



# Development of a Biosolids Management Strategy for U.S. Forces, Korea Installations

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Currently, wastewater sludge for the U.S. Forces, Korea (USFK) and the Eighth U.S. Army (EUSA) is disposed at landfills by Korean contractors. In the United States, CFR 40, Part 503 regulations encourage the beneficial use of biosolids. However, beneficial use of sludge is not practiced in Korea. This report discusses the different regulatory frameworks in the United States and Korea, the current status of USFK/EUSA sludge management at four Directorates of Public Works (DPWs) and improved sludge management systems. Technical alternatives for improving sludge management include mobile mechanical dewatering, alkaline stabilization, composting, reed bed use, and autothermal thermophilic aerobic digestion (ATAD). Technologies were chosen for review based on their ability to

comply with U.S. and Korean regulations and to achieve long-term improvement, and their availability in Korea. The study recommended:

1. Use of mobile mechanical dewatering followed by either aerated static pile composting, windrow composting or alkaline stabilization for the Western Corridor DPW
2. Discontinuation of the current secondary treatment at the Yongsan DPW
3. Conversion of the Camp Humphreys' current sand-drying beds to reed beds
4. Establishment of a long term goal to convert Camp Casey's aerobic digester to ATAD and using the biosolids as a soil supplement at Camp Casey.

## Foreword

This study was performed for the United States Forces, Korea (USFK) and the Eighth United States Army (EUSA). Environmental Program Office, under MIPR 7-017, Work Unit V17, "USFK/EUSA Sludge (Biosolids) Management Study." The technical monitors were Ernest P. Eddy and Munkyu Park, HQ, USFK/EUSA, Assistant Chief of Staff Engineer, Environmental Program Office, Unit #15237, APO 96205-0010.

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# 1 Introduction

## Background

Effective sludge management can be a difficult and expensive task for wastewater treatment plant (WWTP) operators. As sludge regulations become more stringent and more landfills are closed down, many WWTPs are consequently forced to develop new and more effective residual management plans. Solids residual management is a global environmental problem. While it may appear that each nation takes a different approach for residual management, in reality, individual WWTPs have unique combinations of environmental conditions and regulatory requirements. The best solution for solids residual problems may vary by location and by individual WWTP. Key factors affecting the success of good residual management for a WWTP include, but are not limited to:

- the regulatory framework and attitude of government
- available technologies and “know-how”
- economical feasibility and available resources
- public awareness and acceptance.

The U.S. Forces, Korea (USFK) and Eighth United States Army (EUSA) installations have been proactive in environmental protection within the Republic of Korea. In Korea, all host country WWTP's sludge is landfilled. Currently, USFK/EUSA spend about \$1 million a year for contracted sludge disposal. Korean sludge contractors transport sludge to local WWTPs for further thickening, stabilization, and disposal at landfills. One of USFK/EUSA Environmental Program Office initiatives is to develop a sludge management strategy for USFK/EUSA's wastewater treatment plants.

## Objectives

The objectives of this study were:

1. To compile and analyze design and operational data of the 10 USFK/EUSA WWTPs operated by the Western Corridor Directorate of Public Works (DPW), the Yongsan DPW, the Camp Humphreys DPW, and the Camp Casey DPW.
2. To identify and evaluate technical alternatives for beneficial use of sludge and improved sludge management at USFK/EUSA WWTPs.
3. To recommend a sludge management program in which: (a) the technology can comply with Korean environmental regulations as well as U.S. regulations, (b) the system is cost effective and could be implemented with a 5-year return on investment, and (c) the technology is readily available or accessible to USFK/EUSA.

## Approach

1. An extensive literature search was performed to review technologies available for dewatering and/or ultimate use and disposal of WWTP biosolids. Appropriate vendors of the feasible technologies were contacted.
2. U.S. WWTPs that operate compost facilities of similar size to USFK/EUSA's needs were contacted and interviewed.
3. The USFK/EUSA WWTPs discussed in this report were visited by an author to review the unit operations that generate, treat, and affect the beneficial use of sludge as well as available space and equipment that would affect decisions on implementation of sludge management systems.
4. Preliminary cost information from vendors and existing facilities was compiled and compared.

## Scope

Since the technology implementation must meet both Korean and U.S. regulations, this study's recommendations pertain specifically to U.S. Forces, Korea installations. However, USFK sludge generation volume is extremely small in comparison with the volume generated in Korea. It is hoped that the

implementation of improved USFK/EUSA sludge management systems, designed to meet both U.S. and Korean requirements, may provide a constructive model for improved sludge management in Korea and for closer cooperation between the Korean Government and U.S. Forces, Korea.

### **Mode of Technology Transfer**

It is anticipated that the USFK/EUSA will implement the technologies presented in this report at such a time when sludge disposal costs have risen to a level where a 5-year return on investment is possible.

## 2 Regulatory Framework

### United States Environmental Regulations

Although manure and sludge have long been used as agricultural fertilizer, the scientific evaluation of sludge use is relatively recent. Rudolfs (1928) determined the fertilizer value of various sludges at different wastewater treatment plants. Five decades later, the Federal Water Pollution Control Amendments of 1972 recognized land application of sludges as an alternative method for sludge disposal, and also recognized a need for land application research. In 1979, the U.S. Environmental Protection Agency (USEPA) implemented land application criteria including pH, cadmium application rates, and polychlorinated-biphenyl (PCB) concentrations. In 1984, the USEPA issued its “Policy on Municipal Sludge Management,” which actively promoted the beneficial use of sludge while maintaining and improving environmental quality and protecting public health. The “beneficial use of sludge” provides two benefits: (1) it saves landfill space while reducing liability from landfill, incineration, and ocean dumping, and (2) it improves soil properties by increasing nutrient levels while reducing the use of chemical fertilizers as soil amendments or organic fertilizers. In 1993, the USEPA adopted the most comprehensive, technically based sludge regulation to date. These regulations, known as Part 503, encourage the beneficial use of biosolids. (Note that this report uses the terms “biosolids,” “sludge,” and “residual” interchangeably.)

Residual management strategy is greatly affected by different federal, as well as State and local policies, laws, and regulations. In addition to Part 503 regulations, the Federal regulations applied to sludge use and disposal include:

- *Marine Protection, Research and Sanctuaries Act*, which bans ocean dumping of sludge.
- *Toxic Substance Control Act*, which requires sludge containing PCB to be disposed of in a hazardous waste incinerator, in a chemical waste landfill or by an USEPA approved alternative method.

- *Clean Air Act Ambient Air Quality Standards*, *New Source Performance Standards*, and *National Emissions Standards for Hazardous Air Pollutants*, which apply to the operation of sludge incinerators and dryers.
- *Resource Conservation and Recovery Act*, which considers a sludge with hazardous characteristics as hazardous waste and regulates landfill and land application.
- *Clean Water Act*, which requires the USEPA to identify all major sludge use and disposal methods. The USEPA established Part 503 regulations to meet these requirements.
- *National Environmental Policy Act*, which may require an environmental impact statement for sludge facilities that significantly affect the environment.
- *Comprehensive Environmental Response, Compensation, Liability Act and Superfund Amendments and Reauthorization Act*, which apply to clean-up of sludge containing hazardous substance, and information release to the public.

## Part 503 Overview

Title 40 of the Code of Federal Regulations, Part 503 was published on 19 February 1993 and became effective on 22 March 1993. Commonly referred as "Part 503," these regulations establish standards for beneficial land application, surface disposal, and incineration of biosolids. However, since the focus of this study is on the beneficial use of sludge, surface disposal and incineration regulations will not be discussed in this report. The requirements of Part 503 apply to generators, preparers, and appliers of sewage sludge. Land application requirements include pollutant limits, pathogen, and vector attraction reduction as well as site restrictions, management regulations, general requirements, monitoring, and recordkeeping and reporting requirements. Since Part 503 was published, many biosolids treatment processes that previously had not been used in the United States have been re-explored as technologies capable of meeting the new regulations.

Part 503 regulates the concentrations of 10 heavy metals in land applied biosolids. All biosolids must meet the ceiling concentration limits shown in Table 1 to be applied to land. In addition to the ceiling concentration limits, at least one of the other requirements, i.e., pollutant concentration limits, cumulative pollutant loading limits, or annual pollutant loading limits (Table 1) must be met. Note that the limits are on a dry weight basis. Commonly,

**Table 1. Pollutant Limits.**

Pollutant	Ceiling Concentration Limits for All Biosolids (mg/kg)	Pollutant Concentration (mg/kg)	Cumulative Pollutant Loading Rate Limits (kg/hectare)	Annual Pollutant Loading Rate Limits (kg/hectare/year)
Arsenic	75	41	41	2.0
Cadmium	85	39	39	1.9
Chromium	3,000	1,200	3,000	150
Copper	4,300	1,500	1,500	75
Lead	840	300	300	15
Mercury	57	17	17	0.85
Molybdenum	75	—	—	—
Nickel	420	420	420	21
Selenium	100	36	100	5.0
Zinc	7,500	2,800	2,800	140
Applies to	All biosolids that are land applied	Bulk biosolids and bagged biosolids	Bulk biosolids	Bagged biosolids
From Part 503 (EPA, 1994)	Table 1, Section 503.13	Table 3, Section 503.13	Table 2, Section 503.13	Table 4, Section 503.13

analysis and reporting of biosolids are mistakenly performed in incorrect units (e.g., mg/L). This is an easily avoidable error in complying with Part 503.

In addition to the heavy metal requirements, Part 503 specifies pathogen reduction levels. Biosolids are classified as either Class A or Class B according to the achieved pathogen reduction. Class A biosolids may be applied anywhere without site restrictions. Class B biosolids still contain some pathogens and site restrictions must be applied. The site restrictions ensure that Class B biosolids present no hazard to public health. Pathogen reduction should be performed prior to or concurrently with vector attraction reduction, with few exceptions.

Class A biosolids must have either a density of fecal coliform less than 1000 most probable numbers (MPN) per gram total solids or a density of *Salmonella* sp. bacteria less than 3 MPN per 4 grams of total solids. Both these densities are on a dry weight basis. In addition to meeting this requirement, Class A biosolids must meet one of the following six alternatives:

- *Alternative 1: Thermally Treated Biosolids.* Biosolids must be subjected to one of four time-temperature regimes. The regimes are based on the percentage of solids in the biosolids. Equations are used to relate the temperature and time required to treat the biosolids.
- *Alternative 2: Biosolids Treated in a High pH-High Temperature Process.* The pH must be elevated to greater than 12 for at least 72 hours while

maintaining the temperature above 52 °C for at least 12 of the 72 hours. The biosolids must be air dried to over 50 percent solids after this period.

- *Alternative 3: Biosolids Treated in Other Known Processes.* The preparer must demonstrate that the process can reduce enteric viruses and viable helminth ova. The operating conditions used in the demonstration must be maintained after the pathogen reduction demonstration is completed.
- *Alternative 4: Biosolids Treated in Unknown Processes.* This alternative applies to cases where the biosolids treatment is either unknown or operated under conditions that are less stringent than would qualify under any other Class A alternative. Under this alternative, the biosolids are analyzed for enteric viruses and viable helminth ova when being used, disposed, or prepared for sale, give away or tests to ensure that EQ requirements are met.
- *Alternative 5: Biosolids Treated in a Process To Further Reduce Pathogens.* Biosolids must be treated in one of the following Processes to Further Reduce Pathogens (PFRP): composting, heat drying, heat treatment, thermophilic aerobic digestion, beta ray irradiation, gamma ray irradiation, or pasteurization. Minimum operating requirements for each of these PFRPs are established in Appendix B of Part 503. These requirements are presented throughout this report where they apply to USFK/EUSA sludge.
- *Alternative 6: Biosolids Treated in a Process Equivalent to a PFRP.* The treatment process used must be determined to be equivalent to a PFRP by the permitting authority. The treatment process must consistently reduce pathogens to levels that compare to those achieved using one of the listed PFRPs and must be operated under conditions that do so. The permitting authority is responsible for verifying equivalency.

Class B biosolids must meet one of the following three alternatives:

- *Alternative 1: Monitoring of Indicator Organisms.* Seven samples of the treated biosolids must be collected shortly before use or disposal. The geometric mean fecal coliform density of the samples must be less than 2 million colony forming units (CFU) or less than 2 million MPN per gram biosolids. These seven samples should be collected over a 2-week period since the fecal coliform density test has poor precision and biosolids quality can vary.

- *Alternative 2: Biosolids Treated as a Process To Significantly Reduce Pathogens.* Biosolids must be treated in one of the following Processes to Significantly Reduce Pathogens (PSRP): aerobic digestion, air drying, anaerobic digestion, composting, or lime stabilization. Minimum operating requirements for each of these PFRPs are established in Appendix B of Part 503. These requirements are presented throughout this report where they apply to USFK/EUSA sludge.
- *Alternative 3: Biosolids Treated in a Process Equivalent to a PSRP.* The treatment process used must be determined to be equivalent to a PSRP by the permitting authority. The permitting authority is responsible for verifying equivalency.

Vector attraction reduction (VAR) requirements are necessary since vectors, such as flies, mosquitoes, fleas, rodents, and birds, are capable of transmitting pathogens from wastewater sludge to humans and animals. Part 503 contains 12 options for the reduction of vector attraction. Options 1 through 8 reduce the attractiveness of the sludge to vectors. Options 9 and 10 prevent vectors from coming in contact with the biosolids. Options 11 and 12 apply to surface disposal and incineration.

- *Option 1: Reduction in Volatile Solids Content.* The mass of volatile solids in the biosolids is reduced by at least 38 percent during treatment.
- *Options 2 and 3: Additional Digestion of Anaerobically Digested or Aerobically Digested Biosolids.* The preparer must demonstrate after 40 additional days in the digester at temperatures between 30 and 37 °C that the volatile solids in the biosolids are reduced by less than 17 percent during the bench test.
- *Option 4: Specific Oxygen Uptake Rate for Aerobically Digested Solids.* Adequate VAR is demonstrated when the specific oxygen uptake rate (SOUR) of the biosolids is equal to or less than 1.5 milligrams of oxygen per hour per gram of total biosolids, at 20 °C.
- *Option 5: Aerobic Processes at Greater Than 40 °C.* The biosolids must be treated aerobically for at least 14 days at an average temperature of 45 °C. The temperature must not drop below 40 °C during this time.
- *Option 6: Addition of Alkaline Material.* Adequate VAR is achieved when enough alkaline material is added to raise the pH to at least 12, at 25 °C, and maintain the pH without adding any more alkaline material. In addition, the pH must be maintained at 11.5 for an extra 22 hours without adding more alkaline material.

- *Option 7: Moisture Reduction of Biosolids Containing No Unstabilized Solids.* Water must be removed from biosolids containing no unstabilized solids to achieve a solids content of at least 75 percent.
- *Option 8: Moisture Reduction of Biosolids Containing Unstabilized Solids.* Water must be removed from biosolids containing unstabilized solids to achieve a solids content of at least 90 percent.
- *Option 9: Biosolids Injection Biosolids Are Injected Below the Ground Surface.* Class A biosolids must be injected within 8 hours after the pathogen-reducing process is complete. No biosolids may be present on the surface within 1 hour of injection.
- *Option 10: Incorporation of Biosolids into the Soil.* Biosolids are incorporated into the soil within 6 hours of application by plowing or some other means of mixing. Class A biosolids must be applied within 8 hours after the pathogen-reducing process is complete.

The heavy metal, pathogen, and vector attraction reduction requirements discussed above are used to determine which land application option is met. Four options, all of which equally protect public health through management practices, site restrictions, and general requirements, are (in order of increasing regulatory requirements) Exceptional Quality (EQ), Pollutant Concentration (PC), Cumulative Pollutant Loading Rate (CPLR), and Annual Pollutant Loading Rate (APLR).

To qualify under the EQ option, biosolids must meet the ceiling concentration and the pollutant concentration limits in Table 1, Class A pathogen requirements and one of the first eight VAR options. EQ standards are typically met through alkaline stabilization, composting, and heat drying. During land application, the following are not required: site restrictions, general requirements, management practices, and tracking of added pollutants.

To qualify under the PC option, biosolids must meet the ceiling concentration and the pollutant concentration limits in Table 1, Class B pathogen requirements, and one of the first 10 VAR options. Class A biosolids, which meet either VAR Option 9 or 10, are considered PC biosolids. PC biosolids may be land applied anywhere except lawn and home gardens. PC biosolids must meet all management requirements, and PC biosolids that only meet Class B pathogen requirements also require site restrictions.

CPLR biosolids must meet the ceiling concentration limits and the Cumulative Pollutant Loading Rates in Table 1, either Class A or Class B pathogen

requirements, and one of the first 10 VAR options. In addition, CPLR biosolids are subject to general requirements, applicable site restrictions, and management practices. CPLR biosolids may be applied in bulk. When any one or more of the CPLRs in Table 1 is reached at a site, no additional bulk solids subject to these limits may be applied.

APLR biosolids must meet the ceiling concentration limits and the Annual Pollutant Loading Rates in Table 1, Class A pathogen requirements, one of the first eight VAR options and Part 503 general requirements, applicable site restrictions and management practices. APLR biosolids may be sold or given away in labeled bags or other labeled containers. The APLR option limits the total amount of biosolids that may be applied at one site annually. When any one or more of the APLRs in Table 1 is reached at a site in a given year, no additional biosolids may be applied that year.

To ensure the requirements of Part 503 are met, all biosolids, regardless of which land application option is met, must follow frequency of monitoring, recordkeeping, and reporting requirements through sampling and analysis of biosolids. Typically, the preparer is responsible for sampling the sludge. However, the land applier, surface disposer, and incinerator of biosolids may be responsible, depending on the circumstances. When biosolids are to be land applied, they must be sampled for metals, pathogens, vector attraction reduction and nitrogen. Part 503 has a frequency of monitoring schedule for biosolids sampling (Table 2). The main purpose is to ensure that biosolids are sampled before use or disposal. Part 503 provides specific analytical methods to be used during sampling.

## **Korean Environmental Regulations**

The Korean Ministry of Environment has no specific regulations such as the United States Part 503 to encourage and regulate beneficial use of sludge. Korean environmental regulations potentially related to sludge include:

1. *Water Environment Preservation Law, Presidential Decree and Implementation Orders*, which regulates the discharge of wastewater into Korean waters and emphasizes industrial wastewater treatment.
2. *Waste Management Law, Presidential Decree and Implementation Orders*, which regulates hazardous waste generated from industrial activities.
3. *Soil Environment Preservation Law, Presidential Decree and Implementation Orders*, which regulates disposal of hazardous waste to soil environment.

The *Soil Environmental Law Implementation Order Annex 3* shows soil pollution countermeasure standards (Table 3). Table 3 also contains the Pollutant Concentration limits of Part 503 Exceptional Quality biosolids for comparison. Korean standards in Table 3 are concentrations in the environment. In comparison, the U.S. standards for pollutant concentration limits are in the biosolids. The Korean standards are very stringent, and it is unknown at this time whether USFK/EUSA will be required to meet these criteria before land application. However, it has been assumed that the Korean government will allow the U.S. Army to land apply biosolids on USFK/EUSA grounds if U.S. regulations are met.

**Table 2. Frequency of monitoring for surface disposal of biosolids (USEPA 1993).**

Biosolids Amounts (metric tons/year)	Biosolids Amount (English tons)		Frequency
	Average per day	per year	
Greater than zero but less than 290	>0 to <0.85	>0 to <320	Once per year
Equal to or greater than 290 but less than 1,500	0.85 to <4.5	320 to <1,650	Once per quarter (4 times per year)
Equal to or greater than 1,500 but less than 15,000	4.5 to <45	1,650 to <16,500	Once per 60 days (6 times per year)
Equal to or greater than 15,000	>45	>16,500	Once per month (12 times per year)
Methane gas in air			Continuously with methane monitoring device if biosolids unit is covered

**Table 3. Soil Pollution Countermeasure Standards and Part 503 Concentration Limit.**

<b>Pollutant</b>	<b>Farmland (mg/kg)</b>	<b>Industrial Area (mg/kg)</b>	<b>U.S. Part 503 Pollutant Conc. Limit (mg/kg)</b>
Cadmium	4	31	39
Copper	125	500	1,500
Arsenic	15	50	41
Mercury	10	40	17
Lead	300	1,000	300
Chromium (6+)	10	30	1,200
PCB	—	30	—
Cyanide	5	300	—
Phenol	10	50	—
Oil and grease	—	200	—

### 3 Current USFK/EUSA Sludge Management

The USFK and EUSA own and operate approximately 30 small wastewater treatment plants with design capacities ranging from 0.03 to 2.5 million gallons per day (MGD) (1 gal = 3.78 L). Of these plants, WWTPs in four DPWs are discussed below as typical examples in USFK/EUSA and are analyzed in this report.

The Western Corridor DPW operates the seven following WWTPs: (1) Camp Howze (design flow of 0.18 MGD), (2) Camp Edwards (0.09 MGD), (3) Camp Pelham (0.15 MGD), (4) Camp Giant (0.03 MGD), (5) Camp Stanton (0.10 MGD), (6) Camp Greaves (0.10 MGD), and (7) Liberty Bell (0.80 MGD). These are package WWTPs consisting of primary clarification, rotating biological contactors (RBC), secondary clarification, and aerobic sludge digestion. Digested sludge is collected by a Korean contractor and further treated at a Korean night soil plant. The night soil plant sludge is disposed at Kimpo Landfill. Approximately 1,333,488 gal of sludge is disposed annually. Currently, the Western Corridor DPW spends \$90,737 annually for removal and disposal of accumulated sewage sludge.

The Yongsan DPW operates the Yongsan WWTP, which treats wastewater produced by the industrial and residential complexes of Yongsan Main Garrison. The plant discharges into the Han River. Designed for a flow of 2.5 MGD and an influent BOD concentration of 250 mg/L, this WWTP consists of a bar screen, a grit channel, Imhoff tank, RBC, a final clarifier, a sludge storage tank and chlorine contact. Secondary sludge from the final clarifier is returned to the Imhoff tanks where the sludge is resettled and anaerobically digested with the primary sludge in the bottom of the tank. Digested sludge is collected in the storage tank and disposed by a Korean contractor. However, USFK/EUSA pays a sewer user fee for the Yongsan WWTP, and Korean regulations do not require secondary treatment of the wastewater.

The Camp Humphreys DPW operates the Camp Humphreys WWTP, which treats wastewater produced by the industrial and residential complexes of Camp Humphreys. The plant was designed for a flow of 0.5 MGD and discharges into

an enclosed lake, which receives intermittent discharge. Currently, the daily flow rate into the plant is 0.65 MGD. The plant configuration consists of an Imhoff tank, RBC, a final clarifier, sludge drying beds, and chlorine contact. After anaerobic digestion in the Imhoff tank, sludge is dried on the sludge-drying beds. The present estimate of sludge production is 350 dry kg/day. The sludge-drying beds have a total surface area of 14,480 sq ft (1345 m<sup>2</sup>). Dried sludge is removed and disposed by a Korean contractor. Currently, the Camp Humphreys' DPW spends \$19,213 annually for removal and disposal of sludge.

The Camp Casey DPW operates the Camp Casey WWTP, which treats wastewater produced by Camp Casey, a typical troop installation. Designed for a flow of 1.45 MGD, this WWTP currently handles 2.0 MGD and discharges into Casey Creek. The plant consists of three primary clarifiers, two RBC trains with six stages each, three secondary clarifiers, a dissolved air flotation thickener and an aerobic digester. Vacuum assisted drying beds are currently under construction. Sludge is collected and disposed by a Korean contractor.

## Technical Options for Improved USFK/EUSA Biosolids Management

Sludge management consists of the following major steps: thickening, stabilization, conditioning, dewatering, and beneficial use or disposal. These steps should be compatible with each other, and the overall system management should be integrated to minimize total costs. This section briefly summarizes technical options for each plant and recommends strategies to improve USFK/EUSA sludge management.

### Western Corridor

Technical options considered for the Western Corridor's WWTPs must be capable of producing higher quality biosolids, including greater solids content, than the current aerobic digesters. Aerobic digestion is listed as a *Process to Significantly Reduce Pathogens (PSRP)* in Appendix B of 40 CFR, Part 503. Using aerobic digestion as a PSRP, biosolids must be agitated with either air or oxygen to maintain aerobic conditions with the mean cell residence time and temperature between 40 days at 20 °C and 60 days at 15 °C. Since aerobic digestion is only capable of meeting Class B requirements, site restrictions would be applied. A process that could meet Class A requirements is more desirable. The option explored for the Western Corridor DPW is a mobile

mechanical dewatering system followed by either alkaline stabilization or composting.

### ***Mobile Mechanical Dewatering***

The mobile dewatering system would be designed to service all seven WWTPs in the Western Corridor with the capacity to collect from each plant two to three times per month. Such a service would include trailer-mounted equipment, provision of technicians and operators to run the dewatering device, and any required dewatering aids (e.g., polymer). Operational costs include polymer, maintenance, transportation, and power. Water must also be provided for mixing the polymer. All dewatered sludge would be transported to a single location (i.e., regional facility) where either an alkaline stabilization or a composting facility would be located.

Dewatering devices explored for this purpose include a belt filter press, a fixed-volume filter press, and solid bowl centrifuges. In a belt filter press, water is squeezed from the cake by sandwiching biosolids between two filter belts and exerting pressure using rollers. Belt filter presses are the most common dewatering choice, especially for small wastewater treatment plants, i.e., less than 5 MGD. Using a polymer, belt filter presses are capable of producing sludge cake with 16 to 35 percent solids (Black and Veatch 1995). Appendix A to this report includes further information on a belt filter press from Frontier Technology, Inc.

A fixed-volume filter press consists of a series of metal or heavy plastic plates that have filter media lining their sides. Slurry is pushed through the plates and pressure is released when the filtrate flow gets small. The plates are separated and dried cake falls off the plates. This option requires continuous operator attention since the press operates in batch and the operator may need to scrape the cake from the filter plates. (This may not be a concern if a mobile system is used since mobile system operation requires the operator to be present continuously.) The possible solids content of the final product ranges from 30 to 60 percent (Black and Veatch 1995). Appendix B provides information on a filter press from JWI.

Solid bowl centrifuges rely on centrifugal force and the density differences in liquid and solid portions of the sludge to separate them. Centrifuges are the most economical choice to install at large treatment plants, i.e., greater than 50 MGD, but are not usually economical for small treatment plants. Conventional centrifuges achieve between 15 and 25 percent solids. High-solids centrifuges

are capable of achieving between 20 and 32 percent solids, depending on the type of sludge. However, when compared to conventional centrifuges, high-solids centrifuges have a higher capital cost and use double the electricity (Black and Veatch 1995). Appendixes C and D give more information on centrifuges.

The characteristics of the sludge may be important in choosing the most appropriate dewatering option. Western Corridor needs to have its sludge tested in each option to ensure that it is possible to achieve 20 percent solids or greater. Most manufacturers perform these tests free of charge.

### ***Alkaline Stabilization***

Advanced alkaline stabilization combines lime stabilization with pasteurization to achieve Class A biosolids. During lime stabilization, quicklime is added to the sludge. The exothermic reaction of the quicklime with water raises the temperature to 50 °C, which is high enough to inactivate worm eggs, and raises the pH above 12 to kill any pathogens (Metcalf and Eddy 1991). Lime stabilization meets PSRP requirements listed in Appendix B, 40 CFR, Part 503. Advanced alkaline stabilization uses the principles of lime stabilization while also achieving pasteurization. The PFRP requirement for pasteurization is to maintain the temperature of the biosolids at 70 °C or higher for 30 minutes or longer. Most advanced alkaline stabilization processes are proprietary, and the ways in which pasteurization is accomplished differ. Chemicals may be added in addition to the lime to achieve pasteurization. These chemicals may include cement kiln dust, lime kiln dust, Portland cement, or fly ash. A high heat regime may also be used to achieve pasteurization.

Lime stabilization provides no direct reduction of organic matter. Thus, the quantity of sludge produced is not reduced as it would be in a biological stabilization process (USEPA 1979). A larger sludge volume will be a concern for the Western Corridor if the Korean government does not allow land application of sludge. Increasing the quantity of sludge by adding lime will dilute the concentration of metals in the sludge. If land application is allowed, this may be an advantage when meeting the Korean regulations for metals in soil.

Two proprietary alkaline stabilization processes were studied for the treatment of Western Corridor sludge. The first, the N-Viro process, is a patented system that can meet PFRP requirements. Technically, the process is defined as an “advanced alkaline stabilization with subsequent accelerated drying.” Two alternative methods of conducting the N-Viro process have been approved by the USEPA as PFRP equivalent processes. In the first process, alkaline materials

are added to and mixed with the sludge in sufficient quantity to achieve a pH of 12.0 or greater for at least 7 days. For example, Burnham et al. (1992) used 35 percent kiln dust and a small amount of quicklime. Following mixing, the alkaline-stabilized sludge is dried in windrows for at least 30 days and until a minimum solids concentration of at least 65 percent is achieved. In the second process, a pH greater than 12.0 is maintained for at least 72 hours while the sludge is heated to a temperature of at least 53 °C, and maintained at that temperature for at least 12 hours. The Western Corridor will windrow-stabilize biosolids rather than heat drying. Information provided by N-Viro International Corporation is in Appendix E.

CemenTech, Inc. provides a lime/high heat stabilization process, which has been approved by the USEPA as a process to produce Class A biosolids. In this process, the temperature of the sludge is raised to 70 °C for 30 minutes and the pH is raised to 12 for 2 hours and 11.5 for an additional 22 hours. In the Western Corridor's case, manual operating controls will be used due to the very small quantity of sludge produced. Normally, lime is provided to the system from a bulk material silo, but the Western Corridor does not require enough alkaline material to need a silo. Bagged lime would be used instead. Both these factors lower the cost of the system when compared to most alkaline stabilization systems. Appendix F includes more information on CemenTech.

Fresh alkaline stabilization soil has been shown to inhibit seed germination. Any or all of the following soil characteristics may be responsible: high soluble salts, free  $\text{NH}_3$ , fatty acids, and pH. Testing performed at Ohio State University show that a passive storage period of at least 6 months is required before seed germination will occur in N-Viro soil. The tests also showed that the odor of the soil changed from a cement-like smell to that of a moist field soil by the seventh month (Logan et al. 1995). Thus, curing of biosolids for at least 6 months is necessary to achieve a desirable land applicable soil.

Ammonia odors are typically encountered at alkaline stabilization facilities. The elevated pH resulting from the addition of alkaline materials causes the dissolved ammonia in the liquid to be released as a gas. Odor control systems can be chosen from simple enhanced ventilation with a single scrubber to a three-stage system, packed tower/mist scrubber/packed tower. The latter system may use sulfuric acid, sodium hypochlorite, and sodium hydroxide to neutralize and oxidize the odor-causing compounds (WEF 1995a). Alkaline stabilization does have an advantage over other sludge treatment processes that have odor problems in addition to ammonia. The pH is sufficiently high so that hydrogen sulfide odors will not be present (Lue-Hing 1992). In addition,

alkaline stabilization destroys the organisms involved in decomposition of organic matter, which otherwise would cause odor.

Operator safety is a concern with alkaline stabilization. If adequate ventilation is not provided, operators may need to wear respirators due to the ammonia vapors released. In addition, alkaline material creates a caustic dust that causes skin and eye irritation. This is of special concern if bagged lime is used.

### ***Composting***

Composting is an aerobic sludge stabilization process. The heat generated from biochemical reactions destroys pathogens, and the humus-like end product can be used as soil amendment meeting Class A requirements of Part 503 regulations. In composting, where temperatures reach the thermophilic range, practically all viral, bacterial, and parasitic pathogens are eliminated (WEF 1995a).

Historically, composting has been more of an art than a science. About 50 years ago, several mechanical composting systems were introduced in Europe. The static pile method was introduced by the U.S. Department of Agriculture in the 1970s. Many advances were made in composting based on this early work (WEF 1995b). Almost 300 WWTPs in the United States either currently use or plan to use composting for their sludge stabilization (Goldstein and Steuteville 1996).

The objectives of composting are to: (1) reduce pathogens to meet PFRP requirements in Part 503 regulations; (2) further stabilize biosolids by decomposing odor-producing compounds; (3) dry the biosolids; and (4) produce a marketable product. The major factors affecting composting processes include biosolids and amendment characteristics (solids content, carbon-to-nitrogen (C/N) ratio, particle size and shape, porosity, biodegradability, and energy content), initial mix ratios, aeration rates, temperature, and detention time (WEF 1995b).

Aeration must be provided during the composting process to satisfy the oxygen demand of organic decomposition, to remove moisture and to control the temperature. The air flow rate for forced aeration composting is governed by temperature control, which is the most critical and most easily measured of the three air functions. During the early stages of composting, the temperature of the composting mass is the critical operational parameter. As the compost matures, moisture levels decrease to a point where the need to retain moisture becomes more of a concern than temperature control. At this point, forced

aeration of the compost should be limited. Turning of compost piles can be a more effective way to control temperature. As a rule of thumb, aeration demands for temperature control should be approximately 0.2 to 0.25 standard m<sup>3</sup>/ton (WEF 1995b).

Before composting, a mix is formed with the dewatered sludge cake and a bulking agent. The bulking agent provides structural integrity, is a source of carbon, and increases porosity while also increasing the solids content. To allow adequate structural integrity along with porosity and free space, bulking the initial total solids concentration to 40 percent is recommended. The bulking agent is a combination of an organic amendment and recycled compost (Lue-Hing et al. 1992). A higher concentration of recycled compost is economical in that less amendment needs to be purchased. However, too high a recycled concentration in the bulking agent will result in reduced porosity in the mix. A wide variety of organic amendments have been used: wood chips, sawdust, shredded yard wastes, processed agricultural wastes, earthworms, and shredded tires. Lang and Jager (1993) reported that some amendments such as wood ash suppress compost odors. Reducing particle size increases surface area and thereby enhances composting rates because the optimum conditions of decomposition occur on the surfaces of organic materials. However, reducing particle size reduces the pore size, limiting the movement of oxygen required for composting. Thus, an optimum range of particle size exists, depending on the method of aeration used. Coarse amendments can be recovered in post processing, typically by screening. Benedict (1986) indicated that compost screening typically results in the recovery of 65 to 85 percent of wood chips entering the composting process.

Carbon and nitrogen, the principal nutrients in composting, affect the process speed and final volume of the compost. C/N ratios, also referred to as the biodegradable C/N, between 20 and 50 have been cited as optimum. Low C/N ratios (less than 20) result in a loss of excess nitrogen from ammonia volatilization (Haug 1993). In severe cases of nitrogen deficiency, the addition of urea or other nitrogen sources may be required (Kulhman 1990). High C/N ratios (greater than 80) result in a slowing of decomposition rate and subsequent reduction of composting temperatures (WEF 1990). Municipal sludges generally contain adequate nutrients to support composting (Haug 1993).

Composting is performed in two phases, a high rate phase followed by a curing phase. The high rate phase has higher oxygen transfer rates, higher (thermophilic) temperatures, higher biodegradable volatile solids reductions, and higher odor potential than the curing phase. The curing phase is less

controlled and often has fewer design considerations. However, it is equally as important as the high rate phase (Haug 1993). If space is limiting, the bulking agent may be screened from the compost before curing.

The most common types of composting processes used are the in-vessel process, the windrow process, and the aerated static pile process. In-vessel composting processes are proprietary while aerated static pile and windrow composting processes have to be designed by an engineer. Usually, while any of the three processes may be used for the high rate composting phase, the curing phase is either static pile or windrow (Haug 1993).

In the in-vessel composting process, the mixture is fed into one end of a silo, tunnel, or open channel and moved continuously toward the discharge end where it is outloaded after the required detention time. The mixture may move as an undisturbed plug, or be periodically agitated as it is moved through the vessel. Air is forced through the mixture. A retention time of 21 days followed by 30 days of curing is needed. Appendix G gives further information on an in-vessel composting process from Davis Industries.

In the windrow process, the mixture is stacked in trapezoidal windrows with sufficient ratio of surface area to volume to provide aeration by natural convection and diffusion. The windrow is remixed periodically by a mechanical aerator, such as an auger, to further aerate. Smaller facilities may use the same front end loader that is used to build the windrows to turn them. Using a front end loader to turn the windrows allows the operator to pile the windrow higher than mechanical aerators allow. This will reduce the required land area (Roberts 1997). This would be a more cost effective option for the Western Corridor than buying a large and expensive turning machine. Appendix H contains information on a compost turner from Resource Recovery Systems. The amendments are typically of a smaller particle size than with aerated static pile and may include recirculated compost. The active windrow composting period is around 30 days. In the aerated windrow process, the natural convection and diffusion provided in the windrow process are supplemented by forced aeration. Air is supplied through trenches in the paved working surface.

Presently, 43 percent of the composting facilities in the United States use aerated static pile systems (Goldstein and Steuteville 1996). This type of composting has been widely applied for wet substrates, such as sludge cake (Haug 1993). In this process, approximately 1 ft of bulking agent is stacked over a porous bed above air piping that is connected to blowers. The cake/bulking agent mixture is piled over the bulking agent. The piles are covered with a layer

of either bulking agent or finished compost to provide insulation and to capture odor (Story 1997). Air is provided to the pile either through positive aeration or negative aeration, i.e., air is either forced upward or drawn downward through the mixture. When the pile is taken down after composting, the bulking agent may be partially recovered by screening and then reused. Compost from the aerated static pile is usually not dry enough to be screened. Thus, either a curing or a separate drying phase may be needed before screening.

An advantage of the aerated static pile is its low labor requirement. The operator will need only to check the temperature daily and adjust the air flow to the pile, if necessary. All other associated operator tasks are performed periodically (Story 1997). A disadvantage of the aerated static pile is clumping of compost caused by incomplete mixing and nonaerated parts of the pile. Front end loaders may not mix the compost uniformly and may compact the compost, reducing pore size. This can lead to anaerobic conditions that result in odors and inadequate decomposition and pathogen destruction to achieve Class A biosolids. However, operators who were interviewed for this report had no problems with the quality of the compost (Hutchinson 1997; Story 1997). Appendix I contains transcripts from these interviews. An active composting period of 21 days followed by 30 days of curing is required.

When choosing a bulking agent for aerated static piles, the optimum particle size range is between 12.5 and 50 mm (0.5 and 2 in). Use of a larger bulking agent maintains air voids without the need of periodic agitation, as in the windrow process (Haug 1993). For example, sawdust will not provide enough air cavities for proper aeration and heat flow. Wood chips are most commonly used for aerated static pile bulking agent. Using the correct mix ratio is essential in reaching thermophilic temperatures. When starting up a facility, the operator may need to experiment until the correct ratio is found (Hutchinson 1997). For example, a North Carolina facility at Burnsville was able to maintain temperatures between 150 °F (65 °C) and 160 °F (71 °C) for at least 15 days using a mix ratio of 2:1, tree bark: sludge (Story 1997).

The USEPA (1993) established minimum requirements for composting as a PFRP in Appendix B of Part 503 regulations: (1) using either the within-vessel composting method or the aerated static pile composting method, the temperature of the biosolids is maintained at 55 °C or higher for 3 days; and (2) using the windrow composting method, the temperature for biosolids is maintained at 55 °C or higher for 15 days or longer. During the period when the compost is maintained at 55 °C or higher, the windrow is turned a minimum of every 5 days. Appendix B of Part 503 regulations also established minimum

requirements for composting as a PSRP. The biosolids temperature must be raised to 40 °C or higher for 5 days and during 4 hours of that period, the temperature in the pile must exceed 55 °C. This requirement applies to all three types of composting. The Western Corridor's goal is to meet the PFRP requirements.

Odor control is an important aspect of successful composting operation. In-vessel composting facilities suppress odors better than the other processes due to the nature of the enclosed "reactor." Proper mixing is essential for odor control since unmixed sludge clumps can lead to anaerobic conditions (Benedict et al. 1986). The treatment methods for compost odors include wet chemical scrubbing and regenerative absorption (WEF 1995a). In the aerated static pile method, pile cover material acts as an odor scrubber during positive aeration. Negative aeration, however, requires a separate exhaust scrubber system (Benedict et al. 1986). Biofilters using compost and bulking agents have become more popular for odor treatment at composting facilities in the United States.

Condensate and leachate from the composting pile need to be collected and treated. Condensate forms when the moist, hot exhaust gas is cooled (Haug 1993). A composting facility for the Western Corridor would need to be located at one of the WWTPs where pipes could carry runoff from the piles back to the headworks.

Structures to house the composting process provide protection from the weather and play a critical role in odor control. Depending on the circumstances, a structure may only have a roof or it may have walls. For example, the Fort Collins, CO facility has three walls in addition to a roof due to high winds (Putnam 1997). Wind will carry odor from the composting facility. Rain reduces the solids content in the compost, and thus, the composting time must be increased. In the winter, snow and cold temperatures may cause the compost temperature to fall below the Part 503 requirements. The Springville, UT windrow facility, which does not have a shelter, has not been able to maintain their temperatures at high enough levels to meet requirements. In addition, when the snow melts in the spring, the windrows become too wet and the fecal coliform requirements are not met (Roberts 1997). Current aerated static pile facilities that operate without shelters do not experience any problems detrimental to the quality of the compost. The layer of bulking agent over the pile acts as an odor filter and provides insulation from the elements to keep the pile temperature above levels required for pathogen destruction (Story 1997; Steuteville and Goldstein 1997). In Korea, a shelter may not be required, but should be considered due to the volume of rain in the summer months.

Numerous testing methods exist for measuring compost stability. No single test is accepted universally (Jimenez and Garcia). These test methods (WEF 1995a; Haug) include: testing for percent volatile solids, using a respiration test to measure carbon dioxide or oxygen demand, measuring for a C/N ratio less than 20 for manure compost, seed germination and root elongation tests, and measuring redox potential.

### **Cost Comparison**

Table 4 provides rough cost estimates for mechanical dewatering systems. Information on each of these systems is provided in Appendixes A-D. A truck to haul the dewatering trailer is not included in any of the prices quoted and should be considered in final cost decisions. Another addition to the cost of any item purchased in the United States is shipping to Korea. Since a trailer adds to the cost of the system, the Western Corridor may want to consider installing the dewatering system at the stabilization facility and hauling the sludge to that plant before dewatering. Typical annual operations and maintenance (O&M) costs range from \$5,000 to \$12,000.

Table 5 contains prices for composting and alkaline stabilization processes. Information on each of these processes is provided in Appendixes E-I. Comparison between each figure in Table 5 is difficult for several reasons. The in-vessel composting and alkaline stabilization processes are proprietary, and the companies provided figures based on an estimate of the quantity of sludge that is produced by the Western Corridor. The aerated static pile figures were obtained by an author via phone interviews with city officials and plant operators. The interviewed composting facilities were chosen because they handle quantities of sludge similar to that handled by the Western Corridor. The Burnsville, NC facility has no shelter, and the facility already owned a front

**Table 4. Cost comparison of mechanical dewatering systems.**

<b>Dewatering Device</b>	<b>Hyd. Cap. (gpm)</b>	<b>Device Price</b>	<b>Trailer Price</b>	<b>Total System Cost</b>	<b>Percent Total Solids</b>
Frontier Technology, 0.5 m Belt Filter Press	11-20	\$85,000 (skid mounted)		\$105,000 (w/trailer)	20-32
JWI J-Press 100 PSI STD				\$258,000 (w/trailer)	
Sharples Solid Bowl Centrifuge Model PM-38000	50	\$160,000	\$250,000	\$410,000	>16
Trimax Environmental (Centrifuge)		\$50,000- \$100,000	\$10,000- \$20,000	\$150,000- \$200,000	30-35

**Table 5. Cost comparison of different composting processes and alkaline stabilization.**

Process	Company/ facility	Equipment included	Annual O&M Costs	Total Process Cost	Percent Total Solids
Aerated Static Pile Composting	Burnsville, NC	Entire facility	Not significant above rest of WWTP	\$80,000	
	Go Wanda, NY	Conversion of existing drying beds to asp	\$20,000	\$30,000	50-60
In-vessel Composting	Davis Industries, Inc.	Econobay	\$8,499	\$410,000	50-60
Alkaline Stabilization	CemenTech	Model CSP-5		\$59,877	
	N-Viro		\$38,060	\$617,614	62

end loader and other required machinery. The Western Corridor owns a front end loader also. However, if the Western Corridor needs a shelter or additional machinery, the construction cost will be higher than the price quoted in Table 5.

The Springville, UT facility is the only windrow facility that was interviewed. The Springville construction cost of \$250,000 is not quoted in Table 5 because it would not be representative for the Western Corridor since the facility was built for 2 dry tons/day. A price of \$130,000 was quoted on a compost turner from Resource Recovery Systems of Nebraska, Inc. The Western Corridor may decide to use its front end loader in lieu of purchasing a compost turner, however. Windrows are not piled as high as aerated static piles (Haug 1993). Thus, more land area would be required for a windrow facility versus an aerated static pile facility. Aerated static pile has the added cost of air piping and blowers, however. In comparison with the operations and maintenance expenses at an aerated static pile facility, a windrow facility will require more labor due to pile turning, but less energy requirements since blowers are not used. For the purposes of this report, it has been assumed that the construction and operation and maintenance of a windrow facility for the Western Corridor will cost no more than that of an aerated static pile facility.

The total costs of the two alkaline stabilization facilities are difficult to compare. The estimate provided for the N-Viro process by the company was for a 1 dry ton per day facility. The cost was scaled down to a 0.37 dt/d facility by the authors. Thus, the number quoted in Table 5 may not be representative of the actual cost. The N-Viro quote includes site work, construction costs, engineering fees, and a technology fee, none of which are included in the CemenTech quote. The CemenTech quote covers only the basics required for alkaline stabilization.

As stated previously, the Western Corridor currently spends \$90,737 annually on sludge disposal. Assuming that the sludge produced from any of the stabilization processes above can be land applied, a 5-year savings of \$453,685 will be achieved. The following combinations could be used to achieve a 5-year payback:

- CemenTech alkaline stabilization, and a Frontier Technology belt filter press
- aerated static pile composting, and any dewatering option except Sharples with a trailer and JWI J-Press
- windrow composting, and any dewatering option except Sharples with a trailer and JWI J-Press.

These combinations were calculated using an O&M cost of \$12,000/yr for all the dewatering devices, \$20,000/yr O&M, and \$80,000 construction cost for aerated static pile composting, and assuming that, over a 5-year period, windrow composting would cost less than aerated static pile composting, if a front loader were used instead of a compost turner. All other prices were taken from Table 5 as shown.

If the produced biosolids cannot be land applied, the Western Corridor should still consider the processes above. The solids content will be increased dramatically above that of the current aerobically digested sludge that is landfilled. The following sludge volumes were calculated for each process:

- dewatering to 20 percent solids: 166,686 gal/yr
- composting to 50 percent solids: 66,674 gal/yr
- alkaline stabilization to 40 percent solids: 96,700 gal/yr.

A comparison of these volumes to the current sludge volume of 1,333,488 gal/yr shows significant reduction. The tipping fees will be increased, however, due to greater solids content. It is believed that, with the reduced volume and increased fees, the sludge disposal fees for composting and alkaline stabilization will be within 5 percent of the current disposal fees.

Sludge collection/disposal costs are expected to rise sharply in a few years. This study recommends the Western Corridor continue using current procedures and implement the mobile mechanical dewatering system with either aerated static pile composting, windrow composting, or alkaline stabilization when disposal costs significantly rise. The belt filter press is the most suitable dewatering option due to economics. However, before a final decision is made on the

dewatering technology, Western Corridor should have its sludge tested in the various dewatering devices. A greater volume of sludge will be produced from alkaline stabilization than from composting. Thus, if land application is not permitted, aerated static pile or windrow composting will be the more cost effective option. Windrow composting should not be chosen over aerated static pile due to the believed lower costs. Careful consideration should be taken as to how much labor the Western Corridor wishes to expend on stabilization. Aerated static piles are well suited for small treatment plants. Each WWTP has an unique approach, as may be seen from the interviewed composting facilities, and capital costs vary from a few tens of thousand to millions of dollars. It is extremely important that engineers/operators take an active interest in improving sludge management system before any new technology is implemented.

## **Yongsan**

Due to space restriction, a sludge treatment program cannot be implemented at the Yongsan WWTP. However, the need for a sludge treatment program can easily be eliminated at the plant. Currently, the Korean Ministry of Environment does not require secondary treatment at the Yongsan WWTP, and USFK/EUSA pays a wastewater system users fee to the Korean Government. Therefore, it is recommended that RBC operation be halted and the Imhoff tank effluent be directly discharged to Seoul's sewer system. This will result in significant reduction of disposal costs for the secondary treatment sludge from RBCs.

## **Camp Humphreys**

Upgrading the existing sludge drying beds to reed beds is the option considered for Camp Humphreys. Sand-drying beds can have long dewatering times (2 to 4 weeks), intensive labor requirements to remove dried sludge, and can experience clogging. Camp Humphreys WWTP has actually experienced clogging and poor drainage. Reed beds may be a more cost effective technology at this site by virtue of its added microbial degradation and by lesser requirement for operator attention.

Although it was started in Europe more than 10 years ago, reed bed dewatering is still an emerging technology in the United States and a new technology in Korea. Reed bed technology has been largely used in the northeastern United

States, including New Jersey, Pennsylvania, Maine, and Vermont. Like sand-drying beds, the reed bed is a natural dewatering system that is well suited for smaller treatment plants. A disadvantage with such natural systems is the greater requirement for available land. This will only be a concern at Camp Humphrey if the current sludge drying beds do not provide enough area. The reed bed process can produce biosolids with a solids content ranging from 30 to 60 percent (Kim et al. 1993). USACERL has experience with the implementation and operation of reed bed technology through a demonstration at Fort Campbell, KY.

The reed bed process basically operates as a modified sand-drying bed with a dense growth of reed vegetation. Therefore, the construction is similar to that of sand-drying beds. An excavated trench is first lined with an impermeable barrier to prevent leaching to the surrounding soil. Precast Hypalon liners have been successfully demonstrated for lining the trenches at several installations. A 10-in. layer of gravel is placed over the drainage pipe and is then covered with a 10-in. layer of sand. The side walls are commonly made of concrete and include at least 1 m freeboard. This freeboard ensures adequate storage capacity of the sludge for a design period of 10 years. Camp Humphreys' current drying beds may easily be converted to reed beds by raising the side walls. A door, or some other means to facilitate the removal of dried biosolids, also needs to be constructed in each bed.

Once the beds are constructed, reeds are planted at 1-ft centers. Several species are available, but generally the common reed *Phragmites* is used. *Phragmites* is well suited for reed bed use because of its elevated evapotranspiration rate and its great tolerance for variable climates. In fact, on a visit to Korea, *Phragmites* was found in the Han River banks. Once the reeds are established, sludge may be applied to the beds. Reed beds are designed to accommodate stabilized sludge that contains 3 to 4 percent solids.

Reed beds have some important advantages over other natural systems. The dried sludge removed at the end of bed is very similar in quality to compost with regards to pathogen content and stabilization. These results are mainly due to the long detention of the sludge, added microbial degradation due to oxygen provided through the root system, and an additional storage period that follows the final sludge addition. While not yet documented, it is believed that, if the sludge is allowed to weather for 1 year following the last sludge application, it will pass the EQ biosolids criteria. The root system of the reeds enables long term storage through evapotranspiration and maintenance of a pathway for the liquid to drain through.

Reed beds require very little operator attention in comparison with sand-drying beds. Typical operator attention is 200 hours per year to monitor sludge additions and to perform other miscellaneous tasks. Labor requirements for sand-drying beds range from 0.5 hr/yr/m<sup>2</sup>, for large systems, to 4 hr/yr/m<sup>2</sup>, for small systems (USEPA 1987). Thus, for the current sand-drying bed area (1345 m<sup>2</sup>) at Camp Humphreys, the operators may spend between 672.5 and 5,380 hours per year working on the sand-drying beds. Unlike sand beds, which require the removal of the sludge after each individual sludge application, reed beds are designed to hold sludge for a period of 10 years. The time and cost of periodic replacing of sand torn up during sludge removal would be eliminated. One relevant manpower requirement is harvesting of the reeds each fall. Harvesting may be performed manually with hedge clippers or sickles or using mechanical devices. Alternately, the reeds may be burned after filling the bed with 2 in. of water, if local authorities permit.

At the time of disposal, the final volume is significantly lower than the total volume from a sand bed after 10 years, which results in disposal savings. Several ultimate disposal alternatives are available for the sludge after it is removed from the beds. It is likely that the weathering of the sludge over the storage period will result in Class A biosolids. Therefore, under U.S. standards, the material could be as freely used as any commercial soil conditioner, in a manner similar to compost. In the worst case, the biosolids would meet the Class B standards and could still be beneficially applied to land. The solids content of over 40 percent would facilitate ease of application. Landfilling of the sludge remains an alternative. Since the volume of sludge would be reduced through organic destruction, landfilling would be less expensive than currently practiced.

The reed bed has a few disadvantages or potential problems. One commonly occurring problem with the reed bed is infestation, especially by aphids, during the first year of growth. This problem is typically controlled by purchasing lady bugs, a natural predator of the aphids. Another problem that must be considered is the removal and extinction of the reed system from the final compost product. This may possibly be addressed by killing the reeds at the beginning of the 1-year holding period and screening the final product. Another potential disadvantage is the preparation period before the reed bed becomes fully operational. Reeds must be planted during the growing season. The establishment of healthy reeds requires several weeks of growth. Sludge should not be applied until the plants are well established. Some sites have waited up to 2 months before applying sludge (Kim et al. 1993).

The reed bed process is an empirical technology. Further science-based research is needed to “fine tune” this technology. Design parameters for reed bed sizing are widespread based on the number of variables that affect the dewatering rate. Also, data from existing reed bed facilities varies significantly. Experience at Fort Campbell indicates that approximately 20,000 sq ft of reed bed area is required per 1 MGD of wastewater flow when anaerobic digestion is used for stabilization (Kim et al. 1993). This would correspond to 13,000 sq ft (1208 m<sup>2</sup>) for the Camp Humphreys WWTP. The solids loading rate must also be considered, though. Solids loading rates for operational reed bed systems using anaerobically digested sludge with 5 percent total solids range between 2.5 and 12 lb/sq ft/yr (12 and 58.6 kg/m<sup>2</sup>/yr) (Kim et al. 1993). For Camp Humphreys’ present estimated solids production of 350 dry kg/day, a reed bed area between 19,300 and 94,184 sq ft (1792 and 8750 m<sup>2</sup>) is required. The hydraulic loading rate may also be considered. Hydraulic loading rates for operational reed bed systems using anaerobically digested sludge with 5 percent total solids range between 0.49 and 3.28 cu ft/sq ft/yr (0.15 and 1.0 m<sup>3</sup>/m<sup>2</sup>/yr) (Kim et al. 1993). For Camp Humphreys, a reed bed area between 22,150 and 147,700 sq ft (2058 and 13,720 m<sup>2</sup>) is required. These ranges of possible required space illustrate that a good estimate of the requirements for Camp Humphreys is not feasible without more data on sludge characteristics and volume. The solids and hydraulic loading rate estimates are based on typical values for conventional anaerobic digesters. No data is available for Imhoff tank sludge. In addition to the required bed space, at least two extra beds need to be built to allow a reed bed to remain idle the year prior to its excavation and for emergencies. Thus, even at the 13,000 sq ft approximation, which is below the low end of the both loading rate approximations, the current 14,480 sq ft may not be adequate since the additional space for two extra beds is not available.

Costs of implementing reed beds vary as much as the design parameters. Retrofitting existing sand-drying beds to reed beds range in cost from \$0.45/sq ft to \$9.30/sq ft. If Camp Humphreys had only to retrofit the existing beds, implementing this option would be ideal. However, construction of new reed beds is quite costly in comparison, with a range from \$9.33/sq ft to \$25/sq ft (Kim et al. 1993). Without an in-depth analysis of Camp Humphreys’ sludge and construction costs in Korea, an exact construction cost cannot be calculated. However, assuming that the cost of retrofitting Camp Humphreys’ sand beds to reed beds would be \$4.88/sq ft, the DPW would spend \$70,660 to implement this change, which is within the 5-year payback criteria. This study recommends the conversion of Camp Humphreys’ current sand-drying beds to reed beds.

## Camp Casey

The options explored for the Camp Casey WWTP include: (1) upgrading the current aerobic digester to autothermal thermophilic aerobic digestion (ATAD) with land application, and (2) maintaining the existing aerobic digester with the vacuum-assisted bed currently under construction followed by either composting or alkaline stabilization. The current aerobic digester is larger than required and loses energy. A more efficient process is desirable. In addition, as mentioned earlier, conventional aerobic digestion is not capable of producing Class A biosolids. However, implementing composting or alkaline stabilization would also produce Class A biosolids. This is important since the final biosolids products may be reused at golf course or training area rehabilitation projects on Camp Casey grounds.

Autothermal thermophilic aerobic digestion (ATAD) was developed by Pöpel in the 1970s in Germany. In 1977, Herr Fuchs installed the first German ATAD system in Vilsbiburg. Fuchs system is the most commonly used ATAD system in the Federal Republic of Germany (FRG) and probably in the world. Currently, ATAD facilities are successfully being operated in FRG, the United Kingdom, France, Italy, Switzerland, and Canada. Since 1993, when Part 503 came into effect, ATAD has emerged in the United States as a technology capable of meeting PFRP requirements. Currently, Krüger, Inc. has 12 operating ATAD systems in the United States with five more under construction.

ATAD is a compact, fully enclosed process which, with an adequate supply of oxygen, microorganisms, and nutrients, will decompose complex organic substances in wastewater. The heat produced during decomposition is adequate to maintain the desired operating temperature. Thus, ATAD is more efficient than aerobic digestion since no external heat supply is required. This results in lower operation and maintenance costs. ATAD does, however, require energy for aeration and mixing as aerobic digestion does. ATAD achieves a greater reduction of bacteria and pathogens than aerobic digestion in about one fifth the time. Removal rates of up to 70 percent of the biodegradable organics are achievable in thermophilic aerobic digestion (Metcalf and Eddy 1991). When comparing ATAD to other sludge management strategies, advantages include no nitrification and no required chemical additions or amendments.

The ATAD process works well with both primary and secondary sludges and may be operated on either a semi-continuous or a batch basis. Typically, a batch system is used. Since ATAD systems rely on heat to achieve the operating temperature, sludge must be thickened prior to entering the digester to limit

energy needed for heating and mixing. Ideal conditions are obtained when the sludge is thickened to 4 to 6 percent total suspended solids (TSS) (USEPA 1990) and has a chemical oxygen demand of 40 mg/L or greater (WEF 1995a). Camp Casey currently has a dissolved air flotation unit that is capable of meeting the 4 to 6 percent TSS requirement.

The current digester at Camp Casey would be replaced with a minimum of two insulated reactors in series. While single reactor processes do achieve similar reduction in volatile suspended solids, they will not achieve the required pathogen reduction. Temperature and pH parameters vary between the two reactors. The first reactor should maintain a temperature between 35 and 50 °C and a pH greater than or equal to 7.2 while the second reactor maintains a temperature between 50 and 65 °C with a pH around 8. Desired temperatures are acquired through adequately thickened sludge, good reactor insulation, efficient aeration, and foam management. Since the thermophilic operating temperatures in the reactors suppress nitrification, the pH usually will not have to be specially considered during design.

Biosolids treated through ATAD meet the requirements for Class A pathogen reduction in Part 503. Thermophilic aerobic digestion is one of the PFRPs listed in Appendix B of 40 CFR Part 503. To meet these requirements liquid biosolids must be agitated with air or oxygen to maintain aerobic conditions with a mean cell residence time of 10 days at 55 to 60 °C. In addition, Kelly (1993) showed that ATAD reduces volatile solids by 38 percent in a system with a degree C-day product of 400 and a 7-day total retention time. Thus, ATAD is capable of meeting both the Class A and the VAR requirements to create exceptional quality biosolids. ATAD is ideal over aerobic digestion in that Class A instead of Class B requirements are met.

Aerating at the appropriate rate is important. If air is supplied at a higher rate than needed, evaporative latent heat loss will cause cooling in the tank. Inadequate aeration and/or mixing causes poor digestion and a musty or humus-like odor in the exhaust (Kelly 1993). This odor can be sufficiently controlled by returning exhaust air to the rotating biological contactors, water scrubbing, passing through a biofilter, or dilution with ambient air. Gaseous ammonia, which is released by thermophilic aerobic degradation, also releases odor. The elevated pH in the second reactor enhances the stripping of ammonia in the exhaust. Various aeration and mixing devices have been used including aspirating aerators, turbines, and diffused air.

A dense foam layer develops quickly on the reactor due to aeration of the substrate and plays an important part in the ATAD system. Wolinski (1985) reported that the foam layer enhances biological activity, improves oxygen use, and provides insulation to the reactor. However, foam also retards the volume of air entering the reactor (USEPA 1990). Thus, foam volume must be controlled. Methods of foam control include mechanical horizontal shaft foam cutter, vertical mixers and spray systems, and chemical defoamers.

Post treatment of the biosolids includes cooling and thickening. Twenty days of cooling is desirable to reduce the temperature to 20 °C. Post thickening is most successful after the sludge is allowed to cool. Thickening of ATAD biosolids by gravity will typically achieve 6 to 10 percent solids (USEPA 1990).

To completely install an ATAD system, the Camp Casey DPW would spend around a million dollars. Annual operations and maintenance costs would be \$33,800. Over 5 years, the Camp Casey DPW would spend roughly \$1,182,000 on an ATAD for Camp Casey's sludge management. Exact information on the operation and maintenance costs for the plant's current aerobic digester and sludge disposal costs are needed to prove whether a 5-year return on investment is attainable in this situation. It is assumed that a 5-year payback is not possible. However, conversion of the aerobic digester to an ATAD system is a project that most likely would achieve a 10-year return on investment.

Sludge disposal costs are expected to rise significantly in the near future based on rapidly changing Korean environmental regulations and the high inflation rate. This study recommends that, when such a time arrives, upgrading the existing aerobic digester to an ATAD system with land application be compared to the addition of either composting or alkaline stabilization in conjunction with the facility's current processes, and that one of these options be implemented. The final biosolids product will be used as soil amendments at Camp Casey golf courses and for training area land management/erosion control.

## 4 Conclusions and Recommendations

### Conclusions

It is hoped that this study will open a new era in USFK/EUSA sludge management where beneficial use of biosolids replaces landfill disposal. However, regulatory and economic barriers may make this a difficult task. Since no biosolids regulations or practices currently exist in Korea, the management improvements discussed in this report are based on Part 503 criteria for beneficial land application of biosolids. It is assumed that biosolids that meet Part 503 regulations may be land applied at USFK/EUSA installations. The USFK/EUSA Environmental Program Office recommended a 5-year payback as a criteria to compete with other real property improvement projects. This study concludes that, even considering the economic benefits of using processed biosolids as soil amendments, a 5-year payback is currently a difficult criteria to meet. However, an increase in sludge disposal costs is foreseen. At that time, the recommendations in this report should be implemented.

### Recommendations

This study recommends that:

1. The Western Corridor DPW use a mobile mechanical dewatering device to dewater sludge at its seven plants, transport the sludge to a regional facility for stabilization, and install either aerated static pile composting, windrow composting, or alkaline stabilization at the regional facility.
2. The USFK/EUSA discontinue the current secondary treatment at the Yongsan WWTP to reduce operation costs and sludge generation.
3. The Camp Humphreys DPW convert the current sand-drying beds at the Camp Humphreys WWTP to reed beds. This conversion requires low capital investment and can be accomplished with in-house labor.

4. The Camp Casey DPW set a long-term goal to convert the aerobic digester to an ATAD system and, after dewatering in the vacuum-assisted bed, the biosolids be used as soil supplements at Camp Casey's golf course and training land management/erosion control.

Appendix G interview data show the wide variety of approaches and costs to implementing improved biosolids management. It is strongly recommended that USFK/EUSA engineers/operators start implementing improved sludge management strategies in the very near future for the benefit of both Korea and the United States.

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## Abbreviations and Acronyms

APLR	Annual Pollutant Loading Rate
ATAD	Autothermal Thermophilic Aerobic Digestion
C/N ratio	Carbon-to-Nitrogen Ratio
CFU	Colony Forming Unit
CPLR	Cumulative Pollutant Loading Rate
DPW	Directorate of Public Works
EQ	Exceptional Quality
EUSA	Eighth United States Army
FRG	Federal Republic of Germany
MGD	Million Gallons per Day
MPN	Most Probable Number
O&M	Operation and Maintenance
PC	Pollutant Concentration
PCB	Polychlorinated Biphenyl

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PFRP	Process to Further Reduce Pathogens
PSRP	Process to Significantly Reduce Pathogens
RBC	Rotating Biological Contactors
SOUR	Specific Oxygen Uptake Rate
TSS	Total Suspended Solids
USACERL	U.S. Army Construction Engineering Research Laboratories
USEPA	U.S. Environmental Protection Agency
USFK	United States Forces, Korea
VAR	Vector Attraction Reduction
WEF	Water Environment Federation
WWTP	Wastewater Treatment Plant

## **Appendix A: Frontier Technology Belt Filter Press**

Note: the following appendixes include information and proposals regarding specific products, provided by commercial manufacturers to USACERL researchers for use in this study. All information cited here remains the property of the cited manufacturers. All data reproduced here is meant to be used for informational purposes only; citation of trade names does not constitute an endorsement or approval of the use of such commercial products. Views or opinions expressed herein do not represent either the views or policies of any agency of the Federal government, including the U.S. Army, the U.S. Army Corps of Engineers, or the U.S. Army Construction Engineering Research Laboratories.





























## **Appendix B: JWI J-Press**













## **Appendix C: Sharples Centrifuge**

Phone Conversation

Company: Sharples

Contact Person: Ron Moody

phone #: (630) 571-6120

date: 3/20/97

The Sharples PM-38000 was recommended for the Western Corridor's needs. It has a capacity of 50 gpm. The centrifuge costs \$160,000. A trailer, which would include the feed pumps, polymer system, conveyors, etc., is an additional \$250,000.































## **Appendix D: TRIMAX Environmental**

## Phone Conversation

Company: Trimax Environmental

Contact Person: Blake Dermott

phone #: (800) 465-2115

date: 4/24/97

Trimax Environmental buys old machines and reconditions them. The machines are retrofitted to achieve drier sludge than originally intended. Most machines they have are Sharples PC81000, which is a 1975 model. The centrifuge can handle 20 to 25 dry tons/day on a 24-hour day. They achieve 30 to 35 percent solids. Trimax itself owns and operates 95 percent of the systems they have built. However, they can custom-make a system to be purchased and run by someone else with a guarantee of workmanship and a service contract. They also are able to test the sludge and, dealing with the characteristics of the sludge, make the machine specifically for that sludge. For example, they will purchase a belt filter press and install it if it works better with the sludge in question.

The standard trailer is 45-ft long. It contains front end equipment that removes rocks, plastic, rubber, hair and other items that may clog or damage the centrifuge. The trailer also contains a polymer system and the centrifuge. For a system as small as the one required for the Western Corridor, a 5-ton truck or a van that contains the equipment in the back may be more cost effective.

Typically, the centrifuge costs between \$50,000 and \$100,000. The trailer is an additional \$10,000 to \$20,000. The entire system including pumps, polymer system, etc. costs between \$150,000 and \$200,000.

They will provide CERL with information including a video.











## **Appendix E: N-Viro**

























## **Appendix F: CemenTech**



















## **Appendix G: Davis Industries**



































# **Appendix H: Resource Recovery Systems**











# Appendix I: Transcripts of Phone Interviews With Composting Facilities

## Composting Questionnaire

Facility: Burnsville, NC

Contact person: Tom Story, Director of Public Works

phone #: (704) 682-2420

date: 4/23/97

*Which type of composting facility do you have?*

Aerated static pile. We use a back hoe with a front end bucket to build the piles. We lay down approximately 12 in. of bark over a concrete slab with two 4-in. perforated plastic pipes running through it, build up the pile on top of it, and put 12 in. of bark over the top of the pile for insulation. A squirrel cage blower pulls air in through the pile. We are required to run analyses on the pile for fecal density and metals (TCLP and toxicity test). If the analysis is acceptable, then we can distribute the composted material. A trommel screen is used to separate the fines out of the final compost, which is released to the community. The bark is recycled.

We considered lime stabilization (N-Viro) instead, but the lime costs money, a silo and more equipment are required, it's less simple to operate and would have to pay a surcharge for the technology to the company for any biosolids that were land applied.

*Is it indoors or outdoors? Is it under a shelter?*

No shelter: We have a few problems when it rains, but the rain is not enough to cause the temperature to drop below the levels required for pathogen

destruction. Mainly, rain causes the solids content to decrease and, thus, the composting time to increase. Available land area for expansion is another problem we are experiencing.

*How many dry tons per day do you handle?*

We have a 800,000 gpd plant which treats mainly domestic waste with a small amount of industrial. We use contact stabilization and extended aeration. We handle 100 dt/year of sludge.

*What is the percent solids of the incoming sludge? Do you dewater it first?*

We condition and dewater first using a screw press. This is a thickening process with polymer addition. We achieve on average about 13 percent solids (ranges from 10 to 15 percent).

*Do you achieve Class A biosolids in the final product?*

Yes.

*What is the percent solids of the final product?*

We don't run any solids test after the bulking agent is added. The final product has a much high solids content, however. It has the consistency of moist potting soil.

*What do you do with the final product?*

We produce a relatively small amount of biosolids. Thus, it is not cost effective to sell it. We give it away for use as mulch, soil conditioner, reclamation of poor soil. A local Christmas tree farm used a lot of our biosolids.

*What was the construction cost? What is the annual O&M? Does this include amendment?*

We spent \$75,000 to \$80,000 to build the entire facility. This includes the concrete slabs, gutters, pump pit, sump pumps, pipes to pump runoff to head works of plant, two 4-in. perforated plastic pipes, squirrel cage blower, conveyor

belt, storage bins, electrical work, and an engineering fee. We already owned a front end loader and other needed machinery at the plant. So, these are not included in the construction cost. The operations and maintenance cost are not significant over and above the routine maintenance at the WWTP. We decided it would be more cost effective to have an operator split working time between the composting and other tasks at the WWTP than to hire a person to work 8 hours a day when only 1 to 2 hours is needed. The main task which needs to be done daily is read the pile temperature.

*What do you use for amendment?*

Wood chips and/or shredded tree bark. During the fall and winter months, we get these for free from a local plant. During the spring when these are in high demand for lawn use, we have to pay \$10 per dump truck. It basically covers the gas and labor for someone to bring it to our plant. Tree bark is an excellent bulking agent due to the sap and other components which have the ability to generate heat. Our permit requires us to keep the temperature of the pile above 131 °F for 3 days. With a mixing ratio of 2:1 (bark:sludge), we are able to keep the temperature between 150 and 160 °F for 15 days (or longer if necessary). Saw dust does not work as a bulking agent. It does not provide enough air cavities for proper aeration and heat flow.

*Do you have any problems with the performance of you facility? (inadequate aeration, clumping, etc.?) No.*

## Composting Questionnaire

Facility: Fort Collins

Contact Person: Steve Putnam

phone #: (970) 221-6932

date: 4/15/97

*Which type of composting facility do you have?*

The facility was built for aerated windrow composting. However, we have also used aerated static pile. This works out better because there is less labor involved. In the static pile, we cover the pile with a layer of finished compost.

*Is it indoors or outdoors? Is it under a shelter?*

We have high winds here and the usual rain and snow. So, we have to have a shelter. It has three walls and is open to the south.

*How many dry tons per day do you handle?*

The facility was designed for 6 dt/day. However, we actually only compost about 0.25 dt/day. Composting is our backup to using our sludge as fertilizer.

*What is the percent solids of the incoming sludge? Do you dewater it first?*

We anaerobically digest our sludge and then dewater it. To dewater it, we take it up in the mountains where it is very windy, lay it out on a concrete slab, and leave it. We can achieve between 14 and 70 percent biosolids in 2-3 weeks, depending on the weather.

*Do you achieve Class A biosolids in the final product?*

We are not worried about achieving Exceptional Quality biosolids.

*What is the percent solids of the final product?*

*What do you do with the final product?*

Most biosolids are land applied as fertilizer immediately after digestion and dewatering. The extra biosolids are sent through the composting facility to stabilize and reduce the odor.

*What was the construction cost? What is the annual O&M? Does this include amendment?*

We spent \$3.5 million for the entire facility and two pieces of machinery. This price would be cheaper for aerated static pile due to less advanced equipment. We spend \$350-400/dry ton in O&M costs.

*What do you use for amendment?*

wood chips

*Do you have any problems with the performance of you facility? (inadequate aeration, clumping, etc.?)*

## Composting Questionnaire

Facility: Go Wanda, NY

Contact Person: Mike Hutchinson

phone #: (716) 532-5931

date: 4/24/97

*Which type of composting facility do you have?*

Aerated static pile.

*Is it indoors or outdoors? Is it under a shelter?*

We have a pole barn. The aeration area has walls. All other areas have a roof, but no walls.

*How many dry tons per day do you handle?*

1,000 yd/yr

*What is the percent solids of the incoming sludge? Do you dewater it first?*

Yes, we dewater the sludge to 20 percent solids. Our sludge is anaerobically digested first.

*Do you achieve Class A biosolids in the final product? Yes.*

What is the percent solids of the final product? 50 to 60 percent

*What do you do with the final product?*

We give it away to home owners.

*What was the construction cost? What is the annual O&M? Does this include amendment?*

We converted our existing drying beds into the composting area. This cost us roughly \$30,000. We have been composting since 1990. We designed everything ourselves, and a consulting firm handled the permits.

We spend \$20/yd in O&M costs.

*What do you use for amendment?*

Wood chips. The most important thing is to get the correct mixture. You may have to experiment for a while until the right mix is found to reach the proper temperatures. The amount of carbon is important. We use a 2:1 ratio of wood chip to sludge.

*Do you have any problems with the performance of you facility? (inadequate aeration, clumping, etc.?)*

We have experienced no problems with compost quality (i.e., aeration, clumping). We have had problems with our shredding and screening equipment, however.

Could you please send me a copy of your report?

Mike Hutchinson

Village of Go Wanda

Sewage Department

Aldrich Street Extension

Go Wanda, NY 14070

## Composting Questionnaire

Facility: Springville, Utah

Contact Person: Rick Roberts

phone #:(801) 489-2745

date: 5/13/97

*Which type of composting facility do you have?*

Windrow, piled

*Is it indoors or outdoors? Is it under a shelter?*

We have no shelter. The winter causes problems. In the spring, the compost is too wet and our fecal Coliform count does not pass.

*How many dry tons per day do you handle?*

2 dry tons/day

*What is the percent solids of the incoming sludge? Do you dewater it first?*

We dewatered it to 18 to 20 percent solids.

*Do you achieve Class A biosolids in the final product?*

Yes.

*What is the percent solids of the final product?*

50 to 60 percent moisture (40-50 percent solids)

*What do you do with the final product?*

We sell it to the public for use on flowers and other things like that. We do not advertise, and we do not make a profit.

*What was the construction cost? What is the annual O&M? Does this include amendment?*

For the composting facility with a belt press, we spent \$250,000. We use an old loader we already owned to turn our piles. We can build the piles higher than can be used with a turner. We also spent about 30 percent of \$250,000 on a grinder, which we share.

*What do you use for amendment?*

Green waste from the city which residents bring to us for free. Otherwise, they would have to pay to have their yard waste landfilled.

*Do you have any problems with the performance of you facility? (inadequate aeration, clumping, etc.?)*

We may need to look into keeping more of our bulking agent. We need to buy screens.

Winter is our biggest problem. It don't take long to lose temperature. One winter I reheated the piles by mixing in an ammonia fertilizer. We were able to bring the temperatures back up to pass. However, this winter's compost will most likely not meet regulations.

Personally, I wouldn't do it if it is in a moist climate. I would not compost. We are lucky. Most other operations around here cannot meet Class A and end up with Class B biosolids.

## **Appendix J: Krüger**



















