Keeyask Generation Project

Aquatic Effects Monitoring Plan

Lake Whitefish Movement Monitoring Report

AEMP-2020-03

KEEYASK

Manitoba Conservation and Climate Client File 5550.00
Manitoba Environment Act Licence No. 3107

2019 - 2020

KEEYASK GENERATION PROJECT

AQUATIC EFFECTS MONITORING PLAN

REPORT #AEMP-2020-03

LAKE WHITEFISH MOVEMENT MONITORING IN THE NELSON RIVER BETWEEN CLARK LAKE AND THE LIMESTONE GENERATING STATION, OCTOBER 2018 TO OCTOBER 2019: YEAR 6 CONSTRUCTION

Prepared for

Manitoba Hydro

By

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June 2020

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This report should be cited as follows:

Hrenchuk, C.L. 2020. Lake Whitefish movement monitoring in the Nelson River between Clark Lake and the Limestone Generating Station, October 2018 to October 2019: Year 6 Construction. Keeyask Generation Project Aquatic Effects Monitoring Plan Report #AEMP-2020-03. A report prepared for Manitoba Hydro by North/South Consultants Inc., June 2020. xv + 128 pp.

SUMMARY

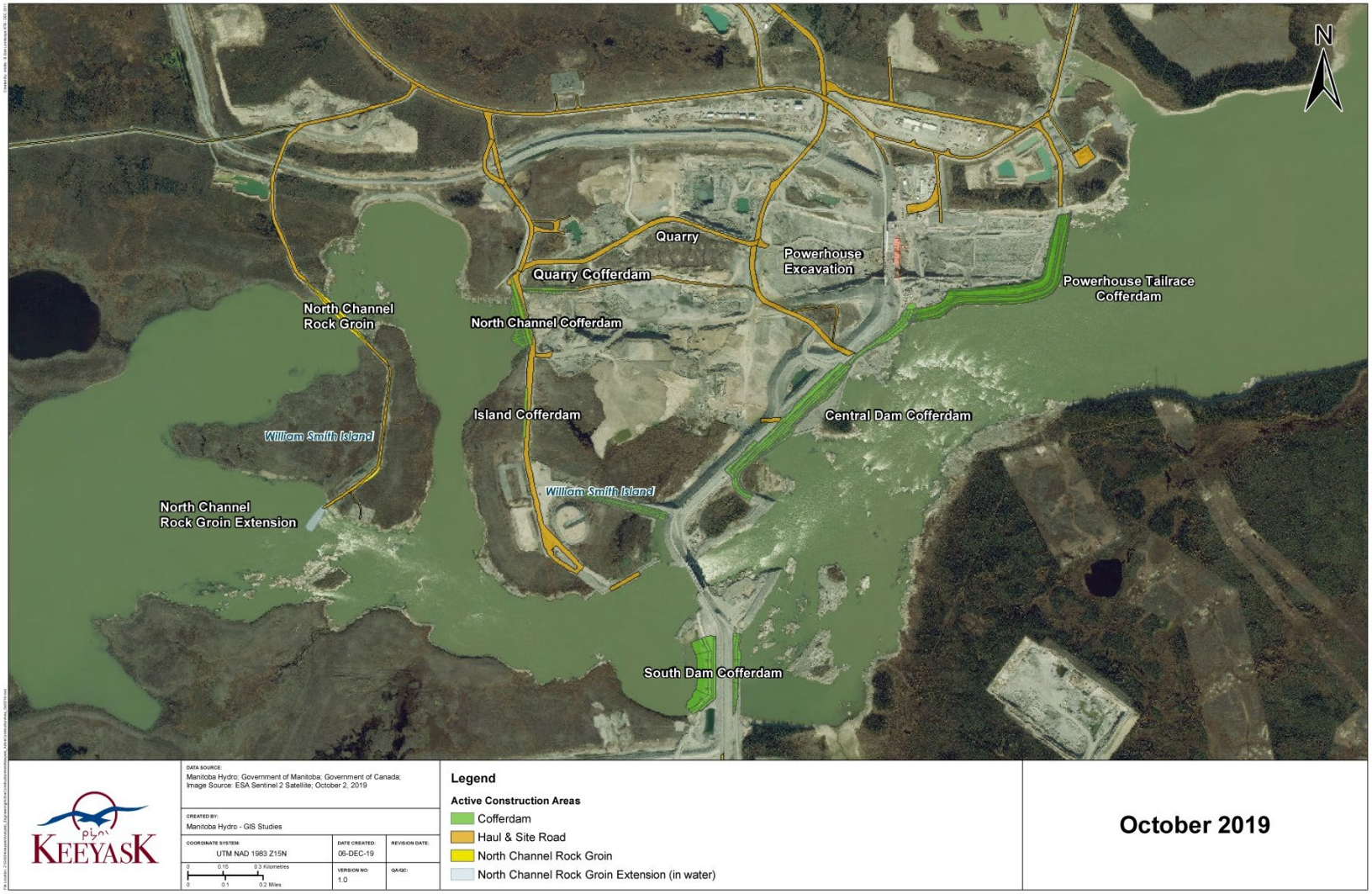
Background

The Keeyask Hydropower Limited Partnership (KHLP) was required to prepare a plan to monitor the effects of construction and operation of the Keeyask Generating Station (GS) on the environment. Besides measuring the accuracy of the predictions made and actual effects of the GS on the environment, monitoring results will provide information on how construction and operation of the GS will affect the environment and if more needs to be done to reduce harmful effects.

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams that blocked flow in the north and central channels of Gull Rapids (see map). During the winter of 2015/2016, the Spillway Cofferdam, which partially blocks the south channel, was constructed. Beginning late in 2016 and continuing in 2017, the Tailrace Cofferdam was constructed. Work was completed in fall 2017 with the exception of an opening that was left to allow fish movement into and out of the cofferdam over the 2017/18 winter. This opening was closed in spring 2018, and the area was dewatered. The spillway was commissioned in August 2018. The South Dam Cofferdam was completed in fall 2018, blocking the channel and forcing the entire flow of the river through the spillway. Almost all work in 2019 was in the dry. The construction activities included the excavation of the tailrace, construction of the tailrace spawning shoal, and completion of the dams and dykes.

The movements of Lake Whitefish over Birthday Rapids and Gull Rapids were monitored prior to construction, but because different methods are being used to collect data under the Aquatic Effects Monitoring Plan (AEMP), the results of the two programs can't be compared. Pre-construction movement studies demonstrated that Lake Whitefish were able to move upstream and downstream over both Gull Rapids and Birthday Rapids. Lake Whitefish also congregated in the area below Gull Rapids during the fall spawning season.

This report presents results of Lake Whitefish movement monitoring from October 2018 to October 2019 and provides a summary of data collected since the monitoring program was initiated in the fall of 2014. Monitoring fish movements is an important component of the overall plan to monitor the impacts of construction and operation of the Keeyask GS on fish. Lake Whitefish were identified as one of the key species to monitor because they are: of commercial and domestic importance; known to pass through Gull Rapids in either direction; and resilient enough to survive the acoustic tagging procedure.



Satellite Imagery - October, 2019

Map illustrating instream structures at the Keeyask Generating Station site, October 2019.

Why is the study being done?

Monitoring during construction is being done to answer two questions:

Are there Lake Whitefish close to the construction site, particularly during spawning?

If Lake Whitefish are in the river close to the construction area, they could be harmed by high amounts of mud in the water.

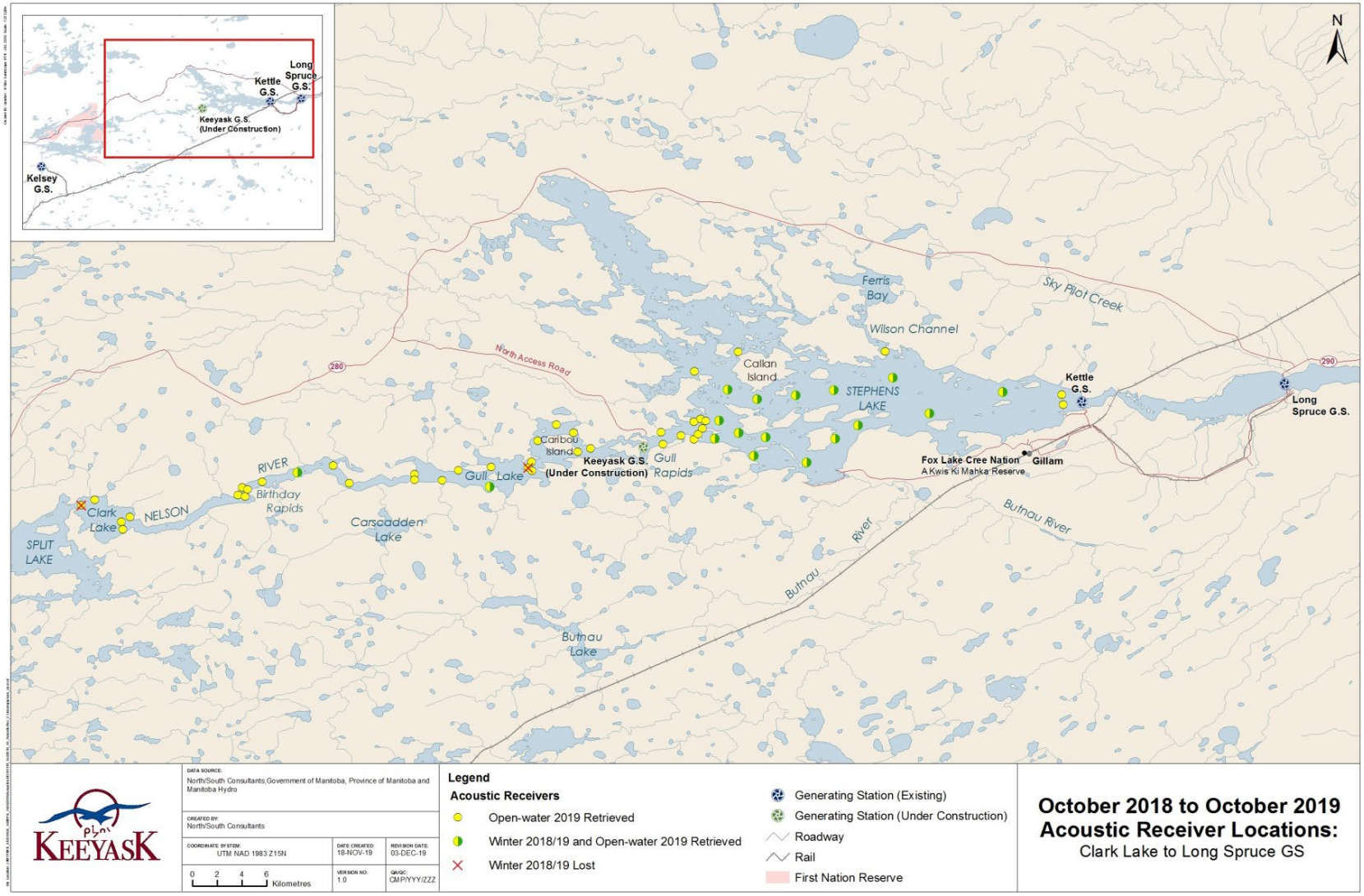
How many Lake Whitefish are moving through and/or away from Gull Rapids during construction and how far are they going?

Movement studies tell us how many whitefish are moving up or down through Gull Rapids (now the Keeyask GS), how far they travel up or downstream away from the site, whether they are leaving the Keeyask area completely and when they are making these movements. The distance they travel is monitored as far upstream as the inlet to Clark Lake and downstream as far as the Limestone reservoir.

What was done?

Movements of Lake Whitefish were tracked using acoustic telemetry. This is a technique in which a tag (transmitter) is surgically implanted inside a fish. Tags are implanted through a small incision which is then closed with sutures. Each tag sends out a sound signal (called a "ping") that is picked up by receivers that were placed along the Nelson River between Clark Lake and the Limestone Generating Station (see the study area map below). Each fish is given a transmitter that sends out a unique ping, and pings can be detected up to 1 kilometre (km) away from a receiver. By looking at the detections recorded by different receivers, the movement of each fish can be tracked.

Sixty Lake Whitefish were tagged in 2014, 20 upstream and 40 downstream of Gull Rapids. Because the batteries in these transmitters expired in winter 2017, 62 additional transmitters were implanted into Lake Whitefish in October 2017. This will extend the tracking of Lake Whitefish movements until summer 2022.



Map showing the study area. The dots represent the locations of receivers in the river. The different colours represent receivers that were in the river at different times of the year.

What was found?

Results from five years of tracking the movements of Lake Whitefish suggest that movement through Gull Rapids is rare. Of the 60 whitefish tagged in 2014 and tracked until the end of the 2017 open-water period, only two moved downstream. Of the 62 whitefish tagged in 2017, only three moved downstream, one of which may be related to tagging stress. No tagged whitefish have moved upstream through Gull Rapids since the start of the study. Since the Keeyask GS spillway was built in 2018, upstream movements are no longer possible.

Upstream of the Keeyask GS, fish spent a large part of their time in the upper section of Gull Lake during the open-water period and do not appear to be using habitat directly upstream of the construction site. In the fall, some of the detected fish made upstream movements out of Gull Lake to the base of Birthday Rapids. These upstream movements are believed to be for spawning.

In Stephens Lake, Lake Whitefish were more evenly spread throughout the lake. Many tagged whitefish were located closer to the base of Gull Rapids in the fall, likely to spawn. Based on detections in the north part of Stephens Lake, it is suspected that some fish spend most of their time in the North Arm of Stephens Lake, and some of these fish move to Gull Rapids in the fall to spawn.

What does it mean?

Lake Whitefish are using habitat immediately downstream of the Keeyask GS. Movements through Gull Rapids (or the Keeyask GS since 2018) have been rare as only five tagged fish have moved downstream during the five-year study. Some of these movements may be related to tagging stress or mortality.

What will be done next?

The additional Lake Whitefish tagged in October 2017 will allow movement data to be collected until summer 2022. Ongoing tracking of fish through GS construction, impoundment, and operation will provide additional information about where the fish are moving, what kinds of habitats these fish need to use over several years, when and where they are spawning, and where they are feeding.

ACKNOWLEDGEMENTS

We would like to thank Manitoba Hydro for the opportunity and resources to conduct this study.

Leslie Flett, Kelvin Kitchekeesik, Saul Mayham, and Tyler Kitchekeesik of Tataskweyak Cree Nation are thanked for their local expertise and assistance in conducting the field work.

The collection of biological samples described in this report was authorized by Manitoba Agriculture and Resource Development (previously Manitoba Sustainable Development), Fisheries Branch, under terms of the Scientific Collection Permit #18-19.

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1.0 INTRODUCTION

The Keeyask Generation Project (the Project) is a 695-megawatt (MW) hydroelectric generating station at Gull (Keeyask) Rapids on the lower Nelson River in northern Manitoba. The Project is approximately 725 kilometres (km) northeast of Winnipeg, 35 km upstream of the existing Kettle Generating Station, where Gull Lake flows into Stephens Lake, 60 km east of the community of Split Lake, 180 km east-northeast of Thompson and 30 km west of Gillam (Map 1). Construction of the Project began in July 2014.

The *Keeyask Generation Project: Response to EIS Guidelines*, completed in June 2012, provides a summary of predicted effects and planned mitigation for the Project. Technical supporting information for the aquatic environment, including a description of the environmental setting, effects and mitigation, and a summary of proposed monitoring and follow-up programs, is provided in the *Keeyask Generation Project Environmental Impact Statement: Aquatic Environment Supporting Volume* (AE SV). As part of the licensing process for the Project, an Aquatic Effects Monitoring Plan (AEMP) was developed detailing the monitoring activities of various components of the aquatic environment including the focus of this report, Lake Whitefish (*Coregonus clupeaformis*) movements, for the construction and operation phases of the Project.

Pre-construction (baseline) movements of Lake Whitefish were monitored from 2001 to 2005 (Barth *et al.* 2003; Murray *et al.* 2005; Murray and Barth 2007). Radio and acoustic telemetry studies focused specifically on detecting the upstream and downstream movements of fish over rapids in the study area (Birthday Rapids and Gull Rapids). Pre-construction movement data revealed that a proportion (28%) of Lake Whitefish did make movements both upstream and downstream over Gull or Birthday rapids. The pre-construction movement data also recorded Lake Whitefish congregating in the area below Gull Rapids during the fall, presumably for spawning. As pre-Project studies were not designed to record detailed movement patterns of Lake Whitefish in the Clark Lake to Stephens Lake reach as a whole, results are not directly comparable to the movement data being collected under the AEMP.

In fall 2014, 60 adult Lake Whitefish were implanted with acoustic transmitters to assess the frequency of movement through Gull Rapids and to monitor the potential impact construction of the Keeyask GS may have on Lake Whitefish. Annual reports detailing the 2014 to 2017 results are provided in Hrenchuk and Barth (2015), Lavergne and Hrenchuk (2016), Burnett and Hrenchuk (2017), Lacho and Hrenchuk (2018), and Lacho and Hrenchuk (2019). Results from October 11, 2018 to October 7, 2019 are presented in this report.

Lake Whitefish movements in the main flow of the Nelson River near the construction site may be affected by the installation of cofferdams that block upstream and downstream movements (Map 2), altered flow patterns, and disturbances such as blasting that may increase emigration from the construction area. Previous studies have shown that Lake Whitefish congregate in the area below Gull Rapids to spawn (Pisiak 2005a, b; Murray and Barth 2007). The broad objective of Lake Whitefish movement monitoring is to better understand their movements and habitat

use during generating station construction and operation, with particular focus on movements in the vicinity of Gull Rapids (now the Keeyask GS).

The key questions (presented in the AEMP) related to Lake Whitefish movement monitoring during construction of the Keeyask GS are:

- What number (or proportion) of tagged Lake Whitefish move past the construction site?
- Are whitefish utilizing habitat in the vicinity of the construction site (particularly during spawning)?

2.0 STUDY SETTING

The study area encompasses an approximately 110 km long reach of the Nelson River from Clark Lake to the upstream end of the Limestone Reservoir (Map 1). This section of river offers a diversity of physical habitat conditions, including a variety of substrate types, and variable water depths (range 0–30 m) and velocities. Water velocities were classified as low (0.2–0.5 metres per second [m/s]), moderate (0.5–1.5 m/s), or high (greater than 1.5 m/s), as described in the Keeyask AE SV.

Clark Lake is located immediately downstream of Split Lake, and approximately 42 km upstream of the Keeyask GS (Map 1). Current is restricted to the main section of the lake, with off-current bays outside the main channel. The Assean River is the only major tributary to Clark Lake, and flows into the north side. Downstream from the outlet of Clark Lake, the Nelson River narrows and water velocity increases for a 3 km stretch, known as Long Rapids. For the next 7 km, the river widens, and water velocity decreases.

Birthday Rapids is located approximately 10 km downstream of Clark Lake and 30 km upstream of the Keeyask GS (Maps 1 and 3). The drop in elevation from the upstream to downstream side of Birthday Rapids is approximately 2 m. The 14 km reach of the Nelson River between Birthday Rapids and Gull Lake is characterized as a large and somewhat uniform channel with medium to high water velocities. There are a few large bays with reduced water velocity and a number of small tributaries that drain into the Nelson River.

Gull Lake is a section of the Nelson River where the river widens, with moderate to low water velocity. Gull Lake is herein defined as the reach of the Nelson River beginning approximately 17 km upstream of the Keeyask GS and 14 km downstream of Birthday Rapids, where the river widens to the north into a bay around a large point of land (Maps 1 and 3), and extending to the downstream end of Caribou Island, approximately 3 km upstream of the Keeyask GS. Gull Lake has three distinct basins, the first extending from the upstream end of the lake downstream approximately 6 km to a large island; the second extending from the large island to Morris Point (a constriction in the river immediately upstream of Caribou Island); and the third extending from Morris Point to the downstream end of Caribou Island (Map 3).

Gull Rapids, now the site of the Keeyask GS, was located approximately 3 km downstream of Caribou Island on the Nelson River (Map 1). Prior to construction, the rapids were approximately 2 km in length, and the river elevation dropped approximately 11 m along the 2 km length. Two large islands and several small islands occurred within the rapids, prior to the river narrowing; these features are within the Project footprint and have now been either dewatered, incorporated into the GS or will be flooded after impoundment (Map 2). A summary of construction activities is provided in Section 2.1.

Just below the Keeyask GS, the Nelson River enters Stephens Lake (Maps 1 and 7). Stephens Lake was formed in 1971 by construction of the Kettle GS. Between Gull Rapids and Stephens Lake, there is an approximately 6 km long reach of the Nelson River that, although affected by

water regulation at the Kettle GS, remains riverine habitat with moderate velocity. After August 2018, all flow was has been passed through the Keeyask GS spillway (see Section 2.1).

Construction of the Kettle GS flooded Moose Nose Lake (north arm) and several other small lakes that previously drained into the Nelson River, as well as the old channels of the Nelson River that now lie within the southern portion of the lake (Map 4). Major tributaries of Stephens Lake include the North and South Moswakot rivers that enter the north arm of the lake. Looking Back Creek is a second order stream that drains into the north arm of Stephens Lake (Map 1). Kettle GS is located approximately 40 km downstream of the Keeyask GS.

The Long Spruce reservoir was formed in 1979 by the construction of the Long Spruce GS. It is a 16 km reach of the Nelson River extending from Long Spruce GS upstream to Kettle GS (Manitoba Hydro Public Affairs 1999). Kettle River and Boots Creek are the only major tributaries flowing into Long Spruce reservoir, with both tributaries entering the reservoir on the south shore (Maps 1 and 6).

The Limestone Reservoir was formed in 1990 by the construction of the Limestone GS. It is a 23 km reach of the Nelson River extending from Limestone GS upstream to Long Spruce GS. Four tributaries of the Nelson River enter the reservoir; Wilson Creek and Brooks Creek enter from the south, and Sky Pilot Creek and Leslie Creek enter from the north. Aquatic habitat within the reservoir ranges from a riverine environment in the upper reach, to more lacustrine conditions just upstream of the Limestone GS.

2.1 CONSTRUCTION SUMMARY

Construction of the Keeyask GS began in mid-July 2014 with the construction of cofferdams in the north and central channels of Gull Rapids (Map 2). These cofferdams resulted in the dewatering of the north and central channels and the diversion of all flow to the south channel. Construction of the Spillway Cofferdam (SWCD), which extends into the south channel of Gull Rapids, was completed in 2015. The rock placement for the inner and outer groins of the Tailrace Cofferdam (TRCD) started in late 2016 and the impervious fill placement was completed in fall 2017. An opening was created to allow fish to move freely over the winter of 2017–2018. The opening was closed in spring 2018 and dewatering of the TRCD occurred in July, at which time a fish salvage was completed. In preparation for commissioning of the spillway, the SWCD was watered-up on both sides of the structure in June 2018. Removal of the SWCD started in early July and continued into August. The spillway was commissioned between August 3 and 7, 2018. Closing the south channel with the upstream South Dam Cofferdam (SDCD) commenced at the beginning of August and river closure was achieved on August 16. This closure and the work that continued to seal the cofferdam forced the entire river flow through the spillway. The downstream SDCD was completed in September and the area between the two cofferdams was dewatered, allowing for fish salvage to be completed by late September 2018. Work continued on the upstream SDCD until it was complete in late fall 2018.

Almost all work in 2019 was in the dry. The construction activities included the excavation of the tailrace, construction of the tailrace spawning shoal, and completion of the dams and dykes.

2.2 FLOWS AND WATER LEVELS

From October 2018 to October 2019, calculated Split Lake outflows ranged from about 2,600 to 3,700 m^3/s. However, over most of the period, outflows ranged from approximately 3,000 to 3,500 m^3/s and were near the historical annual median flow of approximately 3,300 m^3/s. Outflow increased from about 2,600 to 3,600 m^3/s from October to December 2018, and then was variable through the remainder of the winter period. Between June and September 2019, the flow generally ranged from 3,300 to 3,500 m^3/s. Flows dropped to about 2,900 m^3/s in early October 2019 before rising again to almost 3,700 m^3/s by the end of the month. Water levels varied in conjunction with flows, ranging from about 153.2–155.0 m ASL on Gull Lake.

3.0 METHODS

3.1 ACOUSTIC TELEMETRY

Acoustic telemetry involves tracking movements of fish surgically implanted with internal acoustic transmitters (tags). Each transmitter emits a unique signal, recognizable by stationary receivers. When tagged fish come into the detection range of a receiver (generally within 500 m to 1 km, depending on conditions), the transmitter code number, as well as the date and time, are stored in the receiver. Initially, the receiver array used in this study was designed to monitor adult Lake Sturgeon (Hrenchuk 2020a); however, the same array is also used to monitor juvenile Lake Sturgeon (Hrenchuk 2020b), Walleye (Hrenchuk 2020c), and Lake Whitefish (the focus of this report).

3.1.1 ACOUSTIC TRANSMITTER APPLICATION

Acoustic transmitters (Vemco V13-1x, estimated 1,141 day battery life) were applied to 60 fish in September and October, 2014; 20 upstream and 40 downstream of Gull Rapids (now the Keeyask GS) (Tables 1 and 2). Tagged Lake Whitefish had fork lengths ranging from 372 to 565 mm. As the batteries in these tags were due to expire during winter 2017/2018, an additional 62 tags (V13-1x, estimated 1,737 day battery life) were applied to Lake Whitefish in October 2017; 22 upstream and 40 downstream of the Keeyask GS (Tables 1 and 2). Lake Whitefish tagged in October 2017 had fork lengths ranging from 406 to 540 mm (Lacho and Hrenchuk 2018).

Following capture, Lake Whitefish receiving tags were placed in a 76 L nesting fish tub fitted with an aquarium aerator for transport. All tagging was conducted on shore near the site of capture. Prior to transmitter implantation, Lake Whitefish were anaesthetized in a solution of clove oil and ethanol, adapted from Anderson et al. (1997). When the Lake Whitefish became immobile, they were placed in a surgery cradle ventral side up. Because the anesthetic renders a fish unable to ventilate on its own, freshwater was continuously pumped over the gills. A small incision was made through the ventral body wall using a sterilized scalpel. An acoustic transmitter was inserted into the body cavity and the incision was closed with sutures. Lake Whitefish were monitored in a recovery tank until they were able to maintain equilibrium and had regained their strength. They were released in off-current areas near the original capture site.

3.1.2 ACOUSTIC RECEIVERS

Since 2011, stationary acoustic receivers (VEMCO model VR2 and VR2W) have been used to continuously monitor tagged adult Lake Sturgeon in the Nelson River between Clark Lake and the Long Spruce GS; tagged Lake Whitefish have been monitored by these receivers since 2014. In spring 2016, the receiver array was extended to the upper Limestone Reservoir, with

the placement of two receivers downstream of the Long Spruce GS. The intent of adding these receivers was to determine whether fish that had moved into the Long Spruce Reservoir had continued to move downstream.

During the first five years of the construction phase of the Project (beginning in July 2014), receivers were deployed at the same sites as those established during the pre-construction phase (2011–2013). During the open-water period, receivers were deployed in calm water with a flat bottom free of large debris to maximize detection range, and spaced along the main river channel throughout the study area to maximize spatial coverage. In Stephens Lake, receivers were placed at locations within pre-flood river channels, based on the observation that sturgeon tend to stay within river channels, even in flooded environments. The same receivers have been effective in tracking Lake Whitefish movements. At constrictions within the river channel, a series of receivers were deployed to create "gates" with the intent of recording all fish that passed by the river cross-section (described in Section 3.1.2.2).

The retrieval of receivers deployed during winter has proven challenging and several were lost in previous winters, likely moved by ice (Hrenchuk and Barth 2013). Because it appears that receivers will only remain safe from ice if deployed in calm areas at depths greater than 10 m, the number of possible receiver locations during winter is limited, especially in Gull Lake.

3.1.2.1 WINTER 2018/2019

The stationary acoustic receiver array for the winter 2018/2019 (October 11, 2018, to April 30, 2019) period consisted of 19 receivers. Four were set upstream of the Keeyask GS and 15 throughout Stephens Lake (Maps 3 and 4). Low water levels prevented boat access to the river section between Kettle GS and Long Spruce GS, and therefore, an acoustic receiver could not be set downstream of the Kettle GS during winter 2018/2019. A receiver set in this area in October 2017 has not yet been retrieved, however, it is unlikely that this receiver recorded data during winter 2018/2019 due to a lack of battery life. Other than this receiver, the winter 2018/2019 array did not differ from that used in winter 2017/2018.

3.1.2.2 OPEN-WATER 2019

An array of 57 acoustic receivers was used during the 2019 open-water period (defined as May 1 to October 7, 2019). Twenty-seven were set upstream of the Keeyask GS and 30 were set in Stephens Lake (Maps 5 and 6). The 2019 open-water array differed slightly from the array used in 2018. One receiver (#125101) was set in a new location in Stephens Lake, closer to the construction site, at rkm 0.6 (Map 6).

As in 2018, receivers could not be set in the Long Spruce or Limestone reservoirs during the 2019 open-water period due to low water levels. Receivers will be set in both locations during open-water 2020 provided conditions are suitable.

Receiver "gates" were established in several key areas selected by river morphology (channel restrictions) and habitat characteristics (areas with low velocity adjacent to the main flow of the

river). Receiver "gates" consisted of two or more acoustic receivers set parallel to flow to provide complete (or nearly complete) signal coverage of a river cross-section. Areas between the "gates" were referred to as river zones. Receiver gates provide confidence that movements past key points are being detected, which allows for extrapolation of coarse-scale positions (*i.e.*, which zone) during periods when fish remain undetected. When analyzing data, fish detected within a zone that subsequently go undetected for a period of time without passing through a gate, are assumed to be within the zone in which they were last detected.

Four gates were established between Clark Lake and the Keeyask GS (44.0, 34.0, 19.0, and 10.0 rkms upstream of the GS), and two were established in Stephens Lake (4.5 and 40.0 rkms downstream of the GS) (Maps 5 and 6). The area upstream of the Keeyask GS was divided into five zones (Map 5; Zones 1–5), while Stephens Lake was divided into two zones (Map 6; Zones 6 and 7). The Long Spruce Reservoir is referred to as Zone 8 and the Limestone Reservoir as Zone 9; however, monitoring did not occur in these areas in 2019. The location of the "gates" has remained consistent since initiation of the study in 2013.

Water temperature within the Nelson River mainstem was recorded with a HOBO Water Temperature Pro data logger from October 11, 2018 to October 5, 2019. Lake Whitefish spawn during fall when water temperatures are between 6 and 9˚C, often forming pre-spawning aggregations (Green and Derksen 1987; Scott and Crossman 1998; Stewart and Watkinson 2004). Thus, data collected when water temperature measured less than 12˚C (when movements to spawning areas may be occurring) were considered as the "spawning period".

On October 7, 2019, the majority of receivers were removed and a subset (n = 21) were redeployed to monitor movements during winter 2019/2020.

3.1.3 DATA ANALYSIS

False detections can arise on acoustic telemetry receivers due to code collisions and/or environmental noise (Pincock 2012). To filter out false detections, a fish was required to be detected at least two times within a 30-minute interval at a given stationary receiver. Single detections were filtered and not used in most analyses; however, in instances when fish went undetected for lengthy periods, and/or rapid movements were suspected, raw data were also explored. In no instance did examination of raw data suggest that consideration of a single detection would result in a different behaviour or movement pattern compared with the result when single detections were removed.

Movements were analysed in terms of rkm distance, with the base of the Keeyask GS representing a distance of 0 rkm. The area located downstream of the Keeyask GS (i.e., Stephens Lake and the Long Spruce Reservoir) were given positive (+) distance values from the GS, while the area located upstream (i.e., Gull and Clark lakes) were given negative (-) distance values (Figures 1 and 2). The average rkm distance from the GS was calculated over a 4-hour interval and plotted versus time for each fish. Total detection ranges were calculated by subtracting the furthest downstream detection location from the location of the furthest upstream

detection. The proportion of time that all fish spent within each river zone during each 4-hour interval was plotted and presented as a percentage of the study period. For example, a fish spent 44% of the time between May 1 and May 31 within Zone 4 means that the fish was detected within Zone 4 for 44% of the 186 4-hour intervals between May 1 and May 31.

Rapid downstream movements observed within two weeks of tagging were classified as caused by tagging mortality or stress. It the fish made a rapid downstream movement within two weeks of tagging followed by upstream and downstream movements, it was classified as tagging stress. If a fish made a rapid downstream movement within two weeks of tagging and was not detected again or did not display upstream movements, it was classified as a tagging mortality. If a fish was not detected for more than one year, it was classified as missing.

4.0 RESULTS

Tagging and biological information for Lake Whitefish tagged in October 2017 upstream and downstream of Gull Rapids can be found in Tables 1 and 2. Table 3 summarizes the time fish spent in each river zone during the five years Lake Whitefish have been monitored, including fish tagged in both 2014 and 2017. Figures 1 and 2 show the receiver locations upstream and downstream of Gull Rapids during 2018/19 winter and 2019 open-water periods. Figure 3 provides water temperatures in the Nelson River mainstem between October 2018 and October 2019. Figures 4 to 16 provide movement range, and proportional distribution of tagged fish both upstream and downstream of the construction site by season. A detection summary by season and year, including the farthest upstream and downstream detection locations for each tagged whitefish, are presented in Appendix 1. Individual movement summaries for each Lake Whitefish tagged in 2017 are presented in Appendices 2 and 3.

4.1 2017-2018 RESULTS SUMMARY

4.1.1 UPSTREAM OF THE KEEYASK GS

Twenty-two Lake Whitefish were tagged upstream of the Keeyask GS in October 2017. Prior to winter 2018/2019, three moved downstream through the Keeyask GS into Stephens Lake:

- #31738 was tagged on October 11, 2017, at rkm -33.5 and moved downstream through Gull Rapids on July 26, 2018 (Appendix A2-14).
- Two (#31727 and #31740) are considered mortalities and are not discussed in the remainder of this report.
    - #31727 was tagged on October 12, 2017, at rkm -33.5 and moved downstream through Gull Rapids between November 10, 2017, and May 30, 2018. It made multiple upstream and downstream movements before moving to rkm 16.8 on June 25, 2018. It has been detected constantly at this location since that time, displaying no upstream or downstream movements. It is likely that this fish is a mortality and the tag has remained within the detection range of this receiver (Appendix A2-3).
    - #31740 moved downstream immediately after it was tagged on October 11, 2017. It was detected in Stephens Lake 20 days post-tagging where it continued to move downstream and displayed no upstream movements. This fish is considered a tagging mortality (Appendix A2-16).

Therefore, accounting for the three fish that moved downstream, 19 Lake Whitefish were available to be detected upstream of the Keeyask GS at the beginning of the 2018/2019 winter period.

4.1.2 STEPHENS LAKE

Forty Lake Whitefish were tagged in Stephens Lake in October 2017. Thirteen fish were only detected briefly after tagging and/or have not been detected for more than one year. They are currently considered missing and are not discussed for the remainder of the report.

- #31698 was tagged on October 9, 2017, at rkm 0.4. It moved between rkm 1.2 and 4.4 and was last detected on October 15, 2017 (Appendix A3-1).
- #31701 was tagged on October 9, 2017, at rkm 0.4. It was never detected after tagging (Appendix A3-4).
- #31706 was tagged on October 9, 2017, at rkm 0.4. It moved immediately downstream and was last detected at rkm 6.5 on October 15, 2017 (Appendix A3-9).
- #31711 was tagged on October 9, 2017 at rkm 0.4. It moved between rkm 1.2 and 24.7 and was last detected at rkm 6.5 on October 26, 2017 (Appendix A3-14).
- #31713 was tagged on October 9, 2017, at rkm 0.4. It moved between rkm 1.2 and 9.4 and was last detected at rkm 6.5 on October 14, 2017 (Appendix A3-16).
- #31717 was tagged on October 9, 2017, at rkm 0.4. It displayed upstream and downstream movements and was last detected on October 20, 2017, at rkm 24.7 (Appendix A3-20).
- #31719 was tagged on October 9, 2017, at rkm 0.4. It moved between rkm 1.2 and 4.4 and was last detected on October 15, 2017 (Appendix A3-22).
- #31720 was tagged on October 9, 2017, at rkm 0.4. It was detected between rkm 1.2 and 2.7 until October 15, 2017 (Appendix A3-23).
- #31721 was tagged on October 8, 2017, at rkm 0.4. It moved between rkm 1.2 and 4.4 and was last detected on October 15, 2017 (Appendix A3-24).
- #31723 was tagged on October 9, 2017, at rkm 0.4. It moved between rkm 1.2 and 6.5 and was last detected on October 22, 2017 (Appendix A3-25).
- #31752 was tagged on October 10, 2017, at rkm 0.4. It was detected regularly, displaying upstream and downstream movements until November 30, 2017, when it was last detected at rkm 21.6 (Appendix A3-33).
- #31755 was tagged on October 9, 2017, at rkm 0.4. It moved between rkm 1.2 and 4.4 and was last detected on October 14, 2017 (Appendix A3-36).
- #31756 was tagged on October 8, 2017, at rkm 0.4. It moved between rkm 1.2 and 8.4 until October 26, 2017, when it began to move downstream. It was last detected on October 29, 2017, at rkm 36.1 (Appendix A3-37).

In summary, 40 Lake Whitefish were tagged in Stephens Lake in 2017, 13 of which are considered missing. Three fish moved downstream from Gull Lake, one of which continues to

be detected (section 4.1.1). Therefore, 28 fish were available to be detected in Stephens Lake during winter 2018/2019.

4.2 WINTER 2018/2019

4.2.1 UPSTREAM OF THE KEEYASK GS

The 2018/2019 winter receiver array consisted of four receivers deployed in the Nelson River between Clark Lake and the Keeyask GS at rkms -48.2, -29.4, -12.4, and -10.3 (Figure 1). Two of the four acoustic receivers were retrieved; the receivers at rkm -48.2 and -10.3 could not be located and were likely moved by ice (Map 3).

Eleven of 19 (58%) whitefish were located a total of 387 times (range: 6–170 detections per individual) (Figure 4; Appendix A1-1). Fish were detected on one to five days of the 202 day winter period. A near equal number of detections occurred downstream of Birthday Rapids (rkm -29.4; n = 220) and in Gull Lake (rkm -12.4; n = 167) (Figure 5). No detections were logged by any receiver after November 11, 2018.

Individual movement graphs can be found in Appendix 2.

4.2.2 STEPHENS LAKE

Fifteen receivers were deployed in Stephens Lake during the 2018/2019 winter period, between rkms 5.2 and 36.1 (Figure 1; Map 4). All of the 15 receivers were retrieved at the end of the study period.

Eleven of 28 (39%) Lake Whitefish were located a total of 59,935 times (range: 9–36,290 detections per individual) (Figure 6; Appendix A1-2). Fish were detected on two to 147 days of the 202 day winter period (1–73% of the time) for an average of 34 days, or 17% of the study period (StDev = 57.0 days). The farthest upstream detections occurred at rkm 5.2 (by five fish; 45%), while the farthest downstream occurred at rkm 21.6 (by two fish; 18%) (Figure 6; Appendix A1-2). The average total movement range was 6.1 rkm (range: 0.0–16.4 rkm).

The majority of detections (n = 21,982; 37%) were logged in the southern portion of Stephens Lake at rkm 13.9 (Figure 7). Nine fish moved into the northern portion of Stephens Lake and were detected at rkms 6.5 (n = 5,900; 10%), 8.4 (n = 538; 1%), 13.0 (n = 2,650; 4%), and 16.8 (n = 12,718; 21%) (Figure 7).

Individual movement graphs can be found in Appendix 3.

4.3 OPEN-WATER 2019

4.3.1 ACOUSTIC RECEIVER RETRIEVAL

All stationary acoustic receivers deployed upstream of the Keeyask GS (n = 27) and in Stephens Lake (n = 30) during the 2019 open-water period were successfully retrieved (Maps 5 and 6). The receiver array was the same as in 2018; however, an additional receiver was deployed in Stephens Lake 0.6 km downstream of the spillway on the South shore (#125101; Map 6).

Water temperature reached 12˚C on September 26, 2019, and measured 9˚C by the end of the study period (Figure 3). Based on these water temperatures, the time between September 26 and October 7 is referred to as the spawning period.

4.3.2 UPSTREAM OF THE KEEYASK GS

Seventeen of 19 (89%) Lake Whitefish were detected upstream of the Keeyask GS during the 2019 open-water period. Fish were detected 102–22,103 times for 11–116 days of the 160 day open-water period (7–73% of the time) (Appendix A1-3). The average movement range was 13.6 rkm (StDev = 10.3 rkm; range: 0.0–26.4 rkm). The farthest upstream detections occurred just upstream of Birthday Rapids at rkm -34.3 (by one fish; 6%), while the farthest downstream detections occurred in lower Gull Lake at rkm -7.4 (by four fish; 24%) (Figure 8). No fish moved downstream through the Keeyask GS spillway.

Both of the fish that were not detected during the 2019 open-water period were last located in 2018.

- #31735 was last detected in lower Gull Lake at rkm -4.8 on July 18, 2018 (Appendix A2-11).
- #31744 was last detected in the riverine portion of the Nelson River downstream of Birthday Rapids (rkm -26.5) on June 7, 2018 (Appendix A2-20).

4.3.2.1 PROPORTIONAL DISTRIBUTION

As in 2018, individual Lake Whitefish were detected most often in Zone 4 (upper basin of Gull Lake), spending an average of 70% of the study period in this zone (StDev = 44%, range: 0–100%) (Table 2; Figure 9). Lake Whitefish were detected for an average of 17% of the study period in Zone 3 (river reach from Birthday Rapids to Gull Lake; StDev = 32%; range: 0–100%) and 16% in Zone 5 (lower basin of Gull Lake; StDev = 32%, range: 0–93%). A single fish was detected briefly in Zone 2 (the riverine area between Clark Lake and Birthday Rapids) while no Whitefish were detected in Zone 1 (Clark Lake) (Figures 9 and 10).

The use of Zone 3 increased over the open-water period. It was used:

- 12% of the time between June 1 and September 3;
- 27% of the time between September 4 and 29; and
- 48% of the time between September 30 and October 7.

4.3.2.2 MOVEMENT PATTERNS

In general, detections were logged throughout Zones 3, 4, and 5 during the 2019 open-water period, with the highest number of detections occurring immediately downstream of Birthday Rapids (rkm -33.8; n = 35,705; 27%) and in lower Gull Lake east of Caribou Island (rkm -9.3; n = 28,910; 22%). No detections were logged at the two receivers located closest to the Keeyask GS construction site (rkms -5.8 and -4.8) (Figure 11). During the spawning period, 60% of all detections were logged immediately downstream of Birthday Rapids on the north side of the river (rkm -33.8; n = 15,631) (Figure 12).

Of the 17 fish detected during the 2019 open-water period:

- Eight remained exclusively in Gull Lake:
  - Four (#31730, #31734, #31739, and #31746) moved between the upper and lower basins of Gull Lake (Zones 4 and 5).
  - Four (#31722, #31726, #31731, and #31742) were only detected in Zone 4 (upper basin of Gull Lake), moving as far upstream as rkm -19.5.
- Seven (#31729, #31732, #31736, #31737, #31741, #31743, and #31745) remained in Gull Lake for the majority of the open-water period but made distinct upstream movements to Birthday Rapids (rkm -33.8) in fall. All seven fish displayed the same movement patterns during open-water 2018.
- Two (#31728 and #31733) remained exclusively in the riverine area between Birthday Rapids and Gull Lake (Zone 3). The same two fish remained in this riverine area during open-water 2018.

4.3.3 STEPHENS LAKE

Seventeen of 28 fish (61%) were detected in Stephens Lake during the 2019 open-water period. These fish were detected between 213 and 59,102 times over two to 131 days of the 160 day open-water period (1–82% of the time) (Appendix A1-4). The average total movement range was 8.7 rkm (StDev = 7.4 rkm; range: 0.0–27.8 rkm) (Figure 13). The farthest upstream detections occurred at the receiver closest to the Keeyask GS Spillway at rkm 0.6 (by one fish; 6%), while the farthest downstream detections were at rkm 40.8 (by one fish; 6%).

Of the 11 fish that were not detected:

- Three were detected regularly during the 2018 open-water season.
    - #31700 was last detected at rkm 2.7 on September 15, 2018 (Appendix A3-3).
    - #31712 was last detected at rkm 16.8 in the northern portion of Stephens Lake on July 1, 2018 (Appendix A3-15).
    - #31757 was last detected at rkm 7.4 on September 7, 2018 (Appendix A3-38).
- Seven were briefly detected during the 2018 open-water season.
    - #31708 was detected on four days in September at rkm 1.2 (Appendix A3-11).
    - #31718 was detected on two days in June at rkm 3.8 (Appendix A3-21).
    - #31725 was detected at rkm 7.4 only on July 1 (Appendix A3-27).
    - #31747 was detected on four days at the end of September moving between rkms 1.2 and 3.8 (Appendix A3-28).
    - #31749 was detected on six days between May and June moving between rkms 16.8 and 24.7 in the northern portion of Stephens Lake (Appendix A3-30).
    - #31751 was detected on two days in August at rkms 3.8 and 7.4 (Appendix A3-32).
    - #53762 was detected on four days in June between rkms 20.0 and 36.1 (Appendix A3-40).
- #31707 was last detected during winter 2018/2019, at rkm 6.5 on February 28, 2019 (Appendix A3-10).

4.3.3.1 PROPORTIONAL DISTRIBUTION

Overall, Lake Whitefish spent more time in Zone 7 (farther away from the Keeyask GS) than in Zone 6 during the 2019 open-water period (Figures 9 and 14; Table 3). On average, fish spent 64% of the time in Zone 7 (StDev = 43%; range: 0–100%) and 36% in Zone 6 (StDev = 43%, range: 0–100%). By the end of September, however, time spent in Zone 6 started to increase. Zone 6 was used an average of 35% of the time between June 1 and September 29 and 58% of the time between September 30 and October 7.

4.3.3.2 MOVEMENT PATTERNS

During the 2019 open-water period, the highest number of detections (n = 67,552; 56%) were recorded just below the Keeyask GS, near the North shore at rkm 1.2 (Figure 15). During the spawning period, 45% of detections were logged at this receiver, while 63% of detections were logged within 4.6 rkm of the Keeyask GS (Figure 16).

Of the 17 Lake Whitefish detected in Stephens Lake during the 2019 open-water period:

- Ten remained in the upstream portion of Stephens Lake, moving only as far downstream as rkm 9.4.

  - Three (#31714, #31716, and #31738) remained exclusively in the southern portion of the lake.
  - Seven (#31703, #31704, #31705, #31709, #31710, #31750, and #31753) moved between the northern and southern portions of the lake.
- Six (#31699, #31702, #31715, #31724, #31754, and #53761) moved more extensively throughout Stephens Lake, using both the northern and southern portions.
- One (#31748) was last detected immediately upstream of the Kettle GS (rkm 40.8) and may have moved downstream into the Long Spruce reservoir.
  - This fish was detected regularly in lower Stephens Lake at the beginning of the 2019 open-water period moving between rkms 13.0 and 16.8.
  - It began moving downstream on May 25 and was last detected at rkm 40.8 on June 14, 2019.
  - Due to low water levels that prevented access to the Long Spruce reservoir, entrainment could not be confirmed.

5.0 DISCUSSION

This study was initiated in 2014 with the long-term objective of assessing the impacts of construction and operation of the Keeyask GS on Lake Whitefish movement. As predicted in the AEMP and the Keeyask EIS, potential impacts include changes in fish movements due to placement of cofferdams and altered flow patterns, as well as increased emigration due to disturbances such as blasting. Construction was also predicted to alter availability of spawning habitat at Gull Rapids through disturbances associated with construction and changes in attraction flow. 2019 marks the final year of monitoring prior to reservoir impoundment. Acoustic transmitters applied in October 2014 expired in November 2017 and additional fish were tagged upstream (22) and downstream (40) of the construction site in October 2017 to continue movement monitoring during construction of the GS.

5.1 EVALUATION OF METHODOLOGY

Fish movement monitoring, via acoustic telemetry, is a significant component of the AEMP for the Keeyask GS Project used to assess potential impacts of GS construction on several fish species including Lake Sturgeon (adults and juveniles), Walleye, and Lake Whitefish. Of these fish species/life stages, the methodology is most effective for monitoring movements of adult and juvenile Lake Sturgeon. Lake Sturgeon have a low natural mortality rate, occupy main channel habitats where the receivers are located, and in the case of juveniles, rarely move. Monitoring movements of Walleye and Lake Whitefish via acoustic telemetry has been less effective relative to Lake Sturgeon. This is because: i) tagged individuals are detected less frequently due to more frequent utilization of shallow water habitat outside the detection range of receivers; ii) potential use of tributaries and off-current embayments where receivers are not located; iii) stress from the tagging procedure may cause an initial downstream movement of some individuals which complicates data interpretation; and iv) a higher natural morality rate relative to Lake Sturgeon causes a greater proportion of tags to go missing. Despite this, the data collected to date (2014 to 2019) provide a good understanding of Lake Whitefish movements. This has been facilitated by the extensive array of stationary acoustic receivers spread over a ~100 km length of the Nelson River between Clark Lake and the Limestone GS, and the inclusion of receiver gates which provide confidence that movements of Lake Whitefish past key points are being detected.

A large proportion of Lake Whitefish in Stephens Lake (39% of those available to be detected) were not located during open-water 2019. All of these fish were located during the 2018 open-water period and one was located during winter 2018/2019. This is not unexpected based on previous monitoring. Of the Lake Whitefish originally tagged in 2014, 23% went undetected for the entirety of the three-year study, and only 33% were detected during all three open-water periods. Further, one Lake Whitefish that was tagged near Birthday Rapids in 2014 went undetected until the open-water season of 2017. Lake Whitefish frequently use shallow water

habitat outside the detection range of receivers. It is likely that the fish missing in 2019 have moved outside of the detection range of the receiver array.

5.2 WINTER MOVEMENT

A limited amount of winter movement data has been collected from Lake Whitefish upstream of the Keeyask GS since the study commenced in 2014. During the winter period, tracking is limited by the reduced number of receivers, as only four receivers are left in during the winter (ice conditions prevent leaving additional receivers in). Only two of these receivers were recovered after winter 2018/2019, further limiting the amount of data collected. During the 2018/2019 winter period, 58% of fish were located, however, they were only detected for an average of two days. Similarly, in previous years, average detection days have been very low in the winter (four days in 2014/15, seven days in 2015/16, six days in 2016/17, and four days in 2017/18). In all study years, the majority of detections have occurred during October and November downstream of Birthday Rapids (rkm -33.8). These detections are likely related to spawning and post-spawning movements.

The winter receiver array in Stephens Lake is more extensive, and thus more fish can be tracked for a greater proportion of the period. As in all previous study years, the majority of detections during the 2018/2019 winter period occurred at rkm 13.9, in the southern part of Stephens Lake. Lake Whitefish tagged in 2014 have been detected in this area during all previous years. It is suspected that Lake Whitefish may also overwinter in the North Arm of Stephens Lake, out of the detection range of the receiver array. During winter 2018/2019, 82% of fish were detected within the northern portion of the lake.

5.3 OPEN-WATER MOVEMENT

The proportion of Lake Whitefish detected during the 2019 open-water period continued to be high. In 2018, all fish tagged upstream of the Keeyask GS were detected, while 89% were detected during open-water 2019. This was higher than the 47–80% detection rates observed in previous years. In Stephens Lake, 61% of fish were detected, which is similar to the 49%–68% in previous years (Lavergne and Hrenchuk 2016; Burnett and Hrenchuk 2017; Lacho and Hrenchuk 2018; Lacho and Hrenchuk 2019).

As in previous years, Lake Whitefish tended to spend most of the open-water period in Gull Lake, with some fish staying in the lake for the entire open-water period and some making upstream movements out of the lake during the fall. Similar to those tagged in 2014, Lake Whitefish tagged in 2017 were detected at the base of Birthday Rapids during the spawning period (*i.e.*, when water temperatures fell below 12˚C). Movements of fish tagged in 2017 continued to differ from those tagged in 2014 in one respect: no fish were detected upstream of Birthday Rapids in 2018 or 2019. In the three previous study years, fish were detected as far upstream as Clark Lake during the open-water season.

Lake Whitefish in Stephens Lake continued to display movement patterns similar to those observed in 2018, spending more time in Zone 7 farther from the Keeyask GS than Zone 6. This is the opposite of what was observed for fish tagged in 2014, when fish were located in Zone 6 for the majority of the open-water period. However, as in the first three years of the study, the proportion of time spent in Zone 6 increased during the fall. The majority of Lake Whitefish were detected within the northern portion of Stephens Lake, some of which likely moved into the North Arm outside of the receiver array.

5.4 KEY QUESTIONS

The AEMP identified key questions for Lake Whitefish movement monitoring, two of which are relevant to the construction period and are addressed in the discussion below.

What is the number (or proportion) of tagged Lake Whitefish that move past the construction site?

Monitoring the movement of Lake Whitefish for five years has shown that movements past Gull Rapids (now the Keeyask GS) are rare. Three of the 22 (14%) Lake Whitefish tagged upstream of Gull Rapids in 2017 have moved downstream into Stephens Lake (one in 2017 and two in 2018). It is likely that at least one of these fish is a tagging mortality. Of the 20 fish tagged upstream in 2014, two (10%) moved downstream during the three-years the tags were active. No Lake Whitefish have moved upstream over Gull Rapids since the study was initiated in 2014. The Keeyask GS spillway was commissioned in August 2018, after which upstream movements were no longer possible.

Are Lake Whitefish utilizing habitat in the vicinity of construction activities (particularly during spawning)?

Upstream of the Keeyask GS, Lake Whitefish do not frequently use habitat in the vicinity of the construction site. No Lake Whitefish were detected at the two receivers closest to the GS (rkms -5.8 and -4.8) in 2019. In previous years, only one to two fish have been located here during the open-water period.

In contrast, Lake Whitefish in Stephens Lake have been frequently detected in the vicinity of the construction site since the study began. In 2019, only one Lake Whitefish (6%) was detected at a receiver placed 0.6 rkm downstream of the Keeyask GS spillway, however, 53% of detected fish were located by the receiver located 1.2 rkm downstream of the Keeyask GS along the North shore (receiver #125555; Map 6). During the 2019 spawning period, 47% of all detections occurred within 1.2 rkm of the Keeyask GS. Lake Whitefish have been detected in this area during all spawning periods since 2015, indicating that Lake Whitefish have continued to spawn downstream of the Keeyask GS since construction began. This means that Lake Whitefish in Stephens Lake may be especially susceptible to construction-related activities like sedimentation and flow alteration during the fall spawning period.

6.0 SUMMARY AND CONCLUSIONS

- Although Lake Whitefish may go undetected for long periods of time and the number of detections are low compared to Lake Sturgeon, acoustic monitoring continues to provide enough data to meet the objectives of the AEMP.
- In open-water 2019, as in previous years, Lake Whitefish upstream of Gull Rapids spent the majority of the time in Gull Lake, with some fish making upstream movements out of the lake during the fall, likely related to spawning. As in all previous years of the study, Lake Whitefish were detected at Birthday Rapids during the spawning period. No fish tagged in 2017 has been detected upstream of Birthday Rapids since tagging; in contrast, fish tagged in 2014 were detected as far upstream as Clark Lake during all three open-water seasons that they were monitored.
- In Stephens Lake, movement patterns were similar to those observed in previous years, with fish spending more time closer to Gull Rapids during the fall and a large proportion of detections occurring near Gull Rapids during the spawning period. As in previous years, Lake Whitefish were detected frequently in the northern portion of the lake.
- The key questions as described in the AEMP for Lake Whitefish movement monitoring during construction of the Keeyask GS are:
    - *What is the number (or the proportion) of tagged Lake Whitefish that move past the construction site?*

      Results of four years of monitoring suggest that a small proportion of Lake Whitefish tagged in Gull Lake move downstream into Stephens Lake. No Lake Whitefish moved downstream through the Keeyask GS in 2019. Of the fish tagged upstream of the Keeyask GS, two of 20 (10%) tagged in 2014 and three of 22 (14%) tagged in 2017 moved downstream into Stephens Lake. At least one of the movements in 2017 may have been related to tagging stress. Prior to spillway commissioning in 2018, there were no upstream movements through Gull Rapids.
    - *Are tagged Lake Whitefish utilizing habitat in the vicinity of construction activities (particularly during spawning)?*

      So far, Lake Whitefish tagged upstream of the Keeyask GS rarely utilize habitat directly upstream of the construction site. A large proportion of whitefish tagged in Stephens Lake continue to use the area immediately downstream of the Keeyask GS, especially during the spawning period.
- The acoustic tags that were originally implanted in 2014 expired in 2017 and the tags that were implanted in 2017 will last until 2022. Movements will continue to be monitored through GS construction, impoundment, and operation.

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TABLES

Table 1: Acoustic-tag and biological information for each Lake Whitefish tagged with an acoustic transmitter in the Nelson River upstream of the Keeyask GS, fall 2017.Tag id highlighted purple = fish moved downstream through the Keeyask GS.

Acoustic Tag ID	Floy Tag #	Date Tagged	Tag Life (days)	Expiry Date	Fork Length (mm)	Weight (g)
31722	101750	07-Oct-17	1737	10-Jul-22	460	2275
31726	109695	12-Oct-17	1737	15-Jul-22	468	2575
31727	109696	12-Oct-17	1737	15-Jul-22	465	2075
31728	109688	14-Oct-17	1737	17-Jul-22	486	2550
31729	109689	14-Oct-17	1737	17-Jul-22	483	2350
31730	109690	14-Oct-17	1737	17-Jul-22	448	1850
31731	109691	14-Oct-17	1737	17-Jul-22	490	2500
31732	109697	12-Oct-17	1737	15-Jul-22	455	1750
31733	109692	14-Oct-17	1737	17-Jul-22	488	2725
31734	109693	14-Oct-17	1737	17-Jul-22	435	1925
31735	109694	12-Oct-17	1737	15-Jul-22	495	2250
31736	109698	12-Oct-17	1737	15-Jul-22	528	3425
31737	109699	12-Oct-17	1737	15-Jul-22	454	1500
31738	109700	11-Oct-17	1737	14-Jul-22	432	1425
31739	109654	11-Oct-17	1737	14-Jul-22	491	2475
31740	109652	11-Oct-17	1737	14-Jul-22	509	2950
31741	109653	11-Oct-17	1737	14-Jul-22	467	1725
31742	109655	11-Oct-17	1737	14-Jul-22	482	2525
31743	109656	11-Oct-17	1737	14-Jul-22	529	3050
31744	109657	11-Oct-17	1737	14-Jul-22	501	2350
31745	109658	11-Oct-17	1737	14-Jul-22	533	2675
31746	109659	11-Oct-17	1737	14-Jul-22	450	1500

Table 2: Acoustic-tag and biological information for each Lake Whitefish tagged with an acoustic transmitter in Stephens Lake, fall 2017. Tag id highlighted yellow = lost tags.

Acoustic Tag ID	Floy Tag #	Date tagged	Tag life (days)	Expiry date	Fork length (mm)	Weight (g)
31698	101729	09-Oct-17	1737	12-Jul-22	476	1900
31699	101728	09-Oct-17	1737	12-Jul-22	423	1375
31700	101727	09-Oct-17	1737	12-Jul-22	446	2125
31701	101726	09-Oct-17	1737	12-Jul-22	524	2450
31702	101744	09-Oct-17	1737	12-Jul-22	406	1100
31703	101730	09-Oct-17	1737	12-Jul-22	525	2400
31704	101731	09-Oct-17	1737	12-Jul-22	504	2600
31705	101732	09-Oct-17	1737	12-Jul-22	495	2375
31706	101733	09-Oct-17	1737	12-Jul-22	522	2300
31707	101734	09-Oct-17	1737	12-Jul-22	456	1750
31708	101740	09-Oct-17	1737	12-Jul-22	455	1500
31709	101738	09-Oct-17	1737	12-Jul-22	480	2050
31710	101737	09-Oct-17	1737	12-Jul-22	426	1250
31711	101736	09-Oct-17	1737	12-Jul-22	494	2075
31712	101735	09-Oct-17	1737	12-Jul-22	413	1400
31713	101739	09-Oct-17	1737	12-Jul-22	519	2450
31714	101743	09-Oct-17	1737	12-Jul-22	455	1725
31715	101745	09-Oct-17	1737	12-Jul-22	490	2500
31716	101747	08-Oct-17	1737	11-Jul-22	417	1075
31717	101749	08-Oct-17	1737	11-Jul-22	504	2100
31718	101741	09-Oct-17	1737	12-Jul-22	486	2050
31719	101742	09-Oct-17	1737	12-Jul-22	505	2000
31720	101746	09-Oct-17	1737	12-Jul-22	512	2300
31721	101748	08-Oct-17	1737	11-Jul-22	519	2900
31723	109673	10-Oct-17	1737	13-Jul-22	511	2250
31724	109664	10-Oct-17	1737	13-Jul-22	494	2150
31725	109663	10-Oct-17	1737	13-Jul-22	447	1525
31747	109660	10-Oct-17	1737	13-Jul-22	490	2525
31748	109661	10-Oct-17	1737	13-Jul-22	410	1000
31749	109662	10-Oct-17	1737	13-Jul-22	422	1250
31750	109665	10-Oct-17	1737	13-Jul-22	499	2150
31751	109666	10-Oct-17	1737	13-Jul-22	540	2550
31752	109667	10-Oct-17	1737	13-Jul-22	537	2250
31753	109668	10-Oct-17	1737	13-Jul-22	468	2175
31754	109669	10-Oct-17	1737	13-Jul-22	471	1875
31755	109670	10-Oct-17	1737	13-Jul-22	512	2350
31756	109671	10-Oct-17	1737	13-Jul-22	496	1775
31757	109672	10-Oct-17	1737	13-Jul-22	516	2125
53761	109674	10-Oct-17	1737	13-Jul-22	502	1975
53762	109675	09-Oct-17	1737	12-Jul-22	508	2275

Table 3: Proportion of time spent in each river zone by Lake Whitefish implanted with acoustic transmitters upstream of the Keeyask GS and in Stephens Lake during a portion of the 2015 (June 4 to October 11), 2016 (June 4 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), and 2019 (June 2 to October 7) open-water periods.

Tagging Year	Study Year	Upstream of Gull Rapids					Stephens Lake	
		1	2	3	4	5	6	7
2014	2015	0.2	0.5	32.0	45.4	21.9	66.4	45.2
	2016	6.6	5.6	20.8	50.3	16.6	55.3	44.7
	2017	18.8	0.5	19.1	51.3	10.2	52.4	47.62
2017	2018	0.0	0.0	21.6	55	23.4	43.2	56.8
	2019	0.0	0.02	16.8	66.9	16.3	36.4	63.6

FIGURES

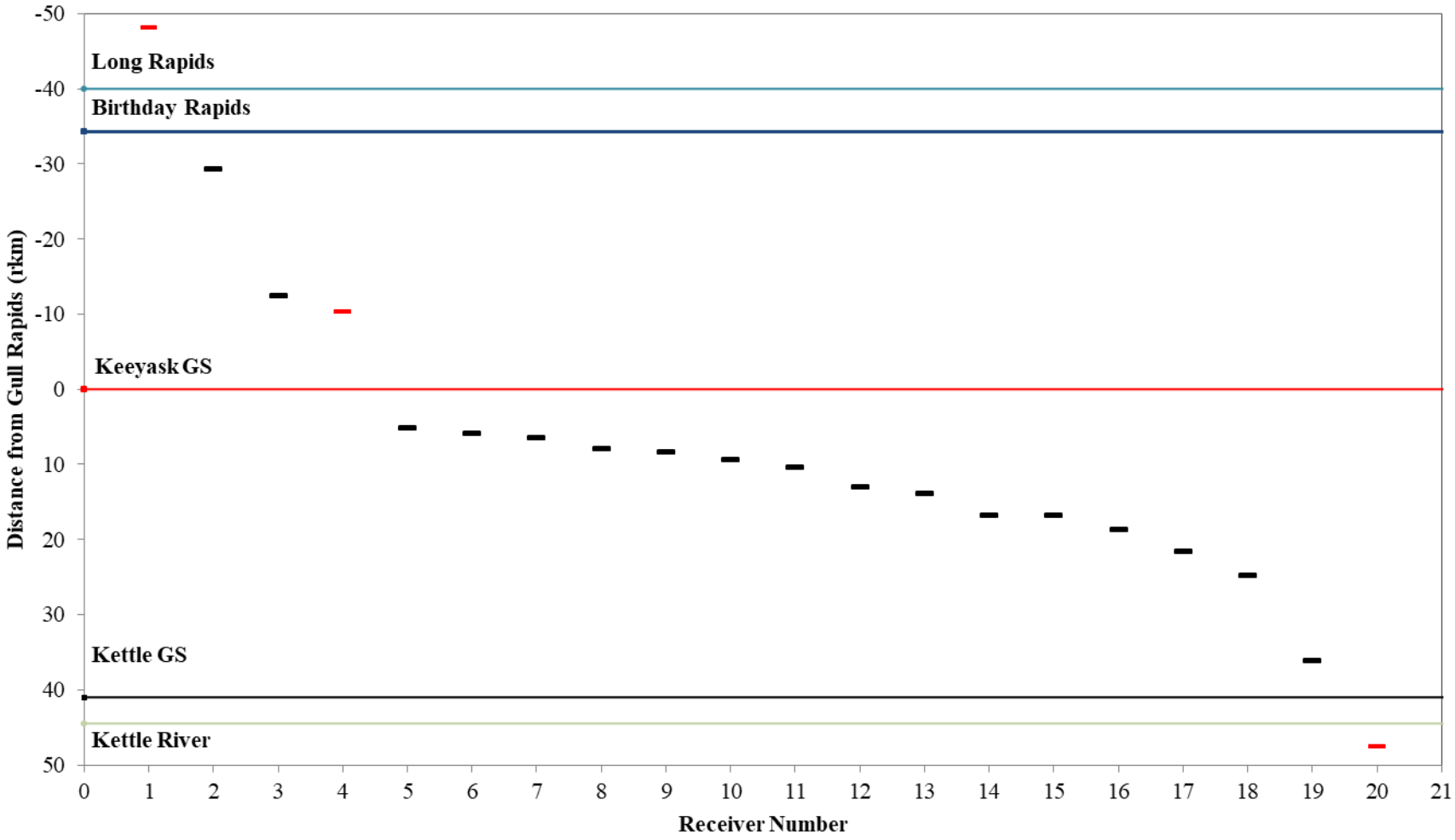


Figure 1: **Locations of stationary acoustic receivers (dashes) in relation to the base of the Keeyask GS (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between October, 2018 and June, 2019. A red dash indicates a receiver that was lost.**

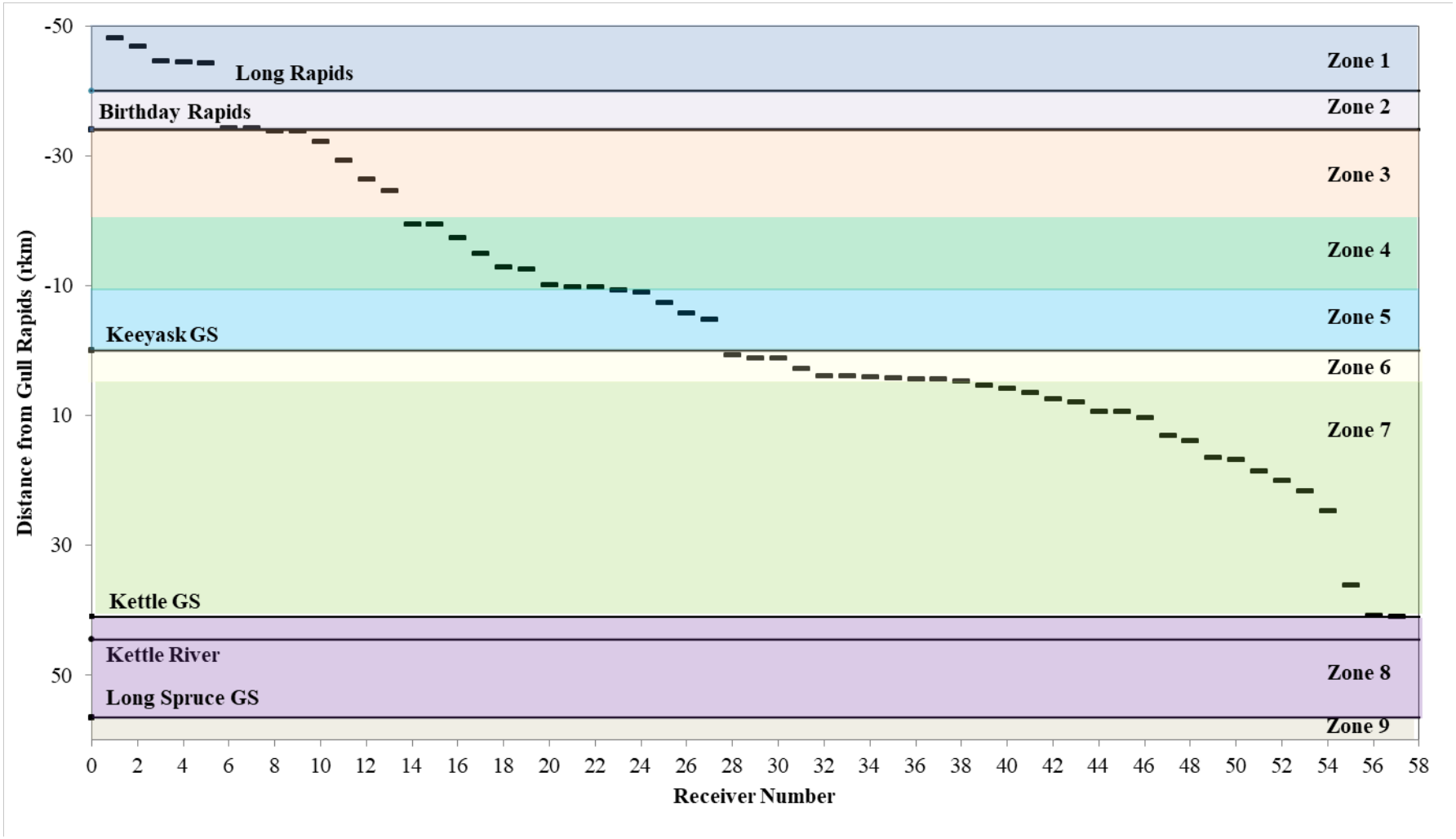


Figure 2: **Locations of stationary acoustic receivers (dashes) in relation to the base of the Keeyask GS (rkm 0) and other major landmarks (lines) in the Nelson River between Clark Lake and the Limestone GS between June and October, 2019. River zones upstream and downstream of Gull Rapids are indicated by shading. A red dash indicates a receiver was lost.**

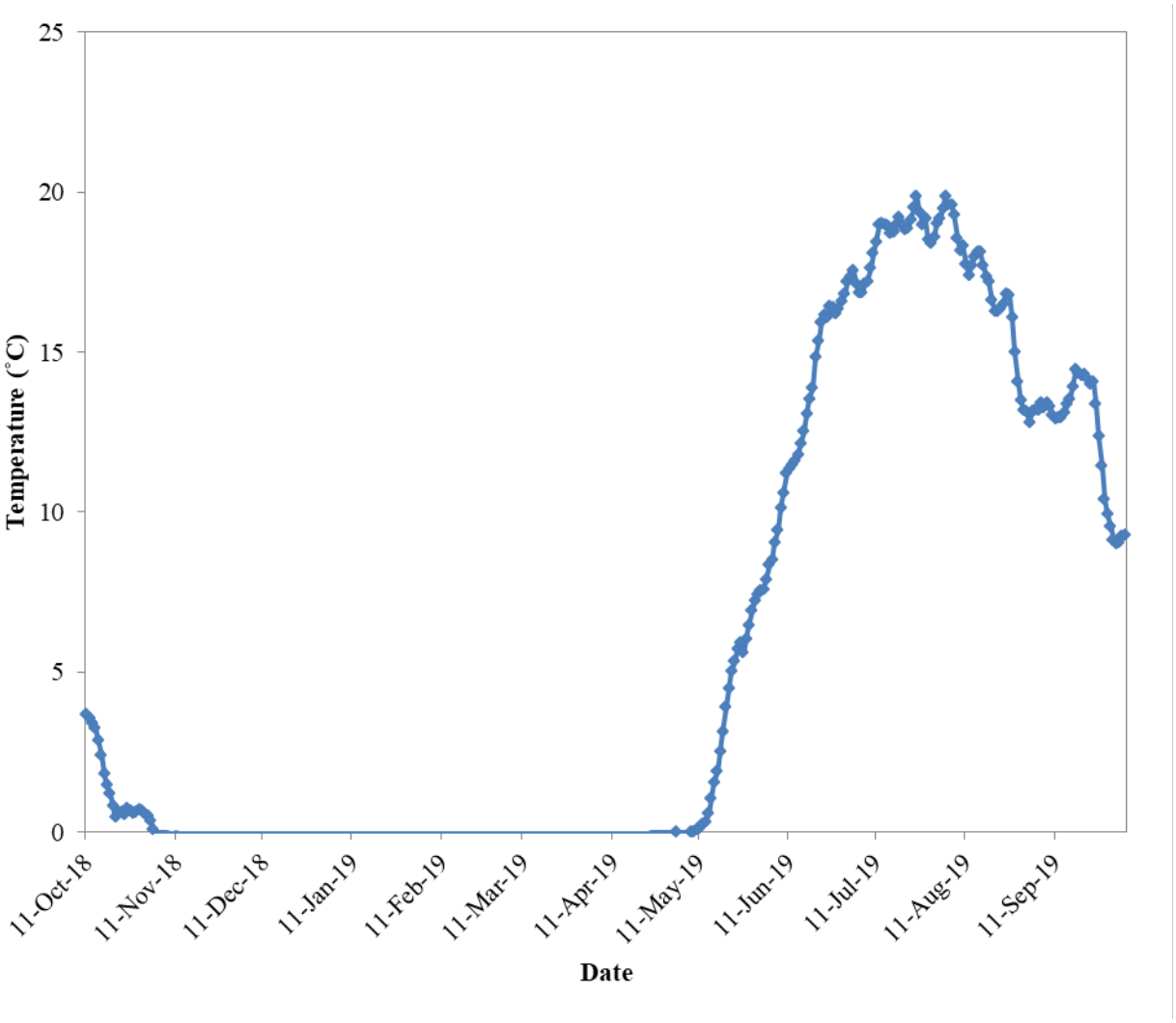


Figure 3: Water temperature in the Nelson River mainstem from October 8, 2018, to October 5, 2019.

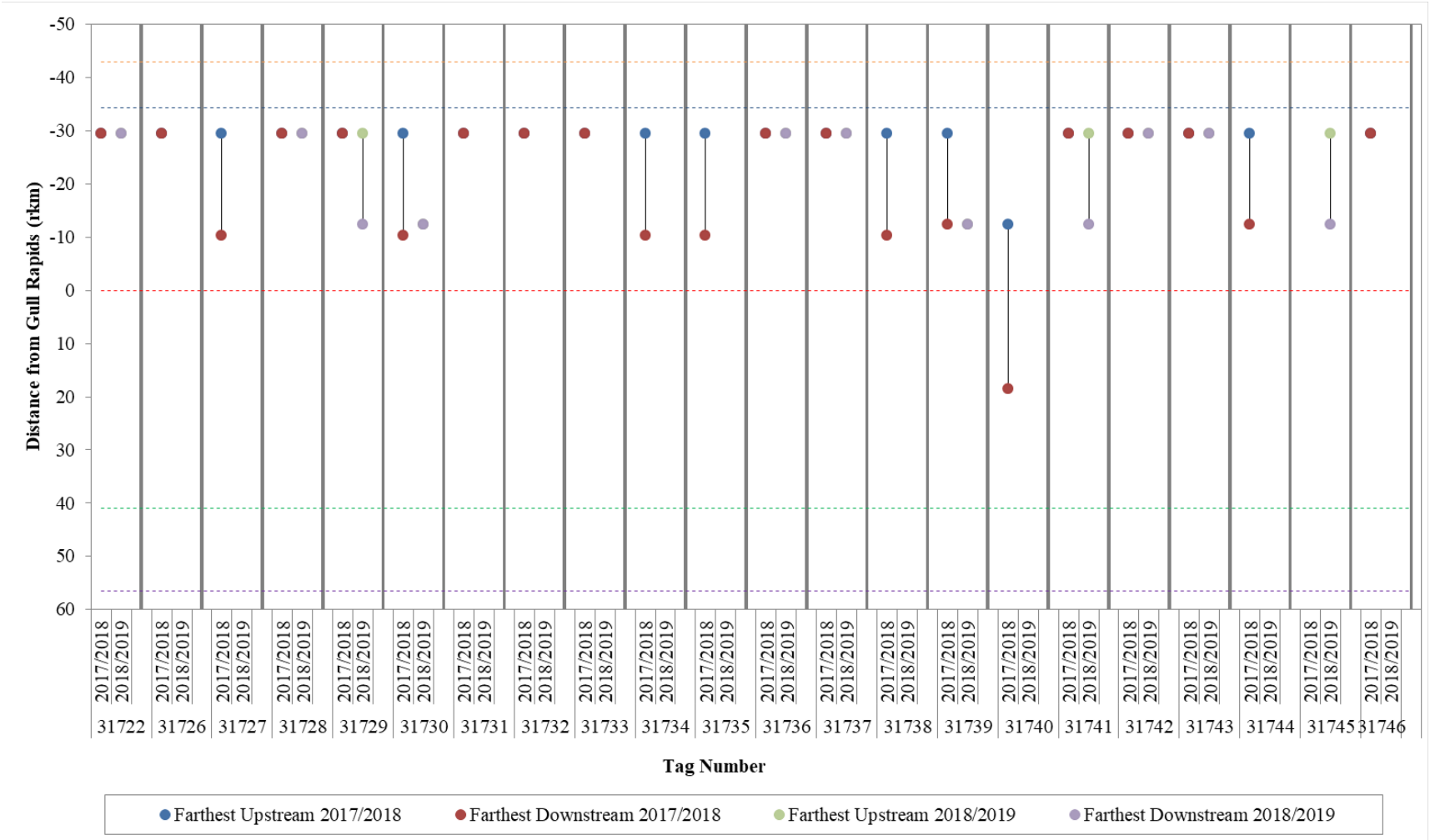


Figure 4: **Detection ranges for individual Lake Whitefish (n = 22) tagged with acoustic transmitters upstream of the Keeyask GS during the 2017/2018 (October 17, 2017 to April 30, 2018) and 2018/2019 (October 11, 2018 to April 30, 2019) winter periods. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids; red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).**

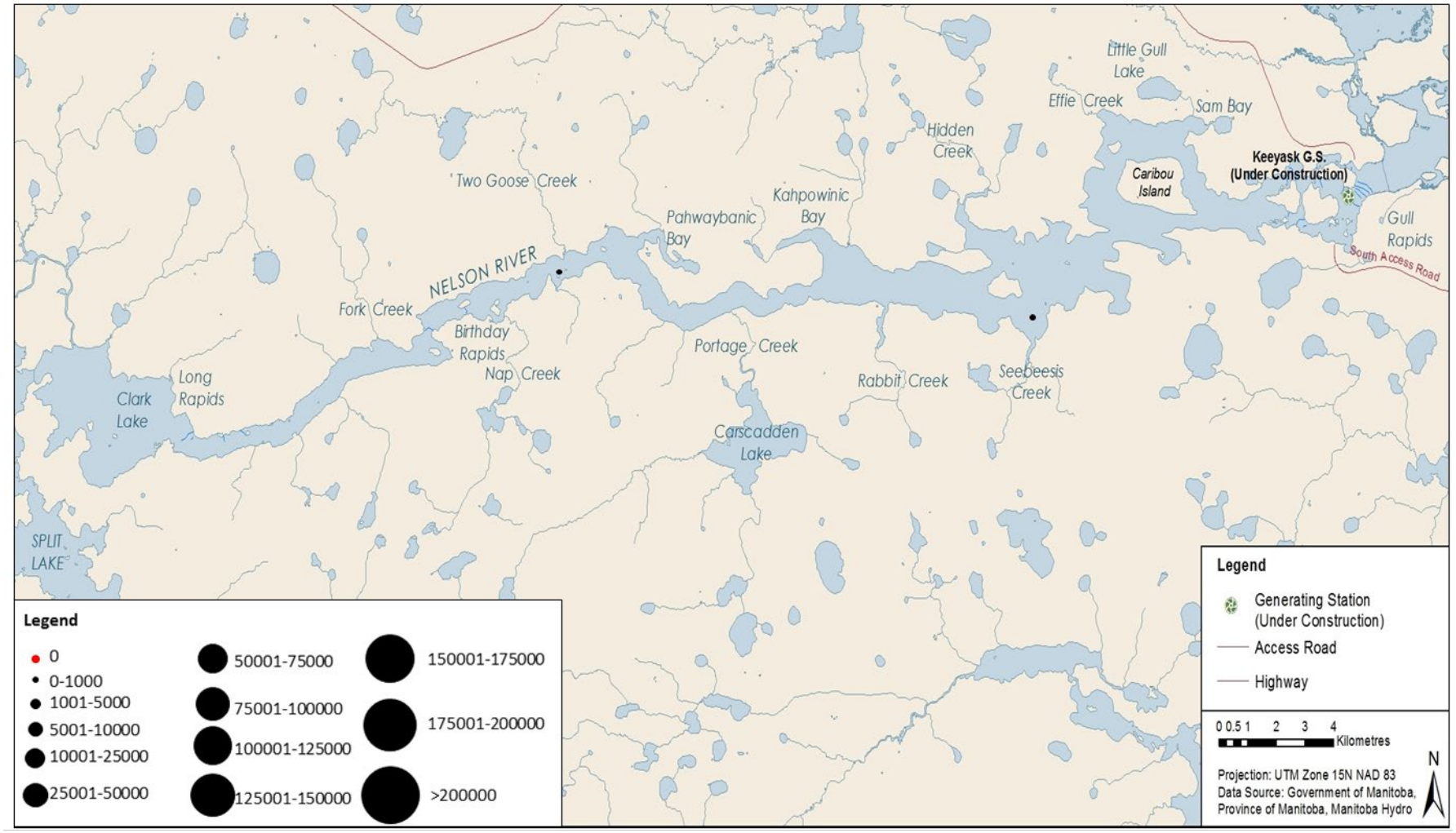


Figure 5: Relative number of detections at each acoustic receiver set between Clark Lake and the Keeyask GS during winter 2018/2019 (October 11, 2018, to April 30, 2019). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot.

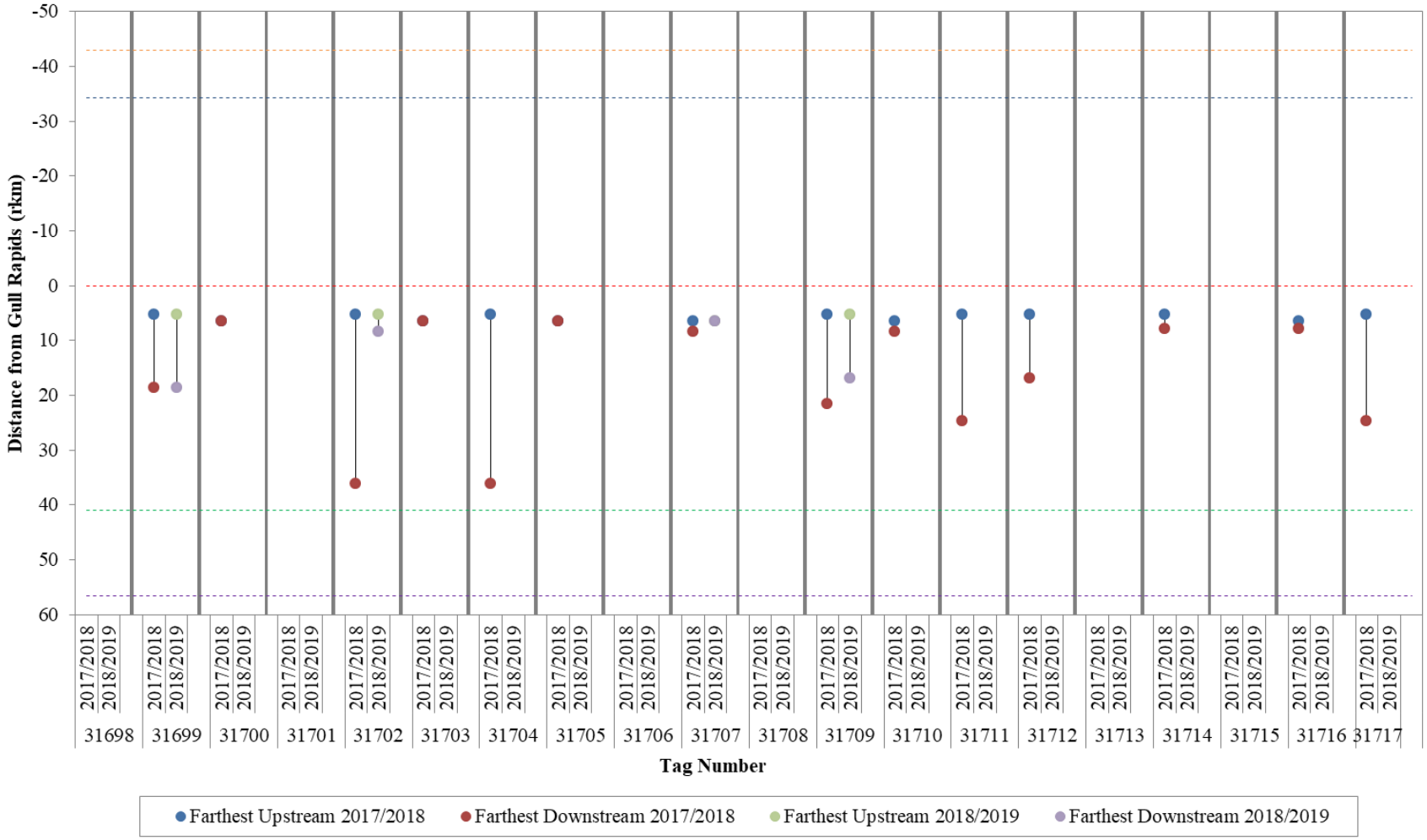


Figure 6: **Detection ranges for individual Lake Whitefish (n = 40) tagged with acoustic transmitters in Stephens Lake during the 2017/2018 (October 17, 2017 to April 30, 2018) and 2018/2019 (October 11, 2018 to April 30, 2019) winter periods. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids; red = Gull Rapids; green = Kettle GS; purple = Long Spruce GS).**

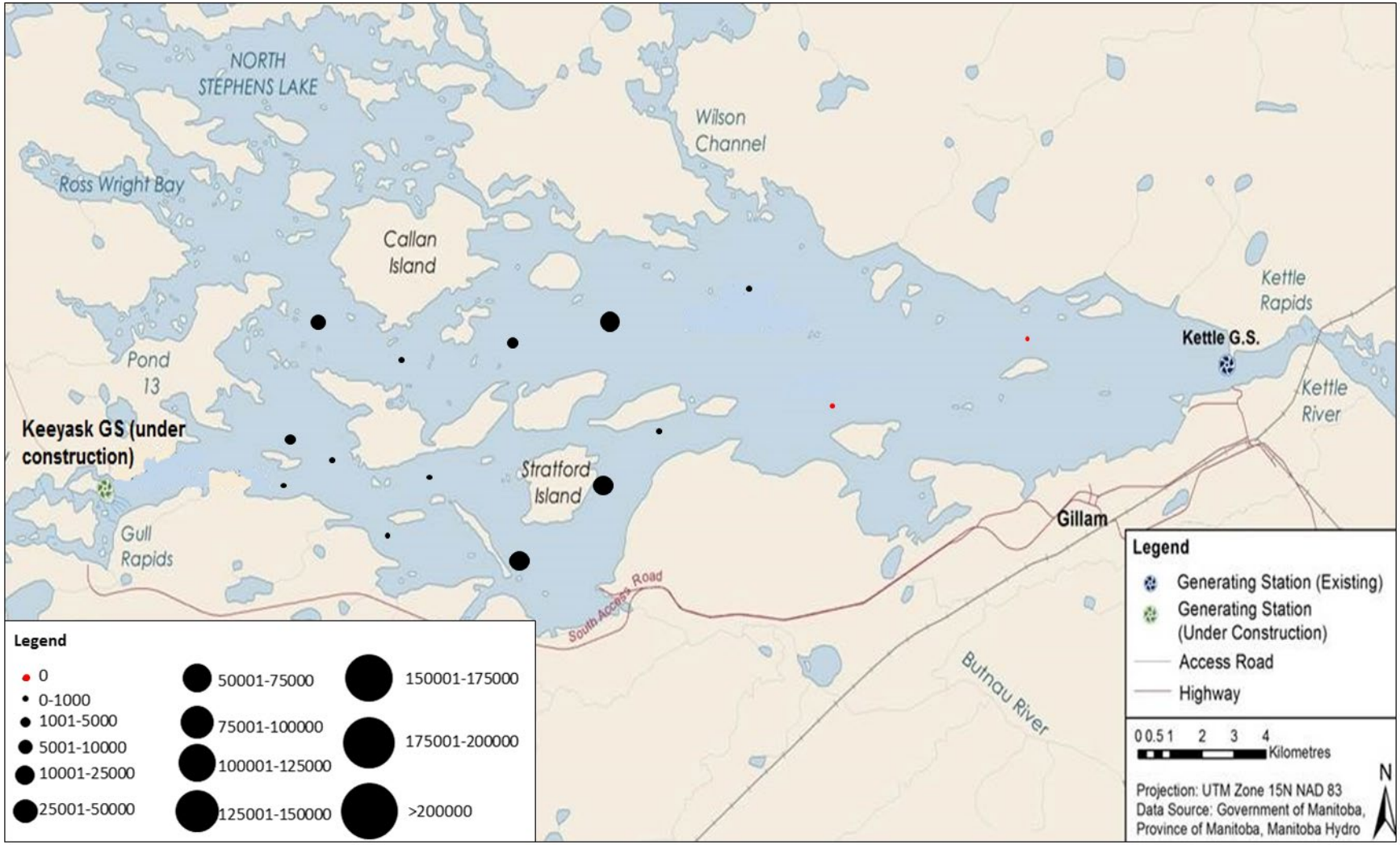


Figure 7: Relative number of detections at each acoustic receiver set in Stephens Lake during winter 2018/2019 (October 11, 2018 to April 30, 2019). Number of detections indicated by size of bubble (defined in legend). Receivers with

no detections indicated with red dot.

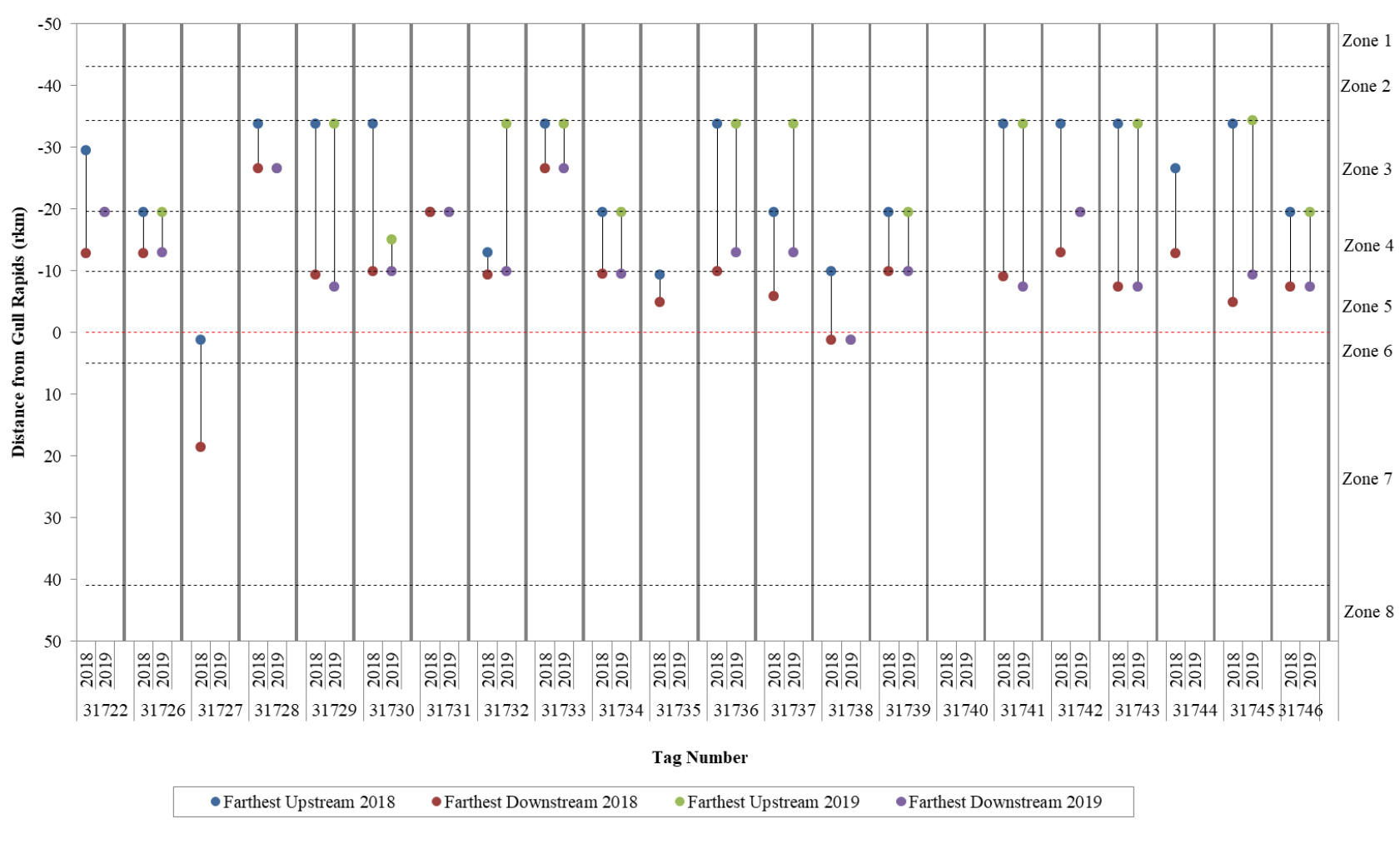


Figure 8: Detection ranges for individual Lake Whitefish (n = 22) tagged with acoustic transmitters upstream of the Keeyask GS during the 2018 (May 1 to October 10) and 2019 (May 1 to October 7) open-water periods. Horizontal dotted lines demarcate zones with the red line representing the Keeyask GS.

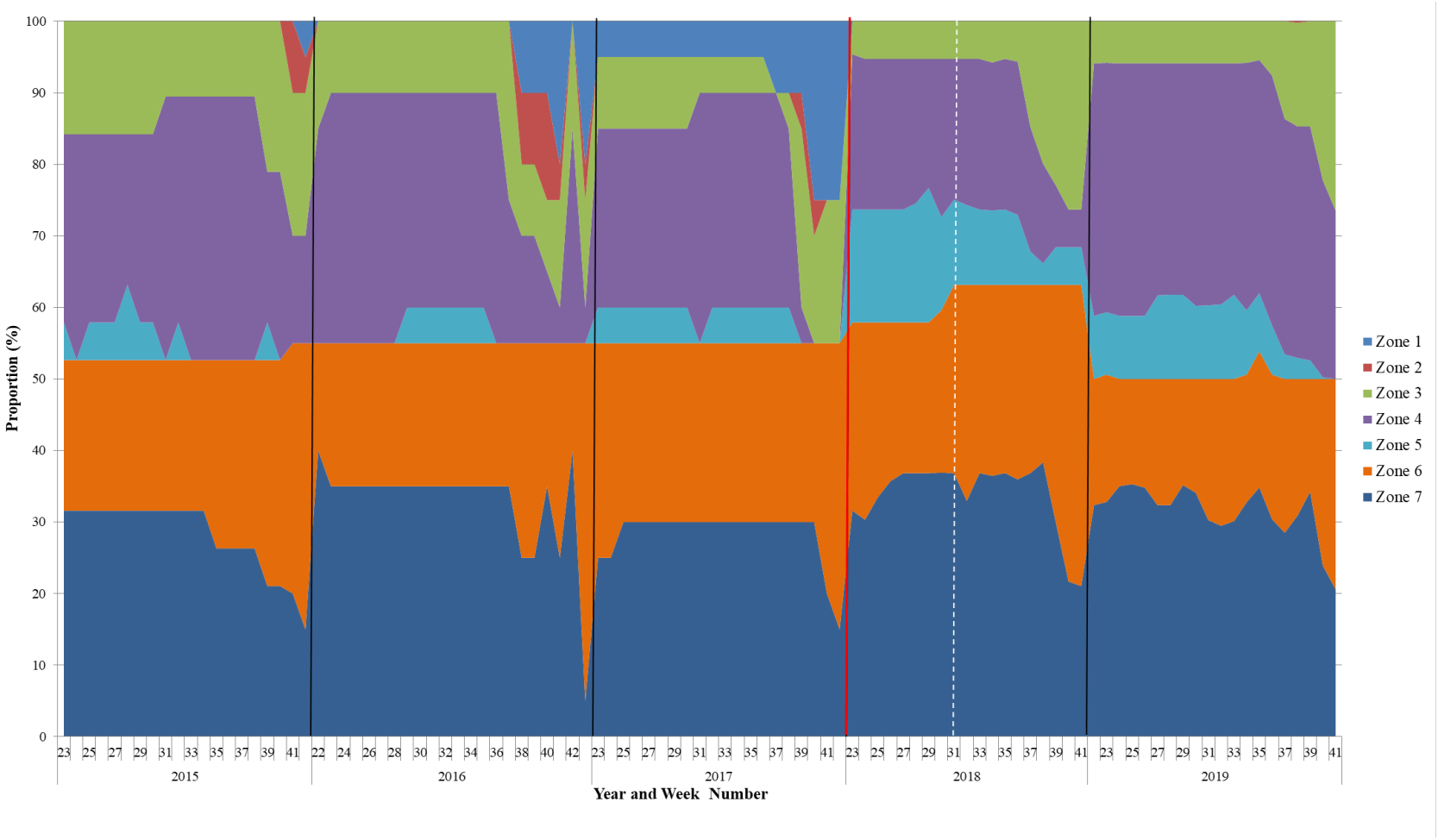


Figure 9: **Proportional distribution of Lake Whitefish with acoustic transmitters tagged in 2014 and 2017 within seven river zones between Clark Lake and the Kettle GS during a portion of the 2015 (June 4 to October 11), 2016 (June 25 to October 19), 2017 (June 7 to October 16), 2018 (June 6 to October 10), and 2019 (June 2 to October 7) open-water periods. Black lines demarcate years, red line indicates when tags expired and new fish were tagged, and white dashed line indicates start of spillway operation.**

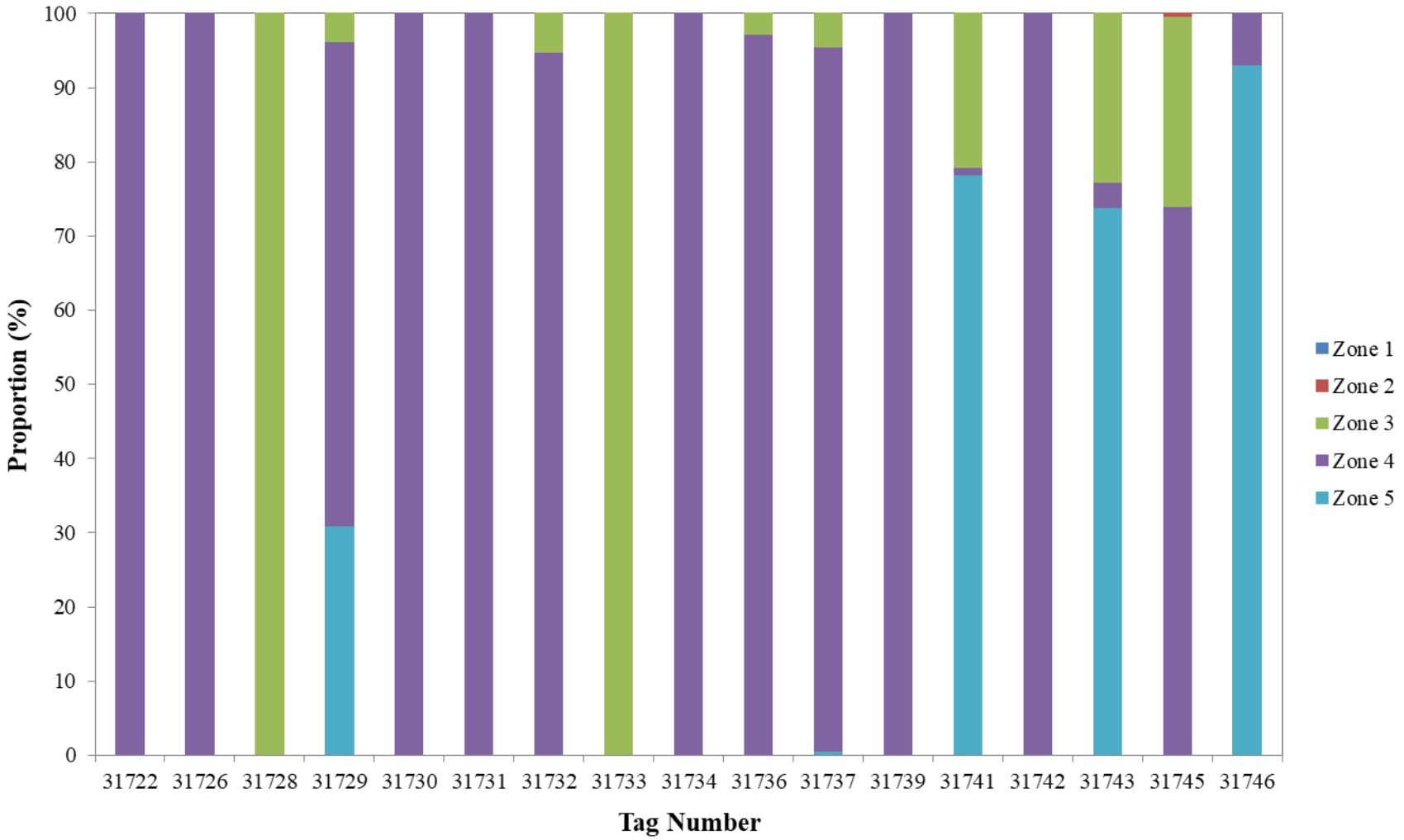


Figure 10: Proportion of time spent within five river zones between Clark Lake and the Keeyask GS by individual acoustic-tagged Lake Whitefish during a portion of the 2019 open-water period (June 2 to October 7).

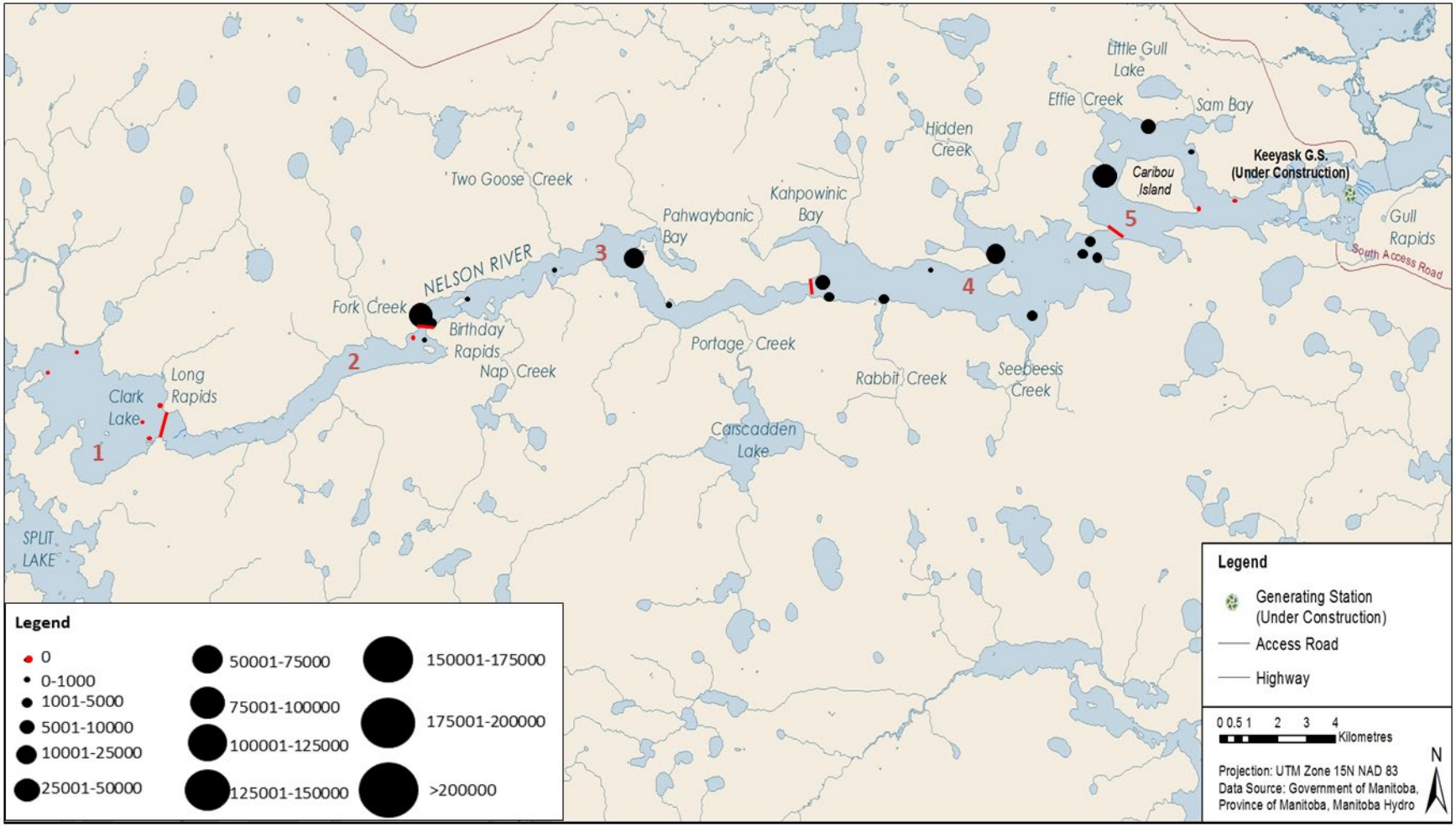


Figure 11: Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and the Keeyask GS during the 2019 open-water period (May 1 to October 7). Number of detections indicated by size of bubble (defined in legend). Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."

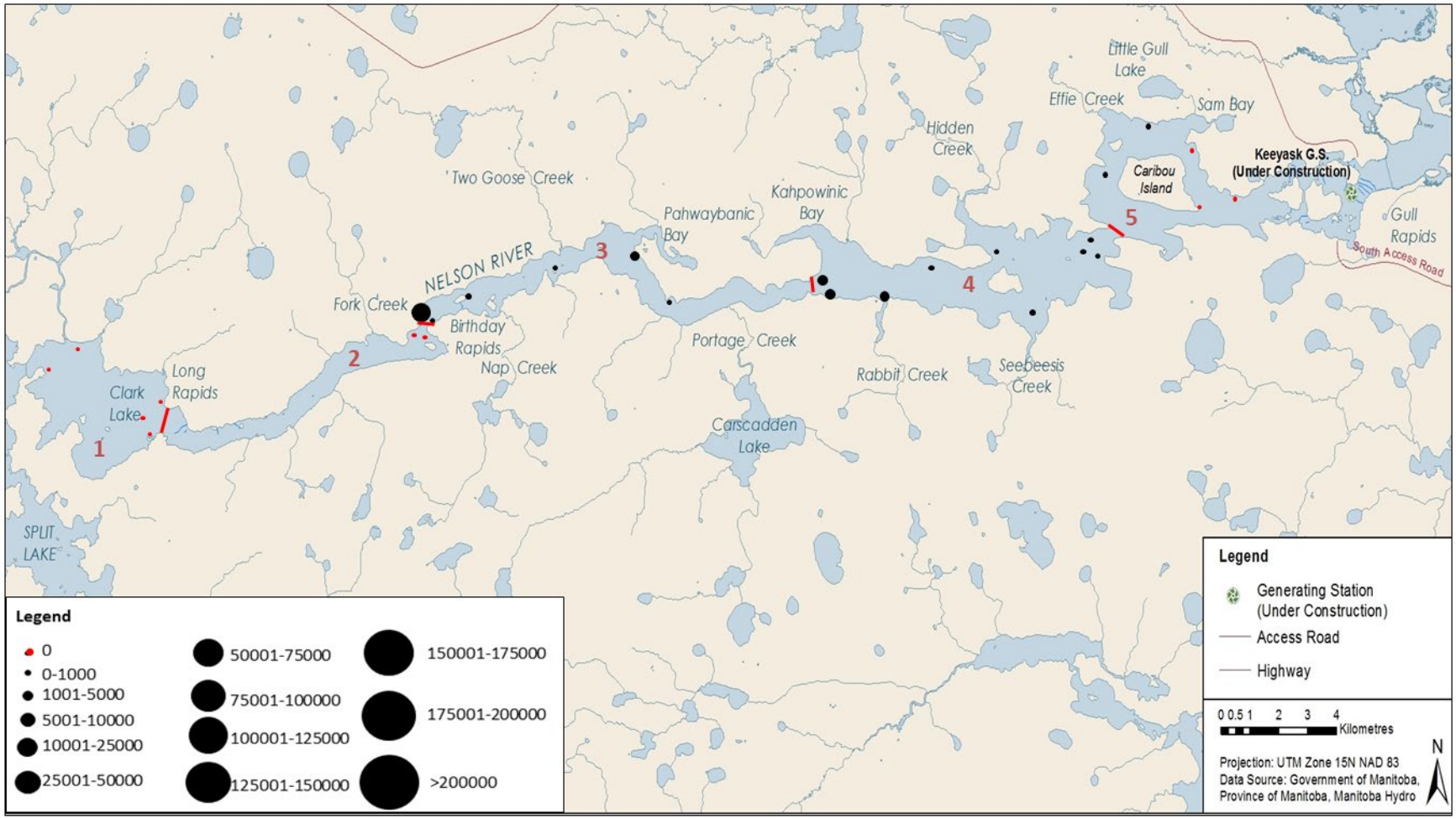


Figure 12: Relative number of detections at each acoustic receiver set in the Nelson River between Clark Lake and the Keeyask GS during the 2019 spawning period (September 26 to October 7). Spawning period was defined as the period when water temperature fell below 12°C (in order to capture movement of Lake Whitefish to spawning sites) to the end of the study period. Relative number of detections indicated by size of bubble. Receivers with no detections indicated with red dot. The river is divided into five "zones" based on placement of receiver "gates."

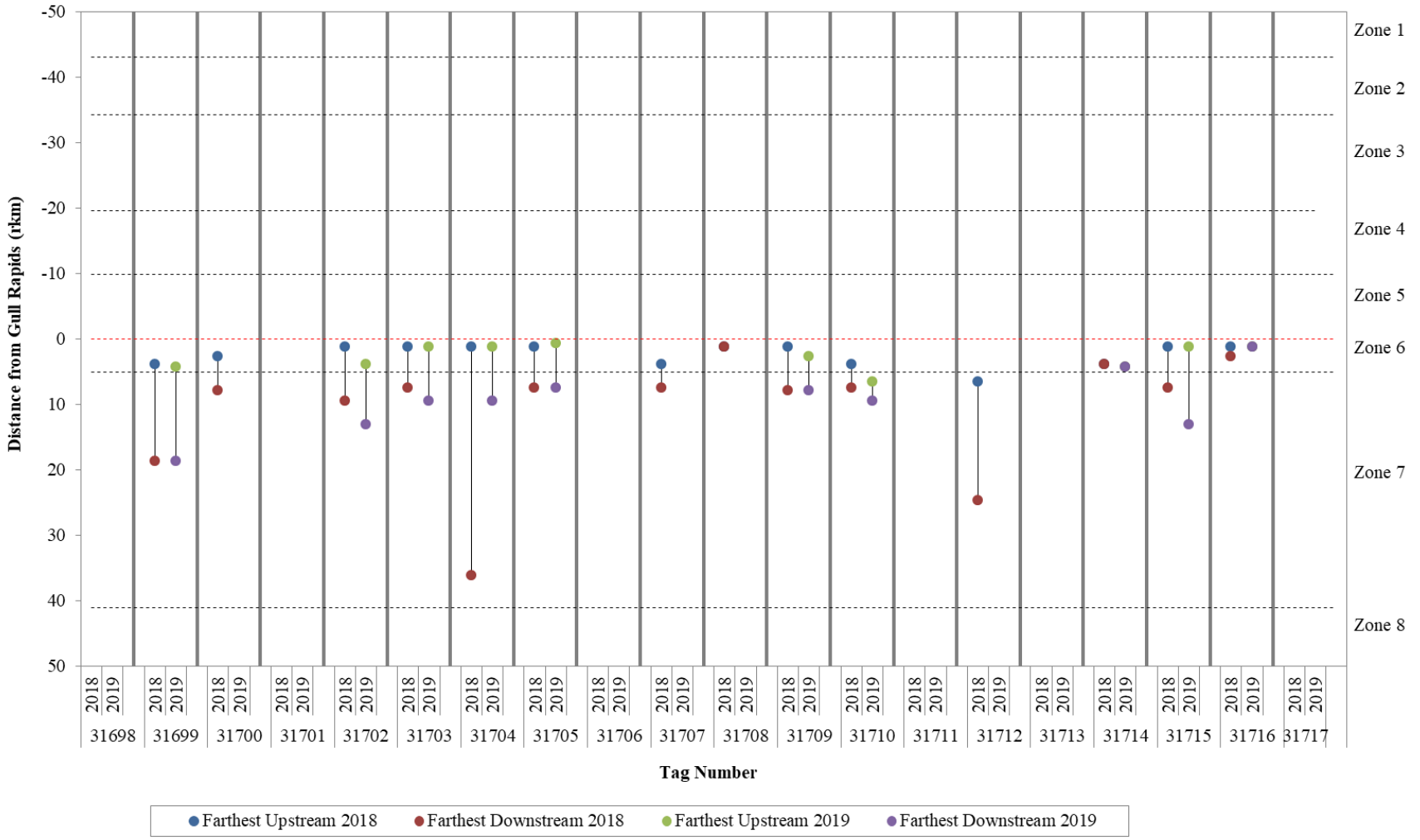


Figure 13: Detection ranges for individual Lake Whitefish (n = 40) tagged with acoustic transmitters in Stephens Lake during the 2018 (May 1 to October 10) and 2019 (May 1 to October 7) open-water periods. Horizontal dotted lines demarcate zones with the red line representing the Keeyask GS.

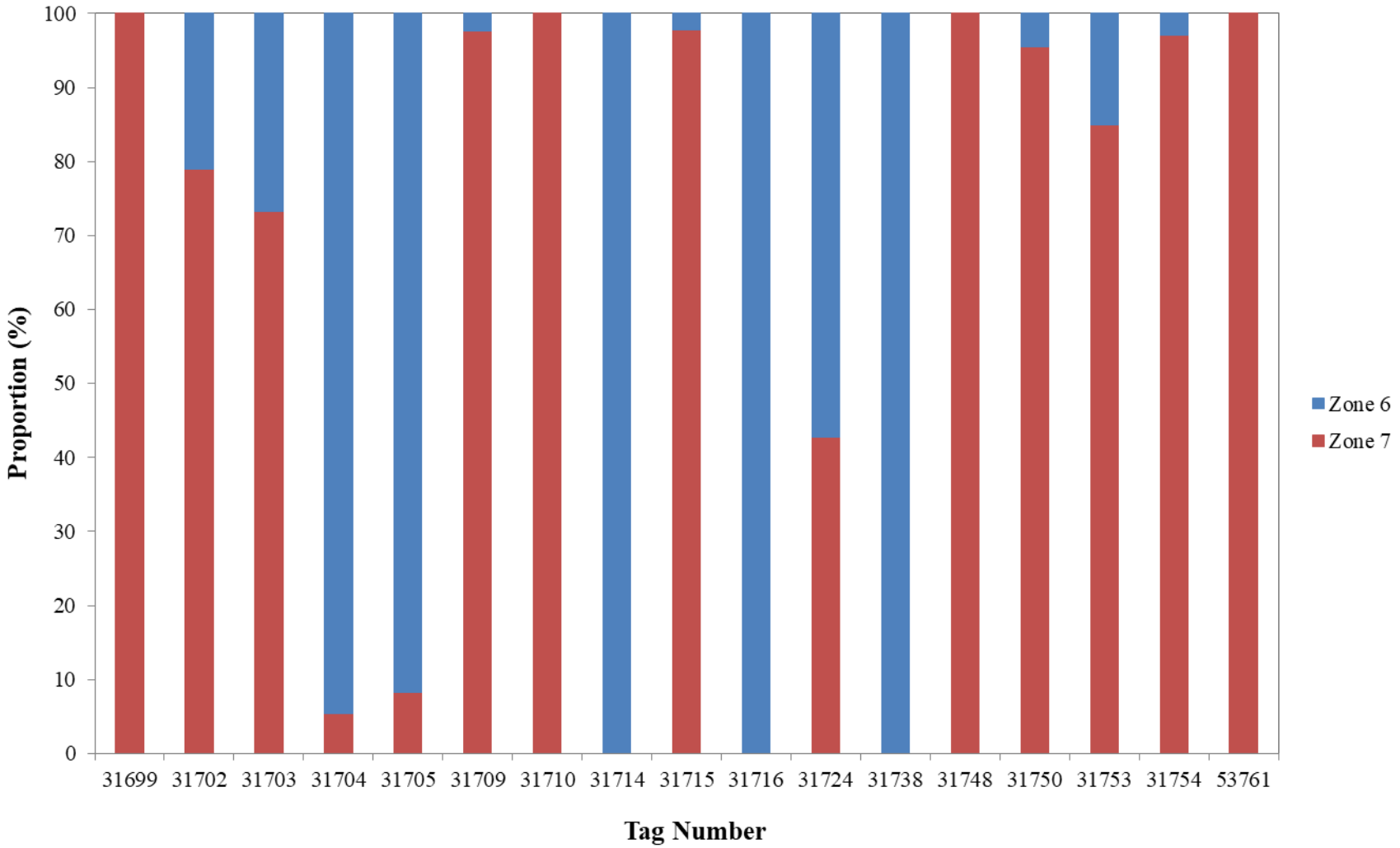


Figure 14: Proportion of time spent in Stephens Lake between the Keeyask GS and the Kettle GS by individual acoustic-tagged Lake Whitefish during a portion of the 2019 open-water period (June 2 to October 7).

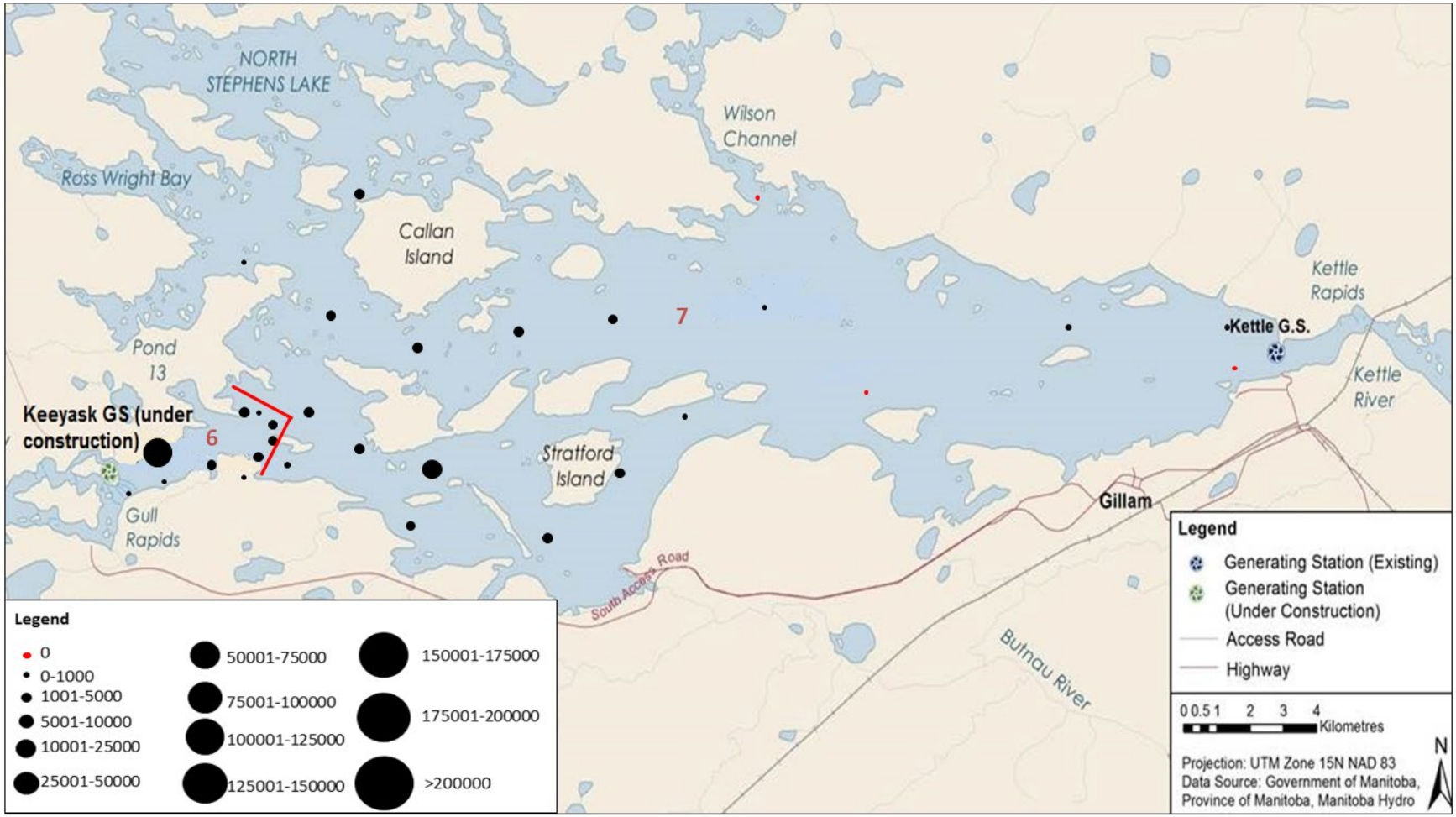


Figure 15: Relative number of detections at each acoustic receiver set in Stephens Lake during the 2019 open-water period (May 1 to October 7). Relative number of detections indicated by size of bubble. Receivers with no detections indicated with red dot. The river is divided into two "zones" based on placement of receiver "gates."

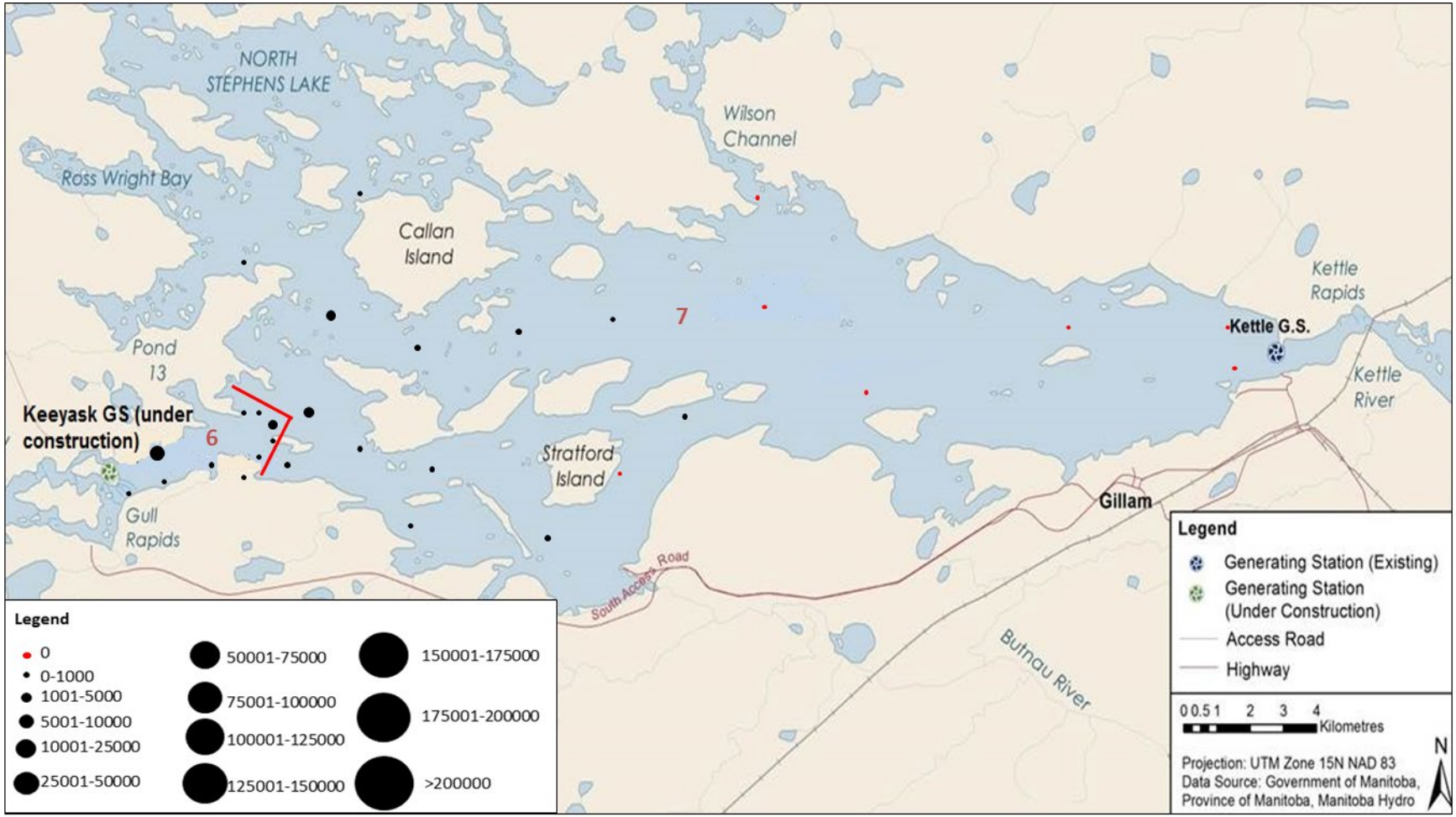
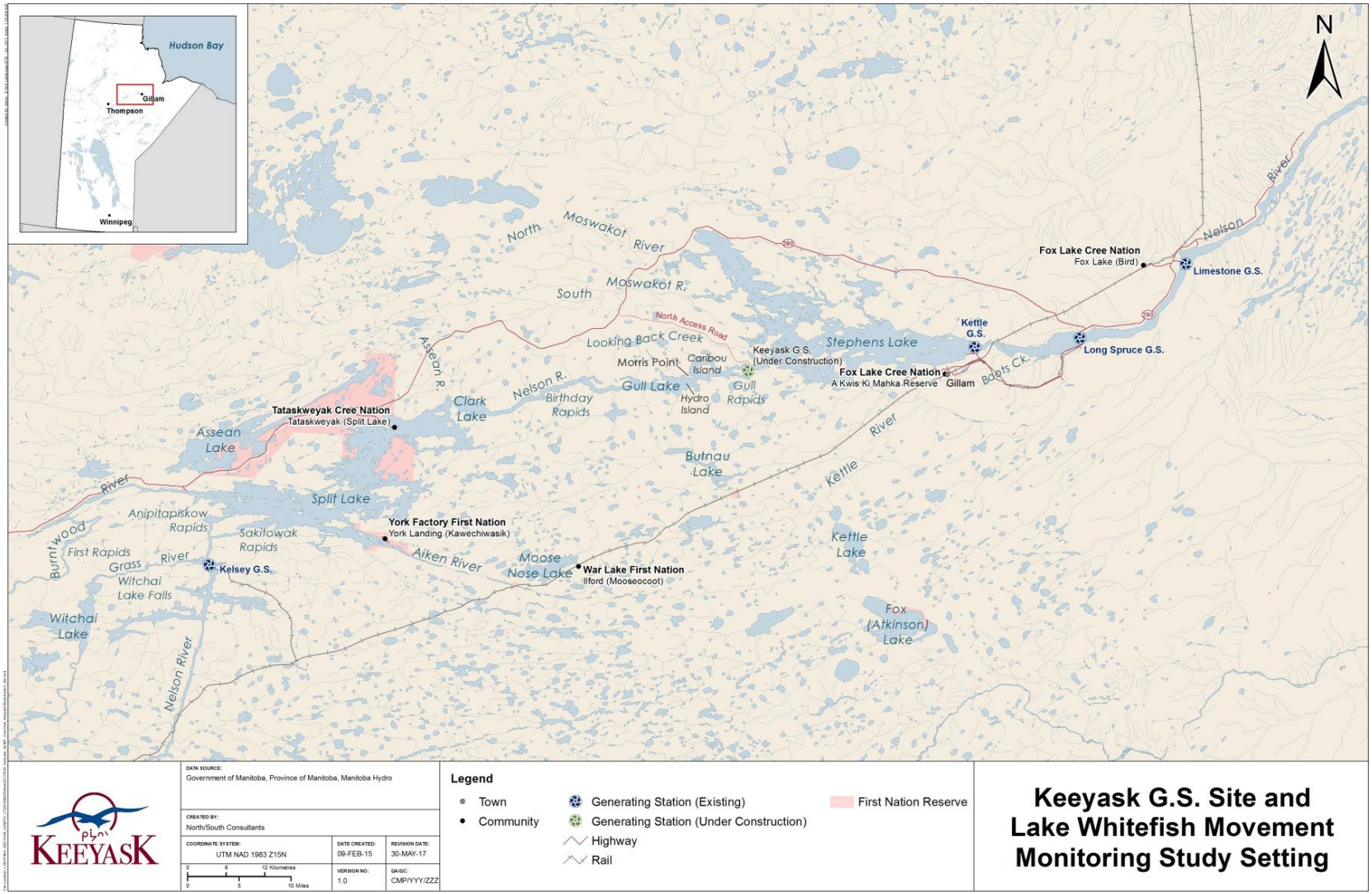
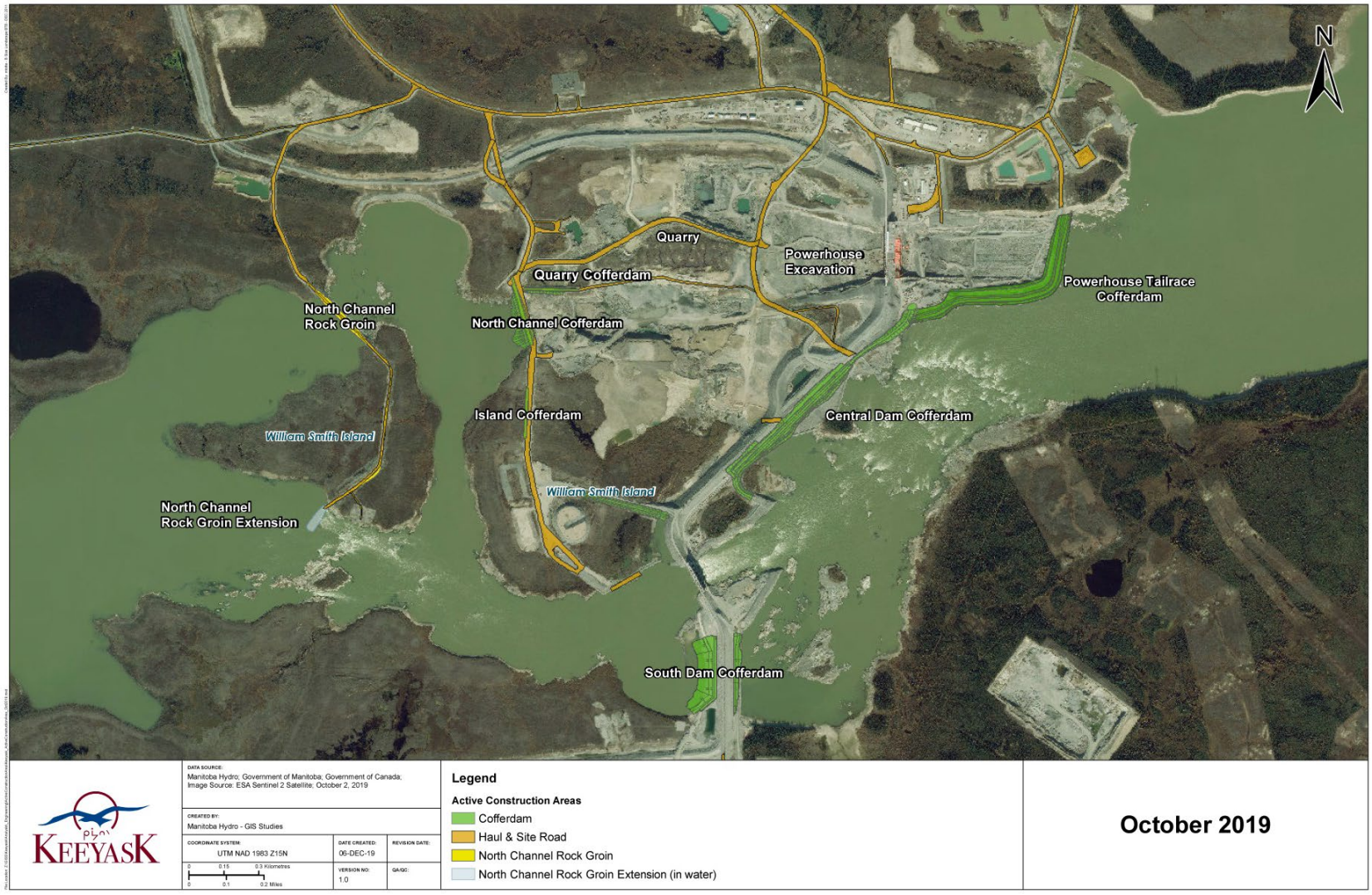


Figure 16: Relative number of detections at each acoustic receiver set in Stephens Lake during the 2019 spawning period (September 26 to October 7). Spawning period was defined as the period when water temperature fell below 12°C (in order to capture movement of Lake Whitefish to spawning sites) to the end of the study period. Relative number of detections indicated by size of bubble. Receivers with no detections indicated with red dot. The river is divided into two "zones" based on placement of receiver "gates."

MAPS

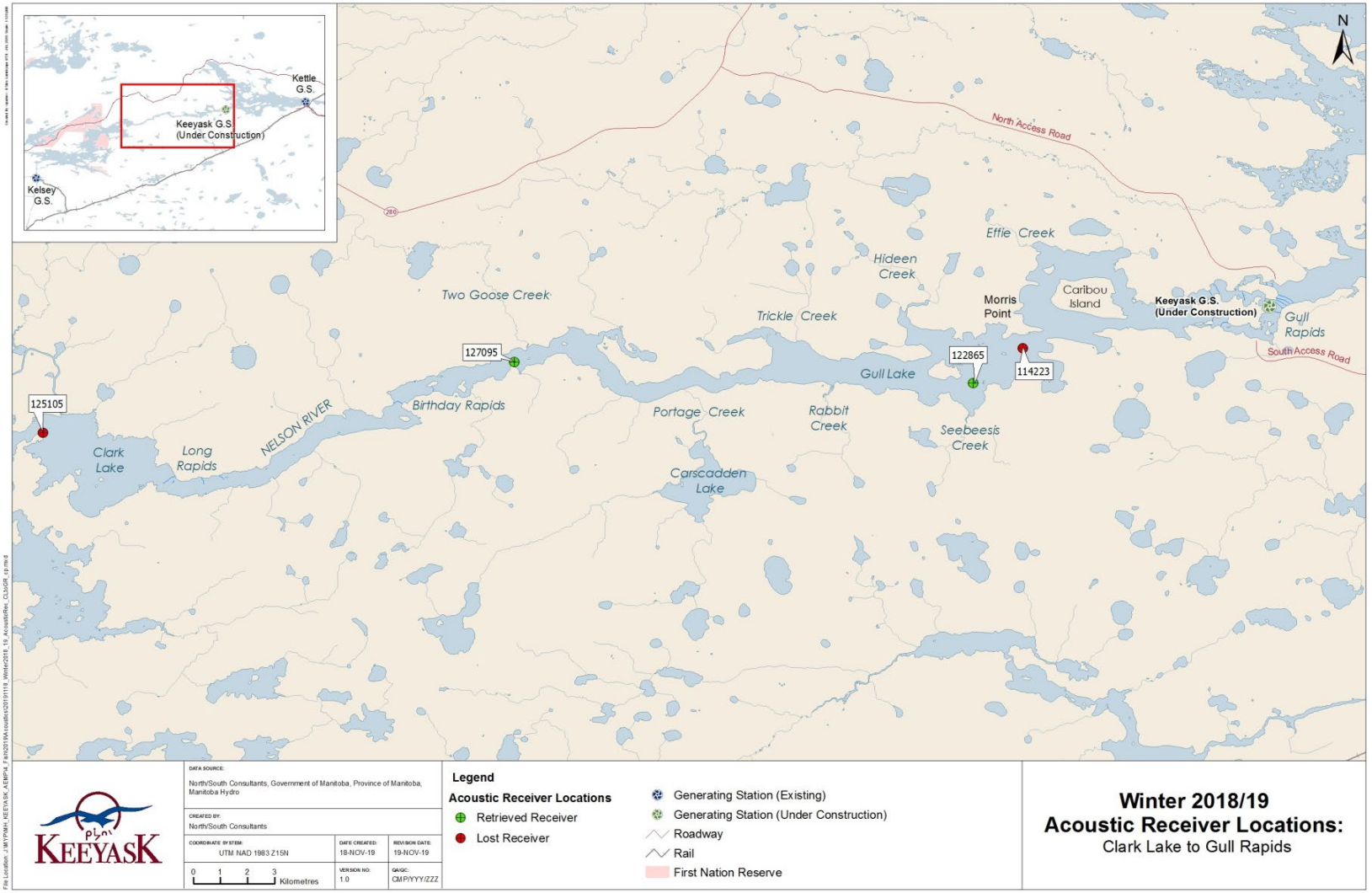


Map 1: Map of the Nelson River showing the site of the Keeyask Generating Station and the Lake Whitefish movement monitoring study setting.

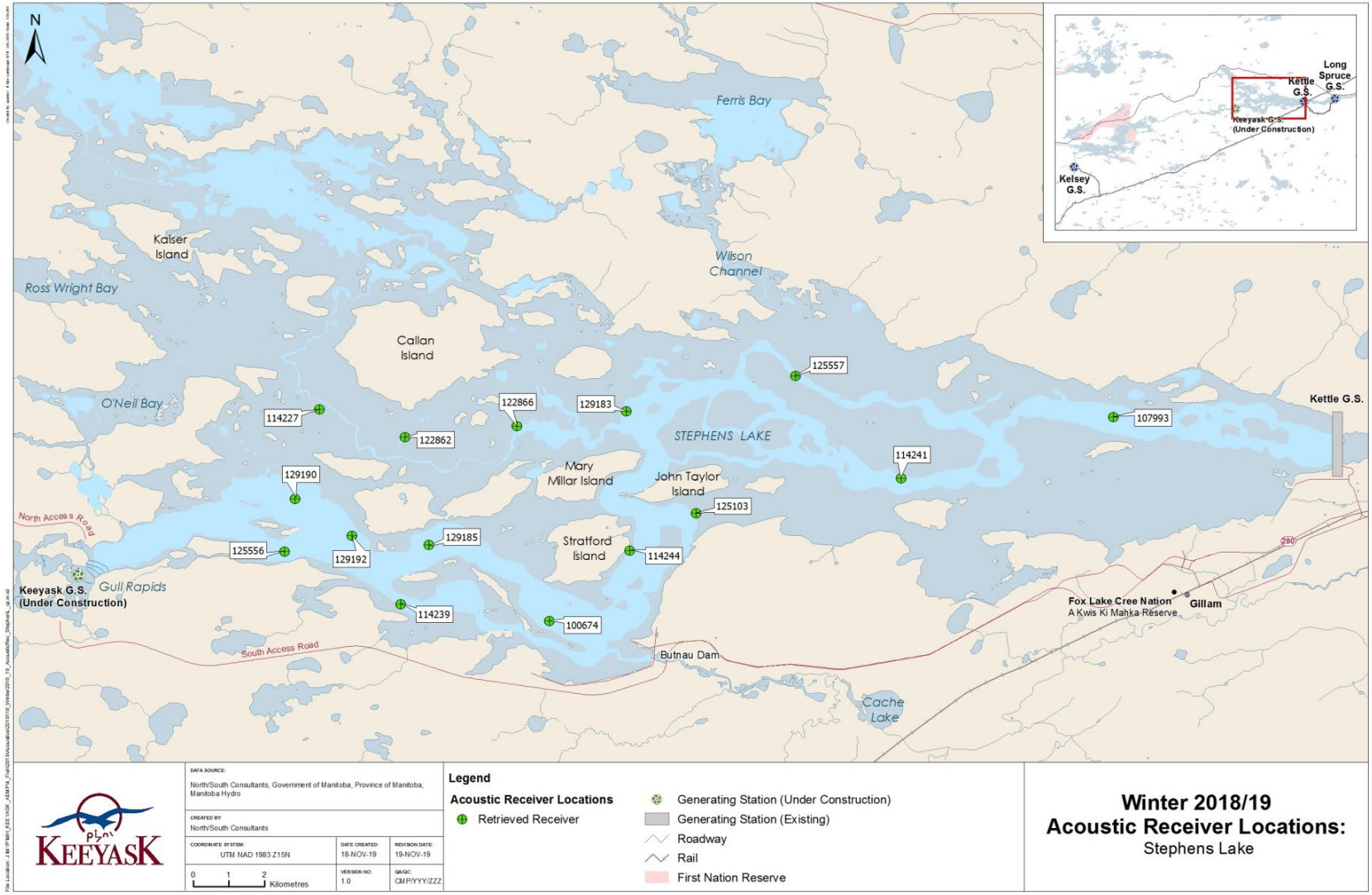


Satellite Imagery - October, 2019

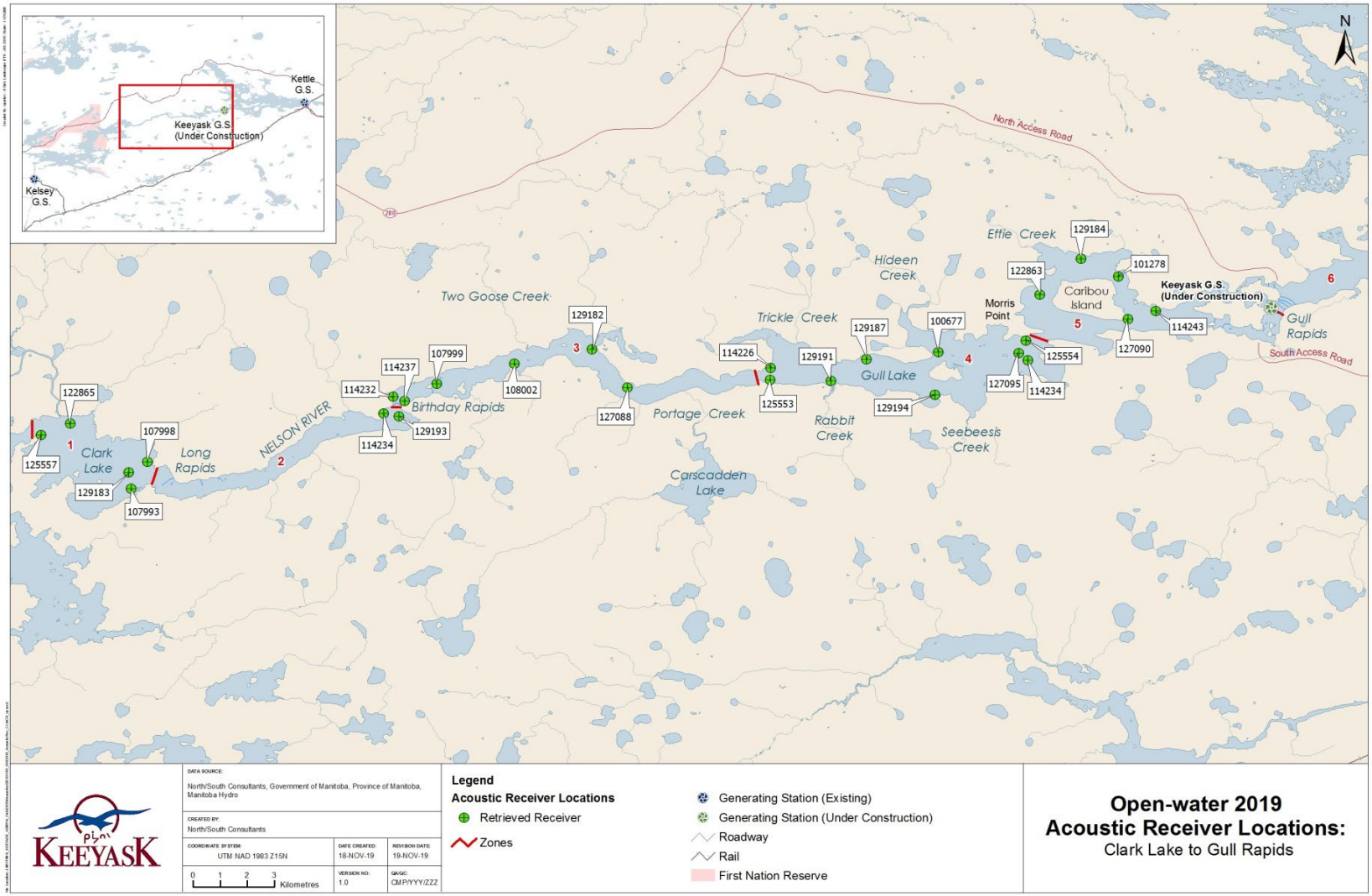
Map 2: Map of instream structures at the Keeyask Generating Station site, October 2019.



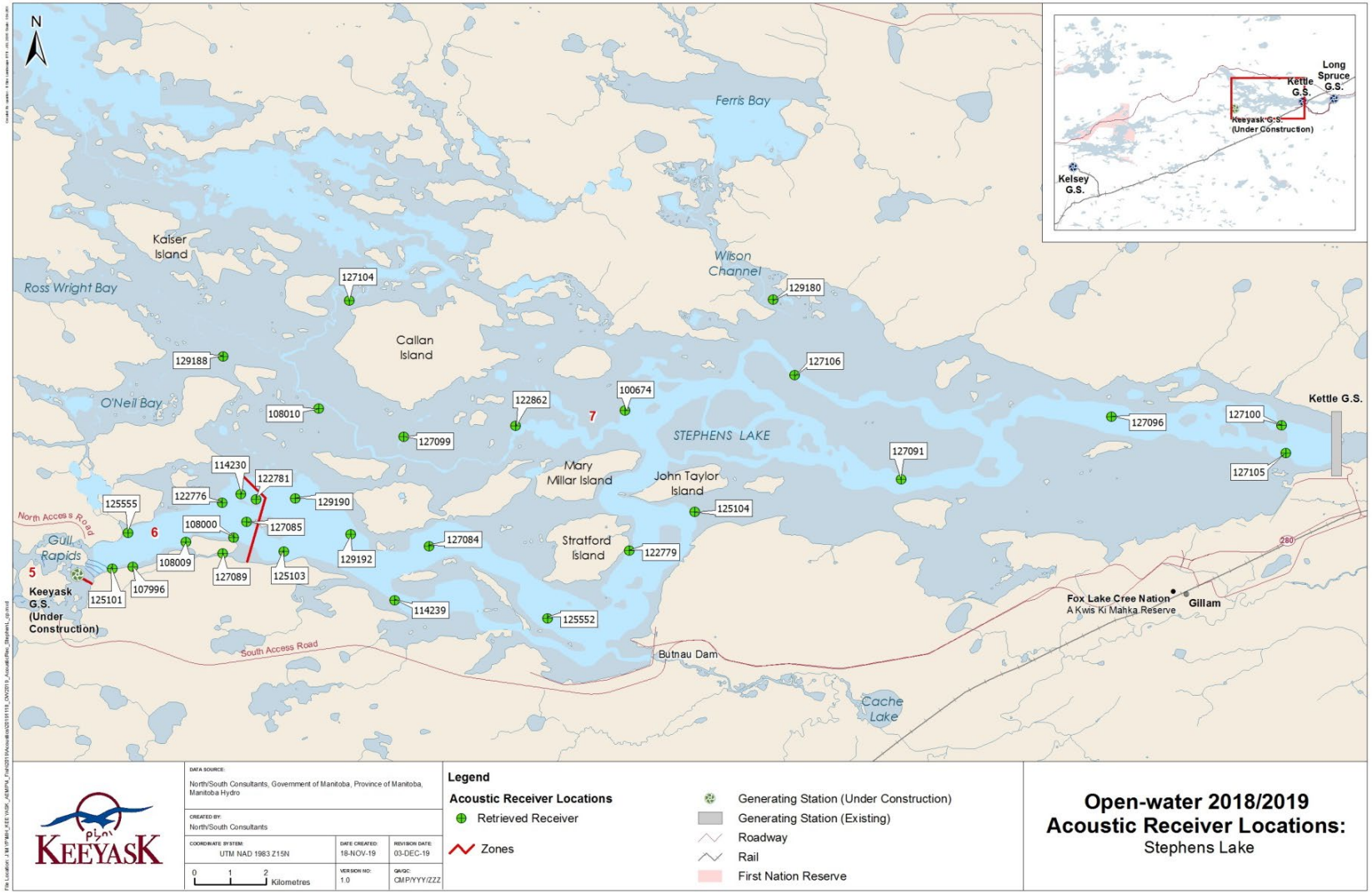
Map 3: Location of stationary receivers set in the Nelson River from Clark Lake to the Keeyask GS between October 2018 and June 2019.



Map 4: Location of stationary receivers set in Stephens Lake from The Keeyask GS to Kettle GS between October 2018 and June 2019. The former (pre-impoundment) river channel is shown in light blue.



Map 5: **Locations of stationary receivers set in the Nelson River from Clark Lake to the Keeyask GS between June and October 2019. The river is divided into five "zones" based on placement of receiver "gates."**



Map 6: **Locations of stationary receivers set in Stephens Lake between June and October 2019. The river is divided into two "zones" based on placement of receiver "gates." The pre-impoundment river channel is shown in light blue.**

APPENDICES

APPENDIX 1:
DETECTION SUMMARIES FOR LAKE WHITEFISH TAGGED AND MONITORED IN THE KEEYASK STUDY AREA BETWEEN 2017 AND 2019.

Table A1-1: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged upstream of the Keeyask GS during the 2017/2018 (October 17, 2017 to April 30, 2018) and 2018/2019 (October 11, 2018 to April 30, 2019) winter periods. Tag id highlighted purple = fish moved downstream through the Keeyask GS.

Tag ID	Date tagged	2017/2018					2018/2019				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31722	07-Oct-17	3	1	-29.4	-29.4	0.0	8	1	-29.4	-29.4	0.0
31726	12-Oct-17	13	2	-29.4	-29.4	0.0	-	-	-	-	-
31727	12-Oct-17	132	5	-29.4	-10.3	19.1	92461	202	16.8	16.8	0.0
31728	14-Oct-17	8	1	-29.4	-29.4	0.0	15	1	-29.4	-29.4	0.0
31729	14-Oct-17	5	1	-29.4	-29.4	0.0	26	2	-29.4	-12.4	17.0
31730	14-Oct-17	106	3	-29.4	-10.3	19.1	6	1	-12.4	-12.4	0.0
31731	14-Oct-17	153	5	-29.4	-29.4	0.0	-	-	-	-	-
31732	12-Oct-17	14	1	-29.4	-29.4	0.0	-	-	-	-	-
31733	14-Oct-17	9	1	-29.4	-29.4	0.0	-	-	-	-	-
31734	14-Oct-17	5914	16	-29.4	-10.3	19.1	-	-	-	-	-
31735	12-Oct-17	50	2	-29.4	-10.3	19.1	-	-	-	-	-
31736	12-Oct-17	26	1	-29.4	-29.4	0.0	6	1	-29.4	-29.4	0.0
31737	12-Oct-17	138	4	-29.4	-10.3	19.1	39	3	-29.4	-12.4	17.0
31738	11-Oct-17	227	7	-29.4	-10.3	19.1	-	-	-	-	-
31739	11-Oct-17	145	3	-29.4	-12.4	17.0	76	4	-12.4	-12.4	0.0
31740	11-Oct-17	948	11	-29.4	18.6	48.0	-	-	-	-	-
31741	11-Oct-17	9	1	-29.4	-29.4	0.0	22	2	-29.4	-12.4	17.0
31742	11-Oct-17	3	1	-29.4	-29.4	0.0	9	1	-29.4	-29.4	0.0
31743	11-Oct-17	4	1	-29.4	-29.4	0.0	10	1	-29.4	-29.4	0.0
31744	11-Oct-17	280	14	-29.4	-12.4	17.0	-	-	-	-	-
31745	11-Oct-17	-	-	-	-	-	170	5	-29.4	-12.4	17.0
31746	11-Oct-17	434	5	-29.4	-29.4	0.0	-	-	-	-	-

Table A1-2: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake during the 2017/2018 (October 17, 2017 to April 30, 2018) and 2018/2019 (October 11, 2018 to April 30, 2019) winter periods. Tag id highlighted yellow = lost tags.

Tag ID	Date tagged	2017/2018					2018/2019				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31698	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31699	09-Oct-17	16567	160	5.2	18.6	13.4	36290	147	5.2	18.6	13.4
31700	09-Oct-17	69	3	6.5	6.5	0.0	-	-	-	-	-
31701	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31702	09-Oct-17	8556	66	5.2	36.1	30.9	122	5	5.2	8.4	3.2
31703	09-Oct-17	7	2	6.5	6.5	0.0	-	-	-	-	-
31704	09-Oct-17	1111	22	5.2	36.1	30.9	-	-	-	-	-
31705	09-Oct-17	44	1	6.5	6.5	0.0	-	-	-	-	-
31706	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31707	09-Oct-17	7193	61	6.5	8.4	1.9	5715	26	6.5	6.5	0.0
31708	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31709	09-Oct-17	841	18	5.2	21.6	16.4	163	2	5.2	16.8	11.6
31710	09-Oct-17	34	3	6.5	8.4	1.9	-	-	-	-	-
31711	09-Oct-17	154	5	5.2	24.7	19.5	-	-	-	-	-
31712	09-Oct-17	12134	73	5.2	16.8	11.6	-	-	-	-	-
31713	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31714	09-Oct-17	77	3	5.2	7.9	2.7	-	-	-	-	-
31715	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31716	08-Oct-17	426	3	6.5	7.9	1.4	-	-	-	-	-
31717	08-Oct-17	173	2	5.2	24.7	19.5	-	-	-	-	-
31718	09-Oct-17	-	-	-	-	-	-	-	-	-	-

Table A1-2: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake during the 2017/2018 (October 17, 2017 to April 30, 2018) and 2018/2019 (October 11, 2018 to April 30, 2019) winter periods. Tag id highlighted yellow = lost tags.

Tag ID	Date tagged	2017/2018					2018/2019				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31719	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31720	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31721	08-Oct-17	-	-	-	-	-	-	-	-	-	-
31723	10-Oct-17	36	2	5.2	6.5	1.3	-	-	-	-	-
31724	10-Oct-17	35	2	6.5	8.4	1.9	198	7	5.2	16.8	11.6
31725	10-Oct-17	29	1	5.2	7.9	2.7	-	-	-	-	-
31747	10-Oct-17	46	2	36.1	36.1	0.0	-	-	-	-	-
31748	10-Oct-17	52985	179	5.2	21.6	16.4	16765	135	5.2	21.6	16.4
31749	10-Oct-17	1100	13	6.5	21.6	15.1	-	-	-	-	-
31750	10-Oct-17	503	5	5.2	6.5	1.3	64	4	5.8	8.4	2.6
31751	10-Oct-17	-	-	-	-	-	-	-	-	-	-
31752	10-Oct-17	736	16	6.5	21.6	15.1	-	-	-	-	-
31753	10-Oct-17	1414	10	6.5	8.4	1.9	16	3	6.5	6.5	0.0
31754	10-Oct-17	9850	73	5.2	8.4	3.2	593	7	5.8	8.4	2.6
31755	10-Oct-17	-	-	-	-	-	-	-	-	-	-
31756	10-Oct-17	346	5	6.5	36.1	29.6	-	-	-	-	-
31757	10-Oct-17	6	2	6.5	6.5	0.0	-	-	-	-	-
53761	10-Oct-17	-	-	-	-	-	9	2	21.6	21.6	0.0
53762	09-Oct-17	-	-	-	-	-	-	-	-	-	-

Table A1-3: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged upstream of the Keeyask GS during the 2018 (May 1 to October 10) and 2019 (May 1 to October 17) open-water periods. Tag id highlighted purple = fish moved downstream through the Keeyask GS.

Tag ID	Date tagged	2018					2019				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31722	07-Oct-17	6868	62	-29.4	-12.8	16.6	6733	58	-19.5	-12.9	6.6
31726	12-Oct-17	13454	93	-19.5	-12.8	6.7	3978	52	-19.5	-12.9	6.6
31727	12-Oct-17	6891	86	1.2	18.6	17.4	-	-	-	-	-
31728	14-Oct-17	16398	77	-33.8	-26.5	7.3	9171	67	-26.5	-26.5	0.0
31729	14-Oct-17	11540	70	-33.8	-9.3	24.5	12091	81	-33.8	-7.4	26.4
31730	14-Oct-17	18066	73	-33.8	-9.9	23.9	2797	43	-15	-9.9	5.1
31731	14-Oct-17	105	13	-19.5	-19.5	0.0	102	11	-19.5	-19.5	0.0
31732	12-Oct-17	3780	73	-12.9	-9.3	3.6	3773	24	-33.8	-9.9	23.9
31733	14-Oct-17	14460	74	-33.8	-26.5	7.3	8963	45	-33.8	-26.5	7.3
31734	14-Oct-17	2432	26	-19.5	-9.9	9.6	491	27	-19.5	-9.9	9.6
31735	12-Oct-17	2746	25	-9.3	-4.8	4.5	-	-	-	-	-
31736	12-Oct-17	16257	82	-33.8	-9.9	23.9	5103	66	-33.8	-12.9	20.9
31737	12-Oct-17	4807	62	-19.5	-5.8	13.7	2665	52	-33.8	-9	24.8
31738	11-Oct-17	4222	73	-9.9	1.2	11.1	294	30	1.2	1.2	0.0
31739	11-Oct-17	4182	40	-19.5	-9.9	9.6	5998	79	-19.5	-9.9	9.6
31740	11-Oct-17	-	-	-	-	-	-	-	-	-	-
31741	11-Oct-17	17796	113	-33.8	-9	24.8	12895	59	-33.8	-7.4	26.4
31742	11-Oct-17	1990	36	-33.8	-12.9	20.9	325	14	-19.5	-19.5	0.0
31743	11-Oct-17	19757	92	-33.8	-7.4	26.4	19373	102	-33.8	-7.4	26.4
31744	11-Oct-17	440	7	-26.5	-12.8	13.7	-	-	-	-	-
31745	11-Oct-17	9343	93	-33.8	-4.8	29.0	14373	69	-34.3	-9.3	25.0
31746	11-Oct-17	26627	121	-19.5	-7.4	12.1	22103	116	-19.5	-7.4	12.1

Table A1-4: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake during the 2018 (May 1 to October 10) and 2019 (May 1 to October 7) open-water periods. Tag id highlighted yellow = lost tags.

Tag ID	Date tagged	2018					2019				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31698	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31699	09-Oct-17	13497	113	3.8	18.6	14.8	18807	123	4.3	18.6	14.3
31700	09-Oct-17	1789	46	2.7	7.9	5.2	-	-	-	-	-
31701	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31702	09-Oct-17	11844	65	1.2	9.4	8.2	9734	56	3.9	13	9.1
31703	09-Oct-17	2854	19	1.2	7.4	6.2	7597	30	1.2	9.4	8.2
31704	09-Oct-17	1888	24	1.2	36.1	34.9	2025	22	1.2	9.4	8.2
31705	09-Oct-17	932	5	1.2	7.4	6.2	886	10	0.6	7.4	6.8
31706	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31707	09-Oct-17	13071	31	3.8	7.4	3.6	-	-	-	-	-
31708	09-Oct-17	21	5	1.2	1.2	0.0	-	-	-	-	-
31709	09-Oct-17	7230	11	1.2	7.9	6.7	536	2	2.7	7.9	5.2
31710	09-Oct-17	361	14	3.8	7.4	3.6	438	8	6.5	9.4	2.9
31711	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31712	09-Oct-17	5045	43	6.5	24.7	18.2	-	-	-	-	-
31713	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31714	09-Oct-17	77	4	3.8	3.8	0.0	1887	29	4.2	4.2	0.0
31715	09-Oct-17	1024	5	1.2	7.4	6.2	213	4	1.2	13	11.8
31716	08-Oct-17	34874	75	1.2	2.7	1.5	59102	131	1.2	1.2	0.0
31717	08-Oct-17	-	-	-	-	-	-	-	-	-	-
31718	09-Oct-17	64	2	3.8	3.8	0.0	-	-	-	-	-
31719	09-Oct-17	-	-	-	-	-	-	-	-	-	-

Table A1-4: Number of detections (n), number of days detected, farthest upstream (U/S) and downstream (D/S) river kilometre (rkm) detection sites, and detection range for Lake Whitefish tagged in Stephens Lake during the 2018 (May 1 to October 10) and 2019 (May 1 to October 7) open-water periods. Tag id highlighted yellow = lost tags.

Tag ID	Date tagged	2018					2019				
		n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)	n	# Days	Furthest U/S (rkm)	Furthest D/S (rkm)	Range (rkm)
31720	09-Oct-17	-	-	-	-	-	-	-	-	-	-
31721	08-Oct-17	-	-	-	-	-	-	-	-	-	-
31723	10-Oct-17	-	-	-	-	-	-	-	-	-	-
31724	10-Oct-17	11143	54	1.2	13	11.8	12347	71	1.2	18.6	17.4
31725	10-Oct-17	62	1	7.4	7.4	0.0	-	-	-	-	-
31747	10-Oct-17	249	4	1.2	4.4	3.2	-	-	-	-	-
31748	10-Oct-17	8800	94	1.2	36.1	34.9	1053	24	13	40.8	27.8
31749	10-Oct-17	52	6	16.8	24.7	7.9	-	-	-	-	-
31750	10-Oct-17	5820	21	1.2	7.9	6.7	288	5	1.2	7.4	6.2
31751	10-Oct-17	15	2	3.8	7.4	3.6	-	-	-	-	-
31752	10-Oct-17	-	-	-	-	-	-	-	-	-	-
31753	10-Oct-17	5106	53	3.8	6.5	2.7	1963	37	4.2	6.5	2.3
31754	10-Oct-17	4662	53	2.7	13	10.3	2666	33	1.2	18.6	17.4
31755	10-Oct-17	-	-	-	-	-	-	-	-	-	-
31756	10-Oct-17	-	-	-	-	-	-	-	-	-	-
31757	10-Oct-17	404	6	6.5	10.3	3.8	-	-	-	-	-
53761	10-Oct-17	1817	46	3.8	24.7	20.9	219	5	6.5	16.8	10.3
53762	09-Oct-17	61	4	20	36.1	16.1	-	-	-	-	-

APPENDIX 2: LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC-TAGGED LAKE WHITEFISH IN GULL LAKE, OCTOBER 2017 TO OCTOBER 2019

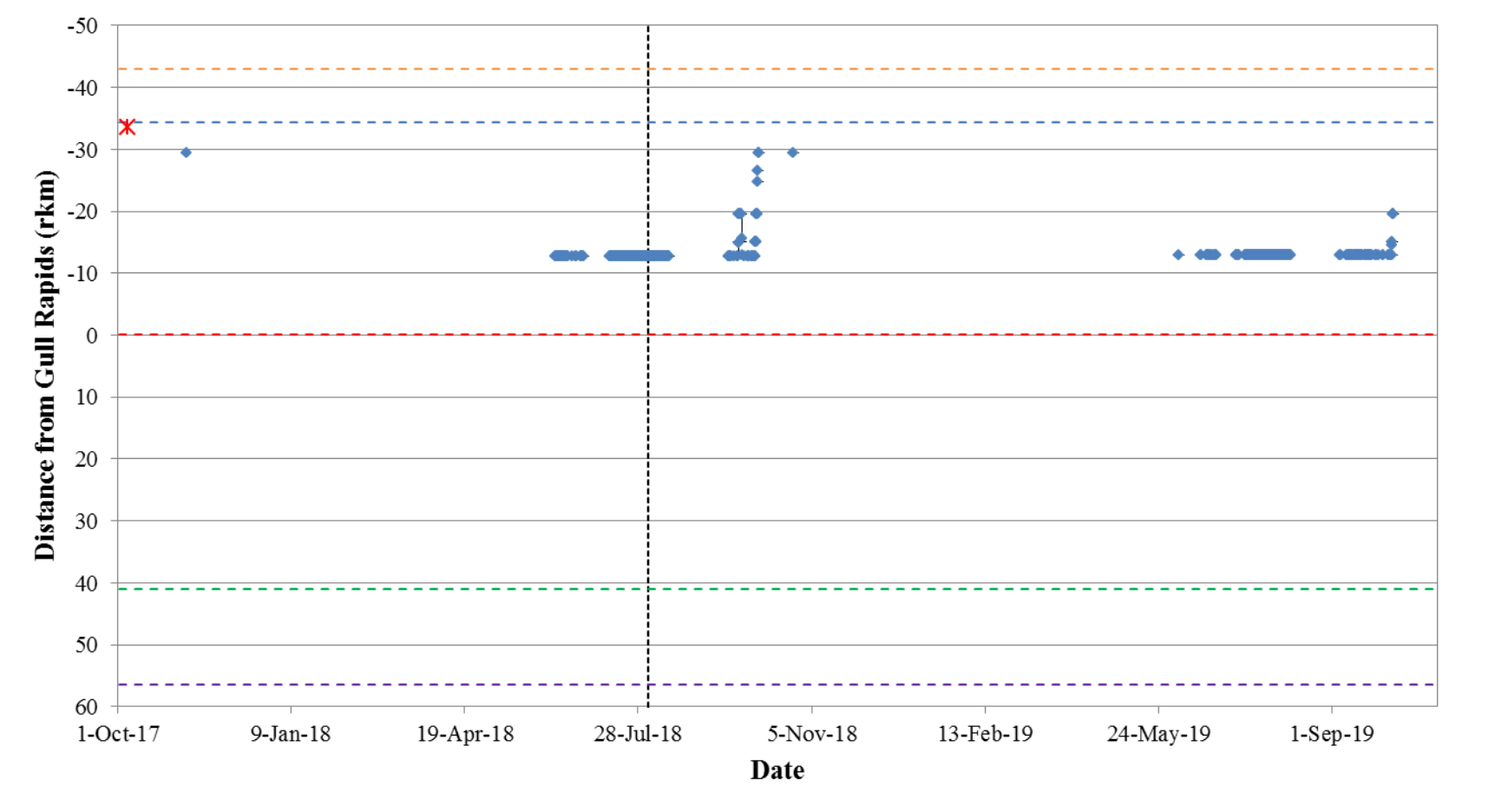


Figure A2-1: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31722) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

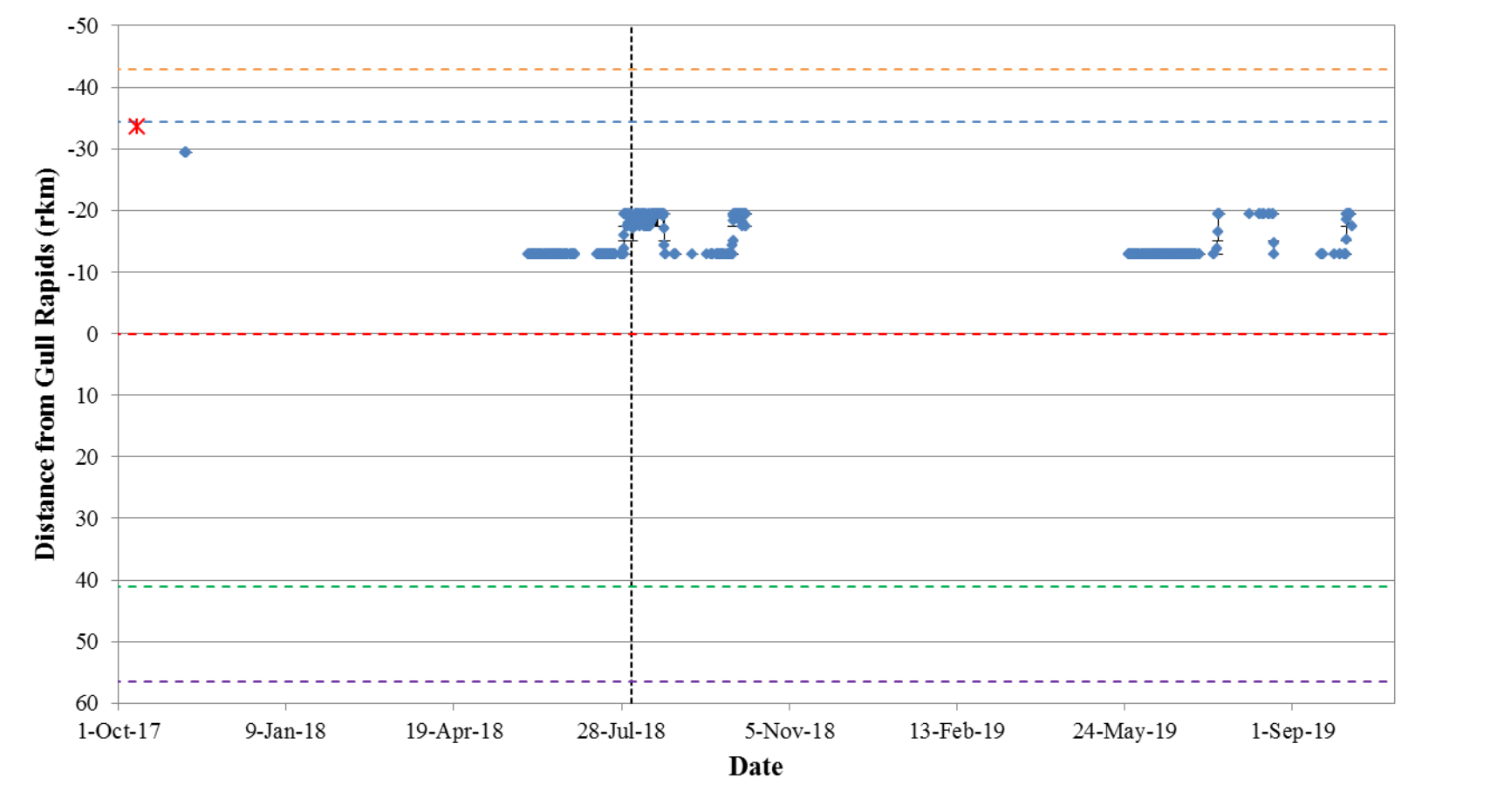


Figure A2-2: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31726) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

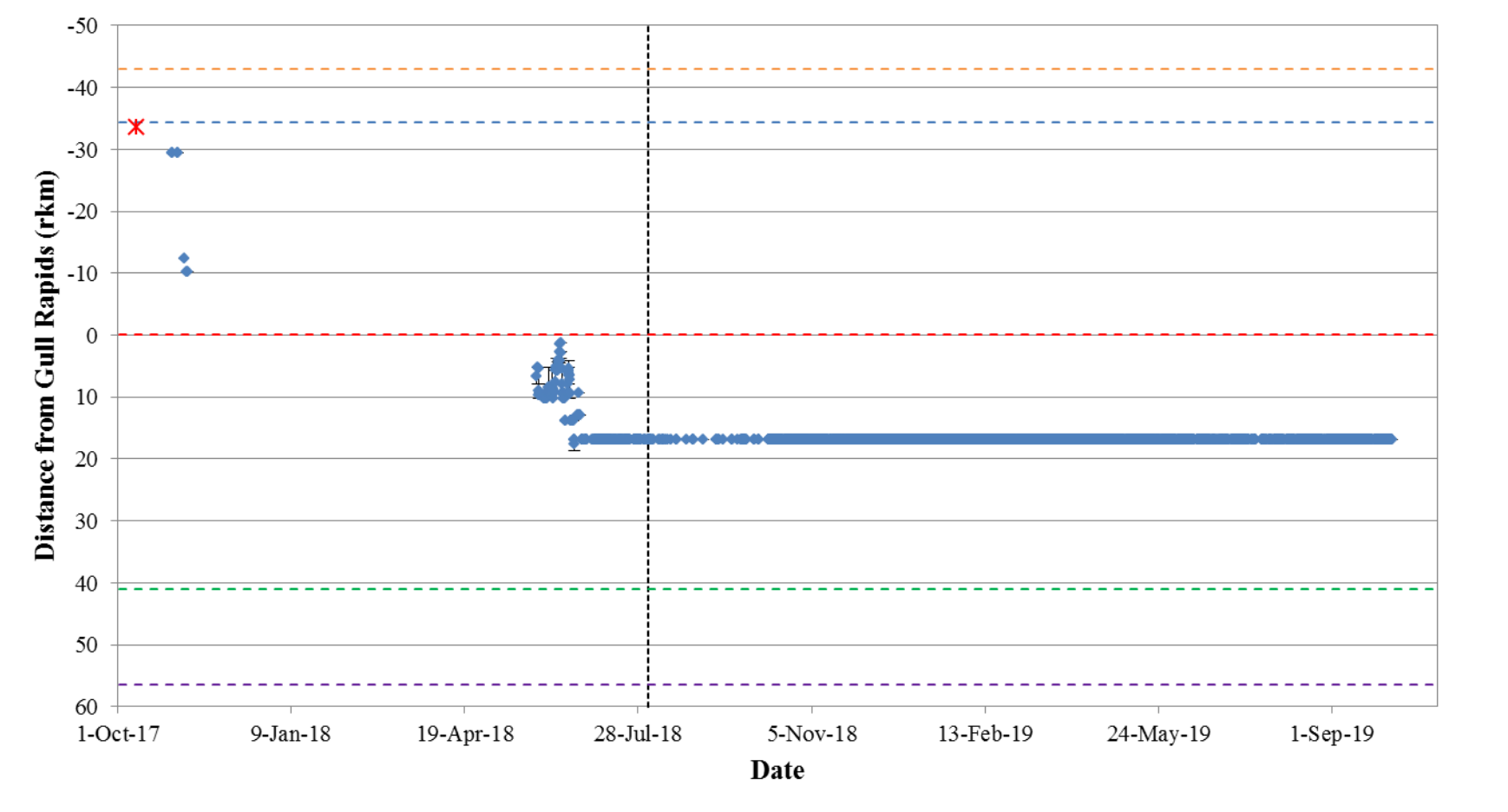


Figure A2-3: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31727) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

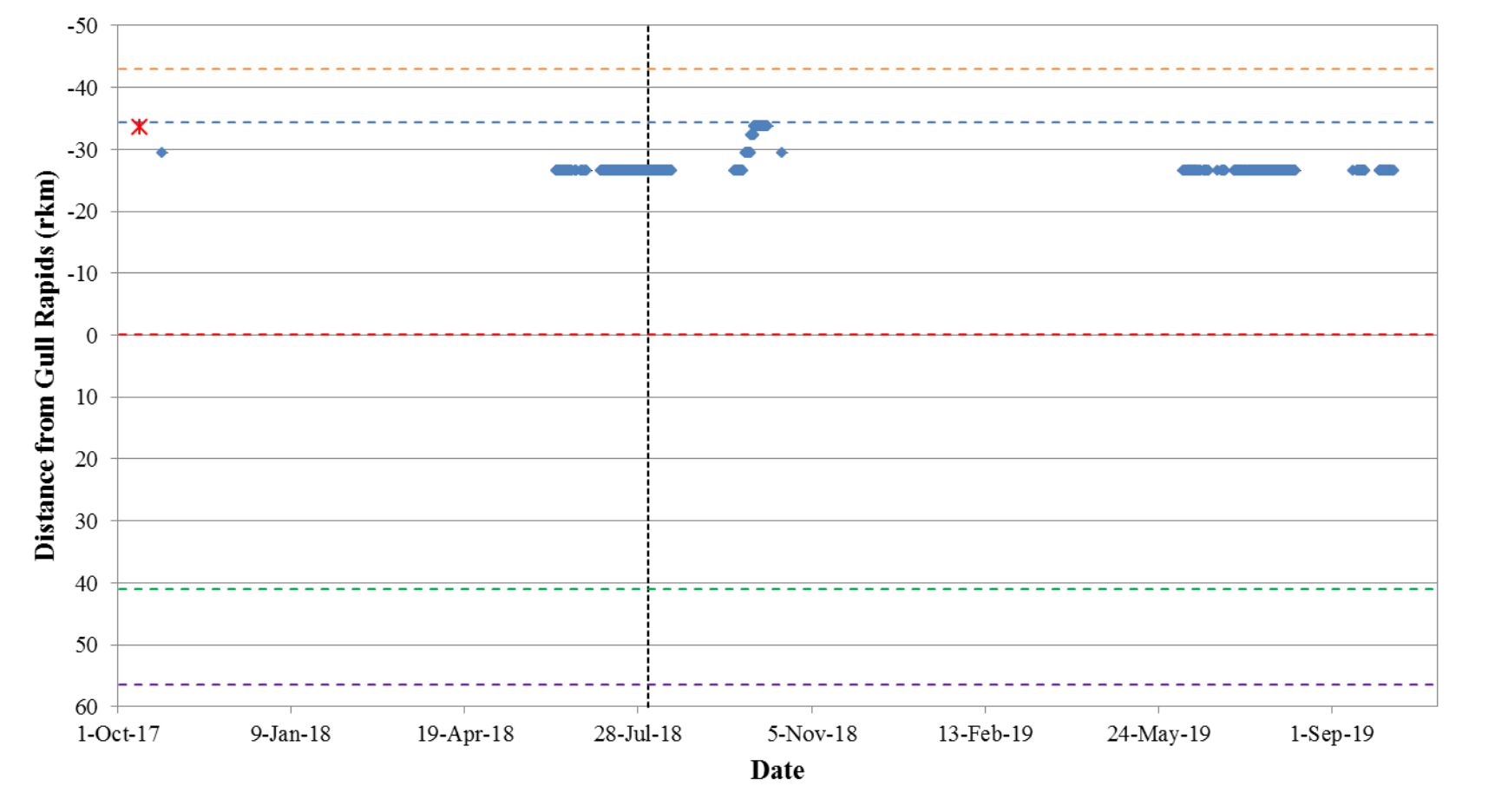


Figure A2-4: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31728) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

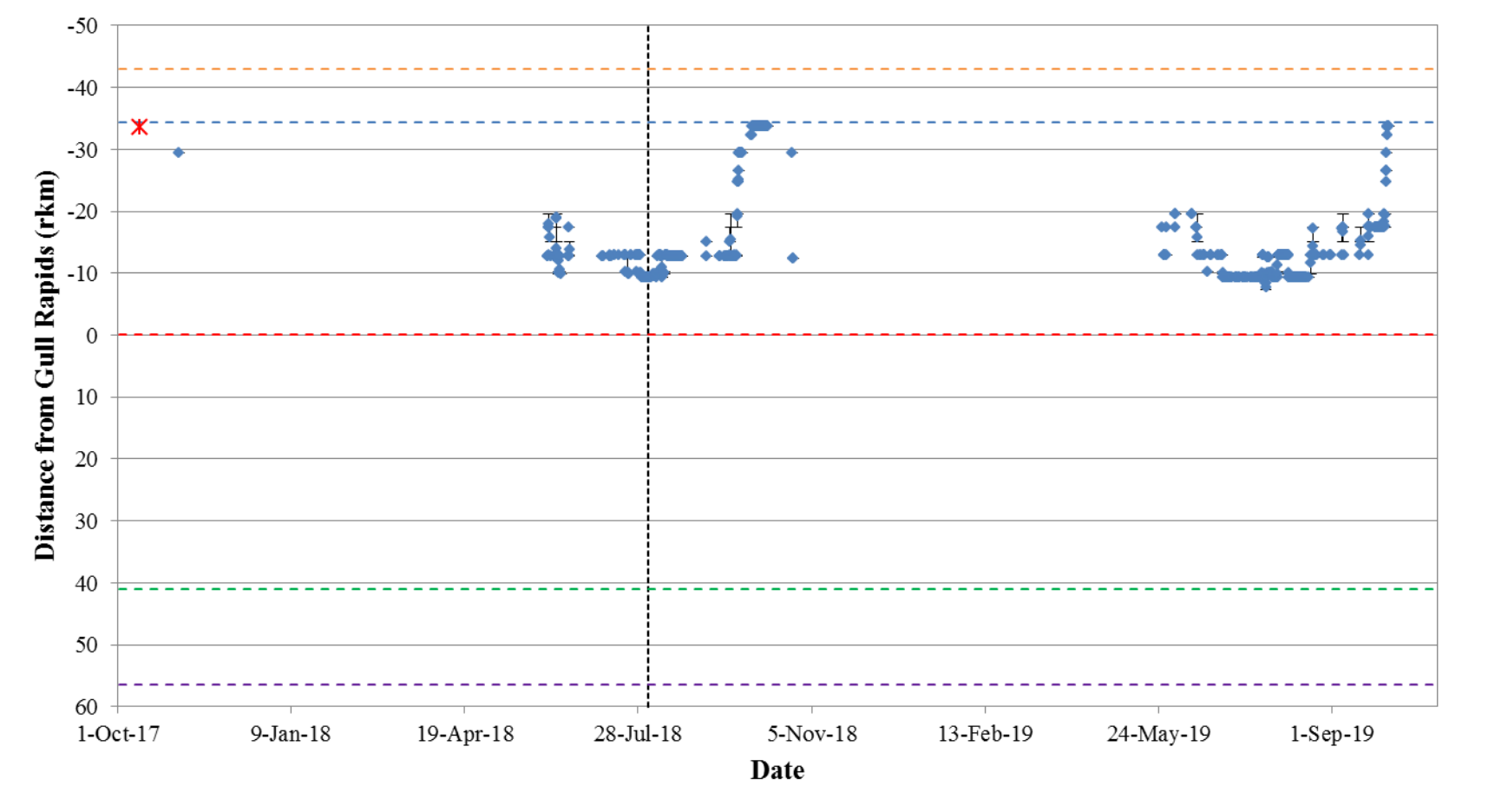


Figure A2-5: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31729) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

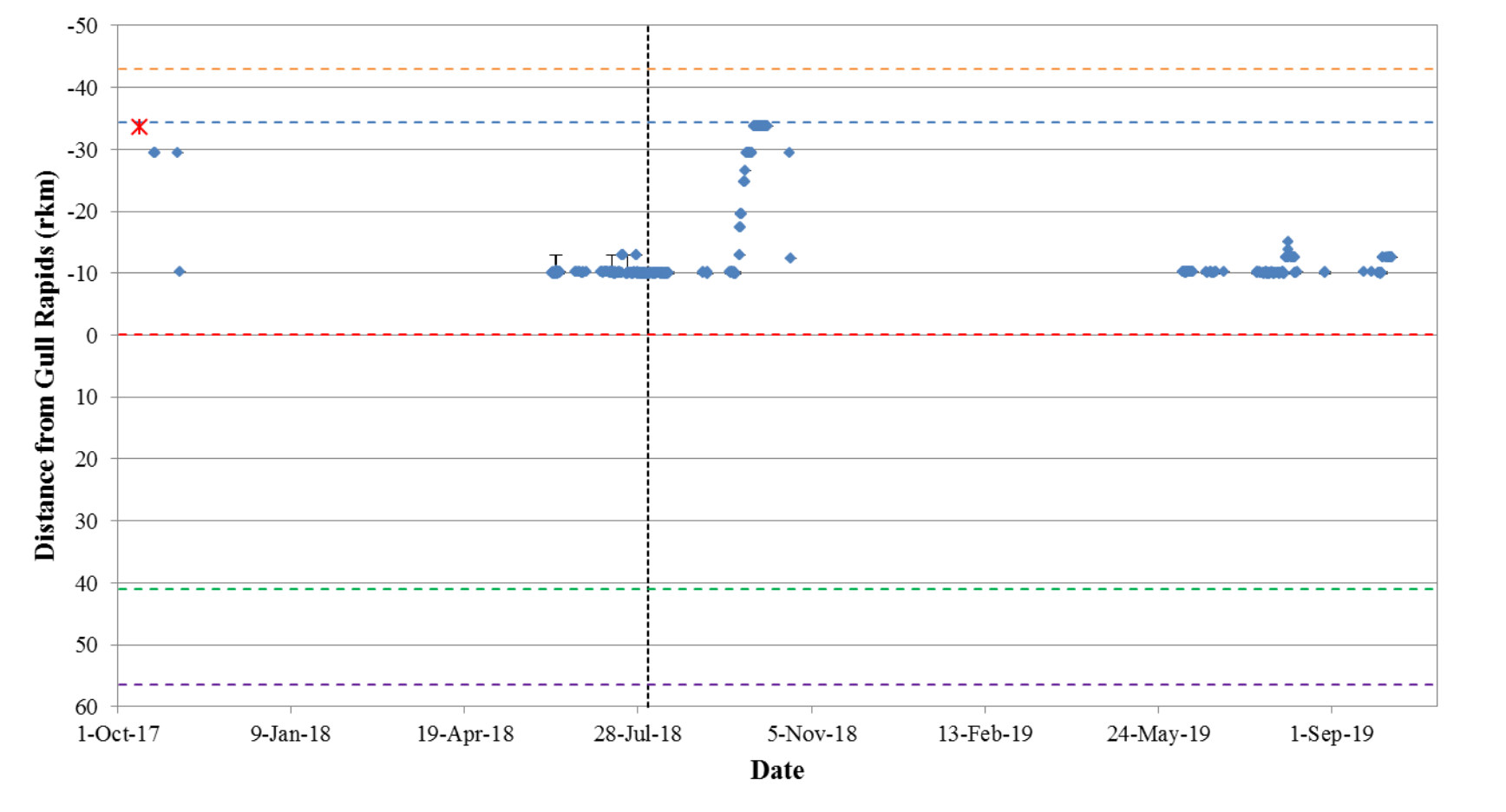


Figure A2-6: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31730) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

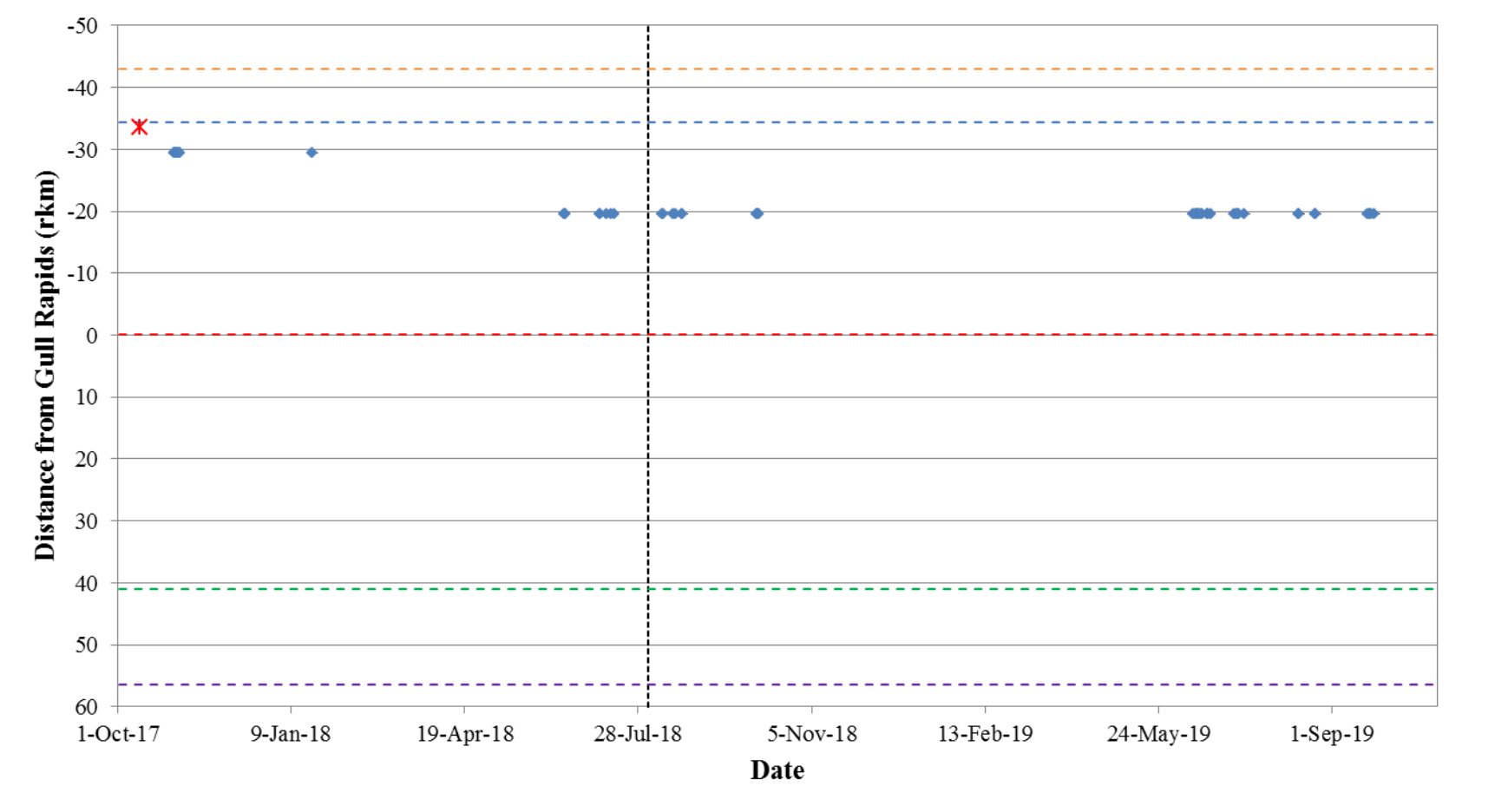


Figure A2-7: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31731) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

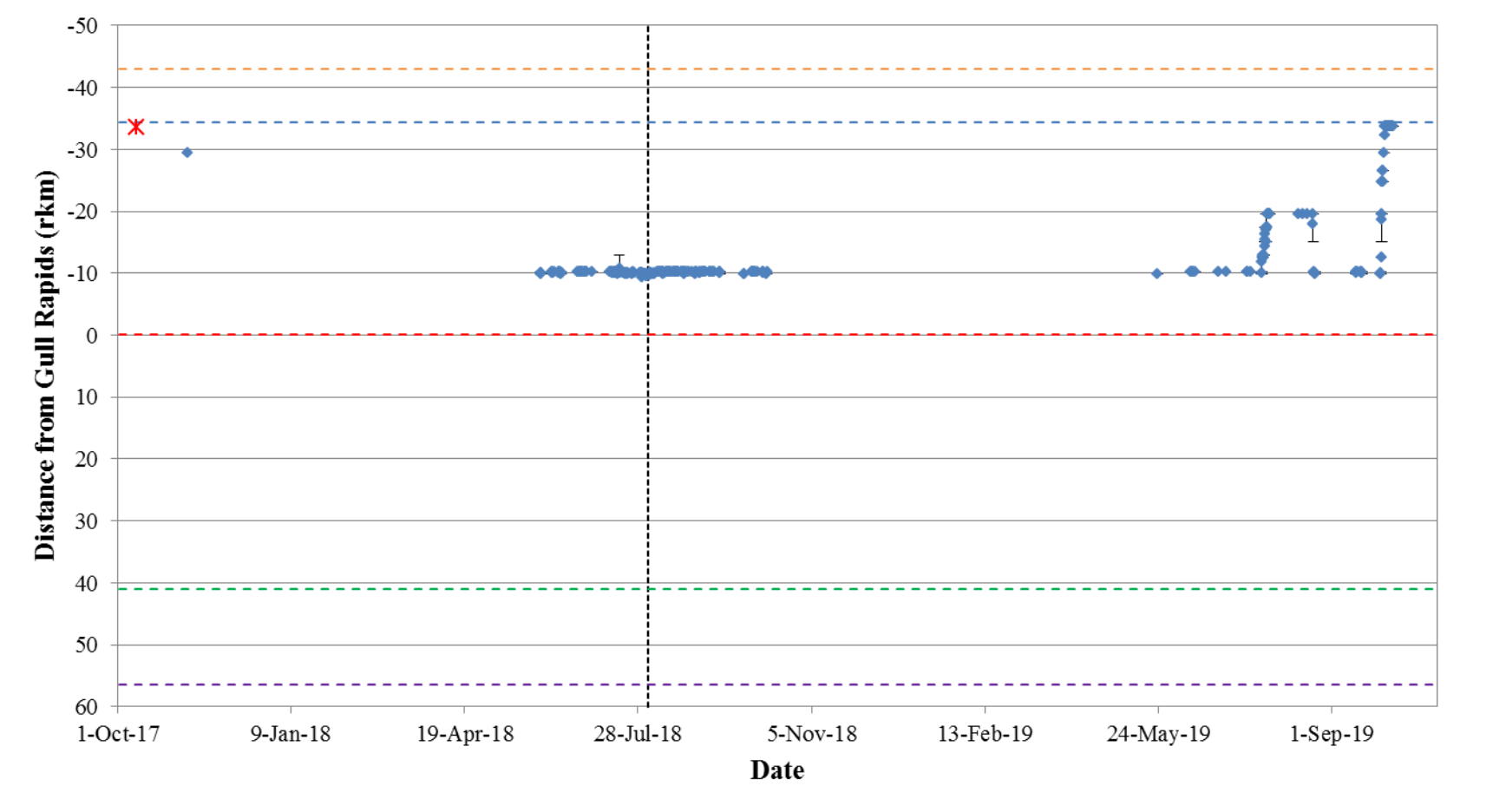


Figure A2-8: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31732) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

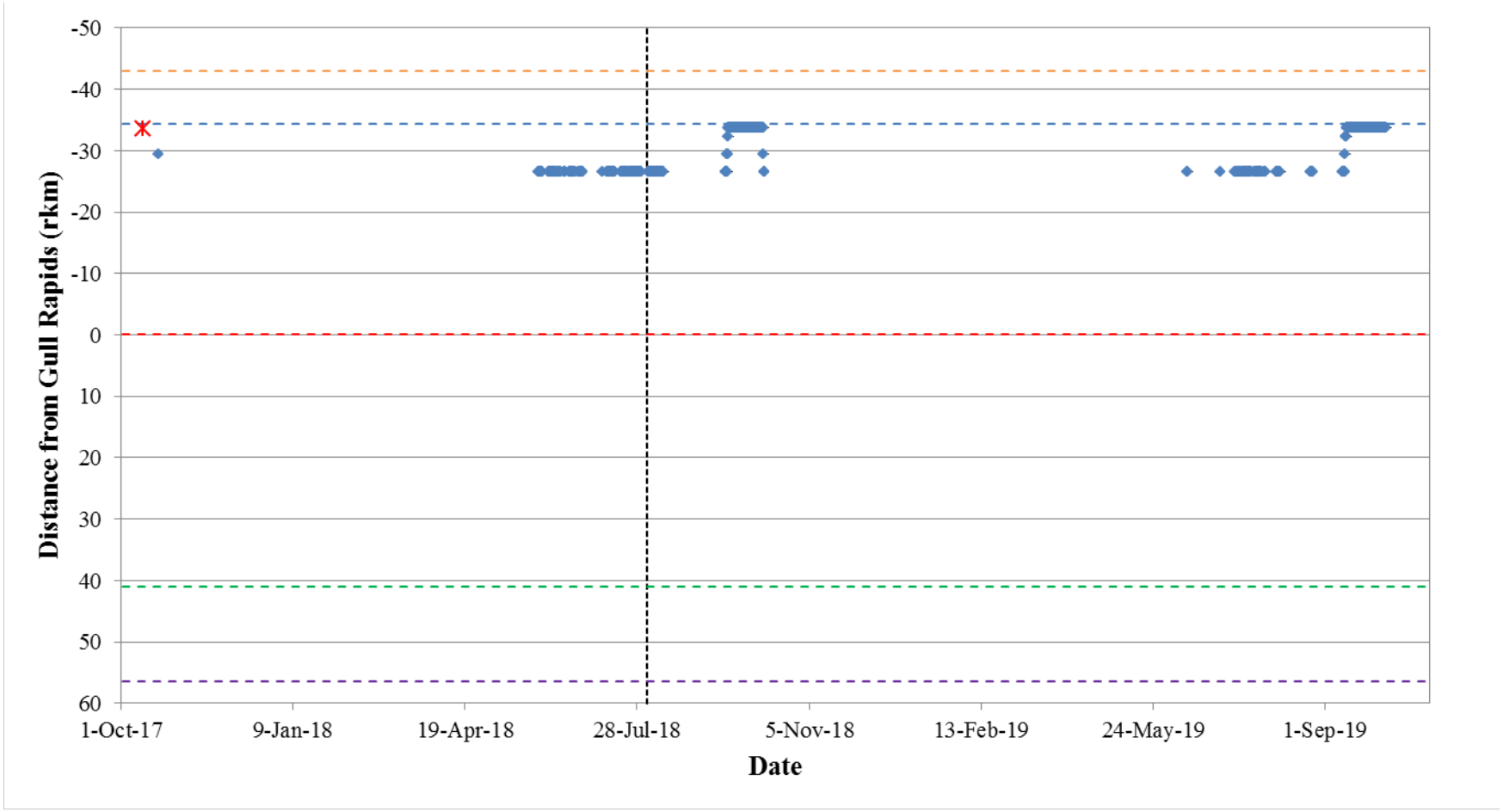


Figure A2-9: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31733) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

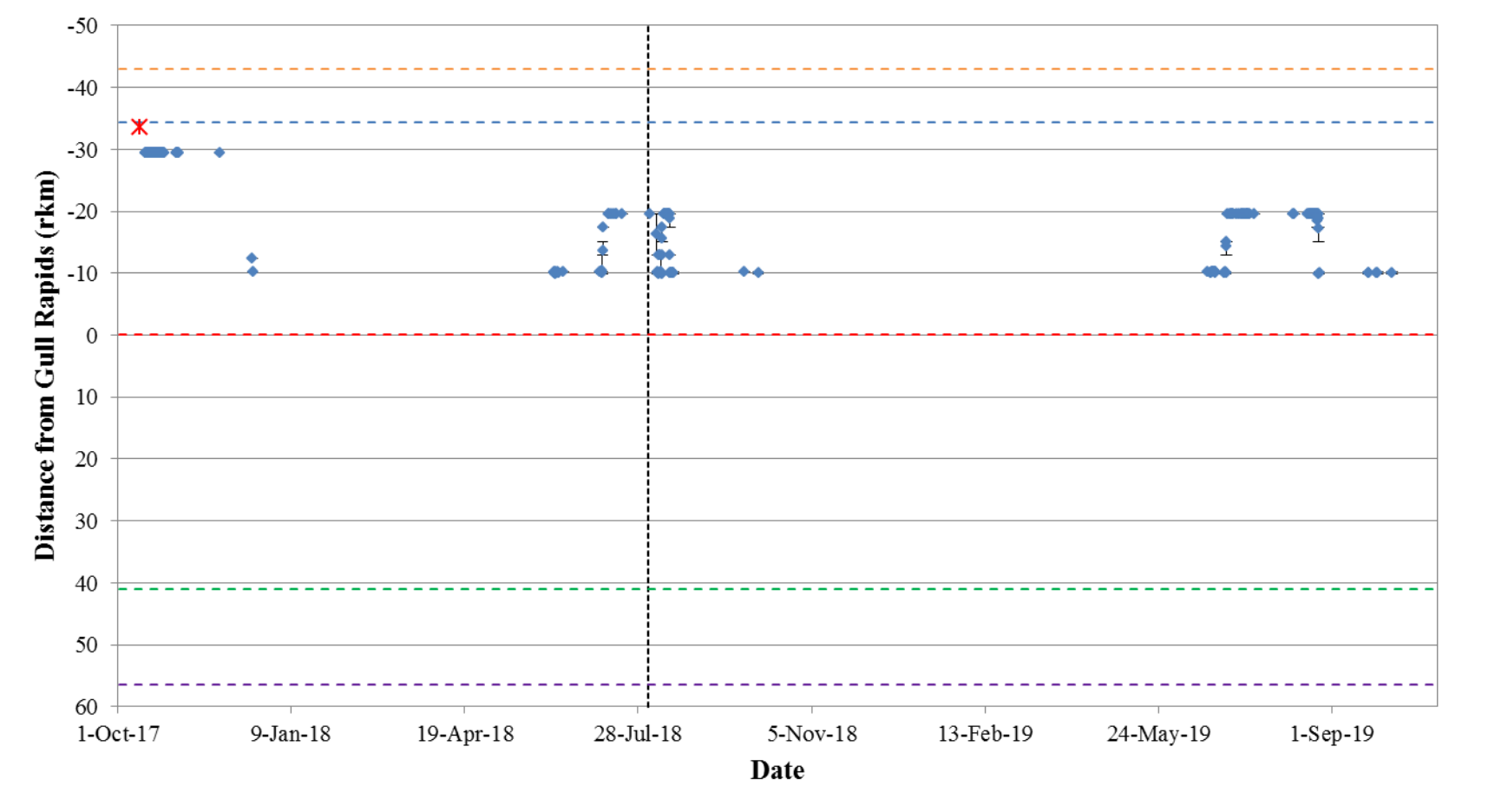


Figure A2-10: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31734) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

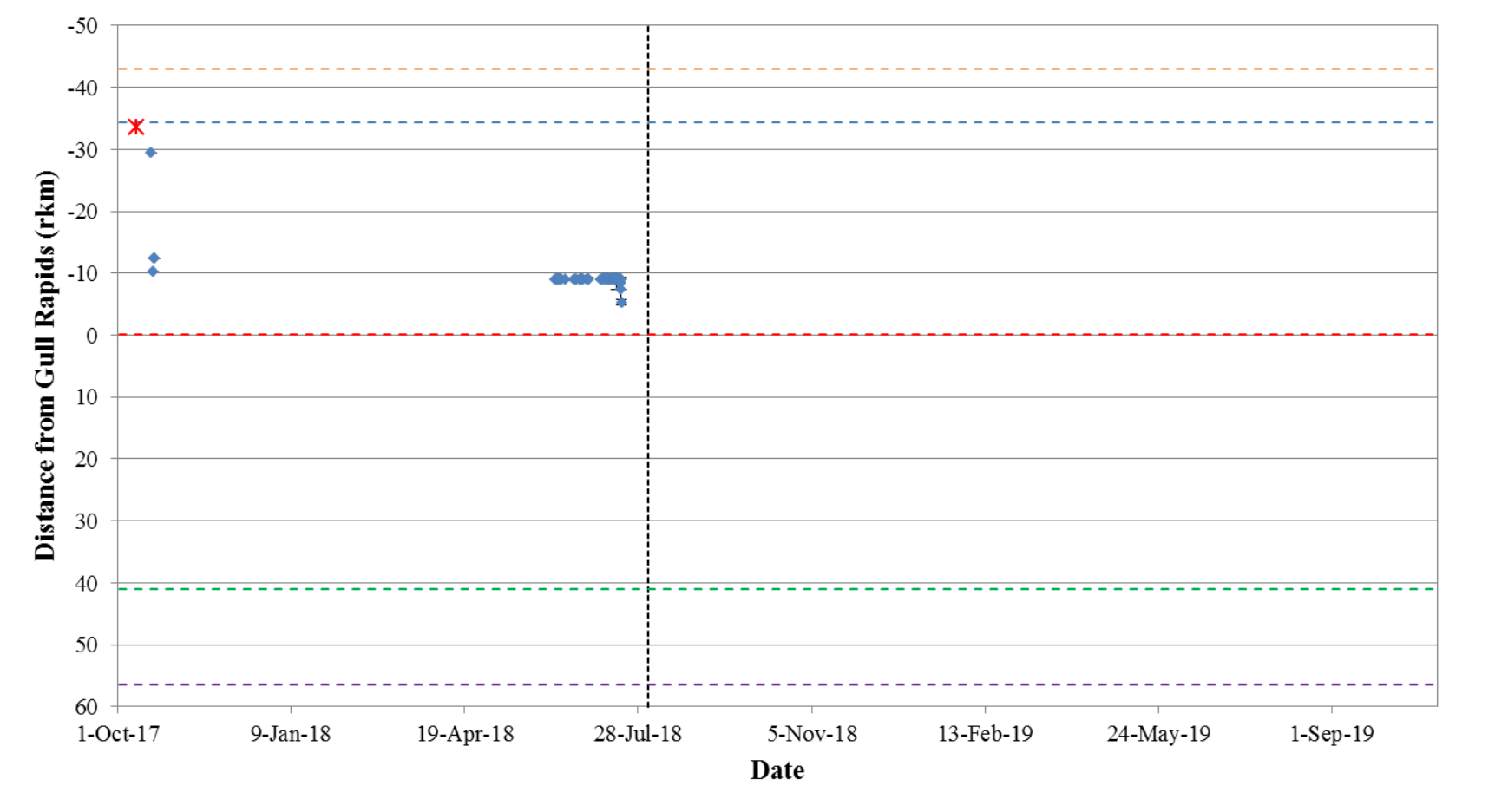


Figure A2-11: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31735) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

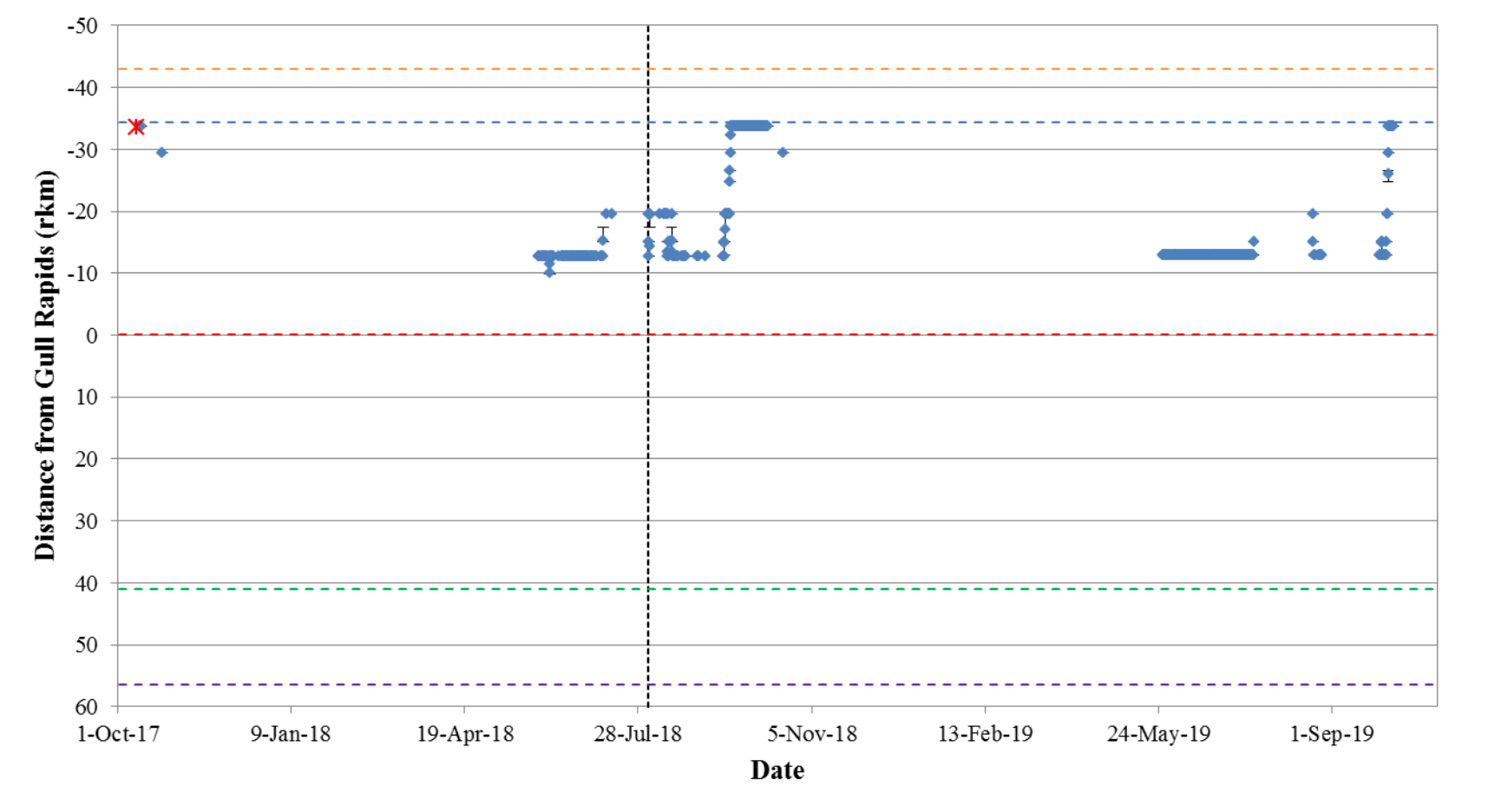


Figure A2-12: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31736) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

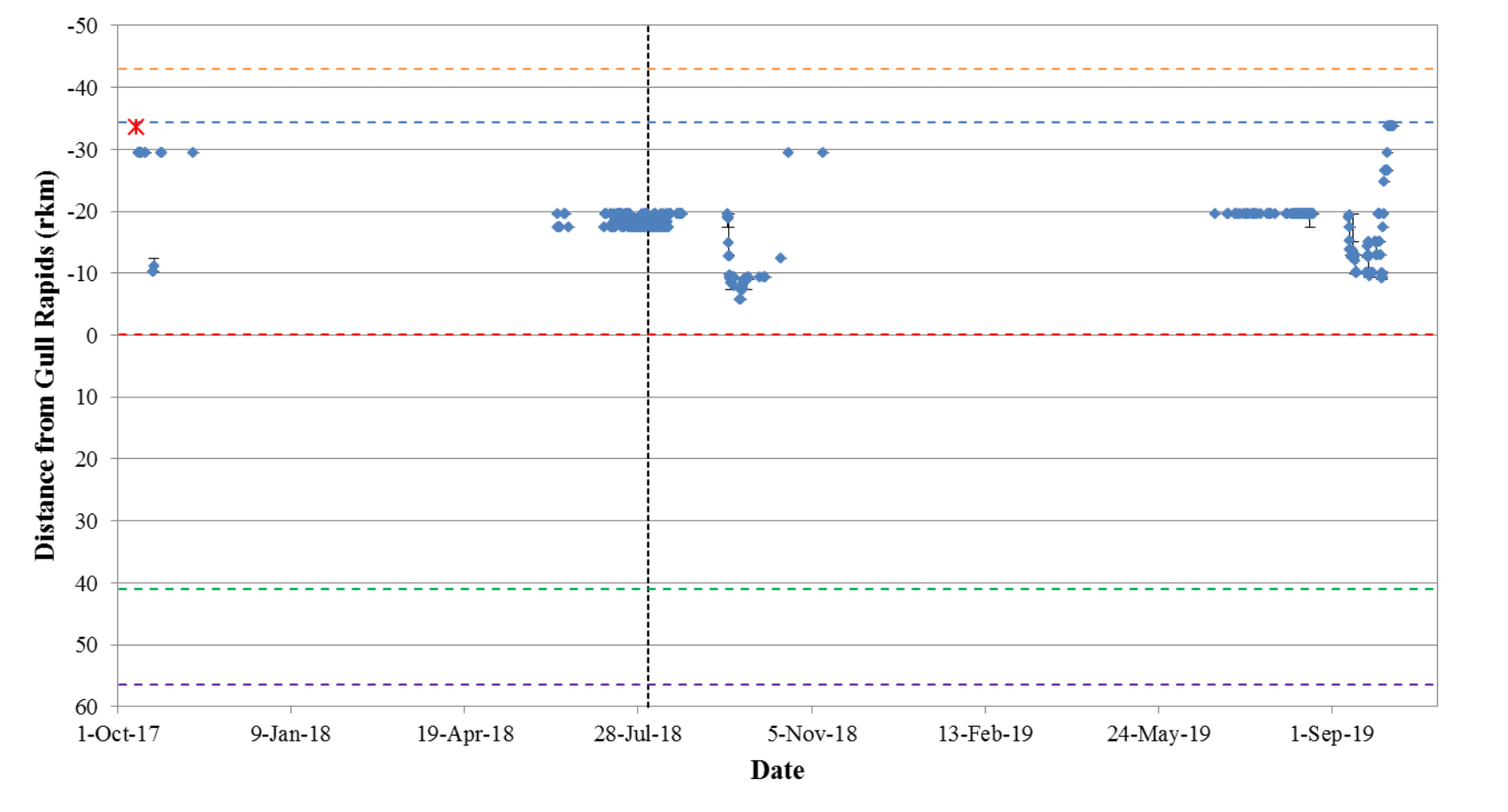


Figure A2-13: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31737) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

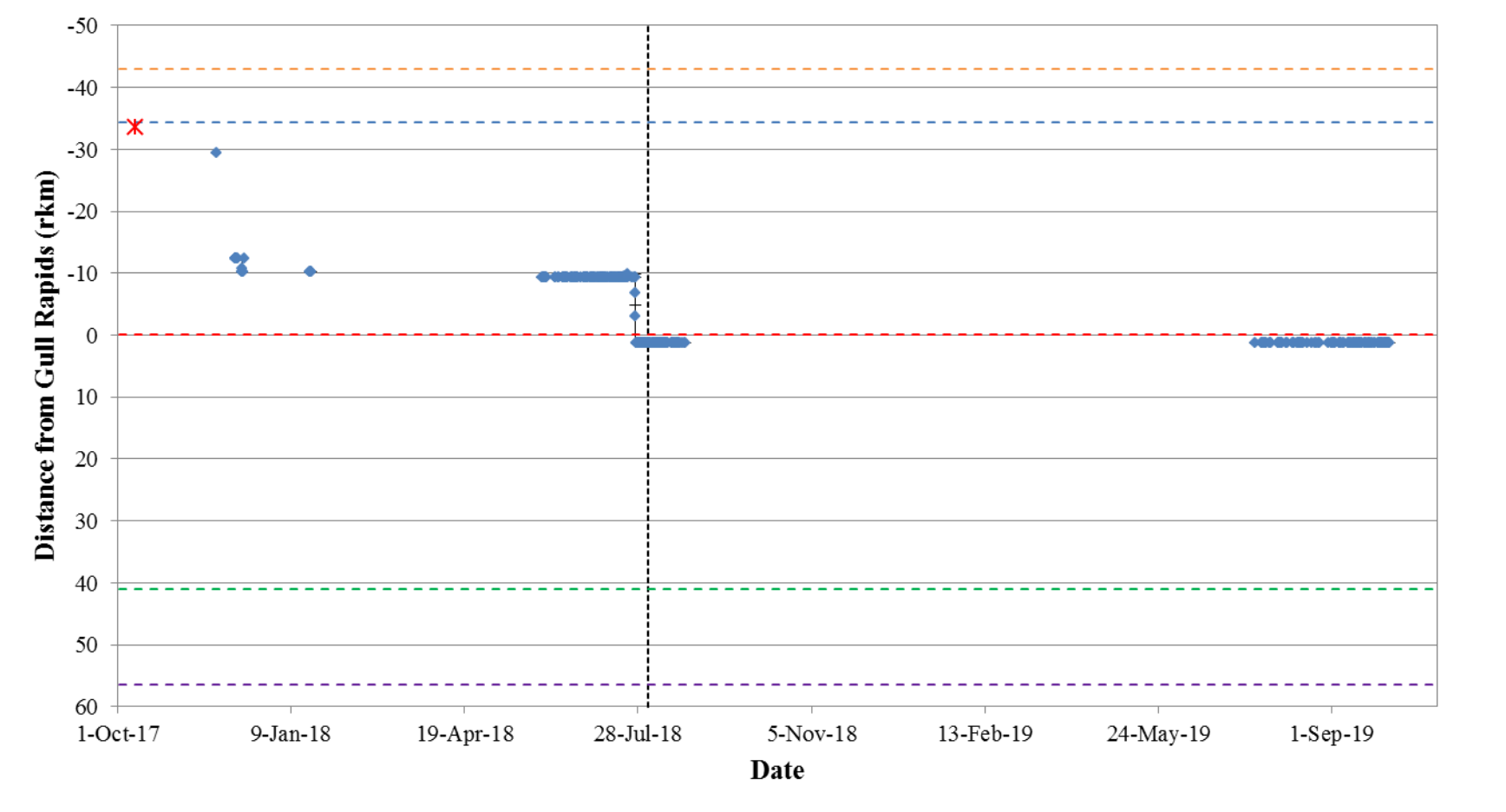


Figure A2-14: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31738) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

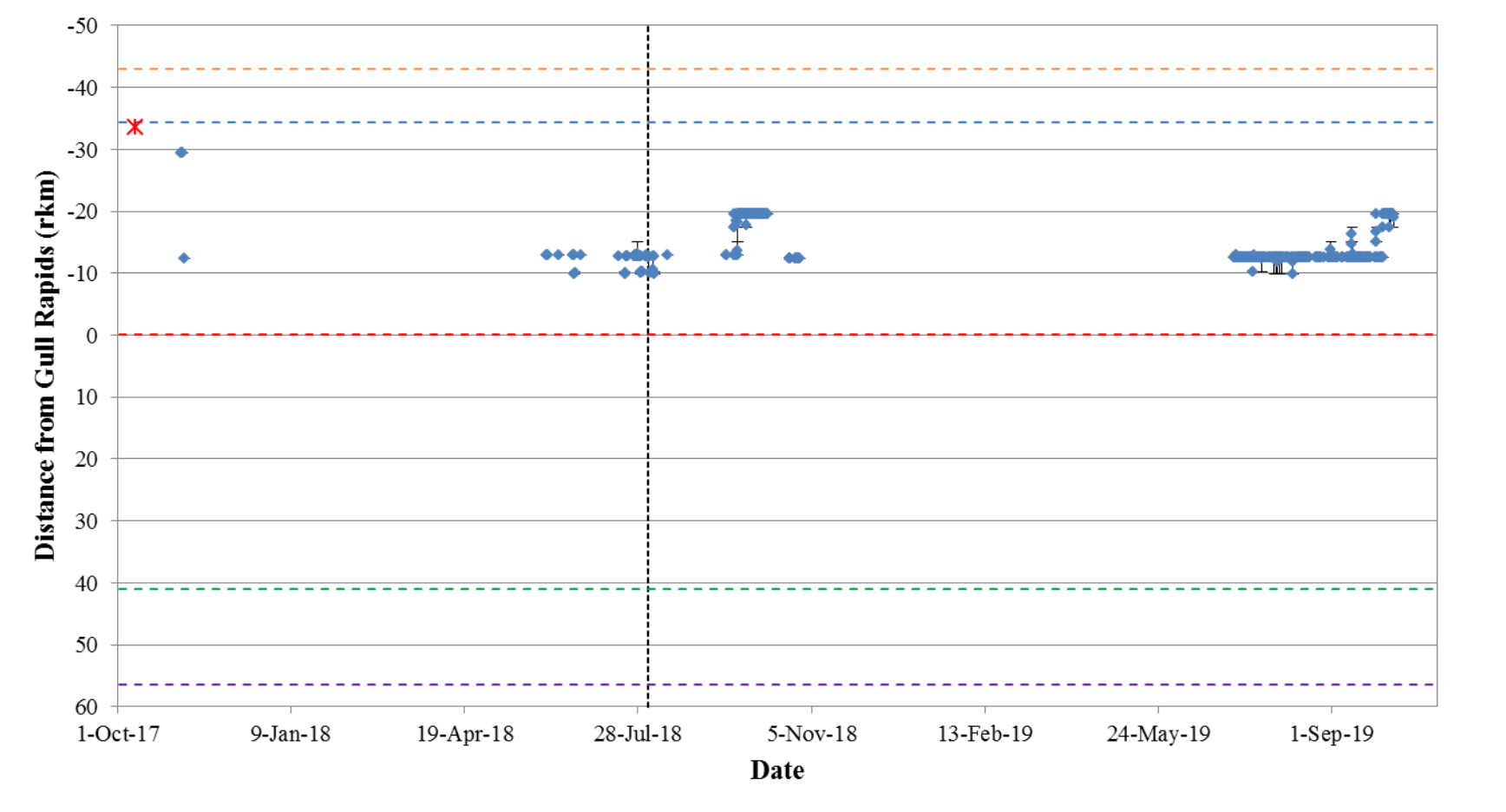


Figure A2-15: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31739) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

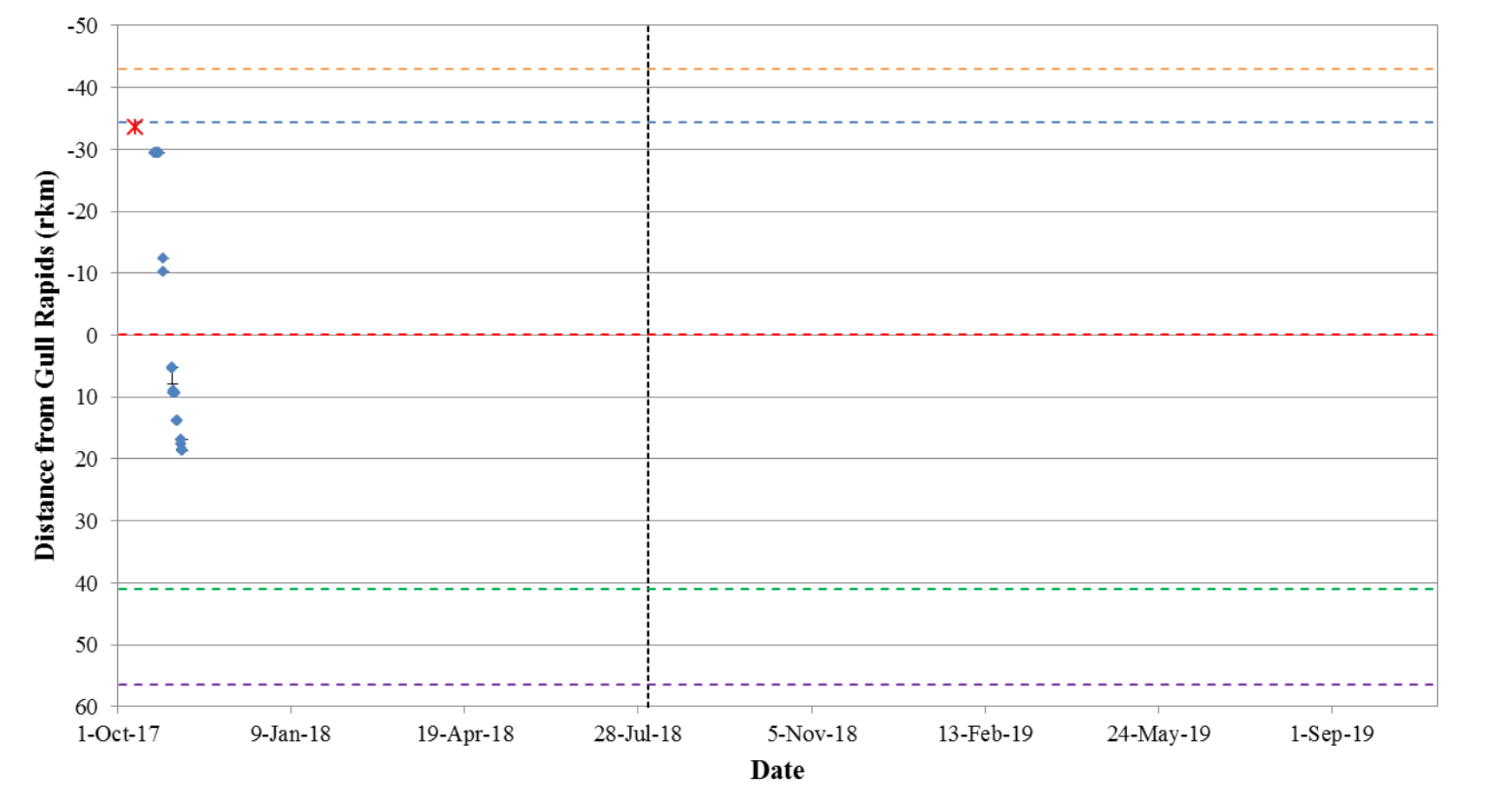


Figure A2-16: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31740) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

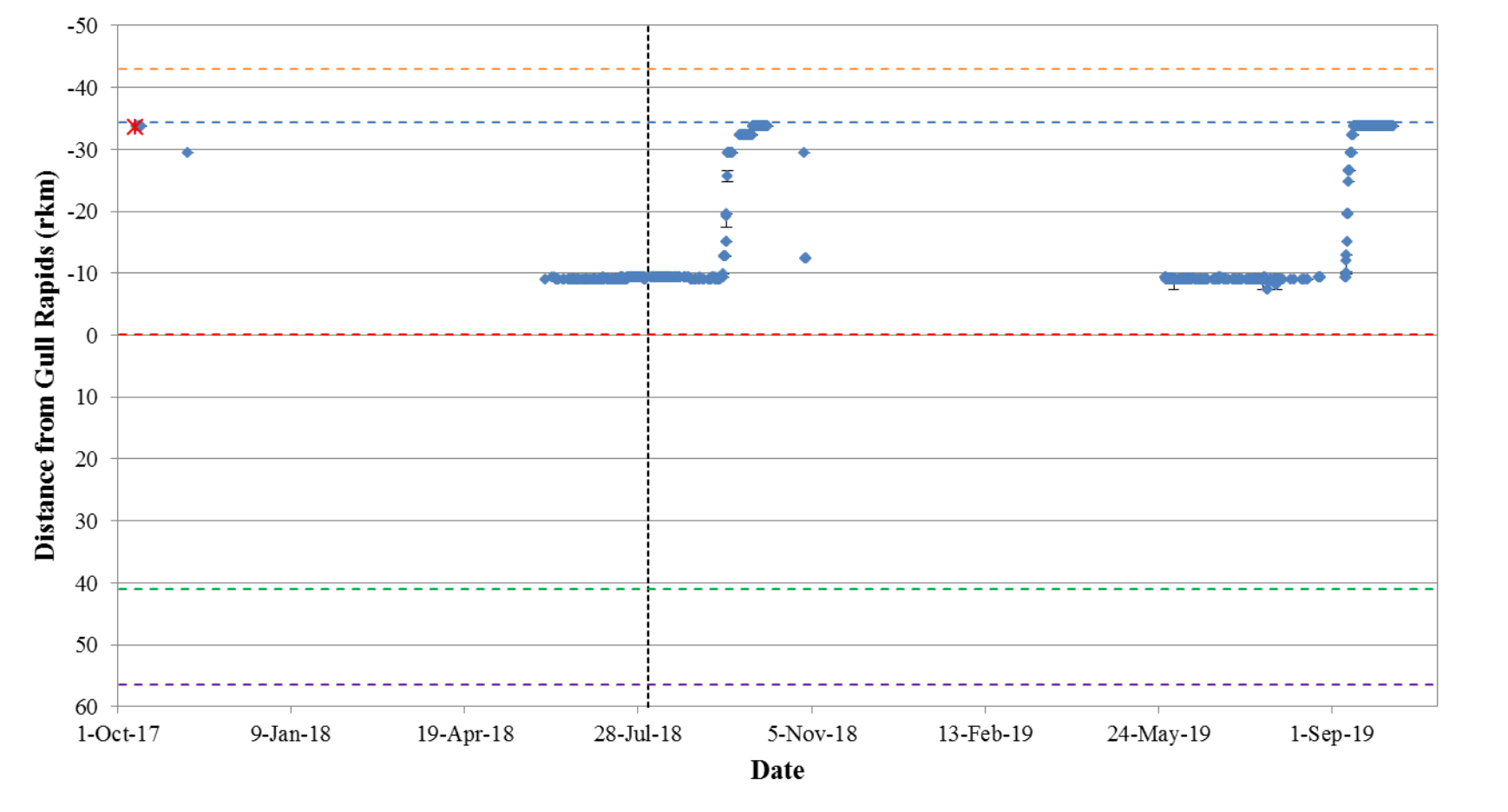


Figure A2-17: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31741) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

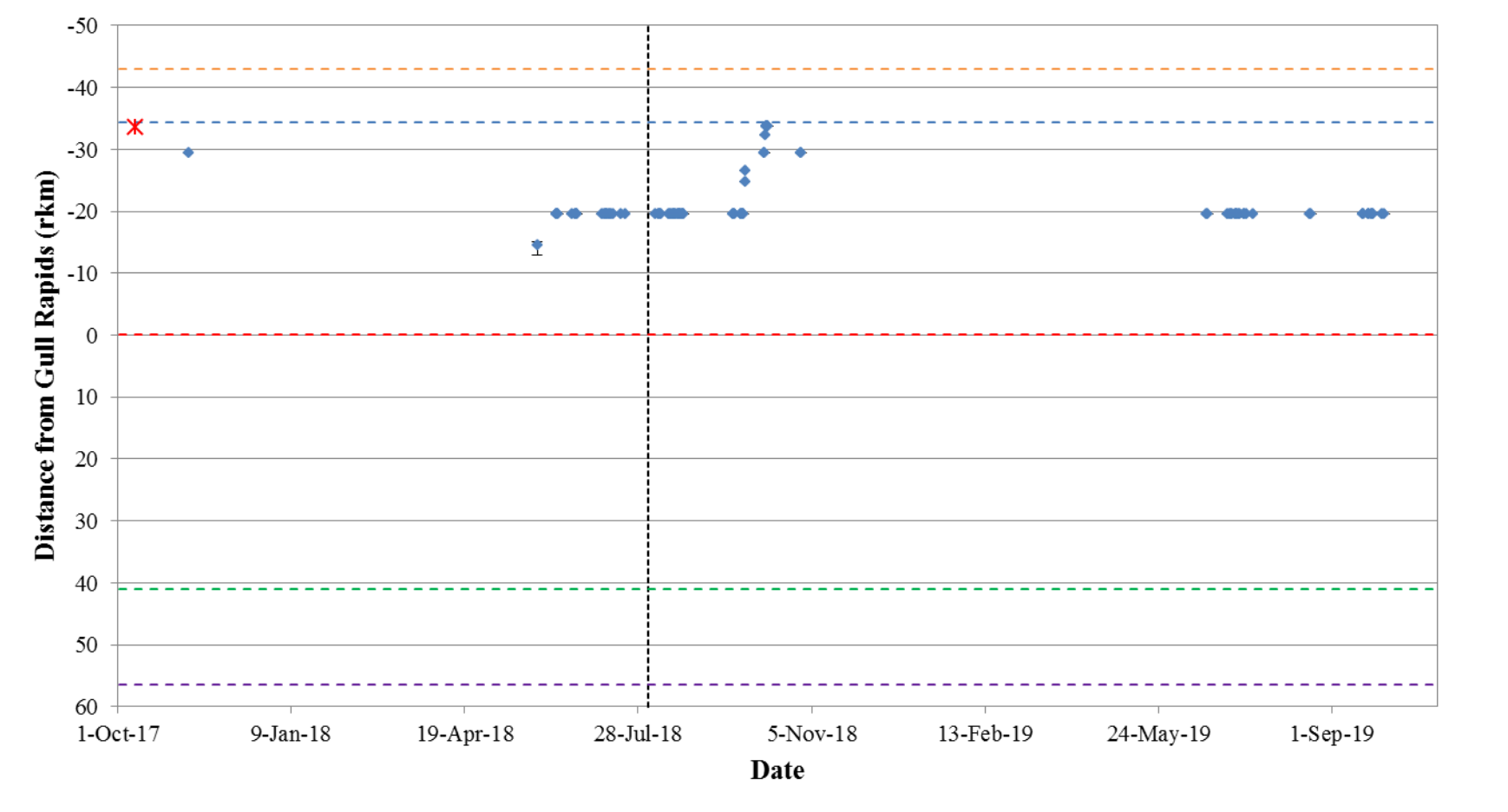


Figure A2-18: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31742) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

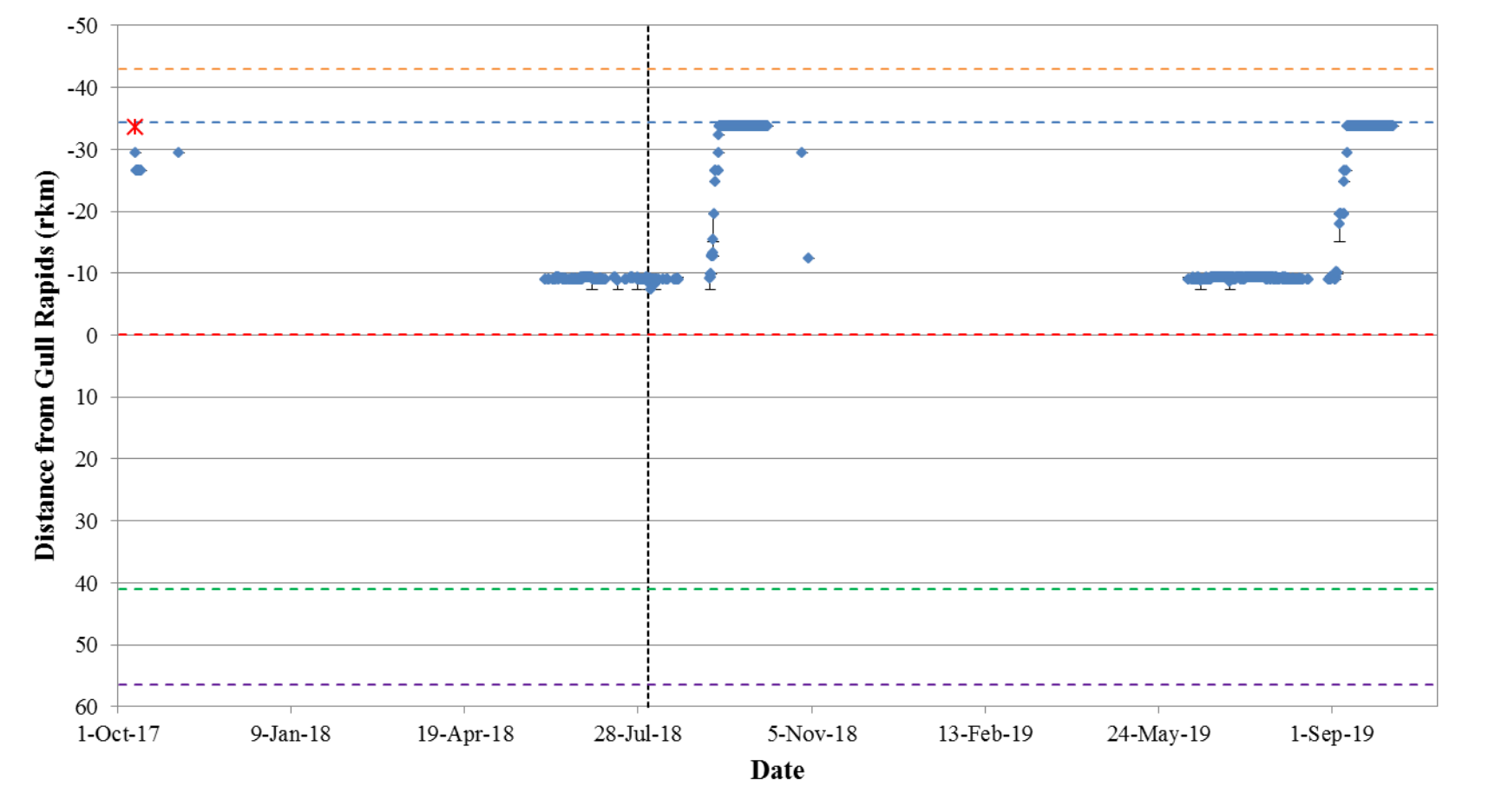


Figure A2-19: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31743) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

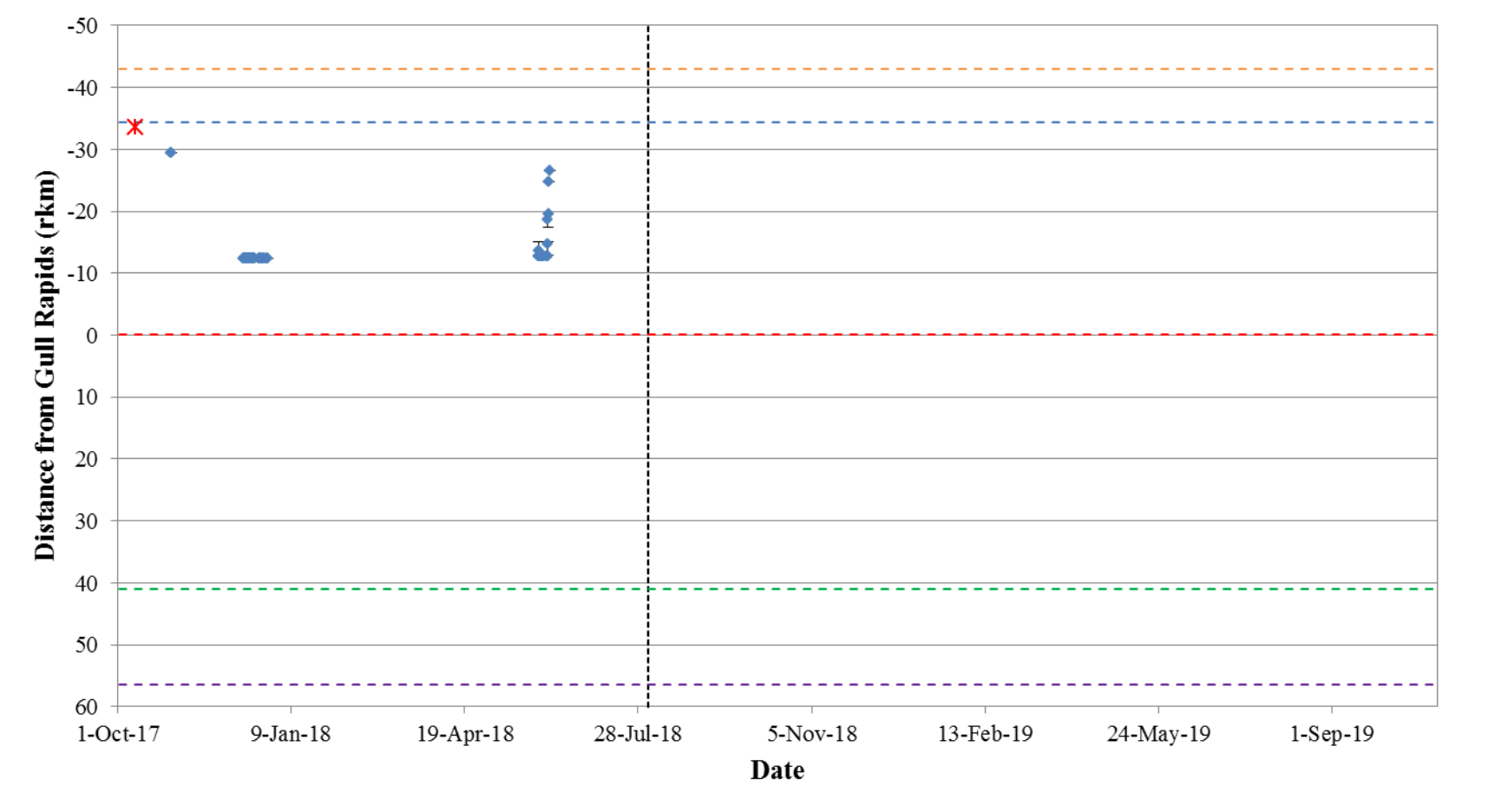


Figure A2-20: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31744) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

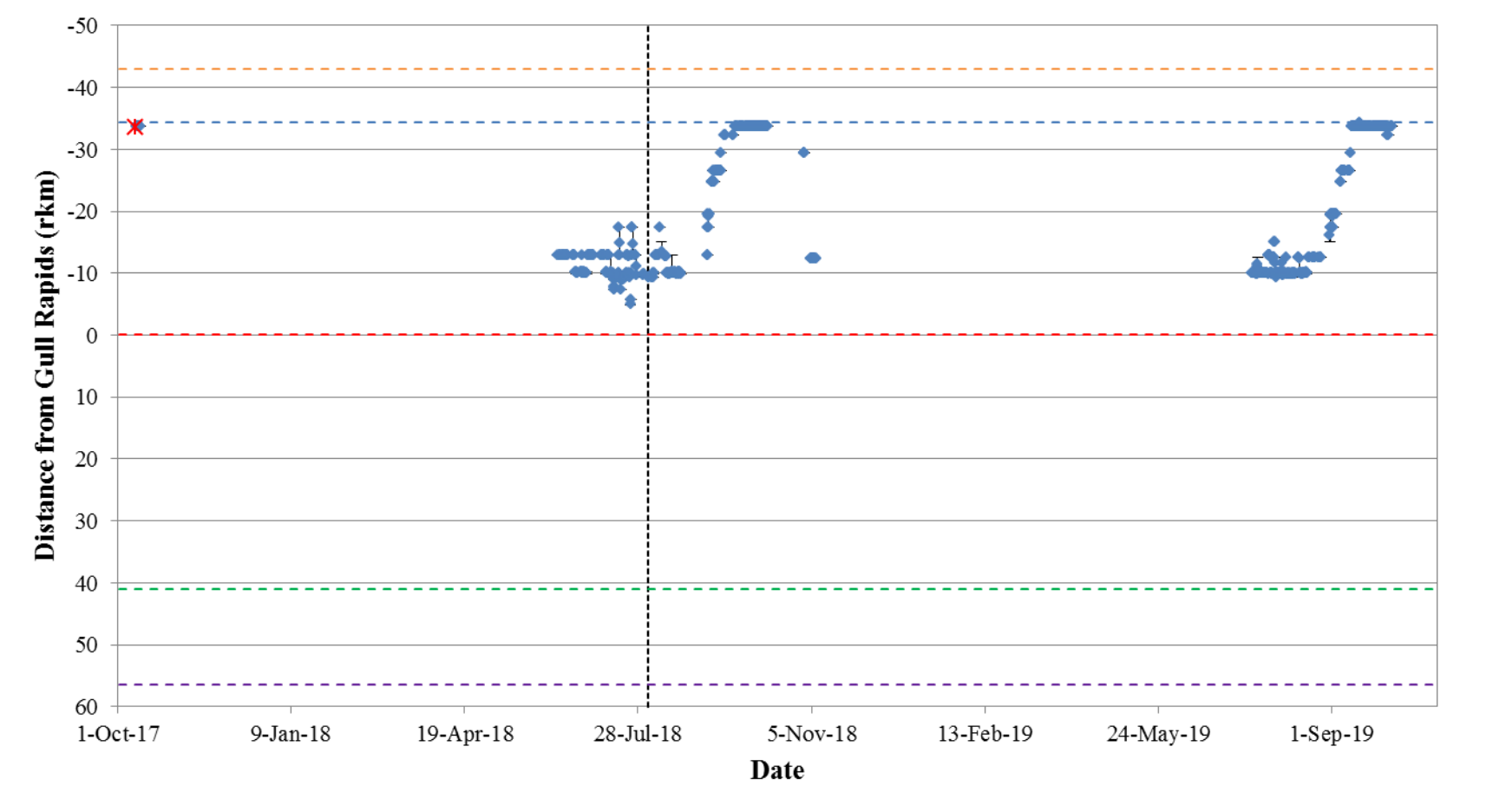


Figure A2-21: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31745) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

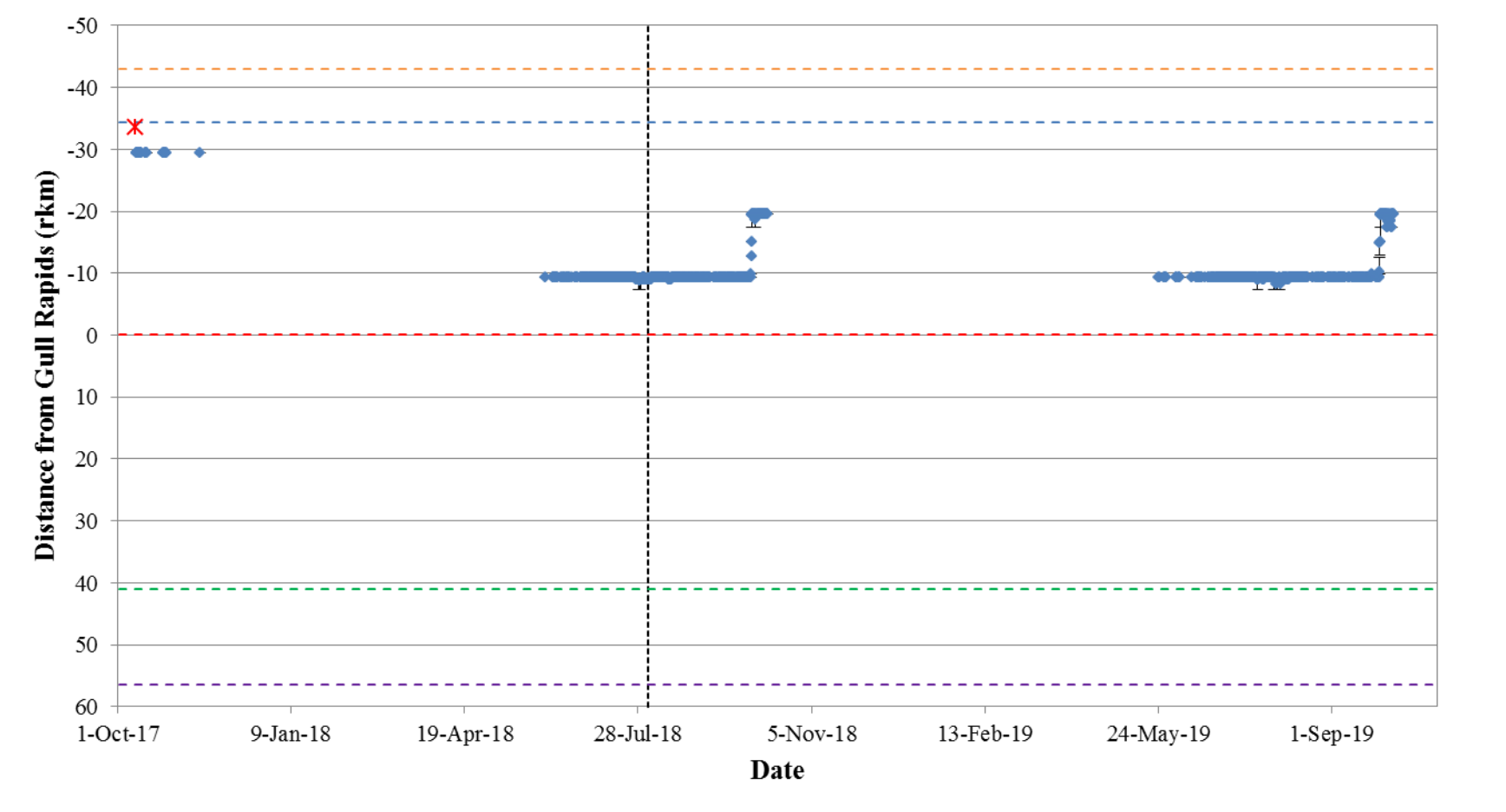


Figure A2-21: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31746) in the Nelson River between Clark Lake and the Keeyask GS, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

APPENDIX 3:
LOCATION SUMMARY FOR INDIVIDUAL ACOUSTIC-TAGGED LAKE WHITEFISH IN STEPHENS LAKE, OCTOBER 2017 TO OCTOBER 2019

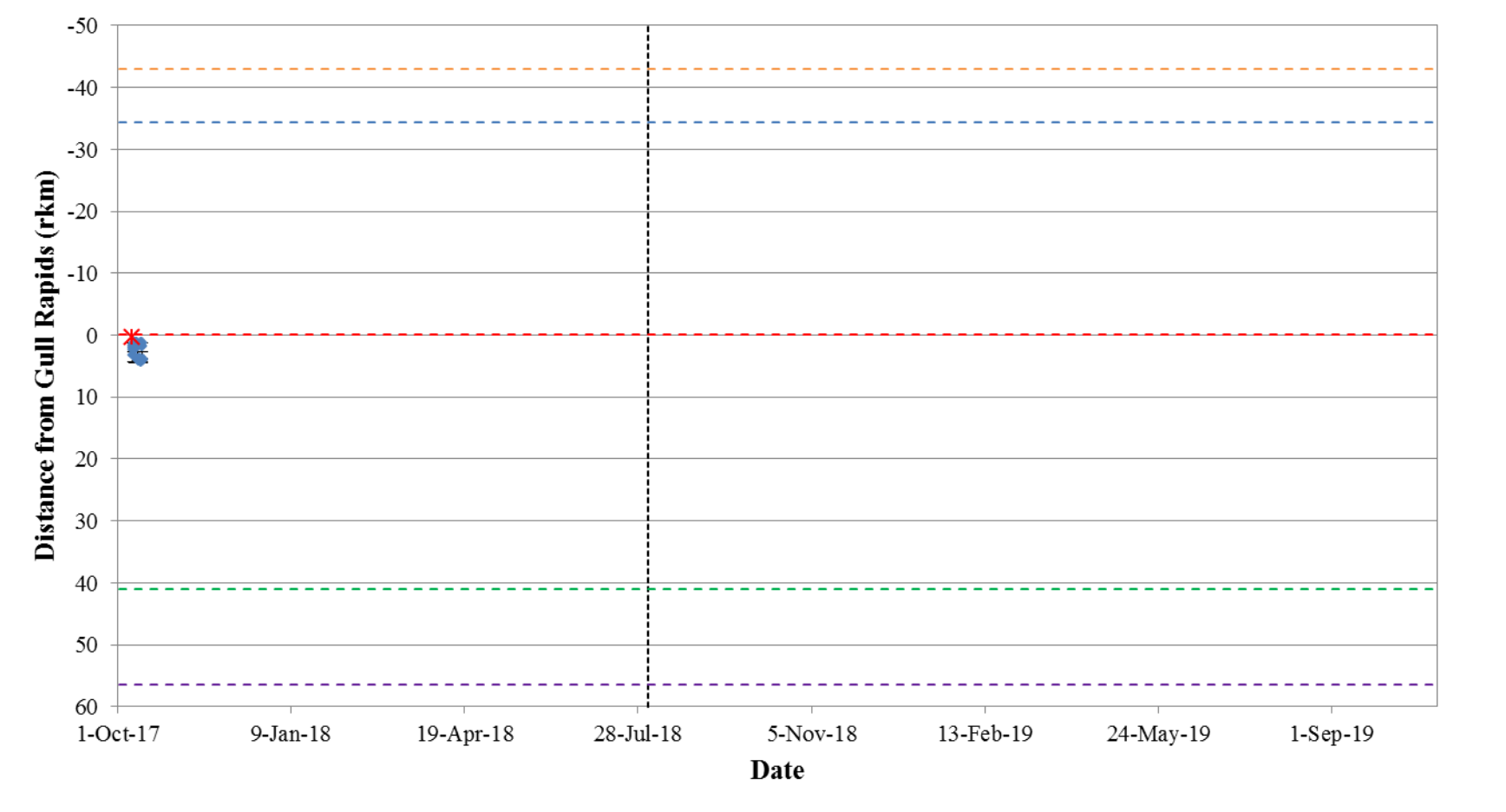


Figure A3-1: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31698) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

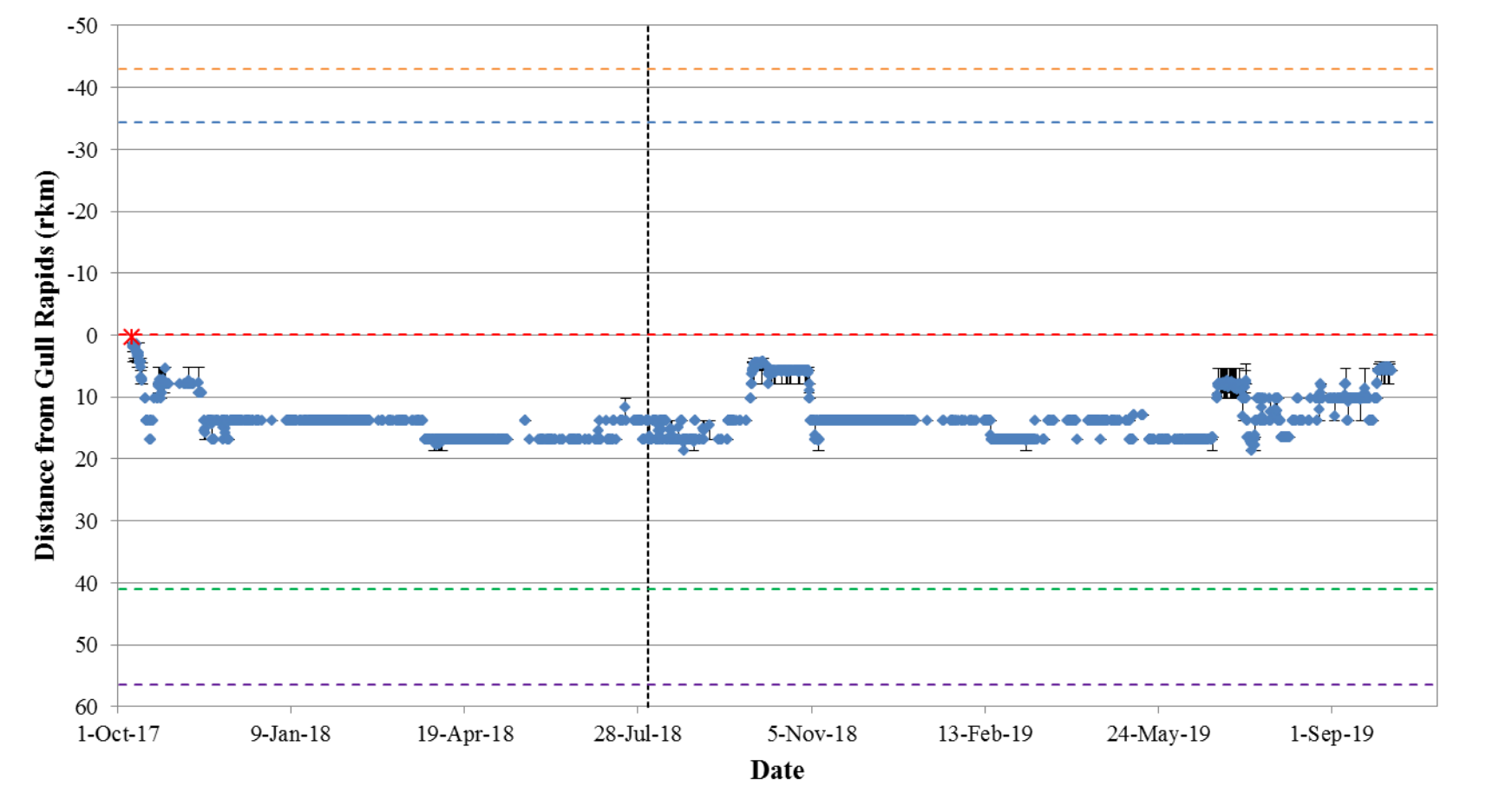


Figure A3-2: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31699) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

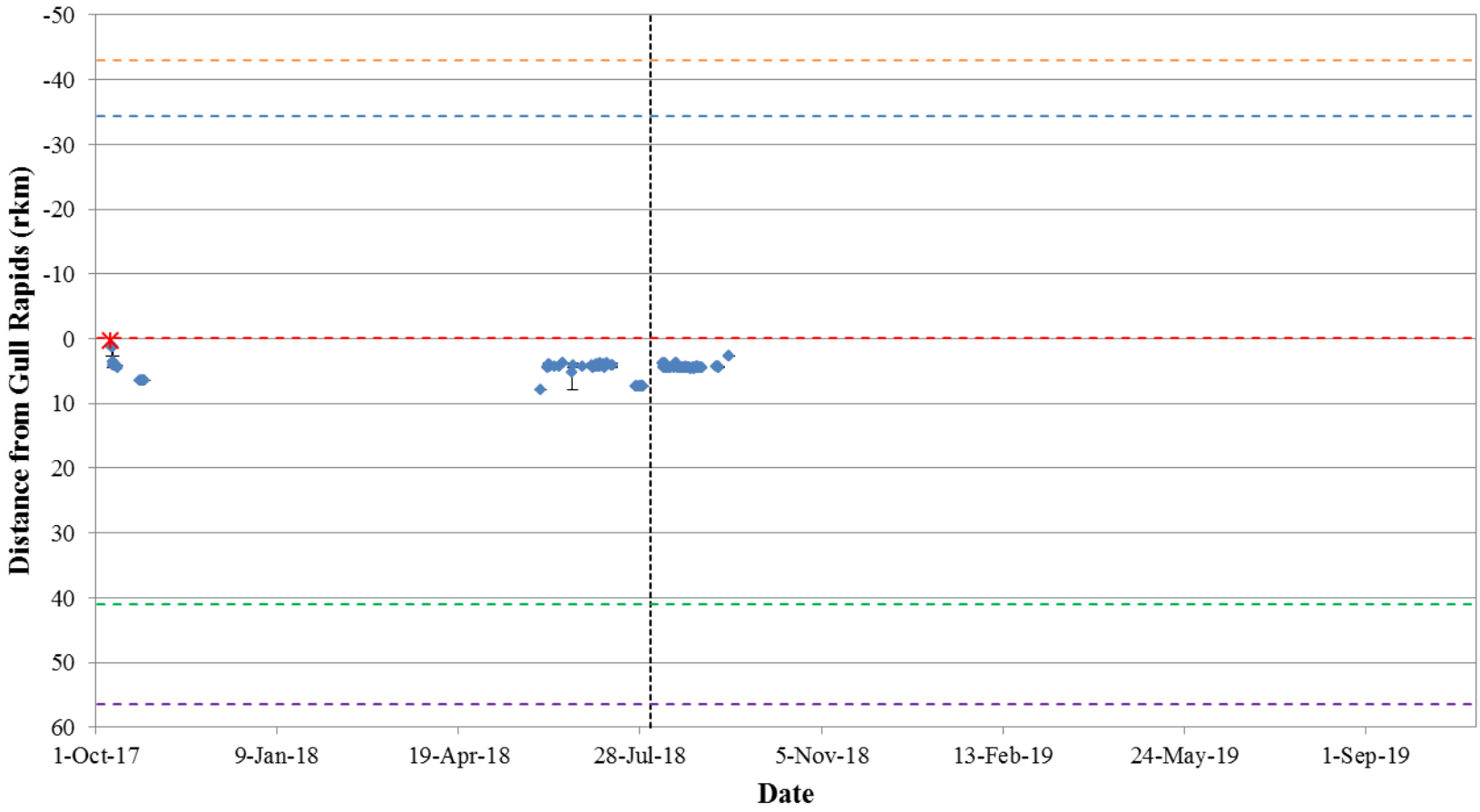


Figure A3-3: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31700) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

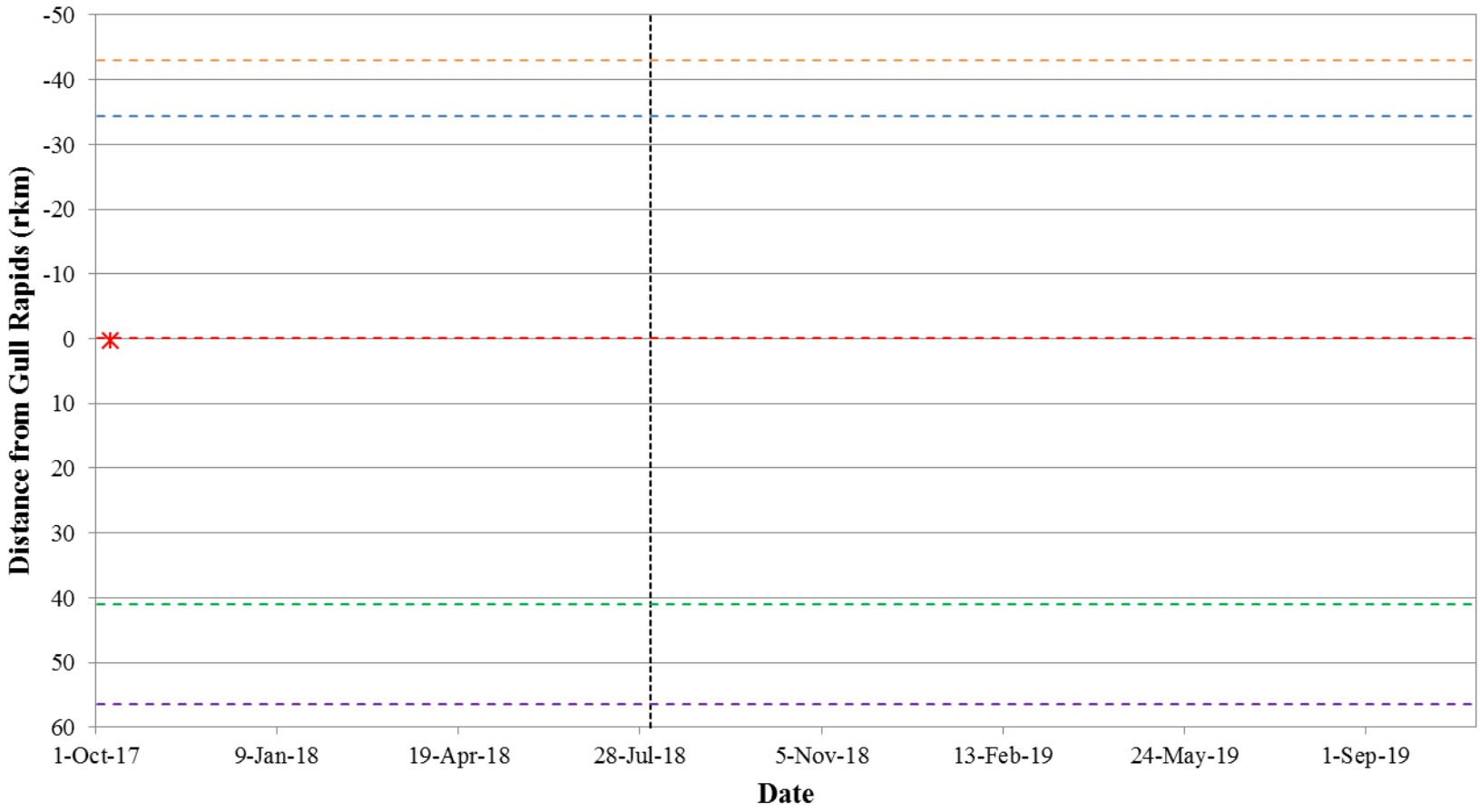


Figure A3-4: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31701) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

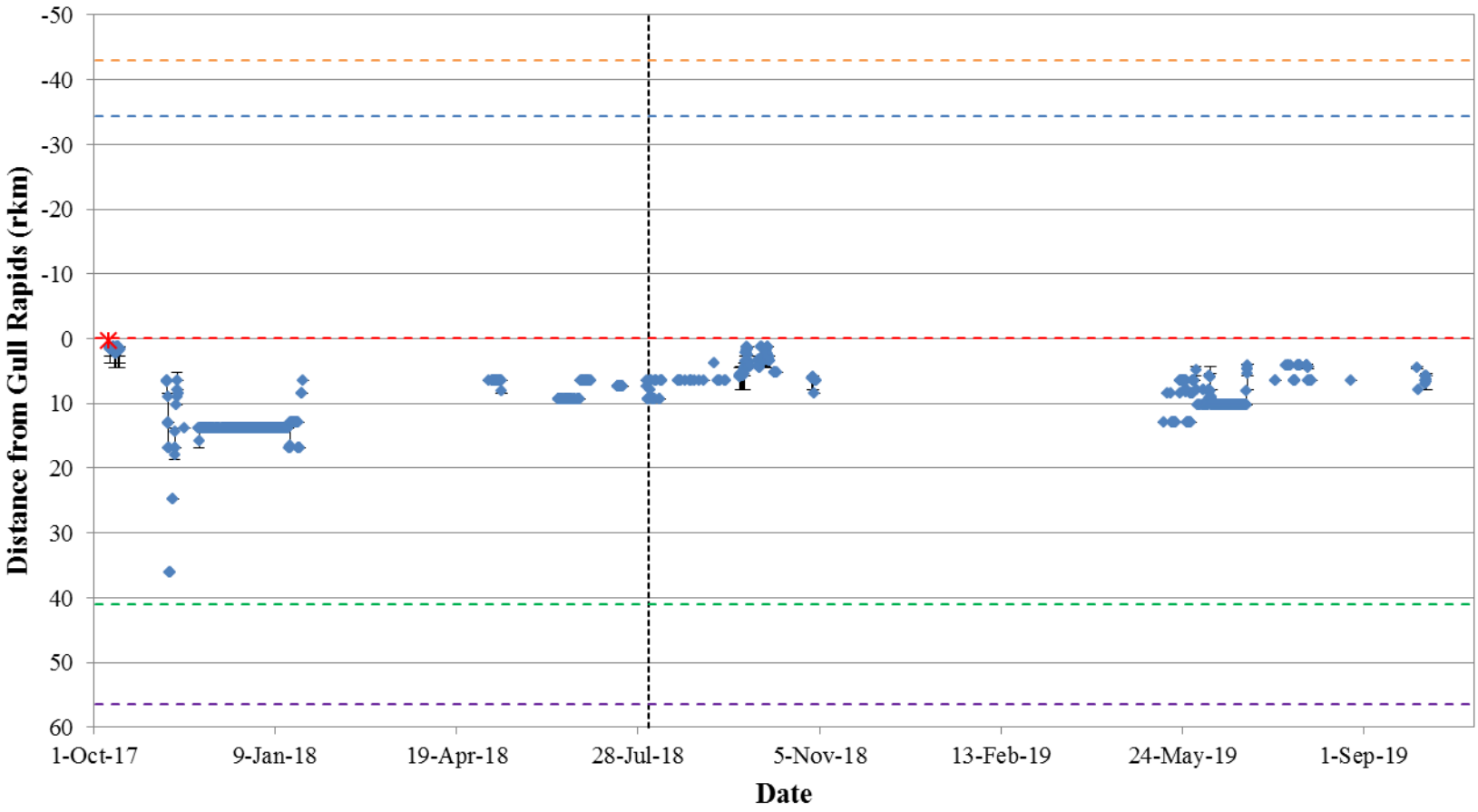


Figure A3-5: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31702) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

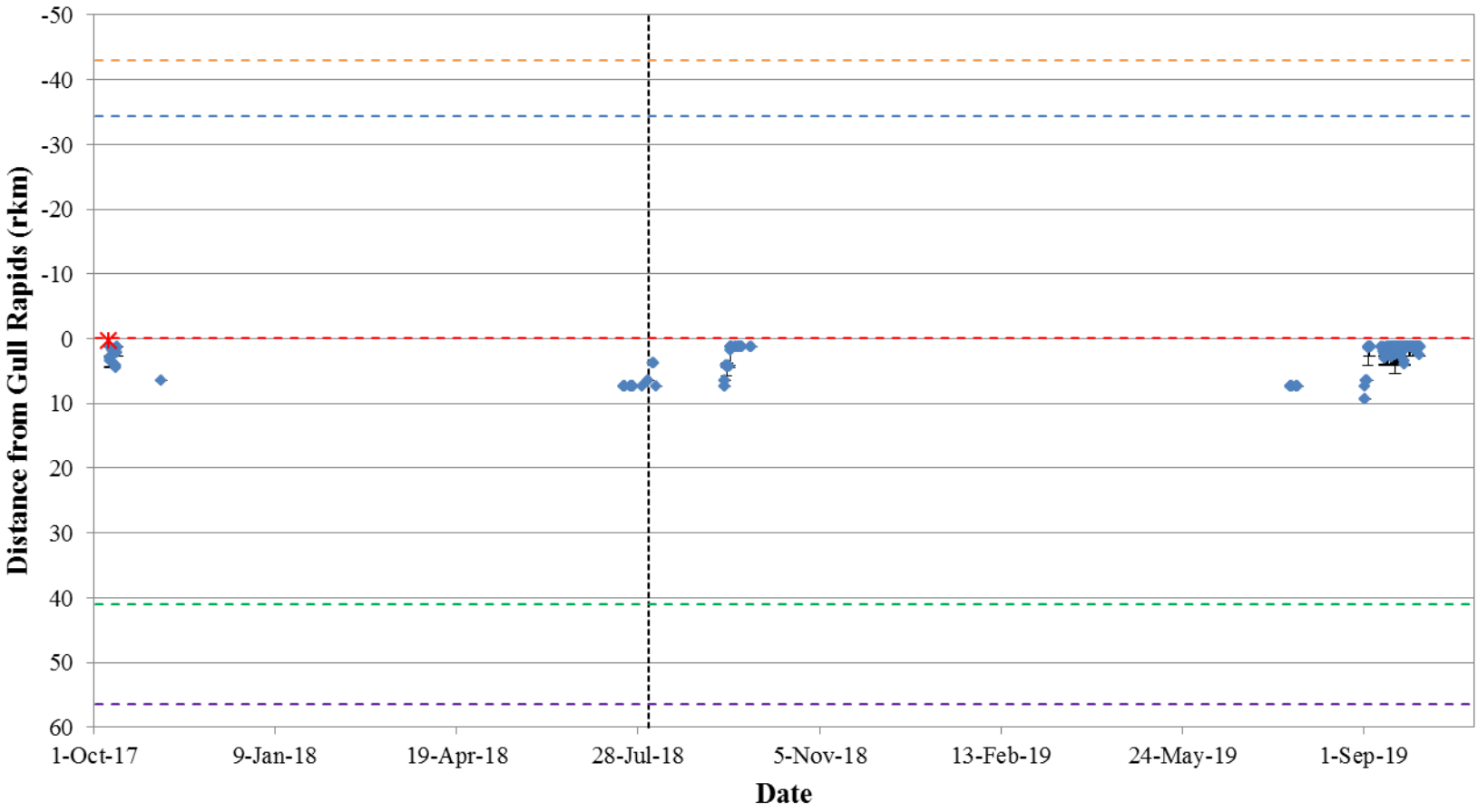


Figure A3-6: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31703) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

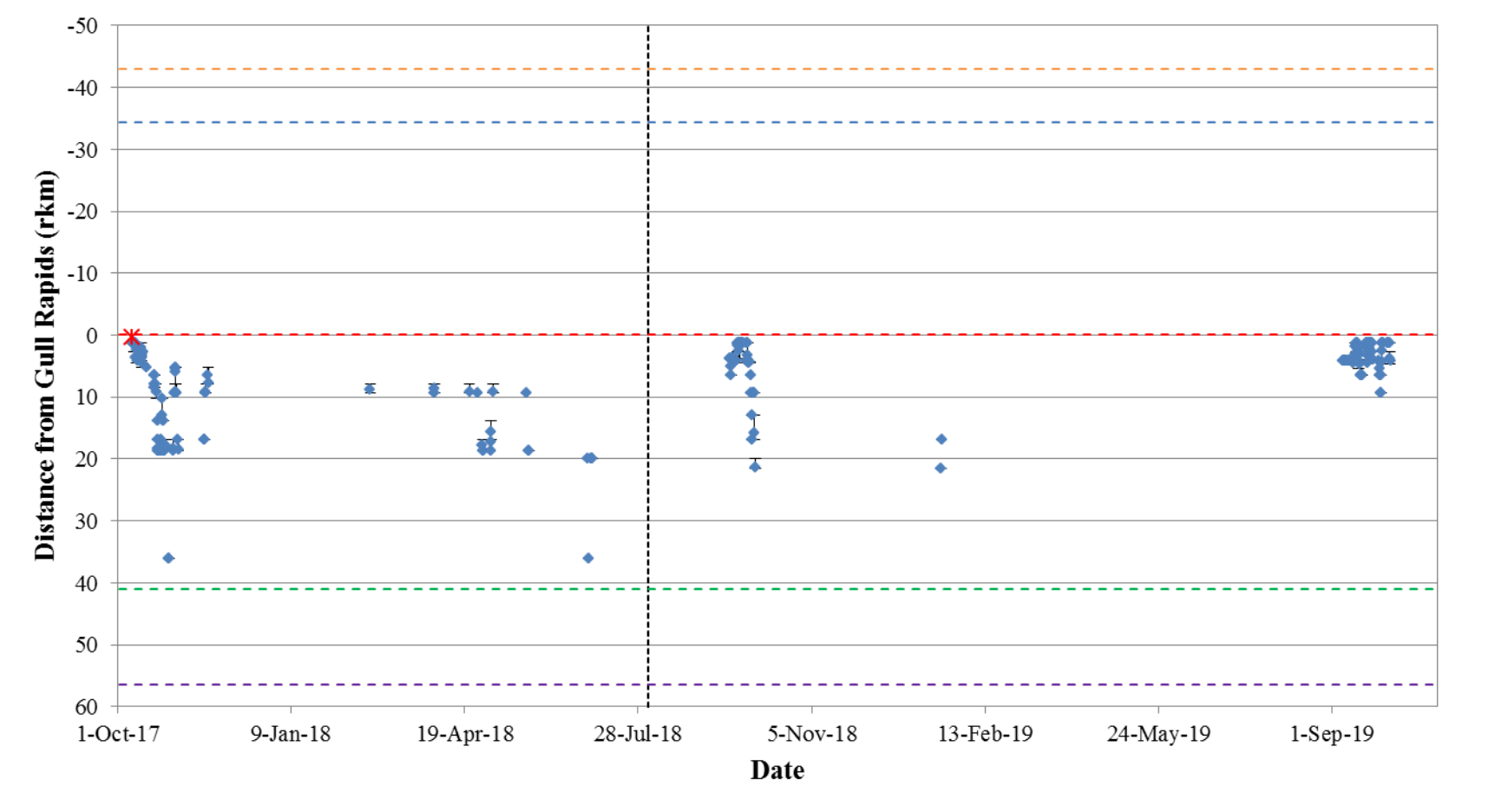


Figure A3-7: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31704) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

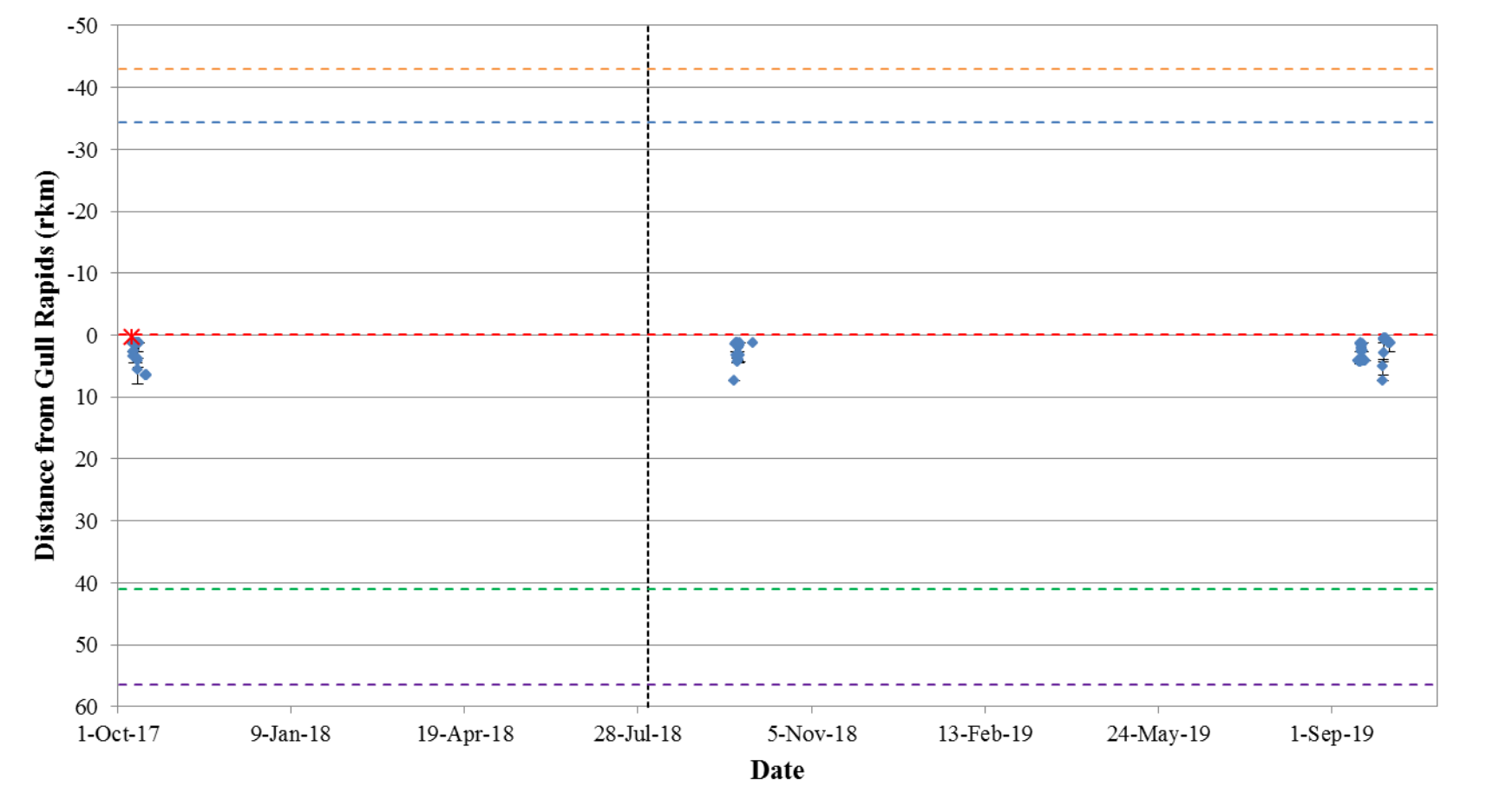


Figure A3-8: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31705) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

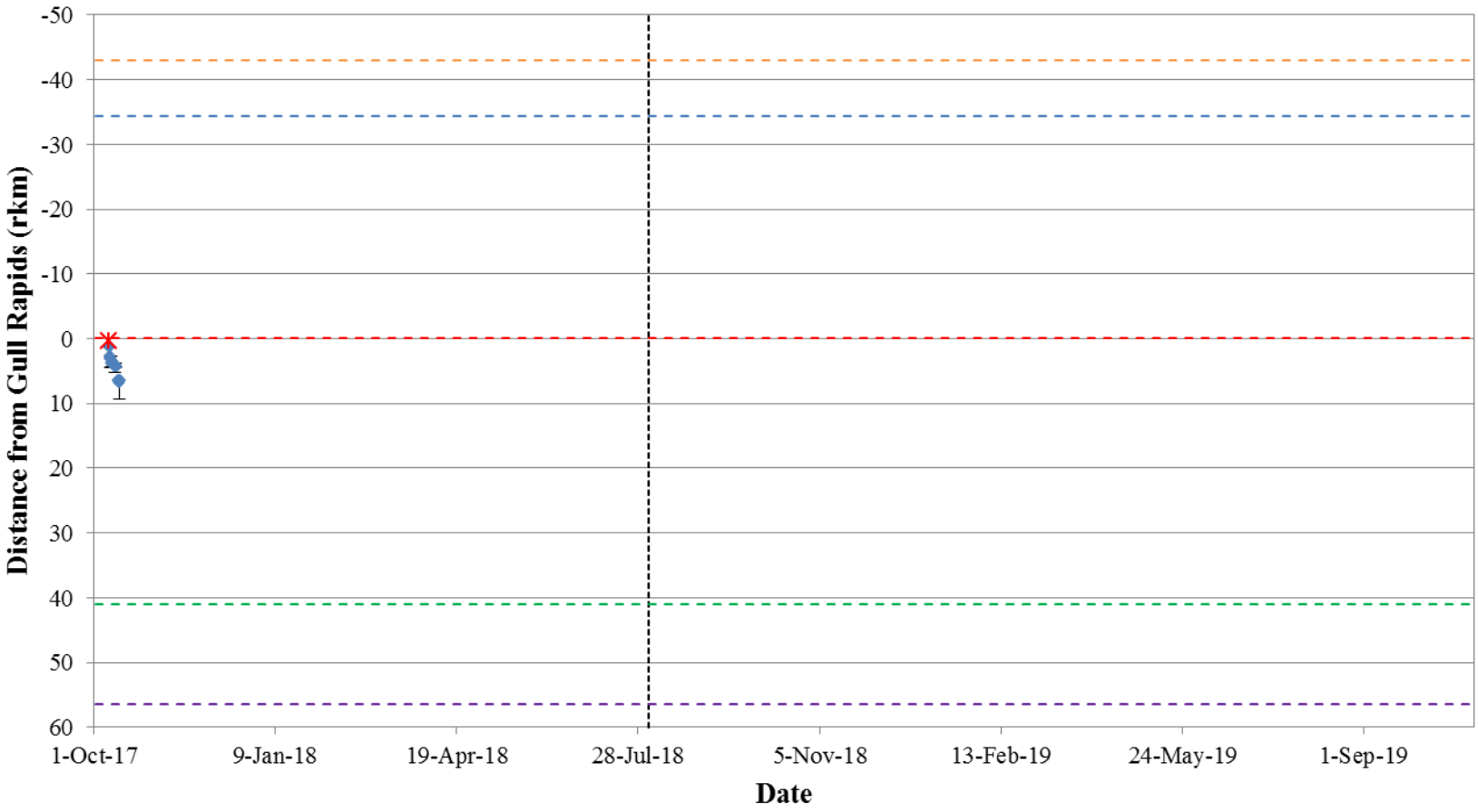


Figure A3-9: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31706) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

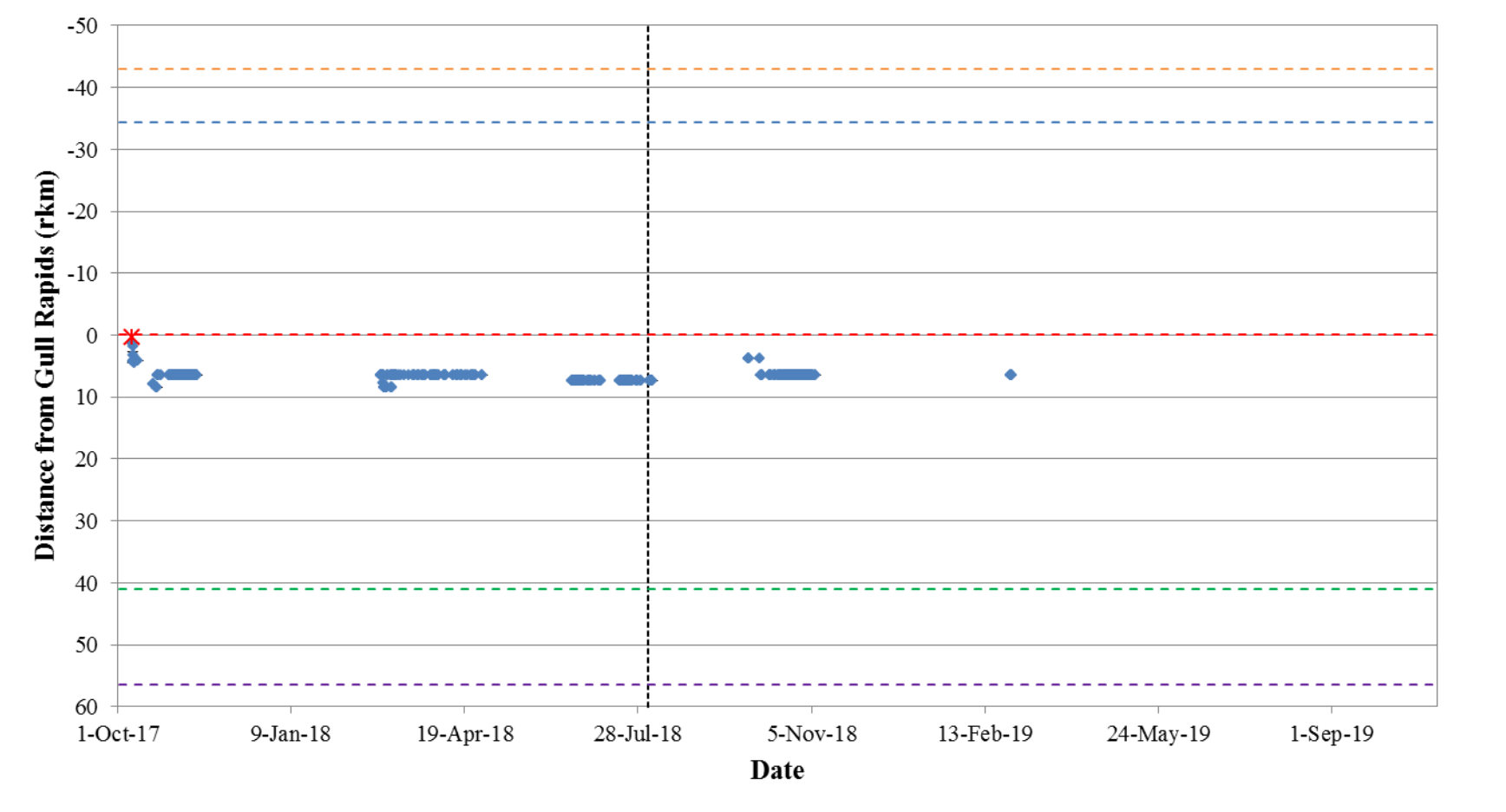


Figure A3-10: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31707) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

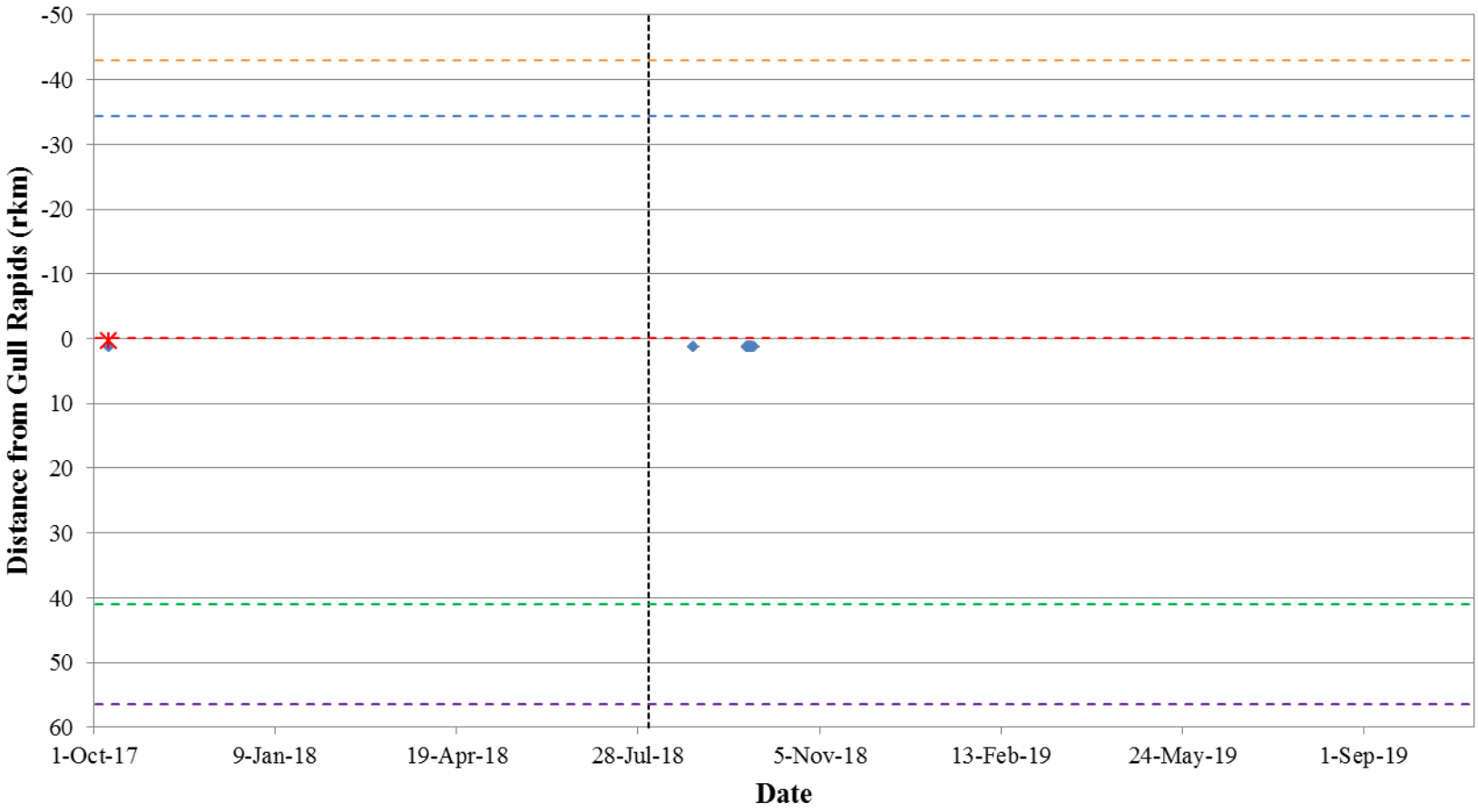


Figure A3-11: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31708) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

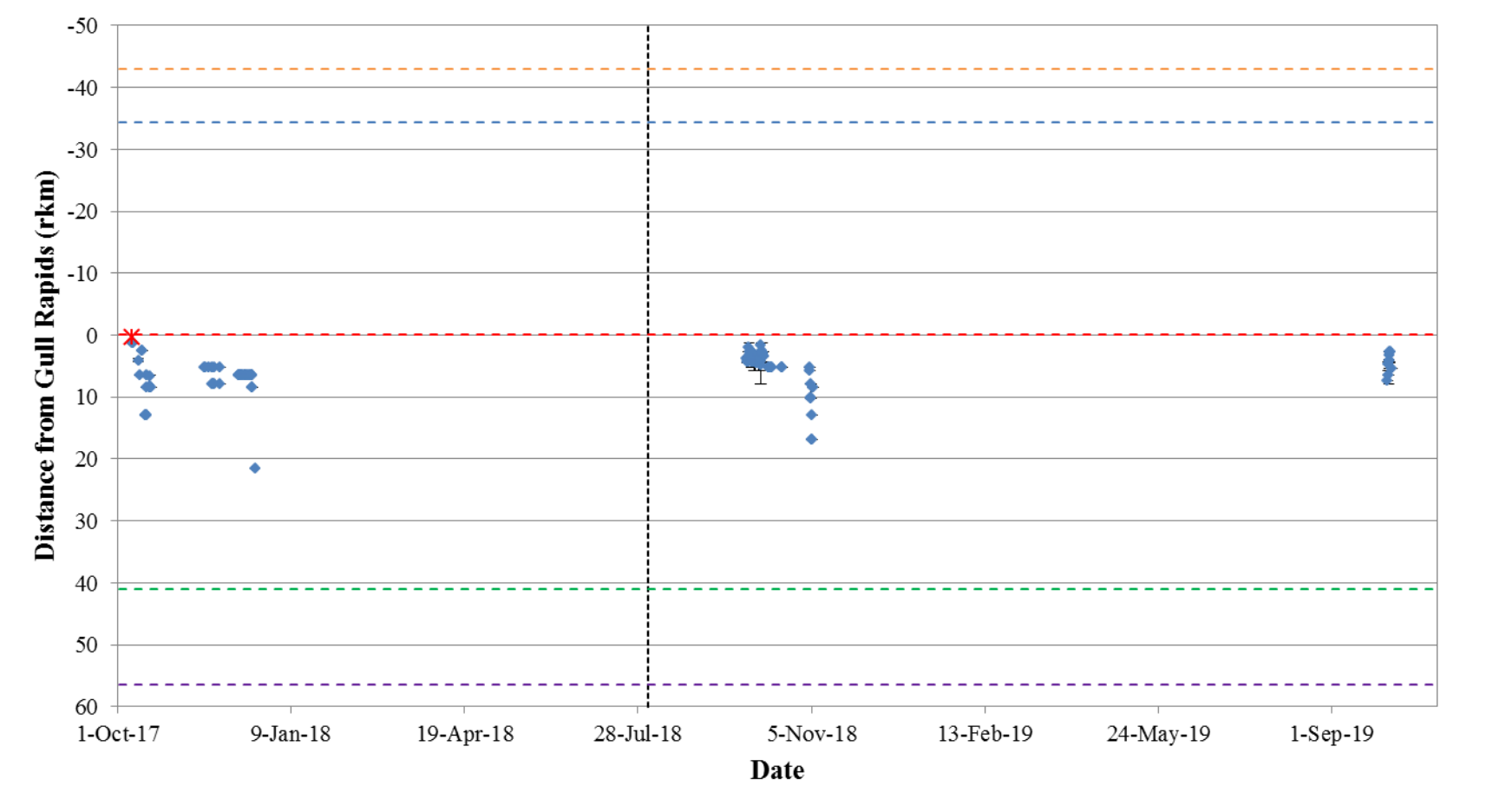


Figure A3-12: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31709) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

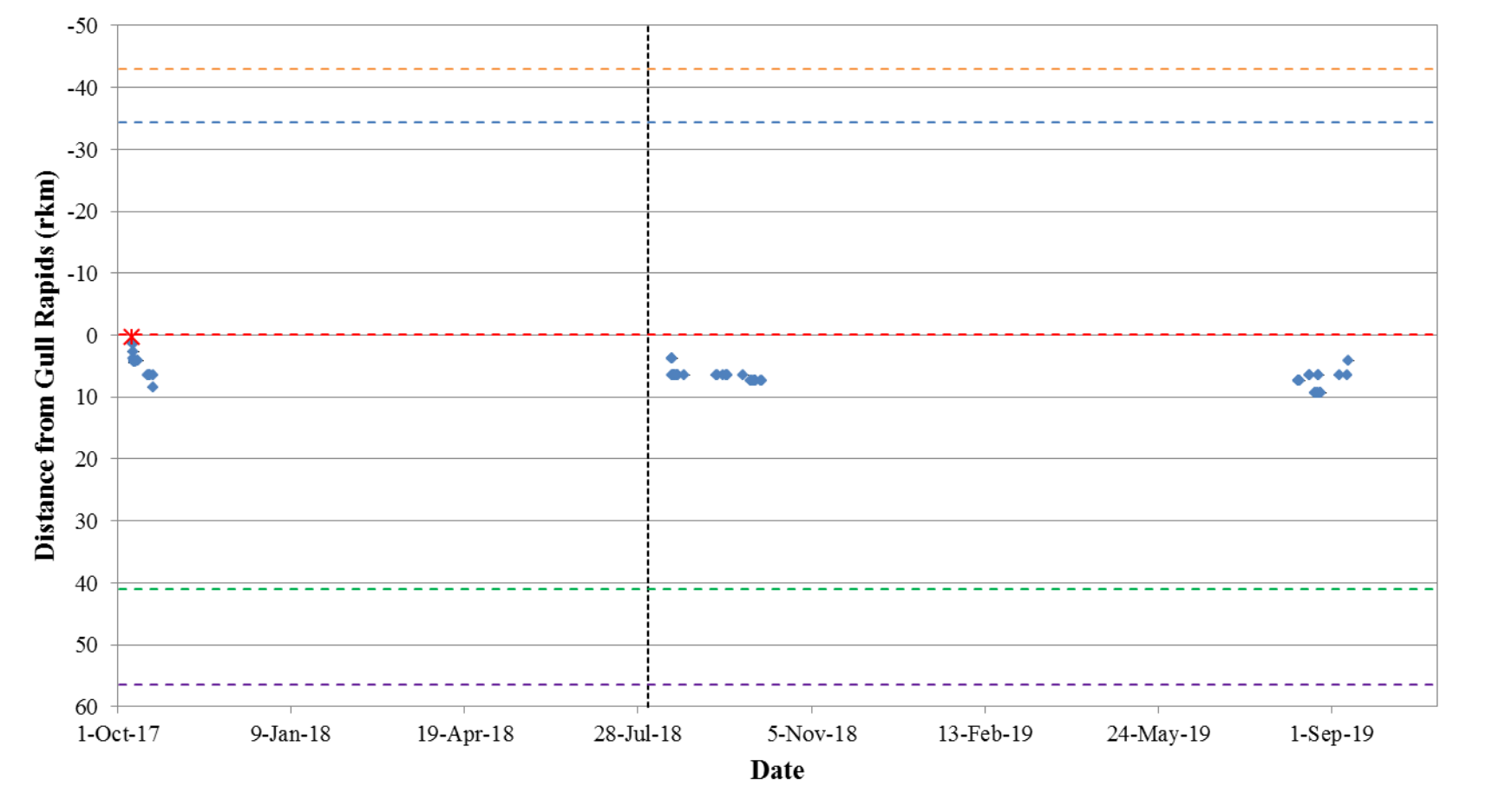


Figure A3-13: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31710) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

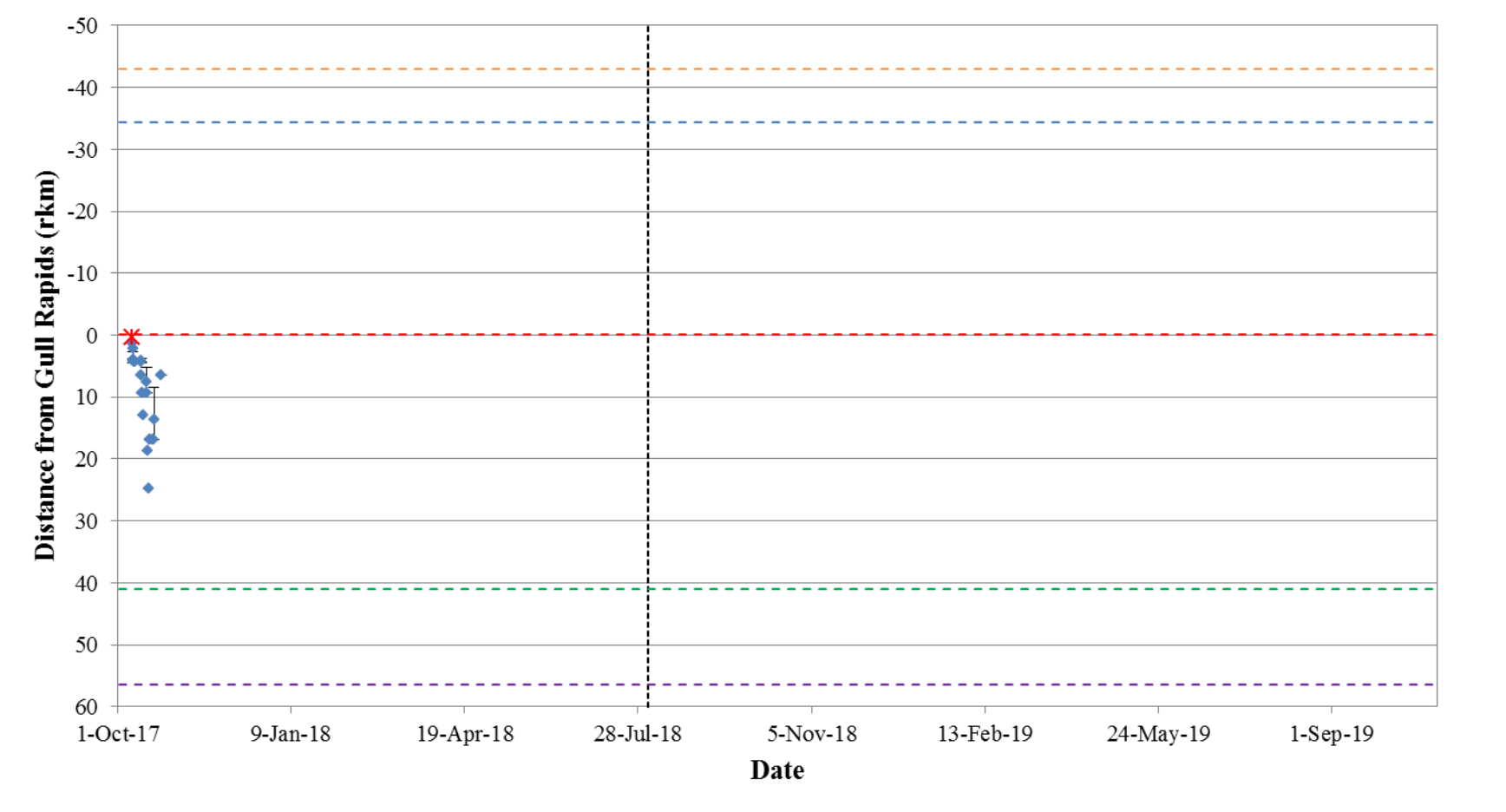


Figure A3-14: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31711) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

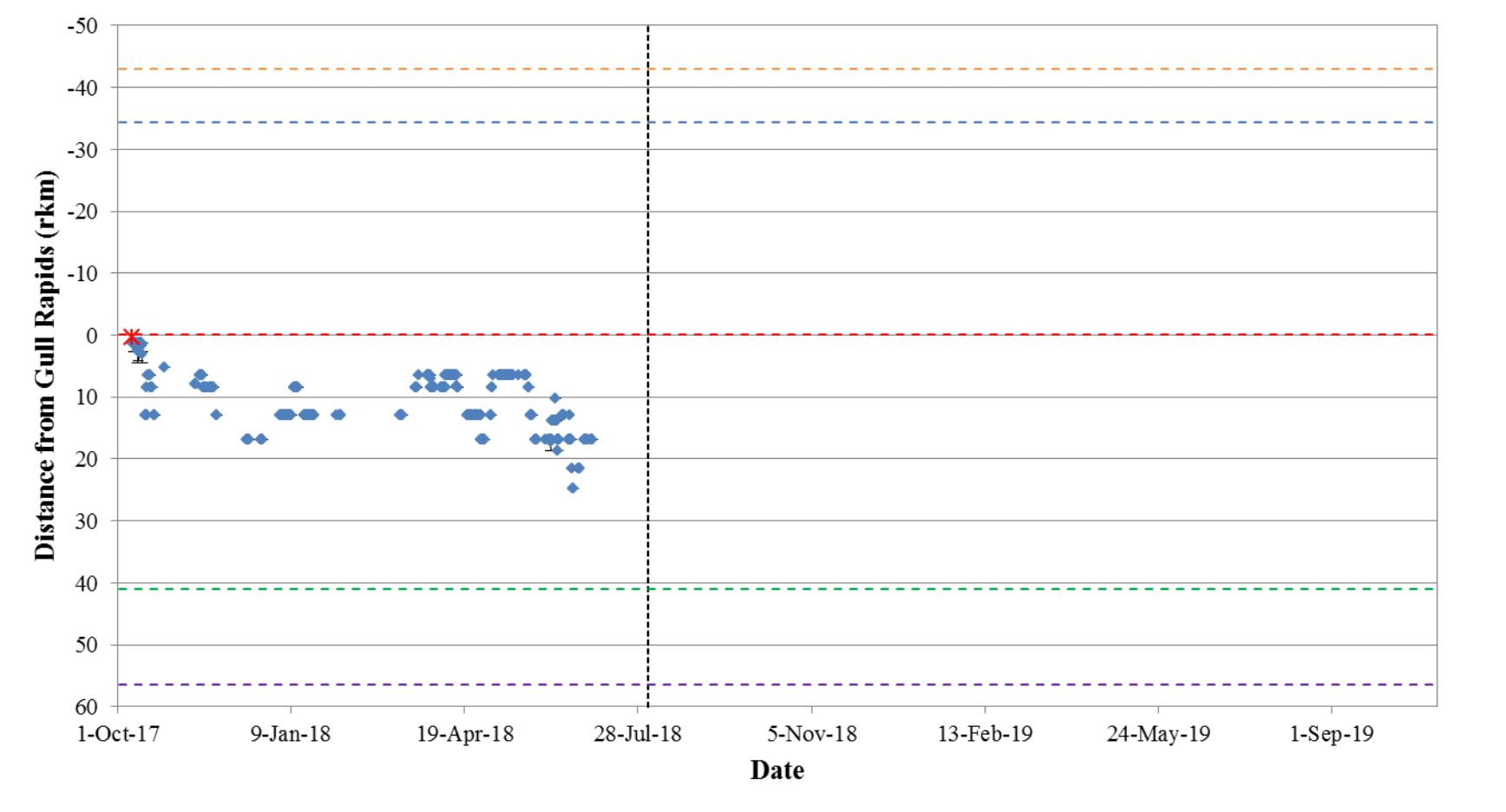


Figure A3-15: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31712) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

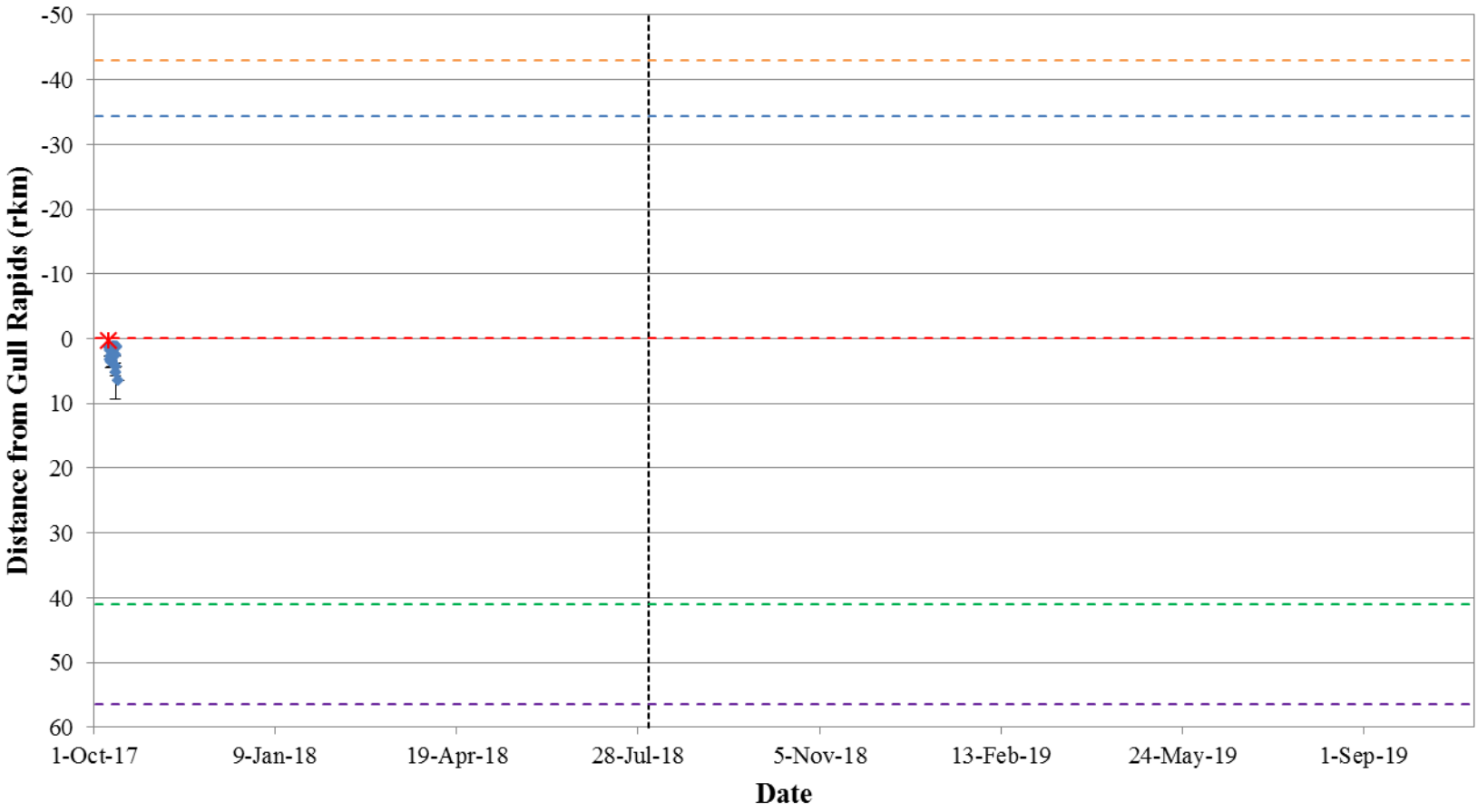


Figure A3-16: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31713) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

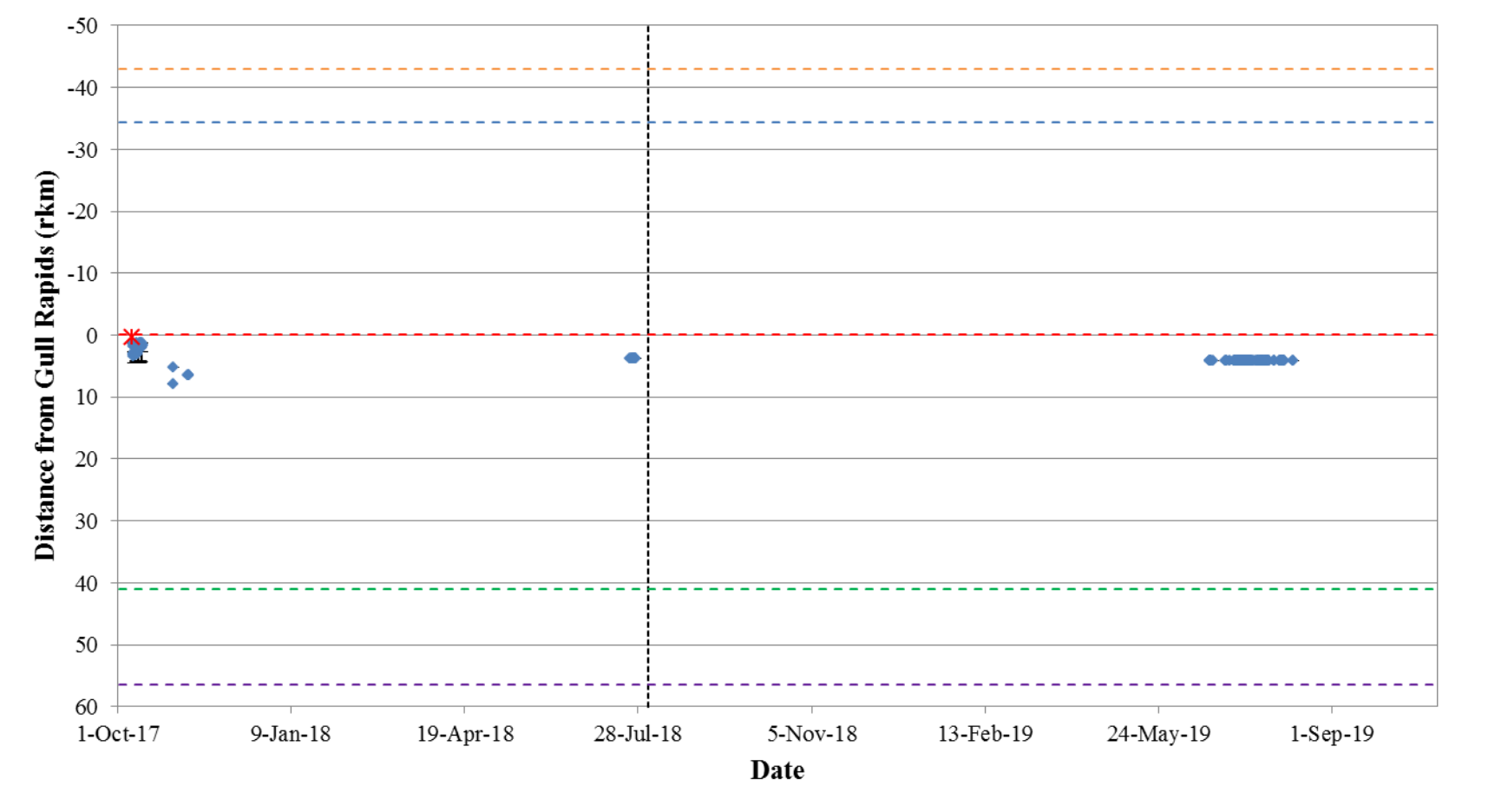


Figure A3-17: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31714) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

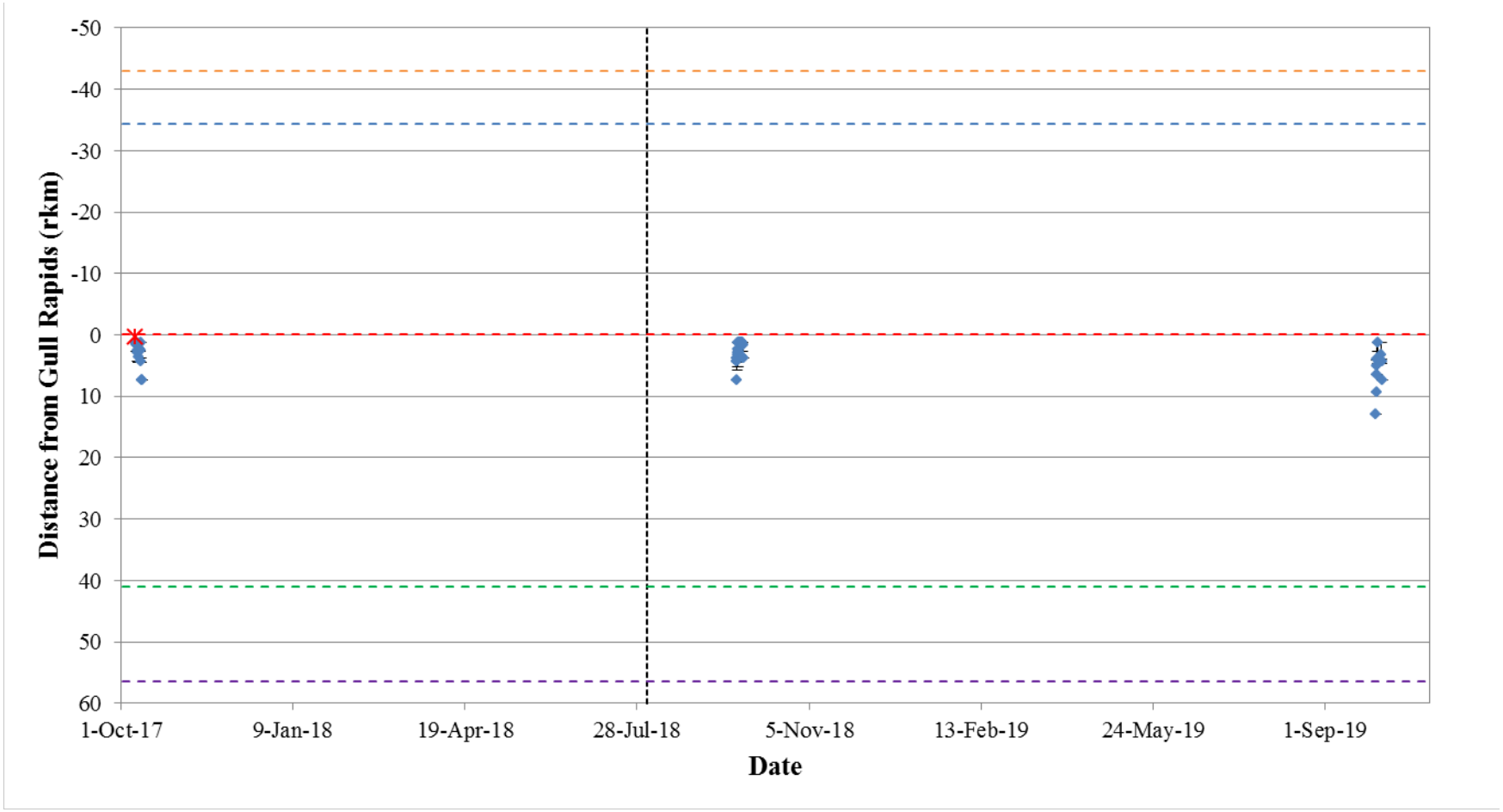


Figure A3-18: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31715) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

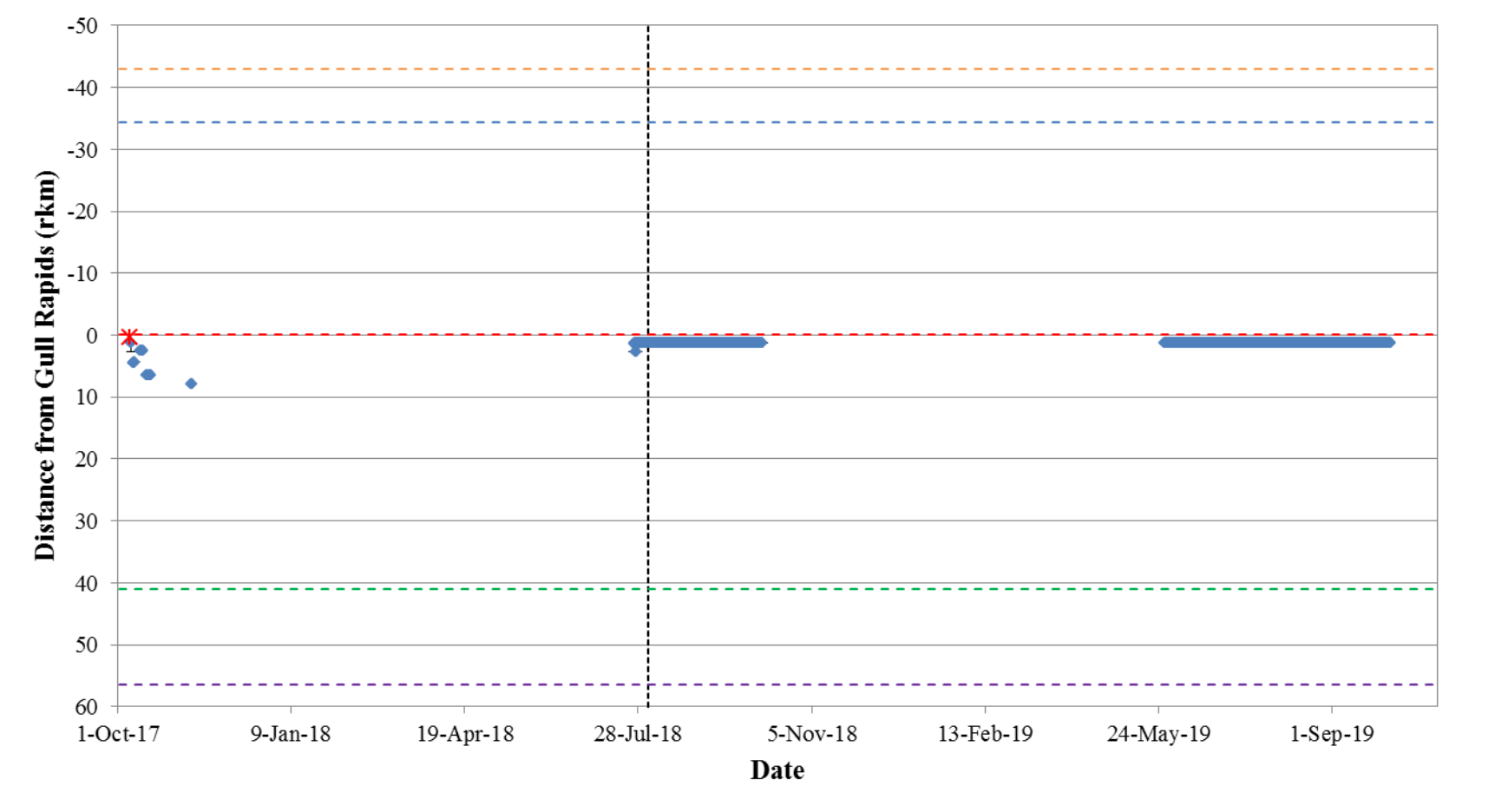


Figure A3-19: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31716) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

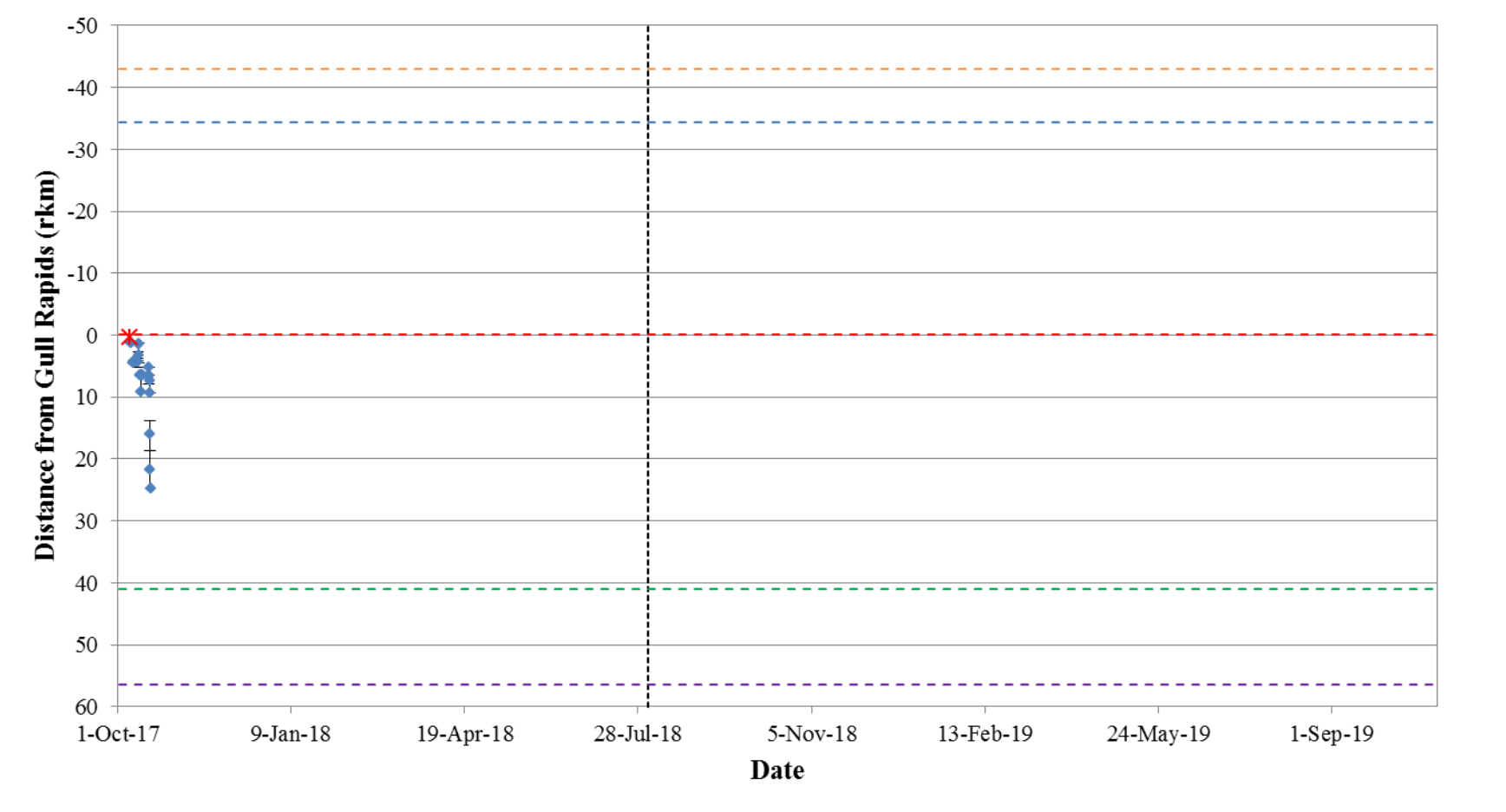


Figure A3-20: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31717) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

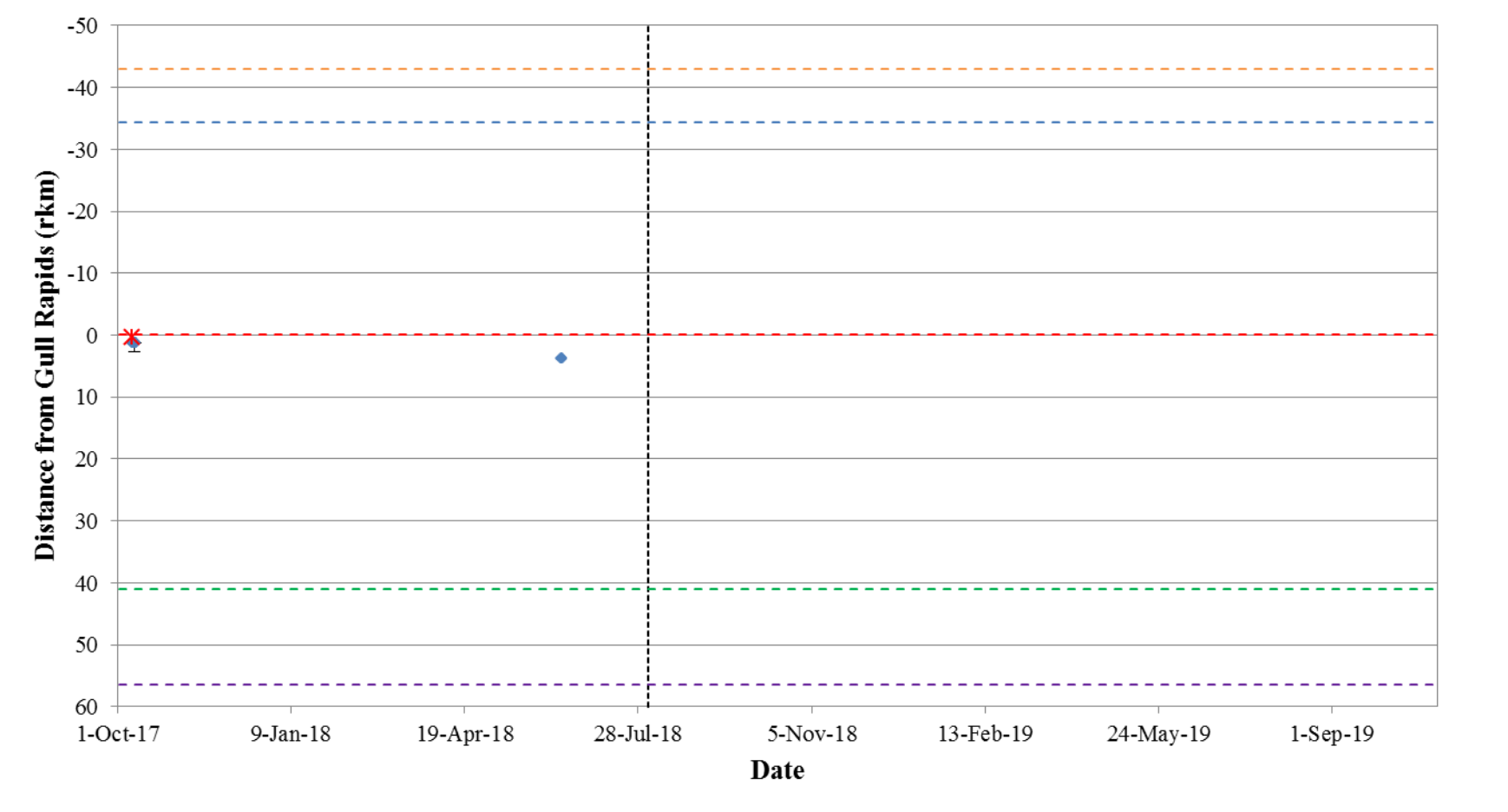


Figure A3-21: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31718) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

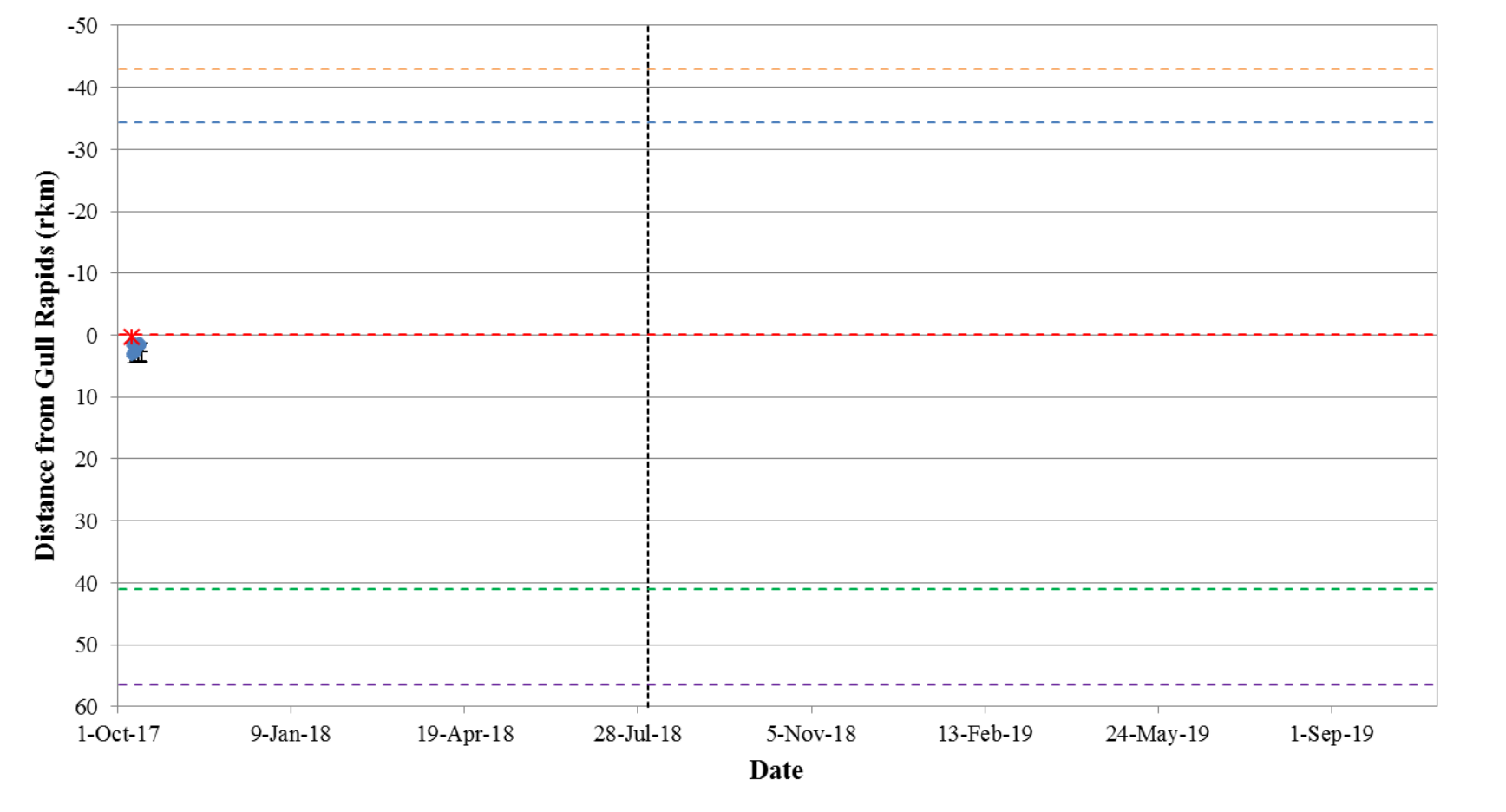


Figure A3-22: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31719) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

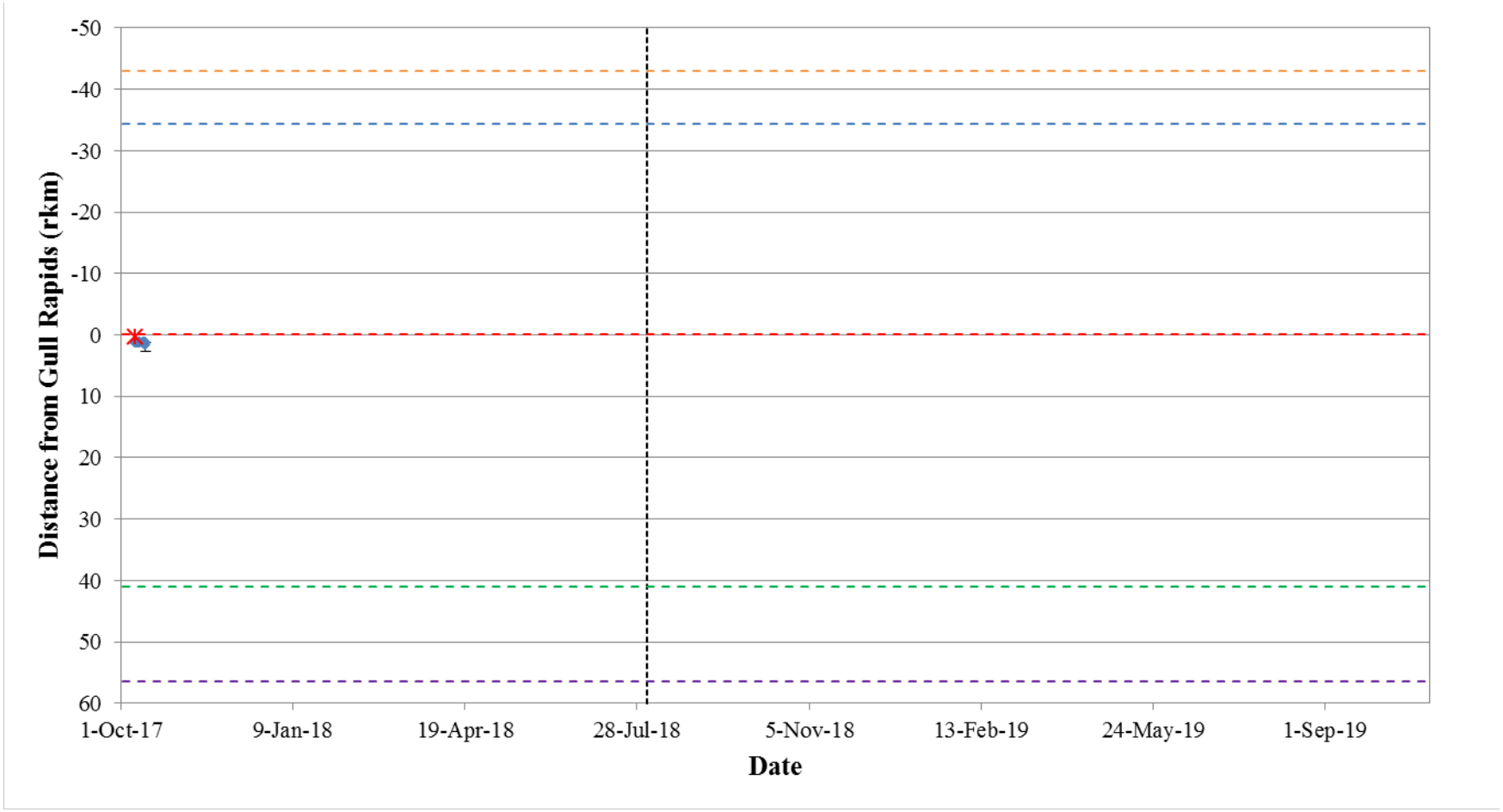


Figure A3-23: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31720) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

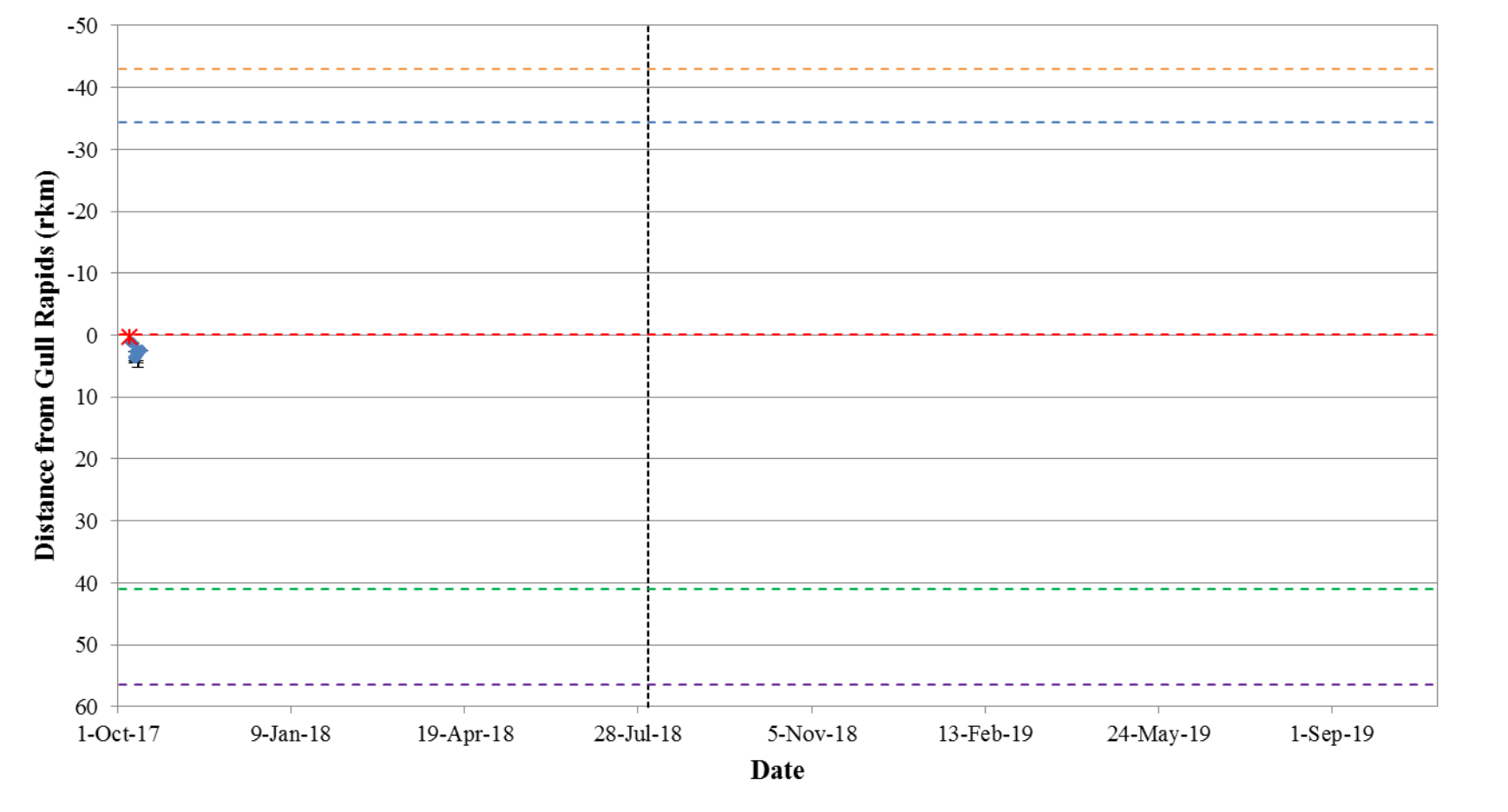


Figure A3-24: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31721) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

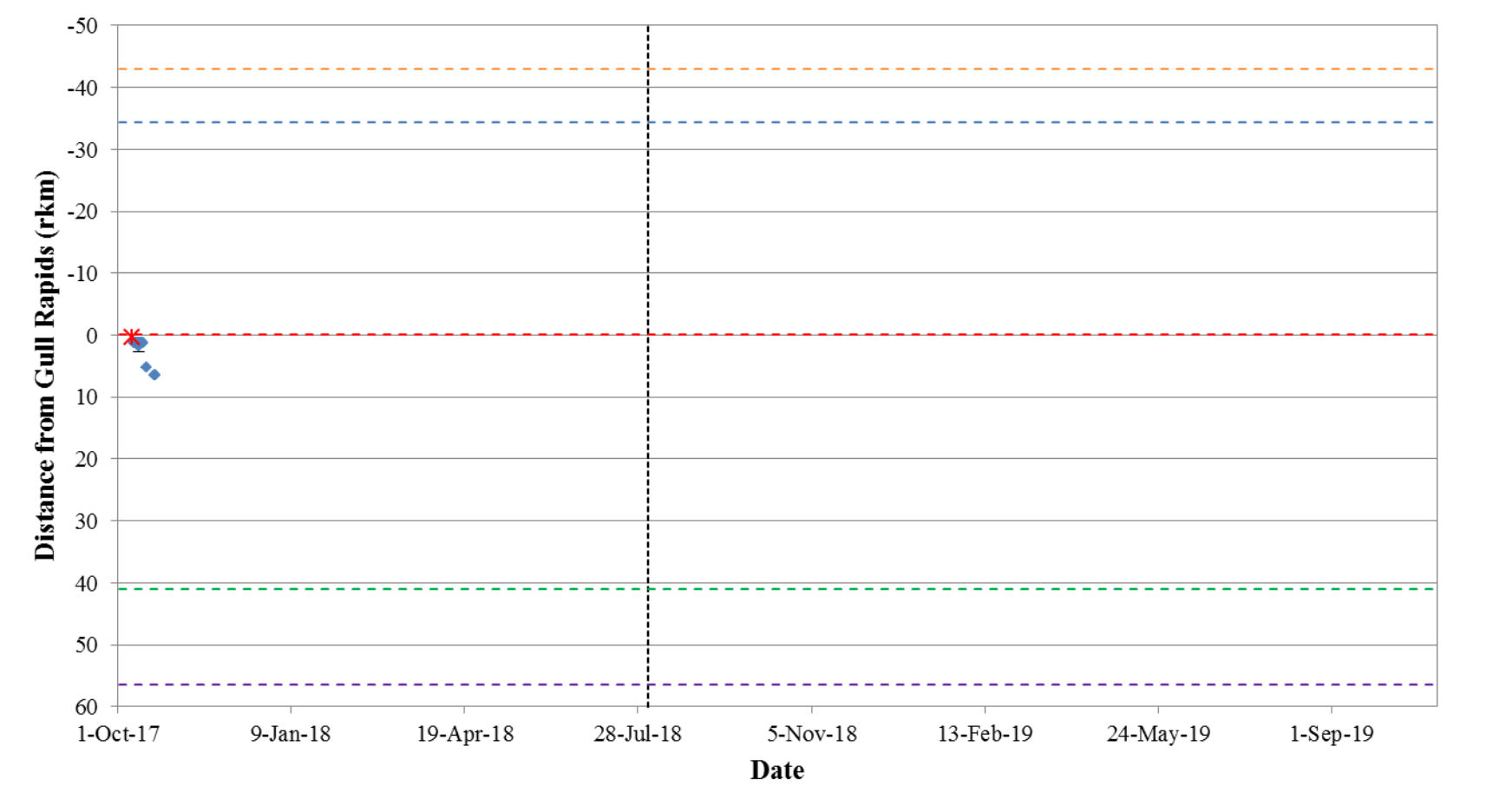


Figure A3-25: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31723) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

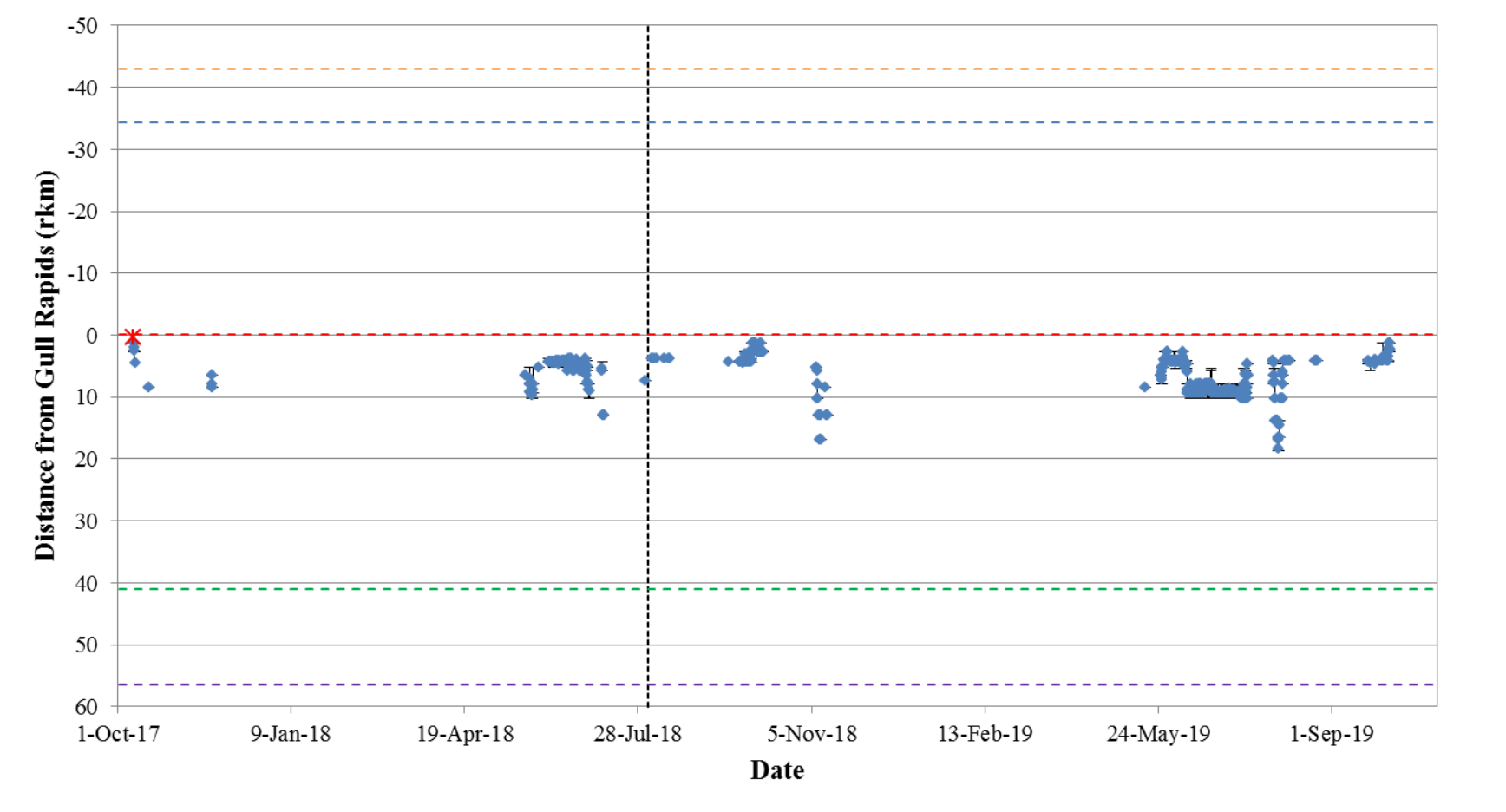


Figure A3-26: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31724) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

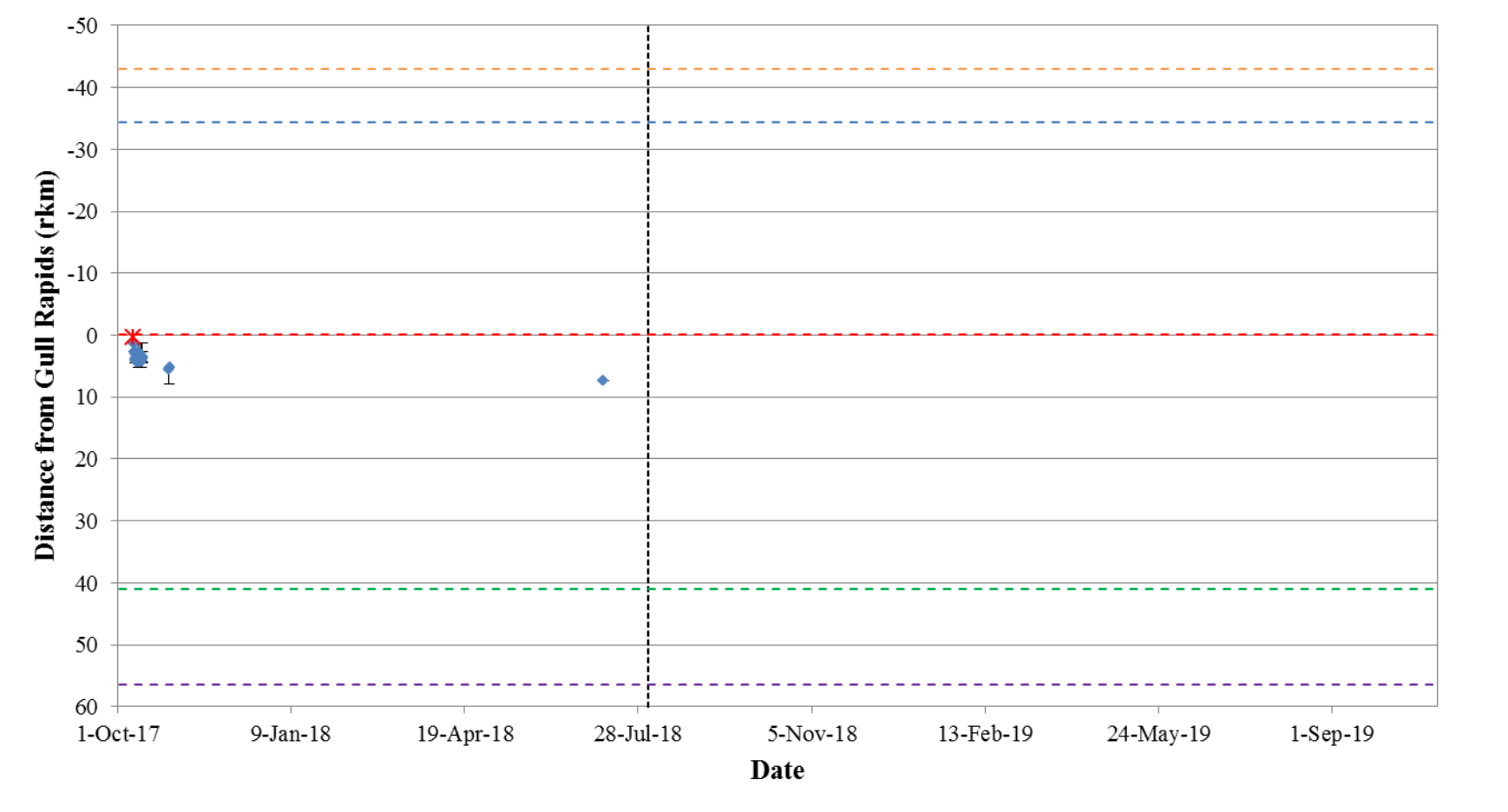


Figure A3-27: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31725) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

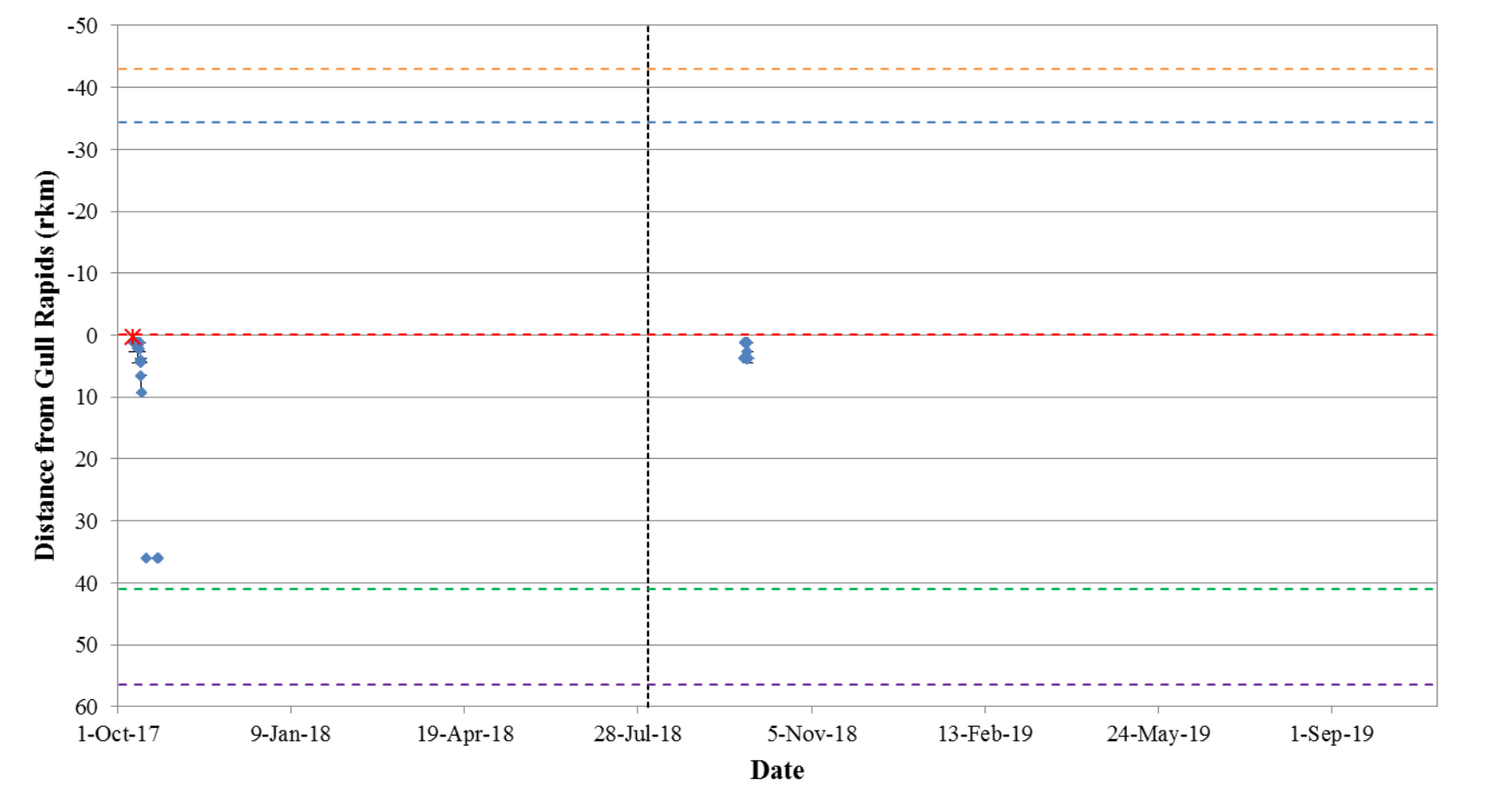


Figure A3-28: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31747) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

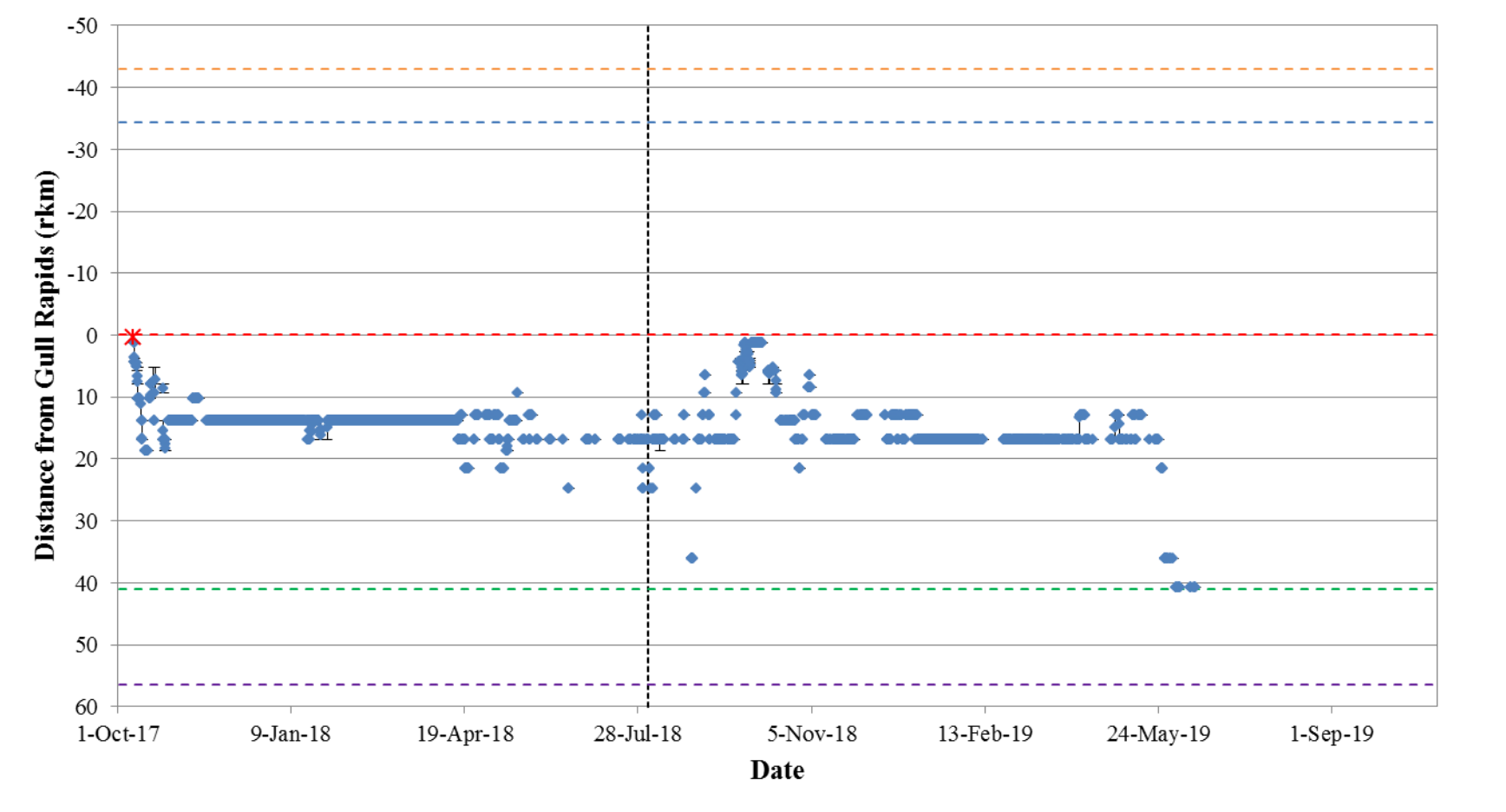


Figure A3-29: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31748) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

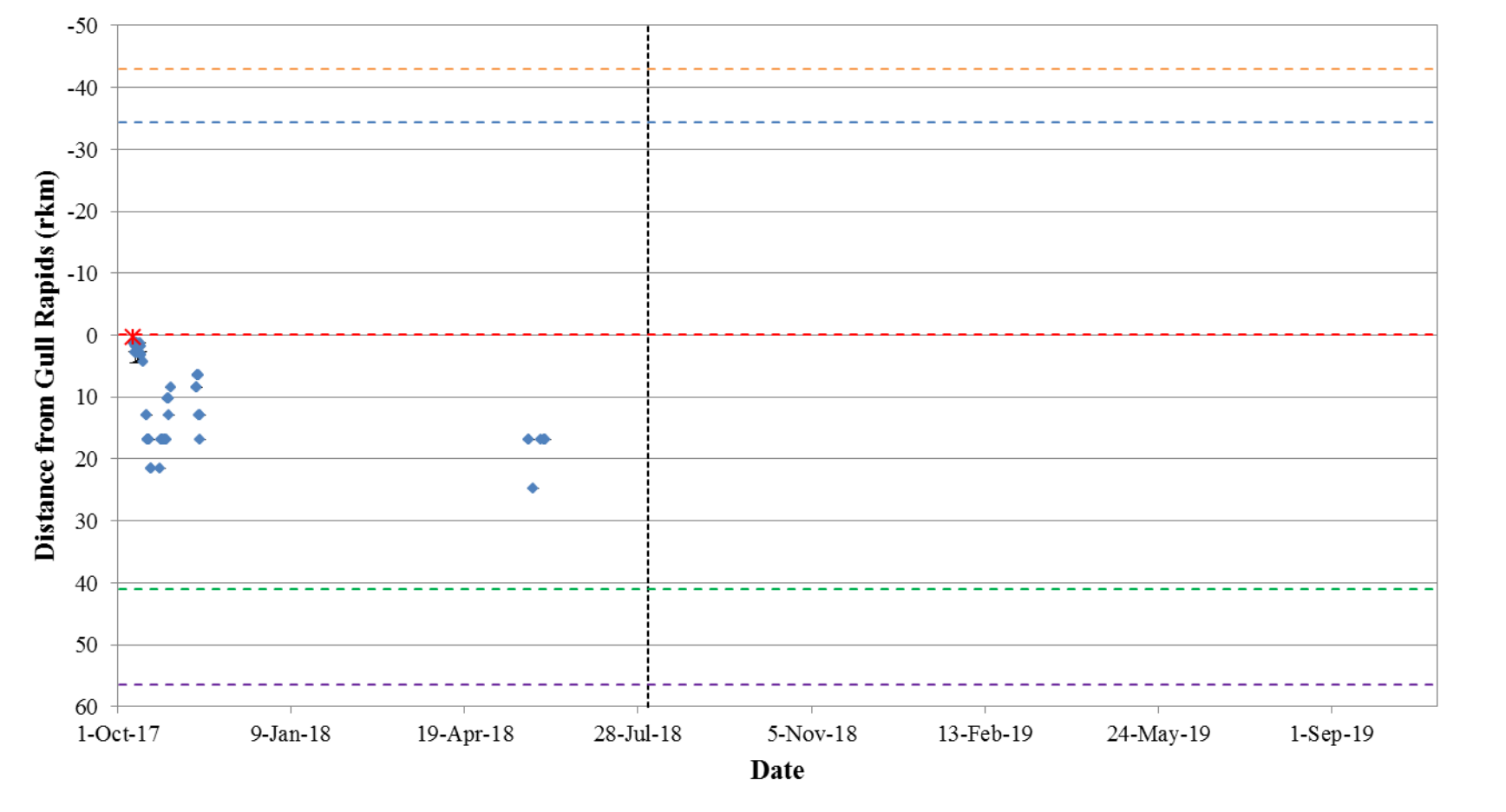


Figure A3-30: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31749) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

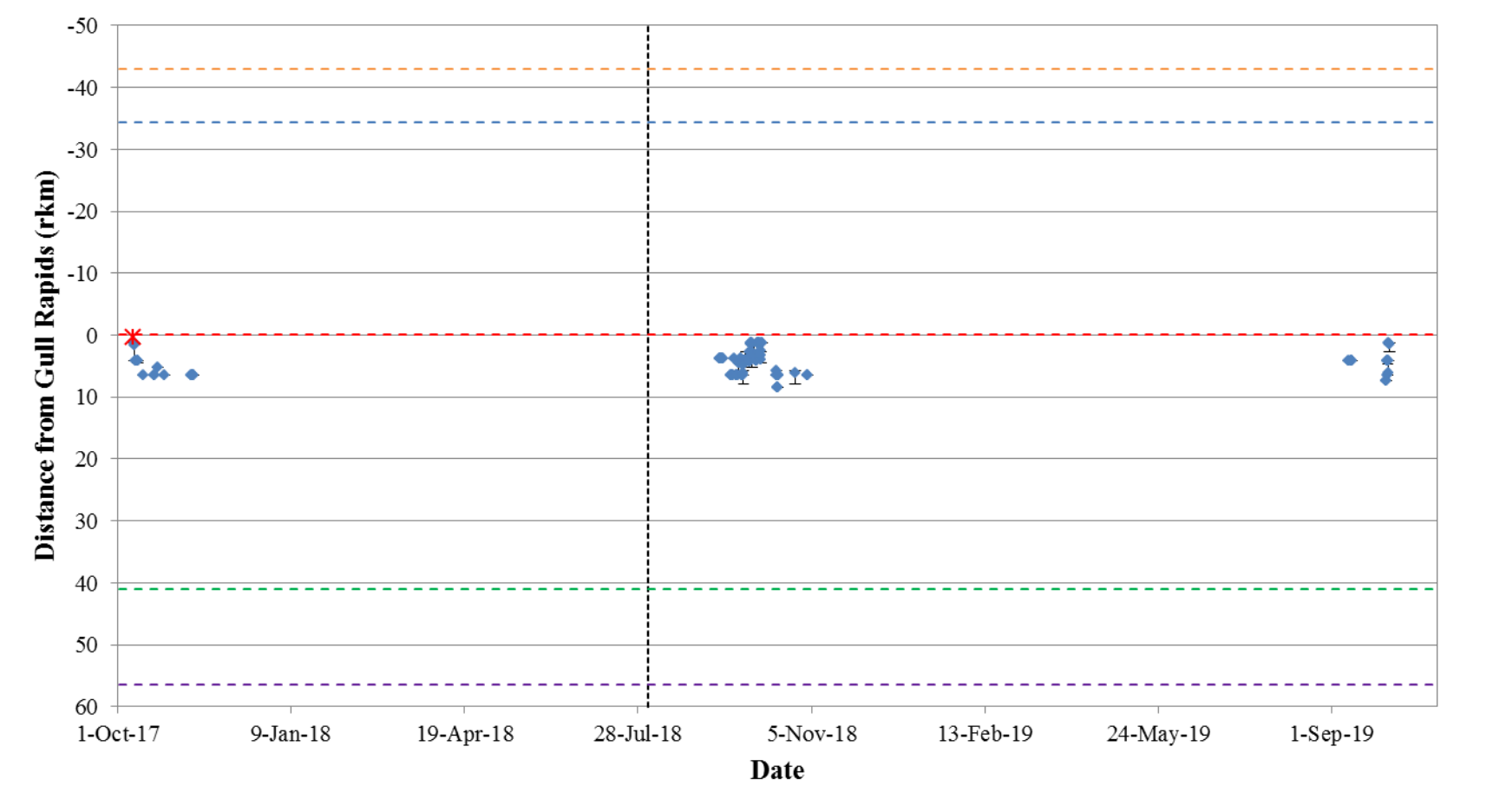


Figure A3-31: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31750) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

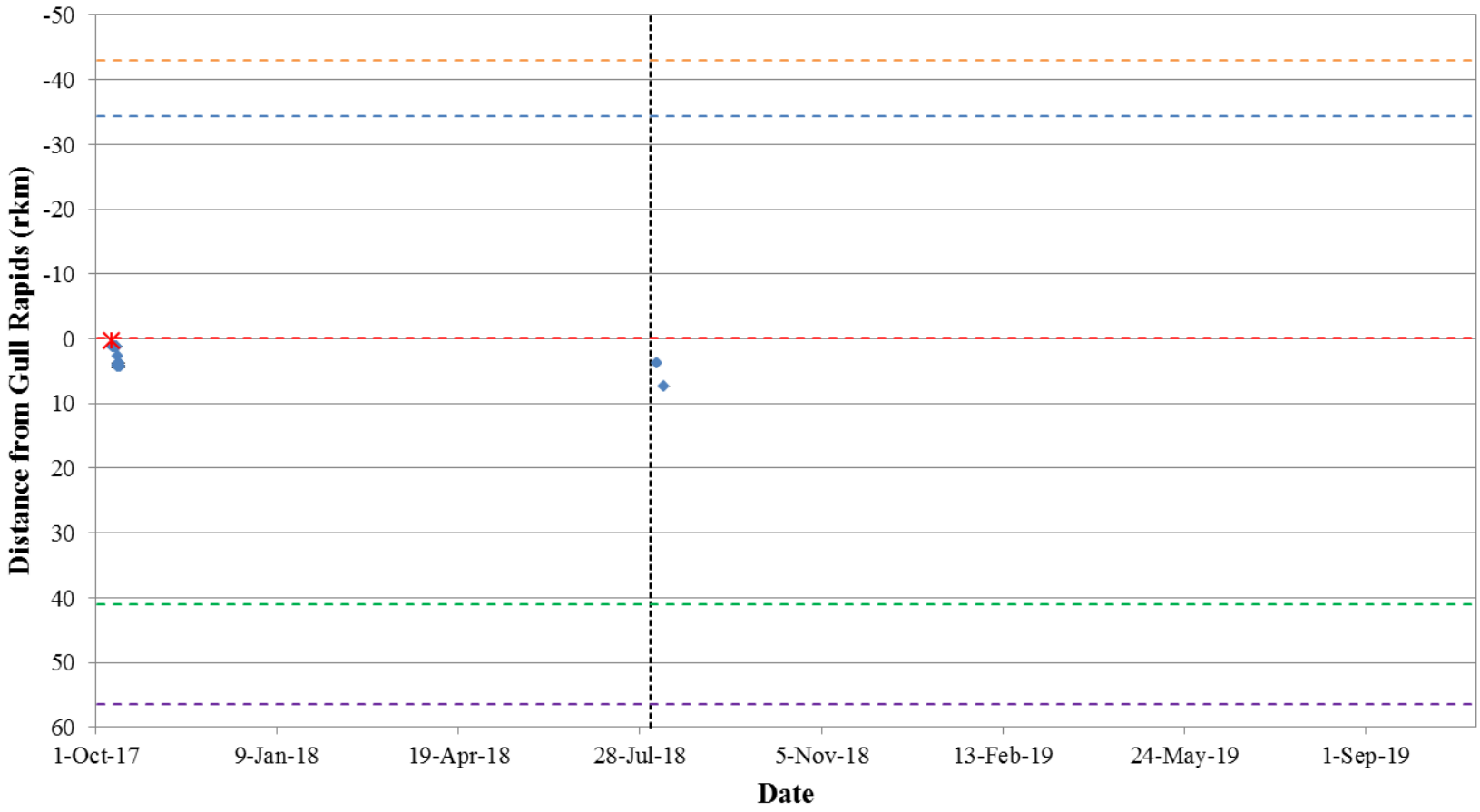


Figure A3-32: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31751) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

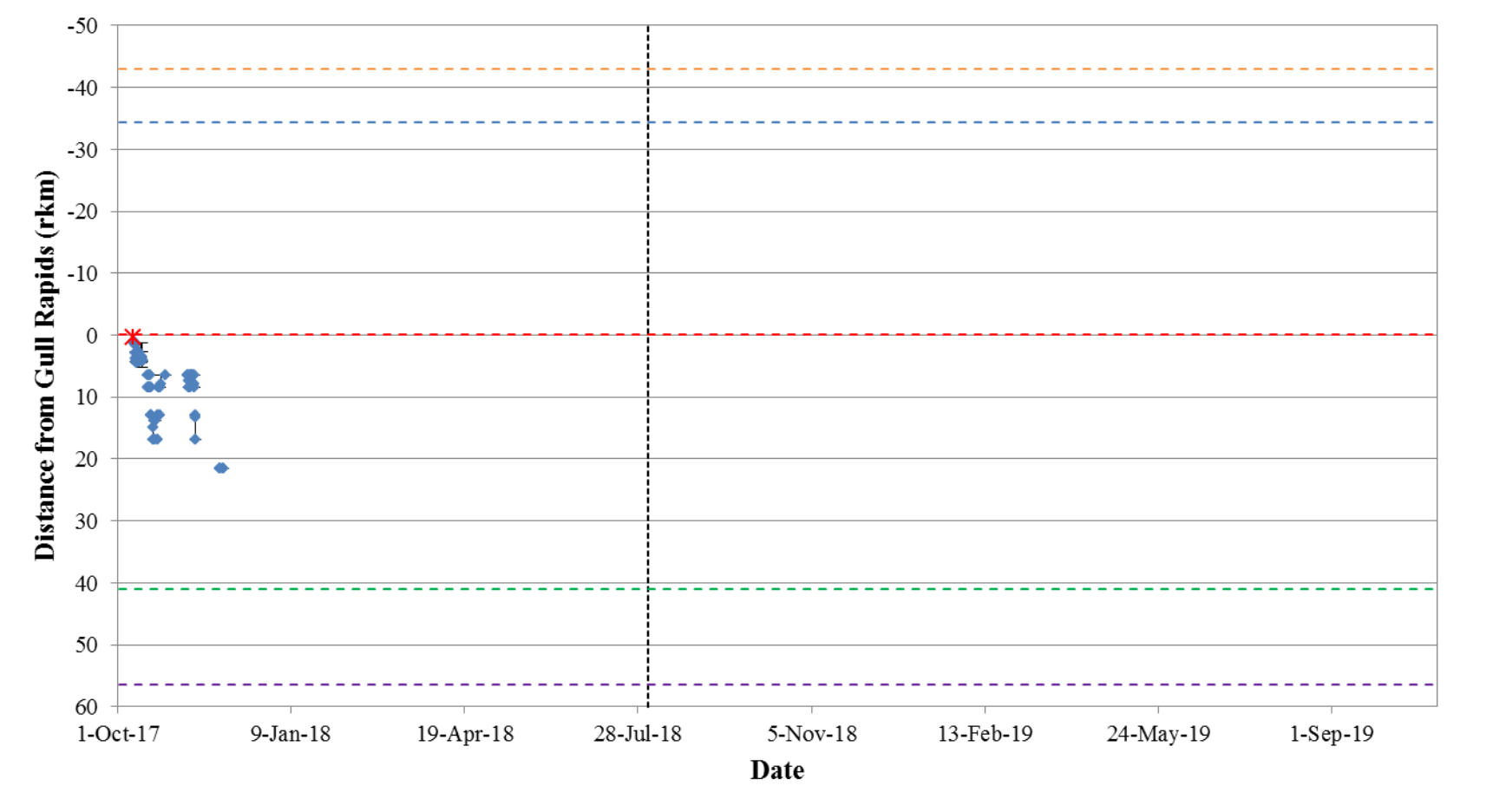


Figure A3-33: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31752) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

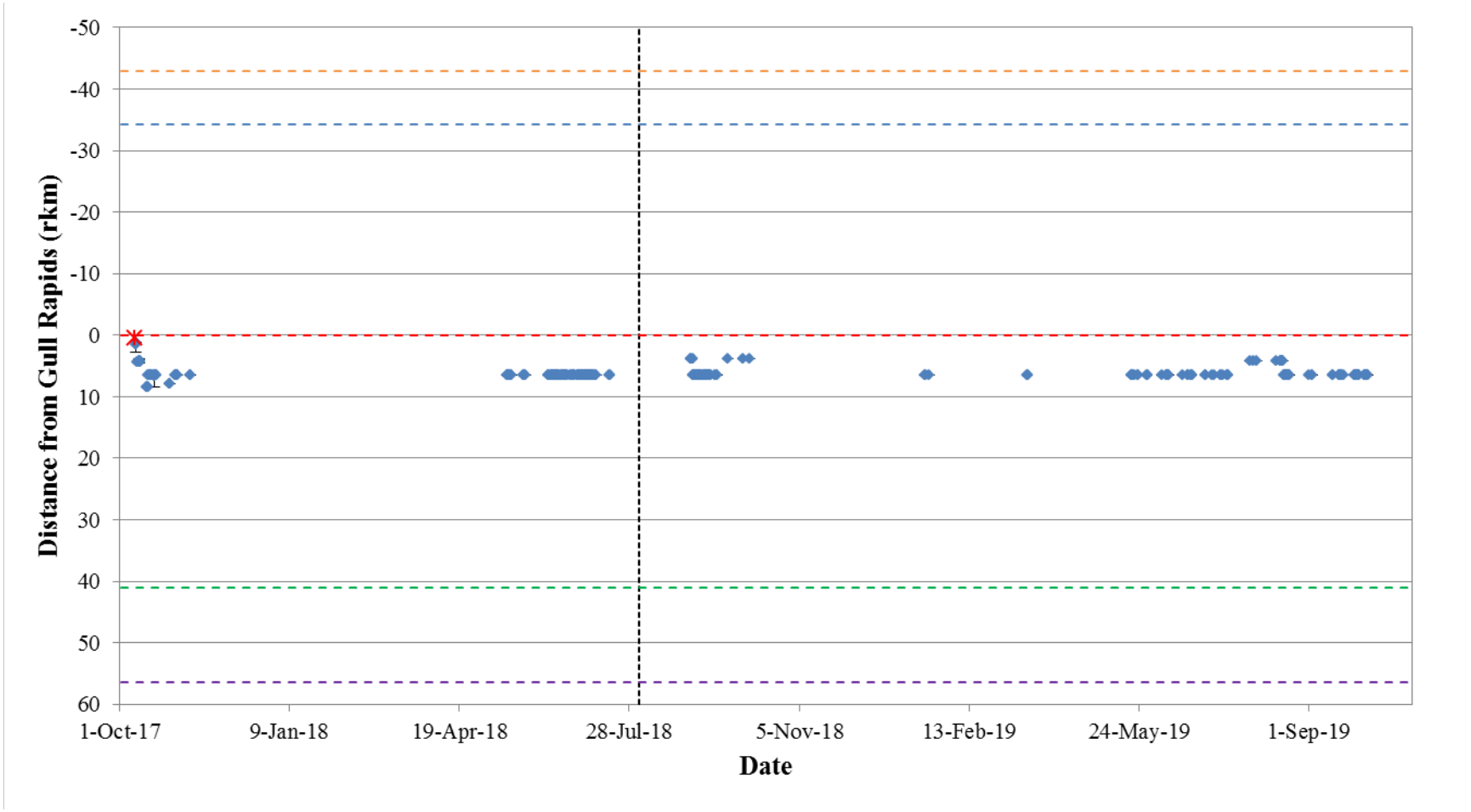


Figure A3-34: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31753) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

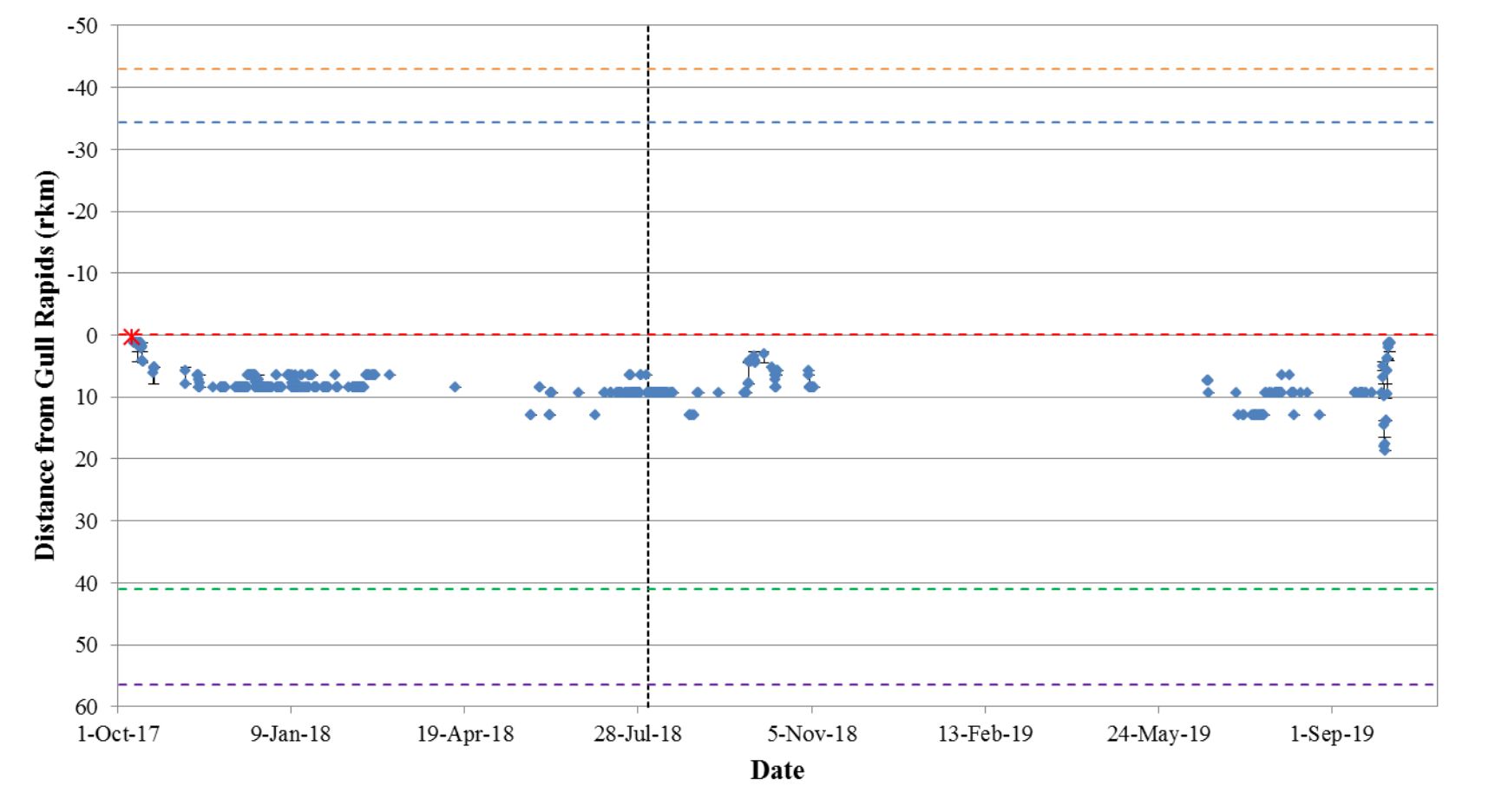


Figure A3-35: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31754) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

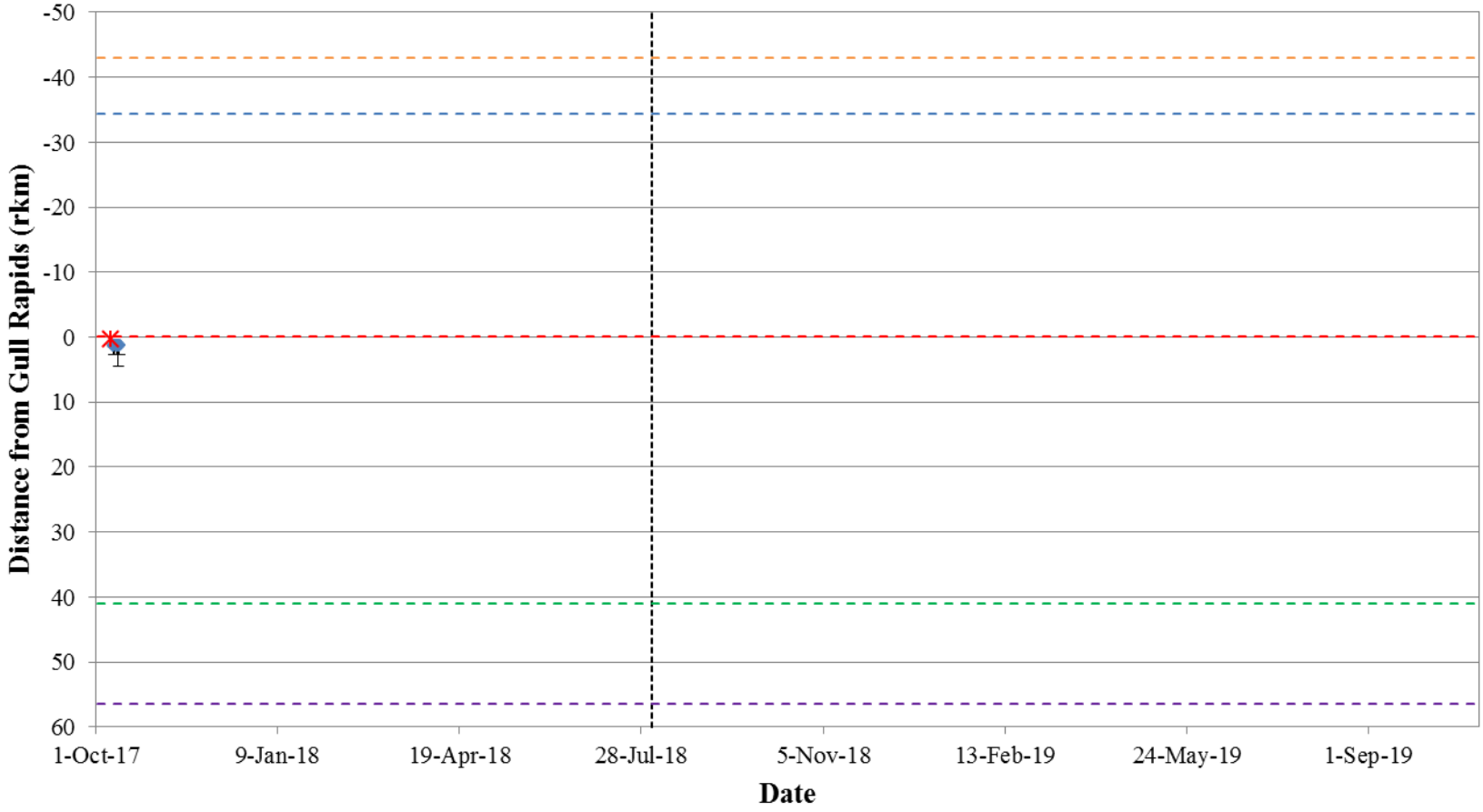


Figure A3-36: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31755) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

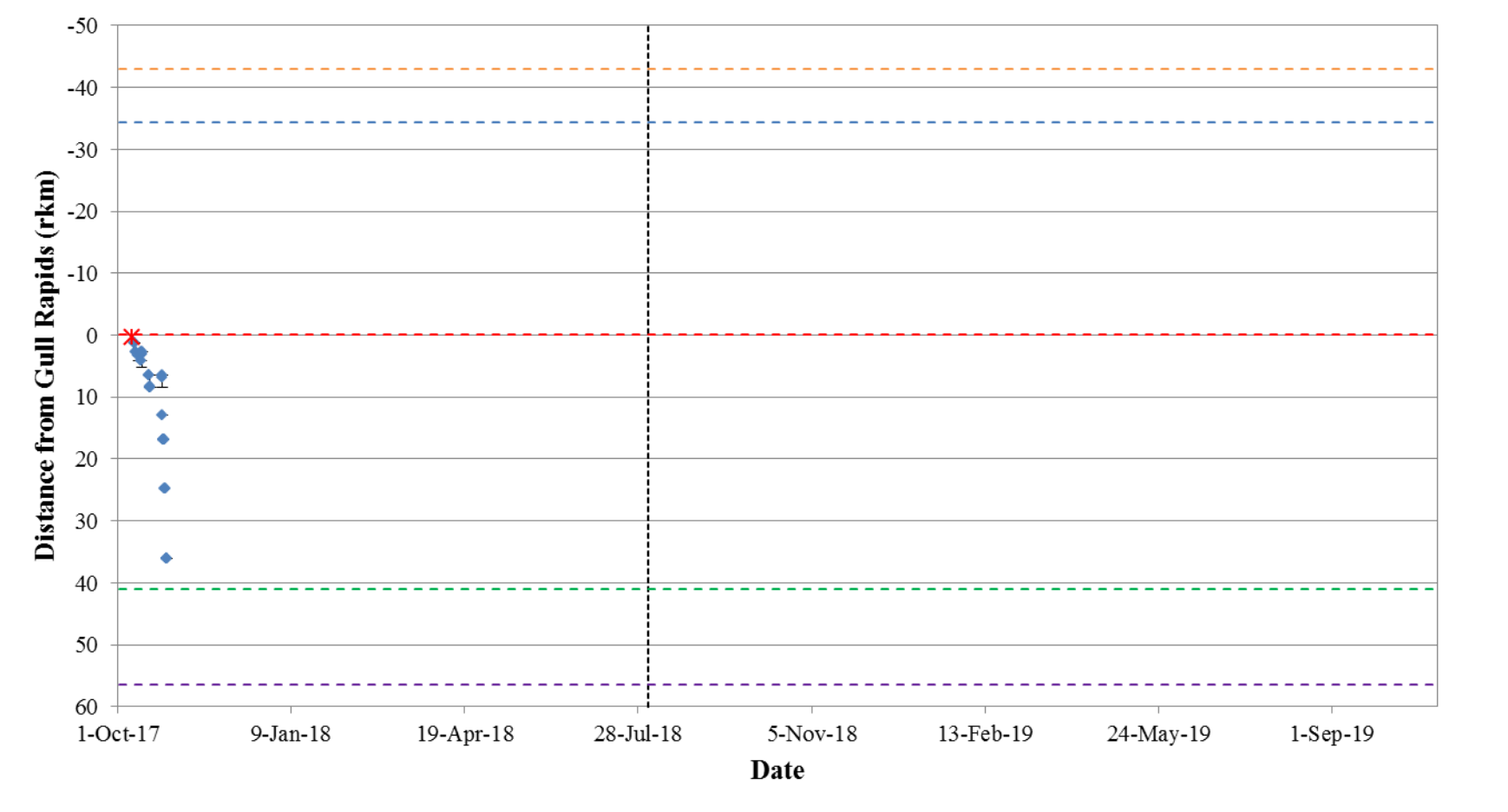


Figure A3-37: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31756) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

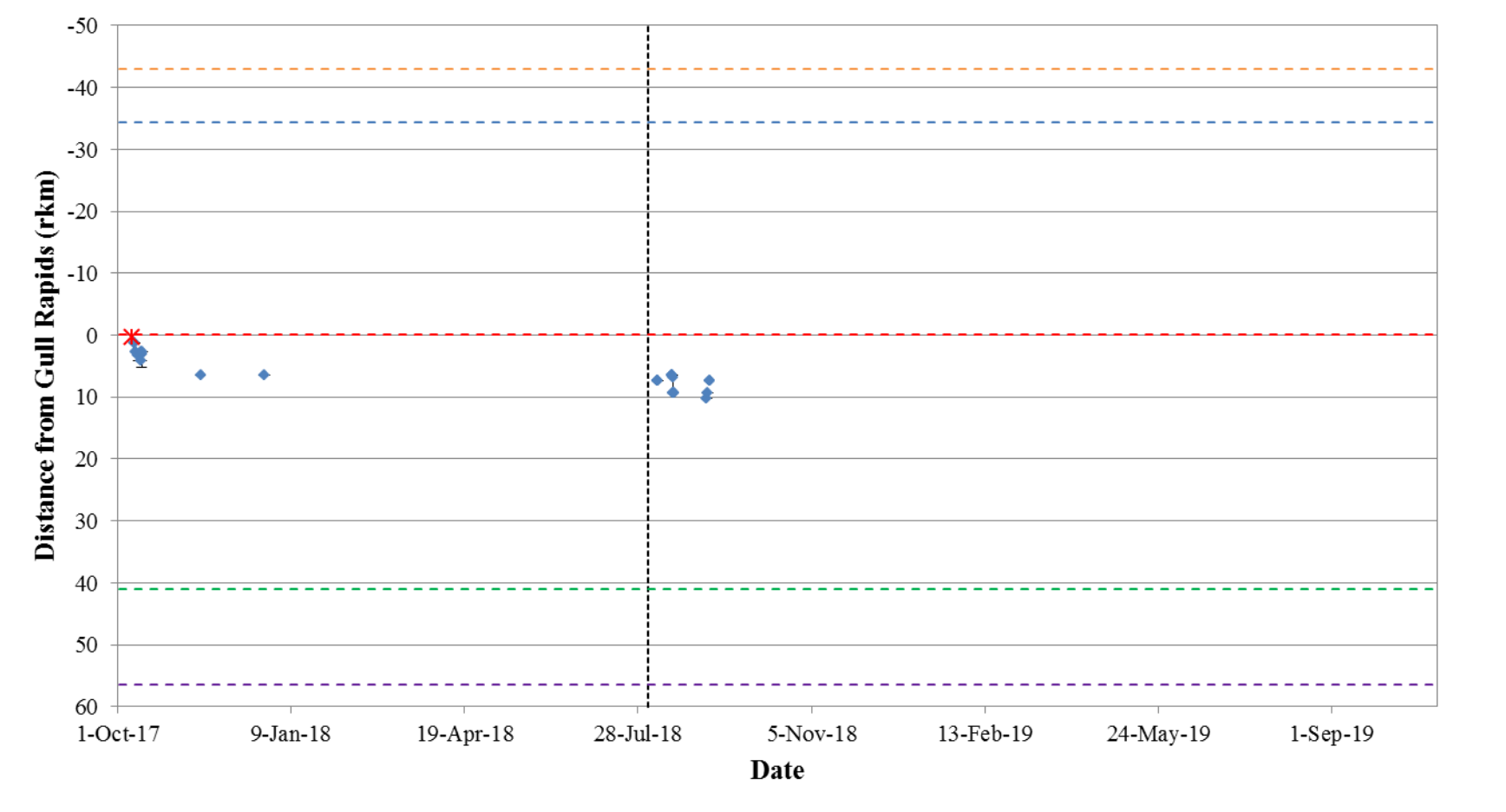


Figure A3-38: Position of a Lake Whitefish tagged with an acoustic transmitter (code #31757) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

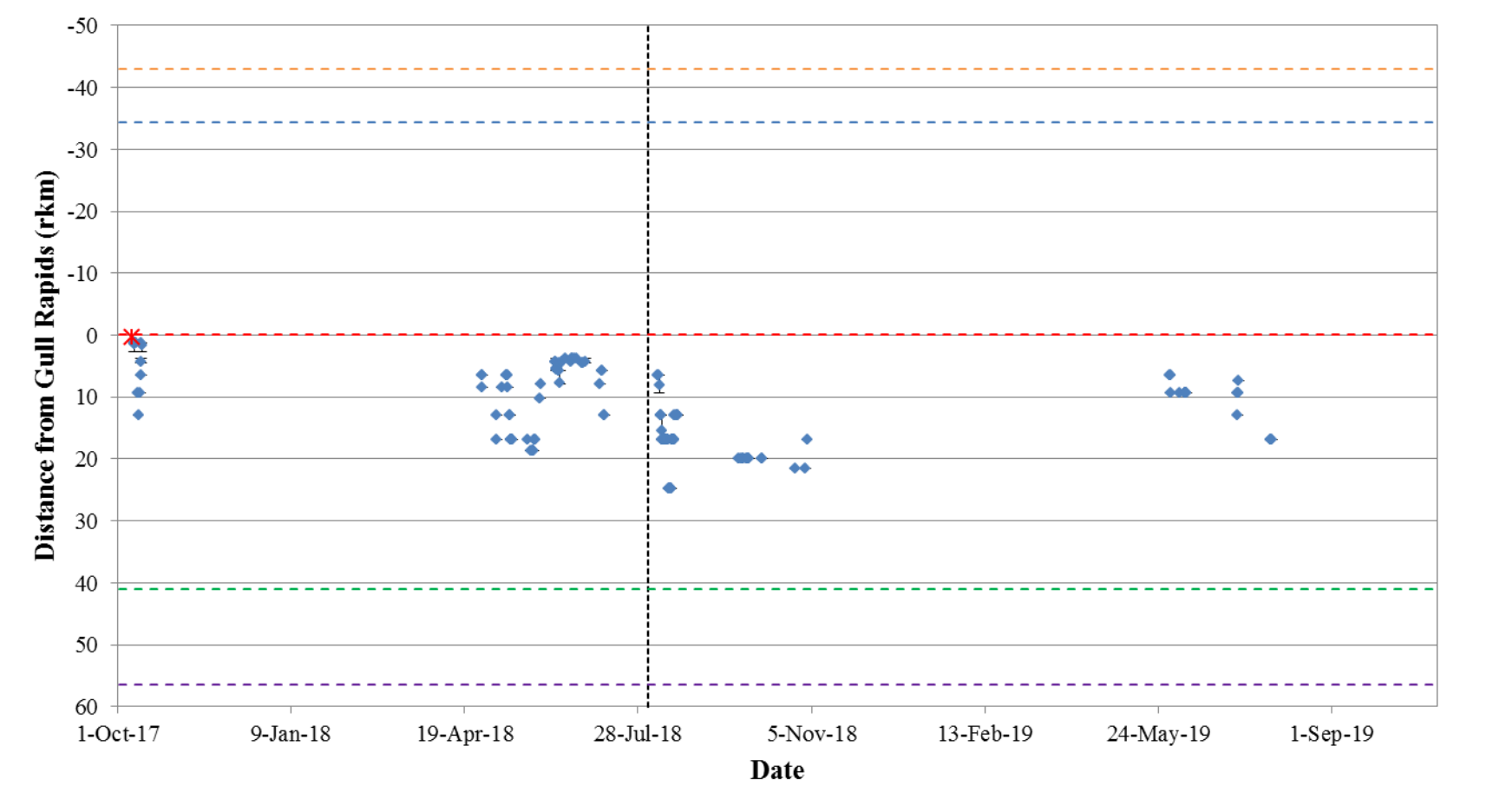


Figure A3-39: Position of a Lake Whitefish tagged with an acoustic transmitter (code #53761) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).

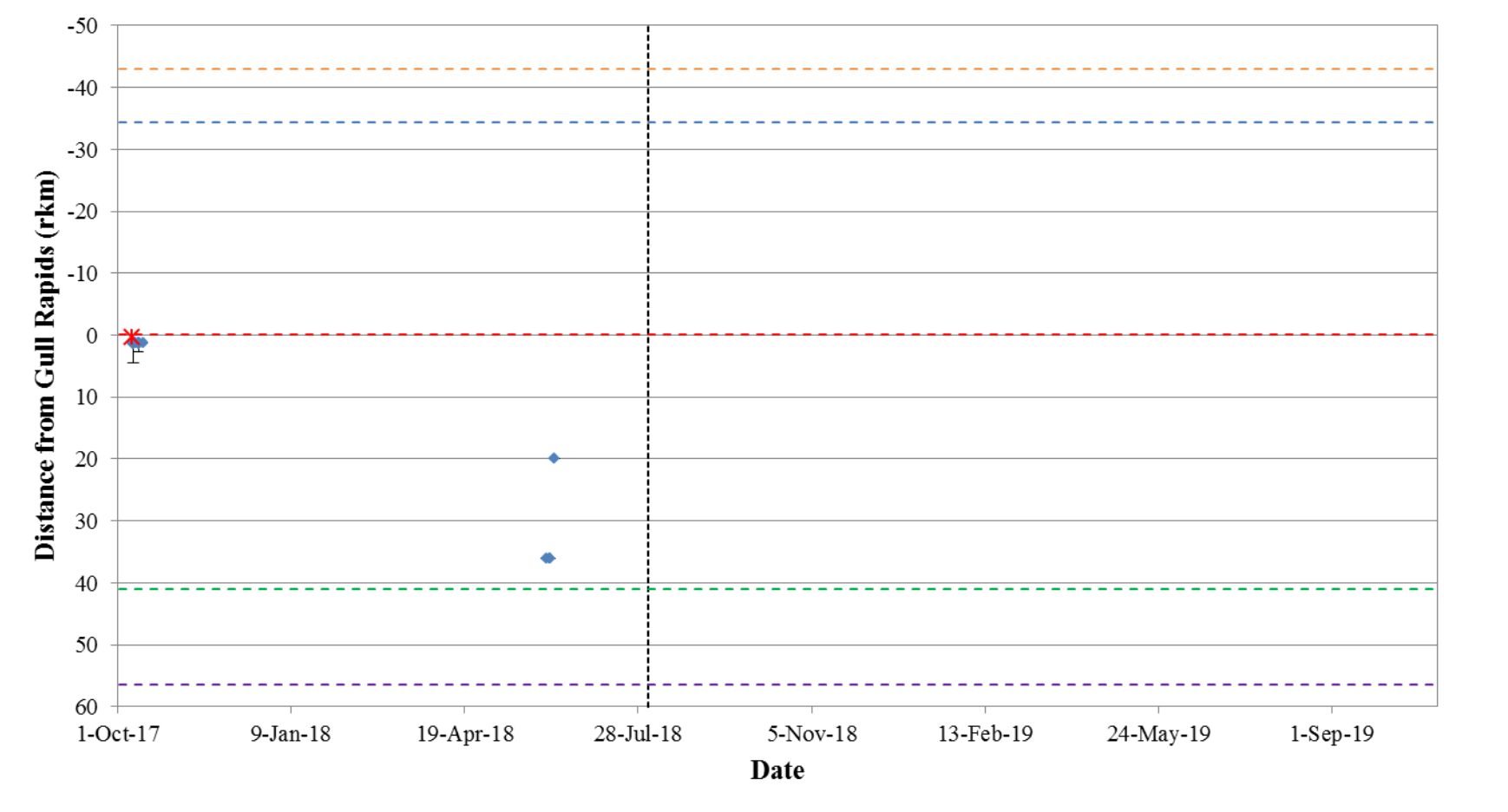


Figure A3-40: Position of a Lake Whitefish tagged with an acoustic transmitter (code #53762) in Stephens Lake, in relation to the Keeyask GS (rkm 0), from October 2017 to October 2019. The date and location of tagging are indicated by a red star. Horizontal dotted lines indicate locations of landmarks (orange = Clark Lake outlet; blue = Birthday Rapids, red = Keeyask GS; green = Kettle GS, purple = Long Spruce GS). Vertical black dotted line indicates start of spillway operation (August 3, 2018).