ST. GEORGE REGIONAL WATER RECLAMATION FACILITY

EXPANSION MASTER PLAN

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Prepared for:

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INTRODUCTION

The City of St. George, Utah (City) desires to expand the capacity of the St. George Regional Water Reclamation Facility (SGRWRF). The SGRWRF serves the wastewater treatment needs of the City and the surrounding communities of Ivins, Santa Clara, and Washington. The City has retained Bowen, Collins & Associates, Inc. (BC&A) to perform a study to identify viable options for the expansion of wastewater treatment capacity at the SGRWRF. The study evaluates growth projections to the year 2030. The study provides recommendations to assist the City in selecting future treatment processes and in determining the scope and scale of expansion for the SGRWRF. The process evaluations will serve as the basis for future process selection, design and construction activities. Figure 1-1 shows the existing plant layout and its associated facilities.

HISTORICAL EVALUATION

Historical Regulatory Summary

In 1972 the United States Congress passed the Clean Water Act (CWA). (Acronyms and abbreviations used in this report are listed in Appendix A.) The principle objective of the CWA was to reduce discharges of pollution through regulation and more technologically advanced treatment standards (Salzman & Thompson, 2003). (References cited in this report are listed in Appendix B.) The National Pollutant Discharge Elimination System (NPDES) was the vehicle used by the Congress to implement the system. As it applies to publicly owned treatment works (POTW) such as the SGRWRF, the CWA provides authority to qualified states (Utah is qualified) to issue permits for point source pollution. The permits are good for five years and renewable thereafter, subject to modification. Effluent discharges must be sampled, monitored and reported on a regular basis.

In order to ensure water pollution control, the CWA retained water quality standards as a safety net to the technology-based effluent limitations. Section 303 of the CWA established a multi-step regulatory process for ensuring pollution control and water quality enhancement. The process is described as follows: First, each state must designate specific beneficial uses for each of its waterways, Second, states must determine water quality standards needed to support the designated uses, Third, states must identify quality limited waterways – those waterways where technology-based effluent limitations are insufficient to attain water quality standards (Salzman & Thompson, 2003). Under section 303(d) of the CWA, implemented in 2000, states must determine the total maximum daily load (TMDL) of pollutants that can be discharged into the impaired waterway and still achieve "applicable water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The TMDL analysis performed on the Virgin River identified total dissolved solids (TDS) and temperature as impairments to water quality standards for the beneficial use designations of the State of Utah.

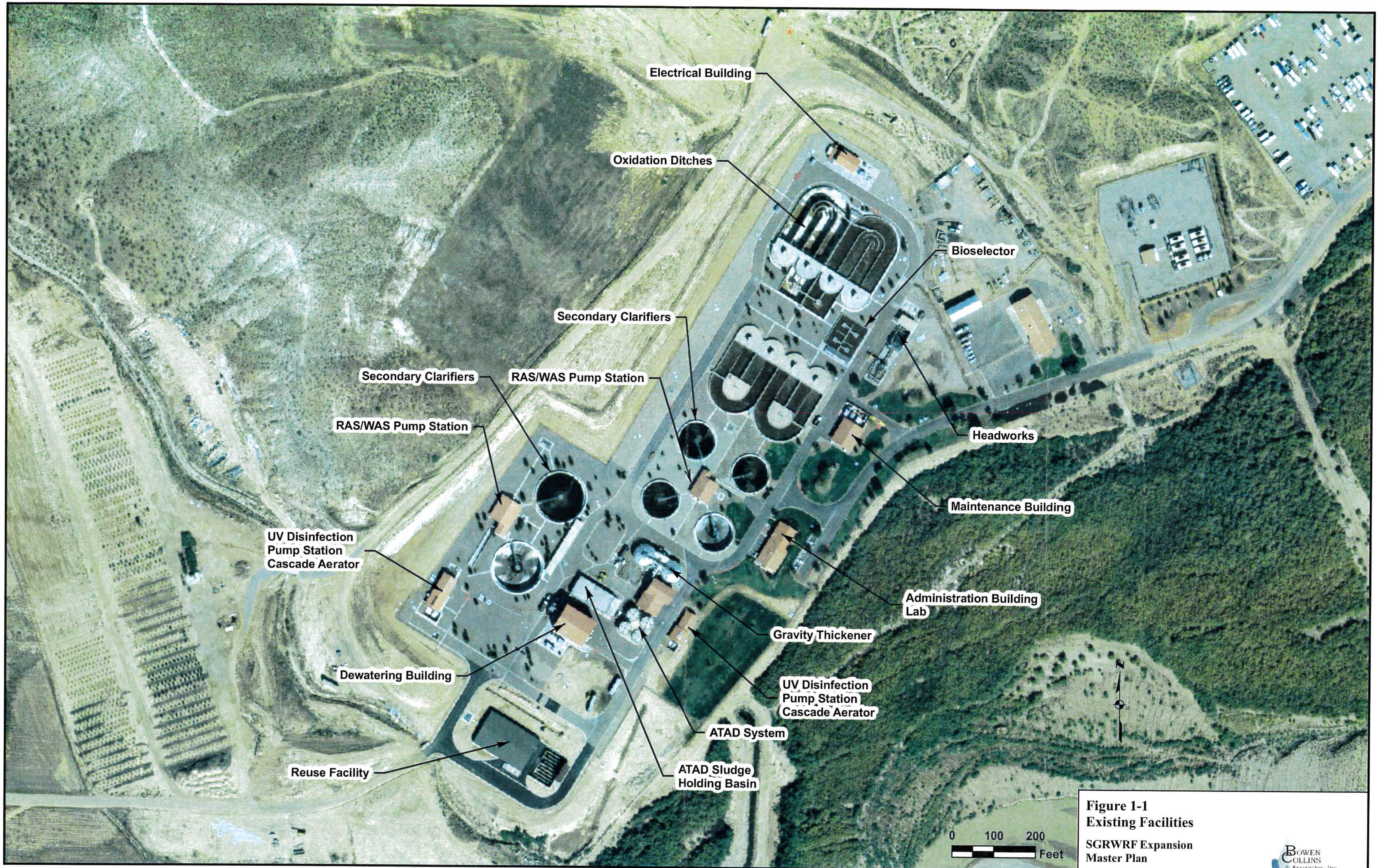

Figure 1-1
Existing Facilities

SGRWRF Expansion
Master Plan

Bowen Collins & Associates, Inc.
Consulting Engineers

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The Water Quality Act of 1987 (WQA), an amendment to the CWA, provided for changes in permitting and added penalties for permit violations. The WQA amended the solids control aspect of wastewater treatment by emphasizing identification and regulation of toxic pollutants in sewage sludge (Metcalf & Eddy, 2003).

"The Standards for the Use or Disposal of Sewage Sludge" Environmental Protection Agency's Code of Federal Regulation (CFR) title 40, part 503, (U.S. EPA, 1994) established conditions for the use or disposal of biosolids from wastewater treatment plants. Limitations were established for contaminants, pathogen content, and vector attraction. Biosolids are classified into two divisions: Class B and Class A. Class B biosolid pathogens have been reduced to levels that are unlikely to pose a threat to public health and the environment under the conditions of CFR 40 part 503. Biosolids that have been processed to Class A standards have reduced pathogen levels (including enteric viruses, pathogenic bacteria and viable helminth ova) to below current detectable levels (Metcalf & Eddy, 2003). Biosolids which do not receive treatment for removal of pathogens are considered unclassified (i.e. screenings).

Plant Summary (1988 – 2007)

Each POTW which discharges into the waters of the State of Utah receives a permit from the Utah Division of Water Quality (DWQ). The DWQ reviews the discharge application for each facility and issues a permit which defines effluent requirements. With each permit the DWQ issues a Statement of Basis, which provides a summary of the facility and a description of the limitations placed on effluent discharges. The Statement of Basis facility description for the SGRWRF is included as follows:

> "Construction of the SGWRF began in 1988 and was completed in 1990. The SGWRF began discharging in 1990 with a 5-million gallon per day (mgd) design capacity, was upgraded in 1994 to an 8.5 mgd capacity, and the latest upgrade was completed in 1999 bringing the plant design capacity to an average daily flow of 17 mgd.
>
> Treatment facilities consist of four 54-inch influent screw pumps, two submersible pumps, two mechanical bar screens, two air lift grit chambers, one bio-selector, four oxidation ditches, six clarifiers, two low pressure ultraviolet disinfection systems, one medium pressure ultraviolet disinfection system and two cascade aeration systems. Sludge is currently wasted from the clarifiers into two gravity thickeners. The sludge is then transferred to the post autothermal thermophilic aerobic digestion (ATAD) holding tank and then pumped into the solids building feeding two centrifuges for dewatering purposes. The sludge is transported to the county landfill for composting, which produces Class A biosolids.
>
> The treatment plant has two discharge points, a 27-inch pipe and a 48-inch pipe located adjacent to each other. Both pipes discharge on the southeast side of the treatment plant, the north bank of the Virgin River, approximately one and one half miles (1.5 miles) southwest of the I-15 bridge across the Virgin River, Washington County, Utah at approximate latitude 37°02'16" N and longitude 113°37'50" W with outfall STORET number 495006." (Utah Division of Water Quality, 2006)."

Consistent plant sampling and operating data records were first kept and preserved in 1990. The average annual daily wastewater flow for that year was 3.63 mgd. Flows continued to grow steadily through 1997 when they reached 7.3 mgd. Wastewater flows remained at or below approximately 7.3 mgd for the following seven years, through 2004. Population growth within the service area continued at a steady rate during this period; however, moderate drought conditions also persisted over this time.

In January 2005, the service area experienced widespread flooding. Several sewer lines were destroyed and large amounts of infiltration caused a spike in plant flows. Once repairs were made, flows moderated but remained approximately 1.4 mgd higher (8.7 mgd) for the remainder of the year. Thereafter, wastewater flows continued to increase. For 2006, the average annual flow was 8.66 mgd. Wastewater flows from January to July of 2007 averaged 9.03 mgd. Treatment of these flows requires the use of three of the four oxidation ditches. The fourth oxidation ditch will remain unused until flows reach 75 percent of plant capacity, or approximately 12.75 mgd.

Regulated Constituents Summary

Five day biochemical oxygen demand (BOD_5), total suspended solids (TSS), ammonia (NH_3) and coli-forms are all monitored at the SGRWRF. Monitoring of silver is also required although sampling frequency has been reduced from monthly to quarterly due to compliance history. Oil and grease are addressed through the SGRWRF pretreatment program. Whole effluent toxicity is monitored daily. Table 1-1 displays the current effluent discharge limits.

Table 1-1
Wastewater Effluent Discharge Limits for the SGRWRF (October 2006)

Parameter	Maximum Monthly Average	Maximum Weekly Average	Daily Minimum	Daily Maximum
BOD_5, mg/L	17.0	24.0	--	--
BOD_5 Min % Removal	85.0	--	--	--
TSS, mg/L	25.0	35.0	--	--
TSS Min 5 Removal	85.0	--	--	--
E-coli	126	158		
Dissolved Oxygen (DO)			5.5	
Ammonia, mg/L as N	3.6	--	--	12.6
WET, Acute Biomonitoring	--	--	--	Pass
Oil and Grease, mg/L	--	--	--	10
Silver, mg/L	--	--	--	0.0342
Total Dissolved Solids, mg/L	--	--	--	1916
pH, Standard Units	--	--	6.5	9

Average annual BOD_5 and TSS wastewater influent concentrations for the year 1990 were reported as 181 mg/L, and 394 milligrams per liter (mg/L) respectively. The first 8 years of sampling data contain erratic fluctuations in BOD_5 and TSS values. (This phenomena is attributed to discharges from a new industrial facility which was cited for violating its pretreatment discharge limits.) Beginning in 1999, BOD_5 and TSS data is much more consistent. Reporting of ammonia concentrations began in 2000. NH_3 has generally averaged between 20 and 25 mg/L over the past 7 years of recorded data. Concentrations for BOD_5, TSS, and NH_3 for the period from July of 2006 to July of 2007 averaged 232 mg/L, 245 mg/L, and 23 mg/L, respectively. Figures 1-2 and 1-3 illustrate average annual influent concentrations for BOD_5, TSS, and NH_3, starting with the dates that the data was first obtained through July 2007.

At an average annual daily flow of 9.14 mgd and the July 2007 wastewater constituent concentrations, the plant has exceeded 50 percent of the solids and organic design loading capacity and 55 percent of the design hydraulic loading capacity.

Figure 1-2
Historical Influent BOD_5 and TSS Concentrations

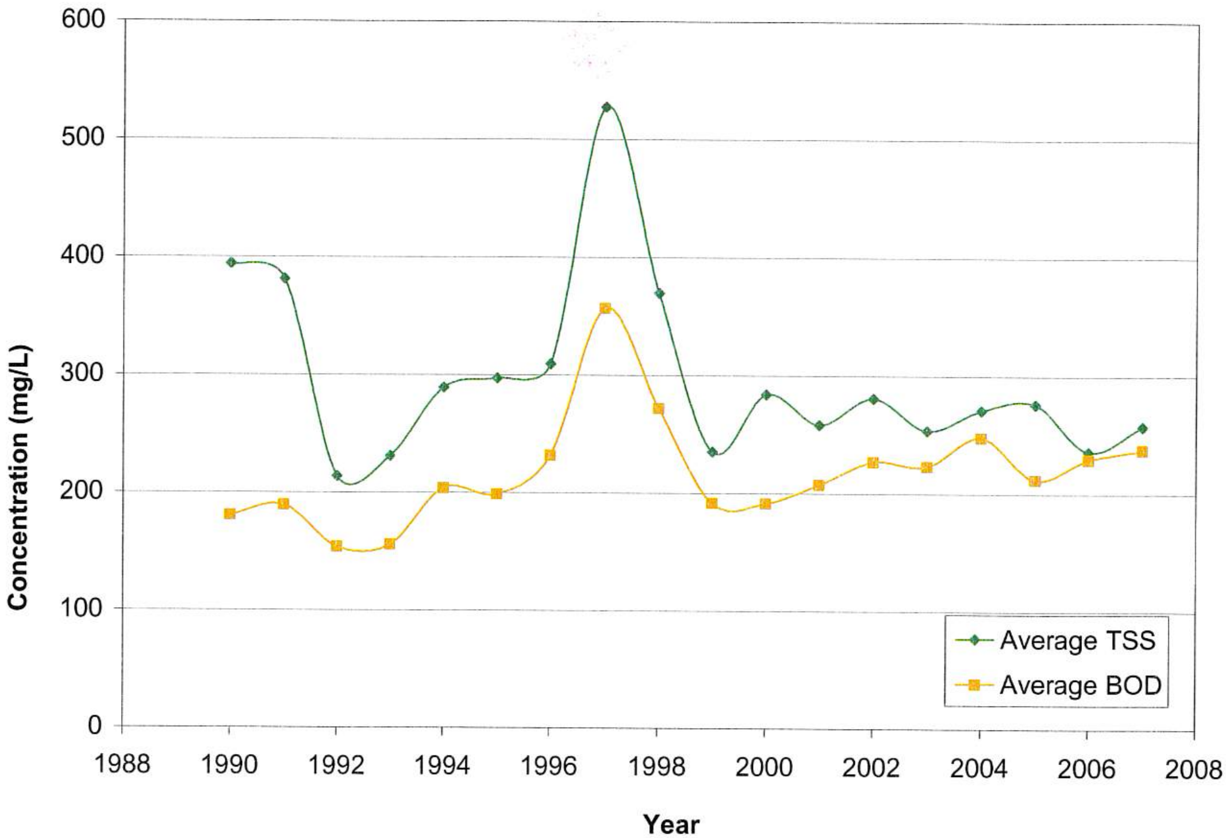
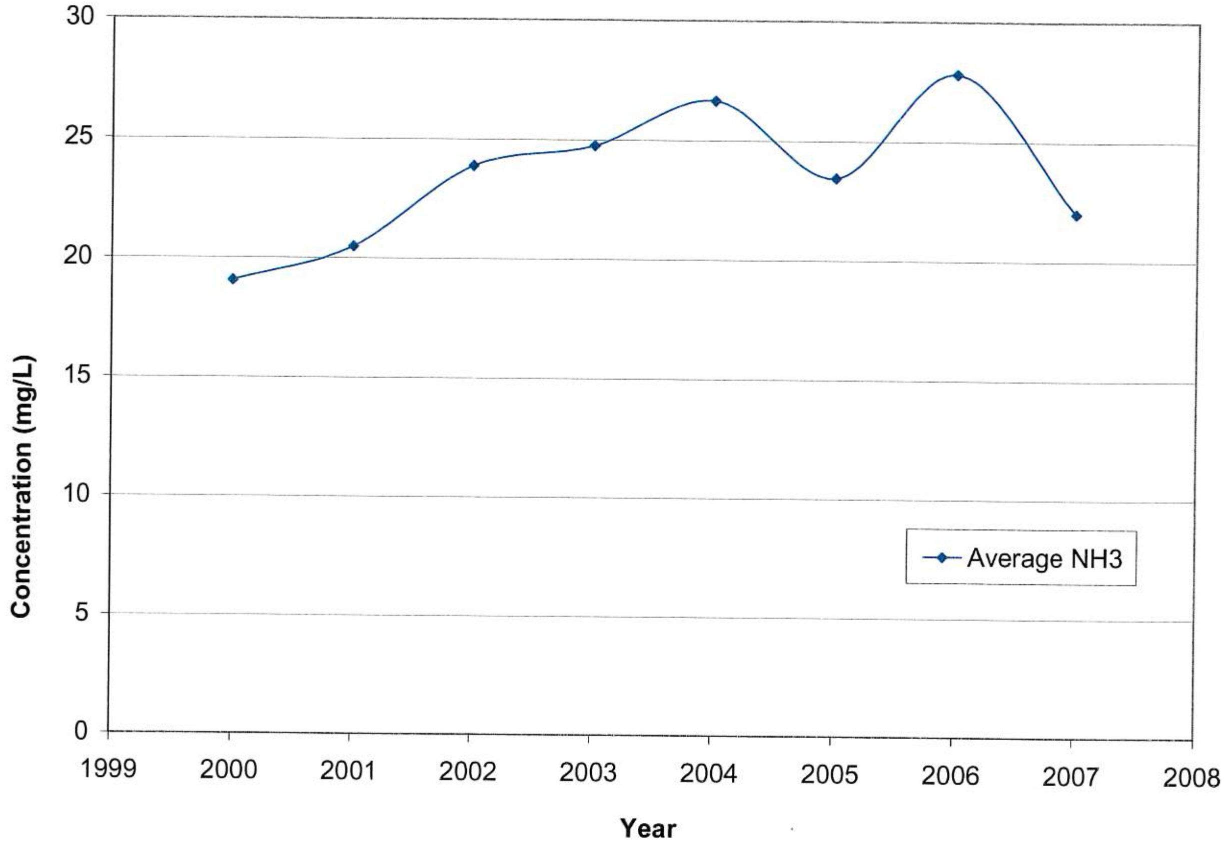


Figure 1-3
Historical Influent NH_3 Concentrations



Review of Industrial Allotments

Currently, the SGRWRF has allotted 3,650 lb/day of both BOD_5 and TSS to industrial dischargers. This allotment is spread over six current industrial users. Anticipated future industrial growth includes a paper recycling facility that is projected to produce 1,500 lbs/day of both BOD_5 and TSS. This value increases the total TSS allotment to 5,150 lbs/day. Assuming an average concentration of 250 mg/L (for both BOD_5 and TSS), the 5,150 lbs/day allotment equates to approximately 2.5 mgd of flow. In addition to current industrial users, it is anticipated that future industrial allotment will be required as Ft. Pierce Industrial Park develops and additional industry moves into the area.

Virgin River TMDL

Studies of the Virgin River have revealed high natural concentrations of TDS. Downstream of the Pah Tempe Springs the concentrations of TDS make the water undesirable for culinary use and only marginal as an irrigation supply. In order to control point sources of TDS pollution DWQ issued discharge permit limitations of 1,916 mg/L for TDS as a daily maximum load associated with the 17 mgd design capacity of the 1998 expansion. This daily maximum load equates to a total TDS load of 49,576 tons per year.

On August 16, 2007, a meeting was held with representatives from BC&A and the DWQ regarding current limitations on wastewater effluent TDS, salinity and ammonia, and potential future restrictions on phosphorus loads and effluent temperature for wastewater effluent discharges to the Virgin River. In attendance from DWQ were representatives from the TMDL section over the Virgin River, the salinity section, the outreach section, permitting, and the assistant director of DWQ. DWQ personnel stated that the SGRWRF should monitor effluent temperatures to verify that SGRWRF effluent does not exceed 28°C (82°F). (Meeting with Utah DWQ, TMDL section manager, Carl Adams, August 16, 2007.)

Current trends in nutrient (nitrogen and phosphorus) removal practiced in Utah, and elsewhere in the United States, has created concern regarding ability of the current SGRWRF process to meet future regulations. The DWQ is currently preparing to study the cost of redefining secondary treatment to include nutrient removal at all wastewater treatment facilities in the State of Utah. If the study indicates that benefits of nutrient removal at all plants, regardless of receiving water body quality, justify the retrofit costs, it is anticipated that these new standards will be implemented statewide. The SGRWRF will have completed its planning and will likely be moving towards expansion before results of this study are released. The SGRWRF effectively treats the nitrogen entering the plant and some incidental phosphorus removal does occur; however, it is recommended that accommodation be made for potential future biological phosphorus removal should the new standards be implemented.

Population Growth (1990-2006)

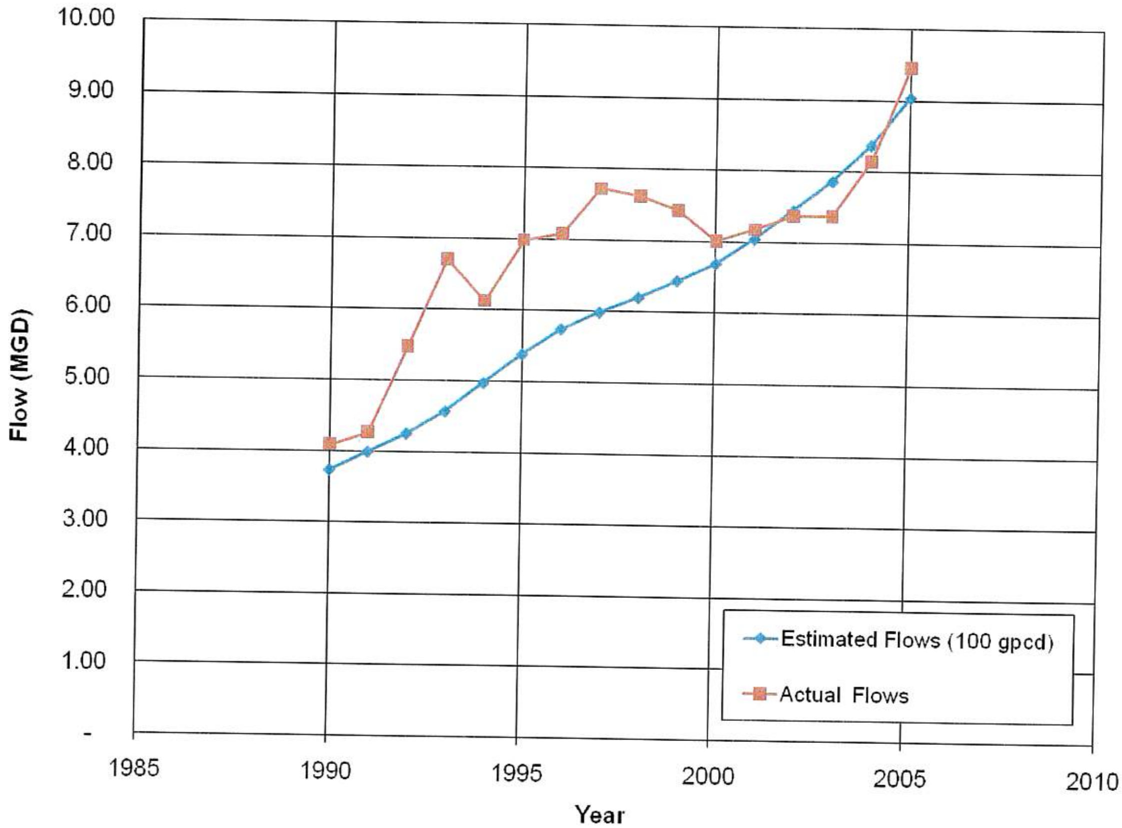
In 1990, the U.S. Census population for Washington County was 49,183 people (U.S. Census Bureau, 2000). The service area for the SGRWRF included approximately 76 percent of those households and had an estimated population of 37,379 people. During the late 1990s and continuing through 2005, Washington County experienced aggressive development and the population increased rapidly. The U.S. Census reported the 2005 population for Washington County as 118,885 people, nearly 2.5 times the 1990 population (U.S. Census Bureau, 2005). The service area for the SGRWRF saw a similar increase to 90,472. The State of Utah Governor's Office of Budget and Planning estimates the 2007 population of the communities within the service area to be 104,983.

The City and surrounding communities experience seasonal fluctuations in population due to the presence of Dixie State College, and a large itinerant retirement and vacation population. Records from the Washington County Assessor's Office show that an average of 24 percent of homes within the SGRWRF service area are secondary residences. However, a comparison of plant flows from 1990 – 2006 during winter months, when population peaks, and summer months reveals no significant increase during the peak winter months.

Flow vs. Population Growth Observations

It is common practice to assume that wastewater flows are contributed at a nominal rate of approximately 100 gallons per capita per day (gpcd). From 1990 to 2000, this contribution rate was exceeded considerably, with 1993 experiencing the highest per capita flow of 130 gpcd. From 2000 to 2007 flows were less than the nominal contribution rate with 2004 experiencing the lowest per capita flow of 88 gpcd. It is believed that a combination of drought conditions and water use conservation measures contributed to the change in rate of wastewater discharge rates from the high value occurring in 1993, to the low value in 2004. For 2005, the average contribution rate was 96 gpcd. With average flows for the year at 9.03 mgd, the per capita discharge rate currently is 86 gpcd. A comparison of population and plant flow data is shown in Figure 1-4.

Figure 1-4
Estimated vs Actual Plant Flow (1990 – 2006)



Summary of Historical Conditions

Since its initial construction in 1990, growth in wastewater flows at the SGRWRF have been characterized by two distinctly different growth periods. Initially, flows grew rapidly from 3.63 mgd to 7.31 mgd during the seven year period from 1990 to 1997. Average annual growth in wastewater flows during this period was approximately 526,000 gallons per year. During this period, there was a corresponding population increase of 22,573 people. This period was followed by a period of zero growth or decline in flows from 1997 to 2004. Flows ranged only from 7.31 mgd in 1997 to 7.38 in 2004. This period had a corresponding population increase of 23,867 people. This was followed by another period of rapid growth, from 7.38 mgd to 9.03 mgd from the end of 2004 to the present. The corresponding population increase was 21,223.

The inconsistent nature of the wastewater flow variations in comparison to the relatively steady population growth within the service area is likely explained by a combination of drought conditions beginning in 1998 and persisting through 2004, and increased awareness and water use conservation by citizens. Drought conditions would have resulted in lower ground water levels and reduced infiltration into the sewer system. The period of growth from 2004 to the present has seen a population increase similar to the two previous periods but in less than half the time. The City and the surrounding communities are currently experiencing rapid growth in both the residential and commercial sectors. It is anticipated that continued rapid growth will continue for the next several years or more.

FUTURE EVALUATION

Population Growth Projection Methods

Several mathematical methods are commonly used in projecting patterns of population growth. Arithmetic projections consider average growth rates over a specified period and produce an arithmetic mean growth rate or an average number of new persons per year entering a service area. Geometric projections consider average rates of growth over a specified period and produce an average growth rate as a percentage of the existing population.

Generally, arithmetic population growth projection methods are used where growth is slow. This type of growth is observed in small, rural towns, communities that are landlocked, approaching buildout, or otherwise limited in potential future growth. Growth that can better be described by geometric methods occurs in areas were land is readily available and economic conditions accommodate aggressive population increases. Growth in most communities falls within the envelope created by these two methods. The U.S Census Bureau, and other local government agencies use a combination of these methods in conjunction with age, race, and gender census demographic data to predict future population growth.

Recently, the City and the surrounding communities have experienced unprecedented growth. Washington County is projected to be the fastest growing county in the state from now until 2050, with an average annual growth rate of 3.9 percent (St. George Chamber, Governor's office of Budget). Favorable economic conditions and an increase in national exposure have brought aggressive residential and commercial construction to the area. Currently, the economic outlook has softened nationally; however, substantial growth has continued within the service area, albeit at a lesser rate.

For the historical period considered in this study (1990 – 2007) the service area population increased from 37,320 persons to 104,983 persons, an arithmetic mean growth rate of 3,980 persons per year and a geometric mean growth rate of 6 percent. Figure 1-5 displays the geometric and arithmetic growth curves for the SGRWRF service area from 2007 through 2030, based on historical growth rates from 1990 to 2005. In addition, population projections by the U.S Census Bureau and the Five County Association of Governments, a local entity, are also included. A regression analysis also was performed on the historical growth data to create a historical trendline curve which was projected forward to predict future growth.

Figure 1-5
Service Area Population Growth and Projections

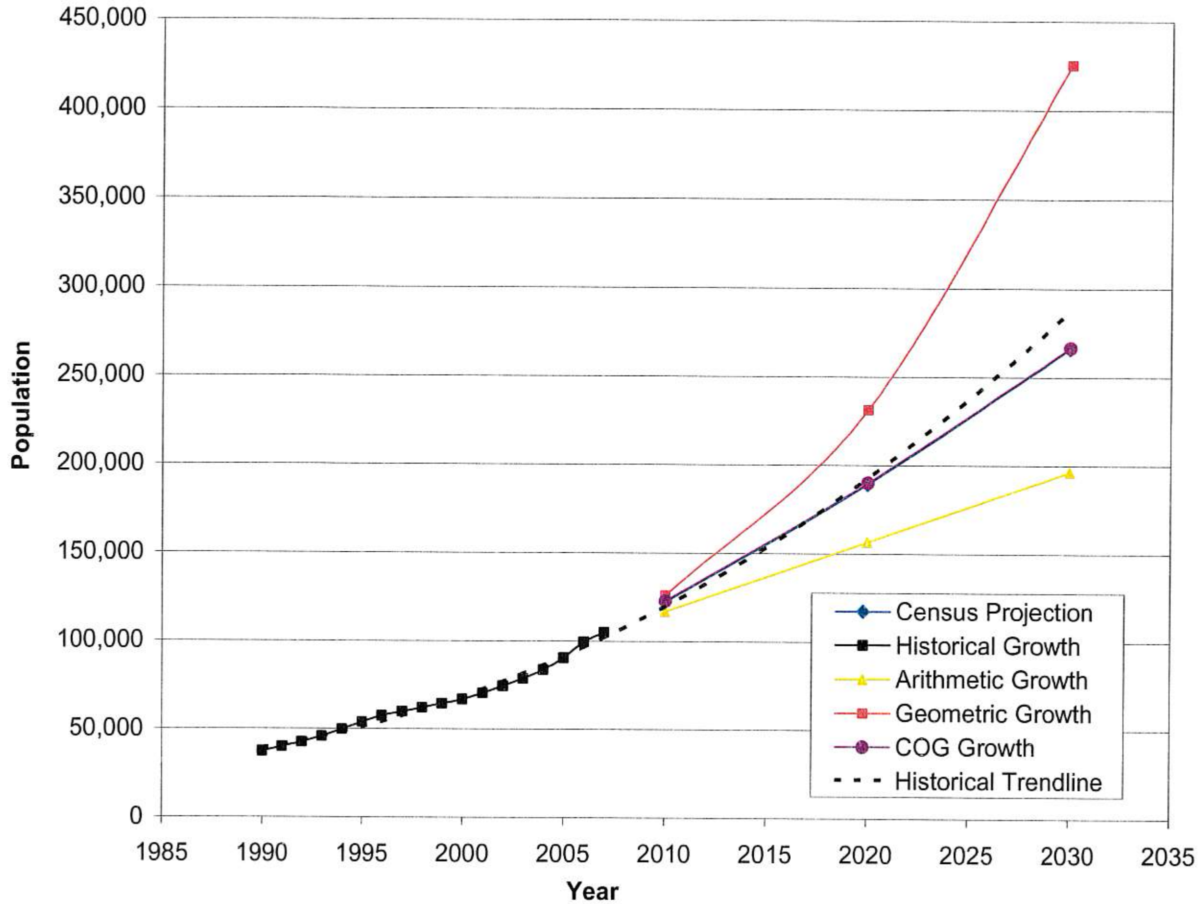


Table 1-2 shows the population values predicted by each method and the values provided by the U.S. Census Bureau and the Five County Association of Governments. Due to the similar values used by the Five County Association of Governments and the U.S. Census Bureau (less than 0.5 percent difference average) the values are indistinguishable on Figure 1-5.

Table 1-2
Population Growth Estimates for SGRWRF Service Area

Year	2010	2020	2030
Arithmetic Growth	116,924	156,725	196,527
Geometric Growth	126,004	231,530	425,431
U.S. Census Bureau	122,200	189,375	266,078
Five County Association of Governments	122,931	190,181	266,716
Historical Best Fit	119,640	192,564	287,302

Projected Population Growth Evaluation and Recommendation

Estimates by the U.S. Census Bureau for areas of rapid growth are sometimes overly conservative and usually underestimate actual growth due to a lack of understanding of local socio-economic factors. By contrast, municipalities and other local entities often overestimate population growth because they are overly optimistic concerning the same socio-economic factors. For that reason, population projections which fall somewhere in between the conservative Census Bureau estimate and local estimates are sometimes used. In this case, there is only 0.2 percent difference between the Census Bureau and the local Five County Association of Governments 2030 population projections. The historical trendline curve produced from the regression analysis provides projections that are 7 to 8 percent higher than the Census Bureau and Five County Association of Government figures.

For purposes of planning wastewater treatment capacity expansion at the SGRWRF, the values of the U.S. Census Bureau, Five County Association of Governments, and the historical trendline projection values were averaged and rounded to 275,000. This service area estimate will serve as the design population for the year 2030.

Potential Service Area Expansion

The service area which contributes flows to the SGRWRF includes St. George City, Santa Clara City, Ivins City and Washington City. The collection system extends to accommodate the Coral Canyon development in Washington City at its furthest extent. Wastewater treatment outside of the service area is performed by Ash Creek Special Service District (ACSSD) and local communities. Potential expansion opportunities exist with some of the small communities near the boundary of the current service area including Winchester Hills, Diamond Valley, and the treatment lagoons operated by ACSSD. Providing service to these small communities would not pose a significant impact to the wastewater system. However, providing wastewater treatment for ACSSD (should they decide to join the SGRWRF service area) would have significant impact. The proposed buildout population for the ACSSD is 250,000 which would result in an estimated flow increase of up to 25 mgd into the SGRWRF system.

Future Wastewater Production Rates

The range of per capita flow contributions within the service area has fluctuated from a high in 1993 of 130 gpcd to a low in 2007 of 86 gpcd. This value includes current industrial flows, but does not include outstanding industrial allotments. Currently there is an emphasis on water conservation within the service area. Water-efficient appliances have combined with higher residential lot densities and water-efficient landscaping to provide continuing declines in per capita water consumption and wastewater flow contributions. Inclusion of industrial and commercial flows will tend to increase the per capita contribution values. With a combination of increased water conservation and continued commercial and industrial growth, it is anticipated that per capita wastewater discharge rates within the service area will remain relatively steady at 85-90 gpcd.

Future Wastewater Treatment Capacity

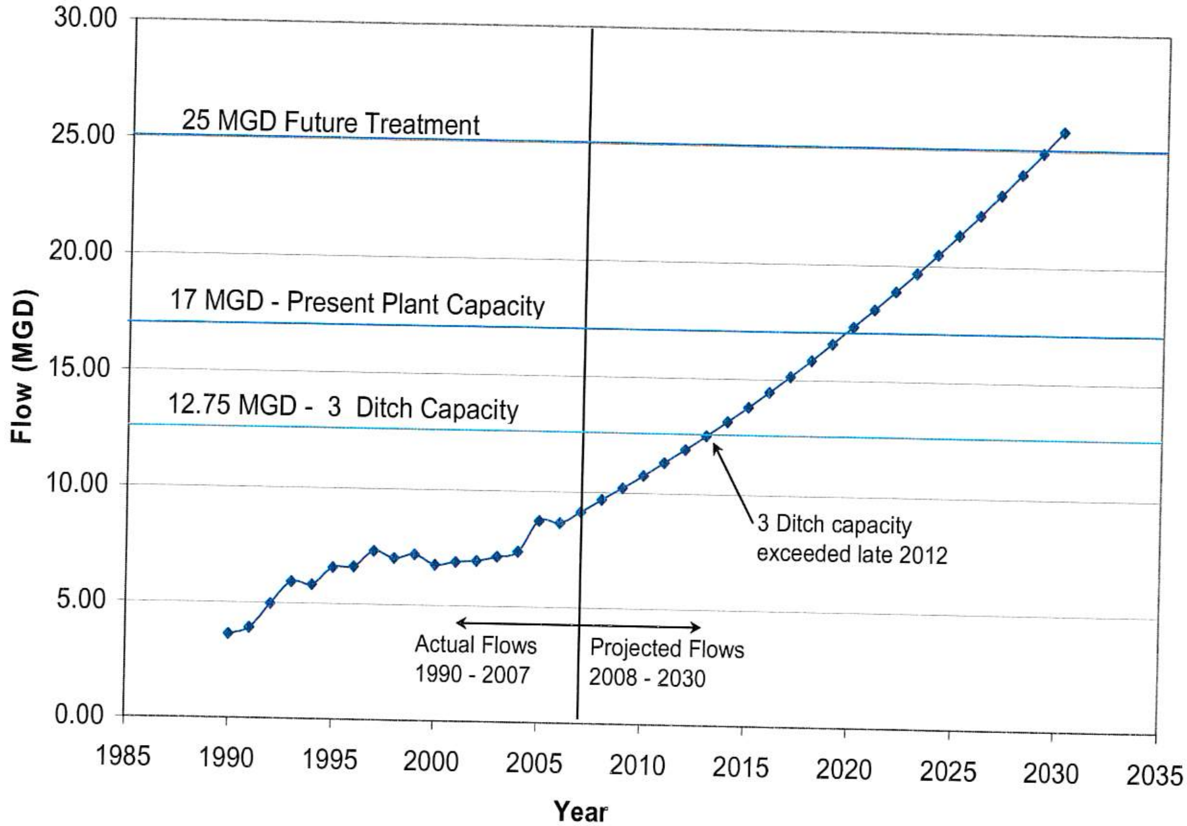
Using 90 gpcd flow production and multiplying it by the recommended population value of 275,000 people within the service area, the SGRWRF will need to be capable of treating 25 mgd as the average annual daily flow by 2030. Currently, plant capacity is 17 mgd. Therefore an additional 8 mgd of treatment capacity, (47 percent additional capacity) will need to be provided.

Annual average daily wastewater flows for 2007 have averaged 9.14 mgd. Treatment of these flows requires the use of three of the four existing oxidation ditches. The fourth ditch will remain unused until plant flows reach 75 percent plant capacity, or approximately 12.75 mgd. Based on the population projections, this flow should be reached by the end of 2012. By planning plant modifications before flows require the use of the fourth ditch, the SGRWRF will be able to make necessary process changes without adversely effecting current operations. For this reason the City has chosen to prepare this expansion master plan, and if appropriate, begin modifications before they could cause treatment process interruptions or upsets. Figure 1-6 displays actual flows from 1990 to 2007 and projected future flows from 2008 to 2030. The figure also designates the point at which plant flows are expected to surpass the 12.75 mgd level, at which time the fourth treatment ditch will need to come online.

The City staff is currently considering changing the treatment process at the SGRWRF from extended aeration to a version of staged aeration activated sludge. This modification would include installation of fine bubble diffusers in the oxidation ditches and the addition of a clarifier, return activated sludge/waste activated sludge (RAS/WAS) pumping, and solids handling capacity. Similar modifications have been successfully completed at the Henderson WRF, in Henderson, Nevada, and are also being implemented at the South Valley WRF, in West Jordan, Utah.

By installing fine bubble diffusers and modifying related facilities and systems, these plants have been able to reduce their hydraulic retention time (HRT) by as much as half, effectively doubling the treatment capacity. The City previously reduced the HRT of the SGRWRF and would not be able to enjoy a 100 percent increase in plant capacity by making these modifications. However, if the conversion from extended aeration oxidation ditch treatment to modified staged aeration allowed a reduction of the HRT to 10 hours, for example, a 38 percent increase in capacity could be realized, an addition of 6.5 mgd. That would reduce the amount of additional expansion that would need to take place to 1.5 mgd to reach 25 mgd at year 2030.

Figure 1-6
Past, Present, and Projected Future Flows and Capacities



CHAPTER 2
LIQUID TREATMENT PROCESS ALTERNATIVES

INTRODUCTION

Currently the SGRWRF uses the extended aeration activated sludge process to treat the wastewater. This process requires the use of large basins and aeration equipment to produce relatively long hydraulic and solids retention times. As described below, this is a stable and reliable process which has functioned effectively over the past 18 years. Expanding liquid treatment capacity will impact related downstream processes such as final clarification and ultraviolet disinfection. These processes are not discussed in depth because it is anticipated that the expansion would require the addition of modules similar to those already in place. Modifications, should there be any, can easily be implemented in the design process. The cost of expanding these processes was accounted for in the cost estimate of the expansion.

ALTERNATIVES

Four alternative processes were selected for evaluation. They include the following:

- Oxidation Ditch. Extended aeration activated sludge process currently employed at the SGRWRF, Timpanogos Special Service District near American Fork, Ashley Valley in Vernal, and numerous other plants in Utah.
- Modified Staged Aeration Activated Sludge. Currently being implemented in Henderson Water Reclamation Facility, Henderson, Nevada, and at the South Valley Water Reclamation Facility in West Jordan.
- Conventional Activated Sludge with Primary Clarifiers (CAS). Currently used at Central Valley Water Reclamation Facility, West Valley City.
- Membrane Bioreactor Activated Sludge. Typically used for smaller plants or where higher effluent quality is required. Plants in Hyrum, Oakley, Jordanelle Special Service District (JSSD) near Kamas, and South Valley Sewer District (SVSD) in Riverton are either operating, under construction, or being designed using this process.

These processes were selected to represent a spectrum of treatment technologies available for the City's plant that are widely used and accepted both in Utah and elsewhere. These processes are known to provide reliable and flexible treatment performance and operations. Each alternative offers differing construction and operating cost requirements to consider. Effluent quality and solids production will vary, although all are expected to meet required performance standards. Finally, each process offers other advantages and disadvantages that must be factored into the selection.

ELEMENTS COMMON TO ALL ALTERNATIVES

Each of the alternatives has a number of basic process and non-process elements that are shared in common with all the other processes, and which are similar or identical from process to process. These elements are listed as follows:

- Headworks
- Influent Pump Station (For the CAS process, this pump station is relocated downstream of the primary clarifiers and called the Primary Effluent Pump Station).
- RAS/WAS Pump Station (Internal to membrane bioreactor process; not a separate structure).
- Ultraviolet (UV) Disinfection Facility
- Post Aeration Basin
- Utility Water Pump Station
- River Outfall
- Solids Dewatering Facility (CAS process dewaters digested combined primary and waste activated sludge. All others dewater waste activated sludge).
- Solids Transport Equipment
- Administration Building
- Maintenance Building
- Chemical Building

The following processes are common to at least three of the processes.

- Secondary Clarifiers (Not required by membrane bioreactor).
- Aerated Sludge Holding Basins (Not used with CAS process).

OXIDATION DITCH PROCESS

The oxidation ditch process was developed in Holland many years ago, and has found wide application in the U.S. over the past 25 years, principally in the form of the "Carrousel" configuration licensed by Door Oliver Eimco. Oxidation ditches use the extended aeration activated sludge process that includes longer hydraulic and solids residence times, with microorganisms that live in the endogenous respiration growth phase. (Typical hydraulic residence times range from 12 to 24 hours, and solids retention time (SRT) from 18 to 30 days.) This is a stable growth phase, and when combined with the long residence times, creates a stable and flexible process that adapts well to changing environmental conditions and wastewater characteristics, and is less easily upset by rapid changes or introduction of toxic and/or highly degradable compounds.

The "Carrousel' configuration uses one or more slow speed vertical turbine aerators providing both mixing and aeration to furnish dissolved oxygen to sustain the microorganism population, plus keep the mixed liquor contents well suspended and transported throughout the basin.

The SGRWRF plant and many others in Utah and throughout the U. S. rely on this proven process. Other oxidation ditch aeration technologies such as horizontal brush aerators are also used, such as in the Timpanogos Special Service District (TSSD) plant in American Fork. However, these are less common in Utah than the vertical aerators.

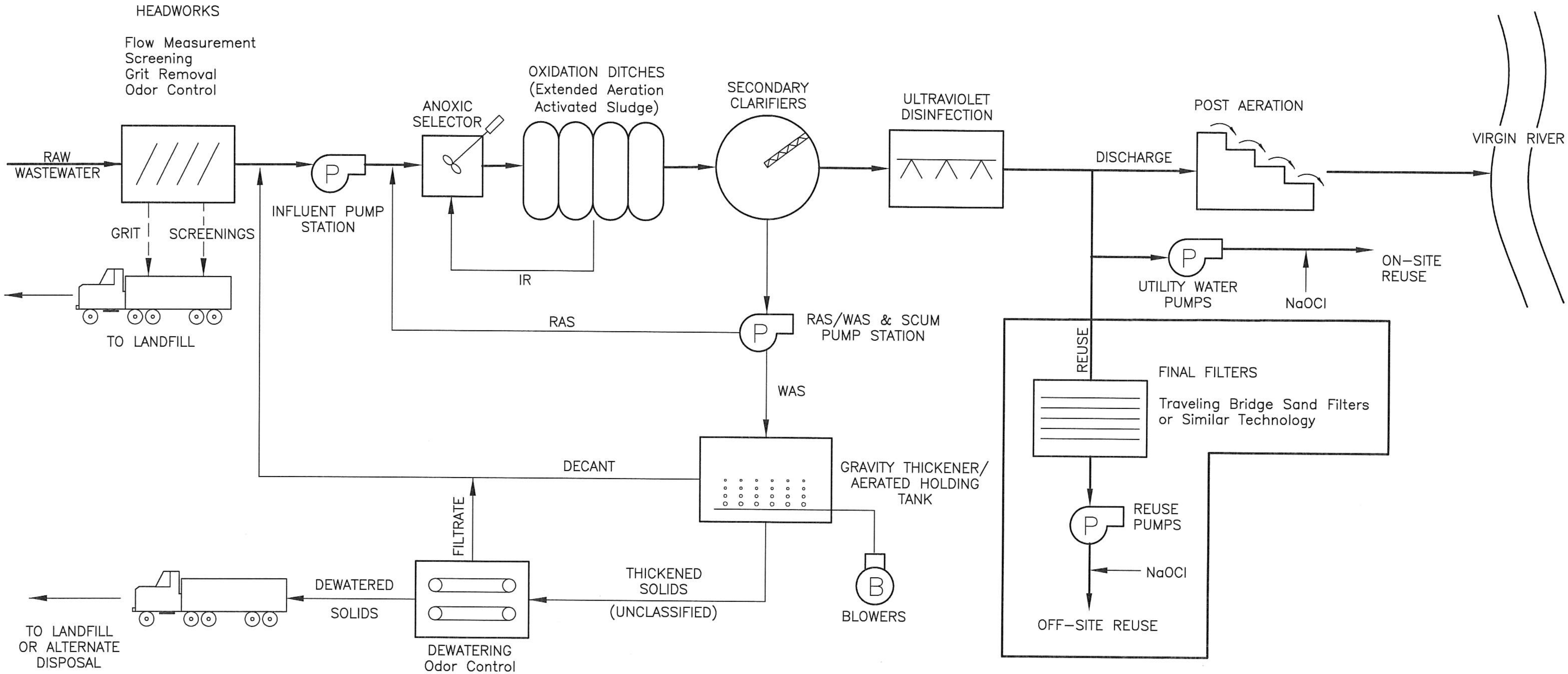
Due to greater SRTs, the extended aeration process provides sufficient residence time for nitrifying microorganisms to develop. These organisms break down ammonia nitrogen (nitrification) in the wastewater and remove it to sufficiently low levels to meet standards for discharge to the Virgin River. Thus, processes for additional nitrogen removal are generally unnecessary. Such a process is an anoxic basin preceding the oxidation ditches where highly nitrified mixed liquor and RAS are mixed with the incoming wastewater so that microorganisms can grow that use the oxygen from the nitrified mixed liquor and release nitrogen to the atmosphere.

However, this type of "pre-anoxic" basin also has the effect of "selecting" the organisms that the low dissolved oxygen environment favors, and limits growth of other organisms that require dissolved oxygen for their metabolism. The favored organisms can thrive on both nitrate oxygen as well as dissolved oxygen. These "facultative" organisms settle more readily than the obligate aerobic organisms, and this phenomenon results in improved secondary clarifier performance and/or higher clarifier capacities.

Currently, the SGRWRF employs a single pre-anoxic selector basin through which all flow into the bio-reactors passes. Additionally, oxidation ditches three and four have individual anoxic selector basins. According to SGRWRF staff, these basins do experience higher levels of nitrification/denitrification when compared to oxidation ditches one and two which do not have individual anoxic selector basins.

Figure 2-1 is a flow diagram for the oxidation ditch process that shows all the proposed major process elements discussed above. For graphical purposes the anoxic selector basin is shown separately from the oxidation ditches. But in reality, the processes are both contained within a single structure with multiple basins. No internal recycle pump is indicated because recycle is controlled by diverting a portion of the mixed liquor in the oxidation ditch into the selector basin via gates and gravity flow.

Table 2-1 contains a summary of advantages and disadvantages for the oxidation ditch process. Some of the basic design criteria for preliminary sizing and cost estimates for the oxidation ditch process are shown in Table 2-2.



IR = INTERNAL RECYCLE
RAS = RETURN ACTIVATED SLUDGE
WAS = WASTE ACTIVATED SLUDGE
NaOCl = SODIUM HYPOCHLORITE

ASSOCIATED FACILITIES (NOT SHOWN)

Administration Building
Maintenance Building
Blower Building

Bowen Collins & Associates, Inc. Consulting Engineers

Figure 2-1
OXIDATION DITCH PROCESS FLOW DIAGRAM
SGRWRF EXPANSION MASTER PLAN

Table 2-1
Oxidation Ditch Process Advantages and Disadvantages

Advantages	Disadvantages
Widely accepted in Utah	Requires more ground area due to larger tankage
Stable (not easily upset)	Higher construction cost due to larger tankage
Simple to operate	Higher operating cost to aerate/mix larger tank volumes
Excellent effluent quality	Vertical aerators may emit higher noise levels
Inherent nitrification capability for ammonia removal	Unclassified residual solids may required further offsite treatment prior to disposal or reuse
Low odors	
Primary clarifiers not used which reduces construction cost and odors	

Table 2-2
Oxidation Ditch Process Design Criteria

Criteria	Value
Solids Retention Time (SRT)	18 days
Hydraulic Residence Time (HRT)	20 hours
Mixed Liquor Suspended Solids (MLSS)	3500 mg/L
Anoxic Selector HRT	1 hour
Aerated Solids Holding Basin HRT/SRT	3 days
Secondary Clarifier Surface Overflow Rate (SOR)	600 gal/sf/day
Secondary Clarifier Solids Loading Rate	20 lbs/sf/day

STAGED AERATION PROCESS

Staged aeration is a more conventional (not extended aeration) activated sludge process as the organisms are generally kept in the log growth and stable growth phases through use of lower SRTs compared to oxidation ditches. Hydraulic residence times are also shorter. Typical hydraulic residence times range from 8 to 12 hours, and SRTs from 8 to 16 days when nitrification is required. Longer SRTs are required to grow and sustain nitrifying organisms, similar to the oxidation ditches. While this feature is not particularly "inherent" to staged aeration, selection of the appropriate SRT will ensure that the nitrifying capability for reduction of ammonia concentrations and loads is provided.

The aeration intensity is "staged", that is more oxygen is provided in the earlier stages of the process when more food is available to the organisms and the oxygen demand is higher, and less oxygen is provided in later stages where less food is available. This is somewhat similar to the older "step" or "tapered" aeration approaches, except that staged aeration attempts to create several larger zones of more uniform aeration and mixing within each zone, with these intensities decreasing zone by zone through the process.

In the past, conventional activated sludge processes were considered more difficult to operate than oxidation ditches or other extended aeration or fixed film processes. Operators were often required to monitor the incoming wastewater and the process more closely and make more frequent adjustments in order to maintain the viability and performance of the process, avoid upsets, and deal with changes in influent characteristics. Sometimes upsets occurred and performance deteriorated despite the operators best efforts.

However, with the addition of anoxic selectors (as described above for the oxidation ditch alternative), it has been discovered by preferentially selecting the facultative organisms, that conventional activated sludge processes are more stable and easier to operate. Thus, little process performance and/or flexibility is sacrificed by using a staged aeration process as compared to oxidation ditches when anoxic selectors are employed. Anoxic selectors also provide the same improved settleability benefit and increased secondary clarifier performance for the staged aeration process as for other processes.

Figure 2-2 is a flow diagram for the staged aeration process and shows all the major process elements. This diagram is almost identical to the oxidation ditch diagram with the following exceptions. External blowers and submerged fine bubble diffusers are used to achieve staging of the aeration and mixing intensity instead of vertical turbines. The submerged fine bubble diffusers also provide more efficient oxygen transfer. Finally, the aerated solids holding tank is larger in order for it to provide additional solids stabilization time, and effectively increase the SRT to a level similar to the oxidation ditch. In this way, solids from the staged aeration process should have similar stability and be able to be disposed of the same way as the oxidation ditch process.

Primary clarifiers, anaerobic digesters and related solids treatment and handling facilities may or may not be employed with a staged aeration process. Use of primary clarifiers and associated processes and equipment has the advantage of reducing the BOD load on the staged aeration process so that its size and cost can be reduced, although not proportionately to the additional cost of the clarifiers and digesters.

The larger advantage of the anaerobic digesters is the ability to generate methane gas that can be used to power equipment at the plant and reduce electrical power costs which are a major component of the overall operating costs. The other significant advantage is that the anaerobic digestion process generates Class B solids that are more readily dewater-able, and also qualify for certain types of reuse such as restricted land application that non-digested solids can not be used for.

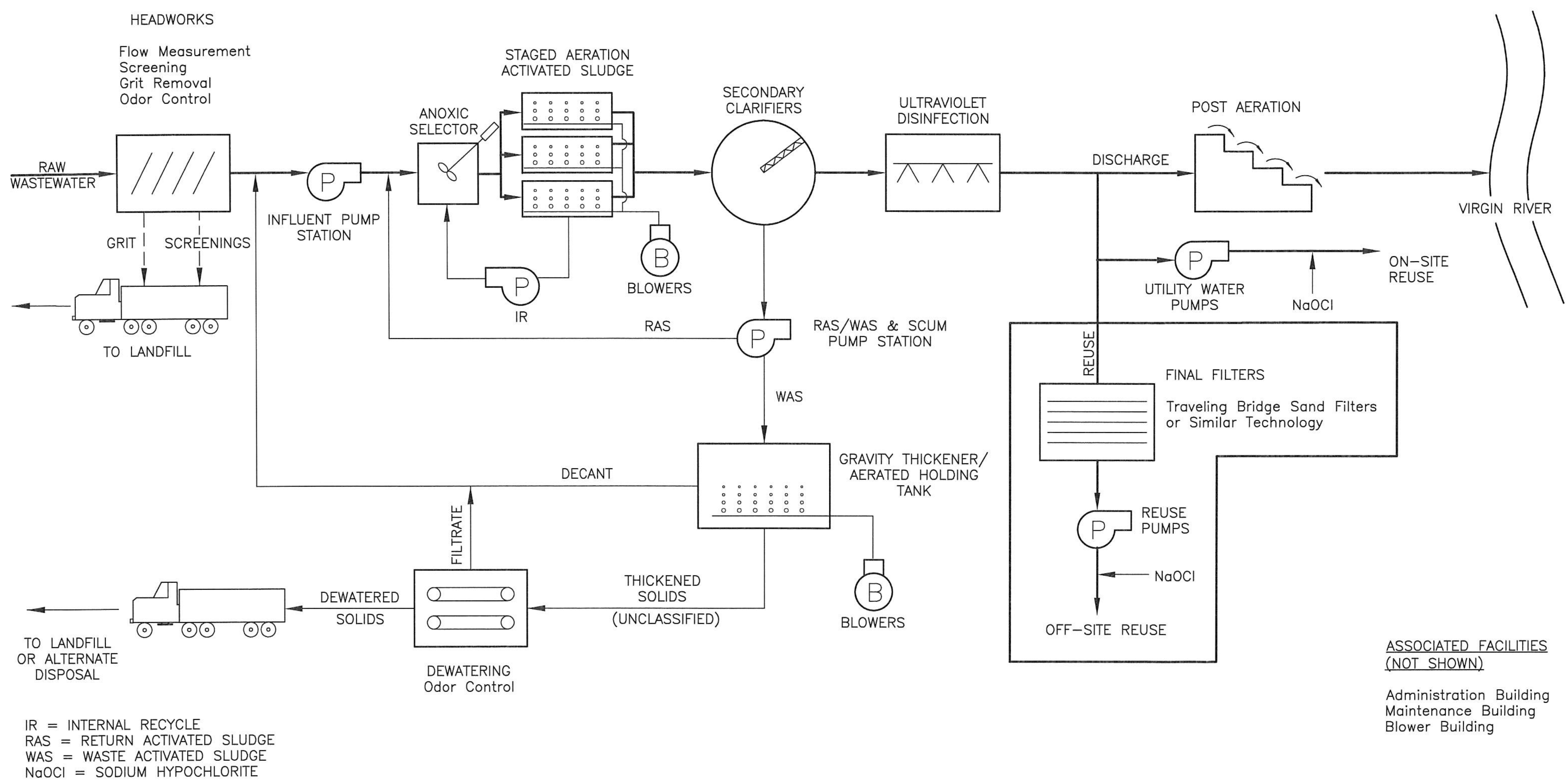


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Figure 2-2
STAGED AERATION PROCESS FLOW DIAGRAM
SGRWRF EXPANSION MASTER PLAN

The overall construction cost including primary clarifiers and anaerobic digesters is higher than without them. But of greater concern is the potential for odors associated with primary clarifiers and anaerobic processing of primary solids. The clarifiers can be covered and ventilated, and the gasses scrubbed prior to exhausting to the atmosphere. The same can be done for the dewatering facility. The digesters themselves are generally sealed, but odors tend to escape. Digesters also require occasional cleaning, and the contents emptied out, thus creating another avenue for odor escape.

Because of odor concerns and projected higher construction costs, it was decided not to include primary clarifiers and related solids treatment and handling facilities with the staged aeration process. This keeps the staged aeration process similar to the oxidation ditches for purposes of comparison. Extended aeration processes such as oxidation ditches generally do not include primary clarifiers in order to decrease costs and increase simplicity. In addition, the higher SRTs employed by these processes tend to create solids that are already semi-digested that are not readily amenable to further treatment by anaerobic digestion.

Note that it has been proposed for the SGRWRF to change from the oxidation ditch process to the staged aeration process in order to increase treatment capacity without immediate construction of additional bioreactors. This change would require that one of the gravity thickeners be retrofitted as an aerated sludge holding basin to provide increased SRTs and solids stability, with eventual construction of separate aerated holding basins as needed.

Table 2-3 contains some of the relative advantages and disadvantages for the staged aeration process. Some of the basic design criteria used for preliminary sizing and cost estimates for the staged aeration process are shown in Table 2-4.

Table 2-3
Staged Aeration Process Advantages and Disadvantages

Advantages	Disadvantages
Less ground area required due to smaller tankage	Staged aeration has not been used in Utah, although Provo employs conventional activated sludge
Reduced operating costs required for aerating smaller tank volume and more efficient aeration system	Actual power cost savings may not be as high as predicted if oxidation ditch alternative is operated at low dissolved oxygen levels
Lower construction costs for smaller tankage	Unclassified residual solids require further offsite treatment prior to disposal or reuse
Improved noise control	Vertical aerators may emit higher noise levels
Stable (not easily upset)	Unclassified residual solids may required further offsite treatment prior to disposal or reuse
Simple to operate	
Excellent effluent quality	
Nitrification for ammonia removal	
Low odors	

Table 2-4
Staged Aeration Process Design Criteria

Criteria	Value
Solids Retention Time (SRT)	10 days
Hydraulic Residence Time (HRT)	12 hours
Mixed Liquor Suspended Solids (MLSS)	3500 gm/L
Anoxic Selector HRT	1 hour
Aerated Solids Holding Basin HRT/SRT	7 days
Secondary Clarifier Surface Overflow Rate (SOR)	600 gal/sf/day
Secondary Clarifier Solids Loading Rate	20 lbs/sf/day

CONVENTIONAL ACTIVATED SLUDGE WITH PRIMARY CLARIFIERS (CAS)

Primary Clarifiers

The first difference noted in this process is the use of primary clarifiers that are required in order to reduce the BOD and TSS loading to the CAS process. Otherwise, serious problems such as odors, plugging and poor performance can result. Raw wastewater solids are settled out by gravity in the primary clarifiers, and primary effluent is pumped to the activated sludge tanks. Removal of large portions of the BOD reduces the load on downstream processes which helps improve their performance and/or reduce their size and cost. The disadvantage is that primary clarifiers can substantially increase the potential for odor generation and require costly measures to control these odors. The filters can be covered and ventilated, and the gasses scrubbed before exhausting to the atmosphere.

Raw Sludge Pump Station

Use of the primary clarifiers also requires a primary sludge pump station to transfer the primary solids to the anaerobic digesters for treatment. The primary sludge pump station also pumps both scum and waste activated solids to the anaerobic digesters from the primary clarifiers where they are co-removed with the raw solids.

Anaerobic Digesters

Raw sludge and co-removed waste activated sludge and scum are treated and stabilized in the anaerobic digesters. This process reduces the volatile content of the solids and meets Class B requirements that enable more flexibility in disposing of the solids by restricted land application techniques or other methods. These solids also dewater more effectively than waste activated solids alone. The performance of the dewatering facility can be improved and the size and cost of the facility reduced as a result. A major benefit provided by the anaerobic digesters is generation of methane gas that can be burned to generate power to help run the treatment plant and offset power costs. A disadvantage is the increased potential for odors as discussed previously.

Primary Effluent Pump Station

The primary effluent pump station replaces the influent pump station used in the other process alternatives, and is relocated down stream of the primary clarifiers. In this location the pump station also serves to provide recycle pumping to the trickling filters from both the trickling filter effluent and the solids contact basin RAS, if desired. Flow requirements for the primary effluent pump station are greater than for the influent pump station which only pumps the raw wastewater flow, and the total dynamic head (TDH) requirements are also assumed to be greater due to the height of the filters to which the primary effluent pump station discharges.

Solids Contact Basins

The solids contact basins are essentially a short term activated sludge process where remaining BOD and TSS are encouraged to come into contact with a suspended growth microorganism population for removal and improved overall process performance. The basins include a RAS/WAS pump station like other activated sludge processes, and blowers and diffusers to provide dissolve oxygen and mixing. The existing oxidation ditches at the SGRWRF would continue to serve as solids contact basins for this phase of the treatment process.

Figure 2-3 is a flow diagram for the conventional activated sludge process and shows all the major process elements. Table 2-5 contains some of the relative advantages and disadvantages for the CAS process. Some of the basic design criteria used for preliminary sizing and cost estimates for the CAS process are shown in Table 2-6. Figure 2-3 is a flow diagram for the conventional activated sludge process and shows all the major process elements.

Table 2-5
Conventional Activated Sludge Process Advantages and Disadvantages

Advantages	Disadvantages
Lower aeration cost due to small activated sludge (solids contact) basin volumes	Larger land area required for more numerous process structures
Operating cost reduction due to onsite generation of power from anaerobic digester methane production	Higher expected construction cost due to numerous process structures, especially anaerobic digesters
Process is used on two large plants in Utah, and a third large plant is being designed	Greater odor potential from primary clarifiers and anaerobic digesters.
Low noise potential	Process operation may be more complex
Relatively stable and reliable process	Nitrification capability of process may be questionable
Good effluent quality	
Class B solids generated by anaerobic digestion process – more disposal options	

Table 2-6
Conventional Activated Sludge Process Design Criteria

Criteria	Value
Primary Clarifier Hydraulic Loading Rate (HLR)	1000 gpd/sf
Primary Clarifier BOD Removal	35%
Solids Contact Basin SRT	2 – 4 days
Solids Contact Basin HRT	0.5 hours
Solids Contact Basin MLSS	2500 mg/L
Secondary Clarifier Surface Overflow Rate (SOR)	600 gal/sf/day
Secondary Clarifier Solids Loading Rate	20 lbs/sf/day

MEMBRANE BIOREACTOR PROCESS

The membrane bioreactor process (MBR) also uses a variation of activated sludge to biologically break down the wastewater constituents, but the major difference is that membranes are used to separate the liquid effluent from the mixed liquor instead of secondary clarifiers. The membrane modules are submerged directly in the aerobic reactor and draw "clarified" effluent from the reactor on a continuous basis. This can be accomplished with or without pumping, but it is assumed that pumping is required for purposes of this evaluation. Effluent quality is very high.

As a result of using membranes to separate the solids from the effluent, much higher mixed liquor concentrations can be maintained as they will not affect settleability. The aerobic reactor basins can be much smaller, substantially reducing land area requirements. The requirement for no secondary clarifiers and no final filters also greatly reduces land area needs.

The MBR process is relatively new, having only been in use for about 10 years in the U. S. There is currently one small operating MBR plant in Utah, and several are in development. Equipment purchase costs are high for this process due to the membrane modules, and operating costs are also high due to membrane replacement requirements. There are several operating plants the size of the proposed SGRWRF facility in the U.S. However, MBRs have typically been used for plants under 2 mgd in capacity due to economic considerations. These plants find more extensive use where very high effluent quality is desired, such as for reuse, infiltration basins, aquifer storage and recovery (ASR) projects, etc.

Several manufacturers currently offer membranes for this purpose, the three most prominent being: Zenon, Siemens, and Kubota. Although some similarities between manufacturers exist their membrane types and configurations are proprietary. Use of MBRs generally requires selection of a membrane technology and then working with a manufacturer-recommended design

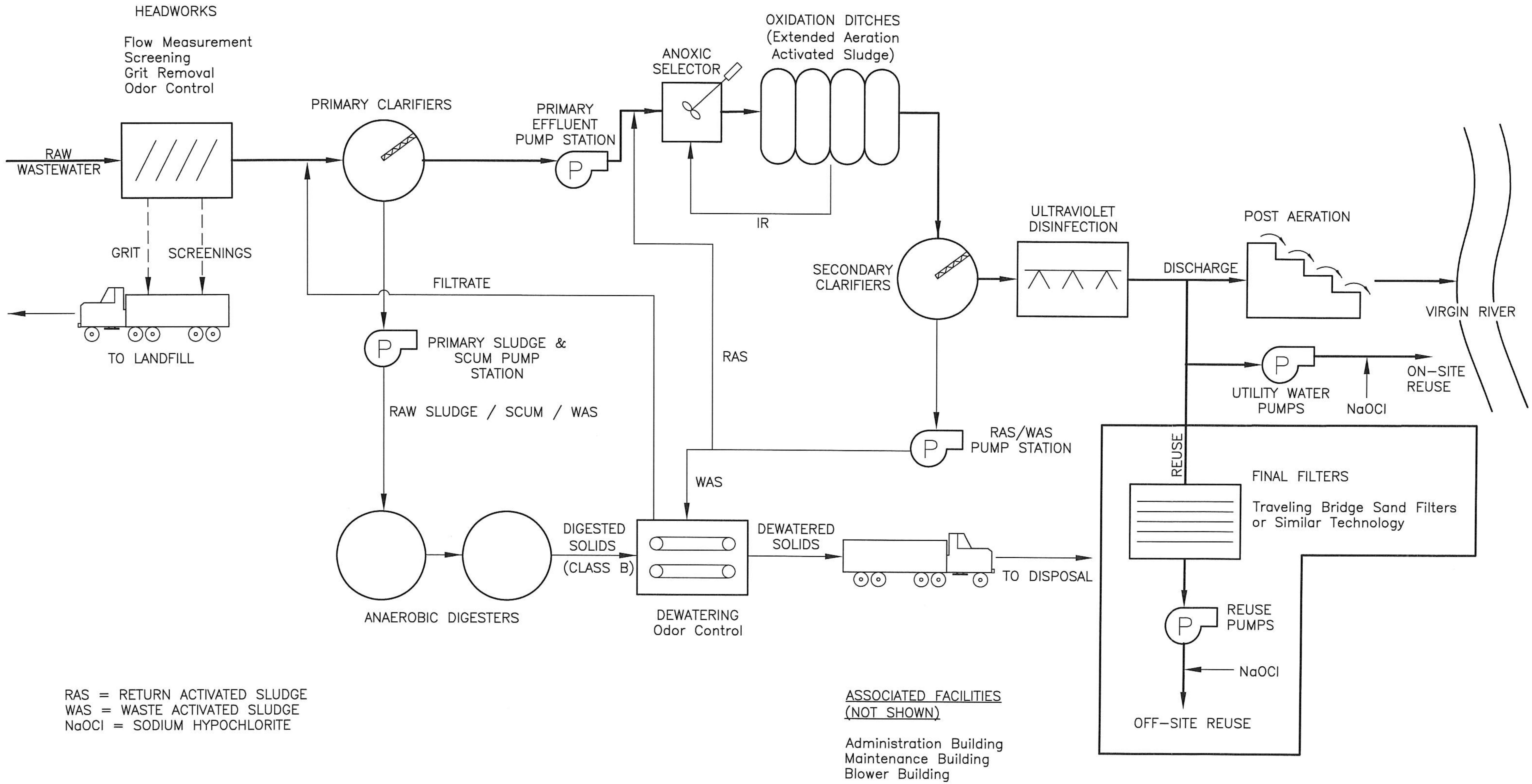

Figure 2-3
CONVENTIONAL ACTIVATED SLUDGE PROCESS FLOW DIAGRAM
SGRWRF EXPANSION MASTER PLAN

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that accommodates their proprietary membrane type and configuration. A proposal prepared by Kubota was used to develop the basic design and cost information for this study.

Figure 2-4 is a flow diagram for the MBR process. Note that the secondary clarifiers and final filters are omitted as discussed previously. The MBR process is shown within the dashed outlined area as separate basins, but in reality a single structure with multiple compartments is used. The pre-aeration basins are provided to increase the HRT/SRT more economically rather than increasing the volume of the membrane bioreactor basins. Internal recycle pumps double as RAS/WAS pumps since there are no separate secondary clarifiers from which solids removal is required. The remainder of the treatment process is similar to both the oxidation ditch and staged aeration alternatives.

Table 2-7 presents some of the relative advantages and disadvantages for the MBR process. Some of the basic design criteria used for preliminary sizing and cost estimates for the MBR process are shown in Table 2-8.

Table 2-7
Membrane Bioreactor Process Advantages and Disadvantages

Advantages	Disadvantages
Lower aeration/mixing cost due to smaller activated sludge basin volumes	No large operating plants in Utah
Less land area required due to smaller activated sludge basins, no secondary clarifiers and no final filters	Process has not been used for plants of this size in the U.S. Only one this size in the world
Very high effluent quality, without final filters or clarifiers	High equipment cost due to membrane modules
Nitrification for ammonia removal	Unclassified residual solids require further offsite treatment prior to disposal or reuse
Low noise potential	High operating cost due to replacement of membranes
Relatively stable and reliable process	Process operation may be more complex due to monitoring and replacement of membranes
Low odor potential	

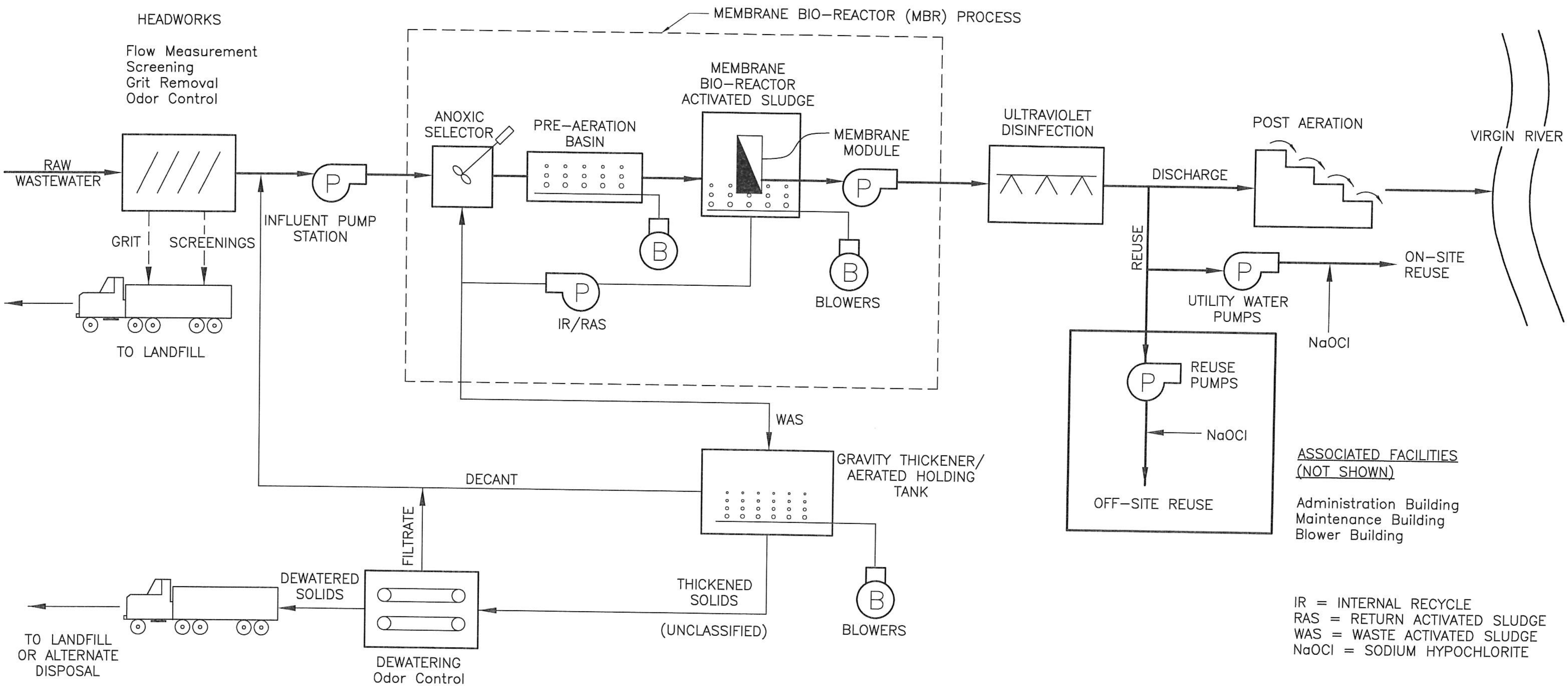

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Figure 2-4
MEMBRANE BIO-REACTOR PROCESS FLOW DIAGRAM
SGRWRF EXPANSION MASTER PLAN

Table 2-8
Membrane Bioreactor Process Design Criteria

Criteria	Value
Solids Retention Time (SRT)	15 – 26 days
Hydraulic Residence Time (HRT)	4 hours
Mixed Liquor Suspended Solids (MLSS)	12,000 mg/L
Anoxic selector HRT	0.8 hr
Membrane Flux Rate	12.4 gal/sf/day
Aerated Solids Holding Basin HRT/SRT	3 days (not by Kubota)

COST ESTIMATES AND ECONOMIC COMPARISON

Construction Cost Estimates

Planning level construction cost estimates were developed using methods intended to provide reasonable and conservative values, suitable for discussion and comparison of treatment process alternatives for this study. Actual plant construction costs will vary from the figures presented, depending on the final plant sizing and design criteria, selection of equipment, architectural and structural features, specific site development requirements, and a number of other factors that are not readily predicted at the planning stage of this project.

Detailed planning level construction cost estimates are presented in Appendix C. Costs are shown by process element or other major structure, with markups for site development, yard piping, electrical and instrumentation.

The site development markup cost is intended to include all on-site civil and drainage improvements required at the site such as berms, grading, paving, curb/gutter/sidewalk, access road, wetlands and limited river channel improvements, fencing, limited filling, utility service connections, and miscellaneous related improvements.

Estimated costs range from $56.7 million for the staged aeration plant, to $116.5 million for the membrane bio-reactor plant. The oxidation ditch plant is estimated to cost approximately 7 percent more than the staged aeration plant at $60.9 million, with the CAS plant at about $88.7 million.

It is predictable that the staged aeration and oxidation ditch plants would be comparable in cost due to their similarities, with the staged aeration costs somewhat lower due to the requirement for less concrete tankage. It is also predictable that both the CAS and MBR processes would be more costly due to large mechanical equipment costs for the MBR process, and a greater number of process structures and related mechanical, site development and yard piping costs for the CAS process.

The oxidation ditch and staged aeration plants are the least expensive to construct and the small difference in estimated construction costs between the two is within the estimating variability contained in the analysis. Thus, other factors also should be considered when deciding between these processes such as potential operating costs, and process familiarity and reliability.

The CAS and MBR process construction costs are 56 and 105 percent higher, respectively, than staged aeration costs, but differences in operating costs and other factors should be considered when evaluating these alternatives.

OPERATING COST ESTIMATES

The following operating cost estimates were developed from similar wastewater treatment facilities currently operating in Utah, and other sources as noted. Figures shown are for overall operating costs, including solids treatment and disposal. Predicted flow values from Chapter 1 were used for each year of operation.

Oxidation Ditch Process

A survey of four oxidation ditch wastewater treatment plants in Utah (St. George, Timpanogos, SVWRF and Ashley Valley) revealed operating costs ranging from $702 per million gallons (MG) treated per year ($702/MG/yr) for the SVWRF, to $1674/MG/yr for Ashley Valley. Of the four plants, SVWRF is the largest at nearly 30 mgd, and Ashley Valley is the smallest at just under 2 mgd. This difference reflects predictable increased operating economies of scale for larger facilities.

The SVWRF plant is closest in size to the future facility, and its operating costs should be the most representative of an oxidation ditch facility required to treat expected flows. Based on $702/MG/yr, for a 20-year analysis period and a discount rate of two percent, the present worth of the annual cost is $67.3 million.

Staged Aeration Process

Currently, there are no staged aeration treatment plants in Utah from which to draw comparative operating data, although the SVWRF and TSSD are in the process of conversion. However, they are similar to the oxidation ditch plants, with expected operating costs somewhat lower due to reduced aeration requirements and increased oxygen transfer efficiency. All other costs should be the same. If power costs constitute 40 percent of plant operating costs, and the staged aeration process is 20 percent more efficient, then overall operating costs for a staged aeration plant would be about 8 percent less than a comparable oxidation ditch plant. An 8 percent reduction in overall operating costs for the SVWRF would result in a value of $646/MG/yr which, for a 25 mgd plant at a two percent discount rate and a 20 year present worth period equates to $61.9 million.

CAS Process

The Central Valley CAS plant in South Salt Lake City with a current flowrate of approximately 52 mgd, reported operating costs for the last three years ranging from $398 to $431/MG/yr, with an average of $410/MG/yr during that time. For comparison, the Central Weber trickling filter plant in Ogden, Utah (35 mgd) reported a cost of $352/MG/yr for the last two years. This seems to compare well with the Central Valley costs, and accounts for the lack of solids contact facilities at the Central Weber plant. The Salt Lake City CAS treatment plant reported operating costs of $383/MG/yr, with a flow of 28.9 mgd, and very small solids contact basins. All three of these plants utilize anaerobic digestion for solids treatment. Assuming $410/MG/yr for CAS operating costs for a 25.0 mgd plant are $39.3 million.

MBR Process

For the MBR process, operating costs similar to those of the staged aeration process are assumed, plus the cost of membrane cleaning and replacement. Membrane cleaning costs of $6000 per year are assumed, plus replacement of 10,000 membrane cartridges per year at $60/cartridge, starting after the eighth year of operation. Labor for membrane replacement is estimated at 0.04 hrs/cartridge (16 hrs per cassette of 400 cartridges) and $25/hr.

Crane and operator costs of $300/hr are assumed, with eight hours per cassette required. This results in costs that are approximately 9% higher for MBR than for the staged aeration process or $710/MG/yr. The 20-year present worth at two percent discount rate is $68.1 million.

ECONOMIC COMPARISON

The primary criterion of the currently proposed expansion is the ability to maximize treatment capacity within existing basins to limit costs. Table 2-9 contains the present worth cost information from the above discussion. The data indicates that both the oxidation ditch and staged aeration process selections are more cost effective than either the CAS or MBR processes when considering construction costs alone. However, the CAS process costs less to operate due to reduced aeration requirements and production of methane gas for energy generation for use on site. This benefit causes the CAS process to be more competitive with the oxidation ditch and staged aeration processes on a present worth basis. The MBR process is more costly to both construct and operate due to membrane equipment and replacement costs. The previous construction cost estimates do not attempt to take into account the differences in land requirements for the different processes. Such consideration would favor the MBR process due to its smaller footprint, but would not be expected to offset the higher construction and operating costs. Consequently, MBR processes are not recommended for the SGRWRF expansion as they are the most costly to construct and operate and would require extensive modifications to existing basins for process conversion.

Table 2-9
Economic Comparison of Treatment Process Alternatives
($1,000,000)

Process	Construction Cost	Annual Operating Cost ($/MG/yr)	Total Present Worth Cost (20 Yrs)
Oxidation Ditch	$60.8	$702	$128.2
Staged Aeration	$56.7	$646	$118.7
Conventional Activated Sludge	$88.7	$410	$128.1
Membrane Bioreactor	$116.5	$710	$184.6

The oxidation ditch and staged aeration alternatives are preferred due to their lower initial costs, and the staged aeration facility should be less costly to operate. The present worth cost of the staged aeration plant is approximately 7.5 percent lower than the oxidation ditch plant. The CAS operating costs are even lower than the staged aeration process, which results in a present worth cost that is only about 8 percent higher as compared to the 56 percent estimated construction cost differential between the two alternatives.

NON-ECONOMIC ISSUES

Acceptance, reliability, experience and general confidence must be considered in making the final process choice. Many successful oxidation ditch wastewater treatment plants have been operating for up to 20 years or more in Utah, but there are no staged aeration plants. There is only one larger non-oxidation ditch activated sludge plant in Utah, although there are staged aeration plants operating in neighboring states. Two large CAS plants currently operate in Utah, and a large two-stage trickling filter facility is being converted to the CAS process.

The long-term success of oxidation ditch plants in Utah and elsewhere in the U. S. speaks well of the performance and stability of this process. However, both initial and operating costs are somewhat higher than for some competing processes as demonstrated above. Larger plants typically find improved economies through use of alternative processes such as staged aeration or CAS, and it is less common to find oxidation ditch facilities larger than 5 to 10 mgd capacity. (The South Valley WRF plant was the largest of its kind in the U. S. when it began operations in 1986 at 12.25 mgd). The CAS process has also found acceptance both in and outside of Utah.

Table 2-10 presents a brief comparison of some of the attributes of the oxidation ditch, staged aeration and CAS processes for consideration.

Table 2-10
Comparison of Three Treatment Processes

Criteria	Oxidation Ditch	Staged Aeration	Conventional Activated Sludge
Initial Construction Cost	Moderate	Lower	Higher
Operating Cost	Higher	Moderate	Lower
Process Used in Utah	Widely Used	No Installations	Several Installations
Predicated Performance and Reliability (effluent quality)	Excellent	Excellent	Good
Complexity of Operation	Lower	Moderate	Higher
Solids Disposal	Unclassified – fewer disposal options w/o additional treatment	Unclassified – fewer disposal options w/o additional treatment	Class B solids – more disposal options available
Odor Potential	Lower	Higher	Higher

Criteria	Oxidation Ditch	Staged Aeration	Conventional Activated Sludge
Noise Potential	Higher	Moderate	Lower
Vector Potential (filter flies)	Lower	Lower	Higher
Land Use Requirements	Moderate	Lower	Higher
Expandability	Similar	Similar	Similar

The CAS process has two key disadvantages including potential odors and the possibility for filter flies and/or other vectors to be generated. These concerns result in the possibility that the plant would have greater difficulty remaining a good neighbor to nearby residents, and that complaints could be generated and additional funds expended to try and mitigate odor and other problems.

The SGRWRF plant is located in a sensitive area, similar to the South Valley WRF, as compared to the predominantly commercial area where the Central Valley plant is located. Thus odor and vector potential is of great concern for the SGRWRF plant expansion. As a result, the CAS process is not recommended for the proposed expansion due to its greater odor and vector potential, as well as its higher initial and 20-year present worth costs.

LIQUID TREATMENT ALTERNATIVE SUMMARY

Both the oxidation ditch and staged aeration plants have low odor potential and are better suited for a more sensitive plant location. Construction, operating and present worth costs are all within seven to eight percent for these two alternatives, and other features of the facilities are quite similar. The oxidation ditch alternative has an advantage of being a more widely accepted and proven process in Utah, but staged aeration has lower estimated construction and operating costs. Both processes are expected to provide excellent performance and reliability and meet effluent discharge water quality standards. Figures 2-5 and 2-6 show conceptual layouts of what future expanded facilities may look like for both the oxidation ditch process and the staged aeration modifications to the existing process.

The estimated construction cost difference between the two plants is within normal estimating variability. The previous discussion points out that, under certain circumstances, operating costs for the two alternatives also could be very similar. Therefore, for all practical purposes, the two options may be viewed as economically equal, and SGRWRF staff may select the process in which it is most confident and best addresses its non-economic concerns. However, with construction cost being the deciding factor, the staged aeration alternative is the process of choice.

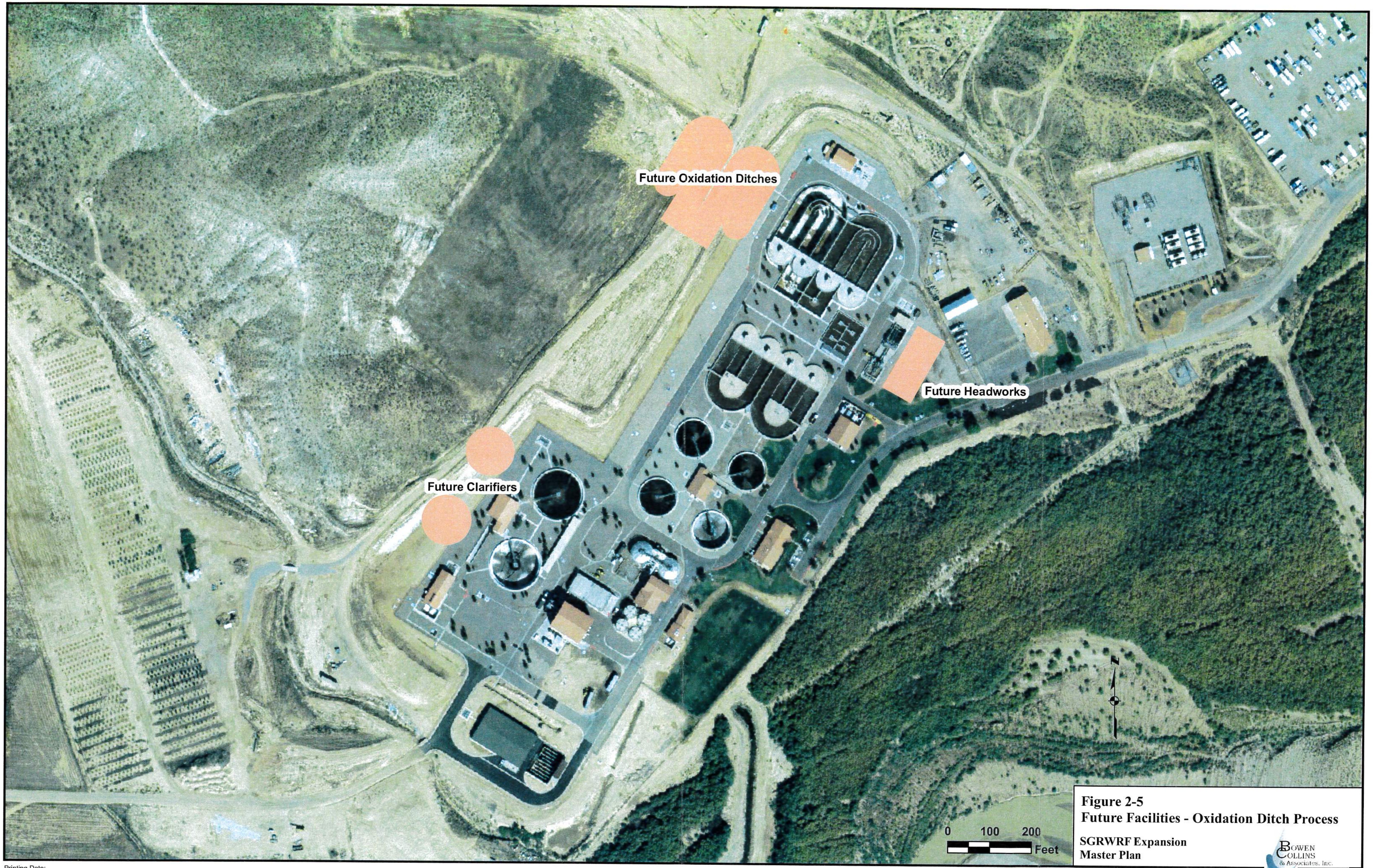

Figure 2-5
Future Facilities - Oxidation Ditch Process

SGRWRF Expansion
Master Plan

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Figure 2-6
Future Facilities - Staged Aeration Process

SGRWRF Expansion
Master Plan

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CHAPTER 3
SOLIDS PROCESSING ALTERNATIVES

INTRODUCTION

Solids processing includes the storage, handling, hauling, conditioning, dewatering, and stabilization and disposal processes. These processes often combine to present the most difficult and expensive problems faced by wastewater treatment plants. This is a trend that will most likely continue in future years.

As part of this Master Plan for the SGRWRF, BC&A was asked to evaluate the current solids processes used by the facility. This evaluation includes the present operating conditions of the processes (i.e. hours of operation, dewatered solids concentration, solids production, and solids storage), the preferred method and timing for expanding the dewatering capabilities was recommended, and the evaluation of the solids treatment and disposal methods. As part of this task, BC&A determined the current disposal costs of composting at the county landfill. All of the treatment and disposal alternatives are assumed to be preceded by mechanical dewatering. Costs for three alternative methods (monofill, thermal drying, and harvesting monofill) were also estimated and an evaluation of the four alternatives is given in the report.

SOLIDS PROCESSING

The wastewater treatment process creates biological solids during the removal of organic wastes from the wastewater influent flow. The biological solids are primarily microorganism cells that are produced as the microorganisms utilize wastes as food. In order to maintain the optimal ratio of "food" to microorganisms, a portion of the biological solids is removed (wasted) from the process each day. In addition to biological solids, the influent wastewater flow stream contains inorganic or non-biodegradable solids that simply pass through the plant and are removed with the biological solids. Collectively, the solids that are removed from the treatment process are called "biosolids." Biosolids that are removed from the process must undergo further processing and handling prior to disposal.

Gravity Thickening

Dewatering is an integral and critical element of the overall biosolids treatment and disposal process and any of the dewatering technologies should be suitable for use with the selected treatment and disposal alternatives. Dewatering is normally accomplished ahead of the treatment and disposal processes to remove water and reduce the volume of material requiring treatment, and to maximize the efficiency and performance of subsequent treatment and disposal operations.

Gravity thickening is one of the most common methods used and is accomplished in a circular tank similar in design to a sedimentation tank. Biosolids are fed into the tank through a center feed well. The biosolids are then allowed to settle and compact through gravitational forces. The dewatered biosolids are removed from the conical tank bottom while the supernatant is pumped back to the biological selector. Gravity thickeners work best for primary and lime sludge and typically have a loading rate of 20-30 lbs of solids per square foot each day (Metcalf & Eddy, 2003). The presence of biological solids, particularly WAS, usually results in lower capture rates and underflow solids concentrations (WEF, ASCE, 1998). However, with precautionary measures in the design parameters, particularly the solids retention time and thickener diameter, this can be overcome (Water Pollution Control Federation, 1980).

Currently the SGRWRF utilizes two Eimco thickeners which each hold approximately 155,500 gallons. Only one of the thickeners is in use at any given time. The maximum influent to the thickeners is 1.8 percent solids by weight. The average influent is 1.1 percent solids by weight. When the biosolids leave the thickeners, it averages 3 percent solids by weight (Bawden, 2007). This is typical performance for gravity thickeners and is considered acceptable as the preliminary solids dewatering process for the SGRWRF. In order to stay within acceptable hydraulic and solids loading criteria, a third gravity thickener will be needed for 25 mgd capacity.

Centrifuges

Centrifuges promote dewatering by subjecting the biosolids to centrifugal forces created by rotating the bowls at high speed (several thousand revolutions per minute [RPM]). The centrifugal force causes the solids to migrate to the interior bowl surface where they are concentrated and removed. Cationic polymers are used for coagulation to initiate the solids separation process, similar to belt filter presses.

The following example illustrates the weight reduction achieved by the dewatering process. If the WAS contains 1,000 pounds dissolved solids (DS) and is 1.8 percent DS by weight, then the total combined amount of solids and water is 55,555 pounds (lbs) by weight. After the thickeners, where the biosolids are 3 percent DS by weight, the combined weight of the solids and water is 33,333 lb. This is a removal of approximately 22,000 lbs of water in the thickeners. After the centrifuges, where the solids content is 15 percent by weight, then the combined amount of solids and water is approximately 6,666 lbs and 49,000 lbs (5,900 gallons) of water has been removed during the dewatering process.

Centrifuges are completely enclosed machines, and release of odors at the dewatering equipment is minimized. By connecting the solids discharge from the centrifuges to enclosed conveyance systems (typically screw type conveyors), odor released from conveying equipment is also reduced. The result is that centrifuge dewatering facilities normally have low odors and few corrosion problems.

The primary disadvantages of centrifuge dewatering include large power requirements, high polymer usage, and noisy operation. Sound control measures are often provided to mitigate high noise levels. The dewatering process that occurs within centrifuges is not directly visible. The fully dewatered cake may be observed, normally as it is discharged into a truck or other container. Operational adjustments made on the basis of the condition of the fully dewatered cake are discernable only following the time lag required for the solids to be dewatered and transported to where they are discharged. Finally, centrifuges are large, heavy equipment that operate at very high speeds. Wear on bearings, drives, motors and other surfaces is of greater concern than for low speed equipment that is not subject to these same forces. As a result, maintenance and repair requirements for centrifuges can be high.

The SGRWRF has two Bird Humbolt CT 3074 centrifuges that each handle 180 gpm. These are typically run on weekdays from 7 a.m. to 1 p.m. at the latest. Each centrifuge uses about 30 gallons of polymer per truckload hauled, which equates to about 2.07 gallons of polymer dose per dry ton of solids (Bawden, 2007). Solids are discharged from the centrifuge at approximately 15% solids and conveyed through a shaftless screw conveyor to a trailer for hauling. Current operating costs are summarized in a table contained in appendix D. Recently the SGRWRF had one of its centrifuges out of service for regular maintenance and had a mechanical failure with the second centrifuge. This left no ability to dewater until repairs could be made. The solids processing building has a third spare bay for a future centrifuge and it is recommended that a third, higher capacity centrifuge be added in the next expansion of the plant.

SOLIDS DISPOSAL

Remote treatment and disposal helps minimize the potential impact to neighboring properties from odors that could be associated with on-site processing of residual biosolids. Biosolids are removed from the treatment system on a daily basis, dewatered to reduce transportation costs, and trucked to the county landfill for treatment and/or disposal. There the solids may be directly disposed of, or undergo further treatment in advance of disposal or beneficial use (compost).

In northern Utah, a number of treatment and disposal techniques are currently practiced at larger wastewater facilities along the Wasatch Front. Treatment processes include anaerobic and aerobic digestion (on-site), composting (on and off-site), blending with soil materials, long term storage, drying, and land application. Disposal methods include various forms of landfilling/land disposal and mine land reclamation, agricultural land application, and distribution for beneficial use following treatment.

In order to dispose of residual wastewater solids in a municipal solid waste landfill it is generally necessary only that the solids not contain hazardous materials, and that no free draining water be present as determined by the United States Environmental Protection Agency (USEPA) Paint Filter Test. These "unclassified" solids are not suitable for beneficial use or other types of disposal where human contact is possible.

Class B and Class A solids are created by subjecting them to one or more treatment processes to reduce pathogen concentrations and limit vector attraction potential. Anaerobic and aerobic digestion, composting, thermal and air drying, lime treatment, soil blending, and ATAD are examples of such processes. Once treated and classified, the solids may qualify for disposal by restricted agricultural and other land application techniques (rangeland, forest land, etc.), or unrestricted agricultural land application and/or distribution to the public and others for turf and garden soil amendments. SGRWRF staff has directed BC&A to evaluate the current disposal method as well as three additional alternatives. These alternatives are: thermal drying, monofill, and harvesting monofill. A brief review of the Cannibal process is also included for potential implementation in the future.

Current Solids Disposal

The SGRWRF currently hauls all of the dewatered solids to the county landfill for composting and/or disposal. The landfill is owned by the same cities which makeup the service area of the

SGRWRF. These cities' appoint board members to oversee the private contractor in charge of operations at the landfill. Currently the cost for this disposal option is $3.00 per wet ton. The landfill composts a portion of the solids and puts the remaining solids into the landfill. The compost is available for purchase by the public for use in landscaping and gardening. This has worked well in the past but the landfill is experiencing increasing numbers of complaints from residents due to odors assumed to originate from the compost. A cost increase is being considered presently, and it is anticipated that costs for disposal will be increased. Due to the SGRWRF member cities ownership of the landfill it is anticipated that this option is viable as a long term disposal option because of the cities vested interest in both the SGRWRF and the landfill.

Thermal Drying

Thermal drying is a mechanical process that drives off water by adding heat to the dewatered biosolids to reduce the moisture content to 8 percent or less. The remaining organic material is in a more concentrated form than compost, and it retains more of its biological mass. Beneficial use of the material is more akin to fertilizer rather than soil conditioning as with compost. The volume of the biosolids material is reduced to about 20 percent of its original volume through the drying process, and no bulking agents are added.

As the name indicates, substantial heat must be applied to the biosolids to drive off moisture and obtain the desired degree of dryness. Thermal drying systems currently on the market include both indirect and direct drying methods.

Direct dryers put the biosolids in contact with heated air through various means, and are capable of producing a dried product that ranges from dusty and non-homogeneous to relatively hard and uniform and suitable for use as or in conjunction with a fertilizer. Indirect dryers use hollow paddles or a rotary drum configuration to both mix and transport as well as transfer heat to the biosolids. Either steam or hot oil is circulated through the equipment to provide the heat source. The dried product typically is not as uniform or hard as can be obtained by some direct drying methods, but is still suitable for many agricultural or landscaping uses, albeit possibly with differing equipment and application rates and methods. 20 year life cycle costs for both direct and indirect dryers are generally $50-$55.00 per wet ton.

Monofill

The City currently owns 300 acres surrounding the SGRWRF. This land could be used to store dewatered solids that come from the SGRWRF. This would eliminate the need to transport the solids to the landfill and the cost charged by the landfill. However, there are numerous political and environmental obstacles that would need to be overcome before this would be a feasible alternative. One of the biggest concerns politically is the potential for odors. With residents in the nearby Bloomington and Sun River neighborhoods, odor has been and will continue to be a concern for the residents. Another concern is the long term viability of a facility that is likely to be encompassed by homes in the future. In considering other sites for a monofill it appears unlikely that a suitable site could be found that is not uncomfortably close to current residential and commercial growth. The site would need to be considered in an area outside of the service area. This would significantly increase hauling costs and makes this option less attractive than the current option. 20 year life cycle costs for monofills are generally $35-$40.00 per wet ton.

Harvesting Monofill

A harvesting monofill would have similar obstacles to a monofill, but adds operational complexity. Additional land would be required for this type of facility. However, the only land available would be Bureau of Land Management (BLM) land, or other land a considerable distance away. In order to obtain a lease from the BLM for this property, the City would have to, at the very least, complete the U.S. EPA process including the writing of an environmental assessment. This option is considered not viable for the same reasons as a monofill. 20 year life-cycle costs for a harvesting monofill are generally $40-$45.00 per wet ton.

Cannibal Process

The Cannibal Solids Reduction Process (Cannibal) is a proprietary process offered by Siemens Water Technologies Corporation. In this process, wasted aerobic biosolids are retained in a separate, mixed, side-stream, anoxic reactor basin where they are broken down (cannibalized) by facultative organisms that are favored by the anoxic conditions. Flow from the "Cannibal" reactor is returned to the aerobic basins where organisms that thrive in that environment in turn break down biosolids from the anoxic basin.

The Cannibal process includes a solids separation module (SSM) to remove inert materials such as grit, hair, and other unbiodegradable material that passes by the headworks. The SSM is a side stream process that passes a portion of the mixed liquor recycle flow through drum screens with 250 μm openings. The screened mixed liquor is further processed by hydrocyclones to remove fine grit. The screenings are compacted to approximately 40 percent dry solids and disposed of in a landfill. Grit removed by the hydrocyclones is also suitable for disposal in a landfill.

The total amount of solids that are wasted (or purged) from the system is dramatically reduced. The SSM is expected to remove 15 to 25 percent of the total solids from the mixed liquor.

The biological yield expected from the Cannibal process is 0.25 pounds of solids produced per pound of BOD removed. Together, the total net yield resulting from the Cannibal process is approximately 0.40, which is a reduction of 50 percent over a conventional process yield of 0.81. The lower yield results in reduced transportation and disposal costs. In addition, the screenings are dewatered to approximately 40 percent dry solids which further decreases transportation and disposal costs.

The solids resulting from the Cannibal process can be dewatered and landfilled or further treated if desired. The Cannibal process produces reduced quantities of biosolids for disposal as the majority of the solids are broken down and consumed internally within the process. The remaining small quantity of solids is removed, dewatered and disposed of at a landfill. Additional removal of inert grit and screenings is also practiced to enhance process and equipment performance and this material is typically landfilled.

Summary of Solids Disposal Alternatives

The thermal drying option creates a Class A material (by meeting time, temperature and/or moisture requirements) that is suitable for public distribution and use. Currently no market for dried biosolids has been established; however, the City owns and operates a large number of golf courses, parks, and recreational athletic fields. The dried biosolids can be beneficially used as a slow release nitrogen fertilizer, soil amendment additive or even pelletized fuel source. The use of biosolids for these applications could reduce the City's chemical fertilizer expenses for the facilities it maintains. This benefit should be considered once thermal drying becomes feasible.

The "Cannibal" process produces unclassified solids that are disposed of in a municipal solid waste landfill. The benefit of the Cannibal processes, as mentioned previously, is the reduction in solids. However, at present, the high capital cost does not justify the cost savings in solids reduction over a 20 year life cycle.

The monofill and harvesting monofill options are independent disposal options which may receive classified or unclassified biosolids.

Even with recent cost increases, and likely future increases, landfill disposal is the most cost effective solids disposal option for the SGRWRF. It is not anticipated that other options would be considered viable until disposal costs at the landfill reached ten times their present level or at least $30.00/wet ton.

CHAPTER 4
NEW HEADWORKS FACILITY

INTRODUCTION

As part of this Master Plan, BC&A was asked to prepare a plan for a new headworks facility. The purpose of the headworks facility is to improve treatment characteristics and reduce maintenance by removing or reducing wastewater constituents that create difficulties with downstream processes and equipment. Headworks facilities typically provide the following processes: 1) flow measurement; 2) septage receiving; 3) coarse and/or fine screens (in some cases grinding, washing and compacting/ dewatering of screenings); and, 4) grit removal, usually accompanied by classification, washing and dewatering. Frequently the headworks facility also includes an influent pump station to lift the wastewater and enable gravity flow to occur through the remaining processes in the treatment train (if site topography does not already permit gravity flow). Due to high odor-producing potential of the raw influent wastewater, the headworks facility is often equipped with odor control equipment to capture and treat odorous gasses before they are released to the atmosphere. Sometimes chemicals are also added to the wastewater to reduce formation and/or release of odorous compounds.

EXISTING HEADWORKS FACILITY

The original SGRWRF headworks design (1988) consisted of three 54-inch screw pumps with a open slot for a fourth pump to be added later, a 12-inch Parshall flume nested in a larger 24-inch Parshall flume, one mechanical bar screen with 3/4-inch openings and a manual bar screen bypass, and two aerated grit chambers. The original design average daily flow was 5 mgd. In 1994, an expansion to the plant added 3.5 mgd of capacity with installation of a second mechanical bar screen to the headworks. In 1998 a second expansion was undertaken to double plant capacity from 8.5 to 17 mgd. Modifications to the headworks included addition of the fourth 54-inch screw pump, provision of an auxiliary influent pump station with installation of two non-clog submersible pumps, and a 1-foot high extension to the existing Parshall flume and the existing influent channel walls. In 2007 the mechanical bar screens with 3/4-inch openings were replaced with 1/2-inch screening elements.

EXISTING SITE CHARACTERISTICS

The SGRWRF has several characteristics which require consideration in configuring a new headworks facility. First, the existing collection system delivers the wastewater to the site 20 feet below the existing grade. This requires either the construction of headworks facilities below grade, or the immediate lifting of the wastewater using an influent pump station to allow for gravity flow through the rest of the headworks facility. Second, the service area of the SGRWRF is subject to occasional extreme weather events typical of the desert climate. These storms can cause extreme high flow events that coincide with large amounts of grit and debris. Third, the service area has experienced unprecedented growth in the past 10 years and is projected to continue seeing aggressive development over the 20 year period covered by this Master Plan. All of these characteristics impact the selection of technologies in the ultimate headworks design. They also form the basis for the recommendation that all equipment used in the new headworks be severe duty and suited to the extreme variation in conditions and heavy use anticipated over the next 20 years.

EXISTING HEADWORKS CONCERNS

Septage Receiving

Currently, waste hauler vehicles with septage to discharge at the SGRWRF are weighed on a truck scale, and then the septage is pumped through a grate above the influent pump station into a common wet well. The vehicles are then weighed a second time, and the amount of septage discharged is calculated using the differential weight measurement. The grate area is messy and open to the air, which makes it prone to spillage and odor concerns.

Wastewater Pumping

The four screw pumps, in tandem with the two submersible pumps, are capable of handling the current peak flows. However, during two recent events there was an electrical failure on the submersible pumps causing an overflow in the upstream collection system. Presently there is no pumping redundancy, or spare pumping capacity during peak flow events. It is considered imperative that the new headworks provide sufficient capacity with redundancy, and also accommodate expansion capacity for future flows.

Flow Measurement

The SGRWRF currently uses a 24-inch Parshall flume for flow measurement. The flume and sidewall extensions constructed during the 1998 expansion have extended the useable life of the flume. However, the accurate flow measurement capacity of the flume is exceeded at flows above 21.33 mgd (33 CFS) which is the maximum flow rating for a 24-inch Parshall flume under free flow conditions. A review of reported flow rates at the SGRWRF for 2007 shows that flows met or exceeded the 21.33 mgd level on 10 occasions from March 2007 to March 2008. In July and August of 2007 flow exceeded 21.33 mgd twice per month, and in September of 2007 it was exceeded on four separate occasions. Hydraulic capacity and flow measurement in the new headworks must be sized adequately to convey and measure peak flows and provide for future capacity.

Screening

The bar screens with 3/4-inch screen openings were replaced with 1/2-inch openings in 2007 in an attempt to reduce the amount of trash that accumulates in downstream processes. However, the bar screens still allow passage of some long narrow plastics, latex and rag materials which create operations and maintenance difficulties in downstream processes. The carryover material which passes the screens has been of sufficient concern to result in screening of effluent prior to discharge. The influent channels to the screens are also undersized for present peak flows. SGRWRF staff reported that flows spilled over the sidewalls during some high flow events, due in part to the high flows and in part to the inability of the screens to cycle fast enough to remove blockage causing debris, resulting in accumulated solids and objectionable materials in the service walkways. The new screens and influent channels must be sized appropriately to handle the higher flow capacities currently needed, as well as projected future flows at the SGRWRF.

Grit Removal

The aerated grit chambers appear to provide adequate grit removal during low to average flows. However, during peak flows, and especially during storm induced peaks, the grit chambers do not appear to capture sufficient grit quantities. Maintenance personnel must manually remove large amounts of grit from the downstream process facilities following these events. Additionally, the air lift pumps used to remove the grit slurry have experienced frequent clogging from pipe coupons (round pipe remnants from sewer taps) which are narrow enough to bypass the screens. New grit facilities must be sized to handle the wide range of flows experienced at the SGRWRF and reliably remove larger grit quantities. Energy consumption requirements for grit removal and processing must also be considered.

Odor

The headworks facility is open to the air and is a source of considerable odor. Turbulence created by the screw pumps and aerated grit chambers further induces release of odors. The SGRWRF currently employs a custom-designed biofilter at the headworks for scrubbing odors. However, it is relatively small and easily overwhelmed by the volume and concentration of odors from the headworks. SGRWRF staff desires to enclose the new headworks to facilitate containment and treatment of hydrogen sulfide (H_2S) and other odorous compounds associated with raw wastewater.

Summary of Concerns

The existing headworks presents two challenges to the SGRWRF staff. First, objectionable material (grit, screenings, etc.) are not removed to the level desired, which results in increased downstream process maintenance and operating costs. Second, the headworks itself has become a source of considerable maintenance during high flow events. When pumps malfunction, upstream system overflows result, and when pumps function properly existing channels overflow. The new headworks plan must provide for integrating septage receiving, wastewater pumping, screening, grit removal, and odor control to minimize downstream process maintenance, improve overall plant operation, and to the extent possible, reduce energy and maintenance requirements and overall operating costs.

SEPTAGE

Septage is the liquid and solid material pumped from a septic tank, cesspool or other primary treatment source. Scum accumulates on the liquified surface within the tank while solid material settles at the bottom, comprising 20 – 50% of the total septic tank volume when pumped. (A septic tank may retain 60 – 70% of the solids, oil and grease that pass through the system.) Septage characteristics are highly variable, often with significant levels of grease, grit, hair and debris in addition to other organic materials. Septage usually has an offensive odor and appearance (it is "septic"), a tendency to foam upon agitation, and a resistance to additional solids settling and dewatering. It is also a host for many disease-causing viruses, bacteria, and parasites. As a result, septage typically requires special handling and treatment (U.S. EPA, 1984).

Table 4-1 presents a summary of septage quantities received from waste haulers at the SGRWRF in 2007.

Table 4-1
Monthly Septage Quantities 2007

Month	Gallons/Month	Daily Average (gal/day)
January	89,258	2879
February	109,548	3912
March	109,233	3524
April	107,965	3599
May	86,968	2805
June	85,151	2838
July	71,040	2292
August	107,922	3597
September	70,143	2338
October	109,777	3541
November	88,355	2945
December	70,977	2290
	2007 Daily Average =	**3050**

Septage Handling

When discharged into a treatment plant, septage can contribute to upsets in the treatment processes and other operational difficulties. Therefore, it is always advisable to include a septage receiving station in the design of wastewater treatment plant headworks when that facility is planning to accept septage. The receiving facility design must account for the anticipated volume of septage, and effects of septage on plant processes and odor control requirements. Washdown equipment and watertight, quick release type hose connections should be provided for the waste hauler trucks, with accommodation for containment of spillage.

Septage Summary

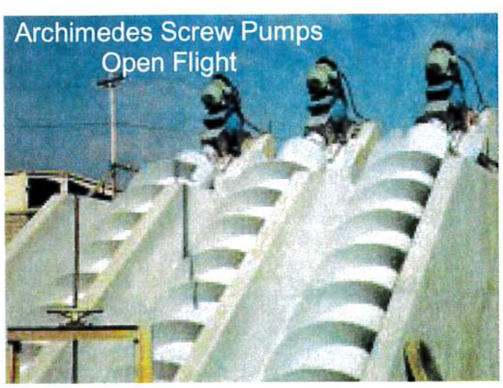
The average daily septage discharge at the SGRWRF for 2007 was 3050 gallons per day as shown in Table 4-1. This quantity represents 0.03% of the average daily flow (at 9 mgd ADF). Offensive odors from discharged septage at the SGRWRF can be detected as much as an hour after each discharge. SGRWRF staff desires to incorporate a new system of septage offloading which will be enclosed for odor control, hold the septage for visual inspection and potential toxicity sampling, possible pre-chlorination, and allow for metering of the septage into the influent wastewater rather than allowing large slug load discharges. The SGRWRF would also like to incorporate a card reading system which will streamline the billing of waste haulers and monitor quantities received each day.

WASTEWATER PUMPING

Wastewater treatment plants employ a variety of pumps depending on particular process requirements. The separation of liquids and solids in the treatment process results in different pump requirements to accommodate differing solids concentrations and flow rates. Currently the SGRWRF uses a combination of submersible, non-clog and Archimedes screw pumps to handle the raw influent plant flow. The screw pumps have operated reliably in the past; however, the submersible pumps are difficult to maintain and have had electrical failures during two recent high flow events which resulted in collection system flooding and overflows. Due to the depth of the wastewater collection system at the upstream end of the plant (the headworks area) it is necessary to lift the raw wastewater influent up to grade for gravity flow. Pumps that provide the necessary lift or "head" for the raw wastewater influent at the SGRWRF must have variable output capacity, reasonable turndown efficiency, and large solids and grit handling capability. State requirements require screening, or screening capability, ahead of pump stations in excess of 1 mgd; however, in the case of screw pumps, this requirement is typically waved. Archimedes screw pumps, vertical turbine solids handling pumps, and centrifugal, non-clog, solids handling type pumps are all considered suitable for service in influent pump stations and are evaluated below for the new SGRWRF headworks.

Archimedes Screw Pumps

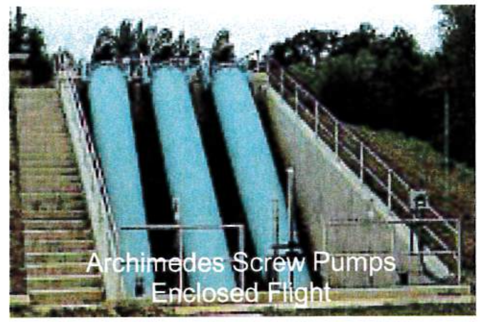
Archimedes (or spiral) screw pumps are one of the oldest types of pumps, having been developed and used for irrigation and other purposes in ancient Greece, and even before that time. In situations that require higher head capacities other pump types are often used. However, screw pumps remain very popular among wastewater facilities due to their ability to handle the wide range of flows and solids contents encountered in raw wastewater pumping. They are able to operate economically down to 30% of maximum design capacity. They are highly efficient, constant speed, variable output pumps. Screw pumps operate at relatively low speeds and have lower maintenance and energy costs. They are non-clogging and very reliable. Screw pumps are generally mounted in a channel that is slightly lower than the influent channel, eliminating the need for a large wet well. The most significant disadvantage is the high initial equipment and installation cost. Screw pumps can be two to three times more expensive to purchase and install than the other two pump types discussed herein. Screw pumps are available in two different basic configurations, open screw and enclosed screw types.



Open screw (external flight) pumps consist of a smaller central tube with one or more helical elements (flights) welded to the exterior. The helical screw is placed in a semi-circular inclined trough and suspended between an upper and lower bearing. Tight clearances between the trough and the helical flights are required for efficient pumping. Rotation of the screw provides the motivating power for lifting the wastewater. (These are the types of pumps currently used at the SGRWRF headworks.)

Enclosed screw (internal flight) pumps come in two varieties, defined by the placement of the helical flights relative to the outer tube. The first variety consists of convoluted helical flights welded to the inside surface of the larger outer tube.

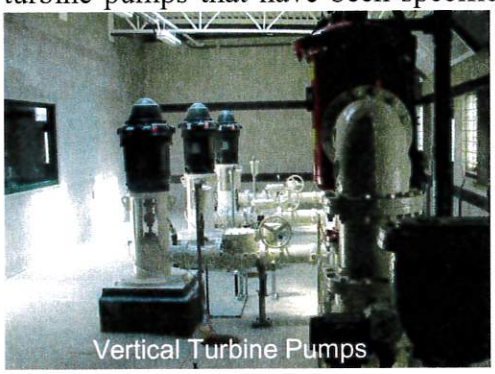
The entire tube is then rotated providing the motivating force. One advantage of this variety is that the lower bearing is not submerged in the wastewater.



The second variety consists of an open channel external flight shaft (described above) rotating inside a tube, rather than a semi-circular inclined trough. This variety is susceptible to air binding when submerged inlet conditions exist. The rotating external tube variety is more commonly employed in wastewater pumping applications.

Vertical Turbine Solids Handling Pumps

Vertical turbine solids handling pumps (VTSH) consist of a variation of surface mounted vertical turbine pumps that have been specifically designed to handle large solids and long stringy rag materials found in raw wastewater. They can pump a large range of flows, meet high head requirements (100+ feet), and be operated using variable frequency drives to match incoming flowrates and possibly increase energy efficiency. These pumps were first used for wastewater in the early 1980's and therefore do not have the extended service record of the other two pump types. But they have proved reliable never-the-less. These pumps require only a wet-well as opposed to the wet-well/dry-pit centrifugal pumps, which can result in significant construction cost savings. However, the initial equipment cost for VTSH pumps can be up to 50% higher than centrifugal pumps, although still less than screw pumps.

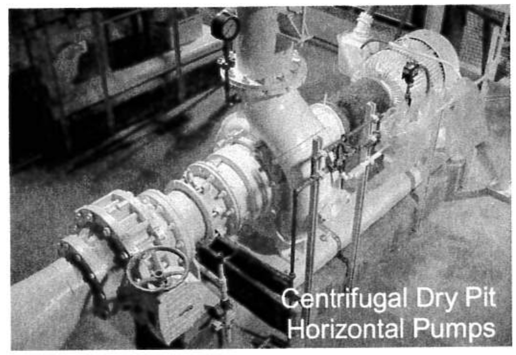


Non-Clog Centrifugal Pumps

Non-clog centrifugal pumps are generally lower head/higher flow type units. Incorporating variable speed drives into the design can reduce the total number of pumps needed, and control the number of motor starts per hour to increase motor service life. There are two basic types of centrifugal wastewater pumping configurations for raw wastewater influent, submersible (wet well only) and wet well/dry-pit.

Submersible type pumping stations normally have lower capital costs than dry-pit pumps because the requirement for a dry pump pit is eliminated; however, maintenance can be more challenging when dealing with larger submersible pumps such as those required to convey the SGRWRF raw influent flow. Submersible pumps are installed directly in the wet well and must be removed from the influent wastewater and thoroughly cleaned prior to any repair or even detailed inspection. The pumps operate in the corrosive and hazardous environment of the influent wastewater wet well, and must be monitored remotely as they cannot be visually inspected without removal.

Dry pit pump configurations combine the benefits of flooded suction, easy access for maintenance, and a less severe duty environment for operation. However, dry-pit pumps require a dedicated pump pit adjacent to the wet well which increases the capital cost due to the additional excavation and backfill, dewatering, concrete and formwork, stairways and other access-related components including lighting, ventilation, bridge and/or monorail cranes, etc. Dry pit centrifugal wastewater pumps can be configured horizontally (as shown in the photograph), or vertically to reduce the equipment footprint and save space and construction cost.


Centrifugal Dry Pit Horizontal Pumps

Wastewater Pumping Summary

Raw wastewater influent pumps must be capable of operating reliably in severe duty conditions and be easily and regularly maintained. The additional capital cost associated with the Archimedes screw and/or dry-pit centrifugal pumps is often justified due to fewer man hours required for maintenance and superior maintenance practices that result in extended equipment service life. In both pump configurations the pumps can be visually checked, maintained and repaired. Additionally, the electrical connections in the Archimedes screw and/or dry-pit configuration are not submerged which eliminates possible failure modes related to the wet electrical connection. High concentrations of grit in the influent wastewater would require that a wet well/dry pit pump configuration incorporate a self-cleaning system of mixing and/or re-suspension of grit loads to prevent cavitation or dry-running of the pumps. Due to the additional complexity of a self-cleaning wet well and the likelihood of heavy grit load events, it is recommended that the SGRWRF incorporate screw pumps into the new headworks facility. The maintenance staff is familiar with the maintenance of the screw pumps and has a high level of satisfaction with the excellent operating record of the existing pumps.

Table 4-2 presents a summary of pump advantages and disadvantages for each pump type considered for use in the new headworks facility.

Table 4-2
Wastewater Pumping Advantages/Disadvantages

Item	Advantages	Disadvantages
Archimedes Screw Pumps	• Constant speed, variable output (simple) • Low maintenance • High reliability • High tolerance for entrained air/gas • Low mechanical vibration and noise • Excellent solids handling capabilities	• Highest initial cost • Large footprint • Low head capacity
Vertical Turbine Solids Handling Pumps	• High head capacity • High efficiency • Variable speed drives can be used Small footprint (no dry pit required)	• Higher initial cost
Centrifugal Non-clog	• Simplicity • Variable speed drives can be used • Placed in wet or dry pit • Controlled by floats or level sensors	• Poor suction efficiency • Cavitation potential • High speeds

FLOW MEASUREMENT

Accurate flow measurement is important in maintaining effective wastewater treatment. Plant flow rates are used for estimating current and future pumping and chemical costs, sizing and determining turndown requirements of pumping facilities, sizing influent channels, determining number of process units, sizing of plant piping, grit chambers, sludge pumping, and for reporting of plant operations to regulatory agencies. Two basic approaches to flow measurement in wastewater treatment plants are commonly used, open channel flumes and closed conduit flow meters. Closed conduit flow meters are further subdivided into two main categories: magnetic and ultrasonic. Ultrasonic flow meters may be Doppler shift or transit-time types, both of which are discussed.

Open Channel Flumes

The most common type of flume used for flow measurement in wastewater treatment facilities is the Parshall flume. Palmer-Bowlus, Cutthroat, and H-type flumes have all been used, but less frequently. Flume geometries are designed to cause the flow regime to pass through critical depth. The flume acts as a control structure and provides a means for determining the rate of flow from a single, upstream water depth measurement. Flumes have associated stilling wells which aid in accurate upstream water level depth measurement and are generally equipped with an ultrasonic level sensor which relays the stilling basin depth and associated flow rate to the treatment facility Supervisory Control and Data Acquisition (SCADA) equipment. Flumes generally provide flow accuracies of within ±5% of the actual flow rate, and can be as accurate as ±2% when optimum upstream and downstream conditions exist. Accuracy is a function of the flume configuration and the upstream and downstream channel geometry, and providing sufficiently long straight runs of channel to induce even flow distribution across the inlet to the flume. Parshall flumes generally consist of prefabricated fiberglass inserts that are cast into a concrete channel. They are available in a number of standard sizes and accommodate a wide range of flows. As mentioned previously, the SGRWRF currently uses a 24-inch Parshall flume for flow measurement. Parshall flumes provide a relatively cost effective and low maintenance solution to flow measurement.

Closed Conduit Flow Meters

Magnetic flow meter units are installed in-line and provide accuracy of ±0.25% of actual flow when flow velocity is at least 1.5 feet per second and sufficient straight lengths of upstream and downstream piping are provided. These meters are generally factory calibrated and arrive ready for installation. These meters maintain their accuracy from 1.5 fps to 30 fps although such high velocities are generally avoided in wastewater treatment. Full pipe flow must be maintained in order to preserve accuracy. Magnetic meters are high accuracy and require little maintenance; however, in large diameters (>24-inch) they can be expensive compared to ultrasonic flow meters.

Ultrasonic flow meters use sonic transducers to calculate flow through a pipe. There are two types of closed conduit ultrasonic flow meters: transit-time and Doppler shift. The two types are separated by the manner in which they send and receive high frequency sound waves and use it to calculate flow. Transit type meters send out two waves, one traveling upstream and one traveling downstream. The measured difference of the time is a function of the process velocity.

A Doppler shift meter transmits a single wave and measures the change in wavelength of the reflected wave. Both types of transducers can be mounted outside the pipe (clamp-on) or inserted into the pipe. Accuracy is generally in the ±2% range. The transducers are the same for a wide range of pipe diameters and are therefore considered very expensive for smaller diameter pipes and inexpensive for larger pipe diameters. When compared to magnetic flow meters this price trade-off generally occurs at pipe diameters in excess of 20-inches. These meters typically require full pipe flow at all times for accuracy. They are non-invasive and low maintenance; however they have pipe thickness and lining restrictions.

Flow Measurement Summary

Flow measurement can be accommodated at either end of the headworks. Given that all flow measurement technologies discussed have acceptable levels of accuracy and are relatively comparable in price, the selection will be made once larger process equipment has been selected and space availability and cost can be assessed more accurately.

SCREENING

Screens often provide the first line of defense for a wastewater facility. Two size categories may be defined for purposes of this evaluation: “fine” screens and “coarse” screens. Fine screens, with 1 mm (1/25-inch) to 6 mm (1/4-inch) openings, are used to remove material that might otherwise reduce treatment effectiveness or become a maintenance problem in downstream processes. Coarse screens, with openings larger than 6 mm (1/4-inch) are used to remove trash, large solids (i.e. rocks and wood), rags, and other debris that may damage or clog pumps, valves, pipes, or other appurtenances. The SGRWRF recently replaced its 3/4-inch bar screens with 1/2-inch bar screens resulting in higher screenings capture. During high flow events the screenings cleaning rake cannot cycle fast enough to remove debris and screenings, and obstructs flow resulting in raw wastewater overflowing the screenings channels.

Coarse Screens

Coarse screens usually consist of vertical bar racks that are manually or mechanically cleaned. In general, coarse screens are suited for deep channels and are relatively inexpensive compared to fine screens, and have a rapid removal rate of large screenings. However, the larger opening size may allow passage of long, narrow materials (plastics, rags, etc.) as described above for the existing SGRWRF headworks screening equipment. Many facilities presently being constructed have elected not to include coarse screens in their headworks due to the desire for higher screenings removal rates, improvements in the reliability of finer screens, and less inert and objectionable material in downstream solids treatment processes.

Fine Screens

Fine screens can be used independently of or in conjunction with coarse screens for preliminary treatment purposes. These screens typically have small openings allowing capture of smaller debris such as cotton swabs, plastics, rags, and latex items that larger bar screens are unable to capture. The screens can also capture and remove some grease and grit, depending on how they are configured and operated. The removal of these wastewater constituents reduces maintenance time and associated costs for downstream processes, as well as improving the aesthetics of the plant and it's products (such as reducing the amount of visible and identifiable trash present in the final clarifier effluent and the biosolids).

Currently, three main categories of fine screens have a strong presence in the municipal wastewater treatment industry: 1) step screens; 2) drum screens; and, 3) perforated-plate band screens. The perforated-plate band screens are divided into two types of flow patterns. Straight-through flow occurs where the screen is placed perpendicular to the wastewater flow. "Into-and-out" flow occurs where the screen is placed parallel to flow and raw wastewater enters the center of the continuous band and flows out either side.

Step Screens. Step screens are a variety of finescreen widely used in Europe and are starting to be used more frequently within the U.S. They consist of two step-shaped sets of vertical plates, one of which is fixed and one of which is movable. The movable plates rotate in a vertical motion by lifting up captured solids to the next step. Openings range from 1 mm to 6 mm, but are typically in the 3 to 6 mm range. They have good capture efficiency once a mat forms on the screen and they have a low profile. However, they lack the strength to span wide channels (>6-feet), and are unable to accommodate deep channels (>20-feet) without use of equipment to lift the screenings up to a grade level operating floor or platform.

Drum Screens. Drum screens consist of a screen mounted on a cylinder that rotates in the flow channel. They are typically used in small to medium sized plants with shallow influent channels. Opening sizes range from 0.5 mm in a wedge wire arrangement to 6 mm (1/4-inch) perforated plate style. Cylindrical drums can be manufactured as large as 10-feet in diameter and, depending on opening size, can accommodate as much as 25 mgd per screen; however, this is not common and not recommended. Drum screens incorporate screenings removal, washing and compacting into a single unit with a single motor. Drum screens have good capture efficiency, hydraulic performance, and easily pivot out of the channel for maintenance. As with all perforated plate and wedge wire screens there is the potential for grease to blind the perforations and there is a potential for pig-tails (twisted rags and other material) in the screw conveyor. The single drive motor adds simplicity, but also makes the entire screening, washing, and compacting system reliant upon the continuous operability of the single motor. The screenings requirements of the new SGRWRF headworks are at the high end of the manufacturing limits of the drum screen suppliers. These limitations make drum screens a less attractive alternative than the other two alternatives.

Perforated Plate Bandscreens. Traditional bandscreens consist of rotating panels situated perpendicular to the flow path, allowing wastewater to flow through the perforations in the panels. A more recent variation of the perforated-plate bandscreen accommodates an installation parallel to the flow which channels the wastewater into the center of the screen and through the perforated plates on the left and/or right side panels. These are suitable for deep channels and have a range of perforation diameters from 1 to 6 mm. Both drum and bandscreens have the highest capture efficiencies of the fine screens; however, there is a potential for grease buildup on the screen.

Screening Summary

It is recommended that SGRWRF replace its coarse screening of raw wastewater with fine screening, and that step and band fine screen varieties be evaluated for the future headworks facility. The fine screens will greatly improve screenings capture efficiency, reduce accumulation of long, narrow materials collecting in solids processes, provide protection for sensitive equipment in the treatment process, and enhance plant aesthetics.

SCREENINGS HANDLING

There are various methods, equipment and systems available to convey, wash, compact, and dispose of screenings after they are removed from the raw wastewater. Belt conveyors, shaftless screw conveyors, and pneumatic conveyors are the most common methods for mechanically transporting screenings. Pumping and hydraulic sluicing are also sometimes employed. Screenings compactors can be used to wash and dewater screenings by up to 50 percent and reduce the volume of screenings by as much as 75 percent (Metcalf and Eddy, 2003 pg 330) through compaction. At this point, the screenings are disposed of; most commonly the materials are transported to a local landfill.

Belt Conveyors

Belt conveyors are generally simpler to operate, require less maintenance, and are more economical than shaftless screw or pneumatic conveyors. However, they can contribute more odor problems as the screenings are left open to the atmosphere, and they may require more space for the mechanical components. Drainage should be provided for as the screenings are conveyed. Holes in the belt should be located to prevent dripping on the carriage assembly. The belt should be made of a material such as rubber that does not rust, and which should be cleaned by a spray wash to prevent the buildup of grease and other material. Belt conveyors can also be messy because they are uncovered as described above. Currently, the SGRWRF uses a belt conveyor to transport both screenings and grit.

Shaftless Screw Conveyors

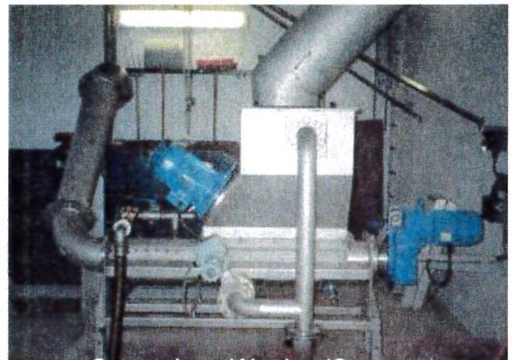
Shaftless screw conveyors are an efficient way of conveying semi-solid and sticky materials. Shaftless design provides a generally non-clogging conveying surface by eliminating intermediate shaft bearings and by having zero clearance between the screw and the trough liner. (To improve wear performance the trough is typically lined with metallic or non-metallic, ultra high molecular weight (UHMW) polyethylene liners or wear bars.) Often, a perforated drain plate or wedge wire screen section is added to accommodate draining of moisture from screenings.

Pneumatic Conveyors

Pneumatic conveyors offer several advantages over other conveying systems because pneumatic systems are enclosed, are therefore less odorous, and typically require less space. However, conveying sticks, stones, and other debris in screenings through pipelines can clog and/or excessively wear fittings and other components. Therefore, the system design should include cleanouts and high-pressure water service for flushing (WEF, MOP 8).

Washing and Compaction

Washing greatly reduces the amount of fecal and other organic matter and associated odors in the final screenings. Compaction both dewaters and reduces the volume of the screenings. These devices typically employ hydraulic ram or screw type systems. Compactors are equipped with controls that sense jams, automatically reverse the mechanism, and set off an alarm when a motor overload occurs. After compacting, screenings are then taken to a conveyor or bin for transport to a disposal facility, usually a landfill. Compactors that use screw type systems (with a wash zone) have a lengthy track record, can semi-continuously wash relatively large amounts of screenings, have a low profile, and are priced competitively. However, the quality of washing may not be very good. Screw presses with agitation zones employ a more efficient washing cycle. However, they generally have a larger footprint, lower washing and output capability, and may also be more costly.


Screenings Washer/Compactor

An increasingly common practice in new headworks facilities is the addition of a grinder or macerator to the washer/compactor equipment. While the number of installations has been limited, references have been good. This type of grinder/washer/compactor configuration helps break down large debris and increases washing efficiency. A recent study in Vancouver, British Columbia showed 4 times greater fecal matter reduction in screenings when a grinder was used. A similar study conducted in King County, Washington showed a reduction of 8.3 wet tons per week of screenings and the associated reduction in hauling costs (WE&T, July 2007, pg 74). Grinding of screenings prior to washing and compacting can increase washing efficiency and reduce the total screenings volume, however, grinders are generally high maintenance items and the cost of this configuration is greater than those without grinders. A screenings bagging system is a lower cost alternative to a grinder and provides enhanced odor control and handling in the absence of a grinder.

Screenings Disposal

Screenings materials must be disposed of in accordance with local, state, and federal regulations. Methods chosen for transport and disposal should consider traffic, air quality, water quality, and other environmental considerations. Lime addition may be required to help control insects, vermin, and odors. The most common type of disposal is at municipal solids waste landfills where it is combined with municipal waste.

Screenings Handling Summary

Currently the SGRWRF produces approximately 2.5 cubic yards of grit and screenings per day. It is anticipated that with finer screens this quantity could increase by double or more. In order to reduce the overall screenings volume it is recommended that the SGRWRF incorporate the grinder/washer/compactor configuration. If selected, the grinder will aid in reducing volume and increasing surface wash area resulting in cleaner screenings. The conveyor system can be selected once final system configuration is determined, however, an enclosed system is encouraged to contain odor. Additionally, the landfill which services the SGRWRF is considering increasing rates. Therefore, a reduction in volume of solids may result in operating cost savings. Even with the proposed rate increase, landfilling of screenings will remain much more cost effective than disposal using an incinerator or monofill.

GRIT REMOVAL

Sand, cinders, gravel, some seeds, egg shells, coffee grinds and other heavy particulate solids in wastewater are commonly known as grit. Grit typically ranges in specific gravity from 1.3 to 2.7, consists of particles larger than 150 microns (0.15 mm), and has a bulk density of 100 lb/ft^3. Grit in wastewater causes increased equipment wear and maintenance, accumulates in channels, pipes, and basins, and decreases the efficiency of downstream processes. Quantities of grit in a system depend on local drainage area characteristics, soil types, condition of sewers, use of household garbage disposals in the area, and whether separate or combined sanitary and storm water sewers are used. Separate sanitary sewer systems like those serving the St. George area may typically experience grit quantities ranging from 0.5 ft^3/Mgal to 5 ft^3/Mgal (WEF, 1998). For the proposed design capacity of the SGRWRF expansion, this equates to a range of 12.5 ft^3/day to 125 ft^3/day or 0.63 to 6.25 tons per day. The current aerated grit chambers function adequately during low to average daily flow. Larger events which occur during the summer irrigation and monsoonal rain season can overwhelm the system and deposit large quantities of grit in downstream areas, particularly the bio-selector.

Grit chambers protect mechanical equipment from wear due to abrasion, reduce clogging of downstream process piping, and reduce downstream process cleaning. Grit chambers are commonly located following the wastewater screens. This configuration helps simplify operation and maintenance of the grit chamber by reducing the amount of rags and other debris that enter the chambers. It is desirable to locate grit chambers ahead of the wastewater pumps in a headworks plant. However, the depth of the influent sewer at the SGRWRF (>20 ft below grade) and the additional cost of construction for deep excavation and control of groundwater makes it more feasible in this specific case to locate the grit chambers after the pumps. There are two main types of grit removal systems, aerated and vortex systems.

Aerated Flow Grit Chambers. Aerated grit chambers rely on a spiral flow pattern created by the introduction of air along one long side of a rectangular channel. Lighter organic particles remain suspended by the motion of the spiral flow, while heavy solids settle and are deposited at the bottom of the tank. The introduction of air must be controlled and periodically adjusted after installation to optimize the settling of heavy grit materials without providing too little agitation to keep organics suspended, or too much agitation which may reduce grit settling and removal. Grit typically settles into a hopper at the bottom of the rectangular basin and is removed by grab buckets, screw conveyors, jet pumps, or airlift pumps, and is then conveyed to washing and classifying units.

Vortex Flow Grit Chambers. Vortex grit chambers consist of circular basins with flat or sloped floors which use a spiral or vortex flow pattern to settle out the grit. As grit enters the circular basin, the flow is directed tangentially around the outside of the basin. Heavy grit particles separate from lighter organics which also exit the basin tangentially, generally at 180 or 270 degrees from the influent channel. The grit is collected into a hopper at the bottom of the basin and pumped out for cleaning and separation.

Two proprietary variations on this design have improved removal efficiencies. The Eutek Headcell is a combination of vortex grit removal and lamella plate settler technology. It delivers grit tangentially through an influent header to multiple concentric plates reducing the settling distance of the grit and increasing overall capture. The Hydro-International Grit King uses internal baffles to induce separate helical flow patterns. An internal baffle called a dip plate creates a shear zone separating an outer downward flow spiral from an inner upward flow spiral. The net zero velocity in the shear zone induces grit to drop out of suspension and into the grit hopper.

Grit Washing and Classifying

Grit Washing/Classifying

After grit is pumped out of the grit hopper in the grit chamber it is washed to aid with handling. The objective of washing grit is to return as much organic content as possible to the treatment flow stream while retaining as much of the grit as possible. This reduces overall grit volume to be landfilled and helps minimize objectionable odors. In order to perform this task efficiently, the nature of the grit to be removed must be accurately determined. Grit washing and classifying can be performed jointly with a hydrocyclone, or separately with inclined screw or reciprocating rake classifiers.

Grit Removal Summary

The SGRWRF aerated flow grit chambers have performed satisfactorily in the past, but have had difficulty in dealing with higher flows associated with monsoonal flash floods and sewer system inflow/infiltration. They have struggled with construction debris, most notably pipe coupons from new sewer laterals which are narrow enough to bypass the coarse screens and clog the air lift pumps. With the large amount of anticipated future growth, construction debris will continue to be a problem. Therefore it is recommended that the SGRWRF implement different grit removal strategies. In order to reduce the energy consumed by the aeration system in the aerated grit chambers and implement a technology that is better able to handle high flow fluctuations, it is recommended that SGRWRF implement vortex flow grit chambers, recessed impeller grit pumps, hydrocyclone washers and screw type classifiers. Vortex technologies should be evaluated and selected based on the ability to provide the best high flow/high concentration grit removal efficiencies.

ODOR CONTROL

A major trend facing many wastewater treatment facilities in growing communities is the conversion of surrounding land and open space into businesses, industry and residential neighborhoods. Sometimes attempts are made to purchase surrounding properties to serve as a buffer to the treatment plant.

There are many chemical compounds which contribute to odor at treatment facilities. H_2S is a common chemical compound at treatment facilities and is an indicator of corrosive conditions. It has a distinctive rotten egg odor and is easily detected in headworks and solids processing buildings at the SGRWRF. At any given time there may be multiple chemical compounds contributing to odor, however, H_2S concentrations are often the most prevalent and dictate the sizing of air handling and capacity of treatment equipment.

Odor sources must be contained and treated in order to reduce corrosion of plant equipment and minimize odor complaints from surrounding neighbors. Odor control can be accomplished through chemical treatment and/or odorous air capture and scrubbing. Chemical addition is sometimes used in retrofit construction and requires a period of assimilation and/or contact exposure for effective odor control. Chemical addition is more commonly used in control of odors associated with the collection system, and is not considered for use in the proposed new SGRWRF headworks facility.

Air Scrubbing Method

Air scrubbing of gas streams collected from covered headworks processes can provide effective odor control. Odor scrubbers may remove odorous compounds from the air stream by different methods, including activated carbon adsorption, biological scrubbers, chemical contact towers, ozonation, or combustion. Odorous air is removed by blowers which create negative air pressure in the treated air space, and then disperse the odorous air through a scrubbing media which removes the odorous compounds and releases the scrubbed air into the atmosphere. Currently, the SGRWRF uses a biological odor control system for both solids processing and a portion of the headworks.

Odor Control Summary

The SGRWRF will incorporate air scrubbing in order to address odor emissions at the new headworks facility. The high replacement cost and short life of activated carbon filters under heavy H_2S loadings generally eliminates them from this specific odor treatment application. Likewise, the cost and hazard associated with storing large quantities of onsite chemicals for treatment in chemical contact towers is unattractive when compared with the simplicity of biological scrubbers. Ozonation and combustion are effective at oxidizing odorous chemical compounds, but are not often found in headworks facilities due to high capital and operating costs. Biological scrubbers, in general, have higher capital costs than carbon and chemical systems, but life cycle costs are considerably lower, especially at high H_2S loading rates. Currently the SGRWRF utilizes a biological system that has worked effectively when properly maintained. A similar biological soil mound system is recommended for the new headworks due to high H_2S removal efficiency and familiarity of plant staff with operation and maintenance of the system. In order for the most effective and economical design of the biological scrubber to be implemented, H_2S levels at the existing headworks should be tested and evaluated for sizing of future scrubbing equipment.

PRELIMINARY HEADWORKS DESIGN AND COST ESTIMATE

The new headworks facility will incorporate the technologies discussed in this chapter to eliminate present operating concerns and improve trash and grit removal and accommodate future expansion. Figure 4-1 shows a preliminary layout of the headworks facility.

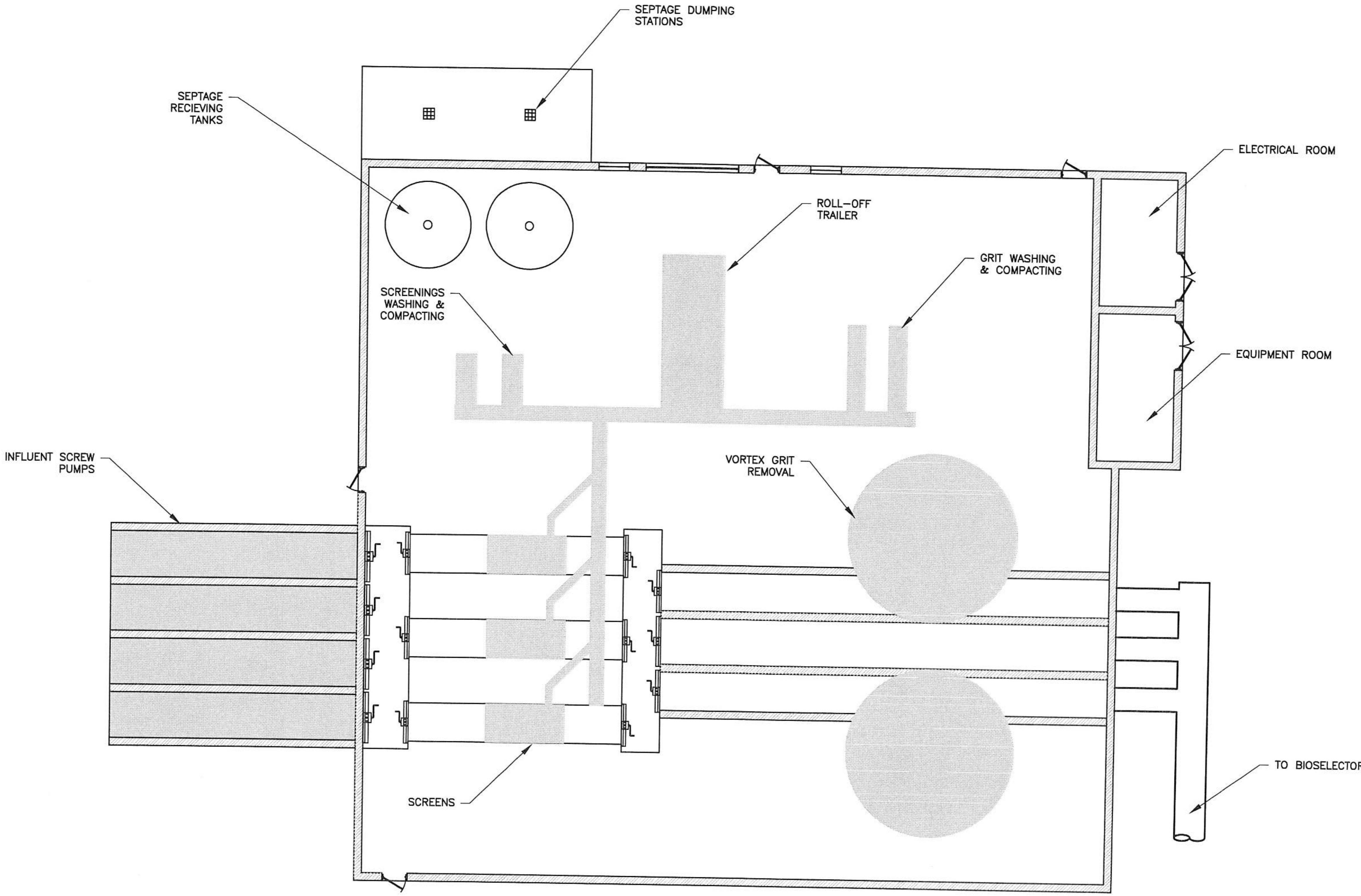


Figure 4–1
PRELIMINARY HEADWORKS LAYOUT
SGRWRF Expansion Master Plan

Bowen Collins & Associates, Inc.
Consulting Engineers

A preliminary cost estimate was prepared based on this preliminary design and is summarized in Table 4-3 below. A more detailed cost breakdown is included in Appendix C.

Table 4-3
New Headworks Facility
Preliminary Construction Cost Estimate*

Item	Description	Total Cost
1	Site Work	$ 377,000
2	Concrete	$ 1,000,000
3	Building	$ 1,250,000
4	Equipment	$ 3,382,000
5	Mechanical	$ 300,000
6	Electrical/Instrumentation	$ 640,000
	Subtotal	$ 6,940,000
	Contractor Overhead and Profit	$ 694,000
	Contingency	$ 1,388,000
	Total Estimate	**$ 9,022,000**

It is anticipated that a minimum of two and a half to three years would be required to design and construct the facility. If population growth continues steadily as projected in Chapter 1, the new facility would need to be functional by January 2012 or when flows reach 12 mgd. This would require design of the facility to begin by January 2009.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

ACSSD	Ash Creek Special Service District
ADF	Average Daily Flow
ASR	Aquifer Storage and Recovery
ATAD	Autothermal Thernophilic Aerobic Digestion
BC&A	Bowen Collins & Associates
BLM	Bureau of Land Management
BOD_5	Biochemical Oxygen Demand
CAS	Conventional Activated Sludge
CFR	Code of Federal Regulations
City	St. George City
CWA	Clean Water Act
DO	Dissolved Oxygen
DS	Dissolved Solids
DWQ	Division of Water Quality
gpcd	Gallons per Capita per Day
HLR	Hydraulic Loading Rate
HRT	Hydraulic Retention Time
H_2S	Hydrogen Sulfide
JSSD	Jordanelle Special Service District
MBR	Membrane Bio Reactor
MG	Million Gallons
mgd	Million Gallons per Day
mg/L	Milligrams per Liter
MLSS	Mixed Liquor Suspended Solids
NH_3	Ammonia
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Treatment Works
RAS	Return Activated Sludge
RPM	Revolutions per Minute
SCADA	Supervisory Control and Data Acquisition
SGRWRF	St. George Regional Water Reclamation Facility
SOR	Secondary Overflow Rate
SRT	Solids Retention Time
SSM	Solids Separation Module
SVSD	South Valley Sewer District
SVWRF	South Valley Water Reclamation Facility
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
TSSD	Timpanogos Special Service District
UHMW	Ultra High Molecular Weight
USEPA	United States Environmental Protection Agency
UV	Ultraviolet

VTSH	Vertical Turbine Solids Handling
WAS	Waste Activated Sludge
WRF	Water Reclamation Facility
WQA	Water Quality Act

APPENDIX B

REFERENCES

APPENDIX B

REFERENCES

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APPENDIX C

DETAILED COST ESTIMATES

Life Cycle Cost Analysis For Treatment Alternatives

		Oxidation Ditch		Staged Aeration		CAS		MBR	
Year	Flow	CC	OC	CC	OC	CC	OC	CC	OC
0	9.7	$ 60,889,434	$ 702	$ 56,731,183	$ 646	$ 88,758,541	$ 410	$ 116,507,612	$ 710
1	10.2		$ 2,618,480		$ 2,409,599		$ 1,529,312		$ 2,648,321
2	10.8		$ 2,758,979		$ 2,538,889		$ 1,611,369		$ 2,790,420
3	11.3		$ 2,904,508		$ 2,672,809		$ 1,696,365		$ 2,937,608
4	11.9		$ 3,055,068		$ 2,811,359		$ 1,784,299		$ 3,089,883
5	12.5		$ 3,210,658		$ 2,954,537		$ 1,875,171		$ 3,247,247
6	13.2		$ 3,371,279		$ 3,102,345		$ 1,968,981		$ 3,409,698
7	13.8		$ 3,536,931		$ 3,254,783		$ 2,065,729		$ 3,577,238
8	14.5		$ 3,707,613		$ 3,411,849		$ 2,165,415		$ 3,749,865
9	15.2		$ 3,883,327		$ 3,573,545		$ 2,268,040		$ 3,927,581
10	15.9		$ 4,064,070		$ 3,739,871		$ 2,373,602		$ 4,110,384
11	16.6		$ 4,249,845		$ 3,910,826		$ 2,482,103		$ 4,298,276
12	17.3		$ 4,440,650		$ 4,086,410		$ 2,593,542		$ 4,491,255
13	18.1		$ 4,636,485		$ 4,266,623		$ 2,707,919		$ 4,689,323
14	18.9		$ 4,837,352		$ 4,451,466		$ 2,825,234		$ 4,892,478
15	19.7		$ 5,043,249		$ 4,640,938		$ 2,945,487		$ 5,100,722
16	20.5		$ 5,254,177		$ 4,835,040		$ 3,068,679		$ 5,314,053
17	21.3		$ 5,470,135		$ 5,033,771		$ 3,194,808		$ 5,532,473
18	22.2		$ 5,691,124		$ 5,237,131		$ 3,323,876		$ 5,755,980
19	23.1		$ 5,917,144		$ 5,445,121		$ 3,455,882		$ 5,984,575
20	24.0		$ 6,148,194		$ 5,657,740		$ 3,590,826		$ 6,218,259
Total Operating Cost			**$ 67,341,632**		**$ 61,969,650**		**$ 39,330,583**		**$ 68,109,058**
20 Yr Present Worth			**$ 128,231,066**		**$ 118,700,834**		**$ 128,089,124**		**$ 184,616,671**

Interest 2%

Oxidation Ditch Cost Summary

BOWEN COLLINS & Associates, Inc. Consulting Engineers

PROJECT: Wastewater Treatment Plant Facility Plan
CLIENT: SGRWRF
JOB NO.: 001-07-03

DATE: 29-May-08
BY: mac
CHECKED:

Component		Oxidation Ditch
Headworks & Influent Pump Station		$ 9,021,943
Oxidation Ditches w/ Anoxic Selector		$ 12,004,923
RAS/WAS & Scum Pump Station		$ 1,317,746
Secondary Clarifiers		$ 3,684,185
UV Disinfection		$ 1,802,970
Aerated Holding Tank		$ 506,667
Dewatering Facility		$ 2,100,000
Dewatered WAS Transport/Disposal		$ 900,000
Blower Building & Aeration Equipment		$ 9,255,000
	Subtotal	**$40,593,434**
Site Development	10%	$4,059,000
Yard Piping	10%	$4,059,000
Electrical, Instrumentation & Control	15%	$6,089,000
Engineering, Legal, Admin.	15%	$6,089,000
	Total	**$60,889,434**

Staged Aeration Cost Summary

BOWEN COLLINS & Associates, Inc.
Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

Component		**Staged Aeration**
Headworks & Influent Pump Station		$ 9,021,943
Staged Aeration Conversion		$ 9,232,672
RAS/WAS & Scum Pump Station		$ 1,317,746
Secondary Clarifiers		$ 3,684,185
UV Disinfection		$ 1,802,970
Aerated Holding Tank		$ 506,667
Dewatering Facility		$ 2,100,000
Dewatered WAS Transport/Disposal		$ 900,000
Blower Building & Aeration Equipment		$ 9,255,000
	Subtotal	**$37,821,183**
Site Development	10%	$3,782,000
Yard Piping	10%	$3,782,000
Electrical, Instrumentation & Control	15%	$5,673,000
Engineering, Legal, Admin	15%	$5,673,000
	Total	**$56,731,183**

Conventional Activated Sludge (CAS) Cost Summary

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan** DATE: 29-May-08
CLIENT: **SGRWRF** BY: mac
JOB NO.: **001-07-03** CHECKED:

Component		**Trickling Filter/Solids Contact**
Headworks		$6,836,500
Primary Clarifiers		$2,279,502
Primary Sludge & Scum Pump Station		$196,410
RAS/WAS Pump Station		$962,314
Secondary Clarifiers		$3,684,185
UV Disinfection		$1,802,970
Dewatering Facility		$2,100,000
2-Stage Anaerobic Digestion		$28,710,000
Dewatered Digested Solids Transport/Disposal		$900,000
Blower Building & Aeration Equipment		$9,255,000
Primary Effluent Pump Station		$2,445,661
	Subtotal	**$59,172,541**
Site Development	10%	$5,917,000
Yard Piping	10%	$5,917,000
Electrical, Instrumentation & Control	15%	$8,876,000
Engineering, Legal, Admin	15%	$8,876,000
	Total	**$88,758,541**

Membrane Bioreactor (MBR) Cost Summary

Bowen Collins & Associates, Inc.

PROJECT: Wastewater Treatment Plant Facility Plan
CLIENT: SGRWRF
JOB NO.: 001-07-03

DATE: 29-May-08
BY: mac
CHECKED:

Component		Membrane Bio Reactor
Headworks & Influent Pump Station		$ 9,021,943
Membrane Bio-Reactor Process		$53,563,999
Bio-Selector Pump Station		$521,033
UV Disinfection		$1,802,970
Aerated Holding Tank		$506,667
Dewatering Facility		$2,100,000
Dewatered WAS Transport/Disposal		$900,000
Blower Building & Aeration Equipment		$9,255,000
Subtotal		**$77,671,612**
Site Development	10%	$7,767,000
Yard Piping	10%	$7,767,000
Electrical, Instrumentation & Control	15%	$11,651,000
Engineering, Legal, Admin	15%	$11,651,000
Total		**$116,507,612**

Headworks Cost Estimate (CAS Alternative, no influent pumps)

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
Flow Measurement				
Site Work				
Excavation	726	cu yds	$9	$6,533
Concrete				
Floor	35	cu yds	$600	$21,106
Walls	89	cu yds	$600	$53,333
Equipment				
4' Parshall flume (nested)	1	ea	$7,000	$7,000
8' Parshall flume	1	ea	$12,000	$12,000
Installation	40	%		$7,600
Screening Building				
Site Work				
Excavation	3578	cu yds	$9	$32,200
Concrete				
Floor	198	cu yds	$600	$119,000
Exterior Walls	344	cu yds	$600	$206,489
Interior Channel Walls	58	cu yds	$600	$35,000
Exterior Channel Walls	50	cu yds	$600	$29,867
Building (above grade)	2,530	sq. ft.	$200	$506,000
Equipment				
Step Screens	3	ea	$275,000	$825,000
Wash Presses	3	ea	$90,000	$270,000
Screening screw conveyor	1	ea	$90,000	$90,000
Screenings/grit container (20 cy)	1	ea	$65,000	$65,000
Installation	40	%		$500,000
Grit Chambers				
Site Work				
Excavation	5161	cu yds	$9	$46,453
Concrete				
Floor	450	cu yds	$600	$270,233
Exterior Chamber Walls	320	cu yds	$600	$192,000
Interior Chamber Wall	78	cu yds	$600	$46,500
Walkway	20	cu yds	$600	$12,000
Equipment				
Vortex Removal	2	ea	$180,000	$360,000
Air Lift Pumps	6	ea	$10,000	$60,000
Grit Removal Pumps	2	ea	$10,000	$20,000
Grit Washer	1	ea	$250,000	$250,000
Grit Conveyor	1	ea	$90,000	$90,000
Installation	40	%		$168,000
Odor Control				
12 ac/hr				
Biofilter @ 3 cfm/sf	8,651	CFM	$135	$1,167,885
SUB TOTAL				$5,469,200
MISC EQUIPMENT	10	%		$ 546,920
MISC METALS	15	%		$ 820,380
				$6,836,500

New Headworks Facility Detailed Cost Estimate

PROJECT: Wastewater Treatment Plant Facility Plan
CLIENT: SGRWRF
JOB NO.: 001-07-03

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
Flow Measurement				
Site Work				
Excavation	726	cu yds	$9	$6,533
Concrete				
Floor	35	cu yds	$600	$21,106
Walls	89	cu yds	$600	$53,333
Equipment				
4' Parshall flume (nested)	1	ea	$7,000	$7,000
8' Parshall flume	1	ea	$12,000	$12,000
Installation	40	%		$7,600
Screening Building				
Site Work				
Excavation	3578	cu yds	$9	$32,200
Concrete				
Floor	198	cu yds	$600	$119,000
Exterior Walls	344	cu yds	$600	$206,489
Interior Channel Walls	58	cu yds	$600	$35,000
Exterior Channel Walls	50	cu yds	$600	$29,867
Building (above grade)	4,500	sq. ft.	$200	$900,000
Equipment				
Step Screens	3	ea	$200,000	$600,000
Wash Presses	3	ea	$65,000	$195,000
Screening screw conveyor	1	ea	$125,000	$125,000
Screenings/grit container (20 cy)	1	ea	$65,000	$65,000
Installation	40	%		$394,000
Grit Chambers				
Site Work				
Excavation	5161	cu yds	$9	$46,453
Concrete				
Floor	450	cu yds	$600	$270,233
Exterior Chamber Walls	320	cu yds	$600	$192,000
Interior Chamber Wall	78	cu yds	$600	$46,500
Walkway	20	cu yds	$600	$12,000
Equipment				
Vortex Chambers	2	ea	$185,000	$370,000
Air Lift Pumps	0	ea	$10,000	$0
Grit Removal Pumps	2	ea	$10,000	$20,000
Grit Washer	1	ea	$250,000	$250,000
Grit Conveyor	1	ea	$90,000	$90,000
Installation	40	%		$144,000
Blower Room / Wet Well				
Site Work				
Excavation	3080	cu yds	$9	$27,720
Concrete				
1st Floor	93	cu yds	$600	$56,000
2nd Floor	31	cu yds	$600	$18,667
Exterior Walls	389	cu yds	$600	$233,333
Building (above grade)	1,140	sq. ft.	$200	$228,000
Pumping Building				
Site Work				
Excavation	6080	cu yds	$9	$54,720
Concrete				
1st Floor	460	cu yds	$600	$276,000
2nd Floor	110	cu yds	$600	$66,000
Exterior Walls	333	cu yds	$600	$199,800
Building (above grade)	2,525	sq. ft.	$200	$505,000
Equipment				
Pumps	3	ea	$185,000	$555,000
Screw Pumps				
Installation	40	%		$222,000
Odor Control				
12 ac/hr				
Biofilter @ 3 cfm/sf	8,750	CFM	$60	$525,000
SUBTOTAL				$7,217,555
MISC EQUIPMENT	10	%		$ 721,755
MISC METALS	15	%		$ 1,082,633
				$9,021,943

Primary Clarifiers Cost Estimate

BOWEN COLLINS & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
SITEWORK				
Excavation	11,260	CU YDS	$ 9	$ 101,336
CONCRETE				
Exterior Wall, Footing, Channel	401	CU YDS	$ 600	$ 240,667
Floor	192	CU YDS	$ 600	$ 115,411
Pipe Inlet Structure	30	CU YDS	$ 400	$ 12,089
SPLITTER BOX	1	EA	$ 20,000	$ 20,000
EQUIPMENT				
115' Dia. Clarifier Mech. Equip.	115	LF	$ 1,000	$ 115,000
Installation	40	%		$ 46,000
Odor Control				
Flat Covers	10,387	SQ FT	$ 25	$ 259,675
Biofilters @ 6 ac/hr	1,798	CFM	$ 45	$ 80,910
SUBTOTAL				$ 991,088
MISC EQUIPMENT				
Installation	10	%		$ 99,109
MISC METALS	5	%		$ 49,554

ESTIMATED (1) PRIMARY CLARIFIER CAPITAL COST = $ 1,139,751

ESTIMATED (2) PRIMARY CLARIFIERS CAPITAL COST = $ 2,279,502

Primary Sludge & Scum Pump Station Cost Estimate

BOWEN COLLINS & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
PRIMARY SLUDGE PUMP STA				
SITEWORK				
Excavation	352	CU YDS	$ 9	$ 3,168
CONCRETE				
Exterior Walls	33	CU YDS	$ 600	$ 19,911
Floor	25	CU YDS	$ 600	$ 14,933
BUILDING	672	SQ FT	$ 50	$ 33,600
EQUIPMENT				
Sludge Pumps	3	EA	$ 13,405	$ 40,215
Installation	40	%		$ 16,086
SCUM PUMP STA				
SITEWORK				
Excavation	256	CU YDS	$ 9	$ 2,300
CONCRETE				
Exterior Walls	16	CU YDS	$ 600	$ 9,600
Floor	5	CU YDS	$ 600	$ 2,889
Roof	5	CU YDS	$ 600	$ 2,889
EQUIPMENT				
Scum Chopper Pumps	2	EA	$ 9,000	$ 18,000
Installation	40	%		$ 7,200
SUB TOTAL				$ 170,791
MISC EQUIPMENT	5	%		$ 8,540
MISC METALS	10	%		$ 17,079
			ESTIMATED PROJECT CAPITAL COST =	**$ 196,410**

Oxidation Ditches w/ Anoxic Selector Cost Estimate

BOWEN COLLINS & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
CARROUSEL TRAIN				
SITEWORK				
Excavation	29,508	CU YDS	$ 9	$ 265,568
CONCRETE				
Exterior Walls	1,609	CU YDS	$ 600	$ 965,333
Interior Walls	1,178	CU YDS	$ 600	$ 706,800
Floor Slab/Footing	2,106	CU YDS	$ 600	$ 1,263,694
Walkway Slab/Beams	321	CU YDS	$ 600	$ 192,454
Effluent Ditch	958	CU YDS	$ 600	$ 575,000
Stairs	3	CU YDS	$ 400	$ 1,067
EQUIPMENT				
150 HP Single Speed Aerators w/ VFD & Dual Impellers	5	EA	$ 100,000	$ 500,000
20 HP Anoxic Mixers	3	EA	$ 26,667	$ 80,000
Flow Control Gates	3	EA	$ 15,000	$ 45,000
ACE System	1	EA	$ 60,000	$ 60,000
Installation	40	%		$ 274,000
AERATED SLUDGE HOLDING BASIN				
SITEWORK				
Excavation	4,143	CU YDS	$ 9	$ 37,283
CONCRETE				
Exterior Walls	222	CU YDS	$600	$ 133,333
Interior Walls	67	CU YDS	$600	$ 40,000
Floor Slab/Footing	133	CU YDS	$600	$ 80,000
EQUIPMENT				
SUBTOTAL				$ 5,219,532
MISC EQUIPMENT	10	%		$ 521,953
MISC METALS	5	%		$ 260,977

ESTIMATED (1) CARROUSEL TRAIN & (1) AERATED SLUDGE HOLDING BASIN CAPITAL COST = $ 6,002,461

ESTIMATED (2) CARROUSEL TRAINS AND (2) AERATED SLUDGE HODING BASINS CAPITAL COST = $ 12,004,923

Staged Aeration w/ Anoxic Selector Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
NITRIFYING ACTIVATED SLUDGE PROCESS				
BASIN				
SITEWORK				
Excavation	43,726	CU YDS	$ 9	$ 393,536
CONCRETE				
Exterior Walls	978	CU YDS	$ 600	$ 586,667
Interior Walls	1,778	CU YDS	$ 600	$ 1,066,667
Floor Slab/Footing	2,417	CU YDS	$ 600	$ 1,450,000
ANOXIC SELECTOR				
Equipment				
Anoxic Mixers (10 HP)	4	EA	$ 10,000	$ 40,000
Installation	40	%		$ 16,000
AERATED SLUDGE HOLDING BASIN				
SITEWORK				
Excavation	6,815	CU YDS	$ 9	$ 61,336
CONCRETE				
Exterior Walls	311	CU YDS	$ 600	$ 186,667
Interior Walls	89	CU YDS	$ 600	$ 53,333
Floor Slab/Footing	267	CU YDS	$ 600	$ 160,000
SUBTOTAL				$ 4,014,205
MISC EQUIPMENT	10	%		$ 401,421
MISC METALS	5	%		$ 200,710

ESTIMATED (1) BASIN CAPITAL COST = $ 4,616,336

ESTIMATED (2) BASINS CAPITAL COST = $ 9,232,672

RAS/WAS Pump Station Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
SITEWORK				
Excavation	432	CU YDS	$ 9	$ 3,888
CONCRETE				
Exterior Wall	29	CU YDS	$ 600	$ 17,422
Floor & Footing	71	CU YDS	$ 600	$ 42,684
BUILDING	2,401	SQ FT	$ 200	$ 480,200
EQUIPMENT				
RAS Pumps	3	EA	$ 62,000	$ 186,000
WAS Pumps	2	EA	$ 11,500	$ 23,000
Installation	40	%		$ 83,600
SUBTOTAL				$ 836,795
MISC EQUIPMENT	5	%		$ 41,840
MISC METALS	10	%		$ 83,679
ESTIMATED PROJECT CAPITAL COST =				$ 962,314

RAS/WAS Scum Pump Station Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
SITEWORK				
Excavation	632	CU YDS	$ 9	$ 5,688
CONCRETE				
Exterior Wall	37	CU YDS	$ 600	$ 22,044
Floor & Footing	109	CU YDS	$ 600	$ 65,333
BUILDING	3,675	SQ FT	$ 200	$ 735,000
EQUIPMENT				
RAS Pumps	3	EA	$ 62,000	$ 186,000
WAS Pumps	2	EA	$ 11,500	$ 23,000
Scum Chopper Pumps	2	EA	$ 9,000	$ 18,000
Installation	40	%		$ 90,800
SUBTOTAL				$ 1,145,866
MISC EQUIPMENT	5	%		$ 57,293
MISC METALS	10	%		$ 114,587
ESTIMATED PROJECT CAPITAL COST =				$ 1,317,746

Membrane Bioreactor Cost Estimate

BOWEN COLLINS & Associates, Inc.
Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
ANOXIC BASIN				
PREAERATION BASIN				
MBR BASIN				
SITEWORK				
Excavation	9,217	CU YDS	$ 9	$ 82,949
CONCRETE (Oxidation Ditch Modifications)				
Exterior Walls	225	CU YDS	$ 600	$ 135,200
Interior Walls	336	CU YDS	$ 600	$ 201,600
Floor Slab/Footing	1,278	CU YDS	$ 600	$ 767,025
SLUDGE HOLDING BASIN				
SITEWORK				
Excavation	4,143	CU YDS	$ 9	$ 37,283
CONCRETE				
Exterior Walls	222	CU YDS	$600	$ 133,333
Interior Walls	67	CU YDS	$600	$ 40,000
Floor Slab/Footing	133	CU YDS	$600	$ 80,000
EQUIPMENT				
Enviroquip MBR System (25 MGD)				$ 41,000,000
Installation	10	%		$ 4,100,000
SUBTOTAL				$ 46,577,390
MISC EQUIPMENT	5	%		$ 2,328,870
MISC METALS	10	%		$ 4,657,739
ESTIMATED 25 MGD PROJECT CAPITAL COST =				**$ 53,563,999**

Bio-Selector Pump Station Cost Estimate

BOWEN COLLINS & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
SITEWORK				
Excavation	933	CU YDS	$ 9	$ 8,400
CONCRETE				
Exterior Walls	72	CU YDS	$ 600	$ 43,200
1st Floor	44	CU YDS	$ 600	$ 26,667
2nd Floor				
BUILDING	1,200	SQ FT	$ 200	$ 240,000
EQUIPMENT				
Vertical Mixed Flow Pumps	3	EA	$ 37,000	$ 111,000
Installation	40	%		$ 44,400
SUBTOTAL				$ 473,667
MISC EQUIPMENT	5	%		$ 23,683
MISC METALS	5	%		$ 23,683
ESTIMATED PROJECT CAPITAL COST =				$ 521,033

Secondary Clarifier (120' Dia) Cost Estimate Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan** DATE: 29-May-08
CLIENT: **SGRWRF** BY: mac
JOB NO.: **001-07-03** CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
SITEWORK				
Excavation	20,096	CU YDS	$ 9	$ 180,864
CONCRETE				
Exterior Wall, Footing, Channel	1,239	CU YDS	$ 600	$ 743,556
Floor	659	CU YDS	$ 600	$ 395,222
Pipe Inlet Structure	60	CU YDS	$ 400	$ 24,178
SPLITTER BOX	1	EA	$ 20,000	$ 20,000
EQUIPMENT				
120' Dia. Clarifier Mech. Equip.	120	LF	$ 1,000	$ 120,000
Launder/Weir Covers	1	EA	$ 50,000	$ 50,000
Installation	40	%		$ 68,000
SUBTOTAL				$ 1,601,820
MISC EQUIPMENT	10	%		$ 160,182
MISC METALS	5	%		$ 80,091

ESTIMATED (1) SECONDARY CLARIFIER CAPITAL COST = $ 1,842,092

ESTIMATED (2) SECONDARY CLARIFIERS CAPITAL COST = $ 3,684,185

UV Disinfection Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
SITEWORK				
Excavation	2,375	CU YDS	$ 9	$ 21,375
CONCRETE				
Floor & Footing	89	CU YDS	$ 600	$ 53,333
Exterior Walls	106	CU YDS	$ 600	$ 63,556
Interior Channel Walls	35	CU YDS	$ 600	$ 20,800
BUILDING	2,400	SQ FT	$ 200	$ 480,000
EQUIPMENT				
Low pressure high intensity UV system (installation included)				$ 1,000,000
SUBTOTAL				$ 1,639,064
MISC EQUIPMENT	5	%		$ 81,953
MISC METALS	5	%		$ 81,953
ESTIMATED PROJECT CAPITAL COST =				$ 1,802,970

Aerated Holding Tank Cost Estimate

BOWEN COLLINS & Associates, Inc.
Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
Aerated Holding Tanks	2			
SITEWORK				
Excavation	9,778	CU YDS	$ 9	$ 88,000
CONCRETE				
Walls	320	CU YDS	$ 600	$ 192,000
Floor & Top	237	CU YDS	$ 600	$ 142,222
SUBTOTAL				$ 422,222
MISC EQUIPMENT	10	%		$ 42,222
MISC METALS	10	%		$ 42,222
			ESTIMATED PROJECT CAPITAL COST =	$ 506,667

Dewatering Facility Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan** DATE: 29-May-08
CLIENT: **SGRWRF** BY: mac
JOB NO.: **001-07-03** CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
STRUCTURE & EQUIPMENT				
New 42 ft Dia Gravity Thickener	1	LS	$ 1,250,000	$ 1,250,000
New Centrifuge	1	LS	$ 850,000	$ 850,000
			ESTIMATED PROJECT CAPITAL COST =	$ 2,100,000

2 Stage Anaerobic Digestion Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
STRUCTURE & EQUIPMENT				
One fixed lid anaerobic digester	1	ea	$ 5,000,000	$ 5,000,000
One floating lid anaerobic digester	1	ea	$ 5,000,000	$ 5,000,000
Solids Pumps	4	ea	$ 35,000	$ 140,000
Cogeneration facility	1	ls	$ 9,000,000	$ 9,000,000
Subtotal				$ 19,140,000
Misc. Metals		25%		$ 4,785,000
Misc. Equipment		25%		$ 4,785,000
			ESTIMATED PROJECT CAPITAL COST =	$ 28,710,000

Transport Disposal Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
EQUIPMENT				
WAS Transport/Disposal Tractor/Trailer	3	ea	$ 150,000	$ 450,000
DS Transport/Disposal Tractor/Trailer	3	ea	$ 150,000	$ 450,000
				$ 900,000

Blower Building Cost Estimate

Bowen Collins & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
BUILDING	5,500	SQ FT	$ 250	$ 1,375,000
EQUIPMENT				
Blowers	13	ea	$ 225,000	$ 2,925,000
Air Piping	1,000	lf	$ 500	$ 500,000
Installation	40	%		$ 1,370,000
SUBTOTAL				$ 6,170,000
MISC EQUIPMENT	25	%		$ 1,542,500
MISC METALS	25	%		$ 1,542,500
ESTIMATED PROJECT CAPITAL COST =				$ 9,255,000

Primary Effluent Pump Station Cost Estimate

BOWEN COLLINS & Associates, Inc. Consulting Engineers

PROJECT: **Wastewater Treatment Plant Facility Plan**
CLIENT: **SGRWRF**
JOB NO.: **001-07-03**

DATE: 29-May-08
BY: mac
CHECKED:

DESCRIPTION	TOTAL QUANTITY	UNIT	UNIT PRICE	TOTAL
Blower Room / Wet Well				
Site Work				
Excavation	3080	cu yds	$9	$27,720
Concrete				
1st Floor	93	cu yds	$600	$56,000
2nd Floor	31	cu yds	$600	$18,667
Exterior Walls	389	cu yds	$600	$233,333
Building (above grade)	1,140	sq. ft.	$200	$228,000
Pumping Building				
Site Work				
Excavation	6080	cu yds	$9	$54,720
Concrete				
1st Floor	456	cu yds	$600	$273,778
2nd Floor	112	cu yds	$600	$67,200
Exterior Walls	332	cu yds	$600	$199,111
Building (above grade)	2,520	sq. ft.	$200	$504,000
Equipment				
Pumps	3	ea	$70,000	$210,000
Vertical non-clog configuration, wet well/dry pit				
Variable speed, submersible motor				
Installation	40	%		$84,000
SUBTOTAL				$ 1,956,529
MISC EQUIPMENT	10	%		$ 195,653
MISC METALS	15	%		$ 293,479
			ESTIMATED PROJECT CAPITAL COST =	$ 2,445,661