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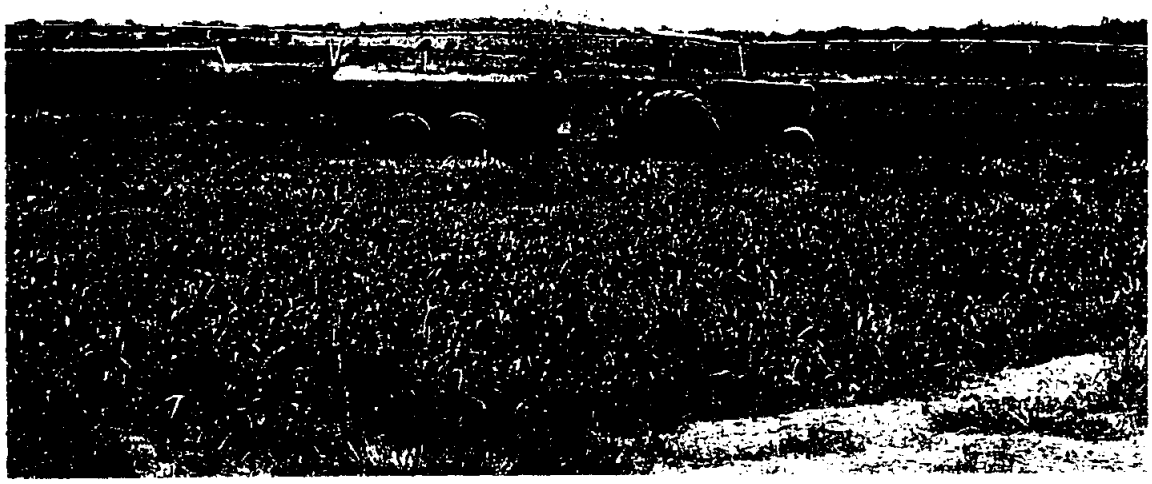

REGIONAL WASTEWATER SLUDGE DISPOSAL ALTERNATIVES STUDY

June 1995

BLACK & VEATCH

Guadalupe-Blanco River Authority
Regional Wastewater Sludge Disposal Alternatives Study

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1.0 Introduction

The purpose of this study is to review land application as an alternative to the current sludge disposal practices of study participants in a four-county area including: Caldwell, Comal, Guadalupe, and Hays Counties. Study participants include: The City of San Marcos, New Braunfels Utilities, The City of Seguin, The City of Luling, and the Guadalupe-Blanco River Authority (which includes four smaller treatment plants and the City of Lockhart wastewater treatment facility). Attachment B in the Appendix shows the locations of the participant's facility.

Due to the promulgation of federal (40 CFR Part 503) and state (30 TAC Chapter 312) sludge regulations in 1993, as well as new landfill regulations (Subtitle 'D'), many communities are evaluating alternative methods to the common past practices of sludge disposal - namely, placement in a municipal landfill. Although landfill prices are still competitive with beneficial reuse in Texas, many communities are anticipating that landfill prices will increase significantly with time.

This report describes the current sludge treatment and disposal practices of study participants, as well as the current and projected future quantities of sludge produced. The sludge quality for each study participant is discussed with a comparison to pertinent parameters in the applicable federal and state regulations.

With the exception of the GBRA facilities (excluding the Lockhart WWTP), all of the other study participants are presently using municipal landfilling as the primary method of disposal. This study also compares the costs of land applying sludge to the current disposal practice of landfilling.

2.0 Executive Summary/Recommendations

In summary, this study has shown that most study participants are spending an average of $99.06 per dry ton to dispose of their sludge, either by landfilling or liquid land application (four GBRA WWTPs only). Currently, approximately 2,177 dry tons of sludge are being disposed by study participants annually. The majority of participants are presently landfilling their sludge, and are transporting the material between four to 33 miles for ultimate disposal.

From laboratory analyses of representative samples collected from study participants, it was shown that all sludge produced meet the minimum requirements for land application with respect to the regulated 10 heavy metals. With the exception of one sample result being higher than the current state "Alternative Pollutant Limit" (APL) for molybdenum, all participants met the most stringent metals requirements (also commonly known as the "Table 3" values) for land application.

Because most participants are currently landfilling sludge as a final disposal method, information on pathogen and vector attraction reduction was not readily available. However, since all participants have sludge stabilization units (either aerobic or anaerobic digesters), it was assumed for this study that the minimum Class 'B' pathogen reduction requirements will be met. This level of pathogen reduction should be verified in the future with indicator organism testing. Therefore, it is recommended that all study participants begin monitoring their sludge products for indicator organisms to verify a Class 'B' level of pathogen reduction.

It was assumed that most participants would not meet the minimum vector attraction reduction requirements. Therefore, it is recommended that provisions be made to meet this restriction by incorporating the sludge into the soil (commonly known as "Option 10") after land application.

If an agreement can be arranged between all interested study participants and the City of San Marcos, it is recommended to develop a centralized land application site on land currently being farmed at the City's airport. This site contains over 600 available acres in agriculture that are suitable for land application. This site is located six to 29 miles from each of the study participants currently generating dewatered sludge (all except the four smaller GBRA facilities). Attachment B shows the location of the recommended land application site.

It is recommended that GBRA investigate the purchase a mobile sludge dewatering unit for dewatering sludge at their four smaller treatment plants if it can be demonstrated that the purchase is cost-effective. These facilities are relatively small generators of sludge (estimated at only 31 combined dry tons for the entire year in 1994), and the per unit cost for disposal is estimated at over $232 per dry ton. However, the estimated annual cost for sludge disposal for these four facilities is only $7,200.

The estimated cost for agricultural land application, including capital and operations and maintenance costs, is approximately $78 per dry ton for each participant presently generating dewatered sludge cake (i.e., this does not include the four smaller GBRA facilities presently generating liquid sludge). This is approximately $20 less than the current disposal method for landfilling.

3.0 Applicable Regulations

3.1 Introduction

Regulations concerning the processing and disposal/beneficial reuse of wastewater sludge are a major factor in choosing and establishing a successful management program. This chapter summarizes federal and state regulations.

Current federal regulations for the utilization or disposal of sludge and sludge products are found in 40 CFR Part 503: *Standards for the Use or Disposal of Sewage Sludge*. Published in the Federal Register on February 19, 1993, Part 503 regulates the following practices:

- Land application - includes bulk land application and distribution/ marketing.
- Surface disposal - includes lagoons, monofills, and some dedicated land application.
- Incineration - includes sludge-only incinerators.

This section of the report will only address the land application process, since other disposal alternatives (surface disposal and incineration) were not considered as viable alternatives in this study.

3.2 Federal Regulations for Land Application of Wastewater Sludge

This section presents a summary of the federal requirements for land application. The 503 regulations establish two levels of quality for sludge with respect to metal concentrations and two levels of quality with respect to pathogen densities. The higher the sludge quality, the fewer the restrictions imposed on the use of that sludge under the 503 regulations.

Land application of sludge requires that the material meet pollutant limits, pathogen reduction requirements, and vector attraction reduction requirements. Land application includes sludge that is sold or given away in a bag, bucket, box, or vehicle or trailer with a load capacity of one metric ton (1.1 tons) or less. Sludge can also be applied in bulk to agricultural land, forest, reclamation sites, or lawns and home gardens.

3.2.1 Pollutants

If land application is practiced, the concentration of pollutants in the sludge must be below the ceiling limits listed in Table 3-1. Sludge that has metal concentrations below the Alternate Pollutant Limits (APL) will not be subject to pollutant loading limits. All other sludge applied in bulk will be required to meet cumulative pollutant loading limits. Sludge above APL that is distributed to the public must be applied at less than the annual pollutant loading limits.

Table 3-1
40 CFR 503 Land Application
Pollutant Limits

Pollutant	Ceiling Limits (mg/kg)*	Alternate Pollutant Limits (mg/kg)*	Cumulative Pollutant Limits (lb/ac)*	Annual Pollutant Limits (lb/ac/yr)*
Arsenic	75	41	37	1.8
Cadmium	85	39	35	1.7
Chromium	3000	1200	2700	134
Copper	4300	1500	1300	67
Lead	840	300	270	13
Mercury	57	17	15	0.76
Molybdenum	75	--	16	0.8
Nickel	420	420	375	19
Selenium	100	36	89	4.5
Zinc	7500	2800	2500	125

* Dry Weight Basis
mg/kg = milligrams per kilogram, or parts per million
lb/ac = pounds per acre
lb/ac/yr = pounds per acre per year

USEPA estimates that approximately 70 percent of the sludge generated in the U.S. will meet the APL limits. For sludge that does not meet APL, pollutant loading

limits are enforced. For an example, for a sludge sample having the same metals concentrations as the ceiling limits, then up to 107 dt/ac could be applied in bulk or 5.4 dt/ac/yr could be applied in a distributed and marketed program.

3.2.2 Pathogen Reduction Requirements

Wastewater sludge prepared for bulk land application to agricultural land, forest, or reclamation sites must meet at least Class 'B' pathogen requirements. Wastewater sludge must meet Class 'A' pathogen requirements if it is distributed to the public or applied to a lawn or home garden.

3.2.2.1 Class 'A'. All Class 'A' sludge must meet one of the following criteria at the time it is sold, given away, or used:

Either

- A fecal coliform density less than 1,000 Most Probable Number per gram of total solids (1,000 MPN/g TS).

Or

- A *Salmonella sp.* density less than 3 Most Probable Number per 4 grams of total solids (3 MPN/4 g TS).

In addition, the requirements of one of the following three alternatives must be met:

Either

- The sludge meets a Process to Further Reduce Pathogens (PFRP) or PFRP equivalency requirements. The processes that meet PFRP requirements are described below.

  (1) **Composting** - Using either the within-vessel composting method or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 55 °C or higher for three days. Using the windrow composting method, the temperature of the sewage sludge is maintained at 55°C or higher for 15 days or longer. During this period, a minimum of five windrow turnings occur.

(2) **Heat Drying** - Sewage sludge is dried by direct or indirect contact with hot gases to reduce the moisture content of the sewage sludge to either 10 percent or lower. Either the temperature of the sewage sludge particles exceeds 80°C or the wet bulb temperature of the gas in contact with the sewage sludge as the sewage sludge leaves the dryer exceeds 80° C.

(3) **Heat Treatment** - Liquid sewage sludge is heated to a temperature of 180 °C or higher for 30 minutes.

(4) **Thermophilic Aerobic Digestion** - Liquid sewage sludge is agitated with air or oxygen to maintain aerobic conditions and the mean cell residence time of the sewage sludge is 10 days at 55 to 60 °C.

(5) **Beta Ray Irradiation** - Sewage sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (ca. 20 °C.).

(6) **Gamma Ray Irradiation** - Sewage sludge is irradiated with gamma rays from certain isotopes, such as Cobalt 60 and Cesium 137, at room temperature (ca. 20 °C).

(7) **Pasteurization** - The temperature of the sewage sludge is maintained at 70 °C or higher for at least 30 minutes.

Or

- An increased sludge temperature should be maintained for a prescribed period of time according to the guidelines shown in Table 3-2:

Table 3-2 Time and Temperature Guidelines				
Total Solids	Temperature [t]	Time [D]	Equation (days)	Notes
≥ 7%	> 50 °C	> 20 min	$D=\frac{131,700,000}{10^{0.14t}}$	No heating of small particles by warmed gases or immiscible liquid.
≥ 7%	>50 °C	> 15 sec	$D=\frac{131,700,000}{10^{0.14t}}$	Small particles heated by warmed gases or immiscible liquid.
< 7%	> 70 °C	15 sec to 30 min	$D=\frac{131,700,000}{10^{0.14t}}$	
< 7%	> 50 °C	> 30 min	$D=\frac{50,070,000}{10^{0.14t}}$	

Or

- The pH of the sludge is raised to greater than 12 for at least 72 hours. During this time, the temperature of the sludge should be greater than 52 °C for at least 12 hours. In addition, after the 72-hour period, the sludge is to be air dried to at least 50 percent total solids. This is a possible alternative for chemical stabilization.

Or

- The sludge is analyzed for the presence of viruses (plaque-forming units) and viable helminth ova. The sludge can be analyzed before or after the pathogen reduction process. However, analyzing for viruses before pathogen reduction requires that the operating parameters for the pathogen reduction process be monitored. The sludge must meet both of the following criteria to be Class 'A':

  - The density of viruses at the time of use or disposal must be less than 1 plaque-forming unit per 4 grams of total solids (1 PFU/4 g TS).

- The density of viable helminth ova at the time of use or disposal must be less than 1 per 4 grams of total solids (1/4 g TS).

3.2.2.2. Class 'B'. All Class 'B' sludge must meet one of the following criteria at the time the material is used or disposed of:

Either

- The sludge meets PSRP or PSRP equivalency requirements. The processes that meet PSRP requirements are described below:

  (1) **Aerobic Digestion** - Sewage sludge is agitated with air or oxygen to maintain aerobic conditions for a mean cell residence time and temperature between 40 days at 20 °C and 60 days at 15 °C.

  (2) **Air Drying** - Sewage sludge is dried on sand beds or on paved or unpaved basins for a minimum of three months. During two of the three months, the ambient average daily temperature is above 0 °C.

  (3) **Anaerobic Digestion** - Sewage sludge is treated in the absence of air for a mean cell residence time and temperature between 15 days at 35 to 55 °C and 60 days at 20 °C.

  (4) **Composting** - Using either the within-vessel, static aerated pile, or windrow composting methods, the temperature of the sewage sludge is raised to 40 °C or higher for five days. For four hours during the five days, the temperature in the compost pile exceeds 55 °C.

  (5) **Lime Stabilization** - Sufficient lime is added to the sewage sludge to raise the pH of the sewage sludge to 12 after two hours of contact.

Or

- At least seven sludge samples should be collected at the time of use or disposal and analyzed for fecal coliform during each monitoring period. The geometric mean of the density of these samples will be calculated and should meet one of the following criteria:
  - Less than 2,000,000 Most Probable Number per gram of total solids (2,000,000 MPN/g TS).

- Less than 2,000,000 Colony Forming Units per gram of total solids (2,000,000 CFU/g TS).

A 1992 Black & Veatch survey of over 50 publicly owned treatment works (POTWs) found that most sludges that have been stabilized through the anaerobic digestion process will meet the fecal coliform pathogen requirements for Class 'B'. A more limited survey found that some aerobically digested sludges may not meet these criteria. It should be noted that most of the GBRA study participants use the aerobic digestion process as the primary stabilization method.

3.2.3 Vector Attraction Reduction Requirements

Vector attraction reduction reduces the potential for spreading of disease by vectors (i.e. flies, rodents, and mosquitoes). One of the reduction criteria listed below must be met prior to use or disposal:

(1) **Aerobic or Anaerobic Digestion** - Volatile solids (VS) are reduced by 38 percent or more. VS destruction is measured between the influent to sludge stabilization and the sludge ready for use or disposal. This criterion should readily be met by most anaerobic digesters, but seldom by aerobic digesters. POTWs with aerobic digesters will need to meet the vector attraction reduction requirement through Alternative (3) or Alternative (4) below.

(2) **Anaerobic digestion** - If 38 percent VS cannot be achieved, then VS reduction must be less than 17 percent when sludge is digested an additional 40 days at 30° to 37° C or higher in a bench-scale unit.

(3) **Aerobic digestion** - If 38 percent VS cannot be achieved, then VS reduction must be less than 15 percent when sludge at less than 2 percent total solids is digested an additional 30 days at 20 °C in a bench-scale unit.

The SOUR test under Alternative (4) will be more convenient for POTWs with aerobic digesters or extended aeration treatment. However, if a POTW cannot meet the SOUR criteria, it should be able to satisfy the Alternative (3) vector attraction reduction criterion.

(4) **Aerobic digestion** - Specific oxygen uptake rate (SOUR) is less than or equal to 1.5 mg 0_2/hr-gram of total solids (TS) at 20 °C.

(5) **Composting or other aerobic process** - Temperature is kept at greater than 40 °C for at least 14 days. The average temperature during this time should be greater than 45 °C.

(6) Chemical stabilization - pH is raised to at least 12 for 2 hours without the addition of more alkali, and remains at or above 11.5 for an additional 22 hours.

(7) **Heat or air drying** - TS is at least 75 percent when sludge does not contain unstabilized solids generated in a primary wastewater treatment process. Blending with other materials is not allowed to achieve the total solids percent.

(8) **Heat or air drying** - TS is at least 90 percent when sludge does contain unstabilized primary solids. Blending with other materials is not allowed to achieve the total solids percent.

(9) **Liquid land application** - Liquid sludge is injected beneath the surface with no significant amount of sludge present on the surface after one hour. If the sludge is Class 'A' for pathogen reduction, the sludge must be injected within 8 hours of discharge from the pathogen reduction process.

(10) **Land application** - Sludge is incorporated into the soil within six hours of application. If the sludge is Class 'A' for pathogen reduction, the sludge must be incorporated within 8 hours of discharge from the pathogen reduction process.

(11) **Surface disposal** - Sludge placed on an active unit is covered with soil or other material at the end of each operating day.

3.2.4 Management Practices

For sludge that does not meet all of the highest quality requirements (i.e., APL, Class 'A'), the following management practices must be followed:

- Apply sludge at a whole sludge application rate that is less than or equal to the agronomic rate for the site.
- Do not apply sludge if it is likely to adversely affect a threatened or endangered species.

- Do not apply to a site that is flooded, frozen, or snow-covered so that the sewage sludge enters a wetland or other surface water.
- Do not apply less than 10 meters from surface water.

3.2.5 Site Restrictions

For any land-applied sludge that meets Class 'B' pathogen reduction requirements, but not Class 'A', these site restrictions must be followed:

- Do not harvest food crops with harvested parts that touch sludge (melons, cucumbers, squash) for 14 months after application.
- Do not harvest food crops with harvested parts below soil surface (potatoes, carrots, radishes) for 20 months after application if sludge was not incorporated for at least 4 months.
- Do not harvest food crops with harvested parts below soil surface (potatoes, carrots, radishes) for 38 months after application if sludge was incorporated in less than 4 months.
- Do not harvest food crops, feed crops, or fiber crops for 30 days after application.
- Do not graze animals on the site for 30 days after application.
- Do not harvest turf for one year after application if turf is placed on land with a high potential for public exposure, or a lawn unless otherwise specified by the permitting authority.
- Public access to land with a high potential for public exposure shall be restricted for one year after application of the sewage sludge.
- Public access to land with a low potential for public exposure shall be restricted for 30 days after application of the sewage sludge.
- Sludge that is distributed and marketed must be accompanied by a label or information sheet which gives the following consumer information:

    - The name and address of the preparer.
    - A statement similar to the following:

        "Application of this sewage sludge product to the land except in accordance with these instructions is prohibited."
    - The annual whole sludge application rate that will not exceed annual pollutant loading rates.

3.2.6 Site Permits

Before land application of sludge with metals concentrations above the APLs begins at any site, the applicator must contact the permitting authority first to determine whether bulk sewage sludge has been applied to the site before, and the quantity that was applied. The applicator must also provide the TNRCC with the location of a new site, its name, address, telephone number, and NPDES permit number.

If bulk sludge is transported over state lines for application, the sludge preparer must notify the permitting authority for the state where the sludge is applied of the following information:

- Site location - street address or latitude and longitude.
- Approximate time period for application.
- Preparer's name, address, telephone number, and NPDES permit number.
- Applicator's name, address, telephone number, and NPDES permit number.

3.2.7 Frequency of Monitoring

Monitoring frequency is based upon the annual sludge production at each plant. After two years of monitoring, the permitting authority may reduce the frequency of monitoring for pollutants and pathogens if sludge quality and pathogen stabilization are consistently within required limits. Monitoring must occur at least annually. Table 3-3 shows monitoring frequencies for various sludge production rates.

Table 3-3
Frequency of Monitoring

Annual Sludge Production (dry metric tons/year)	Annual Sludge Production (dry tons/day)	Annual Monitoring (times/year)
< 290	< 0.87	Annually
290 - 1,500	0.87 - 4.5	Quarterly
1,500 - 15,000	4.5 - 45	Bi-Monthly
> 15,000	> 45	Monthly

3.2.8 Recordkeeping

Information for recordkeeping requirements should be developed and retained for five years. Recordkeeping requirements for the highest quality sludge (APL, Class 'A') include the following:

- The concentration of each pollutant.
- Descriptions of how the pathogen requirements and vector attraction requirements are met.
- Signed certification statements of compliance.

Recordkeeping requirements for sludge that does not meet the highest quality requirements will be increased and can include any or all of the following:

- Site information - location, area, application dates and times, and amount of sludge and pollutants applied.
- Descriptions of how management practices, information gathering, and/or site restrictions are met.
- Additional certifications statements.

3.3 State Regulations for Sludge Management

States are allowed to adopt sludge regulations at least as strict as 40 CFR Part 503. Regulations for sewage sludge use and disposal at the state level were proposed by the Texas Water Commission (TWC) (now the TNRCC) in the April 9, 1993, *Texas Register*. After comments were incorporated, the finalized rule was adopted and published August 6, 1993. These state regulations are codified in 31 Texas Administrative Code (TAC) Chapter 312, *Sludge Use, Disposal, and Transportation*, and were effective August 19, 1993. Overall, the finalized regulations are very similar to the regulations promulgated by the USEPA in 40 CFR Part 503. However, there are various additions that have been incorporated at the state level that warrant recognition. This section presents a summary of additional regulations, rules, and practices adopted by the TNRCC that are not covered by the federal regulation.

3.3.1 Subchapter 'A' - General Requirements

Most of the significant differences between the Texas regulations and the federal rule are contained in the General Provisions Subchapter of 31 TAC Chapter 312. Unlike

the federal regulations, the Texas version also regulates water plant sludge and sludge transport, although these practices are dealt with in separate subchapters not published with the sewage sludge regulations. In addition to the federal exclusions from the rule, this chapter does not apply to wastes resulting from oil, gas, or geothermal exploration, development, and production, or sewage sludge or septage mixed with these wastes. The Texas regulations also exclude experimental use of sewage sludge if, when placed on a beneficial use site or reclamation site, the following conditions are met:

- The total amount of sludge used for one project is less than 25 dry tons or, for all projects by a permittee, less than 50 dry tons.
- All metal concentrations are below the ceiling limits.
- Vector attraction reduction requirements are met.
- Pathogen reduction requirements are met.
- Prior written approval is received from the State.
- The project duration is less than 18 months.

The Texas regulations require a *permit or a site registration* for the beneficial use or disposal of sewage sludge meeting the Class 'B' pathogen reduction requirements, or water treatment sludge. A beneficial use site which qualifies for a permit exemption or for which a permit has not been issued must, at least, be *registered*. A permit exemption is allowed if the following conditions are met:

- The requirements in Subchapter B-Land Application for Beneficial Use are met.
- The pH of the soil at the beneficial use site is greater than 5.5.
- The beneficial use site application area is 1,500 acres or less.
- The beneficial use site receives a minimum of 14 inches of rainfall annually or a comparable amount of irrigation.

Term limits for registration or permits will not exceed five years, including those approved before the effective date of the regulation. Registrations or permits that have been in existence for longer than five years before the effective date of the regulation must submit a renewal application before March 1, 1994. Permit registration requirements do not apply to any person who receives sewage sludge or a derived material sold or given away in a bag or similar enclosure if the material meets the APL metals

concentrations, meets Class 'A' pathogen reduction requirements, and meets a processor vector attraction reduction method.

The Texas regulations establish a sludge fee program based on the amount of sludge disposed of and the disposal/beneficial use method. Each entity holding a registration or permit to treat, process, or dispose of sewage sludge or water treatment sludge is assessed an annual fee, the amount of which is determined by the weight of dry solids disposed of and reported to the commission as of September 1 of each year. Intended to promote beneficial use of highly stabilized sludge, the fees are as follows:

- A minimum fee of $100 is assessed for each registration or permit whether the site is active or inactive.
- Land application of Class 'A' sludge - $0.50 per dry ton.
- Land application of Class 'B' sludge - $0.75 per dry ton.
- Surface disposal - $1.25 per dry ton.
- Incineration - $1.25 per dry ton.

An annual fee is also assessed against each entity holding a registration to transport sewage sludge, water treatment sludge, or septage based on the volume transported. All fees must be paid before October 1 of each year. Failure to pay is sufficient cause for the Commission to revoke the registration or permit, and authorization to process or dispose of waste.

The Texas regulations detail the permit and registration applications processing procedures that must be followed (including references to other chapters of 31 TAC), as well as policies for land application, registration, cancellation, transfer, and re-registration. Among other things, permit applications must include a list and map of land owners adjacent to or within 1/2 mile of the permit site. Persons intending to land apply sludge for beneficial use without a permit must notify the executive director in writing and provide information including a description and composition of the sludge, a description of the sludge-generating processes, and application site information such as location, ownership, soil and subsurface conditions, and management methods.

Specific requirements for public notice, posting of notice, and public meetings are detailed in the Texas regulations. These requirements apply to permit or registration applications (or major amendments) to land apply, surface dispose, or incinerate sludge. Public notice consists of notification by the Commission of various public officials, and applicant placement of the complete application at a courthouse or public library for 30

days of public review. Concurrent with the 30-day public review period, notices must be posted at the proposed site. If a public meeting is requested, the Executive Director decides whether one should be held, and there are specific requirements for advertising the meeting. The purpose of the public meeting is to "facilitate constructive communication between applicants and members of the public and to allow citizens to provide the commission with additional information..." [31 TAC 312.13 (e)(1)], and is not a contested case hearing.

3.3.2 Subchapter 'B' - Land Application for Beneficial Use

Texas land application requirements are very similar to those of 40 CFR Part 503. Most of the differences between the state and federal regulations are a result of additional general requirements and management practices. As an additional general requirement, 31 TAC 312.42(i) states that the "applicant shall determine the background levels of regulated metals in the top six inches of the soil and demonstrate to the satisfaction of the commission that the proposed cumulative metal loading will result in a non-toxic condition or reduce the toxicity of the existing soil." As opposed to federal management practices, no application of sludge to frozen or snow-covered ground is allowed. Buffer zones for the land application of Class 'B' sludge are more detailed than 40 CFR Part 503. The following is a list of buffer zones from 31 TAC 312.44.(d):

- Bulk sewage sludge cannot be applied within 200 feet (60 meters) of state waters.
- For private water supply wells, the buffer distance must be 200 feet (60 meters), and for public wells 500 feet (150 meters).
- Buffer zones to solution channels, sinkholes, or other conduits to groundwater must be 200 feet (60 meters).
- Buffer zones to an occupied residence or public right-of-way must be 300 feet (90 meters).
- Sewage sludge cannot be applied within 1,000 feet (300 meters) of existing schools, institutions, residential, or business development property lines.
- Sewage sludge cannot be applied within 50 feet (15 meters) of a property boundary.
- Sewage sludge cannot be applied within 10 feet (3 meters) of irrigation conveyance canals.

The Texas regulations limit sewage sludge application to land with a seasonal high water table, groundwater table, or depth to water-saturated soils more than three feet below the treatment zone for soils with moderate to slow permeability (less than two inches per hour), or four feet below the treatment zone for soils with rapid to moderately rapid permeability (between six and two inches per hour). In addition, Texas regulations require sludge application by a method and under conditions that prevent runoff beyond the active application area, and protect the quality of the surface water and the soils in the unsaturated zone. Although an application method is not directly stated, the regulation lists numerous conditions under which sewage sludge must be land applied. The following conditions for land application can be found in section 31 TAC 312.44.(h)(1)-(9) and (i):

- Sludge must be applied uniformly over the surface of the land.
- Sludge applied to unvegetated soil must be incorporated into the soil within 48 hours of application.
- Sludge cannot be applied to areas where permeable surface soils are less than two feet thick.
- Sludge cannot be applied during rainstorms or during periods in which the surface soils are water-saturated.
- Sludge cannot be applied to areas having topographical slopes in excess of 8.0 percent.
- If sludge is not incorporated into the soil within 48 hours of application, stormwater runoff generated by storms of up to a 10-year, one-hour event shall be prevented from leaving the application area. Berm construction may be required if deemed necessary.
- Where runoff from the application area is evident, application must cease until the problem is corrected.
- Sludge applied to land within a designated 100-year floodplain must be incorporated into the soil within 24 hours. Sludge cannot be applied to land within a designated floodway.
- If a 100-year floodplain is not designated, the applicant must demonstrate to the satisfaction of the Executive Director that site inundation will be prevented or that the site is not subject to flooding.
- Public health nuisances such as dust and tracking of mud onto roads must be abated.

Monitoring, recordkeeping, and reporting requirements are similar to the federal requirements except that the reporting deadline is September 1 of each year.

3.3.3 Subchapter 'D' - Pathogen and Vector Attraction Reduction

The actual processes specified in the Texas regulations for meeting pathogen and vector attraction reduction requirements are identical to federal definitions. However, the Texas regulations introduce a more restrictive definition of Class 'A' and Class 'B' pathogen reduction that involves an interim compliance period. After March 1, 1994, PFRP, PSRP, and equivalence definitions no longer qualified as compliance alternatives for meeting Class 'A' and Class 'B' designation. In general, this caused more of an emphasis on microbiological testing to determine sludge quality. Site restrictions for Class 'B' land application and vector attraction reduction compliance criteria are almost identical to federal requirements.

4.0 Existing Conditions

This section of the report describes the existing conditions for the study participants in the GBRA study area. Included are descriptions of: the study participants' wastewater treatment facilities, quantity and quality of sludge produced, and the disposal/reuse methods currently in place.

4.1 Wastewater Treatment Facilities

This section of the report describes the existing wastewater treatment facilities currently being operated by the study participants. Tables 4.1.1 and 4.1.2 describe the facilities in detail, and a brief description of facilities by participant follows.

Table 4.1.1
Participant Summary
(General Information)

Operator	Facility (WWTP)	Contact	Phone Number	EPA/TNRCC Permit Number	Permitted Capacity (mgd)	Treatment Process
New Braunfels Utilities	Gruene	John Toeller	210-625-0289	TX0070939/10232-002	1.1	Activated Sludge
	Kuehler-South	John Toeller	210-625-0289	TX0067881/10232-001	4.2	Activated Sludge
	Kuehler-North	John Toeller	210-625-0289	TX0088170/10232-003	3.1	Activated Sludge
GBRA	Lockhart	Edward Montana	210-398-6052	TX0023868/10210-001	1.1	Activated Sludge
	Springs Hill	Nelson Erxleben	210-379-5822	TX0025216/11427-01	0.3	Activated Sludge
	Northcliffe	Nelson Erxleben	210-379-5822	TX0101184/11751-01	0.3	Activated Sludge
	Canyon Park	Nelson Erxleben	210-379-5822	TX0025224/11496-01	0.1	Activated Sludge
	Dunlap	Nelson Erxleben	210-379-5822	TX0025208/11378-01	0.085	Activated Sludge
The City of Luling	South	Chris Powell	210-815-9566	TX0022772/10582-001	0.5	Activated Sludge
	North	Chris Powell	210-815-9566	TX0022764/10582-02	0.9	Activated Sludge
San Marcos	S.M. WWTP	Alfonso Carmona	512-353-4444	TX0047945/10273-002	6.25	Activated Sludge
The City of Seguin	Walnut Branch	Linda Beal	210-379-3212	TX0022365/10277-001	4.0	Activated Sludge Trickling
	Geronimo Creek	Linda Beal	210-379-3212	TX103535/10277-003	2.13	Activated Sludge

Table 4.1.2
Wastewater Treatment/Sludge Summary

Facility (WWTP	Plant Flow [1] MGD	Discharge Limits BOD/TSS/NH3-N/P/DO[2]	Dewatering System Method	Participants Estimated Dewatering Sludge[3] % Total Solids	Sludge Stabilization Process	Sludge Disposed[4] Dry Tons per Year
Gruene	0.027	5/10/3/0/4	Drying Beds	16[5]	Aerobic Digestion	551[6]
Kuehler-South	1.51	10/15/0/0/4	Belt Press[7]	"	Aerobic Digestion	"
Kuehler-North	1.73	20/20/0/0/2	"	"	Aerobic Digestion	"
Lockhart	1.25	10/15/3/0/4	Drying Beds	18-20	Aerobic Digestion	587
Springs Hill	0.09	20/20/0/0/0	N/A	1-2	Aerobic Digestion	9
Northcliffe	0.15	65/0/0/0/0	N/A	1-2	Aerobic Digestion	9
Canyon Park	0.03	10/15/0/1/0	N/A	1-2	Aerobic Digestion	7
Dunlap	0.08	10/15/0/0/0	N/A	1-2	Aerobic Digestion	6
Luling-South	0.15	20/20/0/0/0	Drying Beds	15-20	Aerobic Digestion	22
Luling-North	0.33	20/20/0/0/0	Drying Beds	15-20	Anaerobic Digestion	36
San Marcos	5.00	20/20/0/0/0	Drying Beds Centrifuge	15-20	Aerobic Digestion	800
Walnut Branch	3.98	20/20/0/0/4	Belt Press	18	Aerobic Digestion	89
			Drying Beds	38		
Geronimo Creek	0.83	20/20/0/0/2	Drying Beds	32	Aerobic Digestion	61
					TOTAL	2,177

[1]Actual 30 day monthly average

[2]BOD is Biological Oxygen Demand, TSS is Total Suspended Solids, NH3-N is Ammonia Nitrogen, P is Phosphorus, and DO is Dissolved Oxygen.

[3]Percent total solids are estimates provided by the individual participants.

[4]Disposal quantities were not determined based on the plant flow, but are actual recorded quantities of hauled sludge for the year 1994. These quantities were submitted by the particpants to the Engineer in the sludge survey form.

[5]This figure is an average of the percent total solids disposed by all three New Braunfels Utilities plants.

[6]This figure is the total daily tonnage disposed by all three New Braunfels Utilities plants.

[7]This belt press is located at the North Kuehler plant. the waste activated sludge is pumped from the South Kuehler plant to the North Kuehler plant for dewatering.

4.1.1 New Braunfels Utilities

The New Braunfels Utility system is composed of three activated sludge treatment plants. Total permitted capacity is 8.4 mgd, and recent flows have averaged approximately 3.5 mgd. Aerobic digestion is used to stabilize the sludge produced at the sites. The Kuehler-South and Kuehler-North plants are served by a belt press (located at the Kuehler-North site) to dewater sludge solids. The Gruene plant utilizes drying beds for dewatering. A combined annual total of 536 dry tons of sludge is currently produced from all three facilities.

4.1.2 Guadalupe-Blanco River Authority (GBRA)

The GBRA operates five activated sludge treatment plants with a total permitted capacity of 1.615 mgd. The plants are located from Canyon Lake to Seguin along the Guadalupe River. Recent flows have averaged 1.6 mgd. Total combined annual sludge production from all facilities is 626 dry tons.

Four of the sites (Springs Hill, Northcliffe, Canyon Park, and Dunlap) are extended aeration plants based on the oxidation ditch design. Based on an extended sludge age, aerobic digestion occurs within the oxidation ditch system. No dewatering system is utilized at these sites. Liquid sludge is directly removed and land applied at the GBRA land application site.

The Lockhart site is a conventional activated sludge plant. Aerobic digestion is used for stabilization of sludge solids. Dewatering is achieved by means of drying beds, and the dewatered sludge is hauled to the Texas Disposal Systems Landfill in Austin for final disposal.

4.1.3 City of Luling

The City of Luling operates two activated sludge treatment plants with a total permitted capacity of 1.4 mgd. Recent combined flows have averaged 0.480 mgd. A combination of anaerobic and aerobic digestion is utilized for sludge stabilization. Sludge dewatering is accomplished by means of drying beds at each plant site. Total combined annual sludge production for 1994 was 58 dry tons.

4.1.4 City of San Marcos

The City of San Marcos operates a single activated sludge treatment plant with a permitted capacity of 6.25 mgd. Recent flows have averaged approximately 5.0 mgd. Sludge is stabilized by aerobic digestion. Dewatering is accomplished by drying beds

with additional use of a centrifuge as required. Total annual sludge production for 1994 was 922 dry tons.

4.1.5 City of Seguin

The City of Seguin operates two treatment plants with a total permitted capacity of 6.13 mgd. Recent flows have averaged 4.65 mgd. The Walnut Branch site utilizes both the activated sludge process and trickling filters. The Geronimo Creek site is an activated sludge plant. Both locations utilize aerobic digestion to stabilize sludge solids. The Walnut Branch site has both a belt press and drying beds to dewater sludge solids; the Geronimo Creek site utilizes drying beds only. Total combined annual sludge production for both facilities is 538 dry tons.

4.2 Sludge Quantity (Disposed)

The participating plants average disposed dry tons of sludge per million gallons a day (dry tons/mgd) plant flow was 0.4 with an upper and lower range of 1.3 and 0.1. The participants' cumulative year-end disposed dry tonnage/year was 2,177 dry tons. For individual plant year-end disposal quantities, reference Table 4.2.1, Existing Disposal Practices Summary.

In projecting anticipated sludge productions for the individual plants through the year 2025, several population projections were first established. First, a 1995 population base line was determined for each county. Once this was set, each county's anticipated population growth was established, also through the year 2025, (see Figure 4.2.1). From this particular data, each county's projected population growth was determined in percentage; and, finally, this calculated percentage was use to determine the individual plant projected flows through the year 2025, (see Table 4.2.2, Sludge Production Projections). For the sludge production projection for the entire four-county study region, reference Figure 4.2.2.

Table 4.2.1
Existing Disposal Practices Summary

Plant	Sludge Disposal Method	Sludge Disposed Dry Ton/Yr	Annual Operation[8] Cost $	Annual Disposal Fees 1$	Total Annual Disposal Cost $	Annual Disposal Cost $/Dry Ton	
						Per Plant	Per Operator
Gruene	Comal Landfill	551 [9]	15,835	44.165	60,000	109	109
Kuehler (North & South)	Comal Landfill	"	"	"	"	"	
Lockhart	TDS Landfill	587	N/A	50.000	50,000	85	93
Springs Hill	Gerdes Land Applied	9	1,768	N/A	1,768	197	
Northcliffe	Gerdes Land Applied	9	3,600	N/A	3,600	400	
Canyon Park	Gerdes Land Applied	7	1,893	N/A	1,893	270	
Dunlap	Gerdes Land Applied	6	1,139	N/A	1,139	190	
Luling South	Luling Landfill	22	189	N/A	186	9	9
Luling North	Luling Landfill	36	291	N/A	305	9	
San Marcos	BFI Landfill	800	N/A	80.000	80,000	100	100
Walnut Branch	BFI Landfill	89	7,249	3.865	11,137	125	120
Geronimo	BFI Landfill	61	4,509	2.324	6.833	112	
TOTAL		2,177			215,662		Average Disposal $/Dry Ton[10] $99.06

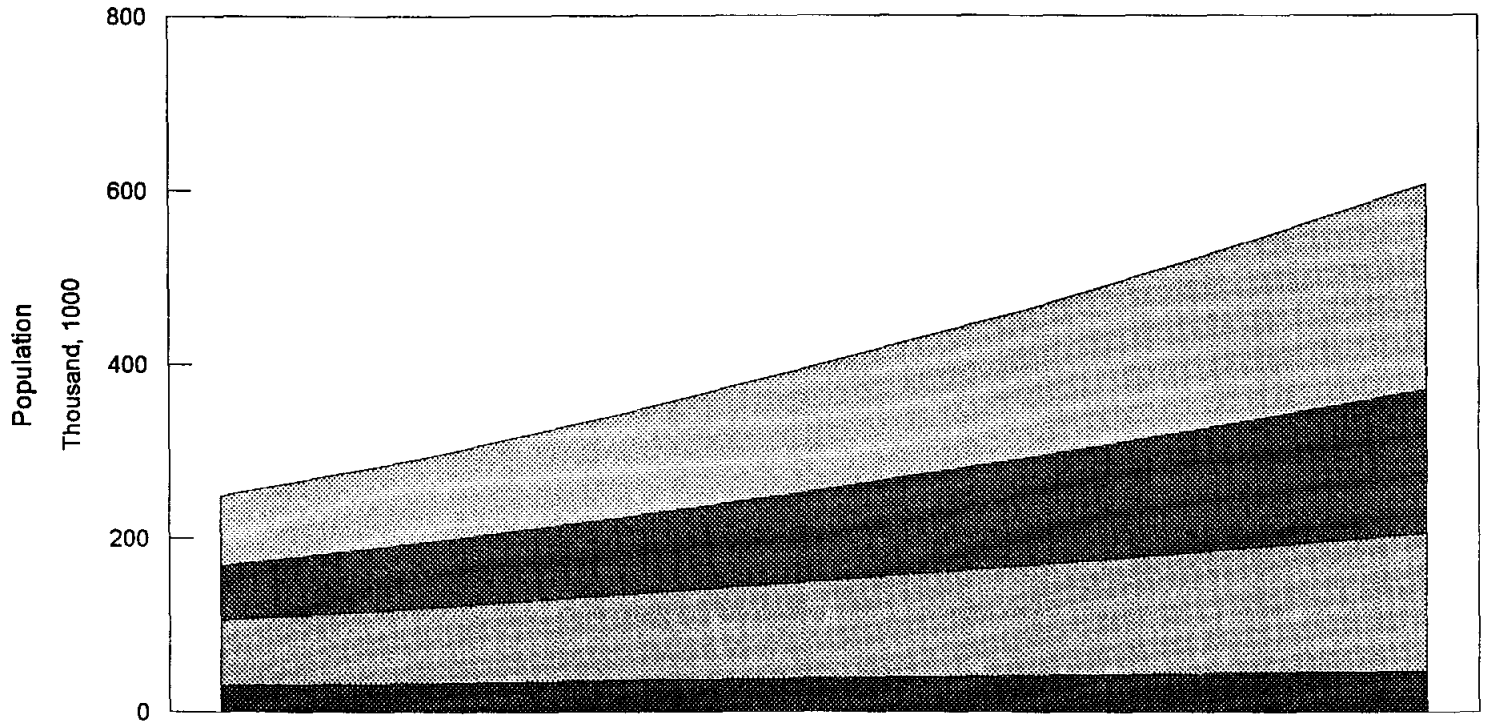
[8]Annual operation cost includes cost to transport sludge to disposal site.

[9]This figure is the total yearly tonnage disposed by all three New Braunfels Utilities plants.

[10]This is the overall dollars per dry-ton considering all the participants.

GBRA Regional Sludge Study

Population Projection for Caldwell, Guadalupe, Comal, & Hays



Year	1995	2000	2005	2010	2015	2020	2025
Caldwell	29,617	32,351	35,289	38,281	41,287	44,017	46,380
Guadalupe	74,878	85,959	97,983	111,150	125,678	141,314	157,899
Comal	63,124	76,158	90,422	106,194	124,140	144,369	165,967
Hays	80,930	97,646	118,901	144,079	170,377	201,122	236,286

Population projections based on "Most Likely Series"

FIGURE 4.2.1

Table 4.2.2
Sludge Disposal Projection[11]
Dry Tons/Year

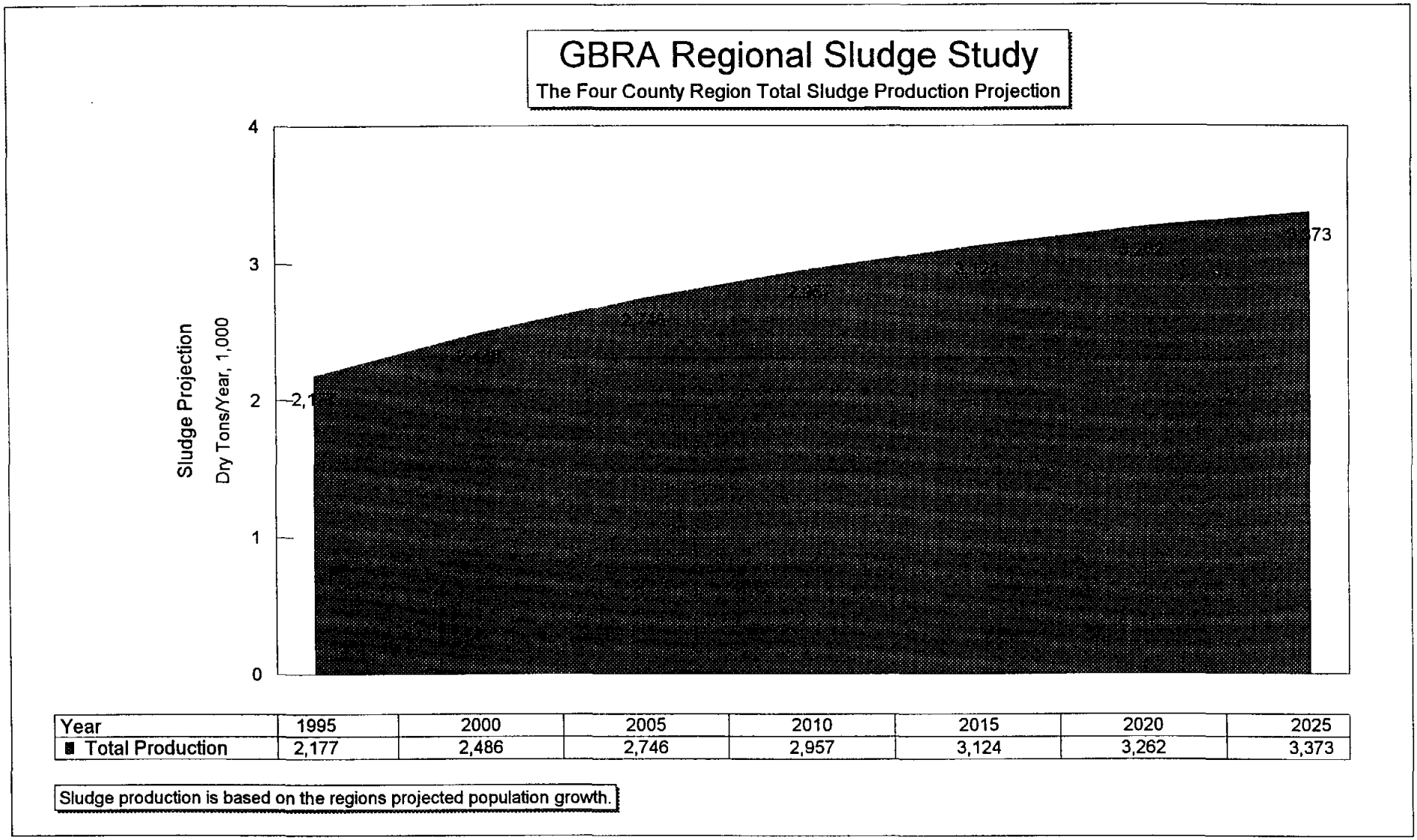
County	Plant	Year						
		1995	2000	2005	2010	2015	2020	2025
Caldwell	Luling-South	22	24	26	27	28	29	30
	Luling-North	36	39	42	44	46	48	49
	Lockhart	587	637	681	720	753	780	800
Guadalupe	Springs Hill	9	10	11	12	13	13	14
	Dunlap	6	7	7	8	8	9	9
	Walnut Creek	89	100	110	118	125	130	135
	Geronimo Creek	61	69	76	81	86	90	93
	Northcliffe	9	10	11	12	13	13	14
Comal	Gruene	551[12]	645	717	775	822	861	892
	Kuehler-South	-	-	-	-	-	-	-
	Kuehler-North	-	-	-	-	-	-	-
	Canyon Park	7	8	9	10	10	11	11
Hays	San Marcos	800	937	1,055	1,151	1,220	1,278	1,326
	TOTAL	**2,177**	**2,486**	**2,745**	**2,958**	**3,124**	**3,262**	**3,373**

4.3 Sludge Quality

As part of this study, participants were asked to provide the most recent information on sludge quality, particularly with respect to nutrients and regulated metals concentration. Because most participants are currently disposing of sludge by landfilling, the needed information required for land applying sludge was not available. Therefore, arrangements were made by GBRA staff to have all participants' sludge samples analyzed

[11]It was assumed that each plant's sludge disposal quantities would increase proportionally to its county's projected population growth.

[12]This figure is the total quantity of dry tons/year disposed by all three of the New Braunfels Utilities plants. This statement is valid for the New Braunfels Utilities combined plants quantity indicated through the year 2025.



Year	1995	2000	2005	2010	2015	2020	2025
Total Production	2,177	2,486	2,746	2,957	3,124	3,262	3,373

Sludge production is based on the regions projected population growth.

FIGURE 4.2.2

at the same time and by the same laboratories (GBRA and Lower Colorado River Authority [LCRA]).

Tables 4.3.1 and 4.3.2 describe the results from the sludge sampling conducted in early March 1995. Table 4.3.1 describes the wet chemistry parameters, particularly the nitrogen series, percent total solids, total phosphorus, and pH. There was a wide variation in results from the different participants due to the many methods used for stabilization and dewatering. For example, a representative sample obtained from a sludge drying bed may contain some inert materials, such as sand, which would reflect a reduced level of nutrients.

Also, the GBRA WWTPs (with the exception of Lockhart) currently have no dewatering capabilities. Because of this, additional transportation costs are necessary for land application due to the quantity of water in the sludge.

Table 4.3.2 describes the sludge quality with respect to the ten (10) regulated heavy metals. Also, the "Ceiling" and "APL" concentrations are listed as a comparison (please see Section 3.2.1, Table 3-1 for an explanation of these values). All of the study participants met the minimum ceiling requirements and, with the exception of the Gruene WWTP result for molybdenum (Mo), all results showed that the most stringent requirements of both the federal and state rules were met. However, the US EPA dropped the Table 3 limit for Mo, and it is expected that the state will do the same in their next ruling release (expected by summer 1995). Therefore, these results indicate there are no serious problems with meeting the minimum requirements for sludge to be land applied.

Table 4.3.1
Sludge Quality Summary
(Wet Chemistry[13])

Plant WWTP	Parameter					
	TKN As Nitrogen mg/kg[14]	Ammonia Nitrogen mg/kg	Nitrate Nitrogen mg/kg	Sludge Total Solids %	Total Phosphorus mg/kg	pH, Lab SU[15]
Gruene	64,013	4,790	22.3	15.7	18.089	6.95
Kuehler (North & South)	30,804	3,289	424	11.2	21,786	6.81
Lockhart	42,574	5,038	23.8	10.1	16,000	6.82
Springs Hill	52,190	5,884	19.8	1.2	17,686	7.25
Northcliffe	64,512	6,936	2.4	1.2	16,290	6.76
Canyon Park	34,854	1,296	2.6	2.9	9,635	7.23
Dunlap	51,054	4,169	5.3	1.7	16,257	7.02
Luling-South	20,681	2,098	7.3	19.1	8,639	6.87
Luling-North	63,089	4,084	33.3	11.4	18,246	7.03
San Marcos	63,089	6,368	13.0	12.3	17,886	6.69
Walnut Branch	4,747	587	570	55.3	14,466	6.42
Geronimo Creek	1,286	503	781	58.9	12,903	6.07
Average	35,817	3,753	133.7	16.8	15,657	6.83
Maximum	64,013	6,936	781	58.9	21,786	7.25
Minimum	1,286	503	2.6	1.2	8,639	6.07

[13]Samples collected in March 1995 and analyzed by GBRA and Lower Colorado River Authority (LCRA) laboratories.

[14]mg/kg - milligrams per kilogram (ppm), dry weight basis.

[15]SU is the abbreviation for Standard Units

Table 4.3.2
Sludge Quality Summary
(Metals)

Plant WWTP	Metals									
	Arsenic mg/kg[16]	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Lead mg/kg	Mercury mg/kg	Molybdenum mg/kg	Nickel mg/kg	Selenium mg/kg	Zinc mg/kg
Ceiling Concentration 503 Table 1	75	85	3,000	4,300	840	57	75	420	100	7,500
Pollutant Concentration 503 Table 3	41	39	1,200	1,500	300	17	**[17]	420	36	2,800
Gruene	<3	2	66	640	57	2	60	15	11	1,284
Kuehler (North & South)	<3	7	690	473	80	2	11	354	8	2,062
Lockhart	<3	4	15	478	40	2	5	16	7	618
Springs Hill	<4	2	13	162	32	3	4	12	10	564
Northcliffe	<4	1	7	243	16	3	3	8	8	258
Canyon Park	<2	5	21	574	74	6	5	18	16	2,443
Dunlap	<3	2	11	276	26	4	5	14	9	458
Luling South	<3	2	19	225	36	1	2	10	4	368
Luling North	<3	6	40	730	152	2	8	29	13	1,505
San Marcos	<3	3	14	355	26	1	10	28	8	493
Walnut Branch	<3	6	90	463	146	2	9	18	9	1,060
Geronimo	<3	8	320	217	37	3	4	10	5	474
Average	<3	4	1,306	405	60	3	11	44	9	966
Maximum	<4	8	690	730	152	6	60	354	16	2,443
Minimum	<2	1	7	162	16	1	2	8	4	258

[16]mg/kg - milligrams per kilogram(ppm), dry weight basis.

[17]Note that the State 30 TAC, Chapter 312 rules have an 18 mg/kg limit; however, it is anticipated that this particular pollutant, Molybdenum, will be removed from the state rules.

No sampling was conducted for pathogen reduction due to most participants landfilling their sludge as a disposal method. GBRA samples regularly for fecal coliform densities, and the City of San Marcos has similar data for their aerobically digested sludge product. The state rules currently require fecal coliform testing as the only method for proving a Class 'B' level of pathogen reduction, so, it is recommended that all study participants develop a pathogen reduction; monitoring program prior to land applying any of their sludge product. Table 4.3.3 shows the information provided on how each participant is currently meeting the minimum Class 'B' pathogen reduction criteria. This information was provided by each participant's spokesperson.

Another issue that needs consideration is the minimum vector attraction reduction requirements. GBRA and the City of San Marcos have conducted Specific Oxygen Uptake Rate (SOUR) testing on their sludge products to demonstrate compliance. However, most participants are using aerobic digestion as the only method of sludge stabilization, and this treatment method typically does not meet the minimum SOUR testing requirements for vector attraction reduction. Therefore, it is recommended that either vector attraction reduction option Nos. 9 or 10 be used. Options 9 and 10 relate to the incorporation of liquid or dewatered sludge, respectively, into the soil.

4.4 Existing Disposal/Reuse Methods

Presently, the participants are either landfilling or land applying their sludge as an ultimate disposal method. This section of the report describes these activities in more detail by participant.

The participants that are landfilling are: the New Braunfels Utilities at the Comal Landfill, the GBRA's Lockhart plant at the TDS landfill, and the cities of San Marcos and Seguin at the BFI landfill. Costs associated with landfilling are discussed in Section 6.1 and are presented in Table 5, Existing Disposal Practices Summary.

GBRA is presently the only participant that is land applying its sludge. The sludge produced by the GBRA plants (Springs Hill, Northcliffe, Canyon Park, and Dunlap) are being hauled to a 20-acre site owned by G. E. Gerdes, Jr. The TNRCC permitted application site is approximately 18 acres and is located in the southwest section of Guadalupe County (reference the attached four- county site map for location of the land application site). The expiration date on the permit is September 26, 1999.

The City of Luling transports its sludge to the city's post-closure landfill. The City has been authorized by the TNRCC to operate a composting facility at this location since 1990. This activity is allowed as long as the landfill cover is not damaged or the

potential for infiltration into the previously deposited waste does not occur. The facility is located on the north side of the City adjacent to the airport (reference the attached four-county site map for location of the post-closure landfill).

Table 4.3.3
Sludge Processing Summary

Facility (WWTP)	Sludge Stabilization Process	Pathogen Reduction (PR)		Type of Vector Attraction Achieved
		Level of PR Achieved	Method for verifying level of PR	
Gruene	Aerobic Digestion	Class 'B'	PSRP[18]	N/A[19]
Kuehler -South	Aerobic Digestion	Class 'B'	PSRP	N/A
Kuehler-North	Aerobic Digestion	Class 'B'	PSRP	N/A
Lockhart	Aerobic Digestion	Assuming Class 'B'[20]	N/A	N/A
Springs Hill	Aerobic Digestion	Class 'B'	Indicator Organism Densities	SOUR[21]
Northcliffe	Aerobic Digestion	Class 'B'	Indicator Organism Densities	SOUR
Canyon Park	Aerobic Digestion	Class 'B'	Indicator Organism Densities	SOUR
Dunlap	Aerobic Digestion	Class 'B'	Indicator Organism Densities	SOUR
Luling -South	Aerobic Digestion	Assuming Class 'B'	N/A	N/A
Luling-North	Anaerobic Digestion	Assuming Class 'B'	N/A	N/A
San Marcos	Aerobic Digestion	Class 'B'	Indicator Organism Densities	N/A
Walnut Branch	Aerobic Digestion	Class 'B'	PSRP	N/A
Geronimo Creek	Aerobic Digestion	Class 'B'	PSRP	N/A

[18]PSRP - Process to Significantly Reduce Pathogens

[19]N/A - Information not available

[20]Will require future verification using Indicator Organism Densities.

[21]SOUR - Specific Oxygen Uptake Rate

5.0 Agricultural Land Application

This section of the study describes the suitability of land in the area for sludge land application. Included are descriptions of: soils and agricultural practices in the area; the TNRCC site registration process; and calculations to determine land application rates and site life; factors for the selection of a site; and recommendations for a site.

5.1 Soil Conditions in Area

Taking into consideration that all existing, proposed, and potential land application sites are located on the east side of Interstate 35 (I-35), descriptions of soil conditions will be limited to Caldwell and Guadalupe Counties.

5.1.1 Caldwell County

Caldwell County is in the south-central part of Texas. The county has a total area of 348,160 acres, or 544 square miles. It is about 21 miles long and 25 miles wide.

The western two-thirds of the county is in the Texas Blackland Prairie area. This area slopes upward from the southeast to the northwest, rising from 400 feet to 600 feet in elevation. Most soils on the prairie are deep clays or clay loams. This area is about 243,000 acres in size.

The eastern one-third of the county is in the Texas Claypan area. The soils in this area are deep and have a fine sandy loam to fine sand surface layer. This area is about 105,000 acres in size. Generally, the pH for Caldwell County is within a range of 4.5 to 8.4.

The aforementioned information was collected from the United States Department of Agriculture Soil Conservation Services, "Soil Survey of Caldwell County, Texas".

5.1.2 Guadalupe County

Guadalupe County is in south-central Texas. The county is bordered on the north by Comal County and Hays County, on the west by Bexar County, on the south by Wilson County, and on the east by Gonzales and Caldwell Counties. Seguin, the county seat, is on U.S. Highway 90 near Interstate Highway 10, about 36 miles east of San Antonio and 160 miles west of Houston. The county covers 715 square miles or 458,240 acres.

The terrain of the county is nearly level to rolling. Elevations range from 300 to 900 feet. The county is bisected by the Guadalupe River. The soils range from deep clays in the northern half of the county to deep sandy loams and sands in the southern half.

The major soils in Guadalupe County are the Crockett, Demona, Windthorst, Maband, Darst, Vernia, and Uhland. These soils make up the Crockett-Demona-Windthorst Association which is approximately 33 percent of the county. The Crockett-Demona-Windthorst Association runs diagonally through the middle of the county from the southwest to the northeast. The second largest association is the Brayon-Barbarosa-Lewisville Association which is a combination of the Branyon, Barbarosa, Lewisville, Trinity, Queeny, and Burleson soils. This association runs along the north side of the Crockett-Demona-Windthorst Association, predominantly in the north, central, and southern portions of the county. The pH for the two associations is within a range of 5.6 to 8.4.

The aforementioned information was collected from the United States Department of Agriculture Soil Conservation Services, "Soil Survey of Guadalupe County, Texas".

5.2 Description of Agricultural Practices in Area

5.2.1 Caldwell County

The western two-thirds, as described above, is approximately 70 percent cultivated. Crops in this area is primarily cotton and grain sorghum. The native vegetation is trees, mainly along streams and tall grasses.

The eastern one-third, as described above, is approximately 35 percent cultivated. Crops in this area consist of peanuts, watermelons, truck crops and forage crops. The native vegetation is mostly tall grasses and hardwood trees.

The aforementioned information was also collected from the United States Department of Agriculture Soil Conservation Services "Soil Survey of Caldwell County, Texas".

5.2.2 Guadalupe County

Farming is the major enterprise. Cotton, corn, grain, sorghum, oats, peanuts, watermelons, and pecans are the principal crops. Cattle, hogs, and poultry are also produced. However, there is a trend toward the conversion of cropland to improve

grassland. This conversion is generally taking place on soils that are low in fertility and eroded. Brush encroachment is becoming a major concern.

The aforementioned information was also collected from the United States Department of Agriculture Soil Conservation Services "Soil Survey of Guadalupe County, Texas".

5.3 Site Registration Process

Persons desiring to land apply sludge for beneficial use must first submit an application to the Texas Natural Resource Conservation Commission (TNRCC). Initial requirements for the land application site include a soil pH greater than 5.5 standard units; an application area not greater than 1500 acres; and a minimum of 14 inches of annual rainfall or comparable irrigation.

The application form must be complete in its entirety and is to include all required supporting data and reports. Each informational request in the application requires a response so that no blanks exist on the form. Falsification of any information is justification for denial of the application, fine or imprisonment.

All applications require completed site soil analyses, metes and bounds legal description of the site with deed of record, and a copy of the TNRCC Transporter's Registration Approval Letter. Sludge analysis reports for nutrients and metals concentrations are also required for sludge produced at wastewater treatment plants. Other requirements include identification of the site operator and sludge source(s). For wastewater sludges, the pathogen reduction requirement must be stated, along with the vector attraction reduction method. The landowner must also be identified as must be any agent authorized to act for the landowner. Certain identified maps must also be submitted showing the application site boundaries and adjacent areas in addition to other required information such as water wells located in the area, soil data, and 100-year flood plain. Sludge application rates and methods must be calculated and reported for the planned vegetation crop(s). Additionally, public notice requirements must be fulfilled regarding the filing of an application for beneficial use.

5.4 Land Application Rate/Land Requirements

Attachment A in the Appendix describes the procedure used to determine the land application rate and land requirements to beneficially use sludge from the participants in

a land application program. This procedure closely follows that used for determining application rates when applying for a site registration through the TNRCC.

For this analysis, the following assumptions were used: the mass-weighted averages for sludge quality (nutrients and metals) were used; there is little, if any, residual plant available nitrogen (PAN) in the soil (please note that soil sampling was not conducted as part of this study); and, corn is to be grown with an anticipated yield of 150 - 200 bushels per acre. Additionally, a winter wheat crop will be cultivated with a target yield of 60 - 80 bushels per acre.

It is also assumed that all sludge land applied meet the minimum Class 'B' pathogen reduction criteria, but not the minimum vector attraction reduction criteria. Therefore, it is recommended that all sludge land applied be incorporated into the soil shortly after application.

From these calculations, the maximum "sludge application rate" based on nitrogen content (or SARn) was found to be at 7.6 dry tons per acre per year (dt/ac/yr). When performing the analysis for metals, it was determined that Mo is the limiting metal, followed by zinc (Zn). Since it is anticipated that the Mo limits will be removed from the revised state sludge rules in the near future, Zn will most likely be the limiting metal. The site life, when applied at an annual application rate of 7.6 dt/ac/yr and based on the current Mo limits, is estimated at 105 years. The site life increases to 170 years when considering Zn as the limiting metal.

The total land requirements were calculated to be 444 acres. This calculation was made assuming all of the study participants' sludge (3,373 dry tons per year) would be land applied at a rate of 7.6 dt/ac/yr.

5.5 Site Selection Process

There were several considerations that were used for determining a site for the land application of sludge including: soils conditions, proximity to sludge generators, and types of crops grown in the area. It should be noted that site visits were conducted with county agricultural extension agents from two counties (Guadalupe and Caldwell), and both were very encouraging of starting a regional sludge land application program and were interested in becoming involved in any activities related to developing a program in their county.

Sites located west of IH 35 were generally not considered because of issues related to the Edwards Aquifer Recharge Zone, and due to the proximity to the larger study participants' WWTPs. As is noted in Section 5.1, soil pH is another consideration,

but most soils within the four-county study area are alkaline, thereby not requiring liming of the soils prior to land application.

Crops grown in the study area are generally for feed and forage, or cotton. Therefore, Class 'B' sludge should be readily accepted in the area as few crops are grown for direct human consumption.

Because of the benefits of having one, large centralized operation, it is more efficient to operate one land application site having enough land to effectively land apply all of the study participants' sludge. The City of San Marcos is considering the registration of their airport site with the TNRCC for future sludge land application. This site contains over 700 acres of land in agricultural production and, when considering the required TNRCC set-back distances, over 600 acres would be available for agricultural land application.

The San Marcos airport site is owned and controlled by the City of San Marcos, and a private producer (farmer) manages the agricultural operation. Most of the major sludge producers in this study are located a short distance (six to 29 miles) away. Sludges are hauled a similar distance (four to 33 miles) for ultimate disposal in a landfill. Also, the pH for soils in this area are alkaline, ranging from 7.9 to 8.4. These factors are additional reasons to consider this site for future beneficial use of sludge.

It is also recommended to expand the existing GBRA land application site, commonly known as the Gerdes property, from the existing 18 acres to at least 36 to 40 acres. This would give the flexibility to continue to apply sludge from the four GBRA WWTPs as well as some portion of the sludge produced from the Cities of Luling and Seguin.

Other land application sites were considered as part of this study. Agricultural extension agents from counties in the study area were contacted to obtain more information on past experiences with these programs, and to investigate whether there was any interest in these programs from the agricultural community. Generally, the agents stated that if the beneficial use of sludge were presented in a positive manner, there would be other opportunities to register additional land application sites as farmers in the area are open-minded to alternatives to traditional farming practices.

6.0 COSTS
(Capital and Operations and Maintenance)

6.1 Existing Sludge Disposal Practices

The disposal practices that are presently being used by the participants are either landfilling or land applying. The following subparagraphs specifically address each participants' existing disposal practice(s) and the associated annual cost. The annual cost includes all expenses incurred by the participants to dispose of their sludge. The expenses include labor, operations & maintenance, permitting fees and, in certain cases, transporting the sludge to the point of disposal. The particular disposal practices and the associated costs are also presented in Table 4.2.1, Existing Disposal Practices Summary.

6.1.1 New Braunfels Utilities

New Braunfels Utilities operate three plants, the Gruene plant and the North and South Kuehler plants. On the Gruene plant site are drying beds which produce a sludge cake with a total percent solids of approximately 30 percent. For the North and South Kuehler plants, a large belt press, which is located at the North Kuehler plant, is used to produce a 14-18 percent sludge cake. The annual disposed quantity of sludge from the three plants is estimated to be in the neighborhood of 551 dry-tons per year.

To date, the Utility is transporting its cake to the Comal Landfill. The Waste Management operated landfill is approximately eight miles from the plants. The Utility is presently paying Waste Management $11 per cubic yard in tipping fees for the disposal of its cake.

Based on the Utilities' annual disposal cost of $60,000 per year, the tipping set at $11 per cubic yard, and the annual production of 551 dry-tons per year, the annual tipping fee and the annual operation and maintenance is $44,165 and $15,835, respectively.

6.1.2 GBRA

In the four-county study area, GBRA operates five plants: Lockhart, Springs Hill, Northcliffe, Canyon Park, and Dunlap. At each of the plants, except Lockhart, one to two percent total solid sludge is drawn off the aerobic digester and transported to private property where it's land applied to 18 of the 20 acres site. This particular land

application activity operates under the TNRCC registration Number 710269. The application site is located one mile west of the City of Marion in Guadalupe County. The four plants (Springs Hill, Northcliffe, Canyon Park, and Dunlap) produce a total of 31 dry-tons per year at an annual disposal cost totalling $7,201. Presently, GBRA has a land applying cost of $232 per dry ton.

Drying beds are used at the Lockhart plant site to produce the sludge cake which is typically in the range of 18-20 percent total solids. The annual disposed quantity of sludge cake from the Lockhart plant is estimated at 587 dry-tons per year. Lockhart is under contract with Central Texas Refuse to haul the sludge cake to the Texas Disposal Systems landfill. The fee is $310 for every hauled 20 cubic yard roll-off. GBRA pays approximately $85 per dry-ton to dispose of the Lockhart sludge

6.1.3 The City of Luling

The City of Luling operate two plants, the North and the South Luling plants. Drying beds at both facilities produce a sludge cake with a total percent solids of approximately 60 to 80 percent. The estimated annual disposed quantity of sludge from the north and south plants is 36 and 22 dry tons per year, respectively.

The City of Luling is presently hauling its sludge cake to their post-closure landfill located on the north side of the City, as authorized by the TNRCC. Considering the annual expenses and permitting expenses of $491 per year and the annual production of 58 dry-tons per year, the annual operation and maintenance is $9 per dry ton.

6.1.4 The City of San Marcos

The City operates the San Marcos plant which is located on the southeast side of the City. The primary means of dewatering the plants' sludge is with a centrifuge. Through this dewatering process, the City is able to produce a sludge cake typically in the range of 15-20 percent total solids. The plant also has drying beds, however, they are used as a back-up to the centrifuge. The annual disposed quantity of sludge cake from the San Marcos plant is estimated at 800 dry-tons per year.

The City is under contract with BFI to haul and dispose of the sludge cake at the BFI landfill. The City is charged a set fee for every 20 cubic roll-off hauled from the plant to the landfill. Considering the hauling and disposing fee, and annual quantity of dry-tons per year produced, the City pays approximately $100 per disposed dry-ton.

6.1.5 The City of Seguin

The City of Seguin operates two plants, the Walnut Branch and the Geronimo plants. Both facilities have been constructed with drying beds; however, the Walnut Branch plant has a two-meter belt press. It has been estimated that the beds produce a sludge cake with a percentage of total solids in the range of 32 to 38 percent, and the press is operated to produce a cake at approximately 18 percent. The annual disposed quantity of sludge from the Walnut Branch and the Geronimo plant is 89 and 61 dry tons per year, respectively.

The City is responsible for hauling their sludge cake to the BFI landfill located near San Antonio. Under their contract with BFI, the City pays a $10 per cubic yard tipping fee plus a $5 per truck weighing fee. Based on the estimated annual disposal cost of $17,970 per year, the tipping fee set at $10 per cubic yard plus $5 per truck weighing fee, and the annual production of 150 dry-tons per year, the annual disposal cost for the City to dispose of its sludge is $125 per dry ton for the Walnut Branch facility and $112 per dry ton for the Geronimo plant.

6.2 Agricultural Land Application

6.2.1 Capital and Operational Costs

Please refer to Table 6.2.1 for a presentation of capital, operational, and transportation expenditures associated with land application of sludge.

TABLE 6.2.1

RECOMMENDED LAND APPLICATION EQUIPMENT
1995 CAPITAL, OPERATIONAL, AND TRANSPORTATION COSTS

EQUIPMENT[22]	ESTIMATED COST
DIESEL TRACTOR, 86 PTO H.P.	$ 30,000
MANURE SPREADER, 321 CUBIC FEET CAP.	$ 16,500
FRONT-END LOADER, 2.6 CUBIC YARD CAP.	$122,000
DISC ATTACHMENT, 8 FEET DISPLACEMENT	$ 5,000
PICKUP TRUCK & RADIO	$ 20,000
OFFICE FURNITURE & COMPUTER	$ 5,000
WASH RACK & MISCELLANEOUS IMPROVEMENTS	$ 5,000
ESTIMATED TOTAL EQUIPMENT COST	$203,500
ASSUMPTIONS: 6% INTEREST RATE, SEVEN YEAR PERIOD TEN-YEAR EQUIPMENT SERVICE LIFE ZERO RESIDUAL VALUE	
TOTAL ANNUAL DEBT COST	$ 36,454
ANNUAL OPERATIONAL COSTS	
FUEL	$ 9,900
MAINTENANCE	$ 6,940
LABOR[23]	$ 62,400
DATA MANAGEMENT & SAMPLING	$ 16,000
TNRCC ANNUAL FEE ASSESSMENT	$ 1,750
AUTO INSURANCE	$ 1,200
GENERAL LIABILITY INSURANCE	$ 855
SITE OFFICE RENTAL & TELEPHONE SERVICE	$ 4,800
TOTAL ANNUAL OPERATIONAL COSTS	$103,845
TOTAL COST TO TRANSPORT SLUDGE	$ 26,110
ANNUAL COST, GRAND TOTAL	$166,409

[22]Ford Tractor, Model 7610 or equivalent.
Spreader, New Holland Model 308 or equivalent.
Front-End Loader, Caterpillar Model 928 or equivalent
Full-size 4-WD pickup truck with 2-way radio.

[23]Two Full-Time Equipment Operators.

1995 TOTAL ANNUAL COST PER PARTICIPANT (BASED ON PERCENTAGE OF TOTAL DRY TONS DISPOSED IN 1994)

PARTICIPANT	CAPITAL/OPERATIONAL COSTS	TRANSPORT COSTS	TOTAL COSTS
New Braunfels Utilities	$36,057	$9,560	$45,617
GBRA (Lockhart site)	$38,302	$6,420	$44,722
City of Luling	$ 3,788	$ 300	$ 4,088
City of San Marcos	$52,331	$8,330	$60,661
City of Seguin	$ 9,821	$1,500	$11,321

TOTAL LAND APPLICATION COST PER DRY TON 1995 COST BASIS

TOTAL COST	$166,409
TOTAL DRY TONS	2,146
ESTIMATED LAND APPLICATION COST	$ 78/ DRY TON

Additional equipment will be required to handle and apply sludge. A tractor is necessary to operate a large side-discharge manure spreader (12 cubic yard capacity) that will actually surface distribute sludge material at the disposal site. A large front-end loader will be utilized to move piled material and load the manure spreader. A disc plow will also be provided to turn the sludge under the top surface as necessary. Other equipment includes a full-size truck with radio to transport operations personnel. It will be necessary to provide an office at the land application site and equip it with furniture and a small computer for recordkeeping and reporting. Provision was also made to install an equipment wash rack and make miscellaneous improvements as required.

It was assumed that this equipment would be financed over a seven-year period at an estimated 6 percent interest rate. Equipment of this nature should have a service life of 10 years and it was assumed that no residual value would remain at the end of this period. Debt service associated with this purchase results in an annual cost of $36,454.

Other costs associated with land application include the cost of fuel, equipment maintenance, labor, and administration. For the purpose of the study, it was assumed

that 9,000 gallons of fuel would be consumed per year at a cost of $9,900. The annual cost to maintain the equipment was estimated at $6,940. It was also estimated that two full-time Equipment Operators would be necessary to operate all the equipment and sustain the program. Labor costs were calculated at $62,400. Sampling and analysis of sludge and soil must also be performed. This data must be carefully recorded along with operational information, and these activities were estimated to cost $16,000 per year. The Texas Natural Resources Conservation Commission (TNRCC) imposes a minimum annual fee of $100 whether or not a site is active. Otherwise, land application of Class 'B' sludge costs $0.75 per dry ton. It was estimated that the TNRCC fees will cost $1,750 per year. Insurance costs include full coverage for operation of the pickup truck in addition to general liability coverage. Finally, a small office will be maintained at the application site for the use and convenience of the program employees.

It will be necessary to transport the sludge from each wastewater treatment plant to the land application site. Cost estimates were obtained from a private contractor in order to provide an equitable cost estimate for all program participants. It was assumed that each participant has the capability to load the transport trucks at each plant location. Total transportation costs are estimated at $26,110 per year.

The total annual cost to operate the land application program is the sum of the above cost factors and equals $166,409. In order to distribute this cost among the study participants, the total annual cost was prorated based on the percentage of total dry tons produced by each participant. GBRA production figures include only dry solids from the Lockhart plant. By example, New Braunfels Utilities produced 551 dry tons of sludge based on examination of 1995 survey figures. The grand total for all participants was 2,146 dry tons. Accordingly, New Braunfels Utilities would assume a cost share of 25.7 percent. Each participant was similarly calculated. Future cost projections for each participant can be examined in Table 6.3.1.

Table 6.3.1
Annual Disposal Cost, Dollars
(Comparison of Current Landfill Practices to Proposed Land Applying Practices)

Year	Disposal Practice	Participants				
		New Braunfels Utilities	San Marcos	The City of Seguin	GBRA (Lockhart Only)	The City of Luling
1995	Continued Landfilling[24]	60,024	80,000	17,970	50,000	491
	Proposed Land Applying[25]	45,617	60,661	11,321	44,722	4,088
2000	Continued Landfilling	84,718	118,560	23,660	68,511	642
	Proposed Land Applying	57,745	76,835	14,402	55,676	6,077
2005	Continued Landfilling	111,962	162,412	29,930	89,111	812
	Proposed Land Applying	72,140	95,499	17,822	68,501	7,535
2010	Continued Landfilling	144,931	215,580	37,480	114,626	1,011
	Proposed Land Applying	89,616	118,186	21,962	84,164	9,271
2015	Continue Landfilling	184,920	278,010	46,796	145,853	1,258
	Proposed Land Applying	110,853	145,537	27,034	103,246	11,405
2020	Continued Landfilling	233,655	354,322	58,027	183,815	1,564
	Proposed Land Filling	136,708	178,854	33,178	126,457	14,030
2025	Continued Landfilling	292,663	447,277	71,779	229,373	1,931
	Proposed Land Applying	168,104	219,402	40,675	154,614	17,193

[24]This is the existing practice of disposing of sludge.

[25]This is the proposed method of disposing of their sludge for the participant that are presently landfilling.

Appendix

ATTACHMENT A

GBRA CALCULATIONS FOR SLUDGE APPLICATION RATE AND SITE LIFE

Assumptions: Mass-weighed average results from survey have been used to determine the following:

NUTRIENTS:	Percent (%) x 20 =	lb/ton
Total Kjeldahl Nitrogen (TKN)	4.5	90
Ammonium Nitrogen (NH4-N)	0.5	10
Nitrate Nitrogen (NO3-N)	0.02	0.4
Total Phosphorus (P)	1.8	36
Total Potassium (K)	--	--

METALS:	mg/kg x 0.002 =	lb/ton
Total Arsenic (As)	<3	<0.01
Total Cadmium (Cd)	5	0.01
Total Chromium (Cr)	199	0.40
Total Copper (Cu)	425	0.85
Total Lead (Pb)	51	0.10
Total Mercury (Hg)	2	0.01
Total Molybdenum (Mo)	9	0.02
Total Nickel (Ni)	107	0.21
Total Selenium (Se)	8	0.02
Total Zinc (Zn)	967	1.93

Assumptions for Fertilizer Requirements:

- Since soil testing was not conducted for this study, it is assumed for this evaluation that there is little, or no background plant available nitrogen (PAN) for plant growth;

- It is assumed that 150 - 200 bushels per acre of corn will be grown as a crop, thereby requiring 180 pounds of PAN per acre (per information provided by TNRCC); and a winter wheat crop is grown with a target yield of 60-80 bu/acre with a PAN demand of 80 lbs/acre resulting in a combined PAN of (180 + 80) = 260 pounds per acre per year.

CALCULATION OF PAN PROVIDED BY THE SLUDGE:

A. Organic Nitrogen = TKN - NH3-N = 90 - 10 = 80 lbs/ton

Multiply by 30 % for aerobically digested sludge: PAN = 24.0 lbs/ton

B. Ammonium Nitrogen (NH4-N) x V = 10 x 1.0 PAN = 10.0 lbs/ton

Where V = Volatilization Factor = 1.0 if incorporated into soil

C. Nitrate Nitrogen (NO3-N) PAN = 0.4 lbs/ton

D. Total PAN = A + B + C = PAN = 34.4 lbs/ton

Therefore, sludge application rate, based on PAN, or SARn

SARn = Nitrogen Needed / Total PAN

= 260 lb/ac/yr / 34.4 lb/ton

= **7.6 dry tons/acre**

Therefore, it is assumed that up to 7.6 dry tons/acre may be applied in a year for the intended crops (corn and winter wheat) to be grown.

MAXIMUM SLUDGE APPLICATION RATE BASED ON METALS (SARm)

Metal	CPLR (lb/ac/yr)	APLR (lb/ac/yr)	MIS (lb/ton)	MAP (lb/ac/yr)	MAX APR (tons/ac)
As	36	1.8	<0.01	0.07	3,600
Cd	35	1.7	0.01	0.07	3,500
Cr	2,677	134.0	0.40	3.04	6,693
Cu	1,339	67.0	0.85	6.46	1,575
Pb	268	13.0	0.10	0.76	2,680
Hg	15	0.76	0.01	0.08	1,500
Mo	16	0.8	0.02	0.15	800
Ni	375	18.7	0.21	1.60	1,786
Se	89	4.5	0.02	0.15	4,450
Zn	2,500	125.0	1.93	14.67	1,295

CPLR: Cumulative Pollutant Application Rate
APLR: Annual Pollutant Application Rate
MIS: Mass of Metals in Sludge
MAP: Metals Applied at SARn (7.6 dry tons/year)
MAX APR: Maximum Application Rate, based on metals concentrations

Calculation of Site Life
Based on Cumulative Loadings of Metals at SARn (7.6 dry tons/ac)

A. Lowest MAX APR Value (limiting metal): Mo = 800 tons/ac
Second lowest AOR Value: Zn = 1,295 tons/ac

divided by

B. SARn SARn = 7.6 dry tons/ac

=

C. Years Remaining, based on Mo: A / B = 105 years

Years Remaining, based on Zn: A / B = 170 years

DETERMINATION OF TOTAL LAND REQUIREMENTS

TOTAL QUANTITY OF SLUDGE DISPOSED IN YEAR 2,025: 3,373 dry tons

MINIMUM ACREAGE REQUIRED AT SARn (7.6 dry tons/ac): 444 acres

Therefore, the following recommendation is made:

SITE	AVAILABLE ACREAGE*
City of San Marcos Airport Agricultural Land Application Site:	608 ACRES
GBRA (Gerdes Property) Land Application Site:	18 ACRES
TOTAL	626 ACRES
Additional (reserve) land:	
R.G. Beiker Property (estimated area)	160 ACRES
GBRA Expansion (Gerdes Property)	18 ACRES
COMBINED TOTAL (SAN MARCOS, GBRA, OTHERS)	804 ACRES

NOTE: As requested by the TNRCC, a conservative analysis to determine the amount of acreage needed based on the accumulation of total nitrogen in the soil indicates a site life in excess of 20 years. This analysis assumed that all available acreage is applied at the maximum agronomic rate based on PAN throughout the entire period. However, initial application years would not require full utilization of the entire available land thereby extending the overall site life.

* - Available acreage accounts for required set-back distances from public right-of-ways, property lines, etc.

GUADALUPE BLANCO RIVER AUTHORITY
REGIONAL WASTEWATER SLUDGE DISPOSAL ALTERNATIVES STUDY
Contract # 95 483 092

The following maps are not attached to this report. Due to their size, they could not copied. They are located in the official file and may be copied upon request.

SM-1 Guadalupe-Blanco River Authority Sludge Disposal Alternatives
Caldwell, Guadalupe, Hays And Comal

Please contact Research and Planning Fund Grants Management Division at (512) 463-7926 for copies.