Box 10000, 623 Main Street, Neepawa, Manitoba R0J 1H0
p: 1.204.476.3393 f: 1.204.476.3791 www.hylife.com

February 17, 2022
File: 111440368

Manitoba Conservation and Climate Client File No. 2755.20

Attention: Director
Environmental Approvals Branch
Manitoba Environment, Climate, and Parks
1007 Century Street
Winnipeg, MB R3H 0W4

Dear Director,

Reference: NOA Request – Licence 2870 RRR R3 Innovations Inc./Town of Neepawa IWWTF, Neepawa, MB

In accordance with Section 14(1) of *The Environment Act*, R3 Innovations Inc. and the Town of Neepawa are jointly submitting a request to alter Environment Act Licence 2870 RRR with an increase in licensed wastewater treatment capacity at the R3 IWWTF from the currently approved 1960 m^3/d to 2290 m^3/d. The increase is proposed to accommodate the proposed increase in processing at the HyLife pork plant (as detailed in a parallel separate request for alteration). The proposed increase recognizes the additional treatment capacity provided by the permanent use of the temporary treatment train (previously installed to facilitate operations during the refurbishment project) to supplement the restored capacity of the recently/soon-to-be refurbished treatment trains.

The NOA includes (among other items) examination of effects of the increased effluent discharge on the Whitemud River, supported by water quality monitoring data (collected in 2019 and 2020) and subsequent water quality modeling. Copies of the water quality assessment reports were provided to MCC as pre-submission materials in May 2021 for review and comment. HyLife held a virtual open house on the project in August 2021 to provide the public with a chance to learn about the planned expansion at the pork processing plant including the R3 IWWTF. No increase in the R3 IWWTF size is proposed as part of the alteration and no change in the licensed effluent discharge quality is proposed.

Should you require any additional information or clarifications please do not hesitate to contact Mr. Sheldon Stott, P.Ag., Senior Director of Corporate Sustainability, HyLife Foods LP, or Mr. Stephen Biswanger, P.Eng., Stantec Consulting Ltd.

Regards,

Sheldon Stott, P.Ag. Senior Director of Corporate Sustainability

Attachment: One NOA Form and Supporting Information
Two hard copies and one electronic copy of NOA

c. Stephen Biswanger, Stantec
Colleen Synchyshyn, CAO, Town of Neepawa

R3 Innovations Inc. IWWTF Treatment Capacity Increase Notice of Alteration

Final

February 22, 2022

Prepared for:

HyLife Foods Ltd./R3 Innovations Inc.

Prepared by:

Stantec Consulting Ltd.
500-311 Portage Avenue
Winnipeg, MB R3B 2B9

111440368

R3 INNOVATIONS INC. IWWTF TREATMENT CAPACITY INCREASE NOTICE OF ALTERATION

Prepared by ______________________________

(signature)

Bill Krawchuk, M.N.R.M., MCIP, RPP

Prepared by ______________________________

(signature)

Johanna Theroux, M.Sc.

Reviewed by ______________________________

(signature)

Stephen Biswanger, P.Eng.

Reviewed by ______________________________

(signature)

George Kroupa, Principal

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LIST OF APPENDICES

Notice of Alteration Form

Manitoba
Conservation and Climate

File No.: 2755.20	Environment Act Licence No.: 2870RRR

Legal name of the Licencee: R3 Innovations Inc./Town of Neepawa

Name of the development: R3 Innovations Inc. IWWTF Treatment Capacity Increase NOA

Category and Type of development per Classes of Development Regulation:
Waste Treatment and Storage — Wastewater treatment plants

Licencee Contact Person: Mr. Sheldon Stott, P.Ag., Senior Director of Corporate Sustainability
Mailing address of the Licencee: Box 1000, 623 Main Street
City: Neepawa Province: Manitoba Postal Code: R3C 1A5
Phone Number: (204) 424-2313 Fax: (204) 424-5177 Email: Sheldon.Stott@Hylife.com

Name of proponent contact person for purposes of the environmental assessment (e.g. consultant):
Mr. Stephen Biswanger, P.Eng.

Phone: (204) 924-7061 Fax: (204) 453-9012	Mailing address: 500-311 Portage Avenue, Winnipeg, MB R3B 2B9

Email address: stephen.biswanger@stantec.com

Short Description of Alteration *(max 90 characters)*:
R3 proposes to increase treated wastewater effluent rate from 1,960 m3/day to 2,290 m3/day

Alteration fee attached: Yes: ☐ No: ☑

If No, please explain: Credit Card Payment

Date: 2022-02-15	Signature: Printed name: Sheldon Stott

A complete Notice of Alteration (NoA) consists of the following components:

- ☑ **Cover letter**
- ☑ **Notice of Alteration Form**
- ☑ **1 hard copy and 1 electronic copy of the NoA detailed report** (see "Information Bulletin - Alteration to Developments with Environment Act Licences")
- ☑ **$500 Application fee, if applicable** (Cheque, payable to the Minister of Finance)

Submit the complete NoA to:
Director, Environmental Approvals Branch
Manitoba Conservation and Climate
1007 Century Street
Winnipeg, Manitoba R3H 0W4
EABDirector@gov.mb.ca

For more information:
Phone: (204) 945-8321 Fax: (204) 945-5229
https://www.gov.mb.ca/sd/permits_licenses_approvals/eal/licence/index.html

Note: Per Section 14(3) of the Environment Act, Major Notices of Alteration must be filed through submission of an Environment Act Proposal Form (see "Information Bulletin – Environment Act Proposal Report Guidelines")

Notice of Alteration Form

Manitoba Conservation and Climate

File No. : 2755.20	Environment Act Licence No. : 2870RRR
Legal name of the Licencee: R3 Innovations Inc./Town of Neepawa	
Name of the development: R3 Innovations Inc. IWWTF Treatment Capacity Increase NOA	
Category and Type of development per Classes of Development Regulation: Waste Treatment and Storage — Wastewater treatment plants	
Licencee Contact Person: Ms. Colleen Synchyshyn, CAO Mailing address of the Licencee: Box 339, 275 Hamilton Street City: Neepawa Province: Manitoba Postal Code: R0J 1H0 Phone Number: (204) 476-7603 Fax: Email: neepawacao@wcgwave.ca	
Name of proponent contact person for purposes of the environmental assessment (e.g. consultant): Mr. Stephen Biswanger, P.Eng.	
Phone: (204) 924-7061 Fax: (204) 453-9012	Mailing address: 500-311 Portage Avenue, Winnipeg, MB R3B 2B9
Email address: stephen.biswanger@stantec.com	
Short Description of Alteration *(max 90 characters)*: R3 proposes to increase treated wastewater effluent rate from 1,960 m3/day to 2,290 m3/day	
Alteration fee attached: Yes: No: [x] If No, please explain: Credit Card Payment	
Date: 2022-02-15	Signature: [redacted] Printed name: Colleen Synchyshyn

A complete Notice of Alteration **(NoA)** consists of the following components:

- ☑ **Cover letter**
- ☑ **Notice of Alteration Form**
- ☑ **1 hard copy and 1 electronic copy of the NoA detailed report** (see "Information Bulletin - Alteration to Developments with Environment Act Licences")
- ☑ **$500 Application fee, if applicable** (Cheque, payable to the Minister of Finance)

Submit the complete NoA to:
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Note: Per Section 14(3) of the Environment Act, Major Notices of Alteration must be filed through submission of an Environment Act Proposal Form **(see "**Information Bulletin – Environment Act Proposal Report Guidelines**")**

Executive Summary

R3 Innovations Inc. and the Town of Neepawa operate the dedicated R3 Innovations Industrial Wastewater Treatment Facility (R3 IWWTF) that exclusively serves the HyLife Foods pork processing plant. The R3 IWWTF is located within the southern part of SW35-14-15W in the Town of Neepawa on property that is owned by R3 Innovations Inc. The R3 IWWTF site is zoned "MH – Industrial Heavy" under the Town of Neepawa Zoning By-law No. 3184-18 (and "Industrial" under the Neepawa and Area Planning District Development Plan By-law No. 108) and has been in operation at this location since construction in 2009. Licence 2870 RRR, originally dated December 18, 2014, is the current *Environment Act* Licence for the facility.

R3 Innovations Inc./Town of Neepawa propose to make changes to the R3 IWWTF facility consisting of the permanent/full time utilization of a 3rd treatment train that was originally planned/constructed to provide temporary capacity during equipment refurbishment. The treated effluent generation rate is anticipated to increase by up to 330 m^3/d at the R3 IWWTF (from 1,960 m^3/d to 2,290 m^3/d) to address an increase in wastewater production from the HyLife pork processing plant due to an increase in hog processing from 42,260 hogs/wk to 46,385 hogs/wk. No increase in the R3 IWWTF size is proposed as part of the alteration and no change in the licensed effluent discharge quality is proposed. Changes to HyLife's pork processing plant are addressed separately in a parallel Notice of Alteration (NOA) application.

As required under *The Environment Act* (Manitoba), an application for NOA to the existing R3 IWWTF licence is submitted with supporting information to Manitoba Conservation and Climate (MCC) for consideration. This NOA application has been prepared by Stantec Consulting Ltd. (Stantec) on behalf of R3 Innovations Inc./Town of Neepawa in general accordance with Manitoba Sustainable Development's (MSDs) Information Bulletin, "*Alterations to Development with Environment Act Licences*" and in accordance with Section 14(1) of *The Environment Act* (MSD 2016). This report documents the relevant portions of the existing R3 IWWTF operations, the proposed alterations, and the potential environmental effects and proposed mitigation measures associated with the alterations.

Potential environmental effects of the Project are limited to the operation phase and are considered typical of project operation activities (i.e., related to the permanent use of the previously installed temporary 3rd treatment train and incremental changes to existing process chemical and energy usage and waste and effluent generation rates). The proposed alteration will ensure continued high quality wastewater treatment and mitigation of water quality effects on the Whitemud River while accommodating increased flows from the HyLife Foods pork processing plant. Residual operational effects are considered negligible to low.

On the basis of the desktop studies undertaken, and information available to date as presented in this report, the proposed alterations are not expected to create significant adverse environmental effects.

1.0 INTRODUCTION

1.1 PROJECT OVERVIEW

R3 Innovations Inc./Town of Neepawa (the proponent) operates an Industrial Wastewater Treatment Facility (R3 IWWTF) located adjacent to the HyLife Foods (HyLife) pork processing facility, along Provincial Trunk Highway (PTH) 16 in the Town of Neepawa in southwestern Manitoba (Appendix A; Figure 1-1). The R3 IWWTF has been in operation since its construction in 2009/2010. The proposed alteration (the Project) includes the permanent utilization of a previously installed/approved 3rd treatment train that was constructed to allow temporary redundant capacity for the refurbishment of the two original treatment trains at the IWWTF. The permanent operation of the 3rd train will provide sufficient capacity to accommodate the increase from 1,960 m^3/d to 2,290 m^3/d at the R3 IWWTF associated with the increase in wastewater generation related to the increase in hog processing (to 9,000 hogs/d, 46,385 hogs/week) at the HyLife pork processing plant. No increase in the R3 IWWTF size (beyond that of the previously approved refurbishment work outlined in the June 2020 and July 2021 NOAs) is proposed. The R3 IWWTF is governed under *Environment Act* Licence No. 2870 RRR (Appendix B). A parallel NOA request is submitted separately for the proposed production capacity increase at the separately licensed pork processing plant.

Section 14(1) of *The Environment Act* requires a proponent to notify the Director (for Class 1 and 2 developments) if the proponent intends to alter a licensed development so that it no longer conforms to licence conditions or has the potential to change the environmental effects (Manitoba Sustainable Development [MSD] 2016). The key consideration for assessing a Notice of Alteration (NOA) is the significance of the environmental effects and human health effects as a result of the alteration and whether there is sufficient detail to allow the Director to determine whether the effects of the alteration are significant, insignificant, or nonexistent (MSD 2016).

The existing treatment facility is considered a Class 2 Development under the Classes of Development Regulation (MR 164/88). This report has been prepared by Stantec on behalf of R3 Innovations Inc./Town of Neepawa (the proponent) and is submitted to Manitoba Conservation and Climate (MCC) in support of a request for Notice of Alteration to Licence 2870 RRR.

This report documents the relevant portions of the currently licensed facility, the proposed alterations, and the potential environmental effects and planned mitigation measures associated with the proposed alterations and operation of the facility.

1.2 THE PROPONENT

For the purposes of development licensing, the proponent is R3 Innovations Inc./Town of Neepawa (hereafter "R3 Innovations").

For further information regarding the R3 Innovations IWWTF please contact the following:

Mr. Sheldon Stott
Senior Director of Corporate Sustainability
HyLife Ltd.
Box 10000, 623 Main Street
Neepawa, MB R0J 1H0
Phone: (204) 476-3393
Email: Sheldon.Stott@HyLife.com

Ms. Colleen Synchyshyn, CAO
Town of Neepawa
Box 339, 275 Hamilton Street
Neepawa, MB R0J 1H0
Phone: (204) 476-7603
Email: neepawacao@wcgwave.ca

This Notice of Alteration was prepared by Stantec Consulting Ltd. The local contact is:

Mr. Stephen Biswanger, P.Eng.
Senior Associate
Stantec Consulting Ltd.
500-311 Portage Avenue
Winnipeg, MB R3B 2B9
Telephone: (204) 924-7061
Email: stephen.biswanger@stantec.com

1.3 LAND OWNERSHIP AND PROPERTY RIGHTS

The existing R3 IWWTF is located in the Town of Neepawa on property owned by R3 Innovations Inc. (Figure 1-2). The legal description for the subject property is described as Parcels A and B, Plan 48468 (NLTO). Current Certificates of Title for the property (the Site) are for R3 Innovations Inc., as noted in CT# 2421295 and CT# 2421294 (Appendix C). The existing R3 IWWTF configuration along with recently approved/constructed building additions occupies approximately 2.0 ha on the site (land area).

1.4 PREVIOUS ALTERATIONS/STUDIES

Since 2008, after acquiring the former Springhill Farms processing plant, HyLife constructed and progressively made modifications to the R3 IWWTF and former Springhill Farms IWWTF (SH IWWTF). The alterations that have occurred at the R3 IWWTF and the SH IWWTF between 2008 and 2021 are summarized in the table below.

Table 1-1 R3 IWWTF-Related Licence Alterations 2008-2021

Submission Date	Notice of Alterations	Studies/NOA Approval
2008	Original R3 IWWTF licensed discharge capacity approved at 1,520 m^3/d	February 2009
2013	Increase in processing capacity at the Hylife pork processing plant to 37,500 hogs/week –additional wastewater treatment infrastructure installed at the R3 IWWTF for changes in wastewater flow and loading. The licensed discharge to the Whitemud River remained at 1,520 m^3/d.	December 2014
2017	Temporary transfer of truck wastewater from R3 Innovations Inc. facility to Town of Neepawa municipal wastewater treatment lagoon for period of 5-6 weeks. The licensed R3 IWWTF discharge to the Whitemud River was unchanged.	March 2017
2018	Addition of a third sludge dewatering centrifuge and change of the supplemental carbon source. Change to the effluent flow measuring location at the R3 IWWTF. The licensed discharge to the Whitemud River remained at 1,520 m^3/d.	April 2018
2019	Upgrade the existing waste activated sludge pump and two return activated sludge pumps and optimization of existing process equipment to meet effluent quality limits. An increase to the annual average discharge rate from 1,520 m^3/d to 1,570 m^3/d to accommodate an increase in production at the hog processing plant from 7,500 to 8,000 hogs per day was approved.	May 2019
2019	Removal of sludge solids from the cells of the SH IWWTF located adjacent to R3 IWWTF for placement into lined roll-off bins and transport to a facility off-site for disposal and management. The licensed R3 IWWTF discharge remained at 1,570 m^3/d.	September 2019
2019	Groundwater impacts delineation study at the SH IWWTF. Newly installed monitoring wells incorporated in the annual groundwater monitoring program going forward as part of Environment Act Licence No. 2870 RRR.	December 2019
2020	Replacement of the primary cell liner at the SH IWWTF. Use of the SH IWWTF under Clause 33 of Licence No. 2870 RRR for temporary/emergency storage only. Contents transferred to the SH IWWTF will continue to be treated to meet licence conditions at the R3 IWWTF and discharged via the R3 IWWTF outfall to the Whitemud River.	September 2020
2020	Increase in treatment capacity at R3 IWWTF by 390 m^3/d to a licensed discharge rate of 1,960 m^3/d to accommodate refurbishment of existing treatment equipment. No change in pork processing production (8,000 hogs/d) at the HyLife pork processing plant.	October 2020
2020	Removal of biosolids sludge from the former SH IWWTF primary cell with temporary placement in the adjacent secondary cells. Subsequent one-time land application of 11,384 m^3 of material to receiving agricultural fields in the spring of 2021 as per Environment Act Licence No. 3340.	November 2020

Table 1-1 R3 IWWTF-Related Licence Alterations 2008-2021

Submission Date	Notice of Alterations	Studies/NOA Approval
2021	Increase in treatment capacity at R3 IWWTF to accommodate the production of 8,200 hogs/d (42,260 hogs/wk) at the HyLife pork processing plant. Additional monitoring and reporting requirements were added to the existing R3 Licence No. 2870 RRR in relation to future wastewater discharge to the on-site SH IWWTF cells and the wastewater effluent flow rate at the IWWTF.	May 2021
2021	Modification to refurbishment project at R3 IWWTF consisting of the installation of a new intermediate section of the effluent line and addition of a third post-anoxic tank.	August 2021
2021	Temporary transfer of stored wastewater from the SH IWWTF cell 3 to cell 1 at the Town of Neepawa municipal wastewater treatment facility.	December 2021

An updated Industrial Services Agreement for Wastewater Treatment (effective date February 1, 2021) has been executed between R3 Innovations Inc. and HyLife Foods LP regarding the scope of services to be provided by the R3 IWWTF as per Clause 15 of Licence No. 2870 RRR (see Appendix B).

1.5 PUBLIC ENGAGEMENT

The existing R3 IWWTF is located on privately owned land within an area that is appropriately zoned for heavy industrial land use. The treatment facility has been operated at this location by R3 Innovations since 2009. Public engagement was conducted for the Project in the form of a virtual open house. Section 4.0 provides details on the public engagement activity undertaken and results for the Project. Further public engagement will involve the placement of the NOA on the Public Registry by MCC for public review and comment.

1.6 FUNDING

HyLife Foods/R3 Innovations will provide funding for all undertakings related to the Project.

2.0 PROJECT DESCRIPTION

2.1 EXISTING LICENSED DEVELOPMENT

The R3 Innovations IWWTF has been in operation since 2009, occupying approximately 2.0 ha of the site zoned “MH – Industrial Heavy” under the Town of Neepawa Zoning By-law No. 3184-18. A site plan showing the R3 IWWTF is provided as Appendix A; Figure 2-1 illustrating the presently licensed facility at the project site (including recently approved above-ground infrastructure). The existing R3 IWWTF area consists of a membrane building, a pre-treatment building, two aeration (aerobic) tanks, one anoxic tank, two post-anoxic tanks, and a flow attenuation tank (Appendix A).

Existing process flows for the R3 IWWTF are as illustrated in the attached process flow diagram (see Appendix A; Figure 2-2). Recently approved additions (see Appendix B) to the primary and secondary treatment systems are as follows:

- A second primary treatment (pretreatment) building housing a primary DAF unit, polymer feed pumps, a 12,000- gallon (45,425 litre) bulk Ferric Chloride storage tank and feed pumps, relocation of existing duty and two backup centrifuges, and addition of a sludge storage tank.
- Addition of a second membrane treatment building (membrane building addition) housing a membrane treatment train.
- Addition of a third aeration tank to maintain capacity in the secondary treatment system during maintenance of other aeration basins and equipment.
- Replacement of a new mid-section of effluent line; and addition of a third post-anoxic tank as part of equipment refurbishment and further refurbishment modifications

Further information on the existing treatment process can be found in previous HyLife/R3 Innovations NOA submissions (Stantec 2021a, b; 2020a, b; 2019a, b; 2018).

Over the year January 1 to December 31, 2020, the average daily volume of wastewater influent to the R3 IWWTF was 1,548 m^3/d. The R3 IWWTF effluent discharged to the Whitemud River over the same period was 1,740 m^3/d (annual daily average). The R3 IWWTF has an interim effluent limit to the Whitemud River as per Environment Act Licence No. 2870 RRR (Appendix B) of 1,911 m^3/d until refurbishment is completed and then a 1,960 m^3/d effluent limit applies (annual daily average). The average effluent concentrations discharged from the R3 IWWTF over the period June 1, 2020 to May 31, 2021, are presented in Table 2-1. Effluent quality has consistently been superior to licence limits.

Table 2-1 Average Effluent Concentrations R3 IWWTF (June 2020-May 2021)

	Environment Act Licence Limits	Average Effluent Conc. (May 2020-May 2021)
Total Nitrogen (mg/L)	15	7.24
Total Phosphorus (mg/L)	1	0.08
TSS (mg/L)	25	<3
5-day BOD (mg/L)	25	<2
Fecal Coliform (MPN/100 ml)	200	<10
E. Coli (MPN/100 mL)	200	<10

Monitoring and reporting presently required under existing Environment Act Licence No. 2870 RRR consists of reporting effluent releases from the R3 IWWTF final discharge point and monthly and annual reports related to:

- temporary storage in, and transfer of, wastewater from the SH IWWTF
- records of sampled wastewater, monthly effluent discharge volumes, maintenance and repairs, and a summary of any sanitary sewer overflows/combined sewer overflows

Additional monitoring and reporting requirements added to existing Environment Act Licence No. 2870 RRR consists of:

- notifying the Environment Officer, minimum of 48 hours in advance, of any wastewater discharge to the on-site wastewater lagoons, including a detailed explanation for the discharge
- submitting a monthly report to the assigned Environment Officer on
  - update on all activities undertaken for the upgrade and expansion of the IWWTF
  - planned upgrade activities related to the IWWTF for the following month
  - total volume of wastewater transferred back from the industrial wastewater lagoon to the IWWTF for treatment and discharge
  - total number of wastewater transfers to the industrial wastewater lagoon, dates and duration of each transfer, total volume of wastewater transferred, and detailed explanation of the reason for the wastewater transfer, and
  - estimated remaining capacity of the industrial wastewater lagoon and remaining freeboard
- recording and reporting the monthly rolling average of the wastewater effluent flow rate at the IWWTF.

2.2 PROPOSED ALTERATION

As described in the Stover Wastewater Treatment Plant Expansion Concept Engineering Report (The Stover Group 2021; Appendix D) the R3 IWWTF has the capacity to treat the increase in influent from the pork processing plant expansion within the existing effluent quality limits via the existing/refurbished treatment system. The permanent use of the additional treatment train to accommodate the wastewater from the pork plant will maintain the quality of the effluent discharged to the Whitemud River. The proposed alterations will result in increased chemical usage and sludge production (approximately 12% more than usage at 8000 hog/d) roughly in proportion to the loading increase.

Although flows will be managed slightly differently to take advantage of all three treatment trains once the refurbishment work is complete, the treatment processes will remain the same (see Appendix A; Figure 2-2). The increase in wastewater discharged to the Whitemud River will be approximately proportional to the increase in hog production at the existing pork processing plant. The refurbishment of treatment equipment at the R3 IWWTF and the subsequent treatment of temporarily stored wastewater in the former SH IWWTF will be addressed first. No changes in the licensed R3 IWWTF effluent quality are proposed; however, an increase in treated effluent discharged to the Whitemud River is anticipated as an annual average up to 2,290 m^3/d (17% increase from the currently approved 1,960 m^3/d). The details of the proposed changes are discussed in the following subsections. Notwithstanding the above, there is no new infrastructure proposed. The proposed alteration will only involve the activation of refurbishment equipment installed to provide additional and equivalent treatment as the refurbished treatment trains.

2.2.1 Changes to Operation Inputs and Outputs

2.2.1.1 Water Use and Wastewater Production

The alterations at the R3 IWWTF will result in a marginal increase in reclaimed utility water usage (from cleaning additional equipment). The change in water use (i.e., cleaning) is conservatively estimated to increase by approximately 1 m^3/d to 2 m^3/d, still within the capacity of the existing water supply agreement with the Town of Neepawa. Overall, the proposed alteration is expected to increase water demand by 100 m^3/d to 200 m^3/d (i.e., utility water). The character (quality) of generated wastewater is not expected to change substantially and will continue to meet license limits. An increase of approximately 330 m^3/d in wastewater production to 2,290 m^3/d (annual average) is estimated. as a result of the pork production increase at the processing plant to 46,385 hogs/week.

2.2.1.2 Chemical Usage

Plant production averaged 7,988 hogs/d over a 5-month period (January 1, 2021 to May 31, 2021), using 1,348 kg/d of ferric chloride ($FeCl_3$), 450 litres per day of magnesium hydroxide (Mg (OH_2)), 204 kg/d of centrifuge polymer, and 55 kg/d of DAF polymer. An increase of 12% in chemical usage (i.e., flocculants, polymer, etc.) is anticipated at the R3 IWWTF as a result of the increase in wastewater received, proportional with the influent loading increase from the plant. This will result in approximately 1,509 kg/d of $FeCl_3$, 504 litres per day of $MgOH_2$, 229 kg/d of centrifuge polymer, and 62 kg/d of DAF polymer. These chemicals will continue be stored appropriately at the facility. Additional ferric chloride and Micro-C storage have been detailed in the previous R3 IWWTF expansion NOA (Stantec 2020b).

2.2.1.3 Fuel, Electrical and Gas Utilities

As there will be no increase in the number and size of buildings as part of the proposed alteration electricity, fuel and natural gas demand is not expected to change substantially at the R3 IWWTF. The operation of the additional treatment train will slightly increase electrical demand at the R3 IWWTF for the addition of a 100 hp blower and a new centrifuge; however, the required increase in equipment power will be accommodated by the existing power feed and transformer which has sufficient capacity (Stott pers comm. 2021) and the increased demand is expected to be negligible in the context of the existing R3 IWWTF electrical load.

2.2.1.4 Waste Management

Packaging waste from increased chemical usage generated from the increase in treatment operations at the R3 IWWTF will require proper handling and disposal at approved disposal sites (landfills). Those materials that can be practically re-used or recycled will be separated for diversion from the waste stream.

The facility currently produces one full 15 m^3 roll-off bin per day (plus a portion of another bin), or approximately 12.25 tonnes per day (less than 30 m^3 per week), of sludge at 30% solids. The volume of sludge generated and handled is expected to increase in quantity by approximately 12.5% over the generation at a processing rate of 8,000 hogs/d (proportional to the influent loading increase). Sludge generated during operation of the R3 IWWTF will continue to be collected for transportation to Waste Connections Canada for disposal at a licensed landfill. The volumes of domestic waste and recyclables generated during operations are not anticipated to substantively change with the Project.

2.2.1.5 Workforce

The number of workers at the R3 IWWTF currently totals approximately seven full-time staff. The increased treatment projected at the R3 IWWTF operation for the Project may include the addition of one to two new wastewater operators.

2.2.1.6 Traffic Volumes

Traffic related to the operation of the R3 IWWTF and pork processing plant is estimated to change from the approximately 950 to 1,000 vehicles/d (staff and operations) to as much as 1,213 vehicles/d for licensed full production of 46,385 hogs/week.

There is potential for increased chemical deliveries to the R3 IWWTF and sludge removal from the R3 IWWTF. Chemical delivery could increase from 3-4 trucks per week to 4-5 trucks per week. Sludge removal is anticipated to remain close to the same as present (2.5 to 3.5 loads per week) using trailers instead of bins.

2.2.1.7 Health and Safety

R3 Innovations' commitment to the ongoing health and safety of its employees remains in place. R3 Innovations health and safety plans will be maintained and updated as necessary for new process equipment addition and can be made available for review upon request.

2.3 PROJECT SCHEDULE

The implementation phase is expected to start in late 2021 as refurbishment of the existing original treatment trains is completed and brought on-line with full operation anticipated by late summer 2022.

3.0 SCOPE OF THE ASSESSMENT

3.1 SCOPE OF THE ASSESSMENT

3.1.1 Spatial and Temporal Boundaries

The existing R3 IWWTF (the Project Site) is located north of PTH 16 in the Town of Neepawa in southwestern Manitoba. For the purposes of this environmental assessment, the Project Site, Local Assessment Area, and Regional Assessment Area are generally consistent with boundaries as in previous NOAs for the facility. The temporal boundaries for the assessment are defined as Implementation phase, Operation phase, and Decommissioning phase. Spatial and temporal boundaries are summarized in Table 3-1.

Table 3-1 Spatial and Temporal Boundaries

Spatial Boundaries	Temporal Boundaries
Project Site (PS) – the physical footprint of the existing R3 IWWTF compound (approx. 2.0 ha) within the subject property, part of SW35-14-15W (see Appendix A; Figure 1-2).	Implementation phase – the period in 2021-2022 over which various pieces of equipment will be available and activated following the completion of treatment train refurbishment at the R3 IWWTF.
Local Assessment Area (LAA) – area up to a three-km radius from the Project site (area over which direct effects of the Project are expected to occur (see Appendix A; Figure 3-1). For the Surface Water component, the LAA is the 105 km of the Whitemud River from upstream of Neepawa to Gladstone corresponding to the model domain for the water quality assessments (Figure 5-1; Appendix E).	Operation phase – the period over which the facility will be in operation, at least 50 years.
Regional Assessment Area (RAA) – area up to a 10-km radius from the Project site (area over which direct effects that act on the PS are compared to determine significance of residual effects) (see Appendix A; Figure 3-2).	Decommissioning phase – there are currently no plans for the R3 IWWTF to be decommissioned. Should decommissioning occur at some point in the future, it would be anticipated to consist of the removal of all R3 IWWTF equipment from the site. Decommissioning would be conducted according to licence conditions and regulatory requirements at the time.

3.1.2 Assessment Approach

This assessment was completed to meet the requirements of a request for Notice of Alteration (NOA) and includes assessing project-specific environmental effects. The assessment focuses on valued components (VCs), which are environmental components of certain value or interest to regulators and other parties and are identified based on the potentially affected biophysical and socio-economic elements. Project-related effects on these VCs are assessed sequentially in the assessment. Residual effects are characterized using specific, predetermined criteria (i.e., direction, magnitude, geographical extent, duration, frequency, reversibility, and ecological/socio-economic context).

3.1.2.1 Selection of Project Interactions and Valued Components

Biophysical and socio-economic VCs that could be affected through interactions of the environment and the Project are identified to scope the assessment. The rationale for selecting each VC is explained and potential general interactions between the Project and VCs are identified in Table 3-2.

Table 3-2 Designation of Valued Components

Valued Component	Potential Project Interaction	Rationale for Exclusion or Inclusion and Project Potential Effect
Air quality/Greenhouse gas emissions	x	Operational air emissions will be limited to truck usage on-site related to delivery of treatment chemicals and sludge removal, as well as general building heating. Operational emissions are expected to result in a negligible net change overall in the context of existing site emissions and operational traffic at the site. Operation activities can contribute to GHG from on-site equipment and truck usage and combustion sourced building heating. As there will be no substantial change to natural gas, electricity, or diesel fuel use as a result of the Project, the effect on GHG emissions at the PS is considered negligible.
Soils/terrain	x	No expansion of the building footprint on the PS will result. Accordingly, interaction with soils/terrain in the LAA and RAA is considered negligible.
Surface water/ Groundwater	√/x	**Operationally, the proposed alterations are mitigation measures to properly treat wastewater influent and protect surface water quality. No change in licence conditions for effluent quality are proposed. A 330 m^3/d increase in licensed daily effluent discharge to the Whitemud River from 1,960 m^3/d is proposed to an annual average of 2,290 m^3/d.** No changes to groundwater are anticipated.
Vegetation	x	No native vegetation is present at the PS and the proposed alterations will occur in previously disturbed/developed area.
Wildlife and wildlife habitat	x	No substantive wildlife or natural wildlife habitat is present on the PS. As no physical changes will occur as a result of the project, no changes to effects on wildlife and habitat are anticipated.
Property and land use	x	Site activities occur within an existing industrial area in an area that has supported the current land use for many years. The PS is zoned for the existing/proposed land use. No negative interaction is anticipated.
Infrastructure and services	√	There will be no need for changes in the provision of municipal infrastructure and services (i.e., external roads, sewer, water) to the site, an expansion to existing service infrastructure is not proposed. **The R3 IWWTF itself is a utility to which alterations will be made to accommodate treatment of increased wastewater flow from the processing plant and sludge production/disposal prior to discharge to the Whitemud River. An increase in chemical usage is anticipated at the R3 IWWTF. There will be a negligible change to electrical use and no change in natural gas use as a result of the Project.**

Table 3-2 Designation of Valued Components

Valued Component	Potential Project Interaction	Rationale for Exclusion or Inclusion and Project Potential Effect
Employment and economy	x	Benefits related to employment and tax generation in the RAA from operation at R3 will continue. No adverse effects related to employment and economy in the RAA are anticipated.
Heritage resources	x	The PS is located within an existing industrial area that is already disturbed; there are no heritage concerns on the PS.
Aesthetics and Noise	x	The PS is located within an existing industrial area; the proposed alteration will occur within current/previously approved buildings and there will be no substantial change to LAA visual aesthetics. Noise generation will continue to be typical of historic use in the area and no noise complaints have been received by HyLife in several years of operation including during previous construction and facility expansions. The project will not substantially affect aesthetics or noise in the LAA or RAA.
Health and Safety	x	Existing worker health and safety programs will be maintained as part of the operations at the PS. The project is not anticipated to change the risks for worker/public Health and Safety.

Following the identification of valued components, an analytical framework is used to evaluate and characterize the potential project effects on those VCs identified as having a potential project interaction (identified in bold in Table 3-2), based on standardized criteria to facilitate quantitative (where possible) and qualitative assessment of residual environmental effects.

3.1.2.2 Residual Effects Description Criteria

Terms used to characterize the residual environmental effects are consistent with those summarized in previous HyLife Foods/R3 NOA application documents and are summarized below.

Table 3-3 Characterization of Residual Environmental Effects

Characterization	Description	Quantitative Measure or Definition of Qualitative Categories
Direction	The long-term trend of the residual effect	Positive— an improvement in the valued component compared with existing conditions and trends Adverse— a decline in the valued component compared with existing conditions and trends Neutral— no change in the valued component from existing conditions and trends
Magnitude	The amount of change in the VC relative to existing conditions	Negligible— no measurable change Low— a change that falls within the level of natural variability Moderate— a measurable change which is unlikely to affect the valued component High— a measurable change which is likely to affect the valued component
Geographic Extent	The geographic area in which an environmental effect occurs	PS— residual effects are restricted to the Project site LAA— residual effects extend into the LAA (up to a 3-km radius of project site) RAA— residual effects extend to other adjacent areas to the property up to a 10-km radius
Frequency	Identifies when the residual effect occurs and how often during the Project or in a specific phase	Single event— residual effect occurs once throughout the life of the Project Multiple irregular event— residual effect occurs sporadically and intermittently (no set schedule) throughout Multiple regular event— residual effect occurs repeatedly and regularly throughout Continuous— residual effect occurs continuously throughout the life of the Project
Duration	The period of time required until the VC returns to its existing condition, or the effect can no longer be measured or otherwise perceived	Short-term— residual effect restricted to the duration of implementation (assumed to be 4 months) Medium-term— residual effect extends up to 10 years Long-term— residual effect extends for longer than 10 years
Reversibility	Pertains to whether the VC can return to its existing condition after the project activity ceases	Reversible— the effect is likely to be reversed after activity completion and decommissioning Irreversible— the effect is unlikely to be reversed even after decommissioning
Ecological and Socio-economic Context	Existing condition and trends in the area where environmental effects occur	Undisturbed— area is relatively undisturbed or not adversely affected by human activity Disturbed— area has been substantially previously disturbed by human development or human development is still present

4.0 PUBLIC ENGAGEMENT

4.1 VIRTUAL OPEN HOUSE

To facilitate public engagement and solicit feedback on the Project upgrades to the HyLife Foods Pork Processing Plant, HyLife Foods conducted a virtual open house from August 20, 2021 to September 3, 2021. The virtual open house was advertised in the Neepawa Banner & Press through a full-page back cover ad published on August 19 and August 26, 2021; placed on the Town of Neepawa Facebook page on August 20, 2021 (3,746 followers), and through posters placed in Neepawa at the municipal town office and post office (August 17 through September 3, 2021). Posters at the Neepawa municipal town office were also handed out to residents paying bills in-person. The virtual open house saw 678 unique visitors on the site. Of those that visited the site, three participants completed the survey and none of the participants requested a meeting. The open house materials made reference to the Project and the R3 IWWTF as the exclusive method of wastewater treatment for the HyLife processing plant capacity increase. Comments from the completed surveys related to the Project included information requested on methodology for environmental monitoring. HyLife reached out to respondents by email on September 30, 2021 to see if any still wanted additional information or a discussion; to date no further requests for information have been received by HyLife.

See Appendix F of the HyLife NOA (Stantec 2022) for summary results of the virtual open house and copies of the advertisement and presentation materials.

Public Engagement
February 22, 2022

5.0 EXISTING CONDITIONS

The existing environment has been described in previous R3 Innovations/Town of Neepawa NOA/EAP submissions, the latest specifically within the 2020 Refurbishment NOA Report (Stantec 2020b) and the Biosolids EAP Report (Stantec 2020c) as well as aquatic environment studies conducted in 2019 and 2020 (Stantec 2021c, 2021d; Toews Environmental Ltd 2020, 2021). A summary of existing conditions follows.

5.1 BIOPHYSICAL ENVIRONMENT

5.1.1 Surface Water

Surface water quality in the Whitemud River is a product of base flow from Lake Irwin (partially regulating Boggy Creek flows) and Stony Creek just upstream of the Town of Neepawa. Water flow through Neepawa is made up of flows from Stony Creek, Kasprick Creek, and Franklin Creek that drain into Park Lake (which acts as a control structure) and then into the Whitemud River. A breach of an earthen berm at the Park Lake Reservoir in the Town of Neepawa occurred on July 1, 2020, due to heavy rains in the watershed. As a result of the rains, numerous properties on the south side of Neepawa were impacted by the flood event including Park Lake, Rotary Park Bridge, Riverbend Campground and Park, as well as two town lift stations (Town of Neepawa 2020). It is estimated that approximately 350,000 m^3 of water and debris flowed out of the reservoir (Stantec 2020d). Point-source inputs to the river near Neepawa are from the Town's municipal lagoon system and the wetland that receives effluent from the R3 IWWTF.

There are two long-term (1973–2009) water quality monitoring stations on the Whitemud River operated by the province. The closest monitoring station to the Project site is on Boggy Creek (Whitemud River) at Neepawa, approximately 6.8 km upstream of the R3 IWWTF discharge. The other monitoring station is located approximately 157 km downstream of the R3 IWWTF discharge at PTH 16 at Westbourne. Water quality in the Whitemud River has been characterized as being typically of 'Good" quality for the majority of years based on the Water Quality Index[1]. Exceptions were noted in 1998 and 2005 when the water quality was rated as 'Fair' (Manitoba Water Stewardship 2010). Total phosphorus and nitrogen data collected over the 1973 to 2009 time period indicated a steady increase in concentrations for both variables for the Whitemud River. Dissolved oxygen levels have typically been above (better than) the Manitoba objective over the monitoring period. There has typically been adequate dissolved oxygen in the watershed to support aquatic life (Manitoba Water Stewardship 2010). Fecal coliform densities have been typically below (better than) the irrigation and recreational objectives for the Whitemud River. The Whitemud River at PTH 16 at Westbourne has historically had higher fecal coliform concentrations than Boggy Creek at Neepawa (Manitoba Water Stewardship 2010). Drinking water parameters monitored at the two stations have typically been well below (better than) the objectives, except for total dissolved

[1] The Canadian Council of Ministers of the Environment (CCME) have developed a Water Quality Index to summarize and report on water quality in a consistent manner. The Water Quality Index consists of 25 variables that are compared with water quality objectives and guidelines contained in the Manitoba Water Quality Standards, Objectives and Guidelines (Manitoba Conservation 2002).

solids (TDS). TDS concentrations are a secondary drinking water objective and primarily considered an aesthetic concern related to hard water (Manitoba Water Stewardship 2010).

In 2019, an open water (July/September) monitoring program was undertaken along a 75 km stretch of the Whitemud River from Neepawa to near Gladstone, Manitoba including six river locations and two effluent discharge points (the Town of Neepawa lagoon and the R3 IWWTF) (See Figure 5-1). In addition to field parameters such as pH, temperature, oxidation reduction potential, turbidity, photosynthetically active radiation, and conductivity, key water quality parameters analyzed included dissolved oxygen, total suspended solids, biochemical oxygen demand, *E.coli*, phosphorus, nitrogen, ammonia, metals, chloride and fluoride. Flow was also measured across the width of the river at each sampling location. Flow measurements in the Whitemud River during the July sampling event ranged from 0.2 m^3/s (Site 2) to 0.7 m^3/s at Site 3 (a point 17 km downstream), and from 0.1 m^3/s (Site 2) to 0.4 m^3/s at Site 6 (a point 82 km downstream) during the September sampling event (Stantec Consulting Ltd. 20201c). Periphyton sampling and analysis of chlorophyl-a was also conducted, along with overnight dissolved oxygen monitoring.

A winter (February 2020) water monitoring program was also completed along the same stretch of the Whitemud River from Neepawa to near Gladstone, Manitoba. Water quality parameters analyzed were similar to the 2019 open water program. Flow was also measured across the width of the river at each sampling location. Flow measurements in the Whitemud River during the February sampling event ranged from 0.1 m^3/s at Site 1 (i.e., upstream of the Town of Neepawa lagoon discharge point) to 0.3 m^3/s at Site 3 (i.e., 17 km downstream) with an average of 0.2 m^3/s measured at the six sites within the study reach (Stantec Consulting Ltd. 2021d). Copies of the water quality data reports are provided in Appendix E.

A 105 km Qual2K water quality model of the study reach was developed and calibrated to the July and September 2019 datasets for open water conditions using the collected data. The model results and previously existing data were used to predict effects of the increase in R3 IWWTF effluent discharged to the Whitemud River (Toews Environmental Ltd. 2020, 2021).

The open water model indicated that dissolved oxygen concentrations in the study reach may fall below the instantaneous minimum Manitoba Water Quality Objective (5.0 mg/L) and the 7-day average Manitoba Quality Objective (6.0 mg/L) primarily due to high levels of primary productivity and respiration by benthic algae (Toews Environmental Ltd. 2020). Empirical data and model results also indicated localized areas of phosphorus enrichment in the riverbed sediments, likely from historical nutrient loading, which release phosphorus and contribute to benthic algae growth and dissolved oxygen depletion. The winter water quality assessment indicated that the Whitemud River in the study reach generally meets the Manitoba Water Quality Objective for dissolved oxygen (3 mg/L) as indicated by a review of historical data. Based on inference from nutrients and metals data, the observed aeration in the receiving wetland, and the effluent’s low biochemical oxygen demand (1.6% of the licensed limit of 25 mg/L), it was concluded that the effluent discharge does not result in excessive anoxic conditions downstream (Toews Environmental Ltd. 2021).

5.1.2 Effluent Characteristics

While effluent monitoring and reporting is reported directly by licence holders, the water quality monitoring program did include grab-sample monitoring of effluent from the R3 IWWTF discharge pipe and the town of Neepawa Lagoon discharge just prior to reaching the Whitemud River as described below:

2019 Monitoring Events:

During the July 2019 monitoring event, effluent from the Town of Neepawa lagoon was discharging at a rate of approximately 0.036 m^3/s. The sampling results showed that the effluent had biochemical oxygen demand (BOD) concentrations within the Town's licence limits (former lagoon Clean Environment Commission Order No. 762VO), but total phosphorus concentrations in excess of the licence limit (<1.0 mg/L) with a concentration of 1.74 mg/L (Stantec Consulting Ltd. 2021c, 2021d). The municipal lagoon was not discharging during the September 2019 monitoring event.

The R3 IWWTF effluent was discharging at a rate of approximately 0.017 m^3/s in both the July and September monitoring events. September monitoring results showed that the end-of-pipe effluent had a temperature of 29.2°C, a dissolved oxygen reading of 6.98 mg/L and a pH reading of 8. The results from the analysis showed that the effluent was within licence limits (Environment Act Licence No. 2870 RRR) for all listed parameters (i.e., CBOD, TSS, *E. coli*, fecal coliforms, total nitrogen, and total phosphorus) as summarized in Table 5-1 (Stantec Consulting Ltd. 2021c).

2020 Monitoring Event:

The Town of Neepawa Lagoon was not discharging during the February 2020 monitoring event.

During the winter 2020 monitoring event, the R3 IWWTF was discharging at an estimated rate of approximately 0.03 m^3/s at the time of sample collection. Monitoring results showed that the end-of-pipe effluent had a temperature of 27.8°C, total suspended solids <2.0 mg/L and a pH of 7.76. Temperature measurements, recorded downstream of the wetland and just prior to (upstream of) discharge to the Whitemud River, indicated that the moderating effect of the wetland reduced the discharge temperature to less than 4°C prior to reaching the Whitemud River. The sampling results indicated R3 IWWTF effluent concentrations of all listed parameters (i.e., CBOD, TSS, *E. coli*, fecal coliforms, total nitrogen, and total phosphorus) were less than licence limits. The effluent analysis also showed that all listed parameters except for total nitrogen (5.14 mg/L) were less than background concentrations in the Whitemud River (measured at Site 1 upstream of the outfall) (Stantec Consulting Ltd. 2021d).

Table 5-1 R3 IWWTF and Neepawa Lagoon End-of-Pipe Effluent Results

Water Quality Parameter	Effluent Limits (mg/L)		Neepawa Lagoon Effluent Sampling Results (mg/L)	R3 IWWTF Outfall Sampling results (mg/L)	
	Neepawa Lagoon	R3 IWWTF	Open water 2019	Open water 2019[3]	Winter 2020
CBOD	25	25	<2.0	<2.0	<2.0
TSS	25	25	7.3	<2.0	<2.0
E.Coli (#/100 mL)	200	200	2	<2	<1
Fecal coliforms (#/100 mL)	n/a	200	9	<5	<1
Total phosphorus	1	1	1.74	0.029	0.035
Unionized ammonia	1.25	n/a	n/a	0.002 (calculated)	0.001 (calculated)
Total ammonia	11 [1]	8.41 [2]	15.7	0.092	0.018
Total nitrogen	n/a	15	18.5	7.45	5.14

NOTES:
1 based on kg of N/d
2 in mg N/L (varies according to Schedule 1 - based on an estimated effluent pH of 8.0)
3 average values from July and September sampling events

5.1.3 Fish and Fish Habitat

The nearest water body to the R3 IWWTF is the Whitemud River, located approximately 1 km to the northwest. Fish species known to occur in the Whitemud River include northern pike, white sucker, fathead minnow, and emerald shiner among other species (AECOM 2013). Angling on the river is primarily for recreational sport fish purposes (Tourism Westman 2020).

The Whitemud River is classified as a Type ‘A’ Habitat (Milani 2013). This classification indicates that flows are intermittent or perennial with indicator fish species present. A Type ‘A’ habitat is classified as having complex habitat that is generally considered to provide the highest quality fish habitat suitable for all life stages. The Whitemud River discharges into Lake Manitoba, approximately 190 km downstream of the PS. Field observations during the February 2020 water monitoring study included abundant small fish in the wetland below the R3 IWWTF effluent discharge point in an open-water plume in the Whitemud River (Stantec, 2021).

The aquatic habitat at six sampling sites and two effluent discharge locations along a stretch of the Whitemud River between the Town of Neepawa and Gladstone, Manitoba (Figure 5-1) was characterized in terms of substrate and vegetative communities (Stantec 2021c). Table 5-2 summarizes the results of the visual characterizations.

Table 5-2 General Visual Observations of Vegetation and Substrate Present at Six Sites and at Effluent Discharge Locations Along the Whitemud River

Site	Substrate	Vegetative Communities		
		Emergent	**Submergent**	**Riparian**
1	cobble, with small rocks and gravel sized particles	Common great Bulrush (*Scirpus validus*), Common duckweed (*Lemna minor L.*), Arum leaved arrowhead (*Peltandra virginica*)	Periphyton on rocks, Narrow Leaf Pond Weed (*Potamogeton strictifolius*)	Yellow and white sweet clover (*Melilotus albus*), Narrow leaved reed grass (*Calamagrostis stricta*), Crowfoot (*Anemone canadensis*), Giant ragweed (*Ambrosia trifida*), Smooth brome (*Bromus inermis*), various grasses, sedges and shrubs
2	silty sand mixed with clay along the shorelines, and gravel sized particles in-stream	Arum leaved arrowhead (*Peltandra virginica*), Common duckweed (*Lemna minor L.*)	Periphyton on wood debris	Raspberries (*Rubus idaeus*), Green Ash (*Fraxinus pennsylvanica*), Cottonwood (*P.deltoides*), White sweet clover (*Melilotus albus*), Perennial sow thistle (*Sonchus arvensis*), various grasses
3	clay and sand which was sticky, very fine, and mucky	Arum leaved arrowhead (*Peltandra virginica*), Narrow-leaved cattail (*Typha angustifolia*), Bulrush (*Scirpus lacustris*)	Periphyton on rocks	Narrow leaved reed grass (*Calamagrostis stricta*), Smooth brome (*Bromus inermis*), Bur oak (*Quercus macropcarpa*), willows, Stinging Nettle (*Urtica dioica*), Canada Thistle (*Cirsium arvense*) various grasses, sedges and sbrubs
4	rocks, gravel, some clay sized particles and several large boulders (>30 cm diameter) were along the left bank (facing downstream)	Narrow-leaved cattail (*Typha angustifolia*), Arum leaved arrowhead (*Peltandra virginica*), Common duckweed (*Lemna minor L.*), Common great bulrush (*Scirpus validus*), grasses along gravel shoreline	Periphyton on rocks, Narrow Leaf Pond Weed (*Potamogeton strictifolius*), filamentous algae	Willows, Cocklebur (*Xanthium strumarium*), Dandelion (*Araxacum officinale*) various grasses, sedges and shrubs
5	Boulder rocks on the left channel bank (>30 cm diameter), gravel and sand sized particles	Grasses along gravel shoreline	Periphyton on rocks	Bur Oak (*Quercus macropcarpa*), Elm (*L. Ulmus*), Smooth Brome (*Bromus inermis*), various grasses, sedges, shrubs
6	Rocky, gravel, substrate with undercutting of bank on north side causing deposit of clay/silt sized particles	None observed	Periphyton on rocks	Elm (*L. Ulmus*), Yarrow (*Achillea millefolium*), Bur oak (*Quercus macropcarpa*), Giant Ragweed (*Ambrosia trifida*), various grasses, sedges, shrubs

Table 5-2 General Visual Observations of Vegetation and Substrate Present at Six Sites and at Effluent Discharge Locations Along the Whitemud River

Site	Substrate	Vegetative Communities		
		Emergent	Submergent	Riparian
R3 Innovations Discharge	Not Assessed	Various wetland plants, Common great bulrush (*Scirpus validus*), Common duckweed (*Lemna minor L.*), Narrow-leaved cattail (*Typha angustifolia*)	Not assessed	Timothy (*Phleum pretense*), Stinging Nettle (*Urtica dioica*), Canada Thistle (*Cirsium arvense*), Brown-eyed Susan (*Rudbeckia triloba*), various tall grasses
Neepawa Lagoon Discharge	Not Assessed	Various wetland plants, Common great bulrush (*Scirpus validus*), Common duckweed (*Lemna minor L.*), Narrow-leaved cattail (*Typha angustifolia*)	Not assessed	Stinging Nettle (*Urtica dioica*), Canada Thistle (*Cirsium arvense*), Phragmites (*Phragmites australis), various tall grasses*

5.2 SOCIO-ECONOMIC ENVIRONMENT

The R3 IWWTF has been in operation since 2009 on part of SW35-14-15W. The land uses adjacent to R3 IWWTF site include a mix of commercial, industrial, agricultural restricted, and open space. The Project site is subject to the Town of Neepawa Zoning By-Law No. 3184-18 and the existing use is considered a legally existing conditional use under the by-law. The proposed R3 IWWTF alteration area is already developed as part of the treatment facility compound and is considered previously disturbed. Under the Neepawa and Area Planning District Development Plan By-law No. 108, the R3 IWWTF site in the Town of Neepawa is designated as “Industrial” (Neepawa & Area Planning District Board 2018).

The Project site is accessible via Provincial Trunk Highway (PTH) 16 and Municipal Road 86W, from the west side of the plant property in addition to the HyLife primary truck access, via the road (Municipal Road 85.5W) along the east side of the pork processing plant property (see Figure 1-2). There is no direct rail service at the Project site. An electric transformer provides power to the site via overhead Manitoba Hydro utility lines located adjacent to the west and south boundaries of the Project site. Potable water is provided from the Town of Neepawa water treatment plant and natural gas is provided by Manitoba Hydro.

A 3-cell lagoon located north of the town’s golf course in Neepawa is used for the town’s sewage treatment (Town of Neepawa 2017). An upgrade to the existing lagoon system is currently underway to provide additional capacity and improved wastewater treatment. The R3 IWWTF discharges treated effluent to the Whitemud River via a dedicated outfall that discharges to an existing low-lying wetland adjacent to the Whitemud River, northwest of the plant. The R3 IWWTF is currently operating with an interim effluent discharge limit of 1,911 m^3/d. Once refurbishment work is completed, the facility’s provisionally licensed discharge rate of 1,960 m^3/d of treated effluent applies (Licence No. 2870 RRR). R3 Innovations is proposing to increase the treated effluent discharge to the Whitemud River from 1,960 m^3/d to 2,290 m^3/d (Appendix B).

6.0 ENVIRONMENTAL EFFECTS AND MITIGATION

This section outlines the assessment of environmental effects for those valued components identified in Table 3-2 as having potential project interactions. Components included in this assessment are surface water and infrastructure and services.

There are no Implementation Phase effects to consider in the assessment for the Project as no new infrastructure is proposed to be added and previous provisional approval has been provided by MCC for the refurbishment of treatment equipment at the R3 IWWTF.

6.1 ASSESSMENT OF ENVIRONMENTAL EFFECTS

6.1.1 Surface Water

The proposed 9.75% increase in processing at the pork processing plant will proportionally increase influent flow to the R3 IWWTF, resulting in an increase to the effluent discharge to the Whitemud River by up to 330 m^3/d to approximately 2,290 m^3/d (annual daily average). A process engineering evaluation concluded that the R3 IWWTF would be able to treat the increased flows and loads via permanent use of the existing third refurbishment treatment train (The Stover Group, 2021) and that the quality of the effluent discharged to the Whitemud River would continue to meet the existing licence limits.

Water quality studies (field monitoring and analytical testing) were conducted along a 75 km stretch of the Whitemud River (from Neepawa to near Gladstone, Manitoba) in the Summer of 2019 and February 2020 (Stantec Consulting Ltd. 20201c 2021d). Key water quality parameters analyzed included dissolved oxygen, total suspended solids, biochemical oxygen demand, E.coli, phosphorus, nitrogen, ammonia, metals, chloride and fluoride. Flow was also measured across the width of the river at each sampling location. In summer 2019, periphyton sampling and analysis of chlorophyl-a was also conducted, along with overnight dissolved oxygen monitoring.

As part of the water quality assessment study, a 105 km Qual2K water quality model of the Whitemud River, including the 75 km study reach, was developed using the collected data. The model results and previously existing data were used to predict effects of the increase in R3 IWWTF effluent discharged to the Whitemud River (Toews Environmental Ltd. 2020; 2021). The open water assessment determined that localized phosphorus enrichment in the riverbed sediments between Neepawa and Gladstone, from accumulated historical nutrient loading, results in phosphorus release and consequently, dissolved oxygen impairments in the open water season. The study concluded that the increase in R3 IWWTF effluent discharge volume would likely cause a negligible increase in phosphorus loading to the river, provided that the R3 effluent quality remains similar to, or improved upon, its current quality (Toews Environmental Ltd 2020, Appendix E). It is anticipated that effects of the Project on water quality in the Whitemud River during the open water season will be negligible.

The winter water quality study determined that the Whitemud River generally meets the Manitoba Water Quality Objective for dissolved oxygen (3 mg/L) and also concluded that the existing R3 IWWTF effluent discharge does not result in excessive anoxic conditions downstream, due to aeration in the receiving wetland and the low biochemical oxygen demand of the effluent (Toews Environmental Ltd. 2021). The results of the winter water quality study corroborated the summer study and concluded that elevated phosphorus concentrations occur likely from the release of historical accumulative loadings of phosphorus from the sediment to the river and that an increase in the R3 IWWTF effluent volume would not be expected to result in negative impacts to the river, provided a similar final effluent quality is maintained (Toews Environmental Ltd. 2021, Appendix E).

The proposed alteration at the pork processing plant will convey flows to the R3 IWWTF with minimal disruption to operations at both facilities. The required equipment alterations at the treatment plant include the permanent use of the third treatment train, installed to provide temporary capacity during refurbishment. This proposed alteration results in no interference with the ability of R3 Innovations to continue to meet effluent quality licence requirements both during refurbishment, and once the proposed alterations at the R3 IWWTF are implemented. The resulting change in effluent quality will not exceed licensed quality limits, and result in negligible changes to surface water quality that would be long-term in duration (increased N, P, BOD, and TSS loadings but decreased N, P, BOD and TSS concentrations in the Whitemud River) with shorter term temperature loading effects . The effects of the R3 IWWTF effluent discharge on Whitemud River water quality are ameliorated by the receiving wetland at the outlet, which provides temperature attenuation and other benefits for the high-quality effluent.

Summary

The effect of the proposed 330 m^3/d increase to the licensed effluent discharge limit at the R3 IWWTF on surface water in the LAA is expected be negligible, long-term in duration, continuous, and reversible upon decommissioning as the effluent quality limits will continue to be met.

6.1.2 Infrastructure and Services

Traffic Infrastructure

During operation, traffic to and from the R3 IWWTF will likely be similar as at present as the number/frequency of chemical and sludge shipments will only negligibly change. Traffic activities will stay generally consistent with those from current operations from a timing perspective.

The potential adverse effects of the increase in IWWTF vehicle traffic along PTH 16 over existing levels (i.e., 3,260 veh/d maximum AADT (MI and University of Manitoba 2020), are anticipated to be negligible, regular, and short-term in duration.

Electricity, Natural Gas and Water Services

The existing electrical service consisting of a primary power feed and transformer has sufficient capacity to supply the additional power demands of the proposed Project. Facility electricity and natural gas heating requirements are not expected to change substantially, as the Project does not include additional buildings or heated spaces. Other existing utility services on-site, including potable water from the Town of Neepawa, and natural gas, are sufficient for the proposed project. The Project will not require any changes to the supply infrastructure by Manitoba Hydro. Similarly, no increase in potable water infrastructure is expected. Potable water usage is anticipated to remain within the volume stipulated under the existing Industrial Services Agreement with the Town of Neepawa.

Wastewater Infrastructure

Wastewater will continue to be treated at the R3 IWWTF. The R3 IWWTF itself is a utility to which alterations will be made, however, the proposed Project will maintain the required level of service.

Waste and By-product Management Infrastructure

Waste and by-product streams will continue to be managed by existing third-party service providers in the RAA or elsewhere in the province. Operational waste sludge volumes requiring disposal from the R3 IWWTF are expected to increase by as much as 28% (from 1,885 kg per day [7700 hogs/d kill rate] to 2,408 kg per day [9000 hogs/d kill rate]), however the increase in volume is expected to be accommodated within the capacity of current practices and operations. The capacity of third-party service providers (waste and sludge disposal contractors) is expected to be sufficient. The sludge generated during operation of the R3 IWWTF will continue to be collected for transport to Waste Connections Canada for disposal.

The volumes of domestic waste and recyclables generated during operations are not anticipated to substantively change with the proposed Project. The management of domestic waste and recyclables will be accommodated within existing disposal and recycling services with negligible effect. Other solid waste materials from the operation of the facility will continue to be managed as appropriate by collection and transport to an approved facility for disposal.

Summary

The potential adverse residual effects on infrastructure and services related to traffic are expected to be negligible for operation, limited to the LAA, short-term in duration, regular in frequency, and reversible upon Project decommissioning. Adverse effects on utility usage (increase in electricity, natural gas, water, and waste management usage) are expected to be negligible, and limited to the PS/LAA, short-term, continuous, and reversible. The effects on waste management infrastructure from the increase in waste and sludge generated at the IWWTF will be negligible and within the capacity of available waste management service providers in the province with short term reversible effects of regular frequency.

6.1.3 Summary of Mitigation Measures

Proposed mitigation measures incorporated as part of this NOA include those standard practices and procedures identified under the previous 2019 NOAs (Stantec 2019a, b) as well as other general mitigation measures that are typically applied in the course of project implementation and operation. Mitigation measures to be employed to prevent or mitigate adverse effects identified in the sections above include the following:

- Vehicle access will be limited to existing access points only.
- Surface water drainage patterns will be maintained on-site.

- Solid waste generated on-site, including generated sludge, will be stored in secure bins, dedicated trailers (sludge), or storage tanks and removed on a regular basis to licensed disposal facilities.
- Proper procedures for storage and handling of hazardous materials (i.e., fuels, chemicals) in designated areas will be adhered to.
- An emergency response spill kit will be maintained and emergency response measures for spill clean-up and remediation will be implemented if necessary.
- Project site employees will be kept aware of safety requirements and on-site implementation works to ensure worker safety.
- The exterior of aboveground tanks will be regularly inspected and maintained to prevent leaks and failures as part of ongoing operations.

6.2 SUMMARY OF RESIDUAL EFFECTS CHARACTERIZATION

A summary of residual environmental effects characterization is found in Table 6-1. Residual effects related to surface water and infrastructure and services are characterized. Positive effects are not addressed, only neutral and adverse effects are characterized.

Table 6-1 Summary of Residual Environmental Effects

Project Effects	Project Phase	Residual Environmental Effects Characterization						
		Direction	Magnitude	Geographical Extent	Duration	Frequency	Reversibility	Ecological and Socio-economic Context
Surface Water	O	A	N	LAA	L	C	R	D
Infrastructure and Services								
Traffic levels	O	A	N	LAA	S	MR	R	D
Utility usage	O	A	N	PS	S	C	R	D
Sludge production/disposal	O	A	N	RAA	S	C	R	D

KEY

Project Activity
I Implementation
O Operation

Direction
P Positive
A Adverse
N Neutral

Magnitude
N Negligible
L Low
M Moderate
H High

Geographical Extent
PS Project Site
LAA Local Assessment Area
RAA Regional Assessment Area

Duration
S Short-term
M Medium-term
L Long-term

Frequency
S Single event
MI Multiple irregular event
MR Multiple regular event
C Continuous

Reversibility
R Reversible
IR Irreversible

Ecological/Socio-Economic Context:
U Undisturbed
D Disturbed

N/A Not applicable

6.3 ACCIDENTS AND MALFUNCTIONS

The effects of accidents and malfunctions for the Project are primarily related to the potential for mechanical equipment failure, fuel or other chemical spills, and transportation accidents as noted in the previous 2019 NOA. During implementation and operation, there exists the potential for fires at the Project site involving mechanical equipment and fuels, potential for environmental effects due to fuel and chemical spills and/or leaks from equipment, and transportation accidents that can result in the release of vehicle fluids to the environment (i.e., diesel, gasoline, oils, etc.) and the materials the vehicles were transporting (i.e., dewatered sludge, biosolids, process chemicals). Accidents and malfunctions can potentially result in harm to on-site personnel, damage to equipment, the release of contaminants and/or hazardous materials from equipment/vehicles and storage tanks due to leaks or improper storage and handling and degradation of the environment and human health and safety.

Potential effects resulting from spills occurring in the implementation and operations phases are anticipated to be irregular and short-term in duration. The potential for an increase in vehicle traffic along PTH 16 over existing levels that could lead to transportation accidents is anticipated to be negligible. Operational traffic at the facility operating at slow speeds and the utilization of qualified transport companies reduces the potential for on-site transportation accidents and risks. Measures to avoid adverse effects associated with fire/explosion, spills and transportation accidents are as follows:

- Flammable waste and materials will be removed on a regular basis and disposed of at an appropriate licensed disposal facility.
- Appropriate fire extinguishers are available on-site during operations and are maintained to manufacturer's standards.
- Potentially hazardous materials and chemicals are stored and handled at dedicated areas and labelled in accordance with applicable regulatory requirements.
- Hazardous materials are transported in accordance with the *Dangerous Goods Handling and Transportation Act* and used according to product-use instructions.
- Dewatered sludge will be transported off-site in suitable trailers to prevent loss of the materials.
- Refueling of vehicles and equipment will adhere to proper procedures and will use designated refueling areas or will be refueled off-site.
- Emergency spill kits will be maintained on-site and staff will be trained to properly deploy spill kit materials and cleanup spills.
- Inspections of hydraulic and fuel systems on equipment and machinery will be undertaken on a regular basis. Leaks detected will be repaired immediately by trained personnel.
- Above-ground tanks will be regularly inspected and maintained to prevent leaks and failures.
- Existing traffic control measures (i.e., speed limits, signage) will be adhered to.
- R3 Innovations continues to maintain policies related to emergency preparedness, workplace hazardous materials information system (WHMIS) and spill response procedures.

During operations at the R3 IWWTF, regular visual inspection of the aboveground storage tanks on the property are undertaken for signs of leakage or other potential signs of wear. The aboveground storage tanks are appropriately protected from collisions to reduce the potential for spills or tank damage.

Summary

To avoid accidents and malfunctions, the proposed plant alterations will be operated in accordance with regulatory requirements. The implementation of, and adherence to, measures outlined above to mitigate potential effects related to accidents and malfunctions will serve to reduce the likelihood of these events occurring.

7.0 SUMMARY CONCLUSIONS

Stantec has prepared this environmental assessment report on behalf of R3 Innovations Inc. in support of the NOA application for the proposed treatment facility alterations. The NOA application is filed in accordance with Section 14(1) of *The Environment Act* which requires a proponent to notify the Director (for Class 1 and 2 developments) if the proponent intends to alter a licensed development (MSD 2016).

Potential interactions of the proposed Project and the environment were evaluated with likely interactions examined to assess residual effects. Those interactions deemed to potentially generate adverse effects were described and evaluated with the assumption of typical mitigation measures representative of best practices and previous construction methods employed at the site.

It is anticipated that the proposed alterations at the treatment facility involving building in treatment capacity to accommodate an increase in wastewater flow to the R3 IWWTF from the pork processing plant, changes in chemical usage and sludge production/disposal resulting from additional treatment demands, and an increase to the discharge rate will be considered as minor alteration to the licensed development. On the basis of the desktop studies undertaken and information available to date as presented in this report, the proposed alterations are not expected to create significant adverse effects to the biophysical and socio-economic environment.

8.0 REFERENCES

8.1 LITERATURE CITED

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8.2 PERSONAL COMMUNICATIONS

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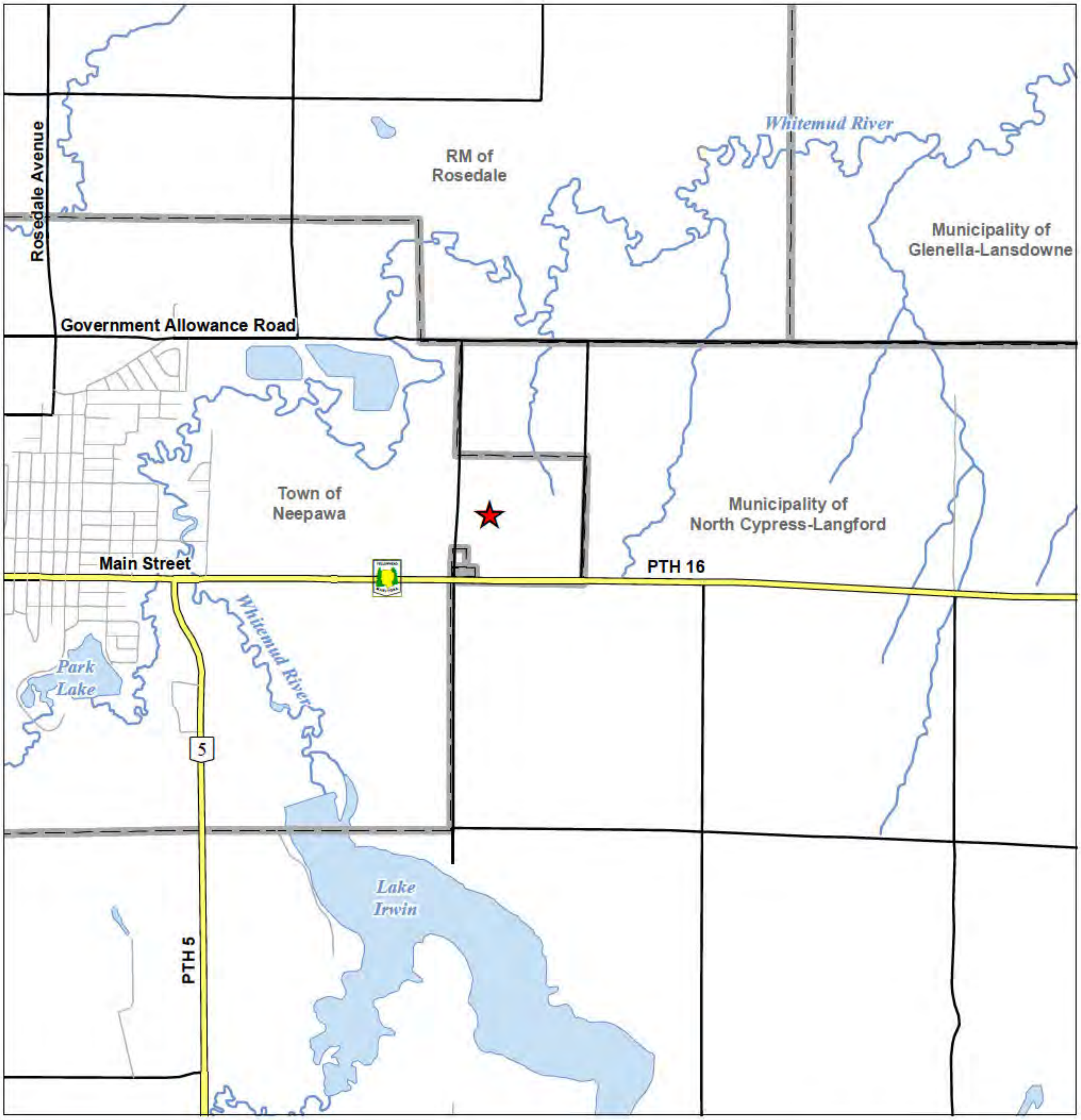
APPENDICES

Appendix A FIGURES

G:\ GIS Project Folder\111440368 HyliteFoods\ArcMaps\Figure1-1a LocationPlan 20200416.mxd Revised: 2020-04-16 By: ACampigotto



Legend

- Site Location
- Major Road
- Minor Road
- Local Road
- Watercourse
- Waterbody
- Rural Municipality

0 0.5 1 Kilometres

(At original document size of 8.5x11)
1:40,000

N

Stantec

Project Location
Town of Neepawa, Manitoba

Prepared by ACampigotto on 2020-04-16
Reviewed by BKrawchuk on 2020-04-16

Client/Project
R3 Innovations Inc.
IWWTF
Notice of Alteration

111440368

Figure No.
1-1

Title
Location Plan

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base Data Sources: Government of Manitoba

Legend

Rural Municipality

MH Industrial Heavy Zone

HyLife Foods (Approximate)

0 100 200 Metres

1 8 000 (at original document size of 8.5x11)

Stantec

Project Location 111440368

Town of Neepawa
Manitoba

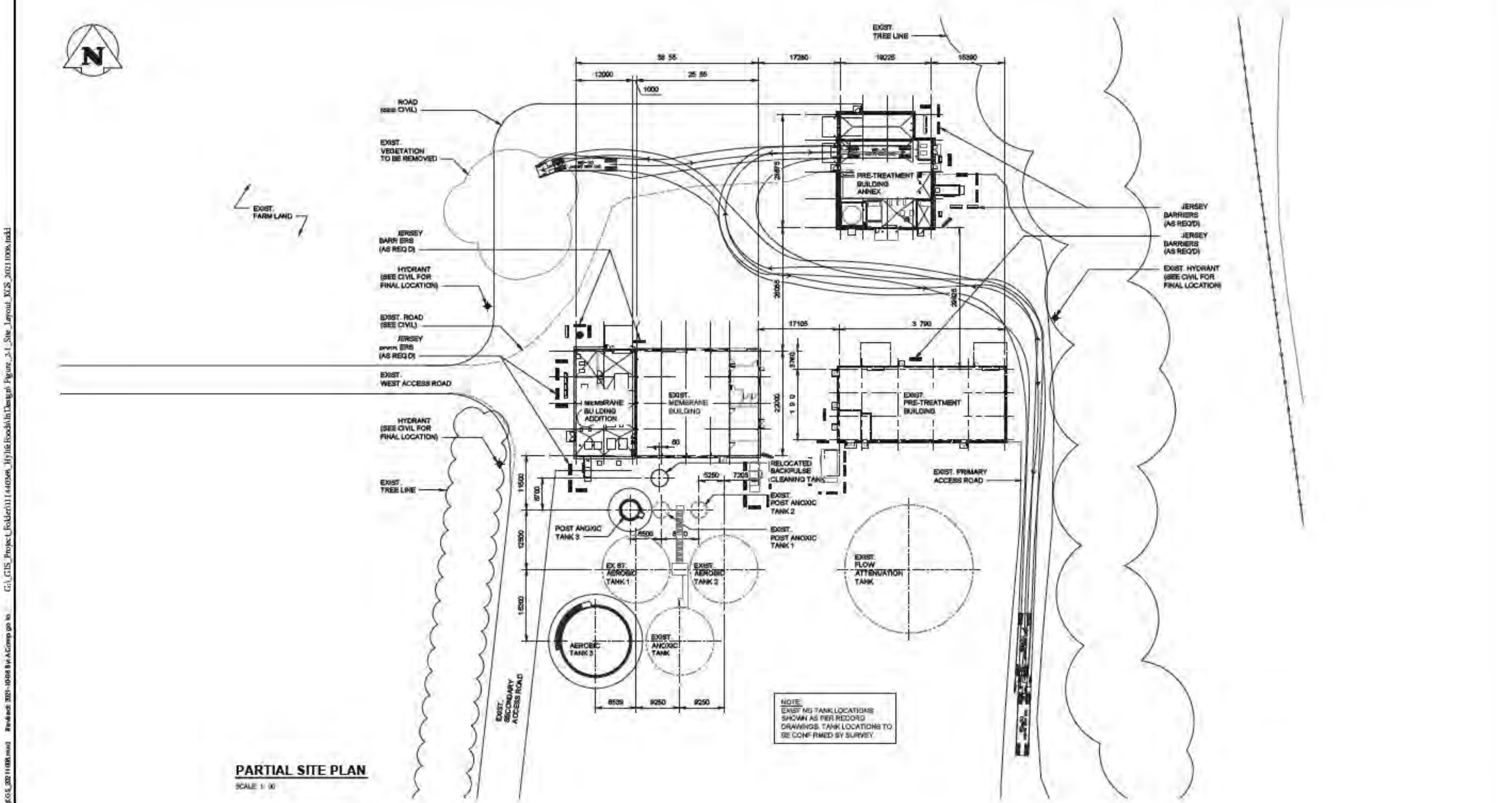
Prepared by AC on 2016-05-11
Technical Review by BK on 2016-05-11

Client/Project
HYLIFE FOODS LTD.
HyLife Foods LP Processing Facility
Notice of Alteration

Figure No.
1-2

Title
Site Plan

Notes
1. Coordinate System NAD 1983 UTM Zone 14N
2. Base features prov ded by the Government of Manitoba and the Government of Canada
3. Imagery courtesy of Microsoft (Bing).



Source: *KGS Group, Drawing Number R320.B.PLN.0201*

Project Location
Town of Neepawa
Manitoba

111440368

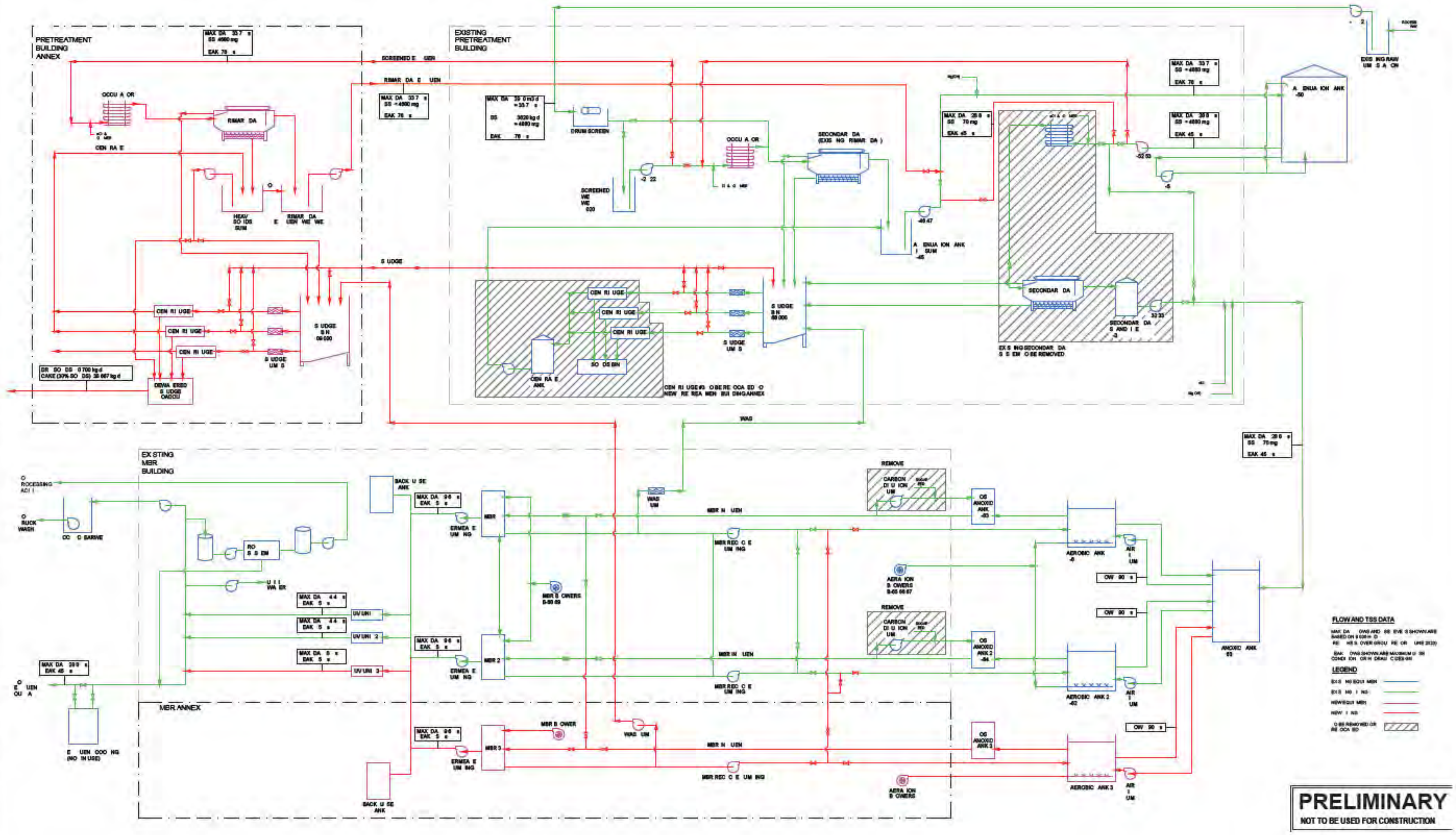
Prepared by AC on 2021-10-08
Technical Review by BK on 2021-10-08

Stantec

Client Project
R3 Innovations Inc.
IWWTF Treatment Capacity Increase
Notice of Alteration

Figure No.
2-1

Title
Site Layout



Source: *KGS Group, Figure Number 2-2, REV C.*

Project Location
Town of Neepawa
Manitoba

111440368

Prepared by AC on 2021-10-08
Technical Review by BK on 2021-10-08

Stantec

Client/Project
R3 Innovations Inc.
IWWTF Treatment Capacity Increase
Notice of Alteration

Figure No.
2-2

Title
Process Flow

Legend

- Site Location
- Local Assessment Area (3 km Radius)
- Rural Municipality

0 0.5 1 Kilometres

(At original document size of 8.5x11)
1:40,000

N

Stantec

Project Location
Town of Neepawa, Manitoba

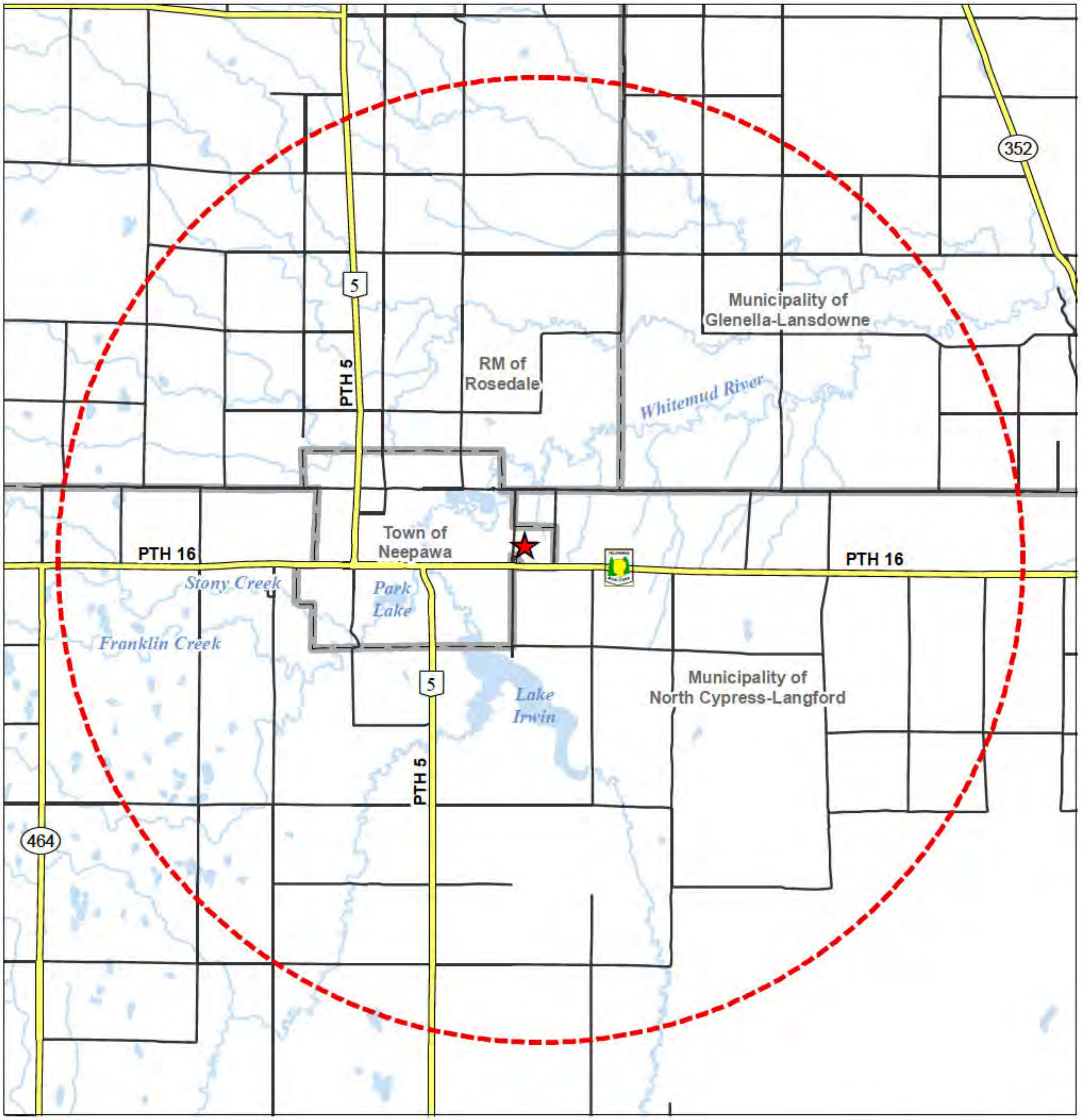
Prepared by ACampigotto on 2020-04-16
Reviewed by BKrawchuk on 2020-04-16

Client/Project 111440368
R3 Innovations Inc.
IWWTF
Notice of Alteration

Figure No.
3-1

Title
Local Assessment Area (3 km Radius)

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base Data Sources: Government of Manitoba
3. Orthoimagery: Microsoft screen shot reprinted with permission from Microsoft Corporation



Legend

- Site Location
- Major Road
- Minor Road
- Watercourse
- Waterbody
- Regional Assessment ARea (10 km Radius)
- Rural Municipality

0 1 2 Kilometres

(At original document size of 8.5x11)
1:125,000

N

Stantec

Project Location
Town of Neepawa,
Manitoba

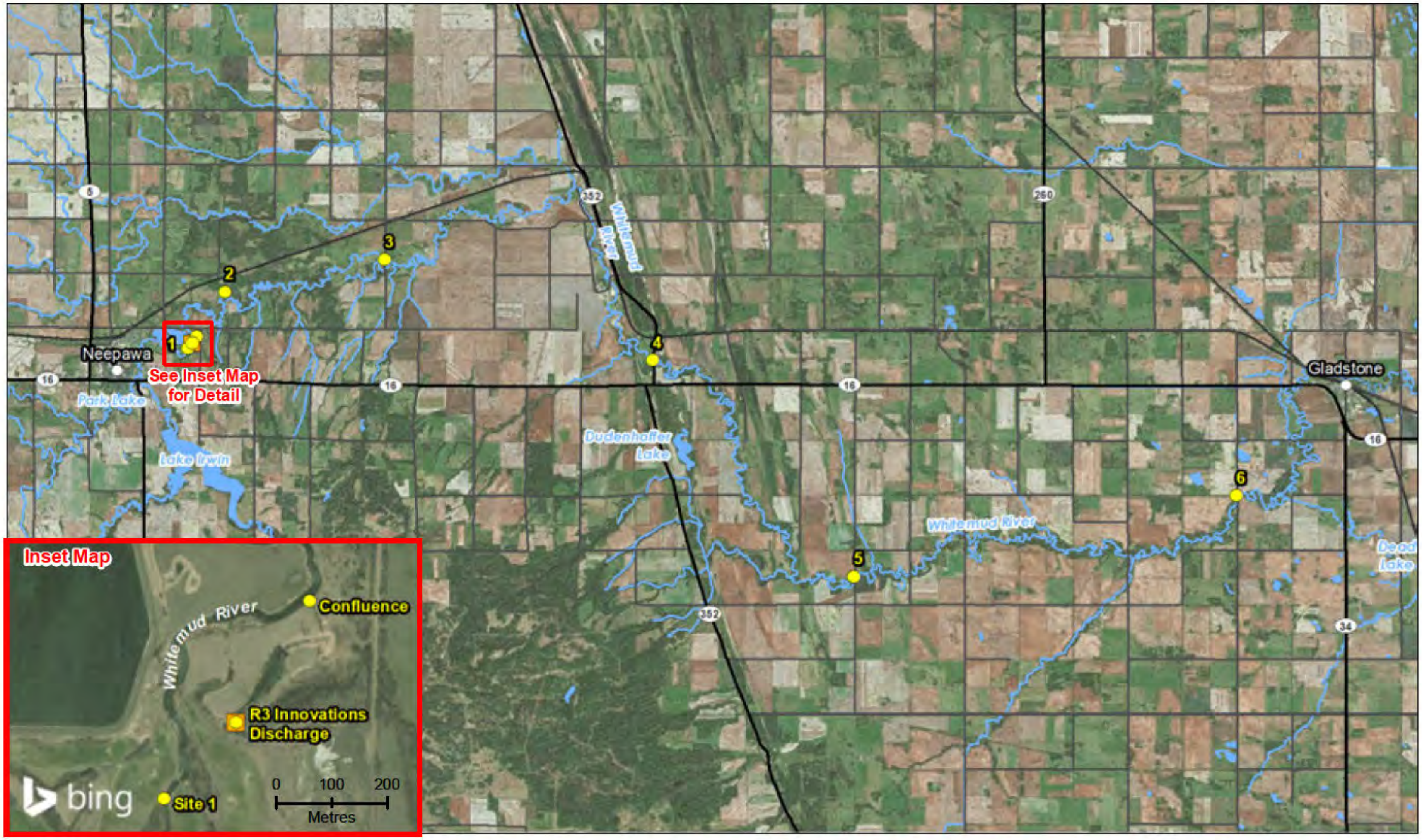
Prepared by ACampigotto on 2020-04-16
Reviewed by BKrawchuk on 2020-04-16

Client/Project 111440368
R3 Innovations Inc.
IWWTF
Notice of Alteration

Figure No.
3-2

Title
Regional Assessment Area (10 km Radius)

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base Data Sources: Government of Manitoba



Legend

- Aquatic Study Site
- R3 Innovations Outfall
- Major Road
- Minor Road
- Railway
- Watercourse
- Waterbody

N

0 2 4 Kilometres
(At original document size of 8.5x11)
1:175,000

Notes
1. Coordinate System: NAD 1983 UTM Zone 14N
2. Base Data Sources: Government of Manitoba
3. Microsoft product sceen shot reprinted with permission from Microsoft Corporation

Stantec

Project Location
Whitemud River, Manitoba

Prepared by ACampigotto on 2020-03-21
Reviewed by JTheroux on 2020-03-21

Client/Project
Hylfe Foods LP
Water Quality Study

111440368

Figure No.
5-1

Title
Site Location Map

G:_GIS_Project_Folder\111440368_HylifeFoods\ArcMaps\WaterQualitySitesAndOutfall_20200321.mxd Revised: 2020-03-23 By: ACampigotto

Appendix B LICENCE AND INDUSTRIAL SERVICE AGREEMENT

Manitoba
Conservation and Climate
Environmental Stewardship Division
Environmental Approvals Branch
1007 Century St. Winnipeg MB R3H 0W4
T 204-945-8321 **F** 204-945-5229

File No.: 2755.20

October 19, 2020

Sheldon Stott
R3 Innovations Inc.
Box 1000
623 Main Street
Neepawa MB R3C 1A5

Dear Sheldon Stott:

Re: R3 Innovations Inc. – Environment Act Licence No. 2870 RRR – Notice of Alteration

Receipt of your July 21, 2020 submission is acknowledged as a Notice of Alteration in accordance with Section 14 of The Environment Act.

The requested change to the Development as Licensed is the expansion and refurbishment of the R3 Innovations Inc. industrial wastewater treatment facility to better manage wastewater flows from the HyLife Foods meat processing facility and an increase to the wastewater effluent discharge rate by 390 m3/day to 1,960 m3/day as an annual daily average.

Specifically, the request is for the construction of a new primary treatment annex building, a new primary dissolved air flotation (DAF) unit, a new aeration basin, sludge storage tank, an expansion to the membrane treatment building with a new membrane treatment train, aeration system blowers and an additional UV disinfection system.

The information provided states that the increase of wastewater treatment capacity to 1960 m3/day will accommodate the higher process wastewater flows generated at HyLife Foods, the temporarily stored wastewater at the former industrial wastewater lagoons and a forecasted increase in utility water use (50 m3/day) at the Development. The information provided states that the wastewater effluent quality will continue to meet Environment Act Licence limits.

The potential environmental effect of the requested changes to the Development as Licensed is insignificant and considered to be a minor alteration in accordance with Section 14(2) of The Environment Act. Approval is hereby granted for the expansion and operation of the Development as described in your July 21, 2020 submission. This approval is conditional upon the acceptance of a revised Environment Act Licence for the R3 Innovations Inc. industrial wastewater treatment facility, which will be provided at a later date.

If you have any questions, please contact Jennifer Winsor, P.Eng., Environmental Engineer, Manitoba Conservation and Climate at Jennifer.Winsor@gov.mb.ca.

Sincerely,

Original Signed By

Shannon Kohler, Director
Environment Act

cc. Kristal Harman, Yvonne Hawryliuk – Environmental Compliance and Enforcement
Siobhan Burland Ross, Jennifer Winsor – Environmental Approvals
Public Registries

INDUSTRIAL SERVICES AGREEMENT FOR WASTEWATER TREATMENT

BETWEEN:

R3 INNOVATIONS INC.
("**R3**")

- and -

HYLIFE FOODS LP,
by its general partner, HYLIFE FOODS INC.
("**HyLife**")

WHEREAS:

A. HyLife owns and operates a hog slaughter and processing plant (the "**Plant**") located on the lands legally described as:

SW 1/4 35-14-15WPM
EXC FIRSTLY: SP 7402 NLTO
SECONDLY: PLAN 23208 NLTO AND 48468 NLTO
AND THIRDLY: ROAD PLAN 4611 NLTO

B. R3 owns and operates the wastewater treatment facility (the "**IWWTF**") located on the land legally described as:

PARCEL "A: PLAN 48468 NLTO
IN SW ¼ 35-14-15 WPM

And

PARCEL "B: PLAN 48468 NLTO
IN SW ¼ 35-14-15 WPM

C. The Plant is licensed pursuant to *The Environment Act* (Manitoba) by virtue of License No. 1102RRR;

D. The IWWTF is licensed pursuant to *The Environment Act* (Manitoba) by virtue of License No. 2870RRR (the "**IWWTF Licence**");

E. The wastewater produced at the Plant has been discharged to the IWWTF since R3 acquired the IWWTF, and the parties desire to reduce to writing the terms of their agreement with respect to the discharge of such wastewater and the services related thereto which are performed by R3 for HyLife, as set out herein.

NOW THEREFORE for good and valuable consideration the receipt and sufficiency of which is hereby acknowledged by each party to this Agreement, and subject to the terms and conditions hereinafter set out, the parties agree as follows:

ARTICLE 1 - DEFINITIONS

1.1 In addition to terms expressly defined elsewhere in this Agreement and unless the context otherwise requires, all capitalized terms in this Agreement shall have the following meanings:

"**Agreement**" means this Industrial Services Agreement between R3 and HyLife.

"**Claims**" means all suits, actions, administrative or legal proceedings and all other claims.

"**Effective Date**" means February 1, 2021.

"**Wastewater Flow Rate**" means the volume of wastewater discharged to the IWWTF by HyLife over a period of time.

"**Environment**" means the environment or natural environment as defined in any Environmental Laws including without limitation, air, surface water, groundwater, land surface, soil and subsurface strata.

"**Environmental Laws**" means all Laws relating in full or in part to the protection of the Environment, use or occupation of land and employee and public health and safety and includes, without limited, those laws relating to the refinement, transfer, production, storage, generation, use, handing, manufacture, processing, transportation, treatment, Release and disposal of hazardous substances and shall include, without limitation, to the extent such legislation is applicable, *The Environment Act*, the *Canadian Environmental Protection Act*, *The Dangerous Goods Handling and Transportation Act* and *The Workplace Safety and Health Act*.

"**Government Authorities**" means all federal, provincial, municipal or local government, quasi-governmental, judicial, public or statutory authorities, commissions, tribunals, agencies, departments, ministries, corporations, boards, bodies or other entities.

"**Plant**" has the meaning given to it in the preamble to this Agreement.

"**IWWTF**" has the meaning given to it in the preamble to this Agreement.

"**IWWTF Licence**" has the meaning given to it in the preamble to this Agreement.

"**Laws**" means all approvals, laws, rules, statutes, codes, standards, by-laws, ordinances, orders, permits, notices, directions, judgments, licenses, regulations and any other requirements of all Government Authorities which are or come in force.

"**Losses**" means all Claims, liabilities, charges, liens, privileges, demands, losses, costs, damages and expenses including, without limitation, legal fees on a solicitor and client basis and disbursements.

"**Related Parties**" has the meaning given to it in Section 4.1.

"**Release**" shall have the meaning prescribed in any Environmental Law and includes, without limitation, any releases, spill, leak, pumping, pouring, emission, emptying, discharge, injection, escape, leaching, disposal, dumping, deposit, spraying, burial, abandonment, incineration, seepage or placement.

"**Upset Condition**" means a state in which the IWWTF is not in compliance with its effluent discharge limits, as those limits may be changed from time to time by Government Authorities.

ARTICLE 2 - SCOPE OF SERVICES RE: IWWTF

2.1 During the term of this Agreement, R3 shall:

(a) be the owner and the operator of the IWWTF;

(b) accept for treatment the wastewater effluent from HyLife's operations at a Wastewater Flow Rate that does not exceed an average of 1,570 cubic metres per day at any time based on the immediately preceding 365-day average at such time, subject to Section 2.3 of this Agreement;

(c) Operate the IWWTF in accordance with applicable Environmental Laws and the IWWTF Licence;

(d) provide HyLife with ongoing information with respect to operations, influent and effluent data, as may be required in order to meet its obligations under this Agreement or as may be desirable for operation of the Plant;

(e) pay and discharge, on a cost recovery basis from HyLife, all expenses incurred in the operation of the IWWTF during the term hereof;

(f) use its best efforts to operate the IWWTF in a manner that minimizes operating costs;

(g) provide HyLife with copies of all groundwater monitoring well results and effluent discharge monitoring data for the IWWTF; and

(h) in the event of an Upset Condition, give expedient attention thereto and cooperate fully with HyLife to reasonably assist in rectifying the Upset Condition.

2.2 During the term of this Agreement, HyLife shall:

(a) ensure that the Wastewater Flow Rate does not exceed an average of 1,570 cubic metres per day at any time based on the immediately preceding 365-day average at such time unless an amount exceeding 1570 cubic meters per day is approved by R3 in advance;

(b) limit the biochemical oxygen demand loading to 6,023 kg over any 24-hour period, unless an amount exceeding 6,023 kg is approved by R3 in advance;

(c) limit six-day production weeks at the Plant to a frequency not exceeding once every four weeks, provided that six-day production weeks used to offset four-day work weeks due to general holidays observed at the Plant in accordance with its collective bargaining agreement with the United Food and Commercial Workers Union shall be permitted as an exception to the foregoing, unless the frequency greater than every four weeks of six-day production weeks is approved by R3 in advance;

(d) limit the wastewater loading to the IWWTF to concentration levels compliant with the IWWTF License;

(e) in the event of an Upset Condition, give expedient attention thereto and cooperate fully with R3 to reasonably assist in rectifying the Upset Condition; and

(f) carry out the maintenance and repair of the IWWTF as directed by the R3, in accordance with generally accepted industry standards and practices to accomplish the desired result in a manner consistent with law, regulation, reliability, safety and environmental protection and as R3 may reasonable require.

2.3 R3 shall have the right to refuse acceptance of effluent discharges in excess of the limits set out in Section 2.2.

ARTICLE 3 - PAYMENT OF COSTS

3.1 HyLife will pay R3 an amount to be determined and invoiced monthly during the term of this Agreement equal to the sum of R3's actual operating costs on account of supplies consumed and services provided in connection with the operation of the IWWTF (collectively, the "**Operating Costs**").

3.2 Invoices for compensation will be prepared by R3 and billed monthly and payment will be made by HyLife within thirty (30) days of receipt of invoice.

ARTICLE 4 - INDEMNIFICATION AND INSURANCE

4.1 In so far as may arise from, under or related to the terms, conditions or covenants under this Agreement:

(a) Each party covenants and agrees that, to the extent arising out of its negligent or willful act or omission or the negligent or willful act or omission of its officers, directors, consultants, employees, representatives, agents or contractors ("**Related Parties**"), it shall be liable for any Losses, including any damage to the property, of the other party and any bodily injury to or death of a Related Party of the other Party.

(b) Each party covenants and agrees to indemnify and hold harmless the other party from and against all Losses whatsoever which may be brought against or suffered by the other party or which such other party may sustain, pay or incur, as a result of, in respect of, in relation to or arising out of its non-fulfilment of a term, condition or covenant or breach of representation, or warranty under this Agreement or its negligent or, willful act or omission or the negligent or willful act or omission of any of its Related Parties in carrying out or performing its obligations, duties, liabilities or responsibilities under this Agreement.

4.2 During the term of this Agreement the R3 and HyLife shall maintain such policies of insurance as a reasonably prudent person would maintain.

ARTICLE 5 - TERM AND TERMINATION

5.1 The term of this Agreement shall commence on the Effective Date and, unless terminated earlier pursuant to this Agreement, shall continue until the first anniversary thereof. This Agreement shall automatically renew for successive one-year periods unless either party provides written notice of termination to the other party not less than thirty (30) days prior to the end of the first year of the term or any renewal period.

ARTICLE 6 - GENERAL

6.1 All time limits stated in this Agreement are of the essence of this Agreement.

6.2 In this Agreement, words importing the singular number shall include the plural number, and vice versa, as the context so requires and words importing the use of any gender shall include the masculine, feminine or neuter genders, as the context so requires.

6.3 The division of this Agreement into paragraphs, articles and general conditions and the insertion of headings are for convenience of reference only and shall not affect its construction or interpretation in any way.

6.4 The terms, conditions and covenants of this Agreement, including, without limitation, Article 4 of this Agreement, which by their nature are intended to survive the completion or other termination of this Agreement, shall survive such completion or other termination.

6.5 This Agreement sets forth the entire understanding of the parties, and supersedes all previous negotiations, representations, or agreements, either written or oral, between the Parties relating in any manner to the subject matter of this Agreement.

6.6 All modifications to this Agreement shall be in writing and duly executed by the Parties.

6.7 This Agreement shall enure to the benefit of, and shall be binding upon, the parties and their respective successors and permitted assigns, as the case may be.

6.8 This Agreement shall be governed and construed in accordance with the laws of Manitoba and the laws of Canada applicable therein. The parties agree to submit and attorn to the jurisdiction of the courts of Manitoba. Any reference in this Agreement to any statute will include such statute as amended.

6.9 Subject to the other terms, conditions and covenants of this Agreement, the parties acknowledge and agree that HyLife and R3 shall each undertake and perform their respective obligations, duties, responsibilities, and liabilities under this

Agreement as an independent contractor and not as an agent or representative of the other party. It is further acknowledged and agreed that nothing in this Agreement nor in any of the acts or omissions of the parties shall be deemed to create a joint venture or partnership relationship between the parties, such relationship being expressly denied.

6.10 Notices

(a) Unless otherwise expressly provided in this Agreement, any notice, request, demand or other communication (collectively and individually referred to as "**Notice**") to be given pursuant to this Agreement shall be in writing and shall be delivered personally, sent by reputable overnight courier, sent by prepaid registered mail (except during a postal disruption or threatened postal disruption), or faxed to the intended recipient as follows:

(i) to R3 at:
c/o HyLife Ltd.
5 Fabas Street
La Broquerie, MB
R0A 0W0
Attention: CEO
Fax No.: (204) 424-6061

(ii) to HyLife at:
623 Main Street East
Neepawa, MB
R0J 1H0
Attention : Chief Operating Officer, Foods Division
Fax No.: (204) 476-7624
With a copy to: Legal@Hylife.com

(b) Any Notice personally delivered shall be deemed to have been validly and effectively given on the date of such delivery provided that such day is a day that is not a statutory holiday in the Province of Manitoba ("**Regular Working Day**"). If such day is not a Regular Working Day, then delivery shall be deemed to have been received on the next Regular Working Day following such day. Any Notice sent by reputable overnight courier shall be deemed to be validly and effectively given on the next Regular Working Day following the day on which it was sent out by reputable overnight courier unless such courier must transport the Notice across a national boundary or provincial boundary, in which case the Notice shall be deemed to have been delivered on the second Regular Working Day after the Notice was given to the reputable overnight courier. Any Notice sent by prepaid registered mail shall be deemed to have been validly and effectively given on the fourth Regular Working Day following the day on which it was mailed provided that any day during which there is any occurrence which interferes with normal mail service shall not be considered a Regular Working Day. Any Notice sent by fax shall be deemed to have been validly and effectively given on the Regular Working Day next following the day on which it was sent.

(c) By giving the other party at least five Regular Working Days notice thereof, any party may, at any time and from time to time, change its address and/or fax number for delivery for the purposes of this Agreement.

6.11 This Agreement may be executed by the parties in separate counterparts, and may be delivered by facsimile or other electronic transmission, each of which, when so executed and delivered, shall be deemed to constitute an original, but all of which together shall constitute one and the same agreement.

IN WITNESS WHEREOF, the parties have caused this Agreement to be duly executed and delivered as of the date first above written.

R3 INNOVATIONS INC.

By:________________________________

HYLIFE FOODS LP, by its general partner,
HYLIFE FOODS INC.

By:________________________________

By:________________________________

Conservation and Climate
Environmental Stewardship Division
Environmental Approvals Branch
1007 Century St.
Winnipeg Manitoba R3H 0W4
T 204-945-8321 **F** 204-945-5229
www.gov.mb.ca/sd

File No.: 2755.20

May 7, 2021

Sheldon Stott
R3 Innovations Inc.
Box 1000
623 Main Street
Neepawa MB R3C 1A5

Dear Sheldon Stott:

Re: R3 Innovations Inc. – Environment Act Licence No. 2870 RRR – Notice of Alteration

Receipt of your March 15, 2021 submission and April 1, 2021 additional information is acknowledged as a notice of alteration in accordance with Section 14 of The Environment Act.

The requested change to the Development as Licensed is an interim increase in wastewater treatment capacity at the R3 Innovations Inc. industrial wastewater treatment facility due to a proposed interim production rate increase at the HyLife meat processing facility (submitted separately as a notice of alteration). The interim wastewater production limit increase is requested prior to the completion of the already approved expansion and refurbishment of the industrial wastewater treatment facility.

Specifically, the request is for an increase of wastewater generated by the HyLife meat processing plant to the industrial wastewater treatment facility to a maximum of 1911 m^3/day from 1570 m^3/day.

The potential environmental effect of the requested changes to the Development as Licensed is insignificant and considered to be a minor alteration in accordance with Section 14(2) of The Environment Act. Approval is hereby granted for the interim increase in wastewater influent capacity the Development as described in your March 15, 2021 submission and April 1, 2021 additional information and subject to the following conditions in addition to Environment Act Licence No. 2870 RRR:

1) The Licencee shall notify the assigned Environment Officer, a minimum of 48 hours in advance, prior to any wastewater discharge to the on-site industrial wastewater

lagoons. The notification must include a detailed explanation of the reason for the discharge.

2) The Licencee shall prepare and submit a monthly report to the assigned Environment Officer with the following information, and additional information as required:
   a) an update on all activities undertaken for the upgrade and expansion of the industrial wastewater treatment facility;
   b) planned activities related to the industrial wastewater facility upgrade for the following month;
   c) the total volume of wastewater transferred back from the industrial wastewater lagoon to the wastewater treatment facility for treatment and discharge;
   d) the total number of wastewater transfers to the industrial wastewater lagoon, the dates and duration of each transfer, the total volume of wastewater transferred and a detailed explanation of the reason for the wastewater transfer; and
   e) the estimated remaining capacity of the industrial wastewater lagoon and remaining freeboard.

3) The Licencee shall, in addition to the reporting requirements of Environment Act Licence No. 2870 RRR or any subsequent revised Licence, record and report the monthly rolling average of the wastewater effluent flow rate at the industrial wastewater treatment facility.

If you have any questions, please contact Jennifer Winsor, P.Eng., Senior Environmental Engineer, Environmental Approvals Branch, at Jennifer.Winsor@gov.mb.ca or 204-945-7012.

Yours sincerely,

for Shannon Kohler, Director
Environment Act

cc: Kristal Harman, Yvonne Hawryliuk – Environmental Compliance and Enforcement Branch
Laura Pyles, Siobhan Burland Ross, Jennifer Winsor – Environmental Approvals Branch
Public Registry

Appendix C CERTIFICATES OF TITLE

STATUS OF TITLE

The Property Registry
A Service Provider for the Province of Manitoba

Title Number	**2421295/5**
Title Status	**Accepted**
Client File	general

1. REGISTERED OWNERS, TENANCY AND LAND DESCRIPTION

R3 INNOVATIONS INC.

IS REGISTERED OWNER SUBJECT TO SUCH ENTRIES RECORDED HEREON IN THE FOLLOWING DESCRIBED LAND:

PARCEL "A" PLAN 48468 NLTO
IN SW 1/4 35-14-15 WPM

The land in this title is, unless the contrary is expressly declared, deemed to be subject to the reservations and restrictions set out in section 58 of *The Real Property Act*.

2. ACTIVE INSTRUMENTS

Instrument Type:	**Caveat**
Registration Number:	**30550/5**
Instrument Status:	**Accepted**
Registration Date:	1952-08-01
From/By:	CROWN TRUST COMPANY
To:	
Amount:	
Notes:	No notes
Description:	No description

Instrument Type:	**Caveat**
Registration Number:	**86-1191/5**
Instrument Status:	**Accepted**
Registration Date:	1986-03-21
From/By:	THE TOWN OF NEEPAWA
To:	
Amount:	
Notes:	No notes
Description:	No description

Instrument Type:	**Caveat**
Registration Number:	**86-2833/5**
Instrument Status:	**Accepted**
Registration Date:	1986-06-24
From/By:	THE RM OF LANGFORD
To:	
Amount:	
Notes:	No notes
Description:	No description

Instrument Type:	**Caveat**
Registration Number:	**86-5122/5**
Instrument Status:	**Accepted**
Registration Date:	1986-11-14
From/By:	MANITOBA HYDRO-ELECTRIC BOARD
To:	
Amount:	
Notes:	No notes
Description:	No description

3. ADDRESSES FOR SERVICE

R3 INNOVATIONS INC.
BOX 10000, 623 MAIN ST. EAST
NEEPAWA MB
R0J 1H0

4. TITLE NOTES

No title notes

5. LAND TITLES DISTRICT

Neepawa

6. DUPLICATE TITLE INFORMATION

Duplicate not produced

7. FROM TITLE NUMBERS

2357476/5 All

8. REAL PROPERTY APPLICATION / CROWN GRANT NUMBERS

No real property application or grant information

9.	**ORIGINATING INSTRUMENTS**	
	Instrument Type:	**Transfer Of Land**
	Registration Number:	**1076408/5**
	Registration Date:	2009-12-17
	From/By:	SPRINGHILL FARMS INC.
	To:	R3 INNOVATIONS INC.
	Consideration:	$1.00
10.	**LAND INDEX**	
	Lot A Plan 48468 IN SW 35-14-15W	

CERTIFIED TRUE EXTRACT PRODUCED FROM THE LAND TITLES DATA STORAGE SYSTEM OF TITLE NUMBER 2421295/5

STATUS OF TITLE

The Property Registry
A Service Provider for the Province of Manitoba

Title Number	**2421294/5**
Title Status	**Accepted**
Client File	general

1. REGISTERED OWNERS, TENANCY AND LAND DESCRIPTION

R3 INNOVATIONS INC.

IS REGISTERED OWNER SUBJECT TO SUCH ENTRIES RECORDED HEREON IN THE FOLLOWING DESCRIBED LAND:

PARCEL "B" PLAN 48468 NLTO
IN SW 1/4 35-14-15 WPM

The land in this title is, unless the contrary is expressly declared, deemed to be subject to the reservations and restrictions set out in section 58 of *The Real Property Act*.

2. ACTIVE INSTRUMENTS

Instrument Type:	**Caveat**
Registration Number:	**30550/5**
Instrument Status:	**Accepted**
Registration Date:	1952-08-01
From/By:	CROWN TRUST COMPANY
To:	
Amount:	
Notes:	No notes
Description:	No description

Instrument Type:	**Caveat**
Registration Number:	**86-1191/5**
Instrument Status:	**Accepted**
Registration Date:	1986-03-21
From/By:	THE TOWN OF NEEPAWA
To:	
Amount:	
Notes:	No notes
Description:	No description

Instrument Type:	**Caveat**
Registration Number:	**86-2833/5**
Instrument Status:	**Accepted**
Registration Date:	1986-06-24
From/By:	THE RM OF LANGFORD
To:	
Amount:	
Notes:	No notes
Description:	No description

Instrument Type:	**Caveat**
Registration Number:	**86-5122/5**
Instrument Status:	**Accepted**
Registration Date:	1986-11-14
From/By:	MANITOBA HYDRO-ELECTRIC BOARD
To:	
Amount:	
Notes:	No notes
Description:	No description

3. ADDRESSES FOR SERVICE

R3 INNOVATIONS INC.
BOX 10000, 623 MAIN ST. EAST
NEEPAWA MB
R0J 1H0

4. TITLE NOTES

No title notes

5. LAND TITLES DISTRICT

Neepawa

6. DUPLICATE TITLE INFORMATION

Duplicate not produced

7. FROM TITLE NUMBERS

2357477/5 All

8. REAL PROPERTY APPLICATION / CROWN GRANT NUMBERS

No real property application or grant information

9.	ORIGINATING INSTRUMENTS	
	Instrument Type:	**Transfer Of Land**
	Registration Number:	**1076409/5**
	Registration Date:	2009-12-17
	From/By:	SPRINGHILL FARMS INC.
	To:	R3 INNOVATIONS INC.
	Consideration:	$1.00
10.	**LAND INDEX**	
	Lot B Plan 48468 IN SW 35-14-15W	

CERTIFIED TRUE EXTRACT PRODUCED FROM THE LAND TITLES DATA STORAGE SYSTEM OF TITLE NUMBER 2421294/5

Appendix D EXPANSION ENGINEERING REPORT

WASTEWATER TREATMENT PLANT EXPANSION
CONCEPT ENGINEERING REPORT

Prepared For:

HyLife Foods
Neepawa, Manitoba, Canada

Prepared By:

THE STOVER GROUP
P.O. Box 2056
Stillwater, OK 74076

And

Geosyntec Consultants International, Inc.

Janet Goodfellow, P.Eng.
Province of Manitoba P.Eng. No: 31419

June 2021

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INTRODUCTION

The HyLife Foods (HyLife) pork processing facility located in Neepawa, Manitoba has been operating with an industrial wastewater treatment facility (IWWTF) referred to as R3 Innovations. The facility was designed in 2008/2009 and constructed in 2009/2010. Biological system startup occurred in June 2010. The facility was expanded/upgraded in 2018. The facility has operated successfully throughout this entire period.

HyLife has continued to increase production over the years such that the existing IWWTF is again approaching its maximum operating capacity. HyLife is again planning increased capacity changes that will result in even more flows and loads to the IWWTF. This report reviews the operating history of the facility, along with the original and current design criteria, and evaluates the proposed changes/upgrades related to the proposed increased production capacity changes.

An upgrade/expansion of the IWWTF was completed in 2018 for an increased kill rate at the production facility. The following expansion/upgrades to the IWWTF were completed:

- New influent process wastewater handling facilities (screen and wet wells) installed at the production facility for the new cut floor and production areas.
- New wastewater pre-attenuation tank installed at the production facility prior to the existing screening facility and IWWTF.
- Expanded capacity of the secondary Dissolved Air Flotation (DAF) feed pumps and the anoxic feed pumps to handle increased flows.
- Expansion of the two existing ultrafilter membrane tanks to maximum capacity by adding another cassette to each tank. Newer higher flow capacity cassettes were also added.
- An additional larger centrifuge was provided for increased sludge processing capacity.

The IWWTF currently operates successfully between about 7,500 to 8,000 hogs kill rate per day while reliably achieving compliance with the Effluent Discharge Criteria presented in Table 6 of this report. Evaluation of both the primary and secondary biological treatment systems were reviewed for expansion/upgrades together relative to proposed additional increased production capacity requirements.

Based on the current production rate and the expanded capacity/capability of the current IWWTF, THE STOVER GROUP (TSG) was previously retained to define the current process design capacity of the expanded IWWTF. The rerated capacity of the IWWTF was presented in the January 2021 report entitled “WASTEWATER TREATMENT PLANT CAPACITY PROCESS ENGINEERING EVALUATION REPORT”. The process engineering analysis presented in that report concluded that the current capacity of the IWWTF provides a kill rate capacity of 8,200 hogs per day over a five-to-six-day production period.

HyLife is currently considering additional increased production capacity changes to a minimum of 9,000 hogs/day that will again affect the flows and loads to the IWWTF; therefore, HyLife requested TSG to provide a concept engineering design for these anticipated increased capacity changes. The current assessment and engineering evaluations provided in this report were based on the operational data from the R3 Innovations IWWTF for the period of February 2017 through July 2019, along with the corresponding production data from the HyLife pork processing plant. An earlier capacity evaluation of the R3 Innovations IWWTF was provided in

January 2021 for the production rate of 8,200 hogs/day using the same data base. The current capacity evaluation includes the additional infrastructure being constructed at the R3 Innovations IWWTF as per the recently approved (October 2020) NoA for equipment refurbishment. All the new equipment additions described in this current engineering evaluation were previously approved through the refurbishment NoA, with the exception of the proposed addition of the third post anoxic tank for the new membrane biological reactor Train 3, which is a new addition to the treatment process. Addition of the new post anoxic tank 3 will be added to allow all three trains to operate in an identical manner.

IWWTF PROCESS DESIGN BASIS

The IWWTF treats wastewater flows from the HyLife pork processing facility at Neepawa, Manitoba. Process wastewater is combined with truck wash, holding area (barn) wastes, and sanitary wastewater prior to initial screening and pumping.

The treatment facility (IWWTF) was designed to treat the weekly production flow, with typically five or six days of production, over a seven-day period. Combined raw influent wastewater is screened and pretreated in a primary DAF system prior to being pumped to a flow-attenuation tank. The attenuation tank fills during the week and drains over the course of the weekend to the secondary biological membrane biological reactor (MBR) treatment system. A secondary DAF is provided for treating the flow-attenuation tank effluent, if needed, to remove additional TSS and COD loading prior to the downstream biological system. Full-scale trials have been performed with the secondary DAF; however, it has not been needed for prior IWWTF operations. Therefore, the process design basis outlined in this report consists of operational/performance data for the IWWTF without the secondary DAF in operation.

Manitoba Conservation and Climate requires nitrogen and phosphorus removal for wastewater treatment facilities in Manitoba. Table 6 later in this report lists the current effluent discharge permit limits. Ferric chloride will be used as a coagulant along with polymer at the primary DAF pretreatment system for both phosphorus and Total Kjeldahl Nitrogen (TKN) removal. A supplemental carbon source, Micro-C, can also be added, as needed, for both Total Nitrogen (TN) and Total Phosphorus (TP) removal to make sure that the effluent discharge limitations are reliably achieved. The performance of the IWWTF has historically reliably achieved the required effluent discharge requirements without the use of Micro-C. Full-scale trials have been performed with Micro-C to confirm the efficacy of using Micro-C in the future, if needed.

Increased production capacity changes at the production facility will increase flows and loads to the IWWTF over the normal five to six-day work week. Production and clean-up will be over the same schedules while increasing both the throughput and process wastewater flows and loads.

Current Operating Conditions

Recent processing facility production expansion conditions have increased the flows and loads to the IWWTF over the normal five to six-day work week. Production and clean-up operations are still performed over the same schedules while increasing both the throughput and process wastewater flows and loads. Production currently occurs during 16 hours per day followed by a clean-up period up to six hours in duration. Periodically production extends into six days per week. Operations of the IWWTF consist of one 10-hour shift and one 8-hour shift from Monday through Friday for 17.5 hours per day coverage, with one 10-hour per day shift coverage over the weekend; unless production continues into Saturday, at which time the Saturday coverage is the same as weekday coverage. Total operations coverage is provided by seven (7) full time personnel.

The current wastewater production prior to the primary treatment system is shown in Table 1 which summarizes flow and loads generated by the production facility from February 2017 to July 2019.

TABLE 1
R3 Innovations IWWTF
Raw Wastewater Production Summary
February 2017 – July 2019

Condition	Hogs/ day	Hogs/ Week	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	7,048	37,143	1,650	1,660	5,100	272	21
Max Month	7,646	38,249	1,890	2,731	8,320	406	29
Max Week	7,711	38,433	1,950	3,985	10,770	464	43
Max Day	7,828	41,524	2,250	10,680	19,620	1,192	89

TSS – Total Suspended Solids
COD – Chemical Oxygen Demand

Using the data in Table 1, unit wastewater production values were calculated on a per hog basis as shown in Table 2.

TABLE 2
R3 Innovations IWWTF
Hog Unit Wastewater Production Summary
February 2017 – July 2019

Condition	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	0.234	0.235	0.724	0.039	0.0030
Max Month	0.268	0.387	1.181	0.058	0.0041
Max Week	0.277	0.565	1.528	0.066	0.0061
Max Day	0.319	1.513	2.784	0.169	0.0127

Expansion Process Design Basis

With the wastewater analysis completed for the period of February 2017 through July 2019 along with the hog unit wastewater production values, the following Tables 3 and 4 provide the estimated increased capacity changes wastewater flow and loads per production day along with anticipated attenuation in the existing attenuation/equalization tank. The flow and loading attenuations have been calculated using a 6-day production week since this is believed to be a frequent occurrence which must be accounted for in the design of the treatment systems. This means that the wastewater generated during the 6-day production week will be treated by the onsite IWWTF in a 7-day period.

TABLE 3
R3 Innovations IWWTF
Design Basis – 9,000 Hogs/day
Wastewater Summary per Production Day

Condition	Flow (m^3/d(	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	2,145	2,120	6,510	350	30
Max Month	2,445	3,490	10,630	520	40
Max Week	2,525	5,090	13,760	590	55
Max Day	2,910	13,620	25,050	1,520	115

TABLE 4
R3 Innovations IWWTF
Design Basis – 9,000 Hogs/day
Attenuated Wastewater Summary (1)

Condition	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	1,840	1,820	5,580	300	23
Max Month	2,090	2,990	9,110	440	31
Max Week	2,160	4,360	11,790	510	50
Max Day	2,490	11,670	21,470	1,300	100

Note: (1) Based on six-day production week

Primary Treatment Removal Efficiencies

The primary treatment system has been and will be expanded to achieve the pollutant removal efficiencies as shown below based on the average day and max month conditions:

- COD Removal 40%
- TSS Removal 75%
- TN Removal 40%
- TP Removal 20%

The new conservatively sized primary DAF being provided as part of the refurbishment NoA will be operated with a chemical assist using ferric chloride coagulant and polymer for enhanced TSS, COD, TKN and TP removal.

Based on these pollutant removal efficiencies obtained with the primary treatment systems, the attenuated flow and loads for production of a minimum of 9,000 hogs per day to be treated by the biological systems are provided in Table 5.

TABLE 5
R3 Innovations IWWTF
Design Basis – 9,000 Hogs/day
Primary Treatment Effluent - Wastewater Summary [(1)]

Condition	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	1,840	450	3,350	180	18
Max Month	2,090	750	5,460	270	25
Max Week	2,160	1,100	7,070	310	37
Max Day	2,490	2,920	12,880	780	78

Note: [(1)] Based on six-day production week

Discharge Limits

The plant permitted discharge limits have remained unchanged from current conditions and are as shown in Table 6. The IWWTF has consistently and reliably achieved the effluent permit treatment requirement since startup and throughout the current operating conditions after the IWWTF expansion in 2018.

TABLE 6
R3 Innovations IWWTF
Effluent Discharge Criteria

Parameter	Value
Carbonaceous five-day Biochemical Oxygen Demand	<30 mg/L (based on 30-day rolling avg.)
Total Suspended Solids	<30 mg/L (based on 30-day rolling avg.)
Total Nitrogen	<15 mg/L (based on 30-day rolling avg.)
Total Phosphorus	<1 mg/L (based on 30-day rolling avg.)
Fecal Coliform	<200/100 mL (based on 30-day geometric mean)
Escherichia coli	<200/100 mL (based on 30-day geometric mean)

A new 60 cubic meter post-anoxic tank is being provided for the third treatment train to make the three biological treatment trains identical which allows better flow balancing between the three membrane trains. The two existing post-anoxic tank volumes are also 60 cubic meters each. The two existing tanks have not been needed to meet the TN limit, nor has an external carbon source, sugar, been required to meet the TN limit. However, the three post-anoxic tanks will provide a safety factor, and space has been reserved for Micro-C feeding as external carbon source, if needed in the future.

PROCESS ENGINEERING EVALUATIONS

Primary Treatment

The existing primary treatment system includes fine screening, primary and secondary DAF units, chemical addition facilities, centrifuges, and several pumping systems all housed in a single building. The primary treatment system must be capable of handling the entire increased capacity flows and loads generated by the production facility as presented in Table 3, while the secondary DAF must handle the attenuated flows and loads presented in Table 4. Therefore, the IWWTF expansion will require a new primary DAF to be installed in a new building (referred to as the Primary Treatment Annex) along with ancillary equipment which then will allow the existing primary DAF to be repurposed as a secondary processing unit.

With the production capacity increase to a minimum of 9,000 hogs/day, the flow and loading rates to the IWWTF are anticipated to increase by around 18.5% over current flows and loads and around 12.5% over the current IWWTF design basis. It was determined that with the increase in flows and loads and the importance of maintaining consistent primary treatment removal rates that both of the existing DAF's will need to be enlarged to handle the new increased production capacity flow rates.

The existing facilities have a large first stage DAF followed by a smaller second stage DAF. The plan will be to install a new larger primary stage DAF, and then reuse the current primary DAF as the second stage DAF. Since there is not adequate room in the existing primary building to install more equipment, the plan is to construct a new building north of the existing treatment building to house the new primary DAF, pipe the new primary DAF effluent to the attenuation tank, and then use the existing primary DAF as the second stage DAF. The new primary DAF will have approximately 50% more surface area than the existing primary DAF, and repurposing the existing primary DAF, as the new second stage DAF will increase the treatment capacity of the second stage DAF by a factor of 3 times. The existing primary DAF is overloaded at the current operating conditions. The new primary DAF will be much larger and will be operating at the same design conditions of 75 liters/second. Ferric chloride addition, as a coagulant, along with a polymer flocculant will provide enhanced removal of the TSS, COD, TKN, and phosphorus in the new primary DAF.

Secondary Treatment

Previous studies by TSG have shown that the current primary treatment and secondary biological treatment systems can handle the attenuated current flows and loads from the processing facility if the primary system is operated to effectively remove the pollutant loads, as previously discussed. With increased capacity to a minimum of 9,000 hogs/day, performance of the primary treatment system will be critical for meeting the effluent discharge criteria. With the primary treatment levels being achieved, the increased flows and loads generated with the increased production capacity, will also require expansion of the membrane biological reactor (MBR) systems to handle the total flow and loads, as provided in Table 5. Table 7 presents the unit process sizing of the expanded secondary treatment train.

Increasing the treatment capacity of the secondary biological system will require the following:

- Addition of a third aeration basin equal in size to the two existing aeration basins which are 1,022 m^3 (270,000 gallons) each.
- Addition of a third post anoxic basin equal in size to the two existing post anoxic basins (60 m^3).
- Addition of a new secondary treatment building annex which will house a new membrane train, blowers, and other associated ancillary equipment required by the MBR equipment supplier.
- Addition of a new UV disinfection system to handle the increased flows.
- Provide additional dewatered centrifuge cake storage capacity

The existing anoxic tank will be adequate to handle the entire flow and loads generated by the increased production. However, a third aeration basin of equal size to the existing two basins will be required. The new aeration basin will be provided with an airlift pump to provide high anoxic recycle flows like the existing system. With this plan to expand the MBR/Aeration systems, it is intended that each aeration basin flow train will take one third of the total flow. A new third post anoxic tank (60 m^3) will also be added in the new parallel flow train.

TABLE 7
R3 Innovations IWWTF
Expanded Activated Sludge (MBR) Process Sizing

Parameter	Value
Anoxic Tank	
Number of Units	1
Working Volume	1,022 m^3
Total Volume	1,215 m^3
Aeration Tanks	
Number of Units	3
Working Volume each	1,022 m^3
Total Volume each	1,215 m3
Membrane Separation (MBR System)	
No. of Units	3
Type of MBR System	Z-MOD-L1120
No. of Cassettes per Train	3
Type of Cassettes	
48M Cyclic	2 (Existing)
52M Leap	1 (New)
Type of Membrane	ZeeWeed 500D
Total of Membrane Modules	402
Membrane Surface Area each	370 ft^2
Post-Anoxic Tanks	
Number of Units	3
Total Volume each	60 m^3

The information provided in Table 8 represents the total attenuated and primary treated wastewater flows and loads for the processing of a minimum of 9,000 hogs per day.

TABLE 8
R3 Innovations IWWTF
Total Flows and Loads to Biological Treatment System
With the Addition to 9,000 Hogs/Day

Condition	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	1,840	450	3,350	180	18
Max Month	2,100	750	5,460	270	25
Max Week	2,160	1,100	7,070	310	37
Max Day	2,490	2,920	12,880	780	78

The information provided in Table 9 represents the total wastewater flows and loads allowed to the existing biological treatment system (two aeration basins) for the processing of 9,000 hogs per day.

TABLE 9
R3 Innovations IWWTF
Flows and Loads to Existing Aeration Basin and MBR System
With the Addition to 9,000 Hogs/Day

Condition	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	1,230	300	2,235	120	12
Max Month	1,400	500	3,640	180	16.5
Max Week	1,440	735	4,715	207	25
Max Day	1,660	1,950	8,590	520	52

Taking the information provided in Tables 8 and 9 which represents the total attenuated and primary treated wastewater flows and loads for the processing a minimum of 9,000 hogs/day and subtracting the flows and loads, capacity of the existing biological treatment system shown in Table 9 provides the additional biological treatment capacity required for the expanded system as presented in Table 10.

TABLE 10
R3 Innovations IWWTF
Flows and Loads to New Aeration Basin and MBR System
With the Addition to 9,000 Hogs/Day

Condition	Flow (m^3/d)	TSS (kg/d)	COD (kg/d)	TN (kg/d)	TP (kg/d)
Average Day	610	150	1,115	60	6
Max Month	700	250	1,820	90	8.5
Max Week	720	365	2,355	103	12
Max Day	830	970	4,290	260	26

A summary of the current operating capacity (7,700 hogs/day) and the new projected full functional operating capacity (a minimum of 9,000 hogs/day) for the upgraded/expanded IWWTF is presented in Table 11.

The February 2017 through July 2019 plant data was used to develop the current and projected average and maximum week operating conditions for the IWWTF presented in Table 11. The projected future operating conditions for the average and maximum week capacity kill rates were calculated using straight-line correlations with the current average and maximum week values operating at 7,700 hogs/day. The projected process design basis kill rate of a minimum of 9,000 hogs/day was determined for the expanded/upgraded IWWTF capacity. The expanded/upgraded IWWTF will include the addition of a new third aeration tank and a third new membrane train along with a third new post anoxic tank. The analysis in Table 11 is based on the existing two aeration tanks, two membrane trains, and two post anoxic tanks for the current production capacity evaluation. The analysis in Table 11 is based on the three aeration tanks, three membrane trains, and three post anoxic tanks for the 9,000 hogs/day minimum production design capacity evaluations. The new IWWTF expansion design will provide over 50% increase to the existing secondary biological treatment system capacity.

The existing primary DAF will be repurposed for use as a secondary DAF for treating the flow-attenuation tank effluent, if needed in the future, to remove additional TSS, COD, TKN, and phosphorus loading prior to the downstream biological system. Full-scale trials have been performed with the existing secondary DAF; however, it has not been needed for prior IWWTF operations/performance. The process design basis and operating conditions presented in Table 11 consists of operational/performance data for the IWWTF without the secondary DAF in operation and confirms that the secondary DAF will not be needed at the new production rate of a minimum of 9,000 hogs/day. However, the repurposed primary DAF as the secondary DAF will still be provided if needed for future operations.

TABLE 11
R3 Innovations IWWTF
Current and Expansion Design Operating Conditions Summary (Attenuation Tank Effluent)

Parameter	Current Operating Conditions without Second Stage DAF Online (5/15/2018-11/23/2018)		Projected Operating Capacity without Second Stage DAF Online	
	Average	Max Week	Average	Max Week
Kill Rate, Hogs/day	**7,700**	**7,700**	**9,000**	**9,000**
Flow, m^3/day (equalized)	1,414	1,671	1,840	2,160
COD, Kg/day – Attenuation Tank Eff	4,371	9,231	5,580	11,790
COD Removal at Primary Treatment, %	40	40	40	40
COD to Biological Treatment, Kg/day	2,623	5,539	3,348	7,074
$cBOD_5$, Kg/day – Attenuation Tank Eff	2,096	4,429	2,675	5,657
$cBOD_5$ Removal at Primary Treatment, %	40	40	40	40
$cBOD_5$ to Biological Treatment, Kg/day	1,258	2,657	1,605	3,394
TKN, Kg/day – Attenuation Tank Eff	233	398	300	510
TKN Removal at Primary Treatment, %	40	40	40	40
TKN to Biological Treatment, Kg/day	140	239	180	306
Total P, Kg/day – Attenuation Tank Eff	18	37	23	50
Total P Removal at Primary Treatment, %	20	20	20	20

TABLE 11 (Continued)
R3 Innovations IWWTF
Current and Expansion Design Operating Conditions Summary (Attenuation Tank Effluent)

Parameter	Current Operating Conditions without Second Stage DAF Online (5/15/2018-11/23/2018)		Projected Operating Capacity without Second Stage DAF Online	
	Average	Max Week	Average	Max Week
Total P to Biological Treatment, Kg/day	14	29	18	40
TSS, Kg/day – Attenuation Tank Eff	1,423	3,416	1,820	4,360
TSS Removal at Primary Treatment, %	75	75	75	75
Total TSS Removed, Kg/day	1,067	2,562	1,365	3,270
Observed Yield, Kg TSS/Kg BOD_5	0.65	0.65	0.65	0.65
Biosolids Production, Kg/day	817	1,727	1,043	2,206
VSS at 70% of TSS, Kg/day	572	1,209	730	1,544
Total Sludge Production, Kg/day	1,885	4,289	2,408	5,476
F/M Ratio, Kg BOD5/day/Kg MLVSS	0.074	0.16	0.070	0.150
MLVSS, mg/L	5,700	5,700	5,700	5,700
TKN in Biomass, %	5.5	5.5	5.5	5.5
TKN to Biomass Growth, Kg/day	45	95	57	121
Total P in Biomass, %	1.3	1.3	1.3	1.3
Total P to Biomass Growth, Kg/day	10.6	22.5	13.6	28.7

TABLE 11 (Continued)
R3 Innovations IWWTF
Current and Expansion Design Operating Conditions Summary (Attenuation Tank Effluent)

Parameter	Current Operating Conditions without Second Stage DAF Online (5/15/2018-11/23/2018)		Projected Operating Capacity without Second Stage DAF Online	
	Average	Max Week	Average	Max Week
Oxygen Demand				
Carbonaceous Demand				
O_2/BOD_5 Removed, Kg/Kg	1.5	1.5	1.5	1.5
O_2 Required, Kg/day	1,886	3,986	2,408	5,091
Nitrification Demand				
O_2/NH_3-N Nitrified, Kg/Kg	4.57	4.57	4.57	4.57
O_2 Required, Kg/day	639	1,091	823	1,398
Total O_2 Demand	2,526	5,077	3,230	6,489
Oxygen Transfer				
Alpha	0.5	0.5	0.5	0.5
SOTE, %	34	34	34	34
AOTR, Kg/hr	105	212	135	270
SOTR, Kg/hr	263	529	337	676
Air Requirements, SCFM	1,627	3,271	2,081	4,181
Blower Horsepower, HP	114	229	146	293

SOTE – Standard Oxygen Transfer Efficiency (1.4%/foot)
AOTR – Actual Oxygen Transfer Rate
SOTR – Standard Oxygen Transfer Rate

FUNCTIONAL OPERATION CAPACITY EVALUATION

As previously discussed, processing has gradually increased over the years with associated upgrades and expansions of the IWWTF, such that the current kill rate is around 8,200 hogs/day over a six-day per week operation. Production currently occurs during 16 hours per day followed by a clean-up sanitation period up to four hours in duration. Periodically production extends into six days per week. Operations of the IWWTF consists of one 10-hour shift and one 8-hour shift from Monday through Friday for 17.5 hours per day (7:00 AM to 12:30 AM) coverage, with one 10 hour per day coverage over the weekend. During the Saturday kill days, the IWWTF is staffed from 7:00 AM to 12:30 AM. Current operations staffing consists of seven (7) full time personnel.

For nitrification, 4.57 lbs O_2/lb NH_3-N nitrified was used to estimate nitrification oxygen demand. Nitrification also consumes about 7.0 lbs alkalinity/lb NH_3-N nitrified. Denitrification of the nitrate-nitrogen (NO_3-N) produces about 2.8 lbs O_2 equivalent per lb NO_3-N denitrified and about 3.5 lbs alkalinity per lb NO_3-N denitrified. All the performance data to date has demonstrated that alkalinity addition is not required for this plant. The additional alkalinity provided by denitrification significantly offsets the amount of alkalinity consumed by nitrification, such that no additional alkalinity is required. This expansion process design analysis did not take credit for denitrification in the design of the aeration equipment, therefore providing for conservative oxygen transfer system design and operating evaluations.

Oxygen transfer requirements were calculated assuming 1.5 lbs O_2/lb $cBOD_5$ removed and 4.57 lbs O_2/lb NH_3-N nitrified. The horsepower requirement for the current average operating conditions is about 114 Hp, as indicated in Table 11. This horsepower requirement can be easily achieved with the existing three 100 Hp (each) blowers, with two or one blower operating. The horsepower requirement for the current maximum week operating conditions was estimated to be about 229 Hp, as indicated in Table 11. These horsepower estimates do not allow for the COD removal by the denitrification occurring in the anoxic basin which provides significant oxygen transfer equivalence. The current aeration basin operating dissolved oxygen concentrations have been in acceptable ranges at the current operating conditions without the second stage DAF online. The actual operating data over the period evaluated shows that the denitrification occurring in the anoxic basin more than makes up for any potential horsepower deficiency at these operating conditions.

The horsepower requirement for the projected average operating conditions for a minimum of 9,000 hogs/day production rate of 146 Hp can be easily achieved with two existing 100 Hp blowers operating. The estimated horsepower requirement for the projected maximum week operating conditions for a minimum of 9,000 hogs/day of 293 Hp is approaching the capacity of the three existing 100 Hp (total of 300 Hp) blowers operating. Therefore, the process design information provided in Table 11 indicates that the limiting factor for expanding production to the minimum 9,000 hogs/day kill rate appears to be the aeration blower horsepower capacity at the anticipated maximum week loads in the existing two aeration tanks. However, the installation of the new treatment train with the third aeration basin, additional aeration blowers, and third membrane train, providing over 50% increase in treatment capacity, will easily provide adequate treatment capacity for the minimum 9,000 hogs/day production rate. The expansion of the IWWTF was designed to operate in a temperature range of 13 to 36 $°C$.

The following paragraphs provides a brief description of each treatment process component and the corresponding treatment capacities for the expanded IWWTF to a minimum of 9,000 hogs/day treatment capacity.

Raw Influent Lift Station

The recent expansion at the IWWTF included a new raw influent lift station with two new 70 L/sec pumps. This new lift station will be able to handle the future expansion and sanitation flows of over 100 L/sec up to an instantaneous peak flow of 150 L/sec during the same sanitation period (typically four hours). The recently expanded/upgraded lift station will provide adequate treatment capacity for the expanded IWWTF to a minimum of 9,000 hogs/day treatment capacity.

Rotary Screen

A new rotary screen, internally fed, 0.030 inches slot openings, was installed during the recent expansion at the IWWTF with a capacity of 140 L/sec. The new screen will be able to handle the projected flows for the 9,000 hogs/day production rate.

Pre-Attenuation Tank

A Pre-Attenuation Tank was also installed during the recent expansion at the production facility. The Pre-Attenuation Tank was installed after the rotary screen with a capacity of 570 m^3. A jet mixing system was provided to mix the tank contents with a recirculation pump capacity of 120 L/sec. The pre-attenuation tank will provide adequate pre-attenuation capacity for the projected flows for the minimum 9,000 hogs/day production rate.

Raw Influent and Screening

Process wastewater flows (pre-attenuation tank effluent), sanitary sewer wastewater, barn waste, and truck wash flows are combined just outside the processing facility. The existing pump station lifts the combined wastewaters into a force main and conveys flows to the primary treatment building at the IWWTF.

These raw influent pumping and screening facilities process all flows that occur during the production and sanitation schedules. Flows can vary widely during a production day. Most of the current wastewater flows occur during the 8-hour workday with additional wastewater coming because of cleaning flows after the production day. The raw influent pumping and screening facilities are sized for 75.6 L/sec. The influent screen size is 1.0 mm. Following wastewater flow pre-attenuation at the production facility, the IWWTF influent screening facility will be adequate for the projected expansion operating basis for the minimum 9,000 hogs/day production rate.

Screened Water Lift Station

The existing screened water lift station was upgraded to handle the screened wastewater flow from the new cut floor and production facility with one new pump at 70 L/sec and replacing the two old 76 L/sec pumps with two new 70 L/sec pumps for a total of three 70 L/sec pumps.

Following wastewater flow pre-attenuation at the production facility, the IWWTF screened water lift station will be adequate for the projected expansion operating basis for the minimum 9,000 hogs/day production rate.

Primary Treatment – First Stage DAF

The existing facilities have a large first stage DAF followed by a smaller second stage DAF. The first stage DAF does not have the hydraulic capacity and solids loading capacity to handle the projected conditions for the minimum 9,000 hogs/day production rate. Therefore, the IWWTF expansion will include the previously refurbishment NoA approved larger primary DAF to be installed in a new building (referred to as the Primary Treatment Annex) along with ancillary equipment which then will allow the existing primary DAF to be used as a secondary processing unit. The plan will be to install the new larger primary stage DAF, and then reuse the current primary DAF as the second stage DAF. Since there is not adequate room in the existing primary building to install more equipment, the plan is to construct a new building north of the existing treatment building to house the new primary DAF, pipe the new primary DAF effluent to the attenuation tank, and then use the existing primary DAF as the second stage DAF. The new floc tube and DAF will both be designed for the screened water flow rate of 70 L/sec. The new first stage DAF will have approximately 50% more available surface area (50% more treatment capacity) than the existing primary DAF, and repurposing the existing primary DAF, as the new second stage DAF, will increase the treatment capacity of the second stage DAF by a factor of 3 times. The new first stage DAF will therefore provide adequate treatment capacity for the projected flows and loads for the minimum 9,000 hogs/day production rate.

Flow Attenuation Tank

The recent production increase to 8,200 hogs/day provides a total estimated 340 m^3/day recycle flow streams through the IWWTF (mainly centrifuge centrate). This tank was sized for 2.5 days at an equalized flow of 1,520 m^3/day. Assuming the same recycle streams of 340 m^3/day for the 9,000 hogs/day production increase, the attenuation tank will provide 1.9 days holding capacity at the average operating conditions and 1.5 days at the maximum week operating conditions. The attenuating tank should provide adequate holding capacity at the new process design conditions.

Primary Treatment – Second Stage DAF

Consistent with the refurbishment NoA, the existing primary DAF will be repurposed for use as the secondary DAF processing unit. Repurposing the existing primary DAF, as the new second stage DAF will increase the treatment capacity of the second stage DAF by a factor of 3 times. The repurposed second stage DAF will therefore provide adequate treatment capacity for the projected flows for the minimum 9,000 hogs/day production rate.

Activated Sludge/MBR System

The activated sludge system is currently operating at F/M ratios of 0.074 and 0.160 Kg BOD_5/day/Kg MLVSS at average and maximum week operating conditions, respectively, with an average MLVSS of 8,076 mg/L. At the projected operating condition of a minimum 9,000 hogs/day production the F/M ratios will actually decrease slightly to 0.070 and 0.150 Kg

BOD_5/day/Kg MLVSS at average and maximum week operating conditions, respectively, assuming the same MLVSS concentration of 8,076 mg/L (due to the addition of the third aeration tank and third membrane train).

The horsepower requirements at the current average and maximum week operating conditions can be provided with the existing aeration equipment and the three 100 Hp blowers. For the projected hog kill rate of a minimum of 9,000 hogs/day, the horsepower requirements for the average condition can be provided with two 100 Hp blowers in operation. The projected horsepower requirements at the minimum 9,000 hogs/day kill rate maximum week operating condition can actually be achieved with the current blower capacity of 300 Hp. Therefore, according to the refurbishment NoA, the installation of the new treatment train with the third aeration basin and third membrane train with two new aeration blowers will easily provide adequate oxygen transfer and treatment capacity for the minimum 9,000 hogs/day production rate.

The empty cassette slots in each of the two existing membrane trains have already been filled. One cassette with the 340 ft^2 membrane module was removed from one of the trains and installed in the other train. Then the second train was fully populated with the existing 340 ft^2 membrane module and two new 370 ft^2 membrane modules. This modification provided a 73% increase in membrane surface area from the previous membrane surface area, thus providing significant increase in hydraulic throughput for the two membrane trains. The refurbishment NoA third membrane train will provide the needed additional hydraulic capacity for the expansion design basis.

Disinfection

The MBR effluent has low effluent suspended solids and turbidity, and as such is easy to disinfect. A closed conduit ultraviolet disinfection system located inside the treatment building is used for disinfection. Two units are provided, each sized with a capacity 22.1 L/sec. The addition of the refurbishment NoA UV system will be required in the MBR annex building to handle the expansion for the projected flows for the minimum 9,000 hogs/day production rate.

Sludge Processing

The projected sludge generation after the production increase to a minimum of 9,000 hogs/day was estimated to be an average of 2,408 Kg/day (100 Kg/hr), with a maximum week value of 5,476 Kg/day (228 Kg/hr). A new centrifuge with a capacity of 635 Kg/hr was installed during the recent IWWTF expansion. The new refurbishment NoA centrifuge will be able to handle the projected sludge generation for the 9,000 hogs/day expansion. Both of the two smaller centrifuges still remain online, providing backup dewatering capacity as well. A larger sludge bin with 109,000 liters holding capacity being provided with the refurbishment NoA will be installed in the new primary treatment annex building. Increased sludge hauling capacity is also provided by converting from dumpsters to sludge trailers. A new sludge trailer bay is also being provided inside the new primary treatment annex building to keep the new sludge trailers inside for winter weather protection. The new sludge handling and processing facilities, as part of the refurbishment NoA, will therefore provide adequate treatment capacity for the projected flows for the minimum 9,000 hogs/day production rate.

Chemical Storage and Handling

The chemical storage and handling facilities are being upgraded and expanded as part of the refurbishment NoA. A new polymer feed system is being provided in the primary treatment building annex consisting of new polymer feed pumps and a new polymer tote handling system. A new 12,000-gallon bulk Ferric Chloride storage tank is also being provided with new Ferric Chloride feed pumps. New polymer feed pumps are also being provided. A new 6,000-gallon Micro-C bulk storage tank and feed pumps are being located where the existing secondary DAF is currently located in the existing primary treatment building. Micro-C can be used as supplemental carbon source, if needed in the future.

Ferric chloride is used as a coagulant along with polymer at the primary DAF pretreatment for both phosphorus and TKN removal, and if needed Micro-C addition after the attenuation tank will be available for additional assurance for both TN and Phosphorus removal.

Supplemental carbon addition has never been needed at the post anoxic tanks; however, space has been provided for a Micro-C storage and feed system inside the building in the location of the post anoxic tanks as a safety factor, in case of future needs.

SUMMARY AND CONCLUSIONS

HyLife is currently planning increased production capacity to a minimum of 9,000 hogs/day that will increase flows and loads to the IWWTF, which will require increased treatment capacity at the existing treatment facilities to ensure continued compliance with the effluent discharge requirements. The impacts of this increased production capacity were investigated in the increased capacity changes concept engineering evaluations provided in this report.

An increased capacity process design basis for a minimum of 9,000 hogs/day was developed from the current operating data base and the anticipated increased capacity changes. This increased capacity process design basis was then used to develop the IWWTF expansion capacity needs. All of the primary and secondary expansion improvements defined below provide more than adequate treatment capacity for 9,000 hogs/day, and are being provided through the approved refurbishment NoA (with the exception of the new post anoxic tank):

Expansion improvements include the following:

1. Primary Treatment:
    a. New Primary DAF approximately 50% larger than the existing Primary DAF
    b. Convert the existing Primary DAF to be utilized as the Second Stage DAF
    c. A new 6,000-gallon Micro-C bulk storage tank will be located where the existing secondary DAF is currently located; Micro-C to be used for supplemental carbon source for TN and TP removal, if needed in the future
    d. Construct a Primary Treatment Building Annex to the North of the existing Primary Building to house the following facilities:
        - New Primary DAF
        - New polymer feed pumps
        - New 12,000-gallon bulk Ferric Chloride storage tank
        - New Ferric Chloride feed pumps
        - New Primary DAF sludge collection hopper and pumping facilities to deliver the sludge from the new primary DAF to the centrifuges
        - New centrifuge mezzanine for all three centrifuges (one new centrifuge with capacity to dewater all the sludge)
        - New sludge trailer bay

2. Secondary Treatment
    a. New third Aeration Basin Tank
        - Diameter: 14.3 m
        - Sidewater Depth: 6.4 m
        - Working Volume: 1,022 m^3
        - Total Volume: 1,215 m^3
        - 570, 9-inch EPDM membrane disc diffusers
        - Two new blowers at 1,200 SCFM @ 12 psi each
    - New Post Anoxic Tank
    - New Suez MBR (Z-MOD-L1120) hollowfiber membrane system, complete system with back pulse tank, membrane aeration, recirculation pumps, membrane cleaning systems and other ancillary equipment.

- New ultraviolet disinfection system with same capacity as each of the two existing ultraviolet disinfection units

The HyLife IWWTF was recently expanded/upgraded to 8,200 hogs/day treatment capacity. The current planned production expansion to a minimum of 9,000 hogs/day capacity will require less than 10% increase in flow and loading treatment capacity above the existing treatment capacity. The IWWTF concept development/design expansion developed for this production expansion to a minimum of 9,000 hogs/day will provide over 50% flow and loading treatment capacity above the existing treatment IWWTF capacity. Therefore, the expanded IWWTF will provide wastewater treatment capacity for the currently planned production capacity increase of a minimum of 9,000 hogs/day production rate.

ATTACHMENT 1

Process Flow Diagram

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

NO.	DRAWING NUMBER	REFERENCE DRAWING TITLE
10	-	-
9	-	-
8	-	-
7	-	-
6	-	-
5	-	-
4	-	-
3	-	-
2	-	-
1	-	-

REFERENCE DRAWINGS

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
C	21/01/18	RE-ISSUED FOR REVIEW	JS	
B	20/10/27	RE-ISSUED FOR REVIEW	JS	
A	20/07/30	ISSUED FOR REVIEW	JS	

REVISIONS 1

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK

REVISIONS 2

CERTIFICATE OF AUTHORIZATION

PERMIT STAMP

AUTHENTICATION FOR CURRENT REVISION

ENG. STAMP

ENGINEER'S SEAL

CLIENT: HYLIFE

KGS GROUP

DESIGN BY:	JS	DATE (YY/MM/DD)	20/07/28
DESIGN CHECK:		DATE:	
DRAWN BY:	RP	DATE:	20/07/30
DWG CHECK:		DATE:	

PROJECT:
R3 INNOVATIONS
WASTEWATER TREATMENT PLANT
CAPACITY UPGRADE

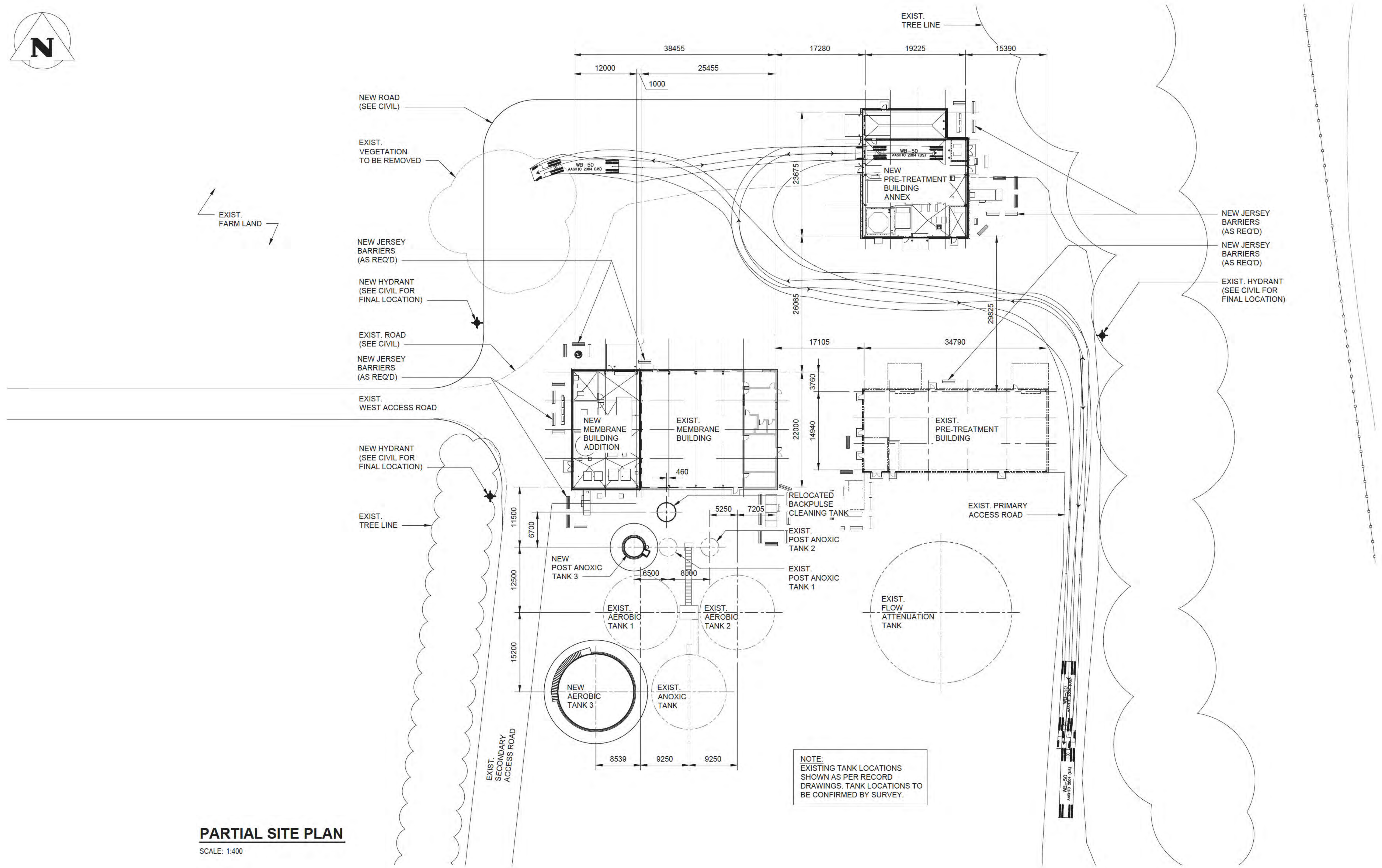
TITLE:
MECHANICAL
PROCESS FLOW DIAGRAM

PROJECT NO.	DWG. NO.	REV.
20-3007-003	R320.M.PFD.0010	C

Filename: U:\FMS\20-3007-003\R320.M.PFD.0010, Tab: 20-3007-003_R320.M.PFD.0010 Plotted By: JSeise 21/01/18 [Mon 9:16am]
24"X36" PLOT SCALE: PROCESS FLOW DIAGRAM

ATTACHMENT 2

Site Layout



PARTIAL SITE PLAN

SCALE: 1:400

NO.	DRAWING NUMBER	REFERENCE DRAWING TITLE
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9	-	-
8	-	-
7	-	-
6	-	-
5	-	-
4	-	-
3	-	-
2	-	-
1	-	-

REFERENCE DRAWINGS

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK
0	21/01/29	ISSUED FOR CONSTRUCTION	SNH	

REVISIONS 1

NO.	YY/MM/DD	DESCRIPTION	DESIGN BY	DESIGN CHECK

REVISIONS 2

CERTIFICATE OF AUTHORIZATION

ENGINEERS GEOSCIENTISTS MANITOBA

Certificate of Authorization

KGS Group

No. 245

PERMIT STAMP

AUTHENTICATION FOR CURRENT REVISION

ENG. STAMP

ENGINEER'S SEAL

CLIENT: HYLIFE™

KGS GROUP

DESIGN BY: SNH	DATE (YY/MM/DD): 20/06/15
DESIGN CHECK:	DATE: 21/01/29
DRAWN BY: SNH	DATE: 20/06/15
DWG CHECK:	DATE: 21/01/29

PROJECT: R3 INNOVATIONS WASTEWATER TREATMENT PLANT CAPACITY UPGRADE

TITLE: BUILDING PARTIAL SITE PLAN PROPOSED

PROJECT NO. 20-3007-003

DWG. NO. R320.B.PLN.0201

REV. 0

Filename: U:\FMS\20-3007-003\R320.B.PLN.0201 - Tab:Layout1 Plotted By: shildebrand 21/01/29 [Fri 1:54pm]
24"x36" PLOT SCALE: 1=1

Appendix E WHITEMUD RIVER ASSESSMENT REPORTS AND WATER QUALITY DATA REPORTS

WHITEMUD RIVER
SUMMER WATER QUALITY ASSESSMENT AND MODEL

Report Prepared for Stantec by Jay Toews, R.P.Bio., P. Biol.

June, 2020

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Consulting and Aquatic Sciences

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June 30, 2020

Stephen Biswanger, P.Eng.
Stantec
500–311 Portage Avenue, Winnipeg, Manitoba R3B 2B9
stephen.biswanger@stantec.com

Re: Final Report: Whitemud River Summer Water Quality Assessment and Model

Dear Mr. Biswanger,

I am pleased to submit the enclosed final report, *Whitemud River Summer Water Quality Assessment and Model*. The report describes the development of a water quality model and interpretation of data collected in 2019 to assess water quality in the Whitemud River between Neepawa and Gladstone, Manitoba, during the late open-water season. It is intended to support planning and licensing of potential increased wastewater volumes in the R3 Innovations Inc. (R3II) facility, which treats wastewater from the HyLife hog processing facility in Neepawa.

The assessment identified local impairments in the Whitemud River that prevent it from meeting water quality objectives and guidelines. The impairments appear to be caused primarily by excessive phosphorus loading to the river in the Neepawa area. Therefore, it is recommended that overall phosphorus releases in the area be reduced to below historical levels, to prevent further accumulation of phosphorus and negative impacts in the river.

In recent years, phosphorus discharge from the R3II facility has been well below its licensed limit and a minor contributor to the total load in the river. The proposed increase in wastewater volume in the R3II facility can be accommodated provided the effluent continues to be of superior quality relative to the current licensed limit and provided any related increase in phosphorus loading is balanced by a larger reduction in other sources, to a achieve a net reduction in overall loading to the river.

I understand that the draft of this report was reviewed by Stantec and HyLife. I trust that the study will provide valuable guidance for current and future planning on the Whitemud River with respect to wastewater treatment and effluent release.

I thank you for the opportunity to work with you on this meaningful project.

Sincerely,

Jay Toews, R.P.Bio., P. Biol.
Toews Environmental Ltd.
Jay.Toews@ToewsEnvironmental.ca

WHITEMUD RIVER SUMMER WATER QUALITY ASSESSMENT AND MODEL

Executive Summary

Toews Environmental Ltd. was retained by Stantec Consulting Ltd. (Stantec), on behalf of HyLife Foods LP (HyLife), to develop a model and assess water quality in the Whitemud River based on available information including data from field studies conducted by Stantec in July and September 2019. The assessment is intended to support possible application by HyLife to increase the licensed volume of effluent discharge from the R3 Innovations Inc. (R3II) wastewater treatment facility, which receives wastewater from the HyLife hog processing facility near Neepawa, Manitoba.

A model using Qual2K software was calibrated to the July and September 2019 datasets for the 105-km reach of the Whitemud River between Neepawa and Gladstone, Manitoba. The Town of Neepawa municipal and R3II wastewater facilities are the main point sources of nutrients in this river reach, which does not have major tributaries or urban development downstream of Neepawa.

Water quality in the Whitemud River

Model results, data from the 2019 field studies, and long-term monitoring data from Manitoba Agriculture and Resource Development revealed the following water quality impairments in the Whitemud River between Neepawa and Gladstone during the open-water season:

- Dissolved oxygen concentrations below the instantaneous minimum Manitoba Water Quality Objective to support sensitive aquatic biota such as sport fish;
- Dense growths of benthic (bottom) algae that negatively affect the river's physical habitat quality and are the primary cause of the low dissolved oxygen concentrations;
- Excessive phosphorus that supports the benthic algae growth and exceeds the Manitoba Water Quality Guideline.

Empirical data and model results indicated that localized phosphorus enrichment in the riverbed sediments between Neepawa and Gladstone, likely resulting from accumulated historical nutrient loading, currently results in phosphorus release that is a major component of the overall active phosphorus load in the river and, therefore, a major contributor to the water quality impairments listed above. Model-simulated reductions in the instream phosphorus concentrations and sediment phosphorus release resulted in reduced growth of benthic algae and improved dissolved oxygen concentrations in the river. Model-simulated adjustment of instream nitrogen concentrations, by a factor of four, did not result in appreciable change in algae growth or dissolved oxygen.

Recommendations

Considering the above, it is recommended that phosphorus reduction be the primary focus of water quality protection and improvement initiatives in the Whitemud River. In particular, overall phosphorus loading in the point sources at Neepawa should be reduced to below past rates, with the specific goal of reducing instream phosphorus loads to the extent of achieving net phosphorus release in the riverbed sediments between Neepawa and Gladstone. Net release, rather than accumulation, of phosphorus in the sediments, would begin to reverse historical impacts and improve water quality conditions over the long term.

It is also recommended that a target minimum flow be identified and maintained in the river to the extent possible, to facilitate better-informed assessment and management of wastewater inputs and to protect the ecological integrity of the river. Although this study did not include detailed analysis of river hydrology, it noted that river flows less than the assumed minimum release from Lake Irwin, upstream of Neepawa, are not uncommon in the river.

Assessment of effects of possible changes to R3II effluent discharge

For the past several years or more, the R3II effluent quality has been consistently superior to the Limits stipulated in the facility's Environment Act Licence. Therefore, a Baseline condition was defined for the river and assessed in parallel with a defined Licence Limit condition, to differentiate between river conditions that have occurred and those that would occur if the R3II effluent was discharged with nutrients and biochemical oxygen demand (BOD) at its Licence Limits.

Results indicated that a 46% increase in effluent discharge volume (from 1570 m^3/day to 2290 m^3/day, as may be proposed), while maintaining the Baseline effluent quality, would cause a small (likely insignificant) increase in phosphorus loading in the river. Such an increase would not have immediate impacts on the river's water quality, due to low concentrations of nutrients and BOD in the effluent.

Increasing the effluent concentrations of phosphorus and BOD to the Licence Limit condition, however, would add considerably to the phosphorus load in the river, with or without an increased discharge rate. Such an increase could contribute to net accumulation of phosphorus in the river and accumulative negative impacts. The calculated phosphorus loads associated with the Baseline and Licence Limit conditions, at the current and potentially increased effluent discharge rates, are summarized in the following table:

Estimated annual phosphorus loads (kg/year) in the R3II effluent.

	Baseline Discharge Rate (1570 m^3/day)	**Increased Discharge Rate (2290 m^3/day)**
Baseline (2019) Phosphorus (0.102 mg/L)	58	85
Licence Limit Phosphorus (1 mg/L)	573	836

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WHITEMUD RIVER SUMMER WATER QUALITY ASSESSMENT AND MODEL

1) Introduction

Toews Environmental Ltd. (TEL) has been retained by Stantec Consulting Ltd. (Stantec), on behalf of HyLife Foods LP (HyLife), to conduct a study of water quality in the Whitemud River. The study focuses on nutrients and oxygen with the purpose of assessing possible effects of licensed treated effluent discharge from the R3 Innovations Inc. (R3II) wastewater treatment facility, which receives and treats wastewater from the HyLife hog processing facility in Neepawa, Manitoba. Depending on the outcome of the assessment, it may be used to support an application to increase the effluent discharge Limit permitted under Manitoba Environment Act Licence 2870 RRR. The proposed increase would be from 1570 m^3/day to 2290 m^3/day, to support a possible expansion of the HyLife facility.

The assessment is based largely on interpretation of data produced in field studies conducted by Stantec in July and September 2019 and focuses on the late open-water season. Additional data would need to be collected to produce a complementary assessment of conditions in winter (ice-covered) conditions.

To support the data interpretation and assessment, Stantec requested that TEL develop an updated version of a Qual2K water quality model created in 2008 (Earth Tech 2008). This report describes the model development, data interpretation and assessment conducted by TEL in 2020. The methods and results of the field studies have been reported in a separate data report (Stantec 2020).

Section 2 of this report presents an assessment of existing water quality in the Whitemud River based on conditions observed in July and September 2019. Section 3 defines baseline conditions used in the assessment of potential effects of alteration of the R3II effluent discharge. Section 4 presents the assessment of those potential effects and a summary of recommendations. Sections 2 to 4 refer to results obtained from the updated Qual2K model, which is described in detail in Appendix A.

2) Assessment of 2019 Conditions

Raw data and summaries describing dissolved oxygen, nutrients, algae and other parameters measured in the Whitemud River in 2019 are provided in the "*Field data report for water quality study for HyLife Foods facility expansion*" (Stantec 2020). The following subsections of this report describe in more detail those parameters pertinent to potential effects of the R3II effluent.

2.1 Whitemud River Flows

As described in Section A.6 of Appendix A, river discharge (flow) in the Whitemud River at the headwater of the model near Neepawa was estimated to be 0.201 m^3/s and 0.244 m^3/s during the July and September 2019 sampling programs, respectively. These flows are close to the base flow of 0.2 m^3/s considered to be a minimum operational release from Lake Irwin.

The base flow of 0.2 m^3/s is used as a low-flow baseline scenario for the purposes of the assessment described in this report. However, the 2008 assessment noted that flows in the river at Neepawa had been lower than 0.2 m^3/s in 44% to 48% of summer (July-September) days based on historical flow data (Earth Tech 2008). Similarly, from 2009 to 2016, July-September flows measured at WSC Gauge 05LL005 near Keyes (downstream of Neepawa, near the middle of the modeled study reach) fell below 0.2 m^3/s in five of eight summer periods, for an average of 17 days in those summers (WSC 2020). It is likely that flows are below 0.2 m^3/s frequently in winter as well, for which data do not exist. Defining a design low flow and establishing minimum instream flows would aid the accurate assessment of impacts of effluent releases and the protection of the ecological integrity of the river, respectively.

2.2. Benthic algae and vegetation

Increased and excessive growth of benthic (bottom) algae and vegetation are caused by nutrient enrichment in streams that provide suitable conditions for their growth. They represent a direct impact to physical habitat quality and cause secondary effects related to dissolved oxygen in streambed substrata and the overlying water. These effects can include:

- Smothering of, and prevention of streamflow through, interstitial spaces of coarse substrata, thus reducing the suitability of these habitats for benthic invertebrates that inhabit them as well as for fish spawning and egg incubation;
- Trapping of sediments, thus compounding the effects described above; and,
- Causing wide diel swings in dissolved oxygen (DO), potentially to concentrations that are too low at night to sustain sensitive organisms.

Benthic growth of diatomaceous algae in small rivers can be significant throughout the year including under ice cover (particularly in late winter), but green macroalgae and plants are productive primarily in the spring and summer. The filamentous green algae *Cladophora* sp. and the vascular plant *Potamogeton pectinatus* often proliferate in nutrient-rich streams and rivers in southern Manitoba. Both can cause the effects described above, but the highly-branched *P. pectinatus*, particularly, can clog shallow stream channels.

Both *Cladophora* and *P. pectinatus* undergo detachment and downstream drift in fall when they senesce due to reduced sunlight, but *Cladophora* can also undergo detachment and downstream drift in summer if the water temperature exceeds a tolerance limit of about 25°C (Dodds and Gudder 1992, Wong et al. 1978, Goldstein 1995). Local examples of both of these seasonal drifts have been observed and documented, with the summer detachment of *Cladophora* occurring prior to mid-July (Toews 2002).

In the Whitemud River sampling programs from July 22-24 and September 9-11 2019, benthic algae were sampled from coarse substrata at all six sites between Neepawa and upstream of Gladstone. Based on photographs and field notes, most or all sampled substrata appeared to be colonized only by diatomaceous algae and associated biofilms. However, dense growths of *P. pectinatus* on riffles at the golf course near Site 1 were observed in July (Figure 2-1). *Cladophora* was not observed in high densities at any sites based on photographs collected during sampling, but fresh growth of *Cladophora* existed in moderate densities at Sites 5 and 6 in September (*personal observation*).

In the measurements collected between July 22 and July 24 2019, temperature in the Whitemud River exceeded 25 °C at Sites 2 to 6 but not at Site 1. It is not certain whether the lack of observed prevalence of *Cladophora* overall, and, particularly, relative to *P. Pectinatus* near Site 1, may have reflected temperature-associated seasonal succession. However, the presence of high densities of *P. pectinatus* and low prevalence of *Cladophora* at the time of sampling suggest that overall benthic productivity has the potential to be higher than indicated by the sampling data, particularly in late spring and early summer. This potential is indicated by model simulations as well, described in Section A.16.

As discussed in Section A.9, growth limitation due to light attenuation in the water column is not likely to be a strong factor in benthic algae production except under high-flow conditions. Additional survey with respect to benthic algae and vegetation and to variations in depth and hydraulic conditions along the river channel would strengthen understanding of the influence and limitation of benthic productivity in the river.

Figure 2-1. Photographs of benthic algae on cobble next to *Potamogeton pectinatus* (top), and growth of *P. pectinatus* over a riffle near Site 1 in the Whitemud River (bottom), July 2019. (Photos provided by Stantec.)

2.3 Phytoplankton (Suspended Algae)

Chlorophyll *a* concentrations in the water, which provide an estimate of phytoplankton densities, were in the ranges of 10-35 µg/L and 4-18 µg/L in the July and September sampling periods, respectively. These values are typical of shallow, nutrient-rich streams that favour growth of benthic, rather than planktonic, algae.

In both July and August, the phytoplankton community composition in the upstream portion of the modeled river was dominated by large taxa characteristic of lake environments (notably, *Aphanizomenon* sp., as well as *Anabaena* sp. and *Aulacoseira* sp. in July). A distinct shift in community composition from these taxa to smaller, faster-growing taxa (diatoms and *Merismopedia* sp.) was observed towards the downstream end of the modeled reach in both the July and September datasets.

Based on these taxonomic observations and on model calibration results described in Section A.15, the overall phytoplankton community in the modeled reach of the Whitemud River appears to represent a transition from a senescent population entrained in the flow from Lake Irwin and Parks Lake, upstream of the modeled reach, to a growing population originating in the river.

Due to this transition and lack of opportunity for either phytoplankton community to reach dense concentrations in the river, the overall influence of phytoplankton on dissolved oxygen and nutrients in the modeled reach of the river is smaller than the potential influence of benthic algae.

2.4 Dissolved Oxygen

Based on measurements collected in July and September 2019, dissolved oxygen (DO) is the parameter most limiting to the Whitemud River's ability to support sensitive aquatic biota. The applicable Manitoba Water Quality Objectives (MWQO) for protection of aquatic life are a 7-day average DO concentration of 6.0 mg/L and an instantaneous minimum DO concentration of 5.0 mg/L when the water temperature exceeds 5 °C (Manitoba Water Stewardship 2011).

In the Whitemud River upstream of the Neepawa municipal lagoon and R3II effluent outfalls, DO just failed to meet the MWQO instantaneous minimum of 5 mg/L, with minimum measured concentrations of 4.4 mg/L (52% saturation) on July 23 2019 and 4.0 mg/L (40% saturation) on September 12 2019 at Site 1. Downstream of the effluent outfalls, DO was well below the MWQO, with the following concentrations recorded:

- July 24-25 2019:
    - 1.8 mg/L (22% saturation) at Site 3 (18 km downstream of the effluent outfalls);
    - 2.1 mg/L (25% saturation) at Site 4 (41 km downstream of the effluent outfalls);
- September 10-11 2019:
    - 3.8 mg/L (38% saturation) at Site 2 (6 km downstream of the effluent outfalls);
    - 3.4 mg/L (34% saturation) at Site 4 (41 km downstream of the effluent outfalls).

Calibrated model results, shown in Figure 2-2, indicate that, during the July 2019 sampling period, DO failed to meet the instantaneous minimum MWQO (5.0 mg/L) for a distance of approximately 100 km, over almost the entire modeled river from the effluent outfalls at Neepawa to just upstream of the Gladstone Dam. During the September sampling period, DO failed to meet the instantaneous minimum

MWQO for a distance of approximately 73 km downstream of the outfalls. The July sampling program coincided with discharge from the Town of Neepawa municipal wastewater lagoon but the September sampling program did not.

Figure 2-2 also shows that DO in the Whitemud River failed to meet the 7-day average MWQO (6.0 mg/L) over a distance of 88 km downstream of the effluent outfalls in July, but did meet the 7-day average MWQO in September. In all cases, the failure to meet either MWQO is caused by the nightly depression of DO concentrations due to high levels of primary productivity and respiration by phytoplankton and benthic algae. Examples of modeled and measured diel variation are presented in Figure 2-3.

The nightly depression of DO concentrations to below the instantaneous minimum MWQO (5.0 mg/L) likely occurs in the Whitemud River downstream of Neepawa from spring through summer except during the spring freshet. Documented observations in the Assiniboine River near Brandon showed that the diel variation in DO caused by instream primary production and respiration was most extreme during low flows early in the open-water season (May-June), coinciding with highest sunlight irradiance (Toews 2002, Toews and Schneider-Vieira 2000).

Model development and results indicated that DO in the Whitemud River is highly sensitive to, and primarily controlled by, primary production and respiration by phytoplankton and benthic algae. At the concentrations of Biochemical Oxygen Demand (BOD) measured in 2019, modelling indicated that DO is less sensitive to moderate changes in BOD concentrations or to adjustments to the various hydrolysis and oxidation rates that describe the decomposition of BOD. (See Section A.11.) These results suggest that, under open-water conditions, small changes to aqueous BOD loading would result only in minor effects to DO in the river. It should be noted, however, that these model simulations were conducted based on BOD in the R3II effluent being in the reported range, which was consistently less than 2 mg/L throughout 2019. Negative impacts to the Whitemud River could be expected should the R3II effluent contain carbonaceous BOD at or near its licensed Limit of 25 mg/L for a prolonged period of time. Model-supported evaluation of conditions in the river under various qualities of effluent discharge is discussed in more detail in Sections 3 and 4 of this report.

The calibrated model of July 2019 conditions shows a sharp minimum DO concentration close to 0 mg/L between Site 1 and Site 2, within the mixing zones of the Neepawa municipal and R3II effluents (Figure 2-2). This DO minimum is caused primarily by the nitrogenous oxygen demand imparted at the time by the ammonia load in the municipal lagoon effluent. Further investigation may be warranted to determine whether this area represents an initial dilution zone that should be considered in future licensing and monitoring; however, a planned upgrade of the municipal wastewater treatment facility may reduce ammonia and BOD in the mixing zone sufficiently to reduce impacts in the future.

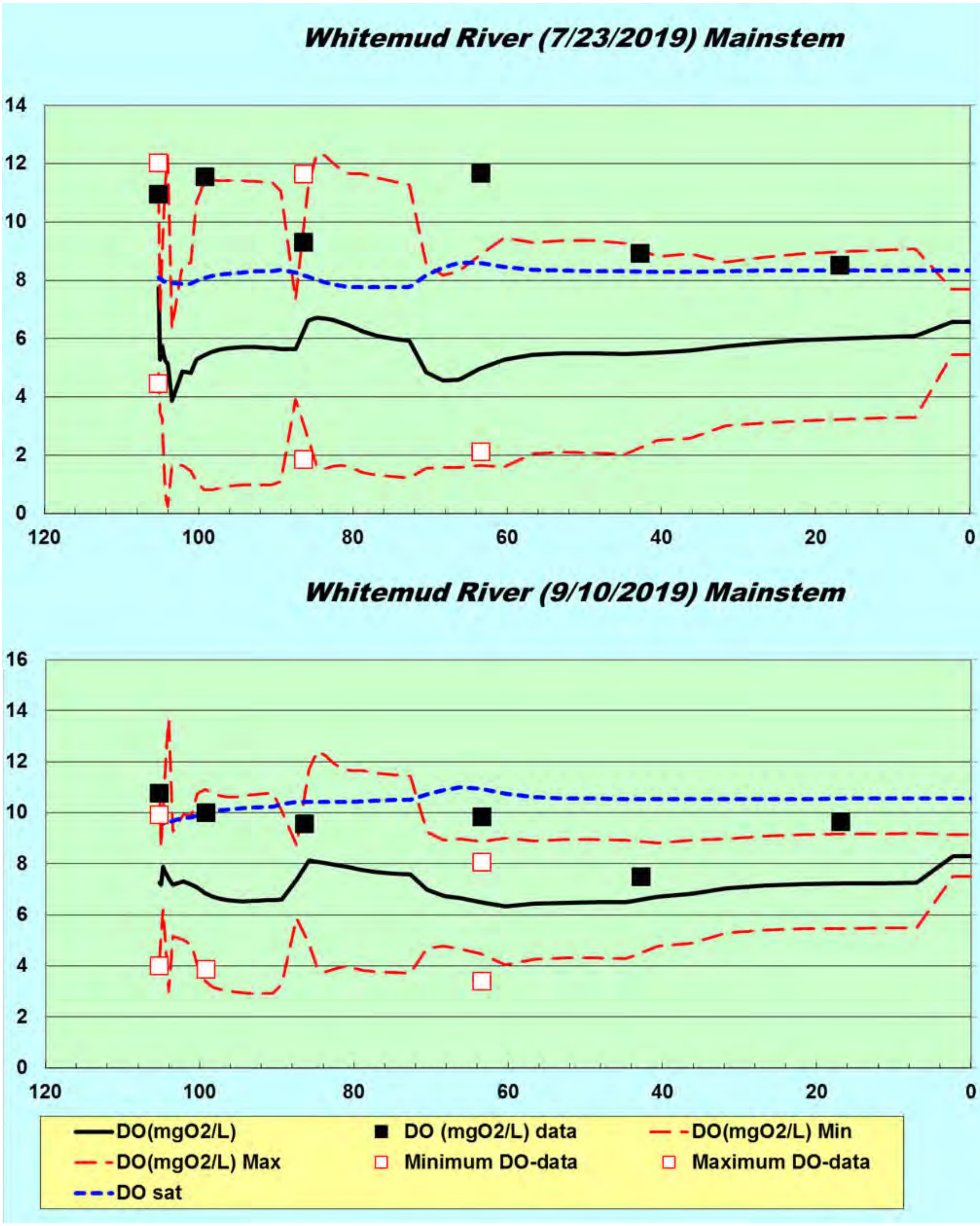

Figure 2-2. Measured data and model estimates of dissolved oxygen in the Whitemud River in July and September 2019.[1]

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[1] In all blue-themed (Qual2K-generated) charts in this report, the lines represent model estimates and the points represent data collected in the 2019 field studies. Not all estimates had corresponding field data. “Minimum” and “Maximum” data refer specifically to the upper and lower ranges of measurements collected by a datalogger left instream overnight. Where “data” may exceed “Maximum” data, the overnight measurements were collected on a different day than the other measurement, thus giving an indication of day-to-day variability in conditions.

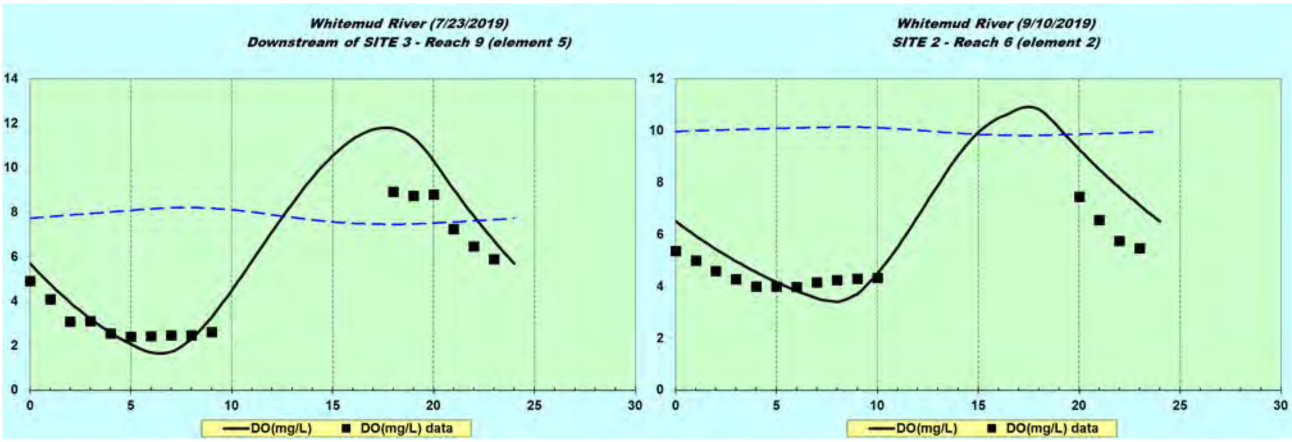

Figure 2-3. Measured data and model estimates of diel variation in dissolved oxygen in the Whitemud River in July 2019 near Site 3 (40 km downstream of the R3II effluent outfall) and in September 2019 at Site 2 (16 km downstream of the R3II outfall).

2.5 Phosphorus

To assess phosphorus and its potential impacts in the Whitemud River system, it is important to focus both on local instream effects and on transport of phosphorus downstream to Lake Manitoba and Lake Winnipeg. These lakes are experiencing increasing incidence of harmful algae blooms, generally considered to be the result of excessive phosphorus loading. The Whitemud River Watershed Integrated Watershed Management Plan (IWMP) set a recommended nutrient reduction goal of 10% (Manitoba Water Stewardship 2010), consistent with targets set out in the Lake Winnipeg Action Plan (Lake Winnipeg Stewardship Board 2006).

The following subsections of this report discuss phosphorus in terms of:

- Instream concentrations measured in 2019;
- Sources and accumulating impacts in the Whitemud River; and,
- Loads transported downstream toward Lake Manitoba.

2.5.1 Instream Phosphorus Concentrations

The narrative Manitoba Water Quality Guideline (MWQG) for total phosphorus in streams and rivers is 0.05 mg/L or low enough to prevent problems associated with eutrophication including nuisance growth of algae or aquatic vegetation (Manitoba Water Stewardship 2011).

Measured phosphorus concentrations were higher than 0.05 mg/L in 2019, particularly during the July sampling period (Figure 2-4). However, the inorganic phosphorus fraction, approximating the fraction available as a nutrient to algae and vegetation, was very close to this guideline in July and September and below it upstream of the wastewater effluent outfalls at Neepawa (discussed in more detail in Section A.13).

As seen in Figure 2-4, total phosphorus concentrations decreased progressively downstream from the effluent outfalls at Neepawa, giving evidence of a lack of external sources along the channel and of nutrient assimilation within the channel. As discussed below, this assimilation is only temporary and should not be interpreted as reduced loading to downstream waterbodies.

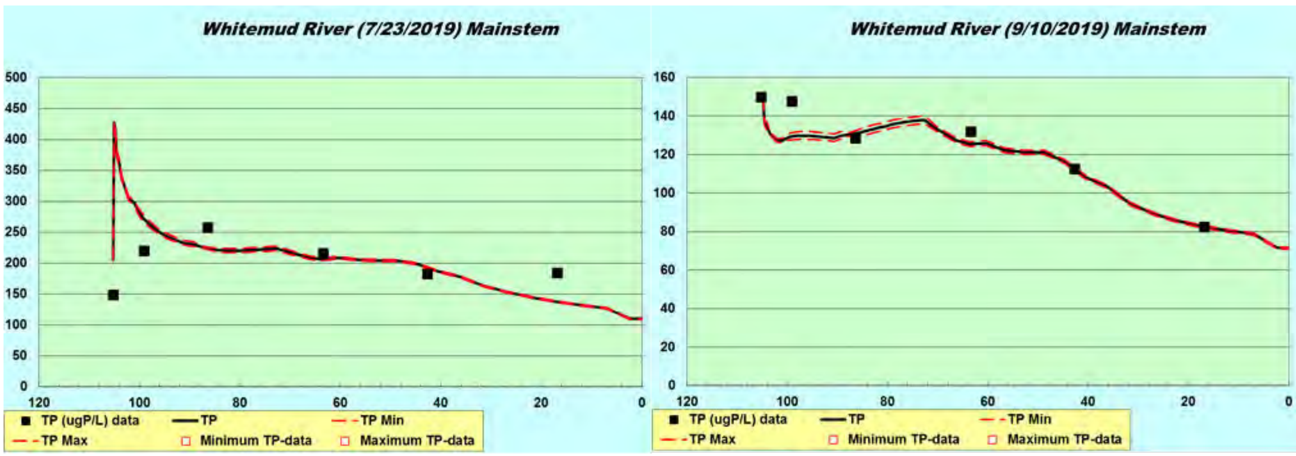

Figure 2-4. Measured data and model estimates of total phosphorus in the Whitemud River in July and September 2019.

2.5.2 Phosphorus Assimilation and Instream Cycling

Attached algae and vegetation account for most of the nutrient assimilation that occurs downstream of point sources to shallow rivers, including the treated wastewater discharges to the Whitemud River near Neepawa (based on model results). The seasonal nature of the assimilation, and the downstream transport of nutrients in large particulate form when algae and vegetation detach and drift, can confound water quality sampling and monitoring programs.

While nitrogen is lost from aquatic environments through volatilization and denitrification, phosphorus is conservative within them and cycles internally between the sediments and the overlying water. In impacted lakes, this cycling occurs as annual internal loading that can increase year-over-year due to accumulation of phosphorus. In impacted rivers, the annual assimilation and partial remobilization results in instream accumulation and increasing downstream loading year-over-year. The assimilated phosphorus gets remobilized in the stream in ways that include:

- Uptake by, followed by detachment and downstream drift of, benthic algae and vegetation (described in Section 2.2);
- Mineralization under anoxic conditions in the sediments, resulting in release as dissolved inorganic phosphorus; and,
- Resuspension of sediments during periods of high flow.

Since the remobilization of assimilated phosphorus by these three means tends to occur in spikes that do not to correspond with point-source loading at the time, it is difficult to distinguish from, and tends to be attributed to, external loading from diffuse sources such as agricultural runoff. Given the conservative nature of phosphorus in the stream, historically assimilated inputs must be accounted for in subsequent high-flow events. Accumulation of a portion of the assimilated loads will result in increasing loads of remobilized phosphorus year over year.

The 2019 data and 2020 Qual2K model indicate that, even though decreasing total phosphorus concentrations indicated net assimilation of phosphorus along the river during the sampling programs, the bottom sediments of the river were a net source of phosphorus in the Whitemud River between Neepawa and Gladstone. (See Section A.13 for details.) The sink responsible for assimilating phosphorus from both the water column and the sediments was benthic algae.

Upon and following senescence of the benthic algae in early winter, the assimilated phosphorus loads would be released downstream as algae sloughed off of bottom substrata, and/or re-adsorbed into the upper layer of sediments. In the first case, the phosphorus associated with sloughed algae could evade water sampling programs. In the second case, the re-adsorbed phosphorus would be transported downstream when the upper layer of sediments undergoes scour in the spring freshet. This “excess” instream phosphorus measured during freshets is typically attributed to external loading from surface runoff. The estimated phosphorus loads associated with this cycling and downstream transport in the Whitemud River are discussed below.

2.5.3 Phosphorus Loads in the Whitemud River

The conservative nature of phosphorus in aquatic ecosystems allows for use of a mass-balance approach to compare and assess effects of point sources relative to the total phosphorus load carried by the receiving water, provided there is good understanding of loads recirculating from the river sediments reflective of residual and accumulative impacts of historic and ongoing loading.

The most complete data available to assess total phosphorus loads currently carried by the Whitemud River are water quality and flow data collected near Westbourne[2] (near Lake Manitoba) by Manitoba Agriculture and Resource Development (MARD) and Water Survey Canada, respectively. Loading rates and the total annual phosphorus load at Westbourne for 2019 were calculated by applying values from five water quality samples collected between December 2018 and December 2019 to the daily flow data collected at WSC Gauge 05LL002, as shown in Figure 2-5. Loads calculated from these data were compiled with other data available for 2019, as summarized in Table 2-1, to characterize phosphorus concentrations and loads in the Whitemud River and point sources at Neepawa. As seen in Table 2-1, the approximate total load carried by the Whitemud River at Westbourne is much larger than the loads discharged to the river near Neepawa on a current annual basis.

[2] The Whitemud River at WSC Station 05LL002 at Westbourne has a drainage area of 6360 km^2. At WSC Station 05LL005 near Keyes (near the middle of the modeled river reach between Neepawa and Gladstone), the river has a drainage area of 1830 km^2. (Water Survey Canada 2020b,c.)

As discussed in Section A.13, model calibration results indicated that the sediments in the Whitemud River contribute phosphorus to the benthic algae and overlying water at net rates up to approximately 50 mg/m^2/day between Neepawa and Gladstone. This phosphorus release from the sediments was accounted for as reach-specific prescribed sediment phosphorus flux. The prescribed sediment phosphorus loading rates (mass/area/time) and the basic channel dimensions used in the hydraulic model (reach length x bottom width) were used to calculate total phosphorus loads (mass/time) contributed by the sediments on a reach-by-reach basis, as shown in Table 2-2. As seen in the tables, the estimated total phosphorus load contributed by the sediments between Neepawa and Gladstone (10,522 kg/year) is similar to the total load carried by the river at Westbourne (12,313 kg/year).

The inorganic phosphorus released from the sediments can be assumed to be a combination of the phosphorus that would be released by “natural” sediments (free of past anthropogenic impacts) plus accumulated phosphorus resulting from past nutrient enrichment from anthropogenic influences. The uneven distribution of loading along the river, indicated by empirical evidence (Section 2.8) and model calibration results (Section A.13), points toward historical impacts and may give insight to the proportion of natural versus accumulated phosphorus, and on potential benefit of phosphorus reduction in point sources. As described in Section 2.7.2, model-estimated sediment phosphorus flux for the Whitemud River without historical phosphorus accumulation in the sediments was approximately 2 mg/m^2/day.

As discussed in Section 2.8, data from 2019 give empirical evidence that the reach of the Whitemud River between Neepawa and Gladstone has become enriched with phosphorus relative to reaches of the river farther upstream and downstream. As described in Section A.13 and shown in Figure A-7, the net phosphorus loading from the sediments was highest between 15 km and 25 km downstream of the wastewater effluent outfalls at Neepawa, and lower downstream as well as upstream in the modeled reach, near the outfalls. This distribution suggests progressive accumulation in the river that has not reached full impact in the lower part of the river near Gladstone. The lower sediment flux rates near Neepawa may reflect reductions in loading from the Neepawa municipal wastewater treatment facility beginning about ten years ago. To verify the empirical evidence and model simulations, direct measurements of sediment phosphorus concentrations and flux rates could help delineate possible historical impacts and potential recovery in the river.

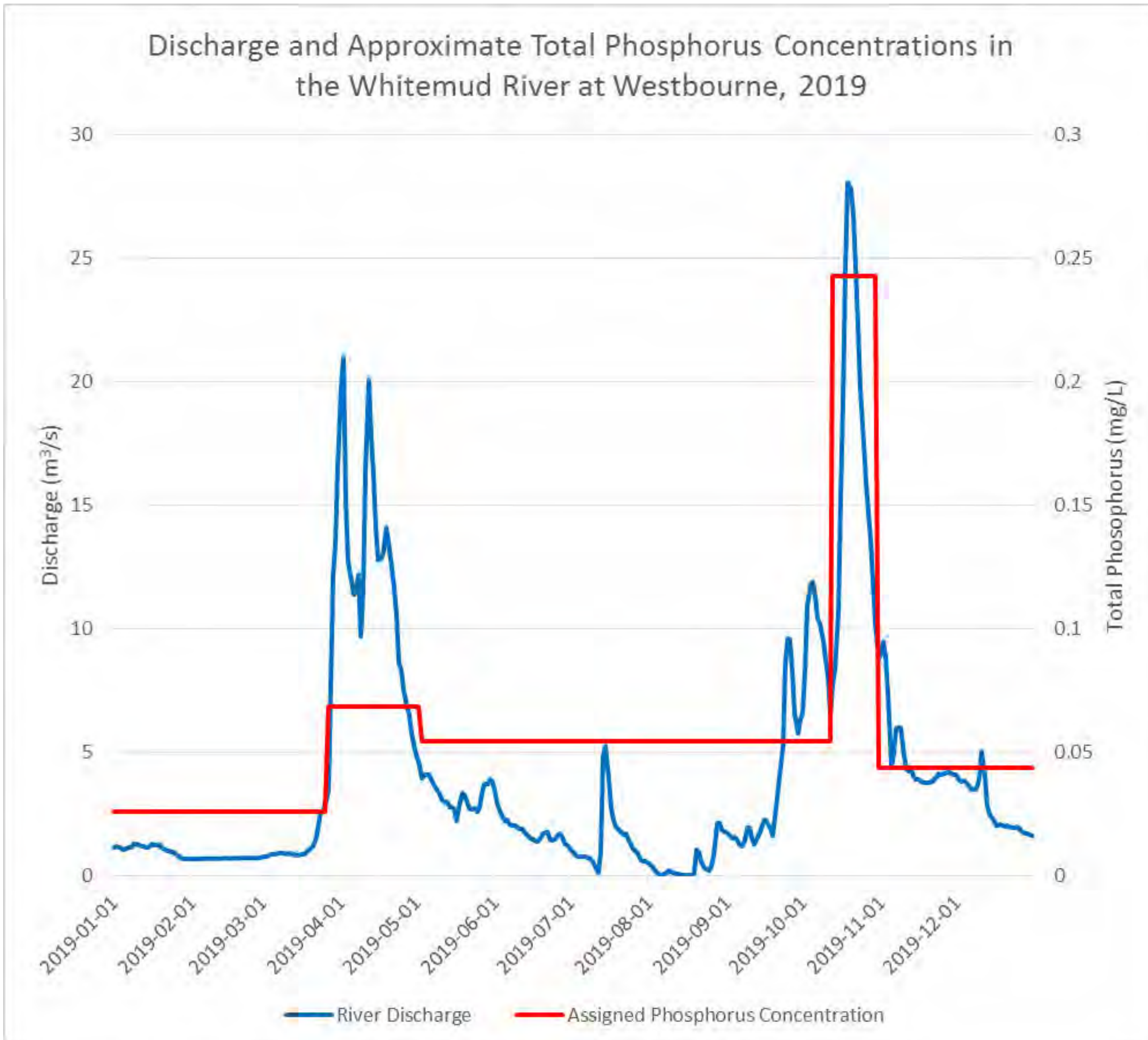

Figure 2-5. Discharge and total phosphorus concentrations in the Whitemud River at Westbourne in 2019. Based on real-time discharge data for Water Survey Canada Gauge 05LL002 (WSC 2020b) and total phosphorus data collected by Manitoba Agriculture and Resource Development on December 20 2018, May 2 2019, July 24 2019, October 17 2019 and December 16 2019 (MARD 2020).

Table 2-1. Concentrations and estimated loads of total phosphorus in the Whitemud River and wastewater effluent discharges in 2019.

		Whitemud River			Wastewater Effluents	
	Date	**Neepawa**	**Keyes**	**Westbourne**	**Neepawa Municipal**	**R3II**
Total Phosphorus Concentrations (mg/L)						
	2018-12-19	0.0491 [a]	No data	0.0259 [b]	1.00 [c]	0.06 [d]
	2019-05-02	0.0871 [e]	No data	0.0683 [e]	No discharge [f]	0.05 [d]
	2019-07-24	0.1490 [g]	0.1825 [h]	0.0545 [e]	1.74 [i]	0.08 [d]
	2019-10-17	0.0858 [e]	No data	0.2430 [e]	1.00 [c]	0.03 [d]
	2019-12-16	0.0577 [e]	No data	0.0438 [e]	No discharge [f]	0.03 [d]
Discharge (m^3/s)						
	2018-12-19	No data	No data	0.97 [j]	No discharge [f]	0.021 [d]
	2019-05-02	No data	1.08 [k]	4.63 [j]	No discharge [f]	0.013 [d]
	2019-07-24	0.20	0.25 [k]	1.49 [j]	0.036 [f]	0.012 [d]
	2019-10-17	No data	3.95 [k]	19.20 [j]	0.036 [f]	0.020 [d]
	2019-12-16	No data	No data	2.24 [j]	No discharge [f]	0.018 [d]
Daily Total Phosphorus Loading Rates (kg/day)						
	2018-12-19	Incomplete data	Incomplete data	2.2	0	0.09 [d]
	2019-05-02	Incomplete data	Incomplete data	27.3	0	0.07 [d]
	2019-07-24	2.59	3.94	7.0	5.4	0.13 [d]
	2019-10-17	Incomplete data	Incomplete data	403.1	3.1	0.05 [d]
	2019-12-16	Incomplete data	Incomplete data	8.5	0	0.04 [d]
Approximate Total 2019 Phosphorus Loads (kg)						
	Total 2019	Incomplete data	Incomplete data	12,313	117 [l]	59

DATA SOURCES:

a. Provincial monitoring data for Station MB05LLS005 (Manitoba Agriculture and Resource Development 2020).

b. Provincial monitoring data for Station MB05LLS001 (Manitoba Agriculture and Resource Development 2020).

c. Total phosphorus concentration in the Neepawa municipal wastewater effluent is assumed to be equal to the licensed limit of 1.0 mg/L at time of discharge.

d. Data provided by HyLife Foods.

e. Draft data provided by Manitoba Agriculture and Resource Development (2020).

f. Timing and rate of discharge of Neepawa municipal lagoon estimated based on release of total of volume of 117,000 m^3 in spring and fall (Theroux *pers. comm.* 2020) at consistent rates.

g. Data reported in this report for Site 1 on July 22 2019.

h. Data reported in this report for Site 5 on July 24 2019.

i. Data reported in this report for Town of Neepawa municipal lagoon effluent on July 22 2019.

j. Real-time discharge data for Gauging Station 05LL002 at Westbourne (Water Survey Canada 2020b).

k. Real-time discharge data for Gauging Station 05LL005 near Keyes (Water Survey Canada 2020c).

l. Neepawa municipal annual phosphorus load based on total discharge volume of 117 000 m^3 (Theroux *pers. comm.* 2020) and licensed limit of 1 mg/L total phosphorus.

Table 2-2. Estimated net loading rates of phosphorus from the sediments by model reach along the Whitemud River between Neepawa and Gladstone in 2019.

Reach Number	Reach Length (km)	Bottom Width [a] (m)	Prescribed Inorganic Phosphorus Flux ($mg/m^2/day$)	Reach Phosphorus Flux (kg/day)
1	0.42	6.35	0	0
2	0.88	10.85	20	0.19
3	0.94	8.90	20	0.17
4	1.75	8.40	25	0.37
5	0.47	7.40	30	0.10
6	10.72	5.90	35	2.21
7	1.47	6.35	40	0.37
8	2.25	5.60	45	0.57
9	6.42	7.35	45	2.12
10	8.30	7.35	45	2.75
11	6.49	11.25	40	2.92
12	3.11	11.25	40	1.40
13	3.37	13.4	40	1.81
14	11.88	11.65	35	4.84
15	4.10	9.90	30	1.22
16	8.57	8.90	25	1.91
17	29.52	8.60	20	5.08
18	4.59	8.75	20	0.80
			Total P Load (kg/day):	**28.83**
			Annual P Load (kg):	**10,522.38**

a. The bottom width accounts only for the bottom of the trapezoidal channel assumed by the model. Actual wetted channel widths and corresponding loading rates would be higher.

2.6 Nitrogen

Similar to instream phosphorus concentrations, total nitrogen concentrations decreased downstream of Neepawa in the July and September 2019 datasets, indicating assimilation along the river, as shown in Figure 2-6. Unlike phosphorus, however, the model indicated no accumulation in the sediments or need to prescribe sediment flux to match measured nitrogen concentrations in the overlying water. A lack of cumulative impact of historical loading is expected, due to the volatilization and denitrification processes that cause nitrogen to be lost to the air rather than accumulating in aquatic ecosystems.

Due to the non-conservative (non-accumulative) nature of nitrogen, this assessment focuses on instream concentrations and potential impacts of nitrogen in the Whitemud River, with less focus on downstream transport than provided for phosphorus.

Applicable Manitoba Water Quality Objectives and Guidelines pertaining to nitrogen are the MWQO for ammonia and the MWQG for nitrate and nitrite. The ammonia MWQO, which ranged from 250 µg/L to 1480 µg/L (based on measured pH and temperature values) in the July and September datasets, was met throughout the modeled reach of the river except over a distance of approximately 3 km downstream from the Neepawa municipal lagoon discharge in July. The nitrate MWQG of 13 mg/L was met throughout the river in both datasets. The R3II effluent itself met the ammonia objective and the nitrate guideline for surface waters during both sampling periods. Measured and modeled ammonia and nitrate concentrations in the Whitemud River during July and September sampling periods are discussed in more detail in Section A.14 and shown in Figure A-10.

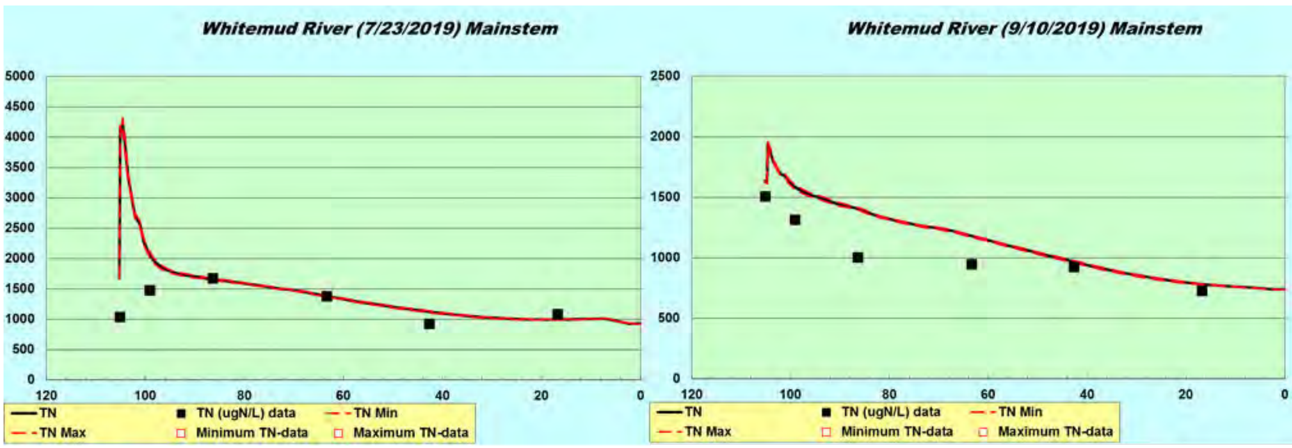

Figure 2-6. Measured data model estimates of total nitrogen in the Whitemud River in July and September 2019.

2.7 Nutrient Limitation

Sections 2.2, 2.3, and 2.4 of this report identified primary production by benthic algae, and associated reductions in DO concentrations to below the MWQO, as primary and secondary impacts of nutrient loading to the Whitemud River. The following subsections evaluate the relative influence of phosphorus and nitrogen on these impacts using the Baseline open-water model developed in Section 3.

The following subsections focus on phosphorus and nitrogen as potentially limiting nutrients in the Whitemud River. Reactive silica, a nutrient required by diatoms, decreased along the modeled river in September due to assimilation by benthic algae and was low in the upstream portion of the modeled river in July, having been consumed by the apparently large *Aulacoseira* population in the upstream lakes. In neither dataset did silica appear to have limited primary production in any part of the river.

2.7.1 Nitrogen Limitation

To assess whether nitrogen was at or near concentrations that might limit growth of phytoplankton or benthic algae in the modeled reach of the Whitemud River, the Baseline 2020 Qual2K model, defined in Section 3, with the wastewater effluent discharges removed, was run with the organic and inorganic nitrogen terms doubled and reduced by half. The results, presented in Figure 2-7, show that this four-fold variation in nitrogen concentrations had little impact on benthic algae, phytoplankton, or dissolved oxygen. These simulations indicate that nitrogen is not at or near limiting concentrations in the Whitemud River between Neepawa and Gladstone.

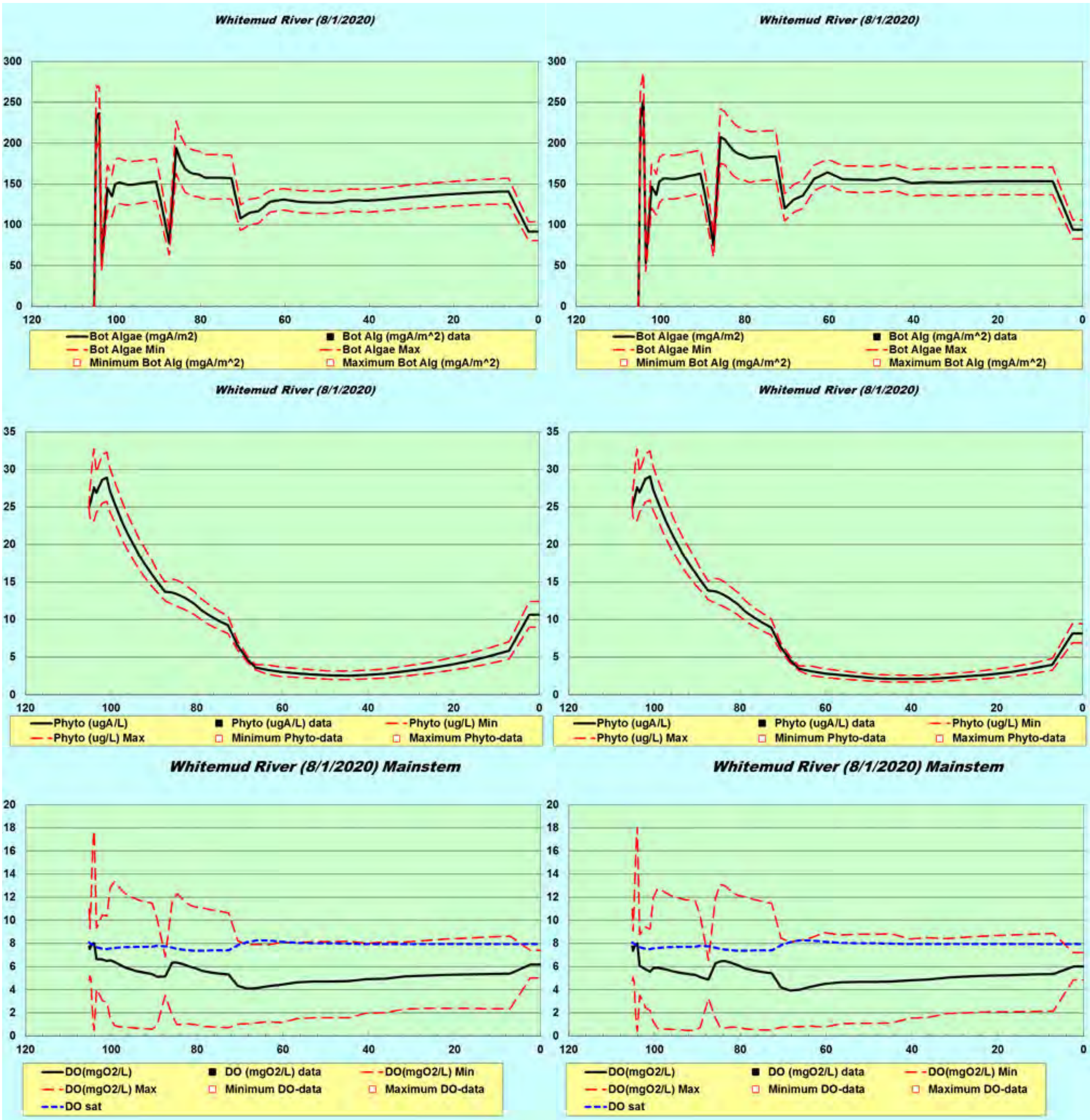

Figure 2-7. Model estimates of benthic algae, phytoplankton, and dissolved oxygen concentrations in the Whitemud River with instream dissolved nitrogen concentrations reduced by half (left) and doubled (right). Estimates generated by Baseline 2020 Qual2K model with wastewater effluent sources removed.

2.7.2 Phosphorus Limitation

Similar to the examination of nitrogen limitation described above, the Baseline model was run with the organic and inorganic phosphorus terms doubled and reduced by half. The results, shown in Figure 2-8, show that, similar to nitrogen, this four-fold variation in instream phosphorus concentrations had little effect on benthic algae, phytoplankton, or dissolved oxygen concentrations in the river.

However, as described in Sections 2.5.2 and 2.5.3, the inorganic phosphorus released from the sediments, partly attributable to the assimilation of past phosphorus loading to the river, is a major component of the bioavailable phosphorus in the system. The evaluation described above and in Figure 2-8 describe the immediate effects of decreasing phosphorus concentrations in the river water, but does not account for the changes that would result from increased or decreased concentrations over time.

To account for the accumulative effects of past phosphorus loading and to simulate the potential reversal of those effects through reduced loading, the simulation described above and in Figure 2-8 was re-run with the prescribed sediment inorganic phosphorus flux removed. The results, shown in Figure 2-9, show a strong decrease in benthic algae and improvement in dissolved oxygen concentrations. The simulation indicates increased growth of phytoplankton along the river, which would result from increased availability of dissolved nitrogen in the water, as the nitrogen would not be consumed by benthic algae fueled by phosphorus from the sediments. The moderate shift from benthic to planktonic primary productivity would increase biodiversity in the system and reduce the accumulative negative impacts associated with dense benthic algae, such as sedimentation of the riverbed, described in Section 2.2.

In this simulation described in Figure 2-9, the model-estimated sediment phosphorus flux (without the additional prescribed flux), was as high as approximately 2 mg/m^2/day. This value represents the model's estimate of phosphorus release from natural (un-impacted) sediments in a river with nutrient concentrations and sediment characteristics similar to the Whitemud River in the Baseline condition and without the Neepawa wastewater effluents.

Figure 2-9 underestimates the improvement in dissolved oxygen concentrations that would result from reducing accumulated phosphorus in the sediments, as the model was calibrated with high prescribed sediment oxygen demand to correspond with the conditions generating the prescribed inorganic phosphorus flux. As reduction or reversal of phosphorus accumulation in the river would result in a parallel reduction in organic matter in the sediments (including respiring benthic algae), an accompanying reduction in sediment oxygen demand would result. However, the prescribed sediment oxygen demand was left intact in the model simulation shown in Figure 2-9.

The results described above indicate the following:

- The Whitemud River between Neepawa and Gladstone is phosphorus-limited.
- Much or most of the current primary productivity in the river is supported by historically-accumulated phosphorus being remobilized from the sediments.
- To achieve or approach the MWQG for phosphorus and primary productivity in the river, and to prevent further accumulative impacts including riverbed sedimentation, the impact of historical phosphorus loading would have to be reversed.

- Therefore, restoration of the ecological health of the river, or reduction of accumulating impacts, can be expected to be seen as improved conditions over time, rather than immediate improvements, through reversal of historical impacts.

Section 2.8, below, describes empirical evidence that supports the conclusion, based on model outputs, that the Whitemud River is phosphorus-enriched between Neepawa and Gladstone, likely due to historical impacts that may be reversible.

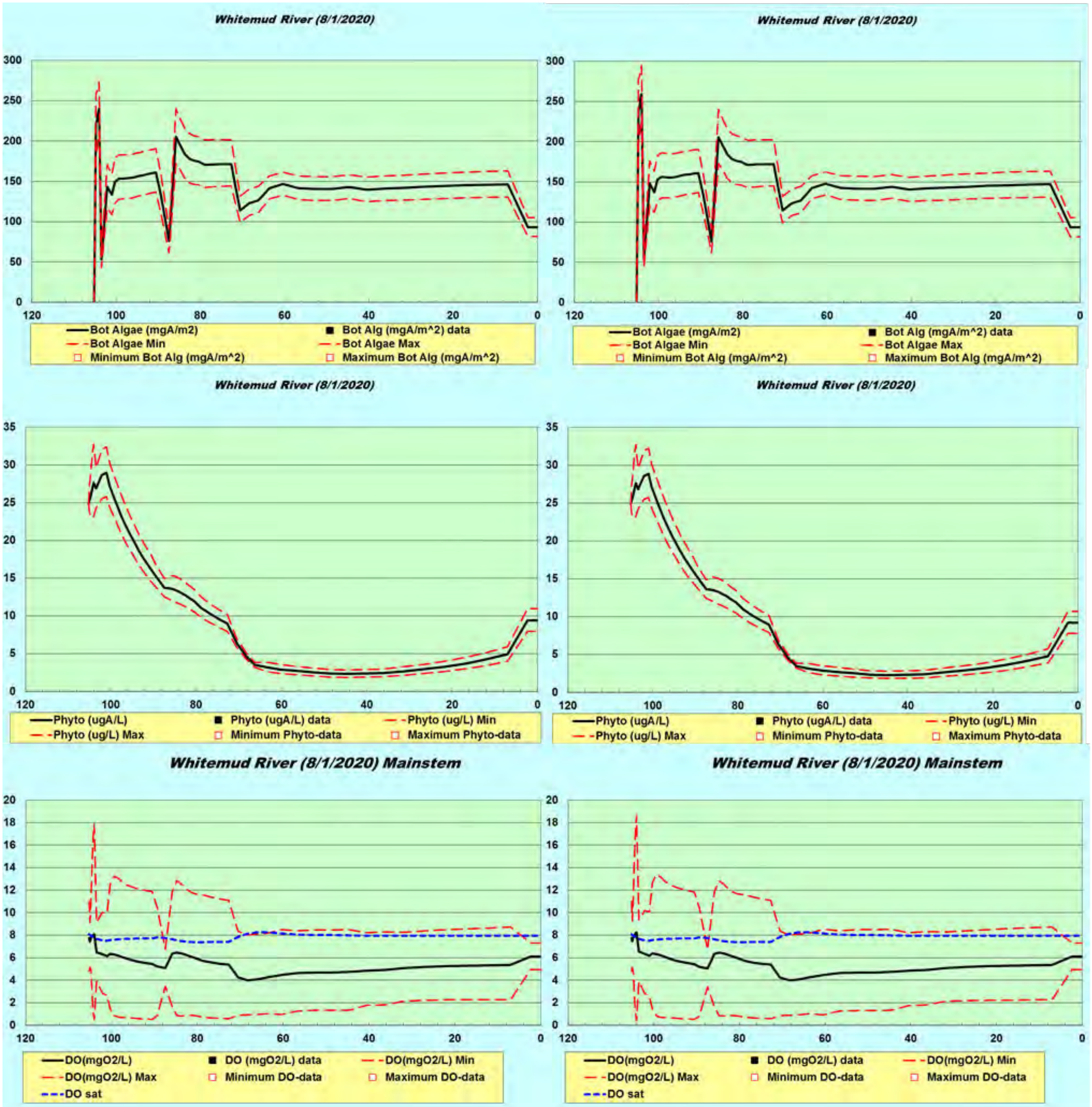

Figure 2-8. Model estimates of benthic algae, phytoplankton, and dissolved oxygen concentrations in the Whitemud River with instream phosphorus concentrations reduced by half (left) and doubled (right). Estimates generated by 2020 Qual2K Baseline model with wastewater effluent sources removed.

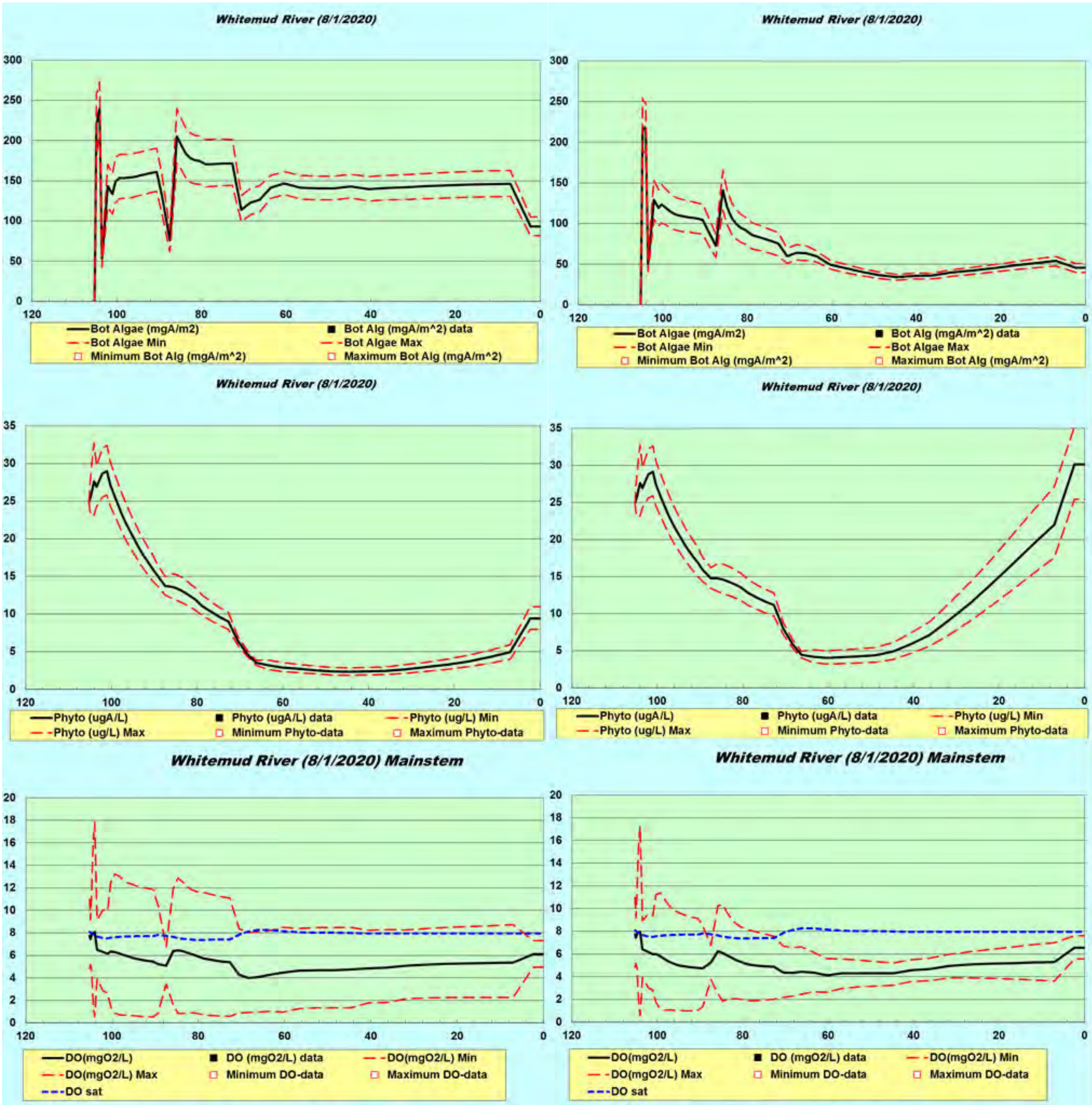

Figure 2-9. Model estimates of benthic algae, phytoplankton, and dissolved oxygen concentrations in the Whitemud River with (left) and without (right) prescribed loading of phosphorus from the sediments. Estimates generated by 2020 Qual2K Baseline model with wastewater effluent sources removed, instream dissolved phosphorus concentrations reduced by half, and prescribed sediment oxygen demand (calibrated to 2019 conditions with prescribed sediment phosphorus loading) left in place.

2.8 Nitrogen/Phosphorus Ratios and Phosphorus Enrichment between Neepawa and Gladstone

Nitrogen/Phosphorus (N:P) ratios are often considered as indicators of nutrient enrichment or of potential nutrient limitation in surface waters. The N:P mass ratios that describe the growth requirements of plants and algae, determined experimentally and based on observed proportions of the two nutrients in growing plants and algae, are generally considered to be between 7:1 and 16:1 (Redfield et al. 1973; Rast and Lee 1978; Koerselman and Meuleman 1996).

The Manitoba Water Quality Standards for industrial and municipal wastewater effluents, 15 mg/L total nitrogen and 1 mg/L total phosphorus (Manitoba Water Stewardship 2011), are loosely based on the N:P ratios described above. In matching the growth requirements and chemical composition of vegetation (actually, slightly nitrogen-rich for freshwater algae), they serve as an attempt to maintain receiving waters in an ecologically-balanced state with co-limiting nutrients.

However, as discussed in Sections 2.5.2 and 2.6, while phosphorus is conserved within aquatic ecosystems over time, nitrogen is continually lost to the air through volatilization and denitrification processes. Therefore, nutrient enrichment at N:P ratios of 15:1, such as in wastewater effluent discharges, leads to phosphorus enrichment in the receiving waterbodies over time.

Average total nitrogen and phosphorus concentrations and ratios in 2019 in the Whitemud River upstream, within, and downstream of the modeled reach between Neepawa and Gladstone are summarized in Table 2-3. The table reveals enrichment of phosphorus between Neepawa and Gladstone relative to the upstream and downstream reaches, thus giving empirical support to the model results, described in Sections 2.5.3, 2.7.2 and A.13, indicating release of historically-accumulated phosphorus in this reach of the river.

The values presented in Table 2-3 suggest that all three reaches of the Whitemud River are within or above the N:P range of 7:1 to 16:1 described above. However, the nutrient concentrations measured in the river water do not account for the phosphorus that circulates directly between the bottom sediments and benthic algae. As discussed in Sections 2.5.3, 2.7.2 and A.13, this phosphorus load represents a major portion of the active phosphorus in the river and supports the river's largest component of primary productivity (the benthic algae).

Therefore, while interpretation only of water chemistry results might lead to a conclusion that N:P in the Whitemud River between Neepawa and Gladstone is near 7.4 (based on water concentrations), consideration of the phosphorus loading from the sediments leads to the conclusion that the river is strongly phosphorus-enriched, partly due to accumulation of past nutrient loading. Re-establishment of ecologically-balanced nutrient ratios would require a substantial reduction in phosphorus loading relative to nitrogen.

Table 2-3. Average nitrogen and phosphorus concentrations and ratios in the Whitemud River in 2019 upstream, within and downstream of the study reach.

	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)	TN:TP
Upstream of Neepawa (Highway 16) [a]	1.08	0.0769	14.8
Neepawa to Gladstone (Sites 1-6) [b]	1.17	0.1636	7.4
Westbourne (Highway 16) [c]	2.35	0.1024	21.2

a. Draft Data, three samples, May-December, at Monitoring Station MB05LLS005 (MARD 2020).

b. Whitemud River water quality study, samples from six sites, July and September (Stantec 2020).

c. Draft Data, four samples, May-December, at Monitoring Station MB05LLS001 (MARD 2020).

3) Definition of Baseline and Licence Limit Conditions

This section describes the settings and conditions used to define the 2020 Qual2K Baseline model, with alternative R3II effluent qualities. Calibrated to the July and September 2019 datasets as described in Appendix A, the model simulates generic summer conditions. It contains temperature and other correction factors expected to simulate water quality fairly accurately within and just outside the range of water quality and weather conditions observed in July and September 2019.

The Baseline model does not necessarily represent worst-case conditions, as the river discharge (flow) is based on an assumed, rather than a statistically-derived, low flow, and the available historical water quality data are insufficient to define worst-case conditions, as discussed in Sections 3.1 and 3.3, below.

The calendar date set in the 2020 Qual2K Baseline model was August 1, to represent summer conditions in between the two datasets used for its development. This may not reflect the most critical season for water quality.

3.1 Whitemud River Base Flow

The river discharge, or flow, used as a basis of all assessments in Sections 3 and 4 of this report, was 0.2 m^3/s with no diffuse or point sources other than the Neepawa municipal and R3II wastewater effluents. As discussed in Section 2.1, this flow is higher than low flows that commonly occur in the river, and, therefore, does not represent worst-case conditions. Defining a design low flow and establishing minimum instream flows would aid the accurate assessment of impacts of effluent releases and the protection of the ecological integrity of the river, respectively.

3.2 Weather

Weather conditions used in the Baseline model were full sunshine (clear skies) with no wind. The hourly temperature and dewpoint temperature data from the July 2019 Qual2K model were used. These temperatures, from July 24 2019, ranged from a morning low of 14.1 °C to a daytime high of 28.1 °C.

3.3 Whitemud River Background Water Quality

The July 2019 headwater (Site 1) water quality values were used as headwater inputs to the Baseline model. Since no historical data are available for the headwater of the model, statistical determination of percentile conditions could not be developed.

3.4 Point Sources

To simulate dry-weather conditions, no diffuse or point sources were input to the 2020 Qual2K Baseline model except the Town of Neepawa municipal lagoon and R3II wastewater effluents, described below.

3.4.1 Neepawa Municipal Wastewater Effluent

In the datasets used to develop the 2020 Qual2K model, no discharge was occurring from the Neepawa municipal wastewater lagoon during the September sampling program. Its discharge during the July sampling program was estimated to be at a rate of 0.036 m^3/s based on a total lagoon (Cell 3) volume of 117,000 m^3, discharged equally over two discharges in spring and fall (Theroux *pers. comm.* 2020).

The Neepawa municipal wastewater treatment facility is undergoing upgrades that will allow continuous discharge to the Whitemud River under terms of Manitoba Environment Act Licence 3270. Discharge Limit criteria in this Licence, to come into effect with continuous discharge under Phase 2 of the upgrades, are as follows:

- 5-day CBOD: 25 mg/L;
- Total suspended solids: 25 mg/L;
- *Escherichia coli*: 200/100 mL;
- Total phosphorus: 1 mg/L;
- Unionized ammonia: 1.25 mg N/L @ 15°C;
- Total ammonia (August limit): 11 kg N/day.

Based on the above Limits, the following settings for the Neepawa municipal wastewater effluent were used in 2020 Qual2K Baseline model:

- Discharge rate based on constant, 365-day discharge of the 2019 lagoon volume (117,000 m^3), equal to 321 m^3/day = 0.00371 m^3/s;
- The licensed CBOD, *E. coli*, total phosphorus and total ammonia Limits listed above;
- pH 8.5;
- Remaining chemistry equal to that used in the July 2019 model.

The phosphorus Limit of 1 mg/L was input as 90% inorganic and 10% organic phosphorus. The total ammonia concentration, based on the limit and estimated discharge rate, was 34.32 mg N/L.

3.4.2 R3II Effluent

In 2019 and previous years, the R3II effluent was of higher quality than its Limits set out in Manitoba Environment Act Licence 2870 RRR. For example, the licensed CBOD Limit for the facility is 25 mg/L, but the reported concentration in the final effluent was less than 2 mg/L every day in 2019. Similarly, total phosphorus concentrations were well below the License Limit, as shown in Figure 3-1.

Table 3-1 compares the 2019 average values, the values measured or estimated in the July 2019 sampling program, and the Licence Limits for the R3II effluent. For the 2020 Qual2K Baseline model, the following values were used to describe the final effluent from the R3II facility:

- The licensed maximum discharge rate of 0.0182 m^3/s (slightly higher than the July 2019 value of 0.017 m^3/s);
- The 2019 average total phosphorus concentration (0.102 mg/L) rather than the July 2019 concentration (0.037 mg/L), input as 90% inorganic and 10% organic phosphorus;
- Remaining chemistry equal to that used in the July 2019 model.

The effluent quality based on the 2019 concentrations, described above, best represents the recent historical conditions influencing the river. Therefore, they were used to define the 2020 Qual2K Baseline model rather than the Licence limit effluent conditions. A comparison of river conditions under the Baseline and Licence Limit effluent qualities is provided in Section 3.5, below.

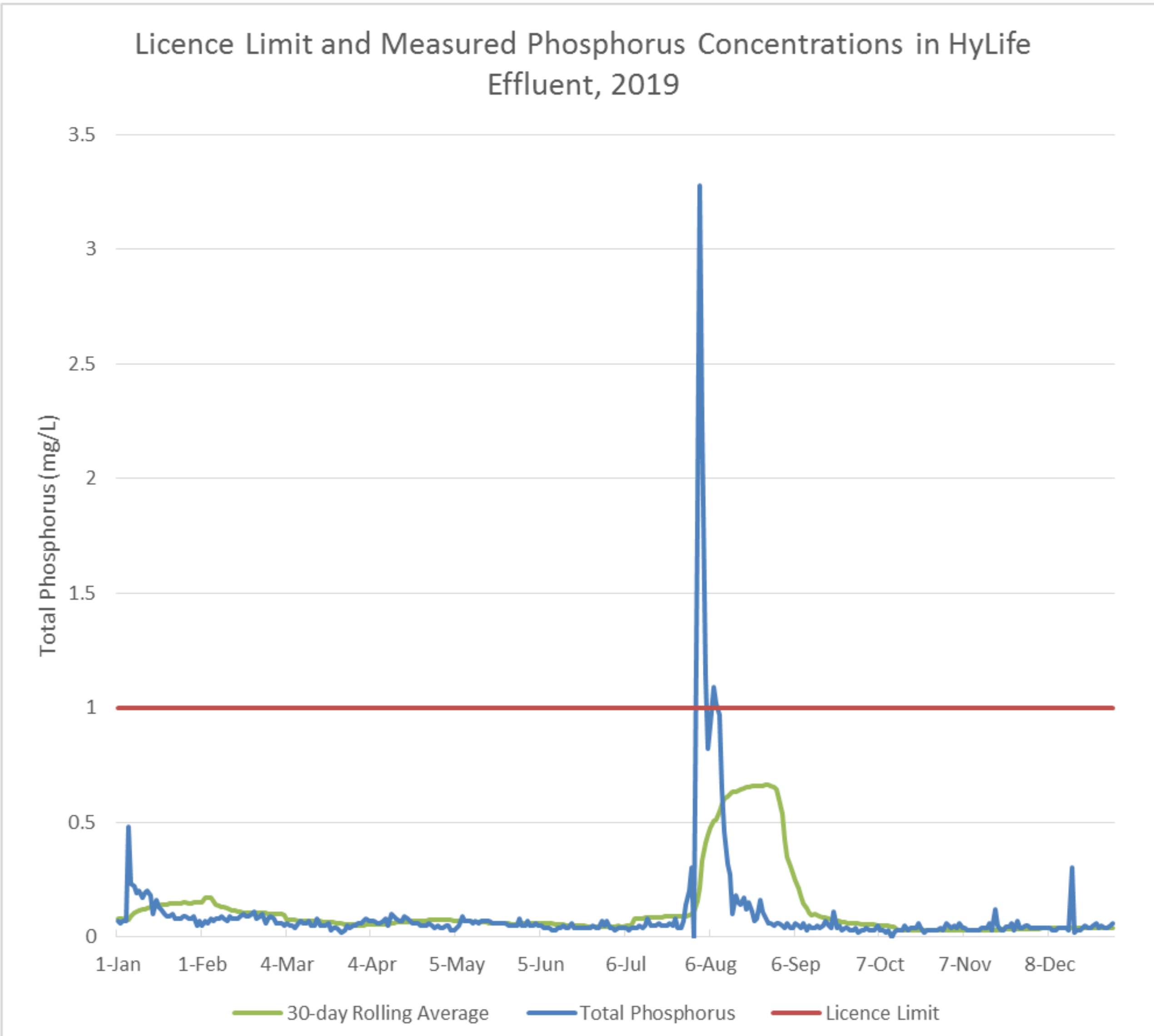

Figure 3-1. Manitoba Environment Act Licence 2870 RRR phosphorus Limit and measured daily total phosphorus concentrations in the R3II effluent in 2019. Data provided by HyLife. The brief phosphorus concentration above 1 mg/L in early August did not cause an exceedance of the Limit, which is based on the 30-day rolling average.

Table 3-1. July 22 2019 concentrations, average 2019 concentrations, and License Limit concentrations in the R3II effluent.

	July 2019 [a]	2019 Average [b]	Licence Limit [c]
$CBOD_5$ (mg/L)	< 2.0	<2.0	25
Total Suspended Solids (mg/L)	<2.0	0.57	25
Fecal coliform bacteria (/100 mL)	2	<10	200
Escherichia coli **(100 mL)**	5	<10	200
Total nitrogen (mg/L)	8.28	7.45	15
Total phosphorus (mg/L)	0.037	0.102	1
Total ammonia (mg/L)	0.164	0.234	1.32 to 15 (pH-dependent)

a. Measured below outfall (Stantec 2020) and used in July 2019 Qual2K Model.

b. Calculated from daily data provided by HyLife.

c. Manitoba Environment Act Licence 2870 RRR.

3.5 Comparison of Baseline and Licence Limit Conditions

The Baseline conditions defined in Section 3.4, used in the 2020 Qual2K Baseline model, most accurately represent the conditions that have occurred in the past several years, except that the Neepawa municipal wastewater facility effluent was defined as the projected licensed continuous discharge rather than the past intermittent discharge.

In terms of the R3II effluent quality, the Baseline condition differs substantially from the Licence Limit condition, which is defined as the R3II effluent having the following concentrations:

- 5-day CBOD: 25 mg/L;
- *E. coli*: 200/100 mL;
- Total phosphorus: 1 mg/L;
- Total ammonia: 8.41 mg N/L (based on the Licence Limit and an estimated effluent pH of 8.0);
- Total Nitrogen: 15 mg/L (Non-ammonia fraction partitioned as 90% inorganic, 10% organic).

Other parameters in the R3II effluent for the Licence Limit condition were left unaltered from the Baseline condition.

Figure 3-2 presents a comparison of simulated benthic algae, phytoplankton and dissolved oxygen concentrations in the Whitemud River under the Baseline and R3II Licence Limit conditions. Comparing Figure 3-2 with the July and September 2019 model simulations presented elsewhere in this report reveals that the conditions observed in 2019 were not the worst-case to be expected in the river in terms of benthic algae and dissolved oxygen. Differences between the 2019 and Baseline conditions, that contribute to poorer water quality in the Baseline condition, include higher total phosphorus loading in the wastewater effluents at Neepawa, lower river flows, lower cloud cover, and less wind. In the Baseline condition shown on the left side of Figure 3-2, the model predicts the diel minimum dissolved oxygen concentrations to remain below 2 mg/L for a distance of 65 km downstream from the effluent outfalls, and below 1 mg/L for portions of that distance.

Comparing the Baseline and Licence Limit conditions in Figure 3-2 shows little difference between the two conditions along the modeled reach of the river. This lack of apparent difference is due to the fact that the river in the Baseline condition is already in a critical state with respect to water quality processes; for example, dissolved oxygen is low enough that incremental oxygen consumption is not discernable against the dominant process of re-oxygenation from the atmosphere, due to the high gradient in relative oxygen saturation at the air-water interface.

In terms of relative downstream impacts, the difference between the Baseline and Licence Limit conditions would be an increase in the annual phosphorus load in the R3II effluent from 58 kg to 573 kg. The additional 515 kg/year would contribute incrementally to the phosphorus accumulation in the modeled reach of the river and would be transported to downstream waterbodies over time. The significance of this increased phosphorus loading is discussed in Section 4.

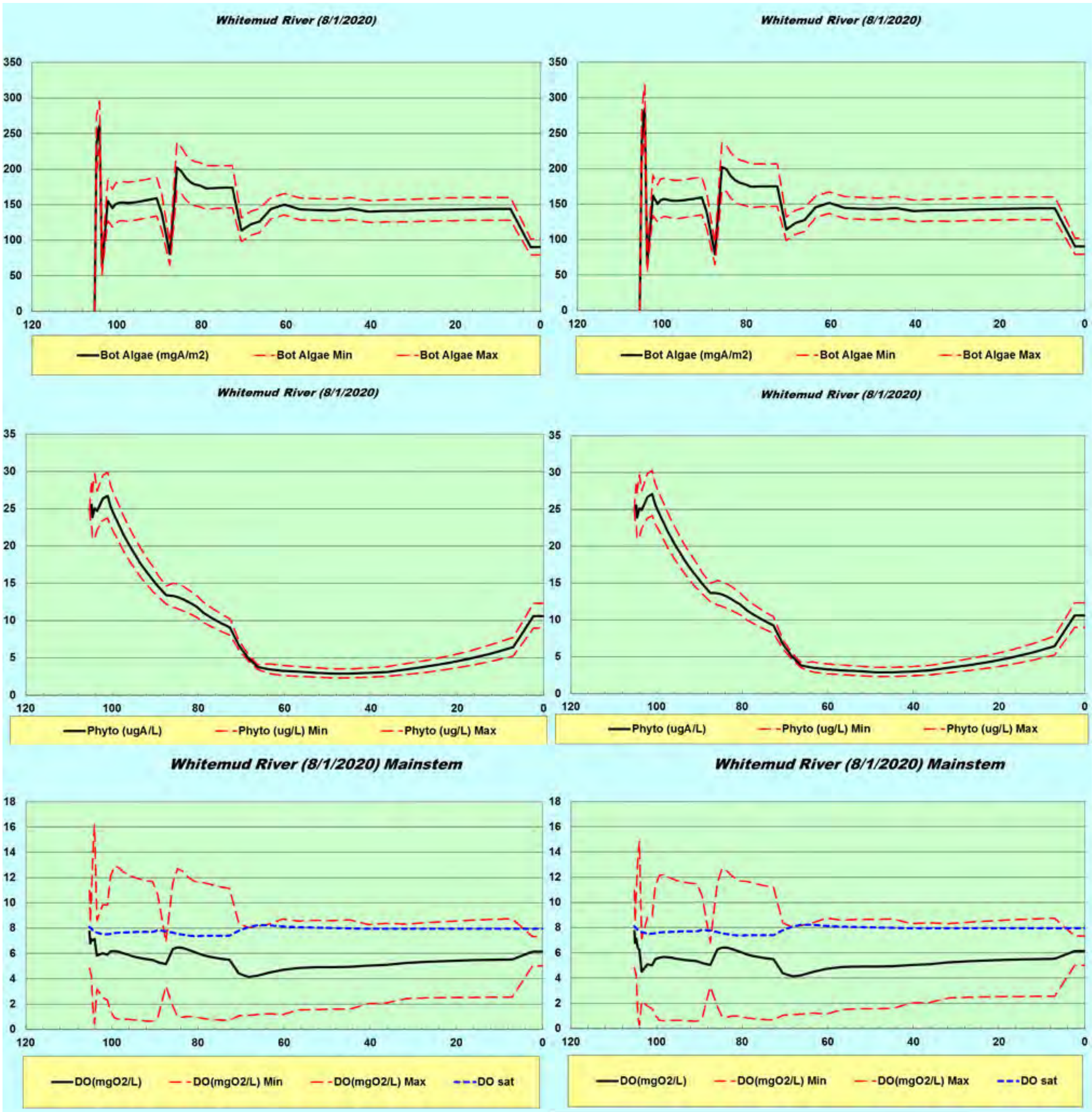

Figure 3-2. Model estimates of benthic algae, phytoplankton, and dissolved oxygen concentrations in the Whitemud River under the Baseline (left) and current Licence Limit (right) conditions.

4) Assessment of Effects of Altered Effluent Loading

As discussed in Section 2, the 2019 study on the Whitemud River, through data collection and modeling, identified the following impairments to water quality in the reach of the river between Neepawa and Gladstone under summer conditions:

- Dissolved oxygen concentrations below the instantaneous minimum MWQO necessary to support sensitive aquatic biota such as sport fish;
- Dense growth of benthic algae that negatively affects the river's physical habitat quality and is the primary cause of the low dissolved oxygen concentrations;
- Excess phosphorus, which supports the dense benthic algae growth and exceeds the MWQG;
- Phosphorus enrichment in the sediments, which is a major component of the excess phosphorus noted above. Empirical data and model results suggest that the phosphorus enrichment represents a localized accumulation in the modeled reach of the river.

Considering the above identified impairments to water quality in the river, the assessment described below focuses on phosphorus loading and how the proposed increase to the R3II effluent discharge volumes might affect benthic algae and dissolved oxygen in the river. Phytoplankton has a smaller influence on dissolved oxygen in the river than benthic algae based on model results but plays a complementary role in primary production, so is presented for additional context.

The following discussions pertaining to phosphorus refer to Baseline (2019) R3II effluent quality and volumes as well as Licence Limit effluent quality and potentially increased discharge volumes. Table 4-1 provides a summary of the total annual phosphorus load in the R3II effluent under the various scenarios of effluent quality and volumes.

Table 4-1. Annual phosphorus loads (kg/year) in the R3II effluent under the Baseline condition, Licence Limit condition and potentially increased discharge volume.

	Baseline Discharge Rate [a] (1570 m^3/day)	Increased Discharge Rate (2290 m^3/day)
Baseline (2019) Phosphorus (0.102 mg/L)	58	85
Licence Limit Phosphorus (1 mg/L)	573	836

a. Maximum hydraulic loading stipulated in Manitoba Environment Act Licence 2870 RRR.

4.1 Effect of Proposed R3II Effluent Volume Increase with 2019 Effluent Quality

Figure 4-1 presents a comparison of the Baseline condition and a 46% increase in the R3II effluent discharge rate (from 1570 m^3/day to 2290 m^3/day) in terms of modeled benthic algae, phytoplankton and dissolved oxygen concentrations in the Whitemud River.

The differences in river conditions between the Baseline condition and the increased effluent volume condition (with 2019 effluent quality) are not apparent for two reasons:

1. The biological processes around the parameters of concern (particularly, dissolved oxygen) are already at a state of limitation, as described in Section 3.5, such that physico-chemical processes (re-oxygenation at the air-water interface) dominate over the effects of the incremental change.
2. The 2019 R3II effluent quality, used in the Baseline condition and in the increased effluent volume in this scenario, has concentrations of pertinent parameters (BOD, ammonia, phosphorus) that are similar to those in the river. Therefore, the effect of the increased effluent volume is simply to add incrementally more flow to the river.

In terms of phosphorus loading and downstream impacts, the 46% increase in R3II effluent discharge rate, maintaining the 2019 effluent quality, would cause an increase in the R3II annual phosphorus load from 58 kg to 85 kg. The additional 27 kg/year would contribute incrementally to the phosphorus accumulation in the modeled reach of the river and would be transported to downstream waterbodies over time. The significance of this accumulation and transport is discussed in Section 4.3.

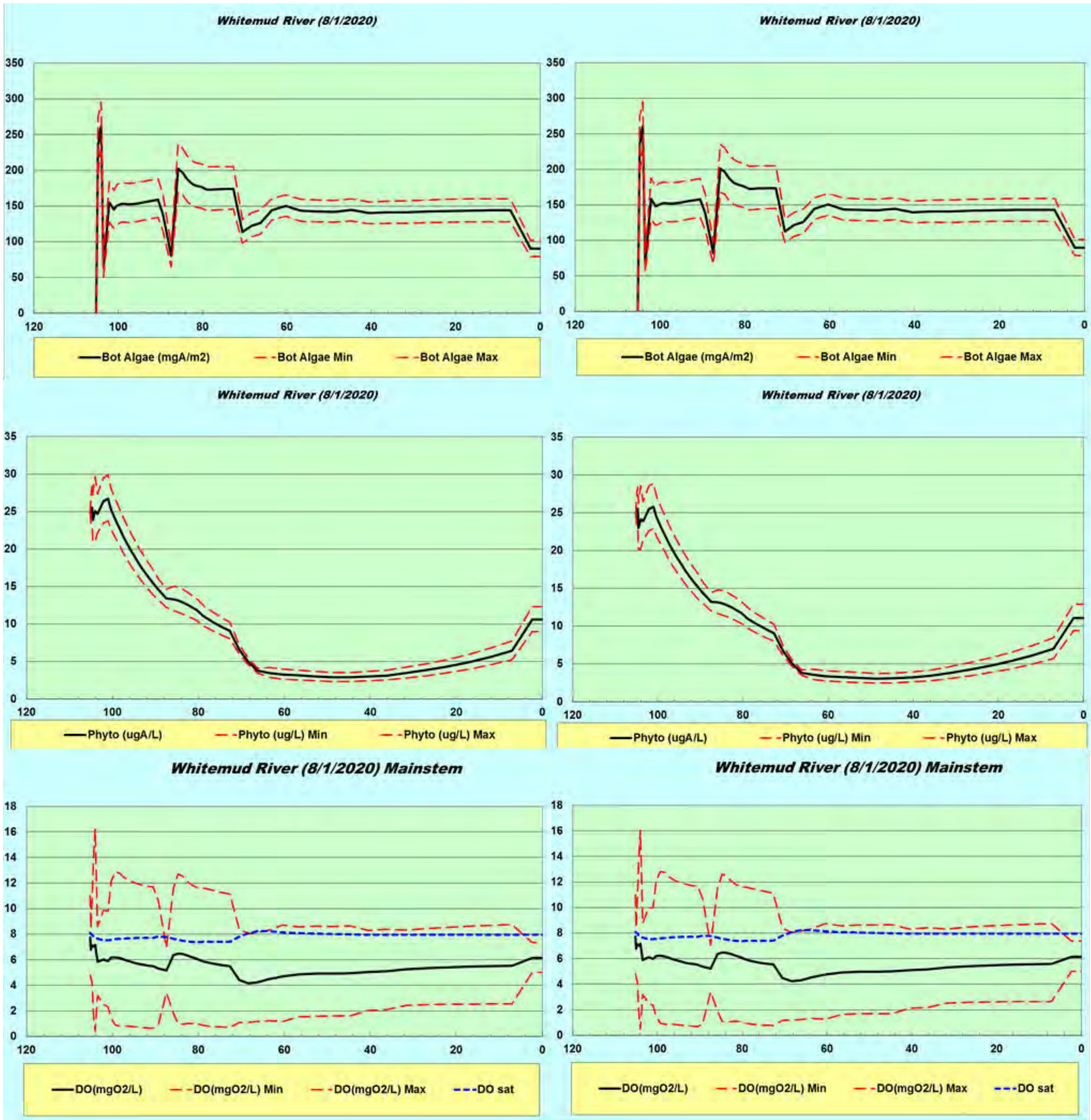

Figure 4-1. Model estimates of benthic algae, phytoplankton, and dissolved oxygen concentrations in the Whitemud River under the Baseline condition, with current R3II effluent discharge of 1570 m^3/day (left) and increased discharge of 2290 m^3/day (right).

4.2 Effect of Proposed R3II Volume Increase with Licence Limit Effluent Quality

Figure 4-2 presents a comparison of the current Licence Limit condition, defined in Section 3.5, with a 46% increase in R3II effluent discharge volume (from 1570 m^3/day to 2290 m^3/day) at the Licence Limit effluent quality. Similar to the Baseline condition described above in Section 4.1, the increased effluent discharge volume under the Licence Limit condition does not result in apparent differences in benthic algae, phytoplankton or dissolved oxygen in the river, because those parameters are already at a critical state, as described in Section 3.5.

In terms of phosphorus loading and downstream impacts, the 46% increase in R3II effluent discharge rate, under the Licence Limit effluent quality condition, would cause an increase in the theoretical annual phosphorus load from 573 kg to 836 kg. The additional 263 kg/year would contribute incrementally to the phosphorus accumulation in the modeled reach of the river and would be transported to downstream waterbodies over time. The significance of this accumulation and transport is discussed in Section 4.3, below.

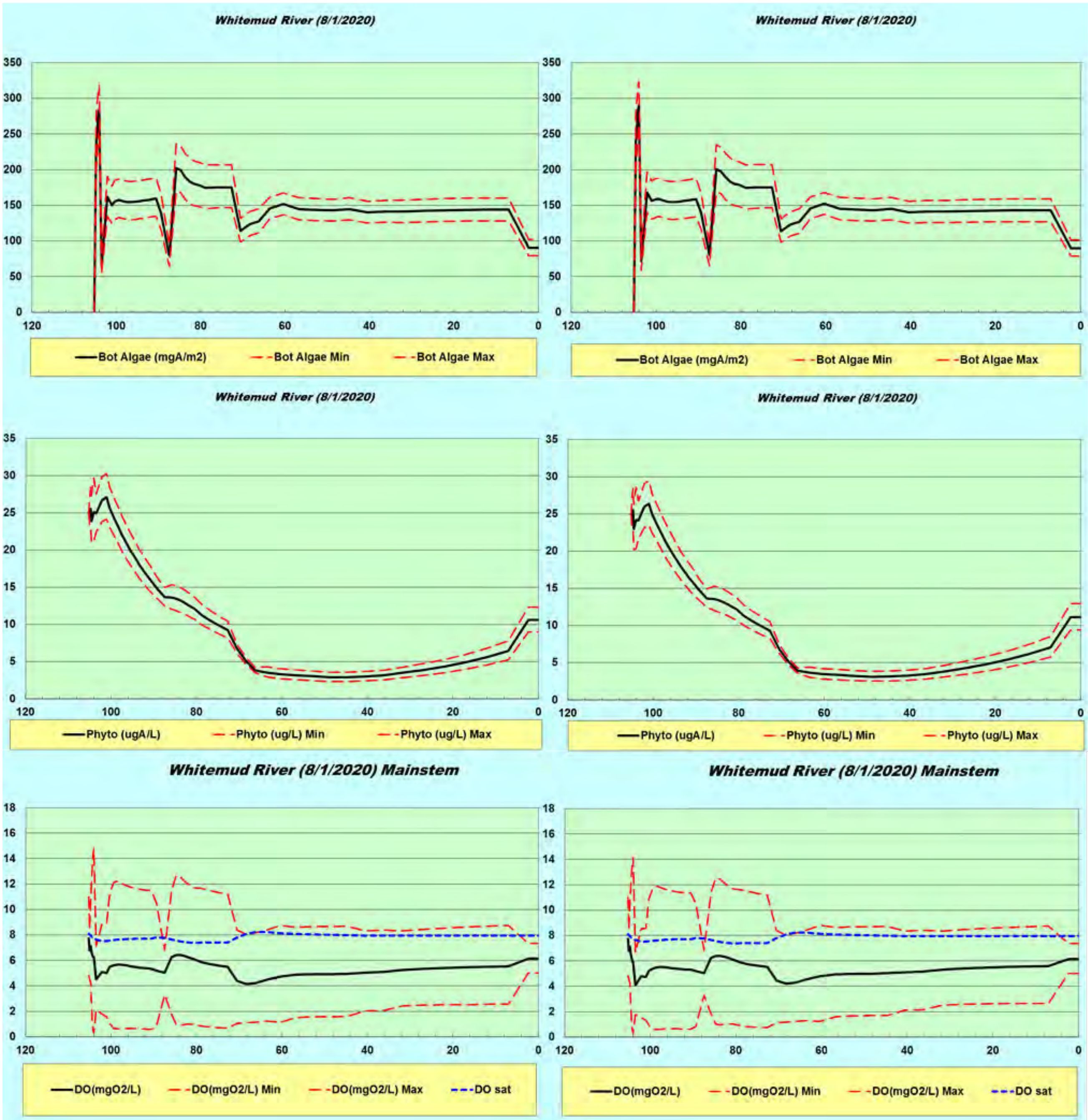

Figure 4-2. Model estimates of benthic algae, phytoplankton, and dissolved oxygen concentrations in the Whitemud River under the Licence Limit condition, with current R3II effluent discharge of 1570 m^3/day (left) and increased discharge of 2290 m^3/day (right).

4.3 Effect of Altered Phosphorus Loading to the Whitemud River

Sections 4.1 and 4.2 of this report described potential and theoretical increases in annual phosphorus loads in the R3II effluent of 27 kg/year and 263 kg/year, based on the Baseline and Licence Limit R3II effluent qualities, respectively (Table 4-1). These loads are small compared to the annual load currently carried to Lake Manitoba by the Whitemud River, estimated in Section 2.5.3 to be 12,313 kg in 2019.

However, as described in Sections 2.5.3 and 5.13, remobilization of accumulated phosphorus in the riverbed sediments accounts for a large portion of the total active phosphorus load in the Whitemud River. Therefore, understanding the long-term impact of changing loads in the river requires consideration of whether net accumulation or net release is occurring in the sediments.

Theoretically, the difference between net accumulation of phosphorus in riverbed sediments (resulting in cumulative impacts and progressively worsening water quality) and net release (resulting in reversal of historical impacts and progressive improvement in water quality) can be identified as a critical value of maximum sustainable external loading. Additional study would have to be conducted to determine this critical value with precision in the Whitemud River. However, information gained from the 2019 study provides the following insights:

- Phosphorus accumulation has occurred in the reach of the Whitemud River between Neepawa and Gladstone, based on empirical data and model results.
- This accumulated phosphorus is a major contributor to ongoing water quality impacts that impair the river's ability to meet water quality objectives and sustain aquatic life.
- The accumulated phosphorus demonstrates that rates of external phosphorus loading have exceeded the critical maximum value of sustainable loading in the past.
- Some recovery may have begun near the upstream end of the modeled reach, based on model calibration results, suggesting that external loading to the river near Neepawa may have decreased to near the critical value in recent years.

Considering the above insights, the potential impacts of changes to the effluent loading rates described in Sections 4.1 and 4.2 cannot be understood simply by comparing them to the annual phosphorus load currently carried by the river. Rather, they need to be compared, to the extent possible, to the difference between the current (Baseline) loading rate and the theoretical critical maximum rate for sustainable loading, which determines whether net accumulation or net release of phosphorus will occur.

To that end, given evidence suggesting that phosphorus loading rates have exceeded the critical maximum for sustainable loading in the past and that the current Baseline condition may be near it:

- The difference between the Baseline and Licence Limit conditions, equal to 515 kg/year at the existing discharge rate or 751 kg/year at the increased discharge rate, is likely significant compared to the difference between the Baseline and the theoretical maximum for sustainable loading. Therefore, increasing the phosphorus concentration to the Licence Limit condition, either at the existing discharge rate or at an increased rate, likely would result in accumulative negative impacts to the river.
- Under the Baseline phosphorus concentration of 0.102 mg/L for the R3II effluent, the increase in phosphorus loading that would result from the 46% increase in discharge rate, equal to 27

kg/year, is likely small compared to the difference between the Baseline and the theoretical maximum for sustainable loading. Therefore, significant accumulative negative impacts would not be expected, provided the effluent phosphorus concentration remains at or below the Baseline condition.

Based on the above, the proposed increase in effluent discharge volume from the R3II facility likely can be accommodated without significant negative impacts to the Whitemud River, provided that the effluent quality is maintained at the 2019 quality (superior to the Licence Limit) or improved. It is recommended that any increase in phosphorus loading be offset by a larger decrease in loading, possibly in other sources, to achieve a net reduction in overall phosphorus loading to the river in the Neepawa area.

4.4 Summary of Recommendations

Several recommendations are made throughout this report pertaining to effluent discharges and further study of the Whitemud River. These recommendations are summarized below:

1. Total net phosphorus loading to the Whitemud River in the Neepawa area should be reduced to below historical levels (in terms of actual loading as opposed to licensed limits). (Section 4.3)
    - An increase in effluent discharge from the R3II facility, while maintaining 2019 effluent quality, likely can be accommodated within an overall net reduction, provided phosphorus release from other sources is reduced.
2. An assessment of water quality in the Whitemud River in winter (ice-covered) conditions should be completed to complement the assessment of open-water conditions provided in this report.
3. Minimum instream flows, with consideration of biological instream flow needs, should be established for the Whitemud River. Instream flow studies are generally conducted by the Province to guide Environmental and Water Rights licensing and management. (Sections 2.1 and 3.1)
4. If the model developed in this report is to be used for further assessment on the Whitemud River, its hydraulic data should be updated and augmented. (Section A.1)

5) References

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APPENDIX A

Development of Qual2K Open-Water Model

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Development of Qual2K Open-Water Model

Initial setup of the 2020 Qual2K model was accomplished by loading the 2008 model data, including the complete hydraulic model, into updated Qual2K software (Qual2Kv2_12b1) and updating with July 2019 water quality data. However, all reaction rates and coefficients were set to the default Qual2K settings, as the water quality data available in 2008 had been minimal and the 2019 data would give more detailed representation of processes in the river on which to base customization of the model.

Initial runs with the 2019 data using default settings revealed numerous discrepancies between the field data and simulated model outputs, including:

- Underestimation by the model of water temperatures;
- Severe underestimation (by more than an order of magnitude) of the diel variation in dissolved oxygen concentrations;
- Overestimation of phytoplankton concentrations and underestimation of benthic algae densities progressively downstream; and,
- Apparent differences in settling and/or elimination of various inorganic and organic suspended parameters including phytoplankton.

To address model irregularities including those described above, the 2020 Qual2K model was calibrated iteratively using both the July and September datasets; that is, limnologically-justified adjustment of kinetic coefficients and correction factors were made identically and in parallel between the July 2019 model and the September 2019 model until best fit of all modelled parameters was achieved on both models.

The result of this approach is a calibrated model that incorporates seasonal succession of phytoplankton and benthic algae as well as kinetic rate temperature correction based on site-specific empirical data. This model should prove more robust in the accurate simulation of conditions in the Whitemud River, over a range of conditions through the open-water season, than would a model calibrated to one dataset using defaults or coefficients and correction factors specific to that dataset.

The development of the multi-season open-water model using the above strategy is described in the following subsections of this report. Data collected in 2019 are reported in the *Field Data Report for Water Quality Study for Hylife Foods Facility Expansion* (Stantec 2020) and are not reproduced fully here. However, the following subsections present and discuss information obtained from the 2019 study in terms of its use in the model and assessment.

A.1 Hydraulic Parameters

The hydraulic portion of the Qual2K model was developed in 2008 based on cross-sectional survey data collected in 2007. The model comprised 19 reaches varying in length from 0.42 km (Reach 2) to 29.52 km (Reach 18). Its functionality at the time was verified partly through corroboration with a HEC-RAS model developed from the same data. The development of those models was reported previously (Earth Tech 2008) and is not reproduced here.

In 2020, the following adjustments were made to the Qual2K hydraulic model:

- Reach 1 was eliminated from the model and the nomenclature of all successive reaches was adjusted by one. (That is, Reach 2 in the 2008 model became Reach 1, Reach 3 became Reach 2, and so on.) These adjustments were necessary because Site 1 (the most upstream location of water quality data collection) was situated just downstream of the Reach 1/Reach 2 boundary as previously defined. Qual2K requires that the headwater water quality conditions be defined at the upstream extent of the model and that the assigned reach nomenclature run sequentially from Reach 1, which must be the headwater reach.
- The river distances among reach boundaries and various landmarks were adjusted to match an updated shape file used to locate the new sampling sites. The location coordinates of the reach boundaries remain unchanged, but the distances changed, such that the total distance of the 19 original model reaches became 106.77 km rather than the 110.89 km reported in 2008. Elimination of the original Reach 1 brought the total model length to 105.25 km.
- The ability of the updated Qual2K model to differentiate between sharp-crested and broad-crested weirs was applied. In 2008, weirs were assigned to various reaches based on observation of physical structures or channel obstructions and/or to better simulate surveyed water level elevations along the channel. In the 2020 Qual2K model, the assigned weirs at the downstream ends of Reaches 1, 3, 4, 7 and 8 were changed to broad-crested weirs, rather than sharp-crested, to better describe the channel geometry based on interpretation of Google Earth imagery.
- The number of computational elements was increased in reaches immediately downstream of weirs, where possible, to add precision to modeled hydraulic properties and effects of the weirs on water quality. This was only possible for Reaches 2, 6 and 9, and was not possible for Reaches 1, 3, 4, 5, 7, 8 or 18, as Qual2K requires that reaches with weirs be comprised of a single element. As the weirs in those reaches were implied based on surveyed water levels and did not necessarily represent physical structures, and as the model treats the entire reach above a weir as a single pool (not accounting for possible riffle-pool sequences), redefining the model reaches based on an inventory of observed physical features would refine the model.

At the river discharges (flows) input to the July and September 2019 models, the predicted total travel times over the 105-km modeled distance were more than 34 days, which corresponded to average velocities of 0.03 m/s to 0.04 m/s, as shown in Figure A-1. Refinement of the model as described above and verification of travel times would reduce uncertainty in estimates of travel time and velocity as well as all rate-dependent physical, chemical and biological processes.

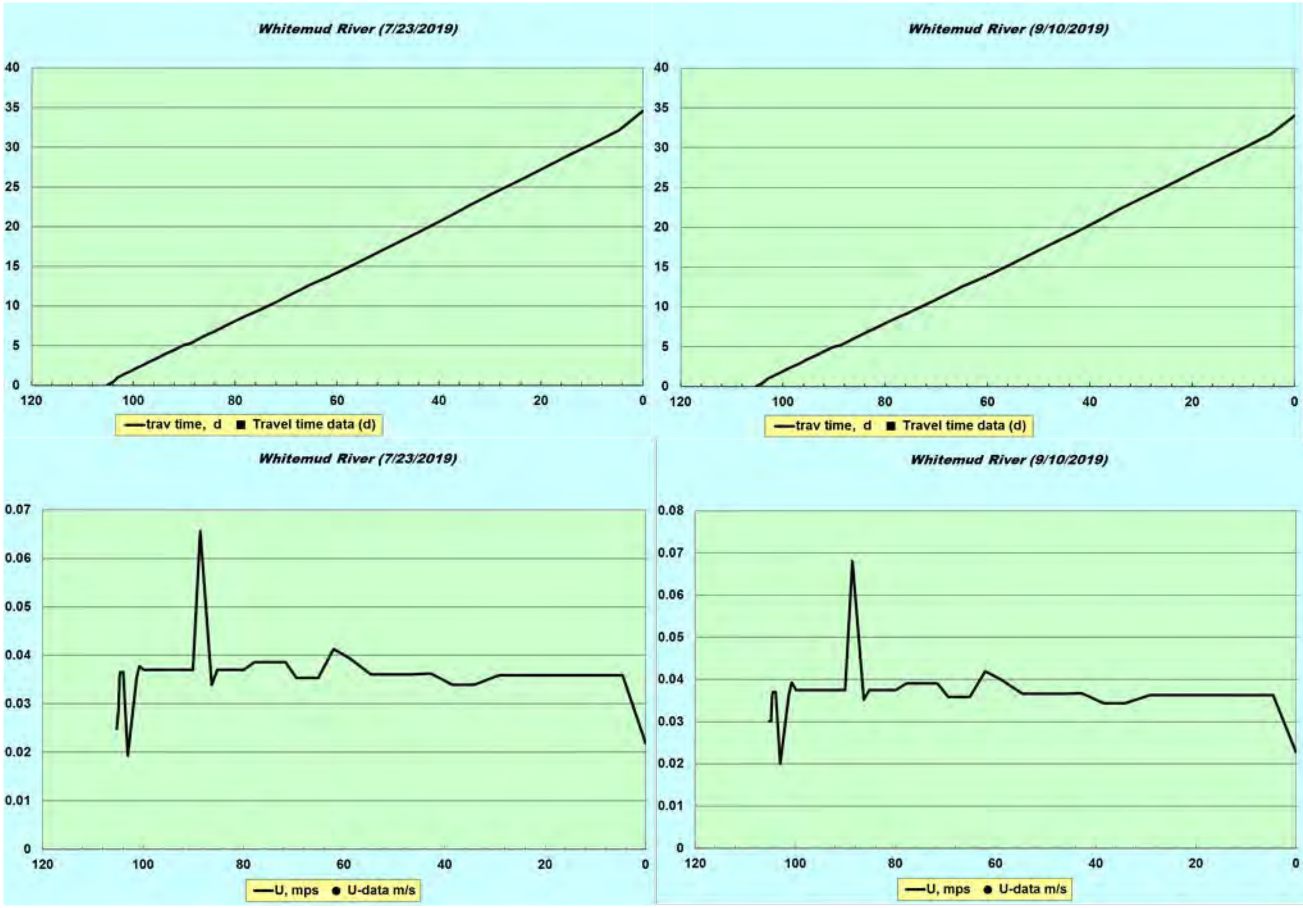

Figure A-1. Model estimates of travel time and average velocities in the Whitemud River in July and September 2019.

A.2 Shade

The Qual2K model determines shading of the wetted river channel based on solar angle and on density and height of bank vegetation. A reach-by-reach visual analysis of Google Earth imagery was used to assign shade values in the 2008 model and were left unaltered for the updated 2020 model.

A.3 Weather

Weather data used for input to the model were those from Environment and Climate Change Canada (ECCC) Station 5010547 at Carberry, approximately 40 km south of the modeled reach of the Whitemud River.

Qual2K is a steady-state model in that it assumes environmental conditions are constant over the time that data are collected and over the time that it takes for water to travel from the upstream to the downstream end of the modeled area. The model allows air temperature, dew point temperature, wind speed and cloud cover data to be input on an hourly basis, over a 24-hour day, for each reach. Wind direction is not accounted for.

To accommodate the model's single 24-hour steady-state structure while best accounting for conditions that changed over the three-day July and September sampling programs, hourly air temperature, dew point temperature and wind speed data (recorded at Carberry) were assigned to each model reach according to the date on which they were sampled, as follows:

- For the July dataset, the hourly weather data for July 22 2019 were assigned to Reaches 1 through 7, the hourly weather data for July 23 2019 were assigned to Reaches 8 through 12, and the hourly data for July 24 2019 were assigned to Reaches 13 through 18.
- For the September dataset, the hourly weather data for September 9 2019 were assigned to Reaches 1 through 6, the hourly weather data for September 10 2019 were assigned to Reaches 7 through 12, and the hourly data for September 11 2019 were assigned to Reaches 13 through 18.

Cloud cover data were not available from the ECCC station at Carberry, so cloud cover data were input to the model based on interpretation of data available from ECCC Station 5012320 at Portage Southport A (approximately 90 km to the southeast) and field observations (Stantec 2020).

A.4 Reaeration

Qual2K automatically selects among several alternative means of calculating reaeration, based on hydraulic characteristics of the channel. For the 2008 Whitemud River model, these hydraulic characteristics were inferred by the model based on input cross-sectional data and the inferred weirs that were added to resolve the original HEC-RAS model. In the updated 2020 model, the resulting outputs seemed to exaggerate differences among the model reaches and, overall, appeared to overestimate reaeration. Therefore, after initial runs of the model, an approximate average of the reach-by-reach reaeration rates calculated by the model was prescribed uniformly over every reach to make the effect of reaeration consistent over the various model reaches. The resulting adjustment in reaeration rates is shown in Figure A-2.

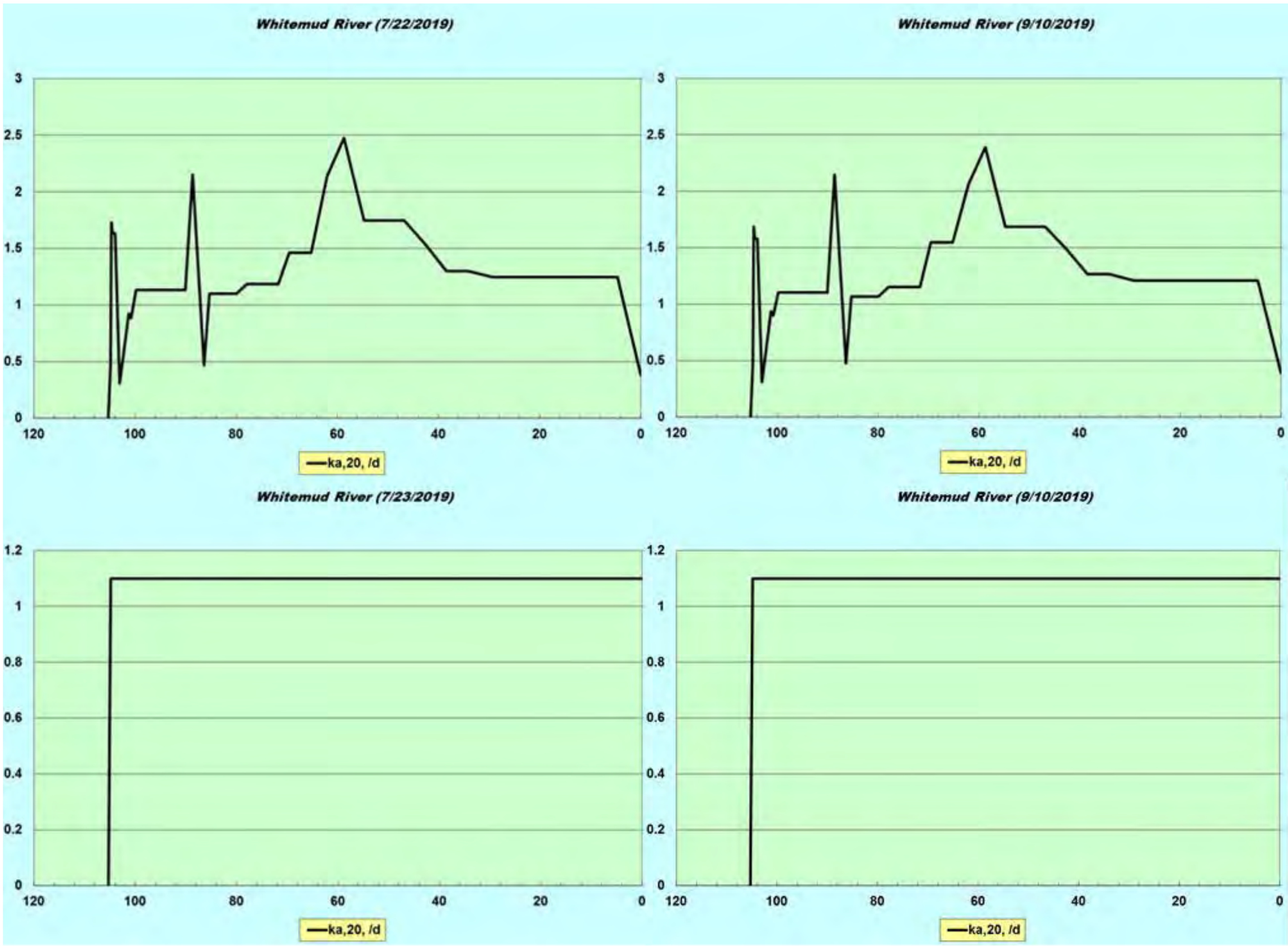

Figure A-2. Model-generated (top) and prescribed (bottom) reaeration coefficients in the July and September 2019 Models.

A.5 Water Temperature

Modeled estimates of water temperatures were low compared to the field data in both the July and September models, but particularly so in the September model. After increasing the sediment thermal diffusivity coefficient to reflect the dominant cobble and clay riverbed substrata according to guidance in the Qual2K User's Manual (Chapra et al. 2012), best fit to water temperature data was achieved by increasing the sediment thermal thickness to 45 cm and selecting the Ryan-Stolzenbach solar shortwave radiation model with an atmospheric transmission coefficient of 0.9. Brutsaert was selected as the atmospheric longwave emissivity model to best represent the temperate latitude.

Modeled estimates of water temperature were still somewhat low, as shown in Figure A-3. This underestimation may be associated with channel hydraulic properties and likely is influential to various rates and temperature correction factors described in further subsections of this report. Therefore, some of these factors may require adjustment if the hydraulic and/or temperature models are altered.

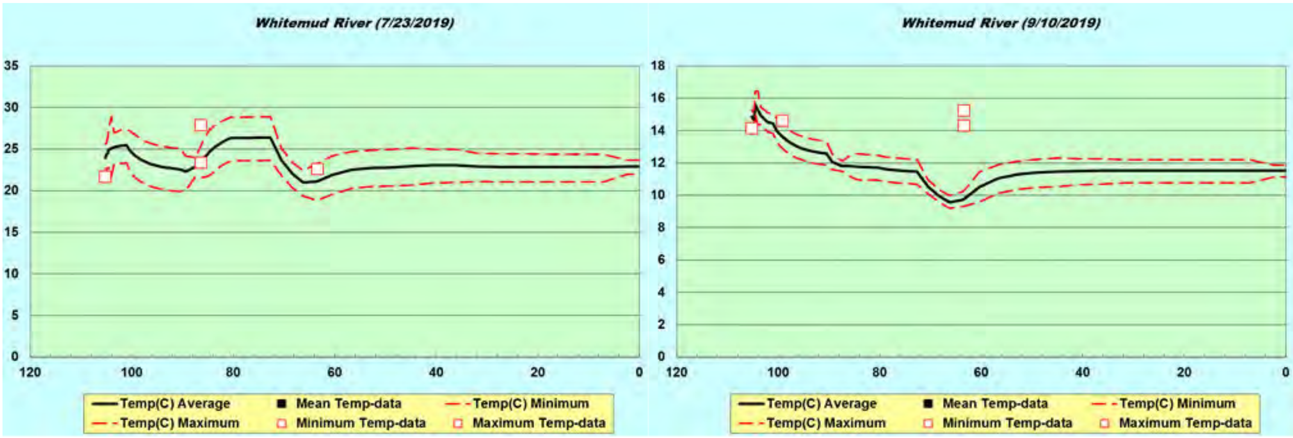

Figure A-3. Measured data and model estimates of water temperature in the Whitemud River, July and September 2019.

A.6 Effluent and River Discharges (Flows)

Whitemud River discharge (flow) estimates were based on data from Water Survey Canada (WSC) for WSC Gauge 05LL005 near Keyes as reported by Stantec (2020). Flows entered into the model were 0.254 m^3/s for the July dataset and 0.264 m^3/s for the September dataset.

The WSC Gauge 05LL005 near Keyes is downstream of Neepawa, 34.6 km from the downstream end of the model. Therefore, headwater discharge was calculated as those discharges minus the estimated Town of Neepawa lagoon and reported R3II effluent discharges. Incremental flows that may have been contributed by tributaries along the channel could not be quantitatively accounted for by the field data and were assigned values of zero for the model. Discharge values entered into the model are summarized in Table A-1.

Flows were decreasing during the July sampling period from a peak of 0.944 m^3/s on July 11 2019 that may have been associated with drawdown of Lake Irwin to accommodate maintenance of the spillway structure. During the September sampling period, flows were increasing in response to scattered heavy rainfall that occurred in September up to and including September 9. Although this rainfall may have resulted in runoff to the river within the study reach between Neepawa and Gladstone, runoff was not noted during the sampling program and measurements of conservative tracer elements suggested that inflows along the stream channel were minimal. (See Section A.8.)

Table A-1. Discharge estimates used in the July and September 2019 Qual2K models of the Whitemud River.

	July 2019 (m^3/s)	September 2019 (m^3/s)
Headwater	0.201	0.244
Neepawa lagoon [a]	0.036	0
HyLife effluent [b]	0.017	0.020
Sites 2-6 [c]	0.254	0.264

Data sources:
[a] Theroux *pers. comm.* 2020.
[b] Data provided by HyLife.
[c] Discharge data for Water Survey Canada Gauging Station 05LL005, at approximately Kilometre 34.6 on the 2020 Qual2K model (WSC 2020c).

A.7 Diffuse and Point Sources

As discussed in Section A.6, river discharge (flow) data were inadequate for the determination of increases along the Whitemud River channel that may have resulted from diffuse sources or flow in tributaries such as Spring Creek. Therefore, diffuse sources and those tributaries were assigned values of zero discharge for calibration of the July and September models, and only the Neepawa municipal lagoon and R3II effluent discharges were input as point sources in the models.

Effluent discharge rates for the R3II facility during the July and September sampling periods, shown in Table A-1, were provided by HyLife. In September, the sampling period followed a period of higher discharge from the R3II facility (up to 25 L/s on September 6) but coincided with fairly consistent discharge from the facility, ranging from 18.8 L/s to 21.4 L/s over the period from two days before sampling until two days after sampling. During the July sampling program, the R3II daily average effluent discharge ranged from 12.1 L/s on July 24 to 22.0 L/s on July 23, and from 9.5 L/s to 24.0 L/s in the week preceding sampling. This variation may have impacted data and model results along the channel downstream, although the R3II effluent was less influential to the river in terms of nutrient and BOD loading than the Neepawa municipal lagoon effluent.

The estimates of effluent discharge from the Neepawa municipal lagoon, shown in Table A-1, were based on an annual total volume release of 117 000 m^3, with half discharged in spring and half discharged in fall and discharge assumed to be at a constant rate (Theroux *pers. comm.* 2020).

For water chemistry, field measurements of the two effluent sources were not collected in July, and data for some parameters were not available from the Town or from HyLife for their respective effluents. Therefore, field-measured parameters (conductivity, dissolved oxygen, temperature, pH and TDS) had to be estimated for the lagoon effluent. The July R3II effluent was characterized based on the following data:

- Flow and temperature data for July 22-24 2019 provided by HyLife.
- Conductivity data from field measurements collected on September 9 2019.

A.8 Tracer Constituents

The July 2019 dataset was examined for conservative (dissolved, non-consumable) water quality constituents that could serve as tracers, or fingerprint parameters, to assess loading and dilution of the Neepawa municipal and R3II effluents along the modeled river. No specific metal or other parameter was sufficiently elevated in the effluents to serve such a purpose. Total Dissolved Solids (TDS) concentrations in the river were measurably elevated by the effluents and were input to the model, but were not distinct from other influences in the river and increased downstream of the effluent mixing zones. Therefore, chloride and fluoride were analyzed in the September sampling program and were input to the model as generic constituents with reaction and settling velocity rates of zero.

Figure A-4 shows plots of TDS concentrations along the river in July and September as well as chloride and fluoride in September. The results suggest that little, if any, inflow occurred along the modeled reach of the river in September. The July TDS results provide little certainty regarding the possibility of diffuse or point-source inflows. They may indicate higher-than estimated discharge from the Neepawa municipal lagoon, intrusion of groundwater with a higher TDS concentration than the river water, or dissolution of salts along the modeled river; however, the lack of a TDS measurement in the municipal lagoon effluent adds uncertainty to the use of TDS as a tracer element for July. For both datasets but particularly for July, it is possible as well that the source water differed along the channel, as the R3II effluent discharge varied and the three-day sampling programs did track with the same parcel of water along the channel over the 34-day time-of-travel estimates described in Section 4.1 of this report.

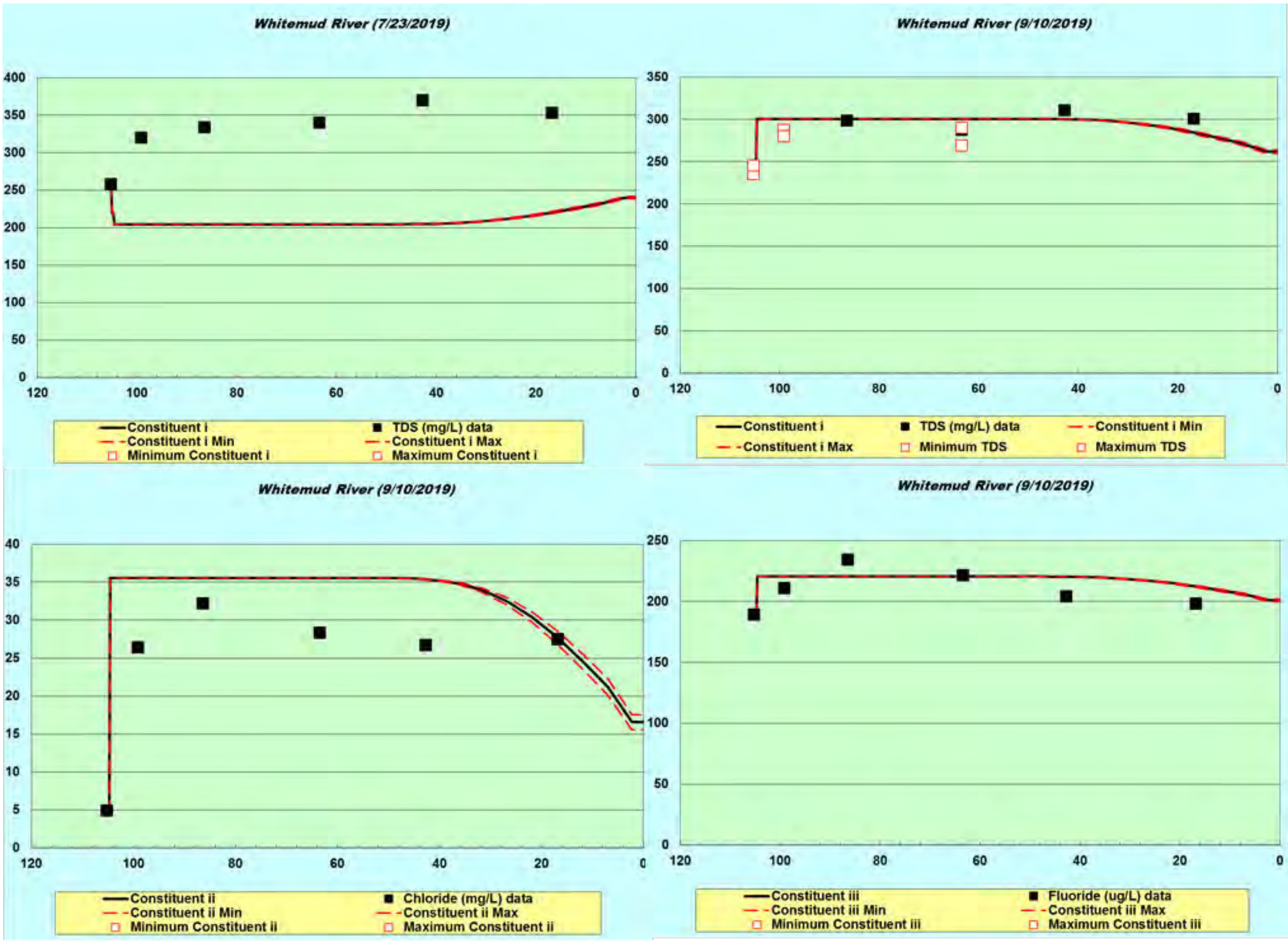

Figure A-4. Measured data and model estimates of total dissolved solids, chloride and fluoride in the Whitemud River in July and September 2019.

A.9 Light Extinction

Profiles of photosynthetically active radiation (PAR) were measured at all sites in July and September 2019 to provide light extinction data (a model input parameter) and to assess the extent to which algae production on the river bottom is limited by light penetration through the water column. Methods and results, including plots of PAR readings, are reported in Stantec (2020).

The natural logs of the measured PAR intensities were plotted against depth to allow calculation of the light extinction coefficient *k* for each set of measurements, as well as the euphotic depth Z_{eu}, defined as the depth at which PAR is 1% of incident (surface) PAR. Z_{eu} serves as an approximation of the maximum depth of primary productivity, below which photosynthesis can be assumed to be negligible. The results are summarized in Table A-2.

The euphotic depths shown in Table A-2 are generally deeper than the majority of the river channel under moderately low flow conditions, which suggests that benthic algae production is possible throughout the river except in the deepest pools. Under the conditions of low flow that are generally focused on in water quality assessments, light limitation due to light attenuation in the water column is not likely to be a strong factor in benthic algae production in the Whitemud River, although some limitation may result from shading where the channel is deeply incised and where there is heavy canopy cover from bank vegetation.

The updated version of Qual2K calculates the light extinction coefficient k as a sum of the sub-components of background k_{eb} (primarily colour associated with some dissolved organic compounds) and k associated with parameters measured in the field (phytoplankton, detritus and inorganic solids). For the 2020 model, the sub-coefficient values were calculated based on the field data for those parameters and k_{eb} was adjusted to make the overall k match the measured values listed in Table A-2. For both the July 2019 and September 2019 datasets, this adjustment meant that the background k_{eb} was reduced to zero, which is reasonable for the Whitemud River, as its highly-drained, clay till watershed contributes little of the tannic compounds that result in the high background colour of some waterbodies.

Table A-2. Light extinction coefficients (k) and euphotic depths (Z_{eu}) calculated from photosynthetically active radiation profiles measured in the Whitemud River, July and September 2019.

	Regression R^2	k (m^{-1})	Z_{eu} (m)
July 22-24 2019			
Site 1	0.996	1.72	2.68
Site 2	0.991	2.25	2.05
Site 3	0.975	2.24	2.06
Site 4	0.972	2.86	1.61
Site 5	0.844	1.55	2.96
Site 6	0.988	3.50	1.32
Average:		**2.35**	**2.11**
September 9-11, 2019			
Site 1	0.931	2.03	2.27
Site 2	0.995	1.36	3.38
Site 3	0.988	1.03	4.46
Site 4	0.991	1.16	3.98
Site 5	0.993	1.68	2.75
Site 6	0.967	1.65	2.80
Average:		**1.49**	**3.27**

A.10 Internal Nitrogen and Phosphorus

Qual2K models the intracellular nitrogen and phosphorus in phytoplankton as defined inputs and outputs. While these terms are generally not measured directly due to the volume of sample that would be required, they can be estimated based on measured or estimated phytoplankton biomass and estimated or specifically-determined stoichiometry of organic matter.

Internal nitrogen and phosphorus were estimated from estimates of phytoplankton biomass derived from measured chlorophyll *a* concentrations. Chlorophyll *a* provides only a rough estimate of phytoplankton biomass; however, as phytoplankton biomass in small rivers such as the Whitemud tend to be low, the uncertainty in these estimates is unlikely to result in large error in modeled outputs.

A.11 Biochemical Oxygen Demand (BOD)

Qual2K requires input of terms for both a fast and a slow form of carbonaceous biochemical oxygen demand (CBOD) and calculates nitrogenous BOD from organic nitrogen and ammonia concentrations. The CBOD terms are modeled as final, ultimate oxygen demand, which requires extrapolation from the 5-day incubations used in the laboratory measurements.

As many of the BOD and CBOD results in the July 2019 dataset, and most in the September 2019 dataset, were below the Limit of Reporting (LOR), a reasonable estimate of the various BOD terms had to be derived from the reported data. For the 2020 Whitemud River model, the same procedure was used that had been used in the 2008 model to estimate the required forms of BOD: Measured BOD concentrations were input as fast CBOD, and slow CBOD concentrations were estimated through the following calculation based on dissolved organic carbon (DOC) concentrations:

$$CBODslow = DOC * 2.7 - BOD,$$

Where the factor 2.7 accounts for the oxygen demand in mg O_2 per mg C for oxidation of carbon.

The use of the reported BOD value (5-day, including NBOD) to approximate the model's fast CBOD term (theoretical ultimate incubation, exclusive of NBOD) accounts for measured differences in BOD along the river and was found to provide a reasonable fit of oxygen processes in the 2008 model. Data reported as less than LOR (<2 mg/L) were assigned values of 1.5 mg/L and 1.0 mg/L for BOD and CBOD, respectively.

The BOD values calculated in this way corroborated reasonably well with chemical oxygen demand (COD) data provided by HyLife for the R3II effluent, in that the sum of the NBOD and fast and slow CBOD values did not exceed the COD values.

The slow CBOD oxidation rate was set to zero, so that only NBOD and fast CBOD contributed directly to oxygen consumption in the water column. This provided for good calibration with fast CBOD and DO concentrations in the river while minimizing potential for confounding influence of slow CBOD, which appeared to have sources in the river that would not contribute substantially to oxygen consumption over the modeled area, as confirmed through sensitivity analysis at various hydrolysis and oxidation rates. Calibration to measured values of fast CBOD as defined was achieved by increasing the fast CBOD oxidation rate by a factor of three and decreasing the temperature correction factor slightly. Figure A-5 shows the calibration results for fast and slow CBOD in the 2020 model for July and September 2019.

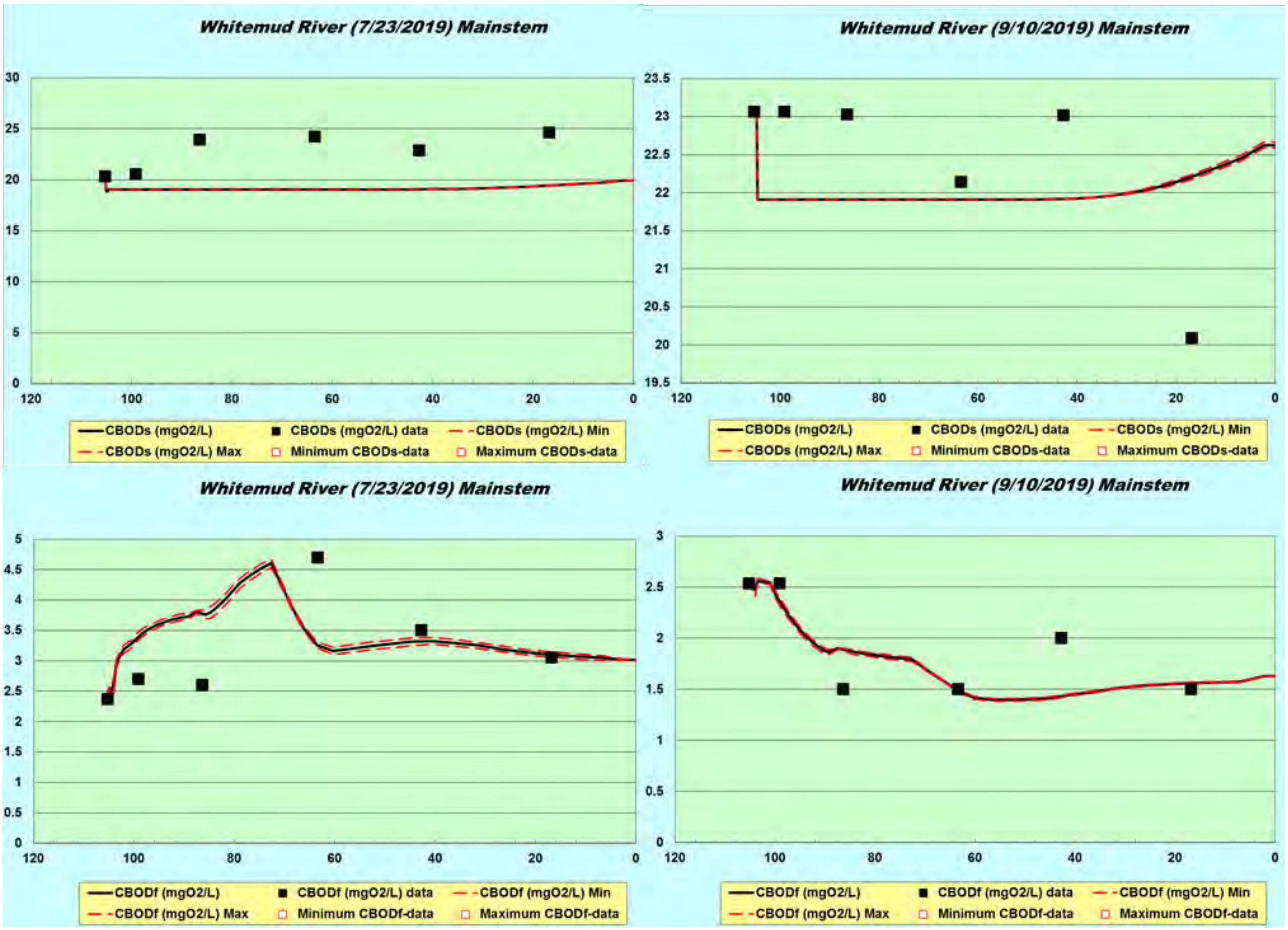

Figure A-5. Estimates based on measured biochemical oxygen demand and model estimates of slow and fast carbonaceous biochemical oxygen demand in the Whitemud River in July and August 2019.

A.12 Sediment Oxygen Demand

Overestimation of dissolved oxygen by the model was corrected partly by assigning 100% Sediment Oxygen Demand (SOD) coverage, as a proportion of bottom area, to all reaches. The 2008 model had varying SOD coverage, ranging from 60% to 80%, based on observed proportions of fine substrata (clay/silt/fine sand) and coarser substrata (sand, gravels and cobble). However, earlier studies in another local river influenced by agricultural runoff and wastewater effluents had shown that variations in SOD were not correlated with sediment grain size (Toews et al. 2000, Toews 2002). In the Whitemud River, no expansive areas of clean bedrock or very coarse substrata (large cobble/boulder) exist to justify characterization of any particular reach as having reduced SOD coverage relative to the other reaches.

Final prescribed SOD added to the model to achieve calibration was 3 g O_2/m^2/day in Reaches 1 to 5 and 2 g O_2/m^2/day in Reaches 6 to 18. The higher SOD in the upstream reaches reflects higher impact of nutrient and organic loading over a distance of approximately 5 km downstream of the Neepawa municipal lagoon and R3II effluent outfalls. The Qual2K model superimposed additional SOD onto the prescribed SOD, such that total SOD ranged from 3.71 g/m^2/day to 4.54 g/m^2/day in the July model and 2.40 g/m^2/day to 4.01 g/m^2/day in the September model. These SOD rates are consistent with rates measured in the Assiniboine River (Toews et al. 2000, Toews 2002) and in diverse international waters with comparable trophic status (Matlock et al. 2007, Rong et al. 2016, Uchrin and Ahlert 1985, Beutel 2003). Figure A-6 presents the prescribed and total estimated SOD over the modeled reach of the river.

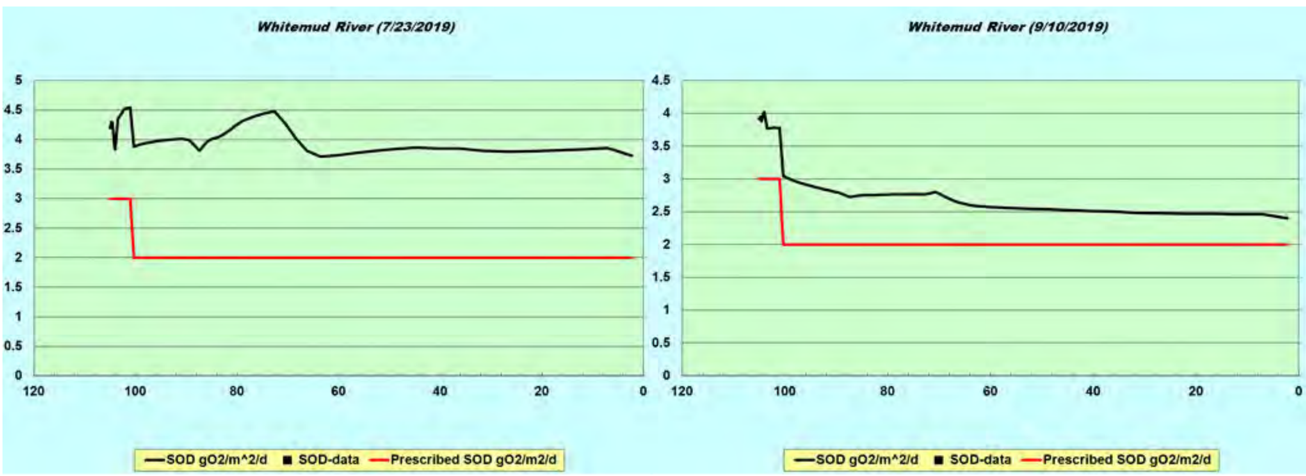

Figure A-6. Prescribed and total model-estimated sediment oxygen demand in the Whitemud River in July and September 2019.

A.13 Phosphorus

The phosphorus terms used as model inputs were derived from the analytical data as follows, according to guidance in the Qual2K user's manual (Chapra et al. 2012):

> Organic phosphorus was calculated as Total Phosphorus minus Soluble Reactive Phosphorus minus phytoplankton internal phosphorus, estimated as the mass equivalent to Chlorophyll *a*:

$$po = \text{TP} - \text{SRP} - rpa\ \text{CHLA}$$

The dissolved orthophosphate analytical result was used to represent Soluble Reactive Phosphorus and was input as the Inorganic Phosphorus term.

In both the July and September models, excess dissolved inorganic phosphorus in the measured data, relative to the model estimates, could be accounted for only as reach-by-reach loading from the sediments. Calibration indicated that the sediment phosphorus flux was highest in Reaches 7 to 13 (15 km to 46 km downstream of the wastewater effluent outfalls at Neepawa) and lowest in the furthest downstream reaches and the upstream reaches below the effluent outfalls (Figure A-7). With this distribution of sediment loading, increasing the organic phosphorus hydrolysis rate coefficient and decreasing the temperature correction factor produced excellent fit between model predictions and measured data for both organic and inorganic phosphorus (Figure A-8). Model results for total phosphorus and possible causes and implications of this distribution of sediment phosphorus loading are presented and discussed in Section 2.5 of this report.

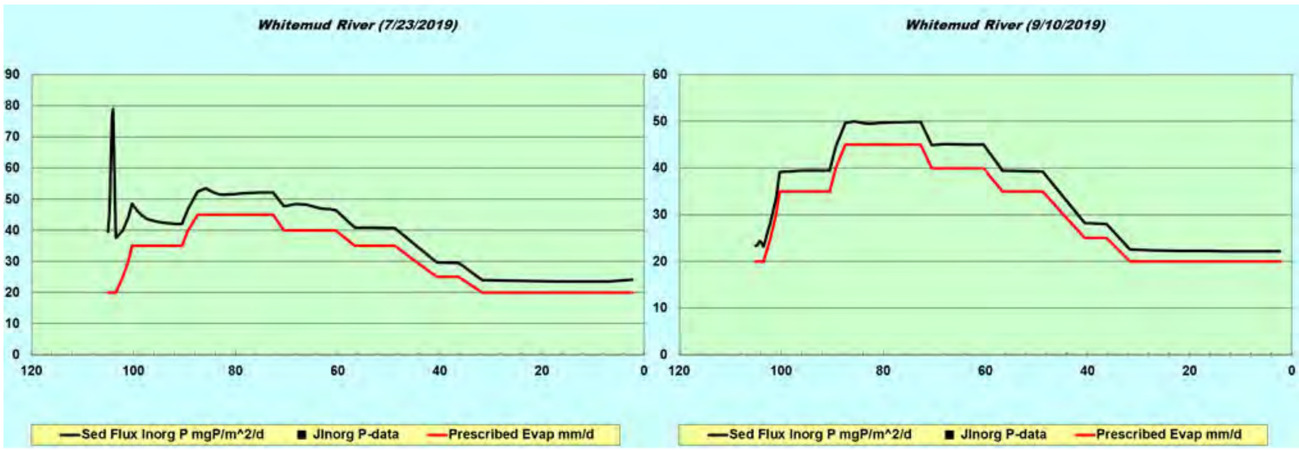

Figure A-7. Prescribed and total model-estimated inorganic phosphorus flux from the sediments in the Whitemud River in July and September 2019.

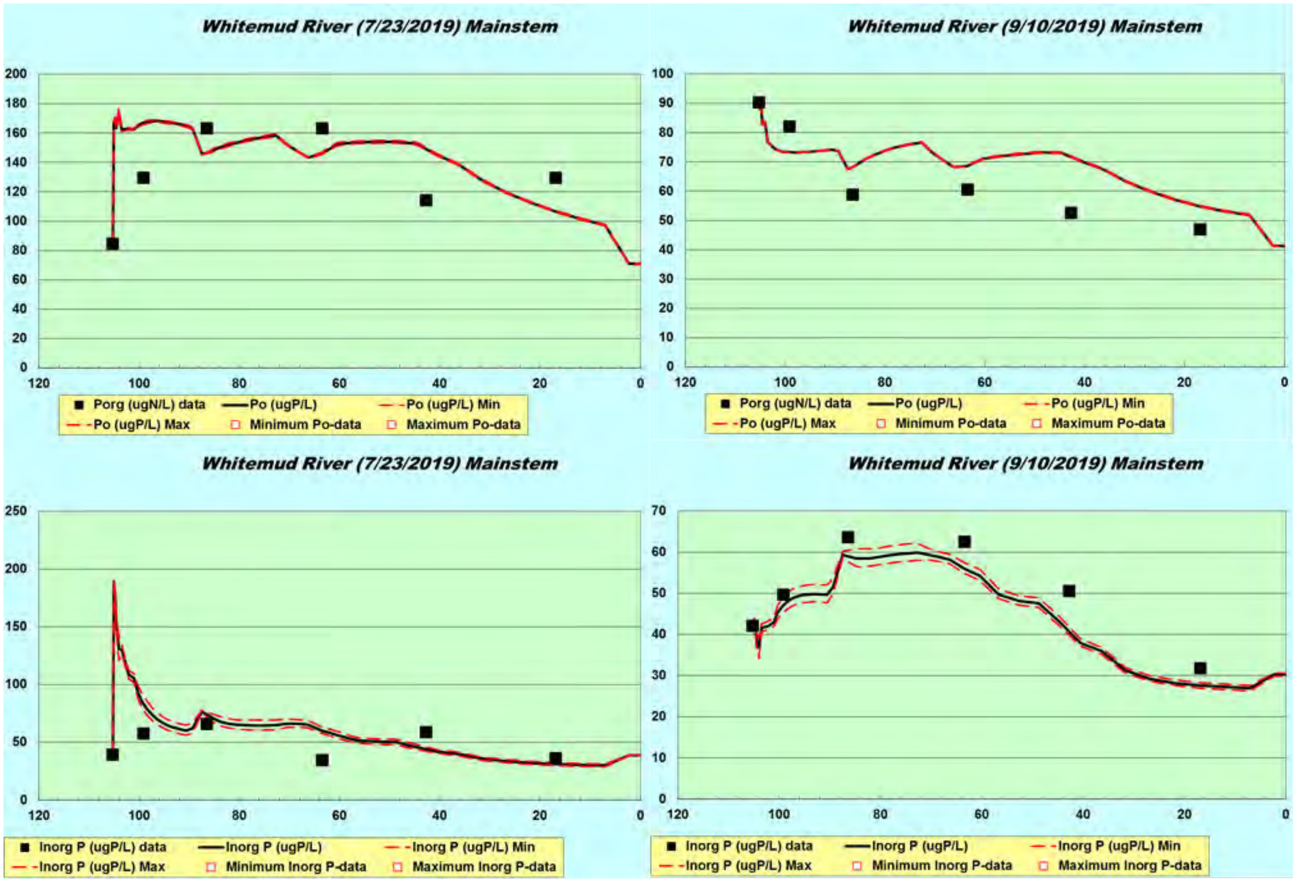

Figure A-8. Measured data and model estimates of organic and inorganic phosphorus in the Whitemud River in July and September 2019.

A.14 Nitrogen

Before and after reasonably-calibrated levels of primary productivity were achieved, the model poorly simulated nitrogen speciation and conversion processes in the river, based on the July and September 2019 data. The discrepancies among modeled and measured data were corrected by the following modifications to the model:

- Increasing the organic nitrogen hydrolysis rate coefficient by a factor of eight, and higher in Reaches 1-6 (up to 15 km downstream of the wastewater effluent discharges at Neepawa);
- Increasing the nitrification rate coefficient by a factor of 5, and higher in Reaches 1-6.

The increase made to the nitrification rate, by a factor of up to fifteen in Reaches 1-5 (totaling approximately 5 km downstream from the wastewater effluent outfalls) was the largest modification to any component of the model in terms of relative change to default coefficients. The large increase in nitrification rate assigned to this localized area likely was somewhat justified, as the ammonia load was part of the discharge from the final cell of the wastewater lagoon facility and, therefore, will have been well-seeded with nitrifying bacteria.

Furthermore, insofar as the aqueous nitrification rate in Reaches 1-5 may be overestimated by the calibrated model, assigning an artificially-high aqueous nitrification capacity just downstream of the lagoon effluent discharge was strategically beneficial for the practical purposes of developing a model to simulate future conditions in the Whitemud River. In reality, much of the observed nitrification in July 2019 would have occurred in the sediments. Modeling it as nitrification in the water column, however, avoided the necessity of prescribing sediment fluxes of ammonia and nitrate and associated SOD to simulate nitrification in the sediments. Qual2K handles prescribed sediment fluxes and SOD as fixed model inputs (independent of aqueous loading) that would require adjustment for every model run with different effluent discharge conditions. Modeling the observed nitrification as localized aqueous nitrification makes the model most adaptable for predictive assessments, particularly considering that the Neepawa municipal lagoon system is undergoing an upgrade that is expected to reduce ammonia loading in the near future. With reduced ammonia concentrations in the future (similar to the calibrated September 2019 model), the potential overestimate of aqueous nitrification capacity in Reaches 1 to 5 will have little effect on water quality simulations, as there will be less ammonia to nitrify.

Unlike several other rate-dependent processes in the model, temperature correction was not modified for nitrification-related processes, as nitrification is known to be highly temperature-dependent across diverse physical and ecological settings. Final calibration of the model left some uncertainty with inorganic nitrogen near the upstream end of the model, possibly reflecting sediment flux processes associated with intermittent discharge of large ammonia loads from the municipal lagoon. As discussed above, preference was to not build sediment flux terms into the model for parameters that will change with pending upgrades to the municipal wastewater treatment system. Final results for organic nitrogen and inorganic nitrogen are presented in Figures A-9 and A-10, respectively.

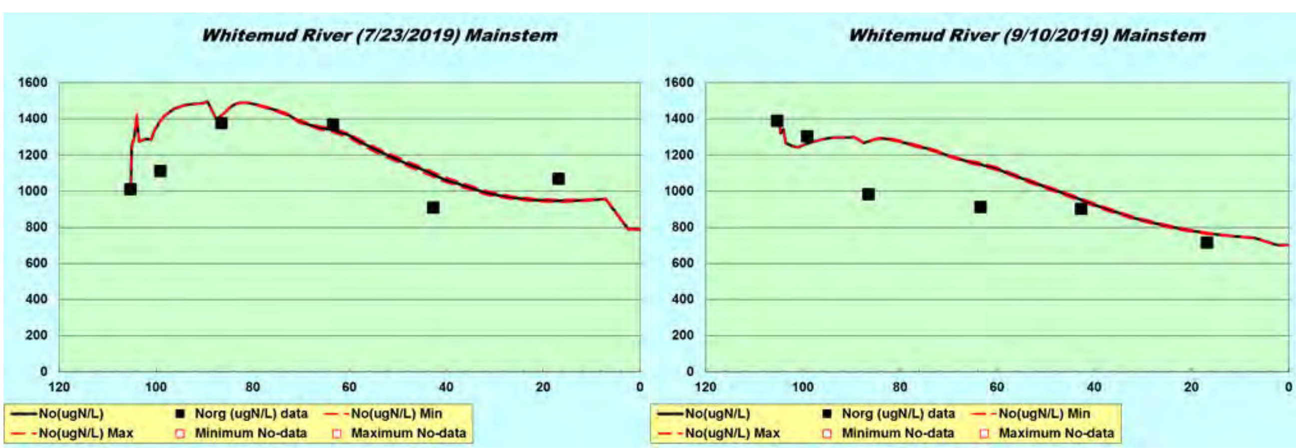

Figure A-9. Measured data and model estimates of organic nitrogen in the Whitemud River in July and September 2019.

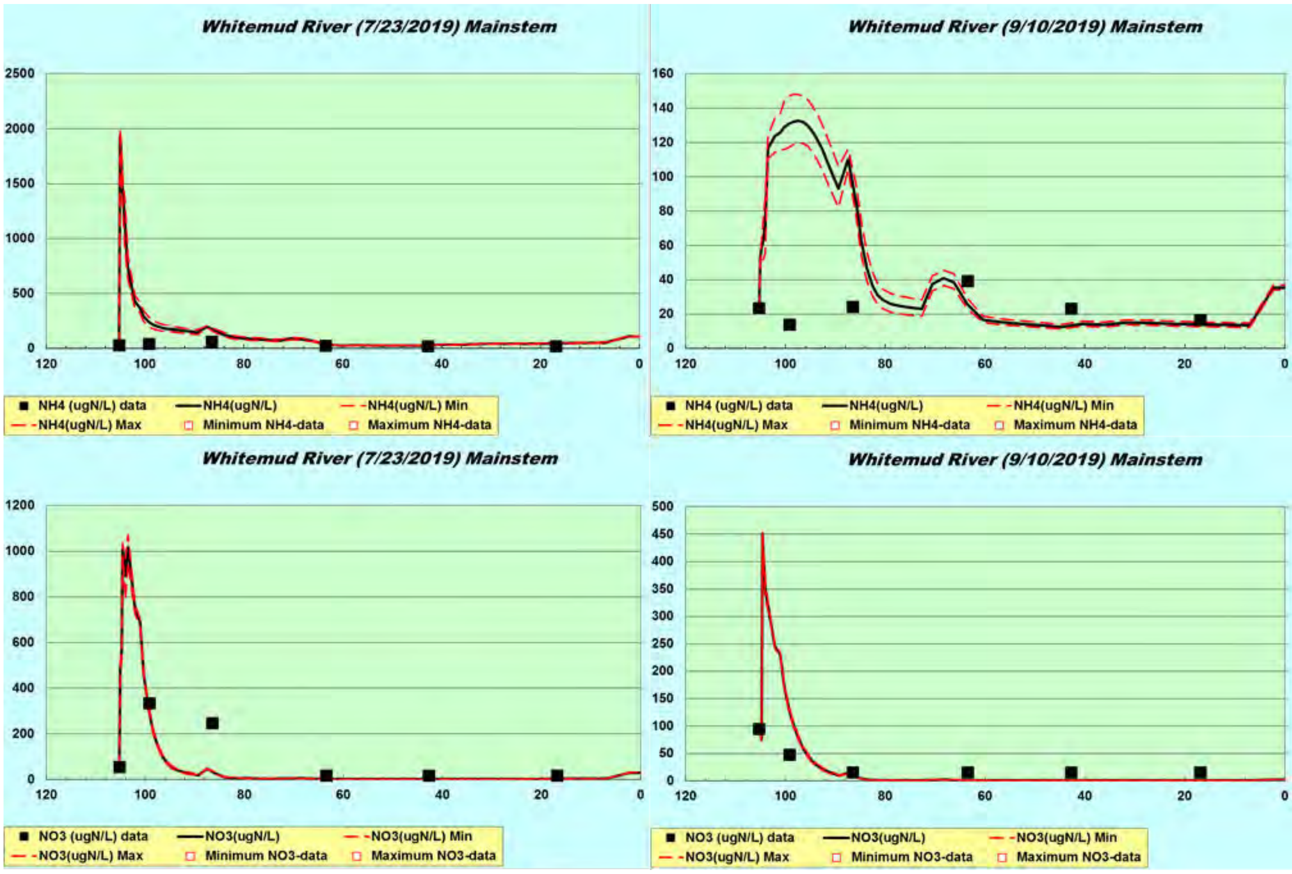

Figure A-10. Measured data and model estimates of ammonia and nitrate in the Whitemud River in July and September 2019.

A.15 Phytoplankton and Chlorophyll *a*

In the July and September 2019 field studies, water samples were analyzed for chlorophyll *a* and phytoplankton taxonomy was conducted to genus level with cell counts but no biomass quantification. Therefore, the chlorophyll *a* data were used directly in the model as phytoplankton concentration estimates without corroborative biomass data. The taxonomy guided interpretation of phytoplankton population growth as well as community structure and function in the river, as described below.

A.15.1 Chlorophyll *a*

The analytical and reporting protocol used by the laboratory for chlorophyll *a* was to distinguish between chlorophyll *a* and pheophytin, which can represent a degraded form of the chlorophyll *a* pigment. Since chlorophyll *a* is reported variably among laboratories as the total chlorophyll *a* + pheophytin result or specifically the chlorophyll *a* result, interpretation of the results with consideration of the environmental context is important to ensure that the approach most appropriate to the situation is followed.

For the 2020 Qual2K Model, the chlorophyll *a* data, exclusive of the pheophytin results, were used to represent chlorophyll *a*, based on the following rationale:

- There was no indication that the phytoplankton samples were compromised post-collection. (The pheophytin in the samples was likely a true representation of the concentrations in the river, as opposed to an indication of sample degradation after collection.)
- Previous data analysis has shown high pheophytin content in phytoplankton in a nearby river, suggesting entrainment of dead or senescent cells in the lotic environment (Toews et al. 1999; Toews 2002).
- The phytoplankton concentrations showed a general decreasing, rather than increasing, trend downstream along the river, which was explained by the fact that the river flows out of lakes (Lake Irwin and Parks Lake) just upstream of the modeled reach. Phytoplankton communities established in the lake environments could be expected to undergo senescence once entrained in the river. As the model simulates chlorophyll *a* as actively growing phytoplankton, the pheophytin would be best considered as associated with detritus in the model.

A.15.2 Phytoplankton Community Structure

In both the July and September 2019 datasets, the phytoplankton communities in the upstream portion of the river study reach were dominated by the large-celled taxa that commonly dominate local lakes (particularly, *Aphanizomenon*, as well as *Anabaena* and *Aulacoseira* in July). In both datasets, these phytoplankton populations in the upstream portion of the modeled river died off between Site 2 and Site 4, giving way to a population dominated by the smaller, faster-growing diatom taxa typical of local, nutrient-rich rivers. In this emergent population that developed along the river in July, the cyanobacterium *Merismopedia* dominated cell counts but likely represented a smaller proportion of total algal biomass relative to the diatoms, as *Merismopedia* species reported in another local river had cell sizes more than three orders of magnitude smaller than the common riverine diatom species (Toews et al. 2000, Toews 2002).

A.15.3 Phytoplankton Model

The community shift described above, from large, lake-dwelling taxa to faster-growing, riverine taxa, can be expected in the Whitemud River between Neepawa and Gladstone. Such a shift is likely representative of the river's phytoplankton community in most or all warm, low-flow open-water conditions that are the focus of water-quality assessments. Therefore, the 2020 Qual2K model was developed to simulate the discontinuous phytoplankton community described by the 2019 data.

Qual2K models phytoplankton generically as chlorophyll *a*, without consideration of the different properties among taxonomic groups. Therefore, the following modifications were made to the model settings in the development of the 2020 Qual2K model:

- For the upper eleven reaches (to just upstream of Sampling Site 4), phytoplankton maximum growth rates were reduced and respiration rates were increased, to describe the senescence of the phytoplankton entrained from the upstream lake environments. In these reaches, phytoplankton settling velocity was set to zero, to describe the positively-buoyant dominant cyanobacterial species. Reported flotation rates for large cyanobacteria range widely (Webster et al. 2000), but neutral buoyancy for a senescent population in the shallow water of the Whitemud River was deemed the most appropriate setting for the model. *Aulacoseira*, which was present in July and known to dominant local lakes in early summer (e.g. Toews 2019), is negatively buoyant, but prescribing a settling rate of zero for the upstream phytoplankton population best describes the cyanobacterial dominance that would be expected in the warm, low-flow conditions relevant to water quality assessments.

- For Reaches 6-10 and 11-18, the phytoplankton settling velocity was increased to 0.12 m/day and 0.24 m/day, respectively. These rates are somewhat lower than the range reported in the literature for similar species (Sherman et al. 1998, Bormans and Webster 1999, Bormans and Condie 1997) and may be an indication of underestimated river velocities by the hydraulic model.
- For all reaches, the growth rate temperature correction factor was eliminated (set to 1), as the observed species succession appeared to account for the difference in temperatures over the observed open-water season.

The model described above optimized the response in dependent parameters in the river (e.g. dissolved oxygen and nutrients) and provided good fit for phytoplankton concentrations based on chlorophyll *a* data in both the July and September 2019 datasets, as shown in Figure A-11. A means to improve the robustness and predictive capability of the model would be to supplement the 2008 hydraulic data, as hydraulic parameters such as depth, velocities and travel time are primary determinants in the net growth of phytoplankton.

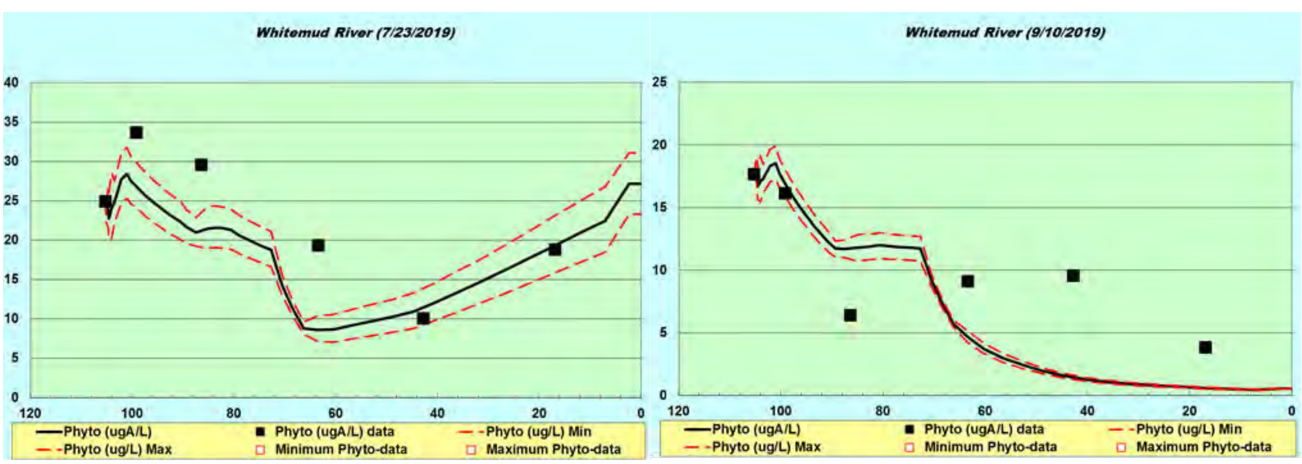

Figure A-11. Measured data and model estimates of chlorophyll *a* (phytoplankton) in the Whitemud River in July and September 2019.

A.16 Benthic Algae

In the 2019 field sampling programs, benthic (bottom) algae were sampled from cobble lifted from the streambed and quantified both as chlorophyll *a* and as ash-free dry mass (AFDM) per unit area. As shown in Figure A-12, data revealed considerable variation within each site and no upstream-downstream pattern or obvious difference among sites. Therefore, model calibration focused on matching model simulations to the range indicated by the data rather than to site-by-site data points.

The 2008 Qual2K model assigned estimates of benthic algae coverage by reach, ranging from 40% to 100% as percent of bottom area, based on observed presence of coarse substrata at cross-section survey points. Based on the light extinction results discussed in Section A.9, on observations of channel characteristics in 2019, and on results shown by early model runs, the 2008 assigned benthic algae coverage estimates were replaced by 100% coverage in every reach. While it is possible that small areas in some or all reaches may not support benthic algae, this adjustment prevents the unjustified limitation to primary productivity in some reaches that would have resulted from the previous estimates.

As part of model development, extensive sensitivity analysis around parameters pertaining to nutrients and dissolved oxygen gave multiple lines of evidence for high levels of primary productivity and respiration that could be attributed only to benthic algae. As a result, the final calibrated model simulated benthic algae at the high end of the range indicated by the data (Figure A-13). Overall benthic primary productivity reflecting the high end of the observed range of benthic algae densities is realistic because:

- Shallow areas colonized by aquatic vegetation, such as those shown in Figure 2-1, would have much higher benthic productivity than the sampled cobble, thus increasing the mean above that indicated by the data; and,
- Light extinction measurements indicated the potential for benthic productivity over most or all of the riverbed, such that light limitation would not reduce the mean density below that indicated by the data.

For benthic algae, as with phytoplankton, the temperature correction factors for maximum growth and respiration were adjusted downward to provide best fit of model results with data for various parameters including dissolved oxygen. Unlike with phytoplankton, empirical data did not exist to demonstrate justification for this adjustment to temperature correction. It is possible that these adjustments compensate partially for the temperature underestimates produced by the model and could require readjustment if the hydraulic and/or temperature models are altered.

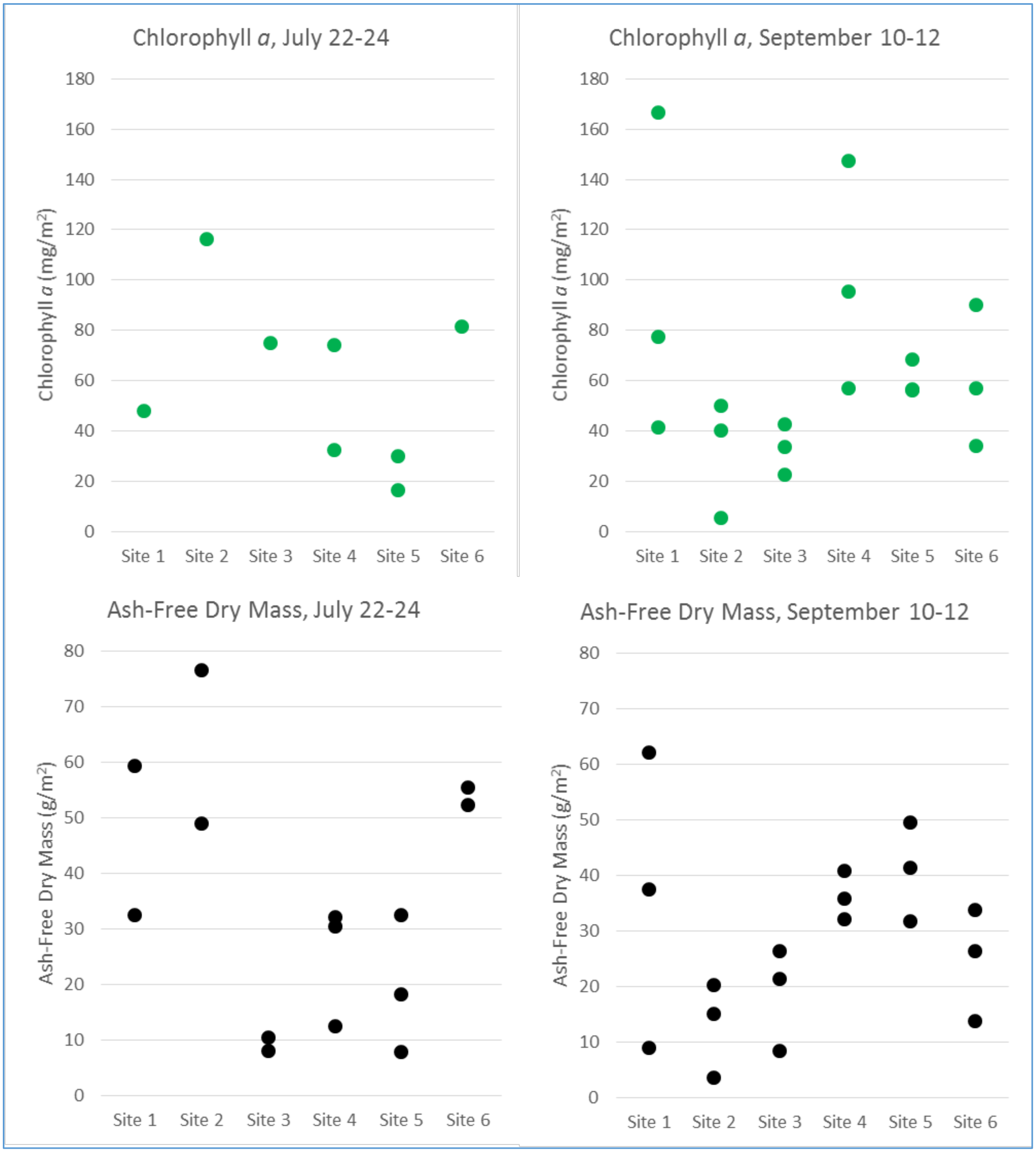

Figure A-12. Benthic algae chlorophyll *a* and ash-free dry mass densities in the Whitemud River in July and September 2019.

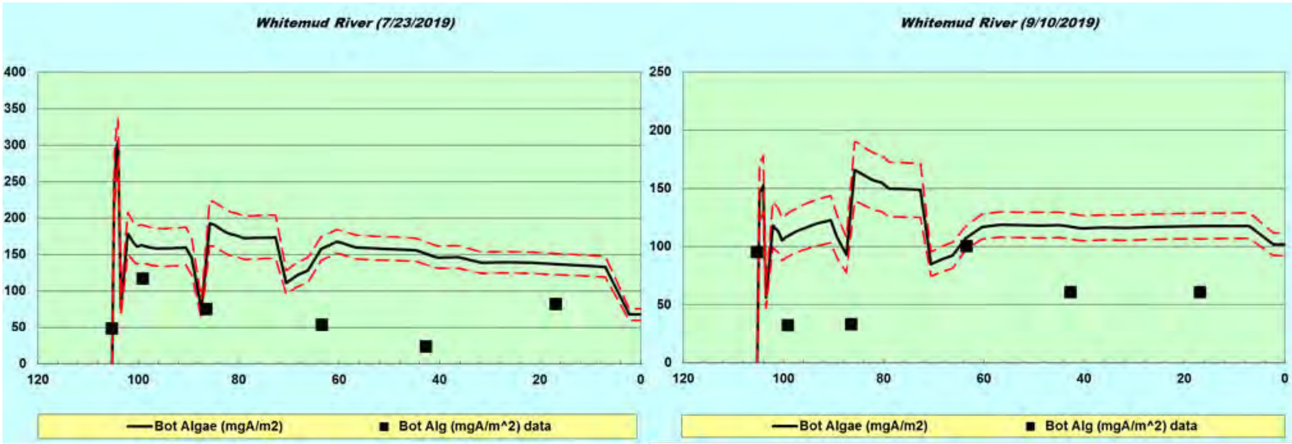

Figure A-13. Average measured data and model estimates of benthic algae densities in the Whitemud River in July and September 2019.

A.17 Rates, Coefficients and Constants Used in the 2020 Qual2K Model

The following tables list the final rates, coefficients and constants used in the calibrated 2020 Whitemud River Qual2K Model.

QUAL2K			
Stream Water Quality Model			
Whitemud River (8/1/2020)			
Water Column Rates			
Parameter	***Value***	***Units***	***Symbol***
Stoichiometry:			
Carbon	**40**	**gC**	**gC**
Nitrogen	**7.2**	**gN**	**gN**
Phosphorus	**1**	**gP**	**gP**
Dry weight	**100**	**gD**	**gD**
Chlorophyll	**1**	**gA**	**gA**
Inorganic suspended solids:			
Settling velocity	**0.01**	**m/d**	v_i
Oxygen:			
Reaeration model	**Internal**		
User reaeration coefficient α	**3.93**		α
User reaeration coefficient β	**0.5**		β
User reaeration coefficient γ	**1.5**		γ

Temp correction	**1.024**		***q_a***
Reaeration wind effect	**None**		
O2 for carbon oxidation	**2.69**	**gO_2/gC**	***r_{oc}***
O2 for NH4 nitrification	**4.57**	**gO_2/gN**	***r_{on}***
Oxygen inhib model CBOD oxidation	**Exponential**		
Oxygen inhib parameter CBOD oxidation	**0.60**	**L/mgO2**	***K_{socf}***
Oxygen inhib model nitrification	**Exponential**		
Oxygen inhib parameter nitrification	**0.60**	**L/mgO2**	***K_{sona}***
Oxygen enhance model denitrification	**Exponential**		
Oxygen enhance parameter denitrification	**0.60**	**L/mgO2**	***K_{sodn}***
Oxygen inhib model phyto resp	**Exponential**		
Oxygen inhib parameter phyto resp	**0.60**	**L/mgO2**	***K_{sop}***
Oxygen enhance model bot alg resp	**Exponential**		
Oxygen enhance parameter bot alg resp	**0.60**	**L/mgO2**	***K_{sob}***
Slow CBOD:			
Hydrolysis rate	**0**	**/d**	***k_{hc}***
Temp correction	**1.07**		***q_{hc}***
Oxidation rate	**0**	**/d**	***k_{dcs}***
Temp correction	**1.047**		***q_{dcs}***
Fast CBOD:			
Oxidation rate	**0.09**	**/d**	***k_{dc}***
Temp correction	**1.04**		***q_{dc}***
Organic N:			
Hydrolysis	**0.015**	**/d**	***k_{hn}***
Temp correction	**1.07**		***q_{hn}***
Settling velocity	**0.0005**	**m/d**	***v_{on}***
Ammonium:			
Nitrification	**0.08**	**/d**	***k_{na}***
Temp correction	**1.07**		***q_{na}***
Nitrate:			
Denitrification	**0.1**	**/d**	***k_{dn}***
Temp correction	**1.07**		***q_{dn}***
Sed denitrification transfer coeff	**0.8**	**m/d**	***v_{di}***
Temp correction	**1.07**		***q_{di}***
Organic P:			
Hydrolysis	**0.03**	**/d**	***k_{hp}***
Temp correction	**1**		***q_{hp}***
Settling velocity	**0.001**	**m/d**	***v_{op}***

Inorganic P:			
Settling velocity	**0.8**	**m/d**	v_{ip}
Inorganic P sorption coefficient	**1000**	**L/mgD**	K_{dpi}
Sed P oxygen attenuation half sat constant	**1**	**mgO_2/L**	k_{spi}
Phytoplankton:			
Max Growth rate	**3.8**	**/d**	k_{gp}
Temp correction	**1**		q_{gp}
Respiration rate	**0.15**	**/d**	k_{rp}
Temp correction	**1.07**		q_{rp}
Excretion rate	**0.3**	**/d**	k_{ep}
Temp correction	**1.07**		q_{dp}
Death rate	**0.1**	**/d**	k_{dp}
Temp correction	**1.07**		q_{dp}
External Nitrogen half sat constant	**100**	**ugN/L**	k_{sPp}
External Phosphorus half sat constant	**10**	**ugP/L**	k_{sNp}
Inorganic carbon half sat constant	**1.30E-05**	**moles/L**	k_{sCp}
Light model	**Half saturation**		
Light constant	**250**	**langleys/d**	K_{Lp}
Ammonia preference	**25**	**ugN/L**	k_{hnxp}
Subsistence quota for nitrogen	**0**	**mgN/mgA**	q_{0Np}
Subsistence quota for phosphorus	**0**	**mgP/mgA**	q_{0Pp}
Maximum uptake rate for nitrogen	**0**	**mgN/mgA/d**	r_{mNp}
Maximum uptake rate for phosphorus	**0**	**mgP/mgA/d**	r_{mPp}
Internal nitrogen half sat constant	**0**	**mgN/mgA**	K_{qNp}
Internal phosphorus half sat constant	**0**	**mgP/mgA**	K_{qPp}
Settling velocity	**0**	**m/d**	v_a
Bottom Algae:			
Growth model	**Zero-order**		
Max Growth rate	**200**	**$mgA/m^2/d$ or /d**	C_{gb}
Temp correction	**1.01**		q_{gb}
First-order model carrying capacity	**1000**	**mgA/m^2**	$a_{b,max}$
Respiration rate	**0.2**	**/d**	k_{rb}
Temp correction	**1.01**		q_{rb}
Excretion rate	**0.12**	**/d**	k_{eb}
Temp correction	**1.07**		q_{db}
Death rate	**0.1**	**/d**	k_{db}
Temp correction	**1.07**		q_{db}

External nitrogen half sat constant	**300**	**ugN/L**	k_{sPb}
External phosphorus half sat constant	**100**	**ugP/L**	k_{sNb}
Inorganic carbon half sat constant	**1.30E-05**	**moles/L**	k_{sCb}
Light model	**Half saturation**		
Light constant	**100**	**langleys/d**	K_{Lb}
Ammonia preference	**25**	**ugN/L**	k_{hnxb}
Subsistence quota for nitrogen	**0.72**	**mgN/mgA**	q_{0N}
Subsistence quota for phosphorus	**0.1**	**mgP/mgA**	q_{0P}
Maximum uptake rate for nitrogen	**72**	**mgN/mgA/d**	r_{mN}
Maximum uptake rate for phosphorus	**5**	**mgP/mgA/d**	r_{mP}
Internal nitrogen half sat constant	**0.9**	**mgN/mgA**	K_{qN}
Internal phosphorus half sat constant	**0.13**	**mgP/mgA**	K_{qP}
Detritus (POM):			
Dissolution rate	**0.23**	**/d**	k_{dt}
Temp correction	**1.07**		q_{dt}
Fraction of dissolution to fast CBOD	**1.00**		F_f
Settling velocity	**0.12**	**m/d**	v_{dt}
Pathogens:			
Decay rate	**0.8**	**/d**	k_{dx}
Temp correction	**1.07**		q_{dx}
Settling velocity	**1**	**m/d**	v_x
Light efficiency factor	**1.00**		a_{path}
pH:			
Partial pressure of carbon dioxide	**347**	**ppm**	p_{CO2}
Constituent i			
First-order reaction rate	**0**	**/d**	
Temp correction	**1**		q_{dx}
Settling velocity	**0**	**m/d**	v_{dt}
Constituent ii			
First-order reaction rate	**0**	**/d**	
Temp correction	**1**		q_{dx}
Settling velocity	**0**	**m/d**	v_{dt}
Constituent iii			
First-order reaction rate	**0**	**/d**	
Temp correction	**1**		q_{dx}
Settling velocity	**0**	**m/d**	v_{dt}

QUAL2K			
Stream Water Quality Model			
Whitemud River (8/1/2020)			
Light Parameters and Surface Heat Transfer Models:			
Parameter	***Value***	***Unit***	
Photosynthetically Available Radiation	**0.47**		
Background light extinction	**0.001**	***/m***	k_{eb}
Linear chlorophyll light extinction	**0.0088**	***1/m-(ugA/L)***	a_p
Nonlinear chlorophyll light extinction	**0.054**	***1/m-(ugA/L)2/3***	a_{pn}
ISS light extinction	**0.052**	***1/m-(mgD/L)***	a_i
Detritus light extinction	**0.174**	***1/m-(mgD/L)***	a_o
Solar shortwave radiation model			
Atmospheric attenuation model for solar	**Ryan-Stolzenbach**		
Bras solar parameter (used if Bras solar model is selected)			
atmospheric turbidity coefficient (2=clear, 5=smoggy, default=2)	**2**		n_{fac}
Ryan-Stolzenbach solar parameter (used if Ryan-Stolzenbach solar model is selected)			
atmospheric transmission coefficient (0.70-0.91, default 0.8)	**0.9**		a_{tc}
Downwelling atmospheric longwave IR radiation			
atmospheric longwave emissivity model	**Brutsaert**		
Evaporation and air convection/conduction			
wind speed function for evaporation and air convection/conduction	**Brady-Graves-Geyer**		
Sediment heat parameters			
Sediment thermal thickness	**45**	***cm***	H_s
Sediment thermal diffusivity	**0.0064**	cm^2/s	a_s
Sediment density	**1.6**	g/cm^3	r_s
Water density	**1**	g/cm^3	r_w
Sediment heat capacity	**0.4**	$cal/(g\ ^oC)$	C_{ps}
Water heat capacity	**1**	$cal/(g\ ^oC)$	C_{pw}
Sediment diagenesis model			
Compute SOD and nutrient fluxes	**Yes**		