Thompson Falls Hydroelectric Project
FERC Project No. 1869

NorthWestern Energy
Initial Study Report
Total Dissolved Gas Study

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April 2022

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List of Abbreviations and Acronyms

ARM	Administrative Rules of Montana
cfs	cubic feet per second
DEQ	Montana Department of Environmental Quality
FERC	Federal Energy Regulatory Commission
flow	Project discharge
GBT	gas bubble trauma
High Bridge	below the Main Channel Dam
ILP	FERC's Integrated Licensing Process
Licensee	NorthWestern Energy
NorthWestern	NorthWestern Energy
Project	Thompson Falls Hydroelectric Project
Relicensing Participants	local, state, and federal governmental agencies, Native American Tribes, local landowners, non-governmental organizations, and other interested parties.
TDG	total dissolved gas
TDG Control Plan	Total Dissolved Gas Control Plan
Thompson Falls Project	Thompson Falls Hydroelectric Project
U.S.	United States

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1.0 Introduction

The Thompson Falls Hydroelectric Project (Thompson Falls Project or Project) is located on the Clark Fork River in Sanders County, Montana. Non-federal hydropower projects in the United States (U.S.) are regulated by the Federal Energy Regulatory Commission (FERC) under the authority of the Federal Power Act. The current FERC License expires December 31, 2025. As required by the Federal Power Act and FERC's regulations, on July 1, 2020 NorthWestern Energy, the current licensee, (NorthWestern or Licensee) filed a Notice of Intent to relicense the Thompson Falls Project using FERC's Integrated Licensing Process (ILP). Concurrently, NorthWestern filed a Pre-Application Document.

The ILP is FERC's default licensing process which evaluates effects of a project based on a nexus to continuing Project operations. In general, the purpose of the pre-filing stage of the ILP is to inform Relicensing Participants about relicensing, to identify issues and study needs (based on a project nexus and established FERC criteria), to conduct those studies per specific FERC requirements which are included in the FERC Study Plan Determination, issued May 10, 2021, and to prepare the Final License Application.

This Total Dissolved Gas (TDG) Initial Study Report has been prepared to comply with the requirements of NorthWestern's Revised Study Plan, filed April 12, 2021, as approved in FERC's Study Plan Determination.

1.1 Total Dissolved Gas Study Background

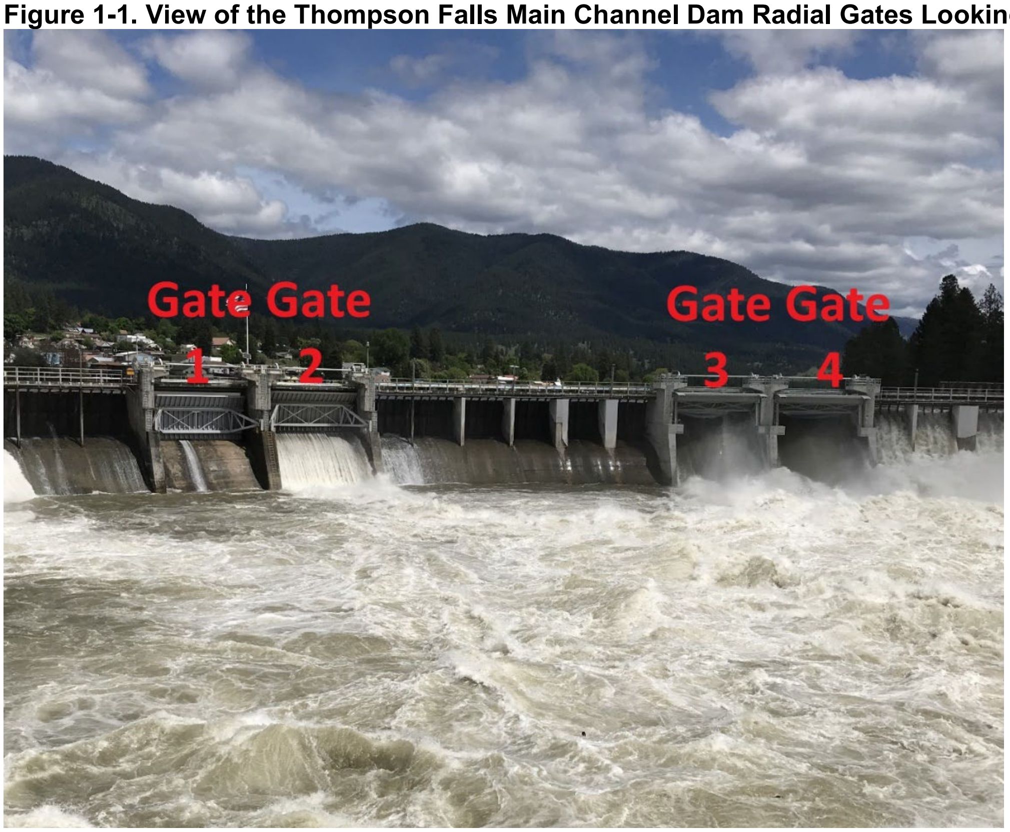
NorthWestern and the prior Licensee monitored TDG in the Clark Fork River most years during the 2003 to 2020 time period. These data have helped to inform NorthWestern on the optimal operations scenario to minimize TDG concentrations. The prior Licensee developed a TDG Control Plan in 2010 in consultation with the DEQ (PPL 2010**)**. The TDG Control Plan outlines operational practices used during the spring runoff period to minimize TDG concentrations in the Clark Fork River downstream of the Thompson Falls Project. Since 2010, the TDG Control Plan has been implemented annually.

In late 2018, construction was completed on two new radial spill gates, resulting in a total of four radial gates on the Main Channel Dam (**Figure 1-1**). Because these new radial gates are a change from the spill panels that were previously in use, the effect on TDG from these radial gates is not yet fully understood. Data collection occurred in 2019, 2020, and 2021, with additional data to be collected in 2022. These data will result in a better understanding of TDG concentrations at a wider range of discharge levels.

Water quality standards developed by the Montana Department of Environmental Quality (DEQ) (Circular DEQ-7) (DEQ, 2019) sets a standard of 110 percent of saturation for TDG. This water quality standard was developed to protect fish from high levels of TDG, which may cause gas bubble trauma (GBT). GBT can cause injury and, in severe cases, death to fish.

Montana's Surface Water Quality Standards and Procedures include language specific to dams. Administrative Rules of Montana (ARM) 17.30.602 defines "naturally occurring" as "conditions or material present from runoff or percolation over which man has no control or from developed land where all reasonable land, soil and water conservation practices have been applied. Conditions resulting from the reasonable operation of dams in existence as of July 1, 1971, are natural." ARM 17.30.636 (1) states that owners and operators of water impoundments that cause conditions harmful to prescribed beneficial uses of state water shall demonstrate to the satisfaction of the department that continued operations will be done in the best practicable manner to minimize harmful effects.

Figure 1-1. View of the Thompson Falls Main Channel Dam Radial Gates Looking Upstream.



1.2 Goals and Objectives of Study

The goal of this study is to gather data on TDG concentrations upstream and downstream of the Project throughout the spring runoff season to gain a better understanding of TDG concentrations in various discharge scenarios. The main objective is to collect additional information on whether and how the Project's new radial gates affect TDG concentrations downstream of the dams and powerhouses.

2.0 Methods

2.1 Study Area

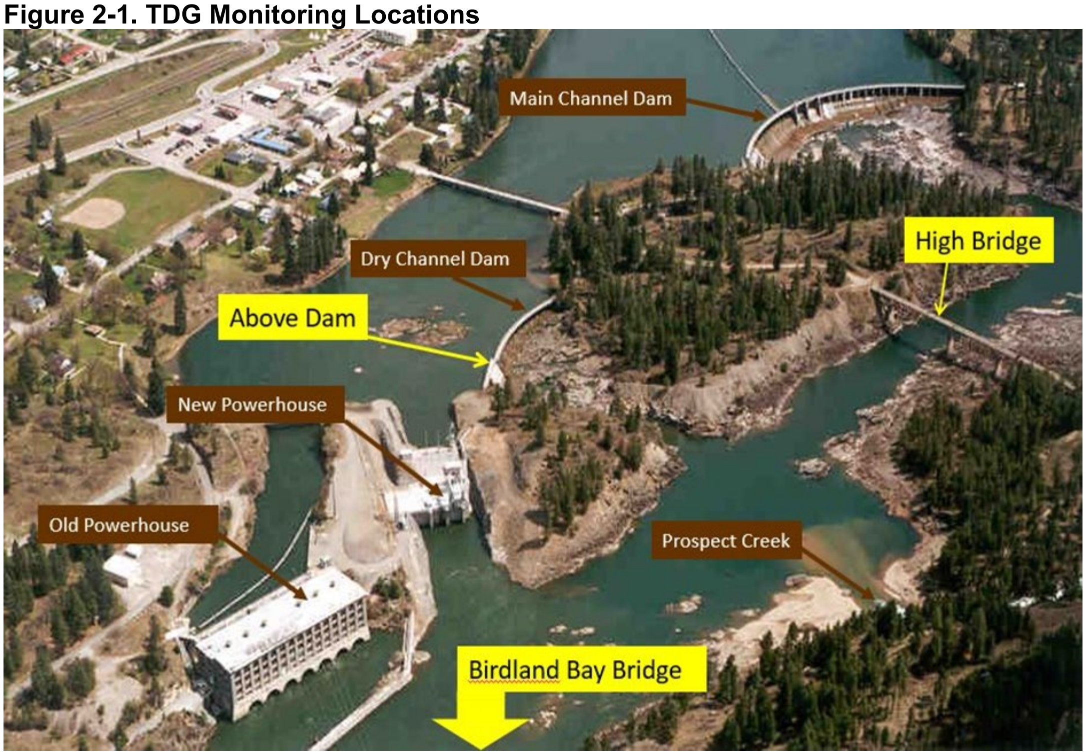
Hach Hydrolab instruments were deployed at three locations to capture TDG concentrations above the dam (Site AD), below the Main Channel Dam at the High Bridge (Site HB), and downstream of the Project at Birdland Bay Bridge (Site BBB). **Table 2-1** provides the locations of each of these monitoring sites.

Table 2-1: Descriptions and Latitude and Longitude of TDG Monitoring Sites.

Site Description	Latitude	Longitude
Above Dam – Upstream face of the Dry Channel Dam	47.593131	-115.356904
High Bridge – Downstream of the Main Channel Dam	47.590720	-115.354920
Birdland Bay Bridge – Clark Fork River downstream of Project at Birdland Bay Bridge	47.621436	-115.391592

The monitoring locations were chosen to represent the TDG concentrations of incoming water upstream of the Project, TDG concentrations of the spill water downstream of the Main Channel Dam, and TDG concentrations leaving the Project which captures a mixture of water from the powerhouse discharge and the spillway discharge.

Figure 2-1. TDG Monitoring Locations



2.2 Study Methods

TDG concentrations are highest during the spring runoff season, so data collection is focused during the spring runoff period, which usually occurs from early May through late June of each year. The first season of the TDG study conducted in 2021 consisted of monitoring TDG concentrations during the spring runoff season (May 12–July 1) at multiple locations around the Project's facilities under different discharge scenarios using Hach Hydrolab instruments. This study used methods that have been being used for ongoing TDG evaluation at the Project.

TDG data were collected throughout the spring runoff season to capture the variability of TDG entrainment in relation to flow rate in the Clark Fork River. During this time, operators of the Thompson Falls Project tested various configurations of spill through the Main Channel Dam using different combinations of the four radial gates. Each gate spill configuration was held for approximately 4 hours to allow the downstream TDG levels to stabilize. This methodology was consistent with testing conducted in 2019 and 2020 and was used to supplement the existing dataset. In 2021, Clark Fork River flows were relatively low, and peaked at a flow of 58,700 cfs at the USGS Clark Fork River at Plains stream gage. In contrast, the median peak streamflow at this gaging station is 74,800 cfs for the period of record (1912-2020) (USGS 2021). Due to the low peak flows in 2021, there were no opportunities to test radial gate configurations at river flows above 80,000 cfs.

The study will continue to be conducted during the 2022 study season, which will allow NorthWestern to capture data during a greater variety of discharge conditions. This Initial Study Report addresses the result of the study conducted to-date, with a Final Study Report to be filed on or before May 12, 2023.

2.3 Variances from the FERC-approved Study Plan

There were no variances to study methodology in 2021. For the 2022 study season, the aging Hach Hydrolab DS5 instruments will be replaced with new Eureka Water Probes Manta instruments. The instrumentation change will be an upgrade to a newer technology, which allows for greater instrument reliability and precision. Results between the Hach and Eureka probes are expected to be comparable, as the QA/QC and instrument calibration procedures will remain the same.

3.0 Results

TDG monitoring was conducted from May 12 through July 1. Hydrolab sondes were used to measure TDG on 15-minute intervals throughout this monitoring period and were calibrated on a bi-weekly basis to ensure sensor accuracy. On June 30, Clark Fork River flows had reduced to the point where the entirety of the river flow was passed through the powerhouses. TDG concentrations are highest during the spring runoff season, so data collection ended at the conclusion of the spring runoff, as specified in the Revised Study Plan (NorthWestern, 2021).

Peak discharge at Thompson Falls Dam occurred on June 6, 2021 and was estimated at 59,801 cfs. This discharge is calculated as the discharge using the USGS Clark Fork River at Plains gage plus the discharge from the Thompson River USGS gage located near its mouth. The peak concentrations of TDG occurred on June 5, 2021 at 120.1 percent TDG directly downstream of the Main Channel Dam, which equated to a peak of 113.3 percent TDG at Birdland Bay Bridge downstream (**Figure 3-1)**. The influence of water from the powerhouses reduces the total amount of TDG observed at Birdland Bay Bridge, which is approximately where the upstream end of the Noxon Reservoir pool is located.

Complete results from TDG monitoring in 2019, 2020, and 2021 are found in Appendix A. A summary of the results for different levels of spill are discussed below.

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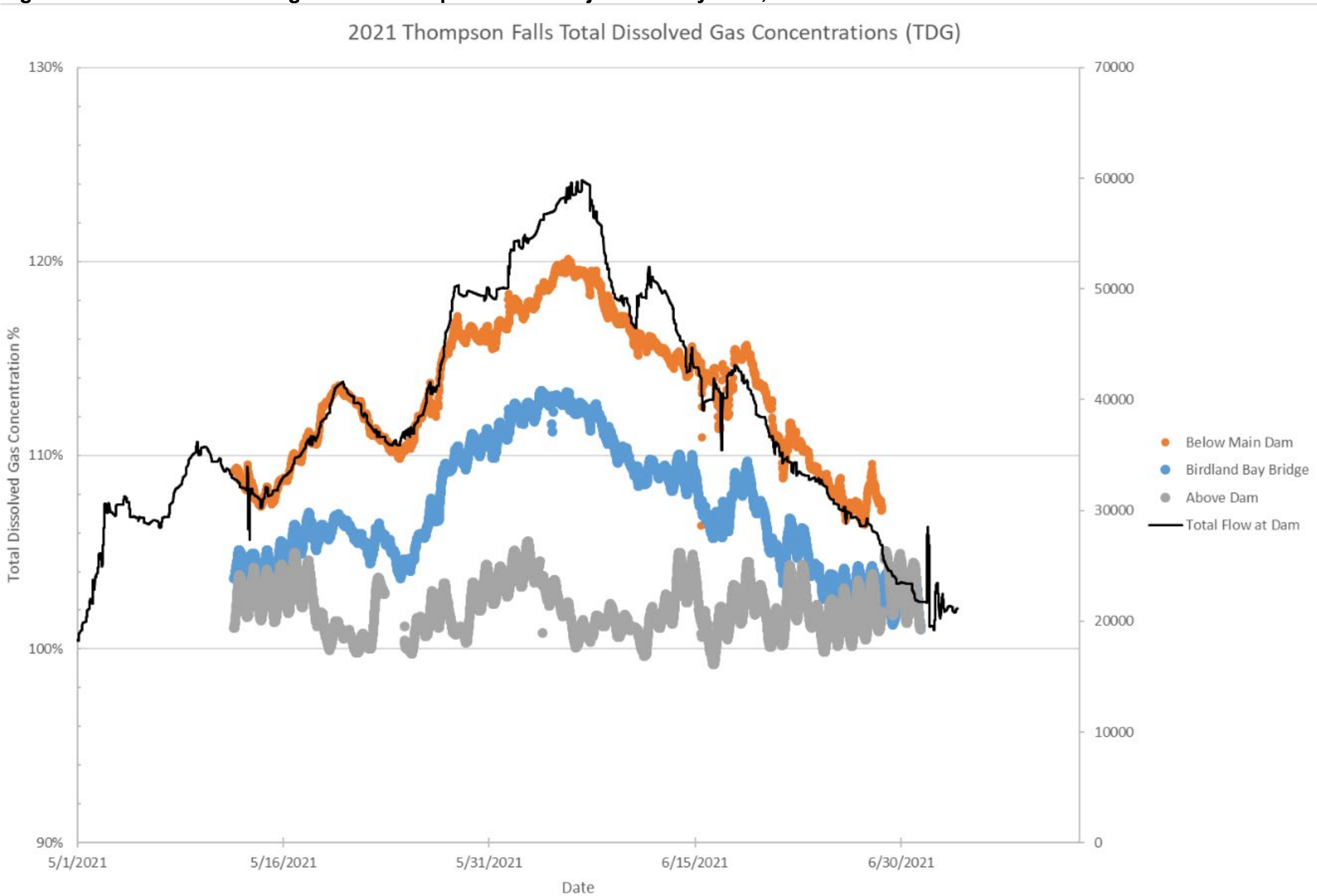
Figure 3-1. TDG and Discharge in the Thompson Falls Project Area by Date, 2021



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During the study period, radial gate testing was conducted to monitor the TDG concentrations in response to different spill configurations. Radial gate testing occurred on the descending limb of the hydrograph at approximately 5,000 cfs intervals from 40,000 cfs down to 30,000 cfs, which is near the point when spill operations ceased for the year. **Table 3-1** shows a summary of the results of gate configuration testing in 2021, as well as a summary of the previous gate configuration testing conducted in 2019 and 2020.

Table 3-1: Maximum and Minimum TDG by Flow Range at the High Bridge, 2019-2021[1]

Total Flow Range (cfs)	Max TDG at HB (% saturation)	Gate Setting at Max TDG	Min TDG at HB (% saturation)	Gate Settings Min TDG
30,000-35,000	112.5	1 full open, 2 4' open	107.5	4-partially open
40,000-45,000	114.4	1 and 2 open	111.7	1 and 4 open
45,000-50,000	118.8	1 and 4 open	116.2	2 and 4 open
55,000-60,000	121.6	3 and 4 open	119.6	1 and 2 open
65,000-70,000	122.7	3 and 4 open	119.8	1 and 3 open
75,000-80,000	123.1	3 and 4 open	121.2	2 and 3 open

3.1 TDG Results at 30,000-35,000 cfs Total Flow

During this phase of the testing, which occurred on June 20, 21, and 25, 2021 river flows were low enough that two full radial gates could not be opened at the same time. The first part of the test, conducted around 35,000 cfs, allowed one radial gate to be fully open and a second gate to be partially open to pass spillway flows. As river flows dropped near 30,000 cfs, only one radial gate was able to be partially opened, while the other three gates remained closed in order to maintain pond elevations.

The gate combination of operating radial gate #4 fully open and radial gate #1 partially open entrained the lowest amount of TDG and operating radial gate #1 fully open and radial gate #2 partially open entrained the highest amount of TDG downriver when flows were near 35,000 cfs. At lower river flows, operating only radial gate #4 partially open during the second half of the test entrained the lowest amount of TDG, and operating only radial gate #1 partially open entrained the highest amount of TDG when river flows were near 30,000 cfs.

3.2 TDG Results at 40,000-45,000 cfs Total Flow

During this phase of the testing, which occurred on June 16 and 17, 2021 river flows were high enough that different combinations of two gates being fully open were able to be tested. The results of this testing showed similar results to the testing conducted around 35,000 cfs, in

[1] No data are available for the 35,000 – 40,000 cfs, 50,000 – 55,000 cfs, 60,000 – 65,000 cfs, or 70,000 – 75,000 cfs flow ranges

which operating radial gate #1 and radial gate #4 open together entrained the lowest amount of TDG, while operating radial gate #1 and radial gate #2 open together entrained the highest amount of TDG at river flows between 40,000 and 45,000 cfs.

3.3 TDG Results at 45,000-50,000 cfs Total Flow

The TDG study approved by FERC is a continuation of testing that occurred in 2019 and 2020. Testing in 2019 occurred on May 23 and 24. The results of this testing showed that operating with radial gates #2 and #4 open together entrained the lowest amount of TDG and operating radial gates #1 and #4 open together entrained the highest amount of TDG at river flows between 45,000 and 50,000 cfs. Contrary to what we saw at other river flows, operating radial gates #1 and #2 open together actually entrained less TDG than operating radial gates #1 and #4 open together, which was the operational scenario that entrained the least amount of TDG at flows lower than 45,000 cfs.

3.4 TDG Results at 55,000-60,000 cfs Total Flow

The initial round of radial gate testing occurred on May 29, 2019, after the installation of radial gates # 3 and #4. Two gate combinations were tested. At river flows ranging from 55,000 to 60,000 cfs, radial gates #1 and #2 when operated open together entrained less dissolved gas downstream than radial gates #3 and #4 did when operated open together.

3.5 TDG Results at 65,000-70,000 cfs Total Flow

Testing on May 30 and 31, 2020 showed that operating radial gates #1 and #3 open together entrained the lowest amount of TDG and operating radial gates #3 and #4 open together entrained the highest amount of TDG at river flows between 65,000 and 70,000 cfs.

3.6 TDG Results at 75,000-80,000 cfs Total Flow

Testing on June 3 through June 4, 2020 showed that operating radial gates #2 and #3 open together entrained the lowest amount of TDG and operating radial gates #1 and #2 open together entrained the highest amount of TDG at river flows between 75,000 and 80,000 cfs.

4.0 Discussion

Low peak flows in the Clark Fork River in 2021 were less than optimal for testing TDG at the Project. Peak flows did not exceed 80,000 cfs, but NorthWestern used this opportunity to fill data gaps on the low end of the hydrograph and test spill gate configurations at river flows below 40,000 cfs. The results of the 2021 testing were compiled in a table with the results of the 2019 and 2020 testing to understand what happens to TDG at various flow regimes and under different radial gate operating scenarios (**Table 4-1**).

Table 4-1: Comparison of the Percentage TDG Entrained Downstream at Various River Flows under Different Radial Gate Operational Scenarios

Total River Flow (cfs)	Lowest %TDG Entrained	Intermediate %TDG Entrained				Highest %TDG Entrained
30,000	4 open	1 open	3 open	N/A	N/A	2 open
35,000	1 and 4 open	2 and 4 open	3 and 4 open	2 and 3 open	N/A	1 and 2 open
40,000-45,000	1 and 4 open	2 and 4 open	1 and 3 open	2 and 3 open	3 and 4 open	1 and 2 open
45,000-50,000	2 and 4 open	2 and 3 open	1 and 2 open	1 and 3 open	N/A	1 and 4 open
55,000-60,000	1 and 2 open	N/A	N/A	N/A	N/A	3 and 4 open
65,000-70,000	1 and 3 open	2 and 3 open	1 and 4 open	1 and 2 open	2 and 4 open	3 and 4 open
75,000-80,000	2 and 3 open	1 and 3 open	1 and 4 open	2 and 4 open	3 and 4 open	1 and 2 open

After testing various radial gate spill scenarios in 2021, the TDG data collected during this study shows that at lower flows, radial gates #1 and #4 tend to entrain the least amount of dissolved gas, while radial gate #2 appears to entrain the most amount of dissolved gas when operated singularly and in tandem with gate #1 (**Table 4-1**). While the radial gate operational scenario that entrained the least amount of TDG differed at various river flows, operating non-adjacent radial gates open in tandem generally entrains less TDG downstream than operating adjacent radial gates open together. While operating non-adjacent radial gates during spill operations will most likely reduce the amount of TDG entrained downstream, operation in this manner may not be practical at all times due to the need to flush large woody debris from the trash boom to prevent the debris from building up on the face of the dam. In cases such as this, radial gate spill operations may need to be altered to ensure dam safety.

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5.0 Conclusions

NorthWestern's study conclusions to-date, are:

1. Operating non-adjacent radial gates in combination with each other will generally reduce the amount of TDG entrained in the river downstream at river flows less than 80,000 cfs, although operation in this manner may not always be possible due to dam safety considerations.

2. Radial gate testing at flows above 80,000 cfs was not conducted in 2021. NorthWestern will monitor TDG again in 2022. Data will be collected at flows above 80,000 cfs as conditions allow.

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6.0 Literature Cited

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Appendix A – TDG Data From 2019 – 2021

Date of Test	Gate 1 Status	Gate 2 Status	Gate 3 Status	Gate 4 Status	Approximate Total River Flow (cfs)	Average % TDG During Testing Phase (HB Site)
6/20/2021	Full Open	4’ Open			30,000-35,000	112.5%
6/20/2021		Full Open	4’ Open		30,000-35,000	111.9%
6/20/2021			Full Open	4’ Open	30,000-35,000	111.0%
6/21/2021	3’ Open			Full Open	30,000-35,000	109.4%
6/21/2021		3’ Open		Full Open	30,000-35,000	109.6%
6/21/2021			3’ Open	Full Open	30,000-35,000	110.3%
6/25/2021	8.3’-8.4’ Open				30,000-35,000	107.8%
6/25/2021		8.4’-8.0’ Open			30,000-35,000	108.5%
6/25/2021			8.0’-7.7’ Open		30,000-35,000	108.1%
6/25/2021				7.7’-8.2’ Open	30,000-35,000	107.5%
6/16/2021	Open	Open			40,000-45,000	114.4%
6/16/2021	Open		Open		40,000-45,000	113.2%
6/16/2021	Open			Open	40,000-45,000	111.7%
6/17/2021		Open		Open	40,000-45,000	112.5%
6/17/2021		Open	Open		40,000-45,000	113.4%
6/17/2021			Open	Open	40,000-45,000	113.5%
5/23/2019	Open	Open			45,000-50,000	118.0%
5/23/2019	Open		Open		45,000-50,000	118.3%
5/23/2019	Open			Open	45,000-50,000	118.8%
5/23/2019	Open	Open			45,000-50,000	118.7%
5/24/2019	Open	Open			45,000-50,000	117.4%
5/24/2019		Open	Open		45,000-50,000	116.7%
5/24/2019		Open		Open	45,000-50,000	116.2%
5/24/2019	Open	Open			45,000-50,000	117.1%
5/21/2019	Open	Open			55,000-60,000	119.6%
5/21/2019			Open	Open	55,000-60,000	121.6%
5/21/2019	Open	Open			55,000-60,000	120.9%
5/30/2020	Open	Open			65,000-70,000	120.5%
5/30/2020	Open		Open		65,000-70,000	119.8%
5/30/2020	Open			Open	65,000-70,000	120.1%
5/30/2020		Open		Open	65,000-70,000	120.7%
5/30/2020		Open	Open		65,000-70,000	120.1%
5/31/2020			Open	Open	65,000-70,000	122.7%
6/3/2020	Open	Open			75,000-80,000	123.5%
6/3/2020	Open		Open		75,000-80,000	121.5%
6/3/2020	Open			Open	75,000-80,000	121.6%
6/3/2020		Open		Open	75,000-80,000	123.0%
6/3/2020		Open	Open		75,000-80,000	121.2%
6/4/2020			Open	Open	75,000-80,000	123.1%