FURTHER EXPANDED FLOWS AND LOADS
R3 INDUSTRIAL WWTP
PROCESS ENGINEERING EVALUATION

Prepared For:

HyLife Foods
Neepawa, Manitoba, Canada

Prepared By:

Pharmer Engineering
1998 West Judith Lane
Boise, ID 83705

PHARMER ENGINEERING LLC

PROVINCE OF MANITOBA
R.D. PHARMER
Member
30268
REGISTERED PROFESSIONAL ENGINEER

May 2013

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The waste stream generated at the HyLife Foods pork processing facility located in Neepawa, Manitoba is treated at 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. Since that time, the facility has operated successfully.

The existing IWWTF consists of chemical conditioning, primary dissolved air flotation, flow attenuation, secondary dissolved air flotation; biological treatment with a membrane bioreactor (MBR) activated sludge system followed by ultraviolet disinfection and effluent cooling prior to discharge. A portion of the treated effluent is pumped to a reverse osmosis system to provide high quality reuse water. A process flow diagram of the IWWTF is shown in Figure 1. The existing IWWTF was provided with a carbon feed system, which consisted of facilities to add sugar to the process, to promote high level of nitrogen removal from the system. Following start-up of the IWWTF, it was found that there was an adequate amount of carbon to drive nitrogen removal so the sugar feed system has not been utilized.

In April 2012, Pharmer Engineering developed an analysis of an expanded condition at the production facility from the current 3,800 hogs to 7,500 plus a casings operation. The production facility throughput and resulting wastewater load was considerably more than the original design condition. In the analysis each unit process was evaluated to identify potential bottlenecks that may exist in the existing process for the expanded operation.

This report examines another increase in load to the IWWTF. A by-product from the casings operation is the production of peptone. Peptone is very strong in nitrogen and fat though it is produced at relatively low quantities (10m^3/day).

This report evaluates the treatment facility needs associated with treating wastewater generated by the peptone processing on top of the loads from the increased production.

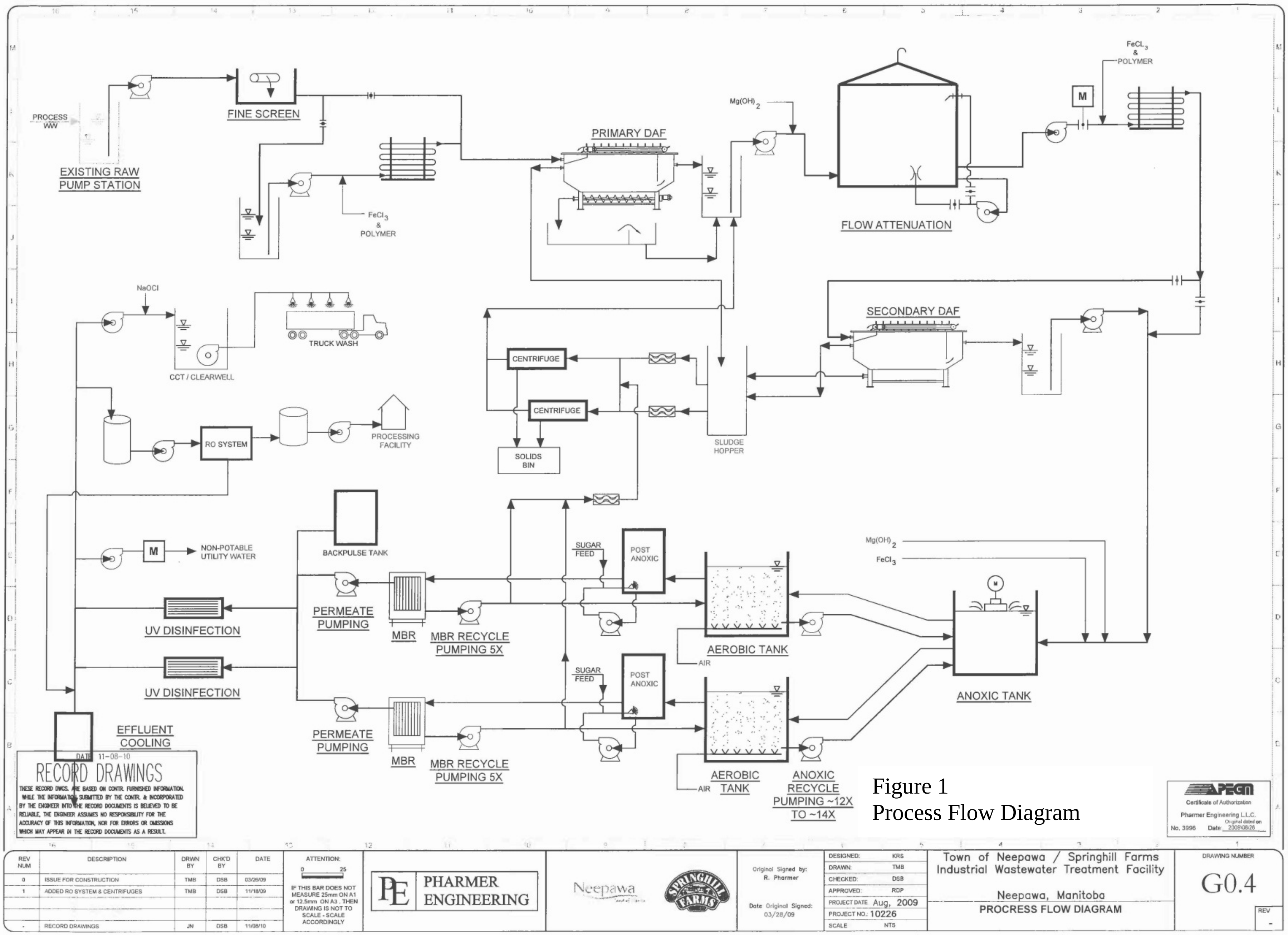

Figure 1
Process Flow Diagram

PROCESS DESIGN BASIS

Table 1 lists the design criteria per hog basis and for a 7-day production week at the HyLife Foods pork processing facility. The first block of columns corresponds to the May 2012 evaluation. Column A is the original design condition distributed over a 7-day period. Column B is the approximate loading in April 2012. Mass balance of the data set and comparison of sludge production in both scenarios suggested the influent load in April 2012 was approximately 80% the organic loading design condition and 51% of the hydraulic loading design condition. Column C was developed for the previous condition. These values represent the new design condition. The April 2012 report included approximate capital improvement with several recommendations associated with getting assistance with operations.

The new potential scenarios are located in Columns D and E. Criteria estimated for peptone waste stream is shown in Column D. The hydraulic condition is input from R3 Innovations. The organic and nutrient strength are a combination of two sampling data points and are considered preliminary at this point in time. This evaluation considers three potential scenario for an increase in production to 7,500 hogs per day plus a casings operation and the subsequent production of peptone.

Table 1
R3 Innovations
7-Day Average Influent Flow and Loads

		A	B	C	D	E
Parameter	Units	Design Condition at Full Licensed Capacity	Approx Current Condition (April 2012) A,B	Rerate Design Condition (April 2012) C	*Add'l Peptone Line*D	*Total Flow and Load With Peptone +*
Flow	M3/Day	1,520	777	1,040	15	1,055
BOD	kg/day	2,184	1,747	3,436	2,587	6,023
	mg/L	1,437	2,249	2,249	8,318	3,275
COD	kg/day	3,135	2,508	4,932	*3,713*	*8,645*
	mg/L	2062	3,228	3,228	*11,940*	*4,701*
TSS	kg/day	513	339	667	156	823
	mg/L	338	436	437	502	448
TKN	kg/day	513	339	667	156	*823*
	mg/L	338	437	437	502	*448*
TP	kg/day	45	38	75	28	*103*
	mg/L	30	49	49	90	*56*
Temperature	^{o}C	25 – 30	25 – 30	25 – 30	25 – 30	25 - 30

A. Design Condition
B. Based on current production of 3,813 hogs per day
C. Projected design condition for 7,500 hogs per day
D. Items in black font are given as input. *Items in blue italics are estimated*

TABLE 2
R3 Innovations IWWTF
Effluent Discharge Criteria

Parameter	Value
Carbonaceous five-day Biochemical Oxygen Demand ($cBOD_5$)	<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)

PROCESS EVALUATION

This section presents a discussion of the unit treatment processes available in the industrial wastewater treatment facility to treat the current and projected future expansion wastewater from the HyLife Foods production facility.

Future production expansion is anticipated to increase processing over two twelve-hour shifts per day. The current average processing rate is 3,813 hogs killed per day with a maximum kill rate of 5,471 hogs per day. Current processing facility production is just over 80% of the original design value. A process evaluation basis of 7,500 hogs per day over a five day per week operations plus case processing was used for the expansion process evaluation. The majority of the increase will be in the form of longer days at the primary side of the treatment facility rather than increased flows during the same period.

Raw Influent and Screening. Process wastewater flows, sanitary sewer wastewater, barn waste, and truck wash flows are combined just outside the processing facility. A new pump station lifts the combined wastewaters into a force main and conveys flows to the primary treatment building at the new treatment site.

New raw influent pumping and screening facilities process all flows generated during the production schedule. Flows can vary widely during a production day. Most of the current wastewater flows occur during the 8-hour work day with additional wastewater coming as a result of cleaning flows after the production day. The raw influent pumping and screening facilities are sized for 4,540 lpm. The influent screen size is 1.0 mm. The influent screening facility will be adequate for the projected expansion operating basis.

Primary Treatment – First Stage DAF. From the influent screen, water can drain to the new first stage DAF unit, sized to treat flows from the raw influent pump station, or to a new screened wet well (normal operation). Water from the wetwell is pumped through a new in-line flocculator for chemical (ferric chloride and polymer) addition and into the first stage DAF by new lift pumps. The purpose of the primary DAF unit is to remove fats/oils and grease material that would cause operational issues in the flow attenuation tank. DAF float sludge drains to the main sludge hopper for removal and treatment.

Effluent from the first stage DAF unit drains to a new sump, from where it is pumped to the flow attenuation tank. The first stage DAF should be adequate for the projected expansion operating basis.

Currently, the majority of the organic load through the screen, pumps, and to the primary DAF occur in an 8 to 12 hour period. After that period each day, the primary side of the facility generally idles. The proposed increases to the production facility will result in longer run periods where the primary side idles only for a few hours a day. This may actually improve operations due to the more continuous operation of the DAF unit.

The treatability of additional waste streams to the IWWTF is expected to be similar to existing conditions. The limited data points obtained on the combined waste suggests high suspended solids and high oil and grease which would be removed through the primary DAF. It is possible that additional pH adjustment may be required in the primary DAF to denature protein and break oil and grease emulsions to improve primary treatment removals prior to biological treatment.

The follow are descriptions of the major unit processes:

Primary DAF. Following screening, the flow is pumped from the processing facility to the primary DAF. Ferric chloride and polymers are added to the flow to enhance the removal of suspended solid materials and fats contained in the waste stream. The addition of ferric chloride depresses the pH of wastewater so magnesium hydroxide is added to increase the pH prior to storage of the flow in the attenuation tank. No changes are anticipated in the Primary DAF system.

Flow Attenuation. The flow attenuation tank is covered and insulated to reduce heat loss during winter time conditions. It is equipped with a mixing system to prevent solids deposition inside the tank. The attenuation tank provides 2.5 days of storage capacity at the average design flow rate. It fills throughout the production work week and drains throughout the two-day weekend. The remaining 0.5 days of storage is used as a minimum water level to ensure the tank can be mixed and the wastewater quality leaving the tank remains consistent. This concept allows the downstream main unit treatment processes to operate at average flows, reducing the variability in wastewater quality.

The flow attenuation tank operation should be generally unaffected by the proposed condition other than receiving flows that are closer to the design condition.

Second Stage DAF. The second stage DAF unit includes a flocculation and coagulation step with metal salt (ferric chloride) and polymer addition capabilities. Flows from the attenuation tank are regulated to the second stage DAF unit. Metal salt and polymer can be introduced upstream of an in-line plug flow flocculation reactor prior to entering the DAF unit. The metal salt and polymer are important for achieving sufficient nitrogen removal so that the activated sludge system can meet permit limits.

Effluent from the second stage DAF unit drains to a large standpipe/wet well, from where it is subsequently pumped to the anoxic basin in the activated sludge process.

Sludge from the second stage DAF flows to the main sludge hopper where it is combined with primary DAF sludge and thickened waste activated sludge for total sludge processing. The second stage DAF should be adequate at the projected expansion operating basis.

The second stage DAF unit has been used only on a trial basis since startup over the last 22 months. Experience shows that the facility can operate without it at the current flows and loads. Therefore no changes are anticipated for this unit process.

Activated Sludge/MBR. The membrane bioreactor (MBR) is an activated sludge process that uses membranes in lieu of clarifiers as the solids/liquid separation step. The activated sludge system relies on suspended bacteria that consume organic material. They convert the organic material, expressed as chemical oxygen demand (COD) or biochemical oxygen demand (BOD_5), into more bacterial biomass. In doing so, nitrogen and phosphorus are consumed to support growth of the bacteria. Metal salts (ferric chloride) are added, as needed, to the treatment process to further reduce soluble phosphorus in the liquid stream. The system uses the aerated reactors to oxidize ammonia to nitrate (nitrification) and a primary non-aerated biological reactor to transform nitrate to nitrogen gas (denitrification). Secondary non-aerated (post anoxic) reactors with external carbon source (sugar) dosing are provided, if needed, to polish additional nitrate out of solution, as may be needed to achieve the stringent total nitrogen discharge limits. The specific unit process sizing information is listed in Table 4.

One membrane tank has been sized to process the design flow during maintenance operations, providing the necessary level of redundancy. The membrane system includes two membrane tanks with two cassettes each. Each membrane tank has room for another cassette providing a 50% expansion capability for future growth or additional flows if required..

Current solids retention time (SRT) conditions are as follows:

- When two aeration tanks are in operation with 10,000 mg/L to 12,000 mg/L mixed liquor suspended solids concentration for current loads, the activated sludge solids retention time has been approximately 50 days.
- In a single tank, that would equate to approximately 25 days.
- If the load to the activated system is roughly doubled, the available SRT will roughly be reduced by a factor of two. The total SRT would then be around 25 days with both tanks in service or 12.5 days with one tank in service.

General Electric (GE), the membrane supplier, has been notified and responded that a minimum aerobic SRT of 12-15 days is acceptable for temperatures above $20^{o}C$. Therefore, the system load can increase by a factor of two and still allow a tank to be taken out of service to inspect or replace aeration diffusers without voiding the membrane warrantee.

TABLE 3
R3 Innovations
Aeration Basin SRT Picture

Parameter	**Design Condition**	**Approximate Current Condition # 3,813 head/day**	**New Design Condition @ 7,500 head/day**	***New Design Condition With Peptone***
COD Load to Current	125%	100%	197%	345%
Current SRT, (2) tanks, days	--	50	--	--
SRT (3) Tanks	NA	NA	NA	22
SRT (2) Tanks	40	50	25.4	14.5
SRT (1) Tanks	20.0	25.0	12.7	7.3
No. Duty+Standby Tanks Required	1+1	1+1	1+1	2+1
No. New Tanks Required	0	0	0	1

Table 3 illustrates the aerobic SRT picture. The increase loading associated with the increased production and case processing, one additional 760 m^3 aeration tank will be required to maintain an aerobic SRT of at least 22 days. Current blower capacity within the existing facility is sufficient to accommodate the increased production capacity without any changes, however, there will be a loss in redundancy with this component of the system as a result. It is recommended that a full service standby be readily available should a blower unit require significant repairs so as to limit the downtime periods. A site plan showing the location of the new aeration basins is shown in Figure 2 at the end of this report.

In discussing the potential operational change with GE, they were given and provided comments on operational data over the last 18 months as well as the new design condition. They noted the following:

- **TMPs**. Transmembrane pressures, the pressure loss across the membrane, are higher than expected and poor recovery after apparent cleaning events. Based on GE comments, R3 Innovations may want to consider bringing them out to help with one of the periodic chemical cleans.
- **SRT.** GE noted a minimum 12-15 day SRT would be acceptable for temperatures above 20^oC. The GE warrantee on the membranes would be unaffected by the operation of at lower SRT.
- **Blowers for Air Scour.** GE noted relatively high back pressure on the blowers for air scour. These units had variable frequency drives installed to allow turndown of the units to meet the GE specifications. GE asked that the blower VFD setting be checked to ensure they are operated as required. GE also suggested pulling the cassettes to

inspect the aeration diffuser to see if there is any biological or chemical fouling at the diffuser orifice.

- **Temperature Effects on Membrane Properties.** The operating temperatures per original design were 10^{o}C to 30^{o}C. Actual operating temperatures in the membrane tanks range up to 35^{o}C. Higher temperatures can affect the membrane properties. GE noted that the membrane cassettes should be pulled and inspected to understand if the membranes have shorted at all as a result of the higher temperatures.

The addition of the additional flow and loads will require additional membrane capacity. Since transmembrane pressures have been higher than expected, we would recommend adding a third cassette to each membrane train.

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 for disinfection capacity of 120% of the design flow (1,825 m^3/day), thereby providing 100% backup capacity.

The addition of 30% additional flow will require an additional UV module.

Effluent Cooling. A cooling tower process is installed to provide controlled effluent temperatures. The process has the ability for recirculation and automatic bypass to regulate the effluent temperature.

Biosolids Handling. Several sludge streams are produced from the primary treatment and the activated sludge systems. The sludge flow from the first stage DAF is high in fats, oils, and grease. The first stage sludge is recombined in a common hopper with sludge from the second stage DAF. The combined DAF sludge streams are mixed with the waste activated sludge prior to dewatering in two centrifuges.

The original design included a sludge calculation for two pretreatment DAF units that were expected to produce approximately 1,200 kg/day total solids, including metal salt complexes, with the second stage DAF producing the most sludge. The activated sludge DAF system is expected to produce 840 kg/day total solids, including metal salt complexes.

Current sludge production appears to be near the design value. The facility produces five 20 cubic yard roll-off bins per week or approximately 35 tones per week. Dry solids production for the 25% cake solids equates to 8.75 dry tones per week. This corresponds to approximately 1,750 kg/day during the production week which is over 80% of the 2,090 kg/day.

Centrifuges operate a total of approximately 6 to 7 hours per day with two centrifuges on-line at the maximum pumping rate of 1.7 L/s. for each pump Doubling the plant loading would approximately double the sludge production. This would result in 12-14 hours of operation per day for each unit. Anything beyond 12 hours per day operation may not provide adequate downtime required for reliable operation. If one unit is out of service for any reason, the other unit will have to run for double duration to process the same volume of sludge. Therefore, if two units run for more than 12 hours, system redundancy will not be properly provided.

The centrifuges were, however, specified for a load greater than the theoretical design number in an effort to extend the wear and increase performance. The centrifuge feed pumps could then be modified to produce more flow. With such a large increase in organic load from the addition of the peptone stream, we recommend replacing the sludge pumps. Pipe sizes need to be checked to ensure they are adequately large.

Current chemicals which are used in the treatment system for both to supplement treatment or for special cleaning of equipment includes the following. For each chemical listed, the impacts on the quantity of chemical used associated with the increased flows and loads as discussed hereinbefore are as follows:

- Citric acid: This is a chemical used for cleaning the MBR membranes. No changes in quantity of this chemical is anticipated
- Ferric chloride: This chemical is used for removal of phosphorus. The chemical usage will increase to an estimated 1,494 kg/day at full production.
- Magnesium Hydroxide: This chemical is used for alkalinity adjustment. The chemical usage will increase to an estimated 1,026 kg/day at full production.
- Polymer: Polymers are used for to both improve solids removal in the dissolved air flotation (DAF) unit and for solids dewatering in the centrifuge. Estimated future quantities will be 45 kg/day for use in the DAF and 102 kg/day in the centrifuge.
- Sodium Hypochlorite: This is a chemical used for cleaning the MBR membranes. No changes in quantity of this chemical is anticipated
- Sugar: Sugar was planned to be used to increase treatment within the system. Sugar has not been required to be used, therefore no change is anticipated
- Potable water: No change

Staffing. Due to the change of HyLife Foods operations going from a single to a double shift of production, R3 Innovations will increase staffing to mirror the production time at the processing facility. This will include 2 additional staff members Monday to Friday working a second shift to accommodate this change.

Monitoring and Inspection Requirements: No additional monitoring or inspection procedures will be required under the new project flow and loads.

Decommissioning of Existing Facilities: No facilities will be decommissioned with operation under the new projected flow and loads.

CONCLUSIONS

This analysis reviewed the R3 Innovations Industrial WWTP with an increased load in mind corresponding to up to 7,500 hogs per week plus the addition casings operation. In the previous analysis, processing facility production over a five day period was expected to result in less than 1,520 m^3/day. Plant production will be over an extended daily period; therefore, wastewater flows will be prolonged, as opposed to generating significantly higher instantaneous flow rates.

Capital Requirements. Table 4 provides a list of associated capital improvements necessary for the addition of the peptone line. The addition of the peptone waste stream will significantly increase the organic loading to the wastewater facility but will not significantly increase the hydraulic loading. If treatability work was available, the organic loading projection may be reduced through treatment at the source. In the absence of that information, one has to assume full treatment at the wastewater treatment facility. That will trigger improvements associated to sludge pumping, an aeration basin, and a new larger blower.

TABLE 4
R3 Innovations
Summary of Required Improvements

New Equipment	**New Design Condition @ 7,500 Hogs per day**	**New Design Condition with Peptone**
COD Loading Factors		
From Current Condition	197%	345%
From New 7,500 Hogs	100%	175%
New Primary Equipment?	No	No
New Sludge Pumping Equip.	No	Required
New Aeration Basin	No	Required
New Blowers	No	Required
New Membrane Equipment	No	Required
New UV Reactors	No	Required
Can this process meet permit?	yes	yes[A]

A. Assumes a low fraction of soluble non-biodegradable organic nitrogen, similar to existing quantities

Cost opinions presented in Table 4 are based on knowledge of the site and an attempt to anticipate local contractor conditions. Further backup on the cost developments is provided as an attachment to this report. Actual budgetary estimates or quotes were obtained for the aeration basin work and the membrane work. Titan Environmental worked through the aeration basin and GE developed a proposal for two new cassettes. The GE proposal evaluated a 50% hydraulic increase and went through the entire membrane package to ensure there would not be a bottleneck for the hydraulic condition with two new cassettes and 36 modules in each to match the existing cassettes.

Tuning/Optimization Recommendations. As noted previously, the Owner should consider certain items to ensure the plant operation is optimized. Some of those items are repeated as follows:

- **Operations.** The wastewater facility is being operated on a long one-shift facility. Doubling the load will require a minimum of doubling the operation time. We recommend R3 Innovations move towards a 24-hour 7-day per week operations program.
- **Special tuning, vendor assistance and training.** The DAF units, membrane units, and centrifuges are each relatively sophisticated systems. We recommend getting help periodically to ensure each system is running as well as possible. This may be quarterly to yearly discussions and site visits. Based on our review and discussions with GE, we believe an on-site review and further training on the membranes is important at this point.
- **Utility Water.** Inventory the utility water system. There has been on-going discussion of adding a variable frequency drive to the utility water pumps. That and other improvements may be necessary. A survey of water demands may also be important. One candidate for volume conservation is the cooling devices for the centrifuge backdrives. They currently allow an unregulated flow of water. At the very least, a rotameter and throttling valve could be installed to understand the water use. It will be likely that the flows could be reduced with a throttling valve without causing overly high temperatures.
- **Carbon/Sugar Dosing System.** To date, the facility has not needed to use the carbon dosing system in conjunction with the post anoxic tanks. Bringing the facility to the operational limit will require all the tools in the plant to be understood and ready for use . We recommend starting the supplemental carbon use prior to the point where any final effluent total nitrogen values approach the permit limit.

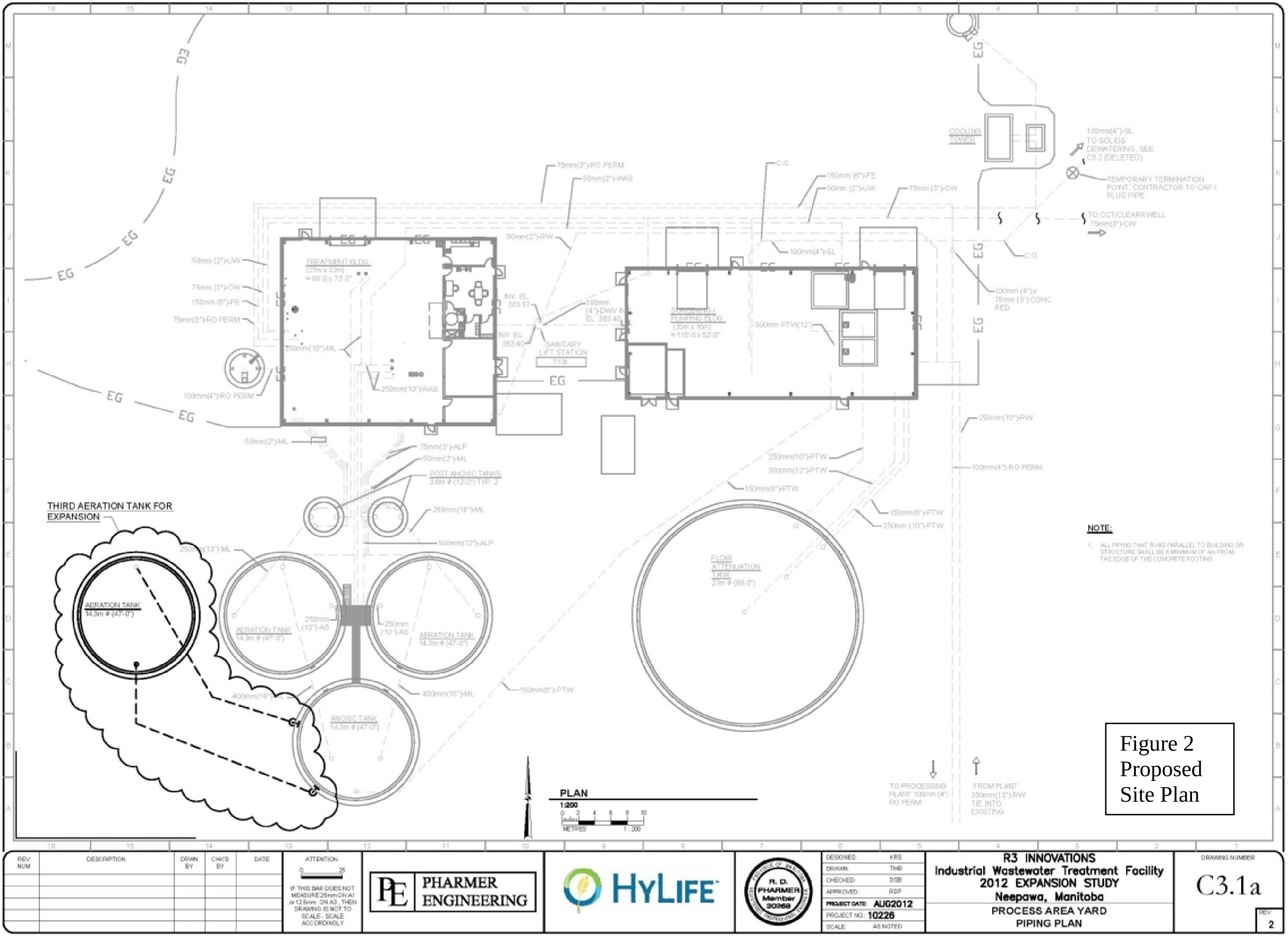

Figure 2
Proposed
Site Plan