TECHNICAL MEMORANDUM

To: Kristen Homel – Oregon Department of Fish and Wildlife

From: Joe Parzych, Mike McAllister, P.E., Josh Epstein - Inter-Fluve

Date: July 10, 2019

Re: Sandy River Delta Chum Project: Sundial Island Feasibility Assessment

Sundial Island, Sandy River Delta, OR

1. Introduction

Inter-Fluve is assisting the Oregon Department of Fish to assess the potential of Sundial Island for supporting a Chum Salmon spawning channel. Sundial Island is located at the mouth of the Sandy River at the confluence with the Columbia River in Multnomah County, Oregon. This memorandum summarizes an assessment of key questions regarding the relationship between seasonal groundwater hydrology and the Columbia River stage that determine the feasibility of a successful Chum Salmon spawning channel on Sundial Island. This memo draws from data collected at the site, which are summarized in greater detail in the accompanying Year 1 and Year 2 monitoring memos.

2. Hydrology background

Surface water and groundwater dynamics were assessed at Sundial Island to assess the expected performance of potential spawning channels. Water level loggers were deployed from 2016-2018, and USGS gage data is available at Vancouver from 1999 to present (USGS #14144700).

2.1 SURFACE WATER

Hydrology at Sundial Island is driven by the Columbia River and Sandy River. The proposed spawning channels outlet into the Columbia River, therefore surface-water fluctuations within these channels would be most heavily impacted by Columbia River stage. A long-term data set was developed for the project site by correlating the USGS gage data to the dataset developed for S1 water level logger and survey data, located Sundial Island (Figure 1).

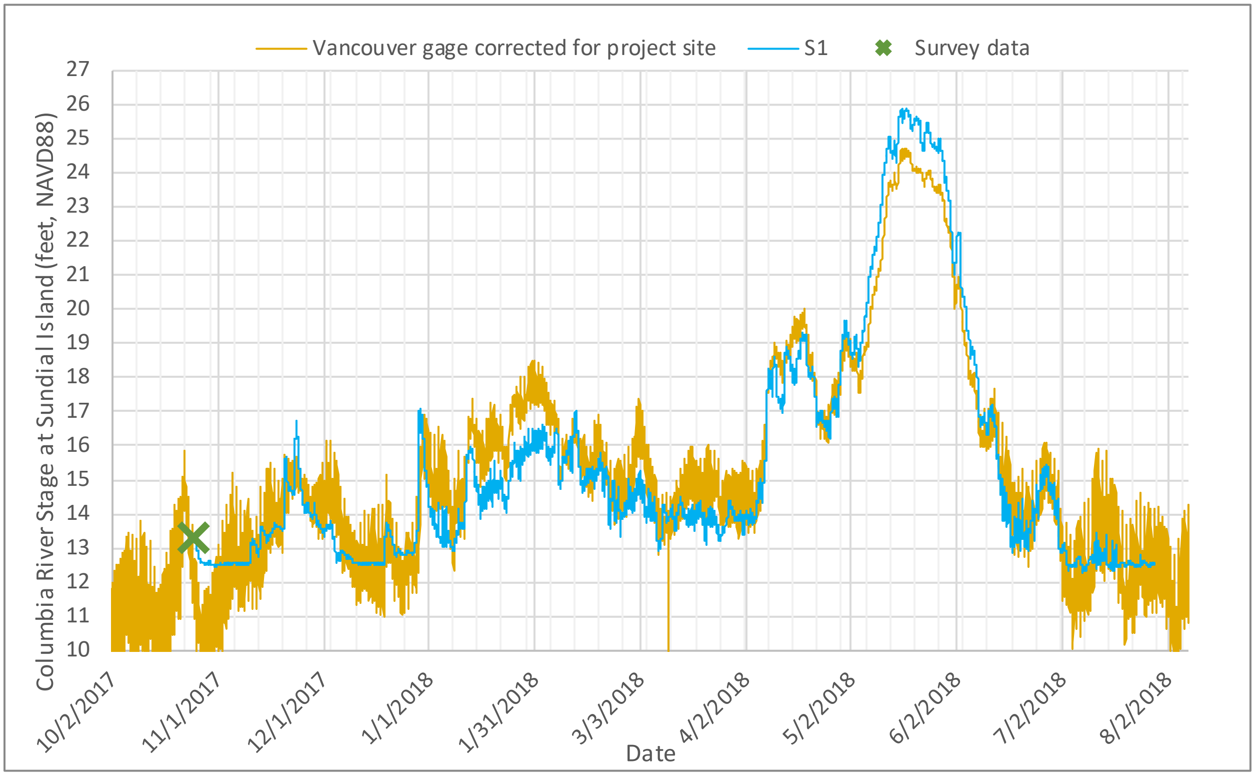

Figure 1. Columbia River stage at Sundial Island corrected from Vancouver gage by adding 1.5 feet to match survey data and hobo-recorded stages.

This long-term data set was then used to calculated mean, 10%, and 90% exceedance stages for the Columbia River at the project site during the period of interest relevant to Chum Salmon spawning and incubation (November through March) (Figure 2).

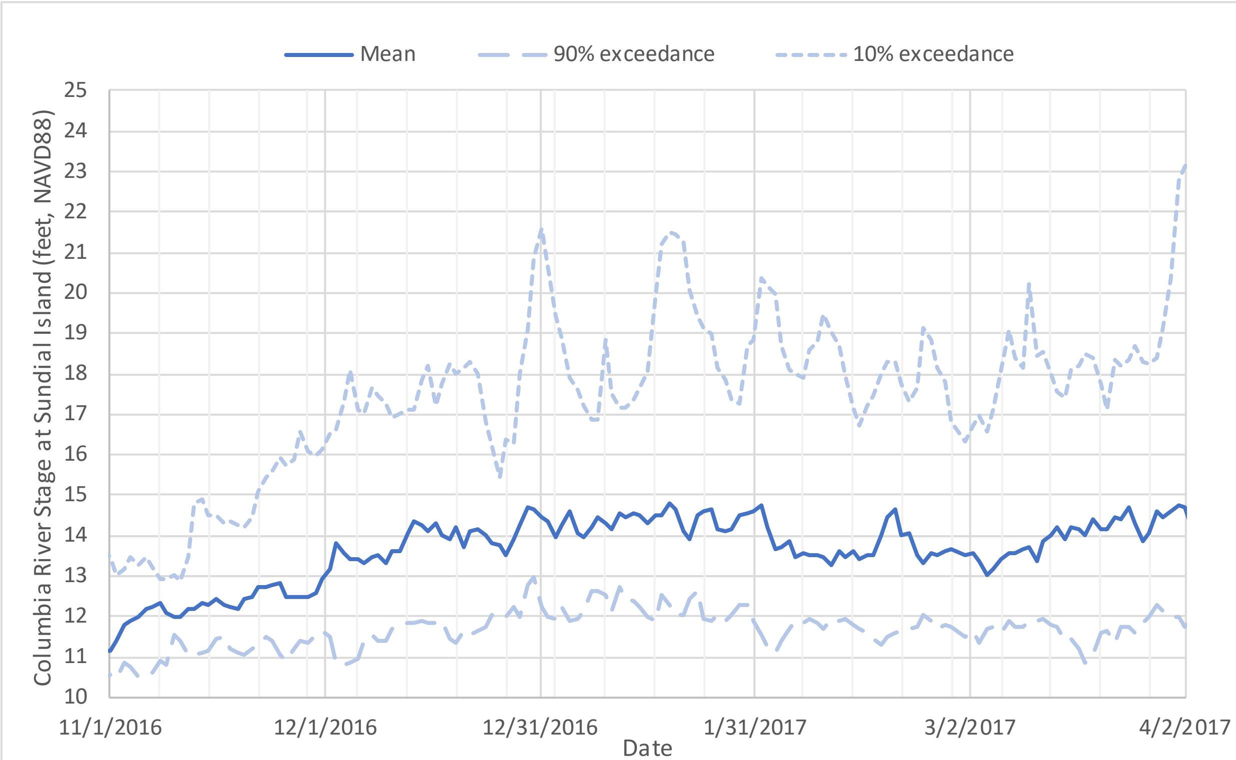

Figure 2. Exceedance stages at Sundial Island corrected from the Vancouver gage by adding 1.5 feet to match survey data and hobo-recorded stages.

Finally, a percent-exceedance curve was calculated for the period of interest (Figure 3).

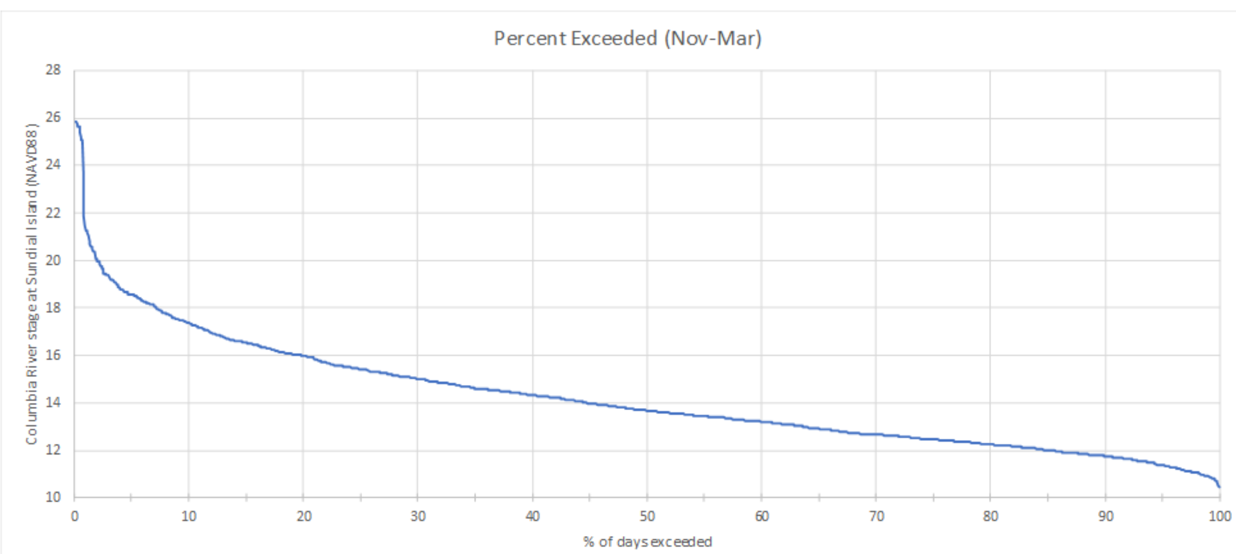

Figure 3. Percent exceedance curve for the Columbia River at Sundial Island, calculated from November through March.

2.2 GROUNDWATER

Groundwater dynamics were assessed to identify the groundwater table elevation, seasonal fluctuations, and slope beneath Sundial Island. Groundwater elevations recorded at the groundwater observation tubes ranged from 12.0 to 27.0 feet, with typical ranges from 13.0 to 16.0 feet. Groundwater table slopes at Sundial Island are greatest in the north-south direction, as the gradient is primarily driven by the stage difference between the Sandy River and Columbia River. Groundwater slopes in the north-south direction were typically between 0.02% and 0.05% (Figure 4). A slope of 0.05% was used in the channel design scenarios discussed in the following sections.

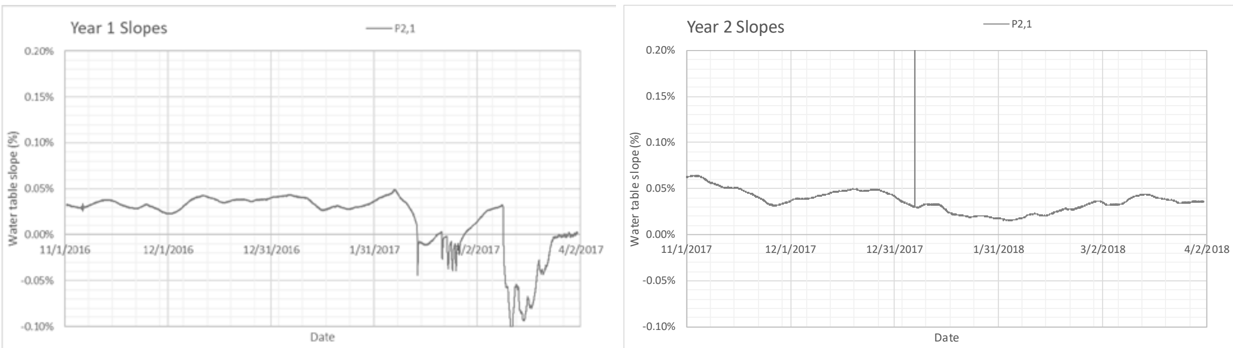

Figure 4. Groundwater table slopes recorded during the period of interest between P2 and P1.

3. Channel design

3.1 CHANNEL ALIGNMENTS

Potential channel alignments were mapped in GIS based on our understanding of the site in areas where groundwater slope was expected to be relatively high, risk of deposition at the mouth was low, and where channels were unlikely to interfere with the BPA power corridor (Figure 5). Channel lengths range from 2,800 feet to 4,500 feet.

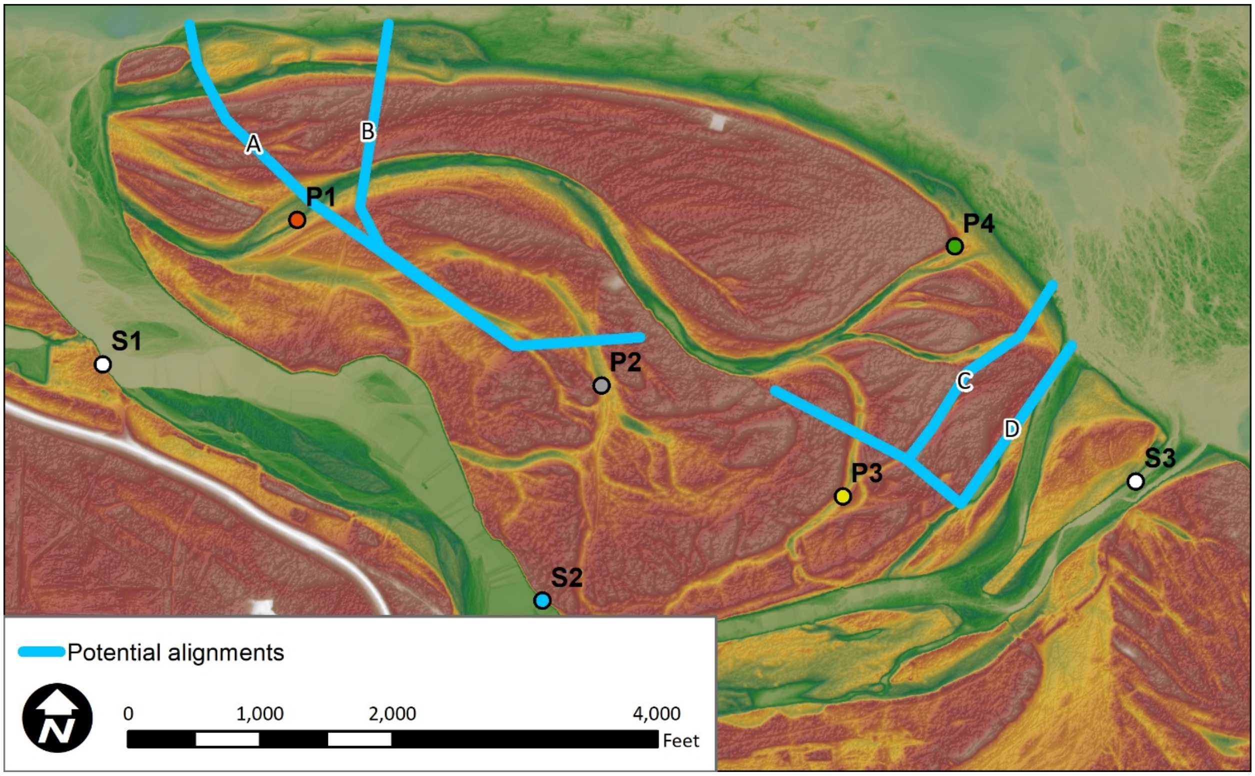

Figure 5. Potential channel alignments drawn in GIS for the project area, background is color-coded LiDAR.

3.2 DESIGN CRITERIA

Engineering design criteria were developed to define features of the spawning channels. These criteria include the following and are graphically depicted in Figure 6.

1. **Channel outlet elevation**: Set such that the outlet is backwatered often (to allow adult fish to enter), but the entire channel is not entirely backwatered frequently (which would promote sediment deposition and may impede spawning and incubation).
2. **Channel bed elevation**: Set below the groundwater table elevation so the constructed channel is gaining groundwater, rather than losing surface water to groundwater.
3. **Channel slope**: Set equal to or less than the groundwater table slope so the channel is gaining groundwater. Slopes of open channels and pipes should be greater than or equal to 0.2% to allow for sand transport.

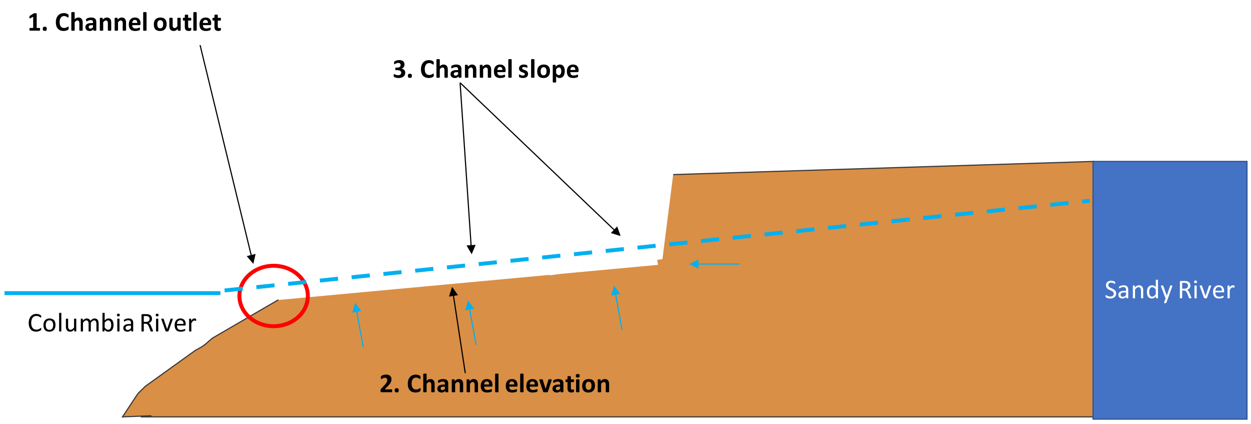

Figure 6. Open channel schematic showing the three primary defining parameters.

Biological design criteria are not explicitly included in this assessment, and would be used during future design phases after additional data are collected at the site to support design development. These criteria would be used to optimize designs for depth, velocity, substrate, and discharge targets needed to facilitate Chum Salmon spawning and incubation.

3.1 PARAMETERIZING DESIGN CRITERIA

Hydrology data for the site were used to set the channel outlet elevation to maximize outlet backwatering and minimize the amount of time the entire channel is backwatered. The elevation of the upstream end of the channel is defined by the outlet elevation, channel slope, and channel length. Given the channel lengths in Figure 5, and the assumption that the channel slope equals the groundwater table slope (0.05%), the change in elevation throughout the channels would range from 1.4 to 2.25 feet.

Potential backwatering of different spawning channels types was investigated assuming a scenario where channel length is 4,000 feet, vertical drop is 2.0 feet (0.05% x 4,000 feet), and the outlet is set at elevation 12.0 feet. By plotting the elevations of the channel outlet (downstream end) and the upstream extent of the channel on the exceedance plot, rates of backwatering become apparent (Figure 7).

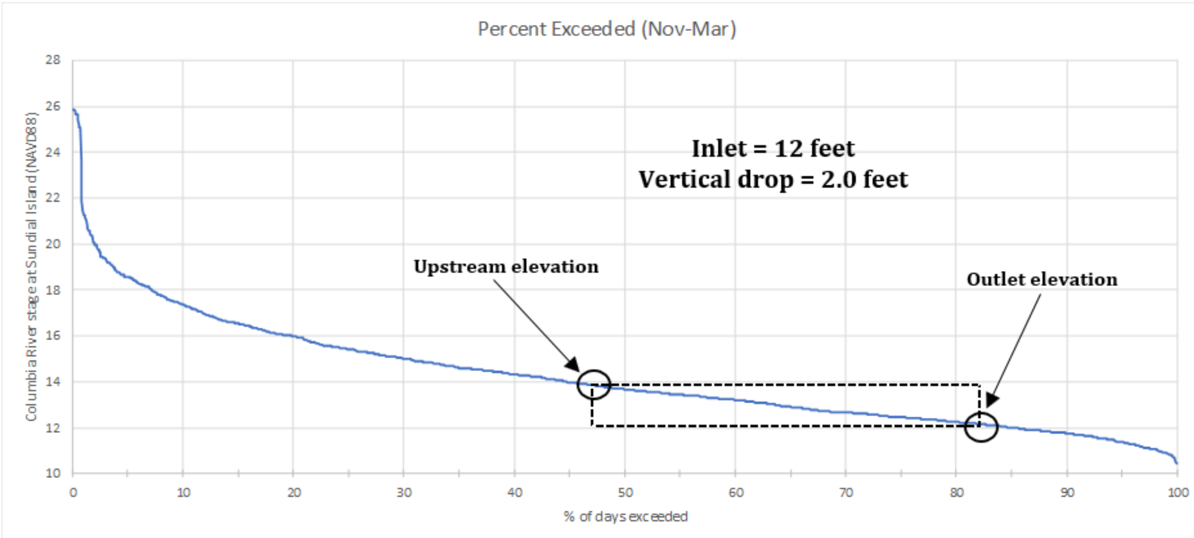

Figure 7. Exceedance plot with a potential channel design scenario plotted.

In this example, the outlet is backwatered 83% of the time by the Columbia River, and the entire channel is backwatered 47% of the time. Adult fish could access the channel 83% of the time from November through March, however the entire channel would be backwatered 47% of the time, which may promote sediment deposition within the channel or interfere with spawning or incubating. The channel in this example would be flowing (to provide aeration for incubating eggs and flow for spawning) for at least a portion of its length, with the outlet backwatered (for fish access), 36% of the time. A channel inlet elevation of 12.0 feet (NAVD88) provides this favorable condition more frequently than other elevations analyzed (13, 14, and 15 feet), and was therefore used in the channel design scenario. The following parameters were used to assess the feasibility of channels in the following section:

1. **Channel outlet elevation**: 12.0 feet
2. **Channel bed elevation**: 12.0 feet to 14.0 feet
3. **Channel slope**: 0.05%

4. Feasibility assessment

Using parameters derived in previous sections, three different channel types were analyzed for feasibility at Sundial Island, 1) open channel, 2) groundwater gallery-fed channel, and 3) surface water-fed channel. For each channel, there is a description of the design, followed by the limitations of that design within the context of Sundial Island.

4.1 OPEN CHANNEL

4.1.1 Description of design

An open channel that relies on groundwater inflow without any surface water or groundwater supplementation was assessed. This design consists of a channel excavated in Sundial Island that is fed by groundwater flow into open channel throughout the length of the channel (Figure 8). Water entering the channel is relatively sediment-free, however the mouth of the channel is susceptible to deposition from the Columbia River.

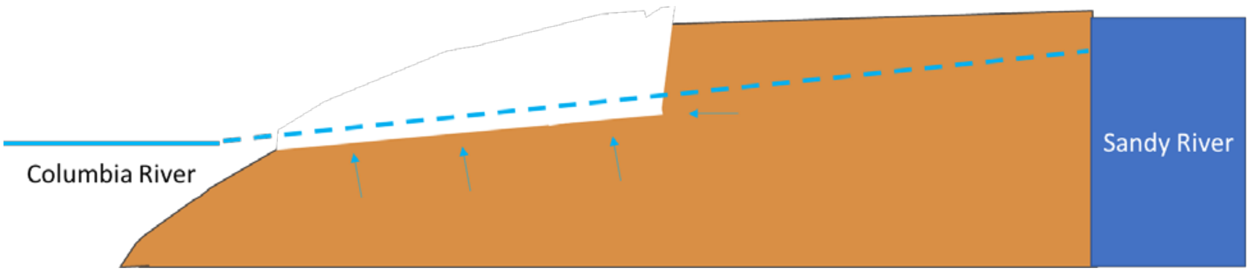

Figure 8. Open channel design schematic.

4.1.2 Limitations of design

The open channel is not feasible at the site as it has a low gradient, is likely accumulate sediment in the channel and lacks of sufficient sediment transport capacity to allow the channel to self-maintain, likely requiring frequent maintenance activities. Over time, backwatering from the Columbia River would deposit fine sediment in the channel, and most sediment would be expected to deposit near the mouth of the channel. A sand bar at the channel mouth would backwater the channel, and after groundwater elevations exceed the sandbar elevation, water would pour over the sandbar and re-carve the channel through the blockage. In the event that a sandbar formed that entirely backwaters the channel, groundwater would be unable to accumulate enough to pour over the sandbar, and maintenance would be required to remove the blockage. Because the vertical drop in the example channel is only 2 feet, a sandbar equal to this height would be sufficient to completely backwater the channel and require maintenance to fix (Figure 9).

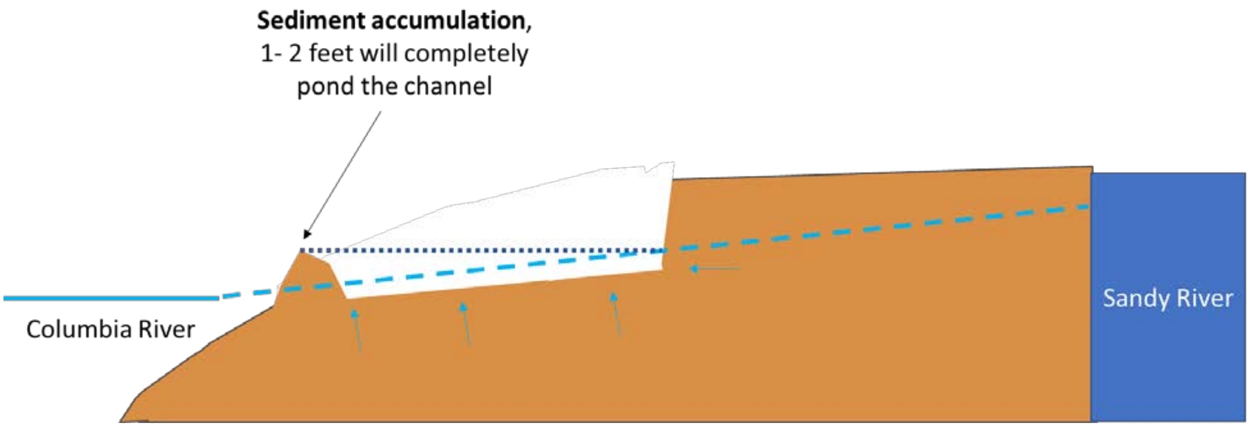

Figure 9. Open channel design schematic, showing potential limitations in the context of Sundial Island.

4.2 GROUNDWATER GALLERY

4.2.1 Description of design

The second channel design assessed is similar to the open channel described in 4.1.1 with the addition of a groundwater gallery system to supplement flow (Figure 10). From the head of the open channel, a groundwater gallery pipe is then installed upstream of the channel to collect groundwater in a perforated pipe, which is then transported into the channel using a conveyance pipe. Water entering the channel is relatively sediment-free, however the mouth of the channel is susceptible to deposition from the Columbia River, similar to the open channel. The gallery pipe and conveyance pipe should have slopes of 0.2% or higher to transport any sand through the pipe and into the channel.

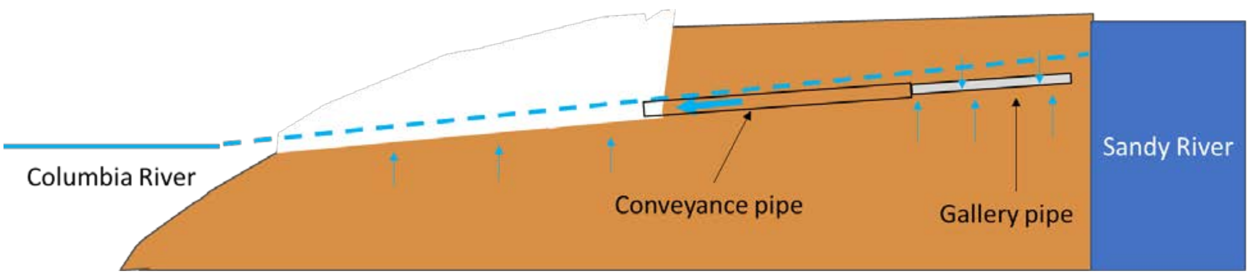

Figure 10. Groundwater gallery design schematic.

When groundwater is routed into the gallery pipe, a drawdown effect occurs where the groundwater table dips in elevation around the pipe (Figure 11). Drawdown can be assessed through pump tests, and for purposes of this assessment a conservative drawdown of 4.0 feet is assumed, adding a 2.0-foot factor of safety to allow the channel to be operational during low water or in the event that drawdown is higher than expected. The diameter of the pipe is also factored in at 1.5 feet. This results in a groundwater gallery pipe that is set 7.5 feet below the groundwater table, and requires a 0.2% slope to transport sand.

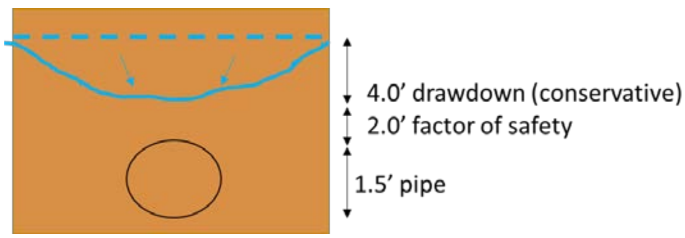

Figure 11. Groundwater gallery pipe cross section view showing drawdown effect.

4.2.2 Limitations of design

The channel with groundwater gallery flow supplementation system is not feasible at the site due to the requirements of the groundwater gallery pipe, sedimentation concerns, and construction feasibility in sandy soils. Because the groundwater gallery pipe would be set 7.5 feet below the groundwater elevation, and the change in elevation of the channel is 2.0 feet from the upstream end to the outlet, the groundwater gallery pipe elevation at the termination of the conveyance pipe would be lower than the channel outlet bed elevation (Figure 12).

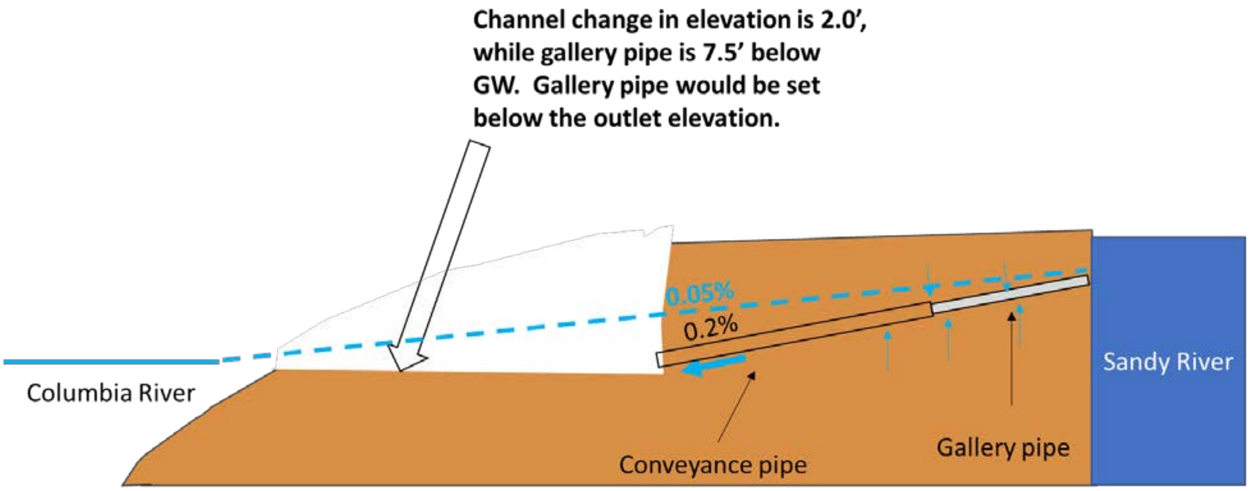

Figure 12. Groundwater gallery design schematic, showing potential limitations in the context of Sundial Island.

Installing a gallery pipe at Sundial Island would require excavating roughly 7.5 feet below the low groundwater elevation. This would require excavating over 20 vertical feet in some areas, 7.5 of which would be below groundwater. These excavation depths would come with significant challenges related to trench side-slope stability, which could require temporary shoring systems that could significantly increase construction costs and ground disturbance.

4.3 SURFACE WATER-FED CHANNEL

4.3.1 Description of design

The third design consists of an open channel excavated in Sundial Island with flow supplemented by surface water conveyed through a pipe from the Sandy River upstream. Water entering the channel would contain suspended sediment from the Sandy River, and the mouth of the channel would be susceptible to deposition from the Columbia River. Similar to the groundwater gallery pipe, the surface water conveyance pipe should have slopes of 0.2% or higher to transport any sand through the pipe and into the channel.

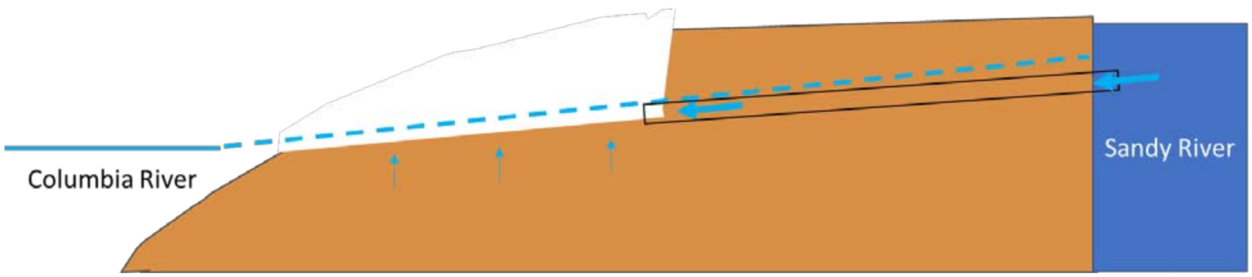

Figure 13. Surface water-fed channel design schematic.

4.3.2 Limitations of design

This channel is not feasible at the site due to sedimentation concerns within the pipe and channel, from both the Sandy River and Columbia River (Figure 14). Sandy River surface water elevations are generally similar to groundwater elevations measured nearby, therefore achieving a 0.2% slope within the conveyance pipe is not possible without setting the pipe lower than the channel in elevation. As sedimentation would come from the Columbia and Sandy Rivers, we would expect sedimentation issues throughout the channel that would likely need to be addressed with frequent maintenance.

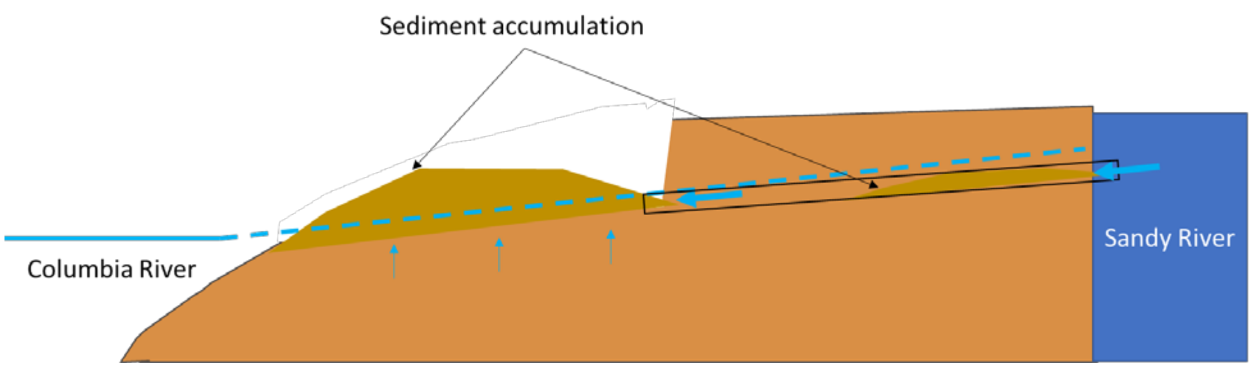

Figure 14. Surface water fed channel design schematic, showing potential limitations in the context of Sundial Island.

5. Conclusions

Surface and groundwater dynamics were assessed at Sundial Island using gage-recorded data and empirically collected water level logger data to assess the feasibility of constructing a Chum Salmon spawning channel on Sundial Island. The flat groundwater gradient through Sundial Island means that changes in elevation within proposed channels are small relative to the larger stage fluctuations of the Columbia River. Therefore, proposed channels that allow fish access (outlet is backwatered) while providing positive velocities through the channel (the entire channel is not backwatered) meet those criteria less than half of the time during the Chum Salmon spawning and egg incubation period.

Engineering feasibility of three channel design scenarios were assessed at Sundial Island, an open channel, groundwater-fed channel, and surface water-fed channel. Each of these channels were determined to be not feasible due to factors arising from the low channel slopes. Groundwater gradient is relatively flat, and sedimentation of constructed channels is expected to occur, requiring frequent maintenance to remove channel blockages.

Inter-Fluve does not recommend continueing to allocate resources to design of a Chum channel on Sundial Island due to the fundamental challenges associated with the low gradient of island. We would advise that ODFW explore other areas of the mainland side of the Sandy Delta where groundwater gradients have the potential to be higher and support the development of a Chum spawning channel.