4.0 EVALUATION OF ALTERNATIVES

Weston & Sampson evaluated two (2) alternatives for collection and disposal of sanitary sewage from the project area. The alternatives include a general layout for a feasible collection system and two (2) alternatives for treatment and disposal.

The collection system for each alternative is the same and includes approximately 10,500 linear feet (lf) of gravity sewers, approximately 9,500 lf of low-pressure sewers, and three (3) pumping stations. See Figure 8 for layout of the collection system. The general layout of the collection system represents a feasible system that could be constructed and provides a solid basis for development of planning level cost estimates.

The following sections include a summary and general description of:

- Wastewater collection system components
- Wastewater treatment system alternatives
- Alternative 1 – Highland Wastewater Treatment Facility
- Alternative 2 – On-Site Wastewater Treatment with Subsurface Water Discharge

4.1. Wastewater Collection

The proposed collection system for the project area includes approximately 10,500 linear feet (lf) of gravity sewers, approximately 9,500 lf of low-pressure sewers, and three (3) pumping stations. This system was developed based on existing mapping and the conceptual layout of the Center. Once the Center is further developed, a more detailed alternative analysis of the collection system alternatives could be undertaken.

A summary of the various components of the sewer collection system is provided below.

Gravity Sewer Collection Systems

Sewers should be installed at a minimum of 6 feet deep, where possible, to minimize excavation costs and to allow installation of sewers beneath the water mains in the project area. Sewers should generally be constructed of standard dimension ratio (SDR) 35, polyvinyl chloride (PVC) pipe, except in areas of high groundwater, where ductile iron pipe or SDR 21 PVC (pressure pipe) should be used. PVC pipe should be bedded with ¾-inch washed crushed stone, unless existing soils prove to be adequate for bedding purposes. Precast concrete manholes with a 4-foot minimum diameter are recommended at approximate 300-foot intervals along the gravity sewer. In addition, manholes are required at intersections and at locations where there is a change in sewer alignment. Sewer service connections should be 6 inches in diameter and should be extended to the approximate property (street) line during construction to prevent the need to cut the new pavement for each sewer connection trench.

Pipeline design is dependent upon existing and future wastewater flows. Pipeline design is also dependent upon a minimum flow velocity of 2.0 feet per second (fps) and a maximum flow velocity of 12.0 fps for pipes flowing full. Minimum velocities will ensure that solids do not settle out of the waste stream and eventually clog the system. Maximum velocities are designed to limit displacement caused by erosion and impact. In order to minimize excavation costs, most sewers will be designed for minimum slope and flow velocity.

New sewer systems are constructed to be generally watertight in order to limit the entry of extraneous non-sanitary water (infiltration) into the system. However, over the life of sewer facilities, it is expected that some extraneous flows will be introduced into the system in the form of infiltration/inflow (I/I). These flows are typically groundwater or storm water that enters the sewer system unintentionally or through non-permitted (illegal) connections. In order to be conservative, an allowance is typically made for I/I in the projected design flows.

In accordance with the *Guides for the Design of Wastewater Treatment Works* (TR-16), it is recommended that an allowance of 250 gallons per day per inch diameter-mile (gpdim) for existing wastewater flows and 500 gpdim for future design flows be allocated.

Wastewater Pumping Stations

Prefabricated 'packaged' pumping stations can be utilized for any application, but are typically used for peak flow rates less than 1 million gallons per day. The most economical design for a pumping station of this type is a duplex submersible pumping station. This design includes two (2) submersible pumps in a precast concrete wet well. For flows less than 100 to 140 gallons per minute (gpm) grinder pumps are required to macerate the waste solids, which would otherwise clog small pumps and piping. Piping for this type of system would typically be 2 inches in diameter. For flows greater than 140 gpm non-clog submersible pumps are used with a minimum 4-inch force main. A duplex submersible pumping station utilizing either grinder or non-clog pumps, when properly designed for extended life and ease of operation and maintenance, has a typical construction cost between $350,000 and $400,000, including standby power. The high cost of these stations is due to the expected depth of the stations. Since these stations will be located in the Center, electrical and control systems may need to be enclosed within a building to protect the equipment and provide a safe working environment for maintenance. The building to be used would likely consist of a precast concrete building. The total construction cost of these types of pumping stations would be approximately $450,000 to $500,000, including standby power.

An alternative to submersible pumps would be to use a flooded suction pumping station, where the pumps and motors are located in a separate, dry enclosure. Flooded suction pumps are solid handling pumps, meaning that they are larger than submersible grinder pumps, but similar in size to submersible non-clog pumps, and have internal openings that allow them to pass solids that would otherwise clog smaller pumps. This also means that they pump at higher flow rates and require a minimum pumping rate of 140 gpm. Flooded suction pumping stations offer the benefit of being able to maintain the pumps and motors in a dry environment. Flooded suction below-grade pumping stations consist of a drywell, which contains the pumps, located adjacent to a wet well at depth usually four to eight feet below the invert of the inlet sewer. Pump accessories, such as electrical equipment and controls are typically located in an above-grade enclosure or small building located on top of the dry pit.

Flooded suction pumping stations need lighting, ventilation, and dehumidification within the dry pit enclosure and need confined space entry to maintain and inspect the pumps. Given the size of the proposed pumping facilities and allowing for the use of a precast concrete building to house the electrical systems and controls, the approximate cost of this type of pumping station would typically be between $1.0 and 1.5 million, including standby power. The generator would be housed within the building.

Given the costs associated with flooded suction pumping stations and the lower flow rates expected in the project area, Weston & Sampson recommends that the Town utilize duplex submersible pump stations with the electrical and control systems housed in a precast concrete building.

Force Mains

Force mains are typically installed below the frost line or 4 feet 6 inches deep. Force mains are generally constructed of Class 52 or 53 ductile iron or DR 11 high density polyethylene (HDPE) pipe. Air/vacuum release valves are installed at all high points along the force main and cleanout structures are typically installed every 1,000 feet of force main.

There are three (3) critical factors in selecting force main sizes, which are as follows:

- Velocity
- Total Dynamic Head
- Retention Time

<u>Velocity</u> is a measure of how fast the wastewater is pumped through the force main and is dependent upon not only the pumping rate but also the size of the force main. Based on TR-16, a minimum self-cleaning velocity of 3 feet per second (fps) should be achieved at least once per day to lower the possibility of clogging within the system. In addition, to control scouring of the pipe, maximum velocities should not exceed 7 fps.

<u>Total Dynamic Head</u> is a measure of the total pressure the pump will have to pump against and is made up of two components, which are as follows:

- Friction Loss
- Static Head

<u>Friction loss</u> is a measure of how much energy is lost due to friction within the pipe and is dependent upon the velocity and the size and type of the force main. Friction losses should be kept to a minimum because increased friction losses can result in larger pumps, which not only costs more, but also consume more power.

Static Head is a measure of the elevation difference between the pump discharge and the maximum elevation for the force main.

Retention Time is a measure of how long any drop of wastewater remains within the force main and is dependent upon the pumping rate and the size of the force main. Retention times should be kept to a minimum because long retention times can lead to development of odors.

At this stage, Weston & Sampson recommends that the Town utilize ductile iron force main piping. Given the length and location of the force mains, it is not anticipated that retention time or dynamic head will have an impact on the project.

Low Pressure Sewer Systems

The proposed collection system includes an area of low-pressure sewer to service a small number of lots. To service this area with gravity sewers and a pump station, would be a significantly higher cost. Low-pressure sewer systems consist of each lot having a grinder pump that would pump to a small diameter pipeline located within the street. The low-pressure sewer in the street is located at a depth no greater than 6 feet and is generally constructed of SDR 21 PVC or SDR 11 high-density polyethylene (HDPE) pipe. The pipe sizes selected for the project will consist of 2-inch to 3-inch piping. The pipe sizes are dependent upon the number of residences that will be connected to the system. Service connections are typically 1½ inches in diameter and are usually constructed of SDR 21 PVC or SDR 11 HDPE pipe.

Pipeline sizing is dependent upon existing and future wastewater flows. Pipeline sizing is also dependent upon maintaining self-cleaning velocities of approximately 3 fps during the peak flow periods. In addition, the main should be flushed at least once or twice per day to limit the development of odor within the system.

Industrial and/or commercial grinder units are generally duplex stations contained within a fiberglass, steel, or HDPE wet well, which is normally 30 inches in diameter. Residential grinder units are generally simplex stations contained within a fiberglass, steel, or HDPE wet well. The depth of the unit installation will vary depending upon the elevation of the pipe leaving the dwelling and the ground surface elevation of the location selected for the unit.

Low-pressure sewer systems are limited by the amount of pressure that can be produced by the system, as each pump unit can produce only a fixed amount. The pressure produced by each pump is used to overcome both the force of gravity as the sewage is pushed up to the discharge location, and the force of friction as the sewage is pushed through the pipes within the system. Both of these attributes, when combined, determine the physical limitations of the system.

There are three (3) types of grinder pumps typically used in low-pressure systems:

- Centrifugal
- Two-Stage Centrifugal

- Positive Displacement

Below is a brief discussion of each grinder pump type.

Centrifugal Pumps: the amount of liquid pumped is dependent upon the pressure against the pump, which results in varying system flows and larger force main diameters. In addition, centrifugal pumps typically cannot pump against more than 45 feet of total dynamic head, making their application limited.

Two-Stage Centrifugal Pumps: similar to traditional centrifugal pumps, the amount of liquid pumped is dependent upon the pressure against the pump, which results in varying system flows and larger force main diameters. However, a two-stage centrifugal can typically pump against 180 feet of total dynamic head, making them applicable to most situations.

Positive Displacement Pumps: the amount of liquid pumped is relatively constant regardless of the amount of pressure against the pump, which results in stable system flows and reduced force main diameters. In addition, positive displacement pumps can typically pump against approximately 138 feet of total dynamic head, making them applicable to most situations. However, their internal components wear more quickly, leading to higher operation and maintenance costs.

In either case, the pumps can typically produce about 120 feet of pressure, of which roughly 80 to 90 feet can be used to overcome the static (or gravity) portion of the pressure.

4.2. Wastewater Treatment

This section presents general information on the wastewater treatment and effluent disposal options that were evaluated for the project. A summary of each of these is presented below.

Wastewater Treatment Facilities

There are two (2) types of facilities for wastewater treatment. The first type is a custom-built facility and the second is a packaged facility. Custom-built facilities are typically used for wastewater flows greater than 80,000 gpd and packaged facilities are typically used for flows less than 80,000 gpd.

Wastewater Treatment Technologies

This study investigated two types of wastewater treatment that could be utilized in the project area. The types are the following:

- Conventional Wastewater Treatment (including fixed media, sequencing batch reactor (SBRs), submerged media, and extended aeration)
- Alternative/Innovative Wastewater Treatment (including membrane filtration, ultra-filtration, and micro-filtration)

Conventional wastewater treatment processes utilize the same basic treatment approach. Wastewater is introduced into a mixed liquor containing microorganisms that consume the organic matter and oxidize the ammonia as they reproduce. Oxygen is supplied to the mixed liquor to maintain the mixture in suspension (for suspended growth systems), and provide for an aerobic environment for the biomass. Typically, systems such as these are preceded by a primary treatment process, which is used to remove the settleable materials from the wastewater stream.

Alternative/Innovative treatment technologies are similar to the conventional process but include further refining of the wastewater to higher levels of treatment. For example, membrane filtration utilizes extended aeration with the additional feature of physical filtration; using membranes that can remove particles down to the micron size range. Effluent from such systems typically approach drinking water quality, and is often times recycled for use in toilets and other non-potable uses. In addition to being the most technologically advanced technique, it also represents the most costly technique considered. However, it may provide a reduced cost in disposal of the wastewater because the water could be recycled or reused. Literature about some of these processes and their manufacturers is in Appendix D.

Each treatment option provides an effluent quality that will meet or exceed the quality typically required by the Connecticut Department of Environmental Protection (DEP). As discussed, some of the processes provide a cleaner effluent, while others require less equipment. Table 1 in Appendix D presents a comparison of the various treatment processes and some considerations when choosing one of the technologies.

Treated Effluent Disposal

Treated effluent disposal options include deep well injection, subsurface disposal, overland disposal, recycling, or discharge to surface waters. Neither deep well injection nor overland disposal are typically used in Connecticut, and are therefore are not included as part of this study. Below is a brief description of the remaining options.

<u>Subsurface Disposal:</u> functions similar to a septic system leaching field. Once the wastewater has been treated by the facility, the wastewater is dispersed into the ground using a series of galleys, pipes, or open groundwater recharge lagoons. Typical systems range in size from 5,000 gpd to 30,000 gpd. The Highlands Wastewater Treatment Facility currently discharges to seepage beds and the Seth Williams Brook when the seepage beds are at capacity (usually during periods of high groundwater).

<u>Water recycling and reuse:</u> is accomplished by processing the wastewater to higher levels of treatment. This water then can be utilized in areas where potable water is not required. For example, the treated wastewater can be utilized for irrigation, or piped into buildings to be used to fill toilets. At this stage, Weston & Sampson does not feel that this alternative should be considered, due to its complexity and potential high cost.

<u>Surface water disposal:</u> Once the wastewater has been treated by the facility, the wastewater is discharged to a surface water body. The discharge or surface water would need to be a water body large enough to support the discharge.

4.3. Alternative 1 – Highlands Wastewater Treatment Facility

The proposed development of the Center will include potential wastewater flows between 441,000 gallons per day (gpd) and 705,000 gpd. These flows were developed using the conceptual layout of the Center and are summarized in Section 3.0 of this report.

Alternative 1 was developed to include the collection system within the Center and transporting the wastewater to the existing Highlands Wastewater Treatment Facility. The figure showing the layout is presented on Figure 8. The components for Alternative 1 are summarized below:

- 10,500 linear feet (lf) of gravity sewers.
- 9,500 lf of low-pressure sewers.
- Three (3) submersible duplex pumping stations.
- 19,100 lf of force main piping.

As shown, the wastewater would be collected and pumped to the Highlands Wastewater Treatment Facility. The addition of the proposed flows would require upgrading the facility. A complete evaluation of the facility would need to be completed in order to determine the required upgrades. Based on discussions with the Ledyard Water Pollution Control Authority, the additional effluent cannot be discharged to the Seth Williams Brook. Therefore and at minimum, additional SBR reactors and seepage beds would be required. Presently, the wastewater treatment facility site is 65 acres in size and would have sufficient space for expansion. The estimated cost for this alternative is between $7.7 million and $12.4 million, as summarized on Table 4-1.

Table 4-1
Planning Level Construction Costs - Alternate 1

Quantity	Description	Low		High	
		Unit Cost	Total Cost	Unit Cost	Total Cost
10,500	Gravity sewer, per linear foot	$100	$1,050,000	$150	$1,575,000
9,500	Low-pressure sewer, per linear foot	$70	$665,000	$90	$855,000
38	Grinder pump, each	$10,000	$380,000	$15,000	$570,000
19,100	Force main, per linear foot	$80	$1,528,000	$100	$1,910,000
3	Pumping station, each	$350,000	$1,050,000	$500,000	$1,500,000
1	Wastewater treatment facility upgrade, each	$3,000,000	$3,000,000	$6,000,000	$6,000,000
Total Estimated Planning Level Construction Cost			***$7,673,000***		***$12,410,000***

Notes:
1. These costs do not include engineering, permitting, or land acquisition.

4.4. Alternative 2 – On-site Wastewater Treatment with Subsurface Discharge

The proposed development of the Center will include potential wastewater flows of between 441,000 gpd and 705,000 gpd. These flows were developed using the conceptual layout of the Center and are summarized in Section 3.0 of this report.

Alternative 2 was developed to include the collection system within the Center and on-site wastewater treatment with a subsurface discharge. The figure showing the layout is presented on Figure 9. The components for Alternative 2 are summarized below:

- 10,500 linear feet (lf) of gravity sewers.
- 9,500 lf of low-pressure sewers.
- Three (3) submersible duplex pumping stations.
- 6,900 lf of force main piping.
- On-site wastewater treatment facility.
- Subsurface disposal field (s).

As shown, the wastewater would be collected and pumped to a packaged wastewater treatment facility located on-site. The location of the wastewater treatment facility was chosen based on proximity to the disposal field. Final selection of the location of the wastewater treatment facility would need to be conducted once the final layout of the Center is completed.

The location of the disposal field was selected based upon discussions with the Town. The soil survey indicates that part of the proposed disposal area may be suitable for on-site disposal.

Weston & Sampson completed preliminary calculations to estimate the maximum flow that the proposed disposal area could support. Calculations for on-site systems with flows greater than 5,000 gpd are based on the Connecticut Department of Environmental (DEP) guidelines. The DEP's guidelines are very site specific and include nitrogen dilution calculations and hydraulic groundwater modeling. As a result, Weston & Sampson used the Connecticut Department of Public Health's (DPH) *Code for Regulations and Technical Standards for Subsurface Sewage Disposal Systems* to create planning level estimates of the approximate flow that the land area could support. These calculations are included within Appendix E.

The preliminary calculations indicate that the area may support up to 7,500 gpd of wastewater. It is possible that a more refined analysis would result in flows as much as 15,000 gpd. Given the total projected flow of 441,000 gpd to 705,000 gpd it appears that the development would require multiple systems to support the proposed flows. Multiple systems on-site do not appear to be feasible due to the location of wetlands, water bodies, and soil conditions.

Weston & Sampson identified a potential area that could be served by the proposed disposal field if an on-site system were utilized. This area was selected as one possible area to be serviced and includes conceptual lots 1 through 17 and the Town Hall and fire station as shown on Figure 9.

The estimated cost for a system that can support 15,000 gpd for this alternative is between $2.1 million and $3.0 million, as summarized on Table 4-2. It should be noted that this cost only includes the collection system components needed to support the 15,000 gpd from lots 1 through 17.

Table 4-2
Planning Level Construction Costs – Alternative 2 (15,000 gpd)

Quantity	Description	Low		High	
		Unit Cost	Total Cost	Unit Cost	Total Cost
4,300	Gravity sewer, per linear foot	$100	$430,000	$150	$645,000
3,600	Force main, per linear foot	$80	$288,000	$100	$360,000
1	Pumping station, each	$350,000	$350,000	$500,000	$500,000
1	Alternative treatment facility, each	$700,000	$700,000	$950,000	$950,000
1	Leaching field, each	$300,000	$300,000	$500,000	$500,000
Total Estimated Planning Level Construction Cost			***$2,068,000***		***$2,955,000***

Notes:
1. These costs do not include engineering, permitting, or land acquisition.
2. These costs include only the collection system within the potential service area as identified on Figure 9.

4.5. Comparison of Alternatives and Cost Benefit Analysis

This section of the report provides a comparison and cost benefit analysis of the two (2) alternatives considered. As part of the evaluation the following criteria will be used:

Technical Feasibility: Each of the alternatives includes several components that need to be constructed. At this stage in the project limited information is available regarding site conditions. This criterion will be used to assess the technical feasibility of each alternative, based on the information available.

Flexibility of System: The Town intends to develop the Center and then seek buyers to purchase and build. With this progression, the Town will not know what type of business will be located in the Center until they are approved and constructed or, at a minimum, until a market study is completed. The proposed sewer system needs to be flexible to allow for multiple uses. A system, which is flexible and will provide the Town of Ledyard the greatest ability to attract buyers, would be the most desirable to the Town.

Cost of System: The overall cost of each alternative will be reviewed and compared to the number of lots that will be serviced to provide an average cost per lot. The proposed Center includes 80 existing lots and 30 future lots, as presently configured.

A tabular summary and comparison of these alternatives is presented in Table 4-3, below.

Table 4-3
Summary of Alternatives

Criteria	**Alternatives**	
	Alternative 1 **Conventional Wastewater Treatment with Surface Water Discharge**	**Alternative 2** **On-site Wastewater Treatment with Subsurface Discharge**
Technical Feasibility for Wastewater Treatment	The design and construction of upgrades to the Highlands Wastewater Treatment Facility can be readily accomplished. The technology has been in use for a number of years and is reliable.	The design and construction of an On-Site Wastewater Treatment Facility can be readily accomplished. The technology has been in use for a number of years and is reliable.
Technical Feasibility of Wastewater Disposal	The ability to discharge additional wastewater from the Highlands Wastewater Treatment Facility must be reviewed and approved by the Connecticut Department of Environmental Protection. The discharge would represent a significant increase and could be difficult to obtain.	The ability to discharge wastewater to on-site disposal field would require extensive evaluation and must be reviewed and approved by the Connecticut Department of Environmental Protection. Based on the preliminary evaluation the disposal system would only be able to support up to 15,000 gallons per day.
Technical Feasibility of Collection System	The collection system as proposed includes gravity sewers, low-pressure sewers; three (3) pump stations and force main sewers. The technology has been in use for a number of years and is reliable.	The collection system, as proposed, includes gravity sewers, one (1) pump station, and force main sewers. The technology has been in use for a number of years and is reliable.
Flexibility of System	The proposed system has a large amount of flexibility. The system could be designed to accommodate any amount of flow. The main limitation would be the amount of treated wastewater CTDEP would allow to be discharged from the Highlands Wastewater Treatment Facility.	Based on the preliminary evaluation the disposal system would only be able to support up to 15,000 gallons per day. This will not support the existing or proposed development of the Center as presently proposed by the Town.

Criteria	**Alternatives**			
	Alternative 1 **Conventional Wastewater Treatment with Surface Water Discharge**		**Alternative 2** **On-site Wastewater Treatment with Subsurface Discharge**	
Range of Cost	$7.7 million to $12.4 million		$2.1 million to $3.0 million	
Range of Cost per Gallon of Wastewater Treated[1]	Low	High	Low	High
	$46	$73	$140	$200
Range of Cost Per Lot[2]	Low	High	Low	High
	$70,000	$113,000	$111,000	$158,000

Notes:
1. Alternative 1 is based on 169,000 gpd and Alternative 2 is based on 15,000 gpd.
2. Alternative 1 is based on 110 lots and Alternative 2 is based on 19 lots.

Through the evaluation of these Alternatives it is clear that transporting the wastewater to the existing Highlands Wastewater Treatment Facility is the alternative that can support the proposed flows from the Center. The proposed flows are estimated to be between 169,000 gpd and 245,000 gpd. A summary of the recommended plan is presented in Section 5.0 of this report.