RDG
RIVER DESIGN GROUP

Technical Memorandum

Hayden Creek Alternatives

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SUBJECT: Hayden Creek and KR-222 Diversion Concept Alternatives

1. Introduction and Objectives

River Design Group, Inc. (RDG) was retained by PacifiCorp via Meridian Environmental, Inc. to develop design concepts to address issues associated with the KR-222 irrigation diversion and to improve stream conditions on Hayden Creek, a tributary to the Klamath River. The KR-222 diversion weir diverts flow from the mainstem Klamath River into a river-right (north) ditch, which intersects two branches of Hayden Creek (East and West Hayden Creek) as the ditch conveys flow parallel to the Klamath River to irrigate PacifiCorp property south of the diversion intake (Figure 1-1). The KR-222 diversion supports a 1.82 cfs PacifiCorp water right, and irrigation and return flows are managed at two poorly functioning control points.

The upstream control point (KR-222-US) is located approximately 700 ft down-ditch from the rock weir and 300 ft upstream of the intersection between the ditch and East Hayden Creek. KR-222-US consists of a leaking headgate and culvert, which releases flow down the ditch year-round even when a plywood gate is in position at the culvert inlet. Return flow function at KR-222-US is impaired as wildfire felled a large tree onto the diversion. The ditch captures all the flow from East Hayden Creek, and a berm prevents flow from entering the historical downstream pathway of East Hayden Creek to the Klamath River. The downstream control point (KR-222-DS) is located at the ditch-West Hayden Creek confluence, which is approximately 200 ft downstream from the ditch-East Hayden Creek confluence. KR-222-DS is managed by placement of a tarp to route flow down the ditch or down West Hayden Creek to the Klamath River. Ditch water preferentially flows down West Hayden Creek when the tarp is not in use. The confluence between the ditch and West Hayden Creek is degraded and poorly defined.

This technical memorandum describes the concept-level design alternatives that target two main issues with the KR-222 diversion. First, the upstream control point, KR-222-US, is damaged and leaking, which releases flow in excess of the 1.82 cfs water right into the ditch year-round. Second, the KR-222 ditch captures all of the flow from Hayden Creek. The goal of the project is to rehabilitate the KR-222 diversion and separate the Hayden Creek channel network from the irrigation system.

Figure 1-1. Hayden Creek project area. Project area features include ditch and return flow channels (white lines), East and West Hayden Creeks (black lines), historical East Hayden Creek (black dashed line), the bedrock rapid crest (gray line), and the KR-222 controls points (red circles). Feature locations are approximate. Imagery from Google Earth.

2. Alternatives Analysis

In this section, we evaluate concept-level design alternatives for Hayden Creek and the KR-222 diversion and provide justification for the selected alternative. The primary objectives of the design are successful separation of the KR-222 diversion ditch from the two branches of Hayden Creek, addressing the leaking upstream control point, KR-222-US, and preserving the water right. Additional alternatives evaluation criteria include fish passage in Hayden Creek, disturbance footprint and amount of earth work, operation and maintenance requirements, stability, and cost.

The selected alternative achieves project objectives by piping the KR-222 ditch above Hayden Creek. More detail on the selected alternative is provided in the accompanying "Hayden Creek Restoration Concepts" design drawings (2022.01.12 draft). Other alternatives evaluated include piping or siphoning ditch flow beneath Hayden Creek and relocating the diversion.

Selected Alternative 1 - Pipe the Ditch above Hayden Creek

The preferred strategy for separating the KR-222 diversion from Hayden Creek is to pipe the diversion over the Hayden Creek channels. See design drawings (DWGs) for additional detail. The approximately 240-ft-long, 10" gravity-driven diversion pipe would follow the existing ditch alignment at a similar elevation and grade to the existing ditch thalweg and would extend from just upstream of the crossing with East Hayden Creek to just downstream of the crossing with West Hayden Creek to minimize the length of pipe required (DWG 3.0; Figure 3-1). The pipe would be placed in the existing ditch, except where it crosses the two branches of Hayden Creek. Steel sheet headwalls and locally sourced boulder rip rap will be placed at the pipe tie-in points. The downstream control point, KR-222-DS would be

removed. This alternative rehabilitates the lower portion of East Hayden Creek, which has been inactive as a result of flow capture by the existing ditch, and will improve fish access into Hayden Creek.

With the proposed pipe alignment and slope, the East and West Hayden Creek channels would be lowered to create appropriate freeboard below the pipe to convey flood flows (DWG 3.1-3.2). The design intent is to provide sufficient freeboard to pass the 100-year recurrence interval flood. Hydraulic modeling has not been completed at this phase, so target freeboard values may be refined in the future. Preliminary concept design calls for East and West Hayden Creeks to be lowered to provide 2.7 ft and 3.3 ft of freeboard, respectively. This freeboard would be achieved by regrading approximately 200 ft of each channel length, resulting in excavation of approximately 335 and 180 cubic yards (CY) of native material from East and West Hayden Creeks, respectively.

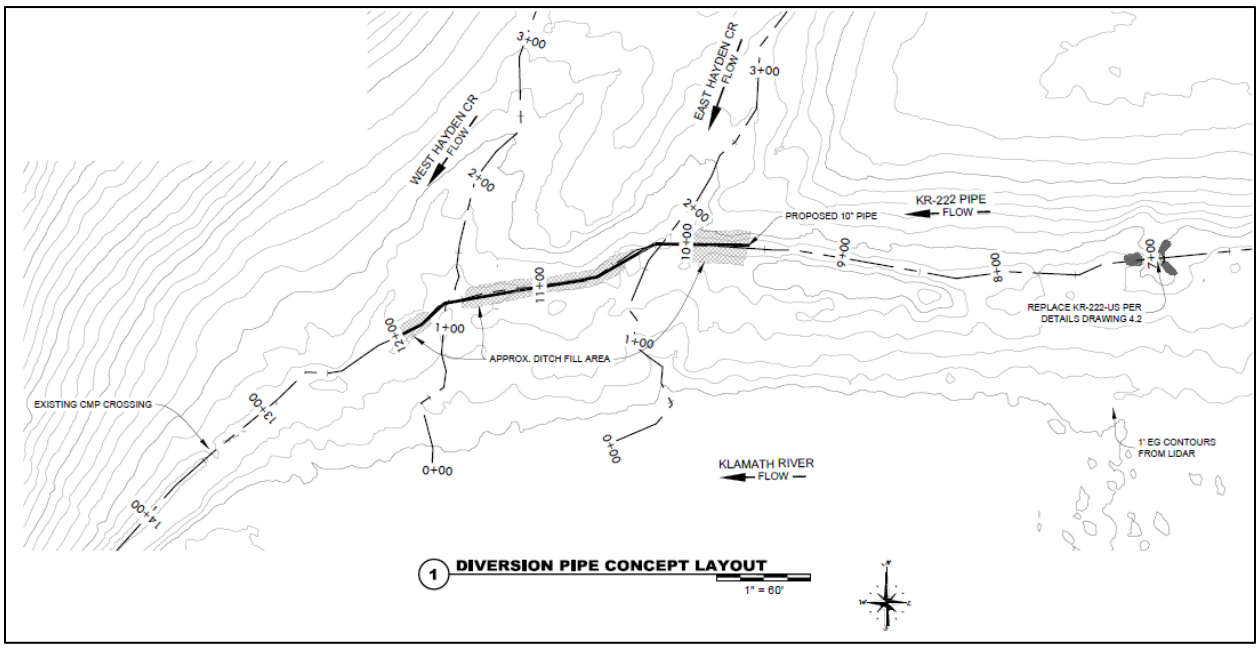

Figure 3-1. Alternative 1 diversion pipe concept from design drawings (DWG 3.0).

Grading would reduce the channel slope downstream of the pipe crossings and steepen the channels upstream (DWG 3.1-3.2). To maintain fish passage, the design slopes would be no greater than the maximum existing channel slope (7%) located in this reach of Hayden Creek (DWG 2.2). The channels would be stabilized with boulder ribs constructed from boulders generated during the channel excavation or otherwise located on-site. The boulder ribs would be designed to ensure channel stability with respect to the vertical channel profile and lateral channel migration adjustments (DWG 4.0). The channel would include a natural streambed design shaped to match local reference conditions with single log large wood members and pools developed for habitat where appropriate. All sediment and large wood will be sourced on-site from within the excavation footprint and surrounding areas, where appropriate and with approval. Large wood will be stabilized by existing stable vegetation and/or by boulders (DWG 4.1). On-site sediment and boulder supply to support natural streambed and boulder stability design elements should be more than sufficient given the preliminary estimated excavation volume (515 CY) and the site's position on a boulder-dominated fan with large-grained material sourced from upslope basalt cliffs.

This alternative would replace the damaged upstream control point, KR-222-US. The existing structure would be removed, and a steel sheet headwall with Waterman gate and stub pipe would be installed in the same location to take advantage of the existing return channels and access road (DWG 4.2). The new structure would be responsible for limiting ditch flow to the 1.82 cfs water right. The idea of moving the KR-222-US control point upstream was dismissed because construction access is challenging, new return channels would need to be excavated, and ditch improvements would need to occur. Approximately 200 ft of the existing ditch will be filled with approximately 105 CY of material placed around the pipe, except where the pipe crosses Hayden Creek. The ditch fill would protect the pipe from erosion and damage and serve as a disposal site for some of the material excavated as part of the pipeline crossing work. Excess materials (approximately 410 CY) will be disposed of on-site, pending review and approval.

Channel stability is an important consideration. In the constructed channel, the boulder ribs will be designed at a spacing and elevation to prevent headcutting and erosion both in the footprint of the excavation and upstream. The side-slopes will be designed at a 2.5:1 slope and revegetated to promote lateral stability. Outside of the project footprint, Hayden Creek should be relatively stable on decadal timescales because it is located on a boulder-surfaced fan that is supplemented by rockfall failure from uphill basalt cliffs and bedrock from thinly-soiled adjacent hillslopes. The existing channel substrate has a large fraction of angular cobbles and boulders lacking evidence of transport with only a few small gravel and sand deposits observed in East Hayden Creek. These observations suggest transport limited conditions and vertical channel stability. Given the sparse evidence of sediment transport in Hayden Creek, significant aggradation in the project footprint is unlikely, although some may occur at the slope break downstream of the pipe crossings. If aggradation is a long-term concern with respect to maintaining sufficient freeboard between the channel bed and the pipe crossings, the project design could be modified to have a removable section of pipe over the channels. Pipe sections could be seasonally removed during times when flooding is most likely.

The selected design alternative has the lowest operation and maintenance requirements, and lowest costs of the evaluated alternatives. Anticipated operation and maintenance include seasonal opening of the upstream control point, KR-222-US, headgate to route flow down the ditch. Given that there is a significant flow reduction at KR-222-US, there may be some sedimentation concerns on the upstream side of the gate. The gate designed could be modified to have a flush valve into the return channels.

Alternative 2 - Pipe the Ditch below Hayden Creek

Alternative 2 routes ditch flow into a buried pipe that follows the existing ditch alignment but at a lower elevation than the Hayden Creek thalwegs at the ditch crossings. The 10-inch pipe would be sized to accommodate the 1.82 cfs water right as in Alternative 1. Currently, the thalwegs of East and West Hayden Creeks are at 2765.5 ft and 2763.7 ft, respectively (DWG 2.1; Figure 3-2). The amount of excavation (linear distance and depth) to accommodate the pipe depends on the desired burial depth of the pipe below the thalwegs of East and West Hayden Creeks. Assuming a minimum of 2 ft of material on top of the pipe at the Hayden Creek crossings, at least 1300 ft of ditch would need to be excavated to accommodate pipe placement such that the pipe outlet daylights in the ditch downstream of Hayden Creek and maintains gravity flow. This could result in approximately 300 to 800 CY of excavation, depending on the width of the trench and the thickness of the overburden along the length of the pipe.

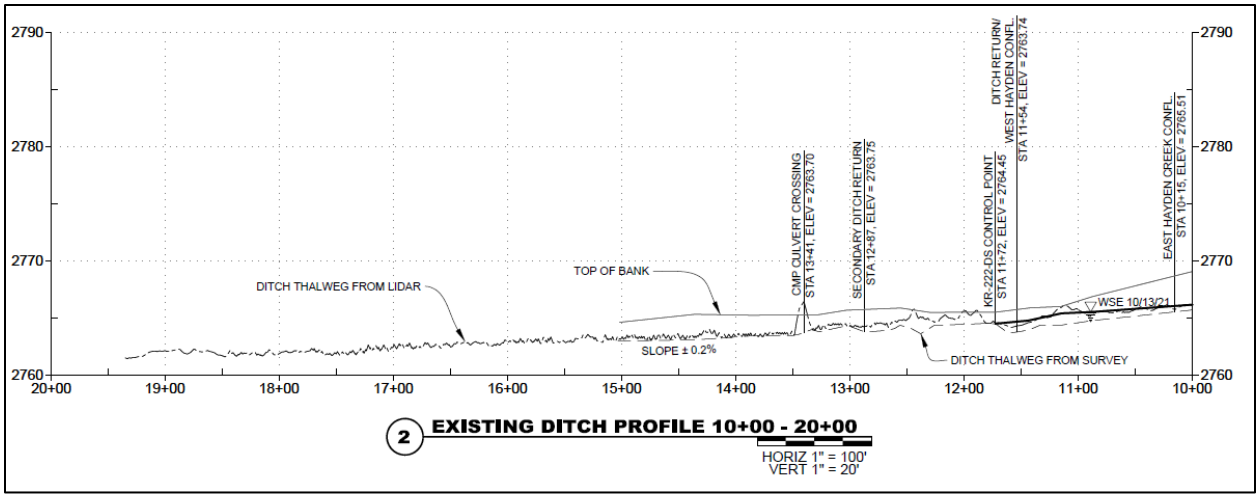

Figure 3-2. Existing ditch profile from DWG 2.1.

The leaking upstream control point, KR-222-US, would still need to be replaced. The pipe inlet could be placed at KR-222-US or a separate headworks for the pipe inlet could be constructed at a location closer to East Hayden Creek, which would shorten the length of pipe and ditch excavation required. The lower reach of East Hayden Creek downstream of the ditch would need to be restored to accommodate a natural flow regime.

One source of uncertainty in the constructability of this alternative is the depth to bedrock beneath the ditch. Upstream of STA 14+00, the excavated material is probably alluvium or colluvium associated with the Hayden Creek fan or the Klamath River terrace (DWG 2.0). However, downstream of STA 14+00, the river-right hillslope impinges upon the Klamath River and ditch, and it is likely that bedrock is much shallower beneath the surface. The difficulty in excavating bedrock depends on the rock strength, fracture and joint spacing, and degree of weathering. As estimated from the relatively high competency of exposed bedrock surrounding the bedrock rapid crest, excavation of the bedrock would be challenging and may require drilling for several hundred feet of the ditch. Pilot drill cores to assess depth to bedrock along the ditch would help constrain bedrock distribution and reduce this uncertainty.

For this alternative, the disturbance would be more extensive but primarily limited to the ditch footprint. This alternative requires at least 1300 ft of pipe, which is over 5 times the Alternative 1 pipe length. To reduce the length of pipe and excavation disturbance for a pipe-burial alternative, a siphon option was also considered. For the siphon option, the pipe inlet and outlet would be located closer to East and West Hayden Creeks at similar elevations to the current ditch thalweg, and the pipe would drop beneath the two channels and then daylight on the down-ditch side. Siphons would require seasonal draining to prevent freezing (and construction of a drainpipe) and would generally require more regular maintenance than the buried gravity pipe in Alternative 1.

Alternative 3 - Relocate Diversion

This alternative would relocate the point of diversion away from its current location at the rock weir on the Klamath River, downstream to the upstream side of the approximately 6 ft tall bedrock rapid crest located approximately 100 ft downstream of the Hayden Creek confluence (Figure 1-1). The East and West Hayden Creek channels would be redefined and regraded at the confluences with the ditch to

ensure effective flow routing to the Klamath River. This alternative involves replacing or removing the existing KR-222-US control point and filling the ditch at its upstream end and around the Hayden Creek confluences. Filling the ditch would reduce the chance that the mainstem Klamath River or Hayden Creeks would reoccupy the ditch. The elevation at the potential point of diversion on river-right of the Klamath River at the crest of the bedrock rapid (STA 14+00) is approximately 2756 ft. To transport water into the ditch, either a screened pump would need to be installed at the diversion point or a gravity-driven flow pathway into the ditch would need to be excavated. The ditch elevation adjacent to the rapid crest at STA 14+00 is 2763 ft (Figure 3-2), 7 ft above the rapid crest elevation. To maintain gravity-driven flow, the ditch would need to be excavated down to 2763 ft or lower along approximately 2000 feet of the ditch downstream of the rapid crest.

This alternative would achieve the primary objective of separating the water right and ditch from Hayden Creek but has several complications and difficulties. The alternative involves moving the water right's point of diversion across state lines from Oregon to California, and this move would cause considerable regulatory challenges. The development of a new intake would require significant cost and logistics compared to the other alternatives. The excavation volume in the ditch, much of it likely in competent bedrock, is several times larger than the other alternatives.

3. Summary

This technical memorandum presents the concept-level design alternatives to address issues with the KR-222 diversion and Hayden Creek. The selected alternative (Alternative 1) involves piping ditch flow over East and West Hayden Creeks, which would be graded to lower elevations to create sufficient freeboard to pass Hayden Creek flood flows. Other evaluated alternatives included piping ditch flow beneath Hayden Creek (Alternative 2) and relocating the diversion downstream of the Hayden Creek confluence with the Klamath River (Alternative 3). Alternatives 2 and 3 likely require challenging excavation into competent bedrock and are therefore dismissed in favor of Alternative 1. Alternative 2 requires significantly more pipe to be installed than Alternative 1. Alternative 3 would also involve transfer of the water right across the state line, a difficult regulatory process that precludes further consideration of this alternative.