US Army Corps of Engineers ®
Portland District

Final Report

Sustainable Rivers Project

Evaluation of E-Flow Implementation and Effects in the Willamette Basin using ResSim Modeling

July 2013

EXECUTIVE SUMMARY

This document describes the results of reservoir modeling of the Willamette River watershed performed to evaluate the feasibility of implementing environmental flow releases at Lookout Point (Middle Fork Willamette), Cougar (McKenzie River) and Detroit dams (North Santiam). This study evaluates potential ways current operations can be adjusted to enhance downstream flow conditions for fish and wildlife while still meeting local needs and operating within all congressional authorities and mandates.

The study is part of the Sustainable Rivers Project (SRP), a national and local partnership between the Corps of Engineers (Corps) and The Nature Conservancy (the Conservancy) aimed at developing, implementing and defining environmental flows downstream of dams. The goal of the SRP is to identify opportunities to change dam operations to provide more ecologically-sustainable flows while at the same time meeting human needs. The first phase of the SRP process is to evaluate and develop environmental flow recommendations for the national eight demonstration sites. The second phase is to develop an implementation framework for the Willamette River environmental flow recommendations. Focus is on the three tributary basins Middle Fork, McKenzie and North Santiam Rivers, which were provided during three workshops conducted by the Corps and The Conservancy in June 2007 (Middle Fork), November 2010 (McKenzie River) and July 2012 (Santiam River).

Recommendations include increasing the number and magnitude as well as duration of seasonal peak flows primarily fall and wintertime high flow events. Environmental flows recommendations were based on hydrologic data of pre- and post- dam conditions as well as using biological expert opinion to determine the most beneficial flow regimes, peaks, durations and timing, etc.

The desire to achieve environmentally beneficial wintertime high flows must be balanced with the need to meet Congressionally authorized project purposes including flood risk management, water supply and recreation. The first step of turning the recommendations into an implementation framework was using HEC-ResSim to model operation changes. This also addressed concerns about potential increases in flood risk or other adverse impacts from these operations. This document provides recommendations on potential operational approaches to achieve environmental flow targets as well as potential consequences.

The Corps' Hydrologic Engineering Center (HEC) ResSim model was used to simulate reservoir operations within the Willamette River basin. The Corps developed a calibrated baseline model of the system's 13 Willamette projects. The model simulation period was water years 1936-2008 (73 years) with a daily time-step. The project team members evaluated the effectiveness of two operational approaches for implementing environmental flows.

Both approaches modified the maximum evacuation release rule of the baseline condition at the three projects analyzed, within current operational flexibility. This rule at each project specifies a maximum project release as a function of the pool elevation. The Release More scenario has a more rapid increase in outflow with elevation at the lower elevation ends of the rule than does the baseline. The Store More alternative has a slower increase in maximum outflow with elevation at the lower elevations ends of the rule than does the baseline.

These scenarios are permissible under current water control manual regulation guidelines because the manuals do not correlate the change in maximum release value to project pool levels. The maximum release rules are used in the model to smooth the operational changes between time steps rather than having large step increases or decreases that do not represent real time regulation. The two operational approaches modeled in this study are simply applying a different smoothing algorithm to the project maximum releases. No Congressional re-authorization is required to perform these operations.

Metrics were developed to quantifiably evaluate benefits and potential adverse impacts. Benefit metrics were based on number and duration of peak flow events. Low, medium and higher end beneficial flows were identified for each of the three reaches and evaluated at the downstream control points: Middle Fork at Jasper downstream of Lookout Point; McKenzie at Vida downstream of Cougar; and North Santiam at Mehama downstream of Detroit dam.

Combined/concurrent flows were also evaluated at the Willamette River at Salem gage. The number of distinct events at representative peak flows as well as the duration of the events was tracked and any increases over the baseline simulation results were deemed a benefit. Adverse impacts were assessed by identifying the change in exceedance probabilities (5, 50, 75 and 95 percentiles) for a given critical flow and stage, as compared to the baseline conditions.

Overall the system appears to be robust and there is flexibility that can be utilized to realize environmental flow opportunities without transferred risk of detrimental downstream consequences. The Release More and Store More options both realized increases in the number of and duration of environmental flows at each of the control points without meaningful increase to flood risk or other detrimental impacts. In addition, the Release More option appeared to provide more available flood storage for concurrent flood events, which could be viewed as a benefit for flood risk management operations.

Although results were similar between the two operational scenarios the Store More action has an inherent risk in that it cannot handle unexpected high inflow events compared to the Release More operations, simply due to the fact that the reservoirs are more full in the Store More scenario. Operators and reservoir regulators are not likely to regulate with this increased risk factor especially if there is an alternative operation that will achieve the same goal. Impacts to other project operations including recreation, hydropower, water supply and Biological Opinion flow targets were also negligible.

There is always risk in using model predictions as argument for implementing actual operational change. However, the modeling performed and described in more detail below was tempered by experienced evaluations by those involved in Willamette hydro regulation. These modeling results were deemed to be well within the bounds of existing variability encountered (and handled) in every day operations and are feasible to implement when the opportunity arises.

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ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
BA	Biological Assessment
BiOp	Biological Opinion
BPA	Bonneville Power Administration
cfs	cubic feet per second
CO_2	carbon dioxide
COP	Configuration/Operation Plan
Corps	U.S. Army Corps of Engineers
CRFM	Columbia River Fish Mitigation
CWA	Clean Water Act
DMA	Designated Management Agency
E flows	Environmental flows
EA	Environmental Assessment
EFH	essential fish habitat
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FERC	Federal Energy Regulatory Commission
FCRPS	Federal Columbia River Power System
FONSI	Finding of No Significant Impact
ft	foot (feet)
ft^3/s	cubic feet per second
FY	fiscal year
ResSim	Reservoir System Simulation
hr	hour
IRRM	interim risk reduction measure(s)
mg/L	milligram(s) per liter
M&I	municipal and industrial
MSL	mean sea level
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NWPCC	Northwest Power and Conservation Council
NWRFC	National Weather Service Northwest River Forecast Center
OAR	Oregon Administrative Rules
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
O&M	Operations and Maintenance
OMET	Operational Measures Evaluation Team
PDT	Project Delivery Team
POR	period of record
RM	river mile(s)
RM&E	research, monitoring, and evaluation
RO	regulating outlet(s)
RPA	Reasonable and Prudent Alternative
sq. ft.	square foot (feet)
TDG	total dissolved gas
TMDL	total maximum daily load
U.S.C.	United States Code
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WCP	Water Control Plan
WTC	water temperature control

1. INTRODUCTION

1.1. SUSTAINABLE RIVERS PROGRAM (SRP)

This study is part of an overall program initiative called the Sustainable Rivers Program (SRP). The SRP began in 2002 as a partnership between The Nature Conservancy (the Conservancy) and the Corps with the objective of developing, implementing and refining a framework for beneficial flows downstream of dams. The Conservancy and the Corps have signed memorandum of agreements (MOAs) at the national level as well as the district level to study current hydro regulation operations. SRP efforts on the Willamette River system focus on identifying opportunity to improve overall downstream ecosystem health and resiliency by modifying dam operations within the existing operational constraints thus meeting existing federal and state mandates and authorities.

The SRP e-flow process proceeds in steps (Richter et al., 2006). At the beginning a comprehensive scientific study is prepared characterizing basin hydrology (pre and post dam conditions), geomorphology, distinct ecological species and habitats as well as human use and impacts. The study identifies a series of flow-ecology hypotheses that form the basis of the environmental flow (e-flow) recommendations. Following the completion of the report, a workshop consisting of technical and local experts is convened to develop the initial set of e-flow recommendations. At the workshop the participants collaborate to develop a range of recommended environmental flow rates and durations which would be ecologically beneficial. The team focuses on reaches where the highest ecologic lift may be realized. The workshop results in a report documenting the e-flow recommendations by reach and includes future monitoring and evaluation. For the recommendations to be implemented, additional investigations are often required to meet Corps and other stakeholder requirements ensuring operational safety and demonstrating that ecological benefits are attainable. This current study fits into the process by helping to demonstrate opportunities for changing reservoir operations while addressing concerns of associated risks from e-flow implementation in the Willamette basin.

1.2. STUDY PURPOSE AND APPROACH

The purpose of this study is to demonstrate the feasibility of how environmental flow operations might be implemented and to quantify likely beneficial as well as potential adverse impacts specifically on the Middle Fork Willamette, McKenzie and Santiam Rivers.

This study will show relative impacts to the system by comparing baseline (modeled) conditions to two potential approaches for operating projects to attain downstream e-flows. A Release More and Store More approaches were developed to evaluate the relative effects. The Release More option releases more flow earlier (maximum release rates) than is normally done. The Store More alternative holds water longer and releases at the maximum release rates. Bother alternatives are permissible under the water control manuals. The HEC-ResSim model was chosen as the tool to model the complex flow combinations and quantify potential impacts to other project purposes. ResSim output was examined to quantify feasibility of implementing the new e-flow operations in the Middle Fork Willamette, McKenzie River and North Santiam Basins by evaluating the potential increases in e-flow events as well as potential impact on flood management, recreation, water quality, hydropower and Biological Opinion (Biop) flow targets.

1.3 PREVIOUS SRP EFFORTS IN THE WILLAMETTE RIVER BASIN

In 2006, The Nature Conservancy and Corps launched the Willamette Sustainable Rivers Project. A summary report on the flow requirements of key Willamette species and communities was completed in 2007 (Gregory et al., 2007a) followed by a flow recommendations workshop focusing on the Coast and Middle Forks of the Willamette River (Gregory et al., 2007b). The result of the workshop was a set of environmental flow recommendations for the Middle Fork Willamette River below Lookout Point/Dexter dams with initial implementation of the recommendations occurring in 2008 through 2012. Since this time, the Corps and the Conservancy have completed hydrologic analyses and held workshops that have defined environmental flow targets and operations for the McKenzie (Risley et al., 2010a,b) and the Santiam (Risley et al., 2012; Bach et al., 2012)) basins. Flow recommendations were not developed for the Coast Fork because opportunity to affect flow rates through hydro-regulation was minimal.

The Corps has implemented initial environmental flow releases on the Middle Fork to evaluate and test the process. The results were encouraging and some of the SRP recommended environmental flows peak targets and durations have been met. The e-flow releases have resulted in increased side channel and floodplain connectivity, with consequent increased habitat benefits. Although the results were promising increased potential flood risk was a concern and continued SRP e-flow efforts were contigent upon additional monitoring and evaluation, e.g. modeling tools and techniques to assess the effects from past and for future environmental flows.

The Corps must balance the requirements of flood risk management with the goal to release the prescribed e-flow. Project inflows and local flows are forecasted by the National Weather Service's Northwest River Forecast Center (NWS-NWRFC) and used by the Corps Reservoir Regulation and Water Quality section (EC-HR) to develop operational plans. Issues arise during real time regulation when the observed project inflows and local flows do not correspond to the forecasted flows on which the release rates are based. Error in the observed versus forecasts may cause flood damages at Harrisburg, Salem and other points downstream. In 2011 the Corps completed a model analysis for the Middle Fork designed to quantify the 1) uncertainty in the local inflow forecasts below Jasper and 2) the potential flood effect at downstream control points. When implementing real-time operation decisions, project release targets are often conservative (i.e. lower than they could be) because of uncertainty in the forecasted flows and downstream locals below Lookout Point. The study found that for the Middle Fork Willamette River basin increasing the number of e-flow discharges (i.e. bankfull flows) was feasible and was achievable under the current Water Control operation.

1.4 STUDY AREA DESCRIPTION

The Willamette River Basin covers approximately 11,500 square miles in northwest Oregon and is part of the lower Columbia River watershed. The basin begins south of Cottage Grove, Oregon and extends north to the Columbia River (Figure 1). The basin is bounded by the Cascade Mountains on the east and by the Coast Range Mountains on the west. There are six subbasins in the Willamette Basin where a system of 13 multipurpose dams and reservoirs are operated by the Corps. Each project contributes to an overall water resource management plan designed to provide flood risk management, hydroelectric power, irrigation, navigation, recreation, and downstream water quality improvement for the Willamette River and many of its tributaries.

The study area is the Willamette tributary reaches of the Middle Fork Willamette, McKenzie and Santiam sub basins. The study evaluated the potential for e-flows at Lookout Point (Middle Fork) Cougar (McKenzie River) and Detroit (North Santiam) dams and evaluated potential flood impacts at the Jasper, Vida, Mehama, Jefferson and Salem downstream gages (control points). Only three of the six Willamette River subbasins were evaluated. These have higher impacts from regulated flows and have historically contained populations of ESA-listed salmonids. The focus of this study was directed where the potential for greatest improvement resides.

The three river subbasins where e-flow operation alternatives were evaluated are described below:

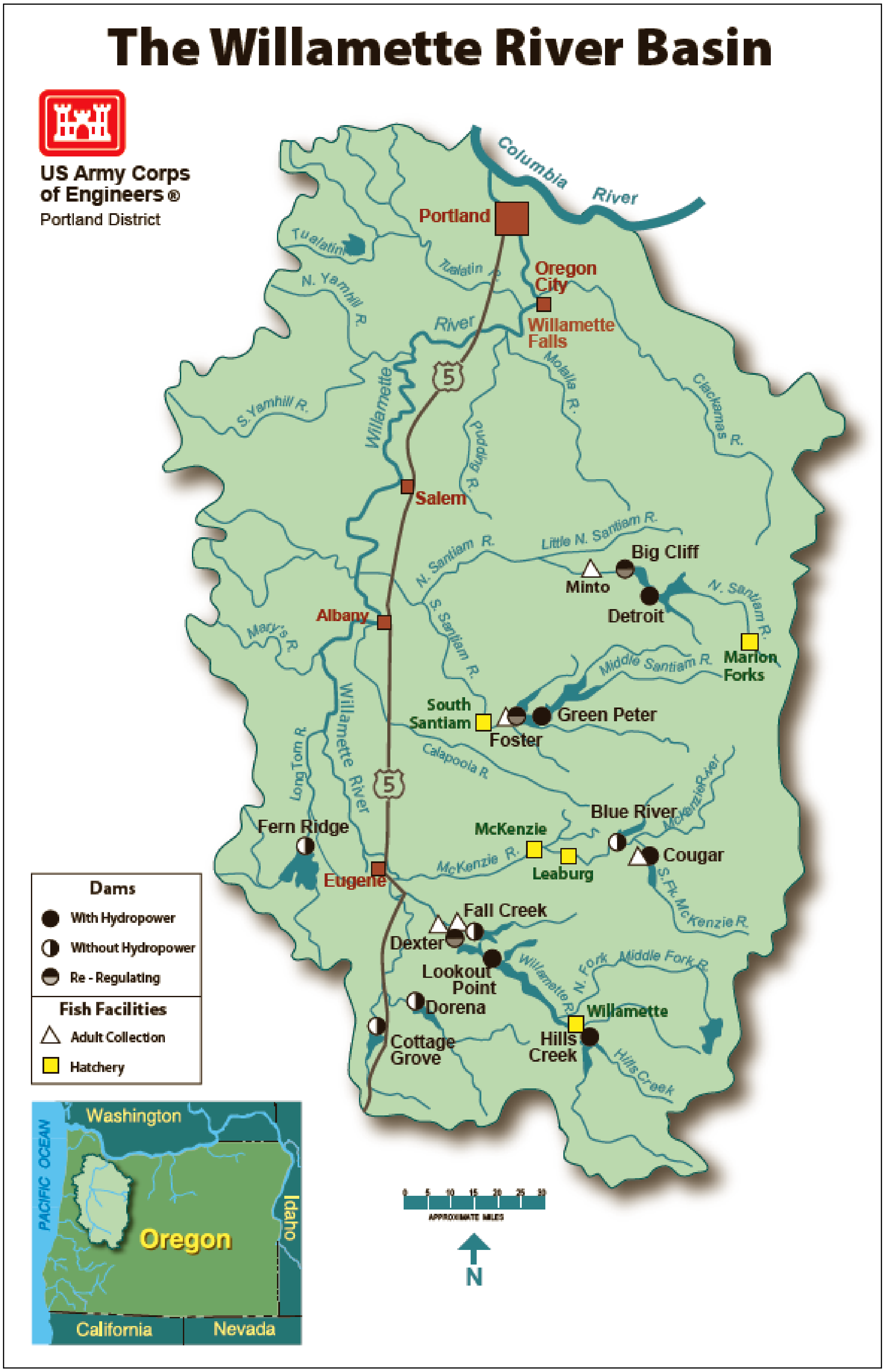
- North Santiam Subbasin. Construction of two Corps dams on the North Santiam River, Detroit and Big Cliff, was completed in 1953. Currently, ESA-listed winter steelhead, spring Chinook salmon and Oregon chub are present in the subbasin. Detroit is a multi-purpose storage project. Detroit reservoir is popular for water-related recreation in summer. Its powerhouse has two turbine units that can produce at total of 100 megawatts (MW) of power. Big Cliff Dam is located about 3 miles downstream from Detroit Dam and is used to control water levels created by peak hydropower generation at Detroit. Big Cliff has one turbine unit that can produce 18 MW of power.

- South Santiam Subbasin. Construction of two Corps dams in this subbasin, Green Peter and Foster, was completed in 1967. Currently, ESA-listed spring Chinook salmon, winter steelhead and Oregon chub are present in the subbasin. Green Peter Dam, located on the Middle Santiam River, is a multi-purpose storage project. Its powerhouse has two turbine units that can produce a total of 80 MW of power. Green Peter reservoir is popular for water-related recreation in summer. Foster Dam, located on the South Santiam River, re-regulates the flow from Green Peter and also acts as a storage project. Its powerhouse contains two turbine units that can produce a total of 20 MW of power. Foster Lake also is popular for recreation in summer.

- Middle Fork Willamette Subbasin. Four Corps projects were constructed in this subbasin. Hills Creek Dam on the Middle Fork Willamette River was completed in 1961 and Lookout Point and Dexter dams on the Middle Fork Willamette were completed together in 1955. Fall Creek Dam on Fall Creek was completed in 1965. Currently, ESA-listed spring Chinook, Oregon chub, and bull trout are present in the subbasin. Hills Creek and Lookout Point are multi-purpose projects operated in tandem and storage between the two projects is generally balanced to capture floodwater during the winter and spring months. In summer, storage from these projects is used extensively to meet minimum flow requirements on the mainstem Willamette River. Hills Creek has two turbines capable of producing 15 MW each and Lookout Point has three turbines capable of producing 40 MW each. Dexter is a re-regulation project located downstream of Lookout Point, and is used to control water levels created by peak hydropower generation at Lookout Point. There is one turbine unit at Dexter that produces 15 MW of power. Dexter reservoir is heavily used for recreation in summer. Fall Creek is a multi-purpose project and currently does not have a powerhouse. Fall Creek reservoir also is heavily used for recreation in summer.

- McKenzie Subbasin. Two Corps dams were constructed in this subbasin. Cougar Dam on the South Fork McKenzie River was completed in 1963 and Blue River Dam on the Blue River was completed in 1968. Currently, ESA-listed spring Chinook, Oregon chub, and bull trout are present in the subbasin. Cougar Dam is a multi-purpose storage project. A water temperature control structure at Cougar began operation in May 2005 to provide more normative downstream water temperatures to improve spring Chinook salmon production. The powerhouse contains two turbine units producing a total of 25 MW of power. Cougar reservoir is popular for water-related recreation in summer. Blue River works together with Cougar to provide flood risk management. Blue River is not under consideration for operational modifications at this time, and no further description or analysis of this project is described in this report. There is currently no outplanting of adult salmonids above Blue River, and water temperature control measures have been determined to be not feasible for the project.

Figure 1. Corps of Engineers Willamette Basin Project



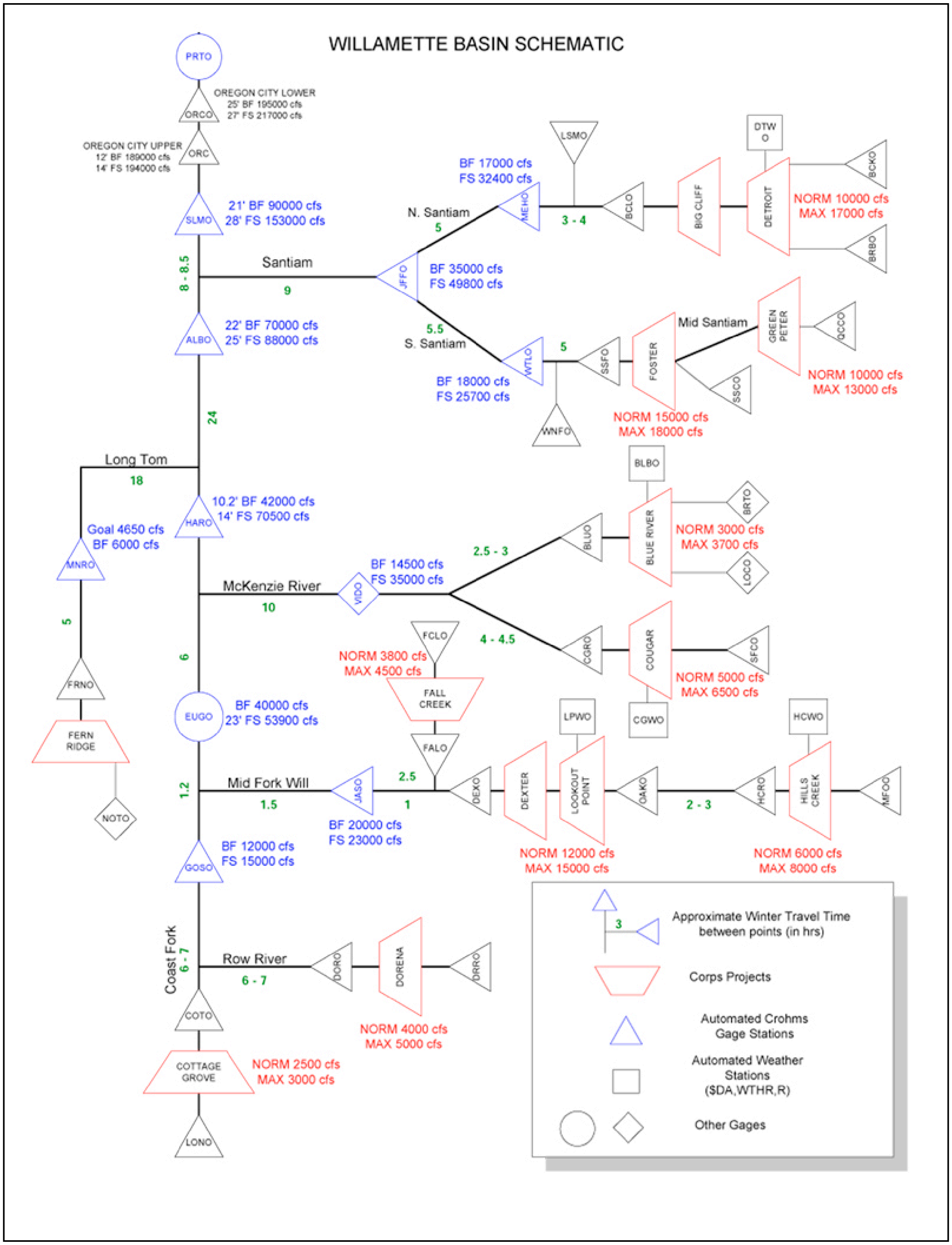
GENERAL OPERATION OF PROJECTS

All Corps' storage projects are operated at or below a flood control rule curve (part of the water control diagram), unless regulating an event. This provides guidance to the reservoir regulators on how to manage the storage in the reservoir to meet the multi-purpose needs. The storage projects are typically drawn down (i.e., storage is evacuated) in the fall to provide space to store high runoff from winter rain events. Rain events cause the reservoirs to rise and then stored water is evacuated once the flood threat has passed. In the early spring, the reservoirs begin to capture some of the runoff to store water for use in the summer months. Some stored water may also be used in the late spring for fish flow augmentation during drier years. The Willamette Basin conservation season occurs from 10 May through 15 November and is a time when water stored in the system is governed by multipurpose uses taking into consideration biological resources, water quality, power generation, irrigation, municipal and industrial (M&I) uses, and recreation. The Corps, together with its partners and customers, determine the order of use for stored water among the various projects and often address environmental variables and other constraints to project operation using real-time adaptive management.

In the fall, the storage projects are drafted down to their minimum pool level in preparation for operating to reduce flood damages, which occurs primarily in December and January. The dams are operated as a system with flood risk management being their primary purpose (see Figure 2). In total, the dams control flows on six major tributaries affecting approximately 27% of the watershed area upstream of Portland, Oregon.

The Corps' dams have a total storage capacity of approximately 1.59 million acre-feet of water at maximum conservation pool. They operate as a system to minimize flooding on the mainstem Willamette River in the large population centers at Oregon City, Eugene, Albany, Salem, and Portland. To do this, reservoir inflow is stored during a storm event and released after the river levels downstream of the project have subsided. This operation reduces flooding downstream of the projects in both the tributaries and the mainstem Willamette River. Figure 2 below shows the basin schematic including important operational flows thresholds and downstream control points.

Figure 2. Willamette Basin Schematic



1.6 SRP ENVIRONMENTAL FLOWS (E-FLOWS)

Environmental flows are central to the SRP and e-flow recommendations formed the starting point for modeling performed as part of this study. Flow recommendations focused on fall flows (October-November), winter high flows (December-February) and smaller spring and bankfull flows (March-May). Each seasonal flow was important to some aspect of ecosystem health. Fall flows enhance channel habitat and provided flows for outmigration. The highest annual peaks occur during the winter and historically provide watering for rearing/spawning habitat in side channels and provide additional ecosystem complexity by recruiting large woody debris and providing flushing flows in off channel areas. The higher peak flows are geomorphically significant and provide motive power for transport of gravel sediments. Spring time flows are important for providing out migration flows as well as scouring and flushing during bank full events.

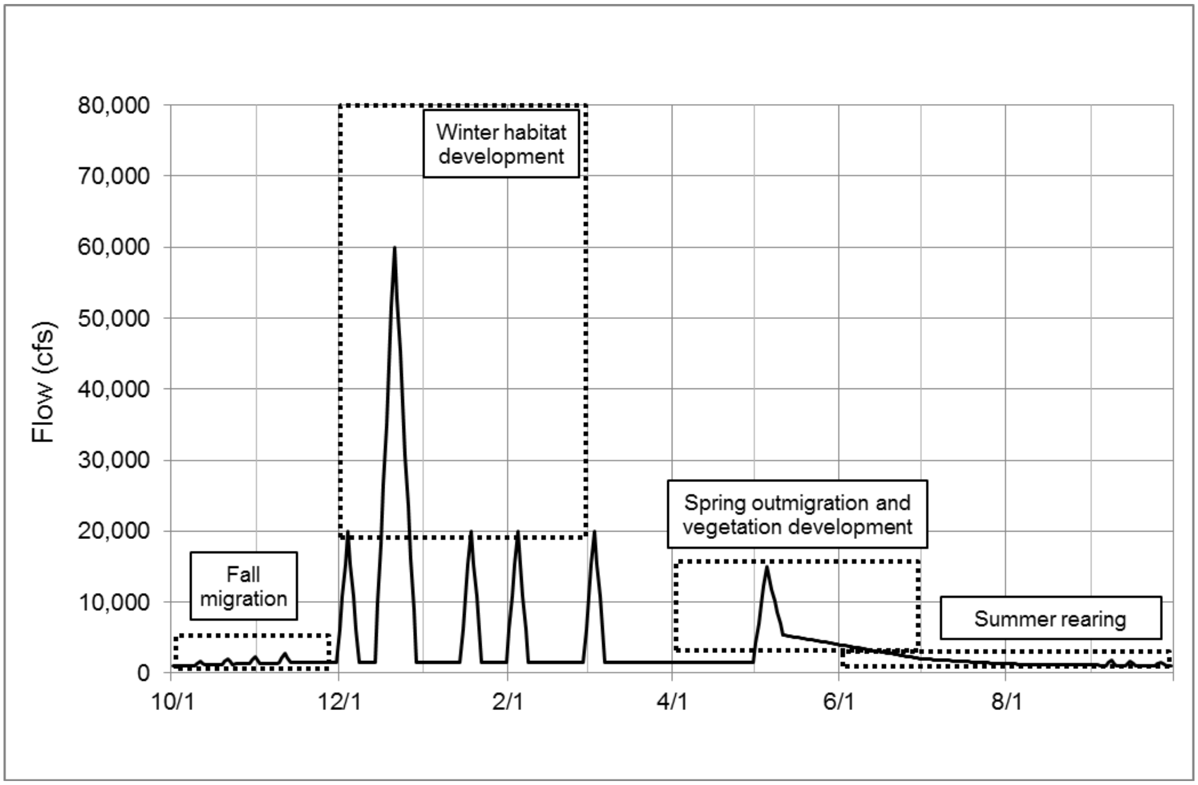
During the workshops the environmental flow recommendations were defined by the following categories 1) time period; 2) number of events per year; 3) range of flow magnitude; and 4) duration and frequency.

For this study the workshop recommendations for evaluating the ecological benefits of reservoir operations were tailored to take advantage of wintertime high flow events. The relevant workshop e-flow recommendations are summarized below.

1.2.1. **<u>1.6.1 Middle Fork Willamette River E-flows</u>**

For the Middle Fork winter high flows generally occurs from mid-November through mid-March. The events are rain driven and usually occur 1 to5 times per year. The resultant flow range is 19,000 to 25,000 cfs. The biological benefit from fall/winter season e-flows are associated with opening and maintaining side channel and backwater habitat for a number of species, including Chinook salmon, lamprey, and chub. The winter high flow event serves as flushing flow and helps create important ephemeral habitats. The flows also serve to facilitate wood recruitment and increase ecological complexity. Flows are high enough to mobilize gravel sediments and help in the formation of channel and bar formations which improve habitat value. A visual plot summary of the e-flows is provided in Figure 3 below.

Figure 3. Middle Fork Willamette River Wintertime Flow Recommendations Plot



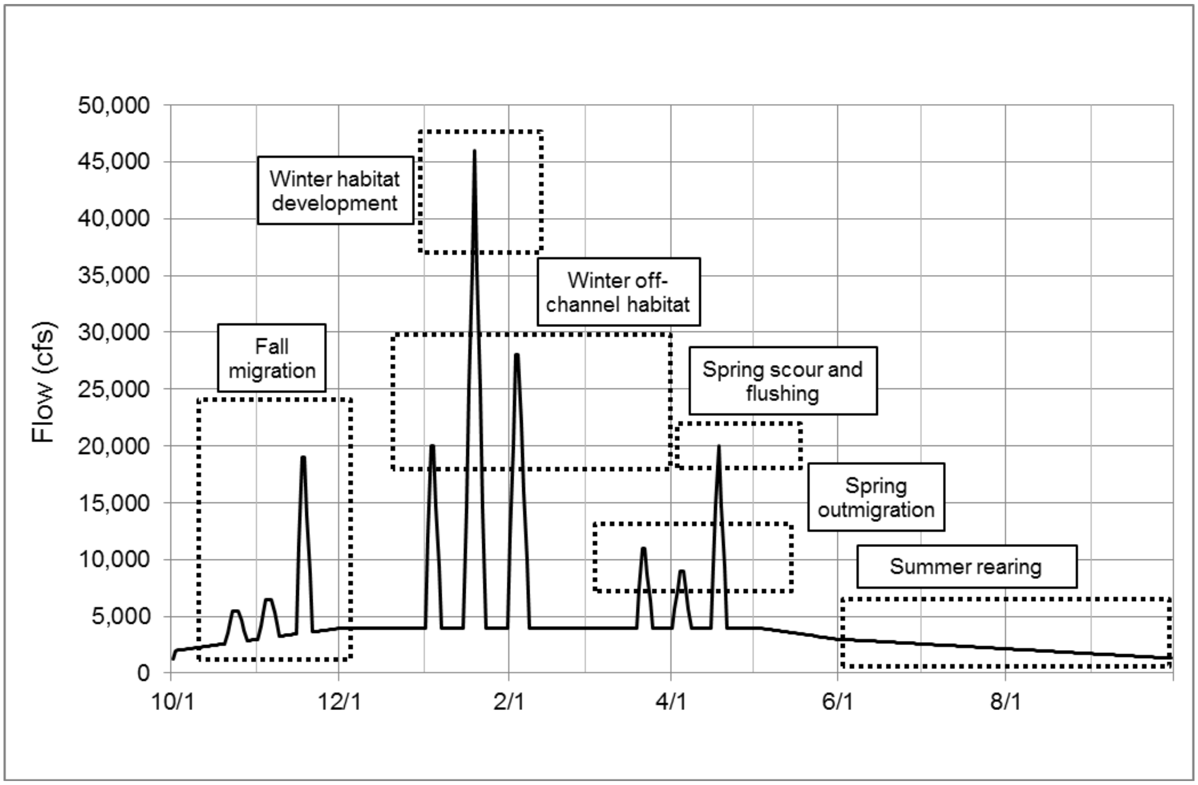
1.2.2. McKenzie River E-flows

Environmental flows were established for four reaches of the McKenzie River, the South Fork McKenzie (Cougar Dam to mainstem McKenzie River confluence), Middle McKenzie (South Fork confluence to the Leaburg canal diversion dam, a stretch of 22 miles), McKenzie reach with Eugene Water & Electric Board (EWEB) canals and Lower McKenzie River (the lower 21 miles from the confluence with the Willamette River). The McKenzie above the South Fork confluence is unregulated and historic flow conditions have not changed, therefore, this reach was not evaluated during the workshop.

The winter high flows in the McKenzie primarily occur from mid-December through the end of February and generally occur about once per year. The flow range is 6,000 to 8,000 cfs with a typical duration of less than 5 days. The return frequency is once every 2 years or less.

SRP recommendations aim to restore some of the small wintertime floods which have been eliminated from the ecosystem in the post-dam period. These floods are important for connecting and wetting side channels, opening up new habitat, forcing gravel movement, and flushing sediment and wood into side channels. Newly connected side channels provide spawning and rearing habitat for spring Chinook. Resident trout, macroinvertebrates, and other species also benefit by increased habitat diversity and clean, unarmored substrates. A visual plot summary of the e-flows is provided in Figure 4 below.

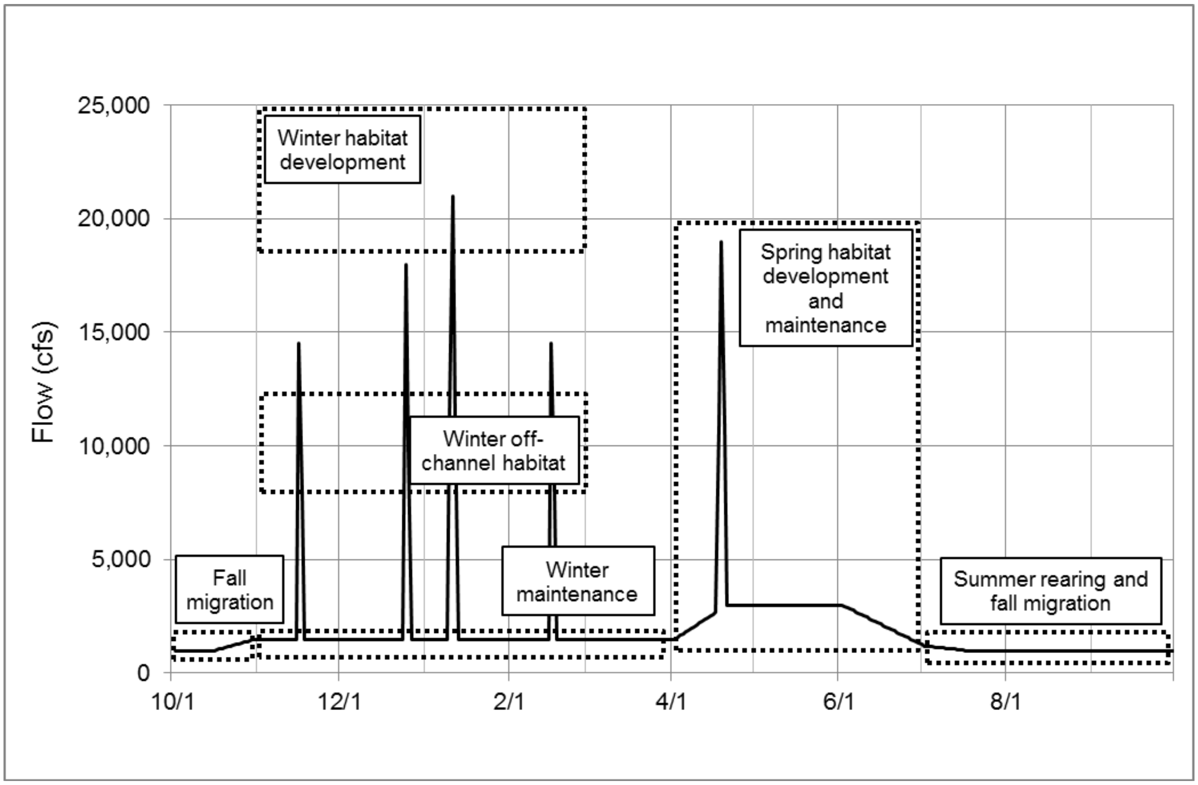
Figure 4. South Fork McKenzie River Flow Recommendations Plot



1.2.3. <u>North Santiam River</u>

Environmental Flows were established for the North Santiam River, the South Santiam River and the mainstem Santiam River below the confluence of the North and South. Wintertime flows occur primarily in the November 1 to March 3 timeframe. Winter base flows consist of sustained flow rates at 1,000-1,500 cfs for 150 days on an annual basis. Winter events up to bankfull historically occurred about 2-5 times annually and are 13,000-18,000 cfs in magnitude over a 3-5 day event duration. For winter events above bankfull, the flow rate is 18,000 cfs for 3-5 days with a frequency of 1 in 10 to 3 in 10. A visual plot summary of the e-flows is shown in Figure 5 below.

Figure 5. North Santiam River Flow Recommendations Plot



2. EVALUATION CRITERIA

This study evaluated different strategies for achieving e-flow targets in the three Willamette River tributaries, the Middle Fork, McKenzie and Santiam Rivers. The proposed e-flow operations in each basin were evaluated for potential impacts to flood risk at the downstream control points, namely the Middle Fork Willamette at Jasper, McKenzie River at Vida and North Santiam at Mehama. The combined flows were also evaluated for flood exceedance at the Willamette River at Salem flow gage. Water quality, hydropower, Biop flow targets and recreation were also evaluated at the reservoirs.

2.1. SUCCESS CRITERIA

The modeling analyses began with the e-flow recommendations as basis for defining the ecological objectives of altering dam outflows. Although the e-flow criteria were a good basis for evaluating success, it was still too broad for the quantitative modeling task conducted for this study. Therefore the study modelers elicited further expert opinion from biologists who were versed in the dam projects as well as the biologically important processes and species in the Middle Fork, McKenzie and Santiam Rivers to help refine the e-flow evaluation targets.

The study project delivery team (PDT) developed a range of environmental target objectives. The approach evaluated three levels of winter and spring e-flows in the Middle Fork, McKenzie and the North Fork Santiam River basins. At each of the three locations, e-flow regimes varied by combinations of season, flow magnitude and duration. The consensus of the study team and others was that each e-flow regime category had equal weighted ecosystem value and positive benefit lift was defined as an increase in any of the categories relative to the baseline condition. Note that the outflow at Cougar was used as the e-flow target because it is a 'controllable' flow while flood risk was checked at McKenzie River at Vida gage. Table 1 summarizes the e-flow targets used as success criteria. These were used as metrics, not target flows in the ResSim runs.

Table 1. E-Flow Category Definitions

Location	MF WILLAMETTE AT JASPER	MCKENZIE AT COUGAR DAM (OUTFLOW)	NO SANTIAM AT MEHAMA
E-Flow Target 1 Definition (Winter):			
Start Date	15-Nov	15-Nov	15-Nov
End Date	15-Feb	15-Feb	15-Feb
Flow Above (cfs)	17,000	6,000	15,000
Duration	1	1	1
E-Flow Target 2 Definition (Winter):			
Start Date	15-Nov	15-Nov	15-Nov
End Date	15-Feb	15-Feb	15-Feb
Min Flow (cfs)	15,000	4,000	12,000
Max Flow (cfs)	16,999	5,999	14,999
Duration	3	3	3
E-Flow Target 3 Definition (Winter):			
Start Date	15-Nov	15-Nov	15-Nov
End Date	15-Feb	15-Feb	15-Feb
Min Flow (cfs)	12,000	3,000	10,000
Max Flow (cfs)	14,999	3,999	11,999
Duration	4	4	4
E-Flow Target A Definition (Spring)			
Start Date	15-Mar	15-Mar	15-Mar
End Date	31-Jul	31-Jul	31-Jul
Flow Above (cfs)	15,000	4,000	12,000
Duration	1	1	1
E-Flow Target B Definition (Spring)			
Start Date	15-Mar	15-Mar	15-Mar
End Date	31-Jul	31-Jul	31-Jul
Min Flow (cfs)	12,000	2500	10,000
Max Flow (cfs)	14999	3999	11,999
Duration	3	3	3
E-Flow Target C Definition (Spring)			
Start Date	15-Mar	15-Mar	15-Mar
End Date	31-Jul	31-Jul	31-Jul
Min Flow (cfs)	10,000	1,500	8,000
Max Flow (cfs)	11,999	2,499	9,999
Duration	4	4	4

2.2. HYDRO-SYSTEM IMPACTS EVALUATION CRITERIA

For this study the PDT also evaluated the ResSim output for potential impacts for flood risk management, recreation, hydropower, water supply and BiOp operations. The output templates used are summarized in Table 2 below. Flood metric thresholds for this study are shown below in Table 3. These metrics were used to compare the e-flow scenarios to the baseline current conditions simulation. The system metrics were evaluated using exceedance statistics. The templates used to describe the current baseline conditions and compare to each e-flow operational scenario are described below and provided in more depth in Appendix A.

Table 2. HEC-ResSim Output Templates

Output Template	Description
BiOp Flow Target Summary	Summarizes statistics for estimated days that instream BiOp flow targets were not met below each dam.
Flood Damage Reduction Summary	Summarizes statistics for days above bankfull, days above flood stage, and peak flow at select downstream target locations for baseline and measures.
Project Summary	Summarizes monthly average outflow for project, Regulating Outlet (RO), turbine, spillway and monthly average reservoir elevation. Includes statistics for number of days in period of record (POR) tributary flows are not met.
Non-exceedance Graphs for Project Elevation and Outflow	Summarizes non-exceedance for baseline and proposed measures for reservoir elevations and outflow by month.
Daily Averages from POR Flows	POR daily average outflow graphs for all projects for baseline and proposed measures. This template shows a snapshot of basin-wide impacts to project outflows to help understand impacts to flood damage reduction.
Non-exceedance Graphs for Regulated Flow at Willamette Control Points	Summarizes monthly flow non-exceedances for baseline and measures at each downstream control point. These templates are used to understand impacts to flood damage reduction and mainstem flows.
Recreation Summary	Summarizes monthly statistics for average reservoir elevation, days below boat ramps as a preliminary indicator for recreation impacts.

Table 3. Bankfull and Flood Stage Levels for Key Willamette Basin Control Points

Station	Bankfull Flow (cfs)	Flood Stage Flow (cfs)
Middle Fork Willamette River at Jasper (JASO)	20,000	23,000
Willamette River at Eugene (EUGO)	40,000	53,900
McKenzie River at Vida (VIDO)	14,500	35,000
Willamette River at Harrisburg (HARO)	42,000	70,500
South Santiam River at Waterloo (WTLO)	18,000	25,700
North Santiam River at Mehama (MEHO)	17,000	32,400
Santiam River at Jefferson (JFFO)	35,000	49,800
Willamette River at Albany (ALBO)	70,000	88,000
Willamette River at Salem (SLMO)	90,000	153,000
*Note that these flow targets may change as rating tables are updated.		

Recreation impacts were evaluated based on impacts to boat ramps (elevations). The study assessed the average reservoir elevations and number of days boat ramps and other facilities were out-of-service or inaccessible due to low water levels. Irrigation and water supply impacts were assessed by comparing the elevation exceedance values of the alternatives and the baseline condition. Elevations were evaluated for water supply to determine if refill was being met. Hydropower impacts were assessed qualitatively through the examination of turbine outlet flow changes.

3. HEC-RESSIM MODEL DESCRIPTION

The Corps' HEC-ResSim model is designed to simulate reservoir operations at one or more reservoirs whose operations are defined by a variety of operational goals and constraints, including downstream flow limitations. The model uses a rule-based description of the operational goals and constraints that reservoir operators must consider when making release decisions. The dam is the root of an outlet hierarchy or "tree" which allows the user to describe the different outlets of the reservoir in as much detail as is deemed necessary. The ResSim model is not an optimization tool and can only be used to simulate rule-based reservoir operations input by the modeler. The model does not run in a forecast mode; it makes decisions based on current system status and current inflows. Additional information on the ResSim model can be found in Appendix A and also on the HEC website (http://www.hec.usace.army.mil/software/hec-ResSim/). For this study, HEC-ResSim was used to simulate conditions under a baseline scenario as well as using two different operational approaches designed to increase the opportunity for e-flow implementation.

3.1. BASELINE

The Corps' HEC-ResSim model (version 3.1 RC3 Build 101) was used to simulate reservoir operations within the Willamette River basin. The Corps developed a baseline calibrated ResSim model of the systems 13 Willamette projects. The model was set up to run a 73-year period of record (POR) that included water years 1936-2008 with a daily time-step.

Dam operations were imposed on the 73-year period of record to simulate project operations over a large span of water year types. A set of baseline operating rules were specified in each zone of the 13 projects, in order to simulate current operating conditions. This baseline rule set imposes current interim operating limits on certain spillway gates representing interim risk reduction measures (IRRMs) in place until gate repairs occur. This represents the way the Corps has managed the basin since 2010 when spillway gate issues were first identified. The rule set also includes any BiOp actions that are currently implemented such as Detroit interim water temperature control (WTC) operations and mainstem/tributary BiOp flow targets.

The baseline model run used in this study is slightly different than the baseline used for BiOp modeling, with modifications to Detroit Dam's winter flood risk management operations. Post-processing graphics have been updated to reflect the newer baseline for SRP.

3.1. DEVELOPMENT OF OPERATIONAL SCENARIOS

Reservoir modeling was conducted to determine the potential opportunities to generate environmental benefits. The operational feasibility of regulating to achieve recommended environmental flow rates was determined by assessing potential project and system-wide impacts using the ResSim model.

The Willamette Valley projects are operated to reduce flood damages as well as meet other authorized project purposes. In a typical flood damage reduction operation, outflows are reduced as needed to keep downstream control points below bankfull levels. The reduction in outflows usually corresponds to a situation where inflows and downstream local flows are higher than expected reflecting forecast uncertainty. Local flows are the flows that enter the system downstream of a project. During some flood events, the local flow component is so large that the project outflow is reduced to minimum flow and downstream gages may still exceed bankfull or flood stage levels. Once the flows have receded downstream, any stored water behind a project is evacuated to prepare for the next event. Less water will be stored in a smaller event and more in a large event.

Each project has operational constraints defined within the Water Control Manual to provide guidance to reservoir regulators. Flood operation outflow constraints for key projects are shown in Table 4. In addition to the project outflow constraints, there are downstream control point constraints as shown in Table 3. By providing a range of flows to the reservoir regulators, it allows flexibility to adjust operations as needed in real-time to respond to flood events. For example, the evacuation rate chosen for Detroit can vary between a minimum flow (1,000 cfs) and maximum evacuation rate (17,000 cfs), which are specified in the Water Control Manual (Table 4) and follow the typical flood damage reduction operations.

Within the baseline ResSim model, a maximum release rule was developed for each project that is a function of the current reservoir elevation. If the project is lower in the pool, maximum releases are lower and as the pool level increases, maximum outflows are increased. This relationship was necessary to keep the model from increasing to 17,000 cfs automatically when there was not much flood storage used (i.e. still low in the pool). A large sudden outflow release would cause the pool to plummet and result in a sharp decrease in outflows as it reached the rule curve. By limiting the maximum outflow as a function of the reservoir elevation, releases simulated real-time post-flood operations more accurately.

Table 4. Outflow Constraints from the Water Control Manuals

Project	Minimum Flow (in cfs)	Normal Evacuation Release (in cfs)	Maximum Evacuation Release (in cfs)
Detroit/Big Cliff Dam	1,000	10,000	17,000
Cougar Dam	100	5,000	6,500
Lookout Point/Dexter Dam	500	12,000	15,000

Within ResSim the maximum outflow rules were adjusted to test flexibility for providing e-flows, while still meeting Water Control Manual constraints. Two different operational approaches for implementing the environmental flows were evaluated and compared to the baseline simulation. The two approaches adjusted operations at Lookout Point, Cougar and Detroit dam individually. A third scenario looked at modifying operations at all three dams simultaneously. Operational alternatives were developed to ‘book end’ likely operations that could generate e-flow conditions. This study was not an exhaustive evaluation of all operational routines. The three alternatives were chosen based on best professional judgment and past modeling and study experience. Running these three alternatives demonstrated the feasibility of operating for e-flow conditions downstream of Willamette projects. It is important to note that the alternatives described below are permissible under each project’s Water Control Manual. Additionally it is important to understand that achieving e-flows downstream of dams is primarily an opportunity driven endeavor and is only possible given the right hydrologic conditions within the basin.

Three e-flow operational alternatives were denoted as:

- **Release More** – This operation would release stored flood water earlier than the baseline and result in less stored water behind the project. Initially this operation was tested individually at Detroit, Cougar and Lookout Point.

- **Store More** – This operation tested slowing down the evacuation of flood water to allow more water to be available for e-flows. Initially this operation was tested individually at Detroit, Cougar and Lookout Point.
- **Combination** – This operation combined Release More options at Detroit, Cougar and Lookout Point in a system run to look at impacts.

A Store More option and a Release More option were evaluated at each of the three projects individually and then a system run was executed to test combining environmental flow operations at multiple projects concurrently (see Table 5). The Release More option stored less by releasing more flow at lower pool elevations than the baseline during high flow events creating environmental pulses in this way. The Store More option modified the original baseline rule to release less water at lower pool elevations thus storing more and having more water available for environmental pulses.

All scenarios considered have been documented in Appendix A, including the ones that were not chosen for recommendation. The results and conclusions section in Section 4 summarizes the analysis in the appendix. All alternatives were compared to the baseline Willamette ResSim model.

Table 5. Summary of Simulations

Project Modified	Report Heading Name	Simulation Name
Detroit	Detroit Store More	DET Store More_021313
Detroit	Detroit Release More	DET Option 2_021213
Cougar	Cougar Store More	CGR Store More_022513
Cougar	Cougar Release More	CGR Release More_022613
Lookout Point	Lookout Point Store More	LOP Store More_022613
Lookout Point	Lookout Point Release More	LOP Release More_022613
Detroit Cougar Lookout Point	SRP Release More-All	ALL SRP Release More

3.1. HEC-RESSIM MODEL RULE CHANGES

Table 6 summarizes the baseline operation set and the corresponding rules that were changed. A total of three rules were changed; one for each of the three modified projects (Detroit, Cougar and Lookout Point). In each case, the same type of rule was targeted, a maximum flow rule.

Table 6. Summary of Baseline (IRRM Baseline_021313)

Project	Baseline Operation Set	Baseline Rules that were Modified	Zones that Contain the Affected Rule
Detroit	Early Imp	Max Evacuation Rule (inside Recession Rules IF block)	Flood Risk Management
Big Cliff	IRRM and Early Imp	No change	
Foster	IRRM Fish Weir	No change	
Green Peter	IRRM and Early Imp	No change	
Fern Ridge	Early Imp	No change	
Blue River	IRRM Baseline	No change	
Cougar	IRRM Baseline	Max Flow (Winter and Conservation)	Top of Dam, Flood Risk Management,

			Conservation
Cottage Grove	IRRM Baseline	No change	
Dorena	IRRM Baseline	No change	
Fall Creek	IRRM Baseline	No change	
Dexter	IRRM and Early Imp	No change	
Lookout Point	IRRM Baseline	Max Evacuation Release	Top of Dam, Max Pool, Primary Flood Risk Management, Secondary Flood Risk Management
Hills Creek	IRRM Baseline	No change	

3.2. Model Limitations

No model perfectly describes the complexities of the real world, therefore, all models have assumptions and limitations. For this model, there are three primary limitations that should be kept in mind while reviewing results. The limitations are described below:

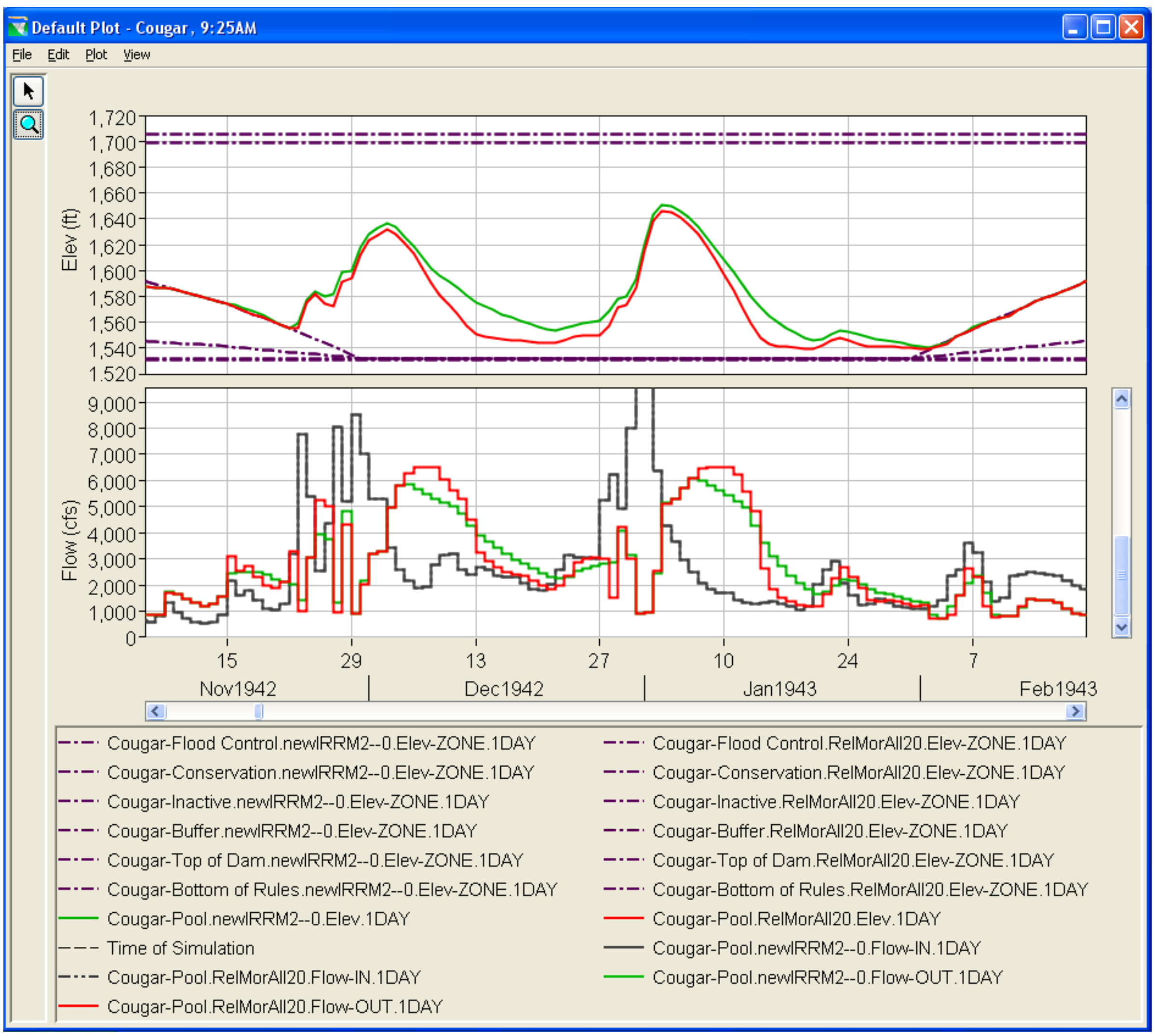
1. When the reservoir elevation is on the rule curve (top of conservation pool), ramp rates are determined by the model and not controlled by any user inputted rules. Not adhering to the ramp down rates can have negative biological impacts. Therefore, incremental changes to the projects outflows were carefully examined. Table 7 shows that there were only a small percentage of times ramp down rates were exceeded in the POR simulation. Furthermore, while an increase from the baseline occurred for the individual project simulations and the combination run, it was very slight. Also, the combination run had fewer increases than the individual projects, suggesting that large rapid flow fluctuations were not an issue when modifying operations at the three projects simultaneously. This was considered a good check for overly aggressive guide curve for induced releases.

Table 7: Ramp Down Rates

The % of ramp down exceedances to the total number of ramp down occurrences.			
Rule Name	Baseline	Individual	Combination
Detroit			
Flood Dcrs Rate_DET	1.9%	1.9%	1.9%
Daily BiOp Max Rate of Decrease	4.6%	4.5%	4.4%
Cougar			
FloodDcrsRamp_Cougar	0.0%	0.0%	0.0%
Revised Daily BiOp Max Rate of Decrease	3.9%	4.2%	4.2%
Lookout Point			
High Q Ramp Down Rates	0.0%	0.0%	0.0%
0.5ft Max Ramp Down @ DEX	4.3%	4.9%	5.0%
FloodDcrsRate_LookP	0.0%	0.0%	0.0%

2. The SRP model has a daily time step in order to analyze year-round implications for the period of record. Running 73 years of data on a smaller timestep results in excessively long computation time with minimal increases in useful data. Often times flood studies utilize smaller time steps to capture the higher instantaneous peaks. For the SRP modeling the maximum outflow rule was modified which impacted the evacuation portion of the flood operation (i.e. post-peak). Since the operation before and during the peak of the flood were not modified, the errors in peaks associated with the daily model were the same for the baseline and proposed simulations. Looking at differences between the baseline and the alternatives would provide enough indication of risk for this level of analysis. An example of how the flood risk management operations were modified in the Cougar Store More simulation is shown in Figure 6. The reduction in flow during the peak of the flood event is unchanged, but the evacuation portion of the operation shows higher discharges in the Release More scenario. The higher discharges provide more opportunity for e-flows.

Figure 6. ResSim Results Comparing Cougar Operations Between the Release More Scenario (Red Lines) and Baseline (Green Lines)



3. ResSim does not assume any forecast error and has perfect knowledge of the local inflows at each downstream control point using maximum flow rules. Outflows from the project are adjusted precisely to meet a downstream flow rule. So the model only floods a downstream control point when it has no other option (i.e. the local flow component is too large and the projects are at minimum). Regulators must make decisions with imperfect forecasts and an incomplete knowledge of what the local inflows will be in real time so flood risk is always likely to be higher than the model can simulate. Despite these limitations, ResSim is still a valuable tool when addressing potential flood damage. The important piece is the comparison to the baseline. Two simulations (the baseline and a modification of the baseline) are evaluated with the same POR. Differences give an indication as to whether the flood risk will increase. Analysis of model results should not be extrapolated to guess at the magnitude or the timing of the flood events, however. This is an important caveat to be considered for implementation.

4. MODELING RESULTS AND IMPACTS

Reservoir modeling was conducted to determine the operational feasibility of holding and releasing flows from Lookout Point, Cougar and Detroit projects with ramifications evaluated specifically at the downstream control points, Jasper, Vida, Mehama and Jefferson gages. ResSim modeling results were assessed for potential project and system-wide impacts (flood and refill) in conjunction with potential benefits as measured in terms of flow peaks and duration of flood events. Each modeling scenario is summarized below with detailed results documented in Appendix A.

Overall the evaluation of the modeling results indicated that the Release More alternative was superior to the Store More alternative. The Release More option resulted in more total e-flow events. The Combination run resulted in similar benefits and was run to determine if there would be potential for increased flooding should all three projects be allowed to operate to e-flow targets as the opportunity (hydrologic) arose. The simulation results, in terms of statistical exceedance comparisons, found that there were negligible adverse impacts to flood risk, water quality and recreation.

4.1. RELEASE MORE ALTERNATIVE

In the ‘Release More’ scenarios the stored flood water was released earlier by allowing the maximum project outflows to be higher at lower pool levels than in the baseline run, while staying within the water control manual limits.

Below is a description of the general impacts and benefits of the ‘Release More’ scenario that was modeled for Detroit, Cougar and Lookout Point Dams. When comparing benefits and impacts between each individual project, the ‘Release More’ option was selected for further consideration in the combination run. For detailed modeling and results information, please see Appendix A.

4.1.1. E-Flow Benefits

Overall the e-flow benefits associated with the Release More alternatives offered an increased number of winter e-flow events compared to the baseline. Spring e-flows were minimally impacted.

North Santiam at Mehama (i.e. Detroit Dam) winter e-flows increased from 108 for the baseline to 137 for the Release More scenario. However, spring e-flows remained the same relative to the baseline at 25 events each. McKenzie River at Cougar Dam outflows showed increases as well for total winter e-flows which increased from 49 to 59. Spring e-flows also stayed fairly constant with a slight decrease from 63 total spring e-flows to 62. The e-flow benefits in the Middle Fork were evaluated at the Jasper gage. The number of total winter e-flows increased from 136 to 144. The spring e-flows increased slightly from 19 to 20.

4.1.2. **Tributary Flow Impacts**

The impact to tributary flows was evaluated using the post-processing report 'BiOp Flow Targets: Summary of Days Flows Not Met. BiOp flow targets cannot be met in every water year in the baseline run due to hydrologic flow fluctuations. Simulation results were compared to the baseline to see if conditions were made worse (i.e. there was a significant increase in the number of days the BiOp flows were not met). For this scenario, regardless of the project to which it was implemented, ResSim indicates that proposed operations would meet downstream BiOp flow targets since flows during the conservation season would not be impacted.

4.1.3. **Flood Risk Management Impacts**

The impacts to downstream control points were evaluated using the post-processing report, 'Flood Damage Reduction Summary' Simulation results were compared to the baseline to see if conditions were made worse (i.e. there was a significant increase in the number of days the bankfull and flood stage flows were exceeded). For the 'Release More' simulations, there were very minor adjustments to the number of days above bankfull and generally even less above flood stage. In some cases, the number of bankfull events increased slightly, but the increase in days above flood stage decreased. Median flow shifted somewhat higher in response to the releasing higher flows early on. Overall peak flow data fluctuated slightly, with the biggest increase at Jasper in the Lookout Point Release More simulation. Peak flows at Jasper were below 16,730 cfs in half of all water years in the baseline run and that increased to 19,320 cfs in the simulation. This value is higher, but still below the bankfull threshold of 20,000 cfs. The 95th percentile flow at Jasper decreased from 25,350 cfs to 23,720 cfs. The more extreme events decreased because more water was pushed out earlier and there was generally greater available storage.

In general, when looking at the decrease in winter pool elevations for the project non-exceedance elevation graphs, there appears to be more flood storage available for concurrent flood events. This could be viewed as a benefit for flood risk management operations.

4.1.4. **Hydropower Impacts**

The post-processing report, 'Detroit and Big Cliff Project Summary' was examined for each project. Flow shifts from one outlet to another were examined to determine if there was a change in the turbine flow. In general flow shifts from turbines to non-generating outlets were minor. All projects had a slight decrease in turbine flow. The change in flow was well under 10% indicating a very minor change in hydropower production. BPA may need to evaluate these types of changes for seasonality and value differences.

4.1.5. **Water Quality Impacts**

Although winter reservoir elevations would likely be lower than baseline under this scenario, refill and summer reservoir storage for the projects evaluated (Detroit, Lookout Point and Cougar Dams) should not be affected. Therefore, water temperature management should not be impacted by this scenario.

Total dissolved gas exceedances would likely increase under this scenario, as compared to baseline, due to the larger number of winter high flow events. These flow events would likely be longer in duration but may not peak as high as the Store More scenario since water would be released sooner, rather than held and stored for later release.

For Detroit Dam and Lookout Point Dams, Total Dissolved Gas (TDG) exceedances typically occur when the amount of water released from the high head dams exceeds the powerhouse capacity of the downstream re-regulating project. The combination of spill operations (non-powerhouse discharges) at both the high head and re-regulating projects have been shown to create large TDG exceedances in downstream river reaches.

Cougar Dam, which does not have a re-regulating project downstream of it, is known to produce TDG levels that exceed State water quality standards when regulating outlet discharges exceed approximately 400-600 cfs (dependant on water temperatures and powerhouse flows). With that said, high flows greater than 6,000 cfs would certainly cause downstream TDG problems, at least in the section of the South Fork McKenzie River just below Cougar Dam.

Under this scenario, the bulk of high flow events would occur during the winter months when spring Chinook salmonid eggs are incubating. Empirical data suggests that incubating eggs are not as susceptible to TDG as compared to sac-fry and/or juvenile salmonids due to the internal hydrostatic pressure found within salmonid eggs (Jensen 1986). Salmonid eggs may also experience some reprieve from the TDG released from high head dams, especially if ground water influences make up a notable proportion of the hyporheic flows surrounding the incubating eggs.

During the spring, once salmonids have hatched below Detroit, Cougar and Lookout Point Dams, they are more susceptible to TDG exceedances from dam operations. According to ResSim model results this scenario would not likely increase the number or duration of spring high flow events as compared to baseline. Therefore, increased impacts to downstream juveniles, beyond baseline, would not be expected.

4.1.6. **Impacts to Storage (Recreation and Water Supply Impacts)**

The post-processing report 'Project Summary' as well as the project non-exceedance graphs for each project were used to assess impacts to storage. Reservoir storage during the conservation season showed only limited changes, which indicated that there would be minimal impacts to recreation, and water supply. As the e-flows were targeting winter and spring seasons, the summer storage levels were not impacted.

4.1.7. **Fish Passage Impacts**

Higher flows during the winter have the potential to improve downstream juvenile fish passage by "flushing" or "pulsing" fish through the reservoir systems and downstream. Future Research Monitoring and Evaluation (RM&E) studies could be conducted to validate or refute this hypothesis.

4.2. STORE MORE ALTERNATIVE

This simulation adjusted maximum outflow rules to hold water and release later at Cougar, Lookout Point and Detroit. This operation tested slowing down the evacuation of flood water to allow more water to be available for e-flows within Water Control Manual limits.

Below is a description of the general impacts and benefits of the Store More scenario. The Store More option was modeled individually for Detroit, Cougar and Lookout Point Dams. When comparing benefits and impacts between each individual project, the Store More option had similar e-flow opportunity and results. The Store More option was not selected for further combined analysis. Compared to the Release More option, the Store More Option did not offer greater benefits and incurred potentially increased flood risk; therefore the Store More option holds projects at a higher pool elevation (fuller) than baseline and is therefore at higher flood risk caused by an incorrect forecast/unexpected inflow. For detailed modeling and results information, please see Appendix A.

4.2.1. **E-Flow Benefits**

The overall total winter and spring e-flow benefits under the Store More alternative were not as good as the Release More alternative. There were few significant advantages over the baseline.

Using the Detroit Store More simulation as an example, the e-flow results for the North Santiam at Mehama show that there was a very slight decrease compared to Baseline of total winter e-flows from 109 to 108. Spring e-flow events increased slightly from 25 to 26. This is over 73 years of record and therefore the numbers essentially show the trend to be unchanging for this simulation run. There was a trend to more type 1 events (higher peaks of 1 day duration) compared to type 3 (lower peaks with longer duration); 77-88 for type 1 and 10-2 for Type 3. (Reference Table 1 for the e-flow categories.) Similar results were observed at Cougar, where overall the number of winter e-flows dropped from 49 to 47 and the number of spring e-flows dropped from 63 to 62. For the Lookout Point Store More run the total winter e-flows decreased from 160 to 143. Total spring e-flows increased a small amount from 18 to 20.

4.2.2. **Tributary Flow Impacts**

The impact to tributary flows was evaluated using the post-processing report, ‘BiOp Flow Targets: Summary of Days Flows Not Met’. BiOp flow targets cannot be met in every water year in the baseline run due to hydrologic flow fluctuations. Simulation results were compared to the baseline to see if conditions were made worse (i.e. there was a significant increase in the number of days the BiOp flows were not met). This scenario, regardless of the project to which it is implemented, is not likely to impact downstream BiOp flow targets since flows during the conservation season would not be impacted.

4.2.3. **Flood Risk Management Impacts**

The impacts to downstream control points were evaluated using the post-processing report, ‘Flood Damage Reduction Summary’. The Corps regulates to stay below bankfull or flood stages. Simulation results were compared to the baseline to see if conditions were made worse (i.e. there was a significant increase in the number of days the bankfull and flood stages were exceeded). For the Store More simulations, there were very minor adjustments to the number of days above bankfull and generally even less above flood stage. In some cases, the number of bankfull events increased slightly, but the increase in days above flood stage decreased. Overall peak flow data fluctuated slightly, with the biggest increase in the southern and mainstem Willamette in the Lookout Point Store More simulation. Peak flows at Salem were below 118,820 cfs in half of all water years in the baseline run and that increased to 120,190 cfs in the simulation. This value is higher, but still below the flood stage threshold of 150,000 cfs.

It is assumed that as the Store More option resulted in slightly higher reservoir elevations during flood season, therefore the amount of flood storage for concurrent events was potentially limited. It should be pointed out that outflows for the Store More simulations were still within the Water Control Manual guidelines, but were slightly less aggressive in maintaining flood risk management space.

4.2.4. **Hydropower Impacts**

The post-processing report 'Project Summary' was examined for each project. Flow shifts from one outlet to another were examined to indicate if there was a change in the turbine flow. In general, flow shifts from turbines to non-generating outlets were minor. Lookout Point and Big Cliff had a slight increase in turbine flow while Cougar and Detroit had slightly less. The change in flow was well under 10% indicating a very minor change in hydropower production. In practice regulators always maximize turbine flow before spill. These winter releases were at levels above powerhouse capacity.

4.2.5. **Water Quality Impacts**

Water temperature management should not be impacted by this scenario, since refill of the projects evaluated (Detroit, Lookout Point and Cougar Dams) would not likely be affected. Total dissolved gas exceedances may be higher [more pronounced] under this scenario, as compared to baseline, due to the larger number of winter high flow events that were greater than the ranges of greater than 15,000 cfs, greater than 6,000 cfs and greater than 17 kcfs for Detroit, Cougar and Lookout Point Dams, respectively. These events, however, would likely be shorter in duration as compared to baseline or the Release More scenario since water would be stored longer behind the high head dams before being released. Furthermore, the mid-range winter flow events would likely decrease as compared to baseline since this water would be stored longer under this scenario for a larger flow release later on.

For Detroit Dam and Lookout Point Dams, TDG exceedances typically occur when the amount of water released from the high head dams exceeds the powerhouse capacity of the downstream re-regulating project. The combination of spill operations [non-powerhouse discharges] at both the high head and re-regulating projects have been shown to create large TDG exceedances in downstream river reaches.

Cougar Dam, which does not have a re-regulating project downstream of it, is known to produce TDG levels that exceed State water quality standards when regulating outlet discharges exceed approximately 400-600 cfs (dependant on water temperatures and powerhouse flows). With that said high flows of greater than 15,000 cfs would certainly cause downstream TDG problems, at least in the section of the South Fork McKenzie River just below Cougar Dam.

Under this scenario, the bulk of high flow events would occur during the winter months when spring Chinook salmonid eggs are incubating. Empirical data suggests that incubating eggs are not as susceptible to TDG as compared to sac-fry and/or juvenile salmonids due to the internal hydrostatic pressure found within salmonid eggs (Jensen 1986). Salmonid eggs may also experience some reprieve from the TDG released from high head dams, especially if ground water influences make up a notable proportion of the hyporheic flows surrounding the incubating eggs.

During the spring, once salmonids have hatched below Detroit, Cougar and Lookout Point Dams, they are more susceptible to TDG exceedances from dam operations. ResSim model results show this scenario would not likely increase the number or duration of spring high flow events as compared to baseline. Therefore, increased impacts to downstream juveniles, beyond baseline, would not be expected.

4.2.6. **Impacts to Storage (Recreation and Water Supply Impacts)**

The post-processing report, Project Summary' as well as the project non-exceedance graphs were examined for each project. Reservoir elevations during conservation season were examined to determine if available storage would be affected for recreation, irrigation or water supply. As the e-flows were targeting winter and spring seasons, the summer storage levels were not impacted, and in fact were slightly improved over baseline. The result was a slight shift in refill timing in some years, likely because there was more storage transitioning from winter flood season to spring refill.

4.2.7. **Fish Passage Impacts**

Higher flows during the winter have the potential to improve downstream juvenile fish passage by "flushing" or "pulsing" fish through the reservoir systems and downstream. Future RM&E studies could be conducted to validate or refute this hypothesis.

4.3. COMBINATION RUN

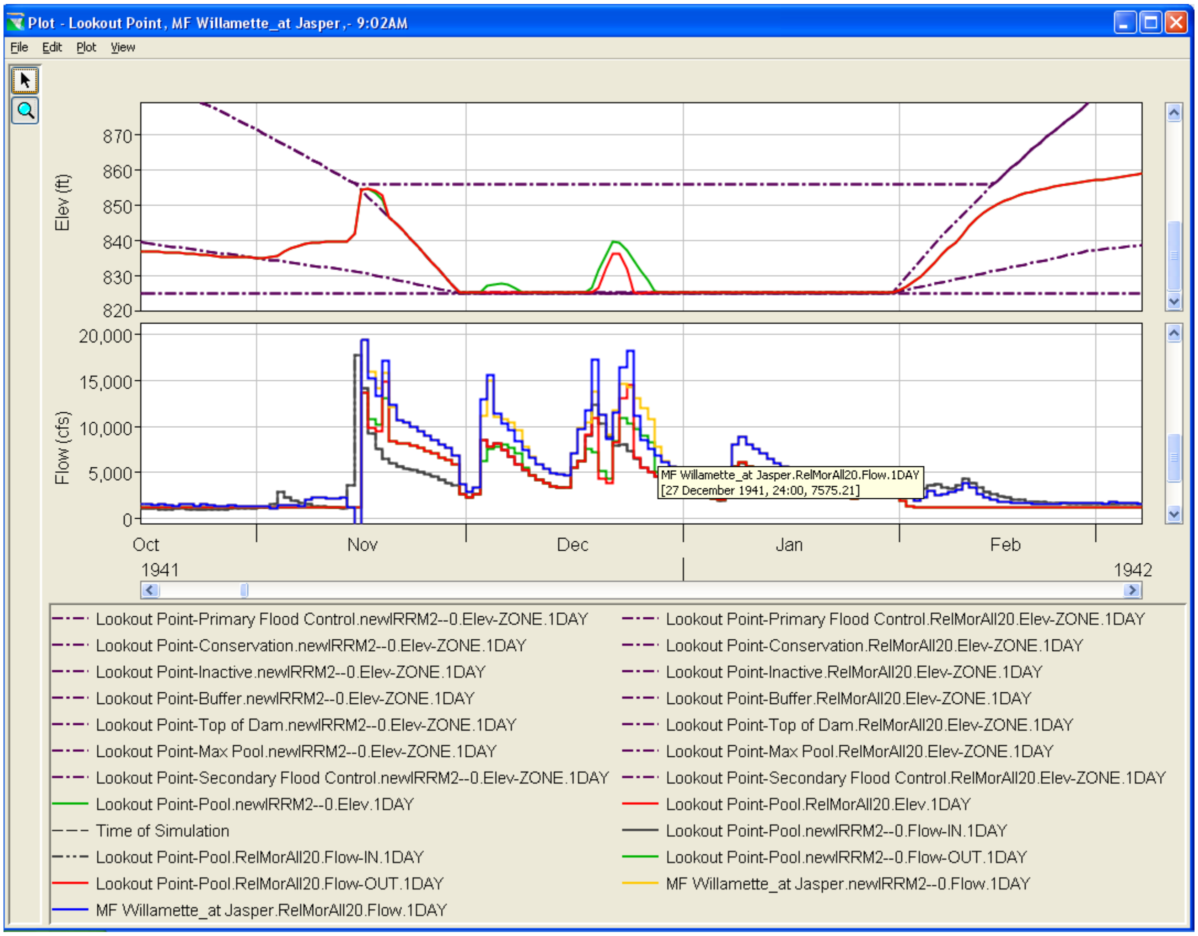
Once evaluations for individual projects were complete a combination run was prepared. Each individual project used the Release More scenario as it provided more e-flow opportunity and allowed more flood storage to be available. This system simulation consisted of allowing all 3 projects, Cougar, Detroit and Lookout Point to operate in the Release More mode. The Store More option was not run for the combination of the three sites because the final iteration in the modeling study, the PDT had determined that the Store More option was not as desirable as the Release More option. Store more is not as desirable from the perspective that it could potentially increases flood risk potential by having pools at a higher level that currently occurs.

General takeaways from this scenario are similar to the 'Release More' model simulations conducted for each project, individually. Please see section 4.1 above for those details.

4.3.1. **E-Flow Benefits**

Appendix A contains the detailed counts of e-flows. In comparison to the three individual Release More simulations the combination run has a small decrease in winter e-flows. The individual run for Detroit has 137 total winter e-flows while the combination run at Detroit has 132. Cougar has consistent values. The individual run for Lookout Point has 144 total winter e-flows while the combination run at Lookout Point has 143. All total spring e-flows remain the same between the individual project simulations and the combination run. An example of how the e-flow pulses changed between baseline and Release More are shown in Figure 7.

Figure 7. Lookout Point Flows and Elevations with Jasper Outflow for Baseline and Release More scenario



4.3.2. **Tributary Flow Benefits**

The impact to tributary flows were evaluated using the post-processing report, 'BiOp Flow Targets: Summary of Days Flows Not Met' Year-round BiOp flow targets cannot be met in every water year in the baseline run due to hydrologic flow fluctuations. Simulation results were compared to the baseline to see if conditions were made worse (i.e. there was a significant increase in the number of days the BiOp flows were not met). Regardless of the project it was implemented at, ResSim indicates that it is not likely to impact meeting the downstream BiOp flow targets, as flows during the conservation season would not be impacted.

4.3.3. **Flood Risk Management Impacts**

The impacts to downstream control points were evaluated using the post-processing report, 'Flood Damage Reduction Summary'. For this impact assessment, simulation results were compared to the baseline to see if conditions were made worse (i.e. there was a significant increase in the number of days the bankfull and flood stages were exceeded). For the combination run, there were very minor adjustments to the number of days above bankfull and generally even less above flood stage. In some cases, the number of bankfull events increased or decreased slightly at the 95th percentile, but the increase in days above flood stage decreased. Harrisburg saw an increase in days above bankfull at the 95th percentile, but not an increase in days above flood stage. Overall peak flow data fluctuated slightly, with the biggest increase at Jasper (as a percentage of the baseline flow) at the 50th percentile. Peak flows at Jasper were below 16,730 cfs in half of all water years in the baseline run and that increased to 18,420 cfs in the simulation. This value is higher, but still below the bankfull threshold of 20,000 cfs. Interestingly, the 95th percentile flows at gages downstream of Jasper decreased slightly. This is likely because the volume evacuated earlier in release more scenario results in lower peaks for extreme events?

In general, when looking at the decrease in winter pool elevations in the project non-exceedance elevation graphs, there appears to be more flood storage available for concurrent flood events. This could be viewed as a benefit for flood damage reduction operations.

4.3.4. **Hydropower Impacts**

The post-processing report 'Project Summary' was examined for each project. Flow shifts from one outlet to another were examined to determine whether there was a change in the turbine flow. In general flow shifts from turbines to non-generating outlets were minor, but slightly less than baseline. The change in flow was well under 10% indicating a very minor change in hydropower production.

Actual operations can be different than modeled results. In general, when releasing high flows, regulators always maximize the turbines first, and then spill the rest. These high flows are above the turbine capacities at these projects, and it was somewhat surprising that there was a slight decrease in powerhouse capacity. In practice powerhouse production will be the same or increase due to these changed operations.

4.3.5. **Water Quality Impacts**

Although winter reservoir elevations would likely be lower than baseline under this scenario, refill and summer reservoir storage for the projects evaluated (Detroit, Lookout Point and Cougar Dams) should not be affected. Therefore, water temperature management should not be impacted by this scenario.

Total dissolved gas exceedances would likely increase under this scenario, as compared to baseline, due to the larger number of winter high flow events. These flow events would likely be longer in duration but may not peak as high as the Store More scenario since water would be released sooner, rather than held and stored for later release.

For Detroit Dam and Lookout Point Dams, TDG exceedances typically occur when the amount of water released from the high head dams exceeds the powerhouse capacity of the downstream re-regulating project. The combination of spill operations [non-powerhouse discharges] at both the high head and re-regulating projects have been shown to create large TDG exceedances in downstream river reaches.

Cougar Dam, which does not have a re-regulating project downstream of it, is known to produce TDG levels that exceed State water quality standards when regulating outlet discharges exceed approximately 400-600 cfs (dependant on water temperatures and powerhouse flows). With that said high flows of greater than 6,000 cfs would certainly cause downstream TDG problems, at least in the section of the South Fork McKenzie River just below Cougar Dam.

Under this scenario, the bulk of high flow events would occur during the winter months when spring Chinook salmonid eggs are incubating. Empirical data suggests that incubating eggs are not as susceptible to TDG as compared to sac-fry and/or juvenile salmonids due to the internal hydrostatic pressure found within salmonid eggs (Jensen 1986). Salmonid eggs may also experience some reprieve from the TDG released from high head dams, especially if ground water influences make up a notable proportion of the hyporheic flows surrounding the incubating eggs.

During the spring, once salmonids have hatched below Detroit, Cougar and Lookout Point Dams, they are more susceptible to TDG exceedances from dam operations. ResSim model results show this scenario would not likely increase the number or duration of spring high flow events as compared to baseline. Therefore, increased impacts to downstream juveniles, beyond baseline, would not be expected.

4.3.6. Impacts to Storage (Recreation and Water Supply Impacts)

The post-processing report 'Project Summary' as well as the project non-exceedance graphs for each project conservation season reservoir elevation was examined to determine if available storage would be affected for recreation or water supply. As the e-flows were targeting winter and spring seasons, the summer storage levels were not impacted.

4.3.7. Fish Passage Impacts

Higher flows during the winter have the potential to improve downstream juvenile fish passage by "flushing" or "pulsing" fish through the reservoir systems and downstream. Future RM&E studies could be conducted to validate or refute this hypothesis.

5. CONCLUSIONS AND RECOMMENDATIONS

The objective of this study was to determine if opportunity exists to adjust outflows from Lookout Point, Cougar and Detroit dams with the goal of achieving e-flows using operating rule sets that are permissible under current Corps hydro-regulation policy as expressed in the projects' current Water Control Manuals.

To determine if this objective could be met, HEC-ResSim modeling was performed and output was evaluated at the dams as well as downstream control points, e.g. the Middle Fork Willamette at Jasper; McKenzie River at Vida; North Santiam River at Mehama and the Willamette River at Salem flow gages. Two different operational approaches for implementing the environmental flows were evaluated and compared to a baseline simulation. Both approaches modified the maximum evacuation release rule of the baseline condition at the three projects analyzed. Compared to the baseline, the Release More scenario has a more rapid increase in outflow with elevation at the lower elevation ends of the rule whereas the Store More scenario has a slower increase in maximum outflow with elevation. These two scenarios were evaluated at each of the three projects individually. A third scenario, Combination, implemented the Release More options at the three reservoirs simultaneously. Proposed alternative operations focused on winter time changes. Springtime alterations were evaluated, but were limited to allowing additional release when the operation was above the current rule curve.

To evaluate the potential benefits, e-flow peaks, event duration and number of events were evaluated and compared to the baseline run. To evaluate potential impacts, exceedance statistics for flood risk, water quality, hydropower, days meeting BiOp flow targets, water supply and recreation water levels were compared to a baseline run. A detailed summary of results was provided above and detailed simulation output is provided in Appendix A. The summary of relevant findings is below:

1) The ResSim analysis indicated that increasing the number of e-flow events within the Middle Fork Willamette, McKenzie River and North Santiam reaches was feasible by using operational flexibility permissible under the current Water Control Manual at Lookout Point, Cougar and Detroit Dams.

2) The Release More scenario provided an overall increase in SRP e-flow events (benefits) while affecting minimal change to system impact metrics such as flood risk, water quality, hydropower and BiOp meeting BiOp targets.

   Flood storage increased under this alternative. This was reflected by median 50% bankfulls increasing but 95% high flow frequency decreasing. The project non-exceedance elevation graphs generally show decreasing winter pool elevations and increased flood space and thereby effectively reducing flood risk relative to baseline conditions and can be viewed as a benefit for flood risk management operations. (Insert appendix reference)

3) The Store More option did not produce significant changes to total e-flows compared to the baseline. The most noticeable change from baseline was events shifted from low peak flow with 4 day duration to events with a high peak and 1 day duration (i.e. Type 3 to Type 1).

There were limitations to the study analysis. For example ecological benefits for each scenario were evaluated by an e-flow range. There were three wintertime e-flow target types and three spring e-flows ranges. The three types of e-flow targets were composed of a high flow one day duration; a medium flow, three day duration and low peak flow four day duration. These were used in lieu of specific flow or duration targets per reach. This approach was taken because there was not a recognized singular objective condition that was known to offer definitive ecological benefits. Although not affecting the overall recommendations as to how to implement an e-flow at a project, more monitoring and evaluation will be needed to better define ecological benefits.

Another limitation of this analysis was that basins were not prioritized relative to their individual potential benefits. That is, this study weighted the benefits of e-flow operations equally across reaches in the Willamette River Basin. This led to the simplifying assumption that achieving any of the target e-flow peaks and durations provided benefits. However, it was hard to determine which basin had the most potential for reach priority species and which dam operations would have the most effect. Future monitoring and/or additional data analysis of existing biological monitoring data could help reduce some of this uncertainty.

Limitations discussed in the results include:

1) The Release More and Store More ResSim model scenarios do not explicitly adjust to meet required ramp down rates, as would be the case for an actual operation, which could result in negative biological impacts. However, analysis of the model scenarios showed that there were only a small percentage of times ramp down rates were exceeded compared to the baseline. This was the case for individual project simulations and as well as the combination run. See Appendix A.
2) The model uses a daily time step in order to analyze year-round implications for the period of record. This is often done to reduce model simulation run time and is balanced against study needs. For this case, since e-flow operations before and during the peak of the flood were not modified, the errors in peaks associated with the daily model were relatively the same for the baseline and proposed alternatives. For the comparison purposes of this study, this was an acceptable trade-off.
3) ResSim does not have a way to quantify error in forecasts, which could result in higher risk of flooding during real-time operations than modeled by ResSim. For purposes of this analysis, the relative comparison against baseline meant that the same amount of error was inherent in the baseline as well as Releases More and Store More simulations. However, inferring from modeling that there is negligible risk because change against baseline is slight is incorrect. There is no assurance flooding will not occur in a given water year, which cannot be accounted for in the model. Implementation of the Release More would need to be tempered by the potential uncertainty of forecasted locals. However, because Release More alternative actually increases winter flood storage, inherent flood risk resulting from uncertainty in forecasts, will be reduced overall.

Though not strictly a limitation of the study itself, it is cautioned that e-flows cannot be guaranteed for every water year. It is important to point out that the e-flows evaluated in this study are all event driven. In this way, the SRP recommended operations are opportunity derived. E-flows generated results from a need to release water after a storm event. For example, if there is a dry winter similar to this past year water year 2013, there would not be water to release for e-flows.

Given this caution the study did show that there is value in adjusting operations at some dams in the Willamette basin. The simulations evaluated indicate positive flow benefit with minimal if any change to the baseline. The definitive recommendations derived from this study are summarized below:

1) The Release More scenario is a recommended as the starting point for a strategy to implement e-flow releases in the Willamette River basin.

2) Follow-on SRP work should focus on identifying specific biological benefits associated with a given e-flow regime (e.g. peak and duration). It is recommended that follow-on SRP efforts identify and prioritize biologically specific species of interest. Setting criteria and metrics for each basin and reach is also advisable.
3) The regulators tasked with implementing e-flows should be informed as to which resources are of national importance, as well as which reaches can be regulated to maximize specific ecological conditions. This will increase the efficiency of e-flow operations. Also, this knowledge will provide increased assurance and justification for managers tasked with approving and explaining e-flow operations.

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1. APPENDIX A. RESSIM RESULTS

This appendix will document the specific assumptions associated with the ResSim model scenarios, as well as, provide more extensive modeling results.

1.1. RESSIM SETUP

Specific assumptions used in the setup of ResSim are shown in Table 1.

Table 1. ResSim Setup Parameters

Watershed	E:\Willamette_Ressim\SRP\watershed\base\Willamette3
Network	SSARR Daily Model

Table 2 summarizes the baseline operation set and the corresponding rules that were changed. Also, the zones containing the modified rules are presented. A total of three rules were changed; one for each of the three modified projects (Detroit, Cougar and Lookout Point). In each case, the same type of rule was targeted, a maximum flow rule.

Table 2. Summary of Baseline

Project	Baseline Operation Set	Baseline Rules that were Modified	Zones that Contain the Affected Rule
Detroit	Early Imp	Max Evacuation Rule (inside Recession Rules IF block)	Flood Control
Big Cliff	IRRM and Early Imp	No change	
Foster	IRRM Fish Weir	No change	
Green Peter	IRRM and Early Imp	No change	
Fern Ridge	Early Imp	No change	
Blue River	IRRM Baseline	No change	
Cougar	IRRM Baseline	Max Flow (Winter and Conservation)	Top of Dam, Flood Control, Conservation
Cottage Grove	IRRM Baseline	No change	
Dorena	IRRM Baseline	No change	
Fall Creek	IRRM Baseline	No change	
Dexter	IRRM and Early Imp	No change	
Lookout Point	IRRM Baseline	Max Evacuation Release	Top of Dam, Max Pool, Primary Flood Control, Secondary Flood Control
Hills Creek	IRRM Baseline	No change	

Although only three rules were changed, Table 3 shows that more than three simulations were run. Different alternatives for each individual rule were created, specifically a ‘store more’ option and a ‘release more’ option. The store more option modified the original baseline rule to release less water at lower pool elevations thus storing more and having more water available for environmental e-flows. The release more option stored less by releasing more flow at lower pool elevations than the baseline during high flow events creating environmental e-flows in this way. Each new rule modification was done within a new operation set. This allowed each change to be run as a separate simulation.

All scenarios considered have been documented in this appendix, including the ones that were not chosen for recommendation. Click on the simulation name in Table 3 to jump to the corresponding simulation.

Table 3. Summary of Simulations

Simulation Name	Project Modified	Operations Set	Rule Name	Recommended?
DET Store More_021313	Detroit	SRP Store More	SRP Max Evacuation Release-Store More	No
DET Release More_041313	Detroit	DET Option 2	SRP Max Evacuation Release-Opt2	Yes
CGR Store More_022513	Cougar	CGR StorMore	Max Flow (Winter and Con)_StorMore	No
CGR Release More_022613	Cougar	CGR RelMore	Max Flow (Winter and Con)_RelMore	Yes
LOP Store More_022613	Lookout Point	LOP StorMore	Max Evacuation Release-StorMore	No
LOP Release More_041213	Lookout Point	LOP RelMore2	Max Evacuation Release-RelMore	Yes
ALL SRP Release More_041213	Detroit Cougar Lookout Point	The 3 operations sets listed above for the corresponding projects were used.	The 3 rules listed above for the corresponding projects were used.	Yes

1.2. Baseline Rules

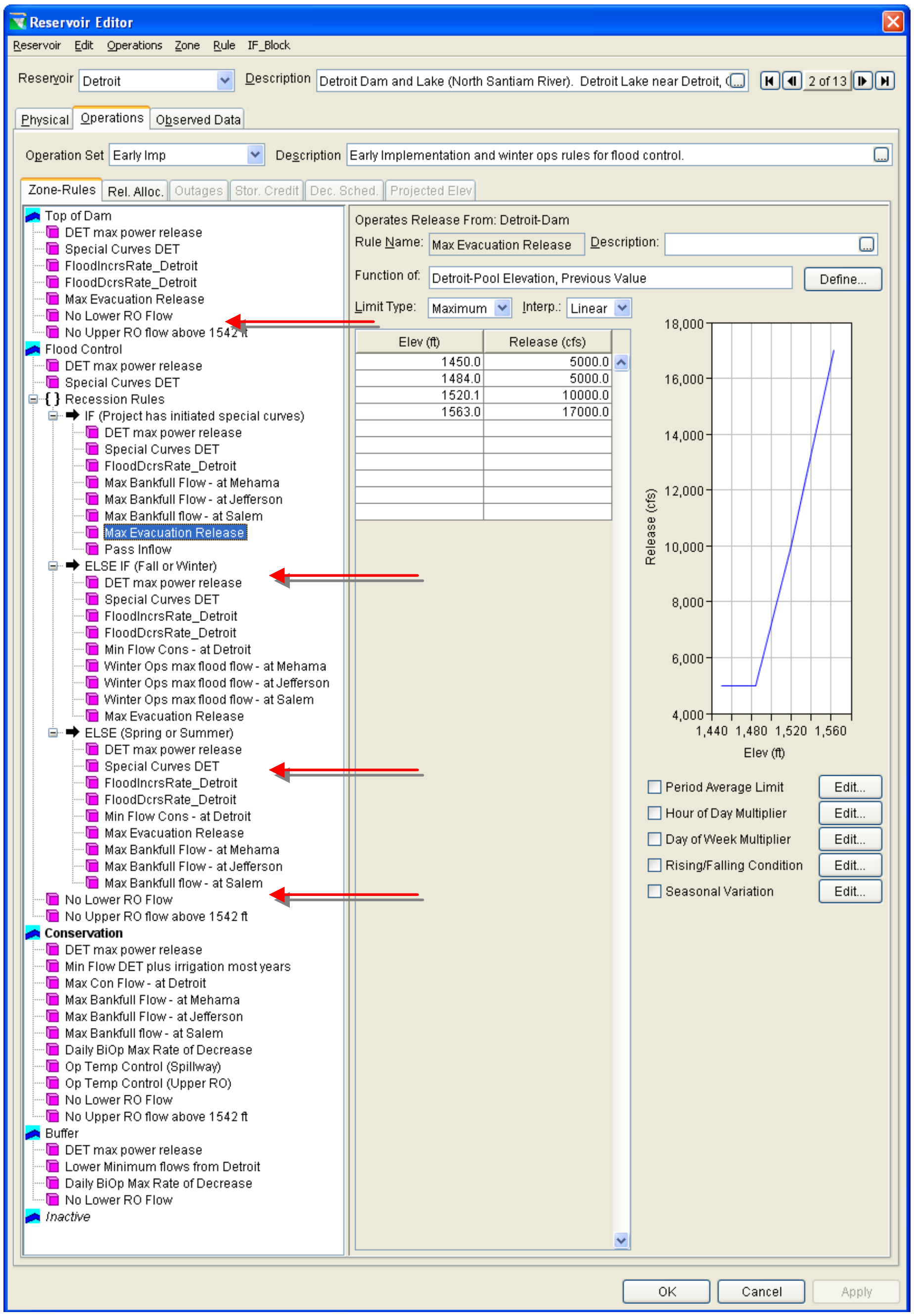
This section describes the baseline run; a model of how the Willamette Valley dams are operated at this time. The Baseline simulation is not discussed in its entirety here, but only the rules modified for this study are highlighted. The analysis for each simulation will refer back to this section. Full baseline documentation resides in the *Willamette River Basin Operational Measures Evaluation Report* (USACE 2012). Slight modifications to the Baseline model described in the referenced 2012 USACE report were made during the course of this study to better simulate current operations.

1.2.1. Detroit

Modifications to operations at Detroit Dam were done by adjusting a single rule in the Flood Control Zone. The rule modified was *Max Evacuation Release*, which limited the maximum outflow from the project depending on the elevation of the simulated reservoir. The rule is within an IF block named *Recession Rules* for the baseline, which was applied to correctly capture the recession rules when modeling Detroit Dam. For any changes to the *Max Evacuation Release* rule, the *Recession Rules* IF Block had to be adapted accordingly and re-named to allow for the new rule in the hierarchy.

A screen shot of the original Baseline Operation Set for Detroit Dam is shown in Figure 1 with red arrows highlighting the IF Block and rule to be changed in the simulations completed for this study. All operations sets for Detroit have the same structure as shown in Figure 1. Only the rule has been modified and, therefore, the overarching IF Block, as well, so as not to change the original. Due to these limited changes, screen shots of the modified operations sets will not be provided in the discussion on simulations where the changes have been implemented. In the following sections, the new names for the rule and IF Block will be identified and a hyperlink to Figure 1 will be included. Specific details of the changes to the rules are also discussed.

Figure 1: Reservoir Editor showing the Baseline Operation Set for Detroit Dam



Description of the *Max Evacuation Release* rule: If the reservoir was in the secondary flood control space (elevation 1450 – 1484 ft) the maximum outflow was restricted to 5,000 cfs. The flow rate of 5,000 cfs corresponds to near maximum turbine capacity of Detroit Dam (actual turbine capacity at min pool is 4,960 cfs). As the pool increases, more flow is allowed with the project increasing linearly to normal evacuation rate (10,000 cfs) at 50% reservoir storage capacity (1520.1 ft) and maximum evacuation rate (17,000 cfs).

Table 4: Baseline Rule Modified for Detroit: *Max Evacuation Release*

	Simulation: Baseline **Rule Name**: *Max Evacuation Release*
Detroit Elevation	**Maximum Release (cfs)**
1450.0	5000
1484.0	5000
1520.1	10000
1563.0	17000

1.2.2. Cougar

Modeling modifications to Cougar Dam operations was achieved by adapting the Baseline rule *Max Flow (Winter and Conservation).* As shown in Figure 2, the rule has been applied to three zones: Top of Dam, Flood Control and Conservation. This figure displays a screen shot of the Baseline Operation Set for Cougar Dam as viewed in ResSim. The red arrows indicate the locations of the modified rule in each affected zone. Since the rule hierarchy was not adjusted and only one rule was modified, the name of the rule is the single useful change that would be different in this window. Changes to the actual rule can also be partially viewed, but are better understood from a table (see Table 5). The modified rule name and a reference back to Figure 2 will be included in subsequent sections describing simulations with modifications to the Baseline rule *Max Flow (Winter and Conservation.).*

Description of the *Max Flow (Winter and Conservation)* rule: Only a portion of the rule can be viewed in Figure 2. Table 5 shows the complete rule, which is entered into ResSim as a seasonal two way look-up table. The two-way lookup table allows the maximum flow release to vary over a range of pool levels and dates. This was used to help smooth the releases as the project transitioned between zones as the same rule could be placed into multiple zones. When the project was below the rule curve, which corresponds to an elevation on a particular date, the maximum flows were typically lower than winter levels, capping the spring – fall augmentation water. When the project was above the rule curve, the maximum flows gradually increased from a ‘typical’ moderate winter flow (1,200 cfs) up to normal and maximum evacuation rates (5,000 and 6,500 cfs respectively). Restricting the maximum release as the project was close to rule curve allows for smoother release transitions during small flood events.

Figure 2: Reservoir Editor showing the Baseline Operation Set for Cougar Dam

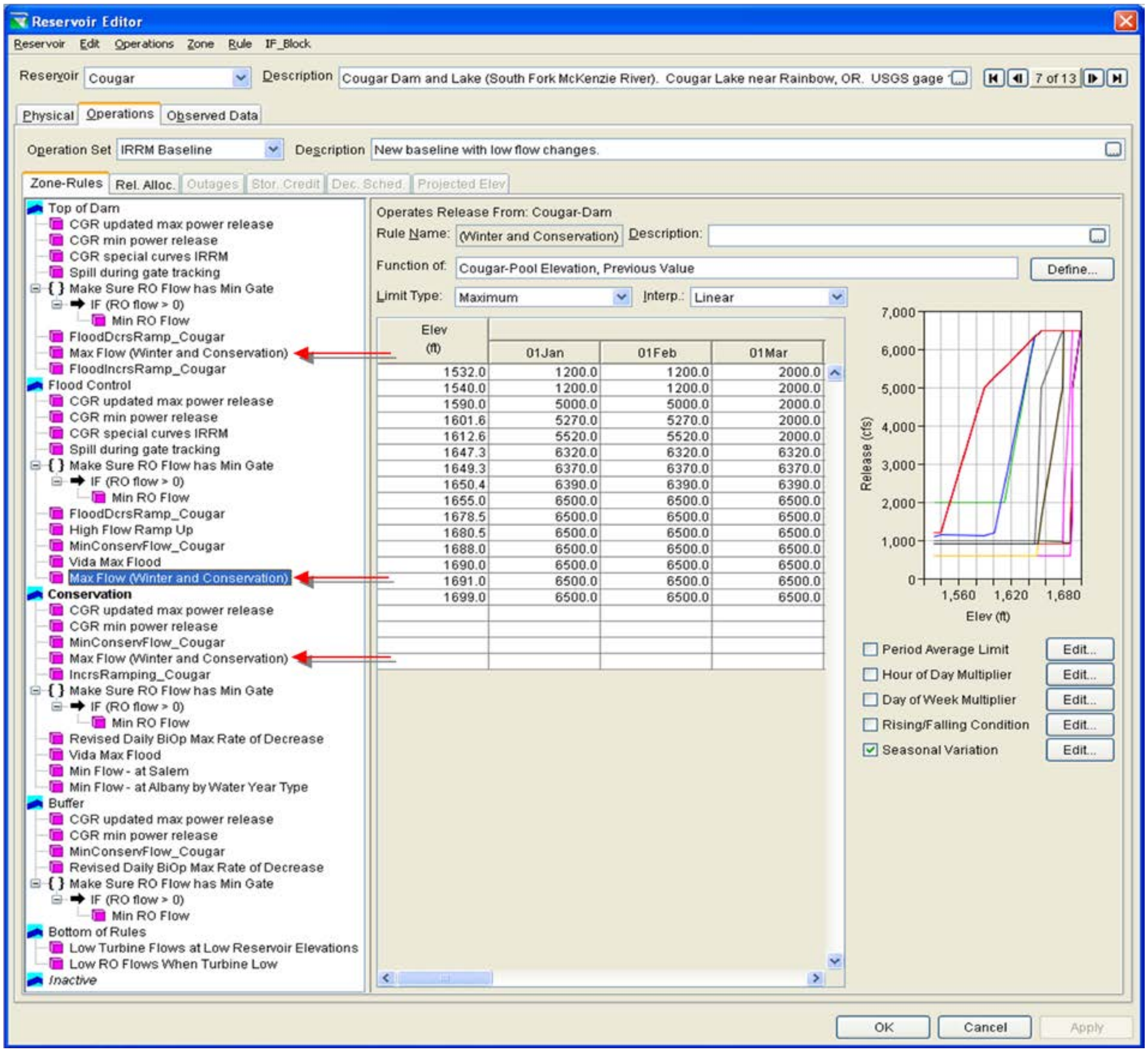


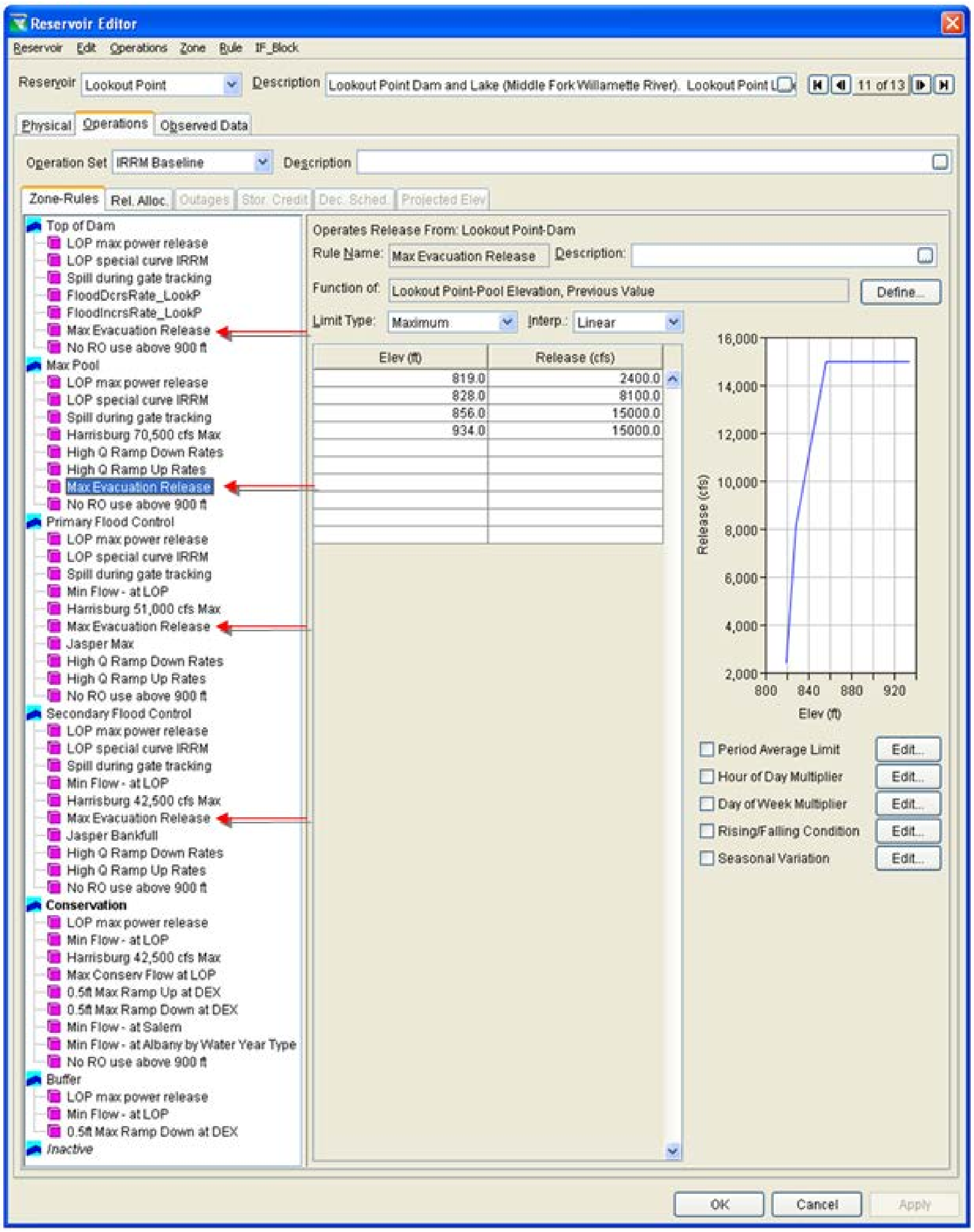
Table 5: Baseline Rule Modified for Cougar: *Max Flow (Winter and Conservation)*

Baseline: *Max Flow (Winter and Conservation)* Rule																
Cougar Elev	1-Jan	1-Feb	1-Mar	1-Apr	1-May	10-May	1-Jun	1-Jul	31-Jul	1-Aug	31-Aug	1-Sep	30-Sep	1-Oct	1-Nov	1-Dec
1532.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1104	1200
1540.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1134	1200
1590.0	5000	5000	2000	900	900	900	900	900	900	1000	1000	580	580	900	1119	5000
1601.6	5270	5270	2000	900	900	900	900	900	900	1000	1000	580	580	900	1200	5270
1612.6	5520	5520	2000	900	900	900	900	900	900	1000	1000	580	580	900	2430	5520
1647.3	6320	6320	6320	900	900	900	900	900	900	1000	1000	580	580	900	6320	6320
1649.3	6370	6370	6370	2000	900	900	900	900	900	1000	1000	580	580	900	6370	6370
1650.4	6390	6390	6390	2580	900	900	900	900	900	1000	1000	580	900	900	6390	6390
1655.0	6500	6500	6500	5000	900	900	900	900	900	1000	1000	580	1570	1570	6500	6500
1678.5	6500	6500	6500	6500	900	900	900	900	900	948	948	580	5000	5000	6500	6500
1680.5	6500	6500	6500	6500	2000	900	900	900	900	945	945	580	6500	6500	6500	6500
1688.0	6500	6500	6500	6500	5000	900	900	900	900	931	931	580	6500	6500	6500	6500
1690.0	6500	6500	6500	6500	6500	3000	3000	3000	3000	1600	1600	1600	6500	6500	6500	6500
1691.0	6500	6500	6500	6500	6500	5000	5000	5000	5000	5000	5000	5000	6500	6500	6500	6500
1699.0	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500

1.2.3. Lookout Point

Max Evacuation Release is the Baseline rule that was modified to increase environmental outflows at Lookout Point Dam. Figure 3 presents all the rules within the operations set used by ResSim to describe operations at Lookout Point Dam for the Baseline simulation. The *Max Evacuation Release* rule is highlighted and shown in the viewer. A more readable version of the rule is provided in Table 6. Red arrows point to each instance of the rule and its priority within each zone. Since the location of the rule (zones and priority) is not changed for this study, only a reference to Figure 3 will be included in subsequent sections that describe modifications.

Figure 3: Reservoir Editor showing the Baseline Operation Set for Lookout Point Dam



Description of the *Max Evacuation Release* rule: The maximum release out of Lookout Point is a function of the reservoir elevation of the dam. This rule was used in all the zones above the rule curve including: Top of Dam, Max Pool, Primary Flood Control and Secondary Flood Control.

The secondary flood control space (elevation 825.0 – 856.0 ft) is effectively divided into two segments for the purposes of this rule:

- First segment (elevation 819.0 ft to 828.0 ft): The maximum releases linearly increase from 2,400.0 cfs to 8,100.0 cfs. The flow rate 2,400.0 cfs is a 'typical' moderate winter flow that can easily be generated with a single turbine. The corresponding elevation 819.0 ft is the top of the minimum power pool for the project. The flow rate 8,100 cfs is the total capacity at full load of the turbines when the project is at minimum pool elevation.

- Second segment (elevation 828.0 ft to 856.0 ft): The releases continue to increase linearly from 8,100.0 cfs to 15,000.0 cfs, but at a less aggressive rate. 15,000 cfs is the maximum evacuation rate of the project. The top of the secondary flood control space is elevation 856.0 ft.

When the reservoir elevation is in the primary flood control space (elevation 856.0 – 929.0 ft), maximum releases are maintained at 15,000 cfs. 15,000.0 cfs is maintained up to the maximum pool elevation, 934.0 ft. The flow rate and elevation relationships were derived from observed operational data during model calibration and reflect how maximum releases were typically increased based on the storage in Lookout Point reservoir.

Table 6: Baseline Rule for Lookout Point*: Max Evacuation Release*

	Simulation: Baseline **Rule Name:** *Max Evacuation Release*
Lookout Point Elevation	**Maximum Release (cfs)**
819.0	2400.0
828.0	8100.0
856.0	15000.0
934.0	15000.0

1.3. DETROIT STORE MORE

Detroit Dam was modeled in ResSim to release less flow lower in the pool to allow for more stored water to be available during the environmental e-flow.

1.3.1. ResSim Rules

Information regarding the Baseline model and rules can be found in Section 1.1 and 1.2. Figure 1 found in Section 1.2.1 provides an example of the Baseline operation set structure for Detroit, as viewed within ResSim. For comparison purposes, a discussion of the original rule in the Baseline simulation can be found in Section 1.2.1.

New Name for the Modified Rule: *SRP_Max Evacuation Release-Store More*

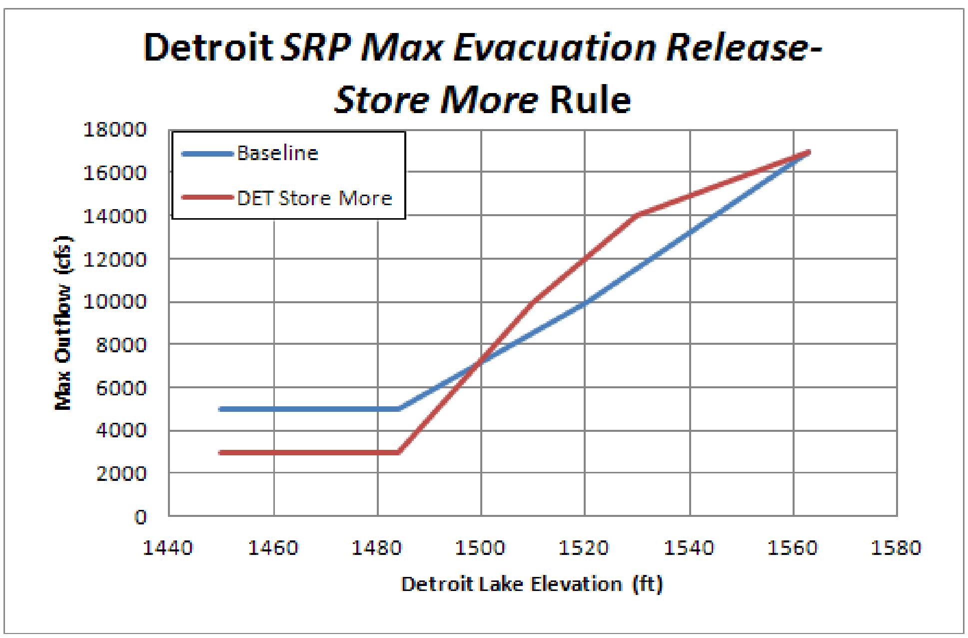
New Name for the Corresponding IF Block: *SRP Recession Rules*

Description of Changes: The rules at Detroit were modified slightly to shift the Baseline *Max Evacuation Release* relationship so that the project would be more restrictive on how much water could be released at lower pool levels, forcing the project to fill higher than the Baseline. The relationships between flows and elevations for the Detroit Store More simulation are summarized and compared to the Baseline in Table 7 and shown graphically in Figure 4. In the new rule for this simulation, *SRP Max Evacuation Release-Store More*, the flows were held lower when the pool was in the secondary flood control space. Flows were capped at 3,000 cfs which is essentially turbine capacity at Big Cliff Dam. Flows were allowed to increase to 10,000 cfs a little sooner than in the Baseline and up to 17,000 cfs.

Table 7. Modified rule for Detroit Store More simulation

	Simulation: Baseline	**Simulation**: DET Store More_021313
	Rule Name: *Max Evacuation Release*	**Rule Name**: *SRP Max Evacuation Release – Store More*
Detroit Elev	**Maximum Release (cfs)**	
1450.0	5000	3000
1484.0	5000	3000
1510.0	-	10000
1520.1	10000	-
1530.0	-	14000
1563.0	17000	17000

Figure 4. Maximum outflow as a function of Detroit Lake elevation for *SRP Max Evacuation Release-Store More* Rule

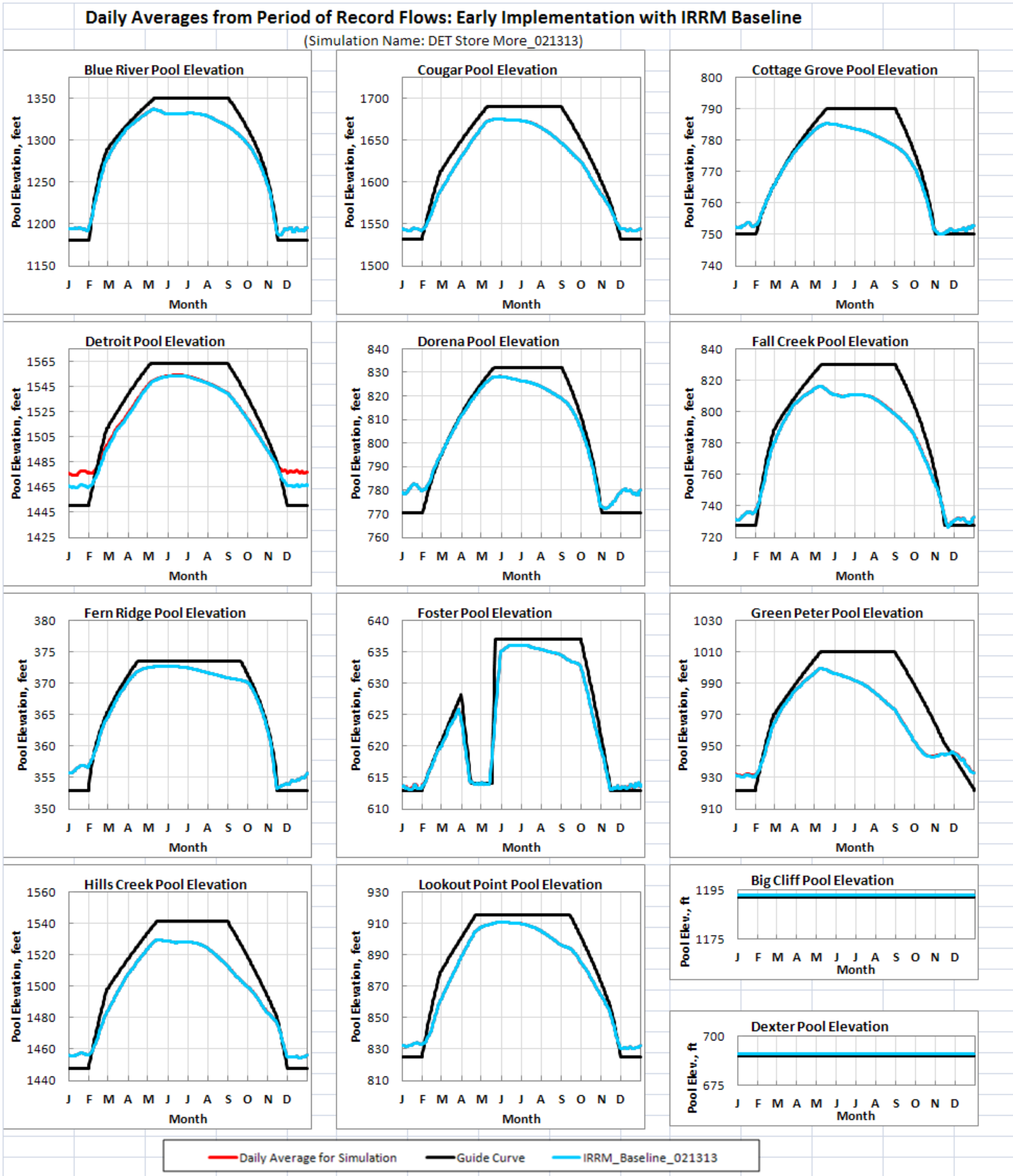


1.3.2. Model Results

Several post-processing charts were examined and compared to assess impacts of the proposed changes due to a store more scenario. Figure 5 summarizes the average project elevations over the

POR for all projects. Based on this average, no project elevations were significantly changed except for Detroit, which was higher in the winter as expected.

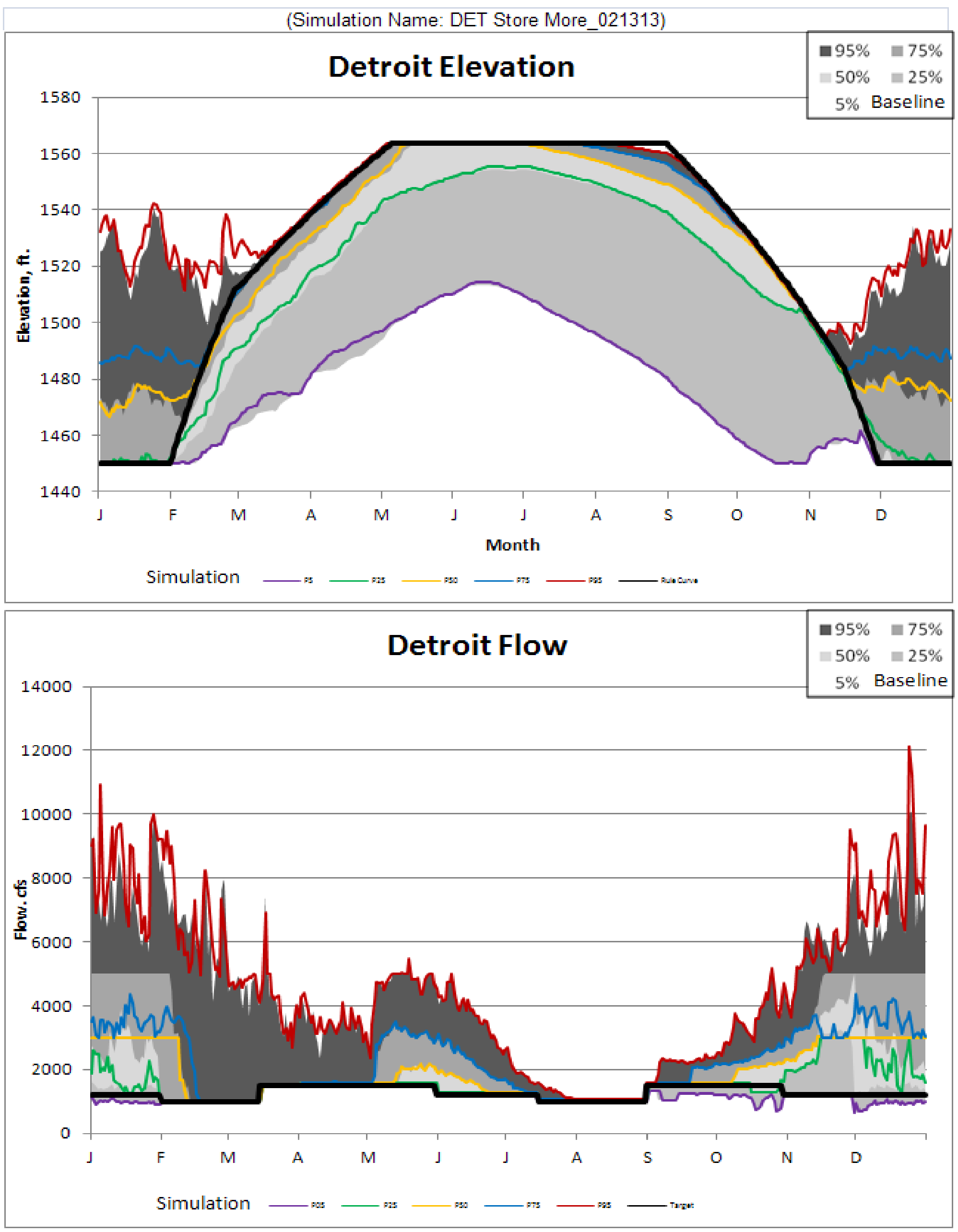
Figure 5: Summary of Average Project Elevations



As seen in Figure 6, the winter elevations of Detroit in the Store More scenario are higher more than 50 percent of the time as compared to the Baseline. The increase is more pronounced in the secondary flood control space (below elev. 1484) with 50th percentile 20 ft higher than Baseline. The differences are less pronounced higher in the pool with the 75th percentile 10-15 ft higher and the 95th

percentile 5-10 ft higher. This pattern is also reflected in changes to the winter flow graphs with the 75th percentile flow lower than the Baseline. The reduction in flows lower in the pool in the *SRP Max Evacuation Release – Store More* rule forces the lake higher. This results in higher evacuation flows (95th percentile) because the higher pool levels result in higher flows. The spring and summer pool levels and flows are similar to Baseline.

Figure 6: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Detroit for Regulated Flow. Compares Simulation DET Store More_021313 statistics (colored lines) to the Baseline statistics (gray areas).



The project summary statistics comparing the baseline with the Detroit Store More simulation are shown in Table 8. There is a slight decrease in the number of days that the tributary flows are not met (a benefit), and negligible impacts to boat ramp elevations.

Table 8: Summary of Exceedance Values for Detroit and Big Cliff Projects

Detroit and Big Cliff Project Summary							Simulation: DET Store More_021313							
Exceedance Values for Average Flows, Elevations, and Number of Days Tributary Flows Not Met.	Exceedance Values for 73 Water Years						Exceedance Values by Water Year Type							
	Conditional formatting compares to Baseline counterpart						Baseline by Water Year Type				Simulation by Water Year Type			
	IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
	5%	50%	95%	5%	50%	95%								
DET Average Outflow	1570	2150	3060	1570	2150	3060	2340	2080	1900	1690	2340	2090	1900	1690
DET Average Upper Regulating Outlet Flow	10	90	340	20	110	370	100	110	90	30	130	110	120	40
DET Average Lower Regulating Outlet Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DET Average Turbine Flow	1300	1750	2170	1300	1710	2120	1810	1700	1600	1600	1790	1680	1600	1590
DET Average Spillway Flow	0	350	530	0	350	550	400	270	140	0	420	290	140	0
DET Average Reservoir Elevation	1482	1518	1530	1483	1522	1532	1521	1515	1512	1492	1524	1518	1515	1495
BCL Average Outflow	1570	2150	3060	1570	2150	3060	2340	2080	1900	1690	2340	2090	1900	1690
BCL Average Turbine Flow	1470	1820	2180	1510	1890	2220	1970	1770	1740	1570	2040	1840	1810	1630
BCL Average Spillway Flow	60	300	900	10	230	860	360	310	260	150	280	230	170	80
BCL Days Tributary Flows Not Met	0	6	62	0	3	59	2	6	3	34	2	4	2	33
Days Below Detroit Lake State Park Boat Ramp D, 1556 ft.	228	269	366	228	265	366	251	284	356	365	248	282	355	365
Days Below Mongold East Boat Ramp, 1540 ft.	180	210	365	176	208	365	200	222	272	365	201	221	271	365
Days Below Kane's Marina , 1546 ft.	201	225	365	199	225	365	216	245	282	365	213	241	281	365
Days Below Hoover Boat Ramp, 1543 ft.	189	219	365	188	216	365	207	233	276	365	207	229	276	365
Days Below South Shore Boat Ramp, 1542 ft.	186	217	365	184	213	365	205	230	275	365	205	227	274	365
Days Below Cove Creek Boat Ramp, 1541, ft.	183	213	365	181	210	365	202	227	273	365	203	225	273	365
Days Below Detroit Lake State Park Boat Ramp G, 1530 ft.	154	186	361	146	184	361	173	191	210	361	170	189	207	357
Days Below Mongold Main Boat Ramp, 1534 ft.	163	196	365	158	192	365	183	198	221	365	183	198	219	365
Days Below Mongold Low-Water Boat Ramp, 1450 ft.	0	1	15	0	0	14	1	1	1	8	0	2	0	5

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Exceedance Value Example for Baseline Run, Detroit Average Reservoir Outflow:
Total project outflow is 1570 cfs or less 5% of the time.
Total project outflow is 2150 cfs or less 50% of the time.
Total project outflow is 3060 cfs or less 95% of the time.

1.3.2.1. Biological Results

A comparison of winter SRP e-flows is shown in Table 9. There was not a significant increase over the Baseline count of e-flows with the total winter e-flows dropping from 109 to 108 and the spring e-flow count rising slightly from 25 to 26 over the POR. Flows were generally shifted higher as indicated by the number of type 3 e-flows decreasing and the number of type 1 e-flows increasing.

Table 9: Comparison of Exceedance Values at the Mehama Control Point between the Simulation DET Store More_021313 and the Baseline

North Santiam at Mehama											
Description of Modeling Target for Flows:				IRRM_Baseline_021313				DET Store More_021213			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	> 15 kcfs	1	77	0	1	2	88	0	0	2
Pulse2	Winter	12 -15 kcfs	3	22	0	0	0	18	0	0	0
Pulse3	Winter	10 - 12 kcfs	4	10	0	0	0	2	0	0	0
PulseA	Spring	> 12 kcfs	1	24	0	0	1	25	0	0	1
PulseB	Spring	10 - 12 kcfs	3	0	0	0	0	0	0	0	0
PulseC	Spring	8 - 10 kcfs	4	1	0	0	0	1	0	0	0
		Total Winter Pulses		109	0	1	2	108	0	0	2
		Total Spring Pulse		25	0	0	1	26	0	0	1

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.3.2.2. Assessing Impacts

A few key areas were assessed to verify impacts were understood including flood risk management, recreation and BiOp operations. The impacts to flood risk management were negligible with minor changes to peak bank full and flood stage flows as well as slight decreases to peak flows at Mehama and Jefferson as shown in Table 10. Exceedance values for control point flows are plotted in Figure 7 and Figure 8. Table 11 highlights that the Detroit Store More simulation, as compared to the Baseline, resulted in negligible changes to BiOp flow targets.

Note: This information was already discussed in the body of the report under the section Model Limitations, but is re-emphasized here. When considering the Flood Damage Reduction Summary table, certain model limitations must be emphasized. ResSim does not forecast flows, therefore, the model does not account for forecast error. Also, ResSim has perfect knowledge of the local inflows at each downstream control point using maximum flow rules. So the model only floods a downstream control point when it has no other option. This means that any increased risk of flooding is not adequately accounted for in the model. Regulators must make decisions with imperfect forecasts and an incomplete knowledge of what the local inflows will be in real time so flood risk is always likely to be higher than the model can show.

Despite these limitations, ResSim is still a valuable tool when addressing potential flood damage. The important piece is the comparison to the Baseline. Two simulations (the Baseline and a modification of the Baseline) are evaluated with the same POR. Differences give an indication as to whether the flood risk will increase. Analysis of model results should not be extrapolated to guess at the magnitude or the timing of the flood events, however.

Table 10: Comparison between Simulation DET Store More_021313 and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: DET Store More_021313							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years Conditional formatting compares to Baseline counterpart						Median Non-Exceedance Values by Water Year Type							
		IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	6	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	8	2	0	1	0	2	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	5	30	7	4	5	0	7	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	2	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	5	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	2	12	3	2	3	1	3	2	2	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	11	3	1	2	0	3	1	2	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	6	30	10	7	5	1	11	7	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	4	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11830	22650	12770	11290	10050	6540	12770	11290	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	8080	16870	25350	18850	16730	14910	10480	18850	16870	14910	10470
Willamette River at Eugene (EUGO)		13410	25350	38550	13410	25350	38550	26760	22780	20520	15760	26760	22780	20520	15760
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14570	24030	14850	14380	14250	12290	14850	14380	14250	12290
Willamette River at Harrisburg (HARO)		25000	50980	88980	25000	50980	88980	57730	48820	54190	38290	57730	48820	54190	38290
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14670	25080	15900	13950	14270	13370	15900	13950	14270	13350
North Santiam River at Mehama (MEHO)		11630	16300	25970	10960	16380	25980	17270	15890	16010	13190	17230	16230	15310	12360
Santiam River at Jefferson (JFFO)		27430	41700	77700	25610	41170	77670	46810	37800	40870	34690	46710	37950	39930	34210
Willamette River at Albany (ALBO)		36780	75670	130470	36780	75670	130470	80340	75670	72820	47750	80340	75670	72820	47750
Willamette River at Salem (SLMO)		65700	118820	203650	65060	118340	203630	125720	124670	131090	83590	125700	124580	130500	83680

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

Figure 7: Non-Exceedance for Regulated Flow at the Mehama Control Point on the North Santiam River. Compares Simulation DET Store More_021313 statistics (colored lines) to the Baseline statistics (gray areas).

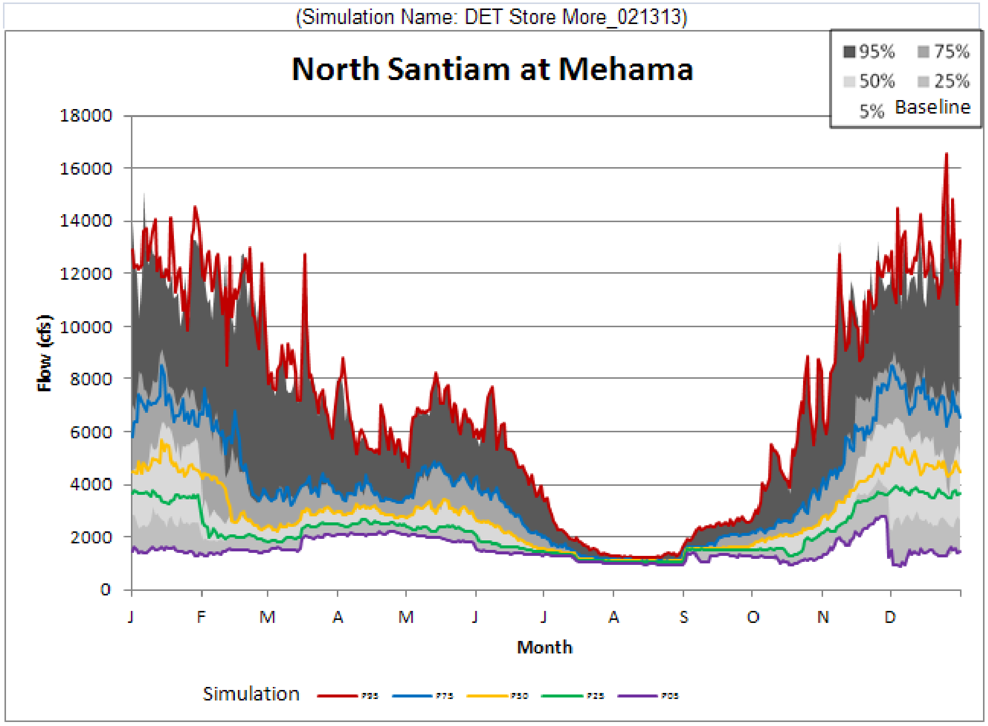


Figure 8: Non-Exceedance for Regulated Flow at the Jefferson Control Point on the Santiam River. Compares Simulation DET Store More_021313 statistics (colored lines) to the Baseline statistics (gray areas).

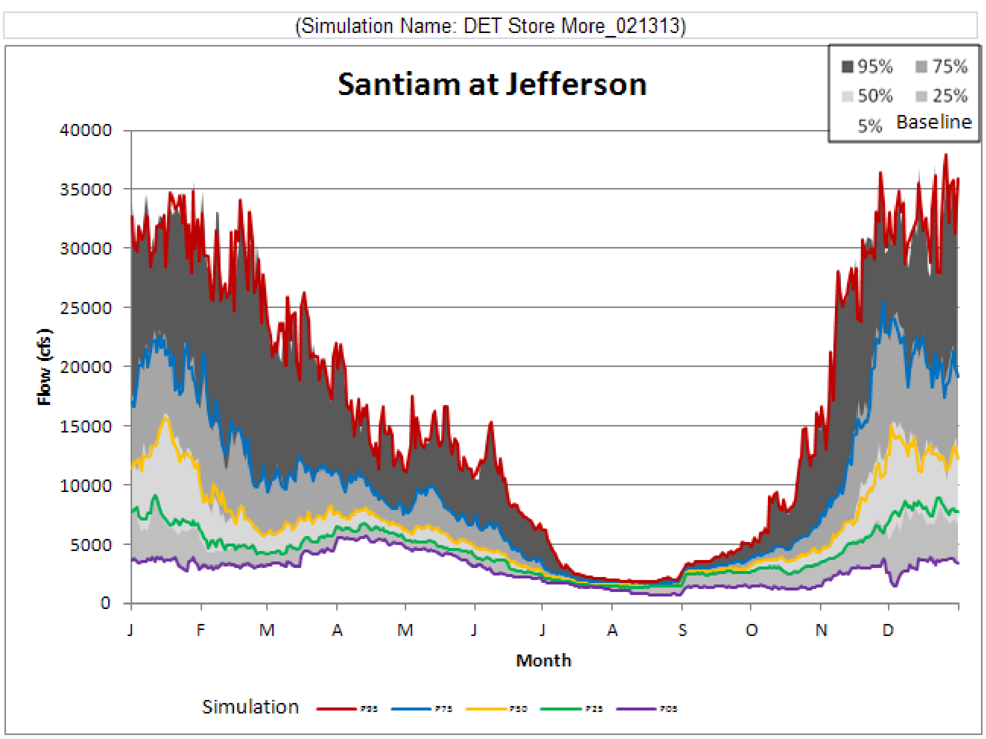


Table 11: BiOp Flow Targets: Comparison between Simulation DET Store More_021313 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

BiOp Flow Targets: Summary of Days Flows Not Met — Simulation: DET Store More_021313

Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	20	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	15	0	0	15	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	26	0	1	13	24	0	1	13	24
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	0	1	7	24	0	1	7	24
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	29	0	0	2	29
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	7	0	0	8	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	7	0	0	7	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	25	19	0	2	0	19	0	2	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	6	1	0	0	6	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	4	30	0	0	4	30
	16 March - 15 May	3000 cfs max	Rearing	6	19	42	6	19	42	29	16	8	7	30	16	8	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	0	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	3	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	26	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	17	0	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	14	1	4	1	5	1	4	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	7	9	1	0	6
	16 - 31 August	Varies		0	3	16	0	3	16	6	0	0	7	6	0	0	7
	01 - 30 September	Varies		0	5	28	0	5	28	5	2	0	15	5	1	0	15
Salem	01 - 31 October	Varies		0	0	12	0	0	12	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	7	17	1	8	13	12	1	8	13	12
	01 -31 May	Varies		0	5	23	0	5	23	0	14	17	21	0	14	18	21
	01 - 15 June	Varies		0	4	12	0	4	12	0	7	6	9	0	7	6	9
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	8	0	0	6	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	8	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	5	0	1
	01 - 30 September	Varies		0	0	24	0	0	24	0	3	0	1	0	3	0	1

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.

1.4. DETROIT RELEASE MORE

Changes to the Baseline rule, *Max Evacuation Release*, at Detroit allowed the project to release more at lower pool elevations and consequently store less. These changes still restricted the releases to the same range of flows as the Baseline and were done over a small range of elevations.

1.4.1. ResSim Rules

Information regarding the Baseline model and rules can be found in Section 1.1 and 1.2. Figure 1 found in Section 1.2.1 provides an example of the Baseline operation set structure for Detroit, as viewed within ResSim. For comparison purposes, a discussion of the original rule in the Baseline simulation can be found in Section 1.2.1.

New Name for the Modified Rule: *SRP Max Evacuation Release-Opt2*

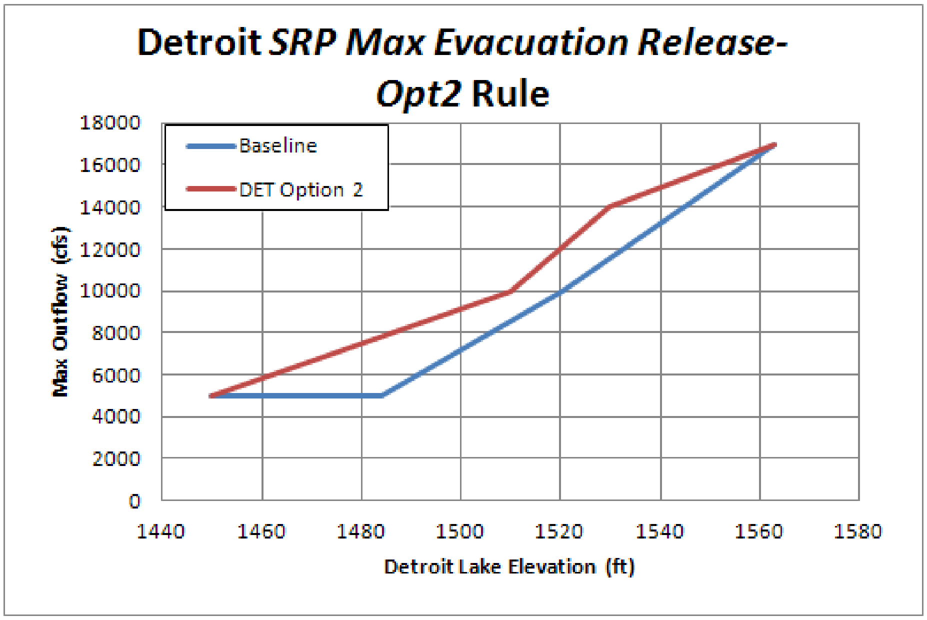
New Name for the Corresponding IF Block: *DET Release More and Fill Less Opt2*

Description of Changes: For this discussion, please refer to Table 12 and Figure 9, which show the relationships between flows and elevations for the Detroit Release More-Option 2 simulation. The new rule, *SRP Max Evacuation Release-Opt2*, shifts releases between 5,000 cfs and 10,000 cfs to occur lower in the pool. Linear interpolation between these two flows begins at elevation 1450.0 ft instead of holding the flow rate at 5,000 cfs up to elevation 1484.0 ft, as is done in the Baseline simulation. Since reservoir elevations low in the pool occur more often, the idea is that a greater amount and greater frequency of e-flows will result. As reservoir elevations increase, releases continue to be held higher by introducing an intermediate flow rate of 14,000 cfs at Elevation 1530.0 ft. For large events, the flow rate is capped at 17,000 cfs by the maximum evacuation rate due to physical constraints.

Table 12: Modified rule for Detroit Release More simulation

	Simulation: Baseline	**Simulation**: DET Release More_041313
	Rule Name: *Max Evacuation Release*	**Rule Name**: *SRP Max Evacuation Release – Opt2*
Detroit Elevation	**Maximum Release (cfs)**	
1450	5000	5000
1484	5000	
1510		10000
1520.1	10000	
1530		14000
1563	17000	17000

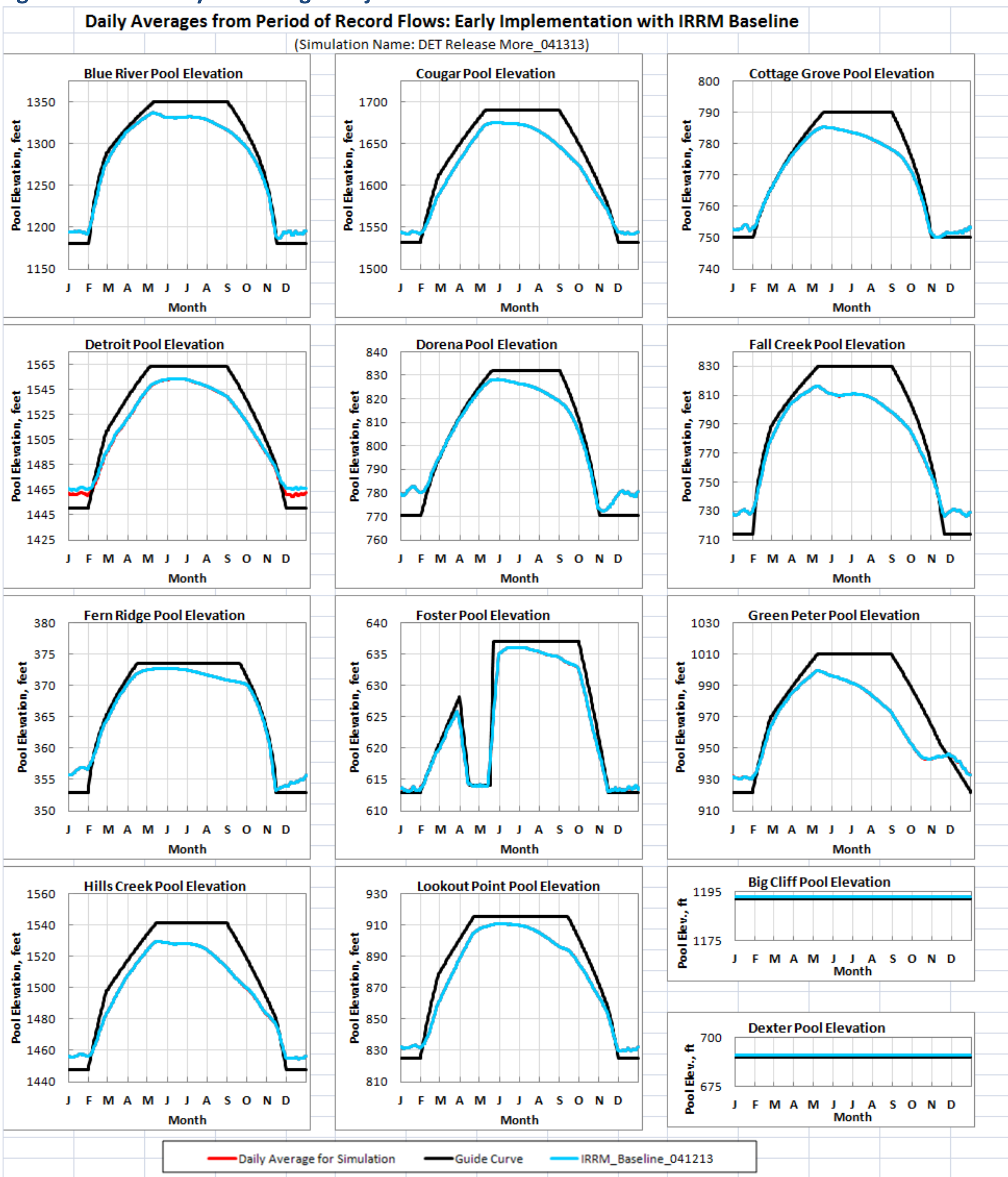
Figure 9: Maximum outflow as a function of Detroit Lake elevation for *SRP Max Evacuation Release-Opt2* Rule



1.4.2. Model Results

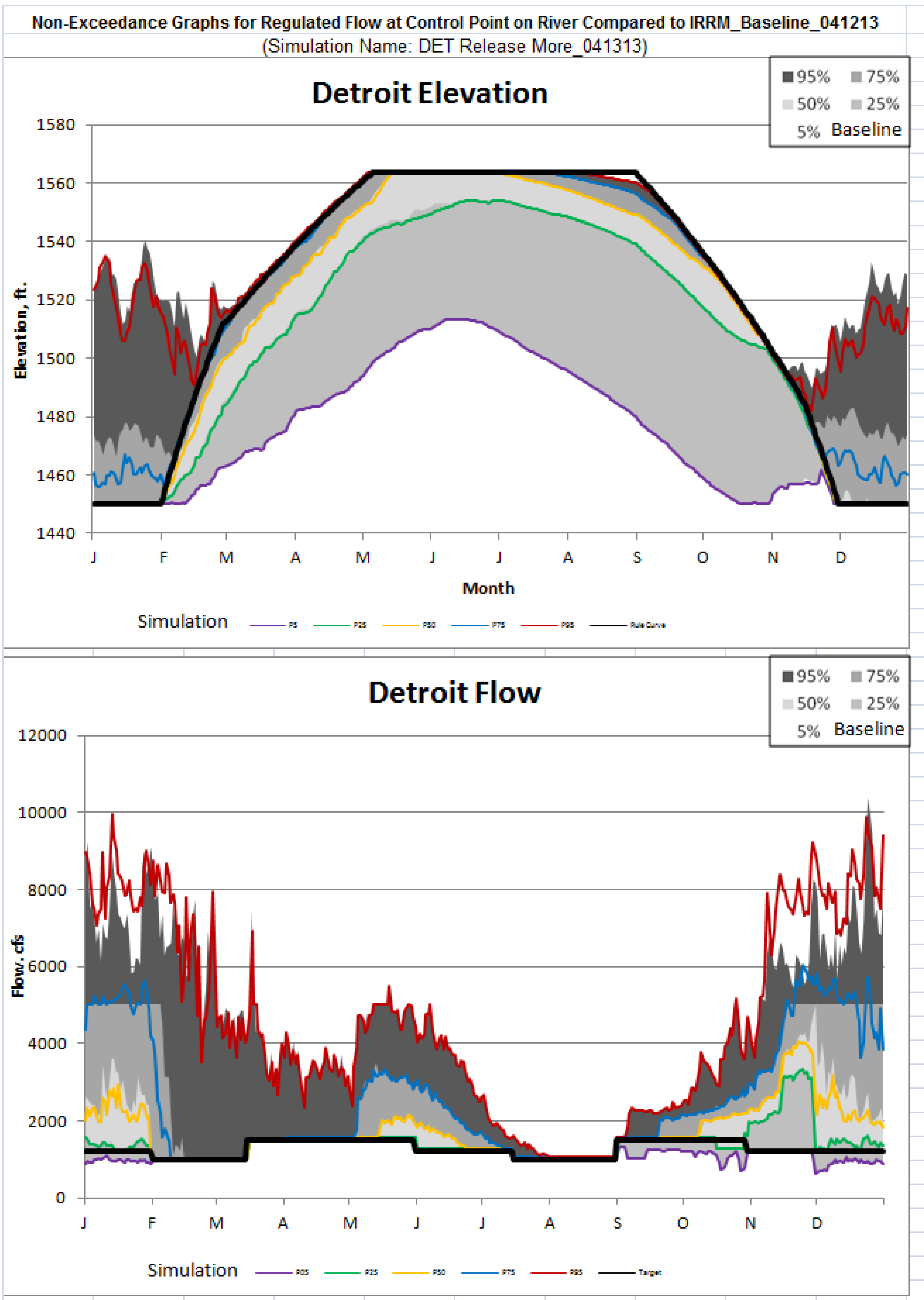
Average project elevations over the POR are shown in Figure 10. Based on this average, no project elevations were significantly changed except for Detroit, which was slightly lower in the winter. This meets expectations because only the rules for Detroit were changed and the specific change was to increase releases, thereby, decreasing pool elevations.

Figure 10: Summary of Average Project Elevations



As seen in Figure 11, the significant differences in flow and elevation occurred during the winter months. By allowing the releases to be higher, a lower pool level is expected. At this time only the 75th and 95th percentiles for elevation are visible above the rule curve for both the Detroit Release More simulation and the Baseline. The change is most pronounced at the 75th percentile, which is generally 10 feet lower than the Baseline.

Figure 11: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Detroit for Regulated Flow. Compares Simulation DET Release More_041313 statistics (colored lines) to the Baseline statistics (gray areas).



The higher maximum flow limits shift the flows as compared to the Baseline. Flows at the 50th percentile are lower by up to 800 cfs. There is no distinctive trend at the 75th percentile. At the 95th percentile the winter flows are greater than the Baseline by up to 1000 cfs, but peaks are maintained below 10,000 cfs in both simulations. Some large event responses (i.e. less frequent storm events) are captured in the 95% statistics. During these events, the project is likely near minimum outflow due to high flows downstream. The forced storage due to capturing nearly all the inflow results in a similar pool level as baseline (slightly less as seen in Figure 11). The maximum flow rule is higher than baseline for all pool levels (Figure 9), resulting in higher outflows at the 95th percentile, upon evacuation of stored flood water. It is important to remember that these graphs are a statistical representation over the whole period of record (73 years), therefore, the elevation is not directly related to the flow. With that in mind, and upon reexamination of the rule, the following conclusions can be made. At lower pool elevations there is a greater disparity between the Baseline and the Detroit Release More simulation. The rule is written so that releases are a function of reservoir elevation. So a lower elevation means lower releases, which in this case, is equal to or lower than Baseline flows up to the 75th percentile.

Notable conclusions from the project summary statistics in Table 13 are that the flows out of the upper regulating outlets at Detroit Dam have significantly increased by more than 130% for the Detroit Release More simulation. Turbine flows at Detroit showed small decreases, less than 100 cfs, which is less than a 5% decrease. This would have a small effect on hydropower production. There were no significant changes to the number of days the water elevation was below the boat ramps so recreation is not affected.

Table 13: Summary of Exceedance Values for Detroit and Big Cliff Projects

Detroit and Big Cliff Project Summary							Simulation: DET Release More_041313							
Exceedance Values for Average Flows, Elevations, and Number of Days Tributary Flows Not Met.	Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart)						Exceedance Values by Water Year Type							
	IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
DET Average Outflow	1570	2150	3060	1570	2150	3060	2340	2080	1900	1690	2340	2080	1900	1690
DET Average Upper Regulating Outlet Flow	10	90	340	30	160	480	100	110	90	30	170	140	170	80
DET Average Lower Regulating Outlet Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DET Average Turbine Flow	1300	1750	2170	1280	1670	2100	1810	1700	1600	1600	1730	1660	1590	1580
DET Average Spillway Flow	0	350	530	0	330	520	400	270	140	0	400	260	150	0
DET Average Reservoir Elevation	1482	1518	1530	1482	1517	1527	1521	1515	1512	1492	1520	1513	1512	1491
BCL Average Outflow	1570	2150	3060	1570	2150	3060	2340	2080	1900	1690	2340	2080	1900	1690
BCL Average Turbine Flow	1470	1820	2180	1450	1800	2150	1970	1770	1740	1570	1950	1730	1710	1550
BCL Average Spillway Flow	60	300	900	60	330	940	360	310	260	150	390	330	290	180
BCL Days Tributary Flows Not Met	0	6	62	0	6	62	2	6	3	34	2	6	3	34
Days Below Detroit Lake State Park Boat Ramp D, 1556 ft.	228	269	366	228	269	366	251	284	356	365	252	287	356	365
Days Below Mongold East Boat Ramp, 1540 ft.	180	210	365	183	212	365	200	222	272	365	201	227	269	365
Days Below Kane's Marina , 1546 ft.	201	225	365	201	226	365	216	245	282	365	214	245	292	365
Days Below Hoover Boat Ramp, 1543 ft.	189	219	365	192	218	365	207	233	276	365	207	239	274	365
Days Below South Shore Boat Ramp, 1542 ft.	186	217	365	188	217	365	205	230	275	365	205	235	273	365
Days Below Cove Creek Boat Ramp, 1541, ft.	183	213	365	185	214	365	202	227	273	365	203	231	271	365
Days Below Detroit Lake State Park Boat Ramp G, 1530 ft.	154	186	361	158	186	361	173	191	210	361	175	191	207	361
Days Below Mongold Main Boat Ramp, 1534 ft.	163	196	365	169	197	365	183	198	221	365	185	203	217	365
Days Below Mongold Low-Water Boat Ramp, 1450 ft.	0	1	15	0	1	15	1	1	1	8	1	1	1	8

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Exceedance Value Example for Baseline Run, Detroit Average Reservoir Outflow:
Total project outflow is 1570 cfs or less 5% of the time.
Total project outflow is 2150 cfs or less 50% of the time.
Total project outflow is 3060 cfs or less 95% of the time.

1.4.2.1. Biological Results

The results presented in Table 14 show that the number of total winter e-flows increased from 108 for the Baseline to 137. This is an improvement over the Detroit Store More simulation, which resulted in no change for total winter e-flows. The spring e-flows remained the same, which is not much of a change from the Detroit Store More simulation, which increased by 1 e-flow.

Unlike many of the other simulations, there is no trend towards higher flows. Both Type 1 and Type 3 e-flows increased from 80 to 94 and 8 to 23, respectively.

Table 14: Comparison of Exceedance Values at the Mehama Control Point between the Simulation DET Release More_041313 and the Baseline

North Santiam at Mehama											
Description of Modeling Target for Flows:				IRRM_Baseline_041213				DET Release More_041313			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	> 15 kcfs	1	80	0	1	2	94	0	1	2
Pulse2	Winter	12 -15 kcfs	3	20	0	0	0	20	0	0	0
Pulse3	Winter	10 - 12 kcfs	4	8	0	0	0	23	0	0	1
PulseA	Spring	> 12 kcfs	1	24	0	0	1	24	0	0	1
PulseB	Spring	10 - 12 kcfs	3	0	0	0	0	0	0	0	0
PulseC	Spring	8 - 10 kcfs	4	1	0	0	0	1	0	0	0
		Total Winter Pulses		108	0	1	2	137	0	1	3
		Total Spring Pulse		25	0	0	1	25	0	0	1

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.4.2.2. Assessing Impacts

A few key areas were assessed to verify that impacts were understood including flood risk management, recreation and BiOp operations. The impacts to flood risk management were negligible with very minor decreases in the number of days above bank full and flood stage. Peak flows were not substantially different at any downstream control points. There were minor increases to the 50th percentile peak flows at Harrisburg, Mehama and Jefferson and slight decreases to Albany and Salem. There were slight decreases to many of the 95th percentile peak flows. Exceedance values for control point flows that are directly affected by Detroit Dam are plotted in Figure 12 and Figure 13. Table 16 highlights that the Detroit Release More simulation, as compared to the Baseline, results in negligible changes to BiOp flow targets.

Table 15: Comparison between Simulation DET Release More and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: DET Release More_041313							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years Conditional formatting compares to Baseline counterpart						Median Non-Exceedance Values by Water Year Type							
		IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	5	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	8	2	0	1	0	2	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	4	34	7	4	5	0	7	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	3	10	3	2	3	1	3	2	3	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	9	3	1	2	0	2	2	2	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	6	31	10	7	5	1	10	8	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	1	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	3	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11650	22660	12770	11290	10050	6540	12770	11160	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	8080	17760	23530	18850	16730	14910	10480	19300	17180	15340	10270
Willamette River at Eugene (EUGO)		13410	25350	38550	13260	25440	36750	26760	22780	20520	15760	26980	24250	20740	15580
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14570	24030	14850	14380	14250	12290	14850	14380	14250	12290
Willamette River at Harrisburg (HARO)		25000	50980	88980	25220	52170	84050	57730	48820	54190	38290	54890	51090	54530	38290
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14700	25080	15900	13950	14270	13370	15900	13950	14270	13440
North Santiam River at Mehama (MEHO)		11630	16300	25970	11820	16810	25400	17270	15890	16010	13190	17410	16340	17040	13530
Santiam River at Jefferson (JFFO)		27430	41700	77700	27570	41790	77700	46810	37800	40870	34690	46780	38160	40880	37080
Willamette River at Albany (ALBO)		36780	75670	130470	36740	74480	127590	80340	75670	72820	47750	79140	74480	73030	47850
Willamette River at Salem (SLMO)		65700	118820	203650	65660	117640	201470	125720	124670	131090	83590	123220	124510	131400	85090

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

When analyzing the Flood Damage Reduction Summary table, refer to the note in Section 1.3.2.2.

Figure 12: Non-Exceedance for Regulated Flow at the Mehama Control Point on the North Santiam River. Compares Simulation DET Release More_041313 statistics (colored lines) to the Baseline statistics (gray areas).

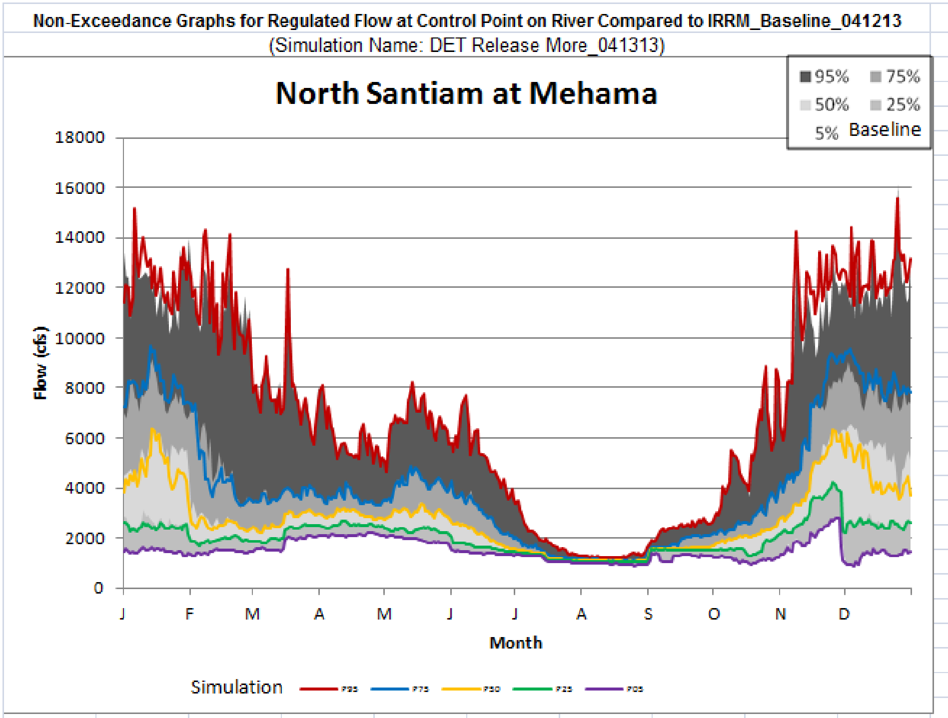


Figure 13: Non-Exceedance for Regulated Flow at the Jefferson Control Point on the Santiam River. Compares Simulation DET Release More_041313 statistics (colored lines) to the Baseline statistics (gray areas).

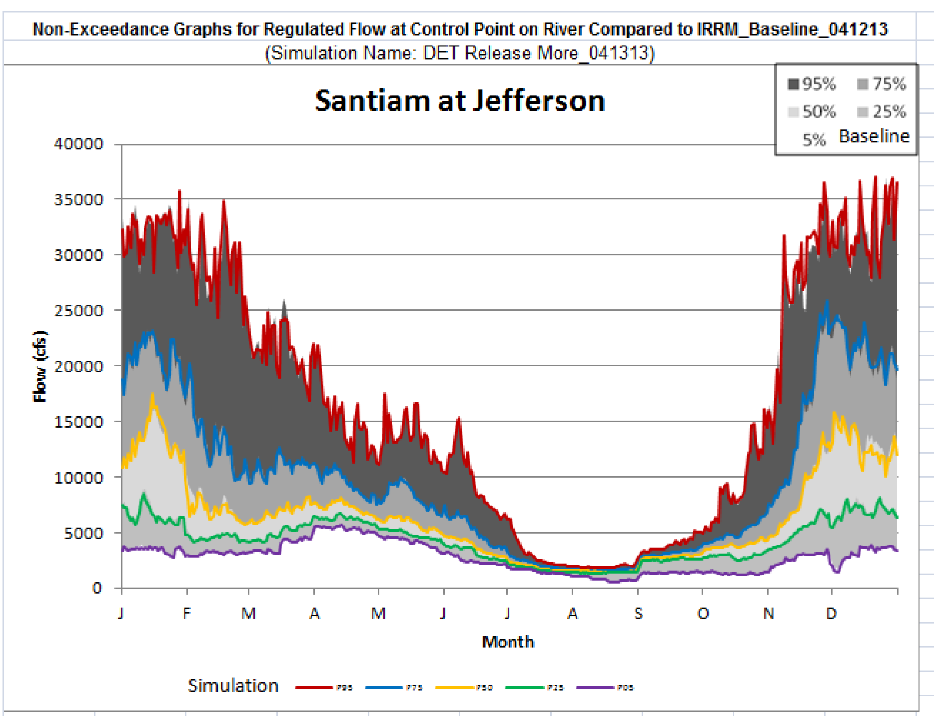


Table 16: BiOp Flow Targets: Comparison between Simulation DET Release More_041313 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

BiOp Flow Targets: Summary of Days Flows Not Met										Simulation: DET Release More_041313							
Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	21	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	26	0	2	12	24	0	2	12	24
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	1	1	9	24	0	1	9	24
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	28	0	0	2	28
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	5	0	0	6	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	8	0	0	8	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	25	18	0	2	0	18	0	2	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	7	1	0	0	7	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	5	30	0	0	5	30
	16 March - 15 May	3000 cfs max	Rearing	5	19	42	5	19	42	30	16	8	7	30	16	8	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	2	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	28	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	15	0	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	15	2	4	1	5	1	4	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	8	9	1	0	7
	16 - 31 August	Varies		0	4	16	0	3	16	6	0	0	7	6	0	0	7
	01 - 30 September	Varies		0	5	27	0	5	27	5	2	0	15	5	2	0	15
Salem	01 - 31 October	Varies		0	0	12	0	0	12	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	7	17	1	8	14	12	1	8	14	12
	01 -31 May	Varies		0	5	23	0	5	23	0	14	15	21	0	14	15	21
	01 - 15 June	Varies		0	4	12	0	4	12	0	6	6	9	0	6	6	9
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	5	0	0	5	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	8	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	5	0	0
	01 - 30 September	Varies		0	0	23	0	0	23	0	3	0	1	0	3	0	1

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.

1.5. COUGAR STORE MORE

Cougar Dam was modeled in ResSim to release less flow lower in the pool to allow for more stored water to be available during the environmental e-flow.

1.5.1. ResSim Rules

Information regarding the Baseline model and rules can be found in Section 1.1 and 1.2. Figure 2 found in Section 0 provides an example of the operation set structure for Cougar, as viewed within ResSim. For comparison purposes, a discussion of the original rule in the Baseline simulation can be found in Section 0.

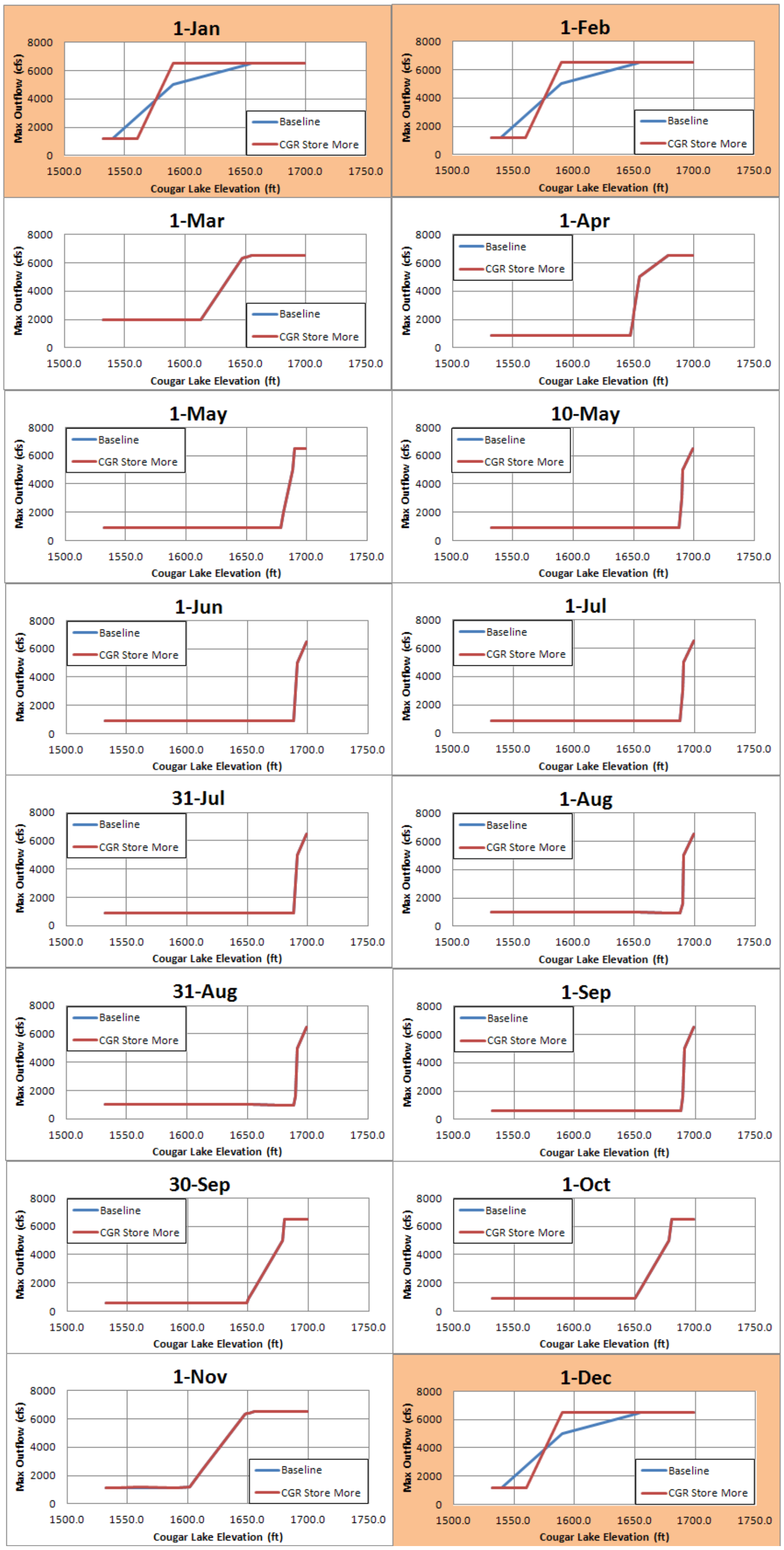
<u>New Name for the Modified Rule:</u> *Max Flow (Winter and Con)_StorMore*

<u>Description of Changes:</u>
As shown in Table 17 and Figure 14; January, February and December were the only months with changes that impacted the simulation because the winter flood risk management operations were targeted for this study. Also, a new inflection point was added for elevation 1560.0 ft to limit outflows for the targeted months to a 'typical' moderate winter flow rate of 1,200 cfs. Maintaining 1,200 cfs longer, fills more than the Baseline run while still low in the pool. For the other months, flows were determined at this elevation by linear interpolation between contiguous values at elevations 1540.0 ft and 1590.0 ft. To provide flood storage that is comparable to the Baseline, flows are released at a higher rate as the reservoir elevation increases. From 1590.0 ft to the top of flood control storage (1699.0 ft), the maximum evacuation rate (6,500 cfs) is released.

Table 17: Modified Rule for Cougar Store More Simulation

Baseline: *Max Flow (Winter and Conservation)* Rule																
Cougar Elev	1-Jan	1-Feb	1-Mar	1-Apr	1-May	10-May	1-Jun	1-Jul	31-Jul	1-Aug	31-Aug	1-Sep	30-Sep	1-Oct	1-Nov	1-Dec
1532.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1104	1200
1540.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1134	1200
1590.0	5000	5000	2000	900	900	900	900	900	900	1000	1000	580	580	900	1119	5000
1601.6	5270	5270	2000	900	900	900	900	900	900	1000	1000	580	580	900	1200	5270
1612.6	5520	5520	2000	900	900	900	900	900	900	1000	1000	580	580	900	2430	5520
1647.3	6320	6320	6320	900	900	900	900	900	900	1000	1000	580	580	900	6320	6320
1649.3	6370	6370	6370	2000	900	900	900	900	900	1000	1000	580	580	900	6370	6370
1650.4	6390	6390	6390	2580	900	900	900	900	900	1000	1000	580	900	900	6390	6390
1655.0	6500	6500	6500	5000	900	900	900	900	900	1000	1000	580	1570	1570	6500	6500
1678.5	6500	6500	6500	6500	900	900	900	900	900	948	948	580	5000	5000	6500	6500
1680.5	6500	6500	6500	6500	2000	900	900	900	900	945	945	580	6500	6500	6500	6500
1688.0	6500	6500	6500	6500	5000	900	900	900	900	931	931	580	6500	6500	6500	6500
1690.0	6500	6500	6500	6500	6500	3000	3000	3000	3000	1600	1600	1600	6500	6500	6500	6500
1691.0	6500	6500	6500	6500	6500	5000	5000	5000	5000	5000	5000	5000	6500	6500	6500	6500
1699.0	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500
CGR Store More: *Max Flow (Winter and Con)_StorMore* Rule																
Cougar Elev	1-Jan	1-Feb	1-Mar	1-Apr	1-May	10-May	1-Jun	1-Jul	31-Jul	1-Aug	31-Aug	1-Sep	30-Sep	1-Oct	1-Nov	1-Dec
1532.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1104	1200
1540.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1134	1200
1560.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1190	1200
1590.0	6500	6500	2000	900	900	900	900	900	900	1000	1000	580	580	900	1119	6500
1601.6	6500	6500	2000	900	900	900	900	900	900	1000	1000	580	580	900	1200	6500
1612.6	6500	6500	2000	900	900	900	900	900	900	1000	1000	580	580	900	2430	6500
1647.3	6500	6500	6320	900	900	900	900	900	900	1000	1000	580	580	900	6320	6500
1649.3	6500	6500	6370	2000	900	900	900	900	900	1000	1000	580	580	900	6370	6500
1650.4	6500	6500	6390	2580	900	900	900	900	900	1000	1000	580	900	900	6390	6500
1655.0	6500	6500	6500	5000	900	900	900	900	900	1000	1000	580	1570	1570	6500	6500
1678.5	6500	6500	6500	6500	900	900	900	900	900	948	948	580	5000	5000	6500	6500
1680.5	6500	6500	6500	6500	2000	900	900	900	900	945	945	580	6500	6500	6500	6500
1688.0	6500	6500	6500	6500	5000	900	900	900	900	931	931	580	6500	6500	6500	6500
1690.0	6500	6500	6500	6500	6500	3000	3000	3000	3000	1600	1600	1600	6500	6500	6500	6500
1691.0	6500	6500	6500	6500	6500	5000	5000	5000	5000	5000	5000	5000	6500	6500	6500	6500
1699.0	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500
Note: Orange fill highlights changes between the two rules																

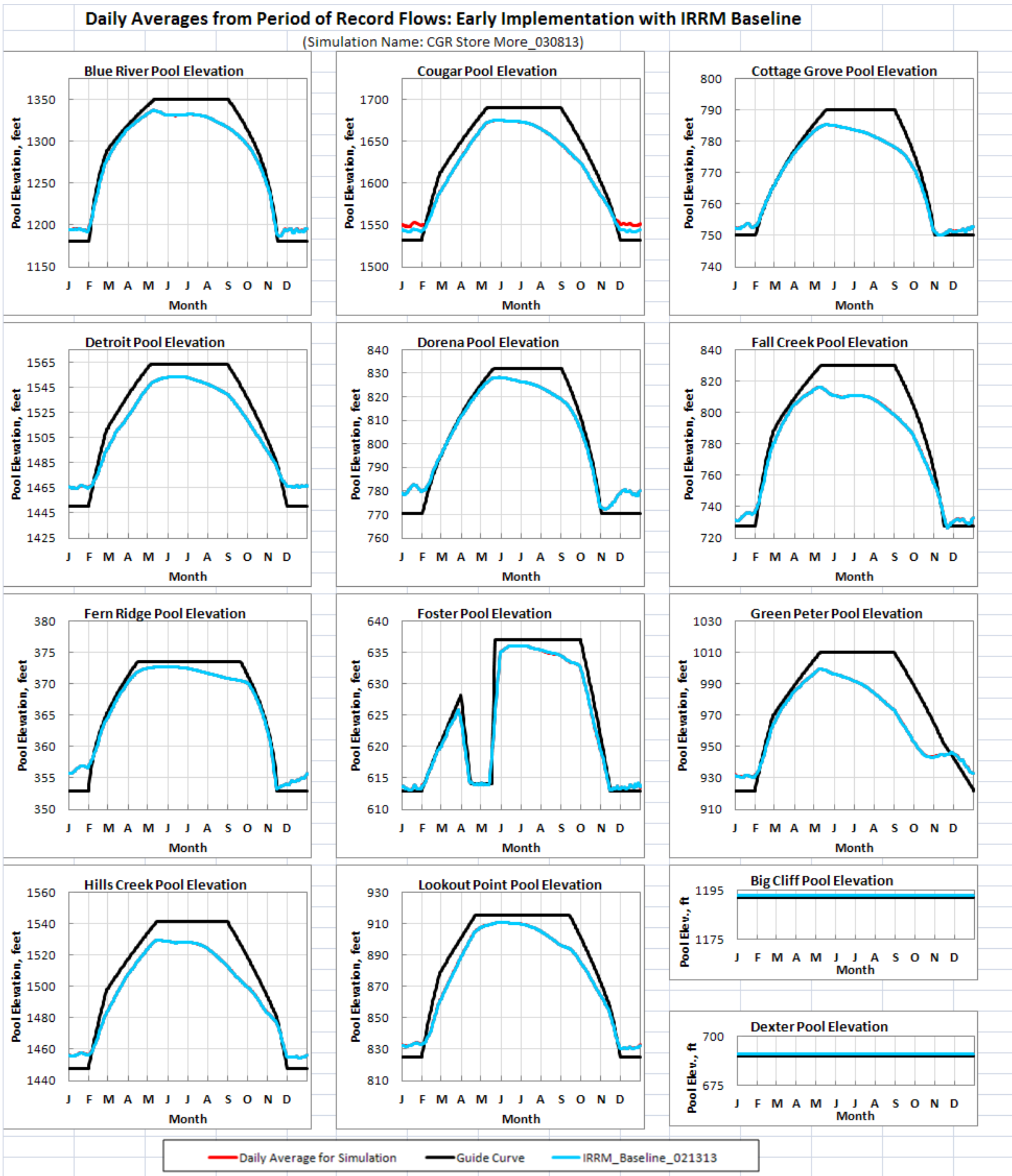
Figure 14: Maximum outflow as a function of Cougar Lake elevation for *Max Flow (Winter and Con)_StorMore* Rule



1.5.2. Model Results

The average project elevations over the POR for all projects are summarized in Figure 15. Based on this average, project elevations remained relatively unchanged except for Cougar, which was slightly higher as is expected for this simulation.

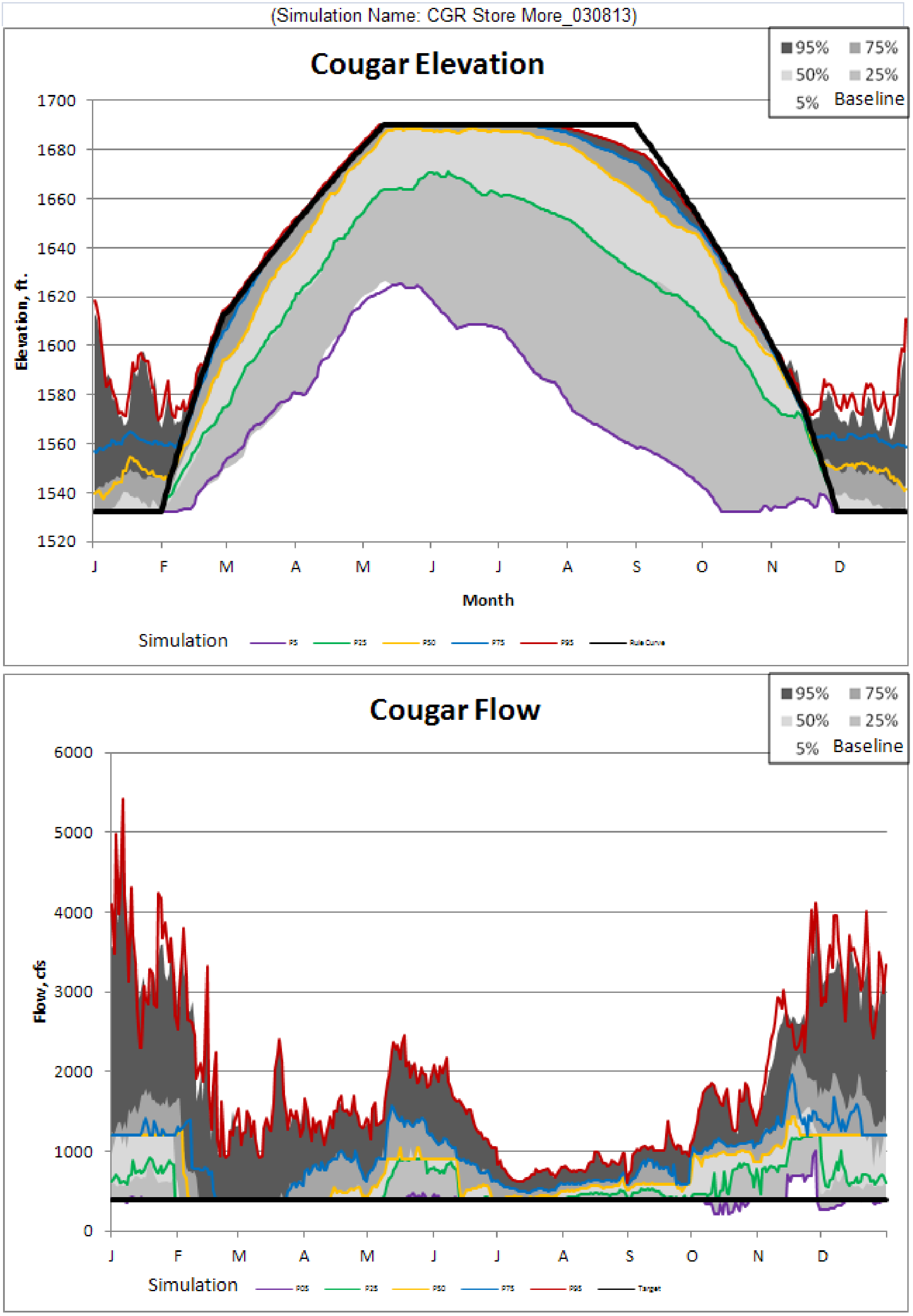
Figure 15: Summary of Average Project Elevations



As shown in Figure 16, the significant differences in flow and elevation occurred during January, February and December. Please note that the Baseline 50th percentile is the first gray area visible above the Rule Curve during the specified months. The 5th and 25th percentiles are not visible on the graph until the spring and summer months. The 50th percentile for the Cougar Store More simulation has the largest increase (approximately 25 feet) compared to the Baseline. The 75th percentile averages about 10 feet higher and the 95th percentile is approximately 5 feet higher. Flows low in the pool show only small changes from the Baseline, which can be seen by examining the 5th percentile, 25th percentile and 50th percentile lines on the second Cougar Flow graph. The largest change in flow is seen in the 75th percentile with the Baseline releasing up to 500 cfs more.

To better understand the relationship between elevation and flow described in the previous paragraph, the rule (Table 17, Figure 14) must be re-examined. Up to elevation 1540.0 feet, the Baseline rule, *Max Flow (Winter and Conservation),* releases 1200 cfs, while the Cougar Store More simulation releases 1200 cfs until elevation 1560.0 feet. Looking again at Figure 16, the 50th percentile for the Baseline does not exceed elevation 1540.0 feet and the 50th percentile for the Cougar Store More simulation does not exceed 1560.0 feet so, based on the rule differences, both are releasing 1200 cfs even though the Baseline is 20 feet lower in the pool. For the same reasoning, the Baseline releases more higher in the pool (75th percentile). At the 95th percentile, the Baseline releases less because the *Max Flow (Winter and Con)_StorMore* rule begins to release 6500 cfs at elevation 1590.0 feet, which is much earlier than the Baseline (6500 cfs begins to get released at elevation 1655.0 ft).

Figure 16: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Cougar for Regulated Flow. Compares Simulation CGR Store More_030813 statistics (colored lines) to the Baseline statistics (gray areas).



As shown in Table 18, there were no marked changes to exceedance values for the Cougar Project. There was a 2% decrease to turbine flows. This is likely offset with a slight increase in pool levels, resulting in an increase in the “head” which is the difference in elevation between the forebay and tailwater elevations. Hydropower generation is a function of the flow and the head, with lower outflow needed to produce the same generation at a higher head (conversely higher discharges are needed at lower heads). It is anticipated that such small changes in flow and head would likely result in an overall negligible impact to hydropower. Recreation would not be impacted.

Table 18: Summary of Exceedance Values for Cougar

Cougar Project Summary		Simulation: CGR Store More_030813													
Non-Exceedance Values for various Water Year Statistics		Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart)						Median Non-Exceedance Values by Water Year Type							
		IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
		5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Average Outflow, cfs		610	850	1210	610	850	1210	910	780	690	660	910	780	690	660
Average RO Flow, cfs		90	230	530	90	230	540	280	170	110	100	290	180	120	100
Average Turbine Flow, cfs		530	620	700	520	610	690	630	620	580	550	630	610	570	550
Average Spillway Flow, cfs		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Days Min Tributary Flows Not Met		0	0	25	0	0	25	0	0	0	3	0	0	0	3
Average Reservoir Elevation, ft		1582	1621	1632	1583	1623	1635	1627	1615	1611	1587	1628	1615	1610	1588
Days Below Slide Creek Boat Ramp	1635 ft.	157	179	341	159	177	339	171	207	225	330	171	202	225	329
Days Below Echo Park Boat Ramp	1635 ft.	157	179	341	159	177	339	171	207	225	330	171	202	225	329

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Average Reservoir Outflow:
Total project outflow is 610 cfs or less 5% of the time.
Total project outflow is 850 cfs or less 50% of the time.
Total project outflow is 1210 cfs or less 95% of the time.

1.5.2.1. Biological Results

Table 19 shows that overall, the number of winter e-flows dropped from 49 to 47 and the number of spring e-flows dropped from 63 to 62. The number of Type 1 e-flows increased the most during the Cougar Store More simulation. Type 3 e-flows decreased. Spring e-flows stayed relatively consistent.

Table 19: Comparison of exceedance values for the flow out of Cougar between the Simulation CGR Store More_030813 and the Baseline

Cougar Dam, Flow Out											
Description of Modeling Target for Flows:				IRRM_Baseline_021313				CGR Store More_030813			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	>6 kcfs	1	4	0	0	0	15	0	0	0
Pulse2	Winter	4 - 6 kcfs	3	29	0	0	1	29	0	0	1
Pulse3	Winter	3 - 4 kcfs	4	16	0	0	0	3	0	0	0
PulseA	Spring	>4 kcfs	1	4	0	0	0	4	0	0	0
PulseB	Spring	2.5 - 4 kcfs	3	13	0	0	0	13	0	0	0
PulseC	Spring	1.5 - 2.5 kcfs	4	46	0	0	1	45	0	0	1
		Total Winter Pulses		49	0	0	1	47	0	0	1
		Total Spring Pulse		63	0	0	1	62	0	0	1

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.5.2.2. Assessing Impacts

A few key areas were assessed to verify that impacts were understood including flood risk management, recreation and BiOp operations. Table 20 and Figure 17 show that there are minimal impacts to flood risk. Vida, the control point for Cougar, is the best indicator of potential downstream flood consequences introduced by operations changes implemented at Cougar. In Figure 17 the 95th percentile shows slightly higher flows passing Vida. This is expected because releases from the dam, during these large events, would be higher (see the explanation for Figure 16). The 75th percentile trends towards decreased flows at Vida. Table 20 has no increase in days above bankfull or days above flood stage at Vida.

Table 21 highlights that the Cougar Release More simulation, as compared to the Baseline, results in negligible changes to BiOp flow targets.

Table 20: Comparison between Simulation CGR Store More_030813 and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: CGR Store More_030813							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years; Conditional formatting compares to Baseline counterpart						Median Non-Exceedance Values by Water Year Type							
		IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	6	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	8	2	0	1	0	2	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	4	31	7	4	5	0	7	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	2	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	3	11	3	2	3	1	3	2	3	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	11	3	1	2	0	3	1	2	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	6	29	10	7	5	1	10	7	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	3	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11830	22650	12770	11290	10050	6540	12770	11290	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	8080	16730	25350	18850	16730	14910	10480	18850	16730	14920	10490
Willamette River at Eugene (EUGO)		13410	25350	38550	13410	25350	38550	26760	22780	20520	15760	26760	22920	20610	15760
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14620	24040	14850	14380	14250	12290	14850	14390	14010	12210
Willamette River at Harrisburg (HARO)		25000	50980	88980	24980	50710	88970	57730	48820	54190	38290	57830	48810	53850	37910
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14700	25080	15900	13950	14270	13370	15900	13950	14270	13370
North Santiam River at Mehama (MEHO)		11630	16300	25970	11630	16300	25970	17270	15890	16010	13190	17270	15940	16010	13190
Santiam River at Jefferson (JFFO)		27430	41700	77700	27430	41700	77700	46810	37800	40870	34690	46800	37800	40870	34690
Willamette River at Albany (ALBO)		36780	75670	130470	36860	75670	130440	80340	75670	72820	47750	80300	75670	72520	47580
Willamette River at Salem (SLMO)		65700	118820	203650	65750	119020	203630	125720	124670	131090	83590	125240	124670	131060	83270

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

** When analyzing the Flood Damage Reduction Summary table, refer to the note in Section 1.3.2.2.*

Figure 17: Non-Exceedance for Regulated Flow at the Vida Control Point on the McKenzie River. Compares Simulation CGR Store More_030813 statistics (colored lines) to the Baseline statistics (gray areas).

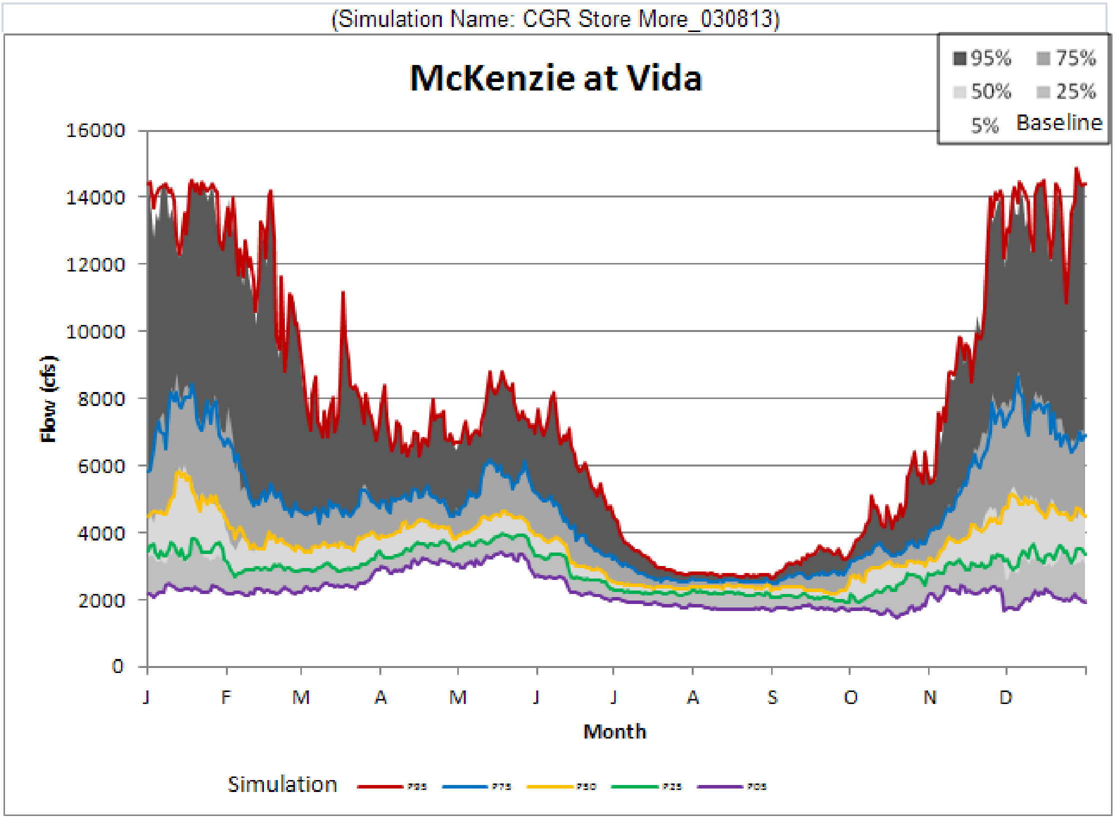


Table 21: BiOp Flow Targets: Comparison between Simulation CGR Store More_030813 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

BiOp Flow Targets: Summary of Days Flows Not Met										Simulation: CGR Store More_030813							
Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	20	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	15	0	0	15	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	26	0	1	13	24	0	1	12	24
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	0	1	7	24	0	1	7	24
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	29	0	0	1	28
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	7	0	0	8	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	2	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	7	0	0	7	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	25	19	0	2	0	19	0	2	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	6	1	0	0	6	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	4	30	0	0	4	30
	16 March - 15 May	3000 cfs max	Rearing	6	19	42	5	18	42	29	16	8	7	30	16	8	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	2	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	28	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	15	1	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	15	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	15	1	4	1	5	1	4	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	7	9	1	0	6
	16 - 31 August	Varies		0	3	16	0	3	16	6	0	0	7	6	0	0	7
	01 - 30 September	Varies		0	5	28	0	5	27	5	2	0	15	5	2	0	15
Salem	01 - 31 October	Varies		0	0	12	0	0	12	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	6	17	1	8	13	12	1	8	13	12
	01 -31 May	Varies		0	5	23	0	5	23	0	14	17	21	0	14	16	21
	01 - 15 June	Varies		0	4	12	0	4	12	0	7	6	9	0	7	6	9
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	8	0	0	8	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	8	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	7	0	1
	01 - 30 September	Varies		0	0	24	0	0	23	0	3	0	1	0	3	0	1

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.

1.6. COUGAR RELEASE MORE

Changes to the Baseline rule, *Max Flow (Winter and Con)*, at Cougar allowed the project to release more at lower pool elevations and consequently store less.

1.6.1. ResSim Rules

Information regarding the Baseline model and rules can be found in Section 1.1 and 1.2. Figure 2 found in Section 0 provides an example of the operation set structure for Cougar, as viewed within ResSim. For comparison purposes, a discussion of the original rule in the Baseline simulation can be found in Section 0.

<u>New Name for the Modified Rule:</u> *Max Flow (Winter and Con_RelMore)*

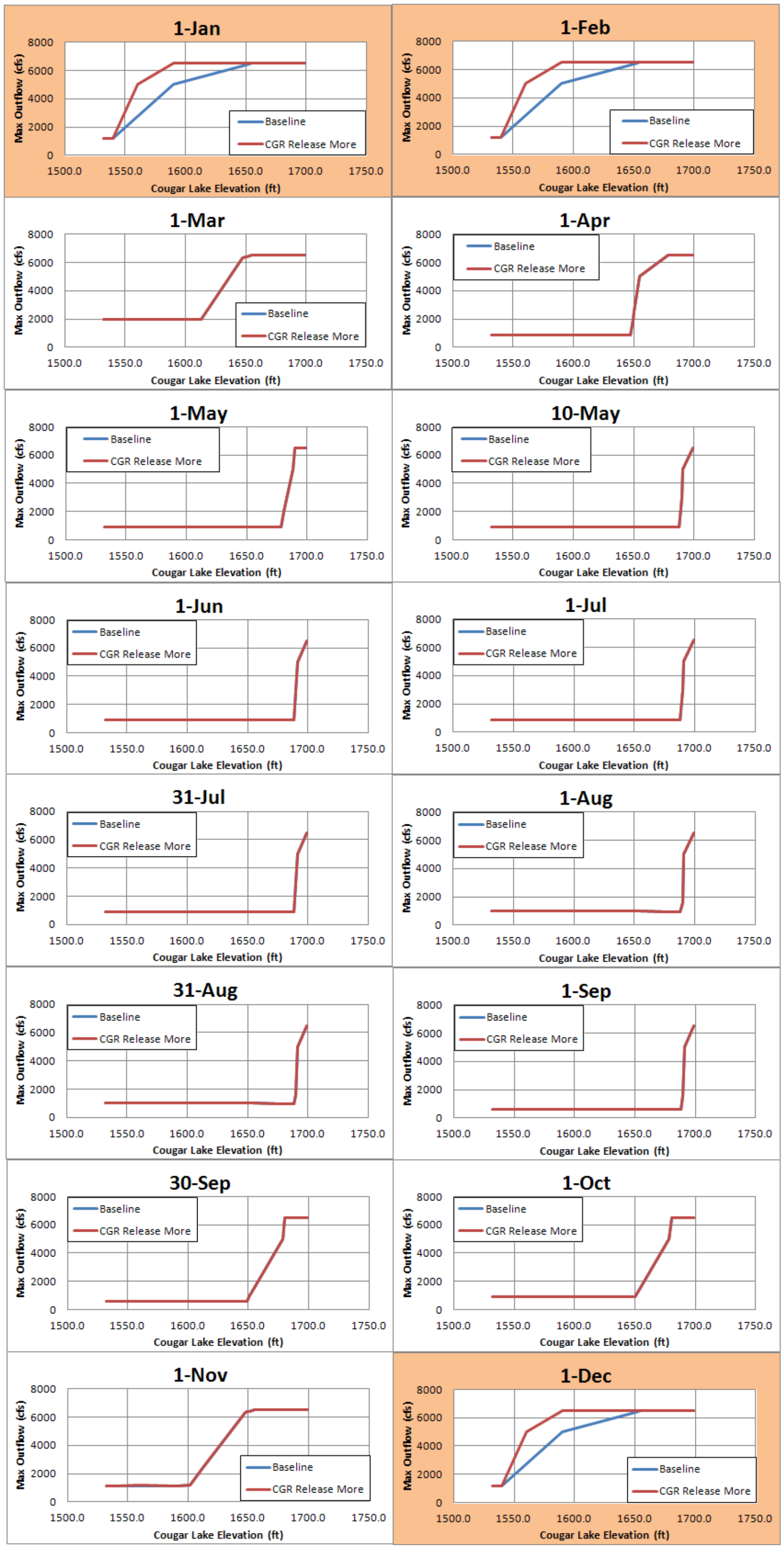
<u>Description of Changes:</u>
As shown in Table 22 and Figure 18; January, February and December were the only months with changes that impacted the simulation because the winter flood risk management operations were targeted for this study. Also, a new inflection point was added for elevation 1560.0 ft to increase outflows earlier for the targeted months, while still low in the pool. For the other months, flows were determined at this elevation by linear interpolation between contiguous values at elevations 1540.0 ft and 1590.0 ft.

Outflows remain higher than the Baseline from 1590.0 - 1655.0 ft. The Baseline interpolates between 5,000 cfs and 6,500 cfs over this range while the Cougar Release More simulation starts releasing 6,500 cfs at elevation 1590.0 ft. From 1655.0 ft-1699.0 ft, the Baseline and the Cougar Release More simulation both released 6,500 cfs. 5,000 cfs is the normal evacuation rate for the project and 6,500 cfs is the maximum evacuation rate. The top of flood storage is elevation 1699.0 ft.

Table 22: Modified rule for Cougar Release More simulation

Baseline: *Max Flow (Winter and Conservation)* Rule																
Cougar Elev	1-Jan	1-Feb	1-Mar	1-Apr	1-May	10-May	1-Jun	1-Jul	31-Jul	1-Aug	31-Aug	1-Sep	30-Sep	1-Oct	1-Nov	1-Dec
1532.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1104	1200
1540.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1134	1200
1590.0	5000	5000	2000	900	900	900	900	900	900	1000	1000	580	580	900	1119	5000
1601.6	5270	5270	2000	900	900	900	900	900	900	1000	1000	580	580	900	1200	5270
1612.6	5520	5520	2000	900	900	900	900	900	900	1000	1000	580	580	900	2430	5520
1647.3	6320	6320	6320	900	900	900	900	900	900	1000	1000	580	580	900	6320	6320
1649.3	6370	6370	6370	2000	900	900	900	900	900	1000	1000	580	580	900	6370	6370
1650.4	6390	6390	6390	2580	900	900	900	900	900	1000	1000	580	900	900	6390	6390
1655.0	6500	6500	6500	5000	900	900	900	900	900	1000	1000	580	1570	1570	6500	6500
1678.5	6500	6500	6500	6500	900	900	900	900	900	948	948	580	5000	5000	6500	6500
1680.5	6500	6500	6500	6500	2000	900	900	900	900	945	945	580	6500	6500	6500	6500
1688.0	6500	6500	6500	6500	5000	900	900	900	900	931	931	580	6500	6500	6500	6500
1690.0	6500	6500	6500	6500	6500	3000	3000	3000	3000	1600	1600	1600	6500	6500	6500	6500
1691.0	6500	6500	6500	6500	6500	5000	5000	5000	5000	5000	5000	5000	6500	6500	6500	6500
1699.0	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500
CGR Release More: *Max Flow (Winter and Con) RelMore* Rule																
Cougar Elev	1-Jan	1-Feb	1-Mar	1-Apr	1-May	10-May	1-Jun	1-Jul	31-Jul	1-Aug	31-Aug	1-Sep	30-Sep	1-Oct	1-Nov	1-Dec
1532.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1104	1200
1540.0	1200	1200	2000	900	900	900	900	900	900	1000	1000	580	580	900	1134	1200
1560.0	5000	5000	2000	900	900	900	900	900	900	1000	1000	580	580	900	1190	5000
1590.0	6500	6500	2000	900	900	900	900	900	900	1000	1000	580	580	900	1119	6500
1601.6	6500	6500	2000	900	900	900	900	900	900	1000	1000	580	580	900	1200	6500
1612.6	6500	6500	2000	900	900	900	900	900	900	1000	1000	580	580	900	2430	6500
1647.3	6500	6500	6320	900	900	900	900	900	900	1000	1000	580	580	900	6320	6500
1649.3	6500	6500	6370	2000	900	900	900	900	900	1000	1000	580	580	900	6370	6500
1650.4	6500	6500	6390	2580	900	900	900	900	900	1000	1000	580	900	900	6390	6500
1655.0	6500	6500	6500	5000	900	900	900	900	900	1000	1000	580	1570	1570	6500	6500
1678.5	6500	6500	6500	6500	900	900	900	900	900	948	948	580	5000	5000	6500	6500
1680.5	6500	6500	6500	6500	2000	900	900	900	900	945	945	580	6500	6500	6500	6500
1688.0	6500	6500	6500	6500	5000	900	900	900	900	931	931	580	6500	6500	6500	6500
1690.0	6500	6500	6500	6500	6500	3000	3000	3000	3000	1600	1600	1600	6500	6500	6500	6500
1691.0	6500	6500	6500	6500	6500	5000	5000	5000	5000	5000	5000	5000	6500	6500	6500	6500
1699.0	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500	6500
Note: Orange fill highlights changes betweent the two rules																

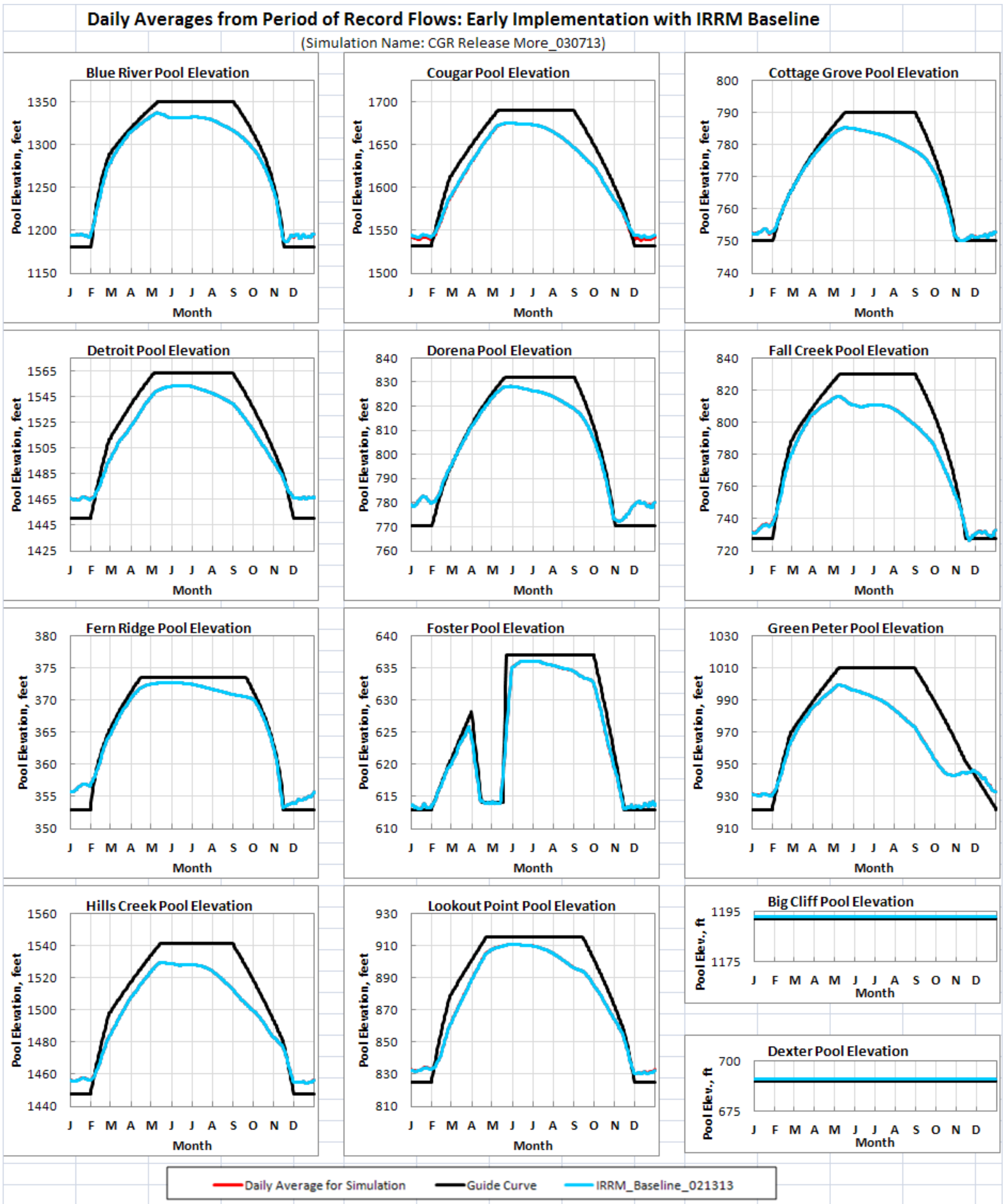
Figure 18: Maximum outflow as a function of Cougar Lake elevation for Max Flow (Winter and Con)_RelMore Rule



1.6.2. Model Results

As depicted in Figure 19, there were small decreases in pool elevation at Cougar for the months of January, February and December. No other projects had significant changes to reservoir elevations. This was expected because only Cougar was modified for this simulation.

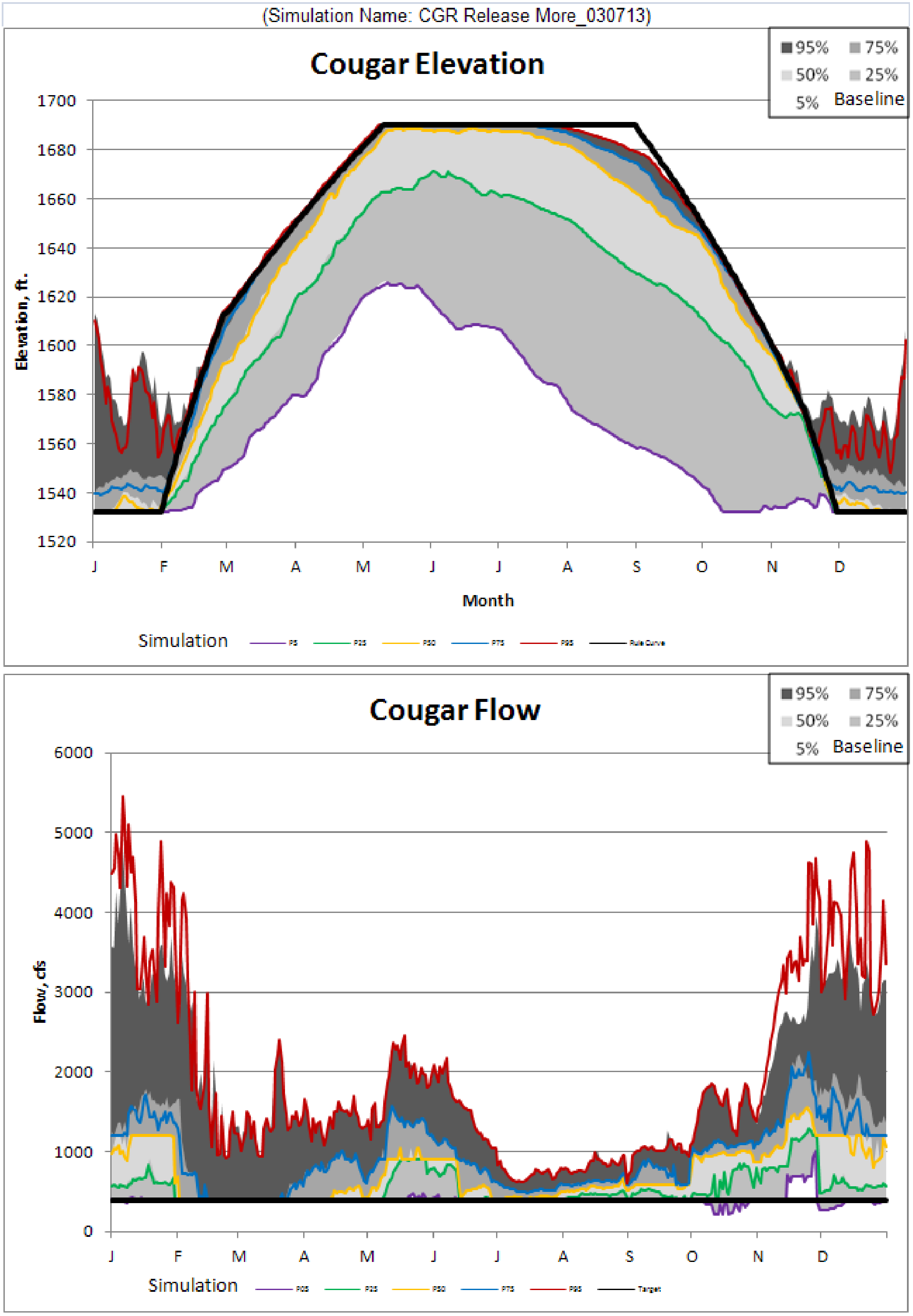
Figure 19: Summary of Average Project Elevations



As shown in Figure 20, the significant differences in flow and elevation occurred during January, February and December. Please note that the Baseline 50th percentile is the first gray area visible above the Rule Curve during the specified months. The 5th and 25th percentiles are not visible on the graph until the spring and summer months. The 50th, 75th and 95th percentiles all have lower elevations than the corresponding Baseline elevations. The 75th percentile highlights the largest difference, 5-10 feet below the Baseline. The 50th and 75th percentile of flow show small decreases. The 95th percentile has the largest change in flow, 500-1000 cfs.

To better understand the relationship between elevation and flow described in the previous paragraph, the rule (Table 22 and Figure 18) must be re-examined. Both the Baseline and the Cougar Release More Simulation begin releasing 6500 cfs at elevation 1655 feet. From elevation 1590.0 feet to 1655.0 feet, the Cougar Release More simulation releases a constant rate of 6500 cfs. During this same elevation range, the Baseline rule, *Max Flow (Winter and Conservation),* dictates the releases from Cougar by linear interpolation between 5000 cfs and 6500 cfs. The elevation range 1590.0—1655.0 feet, is higher into the flood control space during winter months, which is why the 95th percentile flows are impacted the most. Elevation 1650.0 feet is not exceeded during December through February, causing the large deviation from the Baseline for flow. Compared to the Cougar Store More simulation, the Release More simulation had significant elevation changes for small changes in flow.

Figure 20: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Cougar for Regulated Flow. Compares Simulation CGR Release More_030713 statistics (colored lines) to the Baseline statistics (gray areas).



Exceedance values at Cougar have not been significantly affected by the modifications to the *Max Flow (Winter and Conservation)* rule. This can be seen in Table 23. There were slight decreases to turbine flows, but changes are too small to have major impacts. Also, for the 5th percentile, the number of days the reservoir elevation is below the boat ramps increased by less than 1%, meaning negligible impacts to recreation.

Table 23: Summary of Exceedance Values for Cougar

Cougar Project Summary		Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart): IRRM_Baseline_021313 Period of Record 5%	50%	95%	Simulation Period of Record 5%	50%	95%	Median Non-Exceedance Values by Water Year Type (Simulation: CGR Release More_030713): Baseline by Water Year Type Abundant	Adequate	Insufficient	Deficit	Simulation by Water Year Type Abundant	Adequate	Insufficient	Deficit
Non-Exceedance Values for various Water Year Statistics														
Average Outflow, cfs		610	850	1210	610	850	1210	910	780	690	660	910	780	690	660
Average RO Flow, cfs		90	230	530	90	240	550	280	170	110	100	290	170	120	110
Average Turbine Flow, cfs		530	620	700	510	610	690	630	620	580	550	620	620	570	550
Average Spillway Flow, cfs		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Days Min Tributary Flows Not Met		0	0	25	0	0	25	0	0	0	3	0	0	0	3
Average Reservoir Elevation, ft		1582	1621	1632	1581	1621	1631	1627	1615	1611	1587	1626	1614	1608	1586
Days Below Slide Creek Boat Ramp	1635 ft.	157	179	341	158	179	341	171	207	225	330	171	208	225	330
Days Below Echo Park Boat Ramp	1635 ft.	157	179	341	158	179	341	171	207	225	330	171	208	225	330

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Average Reservoir Outflow:
Total project outflow is 610 cfs or less 5% of the time.
Total project outflow is 850 cfs or less 50% of the time.
Total project outflow is 1210 cfs or less 95% of the time.

1.6.2.1. Biological Results

Table 24 provides information on the likelihood of occurrence and characteristics of e-flows, which had previously been identified to produce environmentally beneficial flows. Data for both the Baseline and the Cougar Release More simulation is presented for comparison.

Total winter e-flows increased from 49 to 59. This increase was considerable compared to the Cougar Store More simulation, which actually had the number of total winter e-flows decrease from 49 to 47 (Table 19). Type 1 and Type 2 e-flows increased, while Type 3 e-flows decreased. Spring e-flows stayed fairly consistent with a slight decrease from 63 total spring e-flows to 62.

Table 24: Comparison of exceedance values for the flow out of Cougar between the Simulation CGR Release More_030713 and the Baseline

Cougar Dam, Flow Out											
Description of Modeling Target for Flows:				IRRM_Baseline_021313				CGR Release More_030713			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration 25%	50%	75%	# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration 25%	50%	75%
Pulse1	Winter	> 6 kcfs	1	4	0	0	0	17	0	0	0
Pulse2	Winter	4 - 6 kcfs	3	29	0	0	1	38	0	0	1
Pulse3	Winter	3 - 4 kcfs	4	16	0	0	0	4	0	0	0
PulseA	Spring	> 4 kcfs	1	4	0	0	0	4	0	0	0
PulseB	Spring	2.5 - 4 kcfs	3	13	0	0	0	13	0	0	0
PulseC	Spring	1.5 - 2.5 kcfs	4	46	0	0	1	45	0	0	1
		Total Winter Pulses		49	0	0	1	59	0	0	1
		Total Spring Pulse		63	0	0	1	62	0	0	1

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.6.2.2. Assessing Impacts

A few key areas were assessed to verify that impacts were understood including flood risk management, recreation and BiOp operations. Table 25 and Figure 21provide information on flood risk management. Conclusions drawn from Table 25 are that the Cougar Store More simulation causes minimal impacts to flood risk in comparison to the Baseline. In most cases, impacts are slightly better; there is a small decrease for days above bankfull and days above flood stage.

Table 25: Comparison between Simulation CGR Release More_030713 and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: CGR Release More_030713							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years						Median Non-Exceedance Values by Water Year Type							
		Conditional formatting compares to Baseline counterpart						Baseline by Water Year Type				Simulation by Water Year Type			
		IRRM_Baseline_021313 Period of Record			Simulation Period of Record										
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	6	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	9	2	0	1	0	1	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	5	30	7	4	5	0	7	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	2	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	3	11	3	2	3	1	3	2	3	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	11	3	1	2	0	3	2	2	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	7	29	10	7	5	1	10	7	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	1	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	3	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11720	22650	12770	11290	10050	6540	12770	11290	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	8080	16730	25290	18850	16730	14910	10480	18850	16730	14910	10500
Willamette River at Eugene (EUGO)		13410	25350	38550	13410	25160	38550	26760	22780	20520	15760	26760	22750	20390	15760
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14610	24020	14850	14380	14250	12290	14980	14470	14940	12890
Willamette River at Harrisburg (HARO)		25000	50980	88980	25290	50570	87760	57730	48820	54190	38290	57640	48840	54600	38600
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14700	25080	15900	13950	14270	13370	15900	13950	14270	13370
North Santiam River at Mehama (MEHO)		11630	16300	25970	11630	16340	25970	17270	15890	16010	13190	17270	16290	16010	13190
Santiam River at Jefferson (JFFO)		27430	41700	77700	27430	41700	77700	46810	37800	40870	34690	46810	37800	40870	34690
Willamette River at Albany (ALBO)		36780	75670	130470	36880	75670	130480	80340	75670	72820	47750	80330	75670	73070	48180
Willamette River at Salem (SLMO)		65700	118820	203650	65770	118790	203590	125720	124670	131090	83590	125420	124670	131040	83780

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

When analyzing the Flood Damage Reduction Summary table, refer to the note in Section 1.3.2.2.

For Figure 21, small changes for the 75th and 50th percentile are observed. The only significant changes at Vida occur for large flows in the 95th percentile. Flows are up to 400 cfs greater than the Baseline during December through January. This is reflected by an increase from 8 days to 9 days for the number of days at bankfull in Table 25 (boxed in red). Compared to Figure 17, which shows the same graphic for the Cougar Store More simulation, both the Release More scenario and the

Store More scenario produce similar flows at the Vida control point. Neither are substantially more than the Baseline flow.

Table 26 highlights that the Cougar Release More simulation, as compared to the Baseline, results in negligible changes to BiOp flow targets.

Figure 21: Non-Exceedance for Regulated Flow at the Vida Control Point on the McKenzie River. Compares Simulation CGR Release More_030713 statistics (colored lines) to the Baseline statistics (gray areas).

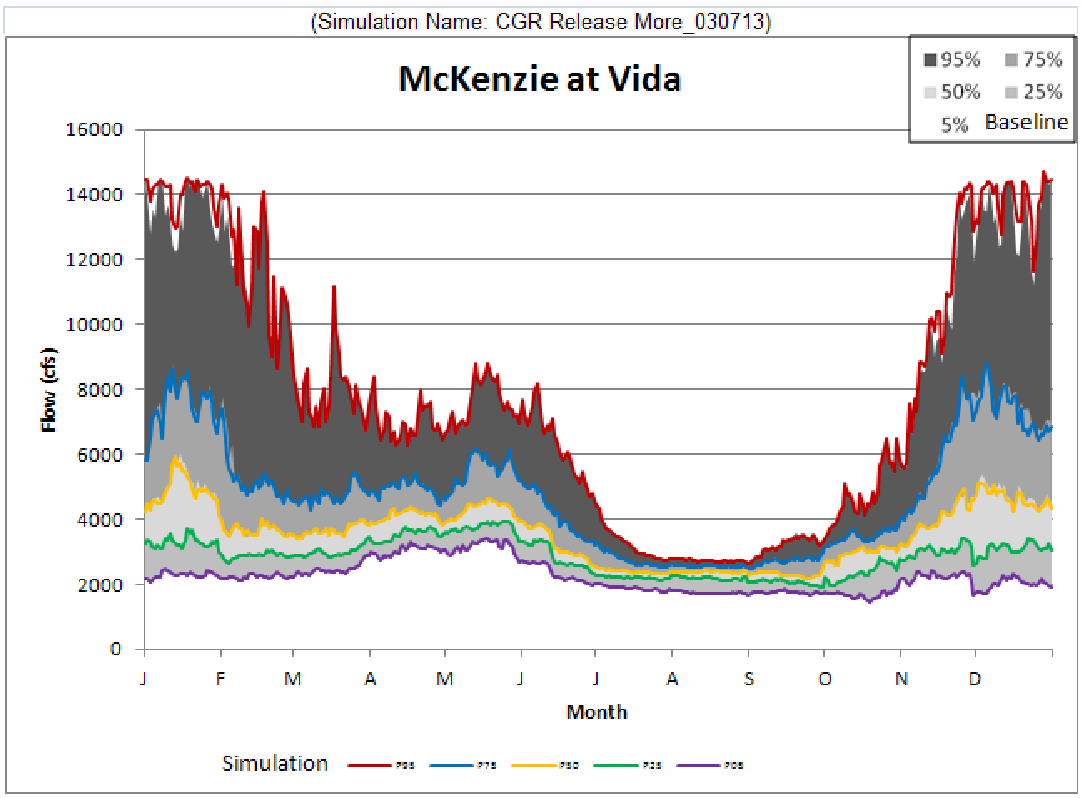


Table 26: BiOp Flow Targets: Comparison between Simulation CGR Release More_030713 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

	BiOp Flow Targets: Summary of Days Flows Not Met									Simulation: CGR Release More_030713							
Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	1	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	1	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	20	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	15	0	0	15	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	26	0	1	13	24	0	1	12	24
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	0	1	7	24	0	1	9	24
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	29	0	0	2	29
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	7	0	0	7	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	25	19	0	2	0	19	0	2	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	6	1	0	0	6	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	1	0	0	0	1	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	4	30	0	0	3	30
	16 March - 15 May	3000 cfs max	Rearing	6	19	42	6	19	42	29	16	8	7	29	16	8	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	2	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	28	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	15	0	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	16	1	4	1	5	1	4	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	7	9	1	0	8
	16 - 31 August	Varies		0	3	16	0	3	16	6	0	0	7	6	0	0	7
	01 - 30 September	Varies		0	5	28	0	5	28	5	2	0	15	5	2	0	15
Salem	01 - 31 October	Varies		0	0	12	0	0	12	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	7	17	1	8	13	12	1	8	12	12
	01 -31 May	Varies		0	5	23	0	5	23	0	14	17	21	0	14	16	21
	01 - 15 June	Varies		0	4	12	0	4	12	0	7	6	9	0	7	6	9
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	8	0	0	6	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	8	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	5	0	0
	01 - 30 September	Varies		0	0	24	0	0	24	0	3	0	1	0	3	0	1

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.

1.7. LOOKOUT POINT STORE MORE

Lookout Point Dam was modeled in ResSim to release less flow lower in the pool to allow for more stored water to be available during the e-flow.

1.7.1. ResSim Rules

Information regarding the Baseline model and rules can be found in Section 1.1 and 1.2. Figure 3 found in Section 1.2.3 provides an example of the operation set structure for Lookout Point, as viewed within ResSim. For comparison purposes, a discussion of the original rule in the Baseline simulation can be found in Section 1.2.3.

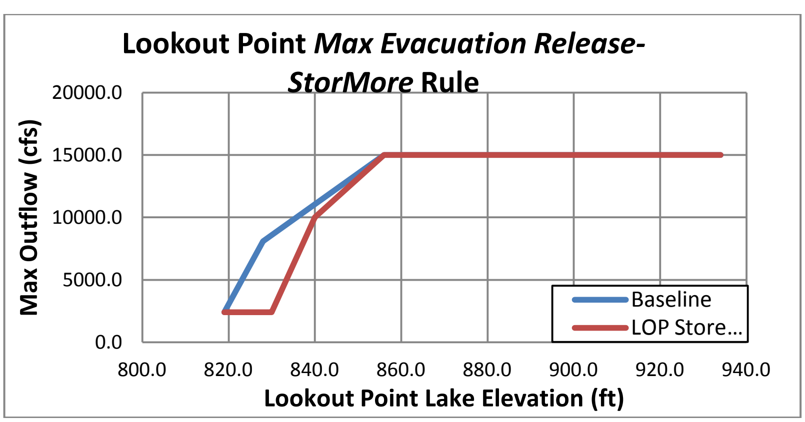
New Name for the Modified Rule: *Max Evacuation Release-StorMore*

Description of Changes: While at a low elevation in the pool, outflows are reduced for the Lookout Point Store More simulation, making more water available for environmental flows. Flows are initially limited to 2400 cfs, a ‘typical’ moderate winter flow that can easily be generated with a single turbine. As the lake elevation approaches the primary flood control space (elevation 856.0 – 929.0 ft), releases rapidly increases to 10,000 cfs, which is approximately the Baseline flow rate for the same elevation. Only flows corresponding to elevations in the secondary flood control space (elevation 825.0 – 856.0 ft) are modified. In the primary flood control zone, releases for the Lookout Point Store More simulation match the Baseline. This is to ensure availability of flood control space.

Table 27: Modified rule for Lookout Point Store More simulation

	Simulation: Baseline	**Simulation:** LOP Store More_022613
	Rule Name: *Max Evacuation Release*	**Rule Name:** *Max Evacuation Release-StorMore*
Lookout Point Elevation	**Maximum Release (cfs)**	
819.0	2400.0	2400.0
828.0	8100.0	-
830.0	-	2400.0
840.0	-	10000.0
856.0	15000.0	15000.0
934.0	15000.0	15000.0

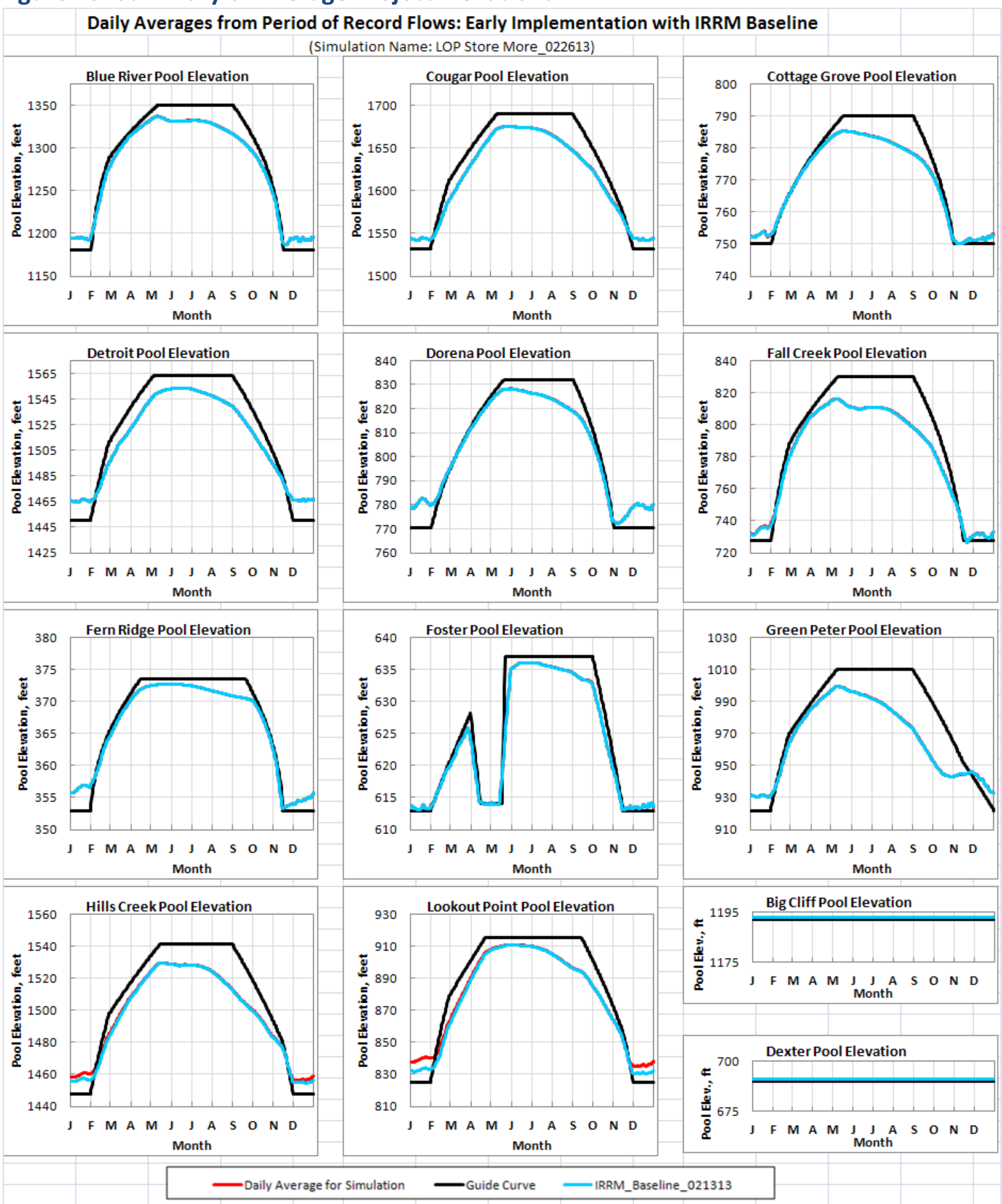
Figure 22: Maximum outflow as a function of Lookout Point Lake elevation for *Max Evacuation Release-StorMore* Rule



1.7.2. Model Results

Project elevations remained unchanged except for increases at Hills Creek and Lookout Point. Lookout Point had a larger increase than Hills Creek because the rule modified, *Max Evacuation Release*, is part of the Lookout Point operation set. Hills Creek was indirectly influenced because Lookout Point and Hills Creek are modeled as a tandem system in ResSim. This means that, during each iteration, a system storage balance is analyzed and the reservoir farthest away from the system rule curve releases flow. In order to set up this system, a tandem operation rule is included in the operation set for the upstream reservoir. In this case the upstream reservoir is Hills Creek, which has the *Tandem-HCR and LOP* rule.

Figure 23: Summary of Average Project Elevations

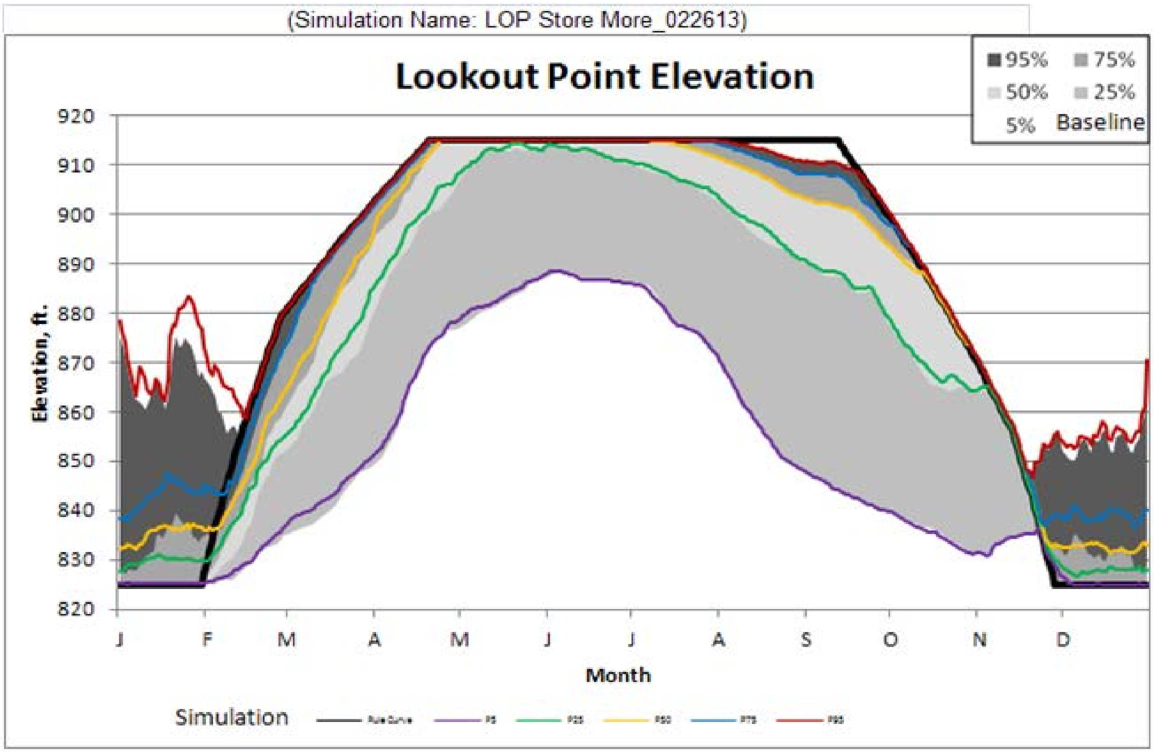


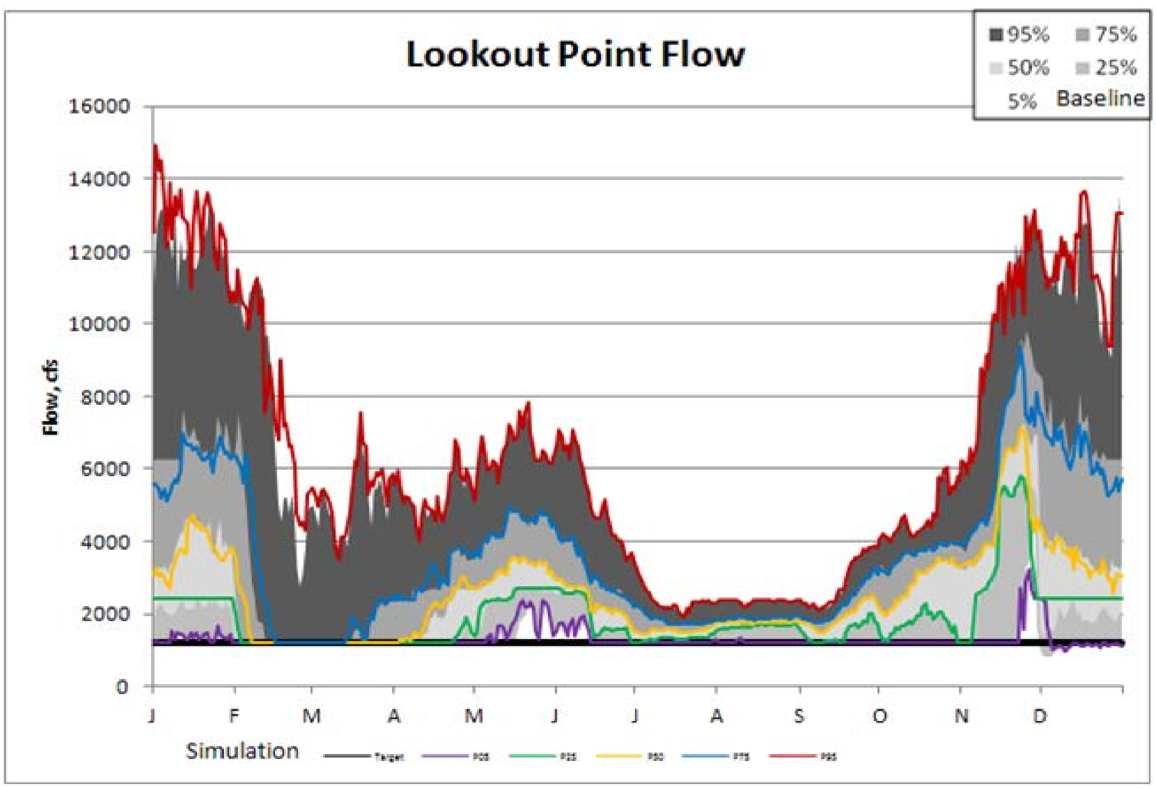
For the top graph in Figure 24, it is important to note that the 5th, 25th and 50th percentiles of the Baseline elevations are on the rule curve; only the 75th and 95th percentiles are visible. These graphs are a daily statistical representation over the whole period of record (73 years), therefore, the elevation is not directly related to the flow.

The significant differences in flow and elevation occurred during January, February and December. More pronounced than the Detroit and Cougar simulations already discussed, Lookout Point is also showing a small but noticeable elevation increase in the spring and summer months for the 5th, 25th and 50th percentiles. The 25th percentile has the most pronounced increase. The higher winter elevations as the project enters the refill period in February result in slightly higher elevations in the spring months. The increases are slight and there are no significant benefits to refill – both runs fill 75 percent of the time.

For elevation, the general trend is an increase over the Baseline. The 50th percentile is approximately 10-15 feet greater than the Baseline (in this case the 50th percentile for the Baseline is on the rule curve.). The 75th percentile elevation is approximately 10 feet higher and the 95th percentile is generally 5-10 feet higher. For flow, the trend is a reduction in flow compared to the Baseline. The 95th percentile does not follow the general trend, however, and is actually an increase over the Baseline. At these high flows, the reservoir has reached a sufficiently high elevation that forces releases to increase.

Figure 24: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Lookout Point for Regulated Flow. Compares Simulation LOP Store More_022613 statistics (colored lines) to the Baseline statistics (gray areas).





Project summary statistics for Lookout Point and Dexter in Table 28 validate that there are no appreciable changes from the Baseline. Therefore, recreation and hydropower will not be negatively affected.

Table 28: Summary of Exceedance Values for Lookout Point and Dexter Projects

Lookout Point/Dexter Summary							Simulation: LOP Store More_022613							
Non-Exceedance Values for Average Flows and Days Minimum Tributary Flows not Met.	Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart)						Median Non-Exceedance Values by Water Year Type							
	IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
LOP Average Outflow	2010	2970	4460	2020	2970	4470	3290	2890	2510	2140	3290	2890	2500	2140
LOP Average Regulating Outlet Flow	0	80	560	0	80	560	110	100	40	0	110	90	50	0
LOP Average Turbine Flow	2010	2840	3860	2020	2840	3860	3170	2700	2470	2110	3170	2710	2460	2110
LOP Average Spillway Flow	0	0	90	0	0	90	0	0	0	0	10	0	0	0
LOP Average Reservoir Elevation	857	880	888	857	882	889	883	878	876	861	884	880	879	861
DEX Average Outflow	2010	2970	4460	2020	2970	4470	3290	2890	2510	2140	3290	2890	2500	2140
DEX Average Turbine Flow	1890	2480	3010	1920	2510	3050	2660	2450	2150	1940	2710	2480	2160	1970
DEX Average Spillway Flow	50	500	1540	40	460	1510	660	420	350	150	630	390	340	130
Days DEX Tributary Flows Not Met, Target 1200 cfs	0	10	82	0	9	79	5	8	21	76	5	8	23	74
DEX Average Rservoir Elevation	691	691	691	691	691	691	691	691	691	691	691	691	691	691
Days LOP Below Black Canyon Boat Ramp, 900 ft.	179	200	365	178	198	365	191	221	272	365	188	220	243	365
Days LOP Below Meridian Park Boat Ramp, 911 ft.	227	261	365	227	259	365	248	295	319	365	247	292	313	365
Days LOP Below Hampton Landing Boat Ramp, 911 ft.	227	261	365	227	259	365	248	295	319	365	247	292	313	365
Days LOP Below Signal Point Boat Ramp, 821 ft.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Average LOP Reservoir Outflow:
Total project outflow is 2010 cfs or less 5% of the time.
Total project outflow is 2970 cfs or less 50% of the time.
Total project outflow is 4460 cfs or less95% of the time.

1.7.2.1. Biological Results

Table 29 shows that the Lookout Point Store More simulation provided minimal benefits in comparison to the Baseline and was detrimental for many of the targeted environmental flows. The total winter e-flows decreased from 160 to 143. Total spring e-flows increased a small amount from 18 to 20. For the winter e-flows, Type 1 increased and Type 2 and Type 3 decreased. This suggests that a general shift toward higher flows occurred in the winter.

Table 29: Comparison of Exceedance Values at the Jasper Control Point between the Simulation LOP Store More_022613 and the Baseline

Middle Fork Willamette at Jasper											
Description of Modeling Target for Flows:				IRRM_Baseline_021313				LOP Store More_022613			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Days in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	> 17 kcfs	1	80	0	0	2	83	0	0	2
Pulse2	Winter	15 -17 kcfs	3	24	0	0	1	19	0	0	0
Pulse3	Winter	12 - 15 kcfs	4	56	0	0	1	41	0	0	1
PulseA	Spring	> 15 kcfs	1	12	0	0	0	14	0	0	0
PulseB	Spring	12 - 15 kcfs	3	5	0	0	0	4	0	0	0
PulseC	Spring	10 - 12 kcfs	4	1	0	0	0	2	0	0	0
		Total Winter Pulses		160	0	0	4	143	0	0	3
		Total Spring Pulse		18	0	0	0	20	0	0	0

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.7.2.2. Assessing Impacts

A few key areas were assessed to verify that impacts were understood including flood risk management, recreation and BiOp operations. As shown in Table 30, impacts to flood risk are negligible as compared to the Baseline. Salem flows at the 50th percentile saw a slight increase of 1300 cfs which is an increase of less than 1%. Exceedance values for control point flows specific to Lookout Point Dam are plotted in Figure 25.

Table 31 highlights that the Lookout Point Store More simulation, as compared to the Baseline, results in negligible changes to BiOp flow targets.

Table 30: Comparison between Simulation LOP Store More_022613 and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: LOP Store More_022613							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years						Median Non-Exceedance Values by Water Year Type							
		Conditional formatting compares to Baseline counterpart						Baseline by Water Year Type				Simulation by Water Year Type			
		IRRM_Baseline_021313 Period of Record			Simulation Period of Record										
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	6	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	8	2	0	1	0	2	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	5	30	7	4	5	0	8	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	3	11	3	2	3	1	3	2	3	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	12	3	1	2	0	3	1	2	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	6	29	10	7	5	1	10	7	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	3	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11830	22650	12770	11290	10050	6540	12770	11290	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	6980	16930	25810	18850	16730	14910	10480	19380	17100	15350	10750
Willamette River at Eugene (EUGO)		13410	25350	38550	12180	25680	38890	26760	22780	20520	15760	27000	23740	21210	15440
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14570	24030	14850	14380	14250	12290	14850	14380	14250	12290
Willamette River at Harrisburg (HARO)		25000	50980	88980	24260	53150	88070	57730	48820	54190	38290	57590	49080	54350	38460
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14700	25080	15900	13950	14270	13370	15900	14000	14270	13370
North Santiam River at Mehama (MEHO)		11630	16300	25970	11630	16330	25970	17270	15890	16010	13190	17270	16290	16010	13190
Santiam River at Jefferson (JFFO)		27430	41700	77700	27430	41700	77700	46810	37800	40870	34690	46830	37800	40870	34690
Willamette River at Albany (ALBO)		36780	75670	130470	35760	76920	131720	80340	75670	72820	47750	80370	74110	72740	48020
Willamette River at Salem (SLMO)		65700	118820	203650	64150	120190	205000	125720	124670	131090	83590	125440	123200	130680	83680

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

When analyzing the Flood Damage Reduction Summary table, refer to the note in Section 1.3.2.2.

Figure 25: Non-Exceedance Values for Regulated Flow at the Jasper Control Point on the Middle Fork of the Willamette River. Compares Simulation LOP Store More_022613 (colored lines) to the Baseline statistics (gray areas).

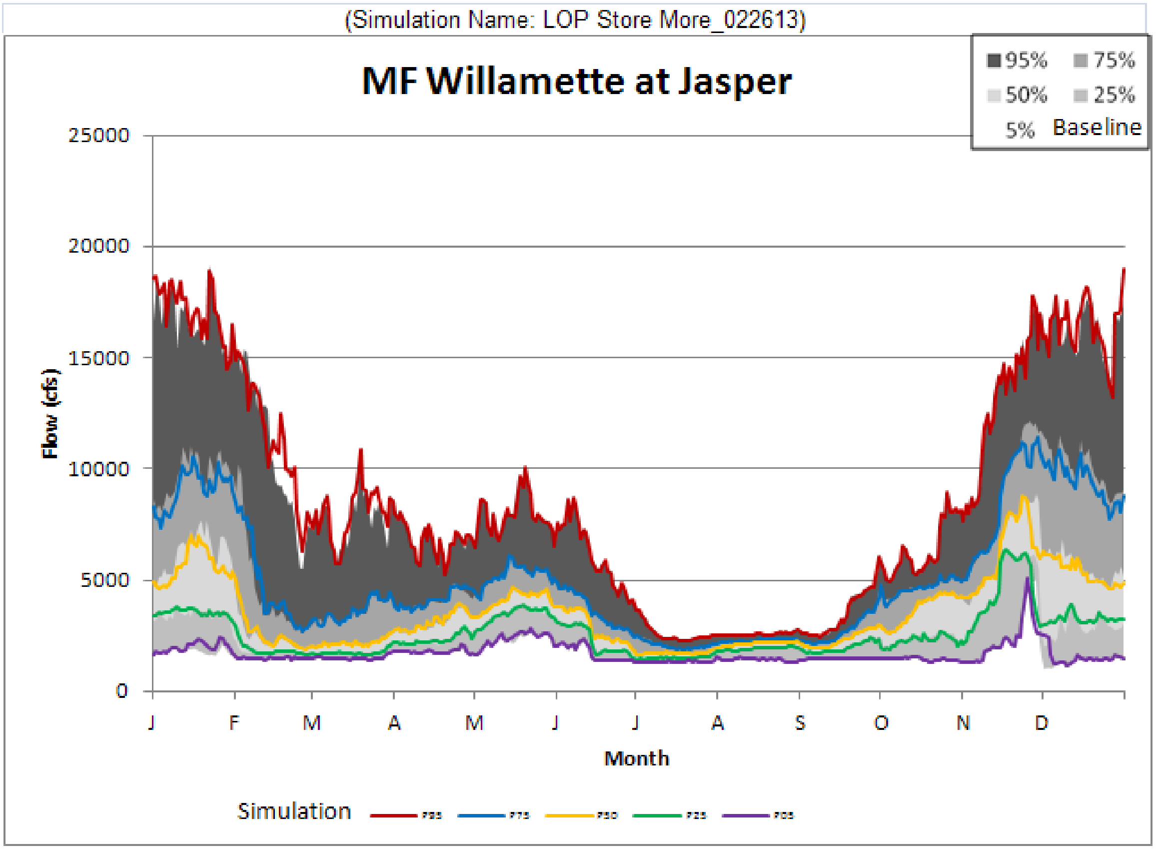


Table 31: BiOp Flow Targets: Comparison between Simulation LOP Store More_022613 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

	BiOp Flow Targets: Summary of Days Flows Not Met									Simulation: LOP Store More_022613							
Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_021313 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	6	0	0	0	0	0	0	0	1
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	20	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	15	0	0	13	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	25	0	1	13	24	0	1	8	23
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	0	1	7	24	0	1	9	22
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	29	0	0	1	29
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	7	0	0	6	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	25	19	0	2	0	19	0	2	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	6	1	0	0	6	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	1	0	0	0	0	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	16	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	4	30	0	0	3	30
	16 March - 15 May	3000 cfs max	Rearing	6	19	42	4	18	42	29	16	8	7	30	16	7	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	2	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	28	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	15	0	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	14	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	14	1	4	1	5	1	4	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	7	9	2	0	7
	16 - 31 August	Varies		0	3	16	0	3	16	6	0	0	7	6	0	0	8
	01 - 30 September	Varies		0	5	28	0	5	28	5	2	0	15	5	2	0	14
Salem	01 - 31 October	Varies		0	0	12	0	0	11	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	7	17	1	8	13	12	1	8	13	12
	01 -31 May	Varies		0	5	23	0	5	24	0	14	17	21	0	14	16	20
	01 - 15 June	Varies		0	4	12	0	4	12	0	7	6	9	0	7	6	8
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	8	0	0	8	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	7	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	6	0	0
	01 - 30 September	Varies		0	0	24	0	0	24	0	3	0	1	0	2	0	1

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.

1.8. Lookout Point Release More

Changes to the Baseline rule, *Max Evacuation Release*, at Lookout Point allowed the project to release more at lower pool elevations and consequently store less.

1.8.1. ResSim Rules

Information regarding the Baseline model and rules can be found in Section 1.1 and 1.2. Figure 3 found in Section 1.2.3 provides an example of the operation set structure for Lookout Point, as viewed within ResSim. For comparison purposes, a discussion of the original rule in the Baseline simulation can be found in Section 1.2.3.

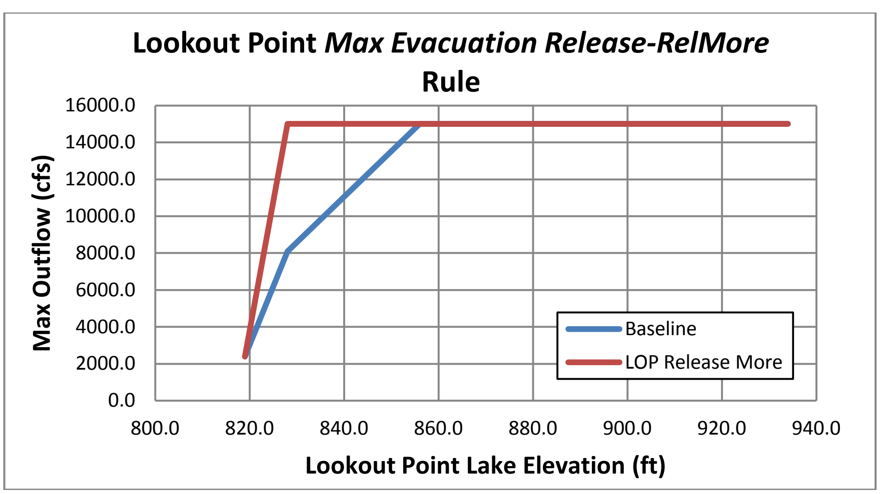
New Name for the Modified Rule: *Max Evacuation Release-RelMore*

Description of Changes: For the Baseline, the maximum evacuation release of 15,000 cfs is not discharged until the reservoir elevation reaches the primary flood control space (elevation 856.0 – 929.0 ft). For the Lookout Point Release More simulation, 15,000 cfs begins to be released in the secondary flood control space (elevation 825.0 – 856.0 ft). Both continue to release 15,000 cfs up to the maximum pool elevation, 934.0 ft.

Table 32: Modified rule for Lookout Point Release More simulation

	Simulation: IRRM Baseline_021313	**Simulation:** LOP Release More_041213
	Rule Name: *Max Evacuation Release*	**Rule Name:** *Max Evacuation Release-RelMore*
Lookout Point Elevation	**Maximum Release (cfs)**	
819.0	2400.0	2400.0
828.0	8100.0	15000.0
856.0	15000.0	15000.0
934.0	15000.0	15000.0

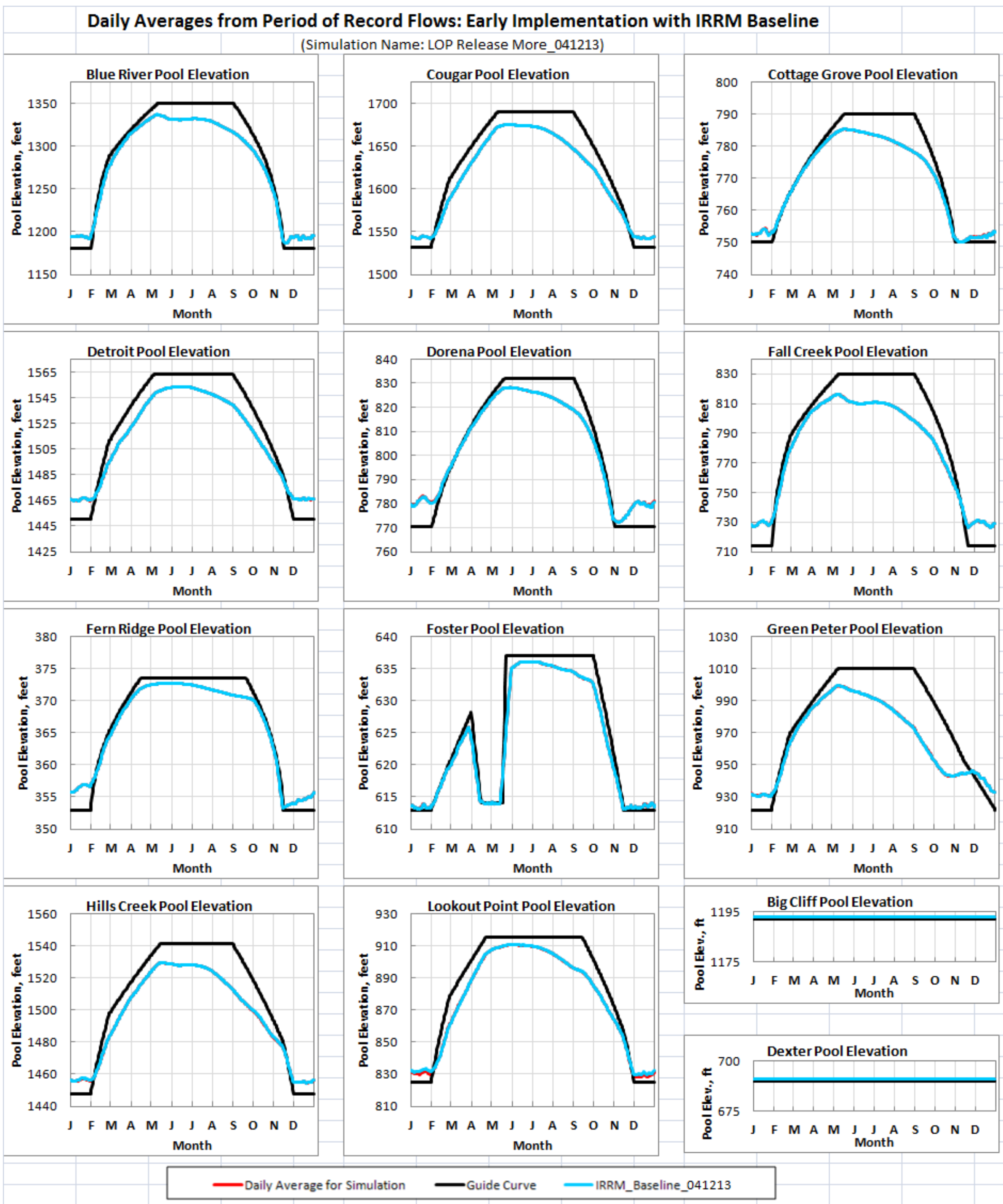
Figure 26: Maximum outflow as a function of Lookout Point Lake elevation for *Max Evacuation Release-RelMore* Rule



1.8.2. Model Results

Project elevations remained unchanged except for small decreases at Hills Creek and Lookout Point. The reservoir elevations at Lookout Point decreased more than at Hills Creek because the rule modified, *Max Evacuation Release*, is part of the Lookout Point operation set. Hills Creek was indirectly influenced because Lookout Point and Hills Creek are modeled as a tandem system in ResSim. This means that, during each iteration, a system storage balance is analyzed and the reservoir farthest away from the system rule curve releases flow. In order to set up this system, a tandem operation rule is included in the operation set for the upstream reservoir. In this case the upstream reservoir is Hills Creek, which has the *Tandem-HCR and LOP* rule.

Figure 27: Summary of Average Project Elevations

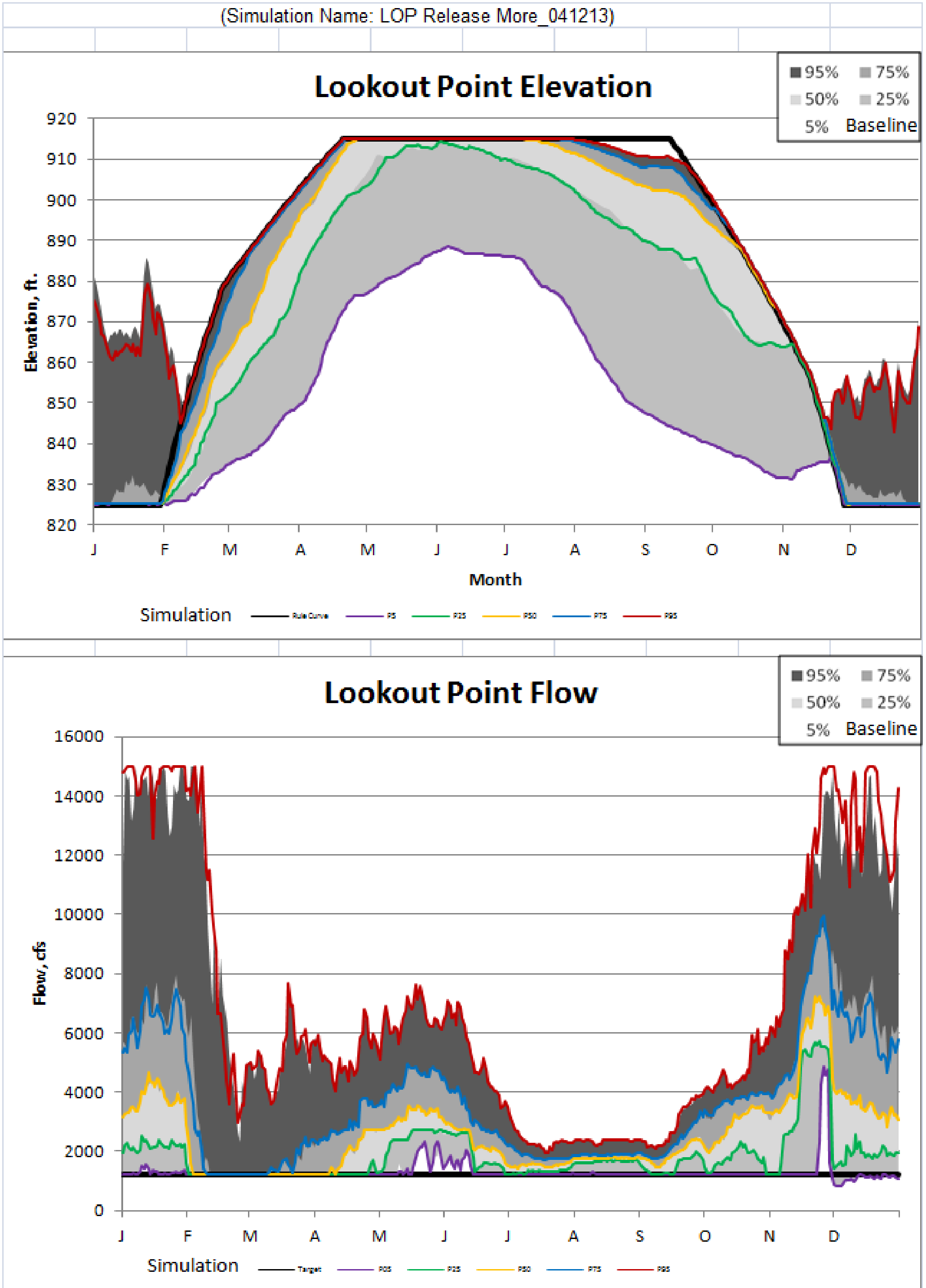


For Figure 28, it is important to note that the 5th, 25th and 50th percentiles of the Baseline elevations are on the rule curve; only the 75th and 95th percentiles are visible. For the Lookout Point Release More simulation, the 95th percentile is the only percentile significantly above the rule curve; the 5th and 25th percentiles are on the rule curve and the 50th and 75th percentiles are barely above the rule curve. These graphs are a statistical representation over the whole period of record (73 years), therefore, the elevation is not directly related to the flow.

The significant differences in flow and elevation occurred during January, February and December. There are no marked differences between the Lookout Point Release More simulation and the Baseline during the spring and summer months for either elevation or flow. This is different from the Lookout Point Store More simulation, which had noticeable elevation increases during the spring and summer months.

For elevation, the general trend is a decrease over the Baseline. The 75th percentile is 10 feet below the Baseline and the 95th percentile is approximately 5 feet below the Baseline. Flows up to the 75th percentile show no distinctive changes from the Baseline, either increasing or decreasing. The 95th percentile shows an increase with flows approximately 5-1500 cfs larger than Baseline flows, but less than 15,000 cfs.

Figure 28: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Lookout Point for Regulated Flow. Compares Simulation LOP Release More_041213 statistics (colored lines) to the Baseline statistics (gray areas).



As shown in Table 33, the flows out of the regulating outlets at Lookout Point Dam have significantly increased by 30% for the Lookout Point Release More simulation. The spillway flows at Lookout Point also increased slightly for high flows. Turbine flows at Lookout Point and Dexter showed small decreases, which may have slight impacts to hydropower production. There were no significant changes to the number of days the water elevation was below the boat ramps so recreation is not affected.

Table 33: Summary of Exceedance Values for Lookout Point and Dexter Projects

Lookout Point/Dexter Summary							Simulation: LOP Release More_041213							
Non-Exceedance Values for Average Flows and Days Minimum Tributary Flows not Met.	Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart)						Median Non-Exceedance Values by Water Year Type							
	IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
LOP Average Outflow	2010	2970	4460	2010	2970	4460	3290	2890	2510	2140	3290	2890	2510	2140
LOP Average Regulating Outlet Flow	0	80	560	0	120	680	110	100	40	0	170	120	80	10
LOP Average Turbine Flow	2010	2840	3860	2010	2790	3730	3170	2700	2470	2110	3080	2690	2470	2090
LOP Average Spillway Flow	0	0	90	0	0	100	0	0	0	0	10	0	0	0
LOP Average Reservoir Elevation	857	880	888	857	879	886	883	878	876	861	882	877	873	861
DEX Average Outflow	2010	2970	4460	2010	2970	4460	3290	2890	2510	2140	3290	2890	2520	2140
DEX Average Turbine Flow	1890	2480	3010	1890	2450	2940	2660	2450	2150	1940	2620	2440	2150	1950
DEX Average Spillway Flow	50	500	1540	50	500	1570	660	420	350	150	670	420	350	140
Days DEX Tributary Flows Not Met, Target 1200 cfs	0	10	82	0	10	83	5	8	21	76	5	7	23	76
DEX Average Rservoir Elevation	691	691	691	691	691	691	691	691	691	691	691	691	691	691
Days LOP Below Black Canyon Boat Ramp, 900 ft.	179	200	365	177	200	365	191	221	272	365	191	221	272	365
Days LOP Below Meridian Park Boat Ramp, 911 ft.	227	261	365	226	261	365	248	295	319	365	248	295	319	365
Days LOP Below Hampton Landing Boat Ramp, 911 ft.	227	261	365	226	261	365	248	295	319	365	248	295	319	365
Days LOP Below Signal Point Boat Ramp, 821 ft.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Average LOP Reservoir Outflow:
Total project outflow is 2010 cfs or less 5% of the time.
Total project outflow is 2970 cfs or less 50% of the time.
Total project outflow is 4460 cfs or less95% of the time.

1.8.2.1. Biological Results

The results presented in Table 34 show that the number of total winter e-flows increased from 136 for the Baseline to 144 for the Lookout Point Release More simulation. This is similar to the Lookout Point Store More simulation. Total winter e-flows increased from 136 to 143. The spring e-flows increased by 1, same as the Lookout Point Store More simulation.

For the winter e-flows, there was a general trend towards higher flows. Type 1 increased from 71 for the Baseline to 119 and Type 3 decreased from 48 to 18 winter e-flows.

Table 34: Comparison of Exceedance Values at the Jasper Control Point between the Simulation LOP Release More_041313 and the Baseline

Middle Fork Willamette at Jasper											
Description of Modeling Target for Flows:				IRRM_Baseline_041213				LOP Release More_041313			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration 25%	50%	75%	# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration 25%	50%	75%
Pulse1	Winter	>17 kcfs	1	71	0	0	2	119	0	1	2
Pulse2	Winter	15 -17 kcfs	3	17	0	0	0	9	0	0	0
Pulse3	Winter	12 - 15 kcfs	4	48	0	0	1	16	0	0	0
PulseA	Spring	>15 kcfs	1	13	0	0	0	13	0	0	0
PulseB	Spring	12 - 15 kcfs	3	4	0	0	0	5	0	0	0
PulseC	Spring	10 - 12 kcfs	4	2	0	0	0	2	0	0	0
		Total Winter Pulses		136	0	0	3	144	0	1	2
		Total Spring Pulse		19	0	0	0	20	0	0	0

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.8.2.2. Assessing Impact

A few key areas were assessed to verify that impacts were understood including flood risk management, recreation and BiOp operations. As shown in Table 35, impacts to flood risk are very similar to the Baseline. Several gages saw a decrease in bank full and flood events at the 95th percentile, the exception being Harrisburg, which saw an increase in bank full at the 95th percentile, but not an increase in flood stage. The peak flows were shifted higher at Jasper at the 50th percentile from 16,730 cfs to 19,320 cfs, which is still below bankfull of 20,000 cfs. Pushing evacuation releases higher in the Release More scenario shifts flows to near bank full, while decreasing more extreme peaks as seen by the decrease in 95th percentile peak flows. There is an increase at Harrisburg's 50th percentile flow as a result of the increases at Lookout Point. The bankfull regulation target at Harrisburg is particularly restrictive and is a known bottleneck for the system. Regulators often regulate to a higher flow in order to move water through the system. The ResSim model is also set up to allow more flow at Harrisburg if needed to keep upstream projects from filling too quickly. Peak flows are well below flood stage and have decreased in the 95th percentile flows.

Exceedance values for control point flows specific to Lookout Point Dam are plotted in Figure 29. The flows monitored at the Jasper control point reflect similar responses as the Lookout Point releases (Figure 28). For the 95th percentile flows at Jasper are higher than Baseline but still below the bankfull threshold of 20,000 cfs. Peak discharges on the Middle Fork were shifted higher due to the increase in maximum releases from Lookout Point. Jasper's 50th percentile peak flows increased, but the 95th percentile flows decreased. The increase in flows carries down to the downstream control points with slight increases on the mainstem flow gages at 50th percentile and slight decreases at 95th percentile.

Table 36 highlights that the Lookout Point Release More simulation, as compared to the Baseline, results in negligible changes to BiOp flow targets.

Table 35: Comparison between Simulation LOP Release More_022613 and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: LOP Release More_041213							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years; Conditional formatting compares to Baseline counterpart						Median Non-Exceedance Values by Water Year Type							
		IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	5	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	8	2	0	1	0	2	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	5	36	7	4	5	0	8	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	3	11	3	2	3	1	3	2	3	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	9	3	1	2	0	2	2	3	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	6	30	10	7	5	1	10	7	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	1	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	3	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11510	22660	12770	11290	10050	6540	12770	11160	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	8080	19320	23720	18850	16730	14910	10480	19710	18660	16500	10920
Willamette River at Eugene (EUGO)		13410	25350	38550	13260	26760	38340	26760	22780	20520	15760	27280	25490	24120	16060
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14570	24030	14850	14380	14250	12290	14850	14380	14250	12290
Willamette River at Harrisburg (HARO)		25000	50980	88980	25390	54700	85750	57730	48820	54190	38290	55860	54710	58150	38820
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14700	25080	15900	13950	14270	13370	15900	13950	14270	13370
North Santiam River at Mehama (MEHO)		11630	16300	25970	11630	16340	25970	17270	15890	16010	13190	17270	16290	16010	13190
Santiam River at Jefferson (JFFO)		27430	41700	77700	27430	41700	77700	46810	37800	40870	34690	46770	37800	40870	34690
Willamette River at Albany (ALBO)		36780	75670	130470	36740	75480	129850	80340	75670	72820	47750	80260	76940	77010	49610
Willamette River at Salem (SLMO)		65700	118820	203650	65660	118750	202640	125720	124670	131090	83590	124690	124840	133950	85270

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

When analyzing the Flood Damage Reduction Summary table, refer to the note in Section 1.3.2.2.

Figure 29: Non-Exceedance Values for Regulated Flow at the Jasper Control Point on the Middle Fork of the Willamette River. Compares Simulation LOP Release More_022613 (colored lines) to the Baseline statistics (gray areas).

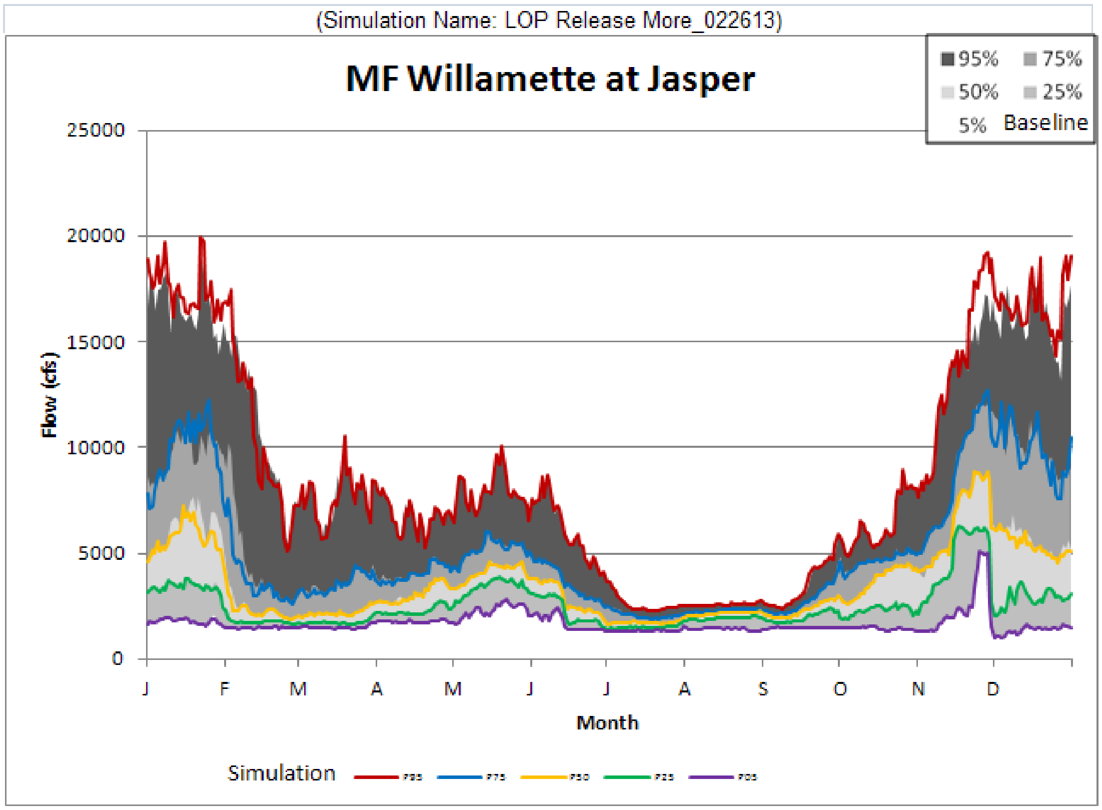


Table 36: BiOp Flow Targets: Comparison between Simulation LOP Release More_022613 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

BiOp Flow Targets: Summary of Days Flows Not Met										Simulation: LOP Release More_041213							
Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	21	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	26	0	2	12	24	0	2	12	24
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	1	1	9	24	0	1	9	24
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	28	0	0	1	28
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	5	0	0	6	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	8	0	0	6	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	25	18	0	2	0	18	0	2	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	7	1	0	0	7	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	5	30	0	0	4	30
	16 March - 15 May	3000 cfs max	Rearing	5	19	42	5	19	42	30	16	8	7	30	16	8	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	2	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	28	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	15	0	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	14	2	4	1	5	1	3	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	8	9	1	0	7
	16 - 31 August	Varies		0	4	16	0	3	16	6	0	0	7	6	0	0	7
	01 - 30 September	Varies		0	5	27	0	5	26	5	2	0	15	5	2	0	15
Salem	01 - 31 October	Varies		0	0	12	0	0	12	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	7	17	1	8	14	12	1	8	13	12
	01 -31 May	Varies		0	5	23	0	5	23	0	14	15	21	0	14	18	21
	01 - 15 June	Varies		0	4	12	0	4	12	0	6	6	9	0	6	6	9
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	5	0	0	5	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	7	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	5	0	0
	01 - 30 September	Varies		0	0	23	0	0	23	0	3	0	1	0	3	0	1

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.

1.9. COMBINATION

1.9.1. ResSim Rules

The final simulation is a combination run using the recommended case, chosen from the individual simulations, for each of the three modified projects. Table 37 presents the chosen option. All other projects used the same rules as the Baseline. For an in-depth discussion on these three rule changes, see Section 1.4.1 for Detroit, Section 1.6.1 for Cougar and Section 1.8.1 for Lookout Point.

Table 37: Identifies the best case individual simulations for the three modified projects to be incorporated into a combination run

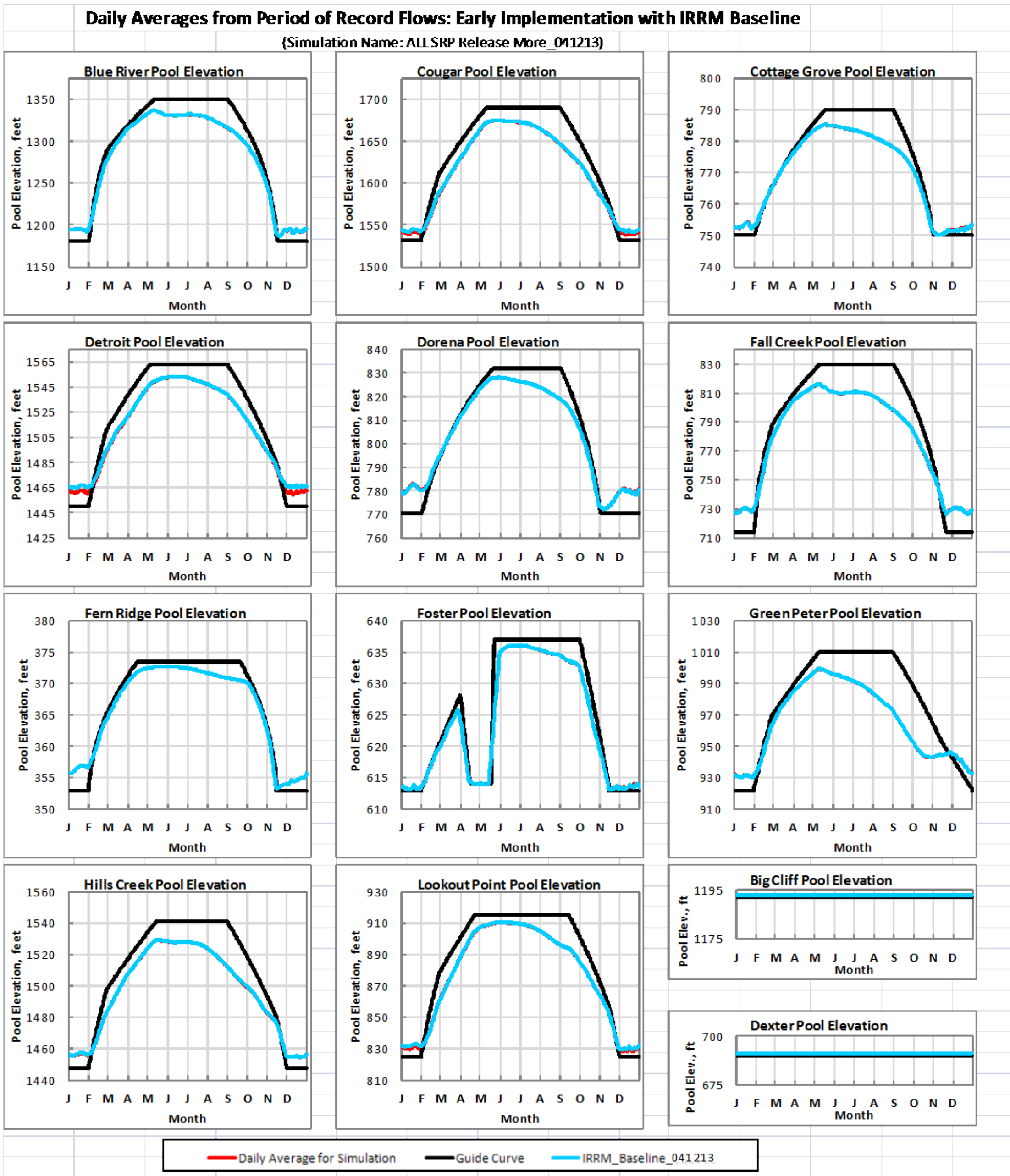
Project	Simulation Chosen:
Detroit	Detroit Release More
Cougar	Cougar Release More
Lookout Point	Lookout Point Release More

The intent of running a combination run is to verify that there were no unintended consequences to other project purposes when the pulses were applied to multiple basins.

1.9.2. Model Results

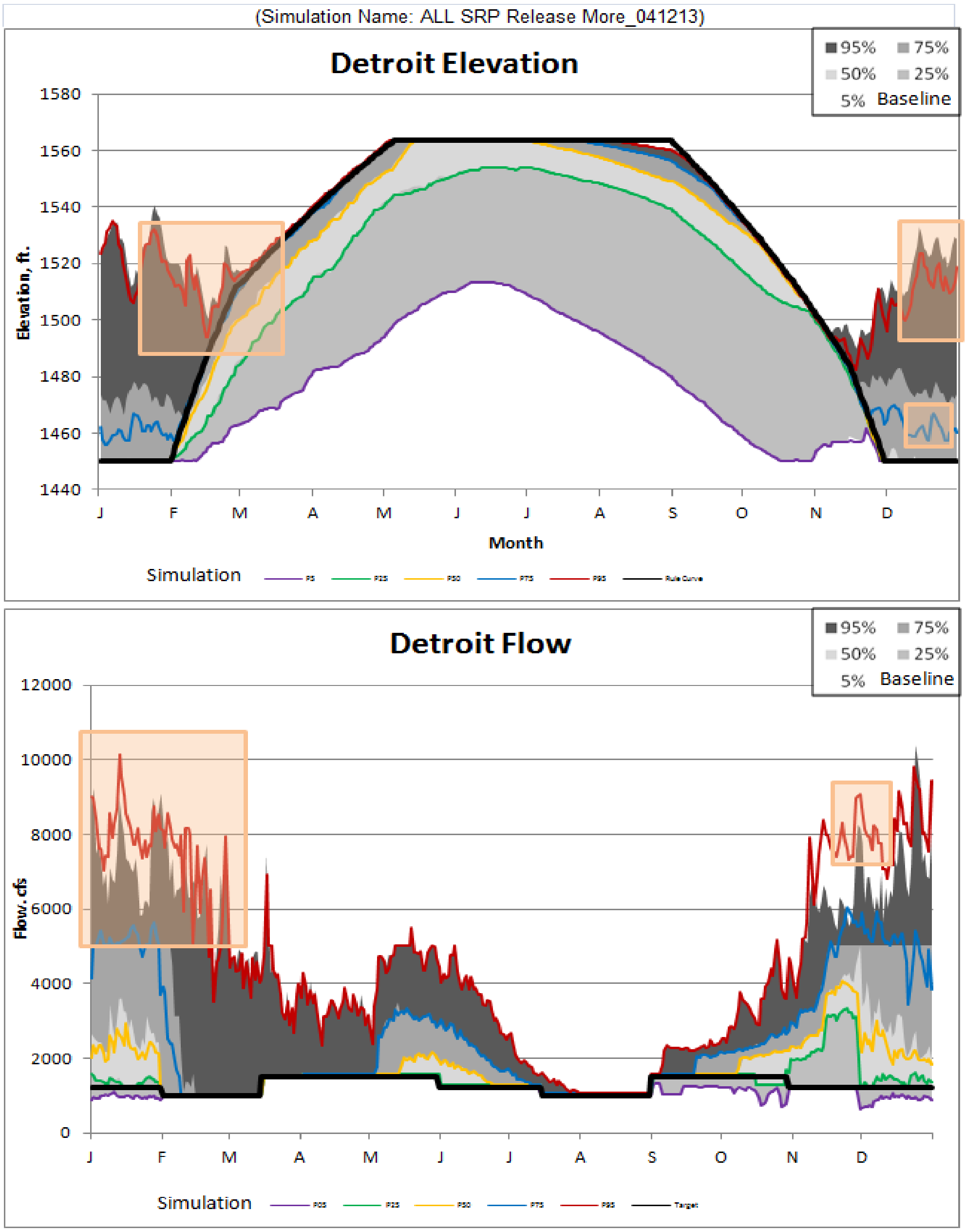
Project elevations for the combination run, shown in Figure 30, reflect changes comparable to the simulations where each project was modified separately. For comparison, the project elevations for the individually run simulations at Detroit, Cougar and Lookout Point are shown in Figure 10, Figure 19 and Figure 27, respectively.

Figure 30: Summary of Average Project Elevations



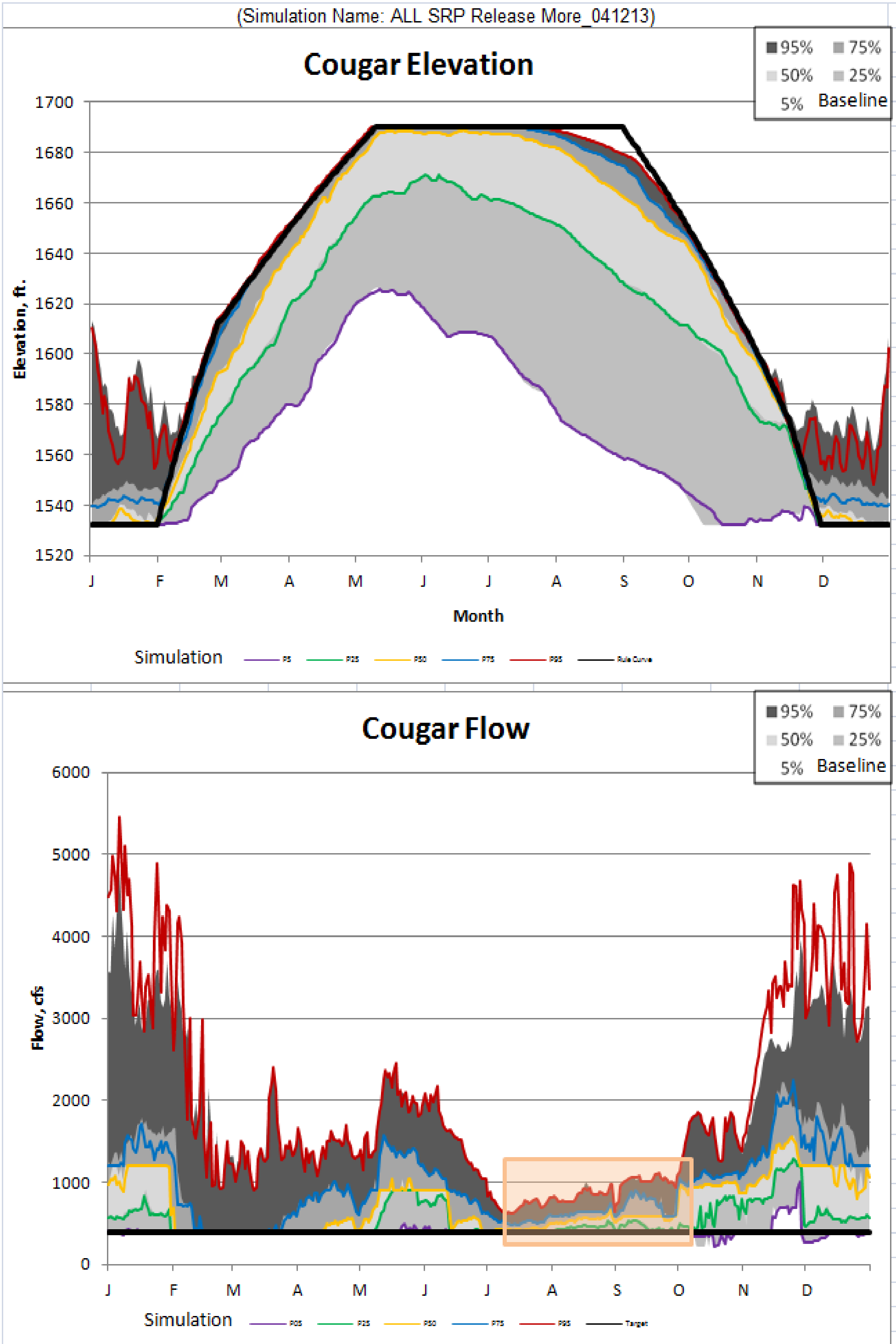
Non-exceedance graphs comparing the Baseline and combination run at each of the three modified projects; Detroit, Cougar and Lookout Point; are shown in Figure 31, Figure 32 and Figure 33. Small changes between the combination run and the individual project simulations occurred almost exclusively during the winter months. This was expected because the modified rule has the greatest impact during those months. Also, the Willamette projects operate as a system so changing multiple projects instead of only one should cause variations. Since the rule modifications at each project were the same, however, the variations are small. Further discussion on the non-exceedance graphs for the individual project simulations at Detroit, Cougar and Lookout Point are shown in Section 1.4.2, Section 1.6.2 and Section 1.8.2, respectively.

Figure 31: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Detroit for Regulated Flow. Compares Simulation ALL SRP Release More_041213 statistics (colored lines) to the Baseline statistics (gray areas).



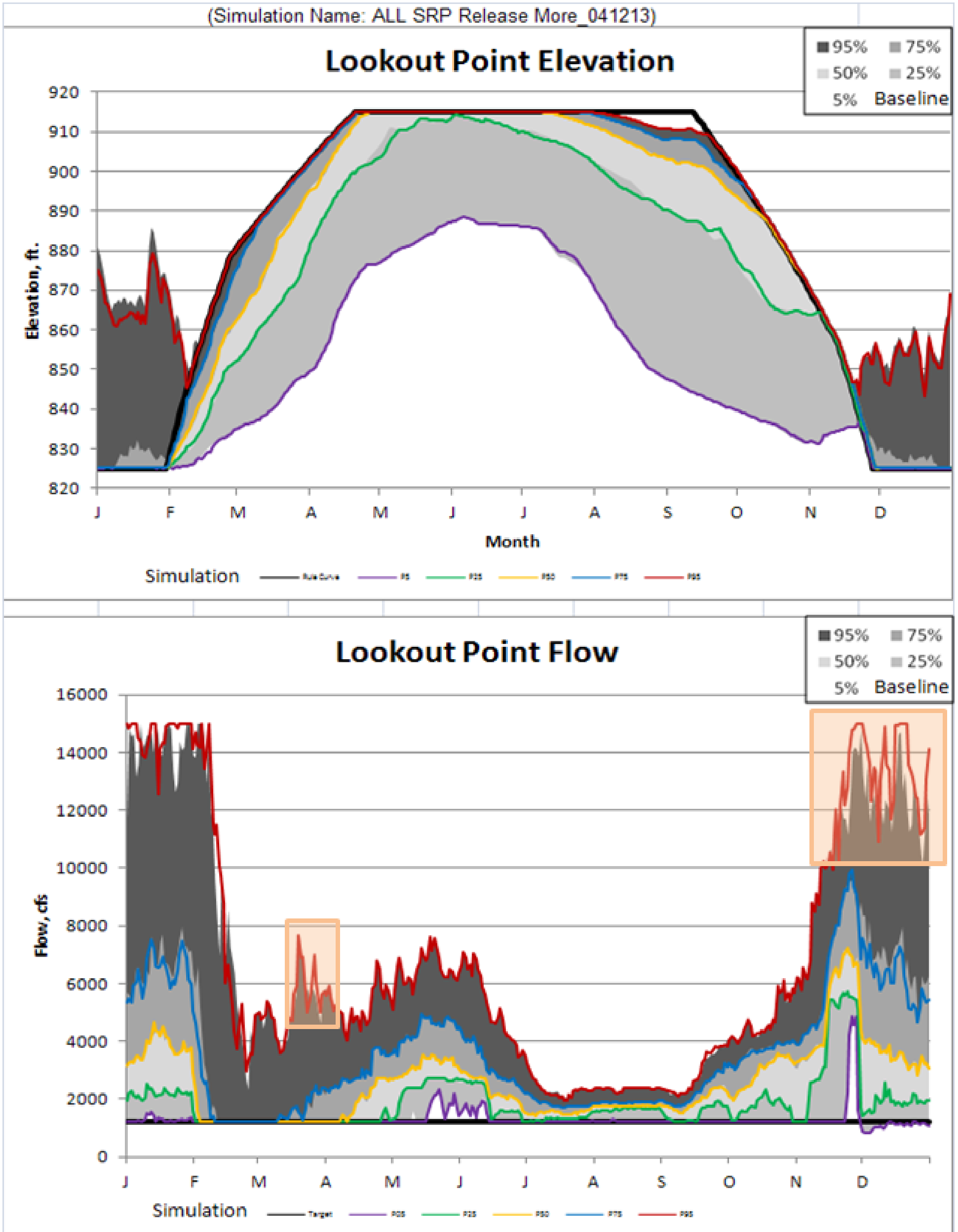
The orange highlighting calls out the areas where there is a difference between the combined simulation, *ALL SRP Release More_041213*, and the single change simulation, *DET Release More_041313.*

Figure 32: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Cougar for Regulated Flow. Compares Simulation ALL SRP Release More_041213 statistics (colored lines) to the Baseline statistics (gray areas).



The orange highlighting calls out the areas where there is a difference between the combined simulation, *ALL SRP Release More_041213*, and the single change simulation, *DET Release More_041313*.

Figure 33: Non-Exceedance Graphs—Reservoir Elevation and Outflow of Lookout Point for Regulated Flow. Compares Simulation ALL SRP Release More_041213 statistics (colored lines) to the Baseline statistics (gray areas).



The orange highlighting calls out the areas where there is a difference between the combined simulation, *ALL SRP Release More_041213*, and the single change simulation, *DET Release More_041313*.

A summary of statistics for the projects that were modified during the combination simulation are presented in Table 38, Table 39 and Table 40. Turbine flows showed small decreases at all the modified projects and their re-regulating dams, which may have slight impacts to hydropower production. The number of days reservoir elevations were below some boat ramps increased, but only by several additional days so impacts to recreation are shown to be limited.

When analyzing the combination run with respect to the individual project simulations, minor differences are apparent. For comparison, the project statistics for the individual project simulations at Detroit, Cougar and Lookout Point are shown in Table 13, Table 23 and Table 33, respectively.

Table 38: Summary of Exceedance Values for Detroit and Big Cliff Projects

Detroit and Big Cliff Project Summary							Simulation: ALL SRP Release More_041213							
Exceedance Values for Average Flows, Elevations, and Number of Days Tributary Flows Not Met.	Exceedance Values for 73 Water Years						Exceedance Values by Water Year Type							
	Conditional formatting compares to Baseline counterpart						Baseline by Water Year Type				Simulation by Water Year Type			
	IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
	5%	50%	95%	5%	50%	95%								
DET Average Outflow	1570	2150	3060	1570	2150	3060	2340	2080	1900	1690	2340	2080	1900	1690
DET Average Upper Regulating Outlet Flow	10	90	340	30	160	440	100	110	90	30	170	140	170	80
DET Average Lower Regulating Outlet Flow	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DET Average Turbine Flow	1300	1750	2170	1280	1680	2100	1810	1700	1600	1600	1730	1660	1590	1580
DET Average Spillway Flow	0	350	530	0	340	520	400	270	140	0	400	260	150	0
DET Average Reservoir Elevation	1482	1518	1530	1482	1517	1527	1521	1515	1512	1492	1520	1514	1512	1491
BCL Average Outflow	1570	2150	3060	1570	2150	3060	2340	2080	1900	1690	2340	2080	1900	1690
BCL Average Turbine Flow	1470	1820	2180	1450	1800	2150	1970	1770	1740	1570	1950	1730	1710	1550
BCL Average Spillway Flow	60	300	900	60	330	930	360	310	260	150	390	330	290	180
BCL Days Tributary Flows Not Met	0	6	62	0	6	62	2	6	3	34	2	6	3	34
Days Below Detroit Lake State Park Boat Ramp D, 1556 ft.	228	269	366	228	269	366	251	284	356	365	251	287	356	365
Days Below Mongold East Boat Ramp, 1540 ft.	180	210	365	183	212	365	200	222	272	365	201	227	269	365
Days Below Kane's Marina , 1546 ft.	201	225	365	201	226	365	216	245	282	365	214	245	280	365
Days Below Hoover Boat Ramp, 1543 ft.	189	219	365	192	218	365	207	233	276	365	207	239	274	365
Days Below South Shore Boat Ramp, 1542 ft.	186	217	365	188	217	365	205	230	275	365	205	235	273	365
Days Below Cove Creek Boat Ramp, 1541, ft.	183	213	365	185	214	365	202	227	273	365	203	231	271	365
Days Below Detroit Lake State Park Boat Ramp G, 1530 ft.	154	186	361	157	186	361	173	191	210	361	175	191	207	361
Days Below Mongold Main Boat Ramp, 1534 ft.	163	196	365	169	197	365	183	198	221	365	185	203	217	365
Days Below Mongold Low-Water Boat Ramp, 1450 ft.	0	1	15	0	1	15	1	1	1	8	1	1	1	8

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Exceedance Value Example for Baseline Run, Detroit Average Reservoir Outflow:
Total project outflow is 1570 cfs or less 5% of the time.
Total project outflow is 2150 cfs or less 50% of the time.
Total project outflow is 3060 cfs or less 95% of the time.

Table 39: Summary of Exceedance Values for Cougar Project

Cougar Project Summary							Simulation: ALL SRP Release More_041213							
Non-Exceedance Values for various Water Year Statistics	Non-Exceedance Values for 73 Water Years						Median Non-Exceedance Values by Water Year Type							
	Conditional formatting compares to Baseline counterpart						Baseline by Water Year Type				Simulation by Water Year Type			
	IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
	5%	50%	95%	5%	50%	95%								
Average Outflow, cfs	610	850	1210	610	850	1210	910	780	690	660	910	780	680	660
Average RO Flow, cfs	90	230	530	90	240	540	280	170	110	100	280	170	130	110
Average Turbine Flow, cfs	530	620	700	510	610	690	630	620	580	550	620	620	580	550
Average Spillway Flow, cfs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of Days Min Tributary Flows Not Met	0	0	25	0	0	25	0	0	0	3	0	0	0	3
Average Reservoir Elevation, ft	1582	1621	1632	1582	1621	1631	1627	1615	1611	1587	1626	1613	1608	1587
Days Below Slide Creek Boat Ramp 1635 ft.	157	179	341	158	179	341	171	207	225	330	171	208	223	330
Days Below Echo Park Boat Ramp 1635 ft.	157	179	341	158	179	341	171	207	225	330	171	208	223	330

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Average Reservoir Outflow:
Total project outflow is 610 cfs or less 5% of the time.
Total project outflow is 850 cfs or less 50% of the time.
Total project outflow is 1210 cfs or less 95% of the time.

Table 40: Summary of Exceedance Values for Lookout Point and Dexter Projects

Lookout Point/Dexter Summary							Simulation: ALL SRP Release More_041213							
Non-Exceedance Values for Average Flows and Days Minimum Tributary Flows not Met.	Non-Exceedance Values for 73 Water Years						Median Non-Exceedance Values by Water Year Type							
	Conditional formatting compares to Baseline counterpart						Baseline by Water Year Type				Simulation by Water Year Type			
	IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
	5%	50%	95%	5%	50%	95%								
LOP Average Outflow	2010	2970	4460	2010	2970	4460	3290	2890	2510	2140	3290	2890	2520	2140
LOP Average Regulating Outlet Flow	0	80	560	0	130	670	110	100	40	0	160	120	80	10
LOP Average Turbine Flow	2010	2840	3860	2010	2790	3730	3170	2700	2470	2110	3080	2690	2460	2090
LOP Average Spillway Flow	0	0	90	0	0	100	0	0	0	0	10	0	0	0
LOP Average Reservoir Elevation	857	880	888	857	879	886	883	878	876	861	882	877	873	861
DEX Average Outflow	2010	2970	4460	2010	2970	4460	3290	2890	2510	2140	3290	2890	2520	2140
DEX Average Turbine Flow	1890	2480	3010	1890	2440	2940	2660	2450	2150	1940	2620	2440	2140	1940
DEX Average Spillway Flow	50	500	1540	50	500	1570	660	420	350	150	670	420	360	140
Days DEX Tributary Flows Not Met, Target 1200 cfs	0	10	82	0	10	83	5	8	21	76	5	7	23	76
DEX Average Rservoir Elevation	691	691	691	691	691	691	691	691	691	691	691	691	691	691
Days LOP Below Black Canyon Boat Ramp, 900 ft.	179	200	365	177	201	365	191	221	272	365	191	221	273	365
Days LOP Below Meridian Park Boat Ramp, 911 ft.	227	261	365	226	261	365	248	295	319	365	248	295	326	365
Days LOP Below Hampton Landing Boat Ramp, 911 ft.	227	261	365	226	261	365	248	295	319	365	248	295	326	365
Days LOP Below Signal Point Boat Ramp, 821 ft.	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Average LOP Reservoir Outflow:
Total project outflow is 2010 cfs or less 5% of the time.
Total project outflow is 2970 cfs or less 50% of the time.
Total project outflow is 4460 cfs or less95% of the time.

1.9.2.1. Biological Results

Table 41, Table 42 and Table 43 present counts of e-flows that meet defined target seasons, flow ranges and durations for the combination run. In comparison to the three individual Release More simulations found in Table 14, Table 24 and Table 34; the combination run has a small decrease in winter e-flows. The individual run for Detroit has 137 total winter e-flows while the combination run at Detroit has 132. Cougar has consistent values. The individual run for Lookout Point has 144 total winter e-flows while the combination run at Lookout Point has 143. Total spring e-flows for Detroit and Cougar remain the same between the individual project simulations and the combination run. At Lookout Point, the individual run has 20 total spring e-flows while the combination run has 19 e-flows.

Table 41: Comparison of Exceedance Values at the Mehama Control Point between the Simulation ALL SRP Release More_041213 and the Baseline

North Santiam at Mehama											
Description of Modeling Target for Flows:				IRRM_Baseline_041213				ALL SRP Release More_041213			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	> 15 kcfs	1	80	0	1	2	95	0	1	2
Pulse2	Winter	12 -15 kcfs	3	20	0	0	0	17	0	0	0
Pulse3	Winter	10 - 12 kcfs	4	8	0	0	0	20	0	0	1
PulseA	Spring	> 12 kcfs	1	24	0	0	1	24	0	0	1
PulseB	Spring	10 - 12 kcfs	3	0	0	0	0	0	0	0	0
PulseC	Spring	8 - 10 kcfs	4	1	0	0	0	1	0	0	0
		Total Winter Pulses		108	0	1	2	132	0	1	3
		Total Spring Pulse		25	0	0	1	25	0	0	1

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

Table 42: Comparison of Exceedance Values for the Flow Out at Cougar Dam between the Simulation ALL SRP Release More_041213 and the Baseline

Cougar Dam, Flow Out											
Description of Modeling Target for Flows:				IRRM_Baseline_041213				ALL SRP Release More_041213			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	> 6 kcfs	1	4	0	0	0	17	0	0	0
Pulse2	Winter	4 - 6 kcfs	3	29	0	0	1	38	0	0	1
Pulse3	Winter	3 - 4 kcfs	4	16	0	0	0	4	0	0	0
PulseA	Spring	> 4 kcfs	1	4	0	0	0	4	0	0	0
PulseB	Spring	2.5 - 4 kcfs	3	13	0	0	0	13	0	0	0
PulseC	Spring	1.5 - 2.5 kcfs	4	46	0	0	1	45	0	0	1
		Total Winter Pulses		49	0	0	1	59	0	0	1
		Total Spring Pulse		63	0	0	1	62	0	0	1

Simulation value compared to Baseline:							
	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

Table 43: Comparison of Exceedance Values at the Jasper Control Point between the Simulation ALL SRP Release More_041213 and the Baseline

Middle Fork Willamette at Jasper											
Description of Modeling Target for Flows:				IRRM_Baseline_041213				ALL SRP Release More_041213			
Name of Flow Target	Target Season	Target Flow Range for Pulse	Target Duration of Pulse, in Days	# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration			# Events in POR with Date, Range, and Duration Targets Met	Exceedance Values for # Events in each Water Year that Flows Meet Target Date, Range, and Duration		
					25%	50%	75%		25%	50%	75%
Pulse1	Winter	> 17 kcfs	1	71	0	0	2	118	0	1	2
Pulse2	Winter	15 -17 kcfs	3	17	0	0	0	9	0	0	0
Pulse3	Winter	12 - 15 kcfs	4	48	0	0	1	16	0	0	0
PulseA	Spring	> 15 kcfs	1	13	0	0	0	13	0	0	0
PulseB	Spring	12 - 15 kcfs	3	4	0	0	0	5	0	0	0
PulseC	Spring	10 - 12 kcfs	4	2	0	0	0	1	0	0	0
		Total Winter Pulses		136	0	0	3	143	0	1	2
		Total Spring Pulse		19	0	0	0	19	0	0	0

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

For this table, the term pulse is equivalent to e-flow.

1.9.2.2. Assessing Impacts

Table 44 shows that impacts to flood risk are very similar to the Baseline. Several gages saw a decrease in bank full and flood events at the 95th percentile, the exception being Harrisburg, which saw an increase in days above bankfull at the 95th percentile, but not an increase in days above flood stage. The peak flows were shifted higher at Jasper at the 50th percentile from 16,730 cfs to 19,280 cfs, which is still below bankfull of 20,000 cfs. Pushing evacuation releases higher in the Release More scenario shifts flows to near bank full, while decreasing more extreme peaks as seen by the decrease in 95th percentile peak flows. There is an increase at Harrisburg's 50th percentile flow as a result of the increases at Lookout Point. The bank full regulation target at Harrisburg is particularly restrictive and is a known bottleneck for the system. Regulators often regulate to a higher flow in order to move water through the system. The ResSim model is also set up to allow more flow at Harrisburg, if needed, to keep upstream projects from filling too quickly. Peak flows are well below flood stage and have decreased in the 95th percentile flows. No increased flood risk is apparent. Also, the differences between the combination run and the individual project simulations are similar.

Table 44: Comparison between Simulation ALL SRP Release More_041213 and the Baseline of non-exceedance values for days above bankfull, days above flood stage and the peak flow at control points.

Flood Damage Reduction Summary								Simulation: ALL SRP Release More_041213							
Non-Exceedance Values for Number of Days in a Water Year that flows are above Bankfull or Flood Stage, with Peak Flows Noted		Non-Exceedance Values for 73 Water Years Conditional formatting compares to Baseline counterpart						Median Non-Exceedance Values by Water Year Type							
		IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
Days Above Bankfull	Bankfull Flow, cfs	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Willamette River near Goshen (GOSO)	12000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Middle Fork Willamette River at Jasper (JASO)	20000	0	0	6	0	0	5	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	40000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	14500	0	1	8	0	1	9	2	0	1	0	1	0	1	0
Willamette River at Harrisburg (HARO)	42000	0	5	30	0	5	35	7	4	5	0	8	4	5	0
Long Tom River at Monroe (MNRO)	4650	0	5	24	0	5	24	9	4	3	1	9	4	3	1
South Santiam River at Waterloo (WTLO)	18000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	17000	0	0	4	0	0	4	1	0	1	0	1	0	1	0
Santiam River at Jefferson (JFFO)	35000	0	3	11	0	3	10	3	2	3	1	3	2	3	1
Willamette River at Albany (ALBO)	70000	0	2	11	0	2	9	3	1	2	0	2	2	3	0
Willamette River at Salem (SLMO)	90000	0	6	28	0	6	31	10	7	5	1	10	8	5	1
Days Above Flood Stage	Flood Flow, cfs														
Willamette River near Goshen (GOSO)	15000	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Middle Fork Willamette River at Jasper (JASO)	23000	0	0	2	0	0	1	0	0	0	0	0	0	0	0
Willamette River at Eugene (EUGO)	53900	0	0	0	0	0	0	0	0	0	0	0	0	0	0
McKenzie River at Vida (VIDO)	35000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Willamette River at Harrisburg (HARO)	70500	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Long Tom River at Monroe (MNRO)	6000	0	0	6	0	0	6	2	0	2	0	2	0	2	0
South Santiam River at Waterloo (WTLO)	25700	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Santiam River at Mehama (MEHO)	32400	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Santiam River at Jefferson (JFFO)	49800	0	0	2	0	0	2	0	0	0	0	0	0	0	0
Willamette River at Albany (ALBO)	88000	0	0	4	0	0	3	0	0	0	0	0	0	0	0
Willamette River at Salem (SLMO)	153000	0	0	3	0	0	3	0	0	0	0	0	0	0	0
Peak Flow at Control Point, cfs															
Willamette River near Goshen (GOSO)		6250	11830	22650	6250	11470	22660	12770	11290	10050	6540	12770	11160	10050	6540
Middle Fork Willamette River at Jasper (JASO)		8080	16730	25350	8080	19280	23720	18850	16730	14910	10480	19710	18360	16470	10810
Willamette River at Eugene (EUGO)		13410	25350	38550	13260	26760	38340	26760	22780	20520	15760	27310	25490	23990	16060
McKenzie River at Vida (VIDO)		9360	14570	24030	9360	14610	24020	14850	14380	14250	12290	14980	14470	14940	12890
Willamette River at Harrisburg (HARO)		25000	50980	88980	25690	54710	85750	57730	48820	54190	38290	55710	54710	58470	39130
Long Tom River at Monroe (MNRO)		2850	5880	9210	2850	5880	9210	6810	5540	6060	4220	6810	5540	6060	4220
South Santiam River at Waterloo (WTLO)		10900	14700	25080	10900	14700	25080	15900	13950	14270	13370	15900	13950	14270	13440
North Santiam River at Mehama (MEHO)		11630	16300	25970	11820	16730	25400	17270	15890	16010	13190	17410	16340	17040	13530
Santiam River at Jefferson (JFFO)		27430	41700	77700	27570	41790	77700	46810	37800	40870	34690	46300	38160	40880	37070
Willamette River at Albany (ALBO)		36780	75670	130470	36840	75480	129870	80340	75670	72820	47750	80340	77250	77240	49890
Willamette River at Salem (SLMO)		65700	118820	203650	65710	119780	202970	125720	124670	131090	83590	124370	124860	134010	86620

Simulation value compared to Baseline:	70% and less	70% to 80%	80% to 90%	90% to 110%	110% to 120%	120% to 130%	130% and more

Non-Exceedance Value Example for Baseline Run, Goshen Bankfull Flows:
Flows are less than Bankfull all days of the year for 5% or less of the water years.
Flows are less than Bankfull all days of the year for 50% or less of the water years (half the time).
Almost always (95% of the time), 4 days or less in a water year, flows were above Bankfull.

When analyzing the Flood Damage Reduction Summary table, refer to the note in Section 1.3.2.2.

Non-exceedance graphs comparing the Baseline and combination run at each of the control points directly downstream of the modified projects are shown in Figure 34, Figure 35, Figure 36 and Figure 37. Only small changes between the combination run and the individual project simulations occurred. Further discussion on the control points for the individual projects can be found in Section 1.4.2, Section 1.6.2 and Section 1.8.2.

Comparing the combination run to the Baseline, Table 45 shows that there are negligible impacts to BiOp flow targets. These results are comparable with the individual project simulations.

Figure 34: Non-Exceedance Values for Regulated Flow at the Mehama Control Point on the North Santiam River. Compares Simulation ALL SRP Release More_041213 (colored lines) to the Baseline statistics (gray areas).

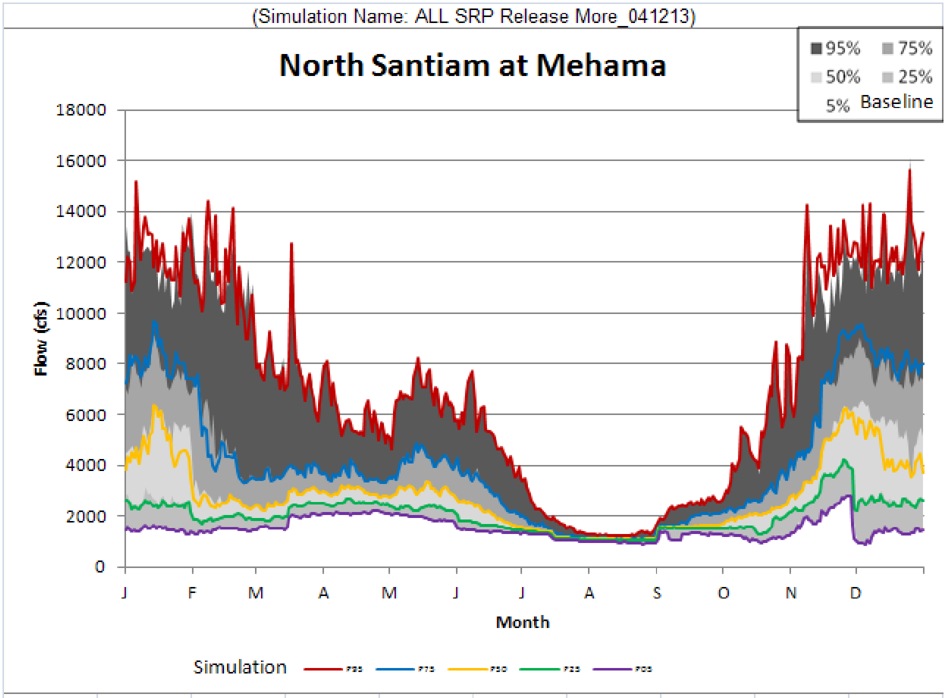


Figure 35: Non-Exceedance Values for Regulated Flow at the Jefferson Control Point on the Santiam River. Compares Simulation ALL SRP Release More_041213 (colored lines) to the Baseline statistics (gray areas).

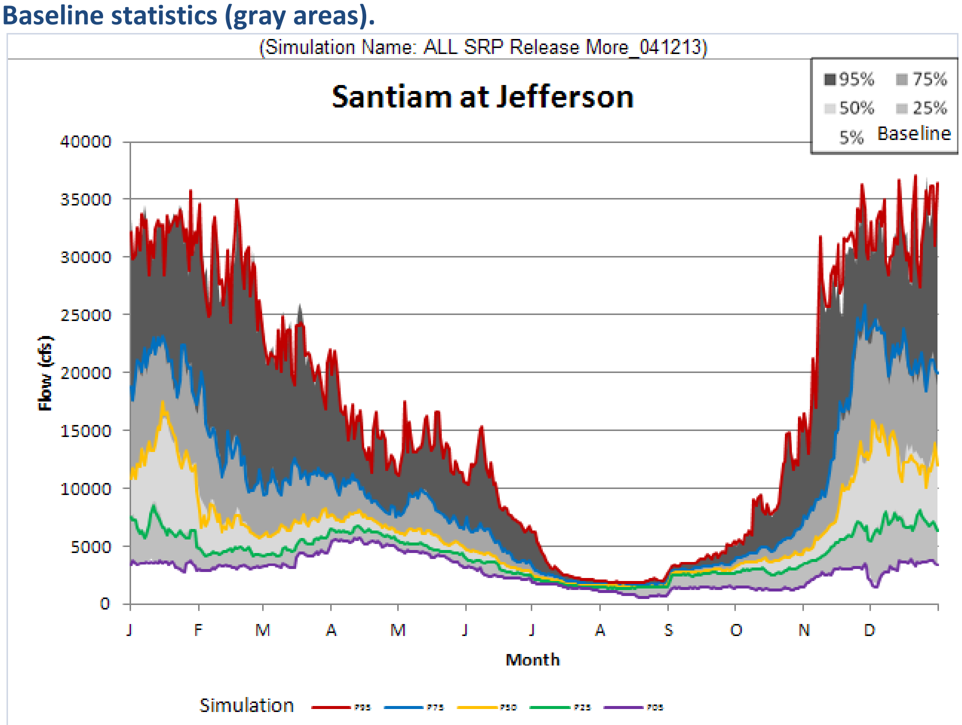


Figure 36: Non-Exceedance Values for Regulated Flow at the Vida Control Point on the McKenzie River. Compares Simulation ALL SRP Release More_041213 (colored lines) to the Baseline statistics (gray areas).

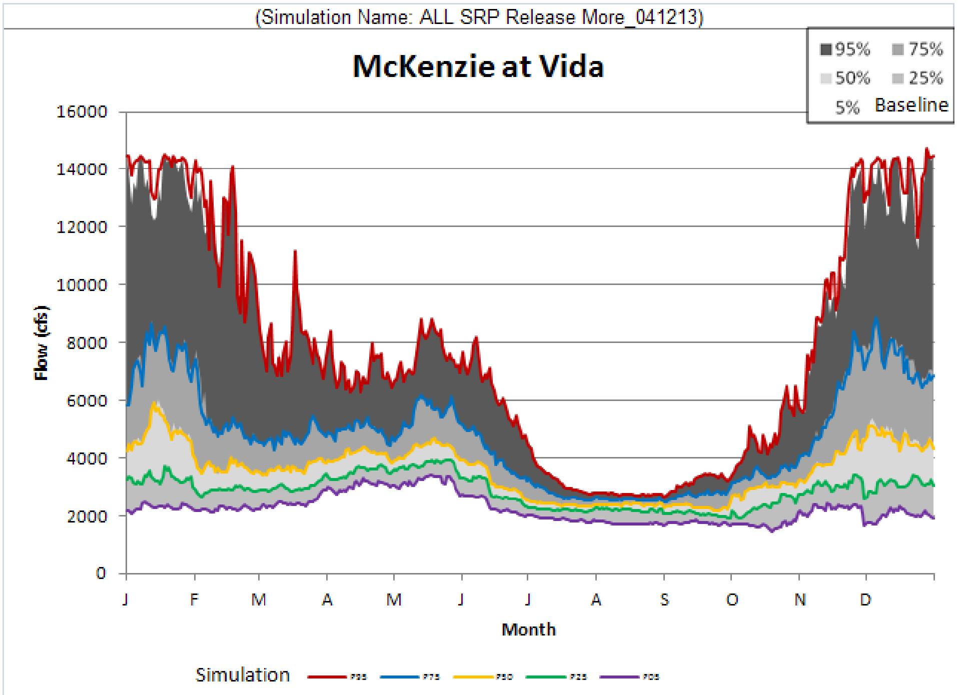


Figure 37: Non-Exceedance Values for Regulated Flow at the Jasper Control Point on the Middle Fork of the Willamette River. Compares Simulation ALL SRP Release More_041213 (colored lines) to the Baseline statistics (gray areas).

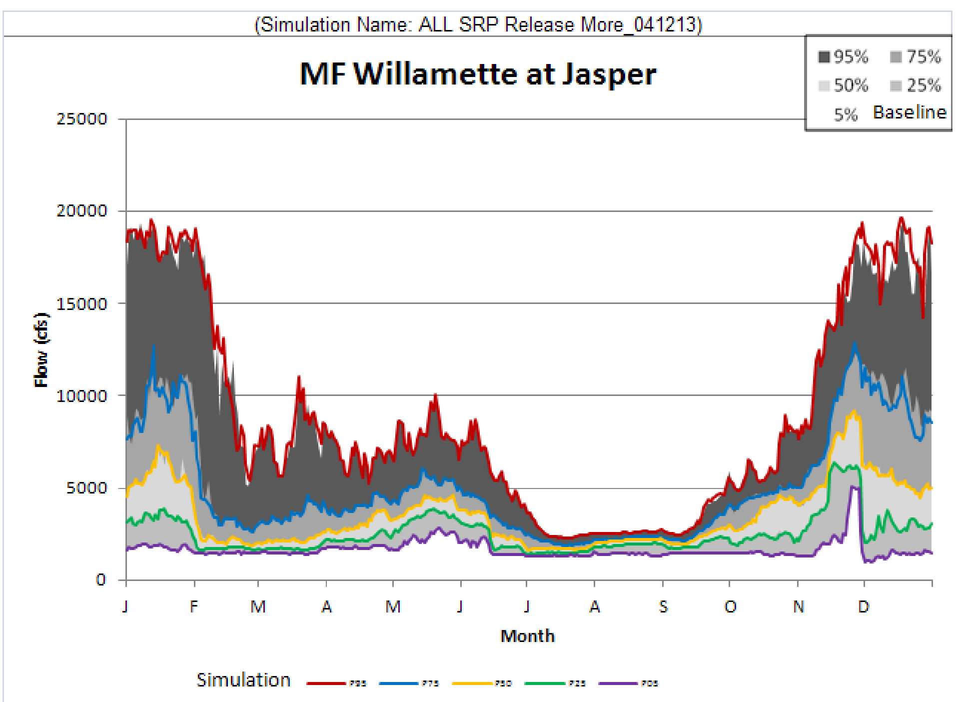


Table 45: BiOp Flow Targets: Comparison between Simulation ALL SRP Release More_041213 and Baseline of non-exceedance values for the number of days specified flow targets are NOT met.

BiOp Flow Targets: Summary of Days Flows Not Met										Simulation: ALL SRP Release More_041213							
Non-Exceedance Values for the Number of Days maximum or minimum flows are not met.				Non-Exceedance Values for 73 Water Years (Conditional formatting compares to Baseline counterpart.)						Median Non-Exceedance Values by Water Year Type							
				IRRM_Baseline_041213 Period of Record			Simulation Period of Record			Baseline by Water Year Type				Simulation by Water Year Type			
	Period	Flow Target	Purpose	5%	50%	95%	5%	50%	95%	Abundant	Adequate	Insufficient	Deficit	Abundant	Adequate	Insufficient	Deficit
Cottage Grove	01 October - 31 December	50 cfs min	Instream	0	0	35	0	0	35	0	0	1	0	0	0	1	0
	01 - 31 January	50 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	75 cfs min	Instream	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 30 September	50 cfs min	Instream	0	0	7	0	0	7	0	0	0	0	0	0	0	0
Dorena	01 October - 31 December	100 cfs min	Instream	0	0	22	0	0	22	0	0	0	0	0	0	0	0
	01 - 31 January	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	190 cfs min	Instream	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 30 September	100 cfs min	Instream	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hills Creek	01 October - 31 December	400 cfs min	Migration & Rearing	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	400 cfs min	Migration & Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	400 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fall Creek	01 - 15 October	200 cfs min	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 March	50 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 April - 31 May	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 June	80 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	80 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	400 cfs max	Chinook Spawning	0	1	21	0	1	20	7	0	0	0	7	0	0	0
Dexter	01 - 15 October	1200 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	1	0	0	0	1
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 30 June	1200 cfs min	Rearing	0	0	27	0	0	26	0	2	12	24	0	2	13	24
	01 July - 31 August	1200 cfs min	Rearing	0	2	31	0	2	31	1	1	9	24	0	1	9	24
	01 - 30 September	1200 cfs min	Chinook Spawning	0	1	30	0	1	30	0	0	2	28	0	0	2	27
	01 - 30 September	3500 cfs max	Chinook Spawning	0	0	5	0	0	7	0	0	0	0	0	0	0	0
Blue River	01 - 15 October	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 October - 31 December	50 cfs min	Chinook Incubation	0	0	9	0	0	9	0	0	0	0	0	0	0	0
	01 - 31 January	50 cfs min	Chinook Incubation	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 February - 31 August	50 cfs min	Rearing	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 - 30 September	50 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cougar	01 - 15 October	300 cfs min	Chinook Spawning	0	0	8	0	0	4	0	0	0	0	0	0	0	0
	16 October - 31 December	300 cfs min	Chinook Incubation	0	0	11	0	0	11	0	0	0	0	0	0	0	0
	01 - 31 January	300 cfs min	Chinook Incubation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 31 May	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 June - 30 June	400 cfs min	Migration & Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 July - 31 August	300 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	300 cfs min	Chinook Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	580 cfs max	Chinook Spawning	0	12	25	0	12	24	18	0	2	0	18	0	1	0
Fern Ridge	01 October - 31 December	30 cfs min	Irrigation	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	01 - 31 January	30 cfs min	Irrigation	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 February - 30 June	50 cfs min	Irrigation	0	0	10	0	0	10	0	0	0	7	0	0	0	7
	01 July - 30 September	30 cfs min	Irrigation	0	3	22	0	3	22	2	2	1	13	2	2	1	13
Foster	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	15	1	0	0	15	1
	16 October - 31 December	1100 cfs min	Chinook Incubation	0	0	28	0	0	28	0	0	7	1	0	0	15	1
	01 - 31 January	1100 cfs min	Chinook Incubation	0	0	14	0	0	14	0	0	0	0	0	0	0	0
	01 February - 15 March	800 cfs min	Rearing	0	0	2	0	0	2	0	0	0	0	0	0	0	0
	16 March - 15 May	1500 cfs min	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 May - 30 June	1100 cfs min	Steelhead	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 July - 31 August	800 cfs min	Rearing	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	30	0	0	30	0	0	5	30	0	0	5	30
	16 March - 15 May	3000 cfs max	Rearing	5	19	42	6	19	42	30	16	8	7	30	16	8	7
	01 - 30 September	3000 cfs max	Chinook Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
Big Cliff	01 - 15 October	1500 cfs min	Chinook Spawning	0	0	15	0	0	15	0	0	0	0	0	0	0	0
	16 October - 31 December	1200 cfs min	Chinook Incubation	0	0	21	0	0	21	0	2	0	11	0	2	0	11
	01 - 31 January	1200 cfs min	Chinook Incubation	0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 February - 15 March	1000 cfs min	Migration & Rearing	0	0	4	0	0	4	0	0	0	0	0	0	0	0
	16 March - 31 May	1500 cfs min	Steelhead Spawning	0	0	1	0	0	1	0	0	0	0	0	0	0	0
	01 June - 15 July	1200 cfs min	Steelhead	0	1	2	0	1	2	1	1	1	1	1	1	1	1
	16 July - 31 August	1000 cfs min	Rearing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 30 September	1500 cfs min	Chinook Spawning	0	0	28	0	0	28	0	0	0	0	0	0	0	0
	16 March - 15 May	3000 cfs max	Chinook Spawning	0	6	37	0	6	37	15	0	0	0	15	0	0	0
	01 - 30 September	3000 cfs max	Steelhead Spawning	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albany	01 - 31 October	Varies		0	0	17	0	0	17	0	0	0	0	0	0	0	0
	01 - 15 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	16 - 30 June	Varies		0	0	0	0	0	0	0	0	0	0	0	0	0	0
	01 - 31 July	Varies		0	2	15	0	2	15	2	4	1	5	1	4	1	5
	01 - 15 August	Varies		0	7	13	0	7	13	9	1	0	8	9	1	0	7
	16 - 31 August	Varies		0	4	16	0	3	16	6	0	0	7	6	0	0	7
	01 - 30 September	Varies		0	5	27	0	5	24	5	2	0	15	5	2	0	15
Salem	01 - 31 October	Varies		0	0	12	0	0	12	0	0	0	0	0	0	0	0
	01 - 30 April	Varies		0	7	17	0	7	17	1	8	14	12	1	8	13	12
	01 -31 May	Varies		0	5	23	0	5	23	0	14	15	21	0	14	17	21
	01 - 15 June	Varies		0	4	12	0	4	12	0	6	6	9	0	6	6	9
	16 - 30 June	Varies		0	0	6	0	0	6	0	3	0	0	0	3	0	0
	01 - 31 July	Varies		0	0	5	0	0	6	0	0	0	0	0	0	0	0
	01 - 15 August	Varies		0	0	8	0	0	7	0	0	0	0	0	0	0	0
	16 - 31 August	Varies		0	0	15	0	0	15	0	5	0	0	0	5	3	0
	01 - 30 September	Varies		0	0	23	0	0	21	0	3	0	1	0	3	0	1

Non-Exceedance Value Example for Baseline Run, Cottage Grove Minimum Tributary Flows for October through December:
Minimum tributary flows were met all days of October through December for 5% of the water years.
Minimum tributary flows were met all days of October through December for 50% of the water years.
Minimum tributary flows were met for 35 days or less of October through December for 95% of the water years.