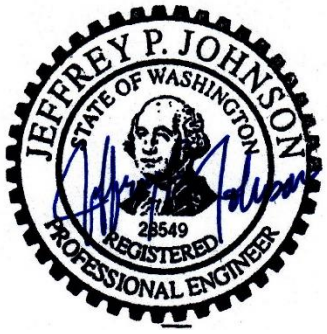
Memorandum

To: Karina Siliverstova, Skagit County Public Works

From: Colin Butler, PE & Jeff Johnson, PE, Watershed Science & Engineering

Date: September 17, 2021

Re: Lake Campbell Outlet Investigation Summary of Findings



INTRODUCTION

Lake Campbell has been experiencing higher than normal lake levels during heavy rain events, causing lakefront properties to experience elevated water levels. It has been speculated that the lake outlet channel does not have adequate capacity to convey large flows from these events, resulting in additional water retention and rising levels in the lake. Skagit County retained Watershed Science & Engineering (WSE) to conduct a site inspection to examine the outlet channel to identify factors that are limiting its capacity. A summary of WSE's investigation and findings is provided below.

PROJECT SITE

Lake Campbell is located on Fidalgo Island approximately three miles south of Anacortes, Washington and two miles northeast of Deception Pass. The lake, which is mostly surrounded by private property and residences, has a surface area of approximately 390 acres and an average elevation of 49 feet. The lake drains through a small outlet stream channel on the south shore that flows 1.1 miles through private property to Skagit Bay (Figure 1).

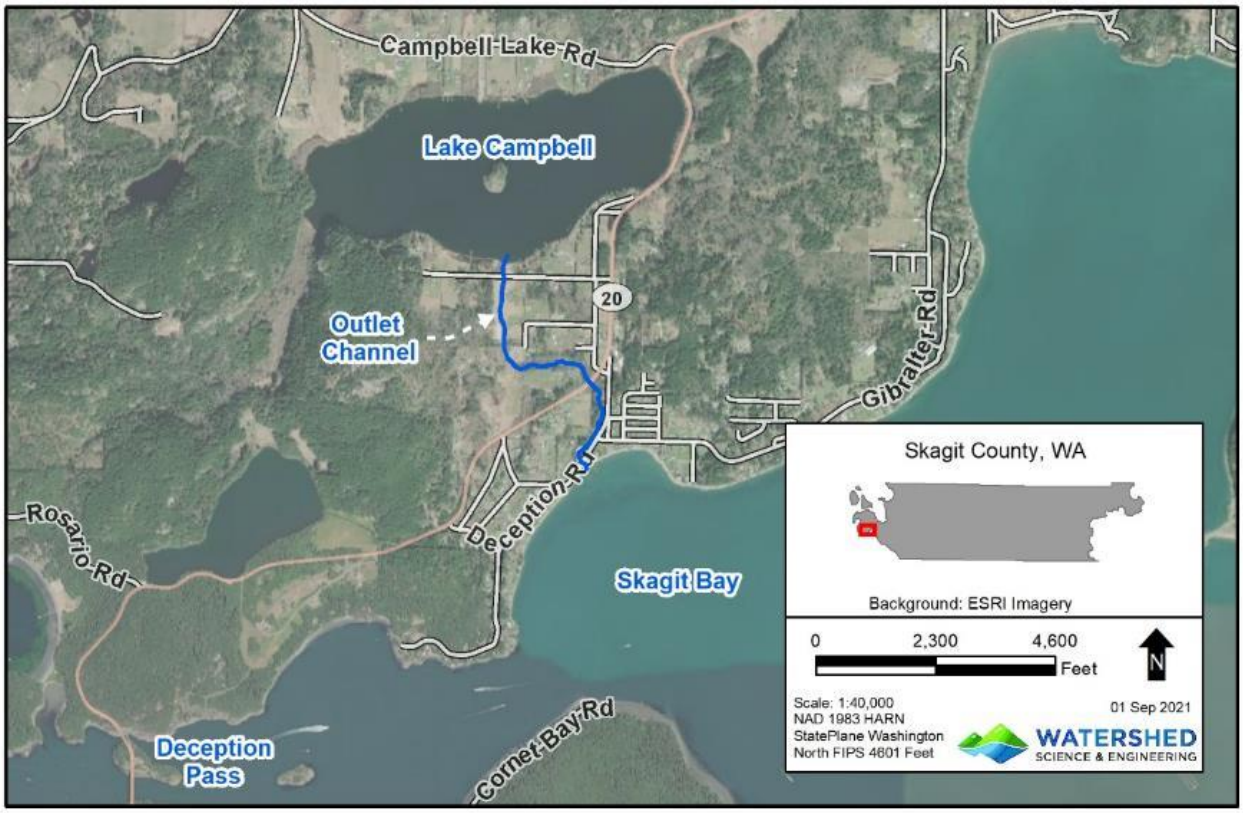


Figure 1 – Project location map showing Lake Campbell, its outlet channel, and the surrounding area

CHANNEL PROFILE

Prior to the site inspection, WSE reviewed the outlet channel profile to identify features that may impact channel conveyance. The profile (Figure 2) was created from the North Puget USGS LiDAR data collected in 2016, which was the best available elevation data for this area. The profile reveals that the reach between Lake Campbell and Buttram Lane has a relatively flat slope and therefore may have reduced capacity due to factors such as surface roughness and channel blockage, so WSE focused the investigation on this reach. Downstream from Buttram Lane, the channel slope steepens which increases conveyance and reduces backwater impacts. As a result, WSE determined that the reach below Buttram Lane was likely not contributing to increased water levels at Lake Campbell.

The reach between the lake and Buttram Lane contains a beaver dam and two private driveway crossings. The two driveways have relatively small culverts according to County records (WSE did not examine the culverts due to property access limitations), but the roadway crests are low based on LiDAR elevations and easily overtopped during floods as confirmed by County photos. This likely limits the impact the driveways and their culverts have on upstream water levels. Buttram Lane is elevated on a high fill which does not overtop and could contribute to increased lake levels, but a 7-foot diameter culvert was installed in 2006 to reduce upstream flooding and accommodate fish passage (see Figure 3). The large capacity of the culvert indicates that Buttram Lane is likely not contributing significantly to increased water levels at Lake Campbell.

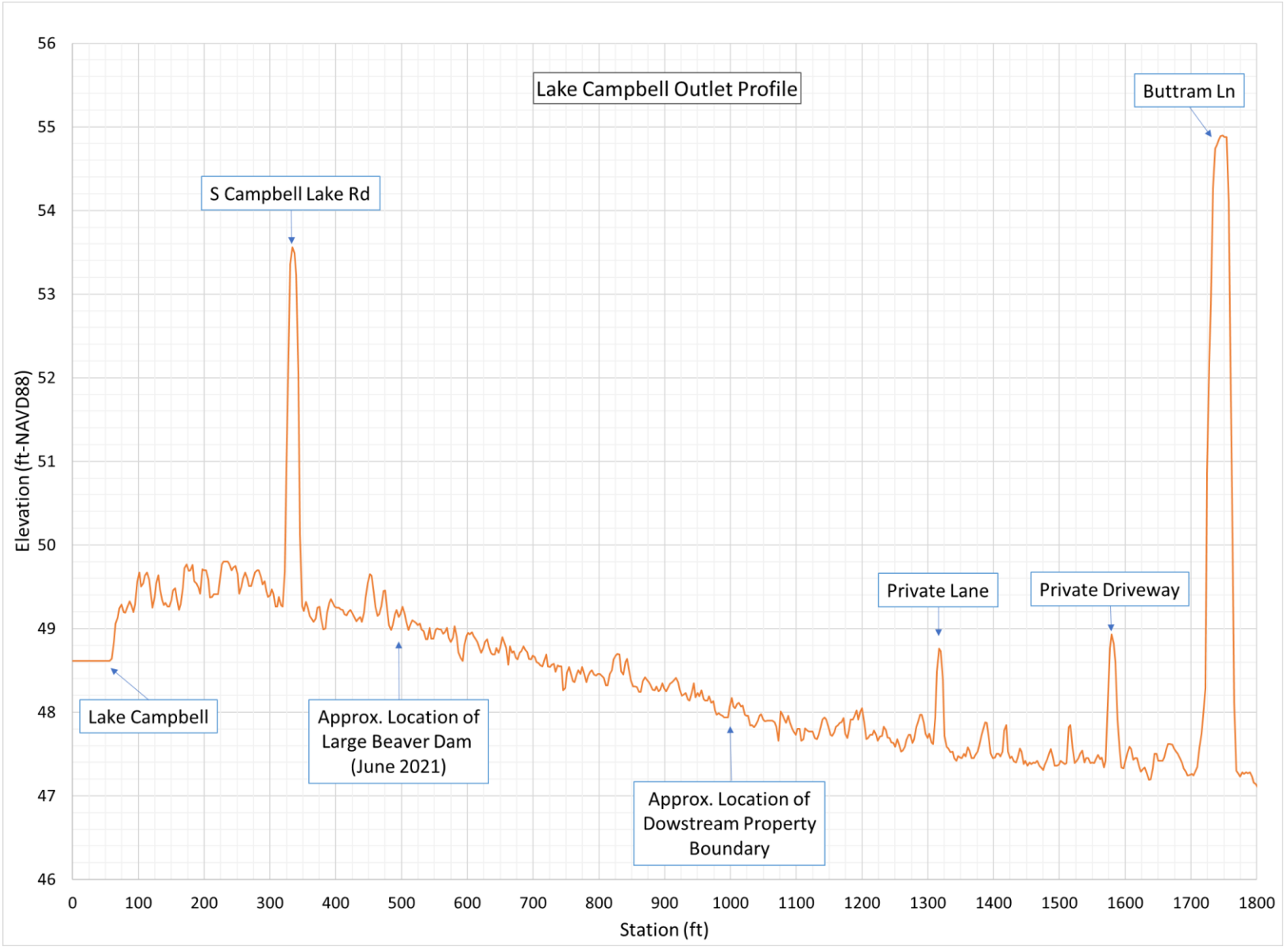


Figure 2 – Longitudinal profile of Lake Campbell outlet with key locations identified (Based on 2016 LiDAR)

Figure 3 – Post-construction photos for 7-foot diameter culvert replacement under Buttram Lane (2006)

SITE INSPECTION

On June 17, 2021, WSE personnel met with County staff and the owner of the large parcel located just downstream of South Campbell Lake Road. The landowner described the history of channel maintenance, beaver activity, and observed water levels during recent highwater events. He mentioned that his father-in-law, who owned the property before him, used to run cattle on the parcel that would eat most of the vegetation, effectively maintaining an open channel downstream of South Campbell Lake Road. He also mentioned that his father-in-law had dredged a section of the channel to create a narrow pond just downstream from the road to provide drinking water for the cattle. This narrow pond exists today.

During the site inspection, WSE examined the following channel features to determine whether they likely impact channel conveyance and therefore upstream lake levels:

- Outlet channel between Lake Campbell and South Campbell Lake Road bridge
- Carp screen upstream from the bridge
- Beaver activity in the vicinity of the carp screen
- Waterway capacity underneath the bridge
- Channel downstream of the bridge
- Beaver dam downstream of the bridge
- Heavily vegetated channel between the beaver dam and the adjacent property boundary to the south (i.e., downstream)

To examine areas and features not easily accessible on the ground, WSE used a drone to capture images and videos of the channel from Lake Campbell to the southern boundary of the adjacent property with a focus on the key hydraulic features described above.

SITE OBSERVATIONS

Based on information collected during the site inspection, WSE determined that there is no single cause of increased water levels within Lake Campbell. Instead, it appears that a combination of multiple factors is likely responsible for the increased lake levels. However, we do not have enough information to determine if any one factor is contributing more than the others. Based upon our observations, we believe all of the following features (ordered from upstream to downstream) are likely contributing to the lack of conveyance capacity within the outlet channel:

- Carp screen upstream of the South Lake Campbell Road bridge combined with mud and debris that beavers had packed along the upstream side of the screen prior to the County's relocation of the screen
- Beaver dam located approximately 150 feet downstream from the bridge
- Dense vegetation in the channel downstream from of the beaver dam

The features are identified in Figure 4, and their effects on channel capacity are described below. The highwater photos used to describe the effects were provided by the County.

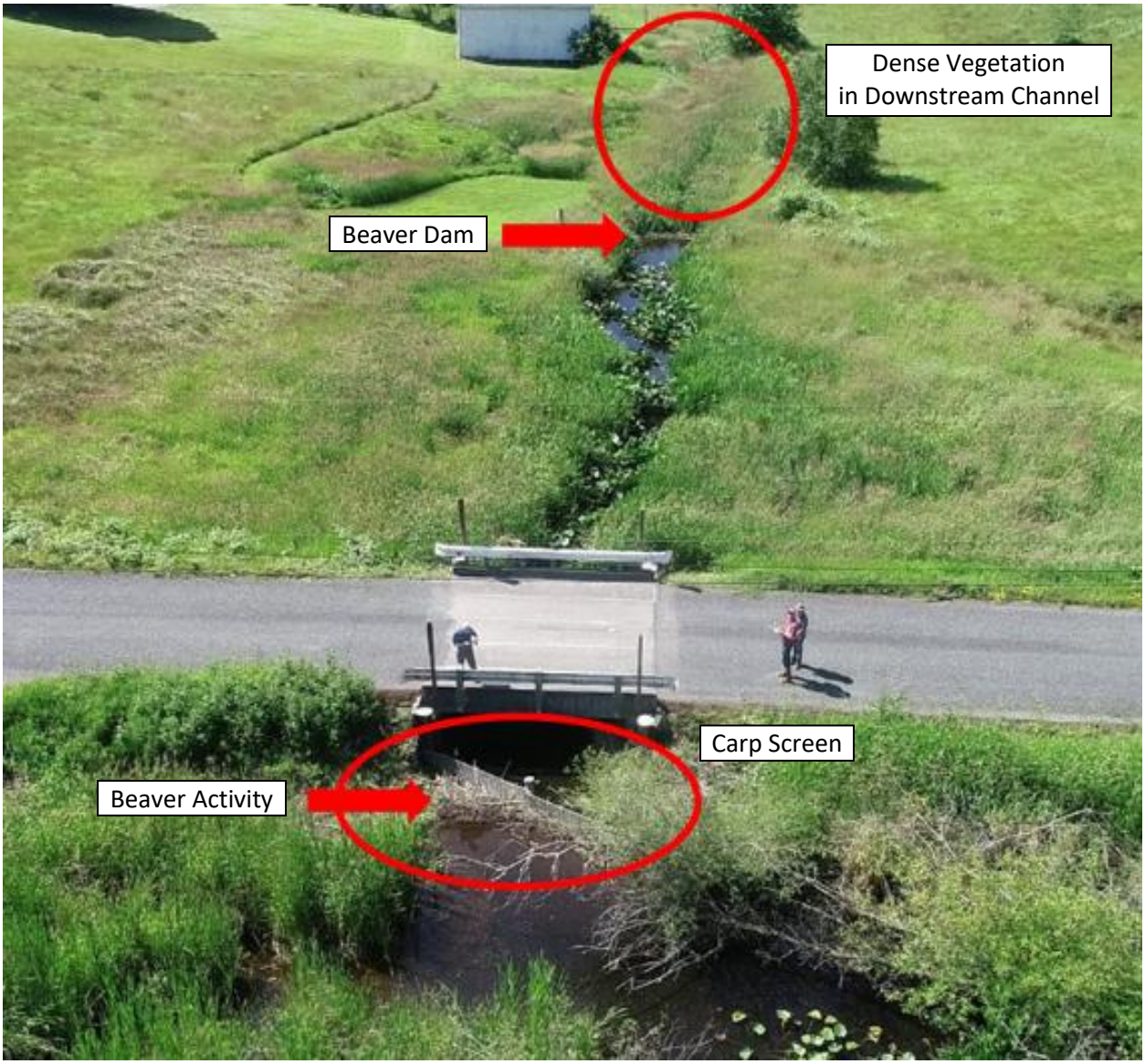


Figure 4 – Features likely affecting outlet channel capacity and therefore lake levels (Photo taken June 17, 2021)

Photo 1 – Carp Screen during low flow (June 17, 2021)

Photo 2 – Carp screen during highwater (Jan. 25, 2020)

Photo 1 show the carp screen during low flow with mud and debris packed along the upstream side as a result of beaver activity. Photo 2 reveals that during the January 2020 highwater event, the drop in water surface elevation across the screen was only a few inches. This suggests that the screen and beaver activity on the screen have some influence on lake levels at this flow, but it is important to note that water levels in the channel downstream would still be high even without the screen and beaver activity. If the screen and associated beaver activity were the sole features responsible, we would expect to see lower water levels in the downstream channel and a much larger drop in the water surface over the screen. Therefore, the carp screen and associated beaver activity are not the only factors affecting lake levels; additional downstream factors are also responsible.

Photo 3 – Carp screen during highwater (Jan. 5, 2021

Photo 4 – Downstream channel (Jan. 5, 2021)

Photo 3 shows the carp screen during a highwater event that occurred on January 5, 2021. There is almost no drop in the water surface over the carp screen during this event. Photo 4 shows the channel downstream from the road during the same event. Ripples on the water surface in the photo indicate that the water levels are high enough for water to actively flow over the submerged downstream beaver dam. However, the capacity of the channel is significantly impacted by the beaver dam and the thick vegetation in the channel. This evidence indicates that the channel downstream from the carp screen is having a significant influence on lake levels.

Photo 5 – Downstream channel on June 17, 2021 (Photographer oriented looking downstream)

Photo 6 – Downstream channel during highwater on Jan. 25, 2021 (Same orientation as Photo 5)

These photos show that vegetation is more dense during the summer (Photo 5) than during the previous winter (Photo 6). The channel remained fairly open at higher water levels during the January 25, 2020 event as shown in Photo 6. This section of the channel was dredged years ago by the landowner's father-in-law. As a result, it is wider and deeper than the channel further downstream, and the vegetation has not yet regrown to the extent that it has further downstream. The water in Photo 6 does not show obvious signs of movement, likely due to the beaver dam at the downstream end of this reach and a more densely vegetated channel below this reach.

Photo 7 – Shallow flooding over private driveway upstream of Buttram Lane (February 2020)

Photo 7 shows water overtopping one of the private driveway crossings upstream of Buttram Lane during a highwater event in February 2020. This driveway may have some influence on upstream water levels as was alluded to in the Channel Profile discussion, but we can't determine the magnitude of its impact without additional data.

RECOMMENDATIONS

While the qualitative descriptions and opinions provided above are insightful, these findings would be more thoroughly supported and confirmed by additional quantitative hydraulic data. Therefore, WSE recommends installing water level recording gages at the six locations identified in Figure 5 and described below:

- Immediately upstream of the carp screen to estimate lake levels (one gage)
- Immediately downstream of the bridge to measure changes across the carp screen and water levels under the bridge (one gage)
- Immediately upstream and downstream of the beaver dam downstream from South Campbell Lake Road to measure changes across the dam (two gages)
- At the downstream property boundary of the parcel immediately downstream from the road. This gage will help to evaluate the effects of the densely vegetated channel (one gage)
- In the channel just upstream of Buttram Lane (pending property access) to evaluate the effects of the full reach on water levels (one gage)

The gages should be installed prior to the upcoming winter flood season (i.e., fall 2021) and remain in place through spring 2022. The County should visit the site several times during periods of heavy rain and elevated lake levels to take photographs of the outlet channel in the vicinity of the gages, making sure to record the date and time of each visit. These photographs and the water surface elevations should be reviewed together after the gaging period to identify which feature(s)/factor(s) have the largest impact on water levels and channel conveyance. This information can then be used along with additional hydraulic analyses to identify potential solutions which are likely to include some combination of the following:

- Beaver dam removal and/or management
- Channel restoration and/or vegetation management
- Carp screen relocation and/or modification

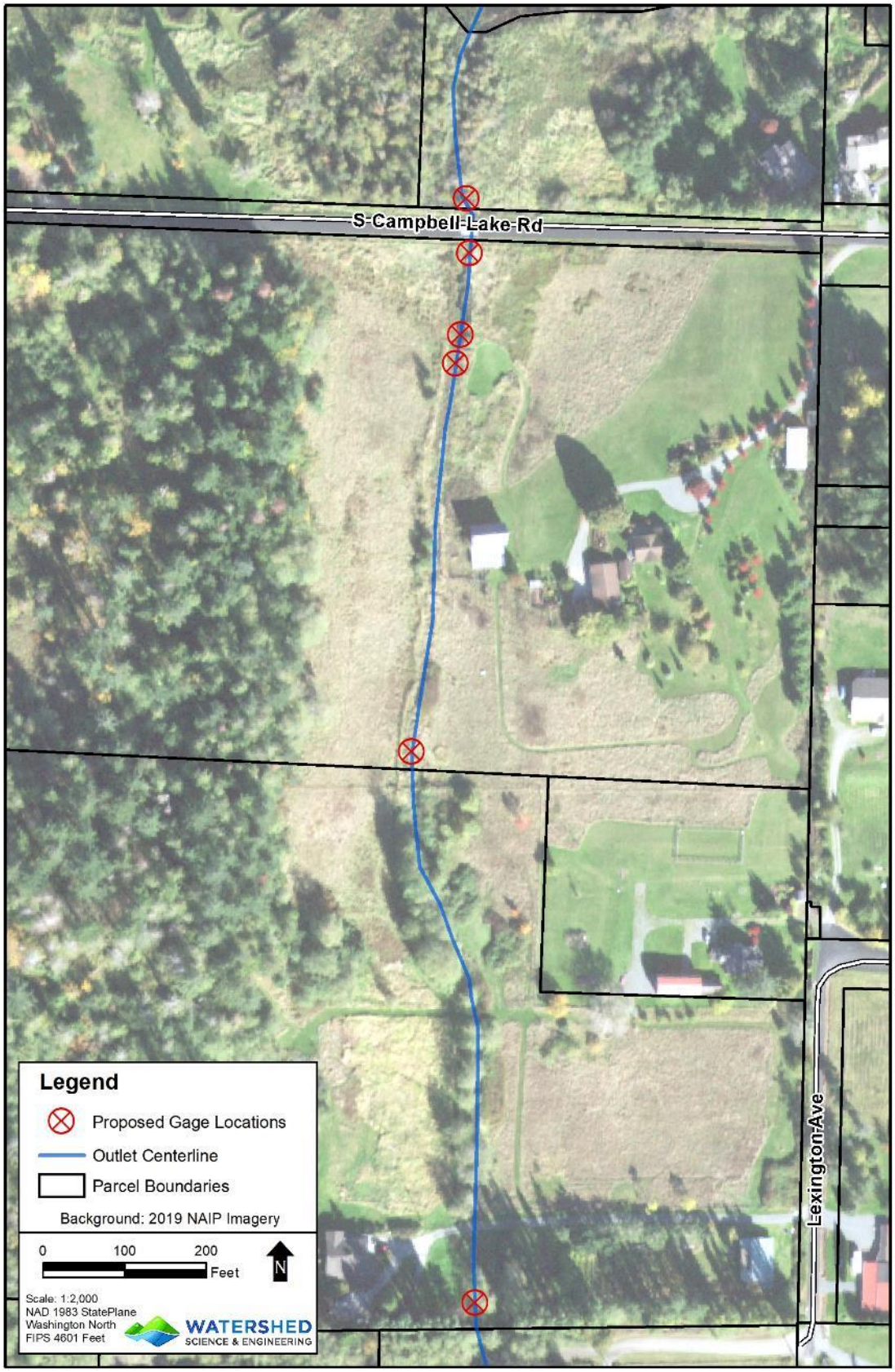


Figure 5 – Proposed gage locations along Lake Campbell outlet channel