Hydrologic Assessment

Executive Summary

ES.1 Introduction

In 1994, Massachusetts embarked on a new approach to environmental management – the Watershed Initiative. Because the initiative involves the state's coordination of its decision-making process across regulatory programs, the multi-disciplinary Basin Teams were created with the goal of understanding watersheds and the impacts of decisions from various regulatory programs. This study was prepared for and funded by the Massachusetts Executive Office of Environmental Affairs on behalf of the Nashua River Watershed Team in response to DEM RFR #450, as part of the Massachusetts Watershed Initiative. The work was completed by Camp Dresser Mckee (CDM) in June 2002.

Available water is a critical component for the future of Nashua River watershed residents and for protection of aquatic resources. Despite being in a water-rich region, many rivers in Massachusetts are severely flow stressed. This project provides the foundation on which future water use decisions can be made in the Nashua River watershed.

The relationship of water withdrawal and wastewater discharge and their effect on river flow is the main objective of this study. In addition, this report examines the effects of future population growth and the associated demand for additional water supply sources and increase in wastewater flow.

The tasks set forth in this report are similar to the river basin plans historically produced by DEM in conjunction with other state and regional planning agencies. The findings of this report are intended to be used as a basis for water management and wastewater discharge permitting and to assess the potential impacts to biological resources of the watershed that may result from consumptive uses of water.

ES.2 Watershed Description

The Nashua River watershed is 538 square miles in area and contains all or part of 31 communities. Seven of the communities are in New Hampshire and the remaining 24 communities are in Massachusetts. Figure ES-1 presents the Nashua River watershed. The communities include older, urbanized cities such as Leominster and Fitchburg and smaller, rural towns such as Ashby and Princeton. The population of many of the towns in the watershed is increasing rapidly, with some having growth rates of 20% predicted over the next twenty years. Flows associated with Devens are accounted for in the flows of the four local communities that make up Devens.

ES.3 Water Supplies

The headwaters of the Nashua River contain Wachusett Reservoir, a major water supply for the metropolitan Boston area. In addition, the City of Worcester has several reservoirs in the headwaters of the Nashua River, which that city uses as water supply. Nineteen communities in the watershed withdraw water either from groundwater wells or from surface water reservoirs for public water supplies. Future growth in these communities will put greater demand on the water resources in the Nashua River.

The existing water suppliers withdraw 183 mgd annually from the groundwater and surface waters in the watershed, or 25.7 mgd if Worcester's and MWRA's water supplies are excluded. The water need for communities with supplies in the watershed is forecasted to increase to 187 mgd in the year 2020 or 29.7 mgd if Worcester and MWRA water supplies are not included.

Currently, 23.8 mgd of water is distributed in water service areas annually in the basin by the public water suppliers. This amount is forecasted to increase to 28.3 mgd in the year 2020.

The assessment of water conservation by the public water suppliers found room for improvement. Two metrics, residential water use of 80 gpcd or less and unaccounted for water (UAW) of 15 percent or less, were used to evaluate the water conservation programs for each public water supplier. Five out of 25 water suppliers exceeded the residential benchmark of 80 gpcd. Eight water suppliers exceeded the UAW benchmark of 15%. In most cases, the water supplier explained the high UAW in the Annual Statistical Report (ASR) submitted to the Department of Environmental Protection. Additionally, seven public water suppliers reported UAW 5% or less, which is unlikely to be accurate.

ES.4 Water Supplies at Risk

An evaluation was performed to identify public water supplies that are in proximity to either a Massachusetts Contingency Plan (MCP) site or solid waste facility. A ranking system was developed based on the proximity and the risk posed by the site to the water supply. Six community water supplies and three non-community water supplies were considered to be at risk from either a nearby MCP site or a solid waste facility.

ES.5 Wastewater Discharges

Seventeen communities have wastewater collection systems in the watershed. A total of 25.0 mgd of wastewater is collected annually in the watershed. The amount of wastewater collected is forecasted to increase to 32.7 mgd in the year 2020. Currently, four communities export wastewater from the watershed: Ashburnham and Gardner (to Gardner's Wastewater Treatment Plant in the Millers River watershed), and West Boylston, Holden and Rutland (to Worcester's Upper Blackstone wastewater treatment plant).

The Nashua River and its tributaries receive the discharge of wastewater from seven public wastewater treatment plants. Three wastewater treatment plants discharge to the North Nashua River. Wastewater treatment plants also discharge to the main stem of the Nashua River.

The North Nashua River is a good example of the impact of water withdrawal and wastewater discharge. The headwaters of the North Nashua River contain numerous water supply sources, both groundwater and surface water reservoirs. Water is withdrawn from these headwater sources and discharged downstream at the municipal-owned wastewater treatment plants of Fitchburg and Leominster.

ES.6 Inflow/Outflow Analysis

An inflow/outflow analysis for the Nashua River was performed. The watershed was divided into 27 separate subareas, which were used to calculate the water balance

at a small scale. This process was performed to determine areas of the watershed that may be subject to diminished river flow, as well as areas that may have the potential for additional withdrawal. The 27 subareas have been grouped into five separate subwatersheds: the Wachusett, North Nashua River, Squannacook River, Nissitissit River, and main Nashua River.

The approach used in the inflow/outflow analysis was to tally the sources and uses of water in each subarea. Information was collected on the location of water supply withdrawals, water distribution and wastewater collection service areas, and areas where wastewater discharge. Annual, August, and winter demand periods were evaluated.

Annual 2000

The 2000 annual inflow/outflow analysis shows a net gain of 0.7 mgd for the Nashua River watershed or a net loss of 156.5 mgd when MWRA's and Worcester's water withdrawals are included.

The findings for individual subareas in the watershed are more telling. Of the 27 subareas in the watershed, only eight have a net gain of flow, and 19 subareas have a net loss of flow. Of the eight subareas that gain flow, five of these subareas gain flow from having a wastewater treatment plant discharge in the subarea.

August 2000

For this scenario, there is a net loss of 1.1 mgd for the Nashua River watershed or a net loss of 165.9 mgd if MWRA's and Worcester's withdrawals are included.

Water withdrawn in August (29.8 mgd) is 3.5 mgd greater than the average annual volume (26.3 mgd), primarily to meet the greater summer water demand.

Of the 27 subareas in the watershed, 9 have a net gain of water and 18 have a loss of water.

Annual 2020

For this scenario, there is a net gain of 0.3 mgd for the Nashua River watershed or a net loss of 157.2 mgd if MWRA's and Worcester's withdrawals are included.

Water withdrawn (30.0 mgd) predicted in 2020 will increase by 3.7 mgd over the annual amount withdrawn (26.3 mgd) in 2000 primarily to meet the increase in water demand.

Wastewater collection is forecast to increase from 25.0 mgd in 2000 to 29.9 mgd in 2020, an increase of 4.9 mgd.

Of the 27 subareas in the watershed, 9 have a net gain of water and 18 have a loss of water.

August 2020

For this scenario, there is a net loss of 1.9 mgd for the Nashua River watershed or a net loss of 167.4 mgd if MWRA's and Worcester's withdrawals are included.

Water withdrawals (34.3 mgd) predicted in 2020 will increase by 4.5 mgd over the August 2000 withdrawn amount withdrawn (29.8 mgd) in 2000, primarily to meet the increase in water demand.

Wastewater collection is expected to increase from 20.3 mgd in 2000 to 24.7 mgd in 2020, an increase of 4.4 mgd.

Of the 27 subareas in the watershed, 9 have a net gain of water and 18 have a loss of water.

ES.7 Subarea Flow and Stream Flow

The average August and 7Q10 flows, for existing and future scenarios, were compared with predicted virgin flows in order to approximate the level of stress of each subbasin. DEM guidelines, as described in the draft memorandum: *Stressed Basins in Massachusetts* (Office of Water Resources, February 26, 2001) were followed to estimate the stress level of each subbasin.

The DEM has defined three hydrologic stress classifications:

High-Stress: net outflow equals or exceeds estimated natural August median flow

Medium-Stress: net outflow equals or exceeds estimated natural 7Q10 flow

Low-Stress: no net loss to the sub-basin.

Based on these classifications, the stress levels for each subarea were determined for existing conditions (year 2000) as well as predicted conditions in the year 2020.

Following the DEM stress classification system,
One subarea—Flag Brook—is predicted to be highly stressed (net withdrawals exceeding median August flow) in the Nashua River Basin under either existing condition. Additionally, Monoosnoc Brook is predicted to be highly stressed in the future (2020).

Seven subareas are predicted to have medium stress under existing conditions (net outflow equal/exceeding natural 7Q10): Quinapoxet River 2, Wachusett Reservoir, Monoosnoc Brook, Falulah Brook, Fall Brook, Wekepeke Brook, and Mulpus Brook. In the future (2020), Quinapoxet River 1 and Catacunemaug Brook are expected to be added to the medium stress list.

It is important to note that a large number of the subareas predicted to have some form of stress also contain multi-month reservoirs. These reservoirs are capable of storing large flows in the spring and holding them for use during low flow periods in late summer. Because of the stored volume, the impact of large demands in these basins may not be as great as the stress-classification system implies; it is possible that normal low flows are still being released from these reservoirs. To properly determine the stress levels in these basins, a more detailed study of each subarea is required.

Because the Wachusett watershed is highly managed for the Worcester and MWRA withdrawals, these withdrawals were not considered in the evaluation of stress in the Wachusett Watershed—a much more detailed analysis would be required to evaluate their uses. Instead, the calculations were based on other uses of water in the watershed, particularly withdrawals by Holden, Rutland, Princeton, Sterling, and West Boylston. Based on these withdrawals, three of the four subareas in the Wachusett Watershed were calculated to have medium-stress in the future.
This definition of stress is for water supply purposes. Stress can also be induced on aquatic life from poor water quality, loss of habitat, and for flow reductions less than those defined above.

ES.8 Recommendations
The findings indicate that 11 of the 27 subareas in the Nashua River watershed are or will be either high stressed or medium stressed under the DEM classification system. The stressed subareas are predominately in the Wachusett and North Nashua subwatersheds. The following is recommended for the stressed subareas:

More detailed inflow/outflow analysis to assess the water balance of the multi-month reservoirs.

Critical review of any additional water supplies that may be sought in the stressed subareas.

Emphasis on development and implementation of water conservation plans for communities with supplies in the stressed subareas, especially for those communities that do not meet the benchmark levels.

Assessment of aquatic habitat impacts from worsening flow stresses.

Critical review of any additional sewering in the basin, especially sewering that moves water out of a stressed subarea or out of the basin.

Wastewater reuse or artificial recharge of wastewater discharges should be considered for any WWTP expansion in stressed subareas.

Additional detail for most impacted sub-basins

Quinapoxet River (upper reaches – from the Quinapoxet Reservoir up)
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Quinapoxet sub-basin is currently under a medium level of stress. With continued withdrawals over the next 20 years, the entire Quinapoxet sub-basin will be experiencing flow stress. The upper reaches as defined above will remain under "medium stress". The lower reaches (remaining portion discharging directly to Wachusett reservoir) will also be under medium stress.

Medium stress means that the net 7Q10 outflow from the sub-basin equals or exceeds the estimated natural 7Q10. 7Q10 is the lowest consecutive 7 day streamflow that is likely to occur in a ten year period in a particular river segment.

High stress means that the net average August outflow from the sub-basin equals or exceeds the estimated natural August average flow.

For the Upper Quinapoxet:
The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.275 MGD (million gallons/day) and the existing 7Q10 is (- 0.718 MGD). In other words - if the Quinapoxet had never been developed 0.275 MGD should be passing through during a

seven day - 10 year low. However, the real seven day - 10 year low is (- 0.718 MGD) - meaning it would be drawing from the aquifer for the discharge.

The calculated average August virgin flow 3.460 MGD and the existing average August flow is 2.467 MGD - a deficit of about 29%

The calculated 2020 average August virgin flow remains the same 3.460 MGD and the 2020 average August flow is 2.078 MGD - a deficit of about 40%

For the Lower Quinapoxet (below the Quinapoxet Reservoir): which is currently considered under "low stress"
The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.567 MGD (million gallons/day) and the existing 7Q10 is 0.188 MGD. In other words - if the Quinapoxet had never been developed 0.567 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is 0.188 MGD.

The calculated average August virgin flow 7.123 MGD and the existing average August flow is 6.744 MGD - a deficit of about 5%.

The calculated 2020 average August virgin flow remains the same 7.123 MGD and the 2020 average August flow is 6.230 MGD - a deficit of about 15%. Putting the lower Quinapoxet into a category of "medium stress"

Wachusett Reservoir (see above note about reservoir operations)
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Wachusett sub-basin is currently under a medium level of stress. With continued development and withdrawal pressures, the sub-basin will continue as "medium stress" by the year 2020. It should be noted that while there is a minimum flow requirement for discharge over the Wachusett Dam, local and regional water suppliers need to recognize the importance of continuing demand for supply on the reservoir

This means that the net 7Q10 outflow from the sub-basin equals or exceeds the estimated natural 7Q10. 7Q10 is the lowest consecutive 7 day streamflow that is likely to occur in a ten year period in a particular river segment.

The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.357 MGD (million gallons/day) and the existing 7Q10 is 1.824 MGD. In other words – if the Wachusett had never been developed 0.357 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is 1.824 MGD. Note, the Massachusetts Water Resources Authority is required to maintain a minimum release of about 1.8 MGD over the Wachusett Dam.

The calculated average August virgin flow 4.485 MGD and the existing average August flow is 2.181 MGD - a deficit of about 51%.

The calculated 2020 average August virgin flow remains the same 4.485 MGD and the 2020 average August flow is 1.621 MGD - a deficit of about 64%.

Flag Brook: (see above note about reservoir operations)
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Flag Brook sub-basin is currently under a high level of stress, and will continue a high level of stress into 2020.

This means that the net average August outflow from the sub-basin equals or exceeds the estimated natural August average flow.

The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.689 MGD (million gallons/day) and the existing 7Q10 is (-3.935) MGD. In other words - if Flag Brook had never been developed 0.689 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is (-3.935) MGD - meaning it would be drawing from the reservoirs and aquifer for the discharge.

The calculated average August virgin flow 4.255 MGD and the existing average August flow is (-0.369) MGD - a deficit of over 109%.

The calculated 2020 average August virgin flow remains the same 4.255 MGD and the 2020 average August flow is (-0.818) MGD - a deficit of over 120%.

Monoosnoc Brook
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Monoosnoc sub-basin is currently under a medium level of stress, but it is bordering on a high level of stress. Looking ahead to the year 2020, the Monoosnoc is placed under a high level of stress.

This means that the net 7Q10 outflow from the sub-basin equals or exceeds the estimated natural 7Q10. 7Q10 is the lowest consecutive 7 day streamflow that is likely to occur in a ten year period in a particular river segment under current conditions.

And in the 2020 projection for a high stress level, the net average August outflow from the sub-basin equals or exceeds the estimated natural August average flow.

The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.622 MGD (million gallons/day) and the existing 7Q10 is (-2.519) MGD. In other words - if the Monoosnoc had never been developed 0.622 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is (-2.519) MGD - meaning it would be drawing from the aquifer for the discharge.

The calculated average August virgin flow 3.840 MGD and the existing average August flow is 0.699 MGD - a deficit of about 82%.

The calculated 2020 average August virgin flow remains the same 3.840 MGD and the 2020 average August flow is (-0.194) MGD - a deficit of over 100%

Fall Brook
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Fall Brook sub-basin is currently under a medium level of stress. Looking ahead to the year 2020, Fall Brook remains under a medium level of stress.

This means that the net 7Q10 outflow from the sub-basin equals or exceeds the estimated natural 7Q10. 7Q10 is the lowest consecutive 7 day streamflow that is likely to occur in a ten year period in a particular river segment.

The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.393 MGD (million gallons/day) and the existing 7Q10 is (-0.277) MGD. In other words - if Fall Brook had never been developed 0.393 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is (-0.277) MGD - meaning it would be drawing from the aquifer for the discharge.

The calculated average August virgin flow 2.426 MGD and the existing average August flow is 1.756 MGD - a deficit of about 28 %.

The calculated 2020 average August virgin flow remains the same 2.426 MGD and the 2020 average August flow is 1.573 MGD - a deficit of about 35%

Wekepeke Brook
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Wekepeke sub-basin is currently under a medium level of stress. Looking ahead to the year 2020, Wekepeke Brook remains under a medium level of stress.

This means that the net 7Q10 outflow from the sub-basin equals or exceeds the estimated natural 7Q10. 7Q10 is the lowest consecutive 7 day streamflow that is likely to occur in a ten year period in a particular river segment.

The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.125 MGD (million gallons/day) and the existing 7Q10 is (- 0.712) MGD. In other words - if the Wekepeke had never been developed 0.125 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is (- 0.712) MGD - meaning it would be drawing from the aquifer for the discharge.

The calculated average August virgin flow 5.254 MGD and the existing average August flow is 4.416 MGD - a deficit of about 15%.

The calculated 2020 average August virgin flow remains the same 5.254 MGD and the 2020 average August flow is 4.211 MGD - a deficit of about 20%

Mulpus Brook
Based on recent findings in an Hydrologic Analysis (inflow/outflow) by Camp, Dresser, Mckee, under contract with EOEA for the Massachusetts Watershed Initiative Nashua Team, the Mulpus Brook sub-basin is currently under a medium level of stress. Looking ahead to 2020, the Mulpus remains under a medium level of stress.

This means that the net 7Q10 outflow from the sub-basin equals or exceeds the estimated natural 7Q10. 7Q10 is the lowest consecutive 7 day streamflow that is likely to occur in a ten year period in a particular river segment.

The calculated 7Q10 virgin flow (estimated undeveloped or pre-development) is 0.173 MGD (million gallons/day) and the existing 7Q10 is (-0.396) MGD. In other words - if Mulpus Brook had never been developed 0.173 MGD should be passing through during a seven day - 10 year low. However, the real seven day - 10 year low is (-0.396) MGD - meaning it would be drawing from the aquifer for the discharge.

The calculated average August virgin flow 7.233 MGD and the existing average August flow is 6.665 MGD - a deficit of about 7.8%.

The calculated 2020 average August virgin flow remains the same 7.233 MGD and the 2020 average August flow is 6.646 MGD - a deficit of about 8.1%.

Tables
Table 8-5, page 8-19 Existing (2000) Stress Level
Table 8-6, page 8-20 Predicted (2020) Stress Level

Maps:
Figure 6-4, page 6-21 August (2000) Water Balance
Figure 6-7, page 6-33 August (2020) Water Balance