ENERGY EFFICIENT SLUDGE MANAGEMENT EVALUATION FOR REDUCED ENERGY CONSUMPTION

FINAL REPORT 08-18
AUGUST 2008

NEW YORK STATE
ENERGY RESEARCH AND
DEVELOPMENT AUTHORITY

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Final Report

Prepared for the
NEW YORK STATE
ENERGY RESEARCH AND
DEVELOPMENT AUTHORITY
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DISCLAIMER:

JOT, has prepared this report based upon the extensive on-site pilot work at the Walworth Wastewater Treatment Plant, in Walworth, New York; the City of Oneida Wastewater Treatment Plant in Oneida, New York and at the NYS Dept of Corrections Drinking water Treatment Facility at Wilton Prison in Wilton, NY. This program could not have been completed without the willingness and overwhelming help on the part of the management and staff of each of these facilities to assist in its success. However, the data provided in this report is based upon the performance of the IeP process and equipment. The calculations regarding system capacities, plant operations, capital costs and cost recovery are based upon legitimate but theoretical equipment configurations that were developed from the evaluation of the data resulting from the pilot work. The calculations and results are in no way intended to represent any aspects of the business or plant operations of the participating facilities.

ABSTRACT

JO Technologies, LLC, with funding assistance from NYSERDA completed an in-plant demonstration project on two variations of a newly introduced sludge dewatering technology. The technology tested is the “active filtration™” technology, which has been used extensively in Europe and is being introduced to the United States by Innovative environmental Products. This demonstration was designed to evaluate energy savings using the “active filtration™” technology on both fresh and wastewater sludges.

The results of the demonstrations were positive. This technology achieved dewatering performance consistent with conventional dewatering technologies with a significant reduction in labor and or energy requirements. Consistent levels of dewatering in excess of 20% solids on municipal wastewater treatment sludge and in excess of 35% solids on municipal drinking water treatment sludge were achieved. The “active filtration™” technology provided a clarified filtrate with no detectable suspended solids and a sludge cake with no free water that is suitable for landfill disposal and for land application. The project demonstrated that these consistent levels of dewatering and filtrate clarity are achievable with a very minimal energy input and essentially no labor for the operation of the equipment.

The treated wastewater sludge included slurries of primary sludge, secondary waste activated sludge, and anaerobically digested sludge. The treated drinking water sludge included spent diatomaceous earth (DE) waste slurry.

The project demonstrated that the “active filtration™” technology can provide significant savings in energy efficiency compared to conventional dewatering technologies, environmental benefits, and significant labor savings.

ACKNOWLEDGEMENTS

IeP wishes to gratefully acknowledge the following entities, without whose cooperation and support successful completion of this project would not have been possible:

- The New York State Energy Research and Development Authority
- The management, staff, and operating personnel of Village of Walworth Wastewater Treatment Plant in Walworth, New York
- The management, staff, and operating personnel of City of Oneida Wastewater Treatment Plant in Oneida, New York
- The management, staff, and operating personnel of Wilton Correctional Facility Drinking water Treatment Plant in Wilton, New York
- The Drew Industrial Chemical Division of Ashland Chemical Co.
- Aftek Inc. of Rochester, New York

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Summary

JO Technologies, LLC, a joint venture between Innovative environmental Products and Op-Tech Environmental Services, in conjunction with the New York State Energy Research and Development Authority (NYSERDA), has successfully completed a series of in-plant demonstrations for the dewatering of municipal wastewater treatment sludge and drinking water filtration sludge using "active filtration™[1]" filtration technology. The hosts for this demonstration project were the Village of Walworth Wastewater Treatment Plant in Walworth, New York; the City of Oneida Wastewater Treatment Plant in Oneida, New York; and the Wilton Correctional Facility Drinking Water Treatment Plant in Wilton, New York.

This technology achieved dewatering performance consistent with conventional dewatering technologies at a significant reduction in labor and or energy requirements. Consistent levels of dewatering were achieved on municipal wastewater treatment sludge in excess of 20% solids and in excess of 35% solids on municipal drinking water treatment sludge with the exception of the testing completed at the Village of Walworth. The "active filtration™" technology provided a clarified filtrate with no visible suspended solids and sludge cake with no free water that is suitable for landfill disposal and for land application. The project demonstrated that these consistent levels of dewatering and filtrate clarity are achievable with a very minimum energy input and greatly reduced labor needs for the operation of the equipment.

The treated wastewater treatment sludge included slurries of primary sludge, secondary waste activated sludge, and anaerobically digested sludge. The treated drinking water filtration sludge included spent diatomaceous earth (DE) waste slurry.

As detailed further in this report, the technologies currently in use for waste and drinking water sludge dewatering are belt presses, plate and frame filter presses, and centrifuges. In all but one case (filter presses), when comparing "active filtration™"to current technology, the efficiency improvement exceeded 30%. When compared to filter press technology, the energy efficiency was equivalent. However, the "active filtration™" technology is fully automated, and the filter press technology requires regular manual labor for its operation and daily cleaning. When "active filtration™" is compared to belt press technology, there are savings in labor in daily set up, monitoring, and cleaning.

Additional potential benefits of "active filtration™" include the following:

1. In the case of the belt press, there is a significant volume of water required for operation and for daily cleaning of the press. In addition to the power requirements associated with pumping, this water is recycled to the head of the waste treatment

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[1] The "active filtration™" technology is marketed throughout Europe by Idee e Prodotti of Milan, It. under the trade name of "Squeeze Box." IeP is the U.S. distributor for this technology.

plant. This places consistent hydraulic, organic, and solids load on the treatment plant. The "active filtration™" does not require water for its routine operation or for daily cleaning; thus, these loads are mitigated with all the associated operational and energy benefits.

2. Current practice for management of spent DE, in many cases, includes sedimentation lagoons in lieu of complicated and expensive DE dewatering systems. These lagoons present a potential or real hazard from discharges to the environment resulting from upset conditions resulting in overflowing. The "active filtration™" provides a very simple, low-cost alternative to conventional technologies and results in discharge of highly clarified filtrate as well, thus mitigating these environmental risks.
3. The "active filtration™" technology accommodates tramp materials such as metal (bolts, etc.) and stones that are frequently present in many sludge streams and that result in damage to the current technologies.
4. The operators of the belt press and the filter press are routinely exposed to contact with the sludge during normal operations and daily clean-up tasks. This sludge can be hazardous to workers. The "active filtration™" technology allows the operators to have essentially no exposure to the sludge.

The estimated operating costs of an "active filtration™" system for a typical wastewater treatment operation are in the range of $0.025 to $0.08 (2008 dollars) per ton of dewatered sludge (calculated at 22% solids). The capital costs are approximately $185 per ton of dewatered sludge per year, compared to $400 to $530 per ton of dewatered sludge per year for conventional technologies (2008 dollars, calculated at 22% solids).

The project work demonstrated that the "active filtration™" might easily be applied to the wide range of sludge dewatering applications. The technology is readily applicable to wastewater plants managing primary sludge, secondary waste activated sludge, anaerobically digested sludge, and drinking water filtration plants using DE.

The use of "active filtration™" instead of currently available technologies will result in significant opportunities for energy savings, the most significant of which include:

1. Reduction of electric power associated with the running of the motors for the belt press technologies
2. Reduction of electric power associated with the pumping of the water required for the operation and daily cleaning for the belt press technologies

3. Reduction of electric power associated with the hydraulic loading resultant from the constant recycling of the water required for the operation and daily cleaning for the belt press technologies
4. Reduction of electric power associated with the operation of sludge centrifuge technologies

The demonstration project confirmed the “active filtration™” technology’s ability to consistently, cost-effectively dewater municipal wastewater sludge and drinking water filtration sludge in most situations. Each of the outlined benefits has the significant additional impact of further reducing U.S. municipal infrastructures’ dependence on foreign oil.

The hardware associated with the IeP technology can be engineered to specific applications using the process data generated by this demonstration trial. The technology itself, because of its modularity and compact footprint, can be easily retrofitted into nearly any existing plant setting. Its deployment results in immediate benefits for plant personnel, environmental stewardship, and increased cost effectiveness.

This demonstration, held with the assistance of NYSERDA, of the “active filtration™” technology’s ability to dewater wastewater and drinking water sludge in such an energy-effective manner, is the first known demonstration of such a process.

Finally, it is the intent of Innovative environmental Products to locate and build its manufacturing facility in upstate New York, employing workers and generating economic activity in an area where blue collar manufacturing jobs are disappearing.

Glossary Of Terms

Sludge: Solid matter dispersed in water produced by drinking water or sewage treatment process

Unstabilized Sludge: Wastewater Treatment plant sludge that contains active biological matter and pathogens

Stabilized Sludge: Wastewater Treatment plant sludge that have little or no active biological matter and pathogens that has been treated with lime, heat, or digestion

Small -to-Medium-Sized Wastewater Treatment Plants: Municipal Wastewater Treatment plants ranging in size up to 10,000,000 Gallons per day of influent. This volume represents the target market for the "active filtration™" technology.

Filtration: Mechanical separation of water from suspended fine or course solids in sludge

Filtrate: The clarified liquids which have passed through a filter

Wastewater sludge: Dewatered solids captured by filters at wastewater treatment plants

Drinking water filtration sludge: Dewatered solids captured by filters at drinking water treatment plants

Sludge dewatering: Removal of free water from the suspended solids in sludge

Sludge cake: Dewatered sludge with no free water

Diatomaceous earth dewatering (DE): Inert material used as a filtration aide in drinking water treatment processes

Oven Dry: Intended to represent the dry basis of a material with 0% moisture content

List Of Abbreviations

DE	Diatomaceous Earth
GPD	Gallons Per Day
GPM	Gallons per Minute
MGD	Millions of gallons per day
NYSERDA	New York State Energy Research and Development Authority
USEPA	United States Environmental Protection Agency
USGS	United States Geodetic Survey
TOC	Total Organic Content
TPY	Tons Per Year
TSS	Total Suspended Solids
JOT	JO Technologies, LLC
IeP	Innovative environmental Products
WWTP	Wastewater Treatment Plant
DWTP	Drinking Water Treatment Plant
OD	Oven Dry

Keywords

filtration, dewatering, wastewater sludge, drinking water filtration sludge, sludge dewatering, spent diatomaceous earth dewatering, spent de dewatering

1. PROJECT OVERVIEW

Project background

Considerable energy, labor, fuel, and expense are consumed by the dewatering of sludge at small- to medium-sized drinking water and wastewater treatment plants (DWTP and WWTP) throughout New York State. Most of the conventional technologies used at these plants have been in use since the 1970s to early '80s, and there have been minimal new developments and improvements in these technologies over the years. The focus of this project is two-fold. The first goal is to optimize the dewatering of municipal sludge in a fully automated and energy-efficient manner. The second goal is to reduce the volume and/or tonnage of the land filled waste sludge being transported from these sites.

The funding provided by NYSERDA supported trials at small- to medium-sized WTP and WWTP of two related, alternative sludge-dewatering technologies that are referred to as "active filtration™" technologies: a filter press called the Squeeze Tower Press and a box filter called the DryBox. This technology is capable of producing dewatered solids concentrations at the upper end of the range of the current technologies with less energy consumption and greatly reduced labor. Importantly, this technology is capable of providing superior solid separation and liquid effluent (filtrate) of equivalent or higher quality than current methods.

The Squeeze Tower Press and the DryBox consume considerably less energy per unit volume of municipal sludge dewatered than the prevalent current methods. Savings are expected in terms of reduced land filling costs by achieving higher solids than conventional technologies, which, in turn, result in reduced tonnages at the landfill. Plants may realize savings in transportation costs based on the reduced tonnage as well. Aside from filtration and dewatering performance, the technology is fully automated and requires significantly less labor than many current methods. Additionally, the technology accommodates tramp materials such as metal (bolts, etc.) and stones that are frequently present in many sludge streams and that result in damage and downtime in the prevalently used technologies.

It was the intent of this project to demonstrate the success of this technology in terms of performance energy and cost savings on the following waste sludge streams:

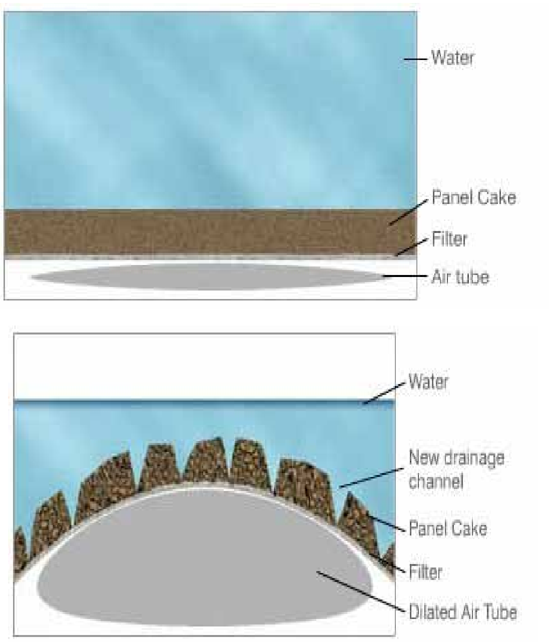
1. Primary sludge from a WWTP – This sludge is typically processed using centrifuge, belt press, or plate-and-frame filter press technology.
2. Secondary sludge from a WWTP prior to the digestion or stabilization process – This sludge is typically processed using centrifuge, belt press, drying bed, or plate-and-frame filter press technology.
3. Anaerobically digested sludge from a WWTP – This sludge is typically processed using centrifuge, belt press, drying bed or plate and frame filter press technology.

4. Spent sludge from the filtration of drinking water at a drinking water treatment plant – This sludge is typically processed using drum filtration technology that uses diatomaceous earth as a filtration aid. The sludge is produced following a chemical flocculation of the water that removes certain contaminants from the water. This sludge is also handled and transported as a damp mass that is removed from storage lagoons and holding tanks to landfills.

“Active filtration™” technology description

“Active filtration™” is a dynamic filtering system, which switches from static filtration to active filtration previously set on an adjustable, predetermined schedule.

Figure 1. Basic Principal of Operation for “active filtration™” Technology



Inflatable air tubes (bladders), ranging from 4 to 18 inches in diameter, positioned under a filtration membrane, cause the “active” motion. They dilate beneath or against the waste material, constantly causing a number of cracks in the forming layers of dewatering sludge. This, in turn, opens up fan-shaped channels in the sludge cake and creates additional passageway for the drainage of the filtrate. This unique feature allows a much better extraction of the filtrate than is allowed by any of the currently used alternatives.

The use of this technique increases the effectiveness of the filtering system, thus enhancing the production of dryer dewatered sludge. It reduces filtration time, and it guarantees more uniform dehydration for the entire sludge mass.

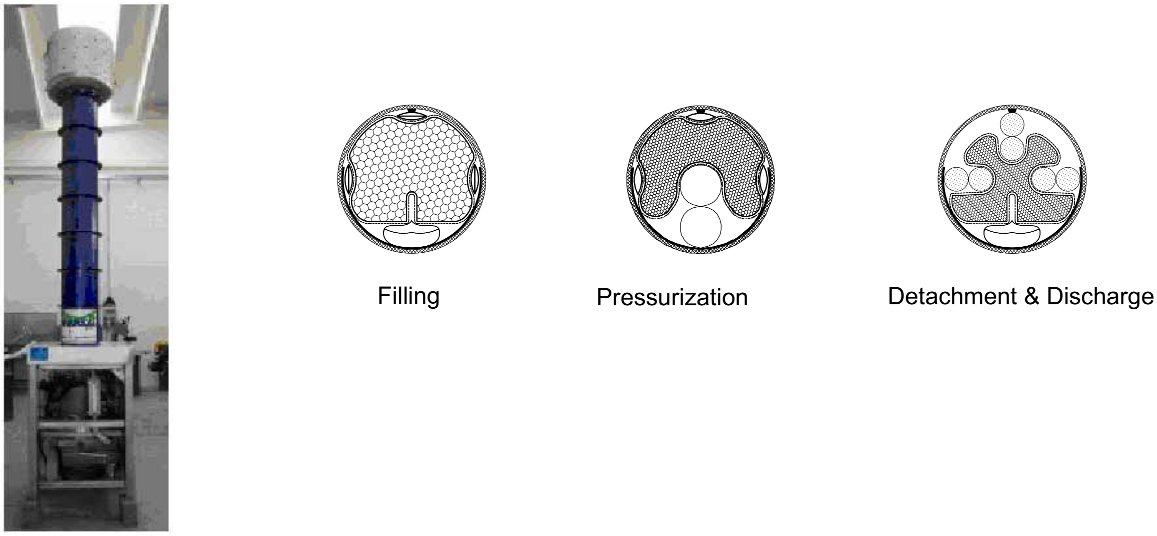
The “active filtration™” technology is marketed in the United States under the trade names of Squeeze Tower Press and DryBox. “Active filtration™” is a patented filtration technology developed in Italy by Idee e Prodotti. Jannanco, LLC is the U.S. distributor for this technology. Innovative environmental Products, Inc. is the sole licensee of the technology in North America.

Squeeze Tower Press

The Squeeze Tower Press style of “active filtration™” technology represents a significant innovation in filtration technology. The sludge and water slurry is squeezed within a strong porous membrane. The sludge solids remain within the membrane and the water, and very fine, undetectable particles pass through.

The Squeeze Tower Press operation has three stages: filling, pressurization, and detachment/discharge. The technology is constructed of a large porous membrane filter bag suspended within a circular arrangement of bladders installed within a metal cylinder. During filling, sludge slurry is pumped into the filter bag with some gravity drainage of the liquid from the slurry occurring. During pressurization large bladders inflate to compress the sludge solids and squeeze out liquid through the porous membrane. During detachment, additional bladders inflate to break up the compacted sludge cake created during the pressurization stage. The three stages are repeated until the Squeeze Tower Press is full. At that time the detachment stage is followed by the discharge stage, and the cake is discharged from the bottom of the press through an automatic bottom door.

Figure 2. Principal of Operation for Squeeze Tower Press “active filtration™” Technology

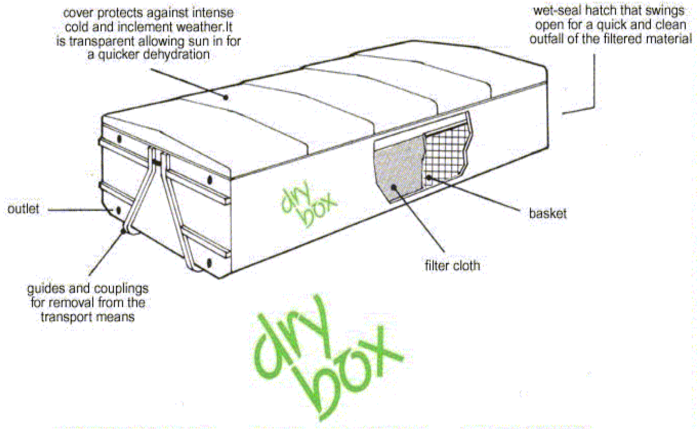


The filtration media in the Squeeze Tower Press is a woven polypropylene cloth. It is manufactured to provide optimum dewatering. The filtration performance is not dependant on ancillary process systems such as dissolved air flotation systems or on additives such as lime or diatomaceous earth.

DryBox

The DryBox consists of mobile rolloff containers that work like a "super" strainer. Filtration is accomplished by using the “active filtration™” system. A large filtration cloth is installed over the bladders in the floor of the DryBox. The bladders are set on top of an under-drain system, which is created by grating that covers the entire bottom and sides of the rolloff container. The entire filtration process takes place inside the container.

Figure 3. Conceptual Schematic of DryBox.



Sludge is loaded from the top. It may be batch fed with bucket loading equipment or fed continuously with a low pressure feed pump. The sludge is contained and initially filtered by gravity through the filter cloth. The liquid is drained out of the box through a pipe coupling. Then the “active filtration™” system is engaged. This consists of two stages: dilation (ON) and stand-by (OFF).

Dilation occurs when the air bladders are dilated by compressed air. This dilation of the bladders warps the panel of sludge cake just formed on the filter cloth thus causing cracks to the sludge mass. The free liquid in the sludge finds additional and preferential drainage channels within these cracks.

Stand-by occurs when the bladders are vented and the sludge panel recedes in order to undergo subsequent dilation and warping to create new drainage channels.

An electric control panel runs the filtering stages, and it provides the opportunity to customize the cycle to obtain an ideal sludge dryness. The cycle is customized by variations in the dilation and standby time setting and the operating pressure.

Once a sludge cake has adequately dewatered in the DryBox, it may be staged temporarily to decant off any remaining free liquid from the container. The DryBox is then hauled with a rolloff transfer truck to the disposal site. The dewatered sludge is dumped from the truck. The filtration cloth may be reused or disposed of at the disposal site, depending upon the nature of the sludge. The filter is not detrimental to landfill operations. As with the Squeeze Tower Press, filtration performance is not dependant on ancillary process systems such as dissolved air flotation systems or on additives such as lime or diatomaceous earth.

Handling and installation costs are negligible. In fact, system handling is limited to filter cloth replacement. Installation does not entail any infrastructure; the operation of the DryBox can be carried out on any reasonable level area that is convenient to the user.

<u>Mini DryBox</u>

The Mini DryBox 200 is a small-scale version of the DryBox. This is used for very small municipal sludge treatment applications, for specialty chemical sludge applications, and for demonstration programs. The Mini DryBox was used for the DryBox demonstration portions of this project.

Figure 4. Mini DryBox 200 Equipment Configuration

The principal of operation is identical to the DryBox with the exception of the method of discharging of the dewatered solids. The solids are collected within a fabric liner within a removable basket. This basket is removed by a fork truck, and the fabric, along with the dewatered solids, is discharged out to the basket's clam-shell-style bottom.

2. DEMONSTRATION METHODOLOGY AND RESULTS

Testing method

Objectives

The objectives of the project were as follows:

1. Verify the technology's ability to achieve a consistent and satisfactory level of dewatering and filtration
2. Determine the quality of the dewatered sludge after "active filtration™" and determine the suitability of the technology for dewatering sludge for disposal at landfills
3. Confirm the technology's ability to dewater sludge at a 30% energy savings compared to specific conventional technologies found at small to medium water and wastewater treatment plants
4. Determine additional treatment requirements, if any, for treatment of anaerobically digested primary and secondary sludge
5. Prepare an economic model for the test sites and for typical water and wastewater treatment plant operation(s) based on the results of this project, and prepare a return on investment analysis from data generated by the project

The project objectives were measured by:

1. Testing the effluent from the existing dewatering technology at the sites and the filtrate from the "active filtration™" technologies for total solids, which was ultimately a visual inspection and comparison due to the high clarity of the filtrate
2. Testing the dewatered sludge from the existing dewatering technology at the sites and from the "active filtration™" technologies for total solids; confirm anticipated total solids concentration from the "active filtration™" technologies of 18% to 23% solids for the DryBox and 25% to 33% solids for the Squeeze Tower Press
3. Conducting periodic processing rate checks on the existing technology and the "active filtration™" technology; calculate and report the energy usage per pound of dewatered sludge.
4. Testing the filtrate for particulates, which was ultimately a visual inspection and comparison due to the high clarity of the filtrate
5. Conducting testing to determine the quantity and characteristics of the filtrate and the dewatered solids from the sludge test stream after dewatering
6. Extrapolating the data from the testing and findings of the project defined above to the anticipated conditions for a commercial scale operation
7. Preparing a simple economic model with potential cost savings and expected return on investment (ROI) based on the data that resulted from the demonstrations

Demonstration Method

Three sources of municipal wastewater treatment sludge were treated at the two host waste treatment plants. These sources were primary sludge, secondary waste activated sludge, and anaerobically digested sludge. The primary sludge and the secondary waste activated sludge were treated unstabilized and stabilized with lime; the anaerobically digested sludge was treated as received. This resulted in a total of five types of sludge being treated across the various site. Each of these sources was treated using both the DryBox and the Squeeze Tower Press (Squeeze Tower Press) orientations of the "active filtration™."

The stabilized condition was tested because many WWTPs across New York State dispose of their dewatered sludge in municipal waste landfills. Regulations require that the sludge from WWTPs be stabilized through digestion or through other stabilization methods prior to delivery to the landfill. The unstabilized condition for the primary and the secondary waste activated sludge was tested because certain WWTPs across New York State send their sludge to beneficial use sites that do not require stabilization. The sludge was stabilized using hydrated lime added to the sludge slurry to a pH in excess of 12.0. The elevated pH was maintained for at least 30 minutes.

In each of these five cases, the sludge was first treated in the DryBox. The sludge in each case was treated with an array of chemical treatment regimens, discussed below, during the DryBox treatment activity until an optimum chemical regimen was determined through qualitative evaluation. Once the optimum chemical regimen was determined, the quantitative testing proceeded with the optimum regimen in the DryBox and the Squeeze Tower Press.

The sludge at the drinking water treatment plant was wasted diatomaceous earth (DE) sludge from the sludge holding tank. This source was only treated with the DryBox. The only chemical regimen that provided consistent results was a single chemical regimen, cationic polymer. Solids concentration were assayed and recorded. In general, the data are based upon multiple replicate tests on the waste stream. The site logistics did not allow for reasonable installation and operation of the Squeeze Tower Press. The results achieved with the DryBox were well in excess of the percent solids concentration required for disposal of the sludge. The Squeeze Tower Press has uniformly provided higher dewatered sludge solids concentrations than the DryBox for every type of sludge ever tested in the U.S. and Europe. Therefore, the Squeeze Tower Press was not tested.

Due to the configuration of the host wastewater treatment sites, an array of waste streams were available for testing at each site. The selection of feed materials was based upon consultation with the managers of the host wastewater treatment plants, and officials from the New York Water and Environment Association (NYWEA) and the New York Rural Water Association.

Table 1. Sludge Sources and Testing Protocol by Host Site

Sludge Treated	Primary				Secondary Waste Activated				Anaerobically digested		DE
Stabilization	Un-Stabilized		Lime Stabilized		Un-Stabilized		Lime Stabilized		Digester Stabilized		N/A
Technology	DryBox	Squeeze Tower Press	DryBox	Squeeze Tower Press	DryBox	Squeeze Tower Press	DryBox	Squeeze Tower Press	DryBox	Squeeze Tower Press	DryBox
Host Site											
Walworth WWTP	X	X	X		X	X					
Oneida WWTP	X		X	X	X		X	X	X	X	
Wilton Drinking water Filtration Plant											X

It should be noted that commercial-scale operation of the "active filtration™" technology DryBox, subsequent to the NYSERDA-funded program, has shown that the process's performance is consistent with the results of this demonstration project.

Equipment Configuration

The pilot equipment consisted of a one meter (1M) Squeeze Tower Press "active filtration™" unit and a 50 liter "Mini" DryBox "active filtration™" unit tested alternately, or in parallel, for comparison. The system also included a small polymer feed tank, chemical feed pumps, a small slurry conditioning tank, mixers, and a feed pump.

Squeeze Tower Press

The Squeeze Tower Press was installed on top of a steel support frame. There is a 14' overhead height requirement for the system when set upon the frame. There was a control panel and a 30' pneumatic umbilical from the control panel to the filter. The internal bladders and filter cloth were installed into the Squeeze Tower Press and remained in place for the entire pilot trial period. A positive displacement pump was used to feed the sludge to the filter. The filtrate was drained off through an outlet at the base of the tower via a flexible hose. It was discharged back to the inlet of the WWTP.

Sludge was drawn off of the normal sludge feed line to the existing dewatering technology and dosed with coagulant and/or flocculent chemicals. Due to the nature of the sludge and the plant layouts, it was first sent to a storage tank to allow for pretreatment and measurements. From the storage tank, the sludge was pumped to the Squeeze Tower Press.

The typical cycle time for the Squeeze Tower Press was between four to six hours for municipal sludges, dependant upon the source. As discussed above, the cycle starts with the filling cycle, during which the press controls alternate between filling, pressing, and detachment. Then the sludge was pressed in the tower for an extended period. The sludge was automatically detached and discharged from the bottom of the press into a container positioned below the unit. Once the automatic discharge cycle was complete, the bottom door closed and the unit automatically started a new cycle.

Figure 5. Field Installation of Pilot Squeeze Tower Press

Mini DryBox

The installation requirements of the Mini DryBox are very minimal. All that is required is a 120 V GFI outlet and the small air compressor that will be supplied with the project. The filtrate is drained off through an outlet in the lower front panel of the unit. It was typically discharged back to the inlet of the WWTP. The sludge was removed within the filter bag by lifting the support basket from the unit with a fork truck.

Sludge was drawn off of the normal sludge feed line to the existing dewatering technology and dosed with coagulant and/or flocculent chemicals. Due to the nature of the sludge and the plant layouts it was first sent to a storage tank to allow for pretreatment and measurements. From the storage tank the sludge was pumped to the Mini DryBox.

A filter bag was manually installed in the DryBox for each test run. The range of fill time for the Mini DryBox was 30 minutes to three hours for municipal sludges. This was done by filling and running the automatic "active filtration™" cycles. The sludge volume gradually would fill the unit and then recede with the "active filtration™" cycles. The typical drainage time was 18 to 24 hours to achieve a sludge that would pass a filter test required for shipment. At the end of a test run the filter cloth and the contained dewatered sludge were removed with a fork truck. The filter basket was returned to the unit and a new cloth was installed.

Figure 6. Sludge Removal Operation of Mini DryBox

Mobilization and Operation

IeP staff completed the installation and set up of the equipment and provided responses to equipment problems. Op-Tech Environmental Services provided transportation of equipment to and between sites. At each site the plant staff assisted in the assembly of the equipment with the project team. At each site IeP was ultimately responsible for daily operation. The plant staff at each site was responsible for monitoring the equipment and testing associated with the pilot test.

Laboratory Testing

In all cases, the influent sludge, the filtrate, and the dewatered sludge were sampled and tested for each test run by the on-site lab at the respective treatment plant. Where applicable, parallel testing was performed on the existing sludge dewatering technology for comparison of results. This was only possible with the anaerobically digested sludge at the Oneida WWWTP. The laboratory analyses were as follows:

1. Influent - % solids
2. Filtrate – visible for suspended solids
3. Dewatered Sludge - % solids

Along with solids measurements, flow rates for influent sludge and filtrate were recorded. A licensed Professional Engineer reviewed the results of these tests.

Performance Evaluation

Solids concentration and characteristics of the sludges tested were evaluated per the above testing protocol. This data was used to compare and confirm the relative operation of the "active filtration™" to the existing dewatering technology. Data was assembled in a matrix format for easy review and comparison. The data was extracted from this matrix for preparation of the final report.

Optimization of the operation of the “active filtration™” technology was augmented by the use of flocculation chemicals in the sludge slurry. The chemical regimens are outlined below. Drew Industrial Division provided consultation on the selection and use of the coagulants for the testing.

From the performance data collected, each of the projected project benefits outlined in this application were recalculated based upon the actual results. The information regarding the extent of the market for each of the competing technologies was verified as well. Data on the capacities and equipment used at the municipal waste treatment plants in New York State was obtained from the Division of Water report titled “Descriptive Data of Wastewater Treatment Plants in New York State,” dated 2004.

Project Execution

Wastewater Sludge

A schematic of the demonstration process is provided in Appendix B. The wastewater sludge demonstration process system was configured as follows:

1. The wastewater sludge supply was delivered into a storage tank. In the case of Walworth, this tank’s capacity was 1500 gallons; in the case of Oneida, the capacity was 300 gallons. The tanks contained conventional tank mixers with 8” propeller blades. The speed of the mixer was not specifically recorded as this is not considered a significant process parameter. The volume of the tanks was not considered a significant process parameter either.
2. Dependant upon the site, the tests on the primary sludge were conducted with the sludge as received, unstabilized, and stabilized with lime by adding lime to the sludge to obtain a pH in excess of 11. The stabilization was conducted in the storage tank.
3. The tests on the secondary waste activated sludge were conducted with the sludge as received, unstabilized, and with the sludge stabilized with lime by adding lime to the sludge to obtain a pH in excess of 11. The stabilization was conducted in the storage tank.
4. In each case, initial qualitative tests were conducted with an array of chemical treatment regimens on the wastewater sludge. The optimum treatment regimen was determined based upon observation of the relative flow rate during filtration and the clarity of the filtrate. The optimum chemical regimen was determined to be very site- and sludge-source specific. However, an initial treatment of the sludge with ferric chloride followed by an anionic or cationic polymer provided the most consistently satisfactory results. The chemical regimens tested included:
    a. Lime stabilization and no lime stabilization
    b. Cationic polymer alone (diluted to 0.25% solids)
    c. Anionic polymer alone (diluted to 0.25% solids)
    d. Ferric chloride followed by cationic polymer
    e. Ferric chloride followed by anionic polymer

    f. Poly aluminum chloride followed by anionic polymer
        i. The poly aluminum chloride was used on only two test runs. Based on the limited benefit and the high potential cost of the chemical, its use was abandoned.

5. The ferric chloride was added to the sludge in three locations: in the storage tank, in line upstream of the sludge transfer pump, and in line downstream of the transfer pump. In the cases where the sludge was lime stabilized, the ferric chloride was added following stabilization. The optimum location of the polymer addition was determined to be down stream of the sludge transfer pump.
6. The supply sludge was pumped from the storage tank. The operating flow rate for the process was in the range of 5 to 10 gpm.
7. At the discharge of the pump on the storage tank the diluted polymer was injected directly into the sludge line. Direct injection of the polymer was determined to be the most effective and stable method of addition with the best results for mixing. The flow rate of the diluted polymer was controlled by a conventional positive displacement, double check ball feed pump. The flow of the polymer was matched at its maximum anticipated flow rate of approximately 200 parts per million (ppm) polymer to sludge slurry. (Please note that this flow rate is very site-specific and unique to the process conditions and the selection of the polymer used for this demonstration. This value has been shown in commercial practice to be very site-specific.)
8. The flocculated sludge slurry was delivered directly into the DryBox. For this process the Mini-DryBox 200 was used. For each replicate, approximately 200 gallons of slurry was delivered into the DryBox. The pneumatic bladder cycles within the DryBox were set at 12 minutes on and 12 minutes off. In all cases there was no free water emanating from the DryBox drain following 20 hours of operation.
9. The filtrate was visually inspected to ensure there was not visible particulate, and then it was discharged to the adjacent floor drain, which eventually returned it back to the head works of the treatment plant.
10. The dewatered sludge solids were sampled and then removed from the Mini Dry Box with a fork truck and stacked for disposal.
11. Following the DryBox treatment regimens of each of the wastewater sludge slurries, each slurry was then treated through the Squeeze Tower Press. The slurry treatment and delivery configuration for the Squeeze Tower Press was essentially identical to that of the DryBox. The filtrate was visually inspected to ensure there was no visible particulate. It was then discharged to the adjacent floor drain, which eventually returned it back to the head works of the treatment plant.
12. The sludge cake from the Squeeze Tower Press automatically discharged from the Squeeze Tower Press down into a five cubic foot wheeled container. The dewatered sludge solids were sampled and then removed and stacked for disposal.

Approximately 20 DryBox batches and 18 SqueezeTower Press batches were run.

Drinking Water Filtration Sludge

The drinking water filtration sludge demonstration process system was configured as follows:

1. The sludge supply was the facility's underground sludge storage tank. Generally, the tank is not agitated. However, during the testing the tank was agitated with an air lance.
2. The slurry was drawn out of the tank via an air diaphragm pump. The flow rate was in the range of 5 to 10 gpm.
3. Initial qualitative tests were conducted with the chemical treatment regimens on the sludge to determine the target range for the addition of the treatment chemicals. For this sludge, the treatment with cationic polymer alone (diluted to 0.25% solids) was used. The dosage rate was in the range of 10 to 30 ppm of dry polymer, based on the sludge supply.
4. The supply sludge was pumped from the storage tank. The operating flow rate for the process was in the range of 5 to 10 gpm.
5. The flocculated sludge slurry was delivered directly into the DryBox. For this process the Mini-DryBox 200 was used. For each replicate approximately 200 gallons of slurry was delivered into the DryBox. The pneumatic bladder cycles within the DryBox were set at 12 minutes on and 12 minutes off. In all cases, there was no free water emanating from the DryBox drain following 20 hours of operation.
6. The filtrate was visually inspected to ensure there was no visible particulate matter, and then it was discharged to the adjacent floor drain, which eventually returned it back to the head works of the treatment plant.
7. The dewatered sludge solids were sampled and then removed from the Mini Dry Box with a fork truck and stacked for disposal.

Approximately eight DryBox batches were run.

Analysis of results

The following is a summary of the results achieved at each site:

City of Oneida Project

Table 2. City of Oneida WWTP Sludge Sources

Dewatered Sludge Percent Solids Concentration from "active filtration™" Technologies

Technology	Sludge Source			
	Anaerobically Digested	Primary Stabilized	Secondary Unstabilized	Secondary Stabilized
Squeeze Tower	20.4 - 23%	32.6%	-	20 – 22%*
DryBox	17.8 – 19%*	20.2 – 21%	11.9 – 12.3%*	9.3 – 11%*

* In all cases where the sludge was below the 20% solids concentration the sludge contained no free water and the filtrate was clear.

1. The influent sludge and the dewatered sludge were tested by the certified wastewater treatment lab technicians at the Oneida WWTP. The raw data is available for inspection upon request.
2. In all cases, the filtrate resulting from the DryBox and the Squeeze Tower Press was a nearly clear liquid with no visible suspended solids.
3. Based on discussion with plant operators the chemical treatment requirements during the pilot testing were determined to be comparable to or below the normal levels experienced by the plant.
4. Once the process parameters were determined and stabilized the dewatered sludge from every wastewater source treated at Oneida met or exceeded the 20% solids concentration when processed through the Squeeze Tower Press. This is the target for disposal of municipal wastewater treatment sludge in New York State.
5. The dewatered sludge from the DryBox treated at Oneida exceeded 20% solids concentration from the treatment of lime-stabilized primary wastewater sludge. Due to the inherent nature of the unstabilized primary sludge, it was understood that this material would not be disposed of in a beneficial use application. Therefore, the testing of the primary sludge in the unstabilized condition was not conducted.
6. The dewatered sludge from the treatment of lime-stabilized secondary sludge in the DryBox at Oneida did not meet the 20% target solids concentration. However, the sludge achieved a condition of no free water and might be suitable for disposal sites requiring that it meets the paint filter test criteria.
7. The dewatered sludge from the DryBox treatment of unstabilized secondary activated sludge did not meet the 20% target solids concentration, and digester sludge was slightly below this

target. However, the sludge achieved a condition of no free water. Due to the inherent nature of the unstabilized secondary sludge, it was understood that it may be likely that this material would be disposed of in a beneficial use application. Therefore, the testing of the secondary sludge in the unstabilized condition was not conducted on the Squeeze Tower Press.

8. The dewatered sludge from the DryBox treatment of anaerobically digested sludge was slightly below 20% target solids concentration. However, the sludge achieved a condition of no free water. The percent solids concentration is, however, consistent with the concentration of solids achievable at some of the existing waste water treatment sites within New York that use belt press technology. This sludge would be suitable for disposal sites requiring that it meets the paint filter test criteria. This sludge should also be suitable for land application, where applicable, or for other beneficial use applications.
9. The energy consumption of the "active filtration™" technology was evaluated. Details of the energy benefits are discussed in section 3 below.
    a. The energy consumption for the DryBox was observed to be in the range of an average of 3 to 7 cubic feet per minute of compressed air at 30 psig for one to five minutes per hour. This is approximately equivalent to 1.5 Hp. Subsequent commercial scale demonstration projects of the process have replicated this flow rate to sludge processing rates of up to 10,000 gallons per day. This provides power consumption at the rate of approximately 0.005 Hp per gallon of sludge.
    b. The energy consumption for the Squeeze Tower Press was observed to be in the range of an average of 5 to 10 cubic feet per minute of compressed air at 30 psig for 10 to 20 minutes per hour. This is approximately equivalent to 1.7 Hp and provides power consumption at the rate of approximately 0.007 Hp per gallon of sludge.
    c. The existing dewatering equipment at the host site required is a belt press. This belt press is reported by the plant operators to have a power consumption rate of approximately 0.010 Hp per pound of sludge.
    d. For this application the "active filtration™" technology would provide an approximate electrical energy savings of 50% on the processing of the sludge.

NYS Department of Corrections Facility at Wilton, New York Project

Table 3. Department of Corrections Drinking Water Sludge

Dewatered Sludge Percent Solids Concentration from "active filtration™" Technologies

Technology	Sludge Source
	Drinking Water Filtration Sludge
DryBox	30% to 35%

1. The dewatered sludge was tested by the certified lab technicians at Adirondack Environmental Services, Inc. The raw data is available for inspection upon request.
2. The DE sludge from the drinking water filtration plant dewatered freely and with a minimum level of coagulant to achieve flocculation suitable for dewatering in the Mini DryBox. The system was operated for four replicate tests, with two samples taken for each test, to confirm sludge uniformity within the Mini DryBox. The results demonstrated sludge dewatered solids consistently at or above 33% solids concentration. In all cases, there was no free water in the dewatered sludge, and the filtrate contained no visible particulate matter.
3. There are two generally accepted current methods of disposal for spent DE.
   a. At the Wilton site, the DE slurry is removed from the storage tank with a vacuum truck. The truck is then driven to a licensed facility for "solidification." At the solidification facility, solidification materials are added to the slurry in a pit to soak up the free water. The resultant damp cake of material is then disposed of at a landfill.
   b. An alternate and more common method of disposal at larger drinking water treatment facilities is for the spent DE slurry to be pumped out into a sedimentation lagoon. On a periodic basis, the lagoon is drained and the water is decanted away from the DE until it is absent of free water. This material is then loaded into transport vehicles and disposed of at a landfill.

Village of Walworth Project

Table 4. Village of Walworth WWTP Sludge Sources

Dewatered Sludge Percent Solids Concentration from "active filtration™" Technologies

Technology	Sludge Source		
	Primary Stabilized	Primary Unstabilized	Secondary Stabilized
Squeeze Tower	12.8 – 13.5%	-	-
DryBox	9.1%	10.6 – 13.4%	13.4%

In all cases, the sludge contained no free water and the filtrate was clear.

1. The influent sludge and the dewatered sludge were tested by the certified wastewater treatment lab technicians at the Walworth WWTP. The raw data is available for inspection upon request.
2. The testing from the Village of Walworth Wastewater Treatment Plant was not successful and has been omitted from inclusion in the statistical data in this report. The plant has historically experienced significant operational problems due to problems with one of the primary sources of its influent and related issues within its digester. This plant has issues with achieving adequate dewatering of its sludge in spite of the best efforts of the staff and other technology suppliers. The sludge is apparently highly hydroscopic so it does not readily dewater. The current sludge management practices include sludge slurry disposal at a nearby larger municipal plant or permitted land application on nearby farms. Both the DryBox and the Squeeze Tower Press were capable of dewatering the sludge to a point of no free water but the sludge did not dewater to the target 20% solids that is required for disposal at the landfill. Therefore, the total equipment requirements needed to reach an acceptable level of dewatering would not be justified for the small incremental benefit in disposal costs of land filling the dewatered sludge compared to current practices.

3. BENEFITS OF “ACTIVE FILTRATION™” TECHNOLOGY

Comparison to conventional technologies

Current technologies in use by small to medium sized WWTP and DWTP include rotary drum and disc filters, continuous duty fixed membrane pressure filters, and dissolved air floatation thickeners. The rotary drum and disc filters may or may not include gravity and vacuum dewatering functions. The fixed membrane filters may or may not include mechanical scrapers or pressure wands to enhance filtration by disrupting the filter cake. All of these conventional technologies have considerably higher energy use and/or higher operations costs than the “active filtration™” technology.

Belt filter presses are used in many small- to medium-sized wastewater treatment plant sludge dewatering applications. Through inspection of the New York State database, it was demonstrated that the belt filter press technology is the prevalent technology for dewatering of sludge in small to medium sized plants throughout New York State. The belt filters require electric power for their operation. These horsepower loadings are in the range of 5 to 15 HP, depending upon the size and the style of the system.

Centrifuge technology currently is not used in the small- to medium-sized WWTP market. However, there is now considerable interest by the manufacturers to move toward this smaller-scale market. There is a potential savings in energy through the use of the “active filtration™” technology as opposed to the use of centrifuge technology, as well as a savings in the capital investment requirements.

The most prevalent method of disposal of DE from the municipal plants within upstate New York State is by lagoon storage and sedimentation of the filter backwash, with periodic removal of the DE sludge from the lagoons with excavation machinery (or vacuum trucks from smaller sites). When the drinking water filters are backwashed the spent DE slurry is discharged into a containment lagoon. The DE eventually settles to the bottom of the lagoon. The water at the top of the lagoon is clarified through the settling process. This water is either discharged to the environment through a permitted outlet or recycled back to the inlet of the filtration plant. The DE sludge is periodically removed from the lagoon with excavation equipment. This sludge is then transferred to a landfill for disposal.

Rotary drum filters are used in a very limited number of drinking water treatment sludge dewatering applications, typically in areas with limited space that do not allow for adequate lagoon operation. The rotary drum filter systems require bulking additives. This is a fiber pre-coat such as diatomaceous earth (DE) or fiber supplement to the filter feed material. This promotes the formation of a thick mat on the filter surface, which is required to achieve adequate filtrate clarity. The use of this bulking agent requires considerable pumping horsepower. In addition, rotary filters require constant consumption of equipment operating horsepower for drive motors and, in many cases, vacuum pumps. Based upon manufacturers’ data, these horsepower loadings are in the range of 25 to 150 HP, depending upon the size and the style of the system.

Dissolved air flotation sludge thickeners (DAFs) are used in many small to medium-sized wastewater treatment plant sludge dewatering applications to pre thicken the sludge in advance of other down stream dewatering equipment. The DAFs require electrical energy for pumps and air compressors and drive motors. These horsepower loadings are in the range of 5 to 25 HP, depending upon the size and the style of the system. This technology represents a very small percentage of the small- to medium-sized plants in New York State. It should be noted that this technology often precedes filter press technology. However, this investigation did not use this additional energy factor in the projection of savings with "active filtration™" over filter press technology discussed in Table 7 below due to its limited application.

Energy benefits

Energy use for the "active filtration™" technologies is considerably lower than all of these conventional technologies. Both "active filtration™" technologies require a minimal quantity of compressed air for their operation. As a result, the associated energy is substantially less than many conventional systems. Pumping energy requirements for slurry delivery to all systems, including "active filtration™," are comparable. The significant energy savings with the "active filtration™" technology are due to the absence of the significant electric power requirements associated with belt drive, drum drive, disc drive, or shower header drive motor, compressor, or centrifuge drive motors of conventional technologies.

As every plant has unique operational characteristics, the benefits vary from plant to plant. The "active filtration™" technology is best implemented at plants of small to medium size that require or desire improvements to their sludge management systems to improve solids concentration, reduce labor, reduce disposal costs, reduce energy, etc. These savings are outlined later in this section.

The energy consumption associated with the Squeeze Tower Press and the DryBox experienced during this demonstration project confirms the results from extensive full-scale pilot tests conducted under previous NYSERDA programs wherein the energy use for the Squeeze Tower Press and the DryBox technologies have been well documented. The energy consumption was observed to be the same as documented in the prior programs.

1. The Squeeze Tower Press used approximately 4 CFM of compressed air at 100 psig for approximately 20 minutes per hour and approximately 8 to 15 CFM for approximately 20 minutes every four to five hours for the treatment of one ton per day of sludge at 25% to 30% moisture. This is approximately equivalent to 11 kWh per day per dry ton.

2. The DryBox used approximately one to two CFM for approximately five to ten minutes per hour for the treatment of 15 tons per day of sludge at 18% to 23% moisture. This is approximately equivalent to 0.1 kWh per day per dry ton. A detailed calculation of the energy consumption for the “active filtration™” technology is provided in Appendix A.

The energy savings over existing technologies are outlined in Table 5 below. The savings are based upon a 10% market penetration.

Table 5. "active filtration™" Technology Energy Benefits Over Existing Technologies

Technology	Average kWh per ton of sludge (dry basis)*	kWh saved per OD ton of sludge w/ Squeeze Tower Press	kWh saved per OD ton of sludge w/ DryBox**	kWh saved per year Squeeze Tower Press market penetration	kWh saved per year DryBox market penetration	Only assumes NYS @ 10% Market Penetration
Squeeze Tower Press	11	----------	----------	----------	----------	
DryBox	0.1	----------	----------	----------	----------	
Belt Presses	33.6	22	33.5	558,800	850,900	79% of 155 targeted sites in New York State (122) use Belt presses so 10% of 122 sites is 12 sites.
		A 65% Reduction	A 99% Reduction			
Centrifuge	171***	160	171	This technology does not currently have well established use in the small to medium sized WWTP market.		
		A 93.5% Reduction	A 99% Reduction			
Vacuum Drum, Coil, etc. Filters	56.0	45	56	Through the investigations conducted as part of this project it was determined that this market is extremely small, only 8% of the total installed wastewater sludge dewatering equipment in New York State. 10% market penetration would represent only one site state wide so detailed investigations were omitted under this project.		
		An 80% Reduction	A 99% Reduction			
Plate & Frame Filter Presses	11	0	11	0 ****	279,400	**** No Energy Savings with Squeeze Tower Press. Benefit is significant reduction in labor.
		No Reduction	A 99% Reduction			

This chart assumes 5.8[2] tons per day of sludge => 25,400 tons per year (TPY).
* kWh per ton values for conventional technologies are taken from historical data.
** DryBox is typically most suitable for Primary Sludge or sludge not intended for land fill disposal.
*** "The Proceedings of the Management of Water and Wastewater Solids for the 21st Century June 19-22, 1994" published by the Water Environment Federation, U.S.A. (article by Mr. Chuzo Nishizaki)

Environmental benefits

One of the significant environmental benefits available from the use of the "active filtration™" technology to replace conventional technologies would be the reduction in the mass of sludge requiring transportation and disposal at landfills. The Squeeze Tower Press provides sludge solids equal to and higher than the competing technologies as shown herein. This data is based upon results of numerous wastewater treatment applications throughout Europe and confirmed through the data from this demonstration project. In all cases, due to the design of the membrane used for the filtration/dewatering, the volume of chemicals

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[2] The value of 5.8 tons per day is based upon the average sludge mass produced per day per unit of water treated at the Oneida site. This value was extrapolated over the average volume treated per day within the target market of small to medium sized wastewater treatment plants listed in the "Descriptive Data of Wastewater Treatment Plants in New York State," dated 2004.

used with the “active filtration™” has consistently been equal to or less than the conventional technologies. While it is well quantified based upon the sludges treated throughout Europe, this project has demonstrated this benefit, along with the other benefits, for the U.S. market.

The DryBox and Squeeze Tower Press technology produces sludge with average solids concentrations of 20% (on Primary Sludge only) for the DryBox and 21.5% (for all sludge) for the Squeeze Tower Press. If we compare the Squeeze Tower Press to the typical belt filter press there is at least a 10% reduction in the mass and volume of solids going to the landfill. Note that this does not reduce the actual dry matter going to the landfill.

There are approximately 122 small-to-medium-sized WWTPs in NYS using belt press technology with a total estimated sludge volume of 5.8 tons per day, or 258,000 tons per year. If there is a 10% market penetration for this technology into this market, it would provide for the dewatering of up to 25,800 tons per year. With the expected performance of the Squeeze Tower Press, this will represent a minimum reduction in the transportation and land filling of approximately 3,400 tons of sludge per mass year. The actual mass of dry material would not be reduced, but the mass of trucked material would be reduced, while providing a measurable savings. This is demonstrated in Table 6 below.

Table 6. “active filtration™” Technology Disposal Benefits Over Belt Press Technology*

	DryBox – 20% Solids in Sludge			Squeeze Tower Press - 22% Solids in Sludge		
Belt Press Average % Solids	% Higher Solids In Sludge	WET Tons reduced/year @ 10% market penetration	Potential Disposal Cost Savings**	% Higher Solids In Sludge	WET Tons reduced/year @ 10% market penetration	Potential Disposal Cost Savings**
19%	5.2%	1,360	$68,000	13.1%	3,400	$170,000

*Only the Belt Press was used for this comparison as the belt press is the primary municipal wastewater sludge dewatering equipment for the target market across New York State.

**Assumes $50/Ton for Sludge disposal cost

In the case of the dewatering of drinking water treatment sludge, the Squeeze Tower Press and the DryBox can provide dewatering without the additional cost of purchase for diatomaceous earth (DE). In addition, the DE is hydroscopic (absorbs water). Therefore, the addition of one ton of DE to a sludge slurry prior to dewatering results in the addition of two to three additional tons of DE requiring transportation and disposal. In this case, there is the potential for the reduction of up to 75% of the volume and mass of sludge going to the landfill. In addition, use of the DryBox for DE dewatering eliminates the cost of the diesel engine emissions from and the interruptions associated with excavation of the spent DE from the lagoon, along with the transfer of the sloppy sludge to a transfer truck. The dewatering takes place in the DryBox, which is the transportation container. The dewatered sludge leaves the site with no free water in a water tight container.

Due to the Patriot Act, there are now very stringent limitations on access to government files relating to the equipment used in drinking water treatment plants. However, empirical data were secured through interviews with the marketing director of a major supplier of diatomaceous earth. His experience is that nearly all of the plants in New York State are using the lagoon sedimentation method, and there are no known municipal sites using DE vacuum drum filters for drinking water filtration. The DE vacuum Drum technology typically is limited to industrial process applications. Therefore, there is no electric energy savings achievable in the municipal market.

Current methods for disposal, discussed earlier in this report (section 2, page 2-10), require significant use of diesel-powered equipment. Based upon market information from the DE industry, New York State drinking water treatment plant operators use approximately 200 tons of DE per year on a dry basis. When this DE is used, it adsorbs more than twice its weight in water, which brings the total disposal volume to at least 600 tons per year. This spent DE is hauled in a damp condition or as a slurry to its destination. The DryBox can consistently achieve 35% solids concentration with the spent DE. This is a reduction in the disposal mass and volume in the range of 29% to over 85% dependant upon the method of disposal practiced by the individual site. A 10% market penetration into this market would result in the reduction of the hauling for disposal of between 23 and 298 tons per year on a wet basis. The calculations demonstrating these volume reductions are provided in Appendix A.

A significant and genuine environmental benefit of using the “active filtration™” technology is the mitigation of the risk of DE entering the environment due to upsets in the operation of the DE backwash lagoons or holding tanks, which have outlets to the environment. There are documented cases where the lagoon may be inadequately sized or overloaded due to any number of issues. The DE and other particulate matter is not allowed sufficient time to settle out of the backwash, and the water exiting the lagoon to the adjacent stream or watersheds contains high levels of this DE or other particulate matter. As an alternative to construction of larger lagoons, the “active filtration™” technology would be used to capture the backwash prior to or in lieu of the lagoon. The clarity of the filtrate from the “active filtration™” equipment would be very high and would be suitable for returning to the inlet of the filtration plant or for discharging to the lagoon. The DE would be in a dewatered condition suitable for the current method of disposal. In addition, the DE would be dewatered to a higher solids concentration than the current method of removal of the damp material from the lagoon by mechanical means.

Another environmental benefit associated with this technology is a reduction of truck emissions and fuel consumption resulting from the reduction of tonnages of sludge that must be shipped to landfills. Based upon U.S. DOT Federal Highway Administration Estimation of Future Truck Emissions, for the average truck traveling 50 miles, the estimated reduction in emissions per 100 truckloads is shown in Figure 7. The calculations demonstrating these pollutant reductions are provided in Appendix A.

Table 7. Sludge Disposal Truck Annual Emissions per 100 Truckloads

Pollutant	**Pounds Per Year**
VOC	4.8
CO	21.4
NOx	98
PM-10	2

The use of the "active filtration™" Squeeze Tower Press at 10% of the small to medium-sized WWTPs will result in an associated 12,900 tons reduction in sludge being transported to the land fills. At an average of 15 tons per truckload, this would represent 226 truckloads per year.

Based upon a these volumes, the estimate of reduced emissions across New York State is represented in the following table.

Table 8. Potential Reduction in Annual Disposal Truck Emissions

Pollutant	**Pounds Per Year**
VOC	11
CO	49
NOx	222
PM-10	4.5

Economic benefits:

There are two primary economic benefits associated with the "active filtration™" technology as compared to specific conventional technologies.

As discussed above, there are significant savings in the volume of land filled sludge for WWTPs using the belt filter press technology and for drinking water treatment plants using vacuum drum filter technology for treatment of their drinking water treatment sludge. This represents a financial savings of approximately $40 for each ton of sludge land filled. Also as discussed above, there are electrical energy savings associated with the lower power consumption of the "active filtration™" technology.

The following chart depicts the economic benefits associated with these reductions. There is an assumption of a 10% market penetration over the next five to ten years.

Table 9. Potential Reduction in Annual Energy Consumption with "active filtration™" Technology versus Belt Filter Press*

Estimated Energy Usage Change (kWh) with Squeeze Tower Press	Estimated Energy Usage Change (kWh) with DryBox	Estimated Annual Energy Savings with Squeeze Tower Press ($) @ 8 ¢/kWh	Estimated Annual Energy Savings with DryBox ($) @ 8 ¢/kWh
558,800	850,900	$44,704	$68,072

*Table assumes a total treated sludge volume of 25,400 tons per year (TPY) based on 10% market penetration.

The DryBox equipment requires no infrastructure. Handling and installation costs are negligible. In fact, system handling is limited to filter cloth replacement. Installation does not entail any infrastructure; the operation of the DryBox can be carried out on any reasonably level area that is convenient to the user.

The DryBox typically is available on a contract per gallon treated basis. Due to the completely mobile nature of the DryBox, it is delivered, filled, dewatered in place, and hauled away to the disposal site. This technology is, therefore, available with no capital nor infrastructure requirements on the part of the operator other than a transfer pump for the sludge.

In place of drying bed technologies that are used in numerous very small municipal WWTPs the DryBox does not provide an energy savings. However, it does eliminate employee exposure to the dewater sludge that results from loading of dumpsters within the drying bed structure with a front end loader.

Similarly, the Squeeze Tower Press, in place of a standalone plate and frame filter press, does not provide an energy savings. However, it eliminates essentially all labor and employee exposure to the sludge associated with emptying and cleaning of the press. In addition, in cases where the Plate & Frame is supported by a DAF unit for pre thickening, the DAF unit consumes from 45 to 55 kWh per ton of OD sludge more than the "active filtration™" technology.

Results of the demonstration project and historical installation cost data from European installation reveal an estimate of capital and operating costs and the overall economic benefits to a typical WWTP. The installation requirement for a Dry Box System is the provision of a flat, durable surface with freeze protection, which renders infrastructure costs minimal. The Squeeze Tower Press has a slightly higher, although modest, infrastructure requirement in that the space must be high bay and freeze protected. Typically, the units are positioned on steel frames above a rolloff container.

Preliminary estimates indicate a capital cost for a typical 2.5 million gallon per day wastewater treatment plant to implement DryBox technology would cost less than $100,000 in total. A similarly sized Squeeze Tower Press installation would cost between $275,000 to $320,000. A comparison of the relative costs and the cost benefits of the "active filtration™" technologies over conventional technologies has been prepared. Savings are based upon the above referenced estimated savings in energy cost, disposal costs, and potential labor savings.

Table 10. Potential Rough Order of Magnitude Return on Investment with "active filtration™" Technology*

Technology/ Process Used for Comparison	Estimated ROM Total Installed Cost -	Estimated Annual Energy & Disposal Savings with Squeeze Tower Press ($)	Estimated Annual Energy & Disposal Savings with DryBox ($)	Estimated Annual Labor Savings **	Capital Savings w/ Squeeze Tower Press	Operating Savings w/ Squeeze Tower Press	Capital Savings w/ DryBox	Operating Savings w/ DryBox
Belt Filter Press for	$422,000	$11,100	$17,600	$40,000	$122,000	$51,100	$322,000	$57,700
Centrifuge	$676,000	$325,000	$292,000	$0	$376,000	$325,000	$576,000	$292,000
Plate and Frame Filter Press	$325,000	$0	-$33,000	$40,000	$25,000	$40,000	$225,000	$7,000
Squeeze Tower Press ROM Installed Cost - $300,000								
DryBox ROM Installed Cost - $100,000 – Typically For Primary Sludges or sludge not intended for landfill disposal								

This Table is based upon the avoided power consumption shown in Table 2 above.
*Assumes 2.55 Million GPD of Influent Water which would be projected to generate approximately 5.8 Tons per Day of Dewatered Sludge
** Assumes Labor Savings of One Employee per Year

From the data provided in Tables 6, 9, and 10, a presentation for the Net Present Value comparison of the technologies has been developed. This comparison is provided in Table 11 below.

Table 11. Net Present Value of Sludge Dewatering Technologies

Technology	15 Year Net Present Value
	Assumes 10% Discount Rate
DryBox	$875,086.25
Squeeze Tower Press	$709,458.00
Belt Filter Press	$1,362,225.42
Centrifuge	$1,234,469.25
Plate and Frame Filter Press	$1,134,492.77

The realization of the financial benefits associated with the "active filtration™" technologies is subject to a number of factors. These include:

1. The equipment and installation costs for any site are extremely site specific. The ROM (Rough Order of Magnitude) estimated values here are based upon estimated equipment costs for the various technologies provided by equipment suppliers of those technologies coupled with industry-accepted factors for installation. These ROM estimates are assuming installation of similar equipment on existing infrastructure as an upgrade replacement.
2. The reduction in labor costs associated with the belt press and the plate-and-frame filter press are based upon observation of actual production applications. Actual staff reductions may be impacted by administrative and peripheral issues not specific to the operation of the dewatering equipment.
3. Savings are based upon the difference in the installed cost of the listed technology compared to the "active filtration™." This assumes that the project is an upgrade replacement.
4. Disposal savings for the DryBox compared to a plate-and-frame filter press and the centrifuge are negative. The DryBox has an electrical energy savings, but the plate-and-frame press and the centrifuge achieve much higher solids than the DryBox (30% versus 25%). The overall savings are provided by the labor savings. The DryBox is limited to applications with primary sludge or to applications, such as landfills, that do not require 20% dry solids for disposal, such as land spreading for agricultural benefit.

4. BASELINE PROCESS DESCRIPTION

Process description

The process design for a typical WWTP or Drinking water Filtration Plant is essentially the same as the configuration currently in use with conventional technologies. The sludge would be collected in an equalization tank. The tank may be used for preliminary chemical additions for sludge stabilization, coagulation, etc. From the sludge tank, the slurry would be pumped to the DryBox or Squeeze Tower Press. The final flocculent would be added in the delivery line to the DryBox or Squeeze Tower Press. As an alternate, the equalization tank may feed to or be used as a flocculation tank with the flocculent being added directly to this tank. In this scenario the treated slurry would be pumped to the DryBox or Squeeze Tower Press with a peristaltic pump or lobe-style positive displacement pump. This alternate pumping technology would be required to minimize the pumping shear forces on the slurry, thereby ensuring stability of the flocs as they enter the DryBox or Squeeze Tower Press, as would be required with any conventional dewatering technology. A simple schematic of a baseline process is provided below.

Figure 7. Baseline Sludge Treatment Process Using a DryBox

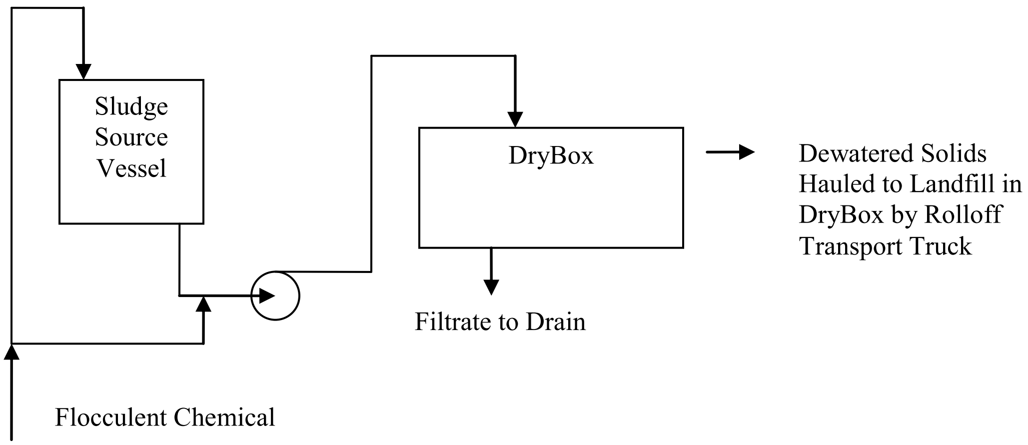
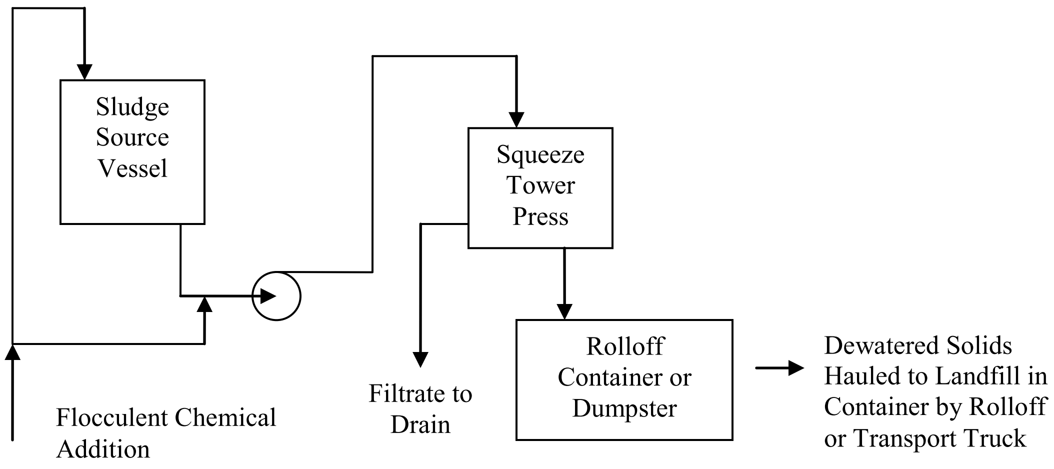


Figure 8. Baseline Sludge Treatment Process Using a Squeeze Tower Press



APENDIX A
DATA AND CALCULATIONS

Table A-1

Energy Consumption Calculations

for the “active filtration™” Technology and Conventional Technologies

Calculation of Energy use for SqueezeTower Press and DryBox

SqeezeTower Press

Per 1 ton @ 25 – 30% moisture

4 cfm @ 100 psig for 20 minutes/hour approx = 1.33 cfm average

+ 8 – 15 cfm for 20 minutes every 4 – 5 hours = 0.53 – 1.25 cfm average

Total = 1.86 – 2.58 cfm average

Assume a typical 200 – 300 cfm compressor uses 20 hp/100 cfm

Compressor load = 1.86 x 0.2 to 2.58 x 0.2 hp
= 0.372 to 0.516 hp
= 0.277 to 0.385 kW

Assume Motor Efficiency = 80%

Compressor energy use = 8.3 to 11.5 kWh/day per ton

DryBox

Per 15 ton/day @ 18 – 23% moisture

1 - 2 cfm @ 100 psig for 5 - 10 minutes/hour approx = 0.08 – 0.33 cfm average

Total = 0.08 – 0.33 cfm average

Assume a typical 200 – 300 cfm compressor uses 20 hp/100 cfm

Compressor load = 0.08 x 0.2 to 0.33 x 0.2 hp
= 0.016 to 0.066 hp
= 0.012 to 0.049 kW

Assume Motor Efficiency = 80%

Compressor energy use = 0.4 to 1.5 kWh/day

Compressor energy use = 0.027 to 0.10 kWh/day/ton

DE Sludge Mass Disposal Reduction with “active filtration™” Technology

Slurry Disposal

The DE in the slurry tank is typically at a solids concentration of 5% to 10%. Thickening argents such as vermiculite are added to raise the solids concentration to at least 25% to ensure there is no free water. The resultant mass of solids being sent to the land fill in a typical 2500 gallon vacuum truck after solidification would consist of approximately 1,500 pounds of DE on a dry basis, 4,900 pounds of vermiculite or other similar material on a dry basis, and approximately 19,000 pounds of water. This total mass of approximately 13 tons would be disposed of at the landfill at a ROM cost of $50 per ton plus approximately $1,000 for the trucking cost and $500 for solidification. The total disposal cost would be in the range of $1,950. This equates to approximately $2500 per ton of DE on a dry basis. Pricing is based upon ROM estimates provided by licensed waste management contractors.

Damp Cake Disposal

Based upon visual observations the resultant mass of spent DE has a percent solids content in the range of 25%. The resultant mass of solids being sent to the land fill in a typical 15 ton disposal truck would consist of approximately 6,500 pounds of DE on a dry basis and approximately 23,500 pounds of water. This total mass of approximately 15 tons would be disposed of at the landfill at a ROM cost of $50 per ton plus approximately $950 for loading and handling and approximately $200 for the trucking cost. The total disposal cost would be in the range of $1,900. This equates to approximately $500 per ton of DE on a dry basis. Pricing is based upon ROM estimates provided by licensed waste haulers.

Table A-2

DE Sludge Mass Disposal Reduction with “active filtration™” technology

	Dry #s DE	Dry Tons DE	Initial % Solids	Total pounds of Waste	Total Gallons of Slurry	Target Moisture Content	Total Final Mass in #	Mass Adsorptant to Add	Total Tons for Disposal	Dry Ton DE per Ton disposed	Total Disposal Trucks Req'd*	Total Tons for Disposal	Reduc in Dispo Tonna
Slurry in 2500 Gallon Vacuum Tuck	1550	0.77	7.50%	20667	2478	25%	27556	6889	13.8	0.056	258	3556	298
Damp Cake in 15 Ton Container	7500	3.75	25%	30000	N/A	25%	30000	N/A	15.0	0.250	53	800	229
Dewaterd DE in 15 Ton DryBox	1050 0	5.25	35%	30000	N/A	35%	30000	N/A	15.0	0.350	38	571	N/A

* Assumes 200 Tons Dry Basis of DE consumed per year requiring disposal

Table A-3
Sludge Transport Pollution Reductions associated with "active filtration™" technology

Pollutant	U.S. DOT Estimate*	Estimated Miles Per Trip	Number of Trips eliminated	Total pollutants avoided**
VOC	0.00096	50	100	4.8
CO	0.00428	50	100	21.4
NOx	0.0196	50	100	98
PM-10	0.0004	50	100	2

* U.S. DOT Federal Highway Administration Estimation of Future Truck Emissions

** Avoided Pounds of Pollutant per 100 truckloads not required due the potential implementation of the "active filtration™" technology

Table A - 4 Raw Data

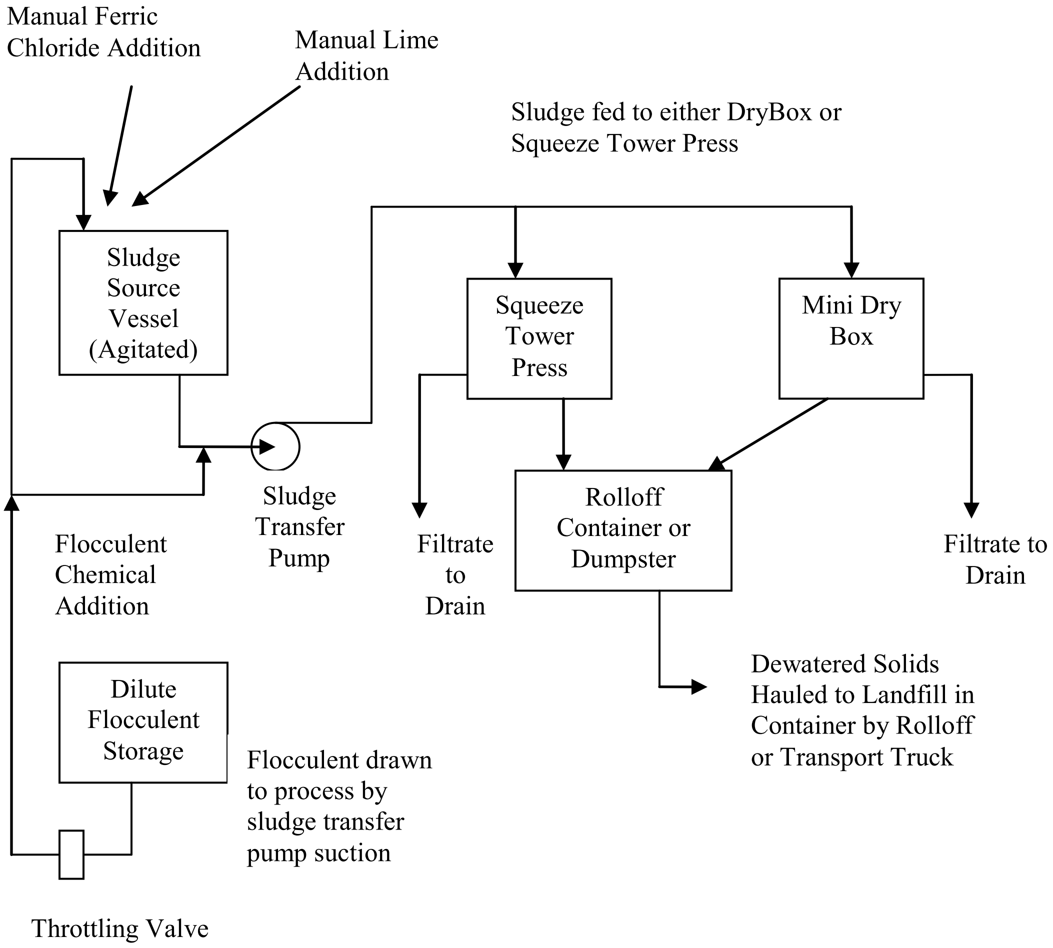
Date	Site	Equipment	Sludge Source	Solids Conc.	FeCl Conc	Poly AlCl3 (PPM)	Lime Conc	Cationic Polymer (PPM)	Anionic Polymer (PPM)	Effluent Clarity	Dewatered Solids % Conc 24 Hr	Free Water	Dewatered Solids % Conc Longer	
	WWTP Sludge													
4/5/2006	Walworth	DryBox												run scra from slu
4/7/2006	Walworth	DryBox	Primary	0.50%	0%	0	0%	37.5	0	Good	11.90%	No		
4/9/2006	Walworth	DryBox	Primary	0.50%	0%	330	0%	0	100	Good	13.40%	No		
4/10/2006	Walworth	DryBox	Primary	0.50%	0%	0	0%	0	100	Good	10.60%	No	13.70%	
4/17/2006	Walworth	DryBox	Primary	0.50%	0%	330	0.38%	0	100	Slow	7.70%	No	9.10%	
4/24/2006	Walworth	DryBox	From DAF	2.50%	0.50%	0	0%	0	~100					Run Scr fabric bl
4/27/2006	Walworth	DryBox	From DAF	2.50%	0.50%	0	0%	0	~100		13.40%	No		
5/14/2006	Walworth	STP	Primary	0.75%	0.25%	0	0%	0	100					Hose Br paste
5/15/2006	Walworth	STP	Primary	0.75%	0.25%	0	0%	0	100		12.80%	No		
5/16/2006	Walworth	STP	Primary	0.60%	0.25%	0	0%	50	0		19.30%	No	13.50%	Partial D Some Le of 13.5%
5/17/2006	Walworth	STP	Primary	0.60%	0%	0	0%	50	0		10.80%	No		
7/17/2006	Oneida	DryBox	Primary	2.17%	0%	0	0.63%	220	0	Good	19.0%	No		1st Batc
7/18/2006	Oneida	DryBox	Primary	2.17%	0%	0	0.63%	220	0	Good	20.2%	No		
7/24/2006	Oneida	DryBox	Digested	3.67%	0.83%	0	0.71%	0	147	Good	18.0%	No		
7/26/2006	Oneida	DryBox	Digested	3.67%	0.83%	0	0.71%	0	147	Good	19.0%	No		
7/31/2006	Oneida	DryBox	Digested	3.08%	0%	0	0.71%	220	0	Good	17.8%	No		
8/1/2006	Oneida	DryBox	Primary	3.44%	1%	0	0.71%	220	0	Crystal	21.0%	No		
8/3/2006	Oneida	DryBox	Secondary	2.38%	1%	0	0.71%	440	0	Good	9.3%	No		
8/4/2006	Oneida	DryBox	Secondary	2.38%	1%	0	0.71%	440	0	Good	9.9%	No		
8/6/2006	Oneida	DryBox	Secondary	2.38%	1%	0	0.71%	440	0	Good	11.0%	No		
8/15/2006	Oneida	DryBox	Secondary	1.15%	1%	0	0.71%	440	0	Good	9.6%	No		
8/16/2006	Oneida	DryBox	Secondary	1.15%	1%	0	0.71%	440	0	Good	10.0%	No		
8/17/2006	Oneida	DryBox	Secondary	1.58%	1%	0	0.00%	0	50	Good	12.3%	No		
8/20/2006	Oneida	DryBox	Secondary	1.58%	1%	0	0.00%	0	50	Good	11.9%	No		
9/15/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	530	0	Good	13.80%	No		1st Batc
9/16/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	530	0	Good	20.4%	No		
9/17/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	530	0	Good	21.0%	No		
9/20/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	212	0	Good	23.0%	No		
9/21/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	371	0	Good	23.0%	No		
9/22/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	371	0	Good	19.5%	No		Problem
9/27/2008	Oneida	STP	Digested	~3%	0.50%	0	0.00%	371	0	Good	19.5%	No		Problem
9/29/2008	Oneida	STP	Secondary	0.91%	0.50%	0	0.00%	371	0	Fair	12.2%	No		Problem
10/25/2006	Oneida	STP	Secondary	0.90%	0.50%	0	0.63%	0	716	Good	20.0%	No		
10/27/2006	Oneida	STP	Secondary	0.90%	0.50%	0	0.63%	0	716	Good	18.3%	No		Problem
10/30/2006	Oneida	STP	Secondary	0.90%	0.50%	0	0.63%	0	716	Good	17.9%	No		Problem
10/31/2006	Oneida	STP	Secondary	0.90%	0.50%	0	0.63%	0	716	Good	20.5%	No		
10/31/2006	Oneida	STP	Secondary	0.90%	0.50%	0	0.63%	0	716	Good	22.0%	No		
11/13/2006	Oneida	STP	Primary	2.97%	0.50%	0	0.63%	0	254	Good	32.6%	No		Average cake. H

Table A - 4 Raw Data

Date	Site	Equipment	Sludge Source	Solids Conc.	FeCl Conc	Poly AlCl3 (PPM)	Lime Conc	Cationic Polymer (PPM)	Anionic Polymer (PPM)	Effluent Clarity	Dewatered Solids % Conc 24 Hr	Free Water	Dewatered Solids % Conc Longer	
	Drinking water DE Sludge													
3/31/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	34.50%	No		Polymer concentr associat concentr
3/31/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	32.70%	No		
4/11/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	33.30%	No		
4/11/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	33.80%	No		
4/12/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	35.40%	No		
4/12/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	38.10%	No		
4/12/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	33.80%	No		
4/14/2007	Wilton	DryBox	Spent DE	~ 5%				~250		Good	34.20%	No		

APENDIX B
PILOT SYSTEM SCEHMATIC

Figure B-1
Pilot System Schematic



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ENERGY EFFICIENT SLUDGE MANAGEMENT EVALUATION FOR REDUCED ENERGY CONSUMPTION

FINAL REPORT 08-18

STATE OF NEW YORK
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NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY
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