Chapter 1.0 EXECUTIVE SUMMARY

1.1 Introduction

The University Area Joint Authority (UAJA), in partnership with the Pennsylvania Department of Environmental Protection (DEP), has implemented a full-scale pilot application of the BioGuide wastewater control technology. An agreement for technical services was signed by both parties and is provided as Appendix 1. A grant of $250,000 was approved by DEP through the Chesapeake Bay Program to carry out this project, with the University Area Joint Authority as a source of matching funds. The Authority participated in a pilot-scale demonstration in the last half of 1996 prior to selection for the full-scale project. The full-scale project was initiated on September 3, 1998 and is ongoing.

The Authority is committed to adding nitrogen reduction to the treatment of its effluent, adding wastewater reuse capability, and increasing current solids recycling capacity in the next upgrade to the facility. The innovative BioGuide wastewater control technology, provided by BioChem Technology, allows real-time, on-line monitoring of wastewater treatment facilities to optimize treatment efficiency. The pilot project demonstrated that use of this technology might allow treatment facilities to recover actual treatment volume through optimization of existing capacity. This recovered capacity could then be applied toward plant modifications to achieve denitrification. Successful implementation of this project will demonstrate that this technology is an economically viable alternative to conventional engineering techniques for total nitrogen reduction. This comparison will be made.

There were two secondary objectives of this project. An analysis of possible energy savings realized by optimization of aeration blower output associated with process optimization was conducted. Results of this analysis will be presented. The BioGuide system also provides continuous monitoring of the treatment process. This information allows operators to make control decisions with confidence.

David A. Smith is administering the full-scale project for UAJA. Mr. Smith is currently the Assistant Executive Director and has been involved with the project from its inception. Herbert, Rowland and Grubic, Inc. is UAJA’s consulting engineer. Brian L. Book and Steven M. Siegfried from that firm have provided invaluable assistance. BioChem Technology has also been an active partner in the project implementation. Mr. George Lee, President of BioChem, and his lead engineer Mr. Xin Yang and their staff have been very helpful.

The BioGuide project has been ongoing almost two years. All data and experience gleaned from implementation of the project has been analyzed and is contained in this final report.

Chapter 2.0 UAJA BACKGROUND

2.1 Plant Description

The University Area Joint Authority owns and operates a wastewater treatment facility located in Centre County, Pennsylvania, along the border between College and Benner townships. UAJA provides wastewater treatment and disposal service for College, Harris, Patton, and Ferguson Townships, and portions of the Borough of State College.

The UAJA plant uses the activated sludge process to remove organic matter from wastewater. This process uses organic matter contained in wastewater as a food source for microorganisms. Nitrification also occurs in the activated sludge process at UAJA. Nitrification is the biological oxidation of ammonia to form nitrate, with nitrite formation occurring as an intermediate step. The autotrophic microorganisms *Nitrosomonas* and *Nitrobacter* carry out this two-step reaction. The biomass present in this system is continuously transferred to a clarifier where settled clarified effluent is discharged, biomass is removed for solids handling, and a percentage of biomass is returned to the aeration basins for mixing with raw wastewater to regenerate the microorganism population. Activated sludge systems are aerobic, therefore compressed air is constantly added to the aeration basins so the microorganisms are able to metabolize.

Other major components of the UAJA system include primary clarification where settleable solids and floating solids are removed from the wastewater. Tertiary filtration follows the activated sludge process and serves as a final polishing step to insure that clarified effluent from the secondary clarifiers meet all discharge regulations set by the Commonwealth of Pennsylvania. Finally, disinfection and dechlorination occur in the facility's chlorine contact tank just before final plant effluent is discharged to Spring Creek. Figure 1 provides a plant layout of the UAJA facility and Figure 2 shows a flow schematic of the plant.

2.2 Expansion of Facility

University Area Joint Authority serves a population that is rapidly growing. The treatment facility was expanded and upgraded in 1992 to a capacity of six million gallons per day (MGD). The plant has already reached 80 percent capacity and plans for another expansion are underway.

Unlike other population centers in Pennsylvania, UAJA serves an area located near the headwaters of a small, high quality stream, Spring Creek, which makes a significant contribution to the community's quality of life. There is no large body of water nearby to receive the treated wastewater generated, so Spring Creek is receiving the wastewater generated by UAJA. Because there is significant concern about the temperature impact of UAJA's discharge on the high quality stream, UAJA will not be permitted to increase its stream discharge beyond 6 MGD.

As an alternative to additional stream discharge from UAJA, elected officials have undertaken an extensive feasibility study to determine future wastewater discharge options. After years of study they have determined that ***Beneficial Reuse*** of treated effluent is the preferred option. This option utilizes UAJA's existing treatment facility for continued treatment of wastewater. The wastewater treatment facility will be expanded to accommodate 9 MGD. Six MGD of treated effluent will continue to be discharged to Spring Creek, while the remaining 3MGD will be treated up to and beyond Safe Drinking Water Act (SDWA) standards by use of microfiltration and reverse osmosis. After this extensive treatment, this drinking water quality effluent can be considered reuse water. The reuse water will be conveyed around the southern and eastern edges of UAJA's service area to a stream augmentation area on Slab Cabin Run, a tributary of Spring Creek which has become flow deficient due to development activities. The water transmission line will be routed near industrial areas, golf courses, and agricultural zones so that these entities will be able to withdraw reuse water for non-potable purposes.

An important component of producing water that meets drinking water standards is removal of nitrogen. The existing plant at UAJA converts ammonia-nitrogen to nitrate-nitrogen, but it was not designed with the capability of converting nitrate-nitrogen to nitrogen gas on a consistent basis. The BioGuide technology and the pilot project have become important tools in the planning for plant expansion as it relates to total nitrogen removal.

Chapter 3.0 BIOGUIDE TECHNOLOGY

BioGuide is an on-line, real time process monitoring and control system for biological treatment processes. Comprised of Biological Activity Meters (computer controlled sampling devices) and the BioGuide Process Management System, BioGuide can provide critical information about wastewater treatment operation. The BioGuide system enables a direct assessment of the biological activity within a treatment process. It does not measure surrogate activity, but the metabolic activity of the microbes themselves. Installed in the bioreactor where nutrient removal is achieved, a Biological Activity Meter (BAM) captures a sample of mixed liquor, and monitors nutrient removal within the sample chamber with various analyzers. The information gathered by these analyzers is fed into the Process Management System and converted to usable process parameters.

Two important parameters determined by the BioGuide system are Nitrification Time (NT) and Denitrification Time (DNT). The NT is the required time to complete the nitrification process under ambient conditions in the reactor basin. The DNT, correspondingly, is the time required to complete the denitrification process. The BAM units capture samples, analyze the nitrification or denitrification capacity of the sample, and convert that information to time. Comparing these values to the hydraulic retention time (HRT) of the reactor enables the user to optimize the aeration basin by attempting to achieve equal HRT and NT. Maximizing this relationship allows for full utilization of the aeration basin's capacity to remove nutrients.

Chapter 4.0 IMPLEMENTATION OF FULL-SCALE PROJECT

4.1 First Quarter Report- Quarter Ending 9/30/98

A list of work elements and completion schedule for each element is delineated in the agreement for technical services entered into by UAJA and DEP. Please refer to Appendix #1. Each quarterly report addresses the status of these work elements as well as providing an analysis of the financial status of the project.

The first quarterly report encompasses only about 40 days of work. Engineers from BioChem Technology visited UAJA on August 24, 1998 to discuss monitoring protocol. Locations for instruments and data acquisition computers were chosen. Plans were made to conduct a 24-hour intensive sampling of the treatment units. This information would be used to calibrate and correlate the on-line instruments. Equipment was delivered to UAJA and it was installed on September 3 and 4, 1998. Data began collecting immediately. On September 11, 1998, instrument locations were refined based upon the data generated to date. Work began on determining the best way to achieve aeration control for the reactors at UAJA. The manufacturer of the existing aeration blowers at UAJA were contacted to discuss retrofitting the units with a variable speed drives (VSD). Discussions were initiated with Herbert, Rowland and Grubic, Inc (HRG) to review the possibility of VSD installation. Appendix 2 provides the entire First Quarterly Report.

4.2 Second Quarter Report – Quarter Ending 12/31/98

Purchase of a VSD for the aeration blowers remained under review. UAJA staff along with HRG engineers conducted several site visits to see this type of control first hand. Several problems were identified and were under scrutiny. A 24-hour intensive sampling and analysis session was conducted in October 1998. This data was used to confirm instrument results. During this quarter plant personnel were trained in maintenance of the instruments and a maintenance schedule was developed. Data collection continued for the entire three months. This data was used as a warm weather baseline for performance of the plant. The work confirmed that the plant has excellent ammonia nitrogen and phosphorus removal. The data indicates that at wastewater temperatures greater than 19 degrees C, an average of 29 percent of the plant tankage is idle with respect to BOD and ammonia removal. The data indicates that some denitrification or nitrate removal occurs, but in order to optimize the process a retrofit will be needed. Appendix 3 provides the entire Second Quarterly Report.

4.3 Third Quarter Report – Quarter Ending 3/31/99

Data continued to be collected during this quarter. A cold weather nitrification study was conducted to compare to the previous warm weather study. It was apparent that the nitrification rate decreases significantly during cold weather. Ammonia nitrogen breakthrough can occur if control parameters are not carefully monitored during these periods. Mixed Liquor Suspended Solids (MLSS) concentration, hydraulic retention time, and oxygen supply are some parameters that can affect nitrification.

A meeting was held on February 9, 1999 between UAJA, HRG, DEP, and BioChem Technology. All parties agreed that purchase and installation of a VSD blower could not be completed before the end of the contract. An alternative automatic aeration control strategy was discussed and agreed upon by all present. This proposal involves installation of air flow meters and modulating butterfly valves on each aeration unit as well as an air pressure transmitter to monitor air pressure in the system. BioChem agreed to update their instruments to measure oxygen uptake rate (OUR). The OUR will be used to pace the aeration control. The estimated cost for this construction was $82,000.00. The project manual and bid contract were provided in the Third Quarterly Report. Appendix 4 provides the entire Third Quarterly Report.

4.4 Fourth Quarter Report – Quarter Ending 6/30/99

This quarter the operators have been making manual adjustments on air output from the blowers based upon the performance of the reactors as measured by the instruments. Significant reductions in air supplied were achieved. More precise aeration adjustments will be possible when the automatic control strategy is in place.

The Aeration Control Modification contract was advertised and bid. Optimum Controls Corporation of Reading, Pennsylvania was the successful bidder for this project with a bid of $94,628.00. The bid advertisement, bid tabulation, and notice to proceed are contained in the Fourth Quarterly Report. The Fourth Quarterly Report is provided as Appendix #5.

4.5 Activity After 6/30/99

Mechanical construction of aeration control on each of the two aeration units has been completed. Modulating butterfly valves, flow straighteners, and air flow meters have been installed on each unit. BioChem Technology engineers have been working to calibrate the new flow meters to provide accurate Oxygen Uptake Rates (OUR) and SCFM requirements. This work is on-going. Automation of the modulating valves is not complete. This work is expected to be finished by October 15, 1999. Operators are trimming the air flow to each unit manually using the new flow meters, information provided by BioGuide, and the modulating valves.

Chapter 5.0 RESULTS

5.1 Expansion Alternatives – Design Issues

Two different alternate designs were developed to compare the success of the BioChem Technology equipment, as it would relate to the expansion of the UAJA facility for Biological Nitrogen Removal (BNR). The first design without the data developed by the BioChem Technology equipment, and without the BioChem Technology control will be called our "conventional" design. This design is based on the application of empirical process models developed around the A2/O patent. The alternative design incorporating the BioChem Technology equipment and controls is presented in contrast to the "conventional" design. Both options utilize the same biological processes in the same sequence. Two large differences between the two designs occur. They are that the aeration requirements for the "conventional" design are somewhat higher than the "BioChem" design, and that the tank volumes are also somewhat higher in the "conventional" design than in the "BioChem" design.

The University Area Joint Authority currently utilizes a separate stage activated sludge process. The general basis of this process loosely follows the proprietary A/O process developed by Air Products, Inc. and currently owned by Kruger, Inc. The process uses a series of Anaerobic Cells (three to be exact) in series with mixing and Return Activated Sludge contact to establish a biological system which stresses the biological population in the Mixed Liquor. These conditions facilitate the release of certain enzymes, which later under Aerobic conditions allow for the luxury biological uptake of Phosphorous, which is one of UAJA's targeted pollutants.

5.1.1 "Conventional Design"

With the anticipated upgrade of the UAJA, removal of Ammonia and Total Nitrogen will be required. The mechanisms which provide for the removal of Total Nitrogen are similar to the A/O process and utilize a series of Anaerobic cells (3 total), followed by Anoxic cells (3 total), followed by Aerobic Cells (4 total). This process is commonly referred to as the A2/O process. This sequence of the Anoxic and Aerobic cells is critical to the success of the A2/O process, as the Anoxic reaction typically requires a source of carbon during the biological conversion of Nitrate to Nitrogen gas. By placing these Anoxic cells prior to the aerobic cells (which provide for the reduction of the carbon bearing BOD compounds), the A2/O process gains the advantage of avoiding an external source of carbon. In addition, there is a large internal recycle between the Anoxic and Aerobic cells to return the once treated water as the Aerobic Cells also cause the reduction of Ammonia to Nitrogen Compounds which require treatment. The overall process design is therefore based on analytical data developed for the site, combined with empirical results to quantify the proper detention times and recycle rates. This then achieves the optimum balance of recycle, tank volume, and aeration, which reduces the largest amount of all pollutants (BOD, Ammonia, Total Nitrogen, and Phosphorus).
In general it is anticipated that 1 to 2.5 hours of Anaerobic detention time is necessary, combined with 2.5 to 3.0 hours of Anoxic detention time, and 6 to 9 hours of Aerobic detention time. The Preliminary Design of the resulting 4.8-MGD A2/O process is then based on the following loading information:

TABLE 1
Primary Clarifier Effluent

Q	4.80	mgd		
BOD	7646	lbs/d	191.0	mg/l
TSS	6605	lbs/d	165.0	mg/l
VSS	4404	lbs/d	110.0	mg/l
nVSS	2202	lbs/d	55.0	mg/l
NH3	921	lbs/d	23.0	mg/l
TKN	1841	lbs/d	46.0	mg/l
P	260	lbs/d	6.5	mg/l

TABLE 2
Return Activated Sludge

Q	1.44	mgd			Notes:	ADF	4.80	mgd
BOD	0	lbs/d	0.0	mg/l		RAS	30.0	percent
TSS	90139	lbs/d	7500.0	mg/l		Concentration	0.75	percent
VSS	69407	lbs/d	5775.0	mg/l		MLSS Volatile	77	percent
nVSS	20732	lbs/d	1725.0	mg/l				
NH3	12	lbs/d	1.0	mg/l				
TKN	12	lbs/d	1.0	mg/l				
P	120	lbs/d	10.0	mg/l				

The existing tanks are configured as follows:

TABLE 3
Existing Tank Information

Zones	Depth	SA (sqft)	V (cft)	V (gal)	Notes
1a	15.0	536	8,034	60,093	24 degrees of outside ring
1b	15.0	536	8,034	60,093	24 degrees of outside ring
1c	15.0	536	8,034	60,093	24 degrees of outside ring
2	15.0	1674	25,106	187,791	75 degrees of outside ring
3	15.0	3013	45,190	338,024	135 degrees of outside ring
4	15.0	1741	26,110	195,303	78 degrees of outside ring
5	10.0	3739	37,393	279,698	inner circle
Total			315,801	2,362,190	

Then preliminary tank sizing would be as follows:

TABLE 4
Anaerobic Tanks Design

Design for	1	To	2.5	hours	Detention Time
NOTE: Basis is forward flow					
Volume	200,000	gallons min			
	500,000	gallons max	Say	500,000	Gallons
Ignoring VSS production the F/M Ratio is:					
F/M	MLSS				
1.28	1000				
0.64	2000				
0.43	3000				
0.32	4000	**Want to be in this range**			
0.26	5000				

TABLE 5
Anoxic Tanks Design

Design for	2.5	to	3	hours	Detention Time
NOTE: Basis is forward flow					
Volume	500,000	gallons min			
	600,000	gallons max	Say	600,000	Gallons
Ignoring VSS production the F/M Ratio is:					
F/M	MLSS				
1.07	1000				
0.53	2000				
0.36	3000				
0.27	4000	**Want to be in this range**			
0.21	5000				

TABLE 6
Aerobic Tanks Design

Design for	6		9	hours	Detention Time
NOTE: Basis is forward flow					
Volume	1,200,000	gallons min			
	1,800,000	gallons max	Say	1,800,000	Gallons
Ignoring VSS production the F/M Ratio is:					
F/M	MLSS				
0.51	1000				
0.25	2000				
0.17	3000				
0.13	4000	**Want to be in this range**			
0.10	5000				

- Total Volume in Anaerobic and Anoxic - 1,100,000 Gallons
- Total Volume in Oxic - 1,800,000 Gallons
- Detention Time in Anaerobic and Anoxic - 5.50 Hours
- Detention Time in Oxic - 9.00 Hours
- F/M in Anaerobic & Anoxic Tanks @4000 mg/l - 0.21 based on Raw BOD
- F/M in Oxic Tanks @4000 mg/l - 0.13 based on Raw BOD
- Overall F/M @4000 mg/l - 0.08 based on Raw BOD
- Note: Need an internal recycle of approximately 100% between Anoxic and Aerobic Tanks
- See similar design parameters for similar A2O plants, MOP 8 Fig 15.12
- Calculate the RAS Rate for 4000 MLSS Concentration in Biological Tanks
- At 4000 mg/l the pounds of TSS is 96,744

Aeration Tank Influent		**RAS**		**Concentration**		
4.8	mgd	1.44	mgd			
7,646	lbs BOD / d	0	lbs BOD / d	0	mg/l	
6,605	lbs TSS / d	90,139	lbs TSS / d	7,500	mg/l	0.75 percent

TABLE 7
Oxygen Demand Calculations

The oxygen demand is then calculated using the following:

		BOD			Ammonia		
SOR	=	1.50	7646	+	4.60	921	
SOR	=	15,705					

Alpha	0.7	Elev	1000	ft above sea			
Beta	0.9						
Temp	5	Theta	0.700649232				
P msl	29.92						
P	28.87						
C sat T	12.78						
C sat 20	9.09						
DO	3						
SOR/AOR	0.311	For a temperature of		5	Degrees C		

Alpha	0.7	Elev	1000	ft above sea			
Beta	0.9						
Temp	25	Theta	1.125899907				
P msl	29.92						
P	28.87						
C sat T	8.26						
C sat 20	9.09						
DO	3						
SOR/AOR	0.398	For a temperature of		25	Degrees C		

Therefore use worse case, 5 degrees C.							
SOR	50,531						
Oxygen Transfer							
Assume	1.50%	Per foot submergence			Diffusers depth		13.5
OTE	20.25%						
Convert to SCFM							
0.0173	pounds of Oxygen per SCFM						
SCFM	10017						

New pilot testing at the Tallahassee Florida plant has also shown that additional control and optimization have resulted from the application of a small second stage Anoxic/Aerobic set of cells at the end of the biological process. It is this general basis around which an upgraded UAJA would be designed. So using the preliminary tank sizing above, the aeration tanks would be configured as follows:

TABLE 8
Tank Sizing

Tank Sizing	Target - Total		per Train		# of Cells	per Cell	
Volume of Anaerobic	500,000	gallons	250,000	gallons	3	83,333	gallons
Volume of Anoxic	600,000	gallons	300,000	gallons	3	100,000	gallons
Volume of Aerobic	1,800,000	gallons	900,000	gallons	4	225,000	gallons

Design Issues:
Want to maintain a similar inlet flow path to save the influent splitter box.
Want to use the interior section which is only 10 feet deep for one of the non-aerated cells (either Aneaerobic or Anoxic).
Use as many of the Old Contact Stabilization Tank Walls given the presence of rebar and structural support.
Use as many of the Barrier Walls as possible to save construction cost.

Existing Cells	Volume				
Anaerobic 1a	60,093	gallons		Use as Anaerobic or Anoxic	
Anaerobic 1b	60,093	gallons		Use as Anaerobic or Anoxic	
Anaerobic 1c	60,093	gallons		Use as Anaerobic or Anoxic	
Aerobic 2	187,791	gallons		Use as Aerobic	
Aerobic 3	338,024	gallons		Use as Aerobic	
Aerobic 4	195,303	gallons		Use as Aerobic	
Aerobic 5	279,698	gallons	* Shallow	Use as Anaerobic or Anoxic	

Ext Anaerobic or Anoxic	459,977	gallons	Revise the Tank Sizing & Provide Second Stage Treatment

Ext Aerobic	721,118	gallons	Provide Additional Tankage

New Aerobic	178,882	gallons

Provide an Additional Anoxic and Aerobic Cell for Second Stage Treatment					
Extra Anoxic	180,000	gallons			
Extra Aerobic	280,000	gallons			
Total New Tankage	638,882	gallons			

Assume Two Tanks					
therefore	319441	gallons			
or	42706	cubic ft			
Assume 15 foot SWD	2847	square ft			

Assume l:w ration of 2:1				
Length	75		Use common wall tanks	
Width	38			75 x 75 square

THEREFORE:							
Cell Ana 1	90,139	gallons					
Cell Ana 2	90,139	gallons					Per

Cell Ana 3	67,867	gallons		Total	248,145	gallons	Train
					496,290	gallons	

Cell Ano 1	71,982	gallons					
Cell Ano 2	67,867	gallons					Per
Cell Ano 3	71,982	gallons		Total	211,831	gallons	Train
					423,662	gallons	
Cell A 1	187,791	gallons					
Cell A 2	338,024	gallons					
Cell A 3	195,303	gallons					Per
Cell A 4	90,648	gallons		Total	811,766	gallons	Train
					1,623,532	gallons	
Cell Sec Ano 1	80,000	gallons					
Cell Sec A 1	140,000	gallons					
	Volume per Train		Volume both Trains				
	1,491,742	gallons	2,983,484	gallons			

Based on these calculations a preliminary layout was developed and is shown in Figure 3.

5.1.2 “BioChem” Design

The BioChem system allows the use of the existing tanks and controls the aeration within the existing tanks to provide removal of BOD, Ammonia, Total Nitrogen and Phosphorus. Based on the successful operation of the BioChem system to date, 29 percent of the existing aerobic tankage would not be needed for the conversion. This would result in a reduction of the overall additional tanks to be constructed in association with an upgrade to the UAJA facility for a design flow of 4.8 MGD. Several systems would need to be expanded or developed to allow ongoing operation of the BioGuide system.

This design is purely empirical in nature and is based on the successful operation at UAJA. There are many common items that are ignored in both designs; including, the conversion from manual control on the aeration blowers to Variable Speed Drives with feedback control, replacement of the existing blowers which are twenty years old, modifications to the existing blower room to meet new codes, and improvements/repairs to the existing tanks. The BioGuide design would incorporate these items with the following list of improvements specific to its biological process:

- Installation of BAM units
- Installation of Anoxic probes
- Installation of feedback control and computer operation systems associated with the BAM and Anoxic Probes
- Forward feed control from the raw influent stream to allow for preparatory trim
- Automatic Air Flow Control Valves on the individual aeration headers into the Aerobic cells
- Construction of 100,000 gallons of additional tank volume in a common wall configuration.

It should be understood that the BioGuide basis of design allows for the greater optimization of the various biological reactions, which are occurring within the different stages of the bioreactors. It is this higher order of control, which results in savings associated with reductions in extra tanks and blowers.

5.2 Capital Cost Savings

The total cost of an expansion of the Biological System using the "Conventional" design techniques and based on the application of an A2/O process would be $1,699,000 ignoring common components. The estimated cost to apply the "BioChem" design on a full scale for long term operation is estimated to be $1,464,000. The estimated cost of the "Conventional" Design is presented in Table 9. The "BioChem" Design is presented in Table 10. These estimates exclude costs associated with common items including the replacement of the four existing blowers have exceeded their 20-year design life. Also, not included in the cost estimate are improvements to the existing blower building, existing biological tanks, and associated equipment that are common to both upgrades. It is therefore the conclusion of this report that using the BioGuide equipment will result in a total capital cost savings of $235,000 for a 4.8-MGD plant upgrade. This equates to a present worth savings of approximately $18,000 per year.

TABLE 9
"Conventional" Design Construction Cost Estimate

Description	Quantity	Unit	Unit Price	Amount
New Blowers	2	ea	$ 80,000.00	$ 160,000.00
Installation	2	Ea	$ 20,000.00	$ 40,000.00
Expansion of the Blower Bldg	1	Ls	$ 250,000.00	$ 250,000.00
Tank Excavation	3600	Cyd	$ 35.00	$ 126,000.00
Foundation	474	cyd	$ 350.00	$ 166,000.00
Walls	375	lft	$ 120.00	$ 45,000.00
Associated Structures (Railing/Stairs)	1	ls	$ 35,000.00	$ 35,000.00
Interunit Piping	900	lft	$ 100.00	$ 90,000.00
Stainless Steel Air Pipe	600	lft	$ 140.00	$ 84,000.00
Diffusers	160	ea	$ 50.00	$ 8,000.00
PVC Header Pipe	1	ls	$ 10,000.00	$ 10,000.00
Demo of Existing Barrier Walls	4	ea	$ 2,700.00	$ 10,800.00
New Barrier Walls	12	ea	$ 4,500.00	$ 54,000.00
Process Controls	1	ls	$ 160,000.00	$ 160,000.00
Anoxic Mixers	4	ea	$ 15,000.00	$ 60,000.00
			Subtotal	$ 1,298,800.00
Associated Project Costs				$ 400,000.00
TOTAL PROJECT COST				$ 1,698,800.00

TABLE 10
"BioChem" Design Construction Cost Estimate

Description	Quantity	Unit	Unit Price $	Amount $
New Blowers	1	ea	80,000.00	80,000.00
Installation	1	ea	20,000.00	20,000.00
Expansion of the Blower Bldg	1	ls	160,000.00	160,000.00
Tank Excavation	950	cyd	35.00	33,250.00
Foundation	100	cyd	350.00	35,000.00
Walls	96	lft	120.00	11,520.00
Associated Structures (Railing/Stairs)	1	ls	35,000.00	35,000.00
Interunit Piping	800	lft	100.00	80,000.00
Stainless Steel Air Pipe	540	lft	140.00	75,600.00
Diffusers	60	ea	50.00	3,000.00
PVC Header Pipe	1	ls	10,000.00	10,000.00
BAM Meters	6	ea	40,000.00	240,000.00
Installation of BAM Meters	6	ea	1,000.00	6,000.00
De Nit Meters	2	ea	20,000.00	40,000.00
Installation of De Nit Meters	2	ea	1,000.00	2,000.00
Feedback Control System	1	ls	60,000.00	60,000.00
Forward Feed Instruments (Flow, Temp, BOD, N)	1	ls	15,000.00	15,000.00
Installation	1	ls	10,000.00	10,000.00
Anoxic Mixers	4	ea	15,000.00	60,000.00
Forward Feed Control System	1	ls	75,000.00	75,000.00
Automatic Flow Valves	8	ea	4,500.00	36,000.00
			Subtotal	1,084,370.00
Associated Project Costs				380,000.00
TOTAL PROJECT COST				$1,464,370.00

5.3 Operating Cost Analysis

The only difference per se between the operating cost of the two alternative designs is the additional installed blowers. Based on the operating data from 1999 compared with prior data, UAJA has experienced a 12.9% reduction in blower demand. Therefore it is assumed that 12.9% of the total design of 1000 HP of aeration blowers could be saved. This equates to an annual cost savings of approximately $24,000 at current electrical prices.

5.4 Present Worth Savings

The total annualized present worth savings of using the BioGuide process in lieu of a conventional design (the A2/O process) is estimated to be $42,000.

5.5 Energy Analysis

Since April 1999 treatment plant operators have been making manual adjustments to the intake of the centrifugal aeration blowers based upon the nitrification information provided by the system. Blower outputs recorded as SCFM were tracked for this period and compared to blower output from the same period the previous year, before BioGuide control was available. Operators were able to use significantly less air to achieve the same nitrification results. Figure 5 compares blower output for the two periods. Electrical costs for the two periods were also compared. Less money was spent on electricity during the BioGuide project. Figure 6 shows this comparison.

5.6 Process Monitoring

The BioGuide system has proven to be a valuable tool in day to day process monitoring. Plant operators can look at BioGuide output over any time period chosen. The operator can look at data collected the previous night to see and adjust for diurnal trends in nitrification or denitrification efficiency. The system can also identify possible shock loads of harmful material to the treatment facility. Trend analysis can help optimize treatment efficiency over time. Additionally, the continuous nature of the BioGuide monitoring allows greater confidence and flexibility in making operational decisions.

Chapter 6.0 CONCLUSIONS

The BioChem Control system allows the plant to operate at its most efficient capability. However, the control system does not effect a fundamental change in the over-riding biological reactions. Therefore the cost savings associated with the BioGuide system is primarily related to operating cost savings from the more efficient use of electrical power associated with the aeration system.

The BioChem Control system affords wastewater facilities with an addition method to upgrade and expand their capacity. In cases where there is not a desirable to build additional tanks or the capability to accommodate excess flexibility does not exist, the BioChem system can be a cost-effective solution to meet the needs of a Wastewater Facility.

The BioChem Technologies equipment is reliable, the computer input and programming is user friendly and clear, and the continuous monitoring handy. The fact that these systems are reliable and available provides the wastewater treatment plant operator with a tool that will have significant impacts on the ability to meet and exceed effluent quality standards.

Chapter 7.0 RECOMMENDATIONS

The second phase of the BioChem Technology pilot program should be implemented. As part of the second phase, an internal recycle should be added along with mixing so that a complete BNR reaction could be studied.

Additional operation data is needed to establish if there is a drop in excess tank capacity during the winter months. Also, allowing the automated system to run for an additional time period will allow UAJA to better establish the overall reliability of the system.

During the period of operation, the UAJA facility has not experienced significant shock loadings or large operational variations. Additional testing under these extremes should be considered.