RECLAMATION

Managing Water in the West

Hydrologic and Biological Assessment of 2017 Upper Klamath Lake Elevations Relative to 2013 Biological Opinion Thresholds

Klamath Project, Oregon/California
Mid-Pacific Region

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Bureau of Reclamation

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Contents

Page

Introduction and Background 1

Threshold Elevation Evaluation and Hydrologic Summary 2

Causative Factors 3

Biological Discussion of 2017 UKL Elevations 5

Conclusion 7

Corrective Actions Taken in 2017 and Next Steps 8

Literature Cited 9

Introduction and Background

On May 31, 2013, the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS; collectively the Services) jointly issued the *Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2023, on Five Federally Listed Threatened and Endangered Species* (BiOp). The BiOp outlines thresholds for minimum surface elevations developed by the USFWS for Upper Klamath Lake (UKL) based on the modeled results of the proposed action. These thresholds represent the lower limits of elevations that are expected to occur in UKL during the term of the proposed action, with very limited exceptions. The BiOp describes UKL elevations below the minimum elevation thresholds as outside the scope of the USFWS analyses and provide for an early warning that hydrologic conditions or water resource management are out of balance compared with the simulated and intended results of implementing the proposed action. Upper Klamath Lake elevations that fall below an end-of-month threshold indicate that Reclamation must identify the reasons for the unexpected elevations and consult with the Services regarding implementation of potential adaptive management actions to prevent further variance from the thresholds. However, if adaptive management is unsuccessful at avoiding threshold variations and the USFWS does not accept the rationale for the variation or mitigation of the effects, the action will be declared to be outside of the USFWS analysis and may trigger reinitiation of consultation.

Additionally, *Term and Condition 1c* of the BiOp requires Reclamation to take corrective actions to ensure UKL elevations are managed within the scope of the proposed action and to take certain actions when an excessive downward trend below thresholds is observed. Specifically, *Term and Condition 1c* requires that Reclamation shall determine the causative factors of the decrease and determine whether these factors are within the scope of the proposed action and the effects analyzed in the BiOp. If Reclamation determines that there are causative factors that may be outside the scope of the proposed action and the BiOp, Reclamation shall immediately consult with USFWS to take corrective actions. The methodology for calculating elevation thresholds was revised in 2015 through two memoranda between Reclamation and the Services.

Reclamation has prepared this assessment, in coordination with the Services, to describe: 1. factors which caused UKL elevations to fall below threshold elevations in April and May 2017, 2. impacts to suckers as a result of missing threshold elevations, and 3. future actions to prevent lake elevations below end-of-month threshold elevations. Hydrologic conditions were evaluated by comparing actual and projected hydrological conditions for 2017 with the hydrological conditions from the Klamath Basin Planning Model (KBPM) that formed the basis of the USFWS effects analysis in the BiOp as described on page 116 of the BiOp. Impacts to suckers are described by reviewing the relationship between surface elevations and habitat availability for suckers for the period of April through July 2017.

Threshold Elevation Evaluation and Hydrologic Summary

Hydrologically, water year 2017 was the 9th wettest year, by cumulative inflow to date, of the past 37 years and annual cumulative inflows are projected to fall between the 20 percent and 40 percent exceedance intervals for the Period of Record since mid-February (Figure 1). The water year was characterized by above average precipitation and snowpack, which peaked on March 9 at 134 percent of median. The last time the snowpack was greater than the 2017 values for March 9 was in 2006, when snowpack was 151 percent of median. In addition, Upper Klamath Basin snowpack is a primary driver of Williamson River and overall UKL inflow forecasts developed by the Natural Resources Conservation Service (NRCS), predictive tools used extensively for implementation of the BiOp. In addition to snowpack, a number of events this past winter affected UKL elevations and thresholds.

This past winter marked the first time PacifiCorp was required to operate UKL to the wet flood control curve under the 2013 BiOp, since projected inflows were greater than 710,000 AF. The wet flood control curve maintains UKL at a lower elevation to try and prevent extensive flooding around UKL if a large snowmelt or rain event occurs.

Upper Klamath Lake elevations were above thresholds throughout the fall/winter (October-February) of 2016-2017. The UKL elevation at the end of March was 4,142.69 feet, just above the end-of-month threshold elevation of 4,142.68 feet, as shown in Figure 1. At the end of April, the lake elevation was 4,142.88 feet, 0.09 feet below the threshold elevation of 4,142.97 (volumetric difference of 7,499 AF). The end of May UKL elevation was 4,142.33 feet, 0.29 feet lower (approximately 24,085 AF) than the threshold elevation of 4,142.62 feet. As of June 28, the UKL elevation is projected to be 0.25 feet above the end of June threshold and subsequent months are expected to remain above their respective thresholds.

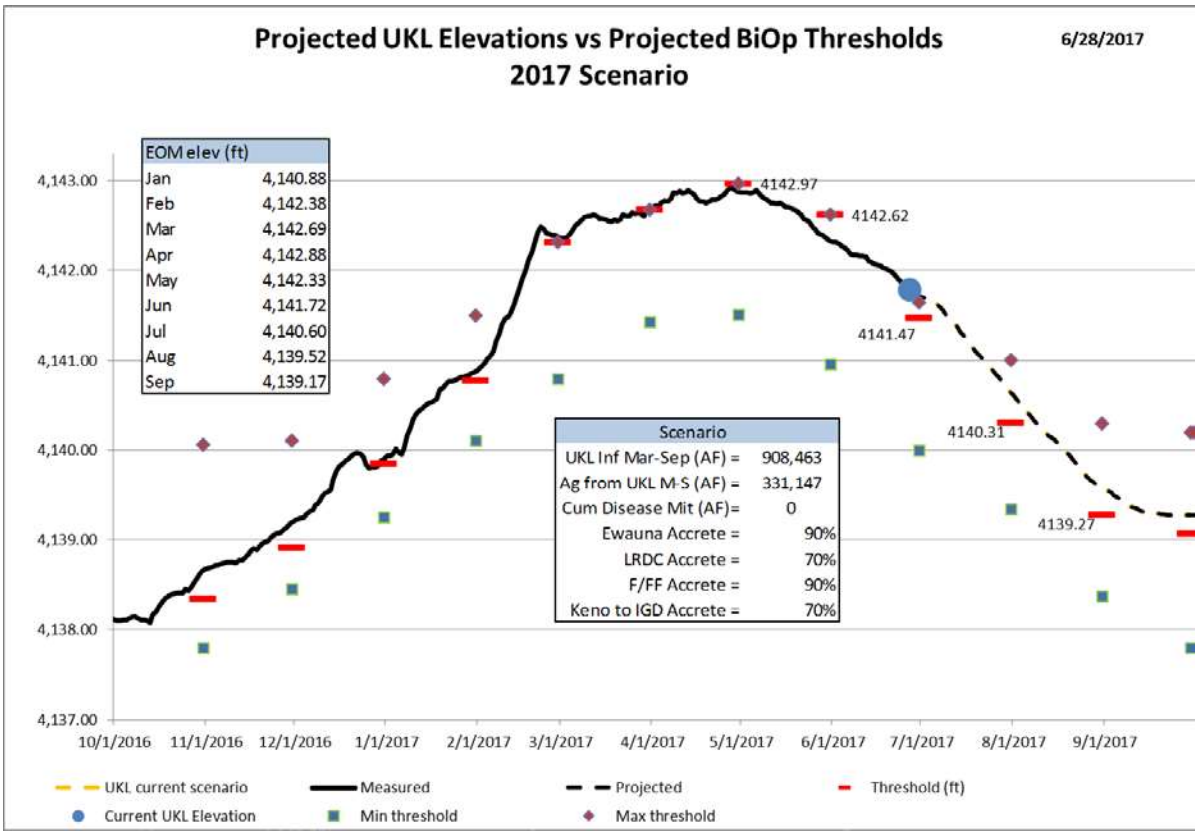

Figure 1. Upper Klamath Lake observed elevations, projections, and thresholds for water year 2017 (as of June 28). Actual 2017 end-of-month thresholds are depicted by red bars, maximum thresholds are depicted by purple diamonds, and minimum thresholds as green squares.

Causative Factors

In March and April, PacifiCorp operated UKL according to the flood control curve for a wet scenario because the NRCS forecasted March-September inflow volume was greater than 710,000 AF. The wet flood control curve applies a conservative UKL fill rate and allows for storage in UKL in case a large snowmelt or rain event occurs. In mid-April, while operating under the wet flood control curve, PacifiCorp did not adjust Link River releases commensurate with declining UKL inflows. This resulted in UKL elevations moving from 0.03 feet above the flood curve on April 13 to 0.20 feet below the curve on April 19. The 0.20 feet in elevation represented a volumetric difference in UKL of 16,659 acre feet (AF). Lacking a mechanism in the BiOp to allow making up for the lost volume (and a considerable reduction in UKL inflows), UKL remained below the flood control curve and UKL operations began transitioning back to the formulaic approach starting on April 16, 2017.

The transition period constituted a joint effort between Reclamation and the Services to mitigate the effect of the unplanned deviation from flood control operations; this transition period lasted

from April 16 until the return to the formulaic approach on April 29, 2017. During the transition period, Reclamation coordinated with NMFS and PacifiCorp to reduce flows at Link River Dam (i.e., increase the refill rate of UKL), while reducing flows at a lower rate below Iron Gate. The coordination with NMFS and PacifiCorp mitigated lake elevation impacts by approximately 10,500 AF while reducing the risk of juvenile salmonid stranding below Iron Gate Dam.

Under the formulaic approach, which began on April 29, the BiOp prescribes Klamath River flow releases based on Williamson River flows (based on the EWA volume) and the UKL fill rate. If the measured Williamson River flows exceed the projected flows or if the UKL fill rate exceeds the expected fill rate, then more water is released from UKL. This methodology works as long as the projected inflow volumes are accurate. Table 1 shows that there was significant over-prediction of both Williamson River flows and total UKL inflows in the month of May.

Since the overall EWA volume is based on NRCS seasonal forecasts, which are only updated at the start of the month, releases were made at a higher rate through the month of May until a revised June inflow forecast was received. The revised June inflow forecast resulted in a reduction of the EWA from 835,000 AF to 795,000 AF. If Reclamation could have adjusted the EWA projection mid-month to better reflect actual hydrology, releases to the Klamath River during the last week of May would have been reduced by approximately 5,200 AF.

	March	April	May	March-May Total (TAF)
NRCS-UKL inflow forecast	275	190	200	665
Actual UKL inflow	293	223	160	676
NRCS-Williamson flow forecast	170	130	143	443
Actual inflow from Williamson River	186	159	120	465

Table 1. Forecasted versus measured flows in 2017 (in Thousand Acre Feet, TAF)

In examining the causes behind the issues experienced in May, it is important to consider several factors. First, NRCS forecasts are provided on the first of each month as a seasonal forecast of total expected inflows from the first of any given forecast month through September. In order to operationalize these forecasts, Reclamation must derive monthly estimates for any given month,

leading to the potential for a misallocated forecast amount. Second, in addition to observed snowpack, NRCS forecasts account for precipitation. May precipitation at the Klamath Falls Airport was 0.29 inches, 21% of the average May precipitation of 1.38 inches. Finally, the KBPM assumed perfect foresight in hydrologic operations, meaning that the model had foreknowledge of the amount of water that was to come into the system and therefore distributed water in a manner to meet stated model goals. In daily operations, Reclamation has no such foresight and cannot be expected to accurately anticipate all possible scenarios. Operations are, necessarily, reactive.

Biological Discussion of 2017 UKL Elevations

The period of April through July each year is important for each life history stage of endangered suckers in UKL. Adult suckers spawn in the tributaries and along the eastern shoreline of UKL from March through May with a peak typically in April, eggs and embryos incubate in gravel at spawning areas for about three weeks following egg deposition, and larval sucker abundance increases in the lake environment after they swim up from natal gravels from May through July. Upper Klamath Lake surface elevations influence the amount of habitat available for each of these life history stages during spring months.

Sucker spawning at the eastern shoreline of UKL typically begins in March, peaks in April, and continues through May. Approximately 91 percent of the composite shoreline spawning habitat is inundated to at least 1 foot depth, and is available for sucker spawning along the eastern shoreline, at a lake surface elevation of 4,142.5 feet (Table 2, NMFS and USFWS 2013). The observed 2017 April end-of-month surface elevation for UKL was 4,142.88 feet. Assuming a linear relationship between surface elevation and available spawning habitat, this elevation results in approximately 99.5 percent of the available spawning habitat at the eastern shoreline inundated to a depth of at least a foot (spawning habitat availability is maximized at an elevation of at least 4,142.9 feet). The 2017 end-of-April threshold surface elevation was calculated at 4,142.97 feet. As a result of the observed end-of-month surface elevation for April being 0.09 ft. below the threshold elevation, there was a less than 0.5 percent reduction in the amount of spawning habitat available at the eastern shoreline spawning areas.

Sucker spawning activity along the eastern shoreline typically decreases during the month of May in comparison to March and April. The end-of-month May threshold elevation was calculated as 4,142.62 ft. In May 2017, the observed end-of-month elevation was 4,142.33 ft., which resulted in approximately 85 percent of the available spawning habitat inundated to at least one foot depth still available throughout the month (Table 2). The end-of-month observed elevation in May was below the calculated threshold elevation and resulted in a reduction of about seven percent of available spawning habitat at the eastern shoreline spawning areas.

Lake Elevation	Sucker Springs	Silver Building Spring	Ouxy Spring	Cinder Flat	Composite of Shoreline Spawning
4,142.5	92				90.5
4,142.0	77	70	61	87	73.8
4,141.5	63				62.0
4,141.0	53	48	25	73	49.8

Table 2. Percent of sucker spawning habitat along the eastern shoreline of Upper Klamath Lake that is inundated to at least a 1 foot depth at lake surface elevations (Table 8.3, NMFS and USFWS 2013).

Following egg deposition at the spawning areas, eggs and embryos incubate in natal gravels for approximately three weeks. Eggs, embryos, and pre-swim-up larval suckers are vulnerable to the threat of desiccation from a decline in lake surface elevations during this time. Surface elevation declines of over one foot during a month may expose embryos and pre-swim-up larvae to this threat during the months of April, May, and June (NMFS and USFWS 2013). Peak sucker spawning at the eastern shoreline typically occurs in April, therefore a surface elevation drop of greater than 1 foot from April-to-May and May-to-June are likely to have the greatest adverse impact on developing suckers through desiccation of spawning areas (NMFS and USFWS 2013). Although the end-of-month observed surface elevations in April and May were below the calculated threshold elevations for both months in 2017, the observed surface elevation change when eggs and embryos would be present was either positive or negative by less than 1 foot for March (+0.31ft.), April (+0.19 ft.), May (-0.55 ft.), and projected for June (-0.83 ft.).

The additional seasonal concern for suckers in UKL from April through July is access to nearshore, shallow areas with emergent vegetation for larval suckers after swim-up from spawning areas. Free-swimming larvae enter the lake environment as early as March and April with peak numbers of free-swimming larval suckers present in UKL from mid-May through mid-June. In UKL, suckers transition from a larval stage to an early juvenile stage in July, becoming less reliant on emergent vegetation habitats. Although emergent wetlands occur at several locations around UKL (e.g., Hanks Marsh, Shoalwater Bay, Upper Klamath National Wildlife Refuge, and Wood River Delta), those at the Williamson River Delta are particularly important to suckers because they are adjacent to the major source of larvae emigrating from spawning areas in the Williamson and Sprague Rivers (Dunsmoor et al. 2000, NMFS and USFWS 2013). As surface elevation in UKL decreases through the summer, so does the area of inundated emergent vegetation at the Williamson River Delta; at an elevation of 4,139.0 feet almost no emergent wetland is inundated (Table 3, NMFS and USFWS 2013).

Upper Klamath Lake Surface Elevation	Tulana Emergent Vegetation (acres)	Goose Bay Emergent Vegetation (acres)	Total Williamson River Delta Emergent Vegetation (acres)
4,143.0	1,080	1,560	2,640
4,142.0	850	1,390	2,240
4,141.0	580	1,080	1,660
4,140.0	290	550	870
4,139.0	0	0	0

Table 3. Acres of potential emergent vegetation habitat at the Williamson River Delta under different Upper Klamath Lake elevations are based on data in Elseroad (2004) and a geographic information system analysis of topographic data. Little or no emergent vegetation is expected below 4,139 feet (modified from Table 8.4, NMFS and USFWS 2013).

As of June 22, 2017, the projected end-of-month June and July surface elevations are 4,141.74 and 4,140.62 feet, respectively. Assuming a linear relationship between the area of potential emergent vegetation and lake surface elevation (Table 3), about 2,100 acres of emergent vegetation will be available for larval suckers at the Williamson River Delta at the end of June and about 1,400 acres at the end of July. The projected amount of emergent wetland habitat available in June and July 2017 is more than was available during the last few years. However, missing the thresholds did reduce available emergent habitat in May, an effect that will carry through July.

Conclusion

This threshold evaluation indicates that the primary causative factors leading to UKL surface elevations below calculated threshold elevations in UKL in April and May 2017 were flood control operations, over-forecasting of monthly UKL inflows in May, and the assumption of perfect foresight in Project operations. All of these factors are outside the scope of the Proposed Action and beyond the control of Reclamation. However, Reclamation recognizes that USFWS has an expectation that threshold elevations will be met consistent with their analysis in the 2013 BiOp and Reclamation is committed to doing everything within its control to avoid these problems in the future. These steps are outlined in the next section.

Reclamation performed an assessment to determine if the hydrologic conditions observed and projected for 2017 are within the range of hydrologic conditions in the POR for the BiOp analyses, and found that the magnitude and pattern of hydrologic conditions during 2017 are within the full range (between 20 and 40 percent exceedance since February), and similar to the magnitude and pattern, of the hydrologic conditions found in the POR.

In addition, Reclamation also assessed the biological effects of the measured and projected UKL elevations based on the USFWS effects analysis included in the BiOp as described on page 116. Reclamation's assessment found that April and May 2017 elevations are within the range of elevations analyzed in the BiOp and the projected end of June 2017 elevation is expected to be greater than the threshold elevation analyzed in the BiOp. The measured end-of-month elevations for April and May 2017 resulted in reduced spawning and nursery habitat but did not likely result in significant negative effects beyond those analyzed in the BiOp.

Based on the hydrological and biological assessments, Reclamation found that the actual and projected 2017 UKL elevations are within the range of conditions observed in the POR and the full range of effects analyzed in the BiOp. Reclamation has consulted with the Services on the causative factors for missing the thresholds, implemented corrective actions in 2017, and will be recommending additional steps to address the causative factors.

Corrective Actions Taken in 2017 and Next Steps

In an effort to prevent UKL elevations from falling below subsequent threshold elevations in 2017, Reclamation implemented the following corrective measures:

1. Reclamation coordinated with the USFWS and pumped 4,650 AF of water out of Agency Lake and Barnes Ranch into UKL during the month of May to increase UKL elevations. The pumping was intended to offset impacts to UKL elevations that could have arisen from implementation of emergency dilution flows. However, Reclamation continued to pump in late May to increase lake elevations, despite having information that indicated emergency dilution flows would not be needed. Continued pumping at Agency Lake Barnes Ranch will not be possible in 2017 due to the potential impacts of nutrient loading from this action.
2. In April 2017, after Reclamation identified the potential to miss the April threshold coming out of flood control operations, Reclamation coordinated with NMFS and PacifiCorp (beginning on April 20) to reduce flows at Link River Dam (i.e., increase the refill rate of UKL), while reducing flows at a lower rate below Iron Gate. This action reduced the risk of juvenile salmonid stranding below Iron Gate Dam while allowing for a faster UKL fill rate. The coordination with PacifiCorp mitigated lake elevation impacts by approximately 10,500 AF.

In addition, Reclamation recommends consideration of the following actions to reduce forecast error, improve stakeholder communication, and identity flexibility within operations to meet subsequent thresholds:

3. Reclamation recommends continued coordination with the USFWS to identify and consider alternative methodologies and time-steps for updating inflow forecasts and

EWA volumes. In addition, Reclamation recommends continued coordination with the Services to find flexibility within the proposed action that would allow for hydrologic adjustments following operational errors (e.g., as occurred coming out of flood control operations in April 2017).

4. Reclamation, in coordination with the USFWS, proposes to continue to track actual UKL elevations as they relate to the remaining end-of-month thresholds with a conservative approach to managing UKL elevations and irrigation deliveries to increase the likelihood of meeting the remaining threshold elevations.
5. Additionally, Reclamation will coordinate with Klamath Basin irrigators to continue conserving water, and PacifiCorp to determine if adjustments in operations are necessary to remain above threshold elevations for the remainder of the irrigation season.

Literature Cited

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