To Lime or Not to Lime… That is the Question

Roy A. Pelletier, David S. Sloan, and Thomas L. Lothrop

Orlando is nestled in Central Florida surrounded by cattle ranches and thousands of acres of orange groves. Although the city continues to grow at a rapid pace because of expansions to theme parks, the Orange County Convention Center, tourism-based businesses, and technology-based industry, large tracts of agricultural properties are still within a 50-mile radius of Orlando's center. Central Florida is blessed with a warm climate year round (no snow covered fields), and high, well-drained sandy soils in western Orange County assuring reliable inclement weather application sites. The city has confidence that beneficial use of Class B biosolids, via land application, will remain a viable option for Central Florida beyond the next decade, assuming there are no major changes to EPA 503 or DEP 62-640.

The Iron Bridge Water Reclamation Facility, the largest three water reclamation facilities operated by the city, is a five-stage Bardenpho nutrient removal facility providing tertiary levels of treatment with a design capacity of 40 MGD. The solids processing operation at Iron Bridge currently uses gravity belt thickeners, followed by stabilization through anaerobic digestion and belt filter press dewatering to approximately 15% solids content. The facility generates approximately 140 wet tons per day of Class B biosolids, which is applied to cattle ranchland by a contractor.

Corrosion of Digesters Spark Evaluation

The anaerobic digestion complex at Iron Bridge provided 12 years of reliable Class B stabilization. Because of high hydrogen sulfide concentrations in the waste sludge stream, the anaerobic digesters began to display signs of severe corrosion in the late 1990s. The corrosion affected the gas transfer lines, process piping, and structural elements of the floating covers. The corrosion occurred despite the fact that the city had implemented an aggressive chemical addition (ferric chloride) prevention program. To assess and document the degree of corrosion impacting operation of the four 100-foot diameter (two million gallon capacity) anaerobic digesters, the city commissioned engineering evaluations and solicited order of magnitude cost proposals to rehabilitate the aging digesters.

Preliminary estimates indicated a cost exceeding four million dollars. Faced with that high cost, the city chose to conduct an evaluation of alternative stabilization options.

The evaluation focused on capturing all biosolids stabilization, dewatering, and beneficial land application related capital and operational costs. It assumed the alternatives would continue to provide Class B levels of stabilization and result in land application of biosolids. Therefore, alternatives were compared solely on overall capital and operational costs. Consideration of social or environmental benefits potentially achieved by a higher level (Class A) of treatment were not factored into the evaluation.

Following initial screening of various Class B stabilization options, the two alternatives identified as being the most cost effective were (1) refurbishment of the four existing anaerobic digesters and related process equipment, and (2) installation of a lime stabilization process. Subsequently both alternatives were subjected to a rigorous in-house cost study.

Existing Anaerobic Digestion Program

Cost evaluation for annual operational expenses of the anaerobic digestion process (to process 20.88 dtpd of sludge feed) addressed electrical demand; propane gas and ferric chloride usage; operator labor; laboratory testing; and preventive and corrective maintenance expenses, including all parts and supplies. The total was $357,556 per year, $46.92 per dry ton.

Cost associated with operation of the belt filter press to process 17.24 dtpd of anaerobically digested sludge, including electrical cost, polymer usage, operator labor, and preventive and corrective maintenance expense, including all parts and supplies, totaled $371,289 per year, $59.00 per dry ton.

The cost for contract hauling and land application of 111 wtpd (at 15.5% solids content) billed at $10.89 per wet ton totaled $424,586 per year, $67.47 per dry ton.

The authors are with the city of Orlando, where Roy A. Pelletier is assistant bureau chief and David S. Sloan is bureau chief, respectively, of the process & operations bureau, and Thomas L. Lothrop, P.E., is deputy director of the public works department.

Cost associated with the operation and maintenance of the anaerobic digestion sidestream treatment process addressed electrical demand, operator labor, and preventive and corrective maintenance expense, including all parts and supplies, totaled $132,783 annually, $21.10 per dry ton.

Sidestream treatment was necessary at the five-stage Bardenpho nutrient removal facility because of the high ammonia concentration of the recycle (750 ppm to 1,000 ppm) representing approximately 38% of the facility raw influent ammonia loading.

The total annual operations and maintenance cost for anaerobic digestion process, sidestream treatment, dewatering and the biosolids land application program was calculated at $1,289,917 per year ($194.48 per dry ton) based on 12 years of actual operating data.

Lime Stabilization Program

The cost evaluation for annual operational expenses associated with dewatering 20.88 dtpd of biosolids including electrical demand, polymer usage, operator labor, and preventive and corrective maintenance expense, including all parts and supplies, totaled $211,622 per year, $27.77 per dry ton.

Cost associated with cake hauling and land application (at a rate of $12 per wet ton) of 121.8 total wtpd of lime stabilized biosolids (116 wtpd cake solids at 18%, and 5.8 tpd of lime) is projected at $533,484 per year, $70 per dry ton.

Cost associated with the lime stabilization process addressed electrical demand, lime cost, operator labor, and pre-

> The operations staff observed a significant reduction in polymer utilization when dewatering unstabilized sludge as compared to dewatering anaerobically digested sludge. The results were repeatable and consistent. After working with multiple polymer suppliers to optimize polymer selection, typical polymer consumption for dewatering of anaerobically digested sludge was found to be about $35 per dry ton. However, the polymer consumption when the same belt filter presses are dewatering unstabilized sludge is about $12.50 per dry ton. At the Iron Bridge facility, this represents an annual savings of nearly $125,000 for dewatering polymer.

Table 1. Process Values

Process Item	Anaerobic Digestion	Lime Stabilization
Volatile Solids Destruction	38%	0
Inerts (Lime) Addition	0	15-25% of dry weight 4-6% of wet weight
Biosolids* Dry Weight (tons per day)	17.24 cake	20.88 cake 5.80 lime 26.68 total
Biosolids* Wet Weight (tons per day)	111	116
Cake Solids	15.5%	22% after lime addition 18% before lime addition
Polymer Use ($ per dry ton)	$35.00	$12.50

* Assumes 96% capture on belt filter press

Table 2. Cost Values

Major Cost Category	Anaerobic Digestion	Lime Stabilization
O&M	$357,556 per year $46.92 per d.t.	$268,622 per year $35.25 per d.t.
Dewatering	$371,289 per year $59.00 per d.t.	$211,622 per year $27.77 per d.t.
High Strength Sidestream Treatment	$132,783 per year $21.10 per d.t.	0
Hauling & Land Application	$424,586 per year $67.47 per d.t.	$533,484 per year $70.00 per d.t.
Totals	$1,289,917 per year $ 194.49 per d.t.	$1,013,768 per year $ 133.02 per d.t.
Annual Savings	0	$276,149

Table 3. Detailed Cost Comparison

	Anaerobic Digestion		Lime Stabilization	
Detailed Cost Item	$/year	$/dt	$/year	$/dt
Electrical Use	$158,684	$20.82	$5,323	$0.70
Propane Gas	$51,400	$6.74	$0	$0.00
Ferric Chloride	$50,120	$6.58	$0	$0.00
Lime	$0	$0.00	$247,689	$32.50
Operator Labor	$34,952	$4.59	$11,650	$1.53
Maintenance	$62,400	$8.19	$4,000	$0.52
Dewatering Polymer	$220,241	$35.00	$95,265	$12.50
Additional Dewatering Costs	$151,048	$24.00	$116,357	$15.27
Sidestream Treatment	$132,783	$21.10	$0	$0.00
Haul & Apply Cake	$424,586	$67.47	$533,484	$70.00
TOTALS	$1,286,214	$194.49	$1,013,768	$133.02
ANNUAL SAVINGS WITH LIME STABILIZATION			$272,446	$61.47

ventive and corrective maintenance expenses, including all parts and supplies, totaled $268,662 per year, $35.25 per dry ton.

The dewatering, lime stabilization, and land application program at Iron Bridge is projected to cost a total of $1,013,768 per year, $133 per dry ton.

When Can Anaerobically Digested Biosolids Be Spread?

Typically, dewatered anaerobically digested sludge is immediately put into a cake truck, transported to agricultural land, and then applied with a spreading device. If the sludge is not dewatered, it is pumped into a liquid tanker and then hauled to the site for land application. It is not common, in either case, to have final results of volatile solids reduction across the anaerobic digestion process prior to spreading. And certainly the results of the metals analyses will not be available for several weeks. So, what do you do? Generally, you spread the residuals and hope — no, pray — that all of the test results are below the standard limits. The permit holder is at risk of violating vector attraction reduction, pathogens, and pollutant limits of 503 Regulations.

The size of the facility and the volume of residuals generated annually will determine the frequency of sampling and testing for fecal coliform, volatile solids reduction, and metals. The Iron Bridge facility falls into the bi-monthly frequency for sampling and testing of the residuals for fecals, volitile solids reduction, and metals. This means that two months elapse before the average results are available from all of the tests performed for that sample period. In a two-month period, the facility will generate about 2,150 truck loads of cake residuals, equal to about 43,000 wet tons (86,000,000 wet pounds, or about 48,587 cubic yards). How many facilities are designed to store such a large volume of cake residuals?

Frequent samples may be obtained for volitile solids reduction testing to provide sufficient data to determine that the vector attraction reduction requirement of 38% volatile solids reduction has been met. If daily volitile solids testing is performed, it may be practical to store a few days worth of cake to obtain the volitile solids reduction test results before land applying the residuals. However, if the results are less than the required 38% volitile solids reduction, you now have to wait an additional 40 days to obtain the results of the extended 40 day bench test, which must be less than 17% additional volitile solids reduction. Where would a facility the size of Iron Bridge store a 40-day volume of dewatered sludge?

Who really stores digested sludge cake or liquid until all of the required test results are obtained? The probable answer is very few, perhaps nobody.

Vector Attraction Reduction Using Class B Lime Stabilization

A Class B lime stabilization process does not require that volatile solids reduction testing be performed. The requirement is to maintain a pH of no less than 12.0 (at 25°C) for at least two hours without further lime addition. Then the pH must remain no less than 11.5 (at 25 °C) for an additional 22 hours without further lime addition. Typical protocol for this requirement is to assure the full 24 hours is achieved on the plant site before lime stabilized cake is hauled and applied to land. Yes, there is still the issue of metals analyses results not being available before the residuals are spread, but metals are indicated very well by long-term trends.

Can Metals Be Diluted With Lime?

Yes they can. When lime is added to sludge cake, the effective concentration of the metals is reduced. Since there are no metals in the lime, and the lime is increasing the overall total dry solids

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Diversified Water Sources Provide for Lee County's Water Supply

Larry Johnson, Glenn Greer, and Philip Waller

Larry Johnson and Glenn Greer are with the Lee County Department of Environmental Services. Philip Waller is with the engineering firm of Montgomery Watson.

Lee County owns a utility system that provides water and wastewater service to a significant portion of the unincorporated areas of the county. Managed under the county's Environmental Services Division and operated by a contract operations company, the system serves about 48,000 water customers and 35,000 wastewater customers. The county has also recently acquired two private utility systems to better integrate its water and wastewater system county-wide.

Lee County is fortunate to have a diversified utility system consisting of multiple water supply sources. Future planning by the county and various state and federal agencies has incorporated consideration of continued use of the multiple and diversified water sources to meet the future public water supply needs of the county.

Existing Water Sources and Treatment

The Corkscrew Water Treatment Plant treats groundwater and the Olga WTP surface water. Three additional water treatment plants — the Green Meadows WTP, the College Parkway WTP, and the Waterway Estates WTP, all treating groundwater and operated under interim contracts separate from the Corkscrew and Olga plants— and some wastewater treatment facilities were acquired from Florida Cities Utilities.

The Corkscrew WTP is supplied by twenty-three 12-inch diameter wells located on a 476-acre wellfield in southern Lee County. The wells, ranging in depth from 105 to 300 feet, provide fresh water with a moderate color (29 to 35 color units) and high carbonate hardness. The Corkscrew WTP utilizes aeration, lime softening, and chloramination to remove hydrogen sulfide, color, and hardness. The current capacity of the Corkscrew WTP is 10 MGD.

The Caloosahatchee River provides surface water to the Olga WTP. Its intake is 0.75 miles upstream of the W.P. Franklin lock structure. The river water has high color (50 to 200 color units), high total organic carbon (10 to 20 mg/L), and relatively low turbidity (1 to 5 NTU). For portions of the year the river has a moderate carbonate hardness (greater than 150 mg/L as $CaCO_3$) and taste and odor constituents. The primary treatment processes at the Olga WTP are alum coagulation, aeration, lime softening, filtration, granular activated carbon, and chloramination. The system is designed to remove color, total organic carbon, turbidity, and taste and odor. The current capacity of the Olga WTP is 5 MGD.

Lee County currently has a potable water supply capacity of 27 MGD. Projections for future water needs show 45 MGD by 2020. Additional water supply development, treatment capacity expansion, conservation, and innovative water supply strategies, such as aquifer storage and recovery, will need to be utilized to meet that need.

Water Supply Source Issues

The challenge for the county is to effectively manage its available water sources to provide safe, economical potable water for its customers. Lee County is similar to most areas of Southwest Florida in having abundant water resources, but with each source having its own problems and costs. Lee County's philosophy is to maximize its flexibility for the future by using multiple water sources, multiple treatment methods, and new storage methods to assure continued reliability and economical potable water rates for customers of the regional utility system. This assures that a problem with one source or treatment technology will not cripple the potable water supplies.

Whereas other local utilities close to the coast have tended to increasingly use brackish water sources from the Floridan aquifer with reverse osmosis treatment that is 30-50% more costly than conventional treatment and requires brine disposal, Lee County's large regional system has the advantage of being able to use major inland water sources to supply potable water throughout the regional service area.

The county is updating its Water Master Plan, originally completed in 1989, to establish water demands and potential supplies through 2020. Expansions of the surface water supply from the Caloosahatchee River and expansion of the groundwater supplies from well fields are included. The Water Master Plan also includes computer modeling of the existing and planned future freshwater groundwater sources to determine their ability to provide water for future growth without damaging the environment.

Lee County is also working with SFWMD and the United States Army Corps of Engineers to plan for regional water sources. Southwest Florida agricultural, public water supply, and environmental interests have worked with SFWMD to establish the Caloosahatchee River Water Management Plan, addressing surface water sources, and the Lower West Coast Water Supply Plan update, addressing groundwater sources. These plans are intended to provide sufficient water resources for all viable uses.

Through modeling, the Caloosahatchee River Water Management Plan has demonstrated that the river can supply needed minimal river flows for the environment and the relatively small public water supply demands. The river water source will need to be supplemented during extreme droughts with water storage from ASR wells. The plan includes up to 20 MGD of surface water for municipal use.

The Lower West Coast Water Supply Plan includes a broad range of water resources to meet the needs of public water supply utilities, agriculture, and the environment. It includes expansion of existing inland well fields, as long as they meet environmental protection criteria. Components of the plan include alternative water supplies, including conservation, storage, and reclaimed water for irrigation, to reduce fresh water demands due to continued growth.

The Corps of Engineers' Everglades Restudy, which has now been renamed "Everglades Restoration," will have a major impact on the water resources available within Southwest Florida. Everglades Restoration includes provisions for large reservoirs and hundreds of ASR wells to capture surface water during the rainy season and store it for use during the dry, tourist season. The massive program will benefit the environment through control of minimal and maximal river flows, as well as increasing available surface water resources.

The Southwest Florida Study, another Corps/ SFWMD plan to expand the restudy scope to Southwest Florida and to implement the water resource and environmental restoration projects described in the other plans, is anticipated to take four years to complete.

Expanding surface water resources from the river works hand-in-hand with the need for controlling minimal and maximal river flows to protect the estuary environment. The quantity of public water supply is small compared to environmental needs, and solving the environmental problems will greatly improve public water supplies from the river. Better control of maximum river flows during the summer will also greatly reduce the nutrients carried into the estuary by the river.

Lee County's Plan

The Lee County Master Plan Update is based on the philosophy of supplying needed potable water demands for a regional public water supply in the county from multiple diverse water sources with multiple treatment methods. The philosophy maintains the most flexibility while achieving economical water supply rates and holding other potential brackish water sources for future planning periods after 2020.

The plan calls for approximately 15 MGD of surface water and 30 MGD of groundwater capacity for the 2020 planning period. The surface water supply will come from several expansions of the Olga water plant, while the groundwater supply will come from fresh water well fields in southern Lee County. Modeling of the groundwater resources has demonstrated that the required expansions of the well fields will meet environmental criteria to protect wetlands and minimize additional salt-water intrusion. Enhanced softening technology will meet enhanced water quality requirements to protect public health. The expanded surface water and groundwater treatment plants will supply cost effective potable water when compared to alternative brackish water technologies.

In addition to the development of more surface water and groundwater, ASR technology is being implemented at three sites: the North Reservoir, the Olga WTP, and the Corkscrew WTP. The North Reservoir and Olga projects are performing drilling and testing of initial test ASR wells, while the Corkscrew ASR site has successfully demonstrated the feasibility of ASR and is undergoing expansion. ASR will provide significant storage capacity within the utility system, reduce the sizes of certain transmission pipelines, and defer water treatment plant capacity expansions by providing another supply source to meet seasonal peak water demands.

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concentration in the sludge, the resultant mg/kg metals values will be lowered by the addition of lime.

For example, if an 18% sludge cake with a molybdenum value of 41 mg/kg is mixed with a lime dose equal to 5% of the sludge wet weight, the resultant molybdenum value will be reduced by nearly 28% of the sludge dry weight, yielding a molybdenum value of about 29.6 mg/kg.

To Lime or Not to Lime

Refurbishment of the four existing anaerobic digesters and related process equipment required an estimated capital expenditure of $4 million. Construction of the entire lime stabilization process, utilizing a CemenTech CSP-30 pre-engineered/skid mounted modular processing unit and silos, required an actual capital expenditure of $325,000. The CemenTech unit, including two 50-ton silos, was installed in less than three weeks using an in-house maintenance crew.

Annual operating expenses associated with anaerobic digestion, as documented over a 12-year period, totaled $1,289,917. Annual operating expenses associated with the lime stabilization process are estimated at $1,013,768.

By choosing to implement a lime stabilization process as opposed to refurbishing the existing anaerobic digesters, the city of Orlando saved $3,675,000 in averted capital expense and will save $276,149 per year, representing a $6,436,490 savings over a ten-year period. In addition, we are confident that vector attraction and pathogen reduction requirements of 503 are met before the biosolids leave the plant site; this is an important aspect of a biosolids program not typically provided by anaerobic digestion.

To lime or not to lime … in our case the obvious answer is to lime. All options should be evaluated before committing millions of dollars in capital expense and ongoing operational costs. ■