COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF ADMINISTRATIVE APPEALS & DISPUTE RESOLUTION

In the Matter of Town of Shrewsbury WMA Permit 2014	OADR Docket No. 2014-002 Shrewsbury

MITIGATION PLAN

The parties[1] to this administrative appeal have entered into a Settlement Agreement ("the Agreement") which incorporates by reference this "Mitigation Plan" ("the Mitigation Plan") and to which the Mitigation Plan is an attachment. As part of their Settlement Agreement the Parties have agreed to the terms and conditions of the Mitigation Plan as a means whereby the Town can reduce the impact of the increase in its authorized withdrawal volume above its baseline of 3.91 mgd as required by Special Condition 8 of the Town's "Water Withdrawal Permit" # 9P4-2-12-271.01 ("the Permit") issued by DEP on January 29, 2014. The Permit authorizes up to 4.35 MGD and the baseline withdrawal is 3.91 MGD, thus the increased volume that must be mitigated is 0.44 MGD. The Mitigation Plan identifies mitigation credits and wastewater adjustments that allow for withdrawals of up to 0.257 mgd[2] (See Mitigation Volume Summary - Table A, at the end of the Mitigation Plan) which is more than Shrewsbury's

[1] Being the Department of Environmental Protection (" DEP"), the Town of Shrewsbury ("the Town") and the Blackstone River Coalition, the Blackstone Headwaters Coalition, the Blackstone River Watershed Association and a group of Twelve Citizens ("the Petitioners") hereinafter collectively "the Parties".

[2] Finalization of this volume will be subject to DEP review and approval of future stormwater projects.

baseline withdrawal of 3.91 mgd. Future withdrawals above 4.17 mgd will need DEP review and approval to confirm additional demands and to evaluate compliance with Performance Standards and Functional Equivalence. Should Shrewsbury need volumes greater than those identified in the Mitigation Volume Summary - Table A, at the end of the Mitigation Plan, Shrewsbury will need to develop a revised Mitigation Plan in consultation with DEP. Future revisions to the Mitigation Plan that propose to increase the volumes to be withdrawn shall assess additional mitigation as required by 310 CMR 36.22 (6). Shrewsbury shall evaluate direct mitigation first, and if the additional mitigation cannot be achieved entirely through direct mitigation, Shrewsbury will then evaluate indirect mitigation measures.

The requirements of the Mitigation Plan as agreed upon by the Parties[3] are hereby incorporated in the Modified Permit (submitted with the Agreement) as follows:

I. DEMAND MANAGEMENT

A. NON-ESSENTIAL OUTDOOR WATERING LIMITS

(1) The Town, at its May 2014 Annual Town Meeting, voted to amend Article 18 of its General Bylaws, "Water Use Restrictions", to limit watering between April 15 and October 15 annually to two (2) days per week as required by Table 4 of Special Condition 7 of the Permit. Previously Article 18 of the General Bylaws allowed "Non-Essential Outdoor Watering" three (3) days per week. This new scheme was

[3] The Parties acknowledge that the Mitigation Plan is subject to amendment since it is a prospective planning document that identifies measures that have been, or will be, taken to offset use of volumes over Baseline. If measures identified in the Mitigation Plan are insufficient to offset requested volumes over Baseline, additional mitigation measures will need to be identified and implemented in order for unmitigated volumes to be used, requiring amendment of the Mitigation Plan. Further, the Parties acknowledge that the Final Permit conditions use of volumes over Baseline on finding sufficient mitigation credits. Consequently, a Permittee may find that it cannot qualify to use all of the volumes over Baseline that are set out in its permit if it fails to implement sufficient offset volumes. Actions included in the Mitigation Plan which are not completed at the time that the Agreement is signed by all the Parties, will only receive mitigation credits when their completion is confirmed to DEP in writing by the Town subject to DEP review and approval .

implemented by the Town on or about July 22, 2014. The impacts on water demand following the institution of this bylaw amendment will be monitored and reported in Shrewsbury's Annual Statistical Reports for 2015 and 2016.

(2) On February 10, 2003, the Town, by vote of its Board of Selectmen acting as Water Commissioners prohibited new connections to its Public Water System for new in-ground and garden irrigation systems in order to reduce demand on the system.

(3) Industrial, Commercial Institutional Water Conservation Program

The Town's Industrial, Commercial and Institutional (ICI) Water Conservation Program will involve the following elements:

1. In January of each year, the Town will review its records to determine, or confirm, the ten (10) largest ICI Customers;

2. An employee of the Town will be assigned to meet with each of the identified ten (10) largest ICI Customers;

3. The purpose of this meeting will be to commence a program to reduce water use:

    a. To identify any changes in consumption from the previous three years;

    b. To review overall water use and work with these users to reduce demand through such methods as water audits, reuse, low flow plumbing fixtures, xeriscaping and restrictions on nonessential outdoor water use;

    c. To offer free of charge technical advice on water saving opportunities including, where appropriate, referral to trade associations for process specific water use reduction recommendations and contact information for EOEEA's Office of Technical Assistance for Toxics Use Reduction;

d. To partner, where possible, with ICI Customers on any public or private grant or loan programs to make improvements that will reduce demand;

e. To offer any other relevant assistance that may be available from the Town based upon available resources.

4. The Town shall report to MassDEP on the results of it's ICI Water Conservation Program with each ASR and the reports shall include the inventory of the ten (10) largest ICI Customers, the results of the Town's review of those customers' water use records, methods and actions taken and their resulting water use reductions.

(4) Toilet Rebate Program

As part of the Town's continuing demand management efforts, effective September 1, 2015, the Town will offer a $35.00 per toilet rebate to its water customers upon proof of the purchase and installation of a new water-saving toilet. Eligible toilet fixtures for this rebate must carry the "WaterSense" label as issued by the Environmental Protection Agency.

II. DIRECT MITIGATION

A. INFLOW & INFILTRATION REMOVAL

(1) The Town is in Year 4 of a Ten Year Program to remove Inflow and Infiltration "I/I). The May 2014 Annual Town Meeting appropriated 1.367 million dollars to perform work identified in Years 1 through 3 and to conduct additional studies in Year 4. All of this work is in the Blackstone Basin moving in phases north of Route 20 in the southerly part of the Town. The next planning phase will be in Year 5 of the Ten Year Program and will be located in subareas to be determined by the Town and its outside consultant based on the greatest potential flow removal.

(2) DEP will only assign mitigation credit for I/I volumes removed by the Town that the Town confirms to DEP in writing for DEP's review and approval. Volumes removed will be subject to the "Location Adjustment Factor" ("LAF") depending on whether they are in the Blackstone Basin or in the Concord Basin. As the Blackstone Basin is the location of the withdrawal, 100% of returns will be credited as opposed to 50% for the Concord Basin or 75% of the returns if the I/I volumes removed are from an area of greater August net groundwater depletion than the location of Shrewsbury's groundwater withdrawal points.

(3) Beginning in 2009, the Town made a conscious effort to eliminate infiltration and inflow (I/I) from its sanitary sewer system. To this end the Town prepared a 10-year schedule and appropriated funds at the 2014 Annual Town Meeting for FY15 for the Year 4 I/I investigations. The Town has retained Weston & Sampson Engineers, Inc. to assist in the investigations, design documents, and conduct inspections. The construction that the Town has undertaken is set out in **Appendix A**, "Sanitary Sewer Infiltration/Inflow (I/I) Elimination Program" which is attached hereto and incorporated herein.

B. STORMWATER RECHARGE

Recharge of stormwater volumes for retrofits and rehabs of existing impervious surfaces that exceed the requirements of DEP's "Stormwater Standards" will qualify for direct mitigation credit as determined by DEP in accordance with the methodology developed in collaboration with the Parties' experts. These volumes will be subject to the "Location Adjustment Factor".

The projects that qualify for direct mitigation credit are set out in **Appendix B**, "Stormwater Recharge Redevelopment Projects" which is attached hereto and incorporated herein.

C. SEPTIC RECHARGE

1. The Town of Shrewsbury is estimated to be 85% sewered. Wastewater presently discharges entirely to the Concord River Basin via the Westboro publicly owned treatment works with two exceptions: the high school and a small industrial area on Bowditch Drive, both of which discharge to the Blackstone River Basin via the City of Worcester's sewer system to the Upper Blackstone Pollution Abatement facility in Millbury. The Poor Farm Brook and Sewall Sub-basins within the Blackstone River Basin are entirely served by septic systems except for the high school and the small industrial area on Bowditch Drive.

2. Should the Town elect to utilize permitted volumes over its Baseline, new septic returns for those volumes proposed above Baseline will be estimated to be returned consistent with Shrewsbury's wastewater disposal percentages (septic vs. sewered) at that time. Those future septic percentage returns will be assigned to their locations in the two Major Basins (Blackstone or Concord Basin) as set out in DEP's "Water Management Act Permit Guidance" – November 7, 2014 ("the Guidance"). Under the Guidance the wastewater adjustment credits for the septic returns for each Major Basin will be calculated separately utilizing the volume of returns for each, proportional to the additional withdrawals above Baseline and subject to the "Location Adjustment Factor" and any amendments to the methodology in the Guidance. At present the methodology for calculating wastewater returns to groundwater is described at pages 31-32 of the Guidance.

The following is an example of how the wastewater adjustment credits for septic returns would be calculated based on Shrewsbury's existing returns and an increase above baseline of 0.234 MGD:

The rate of septic return within the entire town of Shrewsbury is presently 15%. The future rate of septic return is assumed to also be 15%.

0.234 MGD increase above baseline x 15% = 0.035 MGD = future rate of water withdrawn that goes to non-sewered buildings.

For all communities DEP assumes that 85% of water entering a building leaves as wastewater. It is coincidental that Shrewsbury is also 85% sewered.

0.035 MGD x 85% = 0.030 MGD = rate of septic return town-wide from increase above baseline

Assume that the ratio of Concord basin to Blackstone basin septic volume =50/50.

Blackstone basin septic credit = 0.030 MGD x 50% of town-wide septic return = 0.015 MGD

Concord basin septic credit = 0.030 MGD x 50% of town-wide septic return x 50% multiplier for out-of-major basin septic discharge = 0.008 MGD

Blackstone septic credit of 0.015 MGD + Concord septic credit of 0.008 MGD = 0.023 MGD = TOTAL Shrewsbury septic credit for increase above baseline of 0.023 MGD.

*Note: Septic returns will potentially increase as withdrawal above Baseline increases as shown above.

D. Alternative Water Source(s)

The Town of Shrewsbury had an Alternative Water Supply Study completed in 2010. Utilizing the existing study as a beginning point, the Town will evaluate potential alternative water sources and will commit to a comprehensive study of such options through available funding by a consultant with particular expertise in the possible alternatives listed below ("the Study"). One goal of the Study is to enable the Town to evaluate alternative sources for their ability to allow reduction of pumping impacts to Poor Farm Brook. The Town's weighing of such options will consider other financial demands such as the costs of education, infrastructure for economic development and the effect on tax rates. The consultant's draft of the Study will be provided to interested

persons upon the filing of a public records request with DEP. The Study will be completed by July 1, 2015[4].

The possible alternate water supply sources are:

(a) purchasing water from the City of Worcester through;

  (i) its "Shrewsbury Well" located on the former Home Farm property;
  (ii) through the Sunderland Road/Rte. 20 inter connection;
  (iii) through the Lincoln Street (Worcester and Shrewsbury) and Main St., Shrewsbury connection.

(b) purchasing water from the Town of Boylston via a route 70 interconnection;

(c) purchasing water from the MWRA through;

  (i) an interconnection, through Northboro on West Main Street, Shrewsbury;
  (ii) via the Wachusett Reservoir and an interconnection through the City of Worcester yet to be determined.

(d) The reopening of the SAC Park Well (or Lake Street Well) located in the east side of Lake Quinsigamond in Shrewsbury.

(e) new bedrock wells

Each of these alternatives has its potential drawbacks as well as benefits. Inspections and examinations of each potential source will be pursued.

[4] In the event that the Town needs additional time to finalize the Study it will notify DEP of that need in writing no later than ten (10) days prior to July 1, 2015, stating the reasons for the additional time needed and the date by which the final Study will be submitted. If DEP grants the Town the requested extension, the Town may elect to submit the draft final Study on July 1, 2015 and the final Study at the later date.

III. INDIRECT MITIGATION

The Town will look for opportunities to improve the Poor Farm Brook watershed along with the other sub-basins within the Blackstone River Basin and the Concord River Basin. Some of the Indirect Mitigation options include:

A. Habitat Improvement

1. Poor Farm Brook Habitat Funding - The Town will commit $5,000 annually to the Shrewsbury Conservation Commission for expenditures along Poor Farm Brook to improve habitat as it's first priority. Other locations within the Blackstone River watershed in Shrewsbury will be considered. The Town will consult with the Massachusetts Division of Fisheries and Wildlife within the Department of Fish and Game on such habitat improvement projects.

Shrewsbury will evaluate further protection of Poor Farm Brook as part of mitigation planning in consultation with DEP and the Division of Fisheries and Wildlife.

Potential habitat improvements along Poor Farm Brook include, but are not limited to, removal of human generated trash, culvert replacement, protection of the riparian corridor and restoration and revegetation of stream banks with native species (including removal of invasive species).

2. Dam Removal – Poor Farm Dam- The City of Worcester with support from the Town of Shrewsbury applied for and received a "SWMI" grant to conduct the Poor Farm Pond Dam Removal Feasibility Study. The dam is owned by the City, but is located mostly in Shrewsbury and a small portion in Worcester and entirely in land owned by the City of Worcester. The dam and associated City Farm Pond on the Poor Farm Brook was constructed as part of the City's Poor Farm sometime in the 1800s. The Poor Farm was closed in 1932. Prior to the grant, the dam was identified as warranting removal due to safety concerns. The dam removal will support the SWMI goal of habitat protection (Cold Water Fishery Resource) by increasing stream continuity and reducing water temperatures in Poor Farm Brook. The Town would support any effort by the City of Worcester to remove the dam and does not oppose the removal. Indirect credit will be determined based upon the resources contributed to the project by the Town.

B. Water Supply

3. Acquisition of Property in Zone I or Zone II The Town has, through its Subdivision Rules and Regulations, acquired Open Space that the Town accepted through the Town Meeting process and will maintain as Open Space. A majority of these open space parcels were accepted from subdivision projects.

Open space parcels in the Zone I or Zone II that the Town has acquired within both the Blackstone River Basin and the Concord River Basin include:

Blackstone River Basin

Year Acquired	Location	Acreage (ac.)	Purpose
2005	140 N. Quinsigamond	14.87	Open Space
	32 Audubon	9.29	Open Space (Partially in Zone II)
	70 O'Donnell	3.58	Open Space
	54 O'Donnell	2.83	Open Space (Partially in Zone II)
	67 O'Donnell	0.83	Open Space
	55 O'Donnell	3.68	Open Space (Entirely in Zone II)
	4 Willet	8.07	Open Space (Entirely in Zone II)
	29, 31, & 33 O'Donnell	1.29	Open Space (Entirely in Zone II)
	27 Hemingway Street	2.74	Open Space
	28 Hemingway Street	1.07	Open Space
	54 Hemingway Street	1.95	Open Space
2006	8 Jane Street	4.38	Open Space
	366 Grafton Street	4.37	Open Space
	29 Stonybrook Lane	2.36	Open Space
	11 Weagle Farm Road	2.81	Open SPace
2014	33 Hickory Drive	4.37	Open Space
Total Obtained		68.49	

Concord River Basin

Year Acquired	Location	Acreage (ac.)	Purpose
2005	25 Amherst Road	14.52	Open Space
	26 Amherst Road	1.18	Open Space
2006	20 Tralee Lane	1.50	Open Space
	21 Rear Brook Street	7.30	Open Space
2007	656 South Street	21.99	Open Space
2008	30 Oak Ridge Way	2.11	Conservation Land
Total Obtained		48.60	

Credits for Indirect Mitigation - equivalent to .030 mgd per day as shown below:

Mitigation Action	*Instream Flow*	*Water Quality*	*Habitat*	*Stream Continuity*	*Water Supply*	*Total*
Acquire Property Zone 1 or 2					*1*	*1*
Contribute to Fund			*1*			*1*
Acquire other property			*1*			*1*
Total						*3*

C. Stormwater

1. Stormwater Management By-Law Regulations - The 2007 Town Meeting adopted Article 21 of the General By-Laws of the Town of Shrewsbury. Article 21 entitled "Stormwater Management By-Law", is administered by the Board of Sewer Commissioners. There are several key components within the Article that include the ability to create a Stormwater Utility (Section 6.C.) along with prepare rules and regulations associated with stormwater discharge. The Article also states that the lack of preparing the rules and regulations does not relieve a person from meeting all the requirements concerning stormwater from other Departments, Boards or Commissions. The Town has not yet prepared the Rules and Regulations per Article 21, as the Town is awaiting the new NPDES permit. The entire Town is located within a MS4 area. The Town can qualify for mitigation credit once it provides DEP with a copy of the Rules and Regulations adopted under its "Stormwater Management By-Law"and credit assigned will be subject to DEP review and approval.

2. Stormwater Utility - The Town has prepared a draft Stormwater Utility Fee Structure and started to prepare the Rules and Regulations. However, the finalization of these will not be done until the issuance of the new NPDES Phase II General Permit to assure that the Town meets the requirements of the permit. The Town can qualify for mitigation credit once it provides DEP with written confirmation of the establishment of a Stormwater Utility"and credit assigned will be subject to DEP review and approval.

3. Criteria for Indirect Credit for Stormwater Bylaw Activities
The following chart sets out DEP's criteria for assigning indirect credit for the stormwater bylaw activities described in paragraphs 1 and 2 above (promulgation of stormwater bylaw regulations and establishment of a stormwater utility under the bylaw):

Qualitative Mitigation Points (regulations & utility)

Goal: Provide enhanced infiltration & treatment by implementation of an enforceable Stormwater Bylaw:

1. *Geographic Extent of the stormwater authority's rules:*
   a. Urbanized area (MS4) only = **1 point**
2. Entire municipality (including both MS4 areas and any land area not classified as MS4) = **2 points** *Area thresholds for projects that meet stormwater rules:*
   a. Projects 1 acre or larger = **1 point**
   b. **P**rojects ½ acre or larger = **2 points**
   c. Projects 10,000 square feet or larger = **4 points**
   d. Projects 5,000 square feet or larger = **6 points**

3. *Threshold volume that must be infiltrated and treated:*
   a) Meets MA Stormwater Handbook standards = **1 point**
   b) Meets 1 inch of infiltration = **2 points**
   c) Exceeds 1 inch of infiltration = **3 points**

Note: Maximum available points for a Stormwater Bylaw = 10.

Adopting and Implementing a Municipal Stormwater Utility:

4. *Adopting and implementing a municipal stormwater utility:*
   a. Establish a municipal stormwater utility and begin collecting fees through an Enterprise Fund: **6 points**
   b. Appropriate monies from the Enterprise Fund to implement the municipal stormwater program: **additional 2 points**
   c. Pay for design and construct municipal stormwater program infiltrating BMPs from the Enterprise Fund: **additional 2 points**

4. Future Stormwater Discharge Improvements

a. The Ternberry subdivision, which is partially located in the Shrewsbury Zone II, is situated between Old Mill Road and N. Quinsigamond Avenue. The subdivision was accepted by Town Meeting in 2005. The stormwater system discharges into an existing wetland that drains under N. Quinsigamond Avenue directly into Lake Quinsigamond. Algae blooms have been observed in the wetlands just prior to the lake in this location. The Town will investigate potential causes of these algae blooms and, based on the cause, construct mitigation measures. The Town may be able to qualify for mitigation credit upon written confirmation that construction of these mitigation measures is complete. Credit assigned will be subject to DEP review and approval.

b. There are two outfalls that discharge stormwater into Poor Farm Brook within the Town limits and seven outfalls that discharge stormwater into Poor Farm Brook within the limits of the City of Worcester. However, the Town can at this time, only commit to improvements at one of the Shrewsbury outfalls:

i. According to the plans for Bowditch Drive, an 18" culvert discharges runoff from a portion of Bowditch Drive at a headwall located within property owned by the City of Worcester east of the Bowditch cul-de-sac. During recent site visits, the vegetation in the vicinity of the headwall was very thick and therefore the headwall was not observed. The Town controls a Sewer & Drainage Easement through 42 Bowditch Drive, but does not own an easement within the City of Worcester property where the discharge headwall exists. The discharge is located within the Town's Zone II and in close proximity to the Zone I. The Town is committed to review potential stormwater quality measures for this outfall and will coordinate with the City of Worcester on any improvements located within their property. Credit for projects coordinated with the City of Worcester will be determined based upon the projects and the resources contributed to the project by the Town.

The Town may be able to qualify for mitigation credit for installation of best management practices at this outfall upon providing written confirmation to DEP that it has completed construction of the stormwater improvement measures at this location.

TABLE A
MITIGATION VOLUME SUMMARY

Type	Volume (mgd)	Notes
Permitted Volume above baseline	0.44*	
Potential Mitigation Credits:		
Infiltration/Inflow	0.127	See Appendix A
Stormwater Recharge (completed)	0.035	See Appendix B
Stormwater Recharge (Identified Future Projects)	0.042**	See Appendix B Future Projects Section
Indirect Credits	0.030	See Section III of Mitigation Plan
Total Potential Mitigation Credits	0.234	

Wastewater Adjustment (septic credits)	+ 0.023	See Section II Item C of Mitigation Plan
Wastewater Adjusted Withdrawal Volume under current Mitigation Plan	0.257	

*See Permit, Table 2.
**Pending DEP review and approval of Stormwater Recharge (Identified Future Projects)

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TOWN OF SHREWSBURY

MASSACHUSETTS 01545-5398

DIRECT MITIGATION
Appendix A

Sanitary Sewer
Infiltration/Inflow (I/I) Elimination Program

Beginning in 2009, the Town of Shrewsbury has made a conscious effort to eliminate infiltration and inflow (I/I) from the sanitary sewer system. The Town has prepared a 10-year schedule and appropriated funds for prior years investigations and construction. The 2014 Annual Town Meeting appropriated funding for FY15 for the Year 4, I/I investigations and for construction as set out in paragraphs 11 and 13 herein. The Town has retained Weston & Sampson Engineers, Inc. to assist in the investigations, design documents, and inspections. The calculations to obtain the Average Daily Removable I/I are 75%[1] for infiltration and 0.63% for inflow (assumes 48" of precipitation per year in Worcester). The studies and corresponding construction that the Town has undertaken since 2009 include:

1. In 2009, a Sewer and Interceptor Investigation and Hydraulic Report was prepared by Weston & Sampson for the Town. The Interceptor studied was from the old Treatment Plant location in Northborough to the intersection of Grafton Street and Old Brook Road. The interceptor is located in sewer subbasins 4A, 9A, and 9D. A total of 15,120 linear feet of sewer was inspected utilizing television video tapes and 70 manholes were inspected to identify sources of infiltration and inflow. The interceptor study was conducted entirely within the **Concord River Basin**.

2. The Phase I Interceptor Upgrades were designed, bid, and construction commenced in 2011 and were completed in 2012. The project included the replacement of 1,809 linear feet of 24" – 36" PVC sewers and 18 sanitary manholes. The project also cleaned and television inspected 1,438 of sewer interceptor. Sanitary manhole frames were also raised and reset a minimum of 1.5 feet above grade within off-road easements. Based upon the study, the following Infiltration/Inflow was removed in the **Concord River Basin**.

[1] The calculations applied to Shrewsbury are particular to, and a result of, this settlement agreement. DEP intends to develop, with the assistance of stakeholders, a more generally applicable methodology.

Concord Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	432	324
Inflow	586	4

3. The Phase II and III Interceptor Upgrades were designed, bid, and construction commenced in 2013 with completion in 2014. The project included the replacement of 5,201 linear feet of 24" – 36" PVC sewers and replacing 28 sanitary manholes. The project also cleaned and re-lined 9,532 linear feet of 18", 24", and 27" pipe and cementitious lined 36 sanitary sewer manholes along with installing manhole inflow dishes. Based upon the study, an estimated 11,808 gpd of infiltration and 15,696 gpd of inflow were removed from the sewer main replacement, an estimated 3,744 gpd of infiltration and 66,805 gpd of inflow were removed from the manhole replacement, an estimated 5,464 gpd of infiltration and 13,384 gpd of inflow were removed from the re-lining of the sewer mains, and 13,824 gpd of infiltration from the manhole re-lining and inflow dishes were removed. In summary, the Phase II and III Interceptor Upgrades removed: 34,840 gpd infiltration and 95,885 gpd inflow within the **Concord River Basin**.

Concord Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	34,840	26,130
Inflow	95,885	604

4. In 2013, the Shrewsbury Water Department purchased and installed 138 manhole inflow dishes with 119 manholes located within the Blackstone River Basin and 19 manholes located within the Concord River Basin. The estimated inflow removed was 9,496 gpd from the **Concord River Basin** and 312,597 gpd removed from the **Blackstone River Basin**. These removable peak inflow volumes from the inflow dishes installed by the Town are included in the total removable peak inflow from the Years One, Two and Three of the Town-wide Sewer Investigation & Rehabilitation Program volumes.

Blackstone Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	0	0
Inflow	312,597	1,969

Concord Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	0	0
Inflow	9,496	60

Additional Studies done in Blackstone & Concord River Basins
2009 – to present

5. The Town-Wide Sewer Investigation & Rehabilitation Program – Year One Investigation was completed in 2009 with the final report issued in 2010. The project area includes subareas 1A, 1B, 1C, 1D and a portion of 6A. These subareas are located entirely within the **Blackstone River Basin**. The investigations included flow isolation, television inspection of sewer lines, topside manhole inspections smoke testing, dyed-water testing, wet-weather investigations, a cost-effectiveness analysis, and recommendations for sewer system improvements. A total of 58,807 linear feet of sewer mains and 302 sewer manholes were investigated in subareas 1A, 1B, 1C, and 1D plus an additional 11,000 linear feet of smoke testing within subarea 6A.

6. In the spring of 2011, the Town conducted a Town-Wide Flow Metering Project to collect information on the wastewater flow components (Base sanitary flow, inflow, and infiltration) in each of the sanitary sewer subareas. The results of the flow metering were used to re-prioritize subareas for the annual inflow/infiltration program moving forward.

7. The Town-Wide Sewer Investigation & Rehabilitation Program – Year Two Investigation was completed in 2012. The project area includes subarea 9D, which is partially located in both the **Blackstone River Basin** and the **Concord River Basin**. The investigations included flow isolation, television inspection of sewer lines, topside manhole inspections, a cost-effectiveness analysis, and recommendations for sewer system improvements. A total of 70,290 linear feet of sewer mains and 3 sewer manholes were investigated.

8. The Town-Wide Sewer Investigation & Rehabilitation Program – Year Three Investigation was completed in 2013. The project area includes subareas 2B, 6A, and 6B. Subareas 6A and 6B are located within the **Blackstone River Basin** and subarea 2B is located in the **Concord River Basin**. The investigations included flow isolation, television inspection of sewer lines, topside manhole inspections, a cost-effectiveness analysis, and recommendations for sewer system improvements. A total of 58,254 linear feet of sewer mains and 319 sewer manholes were investigated.

9. Smoke testing and dye testing were completed in 2013 for sewer subareas 2B, 6A, 6B, and 9D with a limited amount of smoke testing in sewer subarea 7A. Subareas 6A, 6B, 7A and a portion of 9D are located within the **Blackstone River Basin** while subarea 2B and a portion of 9D are located in the **Concord River Basin**. Approximately 111,300 linear feet of sanitary sewers were smoke tested with a total of eleven (11)

defects detected. Detected defects identified during the smoke testing were then dye tested dye flooded.

10. One major inflow source that was detected with the smoke testing described in paragraph 9 above and confirmed during the dye testing is 235 Boston Turnpike (Worcester City Motel) located in the **Blackstone River Basin**. The roof leaders from the Motel are connected to the sewer service resulting in an estimated inflow of 110,697 gpd. The Water Department is working with the owner of the property to eliminate the inflow by diverting the flow to the storm drainage system. However, the storm drainage system is MA DOT owned and therefore permitting and approval take time and are ongoing. In addition, the Town has been informed that the parcel may be sold and the building demolished. In either case the removal of this connection will result in the elimination of significant inflow volumes to the sewer system.

Subject to DEP review and approval, credit for this inflow removal will be given to the Town upon written confirmation to DEP of the completion of the work and the removed volumes.

Blackstone Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	0	0
Inflow	110,697	697

11. The Sewer System Infiltration Rehabilitation project for improvements identified in Years One, Two and Three of the Town-Wide Sewer Investigation & Rehabilitation Program has been designed with the bid opening held on June 19, 2014. Funding for the construction was appropriated at the May 2014 Annual Town Meeting. The project consists of: 6,100 linear feet of cleaning and inspection, 3,800 linear feet of heavy cleaning and inspection, 2,100 linear feet of sewer line root treatment, 24,000 l. f. of cleaning, inspection, testing and sealing, 100 linear feet of cured-in place short liners, 1,400 linear feet. of cured-in place pipe (re-lining), testing and sealing of 55 service connections, rebuilding 6 manhole bench and inverts, raising and resetting 3 manhole frames and covers to grade, installing 12 manhole frames and covers, installing 145 manhole inflow dishes, and encapsulating one manhole.

Subject to DEP review and approval, credit for this infiltration removal will be given to the Town upon written confirmation to DEP of the completion of the work and the removed volumes.

12. The estimated peak and average daily removable I/I from the **Blackstone River Basin** and **Concord River Basin** are:

Blackstone Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	136,251	102,118
Inflow	557,609	3,512

Concord Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	17,463	13,097
Inflow	51,620	325

13. Funding for the Town-Wide Sewer Investigation & Rehabilitation Program Year Four Investigation was authorized at the May 2014 Annual Town Meeting with the work to be completed during FY15. The project area includes subareas 7A and 8A. Subarea 7A is located within the Blackstone River Basin and subarea 8A is located in the Concord River Basin. The investigations will include: flow isolation, television inspection of sewer lines, topside manhole inspections, a cost-effectiveness analysis, and recommendations for sewer system improvements. A total of approximately 65,000 linear feet of sewer mains and 345 sewer manholes will be investigated.

14. The Town is committed to continuing the Town-Wide Sewer Investigation & Rehabilitation Program by funding investigations and the necessary improvements based upon the investigations and will report the volumes removed in its Annual Statistical Reports for the years in which the removal took place in order to qualify for direct mitigation credits subject to DEP review and approval. In addition, this Appendix will be continuously updated as additional I/I investigations, designs, and construction projects are designed and completed.

15. In summary, the total estimated peak and average daily removable I/I from the Blackstone River and Concord River basins for projects completed in 2014 and for ongoing projects are totaled below. In the Total I/I Elimination table, the Concord Basin values were reduced by 50% to reflect the Location Adjustment Factor (LAF).

Blackstone Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	136,251	102,118
Inflow	668,306	4,209

Concord Basin:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	52,735	39,551
Inflow	148,091	993

Total I/I Elimination:

	Peak Removable I/I (gpd)	Average Daily Removable I/I (gpd)
Infiltration	162,619	121,894
Inflow	742,352	4,676
Total	**904,971**	**126,640**

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TOWN OF SHREWSBURY

MASSACHUSETTS 01545-5398

DIRECT MITIGATION
Appendix B

Stormwater Recharge
Redevelopment Projects

Completed Projects

Blackstone River Basin

The Town has permitted several redevelopment projects in the Blackstone River Basin that have improved groundwater recharge over previous conditions. The following projects have been completed:

1. **25 Bowditch Drive (Phoenix Communications)** expansion to an existing building and parking area was permitted in 2012 to be completed in three phases. Phase 1 work completed in 2013 but the construction of Phases 2 and 3 have not commenced. The existing site had no stormwater management facilities or drainage structures. The runoff from the roof drained without control onto a compacted surface and discharged off-site (towards Poor Farm Brook). The paved and gravel parking lot sheet flowed directly off the site also towards the Poor Farm Brook without any water quality or recharge facilities. The Phase 1 constructing consisted of regrading a portion of the existing paved and gravel parking lot to direct the runoff to crushed stone level spreader, construction a new gravel parking lot with infiltrating bio-retention cells, and an infiltration trench to intercept the roof runoff.

   Per MA DEP Stormwater Management Guidelines, the increase in Phase 1 impervious cover (including graveled areas) totals 19,690 sf that would result in the need for the BMP to be sized for 985 cu. ft. (7,365 gallons) of groundwater recharge. The site is entirely located within HSG A soils and within the Town's Zone II. A small portion of the property is located with the Zone I for the City of Worcester's well.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
19,690	x	24.85	=	40,775	7.481	=	305,036	/365	=	835.71

Based upon the Stormwater Management Report, Bio-retention Cell #1 recharges the 25-year storm event (5.7 inches of rain) and receives runoff from 12,600 sf of impervious surfaces resulting in an average of 813 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
12,600	x	37.77	=	39,659	7.481	=	296,685	/365	=	812.84

Based upon the Stormwater Management Report, Bio-retention Cell #2 recharges the 25-year storm event (5.7 inches of rain) and receives runoff from 3,950 sf of impervious surfaces resulting in an average of 255 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
3,950	x	37.77	=	12,433	7.481	=	93,008	/365	=	254.82

Based upon the Stormwater Management Report, the Recharge Trench recharges the 2-year storm event (3.1 inches of rain) and receives runoff from 29,370 sf of impervious surfaces resulting an average of 1,881 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
29,370	x	37.50	=	91,781	7.481	=	686,616	/365	=	1,881.14

The total estimated additional daily recharge volume is a loss of 835.71 gal/day from increased impervious area but 812.84 gal/day from Bio-Retention Cell #1, 254.82 gal/day from Bio-Retention Cell #2, and 1,881.14 gal/day from the Recharge Trench for a total of 2,113.09 gal/day or **2,113 gal/day**.

2. **42 Bowditch Drive (Metso)** expanded in two phases on an existing building and parking area in which the first phase was permitted in 2011 and constructed in 2012. The second phase was permitted in 2013 and completed in 2014. Between the original impervious cover versus the Phase 2 impervious cover there is a net increase of 99,772 sq. ft. resulting in the need for the BMP to be sized for 4,989 cu. ft. (37,323 gallons) of groundwater recharge. During the permitting process, the Town requested the applicant design the stormwater management system including the infiltration basins as if the site was a clean site (not redevelopment). The original building and associated parking lots were constructed in the early 1970's without any water quality measures or recharge

facilities. The project proposed two infiltration basins for the new parking lots and building expansion along with intercepting some of the existing drainage systems from the existing parking lot and building area. The site is entirely located within HSG A soils and is located within the Town's Zone II. A small portion of the property is located within the Zone I for the City of Worcester's well.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
99,772	x	24.85	=	206,611	7.481	=	1,545,658	/365	=	4,234.68

Based upon the Stormwater Management Report, Infiltration Basin #1 recharges the 100-year storm event (6.5 inches of rain) and receives runoff from 49,149 sf of impervious surfaces resulting in an average of 3,171 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
49,149	x	37.78	=	154,737	7.481	=	1,157,591	/365	=	3,171.48

Based upon the Stormwater Management Report, Infiltration Basin #2 recharges just under the 10-year storm event (4.0 inches of rain) and receives runoff from 333,230 sf of impervious surfaces resulting in an average of 21,468 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
333,230	x	37.72	=	1,047,453	7.481	=	7,835,996	/365	=	21,468.48

The total estimated additional daily recharge volume is a loss of 4,234.68 gal/day from increased impervious area but 3,171.48 gal/day from Basin #1 and 21,468.48 gal/day from Basin #2 for a total of 10,405.28 gal/day or **20,405 gal/day**.

3. **101 N. Quinsigamond Avenue** was the redevelopment of a parcel along the lake from two dilapidated single family dwellings to two new single family dwellings and was permitted in 2009, completed in 2010. The site is located just south of the Zone II limits. The existing site consisted of a 3,825 sf of impervious surfaces including compacted gravel parking areas that discharged directly to Lake Quinsigamond with no recharge or water quality measures. The project increased the impervious surfaces to 7,053 sf. The project entailed moving the

dwellings further away from the Lake, placed the paved driveways on the road side of the dwellings, and regraded the flatter slopes towards the lake reducing potential for erosion. Drywells are provided for the roof runoff. The site is entirely located within HSG A soils.

Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 161 cu. ft. (1,204 gallons) of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
3,228	x	24.85	=	6,685	7.481	=	50,008	/365	=	137.01

Based upon the Stormwater Management Report, the Drywells recharge the entire 100-year storm event (6.5 inches of rain) and receives runoff from 3,527 sf of impervious surfaces resulting in an average of 228 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
3,527	x	37.78	=	11,104	7.481	=	83,070	/365	=	227.59

The total estimated additional daily recharge volume is a loss of 137.01 gal/day from increased impervious area but 227.59 gal/day from the drywells for a total of 90.58 gal/day or **91 gal/day**.

4. **20 Boston Turnpike (White City)** is the renovation and improvements to the White City shopping center. The renovations and improvements started in 2006 and was completed in 2014. The improvements included drainage, landscaping, and parking reconfigurations. The project also included the re-alignment of the site entrances, one as a signalized intersection and the second to accommodate the improvements to the Lake Quinsigamond Bridge on Route 9. The purpose of the improvements was to modernize the site and to provide aesthetic amenities such as landscaped islands, etc. The existing site consisted almost entirely of paved parking lots with buildings with little to no infiltration. The project (constructed in numerous phases) decreased the impervious surfaces by 16,400 sf and provided an underground infiltration chambers for roof drainage. The site is entirely located within HSG A soils.

Based upon the reduction in the impervious area, an average of 696 gal/day of groundwater recharge is expected.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
16,400	x	24.85	=	33,962	7.481	=	254,067	/365	=	696.07

Based upon the Stormwater Management Report, Infiltration Galley recharges the 2-year storm event (3.0 inches of rain) and receives runoff from 16,486 sf of impervious surfaces resulting in an average of 1,055 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
16,486	x	37.47	=	51,478	7.481	=	385,103	/365	=	1,055.08

The total estimated additional daily recharge volume is 696.07 gal/day from decreased impervious area and 1,055.08 gal/day from Infiltration Galley for a total of 1,751.15 gal/day or **1,751 gal/day**.

5. **70, 84, 88-120 Boston Turnpike and 21 S. Quinsigamond Avenue (White City East)** is the renovation and improvements to the White City East shopping center. The improvements started in 2012 included parking reconfigurations, removing the existing Firestone building, constructing a new entrance to the shopping center with a signalized intersection, and reconstruction of the Firestone building. The project was completed in 2014. The existing site consisted of 309,566 sf of impervious surfaces without any infiltration. The project decreased the impervious surfaces to 270,376 sf (39,190 sf or 12.7% decrease). The project provided underground infiltration chambers for roof drainage on the redeveloped buildings and also provided water quality benefits by adding deep sump catchbasins and proprietary stormwater devices. The site is entirely located within HSG A soils.

Based upon the reduction in the impervious area, an average of 1,663 gal/day of groundwater recharge is expected.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
39,190	x	24.85	=	81,156	7.481	=	607,128	/365	=	1,663.36

Based upon the Stormwater Management Report, Infiltration Chamber recharges the 25-year storm event (5.3 inches of rain) and receives runoff from 7,952 sf of

impervious surfaces resulting in an average of 512 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
7,952	x	37.76	=	25,022	7.481	=	187,192	/365	=	512.85

The total estimated additional daily recharge volume is 1,663.36 gal/day from decreased impervious area and 512.85 gal/day from Infiltration Chamber for a total of 2,176.21 gal/day or **2,176 gal/day**.

6. **143-145 N. Quinsigamond Avenue** was the redevelopment of several parcels along the lake from abandoned single family dwellings to a 7-unit condominium unit that was permitted in 2008 and was completed in 2014. The site is located just south of the Zone II limits. The existing site consisted of a 5,751 sf of impervious surfaces discharging directly to the lake. The project increases the impervious surfaces to 10,933 sf. The project provides drywells for the roof runoff and an infiltration basin for the driveway and access road to the site. The site is entirely located within HSG A soils.

   Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 259 cu. ft. (1,938 gallons) of groundwater recharge. The project provided underground infiltration chambers for roof drainage on the redeveloped buildings and also infiltration chambers for the access road.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
5,182	x	24.85	=	10,731	7.481	=	80,279	/365	=	219.94

Based upon the Stormwater Management Report, the Drywells for the roof areas recharges the 100-year storm event (6.5 inches of rain) and receives runoff from 4,560 sf of impervious surfaces resulting in an average of 294 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
4,560	x	37.78	=	14,356	7.481	=	107,400	/365	=	294.25

Based upon the Stormwater Management Report, the Access Drive Underground Chambers recharges the 10-year storm event (4.5 inches of rain) and receives

runoff from 6,098 of impervious surfaces resulting in an average of 393 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
6,098	x	37.73	=	19,173	7.481	=	143,434	/365	=	392.97

The total estimated additional daily recharge volume is a loss of 219.94 gal/day from increased impervious area but 294.25 gal/day from the roof drywells and 392.97 gal/day from Access Road infiltration chambers for a total of 467.28 gal/day or **467 gal/day**.

7. **3 Elm Street (Patrick's Motor Mart)** is the renovation and expansion of the car dealership located at the intersection of Elm Street and Route 9 that was permitted in 2010 and construction completed in 2013. The existing site consisted of a 68,825 sf of impervious surfaces draining to a detention basin with a portion of the existing roof area discharging to an underground infiltration chamber, which remained unchanged during the renovation. The detention basin was improperly maintained/designed/constructed that resulted in chronic drainage issues downstream. The project proposed to increase the impervious surfaces to 69,260 sf (increase of 435 sf). The site is entirely located within HSG A soils.

   Per MA DEP Stormwater Management Guidelines, in the increase in impervious cover would result in the need for the BMP to be sized for 22 cu. ft. (165 gallons) of groundwater recharge. The project proposed to convert the detention basin to an infiltration basin for the parking lot and an underground infiltration chambers for the roof addition runoff.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
435	x	24.85	=	901	7.481	=	6,739	/365	=	18.46

Based upon the Stormwater Management Report, the Infiltration Basin recharges fully in excess of the 25 year storm event (5.3 inches of rain) and receives runoff from 63,162 sf of impervious surfaces resulting in an average of 4,074 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
63,162	x	37.76	=	198,750	7.481	=	1,486,847	/365	=	4,073.55

Based upon the Stormwater Management Report, Roof Recharge Chamber recharges 1 inch of runoff and receives runoff from 4,792 sf of impervious surfaces resulting in an average of 258 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
4,792	x	31.54	=	12,595	7.481	=	94,223	/365	=	258.15

The total estimated additional daily recharge volume is a loss of 18.46 gal/day from increased impervious area but 4,073.55 gal/day from Infiltration Basin and 258.15 gal/day from Roof Recharge Chamber for a total of 4,313.24 gal/day or **4,313 gal/day**.

8. **208-210 S. Quinsigamond Avenue** is the redevelopment of a parcel of land on Lake Quinsigamond from seven (7) dilapidated dwellings to eight (8) town house style dwellings that was permitted in 2013 and was completed in 2014. The existing site consisted of a 12,206 sf. of impervious surfaces including roof area and a paved parking lot without any infiltration. The project proposed a slight decrease in the impervious surfaces to 12,151 sf (decrease of 55 sf). The site is entirely located within HSG A soils. The project proposes dry wells for the roof areas and the overflow parking will employ grass pavers to limit the impervious area.

   Based upon the reduction in the impervious area, an average 2 gal/day of groundwater recharge is expected, therefore negligible.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
55	x	24.85	=	114	7.481	=	852	/365	=	2.33

Based upon the Stormwater Management Report, Drywells recharges the 10-year storm event (4.5 inches of rain) and receives runoff from 7,278 sf of impervious surfaces resulting in an average of 469 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
7,278	x	37.73	=	22,883	7.481	=	171,190	/365	=	469.01

The total estimated additional daily recharge volume is 2.33 gal/day from decreased impervious area and 469.01 gal/day from drywells for a total of 471.34 gal/day or **471 gal/day**.

9. **28 Sherwood Avenue (Sherwood Middle School)** involves the demolition of the Sherwood Middle School and the construction of a new middle school with associated parking. The project was permitted in 2011 and the construction was completed in 2014. The existing site consisted of 415,998 s. f. of impervious surfaces including roof area and a paved parking lot without any infiltration and an antiquated drainage system with no water quality benefits. The project proposed to increase the impervious surfaces to 457,816 s. f. The site is entirely located within HSG C soils.

   Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 871 cu. ft. (6,516 gallons) of groundwater recharge. The project proposed an infiltration basin for the roof and parking lot runoff.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
41,818	x	14.64	=	51,018	7.481	=	381,665	/365	=	1,045.66

   Based upon the Stormwater Management Report, the Infiltration Basin recharges 0.8 inches of rainfall and receives runoff from 96,278 sf of impervious surfaces resulting in an average of 4,637 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
96,278	x	28.20	=	226,253	7.481	=	1,692,601	/365	=	4,637.26

   The total estimated additional daily recharge volume is a loss of 1,045.66 gal/day from increased impervious area but 4,637.26 gal/day from the infiltration basin for a total of 3,591.60 gal/day or **3,592 gal/day**.

The total increase in groundwater recharge from completed projects within the Blackstone Basin is **35,379** gal/day.

Concord River Basin

The Town has not permitted any redevelopment projects in the Concord River Basin that have improved groundwater recharge over the previous conditions.

Future Projects

In addition to the completed redevelopment projects, the following projects have either been approved and not yet completed or are in the review process.

Blackstone River Basin

1. **235 Main Street (Medical Office Building)** is the redevelopment of the abandoned Whittier Farms Dairy site. The project was approved in 2014 with construction expected to begin in early 2015 and be completed in 2016. The existing site consisted of a 46,251 sf. of impervious surfaces (demolished roof area and associated access drives and parking) without any water quality measures or infiltration and discharges to an unnamed intermittent stream that discharges to Lake Quinsigamond. The site is entirely located within HSG A soils and located partially within the Zone II and partially within the Zone III. The project proposes to reduce the impervious surfaces to 34,691 sf. (decrease in 11,560 sf. - a 25.0% reduction). The project proposes several groundwater recharge devises; an underground infiltration chamber for the roof runoff and infiltration basins for the parking lot runoff. The infiltration devises are located with the Town's Zone II.

   Based upon the reduction in the impervious area, an average 491 gal/day of groundwater recharge is expected.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
11,560	x	24.85	=	23,939	7.481	=	179,086	/365	=	490.65

   Based upon the Stormwater Management Report, Infiltration Basin #1 recharges the 100-year storm event (6.5 inches of rain) and receives runoff from 7,858 sf of impervious surfaces resulting an average of 507 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
7,858	x	37.78	=	24,740	7.481	=	185,077	/365	=	507.06

Based upon the Stormwater Management Report, Infiltration Basin #2 recharges the 25-year storm event (5.3 inches of rain) and receives runoff from 23,519 sf of impervious surfaces resulting an average of 1,517 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
23,519	x	37.76	=	74,006	7.481	=	553,642	/365	=	1,516.83

The total estimated additional daily recharge volume is 490.65 gal/day from decreased impervious area, 507.06 gal/day from Basin #1, and 1,516.83 gal/day from Basin #2 for a total of 2,514.54 gal/day or **2,515 gal/day**.

2. **25 Bowditch Drive (Phoenix Communications)** expansion to an existing building and parking area was permitted in 2012 to be completed in three phases. The Phase 1 work was completed in 2013 but the construction of Phases 2 and 3 has not commenced. Based upon our understanding the Phases 2 & 3 will start construction in the summer of 2015 and be completed in the spring of 2016. The existing site had no stormwater management facilities or drainage structures. The runoff from the roof drained without control onto a compacted surface and discharged off-site (towards Poor Farm Brook). The paved and gravel parking lot sheet flowed directly off the site also towards Poor Farm Brook without any water quality or recharge facilities. Phases 2 and 3 involve construction of a small parking lot off of Bowditch Drive and a new gravel access drive around the side of the building connecting the new parking lot constructed in Phase 1 with the new parking lot off Bowditch Drive. A series of drywells are proposed along with an infiltration trench to offset the impervious areas and intercept existing runoff that currently discharges to Bowditch Drive without any water quality improvements or recharge capability.

   Per MA DEP Stormwater Management Guidelines, the increase in Phase 2 & 3 impervious cover (including graveled areas) totals 8,950 sf that would result in the need for the BMP to be sized for 448 cu. ft. (3,351 gallons) of groundwater recharge. The site is entirely located within HSG A soils and within the Town's Zone II. A small portion of the property is located with the Zone I for the City of Worcester's well.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
8,950	x	24.85	=	18,534	7.481	=	138,653	/365	=	379.87

Based upon the Stormwater Management Report, the infiltration trench recharges the 25-year storm event (5.7 inches of rain) and receives runoff from

6,000 sf of impervious surfaces resulting an average of 387 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
6,000	x	37.77	=	18,885	7.481	=	141,279	/365	=	387.06

Based upon the Stormwater Management Report, Drywell #1 recharges the 2-year storm event (3.1 inches of rain) and receives runoff from 2,950 sf of impervious surfaces resulting an average of 189 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
2,950	x	37.50	=	9,219	7.481	=	68,965	/365	=	188.95

The total estimated additional daily recharge volume is a loss of 379.87 gal/day from increased impervious area but 387.06 gal/day from Infiltration Trench and 188.95 gal/day from the Drywell #1 for a total of 196.14 gal/day or **196 gal/day**.

3. **230-232 S. Quinsigamond Avenue (Tatassitt Beach Subdivision)** is the redevelopment of an abandoned boat and swim club into a short private road and three single family dwellings located on Lake Quinsigamond. The project was permitted in 2013 and is currently under construction with the roadway and associated drainage installed. The house lots are currently in various stages of completion. The anticipated completion date for the project is the summer of 2015. The existing site consisted of 16,715 sf of impervious surfaces including roof area and a paved parking lot for general parking and boat storage without any infiltration and direct discharge to the Lake. The project proposes to increase the impervious surfaces to 30,724 sf. The site is entirely located within HSG A soils.

   Per MA DEP Stormwater Management Guidelines, in the increase in impervious cover would result in the need for the BMP to be sized for 700 cu. ft. (5,237 gallons) of groundwater recharge. The project proposes an underground infiltration chambers for the roadway and driveways along with drywells for the house roof drainage areas.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
14,009	x	24.85	=	29,101	7.481	=	217,026	/365	=	594.59

Based upon the Stormwater Management Report, the underground infiltration chambers recharges the 2-year storm event (3.1 inches of rain) and receives runoff from 10,846 sf of impervious surfaces resulting an average of 695 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
10,846	x	37.50	=	33,894	7.481	=	253,559	/365	=	694.68

Based upon the Stormwater Management Report, Roof Drywells recharges the 100-year storm event (6.5 inches of rain) and receives runoff from 1,000 sf of impervious surfaces resulting an average of 65 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
1,000	x	37.78	=	3,148	7.481	=	23,553	/365	=	64.53

The total estimated additional daily recharge volume is a loss of 594.59 gal/day from increased impervious area but 694.68 gal/day from Road Underground Detention Area and 64.53 gal/day from the Roof Drywells for a total of 164.62 gal/day or **165 gal/day**.

4. **378 Main Street (Flavian Hall Replacement – St. John's High School)** is the redevelopment of Flavian Hall located on the St. John's High School property. The existing site consisted of a 24,420 sf of impervious surfaces including roof area and a paved parking lot without any infiltration. The project, currently in the initial construction stage with an anticipated completion in the fall of 2015 proposes to increase the impervious surfaces to 53,790 sf. The site is entirely located within HSG B soils.

   Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 857 cu. ft. (6,411 gallons) of groundwater recharge. The project proposes an infiltration basin for the roof and parking lot along with some offsite access road runoff.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
29,370	x	18.40	=	45,034	7.481	=	336,899	/365	=	923.01

Based upon the Stormwater Management Report, the Infiltration Basin recharges 1.95 inches of rain and receives runoff from 50,030 sf of impervious surfaces resulting an average of 2,991 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
50,030	x	36.30	=	151,341	7.481	=	1,132,180	/365	=	3,101.86

The total estimated additional daily recharge volume is a loss of 923.01 gal/day from increased impervious area but 3,101.86 gal/day from the basin for a total of 2,178.85 gal/day or **2,179 gal/day**.

5. **193 Boston Turnpike (Lakeway Commons)** is the redevelopment of the mostly abandoned property known locally as Spag's along with several other underutilized commercial properties along Route 9 and a few existing residential parcels on the north side of the site. A majority of the Spag's property and the Route 9 commercial properties are entirely made up of buildings and parking lots. An existing culvert containing Kings Brook runs through the site with the existing drainage discharging directly to the culvert with no water quality benefits and no existing stormwater recharge or on-site detention of the stormwater. The existing site consisted of a 16.18 acres (704,315 sf) of impervious surfaces including roof area, paved parking lots access roads, and public and private streets. The project, currently in the initial permitting stage proposes to increase the impervious surfaces to 18.13 acres (789,743 sf). The site is entirely located within HSG A soils, but a higher than expected seasonal high water table of about 5 feet below grade.

   Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 4,247 cu. ft. (31,773 gallons) of groundwater recharge. The project is designed with seven (7) variably sized underground infiltration basins that receive treated runoff from the parking lots. The proposed roof drains discharge directly to the Kings Brook culvert. Construction is anticipated to start construction in the spring of 2015 with completion in the fall of 2016.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
85,428	x	24.85	=	176,907	7.481	=	1,323,442	/365	=	3,625.87

Based upon the Stormwater Management Report, the Infiltration Field #1 recharges 1.00 inches of rain and receives runoff from 110,512 sf of impervious surfaces resulting an average of 5,953 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
110,512	x	31.54	=	290,462	7.481	=	2,172,949	/365	=	5,953.28

Based upon the Stormwater Management Report, the Infiltration Field #2 recharges 1.05 inches of rain and receives runoff from 102,061 sf of impervious surfaces resulting an average of 5,557 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
102,061	x	31.88	=	271,142	7.481	=	2,028,414	/365	=	5,557.30

Based upon the Stormwater Management Report, the Infiltration Field #3 recharges 1.02 inches of rain and receives runoff from 62,334 sf of impervious surfaces resulting an average of 3,373 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
62,334	x	31.68	=	164,562	7.481	=	1,231,087	/365	=	3,372.84

Based upon the Stormwater Management Report, the Infiltration Field #4 recharges 1.02 inches of rain and receives runoff from 64,338 sf of impervious surfaces resulting an average of 3,481 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
64,338	x	31.68	=	169,852	7.481	=	1,270,665	/365	=	3,481.27

Based upon the Stormwater Management Report, the Infiltration Field #5 recharges 1.00 inches of rain and receives runoff from 78,931 sf of impervious surfaces resulting an average of 4,252 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
78,931	x	31.54	=	207,457	7.481	=	1,551,986	/365	=	4,252.02

Based upon the Stormwater Management Report, the Infiltration Field #6 recharges 1.05 inches of rain and receives runoff from 81,849 sf of impervious surfaces resulting an average of 4,457 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
81,849	x	31.88	=	217,446	7.481	=	1,626,710	/365	=	4,456.74

Based upon the Stormwater Management Report, the Infiltration Field #7 recharges 1.00 inches of rain and receives runoff from 76,883 sf of impervious surfaces resulting an average of 4,142 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
76,883	x	31.54	=	202,074	7.481	=	1,511,717	/365	=	4,141.69

The total estimated additional daily recharge volume is a loss of 3,625.87 gal/day from increased impervious area but 5,953.28 gal/day from Infiltration Field #1, 5,557.30 gal/day from Infiltration Field #2, 3,372.84 gal/day from Infiltration Field #3, 3,481.27 gal/day from Infiltration Field #4, 4,252.02 gal/day from Infiltration Field #5, 4,456.74 gal/day from Infiltration Field #6, and 4,141.69 gal/day from Infiltration Field #7 for a total of 27,589.27 gal/day or **27,589 gal/day**.

6. **181 Main Street (Medical Office Building)** is the redevelopment of an abandoned single family house with a paved tennis court, large in-ground pool w/concrete patio, outbuildings, and looping paved driveway into a medical office building. The project was approved in 2014 with construction expected to be completed in the spring of 2015. The site consisted originally of 8,781 sf of impervious surfaces without any infiltration and proposed to increase the impervious surfaces to 30,812 s. f. (24,776 sf within HSG A soils and 6,717 sf within HSG B soils).

   Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 1,019 cf. (7,623 gallons) of groundwater recharge. The project proposes an underground groundwater recharge system. The entire site including the infiltration devise is located with the Town's Zone II.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
18,059	x	24.85	=	37,397	7.481	=	279,768	/365	=	766.49
3,972	x	18.40	=	6,090	7.481	=	45,562	/365	=	124.83
							Total		=	891.32

Based upon the Stormwater Management Report, the Subsurface Infiltration Field recharges the 25 year storm (5.3 inches) inches of rain and receives runoff from 29,567 sf of impervious surfaces resulting an average of 1,907 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
29,567	x	37.76	=	93,037	7.481	=	696,013	/365	=	1,906.89

The total estimated additional daily recharge volume is a loss of 891.32 gal/day from increased impervious area but 1,906.89 gal/day from the Subsurface Infiltration Field for a total of 1,015.57 gal/day or **1,016 gal/day**.

Redevelopment projects within the Blackstone Basin that either have been approved and not yet completed or in the review process total **33,660** gal/day of additional groundwater recharge. Once the projects have been completed and DEP has reviewed the Town's written confirmation of their completion and the volumes removed, credit can be given for the recharge volumes involved.

Concord River Basin

1. **609 Main Street (Shrewsbury Public Library)** is the redevelopment of the public library located on the corner of Boylston Street and Main Street. The project was approved in 2014 with construction expected to begin in early 2015 and be completed in 2016. The project consists of demolishing a portion of the existing library and abutting abandoned credit union building and associated parking lots and constructing a library addition with new parking field. The existing site consisted of a 64,440 sf. of impervious surfaces (demolished roof area and associated access drives and parking) without any water quality measures or infiltration that discharges to the MA DOT drainage system in Main Street. The site is entirely located within HSG B soils. The project proposes to increase the impervious surfaces to 69,665 sf (5,225 sf increase).

   Per MA DEP Stormwater Management Guidelines, the increase in impervious cover would result in the need for the BMP to be sized for 152 cu. ft. (1,137 gallons) of groundwater recharge. The project proposes to collect the existing remaining and proposed roof runoff to discharge through an underground infiltration chamber system and allow the parking lot and access runoff to be treated (84% TSS removal) and discharged to the MA DOT drainage system.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
5,225	x	18.40	=	8,012	7.481	=	59,935	/365	=	164.21

Based upon the Stormwater Management Report, the Infiltration Field recharges 1.25 inches of rain and receives runoff from 17,530 sf of impervious surfaces resulting an average of 996 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
17,530	x	33.26	=	48,587	7.481	=	363,482	/365	=	995.84

The total estimated additional daily recharge volume is a loss of 164.21 gal/day from increased impervious area but 995.84 gal/day from the Infiltration Field for a total of 831.63 gal/day or **832 gal/day**.

2. **1000 Boston Turnpike (Shrewsbury Village)** is the redevelopment/re-configuration of the existing parking lots. Little Bummet Brook, which was altered in the mid 1980's with approval from the Army Corp of Engineers and MA DEP runs between the existing on-site buildings and a majority of the parking areas. A pedestrian bridge crosses the brook to gain access to the retail stores from the parking area. When the brook was originally modified, it was culverted at the eastern end to accommodate an access drive and additional parking spaces. At the inlet side of the outlet pipe, an outlet structure was added for stormwater management purposes. In other words the stream area was modified to act a detention pond for the Village. The stream bank turned into a low flow brook with little to no wetland species and a minimal riverfront benefit. The existing site consisted of a 681,201 sf. of impervious surfaces (roof area and associated access drives and parking) without any water quality measures or infiltration. The existing drainage discharge directly in to the brook. The site is entirely located within HSG B soils. The project proposes to reduce the impervious surface to 611,451 sf. (decrease in 69,750 sf. - a 10.2% reduction). The proposed project is to relocate the Little Bummet Brook and construct separate underground detention basin and three underground infiltration basins. The brook will be reconstructed to mimic adjacent riverfront area and restore the brook back to approximate original conditions. The brook will be shifted to the south to allow the parking lot to abut the retail buildings. The underground infiltration basins will recharge runoff from the existing roofs and most of the existing and relocated parking lots. The project is currently in the permitting process with an anticipated start of the improvements in the spring of 2015 with a completion date of fall 2015.

   Based upon the reduction in the impervious area, an average 2,192 gal/day of groundwater recharge is expected.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
69,750	x	18.40	=	106,950	7.481	=	800,093	/365	=	2,192.04

Based upon the Stormwater Management Report, Infiltration Basin #1 recharges the 1.07 inches of runoff and receives runoff from 128,312 sf of impervious surfaces resulting an average of 7,017 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
128,312	x	32.02	=	342,379	7.481	=	2,561,339	/365	=	7,017.37

Based upon the Stormwater Management Report, Infiltration Basin #2 recharges the 2.66 inches of runoff and receives runoff from 56,024 sf of impervious surfaces resulting an average of 3,552 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
56,024	x	37.12	=	173,301	7.481	=	1,296,464	/365	=	3,551.96

Based upon the Stormwater Management Report, Infiltration Basin #3 recharges the 2.38 inches of runoff and receives runoff from 34,517 sf of impervious surfaces resulting an average of 2,171 gal/day of groundwater recharge.

Impervious surface area	x	Annual Recharge Depth	=	Annual Recharge Rate	Gallon/Cu. Ft. Conversion		Annual Recharge Rate	Years /Day		Daily Recharge Rate
Sq. Ft.	x	In/Year	=	Cu. Ft./ Year	7.481 gal/cu. ft.	=	Gal/year	Year/ 365 days	=	Gal/Day (gpd)
34,517	x	36.83	=	105,938	7.481	=	792,525	/365	=	2,171.30

The total estimated additional daily recharge volume is 2,192.04 gal/day from decreased impervious area, 7,017.37 gal/day from Basin #1, 3,551.96 gal/day from Basin #2, and 2,171.30 gal/day from Basin #3 for a total of 14,932.67 gal/day or **14,933 gal/day**.

Redevelopment projects within the Concord Basin that either have been approved and not yet completed or in the review process total **15,765 gal/day** of additional groundwater recharge. Once the projects have been completed and DEP has reviewed the Town's written confirmation of their completion and the volumes removed, credit can be given for the recharge volumes involved.

Summary

In summary, since 2005, the total increased groundwater recharge from redevelopment projects within the Blackstone River and Concord River basins are totaled below. The Concord Basin values have been multiplied by 50% to reflect the Location Adjustment Factor (LAF).

Completed Projects:

	Total Groundwater Recharge (gpd)	Groundwater Recharge w/LAF (gpd)
Blackstone Basin	35,379	35,379
Concord Basin	0	0
Total	**35,379**	**35,379**

Future Projects:

	Total Groundwater Recharge (gpd)	Groundwater Recharge w/LAF (gpd)
Blackstone Basin	33,660	33,660
Concord Basin	15,765	7,882
Total	**49,425**	**41,542**