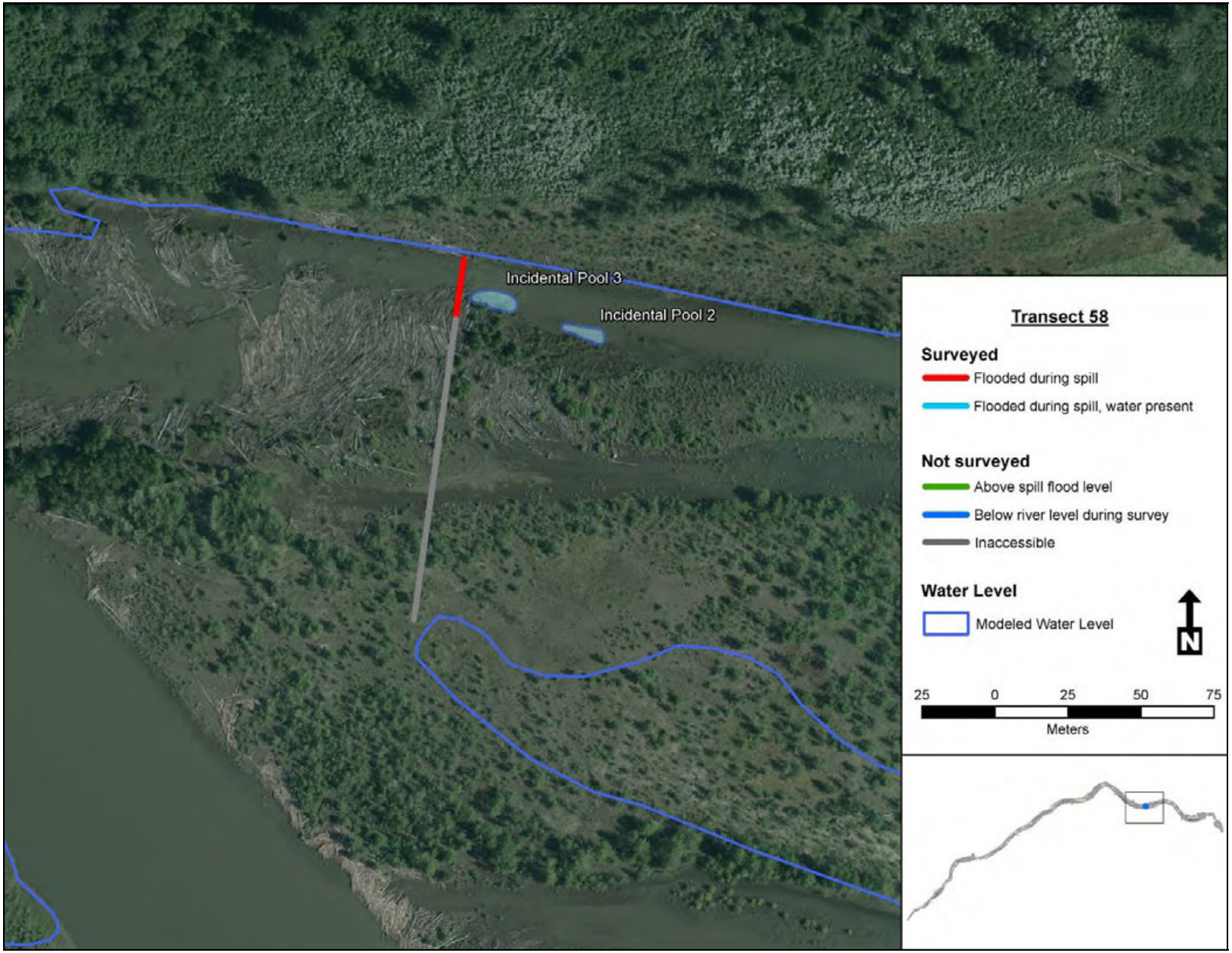

Transect 33
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

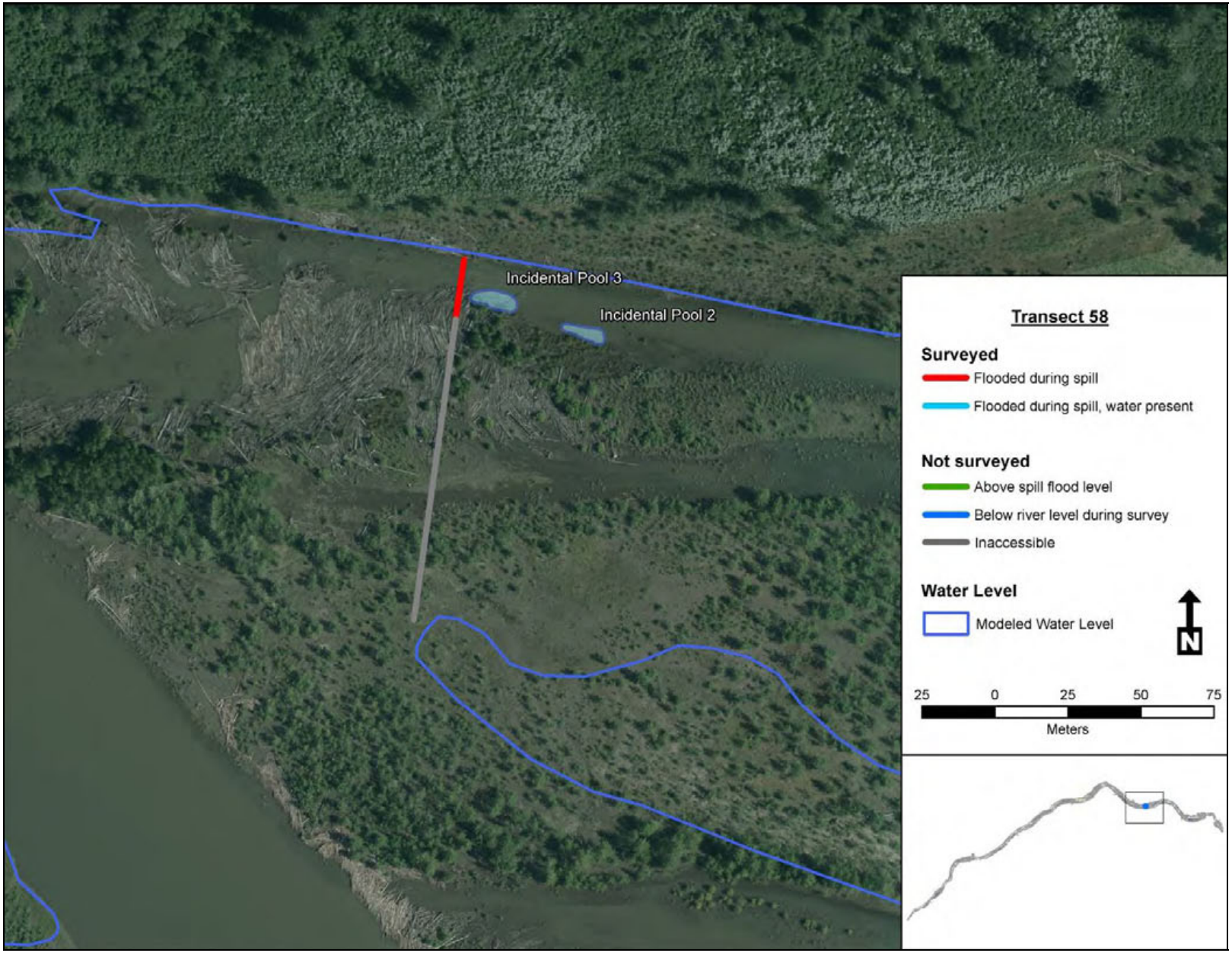
Stratum 3 (Halfway River to Pine River)

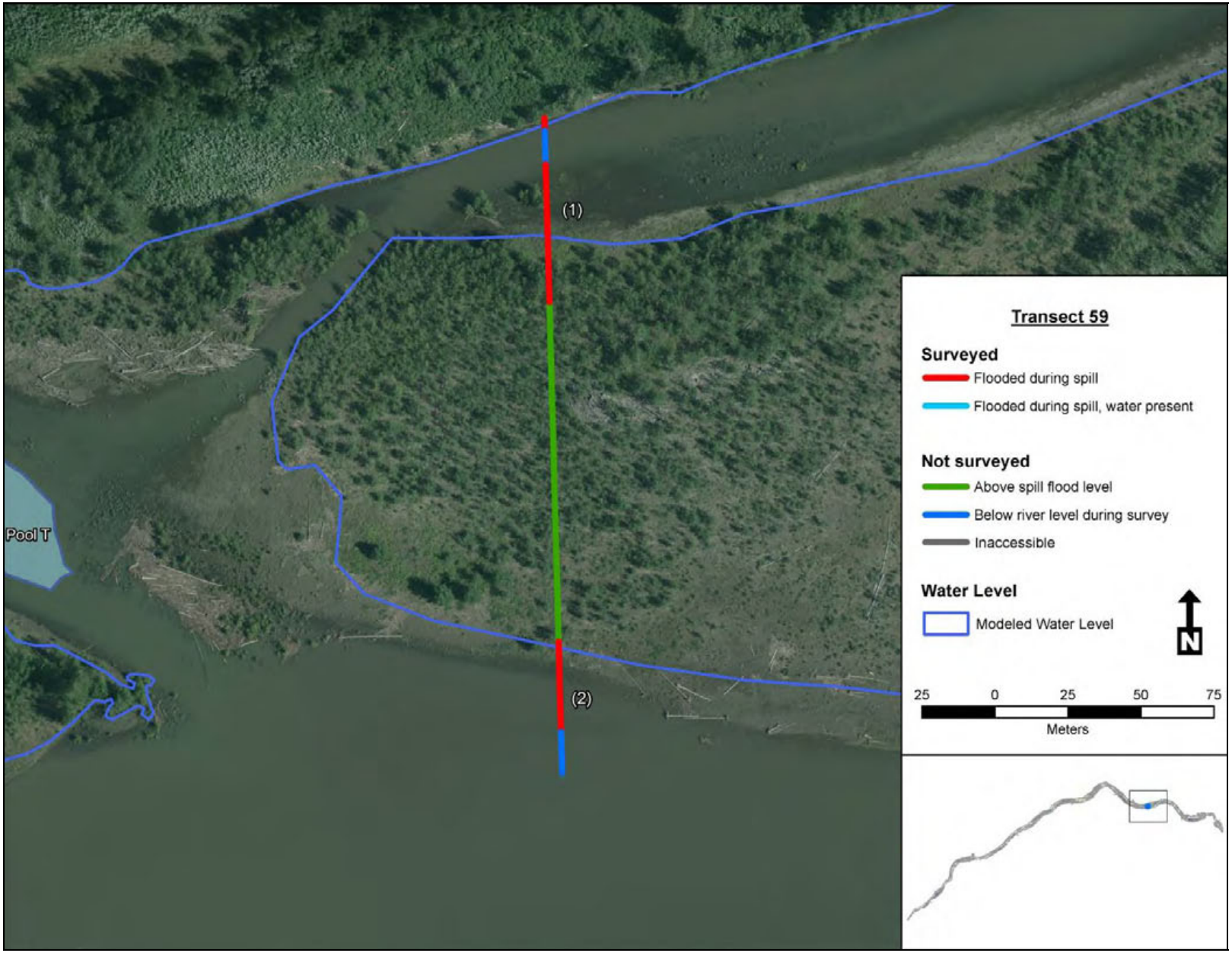


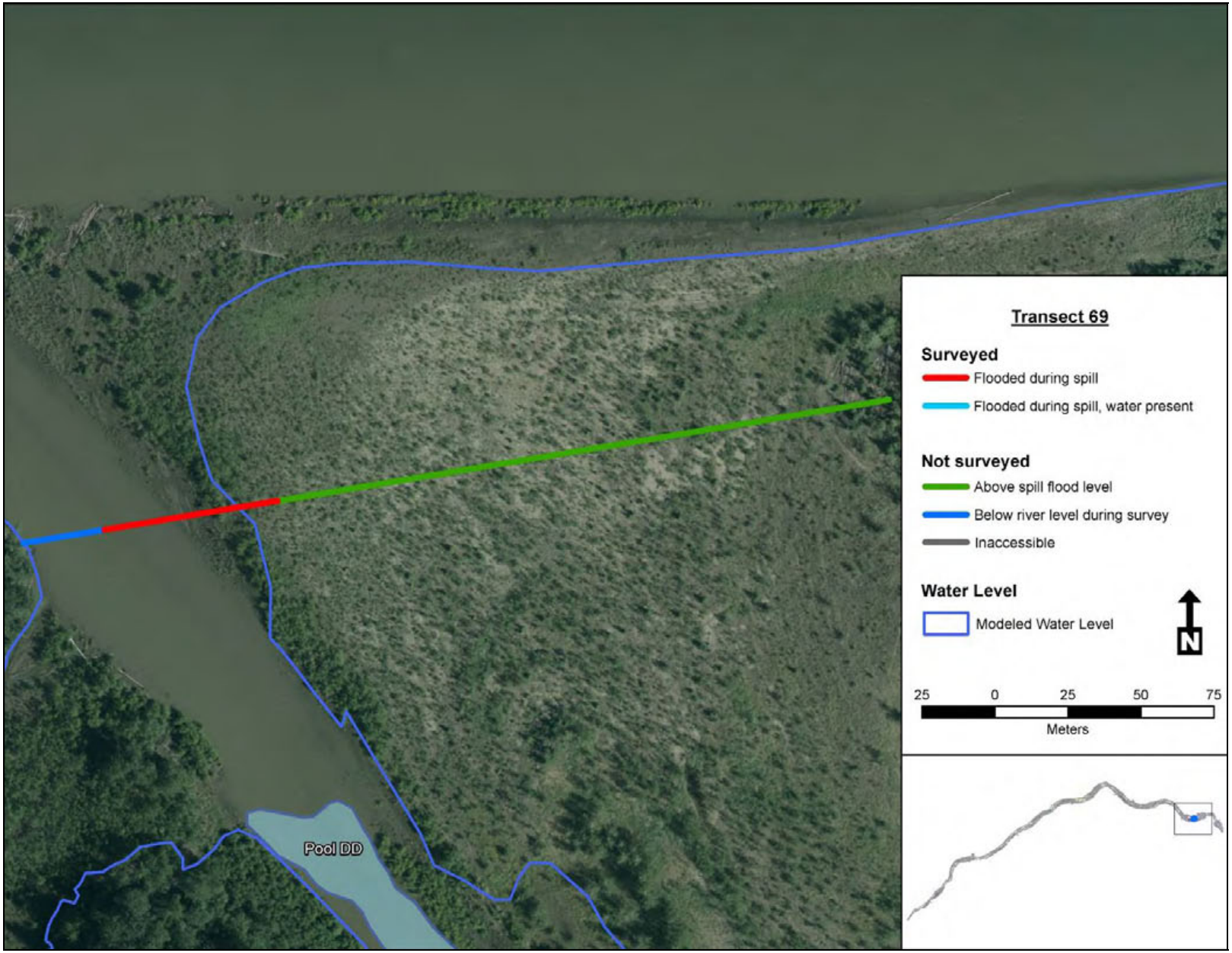

Pool DD
Pool EE
Pool FF
Pool GG
Incidental Stranding Pools
Modeled Water Level
25 0 25 50 75 100 125
Meters
N

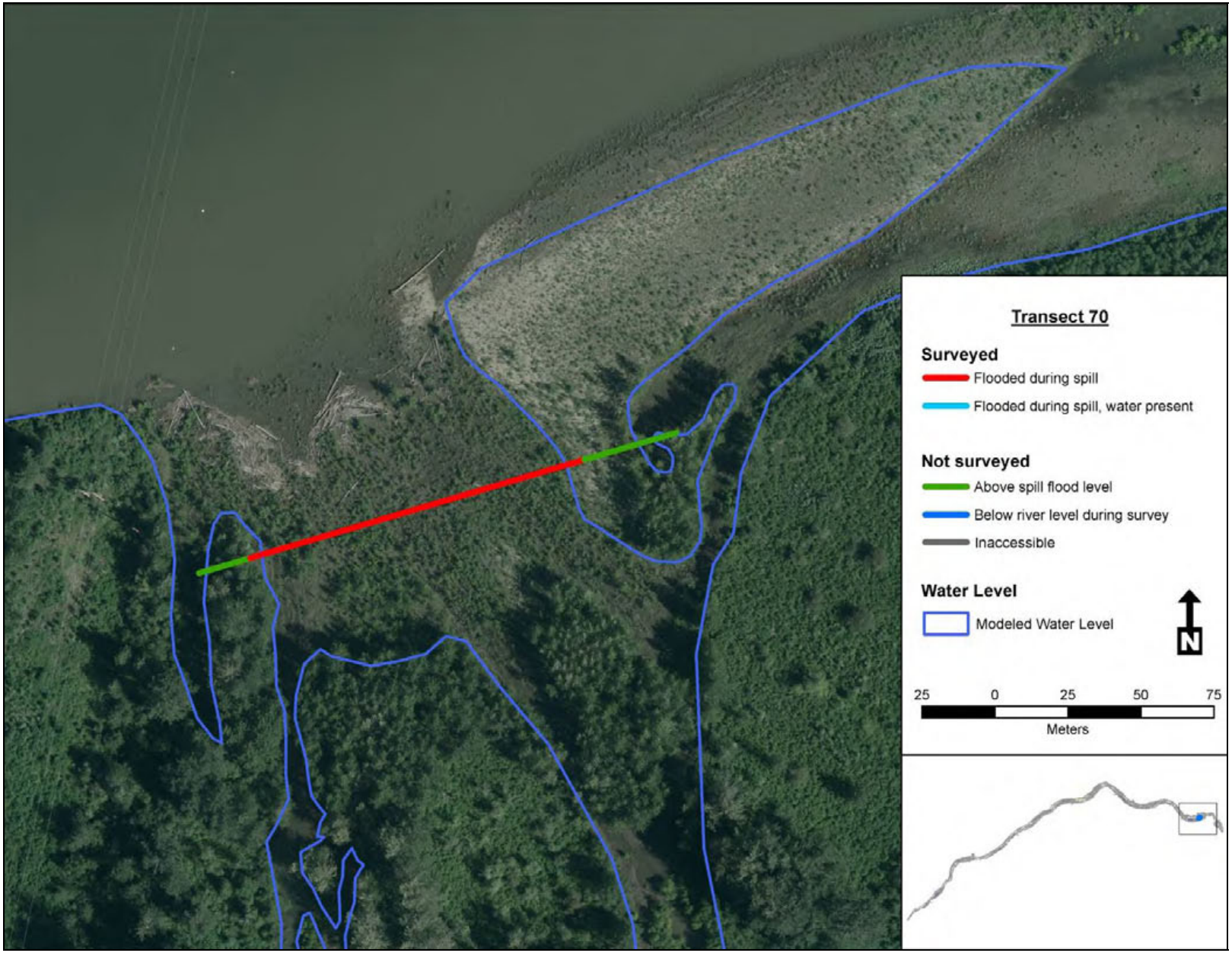

Transect 70
Pool II
Incidental Stranding Pools
Modeled Water Level
25 0 25 50 75
Meters
N


Incidental Pool 3
Incidental Pool 2
Transect 58
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters


Incidental Pool 3
Incidental Pool 2
Transect 58
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters


(1)
(2)
Pool T
Transect 59
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters


Transect 69
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters
Pool DD


Transect 70
Surveyed
Flooded during spill
Flooded during spill, water present
Not surveyed
Above spill flood level
Below river level during survey
Inaccessible
Water Level
Modeled Water Level
N
25 0 25 50 75
Meters

Appendix 7. Site photos from the July 14, 2012 fish stranding survey.

Stratum 1 (PCN to Lynx Creek)

Pool A

Pool B

Transect 3

Transect 4

Transect 5

Transect 6

Transect 10

Transect 11

Transect 12

Stratum 2 (Lynx Creek to Halfway River)

Pool E

Pool F

Pool G

Pool H

Transect 24

Transect 25

Transect 26

Transect 31

Transect 32

Transect 33

Stratum 3 (Halfway River to Pine River)

Pool T

Pool DD

Pool FF

Incidental 2

Incidental 3

Transect 58

Transect 59

Transect 69

Transect 70