Water System

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CFS Group

Sep 7 2006

OUTLINE

Water System Design

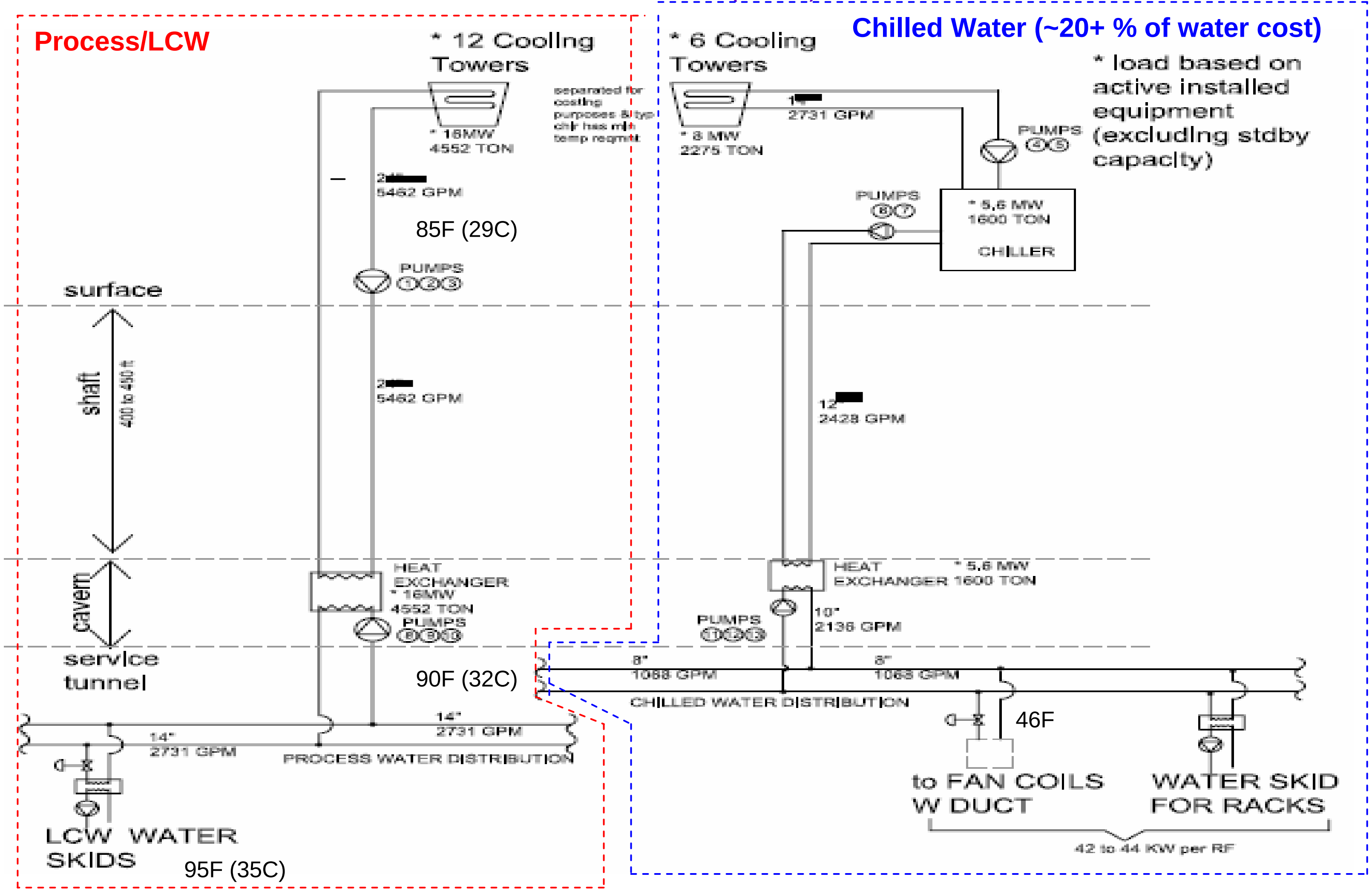
Thermal Loads

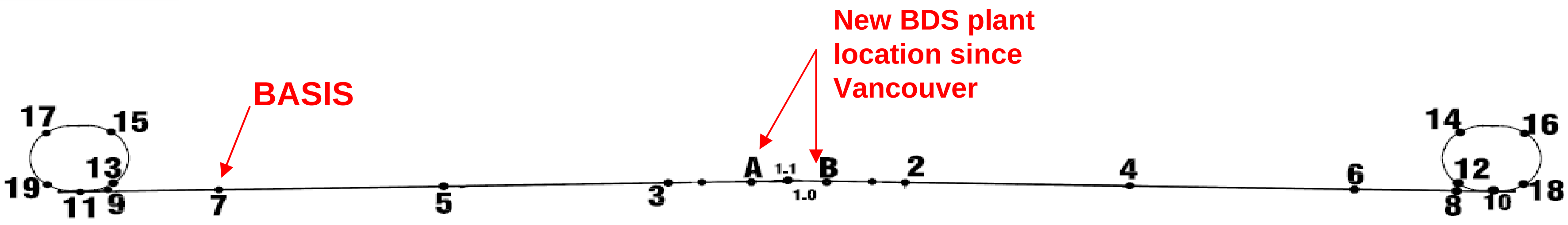
Method of Costing Water Plants

Marc Tasks for CFS Mechanical

Summary

- **Schematic June 1 - Water Plant at Shaft 7(basis) –** Vancouver & current





WATER PLANT LOCATION

Plant No.		Area it serves
17	e- DR	e- DR load total divided by 4 (except for chilled water only the alcoves are considered)
15	e- DR	e- DR load total divided by 4 (except for chilled water only the alcoves are considered)
19	e- DR	e- DR load total divided by 4 (except for chilled water only the alcoves are considered)
13	e- DR	e- DR load total divided by 4 (except for chilled water only the alcoves are considered)
11	RTML	Half of RTML total load
9	e- Source	e- source total load divided by 2 **(wag) Need to be updated per Clay's latest email (need to rearrange distribution later)**
7	ML	Main Linac Total Load x No fo RF at this shaft (128) divided by total no of ML RF (624)
5	ML & e+ source	Same as Shaft 7 (but with 120 total RF) plus half of e+ source total load
3	ML	Same as Shaft 7 (but with 64 total RF) (excluded e+ source transport line for now)
A	BDS and Dump	Half of BDS total load and one 18MW dump

Plant No.		Area it serves
B	BDS and Dump	Half of BDS total load and one 18MW dump
2	ML	Same as Shaft 7 (but with 64 total RF)
4	ML & e+ source & e	Same as Shaft 5 plus half of e- source load **(wag) Need to be updated per Clay's latest email (need to rearrange distribution later)**
6	ML	Main Linac Total Load x No fo RF at this shaft (128) divided by total no of ML RF (624)
8	RTML	Half of RTML total load
12	e+ DR	e+ DR load total divided by 4 (except for chilled water only the alcoves are considered)
14	e+ DR	e+ DR load total divided by 4 (except for chilled water only the alcoves are considered)
18	e+ DR	e+ DR load total divided by 4 (except for chilled water only the alcoves are considered)
16	e+ DR	e+ DR load total divided by 4 (except for chilled water only the alcoves are considered)

- Thermal Loads

Pursue info from Area System leaders, Magnet group and POC.

Mostly total load only (..and changing)

Tabulated (but we're told everything is still preliminary)

Other than the load at shaft 7 (ML), the current Thermal load list is just used as multiplier for sizing, cost ..and electrical power usage tabulation.

Total Thermal load pre-Vancouver was 296MW, currently at 222MW.

Total Heat Load List as of Aug 30 2006

THERMAL LOAD USED (in MW) (..and still changing....)

Updated Aug 25 2006 CFS

Area System	LCW	Air / Chilled Water (does not include heat of compression)	Total	Sources
SOURCES e-	3.72	1.31	**5.03**	**Aug 21** (Clay) 4.36;3.72;2.53 MW for LCW, 1.53;1.31;0.89 MW for Air- Numbers are PSTD (peak simultaneous thermal demand);INPTC (installed nameplate thermal capacity) ;ATL (Average thermal demand)
SOURCES e+	15.8	5.55	**21.35**	**Aug 21** (Clay) 22.8;15.8;10.7 MW for LCW, 8.00;5.55;3.80 MW for Air - PSTD (peak simultaneous thermal demand) ;INPTC (installed nameplate thermal capacity);ATL (average thermal demand)
DR e-	6.71	3.05	**9.762**	**Aug 10** (Andy)-except load to air is not used (which is assume to be dissipated to ventilation air) LOADS STILL NEED TO BE CHECKED WITH MAGNET GROUP --very preliminary accdg to Andy
DR e+	8.25	4.90	**13.154**	**Aug 10** (Andy)-except load to air is not used (which is assume to be dissipated to ventilation air) LOADS STILL NEED TO BE CHECKED WITH MAGNET GROUP --very preliminary accdg to Andy
RTML	12	2.4	**14.4**	**May 24** (Jerry, PT) preliminary ~7 MW per RTML
MAIN LINAC	78	26.83	**104.832**	**Jun 1** (Shigeki et. al.) spreadsheet per RF x 624 RF
BDS	14.71	2.60	**17.3**	**Aug 10** (Andrei) Rough 17.3 MW for 14mrad---TO BE CHECKED---very very preliminary accdg to Andrei. Assume 85%/ 15% distribution to lcw/air
DUMPS	36	0	**36**	**Aug 15** (Andrei) -reconfigure such that one or two plant sized for(2) 18MW serves (6) 18MW dumps, only (2) are active at any time. **Aug 25** (Fred), adjust shaft locations
	175	*49*	**222**	

DRAFT

MAIN LINAC HEAT LOAD PER RF

Currently NO heat load to air from Klystron, Numbers from Shigeki spreadsheet / email Apr 2006

MAIN LINAC - ELECTRON & POSITRON				To Deionized Water						to Chilled Water	To Air		
Components	Quantity Per 36m	Location	Total Heat Load (KW)	Heat Load to Water (KW)	Supply Temp (variation) (C)	Delta Temperature (C delta)	Maximum Allowable Pressure (Bar)	Typical (water) pressure drop Bar	Acceptable Temp Variation delta C	Heat Load to Water (KW)	Heat Load to Air (KW)	Max Space Temp (C)	Source
LCW Skid Pump 5 Hp (placehodler)	1	Service Tunnel	4.14	0	N/A	N/A	N/A	N/A	None	0	4.14		* emil - 5 HP pump placeholder
Fancoils (5 ton Chilled Water) 1 Hp	2	Service Tunnel	1.66	0	N/A	N/A	N/A	N/A	None	0	1.66		* emil - (2) 1HP 5Ton Fancoil placeholder
Rack Water Skid	0.25	Service Tunnel	1.04	0	N/A	N/A	N/A	N/A	None	0	1.04		* emil - 1(5Hp) every 4 RF (placeholder)
Lighting Heat Dissipation ~1.3W/sf		Service Tunnel	1.65	0	N/A	N/A	N/A	N/A	None	0	1.65		* Clay - 14 W per sq m
Lighting Heat Dissipation ~1.3W/sf		Accelerator Tunnel	1.65	0	N/A	N/A	N/A	N/A	None	0	1.65		* Clay - 14 W per sq m
People Heat Dissipation 500btuh each	0	Accelerator Tunnel	0.00	0	N/A	N/A	N/A	N/A	None	0	0.00		* emil - placeholder
People Heat Dissipation 500btuh each	2	Service Tunnel	0.29	0	N/A	N/A	N/A	N/A	None	0	0.29		* emil - placeholder
AC Pwr Transformer 34.5-.48 kV	0.25	Service Tunnel	2.00	0	N/A	N/A	N/A	N/A	None	0	2		* Clay email 3-14-06 typical 112.5 kVa oil xfmr
Emerg. AC Pwr Transformer 34.5-.48 kV		Service Tunnel	1.00	0	N/A	N/A	N/A	N/A	None	0	1.3		* Clay email 3-14-06 typical 75 kVa oil xfmr
RF Charging Supply 34.5 Kv AC-11KV DC	1/36 m	Service Tunnel	19.00	7.50						0	11.5		* C.Jensen email 2-27-06 183 kVa 0.84pf oil ps xfmr **Shigeki Apr 18 2006 ** Clay 5-25-06 LLRF meeting
Modulator		Service Tunnel	7.50	3.50			28.8			0	4		* Shigeki Fukuda Email 3-1-06 **Shigeki Apr 18 2006
Pulse Transformer		Service Tunnel	6.00	5.00						0	1		**Shigeki Apr 18 2006
Klystron Socket Tank		Service Tunnel	1.00	1.00						0	0		**Shigeki Apr 18 2006
Klystron Focusing Coil		Service Tunnel	8.40	8.40	*34>					0	0		* Shigeki Fukuda Email 4-05-06
Klystron Collector		Service Tunnel	61.00	61.00	*35>			2		0	0		* Shigeki Fukuda Email 3-1-06
Klystron Body		Service Tunnel	10.00	10.00	*35>			5	None	0	0		* Shigeki Fukuda Email 3-1-06
Klystron Windows		Service Tunnel	0.50	0.50	*35>			1		0	0		* Shigeki Fukuda Email 3-1-06
Relay Racks		Service Tunnel	13.3	0.0	N/A	N/A	N/A	N/A	None	12.8	0		* Shigeki Fukuda Email 3-30-06 **Shigeki Apr 18 2006 (chilled water) ** Ray larsen Email 8-16 2006
Circulators & Dummy Load		Accelerator Tunnel	24.3	24.3						0	0		**Shigeki Email Apr 28 2006
Waveguide		Accelerator Tunnel	4.00	4.00	N/A	N/A		N/A		0	0.00		* Shigeki Fukuda Email 3-30-06
Other components?????		????								0	0	N/A	
Total			168.4	125.2						12.80	30.23		
RF Component only Loads			154.95										

Total Heat load to Air & Chilled water per RF 43.0 KW

Total Heat load to LCW per RF 125 KW

47.804 1.62683 5.718319167 29.8775

7.03 3.25375 11.43693125

The only change Aug 16 2006

Costing / Sizing Method

Size & Estimate Shaft 7 Water Plant

Used Means 2006 cost book, Vendors budget prices, previous project info and some wags for costing.

Scale all other plants based on loads (except the tunnel piping is scaled based on length). - (using Shaft 7 plant as reference) and distributing it by area system.

Plant Scaling / Multiplier based on loads

PLANT	LOADS (MW)		Multiplier for		Area							
	LCW/process	AIR/Chw *	Process	Chw	e- source	e+ source	DR	RTML	Main Linac	BDS	Exp'mt	Gen'l &
17	1.7	0.2	10%	4%			100%					
15	1.7	0.2	10%	4%			100%					
19	1.7	0.2	10%	4%			100%					
13	1.7	0.2	10%	4%			100%					
11	6.0	1.2	38%	22%				100%				
9	1.9	0.7	12%	12%	100%							
7	16.0	5.5	100%	100%					100%			
5	22.9	7.9	143%	144%		34%			66%			
3	8.0	2.8	50%	50%					100%			
A	25.4	1.3	158%	24%						100%		
B	25.4	1.3	158%	24%						100%		
2	8.0	2.8	50%	50%					100%			
4	24.8	8.6	155%	156%	7.5%	31.9%			60.6%			
6	16.0	5.5	100%	100%					100%			
8	6.0	1.2	38%	22%				100%				
12	2.1	0.3	13%	6%			100%					
14	2.1	0.3	13%	6%			100%					
18	2.1	0.3	13%	6%			100%					
16	2.1	0.3	13%	6%			100%					

Marc's Task / CFS mechanical / from Vancouver

1) Assess CFS mechanical in general
2) Investigate skid cost when produced in mass quantities
3) Investigate savings associated with 2X delta T in process water
4) General issues associated with removal of chilled water (Temperatures, stability, etc)
5) Reduction of mechanical system capital cost
6) Watt (cooling power) per watt (heat rejection)

Cost Reduction List. (Page 1) (see separate pdf for clearer copies)

SEP 5 2006 DRAFT DRAFT DRAFT DRAFT DRAFT DRAFT DRAFT (estimates need to be checked) eh

REDUCTION OF CFS MECHANICAL COST (Process Cooling WBS Shown) (Values in $K)

	Bold red indicate Items for Marc	TOTAL	M LINAC	BDS	Started: Aug 10 2006	
	Items	%reduction based on Initial Cost/Jul 14 numbers	%reduction based on Initial Cost/Jul 14 numbers	% reduction based on Initial Cost/Jul 14 numbers	DRAFT Impact/ Notes	BHP IMPACT
A	Initial Cost (July 14 2006)				Based on 296 MW thermal Load (placeholders)	
B	Check Estimate	*later*	*later*	*later*	*later*	
C	Updated Thermal Load, added missing items, Corrected errors & **reduced Skid to 2X (1 skid to 2 RF),** = Suggest to use this as **NEW BASELINE**	23%	73%	62%	Based on current Thermal load 222 MW (Aug 30 2006) - Note that these numbers are preliminary according to Area System/Contact. BDS load down from ~70MW to ~17MW (preliminary) Numbers from Magnet Group are not considered. It doesn't include the Sources and BDS changes Still waiting for more Vendors info on various Skid sizing. Currently use $90K per skid but doesn't include **quantity discount.**	
	The % in the following are approximate and are %reduction as compared to the Jul 14 estimate.					
1	<u>Make All Chiller Aircooled</u> (1 Skid /2 RF; 20 Delta T on Process; Updated Load per Item C)	25%	6%	63%	Remove Cooling Tower & Pump for the Chillers. Chillers can be located outside the bldg (reduced bldg cost not included). KW electrical capacity increase by ~10 to ~15% There will be no free cooling during winter. Operating cost increase.	+ +
2	**Reduce LCW Skid to 1 Skid to 4 RF at <u>20</u> delta**	29%	10%	65%	Still waiting for more Vendors info on various Skid sizing. Currently use $90K per skid but doesn't include **quantity discount.**	TBD
3	**Increase Process water delt T to 40 F (with 1 skid 2 RF)**	**32%** about 40% of this is due to load reduction and correction	14%	67%	Impact of 40 delta F on RF water load not included (by???)/ Piping scheme to get 40F delta in Rf components not considered 40 delta F is also acceptable in Magnet load (Meeting with magnet Aug 22 2006) Note that BDS Water Dump has 54F delta. Since cost is scaled from Shaft 7, this cost reduction may not be reflected (see add; item below) Impact on BHP..... TBD	TBD
4	**Increase Process water delta T to 40 F (with 1 skid 4 RF)**	**38%** about 40% of this is due to load reduction and correction	21%	70%	Impact of 40 delta F on RF water load not included (by???)/ Piping scheme to get 40F delta in Rf components not considered 40 delta F is also acceptable in Magnet load (Meeting with magnet Aug 22 2006) Note that BDS Water Dump has 54F delta. Since cost is scaled from Shaft 7, this cost reduction may not be reflected (see add; item below) Impact on BHP..... TBD	TBD

Cost Reduction List. (Page 2)

5	Remove Chilled Water ** (*Water Cooled Racks will have dedicated chiller- preliminary concept based on Liebert XDF. Cost for this is assumed as included with other group*)	45% about 40% of this is due to load reduction and correction	36%	67%	Warm Temperature / Temperature stability could be an issue Main Linac (Adolphsen email Sep 5 2006) require 29C (84F) air temperature. Need Chilled Fancoil for this.. Chilled Water system Is still needed for BDS (requirement) A CFD analysis of the space will be pursued to provide the variation of temperature across the tunnel to see if acceptable. OSHA Sec 3 Chap 4 Heat Stress at 95F at 55dewpoint equatte to WGBT of 77F adequate for continuous heavy work. May require chilled water fancoils to maintain to this. Based on Libert cost (info sent to HLRF Sep 1) for rack with chlr,. Assume cost included with other group for this scheme. NOTE That cost reduction in fancoil cost is not included. Impact of BHP......TBD	–
6	Reduce CHW (Variation of Item 5 except CFS will have cost for dedicated CHLR, skids & piping to ML racks, and no fancoils for other equipment heat load to air NOTE: We couldn't find a small water to water dedicated chiller at this point.	32% about 40% of this is due to load reduction and correction	16%		Warm Temperature / Temperature stability could be an issue Main Linac (Adolphsen email Sep 5 2006) require 29C (84F) air temperature. Need Chilled Fancoil for this.. Chilled Water system Is still needed for BDS (requirement) A CFD analysis of the space will be pursued to provide the variation of temperature across the tunnel to see if acceptable. OSHA Sec 3 Chap 4 Heat Stress at 95F at 55dewpoint equatte to WGBT of 77F adequate for continuous heavy work. May require chilled water fancoils to maintain to this. Large footprint for the dedicated rack chiller. Could be space issue... Dedicated Chiller Skid for each water cooled RF Racks (1 per RF), wag at $25installed cost based on phone with Vendor (Ecobay) but to be checked later, and based on aircooled (Libert) email at $15K + install (but this is only aircooled). 10 Ton Ecobay budget of $40K not used for now. NOTE That cost reduction in fancoil cost is not included. Impact of BHP......TBD	TBD
7	Reduce CHW (Variation of Item 5 except provide chilled water only on smaller area in the service tunnel for worker to work)					
8	Eliminate HX and Pump and Cavern				higher water pressure in the tunnel piping. Water Skid should be sized to accept higher pressure (Dan Lacedra of Bornquist suggested 15% increase in cost of the skid for this) Savings in Cavern space for equipment (not considered at this point) Glycol in the tunnel piping, issue or no???	
9	One Large LCW Distribution from the Cavern				No data for large 14" to 18" ss pipe. (discussed with two vendors- Aug 22 2006) Large piping main at Stainless and Cavern pump at Stainless will be very expensive	
10	(1 Skid to 8 RF)					
11	Provide one plant for BDS					
12	Separate Estimate for BDS Plant at 54delta F					
13	Various HX approach temperatures vs HX cost					

Delta T

		BASE: with chilled water to handle other air load	with chilled water to handle other air load	adjusted load (wag portion of load to air back to water)- No chw	adjusted load (wag portion of load to air back to water)- No chw	adjusted load (wag portion of load to air back to water)- No chw	adjusted load (wag portion of load to air back to water)- No chw	adjusted load (wag portion of load to air back to water)- No chw
1	SHAFT 7 LCW PLANT pumps estimate (Main Linac Only)							Aug 28 2006
3	LCW Load per RF (thermal KW) **	125	125	148	148	148	148	148
4	Delta T (delta F)	**20**	**20**	**26**	**26**	**30**	**40**	**40**
5	No of RF at Shaft 7 Plant	128	128	128	128	128	128	128
6	Flow per RF (gpm)	43	43	39	39	34	25	25
7	Total Flow for shaft 7 plant	5,462	5,462	4,975	4,975	4,312	3,234	3,234
8	LCW Plant for shaft 7 (MW)	16	16	19	19	19	19	19
9	Flow at Tunnel (gpm)	2,731	2,731	2,487	2,487	2[illegible]	1,617	1,617
10	**PROCESS PUMP FROM CAVERN TO SKID**							
11	**Piping at Tunnel**							
12	Size along tunnel length	varies	varies		[illegible]aries		varies	varies
13	Max Pipe Size (near base of shaft)	14"	12"		12"		10"	12"
	% portion of this in tunnel pipi	41%	28%	6%	38%		42%	9%
14	Average Pressure Drop (ft / 100 ft)	0.51	1.711	0.73	0.76		0.703	0.64
15	Average Velocity (fps) - low-	4.22	6.5	4.73	4.8		4.3	4.1
16	Tunnel Piping Only Cost (K$)	4,364	$ 3,211	$ 3,547	$ 3,595	$ 3[illegible]	1,840	$ 2,384
	% reduction cost in tunnel piping or	N/A	26%	19%	18%		58%	45%
	(Main linac Process Cooling Co...							
	% reduction cost based on overall ML Process Cooling (incl engg)		TBD	TBD	TBD	TBD	TBD	TBD
	(Main linac Total CFS Cost)							
	% reduction in cost based on overall ML CFS cost (incl engg)		TBD	TBD	TBD	TBD	TBD	TBD
17	Length Tunnel Pipe (one leg) ft-supply& return (~5.1Km)	16728	16728	16728	16728	16728	16728	16728
18	Pressure Drop Piping Only - ft	85	286	122	127	134	118	107
19	Overall % Reduction in cost based on Total Process Cool							
20	**Main Piping from Tunnel to Cavern**							
21	Size	18"	18"	18"	18"	16"	14"	14"
22	Average Pressure Drop (ft / 100 ft)	0.93	0.93	0.77	0.77	1.06	1.08	1.08
23	Pipe velocity (fps)	7.84	7.84	7.14	7.14	7.83	7.25	7.25
24	Length Tunnel Pipe (supply&return) wag	150	150	150	150	150	150	150
25	Pressure Drop Main Piping -tower to Cavern	1.40	1.40	1.16	1.16	1.59	1.62	1.62
26								
27	**Miscellaenaous**							
28	Allowance for Heat Exchngr pressure drop (Cavern) - ft	23	23	23	23	23	23	23
29	Allowance for Heat Exchngr pressure drop (LCW Skid) - ft	23	23	23	23	23	23	23
30	Allowance for Control Valves- ft - wag	30	30	30	30	30	30	30
31	Total Drop for Miscellaneous	76	76	76	76	76	76	76
32								
33	**Subtotal Press Drop**	163	364	200	204	211	195	185
34	Allowance for fittings and safety factor 15% - wag	24	55	30	31	32	29	28
35	Total (ft)	**187**	**418**	**230**	**235**	**243**	**225**	**212**
36	Total (psi)	81	181	99	102	105	97	92
37								
38								
39	Actual Pump Selection- (2 pump runng, 1 stdby) (see attached selection)							
40	Bhp @ Design Point each pump -flow at row9 & head @ row35	167		185	190	176	120	115
41	HP each pump (installed) (non-overloading)	200		225	225	[illegible]	150	150
42	Quantity Pump Running	2		2	2	2	2	2
43	Quantity Pump Stdby	1			1	1	1	1

varies
14"
41%
0.51
4.22

2 pipe less (pipe varies in tunnel)

varies
10"
42%
0.703
4.3

167
200

120
150

25 to 28% reduction

Watt per watt information for water cooling plants

Plant	% Chilled Water	% LCW	Watt per Watt	
CUB (Central Cooling Plant at Fermilab)	60%	40%	0.24	Use Cooling Towers
Tevatron- Fermilab	0%	100%	0.18	Use Pond Water (no fan power)
Main Injector	0%	100%	0.16	Use Pond Water (no fan power)
Shaft 7 Water Plant	26%	74%	0.18	Use Cooling Towers

So current water plant design appear to be ok With regard to this.

- <u>Summary</u>

Basic Water System Design is presented.

Thermal Load still preliminary, still changing, may still be large and need to be checked, confirmed. (Cost Driver)

Skid reduction (1skid to 4RF) and increase delta T (40F) can be pursued. Impact on BHP to be investigated. (*how about impact on water cooled components?)*

Various Cost reduction scheme investigated and continuing (including skid cost)

Watt (cooling power) per watt (heat load) for shaft 7 plant appear reasonable.

Major Cost driver is still Skid, CHW and Large thermal load.

Temperature analysis in next two weeks (also Tom and Lee’s talk).