Thompson Falls Hydroelectric Project
FERC Project No. 1869

NorthWestern Energy
Initial Study Report
Fish Behavior Study

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List of Abbreviations and Acronyms

%	Percent
<	Less than
>	Greater than
°C	degrees Celsius
CFD	Computational fluid dynamics
cfs	cubic feet per second
COPW	Colorado Parks and Wildlife
FERC	Federal Energy Regulatory Commission
fish passage facility	Thompson Falls Fish Passage Facility
fps	feet per second
FWP	Montana Fish, Wildlife and Parks
FWS	U.S. Fish and Wildlife Service
HB	High Bridge
ILP	Integrated Licensing Process
Ladder	Thompson Falls Fish Passage Facility
LL	Brown Trout
MDL	Main Dam Left
MDR	Main Dam Right
NorthWestern	NorthWestern Energy
PH	Powerhouse Fixed Receiver Station
PIT	passive integrated transponder
Project	Thompson Falls Hydroelectric Project
PSI	pound-force per square inch
RB	Rainbow Trout
Scientific Panel	Thompson Falls Scientific Review Panel
TAC	Technical Advisory Committee
Thompson Falls Project	Thompson Falls Hydroelectric Project
U.S.	United States
USGS	U.S. Geological Service
ZOP	zone of passage

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1. Introduction

The Thompson Falls Hydroelectric Project (Thompson Falls Project or Project) is located on the Clark Fork River in Sanders County, Montana. Non-federal hydropower projects in the United States (U.S.) are regulated by the Federal Energy Regulatory Commission (FERC) under the authority of the Federal Power Act. The current FERC License expires December 31, 2025. As required by the Federal Power Act and FERC's regulations, on July 1, 2020, NorthWestern Energy (NorthWestern), the current licensee, filed a Notice of Intent to relicense the Thompson Falls Project using FERC's Integrated Licensing Process (ILP). Concurrently, NorthWestern filed a Pre-Application Document.

The ILP is FERC's default licensing process which evaluates effects of a project based on a nexus to continuing Project operations. In general, the purpose of the pre-filing stage of the ILP is to inform Relicensing Participants[1] about relicensing, to identify issues and study needs (based on a project nexus and established FERC criteria), to conduct those studies per specific FERC requirements which are included in the FERC Study Plan Determination, issued May 10, 2021, and to prepare the Final License Application.

This Fish Behavior Study, Initial Study Report has been prepared to comply with the requirements of NorthWestern's Revised Study Plan, filed April 12, 2021, as approved in FERC's Study Plan Determination.

1.1 Fish Behavior Study Background

The Project is located on the lower Clark Fork River near the town of Thompson Falls, Montana in Sanders County. Between 2009 and 2010, the Licensee constructed a fish passage facility along the right abutment of the Main Channel Dam designed to address upstream fish passage for the federally threatened Bull Trout (*Salvelinus confluentus*). The Thompson Falls Fish Passage Facility (fish passage facility) has operated seasonally since 2011 providing upstream fish passage to over 37,000 fish representing 15 species (plus 3 hybrids), including 18 Bull Trout (NorthWestern 2022).

The goals and objectives of the fish passage facility were reviewed and specifically defined by the Thompson Falls Technical Advisory Committee (TAC), which includes representatives of NorthWestern, Montana Fish, Wildlife and Parks (FWP), U.S. Fish and Wildlife Service (FWS), U.S. Forest Service, and Confederated Salish and Kootenai Tribes. The TAC determined the highest priority for upstream fish passage are Bull Trout, followed by native species and non-native game fish such as Rainbow (*Oncorhynchus mykiss*) and Brown (*Salmo trutta*) trout. These goals and objectives have informed how the fish passage facility is operated (notch vs. orifice

[1] Relicensing Participants includes local, state, and federal governmental agencies, Native American Tribes, local landowners, non-governmental organizations, and other interested parties.

mode) and the seasonal timing of operation (March – October). Rainbow and Brown trout represent 82.7 percent of the salmonids recorded at the fish passage facility (3,747 out of 4,533 trout) over the last 10 years (NorthWestern 2022).

In compliance with the terms and condition (TC) 1-h in the Biological Opinion (FWS 2008) and the License amendment (FERC 2009), NorthWestern, in collaboration with the TAC, formulated a scientific panel to evaluate the fish passage facility, with emphasis on Bull Trout. The Thompson Falls Scientific Review Panel (Scientific Panel 2020) identified a large volume of qualitative data gathered from the fish passage facility but noted a data gap when quantitatively evaluating the proportion of "motivated" fish entering the zone of passage (ZOP) and finding the fish passage facility entrance. The ZOP was defined by the Scientific Panel as shown on **Figure 1-1**. This study was developed to address this data gap.

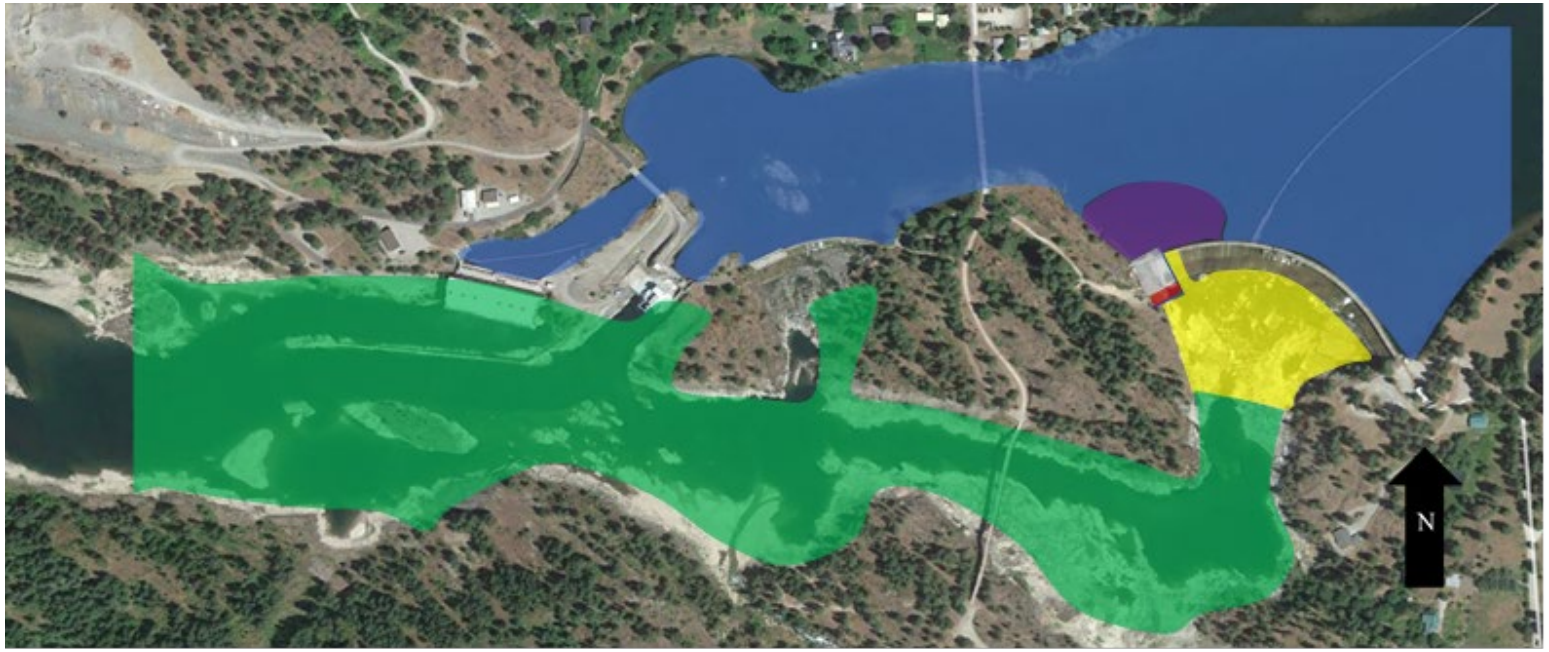
Following the recommendation of the Scientific Panel, and in compliance with the FERC's Study Plan Determination (2021), this study focuses on Rainbow and Brown trout. Rainbow and Brown trout are important game fish in the Project area and serve as surrogate species to better understand upstream fish passage efficacy for Bull Trout (Scientific Panel 2020).

1.2 Goals and Objectives of Study

The goal of this study is to evaluate upstream fish movement *via* radio telemetry[2] through the Project's zone of influence which is defined by the ZOP concept (FWS 2017). The ZOP concept defines discrete areas for analysis of the pathway fish use to move through the influence of the Project. These areas include far field, near field, entry, internal fish passage facility, exit, and upstream (*see* Figure 1-1 for ZOP concept and definitions). The ZOP concept provides a method to measure passage effectiveness and identify attributing causes and influences (Project and non-project related) to upstream passage effectiveness. This study focuses on fish movement in the far field, near field, and fish passage facility entrance, as illustrated in Figure 1-1.

[2] Radio telemetry uses individually coded tags which transmit radio waves which can be detected with receivers mounted on shore.

Figure 1-1. Study Areas as Defined by the Zone of Passage Concept



Notes:
Figure not to scale.
Far Field = Downstream of fish passage facility/dam where the Powerhouse and spill serve as primary attraction to migrating fish
Near Field =In proximity to fish passage facility where fish passage facility attraction flow may lure fish to entrance
Entry = Immediately downstream of entrance channel/gate where fish passage facility discharge dominates hydraulics/velocity field/fish behavior
Internal Passage = Hydraulics, structure, and fish movement with the fish passage facility (i.e., entrance channel, pools, trap, exit channel)
Exit = Immediate upstream of the fish passage facility exit gate/exit channel where inflow into fish passage facility dominates hydraulics/velocity field/fish behavior
Upstream = Beyond the influence of the fish passage facility into the reservoir/impoundment
Source: Thompson Falls Scientific Review Panel 2020

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This is a 2-year study with fish movement and behavior data from June through October 2021 (reported on in this Initial Study Report) and March through October 2022 (to be reported on in the Final Study Report). Due to the battery life in the radio tags, each year will have a separate group of fish being monitored. For example, fish sampled and tagged in spring 2021 will be monitored in 2021 and evaluated in this report and fish sampled and tagged in spring 2022 will be monitored in 2022 and evaluated in the final study report, scheduled for May 2023.

This study evaluates what proportion of radio tagged fish enter the ZOP and find the fish passage facility entrance. The study also measures the duration of time and pathway(s) of these movements during various flow conditions. Internal fish passage facility efficiency is evaluated *via* the remote passive integrated transponder (PIT) tag[3] arrays located in the ladder section of the fish passage facility; those data are reported in the 2021 Annual Report (NorthWestern 2022). In addition, there is a PIT tag antenna array in Prospect Creek, located about 0.42 mile upstream of its confluence with the Clark Fork River.

This Initial Study Report includes a literature review of relative swimming capabilities of minnow, sucker, and salmonid species recorded at the fish passage facility (*see* **Section 3.4 – Literature Review of Fish Swimming Abilities**). The swimming abilities of these fish will be compared to the computational fluid dynamics (CFD) model of the near field (results are being reported in the Interim Study Report on Hydraulic Modeling) to evaluate the potential of any velocity barriers influencing fish movement. These results will be provided in the Final Study Report.

[3] A PIT tag is a small radio transponder that contains a specific code, which allows individual fish to be assigned a unique 10- or 15-digit alphanumeric identification number. They are "passive" and do not require a battery, which allows them to be smaller and last the life of the fish.

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2. Methods

2.1 Study Area

This study focuses on evaluating Rainbow and Brown trout movement from the Thompson Falls Original Powerhouse upstream to the fish passage facility entrance at the Main Dam. This 0.75-mile section of the Clark Fork is further divided into the far field, near field, and fish passage facility entrance. The location of the four fixed stations and estimated detection zone in the Project area are illustrated in **Figure 2-1**. The Powerhouse (PH) and High Bridge (HB) fixed receiver stations represent the far field and the Main Dam Right (MDR) and Main Dam Left (MDL) represent the near field. The fish passage facility entrance is located along the right abutment of the Main Dam.

2.2 Tagging and Monitoring Equipment

Tagging equipment included full-duplex PIT and radio transmitter tags. PIT tags are detected by a remote antennae array system operating in the two fish passage facility entrances, and the lower pools and the top holding pool in the fish passage facility. Radio tags were monitored by fixed and mobile receivers.

Radio transmitters were MCFT3 series tags manufactured by Lotek Wireless. All MCFT3 tags were coded with the same frequency [149.7 megahertz (MHz)] and a unique code identification number. Literature suggests tracking a large number of fish using unique radio codes is more effective than tracking fish using multiple frequencies (Thorstad et al. 2013). Radio tags were equipped with depth and activity sensors. A good faith effort was made to adhere to a 2 percent tag to body weight ratios. For the 2 percent rule fish needed to weigh 340 grams for the smaller tags and 550 grams for the larger tags. The radio transmitters were set to a 5-second burst rate (length of time between transmissions) The MCFT3 tag life were 1.5 or 8 months depending on the tag size (6.8 or 11 grams, respectively).

Each fixed station was set up with a Lotek SRX1200-D2 receiver along with a single 6-Element Yagi antenna, except for the PH, where two antennae were installed (**Figure 2-1**). The PH station had one 6-Element Yagi and one 4-Element Yagi antenna. The station on the left side of the Main Dam was installed along the south side of the radial gate to shield it from duplicative detections with the right-side station. The PH and HB stations were powered using a solar panel to charge a deep cycle battery, the Main Dam stations were powered by a deep cycle battery charged by permanent AC power.

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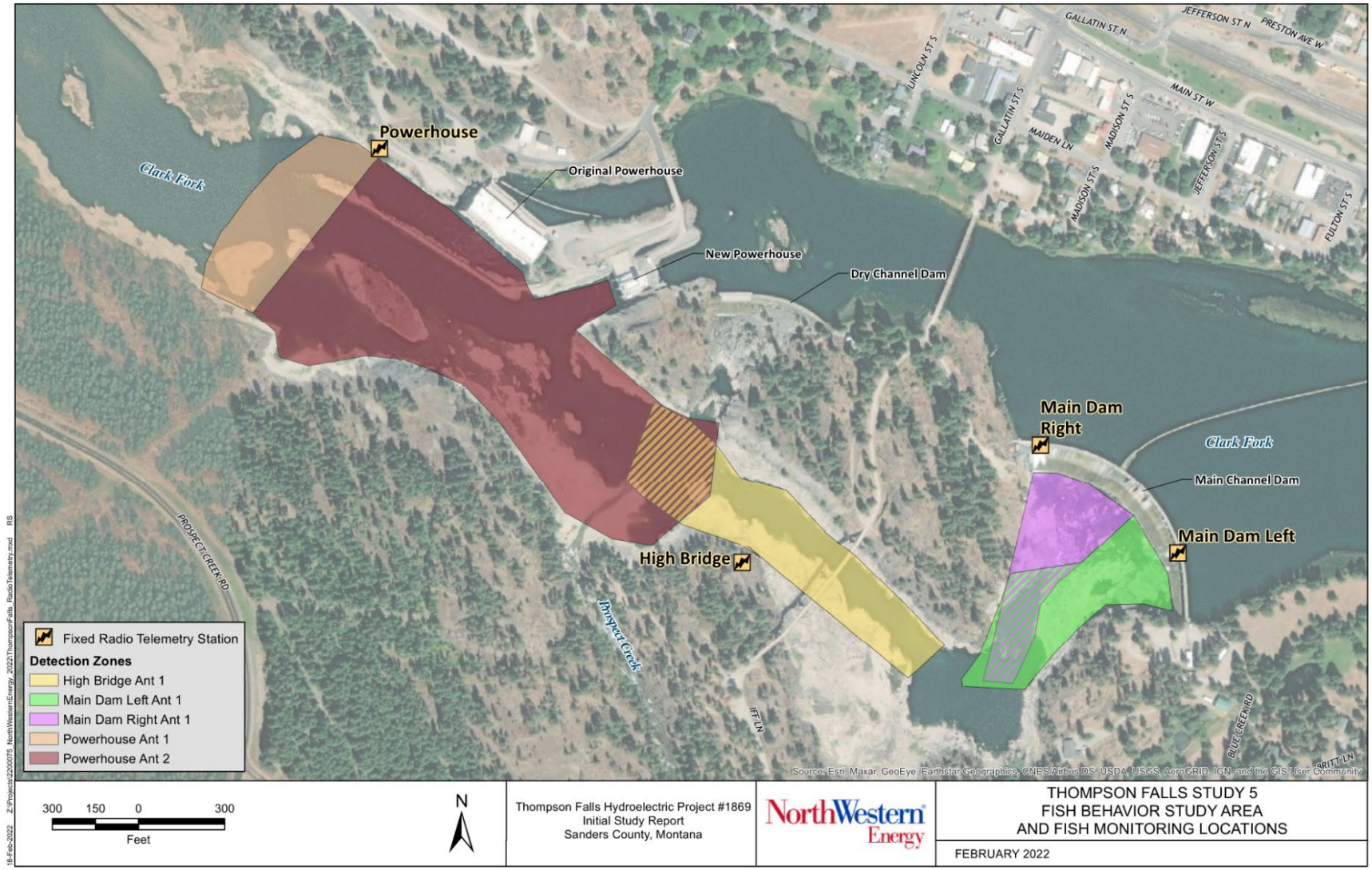
Figure 2-1. Fixed Station Locations and Detection Zones[4]



[4] Detections zones are approximate based on spring 2021 testing and data collection.

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2.3 Fish Collection

Fish collection sites included (1) the mainstem Clark Fork River upstream of the Thompson Falls Project, (2) the lower section of the Thompson River (downstream of the confluence with West Fork Thompson River), and (3) the fish passage facility. Boat mounted electrofishing was used in the Clark Fork River to collect trout of suitable size for radio tagging. Angling was used in the Thompson River, but no fish of suitable size were collected in that location. Fish collection was contingent on accessibility of the sampling areas and water temperature necessary to allow for acceptable recovery of fish post-surgery. Fish collection, radio-tagging and transport occurred when water temperature was less than or equal to 16 degrees Celsius (°C), a standard established in collaboration with FWP for this study.

Fish collection by electrofishing in the Clark Fork River (within 12.5 miles of the Main Dam Spillway) occurred between June 2 and June 16. Water temperatures exceeded 16°C on June 17, thus electrofishing efforts were discontinued. Water temperature declined in the fall, allowing for tagging of Brown Trout at the fish passage facility.

Tagged fish were transported by vehicle in an aerated tank to the Flat Iron boat launch, approximately 4 miles downstream of the dam. All tagging and transport activities occurred the same day the fish was sampled.

Radio tags were internally implanted through the intra-peritoneal (body cavity) following the methods described in Mizell and Anderson (2015). PIT tags (full duplex) were also implanted in each radio tagged fish in the muscle tissue ventral to the dorsal fin.

2.4 Training and Testing Procedures

On May 18, 2021, field crews received training and practice on methods used to complete radio tagging fish surgeries, including anesthetizing, surgery procedure, and recovery process for fish prior to transport and release.

Fixed stations were installed, calibrated, and tested in spring 2021 prior to fish collection activities. Fixed stations were tested to determine tag detection efficiency, and to ensure adequate power supply systems, data downloading, and quality assurance and quality control systems were in place. The zones of detection for each fixed station were determined by moving a submerged radio tag around the area and using the receiver to track when a signal was detected. Through trial and error with detections, associated signal strengths, and adjusting antenna positions, detection areas were determined for each fixed station. The zones of detection presented in **Figure 2-1** reflect the results obtained from testing and actual data collected (fixed station data correlated with manual data collection) during the season. A representative from the manufacturer, Lotek was present, along with FWP and NorthWestern personnel to assist in setup and testing equipment.

2.5 Monitoring Procedures

The fixed stations and radio telemetry monitoring zones are shown in **Figure 2-1**. The fixed telemetry stations recorded data continuously throughout the study season (June – October 2021). Data from the fixed stations were downloaded weekly. Because of the volume of data being collected in 5-second intervals, a database was developed to store all the information and provide an accelerated method to query and process data.

Manual tracking consisted of an individual walking along the bank, within the near and far fields, with a Lotek SRX1200-MD1 receiver and an H antenna 150 MHz. Once a tagged fish was detected, its location was triangulated, and applicable information recorded using a standardized data sheet with a georeferenced grid that was uploaded into a geographic information system (GIS).

Manual radio telemetry monitoring efforts were implemented from June 3 through October 27. The frequency of manual tracking depended on fish detections in the ZOP and varied from multiple times a week, to daily, or multiple times a day. The goal of the manual tracking was to confirm locations of fish and provide higher resolution of the location for an individual fish within the ZOP. Manual tracking extended from Flat Iron boat launch (release site) upstream to Thompson Falls Dam. Only detections within the ZOP are presented in this report, as tracking outside of the ZOP was only to confirm fish were still alive and moving upstream towards the study area. There were 83 manual tracking events when fish were detected during the season.

2.6 Data Analysis

Fish movement data were analyzed to assess fish behavior through a range of flow conditions. The 2021 telemetry monitoring efforts evaluate fish movement behaviors with emphasis on attraction efficiency (FWS 2017) by assessing the following:

- Travel time from the far field to the near field
- Travel time from the near field to the entrance of the fish passage facility
- Movement patterns (e.g., left bank, right bank) in the near field (Main Channel Dam area)
- Proportion of fish that enter the ZOP and locate the entrance of the fish passage facility entrance
- Locations where fish hold within the ZOP

2.7 Variances from the FERC-approved Study Plan

There were no variances during the 2021 study season from the FERC-approved Study Plan (NorthWestern 2021).

3. Results

3.1 Fish Collection and Tagging

The larger 11-gram MCFT3 tags were implanted in 13 trout (7 Rainbow Trout; 6 Brown Trout) collected in June, and the 6.8-gram MCFT3 tags were implanted in three Brown Trout collected at the fish passage facility September 29 and October 1. A summary of spring and fall tagging effort and fish collection results is provided in **Table 3-1**. Total catch per unit effort (angling and electrofishing) for taggable fish of both species was low, 0.56 fish per hour (Table 3-1).

Table 3-1. Trout Collection Sampling Dates, Method, Location, Water Temperature, Effort, and Catch Per Unit Effort in 2021

2021 Season	Date	Method	Location	Water Temp °C	Effort (Hours)	RB	RB CPUE	LL	LL CPUE
Spring	2-Jun	Electrofishing	MCFR	13.7	1.9	1	0.5		
	3-Jun	Electrofishing	MCFR	14.4	2.0	2	1.0		
	7-Jun	Electrofishing	MCFR	13.1	2.5				
	8-Jun	Electrofishing	MCFR	12.7	1.1	2	1.8		
	8-Jun	Angling	TR	12.7	8.0				
	9-Jun	Electrofishing	MCFR	12.7	3.5	1	0.3		
	11-Jun	Electrofishing	MCFR	12.1	1.5				
	14-Jun	Electrofishing	MCFR	14.5	1.0	1	1.0	4	3.9
	16-Jun	Electrofishing	MCFR	15.9	1.6			2	1.3
Spring Summary	**8 days**	**Electrofishing**	**MCFR**		**15.2**	**7**	**0.5**	**6**	**0.4**
	1 day	**Angling**	**TR**		**8.0**	**0**	**0**	**0**	**0**
Fall	29-Sep	Ladder	Ladder	14.8	NA			1	NA
	1-Oct	Ladder	Ladder	13.7	NA			2	NA

Notes:
°C = degrees Celsius; CPUE = Catch Per Unit Effort; Ladder = Upstream Fish Passage Facility Work Station; LL = Brown Trout; MCFR = Main Clark Fork River; NA = not applicable; RB = Rainbow Trout; TR = Thompson River

A summary of each radio tagged trout, including the species, length, weight, radio tag, and PIT tag is provided in **Table 3-2**. There were zero mortalities observed following the surgery procedures and all 16 trout were detected entering the ZOP following their transport and release downstream.

Table 3-2. Trout Tagged and Transported in 2021

Date Tagged & Transported	Species	MCFT3 Tag (g)	Length (mm)	Weight (g)	Radio Tag #	PIT TAG ID[5]
6/2/2021	RB	11	383	682	58	3212832
6/3/2021	RB	11	398	862	49	3212788
6/3/2021	RB	11	457	1052	51	3212871
6/8/2021	RB	11	534	1304	52	3211820
6/8/2021	RB	11	502	1328	56	3211805
6/9/2021	RB	11	409	616	54	3212869
6/14/2021	RB	11	433	705	55	3212787
6/14/2021	LL	11	436	896	39	3212850
6/14/2021	LL	11	444	959	48	3212806
6/14/2021	LL	11	506	1501	59	3212840
6/14/2021	LL	11	392	623	60	3212798
6/16/2021	LL	11	379	574	46	3212853
6/16/2021	LL	11	472	917	47	3212794
9/29/2021	LL	6.8	483	996	28	3212709
10/1/2021	LL	6.8	334	326	26	3212719
10/1/2021	LL	6.8	406	616	27	0300297

Notes:
g = gram; ID = identification; LL = Brown Trout; MCFT3 = Lotek Wireless radio transmitter; mm = millimeters; RB = Rainbow Trout

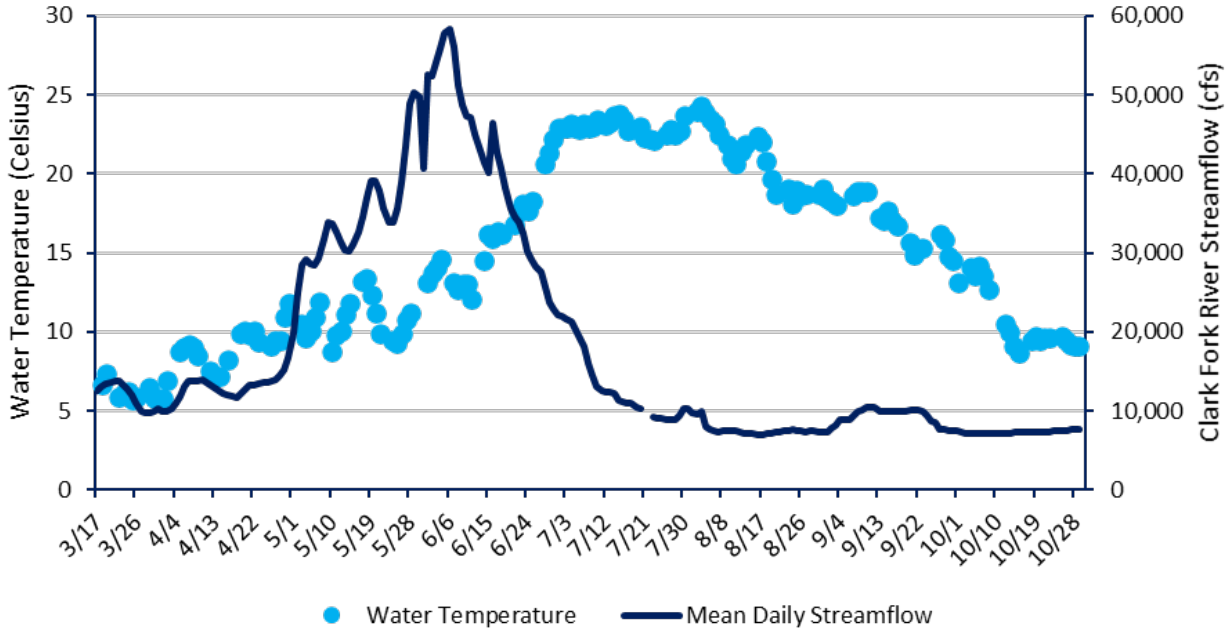
3.2 River Conditions

During fish collection efforts in June, the lower Clark Fork River mean daily flows ranged between 40,100 to 58,400 cubic feet per second (cfs) [U.S. Geological Service (USGS) station #1238900 near Plains). Peak flow occurred on June 6. During June, water conditions were turbid and challenging for electrofishing efforts. June was also a very dry and hot month resulting in a rapid increase in water temperatures, starting at 13.1°C and ending at 22.2°C. A summary of 2021 mean daily streamflow (USGS # 1238900) and a daily water temperature reading at Thompson Falls Dam fish passage facility are shown in **Figure 3-1**.

The Project's combined capacity of the seven generating units is approximately 23,000 cfs. When river inflows exceed this capacity, spill is initiated at the Main Dam spillway. In 2021, spill began at the Main Dam on May 2 and ended on June 30. During non-spill period, NorthWestern releases approximately 200 cfs from the upstream fish passage facility and from the Main Dam Spillway to provide attractant flow for fish throughout the fish passage season.

[5] 98900103 are the first digits of each PIT tag

Figure 3-1. Mean Daily Streamflow in the Clark Fork River near Plains (USGS #1238900) and Water Temperature Recorded at the Upstream Fish Passage Facility, March 17 to October 29, 2021



3.3 Fish Movement Results

The fixed stations collected over 3.8 million data records representing movements of all 16 tagged fish in the ZOP. The HB, MDR, and MDL stations ran continuously throughout the study season. Equipment issues occurred at the PH station resulting in short periods when data was not collected by the PH station (June 3-20; July 7-8; July 25-29; Aug 3-5, August 22-25, October 11-14; October 25-31). However, if fish were near the mouth of Prospect Creek where the PH and HB detection zones overlapped, fish were picked up by the HB station.

Rainbow and Brown trout were detected about 96 percent of the time in the far field (PH or HB). When fish were in the near field, most detections were at the MDR station representing 92 percent of the near field data. Fish did not linger in the near field and displayed short movements in and out of the near field. **Table 3-3** summarizes the number of data records for Rainbow and Brown trout detected at each fixed station in the ZOP.

Table 3-3. Summary of Rainbow and Brown Trout at Each Fixed Station and Total Number of Records for Each Species and Each Station, 2021 Season

Species	# of Fish	Far Field		Near Field		ZOP Detections
		PH	HB	MDR	MDL	Total Records
RB	7	420,026	1,430,526	1,611	23	1,852,111
LL	9	803,148	1,038,564	148,511	12,155	2,002,378
Total Records	**16**	**1,223,174**	**2,469,090**	**150,122**	**12,178**	**3,854,564**

Daily detections of the nine Brown and seven Rainbow trout at each of the fixed stations is illustrated in **Figures 3-2 and 3-3**, respectively. Five fish (4 LL, 1 RB) were detected in the near field (MDR and/or MDL). Of the five fish, three Brown Trout entered the fish passage facility entrance, and two Brown Trout ascended the fish passage facility.

Figure 3-2. Summary of Daily Brown Trout Detections of 9 Individual Fish at Each Fixed Station during the 2021 Study Season, June through October

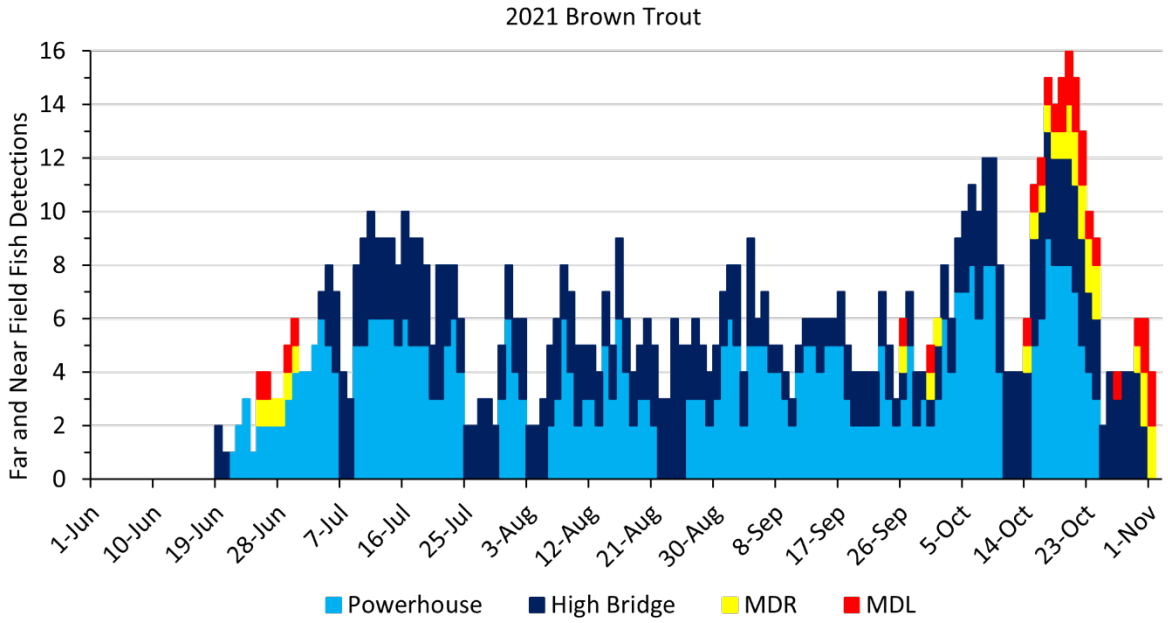
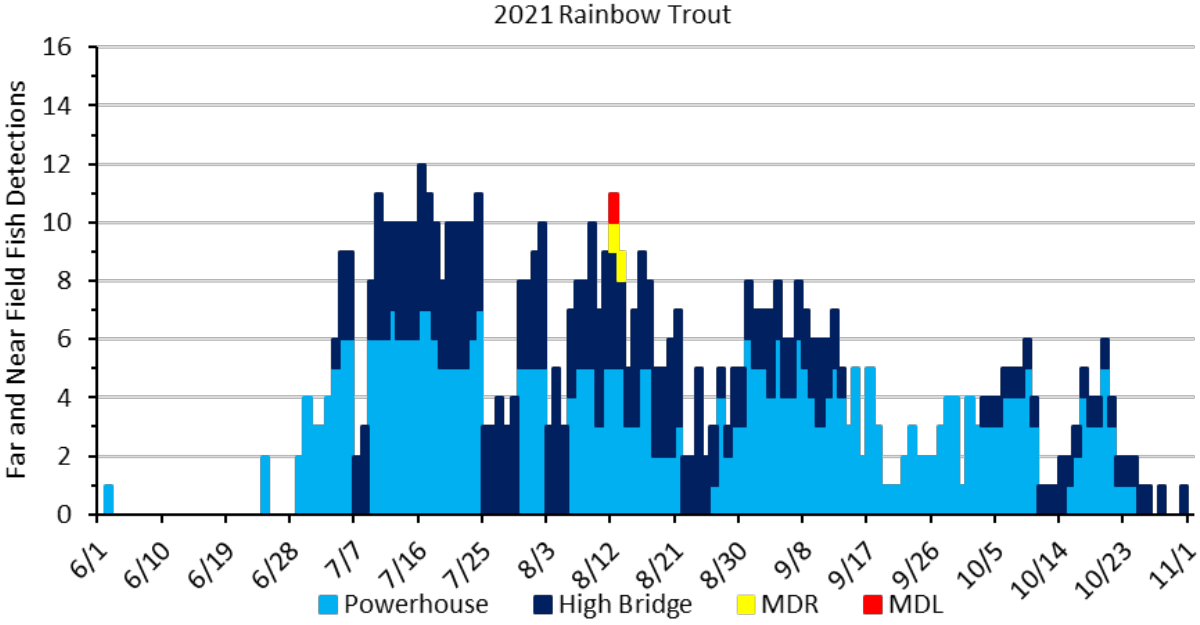


Figure 3-3. Summary of Daily Rainbow Trout Detections of 7 Individual Fish at Each Fixed Station, during the 2021 Study Season, June through October



Other observations included Brown Trout #28 detected by the PIT tag array system in Prospect Creek, located about 0.42 mile upstream from its confluence with the river, October 25 through November 4 and recovery of radio tag #58. The radio tag from Rainbow Trout #58 was recovered near the mouth of Prospect Creek. After evaluating the fixed station receiver signal strengths and sensor data, it is assumed this Rainbow Trout was an angler mortality on approximately September 13.

Table 3-4 identifies all the tagged fish, including the date of radio tagging and transporting downstream, the first date detected in the far field, near field, and fish passage facility entrance, and the travel time between locations, as applicable. The dates only indicate the first detection into a specified location and do not summarize the duration fish were detected in each zone.

Brown Trout travel time from Flat Iron to the far field ranged between approximately 5 hours to 18 days. Brown Trout collected in the spring were first detected in the far field between June 19 and 29. Rainbow Trout travel time from Flat Iron to far field was between 5 hours and 32 days. Rainbow Trout were first detected in the far field between June 2 and July 6. The mean daily streamflow in the Clark Fork River (USGS #1238900) was an estimated 52,300 cfs when the first Rainbow Trout arrived to the ZOP (June 2) and around 38,200 cfs upon the arrival of the first Brown Trout (June 19). Most fish movement into the ZOP was detected following the June 6 peak stream flows during the declining limb of the hydrograph.

The following sections evaluate the travel time fish took between the far field and near field, from the near field to the fish passage facility entrance, movement patterns within the near field, the proportion of fish that entered the ZOP and entered the fish passage facility, and location(s) where fish were observed holding in the ZOP.

Detailed illustrations of individual fish detections and movement patterns within the ZOP are provided in **Appendix A**.

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Table 3-4. Travel Time for 2021 Radio Tagged Trout

Tag #	Spp.	Date Tagged/ Transport to Flat Iron (2021)	Date First Detected (2021)			Travel Time (Days)				Comments
			Far Field	Near Field	Fish Passage Facility Entrance	From Flat Iron to Far Field	From Far to Near Field	From Near to Fish Passage Facility Entrance	Far Field to Fish passage facility Entrance	
26	LL	10/1	10/17			18				
27[6]	LL	10/1 10/25	10/2 10/26	10/19 10/27	10/22	1 1	17 1	3	20	10/22 ascended ladder; 10/25 transported to Flat Iron 10/27 Main Dam
28	LL	9/29	10/1			2				10/25-11/4 detected by Prospect Ck array
39	LL	6/14	6/21	9/30		7	101			9/30 Manual tracked fish just below falls
46	LL	6/16	6/29			13				
47[8]	LL	6/16 10/25	6/19 10/26	10/14 10/31	10/15	3 1	114 5	1	115	10/24 ascended fish passage facility; 10/25 transported to Flat Iron 10/29 Fish passage facility Closed 11/1 Main Dam
48	LL	6/14	6/19			5				
59	LL	6/14	6/20			6				
60[8]	LL	6/14	6/23 6/30	6/25 9/26	6/29	9	2 88	4	6	6/29 water temp 21.3°C
49	RB	6/3	7/5			32				
51	RB	6/3	6/29			26				
52	RB	6/8	7/6	8/12		28	37			8/12 water temp 21.4°C
54	RB	6/9	6/29			20				
55	RB	6/14	6/30			16				
56	RB	6/8	6/24			16				
58	RB	6/2	6/2			<1				9/13 Angler mortality at mouth of Prospect Ck

Notes: < = less than

[6] Brown Trout #27 and #47 were transported back downstream on October 25. Brown Trout #60 entered the near field two separate forays

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3.3.1. Travel Time from the Far Field to the Near Field

Travel time from the far field to the near field is equal to the number of days between the last date a fish was detected at the PH or HB station and first date the fish was detected at the MDR or MDL station.

One-third of the tagged trout, four Brown Trout and one Rainbow Trout, continued to the Main Dam (**Table 3-5**). One Brown Trout was radio tagged in the fall and is evaluated separately from the fish collected in the spring.

Table 3-5. Travel Time from the Far Field to the Near Field in 2021

Collection Time 2021	Radio Tag #	Species	Travel Time (days) Far to Near Field	Date Fish Entered Near Field
Spring	52	RB	37	8/12
	39	LL	101	9/30
	47	LL	114 5	10/14 10/31
	60	LL	2 88	6/29 9/26
Fall	27	LL	17 1	10/19 10/27

Notes: LL = Brown Trout; RB = Rainbow Trout

Trout travel time from the far to the near field showed a large range, 2 to 114 days for the fish collected in the spring (3 LL, 1 RB) and 1 to 17 days for the Brown Trout collected in the fall (Table 3-5). Only one Rainbow Trout was detected in the near field, entering August 12 and returning to the far field August 13. Three Brown Trout made two separate forays from the far field to the near field. Brown Trout #47 and #27 returned to the ZOP and near field after ascending the fish passage facility and being transported downstream a second time in October. Brown Trout #60 entered the near field (and upstream fish passage facility entrance) in late June, a few days after entering the ZOP, and again in late-September, but did not enter the fish passage facility in the fall.

3.3.2. Travel Time from the Near Field to the Entrance of the Fish Passage Facility

Travel time from the near field to the entrance of the fish passage facility is equal to the number of days between the date a fish is first detected by the MDL/MDR station and the date the fish is first detected by the PIT tag array in the fish passage facility entrance (**Table 3-6)**.

Three of the five fish detected in the near field were also detected by the PIT Tag array in the fish passage facility entrance. These fish were all Brown Trout, two from the spring fish collection efforts and one from the fall fish collection. Brown Trout spent 1 to 4 days in the near field before

being detected at the fish passage facility entrance. The travel time between Brown Trout entering the far field (ZOP) and the fish passage facility entrance varied; 6 and 115 days for the two Brown Trout collected in the spring and 20 days for the Brown Trout collected in the fall (**Table 3-6**). As mentioned in the previous section, Brown Trout #27 and #47 ascended the fish passage facility in late October, while Brown Trout #60 returned to the far field after a quick entry into the fish passage facility in late June. Brown Trout #60 also returned to the near field in late September for about half a day before returning to the far field.

Table 3-6. Summary of Radio Tagged Fish that Traveled from the Near Field to the Fish Passage Facility Entrance in 2021 Season

Collection Time 2021	Tag #	Species	Date First Near Field Detection	Travel Time (days) Near Field to Fish passage facility Entrance	Date of First Fish passage facility Entrance Detection	Travel Time (days) Far Field to Fish passage facility Entrance
Spring	47	LL	10/14	1	10/15	115
	60	LL	6/25	4	6/29	6
Fall	27	LL	10/19	3	10/22	20

Note: LL = Brown Trout

3.3.3. Movement Patterns in the Near Field

The two Main Dam fixed stations had over 160,000 detections between June and October representing five individual fish (4 LL, 1 RB). The MDR station recorded 92 percent of the near field data (*refer to* **Table 3-2**). When fish were present in the near field, fish were recorded for a short duration (hours or days) in contrast to fish detected at the far field stations (weeks or months).

Daily detections, based on 5-second intervals, reveal the five fish were detected at both near field stations (MDR and MDL) for 21 days throughout the season with a total of 25 days by the MDR station and a total of 22 days at the MDL station. Daily detections of the four Brown Trout the single Rainbow Trout within the near field (MDR, MDL) are shown in **Figure 3-4 and Figure 3-5**, respectively.

Figure 3-4. Summary of Four Individual Brown Trout Daily Detections in the Near Field (MDR or MDL), 2021 Season

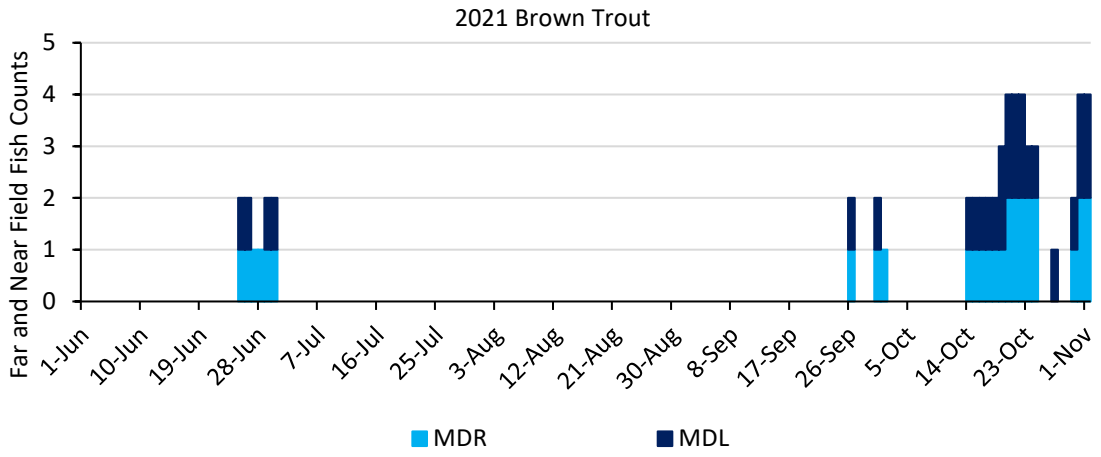
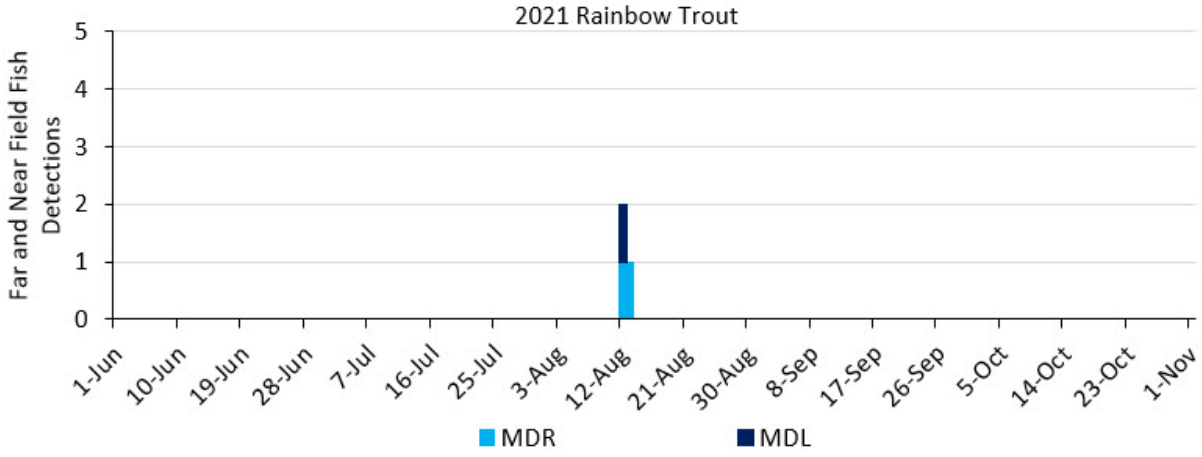


Figure 3-5. Summary of the Individual Rainbow Trout Daily Detections in the Near Field (MDR or MDL), 2021 Season



3.3.4. Proportion of Fish that Enter the ZOP and Locate the Fish Passage Entrance

The Thompson Falls fish passage facility PIT tag array system in the fish passage facility entrance detected three Brown Trout (#27, #47, #60), representing 19 percent of the fish that entered the ZOP. One fish entered in late June, and the other two fish entered in September and October.

Brown Trout #27 was initially PIT tagged during its first fish passage facility ascent, April 2020. Brown Trout #27 returned to the fish passage facility in 2021 and ascended the fish passage facility in just over 1 hour in late September and was radio tagged and released downstream on October 1. This Brown Trout returned upstream to the fish passage facility and ascended in 4.5 hours October 22. This fish was recorded at the work station on October 25, transported, and released back downstream of the dam and returned to the ZOP the next day and near field October 27.

Brown Trout #47 was initially captured and tagged (radio and PIT tags) upstream of Thompson Falls Dam on June 16. After being transported and released 4 miles downstream of the dam the same day, Brown Trout #47 migrated upstream and was detected in the near field October 14 through 24 and entered the fish passage facility on three separate days (October 15, 20, 24) before ascending the fish passage facility (~1 hour 45 minutes) on October 24. This fish was recorded at the work station October 25, transported and released back downstream of the dam and returned to the ZOP the next day and near field October 31.

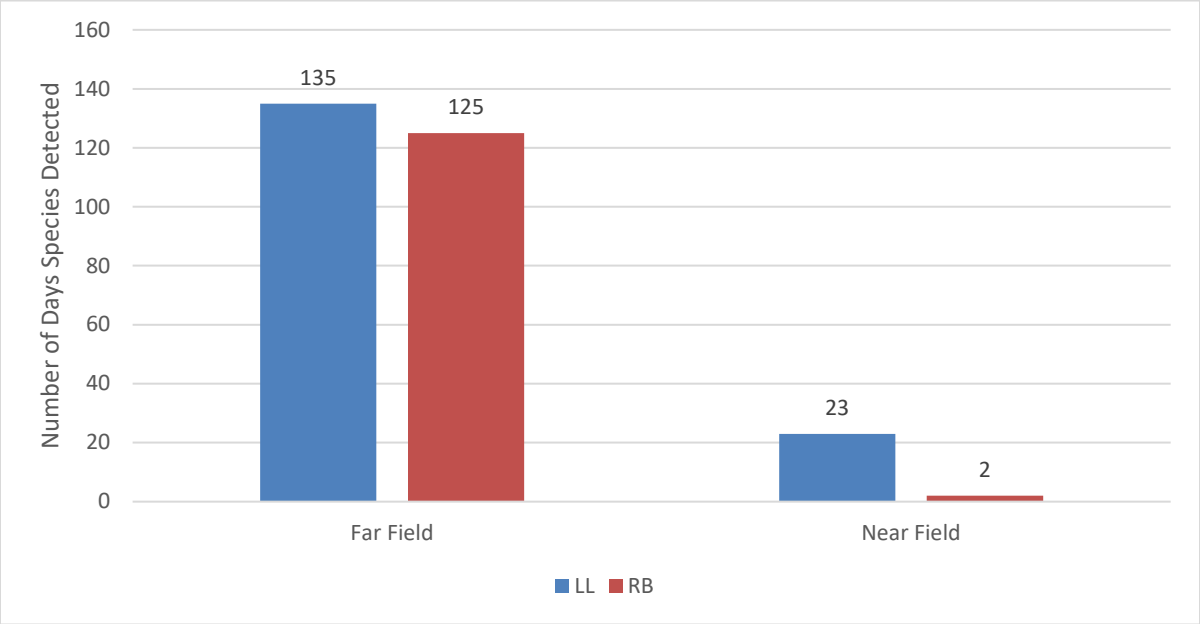
Brown Trout (#60) was initially captured on June 14 upstream of the Thompson Falls Dam where it received a radio and PIT tag prior to being transported 4 miles downstream of the dam. This fish was detected at the fish passage facility entrance for about 10 minutes approximately 2 weeks later, June 29, before returning to the far field detections areas.

3.3.5. Locations Where Fish Hold within the ZOP

Fixed station data indicate fish were remaining in the far field (PH or HB stations) for extended periods of time during the 2021 study season (*refer to* **Figures 3-2**, **3-3**) with about 96 percent of the fish detection records from the far field, PH and HB stations (*refer to* **Table 3-2**).

Rainbow Trout were detected by fixed stations 125 days (out of 154-day study season) in the ZOP beginning June 2 and ending November 1, representing about 81 percent of the study season. Brown Trout were detected 136 consecutive days by fixed stations in the ZOP starting June 19 and ending November 1, representing about 88 percent of the study season. Both species spent most of their time in the far field (**Figure 3-6**).

Figure 3-6. Number of Days Brown Trout (LL) and Rainbow Trout (RB) were Detected in the Far Field (PH or HB) and Near Field (MDR or MDL), 2021 Season (154 days)



Manual tracking located 15 of the 16 fish over the entire season (**Table 3-7**). Eight of the nine Brown Trout were located during the season, totaling 185 detections. All seven Rainbow Trout were detected during the season, totaling 171 detections. One Brown Trout (#26) was not detected *via* manual tracking but was detected briefly by the PH station in mid-October. During 2 days in July, a maximum of seven individual fish were located (**Figure 3-7**).

Figure 3-7. Manual Tracking Days and Number of Brown (LL) and Rainbow (RB) Trout Detected, 2021 Season

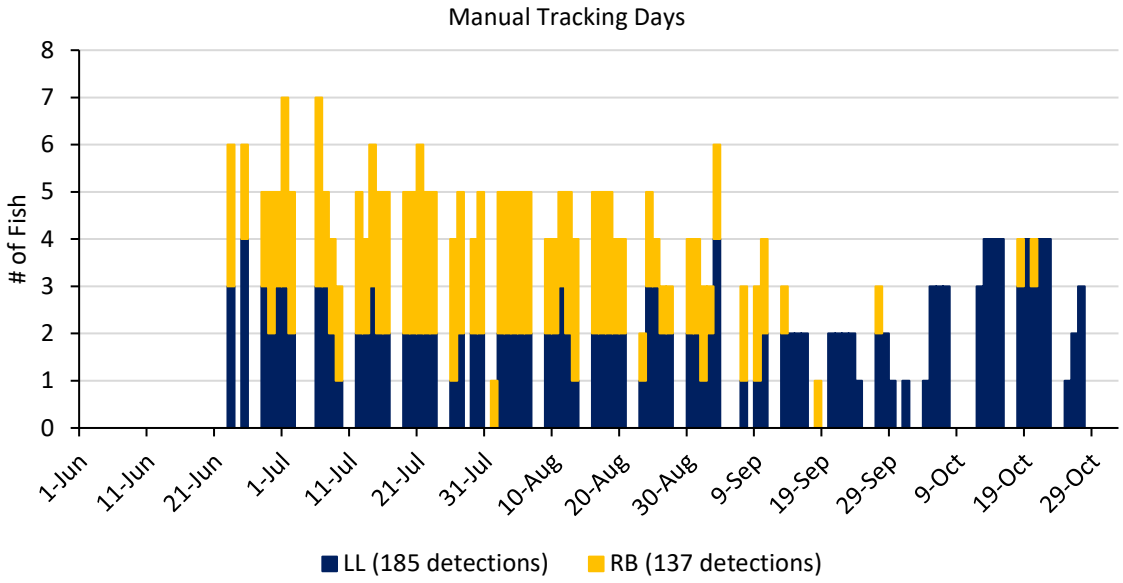


Table 3-7. Summary of Manual Tracking Detection Days for Individual Brown and Rainbow Trout, 2021 Season

LL Tag #	LL Total Detection Days	RB Tag #	RB Total Detection Days
26	None	**49**	22
27	11	**51**	49
28	14	**52**	12
39	47	**54**	10
46	40	**55**	2
47	11	**56**	4
48	2	**58**	38
59	2		
60	58		

Notes: LL = Brown Trout; RB = Rainbow Trout

The manual tracking data indicated most fish move up the main section of the channel and stayed away from the tailrace areas near the Original Powerhouse and New Powerhouse (**Figure 3-8**). Brown Trout were observed and recorded in more areas of the ZOP throughout the study season compared to Rainbow Trout (**Figure 3-9**). Rainbow Trout appeared to congregate near the mouth

of Prospect Creek, especially during the summer months. Prospect Creek is also a popular angling location. Rainbow Trout #58 was harvested at the mouth of Prospect Creek in mid-September (radio tag recovered). Few fish ventured into Prospect Creek and only one fish (#28) was detected by the Prospect Creek PIT Tag array in late October into early November, located about 0.42 mile upstream from the confluence.

Figure 3-8. Manual Tracking of all 15-Radio Tagged Fish, 2021 Season

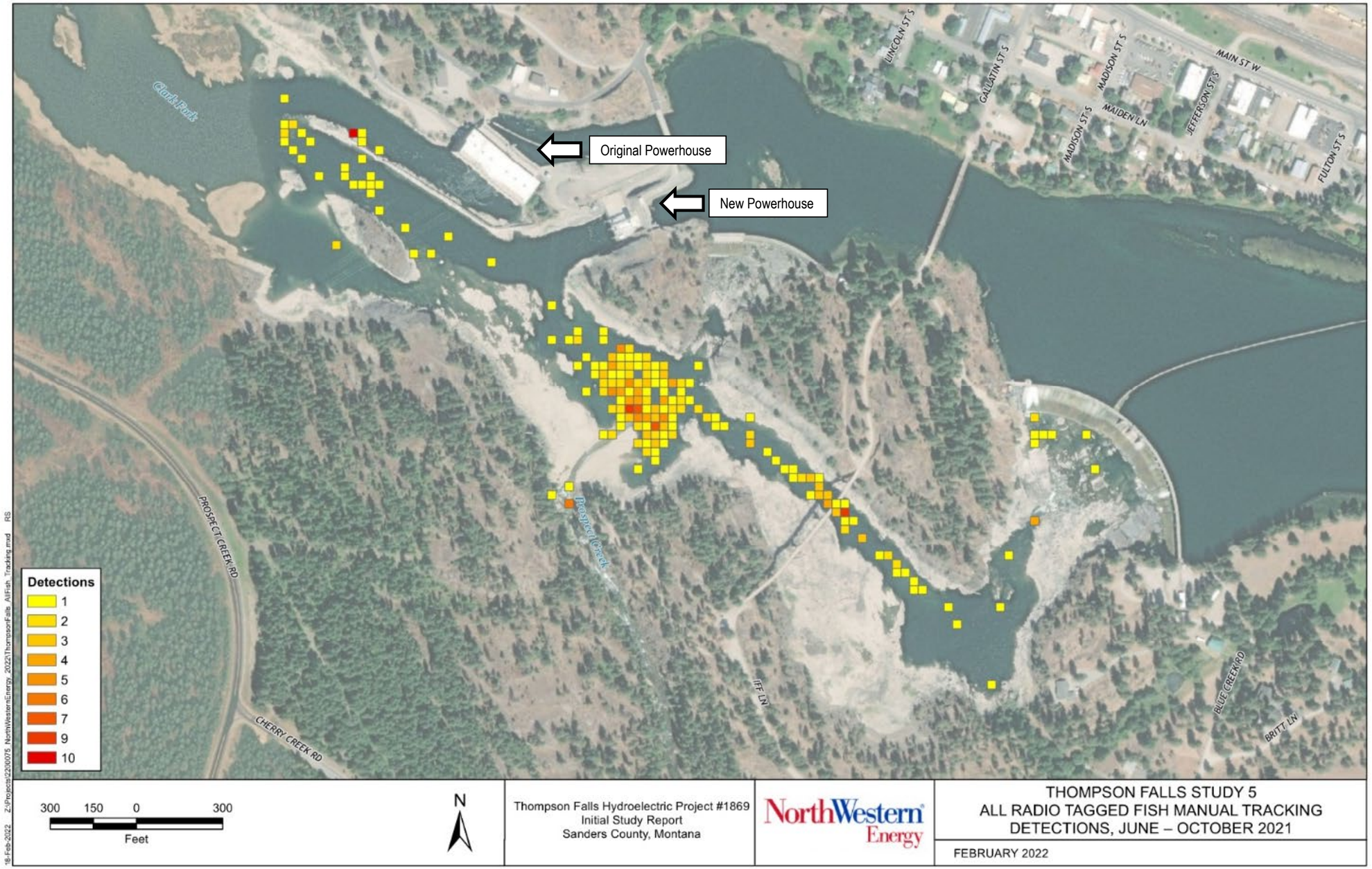
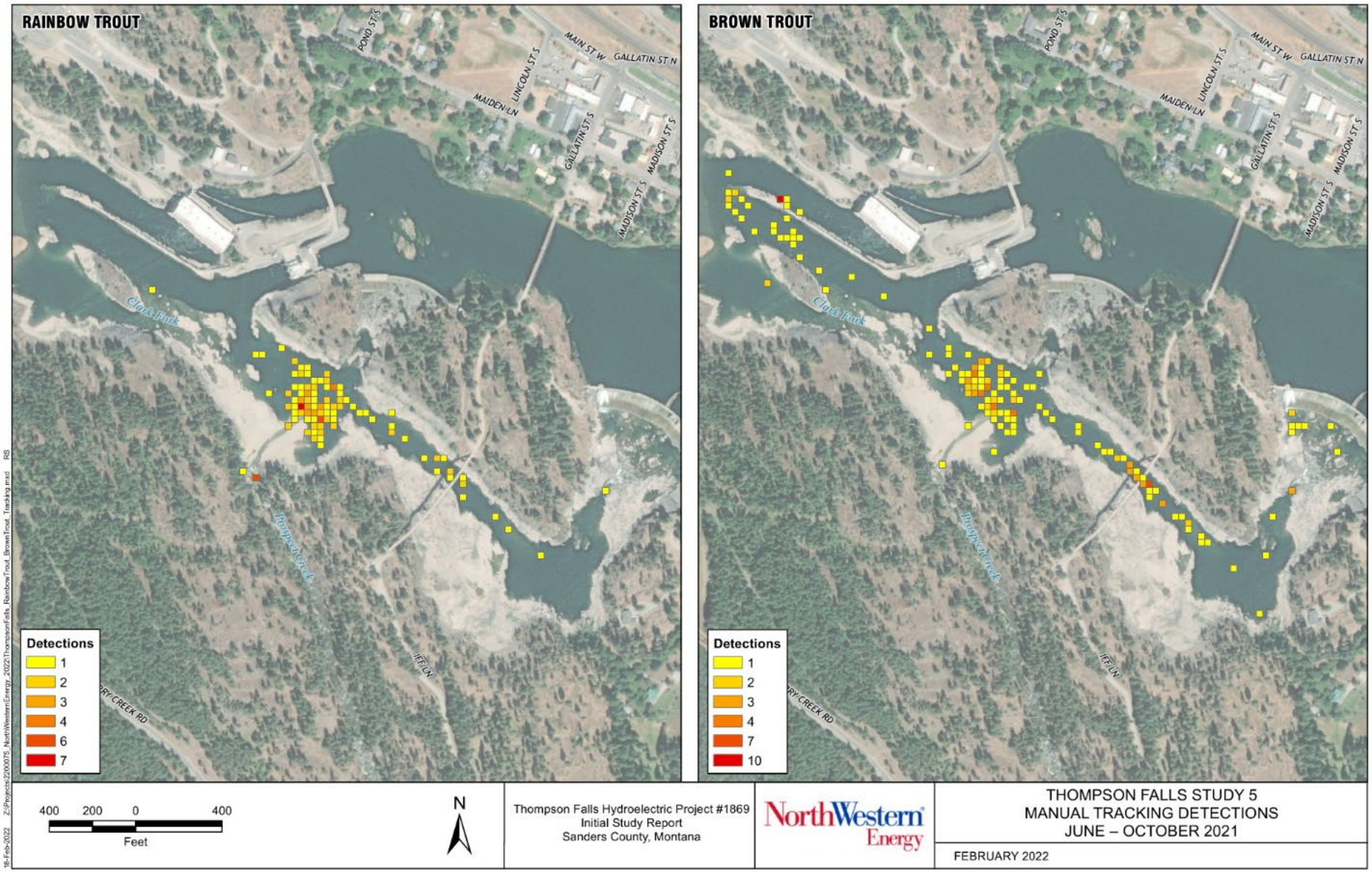


Figure 3-9. Manual Tracking of Brown Trout (right) and Rainbow Trout (left), June – October 2021



The monthly locations of Brown and Rainbow trout detected *via* manual tracking are shown in **Figure 3-10** and **Figure 3-11**, respectively. Yellow indicates one fish detected and the color becomes darker on a gradient from yellow, orange to red to represent a higher number of fish detected at a location. Manual tracking data support the fixed station results and indicate a large proportion of the fish appeared to hold in the far field, specifically near the mouth of Prospect Creek during July and August before dispersing by mid-September. Rainbow Trout appear to move downstream and, in some instances, leave the ZOP, while Brown Trout appear to move throughout the ZOP, including upstream to the Main Dam in October.

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Figure 3-10 Monthly Manual Tracking of Brown Trout, June – October 2021

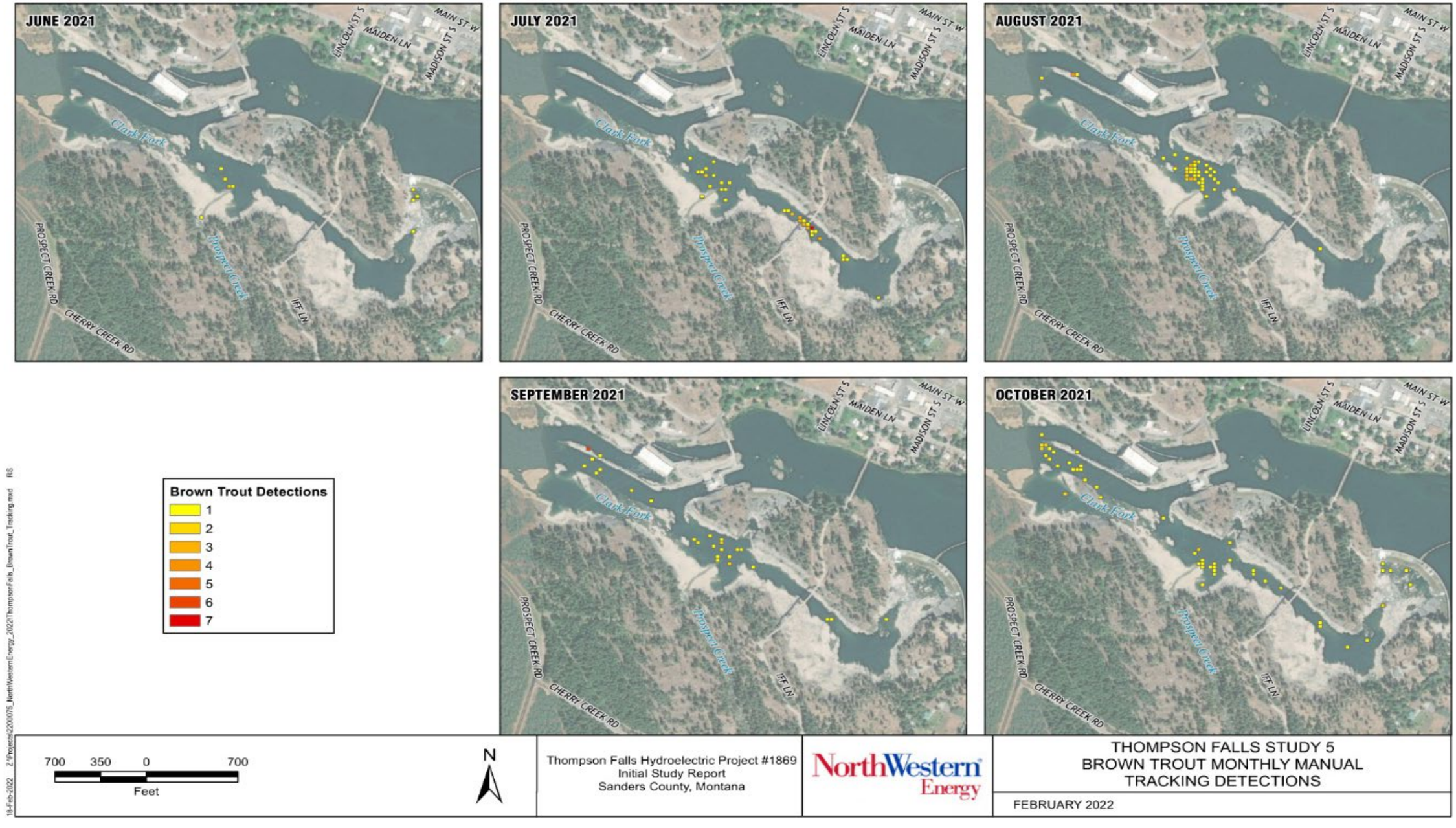
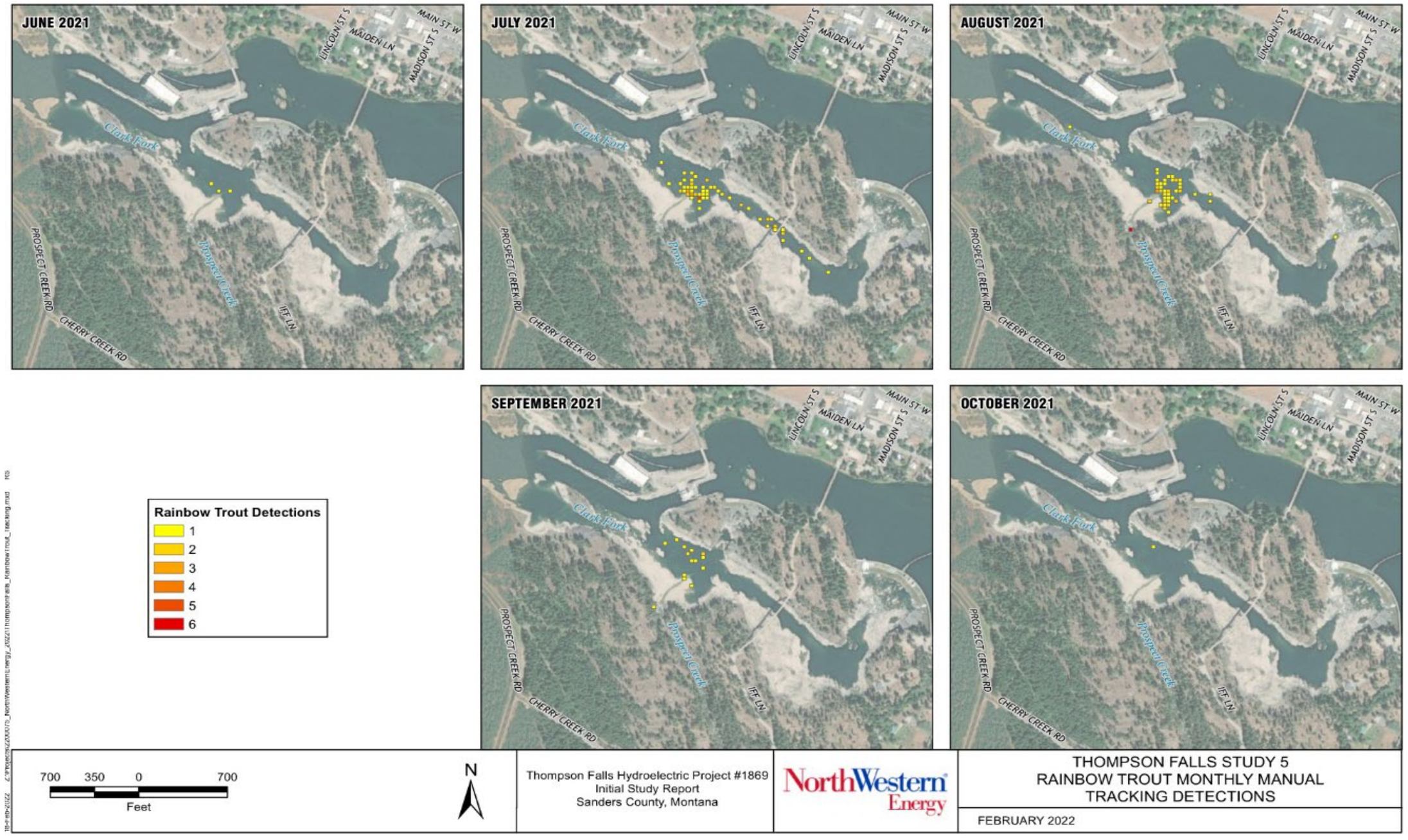


Figure 3-11 Monthly Manual Tracking of Rainbow Trout, June – October 2021



Water Temperature Profiles

NorthWestern collected temperature profile data at three locations: Prospect Hole, HB, and the Dollar Hole (**Figure 3-12**) in early August and September (**Figure 3-13**).

All three sites showed distinct thermal stratification on both sampling dates. Surface water temperatures in the Clark Fork River below the dam were between 22.4 and 23.4°C in early August (Figure 3-13) at all three sites. The HB site had a strong thermocline at 10 feet below the surface, and water temperature was 18ºC below 12 feet. The HB site is nearly 40 feet deep. The Dollar Hole was not as strongly stratified, with water temperature cooler at depth, but still remaining above 21ºC. The Prospect Hole site is shallower than the other two sites (less than 25 feet deep) but did have strong thermal stratification. Water temperature was approximately 18ºC below 10 feet.

By September 7, surface water temperatures had cooled from the summer highs and were between 18.5 and 19.4°C (Figure 3-13). Ten feet below the surface at Prospect Hole and HB, water temperatures were 15.1°C or less. Surface water temperature at the Dollar Hole remained around 19°C for the first 10 feet before declining to approximately 17ºC at about 18 feet below the surface.

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Figure 3-12 Temperature Profile Locations and Fixed Station Detection Zones

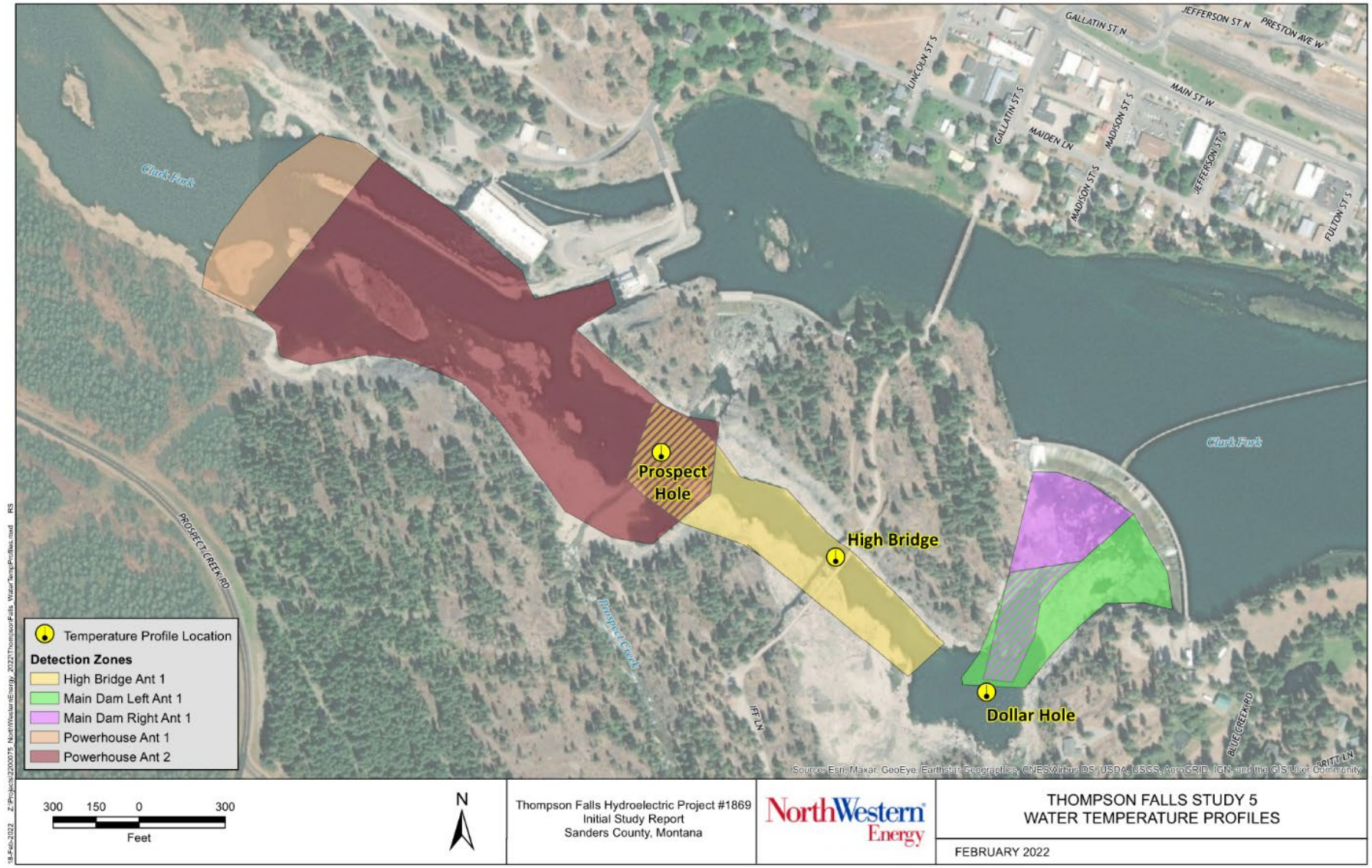
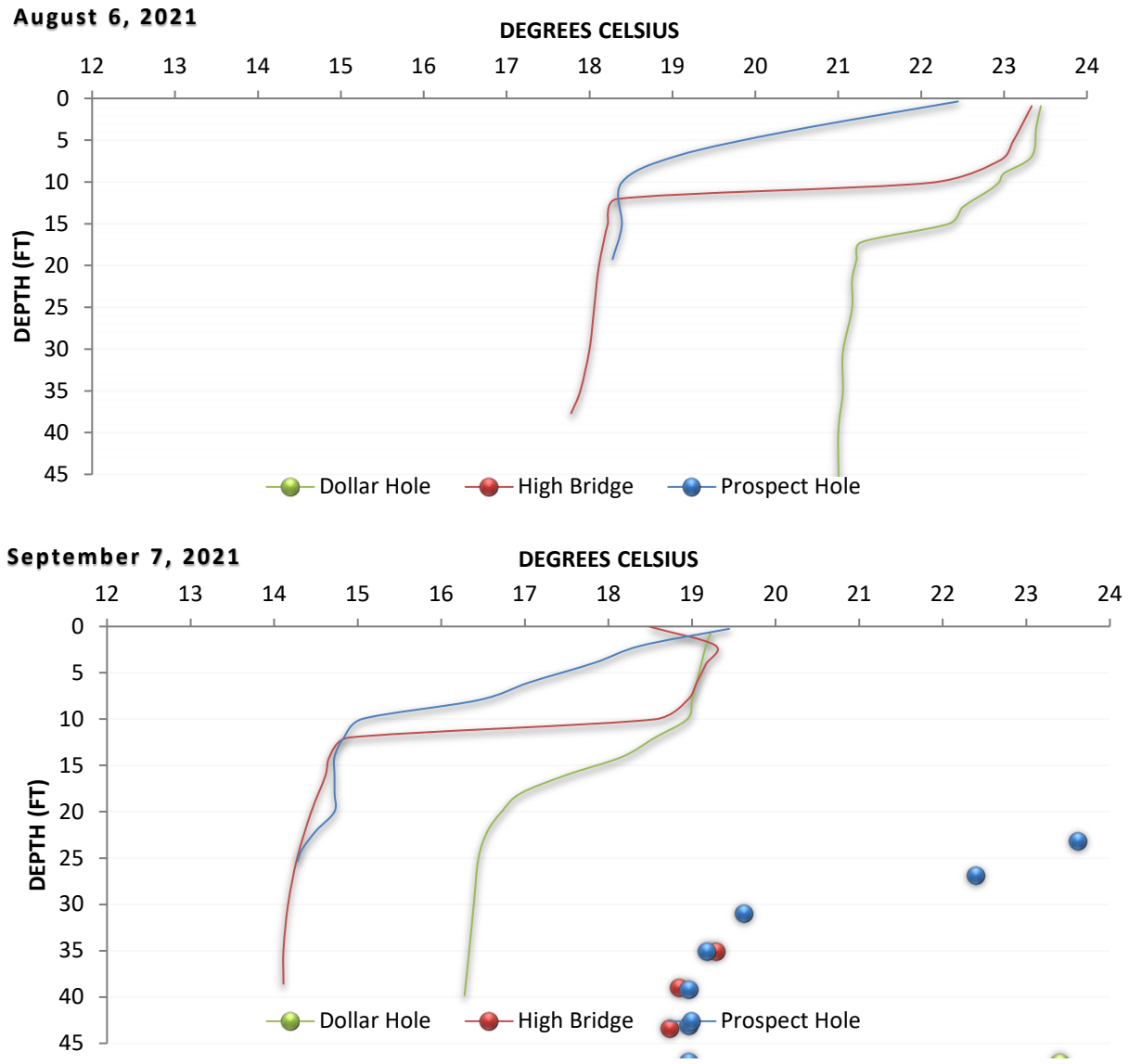


Figure 3-13 Temperature Profiles, August 6 (top) and September 7 (bottom) at Prospect Hole, High Bridge, and Dollar Hole

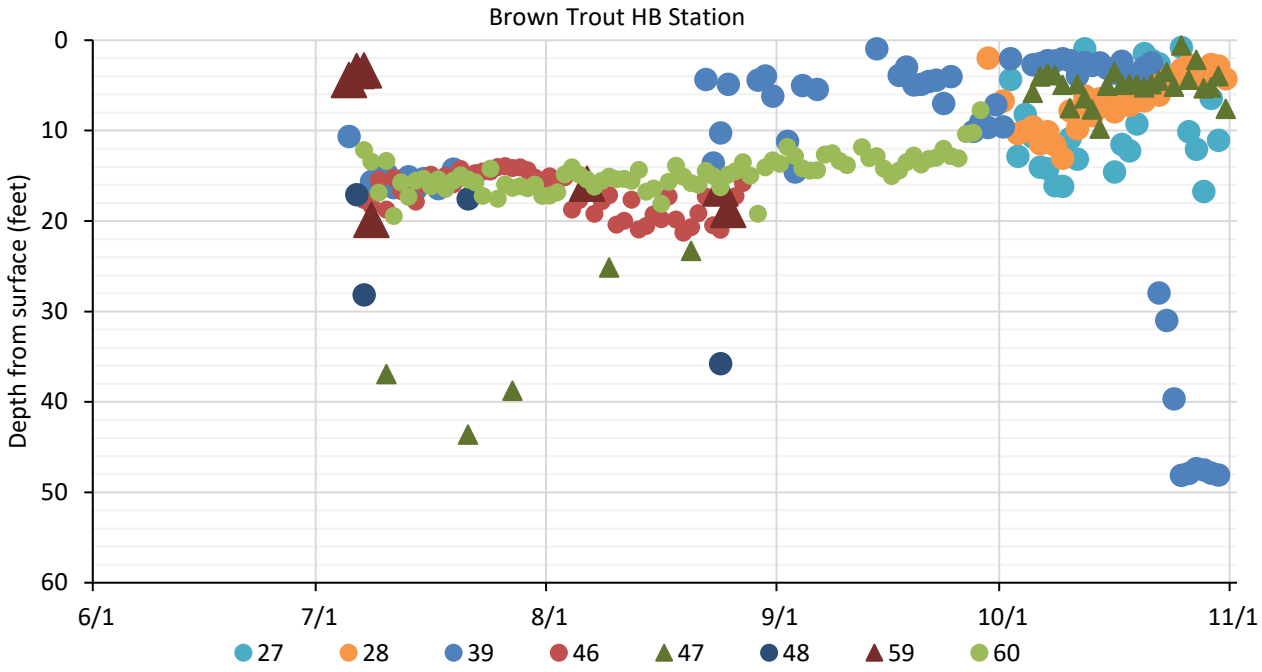


Fish Depth

The HB fixed station detects fish in the vicinity of the HB and the mouth of Prospect Creek (*refer to* **Figure 3-12**), which corresponds to two locations, HB and Prospect Hole, where water temperature profiles were collected. Fish depth data collected by the pressure sensor were used to evaluate habitat use by Rainbow and Brown trout at the different zones of detection. Pressure values were converted from a pound-force per square inch (PSI) to feet (PSI = 2.307 feet). Fish depth from the surface was compared to the temperature profile data to evaluate the hypothesis that fish detected by the HB station were at a depth where water temperature was cooler than surface temperature during the summer (July and August).

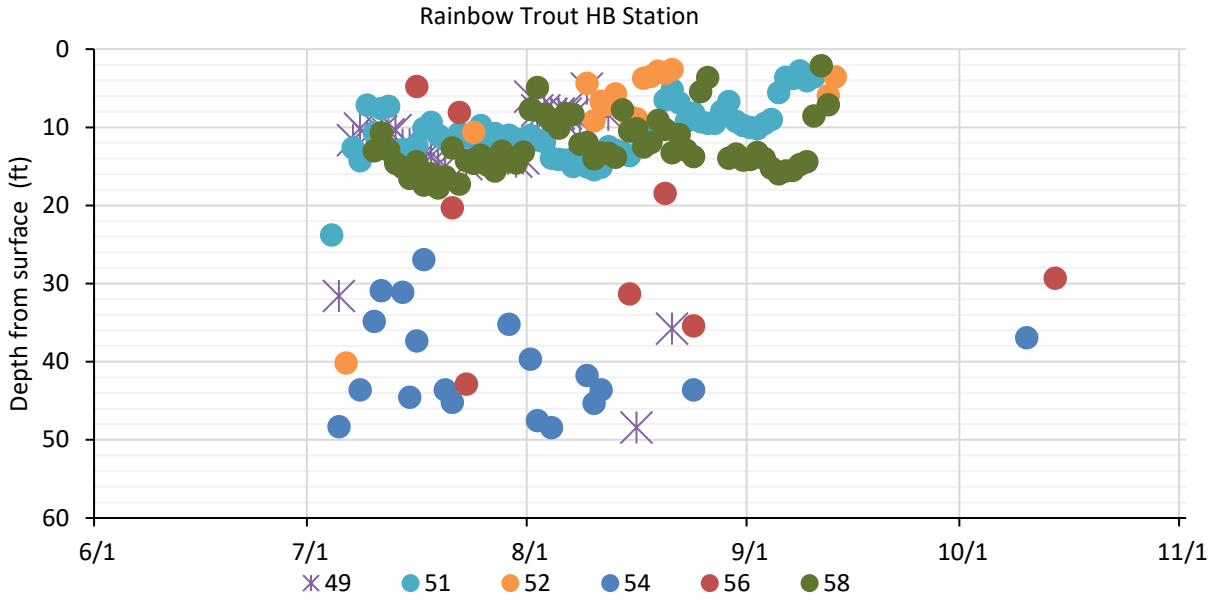
Starting in July and extending through October, eight of the nine tagged Brown Trout were detected by the HB station. Spring tagged fish (#39, #46, #47, #48, #59, #60) provide details of fish movement during July, August, and September, while the fall tagged fish (#27, #28) provide additional data points for movement in October. The spring tagged fish were all detected in the HB zone in July and August and were primarily at depths between 10 and 20 feet (**Figure 3-14**). In September two Brown Trout were present throughout the month but behaved very differently. Fish #39 moved closer to the surface, within 10 feet for most of the month and fish #60 remained below 10 feet from the surface until the end of the month. Fish #39 maintained a depth between 10 and 20 feet until late August, then remaining within 10 feet of the surface until October 22 when the depth data indicate the fish descended to nearly 50 feet. These data suggest the radio transmitter tag may have been expelled or the fish may have been deceased floating to the surface in September before decomposing and sinking to the bottom.

Figure 3-14 Daily Average Depth (feet from surface) of Eight Individual Brown Trout Detected by the High Bridge Station, 2021 Season



As with the Brown Trout, the six-tagged Rainbow Trout were detected by the HB station starting in July and extending into the first half of September (**Figure 3-15**). No Rainbow Trout were detected by the HB station during the second half of September and only two fish (#54, #56) were detected in October (1 day each). The majority of Rainbow Trout were below 10 feet of the surface in July with fish #54 remaining the deepest (>26-50 feet) out of all Rainbow Trout. In August, four of the six Rainbow Trout were more frequently detected between 5 and 15 feet from the surface with a slight trend of moving higher in the water column (2-10 feet) into early September. It should be noted that as fish #58 moved closer to the surface, it was caught by an angler on September 13 at the mouth of Prospect Creek. During the second half of September, no Rainbow Trout were detected by the HB station, but all five remaining live Rainbow Trout were detected by the PH station (and through October). These data suggest Rainbow Trout moved downstream from the Prospect/HB area during the second half of September when surface water temperatures started to decline to a more preferred range.

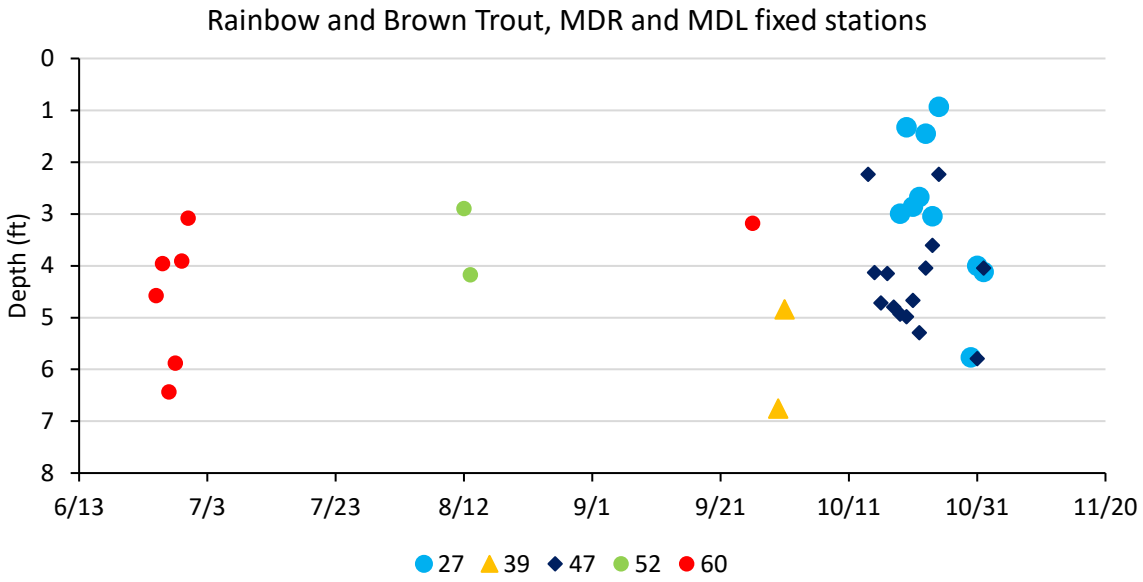
Figure 3-15 Daily Average Depth (feet from surface) of Six Individual Rainbow Trout Detected by the High Bridge Station, 2021 Season



In 2021, surface water temperatures exceeded 21°C between June 18 and August 19. Temperatures declined below 18°C by September 15 and declined below 15°C by the end of September (*refer to* **Figure 3-1**). Brown and Rainbow trout appeared to congregate in the HB detection zone during the warmer months before dispersing within the ZOP once water temperatures declined. By October, Brown Trout detected in the HB detection area were more frequently within 10 feet of the surface and Rainbow Trout were no longer within the HB detection zone and had moved downstream into the PH zone.

Fish were deeper in the water column within the PH and HB zones in contrast to the Main Dam zones. Main Dam pressure sensor data indicate all fish detected were within 7 feet of the surface (**Figure 3-16**). This is likely due to the fact that water depths are less in the Main Dam zones.

Figure 3-16 Daily Average Depth (feet from surface) of Rainbow Trout (#52) and Brown Trout (#27, #39, #47, #60) Detected by the MDR and MDL Stations, 2021 Season



3.4 Literature Review of Fish Swimming Abilities

Swimming abilities can be measured using volitional swim tests or forced swim tests *via* a swim chamber, tunnel, or respirometer. A forced swim test is similar to a "treadmill" test for fish that measures speed (e.g., feet per second, fps) and endurance (for a specified distance/time). Data presented in this Initial Study Report include a combination of volitional and forced swim tests with water temperatures ranging from 10 to 20°C, generally representative of stream conditions in the lower Clark Fork River (although summer temperatures often exceed 20°C).

Swimming speed and endurance vary by species, individual fish size, morphology, condition (health of the fish), and sexual maturity, and can also be strongly influenced by physical factors such as water temperature, season, site geometry, and hydraulics. In general, larger fish are able to swim faster than smaller fish. Fish shaped like a torpedo are more hydrodynamic and stronger swimmers. Fish in good condition have better energy reserves for swimming in contrast to fish in poor condition. Physical factors such as temperature impact metabolic rates in fish and may determine energy reserves available for swimming. Studies often find fish swimming abilities decline at temperatures below or above an optimal range for the species (Nudds et al. 2020; Lea et al. 2016; Mesa et al. 2003; Kolok et al. 1993; Facey and Grossman 1990).

Variability in fish swimming speed and endurance is also related to red and white muscle systems. Red muscle tissue is used for aerobic (i.e., low intensity) movements, whereas white muscle tissue is used for anaerobic (i.e., shorter, higher intensity) movements.

Fish swimming abilities are delineated into following three categories as defined by Beamish (1978):

- Sustained – purely aerobic effort used for long periods of travel at low speeds (> 200 minutes)
- Prolonged – combination of aerobic and anaerobic effort used for short periods of travel at high species (from 20 seconds to 200 minutes)
- Burst – purely anaerobic effort used for maximum swimming speed, inducing fatigue (< 20 seconds)

Prolonged and burst speeds are generally the focus in a fish passage evaluation because movement through a fish passageway is a short duration activity requiring prolonged and potentially burst speed. Thus, water velocity is the fundamental performance standard for accommodating fish passage and is generally determined by the swimming ability of the target species (O'Conner et al. 2017).

A summary of prolonged speeds and burst speeds for minnow, sucker, and salmonid fish species based on available literature is presented in **Table 3-8**. These native and non-native game fish species (in Table 3-8) have been the primary focus during the evaluation of upstream fish passage effectiveness and efficiency at Thompson Falls fish passage facility.

Table 3-8. Summary of Adult Fish Swimming Abilities, Prolonged and Burst Speed in Feet per Second, by Fish Family and Species

Common Name	Prolonged Speed (fps)	Burst Speed (fps)	References
MINNOW	**1.3-2.4**	**2.4-4.4**	COPW 2016 - Fish Passage at River Structures – Research and Design Guidelines (Colorado Parks & Wildlife - Fish Passage and Barrier Studies (state.co.us)
Northern Pikeminnow	1.3-3.8		Furniss et al. 2008; Myrick and Cech 2000; Mesa and Olson 1993
SUCKER	**1.3-2.5**	**2.2-3.2**	COPW 2016
Longnose Sucker	2.0-4.0	4.0-7.9	Katopodis and Gervais 2016; Underwood et al. 2014; FSOC 2012; Myrick and Cech 2000; Richer et al. 2020; Tillinger and Stein 1996, Bell 1991; Jones et al. 1974 cited in Furniss et al. 2008; Watts 1974
Largescale Sucker	1.6-1.9	6.0	Kolok and Farrell 1993; FSOC 2012
SALMONIDS	**2.3-4.0**	**4.5-7.5**	COPW 2016
Westslope Cutthroat Trout	1.6-6.4	3.3-13.5	Blank et al. 2019; FSOC 2012; Tillinger and Stein 1996; Bell 1991 cited in Furniss et al. 2008; Belford and Gould 1989; Aaserude and Orsborn 1986; Watts 1974
Rainbow Trout	1.6-4.0	3.4-13.5	Richer et al. 2020; Blank et al. 2019; FSOC 2012; Furniss et al. 2008; Burgetz et al. 1998; Schneider and Connors 1982; Tillinger and Stein 1996; Webb et al. 1984; Jones et al. 1974 cited in Furniss et al. 2008; Watts 1974; Bainbridge 1962
Mountain Whitefish	1.3-5	2.6-10	Katopodis and Gervais 2016; FSOC 2012; Tillinger and Stein 1996; Watts 1974
Bull Trout	1.3-2.8	3.6-7.5	FSOC 2012; Mesa et al. 2008; Mesa et al. 2003, 2004; Beamish 1980; Jones et al. 1974
Brown Trout	1.6-7.7	4.2-13.2	Aaserude and Orsborn 1986; Belford and Gould 1989; Watts 1974; Tillinger and Stein 1996; Peake et al. 1997; Aedo et al. 2009; Katopodis and Gervais 2016; Richer et al. 2020
Brook Trout	1.4-8.2	6.4-13.5	Katopodis and Gervais 2016; Tudorache et al. 2011; Peake et al. 1997; Tillinger and Stein 1996; Belford and Gould 1989; Watts 1974

Note: fps = feet per second; COPW = Colorado Parks and Wildlife

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4. Discussion

The radio telemetry study followed the movements of 16 tagged fish within the ZOP *via* fixed stations and mobile tracking with a nearly even distribution of Rainbow (n=7) and Brown (n=9) trout sampled. The study focused on movement, behavior, and travel time of fish between the far and near fields and entrance to the fish passage facility.

4.1 Rainbow Trout

In general, travel time calculations from the release site (Flat Iron boat launch) to the far field were likely not accurately capturing the first date of entry when the PH station was not collecting data from June 3 through 20. Even with this equipment issue early on, it is clear that both Rainbow and Brown Trout moved upstream to the ZOP shortly after their release. One Rainbow Trout was detected entering the ZOP approximately 5 hours after its release at Flat Iron, 4 miles downstream. The estimated cruising speed of this fish was approximately 1.2 fps, which is near the estimated prolonged swimming speeds (1.6-2.3 fps) for Rainbow Trout presented in **Table 3-7**. This individual was moving upstream June 2 when total flows exceeded 52,000 cfs (USGS #1238900) and a few days prior to peak flows in the region. The remaining six radio-tagged Rainbow Trout were observed entering the ZOP on average 23 days after their release at Flat Iron in late June and early July when total Clark Fork River flows were rapidly declining (< 30,000 cfs) and water temperatures exceeded 21°C. Data from these fish suggest there are suitable pathway(s) to the ZOP during spring flows.

By early July, Rainbow Trout had entered the ZOP and were in the far field within the detection area of the HB station. As the month progressed and water temperatures increased fish appeared to congregate near the mouth of Prospect Creek between 10 and 20 feet below the surface. Fish remained in the same area into August and early September at depths 2 to 16 feet. In mid-August, one Rainbow Trout entered the near field when water temperatures were just above 21°C, but no Rainbow Trout were detected at the fish passage facility entrance. By mid-September, Rainbow Trout left the HB detection area and moved downstream to the PH detection area or outside of the ZOP.

Based on the temperature data collected in early August and September, there was a defined thermocline in the HB and Prospect Hole areas where water temperatures were about 4 to 6°C cooler 10 feet below the surface. During this time, most Rainbow Trout in the ZOP congregated within the HB detection zone and based on manual tracking data, specifically at the mouth of Prospect Creek. They were detected between 2 and 48 feet deep. No Rainbow Trout were detected migrating upstream into Prospect Creek by the Prospect Creek PIT tag array. Upstream of the HB area (in the Dollar Hole) there appeared to be more mixing through the water column and August temperatures continued to be over 20°C at all water depths and no fish were detected in this area during the summer months.

During the hottest periods of the year, avoidance of unfavorable thermal conditions may be the primary driver of fish behavior. The temperatures recorded 10 feet below the surface at the HB and Prospect Hole in August were within the optimal range for Rainbow Trout, 6.8 to 18.2°C (Bear 2005; Bear et al. 2007).

4.2 Brown Trout

All nine radio-tagged Brown Trout were detected in the ZOP following their transport and release at Flat Iron boat launch. Brown Trout collected in the spring took an average of 6 to 7 days to move upstream into the far field. Brown Trout collected in the fall took less than 2 days to move upstream to the far field. The PH receiver was not working properly during the week immediately following the release of the spring collected Brown Trout and it is plausible some of these fish entered the ZOP earlier. The six spring-tagged Brown Trout were collected following the spring freshet (~58,400 cfs USGS #1238900) and these fish were detected in the far field when total flows were less than 38,200 cfs (USGS #1238900) and water temperatures were just above 16°C.

Four Brown Trout moved into the near field and three fish were detected in the fish passage facility entrance. These fish showed a large range of travel time from the far field to the near field, from less than 1 day to over 100 days. When Brown Trout were in the near field, more time was recorded by the MDR station *versus* MDL station. When in the near field, fish spent between hours to a few days in the near field prior to entering the fish passage facility or leaving the near field.

Manual tracking suggest Brown Trout utilized more area throughout the ZOP during the study season with the majority of fish congregating at the mouth of Prospect Creek during the hotter months (as was observed with Rainbow Trout). It is hypothesized that Brown Trout congregated to Prospect Hole and HB where temperatures were cooler 10 feet below the surface, thus providing more suitable thermal conditions within optimal range of Brown Trout, 12.8 to 19.0°C (NDEP 2017). The relatively higher temperature threshold for Brown Trout may allow for the use of larger areas and for longer periods as compared to Rainbow Trout, who tended to be more confined to thermal refugia.

During the hotter months, no Brown Trout were detected by the Prospect Creek PIT tag antenna array, located about 2,000 feet upstream of the confluence. However, in late October, one Brown Trout (#28) was detected at the array from October 25 to November 4. This fish had previously ascended the fish passage facility on September 29 prior to being transported downstream to Flat Iron and released with a radio tag. The collection of fixed station data ended October 31 and the fish passage facility closed October 29, thus it is unknown if this fish migrated to the Main Dam or fish passage facility entrance later in the season. Freezing conditions and operability of the fish passage facility are limiting factors for upstream fish passage moving into late October and beyond. The fish passage facility is typically closed between mid- and late October to avoid mechanical issues associated with freezing temperatures.

4.3 Summary

The 2021 study season provided insight to fish movement. All 16 tagged fish were detected by the fixed stations in the ZOP and 15 fish also *via* manual tracking. The manual tracking data indicated most fish moved up the main section of the river channel and stayed away from the outlet areas at the Original Powerhouse and New Powerhouse. When fish entered the Main Dam spillway area, the only pathway was up the center of the channel (through the falls) before moving to the right or left bank. Manual tracking only detected fish from the center to the right bank (side of the fish passage facility). When fish entered the near field, their presence was brief and fish spent substantially more time within the zone of the MDR station *versus* the MDL station before either returning downstream to the far field, entering the fish passage facility and then returning downstream to the far field, or entering and ascending the fish passage facility. No fish that entered the near field left the ZOP immediately, but rather remained within the far field for most of the study season.

Thermal conditions were likely a strong contributor to fish distribution of radio tagged fish in 2021. Extended periods of elevated temperatures can negatively impact fish, such as competitive ability, metabolic processes, and swimming abilities (Bear 2005). In general, salmonids optimal swimming performance occurs between 15 and 19°C and starts to decline when temperatures exceed 20°C for extended periods of time (EPA 2003). Reduction in migration fitness due to various stressors also occur when temperatures exceed 17 to 18°C for extended periods (EPA 2003).

In 2021, fish were observed in one primary location near the mouth of Prospect Creek where a defined thermocline set up during the summer months. No fish moved upstream into Prospect Creek past the PIT tag array system during the summer months. Once temperatures subsided in the fall, Rainbow Trout appeared to move downstream, and Brown Trout dispersed throughout the ZOP with some movement towards the Main Dam.

Fifteen of the 16 radio-tagged fish remained in the ZOP the majority of the study season, five fish (4 LL, 1 RB) entering the near field and three fish (3 LL) entering the fish passage facility. It is unclear why more fish did not move upstream into the near field and if this is related to thermal conditions in the area, velocity barriers, motivation factors, condition of the individual fish, or some unknown factor or combination of factors.

It is possible that the timing of fish collection for Rainbow Trout influenced motivation. Fish collection activities (first half of June) were likely targeting post-spawned Rainbow Trout. Some fish were observed to have sagging bellies, potentially due to recent spawning. It is probable these fish had recently migrated downstream and out of tributaries into the Clark Fork River mainstem. The combined stress of post-spawn condition and surgery for radio tagging may have had a greater effect on post tagging behavior and recovery. The level of upstream motivation for these individuals may have been influenced by the timing of capturing and radio tagging Rainbow Trout after spawning.

Fish collection of Brown Trout indicates these fish move upstream into the ZOP regardless of collection upstream of the dam or at the fish passage facility or whether they were tagged in the spring or fall. Fall collected fish displayed quicker travel time between the release site to the far field and from the far field to the near field. However, only three of nine Brown Trout (2 from spring collection; 1 from fall collection) entered the fish passage facility. Based on these initial study results, it remains a challenge to understand motivation for upstream movement.

Data collected at the fish passage facility recorded between 181 and 366 Rainbow Trout (213 RB in 2021) and between 28 and 248 Brown Trout (248 in 2021) ascending the fish passage facility annually. It's indisputable, fish use the fish passage facility and move upstream. This study assumed all fish collected upstream of Thompson Falls Dam or at the fish passage facility are motivated to move upstream. This study showed all fish collected, tagged, transported, and released downstream were motivated to move a minimum of 4 miles upstream. The data collected suggest water temperatures influenced movement patterns, distribution, and behavior, as has been documented by others (Bear et al. 2007, Bear 2005, Dunham et al. 2001). However, the initial study results did not reveal why the radio-tagged fish moved into the ZOP but did not continue to the Main Dam or fish passage facility.

Further, in 2021, 60 percent of the Brown Trout and 51 percent of the Rainbow Trout recorded at the fish passage facility ascended the fish passage facility in July and August. However, only one radio-tagged fish (RB) was detected in the near field during this period. It is unclear if assumptions of motivation are correct, if location of sampling is ideal (i.e., should sampling be focused on the fish passage facility), if timing of fish collection for the study is more critical, or how temperature and stress impact fish movement and/or motivation.

Data collected from the upstream fish passage facility and radio telemetry studies has shown the challenge of quantifying motivation for fisheries to find and ascend the fish passage facility. There are many contributing factors to motivation and no one year is the same as the next when it comes to water conditions and operations. Annual data collected at the fish passage facility since 2011 (PPL Montana 2012, 2013, 2014; NorthWestern 2016, 2017, 2018, 2019, 2019a, 2021, 2022) and radio telemetry data from 2003-2006 (GEI 2007; Haddix and Gillin 2006; Gillin and Haddix 2005) and 2021 (this study) indicate upstream movement is likely influenced by a variety of physical and biological factors and is not necessarily consistent for an individual fish or for each species within a given year or between years.

Continuing this study into 2022 will assess fish movement and behavior during springtime prior to and during peak flows and evaluate if trends observed during the summer and fall 2021 occur again. The data from 2021 and 2022 will be used in conjunction with the fish swimming ability data (presented in Section 3.4 – Literature Review of Fish Swimming Abilities) and Hydraulic Modeling Study to identify potential velocity barriers (e.g., seasonal, year-round) in the near field for the final report, is scheduled to be submitted to FERC in May 2023.

5. Second Study Season

The fish collection methods implemented in 2021 will continue in 2022. As stated in the Revised Study Plan, "NorthWestern will collect a maximum of 60 Rainbow Trout and 40 Brown Trout over the 2-year study." The first year (2021) of the study resulted in the collection and tagging of 16 fish (7 RB and 9 LL). In 2022, fish collection will include a maximum of 53 Rainbow Trout and 31 Brown Trout. Fish may be collected from the three designated sites: main Clark Fork River, Thompson River, and the fish passage facility. Fish collection efforts in 2022 will start earlier in the year to improve opportunities to capture fish in the river and at the fish passage facility prior to high spring flows. Brown Trout may be collected at the fish passage facility in the fall 2022, as was done in 2021, if spring collection efforts do not provide an adequate sample size.

Manual tracking will continue to occur throughout the second study season with frequency dependent on fish presence (as determined from fixed station data) in the ZOP. Manual tracking will focus on spring movement prior to and during peak flows as well as determining if fish tagged in 2022 show similar movement patterns as in 2021 during the summer and fall months.

The results from 2022 fish movements (fixed and manual data) within the ZOP and travel time between the far and near fields will be summarized and compared to 2021 results. The Final Fish Behavior Study Report will also evaluate fish holding areas observed during both study seasons and assess whether hydraulic barriers (e.g., velocity barriers) are contributing or influencing fish movement in the ZOP based on the CFD model from the Hydraulic Modeling Study.

The final study results will be submitted to FERC by May 10, 2023, as part of the Updated Study Report.

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Appendix A 2021 Radio Telemetry Fish Detections

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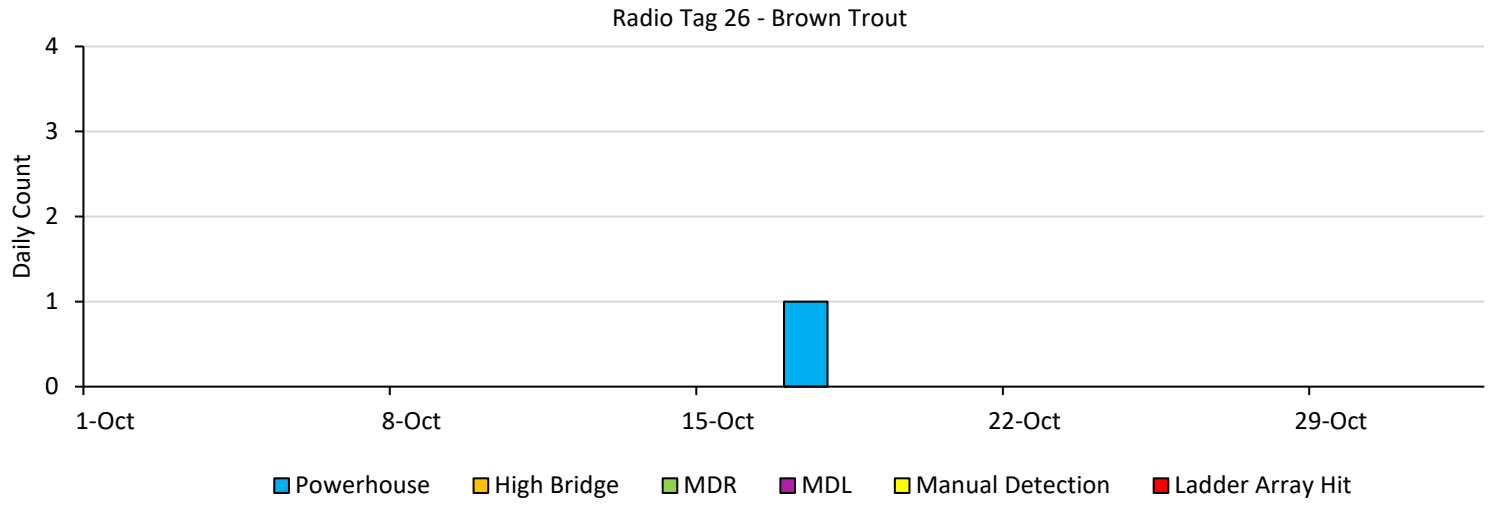
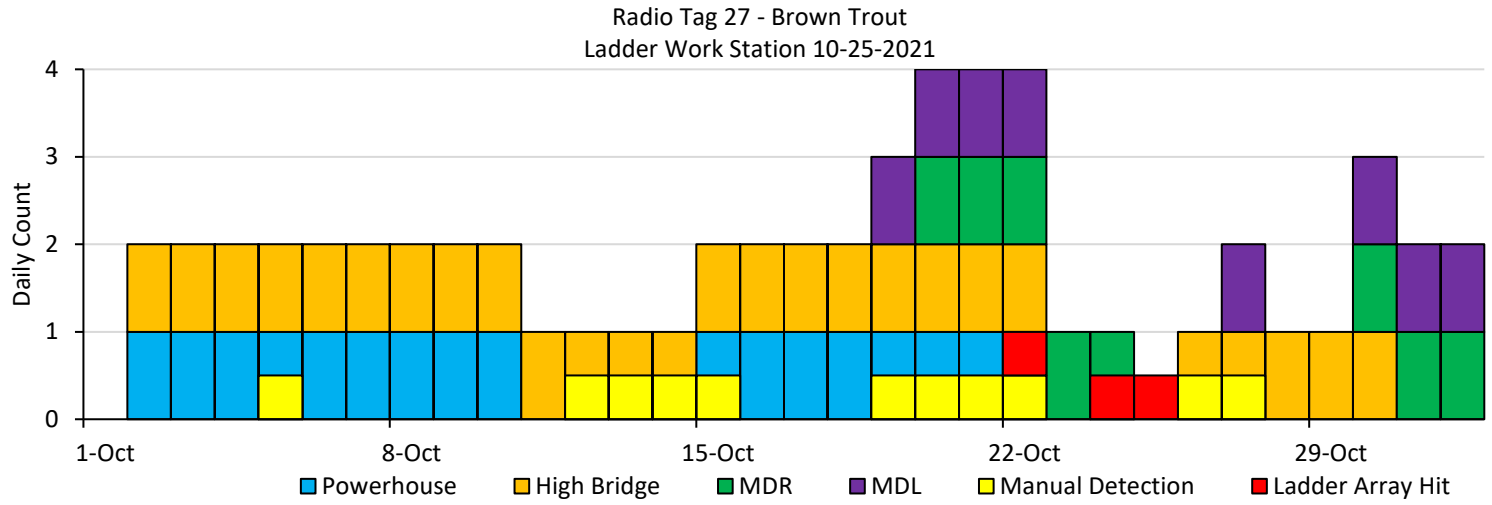
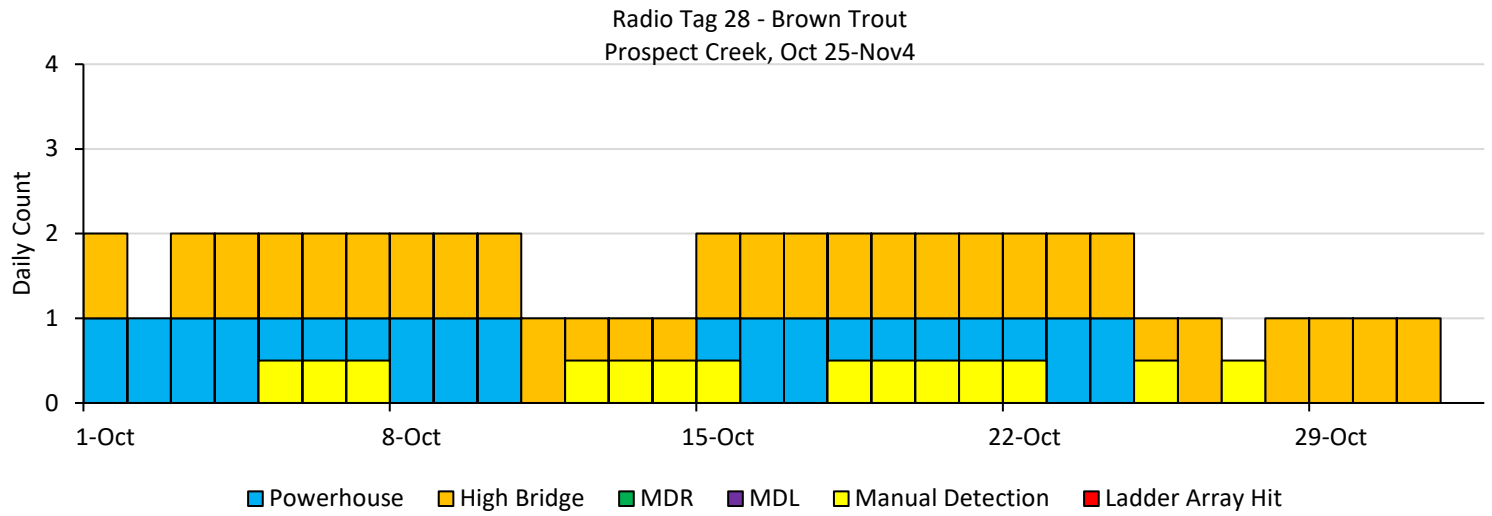
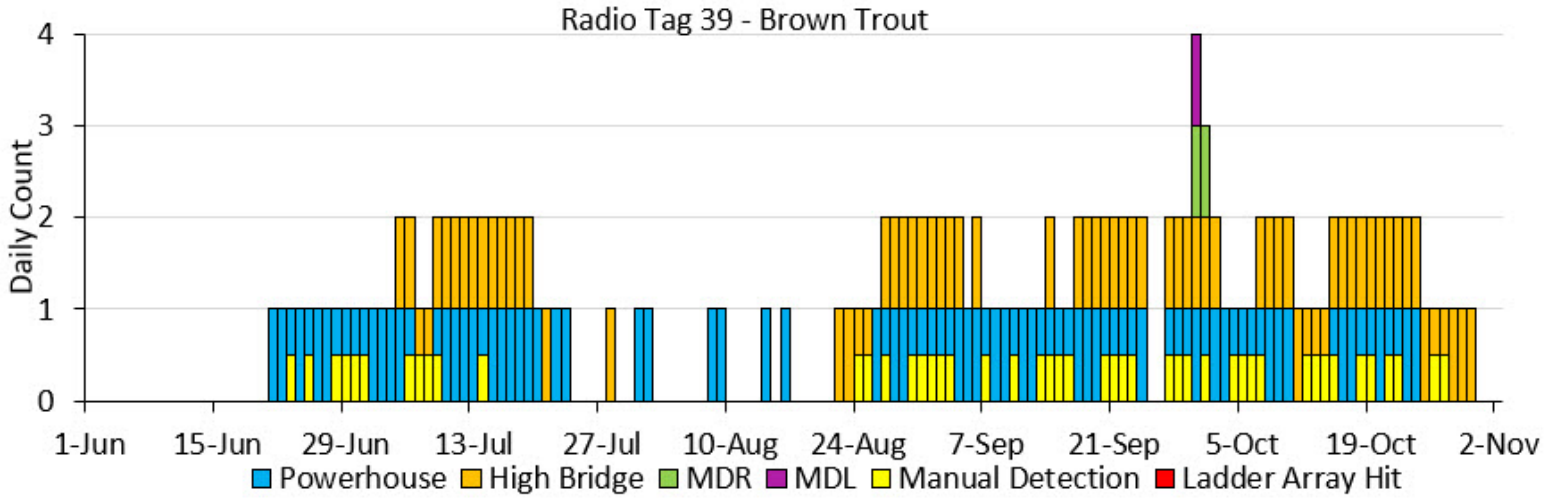
Fixed Station Detections – Individual Fish

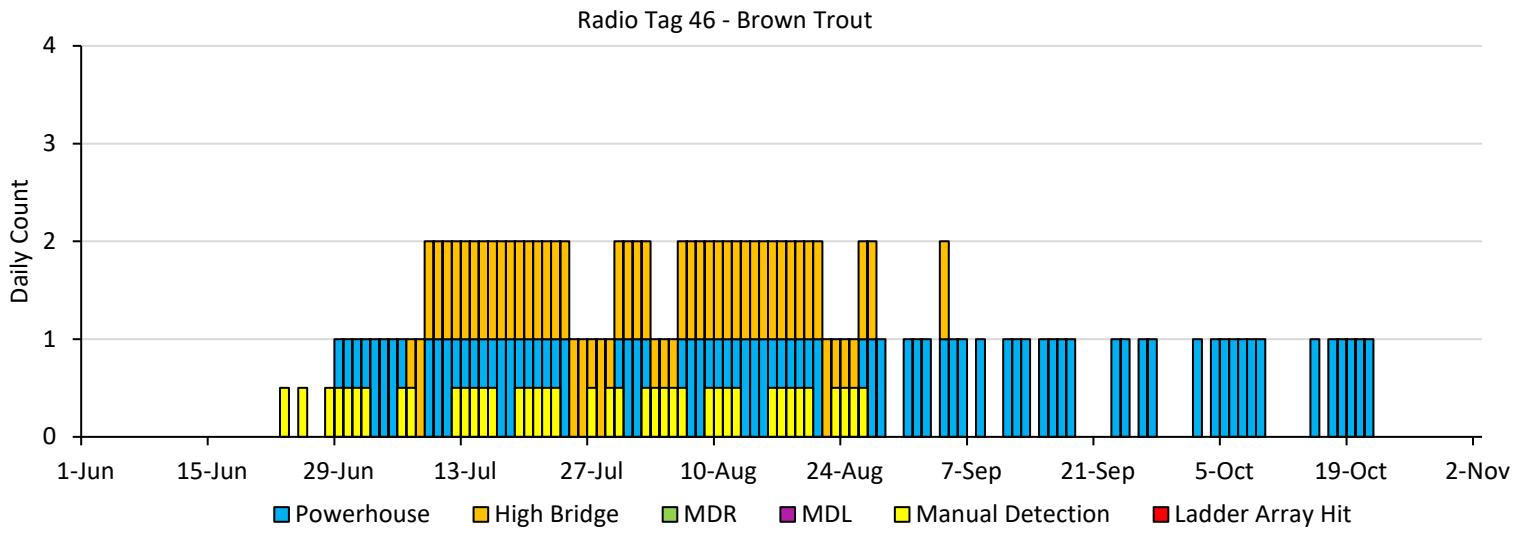
Brown Trout Spring Tags # 39, 46, 47, 48, 59, 60 and Fall Tags #26, 27, 28

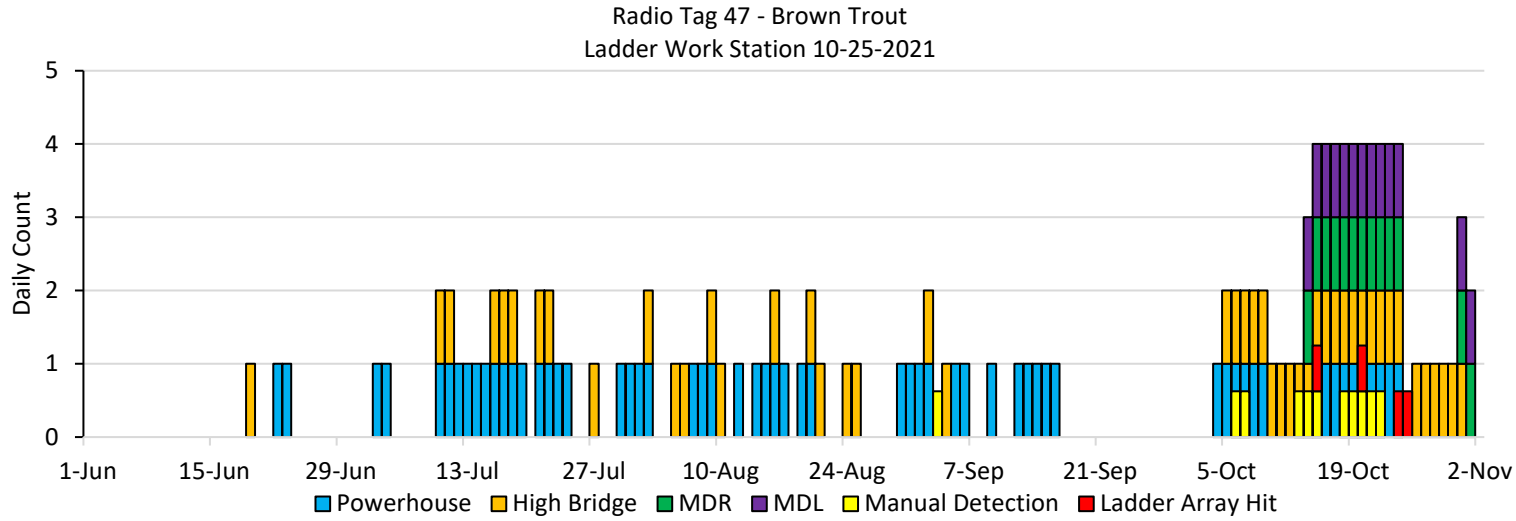


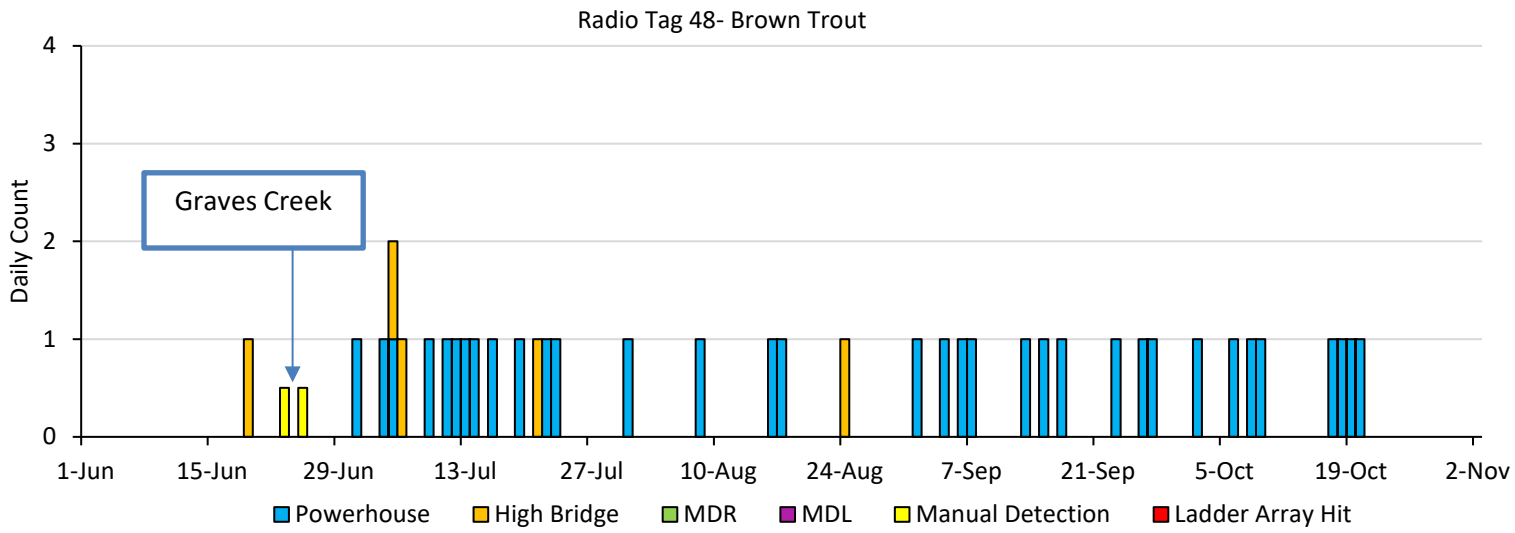


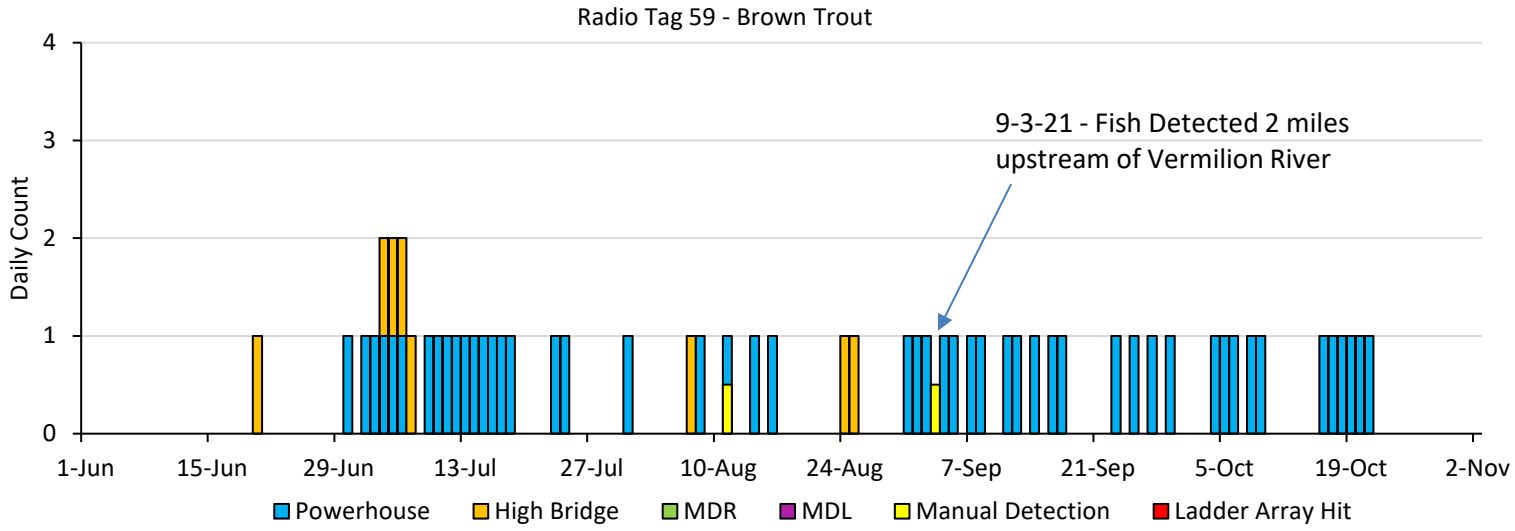

Radio Tag 28 - Brown Trout
Prospect Creek, Oct 25-Nov4
Daily Count
0
1
2
3
4
1-Oct
8-Oct
15-Oct
22-Oct
29-Oct
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit

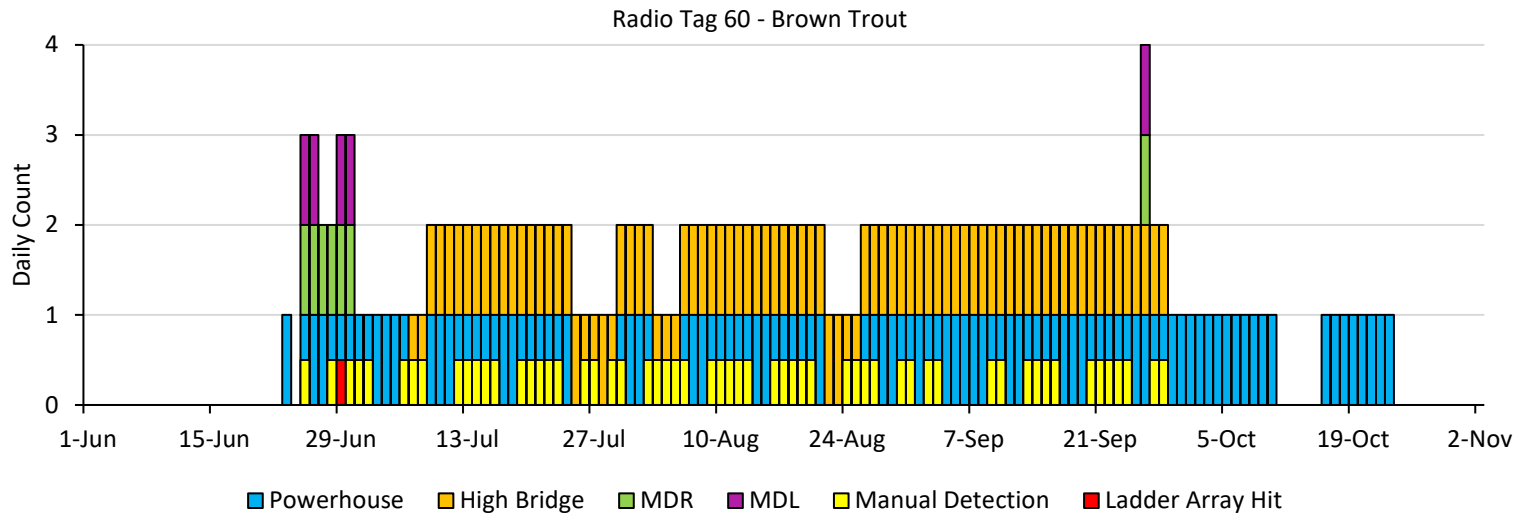

Radio Tag 39 - Brown Trout
Daily Count
0
1
2
3
4
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit



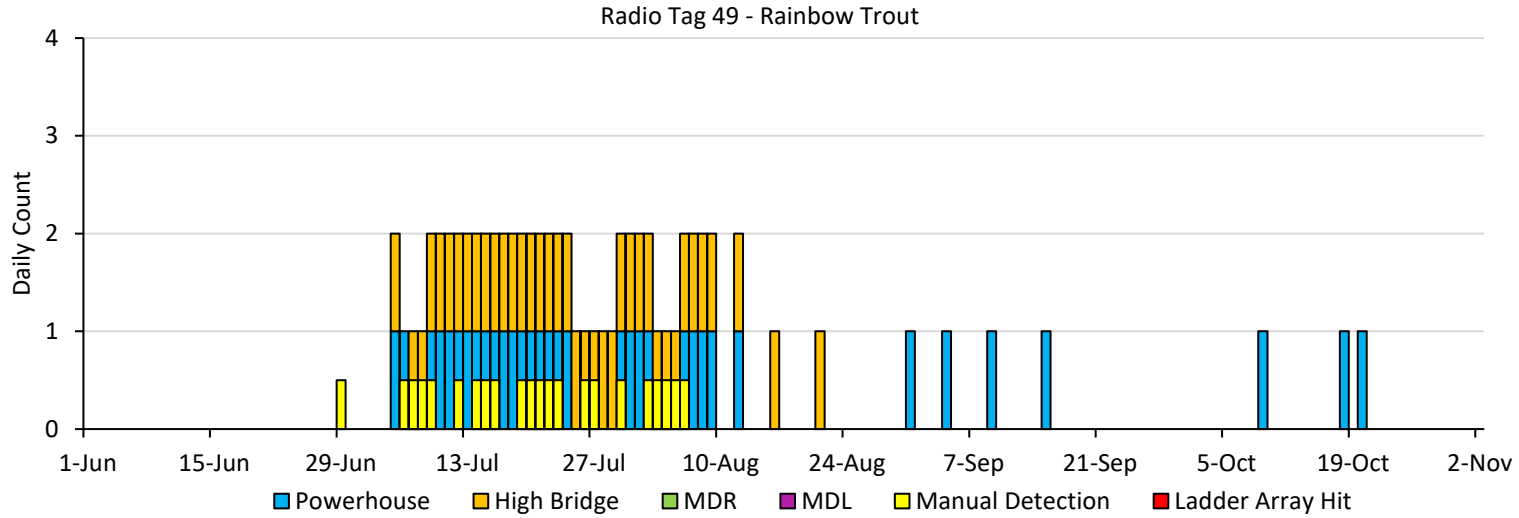


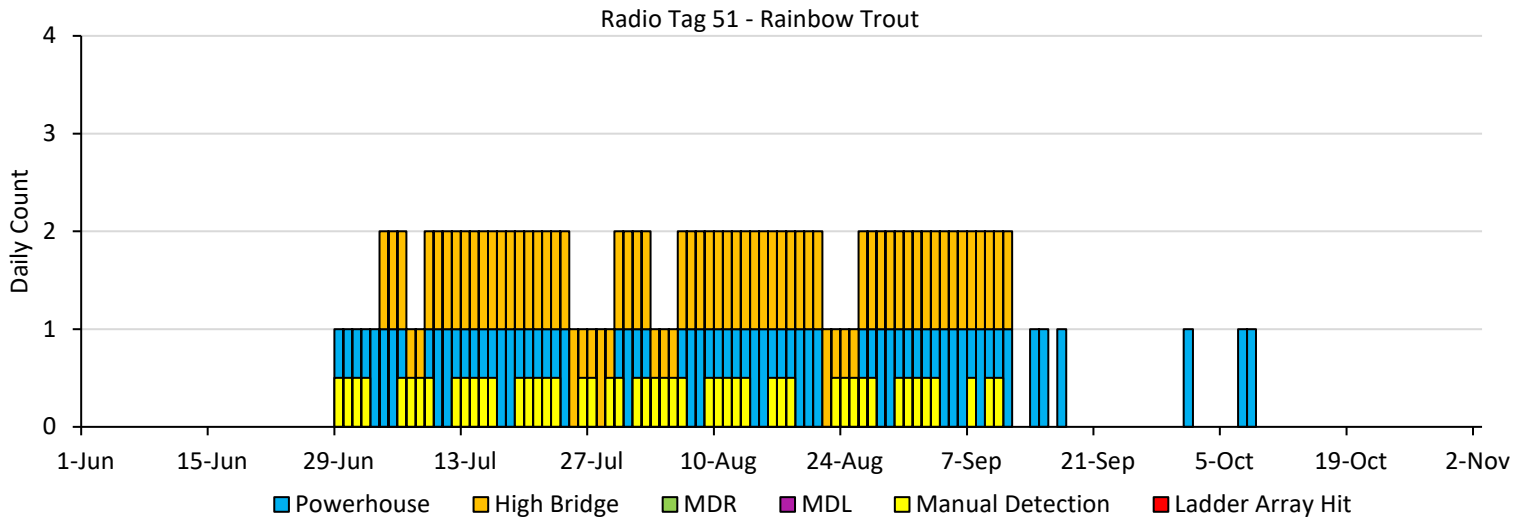

Radio Tag 48- Brown Trout
Daily Count
Graves Creek
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit

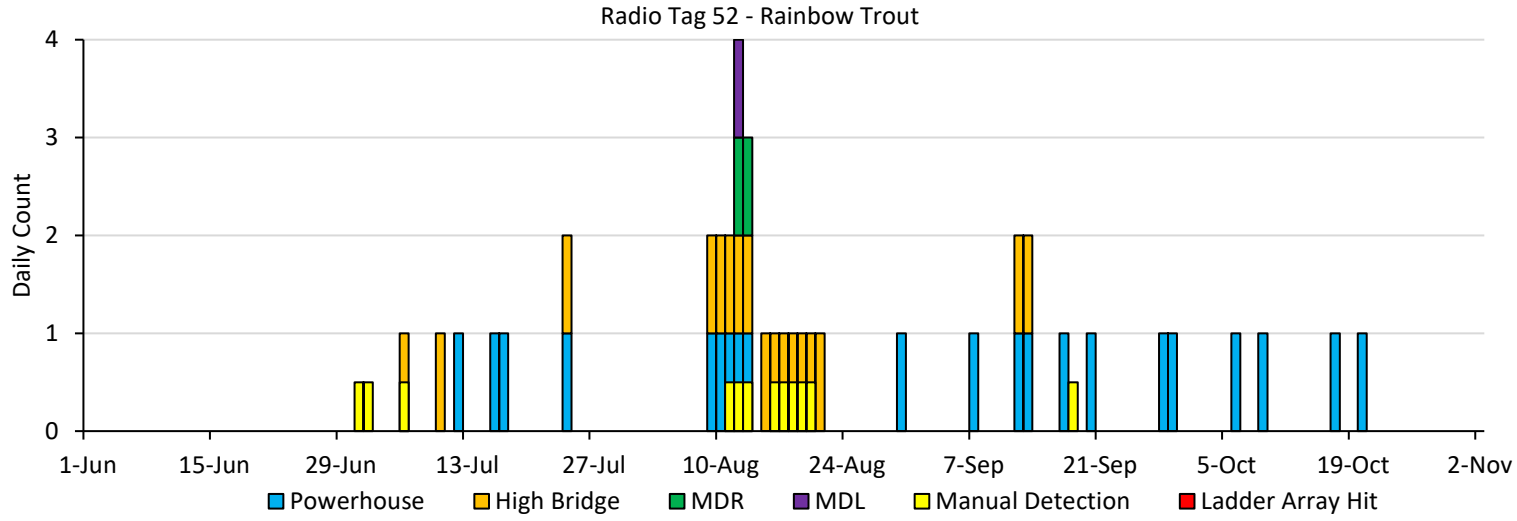

Radio Tag 59 - Brown Trout
Daily Count
9-3-21 - Fish Detected 2 miles upstream of Vermilion River
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit

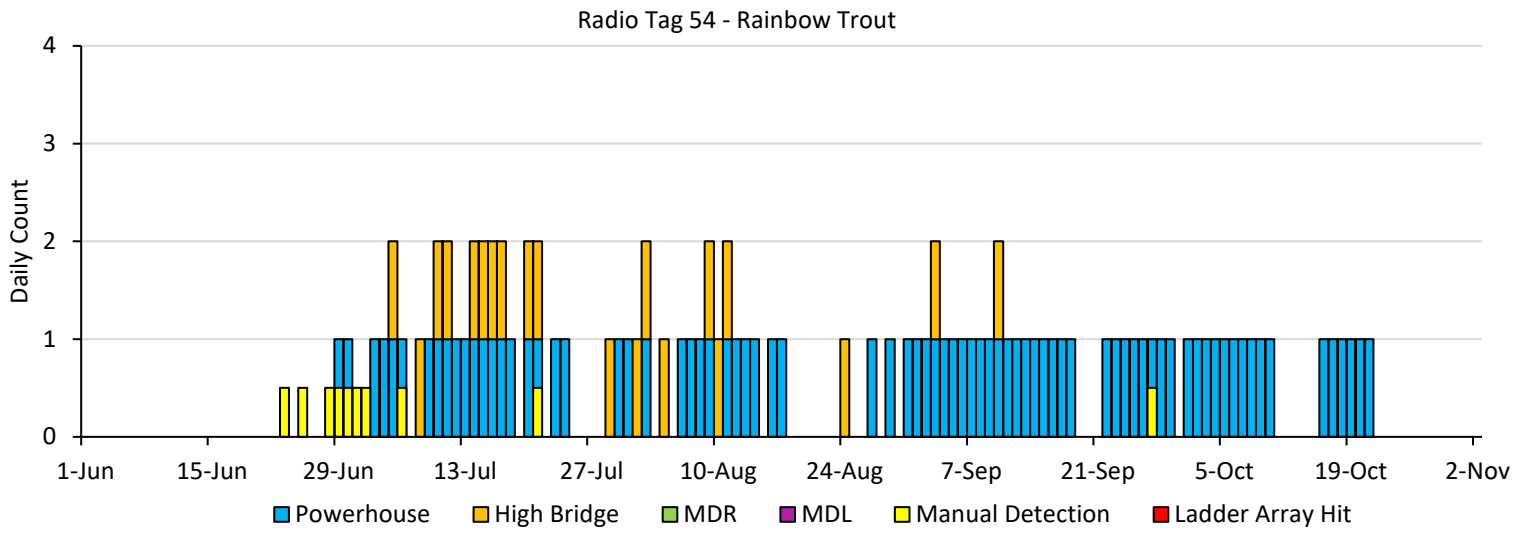


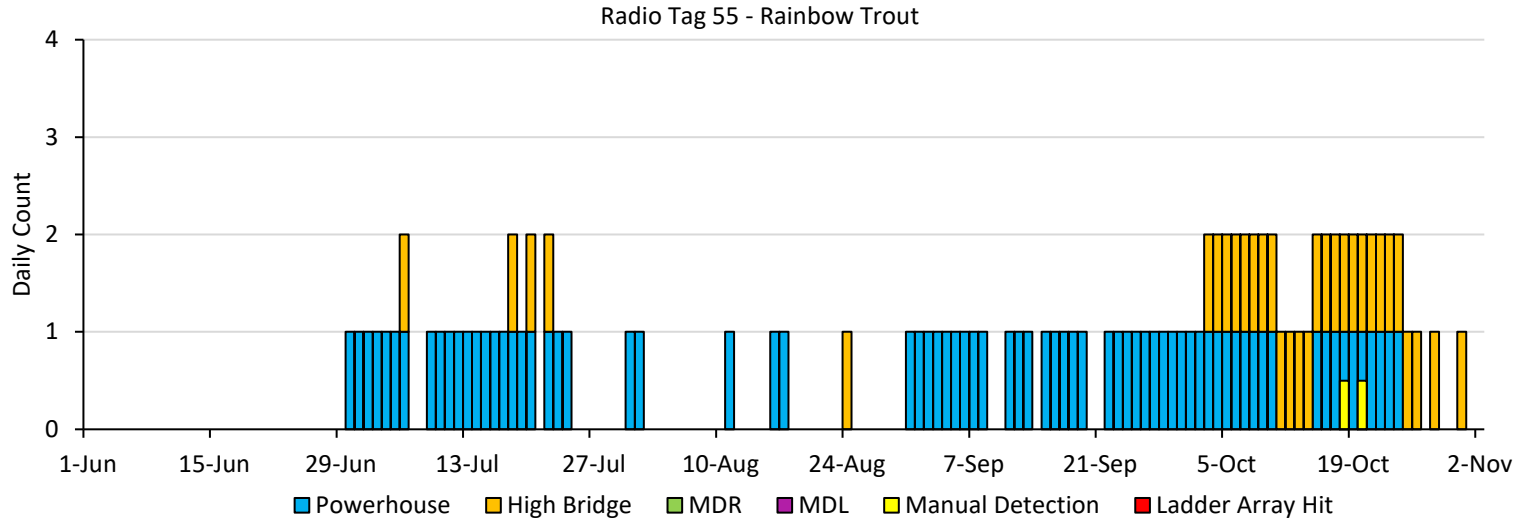
3.3.6. Rainbow Trout #49, 51, 52, 54, 55, 56, 58

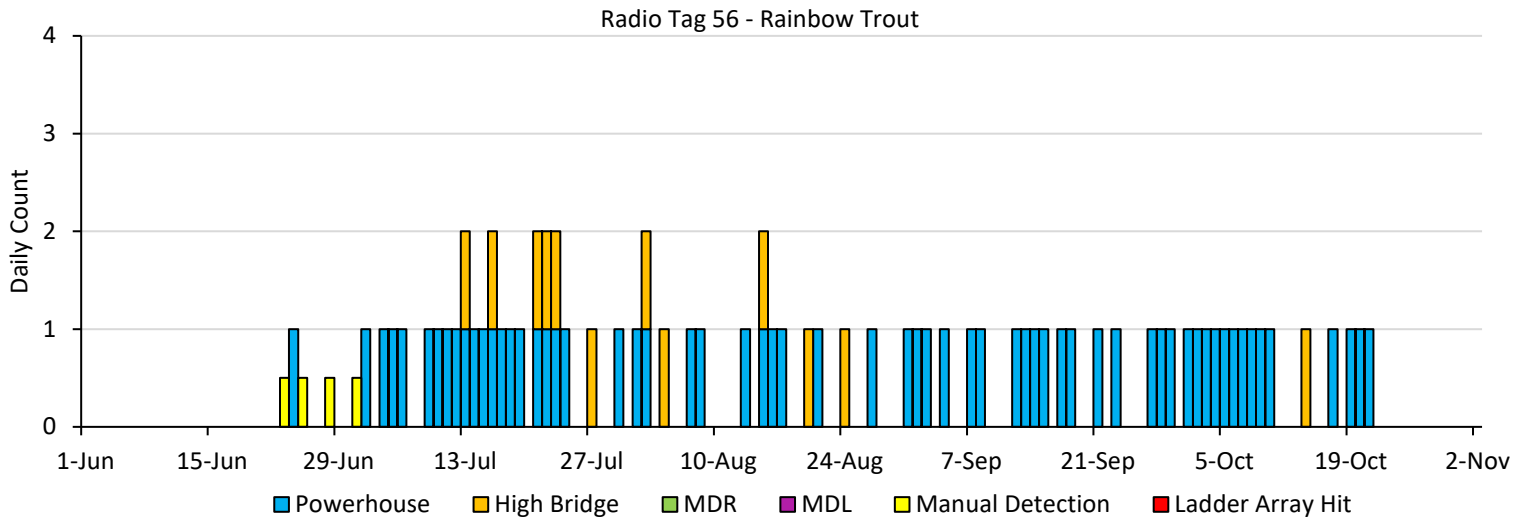


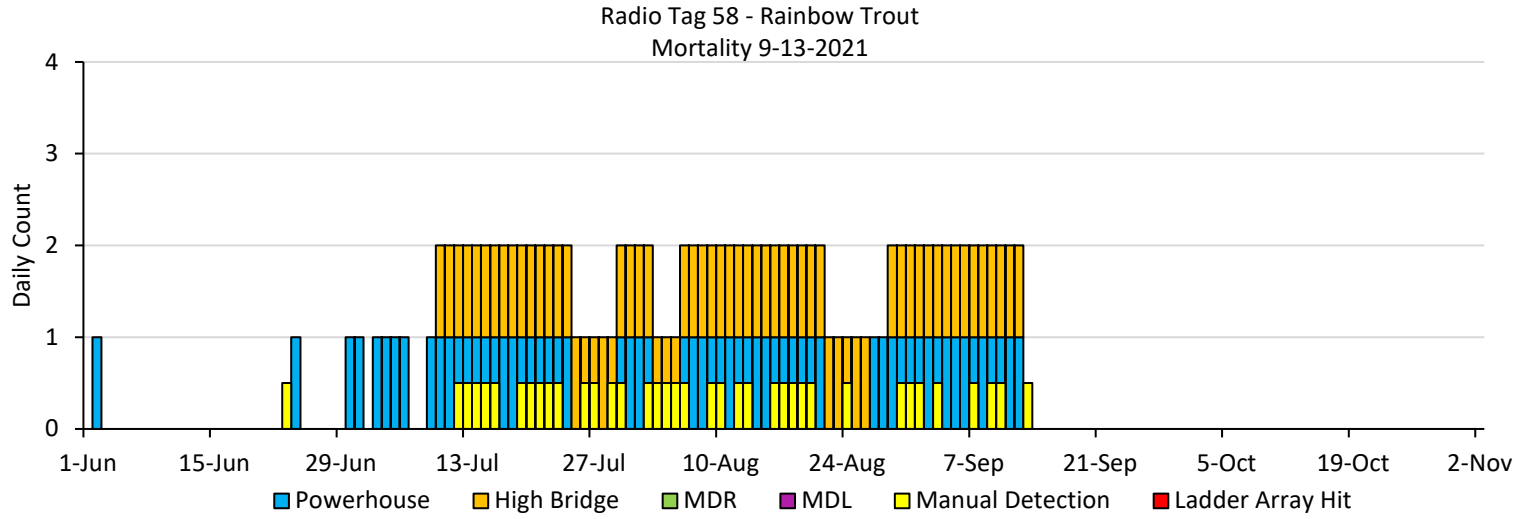

Radio Tag 51 - Rainbow Trout
Daily Count
4
3
2
1
0
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit


Radio Tag 52 - Rainbow Trout
Daily Count
4
3
2
1
0
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit






Radio Tag 56 - Rainbow Trout
Daily Count
0
1
2
3
4
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit


Radio Tag 58 - Rainbow Trout
Mortality 9-13-2021
Daily Count
0
1
2
3
4
1-Jun
15-Jun
29-Jun
13-Jul
27-Jul
10-Aug
24-Aug
7-Sep
21-Sep
5-Oct
19-Oct
2-Nov
Powerhouse
High Bridge
MDR
MDL
Manual Detection
Ladder Array Hit