Horlick Dam Alternatives

Introduction

An inventory of information on the Horlick dam was compiled in Chapter IV. The Horlick dam spillway does not meet WDNR requirements for a Low Hazard dam.[69] Due to the inadequate spillway capacity, structural modifications to the dam would be necessary for the dam to be maintained. Thus, a "no action" alternative is not a viable option for the Horlick dam. Therefore, in this chapter alternatives were developed to meet the regulatory requirements associated with the dam hazard rating and the effects of implementation of those alternatives on the Root River corridor in the vicinity of the dam were addressed. First, issues of concern for evaluating the current conditions and dam alternatives are summarized, next the baseline Horlick dam condition is described, and finally, three potential categories of dam alternatives are detailed.

Issues of Concern

Surface Water and Groundwater Quantity Considerations

Water quantity issues for this dam evaluation encompass floods, normal flow, and groundwater contributions. The effect of the Horlick dam and its impoundment in attenuating large flood peaks would be expected to be negligible (i.e., there would be no significant difference in peak flows between conditions with the dam in place and with the dam removed) because during floods the runoff volume from the approximately 190-square mile watershed tributary to the dam would be very large relative to the active storage volume above the normal impoundment level. Thus, within the range of dam modifications considered under the alternatives described below, including modifications to increase spillway discharge capacity and modifications to fully or partially remove the dam, no significant difference in flood peaks would be expected. During nonflood or normal flow times, it is of interest to compare how the river corridor functions for the various alternatives. And finally, the impoundment may affect the shallow groundwater table in its vicinity. The dam impoundment could either be a source to shallow groundwater or a sink for water from the shallow groundwater.[70,71]

Water Quality

The water quality issues of concern for the Horlick dam alternatives include dissolved oxygen, nutrients, temperature, sediment, and large woody debris. Dissolved oxygen is an important characteristic for fish and aquatic biota health. For most impoundments, dissolved oxygen levels decrease with thermal stratification, and then increase by aeration as water flows over the dam spillway.[72] The limiting nutrient of greatest concern for water quality is phosphorus, and for most impoundments the main phosphorus input is the suspended sediment.[73] Typically the dam impoundment raises water temperatures by slowing the water and increasing the water surface exposed to the sun.[74] Contaminated sediments are of significant concern if they exist, as any modifications to the dam may

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[69] *An April 27, 2014, letter from the WDNR to Racine County established a Low Hazard rating for the dam, based on a dam failure analysis prepared for the County by GRAEF-USA (see Appendix Q). That letter established additional requirements, including the need to bring the spillway discharge capacity into compliance with Chapter NR 333 of the* Wisconsin Administrative Code *within 10 years from the date of the letter.*

[70] *Nancy D. Gordon, Thomas A McMahon et al.,* Stream Hydrology, An Introduction for Ecologists, 2nd Edition, *John Wiley & Sons, Ltd., 2004.*

[71] *Robert G. Wetzel,* Limnology, 2nd Edition*, Sanders College Publishing, 1983.*

[72] *James H. Thrall and Rimas J. Banys,* op. cit.

[73] *Gyles Randall et al., "Phosphorus Transport and Availability in Surface Waters,"* University of Minnesota-Extension Publication WW-06796*, 2002.*

[74] *James H. Thrall and Rimas J. Banys,* op. cit.

alter sediment transport characteristics. Large woody debris is often caught at the dam crest during floods, and then either removed or moved downstream during nonflood times. Large woody debris is considered vital for fish and wildlife habitat and disruption of the natural movement of the debris downstream would be considered a negative from a fishery standpoint.[75] From the view of protection of downstream infrastructure, the large woody debris capture at the dam may be considered a positive.

Natural Resources
The natural resource considerations for the Horlick dam area include the fishery, terrestrial biota, and aquatic invasive species. In almost all cases, a dam is considered a barrier to aquatic species movement. The dam often blocks not only the river but the riverine corridor, disconnecting the system at the dam location.[76] This system disconnection may also be considered positive by preventing upstream movement of aquatic invasive species, assuming that the dam provides sufficient obstruction during all flows.

Another consideration for aquatic invasive species is the ability to move upstream past the dam by another method, such as intentional or unintentional human actions or passage on another species. Unfortunately, this aided transport method is difficult to predict or control, but has been widespread in the dispersal of multiple invasive species including zebra mussel, quagga mussel, Eurasian water milfoil, and purple loosestrife, among others. This is why the WDNR has invested in programs such as Clean Boats, Clean Waters programs to promote information and education on invasive species and how to prevent their expansion into other waterbodies.

Social
Social issues related to dams include aesthetics, safety, and recreation. Aesthetics encompasses how the river corridor looks in the area of the dam, and often are of a very personal nature. Safety includes both the safety of boaters and fisherman in the river, and those onshore and downstream. With the dam in place there is the danger that the dam will fail and a large amount of water and sediment will flow downstream suddenly. Recreational considerations include boating, fishing, biking, hiking, bird watching, and many other uses that can be enjoyed along a river corridor.

Cost
Two costs will be evaluated for each Horlick dam alternative: 1) the capital costs of construction/demolition and 2) maintenance costs. Construction or demolition costs are onetime costs incurred in the dam area to either modify or remove the dam structure. Maintenance costs associated with a structure remaining at the Horlick dam location may include inspections, repairs, studies, dredging, and instream debris management.

Maintenance costs for dam removal may include habitat enhancements and impoundment area restoration. Future structural maintenance costs are somewhat difficult to accurately represent, as some work will depend on how the dam performs and the severity and frequency of future floods.

Baseline Condition
This section discusses the existing state of the Horlick dam for the issues of concern described above.

Surface Water and Groundwater Quantity Considerations
As noted previously in the "Issues of Concern" subsection, the Horlick dam and impoundment as currently configured (see Figure 109) do not significantly attenuate peak flood flows. The water surface profile during a flood drops significantly from the upstream side of the dam to the downstream side, but peak flows are not significantly reduced with the fixed dam crest and minimal storage available in the impoundment area.

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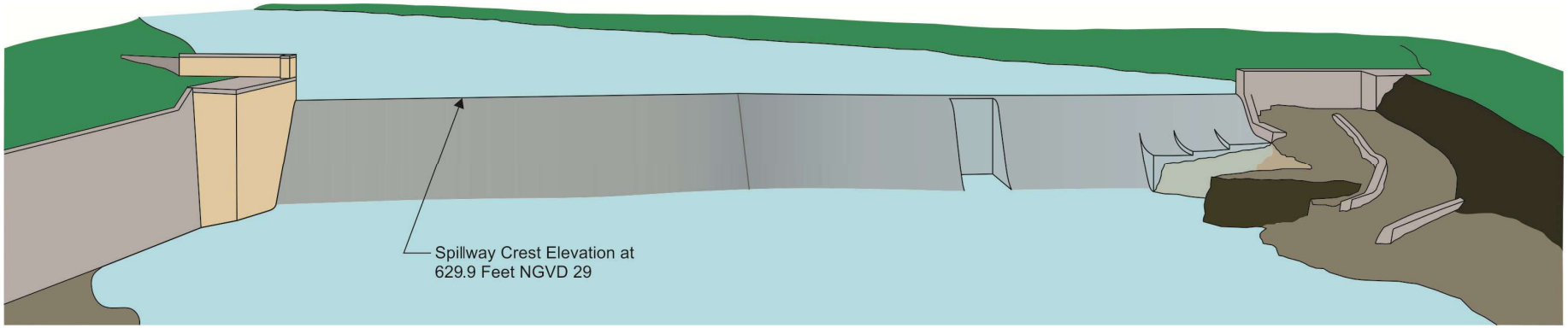
[75] *Jeff Operman et al., "Maintaining Wood in Streams: A Vital Action for Fish Conservation,"* ANR Publication 8157*, University of California, Division of Agriculture and Natural Resources, 2006.*

[76] *James H. Thrall and Rimas J. Banys,* op. cit.

Figure 109

EXISTING CONDITIONS OF HORLICK DAM – LOOKING NORTH (UPSTREAM)



Source: SEWRPC.

Table 74

MODELED FLOW RATES FOR THE ROOT RIVER AT HORLICK DAM

Annual Probability of Occurrence (recurrence interval) or Description	Flow Rate (cfs)	Source
99-Percent (1-year)	686	SEWRPC Gage Analysis 2013
50-Percent (2-year)	1,900	SEWRPC Gage Analysis 2013
10-Percent (10-year)	3,500	SEWRPC Gage Analysis 2013
2-Percent (50-year)	5,200	2012 FIS
1-Percent (100-year)	6,380	2012 FIS
0.2-Percent (500-year)	10,200	2012 FIS
90 Percent Exceeds	10	USGS Water-Data Report 2012
50 Percent Exceeds	56	USGS Water-Data Report 2012
10 Percent Exceeds	410	USGS Water-Data Report 2012
March-June Maximum Mean Daily	1,000	USGS Gage Summary Statistics 1963-2011

Source: U.S. Geological Survey gage 04087240, 2012 Racine County FIS, and SEWRPC.

To evaluate peak and base flow profiles at the Horlick dam, a U.S. Army Corps of Engineers (USCOE) Hydrologic Engineering Center (HEC-RAS) river analysis system model[77] was developed using the USCOE HEC-2 water surface profiles model developed by the SEWRPC staff under a 1990 drainage and flood control plan for the Milwaukee Metropolitan Sewerage District.[78] The hydraulic model was also modified to reflect a 1977 dam survey and WisDOT plans for STH 38 and STH 31. Model cross sections were modified in the impoundment area to match the 2012 SEWRPC channel soundings described in Chapter IV. Flows for which water surface profiles were computed are listed in Table 74. The Horlick dam HEC-RAS model results were checked for reasonableness versus the observed June 2008 and April 2013 flood elevations at STH 38, the Horlick dam, and USGS gage 04087240 just downstream of the dam.

Hydraulic model results for the existing Horlick dam indicate that the current spillway capacity is equal to the peak flow rate during the 10-percent-annual-probability (10-year recurrence interval) flood. This means that larger floods are not contained by the Horlick dam spillway, overflowing the left[79] and right abutments and walkways. Based on model results, the water surface elevation just downstream of the dam (also called the tailwater elevation) is approximately at the top of the existing spillway crest (629.9 feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29)) for the 0.2-percent-annual-probability (500-year recurrence interval) flood. The 0.2-percent-annual-probability velocity at the dam spillway crest is approximately 11.0 feet per second (fps). The 1-percent-annual-probability (100-year recurrence interval) flood tailwater elevation is approximately three feet below the existing spillway crest, with a spillway crest velocity of approximately 9.0 fps. The two-percent-annual-probability (50-year recurrence interval) flood tailwater elevation is approximately four feet below the existing spillway crest, with a spillway crest velocity of approximately 8.0 fps.

[77] *Version 4.1.0.*

[78] *SEWRPC Community Assistance Planning Report No. 152,* A Stormwater Drainage and Flood Control System Plan for the Milwaukee Metropolitan Sewerage District*, December 1990.*

[79] *References to left and right are based on looking downstream.*

Normal or base flows on the Root River are fairly small (10 to 56 cfs) as discussed in Chapter IV. What this means for the current Horlick dam configuration is that the residence time in the impoundment is between two and eight days. It also means that the dam is minimally overtopped during normal flow times (one to three inches), making fish passage downstream over the spillway difficult. During base flow conditions, the pool created by backwater from the Horlick dam extends upstream to STH 31, a length of approximately 3.4 miles.

The Horlick dam impoundment most likely raises the shallow groundwater table in the immediate area. Thus, maintenance of the dam in place may be beneficial to shallow private wells in the vicinity of the impoundment if they are still being utilized. However, if upgrading the spillway capacity of the dam to meet State requirements necessitates lowering the permanent pond elevation, as indicated by several alternatives that are described below, the positive effect of the permanent pond on groundwater levels would be reduced somewhat. Map 70 includes all private well log data found on the Wisconsin Department of Natural Resources (WDNR) website for the three U.S. Public Land Survey sections encompassing the Horlick impoundment.[80] The numerous wells with standing water less than 25 feet below the ground surface (highlighted in yellow) are of particular concern because their water levels would be most likely to be affected by fluctuations in the impoundment level. It is unknown which wells included in Map 70 are still in use.

Water Quality

Water quality data for the Root River in the vicinity of the Horlick dam are set forth in Chapter IV. Unfortunately, the more comprehensive water quality data sets were at Johnson Park which is at approximate river mile 11.5 and at the gage just below the Horlick dam at river mile 5.9 (see Table 21 in Chapter IV of this report). Thus, there are no known water quality data explicitly representing the Horlick dam impoundment.

What can be determined from the available water quality data is that dissolved oxygen concentrations are very good just downstream of the Horlick dam (see Figure 2 and Table 28 in Chapter IV of this report). This may be due to re-aeration over the dam spillway or the fact that the flow over the dam is from the top layer of the impoundment, which has direct interaction with the air surface. Root River total phosphorus levels both five miles upstream and just downstream of the Horlick dam are above the 0.075 mg/l warmwater fish and aquatic life criterion for a significant portion of the water quality dataset (see Figure 29 and Table 28 in Chapter IV of this report). The river temperature dataset is not continuous, thus comparisons to the sublethal and acute standards for small warmwater communities is not possible (see Tables 28 and 23 in Chapter IV of this report). However, if the temperature data in Figure 15 in Chapter IV of this report is compared between the upstream and downstream gages that are closest to the Horlick dam at river miles 11.5 (Johnson Park) and 5.9 (just downstream of Horlick dam) there does appear to be a consistent upward trend in temperature between the upstream and downstream gage, which may be indicative of the rise in water temperatures that would be expected to occur because of the increased residence time and larger water surface area within the Horlick dam impoundment. The only exception to this upward temperature trend between the two gages is the period from 1987 through 1993. The temperature data included in Figure 15 in Chapter IV of this report are from grab samples, thus it is assumed the samples at the upstream and downstream gages were taken on the same day for comparison purposes.

The Horlick dam impoundment has captured significant sediment since its original construction in 1834, as evidenced by the streambed/accumulated sediment profile shown in Figure 105 in Chapter IV of this report. This sediment capture may have caused erosion downstream of the dam as the river attempted to regain sediment equilibrium.[81] But sediment capture in the Horlick impoundment may have benefitted the harbor with reduced sediment volumes at the Root River mouth. It was documented in Chapter IV that contaminated sediment in the impoundment does not appear to be a concern based on testing to date.

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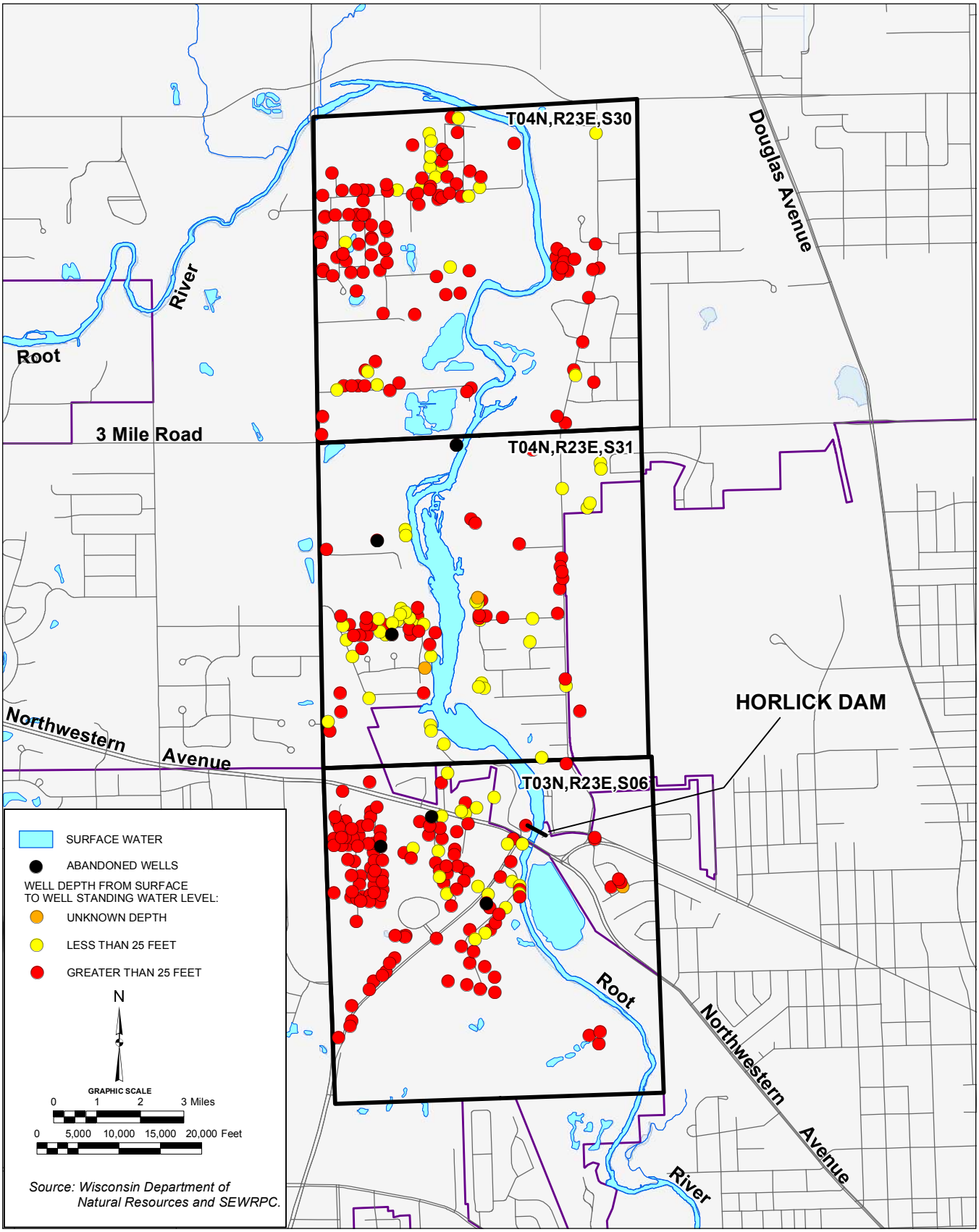
[80] http://dnr.wi.gov/topic/groundwater/data.html.

[81] *Angela T. Bednarek, "Undamming Rivers: A Review of the Ecological Impacts of Dam Removal,"* Environmental Management*, Vol. 27, No. 6, 2001.*

Map 70

PRIVATE WELLS NEAR THE HORLICK DAM IMPOUNDMENT CONSTRUCTED 1940-2010



As evidenced by WDNR inspections, the Horlick dam does catch large woody debris at its crest, although an annual estimate of large woody debris accumulation at the Horlick dam is not available. Some large woody debris also settles in the upstream impoundment, depending on flow conditions and the size of the debris. The WDNR has recommended facilitating downstream movement of debris caught at the dam crest on an ongoing basis. Thus, the Horlick dam does essentially pass large woody debris, albeit often after the flood flows have receded when downstream sections are less able to convey it further downstream until the next major flood.

Natural Resources

A meeting was held between Commission staff and WDNR staff on June 13, 2013, to discuss the Horlick dam and the Root River. A summary of the meeting discussion can be found in Appendix R. Guidance from the WDNR related to the Horlick dam and the Root River fishery and aquatic invasive species discussed in subsequent sections is documented in those meeting notes. In addition, the January 1, 2014, "Fish Passage Guidance" document issued by WDNR was considered in evaluating considerations related to passage of fish and aquatic invasive species and the possible transmission of viral hemorrhagic septicemia (VHS) within the watershed.[82] That document was discussed during an April 24, 2014, meeting between the WDNR and SEWRPC staffs.

Lake Michigan aquatic invasive species are blocked from the upper Root River by the Horlick dam the majority of the time. The WDNR has indicated that the Root River Steelhead Facility, located downstream in Lincoln Park, is not considered a barrier as the flashboards are fully removed for most of the year. The Steelhead Facility flashboards are in place during the annual salmon spawning runs from about early September to November and then from early March to mid/late April.

The WDNR considers both VHS and the aquatic invasive species of sea lamprey and round goby to be of greatest concern for the Root River. To stop the movement of the aquatic invasive sea lamprey, the U.S. Fish and Wildlife Service (USFWS) has recommended at other dam facilities a crest to tailwater difference of at least 1.5 feet for a step ladder fishway design for the 10-percent-annual-probability (10-year recurrence interval) flood. To determine if the Horlick dam is a complete barrier to the migration of aquatic organisms, the WDNR has recommended in their fish passage guidance[83] utilizing the 1-percent-annual-probability (100-year) flood.

During the 10-percent-annual-probability flood, the hydraulic modeling results indicate that the Horlick dam tailwater elevation is approximately six feet below the spillway crest. During the 1-percent-annual-probability flood, the hydraulic modeling results indicate that the Horlick dam tailwater elevation is approximately three feet below the spillway crest. Thus, the dam appears to be a barrier to sea lamprey movement during floods up to, and including, the 10-percent-probability flood and may still be a barrier at the 1-percent-annual probability flood. It should be noted that the tailwater elevation is approximately at the top of the existing spillway crest (629.9 feet above NGVD 29) for the 0.2-percent-annual-probability (500-year) flood, meaning that the dam is no longer a barrier for invasive aquatic species for this extreme flood.

To determine if the dam is a barrier to fish passage for the 0.2- and 1-percent-annual-probability floods, a comparison of hydraulic modeling results to the swimming capacities of three fish species was completed. Smallmouth bass was selected as a smaller native sport species potentially occurring in the Root River. Based on recent dam modification analyses completed at other southeastern Wisconsin locations, northern pike was selected to represent the native fishery for the evaluation of fish passage conditions. Chinook salmon was the third species reviewed, as it is the largest WDNR stocked salmonid population in Lake Michigan. Available prolonged and burst speed data for these three fish species is included in Table 75. Based on the burst speeds listed in Table 75, both the northern pike and Chinook salmon could pass the Horlick dam spillway for the modeled

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[82] *Wisconsin Department of Natural Resources, Bureaus of Fisheries Management, Water Quality, and Watershed Management, "Fish Passage Guidance," January 1, 2014.*

[83] Ibid.

Table 75

ADULT FISH SWIMMING SPEEDS AND LEAPING DATA FOR HORLICK DAM

Fish species	Prolonged Speed (fps)	Burst Speed (fps)	Maximum Leap Height/Distance (feet)
Northern Pike	- -	5.0-13.0[a]	- -
Chinook Salmon	3.4-10.8[b]	10.8-22.4[b]	7.0/5.0[b]
Smallmouth Bass	1.8-3.9[c]	3.6-7.8[c]	- -

[a]*Luther P. Aadland,* Reconnecting Rivers: Natural Channel Design in Dam Removals and Fish Passage, Minnesota Department of Natural Resources*, January 2010 and S.J. Peake,* Swimming Performance and Behaviour of Fish Species Endemic to Newfoundland and Labrador: A Literature Review*, Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2843, 2008.*

[b]*Gregory T. Ruggerone,* Evaluation of Salmon and Steelhead Migration Through the Upper Sultan River Canyon Prior to Dam Construction*, City of Everett, July 2006.*

[c]*Stephan Peake,* An Evaluation of the Use of Critical Swimming Speed for Determination of Culvert Water Velocity Criteria for Smallmouth Bass*, Transactions of the American Fisheries Society 133: 1472-1479, 2004 and Normandeau Associates, Inc.,* Claytor Hydroelectric Project Fish Entrainment and Impingement Assessment, *Appalachian Power Company, R-20979.001, January 2009.*

Source: SEWRPC.

0.2-percent-annual-probability flood, while the smallmouth bass most likely could not get past the dam spillway. Based on the leaping ability of Chinook salmon and the Horlick dam spillway configuration, Chinook should also be able to jump the dam during a two-percent-annual-probability (50-year recurrence interval) flood and any larger event. As the Chinook salmon is considered an aquatic invasive fish species, the current Horlick dam would be deemed an incomplete barrier based on the WDNR Fish Passage Guidance.[84] A summary of fish passage issues for the Baseline Condition and all alternatives is included in Table 76.

Social

The Horlick dam is not in a high profile location in the City of Racine and a bit difficult to view, with the best view being from the STH 38 bridge immediately downstream. Views of the dam and impoundment can also be enjoyed by patrons of the Riverside Inn on the right side of the dam as well. Views and access from Horlick Park on the left side of the dam are limited, with difficult foot access to the walkway over the former fishway via a narrow unmarked path along the park fence line. Access to the impoundment is good, with a boat launch and pier in Horlick Park. Immediately downstream of the dam, access is again difficult along an unmarked path at the end of Rapids Court behind the River Run Family Restaurant.

Safety issues at the current Horlick dam include periodic high flows, the possibility of dam failure, boater and fisherman safety, and access hazards by the public. During high flows, the water can approach the walkways on either end of the dam and be quite turbulent downstream of the dam. Falling or being swept into the Root River at the Horlick dam during high flows would be dangerous. Dam failure could be caused by instability during large floods, resulting in a structural failure. The possible significant downstream effects to property resulting from loss of the dam are described in Chapter IV. Boater safety is a concern near the crest of the dam, which is marked with warning signs only. Fishermen predominately fish downstream of Horlick dam during the salmon runs in spring and fall. The water is typically very shallow during the salmon runs, and most fisherman use waders and walk along the River bottom. Foot access below the dam is probably the biggest safety concern for fisherman.

[84]Ibid. *See Appendix 4 of the WDNR Fish Passage Guidance.*

Table 76

HORLICK DAM ALTERNATIVE SUMMARY—FISH PASSAGE AND INVASIVE SPECIES

Alternative	Spillway Crest Elevation (feet above NGVD 29)	Tailwater Elevation Event at Crest (recurrence interval)	Chinook Passage Event (recurrence interval)	Invasive Species Passage Event[a] (recurrence interval)	Barrier to Invasive Species[b]
Baseline Condition	629.9	500-year	50-year	500-year	Incomplete
Alternative 1–Lower Crest for 100-Year Capacity	626.6	Between 50 and 100-year	2-year	50-year	Incomplete
Alternative 2[c]–Alt 1 with Fishway	626.6	Between 50 and 100-year	2-year	50-year	Incomplete
Alternative 3–Lengthen Spillway for 100-Year Capacity	629.9	500-year	50-year	500-year	Incomplete
Alternative 4–Full Notch of Dam for 500-Year Capacity	620.0	Between 1 and 2-year[d]	50 percent exceeds	10 percent exceeds	Incomplete
Alternative 5–Dam Removal	620.0	Between 1 and 2-year[d]	50 percent exceeds	10 percent exceeds	No

[a]*Species other than Chinook salmon.*

[b]*The January 2014 WDNR* Fish Passage Guidance *defines an incomplete barrier as: "A man made or natural structure which allows the migration of aquatic organisms upstream during events less than the 100 year event."*

[c]*Assumes fishway closed for larger flood events.*

[d]*This condition represents the March through June maximum mean daily flow of 1,000 cfs.*

Source: SEWRPC.

As previously discussed, recreational opportunities at the Horlick dam and impoundment include small watercraft use in the impoundment, fishing, and bird watching. Although birds are attracted to the impoundment and river corridor, bird hunting is not allowed. For most individuals, the almost complete obstruction of fish movement across the dam from downstream to upstream as discussed previously would be considered a negative, but for those enjoying the salmon run, the downstream side of the Horlick dam is a popular fishing spot.

Land ownership along the Root River corridor upstream of the Horlick dam to STH 31 is indicated on Map 71. Publicly owned lands are shaded in green, and property boundaries are shown in black. Privately owned property that includes a portion of the Horlick dam impoundment is indicated with a yellow boundary. It is important to note that the majority of the Horlick dam impoundment is not in private ownership, and the majority of the private property lines end at the water's edge of the current impoundment.

Cost

The Horlick dam was reconstructed in late 1975, making the current configuration of the dam about 39 years old. Based on recent inspections by WDNR, there do not appear to be any substantial concerns with the condition of the dam. Maintenance and future study costs (in 2013 dollars) for the current Horlick dam were estimated by Racine County and SEWRPC staff as outlined below. The majority of these items were called for in the 2008 and 2011 WDNR inspection reports (Appendix K). The cost of implemented actions called for under the WDNR Horlick dam inspection totals $6,000, the ongoing yearly costs are estimated at $1,000, and efforts yet to be completed as required by WDNR total $68,000.

- Woody debris passage—ongoing cost estimated at $1,000/year
- Dam break analysis—(completed 2014) $5,000

Map 71

LAND OWNERSHIP IN THE VICINITY OF HORLICK DAM IMPOUNDMENT

Map 71 (continued)

LAND OWNERSHIP IN THE VICINITY OF HORLICK DAM IMPOUNDMENT

- Take-out sign and benchmark establishment—(completed) $1,000
- Outstanding requested actions from WDNR inspections:
    - Preparation of plans and a condition report for stop logs, sill plate, and embedded slots—$5,000
    - Installation of a bridge operation deck and mechanism for stop log removal—$25,000
    - Development of an Emergency Action Plan—$5,000
    - Development of an Inspection, Operation, and Maintenance Plan—$3,000
    - Investigation of concrete condition—$10,000
    - Preparation of scour study—$10,000
    - Bank repairs—$10,000

Conceptual Alternatives

Three categories of conceptual alternatives for the Horlick dam were developed as outlined below, with the goals of enhancing spillway capacity, providing fish passage, or removing the dam. Four specific alternatives are described, and additional information needs to be addressed during preliminary engineering are identified.

As documented in Chapter IV, the analyses presented in this report are based on the fact that the dam has a Low Hazard rating. For a Low Hazard dam, Chapter NR 333, "Dam Design and Construction," of the *Wisconsin Administrative Code* requires that the spillway safely convey the 1-percent-annual-probability (100-year) flood flow. Under the current Horlick dam configuration, the 1-percent-annual-probability flow is not contained within the spillway as discussed above, overtopping the right and left observation decks at the dam and causing erosion and failure concerns at both locations.

Due to the inadequate Horlick dam spillway capacity discussed in the Baseline Condition section, structural modifications to the dam would be necessary for the dam to be maintained. Thus, a "no action" alternative is not a viable option for the Horlick dam. As noted above, the WDNR staff has stated that Racine County will have 10 years to implement modifications to the dam to meet spillway requirements. Another option available to the County would be removal of the dam.

As described in the Baseline Condition section, the Horlick dam is currently a barrier to fish passage to the upstream watershed for all but the most extreme floods. Downstream fish passage may occur over the dam crest, but during normal flow times it is difficult due to the shallow overtopping depth. As noted above, the Horlick dam is considered an incomplete barrier to aquatic invasive species.

The hydraulic effects of each of the alternatives were evaluated using the HEC-RAS model developed for the Baseline Condition. Modifications to the hydraulic model were made only at the dam location to represent each of the alternative configurations.

The provision of freeboard during the 1-percent-annual-probability spillway design flood was established based on the more restrictive of the following two criteria:[85]

[85]*Freeboard is the difference between the water surface elevation on the upstream side of Horlick dam and the top of the dam abutments. Freeboard provides a level of safety against overtopping of the abutments, since such overtopping could potentially cause structural and safety concerns for the dam.*

- Providing one foot of freeboard to the tops of the existing, or proposed depending on the alternative, left and right concrete abutments for the maximum 1-percent-annual-probability flood elevation, or

- Containing the 0.2-percent-annual-probability flood event within the dam spillway with the upstream water surface elevation at the top of the lowest abutment.

For all the alternatives but full removal (Alternative 5) (i.e., for all alternatives under which the dam would be kept in place), the 0.2-percent-annual-probability flood freeboard criterion governs the design.

Alternatives that Modify the Dam to Enhance Spillway Capacity

ALTERNATIVE 1—LOWER CURRENT DAM SPILLWAY CREST FOR ONE-PERCENT-ANNUAL-PROBABILITY (100-YEAR) FLOOD CAPACITY SURFACE WATER AND GROUNDWATER QUANTITY CONSIDERATIONS

This alternative modifies the dam to safely pass the 1-percent-annual-probability (100-year recurrence interval) flood. Lowering the entire dam spillway by 3.3 feet to elevation 626.6 feet above NGVD 29 would enable safe conveyance of the 1-percent-annual-probability flood within the dam spillway (see Figure 110).[86] Under Alternative 1 the 0.2-percent-annual-probability flood would be just contained within the dam spillway, and there would be approximately two feet of freeboard to the top of the existing left concrete abutment for the maximum 1-percent-annual-probability flood elevation.

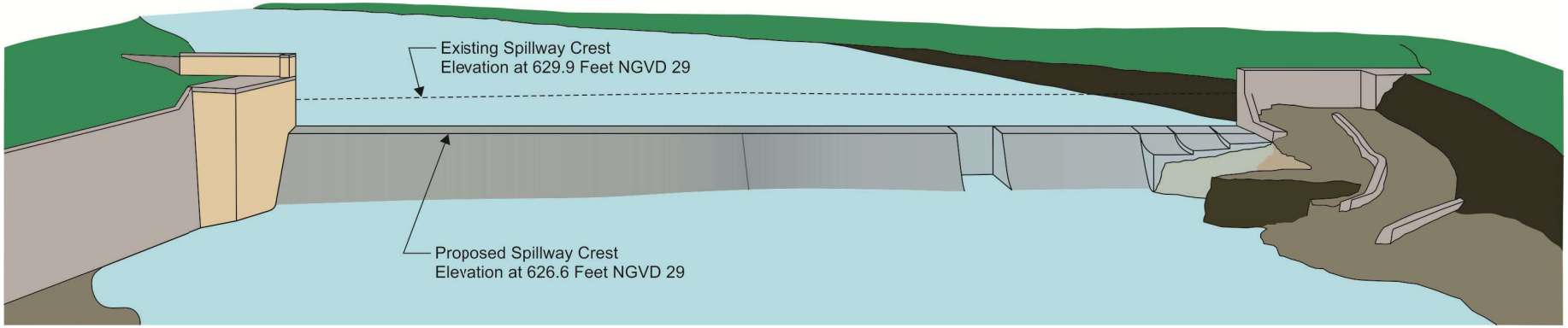
The modifications included under Alternative 1 would significantly alter both the flood and normal flow profiles upstream of the dam to STH 31. The 1-percent-annual-probability profile would be lowered approximately three feet at the dam crest from Baseline Conditions, while the 0.2-percent-annual-probability (500-year recurrence interval) flood would be lowered approximately 2.6 feet. Dam tailwater elevations associated with this alternative would remain the same as the Baseline Condition. The 1-percent-annual-probability flood effects of Alternative 1 are not as pronounced upstream at STH 31, with the water surface elevation upstream of the bridge for Alternative 1 only 0.3 foot lower than the elevations for the Baseline Condition. The 0.2-percent-annual-probability water surface elevation upstream of the STH 31 bridge for Alternative 1 would also be only 0.3-foot lower than the Baseline Condition.

Based on hydraulic model results, the tailwater elevation for Alternative 1 is approximately at the top of the lowered spillway crest (626.6 feet above NGVD 29) for a flood condition between the one- and two-percent-annual-probability (100 and 50-year recurrence interval) floods. The one- and two-percent-annual-probability velocities at the dam spillway crest are approximately 9.8 and 9.1 fps, respectively. The significance of the tailwater elevation being at or just above the Alternative 1 spillway crest is that the dam structure would essentially no longer be a barrier to fish and aquatic species passage for the flows between the one- and two-percent-annual-probability floods. The 1-percent-annual-probability flood tailwater elevation is approximately 0.4 foot above the modified spillway crest. The 0.2-percent-annual-probability (500-year) flood tailwater elevation is approximately 3.3 feet above the modified spillway crest, with a spillway crest velocity of approximately 11.5 fps. And finally, the 10-percent-annual-probability (10-year recurrence interval) flood tailwater elevation is approximately 2.5 feet below the modified spillway crest, with a crest velocity of approximately 8.0 fps.

[86] *The requirement to safely pass the 1-percent-annual-probability (100-year recurrence interval) flood could also be attained by a gate-type system modification to the Horlick dam. This would be significantly more expensive to construct and would also require active operation to safely convey flood flows. Such active operation normally is not desirable, as timing of operations can be difficult to predict. Therefore, this is not a viable option and was not considered further in this study.*

Figure 110

HORLICK DAM CONCEPTUAL ALTERNATIVE 1
LOWER CURRENT DAM SPILLWAY CREST FOR ONE-PERCENT-ANNUAL-PROBABILITY (100-YEAR) FLOOD CAPACITY – LOOKING NORTH (UPSTREAM)



Source: SEWRPC.

With the reduction in spillway elevation to 626.6 feet above NGVD 29, the extent of the impoundment area will be significantly reduced during normal, or base, flow times. It is estimated that the impoundment will extend approximately 1.5 miles upstream, or only encompass the lower half of the original impoundment area. This means that base flow residence times will be lower in the impounded area, which should improve water quality overall. And the upper reach between the alternative impounded area and STH 31 will experience flooded overbanks less frequently, which may allow surface vegetation to establish and improve terrestrial habitat in this area.

With a reduced impoundment area at a lower elevation during normal flow times, shallow groundwater levels most likely will also be lowered. This may adversely affect the still active groundwater wells developed in the shallow aquifer previously discussed and depicted in Map 70.

Water Quality

Water quality impacts associated with Alternative 1 cannot be definitively predicted, but as was discussed earlier, the size of the impoundment would be reduced with this alternative, which should reduce base flow residence times and reduce phosphorus deposition and water temperature in the impoundment area. Dissolved oxygen concentrations may not change dramatically as there would still be an opportunity for aeration over the lower dam spillway. It is very likely that the sediment which has accumulated on the bed of the impoundment over time may be partially flushed out of the downstream portion of the impoundment under this alternative with the lower spillway elevation. It is difficult to predict if this sediment flush would happen all at once or over time, but in all likelihood there would be an adverse impact to downstream reaches. It would be best to lower the dam in small increments over time in such a way as to minimize the potential for a large-scale loss of settled sediment downstream. The lower spillway crest will also more easily facilitate large woody debris passage during high flow times, which may be an adverse impact for downstream reaches as compared to the Baseline Condition.

Natural Resources

During the 10-percent-annual-probability flood, the hydraulic modeling results for Alternative 1 indicate that the Horlick dam tailwater elevation is approximately 2.5 feet below the altered spillway crest (626.6 feet above NGVD 29). During the 1-percent-annual-probability flood, the hydraulic modeling results indicate that the Horlick dam tailwater elevation is approximately 0.4 feet above the spillway crest. Thus, under this alternative the dam appears to be a barrier to sea lamprey movement during floods up to, and including, the 10-percent-probability flood, but no longer a barrier at the 1-percent-annual probability flood or larger floods.

Based on the fish burst speeds listed in Table 75, northern pike and chinook salmon could pass the modified Horlick dam spillway for the modeled one- and two-percent-annual-probability floods, while smallmouth bass most likely could not get past the dam spillway. Based on the leaping ability of Chinook salmon and the modified Horlick dam spillway configuration of Alternative 1, chinook should also be able to jump the modified dam for the 50-percent-annual-probability (2-year recurrence interval) flood and any larger event. As the chinook salmon is considered an aquatic invasive fish species, under Alternative 1, the dam would be deemed an incomplete barrier based on the WDNR Fish Passage Guidance. A summary of fish passage issues for the baseline and all alternatives is included in Table 76.

Social

Alternative 1 does leave a portion of the dam spillway in place, thus the cascading nature of the flows is maintained to a smaller degree. Therefore, the aesthetics are not changed dramatically at the dam. Upstream impoundment area changes would be expected to occur as discussed previously.

Boating and paddling safety issues are still a concern for this alternative, as a portion of the dam will remain in place and the drop between the impoundment and the downstream reach will still occur. Thus the safety concerns that were included in the Baseline Condition still exist, but perhaps to a smaller degree with 3.3 feet less of dam height. The original hydraulic height of the dam is approximately 12 feet, and Alternative 1 would have a hydraulic height of approximately nine feet, which is still significant from the perspective of safety of paddlers and fishers in the vicinity of the dam.

Implementation of Alternative 1 would alter recreational opportunities in the dam and impoundment area in numerous ways. There would be opportunities for new riparian trails and passive recreation, as the impoundment area would be reduced. Passive recreation would ultimately be dependent on ownership status for the exposed land. Small watercraft use would still be viable, but on a much smaller impoundment area. Fishing would also be somewhat altered in the smaller impoundment, and under high-flow conditions the dam may no longer be a full barrier to fish passage and fish normally stopped at the dam may now move farther upstream. This would be considered a positive from a fishery perspective, but possibly a negative for salmon fishing just downstream of the dam. Alternative 1 may affect watercraft access at River Bend Nature Center, but should not adversely affect the access at Horlick Park.

Map 72 includes a comparison of the approximate Baseline Condition for the impoundment as represented on the 2010 SEWRPC digital color orthophotograph, and the estimated extent of the River during normal flow conditions with Alternative 1 implemented. Also shown on Map 72 are several field-surveyed cross sections along the impoundment for comparison purposes between the existing impoundment and estimated normal water surface elevations under Alternative 1. The comparison indicates that the aesthetics of the former impoundment area will change under Alternative 1, with a more riverine look to the corridor between the River Bend Nature Center and STH 31.

With the lowered and reduced extent of the area impounded under Alternative 1, land ownership in this area would be affected. The nine properties highlighted in yellow on Map 71 would gain some dry land with Alternative 1, which would most likely be considered a positive effect. However, the majority of the private landowners between the dam and STH 31 would most likely would no longer have their properties abut the Root River under normal flow conditions. This effect would be most pronounced in the immediate impoundment area, and less so upstream where the River is more confined. A final determination of changes to Horlick impoundment property boundaries would require a review of the individual deed language.

Cost

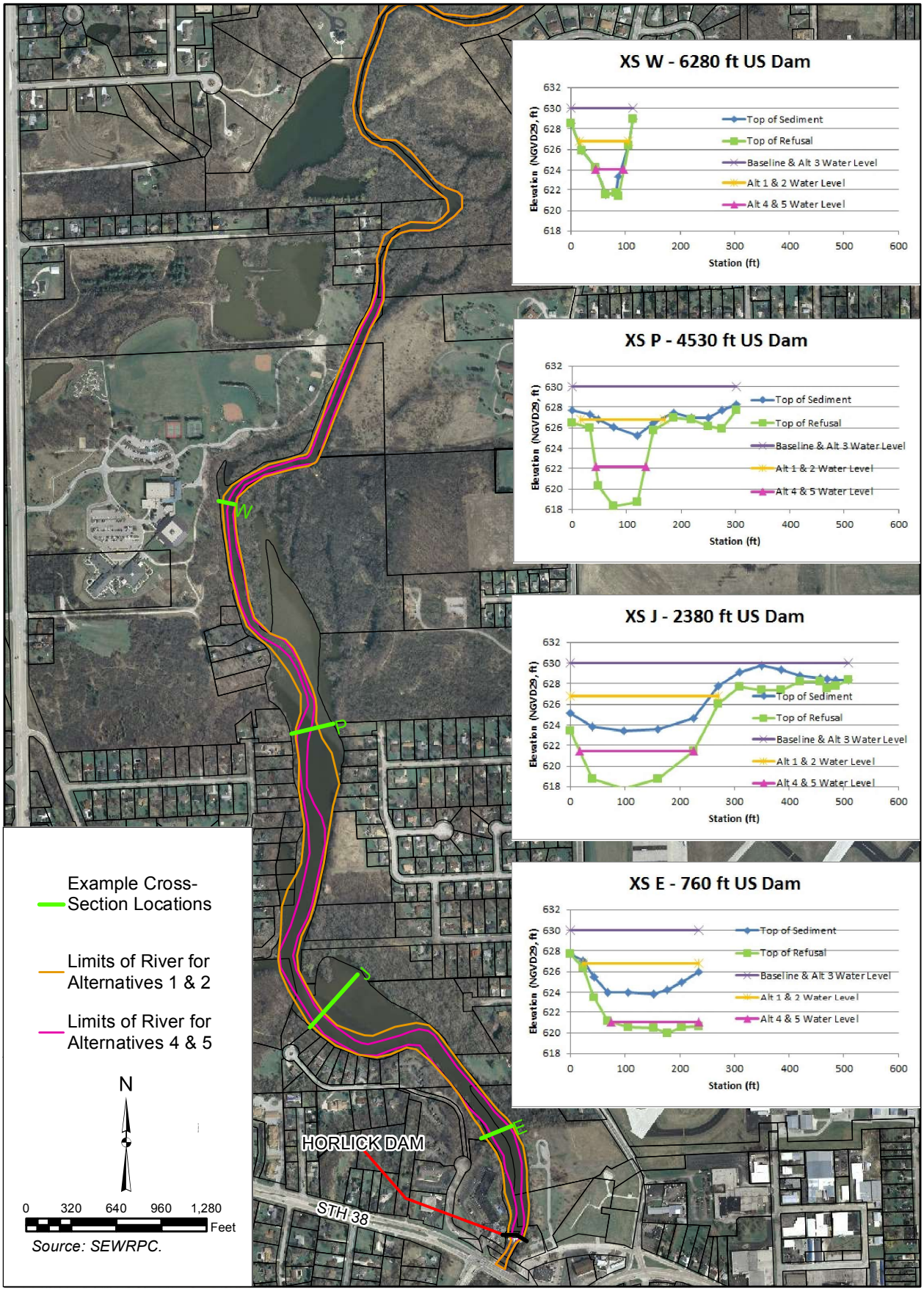
A systems planning-level cost estimate for Alternative 1 was completed in 2013 dollars. Construction cost information was obtained from R.S. Means Heavy Construction Cost Data.[87] Components included in the preliminary cost estimate for Alternative 1 include concrete removal, provision of a slide gate in the existing stop log area to enable drawdown of the impoundment, seeding of the impoundment area, and final finishing to elevation 626.6 feet above NGVD 29. It was assumed that seeding would only be required in the bays of the existing impoundment as depicted in Map 73. Base costs were increased by 35 percent to account for engineering, administration, and contingencies. Based on these assumptions, the systems-level present-worth cost estimate, including capital cost and operation and maintenance, is $411,000. While a significant effort has been made under this system-plan to collect field data and to characterize the anticipated costs associated with this alternative, at the systems-planning level there are many uncertainties in estimating costs relative to alterations of existing dams. Those uncertainties are reduced and estimated costs are refined after an alternative is selected for implementation and preliminary engineering and final design are conducted; however, it should be noted that the WDNR has indicated, that even after the final design stage, the average dam reconstruction change order amount is 40 percent of the initial capital cost estimate, mainly due to unforeseen site conditions once construction begins.

Under Alternative 1 a portion of the dam structure is retained, thus ongoing maintenance costs will also be incurred for this conceptual alternative. Maintenance costs assumed include debris passage, inspection every 10 years, the development of an emergency action plan, an operation and maintenance plan, and minor bank repairs. A summary of all Alternative 1 costs are included in Table 77.

[87] *R.S. Means Company, Inc.,* RSMeans Heavy Construction Cost Data*, 23rd Annual Edition, 2009.*

Map 72

CONCEPTUAL ALTERNATIVES: APPROXIMATE EXTENT OF FLOODPLAIN
DURING BASEFLOW (50 percent exceedence, 56 cfs)



Map 73

SEEDING AREAS FOR PRELIMINARY COST ESTIMATES

Table 77

HORLICK DAM ALTERNATIVE SUMMARY—COSTS

Alternative	Capital Cost[a,b] (dollars)	Annual Operation and Maintenance (dollars)[c]	Total Present Worth Cost (dollars)
Alternative 1–Lower Crest for 100-Year Capacity	$370,000	$2,600	$411,000
Alternative 2–Alt 1 with Fishway	$510,000	$2,900	$555,000
Alternative 3–Lengthen Spillway for 100-Year Capacity	$960,000[d]	$2,400	$998,000
Alternative 4–Full Notch of Dam for 100-Year Capacity	$450,000	$2,100	$483,000
Alternative 5–Dam Removal	$540,000	$ 700	$551,000

[a]*Capital costs based upon year 2013 conditions. Engineering News-Record Construction Cost Index: 12,208.*

[b]*These are systems-level planning costs and the WDNR has indicated that even after the final design stage, the average dam reconstruction change order amount is 40 percent of the initial capital cost estimate, mainly due to unforeseen site conditions once construction begins.*

[c]*Based on an interest rate of 6 percent and a project life of 50 years.*

[d]*Capital cost includes $240,000 for raising Old Mill Drive.*

Source: SEWRPC.

The above preliminary cost estimate does not include dredging of sediment from the Horlick impoundment. It was assumed the Alternative 1 dam lowering would be done in small increments over time or in such a way as to minimize the potential for a large-scale loss of settled sediment downstream. If dredging were required, it was calculated that approximately 72,300 cubic yards (CY) would need to be removed above elevation 620.0 feet above NGVD 29 for an Alternative 1 pilot channel. The elevation of 620.0 feet above NGVD 29 was chosen as that is the elevation of the observed natural shelf upstream of the Horlick dam. With the above assumptions, the preliminary cost estimate in 2013 dollars to dredge the upstream impoundment ranges from $1.5 to $3.6 million. The estimated cost range of sediment removal is only provided for information because different approaches to minimizing sediment release downstream of the dam site are recommended for all alternatives.

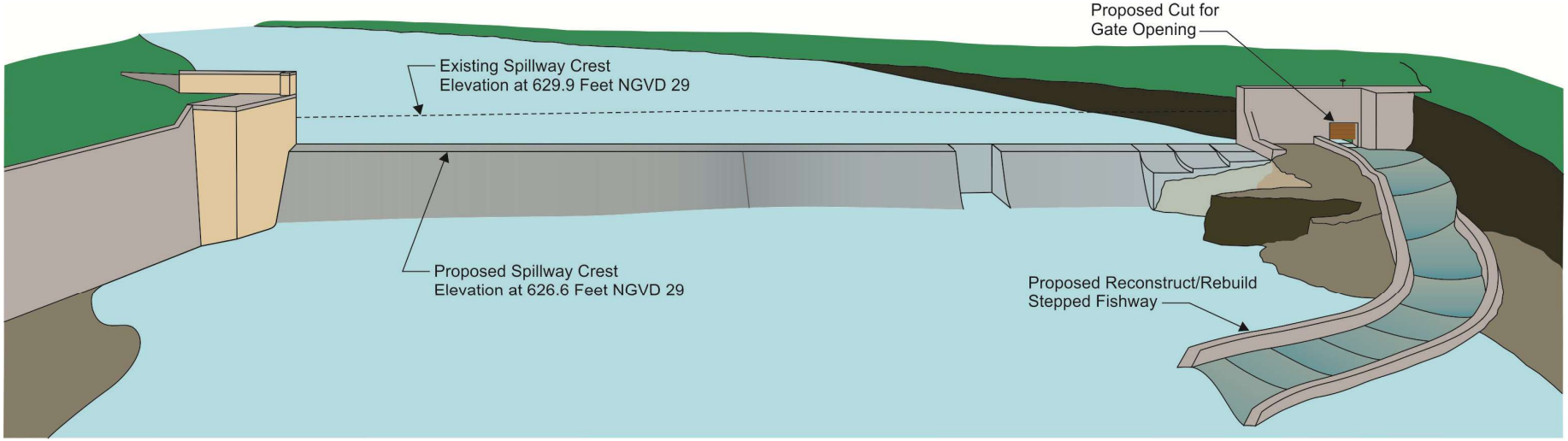
Alternative that Modifies the Dam to Enable Fish Passage under Low and High Flow Conditions

ALTERNATIVE 2—MODIFY CURRENT FISHWAY IN ADDITION TO ALTERNATIVE 1 CHANGES

To provide full fish passage at the Horlick dam, this alternative examines how the current fishway could be modified to allow fish passage during base flow conditions. By definition, the dam would be an incomplete barrier. Alternative 2 includes the modifications of Alternative 1 for providing additional spillway capacity, as it was envisioned that the modified fishway gate would be closed during flood times (see Figure 111). As was noted previously, the dam configuration under Alternative 1 does not present a barrier to aquatic invasive species passage during the 1-percent-annual-probability (100-year recurrence interval) flood, according to the criterion in the January 1, 2014, WDNR fish passage guidance. The dam configuration under Alternative 1 would be considered to present a barrier to sea lamprey passage during a 10-percent-probability flood. Because of the provision of a fishway, that might no longer be the case under Alternative 2. If this alternative were considered for implementation, the fishway design would require close coordination with regulatory agencies, which should be involved at the start of the process.

Figure 111

HORLICK DAM CONCEPTUAL ALTERNATIVE 2
MODIFY CURRENT FISHWAY IN ADDITION TO ALTERNATIVE 1 CHANGES – LOOKING NORTH (UPSTREAM)



Source: SEWRPC.

The gated fishway evaluated under this alternative would be a stair-step structure six feet wide with 10 one-foot high drops spaced approximately 16 feet apart. The overall fishway length would be approximately 160 feet. The current fishway is approximately 100 feet long, so under this alternative, the fishway would be extended and its alignment modified as indicated on Figure 111. The upstream elevation for the fishway sill at the gated structure would be 625.0 feet above NGVD 29, which would be 1.6 feet below the dam spillway crest elevation of 626.6 feet above NGVD 29. This would allow base flows to be conveyed through the fishway, bypassing the spillway. This configuration would require blasting through approximately four feet of rock along most of the existing fishway alignment, and then creating the lower 60 feet of fishway using concrete and large rocks.

Surface Water and Groundwater Quantity Considerations

The hydraulic model results for flood flows for Alternative 2 are the same as for Alternative 1, as it was assumed the fishway gate would be closed during high flow times to protect the structure. An evaluation of normal or base flow conditions was done for Alternative 2 to evaluate adequate fish passage conditions for smallmouth bass. The smaller flows in Table 74 were applied to evaluate velocities and depths over the fishway steps. For the 90-percent-exceedence flow[88] (10 cfs) the velocity over the steps is approximately 2.6 fps, with a water depth of approximately eight inches. The 90-percent-exceedence flow would not pass over the main spillway, while for all larger flows the main dam spillway is utilized along with the Alternative 2 fishway. For the 50-percent-exceedence flow (56 cfs) the velocity over the steps is approximately 4.2 fps at a depth of 1.7 feet. For the March-June maximum mean daily flow (1,000 cfs) which would be split between the spillway and the fishway, the depth over the steps is 3.3 feet with a velocity of 5.8 fps.

Water Quality

The reduction in impoundment area and upstream impact of the dam for water quality would be the same as Alternative 1 during for floods. A slight reduction in impoundment area from that estimated under Alternative 1 would be expected under baseflow conditions as the controlling elevation (the elevation of the spillway crest under Alternative 1, but the elevation of the sill at the upstream end of the fishway under this alternative) has been lowered 1.6 feet. As is the case for all of the other alternatives, under this alternative it is envisioned that the dam would be lowered in small increments over time in such a way as to minimize the potential for a large-scale loss of settled sediment downstream, thus, dredging of accumulated sediment in the impoundment is not called for. Shallow groundwater effects would also essentially be the same as Alternative 1.

Natural Resources

Based on the fish burst speeds listed in Table 75, all three fish species could pass the modified fishway for the base flow conditions of 10 to 1,000 cfs. The shallower overtopping depth for the 10 cfs event may be a concern, but the velocities are all below or within listed burst speeds.

Social

Aesthetic changes to the dam and impoundment are similar to Alternative 1, with the only exception being the fishway protruding into the Root River. Under extremely low flow conditions (10 cfs) flow may only be through the fishway, with a dry downstream face at the main dam spillway.

Safety considerations are similar to Alternative 1, with the added complication of the fishway structure. The fishway structure may be an attraction to fisherman as well as children, and may pose a slip/trip/fall hazard if walked along.

As would be the case for Alternative 1, implementation of Alternative 2 could produce opportunities for new riparian trails and passive recreation, depending on the ownership status for the exposed land along the impoundment. Recreational opportunities under Alternative 2 would be changed from those under Alternative 1

[88] *This is the Root River flow that would occur 10 percent or less of the time (90 percent of the flows exceed this value), based on long-term streamflow gaging by the USGS.*

by the ability of fish to bypass the dam during a larger range of flow conditions. The impoundment size reduction would be very similar to Alternative 1, thus the use of small watercraft would still be viable on the smaller impoundment. Fishing would change dramatically, as fish would no longer be completely stopped at the downstream side of the dam and they could travel upstream along the mainstem and tributaries. Opening up additional habitat to the native and sport fishery would be considered positive.

Private property ownership changes would be very similar under Alternatives 1 and 2, with a slightly smaller impoundment footprint due to the lower controlling elevation at the Alternative 2 fishway.

Cost

A preliminary cost estimate for Alternative 2 was completed in 2013 dollars. Components included in the preliminary cost estimate for Alternative 2 include the features called for under Alternative 1 plus creation of the gated fishway. The base cost was increased by 35 percent to account for engineering, administration, and contingencies. Based on these assumptions, the systems-level present-worth cost estimate, including capital cost and operation and maintenance, is $555,000. While a significant effort has been made under this system-plan to collect field data and to characterize the anticipated costs associated with this alternative, at the systems-planning level there are many uncertainties in estimating costs relative to alterations of existing dams. Those uncertainties are reduced and estimated costs are refined after an alternative is selected for implementation and preliminary engineering and final design are conducted; however, it should be noted that the WDNR has indicated, that even after the final design stage, the average dam reconstruction change order amount is 40 percent of the initial capital cost estimate, mainly due to unforeseen site conditions once construction begins.

Under Alternative 2 a portion of the dam structure is retained in addition to enhancement of the fishway, thus ongoing maintenance costs will also be incurred for this conceptual alternative. Maintenance costs assumed include debris passage, inspection every 10 years, the development of an emergency action plan, an operation and maintenance plan, and minor bank repairs. A summary of all Alternative 2 costs is included in Table 77.

The above preliminary cost estimate does not include dredging of sediment from the Horlick impoundment. As noted above, different approaches to minimizing sediment release downstream of the dam site are called for under this alternative.

Alternatives that Modify the Dam to Enhance Spillway Capacity

ALTERNATIVE 3—LENGTHEN CURRENT DAM SPILLWAY AND RAISE ABUTMENTS FOR ONE-PERCENT-ANNUAL-PROBABILITY (100-YEAR) FLOOD CAPACITY

Surface Water and Groundwater Quantity Considerations

This alternative modifies the dam to safely pass the 1-percent-annual-probability (100-year recurrence interval) flood by lengthening the spillway crest and raising the top of both abutments.[89] This alternative maintains the spillway crest at elevation 629.9 feet above NGVD 29 and lengthens the crest by approximately 20 feet, utilizing the old fishway area, to a total crest length of 140 feet. Both the left and right abutments would be rebuilt to a top elevation of 636.0 feet above NGVD 29, providing approximately 1.4 feet of freeboard to the tops of the abutments based on the maximum 1-percent-annual-probability flood elevation. Also included in this alternative is raising Old Mill Drive to elevation 640.0 feet above NGVD 29, which is described later in this section. These changes would enable safe conveyance of the 0.2-percent-annual-probability flood within the dam spillway (see Figure 112).

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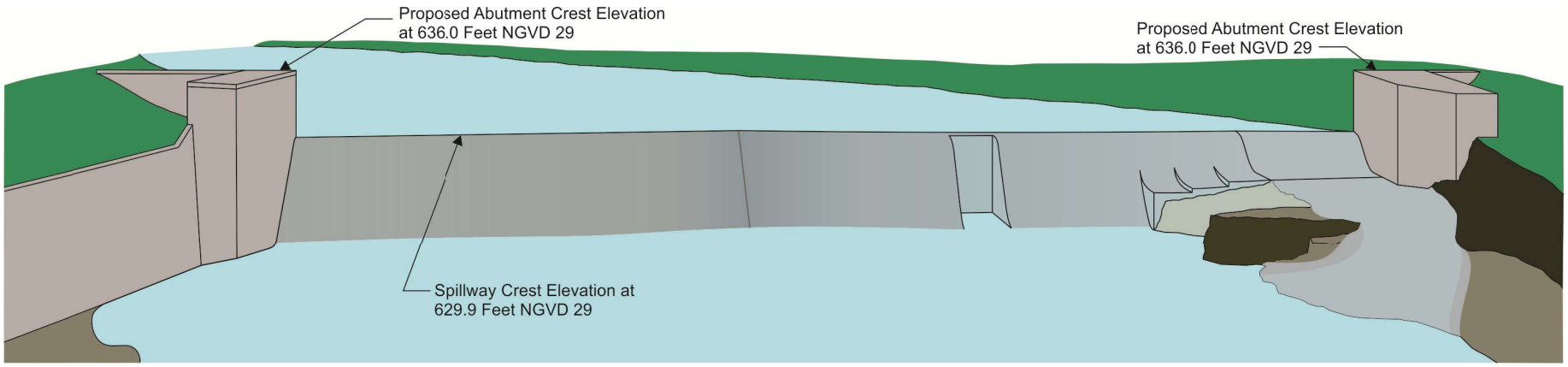
[89] *The possibility of maintaining the Horlick dam spillway crest at its current elevation and raising the dam structures on either side of the spillway was raised during the August 28, 2013, public meeting to review alternatives relative to the dam. In a September 3, 2013, electronic mail message to the SEWRPC staff, Julie Anderson, Racine County Public Works and Development Services Director, asked on behalf of County Executive James Ladwig that such an additional alternative be considered.*

Figure 112

HORLICK DAM CONCEPTUAL ALTERNATIVE 3
LENGTHEN CURRENT DAM SPILLWAY AND RAISE ABUTMENTS FOR
ONE-PERCENT-ANNUAL-PROBABILITY (100-YEAR) FLOOD CAPACITY – LOOKING NORTH (UPSTREAM)



Source: SEWRPC.

Modifications associated with Alternative 3 would minimally alter both the flood and normal flow profiles between the dam and STH 31 in comparison to the Baseline Condition. The 0.2- and 1-percent-annual-probability (500-year and 100-year recurrence interval, respectively) flood stage elevations would be lowered approximately 0.6 foot at the dam crest relative to the corresponding flood elevations under the Baseline Condition. The one- and 0.2-percent-annual-probability flood profiles under Alternative 3 are essentially the same as under the Baseline Condition in the vicinity of STH 31. Dam tailwater elevations associated with this alternative would remain the same as under the Baseline Condition.

The hydraulic model water surface elevation just downstream of the dam is approximately at the top of the existing spillway crest (629.9 feet above NGVD 29) for the 0.2-percent-annual-probability flood. The 0.2-percent-annual-probability velocity at the dam spillway crest is approximately 12.1 feet per second (fps). The 1-percent-annual-probability flood tailwater elevation is approximately three feet below the existing spillway crest, with a spillway crest velocity of approximately 9.7 fps. The two-percent-annual-probability (50-year recurrence interval) flood tailwater elevation is approximately four feet below the existing spillway crest, with a spillway crest velocity of approximately 9.0 fps.

With the same dam crest elevation as under the Baseline Condition, conditions under Alternative 3 during normal flow periods would be almost identical to those for the Baseline. The impoundment size and width would be the same, and the minimal depth over the spillway during normal flow times would still be an impediment to downstream fish passage.

With the impoundment area maintained during normal flow times, no change from the Baseline Condition would be expected for shallow groundwater levels or for the shallow wells depicted in Map 70.

Water Quality

The modifications to the dam under Alternative 3 maintain the upstream impoundment, thus, there should be no change in water quality as compared to the Baseline Condition. It is very likely that the accumulated sediment in the impoundment area would not be flushed downstream with this alternative, and that would be considered positive. The maintenance of the spillway crest at elevation 629.9 feet above NGVD 29 would still be a barrier to large woody debris passage downstream, as it is under the Baseline Condition.

Natural Resources

During the 10-percent-annual-probability flood, the hydraulic modeling results indicate that under Alternative 3 the tailwater elevation would be approximately six feet below the spillway crest. During the 1-percent-annual-probability flood, the hydraulic modeling results indicate that the tailwater elevation would be approximately three feet below the spillway crest. Thus, under Alternative 3, the dam would appear to be a barrier to sea lamprey movement during floods up to, and including, the 10-percent-probability flood and may still be a barrier at the 1-percent-annual probability flood. It should be noted that the tailwater elevation is approximately at the top of the existing spillway crest (629.9 feet above NGVD 29) for the 0.2-percent-annual-probability (500-year) flood, meaning that the dam is no longer a barrier for invasive aquatic species for this extreme flood.

The modifications included under Alternative 3 utilize a portion of the existing fishway as part of the spillway. To provide an adequate hydraulic transition for this condition, the conceptual design and associated cost estimate assume removal of a top layer of the rock ledge at the former fishway location. At the systems planning level, this is considered to be an adequate provision for hydraulic purposes and to reduce the tailwater elevation in the vicinity of the former fishway in an effort to avoid fish passage.

Based on the fish burst speeds listed in Table 75, northern pike and chinook salmon could pass the lengthened Horlick dam spillway during the modeled 0.2-percent-annual-probability flood, while smallmouth bass most likely could not get past the dam spillway. Based on the leaping ability of chinook salmon and the lengthened Horlick dam spillway configuration under Alternative 3, chinook should also be able to jump the modified dam for the two-percent-annual-probability flood and any larger event. As the chinook salmon is considered an

aquatic invasive fish species, under Alternative 3, the dam would be deemed an incomplete barrier based on the WDNR Fish Passage Guidance. A summary of fish passage issues for the baseline and all alternatives is included in Table 76.

Social

Under Alternative 3 the spillway crest would be lengthened and the crest shape would be maintained. Thus, the cascading nature of the flows is maintained as compared to the Baseline Condition, and the aesthetics are not changed appreciably at the dam. The upstream impoundment area will not change as described previously.

Boating and paddling safety issues are still a concern for this alternative as under the Baseline Condition. The original hydraulic height of the dam is maintained, so under Alternative 3 the dam would also have a hydraulic height of 12 feet, which is significant from the perspective of safety of paddlers and fishers in the vicinity of the dam.

Alternative 3 would maintain the Baseline Condition recreational opportunities at the dam and impoundment area. There would be no opportunity for new riparian trails and passive recreation, as no lowering of the impoundment would occur. Under all but the most extreme floods, fish migration upstream would continue to be stopped at the dam under the Alternative 3.

With the impoundment area maintained under Alternative 3, additional unsubmerged land would not be created, and land ownership in this area would not be an issue (see Map 71).

Cost

A systems planning-level cost estimate for Alternative 3 was completed in 2013 dollars. Construction cost information was obtained from R.S. Means Heavy Construction Cost Data.[90] Components included in the preliminary cost estimate for Alternative 3 include abutment concrete removal, concrete construction, provision of a slide gate in the existing stop log area to enable drawdown of the impoundment, and road raise and reconstruction. Base costs were increased by 35 percent to account for engineering, administration, and contingencies. Based on these assumptions, the systems-level present-worth cost estimate, including capital cost and operation and maintenance, is $998,000. While a significant effort has been made under this system plan to collect field data and to characterize the anticipated costs associated with this alternative, at the systems-planning level there are many uncertainties in estimating costs relative to alterations of existing dams. Those uncertainties are reduced and estimated costs are refined after an alternative is selected for implementation and preliminary engineering and final design are conducted; however, it should be noted that the WDNR has indicated that even after the final design stage, the average dam reconstruction change order amount is 40 percent of the initial capital cost estimate, mainly due to unforeseen site conditions once construction begins.

Under Alternative 3, the dam structure is retained, thus, ongoing maintenance costs would also be incurred for this conceptual alternative. Maintenance costs assumed include debris passage, inspection every 10 years, the development of an emergency action plan, an operation and maintenance plan, and minor corridor maintenance. A summary of all Alternative 3 costs are included in Table 77.

The only vehicular access for 15 homes and three condominium buildings located west of the impoundment is along Old Mill Drive at STH 38. Based on the current Federal Emergency Management Agency Flood Insurance Study (FIS) for Racine County, the one- and 0.2-percent-annual-probability floods would be expected to overtop Old Mill Drive under current (Baseline) conditions. It is expected that those two floods would also overtop Old Mill Road to maximum depths of 0.4 to 2.6 feet, respectively, under Alternative 3 conditions. In the other conceptual alternatives evaluated for the Horlick dam under this plan, the one- and 0.2-percent-annual-probability

[90] *R.S. Means Company, Inc.,* RSMeans Heavy Construction Cost Data*, 23rd Annual Edition, 2009.*

flood profiles would be reduced sufficiently to avoid overtopping of Old Mill Drive. Thus, an ancillary benefit of implementing any of those alternatives would be improvement of access to the buildings along Old Mill Drive during large floods. To provide emergency service access to Old Mill Drive during large floods under either current conditions, or Alternative 3 conditions, consideration should be given to raising the grade of the Drive. The above preliminary cost estimate includes raising Old Mill Drive to 640.0 feet above NGVD 29 to eliminate roadway overtopping during the one- and 0.2-percent-annual-probability floods. The cost estimate assumes the road would require a maximum rise of four feet and the total length of road raise and new roadway pavement would be approximately 800 feet. A new longer culvert would also be required in this road section to serve a small tributary area to the immediate west of the Drive.

It should also be noted that the hotel immediately west of the dam embankment is in close proximity to the right dam abutment. If the modifications included in Alternative 3 are selected for further review, the ability to raise and modify the right abutment and not adversely affect the hotel would need to be evaluated in greater detail.

Alternatives for Partial and Full Removal of the Dam

Two dam removal options were evaluated, one that retained a portion of each end of the dam to protect the hotel and park abutments (Alternative 4),[91] and the other being full removal of the dam structure (Alternative 5). Both of these alternatives set the controlling elevation to the top of the existing channel bottom at 620.0 feet above NGVD 29.[92] No additional survey of streambed elevations was made downstream of the existing Horlick dam from what was included in the original CAPR 152 HEC-2 model. Thus the exact slope of the Root River bottom between the dam crest and the model cross section 25 feet downstream is not known and the ability of fish to swim upriver is only evaluated based on tailwater heights and crest velocities at the former dam location.

ALTERNATIVE 4—FULL NOTCH OF CURRENT DAM SPILLWAY

Alternative 4 includes a two-level notch to both contain the 1-percent-annual-probability (100-year recurrence interval) flood within the original dam spillway, and allow fish passage at the natural channel invert elevation of 620.0 feet above NGVD 29 (see Figure 113). The shape of the spillway opening is a Cipolletti notch, with the sloping portion of the notch openings designed to offset the contraction of the water around the structure. This design would include approximately 54 feet of the original spillway at elevation 629.9 feet above NGVD 29, 50 feet of crest length at elevation 621.9 feet above NGVD 29, and a six-foot opening at the Root River bottom of 620.0 feet above NGVD 29. The notch would all be to the right of the stoplog structure. The modifications included under Alternative 4 provide approximately 2.6 feet of freeboard to the tops of the existing left and right concrete abutments for the maximum 1-percent-annual-probability flood elevation. The modifications included in Alternative 4 also just contain the 0.2-percent-annual-probability flood within the dam spillway. Under this design the remaining dam structure would no longer serve as a control for base flows, and it would have a significantly reduced effect at flood flows as compared to the Baseline Condition or Alternatives 1, 2 and 3. The tailwater elevations would remain the same as under the Baseline Condition.

Surface Water and Groundwater Quantity Considerations

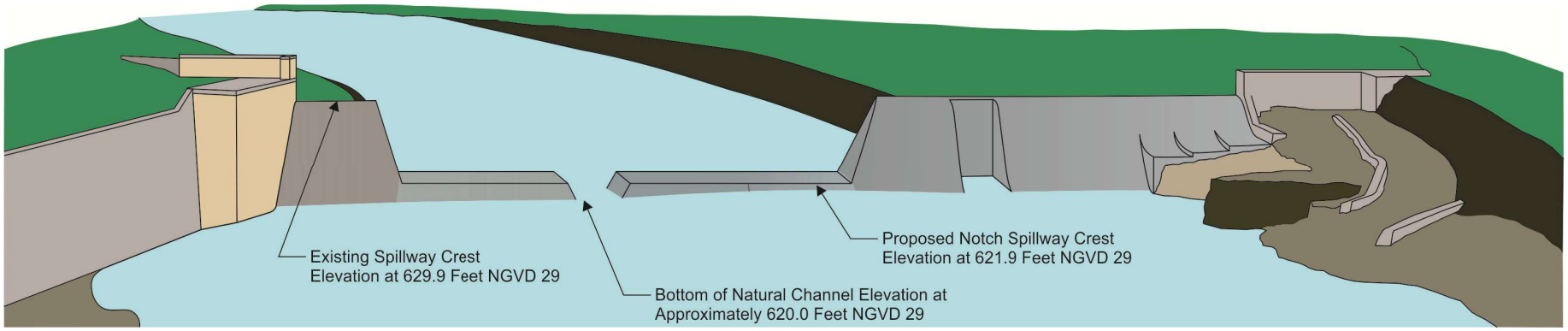
Based on hydraulic model results, the tailwater elevation for Alternative 4 is approximately at the top of the natural ledge (620.0 feet above NGVD 29) for the March-June maximum mean daily flow of 1,000 cfs. This flow is between the 99-percent-annual-probability (one-year recurrence interval) and 50-percent-annual probability (two-year recurrence interval) floods. This flow would pass over both the low notch at 620.0 and mid-level notch at 621.9 feet above NGVD 29. The mean velocity at the Alternative 4 opening for the March-June mean daily flow is approximately 5.6 fps. Only the 90 percent exceedence flow of 10 cfs is wholly contained within the

[91] *Under this alternative, the remaining structure may still be considered a dam by WDNR for regulatory purposes.*

[92] *This was determined to be the approximate top of the shelf immediately upstream of the Horlick dam, as well.*

Figure 113

HORLICK DAM CONCEPTUAL ALTERNATIVE 4
FULL NOTCH OF CURRENT DAM SPILLWAY– LOOKING NORTH (UPSTREAM)



Source: SEWRPC.

six-foot-wide low opening, with a velocity of approximately 2.6 fps. A review of tailwater elevations indicates that the 10-percent exceedence flow (410 cfs) has a tailwater elevation approximately 1.5 feet below the crest at elevation 620.0 feet above NGVD 29, which meets the USFWS criterion for inhibiting passage of sea lamprey.

Based on hydraulic model results the 1-percent-annual-probability (100-year recurrence interval) water surface elevation at the dam under Alternative 4 is approximately four feet lower than the Baseline Condition and 0.6 foot lower than under Alternative 1. The 1-percent-annual-probability flood effects of Alternative 4 are not as pronounced upstream at STH 31, with water surface elevations upstream of the bridge for Alternative 4 being only 0.3 foot lower than the Baseline Condition and essentially the same as Alternative 1.

With this partial removal of a structural barrier on the Root River, the impoundment area will essentially be eliminated under low-flow conditions. Based on hydraulic modeling results, it is concluded that the natural shelf at elevation 620.0 feet above NGVD 29 that extends upstream of the dam for approximately 1,000 feet will control hydraulic profiles for smaller flows. Along the entire corridor between the Horlick dam location and STH 31, flow would be expected to be within the banks for more floods, allowing overbank vegetation to establish and improve terrestrial habitat.

Elimination of the impoundment during normal flow times would most likely lower shallow groundwater levels in the immediate area. This may adversely affect the still active groundwater wells developed in the shallow aquifer previously discussed and depicted in Map 70.

Water Quality

With the elimination of the impoundment under Alternative 4, water quality should improve for all the constituents of concern (dissolved oxygen, phosphorus, and temperature). Normal flows will no longer be impounded and the conversion to a free-flowing river should result in better aeration of the water in the formerly impounded reach upstream from the dam site. This should help improve water quality during larger floods as well, with filtering through and deposition of sediments in overbank vegetation now a viable option to remove and store sediments and contaminants during higher overbank flows.

Under Alternative 4 the notched configuration may provide the added benefit of helping to prevent settled sediment from being transported downstream and to maintain a vegetated flood bench. Nevertheless, it is very likely that some of the settled sediment may be flushed out of the impoundment area for this alternative with the elimination of a complete barrier. It is difficult to predict if this sediment flush would happen all at once or over time, but in all likelihood in the absence of mitigation would be an adverse impact to downstream reaches. It would be best to lower the dam in small increments over time in such a way as to minimize the potential for a large-scale loss of settled sediment downstream. Thus, dredging of sediment accumulated in the impoundment is not called for under this alternative. The two-level spillway crest with a large section set at elevation 621.9 feet above NGVD 29 will also more easily facilitate large woody debris passage during high flow times, which may be an adverse impact for downstream reaches as compared to the Baseline Condition.

Natural Resources

During the 10-percent-annual-probability flood, the hydraulic modeling results for the dam under Alternative 4 indicate that the Horlick dam tailwater elevation is approximately 4.0 feet above the low sill elevation of 620.0 feet above NGVD 29. Thus, the structure configuration under Alternative 4 would not be a barrier to sea lamprey or round goby movements. As was indicated earlier, the tailwater elevation is approximately at the top of the natural shelf (620.0 feet above NGVD 29) for the March-June maximum mean daily flow of 1,000 cfs,[93] indicating that the dam would most likely no longer be a barrier for invasive aquatic species for anything larger

[93] *This flow is between the 99-percent-annual-probability (one-year recurrence interval) and 50-percent-annual probability (two-year recurrence interval) floods.*

than this flow rate. Using the USFWS preliminary 1.5 foot criterion for sea lamprey passage, under Alternative 4 the structure would no longer be a barrier to sea lamprey for any events larger than the 10-percent-exceedence flow rate of 410 cfs.

Using the fish burst speeds listed in Table 75, all three fish species could pass the modified Horlick dam spillway for the March-June maximum mean daily flow of 1,000 cfs when the tailwater elevation would be above the spillway crest. To allow sufficient depth downstream for chinook salmon to jump, it was assumed that a minimum of two feet of depth was required, which translates to the 50-percent exceedence flow rate of 56 cfs under Alternative 4. The 90 percent exceedence flow of 10 cfs is wholly contained within the six-foot-wide low opening, with a velocity of approximately 2.6 fps, which should be passable for all three fish species. Unfortunately, the streambed configuration immediately downstream of the dam is not fully known, thus depths at this low flow rate may minimize fish passage. In other words, this area downstream may be too wide under base-flow conditions to provide adequate water depths for fish passage. This area may need to be reconstructed to promote fish passage for Alternative 4. Under Alternative 4, the dam would be deemed an incomplete barrier based on the WDNR Fish Passage Guidance. A summary of fish passage issues for all alternatives is set forth in Table 76.

Social

Alternative 4 does leave a portion of the dam structure in place, thus the cascading nature of the flows is maintained for larger floods. For smaller floods, the flows will utilize the Root River channel bottom only. Thus, the aesthetics of the dam will change significantly for Alternative 4. The upstream impoundment area will also be eliminated and the corridor between the dam and STH 31 will have a more riverine look.

Safety issues are a relatively small concern for this alternative, as a portion of the dam structure will remain in place but the abrupt drop between the impoundment and the downstream reach will be eliminated. The original hydraulic height of the dam is approximately 12 feet and, under Alternative 4, there would be a naturally sloping five-foot streambed drop between the dam location and STH 38 downstream, which is a significantly reduced safety hazard compared to Alternatives No. 1, 2 and 3.

Implementation of Alternative 4 would significantly alter recreational opportunities at the dam and impoundment area. There would be opportunities for new riparian trails and passive recreation, as the impoundment has been eliminated. Passive recreation would ultimately be dependent on ownership status for the exposed land. With the elimination of the impoundment, the ability to float small watercraft would be dependent on flow conditions. Fishing would become riverine exclusive and under most flow conditions the structure configuration under Alternative 4 would no longer present a full barrier to fish passage. Fish normally stopped at the dam might now move farther upstream. Fishing would change dramatically, as fish would no longer be completely stopped at the downstream side of the dam, and they could travel upstream along the mainstem and tributaries. Opening up additional habitat to the native and sport fishery would be considered positive. This would be considered a positive from a general fishery perspective and the ecological integrity of the entire Root River system,[94] but possibly a negative for salmon fishing just downstream of the Horlick dam, where the dam would no longer serves as a barrier that concentrates the fish. Under Alternative 4 recreational boat access would also be adversely affected at River Bend Nature Center and Horlick Park, as under most flow conditions there would be no impoundment and the current launch locations would be farther from the Root River.

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[94] *Victor J. Santucci, Jr. et al, "Effects of Multiple Low-Head Dams on Fish, Macroinvertebrates, Habitat, and Water Quality in the Fox River, Illinois,"* North American Journal of Fisheries Management, *Vol. 25, 2005* and *Thomas M. Slawski et al, "Effects of Tributary Spatial Position, Urbanization, and Multiple Low-Head Dams on Warmwater Fish Community Structure in a Midwestern Stream,"* North American Journal of Fisheries Management*, Vol. 28, 2008.*

With the elimination of the impoundment area, land ownership in this area would be affected. The nine properties highlighted in yellow on Map 71 would gain some dry land under Alternative 4, which would most likely be considered a positive effect. But for the majority of the private landowners between the dam and STH 31, their properties would most likely no longer be immediately adjacent to the Root River. This effect would be most pronounced in the impoundment area nearest the former dam site, and less so upstream where the Root River is narrower. A final determination of changes to Horlick impoundment property boundaries would require a review of the individual deed language.

Cost

A preliminary cost estimate for Alternative 4 was completed in 2013 dollars. Sources of cost information included RSMeans Heavy Construction Cost Data and summary dam removal costs received from WDNR. Components included in the preliminary cost estimate for Alternative 4 include concrete removal, removal of the old dam, seeding of impoundment area, and final finishing to elevation 620.0 feet above NGVD 29. It was assumed that seeding would only be required in the bays of the existing impoundment as depicted in Map 73. The base cost was increased by 35 percent to account for engineering, administration, and contingencies. Based on these assumptions, the systems-level present-worth cost estimate, including capital cost and operation and maintenance, is $483,000. While a significant effort has been made under this system-plan to collect field data and to characterize the anticipated costs associated with this alternative, at the systems-planning level there are many uncertainties in estimating costs relative to alterations of existing dams. Those uncertainties are reduced and estimated costs are refined after an alternative is selected for implementation and preliminary engineering and final design are conducted; however, it should be noted that the WDNR has indicated that even after the final design stage, the average dam reconstruction change order amount is 40 percent of the initial capital cost estimate, mainly due to unforeseen site conditions once construction begins.

Under Alternative 4, a portion of the dam structure is retained, thus ongoing maintenance costs will be incurred for this conceptual alternative. Maintenance costs assumed include debris passage, inspection every 10 years, and minor bank repairs. A summary of all Alternative 4 costs are included in Table 77.

The above preliminary cost estimate does not include dredging of sediment from the Horlick impoundment. As noted above, different approaches to minimizing sediment release downstream of the dam site are called for under this alternative.

Alternative 5—Full Removal of Dam

Alternative 5 calls for removal of the Horlick dam as depicted in Figure 114. The left side walkway and portion of the spillway were retained, as they are somewhat integral with the natural rock on that side of the Horlick dam. Under this alternative, the structure would be removed as a control for all flows. This means that the natural 1,000-foot shelf at elevation 620.0 feet above NGVD 29 would control the flow profiles upstream from the site of the former dam. The tailwater elevations would remain the same as the Baseline Condition.

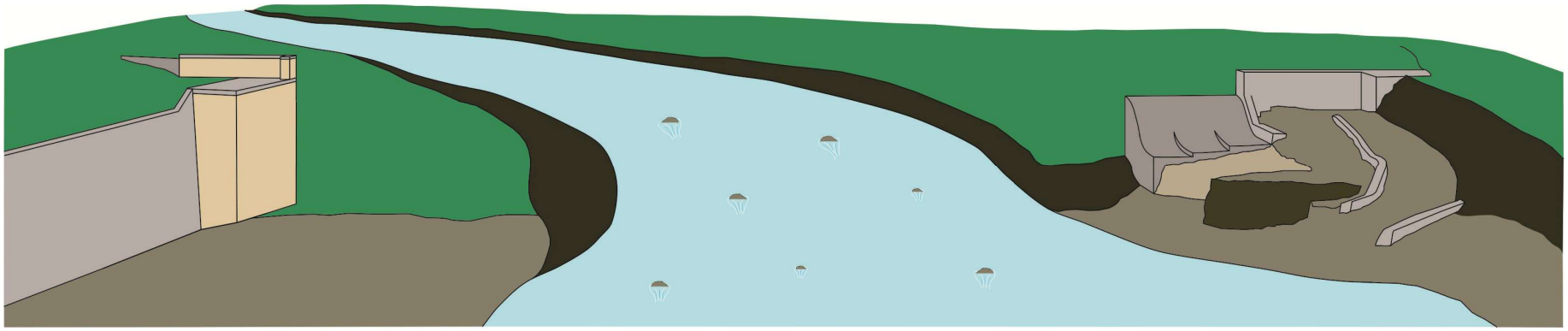
Alternative 5 provides approximately four feet of freeboard to the tops of the remaining left and right concrete abutment sections of the Horlick dam based on the maximum 0.2-percent-annual-probability flood elevation. However, while unlikely, failure of one or both abutments under the Alternative 5 configuration would not be expected to create a significant uncontrolled release of water, since there would be no impoundment of water under this condition.

Surface Water and Groundwater Quantity Considerations

Based on hydraulic model results, the tailwater elevation for Alternative 5 is approximately at the top of the natural ledge (620.0 feet above NGVD 29) for the March-June maximum mean daily flow of 1,000 cfs. This flow is between the 99-percent-annual-probability (one-year) and 50-percent-annual probability (two-year recurrence interval) floods. The mean velocity for Alternative 5 for the March-June mean daily flow is approximately 6.8 fps. The 90 percent exceedence flow (10 cfs) is very shallow across the fully exposed natural ledge, with a depth at the dam location of less than a tenth of a foot. A review of tailwater elevations indicates that the 10-percent exceedence flow (410 cfs) has a tailwater elevation approximately 1.5 feet below the natural ledge at elevation 620.0 feet above NGVD 29, which meets the USFWS criterion for inhibiting passage of sea lamprey.

Figure 114

HORLICK DAM CONCEPTUAL ALTERNATIVE 5
FULL REMOVAL OF DAM – LOOKING NORTH (UPSTREAM)



Source: SEWRPC.

Based on hydraulic model results, the 1-percent-annual-probability (100-year recurrence interval) water surface elevation at the dam for Alternative 5 is approximately eight feet lower than the Baseline Condition or four feet lower than Alternative 4. The 1-percent-annual-probability flood effects of Alternative 5 are not as pronounced upstream at STH 31, with water surface elevations upstream of the bridge for Alternative 5 only 0.3 foot lower than the Baseline Condition and essentially the same as Alternatives 1 and 4.

With the full removal of a structural barrier on the Root River, the impoundment area will be eliminated. Based on hydraulic modeling, the natural shelf at elevation 620.0 feet above NGVD 29 that extends approximately 1,000 feet upstream of the dam location would control hydraulic profiles for all flows. Along the entire corridor between the Horlick dam location and STH 31, flow will be within the banks for more floods, allowing overbank vegetation to establish and improve terrestrial habitat.

Elimination of the impoundment during normal flow times would most likely lower shallow groundwater levels in the immediate area. This may adversely affect the still active groundwater wells developed in the shallow aquifer previously discussed and depicted in Map 70.

Water Quality

With the elimination of the impoundment, water quality should improve for all the constituents of concern (dissolved oxygen, phosphorus, temperature) for Alternative 5. Normal flows will no longer be impounded and should be better aerated by movement through the corridor in a more stream-like setting. This should improve water quality for larger floods as well, with filtering through and deposition of sediments in overbank vegetation now a viable option to remove and store sediments and contaminants during higher overbank flows. It is very likely that the Baseline Condition settled sediment may be flushed out of the impoundment area for this alternative with dam removal. It is difficult to predict if this sediment flush would happen all at once or over time, but in all likelihood in the absence of mitigation would be an adverse impact to downstream reaches. It would be best to lower the dam in small increments over time in such a way as to minimize the potential for a large-scale loss of settled sediment downstream. Thus, dredging of sediment accumulated in the impoundment is not called for under this alternative. Alternative 5 will also not impede large woody debris passage, which may be an adverse impact for downstream reaches as compared to the Baseline Condition. Hence, now the Root River will function like a natural river.

Natural Resources

During the 10-percent-annual-probability flood, the hydraulic modeling results for the removal under Alternative 5 indicate that the tailwater elevation is approximately 4.0 feet above the low sill elevation of 620.0 feet above NGVD 29. Thus, the dam removed configuration under Alternative 5 would not be a barrier to sea lamprey or round goby movements. As was indicated earlier, the tailwater elevation is approximately at the top of the natural shelf (620.0 feet above NGVD 29) for the March-June maximum mean daily flow of 1,000 cfs,[95] indicating that the dam would most likely no longer be a barrier for invasive aquatic species for anything larger than this flow rate. Using the WDNR preliminary 1.5 foot criterion for sea lamprey passage, under Alternative 5 the structure would no longer be a barrier to sea lamprey for any events larger than the 10-percent-exceedence flow rate of 410 cfs.

Using the fish burst speeds listed in Table 75, all three fish species could pass the former dam site for the tailwater-submerged March-June maximum mean daily flow of 1,000 cfs. To allow sufficient depth downstream for chinook salmon to jump, it was assumed that a minimum of two feet of depth was required, which translates to the 50-percent exceedence flow rate of 56 cfs for Alternative 5. The 90 percent exceedence flow of 10 cfs has minimal depth at the controlling ledge as discussed previously, thus, the ledge may be impassible for all three fish species. A summary of fish passage issues for all alternatives is included in Table 76.

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[95] *This flow is between the 99-percent-annual-probability (one-year recurrence interval) and 50-percent-annual probability (two-year recurrence interval) floods.*

Social

Alternative 5 removes the dam structure from the river corridor, thus the cascading nature of the flows is most likely no longer possible for even larger floods. For smaller floods, the flows will utilize the Root River channel bottom only for Alternative 5. Map 72 includes a comparison of the approximate Baseline Condition for the impoundment as represented on the 2010 SEWRPC digital color orthophotograph, and the estimated extent of the River during normal flow conditions with Alternative 5 implemented. Also shown on Map 72 are several field-surveyed cross sections along the impoundment for comparison purposes between the existing impoundment and estimated normal water surface elevations under Alternative 5. The comparison indicates that the aesthetics of the former impoundment area will change significantly under Alternative 5, with a more riverine look to the corridor between the site of the former dam and STH 31.

Safety issues would be minimal for this alternative, as only the left side portion of the dam structure will remain in place. The abrupt drop between the impoundment and the downstream reach will be eliminated, improving safety at the dam. The original hydraulic height of the dam is approximately 12 feet and Alternative 5 has a naturally sloping five-foot hydraulic height between the dam location and STH 38 downstream, which would represent a significantly reduced safety hazard as well.

Implementation of Alternative 5 would significantly alter recreational opportunities at the dam and impoundment area. There would be opportunities for new riparian trails and passive recreation, as the impoundment has been eliminated. Passive recreation would ultimately be dependent on ownership status for the exposed land. With the elimination of the impoundment, the ability to float small watercraft would be dependent on flow conditions. Fishing would become riverine exclusive and under all flow conditions the minimal structure configuration under Alternative 5 would no longer present a barrier to fish passage and fish and other aquatic life normally stopped at the dam might now move farther upstream and downstream as necessary. Fishing would change dramatically as fish would no longer be completely stopped at the downstream side of the dam, and they could travel upstream along the mainstem and tributaries. Opening up additional habitat to the native and sport fishery would be considered positive. This would be considered a positive from the perspective of the general fishery and the ecological integrity of the entire Root River system, but possibly a negative for salmon fishing just downstream of the Horlick dam where the dam would no longer serve as a barrier that concentrates the fish. Under Alternative 5, recreational boat access would also be adversely affected at River Bend Nature Center and Horlick Park, as under most flow conditions there would be no impoundment and the current launch locations would be farther from the Root River.

With the elimination of the impoundment area, land ownership in this area would be affected. The nine properties highlighted in yellow on Map 71 would gain some dry land under Alternative 5, which would most likely be considered a positive effect, but the properties of the majority of the private landowners between the dam and STH 31 would most likely no longer be immediately adjacent to the Root River. This effect would be most pronounced in the impoundment area closest to the former dam site, and less so upstream where the Root River is more confined. A final determination of changes to Horlick impoundment property boundaries would require a review of the individual deed language.

Cost

A preliminary cost estimate for Alternative 5 was completed in 2013 dollars. Sources of cost information included RSMeans Heavy Construction Cost Data and summary dam removal costs received from WDNR. Components included in the preliminary cost estimate for Alternative 5 include concrete removal, removal of the old dam, and seeding of impoundment area. It was assumed that seeding would only be required in the bays of the existing impoundment as depicted in Map 73. A contingency of 35 percent was added to the base cost estimate to account for minor items, engineering, and permitting. Based on these assumptions, the systems-level present worth cost estimate, including capital cost and operation and maintenance, is $551,000. While a significant effort has been made under this system-plan to collect field data and to characterize the anticipated costs associated with this alternative, at the systems-planning level there are many uncertainties in estimating costs relative to alterations of existing dams. Those uncertainties are reduced and estimated costs are refined after an alternative is selected for implementation and preliminary engineering and final design are conducted.

Under Alternative 5 almost all of the dam structure would be removed, thus structural maintenance requirements have essentially been eliminated. It was assumed that reseeding of portions of the former impoundment area would be required after structural removal. A summary of all Alternative 5 costs is included in Table 77.

The above preliminary cost estimate does not include dredging of sediment from the Horlick impoundment. As noted above, different approaches to minimizing sediment release downstream of the dam site are called for under this alternative.

Comparison of Alternative Plans
A summary of all five conceptual alternatives for the major issues of concern is included in Table 78.

Additional Work/Information Required
The decision regarding which of the Horlick dam alternatives is to be implemented ultimately rests with Racine County as the owner of the dam. Numerous additional elements of information need to be considered during the preliminary engineering phase for whichever alternative the County chooses to pursue. The informational needs listed below are not meant to be comprehensive, but are a good starting point for future analysis:

- Determination by WDNR of aquatic invasive species of concern,[96]
- Additional sampling of impoundment sediment for potential contamination,
- Evaluation of structural integrity of right dam abutment at Riverside Inn under Alternative 5, "Full Removal of Dam,"
- Evaluation of structural issues related to lowering or notching the current Horlick dam structure,
- Investigation of the structural integrity of the rock in the fishway area,
- Determination of the prevalence of active shallow private wells in the impoundment area that would be affected by impoundment modifications,
- The exact nature of the natural 1,000-foot shelf—related to unknowns for impoundment area to predict sediment movement and riparian restoration potential, and
- Collection of additional detailed survey data in the reach between the dam and STH 38 to determine if water depths and streambed slopes will allow fish and aquatic invasive species to migrate upstream.

[96] *That determination would be made according to the criteria of the WDNR fish passage guidance.*

Table 78

HORLICK DAM ALTERNATIVE SUMMARY—MAJOR ISSUES OF CONCERN

Alternative	Environmental Considerations					Cultural Considerations						Cost
							Recreation					
	Flooding Upstream of Dam	Water Quality	Fish Passage and Overall Fish Community Improvement	Aquatic Invasive Species and VHS Upstream of Dam	Downstream Movement of Sediment in Impoundment	Safety	Paddling	New Riparian Recreational Opportunities[a]	Fishing Upstream of Dam	Recreational Salmon Fishing Immediately Downstream of Dam	Access to River by Riparian Land Owners[b]	Total Present Worth Costs (dollars)[c]
Baseline (existing) Condition[d]	0	0	0	0	0	0	0	0	0	0	0	N/A[e]
Alternative 1—Lower Crest for 100-Year Capacity	+	+	+	-	-	+	–	+	+	0	–	$411,000
Alternative 2—Alt 1 with Fishway	+	+	++	--	-	+	–	+	++	–	–	$555,000
Alternative 3—Lengthen Spillway for 100-Year Capacity	0	0	0	0	0	0	0	0	0	0	0	$998,000
Alternative 4—Full Notch of Dam for 100-Year Capacity	++	++	++	---	--	++	– –	++	+++	– –	– –	$483,000
Alternative 5—Dam Removal	++	+++	+++	---	---	+++	– –	++	+++	– –	– –	$551,000
Basis for Evaluation	Reduction/ removal of structure will lower upstream flood elevations	Reduction in impounded water should improve water quality	Elimination of structure in River or addition of fishway improves passage	Elimination of structure in River or addition of fishway increases likelihood of passage	Elimination of structure in River lowers or eliminates impoundment and exposes sediment	Reduction/ elimination of structure in River improves public safety	Loss of impoundment area reduces consistent paddling water levels	New options within dewatered impoundment area for trails and passive recreation	Improved fish passage will improve fishing upstream	With addition of fishway or removal of dam, fish would no longer congregate on downstream side of dam	Reduction in water level removes direct access to River	N/A

[a] *The ability to realize enhanced recreational opportunities depends on ownership of lands exposed with a lower or eliminated impoundment.*

[b] *Based on property boundaries provided by Racine County.*

[c] *Based on an interest rate of 6 percent and a project life of 50 years.*

[d] *Alternatives are rated relative to the potential changes from the Baseline Condition which is designated neutrally as "0". Positive (+) or negative (–) signs indicate a more positive or negative effect on the issue of concern as compared to the Baseline Condition.*

[e] *Not applicable.*

Source: SEWRPC.

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