REVIEW OF START UP AND FIRST YEAR OF OPERATION OF ROGERS SUGAR TABER WASTEWATER TREATMENT PLANT

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ABSTRACT

In order to comply with more stringent discharge requirements a wastewater treatment plant has been installed at Rogers Sugar Taber, Alberta factory. The system consists of an USAB-Upflow Anaerobic Sludge Blanket reactor followed by an aerobic activated sludge system including denitrification. The system treats all flume water and condensate for direct discharge to the Oldman River. The USAB is in common use in Dutch and Belgian Sugar Beet factories, but a first for the North American Industry. It was selected in order to adopt the Dutch/Belgian practice of minimizing lime usage by recycling anaerobic effluent to the flume and operating at a neutral pH. Using this practice, we were able to maintain a neutral pH at a historically low lime usage. Calcium deposition presented no major problems through the 160-day campaign. The ability of the system to operate at high calcium loading was demonstrated by a further 128 days of operation treating wastewater from the previous campaign that had been stored in the lime pond. Effluent quality met all discharge requirements of the operating license. BOD_5 averaged 89kg/day, TSS averaged 168 kg/day Ammonia Nitrogen averaged 0.4 kg/day compared with the licence limits of 400,400 and 36 kg/day respectively.

Background

In the spring of 1997, Rogers Sugar Taber Factory was facing environmental uncertainties. An application had been made to Alberta Environment for a new Operating Approval that consolidated air emissions, water discharges and other regulated activities into a single approval. Previously there were separate Operating Licences for water and air. These had expired in 1995 and 1996 but had been extended during the implementation of the new system. The Town of Taber had indicated new, stricter sewer discharge criteria for implementation by January 1, 2000.

In April 1997, Rogers announced an expansion of the Taber facility, increasing beet slicing capacity from 4000 tonnes per day to 6000 tonnes per day and adding thick juice storage. The increase in capacity would be staged with initial construction starting in September 1997. The 1998 campaign slice would increase to 5000 tonnes per day with final upgrades leading to 6000 tonnes per day operation in September 1999.

Under these conditions, it was clear that on site wastewater treatment would be required although the type of treatment and the required discharge limits were not defined.

Operating Approval Discharge Limits

The announcement of the factory expansion and the short schedule made reaching agreement critical. Under the Alberta Environmental Protection and Enhancement Act (EPEA) construction of many of the new facilities required for the expansion required the approval of Alberta

Environment. Alberta Environment supported the expansion and was willing to cooperate but expected that the quality of discharge to be improved.

In setting discharge criteria for existing facilities Alberta Environment takes into consideration the past history of discharge, constraints of the receiving environment and available control technology. Their approach is to see a general reduction with time. They can accept maintaining existing limits but are reluctant to allow any increase.

Even prior to the announcement of the expansion it was clear that the ammonia nitrogen discharge was Alberta Environments major concern. The model they use indicated a discharge of 36 kg/day was the maximum the Oldman River could assimilate. They had less concern over other parameters. To accommodate the need for a new approval for the September 1997 campaign, an approval was issued for the existing 4000 tonne/day slice factory. This is detailed below:

TABLE 1
Licence Limits for Discharge to River

	Biological Oxygen Demand	Total Suspended Solids	Ammonia Nitrogen
	kg	kg	kg
1993 – 1997			
Maximum daily average	1500	600	650
Maximum any one day	2500	1000	400
June 6, 1997 Approval			
Maximum daily average	1500	600	140
Maximum any one day	2500	1000	170
Requirement for September 1, 2000			
Maximum daily average	1200	600	36
Maximum any one day	1800	1000	67
March 6, 1998 Amended Approval			
Maximum daily average	1500	600	140
Maximum any one day	2500	1000	170
Requirement for September 1, 2000			
Maximum daily average	400	400	36
Maximum any one day	800	800	67
Requirements common to all: pH 6.0 to 9.5			
50% or greater survival in 100% industrial wastewater sample for Rainbow trout in 96-hour acute lethality test.			

The changes to the discharge limits were as shown in Table 1. This basically maintained existing limits until the September 2000 campaign. The numeric limits for ammonia were reduced to reflect the historic average discharge levels.

To obtain the approvals required for the expansion an application to Amend the Operating Approval was submitted in September of 1997. Through this period and up to the completion of the expansion there was extensive communication and negation between Alberta Environment and Rogers Sugar. The relationship required a mutual trust between both parties. Rogers Sugar had to proceed with construction of the foundations and other facilities on the basis of an interim approval with the risk of a requirement of possible later changes. Alberta Environment accepted that required treatment works would be in place without detail of what the actual facilities would be.

An agreement was reached on new discharge limits maintaining the existing limits up to September 1, 2000. For discharges after September 1, 2000 additional reductions in BOD and TSS were required but ammonia nitrogen limit was unchanged. This is also shown in Table 1.

The schedule for installation of treatment facilities was agreed on. This required a wastewater treatment plant to be installed and operating for September 1999 and a cooling tower to be installed and operating for September 2000. The cooling tower was needed, as the ammonia limit could not be met unless the ammonia from the evaporator and pan condensers was eliminated from the discharge to the river. The above criteria were incorporated in the Amended Approval issued March 6, 1998.

A second application for Amendment was submitted in August 1999. This was required to obtain some modifications to monitoring requirements and approval of air discharge (some associated with wastewater plant) that were not recognized earlier. The second Amendment to the Operating Approval was issued on September 20, 1999.

Selection of Treatment Technology

Associated Engineering was retained to assist in the selection of treatment technology. This role gradually evolved to include preparation of budget estimate, detail design, project and construction management. The initial project objective was to identify economical, practical and effective wastewater management and/or treatment concepts and to provide an implementation plan for the most favorable concept. Associated Engineering was initially optimistic that a low technology or simple technology could be identified. The screening process quickly eliminated the low technology alternatives and identified three possible options.

1. Anaerobic treatment of mud pond water with effluent disposal to the Taber industrial treatment system.
2. Aerobic treatment of excess condensate with effluent discharge to the Oldman River.
3. Anaerobic treatment followed by aerobic treatment with effluent discharge directly to the Oldman River.

Using historical data a request for budget pricing for the design, supply, installation, and commissioning was submitted to 5 vendors in September of 1997. After evaluating the responses Anaerobic Treatment Systems option three was selected as being the most cost effective on a long-term basis.

An extensive program of sampling and analysis was carried out through the 1997 campaign to confirm and refine the design parameters. Once hydraulic, organic loading and effluent design criteria were finalized (Table 2), seven vendors of treatment equipment were invited to submit bids to provide both anaerobic and treatment equipment. The effluent criteria were established at values that would comfortably meet the requirements of the Operating Approval. Although not required by the Operating Approval denitrification was included in anticipation of future regulations.

The major equipment installed to increase beet slice capacity was sized to accommodate a further increase in slice from 6000 tonnes to 8000 tonnes. The vendors were asked provide bids for two sizes, one with the capacity for a 6000 tonne /day slice and a second for an 8000 tonne/day slice. The system selected was based on an 8000 tonne/day slice.

The bids were requested for an operating strategy that uses three operating phases. During the first phase (early campaign) feed rate is set to maintain a water volume of 12,000 cubic meters in the pond. During the second phase (late campaign) feed rate is set to so as not to exceed the design BOD loading of 28,000kg/day. Excess water is accumulated in the mud pond and treated after campaign (third phase). This use of the mud pond as buffer allows the use of a smaller anaerobic reactor.

To assist in the evaluation of bids visits were made to two factories in the US and nine in Europe.

The US visits confirmed that the anaerobic contact (AC) system could handle high calcium concentration and long campaigns. It was also evident that the system required major post campaign maintenance. In particular a need for cleaning a large volume of calcium sludge from the anaerobic reactor every second year.

In Europe we encountered two strongly held opposing views of flume operation and associated reactor design. In Holland and Belgium the factory personnel and vendor representatives advocated operating the flume at near neutral pH. They practice and recommend the recycle of the effluent the anaerobic reactor to the flume. The buffering capacity of the effluent is high and typically can maintain 6.5 pH to 7.5 pH with minimal use of lime. All these factories operated upflow anaerobic sludge blanket (UASB) reactors. Under the 100 day or less campaign conditions maintenance requirements are limited to a precautionary high pressure or chemical cleaning of UASB influent distribution systems but there is no need to enter the reactor to clean. Sludge is stored within the reactor between campaigns.

TABLE 2

Rogers Sugar, Taber, Alberta, Canada Process Wastewater Treatment Design Criteria – Option B				
ITEM	UNITS	Option B – 8000 t/d Sugar Beet Factory		
		Early Campaign Day 1 - 110	Late Campaign Day 111 - 165	Post Campaign Day 166 - 228
Sugar Beet Production	t/d	8,000	8,000	-
<u>Avg. Flow Rates</u>				
Mud pond Supernatant				
To anaerobic treatment	m^3/d	3,000	2,000	1,200
Condensate				
Condensate to aerobic treatment	m^3/d	800	1,000	-
Condensate to flume system	m^3/d	3,000	3,000	-
Total condensate flow	m^3/d	3,800	4,000	-
Total Flow to Aerobic treatment	m^3/d	3,800	3,000	1,200
<u>Mud Pond Supernatant</u>				
BOD Load (average)	kg/d	20,000	28,000	28,000
TSS Concentration	mg/L	400	2,200	600 to 2,200
VSS concentration	mg/L	240	1,100	300 to 1,100
TKN Load	kg/L	560	320	320
PO_4-P concentration	mg/L	8 to 12	8 to 12	8 to 12
Temperature °C		5 to 20	1 to 5	1 to 10
pH*		5.5 – 8.0	5.0 to 7.0	4.5 to 6.5
Alkalinity as $CaCO_3$	mg/L	800 – 4000	800 to 4000	800 to 4000
Calcium Concentration	mg/L	400 – 1200	1000 to 2000	1200 to 2000
<u>Condensate</u>				
BOD Load (average)	mg/L	100	300	
TSS concentration	mg/L	Negligible	Negligible	
TKN Load	mg/L	60	45	
PO_4-P concentration	mg/L	Negligible	Negligible	
Temperature °C		75 to 80	75 to 85	
pH		9 to 10	9 to 10	
Carbonate Alkalinity as $CaCO_3$		Negligible	Negligible	
Calcium Concentration	mg/L	Negligible	Negligible	
<u>Treated Effluent</u>				
Max. Daily Average (for any operating month)				
BOD**	kg/d	95	95	95
TSS**	kg/d	95	95	95
NH_3-N**	mg/L	5	5	5
NO_3-N**	mg/L	5*	5*	5*
PO_4-P**	mg/L	1	1	1
pH***		6.0 to 8.0	6.0 to 8.0	6.0 to 8.0
Acute lethality (Rainbow trout)		50% or greater survival in 100% effluent sample		

* Nitrate later adjusted to 20 mg/l
** Maximum for any one day twice this value
***pH later adjusted to 6.0 – 8.5

In Germany and Denmark the flume operating philosophy calls for maintaining a high pH through the use of lime. The majority of factories operate anaerobic contact reactors. They do not recycle anaerobic effluent and do not believe that a UASB reactor can be successfully operated in factories that maintain high flume pH.

The types of aerobic treatment varied widely, including aerated lagoons activated sludge systems with integrated denitrification. Aeration systems in use were similarly varied including floating surface aerators, jet aerating, air diffuser systems and fixed mounted surface aeration. All factories visited disposed of excess anaerobic and aerobic sludge to the mud pond.

The factory visits were very useful; we were hospitably received at all locations. There was no hesitation in sharing information, operating limits were volunteered, questions answered, and performance details provided. It was thought that after the factory visits; the preferred type of anaerobic technology would be clearly evident. Our expectation was that final vendor selection would be between two vendors using the same anaerobic technology. However, on the basis of the strongly opposing views on the ability of UASB system to operate at high calcium concentrations, both AC and UASB systems remained under consideration. On this basis, the final vendor selection was between one AC vendor and one UASB vendor. After a final presentation from each of these vendors, a UASB system was selected. Enviroasia was the successful vendor and selected on the following basis:

1. A very strong technical presentation that provided the most detail of process design calculations and assumptions.
2. The proposal incorporated the use of anaerobic reactor effluent recycle to the flume for pH control. This was expected to reduce lime use and the calcium loading to the treatment system. However, a strong operating guarantee was provided that the system would handle the design calcium loading.
3. Lowest capital cost.
4. Minimization of post campaign maintenance requirements.
5. Experience in the treatment of sugar beet waste through their association with Biotim.

Construction

The supply contract for the wastewater plant was signed in September of 1998 leaving less than a year for completion of the detailed design and completion of construction. This required that Enviroasia in Manila and Associated Engineering in Calgary work cooperatively under intense conditions. The detailed design was completed with only one meeting in October. The basic layout was fixed at this meeting and all other communications were by conference calls, e-mail, and electronic exchange of drawings. Concurrent with the design process contracts for construction and equipment supply contacts were prepared and tendered. Site preparation started in November, foundation work was underway in December, and tanks and building shell were completed for May 1999. The electrical, mechanical and instrumentation work proceeded through the summer. Associated Engineering was on site throughout construction. Enviroasia were present to supervise installation of specialty equipment, for loop checks and instrument set up. All major equipment was in place and available for start up by September 15, 1999

Process Description

Anaerobic Treatment

Water from the mud pond is pumped through an exchanger where it is warmed by cross exchange with anaerobic effluent. From the exchanger it enters a mixing tank. During campaign, additional heat is supplied by the addition of factory condensate to the mixing tank. After campaign additional heat is supplied by direct injection of steam through a sparger located in the mixing tank. The tank also has provision for the addition of phosphoric acid as nutrient and sodium hydroxide for pH control. There is also a recycle of anaerobic effluent to maintain a constant level to provide pH buffering.

The conditioned water from the mixing tank is fed at a constant flow rate to the Biotim/Enviroasia UASB. Entry is at the bottom of the reactor through a double influent distribution system.

The influent distribution system consists of 12 parallel loops on the bottom of the reactor. Half of these are connected to one distribution header, half to a second. The flow switched between two headers every 15 minutes. This allows local higher velocity and better sludge water mixing without requiring excessive hydraulic loads.

The flow then becomes a bed of anaerobic active sludge (sludge blanket). The gas generated as the organic acids are broken down provides mixing and expands the sludge bed. The gas lift causes the sludge water biogas mixture to rise to the top of the reactor and passes thorough a three-phase separator. This results in a separation of the mixed liquor into the clarified wastewater, biogas and sludge. The biogas is directed to gas domes located under the roof of the reactor. The biogas is directed to a knockout vessel and sent to a flare or if heat is required to the onsite boiler. The sludge goes back to the bottom of the reactor. The upflow operation results in a natural selection towards a readily settling heavy floc or granular sludge.

The effluent passes through proprietary Biotim/Enviroasia cross flow parallel plate settling modules prior to discharging to an overflow trough. Modules are laid out in two banks of 26 modules running the length of the top of the reactor. The cross section consists of an outer gas dome, a settler section, a central gas dome, and a second settler section. The settler surface area is open to atmosphere. The parallel plate design maximizes the retention of biomass to preventing significant sludge loss even at maximum loading rates.

The troughs from each of the settler sections discharge to a carefully designed discharge channel baffled to supply effluent to users on a priority basis. The first priority is the circulation to the mixing tanks. If the mixing tank needs are satisfied effluent is supplied to the suction line of the pumping to the exchanger on the incoming mud pond line. The cooled effluent is returned to the discharge channel downstream of the pump suction line. If the exchanger loop needs are satisfied effluent flows to the anaerobic effluent recycle tank. If the tank level is adequate, effluent flows to the denitrification basin of the aerobic section of the wastewater plant.

Aerobic Treatment

The effluent of the anaerobic treatment process receives further treatment in an activated sludge system. This system is made up of a denitrification basin, an aeration basin and a clarifier.

The anaerobic effluent enters the denitrification basin along with return activated sludge from the clarifier and a circulation flow from the aeration basin. There is provision for the addition of phosphoric acid if required. The blow down from the cooling tower can also be sent to the basin.

At the design maximum of 3800m^3/day of anaerobic effluent flow, the flow through the basin is 15% anaerobic effluent and 85% recycle. Two bottom mounted submerged mixers are used to provide mixing. The organic (COD, BOD) in the anaerobic effluent provides a carbon source for denitrification bacteria to utilize the oxygen in the nitrate recycled from the aeration basin and in return sludge. There is provision for the addition of pond water directly to the basin if the BOD available in the anaerobic effluent is inadequate.

The mixed liquor from the denitrification basin is sent to the aeration by the circulation pump of the jet aeration system. This pump draws 50% of its flow from the denitrification basin and 50% from the aeration basin. The flow rate of the pump is such that it induces a flow of liquor from the aeration basin through a trough connected to the denitrification basin.

The jet pump feeds the three radial arms of the liquid manifold of the aerator system located at the bottom of the aerator basin. An air header supplied by positive displacement blowers parallels the liquid manifold. There are 16 jets on each arm. The recycled liquid and air are forced through the ejector nozzles. This produces a dispersed plume of small air bubbles. This provides a high oxygen transfer rate and excellent mixing of the basin. All jets point in the same direction to produces a rotational flow within the basin.

Dissolved oxygen in the basin is controlled between 2mg/l and 4mg/l. An in-basin oxygen meter is used to control the operation of two 100 HP and one 50 HP positive displacement blowers. This combination allows blower horsepower to be adjusted in 50 HP increments between 50 and 250 HP by switching different combinations of blowers on and off. The treatment in the aeration basin effectively oxidizes all ammonia present to nitrate and reduces BOD to very low levels.

Mixed liquor from the aeration basin overflows to a circular center fed clarifier. The clarifier is of European design using an edge driven bridge with bottom and surface scrapers. Clarified effluent overflows across a saw tooth weir to an outer discharge channel and then to an effluent holding tank. From the effluent holding tank it is pumped to the factory discharge line to the Oldman River. Settled sludge is drawn off from the center clarifier and pumped to the denitrification tank. Excess sludge is wasted from the underflow line and discharged to the mud pond.

The plant is well instrumented and controlled through an Allen Bradley PLC. This is linked to a PC for graphical process display, data logging, process parameter display, and alarms using the RS View operating system. Enviroasia supplied the programming. The PLC at the wastewater plant is the main control point but there is also a satellite PLC in the factory control room for alarm monitoring after hours.

Review of Waste Water Treatment Plant Operation

Start up was under the direction of Enviroasia who had an engineer on site for several months. Approximately 10,000 cubic meters of stored wastewater was transferred from the lime pond to the mud pond to provide feed for the wastewater plant. This had COD of 10,000 mg/l and a calcium concentration of 1200 mg/l.

The initial start up of the plant was September 15th, 2000. The system was filled with lake water prior to startup. The methane reactor was seeded with anaerobic sludge obtained from the City of Lethbridge (8 truckloads). No outside seed was used for the aerobic portion of the plant. Aerating the system and allowing the bacteria present in the mud pond water to develop naturally generated the activated sludge required for this stage.

The first feed from the mud pond started on September 17th; this was directly to the aerobic portion of the WWTP. The initial feed of water from the mud pond to the methane reactor was started September 21st.
The effluent from the system was discharged back to the mud pond until the quality was acceptable for discharge to the river. Discharge to the river was started September 27th once the BOD and TSS levels were acceptable.

The system was fully nitrifying as of September 30th. Denitrification was established by October 2nd.
Wasting of aerobic sludge started October 20th. There was no need to waste any anaerobic sludge until April 5, 2000. The discharge of effluent to the river continued until December 27th when discharge was stopped as a precaution until testing confirmed and that the WWTP effluent was not toxic. Discharge of the effluent resumed December 31, 1999.

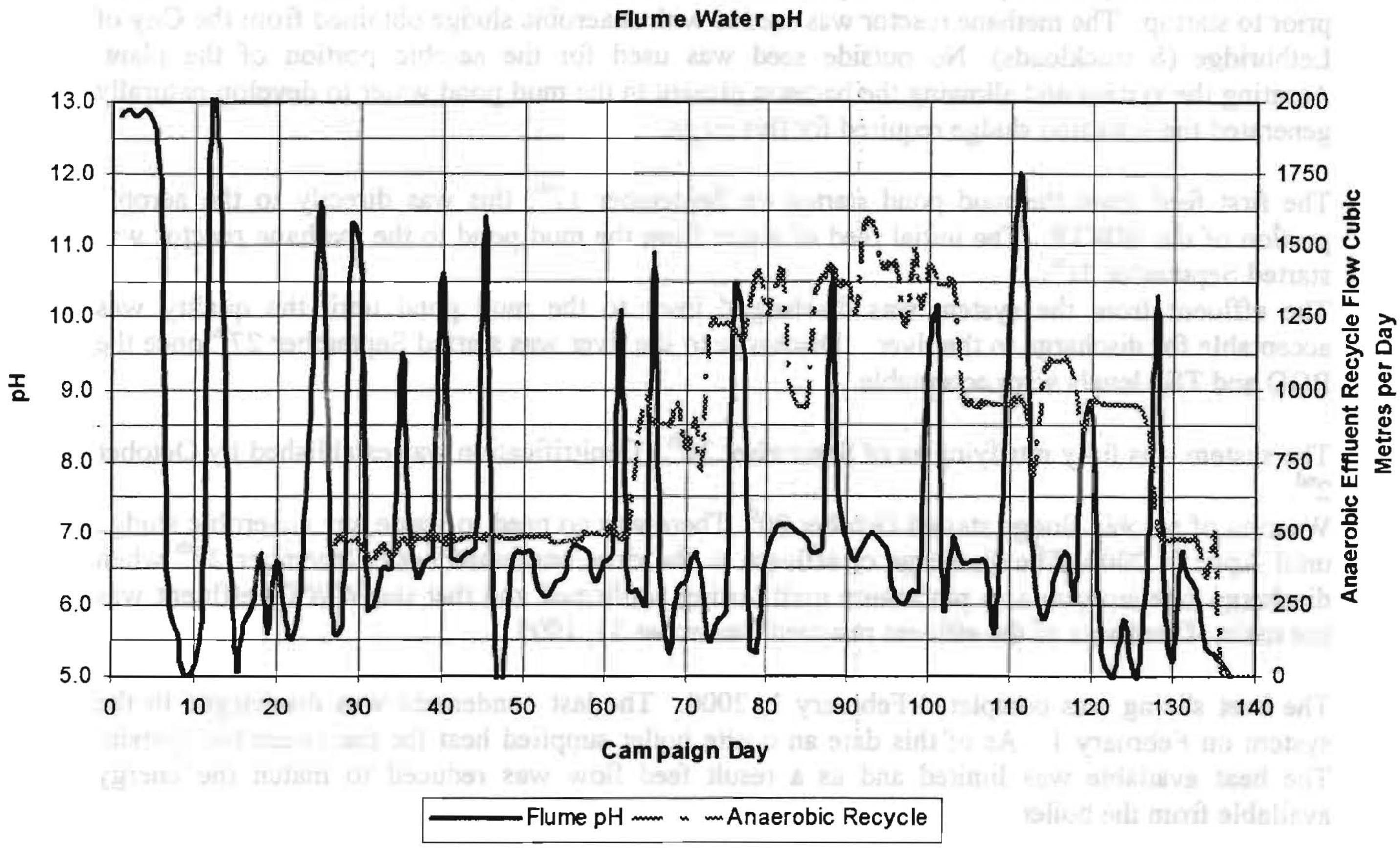
The beet slicing was completed February 1, 2000. The last condensate was discharged to the system on February 1. As of this date an onsite boiler supplied heat for the anaerobic system. The heat available was limited and as a result feed flow was reduced to match the energy available from the boiler.

The water remaining in the pond at the end of campaign had been fed through the system as of March 1, 2000. Return of stored water from the lime pond was started as of February 23, 2000 and continued until July 6, 2000. An estimated 200,000 m3 was transferred out of the lime pond with a further 50,000 m3 remaining in the pond. The processing of thick juice started on May 4, 2000 and was completed on July 8th 2000. The amount of water discharged while processing thick juice is small compared to beet processing. The volume is between 600 to 800 m3/day at a COD of between 2000 to 4000 mg/l. The pond water masked the impact of this water on the treatment plant. Thus full evaluation of treatment requirements and effluent quality during thick juice processing will have to wait till the 2001 thick juice campaign.

Effluent discharge to the river continued from December 31, 1999 until June 30th 2000 when the effluent was recycled to the mud pond due to high TSS. Discharge resumed July 6th through July 8th when it was again stopped because of high TSS. Discharge was again resumed July 11th through July 15th at which time it was stopped for the year. Wastewater continued to be fed to the system until July 19th with effluent being recycled to the mud pond. As of July 19th the system was shutdown and cleaned.

Recycle of Anaerobic Effluent to Flume

Recycle of anaerobic effluent to the flume was started on October 11th.. This had a beneficial effect on pH stability. This is illustrated in the following graph.



As can be seen in the graph there were periodic high pH spikes. These reflect occasions when the slaker was directed to the flume either because of kiln problems or slice interruptions. In the periods between these spikes pH was maintained near neutral with the only lime addition being the dust from the kiln control collectors. This was less effective after day 120 as beet quality dropped.

Evaluation of Performance

By running 300 days the new wastewater plant was well tested in the first year of operation. In some ways there were two back to back campaigns. The initial operation being 1999 beet campaign. Conditions were the best that can be expected as beet storage condition were good and the campaign short at 140 days. Under normal conditions treatment would have been completed by March 15, 2000. Instead the plant continued to operate treating water from the lime pond that had been carried over from the 1998 campaign. The mud pond water quality was as shown in the following table.

TABLE 3
Mud Pond Water Quality

Parameter	Campaign		Post Campaign	
	Average	Range	Average	Range
pH	6.7	5.5 – 7.6	7.1	5.2 – 8.2
TSS mg/l	410	160 – 1100	1687	100 – 11200
COD mg/l	5000	2600 – 17000	9652	1030 – 17220
BOD mg/l	3500	2600 – 11000	6300	400 – 12300
Ca mg/l	770	450 – 1100	911	200 – 1496
TKN mg/l	65	30 – 106	111	35 – 180
NH_3-N mg/l	28	7 to 47	32	10 - 85

The plant performance is compared to design requirements in the following 2 tables.

TABLE 4
Water Flow and BOD Load

Parameter	Design	Campaign		Post Campaign	
	Maximum	Average	Maximum	Average	Maximum
Flow to WWTP					
Mud Pond Water m_3/day	3000	2718	3677	1941	3082
Condensate m_3/day	800	827	1337	0	0
Total m_3/day	3800	3612	4973	1941	3082
Discharge to River m_3/day	3800	2721	3789	1741	3041
BOD Load kg/day	28000	23396	10260	10927	17800

The flow easily exceeds design criteria. The load did not reach design criteria, as BOD concentration was low. Capacity in excess of 34,000kg has been subsequently demonstrated.

TABLE 5
Effluent Water Quality

Parameter	Design	September 27 to March 15	March 15 to May 15	May 15 to July 15
BOD_5 kg/day	95	89	53	117
mg/l		35	33	52.5
TSS kg/day	95	168	138	586
mg/l		76	80.8	318
NH_3-N kg/day		0.6	0.7	0.8
mg/l	5	0.2	0.3	0.6
NO_3-N mg/l	20	10.6	7.3	16.3
pH	6.0 – 8.5	7.7	7.9	8

Acute Lethality Rainbow Trout all periods met the 50% or greater survival in 100% effluent requirement.

The evaluation of effluent quality is mainly based on the September 27th to March 15th, 2000 period. This confirms compliance with BOD, ammonia nitrogen, nitrate nitrogen, and pH design values. The average TSS at 168kg/day easily meets the discharge criteria of 400kg/day but is above the 95kg design value.

For the period March 1st to May 15th effluent quality remained high May 15th was about the time that biological activity began to occur in the pond. This resulted in high suspended solid in the influent which adversely effected performance. The major impact being on the effluent TSS. This met the 600kg/day average Operating Approval limit of that time, but not the 400kg/day limit required after September 2000.

Maintenance and Upkeep Requirements

The wastewater plant is manned with one full time staff operator and a lab analyst who both work day shift Monday to Friday. The operator has full responsibility for wastewater plant. He sets the operating parameter and takes care of routine cleaning and maintenance requirements. Tradesmen and additional labour are called as required.

Calcium fouling was a major concern in selecting the plant. The expectation of any problems would be in the anaerobic reactor. This was not the case throughout the beet campaign. This is demonstrated by the volatile fraction of the anaerobic sludge, which increased from 28.5% to 70% from October to February. It then began to drop reaching 20% in late March and remaining there until the operation stopped.

The heat exchanger warming the incoming mud pond water by cross exchange with anaerobic effluent did gradually foul. Both incoming water and anaerobic effluent sides were required to be cleaned. A skid mounted clean in place (CIP) unit is used to circulate formic acid through the exchanger. This requires 2 to 3 hours. The exchanger is bypassed to maintain reactor feed.

Cleaning was done once every 15 days until April when the required frequency increased to every 5 days. The basket strainer in the influent line from the mud pond line was cleaned weekly until June. After that cleaning every 8 hours was required.

There was calcium scaling in the pumps and the aerobic effluent discharge line. This required occasional manual cleaning of the effluent pump check valve. It gradually increased the pressure drop through the discharge line to the point that full flow could not be maintained. In December a chemical cleaning company was brought in to aid in cleaning the line at a cost of $12,000. Following that sulfuric acid was added to the effluent at about 50ppm. This stabilized the calcium and prevented further problems.

After campaign when a steam boiler was brought into the operation sparger fouling was a problem. Adding a few milliliters per hour of formic acid into the steam line solved this.

In May calcium scaling started to occur in the feed pumps from the mud pumps and the feed line to the WWTP. This was cleaned by back flushing with 3 barrels of formic acid. The cleaning was repeated after shut down.

Cleanup Requirements after Shutdown

After shutdown the system was drained and a vacuum truck contractor was used for vessel clean up

Denitrification Basin	4 hours	Aerator Basin	3 days
Clarifier	2 hours	Anaerobic Reactor	5 days

The anaerobic reactor was drained and the sludge transferred to the denitrification basin for use in September.

The plant operator spent 10 days acid cleaning the anaerobic reactor feed headers and the influent distribution loops. Influent distribution loops were further cleaned with high pressure water jetting.

Two factory labourers were used for 20 days for addition cleaning.