AdvanTex®
Commercial Treatment Systems
Design Criteria

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DOCUMENT

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Equations and Parameters Frequently Used in This Design Criteria

For recommendations regarding minimum hydraulic retention times, primary tankage, and configurations see Appendix A, Table A.

Determining Mass Load in AdvanTex Systems

(For complete information on how to use these equations, see Appendix B.)

	Mass Load (lbs/day)	Mass Load (kg/day)
	Concentration (mg/L) × (8.34×10^{-6}) × Flow (gpd)	Concentration (mg/L) × (0.001) × Flow (m^3/day)

Determining Standard AdvanTex Stage Sizing

(For complete information on how to use these equations, see Performance Requirements and Unit Sizing.)

	Design Avg. (US Units)	Design Max. (US Units)	Design Avg. (SI Units)	Design Max. (SI Units)
Based on Organic Loading Rate (OLR)	0.04lbs BOD_5/ft^2•d	0.08lbs BOD_5/ft^2•d	0.2kg BOD_5/m^2•d	0.4kg BOD_5/m^2•d
Based on Hydraulic Loading Rate (HLR)	25gpd/ft^2	50gpd/ft^2	1m^3/m^2•d	2m^3/m^2•d
Based on Total Nitrogen Loading Rate (TNLR)	0.014lbs TN/ft^2•d	0.028lbs TN/ft^2•d	0.07kg TN/m^2•d	0.14kg TN/m^2•d
Based on Ammonia Loading Rate (ALR)	0.01lbs NH_3-N/ft^2•d	0.02lbs NH_3-N/ft^2•d	0.05kg NH_3-N/m^2•d	0.1kg NH_3-N/m^2•d

Determining Second-Stage AdvanTex Sizing in Two-Stage Systems

(For complete information on how to use these equations, see Performance Requirements and Unit Sizing.)

	Design Avg. (US Units)	Design Max. (US Units)	Design Avg. (SI Units)	Design Max. (SI Units)
Based on Organic Loading Rate (OLR)	0.02lbs BOD_5/ft^2•d	0.04lbs BOD_5/ft^2•d	0.1kg BOD_5/m^2•d	0.2kg BOD_5/m^2•d
Based on Hydraulic Loading Rate (HLR)	75gpd/ft^2	125gpd/ft^2	3m^3/m^2•d	5m^3/m^2•d
Based on Total Nitrogen Loading Rate (TNLR)	0.007lbs TN/ft^2•d	0.014lbs TN/ft^2•d	0.035kg TN/m^2•d	0.07kg TN/m^2•d
Based on Ammonia Loading Rate (ALR)	0.005lbs NH_3-N/ft^2•d	0.01lbs NH_3-N/ft^2•d	0.025kg NH_3-N/m^2•d	0.05kg NH_3-N/m^2•d

Determining Anticipated Treatment Performance from Standard AdvanTex Systems

(For complete information on how to use these equations, see Appendix B.)

Based on BOD_5

$$BOD_{5e} = BOD_{5i} \times (1 - C_{BR})$$

where: BOD_{5e} = BOD_5 effluent from standard AdvanTex stage
BOD_{5i} = BOD_5 primary-treated effluent value
C_{BR} = coefficient of biological removal, 0.90

Based on TKN or NH_3-N

$$TKN_e = TKN_i \times (1 - C_{NR})$$

where: TKN_e = TKN effluent from standard AdvanTex stage
TKN_i = TKN primary-treated effluent value
C_{NR} = coefficient of nitrogen removal, 0.95

Based on NO_3

$$NO_{3e} = (TKN_i - TKN_e) \times (1 - C_{DNR})$$

where: NO_{3e} = NO_3 effluent from standard AdvanTex stage
TKN_i = TKN primary-treated effluent value
TKN_e = TKN effluent
C_{DNR} = coefficient of denitrification, 0.70

Based on TN

$$TN_e = TKN_e + NO_{3e}$$

where: TN_e = TN effluent from standard AdvanTex stage
TKN_e = TKN effluent from standard AdvanTex stage
NO_{3e} = NO_3 effluent from standard AdvanTex stage

Determining Anticipated Treatment Performance for Total Nitrogen from Post-Anoxic AdvanTex Treatment Stages

(For complete information on how to use these equations, see Appendix B.)

$$TN_{PAe} = TKN_e + NO_{3e} \times (1 - C_{DNR})$$

where: TN_{PAe} = TN effluent from post-anoxic stage
TKN_e = TKN effluent from standard AdvanTex stage
NO_{3e} = NO_3 effluent from standard AdvanTex stage
C_{DNR} = coefficient of denitrification, 0.70

Introduction

Orenco's AdvanTex Treatment Systems were developed for the long-term processing of domestic- and commercial-strength wastewater to advanced treatment levels. The heart of all AdvanTex systems is a multiple-pass, packed-bed, fixed-film media filter that reliably provides high-quality effluent in a wide range of applications. These systems have undergone numerous national and international testing protocols, as well as multiple third-party field verification programs. This manual provides design information and guidance for commercial applications using an AdvanTex Treatment System. For other applications, contact Orenco or your local Orenco dealer for more information.

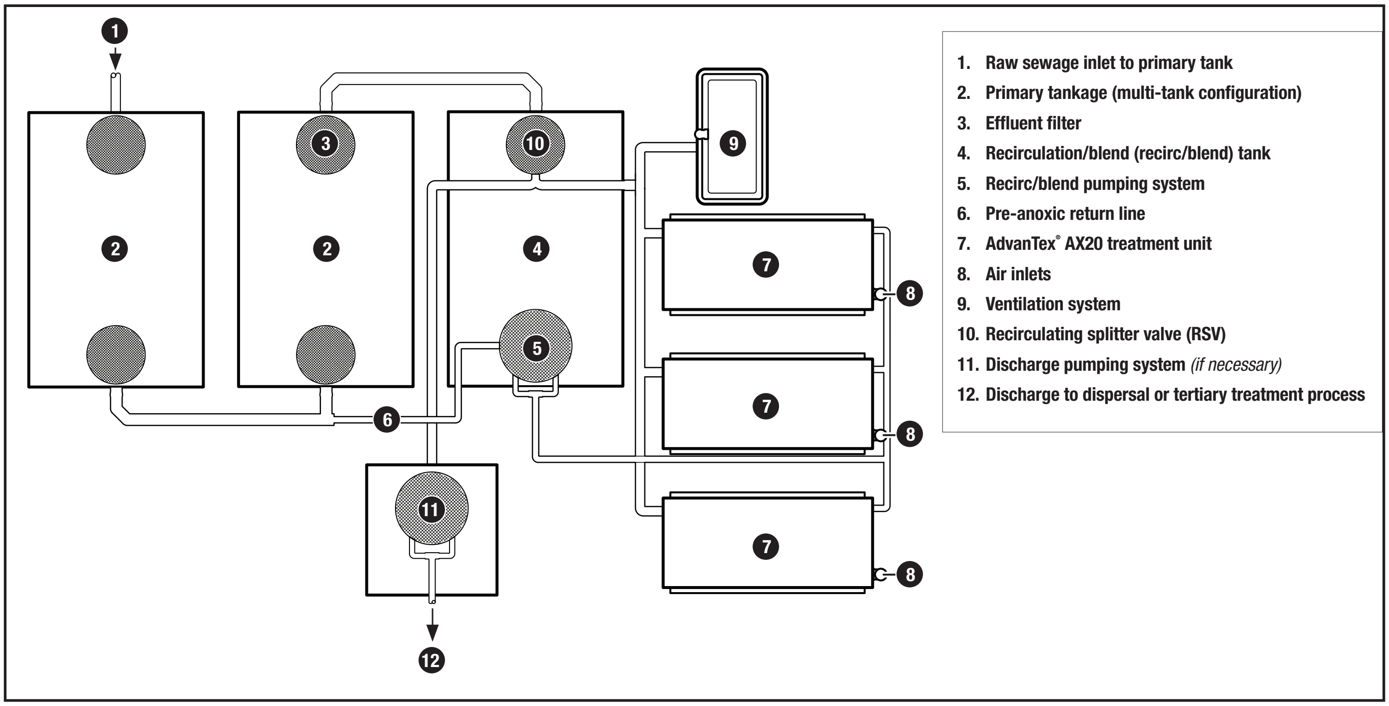
AdvanTex Model Descriptions

Three AdvanTex models are typically used in commercial applications. Your choice of model depends on system sizing requirements and site characteristics. All three operate in the manner described in the treatment process description, and all perform similarly. For exact dimensions and specific treatment configurations, see AdvanTex Treatment System drawings.

AdvanTex AX20

Specifications

Length	91in (2311mm)
Width	40in (1016mm)
Height	31in (787mm)
Dry weight	400lbs (181kg)
Treatment surface area	20ft^2 (1.9m^2), nominal
Installation footprint	25ft^2 (2.3m^2), actual
Installation methods	Partial burial or bermed installation; minimum 6in (150mm) above grade, antibuoyancy flanges available for areas with high groundwater
Recirculation-blend tankage	External
Recirculation method	Recirculating splitter valve



1. **Raw sewage inlet to primary tank**
2. **Primary tankage (multi-tank configuration)**
3. **Effluent filter**
4. **Recirculation/blend (recirc/blend) tank**
5. **Recirc/blend pumping system**
6. **Pre-anoxic return line**
7. **AdvanTex® AX20 treatment unit**
8. **Air inlets**
9. **Ventilation system**
10. **Recirculating splitter valve (RSV)**
11. **Discharge pumping system** *(if necessary)*
12. **Discharge to dispersal or tertiary treatment process**

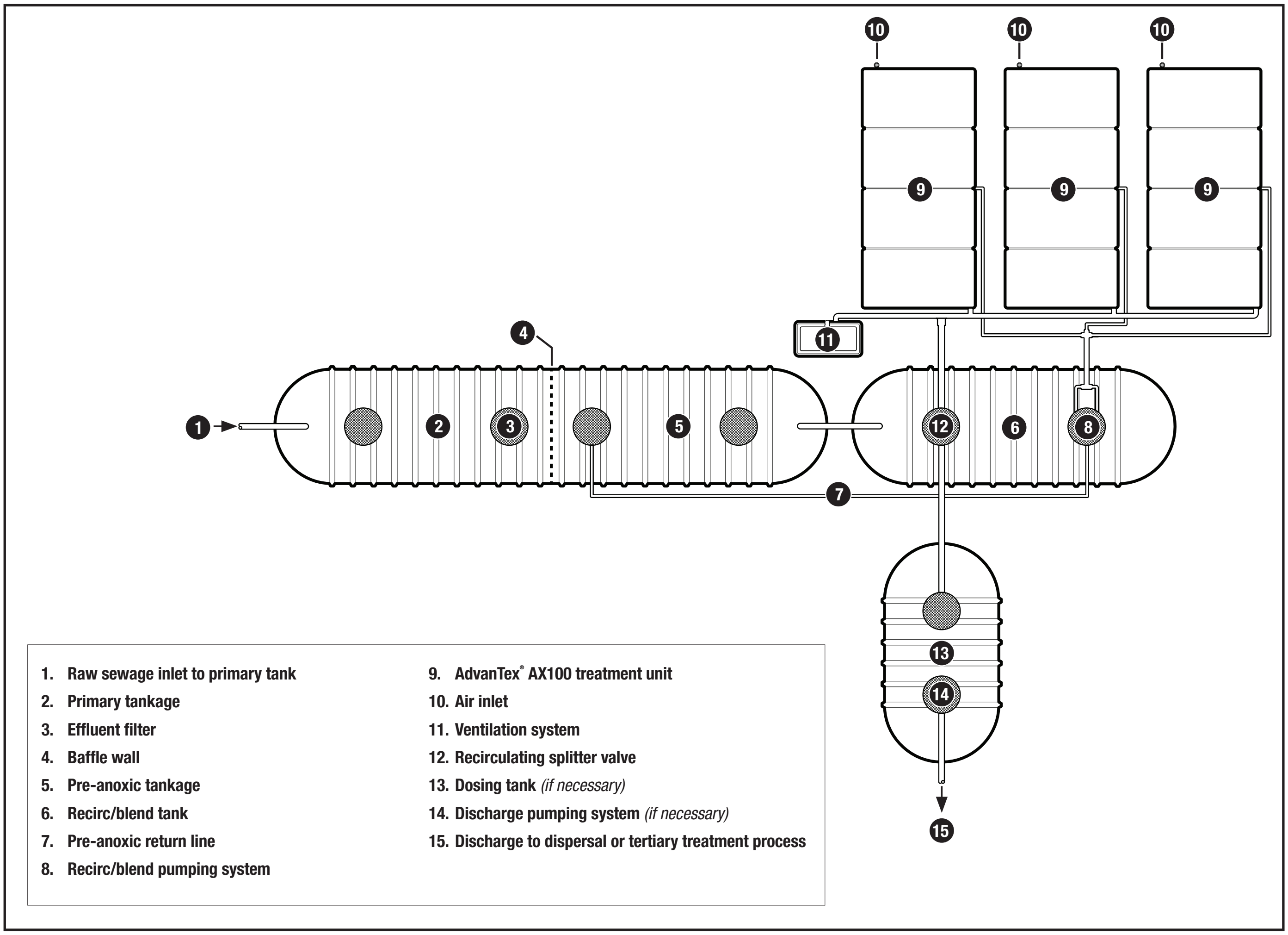
Figure 1. Example of an AdvanTex AX20 Commercial Treatment System

AdvanTex Model Descriptions, cont.

AdvanTex AX100

Specifications

Length	191in (4851mm)
Width	94in (2388mm)
Height	42in (1067mm)
Dry weight	1760lbs (798kg)
Treatment surface area	100ft^2 (9.3m^2), nominal
Installation footprint	128ft^2 (11.9m^2), actual
Installation methods	Partial burial or bermed installation; minimum 6in (150mm) above berm, maximum 9in (230mm) below natural grade
Recirculation-blend tankage	External
Recirculation method	Recirculating splitter valve



1. **Raw sewage inlet to primary tank**
2. **Primary tankage**
3. **Effluent filter**
4. **Baffle wall**
5. **Pre-anoxic tankage**
6. **Recirc/blend tank**
7. **Pre-anoxic return line**
8. **Recirc/blend pumping system**
9. **AdvanTex® AX100 treatment unit**
10. **Air inlet**
11. **Ventilation system**
12. **Recirculating splitter valve**
13. **Dosing tank** *(if necessary)*
14. **Discharge pumping system** *(if necessary)*
15. **Discharge to dispersal or tertiary treatment process**

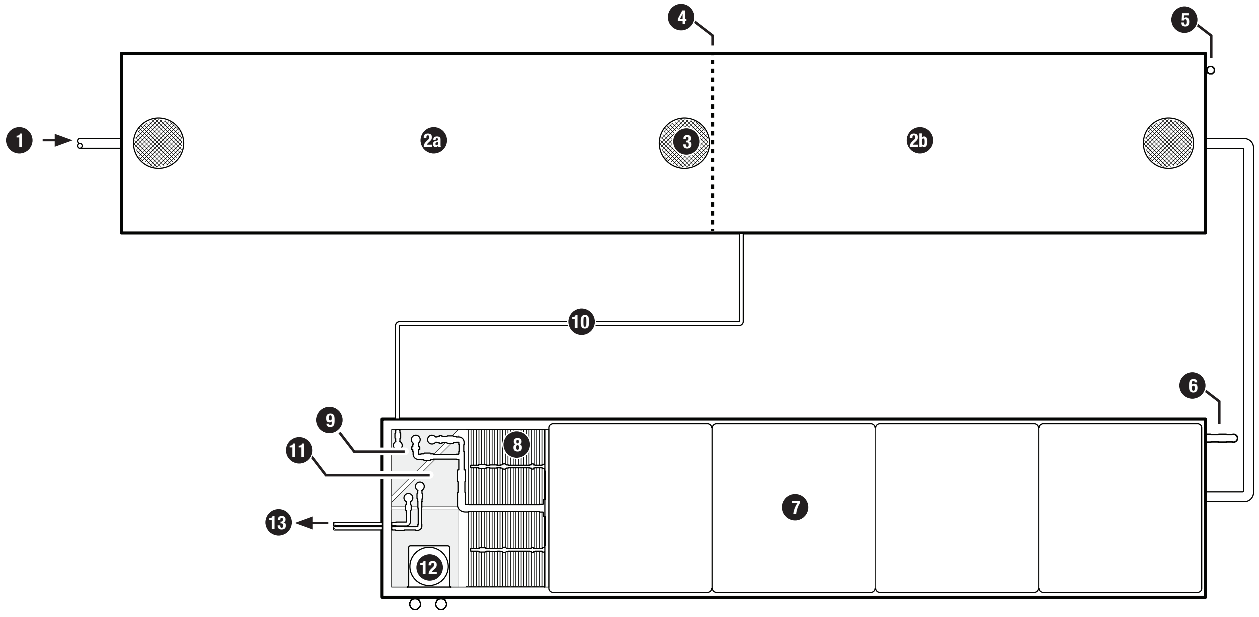
Figure 2. Example of an AdvanTex AX100 Commercial Treatment System

AdvanTex Model Descriptions, cont.

AdvanTex AX-Max

Specifications

Length	14-42ft (4.3-12.8m)
Width	90in (2286mm)
Height	97in (2464mm)
Dry weight	Variable, up to 12,000lbs (5440kg)
Treatment surface area	25-300ft^2 (2.3-27.9m^2), nominal
Installation footprint	112-336ft^2 (10.4-31.2m^2), actual
Installation methods	Partial burial or bermed installation, or free-standing installation; 24-36in (610-910mm) above grade or berm for ease of maintenance; antiflotation available for areas with high groundwater
Recirculation-blend tankage	Included
Recirculation method	Tank baffle wall, recirc-return valve



1. **Raw sewage inlet to primary tankage**
2. **42ft (12.8m) Orenco® T-Max™ Tank:**
    - **a) primary tankage**
    - **b) pre-anoxic tankage**
3. **Effluent filter**
4. **Baffle wall**
5. **Passive primary tank ventilation**
6. **Vent fan inlet**
7. **AX-Max™ unit**
8. **AX-Max unit, treatment media**
9. **AX-Max unit, recirc-blend and pre-anoxic pumping chamber**
10. **Pre-anoxic return line**
11. **AX-Max unit, discharge pumping chamber**
12. **AX-Max unit, active ventilation system**
13. **Discharge to dispersal or tertiary treatment process**

Figure 3. Example of an AdvanTex AX-Max Commercial Treatment System

Design Basis

To ensure that the system is designed properly for a given application, it is critical to first determine the design basis. The design basis for any treatment system consists of careful evaluation of the parameters that control the system's design and subsequent performance. Orenco's *Engineered Project Questionnaire*, NFO-ATX-ADM-2, is available to assist in identifying and characterizing these parameters. It can be downloaded from Orenco's Document Library, under the "resources" tab at www.orenco.com; you can also contact Orenco or your local Orenco dealer for a copy. The questionnaire provides a list of the typical design parameters necessary to determine the suitability of Orenco products to a given project and for forming the system's design basis.

Average Day and Maximum Day Flows

Flows may be defined or calculated differently by application and local regulation; flows as used in this document are defined as follows:

Design Average Day Flow **(Q_A)** is the average of the daily volume to be received for a continuous twelve-month period expressed as a volume per day. For facilities that have critical, seasonal-high hydraulic loading periods (e.g., recreational areas, campgrounds), Design Average is based on the daily average flow during the seasonal period.

Design Maximum Day Flow **(Q_M)** is the largest volume of flow to be received during a continuous 24hr period expressed as a volume per day. The Design Maximum Day Flow is highly dependent on the application and collection technology used. For liquid-only sewer (LOS) or effluent sewer (STEP), grinder sewer, and vacuum sewer, a typical value is two times the Design Average Flow ($2Q_A$).

For gravity sewer applications, a typical value for Q_M is four times the Design Average Flow ($4Q_A$) for new construction and can range to over ten times ($10Q_A\pm$) for existing systems. Make sure to carefully evaluate any existing flow information and regulatory requirements when establishing this design parameter.

Primary-Treated Effluent Wastewater Strength

Organic Constituents in Wastewater

The two primary organic constituents in wastewater used in determining applicability and sizing of AdvanTex Treatment Systems are biochemical oxygen demand (BOD_5) and total suspended solids (TSS). These constituents are typically quantified either in raw wastewater or after the primary treatment stage. In order to determine the waste load to the AdvanTex Treatment System, it is necessary to determine the constituent concentrations after primary treatment. These constituent concentrations in wastewater are referred to as primary-treated effluent throughout this document, and all percent reduction estimates are calculated relative to these concentrations. If these constituents are provided as raw wastewater values, it is the responsibility of the designer to determine the appropriate primary treatment requirements to achieve the primary-treated effluent values used in the design. Industry experts typically estimate that appropriate primary treatment (see Appendix A for primary tank sizing recommendations) will provide 50% reduction of BOD_5 (down to a minimum of 150mg/L) and 90% reduction of TSS (down to a minimum of 50mg/L).

Nitrogen Constituents in Wastewater

The principal forms of nitrogen found in wastewater are Organic Nitrogen (Organic-N), Ammonia Nitrogen (NH_3-N), Ammonium Nitrogen (NH_4-N), Nitrite Nitrogen (NO_2-N), and Nitrate Nitrogen (NO_3-N). These are expressed either individually or as components of the following:

- **Total Kjeldahl Nitrogen (TKN)**, which is the sum of Organic-N + NH_3-N
- **Total Inorganic Nitrogen (TIN)**, which is the sum of NH_3-N + NO_2-N + NO_3-N
- **Total Nitrogen (TN)**, which is the sum of TKN + NO_2-N + NO_3-N

As with the organic constituent concentrations, the nitrogen constituent concentrations must be quantified after the primary treatment stage to determine waste load to the AdvanTex Treatment System and are listed as primary-treated effluent throughout this document. A thorough understanding of the nitrogen cycle and how it works within the wastewater system is important when designing a system to treat for these parameters. A brief description of the processes follows:

Ammonification

Nitrogen is usually introduced into the wastewater system as Organic-N and NH_4-N. Organic-N (including feces, urea, and other animal and vegetable matter) in wastewater is converted into NH_4-N by the process of ammonification. In ammonification, proteins, amino acids, and other nitrogen-containing compounds are biochemically degraded by heterotrophic bacteria. Ammonification typically occurs in primary tankage and transport lines, as well as in the secondary treatment process. Because of this, a raw wastewater ammonia measurement may be significantly lower than the true value. In these instances, TKN is a better measure of overall nitrogen content and should be used when determining waste load to the AdvanTex Treatment System.

Design Basis, cont.

Nitrification and Denitrification

Once primary-treated effluent is introduced into the secondary treatment process, nitrogen removal occurs first by nitrification and then by denitrification. In the first nitrification step, an ammonium-oxidizing autotrophic bacteria, Nitrosomonas, converts ammonium to nitrite. In the second nitrification step, a nitrite-oxidizing bacteria, Nitrobacter, converts nitrite to nitrate. Both steps occur under aerobic conditions. Lastly, denitrification occurs when nitrate is converted to nitrogen gas by heterotrophic bacteria under anoxic conditions (DO < 0.5 mg/L).

Therefore, treatment for NH_3-N and TKN occurs through an aerobic process, while treatment for NO_3-N, TIN, and TN occurs through a combination of aerobic and anoxic processes. For more information about the nitrogen process in wastewater, see Crites & Tchobanoglous' *Small and Decentralized Wastewater Management Systems,* 1st Edition (1998). For information on pH and temperature effects on nitrification and denitrification, see *pH Effect on Nitrification* and *Cold-Weather Considerations*.

Discharge Treatment Levels and Sampling Requirements

Discharge treatment levels and sampling requirements play a significant role in treatment facility design. Secondary treatment (effluent concentrations of BOD_5 and TSS of $\leq$ 30mg/L based on a 30-day average) is a simple process typically requiring only a single-stage AdvanTex Treatment System. Additionally, advanced secondary treatment (BOD_5 and TSS of $\leq$ 10mg/L based on a 30-day average) can typically be accomplished in the same manner. However, many permits now require a higher level of nitrogen treatment. They also commonly include a "not to exceed" value in place of a 30-day average or 30-day arithmetic mean. In these instances, a safety factor is typically applied (or additional processes added) so that the discharge parameters are not exceeded, even under maximum-day flow conditions or maximum-day primary-treated effluent concentrations.

Likelihood of System Expansion and Potential Permit Changes

Permits are typically limited in duration, and over the past two decades, treated effluent discharge requirements have become stricter. In fact, many permit renewals are now asking for measurement of various constituents that were not part of the original treatment facility design. When designers are planning for future expansion, or for future modifications to permits, Orenco recommends using incremental engineering to plan for and provide space for potential future treatment upgrades. By understanding the various stages used in AdvanTex Treatment Systems, designers can lay out the treatment facility in a manner that allows for additional stages in the event that a planned build-out or future permit modification requires it. See *Treatment System Configurations* and *Process Stages – AdvanTex Treatment Systems* for more information.

Highly Variable or Seasonal Flow Considerations

Hundreds of AdvanTex systems are installed in parks, campgrounds, resorts, and lodges that experience highly variable flows (or complete shutdowns for long periods) due to seasonal use, and AdvanTex is ideally suited for these applications. Shortly after the system is placed in service, a thin bacterial film develops in the upper portion of the textile media; removal of BOD_5/TSS occurs the first day after being in service. Independent tests show AdvanTex systems are capable of removing $> 85\%$ $cBOD_5$ and $> 97\%$ TSS within the first few days of operation. Many other technologies (especially suspended-growth technologies) require weeks to treat to this level and struggle during periods of low loading.

The operations and maintenance (O&M) manual provided with each AdvanTex system can help guide the operator on appropriate O&M for systems with highly variable or seasonal flows, including the use of trending to automatically adjust recirculation ratios. For more information on determining which O&M method is best for a particular highly variable or seasonal flow application, contact Orenco.

Water Softener Backwash

Water softener regenerate (backwash) must not be plumbed into any Orenco AdvanTex treatment system. It is a non-organic-based, bacteria-free wastewater. The concentration of sodium and chlorides in water softener backwash alters the settling and general solids-segregating characteristics in wastewater systems, and chlorides are elevated above the 180mg/L toxicity or inhibitory threshold established by EPA for nitrogen removal.

Many jurisdictions prohibit water softener backwash from being discharged to septic systems, advanced treatment systems, and/or sanitary sewer. Instead, there is a provision for constructing a separate, small dispersal area for backwash, as it is essentially a salt/mineral-laden water, free of contaminates, and suitable for ground discharge, as recognized by many states.

Application Types

Applications can typically be classified into one of seven types, each characterized by waste streams and usage. Table 1 lists each application type, examples, the criteria used to establish each type, and associated design notes.

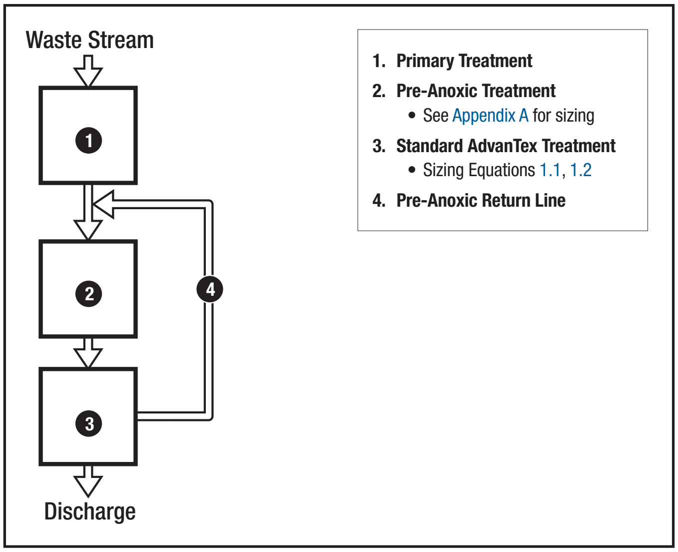
It is important to note that the flow and constituent concentration ranges associated with each application type represent Orenco's observations from similarly classified applications, rather than actual flows and constituent concentrations of the applications at hand. The engineer is responsible for ensuring that a project's wastewater is properly characterized and, whenever possible, waste streams should be sampled and actual values used in the design.

Table 1. Application Types

Application Types	Examples	Characterization Criteria*	Design Notes
Type 1: Domestic Primary-Treated Effluent Quality (Black- and Greywater Waste Blend)	• Apartments • Condominiums • Mobile home parks • Municipal systems • Planned communities • Residential subdivisions • Work camps	• Residential in nature • Black- and greywater • Typical effluent characteristics: – BOD_5 140-250mg/L – TSS 40-140mg/L – TKN 50-80mg/L	Flow contributions may bias some applications toward another application type (for example, communities serving primarily commercial core areas with minimal residential connections, or work camps with commercial kitchens serving meals for workers from other camps).
Type 2: Primarily Blackwater Waste	• Airport facilities • Campgrounds • Fire departments • Golf courses • Manufacturing facilities • Offices • Parks • Public toilets/rest areas • RV parks • Ski resorts • Visitor centers	• Commercial in nature • Primarily blackwater • Typical effluent characteristics: – BOD_5 300-500mg/L – TSS 80-250mg/L – TKN 90-200mg/L	Flow contributions may bias some applications toward another application type (for example, facilities with restaurants, RV parks, or campgrounds with flow contributions from dump stations exceeding 20% of the daily flow).
Type 3: Primarily Blackwater Waste with Surge Flows	• Churches • Schools	• Commercial in nature • Primarily blackwater • Flows and primary-treated effluent quality are heavily dependent on the facilities (for example, schools with cafeterias and shower facilities vary significantly from those without) • Typical effluent characteristics: – BOD_5 300-500mg/L – TSS 80-250mg/L – TKN 90-150mg/L	Due to variations in daily waste volumes, flow equalization tankage should be strongly considered for treatment process optimization in these applications.
Type 4: Primarily Blackwater Waste with Pharmaceuticals or Toxic Inhibitors	• Hospitals • Retirement facilities • Veterinary clinics	• Commercial in nature • Primarily blackwater • Typical effluent characteristics: – BOD_5 300-700mg/L – TSS 100-350mg/L – TKN 70-120mg/L	Antibiotics and other pharmaceutical products may impair microorganism health in the primary tank and the AdvanTex treatment unit. The plan set should note that the wastewater treatment system can be negatively affected by the introduction of these substances; care should be taken to limit their discharge.
Type 5: Blackwater with Restaurant Waste	• Bars/taverns • Casinos • Delis • Gas stations • Hotels/motels • Restaurants • Resorts • Shopping centers • Strip malls	• Commercial in nature • Varies from primarily blackwater with some kitchen sources to primarily kitchen with some blackwater sources • Significant grease and oil (G&O) contributions from raw wastewater • Typical effluent characteristics: – BOD_5 300-1000+mg/L – TSS 80-300mg/L – TKN 90-200+mg/L	Careful evaluation is required to properly size AdvanTex systems for these applications. Waste strength varies significantly depending on hours of business, menu, take-out vs. dine-in eating, dining seat turnover rate, catering and event hosting activities, etc. Restaurant applications require a pre-anoxic return loop. Applications with greater than 50% flow contribution from restaurants and BOD_5 values greater than 800mg/L require pre-aeration and clarification. Recommended grease tank sizes to ensure that G&O contribution to the secondary treatment system does not exceed a maximum of 25mg/L are provided in Appendix A. Commercial dishwashing appliances used in conjunction with AdvanTex treatment must be high-temperature appliances. For systems with existing low-temperature, chemical-type commercial dishwashing appliances, pre-aeration is necessary.
Type 6: Polishing Bioreactors and Greywater Waste	• Organic removal • Ammonia removal • Showers • Sinks	• Typically treated to secondary levels prior to polishing unit • Sized based upon the organic and/or ammonia removal loading rates in this document	Effluent polishing from lagoons or holding ponds requires removal of algae prior to introduction to the polishing bioreactor system. See Appendix F for details on greywater system hydraulic loading and wastewater constituent characteristics. Contact Orenco for support on all high-strength waste projects.
Type 7: High-Strength Process Waste	• Wineries • Breweries • Dairies • Food processing facilities • Slaughterhouses	• Complex waste streams • Careful evaluation is necessary for successful treatment	Chemical cleaning processes used in facilities that produce high-strength process waste should be evaluated for compatibility with AdvanTex biological treatment processes. These applications require a pre-anoxic return loop, pre-aeration, and clarification. Additional treatment processes, such as bioaugmentation (the addition of necessary nutrients required to speed up the rate of degradation of a contaminant), can be necessary in addition to secondary treatment. Contact Orenco for support on all high-strength waste projects.

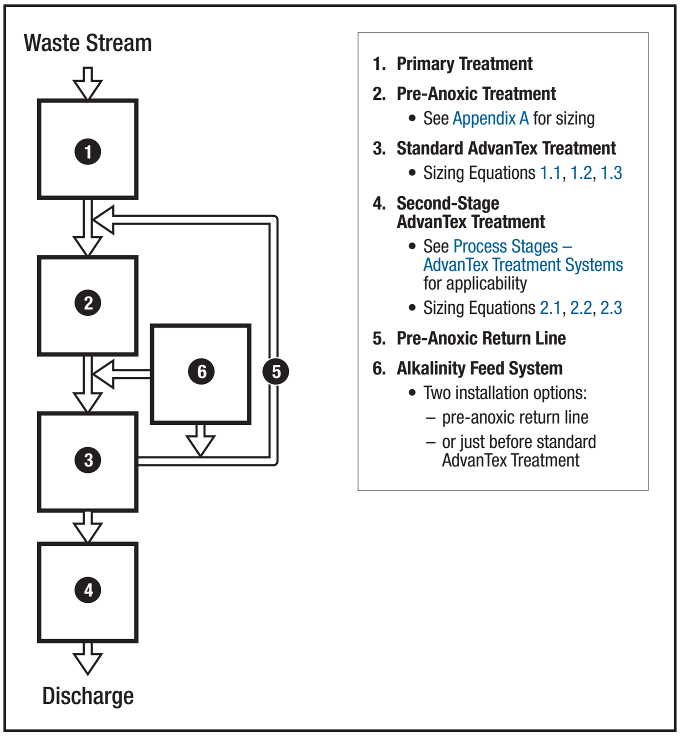
** The term "Typical effluent characteristics" assumes primary-treated effluent is used.*

Treatment System Configurations



1. **Primary Treatment**
2. **Pre-Anoxic Treatment**
    - See Appendix A for sizing
3. **Standard AdvanTex Treatment**
    - Sizing Equations 1.1, 1.2
4. **Pre-Anoxic Return Line**

Figure 4. Treatment Diagram for Removal of Organics



1. **Primary Treatment**
2. **Pre-Anoxic Treatment**
    - See Appendix A for sizing
3. **Standard AdvanTex Treatment**
    - Sizing Equations 1.1, 1.2, 1.3
4. **Second-Stage AdvanTex Treatment**
    - See Process Stages – AdvanTex Treatment Systems for applicability
    - Sizing Equations 2.1, 2.2, 2.3
5. **Pre-Anoxic Return Line**
6. **Alkalinity Feed System**
    - Two installation options:
        - pre-anoxic return line
        - or just before standard AdvanTex Treatment

Figure 5. Treatment Diagram for Advanced Removal of Ammonia

This section shows the three most common treatment system configurations using an AdvanTex Treatment System. Determination of the appropriate configuration is based upon flow, primary-treated effluent constituent concentrations, and discharge permit requirements. Each configuration shows the applicable treatment stages used and where to find the information to properly size the systems.

For systems with restaurant waste contributions, adequate grease tankage or similar means are necessary to ensure that the maximum grease contribution to the secondary treatment system does not exceed 25mg/L greases and oils. Levels above 25mg/L will tend to clog the textile sheets prematurely, preventing adequate aeration and uniform delivery of wastewater constituents for effective biological breakdown.

The appropriate sizing equations are referenced in each figure. When multiple equations are referenced, each calculation should be performed and the largest resulting textile surface area must be used in the design. Please contact Orenco or the nearest Orenco dealer for support regarding the appropriate configuration or sizing criteria.

Standard AdvanTex Systems

Use for BOD_5/$cBOD_5$, TSS, and Nitrogen Discharge Limits

Organic removal is the simplest form of advanced treatment, typically requiring only primary and secondary treatment. When loaded at or below the applicable loading rates, standard AdvanTex Treatment Systems typically achieve treatment levels of < 10mg/L BOD_5/$cBOD_5$ and TSS (based on 30-day average or 30-day arithmetic mean), and they typically provide reduction of total nitrogen (TN) > 60% and removal of ammonia (NH_3-N) of 95% (range 90-99%).

Figure 4 shows the typical configuration for discharge limits associated with these constituents. See *Performance Requirements and Unit Sizing* for the sizing equation listed.

A pre-anoxic stage is recommended for all organic-only removal applications and it is required for systems with high-strength, primary-treated effluent (Application Types 5 & 7).

A two-stage AdvanTex system will be necessary for systems with discharge limits of "not to exceed" 10mg/L BOD_5/$cBOD_5$ or for discharge limits of $\leq$ 5mg/L BOD_5/$cBOD_5$ based on a 30-day average or 30-day arithmetic mean.

AdvanTex Systems for Advanced Ammonia Removal

Use for Systems with Permits Requiring Discharge Limits of > 95% Removal of Ammonia or TKN

For wastewater systems requiring ammonia removal due to restrictive ammonia nitrogen (NH_3-N) or TKN discharge limits (> 95% removal), a second-stage AdvanTex system will be necessary following standard AdvanTex treatment. Figure 5 shows the typical configuration for discharge limits associated with this level of treatment.

The nitrification occurring in the AdvanTex system is heavily influenced by the alkalinity required to buffer the process (7.14mg/L alkalinity per 1mg/L of ammonia-N). For complete nitrification, pH levels of 7.5 to 8.5 are ideal and should be buffered to remain above a pH of 7 for all applications. Immediately preceding the AdvanTex treatment stage, a supplemental alkalinity feeder may be necessary to ensure sufficient alkalinity for nitrification to break down ammonia.

Treatment System Configurations, cont.

Using a pre-anoxic stage helps buffer pH, as denitrification in this stage will return as much as 50% of the alkalinity consumed during nitrification. In addition, readily available BOD is consumed in the pre-anoxic denitrification stage, reducing the BOD load to the secondary treatment unit. Most application types provide adequate carbon in the incoming stream to achieve denitrification and subsequent alkalinity return, but in the design, it is best to ensure that there is enough alkalinity added without relying on this occurrence. As operational data becomes available for the specific treatment system – demonstrating the return of alkalinity through denitrification – alkalinity feed rates can be adjusted downward. See *pH Effect on Nitrification* and Cold-Weather Considerations for more information.

AdvanTex Systems for Advanced Nitrogen Removal

Use for Systems with Permits Requiring Discharge Limits of 60-90% Removal of Total Nitrogen, Total Inorganic Nitrogen, or Nitrate Nitrogen

For wastewater systems with permit limits for TN, TIN, or NO_3-N requiring greater than 60% nitrogen reduction, pre- and post-anoxic treatment stages are needed, as well as possible addition of both supplemental carbon and alkalinity. Figure 6 shows a typical configuration for a system with discharge limits requiring this level of treatment.

The nitrification occurring in the AdvanTex treatment stage is heavily influenced by the alkalinity required to buffer the process (7.14mg/L alkalinity per 1mg/L of ammonia-N). For complete nitrification, pH levels of 7.5 to 8.5 are ideal and should be buffered to remain above a pH of 7 for all applications. The pre-anoxic stage benefits overall operation of the system, since denitrification in this stage returns as much as 50% of the alkalinity consumed during nitrification. A supplemental alkalinity feeder immediately preceding the AdvanTex treatment stage may still be necessary to ensure sufficient alkalinity for nitrification.

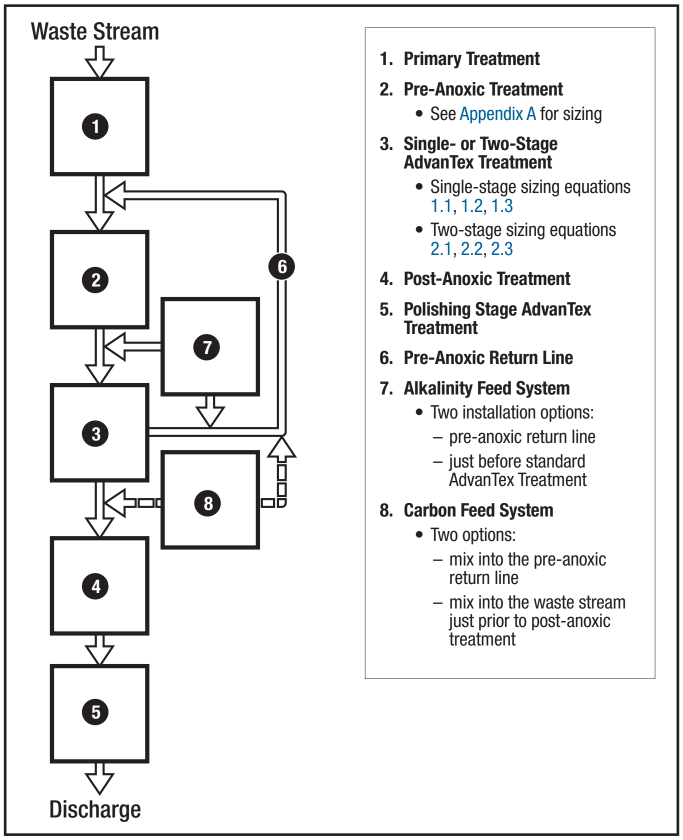


Figure 6. Treatment Diagram for Advanced Removal of Nitrogen

Carbon addition should be balanced to the wastewater flows to ensure carbon-to-nitrogen (C:N) ratios are appropriate. C:N ratios from 4:1 to 6:1 are preferable to ensure that near complete denitrification occurs. Carbon is added in the post-anoxic stage to maintain the proper C:N ratio. A post-anoxic tank with carbon addition is generally adequate for applications requiring up to 80% removal of nitrogen. For applications requiring greater than 80% removal of nitrogen, a moving bed bioreactor (MBBR) is typically necessary. See *Post-Anoxic Treatment Stage* for more information.

Depending on permit requirements, a one-, two-, or three-stage configuration is used. When there are stringent organic removal requirements (effluent BOD_5/$cBOD_5$ < 20mg/L), a two- or three-stage configuration (final stage as polishing) is often used to remove excess carbon ($cBOD_5$) prior to discharge.

For TN, TIN, and NO_3-N discharge requirements of <10mg/L, or for applications with primary-treated effluent TN values of >150mg/L or >80% nitrogen removal requirements, it will be necessary to integrate a two-stage AdvanTex system, followed by a denitrifying moving bed bioreactor (MBBRd), denitrification upflow filter, or other denitrification technology into the treatment process. Contact Orenco prior to designing a system to meet these requirements. See *pH Effect on Nitrification* and Cold-Weather Considerations for more information.

Process Stages – AdvanTex Treatment Systems

Primary Treatment Stage

Purpose and Description

The primary treatment stage is designed to collect wastewater; segregate settleable and floatable solids (sludge and scum); accumulate, consolidate, and store solids; digest organic matter; and discharge primary-treated effluent. Passive, energy-free primary tankage provides the most cost-efficient method of primary treatment available for nonindustrial sewage; BOD removal of >50% and TSS removal of > 90% (when using an effluent filter) are typically accomplished with passive primary treatment.

Process Stages – AdvanTex Treatment Systems, cont.

The primary treatment stage can be configured in several ways, including single- or multiple-compartment tanks, single tanks with meandering baffles (partitions), or multiple tanks in series. Some systems may utilize solids separation devices. Primary treatment includes effluent screening, and effluent may be discharged to the secondary treatment stage via gravity or pump.

Design Notes and Special Considerations

The volume and configuration of primary tankage or inclusion of other primary treatment devices (e.g., solids separation) is dependent on the system, the application type, and the expected waste strength. When using tankage for primary treatment, proper sizing ensures adequate volume for the development of the necessary microbial environments, appropriate sludge and scum storage, and surge volume. For recommendations on sizing of primary tankage, see Appendix A. The tank's structural soundness and watertightness are vital to the system's performance, and all tanks should be reviewed by the engineer and water-tested in the field after installation.

Pre-Anoxic Treatment Stage

Purpose and Description

This process consists of recirculating a portion of the recirc-blend (or filtrate) from the AdvanTex secondary treatment system to an anoxic zone within the initial primary solids settling/collection chamber or, preferably, in a separate pre-anoxic tank. A pre-anoxic treatment stage will tend to balance as well as lower constituent concentrations. By blending primary-treated effluent with AdvanTex filtrate, it also provides an environment for denitrifying a portion of the nitrified filtrate.

The use of a pre-anoxic stage benefits all applications and is essential for those applications with high-strength waste (organic or nitrogen concentrations) and restrictive permit limits, as well as applications desiring higher-quality effluent and enhanced overall removal performance.

Design Notes and Special Considerations

Orenco recommends the use of a pre-anoxic stage for all projects. For recommendations on sizing of pre-anoxic tankage (typically 1 day Q_M), see Appendix A. Pre-anoxic tankage volume is a component of the overall primary tankage. For an LOS or STEP system, the pre-anoxic tank is sized at 50% of the values provided in Appendix A for gravity or onsite tankage options.

The pre-anoxic return ratio (R_{NOX}) is the ratio of flow of the pre-anoxic return loop in relation to the Design Average Day Flow (Q_A). For most applications, the R_{NOX} value is equal to 1± and therefore the return flow to the pre-anoxic stage (Q_{RNOX}) is equal to Q_A.

Alkalinity is often added in this stage because the pre-anoxic return line is a convenient place to add alkalinity while simplifying the overall system layout. The pre-anoxic return line can also be used to introduce supplemental carbon while maintaining a simple design. The establishment of denitrification in this stage reduces organic and nitrogen levels while returning about 50% of the alkalinity consumed during the first stage of secondary treatment (3.57mg/L alkalinity per 1mg/L NO_3-N denitrified).

Consider supplemental carbon addition in the pre-anoxic stage for:

- Systems requiring significant total nitrogen reduction (> 85%)
- Systems with high nitrogen values in primary-treated effluent (Application Types 2, 3, & 5), resulting in low C:N ratios (< 4:1)

Orenco offers liquid chemical feed units for adding alkalinity as well as for adding supplemental carbon. There are advantages and disadvantages to various alkalinity sources and supplemental carbon products, so consider specific project conditions when selecting.

Flow Equalization Stage

Purpose and Description

Flow equalization (EQ) provides stability by leveling out peaks in flow and allowing consistent loading of the treatment system. EQ is strongly recommended for systems with variable flow patterns and restrictive discharge limits. EQ is especially important for systems that have highly variable flow patterns due to usage (for example, resorts and churches) or collection method (such as gravity sewer collection).

The EQ stage consists of a tank or tanks fitted with a timed-dose-controlled pumping system. It follows the primary tank and pre-anoxic tank (if used) and is typically located before pre-aeration/clarification tankage (if used) or a recirculation-blend chamber.

Design Notes and Special Considerations

EQ tank sizing recommendations vary for systems with significant fluctuations in flow. For support with EQ tank sizing, contact Orenco.

For schools and churches, Orenco typically recommends dividing the system's total weekly flow by six and using this value as the Design Average Flow, with one day allowed for recovery. Using this technique, an EQ tank equal to the Design Maximum Day Flow is generally adequate, but calculations should be performed to verify the tank sizing requirement.

Process Stages – AdvanTex Treatment Systems, cont.

By their nature, LOS and STEP collection systems inherently provide a significant amount of flow equalization. When using this collection method, the addition of EQ tanks at the treatment site is only necessary for systems with extreme flow fluctuations (for example, fairgrounds, racing venues, etc.) or highly restrictive permit requirements.

Pre-Aeration Treatment Stage

Purpose and Description

Pre-aeration reduces organic waste strength prior to secondary treatment, with a typical target reduction of BOD_5 to less than 400mg/L. It is used for applications with high-strength waste streams (such as Type 7 applications and any application with a significant volume of restaurant waste, such as Type 5) to condition the waste stream prior to secondary treatment by raising dissolved oxygen levels.

An aeration tank, followed by a clarification tank, is situated between the primary treatment system (or pre-anoxic tank, if used) and the secondary treatment system.

Design Notes and Special Considerations

Pre-aeration units should be sized to provide the appropriate amount of oxygen to reduce organic waste strength or to reduce BOD_5 to less than 400mg/L. For systems with high BOD_5 influent values from restaurant waste, pre-aeration can be sized to accomplish approximately 50% reduction in BOD_5 values. For systems with sugar-based BOD_5 influent values from food or wine processing, pre-aeration can be sized to accomplish approximately 75% reduction in BOD_5 values. For recommendations on sizing pre-aeration and clarification tanks, see Appendix A.

Pre-aeration is required for all Application Type 7 systems and highly recommended for systems that have greater than a 50% contribution of flow from restaurants (primarily Application Type 5 systems). Contact Orenco for more information.

Standard AdvanTex Treatment Stage

Purpose and Description

After primary or pre-anoxic treatment, effluent is transported to the recirculation-blend tank or chamber, where it is blended with AdvanTex filtrate. The blended wastewater is distributed over the AdvanTex textile media and percolates down through the media, where it is filtered, cleaned, and nitrified by the naturally occurring microorganisms populating the media. After treatment, a portion of the filtrate is returned to the recirculation-blend chamber while another portion is transported to the next treatment stage or to dispersal. Note that a portion of the recirc-blend (or filtrate) is often returned directly to the pre-anoxic treatment stage.

In the secondary treatment process, AdvanTex units filter and clean effluent from the primary treatment system. When loaded at or below the applicable loading rate, they typically achieve treatment levels of < 10mg/L BOD_5/$cBOD_5$ and TSS (30-day average or 30-day arithmetic mean), with total nitrogen (TN) reduction typically $> 60\%$ and nitrification averages of 95% (range 90-99%). For nitrogen loading rates and sizing requirements, refer to *Performance Requirements and Unit Sizing*.

Post-Anoxic Treatment Stage

Purpose and Description

The post-anoxic treatment stage provides additional denitrification after secondary treatment in wastewater systems that require significant reductions in TN, TIN, or NO_3-N. Nitrified AdvanTex filtrate from the secondary treatment stage is transported to an anoxic zone inside of the post-anoxic tank. During post-anoxic denitrification, BOD is consumed during the conversion of NO_3 to N_2 gas by facultative heterotrophic bacteria. The N_2 gas is then returned to the atmosphere. There are two options for post-anoxic treatment: standard post-anoxic treatment without media or an anoxic moving bed bioreactor (MBBRd) with media. A supplemental carbon feed unit is required for both options to provide the post-anoxic stage with the necessary carbon-to-nitrogen ratio for effective denitrification.

Design Notes and Special Considerations:

Post-anoxic tanks are typically sized at 100% of the Average Day Design Flow. For denitrification to take place, oxygen levels must be depleted to the level that nitrate becomes the primary oxygen source for microorganisms. Requirements for effective denitrification include:

- Dissolved oxygen levels < 0.5mg/L (preferably < 0.2mg/L)
- Carbon-to-nitrogen ratio greater than 4:1
- Adequate mixing to ensure chemical distribution throughout the vessel
- Sufficient residual alkalinity (100mg/L ±) in the secondary treatment stage to ensure optimum pH in the post-anoxic stage
- Waste stream temperature above 50°F (10°C) at all times and typically above 59°F (15°C)

Process Stages – AdvanTex Treatment Systems, cont.

For standard post-anoxic treatment meeting the above conditions, reduction of nitrate (NO_3) through conversion to nitrogen gas (N_2) should exceed 70%. For additional nitrogen reduction, Orenco recommends a denitrifying moving bed bioreactor (MBBRd). MBBRd units are built in insulated fiberglass vessels. They can achieve up to 85% reduction of nitrate (NO_3) through conversion to nitrogen gas (N_2) and are typically configured as follows:

- Fiberglass vessel, sizing, media, and mixing requirements based on *MBBR Design Guidelines*, NDA-TRT-MBB-1
- Media fill, typically 20% of the vessel volume
- One pneumatic ejector provided per 4 lineal ft (1.22m) of vessel to ensure optimal mixing and food delivery to the media
- Blowers, housed in a control building, to power ejectors

AdvanTex Treatment – Second Stage of Two-Stage and Three-Stage Treatment

Purpose and Description

A second stage of AdvanTex treatment can be used cost-effectively for enhanced nitrification or polishing:

- Nitrifying the waste stream for systems with very low ammonia (NH_3-N) or TKN discharge requirements: typically > 95% removal (nitrification)
- Removing any excess BOD_5 that is not consumed in the denitrification process following the post-anoxic stage on projects with restrictive BOD_5/$cBOD_5$ permit limits, typically 20mg/L or less (polishing)
- Removing BOD_5 for systems with “not to exceed” permit limits of < 10 mg/L BOD_5/$cBOD_5$ or 30-day average permit limits of ≤ 5mg/L BOD_5/$cBOD_5$ (polishing)

The treatment mechanisms are the same as described in *Standard AdvanTex Treatment Stage*. For sizing requirements, see *Performance Requirements and Unit Sizing*.

For information on the importance of pH and temperature on the nitrification process, see *pH Effect on Nitrification* and *Cold-Weather Considerations*.

Final Polishing Treatment Stage – Third Stage of Three-Stage Treatment

Purpose and Description

An AdvanTex Final Polishing Stage unit is typically used for final polishing of BOD_5/$cBOD_5$ for projects with high influent organic and/or nutrient loads and strict organic and nutrient limits:

- Nitrifying the waste stream for systems with very low ammonia (NH_3-N) or TKN discharge requirements: typically > 90% removal (nitrification)
- Removing any excess BOD_5 that is not consumed in the denitrification process following the post-anoxic stage on projects with restrictive BOD_5/$cBOD_5$ permit limits, typically 20mg/L or less (polishing)

The treatment mechanisms are the same as described in *Standard AdvanTex Treatment Stage*. For sizing requirements, see *Performance Requirements and Unit Sizing*. For information on the importance of pH and temperature on the nitrification process see *pH Effect on Nitrification* and Cold-Weather Considerations.

Disinfection Stage

Purpose and Description

Secondary-treated effluent is usually clear and odorless, but it still contains pathogens at levels that can cause illness if ingested or released into the environment. Disinfection is required in many surface discharge or reuse systems. Disinfection can be achieved by any method that destroys pathogens; ultraviolet (UV) rays, chlorine, and ozonation are the most common methods.

Due to the low turbidity of AdvanTex effluent and the fact that UV disinfection requires no chemicals and leaves no toxic residue, UV disinfection is the most common method used following AdvanTex systems.

Chlorination is also a common disinfection method used; however, handling issues and concerns about chemical residue make it less desirable than UV. Ozonation, another common method, is extremely effective and popular for reuse applications within facilities (e.g., toilet flushing), due to its ability to remove any residual color in the effluent stream. Ozonation is typically the least economical of the three methods in the lower-flow applications common with decentralized systems.

Design Notes and Special Considerations

UV disinfection lamps require cleaning and servicing on a regular basis (once a month to once a year, depending on effluent quality and UV system design). Disinfection devices can be integrated into the treatment system and connected to the TCOM control system for monitoring and control.

Process Stages – AdvanTex Treatment Systems, cont.

Reuse applications, such as toilet flushing and industrial processes, require a high level of effluent purity. Chlorination or ozonation are often used in these applications. In some circumstances, tertiary treatment may be required. This can include (in addition to chemical or ultraviolet disinfection) the use of fine mesh filter processes, such as polishing filters; multi-media filtration; micro-, ultra-, or nano-filtration through membranes; reverse osmosis; or cloth/disc filters. Contact Orenco for more information.

Performance Requirements and Unit Sizing

Performance of Typical AdvanTex Systems

When loaded at or below applicable loading rates, AdvanTex systems typically achieve < 10mg/L BOD_5 and TSS (30-day average or 30-day arithmetic mean). Total Nitrogen (TN) reduction typically exceeds 60%, with nitrification exceeding 95%, given liquid temperature levels greater than 50ºF (10ºC) and pH values between 7 and 9. The loading rates provided in *Standard AdvanTex Stage Sizing* are based upon these minimum values for liquid temperature and pH. With additional components and configurations, AdvanTex Treatment Systems can meet more stringent treatment levels.

Standard AdvanTex Stage Sizing

The primary criteria used to determine the amount of textile surface area necessary to meet treatment requirements are the daily flow volumes (Average and Maximum Day), primary-treated effluent Organic Load, Organic Loading Rate (OLR), and Hydraulic Loading Rate (HLR). For facilities that require advanced nitrogen discharge levels (> 60% TN or > 95% NH_3-N), the Ammonia Loading Rate (ALR) or Total Nitrogen Loading Rate (TNLR) should be used in conjunction with the organic and hydraulic loading rates to size the system. AdvanTex Treatment Systems must be sized so the designed treatment area meets or exceeds that required by the controlling loading rate. ***The loading rate that corresponds to the largest textile surface area controls the design.***

Packed-bed filters are effective organic- and nitrogen-removal systems and perform well for TSS removal. Since they treat primary-treated effluent, TSS should be lower than organic load. Therefore, TSS loading is never the determining factor in system sizing, and these loading rates are not covered in this design criteria. Other technologies may be more applicable for systems with higher influent TSS concentrations than BOD_5 concentrations. Contact Orenco or your local Orenco dealer for more information.

Standard AdvanTex Treatment Loading Rates – All Systems

Organic Loading Rates (OLR)

Design Average: 0.04lbs $BOD_5/ft^2{\bullet}d$ (0.2kg $BOD_5/m^2{\bullet}d$)
Design Maximum Day: 0.08lbs $BOD_5/ft^2{\bullet}d$ (0.4kg $BOD_5/m^2{\bullet}d$)
The equation for determining OLR-based treatment area is:

$$A_{OLR} = BOD_{5i} / OLR \qquad \textbf{Equation 1.1}$$

where:
A_{OLR} = Treatment area based on Organic Loading, ft^2 (m^2)
BOD_{5i} = Primary-treated effluent BOD_5 (organic) load, lbs/d (kg/d)
OLR = Organic loading rate, $lbs/ft^2{\bullet}d$ ($kg/m^2{\bullet}d$)

Hydraulic Loading Rates (HLR)

Design Average: $25gpd/ft^2$ ($1m^3/m^2{\bullet}d$)
Design Maximum Day: $50gpd/ft^2$ ($2m^3/m^2{\bullet}d$)
The equation for determining HLR-based treatment area is:

$$A_{HLR} = Q / HLR \qquad \textbf{Equation 1.2}$$

where:
A_{HLR} = Surface area based on Design Average Hydraulic Loading, ft^2 (m^2)
Q = Influent hydraulic load, gpd (m^3/d)
HLR = Hydraulic loading rate, $gpd/ft^2{\bullet}d$ ($m^3/m^2{\bullet}d$)

Systems with Total Nitrogen-Based Discharge Limits

For systems requiring a greater than 60% removal rate for TN, TIN, or NO_3-N, the required textile area is determined by using the Total Nitrogen Loading Rate (TNLR) and the TN value (if available) or TKN value (if the TN value isn't available) in the primary-treated effluent. The value for TN and TKN should be the same after anaerobic primary treatment, but it will vary significantly if pre-aeration is used.

Performance Requirements and Unit Sizing, cont.

Total Nitrogen Loading Rates (TNLR)

Design Average: 0.014lbs TN/ft^2•d (0.07kg TN/m^2•d)
The equation for determining TNLR-based treatment area is:

$$A_{TNLR} = (TKN_i \text{ or } TN_i) / TNLR \qquad \text{Equation 1.3}$$

where:
A_{TNLR} = Treatment area based on Total Nitrogen Loading, ft^2 (m^2)
TKN_i = Primary-treated effluent Total Kjeldahl Nitrogen load, lbs/d (kg/d)
TN_i = Primary-treated effluent Total Nitrogen load, lbs/d (kg/d)
TNLR = Total nitrogen loading rate, lbs/ft^2•d (kg/m^2•d)

Systems with Ammonia-Based or TKN-Based Discharge Limits

For applications requiring ammonia or TKN removal greater than 95%, use both the ALR (see below) and the TNLR (Equation 1.3) and choose the greater of the two values. ALR for primary-treated effluent ammonia and TNLR account for any organic nitrogen that may be converted to ammonia through the primary or secondary treatment processes (see *Primary-Treated Effluent Wastewater Strength*). In the equation below, TKN_i is substituted for $NH_3\text{-}N_i$ if the influent $NH_3\text{-}N_i$ concentration is unknown.

Ammonia Loading Rates (ALR) and TKN Loading Rates (TKNLR)

Design Average: 0.01lbs NH_3-N/ft^2•d (0.05kg NH_3-N/m^2•d)
For projects requiring specific TKN removal, Equation 1.4 can be used by substituting A_{TKNLR} for A_{ALR} and TKN_i for $NH_3\text{-}N_i$.
The equation for determining Ammonia- or TKN-based treatment area is:

$$A_{ALR} = NH_3\text{-}N_i / ALR \qquad \text{Equation 1.4}$$

where:
A_{ALR} = Surface area based on NH_3-N loading, ft^2 (m^2)
$NH_3\text{-}N_i$ = Primary-treated effluent Ammonia load, lbs/d (kg/d)
ALR = Stage 1 Ammonia loading rate, lbs/ft^2•d (kg/m^2•d)

Second-Stage or Third-Stage AdvanTex Sizing in Two-Stage and Three-Stage Systems

For the calculation of second-stage or third-stage AdvanTex treatment area, use the treated effluent produced by the standard AdvanTex system, BOD_{5e} and TKN_e. Effluent values for BOD_5 and TKN are typically based upon 95% nitrification and 70% denitrification through the pre-anoxic stage and standard AdvanTex treatment stage. See Appendix B for a sample calculation.

Second-Stage or Third-Stage Organic Loading Rates (OLR)

Design Average: 0.02lbs BOD_5/ft^2•d (0.1kg BOD_5/m^2•d)
Design Maximum Day: 0.04lbs BOD_5/ft^2•d (0.2kg BOD_5/m^2•d)
The equation for determining OLR-based treatment area is:

$$A_{OLR} = BOD_{5e} / OLR \qquad \text{Equation 2.1}$$

where:
A_{OLR} = Treatment area based on Organic Loading, ft^2 (m^2)
BOD_{5e} = Secondary-treated effluent BOD_5 (organic) load, lbs/d (kg/d)
OLR = Organic loading rate, lbs/ft^2•d (kg/m^2•d)

Second-Stage or Third-Stage Hydraulic Loading Rates (HLR)

Design Average: 75gpd/ft^2 (3m^3/m^2•d)
Design Maximum Day: 125gpd/ft^2 (5m^3/m^2•d)
The equation for determining HLR-based treatment area is:

$$A_{HLR} = Q / HLR \qquad \text{Equation 2.2}$$

where:
A_{HLR} = Surface area based on Design Average Hydraulic Loading, ft^2 (m^2)
Q = Influent hydraulic load, gpd (m^3/d)
HLR = Hydraulic loading rate, gpd/ft^2•d (m^3/m^2•d)

Performance Requirements and Unit Sizing, cont.

Second-Stage or Third-Stage Total Nitrogen Loading Rates (TNLR)

Design Average: 0.007lbs TN/ft^2•d (0.035kg TN/m^2•d)
The equation for determining TNLR-based treatment area is:

$$A_{TNLR} = TKN_e / TNLR \qquad \text{Equation 2.3}$$

where:
A_{TNLR} = Treatment area based on Total Nitrogen Loading, ft^2 (m^2)
TKN_e = Secondary-treated effluent Total Kjeldahl Nitrogen, lbs/d (kg/d)
TNLR = Total nitrogen loading rate, lbs/ft^2•d (kg/m^2•d)

Second-Stage or Third-Stage Ammonia Loading Rates (ALR)

Design Average: 0.005lbs NH_3-N/ft^2•d (0.025kg NH_3-N/m^2•d)
The equation for determining ALR-based treatment area is:

$$A_{ALR} = TKN_e / ALR \qquad \text{Equation 2.4}$$

where:
A_{ALR} = Surface area based on NH_3-N loading, ft^2 (m^2)
TKN_e = Secondary-treated effluent Total Kjeldahl Nitrogen, lbs/d (kg/d)
ALR = Ammonia loading rate, lbs/ft^2•d (kg/m^2•d)

Design Considerations

Recirculation-Blend Tank Sizing

AdvanTex AX20 and AX100 systems require external recirculation-blend tankage. AdvanTex AX-Max units are configured with integral recirculation-blend capacity and do not require an external recirculation-blend tank. The following design considerations apply to recirculation-blend tankage for AX20 and AX100 systems:

- For standard AdvanTex systems, recirculation-blend tankage should be sized to at least 75% of the Design Maximum Day Flow or 100% Average Day Design Flow, whichever is greater.
- For second- or third-stage AdvanTex systems, recirculation-blend tankage should be sized to at least 25% of the Design Maximum Day Flow.

Recirculation Pump Sizing

AX20 units have five laterals and sixty-eight 1⁄8in (3mm) diameter orifices in each unit. A residual pressure of 5ft (1.5m) is used to determine initial timed-dosing settings. Typically, residual pressure ranges from 3 to 6ft (0.9 to 1.8m). This may vary depending on system hydraulics or special treatment requirements. Table 2 provides sizing information about Orenco 4in (100mm) submersible effluent pumps used in AdvanTex AX20 recirculation pumping assemblies for typical design configurations.

Table 2. Recirculation Pump Sizing, AX20

Number of Units	Number and Operation of Pumps	Nominal Flow Rate	60Hz Pump Selections	50Hz Pump Selections
1	2 pumps, alternate dosing	30gpm (1.9L/sec)	1/2hp (0.37kW); PF3005	3/4hp (0.56kW); PF3005
2	2 pumps, alternate dosing	50gpm (3.2L/sec)	1/2hp (0.37kW); PF5005	3/4hp (0.56kW); PF5007
3	2 pumps, alternate dosing	75gpm (4.7L/sec)	1 1/2hp (1.1kW); PF7510	1hp (0.7kW); PF7510
4	2 pumps, 1 pump for 2 units, alternate dosing	50gpm (3.2L/sec)	1/2hp (0.37kW); PF5005	3/4hp (0.56kW); PF5007

AX100 units have four laterals with two spin nozzles per lateral, for a total of eight spin nozzles. The pumping rate is about 50gpm± per AX100 unit (minimum 6gpm ± per nozzle at 3.0psi, or 0.38L/sec at 20.7kPa). Adjusting pressure at the unit inlet can vary flow. Sufficient pump redundancy is required to ensure operational integrity with one or more inoperable pumps. Table 3 provides sizing information for Orenco 4in (100mm) submersible effluent pumps used in AdvanTex AX100 recirculation pumping assemblies for typical design configurations.

Design Considerations, cont.

Table 3. Recirculation Pump Sizing, AX100

Number of Units	Number and Operation of Pumps	Nominal Flow Rate	60Hz Pump Selections	50Hz Pump Selections
1	2 pumps, alternate dosing	50gpm (3.2L/sec)	3/4hp (0.56kW); PF5007	3/4hp (0.56kW); PF5007
2	2 pumps, 1 pump per unit, alternate dosing	50gpm (3.2L/sec)	3/4hp (0.56kW); PF5007	1hp (0.7kW); PF5010
3	2 pumps, simultaneous dosing	75gpm (4.7L/sec)	1hp (0.7kW); PF7510	1hp (0.7kW); PF7510
4	4 pumps, 1 pump per unit, alternate dosing	50gpm (3.2L/sec)	3/4hp (0.56kW); PF5007	1hp (0.7kW); PF5010
5-6	4 pumps, 2 pumps per 2-3 units, simultaneous or alternating dosing	75gpm (4.7L/sec)	1hp (0.7kW); PF7510	1hp (0.7kW); PF7510
7-9	6 pumps, 2 pumps per 2-3 units, simultaneous or alternating dosing	75gpm (4.7L/sec)	1hp (0.7kW); PF7510	1hp (0.7kW); PF7510

AX-Max units are typically designed to accommodate a specific application, based on Design Average and Design Maximum Day Flows, the application type's targeted treatment levels, and other factors. Because of this, AX-Max configurations vary and recirculation pumps for these units are determined on a project-by-project basis. Contact Orenco for more information.

AdvanTex TCOM Control System

The TCOM Control Panel is a telemetry-based panel that can be connected to a land line, cellular service, internet, or satellite service. It controls all sensors and pumping equipment for the system. TCOM panels are an integral part of all commercial AdvanTex Treatment System equipment packages. Telemetry provides real-time operator monitoring and control of system components, as well as remote data collection of key operational parameters and events. The panel's communication function provides notice to system operators in the event of an alarm. Operators can call into the control unit, determine the cause of the alarm, and – often – address the situation without having to be physically present at the treatment facility.

The TCOM unit can be programmed to automatically adjust timer settings using trend data, based on established recirculation ratios, so frequent operator adjustment is not necessary for systems with flow variations. If additional equipment is required for pretreatment, tertiary treatment, or disinfection, the controls for each component can easily be incorporated into the TCOM control panel. This allows Orenco to contact the panel directly to assist the operator in system evaluation and troubleshooting or to manually override operations. TCOM control panels can also integrate into existing SCADA systems. Consult with Orenco early in the design process to discuss any integration needs.

Multiple enclosure types are available with Orenco's TCOM control panels; the enclosure needs to provide the panel with protection from the elements, including direct sunlight, during regular operation and while the operator is accessing the panel. This should be taken into account when determining location of the control unit. Shelters are recommended for panels whenever possible. Contact Orenco for a quote.

AdvanTex System Ventilation

Proper ventilation, achieved by active or passive ventilation, is critical for maintaining aerobic treatment processes in AdvanTex Treatment Systems.

Active Ventilation

Active ventilation is the preferred means of ventilating AdvanTex Systems and is required for the following systems:

- All systems with Design Maximum Day Flows > 10,000gpd (37,854L/d)
- All systems with average primary-treated effluent waste strength > 200mg/L BOD_5 and 100mg/L TSS
- All systems with nitrogen discharge limits
- All AX-Max systems; at least one ventilation assembly is required per two connected units (AX-Max units are typically designed with a built-in active vent system, and one vent system per unit is preferred)

Passive Ventilation

Passive ventilation can be considered in AX20 or AX100 systems receiving primary-treated effluent of residential strength, with constituent concentrations of < 200mg/L BOD_5 and < 100mg/L TSS and with Design Maximum Day Flows < 10,000gpd (37,854L/d) for AX100 systems and 4,000gpd (15,140L/d) for AX20 systems. For proper function, it is critical for air movement to be greater than 5 cubic feet per minute (cfm) for every 100ft^2 of treatment area (0.14m^3/minute for every 9.3m^2). It is also critical to ensure that there is a clear path for airflow through the system if the system relies on passive ventilation. If these conditions cannot be met, active ventilation should be used.

Although activated carbon media is included to adsorb and mitigate odors in AdvanTex passive ventilation systems, slight odors may occur during dosing events. Passively ventilated systems should be located in areas where this will not be perceived as a nuisance.

Design Considerations, cont.

Antibuoyancy Features

AdvanTex AX20 units come standard with antibuoyancy flanges to help prevent the unit from floating out of the ground under saturated soil conditions. Always keep the top of the unit at least 6in (150mm) above grade at all times. When buried to this level, spacing is 5ft (1.5m) between AX20 units. Contact Orenco for details.

AdvanTex AX100 units are designed for installation in areas that are free of water. AX100 units can be bermed and free draining, but the bottom of each unit should be no more than 9in (230mm) below the natural grade to protect it from floating in saturated conditions.

AdvanTex AX-Max units should be ordered with antiflotation provisions if the unit will be partially buried. Spacing of the units varies, but at maximum bury of 6ft (1.83m) with high groundwater conditions, this spacing would be approximately 10ft (3m) between units. When the unit is set at natural grade and the material used for berming is free flowing, anti-buoyancy will not be necessary. Contact Orenco for details.

pH Effect on Nitrification

The pH level is extremely important for nitrification (Figure 7). The effective reaction rate (R_N) is 0.95 at a pH of 8±, dropping to 0.47 at a pH of 7, and dropping precipitously to 0.15 at a pH of 6. Nitrification effectively ceases at a pH of 5. The use of additional alkalinity to buffer the process is critical for all nitrogen removal configurations, and the feed system should be sized to provide a minimum targeted residual of 80mg/L, with a preferred residual target of 100mg/L.

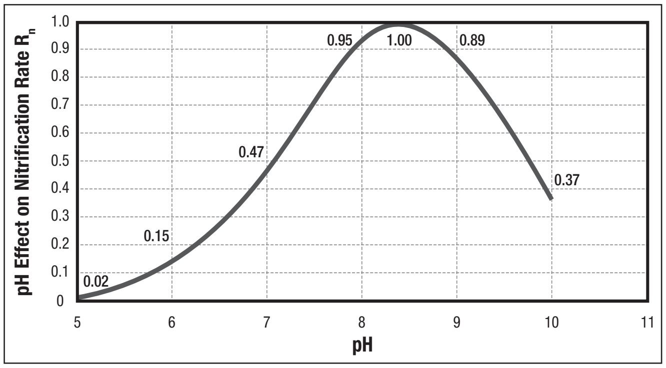


Figure 7. pH Effect on Nitrification

Cold-Weather Considerations

The naturally occurring bacteria that populate the AdvanTex treatment media are active at temperatures above 44ºF (6.7ºC), with an optimal temperature range above 68ºF (20ºC). To ensure treatment in cold climates or areas with seasonal cold weather, it is recommended that the liquid temperature remain above 50ºF (10ºC). Temperature is especially important in the nitrification and denitrification process. If temperature values are expected to be below this threshold, contact Orenco for heating options and/or safety factors for design purposes.

Temperature Effect on Nitrification and Denitrification

Temperatures in the liquid stream and treatment media have an impact on both the nitrification and denitrification processes. Figure 8 shows that the effect of temperature on nitrification and denitrification rates can be used to predict efficiency of the overall treatment process. Orenco bases performance on minimum temperature values of 50ºF (10ºC) during winter operation and 59ºF (15ºC) during summer operation. For actual liquid temperatures below these values, systems should be upsized to achieve treatment expectations described in this document. Following are cold-weather considerations for AX20, AX100, and AX-Max units, as well as general cold-weather considerations for all systems to prevent freezing and avoid damage due to frost heave:

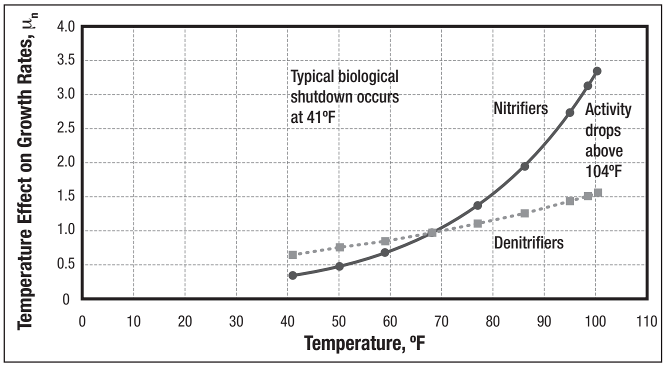


Figure 8. Temperature Effect on Nitrification and Denitrification

AX20 and AX100 Units

- Insulated foam-core lids with a minimum R-value of R6 (RSI1) are standard equipment to prevent heat loss through the top of AX20 and AX100 units. If necessary, insulation board or spray-on insulation foam can be added during installation.
- The depth of the recirculation-blend tank can be increased – but the tank must still be accessible to operators for maintenance activities.
- Warm air ventilation is critical. High flows of cold air through the treatment unit can cause significant temperature drops.
- Orenco fiberglass shelters provide a temperature-controlled air source for the treatment system, easy access to the control system, and housing and storage for chemical feed equipment.

Design Considerations, cont.

AX-Max Units

- Units are configurable for use in climates with extreme temperatures ranging from -60°F to 125°F (-51°C to 52º C).
- Units are constructed with 4in (100mm) foam cells that provide an estimated insulation value of R26 (RSI5).
- Orenco fiberglass shelters provide a temperature-controlled air source for the treatment system, easy access to the control system, and housing and storage for chemical feed equipment.

General Cold-Weather Considerations for All Systems

- Standard cold-weather practices for AdvanTex systems include allowing all lines to drain back to tankage and insulating access lids on primary and recirculation-blend tankage.
- In extreme climates with long periods of subfreezing weather, a warm air source into the treatment unit(s) or immersion heaters may be necessary to keep treatment temperatures above 50ºF (10ºC).
- In areas where snow typically accumulates each winter, air vents must be extended to ensure they are above peak snow levels.
- In areas where frost heave is a concern, backfilling access riser excavations with pea gravel is recommended.

Orenco provides training webinars on general wastewater concepts, design, and operation and maintenance throughout the year. Contact Orenco or a local Orenco dealer to attend a training session.

Orenco staff is prepared to support the designer throughout the project cycle, including the initial evaluation of technologies, preliminary design, and a thorough and timely design review – all without cost. Orenco can also assist with the approval process and the evaluation of operational and lifecycle costs.

Appendix A. Sizing for Primary and Pre-Anoxic Tankage

All secondary treatment systems are limited in their ability to break down and treat organic material. The purpose of primary tankage in AdvanTex Treatment Systems is to reduce and maintain organic material at a level that can be efficiently and economically treated by the AdvanTex treatment unit(s). Primary tankage can anaerobically digest organic material, remove solids, modulate flow, and provide emergency storage volume. To operate effectively, primary tankage must be properly designed and sized, structurally sound, watertight, and well-maintained.

Table A provides recommended minimum tank volumes for the application types defined in this Design Criteria. To calculate recommended minimum tank volumes, multiply the Design Maximum Day Flow specified for the system by the necessary hydraulic retention time (HRT) in days. For example, if local regulations require a 10,000gpd (37.9m^3) system design (based on Design Maximum Day Flow) for an office facility, Orenco recommends a minimum total tank volume of 30,000gal (113.6m^3). To determine preferred tank volumes, add approximately 50% to the minimum values.

The minimums in Table A exceed those set by the United States Environmental Protection Agency (USEPA) and the regulatory requirements for nearly every state in the United States. With regard to tank sizing, longer hydraulic retention times result in improved primary treatment.* Research strongly indicates that the smaller volumes calculated by using the USEPA formula (based on 1940's information), as well as the listed volumes for most state and local health agencies, consistently produce poor-quality effluent. They are also associated with increased pumpout frequencies and costs, increased need for secondary treatment capacity, and an increased need for maintenance activities and their associated costs.

Orenco recommends the use of pre-anoxic tankage prior to the recirculation-blend tank for all systems. Recommended total primary tankage is provided in Table A, followed in parentheses by the recommended configuration of the primary tankage for specific treatment needs, if any, such as a pre-anoxic stage, aeration unit, clarification chamber, or flow equalization.

Table A is intended as a general guideline for decentralized wastewater treatment designs. The system designer is responsible for ensuring adequate primary treatment prior to the secondary treatment system. Check local regulations to ensure that the recommended minimum volumes meet applicable regulatory requirements. For questions about special cases where larger tankage or other measures may be necessary, or for general questions about flow equalization, please call Orenco at (800) 348-9843 or +1 541-459-4449.

**Several references corroborate this statement, including the following:*

Metcalf & Eddy, "Wastewater Engineering Collection, Treatment, Disposal," 1972 (New York, McGraw Hill).

Winneberger, John H. Timothy, "Septic Tank Systems, A Consultant's Toolkit, Volume II The Septic Tank," 1984 (Butterworth Publishers, Ann Arbor Science).

Laak, Rein, "Wastewater Engineering Design for Unsewered Areas," 1980 (Butterworth Publishers, Ann Arbor Science).

Philip, H., et. al., "Septic Tank Sludges: Accumulation Rate and Biochemical Characteristics," 1993 Water Science & Technology.

Appendix A. Sizing for Primary and Pre-Anoxic Tankage, cont.

Table A. Recommended Minimum HRTs, Primary Tankage, and Configurations

Application Type	Hydraulic Retention Time (HRT) in Days		Minimum Volumes & Configurations for Primary Tankage	
	Grease Tankage[1]	Primary Tankage[2]	Without Aeration	With Aeration
Type 1. Residential quality waste[3] (includes apartments, condos, mobile home parks, municipal applications, planned communities, subdivisions, work camps)	n/a	2	2× Design Max. Day Flow (1P + 1A)	n/a
Type 2. Primarily blackwater waste[4,5] (includes airport facilities, campgrounds, fire departments, golf courses, marinas, offices, parks, public toilets, rest areas, RV parks[5], ski resorts, visitor centers)	3	3	3× Design Max. Day Flow (2P + 1A)	n/a
Type 3. Primarily blackwater waste with surge flows[6, 7] (includes churches, schools)	3	3 4	3× Design Max. Day Flow (2P + 1A with no flow equalization) 4× Equalized Design Avg. Day Flow (2P + 1A + $1Q_M$ with flow equalization)	n/a
Type 4. Primarily blackwater waste with pharmaceutical concerns[8] (includes hospitals, retirement facilities, veterinary clinics)	3[4]	4	4× design max. day flow (3P + 1A)	3× design max. day flow (1P + 1A + 0.5 AE + 0.5 C)
Type 5. Blackwater waste and restaurant waste[9, 10] (includes bars/taverns, casinos, delis, gas stations, hotels/motels, restaurants, resorts, shopping centers/strip malls)	3	n/a	4× design max. day flow (3P + 1A)	4× design max. day flow (2P + 1A + 0.5 AE + 0.5 C)
Type 6. Polishing bioreactors (includes polishing bioreactors for organic or ammonia removal, e.g., lagoon compliance)	n/a	n/a	n/a	n/a
Type 7. High-strength process waste[10] (includes wineries, breweries, dairy or food processing facilities, slaughterhouses)	n/a	n/a	n/a	4.5× design max. day flow (2P + 1A + 1AE + 0.5C)

Contact Orenco for support with applications that have characteristics not listed in this chart.

Key: P = Primary Tankage A = Pre-Anoxic AE = Aeration Tankage C= Clarification Tankage

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[1] *HRT is based on a separate kitchen Design Maximum Day Flow integrated into the main flow prior to the primary septic tanks. Orenco recommends a grease tank for any facility with a commercial kitchen. Additional grease tankage provides increased reduction of organics, as well as separation of grease and oil (G&O) prior to secondary treatment. G&O concentrations entering secondary treatment should be limited to 25mg/L. Chemical disinfection dishwashers can cause significant downstream problems due to high volumes of sanitizing compounds and emulsifiers and should not be used in onsite treatment and soil dispersal applications.*

[2] *HRT is based on the sum of the Design Maximum Day Flows from all sources. This assumes each waste source has a separate primary tank and a watertight collection system. For systems using gravity collection to a single primary tank, add 1 day HRT (based on Design Maximum Day Flow). For grinder or vacuum collection systems feeding into primary tankage, the recommended volume for pre-anoxic tankage is 1.5 days HRT; the recommended volume for primary tankage is 2.5 days HRT for a total HRT of 4 days (based on Design Maximum Day Flow).*

[3] *Communities with gravity sewers should review 12+ months of documented wastewater flows to determine Design Maximum Day Flow.*

[4] *For systems with cafeteria or restaurant facilities, use the grease tankage listed.*

[5] *RV dump stations should have a minimum of 7 days of storage; flow should be blended into the balance of the waste stream throughout the course of the day by timer-controlled pumps. Dump station flow contributions should not exceed 20% of the Design Maximum Day Flow.*

[6] *Flow equalization is strongly recommended for this application type to reduce the total treatment area required. If flow equalization is not used, base the total primary tankage volume and treatment area on Design Maximum Day Flow.*

[7] *If using flow equalization for this application type, base the total primary tankage on Equalized Design Day Flow (EDDF) to secondary treatment. EDDF = total weekly flow divided by 6, allowing 1 day for recovery.*

[8] *To reduce septage pumping in these and other specialized applications, we recommend using multiple tanks. The first tank should be small (0.5 to 0.75 day HRT); subsequent tanks should provide the remaining HRT requirements.*

[9] *For facilities with restrooms and kitchen, the primary tank volume is determined by summing the Design Maximum Day Flows of the restrooms and kitchen, then multiplying by the HRT value in the "with aeration" or "without aeration" columns. Kitchen dishwashing appliances should be high-temperature disinfection models only; low-temperature chemical disinfection dishwashers are not recommended.*

[10] *Pre-treatment (e.g., aeration) is necessary to reduce overall influent organic waste strength for this application type.*

Appendix B. Basic Equations

Converting Waste Constituent Concentrations and Flow to Mass

To convert constituent concentrations of the primary-treated effluent (PTE, mg/L) and flow (gallons, imperial gallons, liters, or cubic meters) to mass/day (lbs/d or kg/d), use the following equation:

$$\text{Load} = \text{PTE value (mg/L)} \times \text{Conversion Factor} \times \text{Flow (Q)} \qquad \text{Equation B1}$$

Using flow in gallons to calculate pounds/day:

$$\text{Conversion Factor, } CF_G = \frac{1\text{lb}}{453{,}592\text{mg}} \times \frac{3.785\text{L}}{1\text{gal}} = 8.34 \times 10^{-6} \frac{\text{lbs}\bullet\text{L}}{\text{mg} \bullet \text{gal}} \qquad \text{Equation B1a}$$

Using flow in imperial gallons to calculate pounds/day:

$$\text{Conversion Factor, } CF_{IG} = \frac{1\text{lb}}{453{,}592\text{mg}} \times \frac{4.546\text{L}}{1\text{gal}} = 1.002 \times 10^{-5} \frac{\text{lbs}\bullet\text{L}}{\text{mg}\bullet\text{gal}} \qquad \text{Equation B1b}$$

Using flow in liters to calculate kilograms/day:

$$\text{Conversion Factor, } CF_L = \frac{1\text{kg}}{1{,}000{,}000\text{mg}} \times \frac{1\text{L}}{1\text{L}} = 1 \times 10^{-6} \frac{\text{kg}}{\text{mg}} \qquad \text{Equation B1c}$$

Using flow in cubic meters to calculate kilograms/day:

$$\text{Conversion Factor, } CF_{CM} = \frac{1\text{kg}}{1{,}000{,}000\text{mg}} \times \frac{1000\text{L}}{1\text{m}^3} = 0.001 \times 10^{-6} \frac{\text{kg}\bullet\text{L}}{\text{mg}\bullet\text{m}^3} \qquad \text{Equation B1d}$$

Example 1

PTE value of 150mg/L BOD_5; flow of 1000gal per day
Determine BOD_5 mass load in pounds per day using Equation B1a:

$$BOD_5 \text{ Mass Load} = (150\text{mg/L}) \times (8.34 \times 10^{-6}\ \text{lbs}\bullet\text{L/mg}\bullet\text{gal}) \times 1000\text{gpd} = 1.25\text{lbs/d}$$

Example 2

PTE value of 150mg/L BOD_5; flow of 5 cubic meters per day
Determine BOD_5 mass load in kilograms per day using Equation B1d:

$$BOD_5 \text{ Mass Load} = (150\text{mg/L}) \times (0.001\text{kg}\bullet\text{L/mg}\bullet\text{m}^3) \times 5\text{m}^3\text{/d} = 0.75\text{kg/d}$$

Performing a Mass Balance Calculation for a Blended Waste Stream

Some applications are configured so that the waste stream to the treatment plant is made up of several contributing sources with varying flows and constituent concentrations. To determine the waste strength of a blended waste stream, a mass balance calculation must be performed.

The easiest way to perform the mass balance calculation is to prepare a table listing each source, the flow contribution from the source, and the constituent concentrations being treated.

- List contributing sources, anticipated flows, and corresponding waste strengths
- Waste strengths are provided after primary tankage and are listed as primary-treated effluent (PTE)

Table B1. Sample Mass Balance Calculation Table

Source[1]	**Design Flow**[2]**, Q (in gal, imp. gal, L, or m^3)**	**Constituent 1: BOD_5, mg/L**	**Constituent 2: TSS, mg/L**	**Constituent 3: TKN mg/L**
Source 1	Q_{S1}	BOD_{5S1}	TSS_{S1}	TKN_{S1}
Source 2	Q_{S2}	BOD_{5S2}	TSS_{S2}	TKN_{S2}
Source 3	Q_{S3}	BOD_{5S3}	TSS_{S3}	TKN_{S3}
Source 4	Q_{S4}	BOD_{5S4}	TSS_{S4}	TKN_{S4}
Total[3]	Q_T	BOD_{5B}	TSS_B	TKN_B

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[1] *The table can be built with as many contributing sources and constituents as needed; four sources and three constituents shown for simplicity.*

[2] *The actual unit of measure doesn't matter as long as the same unit of measure is used for all sources in the equation.*

[3] *The total flow (Q_T) is the sum of flow from all contributing sources.*

Appendix B. Basic Equations, cont.

For Constituent 1 (BOD_5), the mass balance equation for blended waste strength concentration (BOD_{5B}) is:

$$\text{Blended } BOD_{5B}\text{, mg/L} = \frac{(Q_{S1} \times BOD_{5S1}) + (Q_{S2} \times BOD_{5S2}) + (Q_{S3} \times BOD_{5S3}) + (Q_{S4} \times BOD_{5S4})}{Q_T} \qquad \text{Equation B2}$$

<u>Example</u>

Determine the blended BOD_{5B} given the following for a camp application, using Equation B2:

Table B2. Sample Equation Table

Source	Design Max. Day Flow, gpd[1]	BOD_5, mg/L	TSS, mg/L	TKN, mg/L
RV Dump Station[2]	250	1800	800	160
Shower House w/ Restrooms[3]	4500	225	75	80
Restrooms[4]	1800	300	100	120
Camp Host Living Quarters	150	150	60	60
Total[5]	**6700**	**302**	**108**	**93**

[1] *For Design Avg. Day Flow (Q_A), assume 50% of Design Max. Day Flow (Q_M); Q_A = 3350gpd.*

[2] *Dump station flow is calculated using 50gal/RV per day.*

[3] *Typically equals Number of Sites × Usage per Site or Number of Visitors × Usage per Visitor (45 sites × 4 users per site × 25gpcd)*

[4] *Typically equals Number of Sites × Usage per Site or Number of Visitors × Usage per Visitor (45 sites × 4 users per site × 10gpcd)*

[5] *Total Waste Strength is determined by mass balance calculation using the volume and strength of each contributing source.*

$$\text{Blended } BOD_{5B} = \frac{(250\text{gpd} \times 1800\text{mg/L}) + (4500\text{gpd} \times 225\text{mg/L}) + (1800\text{gpd} \times 300\text{mg/L}) + (150\text{gpd} \times 150\text{mg/L})}{6700\text{gpd}} = 302\text{mg/L}$$

Determining Alkalinity Demand and Need for Supplemental Alkalinity Addition

Ensuring that the pH remains above 7 (and preferably above 7.5) at all times is critical for ammonia-sensitive applications. Supplemental alkalinity should be included if influent alkalinity is insufficient to buffer the process. During nitrification, 7.14mg/L alkalinity is used per mg/L TKN; during denitrification with a pre-anoxic return loop (at 100% denitrification), half of that – or 3.57mg/L – is returned. Without a denitrification component, there is no return. To be conservative in our calculation of alkalinity demand, we assume a 60% denitrification efficiency and a return of 2.14mg/L during denitrification. To determine alkalinity demand, multiply the primary-treated effluent value for TKN_i (in mg/L) by 5 (or 7.14mg/L minus 2.14mg/L). The buffering demand can be calculated based on the assumptions listed above and using the following equations:

$$\text{Alkalinity Demand} = TKN_i\text{, mg/L} \times \frac{5\text{mg/L Alkalinity}}{1\text{mg/L TKN}} \qquad \text{Equation B3}$$

$$\text{Buffering Demand} = \text{Alkalinity Demand} + \text{Target Residual Alk} - \text{Residual Alk} \qquad \text{Equation B4}$$

The target residual for alkalinity is 100mg/L. If the result of Equation B4 is a positive number, the system will require supplemental alkalinity addition. If the result is a negative number, there is a likely surplus of alkalinity in the source water, and the system should function without alkalinity addition.

<u>Example</u>

PTE values of 80mg/L TKN and 160mg/L alkalinity in waste stream

Target residual of 100mg/L alkalinity

Determine the amount of alkalinity required to buffer the treatment process, using Equation B3:

$$\text{Alkalinity Demand} = 80\text{mg/L} \times \frac{5\text{mg/L Alkalinity}}{1\text{mg/L TKN}} = 400\text{mg/L Alkalinity}$$

Determine the buffering demand using Equation B4:

$$\text{Buffering Demand} = 400\text{mg/L} + 100\text{mg/L} - 160\text{mg/L} = 340\text{mg/L}$$

Therefore, the system will require the addition of supplemental alkalinity to buffer the treatment process.

Appendix B. Basic Equations, cont.

Anticipating Treatment Performance for a Standard AdvanTex Stage

Treated effluent values for BOD_5, TKN, and NH_3-N from a Standard AdvanTex Stage are typically based upon conservative estimates of 90% BOD_5 removal (Coefficient of BOD Removal, C_{BR}), 95% nitrification (Coefficient of Nitrification, C_{NR}) and 70% denitrification (Coefficient of Denitrification, C_{DNR}). The calculations below assume pH values are maintained between 7 and 8.4 and the temperature of the liquid stream is maintained above 50ºF (10ºC) at all times.

$$BOD_{5e} = BOD_{5i} \times (1 - C_{BR}) \qquad \text{Equation B5}$$

$$TKN_e = TKN_i \times (1 - C_{NR}) \qquad \text{Equation B6}$$

$$NH_{3e} = NH_{3i} \times (1 - C_{NR}) \qquad \text{Equation B7}$$

$$NO_{3e} = (TKN_i - TKN_e) \times (1 - C_{DNR}) \qquad \text{Equation B8}$$

Example

PTE values of 225mg/L BOD_{5i}, 120mg/L TKN_i, and 100mg/L NH_3-N in waste stream

Determine the value of BOD_{5e} and TKN_e after the Standard AdvanTex Stage.

Solving for Equation B5:

$$BOD_{5e} = 225\text{mg/L} \times (1 - 0.90) = 22.5\text{mg/L}$$

Solving for Equation B6:

$$TKN_e = 120\text{mg/L} \times (1 - 0.95) = 6\text{mg/L}$$

Solving for Equation B7:

$$NH_{3e} = 100\text{mg/L} \times (1 - 0.95) = 5\text{mg/L}$$

Solving for Equation B8:

$$NO_{3e} = (120\text{mg/L} - 6\text{mg/L}) \times (1 - 0.70) = 34.2\text{mg/L}$$

Therefore, the estimated Total Nitrogen (TN_e) value after the Standard AdvanTex Stage is:

$$TN_e = TKN_e + NO_{3e} = 6\text{mg/L} + 34.2\text{mg/L} = 40.2\text{mg/L}$$

Anticipating Treatment Performance for a Second AdvanTex Stage

In the second stage of a two-stage AdvanTex system, treated effluent values for BOD_5, TKN, and NH_3-N are typically based upon estimates of 90% BOD_5 removal (Coefficient of BOD Removal, C_{BR2}), 90% nitrification (Coefficient of Nitrification, C_{NR2}) and 25% denitrification (Coefficient of Denitrification, C_{DNR2}). Values for pH have to be maintained between 7 and 8.4 and the temperature of the liquid stream has to be maintained above 50°F (10°C) at all times.

Equations B5-B8 above can be used substituting C_{BR2} for C_{BR}, C_{NR2} for C_{NR}, and C_{DNR2} for C_{DNR} and using the effluent values from the first stage as the influent values.

Anticipating Total Nitrogen Treatment Performance for Post Anoxic Stage

For projects requiring 60-80% TN, TIN, or NO_3-N reduction, the use of a post-anoxic stage for conversion of NO_3-N to nitrogen gas (N_2) is often the most cost-effective means. A value for C_{DNR} of 0.7 (70%) is used to anticipate the performance of the post-anoxic stage. These calculations assume pH values are maintained between 7 and 8.4 and the temperature of the liquid stream is maintained above 50ºF (10ºC) at all times.

$$TN_{PAe} = TKN_e + NO_{3e} \times (1 - C_{DNR}) \qquad \text{Equation B9}$$

Example

Determine the value of TN_e after the Post Anoxic Stage, using the example above.
Solving for Equation B9:

$$TN_{PAe} = 6\text{mg/L} + 34.2\text{mg/L} \times (1 - 0.70) = 16.3\text{mg/L}$$

Appendix C. Example Design for an Apartment Complex (Application Type 1)

AdvanTex Treatment for Removal of Organics and Ammonia With $cBOD_5$, TSS, and NH_3-N Discharge Limits

This example is based on a 40-unit apartment complex consisting of 12 one-bedroom units and 28 two-bedroom units. The system will be discharged to a creek; permit requirements include organic and ammonia discharge limits.

Establishing a Design Basis

Flows

List contributing sources, anticipated flows, and corresponding waste strengths.

Table C1. Flows

Source[1]	Design Max. Day Flow per Unit, gpd	Design Max. Day Flow, gpd[1]	Design Avg. Day Flow, gpd
12 one-bedroom units	200	2400	1200
28 two-bedroom units	300	8400	4200
Total	**500**	**10,800**	**5400**

[1] *For Design Average Day Flow, use 50% of Design Maximum Day Flow.*

Discharge Type

For this example project, stream discharge is used.

Influent (Primary-Treated Effluent) and Permit Parameters

Table C2. Influent and Permit Parameters

Source	BOD_5, mg/L	TSS, mg/L	TKN, mg/L	NH_3-N, mg/L	Alkalinity, mg/L
Primary-Treated Effluent (Avg./Max.)	140/250	40/140	50/80	40/70	60
Discharge Permit Requirement (30-day Average)	20	20	N/A	1 summer/3 winter	N/A

Temperature Effects

Temperature impacts the performance of a treatment system. For systems with stringent nitrogen limits, it is important to ensure that liquid and treatment system temperatures are maintained above minimum levels. AX-Max systems use insulated vessels and are preferred for cold environments, though AX100s with external insulation added in the field can also be used.

Alkalinity Needs

Because ensuring that the pH remains above 7 (and preferably greater than 7.5) at all times is critical for ammonia-sensitive applications, alkalinity addition should be included if influent alkalinity is insufficient to buffer the process.

Determine the alkalinity demand for this project:

$$\text{Alkalinity Demand} = 80\text{mg/L TKN} \times \frac{5\text{mg/L Alkalinity}}{1\text{mg/L TKN}} = 400\text{mg/L}$$

Determine the buffering demand for this project:

$$\text{Buffering Demand} = 400\text{mg/L} + 100\text{mg/L} - 60\text{mg/L} = 440\text{mg/L}$$

Determine the alkalinity mass load for this project in gallons per day:

$$\text{Alkalinity Mass Load} = (440\text{mg/L}) \times (8.34 \times 10^{-6}\text{lbs}\cdot\text{L/mg}\cdot\text{gal}) \times 5400\text{gpd} = 19.8\text{lbs/d}$$

The equation shows that a minimum addition of 19.8lbs of alkalinity per day is required for this system to accomplish 100% removal of TKN (assuming complete ammonification occurs).

Appendix C. Example Design for an Apartment Complex (Application Type 1), cont.

Design Specifics

Tankage Requirements

Primary tankage for apartment complexes is usually provided as either a single primary tank or through the use of several distributed primary tanks, with smaller tanks located next to each apartment block. If distributed primary tanks are used, pumps may be required if the treatment facility is located at an elevation higher than the primary tanks.

Apartment complexes fall within Application Type 1 (see Appendix A); therefore, total primary tank recommendations call for a minimum of 2 days of retention at Design Maximum Day Flow. Since a pre-anoxic tank is required and will be situated at the treatment site, provide a minimum of 1 day of retention in primary tankage and 1 day of retention in pre-anoxic tankage.

Table C3. Sample Tank Sizing Recommendations

Tank Sizing	Design Maximum Day Flow, gpd	Recommended Minimum Primary Tank Size, Gallons
Primary Tank	10,800	12,000
Pre-Anoxic Tank	10,800	12,000

A two-stage AdvanTex system is required for ammonia removal. The configuration is shown in Figure C1:

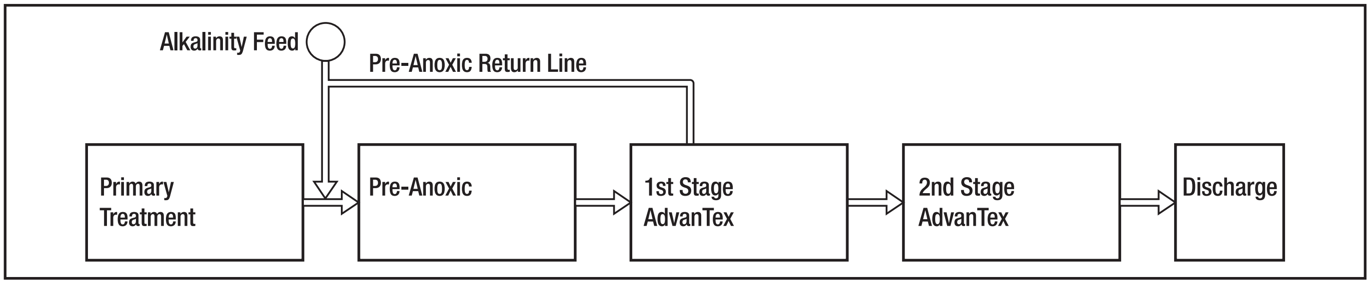

Figure C1. Configuration for Ammonia Removal

Loading Calculations – First Stage

For all first-stage calculations, the Design Maximum Day loading rates are double the Design Average Day loading rates. Since the Design Maximum Day Flow is not greater than two times the Design Average Day Flow, the calculation for Design Maximum Day load is unnecessary.

Organic Loading

Since BOD_5 is greater than TSS, the calculation for the most restrictive parameter (BOD_5) is necessary.

Design Average OLR_A is 0.04lbs $BOD_5/ft^2{\bullet}d$.

Determine the pounds per day of Average Day Organic Load, OL_A:

$$OL_A = (140mg/L) \times (8.34 \times 10^{-6} lbs{\bullet}L/mg{\bullet}gal) \times 5400gpd = 6.31lbs/d$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA}:

$$A_{OLRA} = \frac{(6.31lbs/d)}{0.04lbs/ft^2{\bullet}d} = 158ft^2$$

Hydraulic Loading

Design Average HLR_A is $25gpd/ft^2$.

Determine the textile area required based on Average Day Hydraulic Load A_{HLRA}:

$$A_{HLRA} = \frac{(5400gpd)}{25gal/ft^2{\bullet}d} = 216ft^2$$

Appendix C. Example Design for an Apartment Complex (Application Type 1), cont.

Total Nitrogen Loading

Design Average $TNLR_A$ is 0.014lbs TKN/ft^2•d.

Determine the pounds per day of Average Day Nitrogen Load, TNL_A:

$$TNL_A = (50mg/L) \times (8.34 \times 10^{-6} lbs•L/mg•gal) \times 5400gpd = 2.25lbs/d$$

Determine the textile area required based on Average Day Nitrogen Load, A_{TNLRA}:

$$A_{TNLRA} = \frac{(2.25lbs/d)}{0.014lbs/ft^2•d} = 161ft^2$$

Ammonia Loading

Design Average ALR_A is 0.01lbs NH_3-N/ft^2•d.

Determine the pounds per day of Average Day Ammonia Load, AL_A:

$$AL_A = (40mg/L) \times (8.34 \times 10^{-6} lbs•L/mg•gal) \times (5400gpd) = 1.8lbs/d$$

Determine the textile area required based on Average Day Ammonia Load, A_{ALRA}:

$$A_{ALRA} = \frac{(1.8lbs/d)}{0.01lbs/ft^2•d} = 180ft^2$$

The treatment area associated with the HLR is the most restrictive; therefore, the first-stage AdvanTex area should be a minimum of 216ft^2.

Treatment Unit Options – First Stage

Option 1: Using AX-Max units – 216ft^2 area

AX-MAX225-35 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX100 units – 216ft^2 area

Three AX100 units, 8100gal recirc tank (recirculation-blend tank sized at minimum of 75% of Q_M)

Loading Calculations – Second Stage

For all second-stage calculations, the values used are based on the predicted performance of the first-stage system. Effluent values for BOD_5 and TKN are typically based upon 90% BOD_5 removal, 95% nitrification, and 70% denitrification through pre-anoxic and first-stage AdvanTex treatment.

Organic Loading

Design Average OLR_A is 0.02lbs BOD_5/ft^2•d.

Determine the value of first-stage AdvanTex effluent BOD_{5e}:

$$BOD_{5e} = 140mg/L \times (1 - 0.9) = 14mg/L$$

Determine the pounds per day of Average Day Organic Load, OL_{A2}:

$$OL_{A2} = (14mg/L) \times (8.34 \times 10^{-6} lbs•L/mg•gal) \times (5400gpd) = 0.63lbs/d$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA}:

$$A_{OLRA} = \frac{(0.32lbs/d)}{0.02lbs/ft^2•d} = 16ft^2$$

Hydraulic Loading

Design Average HLR_A is 75gpd/ft^2; Design Maximum HLR_A is 125gpd/ft^2.

Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA}:

$$A_{HLRA} = \frac{(5400gpd)}{75gal/ft^2•d} = 72ft^2$$

Appendix C. Example Design for an Apartment Complex (Application Type 1), cont.

Determine the textile area required based on Maximum Day Hydraulic Load, A_{HLRM}:

$$A_{HLRM} = \frac{(10{,}800\text{gpd})}{125\text{gal/ft}^2\bullet\text{d}} = 86.4\text{ft}^2$$

Ammonia Loading

Design Average ALR_A is 0.005lbs NH_3-N/ft^2•d.

Determine the value of first-stage AdvanTex effluent TKN_e:

$$TKN_e = 50\text{mg/L} \times (1\text{-}0.95) = 2.5\text{mg/L}$$

Determine the pounds per day of Average Day TKN Load, TKN_e:

$$TKN_e = 2.5\text{mg/L} \times (8.34 \times 10^{-6}\text{lbs}\bullet\text{L/mg}\bullet\text{gal}) \times (5400\text{gpd}) = 0.113\text{lbs/d}$$

Determine the textile area required based on Average Day Ammonia Load, A_{ALRA}:

$$A_{ALRA} = \frac{(0.113\text{lbs/d})}{0.005\text{lbs/ft}^2\bullet\text{d}} = 23\text{ft}^2$$

The treatment area associated with the Design Maximum Day HLR is the most restrictive; therefore, the second-stage AdvanTex area should be a minimum of 86ft^2.

Treatment Unit Options – Second Stage

Option 1: Using AX-Max units – 86ft^2 area

AX-MAX100-21 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX100 units – 86ft^2 area

One AX100, 2700gal recirc tank or 2160gal discharge tank (2700gal recirculation-blend tank sized at minimum of 25% of Q_M; 2160gal discharge tank size based on local regulation, but typically sized at minimum of 20% of Q_M)

Other Design Notes

- Ensure access to the treatment site for maintenance activities.
- Ensure availability of water at the treatment site for maintenance activities.
- Provide adequate alkalinity control for the system.
- Provide adequate temperature control for the system.

Appendix D. Example Design for a Campground (Application Type 2)

Standard AdvanTex Treatment for Removal of Organics With $cBOD_5$ and TSS Discharge Limits

This example is based on a campground with 5 RV spaces and dump station, 40 camping spaces, a shower house with restroom facility, a separate restroom-only building, and living quarters for a camp host. The system is to be discharged to a pressurized drainfield, and permit requirements include organic ($cBOD_5$ and TSS) discharge limits.

Establishing a Design Basis

Flows

List contributing sources, anticipated flows, and corresponding waste strengths.

Waste strengths are provided after primary tankage and are listed as primary-treated effluent (PTE).

Table D1. Flows

Source	Design Maximum Day Flow[1], gpd	BOD_5, mg/L	TSS, mg/L	TKN, mg/L
RV Dump Station[2]	250	1800	800	160
Shower House w/ Restrooms[3]	4500	225	75	80
Restrooms[4]	1800	300	100	120
Camp Host Living Quarters	150	150	60	60
Total[5]	**6700**	**302**	**108**	**93**

[1] Design Average Day Flow (Q_A): assume 50% of Design Maximum Day Flow (Q_M); $Q_A = 3350$gpd.
[2] Dump station flow is calculated using 50gal/RV per day.
[3] Typically equals Number of Sites × Usage per Site or Number of Visitors × Usage per Visitor (45 sites × 4 users per site × 25gpcd)
[4] Typically equals Number of Sites × Usage per Site or Number of Visitors × Usage per Visitor (45 sites × 4 users per site × 10gpcd)
[5] Total Waste Strength is determined by mass balance calculation, using the volume and strength of each contributing source.

Determine the mass balance for the blended concentration of BOD_{5B}:

$$\text{Blended } BOD_{5B} = \frac{(250\text{gpd} \times 1800\text{mg/L}) + (4500\text{gpd} \times 225\text{mg/L}) + (1800\text{gpd} \times 300\text{mg/L}) + (150\text{gpd} \times 150\text{mg/L})}{6700\text{gpd}}$$

Using the calculations, the blended concentration of $BOD_{5B} = 302$mg/L (or approximately 300mg/L).

Discharge Type

For this example project, a pressurized drainfield is used.

Influent (Primary-Treated Effluent) and Permit Parameters

Table D2. Influent and Permit Parameters

	BOD_5, mg/L	TSS, mg/L
Primary-Treated Effluent	302	108
Discharge Permit Requirement (30-day Average)	20	20

Seasonal Use

Some camps are only used seasonally, and flows may vary wildly during this period. For those with highly variable flow fluctuations and limited full occupancy, flow equalization and a corresponding downsizing of the treatment facility may be in order.

Temperature Effects

Seasonally low temperatures may impact performance of a treatment system. For camps that are to be used during the winter months, there may be a need to address waste-stream temperature effects. AX-Max systems use insulated vessels and are preferred for cold environments, though AX100s with external insulation added in the field can also be used.

Appendix D. Example Design for a Campground (Application Type 2), cont.

Design Specifics

Tankage Requirements

Distributed primary tankage (locating tanks next to the flow sources) is the most common method of primary tankage due to the configuration of most campground facilities. The primary tanks may require the use of a pump if the treatment facility is located at an elevation higher than the primary tanks. Using a primary tank at the treatment area would likely require either a small liquid-only sewer system or a gravity sewer. A gravity sewer increases the risk for infiltration and inflow (I&I).

Campgrounds fall within Application Type 2 (see Appendix A); therefore, total primary tank recommendations call for a minimum of 3 days of retention at Design Maximum Day Flow. Since a pre-anoxic tank is recommended and will be situated at the treatment site, provide a minimum of 2 days of retention at each distributed site, except for the RV dump station.

Table D3. Sample Tank Sizing Recommendations

Tank Sizing	Design Maximum Day Flow, gpd	Recommended Minimum Primary Tank Size, Gallons
RV Dump Station[1]	250	2000
Shower House w/ Restrooms	4500	9000
Restrooms	1800	4000
Camp Host Living Quarters	150	1000

[1] *Per Appendix A, Table A, primary tankage for an RV dump station should have a minimum of 7 days of storage.*

For the size of the pre-anoxic tank at the treatment site (6700gal), use 6000 or 8000gal. Since the system is only required to treat for organic constituents, it would be configured as shown below:

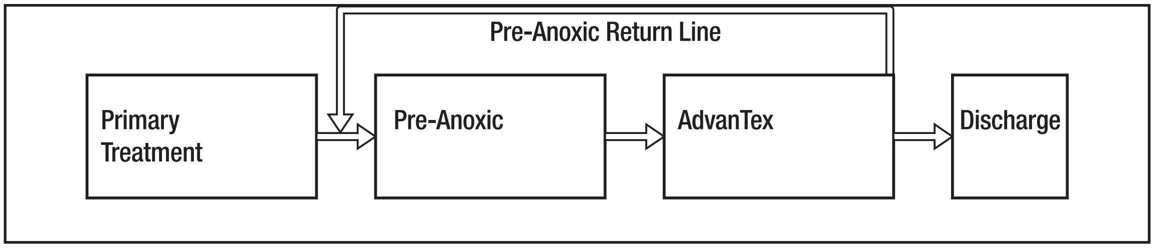

Figure D1. Treatment Configuration for Organic Constituents

Loading Calculations

For all loading calculations, the design maximum day loading rates are double the design loading rates for average day. Since the Design Maximum Day Flow is not greater than two times the Design Average Day Flow, the calculation for design maximum day load is unnecessary.

<u>Organic Loading</u>

Since BOD_5 is greater than TSS, calculating for the most restrictive parameter (BOD_5) is necessary. Design Average OLR_A is 0.04lbs $BOD_5/ft^2{\bullet}d$.
Determine the pounds per day of Average Day Organic Load, OL_A:

$$OL_A = (300mg/L) \times (8.34 \times 10^{-6} lbs \cdot L/mg{\bullet}gal) \times (3350gpd) = 8.4lbs/d$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA}:

$$A_{OLRA} = \frac{(8.4lbs/d)}{0.04lbs/ft^2{\bullet}d} = 210ft^2$$

<u>Hydraulic Loading</u>

Design Average HLR_A is $25gpd/ft^2$.
Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA}:

$$A_{HLRA} = \frac{(3350gal/d)}{25gal/ft^2{\bullet}d} = 134ft^2$$

The area associated with the OLR is the most restrictive; therefore, the AdvanTex area should be a minimum of $210ft^2$.

Appendix D. Example Design for a Campground (Application Type 2), cont.

Treatment Unit Options

Option 1: Using AX-Max units – 210ft^2 area

AX-MAX225-35 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX100 units – 210ft^2 area

Three AX100 units, 5025gal recirc tank, 1500gal discharge tank; recirculation-blend tank sized at minimum of 75% of Q_M (equates to 5025gal minimum); discharge tank size based on local regulation, but typically sized at minimum of 20% of Q_M (equates to 1340gal minimum)

Other Design Notes

- RV dump waste should be limited to no more than 20% of the design flow (average or maximum day) and metered into the system using small doses, preferably with a timed-dose system.
- Ensure access to the treatment site for maintenance activities.
- Ensure availability of water at the treatment site for maintenance activities.

Appendix E. Example Design for a School (Application Type 3)

AdvanTex Treatment for Removal of Organics and Nitrogen with $cBOD_5$, TSS, and TN Discharge Limits

This example is based on a high school with a cafeteria, gymnasium, and sports fields. The system is discharged to a pressurized drainfield; permit requirements include organic ($cBOD_5$ and TSS) and total nitrogen (TN) discharge limits.

Establishing a Design Basis

Flows

School facilities include a cafeteria and gym with seating for 800. Due to their weekly flow characteristics, schools are a perfect application for the use of equalization tankage to evenly distribute the flows over the week. Flow equalization provides a consistent, stable loading of the treatment system, as well as slightly reduces the system size.

Table E1. Flows

Source	Design Max. Day Flow Per Unit, gpd	Design Max. Day Flow, gpd
400 students	25	10,000
60 Employees	15	900
School event seating, 800	5	4000
Total		**14,900**

Determine the Design Average Day Flow using flow equalization to reduce the treatment capacity requirement:

$$\text{Equalized Design Day Flow, } Q_E = \frac{(10{,}900\text{gpd} \times 4 \text{ days}) + (14{,}900\text{gpd} \times 1 \text{ day}) + (4000\text{gpd} \times 1 \text{ day}) + (0\text{gpd} \times 1 \text{ day})}{6 \text{ days}} = 10{,}416\text{gpd; use } 10{,}500\text{gpd}$$

The equation above allows for one day for recovery.

Discharge Type

The discharge type used in this example is a pressurized drainfield.

Influent (Primary-Treated Effluent) and Permit Parameters

Table E2. Influent and Permit Parameters

	BOD_5, mg/L	TSS, mg/L	TKN, mg/L	TN, mg/L	Alkalinity, mg/L
Primary-Treated Effluent (Avg./Max.)	280/350	50/100	160/200	N/A	120
Discharge Permit Requirement (30-day Average)	20	20	N/A	20	N/A

Seasonal Use

Most school applications see regular flows five days per week during the school year. For high schools, there may be 1-2 days per week that see significant additional flows associated with sporting events or other activities. Flows during the summer months are typically only a fraction of the usage while school is in session. Flow equalization and a corresponding downsizing of the treatment facility is typically in order.

Temperature Effects

Seasonally low temperatures may impact performance of a treatment system. For nitrogen-sensitive applications, there may be a need to address waste stream temperature effects. This is especially true for systems with significant nitrogen removal requirements.

Alkalinity Needs

Ensuring that the pH remains above 7 at all times is critical for ammonia-sensitive applications; therefore, alkalinity addition should be included if influent alkalinity is insufficient to buffer the process.

Appendix E. Example Design for a School (Application Type 3), cont.

Determine the alkalinity demand for this project:

$$\text{Alkalinity Demand} = 160\text{mg/L TKN} \times \frac{5\text{mg/L Alkalinity}}{1\text{mg/L TKN}} = 800\text{mg/L}$$

Determine the buffering demand for the project:

$$\text{Buffering Demand} = 800\text{mg/L} + 100\text{mg/L} - 120\text{mg/L} = 780\text{mg/L}$$

The two equations above show that alkalinity addition is required for this system.

Design Specifics

Tankage Requirements

Depending on the size of the facility, distributed tankage or a small gravity collection system leading to primary tankage is typically used. For systems with gravity collection, especially in areas with significant rainfall, an adjustment to the per capita flow may be necessary.

Schools fall within Application Type 3 (see Appendix A); therefore, total primary tank recommendations call for a minimum 3 days of retention at Design Maximum Day Flow. Since a pre-anoxic tank will be used due to the nitrogen reduction requirement, 2 days of primary tankage will be recommended with an additional 1-day pre-anoxic tank situated at the treatment site.

Table E3. Sample Tank Sizing Recommendations (With Flow Equalization)

Source	Equalized Design Daily Flow, gpd	Recommended Minimum Tank Size, gallons
Grease Tankage[1]	2100	8000
Primary Tankage	10,500	25,000
EQ Tank	10,500	12,000
Pre-Anoxic Tank	10,500	12,000
1st Stage Recirculation Tank[2]	10,500	8000
Post-Anoxic Tank	10,500	6000
2nd Stage Recirculation Tank[2,3]	10,500	3000
Discharge Tank	10,500	3000

[1] *Grease flow is estimated at 20% of Design Flow.*

[2] *Excludes AX-Max systems; recirc volume included in AX-Max systems.*

[3] *Tank is sized at 25% of Design Flow.*

Since the system is required to treat for organic constituents and provide nutrient reduction, it would be configured as shown in Figure E1.

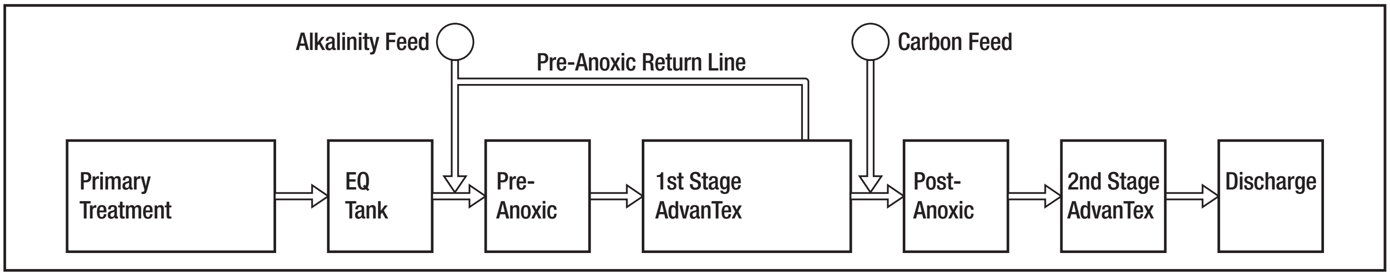

Figure E1. Treatment Configuration for Organic Constituents

When using flow equalization, all calculations are performed with the equalized flow considered as the Design Average Day Flow. Calculations for Design Maximum Day Flow are unnecessary.

Appendix E. Example Design for a School (Application Type 3), cont.

Organic Loading – First Stage

Since BOD_5 is greater than TSS, the calculation for the most restrictive parameter (BOD_5) is necessary. Design Average OLR_A is 0.04lbs $BOD_5/ft^2 \cdot d$. Determine the pounds per day of Average Day Organic Load, OL_A:

$$OL_A = (280mg/L) \times (8.34 \times 10^{-6} lbs \cdot L/mg \cdot gal) \times (10{,}500gpd) = 24.5lbs/d$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA}:

$$A_{OLRA} = \frac{(24.5lbs/d)}{0.04lbs/ft^2 \cdot d} = 613ft^2$$

Hydraulic Loading – First Stage

Design Average HLR_A is $25gpd/ft^2$.
Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA}:

$$A_{HLRA} = \frac{(10{,}500gal/d)}{25gal/ft^2 \cdot d} = 420ft^2$$

Total Nitrogen Loading Calculations – First Stage

Design Average $TNLR_A$ is 0.014lbs $TKN/ft^2 \cdot d$.
Determine the pounds per day of Average Day Nitrogen Load, TNL_A:

$$TNL_A = (160mg/L) \times (8.34 \times 10^{-6} lbs \cdot L/mg \cdot gal) \times (10{,}500gpd) = 14lbs/d$$

Determine the textile area required based on Average Day Nitrogen Load, A_{TNLRA}:

$$A_{TNLRA} = \frac{(14lbs/d)}{0.014lbs/ft^2 \cdot d} = 1000ft^2$$

The area associated with the TNLR is the most restrictive; therefore, the first-stage AdvanTex area should be a minimum of $1000ft^2$.

Treatment Unit Options – First Stage

Option 1: Using AX-Max units – $1000ft^2$ area

Four AX-MAX250-35; one T-MAX-14 (AX-Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX100 units – $1000ft^2$ area

Ten AX100 units, 7875gal recirc tank (recirculation-blend tank sized at minimum of 75% of Q_M)

Loading Calculations – Second Stage

For all second-stage calculations, the values used are based on the predicted performance of the first-stage secondary treatment system. Effluent values for BOD_5 and TKN are typically based upon 90% BOD_5 removal, 95% nitrification, and 70% denitrification through pre-anoxic stage and first-stage AdvanTex treatment.

Organic Loading – Second Stage

Design Average OLR_A is 0.02lbs $BOD_5/ft^2 \cdot d$.
Determine the value of first-stage AdvanTex effluent BOD_{5e}:

$$BOD_{5e2} = 280mg/L \times (1 - 0.9) = 28mg/L$$

Determine the pounds per day of Average Day Organic Load, OL_A:

$$OL_{A2} = (28mg/L) \times (8.34 \times 10^{-6} lbs \cdot L/mg \cdot gal) \times (10{,}500gpd) = 2.45lbs/d$$

Determine the textile area required based on Average Day Organic Load, A_{OLRA}:

$$A_{OLRA2} = \frac{(2.45lbs/d)}{0.02lbs/ft^2 \cdot d} = 123ft^2$$

Appendix E. Example Design for a School (Application Type 3), cont.

Hydraulic Loading – Second Stage

Design Average HLR_A is 75gpd/ft^2.
Determine the textile area required based on Average Day Hydraulic Load, A_{HLRA}:

$$A_{HLRA} = \frac{(10{,}500/d)}{75gal/ft^2 \bullet d} = 140ft^2$$

Total Nitrogen Loading – Second Stage

Design Average $TNLR_A$ is 0.007lbs TN/ft^2•d.
Determine the value of first-stage AdvanTex effluent TKN_e:

$$TKN_e = 160mg/L \times (1 - 0.95) = 8mg/L$$

Determine the pounds per day of Average Day TKN Load, TKN_e:

$$TKN_e = (8mg/L) \times (8.34 \times 10^{-6} lbs \bullet L/mg \bullet gal) \times (10{,}500gpd) = 0.70lbs/d$$

Determine the textile area required based on Average Day Nitrogen Load, A_{TNLRA}:

$$A_{TNLRA} = \frac{(0.70lbs/d)}{0.007lbs/ft^2 \bullet d} = 100ft^2$$

The area associated with the Design Maximum Day Hydraulic Loading Rate is the most restrictive; therefore, the second-stage AdvanTex area should be a minimum of 140ft^2.

Treatment Unit Options – Second Stage

Option 1: Using AX-Max units – 140ft^2 area

One AX-MAX150-28 (Max unit includes recirc-blend tankage and discharge tankage)

Option 2: Using AX100 units – 140ft^2 area

Two AX100 units, 2625gal recirc tank, 2100gal discharge tank; recirculation-blend tank sized at minimum of 25% of Q_M; discharge tank size based on local regulation, but typically sized at minimum of 20% of Q_M

Other Design Notes

- Ensure access to treatment site for maintenance activities.
- Ensure availability of water at treatment site for maintenance activities.

Appendix F. Special Considerations for Greywater Treatment Systems (Application Type 6)

Orenco has increased the permissible hydraulic loading rates when using AdvanTex treatment systems for greywater applications – compared to a standard-stage wastewater treatment application – while retaining the organic and nitrogen loading parameters.

Table F1. Standard AdvanTex Stage Sizing for Greywater

	Design Avg.	Design Max.
Hydraulic Loading Rate (HLR)[1]	40gpd/ft^2	80gpd/ft^2
Organic Loading Rate (OLR)	0.04lbs BOD_5/ft^2•day	0.08lbs BOD_5/ft^2•day
Total Nitrogen Loading Rate (TNLR)	0.014lbs TN/ft^2•day	0.028lbs TN/ft^2•day
Ammonia Loading Rate (ALR)	0.01lbs NH_3-N/ft^2•day	0.02lbs NH_3-N/ft^2•day

[1] *This is the maximum rate allowed by Orenco; local regulations may be more restrictive. Check local regulations.*

Determining Influent Constituent Concentrations

Orenco prefers sampled data to establish influent waste strengths for greywater applications. When sample data is unavailable, NSF350-1 is typically used to estimate influent constituent concentrations. These concentrations are based upon what is being served and are listed in the table below.

Table F2. Expected Range of Greywater Constituents, 30-Day Average

Parameter	Application Type 6A, Shower/Bath Only	Application Type 6B, Laundry Only	Application Type 6C, Shower/Bath and Laundry
TSS	50-100mg/L	50-100mg/L	80-160mg/L
BOD_5	100-180mg/L	220-300mg/L	130-180mg/L
Temperature	25-35°C	25-35°C	25-35°C
pH	6.0-7.5	7.0-8.5	6.5-8.0
Turbidity	30-70NTU	50-90NTU	50-100NTU
Sodium	n/a	50-90mg/L	50-90mg/L
Total Phosphorous P	1.0-4.0mg/L	<2.0mg/L	1.0-3.0mg/L
Total Kjeldahl Nitrogen-N	3.0-5.0mg/L	4.0-6.0mg/L	3.0-5.0mg/L
COD	200-400mg/L	300-500mg/L	250-400mg/L
TOC	30-60mg/L	50-100mg/L	50-100mg/L
E. coli	10^2-10^3cfu/100mL	10^2-10^3cfu/100mL	10^2-10^3cfu/100mL
Total coliforms	10^3-10^4cfu/100mL	10^3-10^4cfu/100mL	10^3-10^4cfu/100mL