Manitoba Hydro

Generation Maintenance Engineering
Generation South - Power Supply

Raw Water System Review

Project ID: GME JobTrac # BDN0245

Report ID: BDN0245 - Report 01

Station ID: 00109 - Brandon Generating Station

By: Shahbaz Shaukat, P. Eng.
Date: December 8, 2006 (Rev. 6)

1.0 Problem:

The Power Supply Thermal Licence Review Team decided a comprehensive water balance diagram was required for the Environmental Impact Statement for Brandon GS Licence Review. In the spring of 2004 this task was assigned to Thermal Technical Services (now Generation Maintenance Engineering (GME)) for completion.

The review of Brandon GS process water flows began to yield questions regarding the accuracy of flow quantification. *Environment Act* Licence 1703 R requires the reporting of the total monthly and daily quantity of water (as cubic metres) and the peak water withdrawal rate (as cubic metres per second) withdrawn from the Assiniboine River. By October of 2004 this issue included a concern that water may be withdrawn at rates exceeding the *Water Rights Act* licence limit of 0.23 $m^3 s^{-1}$ (230 litres/second). This is also problematic with respect to the *Environment Act* Licence reporting since only the daily raw water withdrawal total value is being utilized from the existing monitoring system and the peak withdrawal rate has always been reported as the *Water Rights Act* licence limit (0.23 $m^3 s^{-1}$).

In addition, raw water consumption at Brandon Generating Station has increased by 76% from November 2004 to February 2005 as compared to the previous years for similar hours of unit 5 operation. In December 2004 and January 2005, the monthly average water withdrawal rate appeared to exceed the Water Use License limit for the instantaneous peak water withdrawal rate. There has been no change in the operating procedures at Brandon GS regarding the raw water system that could explain such a significant increase in the raw water consumption. The following graph shows monthly average raw water flow rates and unit 5 operating hours since January 2003.

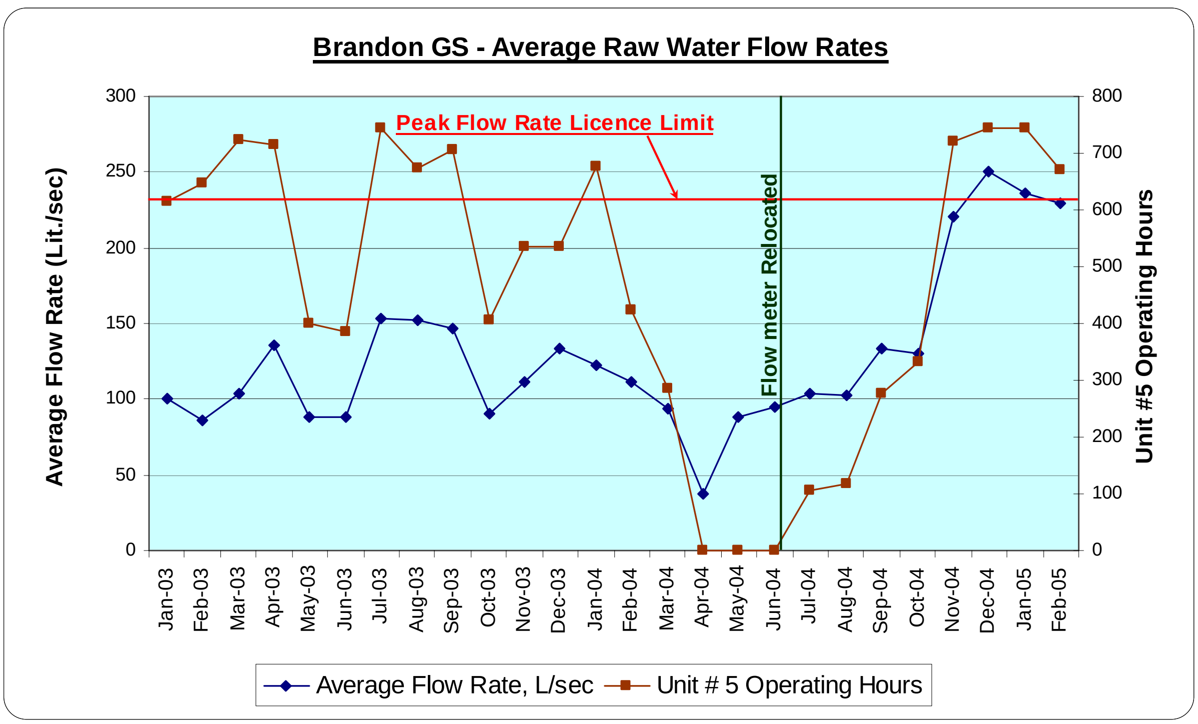


Figure 1: Raw water consumption since January 2003.

The operating hours of the gas turbines since November 2004 compared to previous years, suggest that the gas turbine operation cannot be the reason for the recent increase in water consumption.

This report addresses the original request to quantify water use at Brandon GS and the additional expanded scope items noted above. To summarise, the report addresses:

- the recent increase in raw water consumption
- options for raw water withdrawal licence (compliance) limits
- modifications required to meet the monitoring and reporting requirements of *Environment Act Licence 1703 R.*
- Brandon GS comprehensive water balance

2.0 Raw Water Consumption

2.1 Background

During the Unit 5 major overhaul of 2004 (April – July), to improve our compliance of the Environment Act License 1703R, the raw water flow meter was moved upstream on the same pipeline. It was moved to include in its measurement the quantity of raw water passing through the air compressor heat exchangers and the back pressure relief line. The following illustration based on drawing 1-00109-GE-72290-0014 001/08 explains the movement of the flow meter.

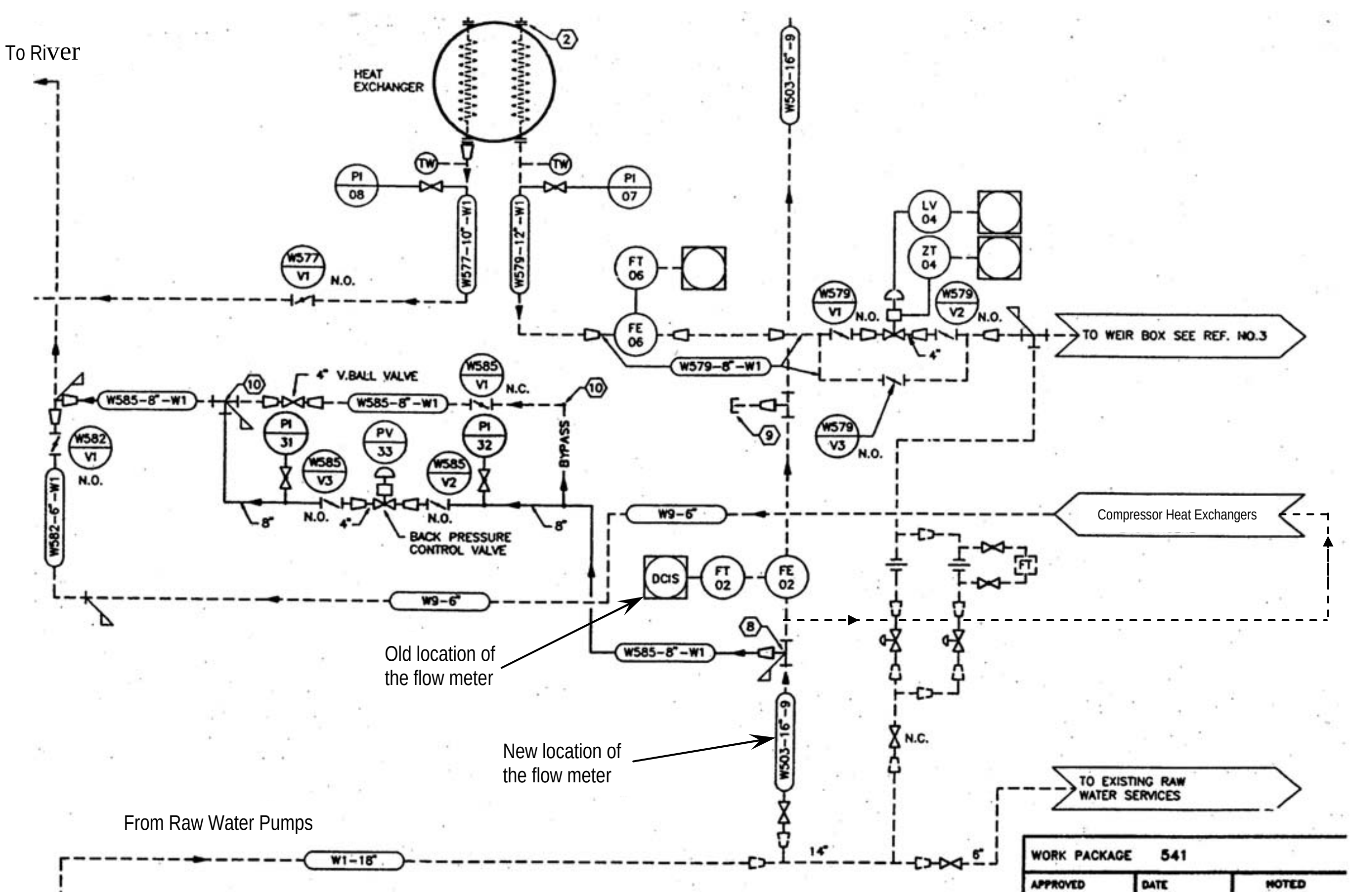


Figure 2: Old and new locations of the raw water flow meter.

The back pressure relief line should not have any flow during normal operation of the plant. It will have flow only when the pressure in the raw water system increases up to 450 kPa. A second pressure relief valve located at the raw water pump house is set at 400 kPa. So the back pressure relief valve inside the plant building is a backup overpressure protection should the valve at the pump house fail to open. According to the raw water pressure trend in DCIS, the pressure relief valve at the pump house has performed satisfactorily during the periods of high water consumption since November 2004.

The flow through the air compressor heat exchangers was manually accounted for even before the relocation of the flow meter by adding an estimated daily usage quantity to the daily raw water consumption reading of the flow meter. The relocation of the flow meter was undertaken in part to record the actual flow through the heat exchangers.

The effect of flow meter relocation in terms of increase in raw water consumption did not appear until November 2004, which was the first subsequent month of significant unit 5 operation as shown by the graph on page 2.

2.2 Analysis

Raw water flow at Brandon GS is measured using an ultrasonic transit time flow meter. For the ultrasonic flow meter to measure flow accurately, the minimum recommended distance of the valves, tees, elbows etc. is 10 to 20 diameters of straight run of pipe upstream and 5 diameters of straight run of pipe downstream of the flow meter location.

The initial flow meter location had only half the minimum recommended distance from the branch line for the air compressor heat exchangers. The accuracy of the original flow meter was questionable as detailed later in the report but even an accurate ultrasonic flow meter would not have worked well at the initial location.

After the relocation, when the higher water consumption was noticed, a spare flow meter of the same manufacture and type was clamped on the same water pipeline to check the accuracy of the original flow meter. The spare flow meter measured on average 45% less than the original flow meter.

The air compressor heat exchangers were originally the bearing cooling heat exchangers for units 1 to 4. Therefore, they are oversized for the air compressors due to their lower heating load as compared to units 1 to 4. It was determined that the total raw water withdrawal rate could be reduced by optimizing the raw water flow through the air compressor heat exchangers. The raw water flow through air compressor heat exchangers was reduced by taking two out of a total of three heat exchangers out of service.

2.3 Flowmeter Accuracy

Both the original and the spare flow meters had never been re-calibrated since their purchase in 1996. The spare flow meter was sent out for re-calibration and when subsequently installed, measured 35-41% less flow than the original flow meter. This difference highlighted the need to get the original flow meter re-calibrated.

Subsequently the original flowmeter was also re-calibrated and re-installed on the same pipeline in the second week of May 2005. The difference in readings between the two flow meters (now both calibrated) dropped to around 5%. This suggests that the original flowmeter raised a false alarm when it measured very high flow numbers in December 2004 and January 2005. It does not necessarily mean that the station did not exceed the license limit for peak water withdrawal during those months.

3.0 Raw Water Withdrawal Limits

3.1 Design Raw Water Requirement of Brandon GS

Following are the design raw water requirements for the different systems at Brandon GS when unit 5, 6 & 7 are running at their maximum continuous capacity.

Sr. #	Description	USgpm	Lit./sec
1.	Wet Bottom Ash Sluicing	1580	99.68
2.	*Dry Ash Sluicing*	*1000*	*63.09*
3.	Ash Hopper Seal Troughs (During flushing)	460	29.02
4.	*Ash Hopper Seal Troughs (Cont. except when flushing)*	*240*	*15.14*
5.	Water Treatment Plant i. Demineralization Trains (Qty: 2) = 919.32 USgpm = 58 lit/sec ii. Cooling Tower Makeup = 1275 USgpm = 80.44 lit/sec iii. Average Accelator Blow down = 95.37 USgpm = 6.02 lit/sec iv. Clinker Grinder = 20 USgpm = 1.26 lit/sec	2309.69	145.72
6.	Air Compressor Heat Exchangers	300	18.93
7.	Lab Sample Heat Exchanger	180	11.36

Table 1: Design Raw water requirement of different systems at Brandon GS.

According to the design raw water numbers in table 1, the maximum design raw water flow rate at Brandon GS would be as follows:

- During wet bottom ash sluicing of unit 5 boiler = 99.68 + 29.02 + 145.72 + 18.93 + 11.36 = 304.71 liters per second (assuming that flushing of ash hopper seal troughs is performed during wet bottom ash sluicing of unit 5 boiler).
- During dry ash sluicing of unit 5 boiler = 63.09 + 15.14 + 145.72 + 18.93 + 11.36 = 254.24 liters per second.

The additional equipments (not listed in table 1) that may run during the simultaneous operation of unit 5, 6 & 7 are listed in the following table with their design raw water flow rates.

Sr. #	Description	USgpm	Lit./sec
1.	Diesel Fire Pump for weekly 30 minutes testing	1000	63.09
2.	HP Ash Pump (Unit 1-4) for weekly 30 minutes cleaning of building vacuum system canisters	1000	63.09
3.	Fire pumps for fighting a fire (largest load)	1700	107.25

Table 2: Design raw water requirement of different equipments at Brandon G. S.

To minimize the total raw water withdrawal rate from Assiniboine River, the item 1 and 2 in table 2 are not operated simultaneously.

3.2 Raw Water Flow Testing

To confirm the design water requirement of different parts of the raw water system used in section 3.1, a raw water flow test was performed on November 09, 2005 followed by some further testing on December 01, 2005. During the tests, conditions were created that we expect to see at the raw water system when all three units at Brandon operate simultaneously at their maximum continuous rating. The original raw water flow meter and a spare flow meter were used to record the total raw water flow rate. Both flow meters have been recently calibrated.

The maximum raw water flow rates measured during the tests were as follows:

- During wet bottom ash sluicing of unit 5 boiler:
    - 345 liters/sec., when HP Ash Pump (unit 1-4) was not running.
    - 383 liters/sec., when HP Ash Pump (unit 1-4) was running.
- During dry ash sluicing of unit 5 boiler:
    - 271 liters/sec., when HP Ash Pump (unit 1-4) was not running.
    - 313 liters/sec., when HP Ash Pump (unit 1-4) was running.

Note: the diesel fire pump was not run during the tests as according to 2002 annual fire testing results (Appendix A), it is expected to have a flow rate similar to the HP Ash Pump of unit 1-4 during its weekly testing.

Appendix B contains the details on the testing procedure and the results obtained.

3.3 New Raw Water Withdrawal License Limits

According to the W*ater Rights Act License # 2001-049* for Brandon GS, the maximum raw water withdrawal rate allowed from Assiniboine River is 230 liters/sec and the yearly total withdrawal limit is 7277.57 decameter^3. The current license limits do not reflect the actual peak and yearly raw water requirement of the Brandon GS. It is recommended that MH apply for new higher license limits for the water withdrawal from the Assiniboine River.

3.3.1 Maximum Raw Water Withdrawal Rate

Based on the design raw water requirement of Brandon GS and the flow test results, following are the two options for the new license limit for maximum raw water withdrawal rate.

1. 370 liter per second, if Manitoba Hydro is exempted of any raw water flow rate limit violation during:
    - fighting a fire and
    - annual testing of the fire system.

   The flow rate for this option is an increase of about twenty two percent in the total design raw water flow rate during wet bottom ash sluicing of unit 5 boiler.

2. 477 liters per second, if Manitoba Hydro is not exempted of any raw water flow rate limit violation during fighting a fire.

The flow rate for this option is the sum of the option 1 and the largest load on fire fighting system i.e. 1700 USgpm for the conveyor # 1.

Following are the assumptions for the two options above:

- Diesel fire pump for testing and HP Ash Pump of unit 1-4 for cleaning canisters of building vacuum system are not operated simultaneously.
- Diesel fire pump for testing and HP Ash Pump of unit 1-4 for cleaning canisters of building vacuum system are not operated when wet bottom ash sluicing system of unit 5 boiler is in service.
- For option 2 only: Annual testing of the fire system is not performed during wet bottom ash sluicing of unit 5 boiler.

3.3.2 Yearly Total Raw Water Withdrawal Limit

Following are the two options for the new license limit for yearly total raw water withdrawal:

1. For 100% operating factor for all the three units = 8792.45 $decameter^3$
2. For 90% operating factor for all the three units = 7913.35 $decameter^3$

Option 2 is recommended as the maximum operating factor of the plant in an year is not expected to be greater than 90%.

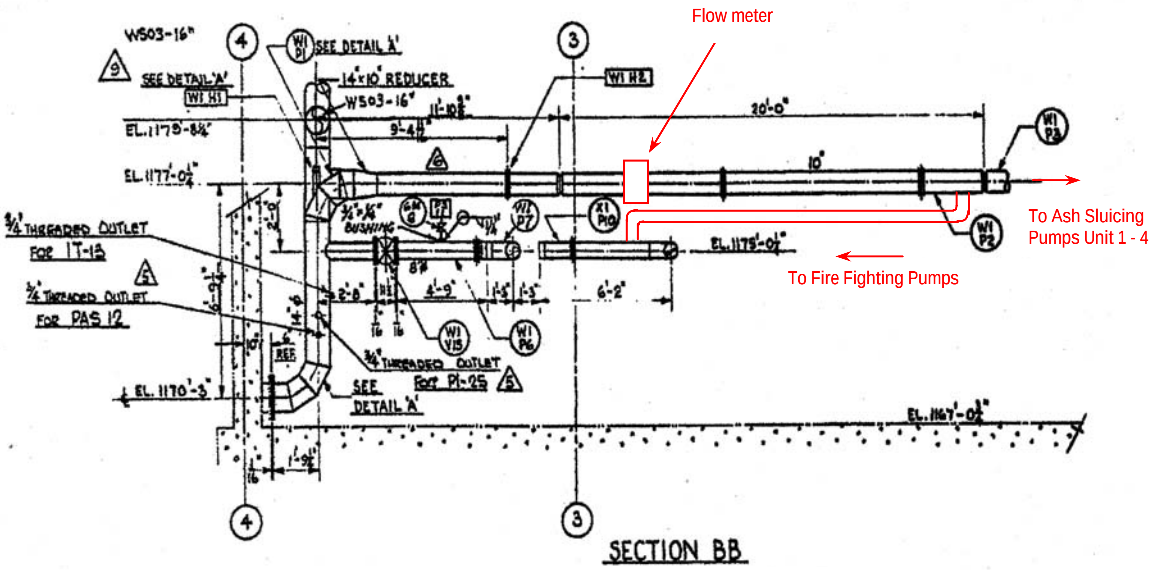
The two yearly total raw water withdrawal limits listed above consist of the following:

i. Water required for running unit 5, 6 & 7.
ii. Water required for weekly cleaning of canisters of the building vacuum system.
iii. Water required for weekly and annual testing of fire pumps.
iv. Water required for fighting a fire for three hours.

4.0 Total Raw Water Flow Measurement

To fully comply with clause 30(b) (ii) of the Environment Act License 1703R, i.e. to determine and record the daily total water and the peak water withdrawal rate withdrawn from the Assiniboine River through the raw water intakes, the following modifications and additions to the existing raw water system are proposed:

i. Change the supply of water to the fire fighting pumps from the existing 14-inch line at the water treatment basement to the ash sluicing line of unit 1 to 4, as shown in the figure 3.
ii. Install a magnetic flow meter on the ash sluicing line to record flows through fire fighting and unit 1 to 4 ash sluicing pumps.
iii. Install a second magnetic flow meter on the 16-inch raw water line in the pulverizer alley close to the location of the existing ultrasonic flow meter. Having a second flow meter on the same line will allow us to monitor accuracy of the two flow meters. An additional advantage would be redundancy, which will be advantageous if one flow meter fails or needs calibration.
iv. Obtain the sum of the flows of the two new flow meters on the HMI screens in the control room.
v. Set up an alarm in DCIS to warn the operators when the total raw water flow rate approaches the license limit.



Drawing # 1-00109-DF-73090-0006 001/09

Figure 3: Piping modifications required to record fire fighting and unit 1 to 4 ash sluicing water.

GME has proposed magnetic flow meters instead of any alternative type for the following reasons:

i. They are expected to provide more accurate and reliable flow measurement compared to the existing ultrasonic flow meter in our raw water system.
ii. They are non-intrusive type; the pressure loss of the magnetic flowmeter is no greater than same length of pipe.
iii. They work in a range from a clean liquid to slurry providing the fluid is conductive. This property will help during spring run off periods.
iv. They require smaller runs of straight pipes before and after the flow meter compared to the ultrasonic flow meters.
v. They fit in the existing pipe as a spool piece, which can be removed and cleaned when required.

5.0 Raw Water Balance Diagram

Figure 4 shows the raw water balance diagram for Brandon GS, which has been prepared based on the designed raw water flows for different systems as suggested in section 3.1 and the raw water flow test results. Appendix A contains the detailed calculations of the water flow numbers shown in the diagram.

The raw water balance diagram has been prepared based on the following assumptions:

a. Two and a half regenerations of the demineralization trains are performed each day.

b. The accelator bottom sludge drain is opened twice a shift for duration enough to fill the sludge sump.

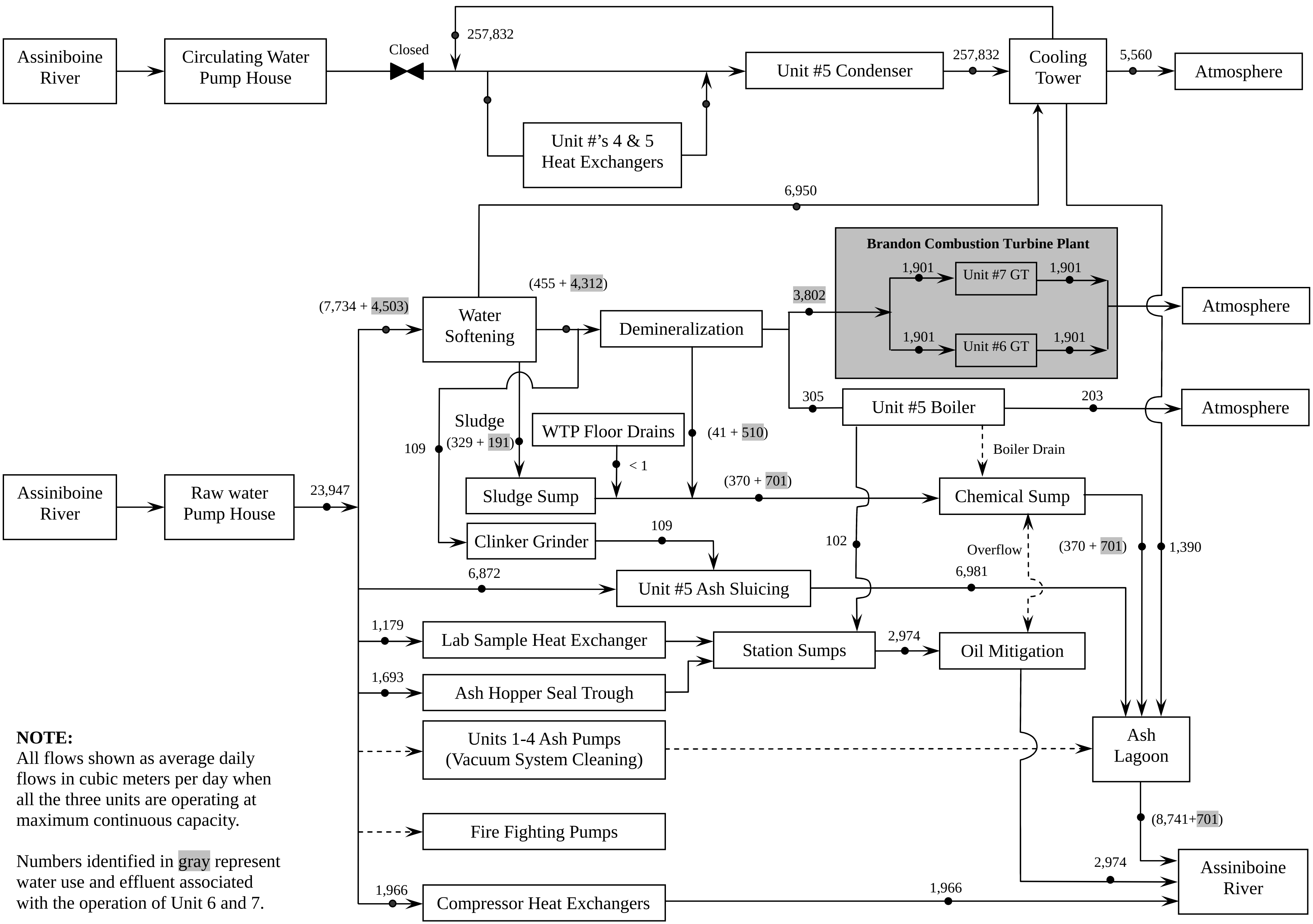
c. The Ash Hopper Seal Troughs have a flow of 460 USgpm during wet bottom ash sluicing for flushing and 240 USgpm during the rest of the day.

d. Wet bottom ash is sluiced twice every shift and the total duration of one cycle is half an hour. For the remainder of the day the ash system runs for dry ash sluicing.

e. The ash lagoon does not have any evaporation loss.

f. Steam used for soot blowing and deaeration at the deaerator is lost to atmosphere while the continuous blow down of the boiler drum goes into the station drains. The steam loss to atmosphere is assumed to be twice that of the continuous blow down.

Brandon Generating Station Raw Water Flows



NOTE:
All flows shown as average daily flows in cubic meters per day when all the three units are operating at maximum continuous capacity.

Numbers identified in gray represent water use and effluent associated with the operation of Unit 6 and 7.

Figure 4: Raw water balance diagram for Brandon Generating Station

6.0 Recommendations

6.1 Compressor Heat Exchanger Piping Modifications

Potential benefits of modifying the compressor heat exchanger cooling water discharge piping to bring the water into use should be evaluated. At a minimum, the discharge piping should be re-routed into the station sumps to meet environmental requirements.

6.2 Flowmeter Calibration

The existing ultrasonic flowmeter should be calibrated periodically in accordance with manufacturer's recommendation to ensure their accuracy.

7.0 Conclusions

7.1 The high raw water consumption recorded between November 2004 and February 2005 is attributed to an inaccurate flow meter.

7.2 M.H. should apply to Manitoba Conservation to revise the existing license limit for peak raw water withdrawal rate. The two options for the new license limit are 370 or 477 liters/sec. For details see section 3.3.1 of this report.

7.3 M.H. should apply to Manitoba Conservation to also revise the existing yearly total withdrawal license limit. The new recommended license limit is 7913.35 decameter^3 (for 90% operating factor for all the three units). For details see section 3.3.2 of this report.

7.4 Two new flow meters should be added and modifications to the raw water piping and DCIS as suggested in section 4.0 should be completed, to ensure the system measures and monitors total raw water coming into the plant.

7.5 The benefits of modifying the compressor heat exchanger cooling water discharge piping to optimize water usage and to use waste heat should be evaluated.

7.6 The existing ultrasonic flowmeter (FE02) should be re-calibrated on regular intervals as per manufacturer's instructions.

Appendix - A: Raw Water System Review
Brandon Generating Station

Design Water Requirement for Brandon GS:

Sr. #	Description	USgpm	Lit/sec	m^3/day
1	Wet Bottom Ash Removal	1580	99.68	717.71
2	Dry Ash Removal	1000	63.09	4996.74
3	Air Compressor Coolers	300	18.93	1635.30
4	Cooling Tower Make-up	1275	80.44	6950.02
5	Demineralizing Trains (02)	919.32	58.00	5011.20
6	Clinker Grinder	20	1.26	109.02
7	Lab Sample Heat Exchanger	180	11.36	981.18
8	Cooling Tower Blowdown	255	16.09	1390.00
9	Boiler 5 make-up	56	3.53	305.26
10	NO_x water required for each gas turbine.	348.71	22.00	1900.80
11	Evaporation and Drift at cooling tower	1019.99	64.35	5559.96
12	Ash hopper seal troughs (Cont. except when flushing)	240	15.14	1199.22
13	Ash hopper seal troughs (During flushing)	460	29.02	208.95
14	Designed CCW flow	47,300	2984.17	257831.97

Daily Design Flows:

1. Ash Sluicing:

The wet and dry ash sluicing volumes given above are based on the operating philosophy that the wet bottom ash sluicing is done twice in a twelve hour shift for 30 minutes each time and for the rest of the time dry ash system is in operation.

Total water used in a day for ash sluicing = 5714.46 = 5715 cu m/day

The outflow numbers from the ash lagoon used in the raw water balance diagram are based on the assumption that there is no evaporation of water in the ash lagoon. The evaporation depends on many variables like temperature, surface area, winds speed, humidity etc. and it is not possible to predict all these variables accurately for a long rage and calculate a value of total evaporation from the ash lagoon.

In the raw water balance diagram, any precipitation at the ash lagoon has not been accounted for either , which will at least mitigate the affects of not considering evaporation.

2. Seal Troughs:

Total water used at the seal troughs is calculated based on the assumption that during wet bottom ash sluicing the flow is maintained at 460 USgpm to flush the seals, while for the rest of the time (during dry ash sluicing) the flow is maintained at 240 USgpm.

Total raw water used at seal troughs in one day = 1408.17 $m^3 \approx$ 1408 m^3

3. Water Treatment Plant:

a. Regeneration Waste:

The regeneration sequence and the water used in each step is shown in the following table.

Step #	Description	Accu. Time Min.	Time Min.	Flow L/Sec	Volume Litres
Cation Exchanger					
1	Closure	0.5	0.5	-	-
2	Backwash sac Polisher	10.5	10	7.57	4542
3	Pack Resin	15.5	5	29	8700
4	Confirm DIL water flow	16.5	1	26	1560
5	Acid into 1.5% Step 1	36.5	20	26	31200
6	Acid Into 3.0% Step 2	46.3	9.8	26	15288
7	Acid Displace	62.3	16	26	24960
8	Bed Settle	64.3	2	0	0
9	Train rinse/recycle	102.3	38	29	66120
10	Train rinse/recycle Conductivity check	104.3	2	29	3480
Anion Exchanger					
1	Closure	0.5	0.5	-	-
2	Pack Resin	5.5	5	29	8700
3	Confirm DIL water flow	6.5	1	12.4	744
4	Caustic into 2.0%	46.5	40	12.4	29760
5	Caustic Displace (warm)	63.5	17	12.4	12648
6	Caustic Displace	80.5	17	12.4	12648
7	Bed Settle	82.5	2	0	0
8	Train rinse/recycle	120.5	38	29	66120
9	Train rinse/recycle Conductivity check	122.5	2	29	3480

Total waste during one regeneration = 220350 litres
Average regeneration waste flow in a day = 6.38 litres/sec

The average flow for regeneration during a day is based on the assumption that two and a half regenerations are required every 24 hours.

Water consumed in one day for regeneration = 550.9 m^3 = 551 m^3

	U 5	GTs
Ratio of demineralized water use between Unit 5 and Gas Turbines =	1.0	12.5
Dividing the water required for regeneration between unit 5 and GTs in the same ratio =	**40.9**	**510.1**
	(41)	**(510)**

b. Accelator Blowdown:

Accelators have two types of blowdown:

1) Automatic Blowdown: Each accelator has five automatic blowdowns that open every 256 seconds and remain open for 16 seconds.

Length of the sludge sump = 8 ft = 24.384 dm
Width of the sludge sump = 5 ft = 15.24 dm
Depth of the sludge sump = 5 ft = 15.24 dm

Rise in sump level after one automatic blowdown = 7.875 inches = 2.0 dm
Sludge removed in one automatic blowdown = 743.32 Liters
Average automatic sludge blowdown rate in a day = 5.81 lit/sec (from both accelator)
Total automatic blowdown in a day from both accelators = 501739.126 litres = 501.74 m^3/day

2) **Bottom Blowdown:** Manual bottom blowdown valve of the accelators is opened twice a shift.
Volume removed in one manual blowdown = 4530.70 litres (assuming one foot of sludge stays in sump all the time)

So total volume of manual blowdown from both accelators in a day = 18.12 m^3

Total (automatic + bottom) sludge drained in a day = 519.86 = 520 m^3
Total blow down rate in a day = 6.02 lit/sec 95.370129 US gpm

	U 5	GTs
Ratio of soft water use between Unit 5 and Gas Turbines =	1.7	1.0
Dividing the total sludge removed between unit 5 and the GTs in the same ratio =	**328.63**	**191.37**
	(329)	**(191)**

4. Unit 5 Boiler Make-up:

Steam loss to atmosphere (soot blowing and deaeration) is assumed to be twice of the continuous blow down of the boiler to station drains.

Total Daily Design Raw Water Requirement:

1. Water used for ash sluicing = 5715 m^3
2. Water used at seal troughs = 1408 m^3
3. Water used at water treatment plant =
   - i. Demin water used by GTs = 3802 m^3
   - ii. Demin water used by Unit 5 = 305 m^3
   - iii. Water used during regeneration = 551 m^3
   - iv. Water supply to clinker grinder = 109 m^3
   - v. Total accelator blow down = 520 m^3
   - vi. Cooling tower make-up = 6950 m^3
4. Lab sample heat exchanger = 981 m^3
5. Air Compressor heat exchanger = 1635 m^3

Total = 21976 m^3

Daily Maximum Water Withdrawal:

According to the results of the tests (Appendix B) performed on raw water system at Brandon Generating Station, the expected maximum raw water flow rate when unit 5, 6 & 7 operate simultaneously are as follows:

1. During wet bottom ash sluicing of unit 5 boiler = 345 liters per sec.
2. During dry ash sluicing of unit 5 boiler = 271 liters per sec.

So water required in a day for the operation of unit 5, 6 & 7 = 23947.20 ≈ **23947 m^3**

During testing it was observed that the actual maximum raw water flow rate to water treatment plant is almost equal to the design requirement and the rest of the plant is collectively using more water than design. In the raw water balance diagram, the daily maximum raw water withdrawal for the three units (23947 m^3) has been distributed among different parts of the raw water system keeping in view their design raw water requirement.

Any additional raw water consumption in a day is as follows:

1. Diesel Fire Pump:

It is run every week for testing for thirty minutes.

According to annual fire test results of 2002, water used in weekly Diesel Fire Pump test = 113.562 m^3

2. HP Ash Pump for Units 1-4:
The canisters of the building vacuum system are cleaned every week for thirty minutes by using raw water.
One HP Ash Sluicing Pump of Unit 1 - 4 is run for this purpose, which has a rated capacity of 1200 USgpm at 450 feet of head.
According to the pump curve and the results of the tests performed on the raw water system, the ash pump of unit 1-4 is expected to run at a flow rate of 1000 US gpm during the cleaning of building vacuum system canisters.

Water required for weekly cleaning of building vacuum system canisters =	113.562 m^3
Total water consumed in one day =	24174.325 m^3
Average Flow rate in a day =	0.27980 m^3/sec

Note: The daily total and daily average flow rate are calculated based on the assumption that diesel fire pump for testing and the ash pump (1-4) for cleaning canister of building vacuum system are run on the same day and no fire is fought that day.

Weekly Maximum Raw Water Withdrawal:

⇨Assuming no fire:

Weekly Maximum Water Withdrawal =	167857.525 m^3	
Weekly Average Flow Rate =	0.2775422 m^3/sec ≅	0.278 m^3/sec

⇨Assuming a fire:

Water required to fight a three hour fire (@ 1700 Usgpm) =	1158.336 m^3	
Weekly Maximum Water Withdrawal =	169015.861 m^3	
Weekly Average Flow Rate =	0.27945744 m^3/sec ≅	0.280 m^3/sec

Yearly Total Raw Water Withdrawal Limit:

If water is withdrawn at an average rate of 278 liters/sec for a whole year, same as the weekly average withdrawal rate, the yearly total raw water withdrawal would be as follows:

1. yearly total for 100% operating factor =	8792.45 decameter^3	20.82% increase from existing limit
2. yearly total for 90% operating factor =	7913.35 decameter^3	8.74% increase from existing limit
3. yearly total for 85% operating factor =	7473.80 decameter^3	2.70% increase from existing limit
4. yearly total for 80% operating factor =	7034.24 decameter^3	-3.34% increase from existing limit

The yearly total raw water withdrawals include the water used during fighting a three hour long fire @ 1700 USgpm and the water used during annual testing of the fire system as listed below.

Water required to fight a 3 hours long fire =	1158.34 m^3
Water used during annual testing =	264.42 m^3

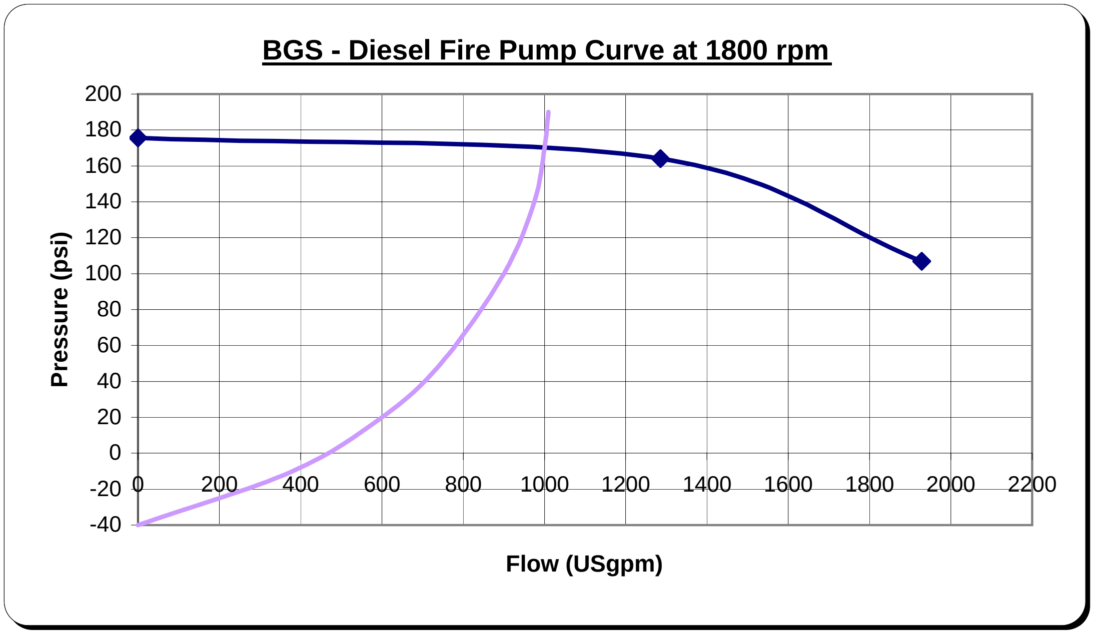
<u>**Water Consumption During Testing of Fire System**</u>

1. Water Used in Weekly Testing of Diesel Fire Pump

During the weekly testing, Diesel Fire Pumps runs at 1800 rpm while the H-Q curve for this pump is based on 1750 rpm. So a new adjusted pump curve for the Diesel Fire Pump running at 1800 is required for calculating the water consumption during weekly testing.
Using Affinity Laws;

Description	**1750 rpm**	**1800 rpm**
Rated Pump flow (Usgpm) =	1250	1285.71
Rated pump pressure (psi) =	155	163.98
Pressure at zero flow (psi) =	166	175.62
Pressure at 150% of the rated flow (psi) =	101	106.85
150% of the rated flow (Usgpm) =	1875	1928.571429

The following graph shows the pump curve at 1800 rpm.



Note: The system curve in the graph above is just a trend line between its starting point and the point where it intersects the pump curve.
Reference to the annual pump test results of 2002, the intersection point between system and pump curves in the graph indicates the flow rate the pump is expected to have when no hydrant is open and only the pressure relief valve is open to protect the pump.
So during the weekly test, the Diesel Fire Pump has a flow rate of approximately 1000 USgpm.

As Diesel Fire Pump is run for thirty minutes for testing purposes.
Total raw water consumed during one weekly test of the pump = 113.562 m^3

2. Raw water used during annual testing of both fire fighting pumps.

As per Fire Marshal of Manitoba Hydro, during the annual fire system test, each fire pump is run for approximately half an hour.
Using the annual fire test data of 2002, the raw water quantity used during the test is as follows:

a. Diesel Fire Pump:

Assuming that the pump is run at zero flow for 6 minutes and 12 minutes each at 100% and 150% of the rated capacity.

i. Water consumed during zero flow (relief valve open) =	22.712	m^3
ii. Water consumed at rated flow =	47.832	m^3
iii. Water consumed at 150% of the rated flow =	88.215	m^3
Total water consumed during the test =	158.760	m^3

b. Electric Fire Pump:

Assuming that the pump is run at zero flow for 6 minutes and 12 minutes each at 100% and 150% of the rated capacity.

i. Water consumed during zero flow (relief valve open) =	25.892	m^3
ii. Water consumed at rated flow =	33.842	m^3
iii. Water consumed at 150% of the rated flow =	45.925	m^3
Total water consumed during the test =	105.658	m^3
Total raw water used during an annual fire system test =	264.419	m^3

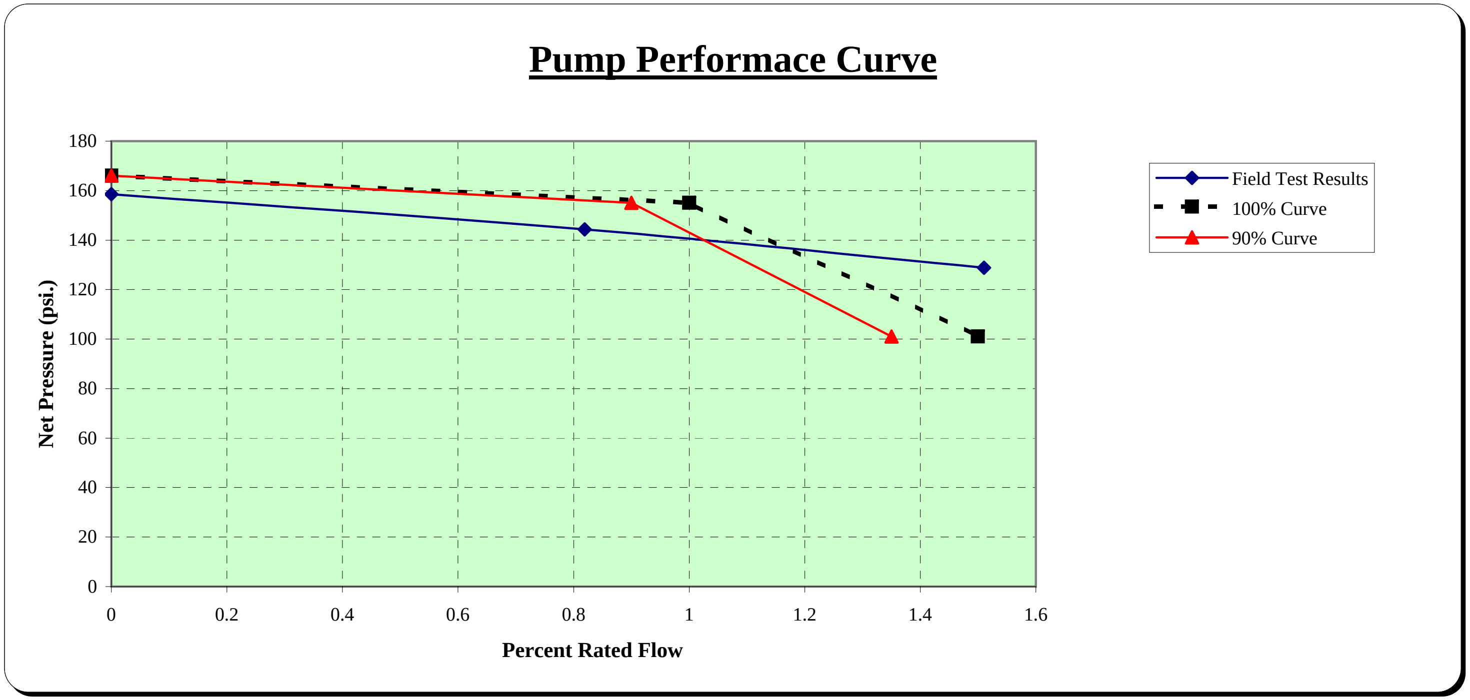
Pump Test Results for: Diesel Fire Pump

Insured Name:	**Manitoba Hydro**	**Date:**	**August 6, 2002**
City:	**Brandon**	**Account:**	**01-17794**
Province:	**Manitoba**	**Index:**	**3968.31**

Pump Data		Rated Net Head (psi)	Rated Flow %	90% Flow
Rated Flow (US gpm)	1250	166	0%	0%
Rated Pressure (psi)	155	155	100%	90%
Rated Speed (RPM)	1750	101	150%	135%

Auto Start @ 70 psi.

RPM	Suct.P	Disch.P	Net Head	Flow	RPM Adj. Net Head	RPM Adj. Flow	% of rated P	% of rated Flow	Rating
1800	40	210	170	0	158	0	102%	0%	-
1800	40	195	155	1053	144	1024	93%	82%	Poor
1800	30	168	138	1942	129	1888	83%	151%	Excellent



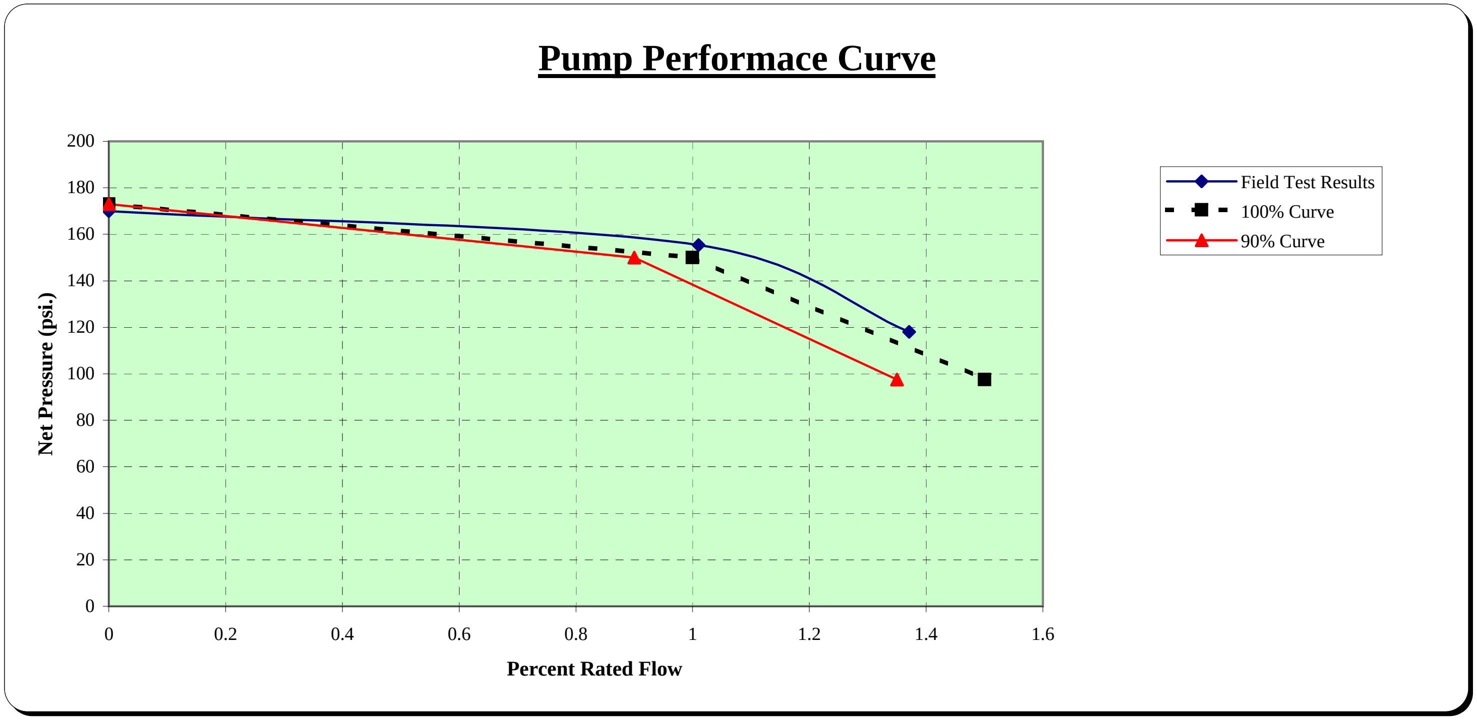
Pump Test Results for: **Electric Fire Pump**

Insured Name:	**Manitoba Hydro**	**Date:**	**August 6, 2002**
City:	**Brandon**	**Account:**	**01-17794**
Province:	**Manitoba**	**Index:**	**3968.31**

Pump Data		**Rated Net Head (psi)**	**Rated Flow %**	**90% Flow**
Rated Flow (US gpm)	750	173	0%	0%
Rated Pressure (psi)	150	150	100%	90%
Rated Speed (RPM)	1800	97.5	150%	135%

Auto Start @ 80 psi.

RPM	Suct.P	Disch.P	Net Head	Flow	RPM Adj. Net Head	RPM Adj. Flow	% of rated P	% of rated Flow	Rating
1770	42	205	163	0	170	0	113%	0%	-
1770	37	186	149	745	155	758	104%	101%	Excellent
1770	35	148	113	1011	118	1028	79%	137%	Excellent



Appendix – B:

Raw Water System – Flow Test Procedure
Brandon Generating Station

1.0 Purpose:

Tests were conducted on the raw water system at Brandon GS for the following two reasons:

1. To find the maximum raw water flow rate when all the three units run simultaneously.

2. To compare the actual maximum flow rate obtained during the test with the design water requirement of the units.

The information collected during the tests will be useful not only in obtaining new higher license limits for raw water use at Brandon GS but also in the replacement of fish screen at raw water intake.

As the probability of all the three units running simultaneously at their maximum continuous rating was very low at least in the near future, the tests were preformed by simulating the conditions that we expect to see at the raw water system when all the three units are running.

2.0 Test # 1:

First test was performed on the raw water system on November 09, 2005. The following sections describe in detail how the test was performed and what were the results.

2.1 The Pre-checks:

The following was confirmed before the start of the test.

- i. Two Raw Water Pumps running and the 3rd pump available for operation.
- ii. Two raw water heat exchangers in service.
- iii. Both accelators available for operation.
- iv. Control valve on raw water inlet line to the accelators on auto.
- v. All accelator automatic blow down drains available on auto.
- vi. All the sand filters available for operation.
- vii. At least two demineralization trains recently regenerated and available to run.
- viii. The two old demin water storage tanks full. It was to avoid the possibility of interruption in unit 5 operation due to lack of demin water.
- ix. Minimum water level in the new demin water storage tank 401.
- x. Discharge piping of the demin water storage tank 401 pumps connected to the regeneration waste piping so the tank 401 could be pressure drained.

The flow meter on the soft water make up line to cooling tower was not available. A feedback from this flow meter is required for the raw water inlet control valve to the accelators to work on auto (pre-check # iv). So a false feedback of 80 litres per second was given to the control valve so it could work on auto and the cooling tower make up valve was fully opened.

2.2 The Test:

1. Started the wet bottom ash sluicing of unit 5 boiler.
2. Opened the cooling tower make up valve to 100%.
3. Started two demin trains and maintained a flow of 29 litres per second through each train going into the demin water storage tank 401.
4. Started the 3^{rd} raw water pump as the levels of the soft water and filtered water tanks kept dropping during the beginning of the test while control valve at the raw water inlet line to the accelators was fully open.
5. Started draining the demin water storage tank 401.
6. Stopped the test after one hour of reaching the steady state condition.
7. Took readings shown in table -1 after intervals of 10 minutes during the test.

Table – 1

Sr. #	Total Raw Water Flow Rate (Original Flowmeter)* Lit/sec	Total Raw Water Flow Rate (Spare Flowmeter) Lit/sec	Raw Water Pressure at the Water Treatment Plant, kPa	Make-up Water Flow to Cooling Tower Lit/sec	Raw Water Flow to Accelators Lit/sec	Opening of Control Valve on Raw Water Inlet Line to Accelators %	Flow Rate Through Demin Trains (Lit/sec)		
							Train # 1	Train # 2	Train # 3
1	276.3	273.18	301	80	92	41	-	28.7	29.3
2	317.0	302.20	256	80	121	100	-	30	29.3
3	330.5	298.42	315	80	138	100	-	29	28.8
4	329.0	312.93	315	80	137	100	-	29.2	28.7
5	335.0	305.99	314	80	137	100	-	28.1	28
6	334.0	306.62	314	80	133	100	-	28	28
7	333.0	310.40	314	80	135	100	-	28.2	26.9
8	328.0	307.25	314	80	135	100	-	27.3	26.7

* As per total raw water flow rate trend on DCIS the maximum total flow rate during the test was 344.77 litres per second (fig. -1).

The test was performed on November 09, 2005 from 1550 to 1700 hrs.

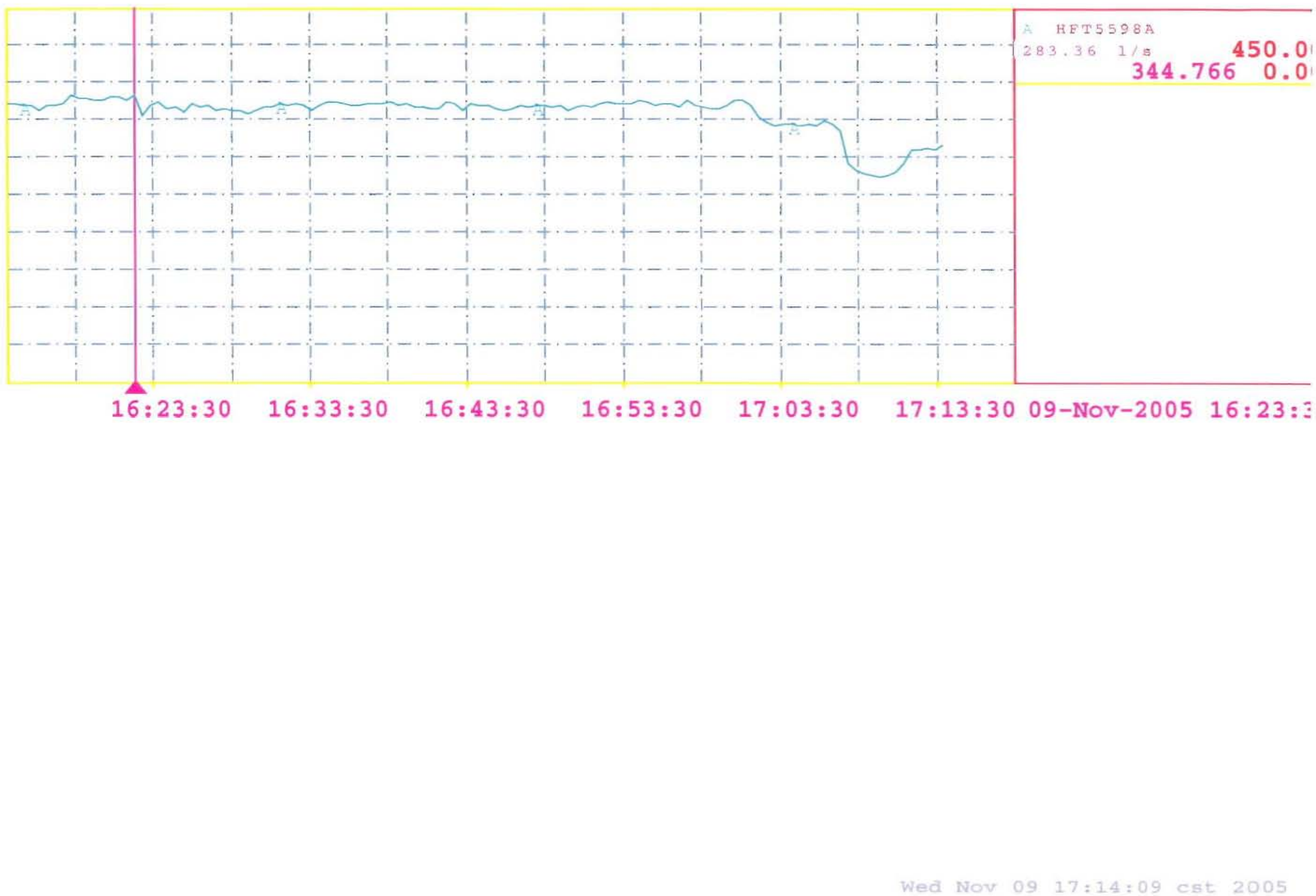


Fig. -1: Raw water flow rate trend during the test.

3.0 Test # 2

This test was performed in light of the results obtained during the first test. During this test, HP Ash Pump of unit 1-4 was also operated to see the affects of its operation on the total water available to the units during wet bottom and dry ash sluicing of unit 5 boiler. Briefly, following were the results:

- Flow rate during wet bottom ash sluicing of unit 5 boiler when HP Ash Pump of unit 1-4 was also running:
  - Flow rate for the units = 320 liters per second
  - Flow rate of HP Ash Pump of unit 1-4 = 63 liters per second
  - Total = 383 liters per second

- Flow rate during dry ash sluicing of unit 5 boiler:
  - When HP Ash Pump of unit 1-4 was not running = 271 liters per second.

  - When HP Ash Pump of unit 1-4 was running:
    - Flow rate for the units = 250 liters per second
    - Flow rate of HP Ash Pump of unit 1-4 = 63 liters per second
    - Total = 313 liters per second