SECTION 4.0 METHODS OF ANALYSIS

This Section identifies and describes the different methods of analysis that were used to evaluate the four wastewater management alternatives described in Section 3. The general categories of analysis include the following:

- Environmental Analysis including:
  - Land Use and Growth
  - Air Quality
  - Surface Water Flow, Groundwater Recharge, and Water Quality
  - Wetlands and Terrestrial Resources
  - Aquatic Resources
  - Rare and Endangered Species

- Non-Monetary Factor Analysis including:
  - Complexity
  - Public Testimony
  - Implementation

- Planning Level Construction Costs including:
  - Capital Costs
  - Land Acquisition

4.1 ENVIRONMENTAL ANALYSIS

The following provides a summary of the methods that will be used to assess potential impacts associated with implementation of the alternatives under consideration. For those environmental parameters for which methods and criteria have been developed, discussions of potential impacts are provided in subsequent analysis chapters for the alternatives. Given the limited amount of site specific information available at this stage of the study, it is difficult to assess the significance of impacts. Thus, the variation in significance of potential impacts is discussed qualitatively. A more detailed assessment of significance of impacts should be completed as part of subsequent evaluation of selected alternatives.

For some of the environmental parameters, no significant distinguishing factors are anticipated for the alternatives, or meaningful evaluation would require specific site information. These parameters include: Environmental Justice, Noise, Traffic, and Floodplain. For these parameters, no methods have been developed for this alternatives report, and general discussions of the types of impacts anticipated are provided below. In addition, construction impacts are also not discussed individually by parameter for each alternative. Anticipated types of construction effects that could be expected regardless of the alternative are noted below. It is understood that the geographic extent, duration, and significance of construction effects will vary depending on the alternative selected, and that this analysis should be conducted in subsequent environmental impact analyses for any selected alternatives.

Environmental Justice. Environmental justice is based on the principle that all people, regardless of race, color, or socioeconomic status, have a right to be protected from environmental pollution (see Executive Order 12898). The purpose of environmental justice is to protect high-minority and/or low-income populations from having a disproportionate share of negative environmental impacts resulting from implementation of projects or policies. Environmental justice is largely related to siting issues and involves analysis using geographic units such as U.S. Census tracts or block groups. Since specific siting information with regard to the proposed alternatives is not available at the time of preparation of this report, this issue would need to be addressed in subsequent analyses concerning implementation of an alternative and is not included in the alternatives analysis of this report.

Noise. Noise effects will vary depending on the nature of the activity being conducted, whether the activity is stationary or mobile, and the proximity of noise receptors. Noise thresholds are often set by community, and limitations may include decibel levels that cannot be exceeded. Noise effects can be mitigated through use of certain best management practices including mufflers on equipment, and implementation of noise barriers.

Traffic. Traffic volumes are generally not expected to be significant for any of the alternatives' operation; however, the nature of the traffic would be expected to vary in terms of employee trips and heavy equipment including truck trips for chemical usage or residuals removal. The extent of the impact on area roadways will depend on the type of roadway and the traffic volumes currently experienced. These types of issues would need to be addressed in more detail in subsequent environmental evaluations depending on the alternative selected.

Floodplain. Construction of above grade structures or fill may have short-term impacts in areas that are located in the 100-year floodplain. Construction equipment located within the 100-year floodplain could potentially pose an obstacle to floodwaters and displace a small amount of flood storage capacity. Above ground structures within the 100-year floodplain may become obstacles to floodwaters and impact flood storage capacity in the long-term. Locating floodplains involves analysis using geographic aids such as Federal Emergency Management Agency flood maps. Similar to environmental justice, this issue would need to be addressed in subsequent analyses concerning implementation of an alternative when specific siting information is available and is not included in the alternatives analysis of this report.

Construction Activities. Construction of the proposed project would result in temporary increases in noise levels as a result of operation of construction equipment and vehicles. Construction vehicles would be equipped with proper muffler systems, and, where necessary, noise barriers could be constructed to reduce noise impacts in sensitive areas. Construction equipment used during the proposed work has the potential to produce engine emissions that could temporarily affect air quality in localized areas in the vicinity of construction. Additionally, construction vehicles and excavation would generate fugitive dust during construction activities. However, the extent of these impacts would be minimized by use of best management practices, such as proper engine maintenance, covering stockpiles, and wetting disturbed areas. Construction will potentially result in localized impacts to roadway capacity including reduction of the existing number of lanes, reduction of lane widths, and local road closures requiring detours. These temporary reductions in roadway capacity could lead to traffic delays. Those alternatives requiring more intensive construction activities could experience these impacts for a longer duration or greater magnitude.

4.1.1 Land Use and Growth Method of Analysis

The land use and growth impact analysis is performed to assess the direct and indirect effects of the alternatives on existing land uses and development. Direct effects include land uses displaced by the area disturbed during construction and/or operation of a project. Indirect effects include the addition or removal of constraints that may affect development or land use patterns in an area or region. The impact analysis focuses on three major areas of concern described below.

Land Use Compatibility and Aesthetics. The alternatives were considered with respect to whether or not the proposed facilities or infrastructure would be compatible with existing land use. The alternative was considered to result in an impact if the action had the potential to displace an existing use or result in a change in view or detrimental change in neighborhood or local character. The potential for disruption to surrounding land uses was also considered (e.g. impacts on noise levels, access, odors). While the degree of impact for this area of concern is rather site dependent, a general comparison of distinguishing factors for the alternatives is provided.

Land Area Impacted. Each alternative was assessed based on the extent of land area that would be altered. This assessment considered the amount of land disturbed for the proposed components for each alternative and the potential for disturbed areas to be restored to existing conditions.

Indirect Growth. The potential for indirect growth was assessed with respect to long-term effects. The alternatives were assessed as to how they may encourage, or discourage, development and additional population. The potential for indirect growth was evaluated by considering the location of the components of the proposed alternatives in relation to currently developed and sewered areas, as well as how the alternatives would constrain or encourage regional wastewater infrastructure regardless of whether or not the alternatives would provide the opportunity for communities to tie into regional wastewater infrastructure. For those alternatives which are expected to potentially generate more significant levels of indirect growth, a discussion is also presented regarding how this growth may alter historic land use patterns within the study area. For instance, would an alternative encourage segmented or disjointed development in an area that has historically had traditional neighborhoods or downtown centers, or encourage development that is compact in a historically low density, rural area.

4.1.2 Air Quality Method of Analysis

This analysis only addresses long-term air quality impacts resulting from implementation of the proposed alternatives since, as discussed in Section 4.1, short-term air quality impacts resulting from construction activities are anticipated to be similar in nature regardless of the alternative and, thus, there are no distinguishing factors to assess.

Potential long-term impacts to air quality were evaluated qualitatively by considering process or odor emissions from the collection, storage, treatment, or disposal of wastewater associated with operation of the alternatives.

4.1.3 Surface Water Flow, Groundwater Recharge, and Water Quality

The alternatives analyses focus on effects to surface water flow, groundwater recharge, and water quality as a result of long-term implementation of the alternatives. The analysis of long-term effects related to flow generally addresses the issue of water balance as a result of increasing, decreasing, or relocating a wastewater effluent discharge. Effects to the Great Bay receiving waters are discussed followed by effects to the Gulf of Maine, as appropriate. Indirect effects on flow and water quality that may occur as a result of induced growth in the study area are addressed in the land use and growth section.

Surface Water Flow/Groundwater Recharge Changes. The analysis of changes in surface flow or groundwater recharge addresses the potential for an alternative to increase or decrease stream flow or groundwater recharge. This change could affect water supply, wetlands habitat, and aquatic life. The determination of the possible extent of change in stream flow was estimated based on the percentage of stream flow that the WWTF effluent discharge represented during low flow conditions. This estimation was based on low stream flow (7Q10 – flow that occurs over seven consecutive days and has a 10 year return frequency) and average annual flow of WWTFs. Consideration of possible changes in localized groundwater recharge was based on the extent that the alternative may change the current subsurface wastewater conditions (e.g. land application of all WWTF effluent).

Water Quality. Assessment of the surface and groundwater quality impacts focused on the potential effect on water quality of receiving waters due to the WWTF discharges under the different alternatives. The water quality analysis was conducted for the Great Bay for all alternatives as well as for the Gulf of Maine for Alternative 2 (Gulf of Maine discharge). For the Great Bay receiving waters, water quality effects were predicted based on salinity modeling results as well as a qualitative pollutant loading analysis. For the Gulf of Maine, water quality effects were based on dilution analyses of three candidate outfall sites and a comparison of anticipated pollutant concentrations and acute and chronic toxicity level for various species. These evaluation methodologies are described below.

Great Bay Salinity Change Analysis

The Great Bay salinity change analysis considered the degree to which salinity concentrations in the receiving waters may change as a result of increasing or relocating wastewater effluent discharges to/from tidally influenced waters. These tidal influenced waters are identified in Table 4-1.

TABLE 4-1. WWTFs DISCHARGING TO TIDAL RECEIVING WATERS

Wastewater Treatment Facility	Tidal Receiving Waters
Newmarket WWTF	Lamprey River
Durham WWTF	Oyster River
Newfields and Exeter WWTFs	Squamscott River
Dover WWTF, Newington WWTF, Portsmouth Peirce Island WWTF, and Pease Development Authority WWTF	Piscataqua River
Hampton WWTF	Tide Mill Creek

The salinity analysis focused on two alternatives: Alternative 1 (No Action) where discharges to existing receiving waters would continue with some increase in discharge flow (due to increased wastewater generation), and Alternative 2 (Gulf Discharge) where effluent discharges to the Great Bay would be eliminated. The impacts of the alternatives on salinity were estimated quantitatively using a two-dimensional model developed at the University of New Hampshire by Jon P. Scott. The model utilizes the RMA-2 and RMA-4 software (Donnell, Letter and McAnally, 2003; Letter and Donnell, 2003). The model is a finite elements model with triangular and quadrilateral elements of varying sizes. The model extends from the Piscataqua River mouth in Portsmouth to the dams in each of the rivers discharging to the estuary system. Details on the model grid and the calibration of the model are provided in Section 6.1 and Appendix C.

Great Bay Qualitative Pollutant Loading Analysis

A qualitative analysis was performed for all of the alternatives to identify water quality changes that may occur in the Great Bay as a result of changes in pollutant loadings. In all alternatives, the pollutant loadings from the WWTFs to the Great Bay are anticipated to decrease based on the more stringent permit limits proposed. However, in some cases the loadings are anticipated to change more than others. For example, under Alternative 2 all of the pollutant loading to the Great Bay from the WWTFs will be eliminated due to the relocation of the discharge. Some of the pollutant loadings discussed include: BOD, nutrient pathogens, etc. The anticipated effects on water quality in the Great Bay as a result of the changes in pollutant loading are discussed, including changes to dissolved oxygen, eutrophication, etc.

Gulf of Maine Water Quality Impacts

The effects on gulf water quality as a result of relocating WWTF effluent discharges from the existing discharge locations to the Gulf of Maine were evaluated. These evaluations were conducted for Alternative 2 only, and specifically for three candidate outfall locations. The water quality impact of the Gulf discharge was based on project WWTF effluent water quality for this alternative, as well as the dilution performance of the three candidate outfall sites.

Outfall performances are estimated in terms of initial dilution. Initial dilution was estimated for the candidate outfalls using mathematical models developed from theoretical and experimental investigations. The initial dilutions and proposed future permitted WWTF effluent concentrations were used to develop concentration of certain pollutants in the Gulf in the vicinity of the outfalls. These pollutant concentrations were then compared to chronic and acute criteria for selected species.

Far-field transport and dispersion were not evaluated for Alternative 2, since high initial dilutions were obtained. A summary of the findings of the gulf discharge modeling is presented in Section 6.1.3. A complete discussion of the development of the outfall concepts and assumptions in the modeling is presented in Appendix D.

4.1.4 Wetland and Terrestrial Resources

The wetland and terrestrial resources impact analysis focused on long-term impacts, including the indirect impact of changes in flow and salinity on wetlands, and the potential for disrupting or displacing terrestrial habitat.

Wetland Resources. Potential effects to wetlands resource areas are assessed based on potential for relatively substantial alterations to surface or groundwater flow or fairly substantial changes in salinity concentrations, both of which could have an effect on freshwater or estuarine wetland size and/or function in the vicinity of WWTFs.

Terrestrial Resources. Long-term impacts are assessed by considering the potential for the alternatives to permanently displace terrestrial habitat due to operation of the proposed facilities. It was considered an impact if it was determined that considerable extents of land were to be disturbed during operation of the proposed components for each alternative.

4.1.5 Aquatic Resources

Long-term impacts are assessed by considering the potential for the alternatives to permanently change flow or salinity, thereby potentially altering local aquatic resource habitat. Impacts in the vicinity of the Gulf of Maine discharge were assessed by evaluating predicted concentrations of treated wastewater discharges at the alternative discharge locations considering dilution available. Water quality criteria and aquatic life criteria were used to assess the potential for both acute and chronic effects. Impacts in the Great Bay receiving waters were evaluated based on potential for significant change in flow volume, or significant change in salinity concentration or location of the salt wedge.

4.1.6 Rare and Endangered Species. Long-term impacts were assessed by considering the potential for the alternatives to permanently change flow or salinity, thereby potentially indirectly altering rare and endangered species habitat.

4.2 NON-MONETARY TECHNICAL ANALYSIS

The four alternatives were analyzed based on non-monetary factors. These factors included the following:

- Complexity of:
  - Treatment
  - Conveyance
  - Disposal
- Public Testimony
- Implementation

More detailed information related to these non-monetary factors are described below.

4.2.1 Complexity

Treatment Complexity. Complexity of treatment looked at the number of facilities (unit processes) that need to be operated as well as the relative sophistication of each unit process. For example, a WWTF that is running a Modified Ludzack-Ettinger (MLE) process for total nitrogen removal is generally more complex to operate and maintain than an aerated lagoon that is only being used for carbon removal. Some of the complexity is due to the process itself (use of anoxic/aerobic zones/clarification vs. use of a lagoon only), and some of the complexity is due to the number of pieces of equipment needed (mixers/recycle pumps/return sludge pumps/aeration/solids handling vs. aerators only).

Conveyance Complexity. Complexity of conveyance looked at the number of components anticipated to be required to convey the treated effluent to its disposal location. For some alternatives, a number of pump stations and pipelines are anticipated to be required to convey the effluent to the disposal location, while conveyance of effluent is not anticipated to be required for other alternatives.

Disposal Complexity. Complexity of disposal looked at the number of components and the level of sophistication of the components anticipated for disposal. For example, some alternatives will continue to use the existing WWTF outfalls for disposal. In other alternatives, a number of components (e.g. ocean outfall, rapid infiltration basins, etc.) are anticipated to be required for disposal of the effluent. The relative sophistication of the operation and maintenance of these disposal alternatives will also be examined.

4.2.2 Public Testimony

Public testimony of the four alternatives was evaluated to assess the general positive or negative testimony related to each alternative. The public testimony received ranged from very general comments (e.g. how an alternative is wanted or not wanted without supporting reason) to more specific comments on how an alternative my have a positive or negative impact on a specific item (e.g. groundwater recharge, nutrient loading to the estuary, etc.)

4.2.3 Implementation

The ease or difficulty of implementing each alternative was assessed. Some items related to implementation that will be addressed include: the need for a regional sewage agreement, public reaction issues, technical feasibility (e.g. ability to find acceptable land application sites or site the large number of decentralized systems), and operational issues (e.g. regional conveyance system or decentralized systems).

4.3 PLANNING LEVEL CONSTRUCTION COSTS

Planning level construction costs were identified for each of the four alternatives. These planning level construction costs are intended to be comparative costs used for relative comparison only and not be used for budgeting purposes. The purpose of preparing costs for these alternatives is only to compare the relative costs among the four alternatives. These costs have been based on engineering judgment and experience with other projects. If any of these alternatives are carried forward, more detailed evaluations of costs should be performed as the concepts and potential designs become better defined. It should be noted that the planning level costs identified were for capital costs only. Operation and maintenance costs for the alternatives have not been addressed.

The development of planning level construction cost for this study is described below.

4.3.1 Planning Level Construction Cost Estimates

Planning level costs were developed for each alternative. These planning level costs are estimates of the project costs which include design and construction engineering, construction, and contingency. These estimates do not include estimates for some unknown factors including pricing for additional studies, permitting, and legal issues required for implementation.

These planning level cost estimates were split into treatment costs, conveyance costs, disposal costs, and other alternative specific costs. It should be noted that these costs are based on engineering judgment and do not take into consideration many unknown factors including soil conditions, space limitations, and right-of-way or easement issues as these are currently undefined. These factors would be identified in subsequent more detailed studies and refined in design stages of a project. The unit costs and correction factors used for these planning level estimates are described below and are outlined in Appendix G.

Treatment Costs. The treatment costs for the four alternatives were developed based on the anticipated upgrade requirements identified in Section 3. These upgrades include the following:

- Anticipated Carbon Removal Upgrades - Including activated sludge upgrades, additional tankage, or cloth disc filtration as appropriate.

- Anticipated Total Nitrogen Removal Upgrades – Standardized to include tankage and process equipment anticipated to implement a Modified Ludzack-Etenger (MLE) process (unless a WWTF currently employees a process that can be easily converter to another nitrogen removal process (e.g. SBRs at Pease Development Authority).

- Anticipated Total Phosphorus Removal Upgrades – Standardized to include the addition of cloth disc filters and chemical addition.

- Other Anticipated Unit Process and Equipment Upgrades – These upgrades do not necessitate the construction new unit processes but are upgrades or expansions to existing processes. These upgrades/expansions include:

  - Influent Pumping
  - Preliminary Treatment (screenings or grit removal)
  - Disinfection
  - Membranes
  - Metals Removal Evaluations
  - Aeration Capacity
  - Solids Handling Capacity

The planning level cost estimates associated with these upgrades (with the exception of total nitrogen upgrades) are based on a unit price per gallon upgraded. Each of the upgrade types identified (e.g. carbon removal, phosphorus removal, aeration capacity, etc.) has been assigned a dollar value per gallon upgraded. For some alternatives, specific WWTFs are anticipated to require upgrades (for specific processes) for the entire 2025 process flow while other anticipated upgrades are only needed for the new flow (incremental flow increase between the 2004 flow and the projected 2025 flow). The planning level estimates for the upgrades are based on either the entire flow or the incremental flow accordingly.

For the total nitrogen upgrades, the planning level estimates are based on a dollar per pound of nitrogen removed per day over 20 years.

An economy of scale factor has been applied to the WWTF upgrade planning level cost estimates since it is expected that a large upgrade will not cost as much (on a dollar per gallon basis) as a smaller upgrade. For example, a carbon upgrade for various WWTFs was assumed to cost

$7.5/gallon. In order to account for the economy of scale, it is assumed that a small plant (less than 0.5 MGD) would have an economy of scale multiplier on the capital cost of 1.0 ($7.5/gal x 1.0 = $7.5/gal), while a larger WWTF upgrade (greater than 5 MGD) would have a economy of scale multiplier of 0.6 (($7.5/gal x 0.6 = $4.5/gal).

The estimated costs for WWTF upgrades associated with Alternatives 1 through 4 are included in the planning level cost tables in Sections 5 though 8, respectively.

Conveyance Costs. The planning level conveyance costs of the four alternatives were developed based on the anticipated conveyance requirements identified in Section 3. These upgrades include the following:

- Conveyance Pipelines
- Pump Stations

The planning level cost estimates associated with the pipelines have been developed on a unit price per linear foot basis for various pipe diameters.

The planning level cost estimates associated with the pump stations are based on a unit cost per pump station basis for various pump station capacities. The unit costs developed are based a range of pump stations that would be anticipated to convey all WWTF effluent from the WWTFs of origin to a Regional Post-Treatment Facility or to a land application site. The planning level cost estimates for Alternatives 2 and 4 are included in the planning level estimate tables in Sections 6 and 8, respectively.

Effluent Disposal Costs. The effluent disposal costs of the four alternatives were developed based on the anticipated disposal requirements identified in Section 3. The following assumptions have been made for disposal costs associated with the four alternatives:

- Alternative 1 (No Action) – There are no effluent disposal costs as the existing outfalls will continue to be used.
- Alternative 2 (Gulf of Maine Discharge) – The effluent disposal cost will consist of a Regional Post-Treatment Facility (RPTF), a final effluent pump station at the RPTF, and the cost of the outfall. The RPTF and the final effluent pump station planning level costs have been estimated based on the total flow from the 17 WWTFs. The outfall cost has been based on a linear foot unit price for the outfall pipe and a linear foot unit price for the diffuser section of the outfall.
- Alternative 3 (Decentralized Discharge) – There are no effluent disposal costs at the existing WWTFs as the existing outfalls will be used. The price of the decentralized systems for this alternative will be included as a disposal cost. A unit price for the standardized decentralized system has been assumed.
- Alternative 4 (Land Application) – The land application effluent disposal cost is based on the US EPA Wastewater Technology Fact Sheet -*Rapid Infiltration Land Treatment.*

The planning level cost estimates for the disposal components of Alternatives 2, 3, and 4 are included in the planning level cost estimate tables in Sections 6, 7, and 8, respectively.

4.3.2 Land Acquisition Costs

The following assumptions have been made for land acquisition for the four alternatives:

- Alternative 1 – Land acquisition is not anticipated (i.e. assume all of the WWTF upgrades can be accommodated in the existing WWTF property).
- Alternative 2 – All pipelines and pump stations will be constructed in public rights-of-way and no land acquisition is anticipated. Land acquisition is anticipated for the RPTF.

- Alternative 3 – Land acquisition is not anticipated (i.e. all of the WWTF upgrades can be accommodated in the existing WWTF property, and the land required for the decentralized systems will be acquired by the developer constructing the units that will use decentralized systems in lieu of sewer).
- Alternative 4 – Land acquisition is not anticipated for the conveyance pipelines. Land acquisition is anticipated for the disposal sites. These anticipated land requirements are summarized in Section 3.4.3.

A single unit price for an acre of land has been assumed for all land to be acquired. It is recognized that certain locations within the Study Area will have land acquisition costs that are higher or lower than this unit price. However, a single unit price is being used to represent a conservative average price for land within the Study Area. The planning level costs associated with land acquisition anticipated for Alternatives 2 and 4 are included in the planning level cost tables in Sections 6 and 8, respectively.