# Fish Passage Plan (FPP) Change Form

**Change Form # & Title**: 23IHR001 – Unit 3 Operating Range

**Date Submitted**: 10-NOV-2022

**Project**: Ice Harbor

**Requester Name, Agency**: Jon Renholds and Chris Peery, Corps NWW

**Final Action: APPROVED as Revised 3-FEB-2023**

**FPP Section**:

IHR section 4.3 Turbine Unit Operating Range

**Justification for Change**:

IHR Unit 3 is being rebuilt with a new Voith Kaplan runner design (adjustable blade) and is currently scheduled to return to service in early 2023. This Change Form adds the new U3 operating range to the FPP.

Based on CFD and physical modeling, flow quality in the Unit 3 draft tube is optimized for fish passage by establishing the minimum blade angle as the lower limit, which is about 200–400 cfs above the 1% lower limit. Therefore, the operating range for Unit 3 will be between the Fish Passage (FP) Lower Limit (minimum blade angle) and the 1% Upper Limit. This range may be adjusted based on results of index testing in spring 2023 and biological testing in September 2023.

During periods of minimum generation, Unit 3 may be operated at the 1% lower limit to provide more flow for spill.

**Proposed Change**:

See following pages for edits to existing FPP in track changes.

* 1. Turbine Unit Operating Range.

**4.3.1.** Turbine unit flow and power output at the lower and upper limits of the ±1% peak efficiency range are defined in **Table IHR-1**. Turbine units will be operated within these ranges according to *BPA’s Load Shaping Guidelines* (**Appendix C**), as summarized below.

**4.3.2.** Ice Harbor Unit 3 was rebuilt with a new adjustable-blade runner design and will have a restricted operating range within the 1%, as defined in **Table IHR-5**. Based on CFD and physical modeling, flow quality in the Unit 3 draft tube is optimized for fish passage by establishing the minimum blade angle as the lower limit, which is about 200–400 cfs above the 1% lower limit. Therefore, the operating range for Unit 3 will be between the Fish Passage (FP) Lower Limit (minimum blade angle) and the 1% Upper Limit. This range may be adjusted based on results of index testing in spring 2023 and biological testing in September 2023.

During periods of minimum generation with a single unit in use, Unit 3 will be operated at the 1% lower limit to provide more flow for spill, in accordance with **section 4.3.3.2** below.

**4.3.3. Off-Season: September 1–April 2.** While not required to do so in the off-season, turbines will normally run within the 1% range since it is the optimum point for maximizing energy output of a given unit of water over time. Unit 3 is still recommended to operate within the range defined in **section 4.2.2**. Operation outside the 1% range is allowed if needed for power generation or other needs.

**Table IHR-1. Ice Harbor Dam Turbine Unit Power (MW) and Flow (cfs) at ±1% of Peak Turbine Efficiency (Lower and Upper Limits of 1% Range) and Operating Limits. a**

|  |  |  |
| --- | --- | --- |
| **Project**  | **IHR Unit 3 c – with STS** | **IHR Unit 3 c – No STS** |
| **Head** | **1% Lower Limit** | **FP Lower Limit** | **1% Upper Limit**  | **Operating Limit** | **1% Lower Limit** | **FP Lower Limit** | **1% Upper Limit**  | **Operating Limit** |
| **(feet)** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** | **MW** | **cfs** |
| 85 | 55.3 | 8,657 | 57.3 | 8,894 | 86.1 | 13,473 | 94.1 | 14,920 | 55.1 | 8,585 | 57.3 | 8,858 | 89.0 | 13,862 | 93.6 | 14,681 |
| 86 | 56.4 | 8,708 | 58.0 | 8,904 | 87.4 | 13,501 | 95.5 | 14,990 | 56.2 | 8,647 | 58.2 | 8,878 | 90.4 | 13,903 | 95.1 | 14,709 |
| 87 | 57.3 | 8,748 | 59.0 | 8,935 | 88.9 | 13,572 | 96.6 | 15,007 | 57.4 | 8,714 | 59.2 | 8,914 | 91.3 | 13,855 | 96.4 | 14,703 |
| 88 | 58.0 | 8,754 | 59.6 | 8,930 | 90.4 | 13,626 | 97.9 | 14,992 | 58.3 | 8,733 | 60.0 | 8,927 | 93.2 | 13,966 | 97.6 | 14,699 |
| 89 | 58.6 | 8,741 | 60.6 | 8,953 | 92.0 | 13,712 | 99.3 | 14,944 | 59.0 | 8,744 | 60.7 | 8,921 | 94.8 | 14,035 | 98.9 | 14,708 |
| 90 | 59.3 | 8,734 | 61.4 | 8,953 | 93.9 | 13,831 | 100.6 | 14,944 | 59.8 | 8,749 | 61.6 | 8,938 | 96.6 | 14,138 | 100.2 | 14,725 |
| 91 | 60.0 | 8,741 | 62.2 | 8,963 | 95.5 | 13,904 | 101.9 | 14,937 | 60.5 | 8,755 | 62.4 | 8,939 | 98.4 | 14,237 | 101.5 | 14,721 |
| 92 | 60.8 | 8,749 | 62.9 | 8,962 | 97.2 | 13,980 | 103.1 | 14,949 | 61.3 | 8,767 | 63.1 | 8,945 | 100.3 | 14,331 | 103.1 | 14,765 |
| 93 | 61.8 | 8,784 | 63.8 | 8,983 | 98.3 | 13,975 | 104.4 | 14,966 | 62.2 | 8,794 | 63.9 | 8,962 | 101.5 | 14,346 | 104.5 | 14,795 |
| 94 | 62.9 | 8,828 | 65.2 | 9,071 | 99.5 | 13,981 | 104.5 | 14,797 | 63.2 | 8,826 | 64.9 | 8,993 | 102.9 | 14,374 | 104.5 | 14,617 |
| 95 | 63.8 | 8,858 | 66.5 | 9,157 | 101.0 | 14,018 | 104.5 | 14,587 | 64.2 | 8,862 | 65.8 | 9,029 | 104.4 | 14,426 | 104.5 | 14,435 |
| 96 | 64.7 | 8,877 | 67.8 | 9,225 | 103.1 | 14,152 | 104.5 | 14,375 | 65.1 | 8,895 | 66.8 | 9,066 | 105.9 | 14,468 | 104.5 | 14,253 |
| 97 | 65.6 | 8,909 | 69.1 | 9,308 | 105.6 | 14,355 | 104.5 | 14,180 | 66.1 | 8,930 | 67.8 | 9,105 | 107.6 | 14,549 | 104.5 | 14,075 |
| 98 | 66.4 | 8,936 | 70.1 | 9,349 | 107.8 | 14,502 | 104.5 | 13,999 | 67.0 | 8,954 | 68.8 | 9,135 | 109.2 | 14,602 | 104.5 | 13,903 |
| 99 | 67.5 | 8,981 | 70.8 | 9,342 | 109.2 | 14,519 | 104.5 | 13,827 | 67.8 | 8,969 | 69.8 | 9,170 | 111.0 | 14,689 | 104.5 | 13,738 |
| 100 | 68.4 | 9,002 | 71.3 | 9,310 | 110.9 | 14,593 | 104.5 | 13,666 | 68.7 | 8,999 | 70.9 | 9,211 | 113.0 | 14,797 | 104.5 | 13,575 |
| 101 | 69.3 | 9,021 | 71.9 | 9,290 | 112.5 | 14,636 | 104.5 | 13,515 | 69.7 | 9,030 | 71.7 | 9,218 | 114.5 | 14,831 | 104.5 | 13,418 |
| 102 | 70.3 | 9,047 | 72.6 | 9,283 | 114.0 | 14,684 | 104.5 | 13,372 | 70.7 | 9,058 | 72.4 | 9,219 | 115.8 | 14,846 | 104.5 | 13,275 |
| 103 | 71.4 | 9,093 | 73.2 | 9,254 | 114.9 | 14,641 | 104.5 | 13,236 | 71.8 | 9,102 | 73.4 | 9,249 | 117.3 | 14,872 | 104.5 | 13,138 |

NOTE: The lower limit for Unit 3 is set at the Fish Passage (FP) Lower Limit, which is about 200-400 cfs above the 1% Lower Limit. The intent is to optimize flow conditions in the draft tube for fish that pass via Unit 3. During minimum generation, Unit 3 will be operated at the 1% Lower Limit to provide more flow for spill. See **section 4.2.2** for more information.

**Comments**:

 10-NOV-2022 FPOM Meeting:

Swank - would like more detail on why the flow quality at the lower 1% is bad.

Renholds - it was qualitatively looked at with beads and dye and determined to be a worse operating point. There was instability in the draft tube below the FP lower limit. Draft tube hydraulics were rougher, more unsteady/turbulent. Assume this relates to fish impacts. The FP lower limit is purely for fish. The unit can run at the 1% lower limit, but modeling shows it’s more turbulent in the draft tube which is assumed to be worse for fish.

Keep this on the agenda for the December FPOM.

 8-DEC-2022 FPOM Meeting:

Peery and Wright added language to meet the intent of the “soft constraint” and allow operating below the FP lower limit, down to the lower 1%, during min gen to provide more spill.

After the meeting, Wright emailed the updated change form to FPOM for review and discussion at the JAN FPOM.

 12-JAN-2023 FPOM Meeting:

Conder and Lorz support this change form. Van Dyke wasn’t ready to approve. Still pending…

3-FEB-2023 FPOM FPP Meeting:

Conder – interested in this because it will also apply to unit 1. Other than during min gen, will it be a hard constraint to operate in this restricted range?

Peery – yes.

Conder - Change “may to “will”.

Wright – agrees that’s more clear and will revise.

**Record of Final Action**:

Approved as revised at the FPOM FPP meeting on February 3, 2023.