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1	1	Cog.Eng. MN Hall	[signature]	5/2/96	H5-61	JE Van Beek			S2-48	3	
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1	1	GA Meyer	See Blk. 19		S2-48						

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M. N. Hall [signature] 5/2/96 Signature of EDT Originator Date	G. A. Meyer [signature] 6/21/96 Authorized Representative for Receiving Organization Date	R. P. Marshall [signature] 5/9/96 Cognizant Manager Date	Ctrl. No. [] Approved [] Approved w/comments [] Disapproved w/comments

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Life-cycle Cost Analysis of Advanced Design Mixer Pump

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Abstract: This analysis provides cost justification for the Advanced Design Mixer Pump program based on the cost benefit to the Hanford Site of 4 mixer pump systems defined in terms of the life-cycle cost. A computer model is used to estimate the total number of service hours necessary for each mixer pump to operate over the 20-year retrieval sequence period for single-shell tank waste. This study also considered the double-shell tank waste retrieved prior to the single-shell tank waste which is considered the initial retrieval.

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Release Approval Date

Release Stamp

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Life-Cycle Cost Analysis of the Advanced Design Mixer Pump

1996

M. N. Hall

Westinghouse Hanford Company
Richland, Washington

EXECUTIVE SUMMARY

This document is a Cost Benefit Analysis of the current design represented by the Lawrence Pump, Inc. (LPI) Project W-151 AZ-101 mixer pumps and the new Advanced Design Mixer Pump (ADMP) designs represented by both LPI and Westinghouse Electro Mechanical Division (WEMD). The cost/benefit comparison used life expectancy projects provided by the vendors as substantial full-system test data is yet unavailable. The ADMP program is a joint developmental program between the Hanford and Savannah River sites. The program objective is to provide an advanced reliability mixer pump to Tank Farms for large-scale waste retrieval to the vitrification facilities. The advanced designs are essentially state of the art designs which have had many hardware improvements incorporated into them. These improvements were developed by the pump design agents and included information identified through mixer pump historical records at the Hanford and Savannah River sites. The improved advanced design mixer pumps, designed to flammable gas tank criteria, have improved motors, drive-shafts, support columns, bearing and seal systems, etc., which the two design agents claim will improve the life and longevity of the mixing system.

This Cost Benefit Analysis assesses the number of mixer pumps needed at the Hanford Site by computer modeling. For the purpose of this analysis, a 20-year retrieval sequence, case 50, was selected as a typical example to project the total number of mixing hours needed for each tank over the 20-year retrieval schedule. The first column of the table below titled, "Case 50 Data," lists the results of this computer analysis.

Number of Mixing Hours Needed

Case 50 Data			W-151			ADMP - LPI			ADMP - WEMD		
#	Tank	Hrs	# RC	# MP	$ K	# RC	# MP	$ K	# RC	# MP	$ K
1	SY-101	4755	3	6	5370	1	2	2250	1	2	2504
2	SY-102	2787	2	4	3670	1	2	2250	1	2	2504
3	SY-103	1662	1	2	1970	1	2	2250	1	2	2504
4	AW-104	23412	12	24	20670	4	8	8280	4	8	8714
5	AW-103	11691	6	12	10470	2	4	4260	2	4	4574
6	AN-101	14683	8	16	13870	3	6	6270	3	6	6644
7	AN-104	15956	8	16	13870	3	6	6270	3	6	6644
8	AN-105	14636	8	16	13870	3	6	6270	3	6	6644
9	AN-106	14639	8	16	13870	3	6	6270	3	6	6644
10	AW-101	13293	7	14	12170	3	6	6270	2	4	4574
11	AW-102	13406	7	14	12170	3	6	6270	2	4	4574
12	AW-105	1726	1	2	1970	1	2	2250	1	2	2504
13	AN-102	1350	1	2	1970	1	2	2250	1	2	2504
14	AN-107	1482	1	2	1970	1	2	2250	1	2	2504
15	AY-101	21417	11	22	18970	4	8	8280	4	8	8714
16	AY-102	16588	9	18	15570	3	6	6270	3	6	6644
17	AZ-101	15560	8	16	13870	3	6	6270	3	6	6644
18	AZ-102	13196	7	14	12170	3	6	6270	2	4	4574
			108	216	188460	43	86	90750	40	80	90812

The data in the remaining three columns, representing the three mixer pump alternatives for the Hanford Site, was generated by processing case 50 data based on certain assumptions. The term "#RC" refers to the total number of pump installations which is derived by dividing the cumulative mixing hours by the assumed pump life. The term "#MP" is the number of pumps (2xRC) assuming 2 mixers per tank, and "$K" is the cumulative cost per tank based on a given replacement cost.

The life-cycle cost is directly influenced by the assumed life of a given mixer pump which effects the number of replacements needed over 20 years. Both advanced design mixer pump vendors projected the estimated service life of their designs when the pumps are used in general tank farm service. Lawrence Pump, Inc. also estimated the probable service life of the Project W-151 mixer pump, which is the current state of the art mixer pump at the Hanford Site, when used in environments other than those specified for tank AZ-101. The three vendor-supplied pump life estimates are shown below.

Assumed Life Basis

Mixer Pump Vendor/Type	Vendor Estimated Life (see Section 4.3)
Lawrence W-151 Pump	2,000-hr
Lawrence ADMP Pump	6,000-hr
WEMD Pump	7,000-hr

The assumed cost to replace a mixer pump at the Hanford Site is estimated using the WHC Projects W-151 and W-211 cost-estimating data (see Section 4.4). The reoccurring costs, such as electrical power and site services were found to be less sensitive, being virtually insignificant between the alternatives and, therefore, are not included.

Assumed Costs Basis

Mixer Pump - Type of Cost	Cost ($K)
W-151 New Pump 1st Install	435
ADMP-LPI New Pump 1st Install	620
ADMP-WEMD New Pump 1st Install	752
SRS- Bingham New Pump 1st Install	310
W-151 Replacement Pump Cost	300
ADMP-LPI Replacement Pump Cost	505
ADMP-WEMD Replacement Pump Cost	535
W-151 Labor/Disposal to Replace	550
ADMP-LPI Labor/Disposal to Replace	500
SRS Labor/Disposal to Replace	225

A description and cost-estimate of the advanced design mixer pump improvement program are identified in sections 3.0 and 9.0. In summary, the ADMP program will purchase a mixer pump and test it in a nonradioactive environment to identify "teething" problems with the new systems and resolve these technical issues prior to approving the pump for service in a radioactive tank. The Hanford Site will procure the mixer pump and deliver it to Savannah River Site. The Savannah River Site has agreed to fund and perform all testing needed for this program. The Savannah River Site will work closely with the Hanford Site and the vendor during this period. The total cost of completing the advanced design mixer pump program, including the procurement of one mixer pump and full-feature testing by the vendors and the Savannah River Site, is approximately $3M.

CONCLUSION

The assumptions listed in this report are used in a spreadsheet program to predict the total savings, breakeven date, and program cost as a function of assumed pump life. The results of this analysis show, under reasonable assumptions, the advanced design mixer pump program would save the government $30M to $100M, and the cost of the program will be recovered in approximately 5 years. A sensitivity analysis was completed using the spreadsheet model which shows a cost savings even when using conservative assumptions. The estimate is conservative as similar savings from the Savannah River Site advanced design mixer pump program could be expected but are not included.

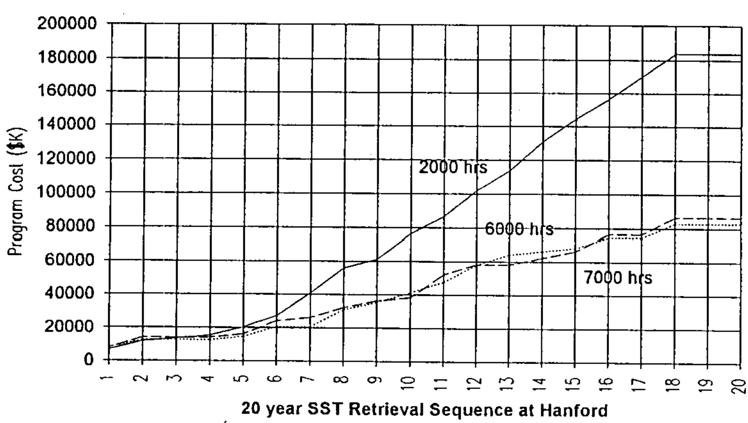
The following table and the corresponding graph are the spreadsheet results which show the estimated total program costs over 20 years. The last two columns on the right show the cost savings of the advanced design mixer pump program compared to the current W-151 mixer pumps over this period.

LCCMOD2 - Report Page - Cost Schedule for ADMP Options

Note: This listing assumes all installs are Replacement pumps (not sensitive to outcome).

Cumulative Number of Pumps				Number of Replacements			Cumulative Cost of Pumps				Cumulative Savings (over 2k)	
Yr	2k hrs	6k hrs	7 K hrs	2k hrs	6k hrs	7 k hrs	Yr	2k hrs	6k hrs	7 k hrs	6 k hrs	7K hrs
1	8	8	8	4	4	4	1	6800	8040	8280	-1240	-1480
2	14	14	12	3	3	2	2	11900	14070	12420	-2170	-520
3	16	14	12	1	0	0	3	13600	14070	12420	-470	1180
4	18	14	12	1	0	0	4	15300	14070	12420	1230	2880
5	24	16	14	3	1	1	5	20400	16080	14490	4320	5910
6	32	24	20	4	4	3	6	27200	24120	20700	3080	6500
7	48	26	20	8	1	0	7	40800	26130	20700	14670	20100
8	66	32	30	9	3	5	8	56100	32160	31050	23940	25050
9	72	36	34	3	2	2	9	61200	36180	35190	25020	26010
10	90	38	40	9	1	3	10	76500	38190	41400	38310	35100
11	102	52	46	6	7	3	11	86700	52260	47610	34440	39090
12	120	58	56	9	3	5	12	102000	58290	57960	43710	44040
13	134	58	62	7	0	3	13	113900	58290	64170	55610	49730
14	154	62	64	10	2	1	14	130900	62310	66240	68590	64660
15	170	66	66	8	2	1	15	144500	66330	68310	78170	76190
16	184	76	72	7	5	3	16	156400	76380	74520	80020	81880
17	200	76	72	8	0	0	17	170000	76380	74520	93620	95480
18	216	86	80	8	5	4	18	183600	86430	82800	97170	100800
19	216	86	80	0	0	0	19	183600	86430	82800	97170	100800
20	216	86	80	0	0	0	20	183600	86430	82800	97170	100800
				108	43	40						

Graph of "Cumulative Cost of Pumps"



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CONTENTS

TABLES

FIGURES

Abbreviations and Acronyms

ADMP	advanced design mixer pump
ADRE	automated diagnostic unit for rotating equipment
ASME	American Society of Mechanical Engineers
CBA	Cost Benefit Analysis
DST	double-shell tank
ESP	extended sludge processing
Full Tank	Savannah River Site Full Waste Tank Mock-up Facility
HLW	high-level waste
INT	integer
ITP	interim tank processing
LCC	life-cycle cost
LCCA	Life-cycle Cost Analysis
LLCMOD	life-cycle cost model
LPI	Lawrence Pump, Inc.
MTBF	mean time between failures
PNNL	Pacific National Northwest Laboratories
RAD	radiation adsorbed dose
ROM	rough order of magnitude
SRS	Savannah River Site
SST	single-shell tank
TRU	transuranic
TWRS	Tank Waste Remediation System
UoD	Uo (velocity) D (jet diameter)
VFD	variable frequency drive
WEMD	Westinghouse Electro-Mechanical Division
WHC	Westinghouse Hanford Company

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Life-Cycle Cost Analysis of the Advanced Design Mixer Pump

1.0 POLICY COMPLIANCE

The Office of Management and Budget, Circular No. A-94, Memorandum No. 64, provides guidance on benefit-cost analysis and recommends that it be based on the life-cycle cost (LCC) of the alternatives considered. While this method is used primarily on large federal projects, its application to clean up projects at the Hanford Site is appropriate if limited in scope. The term Life-Cycle Cost Analysis (LCCA) is a term used principally by the government for expressing the total cost of an article or system based on direct and indirect cost which reoccur and do not reoccur throughout the life of the alternative. The General Services Administration Bulletin, No. FPMR E-153, suggests that all federal agencies abandon the traditional practice of procuring supplies and services on the basis of lowest competitive bids and substitute the criterion of lowest total LCC.

2.0 PURPOSE AND SCOPE

This analysis provides cost justification for the Advanced Design Mixer Pump (ADMP) program based on the cost benefit to the Hanford Site of 4 mixer pump systems defined in terms of the LCC. A computer model is used to estimate the total number of service hours necessary for each mixer pump to operate over the 20-year retrieval sequence period for SST Waste (Certa 1995). This study also considered the DST waste retrieved prior to the SST waste which is considered the "initial retrieval."

The scope of this document is limited to an LCCA of mixer pump systems representing the current retrieval mixing system at the Savannah River and Hanford sites, and the advanced retrieval mixing system (line-shaft drive and submersible).

Table 1 is a list of the mixer pump systems considered in this analysis. The current systems are line-shaft driven dynamic centrifugal single-stage dual-volute slurry pumps with the electric motor mounted out of the process tank. The current pumping systems are widely used by the SRS and the West Valley Site. The advanced systems build on the current systems by applying lessons learned in the design process to both line-shaft drives and submersible motor units.

Table 1. Retrieval Systems Considered.

SYSTEM	#	TYPE	PROJECT
Current System	1(a)	Line-shaft water seal	SRS
	1(b)	Line-shaft water seal	Project W-151
Advanced System (ADMP)	2(a)	Submersible water seal	WEMD
	2(b)	Line-shaft gas seal	LPI

3.0 BACKGROUND OF ADMP PROGRAM

Mixer pumps are high-capacity low-head pumps with closely-spaced suction and discharge ports. They are designed to recirculate the fluids within an underground radioactive waste tank to achieve mobilization and mixing of waste sludge and supernate. There are two basic types of mixer pumps: line-shaft drive and submersible motor. Figure 1 shows the basic configuration of the two types in a double-shell tank.

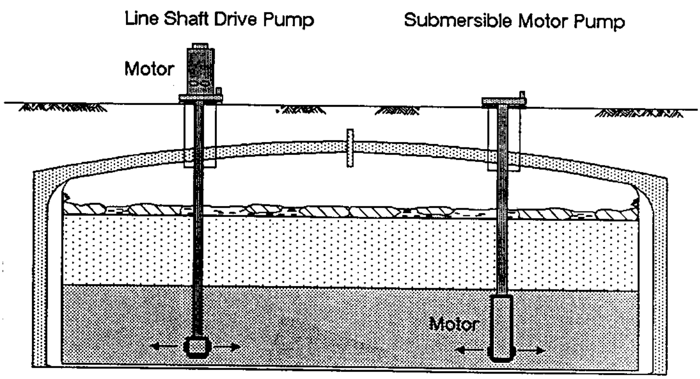


Figure 1. Typical DST Mixer Pump Configuration.

Mixer pumps are key to retrieval systems such as the Westinghouse Hanford Company (WHC) Project W-211, "Initial Tank Retrieval Systems," which is an authorized project at the Hanford Site to provide waste feed up to 10 DSTs to waste treatment and disposal. Mixer pumps may also be used for consolidation of compatible tank wastes to create additional DST storage, or to provide mitigation of some watch-list tanks. The SRS also uses nuclear waste mixer pumps for similar functions.

The ADMP is a joint development program between the Hanford Site and the SRS. Projected needs for both sites are as high as 150 mixer pumps over the next 10 years. The Hanford Site and the SRS jointly developed a performance-based specification used by the WHC to solicit proposals based on the Progressive Procurement Process. The Hanford Site is the lead site and is providing the funding and technical leadership for the prototype mixer pumps. The SRS is the lead site for mixer pump testing and is providing the funding and technical leadership for the testing program.

A Request for Proposal was issued January 4, 1994 with 14 responders submitting proposals. A Source Evaluation Board was formed with technical participants from both sites to rank the proposals on both technical and cost performance. Through the progressive procurement process, the list of vendors narrowed to 2 final Sellers, Westinghouse Electric Corporation and Lawrence Pump, Inc. (LPI), who were awarded contracts in April 1995 for Phase I Design. Figure 2 shows the schedule of the parallel design effort.

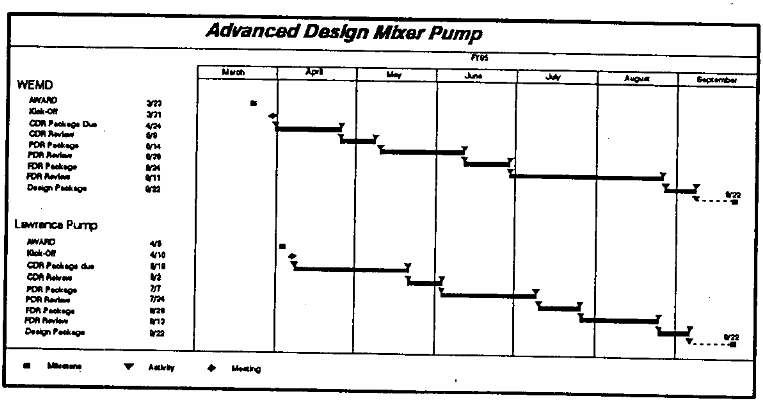


Figure 2. ADMP Phase I Design Schedule.

3.1 METHODOLOGY

This analysis focuses on the overall cost-benefit to the Hanford Site over a period from April 1998 and to August 2022. This duration was established using the modified versions of the Tank Waste Remediation System (TWRS) baseline simulation ARENA/SIMAN model and the TWRS process flowsheet ASPEN model to generate the retrieval sequence (Certa 1995), and the Retrieval Programs Office Multi-Year Project Plan which includes Project W-211.

Within the 20-year period projected by the retrieval sequence model (Certa 1995), it is recognized that the individual tank systems will have different process loads and, therefore, different life-cycle requirements for mixing systems. Tanks such as AW-104 and AW-103, for instance, will require considerably more mixer pump service life than tanks like AP-104 and AP-108, which are designated as spare tanks.

To resolve this problem, a special subroutine sort of the Retrieval Sequence Model was created to identify the approximate total number of hours each tank system would be required to mix. Using this data a unique required "cycle" for each tank was obtained. The LCC, therefore, of one alternative mixing system over the other would be the cumulative cost of all 28 DST mixing systems over the 20-year period.

The key cost driver is the number of mixer pump replacement cycles required over the tank life cycle. Mean time between failures (MTBF) estimates are available for some types of ASME pumps which have been used extensively in industry. This information is only relevant to subcomponents of the ADMP pumps which are totally new designs. The methodology of this analysis was to project the LCC of a given tank mixing system based on assumed reliability factors (see Figure 3).

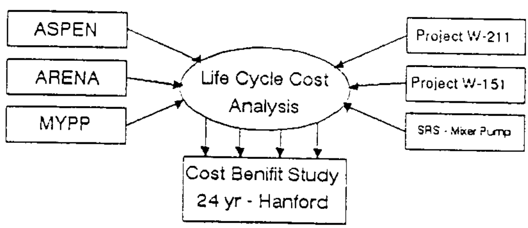


Figure 3. Methodology - Cost vs Reliability Factor Study.

4.0 EXPLICIT ASSUMPTIONS

This section lists underlying assumptions used to arrive at the estimates of future benefits and cost. The analysis contains a statement of assumptions, the rationale behind them, and a review of their strengths and weaknesses. Key data and results are reported in this section to promote independent analysis and review.

4.1 STATEMENT OF GENERAL ASSUMPTIONS

A. *Assumption:* Retrieval sequence 2C3, case 50, is typical of any given retrieval sequence at the Hanford Site and can be used to adequately estimate the number of transfers and sludge washes needed.

Rationale: In all cases, approximately the same volume of waste is moved from SSTs to the high- and low-level waste facilities, which require approximately the same number of hours of blending and transfers. Other cases considered, such as cases 58 and 96, deviated very little in mixing hours needed.

B. *Assumption:* Receiver tanks will not require mixing during transfers. Both mixer pumps in the receiver tank will not have to be operated in order to transfer waste into the tank.

Rationale: Slurry distributer and transfer pump loop circulation can be used, as needed, to distribute solids accumulation in one region of the tank, therefore, mixing of the receiver tank will not be necessary during waste transfers.

C. *Assumption:* Mobilization of the waste for initial retrieval in the DSTs will take 14 days at full power using both mixer pumps.

Rationale: Pacific Northwest National Laboratories (PNNL) has done extensive modeling using simulants to predict the jet force and duration of mixing (10-20 days) to achieve mobilization. For the purpose of this study, 14 days was selected as a reasonable average mobilization time for the first-time mobilization of a given mixer pump.

D. *Assumption:* Prior to the first DST transfer, both mixer pumps in the staging DSTs will be run at full power for 3 days to mix the waste.

Rationale: Mobilization of the waste is assumed to have already occurred, however, a delay in transfer is assumed to have allowed some degree of settling. Under these conditions the resuspension of solids is assumed to take less mixing time than mobilization. Each mixer pump considered has an approximate flow rate of 10,000 gpm. Two mixer pumps at full power circulate 20,000-gal/m or 1,200,000-gal/hr. At this rate, the entire volume of a 1,000,000-gal tank could be ingested through the mixer pump, approximately 68 times in a 3-day period which is considered adequate for tank reuse applications.

E. *Assumption:* Mixer pumps are not needed in the second stage settling tanks and the decanted liquid tanks. The second stage settling tanks are located between the sludge wash tanks and the decanted liquid tanks. The decanted liquid tanks are the last DST storage tanks before the Low-Level Waste Pretreatment Facility.

Rationale: These 2-tank systems will contain only material which has had its solids content removed. The primary purpose of DST mixer pumps is to mix or mobilize undissolved solids into the liquid supernate. Retrieval sequence 2C3, case 50, does not require mixing in these tanks.

F. *Assumption:* Mixer pumps are not needed in the spare tanks or the complexed transuranic (TRU) tanks to retrieve SST waste.

Rationale: Spare DSTs which are needed will be fitted with the spare mixer pumps which are on standby, if needed. Complexed TRU tanks are not part of the Retrieval Sequence as the TRU waste in them is not compatible with other waste types and cannot normally be mixed.

4.2 NUMBER OF MIXER PUMPS NEEDED

4.2.1 The Hanford Site Pump Needs

Assumption: Sequence 2C3, case 50, defines a reasonable estimate of the Hanford Site tank use.

Rationale: The preliminary retrieval and blending strategy has been approved by TWRS Process Technology as a reasonable estimate of material flow during the Hanford Site retrieval sequence, see Figure 4 (Certa 1995).

The computer model noted above uses the ARENA/SIMAN modeling programs and the ASPEN Modeling Program. A computer subroutine algorithm was developed and coded which interfaces with these programs to extract the number of mixer pump running hours and number of transfers for case 50 (see Appendixes A-C).

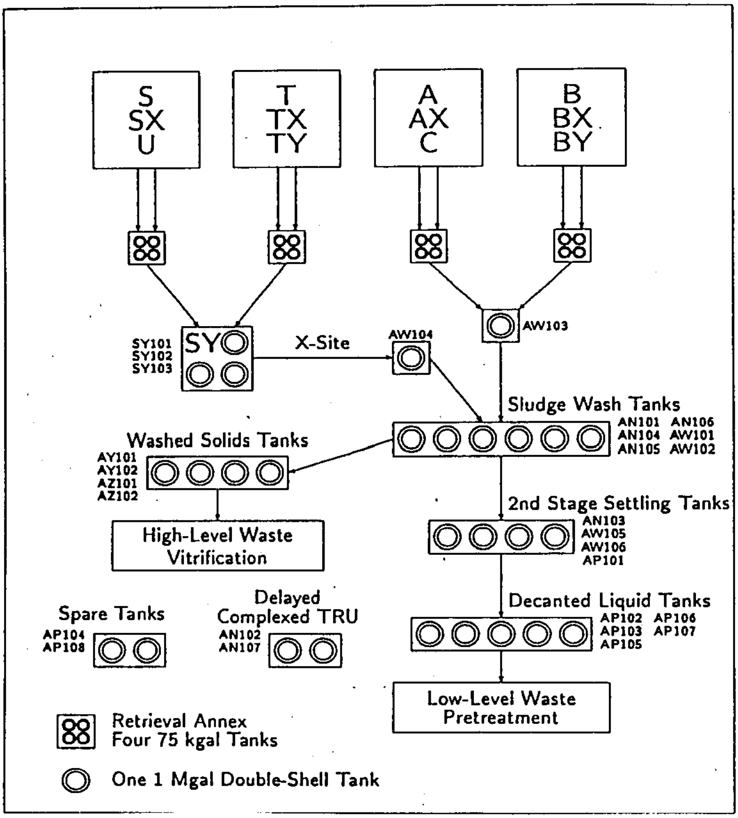


Figure 4. Preliminary Retrieval and Blending Material Flow Diagram.

There are 4 sorts completed which represent the major transfers between the key DSTs (see Table 2).

Table 2. ADMP Subroutine Data File Titles.

Transfer/Wash	Title
1	Fillx.dat
2	Fillswt.dat
3	Fillwst.dat
4	Fillhl.dat

Fillx.dat is the file which shows the number and dates of transfers from the SY Tank Farm to AW-104. This is a cross-site transfer from the 200 West Area to the 200 East Area.

Fillswt.dat is the file which identifies the transfers from AW-103 to the sludge wash tanks in the AN and AW farms.

Fillwst.dat is the file which identifies the transfers from the sludge wash tanks to the washed solids tanks in the AY and AZ farms.

Fillhl.dat is the file which identifies the transfers from the washed solids tanks to the high-level waste (HLW) vitrification plant.

This raw data from the above mentioned files is listed in Appendix A. The data was then ported into an Excel spreadsheet program and totaled. Table 3 is the result of this effort, which begins in the year 2003 and ends in the year 2022. This is the total number of mixing hours to retrieve SSTs. The mixing requirements for DSTs is assumed to take one campaign as follows:

A. Mobilization for 2 weeks (14 days or 336 hr)
B. Mixing while transferring (3 days average or 72 hr)

Accordingly under this assumption, each value listed in column 4 of Table 3 has 408 hours added to account for mixer pump run time to clean out the present DST waste.

Waste in the SSTs is often dry saltcake and water must be added to dissolve it. The resulting solution will have more volume than the dry waste alone and this additional waste is accounted for in this model by the following approximation.

It is reasonable to assume the dry waste will have to be diluted 1/1 with water to obtain a transferable fluid. Using waste volumes it was noted the waste volume in A, AX, and C farms equals 16.5 million gallons of saltcake (WHC 1995). The same document lists B, BX, and BY farms as having 21.9

million gallons of saltcake. This is approximately 38 million gallons of additional waste which must be transferred. Assuming this equates to 38 million gallon tank transfers at 72 hours each to mobilize, this equates to 2,736 hours of additional mixing which should be added to AW-103.

The monthly report also lists values for S, SX, and U farms which is 13.4 million gallons, and for T, TX, and TY farms 9.6 million gallons is listed. This equates to an additional 23 million gallons of waste that must be transferred from the 200 West Area through the SY Farm and AW-104. This equates to 1,656 hr of additional transfers. If the time is evenly split between the 3 SY tanks and added to the total for AW-104, a reasonable approximation is obtained. The numbers listed in Table 3 include the correction factor for new waste generated in transferring SST waste.

Table 3. Results of the ADMP LCC Mixer Pump Use Estimate.

#	Tank	Campaigns	Total Hr **
1	* SY-101	87	5,307
2	SY-102	47	3,347
3	* SY-103	21	2,214
4	AW-104	109	25,068
5	AW-103	62	14,427
6	AN-101	15	14,683
7	* AN-104	16	15,956
8	* AN-105	17	14,636
9	* AN-106	11	14,639
10	* AW-101	10	13,293
11	AW-102	14	13,406
12	AW-105	2	1,726
13	AN-102	1	1,350
14	AN-107	1	1,482
15	AY-101	7	21,417
16	* AY-102	5	16,588
17	AZ-101	6	15,560
18	* AZ-102	5	13,196

* Project W-211 tanks with AW-103 and AP-101.

** All cumulative numbers include an additional 408 hours to account for DST retrieval activity and additional waste created in mobilizing SST waste.

This data shows extremely high usage of AW-103 and AW-104 and very low usage of AW-105, AN-102, and AN-107. While the SY Farm has relatively low cumulative usage hours listed, they have a larger number of campaigns and are actually highly used but for short durations. While the average required mixing time is 11,571 hours, by eliminating the 6 tanks with the lowest cumulative hours, the average mixing system time changes to approximately 15,453 hours (these cumulative averages are not used in the LCC model).

4.2.1.2 Initial Retrieval Assumption

Assumption: For the purpose of this study, the 6 W-211 DSTs with mixer pumps installed prior to 2003 will assumed to have expired, failed, or in need of a new type as of 2003, and the SST retrieval sequence case 50 begins with new same-type mixing systems in all 18 tanks. Also, 408 hours is added to each tank mixing requirement listed in Table 3 to account for DST retrieval.

Rationale: As stated in assumptions 4.1-C and 4.1-D, an additional 17 days or 408 hours per mixer pump was added to account for the initial DST retrieval mixing requirement. As can be seen, this additional number of hours is insignificant compared to the SST retrieval requirement average of 11,571 hours (or 15,453 hours) on the mixing systems, and, therefore, error associated with this method is also insignificant. A preliminary schedule by Project W-211 shows the first 2 mixer pumps installed in 1998, or 5 years prior to 2003, which is the start of the case 50 retrieval sequence.

Due to the cumulative radiation dose allowed by the materials used in the mixer pumps, the 5-year head start will cause a few of the mixer pumps to expire early. The effect in this life-cycle model (LLCMOD) is isolated to the 6 W-211 tanks minus the hydrogen watch-list tanks which have special mixer pumps and not part of this LLCA. It is impossible to assess at this point, without detailed schedule information from Project W-211, the impacts of this effect, although it is assumed to be minor.

4.3 ASSUMED LIFE OF MIXER PUMPS

The mixer pump design life used in the LCC model is the key assumption of this analysis. It is the most sensitive parameter of all considered, having the greatest effect on the total 20-year program cost. The Department of Energy emphasized the importance of having a firm basis for any assumed life factors used in cost/benefit studies.

The reliability of a system is usually determined statistically by testing a significant sample and recording the number of system failures over the design life, or experience gained in actual operation. In this case where the systems under consideration have not been built, a different approach to estimating the life of the pump must be used.

One method of projecting the life is to use MTBF data for the system component, such as bearings and electrical motors. The reliability factors for these components are based on test data, with only the new system loads being estimated. This alternative approach to full-system testing is far less accurate but useful in making out-year budgetary projections. The organization best qualified to project equipment life is the vendor that designed the mixer pumps, having the best understanding of the design and its implications.

4.3.1 Estimate of the WEMD ADMP Reliability Factor

The Westinghouse Electro-Mechanical Division (WEMD) was contacted and asked their estimate for a total system reliability. The WEMD used existing data for canned motors generated over 30 years through testing programs with the U.S. Navy. The WEMD stated this data is applicable to our mixer pump, due to the ADMP's clear water lubrication system and relatively low radiation fields experienced in waste tanks compared to nuclear power reactors. The WEMD estimated their system reliability factor is 2.00 based on the minimum design life requirement of 5,000 hours, and assuming the pump is fabricated with diamond-coated tungsten carbide bearings (see Appendix E).

For equipment located in the hostile environment, which includes the mechanical seal, the estimated number of hours of operation was estimated by the Hanford Site to be something less than 10,000 hours. The SRS stated the weak-link is the lower water seal with which the SRS has no working experience. The lower water seal selected in the Phase I design process is a Bergman seal. The WEMD did state they have been considering coating the seal faces of the lower seal with diamond-coating using the same process used for the bearings. Without the lower water seal, which prevents the abrasive waste material from entering the bearing cavity, the Hanford Site has estimated the life of this mixer pump to be very low (below 1,000 hours). The type of mechanical seals selected by WEMD normally does not last 10,000 hours and, therefore, WHC estimates the life would be something lower than the 10,000 hours. For the purpose of this LCCA, it is assumed the reliability factor for the SRS pump with the standard Bergman seal is 1.4 which equates to an average running life of 7,000 hours.

4.3.2 Estimate of LPI ADMP Reliability Factor

The LPI identified a number of improvements in the advanced design mixer pump over the W-151-type mixer pump, which LPI also designed, to improve overall system reliability. While both pumps have a minimum design life of 5,000 hours, LPI stated due to the advanced features, the advanced pump will last longer. The general improvement categories are as follows.

- Roller bearings used instead of journal bearings to extend life and increase durability.

- Gas-filled column with seal-welded joints to prevent leakage of radioactive material into the column and not add to the waste volume in a failed condition.

- Gas-filled skirt below the lower seal to prevent slurry entrainment in the seal.

- Independent shaft sections which eliminate thermal growth problems.

- Elimination of elastomers to provide greater radiation resistance.

The LPI estimated the MTBF, or overage pump life, is 6,000 hours (see Appendix E). For the purpose of this LCCA, it is assumed the reliability factor of the ADMP is 1.2 which equates to an average running life of 6,000 hours.

4.3.3 Estimate of LPI W-151 Reliability Factor

The LPI speculated on the average life of the W-151 pump in environments other than tank AZ-101 (see Appendix E). The LPI states the AZ-101 waste parameters are very specific which allows them to design a mixer pump with a 5,000-hr life. If these units are installed in tanks with different waste parameters, such as high-abrasion wastes, the MTBF will decrease and thus the pump life will decrease. Considering the use and operation of mixer pumps at the Hanford and Savannah River sites, the W-151 pump could fail at 2,000 hours. The LPI understands the failure mechanisms for the old design and have eliminated most of the possible failure modes with the new ADMP design.

For the purpose of this LCCA, it is assumed the reliability factor of the W-151 type mixer pump used in general service is .4 which equates to an average running life of 2,000 hours. The LPI letter concurs with this estimate (see Appendix E).

4.3.4 Historical Data from Other Sites

SRS Data

As stated in Section 4.2.2 of this document, the SRS has experienced problems with mixer pumps which have failed prematurely relevant to the design life. In one case, tank 51 had a mixer pump which lasted for 1,400 hours before it was removed. This pump failed after significant use, which makes this the best indicator of the pump life under those condition with the present line-shaft water-column design. The majority of the mixer pumps at the SRS have been modified with a new type of mechanical seal being installed in the lowest column section, but is still a temporary fix until a new design is available. See Section 5 of this document for more information on the mixer pumps at the SRS.

West Valley Site Data

The West Valley Site has 10 mixer pumps installed in 2 tanks. The cumulative run time for the pumps is being totaled and will be available early in January 1996. Only 1 mixer pump has failed due to normal wear. This pump failed at approximately 2,500 hours and it is believed the lower mechanical seal faces wore out. The weak-link with this type of pump is the seal. The pumps are single line-shaft drive with water-columns, made by Floway, and use a mechanical seal.

4.3.5 Other Life-Limiting Factors

The actual life of a mixer pump is dependent on many factors, including the environment or pump use. The conditions of the 18-tank mixing units will change over the 20-30 years of the retrieval sequence as new waste-blends are passed through the tanks on the way to final disposal. Factors which effect the estimated pump life are:

Pump Speed	Some pumps may be run at less than full power to keep a tank mixed, while other pumping systems will have to run at full power for extended periods of time to wash sludge or perform in-tank pretreatment.
Start/Stops	The number of campaigns is also a factor in pump life. When a pump is started, the bearing systems have little to no lubrication for a few seconds. Also, machined clearances or tolerances are designed for operating temperatures which occur at design speed. Off-normal temperature conditions result in high-wear of the bearing systems.
Bumping	The mixer pumps are designed to be run once a month for brief periods of time. This maintenance procedure is called pump bumping and keeps material from solidifying within the impeller and causing an imbalance. Also, bumping keeps the bearings and seal lubricant well mixed and distributed. A pump bump is not counted as a normal start/stop and will reduce the expected life to some extent. Bumping also helps tank farm workers identify electrical motor and connection problems before they cause complete system failure.
Abnormal Events	Abnormal events, such as power outages and tank farm shutdown for safety reasons, could effect the life of the mixer pumps. It is assumed that each mixer pump will experience 3 abnormal start/stops during the 10-year installation life. Abnormal events beyond this point could limit the life of a mixer pump.
Abrasive Waste	Waste in the DSTs/SSTs has not been completely characterized. Waste which contains high amounts of abrasive, such as aluminum oxide, may cause excessive wear on pump hydraulic parts, such as the impeller and pump casing. Impeller wear, if not uniform, can cause impeller imbalance which limits the pump life. The pump reliability factor may be lower for tanks which contain abrasive materials.
Radiation	While both ADMP pumps are designed for the maximum radiation dose expected in the waste tanks (10^8 rads), extended downtime due to process changes could cause the pump to expire before it wears out.

All of the factors listed are relevant and are considered as a group to this LCC study, as all of these factors will effect the mixer pump options equally. Accordingly, the factors listed are addressed but not included in the weighing factors of this study.

4.4 COST TO PURCHASE EACH MIXER PUMP CONSIDERED

A. *Assumption:* The present value is estimated in 1995 dollars.

Rationale: This is a relative study which compares two alternatives based on cost. It is assumed both ADMP options will increase with inflation proportionally. Also, this study does not take into consideration the time cost of money as the Government will not borrow funds to procure the mixer pumps. Present value discounts and interest rates are usually used in studies where investments are made, such as cost-effectiveness and lease-purchase studies. Both options use projected LCCs that are in 1995 dollars which is reasonable for a direct cost comparison. The cost estimates are based on rough order of magnitude (ROM) cost estimates, not fixed price bids and, therefore, the costs could escalate.

B. *Assumption:* The direct and indirect cost to purchase a W-151 mixer pump from LPI is assumed to be $435K.

Rationale: A mixer pump of this type will cost $338K plus $67K for the variable frequency drive (VFD). In addition, an indirect procurement cost of 7%, or $30K, should be added. This totals to $435K in 1995 dollars. This estimate is based on the cost to purchase 3 units in FY 95.

C. *Assumption:* The indirect and direct cost to replace a SRS mixer pump is $535K. The direct cost to purchase a SRS mixer pump is $310K.

Rationale: November 1995, the SRS removed and installed a mixer pump in tank 51. The removal cost was $125K, the installation cost was $100K, and the new pump was $310K (Bingham Pump).

D. *Assumption:* The indirect cost to replace a W-211 mixer pump in a Hanford Site DST is $550K.

Rationale: The following breakdown was given for a W-211 replacement pump, should one fail after installation.

Disposal container/skid	$ 30,000
Flex receiver bag	5,000
Labor/equipment to remove pump	220,000
Disposal Fee	155,000*
Labor/equipment to install	130,000
Test and startup	10,000
Total	$550,000

* Assuming $150 ft^3 for mixed waste disposal

The cost to dispose of an ADMP is assumed to be $50K less than a W-211 pump, as the lowest section of the mixer pump can be removed from the pump and disposed of as non-mixed waste. This reduces the disposal fee by an estimated $50K.

E. *Assumption:* A new complete ADMP procurement cost of an SC-3 system:

ROM/9 pumps

WEMD = $752,171
LPI = 620,000

Rationale: The ROM cost is based on an order of 9 pumps and will decrease as the number of units ordered increases. Cost escalation due to cost of money over time was not considered. Estimates are in 1995 dollars. These figures include the VFD drive unit. The average cost between the two options is $686K.

F. *Assumption:* Mixer pumps, when replaced, will not require a completely new mixer pump, as some of the equipment is reusable. The cost to replace an SC-3 system of each type is assumed as follows: W-151 = $300K, WEMD = $535K, LPI = $505K

Rationale: The basis for these estimates comes from letters submitted to the WHC after a request for volume order ROMs:

Cost to replace a LPI W-151 pump:

LPI pump	$ +360,000	
Less turntable	- 23,000	
Less motor	- 37,000	
Total Cost	**$ 300,000**	(Order of 9)

Cost to replace a WEMD pump:

WEMD pump	$ +752,171	
Less turntable	- 50,000	
Less VFD unit	-167,000	
Total Cost	**$ 535,171**	(Order of 9)

Cost to replace an LPI ADMP pump:

LPI pump	$ +620,000	
Less turntable	- 23,000	
Less motor	- 37,000	
Less VFD unit	- 55,000	
Total Cost	**$ 505,000**	(Order of 9)

4.5 COST TO OPERATE EACH MIXER PUMP CONSIDERED

The indirect cost associated with operation of 18-tank systems (36 pumps) for 20 years is assumed as shown in Table 4.

Table 4. Summary of Reoccurring Costs.

Operating Cost	W-151	LPI-ADMP	WEMD-ADMP
Electric power	$1,863K	$1,863K	$2,389K
Bottled nitrogen	N/A	54K	41K
Seal waste disposal @ $.60/gal	2K	N/A	1K
Freeze protection	2,070K	N/A	2,070K
Maintenance (bumping)	6,531K	6,531K	6,531K
Total 20-yr costs	10,412K	8,394K	10,963K

4.5.1 Electric Power

Assumption: The electrical power for each alternative is based on the Hp motor operating requirements for the required life of each mixing system for each tank.

WEMD	$ 2,211K
LPI Options	1,724K

Rationale: Table 5 is the same as Table 3 with the number of campaigns removed and the 408 hours for DST retrieval removed. The total number of hours for all campaigns is listed and the electrical cost of each type of mixer pump is shown over the entire life of the mixing system.

Table 5. Mixer Pump Electrical Power Needs over 20 Years.

#	Tank	Total Hours
1	SY-101	5,307
2	SY-102	3,347
3	SY-103	2,214
4	AW-104	25,068
5	AW-103	14,427
6	AN-101	14,683
7	AN-104	15,956
8	AN-105	14,636
9	AN-106	14,639
10	AW-101	13,293
11	AW-102	13,406
12	AW-105	1,726
13	AN-102	1,350
14	AN-107	1,482
15	AY-101	21,417
16	AY-102	16,588
17	AZ-101	15,560
18	AZ-102	13,196

Total Number of Hours = 208,295

Assuming power cost $0.04/kwh:

WEMD @ 350 Hp + 10% (low-power factor)	= 385 Hp =	$ 2,389K
ADMP LPI @ 300 Hp	= 300 Hp =	1,863K
W-151 LPI @ 300 Hp	= 300 Hp =	1,863K
SRS, LPI, or Bingham	= 300 Hp =	1,863K

Example:

1 Hp = 745 watts

300 Hp x 745 watts = 223,709 watts/hr

(0.04 $/kW•hr•hr) x (223.7 kW hr) x (208,295 hr) = $1,863M

4.5.2 Bottled Nitrogen Gas

Assumption: Bottled nitrogen will cost $54K over 20 years for the LPI gas-column option, and $41K over 20 years for the WEMD mixer pump.

Rationale: During the 20-year life-cycle of the mixer pumps, the nitrogen usage has two different flow rates:

LPI running	.95 bottles/mo/pump
LPI not running	.20 bottles/mo/pump
WEMD running and not running	.20 bottles/mo/pump

From Table 5 the cumulative running time is 208 khr over 20 years, which for 18 tanks total cumulative in-tank dwell time is 3,153 khr.

Running	208 khr = 285 mo
Not running	3,153 - 208 = 2,945 khr or 4,036 mo

Using the information above:

Running	2 pumps x 285/mo x .95 bottles = 541 bottles
Not running	2 pumps x 4,036/mo x .2 bottles = 1,614 bottles

Cost per bottle is assumed to be $25 per bottle as quoted by Oxarc for a Site refill of a 8"x4' cylinder of nitrogen.

Total cost-estimate for LPI = (541 + 1,614) x $25 = $54K

Total cost-estimate for WEMD = (1,616) x $25 = $41K

4.5.3 Seal Water Disposal

Disposal of the seal liquid leakage for the past line-shaft design must be accounted for in the cost comparison. Whatever radioactive waste treatment and disposal processes are used, any net amount of water added to the existing waste inventory for any purpose must go though an evaporation or equivalent process for disposal. Since one purpose of the seal water supply system is to maintain the interior of the support column free of contamination, either fresh or completely decontaminated water must be supplied. Thus any leakage through the pump support column mechanical seals adds to waste volume and eventually must be evaporated.

In addition this water must be buffered by chemicals to minimize corrosion in the mixer pump components and in the waste tank. Such chemical solids follow the seal leakage into the waste stream requiring eventual treatment and disposal.

The amount of leakage is estimated from several years of experience with liquid mechanical seals at the SRS. Mixer pumps in tank 51 at the SRS have experienced seal failures in the past and have had leak rates as high as 3.3 gpm in the failed condition. Under normal conditions the SRS mixer pumps have a leak rate of .02 gpm or (75 ml/min).

The new W-151 mixer pumps have an approximate design leak rate of 2 ml/min not running and 4 ml/min running. The WEMD mixer pump has a designed leak rate of 100 ml/hr or 1.66 ml/min running and it is assumed to be 1 ml/min not running.

W-151 - running	4	ml/hr
W-151 - not running	2	ml/hr
WEMD - running	1.66	ml/hr
WEMD - not running	1	ml/hr

Table 5 shows the total number of hours the mixer pumps must run is approximately 208,295 hours. The total number of hours the mixer pumps will be installed but not running is more difficult to estimate and essentially is the cumulative time between transfers for all the pumps.

(20 years x 36 pumps) - 208,295 hr = 6,095,449 hr

20-year Total Water Usage

W-151 - running	4	ml/hr	208,295K	=	220 gal
W-151 - not running	2	ml/hr	6,095K	=	3,220 gal
WEMD - running	1.66	ml/hr	208,295K	=	91 gal
WEMD - not running	1	ml/hr	6,095K	=	1,610 gal

These totals assume the operating seals functioning normally. Under a failed-seal condition the leak rates have been measured at the SRS to be as high as 10 gpm when the mixer is running. For the purpose of this study, we will assume the seals have not failed. Accordingly, the waste volume increase over 20 years is small (less than 4,000 gal) and the disposal cost of this waste is not considered in the LCC estimate.

4.5.4 Freeze Protection and Water Supply

Assumption: It is assumed the water supply system for a mixer pump which requires water (W-151 and the WEMD) will cost $2,070M.

Rationale: The following is the breakdown of the assumptions used to establish the cost of water-lubricated mixer pumps.

<u>Filtered Water:</u>

In the case of the W-151-type water-lubricated shaft pumps, the water which enters the line-shaft column must lubricate the journal bearings supporting the shaft. In addition to this function, the waste under normal conditions will, to some extent, pass through the lower seal to assure waste does not enter the column. The clearance between the seal and the rotating shaft is small, and thus, requires process water filtration. The annual cost to maintain a water-filtration system for a single mixer pump is estimated to be $700/yr.

Pressurized Water:

The water for the column must be pressurized to balance the hydrostatic pressure at the lower seal (zero pressure differential). The annual cost to run and maintain the pressure system is assumed to be $1,000 per pump/yr.

Freeze Protection:

The annual cost of freeze protection is unknown, but thought to be significant. For the purpose of this analysis it is assumed to be $2,000 pump/yr.

Fill Only in Vertical Position:

The additional cost and risk to fill the W-151 pump in the vertical position versus the horizontal is unknown. However, for this analysis it is assumed to cost $5,000 in additional work plans and safety assessment and crews needed for work in RCA per installation. This cost is included in the $550 installation cost. However, is not included in the SRS cost-estimate for the installation of a mixer pump.

Vent and Fill Same Time:

The additional cost to vent and fill during installation requires additional installation equipment. It is assumed to cost $9,000 per installation for this type of pump. Again, this cost is included in the installation cost of $550.

Disposal of Water in Column (Dip Tube):

On removal, the water in the column must be disposed. The water is usually drained back into the tank through a dip tube. The amount of water is 500-gal, at $.60/gal to evaporate. The cost to dispose of the column water is $300 per removal plus $1,700 for the crew. For the WEMD pump the volume is 50-gal at a disposal cost of $1,730.

Summary of costs:	Filter	$ 700
	Pressurized	1,000
	Freeze protection	2,000
	Total	$3,700 per/yr/pump

Total 20-yr cost for 36 pumps = $2,664M
Actual installation schedule ($2,664M) x (.75) = $1,998M

Column water disposal = 2,000/pump

Total water cost for 36 pumps = $72K

Total freeze protection cost = $2,070K

4.5.5 Pump Maintenance (Pump Bumping)

Assumption: It is assumed the ADMP mixer pumps will be bumped once per month. This preventive maintenance is designed to minimize the long-term effects of internal solid waste buildup which causes seal failure and impeller imbalance. For the purpose of this study we assume the cost of this maintenance program to be $6,531K.

Rationale: The pump bumping was estimated to require 3 Operations personnel for 4 hr/mo at a cost of $70 per/hr. This is the approximate Operations effort used to bump tank 241-SY-101.

1st pump - 3 people x 4 hr x $70/hr = $840/bump
2nd pump - $840 x .80 = $672/bump

for 18 mixing systems, 2 pumps/tank = 36 mixers
over 20 years = 240 months
18 mixers x 240 mo = 4,320 pump bumps

1st pump - $840 per/bump x 4,320 bumps = $3,628K
2nd pump - $672 per/bump x 4,320 bumps = $2,903K

5.0 LIFE-CYCLE COST-ANALYSIS MODEL

The LLCMOD is a computer program written in Microsoft Excel Version 3.0 which accepts data files from the Retrieval Sequence Model, case 50, and post-processes the data into cost and schedule information under different assumed mixer pump reliability factors. The model to evaluate the LPI W-151 pump, the LPI ADMP, and the WEMD ADMP mixer pumps is shown in Figure 5. These 3 pumps were chosen because cost information associated with the purchase, installation, and disposal was available. Verification of this model is seen in Appendix D which shows the equations used in the spreadsheet program.

The model's most sensitive parameter is the assumed life of the mixer pumps. All other assumptions have a comparatively minimal effect on the total program cost and the breakeven date. The end result of the model is a parametric relationship which relates the cost/benefit and cost/recover breakeven point based on an assumed life and production costs of each mixer pump system. Figure 5 is the LLCMOD Summary Report page which shows the results of an example program run under the given assumptions.

Life Cycle Cost Model for ADMP

(LCCMOD - Report Page)

12/13/95 MN Hall

Notes: 1) Program savings includes discounts for reusable equpment and difference between a new pump cost and a replacement pump cost.

Case 50 Data			W-151			ADMP - LPI			ADMP - WEMD		
#	Tank	Hrs	# RC	# MP	$ K	# RC	# MP	$ K	# RC	# MP	$ K
1	SY-101	4755	3	6	5370	1	2	2250	1	2	2504
2	SY-102	2787	2	4	3670	1	2	2250	1	2	2504
3	SY-103	1662	1	2	1970	1	2	2250	1	2	2504
4	AW-104	23412	12	24	20670	4	8	8280	4	8	8714
5	AW-103	11691	6	12	10470	2	4	4260	2	4	4574
6	AN-101	14683	8	16	13870	3	6	6270	3	6	6644
7	AN-104	15956	8	16	13870	3	6	6270	3	6	6644
8	AN-105	14636	8	16	13870	3	6	6270	3	6	6644
9	AN-106	14639	8	16	13870	3	6	6270	3	6	6644
10	AW-101	13293	7	14	12170	3	6	6270	2	4	4574
11	AW-102	13406	7	14	12170	3	6	6270	2	4	4574
12	AW-105	1726	1	2	1970	1	2	2250	1	2	2504
13	AN-102	1350	1	2	1970	1	2	2250	1	2	2504
14	AN-107	1482	1	2	1970	1	2	2250	1	2	2504
15	AY-101	21417	11	22	18970	4	8	8280	4	8	8714
16	AY-102	16588	9	18	15570	3	6	6270	3	6	6644
17	AZ-101	15560	8	16	13870	3	6	6270	3	6	6644
18	AZ-102	13196	7	14	12170	3	6	6270	2	4	4574
			108	216	188460	43	86	90750	40	80	90812

W-151

Assumptions		
Hrs	2000	[hrs]
P Life	10	[yrs]
PC	985	[$K]
PCR	850	[$K]

ADMP - LPI

Assumptions		
Hrs2	6000	[hrs]
P Life	10	[yrs]
PC2	1125	[$k]
PCR2	1005	[$k]

20 Year Program Savings 97,710 [$k]

ADMP - WEMD

Assumptions		
Hrs3	7000	[hrs]
P Life	10	[yrs]
PC3	1252	[$k]
PCR3	1035	[$k]

20 Year Program Savings 97,848 [$k]

Cost Assumptions		
W-151 New Cost =	435	(4.4.2)
ADMP -LPI New =	620	(4.4.5)
ADMP -WEMD New =	752	(4.4.5)
SRS- Binham New =	310	(4.4.3)
W-151 Replace =	300	(4.4.6)
ADMP -LPI Replace =	505	(4.4.6)
ADMP -WEMD Replace	535	(4.4.6)
WHC Indirect - W151	550	(4.4.4)
WHC Indirect - ADMP=	500	(4.4.4)
SRS Indirect Bingham	225	(4.4.3)

Cost to Operated for 20 Yrs = (Note Significant between Options, See Section 4.5)

Figure 5. Life-Cycle Cost Model for ADMP.

5.1 NUMBER OF REPLACEMENT CYCLES

The LCCMOD uses the information in Table 3 and processes it using the following relationships.

The number of replacement cycles is calculated by dividing the cumulative run hours located in column C by the assumed life to estimate the number of installations needed over the life of each tank. The formula takes credit for remaining running hours left after a campaign is finished and applies them to the next campaign. The only run time on the mixer pump not used is in the case of the last campaign. This equation predicts only the number of installations, including the first.

Installations = INT (C9/WHR)+ 1

INT = The integer of

Example: INT (14636/2000) + 1 = (7 + 1) = 8

In this case the program would predict 1 new install, and 7 replacements would be needed if the mixer pump wears out in 2,000 hours and it is needed for 14,636 hours.

5.2 NUMBER OF PUMPS NEEDED PER TANK

The number of pumps needed is calculated by taking the number of installations and multiplying them by 2 (2 pumps per tank). This applies only to Hanford Site DSTs, as the SRS installs 3 to 4 mixers per tank, and in this case the number of installations should be multiplied accordingly.

No. of Pumps = (2 x number of installations)

5.3 COST OF MIXER PUMPS

The cost of the mixer pumps per tank over the 20-year retrieval sequence was calculated by multiplying the number of mixer pumps needed by the cost. The program takes into consideration the difference in cost of a new system over the reduced cost of a replacement system using the following relationship.

Cost = (PC*2)+[PCR*2*ABS(D2-1])

where PC = New cost
PCR = Replacement cost
D2 = Number of installations
ABS = Absolute value function

or

Cost = (2 x cost of new) + (2 x replacement cost x number of replacements)

This function takes into account the cases where only one set of pumps is needed and in this case the second half of the equation is zero, which is correct.

5.4 SUM OF MIXER PUMPS NEEDED OVER 20 YEARS

Using the EXCEL SUM function, the cumulative totals are added to show the number of mixer pumps needed over the 20-year retrieval sequence. The sum represents the cumulative number of mixer pumps, both new and replacements, which will have to be purchased and installed into the 18 DSTs. This information is helpful to visualize the need for commonality and standardization of mixer pumps at the Hanford Site and the SRS.

5.5 SUM OF MIXER PUMP COSTS OVER 20 YEARS

Using the EXCEL SUM function shows the total program cost of procuring mixer pumps for the 20-year retrieval sequence. The difference between these totals is the savings, or cost of the ADMP program, compared to the W-151-type mixer pump at the assumed mixer pump life as stated.

5.6 SUM OF INSTALLATIONS OVER 20 YEARS

The totals shown under the column called #RC, which stands for number of replacement cycles, is the total number of mixer pump installations needed. This number is helpful in error-checking between the LCCMOD spreadsheet and the LCCMOD2 spreadsheet which factors in time, to come up with the breakeven date for different mixer pump assumptions.

5.7 ASSUMED LIFE

The assumed cumulative pump hours used in the model is input from Appendixes A through C, cumulative tank totals located at the end of each appendix. These totals are calculated using the spreadsheet EXCEL SUM function and are manually entered into the LCCMOD spreadsheet.

5.8 ASSUMED COST

The costs listed for new and replacement mixing systems are from vendor ROM estimates assuming outside contracts. This model does not take into consideration the time cost of money as the Government will not borrow funds to procure the mixer pumps. Present value discounts and interest rate are usually used in studies where investments are made, such as cost-effectiveness and lease-purchase studies. Both options use projected mixer pump costs that are in 1995 dollars which is reasonable for a direct cost comparison. The cost-estimates are based on ROM cost-estimates, not fixed price bids and, therefore, the costs could escalate. The cost-assumption references to the appropriate sections of this report are cited on the report page next to the value shown. The cost values are treated as variables in the spreadsheet to allow rapid analysis of different assumed mixer pump costs.

5.9 ASSUMED REPLACEMENT COST

The assumed replacement cost is the cost of the new mixer pump, less the cost of the equipment which can be reused, such as the VFD, turntable, and, in the LPI case, the electric motor. See Section 4 assumptions.

5.10 ADMP PROGRAM SAVINGS 20 YEARS

The value in this cell is the difference between the W-151 total mixer pump program cost, and the ADMP total mixer pump program cost over the 20 years defined by the retrieval sequence for the Hanford Site. This value is listed in terms of thousands of dollars and is the relative indicator whether the ADMP program has value under the present assumptions. This value is significantly different for the SRS, as they have a 32-year retrieval sequence and the number of staging tanks is 8 instead of 18 at the Hanford Site.

6.0 EXAMPLE - RESULTS OF 2,000/6,000/7,000-HOUR LIFE ASSUMPTION

To illustrate the cost/benefit relationship, Table 6 is presented using the assumed life and reliability factors presented in Section 4.3. It must be stated that without sufficient physical testing of a significant sample of mixer pumps, the statistical probabilities related by the reliability factors given is marginal at best. In using the reliability factors supplied by the mixer pump vendors, however, the example becomes the best possible estimate of cost savings of this program.

Table 6. Assumed Reliability Factors Used in LLCMOD.

Type	Design Life	Reliability Factor *	Test Data Pump life	Assumed Life
LPI-ADMP	5,000-hr	1.2	None	** 6,000-hr
WEMD-ADMP	5,000-hr	1.4	None	*** 7,000-hr
LPI-W151	5,000-hr	.4	None	** 2,000-hr
Bingham	25,000-hr	.08	1,400-hr	
Floway	10,000-hr	.25	2,500-hr	

*   See Section 4.3
**   See Section 4.3.2 and 4.3.3
***   See Section 4.3.1

To illustrate the results of the assumptions see Figure 5 which is the LCCMOD report page.

The data file shown in Appendixes A through C is used as input to LCCMOD2 which factors in a new dimension "time" to show "when" the savings is realized. This model does not account for the difference in new pump costs versus replacement pump costs as it was difficult to estimate using the EXCEL software and it was seen to be insignificant regarding the end results. The LCCMOD program predicts approximately a $100M savings for both the 6,000/hr and 7,000/hr mixer pumps.

The LCCMOD2 (see Figure 6) shows similar results and shows the assumed ADMP program cost of $3M will be recovered in the first 5-6 years of the retrieval sequence. See Section 9.0 of this report for a breakdown and description of the cost of the ADMP Program.

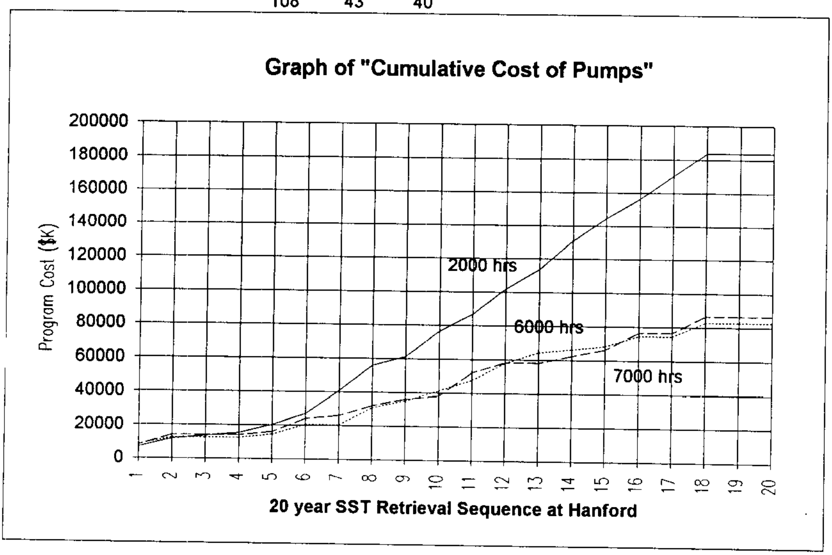
6.1 SIGNIFICANCE OF RESULTS

The majority of the replacement begins 5-6 years into the retrieval sequence (see figures 7, 8, and 9). This equates to the year 2009 to the year 2010, wherein an ADMP would have its greatest value. The benefit of the ADMP program is significant but will not be realized for at least 15 years from 1995. The retrieval sequences at the Hanford Site and the SRS are over great periods of time (20 years and 32 years, respectively). To delay the development of advanced pumps will delay the lag time needed for them to begin benefiting the government. If advanced technology mixer pumps are not implemented at the beginning of the sequence, they will have very little benefit as the cost and time to recover, once the state of the art pumps start to fail, is very significant.

LCCMOD2 - Report Page - Cost Schedule for ADMP Options

Note: This listing assumes all installs are Replacement pumps (not sensitive to outcome).

Cumulative Number of Pumps				Number of Replacements			Cumulative Cost of Pumps				Cumulative Savings (over 2k)	
Yr	2k hrs	6k hrs	7 K hrs	2k hrs	6k hrs	7 k hrs	Yr	2k hrs	6k hrs	7 k hrs	6 k hrs	7K hrs
1	8	8	8	4	4	4	1	6800	8040	8280	-1240	-1480
2	14	14	12	3	3	2	2	11900	14070	12420	-2170	-520
3	16	14	12	1	0	0	3	13600	14070	12420	-470	1180
4	18	14	12	1	0	0	4	15300	14070	12420	1230	2880
5	24	16	14	3	1	1	5	20400	16080	14490	4320	5910
6	32	24	20	4	4	3	6	27200	24120	20700	3080	6500
7	48	26	20	8	1	0	7	40800	26130	20700	14670	20100
8	66	32	30	9	3	5	8	56100	32160	31050	23940	25050
9	72	36	34	3	2	2	9	61200	36180	35190	25020	26010
10	90	38	40	9	1	3	10	76500	38190	41400	38310	35100
11	102	52	46	6	7	3	11	86700	52260	47610	34440	39090
12	120	58	56	9	3	5	12	102000	58290	57960	43710	44040
13	134	58	62	7	0	3	13	113900	58290	64170	55610	49730
14	154	62	64	10	2	1	14	130900	62310	66240	68590	64660
15	170	66	66	8	2	1	15	144500	66330	68310	78170	76190
16	184	76	72	7	5	3	16	156400	76380	74520	80020	81880
17	200	76	72	8	0	0	17	170000	76380	74520	93620	95480
18	216	86	80	8	5	4	18	183600	86430	82800	97170	100800
19	216	86	80	0	0	0	19	183600	86430	82800	97170	100800
20	216	86	80	0	0	0	20	183600	86430	82800	97170	100800
				108	43	40						



6.2 2,000-HOUR MIXER PUMP REPLACEMENT SCHEDULE

Under the assumption that the mixer pump will have a 2,000 actual life, or MTBF equals 2,000 hours, the LLCMOD2 report was generated (see Figure 7). The numbers on the Y axis are related to the tank numbers used in Table 3 for each tank, and the X axis is time in years from 1 to 20 years representing the Hanford Site Retrieval SST Sequence (see Appendix A).

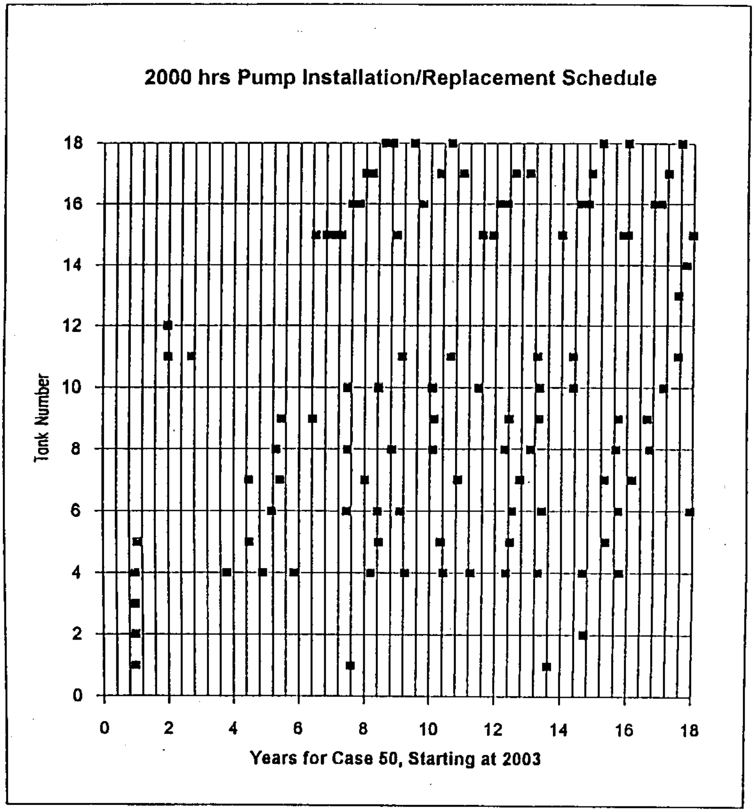


Figure 7. 2,000-hour Mixer Pump Replacement Schedule.

6.3 6,000-HOUR MIXER PUMP REPLACEMENT SCHEDULE

Under the assumption that the mixer pump will have a 6,000 actual life, or MTBF equals 6,000 hours, the LLCMOD2 report was generated (see Figure 8). The numbers on the Y axis are related to the tank numbers used in Table 3 for each tank, and the X axis is time in years from 1 to 20 years representing the Hanford Site Retrieval SST Sequence (see Appendix B).

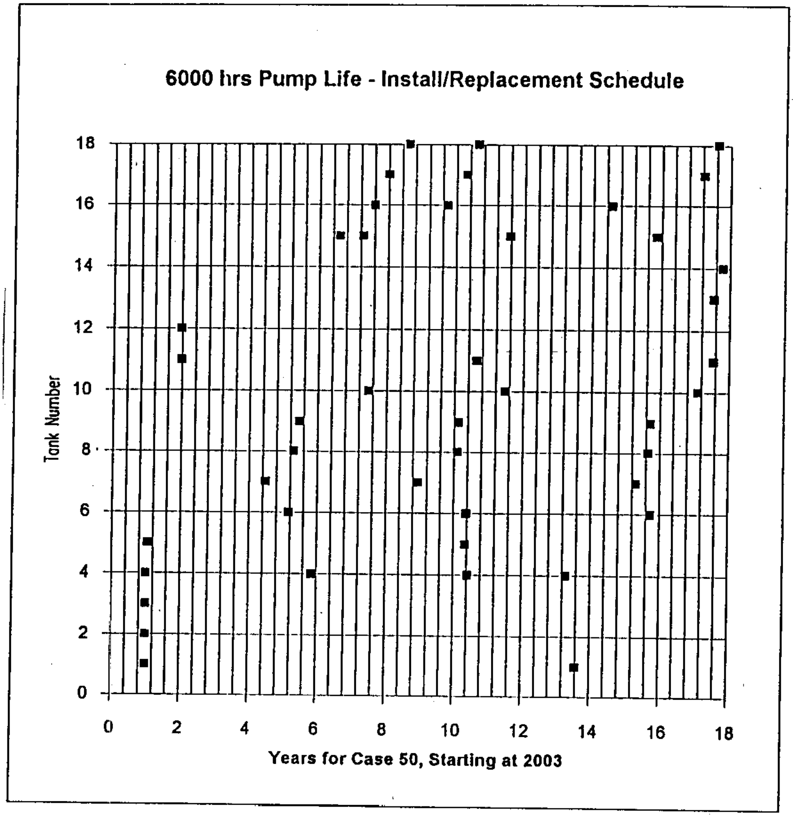


Figure 8. 6,000-hour Mixer Pump Replacement Schedule.

6.4 7,000-HOUR MIXER PUMP REPLACEMENT SCHEDULE

Under the assumption that the mixer pump will have a 7,000 actual life, or MTBF equals 7,000 hours, the LLCMOD2 report was generated (see Figure 9). The numbers on the Y axis are related to the tank numbers used in Table 3 for each tank, and the X axis is time in years from 1 to 20 years representing the Hanford Site Retrieval SST Sequence (see Appendix C).

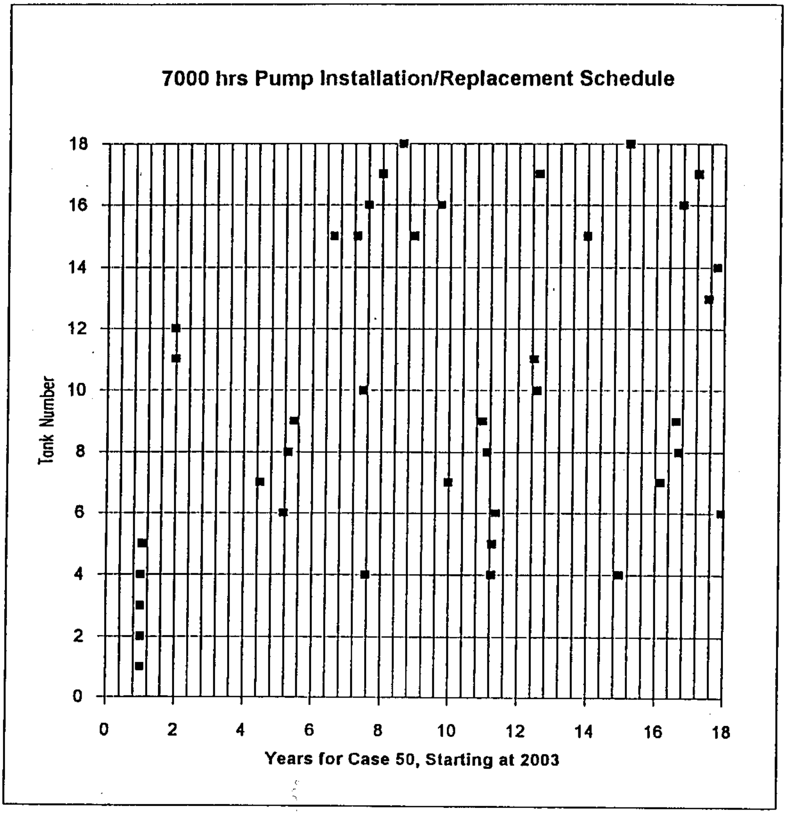


Figure 9. 7,000-hour Mixer Pump Replacement Schedule.

6.5 PARAMETRIC RESULTS

As stated previously, the LCCMOD program predicts the relative benefit of the program under key assumptions. While the WHC is confident the values used in the example are reasonable, it must be stated that the relationship is a parametric relationship. To illustrate the sensitivity of the parametric relationship, the following section presents the results under a range of assumed values.

Figure 10 is the breakeven graph which shows the point at which the 2 systems are equal. By assuming a point above the graphed line or below it, it can be assessed whether the program will have benefit or not and the relative magnitude of the benefit. The data for the graph was generated using LCCMOD and iterating the assumed lives for the mixer pumps until the 20-year program benefit was equal.

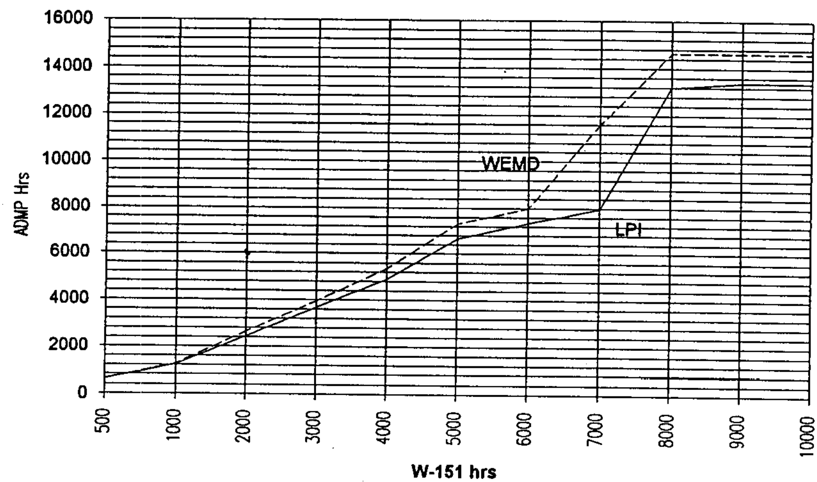


Figure 10. Breakeven Graph for W-151/ADMP-LPI Pumps.

Once a point in Figure 10 is assumed, representing 2 assumed mixer pump lives, the relative cost of each option is shown in Figure 11 and by subtracting the two, the cost savings is calculated.

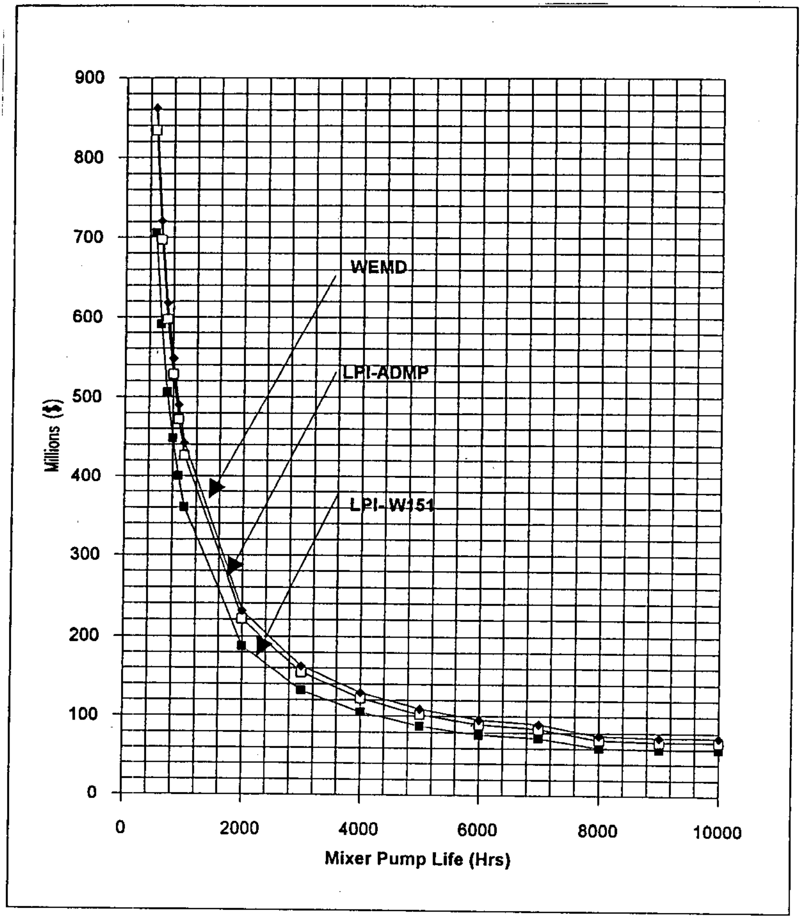


Figure 11. Total Cost of Mixer Pump Program Assuming Life in Hours.

6.6 SENSITIVITY ANALYSIS

In addition to the parametric results of the previous section which produced graphical results, this section is presented in tabular form for clarity and ease of reference. During peer review of this document, DOE-RL requested the following 4 cases be presented to clearly show the sensitivity of the assumptions. Using the LCCMOD spreadsheet program, different estimates were modeled and the results are presented below in Table 7.

Table 7. Tabulated Results of Sensitivity Analysis

CASE	RESULTING SAVINGS OVER 20 YEARS
Case 1 W-151 ...... 2,000 hrs ADMP-LPI ... 6,000 hrs ADMP-WEMD .. 7,000 hrs	 ADMP-LPI over W-151 = $ 97.710M ADMP-WEMD over W-151 = $ 97.848M
Case 2 W-151 ...... 3,000 hrs ADMP-LPI ... 6,000 hrs ADMP-WEMD .. 7,000 hrs	 ADMP-LPI over W-151 = $ 41.610M ADMP-WEMD over W-151 = $ 41.748M
Case 3 W-151 ...... 3,000 hrs ADMP-LPI ... 9,000 hrs ADMP-WEMD . 10,000 hrs	 ADMP-LPI over W-151 = $ 63.720M ADMP-WEMD over W-151 = $ 58.308M
Case 4 W-151 ...... 4,000 hrs ADMP-LPI ... 9,000 hrs ADMP-WEMD . 10,000 hrs	 ADMP-LPI over W-151 = $ 36.520M ADMP-WEMD over W-151 = $ 31.108M

7.0 THE SRS COST/BENEFIT CONSIDERATIONS

Specific information regarding the number of mixing hours needed per tank is not available at this time. Due to the lack of this information, projections of the number of mixer pumps and the associated costs over the 32-year retrieval sequence is not calculated. While specific mixer pump needs for the SRS are unknown they are assumed to be significant, and based on this assumption the SRS has participated thus far in the ADMP development program. A current effort is underway to project the specific pump needs and will be available in early 1996. The following section is a brief overview of what is known regarding the equipment and problems.

7.1 BASIC PUMP CONFIGURATION

The SRS mixer pumps consist of 4 basic designs. All of the pumps have water-filled columns, with line-shafts driving a submersible pump impeller which intakes from the bottom of the tank and discharges to the immediate sides. All of the pumps are powered by above-grade electric motors. The majority of the large mixer pumps installed at the SRS are supplied by the LPI and Bingham. The basic configuration of the 4 types are described below.

A. 125 hp, UoD = 13, 2-nozzle, low-shear sludge pump
B. 150 hp, UoD = 13, 2-nozzle, high-shear sludge pump
C. 200 hp, UoD = 22, 1-nozzle, high-shear sludge pump
D. 300 hp, UoD = 22, 4-nozzle, low-shear mixer pump

All pumps have above-grade electric motors, 360 degree rotation, with slip rings for electrical contact. All have water-filled columns, line-shaft drives of submersible centrifugal single impeller pumps (bottom suction/ discharge). The SRS waste tanks have smaller risers than the Hanford Site waste tanks. The SRS risers are 24" or 36" while the Hanford Site risers are 34" or 42".

7.2 BEARING WATER LEAKAGE RATES

Of the 19 pumps installed at the SRS (tanks 41, 42, 48, 49, 50, and 51), only 4 pumps have had an unacceptable water-column leak rates. The 4 pumps are installed in tank 51 at the SRS and are equipped with the new modified Bergman seals. Currently, all 4 mixer pumps are operating within acceptable limits. Two of these pumps failed during startup earlier and had excessive leak rates (>2.5 gpm). After bumping the pumps, however, the leak rates on pump G, H, and B3 stabilized to .2 to .5 gpm. Pump B1 continues to leak excessively (>7.5 gpm), which is somewhat dependent on operating speed. The SRS believes, from all indications, that the bottom seal on the B1 riser has failed. This assumption was later confirmed when an analysis on a sister pump, which had not been installed, showed hydraulic impeller imbalance was the cause of the seal failure and could be corrected by machining the impellers versus sand casting them.

Under the assumption that none of these pumps will be repaired, the combined leak rate in tank 51 will be approximately 8-9 gpm, depending on speed, only when the pumps are running. This would be unacceptable partly because the leaking mixer pumps are the last feed tank before the vitrification plant. During transfer of waste to the vitrification plant, a process which could take as long as 12-14 days, an additional 180,000 gal of waste could be added to the currently planned waste volume if the seals are not repaired or replaced.

7.3 REPAIR OF LOWER SEALS

Most of the pumps have leaked radioactive material into the water-columns which makes decontamination more difficult and costly. Past-practice at the SRS is to use their 299H Facility to decontaminate and repair jet mixer pumps which had defective or damaged lower confinement seals. In this facility mixer pumps have been decontaminated, disassembled, and the lower seals have been replaced. Recently, however, a mixer pump from tank 51 was disassembled and studied but not repaired. It is the current policy at the SRS not to count on seal repairs in the 299H Facility for mixer pumps. Replacing a mixer pump at the Hanford Site would cost an additional $550,000 in disposal costs which may make the repair option viable. Cost-estimates for this option are not available at this time for the Hanford Site.

The current designs are acceptable to the SRS and they have a current order for 17 mixer pumps of the same design with the modified Bergman lower seal. Thirteen mixer pumps are for waste removal, 2 low-shear and 2 high-flow. Further evidence of the adequacy of this design is supported by the Hanford Site Project W-151 which will use two of the same pumps (water-column, line-shaft drive) that have an improved lower seal.

The projected leak rates of any new design is highly speculative in nature. All mechanical seals may develop increased leak rates after periods of inactivity, due to crystallization of waste which has been known to seep into the pump during periods of inactivity.

7.3.3 The SRS Pump Needs

The SRS has 51 radioactive waste tanks which need waste transferred out to the vitrification facility. These tanks are numbered 1 through 51. To date, there are 21 mixer pumps installed in 6 tanks (see Table 8), and another 17 mixer pumps are on order (see Table 9).

Table 8. List of the SRS Tanks with Mixer Pumps.

Tank	Number of Pumps	Status
Tank 41	3	Low-hr, new seal
Tank 42	4	1,000-hr, old seal
Tank 48	4	Low-hr, new seal
Tank 49	4	Low-hr, new seal
Tank 50	2	Low-hr, new seal
Tank 51	4	1,400-hr, new seal

At present, all of the mixer pumps installed are not leaking water from their lower mechanical seals. The old style seal has been mostly replaced with the new, modified Bergman, which is performing as expected. On the newly installed mixers in Tank 51, the impellers have also been replaced with machined impellers versus sand cast impellers, which is also thought to have contributed to the mechanical seal failure.

Table 9. The SRS Mixer Pumps on Order.

Type	Quantity	Intended Use
Waste removal	13	Staging tanks
Low-shear	2	Staging tanks
High-flow	2	DWPF feed tanks

At this time, the SRS is not able to project how many of the remaining 45 tanks will need mixing systems but will provide computer modeling results from the PRODMOD program, a dynamic program which uses the Simplex programming used in operations research. The PRODMOD is very similar to the ASPEN model used at the Hanford Site to project waste volume needs over the retrieval sequence. Preliminary runs from the PRODMOD show a retrieval sequence of 32 years.

8.0 ADMP DEVELOPMENT PROGRAM TO INCREASE THE RELIABILITY

The history and background of the ADMP program is stated in Section 3.0 of this document. The program was started in November 1993 and to date has completed the development of a mixer pump specification and has completed 2 advanced mixer pump designs under a progressive procurement process. The sunk costs of this program are estimated in Table 10.

Table 10. Sunk Cost of the ADMP Program.

Deliverable	Cost
ADMP Specification	$ 200K
ADMP Designs	1,300K
Procurement/Program Support	50K
Total Sunk Cost	**$ 1,550K**

8.1 DEVELOPMENT PROGRAM STRATEGY

The remaining part of the ADMP development program is essentially a testing program, wherein the "teething" problems of the mixer pump systems are identified and solved. The plan is to take the ADMP pumps to the SRS and test them extensively in a nonradioactive tank for 2,000 to 3,000 hours to identify mechanical problems which are inevitable with any new mechanical system.

Through the Progressive Procurement Process, the WHC downselected to one pump vendor on January 24, 1996 and selected the LPI design for the first pump to be tested. This study shows the relatively small financial advantage of a mixer pump which lasted longer than 6,000 hr (see Figure 11). Both ADMP pump designs, WEMD and LPI, were given the full technical point rating (70/70) in the downselection process as both were considered technically responsive to the minimum requirements of the specification. At that point, cost becomes the driver and the LPI's proposal was the lowest cost.

8.2 DEVELOPMENT PROGRAM DESCRIPTION

The SRS Full Waste Tank Mock-up Facility (Full Tank) will be used to test the ADMP pumping units. The Full Tank is located in the TNX area at the SRS (see figures 12 and 13). It is a full-scale mockup of an HLW tank used for testing HLW processing pumps prior to installation in radioactive tanks. The Full Tank duplicates the tank diameter (85-ft) and mounting structure location (distance from the tank bottom). The Full Tank does not, however, duplicate the tank depth. The Full Tank is an open tank 8-ft deep. A supporting structure overhead provides the mounting support for full-scale pumps. The tank holds approximately 212,000 gal of water, or clay simulant, when filled to the 5-ft level. Services to the facility include electric power, process water, and plant compressed air.

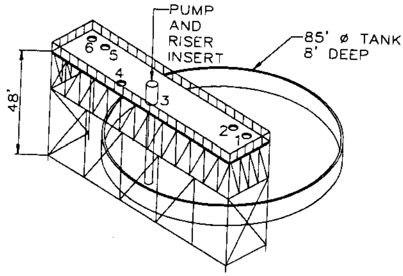


Figure 12. Perspective View of the SRS TNX Test Facility.

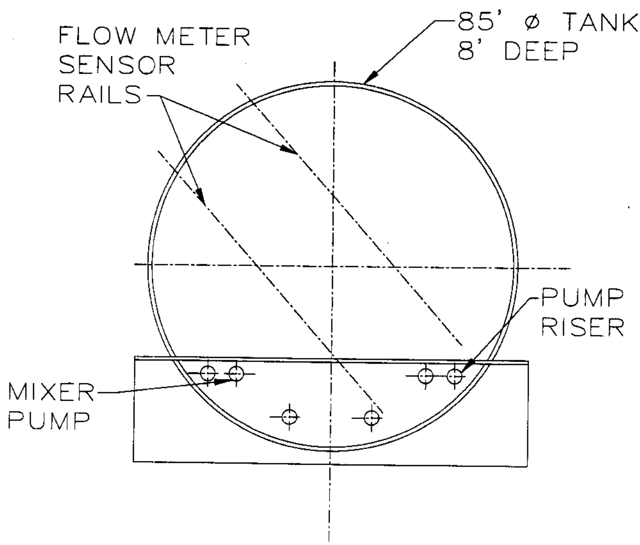


Figure 13. Plan View of the SRS TNX.

Pump positions #3 and #5 will be used for the ADMP test program. Pump position #3 will be used for checkout and position #5 will be used for the long-term reliability tests (2,000 to 3,000 hours). A smaller tank will be installed at position #5 for the simulant tests. The smaller tank will allow testing with smaller volumes of simulant and allows testing at other positions to proceed independently of position #5 (depths >5 ft).

8.2.1 Data Acquisition

Data acquisition will be accomplished in a combination of ways depending on the parameter of interest.

Vibration	The SRS/Interim Waste Technology is planning on purchasing a Bently-Nevada automated diagnostic unit for rotating equipment (ADRE) system to support the HLW processing pump testing. The ADRE system is a state of the art system for the collection and analysis of rotating equipment vibration data. This system will be available for the ADMP test program.
Temperature	The mixer pump thermocouples in the motors and bearings will be monitored for temperature signatures and variance. Output from these thermocouples will be fed electronically to a chart recorder or a Macintosh-based data acquisition system.

Other parameters, such as buffer fluid (water or gas) usage, pressure, motor voltage, amps, etc., are best recorded by Operations personnel in the operating log or operating procedure forms.

8.2.2 Initial Checkout and Water Tests

The objective of the initial 500-hr water test is to check out the ADMP pump operation. Included in this test will be a checkout of the turntable, the data acquisition system, and the pump. During these tests, pump vibration, motor amperage, speed, and voltage will be monitored.

The 500-hr waste test will be conducted on each pump to gain preliminary operation data. Jet profile tests will be included in the water tests. The purpose of these tests is to determine the jet velocity profile away from the pump discharge nozzle. Velocity as a function of distance from the jet centerline will be determined. Hot film anemometers, pressure transducers, or drag targets are potential candidates for measuring the velocity and profile of the discharge jet.

During the 500-hr water tests the following parameters will be monitored:

- Startup vibration signatures
- Shutdown vibration signatures
- Steady state vibration signatures
- Motor or bearing temperatures
- Buffer fluid usage
- Motor parameters (speed, voltage, amps, etc.)

Once the 500-hr water test for the ADMP is completed, it will be evaluated prior to proceeding to the long-term (1,500-hr) reliability test phase. The evaluation will look for abnormal component wear or damage. This will be accomplished by bearing oil analysis and shaft run out measurements to measure bearing wear. Also, column presser checks and impeller inspections will be made to assess structural integrity. This information will be sent to the WHC and the mixer pump vendor to resolve issues prior to proceeding with any long-term reliability testing.

8.2.3 Long-Term 1,500-hour Reliability Tests

Long-term reliability tests will be conducted to assess the pump wear characteristics over the expected mixer pump life. The ADMP will be tested for a minimum of 2,000 hours of operation (including the water test). During this duration, a minimum of 100 start/stops and a minimum of 10 emergency stops are planned. A duty cycle mimicking a typical waste processing operation, such as an ESP waste cycle or an ITP concentration cycle, will be followed for some of the reliability test.

The same parameters identified for the water test will be measured in the long-term test. After these test are complete, the mixer pump will be disassembled and inspected to determine its overall condition. The seal will be sent back to the vendor for evaluation.

A simulant which is representative of the physical properties of the waste will be used (sand in clay) for a portion of the long-term reliability test. Components used in the simulant are limited to non-caustic materials due to safety, cost, and environmental concerns.

8.2.4 Failure Tests

Near the end of the long-term test, the pump will be subjected to several failure scenarios that are deemed most likely to occur during the life of the pump. Seal failure, purge gas control failure, and column pressure loss will be evaluated to assess the impacts to the overall tank system.

8.2.5 Facility Preparations

The following activities are needed to prepare the Full Tank facility at the SRS for the ADMP tests.

- Install a simulant tank (6-ft diameter, 10-ft tall, 2,000-gal) at pump position #5. The tank will need cooling coils and provisions to add and remove slurry simulants. The tank and the supporting equipment will be supplied and funded by the SRS.
- Install new baseplate and turntable (supplied by pump vendors). Fabricate baseplate adaptor plates or modify baseplate.
- Install VFD units to drive pumps.

8.3 DEVELOPMENT COST AND SCHEDULE PROJECTIONS

The development cost of the remaining portion of this program are listed in Table 11.

Table 11. Remaining Development Costs.

Development Activity	Cost
Procurement of ADMP (1 pump)	610K
SRS facility modifications*	200K
SRS test labor*	120K
Hanford Site test labor*	120K
Vendor rework (anticipated)*	100K
Travel/Reviews/Reports	50K
Total remaining cost	$1,200K

* Cost-estimates by the SRS 12/14/95.
** Cost-estimates include the simulant tank and other supporting equipment.

The total cost of the original ADMP program, which includes the procurement of 2 mixer pumps and full-feature testing of each by the vendors and the SRS, was approximately $6.5M. The total cost of the downsized ADMP program, which includes sunk costs, the purchase of 1 pump and reduced testing, is approximately $2.7M.

9.0 COST/BENEFIT CONCLUSIONS

The $3M cost of the ADMP program ($2.7M) will be recovered in the first 5 years. This is a conservative estimate as the cost savings for the SRS were not included in the LCCMOD2 computer estimate (see Figure 6). This study shows the importance of using the ADMP at the beginning of the retrieval sequence as little savings will be realized if the ADMP is deployed in the middle of the sequence. This study also shows that both ADMPs demonstrate an equivalent cost/benefit when measured against the existing design.

10.0 RECOMMENDATION

Based on the findings of this analysis, it is recommended that a mixer pump improvement program be maintained throughout the retrieval sequence at the Hanford Site and the SRS to identify technical issues and apply lessons learned to follow-on mixer pump procurements. The ADMP program is also recommended as the most cost-effective approach to obtaining the advanced reliability mixer pumps needed for the retrieval sequence at the Hanford Site and the SRS.

11.0 REFERENCES

Certa, P. J., 1995, *Preliminary Retrieval Sequence and Blending Strategy Report*, WHC-SD-WM-RPT-167, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Hall, M. N., 1994, *Specification for Performance Requirements of Advanced-Design Mixer Pumps*, WHC-S-0211, Rev. 2, Westinghouse Hanford Company, Richland, Washington.

WHC, 1995, *Waste Tank Summary Report for Month Ending June 30, 1995*, WHC-EP-0182-87, Westinghouse Hanford Company, Richland, Washington.

2000 hrs Data Run - Case 50 **Appendix A**

M.N. Hall 12/13/95

Notes 1) The Replacement dates are shown in 20th of the Retrieval Sequence begining in 2003.

2) Replacement Date is the Date in 20ths wherein the intraval will be exceeded (ie 2000 hrs)

Tank	Start Date	Days	Hours	Cumulative	Replacemen Date	Tank #	
>>>>>> data from FILLHL.DAT							
AN-102	8/14/2021	39.2	942		17.55	13	
AN-107	9/23/2021	44.7	1074		17.8	14	
AY-101	1/1/2010	362.5		8700	6.47	15	
AY-101	1/1/2010	362.5		8700	6.8	15	
AY-101	1/1/2010	362.5		8700	7.04	15	
AY-101	1/1/2010	362.5	8700	8700	7.27	15	6.47
AY-101	6/30/2012	99.4	2385	11085	8.96	15	8.96
AY-101	2/9/2015	116.3	2791	13876	11.58	15	11.58
AY-101	7/8/2017	128.7	3089	16965	13.99	15	13.99
AY-101	5/17/2019	113.0	2712	19677	15.85	15	15.85
AY-101	7/1/2021	43.3	1040	20717	17.97	15	17.97
AY-101	2/7/2023	12.2	292	21009	11.9	15	19.58
		Total =	**21009**		16	15	
					7.82	16	
AY-102	12/28/2010	200.6	4814	4814	7.6	16	7.46
AY-102	4/9/2013	113.3	2719	7534	9.74	16	9.74
AY-102	8/23/2015	112.6	2702	10236	12.11	16	12.11
AY-102	1/31/2018	123.7	2969	13205	14.55	16	14.55
AY-102	4/28/2020	113.1	2714	15919	16.8	16	16.80
AY-102	2/13/2022	10.9	261	16180	12.33	16	18.59
		Total =	**16180**		14.78	16	
					17	16	
					8.22	17	
AZ-101	7/15/2011	144.1	3458	3458	8	17	8.00
AZ-101	11/1/2013	114.8	2755	6214	10.3	17	10.30
AZ-101	2/13/2016	122.8	2947	9161	12.59	17	12.59
AZ-101	6/4/2018	117.2	2813	11974	14.89	17	14.89
AZ-101	10/2/2020	115.7	2777	14750	17.23	17	17.23
AZ-101	7/20/2022	16.7	402	15152	11	17	19.02
		Total =	**15152**		13	17	
					8.82	18	
AZ-102	12/8/2011	151.3	3631	3631	8.6	18	8.40
AZ-102	3/1/2014	113.7	2729	6360	10.63	18	10.63
AZ-102	9/30/2018	121.8	2923	9283	15.22	18	15.22
AZ-102	2/27/2021	113.6	2726	12010	17.63	18	17.63
AZ-102	12/14/2022	32.4	778	12788	9.5	18	19.43
		Total =	**12788**		16	18	
>>>>>>>>> data from FILLSWT.DAT							

AW-103	8/8/2004	1.7	41	41	1.06	5	1.06
AW-103	7/18/2005	7.0	169	210			2.01
AW-103	4/11/2006	9.2	220	430			2.74
AW-103	7/22/2006	8.8	212	642			3.02
AW-103	10/17/2006	8.4	202	844			3.26
AW-103	12/14/2006	8.1	194	1038			3.42
AW-103	5/6/2007	9.9	238	1276			3.81
AW-103	7/7/2007	9.6	231	1507			3.98
AW-103	9/21/2007	9.3	224	1731			4.18
AW-103	11/17/2007	9.0	217	1948			4.34
AW-103	1/10/2008	5.8	139	2087	4.49	5	4.49
AW-103	3/2/2008	7.2	174	2261			4.63
AW-103	4/27/2008	5.8	138	2399			4.78
AW-103	2/17/2009	8.0	191	2591			5.60
AW-103	4/27/2009	7.7	185	2776			5.78
AW-103	5/29/2009	2.2	52	2828			5.87
AW-103	6/5/2009	3.7	89	2917			5.89
AW-103	11/24/2009	2.3	56	2973			6.36
AW-103	2/3/2010	2.3	56	3029			6.56
AW-103	1/13/2011	9.3	222	3252			7.50
AW-103	2/26/2011	6.3	151	3403			7.62
AW-103	7/29/2011	10.6	255	3658			8.04
AW-103	9/17/2011	10.4	249	3907			8.18
AW-103	11/7/2011	2.4	58	3965			8.32
AW-103	12/22/2011	10.9	261	4226	8.44	5	8.44
AW-103	2/22/2012	8.6	207	4433			8.61
AW-103	5/21/2012	10.6	255	4688			8.85
AW-103	6/30/2012	2.1	51	4738			8.96
AW-103	7/9/2012	5.4	129	4867			8.99
AW-103	9/1/2012	9.6	231	5098			9.14
AW-103	10/12/2012	3.1	74	5172			9.25
AW-103	11/4/2012	9.0	217	5389			9.31
AW-103	7/21/2013	10.7	257	5646			10.02
AW-103	9/24/2013	10.0	240	5886			10.20
AW-103	11/17/2013	6.3	150	6036	10.35	5	10.35
AW-103	2/7/2014	9.4	225	6261			10.57
AW-103	4/7/2014	6.8	164	6425			10.73
AW-103	6/20/2014	9.8	234	6659			10.94
AW-103	8/12/2014	9.1	218	6877			11.08
AW-103	10/21/2014	10.1	242	7119			11.27
AW-103	12/17/2014	9.1	219	7339			11.43
AW-103	2/23/2015	3.3	80	7418			11.62
AW-103	3/12/2015	6.8	164	7583			11.66
AW-103	4/22/2015	4.8	114	7697			11.77
AW-103	6/12/2015	2.9	70	7767			11.91
AW-103	12/24/2015	9.9	238	8006	12.45	5	12.45
AW-103	2/29/2016	8.7	209	8214			12.63
AW-103	4/27/2016	1.2	29	8244			12.79
AW-103	6/4/2016	6.5	157	8400			12.89
AW-103	10/4/2016	6.7	160	8560			13.23
AW-103	11/28/2016	10.4	250	8809			13.38

AW-103	1/30/2017	9.1	218	9028			13.55
AW-103	11/29/2017	10.9	261	9288			14.38
AW-103	2/2/2018	9.5	228	9516			14.56
AW-103	4/23/2018	8.7	208	9724			14.78
AW-103	6/16/2018	9.6	231	9955			14.93
AW-103	11/16/2018	10.7	257	10212	15.35	5	15.35
AW-103	3/23/2019	10.7	257	10468			15.69
AW-103	5/30/2019	10.7	257	10725			15.88
AW-103	8/2/2019	3.6	87	10812			16.06
AW-103	8/31/2019	9.2	221	11033			16.14
AW-103	1/21/2020	10.4	251	11283			16.53
			11283				
AW-104	1/15/2003	11.0	264	264	1	4	-0.50
AW-104	3/5/2003	10.2	246	510			-0.37
AW-104	4/23/2003	9.4	226	736			-0.23
AW-104	5/28/2006	9.3	224	959			2.87
AW-104	8/4/2006	11.0	264	1224			3.05
AW-104	10/1/2006	11.0	264	1488			3.21
AW-104	12/14/2006	10.6	255	1743			3.42
AW-104	2/23/2007	10.3	246	1990			3.61
AW-104	4/29/2007	3.0	73	2063	3.79	4	3.79
AW-104	5/18/2007	10.6	254	2316			3.84
AW-104	8/2/2007	10.3	246	2562			4.05
AW-104	10/14/2007	10.0	239	2801			4.25
AW-104	10/30/2007	9.1	218	3019			4.29
AW-104	2/8/2008	11.0	264	3284			4.57
AW-104	3/28/2008	10.2	245	3529			4.70
AW-104	5/11/2008	3.6	86	3614			4.82
AW-104	5/23/2008	11.0	264	3879			4.86
AW-104	6/5/2008	9.1	218	4096	4.89	4	4.89
AW-104	8/27/2008	9.0	215	4312			5.12
AW-104	9/9/2008	9.6	232	4543			5.15
AW-104	10/9/2008	11.0	264	4808			5.24
AW-104	11/23/2008	11.0	264	5072			5.36
AW-104	1/6/2009	10.0	240	5312			5.48
AW-104	2/22/2009	10.1	242	5554			5.61
AW-104	4/1/2009	9.2	220	5774			5.71
AW-104	4/13/2009	9.2	221	5995			5.75
AW-104	5/20/2009	2.7	64	6059	5.85	4	5.85
AW-104	6/2/2009	3.3	79	6138			5.88
AW-104	10/14/2009	11.0	264	6403			6.25
AW-104	12/25/2009	9.1	220	6622			6.45
AW-104	1/12/2011	10.5	253	6875			7.50
AW-104	2/11/2011	11.0	264	7139			7.58
AW-104	3/30/2011	9.3	222	7361			7.71
AW-104	7/30/2011	9.6	231	7593			8.04
AW-104	8/31/2011	11.0	264	7857			8.13
AW-104	9/27/2011	9.2	222	8079	8.2	4	8.20
AW-104	10/20/2011	10.0	239	8318			8.27

AW-104	12/7/2011	9.1	218	8536			8.40
AW-104	1/4/2012	11.0	264	8801			8.48
AW-104	1/20/2012	4.7	112	8913			8.52
AW-104	4/6/2012	11.0	264	9178			8.73
AW-104	5/25/2012	9.7	233	9410			8.86
AW-104	7/5/2012	11.0	264	9675			8.98
AW-104	8/24/2012	9.2	221	9895			9.11
AW-104	10/11/2012	9.2	222	10117	9.25	4	9.25
AW-104	10/23/2012	9.3	222	10339			9.28
AW-104	11/22/2012	3.7	89	10428			9.36
AW-104	12/10/2012	10.2	244	10672			9.41
AW-104	12/21/2012	7.7	184	10856			9.44
AW-104	1/21/2013	2.5	60	10916			9.52
AW-104	8/25/2013	11.0	264	11180			10.12
AW-104	9/7/2013	9.3	222	11402			10.15
AW-104	9/26/2013	11.0	264	11667			10.20
AW-104	11/17/2013	9.1	217	11884			10.35
AW-104	11/25/2013	4.2	102	11986			10.37
AW-104	12/19/2013	11.0	264	12250	10.43	4	10.43
AW-104	1/2/2014	6.6	157	12408			10.47
AW-104	3/12/2014	11.0	264	12672			10.66
AW-104	5/1/2014	10.2	244	12916			10.80
AW-104	6/4/2014	9.4	226	13142			10.89
AW-104	7/19/2014	11.0	264	13406			11.02
AW-104	8/18/2014	9.1	218	13625			11.10
AW-104	9/1/2014	9.8	235	13860			11.14
AW-104	10/13/2014	10.1	243	14103	11.25	4	11.25
AW-104	10/25/2014	9.1	219	14321			11.28
AW-104	12/9/2014	9.2	220	14542			11.41
AW-104	12/21/2014	9.5	229	14770			11.44
AW-104	1/25/2015	9.5	229	14999			11.54
AW-104	2/9/2015	10.5	252	15251			11.58
AW-104	4/19/2015	9.5	229	15480			11.77
AW-104	5/3/2015	10.5	253	15733			11.80
AW-104	5/11/2015	4.6	110	15842			11.83
AW-104	5/27/2015	0.5	13	15855			11.87
AW-104	11/14/2015	10.5	252	16107	12.34	4	12.34
AW-104	12/25/2015	2.7	66	16173			12.45
AW-104	1/13/2016	11.0	264	16437			12.50
AW-104	1/29/2016	11.0	264	16702			12.55
AW-104	2/11/2016	9.3	222	16924			12.58
AW-104	3/4/2016	3.8	92	17016			12.64
AW-104	3/19/2016	9.3	224	17240			12.68
AW-104	3/26/2016	4.7	112	17352			12.70
AW-104	4/20/2016	11.0	264	17616			12.77
AW-104	8/19/2016	11.0	264	17881			13.10
AW-104	10/31/2016	11.0	264	18145	13.3	4	13.30
AW-104	11/15/2016	10.7	257	18402			13.34
AW-104	12/17/2016	7.5	180	18582			13.43
AW-104	12/30/2016	10.2	246	18828			13.47
AW-104	1/25/2017	5.7	137	18965			13.54

AW-104	2/13/2017	5.8	139	19103			13.59
AW-104	3/12/2017	4.5	109	19212			13.66
AW-104	11/27/2017	11.0	264	19476			14.38
AW-104	12/27/2017	11.0	264	19741			14.46
AW-104	2/4/2018	10.1	242	19983			14.57
AW-104	3/6/2018	10.1	241	20224	14.65	4	14.65
AW-104	3/11/2018	1.1	26	20250			14.66
AW-104	3/22/2018	9.4	225	20475			14.69
AW-104	5/8/2018	7.6	183	20658			14.82
AW-104	6/15/2018	11.0	264	20922			14.92
AW-104	6/29/2018	11.0	264	21186			14.96
AW-104	7/25/2018	2.3	56	21242			15.03
AW-104	8/5/2018	8.7	210	21452			15.06
AW-104	8/16/2018	7.3	176	21628			15.09
AW-104	1/5/2019	9.6	231	21858			15.48
AW-104	4/17/2019	11.0	264	22123	15.76	4	15.76
AW-104	6/10/2019	10.5	252	22375			15.91
AW-104	6/17/2019	3.4	81	22456			15.93
AW-104	7/22/2019	10.5	252	22707			16.03
AW-104	9/4/2019	2.0	48	22756			16.15
AW-104	9/15/2019	10.4	249	23004			16.18
			23004				

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AN-101	9/15/2008	56	1341	1341	5.17	6	5.17
AN-101	1/8/2010	0	8	1348			6.49
AN-101	1/1/2011	54	1286	2635	7.47	6	7.47
AN-101	10/17/2011	0	5	2640			8.26
AN-101	12/11/2011	54	1292	3932	8.41	6	8.41
AN-101	8/22/2012	55	1311	5243	9.11	6	9.11
AN-101	11/27/2013	54	1289	6533			10.37
AN-101	12/1/2014	54	1293	7825			11.38
AN-101	1/16/2016	1	12	7838			12.51
AN-101	1/18/2016	54	1285	9123	12.52	6	12.52
AN-101	12/12/2016	1	17	9139			13.42
AN-101	12/14/2016	53	1272	10412	13.42	6	13.42
AN-101	6/8/2018	53	1273	11685			14.91
AN-101	4/9/2019	2	55	11740			15.74
AN-101	4/10/2019	52	1245	12984	15.74	6	15.74
AN-101	6/21/2021	54	1290	14275	17.94	6	17.94
			14275				

AN-104	1/7/2008	4	107	107	4.48	7	4.48
AN-104	1/8/2008	52	1250	1357			4.48
AN-104	12/14/2008	53	1278	2635	5.42	7	5.42
AN-104	10/3/2009	53	1271	3906			6.22
AN-104	7/21/2011	53	1280	5186	8.02	7	8.02
AN-104	6/24/2012	54	1285	6470			8.95
AN-104	7/10/2013	54	1287	7758			9.99

AN-104	5/25/2014	55	1315	9073	10.86	7	10.86
AN-104	4/9/2016	54	1292	10364	12.74	7	12.74
AN-104	1/28/2017	2	47	10411			13.55
AN-104	11/15/2017	52	1250	11662			14.34
AN-104	11/5/2018	3	81	11742	15.32	7	15.32
AN-104	11/5/2018	52	1238	12980	15.32	7	15.32
AN-104	9/4/2019	1	12	12992			16.15
AN-104	9/11/2019	55	1308	14301	16.17	7	16.17
AN-104	8/15/2021	52	1248	15548			18.09
			15548				

AN-105	11/1/2008	55	1310	1310	5.3	8	5.30
AN-105	11/1/2008	0	3	1312			5.30
AN-105	1/4/2011	54	1296	2609	7.48	8	7.48
AN-105	9/7/2011	54	1297	3906			8.15
AN-105	5/9/2012	1	30	3937			8.82
AN-105	5/11/2012	52	1258	5194	8.83	8	8.83
AN-105	8/17/2013	0	1	5195			10.09
AN-105	8/20/2013	54	1302	6498	10.1	8	10.10
AN-105	8/21/2014	1	36	6533			11.11
AN-105	8/22/2014	52	1247	7780			11.11
AN-105	11/4/2015	54	1294	9075	12.31	8	12.31
AN-105	8/8/2016	2	41	9116			13.07
AN-105	8/8/2016	51	1233	10349	13.07	8	13.07
AN-105	11/24/2017	1	27	10376			14.37
AN-105	6/4/2018	53	1266	11642			14.89
AN-105	3/12/2019	54	1288	12930	15.66	8	15.66
AN-105	3/23/2020	54	1298	14228	16.7	8	16.70
			14228				

AN-106	12/30/2008	53	1282	1282	5.46	9	5.46
AN-106	12/16/2009	53	1283	2565	6.42	9	6.42
AN-106	7/18/2011	53	1280	3844			8.01
AN-106	3/26/2012	54	1299	5144			8.70
AN-106	8/28/2013	54	1293	6437	10.12	9	10.12
AN-106	7/8/2014	54	1292	7728			10.98
AN-106	12/14/2015	54	1299	9027	12.42	9	12.42
AN-106	11/1/2016	55	1321	10347	13.31	9	13.31
AN-106	6/6/2018	53	1280	11627			14.90
AN-106	4/6/2019	55	1320	12947	15.73	9	15.73
AN-106	2/21/2020	54	1284	14231	16.61	9	16.61
			14231				

AW-101	1/7/2011	54	1285	1285	7.48	10	7.48
AW-101	12/13/2011	53	1278	2563	8.42	10	8.42
AW-101	10/19/2012	54	1306	3869			9.27
AW-101	8/14/2013	54	1292	5161	10.09	10	10.09
AW-101	1/5/2015	53	1265	6425	11.48	10	11.48

AW-101	1/30/2016	53	1283	7708			12.55
AW-101	11/11/2016	53	1275	8984	13.33	10	13.33
AW-101	11/23/2017	56	1333	10317	14.37	10	14.37
AW-101	6/24/2019	55	1324	11641			15.95
AW-101	8/21/2020	52	1244	12885	17.11	10	17.11
			12885				
AW-102	7/11/2005	55	1323	1323	1.99	11	1.99
AW-102	3/28/2006	1	35	1358			2.70
AW-102	4/2/2006	56	1345	2703	2.71	11	2.71
AW-102	1/8/2011	1	32	2735			7.49
AW-102	7/22/2011	53	1261	3996			8.02
AW-102	9/8/2012	2	47	4043	9.15	11	9.15
AW-102	10/9/2012	52	1238	5281			9.24
AW-102	2/30/2014	1	15	5297			
AW-102	3/1/2014	52	1258	6555	10.63	11	10.63
AW-102	1/2/2016	54	1295	7849			12.47
AW-102	10/20/2016	53	1278	9128	13.27	11	13.27
AW-102	11/18/2017	54	1289	10417	14.35	11	14.35
AW-102	7/6/2019	55	1319	11736			15.98
AW-102	1/28/2021	53	1261	12998	17.55	11	17.55
			12998				
AW-105	7/6/2005	55	1318	1318	1.97	12	1.97
>>>>>> data from FILLX.DAT							
SY-101	3/9/2003	3.6	85	85	1	1	-0.35
SY-101	11/29/2005	2.7	65	150			2.37
SY-101	5/31/2006	3.0	71	221			2.88
SY-101	8/7/2006	3.0	71	293			3.06
SY-101	9/20/2006	0.9	21	313			3.18
SY-101	10/9/2006	2.9	68	382			3.23
SY-101	12/4/2006	1.0	23	405			3.39
SY-101	12/18/2006	2.7	66	471			3.43
SY-101	2/12/2007	1.0	23	493			3.58
SY-101	3/1/2007	2.8	66	560			3.63
SY-101	4/26/2007	0.8	19	579			3.78
SY-101	5/8/2007	1.1	25	604			3.81
SY-101	5/26/2007	2.6	62	667			3.86
SY-101	7/21/2007	1.1	26	692			4.02
SY-101	8/18/2007	2.6	63	756			4.09
SY-101	10/4/2007	0.9	22	778			4.22
SY-101	10/21/2007	2.8	67	845			4.27
SY-101	12/18/2007	3.0	71	916			4.43
SY-101	1/28/2008	0.9	21	937			4.54
SY-101	2/14/2008	2.9	68	1005			4.58
SY-101	3/18/2008	1.0	23	1028			4.68
SY-101	3/31/2008	2.7	66	1094			4.71
SY-101	5/8/2008	0.8	19	1114			4.82

SY-101	5/27/2008	3.1	76	1189			4.87
SY-101	7/5/2008	3.0	71	1260			4.97
SY-101	8/18/2008	0.9	21	1281			5.09
SY-101	8/30/2008	2.9	68	1349			5.13
SY-101	9/28/2008	0.7	17	1367			5.21
SY-101	10/13/2008	3.0	72	1438			5.25
SY-101	11/12/2008	0.8	20	1458			5.33
SY-101	11/26/2008	2.9	69	1528			5.37
SY-101	12/26/2008	0.9	23	1550			5.45
SY-101	1/12/2009	2.8	66	1617			5.50
SY-101	2/12/2009	0.7	17	1634			5.58
SY-101	2/24/2009	2.5	60	1694			5.62
SY-101	3/23/2009	1.0	24	1718			5.69
SY-101	4/15/2009	2.7	65	1783			5.75
SY-101	5/18/2009	0.9	23	1806			5.84
SY-101	5/30/2009	0.9	22	1828			5.88
SY-101	6/3/2009	1.1	27	1855			5.89
SY-101	10/17/2009	3.2	76	1931			6.26
SY-101	2/15/2011	3.2	77	2008	7.59	1	7.59
SY-101	8/3/2011	3.0	71	2080			8.05
SY-101	8/20/2011	0.9	21	2100			8.10
SY-101	10/1/2011	3.2	77	2177			8.22
SY-101	12/10/2011	2.6	63	2240			8.41
SY-101	1/22/2012	1.6	39	2279			8.52
SY-101	4/9/2012	2.8	68	2347			8.74
SY-101	4/26/2012	1.0	24	2371			8.78
SY-101	8/27/2012	3.5	83	2454			9.12
SY-101	10/26/2012	3.0	71	2525			9.29
SY-101	11/23/2012	1.3	31	2556			9.36
SY-101	12/13/2012	2.9	70	2626			9.42
SY-101	1/22/2013	0.9	22	2648			9.53
SY-101	11/20/2013	3.0	73	2721			10.35
SY-101	12/25/2013	3.2	77	2798			10.45
SY-101	2/5/2014	2.9	69	2867			10.57
SY-101	6/6/2014	2.6	61	2929			10.90
SY-101	9/3/2014	3.0	71	3000			11.14
SY-101	10/3/2014	0.9	21	3021			11.22
SY-101	12/12/2014	3.1	74	3095			11.42
SY-101	1/15/2015	0.8	19	3114			11.51
SY-101	1/30/2015	3.2	76	3190			11.55
SY-101	3/9/2015	3.0	71	3261			11.65
SY-101	4/9/2015	0.8	20	3281			11.74
SY-101	4/22/2015	3.1	75	3356			11.77
SY-101	5/22/2015	2.2	53	3409			11.86
SY-101	11/17/2015	2.7	66	3475			12.35
SY-101	12/4/2015	1.1	26	3501			12.39
SY-101	1/15/2016	2.6	63	3564			12.51
SY-101	2/30/2016	1.0	25	3589			
SY-101	3/9/2016	1.3	32	3621			12.66
SY-101	3/28/2016	2.1	51	3672			12.71
SY-101	4/25/2016	2.7	64	3736			12.78

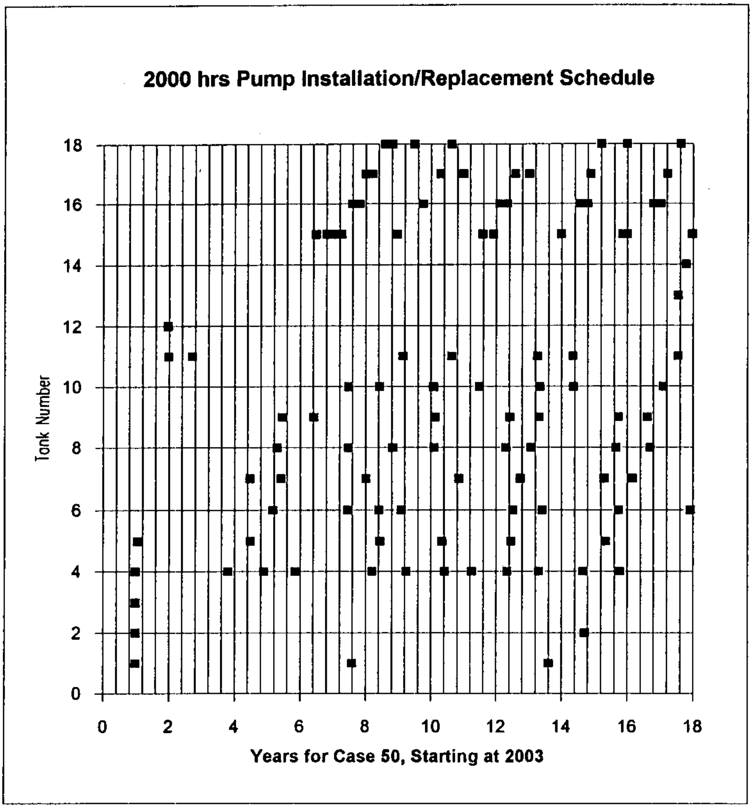
SY-101	5/25/2016	1.1	27	3764			12.87
SY-101	8/22/2016	2.6	62	3825			13.11
SY-101	9/8/2016	1.3	30	3856			13.16
SY-101	11/18/2016	3.2	77	3932			13.35
SY-101	1/27/2017	2.0	47	3980	13.6	1	13.54
SY-101	3/14/2017	1.6	38	4017			13.67
SY-101	3/12/2018	1.0	24	4042			14.66
SY-101	6/17/2018	2.9	69	4110			14.93
SY-101	8/8/2018	3.0	73	4183			15.07
SY-101	4/19/2019	2.7	64	4247			15.77
SY-101	7/11/2019	1.6	38	4285			16.00
SY-101	9/2/2019	2.1	50	4335			16.14
SY-101	9/5/2019	0.5	11	4347			16.15
			4347				
SY-102	1/19/2003	3.8	92	92	1	2	-0.49
SY-102	7/23/2006	0.8	20	112			3.02
SY-102	5/12/2008	1.2	30	142			4.83
SY-102	9/12/2008	2.9	69	211			5.16
SY-102	4/3/2009	2.7	65	276			5.72
SY-102	1/14/2011	2.7	65	342			7.50
SY-102	1/31/2011	1.1	27	368			7.55
SY-102	4/3/2011	3.3	80	448			7.72
SY-102	9/3/2011	3.0	71	520			8.14
SY-102	10/23/2011	3.0	71	591			8.28
SY-102	12/23/2011	1.0	25	616			8.44
SY-102	1/9/2012	1.0	23	639			8.49
SY-102	7/8/2012	3.2	77	716			8.98
SY-102	10/14/2012	3.0	71	787			9.25
SY-102	12/24/2012	3.2	77	864			9.45
SY-102	8/28/2013	3.2	77	941			10.12
SY-102	9/15/2013	1.1	27	968			10.17
SY-102	9/28/2013	2.6	62	1030			10.21
SY-102	11/8/2013	1.2	30	1060			10.32
SY-102	12/8/2013	1.6	38	1098			10.40
SY-102	3/15/2014	2.6	63	1161			10.67
SY-102	4/3/2014	1.2	29	1190			10.72
SY-102	6/21/2014	1.3	31	1220			10.94
SY-102	8/21/2014	2.7	65	1286			11.11
SY-102	10/28/2014	2.7	65	1351			11.29
SY-102	11/29/2014	1.1	27	1378			11.38
SY-102	12/24/2014	2.6	63	1440			11.45
SY-102	5/6/2015	3.2	77	1517			11.81
SY-102	2/2/2016	3.2	77	1594			12.56
SY-102	3/21/2016	2.7	65	1660			12.69
SY-102	12/20/2016	3.0	71	1731			13.44
SY-102	1/19/2017	0.9	21	1752			13.52
SY-102	2/15/2017	2.0	48	1800			13.60
SY-102	11/29/2017	2.8	68	1868			14.38
SY-102	12/16/2017	1.0	24	1892			14.43

SY-102	2/6/2018	2.7	65	1957			14.57
SY-102	2/26/2018	0.8	19	1976			14.63
SY-102	3/26/2018	3.3	78	2054	14.7	2	14.70
SY-102	5/10/2018	2.6	63	2117			14.83
SY-102	6/18/2018	1.0	23	2140			14.93
SY-102	7/4/2018	0.9	21	2161			14.98
SY-102	7/26/2018	0.8	19	2180			15.04
SY-102	8/18/2018	2.5	61	2241			15.10
SY-102	1/8/2019	2.5	60	2301			15.49
SY-102	2/5/2019	0.8	20	2321			15.57
SY-102	5/31/2019	1.2	28	2349			15.88
SY-102	8/25/2019	1.6	37	2387			16.12
			2387				

SY-103	1/4/2003	3.8	92	92	1	3	-0.53
SY-103	12/29/2009	3.7	88	180			6.46
SY-103	9/18/2011	0.9	21	200			8.18
SY-103	1/7/2012	2.9	68	269			8.48
SY-103	5/29/2012	3.4	81	350			8.88
SY-103	11/5/2012	0.9	21	370			9.31
SY-103	9/9/2013	2.7	65	435			10.16
SY-103	5/4/2014	3.0	71	506			10.81
SY-103	7/22/2014	3.0	71	577			11.02
SY-103	8/9/2014	0.9	21	598			11.07
SY-103	10/16/2014	2.9	68	666			11.26
SY-103	12/26/2015	1.0	23	689			12.45
SY-103	1/16/2016	1.2	29	718			12.51
SY-103	2/14/2016	2.8	67	785			12.59
SY-103	11/4/2016	3.7	89	874			13.31
SY-103	1/3/2017	3.0	71	946			13.48
SY-103	12/30/2017	3.0	71	1017			14.47
SY-103	1/25/2018	0.9	21	1037			14.54
SY-103	3/9/2018	2.9	68	1106			14.66
SY-103	7/2/2018	3.0	71	1177			14.97
SY-103	6/13/2019	3.2	77	1254			15.92
			1254				

	Summary of Totals	
1	SY-101	4347
2	SY-102	2387
3	SY-103	1254
4	AW-104	23004
5	AW-103	11283
6	AN-101	14275
7	AN-104	15548
8	AN-105	14228
9	AN-106	14231
10	AW-101	12885

11	AW-102	12998
12	AW-105	1318
13	AN-102	942
14	AN-107	1074
15	AY-101	21009
16	AY-102	16180
17	AZ-101	15152
18	AZ-102	12788



6000 hrs Data Run - Case 50 **Appendix B**

M.N. Hall 12/13/95
Notes 1) The Replacement dates are in 20ths of the Retrieval Sequence begining in 2003
2) Replacement Date is the Date in 20ths wherein the intraval will be exceeded (ie 6000 hrs)

Tank	Start Date	Days	Hours	Cumulative	Replace Date	Tank #	
>>>>>> data from FILLHL.DAT							
AN-102	8/14/2021	39.2	942		17.55	13	
AN-107	9/23/2021	44.7	1074		17.8	14	
AY-101	1/1/2010	362.5	8700	8700	6.6	15	6.47
AY-101	6/30/2012	99.4	2385	11085	7.28	15	8.96
AY-101	2/9/2015	116.3	2791	13876	11.58	15	11.58
AY-101	7/8/2017	128.7	3089	16965			13.99
AY-101	5/17/2019	113.0	2712	19677	15.85	15	15.85
AY-101	7/1/2021	43.3	1040	20717			17.97
AY-101	2/7/2023	12.2	292	21009			19.58
		875.4	21009				
AY-102	12/28/2010	200.6	4814	4814	7.6	16	7.46
AY-102	4/9/2013	113.3	2719	7534	9.74	16	9.74
AY-102	8/23/2015	112.6	2702	10236			12.11
AY-102	1/31/2018	123.7	2969	13205	14.55	16	14.55
AY-102	4/28/2020	113.1	2714	15919			16.80
AY-102	2/13/2022	10.9	261	16180			18.59
		674.2	16180				
AZ-101	7/15/2011	144.1	3458	3458	8	17	8.00
AZ-101	11/1/2013	114.8	2755	6214	10.3	17	10.30
AZ-101	2/13/2016	122.8	2947	9161			12.59
AZ-101	6/4/2018	117.2	2813	11974			14.89
AZ-101	10/2/2020	115.7	2777	14750	17.23	17	17.23
AZ-101	7/20/2022	16.7	402	15152			19.02
		631.3	15152				
AZ-102	12/8/2011	151.3	3631	3631	8.6	18	8.40
AZ-102	3/1/2014	113.7	2729	6360	10.63	18	10.63
AZ-102	9/30/2018	121.8	2923	9283			15.22
AZ-102	2/27/2021	113.6	2726	12010	17.63	18	17.63
AZ-102	12/14/2022	32.4	778	12788			19.43
		532.8	12788				
>>>>>>>>> data from FILLSWT.DAT							
AW-103	8/8/2004	1.7	41	41	1.06	5	1.06
AW-103	7/18/2005	7.0	169	210			2.01
AW-103	4/11/2006	9.2	220	430			2.74
AW-103	7/22/2006	8.8	212	642			3.02

AW-103	10/17/2006	8.4	202	844			3.26
AW-103	12/14/2006	8.1	194	1038			3.42
AW-103	5/6/2007	9.9	238	1276			3.81
AW-103	7/7/2007	9.6	231	1507			3.98
AW-103	9/21/2007	9.3	224	1731			4.18
AW-103	11/17/2007	9.0	217	1948			4.34
AW-103	1/10/2008	5.8	139	2087			4.49
AW-103	3/2/2008	7.2	174	2261			4.63
AW-103	4/27/2008	5.8	138	2399			4.78
AW-103	2/17/2009	8.0	191	2591			5.60
AW-103	4/27/2009	7.7	185	2776			5.78
AW-103	5/29/2009	2.2	52	2828			5.87
AW-103	6/5/2009	3.7	89	2917			5.89
AW-103	11/24/2009	2.3	56	2973			6.36
AW-103	2/3/2010	2.3	56	3029			6.56
AW-103	1/13/2011	9.3	222	3252			7.50
AW-103	2/26/2011	6.3	151	3403			7.62
AW-103	7/29/2011	10.6	255	3658			8.04
AW-103	9/17/2011	10.4	249	3907			8.18
AW-103	11/7/2011	2.4	58	3965			8.32
AW-103	12/22/2011	10.9	261	4226			8.44
AW-103	2/22/2012	8.6	207	4433			8.61
AW-103	5/21/2012	10.6	255	4688			8.85
AW-103	6/30/2012	2.1	51	4738			8.96
AW-103	7/9/2012	5.4	129	4867			8.99
AW-103	9/1/2012	9.6	231	5098			9.14
AW-103	10/12/2012	3.1	74	5172			9.25
AW-103	11/4/2012	9.0	217	5389			9.31
AW-103	7/21/2013	10.7	257	5646			10.02
AW-103	9/24/2013	10.0	240	5886			10.20
AW-103	11/17/2013	6.3	150	6036	10.35	5	10.35
AW-103	2/7/2014	9.4	225	6261			10.57
AW-103	4/7/2014	6.8	164	6425			10.73
AW-103	6/20/2014	9.8	234	6659			10.94
AW-103	8/12/2014	9.1	218	6877			11.08
AW-103	10/21/2014	10.1	242	7119			11.27
AW-103	12/17/2014	9.1	219	7339			11.43
AW-103	2/23/2015	3.3	80	7418			11.62
AW-103	3/12/2015	6.8	164	7583			11.66
AW-103	4/22/2015	4.8	114	7697			11.77
AW-103	6/12/2015	2.9	70	7767			11.91
AW-103	12/24/2015	9.9	238	8006			12.45
AW-103	2/29/2016	8.7	209	8214			12.63
AW-103	4/27/2016	1.2	29	8244			12.79
AW-103	6/4/2016	6.5	157	8400			12.89
AW-103	10/4/2016	6.7	160	8560			13.23
AW-103	11/28/2016	10.4	250	8809			13.38
AW-103	1/30/2017	9.1	218	9028			13.55
AW-103	11/29/2017	10.9	261	9288			14.38
AW-103	2/2/2018	9.5	228	9516			14.56
AW-103	4/23/2018	8.7	208	9724			14.78

AW-103	6/16/2018	9.6	231	9955			14.93
AW-103	11/16/2018	10.7	257	10212			15.35
AW-103	3/23/2019	10.7	257	10468			15.69
AW-103	5/30/2019	10.7	257	10725			15.88
AW-103	8/2/2019	3.6	87	10812			16.06
AW-103	8/31/2019	9.2	221	11033			16.14
AW-103	1/21/2020	10.4	251	11283			16.53
			11283				
AW-104	1/15/2003	11.0	264	264	1	4	-0.50
AW-104	3/5/2003	10.2	246	510			-0.37
AW-104	4/23/2003	9.4	226	736			-0.23
AW-104	5/28/2006	9.3	224	959			2.87
AW-104	8/4/2006	11.0	264	1224			3.05
AW-104	10/1/2006	11.0	264	1488			3.21
AW-104	12/14/2006	10.6	255	1743			3.42
AW-104	2/23/2007	10.3	246	1990			3.61
AW-104	4/29/2007	3.0	73	2063			3.79
AW-104	5/18/2007	10.6	254	2316			3.84
AW-104	8/2/2007	10.3	246	2562			4.05
AW-104	10/14/2007	10.0	239	2801			4.25
AW-104	10/30/2007	9.1	218	3019			4.29
AW-104	2/8/2008	11.0	264	3284			4.57
AW-104	3/28/2008	10.2	245	3529			4.70
AW-104	5/11/2008	3.6	86	3614			4.82
AW-104	5/23/2008	11.0	264	3879			4.86
AW-104	6/5/2008	9.1	218	4096			4.89
AW-104	8/27/2008	9.0	215	4312			5.12
AW-104	9/9/2008	9.6	232	4543			5.15
AW-104	10/9/2008	11.0	264	4808			5.24
AW-104	11/23/2008	11.0	264	5072			5.36
AW-104	1/6/2009	10.0	240	5312			5.48
AW-104	2/22/2009	10.1	242	5554			5.61
AW-104	4/1/2009	9.2	220	5774			5.71
AW-104	4/13/2009	9.2	221	5995			5.75
AW-104	5/20/2009	2.7	64	6059	5.85	4	5.85
AW-104	6/2/2009	3.3	79	6138			5.88
AW-104	10/14/2009	11.0	264	6403			6.25
AW-104	12/25/2009	9.1	220	6622			6.45
AW-104	1/12/2011	10.5	253	6875			7.50
AW-104	2/11/2011	11.0	264	7139			7.58
AW-104	3/30/2011	9.3	222	7361			7.71
AW-104	7/30/2011	9.6	231	7593			8.04
AW-104	8/31/2011	11.0	264	7857			8.13
AW-104	9/27/2011	9.2	222	8079			8.20
AW-104	10/20/2011	10.0	239	8318			8.27
AW-104	12/7/2011	9.1	218	8536			8.40
AW-104	1/4/2012	11.0	264	8801			8.48
AW-104	1/20/2012	4.7	112	8913			8.52
AW-104	4/6/2012	11.0	264	9178			8.73

AW-104	5/25/2012	9.7	233	9410			8.86
AW-104	7/5/2012	11.0	264	9675			8.98
AW-104	8/24/2012	9.2	221	9895			9.11
AW-104	10/11/2012	9.2	222	10117			9.25
AW-104	10/23/2012	9.3	222	10339			9.28
AW-104	11/22/2012	3.7	89	10428			9.36
AW-104	12/10/2012	10.2	244	10672			9.41
AW-104	12/21/2012	7.7	184	10856			9.44
AW-104	1/21/2013	2.5	60	10916			9.52
AW-104	8/25/2013	11.0	264	11180			10.12
AW-104	9/7/2013	9.3	222	11402			10.15
AW-104	9/26/2013	11.0	264	11667			10.20
AW-104	11/17/2013	9.1	217	11884			10.35
AW-104	11/25/2013	4.2	102	11986			10.37
AW-104	12/19/2013	11.0	264	12250	10.43	4	10.43
AW-104	1/2/2014	6.6	157	12408			10.47
AW-104	3/12/2014	11.0	264	12672			10.66
AW-104	5/1/2014	10.2	244	12916			10.80
AW-104	6/4/2014	9.4	226	13142			10.89
AW-104	7/19/2014	11.0	264	13406			11.02
AW-104	8/18/2014	9.1	218	13625			11.10
AW-104	9/1/2014	9.8	235	13860			11.14
AW-104	10/13/2014	10.1	243	14103			11.25
AW-104	10/25/2014	9.1	219	14321			11.28
AW-104	12/9/2014	9.2	220	14542			11.41
AW-104	12/21/2014	9.5	229	14770			11.44
AW-104	1/25/2015	9.5	229	14999			11.54
AW-104	2/9/2015	10.5	252	15251			11.58
AW-104	4/19/2015	9.5	229	15480			11.77
AW-104	5/3/2015	10.5	253	15733			11.80
AW-104	5/11/2015	4.6	110	15842			11.83
AW-104	5/27/2015	0.5	13	15855			11.87
AW-104	11/14/2015	10.5	252	16107			12.34
AW-104	12/25/2015	2.7	66	16173			12.45
AW-104	1/13/2016	11.0	264	16437			12.50
AW-104	1/29/2016	11.0	264	16702			12.55
AW-104	2/11/2016	9.3	222	16924			12.58
AW-104	3/4/2016	3.8	92	17016			12.64
AW-104	3/19/2016	9.3	224	17240			12.68
AW-104	3/26/2016	4.7	112	17352			12.70
AW-104	4/20/2016	11.0	264	17616			12.77
AW-104	8/19/2016	11.0	264	17881			13.10
AW-104	10/31/2016	11.0	264	18145	13.3	4	13.30
AW-104	11/15/2016	10.7	257	18402			13.34
AW-104	12/17/2016	7.5	180	18582			13.43
AW-104	12/30/2016	10.2	246	18828			13.47
AW-104	1/25/2017	5.7	137	18965			13.54
AW-104	2/13/2017	5.8	139	19103			13.59
AW-104	3/12/2017	4.5	109	19212			13.66
AW-104	11/27/2017	11.0	264	19476			14.38
AW-104	12/27/2017	11.0	264	19741			14.46

AW-104	2/4/2018	10.1	242	19983			14.57
AW-104	3/6/2018	10.1	241	20224			14.65
AW-104	3/11/2018	1.1	26	20250			14.66
AW-104	3/22/2018	9.4	225	20475			14.69
AW-104	5/8/2018	7.6	183	20658			14.82
AW-104	6/15/2018	11.0	264	20922			14.92
AW-104	6/29/2018	11.0	264	21186			14.96
AW-104	7/25/2018	2.3	56	21242			15.03
AW-104	8/5/2018	8.7	210	21452			15.06
AW-104	8/16/2018	7.3	176	21628			15.09
AW-104	1/5/2019	9.6	231	21858			15.48
AW-104	4/17/2019	11.0	264	22123			15.76
AW-104	6/10/2019	10.5	252	22375			15.91
AW-104	6/17/2019	3.4	81	22456			15.93
AW-104	7/22/2019	10.5	252	22707			16.03
AW-104	9/4/2019	2.0	48	22756			16.15
AW-104	9/15/2019	10.4	249	23004			16.18
			23004				
>>>>>> data from FILLWST.DAT							
AN-101	9/15/2008	56	1341	1341	5.17	6	5.17
AN-101	1/8/2010	0	8	1348			6.49
AN-101	1/1/2011	54	1286	2635			7.47
AN-101	10/17/2011	0	5	2640			8.26
AN-101	12/11/2011	54	1292	3932			8.41
AN-101	8/22/2012	55	1311	5243			9.11
AN-101	11/27/2013	54	1289	6533	10.37	6	10.37
AN-101	12/1/2014	54	1293	7825			11.38
AN-101	1/16/2016	1	12	7838			12.51
AN-101	1/18/2016	54	1285	9123			12.52
AN-101	12/12/2016	1	17	9139			13.42
AN-101	12/14/2016	53	1272	10412			13.42
AN-101	6/8/2018	53	1273	11685			14.91
AN-101	4/9/2019	2	55	11740			15.74
AN-101	4/10/2019	52	1245	12984	15.74	6	15.74
AN-101	6/21/2021	54	1290	14275			17.94
			14275				
AN-104	1/7/2008	4	107	107	4.48	7	4.48
AN-104	1/8/2008	52	1250	1357			4.48
AN-104	12/14/2008	53	1278	2635			5.42
AN-104	10/3/2009	53	1271	3906			6.22
AN-104	7/21/2011	53	1280	5186			8.02
AN-104	6/24/2012	54	1285	6470	8.95	7	8.95
AN-104	7/10/2013	54	1287	7758			9.99
AN-104	5/25/2014	55	1315	9073			10.86
AN-104	4/9/2016	54	1292	10364			12.74
AN-104	1/28/2017	2	47	10411			13.55
AN-104	11/15/2017	52	1250	11662			14.34

AN-104	11/5/2018	3	81	11742			15.32
AN-104	11/5/2018	52	1238	12980	15.32	7	15.32
AN-104	9/4/2019	1	12	12992			16.15
AN-104	9/11/2019	55	1308	14301			16.17
AN-104	8/15/2021	52	1248	15548			18.09
			15548				
AN-105	11/1/2008	55	1310	1310	5.3	8	5.30
AN-105	11/1/2008	0	3	1312			5.30
AN-105	1/4/2011	54	1296	2609			7.48
AN-105	9/7/2011	54	1297	3906			8.15
AN-105	5/9/2012	1	30	3937			8.82
AN-105	5/11/2012	52	1258	5194			8.83
AN-105	8/17/2013	0	1	5195			10.09
AN-105	8/20/2013	54	1302	6498	10.1	8	10.10
AN-105	8/21/2014	1	36	6533			11.11
AN-105	8/22/2014	52	1247	7780			11.11
AN-105	11/4/2015	54	1294	9075			12.31
AN-105	8/8/2016	2	41	9116			13.07
AN-105	8/8/2016	51	1233	10349			13.07
AN-105	11/24/2017	1	27	10376			14.37
AN-105	6/4/2018	53	1266	11642			14.89
AN-105	3/12/2019	54	1288	12930	15.66	8	15.66
AN-105	3/23/2020	54	1298	14228			16.70
			14228				
AN-106	12/30/2008	53	1282	1282	5.46	9	5.46
AN-106	12/16/2009	53	1283	2565			6.42
AN-106	7/18/2011	53	1280	3844			8.01
AN-106	3/26/2012	54	1299	5144			8.70
AN-106	8/28/2013	54	1293	6437	10.12	9	10.12
AN-106	7/8/2014	54	1292	7728			10.98
AN-106	12/14/2015	54	1299	9027			12.42
AN-106	11/1/2016	55	1321	10347			13.31
AN-106	6/6/2018	53	1280	11627			14.90
AN-106	4/6/2019	55	1320	12947	15.73	9	15.73
AN-106	2/21/2020	54	1284	14231			16.61
			14231				
AW-101	1/7/2011	54	1285	1285	7.48	10	7.48
AW-101	12/13/2011	53	1278	2563			8.42
AW-101	10/19/2012	54	1306	3869			9.27
AW-101	8/14/2013	54	1292	5161			10.09
AW-101	1/5/2015	53	1265	6425	11.48	10	11.48
AW-101	1/30/2016	53	1283	7708			12.55
AW-101	11/11/2016	53	1275	8984			13.33
AW-101	11/23/2017	56	1333	10317			14.37
AW-101	6/24/2019	55	1324	11641			15.95

AW-101	8/21/2020	52	1244	12885	17.11	10	17.11
			12885				
AW-102	7/11/2005	55	1323	1323	1.99	11	1.99
AW-102	3/28/2006	1	35	1358			2.70
AW-102	4/2/2006	56	1345	2703			2.71
AW-102	1/8/2011	1	32	2735			7.49
AW-102	7/22/2011	53	1261	3996			8.02
AW-102	9/8/2012	2	47	4043			9.15
AW-102	10/9/2012	52	1238	5281			9.24
AW-102	2/30/2014	1	15	5297			
AW-102	3/1/2014	52	1258	6555	10.63	11	10.63
AW-102	1/2/2016	54	1295	7849			12.47
AW-102	10/20/2016	53	1278	9128			13.27
AW-102	11/18/2017	54	1289	10417			14.35
AW-102	7/6/2019	55	1319	11736			15.98
AW-102	1/28/2021	53	1261	12998	17.55	11	17.55
			12998				
AW-105	7/6/2005	55	1318	1318	1.97	12	1.97
>>>>>> data from FILLX.DAT							
SY-101	3/9/2003	3.6	85	85	1	1	-0.35
SY-101	11/29/2005	2.7	65	150			2.37
SY-101	5/31/2006	3.0	71	221			2.88
SY-101	8/7/2006	3.0	71	293			3.06
SY-101	9/20/2006	0.9	21	313			3.18
SY-101	10/9/2006	2.9	68	382			3.23
SY-101	12/4/2006	1.0	23	405			3.39
SY-101	12/18/2006	2.7	66	471			3.43
SY-101	2/12/2007	1.0	23	493			3.58
SY-101	3/1/2007	2.8	66	560			3.63
SY-101	4/26/2007	0.8	19	579			3.78
SY-101	5/8/2007	1.1	25	604			3.81
SY-101	5/26/2007	2.6	62	667			3.86
SY-101	7/21/2007	1.1	26	692			4.02
SY-101	8/18/2007	2.6	63	756			4.09
SY-101	10/4/2007	0.9	22	778			4.22
SY-101	10/21/2007	2.8	67	845			4.27
SY-101	12/18/2007	3.0	71	916			4.43
SY-101	1/28/2008	0.9	21	937			4.54
SY-101	2/14/2008	2.9	68	1005			4.58
SY-101	3/18/2008	1.0	23	1028			4.68
SY-101	3/31/2008	2.7	66	1094			4.71
SY-101	5/8/2008	0.8	19	1114			4.82
SY-101	5/27/2008	3.1	76	1189			4.87
SY-101	7/5/2008	3.0	71	1260			4.97
SY-101	8/18/2008	0.9	21	1281			5.09
SY-101	8/30/2008	2.9	68	1349			5.13

SY-101	9/28/2008	0.7	17	1367	5.21
SY-101	10/13/2008	3.0	72	1438	5.25
SY-101	11/12/2008	0.8	20	1458	5.33
SY-101	11/26/2008	2.9	69	1528	5.37
SY-101	12/26/2008	0.9	23	1550	5.45
SY-101	1/12/2009	2.8	66	1617	5.50
SY-101	2/12/2009	0.7	17	1634	5.58
SY-101	2/24/2009	2.5	60	1694	5.62
SY-101	3/23/2009	1.0	24	1718	5.69
SY-101	4/15/2009	2.7	65	1783	5.75
SY-101	5/18/2009	0.9	23	1806	5.84
SY-101	5/30/2009	0.9	22	1828	5.88
SY-101	6/3/2009	1.1	27	1855	5.89
SY-101	10/17/2009	3.2	76	1931	6.26
SY-101	2/15/2011	3.2	77	2008	7.59
SY-101	8/3/2011	3.0	71	2080	8.05
SY-101	8/20/2011	0.9	21	2100	8.10
SY-101	10/1/2011	3.2	77	2177	8.22
SY-101	12/10/2011	2.6	63	2240	8.41
SY-101	1/22/2012	1.6	39	2279	8.52
SY-101	4/9/2012	2.8	68	2347	8.74
SY-101	4/26/2012	1.0	24	2371	8.78
SY-101	8/27/2012	3.5	83	2454	9.12
SY-101	10/26/2012	3.0	71	2525	9.29
SY-101	11/23/2012	1.3	31	2556	9.36
SY-101	12/13/2012	2.9	70	2626	9.42
SY-101	1/22/2013	0.9	22	2648	9.53
SY-101	11/20/2013	3.0	73	2721	10.35
SY-101	12/25/2013	3.2	77	2798	10.45
SY-101	2/5/2014	2.9	69	2867	10.57
SY-101	6/6/2014	2.6	61	2929	10.90
SY-101	9/3/2014	3.0	71	3000	11.14
SY-101	10/3/2014	0.9	21	3021	11.22
SY-101	12/12/2014	3.1	74	3095	11.42
SY-101	1/15/2015	0.8	19	3114	11.51
SY-101	1/30/2015	3.2	76	3190	11.55
SY-101	3/9/2015	3.0	71	3261	11.65
SY-101	4/9/2015	0.8	20	3281	11.74
SY-101	4/22/2015	3.1	75	3356	11.77
SY-101	5/22/2015	2.2	53	3409	11.86
SY-101	11/17/2015	2.7	66	3475	12.35
SY-101	12/4/2015	1.1	26	3501	12.39
SY-101	1/15/2016	2.6	63	3564	12.51
SY-101	2/30/2016	1.0	25	3589	
SY-101	3/9/2016	1.3	32	3621	12.66
SY-101	3/28/2016	2.1	51	3672	12.71
SY-101	4/25/2016	2.7	64	3736	12.78
SY-101	5/25/2016	1.1	27	3764	12.87
SY-101	8/22/2016	2.6	62	3825	13.11
SY-101	9/8/2016	1.3	30	3856	13.16
SY-101	11/18/2016	3.2	77	3932	13.35

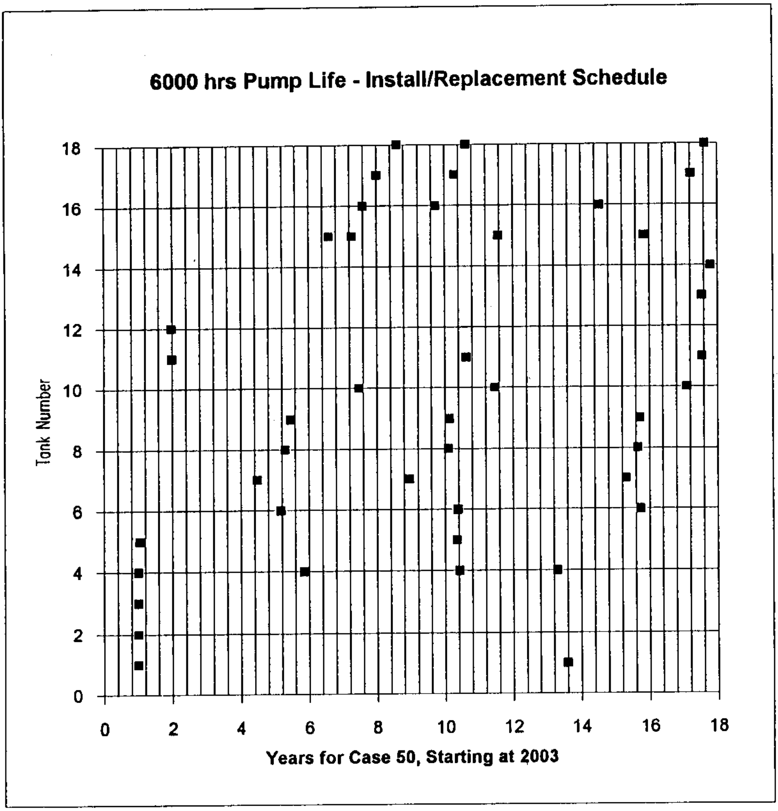
SY-101	1/27/2017	2.0	47	3980	13.6	1	13.54
SY-101	3/14/2017	1.6	38	4017			13.67
SY-101	3/12/2018	1.0	24	4042			14.66
SY-101	6/17/2018	2.9	69	4110			14.93
SY-101	8/8/2018	3.0	73	4183			15.07
SY-101	4/19/2019	2.7	64	4247			15.77
SY-101	7/11/2019	1.6	38	4285			16.00
SY-101	9/2/2019	2.1	50	4335			16.14
SY-101	9/5/2019	0.5	11	4347			16.15
			4347				
SY-102	1/19/2003	3.8	92	92	1	2	-0.49
SY-102	7/23/2006	0.8	20	112			3.02
SY-102	5/12/2008	1.2	30	142			4.83
SY-102	9/12/2008	2.9	69	211			5.16
SY-102	4/3/2009	2.7	65	276			5.72
SY-102	1/14/2011	2.7	65	342			7.50
SY-102	1/31/2011	1.1	27	368			7.55
SY-102	4/3/2011	3.3	80	448			7.72
SY-102	9/3/2011	3.0	71	520			8.14
SY-102	10/23/2011	3.0	71	591			8.28
SY-102	12/23/2011	1.0	25	616			8.44
SY-102	1/9/2012	1.0	23	639			8.49
SY-102	7/8/2012	3.2	77	716			8.98
SY-102	10/14/2012	3.0	71	787			9.25
SY-102	12/24/2012	3.2	77	864			9.45
SY-102	8/28/2013	3.2	77	941			10.12
SY-102	9/15/2013	1.1	27	968			10.17
SY-102	9/28/2013	2.6	62	1030			10.21
SY-102	11/8/2013	1.2	30	1060			10.32
SY-102	12/8/2013	1.6	38	1098			10.40
SY-102	3/15/2014	2.6	63	1161			10.67
SY-102	4/3/2014	1.2	29	1190			10.72
SY-102	6/21/2014	1.3	31	1220			10.94
SY-102	8/21/2014	2.7	65	1286			11.11
SY-102	10/28/2014	2.7	65	1351			11.29
SY-102	11/29/2014	1.1	27	1378			11.38
SY-102	12/24/2014	2.6	63	1440			11.45
SY-102	5/6/2015	3.2	77	1517			11.81
SY-102	2/2/2016	3.2	77	1594			12.56
SY-102	3/21/2016	2.7	65	1660			12.69
SY-102	12/20/2016	3.0	71	1731			13.44
SY-102	1/19/2017	0.9	21	1752			13.52
SY-102	2/15/2017	2.0	48	1800			13.60
SY-102	11/29/2017	2.8	68	1868			14.38
SY-102	12/16/2017	1.0	24	1892			14.43
SY-102	2/6/2018	2.7	65	1957			14.57
SY-102	2/26/2018	0.8	19	1976			14.63
SY-102	3/26/2018	3.3	78	2054			14.70
SY-102	5/10/2018	2.6	63	2117			14.83

SY-102	6/18/2018	1.0	23	2140			14.93
SY-102	7/4/2018	0.9	21	2161			14.98
SY-102	7/26/2018	0.8	19	2180			15.04
SY-102	8/18/2018	2.5	61	2241			15.10
SY-102	1/8/2019	2.5	60	2301			15.49
SY-102	2/5/2019	0.8	20	2321			15.57
SY-102	5/31/2019	1.2	28	2349			15.88
SY-102	8/25/2019	1.6	37	2387			16.12
			2387				

SY-103	1/4/2003	3.8	92	92	1	3	-0.53
SY-103	12/29/2009	3.7	88	180			6.46
SY-103	9/18/2011	0.9	21	200			8.18
SY-103	1/7/2012	2.9	68	269			8.48
SY-103	5/29/2012	3.4	81	350			8.88
SY-103	11/5/2012	0.9	21	370			9.31
SY-103	9/9/2013	2.7	65	435			10.16
SY-103	5/4/2014	3.0	71	506			10.81
SY-103	7/22/2014	3.0	71	577			11.02
SY-103	8/9/2014	0.9	21	598			11.07
SY-103	10/16/2014	2.9	68	666			11.26
SY-103	12/26/2015	1.0	23	689			12.45
SY-103	1/16/2016	1.2	29	718			12.51
SY-103	2/14/2016	2.8	67	785			12.59
SY-103	11/4/2016	3.7	89	874			13.31
SY-103	1/3/2017	3.0	71	946			13.48
SY-103	12/30/2017	3.0	71	1017			14.47
SY-103	1/25/2018	0.9	21	1037			14.54
SY-103	3/9/2018	2.9	68	1106			14.66
SY-103	7/2/2018	3.0	71	1177			14.97
SY-103	6/13/2019	3.2	77	1254			15.92
			1254				

	Summary of Totals	
1	SY-101	4347
2	SY-102	2387
3	SY-103	1254
4	AW-104	23004
5	AW-103	11283
6	AN-101	14275
7	AN-104	15548
8	AN-105	14228
9	AN-106	14231
10	AW-101	12885
11	AW-102	12998
12	AW-105	1318
13	AN-102	942
14	AN-107	1074

15	AY-101	21009
16	AY-102	16180
17	AZ-101	15152
18	AZ-102	12788



7000 hrs Data Run - Case 50 **Appendix C**

M. N. Hall 12/13/95

Notes 1) The Replacement dates are in 20ths of the Retrieval Sequence begining in 2003.

2) Replacement Date is the Date in 20ths wherein the intraval will be exceeded (ie 7000 hrs)

Tank	Start Date	Days	Hours	Cumulative	Replace Date	Tank #	
>>>>>> data from FILLHL.DAT							
AN-102	8/14/2021	39.2	942		17.55	13	
AN-107	9/23/2021	44.7	1074		17.8	14	
AY-101	1/1/2010	362.5	8700	8700	7.27	15	6.47
AY-101	6/30/2012	99.4	2385	11085	8.96	15	8.96
AY-101	2/9/2015	116.3	2791	13876	6.6	15	11.58
AY-101	7/8/2017	128.7	3089	16965	13.99	15	13.99
AY-101	5/17/2019	113.0	2712	19677			15.85
AY-101	7/1/2021	43.3	1040	20717			17.97
AY-101	2/7/2023	12.2	292	21009			19.58
		875.4	21009				
AY-102	12/28/2010	200.6	4814	4814	7.6	16	7.46
AY-102	4/9/2013	113.3	2719	7534	9.74	16	9.74
AY-102	8/23/2015	112.6	2702	10236			12.11
AY-102	1/31/2018	123.7	2969	13205			14.55
AY-102	4/28/2020	113.1	2714	15919	16.8	16	16.80
AY-102	2/13/2022	10.9	261	16180			18.59
		674.2	16180				
AZ-101	7/15/2011	144.1	3458	3458	8	17	8.00
AZ-101	11/1/2013	114.8	2755	6214			10.30
AZ-101	2/13/2016	122.8	2947	9161	12.59	17	12.59
AZ-101	6/4/2018	117.2	2813	11974			14.89
AZ-101	10/2/2020	115.7	2777	14750	17.23	17	17.23
AZ-101	7/20/2022	16.7	402	15152			19.02
		631.3	15152				
AZ-102	12/8/2011	151.3	3631	3631	8.6	18	8.40
AZ-102	3/1/2014	113.7	2729	6360			10.63
AZ-102	9/30/2018	121.8	2923	9283	15.22	18	15.22
AZ-102	2/27/2021	113.6	2726	12010			17.63
AZ-102	12/14/2022	32.4	778	12788			19.43
		532.8	12788				
>>>>>>>>> data from FILLSWT.DAT							
AW-103	8/8/2004	1.7	41	41	1.06	5	1.06
AW-103	7/18/2005	7.0	169	210			2.01
AW-103	4/11/2006	9.2	220	430			2.74
AW-103	7/22/2006	8.8	212	642			3.02
AW-103	10/17/2006	8.4	202	844			3.26

AW-103	12/14/2006	8.1	194	1038			3.42
AW-103	5/6/2007	9.9	238	1276			3.81
AW-103	7/7/2007	9.6	231	1507			3.98
AW-103	9/21/2007	9.3	224	1731			4.18
AW-103	11/17/2007	9.0	217	1948			4.34
AW-103	1/10/2008	5.8	139	2087			4.49
AW-103	3/2/2008	7.2	174	2261			4.63
AW-103	4/27/2008	5.8	138	2399			4.78
AW-103	2/17/2009	8.0	191	2591			5.60
AW-103	4/27/2009	7.7	185	2776			5.78
AW-103	5/29/2009	2.2	52	2828			5.87
AW-103	6/5/2009	3.7	89	2917			5.89
AW-103	11/24/2009	2.3	56	2973			6.36
AW-103	2/3/2010	2.3	56	3029			6.56
AW-103	1/13/2011	9.3	222	3252			7.50
AW-103	2/26/2011	6.3	151	3403			7.62
AW-103	7/29/2011	10.6	255	3658			8.04
AW-103	9/17/2011	10.4	249	3907			8.18
AW-103	11/7/2011	2.4	58	3965			8.32
AW-103	12/22/2011	10.9	261	4226			8.44
AW-103	2/22/2012	8.6	207	4433			8.61
AW-103	5/21/2012	10.6	255	4688			8.85
AW-103	6/30/2012	2.1	51	4738			8.96
AW-103	7/9/2012	5.4	129	4867			8.99
AW-103	9/1/2012	9.6	231	5098			9.14
AW-103	10/12/2012	3.1	74	5172			9.25
AW-103	11/4/2012	9.0	217	5389			9.31
AW-103	7/21/2013	10.7	257	5646			10.02
AW-103	9/24/2013	10.0	240	5886			10.20
AW-103	11/17/2013	6.3	150	6036			10.35
AW-103	2/7/2014	9.4	225	6261			10.57
AW-103	4/7/2014	6.8	164	6425			10.73
AW-103	6/20/2014	9.8	234	6659			10.94
AW-103	8/12/2014	9.1	218	6877			11.08
AW-103	10/21/2014	10.1	242	7119	11.27	5	11.27
AW-103	12/17/2014	9.1	219	7339			11.43
AW-103	2/23/2015	3.3	80	7418			11.62
AW-103	3/12/2015	6.8	164	7583			11.66
AW-103	4/22/2015	4.8	114	7697			11.77
AW-103	6/12/2015	2.9	70	7767			11.91
AW-103	12/24/2015	9.9	238	8006			12.45
AW-103	2/29/2016	8.7	209	8214			12.63
AW-103	4/27/2016	1.2	29	8244			12.79
AW-103	6/4/2016	6.5	157	8400			12.89
AW-103	10/4/2016	6.7	160	8560			13.23
AW-103	11/28/2016	10.4	250	8809			13.38
AW-103	1/30/2017	9.1	218	9028			13.55
AW-103	11/29/2017	10.9	261	9288			14.38
AW-103	2/2/2018	9.5	228	9516			14.56
AW-103	4/23/2018	8.7	208	9724			14.78
AW-103	6/16/2018	9.6	231	9955			14.93

AW-103	11/16/2018	10.7	257	10212			15.35
AW-103	3/23/2019	10.7	257	10468			15.69
AW-103	5/30/2019	10.7	257	10725			15.88
AW-103	8/2/2019	3.6	87	10812			16.06
AW-103	8/31/2019	9.2	221	11033			16.14
AW-103	1/21/2020	10.4	251	11283			16.53
			11283				
AW-104	1/15/2003	11.0	264	264	1	4	-0.50
AW-104	3/5/2003	10.2	246	510			-0.37
AW-104	4/23/2003	9.4	226	736			-0.23
AW-104	5/28/2006	9.3	224	959			2.87
AW-104	8/4/2006	11.0	264	1224			3.05
AW-104	10/1/2006	11.0	264	1488			3.21
AW-104	12/14/2006	10.6	255	1743			3.42
AW-104	2/23/2007	10.3	246	1990			3.61
AW-104	4/29/2007	3.0	73	2063			3.79
AW-104	5/18/2007	10.6	254	2316			3.84
AW-104	8/2/2007	10.3	246	2562			4.05
AW-104	10/14/2007	10.0	239	2801			4.25
AW-104	10/30/2007	9.1	218	3019			4.29
AW-104	2/8/2008	11.0	264	3284			4.57
AW-104	3/28/2008	10.2	245	3529			4.70
AW-104	5/11/2008	3.6	86	3614			4.82
AW-104	5/23/2008	11.0	264	3879			4.86
AW-104	6/5/2008	9.1	218	4096			4.89
AW-104	8/27/2008	9.0	215	4312			5.12
AW-104	9/9/2008	9.6	232	4543			5.15
AW-104	10/9/2008	11.0	264	4808			5.24
AW-104	11/23/2008	11.0	264	5072			5.36
AW-104	1/6/2009	10.0	240	5312			5.48
AW-104	2/22/2009	10.1	242	5554			5.61
AW-104	4/1/2009	9.2	220	5774			5.71
AW-104	4/13/2009	9.2	221	5995			5.75
AW-104	5/20/2009	2.7	64	6059			5.85
AW-104	6/2/2009	3.3	79	6138			5.88
AW-104	10/14/2009	11.0	264	6403			6.25
AW-104	12/25/2009	9.1	220	6622			6.45
AW-104	1/12/2011	10.5	253	6875			7.50
AW-104	2/11/2011	11.0	264	7139	7.58	4	7.58
AW-104	3/30/2011	9.3	222	7361			7.71
AW-104	7/30/2011	9.6	231	7593			8.04
AW-104	8/31/2011	11.0	264	7857			8.13
AW-104	9/27/2011	9.2	222	8079			8.20
AW-104	10/20/2011	10.0	239	8318			8.27
AW-104	12/7/2011	9.1	218	8536			8.40
AW-104	1/4/2012	11.0	264	8801			8.48
AW-104	1/20/2012	4.7	112	8913			8.52
AW-104	4/6/2012	11.0	264	9178			8.73
AW-104	5/25/2012	9.7	233	9410			8.86

AW-104	7/5/2012	11.0	264	9675			8.98
AW-104	8/24/2012	9.2	221	9895			9.11
AW-104	10/11/2012	9.2	222	10117			9.25
AW-104	10/23/2012	9.3	222	10339			9.28
AW-104	11/22/2012	3.7	89	10428			9.36
AW-104	12/10/2012	10.2	244	10672			9.41
AW-104	12/21/2012	7.7	184	10856			9.44
AW-104	1/21/2013	2.5	60	10916			9.52
AW-104	8/25/2013	11.0	264	11180			10.12
AW-104	9/7/2013	9.3	222	11402			10.15
AW-104	9/26/2013	11.0	264	11667			10.20
AW-104	11/17/2013	9.1	217	11884			10.35
AW-104	11/25/2013	4.2	102	11986			10.37
AW-104	12/19/2013	11.0	264	12250			10.43
AW-104	1/2/2014	6.6	157	12408			10.47
AW-104	3/12/2014	11.0	264	12672			10.66
AW-104	5/1/2014	10.2	244	12916			10.80
AW-104	6/4/2014	9.4	226	13142			10.89
AW-104	7/19/2014	11.0	264	13406			11.02
AW-104	8/18/2014	9.1	218	13625			11.10
AW-104	9/1/2014	9.8	235	13860			11.14
AW-104	10/13/2014	10.1	243	14103	11.25	4	11.25
AW-104	10/25/2014	9.1	219	14321			11.28
AW-104	12/9/2014	9.2	220	14542			11.41
AW-104	12/21/2014	9.5	229	14770			11.44
AW-104	1/25/2015	9.5	229	14999			11.54
AW-104	2/9/2015	10.5	252	15251			11.58
AW-104	4/19/2015	9.5	229	15480			11.77
AW-104	5/3/2015	10.5	253	15733			11.80
AW-104	5/11/2015	4.6	110	15842			11.83
AW-104	5/27/2015	0.5	13	15855			11.87
AW-104	11/14/2015	10.5	252	16107			12.34
AW-104	12/25/2015	2.7	66	16173			12.45
AW-104	1/13/2016	11.0	264	16437			12.50
AW-104	1/29/2016	11.0	264	16702			12.55
AW-104	2/11/2016	9.3	222	16924			12.58
AW-104	3/4/2016	3.8	92	17016			12.64
AW-104	3/19/2016	9.3	224	17240			12.68
AW-104	3/26/2016	4.7	112	17352			12.70
AW-104	4/20/2016	11.0	264	17616			12.77
AW-104	8/19/2016	11.0	264	17881			13.10
AW-104	10/31/2016	11.0	264	18145			13.30
AW-104	11/15/2016	10.7	257	18402			13.34
AW-104	12/17/2016	7.5	180	18582			13.43
AW-104	12/30/2016	10.2	246	18828			13.47
AW-104	1/25/2017	5.7	137	18965			13.54
AW-104	2/13/2017	5.8	139	19103			13.59
AW-104	3/12/2017	4.5	109	19212			13.66
AW-104	11/27/2017	11.0	264	19476			14.38
AW-104	12/27/2017	11.0	264	19741			14.46
AW-104	2/4/2018	10.1	242	19983			14.57

AW-104	3/6/2018	10.1	241	20224			14.65
AW-104	3/11/2018	1.1	26	20250			14.66
AW-104	3/22/2018	9.4	225	20475			14.69
AW-104	5/8/2018	7.6	183	20658			14.82
AW-104	6/15/2018	11.0	264	20922			14.92
AW-104	6/29/2018	11.0	264	21186	14.96	4	14.96
AW-104	7/25/2018	2.3	56	21242			15.03
AW-104	8/5/2018	8.7	210	21452			15.06
AW-104	8/16/2018	7.3	176	21628			15.09
AW-104	1/5/2019	9.6	231	21858			15.48
AW-104	4/17/2019	11.0	264	22123			15.76
AW-104	6/10/2019	10.5	252	22375			15.91
AW-104	6/17/2019	3.4	81	22456			15.93
AW-104	7/22/2019	10.5	252	22707			16.03
AW-104	9/4/2019	2.0	48	22756			16.15
AW-104	9/15/2019	10.4	249	23004			16.18
			23004				

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AN-101	9/15/2008	56	1341	1341	5.17	6	5.17
AN-101	1/8/2010	0	8	1348			6.49
AN-101	1/1/2011	54	1286	2635			7.47
AN-101	10/17/2011	0	5	2640			8.26
AN-101	12/11/2011	54	1292	3932			8.41
AN-101	8/22/2012	55	1311	5243			9.11
AN-101	11/27/2013	54	1289	6533			10.37
AN-101	12/1/2014	54	1293	7825	11.38	6	11.38
AN-101	1/16/2016	1	12	7838			12.51
AN-101	1/18/2016	54	1285	9123			12.52
AN-101	12/12/2016	1	17	9139			13.42
AN-101	12/14/2016	53	1272	10412			13.42
AN-101	6/8/2018	53	1273	11685			14.91
AN-101	4/9/2019	2	55	11740			15.74
AN-101	4/10/2019	52	1245	12984			15.74
AN-101	6/21/2021	54	1290	14275	17.94	6	17.94
			14275				

AN-104	1/7/2008	4	107	107	4.48	7	4.48
AN-104	1/8/2008	52	1250	1357			4.48
AN-104	12/14/2008	53	1278	2635			5.42
AN-104	10/3/2009	53	1271	3906			6.22
AN-104	7/21/2011	53	1280	5186			8.02
AN-104	6/24/2012	54	1285	6470			8.95
AN-104	7/10/2013	54	1287	7758	9.99	7	9.99
AN-104	5/25/2014	55	1315	9073			10.86
AN-104	4/9/2016	54	1292	10364			12.74
AN-104	1/28/2017	2	47	10411			13.55
AN-104	11/15/2017	52	1250	11662			14.34
AN-104	11/5/2018	3	81	11742			15.32

AN-104	11/5/2018	52	1238	12980			15.32
AN-104	9/4/2019	1	12	12992			16.15
AN-104	9/11/2019	55	1308	14301	16.17	7	16.17
AN-104	8/15/2021	52	1248	15548			18.09
			15548				
AN-105	11/1/2008	55	1310	1310	5.3	8	5.30
AN-105	11/1/2008	0	3	1312			5.30
AN-105	1/4/2011	54	1296	2609			7.48
AN-105	9/7/2011	54	1297	3906			8.15
AN-105	5/9/2012	1	30	3937			8.82
AN-105	5/11/2012	52	1258	5194			8.83
AN-105	8/17/2013	0	1	5195			10.09
AN-105	8/20/2013	54	1302	6498			10.10
AN-105	8/21/2014	1	36	6533			11.11
AN-105	8/22/2014	52	1247	7780	11.11	8	11.11
AN-105	11/4/2015	54	1294	9075			12.31
AN-105	8/8/2016	2	41	9116			13.07
AN-105	8/8/2016	51	1233	10349			13.07
AN-105	11/24/2017	1	27	10376			14.37
AN-105	6/4/2018	53	1266	11642			14.89
AN-105	3/12/2019	54	1288	12930			15.66
AN-105	3/23/2020	54	1298	14228	16.7	8	16.70
			14228				
AN-106	12/30/2008	53	1282	1282	5.46	9	5.46
AN-106	12/16/2009	53	1283	2565			6.42
AN-106	7/18/2011	53	1280	3844			8.01
AN-106	3/26/2012	54	1299	5144			8.70
AN-106	8/28/2013	54	1293	6437			10.12
AN-106	7/8/2014	54	1292	7728	10.98	9	10.98
AN-106	12/14/2015	54	1299	9027			12.42
AN-106	11/1/2016	55	1321	10347			13.31
AN-106	6/6/2018	53	1280	11627			14.90
AN-106	4/6/2019	55	1320	12947			15.73
AN-106	2/21/2020	54	1284	14231	16.61	9	16.61
			14231				
AW-101	1/7/2011	54	1285	1285	7.48	10	7.48
AW-101	12/13/2011	53	1278	2563			8.42
AW-101	10/19/2012	54	1306	3869			9.27
AW-101	8/14/2013	54	1292	5161			10.09
AW-101	1/5/2015	53	1265	6425			11.48
AW-101	1/30/2016	53	1283	7708	12.55	10	12.55
AW-101	11/11/2016	53	1275	8984			13.33
AW-101	11/23/2017	56	1333	10317			14.37
AW-101	6/24/2019	55	1324	11641			15.95
AW-101	8/21/2020	52	1244	12885			17.11

			12885				
AW-102	7/11/2005	55	1323	1323	1.99	11	1.99
AW-102	3/28/2006	1	35	1358			2.70
AW-102	4/2/2006	56	1345	2703			2.71
AW-102	1/8/2011	1	32	2735			7.49
AW-102	7/22/2011	53	1261	3996			8.02
AW-102	9/8/2012	2	47	4043			9.15
AW-102	10/9/2012	52	1238	5281			9.24
AW-102	2/30/2014	1	15	5297			
AW-102	3/1/2014	52	1258	6555			10.63
AW-102	1/2/2016	54	1295	7849	12.47	11	12.47
AW-102	10/20/2016	53	1278	9128			13.27
AW-102	11/18/2017	54	1289	10417			14.35
AW-102	7/6/2019	55	1319	11736			15.98
AW-102	1/28/2021	53	1261	12998			17.55
			12998				
AW-105	7/6/2005	55	1318	1318	1.97	12	1.97
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SY-101	3/9/2003	3.6	85	85	1	1	-0.35
SY-101	11/29/2005	2.7	65	150			2.37
SY-101	5/31/2006	3.0	71	221			2.88
SY-101	8/7/2006	3.0	71	293			3.06
SY-101	9/20/2006	0.9	21	313			3.18
SY-101	10/9/2006	2.9	68	382			3.23
SY-101	12/4/2006	1.0	23	405			3.39
SY-101	12/18/2006	2.7	66	471			3.43
SY-101	2/12/2007	1.0	23	493			3.58
SY-101	3/1/2007	2.8	66	560			3.63
SY-101	4/26/2007	0.8	19	579			3.78
SY-101	5/8/2007	1.1	25	604			3.81
SY-101	5/26/2007	2.6	62	667			3.86
SY-101	7/21/2007	1.1	26	692			4.02
SY-101	8/18/2007	2.6	63	756			4.09
SY-101	10/4/2007	0.9	22	778			4.22
SY-101	10/21/2007	2.8	67	845			4.27
SY-101	12/18/2007	3.0	71	916			4.43
SY-101	1/28/2008	0.9	21	937			4.54
SY-101	2/14/2008	2.9	68	1005			4.58
SY-101	3/18/2008	1.0	23	1028			4.68
SY-101	3/31/2008	2.7	66	1094			4.71
SY-101	5/8/2008	0.8	19	1114			4.82
SY-101	5/27/2008	3.1	76	1189			4.87
SY-101	7/5/2008	3.0	71	1260			4.97
SY-101	8/18/2008	0.9	21	1281			5.09
SY-101	8/30/2008	2.9	68	1349			5.13
SY-101	9/28/2008	0.7	17	1367			5.21

SY-101	10/13/2008	3.0	72	1438	5.25
SY-101	11/12/2008	0.8	20	1458	5.33
SY-101	11/26/2008	2.9	69	1528	5.37
SY-101	12/26/2008	0.9	23	1550	5.45
SY-101	1/12/2009	2.8	66	1617	5.50
SY-101	2/12/2009	0.7	17	1634	5.58
SY-101	2/24/2009	2.5	60	1694	5.62
SY-101	3/23/2009	1.0	24	1718	5.69
SY-101	4/15/2009	2.7	65	1783	5.75
SY-101	5/18/2009	0.9	23	1806	5.84
SY-101	5/30/2009	0.9	22	1828	5.88
SY-101	6/3/2009	1.1	27	1855	5.89
SY-101	10/17/2009	3.2	76	1931	6.26
SY-101	2/15/2011	3.2	77	2008	7.59
SY-101	8/3/2011	3.0	71	2080	8.05
SY-101	8/20/2011	0.9	21	2100	8.10
SY-101	10/1/2011	3.2	77	2177	8.22
SY-101	12/10/2011	2.6	63	2240	8.41
SY-101	1/22/2012	1.6	39	2279	8.52
SY-101	4/9/2012	2.8	68	2347	8.74
SY-101	4/26/2012	1.0	24	2371	8.78
SY-101	8/27/2012	3.5	83	2454	9.12
SY-101	10/26/2012	3.0	71	2525	9.29
SY-101	11/23/2012	1.3	31	2556	9.36
SY-101	12/13/2012	2.9	70	2626	9.42
SY-101	1/22/2013	0.9	22	2648	9.53
SY-101	11/20/2013	3.0	73	2721	10.35
SY-101	12/25/2013	3.2	77	2798	10.45
SY-101	2/5/2014	2.9	69	2867	10.57
SY-101	6/6/2014	2.6	61	2929	10.90
SY-101	9/3/2014	3.0	71	3000	11.14
SY-101	10/3/2014	0.9	21	3021	11.22
SY-101	12/12/2014	3.1	74	3095	11.42
SY-101	1/15/2015	0.8	19	3114	11.51
SY-101	1/30/2015	3.2	76	3190	11.55
SY-101	3/9/2015	3.0	71	3261	11.65
SY-101	4/9/2015	0.8	20	3281	11.74
SY-101	4/22/2015	3.1	75	3356	11.77
SY-101	5/22/2015	2.2	53	3409	11.86
SY-101	11/17/2015	2.7	66	3475	12.35
SY-101	12/4/2015	1.1	26	3501	12.39
SY-101	1/15/2016	2.6	63	3564	12.51
SY-101	2/30/2016	1.0	25	3589	
SY-101	3/9/2016	1.3	32	3621	12.66
SY-101	3/28/2016	2.1	51	3672	12.71
SY-101	4/25/2016	2.7	64	3736	12.78
SY-101	5/25/2016	1.1	27	3764	12.87
SY-101	8/22/2016	2.6	62	3825	13.11
SY-101	9/8/2016	1.3	30	3856	13.16
SY-101	11/18/2016	3.2	77	3932	13.35
SY-101	1/27/2017	2.0	47	3980	13.54

SY-101	3/14/2017	1.6	38	4017			13.67
SY-101	3/12/2018	1.0	24	4042			14.66
SY-101	6/17/2018	2.9	69	4110			14.93
SY-101	8/8/2018	3.0	73	4183			15.07
SY-101	4/19/2019	2.7	64	4247			15.77
SY-101	7/11/2019	1.6	38	4285			16.00
SY-101	9/2/2019	2.1	50	4335			16.14
SY-101	9/5/2019	0.5	11	4347			16.15
			4347				
SY-102	1/19/2003	3.8	92	92	1	2	-0.49
SY-102	7/23/2006	0.8	20	112			3.02
SY-102	5/12/2008	1.2	30	142			4.83
SY-102	9/12/2008	2.9	69	211			5.16
SY-102	4/3/2009	2.7	65	276			5.72
SY-102	1/14/2011	2.7	65	342			7.50
SY-102	1/31/2011	1.1	27	368			7.55
SY-102	4/3/2011	3.3	80	448			7.72
SY-102	9/3/2011	3.0	71	520			8.14
SY-102	10/23/2011	3.0	71	591			8.28
SY-102	12/23/2011	1.0	25	616			8.44
SY-102	1/9/2012	1.0	23	639			8.49
SY-102	7/8/2012	3.2	77	716			8.98
SY-102	10/14/2012	3.0	71	787			9.25
SY-102	12/24/2012	3.2	77	864			9.45
SY-102	8/28/2013	3.2	77	941			10.12
SY-102	9/15/2013	1.1	27	968			10.17
SY-102	9/28/2013	2.6	62	1030			10.21
SY-102	11/8/2013	1.2	30	1060			10.32
SY-102	12/8/2013	1.6	38	1098			10.40
SY-102	3/15/2014	2.6	63	1161			10.67
SY-102	4/3/2014	1.2	29	1190			10.72
SY-102	6/21/2014	1.3	31	1220			10.94
SY-102	8/21/2014	2.7	65	1286			11.11
SY-102	10/28/2014	2.7	65	1351			11.29
SY-102	11/29/2014	1.1	27	1378			11.38
SY-102	12/24/2014	2.6	63	1440			11.45
SY-102	5/6/2015	3.2	77	1517			11.81
SY-102	2/2/2016	3.2	77	1594			12.56
SY-102	3/21/2016	2.7	65	1660			12.69
SY-102	12/20/2016	3.0	71	1731			13.44
SY-102	1/19/2017	0.9	21	1752			13.52
SY-102	2/15/2017	2.0	48	1800			13.60
SY-102	11/29/2017	2.8	68	1868			14.38
SY-102	12/16/2017	1.0	24	1892			14.43
SY-102	2/6/2018	2.7	65	1957			14.57
SY-102	2/26/2018	0.8	19	1976			14.63
SY-102	3/26/2018	3.3	78	2054			14.70
SY-102	5/10/2018	2.6	63	2117			14.83
SY-102	6/18/2018	1.0	23	2140			14.93

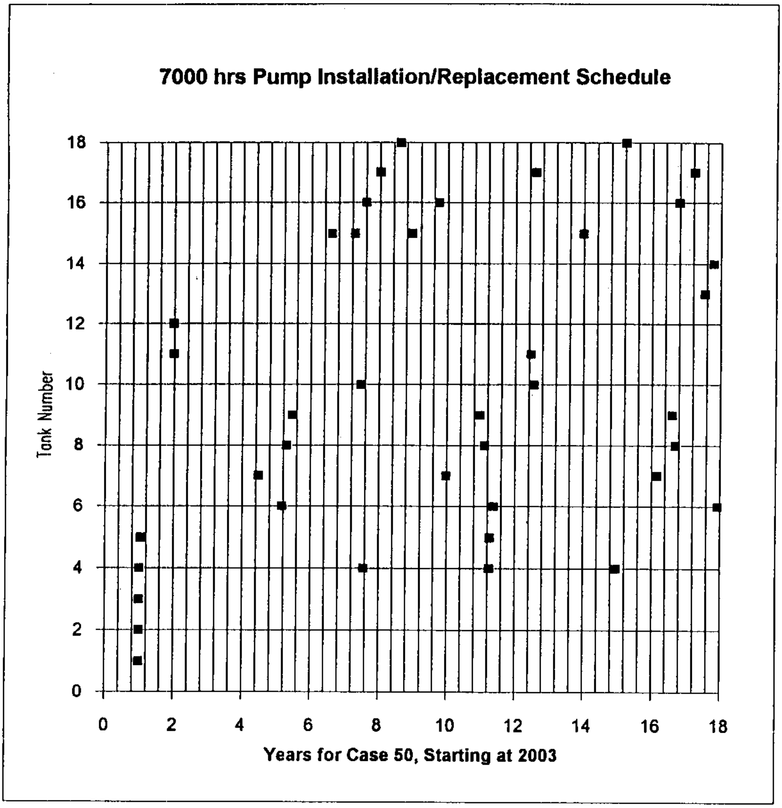
SY-102	7/4/2018	0.9	21	2161			14.98
SY-102	7/26/2018	0.8	19	2180			15.04
SY-102	8/18/2018	2.5	61	2241			15.10
SY-102	1/8/2019	2.5	60	2301			15.49
SY-102	2/5/2019	0.8	20	2321			15.57
SY-102	5/31/2019	1.2	28	2349			15.88
SY-102	8/25/2019	1.6	37	2387			16.12
			2387				

SY-103	1/4/2003	3.8	92	92	1	3	-0.53
SY-103	12/29/2009	3.7	88	180			6.46
SY-103	9/18/2011	0.9	21	200			8.18
SY-103	1/7/2012	2.9	68	269			8.48
SY-103	5/29/2012	3.4	81	350			8.88
SY-103	11/5/2012	0.9	21	370			9.31
SY-103	9/9/2013	2.7	65	435			10.16
SY-103	5/4/2014	3.0	71	506			10.81
SY-103	7/22/2014	3.0	71	577			11.02
SY-103	8/9/2014	0.9	21	598			11.07
SY-103	10/16/2014	2.9	68	666			11.26
SY-103	12/26/2015	1.0	23	689			12.45
SY-103	1/16/2016	1.2	29	718			12.51
SY-103	2/14/2016	2.8	67	785			12.59
SY-103	11/4/2016	3.7	89	874			13.31
SY-103	1/3/2017	3.0	71	946			13.48
SY-103	12/30/2017	3.0	71	1017			14.47
SY-103	1/25/2018	0.9	21	1037			14.54
SY-103	3/9/2018	2.9	68	1106			14.66
SY-103	7/2/2018	3.0	71	1177			14.97
SY-103	6/13/2019	3.2	77	1254			15.92
			1254				

Summary of Totals

1	SY-101	4347
2	SY-102	2387
3	SY-103	1254
4	AW-104	23004
5	AW-103	11283
6	AN-101	14275
7	AN-104	15548
8	AN-105	14228
9	AN-106	14231
10	AW-101	12885
11	AW-102	12998
12	AW-105	1318
13	AN-102	942
14	AN-107	1074
15	AY-101	21009

16	AY-102	16180
17	AZ-101	15152
18	AZ-102	12788



APPENDIX D: LIFE-CYCLE COST MODELS 1 AND 2

	A	B	C	D	E	F
1						
2						
3	12/13/95					
4	Notes: 1)					
5		a new pump				
6	**Case 50 Da**				**W-151**	
7	**#**	**Tank**	**Hrs**	**# RC**	**# MP**	**$ K**
8	1	SY-101	4755	=INT(C8/HRS	=2*D8	=(PC*2)+(PCR*
9	2	SY-102	2787	=INT(C9/HRS	=2*D9	=(PC*2)+(PCR*
10	3	SY-103	1662	=INT((C10/HR	=2*D10	=(PC*2)+(PCR*
11	4	AW-104	23412	=INT((C11/HR	=2*D11	=(PC*2)+(PCR*
12	5	AW-103	11691	=INT((C12/HR	=2*D12	=(PC*2)+(PCR*
13	6	AN-101	14683	=INT((C13/HR	=2*D13	=(PC*2)+(PCR*
14	7	AN-104	15956	=INT((C14/HR	=2*D14	=(PC*2)+(PCR*
15	8	AN-105	14636	=INT((C15/HR	=2*D15	=(PC*2)+(PCR*
16	9	AN-106	14639	=INT((C16/HR	=2*D16	=(PC*2)+(PCR*
17	10	AW-101	13293	=INT((C17/HR	=2*D17	=(PC*2)+(PCR*
18	11	AW-102	13406	=INT((C18/HR	=2*D18	=(PC*2)+(PCR*
19	12	AW-105	1726	=INT((C19/HR	=2*D19	=(PC*2)+(PCR*
20	13	AN-102	1350	=INT((C20/HR	=2*D20	=(PC*2)+(PCR*
21	14	AN-107	1482	=INT((C21/HR	=2*D21	=(PC*2)+(PCR*
22	15	AY-101	21417	=INT((C22/HR	=2*D22	=(PC*2)+(PCR*
23	16	AY-102	16588	=INT((C23/HR	=2*D23	=(PC*2)+(PCR*
24	17	AZ-101	15560	=INT((C24/HR	=2*D24	=(PC*2)+(PCR*
25	18	AZ-102	13196	=INT((C25/HR	=2*D25	=(PC*2)+(PCR*
26				=SUM(D8:D2	=SUM(E8:E25	=SUM(F8:F25)
27						
28			W-151			
29			**Assumptions**			
30		*Hrs*	**2000**	[hrs]		*Hrs2*
31		*P Life*	10	[yrs]		*P Life*
32		*PC*	=D38+D46	[$K]		*PC2*
33		*PCR*	=D42+D46	[$K]		*PCR2*
34						
35						
36						
37		**Cost Assumptio**				
38	W-151 New			**435**		(4.4.2)
39	ADMP -LPI			**620**		(4.4.5)
40	ADMP -WE			**752**		(4.4.5)
41	SRS- Binha			**310**		(4.4.3)
42	W-151 Repl			**300**		(4.4.6)
43	ADMP -LPI			**505**		(4.4.6)
44	ADMP -WE			**535**		(4.4.6)
45						
46	WHC Indir			**550**		(4.4.4)
47	WHC Indire			**500**		(4.4.4)
48	SRS Indirec			**225**		(4.4.3)
49						
50	Cost to Op					

LCCMOD 1

	G	H	I	J	K
1	**Life Cycle Co**				
2	**(LCCMOD - Report**				
3					
4					
5					
6		**ADMP - LPI**			**ADMP - WEMD**
7	**# RC**	**# MP**	**$ K**	**# RC**	**# MP**
8	=INT(C8/HRS2)+1	=2*G8	=(PC2*2)+((PC	=INT(C8/HRS3)+1	=2*J8
9	=INT(C9/HRS2)+1	=2*G9	=(PC2*2)+((PC	=INT(C9/HRS3)+1	=2*J9
10	=INT(C10/HRS2)+1	=2*G10	=(PC2*2)+((PC	=INT(C10/HRS3)+1	=2*J10
11	=INT(C11/HRS2)+1	=2*G11	=(PC2*2)+((PC	=INT(C11/HRS3)+1	=2*J11
12	=INT(C12/HRS2)+1	=2*G12	=(PC2*2)+((PC	=INT(C12/HRS3)+1	=2*J12
13	=INT(C13/HRS2)+1	=2*G13	=(PC2*2)+((PC	=INT(C13/HRS3)+1	=2*J13
14	=INT(C14/HRS2)+1	=2*G14	=(PC2*2)+((PC	=INT(C14/HRS3)+1	=2*J14
15	=INT(C15/HRS2)+1	=2*G15	=(PC2*2)+((PC	=INT(C15/HRS3)+1	=2*J15
16	=INT(C16/HRS2)+1	=2*G16	=(PC2*2)+((PC	=INT(C16/HRS3)+1	=2*J16
17	=INT(C17/HRS2)+1	=2*G17	=(PC2*2)+((PC	=INT(C17/HRS3)+1	=2*J17
18	=INT(C18/HRS2)+1	=2*G18	=(PC2*2)+((PC	=INT(C18/HRS3)+1	=2*J18
19	=INT(C19/HRS2)+1	=2*G19	=(PC2*2)+((PC	=INT(C19/HRS3)+1	=2*J19
20	=INT(C20/HRS2)+1	=2*G20	=(PC2*2)+((PC	=INT(C20/HRS3)+1	=2*J20
21	=INT(C21/HRS2)+1	=2*G21	=(PC2*2)+((PC	=INT(C21/HRS3)+1	=2*J21
22	=INT(C22/HRS2)+1	=2*G22	=(PC2*2)+((PC	=INT(C22/HRS3)+1	=2*J22
23	=INT(C23/HRS2)+1	=2*G23	=(PC2*2)+((PC	=INT(C23/HRS3)+1	=2*J23
24	=INT(C24/HRS2)+1	=2*G24	=(PC2*2)+((PC	=INT(C24/HRS3)+1	=2*J24
25	=INT(C25/HRS2)+1	=2*G25	=(PC2*2)+((PC	=INT(C25/HRS3)+1	=2*J25
26	=SUM(G8:G25)	=SUM(H8:H25)	=SUM(I8:I25)	=SUM(J8:J25)	=SUM(K8:K25)
27					
28	ADMP - LPI				ADMP - WEMD
29	**Assumptions**				**Assumptions**
30	**6000**	[hrs]		*Hrs3*	**7000**
31	=C31	[yrs]		*P Life*	10
32	=D39+D43	[$k]		*PC3*	=D40+D47
33	=D43+D47	[$k]		*PCR3*	=D44+D47
34	**20 Year**				**20 Year**
35	**Program Savings**				**Program Savings**
36	=F26-I26	[$k]			=F26-L26
37					
38					
39					
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LCCMOD 1

	L
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3	
4	
5	
6	
7	**$ K**
8	=(PC3*2)+((PCR
9	=(PC3*2)+((PCR
10	=(PC3*2)+((PCR
11	=(PC3*2)+((PCR
12	=(PC3*2)+((PCR
13	=(PC3*2)+((PCR
14	=(PC3*2)+((PCR
15	=(PC3*2)+((PCR
16	=(PC3*2)+((PCR
17	=(PC3*2)+((PCR
18	=(PC3*2)+((PCR
19	=(PC3*2)+((PCR
20	=(PC3*2)+((PCR
21	=(PC3*2)+((PCR
22	=(PC3*2)+((PCR
23	=(PC3*2)+((PCR
24	=(PC3*2)+((PCR
25	=(PC3*2)+((PCR
26	=SUM(L8:L25)
27	
28	
29	
30	[hrs]
31	[yrs]
32	[$k]
33	[$k]
34	
35	
36	[$k]
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LCCMOD I

	A	B	C	D	E	F
1						
2	Note:					
3	Cum				Number	
4	Num				of Replacement	
5	Yr	2k hrs	6k hrs	7 K hrs	2k hrs	6k hrs
6	1	=E6*2	=F6*2	=G6*2	4	4
7	2	=E7*2+B6	=F7*2+C6	=G7*2+D6	3	3
8	3	=E8*2+B7	=F8*2+C7	=G8*2+D7	1	0
9	4	=E9*2+B8	=F9*2+C8	=G9*2+D8	1	0
10	5	=E10*2+B9	=F10*2+C9	=G10*2+D9	3	1
11	6	=E11*2+B10	=F11*2+C10	=G11*2+D10	4	4
12	7	=E12*2+B11	=F12*2+C11	=G12*2+D11	8	1
13	8	=E13*2+B12	=F13*2+C12	=G13*2+D12	9	3
14	9	=E14*2+B13	=F14*2+C13	=G14*2+D13	3	2
15	10	=E15*2+B14	=F15*2+C14	=G15*2+D14	9	1
16	11	=E16*2+B15	=F16*2+C15	=G16*2+D15	6	7
17	12	=E17*2+B16	=F17*2+C16	=G17*2+D16	9	3
18	13	=E18*2+B17	=F18*2+C17	=G18*2+D17	7	0
19	14	=E19*2+B18	=F19*2+C18	=G19*2+D18	10	2
20	15	=E20*2+B19	=F20*2+C19	=G20*2+D19	8	2
21	16	=E21*2+B20	=F21*2+C20	=G21*2+D20	7	5
22	17	=E22*2+B21	=F22*2+C21	=G22*2+D21	8	0
23	18	=E23*2+B22	=F23*2+C22	=G23*2+D22	8	5
24	19	=E24*2+B23	=F24*2+C23	=G24*2+D23	0	0
25	20	=E25*2+B24	=F25*2+C24	=G25*2+D24	0	0
26					=SUM(E6:E25)	=SUM(F6:F25)

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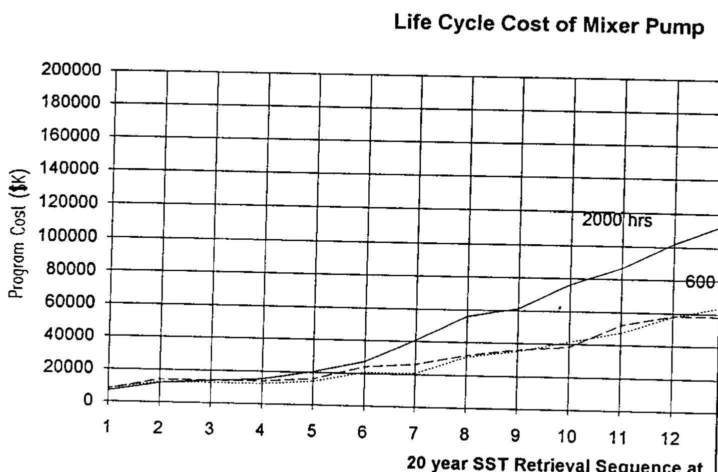

LCCMOD 2

	G	H	I	J	K	L
1						
2						
3			Cumulative			
4			Cost of Pumps			
5	7 k hrs	Yr	2k hrs	6k hrs	7 k hrs	D 2-6
6	4	1	=B6*850	=C6*1005	=D6*1035	=I6-J6
7	2	2	=B7*850	=C7*1005	=D7*1035	=I7-J7
8	0	3	=B8*850	=C8*1005	=D8*1035	=I8-J8
9	0	4	=B9*850	=C9*1005	=D9*1035	=I9-J9
10	1	5	=B10*850	=C10*1005	=D10*1035	=I10-J10
11	3	6	=B11*850	=C11*1005	=D11*1035	=I11-J11
12	0	7	=B12*850	=C12*1005	=D12*1035	=I12-J12
13	5	8	=B13*850	=C13*1005	=D13*1035	=I13-J13
14	2	9	=B14*850	=C14*1005	=D14*1035	=I14-J14
15	3	10	=B15*850	=C15*1005	=D15*1035	=I15-J15
16	3	11	=B16*850	=C16*1005	=D16*1035	=I16-J16
17	5	12	=B17*850	=C17*1005	=D17*1035	=I17-J17
18	3	13	=B18*850	=C18*1005	=D18*1035	=I18-J18
19	1	14	=B19*850	=C19*1005	=D19*1035	=I19-J19
20	1	15	=B20*850	=C20*1005	=D20*1035	=I20-J20
21	3	16	=B21*850	=C21*1005	=D21*1035	=I21-J21
22	0	17	=B22*850	=C22*1005	=D22*1035	=I22-J22
23	4	18	=B23*850	=C23*1005	=D23*1035	=I23-J23
24	0	19	=B24*850	=C24*1005	=D24*1035	=I24-J24
25	0	20	=B25*850	=C25*1005	=D25*1035	=I25-J25
26	=SUM(G6:G25)					
27						
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29	ograms					
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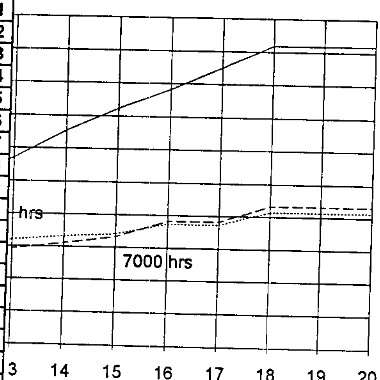

LCCMOD 2

	M
1	
2	
3	
4	
5	D 2-7
6	=I6-K6
7	=I7-K7
8	=I8-K8
9	=I9-K9
10	=I10-K10
11	=I11-K11
12	=I12-K12
13	=I13-K13
14	=I14-K14
15	=I15-K15
16	=I16-K16
17	=I17-K17
18	=I18-K18
19	=I19-K19
20	=I20-K20
21	=I21-K21
22	=I22-K22
23	=I23-K23
24	=I24-K24
25	=I25-K25
26	
27	
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APPENDIX E: VENDOR PERFORMANCE ESTIMATE LETTERS

Ltr. No. 334231-054

Westinghouse Electric Corporation
Energy Systems

Electro Mechanical Division

1000 Cheswick Avenue
Cheswick Pennsylvania 15024-1300
Cable WECHESWICK
(412) 963 5000
Telex 703388

December 15, 1995

Mr. K. S. Hoeft
Westinghouse Hanford Company
P.O. Box 1970
2355 Stevens Drive
Richland, Washington 99352

Dear Mr. Hoeft:

SUBJECT: Mixer Pump Reliability Analysis

In accordance with your verbal request, please find enclosed our reliability and life expectancy analysis for the current EMD Advanced Mixer Pump Design. It is our understanding that this data is to be used for an internal life cycle cost evaluation only. Towards that end, EMD has prepared the enclosed analysis based on good engineering judgement using data present today. This enclosed evaluation shall not be construed as an alteration to the current specification requirements for life expectancy.

Should you have any questions regarding this data, please do not hesitate to contact me directly.

Very truly yours,

T. J. Demmeade, Sr. Marketing Engineer
Government Marketing and Sales

cc: R. Dickinson
J. Drake
E. O'Neil

The wear rate data from the hydraulic component material wear tests can be directly applied to the mixer pump application. The wear rate data from the bearing component material wear tests can be applied to the mixer pump controlled leakage seal.

For type CF3 cast stainless steel, the predicted wear of the pump hydraulic components for 10,000 hours of operation, at maximum speed and with a waste fluid Miller number of 50, is .091 inches. It is clearly understood that the mixer pump will not be operated at its maximum speed all of the time and, the waste fluid will not always have a Miller number of 50. Therefore, the predicted wear of the mixer pump hydraulic components will be less than .091 inches, and the expected operating life of the hydraulic components is greater than 10,000 hours.

For type CF3 cast stainless steel with the chromide ceramic coating, the predicted wear for 10,000 hours of operation, at maximum speed and with a waste fluid Miller number of 50, is .0008 inches. This ceramic coating will be used to limit abrasive wear at the impeller hub running clearance location which controls the impeller pressure balance and thus the impeller thrust load. The expected operating life of the impeller hub seal arrangement is greater than 10,000 hours.

For tungsten carbide with diamond coating, the predicted wear of the bearings for 10,000 hours of operation, at maximum speed and with a waste fluid Miller number of 50, is <.001 inches. The mixer pump bearings will be operating in clean water and therefore, the expected bearing operating life is greater than 10,000 hours. The mixer pump controlled leakage seal will be lubricated with clean water but, the waste fluid will be on one side of the seal interface and could potentially impact the seal wear life. But, since the minimum thickness of the diamond coating on the seal surfaces will be .001 inches, the expected operating life of the controlled leakage seal assembly is greater than 10,000 hours.

Therefore, based on a specified design life of 5,000 hours, the reliability factor for the mixer pump is considered to be 2.00.

mixreli

A reliability analysis is a calculation of the probability that a particular piece of equipment will achieve a specified operating life. For the WEMD Advanced Radioactive Waste Tank Mixer Pump, this is a calculation of the probability that the unit will operate for 5,000 hours over a 10 year period. In order to perform a reliability analysis, it is necessary to have failure rate data for all of the component parts that make up the equipment. However, since the portion of the Advanced Mixer Pump that is above the radiation shield can be maintained, it is only that portion of the Advanced Mixer Pump that is "Down Hole" that needs to be included in the reliability analysis. Failure rate data is required for the stator coils, the electrical power cables, the bearings, the seal, etc. For the reliability analysis to be rigorous, the failure rate data must be for the specific component parts that make up the unit. It is possible however to make a reliability estimate based on failure rate data for similar components operating under similar conditions.

Since the WEMD Advanced Radioactive Waste Tank Mixer Pump has not yet been manufactured, no failure rate data exists for the exact components that are used in the mixer pump design. However, operating experience for components similar to the key components of the mixer pump exists that can be used to make a reliability estimate. This operating experience is summarized below.

WEMD canned motor pumps that employ the same insulation system for the stator coils have operated in excess 100,000 hours over 25 years of service without any maintenance.

WEMD canned motor pumps that employ similar fluid film bearings lubricated with clean water have operated in exess of 100,000 hours over 25 years of service without any maintenance. With the controlled leakage seal arrangement, the mixer pump motor bearings will be lubricated with clean water.

Electrical power cables with the same insulation system have operated at the voltage and current levels of the mixer pump for periods significantly in excess of the 5000 hour design life. And, the thermal rating of the power cables for the mixer pump has been conservatively applied in order to assure that the 5000 hour operating life is achieved.

The wear tests performed by WEMD to support the designs of the hazardous waste pump development programs provide some important wear rate data that can be used to perform an calculation of the expected operating life for the advanced mixer pump. These wear tests were performed with a waste fluid simulant that exhibited a Miller number significantly in excess of the maximum specified value of 50.

LAWRENCE PUMPS INC.
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TEL: (508) 682-5248
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FAX TRANSMISSION

DATE: December 12, 1995 LPI REF: 91189-14

TO: Westinghouse Hanford Co.

ATTN: Mr. Keith Hoeft FAX:509- 372-~~2134~~ 3793

SUBJECT: MKH-SPV-424907
Reliability Comparison to AZ101 Pumps

Dear Kieth,

In response to your request for a design reliability comparison between the AZ101 pumps and the prototype design we are please to submit the following for your consideration.

It is our understanding that MTBF for sleeve bearing pumps previously utilized for remediation service probably somewhere around 2000 hrs. Based upon design features which have been incorporated we estimate that the MTBF for the prototype design should be approximately 6000 hrs.

Best Regards,

Dale B. Andrews
Project Manager

Att: MARK HALL
R-0065

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PUMPS INC.
371 Market St. • Lawrence, MA • USA • 01843

FAX: (508) 975-4291

FAX TRANSMISSION

DATE: December 12, 1995 **LPI REF:** 91189-13

TO: Westinghouse Hanford Co.

ATTN: Mr. Keith Hoeft **FAX:** 509- 372-~~2134~~ 3293

SUBJECT: MKH-SPV-424907
Reliability Comparison to AZ101 Pumps

Dear Kieth,

In response to your request for a design reliability comparison between the AZ101 pumps and the prototype design we are please to submit the following for your consideration.

Design Life

The AZ101 pumps have a design life of 5000 hrs operation over 10 years installed life. At 5000 hrs. sleeve bearing wear will probably be sufficient to put the mechanical seals at risk.

The Prototype pump is also designed for a 10 year installed life, but its rotor and seal have been designed to operate for the full 10 year period.

Reliability

In addition to the increased design life a number of features have been provide to improve the overall reliability of the unit. Some of the features are as follows:

- Seal welding of column joints to prevent leakage from the tank into the column.
- Gas filled column to prevent leakage of radioactive material into the environment.
- Gas filled skirt below the lower seal to prevent slurry entrainment in the seal.
- Remotable independent shaft sections which eliminate thermal growth problems.
- Elimination of Elastomers to provide greater radiation resistance.

Summary

Based upon a comparative study of the two designs we have concluded that the prototype has a significantly higher operational design life and a reliability factor of 4.5 times the AZ101 pump.

Regards,

Dale B. Andrews
Dale B. Andrews
Project Manager

Att: Mark Hall 2-0065 12/12/95 1:08

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