ARLINGTON COUNTY WATER POLLUTION CONTROL PLANT MASTER PLAN 2001 UPDATE

Technical Memorandum XIV

Solids– Heat Drying Options

April 29, 2002

1. INTRODUCTION

This Technical Memorandum provides evaluation of Sludge Alternative 4 – Heat Drying. This approach provides a product containing high solids content (generally above 80 to 90 percent dry solids content) and normally meets Class A pathogen requirements, and is a product typically used for its nutrient or fertilizer value. Heat or thermal drying of sludge is evaluated for the Arlington County WPCP in two different scenarios:

- Alternative 4A – Raw Sludge Heat Drying. Heat drying can be accomplished with raw dewatered sludge feedstock; however, there are concerns with this approach as discussed in this Tech Memo.

- Alternative 4B – Digested Sludge Heat Drying. Heat drying is more commonly accomplished with anaerobically digested (and dewatered) sludge feed material.

2. THICKENING

There are two different approaches for sludge thickening depending on whether digestion is included in the process train:

- For Alternative 4A, sludge thickening to 3.0 to 3.5 percent solids would be conducted by improving the existing gravity thickening process for primary sludge and upgrading/expanding the current DAF process for waste activated sludge thickening.

- For Alternative 4B, co-thickening of all sludges/solids would be used in advance of anaerobic digestion. This thickening process would provide 6.0 percent solids feed to the digestion process.

These two thickening approaches are discussed in the Tech Memo on Sludge Thickening.

3. DIGESTION

For Alternative 4B, complete anaerobic digestion is included in the process train. This would be mesophilic anaerobic digestion of co-thickened solids (including scum), and would provide a Class B pathogen product. This is assumed to be implemented through construction of four new digesters at the site of the existing abandoned digesters and the incineration building. The Tech Memo for Anaerobic Digestion (Tech Memo XII - Alternative 2) describes these facilities and costs.

4. DEWATERING

The existing centrifuge dewatering system would be used for both of these alternatives as follows:

- For Alternative 4A, the dewatering system remains very similar to the existing operation – relatively continuous dewatering 24 hours/day and probably 7 days/week. This relatively continuous dewatering operation would match the continuous operation of the subsequent heat drying system (24/7) to minimize storage of raw dewatered cake. At some point in the planning period, increased redundancy/reliability may warrant the installation of a 4th centrifuge in the dewatering room.

- For Alternative 4B, the dewatering system would also operate in a relatively continuous arrangement – probably 24 hours/day, 7 days/week to feed the continuously-operating heat drying system. Since the sludge quantities are reduced after digestion, there is some reduced dewatering requirements. However, this is partially offset by reduced centrifuge feedrates for digested sludge. At some point in the planning period, increased redundancy/reliability may warrant the installation of a 4th centrifuge.

Costs for dewatering these two products are presented in other Technical Memoranda.

5. HEAT DRYING SYSTEMS

Heat drying systems involve the application of heat to evaporate water from sludge. This becomes a major advantage in reducing the weight of final product and in creating a biosolids product that is free of pathogens (Class A). In addition, if the process creates hard, dry, and similar-sized particles (usually between 1 and 5 mm in size) that are safe and easy to handle (non-dusty material), the product can be marketable as a fertilizer material. If the product becomes re-wetted, it will return to the same odor state that it had prior to the drying operation. Field experience indicates that re-wetted raw dried product will have a higher odor index than re-wetted digested dried product.

5.1 Vendor-Provided Systems

Heat or thermal drying systems are all essentially provided by vendors or manufacturers, and, therefore, each one is different due to its patented characteristics and the specific features and even the approach to drying taken by the vendor/manufacturer. Drying systems are often categorized according to whether they use a “direct’ or “indirect” drying approach as defined here:

- Direct dryers. These are systems whereby hot drying gas (normally heated air) is in direct contact with the sludge material. A large amount of particulates are picked up in these gas streams and major particulate/gas handling and treatment systems are required. However, there is more experience in direct drying (than indirect drying) systems for sludge, and more experience in creating usable fertilizer products.

- Indirect dryers. In these systems, the heating source (hot water or hot oil, typically) does not come into direct contact with the sludge. Instead, the heat is transferred to the sludge through paddles, mixers, or related devices. Therefore, the gas handling system is simpler for this approach, but there is somewhat different challenges in creating usable product and uniform particles with several of the processes available.

Some of the more common heat drying systems are described briefly below:

- **ESP Dryer.** The ESP process is a direct rotary drum process with once-through airflow. The dryer is a triple-pass, rotary dryer. A portion of the dried biosolids product exiting the dryer is recycled and blended with incoming dewatered biosolids to create the feedstock to the dryer. The gas/solids mixture entering the dryer is separated in cyclones and filters, and the dry product is classified by screens into oversize, market size, and fines. The oversize is crushed, mixed with fines, and recycled to mix with the incoming dewatered biosolids. The exhaust gases exiting the separation system are cooled and condensed in a wet scrubber, and the non-condensable fraction is heated in an afterburner to destroy odors.

- **Swiss-Combi.** The Swiss-Combi process is a direct-drying, rotary drum process with air circulation. The dryer is a single-pass, rotary dryer. A portion of the dried biosolids product exiting the dryer is recycled and blended with incoming dewatered biosolids to create the feedstock to the dryer. The gas/solids mixture exiting the dryer is separated in a cyclone and fabric filter, and the dry product is classified by screens into oversize, market size, and fines. The oversize is crushed, mixed with fines, and recycled to mix with the incoming dewatered biosolids. The exhaust gases exiting the separation system are divided into two streams. The first stream is recycled to the dryer. The second stream is condensed, and the non-condensable fraction is heated in an afterburner to destroy odors. The afterburner also provides heat recovery from its flue gas. Some plants report drying raw sludge with this dryer.

- **Andritz.** The Andritz process is a direct drying, rotary drum process with air recirculation. The evaporation process in the Andritz direct dryer takes place within a triple-pass, rotating drum. The high-speed air within the drum pulls the material through the drum until it is dry enough and, therefore, light enough to be lifted and pneumatically conveyed out of the drum. The Andritz dryer drum consists of three concentric arranged cylinders, so that the material to be dried flows through the innermost cylinder, back through the middle cylinder, and finally out through the outer cylinder. Flights on the inner walls of the cylinders lift the material and cascade it into the hot air stream. Andritz does not promote their system for raw primary sludge drying.

- **Seghers.** The Seghers process is an indirect, tray dryer process. The vessel is vertically oriented, and hot oil is passed through the trays while the solids fall from one tray to the tray beneath, similar to a multiple hearth furnace. Dewatered biosolids mixed with recycled dry biosolids are fed through a top inlet in the vertical, multi-stage dryer. The dryer has a central shaft with attached rotating arms that are supported by axial-radial bearings at the bottom of the dryer casing. The rotating arms move biosolids from one heated tray to another in rotating, zigzag motion until it exits at the bottom as a dried, pelletized product. The rotating arms are equipped with adjustable scrapers that move and tumble the solids in thin layers over heated, stationary trays. Round pellets are formed through a pearling process. The solids feed preparation technique, in combination with the rolling across the heat trays, causes the pellets to grow from inside out, the way pearls are formed.

5.2 Dried Product Characteristics

The dried product is generally valued on its nitrogen content for use as a fertilizer amendment providing that it meets the required physical characteristics such as particle size, hardness, and density. To achieve the optimum or desired product, dryer systems may need ancillary equipment items such as screens, grinders, and even a pelletizer/compactor. Sludge screening is assumed necessary for Alternative 4B, but not for Alternative 4A. Dryer systems also employ recycle of dried product to the feedstock at a variable rate to be determined for the specific feedstock and desired product characteristics. In some instances, additives may be mixed with the sludge material to achieve certain desired characteristics. These additives may include oils to assist in binding of product, nutrients to change fertilizer components, and chemical suppressants to minimize heating and potential combustion of product.

Anaerobically digested sludge, when heat dried, usually provides a good, usable product. Removal of hair and plastic debris is important for good product quality, and, therefore, sludge screening is a good approach when a high-quality marketable product is desired. When raw sludge is heat dried, the product can be more odorous than dried digested sludge because little stabilization of the organic material has occurred. The low moisture content in the product is the primary defense against biological activity. If any significant moisture accumulates in the product, then active biological activity is initiated and odor can become significant. For instance, when dried raw sludge is spread on a field, rainfall prior to soil incorporation of the material would likely create an odorous situation.

5.3 Product Auto-Heating and Safety

Hot or warm organic material that contains even small amounts of moisture and has an available oxygen supply can generate sufficient biological activity to produce increasing amounts of heat to the point that smoldering or even active combustion can occur. This is called auto-heating. Many such events have occurred with heat dried sludges in North America and overseas.

The control measures for this problem include the following:

- Reduce temperature in the final product
- Minimize moisture content in the product

- Minimize oxygen content in the air/gas that is in contact with the heat-dried product. This is usually accomplished by containing the final product within a nitrogen gas atmosphere (nitrogen blanketing).

There have also been explosions caused by the organic dust associated with dried sludge. Dust control is, therefore, a major issue in any heat drying facility.

5.4 Heat Dryer Air Emissions Controls

As opposed to some of the original direct or flash dryers that had a large exhaust air flow, most current dryer designs employ recycle of air streams with only the minimum required exhaust air flow. Recycle and/or heat recovery makes sense both in terms of energy conservation and emissions control, because the most effective method of volatile organic compound (VOC) and odor control is combustion or high temperature oxidation.

All exhaust air streams would need to be controlled to limit the concentrations of air contaminants. Some control is achieved within the heating process. For instance, temperature and excess oxygen control enables balancing nitrogen oxides (NOx) against carbon monoxide (CO), the former increasing at higher temperatures, and the latter decreasing, this is similar to what happens with automobile emissions. Other pollutants that may need controlling to achieve regulatory limits include particulates, metals, and sulphur oxides. Control devices may include baghouses, wet scrubbers or electrostatic precipitators. Dryer systems have normally been able to meet necessary air emission regulations in the United States.

The biggest risk in the context of air emissions would be the potential implementation of stricter regulations for control of dioxins, furans, and other trace toxic contaminants. Such regulation is currently proposed in the United States but is the subject of much debate.

The air emission that attracts the highest public awareness is invariably odor. Although the process air can be well oxidized and controlled through the use of thermal oxidizers (high-temperature oxidation), the ventilation air from buildings, storage tanks and truck loading is a much larger air flow and requires treatment before discharge. Essentially, all of the proposed systems require similar size buildings with consequently similar exhaust airflows to be treated. Redundant thermal oxidizers are often installed to insure adequate odor control at all times.

5.5 Cost Estimates for Heat Drying

The basic sizing and design criteria for the Arlington heat drying alternatives are shown in Table 1 along with a listing of cost categories. The primary capital cost categories are defined here:

- Demolition and site preparation – This includes demolition of minor facilities at NE corner of plant site and preparations of the site for a drying facility.

- Dryer Equipment Package – several vendors have been contacted to discuss dryer equipment prices for a facility of this size. Swiss Combi, in particular, was contacted since they have significant experience with drying raw sludges. The system is developed with one dryer operating and one dryer as a backup unit. This allows a high degree of reliability in operation of the system. Especially for Alternative 4B, there could be consideration of smaller dryers, providing less than 100% redundant capacity, if there are backup plans for use/disposal of digested dewatered product.

- Building Cost – this is for a new building to house the drying facilities and equipment. The cost includes mechanical, plumbing, lighting, and civil work associated with the building. The building would be on the northeast corner of the plant site, and would be constructed to fit in architecturally with the plant. A cost spreadsheet has been developed to support this cost.

- Silos – this is an estimate for 200 tons of dry final product storage on-site in silo-type facilities for truck loadout. This provides about five days capacity for the raw sludge drying option, or seven days capacity for the digested sludge drying option.

- Ancillaries – this includes major power supply, piping, and major utilities services for this facility. This also includes sludge cake transfer conveyors to the heat drying building.

From these costs, a total construction cost estimate is shown, with 35 percent for construction contingencies because of this preliminary project description. Another 35 percent is added to provide a capital cost estimate for both Alternative 4A and 4B. Costs for all other facilities – thickening, digestion, etc – are not shown here. Only the costs for heat drying facilities are identified in Table 1.

Table 1 also shows annual O&M costs for these two alternatives. These costs are derived from information provided by the dryer vendors, as well as information from other sludge heat drying facilities. The facility is assumed to operate continuously (24 hours/day, 7 days/week). Fuel cost is less for Alternative 4B because it is assumed that digester gas is used as much as possible to provide the fuel requirement. This use of digester gas (for heat drying) is expected to become more common in the future as more plants implement heat drying technologies. Disposal is assumed for the Alternative 4A heat-dried product. This may be considered a conservative assumption since there could be fertilizer uses for this material that would reduce this annual disposal cost. For Alternative 4B, there is assumed to be no disposal cost or net revenue since revenue generated is likely to cover the marketing and distribution/transport costs associated with this approach.

Table 1. Heat Drying Criteria and Costs

Parameter	Alternative 4A	Alternative 4B
Sludge Type	Raw Dewatered Sludge	Anaerobically Digested Sludge
Dewatering Performance (% solids content)	30%	27%
Volatile Solids Content	78%	62%
Average Load Per Day in Dry Tons	44	29
Peak Load in Dry Tons Per Day	66	40
Annual Average Dry Tons	16,100	10,600
Average Load Per Day in Wet Tons of Cake	147	107
Peak Load in Wet Tons of Cake Per Day	220	148
Number of Operating Hours in a Day/Days in Week	24/7	24/7
Evaporation Capacity Required, Average Day, Pounds of H_2O Per Hour	8,556	6,534
Evaporation Capacity Required, Peak Day, Pounds of H_2O Per Hour	12,833	9,012
Number of Process Trains Operating	1	1
Backup Train Available	1	1
Capital Costs		
Demolition/Site Preparation	$800,000	$800,000
Dryer Equipment Package	$12,500,000	$10,000,000
Building (including mechanical, plumbing, lighting, civil)	$3,200,000	$3,000,000
Silos – Product Storage	$2,000,000	$2,000,000
Ancillaries	$3,800,000	$3,000,000
Base Construction	$22,300,000	$18,800,000
Plus 35% Construction Scope Contingencies	$7,800,000	$6,600,000
Construction Cost Estimate	$30,100,000	$25,400,000
Plus 35% Engineering/Administration/Management, etc.	$10,500,000	$8,900,000
Capital Cost Estimate	$40,600,000	$34,300,000
Annual O&M Costs		
Fuel (Natural Gas)	$800,000	$320,000
Power	$270,000	$220,000
Labor (5 shifts, 2 operators/shift)	$600,000	$600,000
Maintenance	$250,000	$200,000
Product Use/Disposal	$760,000[a]	$0[b]
Total Annual O&M Costs	$2,680,000	$1,340,000

[a] at $45/wet ton.
[b] Cost is shown as zero. Assumed that sales price of the product (i.e., revenue) covers the marketing and transport costs.

6 SLUDGE STRAINING/SCREENING

Removing debris from sludge has become a standard practice in many plants. The 130-mgd Annacis Island Plant in Vancouver, British Columbia successfully removes all its debris from both its primary sludge and primary scum prior to its introduction into its thermophillic digesters. The 55-mgd Wichita South Plant does the same to all its primary sludge and primary scum flows from two plants prior to distribution to their co-thickening DAFTs. It is believed that this process may be mandatory for sludge processes such as heat drying. Annacis Island screens sludge primarily to protect its sludge to sludge heat exchangers. Wichita does it to protect their downstream sludge thickening, stabilization and dewatering processes and to make their biosolids more acceptable for final beneficial use.

To provide similar facilities for the ACWPCP (at 2020 loading of 40/mgd), probably four large Parkson Sludge Cleaners would be needed immediately upstream of the PS thickening process. In some cases, this would be the GSTs; while in the co-thickening processes it would be the DAFTs or GBTs. The units remove all debris larger than 5 mm and are each capable of processing approximately 500 gpm of flow. Four units would be required, three for continuous service and one for standby. In those processes requiring the primary scum to be cleaned separately, the fourth unit could be used for the primary scum that would be kept separate and blended with the thickened sludge downstream of the thickening process. This is the case when the PS is thickened in the GSTs.

The units would be housed in their own two-story building close to the PS thickening process. This would allow their discharge to go directly to the thickening process hydraulic distribution system without requiring extra pumping. The bottom level of the building would house an odor tight compactor box designed to receive the removed debris, compact it, and push it out into a truck for final disposal. It is expected that this method of debris disposal would minimize odors from the entire operations.

The estimated cost for this Sludge Cleaner facility is identified below:

Facilities Element	Cost
Structural Elements	380,000
Mechanical Equipment	1,280,000
Piping/Electrical/Instrumentation	420,000
Subtotal	2,080,000
Plus 35% Construction Contingencies	730,000
Construction Cost Estimate	2,810,000
Plus 35% Engineering/Administration/Finance	980,000
Capital Cost Estimate	3,790,000