The Commonwealth of Massachusetts
WATER RESOURCES COMMISSION

STRESSED BASINS IN MASSACHUSETTS

Approved December 13, 2001

Introduction

The 1999 work plan for the Massachusetts Water Resource Commission (WRC) directs an interagency committee to define a stressed river basin. The WRC has assumed this task in response to the large amounts of time and money regulators and project proponents must invest when trying to evaluate the potential environmental impacts of a project with limited background information on the natural resources of a site. In developing a definition of stressed basins the committee has produced an outline of the information which would identify an area as weak and an interim list of environmentally vulnerable (stressed) basins. The stressed basin classification is intended to flag areas which may require a more comprehensive and detailed review of environmental impacts or require additional mitigation. This information will speed up the process of project review for regulators.

This report summarizes the work of the committee and presents the general conclusions reached by the committee. It also includes more specific recommendations developed by DEM and EOEA staff for future work.

General Conclusions

- A definition of stress includes streamflow quantity, quality and habitat factors

- A lack of adequate quality, biological and hydrological data has necessitated the development of a method to define quantitative stress which was applied at the major basin and major sub-basin level.

- A second method has been developed to determine quantitative stress for a tertiary or secondary sub-basin which can be easily applied on a site specific basis, but has not been applied statewide as part of the classification developed under the first method.

- The second method should be used to refine basin stress classifications for tertiary or secondary sub-basins wherever possible

Limitations

- The committee recognizes that there are quality and habitat stresses and strongly recommends that the interim methods be used only as a first cut to determine hydrological stress.
- The delineation of stressed basins on a large scale is only a relative determination based on a comparison of measurements for Massachusetts' Rivers.
- The downstream gage data is not a good indicator of the condition of the entire basin. Headwater streams may be stressed even though the downstream data indicates no problems.
- The delineations are intended for highlighting areas needing further study and for defining mitigation for potential projects. Delineations are not intended to be used in any other way.
- The flow values used as criteria to define stressed basins are relative values and are not related in any way to habitat needs.
- The basin method using the stream gage data delineates rivers with low flows, relative to other basins, but does not indicate whether the cause is natural or man-made.

Definition of Stress

A stressed basin is defined as a basin or sub-basin in which the quantity of streamflow has been significantly reduced, or the quality of the streamflow is degraded, or the key habitat factors are impaired.

- **Quantity**: A significant reduction in streamflow is defined as a decrease in key low and high streamflow statistics. Low flows in most of Massachusetts reflect ground water levels and are a good indicator of the health of a system. Reduced low flows can impact aquatic habitat and water quality. In addition, low flows are often the first indicator of environmental impacts. However, where flood skimming operations or dam regulations occur, reductions in high flow statistics can be also be significant.

- **Quality**: A degraded water quality is defined as water in a stream that does not meet surface water quality standards.

- **Habitat Factors**: A degraded habitat is defined as a river reach in which key habitat factors, such as temperature, quality, cover, substrate and accessibility, necessary to sustain a biologically diverse community are degraded. The stress can be due to a lack of streamflow, quality degradation, presence of dams, channel modifications, culverting and other factors. Indicators of stressed habitat include the absence or degradation of a target fish or other aquatic community or the absence of the ability of fish to move between multiple habitats necessary to their life cycles. Factors that limit movement include lack of flow, or reaches with no flow, and the presence of dams or other restrictions that prevent passage.

In developing the stress definition, the committee reviewed many types of raw data as well as existing methods used to evaluate environmental impacts (a summary of the data and methods is included in Appendix 1). The committee put together the indicators of stress for which data is currently available or for which easy to use methods are available. The committee determined that there is sufficient information to use the quantity, quality and habitat criteria in a matrix to define sub-basin stress on a case by case basis. A sub-basin for which 1 or more of the criteria are met, would be determined to be stressed. Other factors which are important to quality, quantity and habitat have not been included in this definition because they are not currently available except through site specific field work. For example, habitat can be characterized by assessing cover, substrate riffles and temperature, however this data is only available through intensive field work.

Available Data and Methods

The following summarizes the information which is recommended for defining stress for the quantity, quality and habitat criteria:

- **Quantity**: A significant reduction in streamflow can be estimated by comparing the net amount of water lost from a sub-basin to a range of natural streamflow levels. The net water loss (or gain) can be determined by developing a hydrologic budget for the subbasin. The net water lost or gained can then be compared to estimated natural streamflows to determine the change in flow. This method is based on the inflow/outflow method used by DEM in the River Basin Plans. It is outlined in detail on Page 23.

- **Quality**: A degraded water quality can be determined by using the existing data on water quality included in the state's 303d list. This list of impaired waters is available on the DEP internet site in text form.

- **Habitat Factors**: Degraded habitat factors can be evaluated by reviewing presence/absence data for fisheries available in hard copy form from DFWELE. In addition a preliminary list of dams which impede fish passage is available in the 1998 303d list. Where sufficient data is available the presence/absence of a target fish community can also be used to determine habitat impairment (target fish community as defined by Bain and Meixler, 2000, see Attachment 3).

Early in the review process, the committee realized that a lot of the data is available only in hard copy form. A lack of computerized data make it impossible to delineate stressed sub-basins statewide in a timely manner. Therefore the committee completed a preliminary statewide assessment of quantitative stress on a basin scale using existing computerized flow data. In addition the committee developed a method which incorporates portions of the definition for interim use until a statewide assessment on a sub-basin level is possible.

Interim Methods for Applying the Stress Definition

This section outlines two methods to delineate **hydrologic** stress. Hydrologic stress focuses on the quantity criteria of the stress definition. Because streamflow is a basic requirement for quality and habitat factors selection of the hydrologic stress was deemed appropriate. The first method provides a first cut delineation of stress for large scale river basins and sub-basins across the state using stream gage data. The second method can be used by project proponents to determine whether smaller sub-basins are hydrologically stressed.

<u>Interim Method to Delineate Hydrologically Stressed Basins</u>

The interim method to delineate hydrologic stress for river basins involves the comparison of low flow statistics for 72 stream gages in Massachusetts (Figure 1 and Table 1). For the purposes of stressed basins, hydrologic stress is defined as the **relative** strength of rivers in Massachusetts. The numbers derived for this method are not useful outside of Massachusetts and are not based on habitat or quality needs. The hydrologically stressed basins represent the rivers with the lowest flows (per square mile of drainage area) in Massachusetts.

Most rivers and streams in Massachusetts have low flows in the summer, which are maintained by baseflow (groundwater discharge) to the stream between rainfall events. Streamflow during base flow events can be used as an indicator of the health of the sub-basin's ground water and surface water systems. In a few cases in Massachusetts, aquifers are confined and do not supply flow to streams, for example aquifers along portions of the Hoosic River. For the purposes of this report it will be assumed that base flow is maintained by groundwater and that a lack of sufficient base flow is due to a lack of aquifer material or to man made impacts.

The interim stressed basin method incorporates statistics used by the Nature Conservancy in the Indicators of Hydrologic Alteration (IHA). The IHA analysis produces 33 statistics for a stream gage. The IHA procedure involves determining whether the median of flow statistics for a river have been significantly changed over time. However the IHA analysis, which looks at changes in flow statistics due to a known stress, was not applied. In addition the program evaluates the daily streamflow values as compared to the values of the 25th and 75th percentiles for each statistic.

For the purposes of the stressed basin analysis, it is assumed that the median values of certain statistics, provided by the IHA program, are useful for comparing one river to another. Three low flow statistics are chosen: median of annual 7-day low flow, median of annual 30-day low flow and median of low pulse duration (see IHA web site for more detailed description of parameters at www.tnc.org). The median of the annual 7-day and 30-day flow statistics for each gage are calculated and converted to a unit of flow per square mile of drainage area (cfsm). The low pulse duration in days is also calculated. The median values for the gages are then sorted and ranked (Tables 2-4). Three lists of median flows are developed, one for each statistic. The quartiles of the medians for each statistic are then calculated. The quartiles of the median are used as the thresholds in classifying the relative strength (high, medium, low) of the basin for each flow statistic. For low flow statistics, a classification of high is given to values below the 25th percentile, low is given to values above the 75th percentile and medium is given to values between the 25th (Figures 2-4) and 75th percentiles (the thresholds for high and low are reversed for the low pulse duration). A matrix of the statistics is developed (Table 5). Gages with high values for 2 (or 3) out of 3 statistics are considered stressed.

A number of statistics were evaluated for use in the classification in addition to the 7-day low flow, 30-day low flow and low pulse duration. However, many of the statistics resulted in the same ranking of gages within the high, medium and low classifications. The data was checked for trends, which would indicate the median for any gage is not indicative of current conditions. Trends were assessed using regression equations (which have limited use due to the high variability of flow) and graphical interpretation. Adjustments to the classifications are made where recent trends indicate the gage should be in a different group.

A list of high, medium and low gages is shown in Table 6. A map of these basins are presented in Figure 5. The gage information and data used in the analyses are also included in Table 1. Gages used in the analysis have at least 25 years of data, and 67% of the gages have over 50 years of data. Some gages have been discontinued. However, 67 gages have data through at least 1990. Most gages included part or all of the 1960's drought. Although inclusion of the drought period does not impact results because median values for the period of record are being used.

Figure 1 – map of gages used in stressed basin analysis

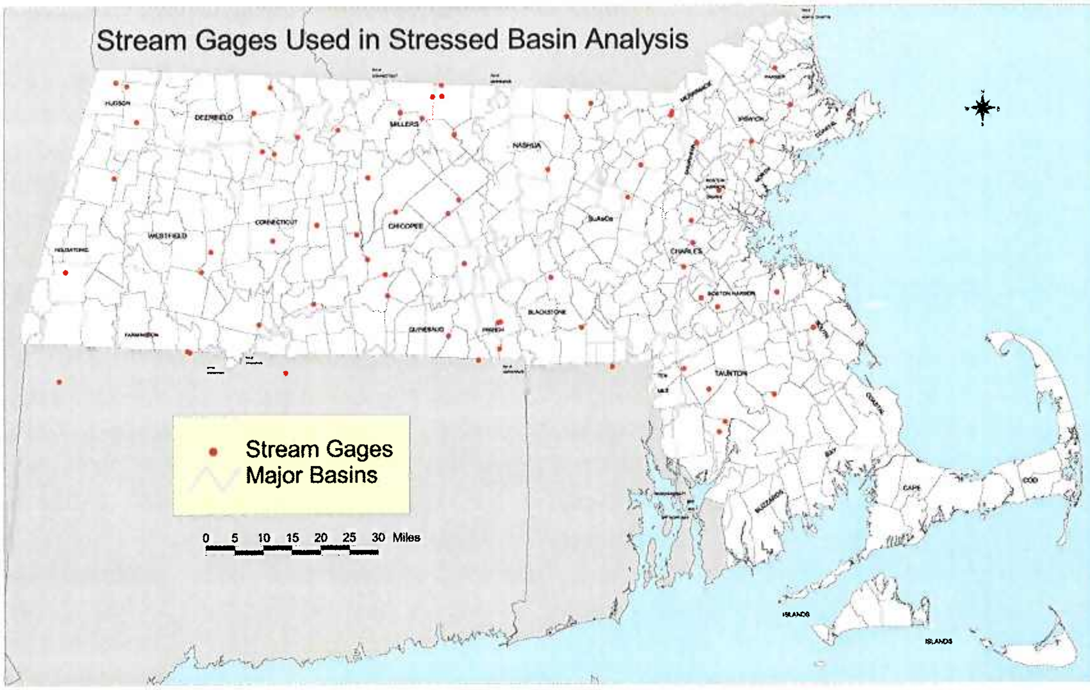


Table 1. - List of gages used in stressed basin analysis

Station #	Station Name	Drainage Area	Start Year	Stop Year	Period of Record** (yrs)
01102500	Aberjona River at Winchester*	24.7	1939	1997	59
01097000	Assabet River at Maynard	116.0	1941	1997	57
01112500	Blackstone River at Woonsocket	416.0	1929	1997	69
01174900	Cadwell Creek nr. Belchertown	2.55	1962	1997	36
01103500	Charles River at Dover	183.0	1938	1997	60
01104500	Charles River at Waltham*	250.6	1931	1997	67
01104200	Charles River at Wellesley	211	1960	1999	40
01177000	Chicopee River at Indian Orchard	689	1929	1999	71
01099500	Concord River below R. Meadow at Lowell*	400.0	1904	1997	94
01170500	Connecticut River at Montague	7860.0	1929	1997	69
01184000	Connecticut River at Thompsanville CT	9660.0	1929	1999	71
01168500	Deerfield River at Charlemont	361	1914	1999	86
01170000	Deerfield River nr. West Deerfield	557	1941	1999	59
01197000	E. Br. Housatonic River at Coltsville	57.6	1936	1997	62
01105500	East Br. Neponset River at Canton	27.2	1953	1999	47
01174500	East Br. Swift River nr. Hardwick	43.7	1937	1997	61
01165000	East Branch Tully River nr. Athol	50.5	1917	1990	74
01171300	Fort River nr. Amherst	36.3	1967	1996	30
01124350	French River at Hodges Village	31.2	1963	1990	28
01125000	French River at Webster	84	1950	1981	32
01333000	Green River at Williamstown	42.6	1950	1999	50
01170100	Green River nr. Colrain	41.4	1968	1999	32
01332500	Hoosic River nr Williamstown	126.0	1940	1997	58
01331500	Hoosic River nr. Adams	46.7	1932	1999	68
01174000	Hop Brook nr. New Salem	3.39	1948	1982	35
01199000	Housatonic River at Falls Village CT	634.0	1913	1999	87
01197500	Housatonic River nr. Great Barrington	282.0	1913	1997	85
01187300	Hubbard River near West Hartland CT	19.9	1939	1999	61
01105730	Indian Head River at Hanover	30.3	1967	1999	33
01101500	Ipswich River at S. Middleton	44.5	1938	1997	60
01102000	Ipswich River at Ipswich	125.0	1930	1997	68
01105870	Jones River at Kingston*	19.8	1967	1999	33
01124500	Little River nr. Oxford	26	1940	1990	51
01100000	Merrimack River below Concord R. at Lowell*	4635.0	1923	1997	75
01171500	Mill River at Northampton	54	1939	1999	61
01166500	Millers River at Erving	372	1916	1999	84
01164000	Millers River at South Royalston	189	1940	1990	51
01162000	Millers River nr. Winchendon	81.8	1917	1999	83
01097300	Nashoba Brook nr. Acton	12.8	1963	1997	35
01096500	Nashua River at E. Pepperell	435.0	1936	1997	62
01105000	Neponset River at Norwood	34.7	1940	1997	58
01094500	North Nashua River nr. Leominster	110	1936	1999	64
01169000	North River at Shattuckville	89.0	1940	1997	58
01105600	Old Swamp River nr. S. Weymouth	4.5	1966	1997	32
01163200	Otter River at Otter River	34.1	1965	1999	35

01101000	Parker River at Byfield	21.3	1946	1997	52
01162500	Priest Brook nr. Winchendon	19.4	1916	1997	82
01176000	Quaboag River nr. West Brimfield	150.0	1913	1999	87
01124000	Quinebaug River at Quinebaug CT	155	1932	1999	68
01123600	Quinebaug River nr Southbridge	99	1963	1990	28
01110000	Quinsigmond River at N. Grafton	25.6	1940	1999	60
01109070	Segreganset River nr. Dighton	10.6	1987	1999	13
01175670	Seven Mile River nr. Spencer, MA	8.68	1961	1999	39
01100600	Shawsheen River nr. Wilmington	36.5	1964	1997	34
01169900	South River nr. Conway	24.1	1967	1999	33
01096000	Squannacook River nr. West Groton*	65.9	1950	1997	48
01175500	Swift River at West Ware*	189	1913	1999	87
01161500	Tarbell Brook nr. Winchendon	17.8	1917	1983	67
01108000	Taunton River nr. Bridgewater	258.0	1930	1997	68
01109060	Threemile River at North Dighton	84.3	1967	1999	33
01187400	Valley Brook near West Hartland CT	7.03	1941	1972	32
01185500	W. Br. Farmington River nr New Boston	91.7	1913	1997	85
01181000	W. Br. Westfield River at Huntington	94.0	1935	1997	63
01108500	Wading River at Mansfield	19.5	1954	1986	33
01109000	Wading River nr. Norton	43.3	1925	1997	73
01173500	Ware River at Gibbs Crossing	197.0	1912	1997	86
01173000	Ware River at Intake Works nr. Barre	96.3	1929	1999	71
01172500	Ware River nr. Barre	55.1	1946	1997	52
01111200	West River nr. Uxbridge	27.9	1963	1990	28
01179500	Westfield River at Knightville	161	1910	1999	90
01183500	Westfield River nr. Westfield	497	1915	1999	85

*Gages with drainage areas that **include** watersheds from which water is being diverted

**Period of record includes the first and last full year of data. The actual period of record may be within 2 +/- years do to partial record years

Table 2. - Median of annual 7-day low flows for each gage

Station Name	Median of Annual 7-Day Low Flow in cfsm
Segreganset River nr. Dighton	0.01
Parker River at Byfield	0.02
Ipswich at S. Middleton	0.02
Ipswich River at Ipswich	0.04
Hop Brook nr. New Salem	0.04
Aberjona at Winchester	0.05
Seven Mile River nr. Spencer, MA	0.05
Nashoba Brook nr. Acton	0.05
Wading River at Mansfield	0.06
Hubbard River near West Hartland CT	0.06
Ware River nr. Barre	0.07
East Branch Tully River nr. Athol	0.07
Cadwell Creek nr. Belchertown	0.07
Valley Brook near West Hartland CT	0.07
East Br. Swift nr. Hardwick	0.07
Quinsigmond River at N. Grafton	0.08
Priest Brook nr. Winchendon	0.08
Little River nr. Oxford	0.09
Old Swamp River nr. S. Weymouth	0.09
Wading River nr. Norton	0.10
Charles River at Waltham	0.10
West River nr. Uxbridge	0.11
W. Br. Westfield at Huntington	0.11
Tarbell Brook nr. Winchendon	0.12
Shawsheen River nr. Wilmington	0.13
Charles River at Wellesley	0.13
Westfield River at Knightville*	0.13
French River at Hodges Village	0.14
Ware River at Intake Works nr. Barre	0.14
Indian Head River at Hanover	0.15
Assabet at Maynard	0.15
Threemile River at North Dighton	0.16
North River at Shattuckville	0.16
Quinebaug River at Quinebaug CT	0.16
Millers River nr. Winchendon	0.16
W. Br. Farmington nr New Boston	0.16
Charles River at Dover	0.17
Squannacook nr. West Groton	0.17
Quinebaug River nr Sturbridge	0.17
Ware River at Gibbs Crossing	0.17
Concord below R. Meadow at Lowell	0.18
Mill River at Northampton	0.18
Green River at Williamstown	0.18
Green River nr. Colrain	0.18
Taunton River nr. Bridgewater	0.19

Neponset River at Norwood	0.19
Millers River at Erving	0.19
Nashua at E. Pepperell	0.20
Quaboag nr. West Brimfield	0.20
Swift River at West Ware	0.20
Millers River at South Royalston	0.20
Fort River nr. Amherst	0.21
South River nr. Conway	0.21
East Br. Neponset River at Canton	0.22
Otter River at Otter River	0.22
Westfield River nr. Westfield	0.23
French River at Webster	0.24
Chicopee River at Indian Orchard	0.26
Merrimack below Concord R. at Lowell	0.27
Housatonic at Falls Village CT	0.28
Connecticut River at Montague	0.31
Blackstone at Woonsocket	0.31
Connecticut River at Thompsanville CT	0.32
E. Br. Housatonic River at Coltsville	0.33
Jones River at Kingston*	0.36
Housatonic nr. Great Barrington	0.36
Deerfield River nr. West Deerfield	0.37
North Nashua nr. Leominster	0.39
Hoosic River nr. Adams	0.39
Hoosic River nr Williamstown	0.43
Deerfield River at Charlemont	0.45

Table 3. - Median of annual 30-day low flows for each gage

Station Name	Median of Annual 30-day Low Flow in cfsm
Ipswich at S. Middleton	0.04
Segreganset River nr. Dighton	0.04
Parker River at Byfield	0.05
Ipswich River at Ipswich	0.08
Aberjona at Winchester	0.09
Seven Mile River nr. Spencer, MA	0.10
Valley Brook near West Hartland CT	0.10
Nashoba Brook nr. Acton	0.10
Hop Brook nr. New Salem	0.11
East Branch Tully River nr. Athol	0.12
Hubbard River near West Hartland CT	0.12
Priest Brook nr. Winchendon	0.13
Ware River nr. Barre	0.13
East Br. Swift nr. Hardwick	0.13
Wading River at Mansfield	0.14
Wading River nr. Norton	0.16
West River nr. Uxbridge	0.16
Little River nr. Oxford	0.16
Charles River at Waltham	0.16
Cadwell Creek nr. Belchertown	0.16
Tarbell Brook nr. Winchendon	0.18
Ware River at Intake Works nr. Barre	0.19
W. Br. Westfield at Huntington	0.19
Quinsigmond River at N. Grafton	0.20
Old Swamp River nr. S. Weymouth	0.21
Westfield River at Knightville*	0.21
Charles River at Wellesley	0.21
French River at Hodges Village	0.22
Charles River at Dover	0.22
Swift River at West Ware	0.22
Indian Head River at Hanover	0.22
Assabet at Maynard	0.22
Squannacook nr. West Groton	0.23
Shawsheen River nr. Wilmington	0.24
Concord below R. Meadow at Lowell	0.24
Quinebaug River at Quinebaug CT	0.24
Ware River at Gibbs Crossing	0.24
Green River at Williamstown	0.24
Millers River nr. Winchendon	0.24
Quinebaug River nr Sturbridge	0.25
North River at Shattuckville	0.25
Green River nr. Colrain	0.25
Quaboag nr. West Brimfield	0.25
Threemile River at North Dighton	0.26

Taunton River nr. Bridgewater	0.26
Mill River at Northampton	0.26
Millers River at South Royalston	0.27
Millers River at Erving	0.27
Neponset River at Norwood	0.28
Nashua at E. Pepperell	0.29
South River nr. Conway	0.29
French River at Webster	0.30
Fort River nr. Amherst	0.30
W. Br. Farmington nr New Boston	0.30
East Br. Neponset River at Canton	0.32
Chicopee River at Indian Orchard	0.32
Otter River at Otter River	0.33
Westfield River nr. Westfield	0.33
Merrimack below Concord R. at Lowell	0.36
Housatonic at Falls Village CT	0.36
Blackstone at Woonsocket	0.40
Connecticut River at Montague	0.41
Connecticut River at Thompsanville CT	0.42
E. Br. Housatonic River at Coltsville	0.44
Housatonic nr. Great Barrington	0.47
Hoosic River nr. Adams	0.48
North Nashua nr. Leominster	0.48
Jones River at Kingston*	0.49
Hoosic River nr Williamstown	0.53
Deerfield River nr. West Deerfield	0.57
Deerfield River at Charlemont	0.68

Table 4. - Median of the annual low pulse duration for each gage

Station Name	Median of Annual Low Pulse Duration in Days
Swift River at West Ware	1.2
Deerfield River at Charlemont	3.1
Nashua at E. Pepperell	3.55
Connecticut River at Montague	3.61
Deerfield River nr. West Deerfield	3.8
Chicopee River at Indian Orchard	4.6
Housatonic nr. Great Barrington	5.19
Housatonic at Falls Village CT	5.4
Ware River at Gibbs Crossing	5.42
French River at Webster	5.5
Connecticut River at Thompsanville CT	5.7
E. Br. Housatonic River at Coltsville	6
Fort River nr. Amherst	6
Millers River nr. Winchendon	6.1
Merrimack below Concord R. at Lowell	6.24
Tarbell Brook nr. Winchendon	6.4
North Nashua nr. Leominster	6.6
Blackstone at Woonsocket	6.8
Hoosic River nr. Adams	6.8
Westfield River nr. Westfield	6.8
W. Br. Farmington nr New Boston	6.89
Jones River at Kingston*	7
Neponset River at Norwood	7.09
Hoosic River nr Williamstown	7.17
Aberjona at Winchester	7.19
Mill River at Northampton	7.3
South River nr. Conway	7.4
Shawsheen River nr. Wilmington	7.56
Cadwell Creek nr. Belchertown	7.6
Millers River at Erving	8
North River at Shattuckville	8
Old Swamp River nr. S. Weymouth	8
W. Br. Westfield at Huntington	8.05
Westfield River at Knightville*	8.3
Assabet at Maynard	8.31
Charles River at Waltham	8.33
Hop Brook nr. New Salem	8.4
Quinebaug River at Quinebaug CT	8.6
Little River nr. Oxford	8.7
Nashoba Brook nr. Acton	8.72
East Br. Neponset River at Canton	8.9
Priest Brook nr. Winchendon	9.17
Green River nr. Colrain	9.5
Hubbard River near West Hartland CT	9.5
Green River at Williamstown	9.7

Millers River at South Royalston	10
Wading River nr. Norton	10.14
Valley Brook near West Hartland CT	10.2
Taunton River nr. Bridgewater	10.29
Ware River at Intake Works nr. Barre	10.3
Otter River at Otter River	10.6
West River nr. Uxbridge	10.7
Ware River nr. Barre	10.71
Indian Head River at Hanover	10.9
Charles River at Wellesley	11
Quinsigmond River at N. Grafton	11
Wading River at Mansfield	11
French River at Hodges Village	11.2
Seven Mile River nr. Spencer, MA	11.3
East Branch Tully River nr. Athol	11.4
Ipswich at S. Middleton	11.5
Squannacook nr. West Groton	11.5
Quinebaug River nr Sturbridge	11.7
Quaboag nr. West Brimfield	12
East Br. Swift nr. Hardwick	12.63
Concord below R. Meadow at Lowell	13.67
Segreganset River nr. Dighton	13.8
Threemile River at North Dighton	13.9
Charles River at Dover	14
Ipswich River at Ipswich	14.8
Parker River at Byfield	21

All river basins did not have adequate coverage of stream gages to be included in this analysis. The map of stress classifications shows these areas as white. No conclusions can be made about the degree of stress in these basins. In particular, the Cape and the Islands have not been included in this analysis. Gages outside of Massachusetts were used in a couple of cases where there was a lack of sufficient coverage in the basin and a gage was available on the same river near the Massachusetts border. In these cases only gages which measured flow originating predominantly within Massachusetts were used. Examples include the Quinebaug River gage in Quinebaug, Connecticut, the Housatonic River gage in Falls Village, Connecticut and the Blackstone Rive gage in Woonsocket, Rhode Island.

In some cases multiple gages are available for the same river. An example is the Charles River Basin which has gages at Dover, Wellesley, and Waltham. It was determined that due to the potential for cumulative impacts, when a downstream gage was classified as highly stressed, the remainder of the basin upstream would be considered stressed as well.

As mentioned under limitations this method provides a relative comparison of stream gages. The values for the breaks between high, medium and low are only useful for grouping basins and have not been correlated to any habitat requirements.

Figure 2. - Median of Annual 7-day Low Flow

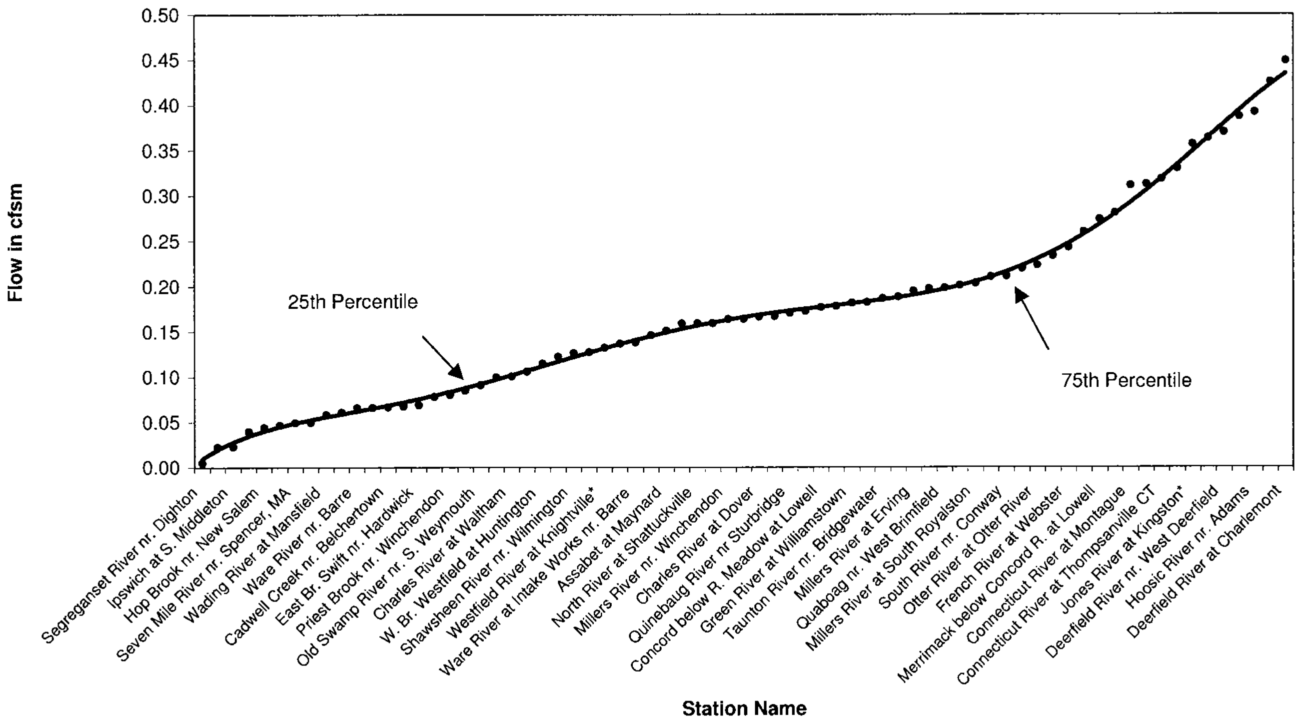


Figure 3. - Median of Annual 30-day Low Flow

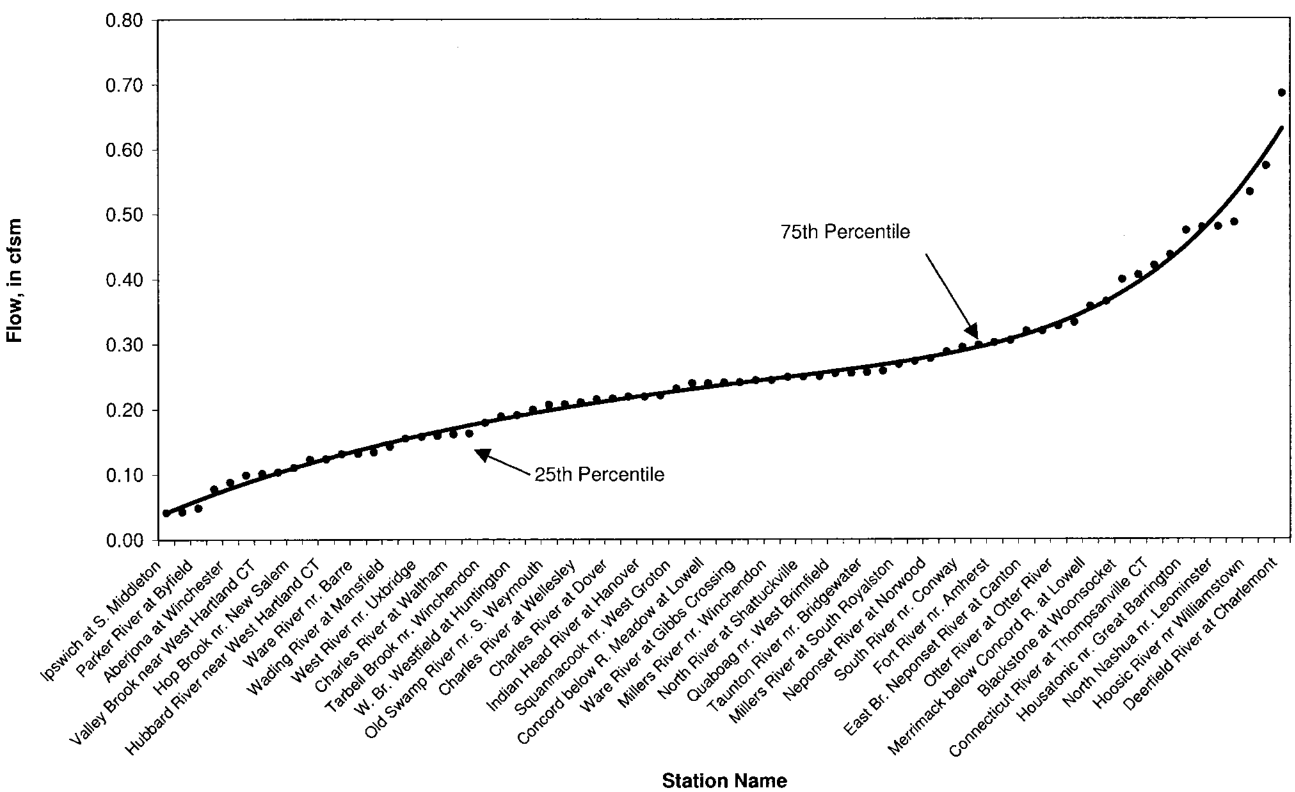


Figure 4. - Median of Annual Low Pulse Duration

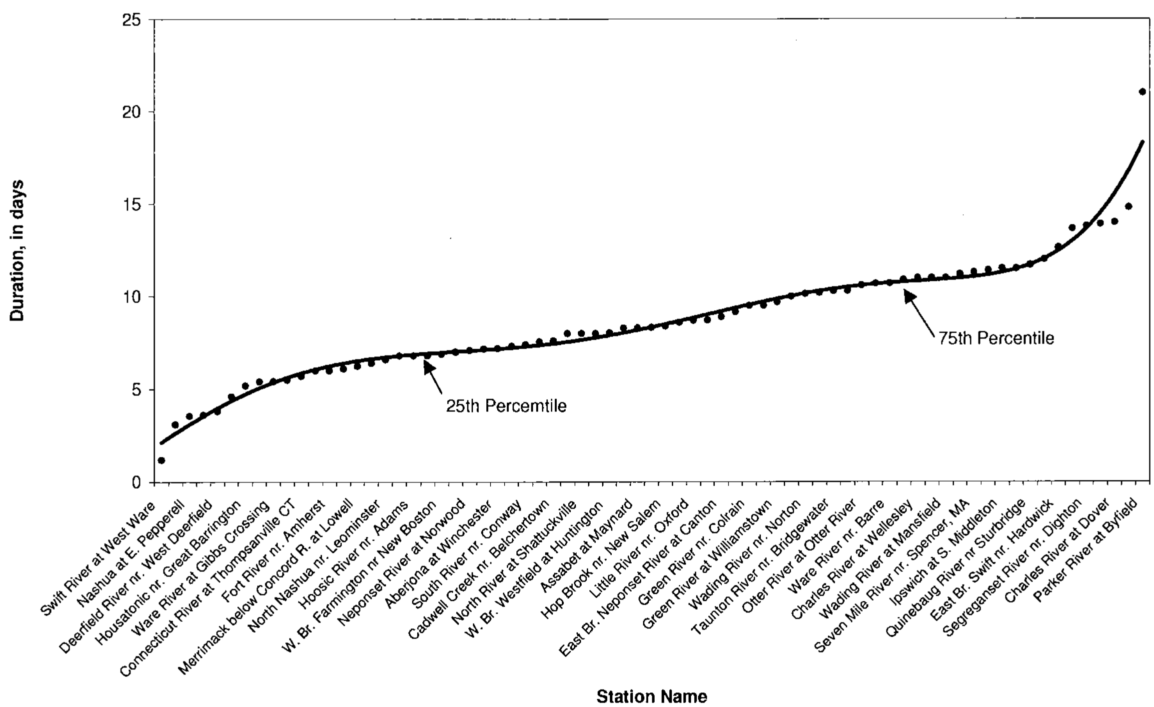


Table 5. – Matrix of high, medium and low classifications for each gage

Station #	Station Name	DRAFT 7-DAY Classification	DRAFT 30-DAY Classification	DRAFT Low Pulse Classification
01102500	Aberjona at Winchester	HIGH	HIGH	MEDIUM
01097000	Assabet at Maynard	MEDIUM	MEDIUM	MEDIUM
01112500	Blackstone at Woonsocket	LOW	LOW	LOW
01174900	Cadwell Creek nr. Belchertown	HIGH	MEDIUM	MEDIUM
01103500	Charles River at Dover	MEDIUM	MEDIUM	HIGH
01104500	Charles River at Waltham	MEDIUM	MEDIUM	MEDIUM
01104200	Charles River at Wellesley	MEDIUM	MEDIUM	HIGH
01177000	Chicopee River at Indian Orchard	LOW	LOW	LOW
01099500	Concord below R. Meadow at Lowell	MEDIUM	MEDIUM	HIGH
01170500	Connecticut River at Montague	LOW	LOW	LOW
01184000	Connecticut River at Thompsanville CT	LOW	LOW	LOW
01168500	Deerfield River at Charlemont	LOW	LOW	LOW
01170000	Deerfield River nr. West Deerfield	LOW	LOW	LOW
01197000	E. Br. Housatonic River at Coltsville	LOW	LOW	LOW
01105500	East Br. Neponset River at Canton	LOW	LOW	MEDIUM
01174500	East Br. Swift nr. Hardwick	HIGH	HIGH	HIGH
01165000	East Branch Tully River nr. Athol	HIGH	HIGH	HIGH
01171300	Fort River nr. Amherst	MEDIUM	LOW	LOW
01124350	French River at Hodges Village	MEDIUM	MEDIUM	HIGH
01125000	French River at Webster	LOW	LOW	LOW
01333000	Green River at Williamstown	MEDIUM	MEDIUM	MEDIUM
01170100	Green River nr. Colrain	MEDIUM	MEDIUM	MEDIUM
01332500	Hoosic River nr Williamstown	LOW	LOW	MEDIUM
01331500	Hoosic River nr. Adams	LOW	LOW	LOW
01174000	Hop Brook nr. New Salem	HIGH	HIGH	MEDIUM
01197500	Housatonic at Falls Village CT	LOW	LOW	LOW
01199000	Housatonic nr. Great Barrington	LOW	LOW	LOW
01187300	Hubbard River near West Hartland CT	HIGH	HIGH	MEDIUM
01105730	Indian Head River at Hanover	MEDIUM	MEDIUM	HIGH
01101500	Ipswich at S. Middleton	HIGH	HIGH	HIGH
01102000	Ipswich River at Ipswich	HIGH	HIGH	HIGH
01124500	Little River nr. Oxford	MEDIUM	MEDIUM	MEDIUM
01100000	Merrimack below Concord R. at Lowell	LOW	LOW	LOW
01171500	Mill River at Northampton	MEDIUM	MEDIUM	MEDIUM
01166500	Millers River at Erving	MEDIUM	MEDIUM	MEDIUM
01164000	Millers River at South Royalston	MEDIUM	MEDIUM	MEDIUM
01162000	Millers River nr. Winchendon	MEDIUM	MEDIUM	LOW
01097300	Nashoba Brook nr. Acton	HIGH	HIGH	MEDIUM
01096500	Nashua at E. Pepperell	MEDIUM	MEDIUM	LOW
01105000	Neponset River at Norwood	MEDIUM	MEDIUM	MEDIUM
01094500	North Nashua nr. Leominster	LOW	LOW	LOW
01169000	North River at Shattuckville	MEDIUM	MEDIUM	MEDIUM
01105600	Old Swamp River nr. S. Weymouth	MEDIUM	MEDIUM	MEDIUM
01163200	Otter River at Otter River	LOW	LOW	MEDIUM

01101000	Parker River at Byfield	HIGH	HIGH	HIGH
01162500	Priest Brook nr. Winchendon	HIGH	HIGH	MEDIUM
01176000	Quaboag nr. West Brimfield	MEDIUM	MEDIUM	HIGH
01124000	Quinebaug River at Quinebaug CT	MEDIUM	MEDIUM	MEDIUM
01123600	Quinebaug River nr Sturbridge	MEDIUM	MEDIUM	HIGH
01110000	Quinsigmond River at N. Grafton	HIGH	MEDIUM	HIGH
01109070	Segreganset River nr. Dighton	HIGH	HIGH	HIGH
01175670	Seven Mile River nr. Spencer, MA	HIGH	HIGH	HIGH
01100600	Shawsheen River nr. Wilmington	MEDIUM	MEDIUM	MEDIUM
01169900	South River nr. Conway	MEDIUM	MEDIUM	MEDIUM
01096000	Squannacook nr. West Groton	MEDIUM	MEDIUM	HIGH
01175500	Swift River at West Ware	MEDIUM	MEDIUM	LOW
01161500	Tarbell Brook nr. Winchendon	MEDIUM	MEDIUM	LOW
01108000	Taunton River nr. Bridgewater	MEDIUM	MEDIUM	MEDIUM
01109060	Threemile River at North Dighton	MEDIUM	MEDIUM	HIGH
01187400	Valley Brook near West Hartland CT	HIGH	HIGH	MEDIUM
01185500	W. Br. Farmington nr New Boston	MEDIUM	LOW	MEDIUM
01181000	W. Br. Westfield at Huntington	MEDIUM	MEDIUM	MEDIUM
01108500	Wading River at Mansfield	HIGH	HIGH	HIGH
01109000	Wading River nr. Norton	MEDIUM	MEDIUM	MEDIUM
01173500	Ware River at Gibbs Crossing	MEDIUM	MEDIUM	LOW
01173000	Ware River at Intake Works nr. Barre	MEDIUM	MEDIUM	MEDIUM
01172500	Ware River nr. Barre	HIGH	HIGH	MEDIUM
01111200	West River nr. Uxbridge	MEDIUM	MEDIUM	MEDIUM
01179500	Westfield River at Knightville	MEDIUM	MEDIUM	MEDIUM
01183500	Westfield River nr. Westfield	LOW	LOW	LOW

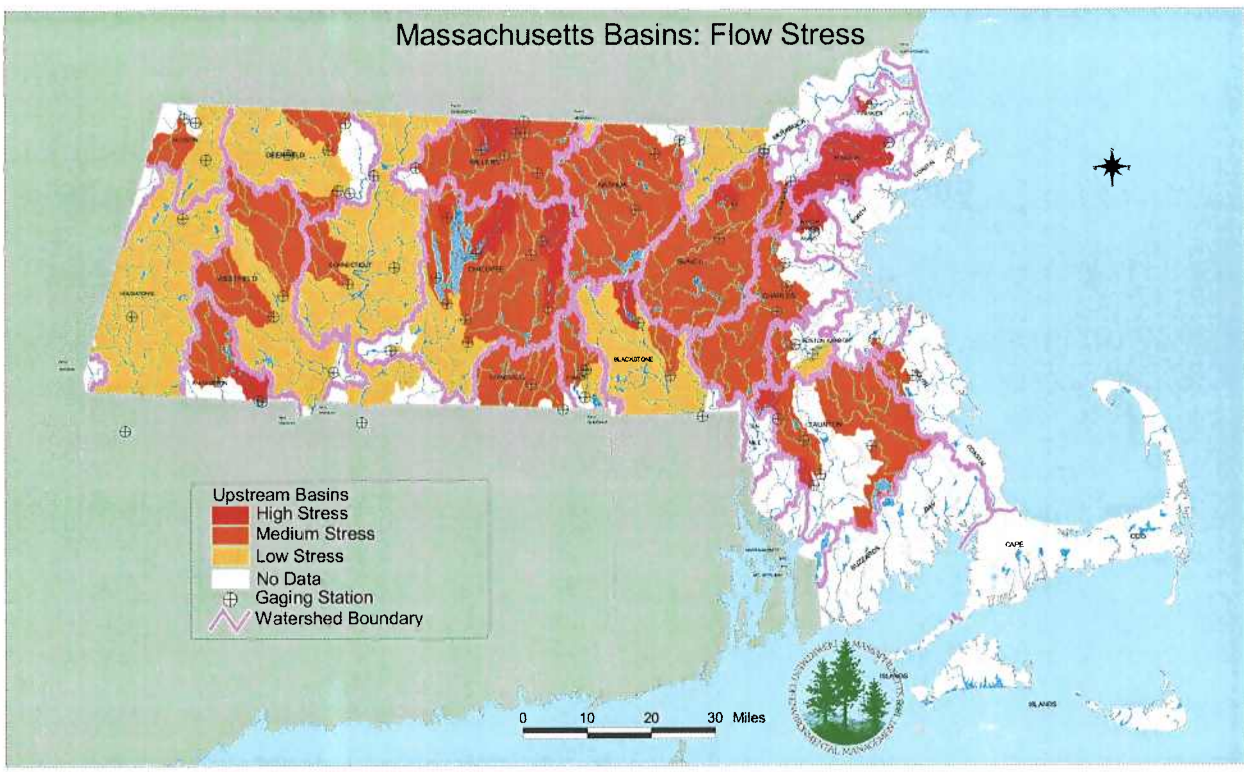
Table 6. – Final stress classifications

Station #	Station Name	FINAL STRESS LEVEL
01102500	Aberjona at Winchester	HIGH
01174500	East Br. Swift nr. Hardwick	HIGH
01165000	East Branch Tully River nr. Athol	HIGH
01174000	Hop Brook nr. New Salem	HIGH
01187300	Hubbard River near West Hartland CT	HIGH
01101500	Ipswich at S. Middleton	HIGH
01102000	Ipswich River at Ipswich	HIGH
01097300	Nashoba Brook nr. Acton	HIGH
01101000	Parker River at Byfield	HIGH
01162500	Priest Brook nr. Winchendon	HIGH
01110000	Quinsigmond River at N. Grafton	HIGH
01109070	Segreganset River nr. Dighton	HIGH
01175670	Seven Mile River nr. Spencer, MA	HIGH
01187400	Valley Brook near West Hartland CT	HIGH
01108500	Wading River at Mansfield	HIGH
01172500	Ware River nr. Barre	HIGH
01097000	Assabet at Maynard	MEDIUM
01174900	Cadwell Creek nr. Belchertown	MEDIUM
01103500	Charles River at Dover	MEDIUM
01104500	Charles River at Waltham	MEDIUM
01104200	Charles River at Wellesley	MEDIUM
01099500	Concord below R. Meadow at Lowell	MEDIUM
01124350	French River at Hodges Village	MEDIUM
01333000	Green River at Williamstown	MEDIUM
01170100	Green River nr. Colrain	MEDIUM
01105730	Indian Head River at Hanover	MEDIUM
01124500	Little River nr. Oxford	MEDIUM
01171500	Mill River at Northampton	MEDIUM
01166500	Millers River at Erving	MEDIUM
01164000	Millers River at South Royalston	MEDIUM
01162000	Millers River nr. Winchendon	MEDIUM
01096500	Nashua at E. Pepperell	MEDIUM
01105000	Neponset River at Norwood	MEDIUM
01169000	North River at Shattuckville	MEDIUM
01105600	Old Swamp River nr. S. Weymouth	MEDIUM
01176000	Quaboag nr. West Brimfield	MEDIUM
01124000	Quinebaug River at Quinebaug CT	MEDIUM
01123600	Quinebaug River nr Southbridge	MEDIUM
01100600	Shawsheen River nr. Wilmington	MEDIUM
01169900	South River nr. Conway	MEDIUM
01096000	Squannacook nr. West Groton	MEDIUM
01175500	Swift River at West Ware	MEDIUM
01161500	Tarbell Brook nr. Winchendon	MEDIUM
01108000	Taunton River nr. Bridgewater	MEDIUM
01109060	Threemile River at North Dighton	MEDIUM

01185500	W. Br. Farmington nr New Boston	MEDIUM
01181000	W. Br. Westfield at Huntington	MEDIUM
01109000	Wading River nr. Norton	MEDIUM
01173500	Ware River at Gibbs Crossing	MEDIUM
01173000	Ware River at Intake Works nr. Barre	MEDIUM
01111200	West River nr. Uxbridge	MEDIUM
01179500	Westfield River at Knightville	MEDIUM
01112500	Blackstone at Woonsocket	LOW
01177000	Chicopee River at Indian Orchard	LOW
01170500	Connecticut River at Montague	LOW
01184000	Connecticut River at Thompsanville CT	LOW
01168500	Deerfield River at Charlemont	LOW
01170000	Deerfield River nr. West Deerfield	LOW
01197000	E. Br. Housatonic River at Coltsville	LOW
01105500	East Br. Neponset River at Canton	LOW
01171300	Fort River nr. Amherst	LOW
01125000	French River at Webster	LOW
01332500	Hoosic River nr Williamstown	LOW
01331500	Hoosic River nr. Adams	LOW
01197500	Housatonic at Falls Village CT	LOW
01199000	Housatonic nr. Great Barrington	LOW
01100000	Merrimack below Concord R. at Lowell	LOW
01183500	Westfield River nr. Westfield	LOW
01094500	North Nashua nr. Leominster	MEDIUM*
01163200	Otter River at Otter River	MEDIUM*

* Data for the Otter River and the North Nashua River watersheds indicate a low stress classification, however they are classified as Medium stress due to a medium stress classification down gradient.

Figure 5 – stressed basin map



Method to Determine if a Sub-basin is Hydrologically Stressed

The stressed sub-basin analysis is a simple water budget comprised of withdrawals and discharges to the sub-basin. The amount of withdrawals and discharges are related to base flow to determine the relative impact of water use on the hydrology of the sub-basin with a focus on low flow periods.

1. The first step in the method is to delineate the tertiary or secondary sub-basin to be assessed. If a mainstem river is to be assessed an appropriate planning unit should be determined such that key hydrologic characteristics and water uses are captured in the sub-basin delineation.
2. Once the sub-basin has been delineated, municipal water supply withdrawals should be located. If possible average annual withdrawals, on a daily basis, for a three year period should be used.
3. Wastewater returns to the sub-basin should also be located and summarized. Careful attention should be paid to determining which portions of a community discharge to the sub-basin via a treatment plant versus areas that discharge via septic systems.
4. The total sub-basin withdrawals, wastewater treatment plant returns and septic returns should be summarized as well as the resulting net inflow or outflow of water from the sub-basin.
5. Determine the estimated natural 7Q10 and August Median flows for the sub-basin. This data is available from the U.S. Geological Survey at http://ma.water.usgs.gov/streamstats/. This web site does not currently provide these data for the Taunton, North Coastal and Buzzards Bay Basins.

STRESS CLASSIFICATION	CRITERIA
HIGH	Net outflow equals or exceeds estimated natural August median flow
MEDIUM	Net outflow equals or exceeds estimated natural 7Q10 flow
LOW	No net loss to the sub-basin

Past inflow/outflow analyses carried out by DEM used a similar method for calculating potential sub-basin yield and stress in a sub-basin. These analyses used the 95% flow duration for the 1980-81 drought. However the 1980-81 drought varied significantly across the state, therefore more reliable statistics have been chosen.

Use of the Stress Classification

EOEA agencies were asked to determine how the stressed basin classification could be used in state environmental programs. In general it was determined that all programs would use the stress delineation where available to flag areas which should undergo a higher level of review. In addition a requirement for project mitigation proportional to the degree of stress can be required by an agency. Finally, agencies that provide funding opportunities could include criteria that would support funding requests that address issues related to the stress classification, such as using the method provided in this definition to identify the level of stress of subbasins, or to mitigate habitat, water quality or water quantity impacts related to stress.

Specifically, the following programs are recommending to use the stressed classification:

1. Interbasin Transfer Act - a stressed classification for a sub-basin would be part of the criteria for evaluating determinations of insignificance. A proposed transfer from a stressed sub-basin could be determined to be significant. For a full application for an interbasin transfer, a stressed classification could also result in a requirement for stream monitoring and resource surveys as part of the information provided in the application. Stressed classifications would also be a factor in reviewing alternatives.

2. New Source Approval - The stressed classification would be included in the site screening document to guide communities on where to look for water supply and to provide a flag for areas which would undergo a higher level of review in the Water Management Act Program.

3. Water management Act - The DEP could identify those basins designated as stressed and require higher performance standards for communities requesting new withdrawal permits. The requirements could mirror the stricter conservation performance standards required in Interbasin Transfer Act applications.

4. NPDES Stormwater Phase 2 – The DEP is investigating avenues to emphasize, in stressed basins, stormwater recharge to the ground rather than simply cleaning up discharges to surface waters. It is most likely that this emphasis will need to be addressed within the required stormwater management plans.

5. Comprehensive Wastewater Management Planning (CWMP) guidance – The draft guidance already requires greater emphasis on local recharge of wastewater and increased emphasis on infiltration/inflow control in stressed basins. The regulatory implementation of the recommendations contained in CWMPs will occur as a result of future permitting and funding decisions.

Recommendations

1. <u>Obtain Data</u>

The committee concluded that it is not currently possible to identify sub-basins of the Commonwealth that should be labeled as stressed on a statewide basis. This conclusion is based primarily on the lack of computerized data. Although a definition was developed using quantity, quality and habitat factors, the data necessary for this analysis is in hard copy form only. This data includes water use data, the 303d list, fisheries presence/absence data, target fish community data and location of dams.

The committee recommends that the hard copy data be computerized and has taken the following steps:

- The U.S. Geological Survey is computerizing the water withdrawal data submitted to the Department of Environmental Protection (DEP) as part of the DEM and DEP cooperative studies program.
- 2000 water use data is being incorporated into MASS GIS.
- Communities are being encouraged to computerize water system and wastewater system distribution information as part of EO 418.
- The Division of Fisheries and Wildlife is continuing an ongoing effort to computerize fisheries information.

2. Use Interim Methods to Determine Quantitative Stress

A lack of computerized data make it impossible to delineate stressed sub-basins statewide in a timely manner. Therefore the committee developed two methods which incorporate portions of the definition for interim use until a statewide assessment on a sub-basin level is possible. Because streamflow is the basic requirement for quality and habitat factors, the committee developed two methods to use to determine quantitative stress. The first method is a statewide first cut to classify the levels of hydrological stress for large basins and sub-basins as high, medium and low. This classification is intended to be an interim delineation until the remaining required data is developed. The second method can be applied by project proponents to a sub-basin to determine existing and potential impacts to streamflow.

3. Future Work

Refine the interim basin delineation with additional water quality data, fish passage data and fisheries presence/absence data:

- The 303d list and other appropriate water quality data will be assessed to determine a method for adding reach data to the basin scale delineation. A quality determination of stress will be added to the matrix of hydrologic data and adjustments to the delineated basins will be made.
- DFW will be assessing Target Fish Communities for each river basin. This data should be used to refine the habitat portion of the stress definition.
- A similar analysis will be done using the fisheries presence/absence data and available data on limitations to fish passage.
- Look for new methods and data to refine the stress definition including developing a quality and quantity monitoring program for small streams.

APPENDIX 1

Summary of Agency Methods and Data

The following is a summary of the data and methods examined by the committee.

Data

1. Water Quality - the Massachusetts DEP maintains the 303d list, which is a list of surface water bodies which do not meet the surface water quality standards of the Clean Water Act. This list is updated every two years and submitted to EPA. Sub-basins drained by rivers or streams on the list can be classified as stressed (impaired). However streams not listed cannot be assumed to be "unstressed" (not impaired) as they may not have been sampled recently or the sample results may be inconclusive.

2. Aquatic Habitat – The Division of Fisheries and Wildlife surveys fisheries in Massachusetts streams and has data goings back to the late 1800's. Some data is computerized and some is in hard copy files. Historic data collected indicating presence of a species can be compared to more recent surveys. The absence of a species formerly surveyed may indicate a stressed basin. However this method is limited by the quality of the older data. In addition, the current survey data is time sensitive, and must be updated to draw any conclusions.

3. Streamflow Statistics – The U.S. Geological Survey has developed an internet program, which estimates natural streamflow at any location on a river or stream. These estimated statistics could be compared to nearby gage statistics to determine a change in flow or stress. This method is only useful at sites with stream gages and is limited by the error of the estimates. These errors become smaller, in relative terms, in larger drainage areas such as those found at gaging stations.

4. Streamflow Statistics – The Nature Conservancy has developed a list of streamflow statistics which it feels can reflect impacts to streams. This data is a useful tool for looking at stress in terms of impacted streams but is limited to stream gage sites with an adequate period of record and in which the stress is "known," such as construction of a dam. The method compares statistics of pre-impact flows to post-impact flows. In addition determining an area to be "unstressed" is difficult if impacts pre-dated the gage period of record.

Current Methods

1. DEP Site Screening Document (Attachment 1) – the DEP Site Screening Document (SSD) was designed as a guide to help those developing new water supplies to take a first cut at identifying potential environmental impacts related to the development of new water supply source development. The SSD has a number of criteria including identification of sensitive receptors and evaluation of potential impacts to streamflow. The committee focused on the work that had been done to identify potential impacts

to streamflow to see if they were useful as a method for defining stress. This method does not incorporate the cumulative impact of existing withdrawals.

2. DEP Draft Sewer Impacts Analysis (Attachment 2) – the DEP sewer analysis contains several methods for calculating the impact of a proposed sewer system to ground water recharge, streamflow and sensitive receptors. The methods involve comparing the amount of water to be sewered out of a sub-basin to the amount of annual recharge to the groundwater system and to the low flow in streams draining the sub-basin. The analysis also includes identification of sensitive receptors and analysis of impact to ground water levels. The streamflow analysis uses the DEM inflow/outflow methodology (see below). This method would be the most appropriate of the sewer analyses for calculating stress.

3. DEM Inflow/Outflow Methodology – the DEM inflow/outflow methodology involves calculating a water use budget for a sub-basin. The net inflow or outflow of water is compared to low-flow statistics for the stream draining the sub-basin. This method would involve choosing a flow criterion such as 7Q10, August median flow, or 1980-1981 98% flow, and comparing that criterion to the net inflow/outflow of the sub-basin. This method is limited by the lack of computerized water use data.

4. Identification and Evaluation of a Target Fish Community – see Attachment 3.

ATTACHMENT 1
DEP SITE SCREENING DOCUMENT

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

ARGEO PAUL CELLUCCI
Governor

JANE SWIFT
Lieutenant Governor

BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

February 5, 2001

Site Screening for
Siting a New or Expanding Source of Public Water Supply

The Department of Environmental Protection (DEP) is committed to early identification of issues relevant during the New Source Approval process for public water supplies. The Site Exam phase will now require that project proponents complete alternatives analysis, a water conservation questionnaire, the attached site screening document and publish public notice in The Environmental Monitor. Conducting alternatives analysis and assessing water conservation measures earlier in the process, and the use of a preliminary screening tool and public notice will ensure that the project proponent and interested parties will have an opportunity to identify issues and state concerns about proposed source locations. Early identification of issues can help to minimize environmental impact and minimize cost and delay to the project proponent. Identification of these issues will assist the agencies and the proponent in determining whether the proposed source is economically viable and protective of the environment and other water users, and will increase technical and regulatory information needed for pumping test design. The public notice will be published in The Environmental Monitor for proposed public water supply sources subject to the Water Management Act. The Department of Environmental Protection will accept written comments regarding proposed sites for a short time following publication of the notice.

A variety of environmental laws may apply to new source development depending on the location and the project design. Applicable laws may include the Safe Drinking Water Act, the Water Management Act, the Wetlands Protection Act, the Interbasin Transfer Act, the Endangered Species Act, and the Clean Water Act. The Department's Guidelines and Policies for Public Water Systems provide additional guidance about the necessary approvals and the timing of obtaining them.

"Site Screening for Siting New or Expanding Source of Water Supply" will allow proponents to screen each site under consideration, enabling them to make informed decisions in selecting sites and evaluating alternatives for new source development. Project proponents of new sources that will exceed the withdrawal threshold of the Water Management Act noted herein, should apply the screening criteria to each source under consideration.
This guidance should not be considered to be a final determination of the approvability of sites, but is intended to provide direction regarding significant issues that will have to be addressed if a particular site is pursued.

It is the goal of DEP to ensure a reliable supply of safe drinking water at an affordable cost in a manner which has the least possible environmental impact. The Department promotes efficient operation and maintenance of water supply and distribution systems, and the use of storm water management and wastewater disposal systems that recharge groundwater. DEP promotes and implements policies which require the assessment of future demands, the improvement of the efficiency of water supply systems, and conservation to avoid the capital costs and environmental impacts associated with the development of new supplies.

Glenn Haas, Acting Assistant Commissioner
Bureau of Resource Protection

COMMONWEALTH OF MASSACHUSETTS
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BOB DURAND
Secretary

LAUREN A. LISS
Commissioner

REQUEST FOR SITE EXAM
Water Management Program

February 5, 2001

Site Screening Worksheet for Siting a New or Expanding Source of Public Water Supply

For a Public Water Supply Pumping 100,000 GPD or Greater

Submit two copies of this form for each source with the Request For Site Exam documentation to DEP/ Drinking Water Program.

Applicant: ______________________________

Consultant: ______________________________ Phone: __________

Site Name ____________________ Basin : ____________________

Section A: Demand Management

1. What is the maximum withdrawal rate you are seeking for your proposed source in million gallons per day (mgd)? __ . __ __ mgd.

	Existing	Final 5-yr block Permit Volume	Buildout*
2. What is the average day demand (mgd) of your system?	______	______	______
3. What is the peak day demand (mgd) of your system?	______		
4.a. What is the approved pumping rate (mgd) of your system?	______		

b. Do any of these sources have restricted capacity? If so, briefly indicate which sources and the reasons for the capacity restrictions in the space below.

5. Can you meet your average day demand with your largest source off-line? Yes ☐ No ☐

*Buildout: EOEA Community Preservation Initiative Buildout projections (See Appendix B). If these projections are not available for your town, note the source of your Buildout projections below.

Section A: Demand Management (cont.)

Note: Failure to meet water conservation standards may jeopardize your application.
Prior to commencement of the development of a new public source, the proponent should conduct a thorough analysis of system demand and have a viable water conservation program in place. Complete the Water Conservation Plan and refer to DEP/Water Management conservation guidelines, *Guidelines and Policies for Public Water Systems, Section 10, revised August, 1996, or as amended; and Water Conservation Standards for the Commonwealth of Massachusetts, adopted 1992.*

If your proposed withdrawal involves an interbasin transfer, also refer to DEM/Office of Water Resources Interbasin Transfer Act water conservation measures in, *Appendix A, Interbasin Transfer Act Performance Standards Guidance, approved 8/12/99, and A Guideline to the Application of the Interbasin Transfer Act and Regulations, December 1985.*

Section B. Potential Environmental Impact

Presence of sensitive or multiple receptors may limit site availability for water supply withdrawal.

1. Which of the following sensitive receptors exist within 1000' of your site?
(Consult the most recent Massachusetts Natural Heritage Program Atlas, MassGIS and other sources.)

- Areas of Critical Environmental Concern Yes _____ No _____
- Priority habitat for rare and endangered species Yes _____ No _____
- Lakes and ponds (or other surface water features) Yes _____ No _____
- Vernal pools Yes _____ No _____
- Stocked trout streams Yes _____ No _____

(See Massachusetts Stocked Trout Waters listing on website: www.state.ma.us/dfwele*)*

Additional considerations:
- Cold water fisheries resource
- NPDES permit sites (National Pollution Discharge Elimination System)

2. Which of the following potential threats or sensitive receptors exist within one-half mile of your site?
(Consult the DEP website at www.state.ma.us/dep*, MassGIS and other sources)*

- Hazardous waste sites Yes _____ No _____
- Wastewater treatment facilities Yes _____ No _____
- CSOs or SSOs Yes _____ No _____
- Landfills Yes _____ No _____
- Agricultural uses Yes _____ No _____
- Automobile graveyards and junkyards Yes _____ No _____
- Industrial Park/plant Yes _____ No _____
- Petroleum and oil bulk stations and terminals Yes _____ No _____
- Public water withdrawals Yes _____ No _____
- Private wells Yes _____ No _____

Section B-1. Stream and Basin Section

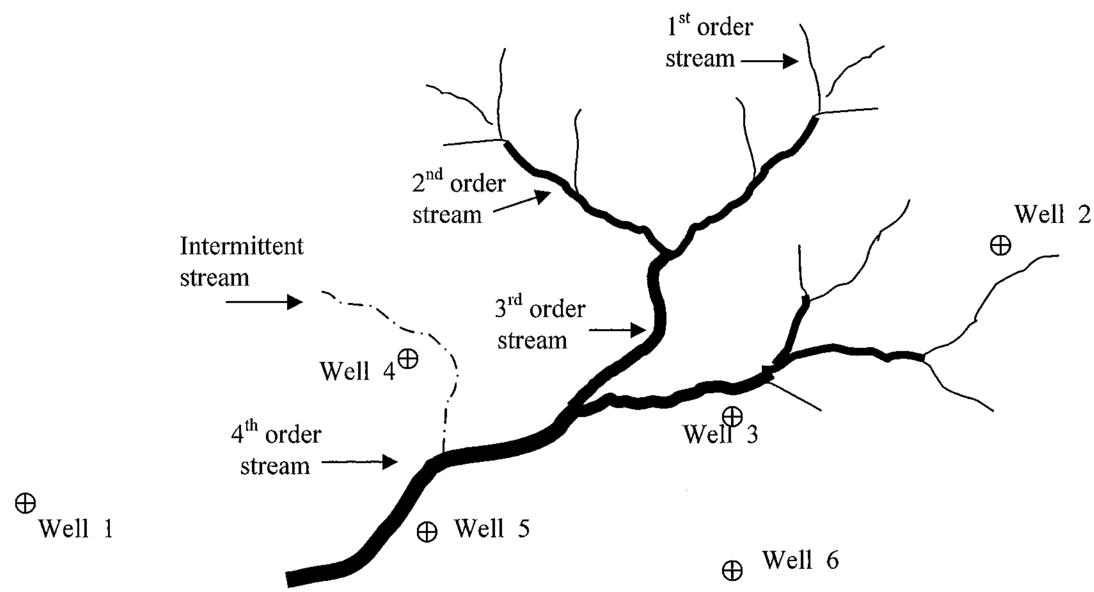
This section is intended to preliminarily evaluate the impacts of proposed sources on streamflow and availability of water in the river basin. The graphic below depicting stream order and well placement illustrates how well location may impact streamflow.

The purpose of this section is not to approve or deny siting a new source, but rather to provide an advisory for caution where siting a withdrawal that may have a significant impact on streamflow.

Stream Order:
A stream of first order is one that has no tributaries. When two streams of first order join, a stream segment of second order begins that may have one or several first-order tributaries along its length. When two streams of second order join, a single stream of third order begins. This stream extends until joined by another third-order river, and there, the fourth order begins, and so on. A junction with a lower-order channel does not change the order of the higher-order stream. (Adapted from the Handbook of Hydrology, 1993)

WATER WITHDRAWAL CONSIDERATION ON STREAMFLOW

PROXIMITY AND STREAM ORDER



Assuming the same pumping rate and a hydrological connection for induced infiltration between a well and a stream, proximity and stream order are two factors which may have a serious impact on flow. Generally, the nearer the withdrawal is to a stream, the greater the impact on flow; and the lower the level of stream order, the greater the impact of a withdrawal on flow. As illustrated above, Wells 1 and 6 may have minimal or no impact on streamflow. Well 5, located near a higher order stream may have less impact on flow than Well 3. Wells 2 and 4 may have the greatest impact on flow due to their close proximity to a first order stream and an intermittent stream.

The following stream screening criteria provides guidance concerning a withdrawal's potential for impact on flow. Generally, for a withdrawal pumping rate less than 7Q10 flow, no significant impact is anticipated. Withdrawals greater than 7Q10 flow, let alone larger pumping volumes greater than 50% of August Median flow, may have significant impacts on flow. Low flow stream statistics (7Q10 and August Median) may be obtained from U.S. Geological Survey (USGS) website noted below. However, statistics obtained from this website are based on unregulated streams and do not take into account cumulative effects on streamflow from existing withdrawals or other impacts, and the proposed withdrawal may warrant further site screening assessment. Stream threshold indicators may also be more restrictive in basins that DEP has determined to be hydrologically stressed.

Responses to the following questions will require internet access to obtain low flow stream statistics from the USGS steamflow statistics website, http://ma.water.usgs.gov/streamstats. The USGS website provides streamflow statistics and basin characteristics for locations of interest by use of an automated procedure that measures characteristics of the land surface area (basin) that drains to the stream and inserts those characteristics into equations that estimate the streamflow statistics (7Q10, August Median, etc).

This methodology is designed to estimate the impact on flow from one proposed withdrawal on an unregulated stream. Withdrawals impacting more than one stream, or where multiple withdrawals or other impacts in the drainage area already exist, will require additional site-specific screening.

Basically, the application allows a user to mouse-click on a point in a stream, from which the program will delineate the contributing watershed drainage area on a map and generate low flow stream statistics along with basin characteristics. Instructions for use are on the website. The USGS display map and corresponding data printout for the proposed withdrawal must be enclosed with this application. Once the low flow statistics have been obtained, the data must be converted into cubic feet per second per square mile (cfsm) and compared to the withdrawal rate.

The click point for the application is the point where the stream intersects the downgradient extent of the preliminary Zone II. The preliminary Zone II delineation is a requirement in the Drinking Water Request For Site Exam part of this application. DEP assumes 100% hydrogeologic communication between the well and the stream so that every drop of water pumped comes from the stream. However, the Department will also consider applied site specific stream depletion methodologies (Jenkins, Barlow, etc.), that attempt to quantify stream flow depletion by wells under Zone II conditions. In such cases, the reduced flow impact may substitute for the withdrawal when comparing the withdrawal rate to stream indicators 7Q10 and 50% of August Median.

To determine the withdrawal's impact on streamflow, follow the steps below.

Step 1: Convert the proposed withdrawal rate given in million gallons per day (Page 1, Section A, Question 1) to gallons per day, and then to cubic feet per second using the following formula:

$$\frac{\_\_\_\_\_\_ \text{ gallons per day}}{7.48 \text{ gal/cu.ft.} \times 1440 \text{ min/day} \times 60 \text{ seconds/minute}} = \_\_\_\_\_\_ \text{ cfs}$$

Step 2: Determine the contributing drainage area in square miles for the proposed withdrawal location. This area must be determined with the USGS watershed tools by clicking on the stream intersect with the preliminary Zone II at the downgradient point.

What is the contributing drainage area of the proposed withdrawal? ______ square miles

What is the distance in feet from the proposed withdrawal to the nearest stream? ______ feet

Step 3: Conversion to cfsm:
Find the flow per unit area (cfsm) for the withdrawal at this location by dividing the cfs flow found in Step 1 by the contributing drainage area in Step 2:

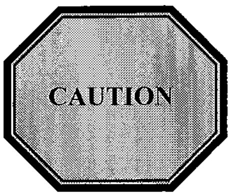
$$\frac{\text{.......... withdrawal (cfs)}}{\text{.......... drainage area (sq. mi.)}} = \text{..........} \text{ cfsm}$$

Example: Find cfsm for a proposed withdrawal at 0.5 mgd with an upgradient watershed of 5 square miles.
Note: 0.5 mgd converts to .77 cfs

$$\frac{\text{withdrawal (0.5 mgd) or } \quad 0.77 \text{ cfs (Step 1)}}{\text{upgradient watershed} \quad 5 \text{ sq. mi. (Step 2)}} = 0.154 \text{ cfsm (Step 3)}$$

Step 4: The 7Q10 streamflow, measured in cfs, represents the probable minimum flow over a 7-day period that will occur on average once in 10 years. With the USGS website, obtain the 7Q10 cfs flow for the stream location point, convert 7Q10 cfs to cfsm (Step 3), and compare this flow with your proposed withdrawal.

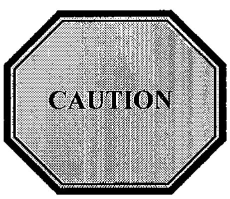
7Q10 flow ________ cfs
7Q10 flow ________ cfsm



Withdrawals which are greater than 7Q10 cfsm of a stream have the potential to increase the frequency and duration of low flow, and may result in moderate to significant environmental impact. Such withdrawals may be unapprovable or severely restricted by permit conditions. This guidance should be used as a planning tool, and applicants are encouraged to select alternatives that minimize environmental impact and meet other water supply planning objectives for water quality and productivity. Further analysis will be necessary to determine the potential impact of all proposed withdrawals and mitigating circumstances.

Step 5: With the USGS website, obtain the August Median cfs flow for the stream at the designated point, convert the August Median cfs to cfsm (Step 3), take 50% of August Median (cfsm) and compare this flow with your proposed withdrawal in cfsm.

August Median:	____________	cfs
August Median:	____________	cfsm
50% August Median:	____________	cfsm



Impacts on streamflow are best determined through physical characteristics of the watershed, site hydrology and pumping tests, but as a screening guideline, a proposed source in which the withdrawal rate of a watershed area is **50% of the August Median** (cfsm) or greater, is considered to have the potential to significantly reduce streamflow. Such withdrawals may be unapprovable or severely restricted by permit conditions. This guidance should be used as a planning tool, and applicants are encouraged to select alternatives that minimize environmental impact and meet other water supply planning objectives for water quality and productivity. Further analysis will be necessary to determine the potential impact of all proposed withdrawals and mitigating circumstances.

Since the August Median statistic may reflect wide ranging and relatively high flows, particularly in small watershed drainage areas, the more conservative 50% of August Median flow was selected as the screening threshold level to protect impacts on river flow from withdrawals.

Section C. Regulatory Review

1. Name all potential water supplies which you have under consideration, including regional sources and those located in other communities, and attach a locus map depicting the location of each.

____
____
____

2. Massachusetts Environmental Policy Act (MEPA) *(MGL ch 30 s. 61 through 62H) (301 CMR 11.00)*
MEPA provides meaningful opportunities for public review of the potential environmental impacts of projects for which agency action is required. The MEPA review is an informal administrative process of environmental planning that enables the proponent and each participating agency to consider the positive and negative, short-term and long-term, and cumulative potential environmental impacts for all phases of a project. *(See MEPA website at www.ma.state.us/MEPA.)*

MEPA review thresholds for water: *(301 CMR 11.03(4)) (other non-water thresholds may also apply)*

ENF and Other MEPA Review if the Secretary So Requires.

- new withdrawal or expansion of withdrawal of 100,000 or more gpd from a new water source that requires new construction for the withdrawal.
- new withdrawal or expansion of withdrawal of 500,000 or more gpd from a water supply system above the lesser of current system-wide authorized withdrawal volume or three-years' average system-wide actual withdrawal volume.
- construction of one or more new water mains five or more miles in length.
- construction of a new drinking water treatment plant with a capacity of 1,000,000 or more gpd.
- expansion of an existing drinking water treatment plant by the greater of 1,000,000 gpd or 10% of existing capacity.
- alteration requiring a variance in accordance with the Watershed Protection Act, unless the project consists solely of one single family dwelling.
- non-bridged steam crossing 1,000 or less feet upstream of a public surface drinking water supply for purpose of forest harvesting activities.

ENF and Mandatory EIR:

- new withdrawal or expansion in withdrawal of
  - 2,500,000 or more gpd from a surface water source; or
  - 1,500,000 or more gpd from a groundwater source.
- new interbasin transfer of water of 1,000,000 or more gpd from a surface or groundwater source or any amount determined significant by the Water Resource Commission.
- construction of one or more new water mains ten or more miles in length.
- new water service to a municipality across a municipal boundary through new or existing pipelines.

Will your water withdrawal require MEPA review Yes ☐ No ☐

3. Water Management Act (WMA) Permit/ DEP Water Management Program *(310 CMR 36.00)*

A water withdrawal permit is required for new or expanded water withdrawals above the threshold volume. Water withdrawal uses may include, but not be limited to **public water supply**; industrial uses; agricultural uses, such as **cranberry growers**; and irrigation uses, such as for **golf courses**.

Threshold volume means:

- an average daily volume of 100,000 gallons for any period of three consecutive months, from a total withdrawal of not less than 9,000,000 gallons; or
- an average daily volume of 100,000 gallons for periods which exceed three consecutive months, calculated by dividing the total withdrawal by the period of operation.
- a permit amendment is required for existing permit holders adding a new source where system wide withdrawal volumes are not being increased.

3a. Will your water withdrawal require a WMA permit? Yes ☐ No ☐

3b. Are you currently a Registrant and/or a Permitee under the WMA? Yes ☐ No ☐

If yes, provide registration and permit numbers:

Registration Number(s)	Permit Number(s)
______________	______________
______________	______________

4. Interbasin Transfer (IBT) Act Approval / Water Resource Commission *(MGL ch 21 ss. 8B-8D)*

(See Massachusetts Major Basin Map at http://ma.water.usgs.gov/basin)

An interbasin transfer is defined as any transfer of the surface and groundwater, including wastewater of the Commonwealth outside a river basin. A water transfer must cross one of the basin boundaries and a municipal boundary line to be considered an interbasin transfer. If a community is sewered to another town out of the basin of the water supply, the Interbasin Act may be triggered.

An interbasin transfer is any action that increases the ability to transfer water or wastewater out of a donor basin over the present rate of interbasin transfer. Actions requiring review include but are not limited to:

- drilling of production wells;
- significantly increasing the capacity of a well;
- development of a reservoir or enlargement of reservoir storage capacity;
- building of transfer facilities, such as pumps, pipelines, tunnels or other conveyance facilities;
- building of water filtration plants where such plants increase the ability to transfer water out-of-basin;
- changes in any withdrawal constraints contained in any provision of MGL, Special Acts, Judicial decree, regulatory agency rule or operating rule of a water supplier;
- structural change in a wastewater system that causes an increase in the transfer out of a donor basin.

Will your water withdrawal require an IBT application review? Yes ☐ No ☐
see ** below

** If your proposed withdrawal will require an IBT review:

- be advised that certain performance standards, including prerequisite requirements, must be met for application approval. See *Interbasin Transfer Act: Performance Standards Guidance, adopted August 12, 1999.*
- the applicant also must meet with DEM/Office of Water Resources staff before the Alternative Analysis is completed and submitted as part of the Request For Site Exam application.

5. Wetlands Permit / Massachusetts Wetlands Protection Act *(MGL ch 131, s. 40) (310 CMR 10.00)*

Administered by DEP and Local Conservation Commissions

Any work in a wetlands or within 100' buffer of the wetlands. This includes creating an access way to the water withdrawal, as well as drilling, pumping, and filling wetlands.

5a. Will your water withdrawal require a Wetlands Permit? Yes ☐ No ☐

5b. Is your proposed withdrawal within the 200' riverfront area? Yes ☐ No ☐

6. 404 Permit / Army Corps of Engineers *(Clean Water Act of 1977)*

Are you planning any dredging or filling for your water withdrawal in a waterway or wetland? Section 404 of the Clean Water Act defines the landward limit of jurisdiction as the high tide line in tidal waters and the ordinary high water mark as the limit in non-tidal waters. When adjacent wetlands are present, the limit of jurisdiction extends to the limit of the wetlands.

Will your water withdrawal require a 404 Permit? Yes ☐ No ☐

7. <u>401 Permit / DEP 401 Water Quality Certification Program</u> *(314 CMR 9.00)*

Provides added protection for projects with the potential for large or cumulative impacts to ensure compliance with the surface water quality standards. Actions, involving but not limited to, any one activity listed below, that require a 401 application review are:

- loss of greater than 5,000 square feet of wetlands;
- within an Outstanding Resource Water;
- involving any real estate subdivision;
- <u>not</u> subject to the Wetlands Protection Act
- containing rare or endangered species habitat in isolated vegetated wetlands;
- within a salt marsh;
- dredging greater than 100 cubic yards.

Will your water withdrawal require a 401 Permit? Yes ☐ No ☐

APPENDIX A

Department of Environmental Management
Office of Water Resources
Basin Plan Status, August 2000

BASIN	VOLUMES	UPDATES
Hudson River Basin	I, II, III*	
Ipswich River Basin (including communities in the North Coastal)	I, II, III	
Charles River Basin	I, II, summary draft III (never completed)	Demands
Concord River Basin	I; Short Hydrology	Some Demands
Blackstone River Basin	I; conceptual plan (3 versions)	Demands?
Nashua River Basin	I	Demands
Neponset River Basin	I; I,II,III combined plan	Demands
Taunton River Basin	I; I,II,III combined plan	Demands + inflow/outflow
North Coastal	I,II,III combined plan	
Mystic River Basin	Short Hydrology/Demands	
Ten Mile River Basin	Short Hydrology/Demands	
Weymouth-Weir Basin	Draft I; Short hydrology/demands	
South Coastal	Draft I; I,II,III combined plan	
Cape Cod	Basin plan	
Islands	Short Hydrology/Demands	
Deerfield River Basin	Short Hydrology/Demands	
Housatonic River Basin	Basin Plan	
Westfield River Basin	Short Hydrology/Demands	
Farmington River Basin	Short Hydrology (combined with Westfield) No Demands	
Millers River Basin	Short Hydrology/Demands	
Chicopee River Basin	Short Hydrology/Demands	
Connecticut River Basin	Short Hydrology/Demands	
Buzzards Bay	Basin Plan	
Parker	no plan	Demands only

*Unless otherwise noted, Volumes I, II and III make up a full basin plan

APPENDIX B

Supportive materials:

- Basin Plans (see Appendix A)
  Contact DEM / Office of Water Resources for further information.
- Outstanding Resource Waters (ORWs)
  Contact DEP Regional Office for further information.
- Stream indicators (7Q10 and August Median) and low flow statistics
  USGS Water Resources Data for Massachusetts
  USGS Gazetteers of Hydrologic Characteristics of Streams in Massachusetts
  USGS websites: http://ma.water.usgs.gov/basin
  http://ma.water.usgs.gov/streamstats
- References:
  - Jenkins, C.T., 1970 Computation of Rate and Volume of Stream Depletion By Wells. USGS Techniques of Water-Resources Investigations, Book 4, Chapter D1.
  - Barlow, P.M., 1999 USGS/ Documentation of Computer Program STRMDEPL – A Program to Calculate Streamflow Depletion by Wells Using Analytical Solutions. (Work in progress)
- NPDES sites
  Contact DEP / Watershed Permitting Program / Surface and Groundwater Sections

List of related programs and phone numbers:

EOEA Basin Team Leader Information		617 727-9800
EOEA Community Preservation Buildout		617 626-1153
Massachusetts Natural Heritage Program		508 792-7270
MEPA		617 626-1020
MassGIS		617 727-5227
DEM/	Office of Water Resources	617 973-8755
	Water Resource Commission	617 626-1050
	Interbasin Transfer Act	617 973-8745
Army Corps of Engineers / 404 Permit		800 362-4367
DEP/	Boston switchboard	617 292-5500
	Western Region	413 784-1100
	Central Region	508 792-7650
	Northeast Region	978 661-7600
	Southeast Region	508 946-2700
	DEP Basin Chiefs, contact DEP regional offices	
	Water Management Program	617 292-5706
	Drinking Water Program	617 292-5770
	Wellhead Protection Program	617 556-1070
	Wetlands and Waterways	617 292-5695
	401 Water Quality Certification Program	617 292-5655
	Bureau of Waste Site Cleanup	617 292-5648
	DEP GIS	617 556-1115

ATTACHMENT 2
DEP DRAFT SEWER IMPACTS ANALYSIS

ATTACHMENT 2

DRAFT STANDARD OPERATING PROCEDURE
Proposed Sewer Project Impact Analysis
5/15/00

This SOP has been established to provide guidance in assessing what impacts sewer projects may have on basin-wide water budgets. It presents a simplified approach for determining how water lost through proposed sewer projects could affect groundwater and surface water.

General

In general, water follows the path of the hydrologic cycle. Precipitation follows several possible natural pathways; including evapotranspiration, recharge of groundwater, and runoff as surface water flow. Human intervention has added an artificial component to this hydrologic cycle by withdrawing water through wells and/or surface water intakes, and reintroducing it back to the basin through septic systems and wastewater treatment facilities. In recent years, the combined effects of population growth, Title 5 issues, and decreasing viable locations for groundwater development, will require communities to evaluate their total water budget. No longer can municipalities solve their septic system problems by sewering and disposing of treated wastewater outside the basin from which it was collected without first evaluating impacts to other natural resources such as water supplies and natural habitats. The relatively small size of Massachusetts unconsolidated aquifers, coupled with an increased consumer demand for public water, dictates the need for a careful planning approach to avoid a water balance deficit. The following is designed to provide a cursory hydrologic assessment of the basin utilizing several different methodologies. Pumping wells need not necessarily be present in order to apply the following procedures.

<u>Procedure #1: Groundwater Impact Analysis</u>: (This procedure identifies additional water table decline under drought-like conditions, solely relying on groundwater storage)

Procedure: The equation ***Q = S.Y.(A)(b)*** is used primarily to calculate the volume of water **(Q)** that can be pulled from unconsolidated deposits of certain area **(A)**, saturated thickness **(b)**, and specific yield **(*S.Y.*)**. The equation can also be used to determine the potential net lowering of the water table due to the prospect of sewering an area that presently recharges aquifers through Title 5 septic systems. Under this situation, ***Q1*** (Q1 is equal to **Q** in equation) is the proposed volume to be sewered out of subbasin, ***S.Y.*** represents the specific yield of the unconsolidated deposits, ***A*** is the area to be sewered, and ***b*** is the net lowering of the water table. Rearrange the equation and solve for ***b*** to determine what impacts would occur to the water table with the changeover from septic systems to sewers. ***Q1*** should be determined using best available water use records. If those are not available or adequate, Title 5 values should be used and transformed to represent realistic average long-term wastewater loads. This can be done by taking two-thirds of the peak loading amounts indicative of Title 5 figures. **S.*Y.*** should be calculated for the glacial till and sand & gravel deposits in the subbasin separately. Then the average ***S.Y.*** will be determined based on the weighted percentage of the subbasin material. ***A*** is determined by defining the area to be sewered and then adding a ½ mile buffer around it. The boundaries of this area should be restricted to the subbasin in which sewering will occur. If a sewering project straddles two or more subbasins, then two or more separate analyses should be done. This procedure identifies the amount of water available from groundwater storage but does not include groundwater recharge from precipitation or surface water features. It can be used solely for drought-like scenarios (no recharge from precipitation).

Example: If ***Q1*** = 100,000 gpd or 13,370 cu.ft/d., ***S.Y.*** = 0.25 (sand & gravel) and 0.13 (till), and ***A*** = 1,607 acres or 70,000,000 sq. ft., then ***b*** could be determined. If the subbasin is comprised of 30% sand & gravel and 70% till, then the average ***S.Y.*** would be 0.17 [(30%)(0.25) + (70%)(0.13) = 0.17]. Therefore ***b*** would equate to an additional 0.001 ft/day water level decline over the entire upgradient subbasin. Next, determine the total water table decline over one month, two month, and three month periods, which represent reasonable non-precipitation-recharge time scenarios in Massachusetts. In this example, the water levels would decline 0.033 ft, 0.067 ft, and 0.101 ft over one, two, and three months, respectively.

Analysis: Procedure #1 should be employed to determine short-term impacts to the subbasin under realistic drought-like conditions potentially occurring primarily during the Summer months from mid-June to mid-September. Results showing an additional water table decline of 0.5 feet or more throughout the proposed area will signal potential significant impacts to the subbasin.

Procedure #2: Streamflow Analysis: (This procedure identifies impacts to streamflows and assumes that water is infiltrated from the stream, or that groundwater which would recharge the stream during baseflow, is intercepted)

Procedure: Calculate or obtain the low flows of streams by establishing the unregulated 7Q10 flow duration for the stretch of the stream or river proximal to the area being sewered (sources for unregulated low flows: 1)USGS Water Resources Investigations Report 99-4006, "Streamflow Measurements, Basin Characteristics, and Streamflow Statistics for Low-Flow Partial-Record Stations Operated in Massachusetts from 1989 Through 1996; 2) USGS Open-file Report 93-38, "Estimation of Low-Flow Duration Discharges in Massachusetts," USGS Chapter 800 Studies). Calculate the average daily pumping withdrawals for the subbasin over the historic period of record from June through September, and the amount of water returned to the subbasin by current septic systems to determine the existing net loss/gain of water to the subbasin. When calculating septic loss/gain, use best available water use records. If those are not available, utilize two-thirds the Title 5 values as discussed previously. Next, recalculate the loss/gain with the proposed sewer project factored in. This should result in less septic returns to the subbasin. The existing and future losses/gains can be used to adjust the 7Q10 flow. This will represent regulated flow conditions. Significant changes to the flow will indicate that streamflows will be reduced during baseflow periods. This procedure assumes that water is infiltrated from the stream, or that groundwater which would recharge the stream during baseflow, is intercepted.

Example: If present conditions exhibit an unregulated low flow for the subbasin at 0.38 mgd, a net withdrawal from groundwater sources at 0.13 mgd, and a net return of water to the subbasin via septic systems at 0.15, then the current net gain to the stream in that subbasin would be 0.02 mgd (0.15 - 0.13 mgd). With the proposed sewer project added in, subtract ***Q1*** (13,369 cu.ft/day or 0.10 mgd) from the current water balance to determine potential impacts. In this case it would result in a net loss of 0.08 mgd (0.02 – 0.10 mgd). The low flow value of 0.38 mgd can then be adjusted to 0.30 mgd (0.38 – 0.08 mgd) which equates to a 21% reduction in streamflow.

Analysis: Procedure #2 should be used to determine the potential impacts to flowing surface water such as rivers and streams. Should the low flow be reduced by more than 25%, then potential significant impacts may occur.

Procedure #3: Sensitive Receptor Analysis: (This procedure identifies sensitive environmental areas)

Procedure: Gather information on sensitive receptors known to be located in areas proposed for sewering. Sensitive receptors and their natural habitats include, at minimum, the following: waterways, certified vernal pools, "rare" plant and animal populations, exemplary natural communities, wetlands, wild or stocked trout streams, surface water bodies supporting important fisheries, anadromous fish runs, and fisheries spawning grounds. Next, target locations (where proposed sewer areas coincide with sensitive receptor and natural habitat areas) for further investigation and conduct an impact analysis through discussions with environmental agency staff. Receptor/habitat information is available through the following sources/agencies: Division of Fisheries and Wildlife Natural Heritage and Endangered Species Program, Division of Marine Fisheries, DEP Office of Watershed Management, DEP Division of Wetlands and waterways, DEM Area of Critical Environmental Concern Program, Municipal Conservation Commissions, and local watershed Associations.

Analysis: Procedure #3 should simply be used to identify sensitive receptors in the subbasin. If current conditions show that sensitive receptors have already been impacted without the proposed sewer project, then more detailed analyses will be required.

Conclusions

The procedures outlined above will only provide a simplistic, yet conservative analysis of the impacts from proposed sewer projects. An analytical evaluation utilizing significant components of the water budget will result. Due to the general nature of these analyses, if one procedure shows the potential for significant impacts to the subbasin, then more detailed analyses must follow. This evaluation will be used by the DEP and should be used by the communities involved to determine if such projects are detrimental to the water supply and sensitive receptors in the area. If the results show that groundwater and surface water are significantly being impacted, then alternative methods must be looked at in order to rectify the situation. For a more detailed study, numerical modelling should be used.

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5/15/00

ATTACHMENT 3
IDENTIFICATION AND EVALUATION OF A TARGET FISH COMMUNITY

Defining a Target Fish Community for Planning and Evaluating Enhancement of the Quinebaug River in Massachusetts and Connecticut

By

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For

Quinebaug River Instream Flow Study Agencies

New England Interstate Water Pollution Control Commission
Connecticut Department of Environmental Protection
Massachusetts Department of Environmental Protection
Massachusetts Division of Fisheries and Wildlife
U. S. Generating Company
U. S. Army Corps of Engineers
U. S. Environmental Protection Agency
U. S. Fish and Wildlife Service

17 July 2000

INTRODUCTION

Efforts to enhance the Quinebaug River for the support of healthy aquatic communities should be guided by clear objectives and be open to objective evaluation. This report covers our effort to develop a model fish community to serve as a target for river enhancements and an endpoint for evaluating program progress. The US Clean Water Act calls for efforts to "restore and maintain the physical, chemical, and biological integrity of the Nation's waters". Biological integrity has been defined (Karr 1991) as the ability to support and maintain "a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region". Thus we propose and demonstrate a method to define a community of fish that is appropriate for a natural river in southern New England by specifying common members, the balance of abundances, species organization, and biological attributes. Our target community is combined with a similarity measurement method to assess the extent that a sampled community is comparable to that of a natural habitat.

Striving for natural habitats and communities may not be practical in settled areas, and a focus on solely natural environmental characters may not yield feasible enhancement actions. Thus we demonstrate an inference approach to summarize the ways that a current community differs from target conditions. That is, we use the target community as a benchmark for assessing comparability and also to identify the nature of departures. For example, exotic fish make up a substantial (ca. 25%) portion of the fish in southern New England, and many of them are valued species with naturalized populations. Departures from a target community may be a result of introduced species, and their influence would compromise a natural community. However, by characterizing deviations from natural conditions the investigator can incorporate other interests in conclusions about current conditions. Finally, some of the methods presented here are new, and we can make adjustments and changes in the method as our shared experiences dictate.

METHODS

A comprehensive list of fish species known to have inhabited the Thames River basin was obtained from Schmidt (1986). He reported 57 species present including 14 species introduced many decades ago such as largemouth and smallmouth bass, walleye, and northern pike. Whitworth's (1996) "Freshwater Fishes of Connecticut" was then reviewed which raised the total list of potential species to 64. From this list, species were deleted for a variety of reasons (Table 1): ten marine and estuarine species only enter coastal freshwater habitats; four species have a restricted distribution to estuarine and coastal areas in the New England region but are more prevalent in other United States regions (Whitworth 1996); five species migrations and habitats are mainly limited to the Atlantic coastal plain; two species were judged out of range by detailed distribution information in Whitworth (1996); and four were historically introduced species that failed to become established. Four anadromous species have been blocked for over a century from reaching the Quinebaug River by several dams. These fish are not included in the community analyses, but were retained for final interpretation of community alterations. Finally, some species (white catfish, swamp darter) were added because of recent occurrence records.

Quality rivers in the same major river basin (Thames River) as the Quinebaug River or similar southern New England coastal basins were used to guide the specification of a target fish fauna. The reference rivers were those recommended by fish biologists of the Massachusetts Division of Fisheries and Wildlife and the Connecticut Department of Environmental Protection as examples of rivers in desirable condition. The reference rivers were not considered to be in a fully natural or a pristine state as such rivers are not available. Thus, these reference rivers provide the best data for characterizing the natural fauna of the Quinebaug River. The rivers chosen and the years of the fish sampling data were: the Ware (1980, 1992) and Housatonic (1999) Rivers in Massachusetts, and the Fivemile (1994), Natchaug (1994), Scantic (1989), and Willimantic (1994) Rivers in Connecticut.

Using the reference river data, a description of a target fish community for the Quinebaug River was produced with some simple spreadsheet calculations. First, the numbers of fish were tallied by species for all collections available from each of the reference rivers. Then, for each river the species tallies were divided by the total number of individuals captured to obtain the proportion of total individuals by species. Stocked species (rainbow and brown trout) were removed from the analysis since these only inhabit the rivers at the stocking size and this provides no useful information on the wild fish community. Proportions of each species were summed across the six reference rivers, and the summed proportions were ranked (1 being the most common dominant species, 2 the next most common dominant, and so on). At this point, all non-native fishes were excluded by eliminating their ranks. The remaining species ranks were then converted to expected proportions used to estimate species abundances in a model or target community. Expected proportions were computed by converting species ranks to reciprocals (1/rank), summing these in decimal form, and dividing reciprocal rank (decimal) by the sum of all reciprocal ranks. This procedure assumes that the expected proportions of the fish community assigned to each species is approximated by their average rank across the set of reference rivers. Uncommon species (less common that the 10th ranked native fish) were grouped into "other", and the expected proportion of this group was the sum of their expected proportions.

Our target fish community, defined by species proportions, was compared to the species composition of recent fish collections (nine sites, Figure 1) along the Quinebaug River provided by the Massachusetts Division of Fisheries and Wildlife (eight sites, 1999) and the Connecticut Department of Environmental Protection (one site, 1994). The comparisons of target and current fish communities were made using a percent model affinity procedure (Novak and Bode 1992). The percent model affinity method yields values on a scale from 0 to 100 which describe the extent that a fish collection at a site on the Quinebaug River matched our target community. High affinity values correspond to higher levels of correspondence with the target community. The percent model affinity method uses a percent similarity measure (Novak and Bode 1992) computed as:

$$\text{Percent similarity} = 100 - 0.5\,(\text{sum } |\text{target P} - \text{observed P}|)$$

where: P = proportions of each species in the community or collection.

The observed proportions of the top 10 target fishes were used to identify the Quinebaug River fish species occurring at expected abundances, under represented, or overly abundant. The species expected in the river that were not recorded were also identified. Interpreting the significance of the deviations from a target community was done by reviewing the habitat requirements and pollution tolerances for species in the observed abundance groups.

Species habitat requirements and pollution tolerances were reviewed (Appendix A) and classified using regional and state ichthyology books (Scott and Crossman 1973, Pflieger 1975, Lee et al. 1980, Trautman 1981, Becker 1983, Burr and Warren 1986, Robison and Buchanan 1988, Jenkins and Burkhead 1994). As a group, these reference books describe the North American life history of fish. Habitat requirements were summarized into three macrohabitat (water body type) classes: generalists (MG), fluvial dependents (FD), and fluvial specialists (FS). The species life history notes (North American scale) and habitat need classifications are reported in Appendix B for all known and potential (current) inhabitants of the Quinebaug River basin. To accommodate regional differences in habitat requirements, three of the habitat classifications (fallfish, longnose dace, and brook trout) were changed from habitat generalists to fluvial specialists (regional) by agreement of this project's fishery agency advisors. American eel is a catadromous fish (migrates to sea for spwaning) that requires access to stream habitats to complete its life cycle. This fish was reclassified as a fluvial dependent for this reason even though the species occupies a wide range of habitats throughout life. We used the pollution tolerance classification of Halliwell et al. (1999) for Northeast US fishes: intolerant (I), moderately tolerant (M), or tolerant (T). Finally, species were designated as native or exotic (introduced) from Schmidt (1986) and Whitworth (1996).

RESULTS

Our review of the potential and known fishes of the Quinebaug River basin resulted in a list (Appendix B) of 36 species we would expect to be found in streams, lakes, and river reaches of the basin. The species list contains native and introduced fishes, and a full range of sensitivities to habitat and water quality degradation. Many of these fish have not been recorded in recent sampling, but they are considered candidate species for collection in any survey. In addition to the 36 expected species in the basin, there are four anadromous fish that could be restored to the fauna by actions outside the study area. These anadromous fish are: blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), Sea lamprey (*Petromyzon marinus*), and Atlantic salmon (*Salmo salar*).

The fish composition data for the six reference rivers (Table 2) provided the guidance for specifying the rank order of species in our target community. Fallfish were a clear dominant fish in two of six rivers, and abundant in three other rivers. Common shiner was a dominant species in two rivers and abundant in another river. These two fishes were ranked first and second respectively, with other high ranked (low rank number) fishes common in most of the reference rivers. Following these results, the rank order of species in our target community for the Quinebaug River is: fallfish, common shiner, white sucker, longnose dace, eastern blacknose dace, tessellated darter, redbreast sunfish, American eel, yellow perch, and pumkinseed. We expect then that a high quality fish community in the Quinebaug River would display approximately this order of abundance by species (fish over ca. 25 mm total length). When converted to expected abundance proportions, the target fish community for the Quinebaug River would be comprised of fallfish (31%), common shiner (15%), white sucker (10%), longnose dace (8%), eastern blacknose dace (6%), tessellated darter (5%), redbreast sunfish (3%), american eel (3%), yellow perch (3%), pumpkinseed (2%), and other (14%, Figure 2).

Using the recent Quinebaug River survey data, a set of comparisons were made between the target fish community and the observed fish communities at the 9 sites plotted on Figure 1. Similarity among target and observed communities was summarized with the percent affinity measure (Table 3). The Quinebaug River sites varied in the extent that fish collections conformed to target conditions. In general, the species expected to be dominant were often abundant, but at levels below target proportions. Also, several fishes expected to be at low abundances (members of the Other class) were sometimes found in high abundances. Affinity index values ranged from a 65% match with target conditions to a 35% match. The spatial variation in these affinity index values (Figure 3) indicated moderate values at the upstream end of the study reach with a slight but steady increase downstream through the high gradient stream sites in the City of Southbridge. The model affinity value for site 53 was unusally low. This site was at the downstream edge of Southbridge where municipal sewage treatment plant and possibly other discharges occur. Further downstream (Site 72), an affinity value similar to upstream sites was obtained, and then just inside the State of Connecticut another low value was recorded.

The affinity values can be explained by comparing species composition values with model community proportions (Table 3). Furthermore, information on species ecology can be combined with the deviations in species abundances (Table 4) to infer the status of the Quinebaug River fish community and environment. The species found at abundances less than expected for a target fish community were largely specialists on flowing water habitats or dependents on streams for part of their life cycle. Fish found at abundances equal to or greater than expected were almost all habitat generalists. Species not recorded included a mix of generalists and fluvial specialists. Pollution tolerances did not appear to vary by abundance group except for the species not found at any site. The missing fishes included five pollution intolerant species, and these sensitive fishes comprised half of the missing fishes. Finally, the four anadromous fishes were indeitified as missing (Table 4) because they would be an important part of the expected fish community if there were no obstacles to migration downstream of the Quinebaug River.

DISCUSSION

This analysis and report provides the first clear look at the present fish community of the Quinebaug River. The recent survey data indicate a river fish fauna that differs from the target community, but it is not a largely foreign assemblage of fish. The common fishes of the river included those expected for natural rivers in the region, and some now abundant introduced species. However, many abundant fishes were predicted by model community composition to be found in relatively low numbers, and these overly abundant fishes tend to be habitat generalists and tolerant of altered water quality. Thus the mix of species appears changed by prevailing river conditions and species introductions, and evidence for both habitat and water quality degradation was seen in the summary of species by abundance group.

The results of change in target community affinity along the river was also informative of the prevailing pattern of river quality. Affinity values were very similar at most sites along the Quinebaug River indicating a moderate correspondence with target conditions. These summary values were obtained across sites with clear variation in species composition but a general abundance of the anticipated stream fishes. Nevertheless, two sites (53, 20) had poor values indicating a sharp departure from target conditions. The fish community at site 53 was dominated by redbreast sunfish and smallmouth bass; species that should be minor community components. This site is easily recognized as a heavily degraded stream location due to pollutant discharges, channelization, bank stabilization, extensive adjacent human infrastructure, and adjacent downstream impoundment. At site 20, spottail shiners were a clear dominant species accounting for more than half of the fish recorded, and common shiner were also overly abundant. This site is not readily identifiable as degraded but is an area recently inundated by a now failed dam. Additional year 2000 fish surveys will likely help clarify the value of our restoration target setting approach and analysis techniques. However, this first application appears to have yielded reasonable results that are helpful in pursuing project goals.

The process of specifying a target fish community revealed how challenging it is to judge what constitutes a natural river fish community. Developing a list of species in the river basin was relatively clear and straightforward with a few notable exceptions. The main starting material (Schmidt 1986, Whitworth 1996) readily yielded a grand list of species expected to be inhabiting the river and associated waters or potentially occurring in the basin. Most refinements to this list could be easily made by a biologist familiar with the regional fauna. However, the inclusion of a few species (e.g., fathead minnow, redfin pickerel, slimy scuplin) was difficult to resolve because experienced regional fish biologists had conflicting accounts of the local distribution of these fish. Handling of anadromous fishes was also complicated by different views on long-term management actions. We included anadromous fishes in the final summary table (Table 4) but we did not include them in the target community specification. Little is known about the extent and abundance of anadromous fish in far inland waters like the Quinebaug River because dams blocking migrations were widely established in the 1800s. Future restoration of anadromous fish to the Quinebaug River depends on actions taken outside the study area. Hence, anadromous fish are not a community component in the context of the current river restoration planning, but they could be an important part of restoration planned within a large scope. Overall, target community composition predictions are straightforward for a potential species list with the exception of adjustments for very recent and far future information.

There was substantial variation in community composition among the six reference rivers recommended as quality rivers for the region. Common species varied considerably in their relative abundance by river, and normally uncommon species were sometimes abundant. Therefore, it would likely be impossible to specify precisely what the fish community should be like for the Quinebaug River or others in the region. To reach a generalized target community, we lessened the influence of reference river survey data by using mean rank abundances to define target community composition. Also, the use of six reference rivers helped to moderate the influence of any one river in defining a target community.

Our target fish community can be used as a general guide of what is considered a healthy fish community for large streams and small rivers in the region. By adopting it as a standard, we could also use the target community to numerically rate the similarity of any fish collection or study site to target conditions. Finally, computing affinity index values for specific collections and sites allows comparisons to be made of target similarity across sites and times. We conducted these analyses as a demonstration exercise with the Massachusetts Division of Fish and Wildlife and Connecticut Department of Environmental Protection fish collections along the Quinebaug River. The results of that exercise show what can be done with a specified target fish community for planning and assessment. However, we believe that additional application trials need to be done to have confidence in these analyses. Additional applications are underway now with other rivers and regions where good data exist for judging the significance of river impacts. Aside from building confidence, additional application experience is needed to fully interpret affinity index values. The percent model affinity method employed here copies much of the approach from the method's original authors (Novak and Bode 1992). In their benthic bioassessment analyses using the percent model affinity, Novak and Bode provide index ranges corresponding with severely impacted, moderately impacted, slightly impacted, and non-impacted. These index ranges were chosen from extensive field experience using the method. As we experiment with further applications of our fish-based affinity method, we will be able to propose index ranges for similar interpretations of aquatic system quality. For now though, the target fish community specified here serves immediate project needs and the method may prove more useful for general application in the near future.

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Table 1. Species deleted from a comprehensive list of Quinebaug River fish and reasons for deletion.

Scientific Name	Common Name	Reason for deletion [¥]
Anchoa mitchilli	Bay anchovy	ME
Alosa pseudoharengus	Alewife	ME
Microgadus tomcod	Atlantic tomcod	ME
Cyprinodon variegatus	Sheepshead minnow	ME
Fundulus heteroclitus	Mummichog	ME
Lucania parva	Rainwater killifish	ME
Menidia beryllina	Inland silverside	ME
Menidia menidia	Atlantic silverside	ME
Gobiosoma bosci	Naked goby	ME
Trinectes maculatus	Hogchoker	ME
Apeltes quadracus	Fourspine stickleback	EC
Gasterosteus aculeatus	Threespine stickleback	EC
Pungitius pungitius	Ninespine stickleback	EC
Morone saxitilis	Striped bass	EC
Osmerus mordax	Rainbow smelt	M
Alosa mediocris	Hickory shad	M
Dorosoma cepedianum	Gizzard shad	M
Aphredoderus sayanus	Pirate perch	M
Enneacanthus obesus	Banded sunfish	M
Percopsis omiscomaycus	Trout-perch	R
Etheostoma fusiforme	Swamp darter	R
Lepomis cyanellus	Green sunfish	Ix
Stizostedion vitreum	Walleye	Ix
Pomoxis annularis	White crappie	Ix
Salvelinus namaycush	Lake trout	Ix

¥ ME = marine and estuarine species which only enter coastal freshwater habitats; EC = species with a restricted distribution to estuarine and coastal areas in the New England region but are more prevalent in other United States regions; M = species migrations and habitats are mainly limited to the Atlantic coastal plain; R = judged out of range by detailed distribution information; Ix = Introduced in the past with no evidence of being established in the basin.

Table 2. Fish species in reference river collections with their mean rank and expected contribution to the Quinebaug River community. Introduced species were deleted from the expected proportion values (dash entries) and the composition of the target community.

Species name	Ware River	Housa-tonic River	Willi-mantic River	Natchaug River	Fivemile River	Scantic River	Mean rank	Expected Pro-portion [*f*]
American Eel			21	24	18	239	10	0.03
Brook Trout						12	20	0.01
Northern Pike				1			27	-
Chain Pickerel	8		7	9	29		16	0.02
Goldfish			3			21	18	-
Common Shiner	25		1440	19	691	342	2	0.15
Golden Shiner	1	1	22		26	11	17	0.02
Spottail Shiner	6		16			1	19	0.02
E Blacknose Dace	5	87	557	13	119	138	5	0.06
Longnose Dace	70	93		6	229	231	4	0.08
Creek Chub		14					15	0.02
Fallfish	226	1	3194	262	175	189	1	0.31
Common Carp		2					22	-
White Sucker	179	43	1092	91	70	131	3	0.10
Creek Chubsucker					1		28	0.01
Yellow Bullhead	2				8		23	-
Brown Bullhead			2	1	7	1	24	0.01
Rock Bass	11	7	10	15		11	14	-
Redbreast Sunfish			150	89	93	24	9	0.03
Green Sunfish			6	1			26	-
Pumpkinseed	36	1	50	22	17	7	13	0.02
Bluegill	6	1	12	91	147	33	7	-
Smallmouth Bass			226	78		1	11	-
Largemouth Bass	116	5	23	7	121	3	8	-
Black Crappie	3					3	25	-
Tesselated Darter	259		104	58	17	125	6	0.05
Yellow Perch	32	2	193	4	37	3	12	0.03
Sea Lamprey						12	20	0.01

f Expected proportion for species below the 10 most common were pooled into Other and that class is expected to compose 14% of the community.

Table 3. Comparison of recent fish collections at nine sites along the Quinebaug River (see Figure 1) and the model fish community (model %). The observed percent composition values are reported with the corresponding site affinity index value.

Fish species	Model %	Percent composition by site								
		50	51	73	54	55	52	53	72	20
Fallfish	31	45	21	28	16	16	31	14	23	7
Common Shiner	15	1	57	5	25	43	14	1	5	21
White Sucker	10	6	8	8	1	10	1	<1	22	6
Longnose Dace	8		8		10	5				1
Blacknose Dace	6		3		1	1				
Tesselated Darter	5	1				2		1		
Redbreast Sunfish	3	8	2	14	19	8	15	30	7	1
American Eel	3					1				
Yellow Perch	3			18	1				9	<1
Pumpkinseed	2	1		16	2		<1	6	3	<1
Other	14	38	1	11	26	16	38	49	32	64
Smallmouth Bass		1		1	10	1	33	34	18	3
Spottail Shiner						13				57
Yellow Bullhead		15	<1	4	10	1	4	8	4	2
Bluegill		13		1	6	<1	<1	2	2	2
Largemouth Bass		8	1	1			1	3	6	<1
Golden Shiner				3					2	
Chain Pickerel		1						1		
Brown Bullhead								1		
Black Crappie		1								
% Model Affinity		57	58	59	60	65	63	35	60	44

Table 4. Review of species relative to target community abundances, source, habitat requirements, and pollution tolerances.

Species	Source	Habitat requirements	Pollution tolerance	Comments
Underrepresented species				
Fallfish	Native	Fluvial specialist	Moderate	Generally below expectations
White Sucker	Native	Fluvial dependent	Tolerant	Sparce numbers at some sites
Longnose Dace	Native	Fluvial specialist	Moderate	Absent at many sites
Blacknose Dace	Native	Fluvial specialist	Tolerant	Absent at many sites
Tesselated Darter	Native	Fluvial specialist	Moderate	Absent at many sites
American Eel	Native	Fluvial dependent	Tolerant	Almost always absent
Species recorded as expected				
Yellow Perch	Exotic	Generalist	Moderate	Occasionally numerous
Golden Shiner	Native	Generalist	Tolerant	Few captures in low numbers
Chain Pickerel	Native	Generalist	Moderate	Few captures in low numbers
Brown Bullhead	Native	Generalist	Tolerant	Few captures in low numbers
Black Crappie	Exotic	Generalist	Moderate	Few captures in low numbers
Overly abundant species				
Common Shiner	Native	Fluvial dependent	Moderate	Dominant fish at some sites
Redbreast Sunfish	Native	Generalist	Moderate	Overly abundant at most sites
Pumpkinseed	Native	Generalist	Moderate	Highly abundant at some sites
Smallmouth Bass	Exotic	Generalist	Moderate	Highly abundant at some sites
Spottail Shiner	Native	Generalist	Moderate	Highly abundant at some sites
Yellow Bullhead	Exotic	Generalist	Tolerant	Highly abundant at some sites
Bluegill	Exotic	Generalist	Tolerant	Abundant at some sites
Largemouth Bass	Exotic	Generalist	Moderate	Abundant at some sites
Missing native species				
Brook Trout		Fluvial specialist	Intolerant	
Redfin Pickerel		Generalist	Moderate	
Bridle Shiner		Generalist	Intolerant	
Fathead Minnow		Generalist	Tolerant	
Creek Chub		Generalist	Tolerant	
Creek Chubsucker		Fluvial specialist	Intolerant	
Banded Killifish		Generalist	Tolerant	
White Perch		Generalist	Moderate	
Swamp Darter		Generalist	Intolerant	
Slimy Sculpin		Fluvial specialist	Intolerant	
Blueback herring		Anadromous		
American shad		Anadromous		
Sea lamprey		Anadromous		
Atlantic salmon		Anadromous		

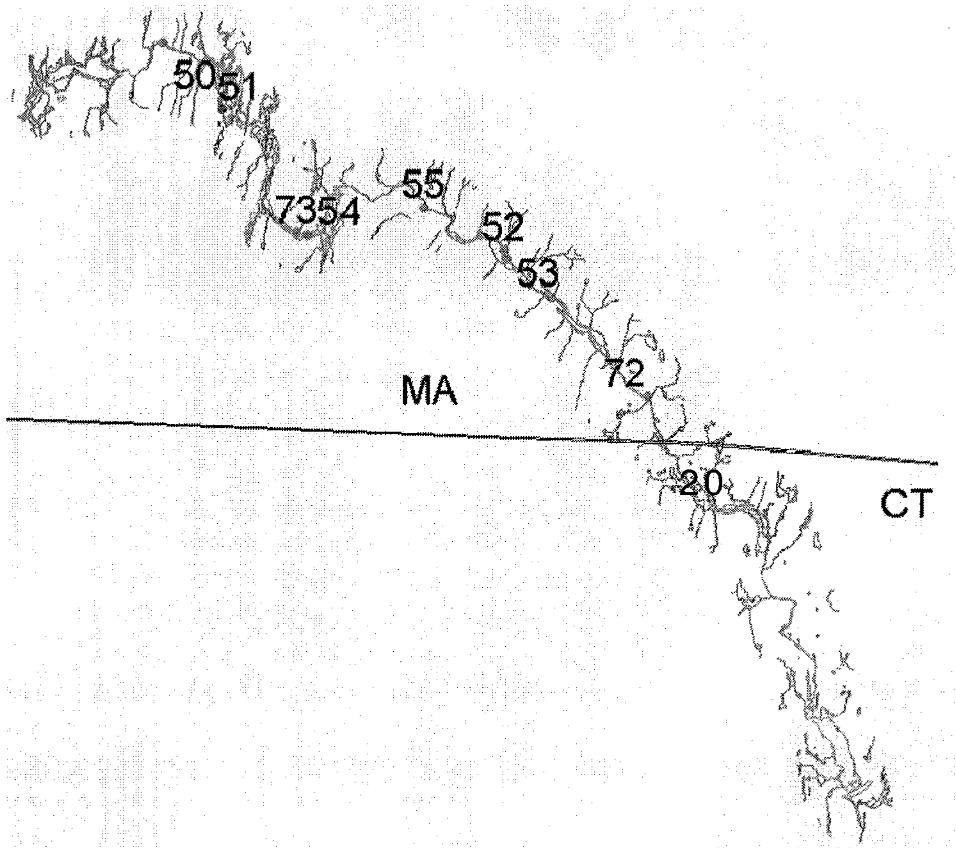
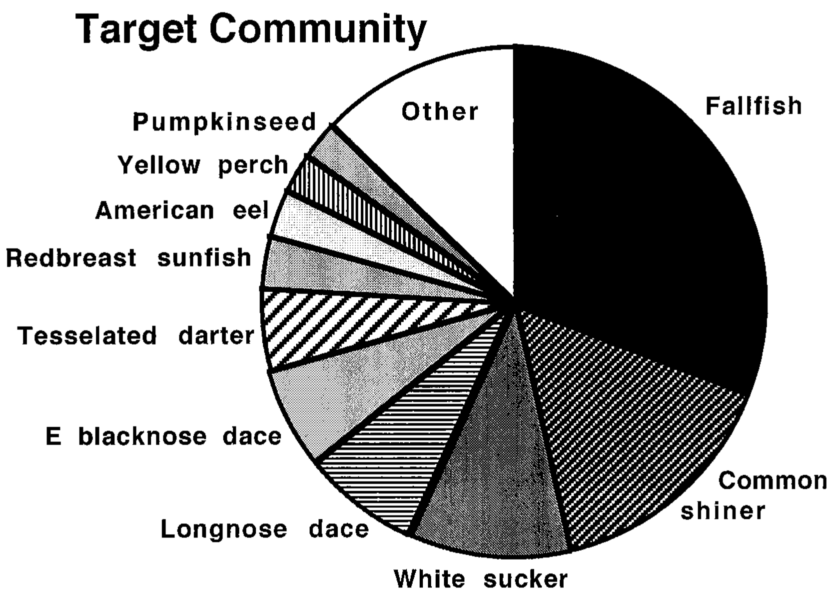


Figure 1. Locations of the Masschusetts Division of Fish and Wildlife 1999 stream sampling sites: Fiskdale (50), Old Sturbridge village (51), Westville Dam area (73), Westville Dam (54), Southbridge Rt. 131 (55), Southbridge at Big Y Store (52), Southbridge at school bus lot (53), and Dudley (72). Route 197 near the town of Quinebaug (20) was sampled by the Connecticut Department of Environmental Protection in 1994.



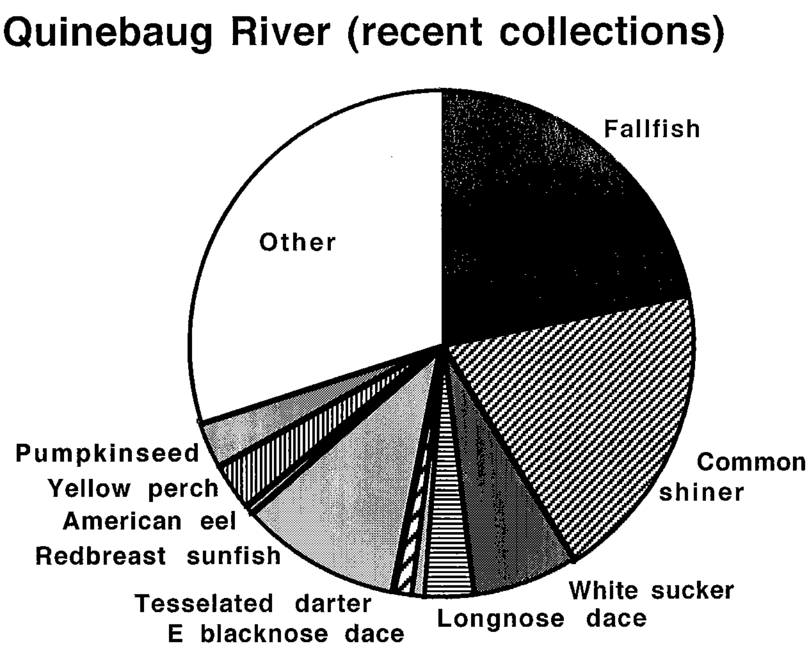


Figure 2. Species composition of target community and the pooled Quinebaug River survey samples of the Massachusetts Division of Fisheries and Wildlife in 1999 and the Connecticut Department of Environmental Protection in 1994.

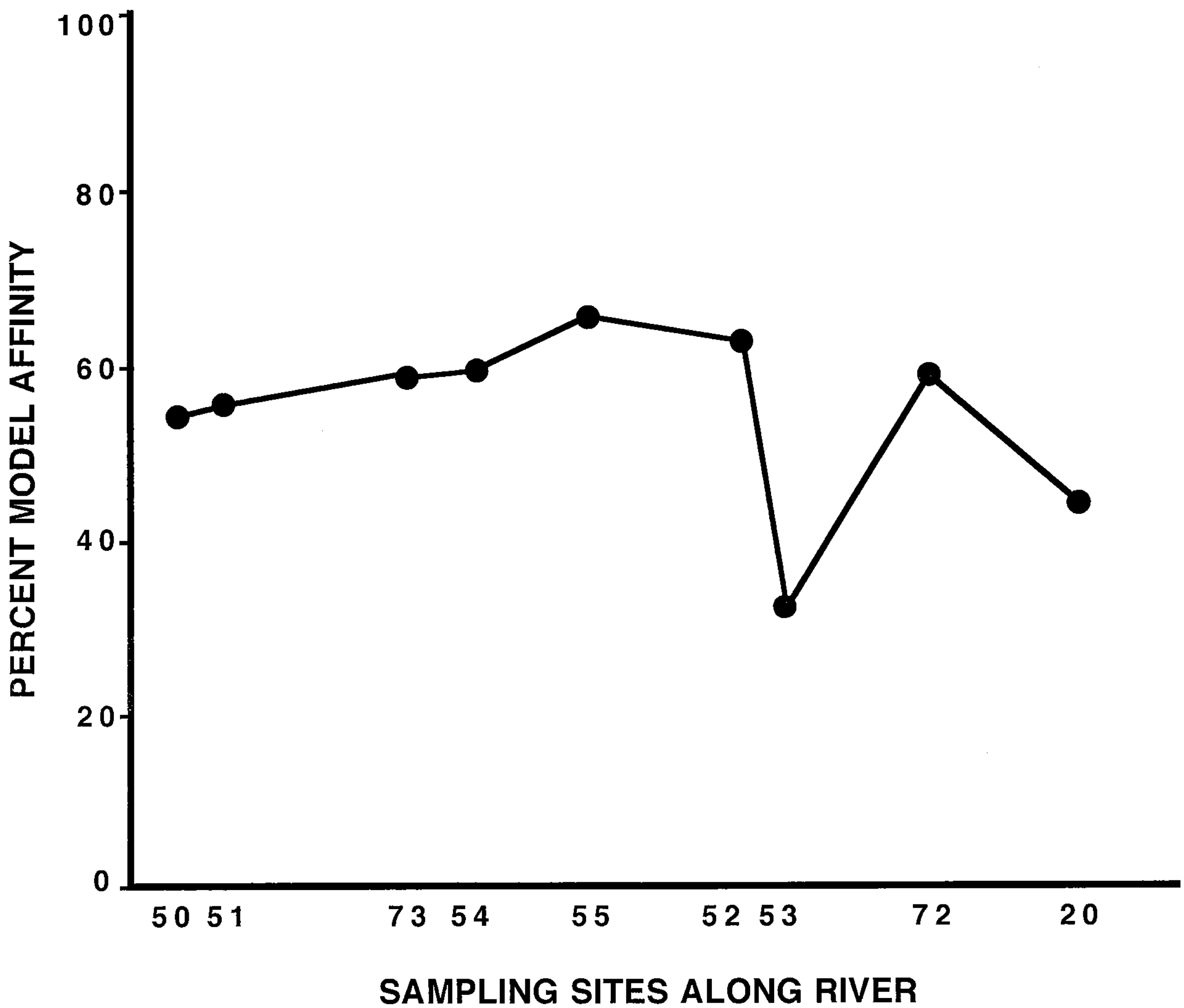


Figure 3. Downstream trend in correspondence of site samples with the target fish community where affinity values of 100 equals a perfect match and zero indicates no similarity. Community affinity values correspond with the sampling sites shown in Figure 1.

APPENDIX A

Review of Life History Information on the
Expected Fishes of the Quinebaug River Basin

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APPENDIX B

Expected Fishes of the Quinebaug River Basin

Common name	Genus	Species	Introduced or Native	Habitat Use Classification	Pollution tolerance
Anguillidae					
American eel	Anguilla	rostrata	N	FD	T
Salmonidae					
Rainbow trout	Oncorhynchus	mykiss	I	FD	I
Brown trout	Salmo	trutta	I	FD	I
Brook trout	Salvelinus	fontinalis	N	FS	I
Esocidae					
Redfin pickerel	Esox	americanus	N	MG	M
Northern pike	Esox	lucius	I	MG	I
Chain pickerel	Esox	niger	N	MG	M
Cyprinidae					
Goldfish	Carassius	auratus	I	MG	T
Common shiner	Luxilus	cornutus	N	FD	M
Golden shiner	Notemigonus	crysoleucas	N	MG	T
Bridle shiner	Notropis	bifrenatus	N	MG	I
Spottail shiner	Notropis	hudsonius	N	MG	M
Fathead minnow	Pimephales	promelas	N	MG	T
E Blacknose dace	Rhinichthys	atratulus	N	FS	T
Longnose dace	Rhinichthys	cataractae	N	FS	M
Creek chub	Semotilus	atromaculatus	N	MG	T
Fallfish	Semotilus	corporalis	N	FS	M
Common carp	Cyprinus	carpio	I	MG	T
Catostomidae					
White sucker	Catostomus	commersoni	N	FD	T
Creek chubsucker	Erimyzon	oblongus	N	FS	I
Ictaluridae					
Yellow bullhead	Ameiurus	natalis	I	MG	T
Brown bullhead	Ameiurus	nebulosus	N	MG	T
White catfish	Ictalurus	catus	I	MG	M
Cyprinodontidae					
Banded killifish	Fundulus	diaphanus	N	MG	T
Moronidae					
White perch	Morone	americana	N	MG	M

APPENDIX B, continued

Expected Fishes of the Quinebaug River Basin

Common name	Genus	Specis	Introduced or Native	Habitat Use Classification	Pollution tolerance
Centrarchidae					
Rock bass	Ambloplites	rupestris	I	MG	M
Redbreast sunfish	Lepomis	auritus	N	MG	M
Pumpkinseed	Lepomis	gibbosus	N	MG	M
Bluegill	Lepomis	macrochirus	I	MG	T
Smallmouth bass	Micropterus	dolomieu	I	MG	M
Largemouth bass	Micropterus	salmoides	I	MG	M
Black crappie	Pomoxis	nigromaculatus	I	MG	M
Percidae					
Tesselated darter	Etheostoma	olmstedi	N	FS	M
Swamp darter	Etheostoma	fusiforme	N	MG	I
Yellow perch	Perca	flavescens	N	MG	M
Cottidae					
Slimy sculpin	Cottus	cognatus	N	FS	I

APPENDIX C

Application of Target Community to Smaller Streams

One recommendation not implemented in this target fish report was dividing the Quinebaug River into two sections: a warmwater lowland reach, and a coldwater upland reach. Many characteristics of the river differ between reaches above and below the steep section in Southbridge. We also found some early accounts (Massachusetts Division of Fisheries and Wildlife) of Quinebaug River that suggested the river upstream of Southbridge was a trout stream. We attempted to specify a target community for the upper Quinebaug River study reach (Brimfield Dam to Southbridge). This effort was abandoned because a target community for the upper river appeared to be the same as that presented in this report.

This appendix reports on our effort to specify a upper river target fish community. The Quinebaug River in the vicinity of Fiskdale has a channel about 20 meters wide on average. Robert Maietta, Massachusetts Department of Environmental Protection, provided us with fish community surveys on nine quality streams with average widths from 5 to 9 meters. The smallest appeared to be coldwater trout streams because brook trout were common or dominant. However, the largest of the streams had a fish community that was very similar to our Quinebaug River target community. The table below presents composition data for Muddy Brook (9.4 m wide, Ware MA) and Turkey Hill Brook (9.1 m wide, Spencer MA) and the Quinebaug River target community. Both streams had fish collections that matched the target community well (affinity values 63 and 74). Turkey Hill Brook had an affinity value considerably higher than any current sample site on the Quinebaug River. Both streams are in the Connecticut River basin and some modification of the target community specification should be done to adjust for Connecticut River basin fishes (e.g., redbreast sunfish). Nevertheless, these quality small streams were very similar to our target fish community. While much smaller than the Quinebaug River, these streams did not have coldwater fish in a high enough abundance to warrant a new taxa category or to displace the most abundant fishes listed in the table below. Our conclusion then is that there is not likely to be a substantial difference in a second target fish community specific to the upper study reach, and that the current target fish community is appropriate for the whole main Quinebaug River.

	Percent composition		
Taxa Category	**QR Target**	**Muddy Brk.**	**Turkey Hill Brk.**
Fallfish	31	43	54
Common Shiner	15	4	19
White Sucker	10	9	10
Longnose Dace	8	33	5
Blacknose Dace	6		6
Tesselated Darter	5	6	2
Redbreast Sunfish	3		
American Eel	3		
Yellow Perch	3		
Pumpkinseed	2	1	0
Other	14	4	4
Percent Affinity		**63**	**74**