



— BUREAU OF — RECLAMATION

Peer Review Report

Low-Flow Operations Study at Bighorn Lake

Date

December 17, 2021

Originating Office

Bureau of Reclamation, Missouri Basin Region, Regional Office, 2021 4th Ave North, Billings, Montana 59101

Reclamation Roles

Director or delegated manager: Brent Esplin, Regional Director, Missouri Basin Region, Bureau of Reclamation

Peer Review Lead: Lauren Allin, Civil Engineer, Missouri Basin Region, Bureau of Reclamation

Peer Review Scope

The subject of this review were the methods, results, and conclusions of the Low-Flow Operations Study. The scientific information subject to review was included in the Low-Flow Operations Study technical report. This scientific information will be used to inform reservoir operations during low inflow water years. The model files were not subject to review, however information on the RiverWare modeling environment and information on the Bighorn system model application's assumptions, inputs and outputs was provided to reviewers.

1. Are the goals, definitions, methods, and results understandable?
2. Was the evaluation of modeled policy scenarios comprehensive?
3. Are limitations and uncertainties appropriately characterized?
4. Are there any issues, concerns, or suggestions that are not covered by the questions above?

Reviewers were to provide comment solely on the scientific information and process being reviewed, and not on any agency decision or policy.

Peer Reviewers

The peer reviewer was selected by Reclamation staff by considering expertise, independence, and absence of conflict of interest. The selected peer reviewer has expertise in hydrology, water resources engineering, and water resources planning and management. The selected reviewer is familiar with the model software used for this study (CADSWES RiverWare) or similar hydrology model software. The selected peer reviewer is listed below:

- Marketa McGuire, Civil Engineer (Hydrologic), Bureau of Reclamation Technical Services Center

Summary of Reviewer Comments

Reviewer comments regarding the four questions identified above for the peer review scope are summarized below.

In response to Question 1, the peer reviewer provided the following input:

“Generally, yes. There are comments and suggestions within the document for helping to improve understanding in the report.

- Executive Summary
 - The goals and objectives of the study could be more clearly defined and described in one place.
 - Recommendations could be summarized in a bulleted list
- Description of forecast methods
 - Forecast methods for developing inflow forecasts are not sufficiently described or referenced. If this information is included in a previous report, please cite that and provide references for the reader.”

In response to Question 2, the peer reviewer provided the following input:

“Yes. The authors thoroughly considered and tested the scenarios described in the study report.”

In response to Question 3, the peer reviewer thought the report appropriately characterized the limitations and uncertainties of the study.

In response to Question 4, the peer reviewer provided the following input:

1. Request a technical writer review the report for a good technical edit to include things like:
 - a. Verb tense
 - b. Consistency of terminology
 - c. Using target as a verb??

- i. Try to avoid “target” used too many times in a sentence, e.g. to target a target....
2. I suggest reviewing the Executive Summary. It can be improved and better explained. I see that the ES was compiled from parts of the main report, but it’s really confusing to a reader who may only look at the ES. Improved context, definitions, and descriptions are needed.
3. Please be clear about what you mean by “benefits” in various descriptions of model results. For the most part, this is confusing and it’s best to simply say the results show. Is more storage a benefit, is higher releases a benefit, etc.?
4. I suggest a consistent set of thresholds on pool elevation figures and release figures
5. I suggest including a description of the forecasts used in this study. How are the forecasts developed? Who develops them? How often do they come? What form do they come in? How are they used?

Specific reviewer comments and agency responses are listed in the following table.

| Reviewer Name | Page(s) or other reference location | Line Number(s) if applicable | Priority | Comment | Agency Response |
|---------------|-------------------------------------|------------------------------|-------------|--|---|
| Reviewer 1 | Review Summary Document | N/A | Substantive | The goals and objectives of the study could be more clearly defined and described in the executive summary | Added some clarity based on comments from reviewer within the document |
| Reviewer 1 | Review Summary Document | N/A | Substantive | Recommendations could be summarized in a bulleted list in the executive summary | Added a summarized bullet list of recommendations |
| Reviewer 1 | Review Summary Document | N/A | Substantive | Forecast methods for developing inflow forecasts are not sufficiently described or referenced. If this information is included in a previous report, please cite that and provide references for the reader. | Added several paragraphs further describing forecasting methods throughout the report |
| Reviewer 1 | Review Summary Document | N/A | Clerical | Review verb tense | Addressed all cases of future tense within the report |
| Reviewer 1 | Review Summary Document | N/A | Clerical | Review consistency of terminology | Addressed inconsistent terminology as identified by reviewer comments within the report |
| Reviewer 1 | Review Summary Document | N/A | Clerical | Review the use of the word target | Reviewed all instances of the word target throughout the report to improve readability |
| Reviewer 1 | Review Summary Document | N/A | Substantive | Review the use of the word benefit throughout the report | Replaced the word "benefit" or similar words with specific descriptions of the results. If "benefit" or similar words were used with accurate descriptions of what benefit means in that instance, the word "benefit" was left in the report. |

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| Reviewer 1 | Review Summary Document | N/A | Substantive | Edit figures throughout the report to display consistent thresholds on pool elevation and release figures | All figures have been edited for consistent thresholds and formatting |
| Reviewer 1 | Page 7 | 128 | Clerical | Rewrite sentence for clarity | Done |
| Reviewer 1 | Page 7 | 130 | Clerical | Rewrite sentence for clarity | Done |
| Reviewer 1 | Page 7 | 143 | Clerical | Define minimum fill threshold | Done |
| Reviewer 1 | Page 7 | 155 | Clerical | Clearly list the objectives of this study in the Introduction and Objectives section. Objectives are identified below in the methods sections and they should go here. | Done |
| Reviewer 1 | Page 8 | 161 | Clerical | Suggested re-word. Hydrology model typically refers to a rainfall-runoff type model. | Done |
| Reviewer 1 | Page 8 | 171 | Clerical | Suggested re-word. | Done |
| Reviewer 1 | Page 8 | 180 | Clerical | Suggested re-word. | Done |
| Reviewer 1 | Page 8 | 183 | Clerical | What is the purpose of having more information about long-range forecasts? What's the goal of this analysis? What does understanding of historical forecast skill provide? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 8 | 185 | Clerical | Please discuss the source of inflow forecasts | Added some clarification to this section of the report. |
| Reviewer 1 | Page 9 | 215 | Clerical | Add some background information on how Montana Area Office operates the lake and what the recommendations mean. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 9 | 220 | Clerical | Since this table includes recommendations, I would combine this section with Recommendations and call it "Results and Recommendations" | Decided to leave Table 1 per the original document. The author wanted to match the executive summary organization to the rest of the report organization where possible |

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| Reviewer 1 | Page 9 | 220 | Clerical | I suggest organizing the policies in this table by recommendation type, starting with those recommended for implementation at the top. | Decided to leave Table 1 per the original document. The author wanted to match the executive summary organization to the rest of the report organization where possible |
| Reviewer 1 | Page 11 | 240 | Clerical | Clarify the use of the word "benefits". I see this terminology is used throughout the report. I've made suggestions for how to say this differently. Because "benefits" is often confusing. | Stated what the results were rather than adding interpretation. |
| Reviewer 1 | Page 12 | 277 | Clerical | Suggested re-word. | Done |
| Reviewer 1 | Page 12 | 289 | Clerical | This is the first mention of "gains" – this needs to be explained. How is this different from forecasted inflows? | Added some explanation of how forecasts are developed and what forecast components are, including forecast gains. |
| Reviewer 1 | Page 13 | 294 | Clerical | Suggested that limitations should be its own section of the executive summary. | Created a new section for limitations |
| Reviewer 1 | Page 15 | 327 | Clerical | It's strange that the 2019 review is mentioned here, but then not introduced until the following paragraph. Suggest introducing the 2019 review first. | Re-arranged report to improve clarity |
| Reviewer 1 | Page 15 | 337 | Clerical | Suggested re-word | Left this wording in the original report format. This language was paraphrased from another document and the author wants to match the original document's language |
| Reviewer 1 | Page 16 | 342 | Clerical | Define minimum fill volume threshold | Added some clarification to this section of the report. |
| Reviewer 1 | Page 16 | 348 | Clerical | Suggested re-word | Done |

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| Reviewer 1 | Page 16 | 357 | Clerical | Make sure that minimum fill volume threshold is the consistent terminology | Went through the report to check for inconsistent terminology instances |
| Reviewer 1 | Page 16 | 362 | Clerical | Add an explanation for what improvements means | Added some clarification to this section of the report. |
| Reviewer 1 | Page 17 | 396 | Clerical | I suggest listing these reports not by publish date but by order of oldest to newest policy. | The ordering of operating criteria in Table 2 was discussed at length between Missouri Basin and Montana Area Office staff. We felt that the original ordering made the most sense and provided the most accurate picture of the history of operations at Bighorn Lake. |
| Reviewer 1 | Page 18 | 403 | Clerical | What about the 2015 criteria (which is also used in 2020)? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 18 | 414 | Clerical | What results would be due to the model itself? This is confusing. What model changes were made? I thought only different policy scenarios were tested. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 21 | 501 | Clerical | Is this described in more detail somewhere? If so, please provide the reference (2019 Criteria Review perhaps). If not, then more explanation here will be necessary, or say this is described in detail below. | Directed readers to the section that describes model limitations to improve clarity |
| Reviewer 1 | Page 21 | 509 | Clerical | I see the following subsections: Minimum Fill Volume Threshold, Early Spring Modeled Operations, Spring Modeled Operations, Summer Modeled Operations. Can you make | Re-did the subheadings and references for consistency |

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| | | | | this list consistent with the subheadings to follow? | |
| Reviewer 1 | Page 22 | 564 | Clerical | Low-flow operations should have a hyphen. Check this throughout. | Went through the report to check for inconsistent terminology instances |
| Reviewer 1 | Page 22 | 565 | Clerical | This is confusing – you mean current year? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 23 | 568 | Clerical | I think you could clarify the language here a bit in the flow chart. I do find these flow charts helpful. | Went through all of the flow-chart diagrams to improve readability and clarity. |
| Reviewer 1 | Page 25 | 601 | Clerical | Most probable is not the same thing as median. Is this really what you did? | Added some explanation to the report on median vs. most probable forecasts and how they are similar and how they are different. |
| Reviewer 1 | Page 26 | 610 | Clerical | Please include a brief description of the sources of these forecasts. You use the median of some ensemble of historical forecasts? This needs to be defined and described. And/or please cite a source where these are described. | Added a section to discuss forecast methods and how forecasts are developed |
| Reviewer 1 | Page 26 | 612 | Clerical | Maybe instead this heading could be: Methodology for RiverWare Simulations | Re-wording the heading |
| Reviewer 1 | Page 26 | 616 | Clerical | This is the terminology you introduced earlier in the report. Good to be consistent. | Went through the report to check for inconsistent terminology instances |
| Reviewer 1 | Page 26 | 619 | Clerical | This is not yet defined or described. One suggestion is that this section could go after the Low—Flow Operating Criteria Methods section. | Added some clarification to this section of the report. |

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| Reviewer 1 | Page 26 | 634 | Clerical | Confusion on calculation methodology | Added some clarification to this section of the report. |
| Reviewer 1 | Page 27 | 674 | Clerical | It seems this section would be a good place to list the policies that were tested? Unless this is done later in the report. | Directed readers to the summary of results section that briefly describes all the policies tested. |
| Reviewer 1 | Page 29 | 738 | Clerical | Remove part of this description. The description here is confusing and I think you've done a sufficient job describing the metric without this. | Removed. |
| Reviewer 1 | Page 29 | 748 | Clerical | Elsewhere in the report you discuss use of median forecasts, and describe this as the most probable forecast. But this is not mentioned at all here. Please include discussion of the forecasts used in the study analysis and how. And distinguish most probable from median. | Added an extra paragraph to discuss forecasting methods and how they apply to this section of the report. |
| Reviewer 1 | Page 31 | 800 | Clerical | Remove a sentence | Removed. |
| Reviewer 1 | Page 31 | 806 | Clerical | I don't see earlier mention of an April 30 target. Are there targets pool elevations at the end of each month? If so, I suggest adding this to Table 3. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 33 | 836 | Clerical | I might suggest putting this threshold on Figure 4 & 6 for those days when this is relevant (Memorial Day to Labor Day). Maybe true for other metrics as well (e.g. powerplant ops), and other similar figures in this report. | Added thresholds to diagrams |

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| Reviewer 1 | Page 36 | 890 | Clerical | Can you describe what you mean by poor September results? Is it simply that the dynamic fill case provided less energy than the static case? Maybe say that instead. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 36 | 908 | Clerical | I thought forecasts went out 12 months? Also, this has me wondering why 12 month forecasts are used since there so little skill in a forecast for the following fall/winter/runoff season? I see you discuss the issues with long-range forecasts later on I'm curious the source of these forecasts and what is the history behind using them? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 38 | 927 | Substantive | No reporting of energy production because the dynamic fill case didn't do as well? I suggest stating the reason for not including those results for 2006 as you do for other years. | Added 2006 energy value results and some discussion about the results. |
| Reviewer 1 | Page 38 | 946 | Clerical | How were they selected? Were years ranked for inflow volume and for forecast error? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 44 | 1048 | Clerical | This is a little confusing. The model was trying to release to get down to 3,547ft? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 44 | 1071 | Clerical | Do you mean compare all the options or just the recommended ones? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 45 | 1076 | Clerical | Suggest making these headings exactly the same as the section headings below that describe them. | Re-did the headings in the table to match report headings. |

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| Reviewer 1 | Page 50 | 1127 | Clerical | I suggest not using target twice in a sentence like this. I've suggested alternate wording in other parts of the report. I just wanted to address this more broadly. | Changing wording throughout the report where possible to meet this request. |
| Reviewer 1 | Page 52 | 1159 | Clerical | Is there more than 1 fall target? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 53 | 1196 | Clerical | How are these targets incorporated into the ruleset? I assume the 3,632ft target is primary and the 3,623ft target is secondary? Or were they considered independently? It might be helpful to include this detail here. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 54 | 1240 | Clerical | I think another sentence explaining this statement is needed. Is this because potentially more water will be stored to allow for more hydropower production and fisheries benefits the next year? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 58 | 1295 | Clerical | How could this policy be considered in an operational context where we don't have the ability to forecast multi-year droughts? | Added some clarification to this section of the report. |
| Reviewer 1 | Page 58 | 1300 | Clerical | It seems perhaps a re-ordering of the alternatives could help understanding. Since this is the current operating policy, maybe this one should be described first in this section? Something for the authors to consider | The author chose not to re-order this section. The order of the report was discussed at length internally. |

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| Reviewer 1 | Page 58 | 1302 | Clerical | I find myself having a hard time keeping track of what policy is the base case and what are alternatives. This is why I suggest referring back to this often – maybe this is easier for others reading the report to follow so this is just a suggestion. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 77 | 1623 | Clerical | This is due to the boat ramp focus? It would be useful to say that. | Added some clarification to this section of the report. |
| Reviewer 1 | Page 78 | 1634 | Substantive | Why not just include all the fall and winter months in the bins even if the results are the same if you just include fall months? Otherwise, this is really just Fall Results, not Fall and Winter Results. | Added the winter releases to the report as well. There are now fall and winter result figures |
| Reviewer 1 | Page 84 | 1722 | Clerical | Is a smaller gap between these metrics better? Maybe a bit more explanation is needed. | Discussed with the area office and decided to leave the language in the original format in this section. |

