MAPLE LEAF PORK - BRANDON, MANITOBA

EXPANDED BIOLOGICAL TREATMENT FOR 18,000 HOGS/DAY

PRELIMINARY STUDY AND REPORT

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PRELIMINARY STUDY AND REPORT

I. INTRODUCTION

The purpose of this Study and Report is to evaluate the treatment capacity of existing pretreatment and waste treatment facilities and determine what will be required for a future double-shift slaughter of 18,000 head per day. The scope of this report includes: 1) description of existing facilities, 2) development of design parameters, 3) projection of probable effluent limitations, 4) assessment of the adequacy of existing pretreatment facilities, and 5) evaluation of existing waste treatment facilities.

II. EXISTING FACILITIES

A. Packing Plant

The Maple Leaf Pork plant at Brandon, Manitoba is a hog slaughtering facility planning to increase production from a current design kill rate of 54,000 hogs/wk during a single shift to 108,000 hogs per during a double-shift, six days/wk. Currently the maximum slaughter has been about 50,435 hogs during a five-day week and nearly 52,890 hogs during a six-day week with around 2500 hogs killed on Saturday. However hog weights, at about 113.5 kg/hog (250 lb/hog), have been somewhat higher than the previous design weight of 109 kg/hog (240 lb/hog). About 1460 people are currently employed at the plant, including salaried and part-time employees.

The plant does no processing, has no smokehouses, produces no case-ready product including ground and seasoned pork, but does bone primal cuts (large pieces from the initial cutting up of the hog carcass).

By-product operations include blood and hair collection, casings saving, bung processing, and edible rendering. Stomachs can be opened and processed as edible, although sales of this material may limit the amount of stomachs processed. No inedible rendering is practiced, so all inedible materials including unopened stomachs and chitterlings and screenings and solids from pretreatment, are loaded on trucks for processing offsite. Much of the blood is collected in stainless steel troughs, equipped with citric acid sprays to prevent clotting, and pumped into a tanker trailer for processing offsite. As much as possible, the remaining "floor blood" is collected and pumped onto the inedible material trailer. Hair is collected and loaded on trucks for processing offsite. Mucosa is recovered from the casings, but the remaining contents are discharged to the sewer. Partial processing of the mucosa is practiced with the resulting peptone directed to wastewater pretreatment. Bungs are saved with the contents discharged to the wastewater pretreatment. Edible lard is recovered for sale with a two-stage centrifugal separation process. The meat tissue from this operation is conveyed to the inedible rendering trucks, while the sludge phase is collected for pumping onto the same inedible trucks.

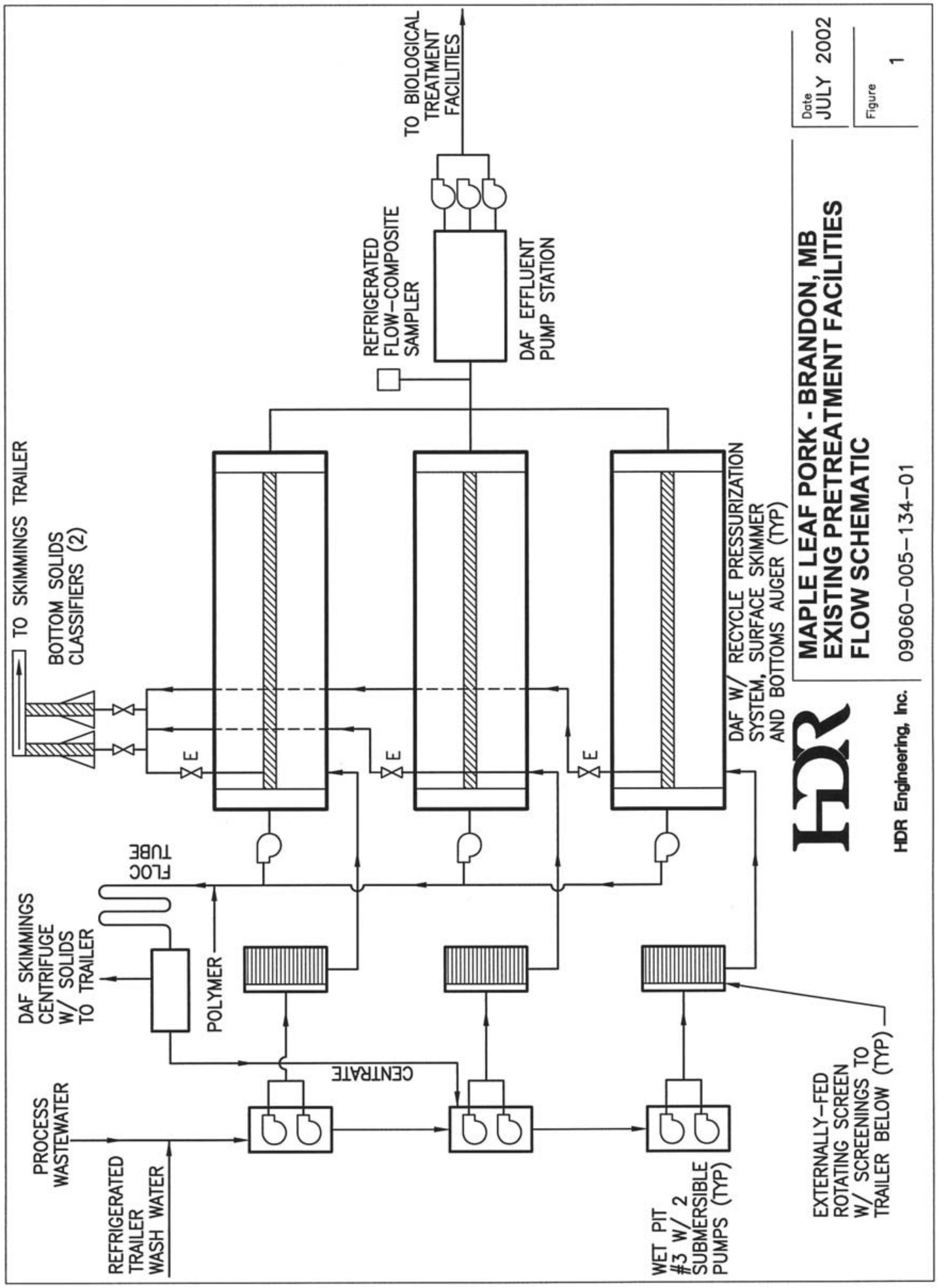
The refrigeration system is direct ammonia cooled. Air compressors are also air-cooled. Potable water is used to wash reefer trucks, but no livestock trucks are washed onsite. Manure from the livestock pens is hosed down to wastewater pretreatment.

B. Pretreatment Facilities

Wastewater from the packing plant flows by gravity to the pretreatment building where it enters three separate wet pits in series. See Figure No. 1. The raw wastewater is pumped with two submersible pumps in each wet pit. The pump controls utilize ultrasonic level sensors in each wet pit to activate pumps in that wet pit. Alternation of the lead is done manually. The two pumps in each wet pit only supply wastewater to one of the three externally-fed rotating screens located on an elevated platform above the wet pits. The screens are equipped with 1.0-mm openings for recovery of coarse solids. The screenings are directed into a trailer for hauling offsite for rendering.

After screening, wastes flow by gravity to three, parallel dissolved air flotation (DAF) systems for recovery of grease and fine solids. Each DAF unit can only receive flow from one of the rotating screens. The above-grade, rectangular stainless steel DAF units are

Figure 1 - Pretreatment Flow Schematic



each equipped with high-pressure recycle pressurization systems. Each DAF tank has effective surface dimensions of 14.3 m long by 3.0 m wide (approx. 46.92 ft x 9.84 ft). The first half of each DAF tank was originally equipped with short, inclined plates about 400 mm apart, although these plates have since been removed from all three of the DAF units due to problems with plugging with fat.

Bottoms solids are augured to the influent end of each DAF tank where they are periodically blown down to a pair of stainless steel classifiers by a time clock-activated electric valve on each DAF. Heavy solids from each classifier are deposited on a belt conveyor that dumps this material into the screenings trailer for off-site rendering.

Material floating on the surface of each DAF is skimmed with a chain and flight mechanism into a small hopper at the influent end of each DAF tank. A level sensor in each skimmings hopper turns the skimmers on or off, depending on the skimmings level in the hopper. DAF skimmings are pumped with progressing-cavity pumps, equipped with VFDs, to a flocculation tube (also called floc tube or windings) on the elevated platform near the rotary screens. A polymer solution is made up on the platform by mixing water and a dry cationic polymer in a polymer makeup unit. This polymer solution is metered into the DAF skimmings as they enter the windings to flocculate the solids before they enter a Pieralisi decanter centrifuge without a back drive. Centrate is discharged back into the middle wet pit, while the solids are discharged into a trailer and hauled to Winnipeg for rendering or landfilling, if the material does not meet the renderer's requirements.

After screening and flotation, the pretreated wastewater flows by gravity to a large, below-grade wet pit. An ISCO refrigerated sampler is available to collect time-composited samples of the influent into the wet pit. Three Gorman Rupp T-8 pumps are available to pump the wastewater from this below-grade pit to the City of Brandon's biological wastewater treatment facilities that serve the Maple Leaf plant. Steam can be injected into the wastewater during production days as necessary to maintain the required 30^{o} C wastewater temperature in the effluent from the anaerobic lagoon at the City's treatment system. There is no temperature regulator to control the amount of steam injected; steam is regulated manually.

Wash water from the refrigerated trailer wash flows by gravity to influent wet pits for pretreatment. No livestock trailers are washed at this facility.

An estimated 138 m^3/day of sanitary wastes from toilets, urinals, lavatories, drinking fountains, the laundry, and the cafeteria flow by gravity to the sanitary waste lift station located just west of the pretreatment building. This sanitary sewage, from about 1460 plant personnel, is pumped with two submersible pumps from a wet pit to a screen for solids removal. After screening the sewage enters a second pit where two submersible pumps lift the sewage to the anaerobic lagoon at the City's adjoining treatment plant. The only way to measure the flow of sanitary sewage is with an hour meter on the pumps, which has not appeared to be reliable.

C. Biological Treatment Facilities

1. Covered Anaerobic Lagoon

Pretreated process waste from the packing plant is metered with a magnetic flow meter and sampled with a refrigerated flow-composite sampler just before entering the anaerobic lagoon. See Figure No. 2. After sampling and metering, the flow is split into four anaerobic influent lines. Additionally there is a valved line from the influent to the anaerobic bypass pump station wet pit. Sanitary sewage is also pumped into the anaerobic lagoon through a separate line. Exclusive of sanitary sewage, anaerobic influent design parameters for the slaughter of 54,000 hogs/wk at 109 kg/hog during a single-shift kill, six days/wk were as shown in Table I.

Figure 2 - Waste Treatment Flow Schematic

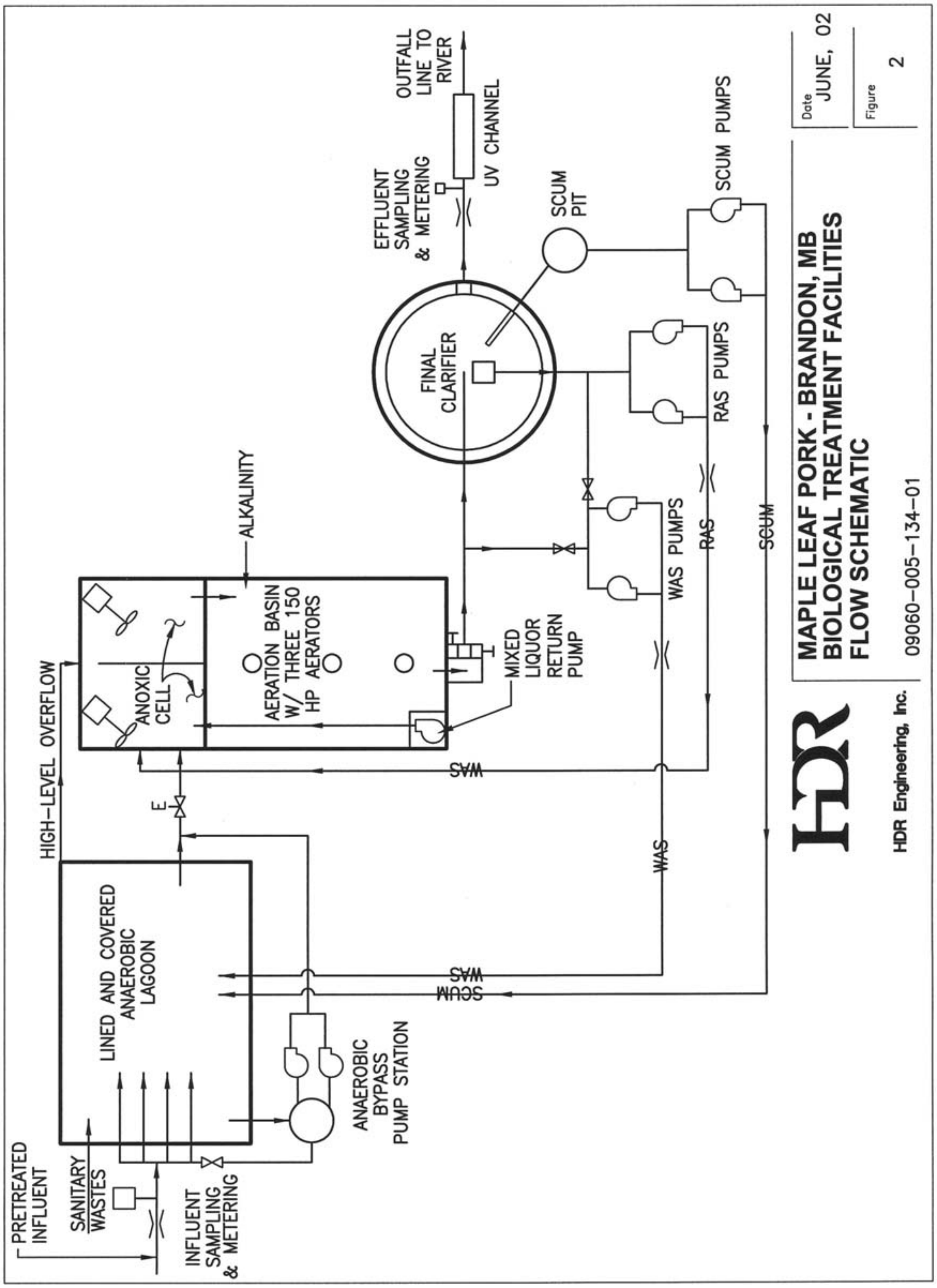


Table I
Existing Production Waste Influent Design Parameters

Parameter	Maximum Week	Concentration
Flow	31,200 m^3/wk	-
COD	103,740 kg/wk	3325 mg/l
$CBOD_5$	59,280 kg/wk	1900 mg/l
Total Suspended Solids (TSS)	39,312 kg/wk	1260 mg/l
Total Kjeldahl Nitrogen (TKN)	6,145 kg/wk	197 mg/l
Phosphorous (P)	1,000 kg/wk	32 mg/l
Oil and Grease (O&G)	5,865 kg/wk	188 mg/l

The anaerobic lagoon is lined with a double HDPE liner with leak detection/collection system. The lagoon is also equipped with an insulated HDPE cover to minimize heat loss and collect biogas from under the cover. Biogas is withdrawn from under the lagoon cover with four biogas blowers (space is available for two more). These blowers are Sutorbilt 4MP positive-displacement blowers V-belt driven by 7.5/15-hp, dual-voltage motors. Each blower is sized for 354 m^3/hr. All blowers are equipped with VFDs and at full speed, one blower is more than capable of handling the entire biogas volume currently generated. Biogas containing an estimated 75 percent methane and small concentrations of hydrogen sulfide can be flared or utilized in a dedicated biogas boiler at the packing plant to generate hot water.

Flow can be pumped around the anaerobic lagoon with a bypass pump station. Flow from the anaerobic influent piping or from two lines from the southeast corner of the anaerobic lagoon can be directed into the wet pit for this pump station. A package pump station is mounted over the wet pit and utilizes two Gorman Rupp T-6 self-priming pumps. A magnetic flow meter is available in an adjoining pit to meter this bypass flow. A portion of the flow is normally bypassed around the lagoon with as much as 2000 m^3/day bypassed at times.

Anaerobic bypass flow combines with two effluent lines from the anaerobic lagoon. Recently provisions were added to automatically throttle the flow rate out of the lagoon to a preset rate to equalize the flow over seven days per week.

As such, the maximum volume with 0.5 m (1.64 ft) of freeboard is 39,973.6 m^3 (10,561,025 gal) and the minimum volume is 30,406 m^3 (8,033,265 gal). This results in the difference of 9,567.6 m^3 (2,527,760 gal) available for flow equalization. A separate high water overflow line to the subsequent anoxic basin is included in case the water level becomes too high (only 0.31 m or 1 ft of freeboard) in the anaerobic lagoon.

Mixed liquor or waste activated sludge (WAS) and scum from the final clarifier are also pumped through separate lines into the anaerobic lagoon for settling, digestion and thickening. The anaerobic lagoon is equipped with five 250-mm (10-inch) sludge draw-off lines so sludge can periodically be removed from the lagoon and land applied at agronomic rates. The solids content of this sludge has varied from 2.5 to 4 percent when sludge has been removed in the past.

2. Activated Sludge System

Effluent from the anaerobic lagoon flows by gravity to a subsequent activated sludge system designed to nitrify and denitrify. The activated sludge system consists of a combination anoxic/aeration basin, a final clarifier and sludge and scum pumping facilities.

a. Anoxic basin. Influent enters the initial anoxic zone of the concrete anoxic/aeration basin. The anoxic cell holds approximately 1152 m^3 (304,360 gallons) at a water depth of 4.5 m (14.76 ft) and is divided into two halves. Each half is equipped with a 7.5-hp submersible mixer. This basin is intended to recover alkalinity and reuse oxygen while treating BOD. To enhance this recovery by providing more BOD for denitrification, flow can be bypassed around the anaerobic lagoon, as discussed previously. Nitrates are returned to this basin with the Return Activated Sludge (RAS) from the final clarifier and by pumping mixed liquor from the end of the subsequent aeration basin back to the inlet end of the anoxic basin with a 420 lps (6660 gpm), 7.5-hp submersible pump.

This submersible pump is the same as the submersible mixers in the anoxic basins and a spare unit is available as a standby. Dissolved oxygen in the anoxic basin is typically around 0.2 mg/l.

Monthly total nitrogen reductions across the entire treatment system, due to both denitrification and nitrogen uptake in the waste sludge, have been as high as nearly 60 percent and as low as 5.5 percent. Despite alkalinity recovery through denitrification, however, 22 metric tonnes of unslaked lime is still added to the subsequent aeration basin every three to four weeks. This unslaked lime stored in a lime silo equipped with a slaker to hydrate the lime before it is added as a slurry.

b. Aeration Basin. After anoxic treatment, the wastewater enters the aerated portion of the anoxic/aeration basin for nitrification of the ammonia and further BOD reduction. This aerated cell holds approximately 3456 m^3 (913,075 gallons) at a water depth of 4.5 m (14.76 feet) and is equipped with three dual-speed, 113/150-hp, slow-speed surface aerators which promote aeration and mixing. A spare 113/150-hp aerator motor is also available as a standby unit. Normally only the first two aerators are operated. Dissolved oxygen is typically around 4.5-5 mg/l near the influent to this basin and 2.0 mg/l near the effluent. In addition to changing the speed of the aerators, oxygen transfer can be varied by adjusting the submergence of the aerator propellers. This is accomplished by varying the height of a slide gate at the effluent structure for the aeration basin. From this basin, the mixed liquor enters an adjoining splitter structure that is designed to potentially split the flow between three final clarifiers.

c. Final Clarifier. Currently mixed liquor enters a single 22.5-m (73.8-ft) diameter final clarifier with an inboard launder. This 4.5-m (14.76-ft) deep, concrete clarifier is equipped with a WesTech double-centerwell, full-sweep skimmer and a sludge scraper mechanism for settled sludge removal. The sludge blanket depth is continuously monitored by a Drexelbrook sludge blanket sensor. A spare clarifier drive unit is available as a standby unit.

d. Sludge and Scum Handling. Settled sludge is pumped from the clarifier sludge hopper and returned to the anoxic cell with one or two Ingersoll Dresser horizontal centrifugal pumps. This RAS flow is metered with a magnetic flow meter.

Sludge can be wasted from the activated sludge system by either pumping waste activated sludge (WAS) from the final clarifier sludge hopper or by pumping mixed liquor from the influent side of the clarifier splitter structure with one or two Ingersoll Dresser horizontal centrifugal pumps. In either case, this flow is metered with a magnetic flow meter and then pumped back to the southeast corner of the anaerobic lagoon.

From the clarifier skimmings hopper, the scum is deposited into a small concrete scum hopper adjoining the final clarifier wall. Scum is pumped from this hopper with one of two Wemco Hidrostall pumps back to the southeast corner of the anaerobic lagoon through a forcemain separate from the sludge wasting line.

3. Effluent Disinfection, Sampling, Metering and Discharge Facilities

Before discharge the final effluent is metered and then disinfected with a Trojan 3000 ultra-violet (UV) disinfection system. UV lamps are mounted on four arms for swinging out of the channel for maintenance. A baffle was installed in the UV channel to block off a third of the channel. If necessary in the future, this baffle can be removed so two more moveable arms with UV lamps can be installed.

After disinfection the effluent is sampled with a refrigerated flow composite sampler and discharged through a 375-mm (14.75-inch) gravity outfall line to the Assiniboine River.

III. DESIGN PARAMETERS

After review of operating data and discussion with management, the following design production basis and flows have been established for a two-shift kill and cut.

A. Production

- Kill and Cut @ double shift, 5 or 6 days/wk
  - 18,000 hogs/day at 120 kg/hog (265 lb/hog)
  - 2,160,000 kg/day

- Maximum Barn Capacity
  - 10,080 hogs

- Byproduct Operations:
  - Stomach processing
  - Casing processing
  - No chitterling processing
  - Bung processing
  - Ham Boning
  - No processing, smokehouses, or case-ready product
  - Possibly ground and seasoned pork
  - Edible Rendering
  - No inedible rendering currently, remote possibility it may be considered in the future

B. Flow

Table II
Production Waste Design Flows

Kill Days/Week	5	5.5	6
Production Shift			
Current Operations			
m^3/hog	0.255	0.255	0.255
m^3/day			
Two Shifts	4600	4600	4600
One Shift	N/A	2300	N/A
Stomach Processing, m^3/day			
Two Shifts	550	550	550
One Shift	N/A	275	N/A
Future Inedible Rendering,			
m^3/day	365	365	365
Two Shifts	N/A	183	N/A
One Shift			
Sanitation, m^3/day	2150	2150	2150
Average Production Days, m^3/day	7665	7665	7665
Monday - Thursday	7665	7665	7665
Fridays	7325	7665	7665
Saturdays, m^3/day	1000	4908	7325
Sundays, m^3/day	1250	1250	1250
Total Weekly, m^3/wk	40,235	44,483	46,900
Peak hourly flow, m^3/minute	6.5	6.5	6.5
Instantaneous peak, m^3/minute	10.5	10.5	10.5

C. Sanitary Waste Characteristics

At least initially, it appears about 900 more employees will be added with the second shift production for a total around 2360. However because additional employees could be required for expanded conversion or value-added products in the future, sanitary wastes of the quantity and character shown in Table III will be used for design, based on a maximum employment of 2,850 persons.

Table III
Sanitary Waste Design Characteristics

FLOW:	
Non-Kill Days	25 m^3/day
Kill–Day Average	250 m^3/day
Peak Hourly	1.1 m^3/minute
Instantaneous Peak	1.65 m^3/minute
CONSTITUENTS:	
$CBOD_5$	480 mg/L
	120 kg/day
TSS	480 mg/l
	120 kg/day
TKN	32 mg/L
	8 kg/day
Total P	12 mg/L
	3 kg/day

IV. PHYSICAL PRETREATMENT EVALUATION

The existing pretreatment facilities were designed for a peak hourly flow of 6.5 m^3/min (1850 gpm) and an instantaneous peak flow of 10.5 m^3/min (2775 gpm). These are essentially the same parameters as the new design parameters, since adding a second production shift doubles the period of production flows and moves sanitation to the third shift. As a result there is little change to design flow rates, the production period just lasts longer. The design of the pretreatment units is essentially all based on peak flow rates. Consequently the existing pretreatment units will continue to adequately pretreat wastewater from a two-shift production. Over the next several years Maple Leaf may implement some relatively minor changes to the pretreatment facilities to simplify and improve operation and maintenance and to improve the quality of the recovered materials. However it is doubtful that these modifications will yield a noticeable change in quality of the effluent from the pretreatment facilities.

A. Raw Waste Lift Station and Piping Modifications

Raw wastewater flows through the three influent wet pits in series. Consequently a disproportionate amount of the solids and fat settle or float in the first wet pit. This is visually evident by comparing the large amount of screenings removed on the first rotating screen that serves the first wet pit with that removed on the third screen that serves the final wet pit. Therefore the subsequent dissolved air flotation units (DAFs) following the screens similarly receive unequal solids and fat loadings. Presumably DAF removals would be somewhat better if the loading to each unit were similar. Mixing the first two wet pits with an air lance using compressed air was tried as a simple, economical solution, but did not prove entirely effective. Current plans are to isolate the third pit and operate the plant on the first two pits, leaving the third pit available as a back up.

The existing raw waste pumps periodically jam with solids discharged into the raw waste pit. Maintenance of these pumps is labor intensive and their useful life is reduced. As a result, consideration in being given to replacing the existing submersible pumps with high-quality, submersible Vaughn Chopper Pumps. To match variable influent flow rates, as many as six submersible pumps may be used.

Currently there is no interconnection in the piping to the screens or in the piping from the screens to the dissolved air flotation (DAF) units. In a "worst-case" scenario, if a certain combination of two pumps, one screen and one DAF were to fail; the packing plant could be shut down. Consequently consideration is being given to modifying the piping from the raw waste lift pumps to provide a common header before the screens. Similarly underflow piping from the screens will enter a distribution hopper to feed each of the three subsequent DAF units.

B. Screening

Consideration is also being given to replacing the existing rotary screens with new FAN Screw Press Separators. These units have smaller 0.5 mm openings, produce drier solids, are compact, and are contained so the release of humidity and odors is minimized. Another potential benefit is that DAF skimmings could be directed back through the screen. The screenings act as a filter to remove and dewater the fat and solids in the skimmings.

The pumps feeding new FAN Separator screens would operate against more head, so screen replacement might logically be done at the same time as the existing pumps are replaced.

C. Access to Elevated Screens, Centrifuge and Polymer Makeup Unit

The current access to the existing screens and centrifuge is by a long vertical ladder. Routinely climbing this ladder to inspect, maintain and operate the centrifuge is tiring. This also makes it difficult to carry parts or other materials up this ladder. To enable good operation of these critical wastewater pretreatment units, it is strongly recommended that the existing ladder be replaced by a set of stairs.

D. Dissolved Air Flotation

Only minor operational changes are contemplated for the DAFs. Because wastewater will enter the DAF on a near-continuous basis with two production shifts and a sanitation shift, the surface skimmers and bottom solids removal systems should be operated continuously during production days to remove the skimmings and bottom solids as they accumulate. Near-continuous removal minimizes biological degradation of these materials and the resulting loss of soluble portions of these materials into the wastewater. To minimize water in the DAF skimmings and stirring up the surface of the DAFs, the surface skimmers should be operated at their slowest speed.

E. Skimmings Handling

Currently each DAF surface skimmer is turned off when the skimmings hopper at the inlet end is full. These hoppers are small and frequently limit operating time for the surface skimmers. This also requires switching back and forth between the three small skimmings hoppers to pump to the existing skimmings dewatering centrifuge. Since skimmings in the three different skimmings hoppers may be somewhat different in character, this complicates optimizing the polymer dosage and operation of the dewatering centrifuge. For these reasons, continually pumping skimmings from each of the existing hoppers with new air-operated, double-diaphragm pumps equipped with flap valves is being considered. The flow rate for these pumps is easily adjusted and they can even run dry at times. As part of this change, skimmings would then be pumped into a large, new stainless steel or glass-lined steel skimmings tank equipped with a mixer to keep the contents homogenized. The existing progressing cavity skimmings pumps would be relocated to pump the skimmings from this new tank for further processing.

F. Pretreatment Sanitation

To encourage good sanitation in pretreatment, minimize odors, and aid in maintenance; consideration is being given to: 1) providing a larger hot water heater, 2) installing an in-line steam blending station, or 3) running a sanitation line from the packing plant to several locations in pretreatment. If this addition is implemented, one outlet will be located on the platform for the screens and centrifuge.

Much of the odor in the pretreatment building was due to old grease caked on the DAF units turning rancid. Therefore grease accumulations along the top edges, and other areas, of the DAF tanks will be hosed off once each day, but it is not necessary to hose off the skimmers each day. However the DAF tanks routinely be drained, thoroughly cleaned, and inspected. To simplify this effort, a new drain line with valve was recently installed from the bottom of each tank to the effluent line.

G. Estimated Pretreated Effluent Characteristics

While the pretreatment modifications discussed previously would offer many benefits, including reduced maintenance and higher-quality recovered materials, they will have minimal impact on the pretreated effluent characteristics. Therefore with, or without, these pretreatment improvements, pretreated effluent characteristics are estimated as follows:

- **Flow**

Kill Days/Week	5	5.5	6
Average Production Days, m^3/day			
Monday - Thursday	7665	7665	7665
Fridays	7325	7665	7665
Saturdays, m^3/day	1000	4508	7325
Sundays, m^3/day	1250	1250	1250
Total Weekly, m^3/wk	40,235	44,083	46,900
Peak hourly flow, m^3/minute	6.5	6.5	6.5
Instantaneous peak, m^3/minute	10.5	10.5	10.5

- **$CBOD_5$**

Kill and Cut	= 6.6 kg/1,000 kg LWK/day x 2,160,000 kg/day
	= 14,256 kg/day
Stomach Processing	= 400 kg/day
Inedible Rendering	= 630 kg/day
Total	= 15,286 kg/day (1995 mg/l @ 7665 m^3/day)

- **COD**

Kill and Cut	= 12.2 kg/1,000 kg LWK/day x 2,160,000 kg/day
	= 26,350 kg/day
Stomach Processing	= 800 kg/day
Inedible Rendering	= 1220 kg/day
Total	= 28,370 kg/day (3700 mg/l @ 7665 m^3/day)

- **Suspended Solids (TSS)**

Kill and Cut	= 3.8 kg/1,000 kg LWK/day x 2,160,000 kg/day
	= 8208 kg/day
Stomach Processing	= 300 kg/day
Inedible Rendering	= 400 kg/day
Total	= 8908 kg/day (1160 mg/l @ 7665 m^3/day)

- **Oil and Grease**

Kill and Cut	= 1.1 kg/1,000 kg LWK/day x 2,160,000 kg/day
	= 2375 kg/day
Stomach Processing	= 40 kg/day
Inedible Rendering	= 215 kg/day
Total	= 2630 kg/day (343 mg/l @ 7665 m^3/day)

- **Total Kjeldahl Nitrogen (TKN)**

Kill and Cut	= 1.1 kg/1,000 kg LWK/day x 2,160,000 kg/day
	= 2375 kg/day
Stomach Processing	= 10 kg/day
Inedible Rendering	= 280 kg/day
Total	= 2665 kg/day (348 mg/l @ 7665 m^3/day)

- **Phosphorus**

Kill and Cut	= 0.135 kg/1,000 kg LWK/day x 2,160,000 kg/day
	= 292 kg/day
Stomach Processing	= 14 kg/day
Inedible Rendering	= 26 kg/day
Total	= 332 kg/day (43.3 mg/l @ 7665 m^3/day)

V. EFFLUENT DISCHARGE CRITERIA

Effluent limits are anticipated approximately as follows for discharge from the City's industrial wastewater treatment plant to the Assiniboine River:

- **BOD_5** 30 mg/l daily maximum
- **TSS** 30 mg/l daily maximum
- **Coliform** as the monthly geometric mean of one grab sample collected at equal time intervals on each of a minimum of three consecutive days per week

Fecal $\leq$ 200 MPN/100 ml

Total $\leq$ 1500 MPN/100 ml

- **Ammonia-N**

  Ammonia-N in the downstream fully mixed zone when Assiniboine River flows $\geq$ 7Q10.

  Shall not cause, or contribute to, un-ionized ammonia concentrations exceeding the Manitoba Surface Water Quality Objective for the prevailing pH and temperature at the nearest downstream model predicted fully-mixed river monitoring station.

  Shall not cause, or contribute to, the dissolved oxygen dropping below 5.0 mg/l at the nearest downstream model predicted location of lowest dissolved oxygen.

  Ammonia-N shall meet the requirements of the Fisheries Act, which specifies that the undiluted effluent shall not be toxic to trout fingerlings at the temperature and pH conditions in the receiving stream. From a practical standpoint, this limits the ammonia to about 5 mg/l in the winter and 2.5 mg/l in the summer.

- **Mixing Zone Toxicity**

  The effluent shall not cause or contribute to acute lethality to aquatic life passing through the mixing zone.

  The effluent shall not be acutely lethal to fish within the mixing zone so that more than 50 percent of the test fish exposed to 75 percent strength effluent die in the 96-hour static acute lethality test (Environment Canada's "Biological Test Method: Acute Lethality Test Using Rainbow Trout", Report No. EPS 1/RM/13 dated July 1990, or any future amendment).

- **Nutrients** – completion of river studies and assessment of the impact of nutrients on the Assiniboine River and Lake Winnipeg were delayed by the lack of low flows during recent years and are not yet complete. Preliminarily Manitoba Conservation has suggested an approach to interim nutrient limits as follows until the river studies and assessment are completed and final nutrient limits can be established:

Interim Nutrient Limits. The interim approach would be that no net increase in the discharge of nitrogen and phosphorus should occur unless it can be clearly shown from river studies and water quality modeling that no effect will be observed on algal growth. Since the river studies and water quality modeling have just been completed and are being analyzed, this dictates that no net increase in the discharge of nitrogen and phosphorus can occur. Therefore Table IV shows: 1) monthly nitrogen and phosphorus discharges from the plant since January 2000, 2) maximum monthly values, and 3) potential effluent criteria for nitrogen and phosphorus for each month. The potential effluent criteria were developed by Maple Leaf as a means to assess the success of various technologies being considered for the industrial wastewater treatment facility expansion in consistently achieving the direction provided in Manitoba Conservation's advice document

Table IV
Monthly Effluent Nutrient Amounts and Potential Effluent Criteria

	TOTAL NITROGEN							TOTAL PHOSPHORUS						
	Monthly Average, kg/day				Maximum Month		**Monthly Effluent Criteria**	Monthly Average, kg/day				Maximum Month		**Monthly Effluent Criteria**
MONTH	2000	2001	2002	2003	kg/day	kg/month	**kg/month**	2000	2001	2002	2003	kg/day	kg/month	**kg/month**
JAN		354.8	292.8	312.7	354.8	10,999	**10,999**		35.5	53.2	75.1	75.1	2,328.1	**2,328.1**
FEB	50.7	296.5	273.6	397.4	397.4	11,127	**11,127**	41.8	17.6	61.1	72.1	72.1	2,018.8	**2,018.8**
MAR	49.6	335.4	259.5	395.8	395.8	12,270	**12,270**	55.1	19.4	58.0	69.8	69.8	2,163.8	**2,163.8**
APR	108.9	363.2	281.3	408.8	408.8	12,264	**12,264**	77.5	34.0	53.6	67.8	77.5	2,325.0	**2,325.0**
MAY	137.1	376.2	281.4		376.2	11,662	**11,662**	37.9	23.4	43.7		43.7	1,354.7	**1,354.7**
JUN	199.3	368.1	317.2		368.1	11,043	**11,043**	42.2	30.2	41.8		42.2	1,266.0	**1,266.0**
JUL	226.5	326.0	341.4		341.4	10,583	**10,583**	51.4	33.0	52.3		52.3	1,621.3	**1,621.3**
AUG	114.2	313.2	349.0		349.0	10,819	**10,819**	35.7	27.8	54.2		54.2	1,680.2	**1,680.2**
SEP	108.7	330.1	338.0		338.0	10,140	**10,140**	40.3	38.2	53.4		53.4	1,602.0	**1,602.0**
OCT	272.3	340.0	313.2		340.0	10,540	**10,540**	50.6	33.8	58.8		58.8	1,822.8	**1,822.8**
NOV	313.7	326.3	401.9		401.9	12,057	**12,057**	63.7	33.2	68.9		68.9	2,067.0	**2,067.0**
DEC	206.9	268.4	376.1		376.1	11,659	**11,659**	37.8	47.8	76.1		76.1	2,359.1	**2,359.1**

Similarly Table V shows: 1) maximum weekly nitrogen and phosphorus discharges for each month since January 2000, 2) maximum weekly values for each month, and 3) potential weekly effluent criteria for nitrogen and phosphorus for each month.

Table V
Maximum Weekly Effluent Nutrients and Potential Effluent Criteria

	TOTAL NITROGEN						TOTAL PHOSPHORUS					
	Max Week, kg/wk				Max. Month	**Weekly Effluent Criteria**	Max Week, kg/wk				Max. Month	**Weekly Effluent Criteria**
MONTH	2000	2001	2002	2003	kg/wk	**kg/wk**	2000	2001	2002	2003	**kg/wk**	**kg/wk**
JAN	270.3	3799	2135	2771	3,799	**3,799**	163.5	334.0	385.6	522.3	522.3	**522.3**
FEB	347.9	2151	1908	2800	2,800	**2,800**	476.0	171.3	458.2	531.5	531.5	**531.5**
MAR	428.0	2591	1785	2938	2938	**2,938**	434.5	178.5	436.3	523.7	523.7	**523.7**
APR	867.7	3080	2078	3461	3,461	**3,461**	430.6	347.7	429.8	607.3	607.3	**607.3**
MAY	1195	2617	2263		2,617	**2,617**	287.0	195.7	388.7		388.7	**388.7**
JUN	1388	2841	2235		2,841	**2,841**	335.3	310.4	354.3		354.3	**354.3**
JUL		2570	2408		2,570	**2,570**		302.6	450.0		450.0	**450.0**
AUG	1608	2689	2767		2,767	**2,767**	333.9	274.9	506.0		506.0	**506.0**
SEP	1345	2449	2645		2,645	**2,645**	393.2	331.6	472.9		472.9	**472.9**
OCT	2411	2594	2438		2,594	**2,594**	498.0	280.8	527.2		527.2	**527.2**
NOV	2259	2436	2983		2,983	**2,983**	451.3	291.7	567.0		567.0	**567.0**
DEC	1537	2126	2778		2,778	**2,778**	443.8	394.9	553.7		553.7	**553.7**

VI. CHEMICAL PRETREATMENT AND BIOLOGICAL TREATMENT EVALUATION AND RECOMMENDATIONS

Much of the design of modifications to the existing treatment facilities is predicated on the need to meet new total nitrogen criteria in the effluent. Table VI shows the reductions required to meet the interim criteria for the lowest month or week.

A. Nitrogen Removal Options

Nitrogen can be removed from the wastewater by chemical pretreatment, through biological treatment, or with a combination of these two methods. Due to the high nitrogen removal rates required, multiple nitrogen removal steps will be required to even attempt to consistently achieve the required nitrogen removals.

Table VI
Nutrient Reductions Required to Meet Benchmark Effluent Nutrient Criteria

Wastewater	Parameter	Interim Limit	5-day Kill Wk	5.5-day Kill Wk	6-day Kill Wk
Influent	**Total N**		2006.2 kg/day[1] 338 mg/l	2218 kg/day[1] 338 mg/l	2338.6 kg/day[1] 338 mg/l
Influent	**Total P**		251 kg/day[1] 42.3 mg/l	277.6 kg/day[1] 42.3 mg/l	292.7 kg/day[1] 42.3 mg/l
Effluent	**Total N**	**Monthly**	338.0 kg/day[2] 56.9 mg/l 83.2 % Removal	338.0 kg/day[2] 51.5 mg/l 84.8 % Removal	338.0 kg/day[2] 48.9 mg/l 85.5% Removal
Effluent	**Total N**	**Weekly**	367.1 kg/day[3] 61.9 mg/l 81.7% Removal	367.1 kg/day[3] 56 mg/l 83.4% Removal	367.1 kg/day[3] 53 mg/l 84.3% Removal
Effluent	**Total P**	**Monthly**	42.2 kg/day[2] 7.1 mg/l 83.2% Removal	42.2 kg/day[2] 6.4 mg/l 84.8% Removal	42.2 kg/day[2] 6.1 mg/l 85.6% Removal
Effluent	**Total P**	**Weekly**	50.6 kg/day[3] 8.5 mg/l 79.8% Removal	50.6 kg/day[3] 7.7 mg/l 81.8% Removal	50.6 kg/day[3] 7.3 mg/l 82.7% Removal

[1] Weekly average influent design parameter, including sanitary wastes [2] Values taken from Table IV. [3] Values taken from Table V.

1. Chemical Pretreatment

There are a variety of chemical pretreatment approaches, but all rely on removal of protein in the wastewater, since protein is about 16 percent organic nitrogen. Removal of protein also inherently removes some phosphorus, since organic phosphorus is a component of protein. The most effective chemical pretreatment is with ferric compounds, either ferric sulfate or ferric chloride. Ferric compounds have an affinity for blood and other proteins and are very effective in their removal. It is also effective in removing phosphorus, both organic phosphorus in the proteins, as well as, inorganic phosphorus. Coagulation with ferric is usually best at a pH around 5.8. After adding ferric for coagulation of the proteins, anionic polymer is added for flocculation of the coagulated solids. While ferric is effective, it also creates a chemically-contaminated sludge that renderers will not take because it darkens their grease and meal and increases the acid content of the grease. This ferric-laden sludge can be land applied, but this necessitates dewatering, stabilization and storage during the portion of the year when land application is not feasible.

Alternatives to the use of ferric compounds consist of a tri-polymer system or a system employing acidulation to the iso-electric point (point of least solubility) of the proteins. Both of these systems are capable of removing organic nitrogen and phosphorus, but not inorganic phosphorus. With the tri-polymer system, about 75-100 mg/l of a polymer named poly-diallyl-dimethyl ammonium chloride is added first. Next 3-5 mg/l of anionic polymer are added and this is followed by about the same amount of cationic polymer. GRAS (generally recognized as safe) polymers can be used with the tri-polymer system. Due to the 75-100 mg/l of poly-diallyl-dimethyl ammonium chloride polymer used with this system, the sludge goes through a glue-like phase as it is dried, so many renderers are unwilling to take this material.

With acidulation, the pH of the wastewater is lowered to the iso-electric point, which is the point of lowest solubility of the proteins. In packing plant wastewater, the iso-electric point is typically around a pH of 4.5. At this point, many of the proteins come out of solution and are flocculated with GRAS polymer for removal. After acidulation to the iso-electric point, the pH of the wastewater must be neutralized before subsequent biological treatment.

Facilities for chemical pretreatment are all nearly the same regardless of whether ferric, a tri-polymer system, or acidulation is used. In all cases some degree of equalization is preferable, followed by addition of chemicals for coagulation of the proteins, then flocculation with polymer and finally removal of the flocculated protein in a DAF system. For ferric or acidulation, the DAF system should be corrosion resistant.

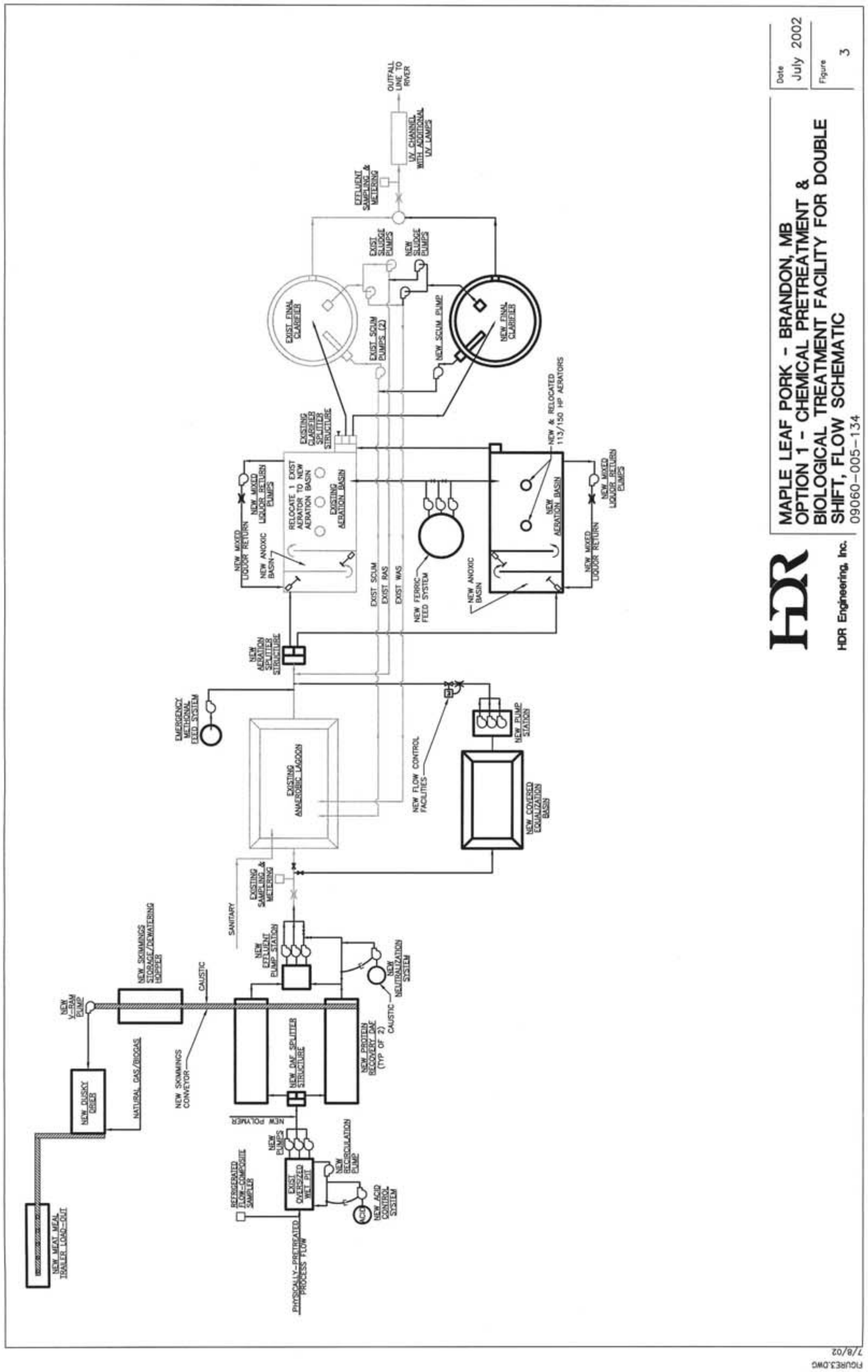
2. Biological Treatment

With biological treatment the two main mechanisms for nitrogen removal are: 1) nitrogen incorporated into the sludge and 2) nitrification/denitrification. Sludge that is wasted from the subsequent activated sludge system and then sent back to the anaerobic lagoon where it will settle, thicken and digest will contain about seven percent nitrogen when it is removed from the anaerobic lagoon along with anaerobic sludge formed by anaerobic treatment of the anaerobic influent wastewater. However, the bulk of the nitrogen removal must occur through nitrification/denitrification. With nitrification/denitrification, ammonia is first nitrified (oxidized) to nitrates/nitrites, which are then denitrified in an anoxic (without dissolved oxygen) environment to nitrogen gas that is released to the atmosphere.

B. Option 1 – Chemical Pretreatment and Biological Treatment

For this option, chemical pretreatment for protein removal will be provided ahead of biological treatment employing nitrification/denitrification. It is assumed acidulation to the iso-electric point will be utilized for chemical pretreatment because the DAF skimmings can be dried for sale as meat meal, which serves to offset the high chemical costs and eliminates chemical sludge disposal. Alternatively the sludge is acceptable to be sent for rendering, provided appropriate sludge characteristics can be attained consistently. Figure 3 shows the configuration of this option.

Figure 3 – Chemical Pretreatment and Biological Treatment Flow Schematic



1. Chemical Pretreatment

In this option, effluent from the physical pretreatment facilities would be forwarded to a new chemical pretreatment process. The existing oversized wet pit in the present pretreatment building would be utilized for partial equalization and acidification of the physically pretreated wastewater. Acid, probably sulfuric, would be metered into the wastewater from bulk storage facilities equipped for spill containment. A new recirculation pump would be provided to keep the oversized wet pit mixed. A pH probe mounted on the recirculation line would pace the feeding of acid to the wet pit.

Three new self-priming pumps (2 duty & 1 standby) would be installed to pump to two new chemical pretreatment DAF systems. Polymer would be added ahead of the DAFs for flocculation of the coagulated proteins. Skimmings would be neutralized with caustic and deposited in a new skimmings storage/decanting hopper. Skimmings would be pumped from the hopper to a new rotary kiln drier for drying to approximately 10 percent moisture. The dried material would be loaded onto trailers for sale as meat meal. Alternatively the skimmings could be thickened, using the existing centrifuge, or similar equipment, and sent for rendering.

Chemically pretreated wastewater would be pumped from a new wet pit with the existing Gorman Rupp pumps relocated from the existing oversized wet pit. Caustic would be used to neutralize the pH of the chemically pretreated wastewater before it is pumped to the biological treatment facilities. Chemically pretreated effluent quality is projected as follows:

	CHEMICALLY-PRETREATED WASTEWATER		
	INFLUENT (effluent from physical pretreatment)	**REMOVAL %**	**EFFLUENT (influent to the biological system)**
Flow, m^3/day	7665	0	7665
$CBOD_5$			
mg/l	1995	65	700
kg/day	15,286	65	5,350
COD			
mg/l	3700	65	1300
kg/day	28,370	65	9,930
TSS			
mg/l	1160	91.4	100
kg/day	8,908	91.4	766
Oil and Grease			
mg/l	343	>85	<50
kg/day	2630	>85	<395
TKN			
mg/l	348	55	157
kg/day	2665	55	1200
Phosphorus			
mg/l	43.3	40	26
kg/day	332	40	200

2. New Equalization Basin

The projected $CBOD_5$:TKN ratio of the chemically pretreated wastewater, at 4.46:1, is well suited for denitrification in the subsequent anoxic basins. Therefore no treatment of the $CBOD_5$ would be necessary, or even desirable, ahead of the anoxic basins. However it would be necessary to equalize the chemically pretreated wastewater over the seven-day week to provide a steady feed to the anoxic basins, but to do so without any biological treatment. Unfortunately the existing anaerobic lagoon is too large for this flow equalization as it would continue to anaerobically treat the $CBOD_5$ in the wastewater. Therefore a new small equalization basin would be constructed to equalize the flow over the seven-day week. This anaerobic equalization basin would be sized for five production days/wk as follows:

Kill Days/Wk	5
Average Production Days	
Monday - Thursday	7,665 m^3/day
Friday	7,325 m^3/day
Minimum Saturday & Sunday Flows Combined	750 m^3
Total Weekly Flow	38,735 m^3/wk
Equalized Weekly Flow Rate	5,533.5 m^3/day

The design volume for the new equalization basin would be 10,317 m^3 [5,533.5 m^3/day x 2 days (outflow) –750 m^3 (inflow)]. To ensure that no treatment, either aerobic or anaerobic, of this stored flow occurs so the $CBOD_5$ is available for denitrification, this lagoon would be covered and gradually be filled during the production week with pretreated effluent and then emptied on the weekends. By keeping this flow in an anaerobic state, but emptying the storage lagoon each week, insufficient anaerobic treatment microorganisms would accumulate to achieve any significant biological treatment of the $CBOD_5$. Because anaerobic treatment is not wanted in this basin, it would no longer be necessary to inject steam into the pretreated effluent.

This basin would be constructed somewhat similar to the existing covered anaerobic lagoon using lagoon-type construction with a double HDPE liner with leak detection provisions and an HDPE cover. The cover would be provided to 1) maintain anaerobic conditions so aerobic treatment does not occur, 2) to minimize odors from the lagoon, and 3) to reduce heat loss during the winter. To minimize the amount of borrow material necessary to construct this new earthen lagoon, however, interior sideslopes would be around 2.5:1, depending on soil conditions, and exterior sideslopes will be 3:1.

Sanitary sewage and WAS would continue to go to the existing anaerobic lagoon. A new pump station would be constructed to pump flow from the new equalization basin, as well as, supernatant from the anaerobic lagoon. The anaerobic effluent flow meter would be relocated and used to meter this pumped flow. A new rate controller would be used to modulate a new throttling valve to maintain the equalized flow at a preset rate.

3. Activated Sludge System with Anoxic Cells

Design influent loadings, including equalization basin effluent following chemical pretreatment and anaerobic lagoon supernatant, to the activated sludge system with anoxic cells are estimated as follows:

	Equalization Basin Effluent	Anaerobic Lagoon Supernatant	Combined Wastewater
Flow, m^3/day	6700	350	7050
$CBOD_5$			
mg/l	700	370	685
kg/day	4700	130	4830
COD			
mg/l	1300	860	1275
kg/day	8700	300	9000
TSS			
mg/l	100	315	110
kg/day	670	110	780
VSS			
mg/l	77.5	230	85
kg/day	520	80	600
Oil and Grease			
mg/l	<50	<15	<50
kg/day	<335	<5	<340
TKN			
mg/l	157	285	163
kg/day	1050	100	1150
Phosphorus			
mg/l	26	38.5	30
kg/day	200	13.5	213.5
Temperature, ^oC			
Minimum	25	4	24
Maximum	30	27	30

To keep loadings at reasonable levels, a second parallel train consisting of an anoxic basin, an aeration basin, a final clarifier and sludge and scum pumping facilities would be added. In general, each of these new units would be similar to the existing units. A new splitter structure would be constructed ahead of the anoxic basins.

With the new aeration basin, it would only be necessary to maintain mixed liquor suspended solids levels around 2800 mg/l to provide a 13.5-day mean cell residence time which results in good nitrification. These concentrations are well below a maximum recommended value of 5000 mg/l. The oxygen transfer rate in the aeration basins would be around 46 mg/l/hr at field conditions, a conservative design value. Slow-speed surface aerators totaling around 375 hp would be required to maintain a minimum dissolved oxygen concentration in the aeration basins. Currently there are three dual-speed, 115/150-hp surface aerators mounted on the existing aeration basin. One of these slow-speed surface aerators would be relocated from this existing aeration basin and installed on the new aeration basin, along with an additional aerator.

To ensure sufficient alkalinity in both aeration basins, arrangements would be made to feed lime slurry from the existing lime silo into the inlet of the new aeration basin.

Since denitrification if far more important than before, flow metering and control provisions would be added to the mixed liquor return pumping systems.

Due to biological uptake of phosphorus in the WAS, phosphorus in the effluent would be projected to be around 21.5 mg/l, which is higher than the potential effluent phosphorus criteria, as outlined in Section V. Therefore provisions would be included to meter ferric chloride solution into the later portion of each aeration basin. Bulk storage facilities with spill containment would be provided for the ferric chloride.

The ferric compound would combine with the orthophosphate to form ferric phosphate. The ferric phosphate would accumulate in the mixed liquor and settle out with the sludge in the final clarifiers and be wasted to the anaerobic lagoon for thickening. This ferric phosphate would increase the inert fraction of the MLSS in the aeration basins so that actual MLSS would be somewhat above the 2800 mg/l previously indicated.

Flow from both aeration basins would combine in the existing clarifier splitter structure where the mixed liquor would be divided between two identical 22.5-m (73.8-ft) diameter final clarifiers, the existing clarifier and a new one. At the maximum equalized flow around 6800 m^3/day, the surface overflow rate would be a conservative 8.55 m^3/day /m^2 (210 gpd/ft^2). At a maximum mixed liquor suspended solids concentration of 5,000 mg/l and 100 percent recycle, the solids loading rate would be 85.5 kg/m^2/day (17.5 lb/ft^2/day), which is considerably less than the recommended maximum of 146.5 kg/m^2/day (30 lb/ft^2/day).

4. Sludge and Scum Handling Facilities

Duplicate RAS, WAS and scum pumps and meters would be installed in the basement of the existing operations building. RAS would be pumped back to the new aeration splitter structure. WAS and scum would be pumped to the existing anaerobic lagoon for thickening, digestion and storage. Each fall this lagoon would be projected to be less than half full when thickened and digested sludge is land applied. An estimated 25,650 m^3 of sludge containing approximately 830,000 kg of solids, 58,000 kg of nitrogen and 16,500 kg of plant-available phosphorus is projected to be removed annually from the anaerobic lagoon and sent to land application. The phosphorus bound with the ferric as ferric phosphate would not be available to the crops.

5. Effluent Sampling, Metering, Disinfection, and Discharge Facilities

Before discharge the final effluent would continue to be sampled and metered with the existing equipment. The baffle that currently blocks off a third of the UV channel would be removed and two more moveable arms with Trojan 3000

UV lamps could be installed to operate in conjunction with the four existing arms.

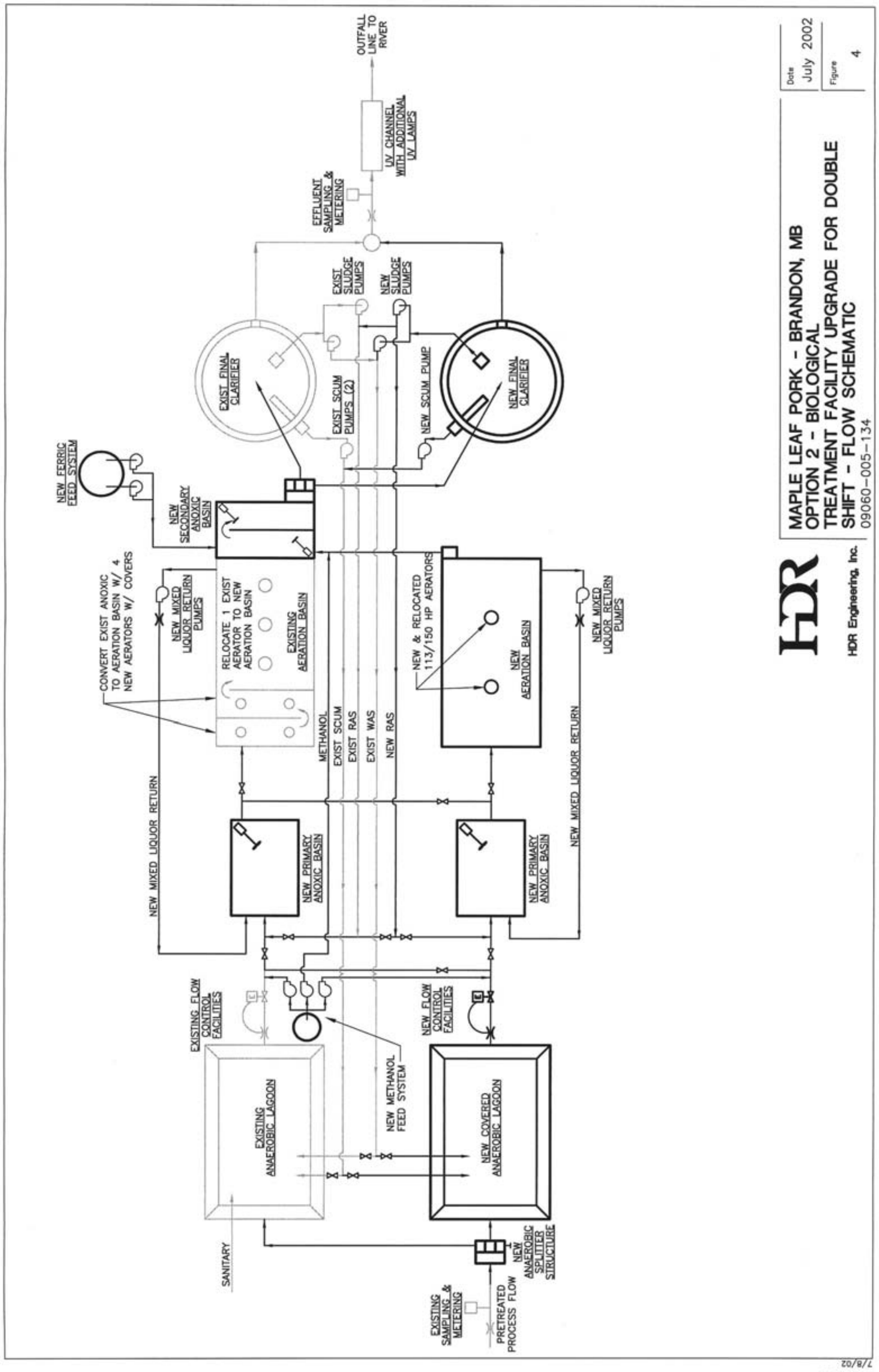
C. Option 2 – Biological Treatment

1. Anaerobic Treatment

This option evaluates expansion of the wastewater treatment plant to accommodate the additional flow from a two-shift operation. Figure 4 provides an overview of this option. In this option, a second covered anaerobic lagoon would be added to reduce both the hydraulic and organic loading to the existing anaerobic lagoon and to provide storage space for WAS from the activated sludge system. This would result in a total maximum volume of 79,950 m^3. In addition to providing adequate volume for treatment of the influent, this would also provide for flow equalization seven days/wk and storage of one year's accumulation of waste activated sludge (WAS) after it thickens to approximately four percent solids. As discussed previously, the maximum flow equalization volume required would be 10,317 m^3. At the end of 12 months, settled and digested sludge would occupy approximately 20,870 m^3 of this anaerobic volume. Therefore the minimum volume remaining for anaerobic treatment would be 48,763 m^3. The maximum weekly influent $CBOD_5$ would be 13,470 kg/day, including sanitary sewage. This would result in an organic loading rate of 0.276 kg $CBOD_5$/ m^3/day (17.2 lb $CBOD_5$/1000 ft^3/day), a good design value. With a weekly influent flow of 46,900 m^3/wk of process wastewater and 1525 m^3/wk of sanitary sewage the detention time at the minimum treatment volume of 48,763 m^3 would be 7 days, a conservative value.

An anaerobic splitter structure would be constructed after the existing sampling and metering facilities to divide the influent equally between the two anaerobic lagoons.

Figure 4 – Biological Treatment Flow Schematic


MAPLE LEAF PORK - BRANDON, MB
OPTION 2 - BIOLOGICAL
TREATMENT FACILITY UPGRADE FOR DOUBLE
SHIFT - FLOW SCHEMATIC
09060-005-134
HDR Engineering, Inc.
Date
July 2002
Figure
4
OUTFALL LINE TO RIVER
UV CHANNEL WITH ADDITIONAL UV LAMPS
EFFLUENT SAMPLING & METERING
EXIST SLUDGE PUMPS
NEW SLUDGE PUMPS
EXIST FINAL CLARIFIER
EXIST SCUM PUMPS (2)
NEW SCUM PUMP
NEW FINAL CLARIFIER
NEW FERRIC FEED SYSTEM
NEW SECONDARY ANOXIC BASIN
CONVERT EXIST ANOXIC TO AERATION BASIN W/ 4 NEW AERATORS W/ COVERS
NEW MIXED LIQUOR RETURN PUMPS
RELOCATE 1 EXIST AERATOR TO NEW AERATION BASIN
EXISTING AERATION BASIN
NEW & RELOCATED 113/150 HP AERATORS
NEW AERATION BASIN
NEW MIXED LIQUOR RETURN PUMPS
METHANOL
EXIST SCUM
EXIST RAS
EXIST WAS
NEW RAS
NEW MIXED LIQUOR RETURN
NEW MIXED LIQUOR RETURN
NEW PRIMARY ANOXIC BASIN
NEW PRIMARY ANOXIC BASIN
EXISTING FLOW CONTROL FACILITIES
NEW FLOW CONTROL FACILITIES
NEW METHANOL FEED SYSTEM
EXISTING ANAEROBIC LAGOON
NEW COVERED ANAEROBIC LAGOON
SANITARY
NEW ANAEROBIC SPLITTER STRUCTURE
EXISTING SAMPLING & METERING
PRETREATED PROCESS FLOW
7/8/02
FIGURE4.DWG

Effluent from the anaerobic lagoons under the maximum loading of a 6-day production week is projected as follows:

Flow (includes 300 m^3/day of WAS supernatant)	
m^3/day	7218
$CBOD_5$	
mg/l	320
kg/day	2310
COD	
mg/l	925
kg/day	6675
TSS	
mg/l	300
kg/day	2165
VSS	
mg/l	225
kg/day	1625
TKN	
mg/l	315
kg/day	2275
Ammonia-N	
mg/l	275
kg/day	1985
Phosphorus	
mg/l	39
kg/day	280

Temperature, ^{o}C	
Maximum	35
Minimum	27

Because insufficient $CBOD_5$ would be available to denitrify the nitrogen in the wastewater, good anaerobic $CBOD_5$ reduction would no longer be that critical. Therefore it should only be necessary to inject steam into the anaerobic influent wastewater to maintain an anaerobic effluent temperature above 27 - 28^{o}C.

2. Biogas Handling Facilities

At a kill of 18,000 hogs/day, an estimated 55,000 m^3/wk of biogas containing 75 percent methane would be generated with a six-day kill, or about 46,000 m^3/wk with a five-day kill. Assuming \$0.36/m^3 (\$10.20/1000 ft^3) of natural gas, the biogas has a value around \$720,000/yr. The existing biogas blowers, safety equipment, emergency flare and biogas boiler are adequate for this volume, although additional biogas safety equipment would be required at the new anaerobic lagoon.

3. Activated Sludge System with Anoxic Cells

For good denitrification in the anoxic basins, it is necessary for the amount of influent $CBOD_5$ to be around 4.5 times the amount of nitrogen removed. With an activated sludge system influent TKN of 2275 kg/day and a potential minimum monthly effluent TN of 335 kg/day, a minimum of 1940 kg/day of nitrogen would need to be removed. This would require about 8730 kg/day (1209 mg/l), of $CBOD_5$. At 2310 kg/day, or 320 mg/l, the $CBOD_5$ in the anaerobic effluent would be well below this amount. Therefore supplemental $CBOD_5$ would be required. This supplemental $CBOD_5$ could possibly be supplemented by bypassing a portion of the flow around the anaerobic lagoon. Approximately 35 percent of the pretreated process waste would need to be bypassed around the anaerobic lagoon to provide adequate $CBOD_5$. Past data reveals the COD (no $CBOD_5$ data is available) in wastewater bypassed from the southeast corner of the anaerobic lagoon is only about 18.5 percent higher than anaerobic effluent COD. This indicates that substantial treatment is occurring even as the flow short circuits across the corner of the anaerobic lagoon.

Therefore, to maintain adequate $CBOD_5$ in the bypassed flow, it would have to be bypassed from the anaerobic influent piping. However this raises several concerns. First, there would be a concern with the potential for grease or blood spills causing problems with the anoxic basins and the activated sludge system. Second, on weekends anaerobic influent flow would be insufficient in both flow and $CBOD_5$ to supply adequate oxygen demand in the anoxic basin to achieve the required amount of denitrification. Therefore it would be necessary to store wastewater from the production week to ensure adequate denitrification during the weekend. It would be necessary to store a maximum of 4275 m^3 with a five-day kill, while storage requirements for a six-day kill would be less at 2490 m^3. This storage would need to be done in an unaerated covered lagoon. Another disadvantage of bypassing pretreated flow to the anoxic basin would be the relatively-high level of TSS in this flow. As a result of these high solids levels, more sludge would be made. For these reasons, methanol, or possibly ethanol if reasonably priced, would be added as a source of $CBOD_5$. Methanol is reasonably priced and contains no nitrogen, phosphorus or TSS so sludge production would be minimized from this source. About 5.5 m^3/day of methanol would be required, so the methanol will be handled in bulk with spill-prevention provisions.

Two new anoxic basins would be constructed, each with a volume around 2500 m^3. Each basin would be equipped with mixers totaling around 30-35 hp.

The existing anoxic basin would be converted to an aeration basin with the addition of aeration. This basin, in addition to the existing aeration basin, would provide a total aeration volume of 4608 m^3. In addition to this volume, a second aeration with a similar 4608-m^3 volume would be added.

With the new aeration basin, the maximum mixed liquor suspended solids levels would be around 4500 mg/l to provide a 13.5-day mean cell residence time that would result in good nitrification. The maximum oxygen transfer rate in the aeration basins would be less than 55 mg/l/hr. Slow-speed surface aerators totaling around 585 hp would be required to maintain a minimum dissolved oxygen concentration in the aeration basins under the worst conditions. One of the 113/150-hp, slow-speed surface aerators would be relocated from the existing aeration basin and installed on the new aeration basin, along with two additional 150-hp aerators. The relocated 115/150-hp aerator would be replaced with a new 150-hp aerator.

To ensure sufficient alkalinity in both aeration basins, arrangements would be made to feed lime slurry from the existing lime silo into the inlet of the new aeration basin.

Flow metering and control provisions would be added to the mixed liquor return pumping systems.

Due to the high nitrogen removals required, a secondary anoxic basin would be constructed at the ends of the two aeration basins for further denitrification. This concrete anoxic basin would receive flow from the two parallel aeration basins, will contain around 2500 m^3, and would be equipped with mixers totaling around 30-35 hp. Methanol would be fed from the common bulk storage tank to provide a source of oxygen demand for the denitrification in this secondary anoxic basin.

Due to biological uptake of phosphorus in the WAS, phosphorus in the effluent would be projected to be around 26 mg/l, which is higher than potential effluent phosphorus criteria. Therefore provisions would be included to meter ferric chloride solution into the secondary anoxic basin. Bulk storage facilities with spill containment would be provided for the ferric chloride. The ferric would combine with the orthophosphate to form ferric phosphate. The ferric phosphate would accumulate in the mixed liquor and settle out with the sludge in the final clarifiers and be wasted to the anaerobic lagoon for thickening. This ferric phosphate would increase the inert fraction of the MLSS in the aeration basins so that actual MLSS would be somewhat above the 4500 mg/l previously indicated.

Flow from the secondary anoxic basin would be reaerated in the existing clarifier splitter structure where the mixed liquor would be divided between two identical 22.5-m (73.8-ft) diameter final clarifiers, the existing clarifier and a new one. At the maximum equalized flow around 6918 m^3/day, the surface overflow rate would be a conservative 8.7 m^3/day /m^2 (215 gpd/ft^2). At a maximum mixed liquor suspended solids concentration of 5,000 mg/l and 100 percent recycle, the solids loading rate would be 85.5 kg/m^2/day (17.5 lb/ft^2/day), which would be considerably less than the recommended maximum of 146.5 $kg/m^2/day$ (30 $lb/ft^2/day$).

4. Sludge and Scum Handling Facilities

Duplicate RAS, WAS and scum pumps and meters would be installed in the basement of the existing operations building. RAS would be pumped back to the new aeration splitter structure. WAS and scum would be pumped to the existing anaerobic lagoon for thickening, digestion and storage. Each fall this lagoon would be less than half full when thickened and digested sludge is land applied.

5. Effluent Sampling, Metering, Disinfection, and Discharge Facilities

Before discharge the final effluent would continue to be sampled and metered with the existing equipment. The baffle that currently blocks off a third of the UV channel would be removed and two more moveable arms with Trojan 3000 UV lamps could be installed to operate in conjunction with the four existing arms.

6. Emergency Storage

If limits more stringent than the levels currently envisioned were imposed, it would be necessary to add an emergency storage pond for times when the effluent was not in compliance with discharge limits.

VII. SUMMARY AND CONCLUSIONS

The proposed treatment schemes are logical approaches to meeting the required interim criteria for total nitrogen. As shown in Tables IV and V, these effluent nitrogen criteria are as low as 10,140 kg/month (338 kg/day) for the lowest month and 2570 kg/wk (367 kg/day) for the lowest week. As illustrated in Table VI, this lowest monthly limit can necessitate removals as high as 85.5 percent, with weekly removals as high as 84.3 percent.

Unfortunately there are no pork, or beef, plants that are required to consistently achieve these high nitrogen removals either in Canada or the United States to act as a model for upgrading the plant in Brandon. There is one pork plant in the central United States that reduces total nitrogen from around 225-250 mg/l to about 60 mg/l (73-76% removal) in a single anoxic step with a portion of the flow bypassed around the anaerobic treatment. However the effluent TN from this plant is somewhat erratic due to variable operating conditions. Consequently it is impossible to guarantee that effluent total nitrogen criteria would be consistently met with either of these two approaches.

Due to the uncertainties of consistently meeting the potential effluent criteria as outlined in Section V, Maple Leaf evaluated the Zenon system. Long-term pilot testing was conducted to substantiate the ability of this system to consistently achieve the required nitrogen removal rates. This testing was performed during the winter of 2002/2003 by Zenon and showed consistently-high nitrogen removal rates. A separate report has been prepared by Zenon, based on the design waste loads contained in this report. This report discusses the pilot testing and the ultimate design derived from it. The Zenon system will incorporate: 1) an initial anoxic step for denitrification, 2) aeration for nitrification and BOD reduction, 3) a secondary anoxic step for additional denitrification, 4) secondary aeration, and 5) removal of very-high quality effluent through Zenon's ultrafiltration membrane system. If the Zenon system performs as indicated in the report, and the pilot testing indicates it will, the total system should achieve the desired effluent characteristics.