

The vision of WMA 4 is to preserve, protect, enhance and restore our water resources and the associated ecosystem and to instill pride in our rivers, streams, lakes and ponds. We will accomplish this through a balanced approach consisting of education, stewardship and managed growth in accord with available water resources while being environmentally sound and economically viable. We have created this vision for the benefit of our children and for future generations. – WMA 4 PAC

Watershed Characterization and Assessment of WMA 4

WMA 4 Highlights

Watershed Management Area 4 (WMA 4) of the Passaic River Basin:

- Covers 188 square miles of area, which is more than 82% developed,
- Watersheds include the Lower Passaic River (freshwater and tidal reaches), and the Saddle River
- Remaining habitats are encroached upon by development
- Has approximately 1.2 million residents
- Most residents are dependent upon surface water supplies, however groundwater sources provide approximately 9 billion gallons per year
- Diverts more than 30 billion gallons of water per year, mostly supplied from surface water sources originating outside of WMA 4
- Receives surface supply of raw and treated water via conduits from WMA 3
- Receives surface flow from 8 square miles in New York in the Saddle River Basin
- Receives surface flow from WMA 6 and WMA 3, which includes 140 square miles in New York
- Suffers from impairment of some surface and groundwater
- Surface water loadings are attributed primarily to:
 - non-point sources in NJ and NY for fecal coliform, BOD₅, sodium and suspended solids
 - point sources in NJ and NY for phosphorus and nitrates
 - both point and non-point sources for ammonia
- Effective planning will require interstate cooperation between NJ and NY, and coordination with planning for WMAs 3 and 6, particularly for the main stem of the Passaic River.

A. IMPORTANCE OF INTEGRATED PLANNING

Interplay between meteorological and deep tectonic forces have been forming the mountains and valleys in what is now the Passaic River Basin for many millions of years. Glaciers advanced and receded (the last about 10,000 years ago), sculpting the land and leaving moraines and a variety of soil deposits. Melting glaciers and runoff from rain and snow contributed to the development of the rivers, streams, lakes and marsh areas that we now see on the surface of the earth. As the last glacier receded, it blocked the flow of the

north flowing rivers and formed glacial lakes. These lakes eventually drained and their remnants have gradually filled in through the accumulation of mineral and organic sediments forming marshes and bogs. These areas have become valuable wetlands. Other wetlands formed due to changes in drainage patterns, sedimentation of lakes and ponds, and other natural processes. As vegetation and animals returned after the last ice age, nature established a certain balance. The land, streams and rivers were able to assimilate the biological waste produced by the inhabitants of the land and water. If there was not enough food to support a population of a certain species, some members of the species migrated or starved. Movement or loss of one species would affect other species in the ecological community. Different species would respond to changes in the environment in different ways. Some would have been able to adapt to a variety of stresses, adjusting their habits to address the changes. Others migrated. Those that could not change their habits or migrate would simply perish.

When man first arrived in the Passaic River Basin, he was in balance with nature, migrating to find food, with a small population in a large area. The pre-Columbian Passaic Basin was nearly completely forested. Then things began to change. Man felled trees to build permanent shelters and cleared forest areas for farming. These land use changes altered the environment to some degree. European settlers cleared larger areas of forest for agriculture, building materials and fuel. Roads were cleared to allow transportation of goods to other areas. Population in some areas could expand beyond the ability of the local area to provide food, since food could be brought in from other areas. However, the population still depended on local water supplies. Dams were built to harness waterpower for mills and later for generation of electricity. The Morris Canal was constructed from Newark to the western limit of the Passaic Basin and on to the Delaware River at Phillipsburg to provide improved transportation across New Jersey. It also served as the local water supply in some areas, including part of Newark. Dams were built to enlarge existing lakes or form new lakes to provide water for the Canal. These activities greatly changed the environment.

Industrial Era

Railroads and better roads were constructed to provide for more economical movement of goods and people. Industrial activities flourished, particularly where power and transportation was available. As cities grew, people were attracted away from the rural areas to better paying jobs in the cities. Wastes from industrial activities were dumped in the river or on local land areas. Wetland areas were filled for development and some wetlands were used as dump sites for waste materials. Some of these industrial wastes caused contamination of river sediments. Macroinvertebrates in the sediments picked up the contaminants, which then progressed up the food chain to the flesh of fish, and to those who ate the contaminated fish. All of these activities changed the environment.

The population growth and industrial activities in city areas resulted in pollution of local water supplies. People in city areas died of typhoid due to poor sanitation. Habits needed to change, people would migrate or perish. It became necessary to convey water from the more rural areas to provide potable water for the city populations. Dams were

constructed to form reservoirs. Pipelines and aqueducts were constructed to convey the water to the cities. Fortunately, considerably sized areas in the Passaic River Basin were preserved to protect these water resources. However, the large reservoirs affected flows and water temperatures in the rivers, which in turn affected the fish population. Clearing of trees from the buffer zone along streams and rivers also affected the water quality, including the temperature of the water. Sewers were built to convey sanitary waste and stormwater runoff to streams and rivers. In some areas along the Lower Passaic, combined sewers were built to carry both sanitary waste and stormwater. During storms producing flows exceeding the conveyance capacity of the combined sewers, excess flows, including a mixture of storm water and sanitary waste, are discharged through combined sewer overflows (CSOs) to the Lower Passaic River. Pollutants from wastewater discharges overwhelmed the streams and rivers, and wastewater treatment facilities were built to reduce the level of pollutants discharged to the water bodies.

Suburban Expansion

Improved roads and the increased use of the automobile permitted people to return to the more rural areas for housing yet commute daily to work in the cities or other economic centers. People moved from the more densely populated areas to individual homes in the outlying areas. Roads became more crowded and were enlarged. Land use underwent major changes. Some corporations moved their business offices out of the cities to more rural locations. More forests were cleared, wetlands filled, sewers, wastewater treatment plants, roads, houses, shopping centers and office facilities were built or expanded. Lands were cleared to provide fields for athletic activities and large lawns in corporate parks. Large fields or lawns near bodies of water provided favorable habitat for Canada geese, and the species has flourished in New Jersey. Stormwater runoff from these areas carries a significant biological loading to the receiving lakes, streams and rivers. Additional pollutants were discharged to water bodies from wastewater plants, from storm sewer discharges, and from runoff from parking lots, streets, lawns, and fields. Increased peak flows due to higher rates of stormwater runoff from increased impervious areas caused erosion of streams. All of these actions changed the environment. Habits had to change, or people would relocate or suffer the effects.

Addressing the Problems

Under the provisions of the federal Clean Water Act of 1972, much has been done to mitigate the impacts of the major land use changes that have occurred in the Passaic Basin in the last century. For two decades the emphasis of the program was on addressing the point sources of pollution, such as domestic wastewater treatment plants and industrial process discharges, and on protecting wetlands. There was a dramatic improvement in the quality of the water in the Passaic River and major tributaries in the 1980's. However, the job is far from finished. The improvements were in rivers affected by wastewater treatment facilities, and were accomplished through an extensive program of treatment plant process upgrades. Most of these improvements did not address removal of phosphorus, and nitrate concentrations increased as a result of reduction of

ammonia loading at wastewater plants. Excess phosphorus and nitrates can lead to algae blooms, resulting in eutrophication in lakes and adversely affecting water supplies.

A review of water quality data for rivers in the Passaic River Basin for the period of 1992 through 2000 reveals an increase in concentrations of certain pollutants at several stream monitoring stations. Increases are noted for BOD₅, fecal coliform, chloride, sodium and other solids loadings. These pollutants, as well as a significant portion of the ammonia loading in the rivers, are attributed to non-point sources (NPS) of pollutants. Non-point sources are those sources which discharge pollutants but are not identifiable as a specific single source location. The NPS pollutants are usually associated with developed areas, but can also come from farms. Residential practices such as over fertilization of lawns, washing an automobile in a driveway, failure to pick up pet waste, feeding geese in the local park, or dumping unwanted materials into a storm drain or onto the ground can all result in non-point source pollutants entering our waterways as they are carried by stormwater runoff. These pollutants have an effect on the environment and on our supply of safe drinking water.

Proper planning and implementation of actions to reduce the pollutants in our waterways must involve not only point source discharges, as has been done for the last 30 years, but must also take into consideration the:

- Effects of land use changes,
- Need to clean up contaminated areas,
- Need to preserve environmentally sensitive areas
- Need to educate the public to avoid contributing to the pollution of lakes and rivers,
- Need to change our habits to protect our environment.

EPA has promulgated Phase I and Phase II Stormwater Management Rules to address NPS pollution. The Phase I rules applied to municipalities with separate storm sewer systems (not CSOs) and with a population exceeding 100,000. Phase I affected few areas in New Jersey, while the Phase II rules will apply to communities with a population exceeding 10,000. The rules include an educational component, identification of illegal discharges, and controls for site disturbance. For many years, New Jersey has had a program requiring installation of soil erosion and sediment control measures in association with land disturbance of more than 5,000 square feet. New Jersey has also advocated adoption of stormwater management ordinances addressing the quantity and quality of runoff from new construction. The *Residential Site Improvement Standards* adopted in 1997 unified stormwater management regulations applicable to new residential development in the State, but do not apply to non-residential development, nor to the impacts of existing development.

Planning must be done on an integrated approach, with consideration of the often competing interests of the ecological system, water supply and wastewater assimilation, and the interests of many stakeholders in the region. The combined effects of point sources and non-point sources of pollutants must be considered, goals identified, and management strategies developed to protect and improve the water resources of the

region on an integrated basis. Attacking the problems individually may result in improvement in one area to the detriment of another. Analysis of the problems on an integrated basis will result in the development of a comprehensive management plan addressing the multiple needs of the area and of the stakeholders.

The Passaic River Basin includes an area of approximately 936 square miles in New Jersey and New York. The Passaic Basin in New Jersey has been divided into three (3) watershed management planning areas (WMAs), identified as WMAs 3, 4 and 6. WMA 3 includes the area tributary to the mouth of the Pompton River near Two Bridges. WMA 4 includes the area tributary to the Passaic River from Two Bridges to the Newark Bay, and WMA 6 includes the area tributary to the Passaic River upstream of Two Bridges.

B. CHARACTERIZATION OF WMA 4

1. Drainage Areas – Major Subwatersheds

Watershed Management Area 4 (WMA 4) covers 188 square miles in New Jersey, and includes three major subwatersheds: the Lower Passaic River from the Pompton River to the Saddle River (83 square miles), the Lower Passaic River from the Saddle River to Newark Bay (54 square miles) and the Saddle River watershed (51 square miles in NJ). The drainage area of the Saddle River extends northerly into New York and includes an additional area of approximately 8 square miles. The reach of the Passaic River below the Saddle River includes the Second River and the Third River. The reach above the Saddle River includes Goffle Brook, Molly Ann Brook, Preakness Brook, Peckman River, and Deepaval Brook.

The Passaic River enters WMA 4 just below the confluence with the Pompton River. At the upstream limit of WMA 4, as the Passaic River enters WMA 4, it has a drainage area of 378 square miles from the area tributary to the Pompton River, and 361 square miles from WMA 6, resulting in a total of 739 square miles. At the mouth of the Passaic River at Newark Bay, the total drainage area of the River is approximately 935 square miles. This includes a total of approximately 148 square miles in New York (16%) and 787 square miles in New Jersey (84%).

Table B.1.1

Major Subwatersheds of WMA 4

Major Subwatershed	Area in NJ – Sq. Mi.	Area in NY–Sq. Mi.	Total Sq. Mi.
Lower Passaic River (Saddle River to Pompton River)	83	-	83
Lower Passaic River (Saddle River to Newark Bay)	54	-	54
Saddle River	51	8	59
Totals	188	8	196

2. Topography, Geology, Soils, and Climate

WMA 4 is located in the Newark Basin subprovince of the Piedmont Physiographic Province. The Newark Basin is primarily lowlands formed on inclined siltstone, shale, and sandstone strata, interrupted in places by long traprock ridges and local hills formed of erosion-resistant diabase or conglomerate. The elevations in WMA 4 range from approximately sea level, where the Passaic River empties into Newark Bay to over 850 feet at a few points along the crests of Watchung Mountains. The majority of the land surface is between 50 and 300 feet above sea level.

During the Pleistocene Epoch of the Quaternary Period, the advance of ice sheets caused the erosion of hills and the deposition of various stratified and unstratified deposits. Coarse-grained stratified deposits typically act as aquifers. Often the advance of ice would block a stream that drained the pre-glacial drainage basin and form a glacial lake. As the ice sheet advanced across the northern portion of the Newark Basin, it formed several lakes, which ranged in size and longevity. Unlike some other portions of the Newark Basin, the glacial lakes were not very extensive in WMA 4. Post-glacial fluvial deposits cover most of the former lakebeds. The deltaic deposits stand in relief, testifying to the former depth of the glacial lakes.

Meltwater from the retreating glacial front often achieved rather great velocities, enabling it to entrain and subsequently deposit well-stratified sands and gravels. These deposits form prolific aquifers, vulnerable to the propagation of contamination, that provide baseflow to portions of the Saddle River, Ho-Ho-Kus Brook, and the Lower Passaic River.

Soils in WMA 4 appear to be predominantly in Hydrologic Soil Group B soils, which formed on glacial outwash, and Group C soils, which formed on glacial till. Soil Group C is characterized by slow infiltration rates, while infiltration rates of Group B soils are greater. WMA 4 also includes large areas which are classified “Urban Land” by the USDA, which contain soils belonging to various hydrologic soil groups that have been significantly altered by impervious surfaces or large-scale regrading.

The climate of WMA 4 is classified as continental climate since the prevailing winds come from the west, over the continent. Prevailing winds are from the northwest from October to April and from southwest during the rest of the year. Average winter temperatures are in the high twenties and low thirties Fahrenheit. Midsummer weather is characterized by high humidity and frequent thunderstorms. Average annual rainfall varies from approximately 44 inches to 50 inches across WMA 4.

3. Land Use and Habitat

As of 1995, more than 82% of WMA 4 was urban land (as a general category, includes all residential, commercial and industrial development), about 11% was forest, and less than 6% was water or wetlands.

Comparison of land use data for 1986 and 1995 reveals that during that 10-year time span there was a loss of approximately 1.6 square miles of forest area and approximately 0.4 square mile of wetland, and an increase of approximately 1.9 square miles of urban area. Thus the total change in land use involved only about 1% of the area of WMA 4.

WMA 4 is the most developed WMA in the Passaic River Basin. As such, the habitats for wildlife and fish communities in the region are stressed by the effects of widespread development, including point discharges and pollution from surface water runoff from developed areas.

4. Water Supply

Between 1990 and 2000, an average of approximately 30 billion gallons of water per year was diverted in WMA 4 for potable water supply purposes, and about 6 billion gallons per year for industrial purposes. Most of this water was supplied from surface water sources, and the greater volume of that is from sources outside the WMA. Even the major surface diversion within the WMA is near the upstream reach of the Passaic River, and dependent upon water entering WMA 4 from WMA 3 and WMA 6.

The NJSWSP recommended consideration of capital projects such as new interconnections within the region and with adjacent planning areas (such as the Raritan Basin), sharing a Hudson River project with New York City (if initiated), increasing the size of existing storage facilities, constructing new storage facilities (including aquifer storage and recovery (ASR) systems in buried valley aquifers), and direct and indirect wastewater re-use. Among the management initiatives to be evaluated are programs aimed at modifying demand and improving operations, such as water conservation, improved drought rule curves, depletive use reduction programs, and improved coordination among presently interconnected purveyors. In addition, it was recommended that a detailed simulation model be developed of the Passaic and Hackensack Rivers that evaluates the region's storage facilities' capability to withstand various drought conditions and changing demand scenarios. The model would include a means for assessing groundwater diversions and wastewater flows in the region in order to properly model available water resources.

Finished water has been transferred from the Raritan to the Passaic Basin for drought relief for NJDWSC, and in turn for NJAWC, Jersey City, PVWC and United Water NJ.

The groundwater characterization and assessment indicates a variety of groundwater sources that vary from low producing to prolific. Based on data from 1990-2000, groundwater use in WMA 4 averaged approximately 9 billion gallons per year. About 8 billion gallons was for public water supply use, and 1 billion gallons for industrial, commercial and irrigation use. The evaluation of the available groundwater for the future is an area that requires significantly more investigation and improved methods of estimating the interrelationship between groundwater and surface water availability.

5. Population

This data, summarized in Table 1.20.1, shows that from 1990 to 2000, population in WMA 4 watersheds has increased by 74,530, or over 6%. The New Jersey portion of WMA 4 watersheds had a greater increase in terms of number of people, and the New York portion of WMA 4 watersheds had a greater increase in terms of percentage.

**Table 1.20.1
Population of Watershed Management Area 4**

	1990 Census	2000 Census	Change	% Change
New Jersey	1,117,585	1,185,899	68,314	6.11
New York	33,659	39,875	6,216	18.47
Total	1,151,244	1,225,774	74,530	6.47

Source: US Census Bureau

The following population forecasts from the New Jersey Division of Labor were available for the Bergen, Essex, and Passaic Counties area:

**Table 1.16.14
Population Forecast (New Jersey Department of Labor)**

County	Est. 1998	2005	2008	2010	2015
Bergen	875,200	905,600	918,800	928,800	953,500
Passaic	494,900	498,600	501,100	503,800	505,300
Essex	766,400	778,400	783,600	787,000	800,600
Total	2,136,500	2,182,600	2,203,500	2,219,600	2,259,400

This indicates a trend for increase in population of 5.7 percent by the Year 2015. These counties are dependent upon surface supply from PVWC, NJDWSC, and the City of Newark. The potential for population growth and increased demands indicates that these

stakeholders must work together with the State of New Jersey to develop proactive plans for providing water in the future.

6. Watershed Stressors

The waterways of WMA 4 receive pollutants from both point and non-point sources. The point sources in WMA 4 mainly consist of discharges from domestic wastewater treatment plants. Non-point sources are numerous and include sources such as stormwater runoff from developed areas, combined sewer overflows, fertilizers and pesticides from golf courses and lawn areas, leaking sewer lines and underground storage tanks, surface runoff and groundwater seepage from contaminated soil areas, soil erosion and sediment. WMA 4 has several identified contaminated sites, including 73 listed Superfund sites.

There are 5 major permitted domestic wastewater treatment facilities that discharge to the surface waters in the watersheds of WMA 4, with a total permitted average design discharge of approximately 38 MGD. Actual average daily discharge in 2000 was reported to be about 22 MGD. All of these facilities are in New Jersey.

The two larger plants have a combined capacity of 28.5 MGD, and include the Wayne Township Mountain View facility (13.5 MGD), tributary to the Passaic River in the western part of WMA 4, and the Northwest Bergen County Utilities Authority facility (15 MGD) in the Saddle River watershed. The Wayne facility provides treatment by rotating biological contactors, while the Northwest Bergen facility has activated sludge. Neither facility has tertiary treatment by filtering or micro-screening.

7. Surface Water Quality Impairments

The NJDEP has recommended delisting certain parameters previously listed on the 1998 303(d) List for waterways in WMA 4. The delisted parameters mostly are heavy metals. The resultant list of parameters not attaining standards at five primary sampling stations in WMA 4, as indicated in NJDEP's 2002 Integrated List, is presented in the Table 4.7.3, which is repeated below.

A more detailed list of waterways and parameters not attaining standards, based on reported data from numerous monitoring points on streams and at lakes in WMA 4, is presented in Table 4.7.4 in Section 4 of this report. The non-attainment parameters vary with location, but non-attainment for total phosphorus (TP), fecal coliforms (FC), or aquatic life appears for several sites. Heavy metals impairment appears for three sites on the Passaic River. Data revealing non-attainments was furnished primarily by governmental agencies, including USGS and NJDEP.

(Repeated) Table 4.7.3 2002 Integrated List for Primary Stations vs. 1998 303(d) List*

Waterway	Site ID	Parameters Non- Attaining Standards (2002)	Previously on 1998 303(d) List	Parameters Delisted
Passaic River, Elmwood Pk	01389880	TP, FC, As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn	TP, FC, As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn	
Lower Passaic River & Estuary		As, Hg	As, Cu, Pb, Hg, Ni	Cu, Pb, Ni
Passaic River at Little Falls	01389500	TP, FC, As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn	TP, FC, NH3, As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn	NH3
Passaic River at Singac	01389130	TP, FC, As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn	TP, FC, As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn	-
Saddle River at Fair Lawn	01391200	TP, FC, NH3	TP, FC, NH3, As, Be, Cd, Cr, Cu, Fe, Pb, Hg, Zn	As, Be, Cd, Cr, Cu, Fe, Pb, Hg, Zn
Saddle River at Lodi	01391500	TP, FC	TP, FC, DO, NH3, As, Be, Cd, Cr, Cu, Fe, Pb, Hg, Zn	DO, NH3, As, Be, Cd, Cr, Cu, Fe, Pb, Hg, Zn

* Source: NJDEP website

C. ASSESSMENT OF WATER QUALITY FOR WMA 4

1. Trends

1. Review of stream water quality data reveals that a distinct water quality improvement occurred during the period from the mid-1980s through the early-1990s. Results from the short-term trend analysis (1992-2000) were markedly different from the result of the long-term assessment. Apparently, most of the significant beneficial water quality trends were completed by 1992 and, in the period since then, a more stable water quality regime was present. Outside of increasing trends related to chlorides, there has not been a significant change in water quality.

Statistical tests were conducted to determine if significant differences could be attributed to seasonal effects. Various seasonal effects can include: an increase in streamflows during the winter; an increase in biological activity during the summer, and the relaxation of seasonal effluent limitations during the winter. For discharge-related parameters, the expected difference is that higher concentrations should be present during the summer due to reduced in-stream dilution and a relatively constant point source discharge load. The results of the seasonal difference analysis indicate the following:

1. As expected, dissolved oxygen and streamflows are significantly higher in the winter at most stations – this is a typical seasonal pattern.
2. Many discharge-related parameters are expected to have significantly higher concentrations in the summer. These parameters can include BOD₅, TKN, total

phosphorus, and dissolved phosphorus. To some extent, this tendency holds true at stations 01389005 (Passaic River below Two Bridges) 01389500 (Passaic River at Little Falls), 01389880 (Passaic River at Elmwood Park), and 01391500 (Saddle River at Lodi). Given that mean summer flows are only 30%-50% of those in winter, this finding is readily understandable.

3. Higher summer pH levels are present at three stations (the two on the Saddle River, and the Passaic River at Elmwood Park) with a seasonal difference of 0.4-0.5 pH units being noted – a finding that may be an indication of algal activity. At one station 01389880 (Passaic River at Elmwood Park), the mean summer pH was about 8.0 while the mean winter pH was about 7.5.
4. Higher winter concentrations of chlorides and sodium at three stations (same three as in 3 above) may be caused by road de-icing operations – an expected result.

2. Loading Assessment

A loading assessment was completed to provide an indication of the relative loading in WMA 4 from point and non-point sources for parameters of concern. The analysis was based on four years (1997-2000) of data for stream flow and water quality, and discharge data for permitted domestic wastewater treatment plants. The simulation was conducted based on a mass balance approach, which considered the effects of dilution by stream flow on loadings from the wastewater facilities, and estimated the magnitude of the non-point source load based on calibration to the observed in-stream concentration data. The loading assessment was conducted for those parameters with a significant point source and stream water quality database. A simplified assessment was conducted for total suspended solids (TSS) and fecal coliforms, which suggested that, typically, there is less than 1% of the TSS loading and less than 0.1% of the fecal coliforms loading originating from point sources. Thus these two parameters are considered to be non-point source dominated. Lack of data did not allow for such an assessment of chlorides and sodium, which tend to be associated with both point sources and non-point sources, such as road salting in winter.

The four parameters included in the detailed loading assessment are:

- Biochemical oxygen demand (BOD₅)
- Ammonia nitrogen (NH₃)
- Total phosphorus (TP)
- Nitrate nitrogen (NO₃)

A more detailed assessment was performed for primary stations that may receive significant point source impacts, namely the Passaic River below Two Bridges, at Little Falls, and at Elmwood Park, and for the Saddle River at Lodi. The point source discharges upstream of the primary stations on the Saddle River at Ridgewood are small, and therefore most of the pollutant loading in the upstream watershed is attributed to non-point sources.

For the detailed loading assessment, a simulation of concentrations for the period 1997 – 2000 was conducted based on the assumption that the streams were effluent dominated. This procedure was able to describe a fair degree of the trends and variability in the observed data. Results from this loading assessment are displayed in Plates 5.16.1 – 5.16-8 (see Section 5.16 of this report) as plots of projected concentration versus streamflow and projected concentration versus time. The projected non-point load and the percentage of point source loads are presented in Tables 5.16.1 and 5.16.2, which are repeated below. Observations and limitations relevant to the approach are presented in Section 5.16 of this report.

(Repeated) Table 5.16.1 Projected Non-Point Load (Daily Mean) (1997 to 2000)

Station	Location	Cumulative Non-Point Load (lbs/day)			
		BOD ₅	NH ₃	TP	NO ₃
01389005	Passaic R. below Two Bridges	21234	212	159	1646
01389500	Passaic R. @ Little Falls	21562	310	162	1671
01389880	Passaic R. @ Elmwood Park	22776	228	171	1765
01391500	Saddle R. @ Lodi	2034	20	15	158

(Repeated) Table 5.16. 2 Percent Point Source Load Contribution (Daily Mean) (1997 – 2000)

Station	Location	Percentage Point Source Load			
		BOD ₅	NH ₃	TP	NO ₃
01389005	Passaic R. below Two Bridges	7%	59%	88%	80%
01389500	Passaic R. @ Little Falls	7%	59%	89%	81%
01389880	Passaic R. @ Elmwood Park	7%	59%	89%	81%
01391500	Saddle R. @ Lodi	21%	97%	95%	90%

As indicated above, a substantial portion of the total loading entering WMA 4 (Passaic River below Two Bridges) from WMA 3 and WMA 6 is attributed to point sources for total phosphorus and nitrates. Point source loading for ammonia is most prominent in the Saddle River at Lodi. BOD₅ loading is dominated by non-point sources.

The Passaic River at Elmwood Park station is just upstream of Dundee Dam, which is just upstream of the head of tide on the Passaic River. The Saddle River at Lodi station is about 2 miles upstream of the head of tide on the Saddle River. Thus these stations are representative of the total loading for the respective freshwater watersheds. The estimated percentage contributions of total loading to the freshwater Passaic River and Saddle River watersheds from point vs. non-point sources for the indicated parameters are summarized below.

**WMA 4 Passaic River at Dundee Dam
Percentages of Total Loading (1997-2000)**

Source	BOD ₅	NH ₃	TP	NO ₃
Point	7%	59%	89%	81%
Non-point	93%	41%	11%	19%

**WMA 4 Saddle River Watershed
Percentages of Total Loading (1997-2000)**

Source	BOD ₅	NH ₃	TP	NO ₃
Point	21%	97%	95%	90%
Non-point	79%	3%	5%	10%

The above estimated loading percentages should not be viewed in terms of their absolute numbers, since they are based on a preliminary (screening-level) analysis. However, they do serve as an indication of the relative contributions from point and non-point pollution sources to waterbodies in WMA 4, and can provide some guidance as to where efforts should be concentrated to reduce loadings of those parameters exceeding standards.

Results for station 01389880-Passaic River at Elmwood Park, tend to overpredict nitrate and phosphorus concentrations during summer conditions. Data indicates that there is less loading in the stream than is present in the upstream effluent discharges. In a 1987 study of the Passaic River, NJDEP documented the reaches directly upstream of this station (Dundee Lake) as being highly eutrophic and having a noticeable degree of nutrient uptake. While additional data is needed to confirm this result, it currently suggests an upstream sink for at least these constituents. This finding should be considered and further explored in connection with future detailed analyses, such as in a TMDL analysis for WMA 4.

Findings suggest that the freshwater portions of the Passaic River and lower Saddle Rivers are effluent dominated with regard to total nitrogen, nitrate nitrogen, total phosphorus, and dissolved phosphorus. While a detailed analysis was not possible for total dissolved solids, chlorides, and sodium, preliminary results suggest both point source and non-point source influences. Non-point sources are likely the major contributors to in-stream BOD₅, TSS, and fecal coliform loads.

The above percentages indicate that point sources and non-point sources contribute significant percentages of the ammonia nitrogen loading. However, other processes, such

as the in-stream decay of ammonia, also have an important effect on in-stream concentrations and transported loads. While this effect was factored into this first-order analysis, its presence adds an additional degree of uncertainty to this result. Similar in-stream processes can also affect the concentrations of other parameters, such as BOD5.

Since the point source discharges in the Saddle River watershed upstream of Ho-Ho-Kus Brook are small, non-point sources are expected to be the major contributors to in-stream pollutant loadings in the upper part of the Saddle River watershed.

3. Data Gaps

Due to the large volume of data being collected by multiple agencies, the major waterways can be fairly well addressed with regard to an assessment of status. Additional data collection is desirable with regard to sensitive waterbodies, potable water intakes, lakes and lower-order streams. A central repository should be established for all pertinent data.

With regard to specific parameters, it was noted that there was a lack of consistent data with respect to Total Suspended Solids and chlorophyll-a due to an intermittent test schedule at most stations. These two parameters should be sampled on a regular (preferably monthly) basis. The existing monitoring network appears to adequately represent the water quality in the major streams in the watershed. However, sampling should be coordinated between the different agencies in order to develop a more consistent and comprehensive database.

Nitrate data was available for only about 25% of the treatment facilities and then only for the final 6-18 months of the simulation period. For the analysis presented in this report, the missing data was replaced with the facility mean concentration if available or, otherwise, with the mean of all available data. Additional effluent nitrate data is desirable to better refine this procedure. A more comprehensive set of nutrient data should be collected at wastewater treatment plants. It would also be desirable to acquire additional effluent data related to certain other parameters such as TDS, chlorides, and sodium.

The procedures utilized are highly dependent of accurate flow data – particularly under low flow conditions. Data from some streamflow monitoring sites in upstream watersheds of WMA 3 and WMA 6 suggests the presence of seasonal hydrologic sinks during which observed streamflows could be less than observed upstream inputs. Additional work is need to verify and quantify the presence of these sinks which may be due to evapotranspiration from adjacent wetland areas or groundwater withdrawals for water supply purposes.

Neither the available data nor the preliminary analysis provides much insight into the level of biological productivity within the subject streams. Studies of in-stream productivity often require the use of both long-term and short-term (intensive) data

collection to evaluate conditions. Additional work in this area will be needed if such issues need to be addressed.

The current study focused on conventional pollutants. Non-conventional ones were not included due to limited availability of historic data and/or questions related to its reliability. However, the WMA’s status with regard to such parameters can be a source of concern. Future sampling may be conducted to address these concerns – all such sampling should make use of the current “clean method” techniques.

Many of the GIS data sources accessed in preparation of this report are periodically correcting, updating and expanding their databases. Therefore there will be a need to periodically update the GIS database prepared for this study. There is significantly more GIS data available for the New Jersey portions of the WMA 4 watersheds than there is for the New York portions. Approximately 8 square miles, about 14%, of the total Saddle River watershed area is in New York. Future land use changes in New York can affect water resources in WMA 4 in New Jersey. Therefore it would be appropriate to make arrangements for sharing of pertinent data with New York agencies. This should be coordinated with data sharing for WMA 3, which has a tributary drainage area of about 140 square miles in New York.

D. KEY ISSUES

Watershed Management Area 4 (WMA 4) is highly developed throughout the watershed, with the density of development generally increasing in a north to south direction. The Passaic River runs in an inverted “V” shape roughly through the center of the watershed, and is tidal for a little less than half of its length in WMA 4. There are a high number of wells in the northern half of the watershed, and a small number of wells in the southern portion, with few wells in the central area. While most of the wells are located in areas with relatively high yielding bedrock aquifers, many are located in areas with high yielding surficial aquifers, generally following the river valleys, which are more readily affected by surface water conditions. There are numerous contaminated sites in WMA 4, many of which are located along the rivers. Most of the population in the central and southeastern portions of WMA 4 is dependent upon surface water supplies originating outside of WMA 4. Thus surface water issues affecting WMA 4 are complex, since they involve:

- Preservation of internal streams and lakes for ecological purposes, recreational use, and for protection of groundwater,
- Both freshwater and tidal regimes, and
- Concerns for surface water conditions outside of the WMA.

Some of the key issues regarding surface water quality in WMA 4 are described below.

1. Existing water quality impairments (“a” to “f” per NJDEP 2002 Integrated List, and “g” per NJDEP Category 5 List)
 - a. Passaic River at Elmwood Park - for total phosphorus, fecal coliforms, and several heavy metals (As, Cd, Cr, Cu, Pb, Hg, Ag, Th, Zn, Cn).

- b. Lower Passaic River & Estuary – for As, Hg
 - c. Passaic River at Little Falls - for total phosphorus, fecal coliforms, and several heavy metals (same as at Elmwood Park).
 - d. Passaic River at Singac – for total phosphorus, fecal coliforms, and several heavy metals (same as at Elmwood Park).
 - e. Saddle River at Fair Lawn – for total phosphorus, fecal coliforms, ammonia nitrogen.
 - f. Saddle River at Lodi – for total phosphorus and fecal coliforms.
 - g. Approximately 35 additional monitoring sites throughout WMA 4 (see Table 4.7.4 in Section 4.7) – for non-attainment of standards for aquatic life at many locations, fecal coliforms at several locations, total phosphorus or pH at a few locations.
2. Water quality issues/parameters not listed by NJDEP for WMA 4
- a. Passaic River Below Pompton River at Two Bridges – for nitrates (in addition to total phosphorus included above under 1.g.)
 - b. Passaic River, at and below Paterson – combined sewer overflows, floatables
 - c. Passaic River, Great Falls to Newark Bay – bank conditions
 - d. Passaic River, Dundee Lake – nutrient loadings
 - e. Passaic River (tidal reach, below Dundee Dam to Newark Bay) – fish consumption ban, dioxins in sediments and moving up the food chain, contaminated sediments moving downstream, debris, public access, wildlife habitat
 - f. Ho-Ho-Kus Brook – for fecal coliforms, nitrates, BOD
 - g. Saddle River – for nitrates, BOD
 - h. Celery Farm – non-point source pollution
 - i. Brewster Pond – nutrient loading, pesticides
 - j. Third River, Clarks Pond - sediment
 - k. Second River and Third River – debris, ecosystem health
 - l. Peckman River – debris, ecosystem health
 - m. Goffle Brook – ecosystem health, erosion control
 - n. Diamond Brook – erosion control, debris
3. Water Quality Assessment Findings (with respect to conventional parameters – DO, BOD₅, pH, total phosphorus, dissolved phosphorus, ammonia, nitrate, total nitrogen, TKN, fecal coliforms, total dissolved solids, total suspended solids, chlorides and sodium):
- a. Status Assessment
 - i. For most important parameters, highest concentrations were present along the lower portions of Singac Brook, Peckman River, Ho-Ho-Kus Creek, and the Saddle River.
 - ii. Somewhat lower, but still high, concentrations were also present along the freshwater portions of the Passaic River.

- iii. Generally low concentrations were present along the upper Saddle River and minor tributaries not listed above, except for elevated nitrate concentrations and fecal coliform counts.
 - iv. Fecal coliform exceedances common throughout WMA 4 with “unacceptable” ratings at 18 of 22 stations, and “marginal” values at the other 3. Median values were in exceedance of criteria for all stations in the freshwater zone and all but one in the tidal zone.
 - v. Total phosphorus “unacceptable” rating at 10 of 19 stations. Primary “acceptable” areas are along the upper Saddle River and minor tributaries (such as Diamond and Goffle Brooks).
- b. Trend Analysis
- i. Long-term reductions in the 1980s for ammonia and TKN concentrations (as much as 80% reduction noted), accompanied by increased (often doubling) concentrations for nitrates, except where less affected by wastewater treatment plant effluent.
 - ii. General, but less dramatic, improvements with respect to DO, BOD₅, total phosphorus and dissolved phosphorus.
 - iii. Steady increasing trend at all primary stations (except Saddle River at Ridgewood) for chloride. Similar, but less prominent increases for sodium and TDS concentrations. Concentrations significantly higher in winter (possible impact from road de-icing).
 - iv. Since early 1992 little change in overall water quality except for continuation of increase in chlorides.
- c. Loadings Assessment
- i. Two largest domestic wastewater dischargers (Wayne Twp. Mountain View and Northwest Bergen County facilities) together discharge 15.4 MGD, 70% of the total wastewater discharge.
 - ii. Cumulative mean of approximately 70.3 MGD of wastewater effluent is discharged to Passaic River Basin waterways upstream of entry of flow from the Passaic River and Pompton River into WMA 4.
 - iii. Analysis of wastewater effluent data and stream water quality data for 1997-2000 suggests the following preliminary breakdown between point source and non-point source contributions:
 - 1. For the Passaic River upstream of Dundee Dam, analysis suggests that:
 - a. Point sources contribute between 60% and 90% of the ammonia, nitrate, and total phosphorus.
 - b. Seasonal assessment indicates that point source contribution could be 5%-10% higher during a critical summer low flow period.
 - c. Point sources contribute less than 10% of BOD₅ loads – non-point sources are dominant for this parameter.
 - 2. For the Saddle River at Lodi:
 - a. Point sources contribute approximately 90% or more of the ammonia, nitrate and total phosphorus.

- b. Upstream major point source discharges, with total effluent flow exceeding 12 MGD.
 - c. Approximately 5% of the time, observed streamflows were less than the upstream wastewater discharge flow.
 3. For the Passaic River at Elmwood Park, review of data and analysis indicates potential upstream sink for nutrients (possibly Dundee Lake).
 4. Fecal coliform and TSS loads are attributed almost entirely to non-point sources (except for Saddle River at Lodi where point source contribution to TSS may be approximately 25% of the total).
 5. Existing data not sufficient to estimate relative contributions for TDS, chlorides and sodium. Seasonal (winter) increases point towards road de-icing, but there may also be point source contributions.
4. Water quality issues in WMA 3 and WMA 6, as they affect the quality of water entering WMA 4, or surface water for potable supplies used by communities in WMA 4.
5. Non-point source pollution from existing land use.
6. Contaminated sites
 - a. Concern that the contaminated groundwater may migrate to the streams
 - b. Concerns with surface runoff from contaminated sites
7. Lake management
 - a. Reduce nutrient loading
 - b. Reduce use of chemicals for weed control
 - c. Temperature and DO conditions, particularly in summer months
 - d. Sediment control
8. Cleanup of contaminated sites
 - a. Superfund sites (approximately 73 listed within WMA 4, including the Passaic River from Dundee Dam to Newark Bay)
 - b. Other contaminated sites (numerous listings in WMA 4)
9. Need for coordinate planning with agencies in New York with jurisdiction over the tributary areas in the Saddle River watershed.
 - a. Approximately 8 square miles in Rockland County, New York, in the Saddle River watershed is tributary to WMA 4. The flow enters New Jersey via approximately three separate streams.

E. MANAGEMENT APPROACHES

Watershed Management Area 4 Area-Specific Management Options

Note: The following WMA-Specific Options are intended to illustrate the potential implementation of goals and approaches discussed in Section 8, Parts 1 and 2, based on water quality findings. This is not intended as a “Management Plan”, which needs to be developed during project phases subsequent to this “characterization phase”.

Observations: re: Discharges – Passaic and Saddle Rivers

The results of the loading assessment suggest that much of the Passaic and Saddle Rivers are effluent dominated with regard to total nitrogen, nitrate nitrogen, total phosphorus, and dissolved phosphorus. Point source discharges contribute approximately 59% of the ammonia-N, 89% of TP, and 81% nitrate loads (based on the loading estimates to the Dundee Dam). Point source discharges become even more problematic during lower flow conditions during the summer growing season.

A distinct water quality improvement occurred during the period from the mid-1980's through the early-1990's. Improvements were detected for ammonia-N (which also reduces in-stream nitrogenous oxygen demand), TKN, BOD, and total phosphorus. The decreasing ammonia-N was accompanied by an increasing trend in nitrate nitrogen, suggesting that nitrification activity was shifted from the receiving stream to a treatment process. This has resulted in a serious water supply concern regarding nitrate concentrations, which approach 10 mg/L during low flow conditions. In-situ continuous data-logging of dissolved oxygen, pH, and conductivity, should be performed through an annual cycle to verify that adequate dissolved oxygen persists at all times (including the low-flow dark cycles) at several locations in the Passaic and Saddle Rivers.

Considering that less than 10% of the water load (i.e. the wastewater treatment plant effluent portion) contributes more than 59% of the ammonia, > 89% of TP, and > 80 % of the Nitrate loads to the WMA 4 River Resources (especially in the Passaic and Saddle Rivers), one management option that should be considered is improved wastewater treatment. An ambitious water conservation program is also suggested for consideration. The loadings from various wastewater treatment facilities vary widely. Dissolved Inorganic Nitrogen (DIN) / MGD varies from 123 to 246 lb DIN/MGD. Discharged phosphorus varies from 16 lb TP/MGD to 50 lb TP/MGD. The N:P ratio at discharges is variable and relatively low, from about 3.0 to over 9.3 (lb DIN/MGD : lb TP/MGD). “Water quality goals” (and/or surface water quality standards) should be established that adequately protect specific resources (for example, by stream order reaches). Major wastewater treatment plants should be designated highest priority for upgrading for significant improvement in water quality of river flow. All wastewater treatment plant discharges should collectively be improved to ensure compliance with water quality standards and goals during all flow regimes of receiving waters (especially lower flows). Phosphorus discharge reduction should be accomplished while maintaining a DIN:TP ratio well above 7.2 (mg:mg), maintaining nitrate concentrations below an achievable concentration (e.g. 4-6 mg/L), and maintaining dissolved oxygen

concentrations above the water quality standard/goal at all times. Some treatment processes and discharge quantities may need to be seasonal or flow-stage based.

Non-Point Sources

The loading assessment suggests that Flow, TSS, and BOD loading are strongly dominated by non-point loading sources. The long-term increasing trend for TDS, chlorides, and sodium are of concern. A comprehensive Non-Point Source program should be established. “Local disposal” and “first flush” techniques should be emphasized.

Lower Passaic River: Water supply concerns (especially at the existing supply intake at Little Falls) include concentrations of nitrate, phosphorus, TOC, and sodium. The lower reaches of the Passaic River are low gradient reaches, oxbow formations are apparent in several areas. During the summer low flow period the residence time increases and turbulent mixing decreases. The lower reaches of the mainstem rivers behave like shallow lakes during the summer and experience similar “eutrophication effects”. In-stream restoration measures should be examined, including restoring channel morphology via area/reach selective dredging, streambank stabilization, wing-wall structures to improve low flow hydrodynamics and increase the re-aeration coefficient, installation of habitat structures. The watershed areas in the lower mainstem river reaches are highly urbanized. Structural stormwater quality management systems may be feasible and prudent, especially for management of the first wash of the extensive impervious surfaces. Restoring the Lower Passaic, and Dundee Dam/Lake, to a condition suitable for passive recreational uses (linear parks, trails, etc.) and perhaps recreational fishing should be considered for this urbanized area of Northern New Jersey.

Glacial Lake Passaic (WMA 3, 4, and 6): Approximately 15,000 to 25,000 years ago, the Wisconsin Glacier reached its southern extreme and began to withdraw. The meltwater created a great lake approximately 200 ft deep, 30 miles long and 10 miles wide, extending from the area now known as the Great Swamp to the Little Falls Gap and the Great Falls in Patterson. Glacial Lake Passaic resulted in the deposition of impermeable clays and silt over sand and gravel aquifers. Today, extensive wetland resource areas exist where the ancient Glacial Lake Passaic once was, including the Great Swamp, Black Meadows, Great Piece Meadows, Lee Meadows, Troy Meadows, and Hatfield Swamp. Preservation of these wetland resources, and associated upland habitat areas is very important. Impact potential includes changes in peak runoff and increased flooding of wetland areas due to increased development and impervious areas.

Stormwater management is essential to maintain historic peak flow, baseflow conditions, and prevent increased inundation frequency or intensity. Loading of sediments and nutrients are also of concern in the “Glacial Lake Passaic Region” as increased loading would cause reduced water storage capacity, excessive growth of algae and plants, and changes in floristic composition (altering habitat structure). During the development of a “Watershed Management Plan”, subsequent to this characterization phase study, the “Glacial Passaic Lake Region” from the Great Swamp to Great Falls in Patterson, should be closely examined to establish adequate protective measures for extensive wetland

resource areas and river corridors. Some of the important potential impacts, and management options for resource protection, include:

- *Increased Flooding* (frequency and intensity) – Stormwater management to prevent increased peak flow and to maintain adequate baseflow; consider managed turf areas (lawns, golf courses, etc.) as impervious areas during stormwater system design.
- *Aquifer Contamination* – preserve critical recharge areas and river riparian corridors by land acquisition, purchase of development rights, and protective easements.
- *Nutrient and Sediment Loads* – Identify sensitive nutrient-poor wetland areas (ombrotrophic bog formations, etc.), map floristic composition in sensitive wetland areas, develop stormwater management programs and regulations to protect against sediment and nutrient enrichment (local disposal of storm runoff, first flush approaches, sediment collection systems, created wetland systems for runoff water quality renovation). Collectively review discharges, and improve treatment of discharged waters to ensure compliance with NJ-SWQS during all flow regimes.

Other WMA 4 Water Resources: Identification of specific goals and management approaches for all water resources is beyond the scope of this “characterization phase”. Indeed, individual water resources (lakes, reservoirs, stream order reaches) will need specific and individual study and evaluation in order to make informed management decisions. The information contained in Parts 1 and 2 (Sections 8.1 and 8.2) describe potential approaches to be examined.