1

process improvements will have an impact on sludge production and quality – primarily the additional chemical precipitate sludge resulting from the low level phosphorus requirements. The staff needs to be provided an opportunity to develop a comfort level with the changes in sludge production, and the refurbishment of the dewatering and support systems should be coordinated to support this need.

*4.2.6.10 Sludge Composting*

The sludge composting system and facilities serves the town well and continues to provide good functionality. While lacking automation, the system can be run in its current mode for the foreseeable future with limited maintenance-type improvements. Modernization or refurbishment of this system is not a priority.

The composting process is supported by rolling stock (dump truck and front end loader), which need to be continuously maintained. Future changes to rolling stock, including new equipment, should be expected to be implemented (timed as needed) through the sewer department budget.

Site drainage and runoff control for the composting area needs to be specifically reviewed to ensure that drainage from uncovered areas is directed and treated properly. A new stromwater treatment system is likely required to meet stormwater treatment provisions at the site.

*4.2.6.11 Buildings and Structures*

The buildings are all in need of general modernization. The WWTF as a whole lacks adequate staff support facilities, such as dedicated personnel restrooms, locker facilities, and staff support areas. The WWTF also needs a maintenance garage for equipment maintenance and repair, and the staff have highlighted this as a key facility need.

All of the enclosed process and support buildings need building envelope and systems rehabilitation – roof replacement, windows, doors, etc. In addition, from an energy standpoint, the existing building heating, ventilating and cooling systems are outdated and would benefit greatly from modernization to meet new efficiency standards.

Specific building needs include lab modernization improvements in the administration/laboratory building. In the headworks building, better air handling and/or area segregation is needed to control odorous and corrosive air in the grit dewatering area. Similarly, better air handling systems are needed in the sludge dewatering and storage rooms of the operations building. The existing maintenance building should be re-evaluated for improved use – assuming the site can be improved to add proper staff support and maintenance areas.

*4.2.6.12 Electrical Systems*

The electrical systems at the WWTF are primarily in need of modernization. While systems are generally functional, they are outdated, and upgrades to equipment and processes driven by other needs are likely to trigger the need to comply with updates to the National Electric Code (NEC), National Fire Protection Association (NFPA) guidance, and other governing standards for electrical systems.

The existing 300 kW standby generator set has the ability to support normal plant operations for the current facility. The generator has run for a limited number of service hours, and is serviceable. Because of the needs related permit changes, the plant will likely be adding significant new equipment and systems, and a new standby generator system (engine generator set, fuel system, transfer switch, and supporting wiring and controls) is likely to be needed at the WWTF. The generator need should be confirmed following preliminary design.

*4.2.6.13 Instrumentation and Controls*

The existing WWTF instrumentation and control (I&C) system is in need of modernization. The system will also need to be greatly enhanced to support new process changes related to the discharge permit changes. Coordination with the operations staff is needed to determine the level of automation and control needed, but a need exists for at least a Supervisory Control and Data Acquisition (SCADA) system with basic functional support, monitoring and alarming ability.

*4.2.6.14 Summary of Process Area Needs*

The existing WWTF needs discussed in the previous sub-sections of this report are summarized in Table 4-5: Summary of WWTF Needs by Process Area. Alternatives and recommendations relative to these needs are presented in the following sections of this report.

**Table 4-5**
**Summary of WWTF Needs by Process Area**

| Process Area | Primary Need | Secondary Need | Notes |
|---|---|---|---|
| Headworks | New Screening | Modernization | |
| Septage Receiving | Modernization | - | |
| Primary Treatment | Replacement | Hydraulic Profile Change | Clarifier elevation change need. |
| Forward Flow Pumping | Modernization/ Efficiency | Hydraulic Profile Change | |
| Secondary Biological Treatment | Process Change* | Modernization | Tank hydraulic improvements need. |
| Secondary Clarification | Process Change* | Modernization | Settling loading review need. |
| Disinfection | Process Change to Liquid Systems | Modernization | |
| Outfall | Improved Access for Monitoring | - | |
| Sludge Storage & Dewatering | Modernization | - | |
| Sludge Composting | Site Drainage Improvements | Rolling Stock Modernization | |
| Buildings & Structures | Modernization/Energy Efficiency | Space Needs | Support space needs. |
| Electrical Systems | Modernization/Code Compliance | Process Improvement Support | |
| Instrumentation & Controls | Modernization | Improved Process Control Support | |

* These systems have existing needs but are primarily affected by the permit changes that will require overall process changes at the WWTF.

## 4.3 Water Supply Needs

The Bridgewater Water Department maintains, upgrades, and expands its facilities to meet the needs of existing and future customers on a continual basis. Projects are proposed and funded through the Town of Bridgewater annual budget process. The BWD includes capital projects for supply, distribution and storage in its ongoing maintenance and replacement programs.

The BWD has been evaluating additional well supply sites to increase operational flexibility and reliability. The Town has purchased land at Beech Street next to the Titicut Conservation Parkland for a possible additional well. The BWD has evaluated the benefits of additional water storage in the Beecher Street portion of their service area. An additional service pipe is included in the BWD long term plans.

The Town has a Capital Improvement Plan in place for their water system. There are three types of upgrades of their distribution system that are included in their Capital Improvement Plan for their water system. These include 1) increasing the size/capacity of undersized sections, 2) looping (additional water main connections) certain sections to improve reliability and circulation and 3) replacing asbestos/concrete (A/C) main nearing the end of its service life. Looping is needed in certain areas to improve operational flexibility as well as increase reliability during service related water main shutoffs. The BWD has approximately 47 miles of AC water main in service that were put into service in the 1950s and 1960s. Since AC water main has proven to become more failure prone at the end of its service life, BWD is working to replace A/C sections of its system as funding allows.

## 4.4 Stormwater Management Needs

As discussed in Section 3.6, the permit for stormwater discharges from Small Municipal Separate Storm Sewer Systems (MS4 Permit) was re-issued by the Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Protection (MassDEP) on April 4, 2016, and becomes effective on July 1, 2017. Bridgewater is required to file a Notice of Intent (NOI) seeking authorization to discharge stormwater under the new MS4 Permit by September 29, 2017, and then comply with all of the permit's requirements. Under their MS4 Permit, Bridgewater is required to employ best management practices for the six minimum control measures discussed in Section 2.4 in an effort to reduce the discharge of pollutants from the MS4 to the maximum extent practicable. An overview of those requirements and the timeframe for completion as outlined in the permit was provided in Section 3.6. This section provides a more detailed account of what Bridgewater will need to do to comply with the conditions of the new permit.

### *4.4.1 Stormwater Management Plan*

The MS4 Permit requires the Town to develop a written Stormwater Management Plan (SWMP) outlining those activities and measures that the Town will implement to meet the terms and conditions of the permit. The SWMP must be developed during the first year of the permit and then modified and updated as needed throughout the permit term to document activities being undertaken by the Town to comply with the conditions of the permit.

### *4.4.2 Public Education and Outreach*

Under the new permit, the Town will be required to continue to implement the public education program they developed in compliance with the 2003 MS4 Permit. However, the permit does identify specific target audiences that must be the focus of education and outreach efforts. These include (1) residents, (2) businesses, institutions (churches, hospitals) and commercial facilities, (3) developers (construction) and industrial facilities. A minimum of two educational messages must be distributed to each audience over the permit term. To satisfy this requirement, the use of available printed materials is encouraged as is partnering with other MS4s, community groups or watershed associations to implement the required public education program. The Town must evaluate the effectiveness of their public education program and modify any ineffective messages throughout the permit term.

### *4.4.3 Public Involvement and Participation*

The permit requires the Town to provide opportunities on an annual basis for the public to participate in the review and implementation of the Town's Stormwater Management Program. Public participation activities may include, but are not limited to, posting stormwater information on the Town website, establishing a hotline where illicit discharges can be reported, organizing stream clean-up teams, and forming a Stormwater Advisory Committee.

### *4.4.4 Illicit Discharge Detection and Elimination*

The new MS4 Permit requires the Town to implement an Illicit Discharge Detection and Elimination (IDDE) Program to locate and eliminate non-stormwater discharges from the municipal separate storm sewer system. The Town has already adopted an IDDE bylaw in accordance with the 2003 MS4 Permit, which prohibits illicit discharges, and gives the Town the authority to investigate suspected illicit discharges, eliminate illicit discharges and implement enforcement procedures. The new permit requires the Town to eliminate any illicit discharges within 60 days of becoming aware of the discharge. If elimination within 60 days is not feasible, the Town must establish an expedited schedule for elimination.

As part of the Town's implementation of their IDDE Program under the new permit, the Town must develop a more comprehensive drainage map than what was required under the 2003 MS4 Permit. The 2003 MS4 Permit required the Town to map 100% of their outfalls. To date, the Town has located, mapped and inspected an estimated 277 outfalls and 1,375 catch basins. The remaining estimated 213 outfalls have been identified on paper maps, and the Town has plans to incorporate those outfalls into the GIS. Under the new MS4 Permit, the Town is required to map open channel conveyances, interconnections with other MS4s, municipally-owned stormwater treatment structures, all water bodies within Town and their use impairments, and perform initial catchment delineations within two years of the permit effective date. The Town will be required to map all drainage pipes, drain manholes and their remaining catch basins, as well as provide updated catchment areas, within 10 years of the permit effective date. The Town is also required to integrate mapping of their sanitary sewer system with their drainage mapping where sanitary sewer mapping is available.

The Town will need to develop a written IDDE Plan, which details how catchments will be prioritized for investigation and outlines written procedures for how dry weather screening and sampling will be conducted, and how catchments will be investigated. Catchments associated with regulated outfalls and interconnections must be assessed and ranked based on their potential to have illicit discharges, and then investigated over a 10-year period. The sampling and catchment investigation requirements as identified in the MS4 Permit are some of the more extensive requirements outlined in the new permit having the greatest cost implications. The Town will be required to perform dry weather screening and sampling at all regulated outfalls and interconnections. In addition, wet weather sampling also needs to be performed at regulated outfalls and interconnections that have a minimum of one System Vulnerability Factor (SVFs) as identified in the permit. SVFs include, but are not limited to, areas with sanitary sewer overflows, areas with common trench construction serving both sanitary sewer and storm drain alignments, areas where the sanitary sewer and storm drain cross and the sanitary sewer is located above the storm drain, areas where sanitary sewer defects have been identified, etc. The Town must implement a comprehensive IDDE investigation program in all regulated catchments regardless of dry and wet weather sampling results. All key junction manholes within each catchment that have dry weather flow must be opened and sampled for ammonia, chlorine and surfactants at a minimum. Where sampling results indicate evidence of an illicit connection, the drainage area tributary to that particular junction manhole must be further investigated to locate the source of the illicit connection. Since Bridgewater has approximately 490 outfalls, the IDDE investigation effort and required sampling may be fairly extensive depending on the number of the outfalls that are regulated, located within the urbanized area, and/or have not been classified as excluded based on the catchment ranking completed.

#### 4.4.5 Construction Site Stormwater Runoff Control

The Town already has a Construction Site Runoff Control Bylaw in place as required under the 2003 MS4 Permit. The Town will be required to update this bylaw to ensure compliance with the requirements of the new MS4 Permit. The new MS4 permit requires the Town to have the following in place: (1) written procedures for site inspections and enforcement of erosion control measures; (2) requirements for construction site operators to implement a sediment and erosion control program that includes appropriate BMPs; (3) requirements for construction site operators to control wastes; and (4) written procedures for site plan review, inspection and enforcement.

#### 4.4.6 Post Construction Stormwater Management in New Development/Redevelopment

In 2004, the Town adopted regulations to address post-construction runoff from new development and re-development sites to comply with the 2003 MS4 Permit. These regulations were further amended in 2007 and 2012 to require compliance with the MADEP Stormwater Management Standards. Under the new MS4 Permit, the Town will be required to review the regulations that they have in place to ensure continued compliance with the latest requirements, and make modifications to meet the conditions of the permit. The Town must also develop a report assessing current street design and parking lot guidelines and other local requirements that affect the creation of impervious cover; and develop a report assessing local regulations to determine the feasibility of making various green practices allowable when appropriate site conditions exist.

#### 4.4.7 Pollution Prevention/Good Housekeeping for Municipal Operations

Under the new MS4 Permit, the Town will be required to develop written operations and maintenance (O&M) procedures for permittee-owned operations to include the following:

- Parks and open space, including proper use, storage, and disposal of pesticides, herbicides, and fertilizers; lawn maintenance and landscaping activities; pet waste handling collection and disposal; waterfowl congregation areas; trash containers at parks and open space.
- Buildings and facilities, including use, storage, and disposal of petroleum products and other potential stormwater pollutants; spill prevention; and dumpsters and other waste management.
- Vehicles and equipment, including storage of vehicles; fueling areas; and vehicle washing.
- MS4 infrastructure, including catch basin inspection and cleaning; sweeping and/or cleaning streets and Town parking lot.
- Winter operations, including the optimized use and storage of salt and sand.
- Inspection and maintenance of Town-owned structural BMPs (e.g., water quality swales, retention/detention basins, infiltration structures, etc.).

The Town must optimize inspection, cleaning and maintenance of catch basins to ensure that at any given time no catch basin is more than 50% full. All streets must be swept a minimum of once per year in the spring.

The Town is required to develop a Stormwater Pollution Prevention Plan (SWPPP) for any waste handling facilities including maintenance garages, public works yards, transfer stations and wastewater treatment facilities that are not already covered under a Multi-Sector General Permit. It appears that Bridgewater previously applied for a No Exposure Certification for their Wastewater Treatment Facility under the 2008 Multi-Sector General Permit.

#### *4.4.8 TMDLs*

As discussed in Section 2.4.10, the 2014 Final Integrated List of Waters for Massachusetts lists the Matfield River (MA62-32) as having an approved TMDL for bacteria. The Matfield River is included under the Final Pathogen TMDL for the Taunton River watershed. In order to limit bacterial contamination in the watershed, the Town is required to reduce bacteria in discharges to the Matfield River by implementing BMPs to meet the TMDL. These BMPs are identified in the new MS4 Permit and include enhanced public education requirements that require distribution of information on proper pet waste management and septic system maintenance. In addition, any catchments draining to waters impaired for bacteria must be designated as problem catchments or high priority in implementation of the Town's IDDE Program.

#### *4.4.9 Impaired Waters*

As discussed in Section 2.4.11, the 2014 Final Integrated List of Waters for Massachusetts identifies the Matfield River as impaired for total phosphorus, and Mount Hope Bay as impaired for total nitrogen. There are specific requirements included in the 2016 MS4 Permit regarding discharges to water quality limited water bodies or their tributaries where phosphorus or nitrogen is the cause of the impairment, and there is no approved TMDL.

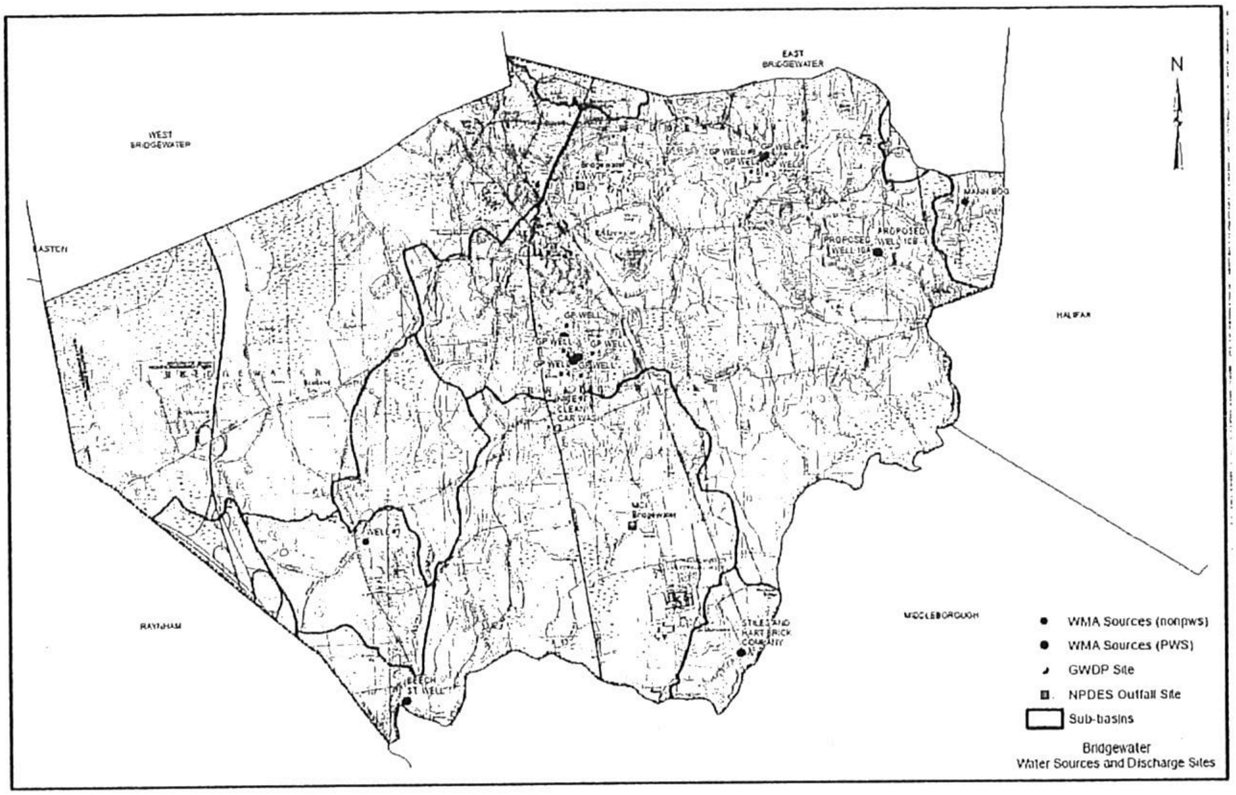
The Town must identify and implement BMPs designed to reduce phosphorus discharges in those catchments tributary to the Matfield River. These BMPs are identified in the new MS4 Permit and include enhanced public education requirements that require distribution of information on proper use of slow-release and phosphorus-free fertilizers, proper management of pet waste, and proper disposal of leaf litter. In addition, the Town's stormwater regulations must include a requirement that new development and redevelopment stormwater BMPs be optimized for phosphorus removal. Also, when considering municipal infrastructure to retrofit with stormwater BMPs, BMPs that infiltrate stormwater must be considered where feasible. There are also enhanced good housekeeping requirements, which include increased street sweeping of municipally owned streets and parking lots to at least twice per year in catchments tributary to the Matfield River. A Phosphorus Source Identification Report must also be developed that examines the area tributary to the Matfield River, and identifies catchments with potentially high phosphorus loads to target for implementation of structural BMPs aimed at reducing phosphorus levels. Potential retrofit opportunities within the existing drainage system must be identified and evaluated as to feasibility and cost implications must be assessed. One structural BMP must be installed as a demonstration project by Year 6 of the Permit, and a schedule for implementation of additional BMPs must be developed.

The Town must also identify and implement BMPs designed to reduce nitrogen discharges in those catchments tributary to Mount Hope Bay. Since the entire town discharges to the Taunton River, which discharges to Mount Hope Bay, BMPs must be implemented within all MS4 regulated areas town-wide. The actual BMPs to be implemented for nitrogen reduction mirror those BMPs for phosphorus reduction including the development of a Nitrogen Source Identification Report.

## 4.5 Water Balance

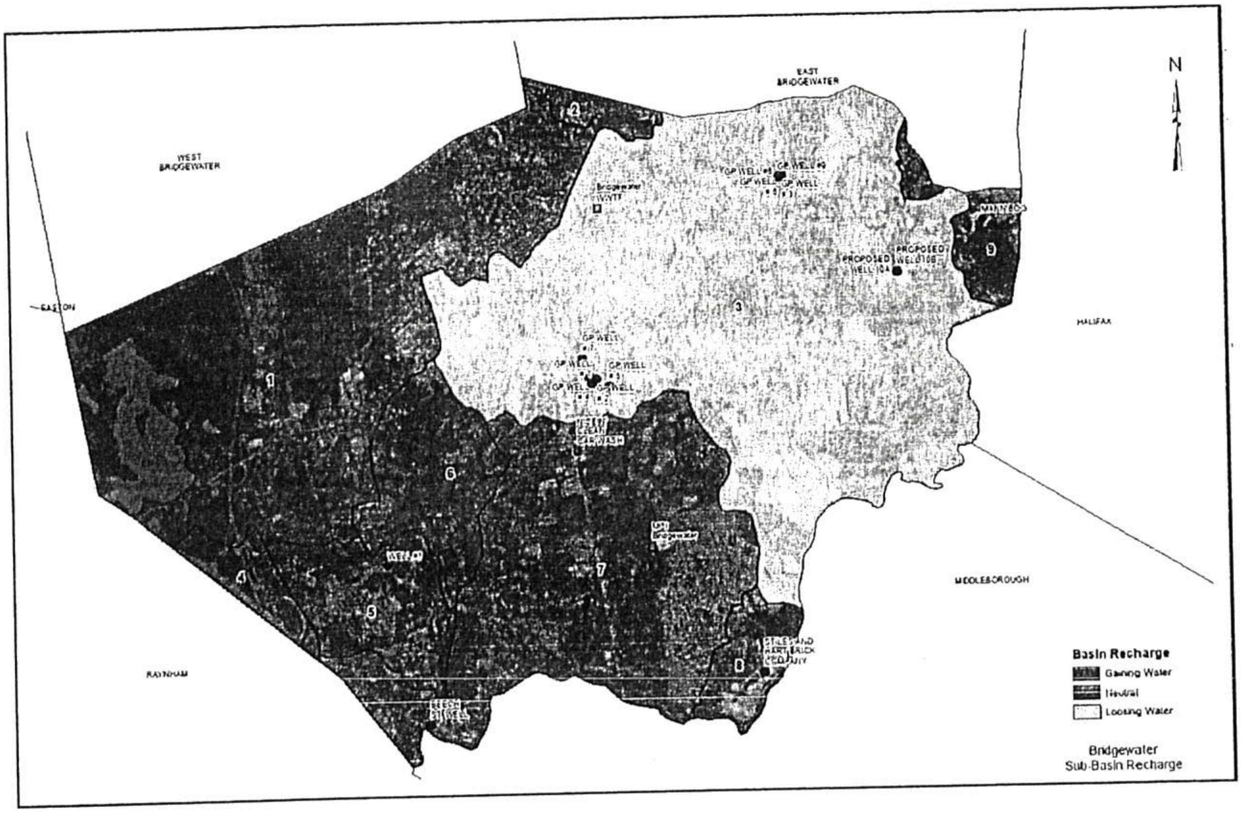
Local water balance considerations may be factored into the decision making for Bridgewater's water resources management, particularly to the extent that options are available that can effect a positive change in local basin and sub-basin conditions. The major impacts on local water balance are water supply sources (withdrawals) and wastewater discharges. Septic systems serving individual homes and businesses also provide for recharge where the properties are served by a public water system – these impacts are generally positive and depend on the balance of sewered v. un-sewered properties. Stormwater recharge and other factors can affect these conditions as well, though are less well mapped and variable in their quantities. Figure 4-1: Water Sources and Discharge Sites shows the location of public water sources and significant wastewater discharge sites in the community.

**Figure 4-1**
**Water Sources and Discharge Sites**




The nominal balance in various sub-basins within town can be mapped from these general contributions to water balance. This process provides a map-based tool for considering areas for optional recharge-friendly decision making. As many water resource decisions are limited by a large number of geophysical conditions, and often by geo-political conditions as well, local water balance alone cannot be considered a major driver for all decisions. For presentation purposes, the general local sub-basin water balance conditions in Bridgewater have been mapped – showing basins that are generally gaining water, those that are relatively neutral, and those that are losing water. Figure 4-2: Basin Recharge Conditions shows these general basin recharge conditions.

**Figure 4-2**
**Basin Recharge Conditions**

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# 5.0 ALTERNATIVES

This section of the CWMP discusses alternatives for addressing the various water resources management areas of need identified in Section 4 of the report. The discussion of alternatives is divided into several key areas for organization purposes.

## 5.1 Wastewater Management Alternatives

Building on prior planning studies, the needs analysis presented a general picture of which areas in the Town of Bridgewater may have challenges relying on on-site septic systems for wastewater disposal. There are several available alternatives for wastewater management that may be evaluated to minimize these potential challenges. Each alternative falls into one of two major categories – on-site solutions, and off-site solutions.

### *5.1.1 On-Site Wastewater Solutions*

On-site systems include individual septic systems that treat and dispose of wastewater on the same parcel on which the wastewater is generated. These systems often consist of a septic tank to separate solids and a leaching field to treat the wastewater and re-distribute the discharge back to the ground. Some on-site systems require additional treatment components (for example, innovative/ alternative systems) or special construction (for example, mounded systems), which are discussed later in this Section.

Conventional Title 5 systems are not designed to achieve a high level of treatment of biochemical oxygen demand (BOD), total nitrogen removal or phosphorus removal. Title 5 septic tanks do not remove a high level of nutrients from the wastewater before it enters the soil absorption system. Properly designed, installed, and maintained systems still discharge pollutants into the groundwater. Unsaturated soils in a soil absorption system are effective at removing bacteria, viruses, and most nutrients (with the exception of some forms of nitrogen and high levels of phosphorus). Systems with saturated soils, an inadequate separation between the soil absorption system and the groundwater, rapidly percolating soils, an inadequately designed soil absorption system, or other limitations will contribute even higher levels of pollutants to the groundwater. Therefore, it is sometimes desirable, particularly in sensitive areas, to achieve a higher level of treatment than a conventional Title 5 system can provide.

Current Title 5 regulations allow for the use of innovative/alternative (I/A) technologies under the provisions of Sections 15.280 – 15.289 of the Code. Alternative systems provide substitutes or alternatives for one or more of the components of a conventional system while providing equal or greater environmental and health protection. The revised Title 5 regulations specifically identify the requirements for approval of I/A technologies, and classify the level of approval as remedial, piloting, provisional, and general. These alternatives are being used throughout the state for upgrades of systems on sites that cannot accommodate a conventional system. A list of approved I/A system technologies is maintained on the Massachusetts DEP web site.

### *5.1.2 Off-Site Wastewater Solutions*

Off-site systems collect wastewater from a community or neighborhood, and treat and dispose of the wastewater on a parcel separate from the wastewater generation point(s). Examples of off-site system solutions include:

a) Localized sewer systems (cluster) with a shared Title 5 treatment system;
b) Localized sewer systems (cluster) with a neighborhood treatment system;
c) Centralized sewer systems with a large-scale wastewater treatment plant (such as the Bridgewater WWTF).

These off-site options are each generally described as follows.

*5.1.2.1 Shared Title 5 Systems*

Groups of homes or businesses that discharge a total of 10,000 gallons per day (gpd) or less of wastewater (on a maximum daily flow basis) can utilize Title 5 requirements to design their wastewater treatment and disposal site. This off-site alternative is the most similar to conventional on-site 'septic' systems. Typically, shared Title 5 systems are large on-site systems located on a vacant parcel or a vacant portion of a larger developed parcel in a neighborhood where individual lots have challenges in siting on-site systems. In most instances, shared systems are made up of a large septic tank and a larger leaching field. On occasion, however, in environmentally sensitive areas, these systems require additional components/equipment (I/A technology, as discussed in Section 5.1.1) to provide an increased level of treatment. These systems generally serve a collection area of less than thirty, average-size (3-bedroom) homes, and can be as small as just a few homes sharing a system on the property of one or several homeowners.

Shared Title 5 systems require special approval from DEP, as well as legal agreements and documentation regarding ownership, maintenance, and other issues. Shared systems must be pumped at least once per year. A conventional shared system for a particular area would include a localized collection system, a large septic tank, a dosing (pump) chamber, and a large soil absorption system. For design flows over 5,000 gpd, leaching trenches are the only type of soil absorption system allowed by DEP. Assuming the use of leaching trenches, the footprint for a 10,000 gpd soil absorption system could be approximately 1 acre or more, including sufficient reserve area. Availability of suitable land is therefore often a limiting factor in the application of shared systems. A second major factor is the administrative and legal constraints of having several property owners share the systems costs.

*5.1.2.2 Small Decentralized Cluster or Neighborhood Treatment Systems (NTS)*

This type of off-site system collects wastewater from a localized area that is larger than that allowed for a Title 5 system (i.e., will generate a flow greater than 10,000 gpd), and requires construction of a small, neighborhood treatment and groundwater disposal system. This type of off-site system is relatively new compared to centralized sewer systems but offers the benefit of groundwater recharge with higher quality effluent than individual on-site systems. Groundwater recharge is a term used for putting water back into the same general area from which it was taken, in order to replenish the groundwater.

A neighborhood treatment system generally includes below ground tankage and small-scale wastewater treatment components/equipment, which are often enclosed in a small above ground structure. Groundwater disposal systems are similar to leaching fields used in on-site systems, but they generally have a larger footprint designed to process greater flows of high quality effluent. Groundwater discharges require a DEP permit to discharge the effluent to the ground. Siting a system can be challenging based on the need for a suitable discharge site.

This wastewater management alternative could generally be considered for areas in Bridgewater where groundwater recharge would be beneficial to:

- replenish base flow to area surface waters (lakes, ponds, brooks, streams or rivers);
- recharge the groundwater supply in drinking water aquifers; and
- maintain the water balance in sub-watershed basins.

The difficultly in analyzing and recommending this wastewater management alternative is public acceptance. Due mainly to the negative connotation associated with wastewater and the idea of having a 'treatment plant' in a neighborhood, there is often great resistance on the part of local residents to allow a municipality to locate a NTS. A good deal of public education on this wastewater management alternative would need to be conducted to prevent consideration of an alternative concept to which local residents are opposed.

Even after a potential site has passed the public acceptance test, the site must be technically analyzed to confirm that soils are appropriate to adequately filter the NTS effluent, that groundwater is deep enough to not cause a surcharge or excess mounding effect, and that sensitive receptors (like drinking water supplies, surface waters, wetlands, etc.) are not negatively impacted.

#### *5.1.2.3 Centralized Sewer and Large-scale Wastewater Treatment Plant*

The Town of Bridgewater has a limited system of sewers that collects wastewater flow from residences, businesses and institutions and transports this flow to a municipal wastewater treatment facility (WWTF) located off Morris Avenue. The sewer system currently receives flow predominantly from the Town Center area as well as from various developed portions of the town lying east and west of the town center. Flow is treated at the WWTF and discharged to the Town River, which flows to the Taunton River.

Since the Town has a centralized sewer system, extension of new sewer pipelines to serve needs areas and return flow to the WWTF is an appropriate alternative. Analysis of this alternative, however, required confirmation that both the existing sewer system and the existing WWTF have available capacity, and these issues are further discussed later in this section.

### *5.1.3 Evaluation of Wastewater Management Alternatives*

Following up on information presented in the Needs Analysis, the applicability of on-site and off-site solutions for wastewater management to various areas of Bridgewater defines the best alternative for each area. In general, most of the un-sewered areas in Bridgewater were developed using on-site (Title 5) systems, and as such can be supported by such on-site solutions. The best solution for areas which can continue to be supported by on-site systems is obviously to maintain those systems, and to repair and reconstruct those systems, where and when necessary.

The cost to maintain a functional septic (Title 5) system for a single family home is generally low, consisting primarily of the cost to monitor and periodically pump the septic tank. The costs for these systems are more challenging when the need arises to repair the system, to significantly upgrade, or replace the entire system. The capital costs for septic system replacement vary widely as these costs are a function of many factors. For single family homes, some repairs are reported to be possible for as low as several thousand dollars, and replacement costs as high as $100,000 have been reported. However, septic system replacement costs are likely to generally vary from $10,000 to $40,000 for a typical single family home. Due to the variation in costs for system replacement, the financial comparison of on-site and off-site solutions for properties is subjective.

Areas where significant needs for off-site solutions have been demonstrated are less suitable for long-term reliance on on-site systems. As such these areas need to be evaluated for the best possible off-site solution. Recognizing that there is remaining capacity in the town's WWTF, the primary focus for Bridgewater is to evaluate possible extension of sewers to these unsewered needs areas. Possible sewer extension solutions for identified needs areas, as well as possible sewering technologies, are presented in the following discussions.

## 5.2 Sewer Collection System Technology Alternatives

The collection portion of a centralized system can be developed using a variety of technologies for conveyance of the wastewater to the centralized treatment and disposal site. These technologies generally may include:

- Conventional gravity sewers, with pump stations and force mains,
- Individual grinder pumps and low-pressure sewers,
- Innovative and alternative (I/A) technologies such as septic tank effluent pump (STEP) systems, vacuum sewer systems, and small diameter variable slope (SDVS) gravity sewer systems,
- Some combination of these technologies (a hybrid system).

The existing wastewater collection system for the Town of Bridgewater is primarily a conventional system, consisting of conventional gravity sewer lines and pump stations, but also includes some limited low-pressure sewer lines serving some areas. Since more innovative and alternative (I/A) technologies have not been employed in Bridgewater's municipal system in the past, and since they do not lend themselves well to the proposed sewer extension areas, they may be less appropriate for future projects. We have, however, provided a limited discussion on these technologies for completeness.

### *5.2.1 Conventional Gravity Sewers with Pump Stations*

A conventional gravity sewer system consists of sewer lines that allow residential, commercial, and industrial customers to discharge into a sanitary system consisting of gravity pipes, which flow downhill, and are not pressurized. Gravity sewer systems operate by collecting the wastewater via continuously sloped pipe, typically 8-inch minimum diameter, and transport the wastewater to the WWTF or to localized low points in the collection system. The design of a gravity sewer system is dependent on the velocity of the wastewater within the pipes. Minimum velocities of approximately 2 feet per second (fps) are recommended to assure that suspended matter does not settle out in the conduit. The industry standard minimum slope to achieve this velocity in an 8-inch pipe flowing full or half full is 0.0040. Maintaining this velocity is particularly challenging in end run pipes, where only a few homes contribute flow to the line. It is recommended that steeper slopes be employed in these areas. Maximum velocities (typically 8 to 10 fps) are set to prevent excessive scouring of the pipe, which can lead to structural failure of the system.

Extremely flat or hilly terrain poses a problem to gravity sewer installations since the gravity sewers must continually slope downward. This results in the sewer becoming increasingly deep or the need for a wastewater pumping station. Pump stations are located at low points to collect and pump the wastewater to the WWTF or to the nearest high point in the collection system, where the process of gravity flow continues. Pump stations may also be required where wastewater must be transported between drainage basins. Wastewater is pumped from the pump stations to the centralized treatment and disposal site (or to the closest gravity manhole that flows to the centralized treatment and disposal site) via a pressurized pipe called a force main. A discussion of pump station configuration alternatives is included later in this section of the report.

Conventional sewer systems are typically limited by topography and the higher cost that develops from installing pipelines in deep excavations. Higher costs for these systems can also result when multiple pump stations are needed to serve limited numbers of properties.

### *5.2.2 Low Pressure Sewers*

Low-pressure sewer systems have proven to be a viable alternative where implementation of gravity sewer systems is impractical and/or uneconomical due to topography or other constraints.

A low-pressure sewer system includes small diameter pressure sewers fed by individual grinder pumps at each source of flow. A pressure sewer system makes use of small diameter piping, buried at a relatively shallow depth (typically five feet deep) following the profile of the ground. The pressure main and service pipe are generally manufactured from polyvinyl chloride (PVC) or high-density polyethylene (HDPE). The pressure sewer mains and laterals are buried below the historical depth of frost penetration, and should be located to avoid conflicts with other utilities.

The pressure sewer system is separated into branches of sewers of different sizes depending on the number of connections to each branch. Standard manholes are not required in a pressure sewer system. Instead, flushing connections/drain manholes are installed at the end of branches and where major changes in directions or size of pipe occur. Air relief/vacuum valve manholes are installed at high points in the system to allow trapped air to be removed from the pipes.

In a low-pressure sewer system, each customer will utilize an individual grinder pump for discharge of sewerage into the main. Each grinder pump unit is equipped with a grinder pump, check valve, tank, and necessary controls. The units can be located outdoors close to each customer's existing septic tank or cesspool so that the connection to the existing service pipe exiting the building can be made easily. The units can also be located inside the building if permissible under local plumbing codes. The grinder pump macerates the solids present in the wastewater to a slurry, in the manner of a kitchen sink garbage grinder, and discharges wastewater to the pressure sewer collection pipes. Apartment buildings, motels, and restaurants require larger pump units – often duplex pump systems are used for these properties. If a pump malfunction occurs, a high liquid alarm is activated. This alarm may be a light mounted on the outside of the building or an audible alarm that can be silenced by the customer, or may include telemetry for remote response. The customer will then notify an approved technician or contractor to come and make necessary repairs.

A low-pressure sewer system collects and transports the wastewater from each customer located in low points to the nearest gravity sewer. Within the right-of-way, air relief manholes with air and vacuum valves would be installed at all high points and terminal flushing drain manholes would be installed at all low points. In addition, cleanouts would be installed approximately every 1,000 feet to provide access for periodic maintenance.

Low pressure sewers are limited by the ability of the individual pumps to overcome higher system pressures – this can result from very large pressure system networks. In the case of large service areas, a conventional pump station may be added to help transmit flows to a remote connection or treatment point. Shallower excavations and smaller pipes make low pressure systems economical to install, though many property owners have concerns with the maintenance required for the individual pumps.

### *5.2.3 Hybrid Collection System (Conventional/Low Pressure)*

A hybrid system is a combination of conventional wastewater collection system components and low pressure sewers (with individual grinder pumps). These combined systems are designed to maximize the use of gravity sewers and utilize grinder pumps and lower pressure sewers where the topography, subsurface conditions (ledge, groundwater, coastal areas, etc.), property spacing, or environmental or economic considerations warrant their use.

As discussed, the existing wastewater collection system in Bridgewater is primarily a conventional system, but the presence of low pressure components make the town's system a hybrid system. This approach offers balanced benefits of both system configurations, and is appropriate to consider for most municipal service areas.

*5.2.4 Septic Tank Effluent Pumping (STEP) System*

Septic tank effluent pumping (STEP) systems are similar in overall construction, operation, and maintenance to grinder pumps and pressure sewers with the exception that solids and grease are removed from the wastewater at each residence or commercial/industrial establishment utilizing a conventional septic tank prior to pumping. This system employs a combination of on-site/off-site system technologies. Preliminary treatment takes place on each individual property and secondary treatment takes place at a centralized (or decentralized) facility.

STEP systems require the installation of watertight septic tanks at each home to remove solids and grease followed by an effluent pump that conveys the wastewater to a low pressure sewer system. A screen is typically installed between the septic tank and the effluent pump to prevent solids from entering the piping system. The STEP pressure sewer system requires the same integral components as the grinder pump pressure sewer system. Since a majority of the solids are removed in the septic tank, velocities of only 0.5 fps are required in the pipelines. Therefore, slightly longer mainline pressure sewers may be utilized as compared to grinder pump pressure sewers. Wastewater delivered to the treatment system from a STEP system typically has 30% lower biochemical oxygen demand (BOD), and can therefore be easier to treat. The STEP effluent wastewater tends to have a high ammonia (and therefore nitrogen) content. Unfortunately, this causes the septic wastewater to have a higher potential for generating odors and can cause corrosion in collection system structures.

STEP systems require periodic pump outs to remove accumulated solids (septage) and grease from the septic tank to protect the effluent pumps. The septage is typically removed at an interval of approximately three to five years depending on system usage, and must be conveyed for disposal to an approved facility. This interval is the same as recommended for an on-site wastewater disposal system.

Due to the anaerobic nature of the effluent, STEP systems are not typically utilized where a conventional treatment facility is proposed to provide treatment. Also for this reason, STEP systems may tend to experience more odor nuisance problems.

*5.2.5 Small Diameter Variable Slope Sewers*

Small diameter gravity sewers - sometimes called small diameter variable slope (SDVS) gravity sewers, work on the same principle as conventional gravity sewers. That is, the wastewater is conveyed through the sewer pipeline by gravity. The small diameter gravity sewer does not, however, conform to a continuous downward sloping grade, instead generally following the ground contours with both upward and downward sloping sections. Actual flow in the small diameter gravity sewer therefore varies between pressurized conduit flow and open channel (gravity pipe) flow. The small diameter gravity sewer discharges into either a conventional gravity interceptor or a pump station.

Like STEP systems, the small diameter gravity sewer systems utilize a septic tank at each individual home to collect and retain solids, which could clog the small sewer lines. A screen is often place on the effluent (discharge) end of the septic tank to prevent the entrance of solids. The main design requirement for these systems is that each individual home septic tank discharge be located at an elevation sufficiently above the sewer outlet to induce gravity flow in the sewer line (i.e. above the hydraulic grade line for the sewer). For this reason, SDVS are dependent on the terrain in the area, although somewhat less so than conventional gravity sewers.

Small diameter gravity sewer systems have the pipeline cost advantages of pressure, STEP or vacuum sewer systems (i.e. small pipe, shallow installation depth and narrow trench widths). They have the additional advantage, however, of not requiring pumping for conveyance of the wastewater. Therefore small diameter gravity sewer systems are less costly to construct, operate and maintain. Unfortunately, due to topography of the service area, small diameter gravity sewer systems are often not feasible where pressure, STEP and vacuum sewer systems would be. Also, in many areas where small diameter gravity sewers are feasible, conventional gravity sewers are also feasible, and are usually recommended.

*5.2.6 Vacuum Sewer System*

Similar to pressure sewers, vacuum sewers use small diameter sewer mains to collect wastewater from individual homes. The vacuum pipeline, however, is not continuously filled with wastewater as with pressure sewers. A central vacuum sewer collection station equipped with vacuum pumps provides a constant negative pressure (gauge) in the mains. Sufficient suction is generated to carry wastewater from individual building connection inlets through the vacuum main to the collection station. The collection station is typically equipped with conventional sewage pumps to transmit the collected wastewater to a nearby interceptor sewer or WWTF.

Building connections in a vacuum sewer system consist of a valve chamber, with a pneumatically controlled valve, which allows wastewater to enter the vacuum main as it accumulates in the valve chamber. A single valve chamber and service connection may be used to serve up to four individual homes. The service connection pipeline from the valve chamber to the main is typically 3 inches in diameter. Vacuum sewer mains vary from 4 inches to 8 or more inches in diameter. Mains are installed generally following ground surface contours, but allowable elevation changes are more limited than with pressure sewers.

The major advantage of vacuum sewers is the elimination of individual pumping systems for each home connected. The vacuum valve chamber requires no electrical connection, and is less costly to install and maintain than a grinder or STEP pump unit. Since the sewer main is continuously evacuated of all wastewater, the possibility of wastewater leaking out of the pipeline is eliminated. The opportunity for groundwater infiltration in to a vacuum sewer is greater than with a pressure sewer. Resulting loss of vacuum pressure in the main is monitored continuously, however, and leaks are quickly detectable. Vacuum sewers are less susceptible to grease accumulation since floatable wastes such as grease are accepted into the vacuum collection system as easily as the liquid wastes.

Vacuum sewers have been used in all climates, but recent installations in New England have experienced operational challenges in extreme cold winter periods, making the application of this technology challenging in areas like Bridgewater.

*5.2.7 Sewer Installation Alternatives*

The construction of conventional and alternative sewer systems typically require significant excavation, which contributes to the significant costs of developing a system. Alternative methods of pipeline installation have been developed, and should be considered for new system installation. These alternative systems increasingly include 'no-dig' (e.g. trenchless) and limited dig technologies. A few of the notable technologies that should be considered are discussed in this section, including pipe jacking, microtunneling, pipe ramming, and horizontal directional drilling.

*Pipe Jacking*

Pipe jacking is a trenchless method of installing a carrier pipe or casing by pushing it through the ground while excavating and removing the soil as the line advances. It is a sophisticated, non-disruptive, one-pass method of pipe installation for larger diameter pipelines.

The major advantages of the pipe jacking technology are as follows:

- Larger diameter pipe can be installed
- Accurate line and grade can be achieved
- No significant cost penalty for greater depths is realized
- Excavation can be controlled

The major disadvantages of the pipe jacking technology are as follows:

- Man entry into the jacking pit and into the pipe is required
- Boulders larger than pipe diameter pose a significant hindrance to the use of this technology
- Dewatering issues can be difficult
- Minimum recommended pipe diameter of 36 inches is required to allow for man entry
- Not always suitable in areas of solid bedrock
- Excavation of jacking and receiving pits is required

*Microtunneling*

Micro-tunneling is generally defined as remotely controlled pipe jacking that does not require personnel entry into the pipe. It is an accurate, laser-guided method for installing pipelines in varied soil conditions (i.e., from soft ground to hard rock). The installation of sewers and pipelines by microtunneling as a commercial alternative to open cut construction is fast becoming an accepted form of construction. It was first used in the United States in the early 1980's.

The major advantages of the microtunneling technology are as follows:

- Dewatering requirements are limited
- Extremely accurate line and grade can be achieved
- Operation is fully remote controlled, reducing the risk of accidents
- Wide range of pipe material (e.g., fiberglass, reinforced concrete, steel, polyvinyl chloride) and diameter options can be implemented

The major disadvantages of the microtunneling technology are as follows:

- Machines are expensive, therefore driving overall project costs up
- Contractors lack experience in this technology, especially in varying ground conditions
- Method is not cost-effective for smaller diameter installations

*Pipe Ramming*

Commonly used to cross roads, railways, and embankments, pipe ramming is a non-steerable method of forming a bore by driving a steel casing from a drive pit to an exit pit using a pneumatically operated percussion hammer. For smaller diameters the casing may be closed, but in larger sizes an open-ended casing is used. Upon completion of the bore, spoil is removed from the open ended casing using compressed air and water.

The major advantages of the pipe ramming technology are as follows:

- Set up is simplified resulting in reduced mobilization costs
- The bore pit is relatively small in size
- Provides ability to bore through cobbles and small boulders
- High groundwater table is easily dealt with

- Workers are not required to remain in the excavation during the operation

The major disadvantages of the pipe ramming technology are as follows:

- It is a non-steerable method
- It is only useful for shorter installations (i.e., maximum achievable length is 165 feet, with a diameter range of 8 to 36 inches)
- Intermittent stations are required for longer installations
- Unsuitable in areas of solid bedrock
- It is not recommended where line and grade are critical

*Horizontal Directional Drilling (HDD)*
Horizontal Directional Drilling (HDD) is a steerable method for the installation of pipelines. This trenchless technology method is performed by drilling a pilot hole, reaming the pilot hole to a larger diameter, and pulling back the product pipe. This technology was originally developed by the oil industry for river crossings of small diameter where a high degree of accuracy was not required. These systems are now widely used for installing underground pressure pipes where open excavations are not advisable.

The major advantages of the HDD technology are as follows:

- All of the equipment is on the surface
- No dewatering is required
- Long lengths can be achieved without requiring intermediate pits or stations
- Provides a powerful, steerable system
- Installations can be performed through a wide variety of geologic formations
- Allows for installation of a large range of pipe diameters
- Provides a predictable, short construction schedule
- Costs are typically lower than for other viable methods

The major disadvantages of the HDD technology are as follows:

- Utility crossings must be exposed where depths cannot be accurately determined using a non-destructive utility locator
- Costs and time of construction can vary significantly, depending upon size and length of pipe and soil conditions
- Not recommended if line and grade are critical (i.e., in the case of gravity sewers)
- Magnetic interference can affect the bearing sensors of the steering tool

*Application of Alternative Technologies*
Each of these technologies discussed has applicability for certain parts of new pipeline installation. The preliminary design of sewer extension projects in town should consider the use of alternative installation technologies to limit project impacts and control sewer extension costs.

## 5.3 Sewer Extension Alternative Analysis

Figure 5-1: Locus Map depicts the identified sewer needs areas from Section 4 and the approximate extents of the existing sewer system. Identified areas of need for an off-site wastewater solution were evaluated for the ability to connect, and best methodology for extending sewer to the existing Bridgewater sewer system. This analysis was conducted by reviewing the topography of the needs areas to determine the best technology for sewering – gravity sewers, low pressure sewers, and hybrid solutions. Where gravity sewer was appropriate, the plan identifies preliminary locations for pump stations at area low spots, and provides for force mains to transmit proposed flow to the existing sewer system. The connection points are assumed to be at the nearest existing sewer system point possible.

### 5.3.1 *Lakeside Drive Area*

This subarea includes properties on Lakeside Drive, Lakewood Lane, Paddock Road, Bridle Road, Horseshoe Lane, and Saddle Drive. This subarea is fairly extensive with varied topography, lying on the east side of Lake Nippenicket. Therefore, sewering the area would require the use of gravity sewers, low pressure sewers with individual grinder pumps, force main, and a pump station. This area consists primarily of residential properties, and includes 72 developed parcels and 9 vacant parcels.

The varied topography divides this area into two sections, lower-lying parcels that can be serviced by gravity sewer, and the more variable grade upland parcels that can be served with low pressure sewer. The proposed low pressure area begins at the northern most part of Lakeside Drive, extending halfway between Lakewood Lane and Saddle Drive. The low pressure sewer would be connected to proposed gravity sewer, which then would flow to a pump station located near the intersection of Lakeside Drive and Saddle Drive. The pump station would be connected via a new force main to the existing sewer force main on Pleasant Street, at the intersection of Pleasant and Lakeside. The lower section of this needs area will be serviced by gravity sewer that connects directly to the proposed pump station. Figure 5-2: Proposed Sewer Connection Layout for Lakeside Drive Area and Goodwater Way Area (attached) depicts the proposed sewer connection layout and the Table 5-1: Lakeside Drive Area Sewer Connection Summary, below, presents a summary of the approximate sewer system construction components needed to serve this area, along with a planning level construction cost.

**Table 5-1**
**Lakeside Drive Area Sewer Connection Summary**

| Component | Approx. Qty | Unit Cost | Approx. Component Cost | Properties Served |
|---|---|---|---|---|
| Gravity Sewer | 5500 lf | $230 | $1,265,000 | 59 |
| Low Pressure Sewer | 2100 lf | $150 | $315,000 | 22 |
| Force Main | 2200 lf | $100 | $220,000 | N/A |
| Pump Station | 1 | $500,000 | $500,000 | N/A |
| | | **Total** | **$2,300,000** | **81** |

The sewer construction cost per lot served, based on the proposed layout, would be approximately $28,400 per property for this area. Replacement of existing septic systems in this area is likely to be moderately difficult for many properties based on soil conditions and variable topography.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems and would provide a higher degree of environmental protection to Lake Nippenickett.

### 5.3.2 *Goodwater Way/ Pleasant Street Area*

This subarea is nearly adjacent to the Lakeside Drive Area and includes properties on Goodwater Way, Lakeview Park Lane, and Sunset Lane. This area consists primarily of residential properties, and includes 21 developed parcels and 7 vacant parcels. The proposed layout consists entirely of low pressure sewer, connecting to the existing Lakeside Pump Station on Lakeshore Center Street. Figure 5-2: Proposed Sewer Connection Layout for Lakeside Drive Area and Goodwater Way Area (attached) also depicts the proposed sewer connection layout for this area. Table 5-2: Goodwater Way/ Pleasant Street Area Sewer Connection Summary, below, presents a summary of the approximate sewer system construction components needed to serve this area, along with a planning level construction cost.

**Table 5-2**
**Goodwater Way/ Pleasant Street Area Sewer Connection Summary**

| Component | Approx. Qty | Approx. Unit Cost | Approx. Component Cost | Properties Served |
|---|---|---|---|---|
| Gravity Sewer | 0 | $230 | 0 | N/A |
| Low Pressure Sewer | 1375 lf | $150 | $206,250 | 28 |
| Force Main | 0 | $100 | 0 | N/A |
| Pump Station | 0 | $500,000 | 0 | N/A |
| | | **Total** | **$206,250** | **28** |

The cost per lot served, based on the proposed layout, would be approximately $7,400 per property. Replacement of existing septic systems in this area is likely to be moderately difficult for many properties based on small lots, soil conditions and variable topography.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems and would provide a higher degree of environmental protection to Lake Nippenickett.

### *5.3.3 Dundee Drive/ Aberdeen Lane Area*

This subarea includes properties on Dundee Drive, Aberdeen Lane, Glenmore Ln, Vernon Street, Robin Road, and Red Wing Drive. This subarea has varied topography and, therefore, requires the use of gravity sewers, low pressure sewers with individual grinder pumps, force main, and a pump station. This area consists primarily of residential properties, and includes 57 developed parcels and 7 vacant parcels.

The proposed layout consists of low pressure sewer on the circle of Dundee Drive and the portion of Red Wing Drive depicted in the needs area. The remaining streets are proposed to be serviced by gravity sewer connecting to a pump station on a parcel at the southernmost part of Vernon Street within the needs area. Figure 5-3: Proposed Sewer Connection Layout for Dundee Drive/Aberdeen Lane Area (attached) depicts the proposed sewer connection layout and Table 5-3: Dundee Drive/Aberdeen Lane Area Sewer Connection Summary, below, presents a summary of the sewer system construction components needed to serve this area, along with a planning level construction cost.

| Table 5-3<br>Dundee Drive/ Aberdeen Lane Area Sewer Connection Summary | | | | |
|---|---|---|---|---|
| **Component** | **Approx. Qty** | **Approx. Unit Cost** | **Approx. Component Cost** | **Properties Served** |
| Gravity Sewer | 4400 lf | $230 | $1,012,000 | 39 |
| Low Pressure Sewer | 1800 lf | $150 | $270,000 | 25 |
| Force Main | 5600 lf | $100 | $560,000 | N/A |
| Pump Station | 1 | $500,000 | $500,000 | N/A |
| | | **Total** | **$2,342,000** | **64** |

The cost per lot served, based on the proposed layout, would be approximately $36,600 per property. Replacement of existing septic systems in this area is likely to be moderate to severely difficult for many properties based on soil conditions and high groundwater conditions.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems and would provide a higher degree of environmental protection to adjacent wetland areas.

### 5.3.4 *Norlen Park Area*

This subarea includes properties on Norlen Park, Vernon Street, Pleasant Street, Hunters Drive, and Route 104. This area consists primarily of residential properties, and includes 57 developed parcels and 6 vacant parcels. The proposed layout consists entirely of low pressure sewer, connecting to the existing force main from the Pleasant Street Pump Station. Figure 5-4: Proposed Sewer Connection Layout for Norlen Park Area (attached) depicts the proposed sewer connection layout and Table 5-4: Norlen Park Area Sewer Connection Summary, below, presents a summary of the sewer system construction components needed to serve this area, along with a planning level construction cost.

| Table 5-4<br>Norlen Park Area Sewer Connection Summary | | | | |
|---|---|---|---|---|
| **Component** | **Approx. Qty** | **Approx. Unit Cost** | **Approx. Component Cost** | **Properties Served** |
| Gravity Sewer | 0 lf | $230 | $0 | 0 |
| Low Pressure Sewer | 5688 lf | $150 | $853,200 | 63 |
| Force Main | 0 lf | $100 | $0 | N/A |
| Pump Station | 0 | $500,000 | $0 | N/A |
| | | **Total** | **$853,200** | **63** |

The cost per lot served, based on the proposed layout, would be approximately $13,600 per property. Replacement of existing septic systems in this area is likely to be moderately difficult for many properties based on soil conditions.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems and would provide a higher degree of environmental protection to adjacent wetland areas.

### *5.3.5 Bayberry Circle/Ashtead Road Area*

This subarea includes properties on Bayberry Circle, Ashtead Road, Bayberry Circle, Forest Street, and Cross Street. This area consists primarily of residential properties, and includes 87 developed parcels and 22 vacant parcels. The proposed layout consists entirely of gravity sewer, connecting a proposed pump station on Cross Street. The pump station is connected by force main to an existing sewer at the intersection of Stephanie and South Street. Figure 5-5: Proposed Sewer Connection Layout for Bayberry Circle/Ashtead Road Area (attached) depicts the proposed sewer connection layout and Table 5-4: Bayberry Circle/Ashtead Road Area Sewer Connection Summary, below, presents a summary of the sewer system construction components needed to serve this area, along with a planning level construction cost.

**Table 5-5**
**Bayberry Circle/Ashtead Road Area Sewer Connection Summary**

| Component | Approx. Qty | Approx. Unit Cost | Approx. Component Cost | Properties Served |
|---|---|---|---|---|
| Gravity Sewer | 10,600 lf | $230 | $2,438,000 | 109 |
| Low Pressure Sewer | 0 lf | $150 | $0 | N/A |
| Force Main | 10,200 lf | $100 | $120,000 | N/A |
| Pump Station | 1 | $500,000 | $500,000 | N/A |
| | | Total | $3,058,000 | 109 |

The cost per lot served, based on the proposed layout, would be approximately $28,100 per property. Replacement of existing septic systems in this area is likely to be moderate to severely difficult for many properties based on soil conditions.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems.

### *5.3.6 Atkinson Drive Area*

This subarea includes properties on Atkinson Drive, Fiske Drive, Sunrise Drive, Bridgewater Avenue, and South Street. This area consists primarily of residential properties, and includes 79 developed parcels and 17 vacant parcels. This subarea is varied topography and, therefore, requires the use of gravity sewers, low pressure sewers with individual grinder pumps, force mains, and pump stations.

Fiske Drive and Atkinson Drive are proposed to be primarily gravity sewer with the exception of a small portion of Atkinson Drive that extends from house #97 to house #101. Sunrise Drive, Bridgewater Avenue and South Street (within the project area) are entirely serviced by low pressure sewer. The low pressure sewer connects to the gravity line at the intersection of South Street and Fiske Drive. The gravity flow then feeds into a proposed pump station on the cul de sac on Atkinson

Drive. The proposed pump station then pumps through force main to the existing sewer at the intersection of Stephanie and South Street. Figure 5-6: Proposed Sewer Connection Layout for Atkinson Road Area (attached) depicts the proposed sewer connection layout and Table 5-6: Atkinson Drive Area Sewer Connection Summary, below, presents a summary of the sewer system construction components needed to serve this area, along with a planning level construction cost.

Table 5-6
Atkinson Drive Area Sewer Connection Summary

| Component | Approx. Qty | Approx. Unit Cost | Approx. Component Cost | Properties Sewer |
|---|---|---|---|---|
| Gravity Sewer | 3700 lf | $230 | $851,000 | 55 |
| Low Pressure Sewer | 4000 lf | $150 | $600,000 | 41 |
| Force Main | 14,000 lf | $100 | $1,400,000 | N/A |
| Pump Station | 1 | $500,000 | $500,000 | N/A |
| | | Total | $3,351,000 | 96 |

The cost per lot served, based on the proposed layout, would be approximately $34,900 per property. Replacement of existing septic systems in this area is likely to be moderate to severely difficult for many properties based on soil conditions and portions with high groundwater.

Based on this area's distance from the existing sewer system, previous planning efforts have evaluated siting a small wastewater treatment plant in this area to treat wastewater from this neighborhood locally. This alternative has been met with opposition from area residents regarding the use of low pressure sewers and the siting of a possible wastewater treatment plant. Though the acceptance of using low pressure sewer may be more prevalent now, wastewater treatment plant is likely to remain an issue for area residents.

Considering the possible cost of septic system replacements and the likely resistance of residents to site a wastewater treatment plant, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems.

### *5.3.7 Whitman Street Area*

This subarea includes properties on Whitman Street, Tuskoosa Circle, and Darlene Drive. This area consists primarily of residential properties, and includes 38 developed parcels and 3 vacant parcels. This subarea is varied topography and, therefore, requires the use of gravity sewers, low pressure sewers with individual grinder pumps, force mains, and a pump station.

Whitman Street is proposed to be entirely serviced by gravity sewer. Tukoosa Circle and Darlene Drive are both connected by low pressure sewer to the gravity sewer on Whitman Street. The gravity sewer would flow to a proposed pump station in front of house #220 Whitman Street and new force main would be connected on Plymouth Street to the existing sewer at the intersection of Hayward Street. Figure 5-7: Proposed Sewer Connection Layout for Whitman Street Area (attached) depicts the proposed sewer connection layout and Table 5-7: Whitman Street Area Sewer Connection Summary, below, presents a summary of the sewer system construction components needed to serve this area, along with a planning level construction cost.

| Table 5-7<br>Whitman Street Area Sewer Connection Summary | | | | |
|---|---|---|---|---|
| Component | Approx. Qty | Approx. Unit Cost | Approx. Component Cost | Properties Served |
| Gravity | 3000 lf | $230 | $690,000 | 22 |
| Low Pressure | 1100 lf | $150 | $165,000 | 19 |
| Force Main | 1000 lf | $100 | $100,000 | N/A |
| Pump Station | 1 | $500,000 | $500,000 | N/A |
| | | Total | $1,455,000 | 41 |

The cost per lot served, based on the proposed layout, would be approximately $35,500 per property.
Replacement of existing septic systems in this area is likely to be moderate to severely difficult for many properties based on soil conditions and portions with high groundwater.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems.

### *5.3.8 Hayward Street Area*

This subarea includes properties on Hayward Street, Yoke Road, and Arrowhead Drive. This area consists primarily of residential properties, and includes 48 developed parcels and 1 vacant parcel. This subarea is varied topography and, therefore, requires the use of gravity sewers, low pressure sewers with individual grinder pumps, force mains, and a pump station.

Hayward Street is proposed to be entirely serviced by gravity sewer. Arrowhead Drive and Yoke Drive are both connected by low pressure sewer to the gravity sewer on Hayward Street. The gravity sewer flows to a proposed pump station in front of house #245 Hayward Street and is connected by force main on Plymouth Street to the existing sewer at the intersection of Hayward Street. Figure 5-8: Proposed Sewer Connection Layout for Hayward Street Area (attached) depicts the proposed sewer connection layout and Table 5-8: Hayward Street Area Sewer Connection Summary, below, presents a summary of the sewer system construction components needed to serve this area, along with a planning level construction cost.

| Table 5-8<br>Hayward Street Area Sewer Connection Summary | | | | |
|---|---|---|---|---|
| Component | Approx. Qty | Approx. Unit Cost | Approx. Component Cost | Properties Served |
| Gravity | 2100 lf | $230 | $483,000 | 25 |
| Low Pressure | 2000 lf | $150 | $300,000 | 24 |
| Force Main | 0 lf | $100 | $0 | N/A |
| Pump Station | 1 | $500,000 | $0 | N/A |
| | | | $783,000 | 49 |

The cost per lot served, based on the proposed layout, would be approximately $16,000 per property. Replacement of existing septic systems in this area is likely to be moderate to severely difficult for many properties based on some small lot sizes, soil conditions and portions with high groundwater.

Considering the possible cost of septic system replacements, this unit cost suggests that sewering could be cost effective in comparison to keeping the area served by septic systems and would provide a higher degree of environmental protection to Town River.

## 5.4 Wastewater Treatment Disposal Alternatives

Wastewater generated in the Town of Bridgewater is treated by various means and may be treated and disposed of by one of the following methods:

- Treatment and disposal to surface water
- Treatment and disposal to groundwater
- Treatment and disposal to regional facility (out of town)
- Treatment and beneficial reuse

Each of these treatment and disposal options have applicability and logistic limitations, which are presented briefly in this section.

### *5.4.1 Treatment and Disposal to Surface Water*

The existing Bridgewater WWTF treats wastewater and disposes of treated effluent to the Town River, a tributary of the Taunton River. The facility has a permit to discharge treated effluent under the National Pollutant Discharge Elimination System (NPDES) program administered by the U.S. EPA under Section 402 of the Clean Water Act. Discharges to surface waters are also regulated by Massachusetts DEP under the Surface Water Discharge Permit Program (314 CMR 3.00) and the Massachusetts Clean Water Act (MGL c. 21, s. 26-53). EPA is the lead agency in NPDES permitting using compliance with water quality standards set under the DEP state Surface Water Discharge Permit Program (314 CMR 3.00). The DEP cosigns the issued permit, and if it is determined that water quality standards will be met, a Section 401 Water Quality Certificate is issued.

The Surface Water Discharge and NPDES Permit Programs have been established to limit or prohibit discharges of pollutants to surface waters to assure that surface water quality standards of receiving waters are protected, maintained or attained. The anti-degradation provision of the Surface Water Quality Standards (314 CMR 4.04) requires that in all cases existing uses shall be maintained and protected.

As discussed in Section 2 of this report, the Bridgewater WWTF is in the process of getting a new NPDES permit, and the discharge criteria represent a concern to the town because of the extreme level of treatment needed to meet the proposed permit conditions. The Bridgewater WWTF currently has capacity remaining under its average daily flow permit limit of 1.44 mgd, but this capacity is limited.

Increases to the existing permitted discharge limit or permitting for a new point discharge to a surface water would be difficult. Permit limits for surface water discharges are becoming more stringent with each round of permitting. Also, because there is recognition of the finite water supply available, DEP encourages the focus on water balance within municipalities and more importantly within watershed basins. The majority of the town's water supply is derived from groundwater wells and therefore, replenishing the groundwater supply with treated effluent may be appropriate for new (or increases to existing) discharge permits. Despite these conditions, the town should continue to discuss options for limited increase in discharge capacity with EPA and DEP.

The State of Massachusetts also owns and operates a WWTF with a surface water discharge permit – this facility serves the Massachusetts Correctional Institute (MCI Bridgewater) located off of Conant Street. The MCI Bridgewater WWTF has a permit capacity of 0.55 mgd (average daily flow), and discharges to the Sawmill Brook, a small tributary to the Taunton River. The facility currently treats average flows ranging from 300,000 gpd to 450,000 gpd.

In general, treatment and disposal surface water is an appropriate alternative for flows that can be transmitted to and treated at the Bridgewater WWTF within the facility's remaining capacity. This solution is appropriate for defined needs areas, and to support wastewater needs for planned growth.

### *5.4.2 Treatment and Disposal to Groundwater*

Groundwater disposal of treated wastewater is the most commonly applied solution in rural areas, where individual 'septic' systems treat waste before discharging to the ground via infiltration systems. These discharge are covered under the Massachusetts Title 5 program for individual systems. This fully decentralized wastewater treatment and disposal method has proven effective for much of the Town of Bridgewater, and continues to be a preferred wastewater management method for individual parcels, where options are not required based on defined needs.

Groundwater disposal is becoming more common in Massachusetts for collected wastewater from communities and significant developments. The groundwater disposal option involves the discharge of highly treated effluent from a wastewater treatment facility into an infiltration bed or subsurface distribution system, designed to handle the design year flows. For purposes of this discussion, the location of the discharge may be considered independent of the location of the treatment facility since the treated effluent could be transmitted by pressure main to the infiltration system.

The requirements for groundwater discharge of wastewater are outlined in the state laws pertaining to the Groundwater Discharge Permit Program (314 CMR 5.00 and 6.00) – this program generally covers discharges of 10,000 gpd or more to the ground. The principal constituents of concern for groundwater discharges are pathogens and nitrogen. Traditionally, the need to remove nitrogen has been a disadvantage for groundwater discharge options, but recent changes requiring low levels of effluent nitrogen in surface discharges make groundwater disposal a more reasonable alternative.

Potential sites for use as a groundwater disposal site must be comprised of sandy or gravely soils that exhibit moderate infiltration rates. Sites, which contain poor soil permeability, high groundwater levels, and ledge inhibit the downward flow of water and are generally unacceptable. Soil properties can be improved by excavation and amending the soils in the discharge area or mounding the infiltration beds. Soils with slight or moderate limitations for wastewater disposal are considered acceptable for effluent beds. The groundwater discharge option is also restricted by discharge standards, which prohibit anti-degradation of the groundwater and therefore require a strict level of treatment prior to discharge.

In general, groundwater discharge may be an option for Bridgewater if additional capacity is needed at the WWTF and an increase in the NPDES surface water discharge permit cannot be obtained. This option also remains viable for individual properties and smaller developments in town.

#### 5.4.3 Regional Treatment and Disposal

Several communities in the Bridgewater area have their own wastewater systems – the largest in the region are the Brockton and Taunton systems, neither of which are direct abutters to Bridgewater. The Town of Raynham is a member community in the Taunton wastewater system, and a small number of properties in Bridgewater are connected to this system along the Raynham border. In addition, the Town of Middleborough has its own wastewater collection and treatment system, but the Middleboro system is remote from areas of development in Bridgewater.

Regional disposal options are limited in town, as there are no other large systems with infrastructure near the town's needs areas. In general, this option should be reserved for small properties located along the Raynham border, where other options are not feasible.

#### 5.4.4 Treatment and Disposal via Beneficial Reuse

Historically, treated effluent is discharged either to a surface water body or to the ground with percolation through the soil to the groundwater. Another option is to reuse the wastewater for non-potable needs. The State of Massachusetts and some communities have adopted policies on wastewater reuse in an effort to conserve valuable water resources and provide a means for the disposal of treated effluent. One common approach to beneficial reuse is to recharge aquifers through groundwater discharge – this practice is considered indirect reuse.

Direct reuse of highly treated effluent is also permissible in certain areas, and is seeing more common application. Typical methods of reuse include outside watering applications in landscaping and agriculture and inside recycling for use as toilet water. Commercial and industrial facilities in Massachusetts have demonstrated the effectiveness of these systems.
A properly developed wastewater reclamation program can provide valuable benefits to both the municipality and the water/wastewater system users. With proper treatment, reclaimed wastewater demonstrates minimal health risks, while providing the community with a solution to their wastewater disposal problem.

Unfortunately in New England, systems that rely primarily on landscape watering for effluent reuse must often be supplemented with a permanent disposal option (such as surface or groundwater disposal) for use in winter months.

Effluent reuse options tend to present themselves with larger facilities which are industrial and institutional in nature. In these cases, controls on the water quality and use can be better implemented. Based on the more stringent effluent quality currently being required in the Bridgewater WWTF discharge permit, the town should keep the option of possible effluent reuse open for future discussion.

### 5.5 Wastewater Treatment Facility Alternatives

The discussion of alternatives to address the defined needs at the Bridgewater WWTF is separated into two primary parts – the overall process alternatives, focused on meeting the future permit conditions, and some individual process area discussions, needed to address specific issues with facilities or unit operations. The magnitude of the overall process considerations take precedence over the options for individual areas and systems, and as such overall process alternatives are presented first in this discussion.

#### 5.5.1 WWTF Process Alternatives Screening

The evaluation of the Bridgewater WWTF has identified needs in a number of areas that must be addressed. The major considerations for the WWTF relate to:

1. Condition, modernization and efficiency,
2. Treatment capacity (flows and loads), and
3. Ability to meet future permit limits.

As discussed in the needs development section of this report, major and minor changes to the permit are expected. By far, the most significant change is the stricter effluent nutrient limits. The new draft NPDES permit conditions proposed by EPA include a lower limit on effluent total phosphorus (P) of 0.2 mg/l, as compared to the current seasonal phosphorus limit 1.0 mg/l. The new draft permit also includes a new limit on effluent total nitrogen (TN) of 60 pounds per day, which is based on a concentration of 5.0 mg/l of total nitrogen. This compares to the current permit, which provides no total nitrogen limit, but includes a seasonal ammonia limit of 3.0 mg/l. As currently designed, the facility is not capable of meeting these new lower effluent nutrient limits. The existing WWTF process currently typically achieves effluent TN levels between 25 and 30 mg/l, but only has the ability to nitrify and therefore effluent inorganic nitrogen levels are not controllable. The facility currently meets the seasonal (summer) phosphorus limit consistently by feeding ferric chloride (FeCl). Significant capital improvements will be required to allow the facility to meet the new nutrient limits as proposed by EPA.

There are a number of different processes available that can, when properly applied, provide increased nitrogen and or phosphorus removal at the Bridgewater WWTP. These include both physical/chemical and biological treatment methods each having their own advantages and disadvantages depending on various site constraints such as available space, compatibility with existing processes and ability to meet the specified permit limits. This section provides a brief description of the available processes, preliminary thoughts on their possible implementation approach, and a qualitative discussion of both general and site specific advantages and disadvantages.

*5.5.1.1 Phosphorus Removal Technologies*

Phosphorus removal technologies generally fall into two basic process categories physical chemical and suspended growth biological phosphorus removal. There are several variations of physical chemical removal, while enhanced biological phosphorus removal is generally limited to the anaerobic selector process. These processes are not mutually exclusive and the various options are discussed further below.

*Chemically Enhanced Primary Treatment (CEPT) Process*

CEPT is a somewhat generic term that refers to the use of one or more chemical additions to the wastewater stream prior to the primary clarifiers. The chemicals can serve several functions depending on the overall treatment goals. In the case of Bridgewater, this includes enhancing solids capture and precipitation of soluble phosphorus providing removal of both particulate as well as soluble phosphorus in the raw waste stream.

The two most commonly used chemicals for precipitation of soluble orthophosphate are iron salts (typically ferric chloride) and aluminum sulfate (Alum). These chemicals combine with soluble orthophosphate in the wastewater to create the insoluble metal-orthophosphate precipitate. They also, however, form other precipitates most notably the associated metal-hydroxide. The formation of this ancillary precipitate increases the dose of the chemical required beyond that for orthophosphate precipitation alone, which in turn increases the amount of primary sludge produced. Chemical sludge production, increases in total sludge, typically ranges from 10% to as much as 30% of that without chemical addition. These chemicals also act to improve the coagulation, flocculation and removal of particulates in the wastewater in the primary clarifiers. This can significantly reduce the load not only of phosphorus but also solids, Biochemical Oxygen Demand (BOD) and particulate organic nitrogen on the downstream treatment process. The formation of the precipitates and enhanced capture of exiting particulates in the waste stream can significantly increase total primary sludge production and reduce total secondary sludge production. The resulting shift in sludge blend ratio and the nature of the chemicals themselves will have an effect on solids handling process including thickening, dewatering and composting. An increase in primary sludge fraction often improves dewaterability (as does ferric addition). Alum sludge, on the other hand, has a tendency to be less amenable to dewatering.

The incorporation of a small amount of polymer together with a metal salt can further improve solids capture providing as much as 60% BOD and 80% TSS removal with phosphorus removal potential in a similar range. In fact, in some instances phosphorus removal can be so effective as to result in a nutrient limitation in the downstream biological process, although this is not common and fairly easy to control. Typically CEPT is designed to provide a bulk reduction of phosphorus with polishing to effluent levels provided later in the process stream. Regardless, chemical precipitation alone may not reliably achieve the required effluent phosphorus limits proposed.

Capital improvements necessary to implement CEPT are generally rather modest requiring a fairly simple chemical storage and feed system with containment. Small chemical metering pumps would feed the chemical from liquid chemical storage tanks into a carrier water stream that is then injected into the wastewater flow upstream of the primary clarifiers. Alum can be obtained as an anhydrous powder that must then be mixed with water to provide the feed solution. The specific addition point is not too critical but should provide flash mixing followed by some flocculation/coagulation time to maximize effectiveness. Plant influent pumps or primary influent channels/piping can provide adequate mixing with flocculation and coagulation time provided in the primary clarifier influent stilling well. Polymer (when used) is typically injected in a dilute solution immediately prior the flocculation point. In the case of Bridgewater, with the current gravity influent flow to the primary clarifiers, chemical could be added to the influent manhole to provide mixing, with polymer (if needed) injected further downstream and coagulation/flocculation in the primary clarifiers. If influent flow pumping is moved ahead of the primary clarifiers (as is being considered), then these additions of chemicals could be done at the forward flow pump station.

*Enhanced Biological Phosphorus Removal (BioP) Process*

Enhanced Biological Phosphorus Removal is a suspended growth activated sludge process that incorporates an anaerobic selector zone ahead of the conventional aerobic activated sludge zone. The incorporation of this selector zone creates an alternating anaerobic-aerobic environment for the recycled activated sludge organisms that promotes the uptake and storage of phosphorus by the organisms in excess of that required for normal cell growth, referred to as "luxury uptake". This biologically stored phosphorus is removed via the waste activated sludge. The viability and effectiveness of the process is dependent on (among other things) the amount of readily available soluble organic matter in the influent waste stream.

The BioP process is only applicable to suspended growth systems because fixed film systems cannot provide the anaerobic/anoxic cycles and sludge wasting in such a manner as to allow for wasting of phosphorus rich organisms. There are facilities that operate in a hybrid fixed-film/activated sludge configuration that can provide the requisite conditions for the suspended growth organisms to support BioP removal, but these processes are not common.

Because this process does not rely on chemical additional and precipitate formation, it does not significantly increase sludge production the way the CEPT or other chemical treatment options do.

However, as a suspended growth process it typically will produce more sludge than the existing RBC process. Furthermore, even under the best of conditions the BioP process alone cannot be expected to reliably produce an effluent total phosphorus level significantly less than 1 mg/l. Therefore, a post biological treatment chemical addition polishing step would also be required to achieve the proposed effluent total P limit. As previously noted, chemical precipitation of phosphorus does increase sludge production, although when used as a polishing step for the BioP process the chemical requirements and sludge production are considerably less than that for a CEPT process.

Capital improvements necessary at Bridgewater to employ the BioP process would include at a minimum (if the RBC process were to be employed) the implementation of a hybrid fixed film/suspended growth activated sludge process. It is likely that it would also require additional secondary clarification capacity to capture the new suspended growth biomass as well as a return activated sludge pumping system to recycle the biomass to the treatment tanks. It is also likely that it would require additional process tankage to establish the anaerobic selector. Alternately, it is more probable that if BioP is to be employed, the secondary treatment RBC process would be replaced in its entirety with a suspended growth BioP process. In either case, a chemical addition polishing step would be required to achieve the proposed effluent limits. Regardless of the approach, employing a BioP process at Bridgewater would require major capital improvements to the existing facility.

*Chemical Precipitation with Increased Dosage, using Current Secondary Treatment Process*

The basic concept of chemical precipitation was discussed previously under the CEPT process discussion, but can be employed in a variety of ways. In this approach chemical precipitation would be performed with addition of metal salts directly into the secondary treatment process influent. The RBCs would provide sufficient turbulence for good flocculation and coagulation of the precipitates, which would then be settled out in the secondary clarifiers. Initial chemical mixing could be provided by injection into the primary effluent lift pump suction lines.

Like any chemical precipitation approach this would increase the net sludge production and will alter the sludge characteristics and subsequent solids handling performance. This effect is likely to be less pronounced than that which would be expected in the CEPT process, as it would not impact primary sludge production or the overall primary sludge to secondary biological sludge ratio of the existing facility. The impact to solids handling would be limited to the increase in chemical sludge and the effects the chemicals themselves may have on the sludge thickening and dewatering characteristics.

In order to maximize phosphorus removal, excess chemical addition will be necessary due to the competing precipitation reaction with hydroxide previously mentioned. This will increase solids loads on the final clarifiers which may require additional clarification capacity.

This approach alone will likely not achieve the proposed effluent limits for total phosphorus without a post filtration step to maximize solids capture.

*Multi-Point Chemical Addition Approach (CEPT and Chemical Precipitation in Secondary Clarifiers)*

The multi-barrier chemical addition approach, as the name implies, relies on chemical precipitation with metal salts at several locations within the overall treatment system. As proposed here it would include both the CEPT process previously described and chemical addition in the secondary treatment process with settling in the secondary clarifiers. As such the impacts of these processes previously discussed are applicable here, including chemical consumption, increased sludge production, changes in sludge handling characteristics, etc. However, with the CEPT process providing bulk reduction of phosphorus, as well as reducing BOD and TSS loads to the secondary system, the net chemical addition to the secondary system would be reduced over the option of chemical to the secondary system alone. This reduction may be sufficient to eliminate the need for additional secondary clarifier capacity. Regardless, as with these processes applied independently they may not reliably achieve the proposed effluent limits without some solids polishing step such as filtration. Other capital improvements however are limited to the addition of a chemical storage and feed systems. As such, in relation to other options this alternative has a lower capital cost.

*Chemical Precipitation with Added Ballasted Flocculation Process (e.g. CoMag or ActiFlo)*
Chemical precipitation with Ballasted Flocculation is an enhancement of the chemical precipitation process which improves the level of phosphorus removal by incorporating a polymer or other coagulant aid in conjunction with a ballast material to improve the capture and settling of particulates (including the phosphorus precipitates). The ballast serves two functions, it creates surfaces on which small less dense solids present in the wastewater can coagulate, and with its high density increases the net density of the coagulated particles (in effect like an anchor), speeding the settling and separation process. The ballast and captured solids are then collected and sent through a separate process (different for each proprietary process) where the ballast is separated from the waste solids.

There are several ballasted flocculation specific processes, all of which are proprietary. The difference between them is largely being the ballast material and method of ballast separation/recovery. These processes can achieve a high level of phosphorus removal with the right chemical doses and polymer. The improved settling reduces the settling area required. In the case of CoMag, the ballast is magnetite- a fine granular magnetic material that is separated in a side stream process that employs electromagnets to extract the ballast. The CoMag process typically applies a separate (tertiary) clarifier process. A modification of this process- the BioMag process- is combined into a secondary biological treatment. This allows it to be used in conjunction with existing process units like final clarifiers. The Actiflo process employs sand as the ballast, which is separated by specially designed cyclone separation equipment much like a grit separation cyclone. The ActiFlo process requires separate process tankage for proper flocculation, and settling.

These processes require significant energy to operate due largely to the separation equipment and methods. Their footprint is small however, in comparison to conventional gravity settling tanks. In addition, the CoMag process with chemical addition for phosphorus removal has demonstrated the ability to achieve the proposed effluent phosphorus levels- although chemical requirements are quite high to achieve it. As for the other process impacts, they are essentially the same as that for any of the previously mentioned metal precipitation process discussed.

These processes would include new ballast separation equipment and facilities, and possibly new proprietary process tankage. As with any chemical feed scenario they would also require chemical storage and feed facilities.

*Chemical Precipitation with Added Effluent Filtration (Cloth, Granular or other Filter Media) Process*
This alternative employs chemical addition with metal salts followed by effluent filtration to provide higher levels of phosphorus removal than chemical addition alone. Several forms of effluent filters are available including cloth, single and multimedia granular bed media in varying physical configurations. All require periodic backwashing to remove the buildup of particulate on the media. The backwash is typically returned to the raw influent for reprocessing. Filtration systems by nature have significant head loss through them and often require either additional influent or effluent pumping as a result. In addition, the backwash also requires pumping and a stored source of

filtered water. Most systems therefore incorporate a backwash clear well which stores filtered water for the backwash cycles. In addition, to provide some backwash flow equalization some systems also provide a backwash mudwell.

Filtration following chemical addition for phosphorus precipitation and removal is capable of achieving the proposed effluent total phosphorus limits, and is typically used as a polishing step in concert with either a multipoint chemical feed approach or a treatment scheme incorporating the BioP process to achieve these levels and not overload the effluent filters. As a polishing, step the phosphorus load, and therefore chemical requirements, are typically lower than when chemical is employed earlier in the process train. Therefore the additional sludge produced is generally not significant in the overall process scheme.

In Bridgewater, influent pumping to the filter would likely be required with effluent discharged by gravity. Incorporating filtration into the Bridgewater facility under any scenario as a new process would require effectively the same level of capital improvements regardless of any other improvements with which it may be paired.

#### *5.5.1.2 Nitrogen Removal Processes*

Nitrogen removal in municipal waste applications is typically achieved by biological processes. There are a number of different specific process configurations employed depending on the nitrogen removal requirements, but all rely on two basic biological processes, nitrification and denitrification. Nitrification is the conversion of ammonia nitrogen to nitrite and then nitrate by a select group of bacteria that require oxygen (aerobic conditions) to do so. Alternately, denitrification is the conversion of nitrate and or nitrite to nitrogen gas by a number of different bacteria and requires the absence of oxygen (or anoxic conditions). Nitrification must be achieved first before denitrification can take place. In nitrification, ammonia is effectively the "food" source for the bacteria with the dissolved oxygen necessary provided by mechanical means. In denitrification, the oxygen in the nitrate resulting from nitrification serves as the oxygen source which the bacteria use for consumption of other organic matter (food) in the wastewater. This basic process description is an oversimplification but sufficient for purposes of the subsequent process discussions. The source of food for denitrification can be the organics in the wastewater itself and/or chemical feed (such as methanol, acetic acid and others).

Denitrification can be achieved in anoxic zones virtually anywhere within the secondary process flow scheme - and there are a host of different biological nitrogen removal process configurations in use, depending on the treatment level required. However, to achieve the level of nitrogen removal required by the proposed permit a final post denitrification step will be necessary following the aerobic nitrification process. It may or may not require an external chemical feed for "food", but providing for a readily degradable external source will speed the post denitrification biological process and reduce the treatment volume required (all else being equal).

In the following discussion of alternatives, the first several alternatives for nitrogen treatment focus on keeping the presently employed RBC process in use, while the latter options discussed include complete replacement of the biological process systems.

*Modify Secondary RBC Process to Add Anoxic Stage (Submerged RBC) for Denitrification*

This process alternative includes submerged RBCs to provide the anoxic conditions necessary for denitrification, with nitrification being provided by some or all of the existing RBCs. Submerged RBCs have the ability to achieve the nitrogen removal levels required but while technically feasible are not in widespread use for several reasons. Notably they require a sealed submerged bearing which complicates maintenance. In addition, other more efficient processes are available. Being a fixed film biological process the sludge production and character are essentially the same as the existing RBC process.

Implementation of submerged RBCs at Bridgewater would require either modification of existing excess RBC tankage or installation of new units. Using existing tankage presents several problems. First the existing tanks would need to be deeper, either by raising the sidewalls or increasing the depth by excavation. Raising the sidewalls (if feasible) is probably simpler than excavating and making them deeper. On the other hand, raising the side walls would require an intermediate lift station to get the flow into the raised units. An option to raise the primary clarifiers is the most likely solution for achieving this hydraulic profile change. Regardless of the implementation approach, the use of submerged RBCs does not in our opinion represent an option with benefits sufficiently significant to be worth pursuing.

*Modify Secondary RBC Process to Add Anoxic Zone (MBBR Media Anoxic Reactor) for Denitrification*

This alternative takes advantage of the existing RBC's capacity for nitrification and adds a separate anoxic zone for denitrification utilizing the Moving Bed Bio-Reactor (MBBR) process. This could be achieved with either a single post-denitrification zone or with both a pre- and post-denitrification zone. The MBBR process (like the RBCs) is a fixed film process- the difference is rather than employing a fixed mounted sheet media like that on the RBC shaft, the MBBR employs a loose "floating" media that is essentially suspended in the wastewater filled tank. There are many different media configurations but in all cases the basic purpose is the same, the media provide surface area on which the bacteria grow. The media and ancillary system components to protect it and retain it in the tank are typically proprietary, with each manufacturer having their own specific designs and equipment.

The basic advantages of this type of system are similar to that of other fixed film processes- reduced sludge production, low solids loads on the final clarifiers, biomass retention and density (as well as greater protection from shock loads and upsets relative to conventional suspended growth systems). They also can suffer from some of the same disadvantages of fixed film, systems such as the tendency to produce pin flock and potential for media clogging. In addition, these floating media type fixed film systems also require some significant measures to retain and protect the media from rags and stringy material that can cause problems for them, such as requiring fine screens on the influent and effluent of the tanks.

Recognizing these requirements, MBBR technology can achieve the proposed effluent nitrogen levels provided the process scheme includes a post denitrification zone. Further, as a fixed film process, MBBR may not require additional secondary clarifiers at Bridgewater.

Implementation at Bridgewater would at a minimum require the installation of new post anoxic MBBR reactor tanks with mixers, carbon feed systems, and (depending on the hydraulics) may require a lift station. Additional secondary clarification may not be necessary. It may be more advantageous to provide both pre- and post- anoxic MBBR reactors with an internal recycle from the end of the RBC nitrification stage, to take advantage of influent carbon and reduce the volume of the post denite MBBR reactors.

*Modify Secondary RBC Process to Add Anoxic Zone (Liquid Phase) for Denitrification*

This alternative combines the existing fixed film RBC process for nitrification with a suspended growth "activated sludge" process for denitrification. Suspended growth activated sludge systems, as the name implies, rely on biomass suspended in the wastewater as opposed to being attached to some fixed surface as in RBCs or MBBRs. The suspended biomass is referred to as mixed liquor suspended solids, or MLSS. All such systems require separation and return of the biomass to the reactors to maintain the biomass population on the process. This is typically achieved with secondary clarifiers and a sludge pump station to return the settled biomass from the clarifiers to the reactors. Less common is the use of membrane separation. This scenario assumes conventional secondary clarification with return sludge pumping is employed. Membranes are discussed later under another alternative.

Like the MBBR process, this option could be employed in two ways at Bridgewater, as a post-anoxic zone only following the RBCs, or as both a pre- and post-anoxic zone to take advantage of the available carbon in the influent for denitrification. A pre-anoxic zone alone would not achieve the proposed effluent total nitrogen limits. In either case a suspended growth anoxic zone may require additional secondary clarifiers at the plant due to the increased solids load resulting from the suspended biomass. In addition, a new activated sludge recycle pump system will be required to maintain the biomass levels in the reactor. The post anoxic zone would be most efficient using an external carbon source requiring the installation of a chemical storage and feed system. All applicable suspended growth activated sludge systems will also result in a significant increase in waste solids production over fixed film type systems that will increase thickening and dewatering capacity needs.

*Modify Secondary RBC Process to Add New Effluent Denitrification Filter Process (Deep Bed Sand Filters)*

Deep Bed denitrification filters are fixed film biological filters that provide both biological denitrification as well as solids filtration (although denitrification is their primary objective). There are a number of different physical configurations, including the more conventional intermittent backwash down flow type, and the continuously backwashed upflow type. Denitrification filters are very similarly to conventional solids filtration filters with three significant differences. They use a generally coarser sand media with a very high uniformity coefficient. The larger size and uniformity provide for growth of biomass on the media surface while limiting the rate of clogging that would result in finer media filters. Because they are employed following biological treatment for removal of BOD and the short hydraulic retention time they provide, they require addition of readily degradable carbon to ensure full denitrification. Finally, to provide sufficient surface area to support the necessary biomass and sufficient retention time to allow complete denitrification the media, depth (as much as 10 feet) is significantly greater than the 3 to 4 feet typical in sand filters for solids removal alone.

Deep bed denitrification filters can provide complete denitrification and when preceded by a fully nitrifying treatment process can consistently meet the proposed effluent total nitrogen goal. They also provide a very high level of solids removal. Denitrification filters are typically employed following a system that provides partial denitrification by way of a pre-anoxic reactor. Otherwise, the high filter influent nitrogen levels can result in frequent backwashing and high backwash recycle rates due to the resulting increased biological growth produced within the media bed. Because of their deep bed configuration and high head loss, denitrification filters typically require filter influent pumping in addition to the backwash pumps, wetwell and mudwell required by solids filters.

Implementation of effluent denitrification filters at Bridgewater would require a filter influent lift station as well as backwash pumps, backwash clear well and mudwell. It is also likely that a pre-denitrification step would be required to limit the nitrate loads to the filters. Adding complexity to the

Bridgewater application is the need for effluent filtration to support meeting the low effluent phosphorus limits (as previously described). Using the deep-bed type denite filters for phosphorus removal as well presents a problem with conflicting filter design intent. Attempts to remove phosphorus precipitate flow on the denite filters typically create operational problems (e.g. the need for frequent backwash) and may compromise the plants ability to meet both effluent limits.

*Modify Secondary RBC Process to Add New Effluent Denitrification Filter Process (BlueWater Filter)*

The BlueWater® denitrification filter technology is a proprietary deep bed granular media filter that employs an "upflow" design-in which wastewater is introduced through piping to the lower portion of the media bed and flows up through the media, exiting at the top of the unit. It also employs a continuous backwash rather than an intermittent backwash approach. The "dirty" media is lifted from a hopper at the bottom of the unit by a combination of air and water through a central riser pipe during which the turbulence causes a scrubbing action that washes the media as it rises. At the top of the filter the cleaned media settles by gravity back on to the discharge side of the media bed, while the removed solids are carried over a special backwash weir by the backwash water and (typically) sent to the plant drain for return to the head of the plant for reprocessing.

The application of continuous backwash upflow denitrification filters at Bridgewater would eliminate the need for the wash water clear well and the backwash water equalization tank (or "mudwell") required by the conventional intermittent down flow filters eliminating the tankage and pumping associated with these elements. The tradeoff relative to the intermittent backwash units is that the total daily backwash flow is higher for the continuously backwashed units. Intermittent systems backwash volumes typically range from 3 to 5% of forward flow, while continuous backwash units backwash volume can be from 5% to 7% of the forward flow.

*Replace RBC Process with New Sequencing Batch Reactor (SBR) Secondary Process*

This alternative abandons the existing RBC process completely in favor of a suspended growth or "activated sludge" biological treatment approach using the Sequencing Batch Reactor (SRB) configuration. Like all suspended growth activated sludge systems (as the name implies) and SRB relies on biomass suspended in the wastewater as opposed to being attached to some fixed surface. What make the sequencing batch reactor process unique is that it processes wastewater in batches, rather than in a continuous flow through process. The sequencing batch process creates, over time for a single batch, the same basic processes that a conventional flow through system creates in the space of a series of tanks through which the waste continuously flows. With current technology, this is all controlled through a preprogrammed PLC that allows preset operating cycles, as well as any number of alternate and or manual operations. Typical SBR conventional cycles include fill/react, react, settle and decant phases. The react phases may provide anaerobic, anoxic and or aerobic periods in almost any sequence. This flexibility provides the ability to achieve both biological nitrogen and phosphorus removal within the same reactor.

The batch mode of operation provides some distinct advantages and disadvantages relative to the continuous flow through approach. As a batch process, the SBR process does not require separate tanks to create the required nitrification, denitrification reactions, or clarification. This can be a significant advantage as it not only eliminates the secondary clarifier tanks and sludge collection mechanisms, but also the need for return sludge pumping. Alternately, the system typically requires influent pumping and often employs effluent equalization to avoid oversizing downstream processes like disinfection as a result of high batch discharge rates necessary to decant the batch volume in a relatively short period. The SBR process with proper cycling can achieve the proposed effluent nitrogen limits. However, as with all biological phosphorus removal processes, it cannot achieve the proposed phosphorus limits without the help of chemical polishing and filtration.

Implementation of and SBR system at Bridgewater would require modifications to the current primary effluent lift station, demo of the existing RBCs and possibly demolition of the secondary clarifiers. It may be possible to use the existing secondary clarifiers as effluent equalization with the addition of pumping.

*Replace RBC Process with New Membrane Bioreactor (MBR) Secondary Process*
Membrane bioreactors are a variation of the conventional flow through suspended growth activated sludge process that employs membrane filters in lieu of conventional gravity clarifiers for solids separation. There are two basic membrane configurations: (1) the submerged type that has racks of membrane modules submerged directly in the activated sludge reactor tanks and draw effluent with the use of vacuum suction pumps (pulling a vacuum in the downstream side of the membranes), and (2) the external or closed vessel type where the membranes are contained in closed tubular modules with the activated sludge reactor tank effluent pumped through them.

Membrane systems are proprietary, with each manufacturer having their own specific differences, but all operate in one of these two configurations. As activated sludge suspended growth systems they can be designed to provide both biological nitrogen and phosphorus removal with the appropriate configuration of the activated sludge tankage. As such they can achieve the effluent total nitrogen levels proposed, but would require chemical polishing to achieve the effluent phosphorus levels proposed.

Implementation at Bridgewater would require the demolition and replacement of the existing RBC system with new activated sludge process tanks. The existing secondary clarifiers may be able to be incorporated into such a system in some fashion (for example, as equalization tanks) but the existing RBC tanks are too shallow to provide either sufficient volume or aeration of an activated sludge system. In either case, effluent pumping (pressure or vacuum) is required as well as an internal recycle if a pre-anoxic zone is to be employed. If a closed vessel type system is used, the membrane system would require a building as well to house the membrane system and protect it from freezing.

*Replace RBC Process with New Activated Sludge Secondary Process (MLE)*
The Modified Ludzack-Ettinger MLE configuration of the activated sludge process includes a pre-anoxic zone for denitrification followed by an aerobic zone for nitrification. Aerobic zone effluent is returned to the pre-anoxic zone (referred to as Internal Mixed Liquor Recycle, or IMLR) to take advantage of the available influent carbon to support the denitrification process. Due to practical limitations of IMLR rates (which are typically between 100% to 300% of the influent flow) and influent carbon levels, the MLE process alone cannot achieve the effluent total nitrogen levels proposed. A post denitrification process would be required. The post denitrification process could be either a suspended growth process or a granular media filter (fixed film) process.

Implementation of an MLE process at Bridgewater would require demolition of the existing RBCs and construction of new tankage to provide the pre-anoxic and aerobic reactors, new internal mixed liquor recycle pumping system, additional final clarifiers and return sludge pumping system to handle the higher solids loading rates of a suspended growth system, and new mechanical aeration systems and anoxic zone mixers. Solids handling improvements may also be expected to handle the higher solids production.

Replace RBC Process with New 4-stage Denitrification Process (MLE with Post Denitrification

Reactor)
This alternative is similar to the MLE process described above with the addition of new suspended growth post-anoxic zone reactors prior to secondary clarification. This process also typically requires the addition of a small reaeration zone prior to the secondary clarifiers to re-establish aerobic conditions in the sludge (which helps promote good settling characteristics). As noted earlier, the post-anoxic zone typically includes an external carbon source storage and feed system to optimize the post denitrification process. This process can meet the proposed nitrogen limits.

Implementation at Bridgewater would require demolition of the exiting RBCs and construction of new suspended growth process tankage in the MLE with post anoxic zone configuration, complete with new aeration systems, internal mixed liquor recycle and return sludge pumping, as well as additional finals clarifiers to handle the increased solids loads. Here again, solids handling improvements may be necessary to accommodate the additional waste solids.

*5.5.1.3 Nitrogen and Phosphorus Removal Technologies*
Various combination of the phosphorus and nitrogen removal technologies identified above can be employed together to achieve both phosphorus and nitrogen removal. In the case of the suspended growth activated sludge processes, there are three specific process configurations that are intended to do just this. The A2O and the 4- and 5-stage modified bardenpho processes. These are in effect modifications/combinations of several previously discussed processes. Each is discussed further below.

*Replace RBC Process with New Activated Sludge Secondary Process (A20)*
The A2O, or Anaerobic/Anoxic/Oxic, process is a suspended growth process that incorporates an anaerobic zone followed by an anoxic zone and then an aeration zone as the name implies. The anaerobic zone supports the BioP process development for phosphorus removal while the anoxic zone provides for denitrification of returned mixed liquor and the aeration zone provides nitrification. The latter two processes are effectively the same as the previously discussed MLE process. Like the MLE and BioP processes this process may not consistently meet the proposed effluent limits for Nitrogen and Phosphorus.

Implementation of an A2O process at Bridgewater has all the same requirements as the BioP and MLE processes previously discussed.

*Replace RBC Process with New 4 or 5-stage Bardenpho® Secondary Process*
The 4-and 5-stage Bardenpho process are also variants of the previously discussed options. The 4- stage process includes a pre-anoxic selector followed by an aerobic zone for nitrification, an anoxic zone for denitrification and a reaeration zone. The 5 stage processes adds a pre-anoxic zone between the anaerobic zone and the aeration zone and as such also requires an internal mixed liquor recycle (IMLR) pumping system. These processes can achieve the proposed effluent nitrogen limits but not the effluent phosphorus limits, unless combined with phosphorus polishing.

The improvements necessary at Bridgewater to implement any of these processes are similar to those previously mentioned for the nitrogen and BioP processes previously described, and include demolition of the existing RBCs, new process tankage for the processes described, new aeration systems, additional final clarification and return sludge pumping as for the pre-anoxic zones and IMLR pumping system. Also like the other suspended growth processes improvements to solids handling are expected to be necessary to handle the increased sludge production from these processes.

*5.5.1.4 Comparison of Screened Process Alternatives*

The following Table 5-9: WWTF alternatives for Nutrient Removal presents a summary of the WTF process alternatives described above and some key qualitative advantages and disadvantages for each alternative.

**Table 5-9**
**WWTF Process Alternatives for Nutrient Removal**

| Alt. # | Description of Process Alternative | Target Nutrient | Advantages | Disadvantages |
|---|---|---|---|---|
| | *Phosphorus Removal Technologies* | | | |
| A | Enhanced Biological Phosphorus Removal (BioP) Process | P | - Reduced chemical usage<br>- Little increase in sludge production<br>- No additional chemicals in sludge | - Cannot meet permit limit without additional processes<br>- P can be re-released from sludge<br>- Capital improvements required |
| B | Chemically Enhanced Primary Treatment (CEPT) Process | P | - Reduces overall load to biological process<br>- P remains bound in sludge<br>- Limited capital improvements required<br>- Reduced load to secondary treatment | - Increased load on primary clarifiers<br>- May not meet permit limit alone<br>- Can starve biological process for P<br>- Additional chemicals in sludge<br>- Potential negative impacts on solids handling performance |
| C | Chemical Precipitation with Increased Dosage, using Current Secondary Treatment Process | P | - Limited capital improvements required | - Increased load on secondary clarifiers<br>- Higher chemical usage<br>- May not meet permit limit alone<br>- Increased sludge production<br>- Additional chemicals in sludge<br>- Potential negative impacts on solids handling performance |
| D | Multi-Barrier Approach, using CEPT and Chemical Precipitation in Secondary Clarifiers | P | - May be capable of meeting permit limit without major new process components<br>- Reduced load to secondary treatment | - Requires multi-point chemical feed<br>- Somewhat increased sludge production<br>- Potential negative impacts on solids handling performance |
| E | Chemical Precipitation with | P | - Demonstrated ability | - New additional |