SAVANNAH RIVER SITE WASTE REMOVAL PROGRAM PAST, PRESENT, AND FUTURE

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ABSTRACT

The Savannah River Site has fifty-one high level waste tanks in various phases of operation and closure. These tanks were originally constructed to receive, store, and treat the high level waste (HLW) created in support of the missions assigned by the Department of Energy (DOE). The Federal Facilities Agreement (FFA) requires the high level waste to be removed from the tanks and stabilized into a final waste form. Additionally, closure of the tanks following waste removal must be completed. The SRS HLW System Plan identifies the interfaces of safe storage, waste removal, and stabilization of the high level waste and the schedule for the closure of each tank.

HLW results from the dissolution of irradiated fuel components. Desired nuclear materials are recovered and the byproducts are neutralized with NaOH and sent to the High Level Waste Tank Farms at the SRS. The HLW process waste clarifies in the tanks as the sludge settles, resulting in a layer of dense sludge with salt supernate settling above the sludge. Salt supernate is concentrated via evaporation into saltcake and NaOH liquor.

The Waste Removal Program includes the design, construction, testing (sometimes demonstration), turnover to the operating group, and operation of waste suspension and transfer equipment to remove the sludge and salt in these HLW tanks. Thirty-four million (34,000,000) gallons of HLW is stored in 49 tanks with an activity level of 300,000,000 curies in sludge (mostly Sr/Y-90) and 180,000,000 curies in saltcake/supernate (mostly Cs/Ba-137).

This paper discusses the history of SRS waste removal systems, recent waste removal experiences, and the challenges facing future removal operations to enhance efficiency and cost effectiveness. Specifically, topics will include the evolution and efficiency of systems used in the 1960's which required large volumes of water to current systems of large centrifugal slurry pumps, with significant supporting infrastructure and safety measures. Interactions of this equipment with the waste tank farm operations requirements will also be discussed. The cost and time improvements associated with these present-day systems is a primary focus for the HLW Program.

INTRODUCTION

Waste Removal consists of the following functions:

- Preparation of bulk waste
- Transfer of bulk waste
- Preparation of heel
- Transfer of heel
- Spray washing
- Annulus cleaning
- Tank Isolation
- Tank Closure

Additional WR functions include sampling, improved ventilation systems, alternative level indication, internal camera inspection equipment, controlled release of trapped hydrogen, and mapping of residual sludge to within one inch of the bottom of an SRS HLW tank (75' to 85' in diameter).

To make the effort even more challenging, the tanks have significant obstacles to overcome before any waste can be retrieved. Physical obstacles include:

- Support columns (produce shadowing effects)
- Horizontal cooling coils
- Vertical cooling coils
- Tank integrity
- High Level Waste environment on tank top and in surrounding area
- Tank bottoms located 45 to 50 feet below ground surface
- Carbon steel tanks
- Contamination containment for potentially leaking equipment
- Non-symmetrical riser positions
- Confined spaces
- Contaminated large equipment disposition
- Potential leakage from primary tank
- Transfer line over pressurization
- Limited openings into the primary tank and annulus space (no larger than 24 inches in diameter)
- Some tanks in water table
- Ventilation duct at the bottom of the annulus space
- High volumes of material in very low tank levels 2,710 gallons/in. to 3,540 gallons/in.
- Dark/humid environment for monitoring equipment
- High radiation rates in tank and at riser openings
- Surrounding tanks are processing waste (conflicting objectives)
- Tank top loading is limited
- All transfers out of the tanks are from one riser location

Some of the non-physical obstacles include criticality and in-depth knowledge of waste characterization. See **Fig. 1** for the location of some of these obstacles.

PAST WASTE REMOVAL PROGRAM

The early Waste Removal (WR) efforts within the High Level Waste Program consisted of salt and sludge suspension and transfer demonstrations to qualify the technology for future long-term applications. These early demonstrations produced valuable information that lead to the base lining of present day waste removal equipment. These demonstrations did not have to contend with impending FFA closure dates or a refined Authorization Basis that requires engineered safety design features versus administrative controls to prevent or mitigate postulated accidents. The residual salt/sludge that remained after the demonstrations was considered to be attainable through the future heel removal activities.

These bulk WR demonstrations left upwards of 15,000 gallons of sludge/salt in the tank. The demonstrations performed mixing operations with water monitor sluicing and motor-operated long-shaft slurry pumps. Waste was transferred utilizing steam jets and long-shaft transfer centrifugal pumps during these demonstrations. These demonstrations concluded that sluicers (water monitors) used significant volumes of liquid to overcome the initial shear stress of the waste and maintain enough velocity to overcome the yield strength of the waste material to move it from one tank to another. Long-shaft slurry pumps proved to be effective for bulk waste removal (even though greater than 15,000 gallons of residual waste could remain in the tank).

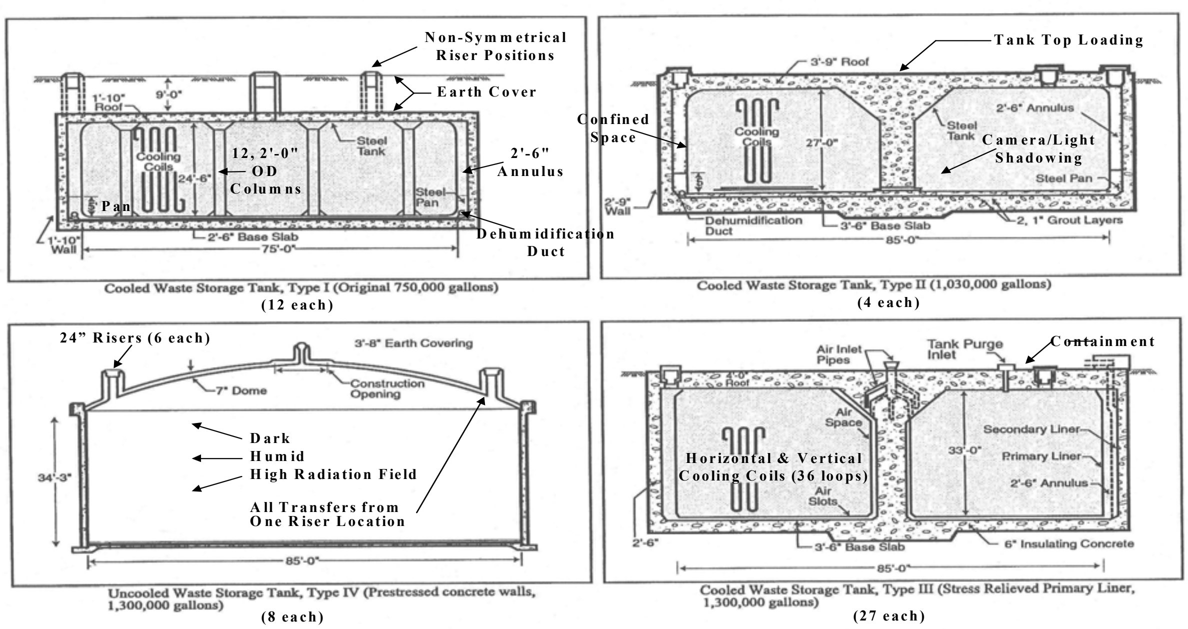

Fig. 1. Obstacles to Waste Removal

In two cases, Tank 16H and 24H, the primary tank was chemically treated after significant water was used with mixing pumps and a transfer pump. In the case of tank 16H, the chemical cleaning (oxalic acid) provided for a very complete residual cleaning mechanism that left the 16H primary tank waste free. The annulus space of tank 16H still has a large quantity of waste (8k to 10k gallons) that leaked from the primary tank through numerous leak sites.

A limited number of technologies were pursued to retrieve the waste with various degrees of results. Demonstrations did in fact remove large quantities of waste at the expense of significant water additions to the tank farm. See **Table I**I for details of past WR technologies deployed at SRS in HLW tanks. Early WR activities were delayed due to funding and downstream processing issues. As a result of some of the delays and the fact that the tank farms are aging, efforts are being pursued today to maintain previously deployed WR equipment (large slurry pumps) and to relocate WR services to above grade locations.

PRESENT WASTE REMOVAL PROGRAM

The present waste removal time frame in this report is 1995 to 2001. Current WR designs focus on single tank equipment/system usage to meet HLW System Plan needs. As a result, Tanks 7, 8, 11, 17, 18, and 19 all have unique designs to accomplish similar functional requirements. Tank 7, 8 and 11 WR designs utilize long-shaft slurry pumps for mixing and long-shaft transfer pumps for transfer capability. Whereas Tanks 17, 18, 19 and 20 utilized alternative waste/heel removal mixing and transfer systems.

For example, Tank 19 (Flygt mixers, submersible electric motor driven transfer pump, air driven pitbull pump, and a backup robotic crawler with water monitor) and Tank 18 (10,000 gpm long-shaft slurry pump with a submersible electric motor driven transfer pump) utilized technologies that were designed to capitalize on alternative WR technologies and in turn reduce the costs associated with WR design, construction, and operation.

The energy expended in present day WR is focused on both bulk and heel waste removal. Many new alternative technologies have been identified and designed; however, these designs are typically single deployments (no reuse) and require extensive funding to develop. The primary reason for the high expenses of present day technologies is the risk associated with the effectiveness of equipment operation. Operations have taken longer than expected due to equipment malfunctions, constructability issues, and operational effectiveness. These present day efforts have shown that a strong need exists for performance feedback systems that provide in-situ (real time) data that can be used to define efficiencies of equipment and progress of waste mobilization and transfer.

Characterization of the waste to be dispositioned is also essential to ensuring that enough energy goes into mixing and transferring the waste, but not too much such that the waste is peptized or too much energy is utilized that creates unnecessary expenditures. Much of the alternative design has been developed through a cooperative effort of SRS and the Tanks Focus Area, EM-50 organization. See Table II for details of present day WR technologies deployed at SRS in HLW tanks.

Table I. HLW Waste Removal History

Tank No.	Waste Type	WR Date	Waste Removed (KGal)	Heel Remaining (KGal)	Technology Used Sludge Slurry	Technology Used Salt Dissolution	Transfer Method	Comments
1F	Sludge	1969	34	7	Water Sluicer(4)	NA	****	Note 1
2F	Sludge	1966	44	5	Water Sluicer(4)	NA	****	Note 1
3F	Sludge	1968	67	5	Water Sluicer(3)	NA	****	Note 1
8F	Sludge	2001	180	15*	LPI (4)	NA	TTP	Note 2
17F	Sludge/Salt	1985	373	10	BW(3)	NA	TTP	Note 3
	Sludge Heel	1997	10	2.2	Flygt Mixers(3)/Water Sluicer(1)	NA	TTP	Note 3
18F	Sludge	1987	518	42	BW(3)	NA	TTP	Note 4
19F	Salt	1982	1000	33	NA	BW(2)	TTJ	Note 5
	Sludge/Zeolite Heel	2000	18**	15	Flygt Mixers(3)	NA	GP/PB	Note 5
20F	Salt	1983	1000	2	Pumpdown of ballast water only	BW(3)	TJ	Note 6
	Sludge Heel	1983	2	<1	BW(3)	NA	TJ	Note 6
33F	Salt	1983	99	4	NA	Density Gradient		Note 14
9H	Sludge	1966	38	5	Water Sluicer(4)	NA	****	Note 1
10H	Sludge	1967	58	5	Water Sluicer(3)	NA	****	Note 1
	Salt	1980	284		NA	Density Gradient	TJ	Note 7
11H	Sludge	1969	176	49	Water Sluicer(4)	NA	****	Note 1
14H	Sludge	1968	80	18	Water Sluicer(2)	NA	****	Note 1
15H	Sludge	1982	125	245	BW(2)	NA	TP	Note 8
16H	Sludge/Heel	1979	67	1.4	BW(3)	NA	TP	Note 9
		1980	1.4	0	Chemical Cleaning	NA	TP	Note 9
21H	Sludge	1986	205	14	BW(3)	NA	TP	Note 10
22H	Salt	1986	900	0	NA	BW(3)	TP	Note 10
	Sludge	1986	78	21	BW(3)	NA	TP	Note 10
24H	Salt/Heel	1981	1000	11	NA	BW(2)	TTJ	Note 11
	Zeolite Heel	1985	0	11	Chemical Cleaning		TTJ	Note 11
40H	Sludge Processing	1987	400***					Note 12
42H	Sludge Processing	1983	400***					Note 13
51H	Sludge Processing	1983	400***					Note 12

TTP-Telescoping Transfer Pump, TTJ-Telescoping Transfer Jet, LPI- Lawrence slurry pump,

BW – Bingham-Willamette slurry pump, TJ – Transfer jet, TP – Transfer pump, GP - Goulds pump, PB - Pit Bull pump

Table I. HLW Waste Removal History - continued

*	Bulk Waste Removal completed 1/01. Four LPI slurry pumps successfully mobilized Tank 8, a previously dry sludge tank that had been rewet to support the WR evolution.
**	Transfer of sludge/zeolite heel to Tank 18F was completed on 6/01. Planning for Tank 19 closure is in progress.
***	Tanks 40H and 51H are Extended Sludge Processing Tanks/DWPF Feed Tanks, Tank 42H was an ESP Tank, but has been returned to service as HLW storage tank.
****	Tanks 1F,2F,3F,9H,10H,11H, and 14H had the sludges removed by Sluicers which also were the transfer pumps for moving the sludges to Tank 7F and 13H. Tanks were converted to salt service except for Tank 11H.
Note 1	Tanks were filled with salt after sludge removal. Density Gradient methods for Salt Removal were tested in Tank 10H. Salt from all these tanks will be removed with 3 LPI Pumps in each tank.
Note 2	Sludge has been slurried with 4 Lawrence Pumps and has been transferred to ESP for processing. A second transfer of 15k gallons of sludge heel is also planned to reduce the existing heel.
Note 3	Salt and sludge was removed from Tank 17F and transferred to 18F where sludge settled and salt solutions were processed in the evaporator system. Heel remaining was removed by a combination of Flygt Mixers and a water monitor. Following heel removal, tank was filled with grout and closed.
Note 4	Tank 18F received and stored the sludge from 17F,19F, and 20F. The salt from those tanks passed through 18F to the evaporator systems. Tank 18F sludge was slurried and transferred to ESP.
Note 5	Tank 19F had the soluble salts removed using 2 Bingham Willamette pumps. The remaining heel was removed with 3 ITT Flygt Mixers. The solution was transferred with a 200 gpm submersible Bibo pump. Solutions were transferred to 18F where solids were allowed to settle and the supernate was recycled to 19F with a 200 gpm pump.
Note 6	Salt in Tank 20F was initially removed by Density Gradient method, when inhibitor control required too much fresh inhibitors, the process was ended and the remainder of the salt was removed with 3 Bingham-Willamette slurry pumps. Tank 20F has been filled with grout and closed.
Note 7	Tank 10H was used to demonstrate Density Gradient techniques, See note 1 for remaining salt.
Note 8	Sludge was removed from 15H to provide for demonstration of sludge processing in 42H.
Note 9	Tank 16H was demonstration tank for removal of sludge with long shaft slurry pumps (BW), essentially all sludge was removed by combination of bulk removal, water washing and oxalic acid cleaning. Tank 16H annulus remains to be cleaned before the tank can be closed.
Note 10	Salt and bulk sludge were removed from Tanks 21 and 22H. Heel will be removed after the tanks are removed from serving as DWPF recycle tanks.
Note 11	Salt from 24H was removed as part of demonstration for salt removal using slurry pumps. After salt removal, oxalic acid and water washing was unsuccessful in removing the zeolite heel. Tank is currently used to store DWPF recycle.
Note 12	Tanks 40H and 51H are the two ESP processing/ DWPF feed tanks. Four Quad Volute pumps are used to wash and feed to DWPF ~400,000 gallons of sludge per batch.
Note 13	Tank 42H was used to demonstrate sludge washing and aluminum dissolution process, but has had all its sludge removed to 51H and is now in supernate storage service.
Note 14	Salt dissolution was done on Tank 33F so that it could be used as the fresh high heat waste receipt tank. The tank is currently a low heat waste receipt tank and an intermediate feed tank for the 2F evaporator.

Table II. Present Day Waste Removal Technology

Technology Type	System Attributes	Waste Form	System Operability	Comments
Slurry Pump (SP): 38 SPs in HLW (4 Out Of Service, 9 uninstalled, 4 of the 9 failed vibration tests. All 4 failed SPs have had bearing design improvements; tilt pad bearing instead of bushings. The SPs range from the following specs: 1) 150hp/25' ECR/1750 rpm/1200 gpm/2 nozzles, 2) 300 hp/40' ECR/2200 rpm/4000 gpm/4 nozzles, 3) 75hp/900 rpm/900 gpm/2 nozzles, 4) 300 hp/50' ECR/1100 rpm/2 nozzles/5200 gpm/nozzle	45' long-shaft centrifugal pump, journal bearings with a lower product lube bearing, mechanical seals used to reject contamination in 30 psi bearing water column, 1200 gpm, 2 radial /tangential 1-1/2" nozzles, 12K lbs weight, 2-1/2" nitronic 50 shaft with tungsten carbide product lube bearing shaft coating, 14" 304L SS column, 1780 rpm, 150 hp, 480 v, 165 amp, variable frequency drive control, 360 degree rotation utilizing a 1/3 rpm rotek bearing and electrical motor slip ring, 10" spacer cans used to raise and lower pumps.	Non-Newtonian, Bingham plastic. In F-Tank Farm, the waste is composed of Al, Fe, Mn, Ni, U^{238}, Mg, and Zn. HTF is made up of Al and Fe. The average density of the waste in g/ml is 1.38 in FTF and 1.26 in HTF and the wt% insoluble solids is 19.3 in FTF and 11.7 in HTF. The average yield stress in Dynes/ cm^2 is 200 in FTF and 15 in HTF and the average particle size is 0.5 microns. The average pH of the waste is between 13-14 for both Tank Farms. The SpG= 1.3 to 1.5	Slurry Pumps are installed in 24" risers only after concentricity checks are performed, SPs must be submerged at a min. of 16" of fluid above the bottom of the pump screen (10" above center line of pump discharge nozzles) required to prevent vortexing and roostertailing, 1600 rpm to protect against reasonant frequency excessive vibration, Tk 8 performance: 132.8K gallons of sludge, 230K gallons liquid, 2:1 water to sludge ratio, 15K gallons sludge remained.	Due to the obstructions in type I, II and III HLW tanks, the slurry pumps meet the fundamental deployment requirements that other technologies can not. For this reason, the long shafted centrifugal pump will certainly be considered for future waste removal.
Hydrolaser/Hydrolance – Both were used in Tk 19, Vendor (Augusta Industrial) operated Hydrolaser.	High pressure delivery (10 to 30Kpsi) system, hose and nozzle (32 gpm/1/4" dia). 3 nozzles, 120° apart and 75° downward. One nozzle straight down.	This technology has been demonstrated in Tank 19 on zeolite and sludge (fast settling solids, 1-6 fps).	The hydrolaser broke up a 42" high by 30" dia. Mound of zeolite using a 13:1 fluidic dislodging ratio. Miminal impact on sludge at 15'.	It is very effective at contact on extremely hard materials yet very ineffective at distances over 6" with most any material.
Submersible Mixer (Flygt Mixer): SRS has deployed six mixers since 1997 (one 15 hp, two 4 hp, and three 50 hp). Tank 17 and 19 operating procedures are utilized to operate the mixers.	The 50 hp motor in the Tank 19 design turns a shrouded propeller at speeds up to 860 rpm. This mixer delivers 9,000 gpm (9K gpm is less than vendor published values of 20K gpm due to introduction of a shroud on mixer discharge) while providing a velocity of 1.0 fps at a 50 ft. distance and a cleaning radius of 21 feet.	Same as waste form in Slurry Pump section. Mixers are challenged by a stationary single-point transfer location due to their limited suspension and effective cleaning radius (ECR).	The mixers require a 36 inch liquid level for operation to prevent excessive vortexing. The weight of the 10,000 lb. Mixer mast assembly rests on the tank floor, while the rotek bearing is supported by structural steel that prevents tank top loading.	The effectiveness of the mixers was challenged during the R&D of the product due to multiple failures. The failures have been addressed through CFD modeling, structural fatique analysis, and a large number of small and large scale testing with sludge/ zeolite simulants.
Sluicers (Waterbrush): Tk 17F (1 sluicer).	100 gpm flowrate, was mounted from the Tank 17 ceiling with high powered lights for aiming assistance, pan and tilt automatic operation, capable of flowing a concentrated 3" to 4" diameter stream at 80'.	Same as waste form in Slurry Pump section. Waterbrush extremely effective at moving fast settling solids through the use of eroding properties.	Water addition to the tank farm averaged from 4:1 to 15:1 water to sludge ratio removal capability. The sluicer had 360 degree rotation capability to reach all areas of the tank.	Sluicing is a very viable technology for both salt and sludge removal but at a high water to waste ratio. Future HLW system planning limits water additions.
Pulse Tube Mixer (PTM): One mixer is presently installed in FTF-PT1 and is presently not in use due to no transfers requiring its operation.	The PTM utilized a 111 gallon charge vessel that vacuumed waste through a 2" suction tube and then discharged through the same 2" tube to agitate with the process fluid.	See waste form as defined in Slurry Pump Section. The pump tank is approximately 8K gallons in volume.	The system can be deployed through a 2" riser since the suction/discharge line is the only component that needs to be intrusive to the tank/vessel.	The pump tank remained slurried for the duration of the Tank 8 to 40 transfer and was therefore considered successful.

Table II. Present Day Waste Removal Technology - continued

Technology Type	System Attributes	Waste Form	System Operability	Comments
Flusher Nozzle (Water Mouse): Modified sewer cleaning tool was utilized in Tank 17 heel removal evolution. The technology is off the shelf except for the steering mechanism that was designed and built by SRS.	Tank 17 had a distribution of sludge around the perimeter of the tank. The water mouse propelled itself to the tank wall with 80 gpm well water pressurized by a vendor supplied 2K psi pump. The technology then repositioned the heel from the perimeter to a distance 5 to 10 feet from the tank wall.	See waste form as defined in Slurry Pump Section. The beginning 10K gallon sludge heel in Tank 17 had been reduced to 2.2K gallons of heavily washed, fast settling solids (including 10% concrete fragments from tank ceiling).	The initial use of the water mouse proved to be hazardous due to the 45' high x 85' diameter working space the system needed to be used in. The steering mechanism that was designed by SRS eliminated the control issue.	This technology can only be utilized if water additions are allowed in the HLW system. Its effectiveness was proven to be valuable in the heel redistribution process. The technology will not work in an obstructed tank.
SRS Crawler: One SRS designed, built, tested vendor supplied water monitor (Akron) on vendor supplied submersible tracks (INTUK). Not installed.	100 gpm steerable water monitor mounted to a tracked vehicle, operates in < 4" sludge/liquid. Collapsible platform for 24" riser deployment that expands to a 5' x 5' working system.	See waste form as defined in Slurry Pump Section. The residual waste form (like beach sand) would more than likely remain that must be eroded.	The crawler was staged to be used to move residual solids that remain at the completion of Flygt mixer operations in Tank 19.	The crawler is able to get the sluicing tool to the sludge/ solids locations. Other crawlers are available commercially (Houdini, ARD).
Air Driven Transfer Pumps (Wilden, Pitbull): Numerous pumps are used throughout SRS and industry to pump heavy slurries/ materials from tanks/ sumps.	Double diaphragm 120 gpm @ 40 ft. of head capacity used in Tk 17. Required a 120 psi dry/lubricated air supply. System was enhanced with a flushing system, a set of nibbler dams to assist with pushing material to the suction of the pump and an anti-cavitation plate to support low level pumpdowns.	See waste form as defined in Slurry Pump Section. Note: 3 pumps were used in Tk 17 due to system failures caused by inadequate flushing, air line freezing, and material compatibility.	The pumps transferred a total of 7.6K gallons of sludge from Tk 17. The ratio of water to sludge ranged from 9:1 to 19:1. System performance was monitored by measuring the rad rates on the above grade transfer line.	Materials of construction, flushing, dry / lubricated air are all very significant design attributes that need to be considered for successful deployments.
Submersible Centrifugal Pump (Bibo, GPM, Goulds): One pump is currently installed in Tank 19 and has successfully operated for over 400 hours.	Centrifugal pump, 13 hp to 20 hp, submersible, 180 gpm @ 125' head, capable of pumping down to 1-1/2", used to transfer waste from Tank 19 to Tank 18.	See waste form as defined in Slurry Pump Section.	The pumps are stationary in the Tank 19 & 18. They can be elevated or lowered with great difficulty due to the fact that they are in fixed positions.	Proven system that would be considered disposable as long as the space that the pump system occupied in the tank riser was not needed for isolation and closure activities.
Telescoping Transfer Pump (TTP): Approx. 20 TTPs in HLW System.	Long shafted centrifugal pump, telescoping, 80 to 100 gpm, 75 hp, 4,800 lbs w/o bearing water in column, 3600 rpm, 460v, 45' long, 2-1/2" dia. discharge nozzle, nitronic 50 shaft, 2.5" dia. Shaft, 304L SS column.	See waste form as defined in Slurry Pump Section.	The TTP requires a 24" riser to accommodate the 23" dia. Pump casing. Bearing water for contamination control in pump column. The pump can be telescoped to different elevations.	The Tank 8 TTP worked flawlessly once the impeller clearance caused by a cold set was resolved. The system is effective for emptying a HLW tank down to a depth of 3 inches.

FUTURE WASTE REMOVAL PROGRAM

Even though SRS is the first DOE Site to close HLW tanks (Tanks 17F and 20F closed in 1997), the practice of combining bulk waste and heel removal technologies is not seen in any of the tank WR designs developed to date. WR of the future will have the challenge of limited funding and an operating environment with limited liquid storage capability. The vitrification process at SRS requires the consistent flow of sludge to the ESP process from the WR evolutions. Limited quantities of sludge are available in some of the tank farm tanks; therefore numerous tanks will have sludge extraction performed on them with extensive efforts in a short time period. Future WR efforts will in fact entail upwards of six to nine tanks having WR performed on them simultaneously.

Future WR will utilize an improved Operating strategy that will consist of consolidated controls to reduce costs and the streamlining of training so that operators can safely perform multiple tank WR evolutions. Equipment will be designed to perform both bulk and heel removal to reduce equipment costs. Disposition of contaminated large equipment will be reduced/eliminated as a result of improved system design. Electrical power/controls will be made portable (where applicable) to provide for multiple tank reuses.

Evaluations/investigations are ongoing to select a WR design that will meet all of the requirements of WR at SRS given a set of functional requirements and assumptions. A new perspective for future waste removal will be the pursuit of areas of performance that have not been measured before such as annulus cleaning, bulk and heel removal performed with the same technology, tanks potentially leaking, reduced funding and more challenging FFA tank isolation and closure dates. WR Equipment/systems under evaluation include the following:

- Electrical motor driven mixing centrifugal pumps (long and short shaft)
- Submersible transfer pumps
- Water monitors
- Robotics (crawlers/ manipulators arms)
- Air operating pumps
- Vacuum systems,
- Chemical cleaning
- Portable, disposable, reusable technology
- Combinations of items listed

From the beginning of early Waste Removal, long-shaft slurry pumps have proven to be a very effective system for imparting significant jet velocities to mobilize and suspend waste. However numerous failures have been associated with this design that have resulted in modifications and improvements in testing at SRS that has produced a much improved design for future use. Even with these improvements, the long-shaft slurry pump still possesses elements that prevent it from being considered the "technology of choice" for future waste removal (cost and infrastructure). Some Figure 2 shows design issues.

It is understood that the largest expense for the WR Program is not necessarily the equipment itself, but the following items:

- Infrastructure that supports the WR Program (structural supports to keep loads off of the tank tops, power, controls, steam, air, and bearing cooling water)
- Effectiveness of the equipment to achieve the waste removal objective
- Impact on training and procedures due to the complexity of the system
- Reusability of the equipment
- Costs associated with construction co-occupancy in operating facilities
- Contaminated waste disposition
- Authorization Basis compliance
- Regulatory requirements

The achievements associated with the pursuit of alternative technologies will continue to be accomplished with the oversight of the Tanks Focus Area (TFA) Program that support to all DOE Complex organizations. The TFA reports technology deployments through an official reporting system. Technology reviews are conducted on a periodic basis and progress is documented on an internet site. Historical technology performance will be utilized to qualify whether a technology will apply to SRS. In addition, international technology interfaces are also being pursued to identify future technology.

A definition of the decision making process and subsequent business plan for future WR can be seen in a Strategic Objective and the supporting Fundamental Objectives diagram (see Figure 3). The values that influence the objectives go further to define the complexity of performing the WR Program faster and cheaper.

DEFINITION OF SUCCESS FOR THE WASTE REMOVAL PROGRAM

My personal formula for successful WR is defined as:

Reasonable Mixing x Significant Transfer Capability + Patience = Successful WR

The mixing of the waste can be accomplished with many different technologies given enough time and the ability to add or recycle liquids to facilitate mixing. The core aspect of the formula is that care must be taken in the approach to transferring the waste. Every SRS high level waste tank has a set location for the underground transfer line out of the tank. If the underground line is to be used without significant effort, the waste must be relocated to the transfer line riser location. If the waste is mixed too much, then it will peptize and not settle, as required, in the receipt tank. If the waste is not thoroughly mixed, then significant quantities of waste will never reach the transfer line riser location where the transfer system is typically located due to the fast settling velocities of the waste particles.

A balance must be achieved in the way the waste is mixed or the transfer mechanism must be taken to the waste. Patience is inserted into the formula to highlight the time factor involved with the evolution. At times the implementing organization will want to expedite the evolution; therefore, it is imperative that an operating strategy and a decision logic is documented. Risks need to be understood and compensatory measures developed to ensure success of the technology.

Lastly, the success of any technology will only be as good as the basis of the decisions that selected the technology. These bases need to be clearly understood by the entire implementing team and reinforced throughout the evolution.

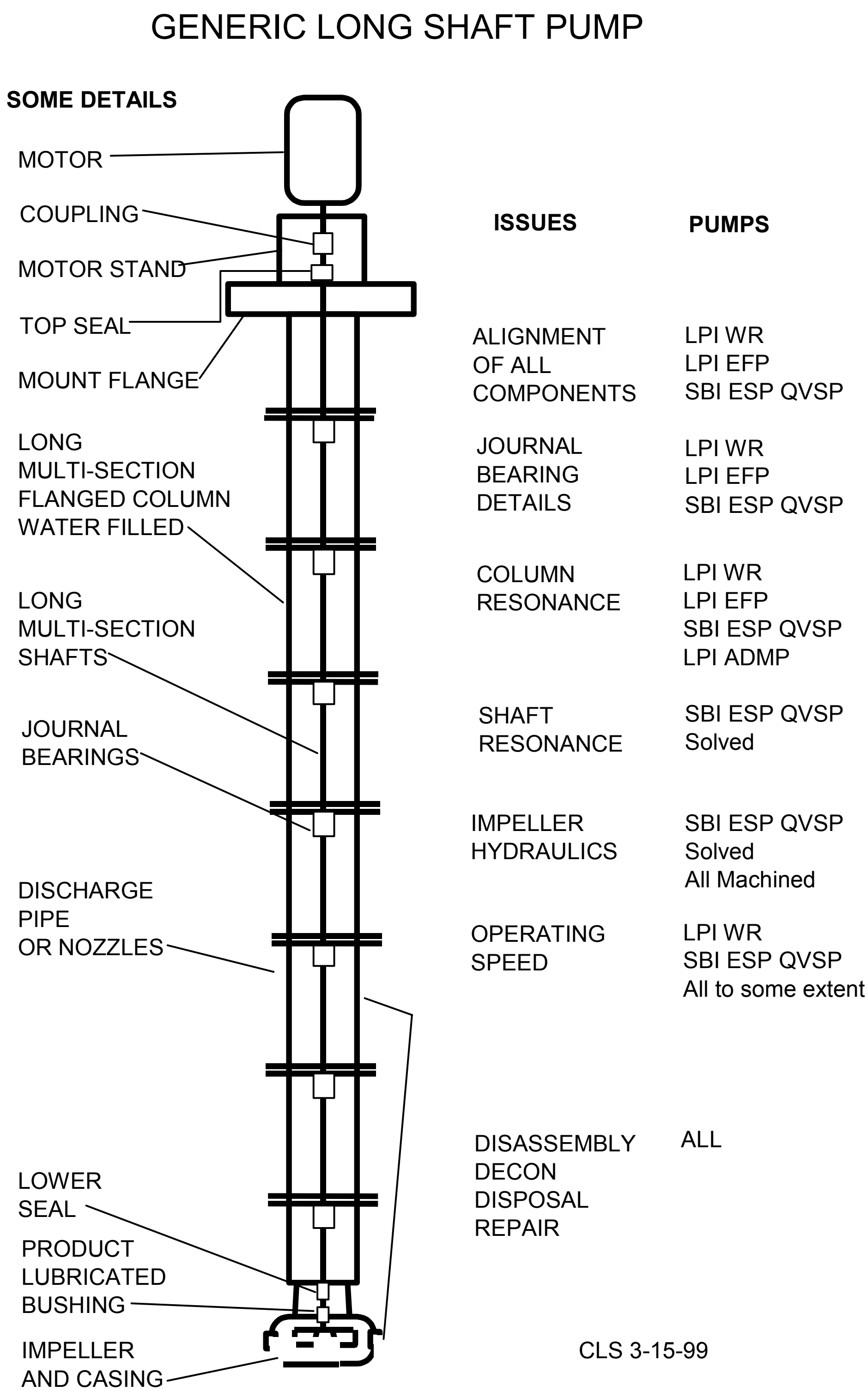

Fig. 2. Generic Long Shaft Pump

Value-Focused Business Plan

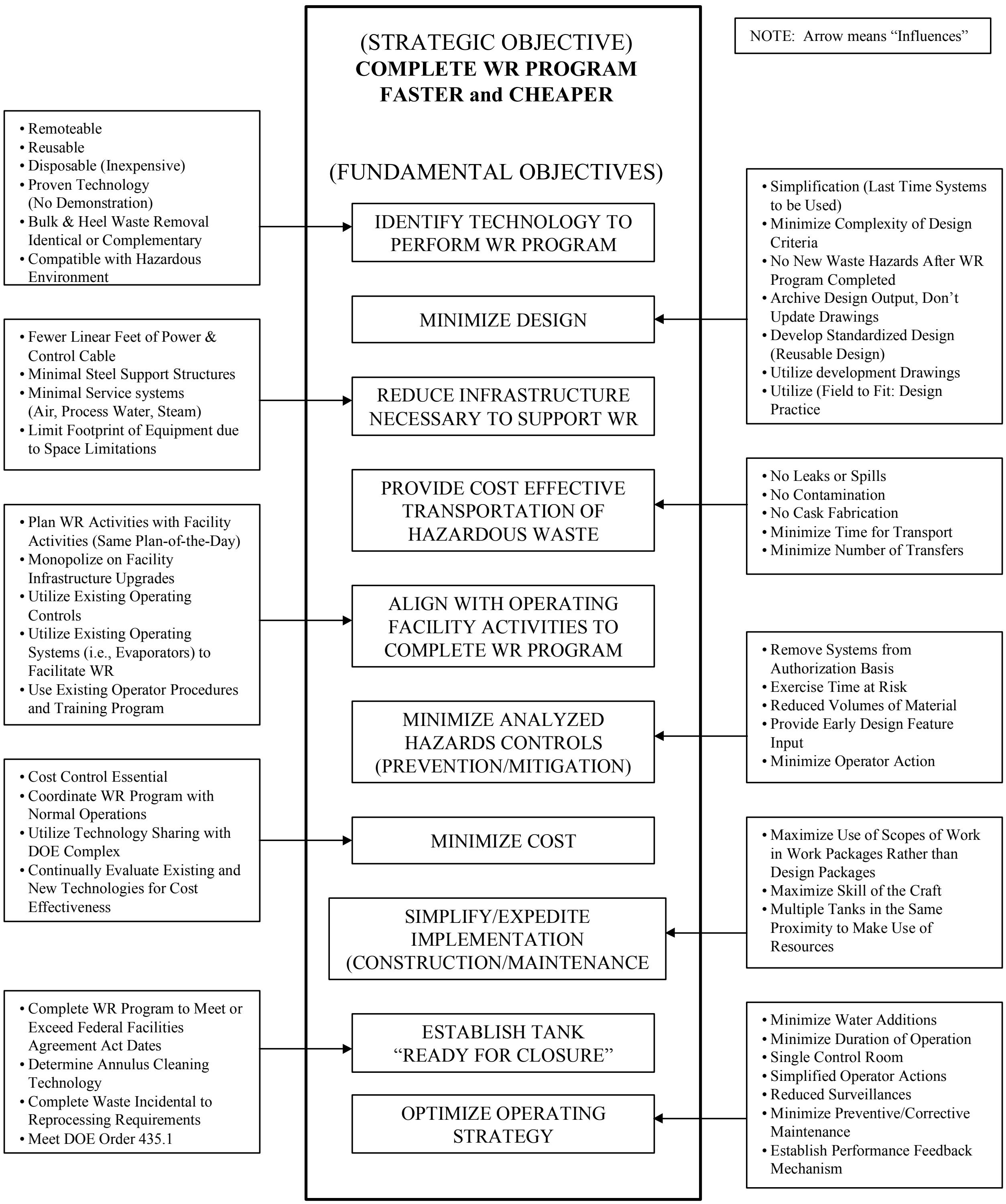

Fig. 3. Value-Focused Business Plan

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