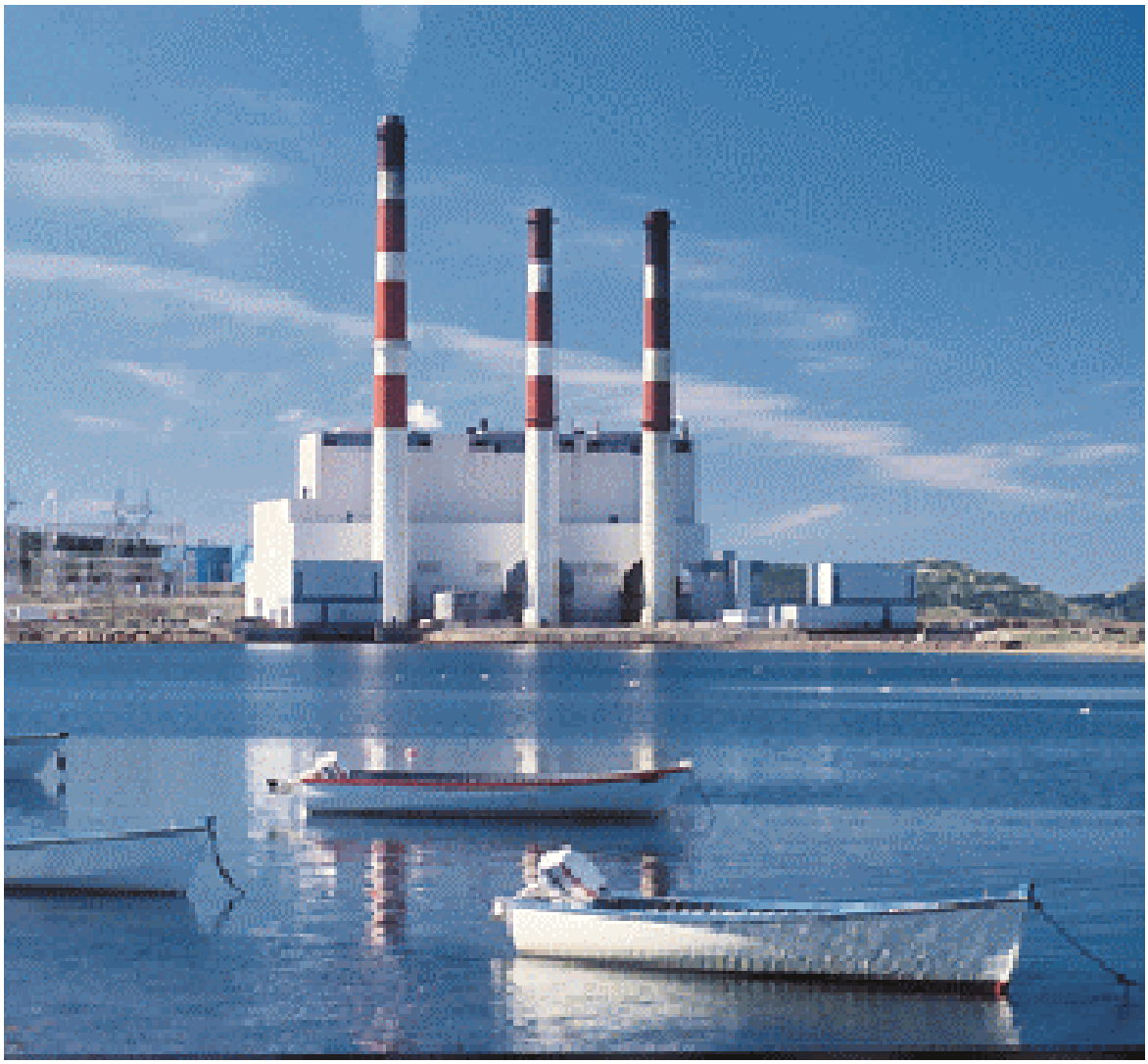
Tab 2

DISTRIBUTED CONTROL SYSTEM

LIFECYCLE PLANNING



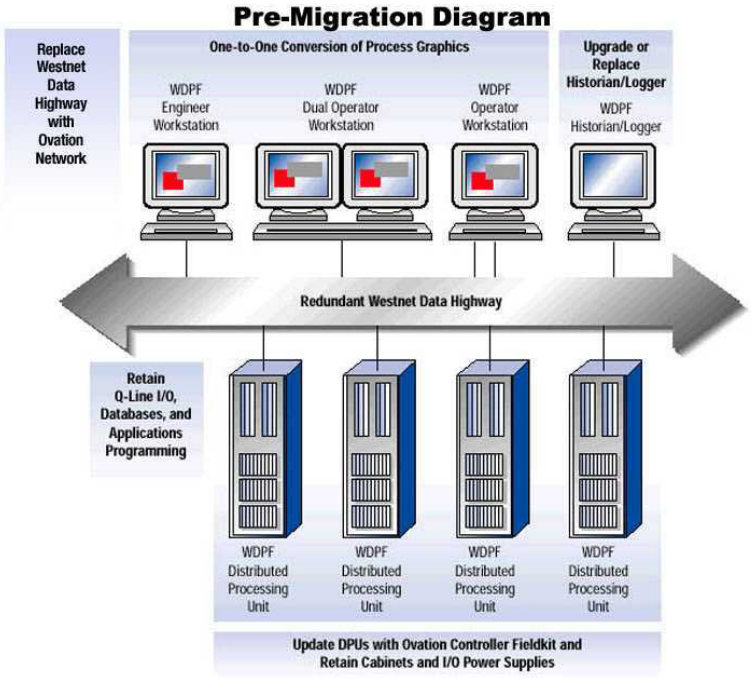
Holyrood Thermal Generating Station

November 2002

Background

The distributed control system (DCS) in the Holyrood Thermal Generating Station provides boiler control, boiler auxiliary systems control, station service control, burner management control (stage 2 only), turbine and generator monitoring, and control for other plant systems. DCS reliability is essential to the overall operation of the generating units. The existing DCS on stage 1 is a Westinghouse Distributed Processing Family (WDPF) level 6 system that was implemented in 1988. The existing DCS on stage 2 is a WDPF level 7 system that was implemented in 1992 (active technology that was used primarily to maintain consistency with stage 1). Picture 1 illustrates all sections of the WDPF DCS.

Picture1:



Westinghouse Process and Control (now Emerson Process Management) implemented a ten year service commitment with four life stages:

1) Current – Current technology with a 10 year or greater support commitment. Current technology is recommended for new systems or major expansions.
2) Active – Technology early in the defined 10 year support commitment period. Active technology is only recommended for expanding existing systems.
3) Maintained – Technology that is no longer available for new acquisitions, but spares are guaranteed to support existing systems. Generally not available for new systems or expansions.
4) Retired – Technology that has passed the 10 year support commitment time frame. Retired technology is no longer available for purchase. Availability and pricing is not guaranteed for repairs and spares for existing systems.

Support commitment expired for WDPF level 6 systems in January 2002 and will expire for WDPF level 7 systems in January 2003. An action plan is essential to allow time for the budgeting process to allocate funding for new equipment and the inevitable increase in maintenance costs for the present system. The obsolescence issue regarding the DCS at the Holyrood Generating Station is:

What is the best life-cycle cost decision to ensure reliable and effective operation of the DCS?

Life-Cycle Planning Basics

Emerson defines System Life-Cycle Planning as:

> A user business plan that reviews the current maintenance and support level of a control system versus future requirements and expectations

The practical end-of-life of a DCS is determined by the time when spare parts (both hardware and software) are no longer available to maintain the system for reliable operation. New technologies with new features and lower costs lead to obsolescence as the new components replace the previous generation of components and reduce demand for the older components. Manufactures adjust to the changing demands and reduce production of the older components in favor of the newer components that are in higher demand. Control systems companies are impacted by component obsolescence and thus are forced to advance with technology. Emerson has developed three programs to assist their customers with obsolescence issues:

1) Stocking refurbished spares for parts with components that do not have direct replacements
2) Providing direct replacement parts where possible
3) Internet software for self-assessment of obsolescence issues

Equipment obsolescence is an inevitable aspect of the control system industry. Newfoundland and Labrador Hydro must properly manage control system obsolescence to prevent major production outages and ensure reliable power for the people of Newfoundland and Labrador. An active life-cycle planning program will ensure awareness of all obsolescence issues with sufficient time to prepare for them and continue reliable production.

Future Direction of Control Systems

WDPF level 8 will not remain a current system much longer and will most likely enter it's ten year sourcing commitment stage by the time we are ready to implement a new system. This platform already has sourcing problems – two problems with alternate solutions are posted on Emerson's website.

Emerson has stated that they plan to utilize the Ovation platform as the current platform for the foreseeable future. Their plan is to upgrade to newer versions of Ovation as required. Presently Emerson is stating that they intend to fully support (at least for the next ten years) both NT and Solaris Ovation systems. The one factor affecting system life unknown to everyone including Emerson is the operating system suppliers (Microsoft and Solaris) intention for future development and support. Most Ovation systems in operation are Solaris, while most new Ovation customers are choosing NT. Traditionally unix based operating systems including Solaris have a reputation for being more stable and more secure than Windows operating systems. Emerson is unaware of any stability problems with either system. Since the price for Ovation systems with either operating system is essentially the same, system stability and operating system supplier support will be the deciding factors for choosing NT or Solaris at the time of purchase.

The trend in DCS investment today focuses on software and non-proprietary off-the-shelf hardware compared to previous self-contained proprietary systems. Data loggers, tuning packages and other add-ons do not have to be purchased from the same controls manufacturer.

Lifecycle Planning Alternatives

Existing cabinets, I/O, terminations graphics and logic are preserved when upgrading to WDPF level 8 or migrating to Ovation from the current WDPF systems. This reuse of assets saves equipment and labour costs, and reduces outage time to implement the changes. Labour related to commissioning I/O terminations can easily match equipment costs. Thus upgrading or migrating is more cost efficient than implementing a DCS from a different supplier.

Planning for maintenance and upgrades to the existing Holyrood DCS is essential to ensure a functional system and reliable production. Many parts for the existing DCS are no longer available and economic replacements do not exist. When spare parts are depleted, redundancy required for reliable control will be lost. Further operational failures will block operational control leaving the unit unavailable for production. Some parts with obsolete components have replacement parts that can be substituted when all spares are consumed. Table 1 illustrates the parts with obsolete components that do not have direct replacements. Emerson will repair these parts as long as components are available but prices will escalate as components become more expensive. Eventually Intel co-processors – like the Matrox boards – will not be available.

Table 1: Obsolete Parts

Drop	Quantity	Part	Sourcing Issue	Comments
Level 7 DPU	12	MSX card	Intel processor obsolete	Stock enough spares to last until the existing system is upgraded or Migrated
Classic MMI	12	Matrox MMI interface Board	No longer manufactured	WPC Source obsolescence Start upgrading MMIs with WeStations in 2004
		MSP card	Intel co-processor obsolete	Stock enough spares to last until the existing system is upgraded or Migrated
PCH MMI	4	OS2 operating system	Discontinued IBM operating system	Difficult to obtain compatible software and hardware

A Drop is a distinct section of the control system including distributed processing units (DPU), and man machine interfaces (MMI). The MMIs are operator consoles and engineering workstations. A PCH is a type of MMI technology consisting of a personal computer and a proprietary interface to the DCS communication highway. MSX and MSP cards are parts of the DPU and Classic MMI respectively that perform processing functions with obsolete 8088 and 8086 technology.

Eventually an Ovation system will need to be implemented considering WDPF level 8 is the last generation of WDPF.

The list of life-cycle alternatives analyzed has been reduced to include:

1) Replace the existing WDPF systems with an Ovation system in 2004/2005
2) Gradually upgrade the existing WDPF systems with a WDPF level 8 system
3) Extend the life of the existing WDPF systems and assess migration to Ovation annually

Replace The Existing WDPF Systems With an Ovation System in 2004/2005

Replacing the existing WDPF systems with an Ovation system in 2004/2005 is the least complicated alternative to implement with the least number of unknowns in equipment performance and costs. The only negative aspect to this option is the requirement for large expenditures earlier than for all other alternatives. This alternative utilizes the most current technology available from Emerson which will provide the longest new system life before a replacement is required. Extra work required in either of the other two alternatives is eliminated. Migration tools have been proven by Emerson through previous successful migrations in other generating stations with minimal outage requirements (less than two days). Emerson is focusing on Ovation technology which will translate into better support in the future for an Ovation system than for a WDPF system. Phasing the project over two years will provide time for operators and technicians to adjust to the new system while one unit is still operating with the existing system. As with all alternatives, technicians will require training to maintain the new equipment. The changes will be almost transparent from an operations perspective, so Operators will only require minimal orientation by plant personnel. This

alternative results in minimal requirements of plant engineering for active life-cycle planning during the first 5 years after migration.

Gradually Upgrade The Existing WDPF Systems With a WDPF Level 8 System

Gradually replacing the existing WDPF systems with a WDPF level 8 system will spread the bulk costs over more time and will defer the large lump sum costs to a later date. Level 8 WDPF components purchased in 1999 to expand the stage 1 system will be utilized for a longer period of time for this option. Less training is required in the short term for technicians, however overall training requirements will be greater. This alternative will require stocking of "last-buy" and used spares to support existing equipment until it is replaced. Two major impacts with this alternative are that the plant will be operating with a "mix-and-match" system, and WDPF level 8 systems may not be available long enough for a complete gradual upgrade. Considerable time will be required by plant engineering to ensure obsolescence issues are addressed accordingly.

Extend The Life of The Existing WDPF Systems and Assess Migration to Ovation Annually

Extending the life of the existing WDPF systems is the alternative that carries the greatest risk and requires constant attention by plant engineering to locate sources of used spare parts and to address obsolescence issues. Reliability and availability of the electrical system and generating units is compromised by the uncertainty of available spares. Unbudgeted costs are highly probable to purchase WDPF level 8 equipment once spares are depleted. WeStation man machine interfaces (MMI) have to be purchased in the near future because Matrox (communication) boards are no longer available for the Classic MMI. This alternative postpones the inevitable expense of a new system and promotes a future migration to Ovation due to the age of WDPF level 8 technology.

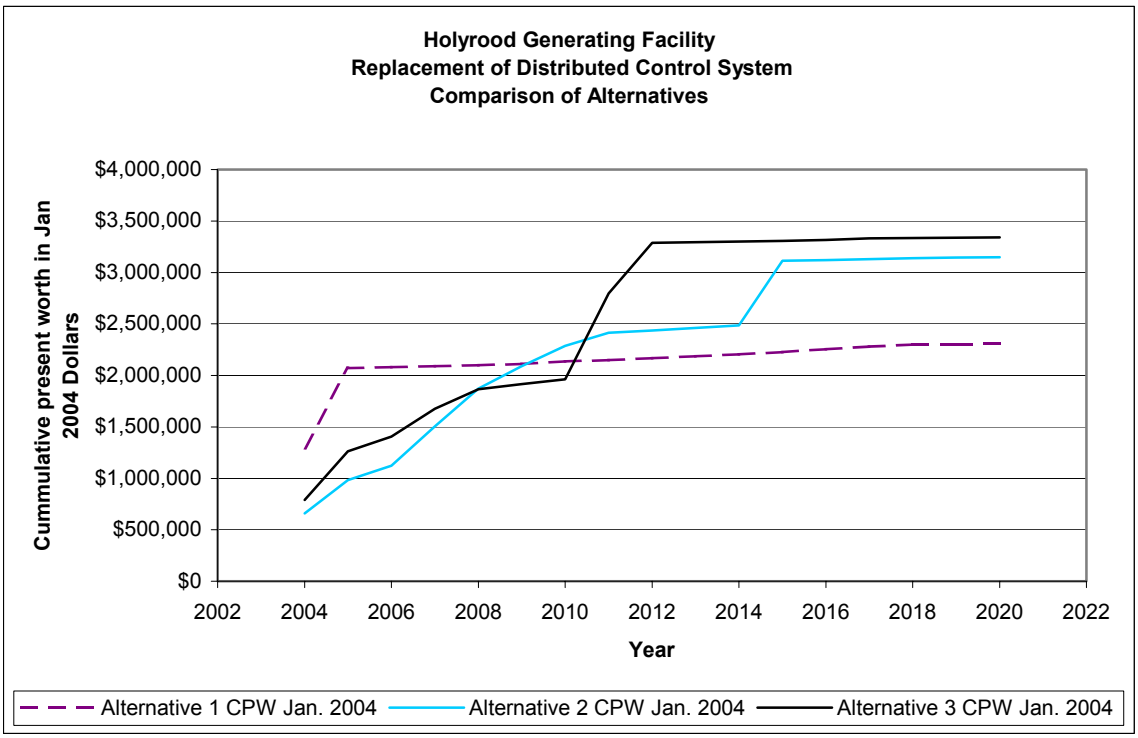
Comparison of Replacement Options

Cost analysis was performed based on a planning horizon to the year 2020. Standard inflation and interest rates and the Conference Board of Canada's projected exchange rates were used to normalize costs. Total present cost over the time frame service life and the time when a given alternative becomes the lowest cost alternative are the two main measures of cost comparison. Alternative 1 – Migrating to Ovation in 2004/2005 – has the lowest present cost of all three alternatives for the period up to 2020, with alternatives 2 and 3 being 35% to 45% more expensive. Table 2 and Chart 1 on page 5 illustrate the cost analysis for the three options. The cross over point, which identifies the year in which Alternative 1 has the lowest present cost, occurs in the 6th year after the completion of the project.

Capital costs for Alternative 1 include purchase and installation of new equipment, spare parts, and Hydro labour for 2004 and 2005. The 2004 capital cost also includes training for Technicians. The 2010 and 2016 capital costs are for software upgrades. A table containing a brief list of capital and operating expenses is located on page 7.

Net Present Cost Analysis of Holyrood's Distributed Control System
Capital & Operating Costs

Year	Alternative 1				Alternative 2				Alternative 3			
	Capital	Operating	Total Cap and Operating	CPW Jan. 2004	Capital	Operating	Total Cap and Operating	CPW Jan. 2004	Capital	Operating	Total Cap and Operating	CPW Jan. 2004
2004	1,368,463	36,397	1,404,860	1,294,802	482,812	231,557	714,369	658,405	619,911	235,751	855,663	788,629
2005	906,960	5,753	912,713	2,070,111	225,400	155,835	381,235	982,247	392,716	163,775	556,491	1,261,343
2006	0	12,749	12,749	2,080,092	0	177,839	177,839	1,121,479	0	185,969	185,969	1,406,940
2007	0	13,055	13,055	2,089,512	404,117	126,016	530,133	1,504,009	239,808	134,341	374,148	1,676,916
2008	0	13,368	13,368	2,098,402	470,304	86,002	556,306	1,873,978	166,455	120,048	286,503	1,867,453
2009	0	23,371	23,371	2,112,727	298,966	55,633	354,599	2,091,328	0	80,327	80,327	1,916,690
2010	8,898	31,779	40,677	2,135,707	290,742	52,813	343,555	2,285,411	0	81,662	81,662	1,962,823
2011	0	24,506	24,506	2,148,466	214,661	32,465	247,126	2,414,082	1,570,920	29,735	1,600,655	2,796,235
2012	0	43,719	43,719	2,169,446	0	45,921	45,921	2,436,118	1,015,525	7,181	1,022,706	3,287,011
2013	0	36,342	36,342	2,185,520	0	55,072	55,072	2,460,476	0	15,051	15,051	3,293,667
2014	0	47,244	47,244	2,204,778	0	57,046	57,046	2,483,730	0	15,412	15,412	3,299,950
2015	0	55,443	55,443	2,225,608	1,655,643	24,412	1,680,055	3,114,930	0	15,782	15,782	3,305,880
2016	9,436	71,963	81,399	2,253,794	0	12,883	12,883	3,119,391	0	27,592	27,592	3,315,434
2017	0	84,958	84,958	2,280,908	0	34,862	34,862	3,130,517	9,605	37,518	47,123	3,330,473
2018	0	61,244	61,244	2,298,922	0	26,930	26,930	3,138,438	0	17,664	17,664	3,335,668
2019	0	9,488	9,488	2,301,494	0	17,507	17,507	3,143,184	0	8,019	8,019	3,337,842
2020	0	9,716	9,716	2,303,922	0	17,927	17,927	3,147,663	0	8,211	8,211	3,339,894



Alternative 1: Replace the current WDPF systems with ovation systems in 2004/2005
Alternative 2: Gradually replace the current WDPF systems with level 8 WDPF systems
Alternative 3: Extend the life of the current WDPF systems and analyze migration annually

Capital costs for Alternative 2 include the purchase of used and/or 'last buy' spares. Between 2004 and 2011 the Capital costs are to purchase and install parts of a WDPF level 8 system. The 2004 figure includes upgrade training for technicians to cover the major differences in the newer technology. The 2015 capital cost is to purchase and install new equipment for Stage 1 and allocate the retired WDPF level 8 equipment as spares for Stage 2. A table containing a brief list of capital and operating expenses for this alternative is located on page 8.

Capital costs for Alternative 3 include the purchase of used and/or 'last buy' spares. Between 2004 and 2008 WDPF level 8 equipment will be required in addition to the purchase of used spares to ensure sufficient components are available for reliable operation. Purchase and installation of new equipment, training for new equipment, spare parts, and hydro labour is allocated for 2011 and 2012. The 2017 capital cost is for a software upgrade. A table containing a brief list of capital and operating expenses for alternative 3 is located on page 9.

Operating costs for all alternatives include the repair of failed components, and labour associated with changing failed components and modifying graphics and logic. The differences between each year reflect the increase in failure rates and repair costs as the technology ages and is based on experience from the current WDPF system. Consideration was taken that not all parts will need to be repaired to maintain an adequate number of spares in the 2 years before a system is retired, and that retired equipment can be used as spares while upgrading in stages.

Risk analysis of spare parts on-hand and extrapolated failure rates show sufficient plant spares to operate the WDPF system until 2004. If migration to Ovation is delayed until after 2004, used or refurbished spare parts would have to be purchased (potentially at a premium price if available) to maintain the WDPF systems. Availability of used and rebuilt spares for purchase or repair is uncertain and expected to be minimal and costly at best. Compatible equipment may not be available for all other alternatives. The existing systems will not last to the end of the study period. An Ovation system (with minor software upgrades) will serve the plant over this time frame unless an unforeseeable major technological advancement stops production of compatible components for spare parts.

Non-monetary considerations include a faster control time of the Ovation system compared to all levels of WDPF systems. All levels of WDPF communicate over a coax-cable based highway while Ovation communicates over a fast Ethernet network. Ovation utilizes Pentium processors in comparison to WDPF level 8 which utilizes 486 processors, WDPF level 7 which utilizes 286 processors, and WDPF level 6 which utilizes 8086 processors. Ovation is the most current control system offered by Emerson and is the focus of their control system technology for the foreseeable future.

Recommendations

Implement an Ovation control system for stage 1 in 2004 and for stage 2 in 2005. This alternative has the lowest net present cost, has the longest predictable life expectancy, is the most reliable, and will require the least maintenance resources.

Analyze other suppliers during the tendering stage. Future technologies by other manufacturers may enable another supplier to adapt the WDPF cabinets, I/O, graphics and logic to their controllers and MMI allowing for more competitive pricing.

Updates

1) Since this analysis was performed, Emerson has announced that WDPF level 8 has been assigned Active status with a support commitment date of January 2012. This move to Active status eliminates Alternative 2 for all practical purposes.

2) Components are no longer available to repair Matrox boards and Emerson has sold all of their reserve Matrox board stock. There are sufficient plant spares to operate until, but not beyond, the 2004 outage season.

Alternative 1: Migrate to Ovation in 2004/2005						
Year	Component	Capital		Operating		Comments
		2002 Cost (CDN$)	Year Total (CDN$)	2002 Cost (CDN$)	Year Total (CDN$)	
2004	Ovation System & Training	$1,223,068				Migrate Stage 1 in 2004
	Engineering & Labour	$82,000	$1,305,068			
2005	Ovation System & Installation	$786,672				Migrate Stage 2 in 2005
	Engineering & Labour	$58,000	$844,672			
2010	Software Upgrade	$7,360	$7,360			
2016	Software Upgrade	$6,770	$6,770			
2007 to 2020	Card and Monitor repair/replacement			$8,201 per Card & $6,491 per Monitor	Range from $8,201 to $56,000 per year	Number of Card/monitor Repairs increase With System Age

Alternative 2: Gradualy Replace with a Level 8 WDPF						
Year	Component	Capital		Operating		Comments
		2002 Cost (CDN$)	Year Total (CDN$)	2002 Cost (CDN$)	Year Total (CDN$)	
2004	Operator Interface & Processing Equipment	$340,770				WEStations & WPC components
	MSP Last Buy Spares	$92,760				
	Labour/Engineering	$26,916	$460,446			Plant and Head Office
2005	Operator Interface & Processing Equipment	$197,884				WEStations & WPC components
	Labour/Engineering	$12,036	$209,920			Plant and Head Office
2007	Operator Interface & Processing Equipment	$332,012				WEStations & WPC components
	Labour/Engineering	$26,916	$358,928			Plant and Head Office
2008	Operator Interface & Pr	$377,468				WEStations & WPC components
	Labour/Engineering	$30,456	$407,924			Plant and Head Office
2009	Operator Interface & Processing Equipment	$229,090				WEStations & WPC components
	Labour/Engineering	$24,144	$253,234			Plant and Head Office
2010	Operator Interface & Processing Equipment	$220,800				WEStations & WPC components
	Labour/Engineering	$19,696	$240,496			Plant and Head Office
2011	Operator Interface & Processing Equipment	$159,170				WEStations & WPC components
	Labour/Engineering	$14,232	$173,402			Plant and Head Office
2015	Ovation System,Training	$999,190				Migrate Stage 1 in 2015.
	Processing Equipment	$135,185				WPC Components
	Labour/Engineering	$82,000	$1,216,375			Plant and Head Office
2004 to 2014	Card and Monitor repair/replacement			$5,138 per Card & $6,000 per Monitor, Plus Labour and Engineering	Range from $36,000 to $180,000 per year	Number of Card/monitor Repairs decrease as introduction of new system approaches, Per unit cost increases are 10% yearly
2015 to 2020	Card and Monitor repair/replacement			Warranty work in Early Years	Range from $2,000 to $18,000 per year	Number of Card/monitor Repairs increase as new system ages

Alternative 3: Maintain Current WDPF and Analyze Migration Annually						
Year	Component	Capital		Operating		Comments
		2002 Cost (CDN$)	Year Total (CDN$)	2002 Cost (CDN$)	Year Total (CDN$)	
2004	Operator Interface & Processing Equipment	$333,380				WEStations & WPC components
	Used & Last Buy Equipment	$230,898				
	Labour/Engineering	$26,916	$591,194			Plant and Head Office
2005	Operator Interface & Processing Equipment	$197,884				WEStations & WPC components
	Used Equipment	$155,825				
	Labour / Engineering	$12,036	$365,745			Plant and Head Office
2007	Operator Interface	$52,605				WEStations
	Used Equipment	$147,159				
	Labour / Engineering	$13,228	$212,992			Plant and Head Office
2008	Operator Interface	$52,290				WEStation
	Used Equipment	$78,015				
	Labour / Engineering	$14,072	$144,377			Plant and Head Office
2011	Ovation System & Training	$1,047,991				Migrate Stage 1 in 2011
	Processing Equipment	$138,988				WPC Components
	Labour / Engineering	$82,000	$1,268,979			Plant and Head Office
2012	Ovation System	$693,108				Migrate Stage 2 in 2012
	Processing Equipment	$50,000				WPC Components
	Labour / Engineering	$58,000	$801,108			Plant and Head Office
2017	Software Upgrade	$6,730	$6,730			
2004 to 2010	Card and Monitor repair/replacement			$5,138 per Card & $6,000 per Monitor, Plus Labour and Engineering	Range from $47,000 to $180,000 per year	Number of Card/monitor Repairs decrease as introduction of new system approaches, Per unit cost increases are 10% yearly
2015 to 2020	Card and Monitor repair/replacement			$7,710 per Card & $6,000 per Monitor, Plus Labour and Engineering	Range from $8,200 to $23,000 per year	Number of Card/monitor Repairs increase as new system ages