Outline for the Biosolids Paper

I. Background Information

A. The City

It's location and proximity to St. Louis / it's phenomenal growth rate (mention Post article) / mention other civic accomplishments (Ozzie Smith Fields Baseball Complex and the likelihood of a minor league baseball team playing in the near future)

B. The Wastewater Treatment Facility

Type of facility / when it was constructed / how successful it has operated (mention NPDES limits and the facilities above and beyond success at compliance) / mention Alliance and that the plant was the recipient of last years MWEA Plant of the Year Award

D. Part 503 Regulations

When they were to have gone into effect / time frame for O'Fallon / discussions with MoDNR / Class "A" versus Class "B" / marketability (turf farms and pastureland)

C. Basis of Evaluation

MEMC's impact / What they do / their impact on the City's wastewater treatment plant (in particular the sludge facilities)

II. Design Criteria

How to upgrade to Class "A" or Class "B" biosolids / The inability of the existing digester to achieve even minimal volatile solids destruction / How to handle future problems associated with industrial solids loads from MEMC / How to expand the facilities in the future to account for residential growth and industrial expansion / How to expand economically / How to incorporate the existing facilities for sludge treatment

III. Evaluation

A. Stabilization

Aerobic Digestion
Anaerobic Digestion
ATAD
Lime Stabilization

B. Thickening
C. Dewatering
D. Existing Digester

IV. The Results and Conclusions

The City's desire to proceed with Class "A" Lime Stabilization / Gravity Belt Thickener Options / Belt Filter Press Options / Sludge Pumping / Filtrate Pumping / Washwater Pumping / Sludge Storage and Blending

UPGRADING THE CITY OF O'FALLON, MISSOURI SLUDGE TREATMENT PROCESS TO PRODUCE CLASS "A" BIOSOLIDS

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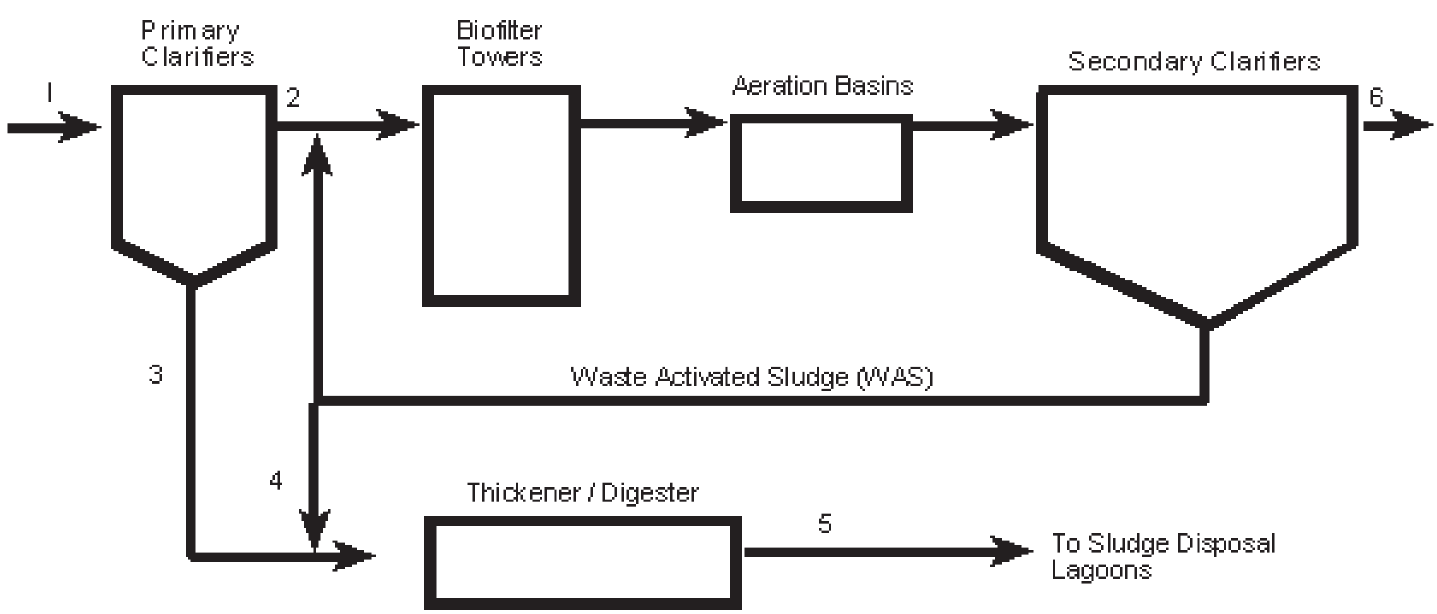
I. BACKGROUND INFORMATION

A. General

The City of O'Fallon, Missouri is located in St. Charles County, approximately 35 miles west of St. Louis, and is one of the fastest developing communities in the Mid-West. The City's population, the phenomenal growth of which was the subject of a recent article in the St. Louis Post-Dispatch, has nearly doubled since 1990 (from 17,427 to 33,818). A decade earlier, the population total was 8,677. Although the City has annexed 5.5 square miles since 1988, only one sub-division with approximately 50 residents, has been added as a direct result of annexation. The remaining population growth has been attributable to the development which has occurred in the City. According to the East-West Gateway Coordinating Council, O'Fallon's population is expected to continue growing at a rate of almost 3% per year through the Year 2015.

B. Existing Facilities

The wastewater treatment facilities for the City of O'Fallon, Missouri provide secondary treatment of the wastewater using the activated biofilter process (a combination suspended growth and attached-growth biological treatment process). The treatment plant was constructed in 1983 with an original hydraulic capacity of 5.0 MGD. This plant replaced an old "Oxigest" package plant which had been in operation since 1971. Consequently, the package plant was converted into a combination thickener/digester for sludge treatment. The aerobically-digested sludge is currently pumped to lagoons for permanent disposal. The plant was upgraded in 1990, with the addition of flow equalization basins, and again in 1991 in an expansion which increased the hydraulic capacity to 7.5 MGD. A layout of the existing facilities is shown in Figure No 1.



In conjunction with the construction of a conventional mechanical treatment plant in 1983, the City made a decision to retain the Mid-Missouri Engineers (now Alliance Water Resources) for professional services to operate and maintain the wastewater treatment plant. This partnership has proven highly successful over the last fourteen years as the plant has consistently achieved wastewater effluent levels for biochemical oxygen demand (BOD) and total suspended solids (TSS) which are substantially lower than the maximum allowed under the plant's NPDES limits. In addition, the plant was selected as the Missouri Water Environment Association's 1995 Plant of the Year for large facilities because of its successful operation.

C. Part 503 Regulations

With the promulgation of the U.S.E.P.A. Part 503 Regulations on February 19, 1993, the City's existing method of sludge disposal to lagoons became obsolete. In order to attain compliance with these regulations, the City began an evaluation of their long-term sludge handling and treatment needs in order to determine the most appropriate level of treatment for biosolids production. Production of Class "A" biosolids is required for land application onto public-use sites such as residential areas, road banks, parks, golf courses, schools, and other similar areas. In addition, Class "A" is also required for applying biosolids to turf, vegetable crops, root crops, or home gardens. Class "B" biosolids can be applied on grain and forage crops, pastures, grassland, fallowland, and timberland. Certain pathogen and vector attraction reduction requirements have to be met for sludge to be classified as Class "A" or Class "B."

Pathogen reduction requirements for Class "A" biosolids are commonly achieved by complying with one of the "Processes to Further Reduce Pathogens" (PFRP), as outlined below:

Processes to Further Reduce Pathogens (PFRP)

* Compost, using the within-vessel method or the static aerated pile method. This maintains the temperature of 55o C or higher for three days. Or, maintain the temperature of a windrow compost at 55o C or higher for 15 days or longer. Turn the windrow at least five times when the compost temperature is above 55o C.
* Heat drying with hot gases reduces the moisture content to 10 percent or lower. The temperature of the sludge exceeds 80o C.
* Heat treat liquid sludge to a temperature of 180o C or higher for 30 minutes.
* Thermophilic aerobic digest sludge for at least 10 days at a temperature between 55o C and 60oC.
* Beta ray irradiate sludge with an electron accelerator at dosages of at least 1.0 megarad at 20o C.
* Gamma ray irradiate waste within certain isotopes, such as Cobalt 60 and Cesium 137 at dosages of at least 1.0 megarad at 20o C.
* Pasteurize sludge. Maintain the temperature at 70o C or higher for 30 minutes or longer.
* Use an equivalent treatment process approved by the permitting authority.

Pathogen reduction requirements for Class "B" biosolids are commonly achieved by complying with one of the "Processes to Significantly Reduce Pathogens" (PSRP), as outlined below:

Processes to Significantly Reduce Pathogens (PSRP)

* Aerobic digestion between 40 days at 20o C and 60 days at 15o C.
* Anaerobic digestion between 15 days at 35 to 55o C and 60 days at 20o C.
* Air dry for at least three months. Two of the months must have average daily temperature above freezing.

* Compost with temperatures greater than 40o C for five days. The temperature must be greater than 55oC for four hours during the five days.

* Lime stabilization to a pH greater than 12 for two hours. If the sludge is domestic, lime stabilize to a pH greater than 12 for 30 minutes.

* Use an equivalent treatment process approved by the permitting authority.

Vector attraction treatment requirements for both Class “A” and Class “B” biosolids are presented below:

Alternatives for Vector Attraction Treatment

* Reduce volatile sludge solids by 38%.

* Alternate sludge testing for volatile solids: Digest sludge samples in laboratory (30 days for aerobic sludge and 40 days for anaerobic sludge). The resulting volatile solids reduction during the testing must be less than 15 percent for aerobic sludge and less than 17 percent for anaerobic sludge.

* SOUR (Specific Oxygen Uptake Rate) is less than 1.5 mg oxygen per hour per gram of total dry weight solids at 20o C. For anaerobic sludge, the sample must be aerated in the lab until dissolved oxygen saturation is reached before testing.

* Aerobic sludge digester at an average temperature of greater than 45oC for more than 14 days and at least 40oC.

* The pH must be greater than 12 for two hours and greater that 11.5 for at least 22 hours.

* Dry sludge to less than 25 percent moisture for stabilized sludge or less than 10 percent moisture for primary sludge.

* Subsurface inject the sludge.

* Incorporate the sludge into the soil within six hours after spreading.

* If the sludge is domestic septage only, the pH must be greater than 12 for 30 minutes.

* Use an equivalent treatment process approved by the permitting authority.

Under terms of the Part 503 regulations, compliance was to be attained by February 19, 1995. However, the Missouri Department of Natural Resources (MoDNR) allowed O’Fallon an extension to this compliance date in order for them to review their long-term needs and proceed with planning and design of biosolids treatment facilities capable of serving the City well into the 21st century. MoDNR should be commended for taking a common-sense approach to O’Fallon’s compliance situation since this has allowed the City to fully develop a comprehensive biosolids plan beneficial to the public and environment, as opposed to forcing the hasty construction of facilities which might well have been ill-suited to serving the City’s best interest in the long-term. Currently, the City is proceeding with plans to abandon their sludge lagoons that have been used for many years, while simultaneously developing plans to construct new biosolids treatment and handling facilities.

D. Basis of Evaluation

Commensurate with the City’s aforementioned residential population growth, industrial development and expansions are also expected to have a significant impact on the wastewater treatment plant. Current projections, based on discussions with various industries, indicate that the industrial wastewater flow and solids discharge to the City’s wastewater treatment plant will approach 3 million gallons per day (mgd) and 30,000 lb/d (population equivalent 150,000) within the next five years. In addition, a high percentage of the industrial wastewater solids are expected to be inorganic with volatile solids concentrations as low as 25%.

Meetings were conducted with the treatment plant operators to establish the design basis for this evaluation. Several considerations, such as the design influent solids load, the biosolids treatment level, and the operation schedule, were determined.

Because of the significant potential for continued residential growth and industrial expansion which will increase the solids load to the plant, accommodations for future expansion were a vital part of this evaluation. In order to accomplish this, the biosolids stabilization equipment will be sized to process the currently anticipated solids load in an 8 hour per day, 5 day per week operating schedule. In this manner, the capacity of the biosolids facilities could be readily expanded in the future simply by extending the operating hours.

In addition, because of their potential greater attractiveness for marketing purposes, it was decided that Class "A" biosolids would be produced by the biosolids processing facilities to be designed for O'Fallon. Among the advantages of producing Class "A" biosolids rather than Class "B" are the following:

* Higher quality end product.
* Greater public acceptance.
* Less regulatory restrictions regarding land application.
* Land application customers are not required to obtain a permit.
* Larger market of land application customers to choose from which eventually results in lower disposal costs.
* Less odor in the final end product.

II. BIOSOLIDS FACILITIES DESIGN CONSIDERATIONS

A. Design Criteria

The following design criteria were used to re-evaluate the biosolids stabilization processes:

Biosolids Load:

20,000 lb/d (Domestic)
30,000 lb/d (Industrial)
50,000 lb/d (Total)

Biosolids Produced:
Class "A"

Operation Schedule:
8 hours/day
5 days/week

The design domestic (residential/commercial) sludge production is based on a ten year design period. The design industrial sludge production is based on the solids load projected for the next five year period. The City of O'Fallon is to be commended for taking the lead among communities in this area by targeting Class "A" biosolids production for its facilities since they are of much higher quality for beneficial public use than are Class "B" biosolids.

However, investigations of facilities in which prices for Class "B" biosolids had been established which were subsequently upgraded to Class "A" facilities, were found to have saved as much as $25-35 per wet ton for disposal. For O'Fallon, the break-even savings cost for constructing a Class "A" facility versus a Class "B" (conservatively assuming that the additional cost is $1,000,000, the interest rate 7%, and the payback period 10 years) would be less than $5.00 per wet ton. Therefore, very early in the discussion phase (for economic as well as public acceptance reasons), the City committed to a Class "A" facility. It should be noted that several turf farms, which predominantly benefit from the addition of Class "A" biosolids, are currently operating in the immediate area of the City's wastewater treatment facilities.

B. Sludge Handling Considerations

Of the many available unit operations considered useful in handling (processing) biosolids in preparation for their disposal, it was determined that only thickening and/or dewatering was needed for the biosolids situation at the O'Fallon wastewater treatment facility.

Thickening and Dewatering

Thickening and dewatering operations are used to increase the solids concentration of biosolids and subsequently reduce the volume. Initial evaluations resulted in the conclusion that dewatering the biosolids would be cost effective. In addition, discussions with the City and Alliance indicated that this would also be preferable based on the target marketplace for disposal. Evaluations were conducted on various types of equipment and processes to accomplish thickening and dewatering. Based on economic as well as operational factors, gravity belt thickeners and belt filter presses were determined to be the most feasible means of accomplishing this for the City.

C. Biosolids Stabilization Considerations

Of the numerous available methods for stabilizing biosolids prior to their disposal, the following were considered practical alternatives for use in conjunction with the O'Fallon wastewater treatment facilities:

* Aerobic digestion
* Anaerobic digestion
* Autothermal Thermophilic Aerobic Digestion (ATAD)
* Lime stabilization / pasteurization

Aerobic Digestion

New aerobic digestion facilities were considered for the plant. However, in order to comply with the Part 503 regulations regarding vector attraction potential reduction, one of several criteria can be met, depending on the type of sludge processing provided. For a facility using aerobic digestion as its stabilization alternative, the two most logical alternatives are to achieve either a volatile solids reduction of 38% or a specific oxygen uptake rate of less than 1.5 mg per hour per gram of dry weight solids. Although treatment plants which have consistent wastewater influent characteristics can usually comply with one or both of these requirements, plants which are subject to fluctuations in wastewater quality or have a significant amount of non-organic solids would likely find these parameters difficult to meet. Additionally, aerobic digestion historically ceases to be cost effective at plant flowrates of 5 MGD or higher due to its capital costs, labor and energy requirements. However, the most significant disadvantage to this alternative is that it can only produce Class "B" biosolids. To produce Class "A" biosolids either now or in the future, this process would need to be followed with either lime stabilization/pasteurization or some other equivalent Process to Further Reduce Pathogens (PFRP). Therefore, as a stand-alone process, aerobic digestion was eliminated from further consideration.

Anaerobic Digestion

Anaerobic digestion typically has a very high initial capital cost associated with it as well as being relatively labor intensive to operate. In addition, like aerobic digestion, it will produce only Class "B" biosolids. Again, to produce Class "A" biosolids either now or in the future, this process would need to be followed with either lime stabilization/ pasteurization or some other equivalent Process to Further Reduce Pathogens (PFRP). Therefore, as a stand-alone process, anaerobic digestion can be eliminated from further consideration.

ATAD

The ATAD process, although well-developed in European countries, is still an emerging technology in the United States. This process uses the heat released during digestion to achieve thermophilic temperatures greater than 55oC, and is normally operated in two or more stages. The ATAD process requires significantly less physical space than does either aerobic digestion or anaerobic digestion. In addition, this process can routinely produce Class "A" biosolids because of the pathogen and volatile solids destruction obtained through the digestion process. ATAD converts soluble organic material to end-products which can be subsequently removed. The biological catabolic reaction results in a release of heat, which, if conserved in insulated tanks, will raise the reactor temperatures to the thermophilic range. The major advantages of the ATAD system are summarized as follows:

* Produces Class "A" biosolids
* Requires a small footprint
* Manual or automatic operation
* Considerable sludge volume reduction
* No coagulant such as lime or aluminum required
* High solids treatment results in a short retention time

Lime Stabilization / Pasteurization

The lime stabilization/pasteurization process also requires a relatively small footprint compared to other sludge stabilization alternatives. This process routinely produces Class "A" biosolids because of the pathogen destruction obtained by heating the sludge to a temperature of 70oC for 30 minutes, in addition to raising the pH to above 12 for over 24 hours to comply with the vector attraction requirements. Several different lime stabilization processes were initially considered for sludge treatment.

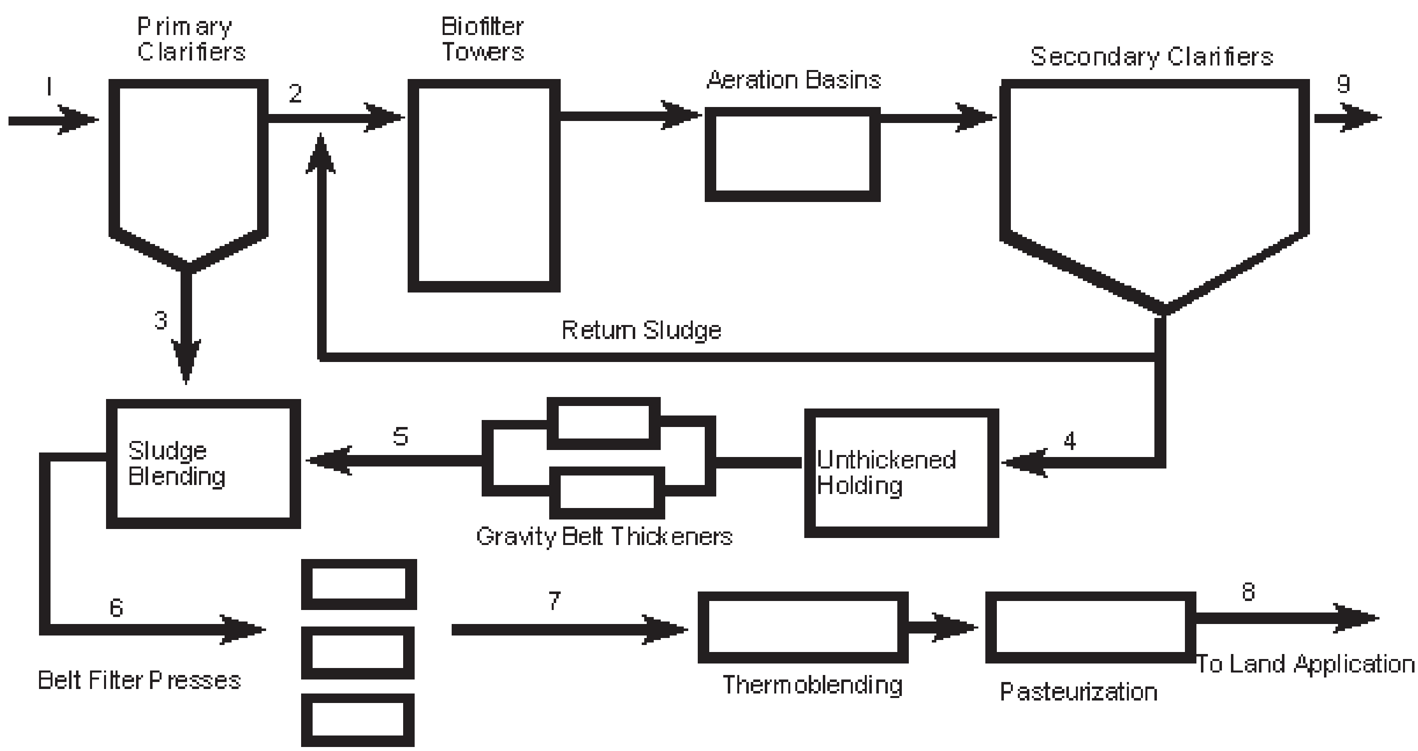
Upon further evaluation, it was determined that the combination of adding lime and electrical heat to the sludge, known as envessel pasteurization as developed by the RDP Company, would provide the most economical alternative for the City to pursue. Envessel pasteurization is dependent on the exothermic reaction of lime and water to achieve process temperatures of 70oC or higher. However, to achieve these temperatures with lime only requires approximately 1 lb. of lime per pound of dry solids. With electrical heat addition, the lime required can be reduced to as little as 0.3 lb. of lime per pound of dry solids. In addition, where land application is governed by liming rates (typically 1 to 1.5 tons per acre per year), the lime-only method would necessitate that considerably more land be available for biosolids application due to the lime content being on the order of 3 to 4 times higher than biosolids processed with envessel pasteurization. Among the advantages this type of system provides are the following:

* Produces Class “A” biosolids
* System readily operates in an intermittent phase
* Requires very small footprint
* Highly marketable end product
* Supplemental heat significantly reduces operating costs
* Dewatered solids easily handled

III. EVALUATION

A. Existing Treatment Facility Modifications

The process flow diagram for the existing treatment facility is illustrated in Figure No. 2. As shown in the diagram, current underflow solids concentrations from the primary clarifiers average approximately 1.3%. Typically, underflow solids concentrations from primary clarifiers should average about 3%. However, the underflow solids discharge line for Primary Clarifiers No. 1 and No. 2 are discharged by gravity several hundred feet to a wetwell and then pumped to the existing thickener/digester. Solids concentrations higher than about 1.3% have historically tended to conglomerate in the discharge line until flow is completely restricted.



With the solids loads which are projected for the City, underflow concentrations this low will necessitate inordinate provisions for thickening and dewatering prior to either ATAD or Envessel pasteurization. Therefore, it was of paramount importance to increase the solids concentrations as much as possible prior to thickening and dewatering. Discussions with operating personnel indicated that higher underflow solids concentrations could be achieved with Primary Clarifiers No. 1 and No. 2 if sludge pumps were added directly adjacent to the basin. The evaluation thus proceeded under the assumption that Primary Clarifiers No. 1 and No. 2 would be retrofitted with sludge pumps in order that the underflow solids concentrations could be increased to approximately 3%. In addition, the discharge piping for the underflow solids from Primary Clarifier No. 3, which has an existing sludge pumping system adjacent to the basin, would be re-routed to the new biosolids handling facilities.

The plant currently has an aerobic digester which was constructed in 1982 by retrofitting an old "Oxigest" package treatment plant. However, this digester is overloaded hydraulically and does not provide adequate volatile solids destruction. Test data and design conditions regarding the utilization of the existing aerobic digester were evaluated for the purpose of determining whether it would be feasible to continue using this facility on a regular basis for partial biosolids treatment. A review of test data gathered by the operators for a one year period indicated that the digester achieves less than 10% volatile solids destruction. In addition, due to its age (as well as the significant operator attention and energy required), it was decided that the existing digester has very little, if any, useful life remaining. Therefore, it was eliminated from consideration as a possible biosolids treatment unit to be used in combination with other stabilization processes.

B. Thickening

Thickening the sludge to an influent concentration of 2.5-7% is required prior to stabilization with ATAD. In addition, thickening the secondary waste activated sludge prior to envessel pasteurization is necessary based on cost-effective analysis conducted which indicated that excessive stabilization and dewatering equipment would be required with an unthickened sludge. Therefore, based on the evaluation presented below, two gravity belt thickeners were recommended for use prior to either ATAD or lime stabilization and pasteurization:

Provisions Required to Thicken Secondary Waste Activated Sludge

Conditions	
Influent Solids Concentration:	1%
Effluent Solids Concentration:	5%
Hydraulic Loading (gpm/m):	150
Results	
Gravity belt thickeners (2.5 m belt width) required:	2
Operation schedule (hours per week):	40

C. Dewatering

Provisions for dewatering will be required for both ATAD and lime stabilization, although at different stages. Based on the evaluation presented below, three belt filter presses (2.5 meter belt widths) will be required.

Provisions For Dewatering

Conditions

Influent Solids Concentration:	3.7%
Effluent Solids Concentration:	18%
Solids Loading (lb/hr/m):	1,200
Hydraulic Loading (gpm/m):	75

Results

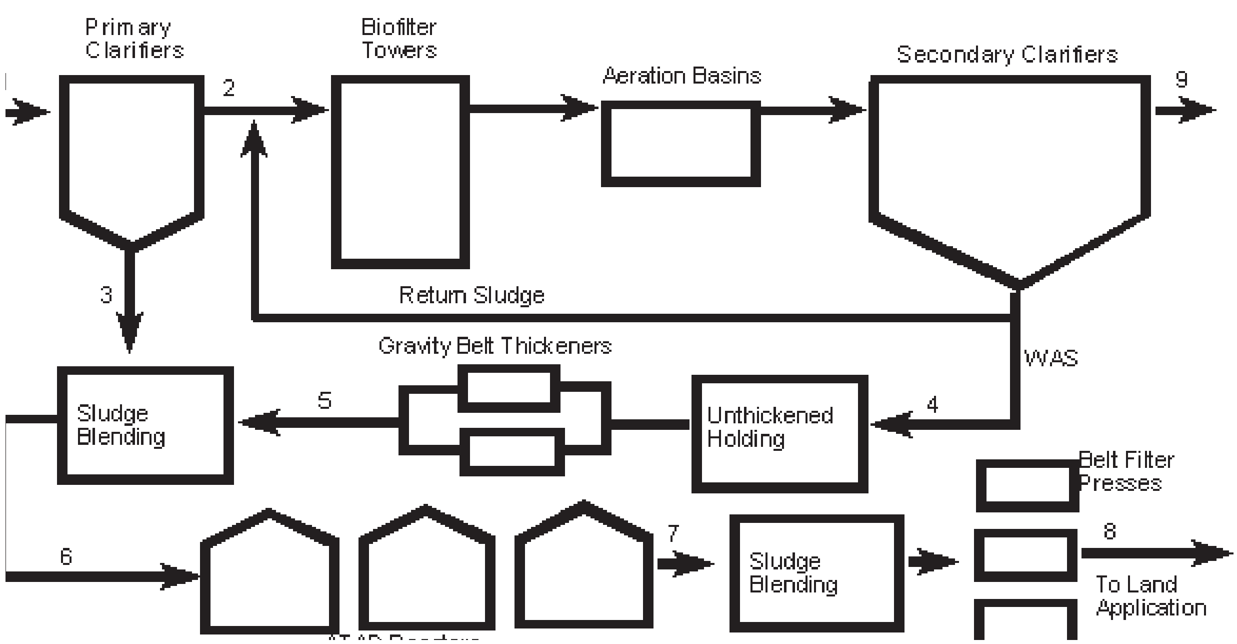
Belt filter presses (2.5 m belt width) required:	3
Operation schedule (hours per week):	40

D. Stabilization

Based on an initial "screening" of the four alternate biosolids stabilization methods previously described, only two - ATAD and Envessel Pasteurization - were judged to be worthy of detailed analysis based on the City's economic and non-economic considerations as well as the priorities for class of biosolids production.

ATAD

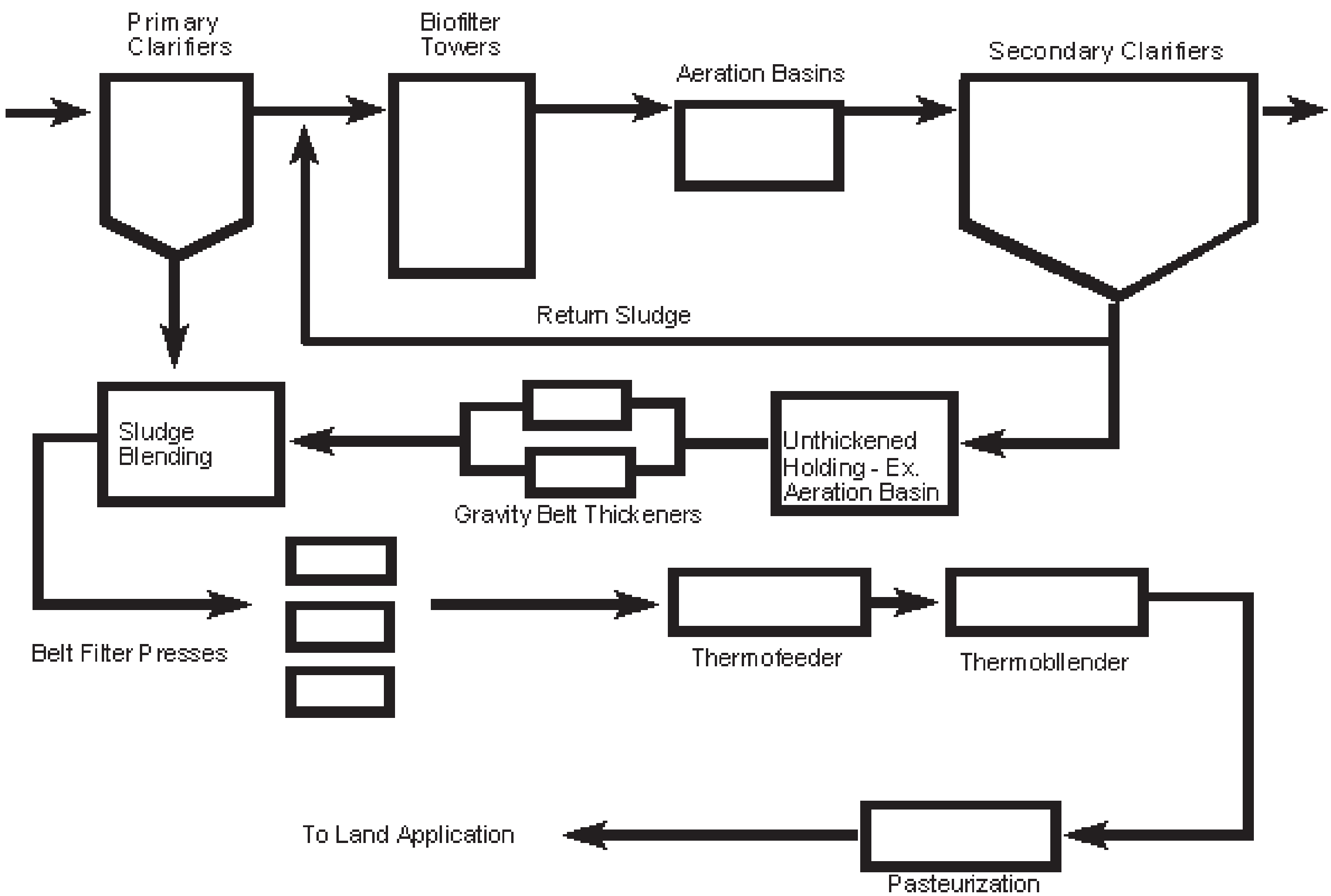
The ATAD process was analyzed for treating the City's sludge to produce Class "A" biosolids. Results of this evaluation, based on the JetTech system by U.S. Filter, are presented (along with a schematic of the process diagram) in Figure No. 3. As shown in the schematic, primary sludge and thickened secondary waste activated sludge will be pumped to a sludge blending tank. The blended sludge will then be batch fed to the ATAD reactors through the reactor feed pumps in a one hour period. In this manner, the reactors are isolated for the remaining 23 hours during each day. Motive pumps and aspirating aerators supply aeration and mixing to the reactor tanks. Each day, as aeration and mixing are stopped, stabilized sludge is discharged from the third reactor to the sludge holding tank. The first and second reactors are subsequently filled with blended and partially treated sludge. When all three reactors are full, aeration and mixing are resumed. Foaming, which typically occurs as a response to a population shift of competitive bacteria and results in a lowering of the liquid surface tension, is controlled by foam cutters installed inside each reactor. Sludge from the treated sludge holding tank is then pumped to three belt filter presses and dewatered. The dewatered sludge is then conveyed to a biosolids storage facility.



The major disadvantage of this process, when compared to lime stabilization/pasteurization, is that in this case the biosolids produced by ATAD must be handled in the dewatered form. There is limited data demonstrating the dewaterability of ATAD sludge, since it is a relatively new technology. However, some plants have determined that significantly more polymer usage is required and the higher process temperatures slightly reduce the dewaterability of the biosolids.

Lime Stabilization and Pasteurization

Envessel pasteurization, the patented process developed by the RDP Company which simultaneously takes advantage of the exothermic reaction of lime and water and electrical heat addition to achieve a process temperature of 70oC for 30 minutes and thus produce Class “A” biosolids, was also analyzed for use as the lime stabilization treatment. Results of this evaluation are presented (along with a schematic of the process diagram) in Figure No. 4. As shown in the schematic, primary sludge and thickened secondary waste activated sludge will be pumped to a sludge blending tank. Raw untreated sludge will then be dewatered by three belt filter presses and conveyed to a thermofeeder which begins raising the temperature of the sludge with electrical heat addition to precondition the cake prior to the addition of quicklime. The preconditioning enhances the hydration reaction and subsequently the exothermic reaction rate. From the thermofeeder, the biosolids will be transferred into a thermoblender and mixed with quicklime. The sludge-lime mixture is then augered into the pasteurization vessel to fully complete the time-temperature requirements for producing Class “A” biosolids. The pasteurized biosolids are then conveyed to a biosolids storage facility.



IV. CONCLUSIONS AND RECOMMENDATIONS

As indicated, the City of O'Fallon, Missouri, is faced with the need to make substantial improvements to their wastewater treatment sludge handling and disposal facilities, in order to both meet the requirements of Part 503 regulations and to deal with increased quantities of sludge resulting from the City's dramatic growth.

After careful evaluation, it was determined that waste activated sludge thickening and biosolids dewatering (using a combination of gravity belt thickeners and belt filter presses) was needed. In addition, four alternate sludge stabilization processes were evaluated.

Cost-effectiveness analyses were conducted on the ATAD and the lime stabilization/ pasteurization processes. A summary of the results for the ATAD system are presented below:
ATAD System

Estimated Capital Cost	$8,807,000
Operation and Maintenance Cost	$861,000
Total Present Worth	$2,086,000

A summary for the lime stabilization and pasteurization process (also developed assuming an interest rate of 6.5% and a payback period of 10 years) are presented below:
Lime Stabilization/Pasteurization System

Estimated Capital Cost	$7,970,000
Operation and Maintenance Cost	$734,000
Total Present Worth	$1,843,000

As indicated by comparisons of the present worth, the lime stabilization/pasteurization process was determined to be the most cost-effective solution for use by the City of O'Fallon, Missouri for complying with the Part 503 regulations; and was therefore the recommended option for sludge processing to produce Class "A" biosolids.

The City of O'Fallon is currently in the process of obtaining the design of a sludge handling and treatment system consistent with the recommendations made herein. Construction on this project is expected to begin later this year with the facilities going on-line in 1998.