US Army Corps of Engineers®
Portland District

WILLAMETTE VALLEY SYSTEM OPERATIONS AND MAINTENANCE

APPENDIX H: DAM SAFETY

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1. INTRODUCTION

This appendix provides a qualitative assessment of the proposed alternatives as they relate to the existing understanding of dam safety risk at each project. There are ongoing dam safety risk assessments for each of the WVS dams. At several dams, potential failures modes (PFMs) have been identified that are potentially actionable from a societal risk perspective based on USACE's tolerable risk guidelines (TRGs).

The potential effects to dam safety are considered for individual dams based on the current understanding of each dam's risk-driving failure modes and any new PFMs due to the construction or implementation of the proposed measures. Effects also consider impacts to routine activities under the USACE Dam Safety Program, which includes routine inspections, monitoring, and maintenance. Several measures will require a dam safety risk assessment and mitigation measures. There is no affected environment description associated specifically with dam safety; the existing conditions described for all resources in Chapter 3, Affected Environment and Environmental Consequences, apply to the dam safety scenario. In accordance with the USACE principle "Do No Harm," the final implementation of the selected alternative cannot result in increase to dam safety risk.

2. METHODOLOGY

This section discusses the potential effects to dam safety due to the measures within the analyzed action alternatives. The discussion includes the methodology and the effects of proposed measures to dam safety.

Although final implementation of the selected alternative would not increase dam safety risk for any individual dam, the potential effects to dam safety risk can be evaluated on a qualitative scale directly correlated with the level of dam safety risk assessment and mitigation measures that would be required for implementation. Other effects to dam safety could include those that impact routine activities under the USACE Dam Safety Program, including routine inspections, monitoring, and maintenance (EIS Section 1.12.2, Interim Risk Reduction Measures). The USACE Dam Safety Program scope and responsibilities are described in USACE Engineering Regulation (ER) 1110-2-1156: Safety of Dams – Policy and Procedures (USACE 2014).

For the purposes of this assessment, minor effects to dam safety are those that over the long term may result in erosion, degradation, or aging of equipment due to increased and prolonged use. Some measures would result in increased use of outlets and more operational cycles than would normally occur. This may cause increased rates of wear and tear to the project outlets/mechanical electrical operating equipment and structural features such as stilling

basins. Mitigation for these effects would typically consist of more frequent dam safety monitoring, inspections, and repairs than under current conditions.

Dam safety monitoring, inspections, and repairs are funded and executed through the Dam Safety Program. The increased frequency of such activities would constitute a minor effect to the Dam Safety Program, which would require increase in budget and resources to address these activity requirements.

Other minor effects to dam safety are measures that would have drawdowns below current winter pool elevations with the potential to initiate landslides around the reservoir rims. A qualitative landslide assessment would be conducted prior to implementing any operational measure, which would inform the need for enhanced dam safety monitoring during drawdown operations and increased scope of the routine dam safety inspections to include these areas of potential landslides. Assessments would include consideration of potential increase in debris loading within a reservoir and whether any landslides could be large enough to block access to a dam. Based on the existing landslide assessments that have been conducted to date, the effects to dam safety are generally considered minor.

Table 2-1 describes the evaluation criteria for the effect factors (magnitude, duration, and extent), and provides a definition for the scale of each effect factor. Table 2-2 provides a summary of the effects to dam safety for each alternative. These effects are discussed in greater detail in Section 2.1, Discussion of Dam Safety Effects by Alternative.

Table 2-1. Evaluation Criteria for Potential Effects to Dam Safety.

Effect Factors and Scale	Definition
None/Negligible	No measurable effects to dam safety risk or change in the scope of the Dam Safety Program.
Minor	Some measures would result in increased operations/use of regulating outlets/spillways/stilling basins, which would result in measurable erosion or equipment fatigue over long durations. Minor effects would include modifications to the scope of the Dam Safety Program for more frequent dam safety monitoring, inspection, and maintenance requirements.
Moderate	Changes to the resource would be measurable. Changes have the potential to result in increased dam safety risk and/or operational reliability and would need further assessment prior to implementation. Mitigation measures may be necessary to reduce potential adverse effects. Increased monitoring and evaluation would constitute a moderate impact to the Dam Safety Program to incorporate these requirements.
Major	Changes would be readily measurable and would have substantial effects to dam safety risk. Operational or structural measures would increase the risk of existing potential failure modes or create new potential failure modes. Mitigation measures would be necessary to reduce potential adverse effects. The addition of new structural features would also require an increased scope to the Dam Safety Program by adding to the number of structures and features that require routine inspection and monitoring.

Table 2-2. Summary of Effects to Dam Safety Under Each Alternative.

Alternative	Short-term Effects	Medium-term Effects	Long-term Effects
NAA	Negligible adverse effects for all dam projects	Negligible adverse effects for all dam projects	Permanent negligible adverse effects for all dam projects
1	Minor adverse effects for FOS	Minor adverse effects for LOP, CGR, DET, GRP, DEX	Permanent minor adverse effects to LOP, HCR, CGR, DET
2A, 2B, 5, and 6	Moderate adverse effects to CGR, FOS, GPR	Minor adverse effects to LOP, DET, GRP	Permanent and/or recurring major adverse effects to LOP, CGR, DET
3A	Moderate adverse effects to LOP, HCR, CGR, BLR, DET, GRP	Minor adverse effects to BLR, HCR, GRP	Permanent and/or recurring major adverse effects to LOP, HCR, CGR, BLR, DET
3b	Moderate adverse effects to LOP, HCR, CGR, BLR, DET, GRP	Minor adverse effects to BLR, HCR, GRP	Permanent and/or recurring major adverse effects to LOP, HCR, CGR, BLR, DET
4	Minor adverse effects to FOS	Minor adverse effects to HCR, LOP, CGR, DET, DEX	Permanent minor adverse effects to LOP, HCR, CGR, DET

FRN = Fern Ridge Dam
CTG = Cottage Grove Dam
DOR = Dorena Dam
DEX = Dexter Dam
LOP = Lookout Point Dam
FCR = Fall Creek Dam
HCR = Hills Creek Dam
CGR = Cougar Dam
BLU = Blue River Dam
FOS = Foster Dam
GPR = Green Peter Dam
BCL = Big Cliff Dam
DET = Detroit

2.1 Discussion of Dam Safety Effects by Alternative

The effects to dam safety are considered on an individual dam basis in the context of the individual measures. The alternatives propose different combinations of measures that may also include different combinations of projects for which the measures are to be implemented.

In general, measures that would reduce the quantity and/or duration of stored water (by dipping below minimum power pool or releasing more water) would generally result in increased flood storage and a dam safety risk reduction. However, in the short to medium term, additional surveillance and monitoring would be required to understand project behavior under the new loading conditions and establish new baseline metrics. Structural measures such as construction of a selective withdrawal structure or fish collection structures would likely require excavation and construction adjacent to the dam and alteration of the dams' foundations, which could increase dam safety risk.

A qualitative or quantitative dam safety risk assessment would be performed for any structural measures; this may result in constraints and criteria that would be required to be incorporated into the proposed design or implementation of these measures. Structural measures would also

increase the scope of the Dam Safety Program by increasing the need for inspection and monitoring of the added structural features.

In general, the effects to dam safety and changes to the designs are considered to have moderate impact, but some alternatives may present major impacts with unacceptable risks to dam safety if left unmitigated. For example, Measure 720 for use of the diversion tunnel at Cougar Dam has the potential for major adverse effects to dam safety. Implementation of that alternative would require further analysis and a quantitative assessment to ensure proper mitigation measures are applied throughout design, construction, and implementation.

2.2 No-action Alternative

All of the WVS dams are currently subject to ongoing dam safety risk assessments. Several dams have Interim Risk Reduction Measures (IRRMs) in place to reduce dam safety risk while the dam's risk is being further studied. The No-action Alternative (NAA) is not expected to affect any risk-driving failure modes or existing IRRMs because the NAA does not include proposed operational or structural changes to the dams.

2.2.1 Climate Change

Appendix F1, Qualitative Assessment of Climate Change Impacts, and Appendix F2, Supplemental Climate Change Information, describe projected climate change trends likely to be experienced in the WVS. Modeled changes applicable to dam safety include decreases to snowpack as more winter precipitation falls as rain instead of snow. Because precipitation is not stored as snow upstream of the reservoirs, fall and winter inflows are likely to increase, which could result in more frequent flood risk management operations and demand on the flood risk management storage within the reservoirs. Flood risk contribution from the annual spring snow melt may be reduced, especially in higher elevation reservoirs that are presently influenced by snowpack, like Cougar, Hills Creek, and Blue River Dams. However, flood risk at these reservoirs is still primarily driven by rainfall and rain-on-snow events.

Low elevation WVS dams, such as Fern Ridge Dam and Cottage Grove Dam, with little or no annual snowpack are projected to experience higher wintertime inflow volumes but similar peak runoff timing compared to historical baselines. Overall, the effects of climate change to dam safety are expected to be similar across all alternatives and have a minor effect of possible increased flood operations during the winter.

2.3 Alternative 1 – Improve Fish Passage Through Storage-focused Measures

Alternative 1 would combine Measures 304, 718, 723, 105, 174, 479, 392, 52, 639, 722, 384, 719, and 726. Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and the dam as compared to the NAA.

This alternative includes structural Measures 105, 174, 479, and 392. All of the structural modifications have the potential for moderate to major effects to existing dam safety risk as

compared to the NAA and would require project-specific risk assessments when design details are developed. Based on the results of the risk assessments, mitigation measures or alteration of the designs may be required, which would not occur under the NAA. Compared to the NAA, additional routine dam safety inspections and monitoring could also be required, constituting moderate effects to the Dam Safety Program.

Unlike the NAA, construction of selective withdrawal structures at Lookout Point, Foster, Green Peter, and Detroit Dams would likely require substantial excavations adjacent to the dam foundations and modification of the existing dam structures, posing potential major effects to dam safety risk. Currently, there has been minimal development of construction details of these structures. The design and modifications to spillways or regulating outlets to reduce total dissolved gas (TDG) at Dexter, Lookout Point, Cougar, Foster, Green Peter, and Detroit Dams would incorporate impacts to flow capacity/performance and not impact the ability to pass flood flows and safely pass low and moderate flows, which would not occur under the NAA. Modification of the existing outlets at Foster Dam for temperature control under this alternative would involve modifying the concrete non-overflow monolith section and the spillway.

Unlike the NAA, there are potential major adverse effects to dam safety that would need to be addressed in the risk-informed design process. Design, construction, and operation of one of these structural improvements would require substantial involvement and review from a dam safety perspective. Overall, structural improvements would have a moderate to major potential for effects to dam safety as compared to the NAA that would need to be evaluated and mitigated throughout the design, construction, and implementation processes.

Alternative 1 also includes Measures 304 and 718 to drawdown into the inactive or power pool and respective rule curves for several dams, which would result in a minor beneficial impact by providing additional flood storage for the winter season, unlike the NAA. However, the removal of the stabilizing force from the pool load could cause instability of steep upstream embankment and reservoir rim slopes. The stability of upstream embankment slopes and reservoir rims without the pool load would need to be evaluated and monitored, although the effects to dam safety are expected to be minor as compared to the NAA. Minor to moderate effects to the Dam Safety Routine Program would consist of increased frequency of monitoring and inspection of these slopes.

There would be a moderate effect to dam safety for Green Peter Dam under Measure 304 as compared to the NAA, which impacts the dam's primary and backup power sources for operating outlet gates. This measure implementation would require mitigation with an additional backup power source.

Unlike the NAA, Measure 723, reduce minimum flows to Congressionally authorized minimum flow requirements, is proposed only under Alternative 1 for the following dams: Fern Ridge, Cottage Grove, Dorena, Dexter, Lookout Point, Fall Creek, Hills Creek, Cougar, Blue River, Foster, Green Peter, Big Cliff, and Detroit. This measure would allow the reservoir to capture more spring runoff and increase the probability of refilling to follow the water control diagrams.

However, this measure would not include the benefit of high late spring/early summer outflows as outlined in Measure 30a. The measure would only allow for refilling within the existing operational range in accordance with the respective water control diagrams for each project. The measure would not change the water control diagram as compared to the NAA; therefore, it would not increase the amount of time that the reservoirs are held at their highest level during the summer conservation season. Measure 723 would have a minor effect to dam safety risk as compared to the NAA.

2.4 Evaluation of Interim Operations Measures

The Interim Operations measures are summarily described in EIS Section 2.8.5, Interim Operations, and in detail in Appendix A, Alternatives Development. The potential effects to dam safety for the Interim Operations are considered qualitatively for Alternatives 2A, 2B, 3A, 3B, 4, 5, and 6 for the temporal scope of the EIS (30 years) (EIS Section 1.4.2, Temporal Scope).

In general, the Interim Operations measures would result in higher use of some dam components such as regulating outlets, stilling basins, or spillways as compared to the NAA. Therefore, minor to moderate effects to dam safety would occur, and most would result in increased monitoring and survey requirements as compared to the NAA. The monitoring frequency may be adjusted after initial surveillance and evaluations of the dams are completed. Additionally, several measures would include deep drawdowns and require a slope stability evaluation. Table 1-3 provides a summary of the dam safety effects at each dam that would result from Interim Operations under the action alternatives.

Table 2-3. Evaluation of Interim Operations Effects on Dam Safety under the Action Alternatives.

Operation Description by Dam	Dam Safety Effects
Detroit	
Spring downstream fish passage and operational downstream temperature management.	No dam safety impacts expected.
Late fall drawdown to elevation 1395 feet for fish passage.	A landslide assessment of the reservoir rim area will need to be conducted. No dam safety impacts are expected but operation would expose areas of the dam not seen since original construction. Increased monitoring would occur during and after drawdown operations to include visual monitoring of the dam and potential landslide areas along the access roads, potential installation of new instrumentation, additional instrumentation readings (uplift piezometers and tiltmeters), and post-drawdown hydrosurvey of the stilling basin and regulating outlet inspection due to the potential for increased usage.
Nighttime regulating outlet prioritization for improved downstream fish passage.	The lower regulating outlets (LROs) at Detroit Dam are rarely used. Historically, the operation of the LROs resulted in severe cavitation damage to the

Operation Description by Dam	Dam Safety Effects
	concrete conduit, which had to be repaired. Stilling basin and baffle block damage was also observed due to LRO use. Therefore, dam safety monitoring for this action would consist of an inspection of the LROs and a hydrosurvey of the stilling basin.
Big Cliff	
Spread spill across spillways to reduce downstream TDG exceedances.	No dam safety impacts expected.
Green Peter	
Outplanting plan for reintroduction of adult Chinook salmon above Green Peter Dam.	No dam safety impacts expected.
Utilize spillway for improved downstream fish passage in the spring; perform spill operation until May 1 or for 30 days, whichever is longer.	The Green Peter Dam stilling basin has existing areas of erosion primarily attributed to use of the north regulating outlet. Monitoring would consist of a hydrosurvey of the stilling basin following the spring spill operation.
Deep drawdown and regulating outlet prioritization for improved downstream fish passage.	A landslide assessment of the reservoir rim area was conducted. No dam safety impacts are expected but operation would expose areas of the dam not seen since original construction. Increased monitoring would occur during drawdown operations to include visual monitoring of the dam and potential landslide areas along the access roads, an additional survey, installation of new instrumentation (crack meters), and additional instrumentation readings (uplift piezometers and tiltmeters).
Foster	
Delay refill and utilize spillway in the spring for improved downstream fish passage; use the fish weir in the summer for improved downstream temperature management and upstream fish migration/passage.	No dam safety impacts expected.
Utilize the spillway for improved downstream fish passage in the fall.	No dam safety impacts expected.
Cougar	
Reservoir drawdown and regulating outlet prioritization for improved downstream fish passage.	The Cougar Dam fall drawdown and spring delayed refill implemented in Fall 2021 required additional visual monitoring and weekly evaluation of dam safety instrumentation data (piezometers, weirs) as well as a set of inclinometer readings during the drawdown. Cougar Dam has a past performance history of differential settlement since original construction and first filling that has increased during previous drawdowns below the minimum conservation pool. However, this measure only

Operation Description by Dam	Dam Safety Effects
	requires a drawdown 20 feet below current minimum conservation pool, and the dam safety impacts are expected to be minimal. (Deeper drawdowns for Cougar Reservoir considered in other measures have potentially major impacts to dam safety).
Delayed reservoir refill and regulating outlet prioritization for improved downstream fish passage.	No dam safety impacts expected.
Hills Creek	
Nighttime regulating outlet prioritization for improved downstream fish passage.	No dam safety impacts expected.
Lookout Point	
Utilize spillway for improved downstream fish passage in the spring; regulating outlet use in the fall for downstream temperature management.	No dam safety impacts expected.
Deep drawdown and regulating outlet prioritization for improved downstream fish passage.	For Lookout Point Dam, a landslide assessment of the reservoir rim area was conducted, and recommended monitoring was performed along portions of the reservoir during implementation of this operation. Impacts to dam safety are expected to be minor for this operation. Increased monitoring of the dam would include visual inspections during the deep drawdown and more frequent collection of downstream piezometer data during refill.
Fall Creek	
Extended deep drawdown and regulating outlet prioritization for improved downstream fish passage.	For Fall Creek Dam drawdown in fall 2021, additional visual monitoring and inspection was performed during the initial deep drawdown. Compared to previous drawdown inspections, additional erosion adjacent to the regulating outlet intake training walls was observed. Impacts to dam safety could be moderate if this operation were continued for the next 30 years because of the likely continued erosion around the regulating outlet. A major repair may be needed if the operation were continued.
Delayed reservoir refill and regulating outlet prioritization for improved downstream fish passage.	No dam safety impacts expected.

2.5 Alternative 2A – Integrated Water Management Flexibility and ESA-listed Fish Alternative

Alternative 2A combines Measures 30a, 304, 718, 105, 166, 479, 721, 40, 392, 714, 52, 722, 384, 719, and 726. Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and dam as compared to the NAA.

This alternative includes structural Measures 105, 479, and 392. All of the structural modifications have the potential for moderate to major effects to existing dam safety risk as compared to the NAA and would require project-specific risk assessments when design details are developed. As discussed in Section 1.1.3, Alternative 1, these structural improvement projects would have a moderate to major potential for effects to dam safety that would need to be mitigated through design, construction, and operation.

Based on results of the risk assessments, mitigation measures or additional design considerations may be required. Unlike the NAA, construction of a selective withdrawal structure at Detroit Dam would involve some amount of foundation excavation and modification of the existing dam structures. Currently, there has been minimal development of construction details of these structures.

Modification of the existing outlets at Foster Dam for temperature control under this alternative would involve modifying the concrete non-overflow monolith section and the spillway. There are potential major adverse effects to dam safety that would need to be addressed in the risk-informed design process. Design, construction, and implementation of one of these structural improvements would require substantial review and input from a dam safety perspective. Overall, structural improvements would have a moderate to major potential for effects to dam safety compared to the NAA that would need to be evaluated and mitigated throughout the design, construction, and implementation processes.

Alternative 2A would also include Measures 304, 718, and 40 to drawdown into the power pool and respective rule curves for several dams and reservoirs, which would result in a minor benefit by providing additional flood storage for the winter season as discussed under Alternative 1. The minor to moderate effects to dam safety from Measures 304, 718, and 40 include potential slope instability and additional surveillance and monitoring. The effects of slope instability are identical to those described under the assessment of Alternative 1 as compared to the NAA.

Measure 714 and Measure 721 under this alternative also include increased use of the spillway at Green Peter Dam. Increased spillway use would require additional surveillance and monitoring for signs of erosion in the stilling basin. The effects of these measures would be minor to moderate as compared to the NAA.

2.6 Alternative 2B – Integrated Water Management Flexibility and ESA-listed Fish Alternative

Alternative 2B combines Measures 30a, 304, 718, 105, 166, 479, 721, 40, 392, 714, 720, 52, 722, 384, 719, and 726. Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and dam as compared to the NAA.

The impact assessment and mitigation related to operational, construction, and structural modifications under Alternative 2B would be identical to the assessment described under Alternative 2A. Structural modifications at Cougar Dam under Alternative 2B are described below.

Alternative 2B also includes the same measures to drawdown below the power pool and respective rule curves for several dams and reservoirs as described under Alternative 2A. Effects and mitigation anticipated under Alternative 2B would be the same as those described under Alternative 2A.

Unlike the NAA, Measure 40 and 720, use the diversion tunnel at Cougar Dam, has the potential for major adverse effects to dam safety. Modification of the Cougar Dam diversion tunnel would require a drawdown to streambed, rehabilitation of the existing diversion tunnel and/or construction of a new low-level outlet, construction of an upstream access tower, and potentially other structural modifications that have not yet been identified or developed. There are settlement and other related dam safety concerns for deep drawdowns at Cougar Dam.

Implementation of this alternative would require further analysis and a quantitative risk assessment so that appropriate mitigation can occur during design and construction at Cougar Dam, which would not occur under the NAA. A lower operating pool at Cougar Dam would mean that Blue River Dam would be used for storage to rebalance system outflows along the McKenzie River. As a result, Blue River Reservoir would be more likely to meet the target reservoir elevations governed by its water control diagram. The operation would not extend the duration of time at which the reservoir is held at a high pool because it would not alter the existing water control diagram. This operation would, therefore, be expected to have no impact to dam safety risk at Blue River Dam compared to the NAA.

2.7 Alternative 3A – Improve Fish Passage through Operations-focused Measures

Alternative 3A combines Measures 30a, 304, 718, 166, 721, 40, 714, 720, 52, 722, 384, 719, and 726. Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and dam as compared to the NAA.

Impacts to Green Peter Dam associated with Measure 714 and Measure 721 would be the same as those described under Alternative 2A. These measures under this alternative also include using the spillways at Hills Creek, Blue River, and Fall Creek Dams, which are typically only for emergency flood risk management use and would require some additional structural modifications and increased monitoring as compared to the NAA.

The potential for damaging erosion in the unlined rock portions of the spillways would need to be evaluated and mitigated against during design and construction. In addition, spillway flows could potentially flood the powerhouse, and impacts would require further evaluation. Measure 721 and Measure 714 would pose potentially moderate, adverse effects to dam safety at Hills Creek, Blue River, and Fall Creek Dams, which would require risk assessments and mitigation measures during design, construction, and implementation phases.

At Hills Creek Dam, substantial modifications to the existing spillway structures would be needed to accommodate flows passing through the spillway and the associated flip bucket, which would not occur under the NAA. Spillway flows have been identified as having the potential for flooding of the powerhouse. Additionally, an existing rock gully extends from the end of the left spillway training wall and has been identified as a potential area for erosion and would need to be evaluated. Fall Creek Dam spillways would need some plunge pool and spillway channel modifications.

Impacts associated with Measure 720 would be the same as those described under Alternative 2B. However, Measure 720 under this alternative also includes a drawdown to the regulating outlets at Lookout Point and Detroit Dams. A spring reservoir drawdown would reduce the amount of water stored behind the dams in the summer, which has a minor beneficial effect to dam safety risk as compared to the NAA. However, the removal of the stabilizing force from the pool load could cause instability of steep upstream embankment and reservoir rim slopes, as described under Alternative 1. The stability of upstream embankment slopes and reservoir rims without the pool load would need to be evaluated and monitored, although the effects to dam safety are expected to be minor as compared to the NAA. Minor to moderate effects to the Dam Safety Program would include increased frequency of monitoring and inspection of these slopes.

Impacts associated with Measures 304, 718, and 40 would be the same as those described under Alternative 2B.

2.8 Alternative 3B – Improve Fish Passage through Operations-focused Measures

Alternative 3B combines Measures 30a, 304, 718, 166, 721, 40, 714, 720, 52, 722, 384, 719, and 726. Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and dam as compared to the NAA.

Measure 720, use the diversion tunnel at Cougar Dam, would have potential for major adverse effects to dam safety as compared to the NAA. The effects are identical to those described under Alternative 2B. Measure 720 also includes a drawdown to the regulating outlets at Blue River and Green Peter Dam, which would have minor to moderate effects to dam safety as compared to the NAA.

The removal of the stabilizing force from the pool load could cause instability of steep upstream embankment at Hills Creek Dam and to reservoir rim slopes at both dams. The stability of upstream embankment slopes and reservoir rims without the pool load would need to be

evaluated and monitored, although the effects to dam safety are expected to be minor to moderate as compared to the NAA. Minor to moderate effects to the Dam Safety Routine Program would be identical to those from Measure 304 and Measure 718, which are described under Alternative 1.

Measure 714 and Measure 721 under this alternative would include modifying the spillway structures at Hills Creek Dam and Blue River Dam. The impacts at Hills Creek and Blue River would be identical to those described under Alternative 3A as compared to the NAA. The effects of these measures on Green Peter Dam would be identical to those described under Alternative 2A when compared to the NAA.

This alternative includes Measures 304, 718, and 40 to drawdown below the power pool and respective rule curves for several dams and reservoirs, which would have a minor beneficial effect of providing additional flood storage for the winter season, as evaluated and described under Alternative 1. Minor dam safety impacts associated with slope instability are identical to those described under Alternative 1.

There would be a moderate effect to dam safety for Green Peter Dam (Measure 304 and Measure 40) under Alternative 3B. This would impact the dam's primary and backup power sources for operating outlet gates as compared to the NAA, which would need to be mitigated with an additional backup power source.

2.9 Alternative 4 – Improve Fish Passage with Structures-based Approach

Alternative 4 combines Measures 30a, 304, 718, 105, 166, 174, 479, 721, 392, 52, 639, 722, 384, 719, and 726. Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and dam as compared to the NAA.

This alternative includes the following structural measures: construction of selective withdrawal structures at Lookout Point, Hills Creek, and Detroit Dams; construction of downstream fish passage at Lookout Point, Hills Creek, Cougar, Foster, and Detroit Dams; structural improvements for TRG; and modification of existing outlets. These structural modifications have the potential for moderate to major effects to existing dam safety risk and would require project-specific potential risk assessments as more design details are developed. Based on the results of the risk assessments, mitigation measures or alteration of the designs may be required.

Impacts associated with Measures 304 and 718 would be the same as those described under Alternative 2A.

Alternative 4 includes Measure 721, which includes using the spillway at Green Peter Dam. Dam safety effects would be identical to those described under Alternative 2A.

2.10 Alternative 5 – Preferred Alternative – Refined Integrated Water Management Flexibility and ESA-listed Fish Alternative

Alternative 5 combines Measures 30b, 304, 718, 105, 166, 479, 721, 40, 392, 714, 720, 52, 722, 384, 719, and 726. Alternative 5 effects would be the same as those described under Alternative 2B except that the integrated temperature and habitat flow regime (Measure 30a) would be replaced by a refined integrated temperature and habitat flow regime (Measure 30b). Overall, the effects to dam safety for implementation of this alternative are considered minor to major depending on the measure and project as compared to the NAA. A full description of the effects can be found under Alternative 2B.

2.11 Alternative 6 – Ceasing Federal Hydropower Operations

Alternative 6 combines the disposition of hydropower and the Measures in Alternative 5, with the exception of the minimum flow targets. Measure 30b would be replaced with the 2008 BiOp flow targets, as used in the NAA. Disposition of hydropower would occur at Hills Creek, Lookout Point, Dexter, Cougar, Green Peter, Foster, Detroit, and Big Cliff Dams.

Disposition of hydropower would include significant structural and operational modifications to the affected dams which could have potential minor to major adverse effects to dam safety as compared to the NAA. Effects would need to be addressed in the risk-informed design process. All dam modifications would require project-specific risk assessments once the specific details of design and operation of the modifications are better developed. Based on the results of the risk assessments, mitigation measures or alterations to design would be required, which would not occur under the NAA. Mitigation measures could include increased surveillance and monitoring activities for the dam safety routine program, increased maintenance or repairs to dam components, and alterations to specific design criteria and constraints that would help minimize the dam safety impacts.

For Hills Creek and Cougar Dams, inspection and maintenance of the RO and stilling basin requires full closure of the RO. The penstocks are used to bypass minimum outflows during routine inspection and maintenance of the RO and the stilling basin. Under Alternative 6, modified penstocks would have reduced outflow capacity compared to the NAA, which would limit operational flexibility and the ability to inspect and maintain ROs and stilling basins while meeting the minimum downstream outflow requirements. If ROs and stilling basins are not inspected on a minimum 5-year frequency, the operational reliability of the project would be reduced as compared to the NAA. Operational changes under Alternative 6 would require increased use of ROs and spillways to meet minimum flow requirements, which would require increased inspection of dam components to monitor for accelerated wear and tear. For some dams like Detroit, the increased use of LROs and higher flows discharging into the spillway stilling basin would worsen existing conditions. Compared to the NAA, additional routine dam safety inspections and monitoring would increase in frequency which constitutes minor to moderate effects to the Dam Safety Routine Program.

Outside of ceasing hydropower, the other Alternative 6 effects would be the same as those described under Alternative 5. The overall effects to dam safety for implementation of this alternative are considered minor to major depending on the project as compared to the NAA.

3. CUMULATIVE EFFECTS FOR DAM SAFETY

Under all alternatives, USACE would continue to perform risk assessments as part of an ongoing dam safety program and to assist in the prioritization of investment for aging infrastructure. The risk assessments evaluate the life safety risks associated with the dams to determine if risk reduction actions are needed and, if so, what actions should be taken. The assessments consider a wide range of hazard scenarios from the most likely to the most extreme and unlikely. Assessments consider risk under the most current operational condition of the dam and utilize the most up-to-date hydrologic flood and seismic loading data. Routine risk assessments are conducted on all dams with a minimum frequency of every 10 years.

USACE is conducting advanced risk assessments, called Issue Evaluation Studies (IESs) on several WVS dams, which would continue under all alternatives including the NAA. IESs are warranted when the findings from the routine risk assessments determine the dam safety risk to be moderate to high. Dam safety risk at WVS dams is primarily driven by the high downstream population and the combined unlikely occurrence of a large earthquake occurring during sustained summer conservation pools. Alternatives that include measures that would increase the likelihood of refilling reservoirs to meet the water control diagram would not increase the overall dam safety risk because they would not constitute an increase in the duration of time that the reservoirs are held at the summer conservation elevations. Alternatives that include measures that would increase flood storage through seasonal deep reservoir drawdowns could reduce the likelihood of seismic-driven potential failure modes if the reservoirs are unable to refill due to low seasonal inflow. However, drawdowns could exploit other project vulnerabilities, which would constitute a minor to major impact to dam safety that requires mitigation. For example, a seasonal deep reservoir drawdown at Cougar Dam with delayed refill would reduce the seismic-driven risk but would increase seepage-related risks due to settlement-induced cracking of the embankment.

As of summer 2025, there are currently five ongoing IESs at the following dams: Foster, Blue River, Cougar, Lookout Point, and Hills Creek. For Detroit, Big Cliff, Fall Creek, and Fern Ridge, some initial risk assessment and screening of structural failure modes has been assessed and advanced risk assessments (IESs) are pending.

Preliminary results for Lookout Point, Hills Creek, and Detroit Dams identified unacceptable risk for seismic potential failure modes. The preliminary results of the risk assessments indicate that a large earthquake could cause the spillway gates and the concrete supports on either side to become damaged. In addition to the spillway gates and piers, the rockfill embankment at Hills Creek Dam has the potential for settlement during an earthquake event. If this occurs during the summer storage season when the reservoir levels are sustained at their highest, the

damaged gates/embankment may no longer be able to hold back the water, allowing a high volume of outflows that could cause flooding of areas downstream.

Interim risk reduction measures (IRRMs) were implemented in spring 2020 at Lookout Point and Hills Creek Dams and in Spring 2021 at Detroit Dam to reduce life-safety risk while issues are studied further. These measures include reducing the maximum conservation pool (summer refill target) by 5 feet at Lookout Point and Detroit Dams and by 10 feet at Hills Creek Dam. IRRMs are typically in-place for 3 years; however, the timelines of the advanced studies may exceed 3 years, requiring the summer pool restrictions to remain in place for longer timelines. The pool restrictions would not have an effect on any of the proposed or implemented operational measures beyond the existing effect of the NAA.

At this time, pool restrictions have not been determined beneficial for the remaining WVS dams. Dams where risks remain above the USACE TRG following completion of an IES will be elevated through a Dam Safety Modification Study (DSMS). Dam modifications to reduce risk would vary by project and would consider a range of alternatives, including permanent pool restrictions, change to operations, rebuilding spillways, other structural modifications, or even dam removal.

4. REFERENCES

USACE (United States Army Corps of Engineers). 2014. Engineering and Design, Regulation No. 1110-2-1156: Safety of Dams – Policy and Procedures, March 31, 2014.