Appendix A

Comments and Responses

Table A-1. Topics and Associated Codes.

Topic	Topic Code	Topic	Topic Code	Topic	Topic Code
Alternative Analysis	ALT	Methods	METH	Resource Concerns	RES
Construction Process	CONS	National Economic Efficiency Analysis	NEE	Safety/Security	SAFE
Consultation	CONSU	Permitting	PRMT	Soils	SOIL
Cultural Resources	CUL	Project Cost	COST	System Design	SYS
Endangered Species Act	ESA	Project Benefits	BNFT	Vegetation/Trees	VEG
Fire	FIRE	Property Rights	RIGHT	Visual	VIS
Fish and Aquatic	FISH	Property Value	PROP	Water	WAT
General	GEN	Public Process	PUB	Wetlands	WETL
Irrigated Acres	IRA	Purpose and Need	PURP	Wildlife	WILD
Maps	MAP	Recreation	REC	Wild and Scenic	WAS

Table A-2. Responses to Comments Received During the Klamath Drainage District Watershed Plan-EA Public Comment Period

Comment ID	Topic Code	Comment	Response
1.01	FISH	While supportive of the concept of the plan, I have the following concern. Along with 20 others, I am an account holder in the Klamath Hills District Improvement Company (KHDIC) which is in contract with KDD for O&M of the North Canal. The North Canal supplies water used for pumped irrigation by KHDIC account holders who have pump stations spread along the length of said canal. My concern is that by connecting the North Canal to the P1 Lateral and refuge waterways, that this connection will allow fish to enter the North Canal from the refuge and swim up into the North Canal. If one new fish screen is built at the Klamath River input into the North Canal, perhaps another fish screen ought to be added at the southern terminus of the extended North Canal at the refuge waterway connection to the P1 Lateral. That way, fish will be prevented from entering the North Canal at both ends. The North Canal, which was built in the last hundred years, is not part of the traditional habitat of any fish species. The proposed project should make sure that fish in the river and refuge waterways are protected and not allowed to swim into the North Canal where numerous water pumping stations could present dangers to fish. Again, I support the proposed plan, but think that precautions need to be made to protect fish from getting into the North Canal at both ends.	North Canal is not considered as traditional habitat for suckers, and individuals that are entrained by the North Canal from the Klamath River are accounted for in USFWS incidental take statement for the Klamath Project in the most recent biological opinion (2024). The 2024 biological opinion also included the reintroduced population of suckers into Lower Klamath Lake and accounted for entrainment from other Klamath Project facilities in USFWS incidental take statement, including the P-1 Lateral. Once individuals are accounted for in an incidental take statement with USFWS, those individuals lose their protections as they have already been considered to have perished and those impacts have been mitigated for. Thus, the current operations of pump stations in the North Canal are not impacted by the presence of suckers in the North Canal. The extension of the North Canal to the P1 lateral would allow suckers present in LKNWR that are entrained into the P-1 lateral to enter into the North Canal. However, suckers in the P-1 lateral are already covered by the Klamath Project biological opinion and their potential movement into the North Canal would not impact operations of pumps in the North Canal as they have already been accounted for in an incidental take statement. Thus, irrigation operations, such as diversions and pumping, in the North Canal would not be impacted by the presence of suckers with the extension of the North Canal into the P-1 lateral. See Appendix D.2.9.
2.01	SOIL	Thank you for the chance to review and comment on the Klamath Drainage District Infrastructure Modification Project prepared by the Natural Resources Conservation Service. Caltrans' hydraulic engineer is concerned that the existing Lower Klamath National Wildlife Refuge water along Hwy 161 contributes to softening of the	The following text was added to Section 6.4.2.1: The North Canal Extension may also have minor, long-term indirect impacts on soil stability of the CSH 161 fill prism. An additional point of delivery into LKNWR would allow for future water deliveries to LKNWR if the refuge obtains additional water rights to be delivered through the North Canal. Increased water fluctuations may result in softening up of CSH 161 fill prism soils and could cause additional burrowing by animals including muskrats (WDFW 2024). If

		highway fill and provides immediately adjacent habitat for animals (possibly muskrats etc.) that burrow into the highway fill.	additional water rights are obtained, the refuge and KDD would work with Caltrans to minimize impacts to CSH 161 fill prism stability.
2.02	WAT	Increasing the amount of water to the Lower Klamath National Wildlife Refuge may increase the cost of maintaining the highway depending on proposed water levels and locations of water ponding.	The North Canal would have water in it year round. Water conveyed to the P-1 lateral would be based on future water management discussions with the Refuge managers.
2.03	WAT	Their questions are: 1. What would the changes to water elevation be adjacent to the highway,	Evaluation of the canal capacities shows that the future elevations would be no more than 2 feet higher than the existing canal bottom (see Structural Table 3B, channel elevations 4081 ft msl, water surface elevation 4,083 ft msl).
2.04	WAT	2.What increase in duration of water ponding would occur adjacent to the highway, and where would these changes occur.	The North Canal would have water in it year round. Water conveyed to the P-1 lateral would be based on future water management discussions with the Refuge managers.
2.05	PRMT	The State's permit engineer had these comments: 1.Culvert placement and any work with the CT ROW will require an encroachment permit and depending on scope of work may be eligible for QMAP process.	Section 8.4.2 State Permits includes the requirement for an encroachment permit from the California Department of Transportation.
2.06	GEN	2. Maintenance may want to look at who is going to be responsible to maintain these culverts, may require maintenance agreement.	The District and Refuge would develop an operations and maintenance plan for the North Canal/P-1 connection. They would coordinate with Caltrans during the development of this plan.
2.07	CONS	3. Caltrans preference would be trenchless construction method.	An initial description of construction methods are described in Section 8.2 and 8.6. More specific construction means and methods would be determined in future design phases, during the design process consideration of any changes to effects would be considered. Caltrans would be kept informed throughout the process.
3.01	GEN	On behalf of the City of Klamath Falls, I would like to express our appreciation for the opportunity to provide comments on the Draft Watershed Plan - Environmental Assessment for the proposed Klamath Drainage District Infrastructure Modernization Project. The City supports the preferred alternative, as outlined in the Environmental Assessment. The City recognizes the significant benefits that the proposed project offers, including the	Thank you for your comment.

		extension of the North Canal and its connection to the P1 lateral, the installation of fish screens at the North Canal Diversion on the Klamath River, modifications to increase flow capacity, upgrades to pump stations, and the installation of flow monitoring and automated gates throughout the district. We particularly support the project's goals to save water by reducing conveyance inefficiencies, improving irrigation water management and agricultural water supply, enhancing water quality in the Klamath River, and increasing critically needed wildlife habitat. Additionally, preventing fish entrainment in canals and drains is a crucial step toward preserving our local aquatic ecosystems. The City believes that these improvements will not only benefit the agricultural community but also contribute positively to the overall environmental health of the region. We are committed to supporting initiatives that align with sustainable water management and farmland conservation. Thank you once again for the opportunity to comment on this important project. We look forward to seeing the positive impacts it will bring to our community and the surrounding environment.	
4.01	PRMT	The Department of State Lands regulates the removal and fill of material within waters of this state. This includes within wetlands and below the ordinary high water line of jurisdictional waterways per the Removal-Fill Law (OAR 141-085-0515). Based on review of the draft Environmental Assessment documents, it appears that the proposed project involves impacts to waters of this state, and a state Removal-Fill permit is likely required. As a first step in the	The Plan EA recognizes impacts to waters of the state would occur and the appropriate permitting process would be followed with DSL as mentioned in the *Mitigation, Minimization, and Avoidance Measures* in the Office of Management and Budget (OMB) Fact Sheet and in Appendix E.9.

		permitting process, a wetland and waters delineation by a qualified wetland professional is needed for the North Canal extension to P-1 Lateral (Figure C-12) and the fish screen installation/levee break repairs at the North Canal intake (Figures C-2 & C-14). A wetland delineation report should then be submitted to DSL for review and approval. After the boundaries of waters of this state are established in these areas, please contact Mike Schmeiske (michael.schmeiske@dsl.oregon.gov, 541-388-6162) to discuss avoidance and minimization of impacts prior to submitting a Removal-Fill permit application. Thank you for the opportunity to comment. We look forward to working with the District and partners in the future	
5.01	CONSUL	Water availability for KDD and LKNWR is currently governed by the Bureau of Reclamation's Endangered Species Act section 7 consultation for ongoing operations of the Klamath Project. Reclamation has completed numerous section 7 consultations over the last three decades on Klamath Project operations, with the most recent one completed in November 2024, as documented in biological opinions issued by the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). Reclamation's current section 7 consultation is based on a hydrologic planning model, referred to as the Klamath Basin Planning Model (KBPM), which contains formulaic rules for the hydrologic circumstances under which water can be diverted through the Ady or North canals to either KDD or LKNWR (among other points of diversions and places of use).	Thank you for your comment.
5.02	WAT	Table 3-1 correctly specifies that the proposed action does not involve any changes to water diversion or water rights. Until an alternative	Please see Sections 2.1.2, 6.6.2.2.2, 6.6.2.2.6, and 6.6.2.5 of the Plan-EA. regarding how the Proposed Action would improve efficiency. Regarding the request to discuss how the project would alter the timing and disposition of drainage water in the Klamath Straits

		comes forward to the operations set forth in Reclamation's most recent section 7 consultation, water availability for KDD and LKNWR will continue to be governed in accordance with the KBPM. Reclamation's section 7 consultations, beginning in the late 1990s and leading up to today, have incrementally reduced the amount of water available for diversion to agricultural and refuge, including KDD and LKNWR. The draft EA discusses "water shortages" for KDD and LKNWR and appears to attribute the condition to "severe droughts" (p. 10). As noted above, the draft EA does not address how and why the proposed action would address this problem. To address this point, discussion should be added to the EA (in various sections) explaining how the proposed action would provide greater water efficiency for KDD, allowing existing water supplies to be better managed and utilized. Specific information should also be added explaining how the proposed action would potentially alter the timing and ultimate disposition of drainage water in the KSD (i.e., through recirculation via KDD's existing recirculation pumps and/or the contemplated Center Canal connection). Analysis of recent (e.g., past ten years) drainage patterns would likely be helpful to this discussion. A broader point should also be added, stating that the proposed action would help provide operational capacity for alternative water management in the Klamath Project, which may ultimately result in more water being available for KDD and LKNWR than currently.	Drain (KSD): Ultimately, the timing and disposition of drainage water discharged into the KSD would depend on allocations and water management decisions. It is anticipated that discharges into the KSD would continue to follow current seasonal fluctuations. Reductions in discharges would be associated with pumping from the KSD to the Center Canal and consumptive use on agricultural lands. Regarding the request to describe how the proposed action would make more water available to the District or the Lower Klamath National Wildlife Refuge: The infrastructure improvements would enable more efficient water management but would not directly increase the availability of water.

5.03	WAT	Pages 10, 22: "Donnelly et al. 2020" is identified as the source of statement that wetland acres in LKNWR have declined by 47% since 2012. That article only addresses the Tule Lake Basin (not Lower Klamath) and the quoted figure is in reference to all wetlands in the study area in snowmelt watersheds. The actual reduction in wetland acres in LKNWR since 2012 is likely greater than 47 percent.	Information presented in the Plan-EA sourced from Donnelly et al. 2020 was determined to be inaccurate per the commentor's comment. However, Donnelly et al. 2020 did analyze the Lost Watershed (HUC 18010204) which includes Lower Klamath Lake and Tule Lake. No other published documentation for wetland area losses were found for LKNWR, Text in Section 2.1.1 of the Plan-EA was edited to state "Declining precipitation and drought conditions have resulted in an over 10 percent decline in wetland acreage in the region from 2000 to 2018 (Donnelly et al. 2020). Due to limited water supply to LKNWR in recent years, wetland acreage in the refuge have likely declined at a faster rate than the region."
5.04	GEN	Pages 23-24: Table 4-1: All federal land interests (whether fee title, easement or otherwise) are owned by the federal government. Agencies may have administrative jurisdiction over federal lands and land interests, but ownership lies with the federal government, not a particular agency.	In Section 4.2.2, we updated the text to read "United States Federal Government" instead of "U.S. Agency"
5.05	GEN	Pages 23-24: Table 4-1: The P-1 Canal is a facility of the Klamath Project, which was built and is currently operated and maintained by the U.S. Bureau of Reclamation. Formal assignment (or transfer) of operation and maintenance (O&M) of this facility from Reclamation to the U.S. Fish and Wildlife Service is anticipated but has not yet been completed.	In Section 4.2.2, we changed the management of the P-1 Lateral to Bureau of Reclamation and added a table note to Operations and Maintenance Responsible Party cell to indicate anticipated future management by USFWS.
5.06	COST	Pages 23-24: Table 4-1: Footnotes 1 and 2 address the O&M costs of the Klamath Straits Drain, but do not accurately describe how those costs are allocated among the various entities. For simplicity's sake, it likely suffices to say that the entities that contribute water to the Klamath Straits Drain, including KDD, USFWS, Reclamation, and Tulelake Irrigation District, share in the costs of Klamath Straits Drain in proportion to their relative contribution of such water to annual drainage pumping.	On Table 4-1 we replaced the table notes with "The entities that contribute water to the Klamath Straits Drain, including KDD, USFWS, Reclamation, and Tulelake Irrigation District, share in the costs of Klamath Straits Drain in proportion to their relative contribution of water to annual drainage pumping"
5.07	WAT	Page 24: Last sentence of the last full paragraph is incorrect, as KDD does not "provide[] drainage via the KSD…" Suggest revising the sentence as follows: "The refuge receives water from the	In Section 4.2.3, the sentence was changed to "The LKNWR receives water from the Klamath River via the Ady Canal and drainage water released from the refuge is pumped back to the river via the Klamath Straits Drain."

		Klamath River via the Ady Canal and drainage water released from the refuge is pumped back to the river via the Klamath Straits Drain.”	
5.08	MAP	Page 26, Figure 4-2: Suggest revising the title on the key to “Land Ownership/Administration”; also suggest changing the title of the map to something like “Project Area” or “Lower Klamath Lake Area” since the map depicts more than just “Klamath Drainage District.”	The title for Figure 4-2 was changed to Land ownership/administration and the subtitle was changed to Klamath Drainage District Planning Area"
5.09	WAT	Page 30 (Water Resources): Groundwater may be used for irrigation in the planning area at least in one known case (Sukraw well) and likely others.	In Section 4.6, text was revised to read "The District does not have a water right for groundwater please see section 4.6.5 for a list of District water rights."
5.10	WAT	Page 31: “FCA 2019a” is cited as the source for the statement that “Agricultural use of land became even more important industry in the area as logging activities closed in 1928 due to drought.” This is not an accurate description of the logging industry in the Klamath Basin.	The statement was determined to be inaccurate and was removed.
5.11	WAT	The reference to 1906 should be more precise. The Klamath Project was authorized in 1905. Construction started in 1906, and the first irrigation deliveries occurred in 1907.	See Section 4.6.1: Text was edited to: "Water for irrigation via the Klamath Project was one of Reclamation’s first projects, with water deliveries beginning in 1907 and providing water for many irrigation districts in the area that support the ecosystem services of providing food and crops."
5.12	WAT	The statement that “Water within KDD canal and drainage infrastructure influences water quality within both the LKNWR and the Klamath River” is imprecise and inaccurate to some degree. Water quality in the Klamath River is primarily influenced by water quality in Upper Klamath Lake. Water quality in KDD canals reflects water quality in the Klamath River. Water quality in LKNWR likewise reflects water quality in the Klamath River, to the extent that the river is the source of water in LKNWR. KDD’s diversions for both agriculture and the refuge do not materially alter the thermal regime or water quality in the Klamath River because this section of the river is managed as an impoundment, through	Please see Section 4.6.1. Text in the Plan-EA was changed to highlight the role the Klamath River has in the water quality within KDD. Internal changes to water quality still have influences on water quality in LKNWR and the Klamath River. Text was edited to "Water quality within KDD's conveyance infrastructure is a reflection of its source water (the Klamath River) and the internal changes to water quality after conveyance and application of the water for irrigation. The resulting water that is pumped and discharged into the Klamath River via the Klamath Straits Drain influences water quality in LKNWR and the Klamath River."

		operation of Keno Dam. As a result, regardless of the rate of diversions at the Ady and North canals (along with other points of diversion), water levels upstream of Keno Dam by and large remain the same. Water quality in KDD's drains reflects the water quality in KDD's canals after application of the water for agricultural purposes. As such, the concentration of constituents in drainage water is higher, due to evapotranspiration of water during irrigation. Sediment, salts, and other constituents may also be added to the water during the irrigation process, which is then reflected in the water quality in KDD's drains. To the extent that KDD's drainage water is recycled and delivered to the refuge, the water quality within the refuge will reflect the water quality of KDD's drainage system. To the extent that KDD's drainage water is pumped and discharged into the Klamath River via the Klamath Straits Drain, water quality in the Klamath River may be influenced by these discharges.	
5.13	GEN	Page 31: Replace the term "private landowners" with "agricultural producers."	See Section 4.6.2.1: "private landowners" was replaced with "private agricultural producers"
5.14	GEN	Strike the following language "and retains most water rights for LKNWR wildlife management activities." This statement is inaccurate and superfluous.	This statement 'and retains most water rights' has been removed.
5.15	WAT	Last sentence in the second to last paragraph revise as follows: "USFWS and KDD have an agreement for use of the Ady Canal to deliver water to the refuge. KDD and Reclamation have an agreement providing that the district will provide water delivery and drainage services to Area K lands similar to private lands in the district.	Please see Section 4.6.2.1 Language was updated to read "USFWS and KDD have an agreement for use of the Ady Canal to deliver water to the LKNWR. Through an agreement with Reclamation, KDD provides water delivery and drainage services to Area K lands similar to private lands in the District.
5.16	WAT	The first sentence of last paragraph, revise as follows: "Drainage water pumped to the Klamath	See Section 4.6.2.1 Text was revised to the following: "Drainage water pumped to the Klamath River via the KSD could originate from several potential sources. In recent

		River via the Klamath Straits Drain comes from several potential sources. In recent times, the predominant source of water is agricultural return flows from lands within KDD, particularly in the late winter and spring, when landowners drain fields irrigated during the fall and winter period. During the summer irrigation season, most agricultural return flows from KDD lands are recycled and reused for irrigation purposes, rather than being discharged into the Klamath Straits Drain. As a result, the Klamath Straits Drain has generally not operated outside of the late winter and early spring period. The Klamath Straits Drain was completed and became operable in 1946. During the first seven decades of operation, a large amount of the water discharged to the river through the Klamath Straits Drain came from the refuge and/or from Tule Lake Sump 1 in Tule Lake National Wildlife Refuge. Since 1942, water from Tule Lake Sump 1 can be pumped to LKNWR through Pumping Plant D and the Tule Lake Tunnel, a 4,000-foot-long tunnel underneath Sheepy Ridge. At the terminus of this tunnel, the water may be distributed to and around LKNWR through the P Canal system. To the extent that water pumped through the Tule Lake Tunnel is in excess of the needs of LKNWR, the water may be released into and pumped to the river through the Klamath Straits Drain. Beginning in 2010, due to an overall lack of water within the refuge, USFWS largely ceased releasing water from the refuge into the Klamath Straits Drain. Beginning around this time, USFWS also started developing infrastructure to allow water to be recycled within the refuge, further lessening the need to release water into the Klamath Straits Drain.	years, the primary source of this water seems to be agricultural return flows from lands within KDD, particularly during the late winter and spring, when landowners drain fields irrigated during the fall and winter. During the summer irrigation season, much of the agricultural return flows from KDD lands are reportedly recycled and reused for irrigation. Consequently, the KSD operates primarily during the late winter and early spring periods. Historically, the KSD also discharged KID's and TID's tailwater from Tule Lake Sump 1 in TLNWR. Since 1942, water from Tule Lake Sump 1 can be pumped to LKNWR through Pumping Plant D and the Tule Lake Tunnel, a 4,000-foot-long tunnel underneath Sheepy Ridge. At the terminus of this tunnel, the water may be distributed to and around LKNWR through the P Canal system. However, beginning in the early 2010's when less water was available for agricultural purposes from Upper Klamath Lake, the amount of water being pumped from Sump 1 began to decline. Since 2020, no water has been pumped from Sump 1 through the Tule Lake Tunnel unless special arrangements are made for this water to be sent to LKNWR."

		At roughly the same time, due to less water being available for agricultural purposes from Upper Klamath Lake, the amount of water being pumped from Sump 1 began to decline. Since 2020, no water has been pumped from Sump 1 through the Tule Lake Tunnel unless special arrangements are made for this water to be sent to LKNWR.	
5.17	GEN	Page 32: Replace the term "superseded" with "supplemented."	See Section 4.6.2.1 The sentence was replaced with: "KDD initially entered its first contract with Reclamation in 1917. This contract authorized the closing of the gates at the KSD to drain the land for farming and to develop drainage and conveyance infrastructure. In 1921, KDD signed its first contract with Reclamation to provide water to 27,500 acres of land with subsequent contracts in 1929, 1940, 1943 and 1947 to support continued water delivery (Contract No. I1r-402)."
5.18	WAT	The Klamath Basin Adjudication encompasses both water rights established prior to adoption of Oregon's water code and federally-reserved water rights (regardless of the date they were established). Replace the term "vested" with "claimed to have been established."	See Section 4.6.2.1 The term "vested" was replaced with "claimed to have been established."
5.19	GEN	Replace the phrase "established through a proceeding in Klamath County Circuit Court" with "confirmed through a process in accordance with state law."	See Section 4.6.2.1 The phrase "established through a proceeding in Klamath County Circuit Court" was replaced with "confirmed through a process in accordance with state law."
5.20	GEN	Replace "managed" with "administered."	See Section 4.6.2.1 The term "managed" was replaced with "administered".
5.21	GEN	Replace "Final Order of Determination" with "Amended and Corrected Findings of Fact and Order of Determination (ACFFOD)." The Klamath County Circuit Court (not district) is responsible for adjudicating exceptions to the ACFFOD. The District was awarded certain water rights in the ACFFOD.	See Section 4.6.2.2: The term "Final Order of Determination" was replaced with "Amended and Corrected Findings of Fact and Order of Determination (ACFFOD)."
5.22	GEN	Pages 32-33: Lands within KHDIC were at one time contemplated for water service through the Klamath Project, but no contract was ever consummated with the Reclamation for such. Instead the district exercises water rights obtained in accordance with Oregon law.	Thank you for your comment. The information provided by the commentor does not appreciably change the intent of the section and no text edits were made.

5.23	WAT	Page 33, Table 4-6: There are specified periods of use, maximum diversion rates, and annual maximum on-field and point of diversion duties for KA-100) and specifically for lands within KDD and served through the Ady and North Canals. The district's contracts with Reclamation are not a "water right" as indicated in the title to the table.	See Section 4.6.2.1. The District's contract with Reclamation is relevant to water management and shall remain in the table. However, the Table 4-6 title was updated to "District Water Rights and Contracts Associated with the Plan Area."
5.24	WAT	Pages 33 and 34: USFWS "claims" not "owns" the water rights for LKNWR. The description of water rights for LKNWR is not accurate. As established in the ACFFOD, Claim 312 encompasses a place of use of 25,881.7 acres, but is restricted to irrigation of up to a maximum of 10,000 acres per year within this place of use. The total annual volume available for irrigation under Claim 312 is 35,000 acre-feet. The approved period of use is February 15 through November 15, depending on the point of diversion used. Claims 313-316 have later priority dates, different time and duty restrictions, and are designated for different areas within LKNWR. The water right claims for Tule Lake National Wildlife Refuge are separate and distinct from Claims 312- 316 for LKNWR.	See Section 4.6.2.2. The sentences were revised to read: "The LKNWR receives water from the Klamath River and Upper Klamath Lake. USFWS claims the water rights on the LKNWR for wildlife use through water rights claims (KA 312 [not year-round] and KA 313, 314, 315, and 316As established in the Amended and Corrected Findings of Fact Order of Determination (ACFFOD), Claim 312 encompasses a place of use of 25,881.7 acres, but is restricted to irrigation of up to a maximum of 10,000 acres per year within this place of use. The total annual volume available for irrigation under Claim 312 is 35,000 acre-feet. The approved period of use is February 15 through November 15, depending on the point of diversion used. Claims 313-316 have later priority dates, different time and duty restrictions, and are designated for different areas within LKNWR."
5.25	GEN	Use the acronym ACFFOD instead of FOD.	See Section 4.6.2.2. Text was changed to "ACFFOD" to reflect the current adjudication documentation.
5.26	GEN	The ACFFOD is enforceable pending a final decree, unless stayed by the circuit court.	See Section 4.6.2.2. Sentence was edited to add the potential for the staying of the ACFFOD by the circuit court. Text was edited to "In the interim, the ACFFOD is enforceable until the circuit court issues a final decree or the circuit court stays the determination."
5.27	ESA	Strike the last sentence in the first paragraph on page 34. There is no current or ongoing work on the matter of a "within-Project priority" for LKNWR.	See Section 4.6.2.2. Sentence was edited to more clearly reflect that Endangered Species Act compliance of the Kamath Project influences project water delivery. Text was edited to "USFWS, NMFS, and Reclamation continue to work toward a common understanding of water conveyance timing and allocations that is consistent with Reclamation's water delivery contracts and the Klamath Project Operations 2024 Biological Opinions (NOAA NMFS 2024, USFWS 2024)."

5.28	GEN	Replace the phrase "is actively seeking" with "has analyzed the impacts of acquiring".	Thank you for your comment.
5.29	GEN	Table 4-7: Remove the word "District" from the title to the table.	See Section 4.6.2.2 Text was edited to remove the word "District" from the title of Table 4-7. These water rights are not the District's but are conveyed to Lower Klamath National Wildlife Refuge through KDD infrastructure.
5.30	GEN	Page 37: Second to last paragraph, KDD	This was deemed an incomplete comment. When contacted for clarification, the commenter stated they had no additional input to provide.
5.31	WAT	Page 39: The statement that "At times, the KSD contributes more than half of the Klamath River's flow above Keno Dam" is outdated and no longer factually correct. It is physically feasible; however, under current flow regime management for releases from Link River Dam, coupled with the dramatic change in KDD's drainage practices (i.e., recycling water for agricultural and/or refuge use), the Klamath Straits Drain rarely (for a few weeks a year) reaches up to approximately one-fourth of the flow at Keno Dam.	Text in Sections 2.1.4, 4.6.3.2, and 4.6.4 have been revised to more accurately reflect the present flow regime. "Historically, the KSD contributed more than half of the Klamath River's flow above Keno Dam (Hiatt 2019), but recently recirculation of drain water into KDD canals has resulted in a reduction of the total drain discharge, including a reduction in nutrient loads, into the Klamath River."
5.32	WAT	Page 39: Strike the sentence "The KSD transports nutrient loads into and out of the Klamath River." This statement is inaccurate.	See Section 4.6.4 The sentence in the Plan-EA was inaccurate as the Klamath Straits Drain does not receive inflow from the Klamath River but only discharges water into the river. Text was edited to "The KSD transports nutrient loads into the Klamath River."
5.33	FISH	Page 41: Strike the last sentence of the second paragraph in section 4.7.2. This statement is speculative.	During coordination with NMFS, they indicated upstream areas of Keno Dam were not currently being discussed for designation of essential fish habitat. The sentence that this comment refers to has been removed. See Section 4.7.2
5.34	ESA	Page 42, the first full paragraph: Revise (or strike) the statement "Endemic fish, such as the endangered shortnose sucker and Lost River sucker, face critical population decreases that threaten the survival of the species." Long-term monitoring of suckers by USGS has conclusively shown that the fishes' survival is not directly tied to water quantity or quality. See J. Krause et al., "Water and Endangered Fish in the Klamath River Basin: Do Upper Klamath Lake Surface Elevation and Water Quality Affect Adult Lost River and Shortnose Sucker Survival?" North	Thank you for your comment. Krause et al. 2022 showed strong evidence to suggest that adult sucker survival was resilient to interannual variation in lake levels and water quality from 1999-2021. However, sucker populations are declining due to lack of sufficient survival of juveniles as described in the 2023 USFWS Biological Opinion for the Klamath Project. Although no empirical evidence has been collected yet to clearly describe the link, one prominent hypothesis documented in the 2023 USFWS BO is "that water quality is directly responsible for the unnaturally high levels of juvenile mortality." Another is that water quality interacts with other sources of mortality by causing chronic stress that renders the individuals more susceptible to forms of predation or infection..." This hypothesis corresponds with "The declines in captures commonly occur during the periods with the most degraded water quality conditions in UKL...". Thus, the language commented upon in the Plan EA is consistent with the current understanding of sucker biology and no changes were made to the text.

		American Journal of Fisheries Management, 42:1414–1432 (2022).	
5.35	WAT	Amend the statement “influenced by climate, runoff, and tailwater” to as follows: “primarily influenced by water quality conditions in Upper Klamath Lake…”	See Section 4.7.2 Text was edited to "Water quality conditions in the Klamath River and District-operated canals are primarily influenced by Upper Klamath Lake in addition to climate, runoff, and tailwater, resulting in poor water quality due to impaired waters for parameters such as temperature, dissolved oxygen, dissolved solids, sediments, turbidity, nutrients (primarily nitrogen and phosphorus), and bacteria (DEQ 2022)."
5.36	FISH	Page 44: Strike the last sentence of section 4.7.3.5. This statement is speculative.	During coordination with NMFS, they indicated upstream areas of Keno Dam were not currently being discussed for designation of essential fish habitat. The sentence that this comment refers to has been removed. See Section 4.7.3.5
5.37	WAT	Page 45, section 4.8.1: As noted above, water quality in KDD canals reflects water quality in the Klamath River (not visa versa). Water quality in KDD’s drains reflects the water quality in KDD’s canals after application of the water for agricultural purposes.	Text in the Plan-EA was changed to highlight the role the Klamath River has in the water quality within KDD. Internal changes to water quality still have influences on water quality in LKNWR and the Klamath River. In Section 4.8.1, text was updated to " Water quality within KDD's conveyance infrastructure is a reflection of its source water (the Klamath River) and the internal changes to water quality after conveyance and application of the water for irrigation. The resulting water quality in KDD's conveyance infrastructure influences water quality in LKNWR and the Klamath River."
5.38	GEN	Page 69, section 6.6.2.1.1: The statement does not explain how the proposed action would “improve” KDD landowners’ “ability to use water rights.” Specific reference should be made of the additional capacity and flexibility that will be created by the project to recycle drainage water for agricultural and refuge use (as in section 6.6.2.2.2). Also the project addresses conditions (like fish entrainment) that may be a constraint on landowners’ ability to exercise water rights.	Fish entrainment is not a constraint on a landowners' ability to exercise water rights as entrainment is covered by the Klamath Project Biological Opinion. Text was edited in Section 6.6.2.1.1 to state "Under the Modernization Alternative, there would be no effect to the District’s water rights, but modernization activities would improve the District’s and its patrons’ ability to use water rights. The Modernization Alternative will increase the availability of water to meet patrons water rights through improvements to recirculation and water management within the District's conveyance network. The locations of the District’s points of diversions would not change under this alternative."
5.39	GEN	Page 70, second to last paragraph: Replace the word “Irrigating” (before wetlands) with the term “Maintaining.”	See Section 6.6.2.2.2, "irrigating" was replaced with "maintaining".
5.40	WAT	Page 75, sections 6.7.2.2.3 and 6.7.2.2.4: These sections should note that any impacts associated with any increased storm water runoff from the access road on the North Canal not be offset by the water quality benefits associated with less KSD water being discharged into the Klamath River.	In a coordination meeting with NMFS Branch Supervisor for the region after release of the Plan-EA for public comment, it was determined that the increases in stormwater runoff on roads that would be infrequently used by the District would not significantly contribute to impairments in water quality within the Klamath River. Section 6.7.2.2.3 and 6.7.2.2.4 will be edited to reflect this change in impact determination.

5.41	GEN	Page 83, section 6.10.3.6: The gates in the railroad embankment across the Klamath Straits were first closed in 1914. After Reclamation reopened the gates the following spring, landowners negotiated and finally entered into an agreement with Reclamation for their closure in October 1915. The November 30, 1917 contract was the first contract with the district for the permanent closure of the gates in the railroad embankment across the Klamath Straits.	See Section 6.11.3.6 (formerly 6.10.3.6). The sentence was revised to indicate permanent closure of gates under the 1917 contract. Sentence was revised to: "This contract authorized permanent closure of the gates at the Klamath Straits to drain the land, making it possible to farm."
5.42	GEN	KWUA appreciates the opportunity to thoroughly review and comment on the Draft Plan-EA. Clearly, considerable thought and effort has gone into this planning effort so far. KWUA supports the proposed action and KDD's broader efforts to modernize its infrastructure and operations in a manner that supports and enhances fish and wildlife resources.	Thank you for your comment.

Appendix B

Project Map

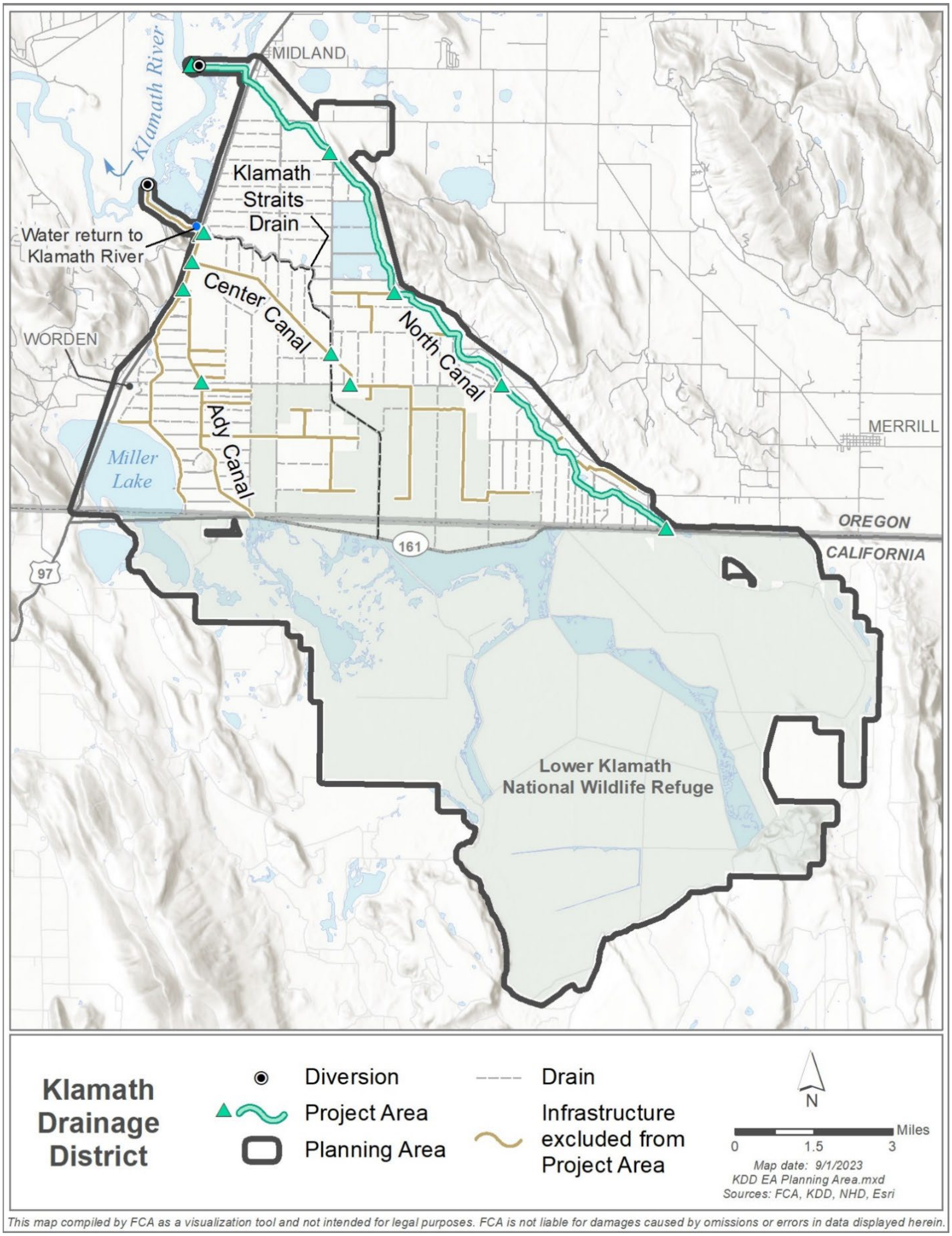

Figure B-1. Klamath Drainage District planning area and project area.

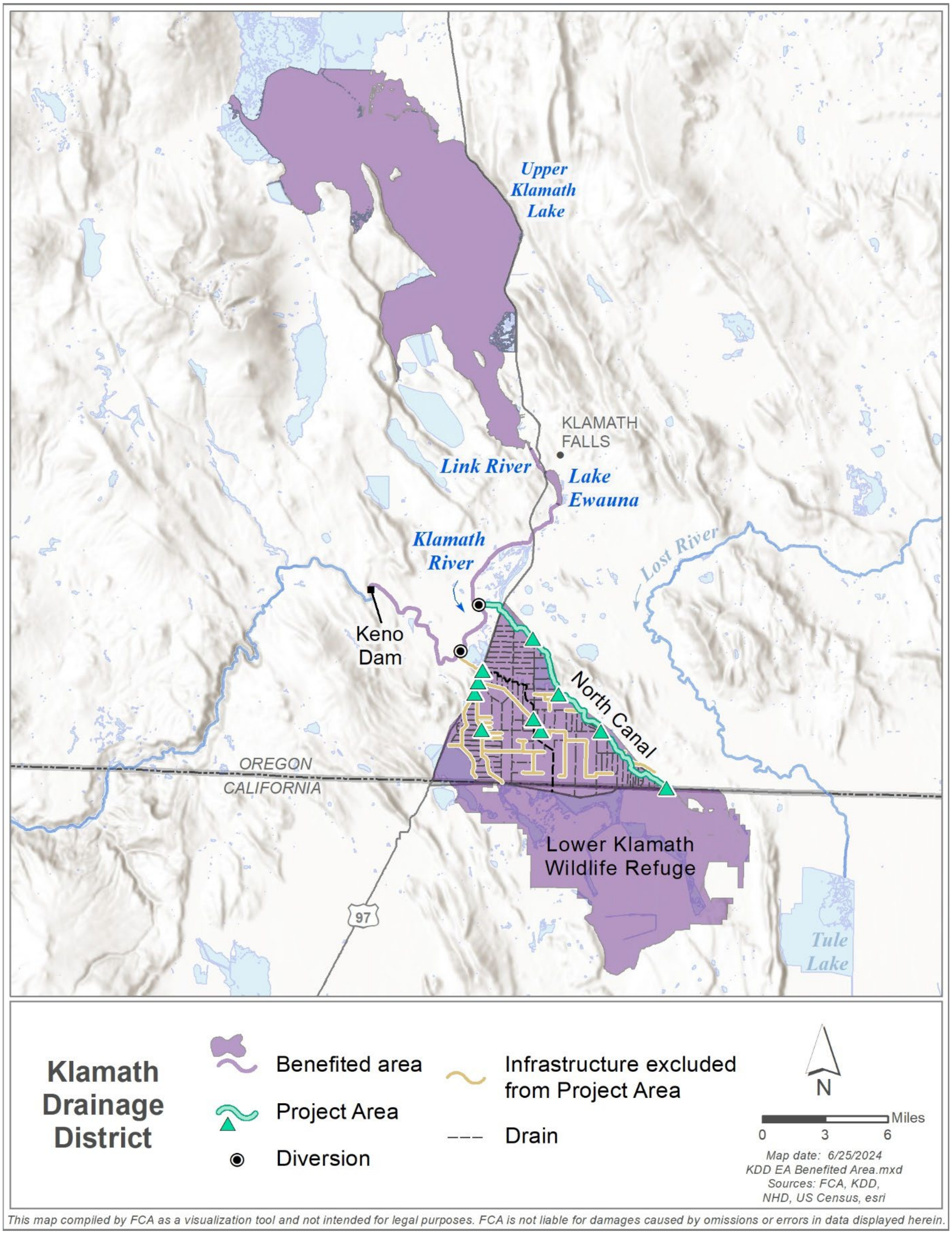

Figure B-2. Areas benefited by the Klamath Drainage District Project.

Appendix C

Supporting Maps

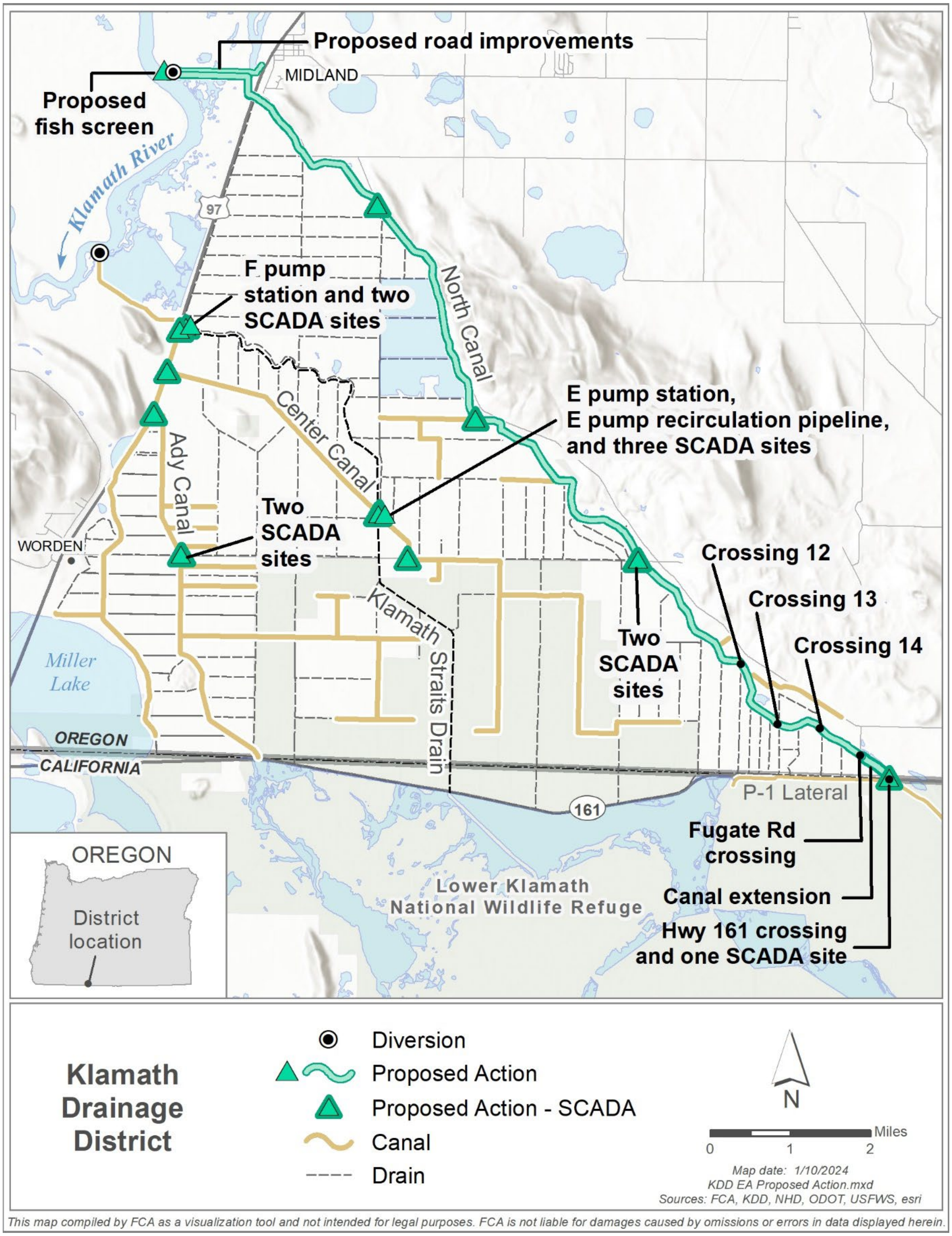

Figure C-1. District Infrastructure Modernization Alternative.

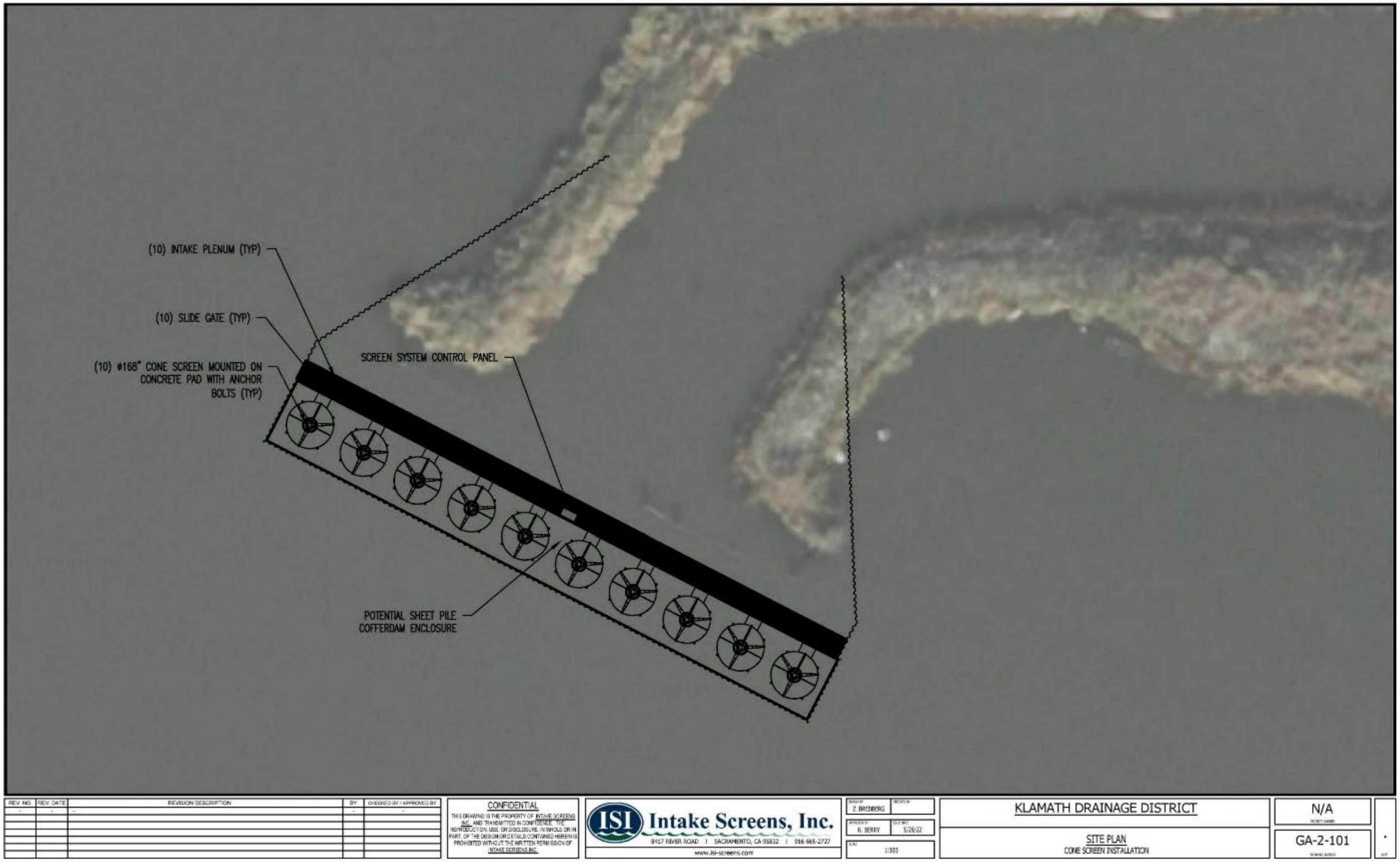

Figure C-2. North Canal Diversion fish screen overview design.

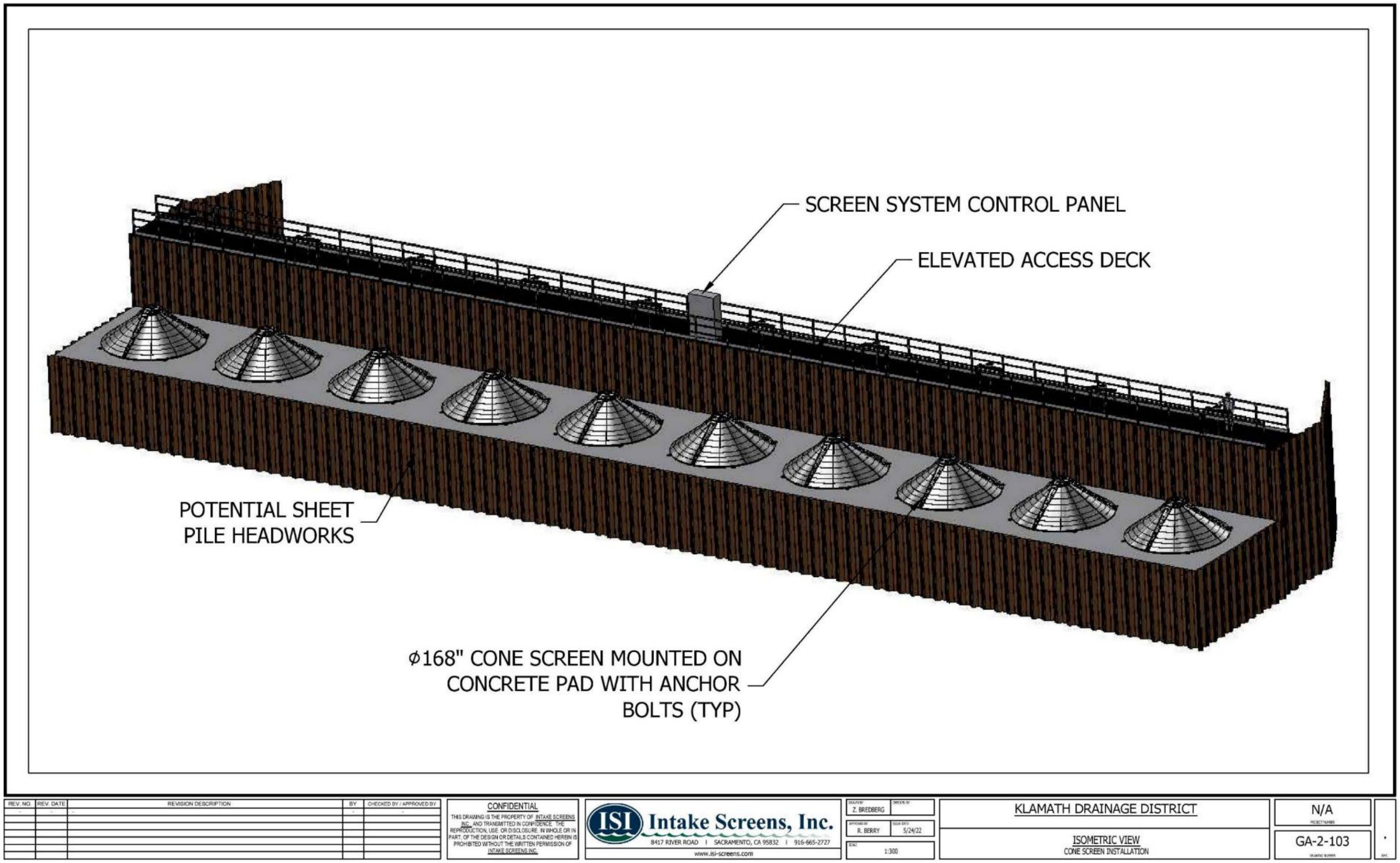

Figure C-3. Isometric view of North Canal fish screen.

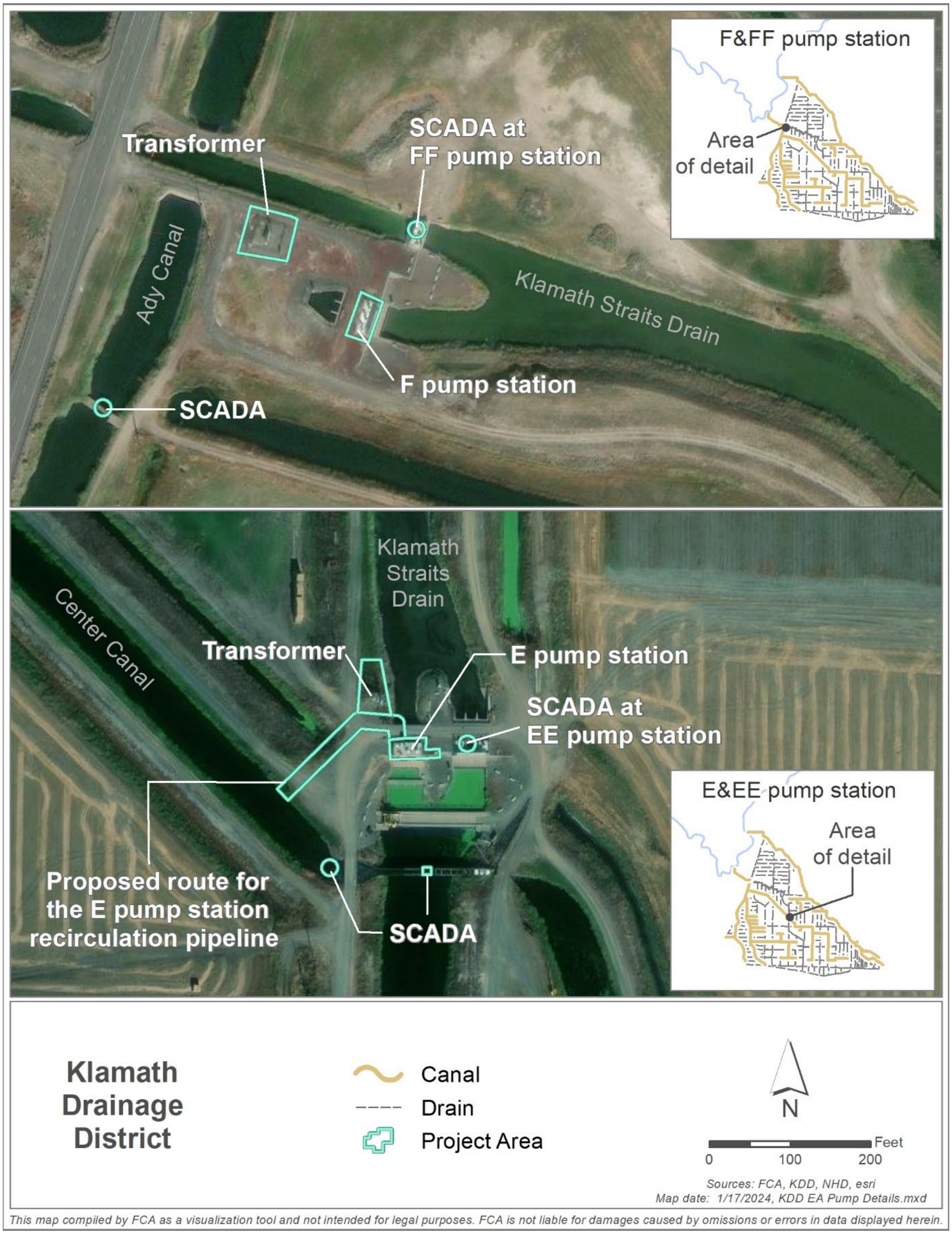

Figure C-4. E and F Pump Station Project overview.

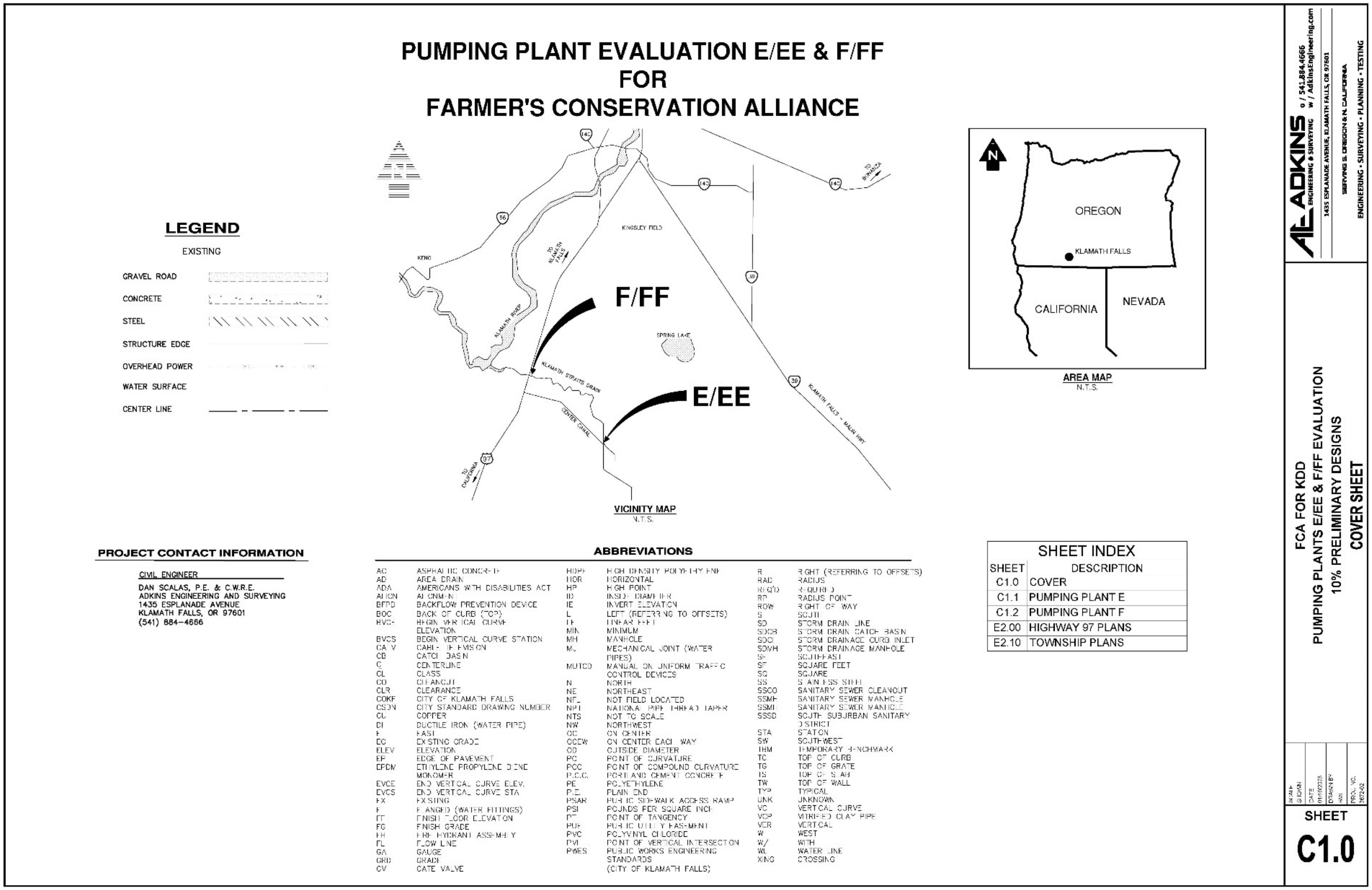

Figure C-5. Pumping plant evaluation overview.

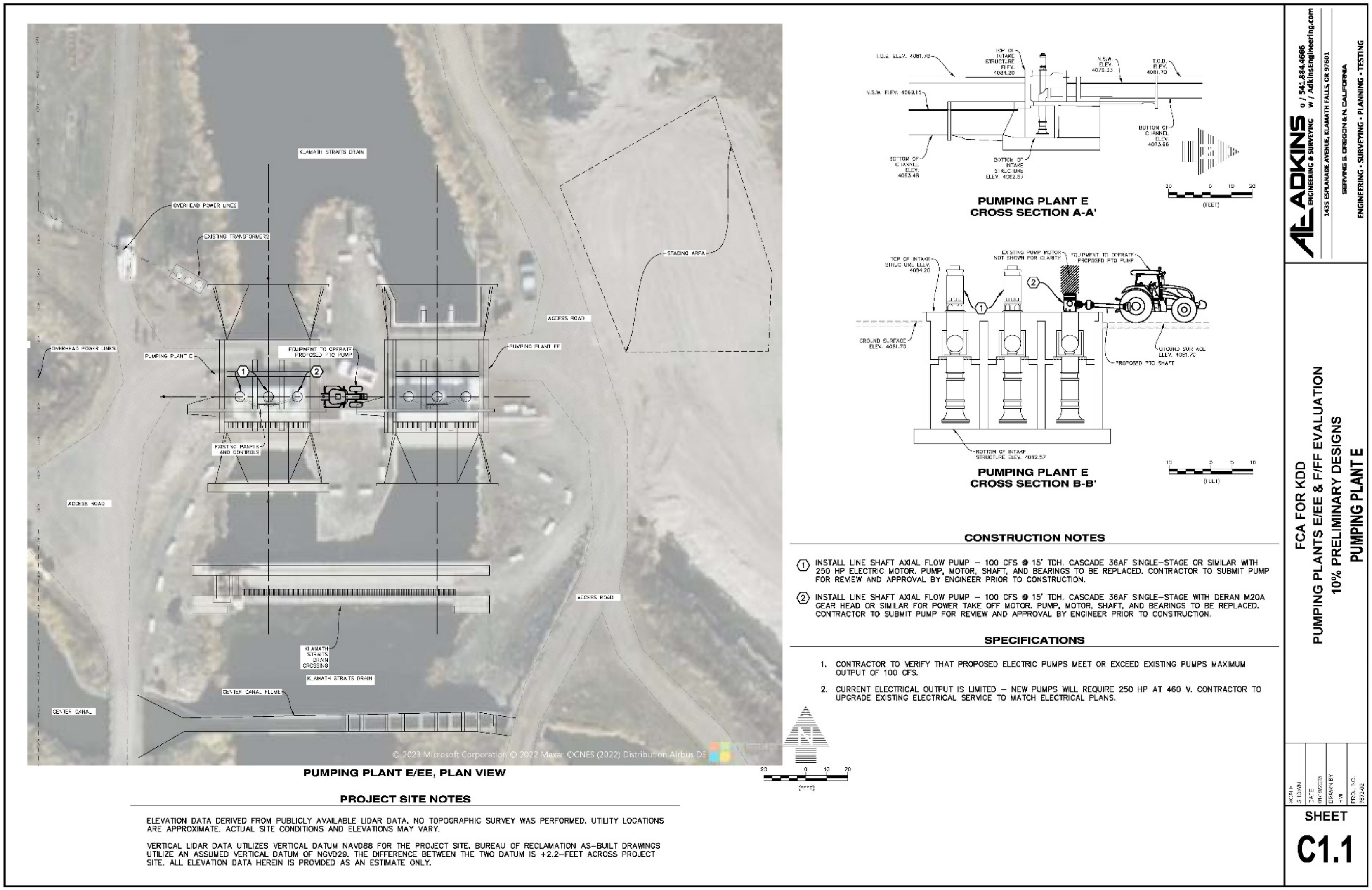

Figure C-6. Pumping Plant E/EE overview.

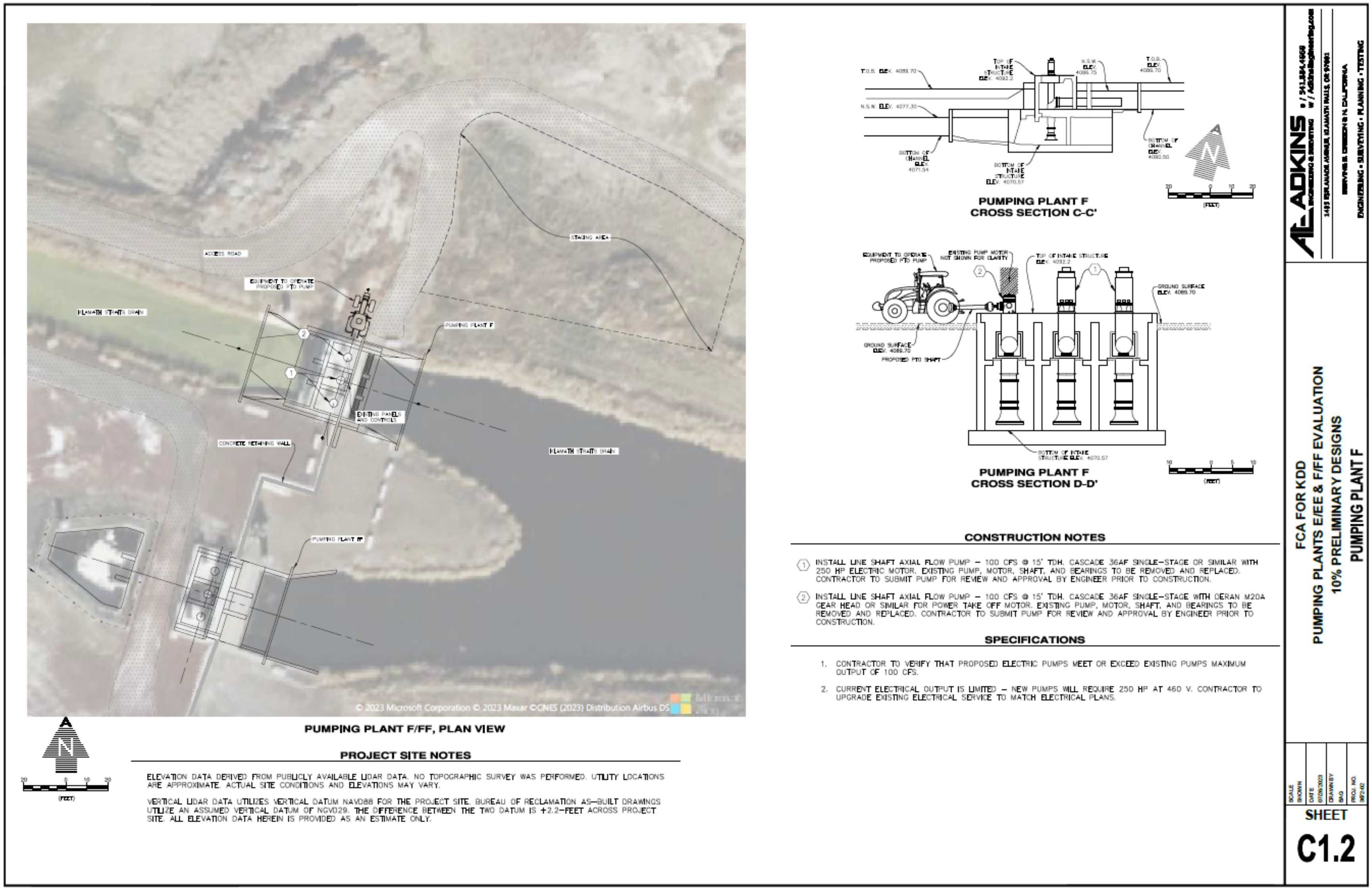

Figure C-7. Pumping Plant F/FF overview.

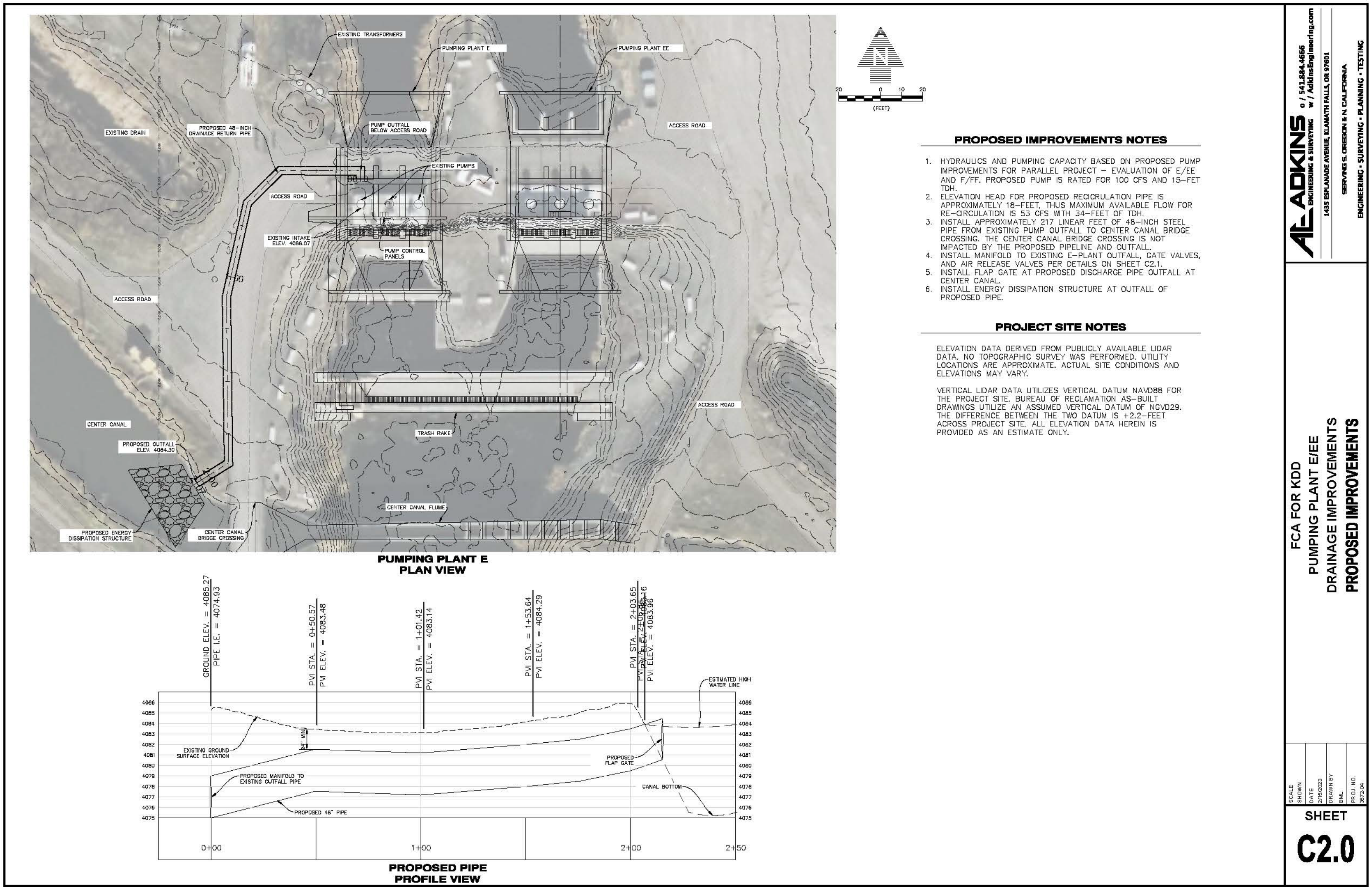

Figure C-8. Overview of proposed E Pumping Plant recirculation pipeline.

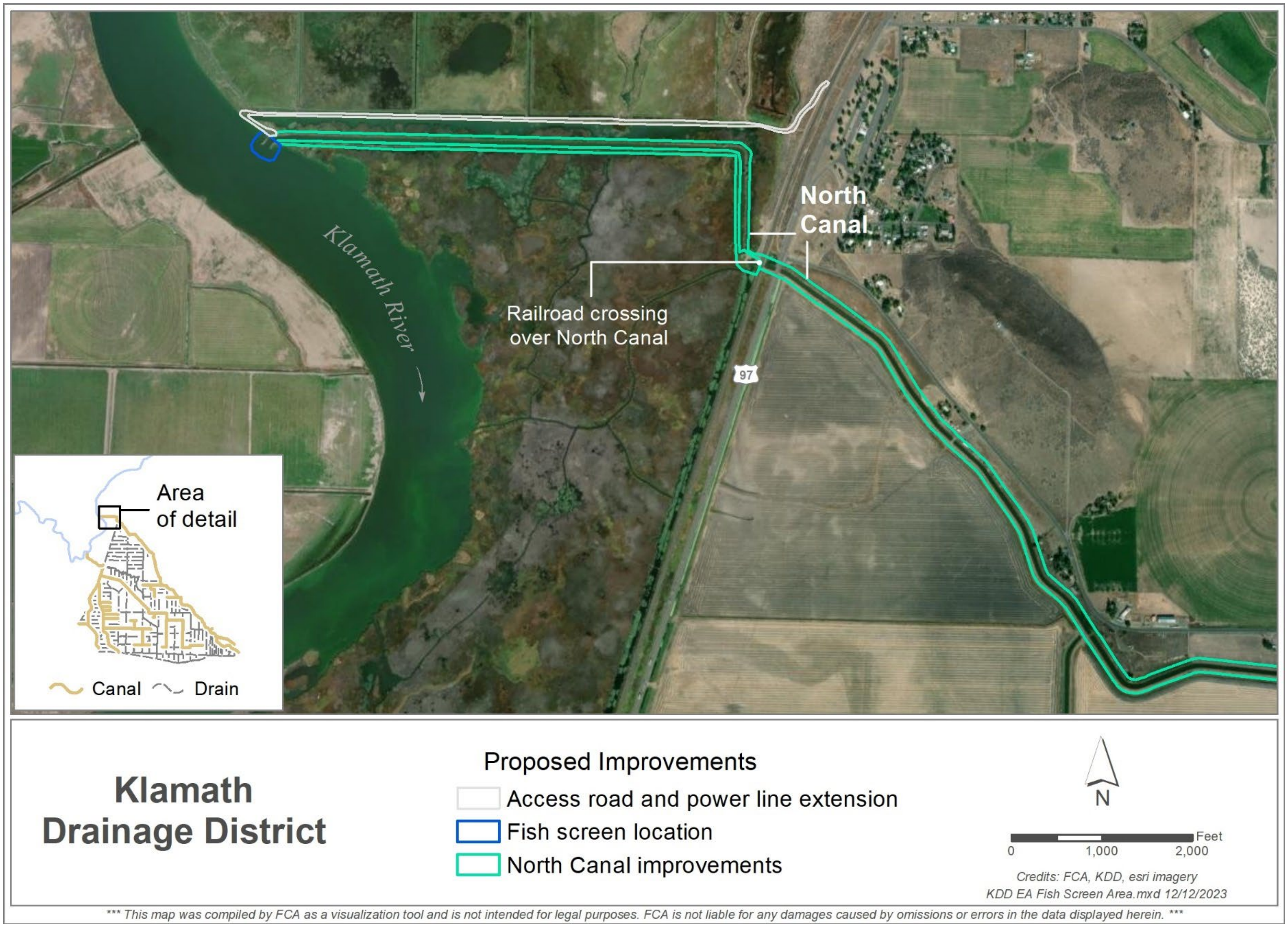

Figure C-9. Location of Klamath Drainage District North Canal railroad crossing.

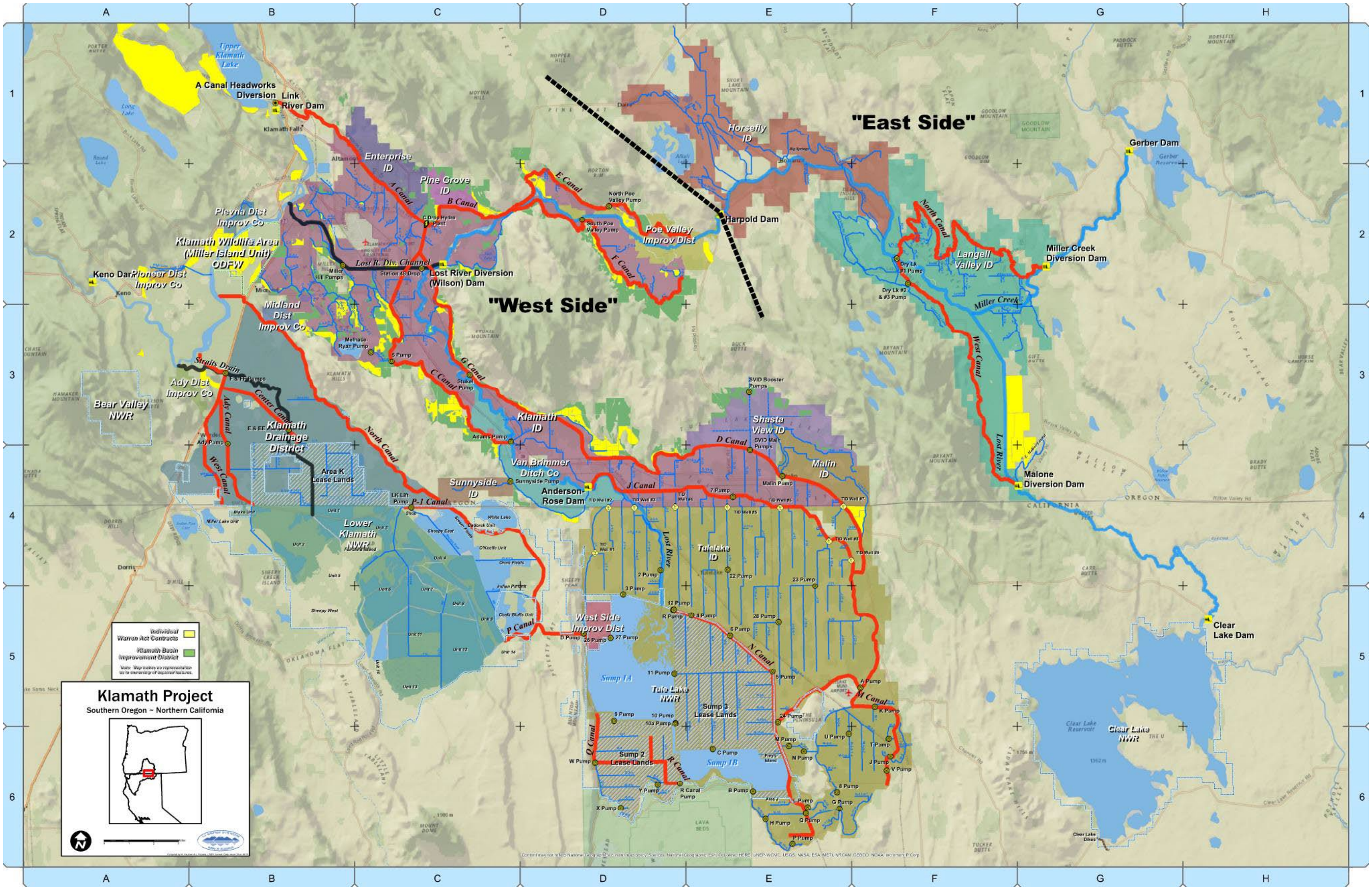

Figure C-10. Klamath Project Irrigation Districts.

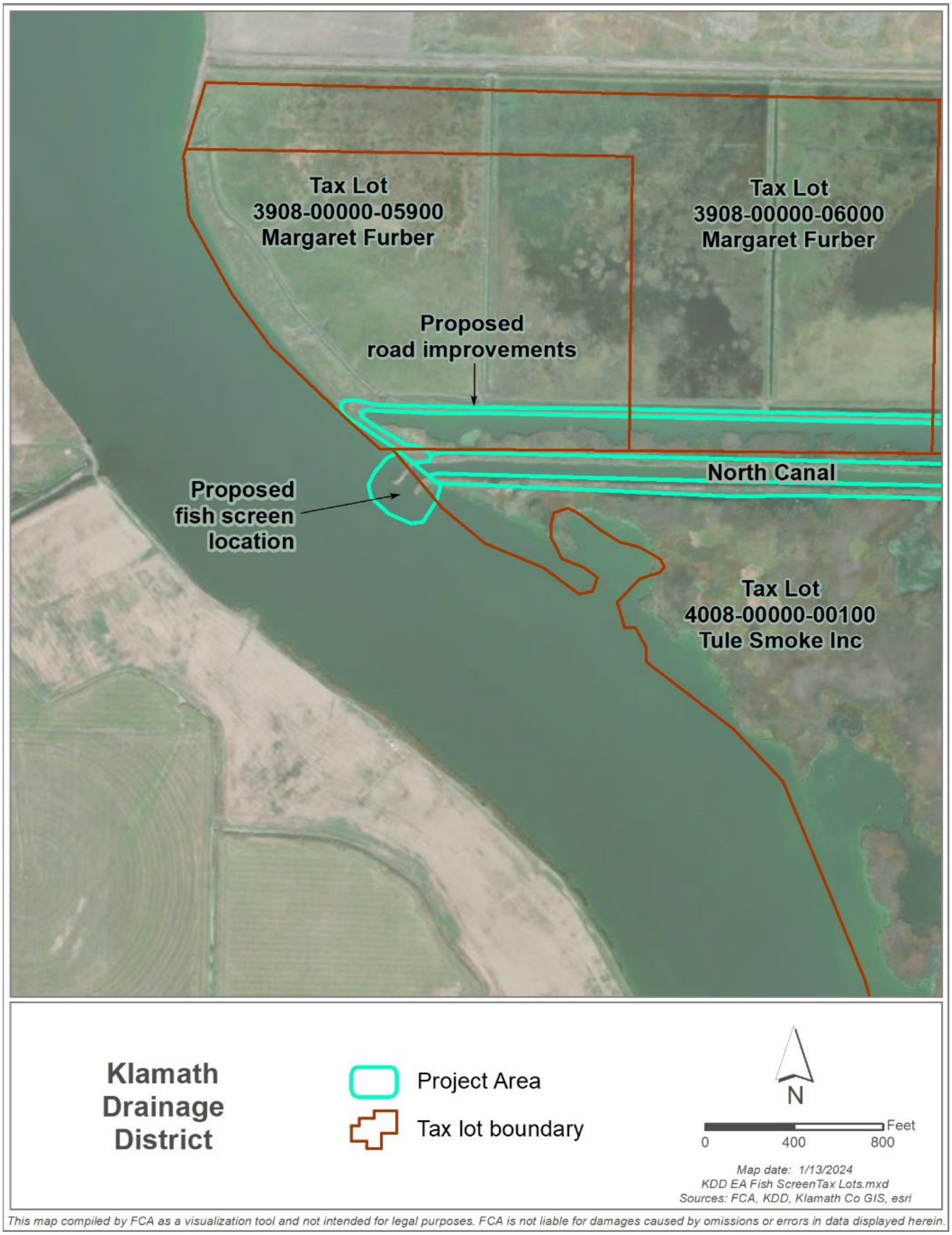

Figure C-11. Tax lots associated with the North Canal Fish Screen Project.

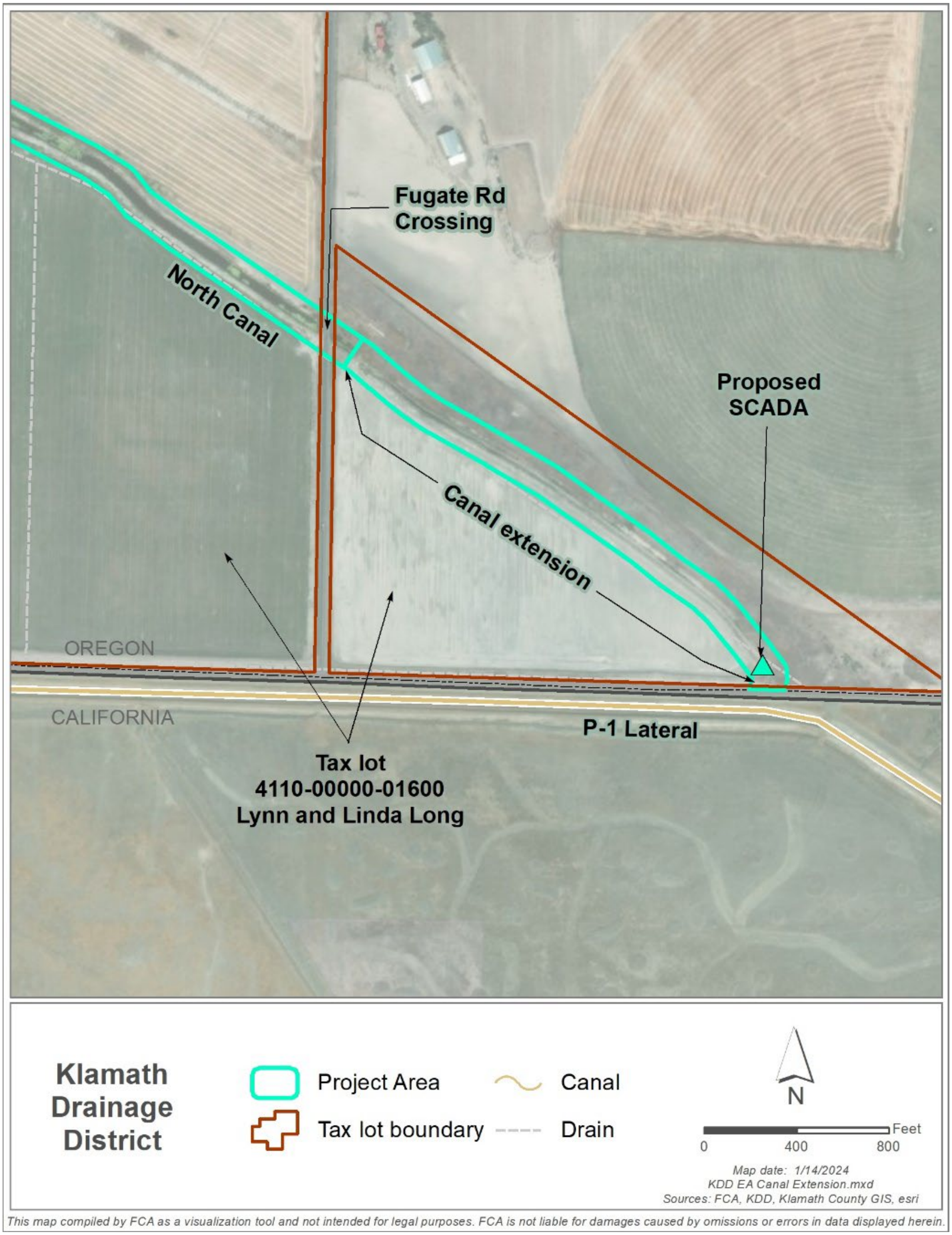

Figure C-12. Tax lots associated with the North Canal Extension Project.

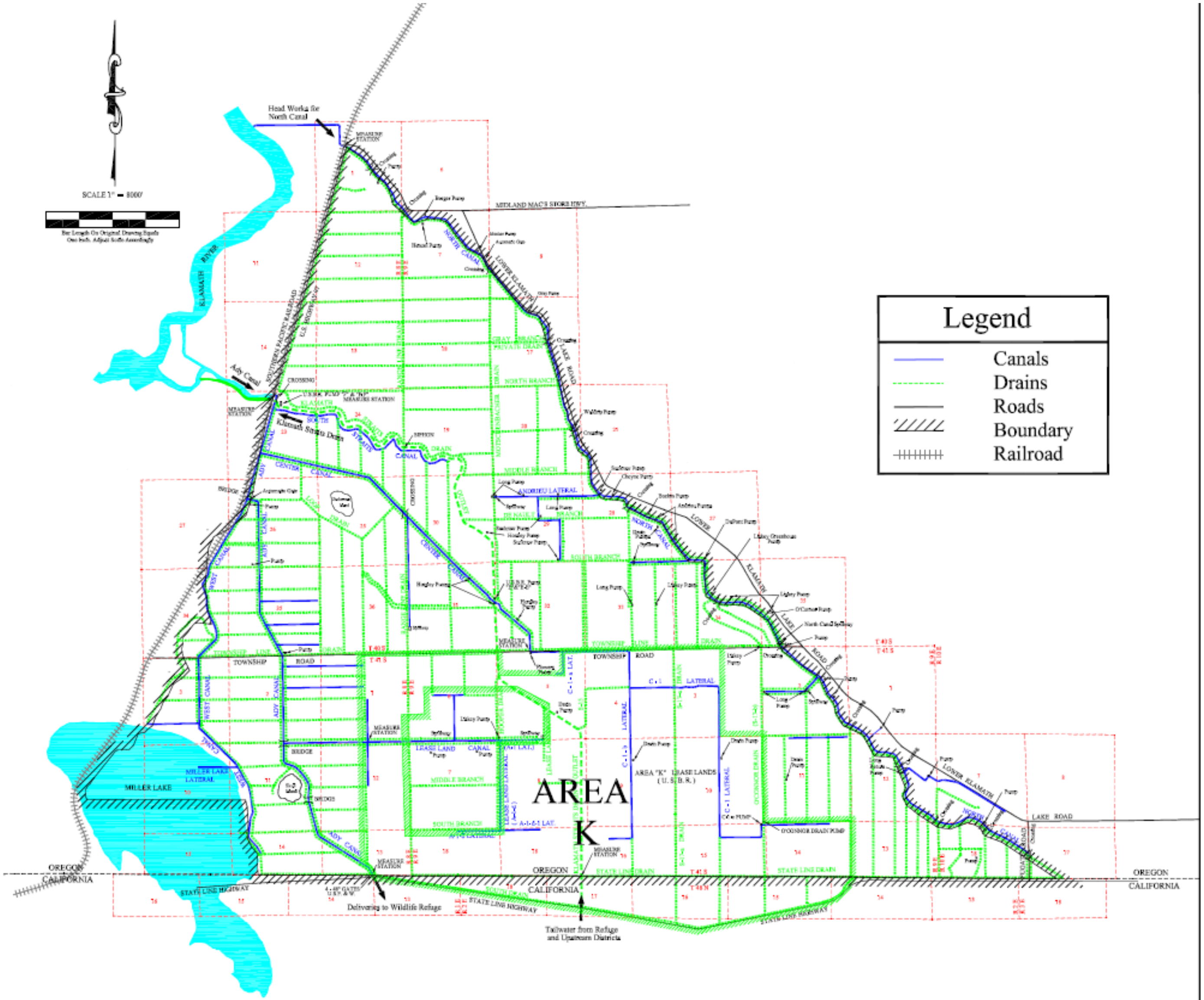

Figure C-13. Klamath Drainage District flow diagram.

Figure C-14. Example of break in southern North Canal levee.

Appendix D

Investigation and Analyses Report

D.1 National Economic Development Analysis

Highland Economics LLC

Klamath Drainage District

Barbara Wyse and Winston Oakley

7/3/2024

1 Introduction

This appendix outlines the costs and benefits of the Modernization Alternative (also referred to as the Project) and the No Action Alternative. The Modernization Alternative represents future conditions with federal funding through Public Law No. (Pub. L. No.) 83-566. The No Action Alternative represents the future if Klamath Drainage District (KDD or District) does not receive federal funding through Pub. L. No. 83-566 and continues current operation and management.

This National Economic Development (NED) analysis is divided into six sections. Following this introduction, the second section describes key economic analysis parameters. The third section describes the costs of the alternatives, while the fourth section presents benefits. The fifth section compares benefits and costs of the Modernization Alternative over the No Action Alternative. References are presented in the sixth section.

All economic values are presented in 2023 dollars rounded to the nearest $1,000. Unless otherwise noted, all NED values are presented in average annual values (following the approach described in the NRCS Water Resources Handbook for Economics) using the 2.5 percent planning rate for federal water projects for fiscal year 2023 (U.S. Bureau of Reclamation, 2022). Under this method, all costs and benefits are evaluated at the 2023 price level for all applicable years in the study period, then converted to a present value over the entire analysis period using the 2.5 percent planning rate as the discount rate. Finally, each present value is amortized to average annual values over the evaluation period using the 2.5percent rate.

1.1 Project Overview

The Klamath Drainage District (KDD or District) Infrastructure Modernization Project is an agricultural water conveyance efficiency and habitat improvement project. The Modernization Alternative would extend the North Canal to the Lower Klamath National Wildlife Refuge (LKNWR), install Supervisory Control and Data Acquisition (SCADA) systems, install a fish screen at North Canal diversion point on the Klamath River, replace the E and F pump stations, install recirculation piping infrastructure in the E Pumping Plant, and upgrade turnouts.

1.2 Project Location

The District is located just south of Midland in Klamath County, Oregon. The District serves roughly 27,000 acres of irrigated farmland. KDD diverts natural flow from the Klamath River and its tributaries, and also diverts stored water released from Upper Klamath Lake. The planning area is defined as the entire District.

1.3 Watershed Plan–EA Alternatives

1.3.1 No Action Alternative

Under the No Action Alternative, federal funding through Pub. L. No. 83-566 would not be available to implement the Project. The District and the Bureau of Reclamation (Reclamation), which operates pump plants in KDD, would continue to operate and maintain infrastructure consistent with past and current operations. The No Action Alternative assumes that modernization of the District's system to meet the purpose and need of the Project would not be reasonably certain to occur. The No Action Alternative is a near-term continuation of the standard operation procedures, which maximize the operational efficiency of the district with the current infrastructure.

1.3.2 Modernization Alternative

The Modernization Alternative is KDD's desired alternative. Under this alternative, federal funding through Pub. L. No. 83-566 would be available. The District would perform the following actions:

- Extend North Canal to LKNWR (2,451 feet or 0.46 miles)
- Install 14 SCADA systems
- Install a fish screen at the North Canal Diversion
- Upgrade the E and F Pumping Plants (currently owned and operated by Reclamation)
- Install recirculation piping infrastructure at the E Pumping Plant
- Upgrade 76 turnouts

2 Economic Analysis Parameters

This NED analysis compares the economic benefits and costs of the Modernization Alternative that differ from the No Action Alternative to estimate the net benefits of implementing the Modernization Alternative. All economic values are presented in 2023 dollars rounded to the nearest $1,000. Unless otherwise noted, all NED values are presented in average annual values (following the approach described in the NRCS Water Resources Handbook for Economics) using the 2.5-percent planning rate for federal water projects for fiscal year 2023 (U.S. Bureau of Reclamation, 2022). Under this method, all costs and benefits are evaluated at the 2023 price level for all applicable years in the study period, then converted to a present value over the entire analysis period using the 2.5 percent planning rate as the discount rate. Finally, each present value is amortized to average annual values over the evaluation period using the 2.5 percent rate.

2.1 Evaluation Unit

The proposed project consists of six project groups, which are the evaluation units for this analysis. Each of the project actions noted above under the Modernization is an evaluation unit. These are the project groups

1. Project Group (PG) 1 North Canal Extension
2. PG2 SCADA System
3. PG3 Fish Screen
4. PG4 E and F Pumping Plants
5. PG5 E Pump Recirculation
6. PG6 Upgraded Turnouts

An important note for the incremental analysis is that the costs for constructing any given project group would not change if it were the only project group to be constructed.

2.2 Project Implementation and Analysis Timeline

District staff predict that, if Pub. L. No. 83-566 funds are made available, construction of the six project groups would likely be completed over approximately three years, with some overlap in construction timing between project groups. For each project group, this analysis assumes that full benefits would be realized the year after construction is completed (e.g., for PG1 North Canal Improvements, which would be constructed in Year 0, full benefits would be realized in Year 1). This information is summarized in Table D-1.

2.3 Analysis Period

The analysis period is defined as 103 years, which includes three years of project construction/installation and 100 years of project life, based on the expected life of the North Canal Extension (during which time it is expected to bring significant project benefits). Accordingly, the study period extends from Year 0 (construction start) to Year 102 (last year of potential useful life for the project). The anticipated installation/construction timing, as well as the life of each project group, is summarized in Table D-1.

Table D-1. Construction Timeline and Project Life for the Modernization Alternative, Klamath River Watershed, Oregon.

Works of Improvement	Construction Start Year	Construction End Year	Project Life Start Year	Project Life End Year
PG1 North Canal Improvements	0	0	1	100
PG2 SCADA System	0	0	1	100
PG3 Fish Screen	1	2	3	102
PG4 E and F Pumping Plants	2	2	3	102
PG5 E Pump Recirculation	2	2	3	102
PG6 Upgraded Turnouts	1	1	2	101

Prepared July 2024

3 NED Costs

3.1 Costs of the No Action Alternative

Under the No Action Alternative, federal funding through Pub. L. No. 83-566 would not be available to implement the project. The District and Reclamation (which operates the E/EE and F/FF pumping plants within the District) would continue to operate and maintain the existing system consistent with past and current management, which would include replacing infrastructure that reaches the end of its useful life before the end of the period of analysis. Part of this continued management under the No Action Alternative would include planned replacement of several infrastructure components that would also be replaced under the Modernization Alternative. Specifically, under No Action, Reclamation anticipates replacing the E and F pumping plants (which would also be replaced in the PG4 under the Modernization Alternative, but in an earlier year) and KDD anticipates replacing a temporary pump (that would be rendered unnecessary by PG5 E Pump Recirculation in the Modernization Alternative). We present these No Action replacement costs in this section, and then compare them against the costs of the Modernization Alternative to estimate the NED cost difference between the No Action and Modernization Alternatives.

In the No Action Alternative, Reclamation plans to replace the 10 pumps that operate the current E, EE, F, and FF pumping plants during the period of analysis. Reclamation is currently replacing one pump every other year until all pumps are replaced; to date it has replaced two pumps in the EE and FF pumping plants (White, 2023). Reclamation would then have to replace these pumps roughly every 30 years after their initial replacement. Reclamation estimates that it would cost $1.44 million to replace all three E pumps (average cost of $480,000 per pump) and $1.405 million to replace all three F pumps (average cost of $468,000 per pump). The F pumps are assumed to be replaced in Years 1, 3, and 5, and again in every following 30-year increment based on a 30-year pump life. The E pumps are estimated to be replaced in years 7, 9, 11 and again in every following 30-year increment.[1] Because the timing and costs of replacing the EE and FF pumps would be unaffected by the Modernization Alternative, these replacement costs are not included.

Currently, recirculation on the Klamath Straits Drain is aided by a temporary, mobile pump. Under the No Action Alternative, KDD would have to replace this pump in roughly Year 20 at an estimated cost of $70,000, and again every 30 years afterwards (White, 2023). Accordingly, our analysis models a cost of $70,000 in Years 20, 50, and 80. This cost would be avoided in the Modernization Alternative by the PG5 E Pump Recirculation.

As shown in Table D-2, the annualized replacement costs under the No Action Alternative (that would be avoided under the Modernization Alternative) total $124,000.

[1] Reclamation did not provide information on the order of pump replacement for the 12 pumps. We assume that Reclamation would replace the E and F pumping plants first, since those were prioritized for replacement under the Modernization Alternative. We model the less expensive F Pumping Plant being replaced before the E Pumping Plant, which provides the most conservative estimate of the benefits of the Modernization Alternative (since discounting reduces the present value of future avoided costs).

Table D-2. Replacement Costs of the No Action Alternative, Klamath River Watershed, Oregon, 2023 dollars[1]

Works of Improvement	Cost per Replacement	Remaining Useful Life of Current Infrastructure (years)	Useful Life of Replacement Infrastructure (years)	Annualized Costs of Replacement
PG1 North Canal Improvements	N/A	N/A	N/A	$0
PG2 SCADA System	N/A	N/A	N/A	$0
PG3 Fish Screen	N/A	N/A	N/A	$0
PG4 E and F Pumping Plants	$2,845,000	1-11	30	$122,000
PG5 E Pump Recirculation	$70,000	20	30	$2,000
PG6 Upgraded Turnouts	N/A		N/A	$0
Total	**N/A**	**N/A**	**N/A**	**$124,000**

[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent. Prepared July 2024

3.2 Costs of the Modernization Alternative

The costs of the Modernization Alternative include the initial construction/installation costs of each project group, as well as other costs that are the direct result of project implementation that would occur during the analysis period. These costs are referred to as "Other Direct Costs" and include costs of operations, maintenance, and replacement (OMR). All costs are presented in 2023 dollars and converted to present value in the current year (and not the construction year), so no inflation of construction costs was included.

3.3 Project Installation Costs

Project installation costs include mobilization and staging of construction or installation equipment, delivery of construction materials to project areas, dewatering (where necessary), installation/construction of equipment, excavation (where necessary), compaction of backfill that is native material, restoration and reseeding of the disturbed areas, and any costs associated with obtaining easements or land acquisitions. There are no expected installation costs associated with cultural mitigation. In the case of PG2 SCADA System, the project installation costs include the equipment, installation (including providing power through solar panels or grid power), and set-up of the system.

The total cost of installation/construction of the Modernization Alternative is estimated at $16,524,000 (Farmers Conservation Alliance, 2023). This includes the costs of construction; engineering, construction management, survey costs (estimated at 10 to 30 percent of construction costs); contractor markup (estimated at 11 to 18 percent of construction costs); contingency costs (estimated at 12 to 30 percent of the subtotal of other cost components).

The total costs also include project administration costs for NRCS and KDD (estimated at 7 percent of the subtotal of previously mentioned cost components; the project administration total is split with 75 percent for NRCS and 25 percent for KDD), and technical assistance from NRCS (estimated at 8 percent of the subtotal of previously mentioned cost components). Permitting costs are estimated at 1 to 5 percent of construction costs. Easement costs (including associated contingency costs) are estimated to total $77,000. The costs of project installation are provided in

Table D-3 and Table D-4 (which correspond to NWPM 506.11 Economic Table 1 and NWPM 506.12 Economic Table 2, respectively). The average annualized cost of installation/construction of the Modernization Alternative is $435,000.

Table D-3. Estimated Installation Cost, Klamath River Watershed, Oregon, 2023 dollars.[1]

Works of Improvement	Unit	Federal Land – Number	Nonfederal Land – Number	Total – Number	Pub. L. No. 83-566 Federal Land NRCS[2]	Pub. L. No. 83-566 Nonfederal Land NRCS[2]	Pub. L. No. 83-566 Estimated Total	Other Funds Federal Land	Other Funds Nonfederal Land	Other Funds Estimated Total	Estimated Cost – Total
PG1 North Canal Improvements	acres	0.0	250.6	250.6	$0	$671,000	$671,000	$0	$256,000	$256,000	$927,000
PG2 SCADA System	square feet	4,055.9	3,822.0	7,877.9	$179,000	$168,000	$347,000	$54,000	$50,000	$104,000	$451,000
PG3 Fish Screen	acres	0.0	16.6	16.6	$0	$8,187,000	$8,187,000	$0	$2,545,000	$2,545,000	$10,732,000
PG4 E and F Pumping Plants	acres	0.1	0.0	0.1	$2,886,000	$0	$2,886,000	$865,000	$0	$865,000	$3,751,000
PG5 E Pump Recirculation	square feet	3,933.0	0.0	3,933.0	$489,000	$0	$489,000	$147,000	$0	$147,000	$636,000
PG6 Upgraded Turnouts	square feet	0.0	1,900.0	1,900.0	$0	$22,000	$22,000	$0	$5,000	$5,000	$27,000
Total project	**N/A**	**N/A**	**N/A**	**N/A**	**$3,554,000**	**$9,048,000**	**$12,602,000**	**$1,066,000**	**$2,856,000**	**$3,922,000**	**$16,524,000**

[1]Price base: 2023 dollars.
Prepared July 2024

[2]Federal agency responsible for assisting in installation of works of improvement.

Table D-4. Estimated Cost Distribution-Water Resource Project Measures, Klamath River Watershed, Oregon, 2023 dollars.[1]

Works of Improvement	Pub. L. No. 83-566 Construction	Pub. L. No. 83-566 Engineering	Pub. L. No. 83-566 Project Admin Subtotal [2]	Total Pub. L. No. 83-566	Other Funds - Construction	Other Funds - Engineering	Other Funds - Real Property Rights	Other Funds - Project Admin	Other Funds - Permitting	Total Other	Total - Installation costs
PG1 North Canal Improvements	$545,000	$22,000	$104,000	$671,000	$181,000	$7,000	$32,000	$6,000	$30,000	$256,000	$927,000
PG2 SCADA System	$286,000	$10,000	$51,000	$347,000	$95,000	$3,000	$0	$3,000	$3,000	$104,000	$451,000
PG3 Fish Screen	$6,758,000	$227,000	$1,202,000	$8,187,000	$2,252,000	$76,000	$45,000	$72,000	$100,000	$2,545,000	$10,732,000
PG4 E and F Pumping Plants	$2,382,000	$80,000	$424,000	$2,886,000	$793,000	$27,000	$0	$25,000	$20,000	$865,000	$3,751,000
PG5 E Pump Recirculation	$348,000	$33,000	$108,000	$489,000	$116,000	$11,000	$0	$5,000	$15,000	$147,000	$636,000
PG6 Upgraded Turnouts	$17,000	$1,000	$4,000	$22,000	$5,000	$0[3]	$0	$0	$0	$5,000	$27,000
Total project	**$10,336,000**	**$373,000**	**$1,893,000**	**$12,602,000**	**$3,442,000**	**$124,000**	**$77,000**	**$111,000**	**$168,000**	**$3,922,000**	**$16,524,000**

[1]Price base: 2023 dollars.
Prepared July 2024
[2]Includes project administration costs and technical assistance costs.
[3]Other Funds-Engineering for PG6 is less than $500 and was therefore rounded to $0.

3.4 Other Direct Costs

Other direct costs are costs that result from the project but occur after installation/construction. For the Modernization Alternative, other direct costs include additional OMR. In PG1 North Canal Improvements, the District estimates that operating and maintaining (O&M) the new infrastructure would require roughly $60,000 annually, which includes a new full-time equivalent (FTE) position. Furthermore, transporting an additional 1,000 acre-feet (AF) per year of water to LKNWR through the North Canal (as is further explained in Section 4.2.1.1.2) would cost roughly $75 per AF in additional O&M, or $75,000 per year. In PG2 SCADA System, KDD estimates that staff training and system maintenance would require about $10,000 per year. KDD estimates that maintaining the fish screen in PG3 Fish Screen will cost approximately $20,000 annually in O&M. Finally, KDD estimates that PG5 E Pump Recirculation will incur $10,000 per year in labor to adjust gates and $19,000 in annual energy costs (White, 2023).[2]

Accounting for timing of costs, (i.e., future costs are discounted) the average annualized cost of O&M under the Modernization Alternative is estimated at approximately $192,000, as shown in Table D-5.

Table D-5. O&M Costs Under the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Project Group	Increase in Average Annual O&M Costs	Annualized O&M Costs
PG1 North Canal Improvements	$135,000	$135,000
PG2 SCADA System	$10,000	$10,000
PG3 Fish Screen	$20,000	$19,000
PG4 E and F Pumping Plants	$0	$0
PG5 E Pump Recirculation	$29,000	$28,000
PG6 Upgraded Turnouts	$0	$0
Total	**$194,000**	**$192,000**

Note: Totals may not sum due to rounding. Prepared July 2024
[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

In addition to the O&M costs, some of the project components will require replacement prior to the end of the project life. SCADA and telemetry equipment has a useful life of roughly 20 years, while pumps in PG4 E and F Pumping Plants have a useful life of around 30 years. Accordingly, PG2

[2] This assumes equivalent energy use between diesel fuel under the No Action and electricity use under the Modernization Alternatives. The conversion uses factors of 3.79 gallons per liter, 30 percent efficiency in diesel's conversion to kinetic energy, and 10 kWh per liter of diesel, for a total of 162,364 kWh equating to 14,280 gallons of diesel. The cost of electricity is $0.12 per kWh (Neuman, 2023).

SCADA System will require replacement in Years 21, 41, 61, and 81 (20 years after installation and every 20 years thereafter); and PG4 E and F Pumping Plants will require pump replacements in Years 33, 63, and 93 (30 years after construction and every 30 years thereafter). The replacement costs under the Modernization Alternative are summarized in Table D-6.

Table D-6. Replacement Costs Under the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Works of Improvement	Cost per Replacement	Useful Life (years)	Annualized Costs of Replacement
PG1 North Canal Improvements	N/A	N/A	$0
PG2 SCADA System	$48,000	20	$2,000
PG3 Fish Screen	N/A	N/A	$0
PG4 E and F Pumping Plants	$1,797,000 [2]	30	$37,000
PG5 E Pump Recirculation	N/A	N/A	$0
PG6 Upgraded Turnouts	N/A	N/A	$0
Total	**N/A**	**N/A**	**$39,000**

[1] Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent. Prepared July 2024
[2] The cost of replacement is less than the cost of installation under the Modernization Alternative because it only includes the cost of pumps, motors, and gearheads, and does not include the design, engineering, and other non-infrastructure costs included in the Modernization Alternative.

In total, the other direct costs (including OMR costs) under the Modernization Alternative are estimated at $231,000, as shown in Table D-7.

Table D-7. Other Direct Costs of the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Works of Improvement	Annualized O&M Costs	Annualized Costs of Replacement	Annualized Other Direct Costs
PG1 North Canal Improvements	$135,000	$0	$135,000
PG2 SCADA System	$10,000	$2,000	$12,000
PG3 Fish Screen	$19,000	$0	$19,000
PG4 E and F Pumping Plants	$0	$37,000	$37,000
PG5 E Pump Recirculation	$28,000	$0	$28,000

Works of Improvement	Annualized O&M Costs	Annualized Costs of Replacement	Annualized Other Direct Costs
PG6 Upgraded Turnouts	$0	$0	$0
Total	**$192,000**	**$39,000**	**$231,000**

[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent. Prepared July 2024

3.5 Summary of Costs under the Modernization Alternative

The costs of the Modernization Alternative are equal to the estimated average annual installation/construction plus the other direct costs outlined above for each project group. In total, across all project groups, the average annual project costs are $666,000. These costs are summarized in Table D-8. Because there are costs under the No Action Alternative (as described in Section 3.1), the costs shown in the table below are not the NED costs (for the NED costs, see Table D-10).

Table D-8. Estimated Average Annual Costs of the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Project Group	Project Outlays (Amortization of Installation Cost)	Project Outlays Operation, Maintenance, and Replacement Cost	Total Average Annual Costs
PG1 North Canal Improvements	$25,000	$135,000	$160,000
PG2 SCADA System	$12,000	$12,000	$24,000
PG3 Fish Screen	$282,000	$19,000	$301,000
PG4 E and F Pumping Plants	$98,000	$37,000	$135,000
PG5 E Pump Recirculation	$17,000	$28,000	$45,000
PG6 Upgraded Turnouts	$1,000	$0	$1,000
Total	**$435,000**	**$231,000**	**$666,000**

Note: Totals may not sum due to rounding. Prepared July 2024
[1] Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

3.6 Costs of the Modernization Alternative Over the No Action Alternative

As described in Section 3.1, the No Action Alternative will require replacement costs that would be avoided under the Modernization Alternative. To calculate the NED costs, we start by subtracting the replacement costs under the No Action Alternative (shown in Table D-2) from the other direct costs under the Modernization Alternative, which include the replacement costs of the Modernization Alternative (shown in Table D-8). This is shown in Table D-9, where the second column is subtracted from the third column to generate the values in the last column. In the case of PG4 E and F Pumping Plants, the value in the last column is negative, indicating that the Other Direct Costs of the Modernization Alternative are lower than under the No Action Alternative.

Table D-9. Other Direct Costs of the Modernization Alternative Over the No Action Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Works of Improvement	Annualized Costs of Replacement under No Action Alternative	Other Direct Costs of the Modernization Alternative	Other Direct Costs the Modernization Alternative over the No Action Alternative
PG1 North Canal Improvements	$0	$135,000	$135,000
PG2 SCADA System	$0	$12,000	$12,000
PG3 Fish Screen	$0	$19,000	$19,000
PG4 E and F Pumping Plants	$122,000	$37,000	-$85,000
PG5 E Pump Recirculation	$2,000	$28,000	$26,000
PG6 Upgraded Turnouts	$0	$0	$0
Total	**$124,000**	**$231,000**	**$107,000**

[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent. Prepared July 2024

Combining the NED Other Direct Costs in the table above with the annualized installation costs (shown in Table D-8) provides the total annualized NED costs of the Modernization Alternative. These are shown in Table D-10, which corresponds to NWPM 506.18 Economic Table 4.

Table D-10. Estimated Average Annual NED Costs, Klamath River Watershed, Oregon, 2023 dollars.[1]

Project Group	Project Outlays (Amortization of Installation Cost)	Other Direct Costs of the Modernization Alternative over the No Action Alternative	Total Average Annual Costs
PG1 North Canal Improvements	$25,000	$135,000	$160,000
PG2 SCADA System	$12,000	$12,000	$24,000
PG3 Fish Screen	$282,000	$19,000	$301,000
PG4 E and F Pumping Plants	$98,000	-$85,000	$13,000

Project Group	Project Outlays (Amortization of Installation Cost)	Other Direct Costs of the Modernization Alternative over the No Action Alternative	Total Average Annual Costs
PG5 E Pump Recirculation	$17,000	$26,000	$43,000
PG6 Upgraded Turnouts	$1,000	$0	$1,000
Total	**$435,000**	**$107,000**	**$542,000**

Note: Totals may not sum due to rounding. Prepared July 2024
[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

4 NED Benefits

4.1 Benefits of the No Action Alternative

Relative to current conditions, there are no additional benefits of the No Action Alternative. Under the No Action Alternative, the District would continue under current management direction and management intensity, with no benefits above those currently provided. Consistent with current management direction and intensity, the District (and Reclamation, in the case of the E and F pumping plants) would replace aging infrastructure such as pumps at the end of their useful life.

4.2 Benefits of the Modernization Alternative

This section describes the benefits of the Modernization Alternative.

4.2.1 Project Benefits

The benefits of the Modernization Alternative include both on-site benefits (such as avoided District O&M costs) and off-site benefits (such as improved wildlife habitat and water quality benefits). The following subsections describe both on- and off-site benefits, some of which are quantified and included in the analysis (such as O&M savings) and others that are considered but not quantified (such as water quality). Of the Modernization Alternative benefits that are included and quantified in the analysis, the average annual values are summarized in Table D-11 for each project group (which corresponds to NWPM 506.20 Economic Table 5a).

Table D-11. Estimated Average Annual Damage Reduction Benefits, Klamath River Watershed, Oregon, 2023 dollars.[1]

PG1 North Canal Improvement On-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Reduced OMR	$10,000	N/A
On-site Subtotal	$10,000	N/A
PG1 North Canal Improvements Off-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Avoided Carbon Emissions[2]	N/A	$0
Habitat Value	N/A	$150,000
Off-site Quantified Subtotal	N/A	$150,000
PG1 Total Quantified Benefits	N/A	**$160,000**
PG2 SCADA System On-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Reduced OMR	$40,000	N/A
On-site Subtotal	$40,000	N/A
PG2 SCADA System Off-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Avoided Carbon Emissions[2]	N/A	$0
Habitat Value	N/A	$0
Off-site Quantified Subtotal	N/A	$0
PG2 Total Quantified Benefits	N/A	**$40,000**
PG3 Fish Screen On-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
On-Site Damage Reduction Benefits	N/A	N/A
Reduced OMR	$0	N/A
On-site Subtotal	$0	N/A

PG3 Fish Screen Off-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Avoided Carbon Emissions[2]	N/A	$0
Habitat Value	N/A	$0
Fish Value	N/A	Positive, Unquantified Benefits
Off-site Quantified Subtotal	N/A	$0
PG3 Total Quantified Benefits	**N/A**	**$0**
PG4 E and F Pumping Plants On-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Reduced OMR	$29,000	N/A
On-site Subtotal	$29,000	N/A
PG4 E and F Pumping Plants Off-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Avoided Carbon Emissions [2]	N/A	$0
Habitat Value	N/A	$0
Off-site Quantified Subtotal	N/A	$0
PG4 Total Quantified Benefits	N/A	**$29,000**
PG5 E Pump Recirculation On-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Reduced OMR	$77,000	N/A
On-site Subtotal	$77,000	N/A
PG5 E Pump Recirculation Off-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Avoided Carbon Emissions[2]	N/A	$1,000
Habitat Value	N/A	$0
Off-site Quantified Subtotal	N/A	$1,000
PG5 Total Quantified Benefits	N/A	**$78,000**

PG6 Upgraded Turnouts On-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Reduced OMR	$0	N/A
Water Use Transparency	Positive, Unquantified Benefits	N/A
On-site Subtotal	$0	N/A
PG6 Upgraded Turnouts Off-Site Damage Reduction Benefits	**Agricultural-related**	**Nonagricultural**
Avoided Carbon Emissions[2]	N/A	$0
Habitat Value	N/A	$0
Off-site Quantified Subtotal	N/A	$0
PG6 Total Quantified Benefits	N/A	**$0**

Note: Totals may not sum due to rounding. Prepared July 2024
[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.
[2]This value represents the benefit of avoided carbon emissions as measured by the social cost of carbon. These benefits would also accrue to local residents, but the majority of the value would be experienced outside the proposed project area.

4.2.1.1 Benefits Considered and Included in Analysis

4.2.1.1.1 O&M Cost Savings

Relative to the No Action Alternative, the Modernization Alternative would result in O&M cost savings for most project groups. In PG1 North Canal Improvements, KDD expects that $10,000 per year in O&M will be avoided due to reduced pumping in the Klamath Straits Drain. PG2 SCADA System is expected to save $40,000 per year in labor costs by avoiding the need to manually adjust water delivery infrastructure. PG5 E Pump Recirculation would save approximately $10,000 per year in labor costs needed to operate a temporary pump and avoid $71,000 per year in costs to fuel the pump (White, 2023).

PG4 E and F Pumping Plants will also result in O&M savings to KDD and Reclamation, who currently owns and manages the E, EE, F, and FF Pumping Plants.[3] These four pumping plants share the work of pumping Klamath Straits Drain water. The E and EE plants are colocated, and the F and FF pumping plants are colocated. Because these four plants share the total District pumping demand on the Klamath Straits Drain, their O&M is interrelated. By replacing the E and F pumping plants, the Modernization Alternative will impact O&M of all four pumping plants.

[3] KDD has initiated talks to transfer OMR responsibility for the E and F Pumping Plants from Reclamation to KDD, and it is assumed KDD would take responsibility for these plants under the Modernization Alternative.

Under the Modernization Alternative, KDD would assume control over the E and F pumping plants, which are expected to account for 99 percent of the total pumping load for the four plants (White, 2023). The four plants currently incur a total of roughly $428,000 per year in O&M costs under Reclamation management, including labor and materials (Brown, 2023).[4] Reclamation records indicate that annual O&M at the plants is proportional to the amount of pumping done at the plants.[5] Therefore, when the E and F pumping plants assume 99 percent of the total pumping, they are expected to assume 99 percent of the total O&M costs, or about $423,000 per year. Due to KDD's proximity to the pumping plants and associated reduce travel costs and lower labor costs of KDD personnel, KDD anticipates a 33 percent cost reduction in O&M relative to current Reclamation O&M costs (White, 2023). Given that Reclamation costs are an estimated $423,000 annually for the two primary pumping plants, this would represent a savings of $140,000 per year. We adopt this value as the estimated annual O&M savings when KDD has control of the E and F pumping plants. Under the No Action Alternative, we assume that KDD would take over the E and F pumping plants after Reclamation finished replacing all the E and F pumping plants in Year 11 (as explained further in Section 3.1). Therefore, O&M cost savings benefits of PG4 E and F Pumping Plants ($140,000 per year) would accrue from Year 3 to Year 11, when KDD would assume control over the pumping plants under the Modernization Alternative but not under the No Action Alternative. After Year 11, KDD would have control of the plants under both scenarios, so there would be no additional benefits of the Modernization Alternative.

The estimated annual O&M savings are shown Table D-12. In total, the project is expected to reduce District O&M costs by $156,000 per year.

Table D-12. Avoided District OMR Savings Under the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Project Group	Average Annual O&M Savings	Annualized O&M Savings
PG1 North Canal Improvements	$10,000	$10,000
PG2 SCADA System	$40,000	$40,000
PG3 Fish Screen	$0	$0
PG4 E and F Pumping Plants	$140,000[2]	$29,000
PG5 E Pump Recirculation	$81,000	$77,000

[4] This does not include the cost of energy use, which is expected to remain roughly the same under the Modernization Alternative (White, 2023).

[5] Reclamation records indicate that E and EE Pumping Plants do 45 percent of the pumping and require 44 percent of the O&M (Brown, 2023).

Project Group	Average Annual O&M Savings	Annualized O&M Savings
PG6 Upgraded Turnouts	$0	$0
Total	**$271,000**	**$156,000**

Note: Totals may not sum due to rounding. Prepared July 2024
[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.
[2]Benefits accrue only from Years 3 to 11.

4.2.1.1.2 Habitat Value

The Modernization Alternative is expected to enhance wetland habitat in LKNWR by (1) increasing operational flexibility in the distribution of water throughout LKNWR, and (2) increasing the average annual amount of drainage water from KDD available to wetlands in LKNWR. The wetland habitat at LKNWR is directly reliant on delivery of water through KDD. Without water deliveries from KDD, the amount of wetland habitat at LKNWR declines, and consequently, the wildlife population supported at the refuge also declines.

Currently, LKNWR can only receive tailwater from KDD through the Klamath Straits Drain and Ady Canal. The North Canal Extension Project increases operational flexibility by making it possible to deliver water directly to eastern areas of LKNWR that currently can only receive water after the more western portions of LKNWR have been over-watered. This operational flexibility may increase the acreage of wetlands that receive water in a given year. The Modernization Alternative would also allow KDD to deliver drain water from North Canal to LKNWR, which would provide LKNWR with an estimated 1,000 AF per year of additional water on average (White, 2023). An additional 1,000 AF per year water delivered to LKNWR would translate into 300 acres of additional wetland habitat at the refuge (Austin, 2022). In sum, by providing flexibility in water management and potentially increasing water deliveries, the Modernization Alternative would allow LKNWR to support a larger area of wetlands, which provide critical habitat to waterfowl and recreational opportunities to hunters and wildlife watchers.

4.2.1.1.3 Background on the Value of LKNWR

LKNWR was established in 1908 as the Nation's first waterfowl refuge (U.S. Fish and Wildlife Service, 2023a). As part of the Klamath Basin National Wildlife Refuge Complex, LKNWR is one of the most important sources of habitat for waterfowl on the West Coast's Pacific Flyway – a major waterfowl migration corridor that connects breeding grounds in the northern North America with major wintering grounds in South America (Gilmer, Yee, Mauser, & Hainline, 2004). Approximately 80 percent of the Flyway's migrating waterfowl travel through the Klamath Basin during spring and fall migrations, and around half of these waterfowl visit LKNWR, with totals reaching as many as 1.8 million birds (U.S. Fish and Wildlife Service, 2023a). These migrating birds rely on the refuge for rest, refueling, breeding, molting, and staging (California Waterfowl Association, 2023).

The refuge produces between 30,000 and 60,000 waterfowl annually and hosts a panoply of species: as many as 100,000 shorebirds, 500 bald eagles, 30,000 tundra swans, 500,000 ducks, 50,000 geese, sandhill cranes, white-faced ibis, heron, egret, cormorant, grebe, white pelican, and gulls (U.S. Fish and Wildlife Service, 2023a; U.S. Fish & Wildlife Service, 2022). Among the species hosted by

LKNWR are 25 species listed as threatened or sensitive by California and Oregon (U.S. Fish and Wildlife Service, 2023a; U.S. Fish & Wildlife Service, 2022).

Historically, the abundance of waterfowl in the Klamath Basin has offered a variety of quality recreational opportunities. Ducks are the most hunted species, and average bags range from three to four ducks when populations are plentiful (U.S. Fish & Wildlife Service, 2022). The variety and profusion of waterfowl also draw many bird watchers to LKNWR. Based on personal observations, refuge managers have historically estimated that visitation by birdwatchers and hunters is approximately 20,000 people annually (Austin, 2022). However, a recent count based on cell phone tracking indicated that there may have been as many as 61,000 non-local people visiting the Refuge in a recent year.

Recent water shortages at LKNWR have led to drastic decreases in the acreage of wetland habitat and the number of waterfowl visiting the Refuge. This, in turn, has led to declines in the number of recreators. From 1982 to 2012, the refuge averaged approximately 25,000 acres of wetlands; from 2013 to 2019, wetland acreage fell by nearly half (13,000 acres) (National Wildlife Refuge Association, 2022). LKNWR needs approximately 100,000 acre-feet of water per year to maintain 25,000 acres of wetlands (Trail, 2022). In 2022, there were no water deliveries to the refuge and, as a result, no wetlands (Trail, 2022). Spatial imaging suggests that around 95 percent of the Klamath Basin’s wetlands have been lost (Trail, 2022).

The lack of water in LKNWR has a devasting impact on the populations of visiting waterfowl. Despite historical records exceeding 1 million birds, LKNWR has not seen more than 0.5 million since 2002, and in 2022 the estimate was around 93,000, which was the lowest peak ever recorded (Trail, 2022). The lack of birds results in fewer outdoor recreationists visiting the refuge to hunt and watch wildlife (National Wildlife Refuge Association, 2022).

Recent federal funding allocations to support the Klamath Basin waterfowl habitats indicate the public importance of restoring the area’s wetlands. For example, the 2021 Infrastructure Investment and Jobs Act included $162 million to support restoration of Klamath Basin wildlife habitat (U.S. Congress, 2021). In May 2021, the NRCS allocated $3.8 million to enhance habitat for migratory waterbirds, fish, and other wildlife in the Klamath Basin (Dennis, 2022). Further, in 2022, the U.S. Fish and Wildlife Service announced $2.6 million in grant funding to Ducks Unlimited to improve wetland habitats in LKNWR and neighboring Tule Lake National Wildlife Refuge (Ducks Unlimited, 2022).

By increasing the water available for wetland habitats in LKNWR, the Proposed Action is expected to support greater numbers of waterfowl and recreation values both at LKNWR and throughout the Pacific Flyway, thereby increasing the value of the recreational and habitat benefits provided by LKNWR.

4.2.1.1.4 Estimates of the Economic Value of Wetland Habitat

Values of wetland habitat from economic literature vary broadly, ranging from a few dollars per acre up to hundreds of thousands of dollars per acre. Value varies depending on the type and location of the wetland, types of ecosystem services provided, and study methodology. In general, the highest values provided by wetlands are associated with the provision of the following ecosystem services: a) flood regulation and storm buffering, b) aesthetic views and open space, c) water quality enhancement, d) carbon storage, and e) biodiversity and habitat. Depending on the population, socioeconomic activities, and land uses near the wetland location, these ecosystem services can translate into economic, social, and cultural benefits related to recreation, food provision (e.g., from hunting), scenic amenities, avoided storm damages, climate regulation, and avoided water treatment costs. Additionally, many people directly value habitat function and species preservation. The following section summarizes the magnitude of these values as estimated in the natural resource economics literature. All values have been converted to 2023 dollars using the Gross Domestic Product Implicit Price Deflator (GDPIPD), unless noted otherwise.

Although conducted several decades ago, a particularly pertinent 1991 study estimated the value of San Joaquin Valley (SJV) wetlands to California residents. This study is pertinent because SJV is also part of the Pacific Flyway and provides habitat to some of the same waterfowl populations as LKNWR. The study found California residents' willingness prevent removal of 58,000 acres of wetlands in SJV averaged payments of $331 per household per year and $546 per year to increase wetlands by 40,000 acres[6] (Loomis, Hanemann, Kanninen, & Wegge, 1991). This translates to a value of $0.006 to $0.014 per acre per household per year. In 2021, there were an estimated 50,900 households in Upper Klamath Basin counties (Klamath, Siskiyou, and Modoc) (U.S. Census Bureau, 2021). If these households value the wetlands at rates similar to those California holds for SJV wetlands, the annual value of LKNWR wetlands to households in the Basin would range from approximately $300 to $700 per acre.

A follow-on 1997 study also examined the effect of distance on willingness to pay, with California households outside SJV willing to pay roughly $440 per year to increase SJV wetlands by 40,000 acres, and Oregon households willing to pay $140 per year (Pate & Loomis, 1997). This translates to values of $0.004 (for Oregon) to $0.011 (for California outside the SJV) per household per acre per year. The study's results indicate that the value of wetlands in the Modernization Alternative may extend well beyond the Klamath Basin. If we apply these values to the households of California and Oregon that lie outside the Klamath Basin counties,[7] and conservatively use the Oregon household value of $0.004 per household per acre per year, the annual value per acre of LKNWR wetlands (including the previously cited values within the three-county area) would be roughly $17,000 per acre.

In addition to the studies specific to wetland areas of the Pacific Flyway, there are numerous studies of wetland value in the economics literature. One 2008 review and meta-analysis of U.S. wetland valuation studies aimed to use values from the economics literature to quantify the economic benefits of U.S. agricultural conservation programs (Randall, Kidder, & Chen, 2008). For wetland habitat, the study identified 72 valuations of terrestrial habitat from 34 U.S. studies. This study found that the average value per acre per year of all services provided by freshwater wetlands was approximately $580 per acre[8], including the value for habitat, aesthetics, and general open space value. For a Prairie Pothole region wetland (which may be similar to LKNWR wetlands in the sense that they are shallow and are particularly important for birds in the Central Flyway), however, the estimated average value was approximately $43 per acre per year.[9] On the other hand, compared to the average Prairie Pothole region wetland, LKNWR wetlands would be expected to have much higher recreation and aesthetic benefits as they are open and accessible to the public (in contrast to

[6] The study presented values of $154 and $254 in 1988 dollars, which we inflated to 2022 dollars using the GDPIPD.

[7] California households totaled 13,217,586 in 2021, while Oregon households totaled 1,658,091 (U.S. Census Bureau, 2021).

[8] The study presented this value as $424.46 in 2007 dollars.

[9] The study presented per acre value as $31.30 in 2007 dollars.

conservation reserve program lands that are on private land). LKNWR wetland habitat would likely also have relatively high habitat benefits given that there are Refuge staff actively managing the habitat.

A 2006 review of 215 wetland value observations obtained from 80 studies found an average wetland values per acre of $2,002 annually, but a much lower median value of $107 per acre per year (Brander, Raymond, & Vermaat, 2006).[10] This same study, however, found that for wetlands providing biodiversity services, the biodiversity benefit was valued at $12,200 per acre per year on average.[11] Finally, a 2001 review of 39 wetland valuation studies estimated average wetland value per acre at $1,825 per year (Woodward & Wui, 2001).[12] This study also estimated value for single service wetlands. This study indicated that the highest valued service provided by wetlands is birdwatching, with an average value of $2,417 per acre per year.[13] As LKNWR is managed for biodiversity and is open and accessible to the public for birdwatching (and hunting), these values may be reasonable for LKNWR habitat.

As another approach, we review the value per acre that the NRCS is paying for wetlands as part of the Wetland Reserve Easement (WRE) program. As part of its Agricultural Conservation Easement Program, NRCS purchases WRE on private farmland. The easement value is based on the lowest of the following three values: an appraisal, a Geographic Area Rate Cap (GARC), or a landowner offer. In Modoc and Siskiyou counties for the Fiscal Year 2023, the GARC for WRE payment for a permanent easement on irrigated pasture and wet meadow is $4,640 per acre; payment for a permanent easement on wild rice or cropland with a marginal water supply is $3,000 per acre; and payment for a permanent easement on wild rice or cropland with 100 percent water supply is $5,325 per acre (Natural Resources Conservation Service, 2022). Over 100 years using a 2.5 percent discount rate this equates to approximately $145 per acre per year that NRCS is willing to pay for an acre of wetland in Siskiyou and Modoc counties. This payment is based on the agricultural value of the land but indicates that NRCS expects that the ecosystem service value of wetlands on farms is at least $145 per acre.

WRE payments are intended to compensate landowners for the value of their land in exchange for restoring habitat areas; by enrolling the WRP, landowners sell most of their use rights with the exception of hunting, fishing, and other recreational use. In other words, WRE payments do not represent the value of the wetland habitat, but rather the difference in the market value of the land with and without the easement. However, the WRE payments nonetheless indicate government agencies' willingness to pay for the habitat and other benefits provided by wetlands.

As another approach, we review the price of credits in regional wetland mitigation banks. Wetland mitigation banks are wetlands that have been created or restored to offset the loss of wetlands elsewhere in the region due to development or other causes. The price of wetland mitigation banking provides a useful reference point because it indicates the cost of providing the wetland benefits of PG1 North Canal Improvements through alternative means. Because wetland mitigation

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[10] Values reported in the study were $2,800 and $155 per hectare in 1995 dollars, which we inflated to 2023 dollars and converted to per acre values.

[11] Value reported in the study was $17,000 per hectare in 1995 dollars, which we inflated to 2023 dollars and converted to per acre values.

[12] Value reported in the study was $915 per acre in 1990 dollars, which we inflated to 2023 dollars.

[13] Values in the study were reported as $1,212 in 1990 dollars, which we inflated to 2023 dollars.

is typically required by law to ensure continued provision of ecosystem services, the public policy of requiring mitigation indicates that the perceived value of benefits of ecosystem services provided by mitigated wetlands outweigh the costs of mitigation.

The Oregon Department of State Lands (DSL) administers the State's wetland mitigation program and provides a calculator to compute the costs of DSL-provided wetland mitigation. According to this calculator, the cost of wetland mitigation banking in the Klamath River Basin ranges from roughly $59,000 to $206,000 per acre depending on the number of mitigation credits generated per acre (Oregon Department of State Lands, 2021).[14] Amortizing over 100 years at a 2.5-percent discount rate, this equates to approximately $1,610 per acre per year to $5,600 per acre per year.

Table D-13 summarizes the values described above from the literature. As noted above, wetlands differ in type and quality, and both ecological and economic benefits from their protection vary by location. In addition, wetland benefits are not constant for every acre, but vary depending on size and configuration. As noted by authors of one of the wetland meta-analysis studies, "The use of benefits transfer to estimate wetland values faces substantial challenges. From our analysis it is clear that the prediction of a wetland's value based on previous studies is, at best, an imprecise science" (Woodward & Wui, 2001). So, while the benefit estimates from previous studies relate to the conservation of wetlands, it is difficult to know how the average value from these studies would compare to the value per acre of wetlands in the LKNWR.

Table D-13. Wetland Values from Scientific Literature, 2023 dollars.[1]

Study or Source	Value per acre per year (2023$)	Description of Value
Loomis, Hanemann, Kanninen, and Wegge (1991)[2]	$56,200	Willingness to pay of California households to prevent loss of wetlands in the San Joaquin Valley
Loomis, Hanemann, Kanninen, and Wegge (1991)[2]	$134,300	Willingness to pay of California households to increase wetlands in the San Joaquin Valley
Pate and Loomis (1997)[2]	$121,900	Willingness to pay of California households outside the San Joaquin Valley to increase wetlands in the San Joaquin Valley
Pate and Loomis (1997)[2]	$4,200	Willingness to pay of Oregon households to increase wetlands in the San Joaquin Valley
Randle, Kidder, and Chen (2008)	$600	Average value of wetlands from 34 U.S. studies

[14] This calculation is based on a real market value of land set at $1,899 per acre, which is the most common assessed value of land for a sample of parcels in Klamath County that lie within LKNWR boundaries (Klamath County, 2023). The restoration cost in the Klamath Basin ($35,899 in 2021 dollars) was adjusted for inflation to $39,710 in 2023 dollars using the GDPIPD.

Study or Source	Value per acre per year (2023$)	Description of Value
Randle, Kidder, and Chen (2008)	$40	Average value of wetlands in the Prairie Pothole region
Brander, Raymond, Vermaat (2006)	$2,000	Average value of wetlands from 80 studies
Brander, Raymond, Vermaat (2006)	$100	Median value of wetlands from 80 studies
Brander, Raymond, Vermaat (2006)	$12,200	Average value of wetlands providing biodiversity benefits
Woodward and Wui (2001)	$2,400	Value of wetland that provides bird watching opportunities
Natural Resources Conservation Service (2022)	$145	GARC for WRE payment for a permanent easement on wild rice or cropland with a 100% water supply in Modoc and Siskiyou Counties, amortized to an annual payment.
Oregon Department of State Lands (2021)	$1,610	Estimated cost of wetland mitigation banking when each acre is worth 1 mitigation credit, amortized to an annual payment.
Oregon Department of State Lands (2021)	$5,600	Estimated cost of wetland mitigation banking when each acre is worth 3.5 mitigation credits, amortized to an annual payment.

[1]All values in the original studies were converted to 2023 dollars per acre per year. Prepared July 2024
[2]Values were derived by multiplying per-household values by the number of households in the original study and dividing by the acreage change.

However, as noted above, relative to other wetlands, LKNWR wetlands would be expected to have relatively high habitat value based on their location in the Pacific Flyway and their use by a diverse range of waterfowl, including many special status species. It is also expected to have relatively high recreation and aesthetic value given it is a public refuge. To be conservative, we apply the approximate midpoint of the range of values (about $300 to $700 per acre per year) estimated for the value of SJV wetlands,[15] which support the same migratory waterfowl as the LKNWR: $500 per acre per year. We expect that this is a conservative or minimum per acre value of LKNWR wetlands. Accordingly, when presenting this value in the NED, we indicate a + sign after this value to indicate that it is likely an underestimate of total value.

KDD expects to supply the LKNWR with an additional 1,000 AF of water on average each year (White, 2023). This water is expected to support 300 acres of additional wetland habitat (Austin,

[15] This per acre value reflects only the estimated value of LKNWR wetlands to Upper Klamath Basin households (based on per household values per acre for wetlands derived in the San Joaquin Valley), and thus, is a conservative estimate of value.

2022). At a value of $500 per acre per year, the additional 300 acres of wetland would provide benefits of $150,000 per year. Because PG1 North Canal Improvements would contribute all the additional water, it would generate all the additional benefits, as shown in Table D-14.

Table D-14. Annual Average Wetland Habitat Benefits of Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Project Group	Annual Additional Water Deliveries to LKNWR (AF/yr)	Additional Wetland Habitat Supported (acres)	Average Annual Net Benefit of Wetland Habitat
PG1 North Canal Improvements	1,000	300	$150,000+
PG2 SCADA System	0	0	$0
PG3 Fish Screen	0	0	$0
PG4 E and F Pumping Plants	0	0	$0
PG5 E Pump Recirculation	0	0	$0
PG6 Upgraded Turnouts	0	0	$0
Total	**1,000**	**300**	**$150,000+**

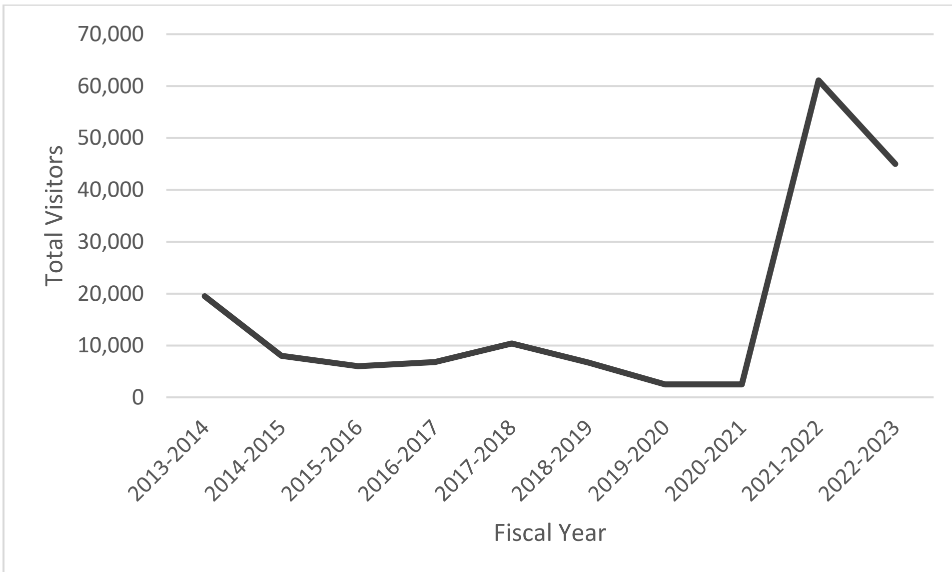
Note: Totals may not sum due to rounding. Prepared July 2024
[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

4.2.1.1.5 Recreation Value of Habitat

Another method of assessing the benefits of PG1 North Canal Improvements is to estimate the value of increased recreation due to the additional wetland habitat. LKNWR hosts tens of thousands of visitors each year who birdwatch, hunt, explore the Refuge by vehicle and by foot, take photographs, and visit the visitor center (U.S. Fish and Wildlife Service , 2023b). Because the amount of wetland habitat is a key determinant in the size of bird populations migrating through the Refuge, and because the birds are the primary attraction for visitors (whether hunting or observing), the amount of wetland habitat has an indirect but important impact on visitation levels at the LKNWR (Austin, 2022). By increasing the amount of wetland habitat, PG1 North Canal Improvements could positively impact recreation levels at the LKNWR. However, we do not estimate this value due to the inadequacy of available data, as explained further below.

Data on visitation at the LKNWR comes from U.S. Fish and Wildlife Service's National Wildlife Refuge System's Annual Performance Reports from Fiscal Years (FY) 2013–2014 and 2022–2023 (U.S. Fish and Wildlife Service , 2023b). This data is shown in Figure D-1. The chart shows a drastic increase in visitors to the LKNWR in FY 2021–2022, which is unexpected given it was a dry year with little to no water deliveries. We would expect visitation to be much higher in 2017, given that water deliveries in this year were over eight times higher than in 2022 and peak fall duck counts were at their highest level since 2014 (White, 2023; Vradenburg, 2023).

This unexpected pattern is due to a change the Refuge made in the method of visitor counting. Prior to 2022, the Refuge used professional judgement to estimate visitation levels, but starting in 2022, they began using a service that tracked cell phone locations. The service counted any cell phone that was turned on and had location tracking enabled, stopped for 15 minutes or more at one of the Refuge's main lots, and had a billing address farther than 50 miles distant. In this way, the service counts a portion of the non-local visitors to Refuge parking lots; it does not count local visitors, visitors without cell phones, or any visitor who did not have their cell phone turned on with tracking enabled during their visit. Because of this, the Klamath National Wildlife Refuge Complex's Visitor Services Manager considers the more recent counts "an accurate minimum" of the Refuge's actual visitation (Fitzroy, 2022).



Source: (U.S. Fish and Wildlife Service , 2023b)

Figure D-1. Total Visitation to the LKNWR, FY 2013–2014 to 2022–2023.

The drastic difference in visitor counts between the previous method and the new method make it difficult to ascertain what the actual level of visitation is at the LKNWR, and how it varies depending on water deliveries. Because of a lack of water deliveries in 2022, the Refuge had the lowest peak population count of waterfowl ever recorded, and the 2022/2023 hunting season was closed (U.S. Fish & Wildlife Service, n.d.; Trail, 2022). Accordingly, we would expect that visitation would be lower than normal in 2022. Because the data shows a drastic increase, it is likely that the counts prior to 2022 were inaccurately low. However, it is also unclear why so many people visited the Klamath Basin Complex Refuges when there were so few birds and no hunting opportunities, although it is possible the COVID-19 pandemic played a role in people's outdoor recreation decisions.

Given the issues with the data, we are not able to reliably estimate the change in visitor levels that are likely to result from an increase in wetland habitat under the Modernization Alternative. It is possible, and even likely, that the change in visitation would be small given the small relative increase in wetland acreage. The 300-acre increase that is expected to occur under the Modernization Alternative represents less than one percent of the roughly 33,000 acres of wetland habitat provided at the LKNWR over the last decade (U.S. Fish and Wildlife Service , 2023b). Given the small relative increase, it is possible that visitation response may be small under the Modernization Alternative.

However, even if visitation response or value per visit effects at the LKNWR are small, total recreation value of enhanced habitat and waterfowl productivity could still be large as wildlife-related recreation throughout the entire Pacific Flyway may be enhanced by increased bird populations. Recreation value is also just one portion of the value provided by the Refuge, as it does not include benefits to people who value the existence of the Refuge's habitat and the ability to maintain the habitat for future generations, or values related to other ecosystem services provided by wetlands. In summary, because of a lack of reliable visitor data, and because recreation would only represent a fraction of the total value of increasing wetland habitat, this analysis does not estimate the value to recreation of increased wetland habitat at LKNWR.

4.2.1.1.6 Carbon Emission Reductions

The Modernization Alternative is expected to reduce carbon dioxide (CO_2) emissions by switching the fuel used to recirculate drain water. Specifically, PG5 E Pump Recirculation will replace a temporary, diesel-powered, mobile pump with permanent electric pumps in the E Pumping Plant. The switch from diesel fuel to electricity is expected to reduce CO_2 emissions. The current diesel pump uses approximately 14,280 gallons of diesel per year.[16] At 22.45 pounds of CO_2 per gallon of diesel, the annual fuel use generates approximately 145 metric tons (Mt) of CO_2 (U.S. Energy Information Administration, 2023). Every megawatt-hour (MWh) of energy used by electric pumps is estimated to translate into approximately 0.7525 Mt of carbon emissions.[17] By assuming the new pump will require an equivalent amount of energy to the old pump, we estimate the electric pumping will require approximately 162 MWh per year.[18] The associated CO_2 emissions would be approximately 121 Mt per year. Accordingly, the Modernization Alternative would result in an estimated reduction of 23 Mt of CO_2 each year.[19]

To value the potential decrease in carbon emissions, this analysis uses the social cost of carbon (SCC) per ton of carbon dioxide, which is the estimated incremental additional cost to society per unit of carbon emitted based on the expected damages associated with climate change. There are many estimates of the SCC, and the estimates vary based on what types of damages are included, the discount rate chosen, the geographic area under consideration (such as global damages versus U.S. domestic damages), and the projected level of global warming and associated damages. The Office

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[16] Estimate based on KDD's total fuel cost of $71,400 in Fiscal Year 2021-2022 and a fuel cost of $5.00 per gallon (White, 2023).

[17] This assumes that marginal changes in energy demand are met with fossil fuel-based production, such that 100 percent of District hydro energy production results in reduced fossil fuel powered generation. This is reasonable since PacifiCorp's baseload power is almost entirely fossil fuel-based, and the hydropower generated under the Modernization Alternative is expected to displace PacifiCorp's baseload power (Perkins, 2022). Furthermore, this estimate assumes 0.7521 metric tons of carbon emitted from one MWh of fossil fuel powered electricity generation based on 1) the current proportion of fuel sources—oil, natural gas, and coal—for fossil fuel powered electrical power generation in the West, and 2) the associated metric tons of CO_2 produced per MWh powered by each fossil fuel source, as reported by the Energy Information Administration.

[18] Using a conversion factor of one liter of diesel equating to 10 kWh of electricity and 30 percent energy conversion efficiency.

[19] While some construction activities under the Modernization Alternative would increase carbon emissions through the use of vehicles and heavy machinery, the amount of emissions from these sources is relatively small and temporary. These emissions would also likely be offset by the annual vehicle emissions avoided when the need to inspect and maintain canals is reduced (as described in the Operations and Maintenance Cost Savings section). For these reasons, we do not include vehicle emissions in the analysis of carbon.

of Management and Budget convened an Interagency Working Group (IWG) on the Social Costs of Greenhouse Gases, which in 2013 developed a set of SCC estimates that could be used across federal agencies (Interagency Working Group on Social Cost of Greenhouse Gases, 2013). In February 2021, the IWG updated its estimates of the SCC. They estimated that in the year 2020, at a 3 percent discount rate, the SCC value was $59 per Mt (Interagency Working Group on Social Cost of Greenhouse Gases, 2021).[20] We apply this value to the net change in carbon emissions each year throughout the project life to estimate the change in carbon emissions from the Modernization Alternative.

At an SCC value of $59 per Mt, the 23 Mt of annual avoided carbon emissions would have a value of roughly $1,000 (as shown in Table D-15).

Table D-15. Annual Average Reduction in Carbon Costs of Modernization Alternative, Hood River Watershed, Oregon, 2023 dollars.[1]

Project Group	Annual Carbon Emissions Under No Action Alternative (Mt/yr)	Annual Carbon Emissions Under Modernization Alternative (Mt/yr)	Annual Carbon Emissions Avoided (Mt/yr)	Average Annual Net Benefit of Avoided Carbon Costs
PG1 North Canal Improvements	0	0	0	$0
PG2 SCADA System	0	0	0	$0
PG3 Fish Screen	0	0	0	$0
PG4 E and F Pumping Plants	0	0	0	$0
PG5 E Pump Recirculation	145	121	23	$1,000
PG6 Upgraded Turnouts	0	0	0	$0
Total	**145**	**121**	**23**	**$1,000**

Note: Totals may not sum due to rounding. Prepared July 2024
[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent.

4.2.1.2 Benefits Considered but Not Included in Analysis

This section describes potential benefits of the Modernization Alternative that are not quantified in the analysis.

4.2.1.2.1 Fish Value

The PG3 Fish Screen is expected to prevent fish from the Klamath River from entering the North Canal Diversion and becoming entrained in KDD's water conveyance system. The Oregon

[20] This value has been adjusted for inflation to 2023 dollars using the GDP Implicit Price Deflator.

Department of Fish and Wildlife has found that "more than 98 percent of young salmon and steelhead survive an encounter with a properly designed fish screen" (Oregon Department of Fish and Wildlife, 2013). Entrained fish are likely to perish in KDD's conveyance system. The project will protect fish populations in the Klamath River, including the shortnose sucker and Lost River sucker, which are federally listed endangered species (U.S. Fish and Wildlife Service, 2023c). The Upper Klamath River is designated Critical Habitat for these species.

The importance of the fish screen would increase in the near future as salmon (which are protected at both state and federal levels) are reintroduced to the Upper Klamath River. Reintroduction is planned now that the four dams that once blocked salmon passage on the Klamath River have been removed(California Trout, 2023). Once salmon repopulate the Upper Klamath River, the PG3 Fish Screen would help ensure that KDD's North Canal diversion does not negatively impact their recovery.

Reestablishing fish habitat in the Klamath River is a national priority due to the ecological and cultural values supported by this habitat. Prior to the dams' construction, the Klamath River was the third-largest salmon-producing river on the West Coast, and it served as an important food source for native tribes in the area (National Oceanic and Atmospheric Administration, 2022). The River was once home to Chinook salmon, coho salmon, steelhead, Pacific lamprey, bull trout, and Redband trout, among other species; all of which have experienced declines in population due to various sources of habitat degradation, including the erection of dams (O'Keefe, Pagluico, Scott, Cianciolo, & Holycross, 2022). This has changed the lives of native tribes that have relied on the fish as a major source of food, cultural practices, and way of life. Removing the dams will reopen access to more than 400 miles of habitat for these fish species, including the stretch of river where the PG3 Fish Screen would be located (National Oceanic and Atmospheric Administration, 2022).

The PG3 Fish Screen has been designated as an important component in the federal planning process to restore the Upper Klamath River. To prioritize the projects most important to reestablishing salmon species in the Klamath River, a team of experts comprised of staff at the National Oceanic and Atmospheric Administration (NOAA), the Pacific State Marine Fisheries Commission (PSMFC), and Trout Unlimited (TU) ranked the importance of potential Klamath habitat restoration and fish screening projects. Among the projects evaluated in their 2022 report was the PG3 Fish Screen at the North Canal Diversion. The team assessed projects based on their size, the number of fish species affected, and the impact on fish. Out of 91 diversions that were evaluated for fish screening projects, 26 projects received the highest priority ranking. The PG3 Fish Screen was one of these 26 projects receiving the highest priority ranking. Only one fish screen received a higher overall priority score than the PG3 Fish Screen (O'Keefe, Pagluico, Scott, Cianciolo, & Holycross, 2022).

The 2022 study prioritizing projects did not directly estimate the number of fish deaths that would be avoided by each fish screen, nor were there other sources available for quantifying the ecological benefit of the PG3 Fish Screen. For this reason, we do not attempt to quantify the benefits of the PG3 Fish Screen. However, for context, we note that people in the Pacific Northwest highly value salmon species, even if they do not consume them for food or enjoy them recreationally. One recent economic study found that, on average, households in the Pacific Northwest value a one-year increase of 1,000 salmon between $0.09 and $0.22 (Lewis, Kling, Dundas, & Lew, 2022).[21] Applying the average of $0.16 per household to 9.4 million households in the Pacific Northwest (as the

[21] We adjusted the original values of $0.08 and $0.19 from 2017 dollars to 2023 dollars using the GDPIPD.

original study did) results in total value of roughly $1,500 per fish. At this rate, PG3 Fish Screen would have to save approximately 200 salmon per year in order to outweigh its total annual costs of $308,000. In addition to the value to the general Pacific Northwest population, enhancing salmon restoration provides cultural value of the fish to the tribes, whose traditional way of life depends on the species.

The Modernization Alternative includes PG3 Fish Screen because it will provide ecological and cultural benefits and is an important component of restoring the Upper Klamath River, a federal priority. This fish screen was chosen as the Modernization Alternative for PG3 Fish Screen because it represents the least expensive alternative that still met the efficacy standards for the fish screen. A discussion of the alternatives, their associated costs, and efficacy is provided in Section 5 of the Plan-EA.

4.2.1.2.2 Water Use Transparency and Control

PG6 Upgraded Turnouts would install new monitoring equipment at 76 patron turnouts that would allow KDD to measure the amount of water going to each patron. This would provide the District and its patrons with a variety of benefits. First, KDD would be able to ensure the correct allocation of water for each patron, ensuring fairness and compliance with water right quantity and seniority. The upgraded turnouts would also help avoid and resolve conflicts over water, since accurate measurements would enhance accountability and help ensure use of water in accordance with allotment. This would help to foster cooperation and trust within the District. It would also provide patrons with the ability to monitor their own water use, which may help them better manage their allotted water and optimize their crop yields. The likelihood of any change in on-farm production and the magnitude of any change is not known, nor are there known case studies to draw from to make an educated estimate, so this potential benefit is not quantified. While the social benefits of monitoring and measuring water use are also not quantifiable, they are expected to be valuable to the community. In sum, while PG6 Upgraded Turnouts does not have any quantified benefits in this analysis, it is included in the Modernization Alternative because the qualitative benefits are believed to outweigh its small, annualized cost ($1,000).

In addition to reducing O&M costs, PG2 SCADA System will generate agricultural water management benefits. The system will allow the District to deliver water with more precision, providing the desired amount of water when it is needed to the areas that require it. This will increase water management efficiencies, which has the potential to reduce water waste and improve patron yields. Because these benefits to water management are difficult to predict and quantify, we do not include them in this analysis. However, they are expected to be positive.

4.2.1.2.3 Instream Flow Quantity and Quality

PG5 E Pump Recirculation would allow KDD to increase their reuse of water drained off District fields, which would effectively increase the total amount of usable water available to the District and reduce pollutants entering the Klamath River. This could help alleviate some of the water quantity and quality problems in the Klamath River. In dry water years, the Klamath River suffers from low flows (Neumann, 2022). The river typically has poor water quality in the summer as a result of natural processes and man-made pollution, including agricultural runoff from KDD’s system (Sullivan, Sogutlugil, Deas, & Rounds, 2014).

Reusing the drain water could result in more water staying in the Klamath River. If KDD extracts less than its full water rights in a given year, the amount of water recirculated by PG5 E Pump Recirculation would offset water KDD would otherwise extract from the Klamath River (White, 2023).[22] In this way, PG5 E Pump Recirculation could allow for more water to remain instream. Additionally, when drain water is reused rather than flowing into the Klamath River, it reduces the amount of agricultural runoff into the river. A 2014 study by the U.S. Geological Survey found that recirculating water in the Klamath Straits Drain (as PG5 E Pump Recirculation would do) could reduce pollutant loads in the Klamath River (Sullivan, Sogutlugil, Deas, & Rounds, 2014).

If PG5 E Pump Recirculation improves instream flow, it could have beneficial effects on wildlife. Multiple protected species rely on the river, including the shortnose sucker, Lost River sucker, coho salmon, and Southern Resident Killer Whales (through their reliance on Chinook salmon as food) (Neumann, 2022). If the improved flows benefited these species, it would likely generate economic benefits. Numerous scientific studies have demonstrated that people derive value from protecting and supporting endangered species and salmon specifically (Bell, Huppert, & Johnson, 2003; Loomis J. , 1996; Layton, Brown, & Plummer, 2001; Olsen, Richards, & Scott, 1991; Richardson & Loomis, 2009). Consequently, PG5 E Pump Recirculation could generate economic benefits by enhancing instream flow conditions.

While improved instream flow (water quantity and quality) is a potential benefit of the Modernization Alternative, we do not quantify it due to the uncertainty surrounding the magnitude of the water improvements (i.e., how much additional water and the improvement to water quality) and the degree to which those improvements would improve species populations.

4.2.1.3 Benefits of the Modernization Alternative over the No Action Alternative

Because the No Action Alternative provides no benefit above current conditions, the NED benefits of the Modernization Alternative over the No Action are equal to the NED benefits of the Modernization Alterative. These are summarized above in Table D-11.

5 NED Benefits Compared to Costs

Across all project groups, the Modernization Alternative would provide quantified net average annual NED benefits of -$235,000. The NED costs and benefits are summarized in Table D-16 (which corresponds to NWPM 506.21 Economic Table 6). Overall, in addition to the quantified benefits, the Modernization Alternative would provide benefits by protecting wildlife, providing water use transparency, improving water quality, and bolstering the reliability and efficiency of KDD. The Project also helps to increase the overall reliability of water necessary to sustain the rural way of life and the Klamath Basin community identity rooted in historic agricultural land uses.

[22] If KDD uses its full water rights in addition to the water reused with PG5 E Pump Recirculation, the reused water would not be offsetting extractions from the Klamath River, it would simply be augmenting the District's water supply and helping to alleviate agricultural damages. These potential benefits are described in Section 4.

Table D-16. Comparison of NED Costs and Benefits of the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Works of Improvement	Agriculture-related Reduced OMR	Nonagri-cultural Carbon Value	Nonagri-cultural Habitat Value	Average Annual Benefits	Average Annual Cost[2]	Benefit Cost Ratio
PG1 North Canal Improvements	$10,000	$0	$150,000	$160,000	$160,000	1.0
PG2 SCADA System	$40,000	$0	$0	$40,000	$24,000	1.7
PG3 Fish Screen	$0	$0	$0	$0	$301,000	0.0
PG4 E and F Pumping Plants	$29,000	$0	$0	$29,000	$13,000	2.2
PG5 E Pump Recirculation	$77,000	$1,000	$0	$78,000	$43,000	1.8
PG6 Upgraded Turnouts	$0	$0	$0	$0	$1,000	0.0
Total	**$156,000**	**$1,000**	**$150,000**	**$307,000**	**$542,000**	**0.6**

[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent. Prepared July 2024
[2]From Table D-10.

5.1 Incremental Analysis

The Modernization Alternative is evaluated using an incremental analysis, which identifies how total costs and benefits change as project groups are added (or removed). The design of each project group is independent of the number of project groups included and the order of installation. Table D-17 presents the incremental costs and benefits of the Modernization Alternative.

Table D-17. Incremental Analysis of Annual NED Costs and Benefits Under the Modernization Alternative, Klamath River Watershed, Oregon, 2023 dollars.[1]

Project Groups	Total Costs	Incremental Costs	Total Benefits	Incremental Benefits	Net Benefits
5	$43,000	N/A	$78,000	N/A	$35,000
5, 2	$67,000	$24,000	$118,000	$40,000	$51,000
5, 2, 4	$80,000	$13,000	$147,000	$29,000	$67,000
5, 2, 4, 1	$240,000	$160,000	$307,000	$160,000	$67,000
5, 2, 4, 1, 6	$241,000	$1,000	$307,000	$0	$66,000

5, 2, 4, 1, 6, 3	$542,000	$301,000	$307,000	$0	-$235,000

[1]Price base: 2023 dollars amortized over 100 years at a discount rate of 2.5 percent. Prepared July 2024

5.2 Modernization Alternative

The No Action Alternative provides no benefits relative to current conditions. As the Modernization Alternative would provide net quantified NED benefits of -$235,000, plus potential other unquantified values, the Modernization Alternative is the Preferred Alternative.

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D.2 Project Formulation – Alternatives Considered

This appendix section presents the alternatives considered in the formulation phase.

During the formulation phase, alternatives were evaluated based on meeting both National Environmental Policy Act (NEPA) and environmental review requirements specific to NRCS federal investments in water resources projects (PR&G). According to NEPA, "agencies shall rigorously explore and objectively evaluate all reasonable alternatives" (40 CFR 1502.14). According to PR&G DM9500-013, alternatives should reflect a range of scales and management measures and be evaluated against the Federal Objective and Guiding Principles; against the extent to which they address the problems and opportunities identified in the purpose and need; and against the criteria of completeness, effectiveness, efficiency, and acceptability:

1. Completeness is the extent to which an alternative provides and accounts for all features, investments, and/or other actions necessary to realize the planned effects, including any necessary actions by others. It does not necessarily mean that alternative actions need to be large in scope or scale.
2. Effectiveness is the extent to which an alternative alleviates the specified problems and achieves the specified opportunities.
3. Efficiency is the extent to which an alternative alleviates the specified problems and realizes the specified opportunities at the least cost.
4. Acceptability is the viability and appropriateness of an alternative from the perspective of the Nation's general public and consistency with existing federal laws, authorities, and public policies. It does not include local or regional preferences for particular solutions or political expediency.

Alternatives eliminated during formulation are shown in Table D-18 and discussed. Alternatives selected for further evaluation are discussed in the Plan-EA.

Table D-18. Alternatives Considered During the Formulation Phase and Criteria in PR&G Achieved.

Alternative	Completeness	Effectiveness	Efficiency	Acceptability	Selected for Further Evaluation
Canal Lining	Yes	No	Yes	Yes	Yes
Treated Wastewater Reuse	Yes	Yes	No	Yes	No
On-District Storage	Yes	Yes	No	No	No
North Canal Piping	No	No	No	Yes	No
Re-routing the Klamath Straits Drain	No	Yes	Yes	Yes	No
Pumped Storage via the Klamath Straits Drain	No	Yes	No	No	No

Alternative	Completeness	Effectiveness	Efficiency	Acceptability	Selected for Further Evaluation
Improving Water Supply to the Ady Canal Via the F and FF Pumping Plants	No	Yes	Yes	Yes	No
Klamath River Ady Diversion Fish Screen	No	Yes	Yes	Yes	No
East Side State Line Drain Recirculation Pump	Yes	No	No	Yes	No
P-1 Lateral Fish Screen	Yes	Yes	No	Yes	No
No Action (Future without Federal Investment)	No	No	Yes	Yes	Yes
Modernization Alternative	Yes	Yes	Yes	Yes	Yes

D.2.1 Treated Wastewater Reuse

This project would increase water supply to the District and eliminate the discharge of treated wastewater to the Klamath River by building a pipeline between the Klamath Falls wastewater treatment plant and North Canal. The 6-mile-long pipeline would supply approximately 1,344 acre-feet of class A treated wastewater to KDD each year, bolstering water supply and potentially reducing diversions from the Klamath River. The City of Klamath Falls and the South Suburban Sanitary District (SSSD) both support this initiative. The infrastructure to treat and convey the wastewater would cost an estimated $47.4 million. In addition to high costs, this alternative would require coordination with two entities, the City of Klamath Falls and SSSD, that were not included in the Scoping Process. This alternative would not meet the purpose and need. Additional high costs and logistics complexities of this project would not make it inefficient; therefore it was eliminated from detailed study.

D.2.2 On-District Storage

To increase water supply, reduce tailwater, and decrease pumping costs, the District would like to construct re-regulation reservoirs at key locations in its conveyance system. However, acquiring and excavating land to build re-regulation reservoirs may be costly or reduce irrigable acreage within the District. This alternative would be consistent with existing federal laws; however because it would require the conversion of existing agricultural land to storage, which would not be viable or appropriate from the perspective of the general public, this alternative would not be acceptable. This alternative was eliminated due to lack of acceptability and efficiency.

D.2.3 North Canal Piping

Piping the North Canal would address water supply issues by reducing evaporation and transpiration from open canals. Several factors precluded this project from reaching further evaluation: the size and topography over which North Canal flows would require large diameter pipe that is costly to manufacture, deliver and install; low water velocities could allow sediment to fall out of suspension in the pipeline, creating maintenance issues; and the shallow groundwater table in the former lakebed could cause a pipeline to float when empty, requiring special construction to secure the pipeline to the underlying area. This project was eliminated due to lack of completeness, effectiveness, and efficiency.

D.2.4 Re-routing the Klamath Straits Drain

This project would increase water supply to LKNWR by re-routing the Klamath Straits Drain south across the Oregon-California border and into the refuge rather than north via the E/EE and F/FF pumping plants. Energy consumption at the pump stations would also decrease. Functional changes to the Klamath Straits Drain may be required to overcome the topography of the area to allow water deliveries by gravity or pumping. Also, KDD currently relies on drainage water from the Klamath Straits Drain to supply re-use water for irrigation to lands in the southwest corner of the District. This project was excluded from further discussion due to lack of completeness.

D.2.5 Pumped Storage via the Klamath Straits Drain

This project aims to create renewable electricity by simulating a pumped storage scenario river between LKNWR and the Klamath River via the Klamath Straits Drain. This alternative would generate revenue through electricity sales that would offset the high pumping costs the District currently faces. The environmental effects of drawing water to and from the Klamath River are potentially large. As a result of the Klamath Dam Removal efforts, salmonoids will be returning to the Klamath River as far as Keno Dam in the coming years. While this alternative would be consistent with existing federal laws, the environmental effects of drawing water to and from the Klamath River in a reach that provides salmonoid habitat would not be viable or appropriate from the perspective of the general public. As a result, this alternative would not be acceptable. Furthermore, the available head between the Klamath River and LKNWR is low, limiting the potential for developing financially-feasible low-head hydropower in the Klamath Straits Drain. This alternative was eliminated from further study due to lack of completeness, efficiency, and acceptability.

D.2.6 Improving Water Supply to the Ady Canal via the F and FF Pump Stations

This project would allow the F and FF pump plants to supply drainage water from Klamath Straits Drain to Ady Canal near its head to re-use for irrigation purposes. Currently, the FF Pumping Plant pumps water through a siphon to the Klamath River. The F Pumping Plant is mostly idle. By enabling Reclamation to move water from Klamath Straits Drain to Ady Canal rather than the Klamath River, water quality could improve in the Klamath River and water supply could increase for KDD patrons served off KDD Canal. Additionally, the District already functions in this manner by pumping water from Klamath Straits Drain into Ady Canal via the Township Pumps. This alternative was eliminated from further study due to lack of completeness.

D.2.7 Klamath River Ady Diversion Fish Screen

Screening the Ady Diversion would keep anadromous and residential fish from entering Ady Canal. However, Reclamation owns the Ady Diversion, therefore installing the Ady Diversion fish screen is outside of the scope of this Plan-EA and could not be funded using Pub. L. No. 83-566. This alternative was eliminated from further study due to lack of completeness.

D.2.8 East Side State Line Drain Recirculation Pump

Installing a new District recirculation pump and motor along the East Side State Line Drain would improve the District's capacity to recirculate water and deliver water to LKNWR and would reduce the amount of tailwater discharge to the Klamath River. However, this project has been funded by U.S. Fish and Wildlife Service and managed by Ducks Unlimited and, therefore, eliminated from further study.

D.2.9 P-1 Lateral Fish Screen

Screening the connection between the North Canal and the P-1 Lateral would keep fish from entering the District from the Lower Klamath National Wildlife Refuge. There are low numbers of suckers in LKNWR and thus the risk of entrainment is low. However, there is a chance some suckers entrained into the P-1 lateral may move into the North Canal. The 2024 Biological Opinion on Klamath Project Operations included the reintroduced population of suckers in Lower Klamath Lake and accounted for entrainment from other Klamath Project facilities in USFWS incidental take statement. This included the P-1 Lateral. Once individuals are accounted for in an incidental take statement with USFWS, those individuals lose their protections as they have already been considered to have perished and those impacts have been mitigated for. This alternative was eliminated from further study due to the lack of efficiency.

D.3 Engineering

The Klamath Drainage District System Improvement Plan, a summary of engineering analyses completed to date for KDD proposed projects, is included below.

Technical Memorandum

To: Klamath Drainage District

From: Daniel B. Scalas,
P.E. & C.W.R.E. Date:
August 25, 2022
Re: Cost Estimate

Executive Summary

This technical memorandum provides the existing conditions, proposed solutions, design assumptions, and approximate construction costs as originally proposed by the permit application drawings, as prepared by MWH and received by Klamath Drainage District (KDD) on September 4, 2009. The proposed project includes the construction of approximately 2,400 linear feet of irrigation canal, the implementation of two paved roadway crossings, a canal-mounted flow measurement device, and three additional rural unpaved road crossings. The purpose of the project is to increase the total flow through the canal and connect the North Canal to the existing P-1 Lateral. This increase in flow rate will allow for additional water to be provided to the refuge without disrupting KDD water delivery operations. The design flow rate to the P-1 Lateral, based on the proposed construction documents, is 92 cubic feet per second (cfs). KDD has requested that the provided cost estimate reflect a 100 cubic feet per second allowable throughput. The technical memo, as provided by MWH on February 10, 2009, indicated that replacing the 48" corrugated metal pipe (CMP) culverts indicated on the construction documents with 4'x5' concrete box culverts would increase the total throughout from 92cfs to 100cfs. The associated cost estimate follows the AACE Class 4 methodology, which is expected to be accurate to the -30% to +50% range.

Due to the lack of existing topography data, some assumptions and/or approximations were made regarding the cross-section data and approximate quantities derived throughout construction. Additional assumptions are included in Cost Estimate Assumptions below.

Existing Conditions

MWH identified fifteen crossings along the existing North Canal. Three (3) crossings must be upgraded to allow for the design flow rate to be achieved. Each crossing has an existing culvert with various diameters, variable roadway width, paving material, design flow volume. Two paved crossings, Fugate Road and California State Highway 161 (CSH161) will need to be modified to achieve the design flow volume. Fugate Road currently has one (1) 48" diameter culvert installed. This allows for some irrigation to pass beyond the roadway until it encounters an existing terminal embankment, approximately Station 1+25 of the construction documents. Highway 161 does not allow for any flow to pass under the roadway.

Crossing 12 currently utilizes two (2) culverts of size 42" and 48" diameter. Crossings 13 and 14 have a single culvert of diameter 42" and 36", respectively. Full crossing details, including culvert diameter and approximate location can be found in Table 1 of the *North Canal Hydraulic Evaluation Memo* prepared on February 10, 2009 by MWH.

Proposed Conditions

MWH has proposed the removal and reconstruction of the previously mentioned crossings, a flow measurement device, and a canal extension between Fugate Road and CSH161. Canal construction is expected to remove existing material from center alignment and construct embankments along either side of the centerline of the canal. It is anticipated that the project will require more embankment material than can be removed from the center alignment. Additional fill material may be collected from the surrounding areas or provided from another location. Transportation costs associated with soil infill from an off-site location have not been included within the cost estimate.

Per the *North Canal Hydraulic Evaluation Memo,* Crossing 12, Fugate Road and CSH 161 will require the implementation of two (2) additional 48" culverts to meet the 92cfs design flow volume. Crossings 13 & 14 require three (3) 48" culverts to meet the 92cfs design flow volume. To achieve 100cfs flow, the 4'x5' box culverts will need to be implemented instead of the 48" culverts for the Fugate Road and CSH 161 crossing locations. Excavation and removal costs for existing drainage systems have been added to the cost estimate. An inlet structure at CSH161 and the flow measurement device are proposed. Structures were estimated as unit and construction placement costs. Fixed and variable items were adjusted for installation costs.

Installation of a bridge crossing instead of culverts is a possibility but was not evaluated within the scope of this memo. The original design, as proposed by MWH, incorporated a series of culverts and design flow values were based on these assumptions. Further evaluation of bridges could be pursued within the pre-design phase at KDD's direction.

Alternatively, implementing a gaging station rather than the proposed flow meter is a possibility. Proposed design and cost estimate was based on flow meter installation in a similar fashion to the culverts. Alternative design could be pursued in pre-design phases. Some implementation of intelligent infrastructure could be included, but has not been included at this time.

Cost Estimate Assumptions

Submitted drawings were reviewed for unit and quantity values required for construction. Unit prices were derived from past and current projects with similar project scopes and service. Past project numbers were adjusted for inflation and other construction costs.

Due to the lack of existing topography, some inference and estimation was applied to the provided plan and profile drawings. Earthworks quantities were calculated using provided cross-sections and a series of linear interpolation between stations to determine total cut/fill quantities. It is assumed that cross-sectional volumes are approximate and may be subject to change as additional data is available.

Conclusion

Presented within the previously mentioned memo, there are multiple potential solutions based on different design flow volumes. This cost estimate is primarily based on the construction drawings as submitted for permit, with the substitution of box culverts for the Fugate Road and CSH 161 crossings. As previously mentioned, this equates to 100 cubic feet per second of water delivered to the P-1 Lateral. It does not account for variations relating to alternative flow volume rates.

Please feel free to contact us if you have any questions, comments, or concerns about what has been presented in this memo.

Sincerely,

Daniel B. Scalas,

P.E. & C.W.R.E.

Attached: Cost

Estimate

Estimate of Probable Construction Costs

Project: North Canal Extension Project

DRAFT

Prepared by: T. Lundsten
Reviewed by: D. Scalas
Date: August 24, 2022

BID ITEM NO.	DESCRIPTION	UNIT	QUANTITY	UNIT PRICE	TOTAL
1	Mobilization (5% of construction cost)	LS	1	$25,000	$25,000
2	Temporary Work Zone Traffic Control, Complete-In-Place	LS	1	$15,000	$15,000
3	Temporary Water Management Practices	LS	1	$10,000	$10,000
4	Earthworks	CY	8838	$10	$88,378
5	Crossing 12 Improvements	LS	1	$38,734	$38,734
6	Crossing 13 Improvements	LS	1	$57,887	$57,887
7	Crossing 14 Improvements	LS	1	$37,183	$37,183
8	Fugate Road Crossing	LS	1	$78,456	$78,456
9	Highway 161 Crossing	LS	1	$154,093	$154,093
10	Outlet Headwall Structure	LS	1	$53,120	$53,120
11	Water Flow Meter Weir	LS	1	$19,750	$19,750
				SUM OF ESTIMATED CONSTRUCTION COST	**$577,602**
				CONSTRUCTION CONTINGENCY (15%)	**$86,640**
				SUBTOTAL OF ESTIMATED CONSTRUCTION COSTS	**$664,243**
				ENGINEERING/SURVEYING (10%)	**$66,424**
				CONSTRUCTION ADMINISTRATION (10%)	**$66,424**
				ENVIRONMENTAL/PERMITTING	**$30,000**
				TOTAL ESTIMATED PROJECT COST (YEAR 2022 PRICES)	**$827,091**

MWH
BUILDING A BETTER WORLD

MEMORANDUM

TO:	Greg Austin - KBNWRC Monique King - EN	DATE:	February 10, 2009
FROM:	Bill Cutting / Dave Whitbeck - MWH	REFERENCE:	1520894
SUBJECT:	North Canal Hydraulic Evaluation Memo		

Klamath Drainage District's North Canal presently terminates at an earthen embankment approximately 100 feet east of Fugate Road. The Lower Klamath NWR would like to extend the North Canal approximately 0.5 miles to the southeast and connect it with the P-1 Lateral located on the south side of California State Highway 161. This extension would provide means to deliver water from the Klamath River to the Refuge through the North Canal. The Service has set a delivery target of 100 cfs as its ultimate objective. Both KDD and the Service believe that there are mutual benefits to extending the North Canal in this manner. This memo summarizes the preliminary results of an analysis of the improvements necessary to the North Canal to allow efficient delivery of 100 cfs through to the P-1 Lateral. An analysis of the requirements to deliver lesser amounts, 30, 50, and 80 cfs, is also included.

Existing Conditions

The North Canal has 15 crossings along its length. See Figure 1 for the structure locations. The capacity of the crossings decreases progressively along the canal's length. See Table 1 for a description of the structures. Flow capacity in the upper reaches of the canal has been estimated to be 250 cfs. Due to hydraulic restrictions created by the structures, capacity in the lower reaches is significantly less. See Figures 2 through 5 for typical crossing structures.

Table 1 Description of Existing Crossings along the North Canal

Crossing	KDD Structure Number(s)	Approx. Canal Mile	Structure Description	Location Notes
1	1, 2, 3	0.00	Pipe Culvert with Triple 54"-Dia Barrels	BNSF Railroad
2	4, 5, 6	0.04	Pipe Culvert with Triple 54"-Dia Barrels	Highway 97
3	N/A	0.56	Box Culvert with Triple 5'x6' Barrels	
4	N/A	1.07	Box Culvert with Triple 5'x6' Barrels	
5	N/A	2.38	Box Culvert with Triple 5'x6' Barrels	
6	N/A	3.47	Box Culvert with Triple 5'x6' Barrels	
7	N/A	4.51	Box Culvert with Triple 5'x6' Barrels	
8	457	5.75	3 x 48"-Dia CPE Pipes	
9	483	7.44	3 x 48"-Dia CPE Pipes	Township Road
10	564	8.44	3 x 48"-Dia CPE Pipes	
11	569,638	8.91	2 x 48"- and 1 x 36"-Dia CPE Pipes	
12	577,639	9.66	1 x 48"- and 1 x 36"-Dia CPE Pipes	
13	583	10.34	1 x 42"-Dia CPE Pipe	
14	588	11.30	1 x 36"-Dia CPE Pipe	
15	641	12.49	1 x 36"-Dia CPE Pipe	Fugate Road

North Canal Extension

As a separate effort, MWH is evaluating the construction measures necessary to extend the North Canal from Fugate Road, across California State Highway 161, and to connect it with the P-1 Lateral. The proposed alternative resulting from that evaluation involves the following upgrades. First, the existing 36-inch diameter culvert beneath Fugate Road will be removed and replaced by two 48-inch diameter culverts. Second, the existing embankment at the terminus of the North Canal, located just downstream of Fugate Road, will be removed. The existing drainage ditch running to the southeast towards Highway 161 will be expanded and its embankments will be raised. Finally, beneath Highway 161 new conveyance in the form of a two 48-inch diameter culverts will be constructed. The design capacity of these improvements is 100 cfs, although the existing North Canal is not currently capable of delivering that flow to the end of the canal.

System Hydraulic Analysis

A hydraulic analysis of the system was performed to assess which crossing structures will need to be modified in order to deliver a steady-state flow of 100 cfs through the North Canal to the P-1 Lateral. Friction losses in each reach between structures was estimated using physical data obtained during an October 2008, survey of the canal and Manning's Equation. Losses through the structures were estimated by using the orifice equation and coefficients determined by empirical equations developed by Yarnell et al ('1926). Culvert equations were compared to values determined by the Manning Equation.

Existing Structures.
If no modifications are made to existing structures with the exception of adding new culverts beneath Highway 161, a maximum of approximately 39 cfs can be delivered through the system, assuming no other diversions in the North Canal are operating. Any additional withdrawals from the upper reaches will increase energy losses in the system and reduce the potential to deliver water to the P-1 Lateral.

Fugate Road Modifications
If the existing culvert beneath Fugate Road is removed and replaced by two 48-inch diameter culverts, as described previously, the potential maximum flow that can be delivered to the P-1 Lateral will increase to approximately 47 cfs. Again, any additional withdrawals from the upper reaches of the canal will reduce the potential to deliver water to the P-1 Lateral.

50 cfs Capacity
Deliveries of 50 cfs can be achieved in the canal by upgrading the Fugate Road and Highway 161 crossings as described in the North Canal extension efforts, plus adding one additional 48-inch diameter culvert beneath crossing 14.

80 cfs Capacity
Deliveries of 80 cfs can be achieved in the canal by upgrading the Fugate Road and Highway 161 crossings as described previously, plus replacing the structures at crossings 13 and 14 with two 48-inch diameters each.

100 cfs Capacity
In order to be able to deliver up to 100 cfs through the North Canal at times when no other diversions are operating, additional structural modifications will need to be performed at Crossings 12, 13, and 14. At Crossing 12, the 36-inch pipe will need to be removed and replaced with two 48-inch diameter

culverts, for a total of three 48-inch culverts at the crossing. Similarly, the existing culverts at Crossings 13 and 14 will need to be removed and replaced by three 48-inch diameter culverts each.

If modifications to crossing 12, 13, and 14 are performed and the Fugate Road and Highway 161 crossings are constructed as described previously (2 x 48"-Dia CPE pipes each), the maximum capacity of the system to deliver water to the P-1 Lateral will be approximately 92 cfs. In order to increase delivery potential to 100 cfs, the modifications at Fugate Road and Highway 161 need to be changed to ffx4' box culverts, as opposed to 48"-dia CPE pipes. Box culverts would be necessary to provide sufficient capacity to reduce energy losses such that 100 cfs can be delivered.

Impacts

Water delivered to the Refuge through the North Canal will cause drawdown of the canal below current normal operating levels. The extent of this drawdown will increase as more flow is delivered and may cause a notable change in delivery potential to some North Canal customers near the downstream end of the system. To better estimate the impacts of this drawdown, it is recommended that anticipated timing of deliveries to the Refuge be determined and the hydraulic model used in the evaluation refined. The seasonal timing of deliveries will greatly impact the number of crossing modifications that will be necessary to deliver the desired water. For example, if the Refuge anticipates needing water during the height of summer, when irrigation diversion in the North Canal are high, significant increases in capacity will be necessary at most of the downstream crossings. Conversely, if the Refuge only anticipates needing water during times when irrigation diversions in the North Canal are low, fewer modifications will be required. Refinement of the model and a better understanding of the current operations of the North Canal will allow the extent of the modifications to be determined based on typical canal operating conditions.

References

1. D.L. Yarnell, F.A. Nagler, and S.M. Woodward, "Flow of Water through Culverts," *Univ. Iowa Studies in Eng.*, 1926

Figure 2 – Triple 54" Culverts at Crossing 1 (BNSF Railroad)

Figure 3 -Typical Triple Box Culvert Crossing

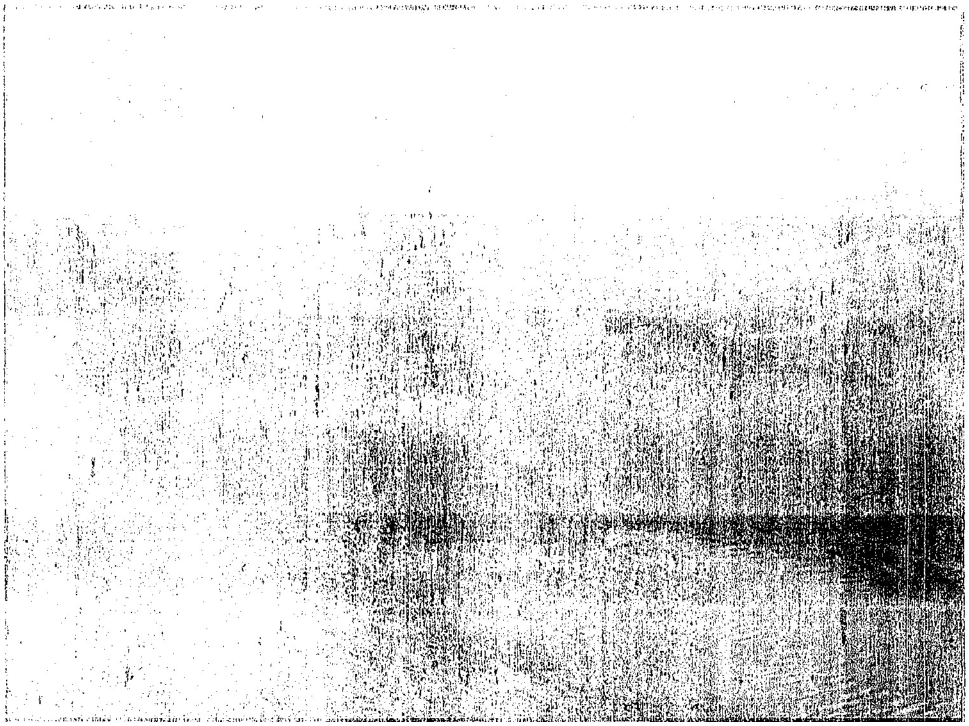


Figure 4 – Typical Triple Culvert Crossing

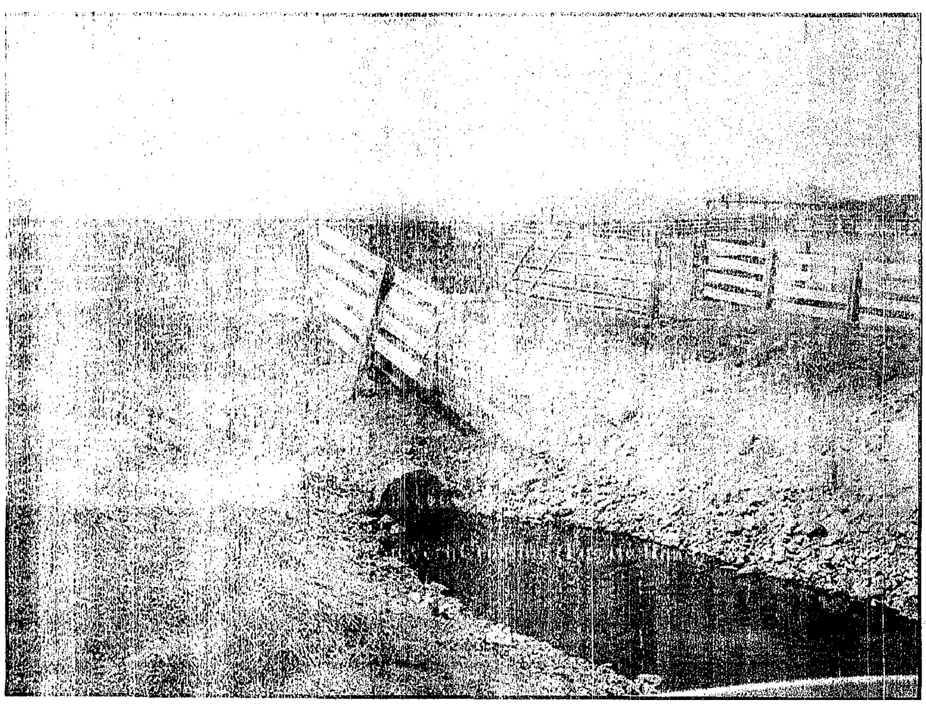


Figure 5 - 36" Culvert Crossing (Fugate Road)

KDD NORTH CANAL FISH SCREEN

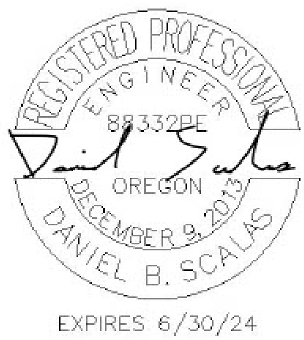
FEASIBILITY REPORT

FOR

FARMERS CONSERVATION ALLIANCE

KLAMATH FALLS, OR

August 11, 2022



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Executive Summary

The North Canal is a diversion canal that diverts water from the Klamath River for irrigation purposes. With the proposed removal of four dams (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) on the Klamath River to increase salmon migration, the Klamath Drainage District (KDD) is acting proactively to install a fish screen on the North Canal to prevent fish entrapment. The North Canal diverts water from a section of the Klamath River known as the Keno Reach. The beginning and end of the Keno Reach are distinguished by two dams, Link River Dam and Keno Dam: The flow within the Keno Reach is controlled by the Link River Dam and water level is regulated by the Keno Dam. Due to the influence of these two dams, the Keno Reach acts as a reservoir with low water velocity. The Klamath River is fairly shallow near the mouth of the North Canal at around 4.5 to 5 ft water depth. The Klamath River also has annual algal blooms which are overgrowths of algae naturally found in the river. This overgrowth typically starts as surface debris and as it decays, it sinks lower in the water column. The fish screen needed to be capable of intakes up to 500 cfs for irrigation purposes as the North Canal's water right allows maximum flows of 480.46 cfs. These factors were considered when selecting a fish screen alternative.

Three fish screen alternatives were preselected for analysis through discussions with Oregon Department of Fish and Wildlife (ODFW), National Marine Fisheries Service (NMFS), and KDD, which were the conveyor, cone, and cylinder screens. The conveyor screen has ability to physically move debris into the North Canal or further downstream in the river to prevent gathering debris near the intake. The cone screen has a simple design and requires the least amount of maintenance. The cylinder screen can be fully submerged into the water and comes with the option of a retrievable track for maintenance. KDD decided to use the cone screen because the conveyor screen could not provide the required intake flow and the cylinder screen would require more maintenance and capital cost. The cone screen alternative will be taken to 10% design.

Chapter 1 - Introduction

The Klamath Drainage District (KDD) is proactively working to install a fish screen at the entrance of the North Canal Diversion with the help of Farmers' Conservation Alliance (FCA), which is a nonprofit entity that is helping to improve and modernize irrigation districts. The FCA is also assisting the grant funding for the project. This decision to install the fish screen is partially because of the removal of J.C. Boyle, Copco 1, Copco 2, and Iron Gate dams on the Klamath River. The dams are being removed in an effort to increase the salmon population (Powers 2022). The proposed fish screen will prevent entrapment of anadromous fish within the North Canal. The section where the North Canal is located is called the Keno Reach which is controlled by the Keno and Link River Dams. These two dams are not slated for removal at this time. The Link River Dam controls the flow within the Keno Reach and the Keno Dam controls the elevation. The two dams work in tandem to allow slight variation in elevation within the reach while the flow can vary significantly.

Three fish screens were selected as viable options for the site conditions which include conveyor, cone, and cylinder screens, as mentioned in the technical memorandum titled, "Fish Screen Alternatives," and dated May 19, 2022. These screens work well in low sweeping velocities and have self-cleaning options to meet design criteria and prevent clogging of the screen from algal blooms and other material. The design of the fish screen must consider all life stages of the native fish. The native migratory fish of the proposed location are Chinook, Steelhead, Pacific Lamprey, Redband Trout, Klamath largescale suckers, endangered Lost River suckers, and endangered Short-Nose suckers per communication with ODFW (Nordholm, virtual communication, April 28, 2022).

Chapter 2 - Existing Facilities

a) Background

The 21-mile stretch from the Link River Dam to the Keno Dam is referred to as the Keno Reach (Sullivan et al. 2008). Figure 2-a shows the extent of the Keno Reach. The reach acts like a reservoir as both the water level and flow are controlled by the Link River and Keno Dams. The Link River Dam is owned by the United States Bureau of Reclamation (USBR) and operated by PacifiCorp for water level control of the Upper Klamath River and to regulate flows in the Keno Reach. The PacifiCorp owns and operates the Keno Dam to control the water level within the Keno Reach. The normal full elevation of the reach is at 4091.5 ft on the North American Vertical Datum of 1988 (NAVD88).

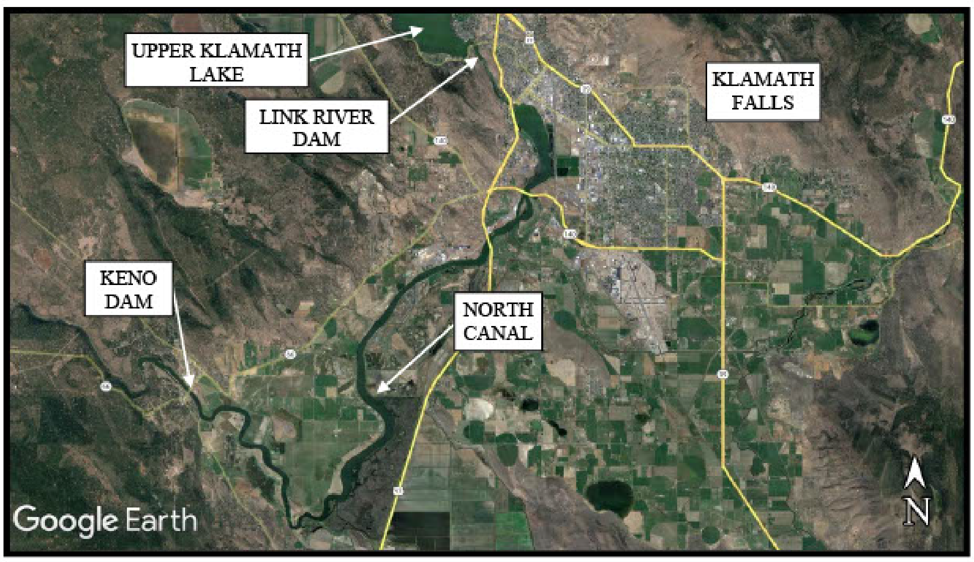

Figure 2-a. Vicinity map of the Keno Reach

b) History

The North Canal is owned and operated by KDD. It was constructed in the 1940s when the USBR increased the area of irrigable lands in the Klamath Project. The state water right permit (S 43334) for diverting into the North Canal was approved in 1978 and allows for a maximum diversion rate of 480.46 cfs (OWRD, n.d.). The flow rate of the North Canal varies significantly, ranging between 0 to 200 cfs. Figure 2-b shows historical data for discharge flow rates through the North Canal from 2012 to present.

2-1

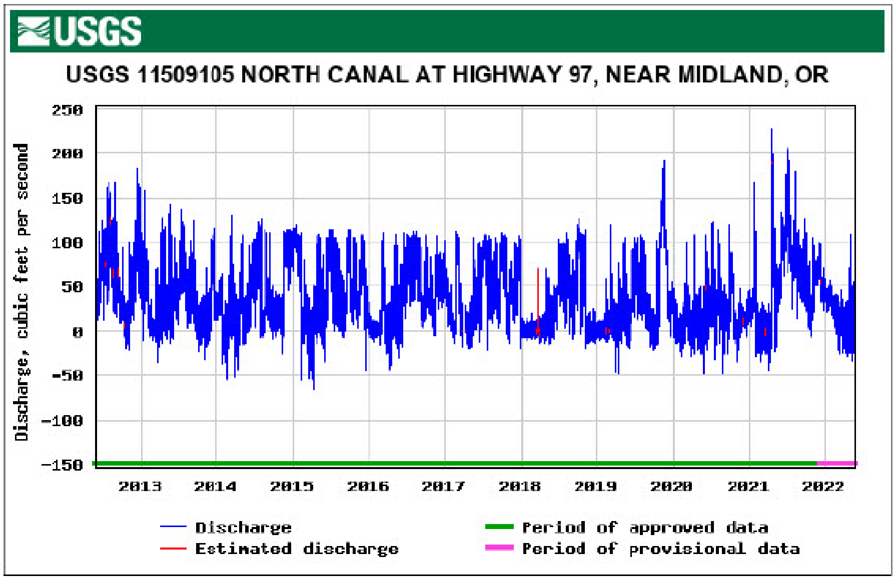

Figure 2-b. Historical flows of North Canal for past ten years

c) Soil Map

The area where the North Canal meets the Klamath River consists of silty and loamy soils as shown in Figure 2-c. The soil near the entrance of the North Canal is Teeter silt loam which is composed of silty lacustrine deposits that contain diatomaceous material and volcanic ash. This information provides insight into the sediment that goes into the river through erosion and runoff from the riverbanks, which would likely be a silt and loam mixture.

The soil data for risk of corrosion for structural material was researched as the corrosion could determine the materials used in the fish screen. The risk of corrosion for uncoated steel is high which could be a result of various factors such as soil moisture, acidity, and electrical conductivity of the soil. Factors such as these chemically interact with the steel causing weakening or corroding of the material's integrity. Almost every soil shown on Figure 2-c had a high steel corrosion risk. There is a moderate risk of corrosion of concrete caused by factors such as moisture content, acidity, and sulfate and sodium content. The moderate risk of corrosion of concrete was for nearly all the soils except for Tulana silt loams which had a high risk for corrosion. The data for the corrosion of steel and concrete are in Appendix C.

2-2

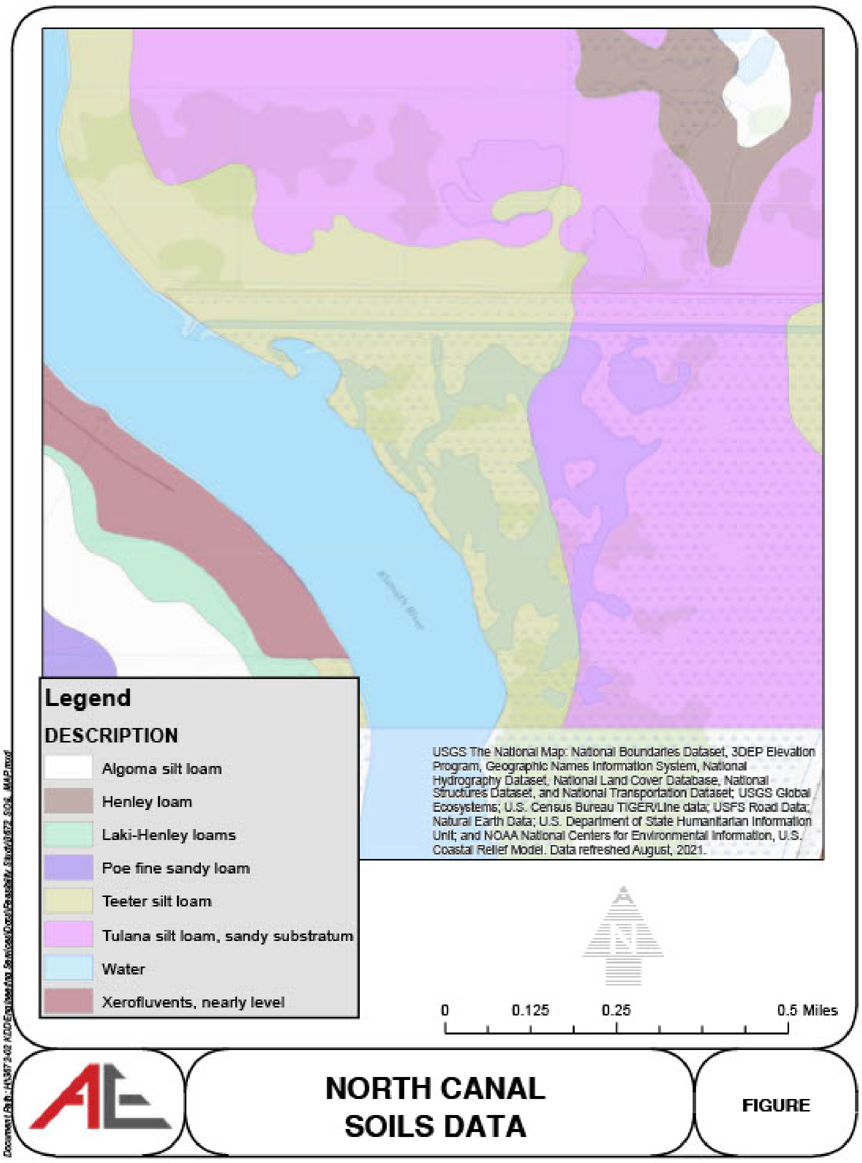

Figure 2-c. Soil map of the junction of Klamath River and North Canal

2-3

d) Klamath River Flow

The average flow (calculated using data from the last ten years) for the Klamath River measured from a gage near Keno (USGS 11509500) was 896.7 cfs. The high flow over the last ten years was 10,300 cfs and low flow was 172 cfs. The frequency at which certain flows are expected are shown in Table 2-d, for example, a 20,027 cfs flow is expected to occur once every 500 years, alternatively this could be described as a 0.2% chance of this flow occurring at any given year.

Table 2-d. Flow frequency of Klamath River

River Frequency (years)	% any given year	CFS
2	50	4,180
5	20	6,731
10	10	8,582
25	4	11,069
50	2	13,016
100	1	15,033
500	0.2	20,027

For comparison to the table above, the flow measured at North Canal with an Acoustic Doppler Current Profiler (ADCP) was 1,190 cfs, measured in 2007 through scientific investigations conducted regarding the Keno Reach (Sullivan et al. 2008). Per the study, water velocity was measured using an ADCP at certain cross-sections of the Klamath River. The water velocity was measured to be 0.07 ft/s in May 2007 and 0.78 ft/s in September 2007 (the author mentioned this high recording may have been attributed to high winds). The water velocities were measured on the edge of the Klamath River near the entrance of the North Canal. For reference, the average water velocity for the entire cross-section was 0.16 ft/s in May and 0.17 ft/s in September. The flow was 1,190 cfs when the ADCP measurements were taken and the average flow for the Klamath River is around 896.7 cfs, which means that the velocity, at the time of recording in 2007, was a bit higher than what it would be with average or below average flows.

e) Keno Dam Status

There are four dams slated for removal in the Klamath River for 2023, which are J.C. Boyle, Copco 1, Copco 2, and Iron Gate. These dams are being removed to improve migration of all anadromous fish (Powers 2022). Currently, there are no plans to remove the Keno Dam which controls the water level within the Keno Reach. The dam was constructed in 1967 replacing an existing shallow reef (Rounds and Sullivan 2013). An agreement was established between all involved parties, including PacifiCorp and USBR, that if the Keno Dam were ever to be removed, the Keno reef must be restored. If the dam were ever removed and replaced with a reef, the water levels are estimated to be about a foot lower than current conditions. Rounds and Sullivan (2013) modeled the length of time that it takes water particles to enter and exit the reach, also known as residence time, which showed that the residence times between the Keno Dam and Keno reef are similar. This means that the replacement of the dam with the reef will not result in a significant change in the environment within the Keno Reach, especially with processes such as particle settling, algal growth, and organic decomposition. Per the Klamath Hydroelectric Settlement Agreement, after the decommissioning of the J.C. Boyle, Copco 1, Copco 2, and Iron Gate dams, the ownership of the Keno Dam will be transferred from PacifiCorp to USBR (PacifiCorp Energy 2012).

Chapter 3 - Design Criteria

a) Location Map

The potential locations of the proposed fish screen are shown in Figure 3-a. Initially KDD wanted the fish screen to be installed at Location 1, right before the canal travels under the railroad tracks for ease of access for maintenance. The feasibility of installing the fish screen at Location 1 was discussed with National Marine Fisheries Service (NMFS) and Oregon Department of Fish and Wildlife (ODFW). The discussion included issues such as the lack of bypass flow and sweeping velocity near the railroad tracks. NMFS and ODFW, both agreed that Location 1 would not be able to reroute fish back to the Klamath River because there was no head available to return fish from the canal to the river, which led to the selection of Location 2 for the fish screen (Thomas, virtual communication, April 20, 2022). The potential issues with low sweeping velocity at the river with Location 2 was discussed, which included not being able to push the fish and debris past the screens and debris buildup around and on the screens. NMFS suggested using screens that could accommodate for low sweeping velocities (Thomas, virtual communication, April 20, 2022). Another issue with Location 2 is the possibility of fish entrapment in the North Canal from fish entering the North Canal through the small natural channels along the south levee. NMFS said the issue could be resolved by blocking the channel entrances where they connect with the North Canal (Thomas, virtual communication, April 20, 2022).

Due to the low sweeping velocity, passive fish screens are not a feasible option as they depend on the flow of the water to clean the screens. On the other hand, active fish screens require power to mechanically clean the screens. There are power lines extending from Highway 97 to the white circle shown on Figure 3-a. These power lines can be extended to power the fish screen at Location 2.

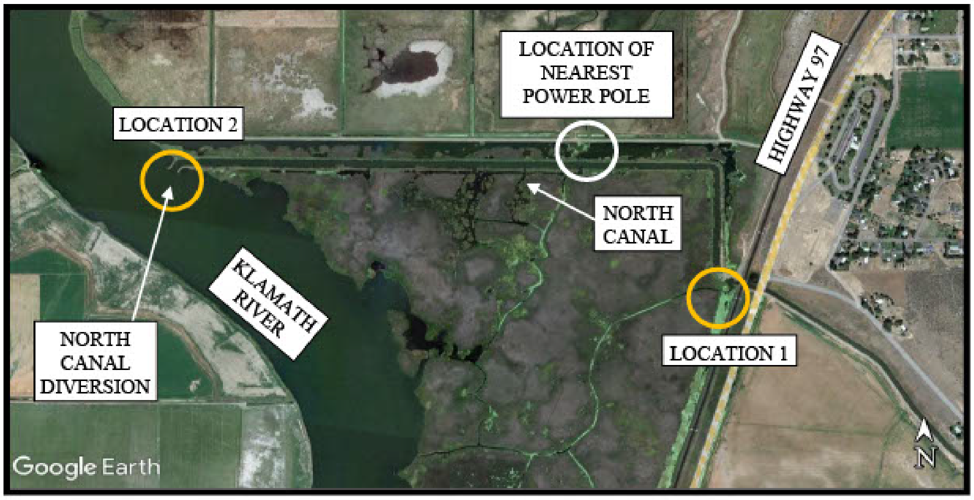

Figure 3-a. Vicinity map with the two locations for possible fish screen placement

b) Debris in River

With low sweeping velocity, debris management on and around the fish screens could be a potential issue. To better understand the types of debris that the fish screens would have to deal with, there was a discussion with the District Manager of KDD, Scott White. According to Scott, the types of debris seen in the North Canal are algae and driftwood.

The Klamath River tends to get algae blooms because of the water conditions and abundance of phytoplankton (Sullivan et al. 2008). The main algae that cause annual blooms are the blue-green algae (*Microcystis aeruginosa*). These algal blooms will generally remain on the water surface but will sink lower as they decay. These blooms will increase algal debris in the river and may require additional cleaning of the screen.

Debris buildup around the screens would be an issue especially if larger sediment is being moved by the river. Since the nearby soils are composed primarily of silt, the sediment carried by the river due to erosion and runoff will be mostly silt. Since silt particles are so small, they will not settle in moving water. Suspended sediment will pass through the fish screen instead of accumulating. Since the Keno Reach flows are regulated by the Link River Dam, significant sediment accumulation should not be expected.

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c) Native Fish

The design of the fish screen must consider all life stages of the native fish and the potential reintroduction of salmonids. As previously mentioned, there are four dams that are planned to be removed to increase salmon migration; this potential increase in salmonid migration must also be considered for the fish screen design. The native and migratory fish at the proposed location are Chinook, Steelhead, Pacific Lamprey, Redband Trout, Klamath largescale sucker, Lost River sucker, and Short-Nose sucker. This list of native migratory species was provided by ODFW (Nordholm, virtual communication, April 28, 2022). The information for most of the following native fish is also provided by the ODFW website (ODFW 2021):

- The Chinook (*Oncorhynchus tshawytscha*) are distinguished by the spring-run (March-July) and the fall-run (September-December). Chinook are listed as a threatened species on the federal listing. Chinook can grow to 914 mm fork length and 30 lbs. Chinook fry are approximately 30-45 mm fork length.
- The Steelhead (*Oncorhynchus mykiss*) are distinguished by the summer run (May-October) and the winter run (November-April). Steelhead are listed as a threatened species on the federal listing. Steelhead migrate to the ocean during the first or second year after spawn and return one to three years later for spawning.
- The Lost River suckers (*Deltistes luxatus*) were listed as endangered in 1988 under the Endangered Species Act (ESA) in both the state and federal listing. Spawning migration from the Upper Klamath Lake and Lake Ewauna to tributaries occurs during March through June yearly (Banet and Hewitt 2019). The females have a median fork length of 675-689 mm, while the males are 609-625 mm. These suckers can live up to 50 years.
- The Short-Nose suckers (*Chasmistes brevirostris*) were listed as endangered in 1988 under the ESA in both the state and federal listing. These suckers reside in lakes and travel to tributaries during spawning season, which is March through June (Banet and Hewitt 2019). The females are approximately 460 mm and males are 430 mm. They can live to be 30 years old.
- The Pacific lampreys (*Entosphenus tridentatus)* grow up to 635 mm (USDA, n.d.). After spending one to three years in the ocean, the lampreys migrate to freshwater to spawn. The larvae stay in freshwater silt substrates for three to seven years before transforming into juveniles and then migrating to the ocean.

- There are ten different populations of Redband trout (*Oncorhynchus mykiss ssp*) in the Klamath Basin. One particular population uses the Klamath River and tributaries below the Link River for migratory and residency purposes. This population spawns in Spencer Creek which is 9.5 miles downstream from Keno.
- The Klamath largescale sucker (*Catostomus snyderi*) mostly resides in tributaries (KFFS 2018). Theses suckers spawn between March and April. The females can grow up to 575 mm.

d) NMFS and ODFW Requirements

The fish screen alternatives were preselected through discussions with ODFW and NMFS. ODFW suggested conveyor screens and NMFS suggested conveyor, cone, and cylinder screens (Thomas, virtual communication, April 20, 2022). Design requirements from NMFS and Natural Resources Conservation Service (NRCS) are compiled into Table 3-d for the selected alternatives of fish screens. The NMFS design criteria pertains to only cylinder, vertical, and horizontal screens, while the NRCS design criteria pertains to conveyor screens (NMFS 2022, Mefford 2013).

Table 3-d. Design criteria for fish screens from NMFS and NRCS

		Cylinder	Vertical	Cone
Approach Velocity (ft/s) for Passive Screens		<0.2	<0.2	--
Approach Velocity (ft/s) for Active Screens		<0.33	<0.4	<0.33
Sweeping Velocity (ft/s)		0.8-3 (if screen longer than 6') otherwise sweeping can be lower than approach	0.8-3 (if screen longer than 6') otherwise sweeping can be lower than approach	<0.5
Submergence		One screen radius of submergence and clearance from bottom	--	More than 6in of submergence
Maximum Screen Opening Size	Circular Screen Openings [diameter]	<3/32 in or 2.38 mm		
	Rectangular Screen Openings [width]	<0.069 in (approximately1/16 in) or 1.75 mm		
	Square Screen Openings	<3/32 in or 2.38 mm		
Material		wedge-wire, perforated plate, or woven wire		wedge-wire, perforated plate
Screen Open Area (%)		>27		
Screen Cleaning		Debris removal at least every 5 mins daily		
Intake		Must include trash rack if screen placed in canal (Location 1 per Figure 3-a), not necessary along river (Location 2 per Figure 3-a)		
Inspection		Must be inspected by NMFS, preferably at key milestones during construction		
Sediment		Provisions needs to limit build-up		
End of Pipe Screens	Location	In places with sufficient ambient velocity to sweep debris from screen face		
	Submergence	At least one screen radius below min water surface		
	Escape Route	Clear route for fish that approach intake		

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The approach velocity is the flow that is perpendicular to the screen which must be less than 0.4 ft/s or 0.33 ft/s (depending on the type of screen) to minimize screen contact for juvenile fish. Larger approach velocities could cause impingement. Sweeping velocity, which is the flow parallel to the screen, generally should be between 0.8 to 3 ft/s to minimize screen contact, especially if the fish screen is longer than 6 ft. In the case of the Klamath River, the sweeping velocity is around 0.16 to 0.17 ft/s (Sullivan et al. 2008). Figure 3-b shows approach velocity (Va) and sweeping velocity (Vs) relative to the channel flow and fish screen.

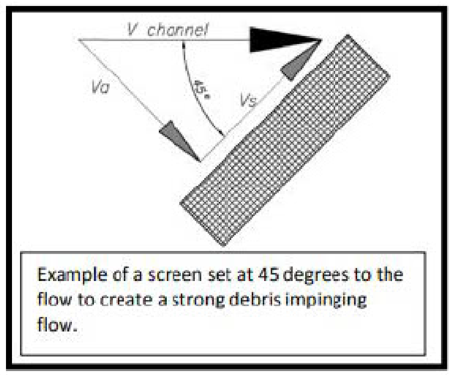

Figure 3-b. Illustration of sweeping velocity versus approach velocity (Mefford 2013)

The sweeping velocity is lower than the provided range for large screens. This issue was discussed with Steve Thomas from National Oceanic and Atmosphere Administration (NOAA), shown in Appendix A. Steve said that debris management would be necessary in areas of low sweeping velocity. Steve also mentioned that if the debris is largely floating material, then completely submerged screens such as the cone or cylinder may work well. Steve also recommended conveyor screens as they would be able to move debris over the fish screen where it could be collected or allowed to move downstream.

The regulations for fish screens from ODFW are more focused on the installation and maintenance aspects (ORS 2013). Per Oregon Revised Statutes (ORS) 509.585, approval of the alternatives to fish passage must be obtained from ODFW prior to construction. Especially since there are native migratory fish in the waters, ODFW requires the submittal of a fish passage plan to the department to determine that the alternatives provide a benefit to native migratory fish.

Per ORS 509.610, the owner or operator of the fish screen must provide maintenance or repair to the screen to always allow fish passage. This rule pertains to maintaining the conditions of the fish screen and its surrounding area, which coincides with a similar rule from NMFS regarding screen cleaning. The discussion with Steve Thomas from NOAA mentioned debris cleaning to avoid fish entrapment which pertains to this rule. Each day of noncompliance with ORS 509.610 shall be considered a separate offense to the ODFW. The fish screens must stay clean to allow optimal intake and prevent fish impingement. Cone and cylinder screens may become clogged from standing debris overtime, whereas the conveyor can displace or remove the debris away from the intake area. Per ORS 509.620, if the fish screen does not do an adequate job in keeping fish out of the North Canal, then ODFW can call for the installation of a new fish screen.

An additional criteria for fish screen design is the request from KDD for the screen to be capable of passing 500 cfs into the North Canal. Currently the North Canal operates from 0 to 200 cfs, however in the future KDD may like to increase the intake of the North Canal to approximately 500 cfs consistent with its water rights.

Chapter 4 - Alternatives Considered

Discussions with ODFW and NMFS regarding the types of screens that would be appropriate at this location led to ODFW's recommendation of a conveyor type screen and NMFS's recommendation of conveyor, cone, or cylinder type screens. Further research concluded that the three recommended screen types can function with low sweeping velocities. The screens also do not require a bypass flow if placed strategically to allow sweeping velocity to move debris and fish past the screens.

Intake Systems, Inc (ISI) and Hydrolox were consulted regarding the considered alternatives. ISI provides design, manufacturing, fabrication, installation, and maintenance for cone and cylinder fish screens. ISI has also been recognized by NOAA for innovations in fish protection. Hydrolox specializes in design, fabrication, and installation of polymer conveyor screens.

a) Hydrolox Conveyor Screen

Appendix C contains the brochure from Hydrolox which explains the components and applications for the types of conveyor screens that they offer. Hydrolox offers both vertical and horizontal traveling conveyor screens. For the purpose of this study, only the vertical traveling conveyor screens will be considered. The conveyor belt would span the entire width of the North Canal (DeRousse, virtual communication, May 12th, 2022). The intake of the conveyor screens is limited to the low water height of the river, which was estimated to be around 5 ft. Using the low water height, the total intake was calculated to be 58.1 cfs. The intake is low and insufficient for the requirements at this location. A V-shaped configuration of the fish screens was discussed as a potentially viable option, the V-shaped configuration would be oriented so that the pointed end would point into the North Canal. However, the V-shape design causes an increase in the velocity as the intake narrows. The intake velocity becomes higher than the allowable approach velocity of 0.4 ft/s.

i) Components and Maintenance

For this section refer to Figure 4-a, these illustrations were taken from the Hydrolox Brochure contained in Appendix C. The Hydrolox Brochure provides information on the key components of the conveyor system. Appendix E contains the standard drawings for the typical arrangement of components.

4-1

Traditional metal fish screens require more maintenance as the screens are susceptible to corrosion which requires frequent maintenance and replacement. Hydrolox conveyor screens are lower maintenance than other types of traveling screens because of the engineered polymer material for the screen and the design of the system. Hydrolox screens are designed differently than traditional conveyor screens because there are no moving components in the water, which results in typical maintenance being at deck level. Traditional conveyor screens are chain driven which tends to be the part that needs the most maintenance both above and below the water surface. Hydrolox uses a positive drive system and a fixed half pipe to move the screen which eliminates the need for a chain to keep the screen in motion. The fixed half pipe maintains the shape of the conveyor at the bottom of the screen and prevents debris and aquatic life from passing through the screen from the bottom. The bearings and drive chain need to be greased periodically to maintain performance level in the water. Tension in the screen is maintained using a bar that pushes on the screen which needs to be re-tensioned every five to six years. Re-tensioning the screen means removing a few rows of the interlocking mesh and resetting the tensioning arm. Removing the interlocked, brick-laid pattern for tensioning simply requires the removal of the full-length rods that holds it together and removing a polymer section and rejoining the shortened screen with the rod.

The screen is constantly cleaned using a spray bar. The spray bar can be automated to clean itself, but that adds to cost. The fish screen includes a fish return trough, and an optional debris return trough. The fish trough is helpful to return fish that may have gotten entrapped onto the conveyor screen. The fish trough would also eliminate fish impingement into the North Canal. For debris management, the backside of the wall of screens can have a trough to gather debris and dump back into the river further downstream. The traveling screens made by Hydrolox consist of engineered polymer which minimizes microfissure on the screen surface making it difficult for algae to get stuck onto the screen permanently. Algae sticking to the surface of traveling screens is common with steel wire screens.

Hydrolox conveyor belts can withstand freezing temperatures. The system is not porous which prevents water from getting into and freezing and/or expanding. The conveyor belt has joints every 3.5 inches which help break any ice as it moves over the sprocket. Hydrolox recommends running the screens continuously in conditions where ice could form (DeRousse, virtual communication, May 24th, 2022). The continuous motion of the conveyor and the use of spray wash generally keeps the ice from interrupting the system. The system does come with a 3-year warranty for mechanical issues.

Appendix F contains the product line provided by Hydrolox. This appendix contains the part sizes that would be used in the screens. It also contains a table of the advantages of using Hydrolox compared to a steel vertical conveyor screen. These advantages can be summarized as elimination of uneven wear and mistracking, lack of underwater maintenance, lack of on-site repair, screens will not corrode, less biofouling, compliance with NMFS, and reduced debris carry over.

Appendix G and Appendix H contain examples of the application of Hydrolox in Yakima and the Snake River. The Yakima application replaced a failing steel mesh screen because of sediment buildup, debris buildup, and uneven wear. The replacement resulted in a 60-70% reduction in operations and maintenance and eliminated debris carry over. The location of the screen was in very abrasive waters, so the design life of the Hydrolox screen was only about five to six years which was five times higher than the original steel mesh screen. The Snake River project was designed to keep fish out of the irrigation ditches where 90% of the fish would end up with almost 100% mortality rate.

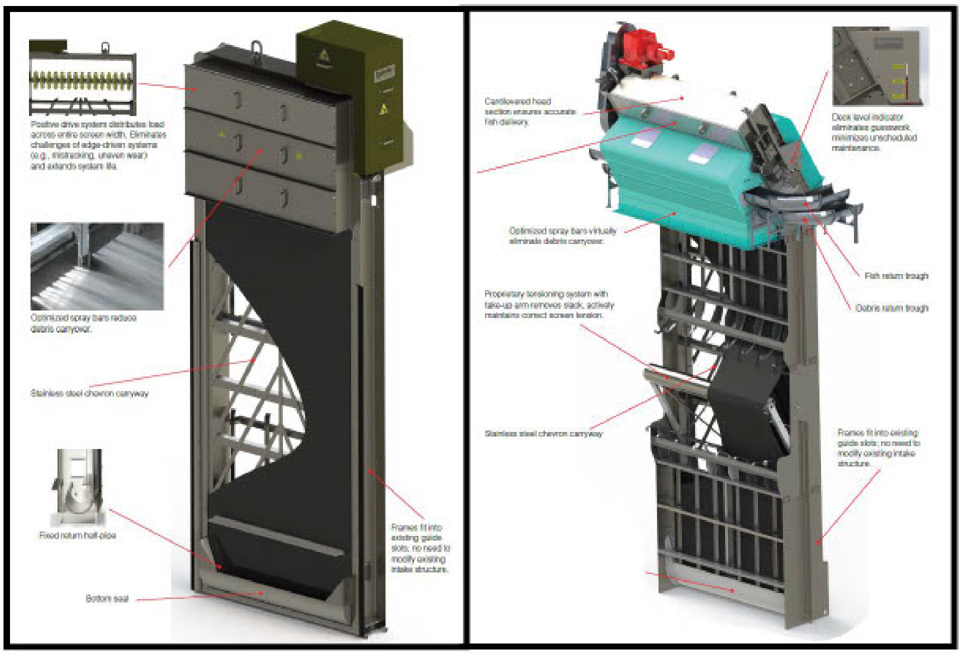

Figure 4-a. Components of vertical traveling conveyor screens from Hydrolox, Series 1800 (left), Series 6000 (right)

b) Information for Cone Screen from ISI

Appendix I contains the brochure for cone screens provided by ISI, which is the source of the information provided below along with a meeting held with ISI (Burnett and Berry, virtual communication, May 9th 2022).

ISI cone screens consist of wedge-wire screen which are sized for low approach velocities for fish protection. The water enters the screen through gravity, pumping, or siphon. An external cleaning brush is controlled through the brush drive assembly to prevent debris and sediment buildup and biofouling. The brush rotates in both directions to avoid uneven wear on the bristles. Brush cleaning is automated to a frequency and duration that meets site requirements. The cone screen can be monitored and controlled remotely. This type of screen is ideal for shallow water and silty conditions. The screen is low maintenance and requires minimal power input. Figure 4-b provides an image of a cross-section of a cone screen from the brochure in Appendix I.

4-4

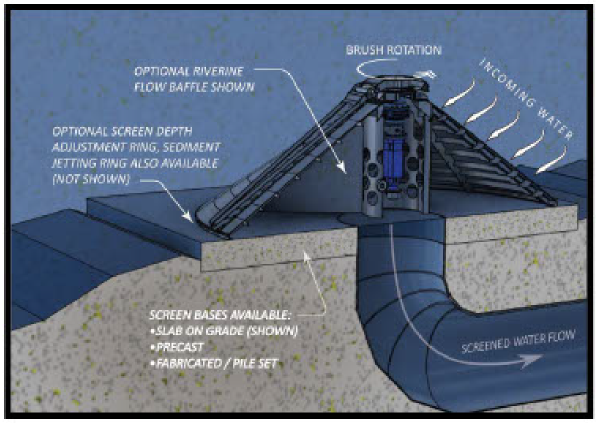

Figure 4-b. Screen design and optional components

Cone screens can be partially or fully submerged. Partially submerged screens are designed to have enough submerged surface area to intake the required flow. Due to the multiple screens and the variability in gravity flow rate, the cone screens must be power driven rather than turbine driven. The screens can be installed in a way to pull the drive assembly without removing the entire screen. The screens are held down to the foundation by only four bolts for easy removal if it is ever needed. It is possible to build a bridge deck for a portable davit crane to pull the screens out. If a pile foundation is used, cone screens can be prefabricated and set on the foundation without the need for dewatering.

The system can be designed to handle surface and frazil ice (Burnett, virtual communication, May 24th, 2022). The installation of heated water jetting or an air bubbler system will mitigate the formation of ice and prevent the ice from catching on the screen. The tops of cone screens can become iced over, but it will not affect the intake because the intake occurs below the water surface.

ISI suggests installing ten 14-ft diameter screens for a total maximum flow of 579.15 cfs with 0.33 ft/s approach velocity or 500 cfs with 40% screen surface area redundancy. With 50% screen open area, each cone unit can provide flow rates up to 57.91 cfs at full submergence. The screen material would be wedge-wire with 1.75 mm slot openings. These design aspects satisfy all the requirements from the design criteria in Table 3-d. Each cone screen will include an electric external brush controlled by a Siemens programmable logic control (PLC) system for

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manual and programmed cleaning. A typical brush cleaning cycle would be one minute of clockwise rotation and one minute of counterclockwise rotation.

Appendix J contains a standard drawing of the cone screen with more descriptions and details. Appendix K contains the shop drawings and a potential configuration of the system transposed onto the mouth of the North Canal.

c) Rotary Cylinder (Barrel) Screen
Appendix N contains the brochure for cone screens provided by ISI, which is the source of the information provided below along with a meeting held with ISI (Burnett and Berry, virtual communication, May 9th 2022).

ISI cylinder screens are customizable in size, configuration, drive type, and orientation. The cylinder does have the option to be fixed or retrievable. The retrievable option places the cylinder screens on a retrievable track which provides easier maintenance of the screen. The retrievable track system can include an electric hoist system and trash racks. The system has interior and exterior mechanical brushes that prevent debris and sediment buildup and biofouling. The interior brush works to remove rocks and grit that may have gotten stuck in the screen. The cleaning system can be programmed to suit site conditions. The fish screen is sized to allow low approach velocities for fish protection. It is ideal for rivers with biofouling and silty conditions. Figure 4-c shows the components and optional parts that ISI provides from the brochure in Appendix N.

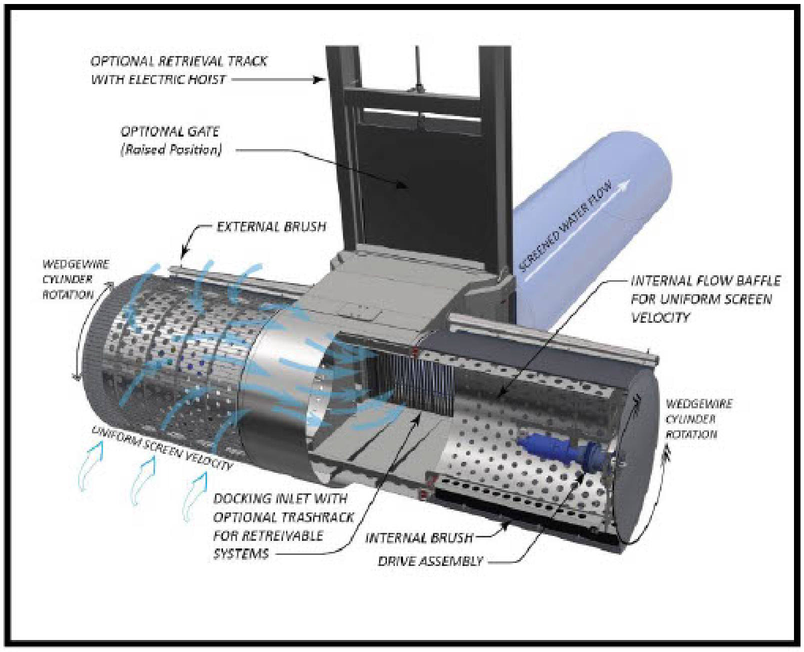

Figure 4-c. System and components of cylinder screen

The system can be designed to handle surface and frazil ice. The installation of heated water jetting or an air bubbler system will mitigate the formation of ice and prevent the ice from catching on the rotating screen. Since the screens are placed underwater, dealing with external surface and frazil ice should not be much of an issue.

ISI recommends installing 14 36-inch diameter cylinder screens. The screen material would be wedge-wire with 1.75 mm slot openings. With 50% screen open area, each cylinder would provide 34.23 cfs at full submergence. The total diversion capacity would be 478.5 cfs at 0.33 ft/s approach velocity or 478 cfs with 16% redundancy. These design aspects satisfy all the requirements from the design criteria in Table 3-d. Each screen would have an internal and external brush controlled by a Siemens PLC system for manual and programmed cleaning. A typical cleaning session would be one minute clockwise brush rotation and one minute counter clockwise rotation. With a retrievable system, the screen could be lowered or raised on the retrieval track with an electric hoist.

4-7

Appendix O provides the drawings for the configuration of mounted cylinder screens. Appendix P provides the drawings for the configuration of retrievable cylinder screens. Appendix Q contains an application of the cylinder screens for a dam diversion in the Yellowstone River. This system was installed to protect the federally endangered Pallid Sturgeon and other native fish.

d) Construction Considerations

Each proposed scenario will require a structure to be constructed across the entrance of the diversion. The proposed alternatives are not expected to have any effect on the flow of the Klamath River due to the design requirements, which limits the approach velocity so the intake does not affect the fish.

Due to the type of deep silty soil that is in the area, the fish screens must be set on pile foundations. A geotechnical investigation of the site must be completed before the foundation can be designed. The piles will need to be driven into the bottom of the river using a barge.

The North Canal southern levee is discontinuous because of natural waterways that connect the canal to the river. An example of a natural waterway in the southern levee is shown in Figure 4-d, highlighted by the yellow circle. These waterways will need to be sealed using embankment fill or sheet pile so that fish do not travel up the waterways and become entrapped in the canal. A barge will be required to deliver and install the sheet pile to the breaks in the southern levee.

Figure 4-d. Example of a break in the southern levee of the North Canal

4-8

Chapter 5 - Life Cycle Cost Analysis

A Life Cycle Cost Analysis (LCCA) was conducted for each fish screen option to provide an estimate of costs for construction, operation, and maintenance. All maintenance costs were calculated for a 20-year period because each system is expected to last 20 years before it needs to be replaced. Each cost estimate factors in a 20% construction contingency, 10% engineering cost, 10% construction administration and 8% mobilization cost.

a) LCCA for Hydrolox

The capital cost includes the design, manufacture, and installation of seven screens, which can provide 58.1 cfs of flow. It also includes the startup, training, and checkup from Hydrolox. The capital cost also accounts for site preparation, pile footing, concrete foundation, sheet pile, dewatering, catwalk, access road, power extension, slide gates, and south levee sheet piling. A breakdown of the capital costs is shown in Figure 5-a.

The Operations, Maintenance, and Replacement (OM&R) includes weekly and monthly inspection, power cost, and necessary maintenance. The OM&R also includes components that will need to be replaced such as module, brush, epoxy coat, and the components of the spray wash system. Present value (PV) of the OM&R puts the future cost into present terms. Table 5-a shows the estimated costs for the Hydrolox conveyor screen.

Table 5-a. LCCA for conveyor screen

LCCA HYDROLOX	
CAPITAL COST	$ 4,591,057
ANNUAL OM&R	$ 27,320
PV OF OM&R	$ 530,485
SALVAGE VALUE	$ 614,150
PV OF SALVAGE VALUE	$ 434,096
LIFE CYCLE COST (PV)	$ 4,687,446

FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT
PRELIMINARY COST ESTIMATE - CONVEYOR SCREEN
(YEAR 2022 COST)

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
General					
1	8% MOBILIZATION	LS	$240,500	All Req'd	$240,500
2	10 SCREENS, 10 SLIDE GATES, 10 INTAKE, CONTROLS INCLUDES DESIGN & FABRICATION, TESTING, TRAINING, 2-YEAR WARRANTY	LS	$682,000	All Req'd	$682,000
3	SITE PREPARATION	LS	$140,000	All Req'd	$140,000
4	20' PILE FOOTINGS	EA/FT	$160	28	$89,600
5	CONCRETE FOUNDATION	CUYD	$1,228	833	$1,023,583
6	SHEET PILE	LS	$130,000	All Req'd	$130,000
7	DEWATERING	LS	$100,000	All Req'd	$100,000
8	ACCESS ROAD IMPROVEMENT (14FT GRAVEL ROAD)	FT	$17	6,900	$117,300
9	SLIDE GATES	EA	$10,000	7	$70,000
10	METAL WORK (CATWALK + RAILING)	LS	$28,914	All Req'd	$28,914
11	POWER EXTENSION	FT	$60	4,600	$276,000
12	SHEET PILE FOR SOUTH LEVEE	LS	$110,000	All Req'd	$110,000
12	DEBRIS BOOM	LS	$200,000	All Req'd	$200,000

Sum of Estimated Construction Cost	**$3,207,898**
Contingency (20%)	$641,580
Engineering (10%)	$320,790
Permitting and Environmental Compliance	$100,000
Construction Admin (10%)	$320,790
TOTAL ESTIMATED PROJECT COST (2022 DOLLARS)	**$4,591,057**

PRELIMINARY COST ESTIMATE
CONVEYOR SCREEN
FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT

FIGURE 5-a

Figure 5-a. Capital cost breakdown for conveyor screen

5-1

b) LCCA for Cone

The LCCA for the cone screen accounts for ten screens which can provide the required 500 cfs flow. The capital cost includes the design and fabrication of ten screens, intake plenums, slide gates, and controls. The capital cost also includes the site preparation, pile footing, concrete foundation, sheet pile, dewatering, catwalk, power extension, south levee sheet piling, screen testing, on-site training, and a 2-year warranty. A breakdown of the capital costs is shown in Figure 5-b.

The annual OM&R includes the weekly and monthly inspections for the system along with replacing the internal brush and motor. Table 5-b shows the cost breakdown.

Table 5-b. LCCA for cone screen

LCCA CONE	
CAPITAL COST	$ 8,790,987
ANNUAL OM&R	$ 15,020
PV OF OM&R	$ 291,650
SALVAGE VALUE	$ 1,473,960
PV OF SALVAGE VALUE	$ 1,041,831
LIFE CYCLE COST (PV)	$ 8,040,807

FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT
PRELIMINARY COST ESTIMATE - CONE SCREEN
(YEAR 2022 COST)

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
General					
1	8% MOBILIZATION	LS	$480,500	All Req'd	$480,500
2	10 SCREENS, 10 SLIDE GATES, 10 INTAKE, CONTROLS INCLUDES DESIGN & FABRICATION, TESTING, TRAINING, 2-YEAR WARRANTY	LS	$2,000,000	All Req'd	$2,000,000
3	SITE PREPARATION	LS	$140,000	All Req'd	$140,000
4	20' PILE FOOTINGS	EA/FT	$160	40	$128,000
5	CONCRETE FOUNDATION	CUYD	$1,228	2,000	$2,456,600
6	SHEET PILE COFFER DAM	LS	$130,000	All Req'd	$130,000
7	DEWATERING	LS	$100,000	All Req'd	$100,000
8	ACCESS ROAD IMPROVEMENT (14FT GRAVEL ROAD)	FT	$17	6,900	$117,300
9	METAL WORK (CATWALK + RAILING)	LS	$69,448	All Req'd	$69,448
10	POWER EXTENSION	FT	$60	4,600	$276,000
11	SHEET PILE FOR SOUTH LEVEE	LS	$110,000	All Req'd	$110,000
12	DEBRIS BOOM	LS	$200,000	All Req'd	$200,000
	Sum of Estimated Construction Cost				**$6,207,848**
	Contingency (20%)				$1,241,570
	Engineering (10%)				$620,785
	Permitting and Environmental Compliance				$100,000
	Construction Admin (10%)				$620,785
	TOTAL ESTIMATED PROJECT COST (2022 DOLLARS)				**$8,790,987**

PRELIMINARY COST ESTIMATE
CONE SCREEN
FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT

FIGURE 5-b

Figure 5-b. Capital cost breakdown for cone screen

5-3

c) LCCA for Fixed Cylinder

The LCCA for the cone screen accounts for ten screens which can provide the required 500 cfs flow. The capital cost includes the fabrication of 14 screens, intake, 14 slide gates, controls, site preparation, pile footing, concrete foundation, sheet pile, dewatering, catwalk, power extension, south levee sheet piling, testing, on-site training, and a 2-year warranty. Figure 5-c details the components used to estimate the capital cost.

The OM&R includes weekly and monthly inspections and replacement for internal and external brush and motor. Table 5-c shows the breakdown of the costs.

Table 5-c. LCCA for mounted cylinder screen

LCCA FIXED CYLINDER	
CAPITAL COST	$ 11,456,261
ANNUAL OM&R	$ 11,720
PV OF OM&R	$ 227,573
SALVAGE VALUE	$ 1,809,695
PV OF SALVAGE VALUE	$ 1,279,137
LIFE CYCLE COST (PV)	$ 10,404,697

FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT
PRELIMINARY COST ESTIMATE - FIXED CYLINDER SCREEN
(YEAR 2022 COST)

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
General					
1	8% MOBILIZATION	LS	$633,000	All Req'd	$633,000
2	10 SCREENS, 10 SLIDE GATES, 10 INTAKE, CONTROLS INCLUDES DESIGN & FABRICATION, TESTING, TRAINING, 2-YEAR WARRANTY	LS	$3,000,000	All Req'd	$3,000,000
3	SITE PREPARATION	LS	$140,000	All Req'd	$140,000
4	20' PILE FOOTINGS	EA/FT	$160	80	$256,000
5	CONCRETE FOUNDATION	CUYD	$1,228	2,456	$3,016,159
6	SHEET PILE COFFER DAM	LS	$158,600	All Req'd	$158,600
7	DEWATERING	LS	$120,000	All Req'd	$120,000
8	ACCESS ROAD IMPROVEMENT (14FT GRAVEL ROAD)	FT	$17	6,900	$117,300
9	METAL WORK (CATWALK + RAILING)	LS	$84,556	All Req'd	$84,556
10	POWER EXTENSION	FT	$60	4,600	$276,000
11	SHEET PILE FOR SOUTH LEVEE	LS	$110,000	All Req'd	$110,000
12	DEBRIS BOOM	LS	$200,000	All Req'd	$200,000

Sum of Estimated Construction Cost	**$8,111,615**
Contingency (20%)	$1,622,323
Engineering (10%)	$811,162
Permitting and Environmental Compliance	$100,000
Construction Admin (10%)	$811,162
TOTAL ESTIMATED PROJECT COST (2022 DOLLARS)	**$11,456,261**

PRELIMINARY COST ESTIMATE
FIXED CYLINDER SCREEN
FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT

FIGURE 5-c

Figure 5-c. Capital cost breakdown for fixed cylinder screen

5-5

d) LCCA for Retrievable Cylinder

The LCCA for the cone screen accounts for ten screens which can provide the required 500 cfs flow. The capital cost contains all the same items as the fixed screens but adds the cost of retrievable tracks. Figure 5-d shows the breakdown for the capital cost estimate.

The OM&R includes weekly and monthly inspections and replacement for internal and external brush and motor. Table 5-d contains the cost estimates.

Table 5-d. LCCA for retrievable cylinder screen

LCCA RETRIEVABLE CYLINDER	
CAPITAL COST	$ 13,358,161
ANNUAL OM&R	$ 31,720
PV OF OM&R	$ 615,922
SALVAGE VALUE	$ 1,809,695
PV OF SALVAGE VALUE	$ 1,279,137
LIFE CYCLE COST (PV)	$ 12,694,946

FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT
PRELIMINARY COST ESTIMATE - RETRIEVABLE CYLINDER SCREEN
(YEAR 2022 COST)

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
General					
1	8% MOBILIZATION	LS	$741,500	All Req'd	$741,500
2	10 SCREENS, 10 SLIDE GATES, 10 INTAKE, CONTROLS INCLUDES DESIGN & FABRICATION, TESTING, TRAINING, 2-YEAR WARRANTY	LS	$4,250,000	All Req'd	$4,250,000
3	SITE PREPARATION	LS	$140,000	All Req'd	$140,000
4	20' PILE FOOTINGS	EA/FT	$160	80	$256,000
5	CONCRETE FOUNDATION	CUYD	$1,228	2,456	$3,016,159
6	SHEET PILE COFFER DAM	LS	$158,600	All Req'd	$158,600
7	DEWATERING	LS	$120,000	All Req'd	$120,000
8	ACCESS ROAD IMPROVEMENT (14FT GRAVEL ROAD)	FT	$17	6,900	$117,300
9	METAL WORK (CATWALK + RAILING)	LS	$84,556	All Req'd	$84,556
10	POWER EXTENSION	FT	$60	4,600	$276,000
11	SHEET PILE FOR SOUTH LEVEE	LS	$110,000	All Req'd	$110,000
12	DEBRIS BOOM	LS	$200,000	All Req'd	$200,000

Sum of Estimated Construction Cost	**$9,470,115**
Contingency (20%)	$1,894,023
Engineering (10%)	$947,012
Permitting and Environmental Compliance	$100,000
Construction Admin (10%)	$947,012
TOTAL ESTIMATED PROJECT COST (2022 DOLLARS)	**$13,358,161**

PRELIMINARY COST ESTIMATE
RETRIEVABLE CYLINDER SCREEN
FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT

FIGURE 5-d

Figure 5-d. Capital cost breakdown for retrievable cylinder screen

5-7

e) Comparison of LCCA
Table 5-e shows a side-by-side comparison of the LCCA for each alternative.

Table 5-e. Comparison of LCCA for alternatives

COSTS	CONVEYOR	CONE	FIXED CYLINDER	RETRIEVABLE CYLINDER
CAPITAL COST	$ 4,591,057	$ 8,790,987	$ 11,456,261	$ 13,358,161
ANNUAL OM&R	$ 27,320	$ 15,020	$ 11,720	$ 31,720
PV OF OM&R	$ 530,485	$ 291,650	$ 227,573	$ 615,922
SALVAGE VALUE	$ 614,150	$ 1,473,960	$ 1,809,695	$ 1,809,695
PV OF SALVAGE VALUE	$ 434,096	$ 1,041,831	$ 1,279,137	$ 1,279,137
LIFE CYCLE COST (PV)	$ 4,687,446	$ 8,040,807	$ 10,404,697	$ 12,694,946

Note: the conveyor screen is not feasible due to low flow capacity. The cost shown for the conveyor screen is for 58.1 cfs instead of 500 cfs.

Chapter 6 - Proposed Project

a) Preliminary Project Design

KDD concluded to proceed with the cone screen alternative for preliminary design. The alternative had a reasonable cost estimate and was low maintenance compared to the cylinder screen. The cylinder screen options had more moving parts to maintain. The conveyor screen could not provide the required intake. If Hydrolox comes up with a solution to provide the required intake prior to the construction of the fish screen, then KDD will reconsider the conveyor screen as an alternative.

b) Debris Management

For the cone screens, KDD expressed concerns regarding heavy debris, such as wood and algal debris. Their concerns were that the screen may become damaged if woody debris, such as logs, collide into it or algal debris will clog up the screen and any debris that is brushed off will travel downstream to the next screen. KDD would like to install a debris boom to redirect logs away from the fish screens. ISI claims that with a 40% screen redundancy, algae or debris should not cause any issues with limiting the intake flow. ISI also said that the mechanical brush should be sufficient in cleaning the screen and resuspending the debris. They can provide jetting systems to push sediment and debris away from the screens. The jetting system sprays start at 50gpm per nozzle at 50psi through a 1/2-inch nozzle. The jetting system is pressurized with submersible electric pumps and surge tanks. ISI currently does not believe the jetting system is required, but KDD would like the redundancy for worst case scenarios. Figure 6-b shows a debris boom configuration and an example of a jetting system installed around the cone screen.

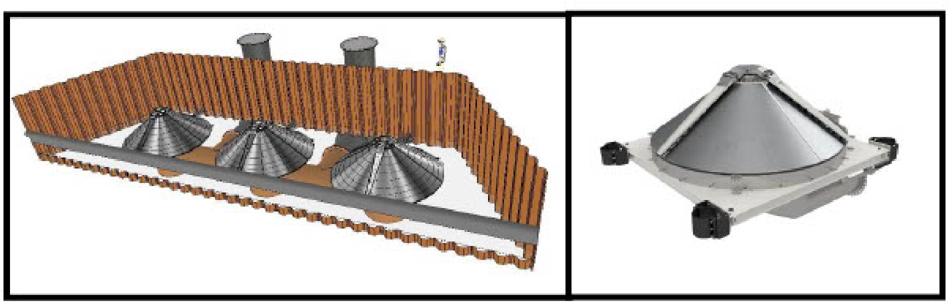

Figure 6-b. Potential debris boom configuration (left), example of jet spray system surrounding screen (right)

6-1

c) Winter Conditions
The Klamath River tends to freeze over due to the climate in the Klamath Basin. ISI recommends an air bubbler system around the screen array for surface and frazil ice. The system would use compressed air to move warmer water to the surface. This process adds oxygen into the water which is beneficial for the fish. The addition of oxygen also helps digest algae and break anoxic and hypoxic sediment. The air bubbler may help mitigate the formation of algae near the screening facility if the air bubbler is run year-around. Figure 6-c shows the components of a typical bubbler system.

Figure 6-c. Example of air bubbler system

d) Description of Project

The screen facility will have ten 14-ft diameter mechanical brush cleaned wedge-wire cone screens mounted on a concrete base within a sheet pile headwork. The facility will be installed perpendicular to the North Canal. Each cone screen would be constructed from type 304 stainless

6-2

steel with 1.75 mm wedge-wire slot openings and wire width. The screens will have a 50% open area to provide a capacity of 70.2 cfs at full submergence, resulting in a total diversion capacity for the ten screens of 702 cfs at a 0.4 ft/s approach velocity (NMFS maximum allowable approach velocity) or 40% screen surface area redundancy at a 500 cfs diversion rate. Each cone screen would have an intake plenum to convey water from the cone screen into the diversion and a slide gate to close off flow through the plenum. Each cone screen would be equipped with an electric powered external brush cleaning system that would be controlled by a Siemens based PLC with touch-screen Human-Machine Interface (HMI) for manual and programmed screen cleaning. A typical brush cleaning cycle includes one minute of clockwise brush rotation followed by one minute of counterclockwise brush rotation. ISI estimates two to four cleaning cycles per day, or four to eight minutes of screen cleaning for this system.

The estimate for the cost of the system provided by ISI was $1.75-2.0 million. This estimate included design and fabrication of this equipment, factory acceptance testing, on-site training, a replacement brush for each screen, an extra drive assembly, and a 2-year warranty. Excluded from this estimate is shipping, tax, bonding, design and construction of the headworks, and on-site installation of the ISI provided equipment.

e) Project Schedule
The estimated project schedule begins with this feasibility study and continues until the project closes out. Table 6-e provides a quarterly estimate of the project schedule.

Table 6-e. Estimated project schedule

Activity	Estimated Start Date	Estimate Completion Date
Feasibility Study	2nd Quarter 2022	2nd Quarter 2022
Watershed Plan	3rd Quarter 2022	2nd Quarter 2024
Engineering	3rd Quarter 2024	1st Quarter 2025
Permitting	1st Quarter 2025	3rd Quarter 2026
Bidding	4th Quarter 2026	4th Quarter 2026
Construction	4th Quarter 2026	4th Quarter 2027
Project Close Out	4th Quarter 2027	4th Quarter 2027

f) Permit Requirements
For work within waterways, permits from Department of State Lands (DSL) and United States Army Corps of Engineers (USACE) must be completed. Oregon's Removal-Fill Law requires a permit from DSL prior to the removal or fill of organic or inorganic material in waters of the state, such as wetlands and reservoirs (DSL 2021). The National Wetlands Inventory identifies the area adjacent to the southern levee as a freshwater emergent wetland. The wetland is owned by Tule Smoke Hunting Club where the primary use of the wetlands is for duck hunting. A General Authorization permit is used for nine types of removal-fill activities including piling placement and waterway habitat restoration. Pile foundations will be necessary at this location and will be discussed in a following section. A fish screen could be considered waterway habitat restoration to assist fish migration. The USACE requires a nationwide or regional permit for construction in waters of the US (USACE 2014). USACE will determine the type of permit required.

The project has not yet been discussed with the Tule Smoke Hunting Club. They will need to grant temporary and permanent access for construction work on their property and for maintenance of the screens. They will also need to grant permission to seal off the southern levee.

g) Sustainability Considerations
ISI has installed cone screens powered using solar panels. One such project that they did was for an irrigation diversion, contained in Appendix N. The diversion had a single 14 ft diameter cone screen with a capacity of 70 cfs. The cone screen was powered by a 500-Watt solar system with six deep-cycle batteries and a charging system. Solar power was chosen for that location to avoid having to run power to the site.

For the North Canal, assuming each cone screen will require one 500-Watt solar panel with 7 ft by 3.5 ft dimensions, then the total area needed for solar coverage would be 245 sqft. Solar panels could be installed in this location because of the amount of sunlight the region receives yearly. Factors such as nighttime operation, cloudy weather, and snow covering the panels must also be considered in the design of the panels. An in-depth analysis of solar power is not included in this study, but it could be considered at a later date.

h) Total Project Cost Estimate

The LCCA for the cone screen facility provides an estimate of the expected costs for the facility with a design life of 20 years as shown in Figure 6-h. This includes the additional cost for the air bubbler system for winter conditions, jet spray system for repelling debris, maintenance for debris boom, and excavation/backfill for placing the system. The capital cost includes the high end of the cost estimate from ISI ($2.0 million) and the OM&R accounts for maintenance of the screens, yearly replacement of one mechanical brush, replacement for jet spray system, and replacement for air bubbler system. Table 6-h provides a present value cost breakdown which includes the bubbler and jet spray. The replacement of the mechanical brush is accounted for both in the capital cost and OM&R to be conservative. The total construction cost for the project would be $9.5 million.

Table 6-h. LCCA for cone screen with air bubbler and spray systems

LCCA CONE	
CAPITAL COST	$ 9,505.183
ANNUAL OM&R	$ 20,140
PV OF OM&R	$ 391,068
SALVAGE VALUE	$ 1,473,960
PV OF SALVAGE VALUE	$ 1,041,831
LIFE CYCLE COST (PV)	$ 8,854,420

6-5

FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT
PRELIMINARY COST ESTIMATE - CONE SCREEN
(YEAR 2022 COST)

NO.	ITEM	UNIT	UNIT PRICE	AMOUNT	TOTAL PRICE
General					
1	8% MOBILIZATION	LS	$480,500	All Req'd	$480,500
2	10 SCREENS, 10 SLIDE GATES, 10 INTAKE, CONTROLS INCLUDES DESIGN & FABRICATION, TESTING, TRAINING, 2-YEAR WARRANTY	LS	$2,000,000	All Req'd	$2,000,000
3	SITE PREPARATION	LS	$140,000	All Req'd	$140,000
4	20' PILE FOOTINGS	EA/FT	$160	40	$128,000
5	CONCRETE FOUNDATION	CUYD	$1,228	2,000	$2,456,600
6	SHEET PILE COFFER DAM	LS	$130,000	All Req'd	$130,000
7	DEWATERING	LS	$100,000	All Req'd	$100,000
8	ACCESS ROAD IMPROVEMENT (14FT GRAVEL ROAD)	FT	$17	6,900	$117,300
9	METAL WORK (CATWALK + RAILING)	LS	$69,448	All Req'd	$69,448
10	POWER EXTENSION	FT	$60	4,600	$276,000
11	SHEET PILE FOR SOUTH LEVEE	LS	$110,000	All Req'd	$110,000
12	DEBRIS BOOM	LS	$200,000	All Req'd	$200,000
13	JET SPRAY SYSTEM	EA	$15,000	10	$150,000
14	AIR BUBBLER SYSTEM	LS	$24,000	All Req'd	$24,000
15	EARTHWORK CUT (2649) & FILL (2153)	CUYD	$70	4,802	$336,139
				Sum of Estimated Construction Cost	**$6,717,987**
				Contingency (20%)	$1,343,597
				Engineering (10%)	$671,799
				Permitting and Environmental Compliance	$100,000
				Construction Admin (10%)	$671,799
				TOTAL ESTIMATED PROJECT COST (2022 DOLLARS)	**$9,505,181**

PRELIMINARY COST ESTIMATE
CONE SCREEN
FISH SCREEN ALTERNATIVE
FOR
KLAMATH DRAINAGE DISTRICT

FIGURE 6-h

Figure 6-h. Capital cost for cone screen with bubbler and jet spray systems

6-6

Chapter 7 - Conclusion and Recommendations

Three fish alternatives were presented to KDD. The alternatives were conveyor, cone, and cylinder screens. KDD decided on the cone fish screen as the preferred alternative on the basis that the conveyor screen could not provide the required intake flow and the cylinder screens had more moving parts. The cone screen fish design will cost $9.5 million to construct. The next step includes 10% design drawings and a design report for the cone fish screen. A pilot study should be conducted during the engineering phase to confirm that the screens will work.

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Appendix A Fish Screen Length Clarification Email with Steven Thomas, NOAA

On Thu, Apr 28, 2022 at 12:06 PM Natasha Karan <NKaran@adkinsengineering.com> wrote:

Good afternoon Steve,

My name is Natasha, I'm with Adkins Engineering and Surveying. We had a video call with you on April 20th about fish screens between North Canal and Klamath River. So, we found that the average channel velocity for Klamath River in the proposed location is about 0.16ft/s. Due to this low velocity, I wanted some clarification about a part of the criteria pertaining to vertical and drum screens mentioned below:

11.6.1.5 Screens Longer Than Six Feet:

> Screens longer than 6 feet must be angled and must have *sweeping velocity* greater than the *approach velocity*. This angle may be dictated by site-specific geometry, hydraulic, and sediment conditions. Optimally, *sweeping velocity* should be at least 0.8 ft/s and less than 3 ft/s.

Is the sweeping velocity too low to accommodate for screens larger than 6ft? If so, could we have multiple smaller screens that are spaced out by a certain length instead?

Thank you for your time,

m / 541.217.9251
a / 1435 Esplanade Ave, Klamath Falls, OR 97601
w / NKaran@AdkinsEngineering.com

From: Steve Thomas - NOAA Federal <steve.thomas@noaa.gov>
Sent: Thursday, April 28, 2022 12:58 PM
To: Natasha Karan <NKaran@adkinsengineering.com>
Subject: Re: Clarification on Fish Screen Criteria (Klamath River and North Canal)

Hello Natasha,

Thank you for your question. In waterways where the natural flow is less than the preferred sweeping velocity, fish will be exposed to the screen (and draw of water from the diversion) for an extended period of time. In lakes, tidal areas, and other low velocity environments the design approach velocity should be 0.33 ft/s since salmonids can swim at that speed for extended periods of time. Since the sweeping flow may not effectively move debris away from the screen, mitigating measures should be taken such as adding a debris boom, if the debris at the site floats, or including a system to collect the debris to keep the screen clean may be needed.

I hope this helps.

Steve

Steven L. Thomas, P.E.

(he/him/his) why this is important

Fish Passage Engineer
West Coast Region
NOAA Fisheries | U.S. Department of Commerce
Mobile: (707) 696-3123
www.fisheries.noaa.gov

On Fri, Apr 29, 2022 at 9:12 AM Natasha Karan <NKaran@adkinsengineering.com> wrote:

Good morning Steve,

Thank you for that information.
So, with such a low sweeping velocity, what type of fish screen would you recommend that wouldn't require a debris boom? Would a vertical conveyor screen work?

Thank you for your time,

m / 541.217.9251
a / 1435 Esplanade Ave, Klamath Falls, OR 97601
w / AdkinsEngineering.com

From: Steve Thomas - NOAA Federal <steve.thomas@noaa.gov>
Sent: Friday, April 29, 2022 12:28 PM
To: Natasha Karan <NKaran@adkinsengineering.com>
Subject: Re: Clarification on Fish Screen Criteria (Klamath River and North Canal)

Hi Natasha,

In areas with low sweeping velocity debris management by some means is needed, either using something like a debris boom to keep floating debris from encroaching on the screen, or by physically handling the debris as it accumulates on the screen. If the debris is only floating material, then screens that are completely submerged may work well. That would include conical screens, cylindrical screens (fixed or retrievable), and flat plate screens.

Traveling screens (conveyor belt-like things) may be a good option if they are on an incline so debris will travel up and over the top with the moving screen material. Debris could then be collected or allowed to move downstream in the diverted water. This may be a good option. I do not have much experience with traveling screens. I've seen three installations of Hydrolox traveling screens and all have had high maintenance requirements that if left undone can result in catastrophic failure. Traveling screens in highly controlled environments (like as secondary dewatering screens in fish screen bypass systems) have a long track record in the PNW. In a natural environment, I'd be somewhat concerned about the toe of the screen getting buried in sediment. The lower seal would need to be inspected regularly to ensure fish are not entrained. Traveling screens may have problems with maintaining moving parts under water, but the plusses may outweigh the negatives for your situation.

In areas with lots of leafy debris a cleaning system that uses a brush may be capable of keeping sufficient screen area open to allow diversion operations, but the screen would need to be checked often. When debris build up is too great the debris would need to be removed from the area manually. If the site has mats of filamentous algae, manually managing that material will be an intensive part of regular maintenance. We are considering traveling screens for a site with mats of algae in southern California. I'll need to look into their ability to handle algal mats, so if you have information on that please let me know.

I hope this helps.

Steve

Steven L. Thomas, P.E.

(he/him/his) why this is important

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Appendix B ORS Chapter 509 – General Protective Regulations

2015 EDITION

FISH PASSAGE; FISHWAYS; SCREENING DEVICES; HATCHERIES NEAR DAMS

509.580 Definitions for ORS 509.580 to 509.590, 509.600 to 509.645 and 509.910; rules. As used in ORS 509.580 to 509.590, 509.600 to 509.645 and 509.910:

(1) "Artificial obstruction" means any dam, diversion, culvert or other human-made device placed in the waters of this state that precludes or prevents the migration of native migratory fish.

(2) "Construction" means:

(a) Original construction;

(b) Major replacement;

(c) Structural modifications that increase storage or diversion capacity; or

(d) For purposes of culverts, installation or replacement of a roadbed or culvert.

(3) "Emergency" means unforeseen circumstances materially related to or affected by an artificial obstruction that, because of adverse impacts to a population of native migratory fish, requires immediate action. The State Fish and Wildlife Director may further define the term "emergency" by rule.

(4) "Fundamental change in permit status" means a change in regulatory approval for the operation of an artificial obstruction where the regulatory agency has discretion to impose additional conditions on the applicant, including but not limited to licensing, relicensing, reauthorization or the granting of new water rights, but not including water right transfers or routine maintenance permits.

(5) "In-proximity" means within the same watershed or water basin and having the highest likelihood of benefiting the native migratory fish populations directly affected by an artificial obstruction.

(6) "Native migratory fish" means those native fish that migrate for their life cycle needs and that are listed in the rules of the State Fish and Wildlife Director.

(7) "Net benefit" means an increase in the overall, in-proximity habitat quality or quantity that is biologically likely to lead to an increased number of native migratory fish after a development action and any subsequent mitigation measures have been completed.

(8) "Oregon Plan" means the guidance statement and framework described in ORS 541.898. [2001 c.923 §1]

Note: 509.580 to 509.595 were enacted into law by the Legislative Assembly but were not added to or made a part of ORS chapter 509 or any series therein by legislative action. See Preface to Oregon Revised Statutes for further explanation.

509.585 Fish passage required for artificial obstructions; statewide inventory; waiver of requirement by commission; rules; exemptions. (1) It is the policy of the State of Oregon to provide for upstream and downstream passage for native migratory fish and the Legislative Assembly finds that cooperation and collaboration between public and private entities is necessary to accomplish the policy goal of providing passage for native migratory fish and to achieve the enhancement and restoration of Oregon's native salmonid populations, as envisioned by the Oregon Plan. Therefore, except as provided in ORS chapter 509, fish passage is required in all waters of this state in which native migratory fish are currently or have historically been present.

(2) Except as otherwise provided by this section or ORS 509.645, a person owning or operating an artificial obstruction may not construct or maintain any artificial obstruction across any waters of this state that are inhabited, or historically inhabited, by native migratory fish without providing passage for native migratory fish.

(3) The State Department of Fish and Wildlife shall complete and maintain a statewide inventory of artificial obstructions in order to prioritize enforcement actions based on the needs of native migratory fish. This prioritization shall include, but need not be limited to, the degree of impact of the artificial obstruction on the native migratory fish, the biological status of the native migratory fish stocks in question and any other factor established by the department by rule. The department shall establish a list of priority projects for enforcement purposes. Priority artificial obstructions are subject to the State Fish and Wildlife Commission's authority as provided in ORS 509.625. Unless requested by persons owning or operating an artificial obstruction, the department shall primarily direct its enforcement authority toward priority projects, emergencies and projects described in subsection (4) of this section. The priority project list shall be subject to periodic review and amendment by the department and to formal review and amendment by the commission no less frequently than once every five years.

(4) A person owning or operating an artificial obstruction shall, prior to construction, fundamental change in permit status or abandonment of the artificial obstruction in any waters of this state, obtain a determination from the department as to whether native migratory fish are or historically have been present in the waters. If the department determines that native migratory fish are or historically have been present in the waters, the person owning or operating the artificial obstruction shall either submit a proposal for fish passage to the department or apply for a waiver pursuant to subsection (7) of this section. Approval of the proposed fish passage facility or of the alternatives to fish passage must be obtained from the department prior to construction, permit modification or abandonment of the artificial obstruction.

(5) Consistent with the purpose and goals of the Oregon Plan, the department shall seek cooperative partnerships to remedy fish passage problems and to ensure that problems are corrected as soon as possible. The department and the person owning or operating the artificial obstruction are encouraged to negotiate the terms and conditions of fish passage or alternatives to fish passage, including appropriate cost sharing. The negotiations may include, but are not limited to, consideration of equitable factors.

(6) The department shall submit a proposed determination of the required fish passage or alternatives to fish passage to the commission for approval. The determination may be the result of the negotiations described in subsection (5) of this section or, if no agreement was reached in the negotiations, a determination proposed by the department. If a protest is not filed within the time period specified in ORS 509.645, the proposed determination shall become a final order.

(7)(a) The commission shall waive the requirement for fish passage if the commission determines that the alternatives to fish passage proposed by the person owning or operating the artificial obstruction provide a net benefit to native migratory fish.

(b) Net benefit to native migratory fish is determined under this subsection by comparing the benefit to native migratory fish that would occur if the artificial obstruction had fish passage to the benefit to native migratory fish that would occur using the proposed alternatives to fish passage. Alternatives to fish passage must result in a benefit to fish greater than that provided by the artificial obstruction with fish passage. The net benefit to fish shall be determined based upon conditions that exist at the time of comparison.

(c) The State Fish and Wildlife Director shall develop rules establishing general criteria for determining the adequacy of fish passage and of alternatives to fish passage. The general criteria shall include, but not be limited to:

(A) The geographic scope in which alternatives must be conducted;

(B) The type and quality of habitat;

(C) The species affected;

(D) The status of the native migratory fish stocks;

(E) Standards for monitoring, evaluating and adaptive management;

(F) The feasibility of fish passage and alternatives to fish passage;

(G) Quantified baseline conditions;

(H) Historic conditions;

(I) Existing native migratory fish management plans;

(J) Financial or other incentives and the application of incentives;

(K) Data collection and evaluation; and

(L) Consistency with the purpose and goals of the Oregon Plan.

(d) To the extent feasible, the department shall coordinate its requirements for adequate fish passage or alternatives to fish passage with any federal requirements.

(8) A person owning or operating an artificial obstruction may at any time petition the commission to waive the requirement for fish passage in exchange for agreed-upon alternatives to fish passage that provide a net benefit to native migratory fish as determined in subsection (7) of this section.

(9)(a) Artificial obstructions without fish passage are exempt from the requirement to provide fish passage if the commission:

(A) Finds that a lack of fish passage has been effectively mitigated;

(B) Has granted a legal waiver for the artificial obstruction; or

(C) Finds there is no appreciable benefit to providing fish passage.

(b) The commission shall review, at least once every seven years, the artificial obstructions exempted under this subsection that do not have an exemption expiration date to determine whether the exemption should be renewed. The commission may revoke or amend an exemption if it finds that circumstances have changed such that the relevant requirements for the exemption no longer apply. The person owning or operating the artificial obstruction may protest the decision by the commission pursuant to ORS 509.645.

(10) If the fundamental change in permit status is an expiration of a license of a federally licensed hydroelectric project, the commission's determination shall be submitted to the Federal Energy Regulatory Commission as required by ORS 543A.060 to 543A.410.

(11) To the extent that the requirements of this section are preempted by the Federal Power Act or by the laws governing hydroelectric projects located in waters governed jointly by Oregon and another state, federally licensed hydroelectric projects are exempt from the requirements of this section.

(12) A person subject to a decision of the commission under this section shall have the right to a contested case hearing according to the applicable provisions of ORS chapter 183. [2001 c.923 §2]

Note: See note under 509.580.

509.590 Fish Passage Task Force; reports to legislature. (1) The State Fish and Wildlife Director shall establish a Fish Passage Task Force to advise the director and the State Department of Fish and Wildlife on matters related to fish passage in Oregon, including but not limited to funding, cost sharing and prioritization of efforts. The director shall determine the members and the specific duties of the task force by rule.

(2) The department shall provide staff necessary for the performance of the functions of the task force.

(3) A member of the task force may not receive compensation for services as a member of the task force. In accordance with ORS 292.495, a member of the task force may receive reimbursement for actual and necessary travel or other expenses incurred in the performance of official duties.

(4) The task force shall report semiannually to the appropriate legislative committee with responsibility for salmon restoration or species recovery, to advise the committee on matters related to fish passage. [2001 c.923 §3; 2007 c.354 §17]

Note: See note under 509.580.

509.592 Task force advice to department regarding project funding; department report on deposits and expenditures. (1) The Fish Passage Task Force established pursuant to ORS 509.590 shall provide advice to the State Department of Fish and Wildlife regarding the projects to be funded and the expenditures to be made from the Fish Passage Restoration Subaccount created under ORS 497.141.

(2) The department shall maintain a record of all moneys deposited to or expended from the subaccount. The department shall make an annual report of the deposits and expenditures available to the public on the department's website. [2013 c.674 §2]

Note: 509.592 was enacted into law by the Legislative Assembly but was not added to or made a part of ORS chapter 509 or any series therein by legislative action. See Preface to Oregon Revised Statutes for further explanation.

509.595 Director to report on fish passage rules, adequacy and implementation. The State Fish and Wildlife Director shall report to the Governor, the Speaker of the House of Representatives, the President of the Senate and the appropriate legislative committee with responsibility for salmon restoration or species recovery:

(1) Prior to the adoption of rules relating to fish passage;

(2) Prior to the establishment of the general criteria for determining the adequacy of fish passage and of alternatives to fish passage required to be established under ORS 509.585 (7)(c); and

(3) Semiannually on the progress that the director has made in implementing ORS 509.580 to 509.590. [2001 c.923 §20; 2007 c.354 §18]

Note: See note under 509.580.

509.600 Destroying, injuring or taking fish near fishway; permits to take fish. (1) A person may not willfully or knowingly destroy, injure or take fish within 600 feet of any fishway,

except as permitted by subsection (2) of this section. Actions that violate this section include, but are not limited to:

(a) Hindering, annoying or disturbing fish entering, passing through, resting in or leaving such fishway, or obstructing the passage of fish through the fishway at any time or in any manner.

(b) Placing anything in the fishway.

(c) Using any fishing gear within 600 feet of the fishway.

(d) Taking fish at any time anywhere within 600 feet of the fishway.

(e) Doing any injury to the fishway.

(2) The State Fish and Wildlife Commission may by rule or by issuance of permits authorize the taking of fish within 600 feet of any fishway. [1965 c.570 §104; 1973 c.723 §122; 1981 c.646 §6; 2001 c.923 §8]

509.605 [Amended by 1955 c.707 §49; 1963 c.178 §1; 1965 c.570 §131; 1973 c.723 §123; repealed by 2001 c.923 §21]

509.610 Maintenance of fish passage required. (1) Subject to ORS 509.645, when the State Department of Fish and Wildlife requires fish passage to be provided pursuant to ORS 509.585, the person owning or operating an artificial obstruction shall keep the fish passage in such repair as to provide adequate fish passage of native migratory fish at all times.

(2) Each day of neglect or refusal to comply with subsection (1) of this section, after notification in writing by the department, constitutes a separate offense.

(3) A person owning or operating an artificial obstruction is responsible for maintaining, monitoring and evaluating the effectiveness of fish passage or alternatives to fish passage. [Amended by 1955 c.707 §52; 1965 c.570 §132; 2001 c.923 §9]

509.615 [Amended by 1957 c.135 §1; 1963 c.111 §1; 1965 c.570 §135; 1987 c.488 §2; 1993 c.478 §9; 1995 c.426 §6; repealed by 2007 c.625 §16]

509.620 Condemning inadequate or nonfunctioning fish passage; requiring new fish passage. If, in the judgment of the State Department of Fish and Wildlife, fish passage is not functioning as intended or is inadequate, as constructed under ORS 509.585, the State Fish and Wildlife Commission may condemn the fish passage and order new fish passage installed in accordance with plans and specifications determined by the department. [Amended by 2001 c.923 §10]

509.625 Power of department to inspect artificial obstructions and have fish passage constructed or remove obstruction. (1) The State Department of Fish and Wildlife may determine or ascertain by inspection of any artificial obstruction whether it would be advisable to construct fish passage, or order the construction pursuant to ORS 509.585 of fish passage, at the artificial obstruction. Without affecting other remedies to enforce the requirement to install fish passage, if the State Fish and Wildlife Commission determines that an emergency exists, the commission may order the construction, pursuant to ORS 509.585, of fish passage in the waters of this state inhabited by native migratory fish as deemed adequate to provide passage for native migratory fish.

(2) Where fish passage has previously been constructed with or without the approval of the commission and has proved useless or inadequate for the purposes for which it is intended, the commission may improve or rebuild such fish passage. However, such construction or reconstruction shall not interfere with the prime purpose of the artificial obstruction. This subsection may not be construed to require the improvement or rebuilding of fish passage by the commission.

(3)(a) The commission may order a person owning or operating an artificial obstruction on the priority list created pursuant to ORS 509.585 who has been issued a water right, owners of lawfully installed culverts or owners of other lawfully installed obstructions to install fish passage or to provide alternatives to fish passage if the commission can arrange for nonowner or nonoperator funding of at least 60 percent of the cost.

(b) Notwithstanding paragraph (a) of this subsection, the commission may order installation of fish passage or alternatives to fish passage without regard to funding sources:

(A) If the person owning or operating the artificial obstruction is already subject to an obligation to install fish passage or to provide alternatives to fish passage under ORS 509.585;

(B) If the commission declares an emergency under this section; or

(C) If the person owning or operating the artificial obstruction has not been issued a water right or if the artificial obstruction has been otherwise unlawfully installed.

(4) If a person who owns or operates an artificial obstruction and who is required to provide fish passage under ORS 509.585 fails to provide fish passage in the manner and time required by the State Department of Fish and Wildlife, the commission may remove, replace or repair the artificial obstruction or any parts of the obstruction at the expense of the owner or operator. [Amended by 1955 c.707 §53; 1963 c.232 §1; 1965 c.570 §133; 2001 c.923 §11]

509.630 Power of department to establish fish passage in natural stream obstructions. The State Department of Fish and Wildlife may determine or ascertain by inspection of any natural obstruction whether it would be advisable to construct fish passage over or around such natural obstruction. If it is deemed advisable the State Fish and Wildlife Commission may construct fish passage that provides adequate passage for native migratory fish in the waters of this state inhabited by native migratory fish. [Amended by 1965 c.570 §134; 2001 c.923 §12]

509.635 Oregon City fishway under control of commission; removal of obstructions. (1) The fishways over the falls in the Willamette River, near Oregon City, are under the care and control of the State Fish and Wildlife Commission, which may make any extensions, additions, alterations or repairs to the same that become necessary.

(2) The commission, or its duly authorized representatives, may remove any artificial obstructions placed in the Willamette River above the falls which would prevent the free passage of fish up the river. [Amended by 1965 c.570 §136]

509.640 [Amended by 1955 c.707 §54; repealed by 2001 c.923 §21]

509.645 Filing protest with commission; review and determination by commission; alternative dispute resolution. (1) A person owning or operating an artificial obstruction may request alternative dispute resolution at any point in the process of determining fish passage requirements.

(2) A person owning or operating an artificial obstruction may file a protest with the State Fish and Wildlife Commission within 30 days from the receipt of the State Department of Fish and Wildlife determinations under ORS 509.585. The person shall identify the grounds for protesting the department's determinations.

(3) The commission may, after sufficient opportunity for public review and comment, approve, deny or modify the proposed determinations. [1955 c.707 §51; 1973 c.723 §124; 2001 c.923 §13]

ENFORCEMENT

509.910 Injunction to prevent certain violations; jurisdiction; service on corporation. (1) The State Fish and Wildlife Commission may maintain an action for an injunction to enjoin and restrain any person, municipal corporation, political subdivision or governmental agency of this state from violating any of the provisions of ORS 509.130, 509.140, 509.505, 509.585, 509.610 and 509.625.

(2) Any action authorized by this section shall be tried in the circuit court of the county in which the violation occurs or in Marion or Multnomah County.

(3) If the defendant is a corporation with its principal office and place of business in a county other than in which the waters flow or are situated, such action shall be deemed an action of local nature and service of summons made on a corporation in any county where the corporation has its principal office and place of business. If it is a foreign corporation, service may be made on the statutory agent but if there is no such statutory agent then upon the Secretary of State as in other cases provided by law. [1963 c.303 §1; 1977 c.242 §8; 1979 c.284 §16; 2001 c.923 §14; 2007 c.625 §10]

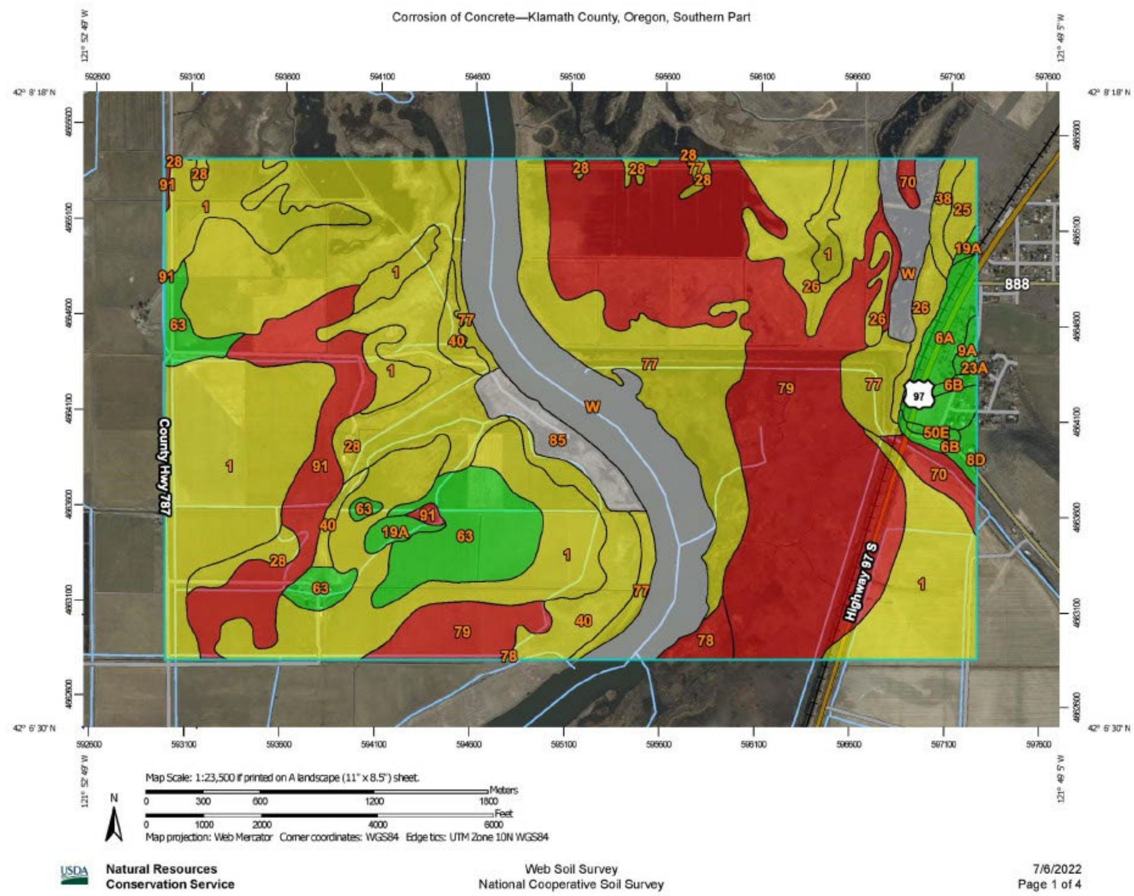
509.990 [Subsection (8) of 1963 Replacement Part enacted as 1955 c.477 §2; subsection (10) of 1963 Replacement Part enacted as 1957 c.152 §8; repealed by 1965 c.570 §152]

509.991 [1965 c.570 §59e; repealed by 1969 c.675 §21]

509.992 [1969 c.675 §15; repealed by 1977 c.242 §10]

CHAPTER 510 [Reserved for expansion]

Appendix C Soil Corrosion


Corrosion of Concrete—Klamath County, Oregon, Southern Part
County Hwy 787
Highway 97 S
97
888
Map Scale: 1:23,500 if printed on A landscape (11" x 8.5") sheet.
Meters
0 300 600 1200 1800
Feet
0 1000 2000 4000 6000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84
Natural Resources
Conservation Service
Web Soil Survey
National Cooperative Soil Survey
7/6/2022
Page 1 of 4

Corrosion of Concrete—Klamath County, Oregon, Southern Part

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- High
- Moderate
- Low
- Not rated or not available

Soil Rating Lines
- High
- Moderate
- Low
- Not rated or not available

Soil Rating Points
- High
- Moderate
- Low
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Klamath County, Oregon, Southern Part
Survey Area Data: Version 20, Oct 27, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 10, 2019—Oct 28, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Natural Resources Conservation Service | Web Soil Survey National Cooperative Soil Survey | 7/6/2022 Page 2 of 4

Corrosion of Concrete

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1	Algoma silt loam, MLRA 21	Moderate	635.6	22.8%
6A	Calimus fine sandy loam, 0 to 2 percent slopes	Low	49.7	1.8%
6B	Calimus fine sandy loam, 2 to 5 percent slopes	Low	16.3	0.6%
8D	Calimus-Capona loams, 15 to 35 percent slopes	Low	0.2	0.0%
9A	Capona loam, 0 to 2 percent slopes	Low	5.6	0.2%
19A	Fordney loamy fine sand, 0 to 2 percent slopes, north, MLRA 21	Low	13.0	0.5%
23A	Harriman loam, 0 to 2 percent slopes	Low	0.4	0.0%
25	Henley loamy fine sand	Moderate	14.9	0.5%
26	Henley loam	Moderate	114.3	4.1%
28	Henley-Laki loams, MLRA 21	Moderate	335.5	12.1%
38	Laki loam	Moderate	13.4	0.5%
40	Laki-Henley loams	Moderate	86.3	3.1%
50E	Lorella very stony loam, 2 to 35 percent south slopes	Low	3.6	0.1%
63	Poe fine sandy loam	Low	131.9	4.7%
70	Scherrard clay loam	High	26.0	0.9%
77	Teeters silt loam	Moderate	244.6	8.8%
78	Tulana silt loam	High	16.6	0.6%
79	Tulana silt loam, sandy substratum	High	616.6	22.2%
85	Xerofluvents, nearly level		43.1	1.5%
91	Zuman silt loam	High	136.9	4.9%
W	Water		278.5	10.0%
Totals for Area of Interest			**2,783.1**	**100.0%**

Description

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens concrete. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The concrete in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the concrete in installations that are entirely within one kind of soil or within one soil layer.

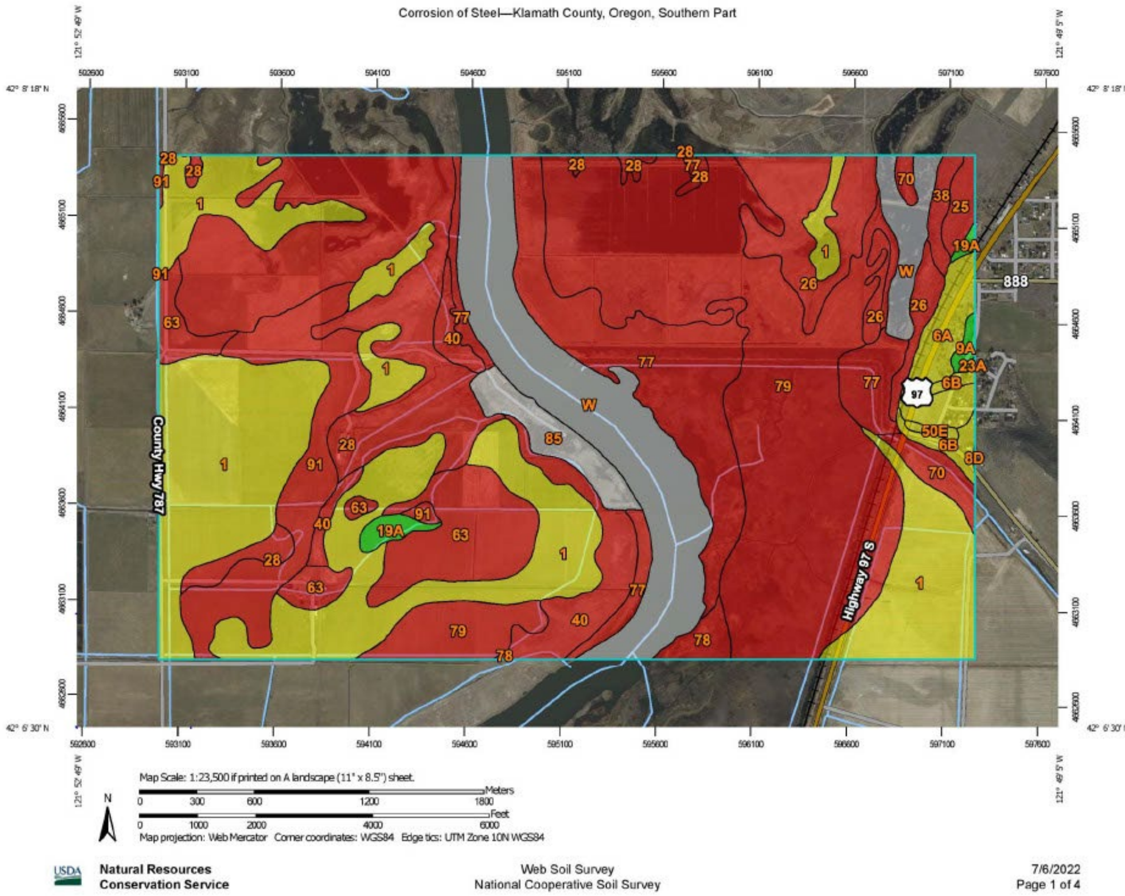
The risk of corrosion is expressed as "low," "moderate," or "high."

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher


Corrosion of Steel—Klamath County, Oregon, Southern Part
County Hwy 787
Highway 97 S
97
888
Map Scale: 1:23,500 if printed on A landscape (11" x 8.5") sheet.
Meters
Feet
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84
Natural Resources Conservation Service
Web Soil Survey
National Cooperative Soil Survey
7/6/2022
Page 1 of 4

Corrosion of Steel—Klamath County, Oregon, Southern Part

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils

Soil Rating Polygons
- High
- Moderate
- Low
- Not rated or not available

Soil Rating Lines
- High
- Moderate
- Low
- Not rated or not available

Soil Rating Points
- High
- Moderate
- Low
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Klamath County, Oregon, Southern Part
Survey Area Data: Version 20, Oct 27, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Oct 10, 2019—Oct 28, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Corrosion of Steel

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1	Algoma silt loam, MLRA 21	Moderate	635.6	22.8%
6A	Calimus fine sandy loam, 0 to 2 percent slopes	Moderate	49.7	1.8%
6B	Calimus fine sandy loam, 2 to 5 percent slopes	Moderate	16.3	0.6%
8D	Calimus-Capona loams, 15 to 35 percent slopes	Moderate	0.2	0.0%
9A	Capona loam, 0 to 2 percent slopes	Low	5.6	0.2%
19A	Fordney loamy fine sand, 0 to 2 percent slopes, north, MLRA 21	Low	13.0	0.5%
23A	Harriman loam, 0 to 2 percent slopes	Low	0.4	0.0%
25	Henley loamy fine sand	High	14.9	0.5%
26	Henley loam	High	114.3	4.1%
28	Henley-Laki loams, MLRA 21	High	335.5	12.1%
38	Laki loam	High	13.4	0.5%
40	Laki-Henley loams	High	86.3	3.1%
50E	Lorella very stony loam, 2 to 35 percent south slopes	Moderate	3.6	0.1%
63	Poe fine sandy loam	High	131.9	4.7%
70	Scherrard clay loam	High	26.0	0.9%
77	Teeters silt loam	High	244.6	8.8%
78	Tulana silt loam	High	16.6	0.6%
79	Tulana silt loam, sandy substratum	High	616.6	22.2%
85	Xerofluvents, nearly level		43.1	1.5%
91	Zuman silt loam	High	136.9	4.9%
W	Water		278.5	10.0%
Totals for Area of Interest			**2,783.1**	**100.0%**

Description

"Risk of corrosion" pertains to potential soil-induced electrochemical or chemical action that corrodes or weakens uncoated steel. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. Special site examination and design may be needed if the combination of factors results in a severe hazard of corrosion. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than the steel in installations that are entirely within one kind of soil or within one soil layer.

The risk of corrosion is expressed as "low," "moderate," or "high."

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Appendix D Hydrolox Brochure

Powerful Solutions for Intake Screening

Hydrolox Traveling Water Screens

The Engineered Polymer Concept

Hydrolox traveling water screens are made from engineered polymer modules assembled in an interlocked, bricklayed pattern with full-length hinge rods an inherently strong design. These modular components allow for fast, on-site maintenance, eliminating the need to replace the entire screen. All polymer components are molded in-house, and we maintain an extensive inventory in order to meet both your normal and emergency delivery needs.

Coupled with an innovative frame design, Hydrolox screen systems deliver significant, measurable advantages over conventional chain-and-basket steel screens. Hydrolox traveling water screens have no side chains, no submerged moving parts, and are designed to remain in the water year-round, with no need for cranes or divers in most cases.

"Our steel band screen was expensive to maintain, and it caused a lot of problems. The Hydrolox screen has been a problem-solver. The downtime, expenses, and cleaning difficulties we experienced previously are no longer an issue. I would recommend Hydrolox screen technology to any power generation facility."

—Stephen Crooks
Project Engineer, Scottish and Southern Energy (SSE)

Longer screen life

Engineered polymer screens are proven to last up to five times longer than steel. A positive-drive system virtually eliminates uneven wear and mistracking.

Virtually maintenance free

Innovative system eliminates side chains (to reduce overall weight) and is free of submerged moving parts. Maintenance and downtime have all but been eliminated.

Run 24/7 with lower operational costs

The modular screen design allows repairs to be made at deck level without needing to lift the screen, thereby lowering operational costs. Screens are designed to remain in the water and operate 24/7, year-round.

Less biofouling

Hydrolox screens' non-adhering surfaces are smooth, easy to clean, and far less prone to biofouling than metal screen options.

Zero corrosion with reduced ice adhesion

Engineered polymer material does not corrode and is less likely to experience ice adhesion.

Improved safety

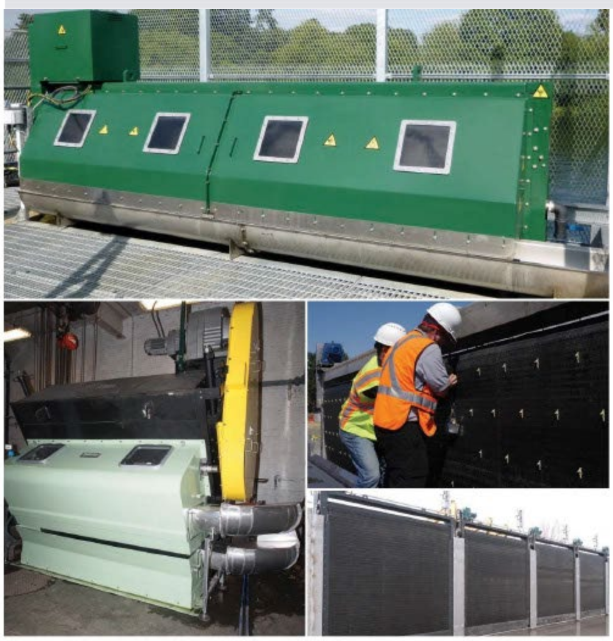
Heavy and difficult to handle, steel materials (especially baskets) threaten worker safety. Hydrolox screens' engineered polymer material and compact screen design reduce system weight by up to 40%.

Better cleaning and debris removal

System features an enhanced spray bar design with excellent mesh coverage to facilitate cleaning and debris removal. Stringy debris are less likely to wrap or cling to screen material.

Proven in field and lab tests

Field and laboratory tests have confirmed that Hydrolox traveling water screens offer outstanding protection to aquatic life.



Innovative technology makes the difference.

Hydrolox™ engineered polymer traveling water screens are changing the way facilities think about intake screen performance. Proven to exclude debris and reduce harm to aquatic life, these effective, longer-lasting solutions are easy to install, require virtually no maintenance, and address the needs of water-extracting facilities across a wide range of industries.

We offer single-point-of-contact project management services to help eliminate bottlenecks during screen installation. Our team supervises the entire process, working with your preferred subcontractors and in-house crew (as needed) to help you minimize downtime while optimizing in-house resources, screen performance, and screen life. This process can include initial site surveys to develop scope of work; project meetings; and factory acceptance testing.

All Hydrolox screens are backed with industry-leading three-year or four-year warranties (warranty terms determined by specifics of screen, application, and installation). In addition to comprehensive on-site support before, during, and after installation, we also provide ongoing expert technical support and award-winning customer service.

"I am extremely pleased with my experience of working with Hydrolox—that's the best part of the whole project. I can't think of any area that needs improvement from a customer standpoint."

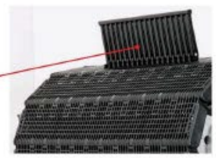
—Danny Vicknair
Maintenance Technician, Entergy Corporation

hydrolox®
ENGINEERED POLYMER SCREENS

Series 6000 Vertical Traveling Screens

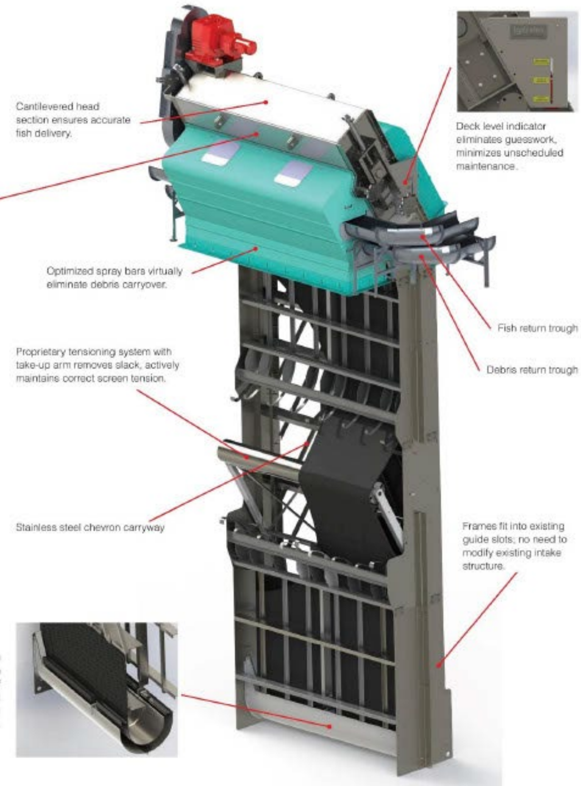
Series 6000 Vertical Traveling Screens **substantially reduce the total cost of ownership** for cooling water intakes and similar screening applications. These screen systems can be manufactured to order in virtually any width or length and can be configured for either debris handling only (vertical) or debris and fish handling (cantilevered). Available in either mesh top or flush grid, they are designed to operate 24/7, year-round.

Positive drive system distributes load across entire screen width. Eliminates challenges of edge-driven systems (e.g., mistracking, uneven wear) and extends system life.



Patented debris-handling flights withstand impact from most debris without damage.

Ristroph-style fish collection bucket complies with fish impingement and entrainment regulations.



Industries
- Power Plants (Fossil Fuels, Nuclear, etc.)
- Oil Refineries
- Chemical Plants
- Pulp & Paper Mills
- Hydroelectric Power

Series 1800 Vertical Traveling Screens

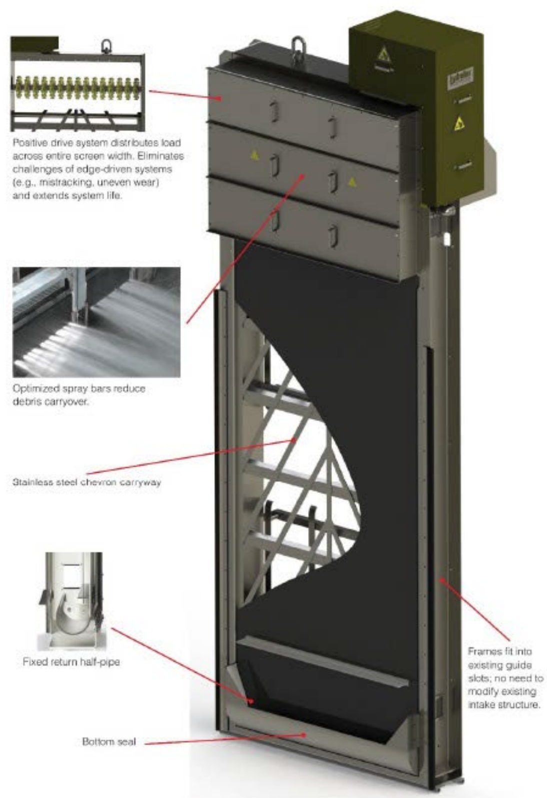
Featuring a mesh top design, Series 1800 Vertical Traveling Screens can be manufactured to order in virtually any width or length and can be installed at a variety of angles to facilitate debris removal. They have proven especially beneficial in overcoming common screening challenges for facilities in irrigation districts, fisheries, and drinking water extraction sites.

Patented debris-handling flights withstand impact from most debris without damage.

Take-up screws raise or lower drive shaft to tension belt.

Fish-friendly debris pegs remove debris in high cross-flow environments.

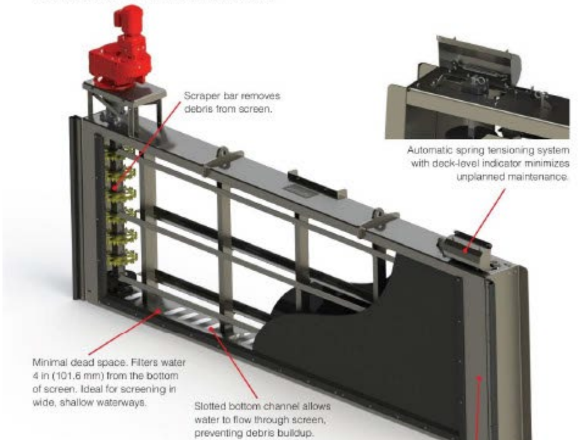
Debris return trough (also available: debris takeaway conveyor option)



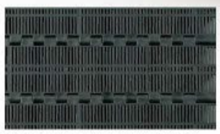
Industries
- Municipal Water Intakes
- Run of River Hydro
- Pumping Plants
- Irrigation Diversions
- Waste Water Screening

Series 1800 Horizontal Traveling Screens

Series 1800 Horizontal Traveling Screens help facilities in irrigation districts, fisheries, and drinking water extraction sites overcome common screening challenges. Suitable for irrigation diversion and smaller, low-flow intakes, these screens are compliant with NOAA fish-protection screening criteria from anadromous species and can be operated using solar power.



Hold-down tabs prevent screen misalignment.



Smooth, non-corrosive engineered polymer screen surface enables easier debris clearing and longer screen life.

Compliance

Our screen systems ensure full compliance with water screen regulations for fish protection. This applies to regulations in both North America and the European Union and includes: Section 316(b) of the Clean Water Act; NOAA and NMFS criteria; the 2009 Eels Regulations (UK); Drinking Water Inspectorate (DWI) regulations; and the 2015 Water Framework Directive (EU).

"Best Technology Available" for 316(b)

Section 316(b) of the EPA's Clean Water Act requires that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available (BTA) for minimizing adverse environmental impacts—impingement and entrainment.

Under the terms of the rule, Hydrolox traveling water screens qualify as a BTA for minimizing impingement mortality ("modified traveling screens"). Specifically, the EPA noted that Hydrolox screen designs have "shown promise in reducing impingement mortality."

Compliance with the Eels Regulations

The Eels Regulations require companies in the UK who utilize water extraction to meet a threshold of 40% eel "escapement" by 2015.

Hydrolox traveling water screens offer the ideal solution for Eels Regulations compliance. Independent testing with a well-known research organization in the UK has identified Hydrolox as the best technology for fish protection available on the market. The Environment Agency has identified Hydrolox traveling water screens as a solution for those facilities managing glass eel, elver, and adult yellow/silver eel populations. In many cases, retrofitting to Hydrolox is an option.

dwi

contact

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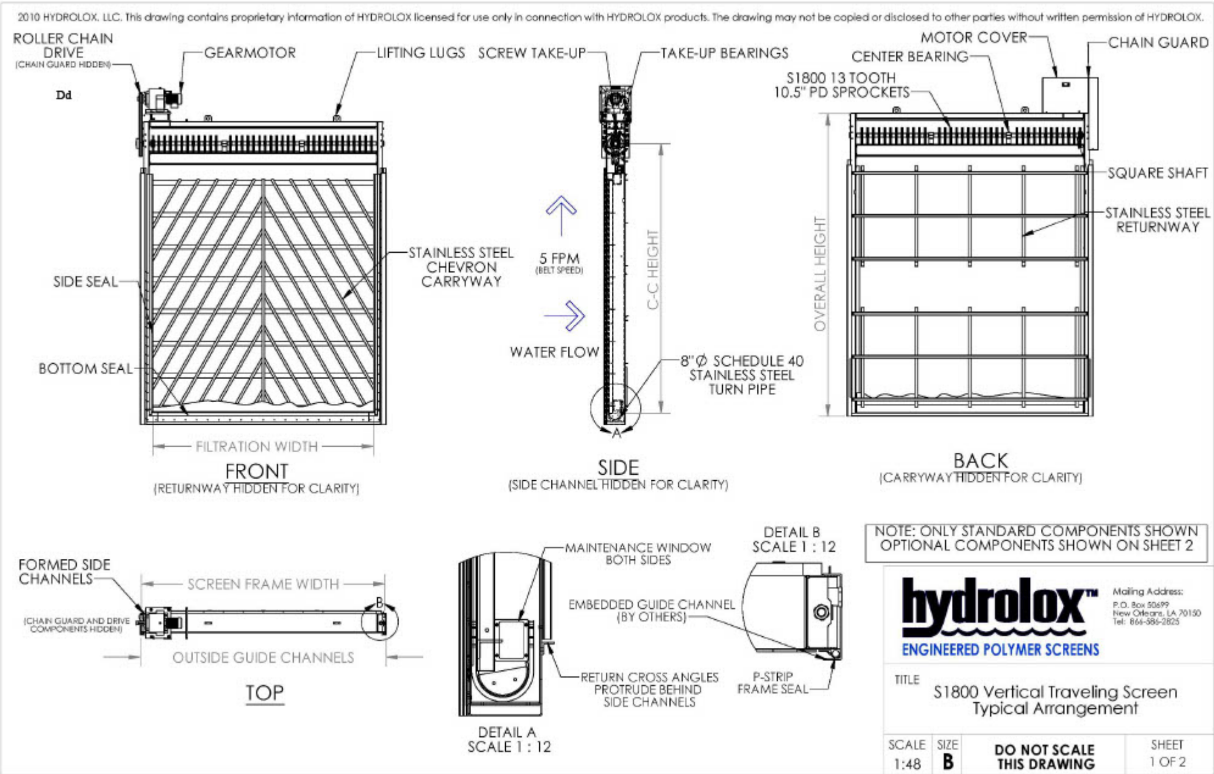
New Orleans, LA 70123
1.866.586.2825 (toll free)

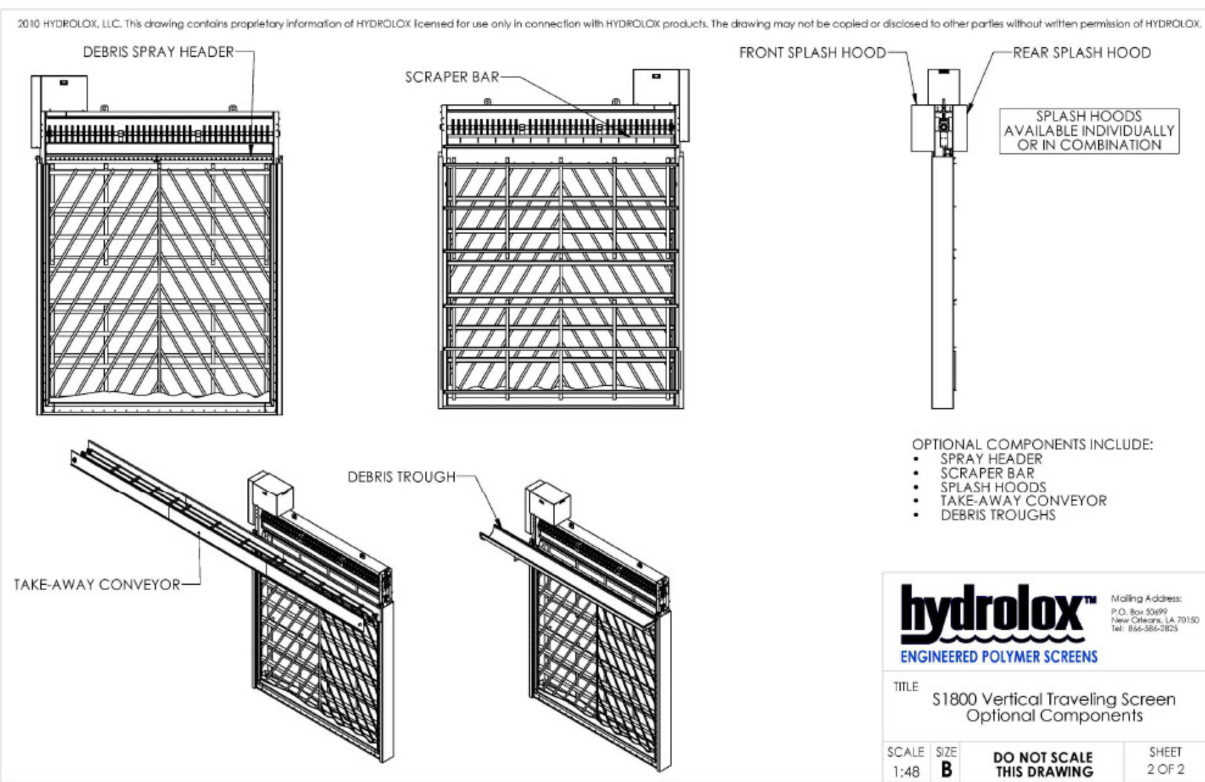
Europe
Lemelerbergweg 31A
1101 AH Amsterdam, Netherlands
00800 3344 5544 (toll free)

info@hydrolox.com
www.hydrolox.com

hydrolox®
ENGINEERED POLYMER SCREENS

Appendix E Hydrolox Standard Drawings


2010 HYDROLOX, LLC. This drawing contains proprietary information of HYDROLOX licensed for use only in connection with HYDROLOX products. The drawing may not be copied or disclosed to other parties without written permission of HYDROLOX.
ROLLER CHAIN DRIVE (CHAIN GUARD HIDDEN)
GEARMOTOR
LIFTING LUGS
SCREW TAKE-UP
TAKE-UP BEARINGS
MOTOR COVER
CHAIN GUARD
CENTER BEARING
S1800 13 TOOTH 10.5" PD SPROCKETS
SQUARE SHAFT
STAINLESS STEEL RETURNWAY
STAINLESS STEEL CHEVRON CARRYWAY
5 FPM (BELT SPEED)
SIDE SEAL
BOTTOM SEAL
WATER FLOW
C-C HEIGHT
OVERALL HEIGHT
8"Ø SCHEDULE 40 STAINLESS STEEL TURN PIPE
FILTRATION WIDTH
FRONT (RETURNWAY HIDDEN FOR CLARITY)
SIDE (SIDE CHANNEL HIDDEN FOR CLARITY)
BACK (CARRYWAY HIDDEN FOR CLARITY)
NOTE: ONLY STANDARD COMPONENTS SHOWN OPTIONAL COMPONENTS SHOWN ON SHEET 2
FORMED SIDE CHANNELS
SCREEN FRAME WIDTH
(CHAIN GUARD AND DRIVE COMPONENTS HIDDEN)
OUTSIDE GUIDE CHANNELS
TOP
MAINTENANCE WINDOW BOTH SIDES
EMBEDDED GUIDE CHANNEL (BY OTHERS)
RETURN CROSS ANGLES PROTRUDE BEHIND SIDE CHANNELS
DETAIL A SCALE 1 : 12
DETAIL B SCALE 1 : 12
P-STRIP FRAME SEAL
hydrolox™ ENGINEERED POLYMER SCREENS
Mailing Address: P.O. Box 50699 New Orleans, LA 70150 Tel: 866-586-2825
TITLE S1800 Vertical Traveling Screen Typical Arrangement
SCALE 1:48
SIZE B
DO NOT SCALE THIS DRAWING
SHEET 1 OF 2


2010 HYDROLOX, LLC. This drawing contains proprietary information of HYDROLOX licensed for use only in connection with HYDROLOX products. The drawing may not be copied or disclosed to other parties without written permission of HYDROLOX.
DEBRIS SPRAY HEADER
SCRAPER BAR
FRONT SPLASH HOOD
REAR SPLASH HOOD
SPLASH HOODS AVAILABLE INDIVIDUALLY OR IN COMBINATION
DEBRIS TROUGH
TAKE-AWAY CONVEYOR
OPTIONAL COMPONENTS INCLUDE:
• SPRAY HEADER
• SCRAPER BAR
• SPLASH HOODS
• TAKE-AWAY CONVEYOR
• DEBRIS TROUGHS
hydrolox™ ENGINEERED POLYMER SCREENS
Mailing Address: P.O. Box 50699 New Orleans, LA 70150 Tel: 866-586-2825
TITLE S1800 Vertical Traveling Screen Optional Components
SCALE 1:48
SIZE B
DO NOT SCALE THIS DRAWING
SHEET 2 OF 2

Appendix F Hydrolox Parts

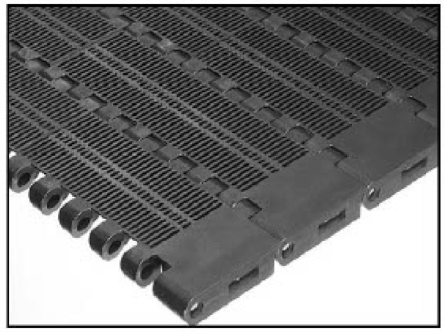
Product Line Extension

Series 1800 Mesh Top Engineered Polymer Screen

Series 1800 Mesh Top Engineered Polymer Screens (EPS) overcome many screening challenges faced by irrigation districts and fisheries. Testing and use by federal and state agencies have demonstrated that Series 1800 Mesh Top EPS offers significant advantages over competing technologies. Made from lightweight materials that are UV-resistant and corrosion-free, Series 1800 Mesh Top EPS is designed to withstand abrasive conditions over many years.

- Meets or exceeds NOAA Fisheries criteria for protection of anadromous fish species.
- Prevents entrainment of fish.
- Improves debris removal and optimizes water filtration.
- Lowers installation costs.
- Virtually eliminates downtime.
- Reduces maintenance costs with self-cleaning mechanism.

Contact Hydrolox today for a sample of this new product or for more information.



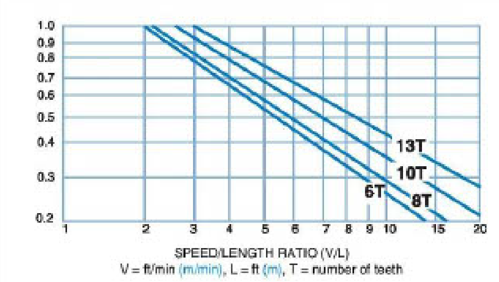
Friction Factors[a]	F_w Friction between wearstrip and belt wearstrip material				F_p Friction between product and belt product material (used in backup conditions)[b]				
Belt Material	UHMW	HDPE	NYLATRON	STEEL (CS & SS)	GLASS	STEEL	PLASTIC	CARDBOARD	ALUMINUM
	WET (DRY)	WET (DRY)	WET (DRY)	WET (DRY)	WET (DRY)	WET (DRY)	WET (DRY)	WET (DRY)	WET (DRY)
Acetal (S)	0.10 (0.10)	0.09 (0.08)	0.13 (0.15)	0.18 (0.19)	0.13 (0.14)	0.13 (0.13)	0.13 (0.16)	- (0.18)	0.33 (0.27)
AR Nylon (S)	- (0.19)	- (0.11)	- (0.24)	- (0.31)	-	-	-	- (0.22)	- (0.31)
Max. Temp. (A)	- (0.32)	- (0.22)	- (0.36)	- (0.30)	-	-	-	- (0.22)	- (0.31)
(S) = smooth, clean conditions. (A) = abrasive, dirty conditions. NR = not recommended.									

a Friction factor values are highly dependent on environmental conditions. The low value of the friction factor range is an experimentally derived friction factor for new belting on new wearstrip. This value should only be used in the cleanest environments or where water or other lubricating agents are present. Most applications should be adjusted based on the environmental conditions surrounding the conveyor.

b Friction factors for friction between product and belt only apply for Flat Top, Perforated Flat Top, Mesh Top, Flush Grid and Raised Rib belts.

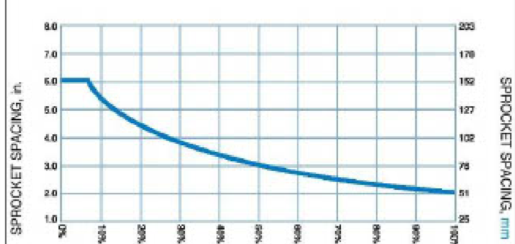
Sprocket Description			A		B		C		E	
Pitch Diameter		No. Teeth	Range (Bottom to Top)		in.	mm	in.	mm	in.	mm
in.	mm		in.	mm						
5.0	127	6	1.77-2.10	45-53	1.87	47	4.95	126	2.91	74
6.5	165	8	2.62-2.87	66-73	2.23	57	6.48	165	3.68	93
8.1	206	10	3.45-3.65	88-93	2.59	66	8.04	204	4.46	113
10.5	267	13	4.67-4.82	119-123	3.02	77	10.40	264	5.64	143

S Strength Factor



Divide belt speed "V" by the shaft C_L distance "L". Strength Factor is found at intersection of speed/length ratio and appropriate sprocket line.

Sprocket Spacing as a Function of Belt Strength Utilized



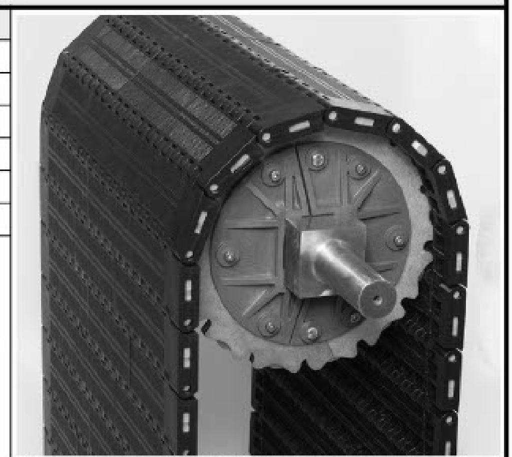
HYDROLOX
U.S. 1-866-586-2825
Europe +800 3344 5544
www.hydrolox.com

hydrolox®

Product Line Extension

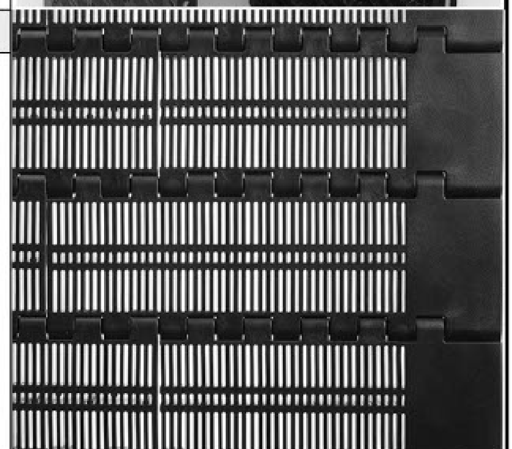
Mesh Top

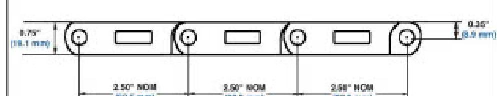
	in.	mm
Pitch	2.50	63.5
Minimum Width	5	127
Width Increments	1.00	25.4
Opening Size (approximate)	0.068 x 0.75	1.7 x 19.1
Open Area	32%	
Hinge Style	Open	
Drive Method	Center-Driven	



Product Notes

- Always check with Customer Service for precise belt width measurement and stock status before designing a screen or ordering a belt.
- Fully flush edges with recessed rods prevent edge damage and rod migration.
- Available with Flights and other Series 1800 accessories.
- Tapered hole slots are 0.068 inch (1.7 mm) wide, 0.75 inch (19.1 mm) long, and prevent fish injury.
- Made of corrosion-resistant polymer.
- UV-resistant material suitable for years of low-maintenance, continuous outdoor use.

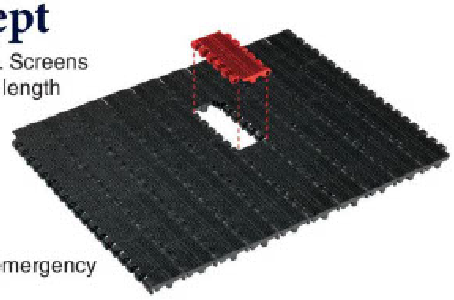




Belt Data

Belt Material	Standard Rod Material Ø 0.312 in. (7.9 mm)	BS Belt Strength lb/ft	BS Belt Strength kg/m	Temperature Range (continuous) °F	Temperature Range (continuous) °C	W Belt Weight lb/ft²	W Belt Weight kg/m²
UV Resistant Acetal	Acetal	1500	2230	-50 to 200	-46 to 93	2.27	11.08
UV Resistant Nylon	Nylon	1000	1488	-50 to 240	-46 to 116	1.81	8.84

The Hydrolox® Screen Concept



Hydrolox screens are made from engineered polymer modules. Screens are assembled in an interlocked, bricklayed pattern with full length hinge rods – an inherently strong design.

Screens can be made to order in virtually any width and length. Modular components also allow for fast, on-site maintenance without having to replace an entire screen.

Hydrolox molds all components in-house and maintains an extensive inventory in order to meet both your normal and emergency delivery needs.

Hydrolox Polymer Screens vs. Steel Screens

Our engineered polymer components and innovative screen frame design combine to produce traveling water screens with significant, measurable advantages over conventional chain and basket steel screens.

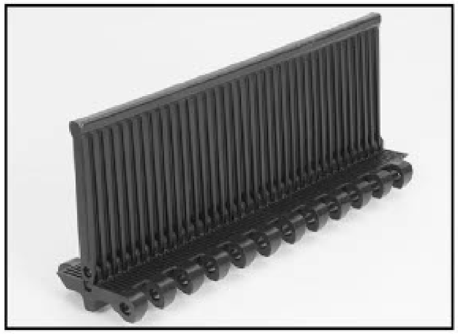
Major Screen Issues	Steel Vertical Traveling Screen Problems	Hydrolox™ Engineered Polymer Vertical Traveling Screen Solutions
Limited Screen Life	Screen life is severely limited by highly abrasive environments. Uneven wear on basket chains causes mistracking and shortens screen life.	Engineered polymer screens are proven to last at least five times longer than steel. The positive-drive system, which requires no chains and is driven by direct sprocket engagement, virtually eliminates uneven wear and mistracking.
Maintenance	Submerged moving parts increase maintenance and are not easily accessible.	System contains no submerged moving parts and requires almost no unscheduled maintenance and downtime.
Operational Costs	Screens require frequent maintenance, including repairs that cannot be done on site.	The modular design allows repairs to be made on site and lowers operational costs. Screens are designed to remain in the water year round.
Corrosion	Steel screening material is highly corrosive, especially in saltwater environments.	Polymers do not corrode.
Biofouling	Steel components readily biofoul.	Engineered polymer material is less likely to biofoul.
Safety	Heavy steel baskets are difficult to handle and can present safety hazards.	System's compact design is approximately 40% lighter. Lightweight engineered polymer material improves worker safety.
Compliance	System is difficult to seal and prone to fish entrainment.	System ensures full compliance with water screen regulations for aquatic life protection: Clean Water Act's 316(b), NOAA, NMFS, 2009 Eels Regulations (UK), Drinking Water Inspectorate (DWI), and 2015 Water Framework Directive (EU). Smooth surface and tight seals minimize de-scaling.
Debris Carryover		Enhanced design of the screen's spray bar has better mesh coverage to greatly reduce carryover.

Product Line Extension

3-Piece Debris Flights

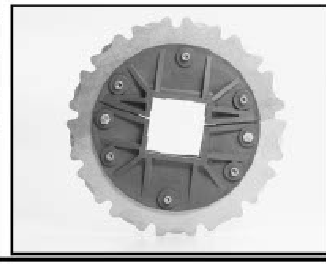
Available Flight Height		Available Materials
in.	mm	
4.0	102	UV Resistant Acetal, Nylon

Note: Flights consist of 3 pieces: the base module, the attachment, and the rod.
Note: Flight surface has 0% open area and a No-Cling surface. The base module has the S1800 Mesh Top design.
Note: The minimum indent is 2 in (51 mm).



Metal Split Sprocket Data[a]

No. of Teeth (Chordal Action)	Nom. Pitch Dia. in.	Nom. Pitch Dia. mm	Nom. Outer Dia. in.	Nom. Outer Dia. mm	Nom. Hub Width in.	Nom. Hub Width mm	Available Bore Sizes			
							U.S. Sizes		Metric Sizes	
							Round in.	Square in.	Round mm	Square mm
13 (2.91%)	10.5	267	10.3	262	1.5	38		2.5		60
								3.5		90



a Contact Customer Service for lead times.

Appendix G Hydrolox Application in Yakima

Hydrolox™ Screen Achieves Longer Life and Reduced Maintenance in Highly Abrasive Application

–Yakima, Washington

Background

After experiencing a drought year, the United States Bureau of Reclamation (USBR) at the Okanogan Irrigation District sought to install a water screen at Shell Rock station in order to activate the pumping site. The environment at Shell Rock is highly abrasive, due to its location on the outside bend of the Okanogan River. During a drought, the water in the river is sediment-laden and full of debris.

Problem

Initially, a steel mesh screen was installed in the application, but it lasted only one and a half years due to frequent problems:

- Sediment build-up under the screen inhibited sprocket tracking.
- Debris was frequently carried over the screen, entering irrigation water pumps and flowing downstream.
- The screen was driven by two sprockets on the ends and sagged in the center, leading to uneven wear.

Solution

Working with Hydrolox representatives, the USBR built a frame to accommodate the Hydrolox Series 1800 traveling engineered polymer screen—an answer to their steel screen problems:

- The Hydrolox screen features a sprocket-driven positive drive system, which eliminates uneven wear and mistracking.
- The smooth polymer surface of the Hydrolox screen allows debris to be easily washed away. Also, a spray bar was installed on the front side of the new screen to help eliminate debris carryover.
- The Hydrolox screen mesh extends the life of the screen with non-corrosive, abrasion-resistant screen material.
- Elimination of submerged foot sprockets reduces operations and maintenance.

And, the innovative design of Hydrolox engineered polymer screens offers additional advantages:

- Compliance with the National Oceanic & Atmospheric Administration's fish-screening criteria for anadromous species
- Screens last up to four times the life of steel screens

Results

Three years after installation, Hydrolox performed a wear analysis of the screen's modules. The results predicted the screen to last at least another two years in the highly abrasive environment, achieving a service life of 3-5 times longer than the steel screen. Since the initial installation of the Hydrolox screen, the USBR reports a 60%-70% reduction in operations and maintenance. Debris carryover has also been eliminated.

Mark Briggs of the USBR reports that the success of the installation was due in large part to the successful partnership between Hydrolox and the USBR: "The support Hydrolox gave was tremendous. That's what helped it work out as smoothly as it did—Hydrolox helped us make sure the spacing and the back support were the right dimensions."

Hydrolox screen as installed at Shell Rock pumping station in the Okanogan Irrigation District.

And because the Hydrolox screen is supported all the way across the mesh, Briggs says, problems associated with sediment build-up and uneven wear are diminished. "It doesn't sag like the other screens…and as far as holding up in highly corrosive waters—it definitely shows an improvement."

For more information contact us at: U.S. 1-866-586-2825, Europe +800 3344 5544, or www.hydrolox.com

hydrolox® ENGINEERED POLYMER SCREENS

Success Stories

Appendix H Hydrolox Application in Snake River

Hydrolox™ Protects Fish for Fall River Electric

CUSTOMER	Fall River Electric Cooperative
LOCATION	Chester Hydro Plant, Fremont County, ID
APPLICATION	Fish bypass system
SOLUTION	Series 1800 Mesh Top Screen
MISSION	Provide clean, renewable energy to local residents and farmers while protecting the sensitive fishing area

The Hydrolox Advantage

- Designed to operate 24/7/365
- Last up to five times longer than traditional chain-driven steel screen systems
- Proven in field and laboratory tests to offer outstanding protection for aquatic life

CUSTOMER OBJECTIVES

The Fall River Electric Cooperative's Chester Hydro Plant is located on the Henry's Fork of the Snake River, an important fishing area for conservation that provides 3.3 MW of power. The two large irrigation ditches on either side of the plant were experiencing problems with fish – 90% of them were ending up in the ditches with near-100% mortality rates. Fall River needed to find a low-maintenance way to ensure fish safety to continue this plant's renewable energy production.

HYDROLOX EXECUTION

Fall River partnered with Henry's Fork Foundation, Trout Unlimited, Idaho Fish and Game, and U.S. Fish and Wildlife to work toward a solution. The group decided to contact Hydrolox due to the water screen manufacturer's reputation for low-maintenance, high fish-protection technology. A total of 15 Series 1800 Mesh Top Screens were installed in front of the irrigation ditches next to Chester Hydro Plant. These 11-ft-by-11-ft screens ensure the local trout population can safely navigate down Snake River.

The S1800 Mesh Top Screen is composed of lightweight materials that are corrosion-free and UV-resistant, making it suitable for years of low-maintenance, continuous outdoor use. The screen's small mesh openings allow for more effective fish exclusion, and its self-cleaning mechanism improves debris removal.

RESULTS

More than five years after installation, the S1800 screens require very little maintenance and fish are no longer trapped in irrigation ditches. Dave Peterson, Fall River Manager of Engineering, says, ***"Everything runs much smoother since we installed the Hydrolox water screens. Fall River Electric can provide power for the area knowing that the Snake River's fish remain unharmed."***

For more information about Hydrolox, visit **www.hydrolox.com**.

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Hydrolox Europe, Amsterdam, The Netherlands, Toll Free: +00800-3344-5544

hydrolox®

Appendix I ISI Cone Screen Brochure


SELF-CLEANING
CONE SCREENS
Customizable Shallow Water Screen Solutions
ISI INTAKE SCREENS, INC.

ISI cone screens are a rugged and reliable self-cleaning screen solution for challenging intake conditions. Designed to provide maximum screen area for any given water depth, we offer cone screens in a wide variety of sizes and drive types to suit the needs of your site.

The mechanical brushing action prevents debris buildup, sedimentation, biofouling, and increased head loss at the screen. ISI cone screens are a proven technology for irrigation, municipal, and industrial water supplies.

HOW IT WORKS

The screen unit consists of a conical-shaped wedgewire screen, an external brush cleaning system, and brush drive assembly with controls. Gravity, siphon, or pumping is used to convey water through the screen.

The screen is sized to achieve low approach and through-screen velocities to meet head loss and fish protection requirements and minimize debris accumulation.

Screen configurations can be customized to include steel or concrete bases, piping, and slide gates as appropriate for the site.

Brush-cleaning frequency and duration is programmed to meet site conditions using the provided control panel (excluding turbine drive screens).

INTAKE SCREENS, INC.

www.isi-screens.com

FEATURES

Flow rates up to 60 cfs (26,930 gpm; 38.8 MGD; 6,116 m^3/h) from a single screen with the opportunity to have multiple screens at a site.

Screen slot sizes ranging from 0.5 to 9-mm.

Brush-cleaning drive types to best suit site conditions: electric, hydraulic (can be solar powered), and turbine.

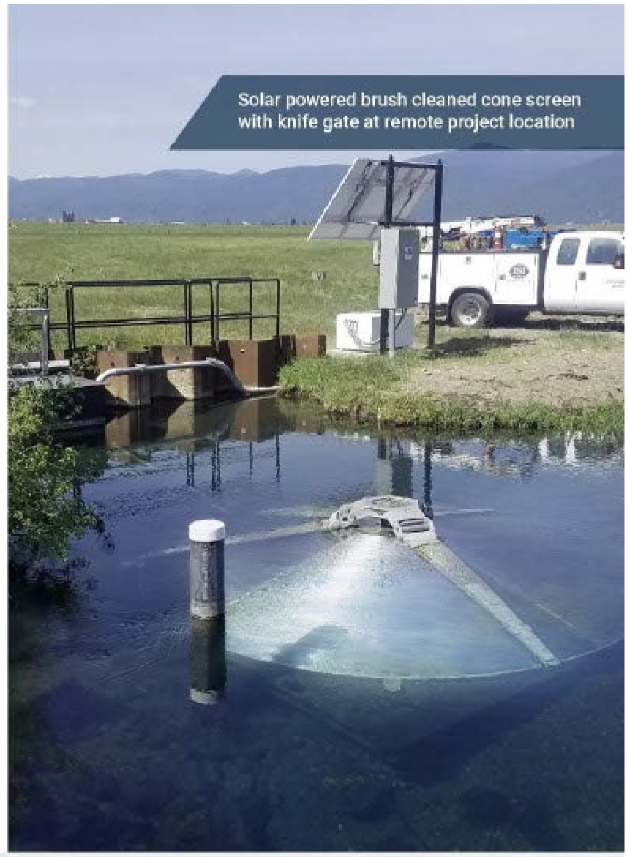
Screen materials including Type 304 and 316 stainless steel with custom materials available (e.g., 2507 super duplex stainless steel).

Sized to be compliant with state, federal, and international fish protection requirements.

Optional riverine flow baffle distributes flow evenly across the screen surface.

Control panel to match customer equipment and remote monitoring and control needs.

Sediment jetting systems and screen depth adjustment rings provided as optional equipment.



Solar powered brush cleaned cone screen with knife gate at remote project location

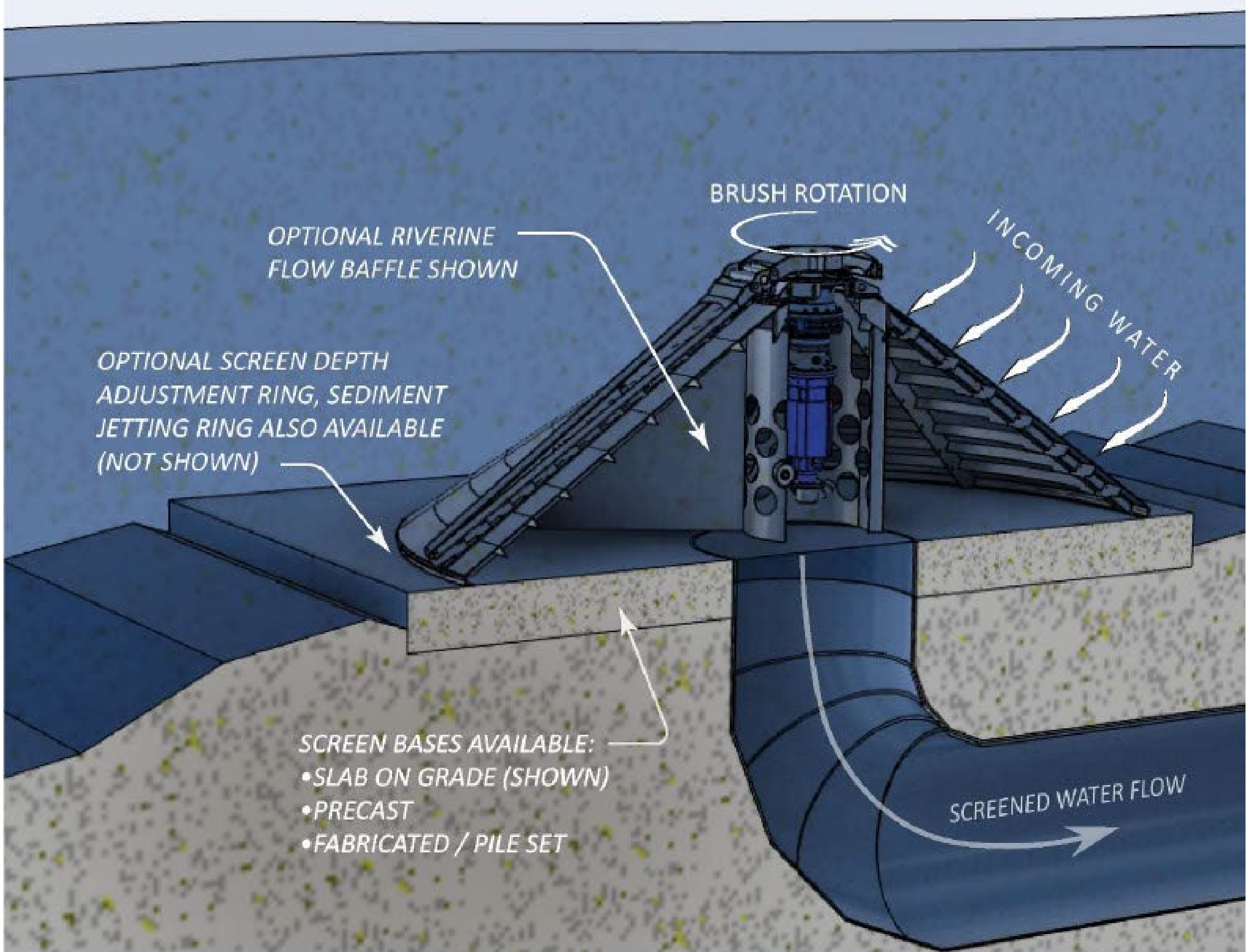
Brush cleaned cone screen located in concrete alcove

BENEFITS

- **Ideal solution for shallow water** rivers and streams, tidal estuaries, backwater areas, silty conditions, and heavy debris.
- **Designed to exceed** fish protection requirements
- **Protects pump** and other downstream equipment from clogging debris
- **Low head loss,** low maintenance, and minimal power input
- **Easy installation** and removal

8417 River Road | Sacramento, California 95832 | (916) 665-2727 | info@isi-screens.com

SCREEN DESIGN & OPERATION



DESIGN AND OPERATION SUPPORT

Working with ISI means access to over 25 years of experience in intake screen design and fabrication including design-build project delivery. Detailed documentation on operation and maintenance provided with all ISI screens. On-site installation guidance and operator training available.

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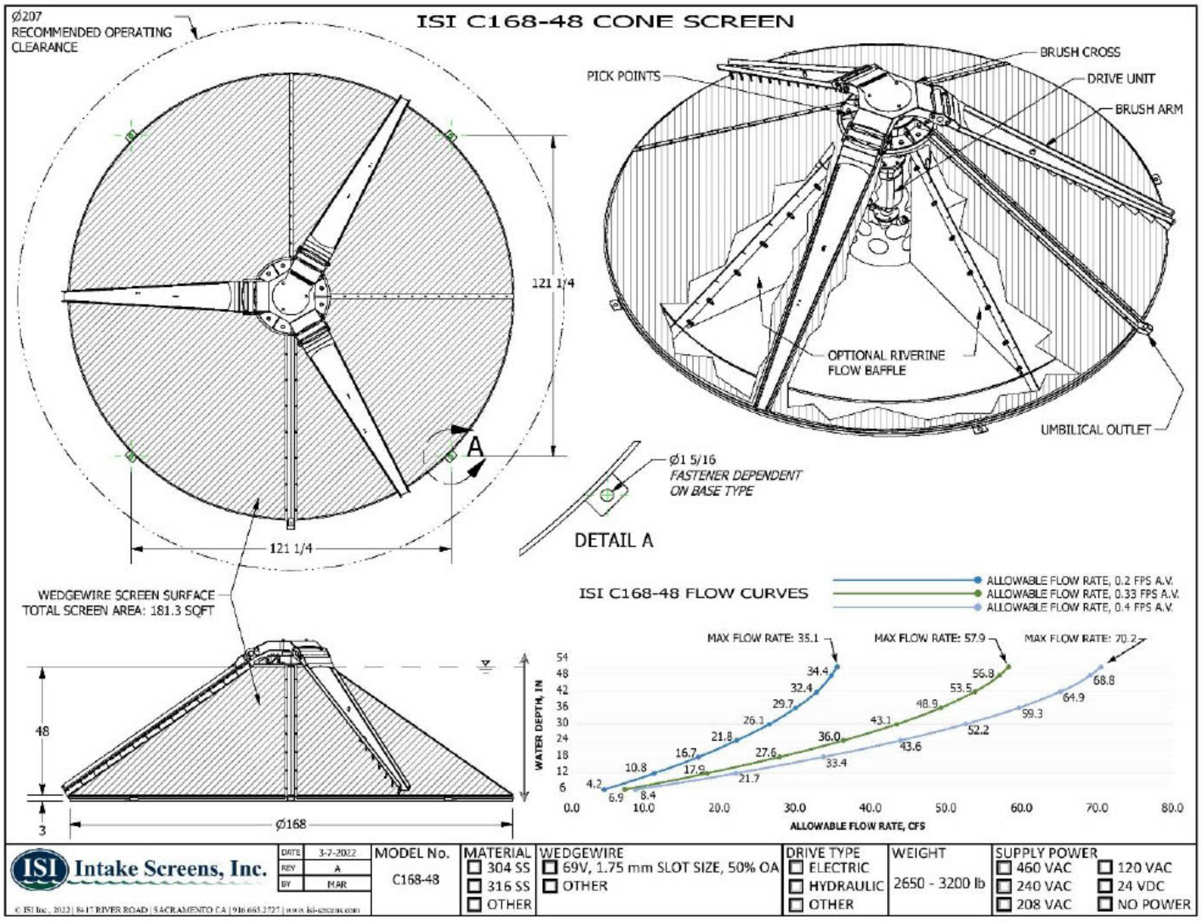
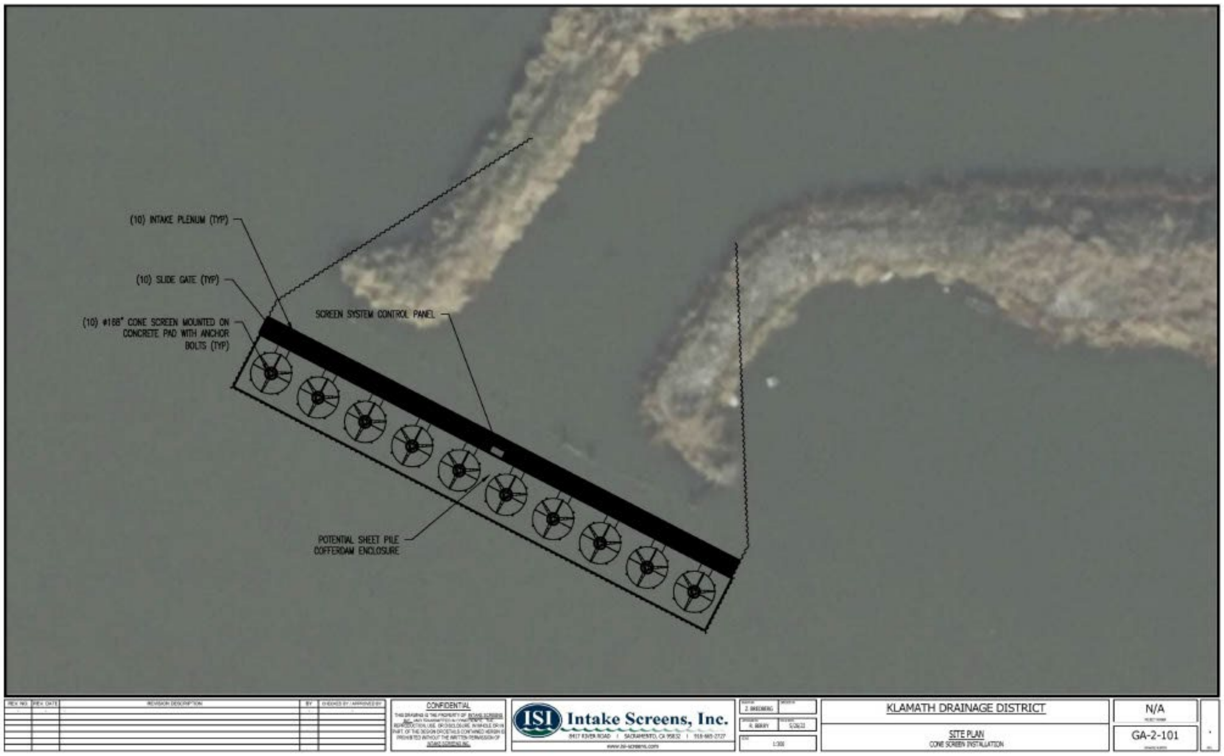
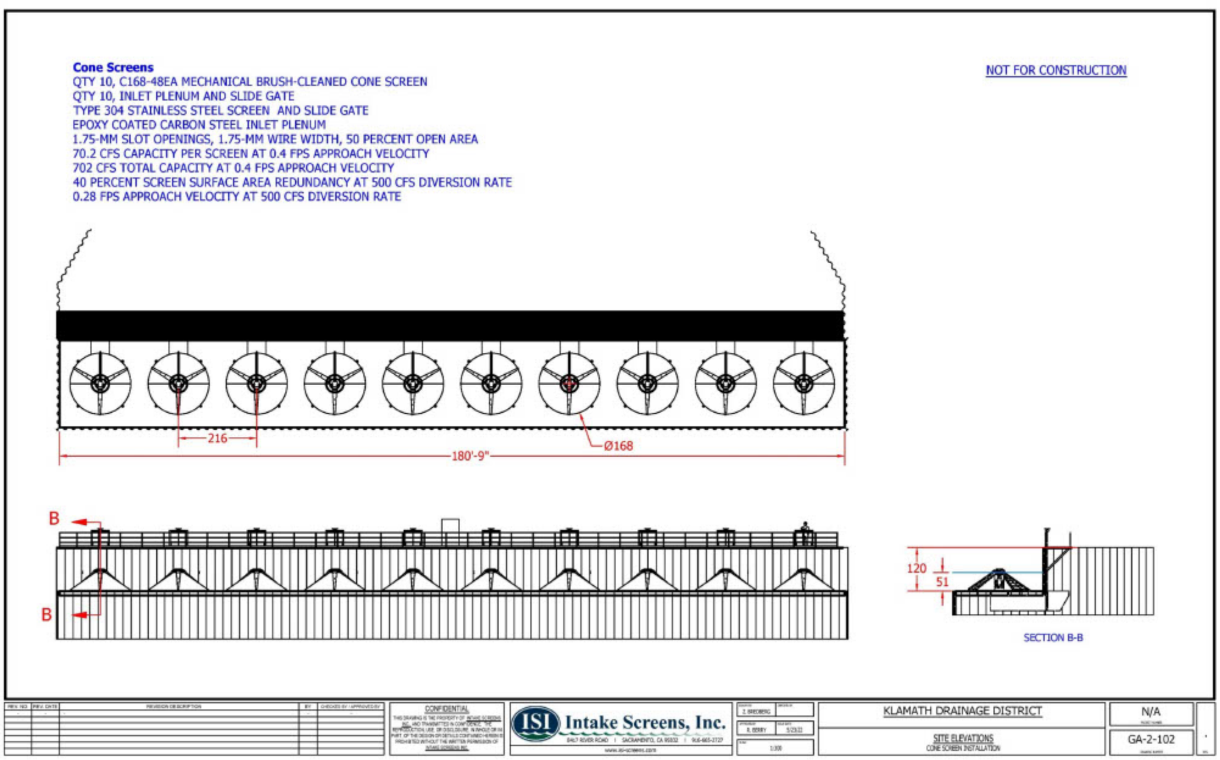
Appendix J ISI Cone Screen Data Sheet


ISI C168-48 CONE SCREEN
Ø207
RECOMMENDED OPERATING
CLEARANCE
PICK POINTS
BRUSH CROSS
DRIVE UNIT
BRUSH ARM
OPTIONAL RIVERINE
FLOW BAFFLE
UMBILICAL OUTLET
121 1/4
Ø1 5/16
FASTENER DEPENDENT
ON BASE TYPE
DETAIL A
WEDGEWIRE SCREEN SURFACE
TOTAL SCREEN AREA: 181.3 SQFT
48
3
Ø168
ISI C168-48 FLOW CURVES
ALLOWABLE FLOW RATE, 0.2 FPS A.V.
ALLOWABLE FLOW RATE, 0.33 FPS A.V.
ALLOWABLE FLOW RATE, 0.4 FPS A.V.
MAX FLOW RATE: 35.1
MAX FLOW RATE: 57.9
MAX FLOW RATE: 70.2
WATER DEPTH, IN
ALLOWABLE FLOW RATE, CFS
Intake Screens, Inc.
DATE 3-7-2022
REV A
BY MAR
MODEL No. C168-48
MATERIAL 304 SS 316 SS OTHER
WEDGEWIRE 69V, 1.75 mm SLOT SIZE, 50% OA OTHER
DRIVE TYPE ELECTRIC HYDRAULIC OTHER
WEIGHT 2650 - 3200 lb
SUPPLY POWER 460 VAC 240 VAC 208 VAC 120 VAC 24 VDC NO POWER

Appendix K Cone Screen Shop Drawings


(10) INTAKE PLENUM (TYP)
(10) SLIDE GATE (TYP)
(10) #168" CONE SCREEN MOUNTED ON CONCRETE PAD WITH ANCHOR BOLTS (TYP)
SCREEN SYSTEM CONTROL PANEL
POTENTIAL SHEET PILE COFFERDAM ENCLOSURE
CONFIDENTIAL
Intake Screens, Inc.
KLAMATH DRAINAGE DISTRICT
SITE PLAN
CONE SCREEN INSTALLATION
N/A
GA-2-101


Cone Screens
QTY 10, C168-48EA MECHANICAL BRUSH-CLEANED CONE SCREEN
QTY 10, INLET PLENUM AND SLIDE GATE
TYPE 304 STAINLESS STEEL SCREEN AND SLIDE GATE
EPOXY COATED CARBON STEEL INLET PLENUM
1.75-MM SLOT OPENINGS, 1.75-MM WIRE WIDTH, 50 PERCENT OPEN AREA
70.2 CFS CAPACITY PER SCREEN AT 0.4 FPS APPROACH VELOCITY
702 CFS TOTAL CAPACITY AT 0.4 FPS APPROACH VELOCITY
40 PERCENT SCREEN SURFACE AREA REDUNDANCY AT 500 CFS DIVERSION RATE
0.28 FPS APPROACH VELOCITY AT 500 CFS DIVERSION RATE
NOT FOR CONSTRUCTION
216
Ø168
180'-9"
B
B
120
51
SECTION B-B
CONFIDENTIAL
Intake Screens, Inc.
KLAMATH DRAINAGE DISTRICT
SITE ELEVATIONS
CONE SCREEN INSTALLATION
N/A
GA-2-102