

Colville Tribes, Fish & Wildlife Department

2018 Okanogan Subbasin Steelhead Spawning Abundance and Distribution



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Executive Summary

The Okanogan Basin Monitoring and Evaluation Program (OBMEP) monitored summer steelhead (*Oncorhynchus mykiss*) spawner abundance and distribution within the Okanogan River subbasin from 2005 through 2018. Monitoring has been conducted through a combination of redd surveys, underwater video counts, and Passive Integrated Transponder (PIT) tag detections. Over the past 14 years of monitoring, the estimated average total number of steelhead spawners in the Okanogan subbasin was 1,324 (geomean 1,170). The average natural-origin spawner abundance (NOSA) was 298 (geomean 256). The spawning estimates for 2018 of 453 steelhead (120 natural-origin, 333 hatchery) were the lowest recorded since data collection began in 2005. Spawning estimates were also compared with recovery goals, as outlined by the Interior Columbia Basin Technical Recovery Team (ICBTRT). The Upper Columbia Spring Chinook and Steelhead Recovery Plan states that 500 naturally produced steelhead adults would meet the minimum abundance recovery criteria within the U.S. portion of the Okanogan subbasin; if the Canadian portion of the subbasin was included, minimum abundance recovery criteria would be 1,000 naturally produced adults (UCSRB 2007).

Results from adult steelhead enumeration efforts in the Okanogan subbasin indicate that in general, the number of natural-origin spawning steelhead in the Okanogan River has been increasing since data collection began in 2005. The slope of the trend line from 2005 to 2018 abundance estimates suggests that the number of natural-origin spawners increased at an average rate of 6 fish per year. The proportion of hatchery origin spawners (pHOS) from 2005 through 2013 averaged 0.85, but the average pHOS decreased to 0.74 in 2014 through 2018. Spawning occurred throughout the mainstem Okanogan River, but was concentrated in distinct areas that contained suitable water velocities and substrates. The highest concentration of steelhead spawning has been documented below Zosel Dam on the Okanogan River and in braided island sections of the lower Similkameen River. The release location of juvenile hatchery steelhead likely influences the spatial distribution of spawning adults. Hatchery releases occur in Omak Creek, Salmon Creek, and the Similkameen River.

On years when spring runoff takes place after peak spawning is completed, redd surveys can provide a reasonable depiction of steelhead spawning distribution and an estimate of escapement. Defining the physical location of redds informs managers about which, and to what extent, habitats are being used for spawning and allow for tracking of spatial status and trends through time. However, conducting redd surveys on years with early runoff is not always effective due to poor water clarity. Since OBMEP began collecting steelhead spawning data in 2005, the importance of not relying solely on redd surveys for abundance estimates has become evident. Implementation of Upper Columbia Basin-wide PIT tag interrogation systems (Project # 2010-034-00), coupled with the representative marking of returning adults at Priest Rapids Dam, provides managers an additional means to estimate abundance on years with poor surveying conditions. Data from instream PIT arrays also helps validate redd survey efficiency, describes spatial distribution, and the extent of upstream spawning where previously unknown. The Fish and Wildlife Program should consider continuing these efforts to allow managers to more accurately describe the spatial extent of spawning in tributaries, to monitor effectiveness of barrier removal projects, and better define escapement estimates.

Table of Contents

Executive Summary	2
Table of Contents	3
1.0 Introduction	4
2.0 Methods	4
2.1 Sex Ratio and Number of Fish Per Redd	7
2.2 PIT Tag Expansion Estimates	8
3.0 Okanogan Subbasin Summer Steelhead Spawning Estimates	8
3.1 Steelhead Spawning Estimates: Okanogan and Similkameen River Mainstem	10
3.2 Steelhead Spawning Estimates: Tributaries to the Okanogan River	20
3.2.1 Loup Loup Creek	22
3.2.2 Salmon Creek	24
3.2.3 Omak Creek	28
3.2.4 Wanacut Creek	30
3.2.5 Johnson Creek	32
3.2.6 Tunk Creek	34
3.2.7 Aeneas Creek	36
3.2.8 Bonaparte Creek	38
3.2.10 Antoine Creek	40
3.2.11 Wildhorse Spring Creek	42
3.2.12 Tonasket Creek	44
3.2.13 Ninemile Creek	47
3.2.14 Foster Creek (located outside the Okanogan subbasin)	49
3.3 Zosel Dam and Upstream Locations	51
4.0 Discussion	51
References	54

1.0 Introduction

Within the Upper Columbia River Basin, the furthest upstream and northern-most extent of currently accessible anadromous habitat is found in the Okanogan River. Summer steelhead (*Oncorhynchus mykiss*) are listed as threatened in the Upper Columbia Evolutionarily Significant Unit (ESU) under the Endangered Species Act (ESA) (NMFS 2009). To recover this ESU requires that all four populations (Wenatchee, Entiat, Methow, and Okanogan) meet minimum adult abundance thresholds, have positive population growth rates, and each population must be widely distributed within respective basins (UCSRB 2007). Within the Okanogan River subbasin, the Okanogan Basin Monitoring and Evaluation Program (OBMEP) monitors adult abundance attributes. OBMEP developed protocols derived from the Upper Columbia Strategy (Hillman 2004) that called for a complete census of all spawning. Preliminary methodologies for implementing redd surveys were developed in 2005 and revised in 2007 (Arterburn et al. 2007). In addition to redd surveys, adult weir traps, Passive Integrated Transponder (PIT) tag arrays, and underwater video counting were combined to improve escapement estimates and coordinate with other on-going data collection efforts. In cooperation with the Washington Department of Fish and Wildlife (WDFW), OBMEP expanded the use of instream PIT tag arrays to enhance the monitoring of adult summer steelhead use of small tributaries to the Okanogan River.

This document builds upon knowledge and information gained from preceding years' surveys. A literature review of historic spawning information related to the Okanogan River subbasin can be found in Arterburn et al. 2005. Previous years' data and reports can be accessed at:

<https://www.okanoganmonitoring.org/Reports/SteelheadSpawningSurveys>

2.0 Methods

OBMEP - Adult Abundance - Redd Surveys (ID:192)

<https://www.monitoringmethods.org/Protocol/Details/192>

OBMEP - Adult Abundance - Adult Weir and Video Array (ID:6)

<https://www.monitoringmethods.org/Protocol/Details/6>

Estimate the abundance and origin of Upper Columbia steelhead (2010-034-00) v1.0 (ID:235)

<https://www.monitoringmethods.org/Protocol/Details/235>

The Okanogan River flows from the northern headwaters near Vernon, BC to the confluence with the Columbia River near Brewster, WA (Figure 1). Counts of summer steelhead spawning occurred downstream of anadromous fish migration barriers in the mainstem Okanogan River and its tributaries accessible to anadromous fish within the United States (Arterburn et al. 2007, Walsh and Long 2006) following the OBMEP redd survey protocol. The area of the Okanogan River downstream from Chiliwist Creek has very low gradient and is inundated by the Columbia River (Wells Pool/Lake Pateros). Consequently, this lower reach (~23 km) of the Okanogan River was excluded from surveys because it lacks appropriate velocity and substrate needed for summer steelhead to spawn. Mainstem and tributary redd survey reaches are listed in Table 1. Redd surveys were supplemented with adult weir traps, instream PIT tag arrays, and underwater video counts at locations where habitat was too extensive or when access could not be arranged with private landowners.

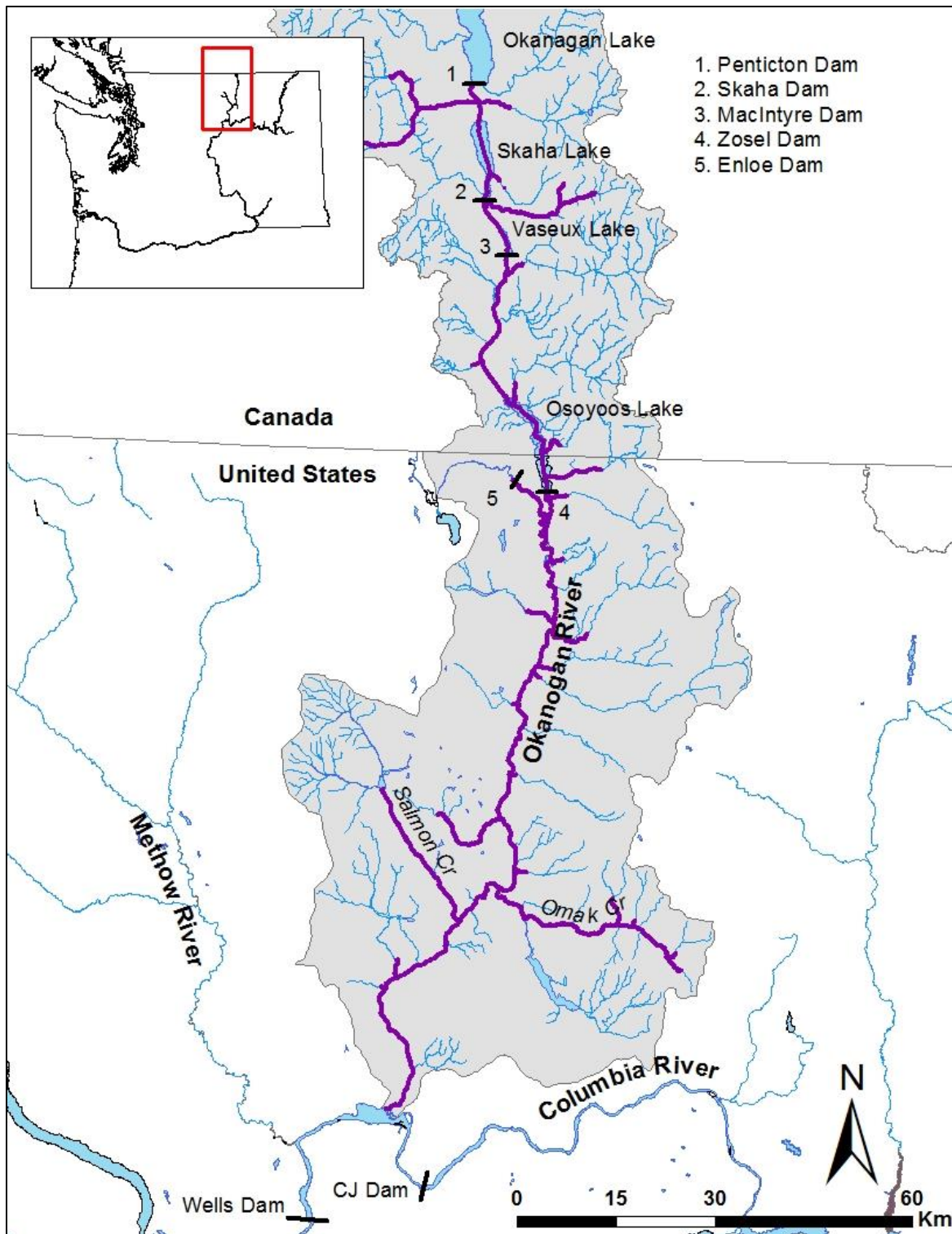


Figure 1. Study area, the Okanogan River subbasin in north-central Washington State and southern British Columbia.

The Okanogan River was divided into seven survey reaches and the Similkameen River was surveyed as two reaches. Survey reaches were determined by access points along the river and outlined in Table 1. Discharge data, air and water temperature, and local knowledge of fish movements collected from previous years were used to determine when to begin surveys on the mainstem. Mainstem surveys were conducted from rafts and on foot in a downstream progression. All island sections or other mainstem areas that could not be floated due to limited access and/or obstacles (e.g. wood debris, braided channels, and diversions) were surveyed on foot. Raft surveys were conducted by a minimum of two people using 10 foot catarafts. Small tributaries were surveyed on foot, walking in an upstream direction, and are typically attempted once per week during the steelhead spawning period.

Table 1. Okanogan subbasin steelhead redd survey reaches.

Redd Survey Reach	Location and Description	Reach Length (km)
Okanogan River 1	Okanogan River at Loup Loup Creek (26.7) to Salmon Creek (41.4)	14.7
Okanogan River 2	Okanogan River at Salmon Creek (41.4) to the office (52.3)	10.9
Okanogan River 3	Okanogan River at the office (52.3) to Riverside (66.1)	13.8
Okanogan River 4	Okanogan River at Riverside (66.1) to Janis Bridge (84.6)	18.5
Okanogan River 5	Okanogan River at Janis Bridge (84.6) to Tonasket Park (91.4)	6.8
Okanogan River 6	Ok. R. at Horseshoe Lake (112.4) to confluence with Similk. R. (119.5)	7.1
Okanogan River 7	Okanogan River at Similk. R. confluence (119.5) to Zosel Dam (127.0)	7.5
Similkameen River 1	Similkameen/Okanogan Confluence (0) to sewer plant (6.6)	6.6
Similkameen River 2	Similkameen from sewer plant (6.6) Enloe Dam (14.6)	8.0

Geographic position of redds were collected with a Trimble GeoXT™ GPS unit and downloaded into GPS Pathfinder® after each survey. Waypoints were reviewed and differentially corrected. To avoid recounting, flagging was tied to bushes or trees adjacent to the area where redds were observed. Individual flags were marked with the survey date, direction and distance from the redd(s), consecutive flag number, total number of redds represented by the flag, and surveyor initials. Incomplete redds or test pits were not flagged or counted.

Abundance of steelhead spawning within survey reaches were then converted to Hydrologic Unit Code (HUC), which adds to consistency within other approaches. HUCs also directly correspond to the Diagnostic Units (DU) used in habitat modeling within the subbasin (Figure 2). Each unique tributary to the Okanogan River also represent individual HUCs.

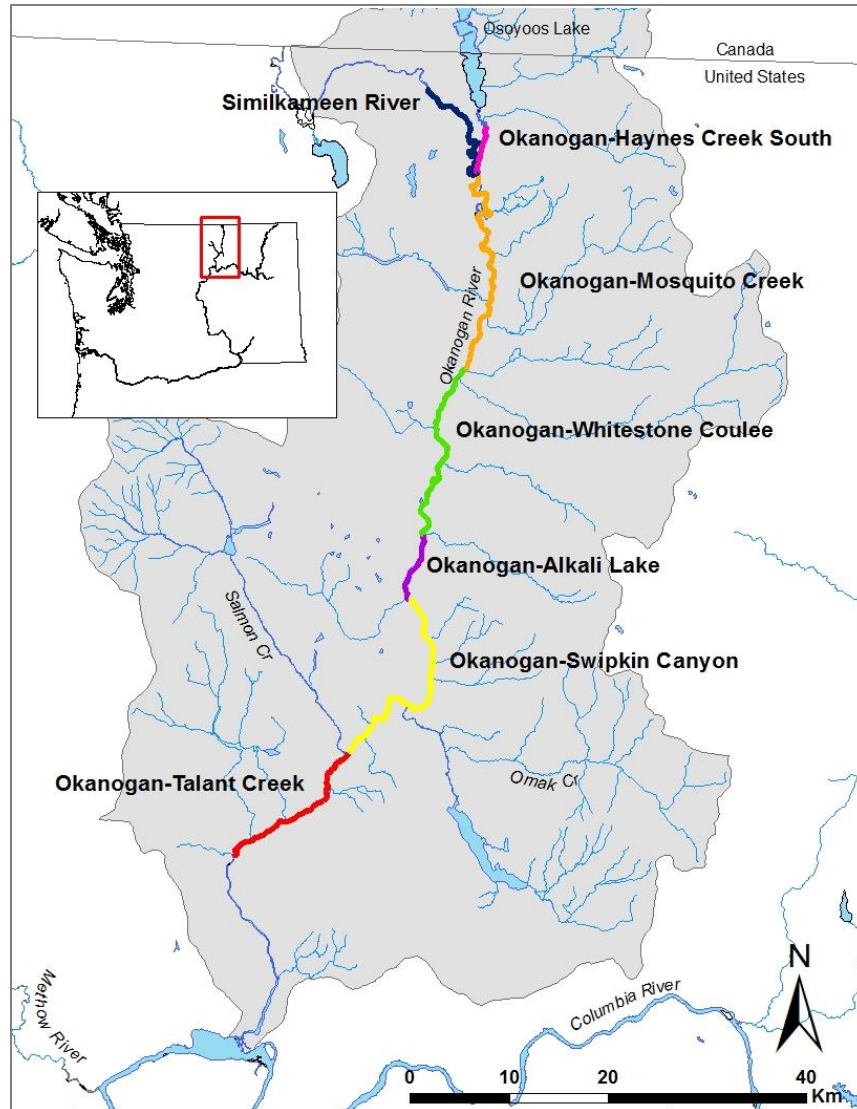


Figure 2. Mainstem Okanogan and Similkameen Rivers Hydraulic Unit Codes and diagnostic unit reaches.

2.1 Sex Ratio and Number of Fish Per Redd

OBMEP employed a method that has been used by the Washington Department of Fish and Wildlife (WDFW) in the Upper Columbia Basin to extrapolate escapement estimates from redd counts using the sex ratio of fish collected randomly throughout the run at Wells Dam. A sample of 313 summer steelhead, including 143 males (114 hatchery and 29 natural-origin) and 170 females (123 hatchery and 47 natural-origin), were sexed at Wells Dam during the 2017 upstream migration by WDFW personnel (Charles Frady, WDFW, pers. comm.). Adjusted proportionally for the run, a sex ratio of 0.84 males per female or 1.84 fish per redd (FPR) was used to expand redd counts on the mainstem Okanogan River into steelhead spawning estimates. All calculations using sex ratio multipliers assume that each female will produce only one redd.

2.2 PIT Tag Expansion Estimates

Throughout the spring of 2018, permanent and seasonal PIT tag arrays were operated near the mouth of all tributaries to the Okanogan River known to contain steelhead spawning. CCT works, in conjunction with the WDFW which is the lead investigator on project number 2010-034-00, to operate and maintain PIT tag detection sites in the Okanogan subbasin, along with data collection and management of those datasets. Any expanded PIT tag estimates presented in this document should be considered preliminary estimates as data analyses are currently in progress for the entire Upper Columbia for multiple years of the project. Final analyses of these data will be reported under project number 2010-034-00.

Population estimates derived from PIT tag detections were calculated following Murdoch et al. 2011. In the 2018 brood year, a representative sample of steelhead were captured at Priest Rapids Dam (PRD) from July through November, 2017. All fish were scanned for hatchery marks, sexed and marked with a PIT tag unless previously tagged. A portion of the total run, approximately 22.42% of hatchery and 22.37% of natural-origin steelhead, were included in this sample group (Ben Truscott, WDFW, pers. comm.). These mark-rates were used to expand the number of detections into escapement estimates for tributaries with PIT tag arrays. For example, if five hatchery and two natural-origin steelhead from the PRD sample group were detected at an instream PIT array in Omak Creek, the escapement estimate would be 22 hatchery steelhead ($22 = 5 / 0.2242$) and 9 natural-origin steelhead ($9 = 2 / 0.2237$). This method assumes that marked fish are representative of unmarked fish. Given relatively few detections at many locations (particularly at smaller tributaries) escapement estimate confidence bounds derived from PIT tag detections may be quite wide. In addition to fish tagged at Priest Rapids, adult steelhead may have also received PIT tags at other locations e.g., out-migrating juveniles, adults returning to Bonneville Dam, Wells Dam, among others. However, it is unknown how representative those fish are to the run at large. Therefore, only PIT tags from the PRD release group, project 2010-034-00, were used to estimate steelhead escapement.

3.0 Okanogan Subbasin Summer Steelhead Spawning Estimates

Based on expanded redd counts and PIT tag detections from project 2010-034-00, an estimated 453 summer steelhead (333 hatchery and 120 natural-origin) spawned in the Okanogan subbasin in 2018. From 2005 through 2018, an estimated average of 1,621 steelhead spawned in the Okanogan subbasin (Table 2). The long-term average for natural-origin and hatchery steelhead was estimated to be 298 and 1,324, respectively. The proportion of hatchery origin spawners (pHOS) from 2005 through 2013 averaged 0.85, but the average pHOS decreased to 0.74 in 2014 through 2018.

Results from steelhead adult enumeration efforts indicate that, in general, the abundance of natural-origin spawning steelhead in the Okanogan River subbasin has increased since data collection began in 2005 (Figure 3). The abundance of hatchery steelhead has been variable, ranging from about 700 up to nearly 3,000. A summary of the estimated number of adult steelhead spawners, distributed by mainstem survey reach and individual tributaries, are presented in Table 3. Detailed results for unique tributaries and mainstem reaches are further detailed in sections 3.1 to 3.3 of this document.

Table 2. Okanogan subbasin summer steelhead spawner abundance estimates, 2005–2018.

Year	Hatchery Steelhead	Natural-Origin Steelhead	Total	Natural-Origin 12-yr geomean
2005	1,080	146	1,226	
2006	702	197	899	
2007	1,116	152	1,268	
2008	1,161	225	1,386	
2009	1,921	212	2,133	
2010	2,768	728	3,496	
2011	1,341	333	1,674	
2012	2,475	327	2,802	
2013	1,687	250	1,937	
2014	838	518	1,356	
2015	1,009	452	1,461	
2016	1,175	391	1,566	292
2017	929	115	1,044	286
2018	333	120	453	274
Average	1,324	298	1,621	284

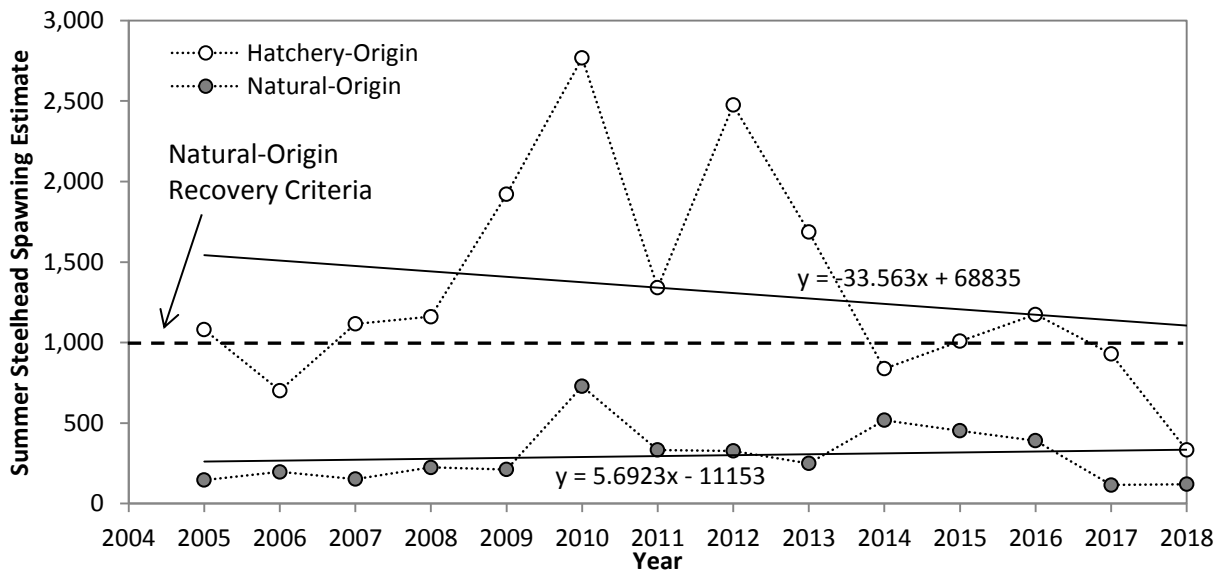


Figure 3. Trend in the estimated number of summer steelhead spawning in the Okanogan River subbasin, 2005–2018.

Table 3. Estimated number of hatchery and natural-origin steelhead spawning for each sub-watershed or assessment unit in 2018 compared with long-term averages.

Category	Location/HUC	2018 natural-origin spawner abundance	Average # of natural-origin spawners 2005–2018	2018 hatchery spawner abundance	Average # of hatchery spawners 2005–2018
WA Mainstem	Okanogan-Davis Canyon	0	0	0	0
WA Mainstem	Okanogan-Talant Creek	0	1	1	12
WA Mainstem	Okanogan-Swipkin Canyon	1	6	2	52
WA Mainstem	Okanogan-Alkali Lake	0	4	0	30
WA Mainstem	Okanogan-Whitestone Coulee	2	7	5	63
WA Mainstem	Okanogan-Mosquito Creek	0	2	1	15
WA Mainstem	Okanogan-Haynes Creek South	6	42	19	368
WA Mainstem	Similkameen River	4	25	12	218
WA Tributary	Loup Loup Creek	13	11	49	35
WA Tributary	Salmon Creek	40	34	36	121
WA Tributary	Omak Creek	17	68	169	153
WA Tributary	Wanacut Creek	0	1	5	3
WA Tributary	Johnson Creek	2	6	5	24
WA Tributary	Tunk Creek	0	9	0	29
WA Tributary	Aeneas Creek	0	0	5	2
WA Tributary	Bonaparte Creek	9	29	36	63
WA Tributary	Antoine Creek	18	4	9	10
WA Tributary	Wild Horse Spring Creek	0	9	0	39
WA Tributary	Tonasket Creek	9	7	9	22
WA Tributary	Ninemile Creek	5	7	9	17
Area	Washington State Mainstem	13	87	40	758
Area	Washington State Tributaries	113	185	332	518
Area	British Columbia	9	6^a	0	12^a

^a Average from British Columbia only contain data from 2013-2017.

3.1 Steelhead Spawning Estimates: Okanogan and Similkameen River Mainstem

Runoff in the spring of 2018 was the third highest on record in the Okanogan subbasin. Due to the higher than average discharge and turbidity beginning in early March 2018 (Figure 4 and 5), using redd surveys to document the timing and distribution of steelhead spawning activity in the Okanogan River mainstem was largely unsuccessful. Discharge rates remained high through June, at which time spawning had long since concluded and steelhead redds were indistinguishable. For reference, locations of redds marked during previous years surveys (2005–2016) on the mainstem Okanogan and Similkameen Rivers are shown in Figures 6–12.

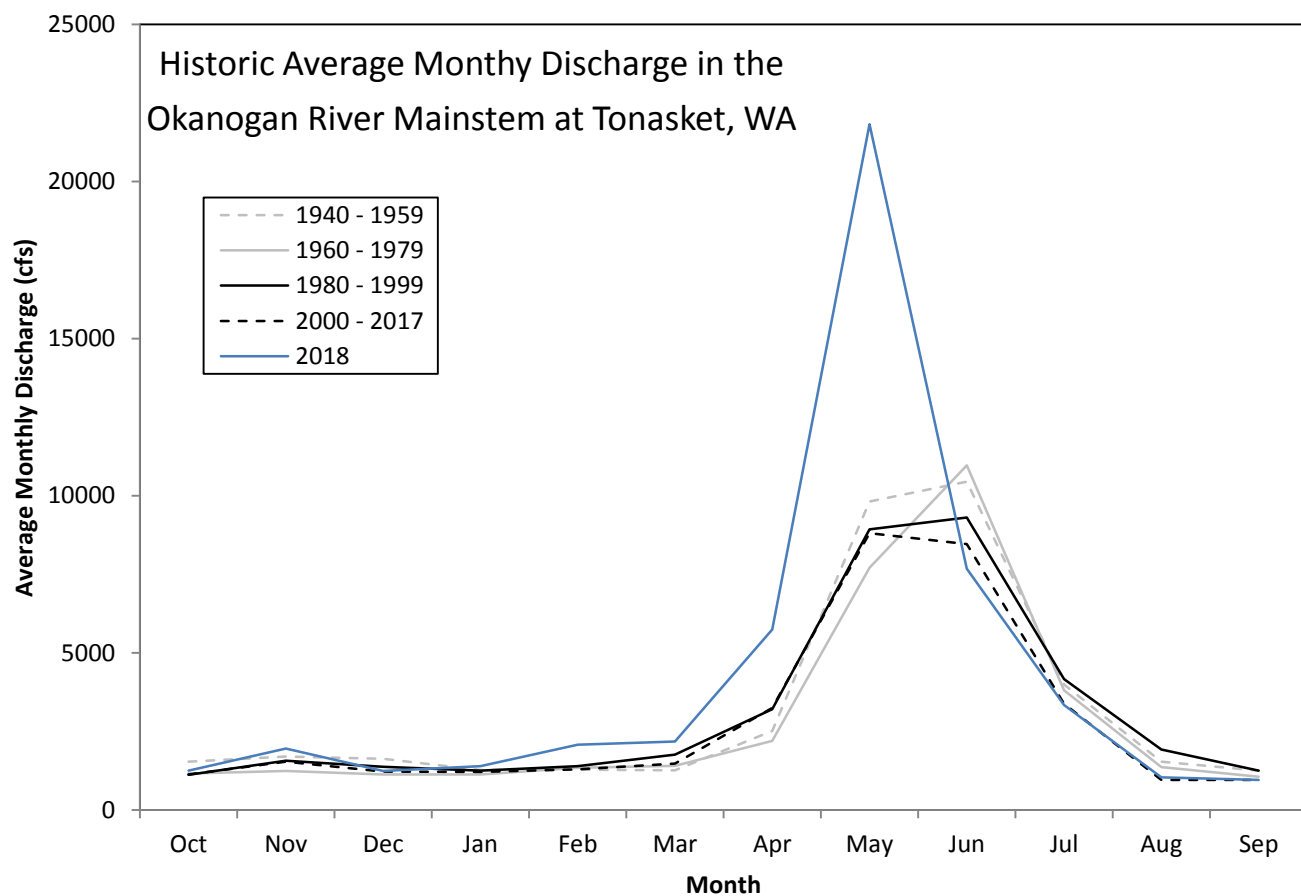


Figure 4. Average monthly discharge of the Okanogan River at Tonasket, WA (USGS Station 12445000, Okanogan River near Tonasket, WA).



Figure 5. Okanogan (left) and Similkameen Rivers (right) as shown during early May 2018.

Although redd surveys were unable to capture the distribution of spawning activity in the mainstem Okanogan and Similkameen Rivers, an estimate of mainstem spawning by reach was calculated as follows:

The proportional distribution of spawning in each mainstem reach was determined when successful mainstem spawning surveys occurred between 2005 and 2011. These proportions are listed in Table 4, column A. The total number of natural-origin and hatchery steelhead that spawned in the mainstem Okanogan River in 2018 can be estimated using the proportion of PRD marked fish only detected at the lower Okanogan River PIT array (OKL) i.e. entered the Okanogan River, but did not enter a tributary stream. A total of 5 hatchery and 3 natural-origin PIT tagged steelhead matched these criteria. Expanding these tags by the mark rate from PRD rendered a total mainstem spawning estimate of 40 hatchery ($40 = 5 / 0.2242$) and 13 natural-origin steelhead ($13 = 3 / 0.2237$). To estimate how many fish spawned per reach, the total mainstem spawning estimate was multiplied by the historical proportion of spawning recorded in each reach (2005–2011). This calculation assumes no change in the spatial distribution of spawning between the reference period (2005–2011) and 2018. Specific calculations are outlined below in Table 4.

Table 4. Modeled estimate of mainstem steelhead spawning in 2018.

Mainstem Survey Reach	A. Avg. Proportion of Mainstem Spawning by Reach (2005-2011)	B. Natural-Origin Steelhead (B=A*13)	C. Hatchery Steelhead (C=A*40)	B. Total Estimate (D=A+B)
Okanogan River 1	0.015	0	1	1
Okanogan River 2	0.055	1	2	3
Okanogan River 3	0.012	0	0	0
Okanogan River 4	0.047	1	2	3
Okanogan River 5	0.076	1	3	4
Okanogan River 6	0.02	0	1	1
Okanogan River 7	0.486	6	19	25
Similkameen River 1	0.165	2	7	9
Similkameen River 2	0.124	2	5	7
Mainstem Total	1	13	40	53

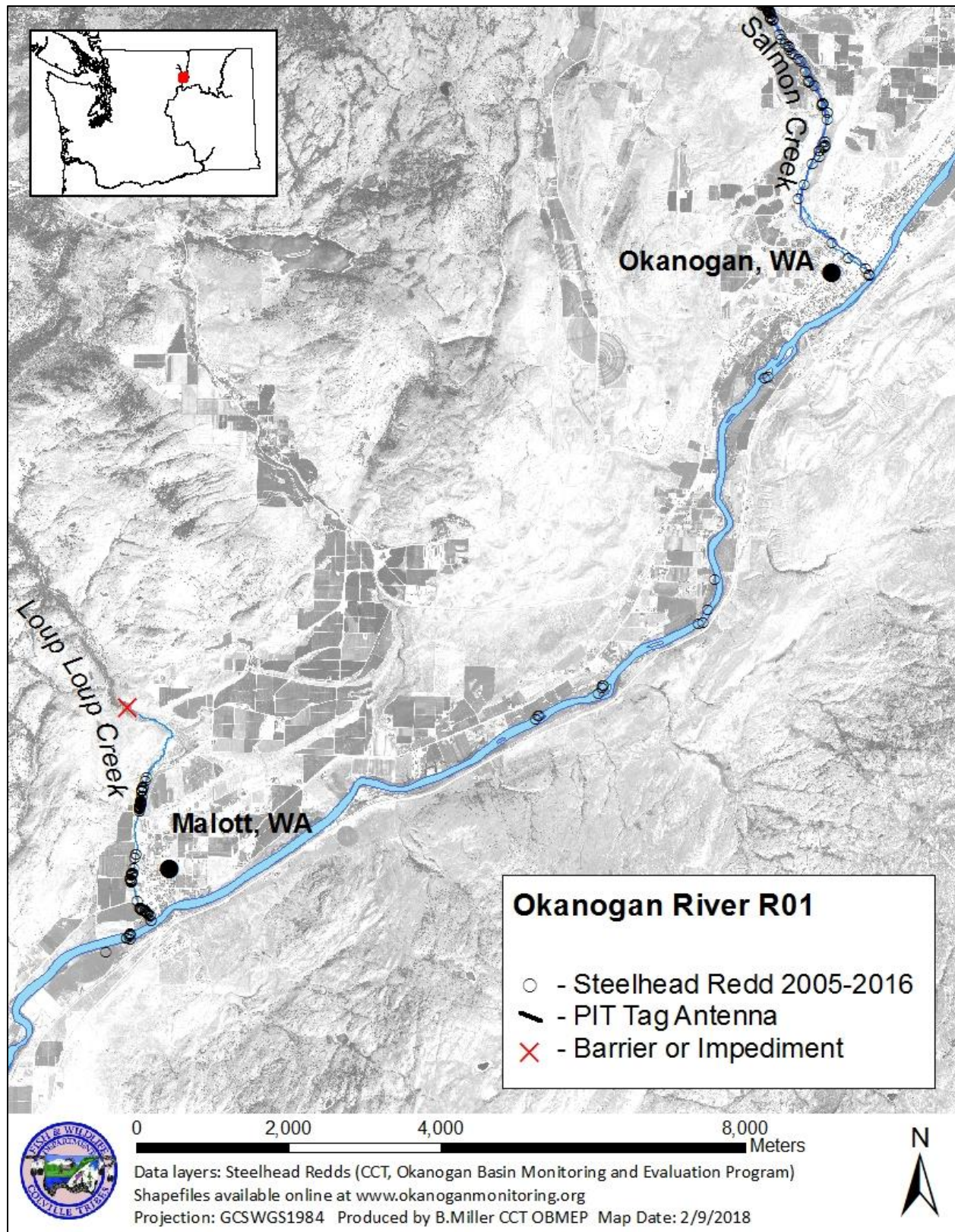


Figure 6. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO1, from Salmon Creek to Loup Loup Creek.

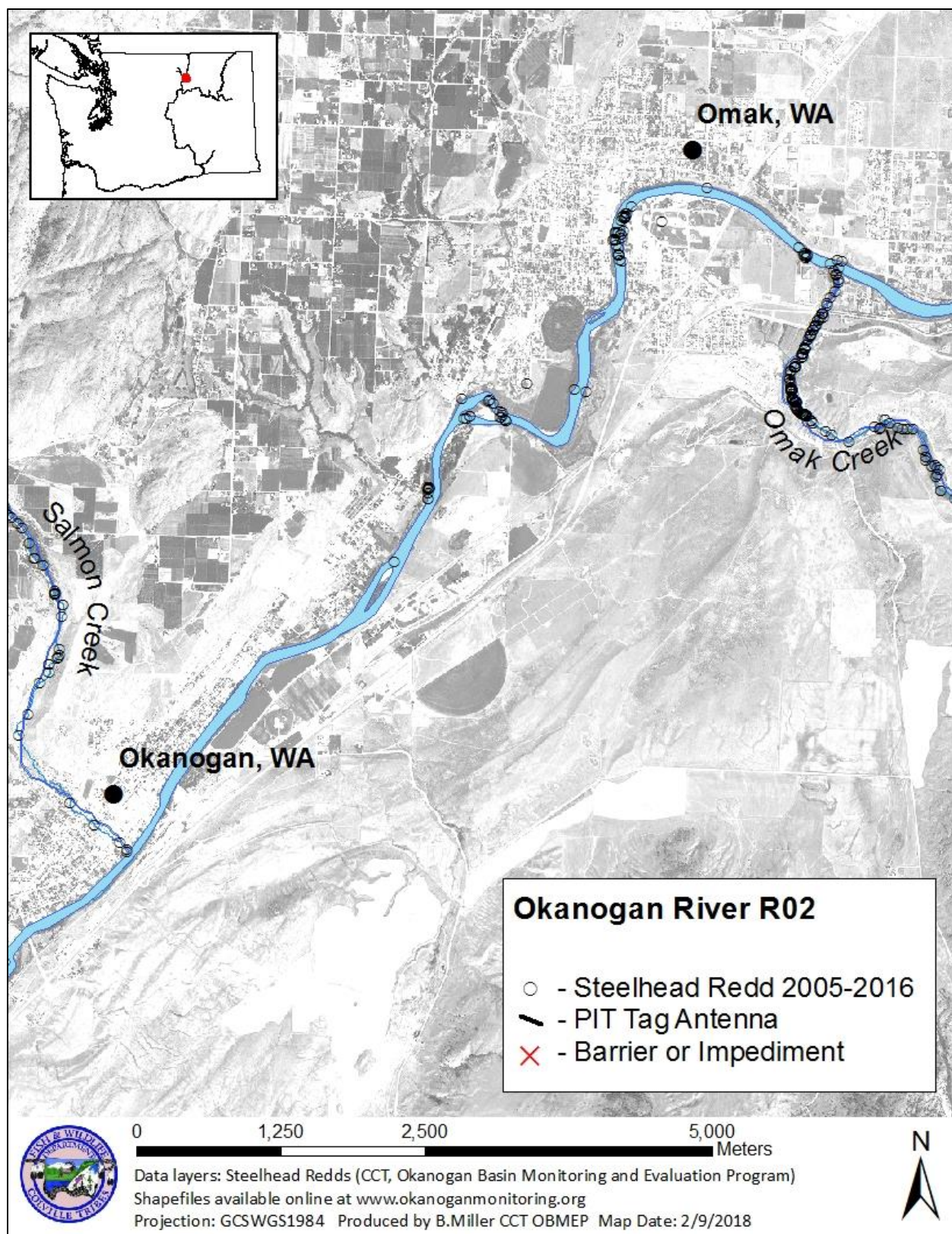


Figure 7. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach R02, from Omak Creek to Salmon Creek.

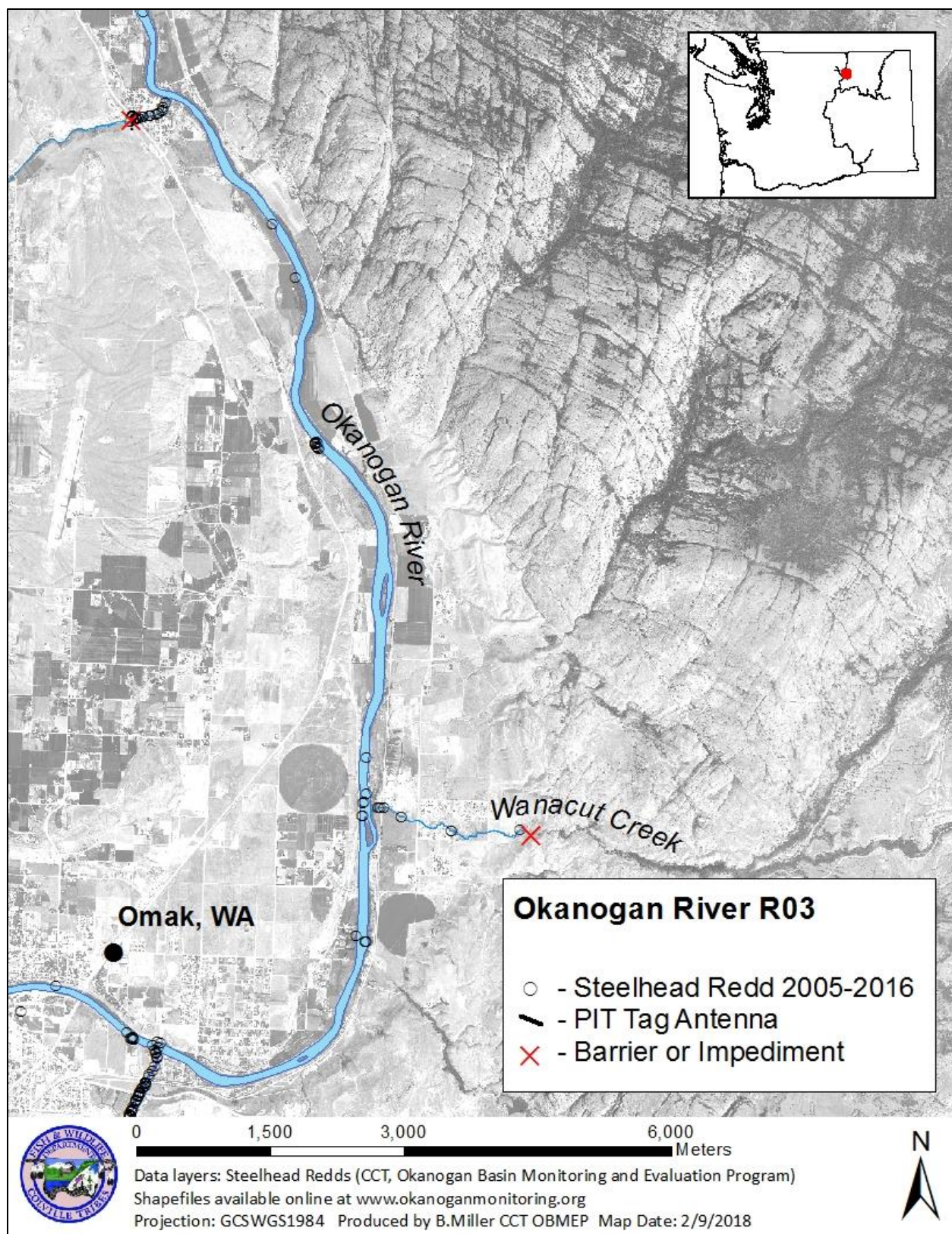


Figure 8. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach R03, from Johnson Creek to Omak Creek.

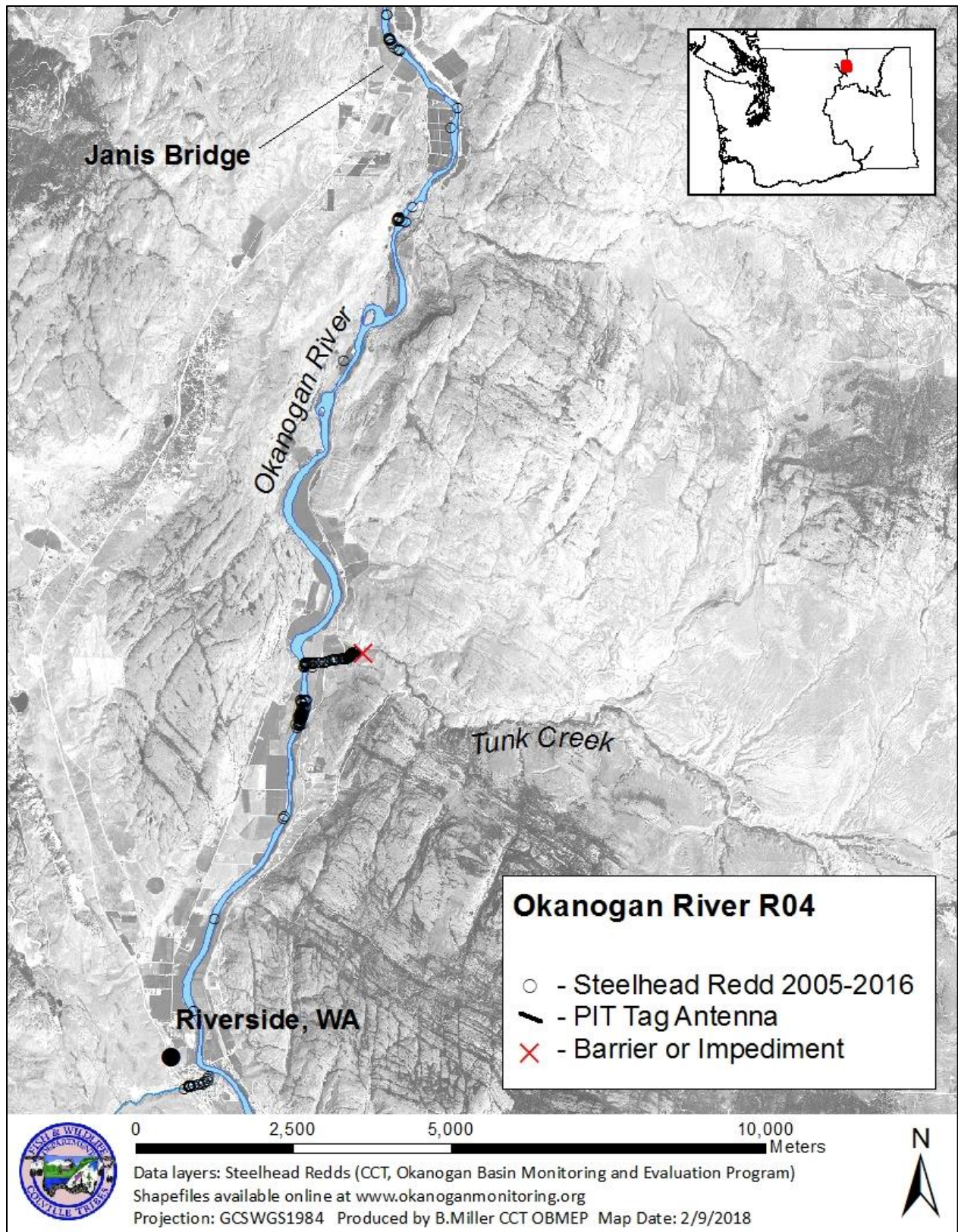


Figure 9. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach R04, from Janis Bridge to Johnson Creek.

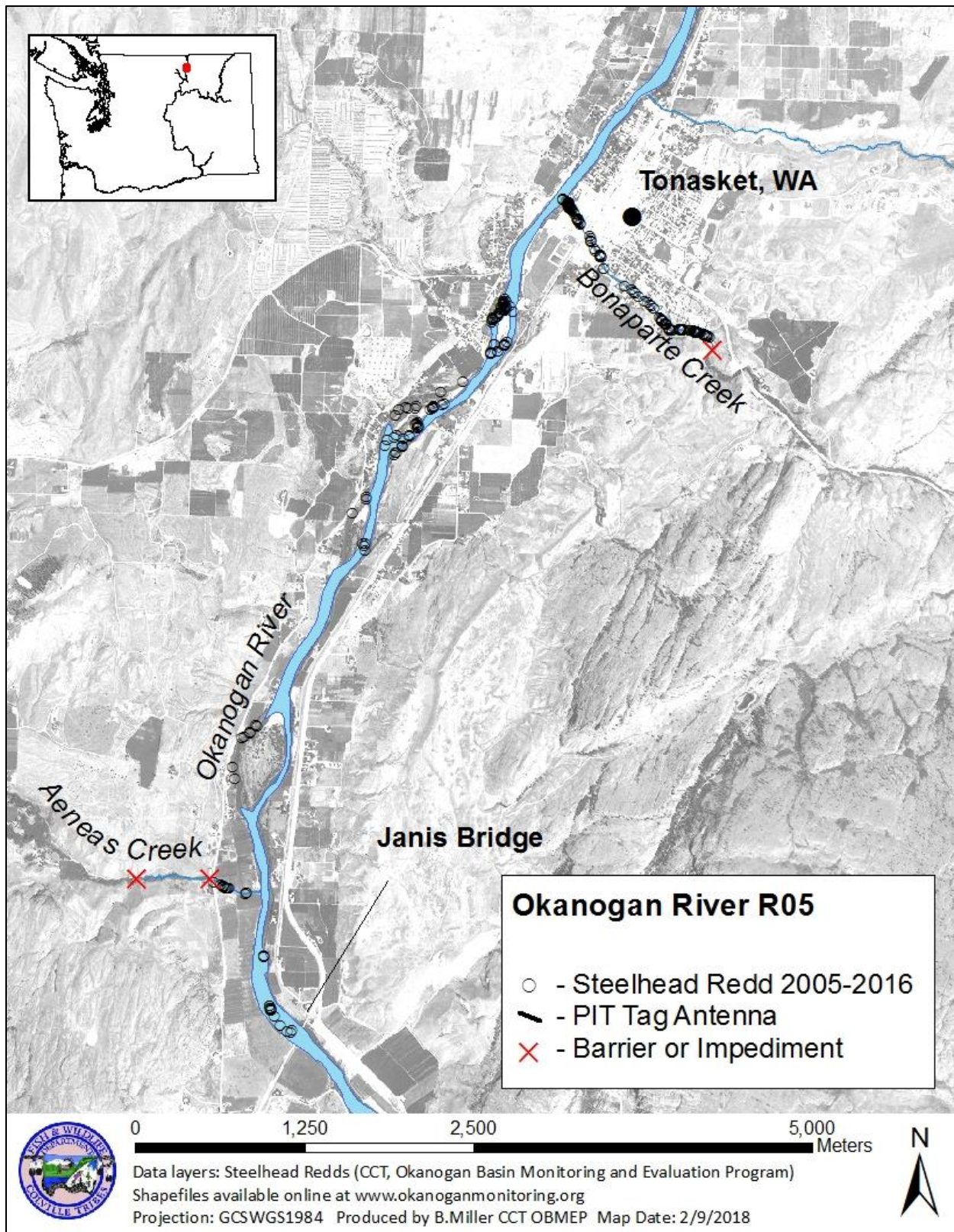


Figure 10. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach R05, from the Tonasket boat launch to Janis Bridge.

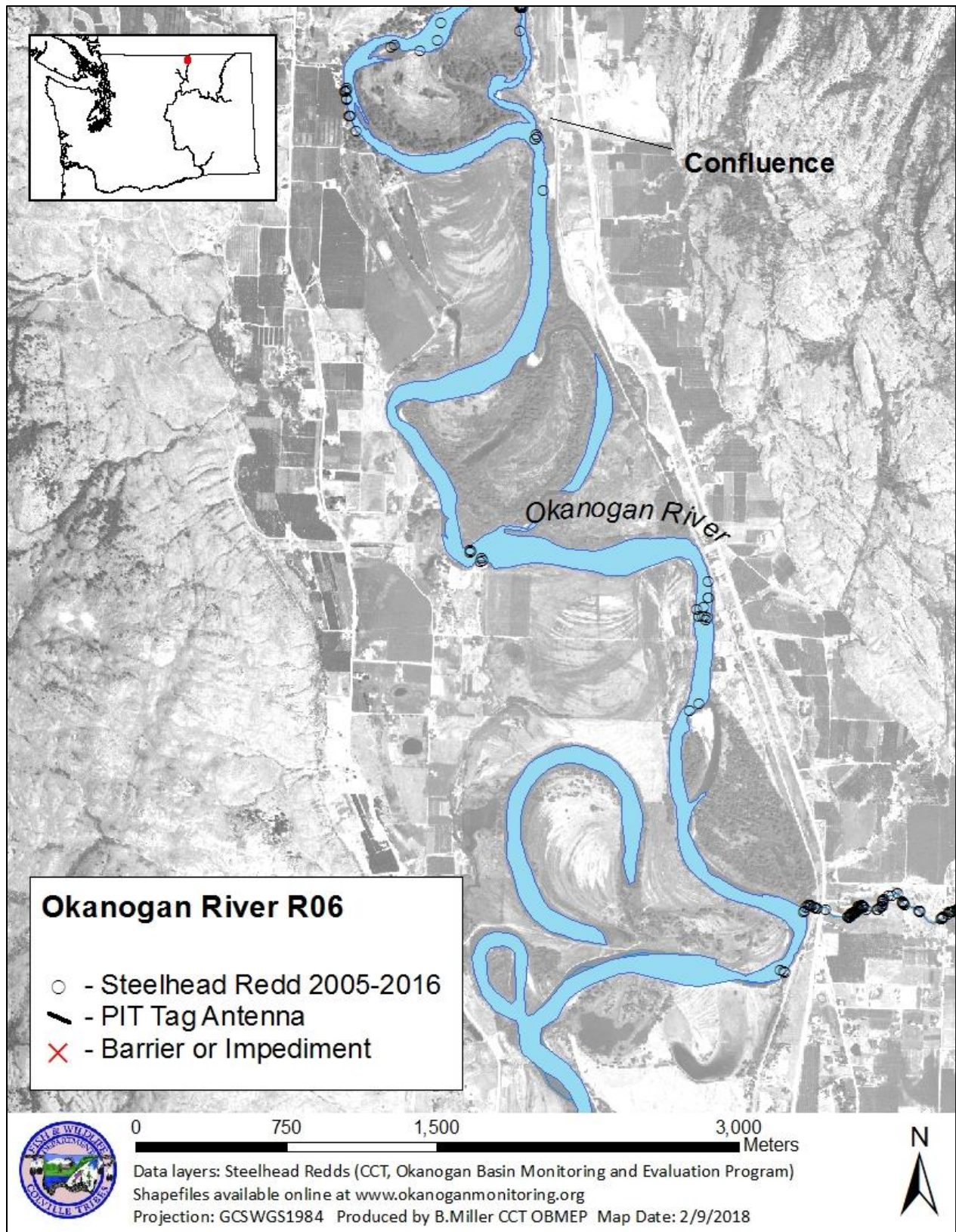


Figure 11. Spatial distribution of summer steelhead redds documented in Okanogan River survey reach RO6, from the confluence of the Similkameen and Okanogan Rivers to Horseshoe Lake.

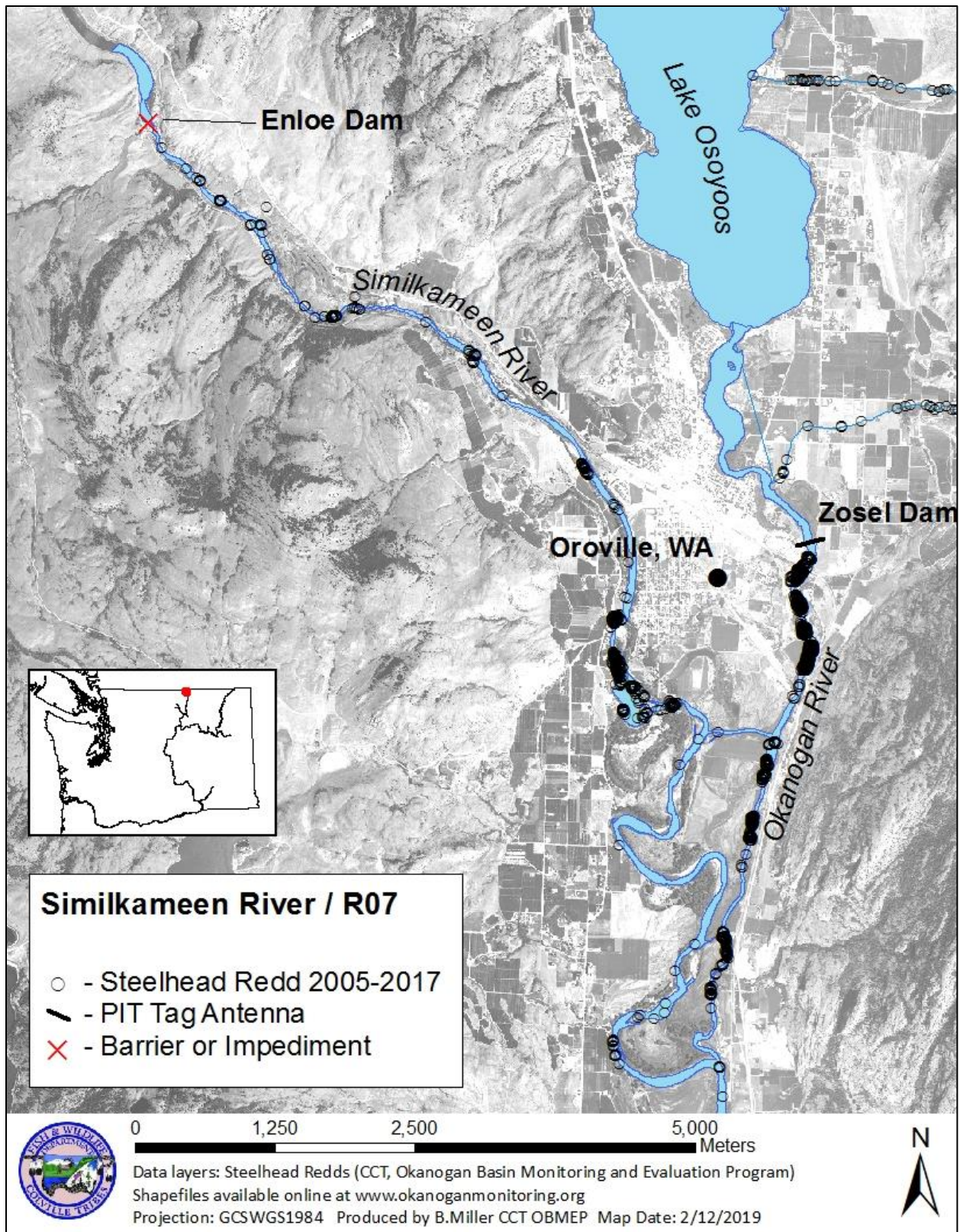


Figure 12. Spatial distribution of summer steelhead redds documented in the Similkameen River, from Enloe Dam to the confluence, and in Okanogan River survey reach R07, from Zosel Dam to the confluence.

3.2 Steelhead Spawning Estimates: Tributaries to the Okanogan River

Tributary redd surveys were also affected by extreme high flows and turbid water conditions from an early runoff period, which began in early-March in most tributaries (Figure 14 and 15). For reference, peak steelhead spawning typically occurs around April 15th. Although difficulties existed in documenting redds with visual surveys, spawning estimates could still be estimated in most tributaries from PIT tag detections under project #2010-034-00.

In the following sections, a summary of spawning estimates for steelhead in tributaries to the Okanogan River are presented, along with spatial distribution information. Detailed maps are presented in the following sections for each tributary which outline spatial distribution of historic observations from 2005–2018. GIS shapefiles of documented steelhead redds can be downloaded at: www.okanoganmonitoring.org



Figure 13. Redd surveys during 2018; clockwise from the top: Antoine, Wanacut, Upper Salmon, and Lower Salmon Creeks.

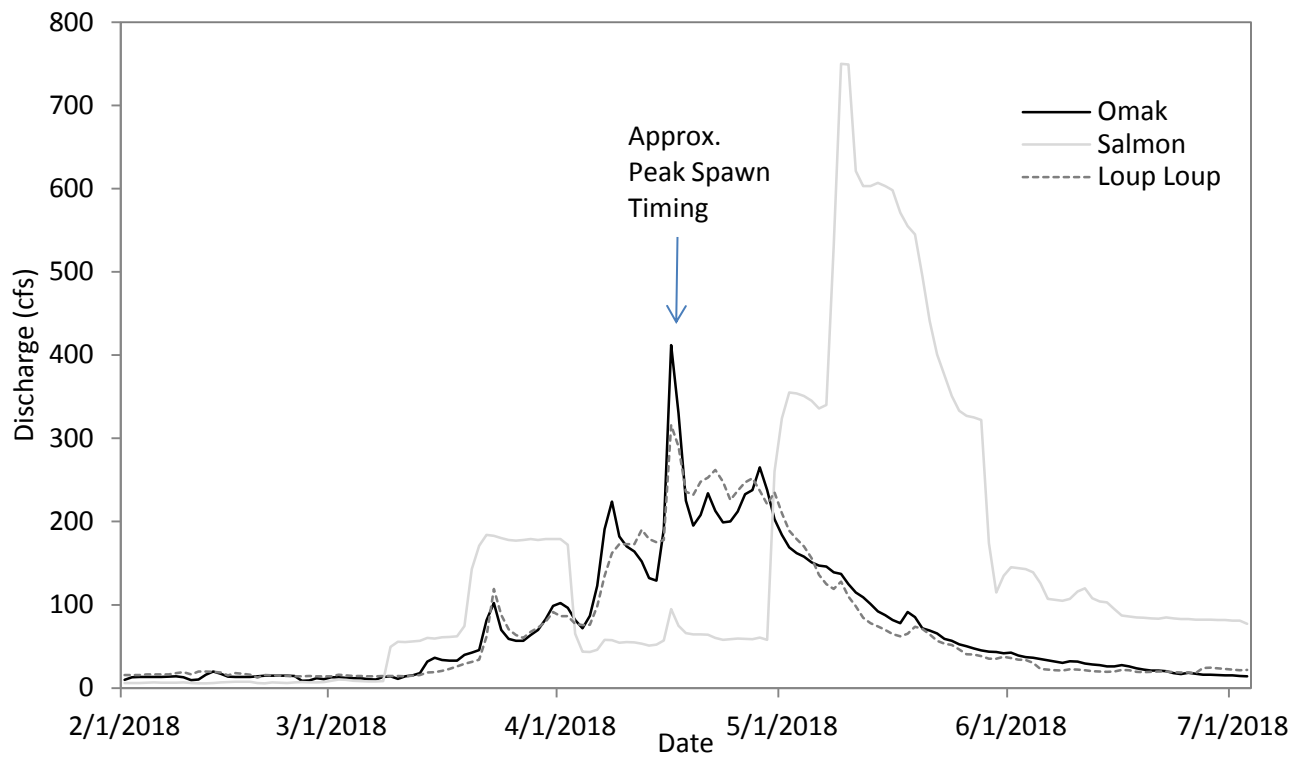


Figure 14. 2018 discharge in three tributaries in the northern Okanogan subbasin.

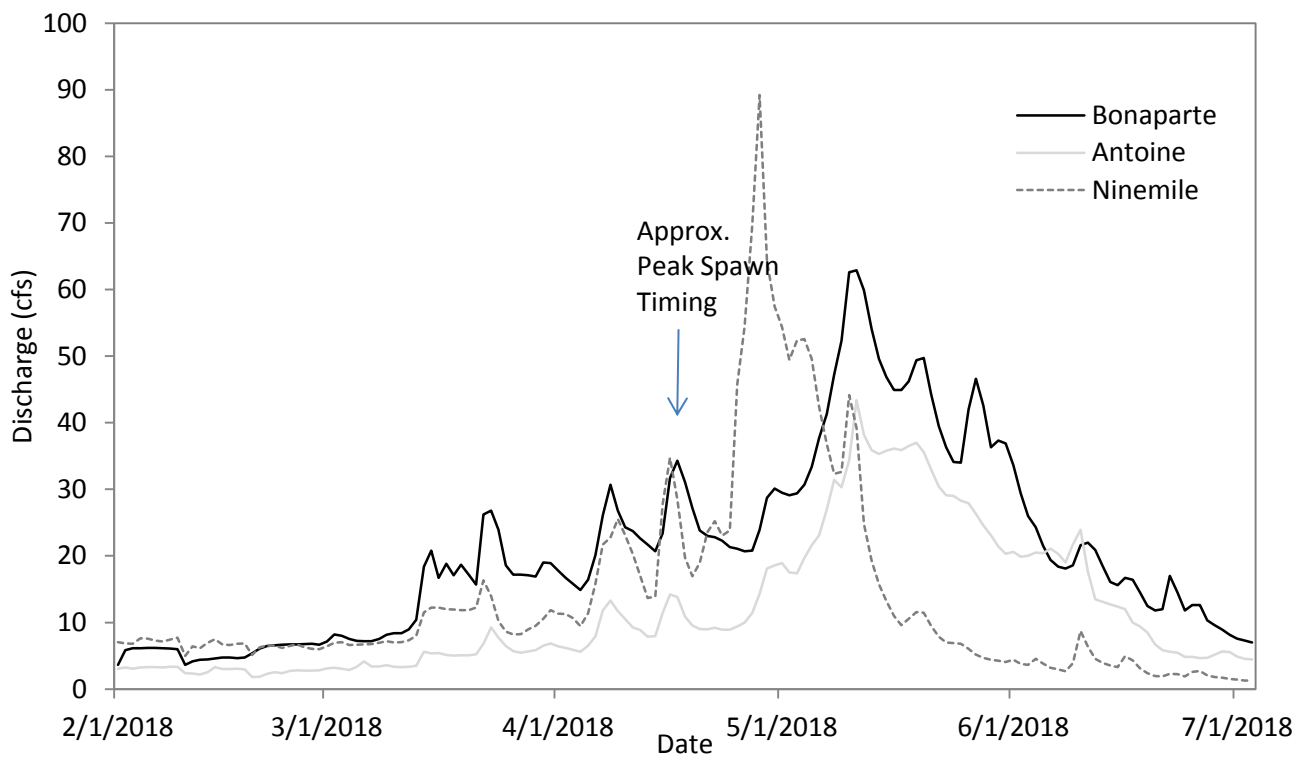


Figure 15. 2018 discharge in three tributaries in the northern Okanogan subbasin.

3.2.1 Loup Loup Creek

Loup Loup Creek is a tributary that enters the Okanogan River at river kilometer (RKM) 24, in the town of Malott, WA. The lower sections of the creek frequently went dry during mid-summer, until 2010, when the point of diversion was transferred to the Okanogan River and the irrigation diversion on Loup Loup Creek was removed. PIT tag interrogation site LLC consists of three pass-over HDPE antennas configured in three separate rows near the mouth of the creek.

Due to extremely high flows beginning in mid-March, conditions in Loup Loup Creek were unfavorable to conduct redd surveys throughout the spring of 2018. Although no walking surveys were successfully conducted, locations of steelhead redds documented in previous years are shown for reference in Figure 17. The instream PIT tag interrogation site LLC was operational throughout the spring and a total of three natural-origin and 11 hatchery PIT tags from the PRD release group were detected. Those tags were expanded by the PRD mark rate resulting in a total spawning escapement estimate of 13 natural-origin and 49 hatchery steelhead for Loup Loup Creek in 2018. Trends in steelhead spawning escapement for Loup Loup Creek are included for reference in figure 16.

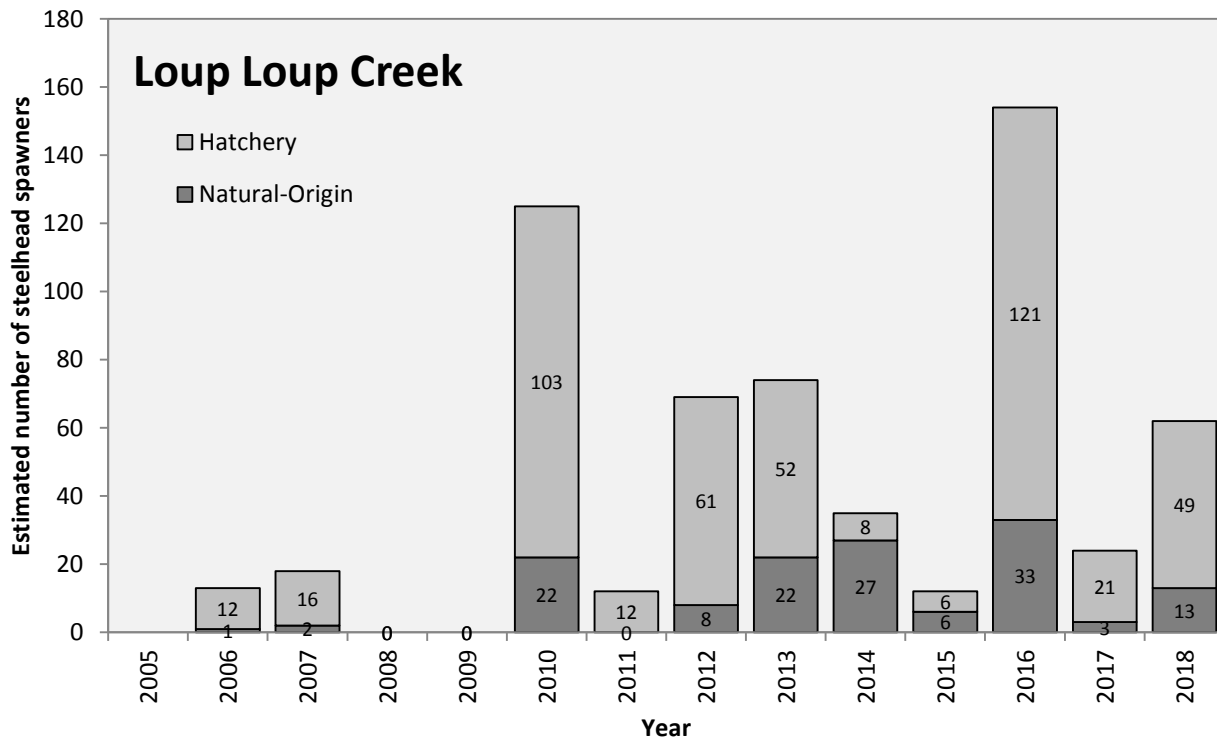


Figure 16. Trend in the number of steelhead spawners in Loup Loup Creek.

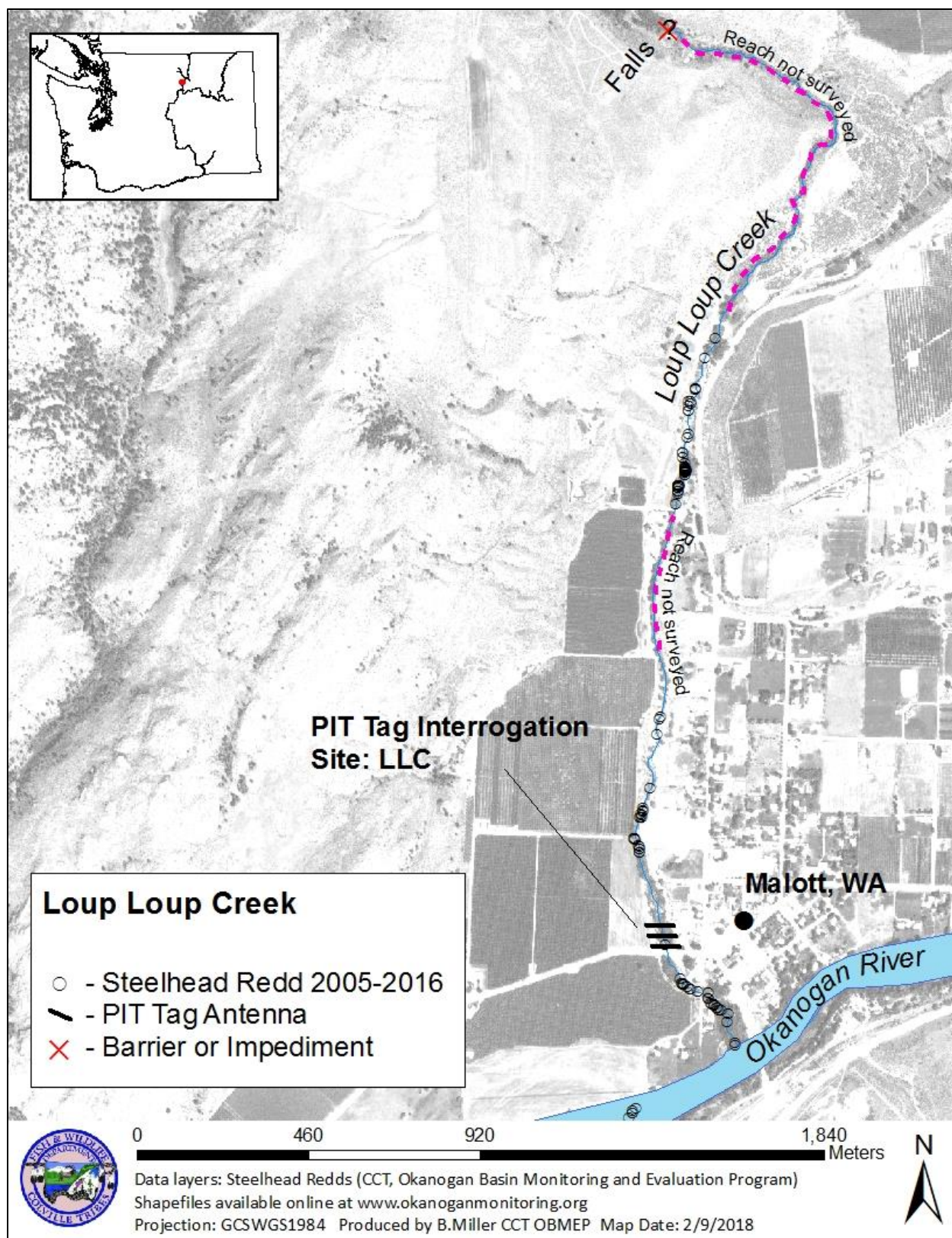


Figure 17. Spatial distribution of historical summer steelhead redds documented in Loup Loup Creek.

3.2.2 Salmon Creek

Salmon Creek is a highly managed medium sized tributary, which enters the Okanogan River at RKM 41.3 in the city of Okanogan, WA. Since the early 1900's, the majority of water from Salmon Creek had been diverted for irrigation usage. Resulting in a largely dry stream channel extended from the Okanogan Irrigation District (OID) diversion dam (7.2 km) to the confluence with the Okanogan River. Occasionally, uncontrolled spills occurred downstream of the OID diversion dam in high water years. These spills typically occurred in mid-May to June, which is after peak spawning for summer steelhead in the Okanogan basin. To provide sufficient water during the migration window of spring-spawning steelhead, the Colville Tribes purchased water from the OID and allowed it to flow down the channel to the Okanogan River. After several years of successful steelhead passage, the Tribes negotiated a long term water lease agreement with the OID. Since 2006, the long term water lease has provided seasonal water for returning adults and outmigrating juvenile salmonids.

In 2018, spill was started early at Conconully dam to make room for more water in the reservoir with roughly 200 cfs spilling in early march through the beginning of April (Figure 14). Flows were reduced in mid-April which allowed for walking redd surveys. Water clarity remained favorable and upper Salmon Creek was surveyed walking downstream from Conconully Dam to Happy Hill road over two days, 19 April and 23 April. A total of 22 redds were documented (Figure 19). When expanded by 1.84 fish per redd, those redds rendered an estimate of 41 fish spawning in this reach. Two large mud slides occurred just below Happy Hill road, making the creek to turbid to survey below that point. Shortly after the surveys occurred, spill reached nearly 800 cfs and further surveys were not feasible. For reference, redd locations from previous years in the lower section of the creek are shown in Figure 20.

A PIT tag interrogation site (SA1) is located 2.9 km upstream from the mouth of Salmon Creek. The instream array consisted of four pass-over HDPE antennas configured in two separate rows. A second PIT tag interrogation site (SA0) is located immediately downstream of the OID diversion dam and consists of five pass-over PVC antennas configured in two separate rows. During the 2018 spawning season, all of the tags detected on the upstream site SA0 were detected on SA1, which rendered a detection efficiency estimate of 100%. The total spawning estimate for Salmon Creek was determined based on PIT tag detections from fish marked in PRD sample group. A total of 9 natural-origin and 8 hatchery steelhead from the PRD mark group were detected at SA1. Those tags were expanded using the PRD mark rate, resulting in a spawning escapement estimate of 40 natural-origin and 36 hatchery steelhead in 2018. For reference, trends in steelhead spawning escapement for Salmon Creek are included in Figure 18.

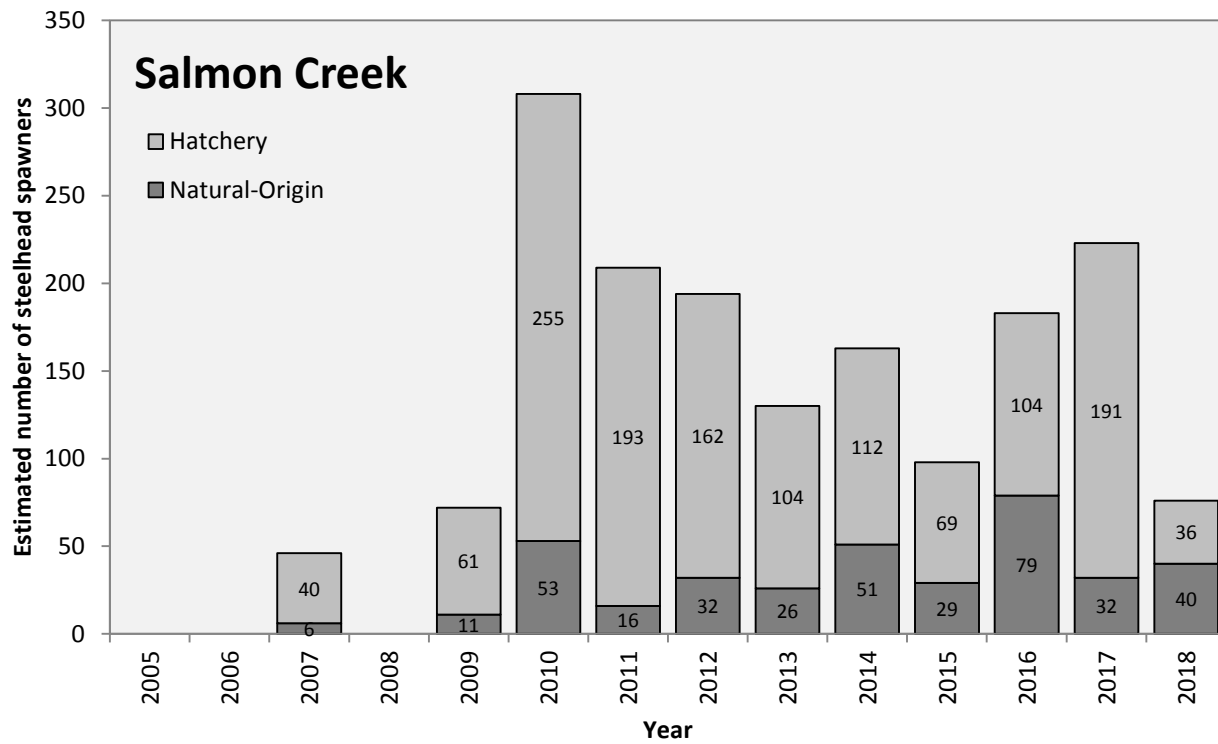


Figure 18. Trend in the number of steelhead spawners in Salmon Creek.

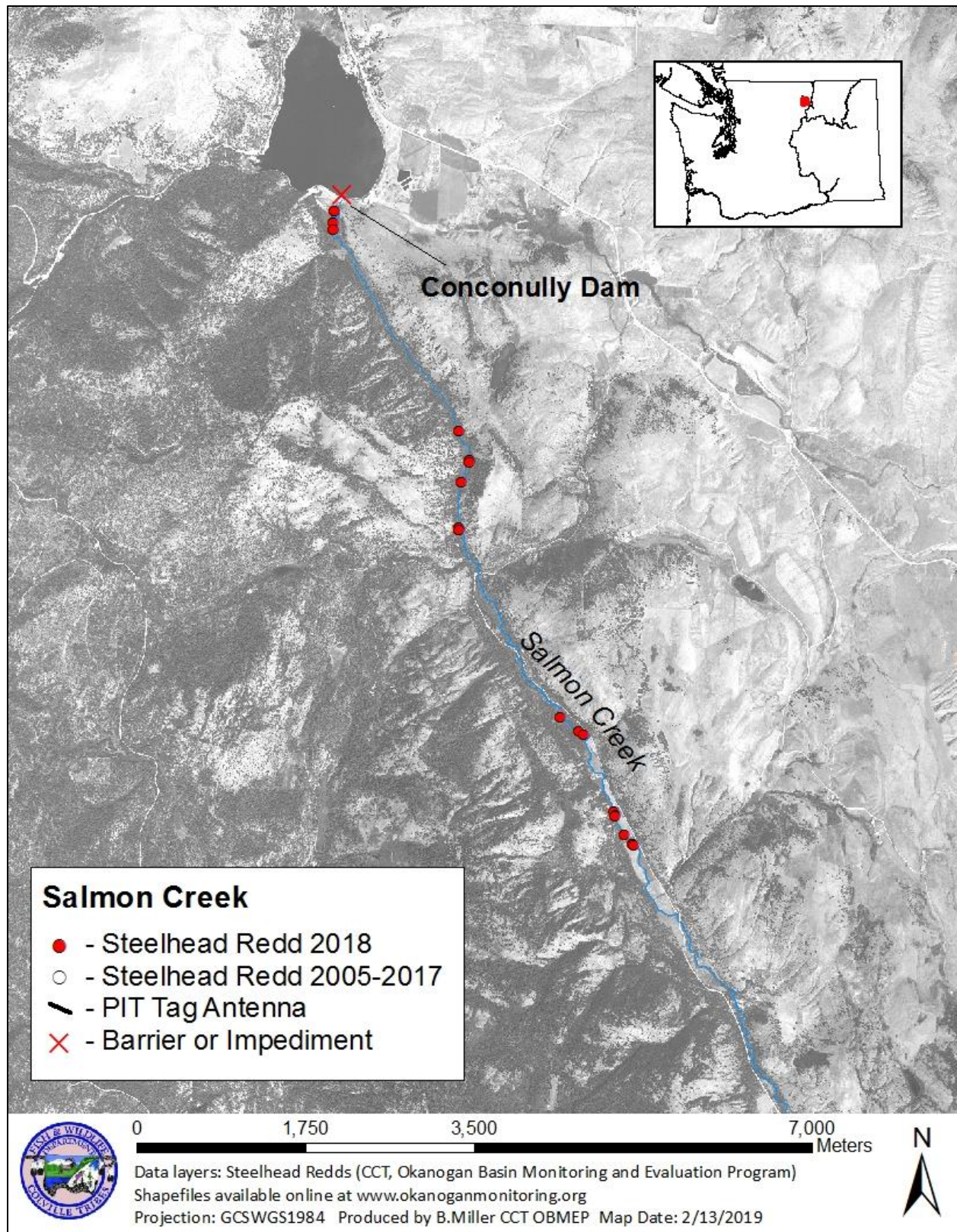


Figure 19. Spatial distribution of summer steelhead redds documented in upper Salmon Creek, below Conconully Dam.

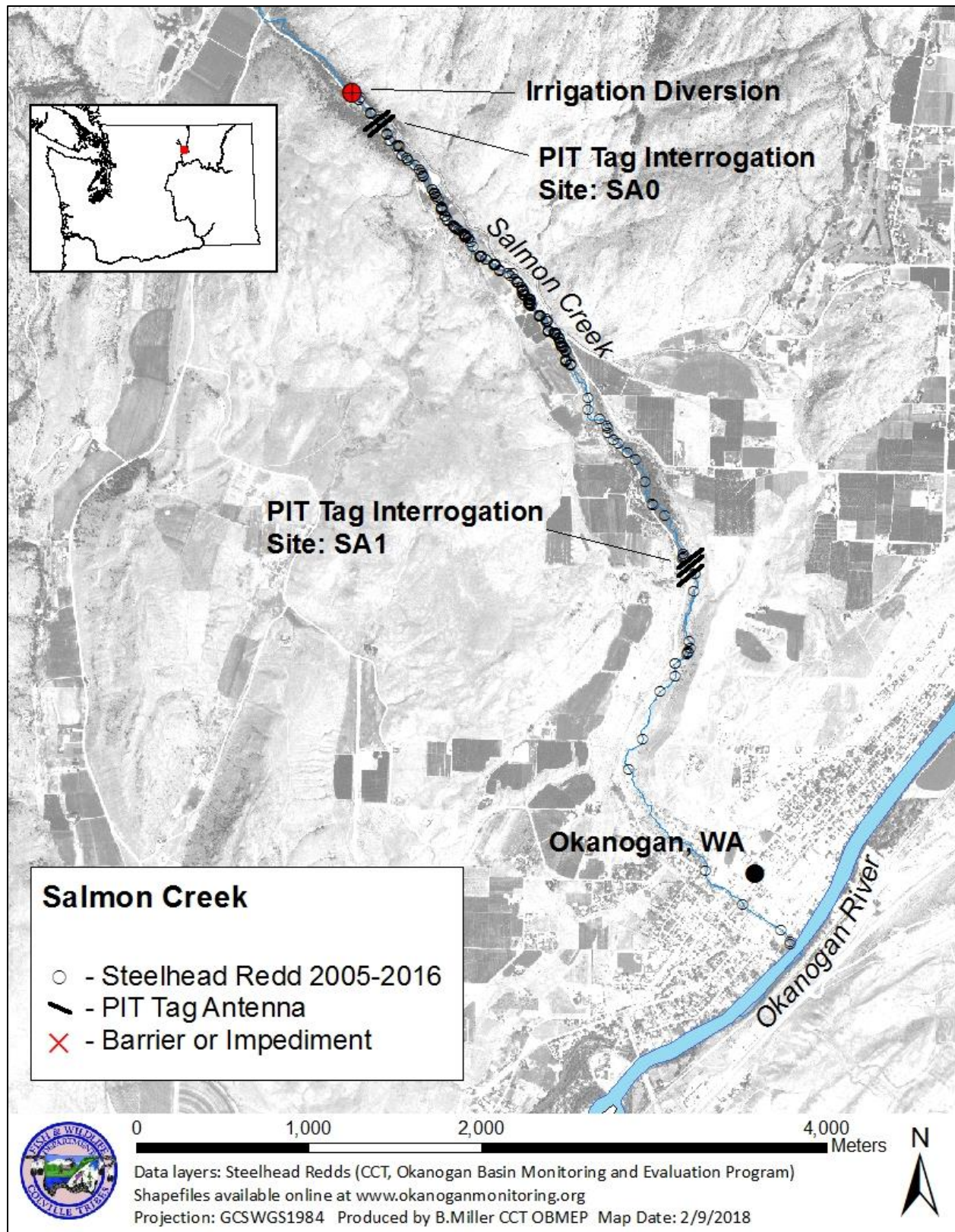


Figure 20. Spatial distribution of historical summer steelhead redds documented in lower Salmon Creek, from the confluence to the irrigation diversion.

3.2.3 Omak Creek

Omak Creek is characterized as a perennial, medium sized tributary that enters the Okanogan River at RKM 51.5, approximately 1.0 km upstream from the city of Omak, WA. Discharge rates in the creek typically range from a base flow of 2–4 cfs to over 150 cfs during peak runoff. During the base flow period, wetted widths range from approximately 2 to 8 m. A PIT tag interrogation site (OMK) consisted of four pass-over HDPE antennas configured in two separate rows located 0.24 km upstream from the confluence with the Okanogan River. Two additional PIT tag interrogation sites were also operated below (OBF) and above (OMF) Mission Falls to monitor passage rates. Each of these sites consisted of a two pass-over HDPE antennas configured in a single row.

In 2018, runoff in Omak Creek began unusually early, reaching 100 cfs in mid-March. Extremely high flows which threatened bridges, culverts, and washed out the adult weir trap, also precluded redd surveys from occurring. Redd distributions from previous years are shown in Figure 22. The total spawning estimate for Omak Creek was estimated based on PIT tag detections. A total of 3 natural-origin and 36 hatchery steelhead were detected at OMK. Those tags were expanded using 79% detection efficiency at OMK (determined by upstream detections) and the PRD mark rate for a total spawning escapement estimate of 17 natural-origin and 169 hatchery steelhead in 2018. For reference, trends in steelhead spawning escapement for Omak Creek are included in Figure 21.

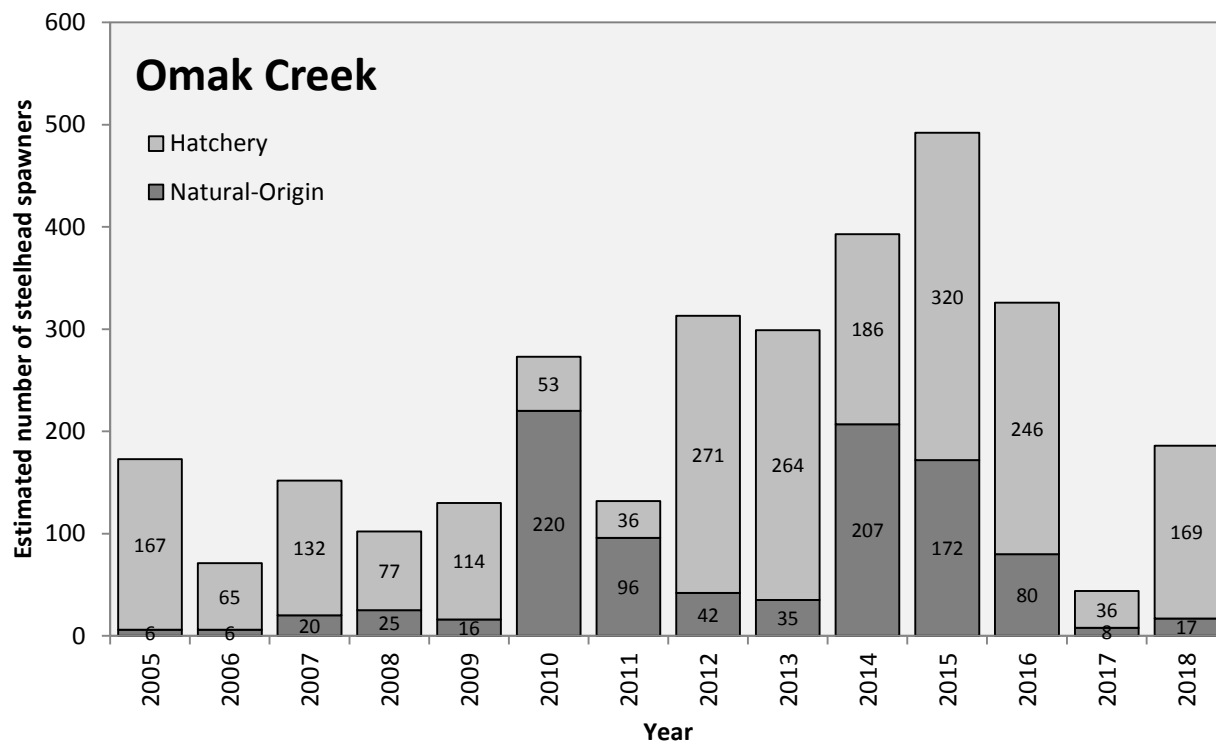


Figure 21. Trend in the number of steelhead spawners in Omak Creek.

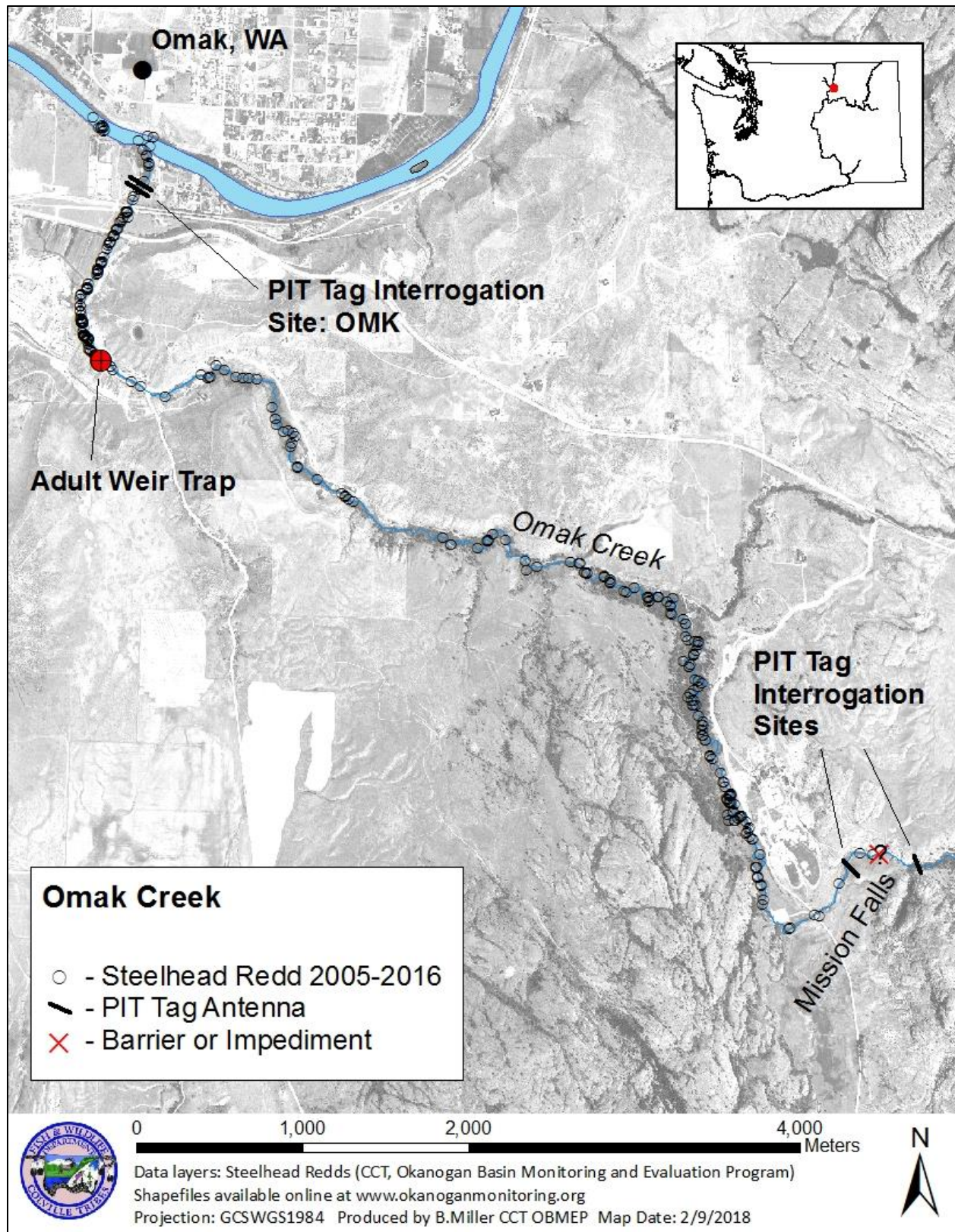


Figure 22. Spatial distribution of historical summer steelhead redds documented in Omak Creek, from the confluence to Mission Falls.

3.2.4 Wanacut Creek

Wanacut Creek is a small stream that joins the Okanogan River at approximately RKM 56, between Omak and Riverside, WA. The 51 km² Wanacut Creek drainage stems from Omak Mountain, located on the Colville Reservation. A large natural falls exists a short distance from the confluence with the Okanogan River and the creek frequently flows subsurface in the lower most reaches. A temporary PIT tag interrogation site (WAN) is placed seasonally near the mouth of the creek to record PIT tagged steelhead movements.

Over the past 11 years of surveys conducted on Wanacut Creek (2007–2017), six years had no steelhead spawning and the remaining 5 years had an average of 7 steelhead spawners. The maximum spawning estimate was 12 in 2012 (Figure 23).

Conditions in Wanacut Creek were unfavorable to conduct redd surveys throughout the spring of 2018. Although no walking surveys were successfully conducted, the location of redds observed in previous years (2005–2016) are shown in Figure 24. The total spawning estimate for Wanacut Creek was estimated based on PIT tag detections. Only one hatchery steelhead was detected at WAN, resulting in a spawning escapement estimate of 0 natural-origin and 5 hatchery steelhead for Wanacut Creek.

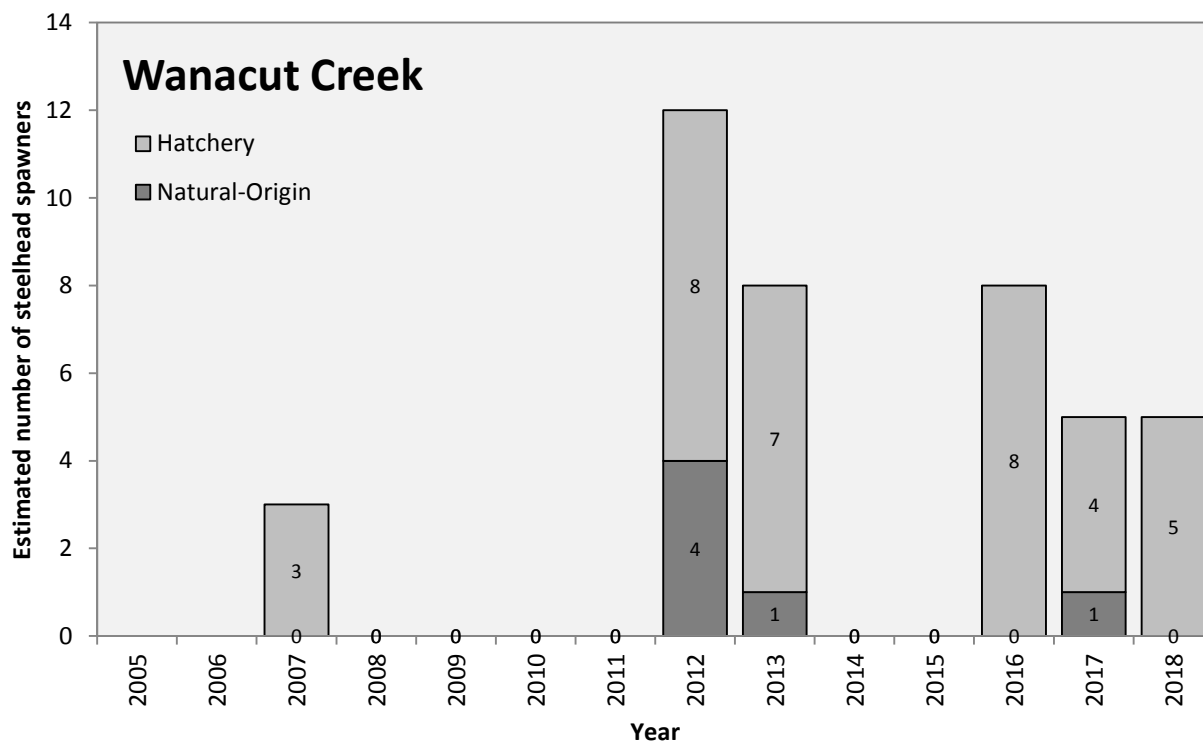


Figure 23. Trend in the number of steelhead spawners in Wanacut Creek.

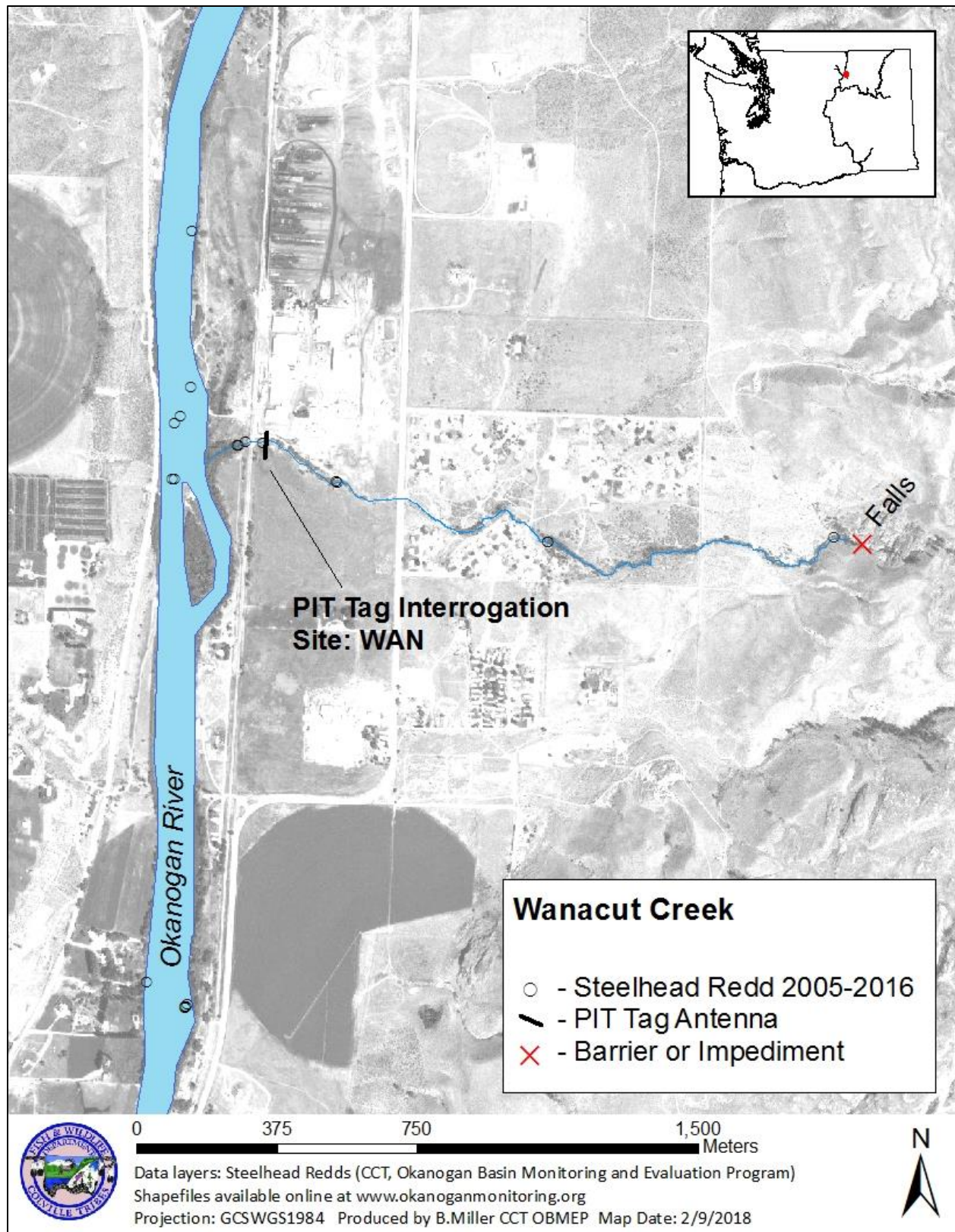


Figure 24. Spatial distribution of historical summer steelhead redds documented in Wanacut Creek.

3.2.5 Johnson Creek

Steelhead surveys have occurred in Johnson Creek since 2012. Compared to previous survey years, Johnson Creek had significantly elevated flows during 2018. However, redd surveys were conducted from the mouth of Johnson Creek to the US 97 culvert, 4 redds were identified in this reach. The spatial distribution of steelhead spawning in Johnson Creek for 2018 and previous years are shown in Figure 26.

Johnson Creek had two PIT tag arrays installed in 2018. A permanent single pass-through antenna located near the mouth (JOH) and a single temporary antenna above the US 97 culvert. No steelhead from the PRD mark group were detected in Johnson Creek in 2018. The total spawning escapement estimated from PIT tag detections alone would be 0. However, since 4 redds were found, those redds were expanded by 1.84 fish per redd and 76.8% hatchery rate from Wells dam for a total spawning escapement estimate of 5 hatchery and 2 natural-origin steelhead. For reference, trends in steelhead spawning escapement for Johnson Creek are included in figure 25.

One hatchery steelhead not included in the PRD mark group was detected at JOH on 12 April. That fish was subsequently detected above the highway culvert on 15 April when flows were approximately 20 cfs. No redd surveys have occurred above the US 97 culvert, thus the upstream spatial extent of steelhead spawning is unknown. However, a small number of PIT tags have been detected above the structure over the past 8 years (2011–2018).

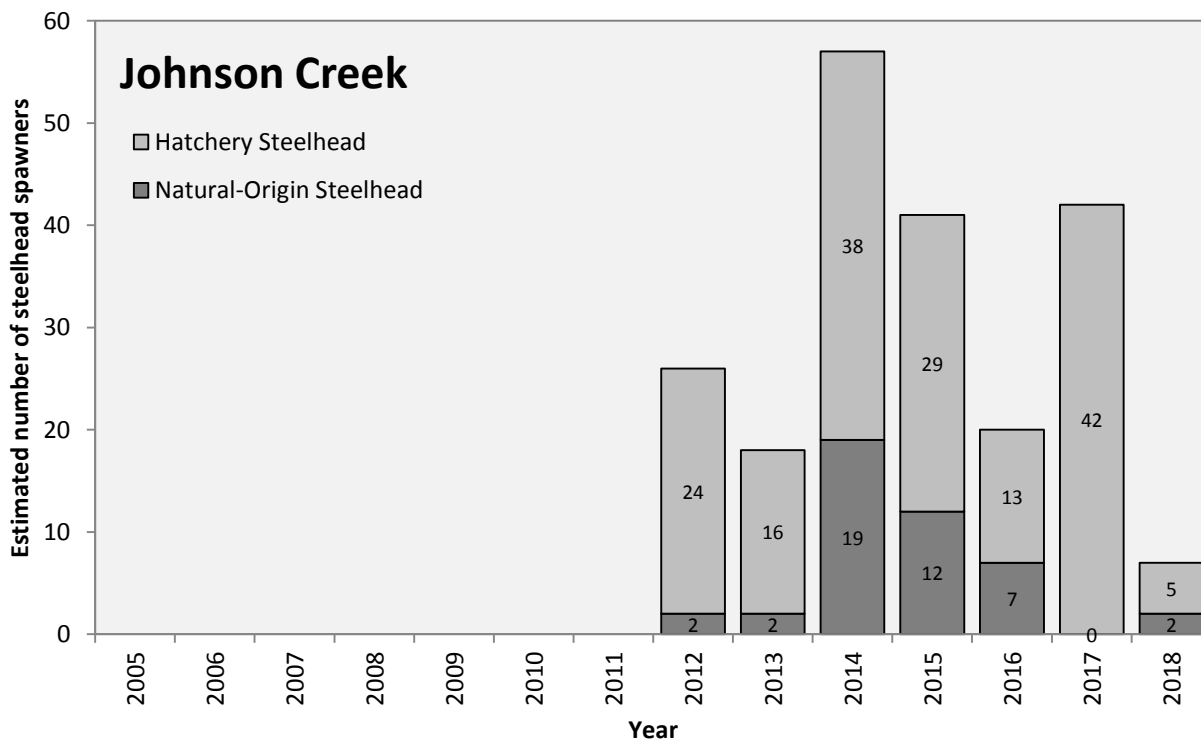


Figure 25. Trend in the number of steelhead spawners in Johnson Creek.

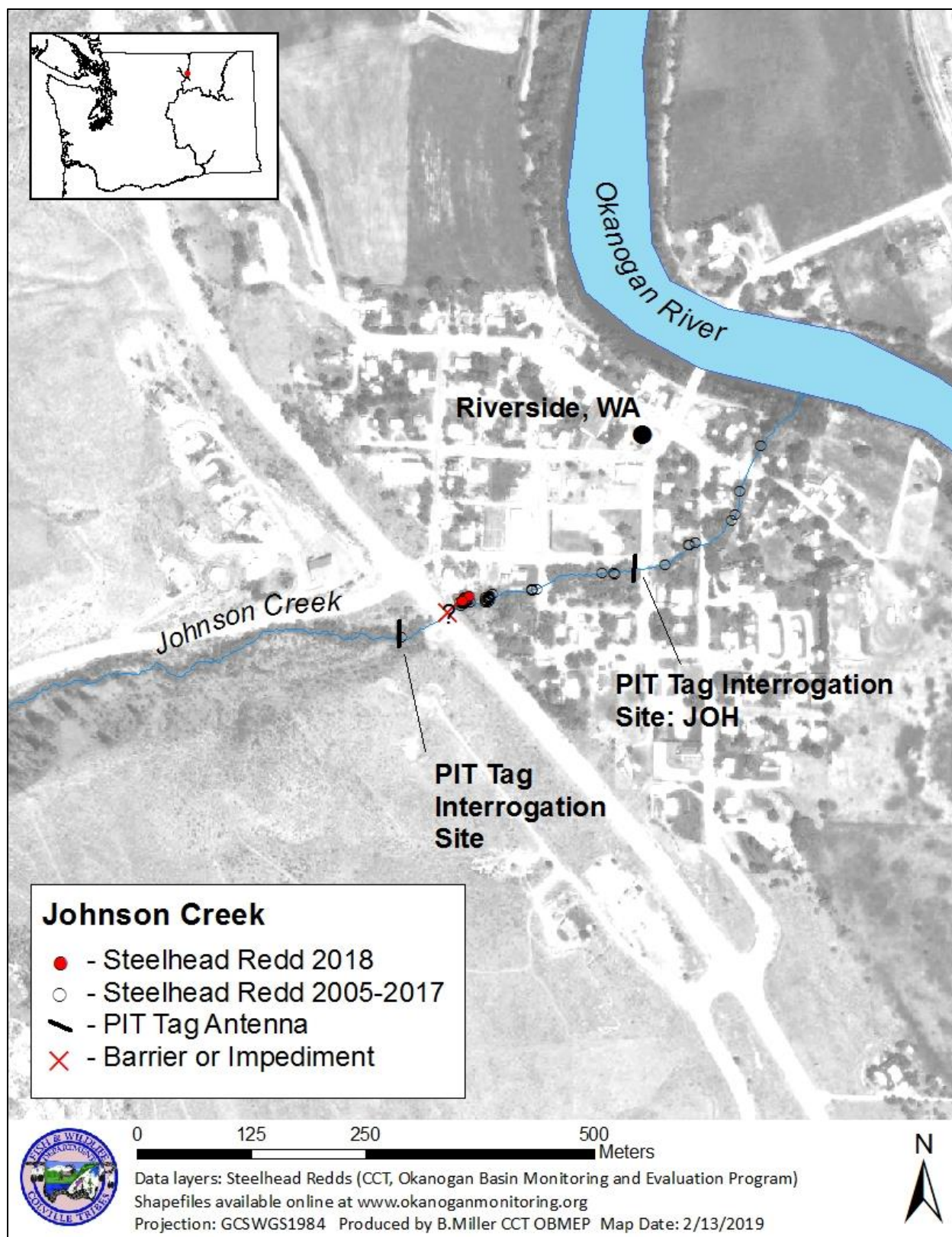


Figure 26. Spatial distribution of summer steelhead redds documented in Johnson Creek, from the confluence to the gabion weir.

3.2.6 Tunk Creek

Tunk Creek is a small tributary that joins the Okanogan River at RKM 72, upstream of Riverside, WA. Although the drainage area of Tunk Creek is approximately 186 km², only the lower 1.2 rkm are accessible to anadromous fish, due to a natural falls. The creek frequently flows subsurface in the lower reaches during mid-summer. A temporary PIT tag detection site (TNK) consisting of a single pass-over antenna is installed seasonally near the mouth of the creek.

Conditions in Tunk Creek were unfavorable to conduct redd surveys throughout the spring of 2018. Although no walking surveys were successfully conducted, the location of steelhead redds observed in previous years are shown in Figure 28. The majority of steelhead spawning in Tunk Creek occurs in a relatively short reach just downstream of the falls. No PIT tagged steelhead were detected at TNK in 2018, resulting in a spawning escapement estimate of 0. For reference, from 2005 to 2017 the average spawning escapement for Tunk Creek was 41 total fish, with the majority being hatchery fish (pHOS 0.76). Trends in steelhead spawning escapement for Tunk Creek are included in figure 27.

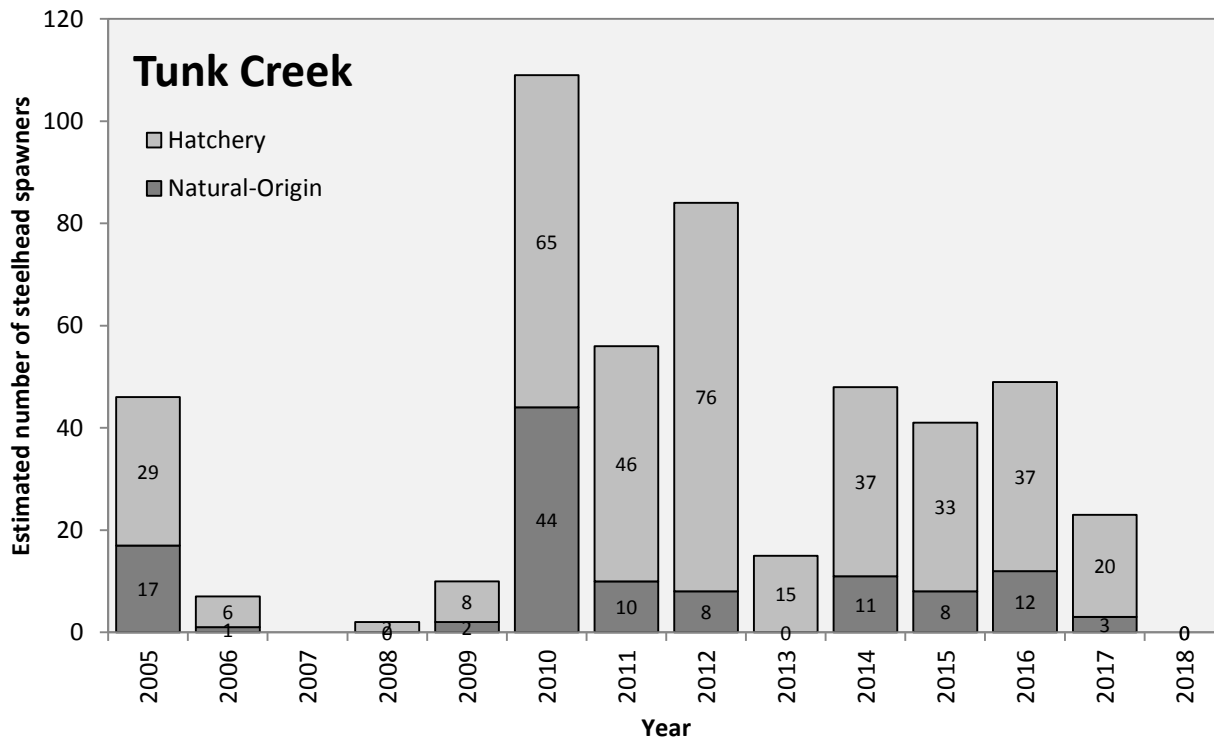


Figure 27. Trend in the number of steelhead spawners in Tunk Creek.

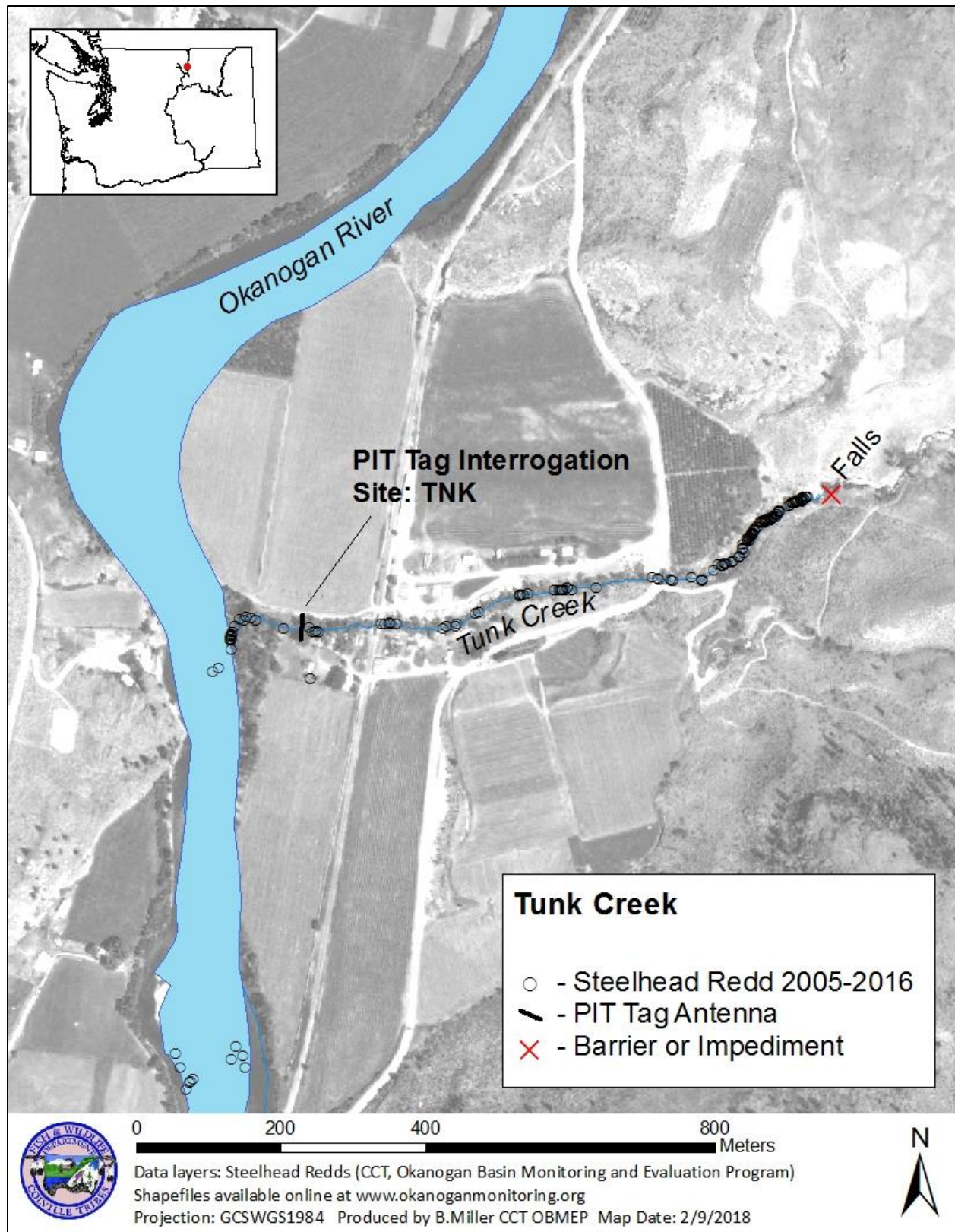


Figure 28. Spatial distribution of historical summer steelhead redds documented in Tunk Creek.

3.2.7 Aeneas Creek

Aeneas Creek is a small creek that enters the Okanogan River just south of the town of Tonasket, WA (RKM 85). The lower section of the creek was impounded with a series of very large beaver dams that were cemented in with calcified clay. In 2012, many of these structures were removed, allowing adult steelhead passage at the mouth of the creek. Although potential passage has not been studied at this location, the total habitat accessible to anadromous fish appears to be limited by a culvert and steep gradient (Figure 30). Spawning surveys were attempted in Aeneas Creek in 2018, but were problematic due to high flows and turbidity, no redds were found.

A permanent PIT tag detection site (AEN) consisting of a single pass-through antenna operated near the mouth of the creek to document utilization of the creek by adult steelhead. Only one hatchery steelhead from the PRD mark group was detected in 2018, resulting a total spawning escapement estimate of 5 hatchery and no natural-origin steelhead. For reference, trends in steelhead spawning escapement for Aeneas Creek are included in figure 29.

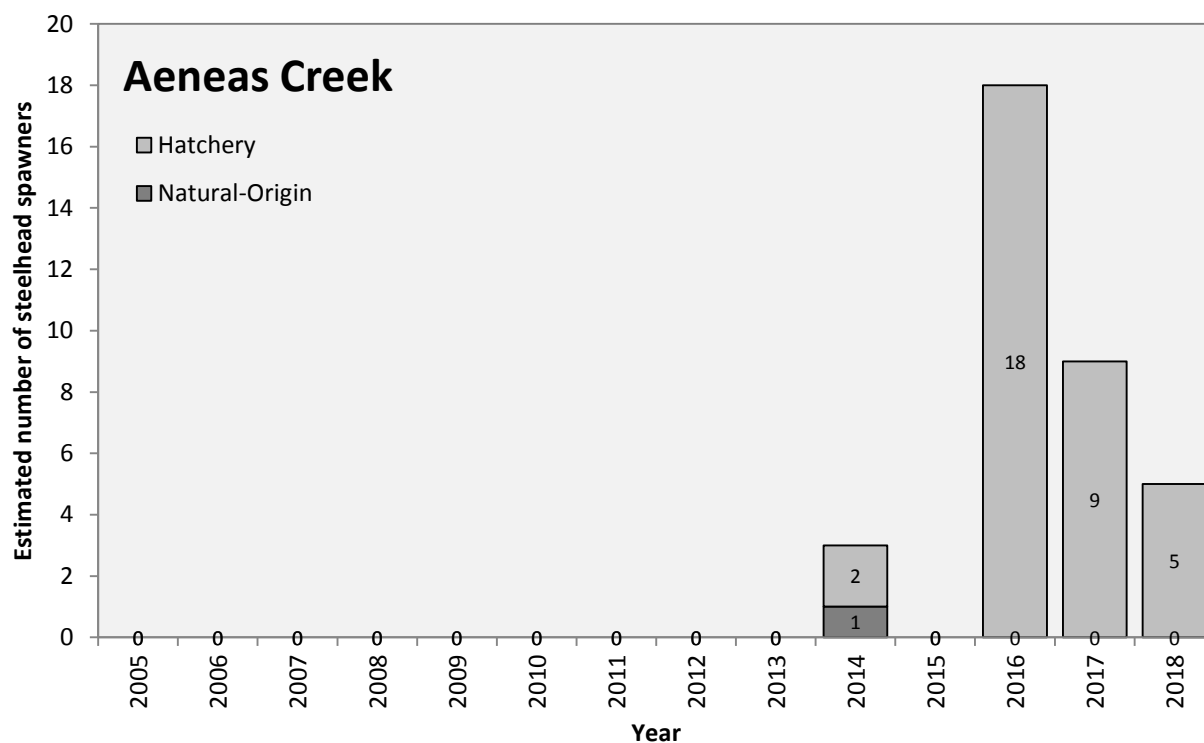


Figure 29. Trend in the number of steelhead spawners in Aeneas Creek.

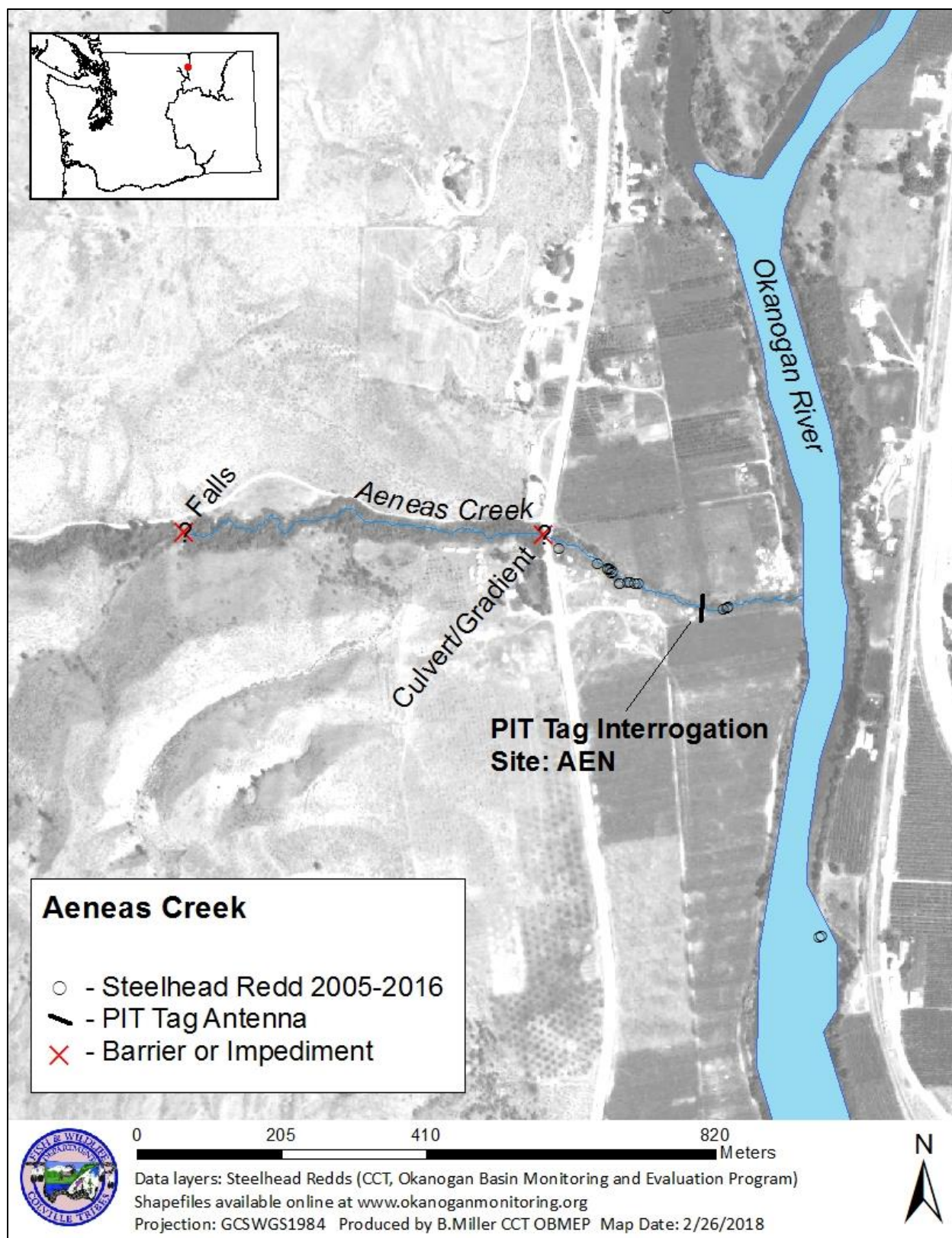


Figure 30. Spatial distribution of historical summer steelhead redds documented in Aeneas Creek.

3.2.8 Bonaparte Creek

Bonaparte Creek flows out of Bonaparte Lake, near Wauconda, WA, and enters the Okanogan River at RKM 91. The Bonaparte Creek watershed has a drainage area of 396 km²; discharge ranges from 1 cfs during base flow conditions and usually reaches 20–40 cfs during runoff. During summer base flow, wetted widths range from 1.5 m to 3 m. Only 1.6 rkm of stream below a natural falls is accessible to anadromous fish (Figure 32). In 2018, elevated flows reduced visibility and no redd surveys were conducted. Steelhead spawning surveys have occurred on Bonaparte Creek since 2005.

A permanent PIT tag interrogation site (BON) consisting of three pass-over PVC antennas arranged in three separate rows was located just upstream from the confluence with the Okanogan River. Based on tag detections from the PRD mark group (2 natural-origin, 8 hatchery), the estimated spawning escapement was 9 natural-origin and 36 hatchery steelhead in Bonaparte Creek for 2018. For reference, trends in steelhead spawning escapement for Bonaparte Creek are included in Figure 31.

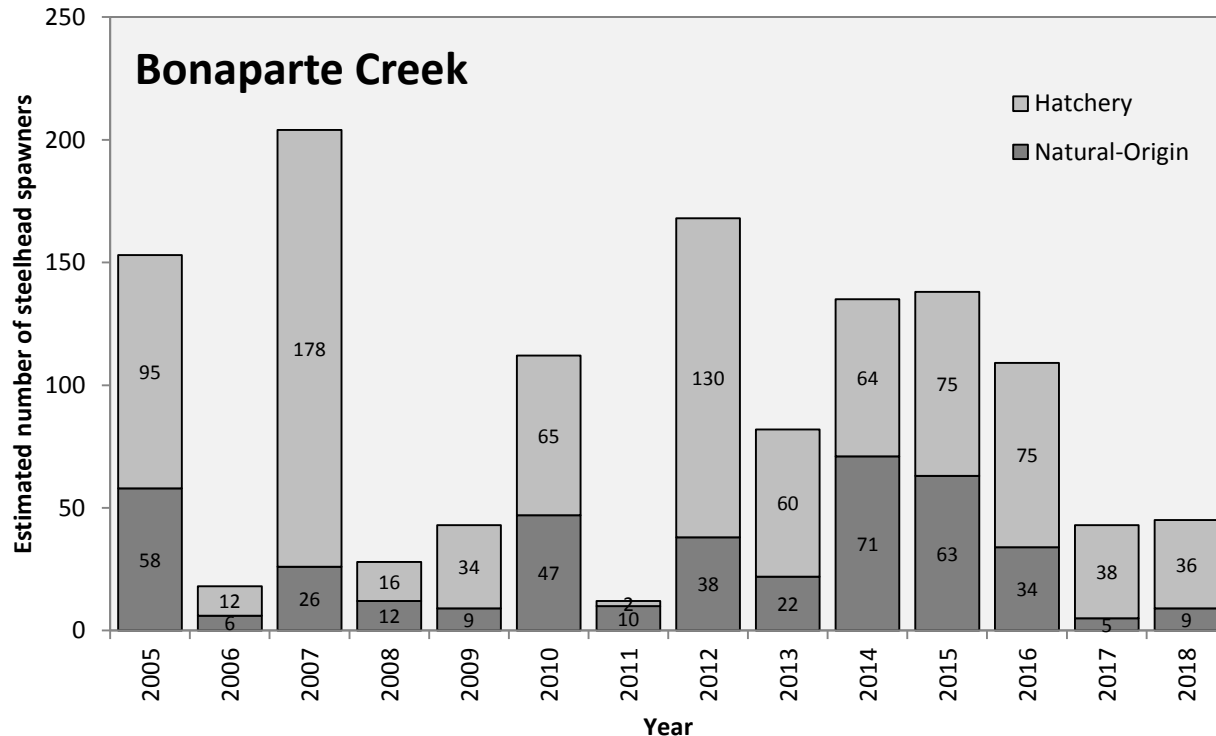


Figure 31. Trend in the number of steelhead spawners in Bonaparte Creek.

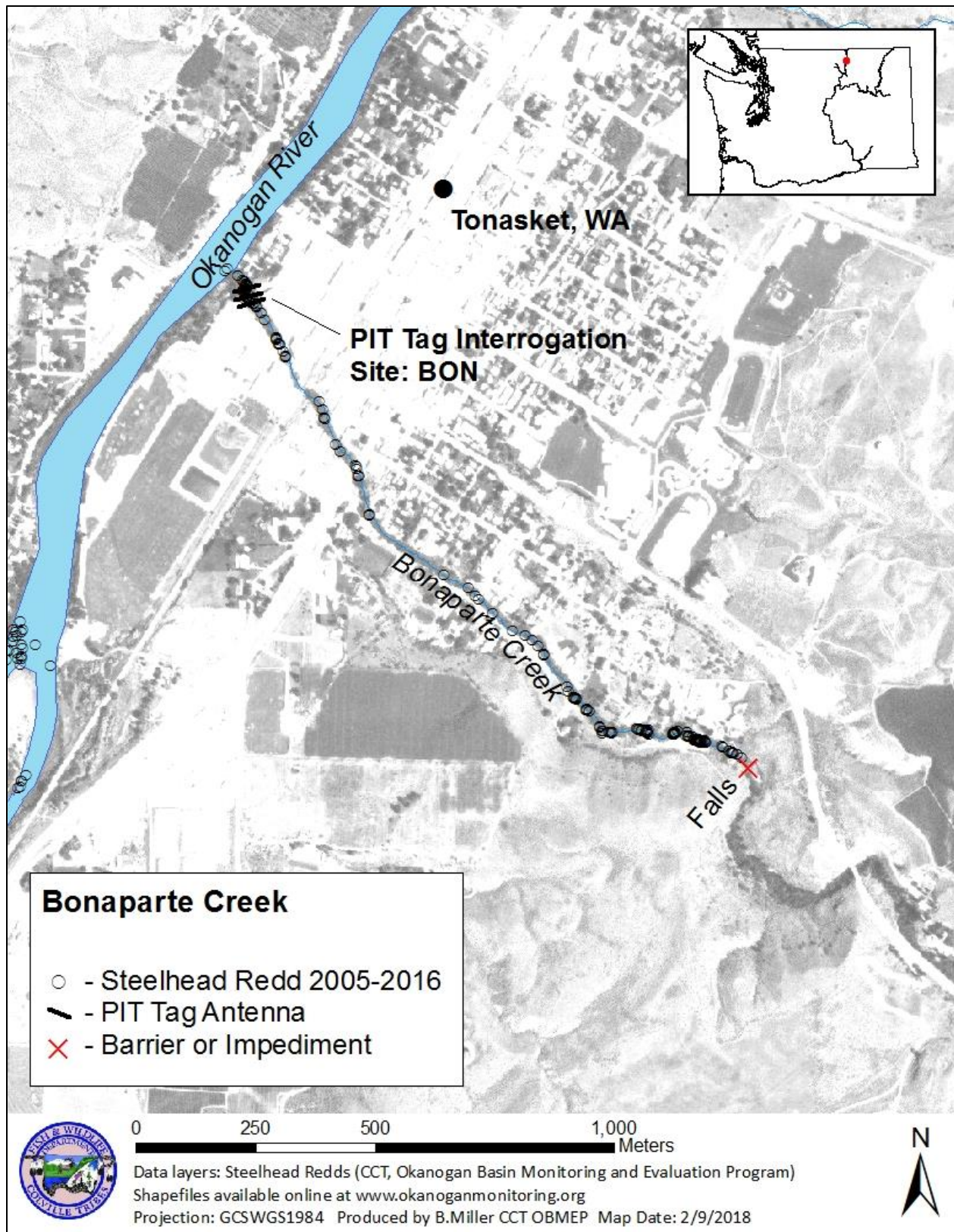


Figure 32. Spatial distribution of historic summer steelhead redds documented in Bonaparte Creek.

3.2.10 Antoine Creek

Steelhead surveys have occurred in the lower portion of Antoine Creek since 2006. The average number of estimated spawners is only five per year from 2006–2015. Utilization by adult steelhead has been relatively limited, potentially due to poor accessibility near the mouth of the creek. In part, this may be due to an approximately 6 foot high cut bank falls with a very shallow plunge pool near the confluence with the Okanogan River. Frequently, wood debris piled up in this slot and likely inhibited upstream passage. In late 2015, habitat modifications were completed near the mouth of Antoine Creek, designed to increase passage success for the 2016 spawning period (Keith Kistler, CCT, pers. comm.). Additionally, a small concrete dam was removed in Antoine Creek in the fall of 2013, which potentially opened up an additional 11 rkm of habitat in the upper creek. In 2016, an estimated 72 steelhead spawned in Antoine Creek, 51 hatchery and 21 natural-origin. In 2017, an estimated 28 hatchery and 5 natural-origin fish for a total estimate of 33 adult spawners returned to the creek (Figure 33).

Complete redd surveys occurred in Antoine Creek for the first time in 2018. On April 25th, surveyors walked upstream from the mouth of the creek through Antoine Valley Ranch and located 15 redds (Figure 34). When expanded by 1.84 fish per redd, those redds represented roughly 28 fish.

Four natural-origin and two hatchery PIT tagged steelhead in the PRD mark group were detected on PIT tag interrogation site ANT in 2018. Those fish were expanded for a total spawning escapement estimate of 18 natural-origin and 9 hatchery steelhead, or a total of 27 fish. A temporary PIT tag interrogation site was operated on AVR for the first time in 2018. Two natural-origin and two hatchery fish from the PRD mark-group were detected on this antenna for a total estimate of 9 natural-origin and 9 hatchery fish passing this point. This is the first observation of adult steelhead this high in the Antoine Creek watershed.

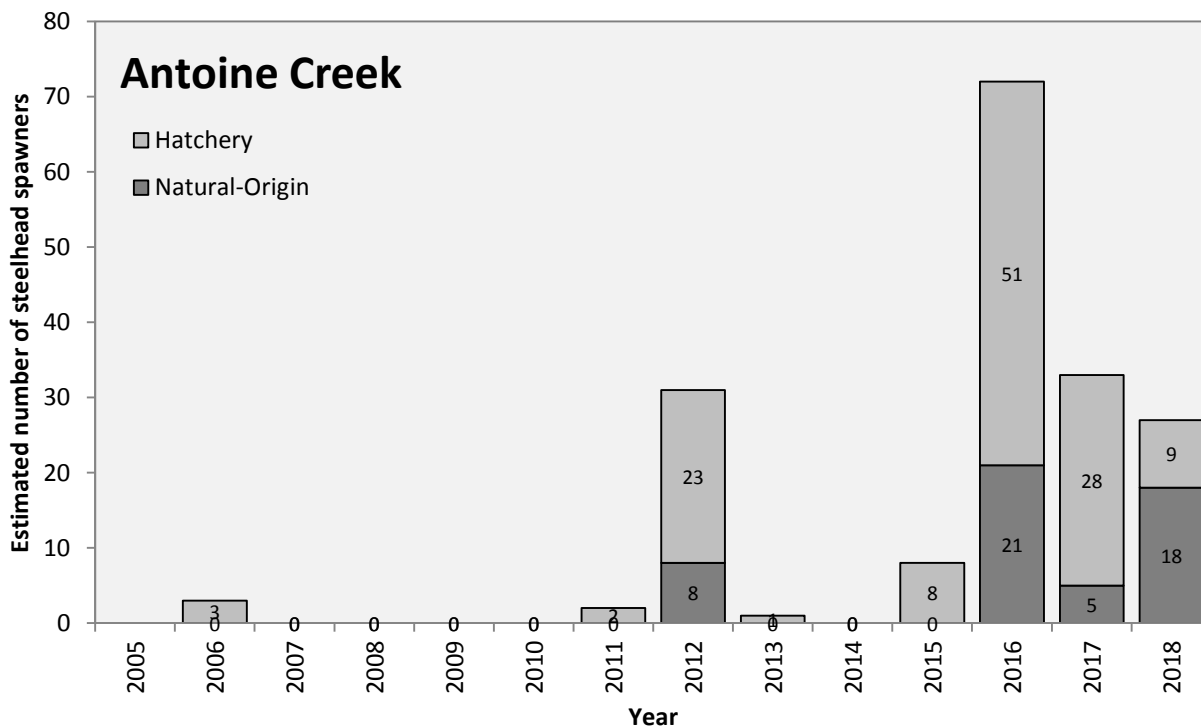


Figure 33. Trend in the number of steelhead spawners in Antoine Creek.

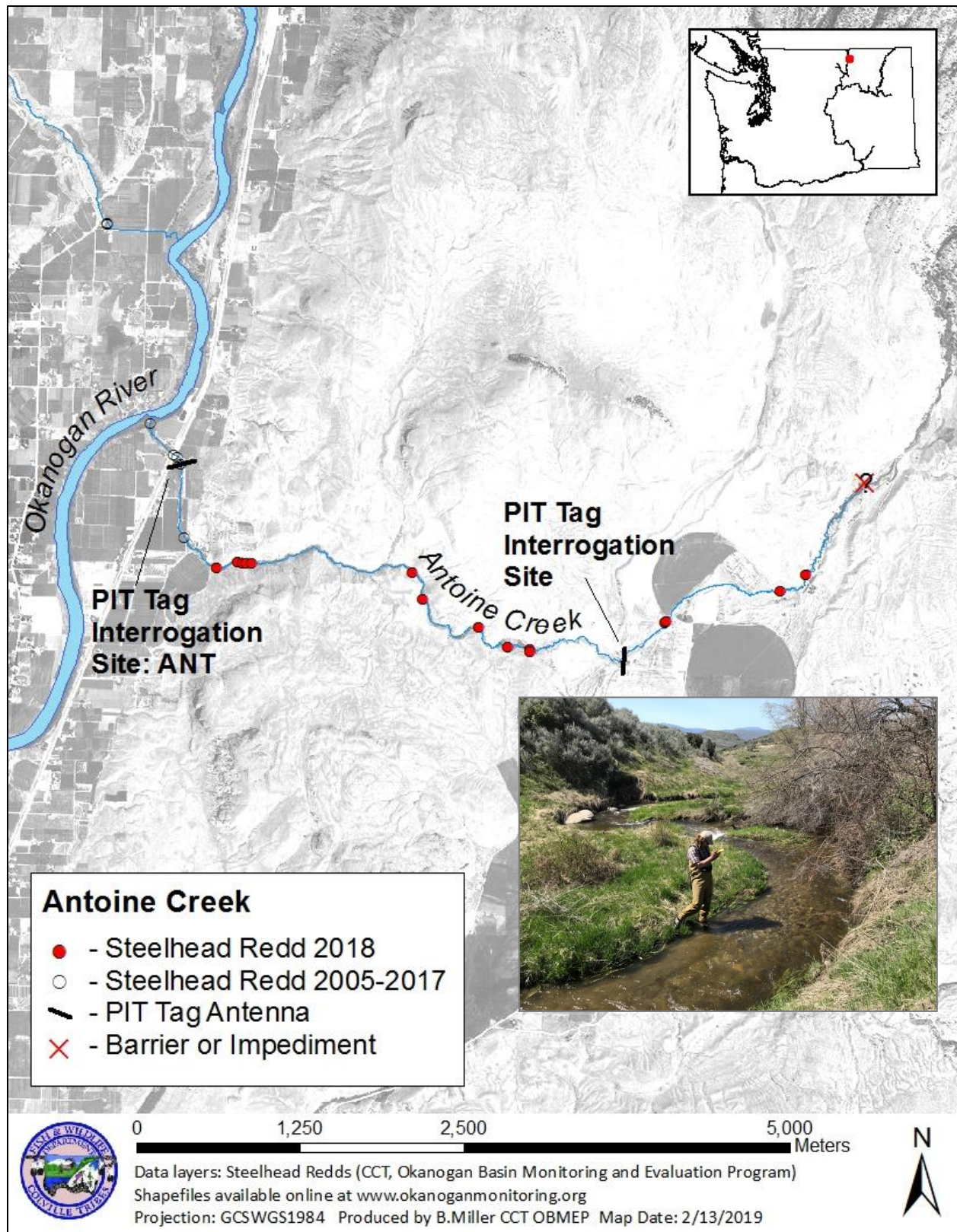


Figure 34. Spatial distribution of summer steelhead redds documented in Antoine Creek.

3.2.11 Wildhorse Spring Creek

Wildhorse Spring Creek is a fairly small watershed the flows off of the west side of Mt. Hull near Oroville, WA. Some years, there is not enough water depth for adult steelhead to access the creek. However, on years where sufficient water flows to allow for adult steelhead access, it is not uncommon for large numbers of fish to utilize this creek for spawning. Surveys have occurred over the previous 12 years (2006–2017). On four of the years (2008, 2009, 2014, 2015) zero steelhead were estimated to have entered the creek. In the remaining years, an annual average of 87 steelhead spawned in the creek (max=278 in 2012, Figure 35 and 36).

In 2018, although sufficient flow existed, no steelhead were detected on the PIT tag interrogation site. As has occurred in previous years, no steelhead were estimated to have used Wildhorse Spring Creek in 2018. Due to turbid water, no redd surveys could be conducted in 2018.

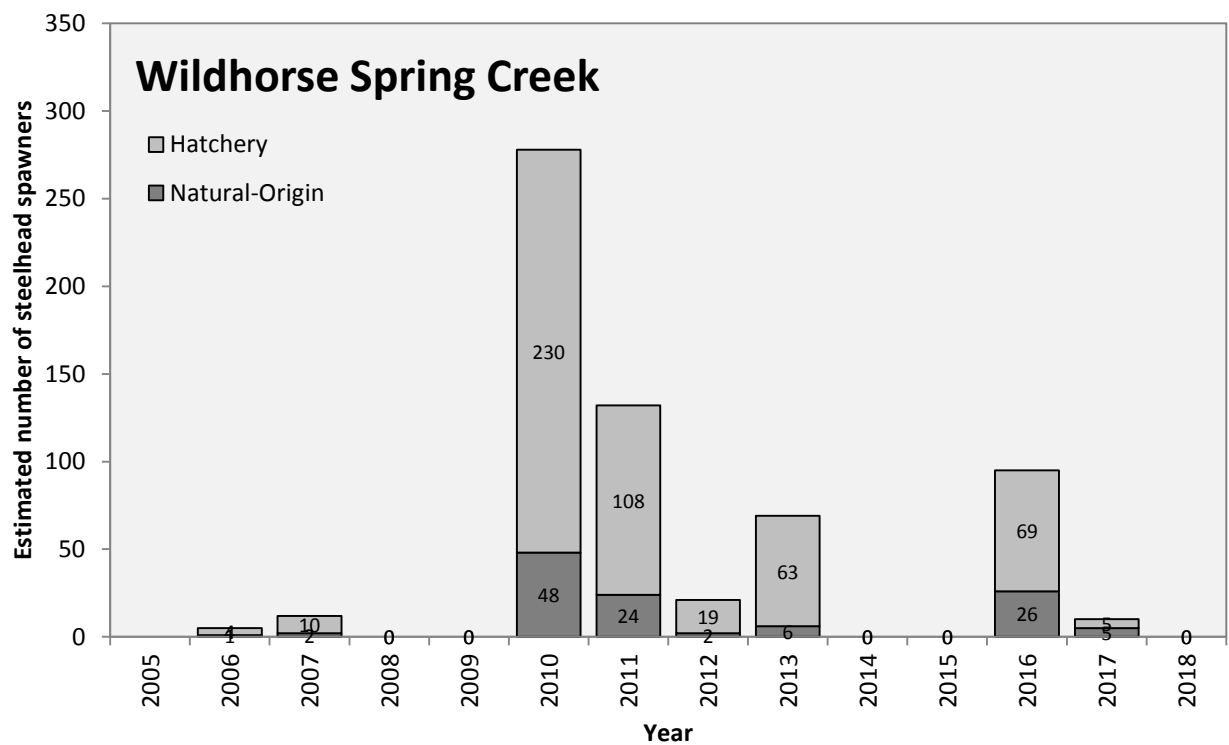


Figure 35. Trend in the number of steelhead spawners in Wildhorse Spring Creek.

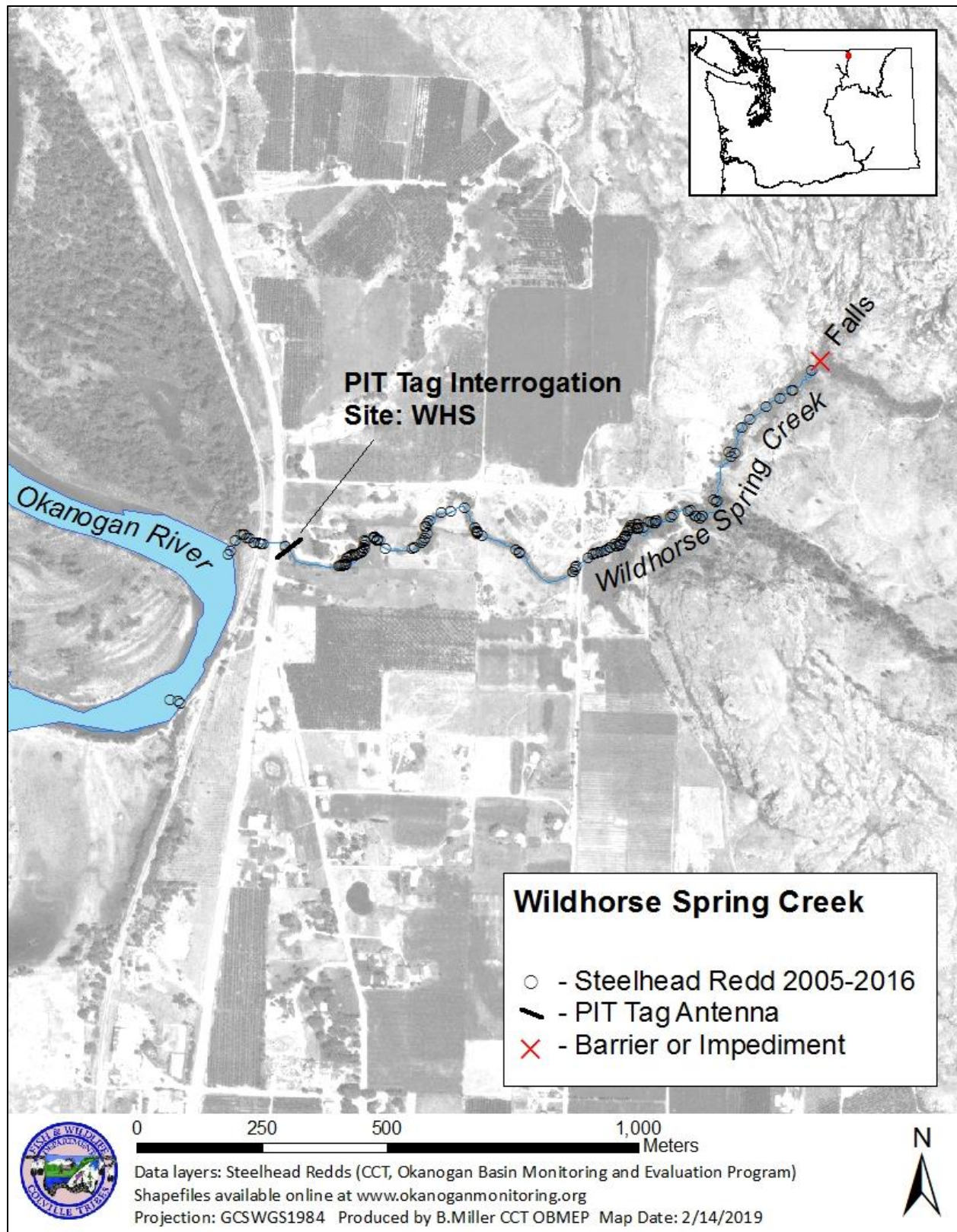


Figure 36. Spatial distribution of summer steelhead redds documented in Wildhorse Spring Creek.

3.2.12 Tonasket Creek

Tonasket Creek enters the Okanogan River at RKM 125, just upstream from Zosel Dam, at the tail end of Lake Osoyoos. The lower reach is known to go dry on an annual basis; however, there is typically some flow in the upper-most reach, below the natural falls (Figure 39). A seasonal PIT tag detection site (TON) consisting of a single pass-through antenna is operated near the confluence of the creek with the Okanogan River. Again as in other creeks, no redd surveys could occur in 2018 due to high flows throughout the steelhead spawning season, which nearly washed out the lower bridge (Figure 37). Based on PIT tag detections expanded from the PRD mark group, in 2018, an estimated 18 steelhead spawned in Tonasket Creek, 9 natural-origin and 9 hatchery steelhead. From 2006 to 2017, the average spawning escapement was 30 (Figure 38).



Figure 37. High water events in Tonasket Creek in the spring of 2018.

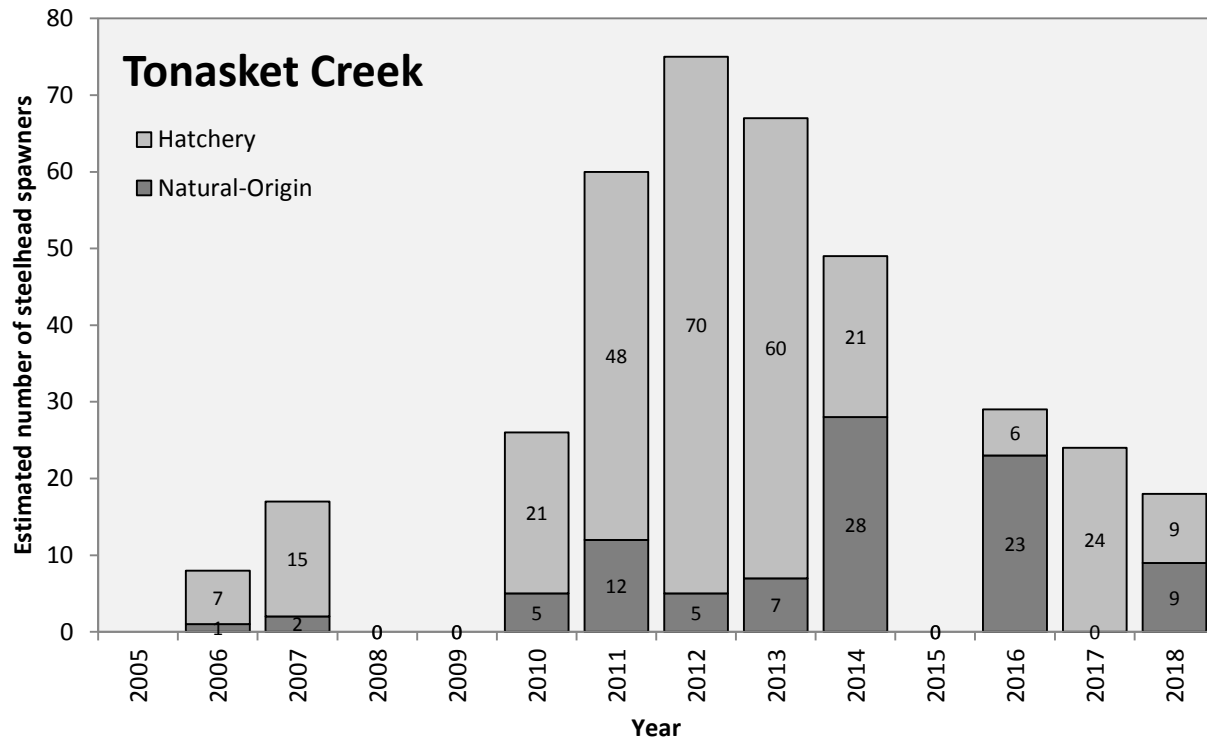


Figure 38. Trend in the number of steelhead spawners in Tonasket Creek.

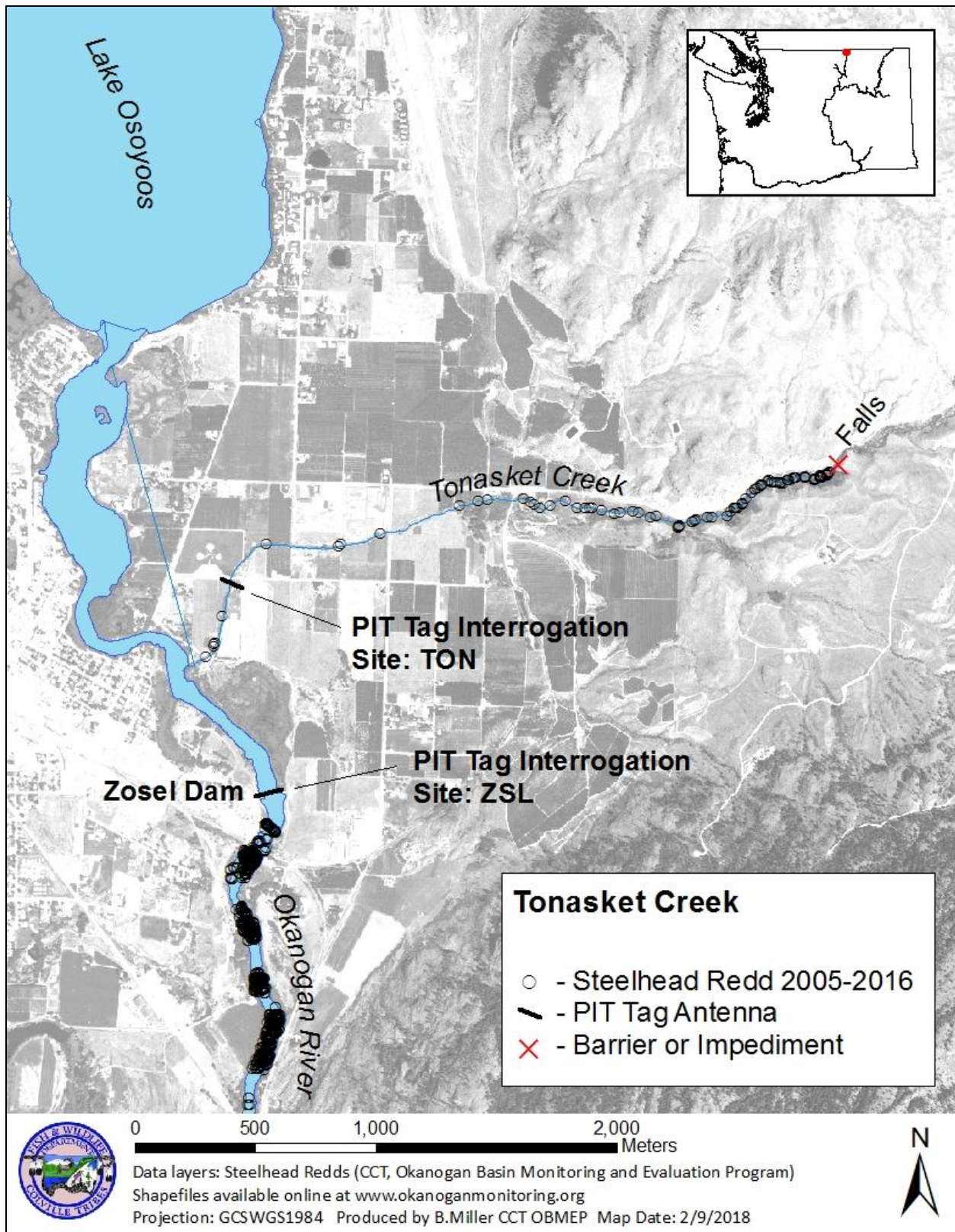


Figure 39. Spatial distribution of historic summer steelhead redds documented in Tonasket Creek.

3.2.13 Ninemile Creek

Ninemile Creek enters the eastside of Osoyoos Lake, just south of the British Columbia border. The creek is known to flow sub-surface annually in the middle reach, but surface flows are usually present in the upper and lower reach. A permanent PIT tag detection site (NMC) consisting of three pass-through PVC antennas is located near the mouth of the creek. In 2018, an estimated 5 natural-origin and 9 hatchery steelhead spawned in Ninemile Creek. From 2005–2017, the average number of steelhead in Ninemile creek was 25 (max=77 in 2008, Figure 40). Steelhead redds marked in previous survey years are shown in Figure 41 for reference.

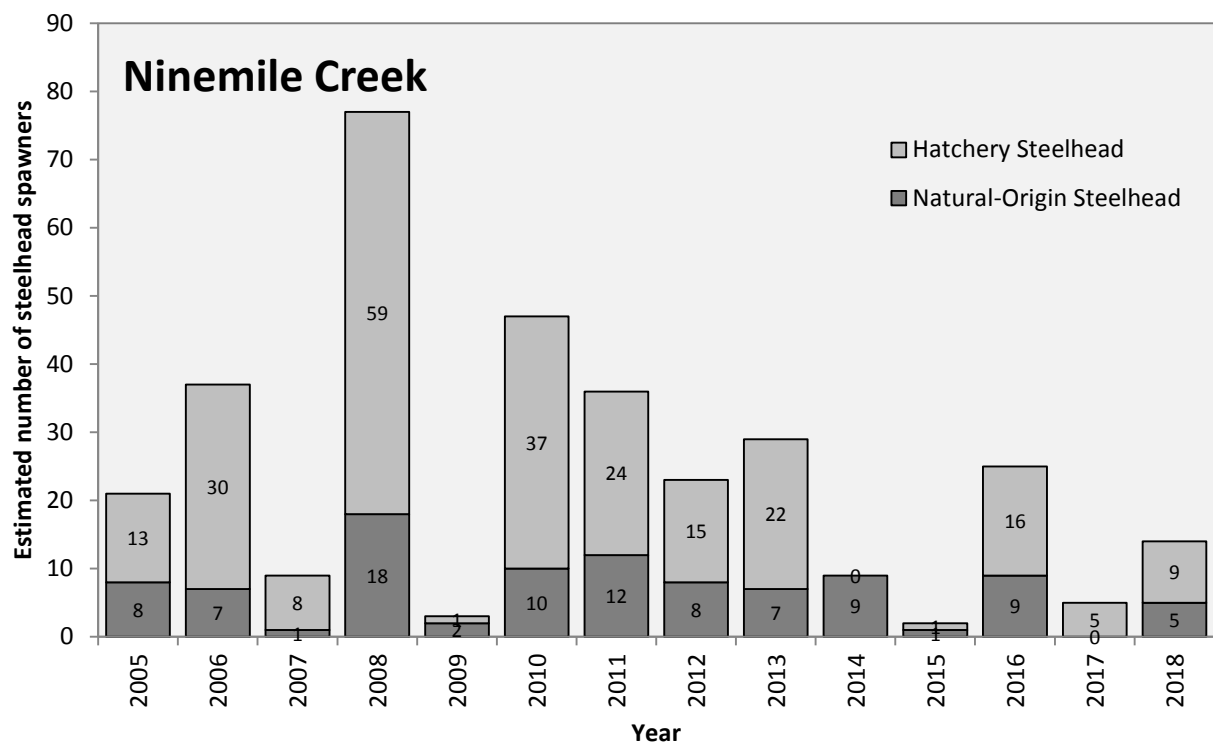


Figure 40. Trend in the number of steelhead spawners in Ninemile Creek.

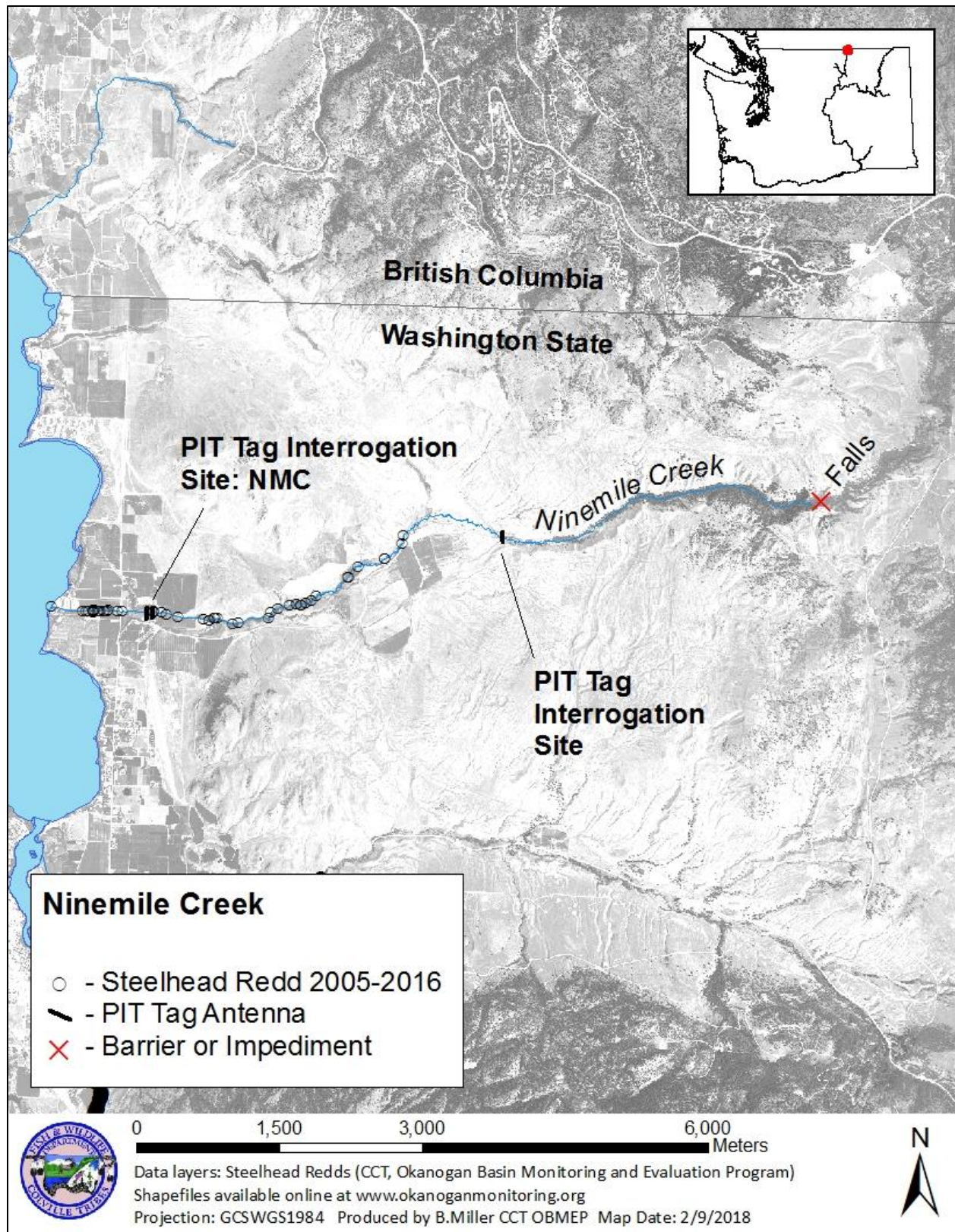


Figure 41. Spatial distribution of historic summer steelhead redds documented in Ninemile Creek.

3.2.14 Foster Creek (located outside the Okanogan subbasin)

Although Foster Creek is not located within the Okanogan subbasin, OBMEP installed a PIT tag detection site (FST) and conducted a post-peak redd surveys in 2018 to further describe the spatial extent of Upper Columbia River steelhead above Wells Dam. During 2018, sufficient water flowed down Foster Creek for adult steelhead to migrate into the upper reaches, past the dam outflow pipe. Foster Creek was surveyed on May 9 from the mouth to Foster Creek Dam and a total of 27 redds were observed.

A total of 6 natural-origin and 17 hatchery PIT tagged steelhead from the PRD mark-group were detected at FST. Those tags were expanded to 27 natural-origin and 76 hatchery steelhead spawners. Spatial distribution of redds located during the 2018 survey and on previous years surveys are detailed on Figure 43.



Figure 42. Redd surveys conducted in Foster Creek in 2018.

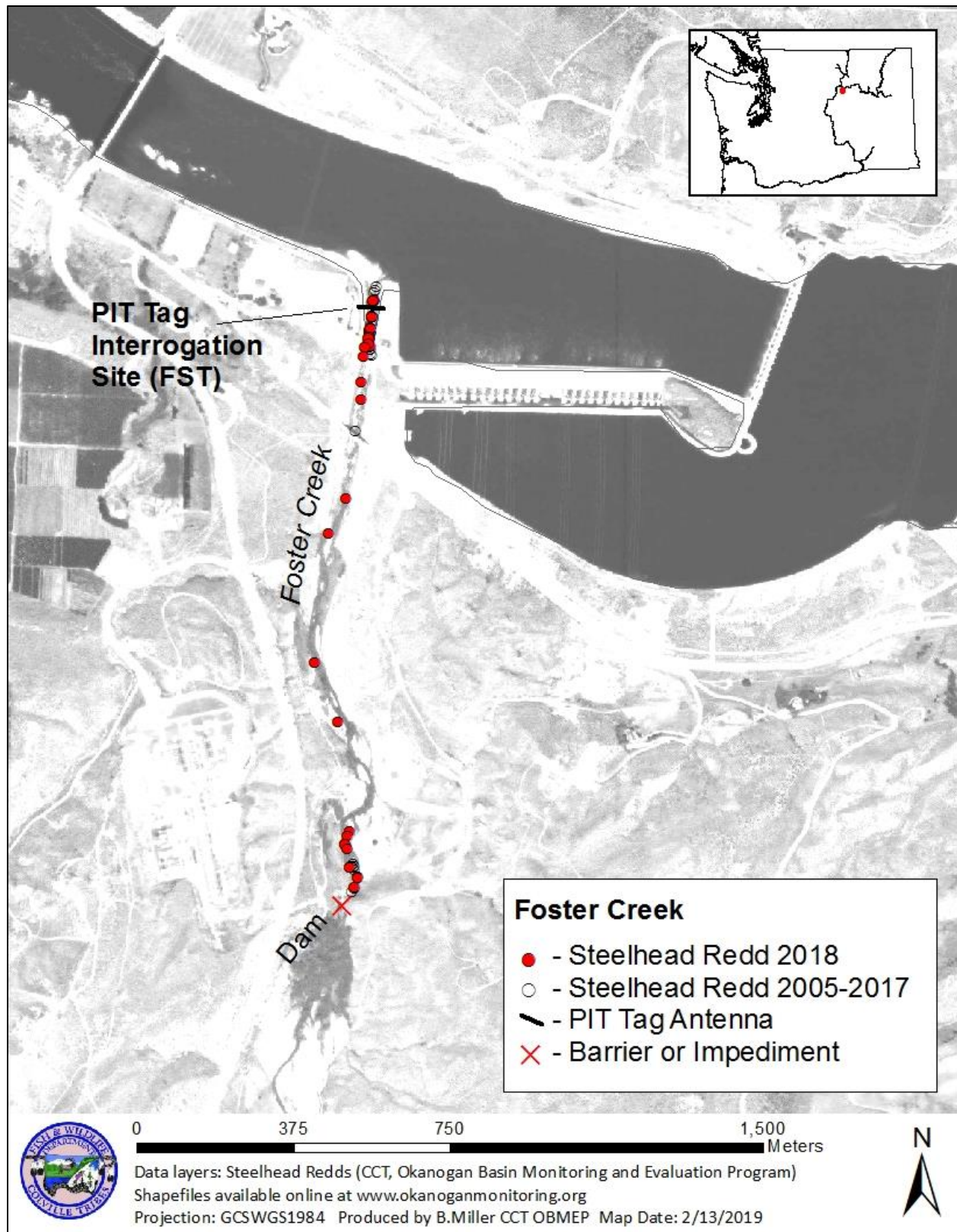


Figure 43. Spatial distribution of summer steelhead redds documented in Foster Creek.

3.3 Zosel Dam and Upstream Locations

Zosel Dam regulates Lake Osoyoos, which extends into the Canadian portion of the subbasin. A vertical-slot fishway provides upstream passage and is equipped with a PIT tag detection array (ZSL). Zosel Dam was constructed in its current state in 1987 with undershot spillways. When these spillway gates are raised to a height of more than 12 inches, fish may be able to ascend through the spillways and bypass the fishway and PIT tag array. Underwater video enumeration of steelhead was discontinued at Zosel Dam in 2015 due to sufficient PIT tag detection sites upstream of that point. The fall back rate at Zosel Dam is currently unknown, but may be relatively large due to the heavily utilized spawning habitat available in Okanogan reach 07.

Three perennial tributaries flow into Lake Osoyoos, two on the Washington State side of the border (Ninemile and Tonasket creeks) and one in British Columbia (Inkaneep Creek). Both Ninemile and Tonasket creeks have had PIT tag interrogation sites installed for a number of years; additionally, a permanent PIT tag interrogation site was installed in Inkaneep Creek in 2015. Approximately 5 km upstream of Lake Osoyoos, on the Okanagan River mainstem, a permanent instream PIT array spans the entire channel (site OKC situated at Vertical Drop Structure 3) which has been in operation since 2010. Since all salmon migrating upstream of Lake Osoyoos must cross over OKC, it has been a pivotal detection site for enumerating adult salmon abundance and observing migration timing. PIT tag interrogation sites were also installed on three other British Columbia tributaries located further up the subbasin, Vaseux, Shingle and Shuttleworth creeks.

Until 2009, the outlet dam of Vaseux Lake (McIntyre Dam) was the upstream migration barrier for anadromous salmonids. The dam was redesigned in 2009 and, currently, the outlet dam of Okanagan Lake at Penticton, BC is the upstream barrier. A dam also exists at the outlet of Skaha Lake (Okanagan Falls, BC), which had a fish ladder installed in 2014. As well, 17 Vertical Drop Structures (VDS) currently exist along the Okanagan mainstem, 13 between Oliver, BC and Lake Osoyoos, and four between Skaha Lake and Vaseux Lake. The majority of the Canadian portion of the mainstem Okanagan River is characterized as being straightened and channelized. The main tributaries to the mainstem Okanagan River include Shingle Creek, Ellis Creek, McLean Creek, Shuttleworth Creek, Vaseux Creek, and a number of small perennial streams.

A total of 4 PIT tagged steelhead were detected on OKC. All 4 were subsequently detected on the Vaseux Creek PIT tag interrogation site. Two of those were from the PRD mark-group, for a total estimate of 9 natural-origin steelhead spawning in Vaseux Creek.

4.0 Discussion

OBMEP monitored adult Viable Salmonid Population (VSP) abundance attributes (McElhany et al. 2000) within the subbasin for Okanogan River summer steelhead. Over the past 14 years of monitoring, the estimated average total number of steelhead spawners in the Okanogan subbasin was 1,324 (geomean 1,170). The average natural-origin spawner abundance (NOSA) was 298 (geomean 256). The spawning estimates for 2018 of 453 steelhead (120 natural-origin, 333 hatchery) were the lowest recorded since data collection began in 2005 (Figure 44). Spawning estimates were also compared with recovery goals, as outlined by the Interior Columbia Basin Technical Recovery Team (ICBTRT). The Upper Columbia Spring Chinook and Steelhead Recovery Plan states that 500 naturally produced steelhead adults would meet the minimum abundance recovery criteria within the U.S. portion of the Okanogan subbasin; if the Canadian portion of the subbasin was included, minimum abundance recovery criteria would be 1,000 naturally produced adults (UCSRB 2007).

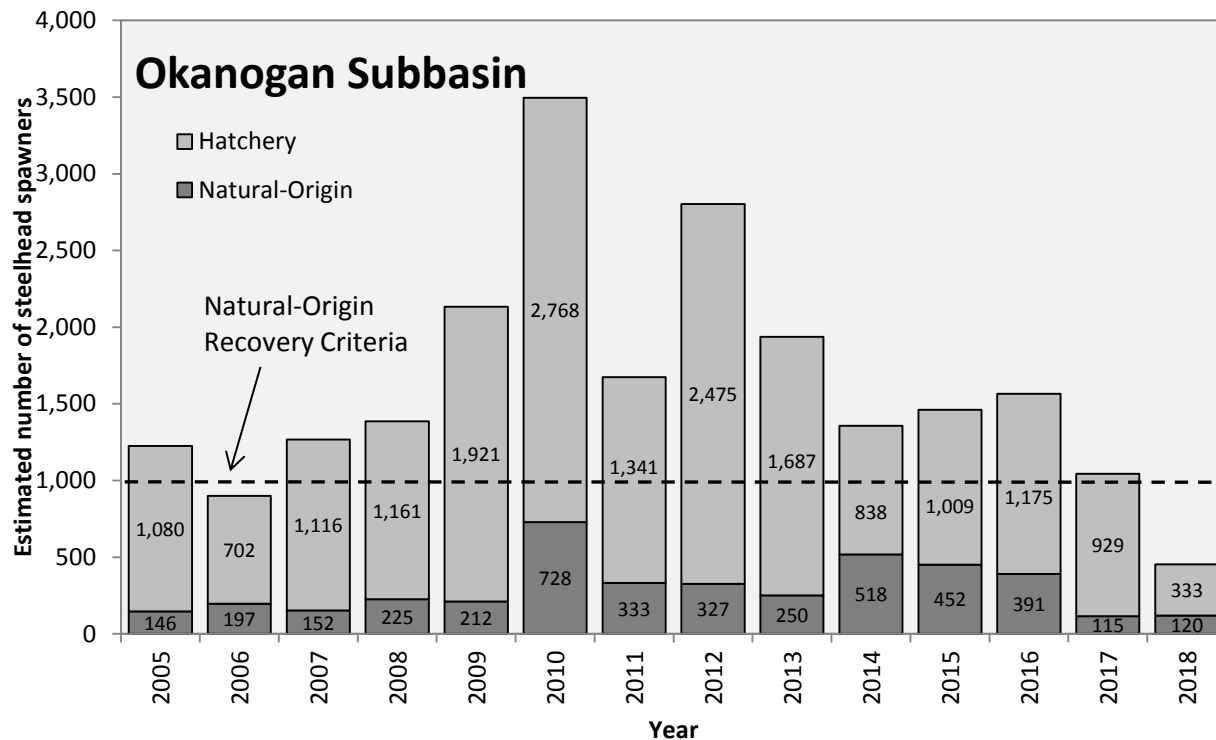


Figure 44. Estimated number of steelhead spawners in the Okanogan subbasin compared with recovery goals.

Results from steelhead adult enumeration efforts indicate that the number of naturally produced spawning steelhead in the Okanogan River subbasin has generally increased since data collection began in 2005. Spawning has been documented throughout the mainstem Okanogan River, although narrowly focused to distinct areas that contained suitable spawning substrates and water velocities. Steelhead spawning has been observed to be most heavily concentrated below Zosel Dam on the Okanogan River and in braided island sections of the lower Similkameen River. It is likely that distribution of spawning is influenced by stocking location because juvenile hatchery steelhead have been released in the Similkameen River, Omak Creek, and Salmon Creek where high volumes of spawners are consistently recorded.

Detailed percent-wild information has been provided annually and every attempt has been made to ensure that these estimates are as accurate as stated methods currently allow. However, these data should be used with caution, as it is difficult to define natal origin through visual observation alone (i.e. intact adipose fin) on redd surveys and underwater video. Values presented in this document represent our best estimate from available information, but the variability surrounding point estimates are currently undefined.

Large variations in estimates exist in many reaches from year to year, but often, these accurately reflect real-world situations rather than survey bias or calculation error. Small creeks may have extremely low flows for two years, blocking access with no spawning occurring, and then experience a large run of fish the following year when sufficient flows exist (e.g. Loup Loup Creek escapement of 0, 0, and 125 for 2008, 2009, and 2010, respectively). This irregular nature of small scale population data frequently results in data being scattered loosely around a linear trend line. We have made every effort to ensure that the reported values are as accurate as possible, including using multiple data collection methods for validation, comprehensive on-the-ground surveys, and best scientific judgment based on extensive local experience with the subbasin.

Annual variations in physical habitat and environmental factors can profoundly impact redd distributions in small tributaries to the Okanogan River. Changes in summer steelhead spawning distribution within tributaries appear to be driven by the following four factors: 1) discharge and elevation of the Okanogan River, 2) discharge of the tributary streams, 3) timing of runoff in relation to run timing of steelhead, and 4) stocking location of hatchery fish. The first three factors are largely based upon natural environmental conditions, which can be altered dramatically by such things as water releases from dams, irrigation withdrawals, and variations in climate. Years such as 2006, 2008, and 2009 clearly show how low tributary discharge can dramatically alter spawning location and reduce the available tributary habitat for steelhead to utilize.

The overall outcome of adult steelhead monitoring in the Okanogan subbasin is to guide natural resource managers' decisions to minimize threats to steelhead, choose restoration actions that will have the most positive impact, and set measurable steelhead enhancement objectives to coincide with fiscal investments over multiple jurisdictions. As monitoring efforts proceed, the Okanogan Basin Monitoring and Evaluation Program expects to continually deliver practical status and trend monitoring data and to make those data useful and readily available for use in more comprehensive, broad-scale analyses.

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