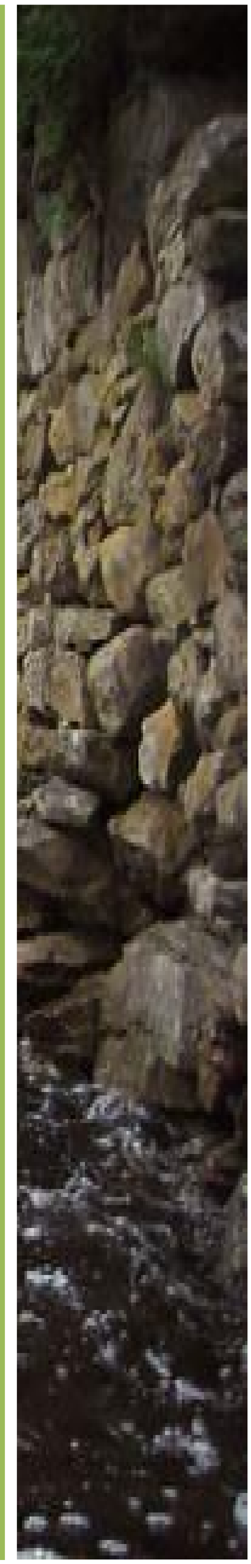
Piscataquog River Watershed Stream Crossing Vulnerability Assessment Project

Evaluating Stream Crossing Vulnerability to Storm Event Flows



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With Assistance from:
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Final Report

A Partnership between Trout Unlimited and Southern New Hampshire Planning Commission

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Piscataquog
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Culvert Assessment

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Introduction

This report provides the methodology and results of a hydrologic and hydraulic modeling project conducted to assess stream crossing vulnerability throughout the Piscataquog River watershed. The primary goal of this landscape-scale assessment project was to evaluate and provide a rating for road stream crossings, with respect to their vulnerability to high water flows during severe storm events. A secondary goal was to develop the modeling tools, organized in a user-friendly format, so they can be offered to communities throughout New Hampshire that would be interested in running similar analyses.

Trout Unlimited (TU), the Southern NH Planning Commission (SNHPC), and other state and federal partners have collaborated to develop a geographic information system (GIS) based hydraulic capacity (HC) modeling tool to evaluate whether a particular stream crossing will pass instream water flows during the 2, 10, 25, 50 and 100 year return interval storms. This project builds upon field data collected on aquatic connectivity and geomorphic conditions of the Piscataquog River during the summer of 2012 (TU 2012). These two projects were managed by TU and the NH Department of Environmental Services Geological Survey (NHGS) respectively.

The Piscataquog River watershed is 217.8 square miles (138,880 acres) in size and includes the following 11 communities: the towns of Deering, Dunbarton, Francestown, Greenfield, Goffstown, Henniker, New Boston, Mont Vernon, Lyndeborough, Weare, and the southwestern edge of the City of Manchester.

An estimated 400 stream crossings surveyed in 2012 (Figure 1) were evaluated for stormwater vulnerability. The majority of the identified stream crossings were drainage pipes or box culverts and were installed to carry water under a public right of way or a private road. Hydrologic information was processed and summarized in GIS; this GIS output and the 2012 field data were entered as into to an Excel spreadsheet model where the hydraulic modeling was performed.

Model results for this analysis have been mapped showing the HC rating of each stream crossing to determine existing problem areas. This information could then be used to proactively develop a long-term strategy to reduce community risk associated with undersized and vulnerable road crossings. The results from this data analysis will provide municipalities and state agencies with valuable information necessary for implementing new conservation initiatives and conducting detailed safety and hydraulic capacity investigations of hazardous culverts.

With this updated stream crossing information, municipal road agents and public works staff will be able to prioritize restoration efforts on inadequate crossings, reducing the chance of inundation in flood prone areas and culvert wash-outs during the extreme storm events. In the end, this proactive approach to addressing infrastructure needs at the community level will help, in both the short and long term, to reduce emergency repair costs associated with potential storm damage. Restoring connectivity to these problem sites will also serve to protect critical community water quality resources as well as improve a diversity of aquatic habitat frequently associated with stream fragmentation. We believe the key to protecting a community's infrastructure resiliency is to be prepared; and a big part of that preparedness is to understand the vulnerability of road crossings in each community under a variety of storm scenarios.

This user-friendly strategic planning tool is being made available to all NH communities interested in performing this type of analysis. With the appropriate field data collected, access to a person with GIS skills, and the ability to run an Excel model, towns and regional planning commissions will be able to complete a detailed assessment of the current vulnerability of all road stream crossings across their political boundaries.

How this Report Can Be Used

All 11 communities within the watershed will be able to use the data in this report to evaluate both the HC and potential environmental conditions associated with the stream crossings – many of which have been identified as impaired or undersized (see sections on Methodology and Results). Municipal officials, Road Agents and public works/engineering staff specifically will find this report helpful as supporting technical data in seeking funding to justify the removal, replacement or retrofit of inadequate crossings --- thereby reducing the chance of road and culvert wash-outs during extreme storm events and improving HC. Over 50 percent of the drainage structures in the watershed were found to be either in old, rusting, eroding and/or in collapsing conditions. In short, this report will directly benefit:

- municipal road agents, public works department staff and state agencies in prioritizing and seeking funding for future stream crossing and culvert replacement and upgrades;
- municipal conservation commissions and environmental organizations in identifying and developing important wildlife habitat connectivity restoration projects for many aquatic organisms, including brook trout;
- Piscataquog River Local Advisory Committee (PRLAC) in implementing an important goal of the updated 2010 Piscataquog River Management Plan- to restore water quality and protect the natural flow of the river for fish and wildlife habitat and public water uses.

Stakeholders are encouraged to read through this report to gain a general understanding of the methodology of the model, and to review the results for their specific town, sub-watershed or neighborhood. The next steps for stakeholders would include the synthesis of the results and development of a prioritization for proactively addressing stream crossing replacement or culvert upgrades. A prioritization can be based on stakeholder interests and specific circumstances within a town, such as the presence of culverts near dams, road banks, private lands, emergency services, etc. For example, a crossing that is unable to pass the 25-year peak flow and is adjacent to a roadway serving as a primary path to emergency services would most likely have a higher priority for repair or replacement than a similar crossing adjacent to recreational playing fields.

The results tables and related maps in this document utilize a color coded system for pass, transitional or fail with regard to HC that can be used for prioritizing vulnerable community infrastructure. Additionally, the tables also provide a similar grading for aquatic organism passage (AOP) which can also be an evaluation metric in the prioritization process. These AOP results were provided in a previous report (TU 2012) sent to all the towns in the watershed and are included here for completeness.

Additionally, TU and SNHPC are currently working to develop a tool that allows users to include HC and AOP as well as other biologic and geomorphic variables in the prioritization process. The release date for this tool, at the time of this publication, is not known; however SNHPC will relay all updated information regarding this tool to the towns once it is available for general release.

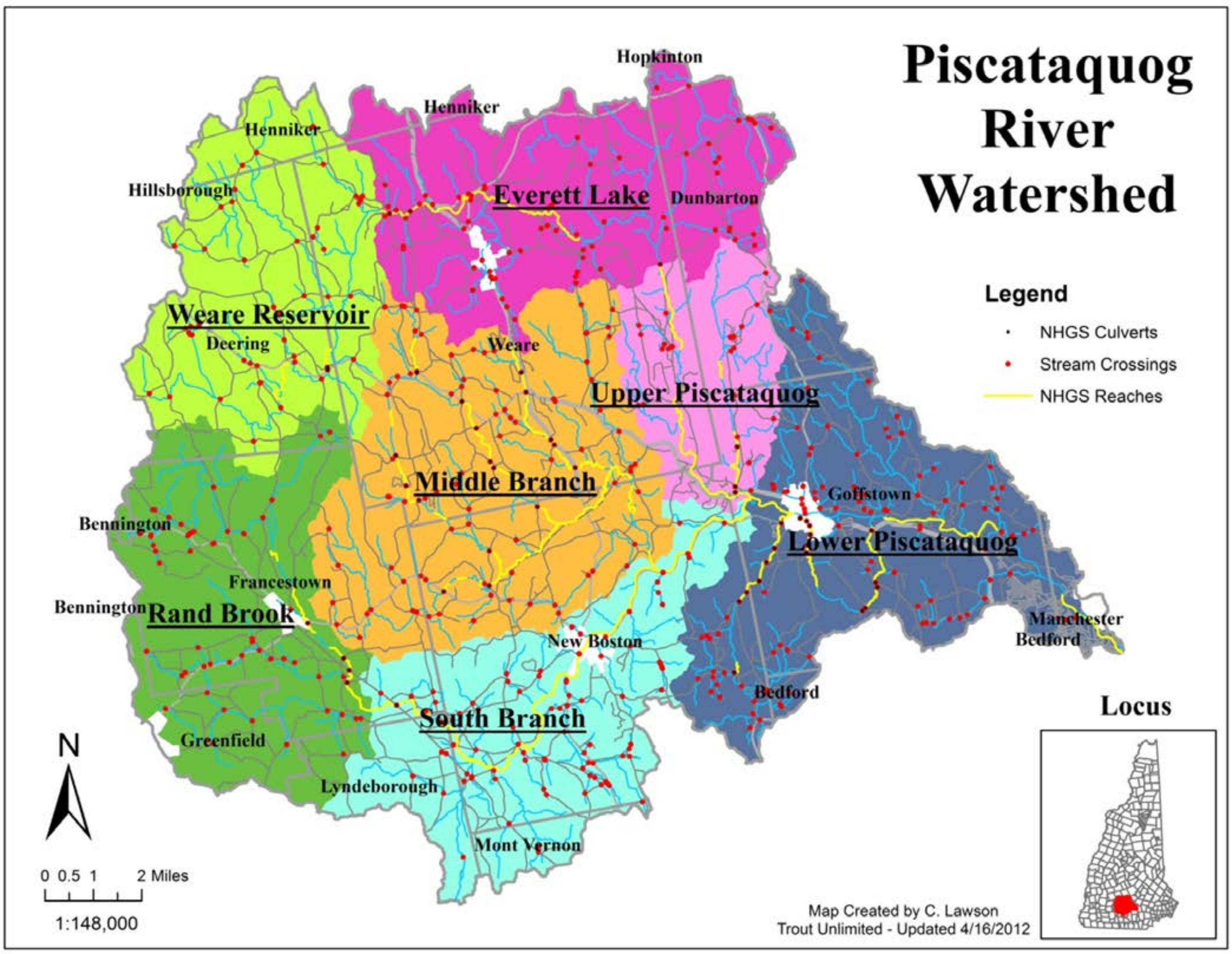


Figure 1. Map Showing Identified Road Stream Crossings within the Piscataquog River Watershed.

Methodology

The following provides a detailed description methodology for the hydrologic, hydraulic and GIS components of the model. For a detailed description of how to use the Excel model and generate the appropriate GIS input data for the model, see Appendix 1.

Hydrology and Hydraulics

For the Excel modeling part of the project, there are two main components: the hydrology and the hydraulics. The hydrology is a summary and analysis of storm water runoff upstream of the culvert. This step calculates the peak flow at five defined return periods for each culvert. The hydrologic analysis is based on data provided by the GIS component of the project (watershed area, flow path, etc.). The hydraulic analysis describes how the culvert crossing passes the calculated flows and is accomplished with additional user input further describing the crossing (culvert dimensions, slope, material type, etc.). Overall, the model is meant as a guide to help determine the overtopping susceptibility of analyzed culverts for specific flood flows. It is not meant to be exact in its analysis. Rather, this analysis can be thought of as a screening tool. Both hydrologic and hydraulic components use some estimates and simplifying assumptions in order to generate results. This leads to certain limitations in their respective methods (discussed further on).

I. Hydrology

The hydrology component calculates the upstream watershed's peak flood flow conveyed to each culvert at five return periods: 2-, 10-, 25-, 50-, and 100-years. A return period can be defined as an estimate of the likelihood of an event, such as river discharge flow, to occur over an extended period. It is calculated based on a statistical analysis of historic data. There are many ways to calculate peak flows for a watershed. For the purpose of obtaining flood flows with limited information requirements, two quick and easy methods were employed for this model: the SCS Method (USDA, 1986) and the Regional Regression Equations for New Hampshire (Olson, 2002). These methods require much less data to run than full watershed models, yet both are considered to be acceptable methods of analysis in lieu of discharge data at a site. If these results demonstrate overtopping susceptibility of a specific culvert, and the structure becomes a high priority location after the prioritization process, then a full watershed model should be performed. Full watershed models are very involved, require increased input data, and are time-consuming.

A. SCS Method

The SCS Method is a very common method to compute peak flows and is in many cases the industry standard. The method: 1) assumes an even depth of rainfall over the entire watershed at a constant rainfall intensity; 2) estimates the amount of the total volume that will influence the peak flow; and 3) accounts for the hydrograph dampening that occurs due to travel time and land cover in the watershed. A full description of the entire method, components, and equations can be found at http://www.cpesc.org/reference/tr55.pdf. This method is good for estimating flows from watersheds that are relatively homogenous, rural areas with few impoundments and storage. In general, this method should be used for watersheds smaller than two square miles which have a time of concentration not exceeding 10 hours. This method is generally considered to result in very conservative (higher) peak flows.

The data required to use this method for each crossing is determined from the GIS portion of the project. If other sources for data are preferred, the data may also be entered into the model manually. The direct data that is input from GIS includes the Drainage Area, the upstream watershed runoff Curve Number (CN); the 24-hour Precipitation Depth for the 2-, 10-, 25-, 50-, and 100-yr storms; the Watershed Slope; the Area of Wetlands and Ponds in the Watershed; and the Watershed Length. The Drainage Area is simply the total upstream area of the watershed that contributes flow to the culvert undergoing analysis. Verify units provided as it should be given in square feet (the actual equation in this method uses the area in square miles, but this conversion occurs internally in the Excel model). The CN is basically a coefficient used in the model's equations that estimate precipitation losses due to 1) soil infiltration capacities, 2) watershed land cover condition, and 3) antecedent soil moisture condition.

A CN is assigned to each sub-area in the watershed based on soil type and land use. A weighted CN is developed for the entire watershed and is unitless. The 24-hour Precipitation Depths for the five return periods are determined in GIS using new, updated rainfall amounts published by Northeast Regional Climate Center located in the Department of Earth and Atmospheric Sciences at Cornell University (http://precip.eas.cornell.edu/). These updated rainfall amounts account for climate change and reflect the increasing trend in rainfall amounts in the northeast. Each amount represents the expected rainfall depth to occur over a 24-hour period for specific return periods. Model input for rainfall volumes are in inches. The Watershed Slope uses the USGS 10-85 method. For runoff hydrology, it is the most representative watershed slope rather than the overall watershed slope which may be slightly steeper (and not as well correlated to flood flows). Often on a river system there is a steep slope at the beginning and/or the end of the runoff travel path. In most northeast watersheds, hills may exist upstream and dams are present downstream or near the coast.

The 10-85 method uses the stream elevations at locations 10% and 85% along the runoff travel path and divides their elevation difference by the travel length between them. This slope is dimensionless (ft/ft) even though it is used in the equation as percent (the conversion occurs internally in the program). The Area of Ponds and Wetlands is determined in GIS from a pond and wetland polygon shape file similar to the calculation the watershed areas. This area should be given in square feet. Finally, the Watershed Length is determined for a raindrop's path that would take the longest time to reach the outlet. This is difficult to automate. It can be estimated using the longest flow path tool in ArcGIS given in feet. The model then uses all these watershed properties to calculate the expected five return period peak flows for each crossing.

B. Regional Regression Equations for New Hampshire

The Regional Regression Equations for New Hampshire were developed by the United States Geological Survey (USGS) in cooperation with the New Hampshire Department of Transportation (NHDOT). These equations were determined using many watershed properties as variables and comparing the predicted flows to observed flows at 117 gaged locations. A full description of how the equations were developed, the methods, procedures, and equations can be found at http://pubs.usgs.gov/sir/2008/5206/pdf/sir2008-5206.pdf. The regressions are unique to New Hampshire, based on gaged stream floods, and an equation is given for each of the five return periods. This method is most suited for estimating peak flows on rural, ungaged streams in New Hampshire. These equations are likely accurate within the ranges of properties of the watersheds used in this study [e.g. Drainage Area of between 0.70 and 1,290 square miles, a Mean April Precipitation between 2.79 and 6.23 inches, a Percentage of Wetlands and Ponds between 0 and 21.8%, and a Watershed Slope between 5.43 and 543 feet per mile (or 0.1 to 10%)].

The equations given in this method are empirical relationships based on four watershed properties: the Drainage Area, the Mean April Precipitation, the Percent of Wetlands and Ponds in the watershed, and the Watershed Slope. The Drainage Area, the Wetlands and Ponds and the Watershed Slope are all the same as described in the SCS Method section. The Mean April Precipitation is a value given in inches determined from average monthly rainfall amounts over the last 30 years, as published by the PRISM Climate Group from Oregon State University (http://www.prism.oregonstate.edu/). Each return period has its own equation, and although the four watershed properties remain constant, each equation has unique coefficients and exponents.

C. Discussion

While both hydrologic methods employed in this model are published government methods, neither is a substitute for a full watershed analysis. Both methods are screening level estimates of the flood peak flows expected at each crossing. Both methods suggest using watersheds that are relatively rural and somewhat homogenous. This is because the more urban the watershed, the more complex the runoff characteristics and the more hydrograph routing required: all of which add variability to the flood peak estimates. Neither of the employed methods performs hydrograph routing. As the watershed becomes more urban, peak flow becomes more unpredictable on a large scale. Peak flow can increase due to factors such as the straightening/channelization of streams or increased amounts of impervious surface. However, urbanized environments typically have more hydraulic controls such as road crossings, stormwater ponds and dams, which act to attenuate and lag peak flows. The two employed methods are the most efficient methods available for the purpose of this model. They were selected in part for: 1) their wide acceptance; 2) the ease of understanding and entry by the end-user; and 3) for the level of complexity of the model.

Either method could actually be used to calculate flows at each crossing; however, the model selects the most appropriate method for each culvert analysis based on the previously mentioned limits of use related to each method. In the development of this program, several watersheds were analyzed and the two methods were compared. It was determined that for all watersheds under one square mile, with a time of concentration not exceeding 10 hours, the program uses the SCS Method. For all other watersheds, the Regression Equations are used.

II. Hydraulics

The hydraulic component of the project involves analyzing how a selected culvert performs in passing the calculated flows; the depth of water upstream of the culvert, also known as the Headwater Depth. The calculation method is based on the U.S. Department of Transportation Federal Highway Administration's (USDOT FHA) Hydraulic Design Series number 5 (HDS-5), Hydraulic Design of Highway Culverts. This method utilizes field-collected information regarding a crossing in addition to empirical formulas. As a simplifying assumption, inlet control was assumed to occur at each culvert. This means in flooding conditions, the culvert inlet hydraulically acts as an orifice. The program computes headwater depths based on field-collected crossing information. For re-sizing culverts, the program uses a geomorphic approach such that the culvert acts under outlet control, whereby flow in the culvert is more like the open channel flow in a stream.

A. Existing Culvert Hydraulics

The existing culvert crossing hydraulics are analyzed for the peak flows determined from the hydrology. Additional input consists of user-determined culvert properties. HDS-5 describes equations developed for various possible culvert hydraulic conditions; inlet control, outlet control, submerged and unsubmerged.

The equations for unsubmerged culverts generally apply to a Headwater to Interior Rise (culvert height) Ratio of 1, while the equations for submerged culverts apply from about a ratio of 1.5 and higher. Between ratios of 1 and 1.5, the Headwater depth can be approximated using a linear interpolation between the submerged and unsubmerged equations. This results in an iterative process that would be complex to code in the Excel model. Therefore, the same methodology used in the FHWA free computer program, HY-8, which is based on the HDS-5 report, was employed in this program. This method uses a 5^{th} order polyline fit to the empirical culvert hydraulic relationships for inlet control. For variables, the equation relates Headwater Depth divided by culvert Rise (height) to Flow divided by Area times the square root of the Rise. This polyline is a very close fit for all ratios of Headwater Depth to Rise from 0.5 to 3. Above a ratio of 3, the standard orifice equation for a Submerged culvert under Inlet Control can be used. Below a value of 0.5, the Headwater is not calculated as the culvert is considered successful in passing the flow (outlet control).

Each culvert type is described by the shape (e.g. circular, square, arch), the material (e.g. concrete, plastic, metal), the inlet edge configuration, and the inlet end type. Changing one of these four descriptors differentiates the culvert type, and results in different coefficients and variables used in the equation to compute Headwater Depth. The required user input for the hydraulic section consists of the Culvert Type Reference Number (based off the four variables described previously for the Culvert Type), the Culvert Length, the Inlet Elevation, the Outlet Elevation, the Road Elevation, the Number of Barrels, the Interior Rise, the Interior Span, the Culvert Wall Rise (only applicable to Arch pipes), and Embedded Depth (only applicable to embedded culverts). The three Elevation values, the Number of Culvert Barrels, and the Culvert Length are self-explanatory. The Interior Rise is the vertical height of the culvert measured from the invert of the culvert or from the bottom of the thalweg in an embedded culvert or open-bottom culvert. The Interior Span is the width of the culvert. The Culvert Wall Rise applies only to arch pipes, and refers to the height of the side wall of the arch. Finally, the Embedded Depth refers to the depth of sediment above the invert of the culvert. If the culvert is embedded, the Interior Rise and the Embedded Depth should add up to the total culvert vertical height.

All of the mentioned input has information, examples, and images in the model to help the user understand and correctly collect and enter the required information into the model. The Excel model uses the input to determine the Headwater Depth for each flow through the culvert. The culvert is then rated based on the ratio of the Headwater Depth to the Interior Rise ratio of the culvert. The culvert is considered Passing if the ratio is under 0.85, the culvert is considered Failing if the ratio is over 1.15, and the culvert is considered Transitional if the ratio is between 0.85 and 1.15.

The hydraulic methods used in the Excel model were chosen for several reasons. The required input is easier to understand and collect than other methods, the model is meant for non-engineers, the hydraulics do a good job approximating the results, and it also requires much less effort in calculations internal to the model while still providing results that may be used for rating each culvert.

As stated in the opening paragraph of the hydraulics section, there are equations for Submerged and Unsubmerged culvert hydraulics and for Inlet and Outlet Control. For simplicity, the Excel model assumes all culverts are under Inlet Control. The Outlet Control Headwater depths are not calculated due to their complexity in integrating them within the model and the potential error in the collection of the data. Despite not calculating the Outlet Control Headwater depths, the model should still give an accurate representation of the culvert ratings for the model's purpose. When the model does compute a Headwater Depth to the Interior Rise ratio less than 1.15, users should consider the potential for outlet control, especially if the culvert is under the influence of downstream backwater (ponding) effects.

B. Proposed Culvert Hydraulics

Proposed crossings are offered for two types of culvert installations: Rectangular round culvert(s) and 20 percent Embedded Circular culverts. There are of course other possibilities; however, for simplicity of coding, this model gives two options for the user to consider. The approximate stream bankfull width is calculated using the Regional Hydraulic Geometry Curves and Regression Equations (NHST, 2005 or Schiff, MacBroom, and Armstrong Bonin, 2007), and the recommended minimum natural-channel stream crossing span determined using the guidelines in the NH Stream Crossing Guidelines (NHDES, 2009).

Determining the proposed number of barrels and the sizes for both culvert types is accomplished by setting the desired Headwater Depth to Rise ratio to 1 in the Unsubmerged Inlet Control equation. Then solve for the Area times the square root of the Internal Rise parameter. When this value is determined, the model finds a similar value from a table of culverts by size and quantity.

This method of calculating proposed culvert sizes is different than what is suggested in the HDS-5 report. It uses approximate equations and general assumptions. The proposed culvert sizes are not intended to be used as an exact design; rather, they should be used as a guide to estimating the size of required openings. The Project Team strongly recommends that a full watershed model, using a more detail hydraulic analysis, be utilized in a final stream crossing design.

Results

Results presented in this report summarize an analysis of the entire Piscataquog River watershed. Per the discussion above, the GIS methodology was executed for the 217 mi^2 watershed and the GIS output file was used as input data for the Excel model. Likewise, the stream crossing field data was also used as input data. A total of 400 stream crossings were processed using this model; the results generated were color coded by specific categories. The HC categories were: 1) **Red**, culvert failed to pass the projected instream flows; 2) **Yellow**, refers to a transitional status where a crossing will pass flows between 85% and 115 % of its capacity; and 3) **Green**, identifies where 100% of the flows will pass through the structure. All results and ratings, GIS output and field data for each assessed stream crossing is included with this report and is also available via a CD if requested from the SNHPC.

As discussed under the Hydraulics section of the Hydrologic and Hydraulic Methodology section above, each culvert is rated based on the ratio of the Headwater Depth to the Interior Rise ratio of the culvert. The culvert is considered Passing if the ratio is under 0.85, the culvert is considered Failing if the ratio is over 1.15, and the culvert is considered Transitional if the ratio is between 0.85 and 1.15.

Table 1 below summarizes the results for the watershed relative to the pass/transitional/fail categories, for each storm recurrence interval. The table indicates that of the 400 culverts assessed, for the 25-year recurrence interval 58% or 232 failed; 10% or 38 were transitional; and 19% or 77 passed. In many instances, if a water flow analysis was done during the design phase of a culvert installation, the precipitation associated with the historic 25 year return interval was the basis for the culvert sizing. As we now know, climate change has skewed this precipitation volume and this sizing protocol is no longer applicable. New Hampshire is currently using either the 50 or 100-year recurrence interval for design calculations. As shown in the table, using the present rainfall data, the 100-year event shows that 71% or 284 failed; 4% or 17 were transitional; and 12% or 46 passed. Color coded graphs, as a visual representation for all seven sub-watersheds as well as the entire watershed, for each recurrence interval are displayed in bar graph form below Table 1.

Table 1. Map Showing Identified Road Stream Crossings within the Piscataquog River Watershed

Return Interval	Fail		Transition		Pass		No Result	
	#	%	#	%	#	%	#	%
2	111	28	27	7	209	52	53	13
10	183	46	46	12	118	30	53	13
25	232	58	38	10	77	19	53	13
50	264	66	28	7	55	14	53	13
100	284	71	17	4	46	12	53	13

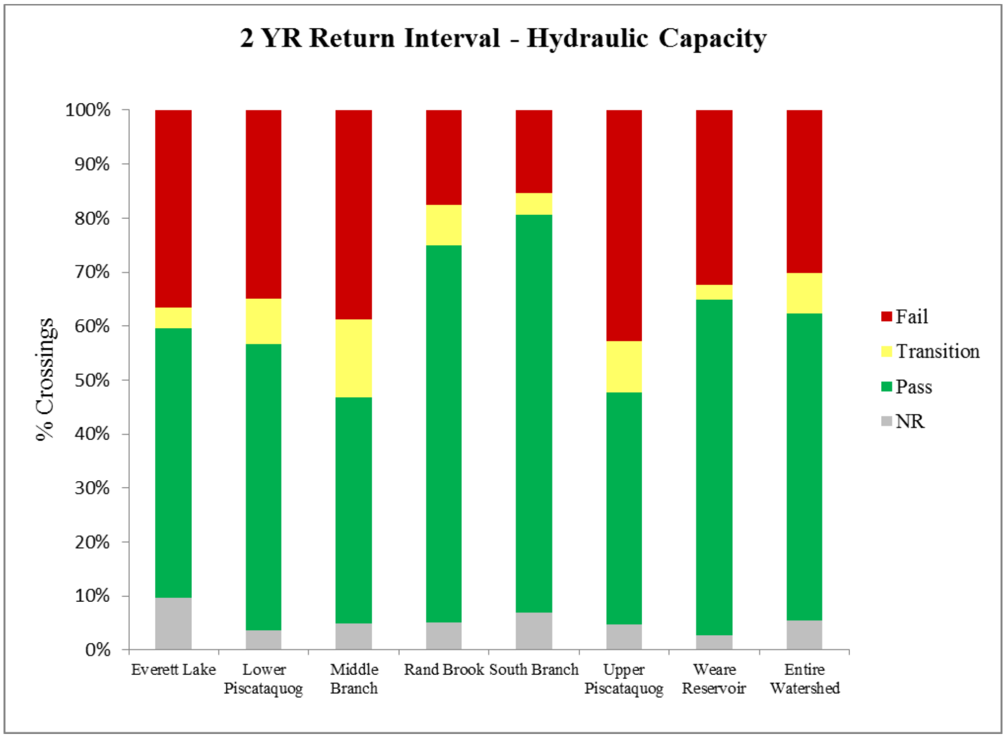


Figure 2. Results of all crossings by catchment for the two-year return interval.

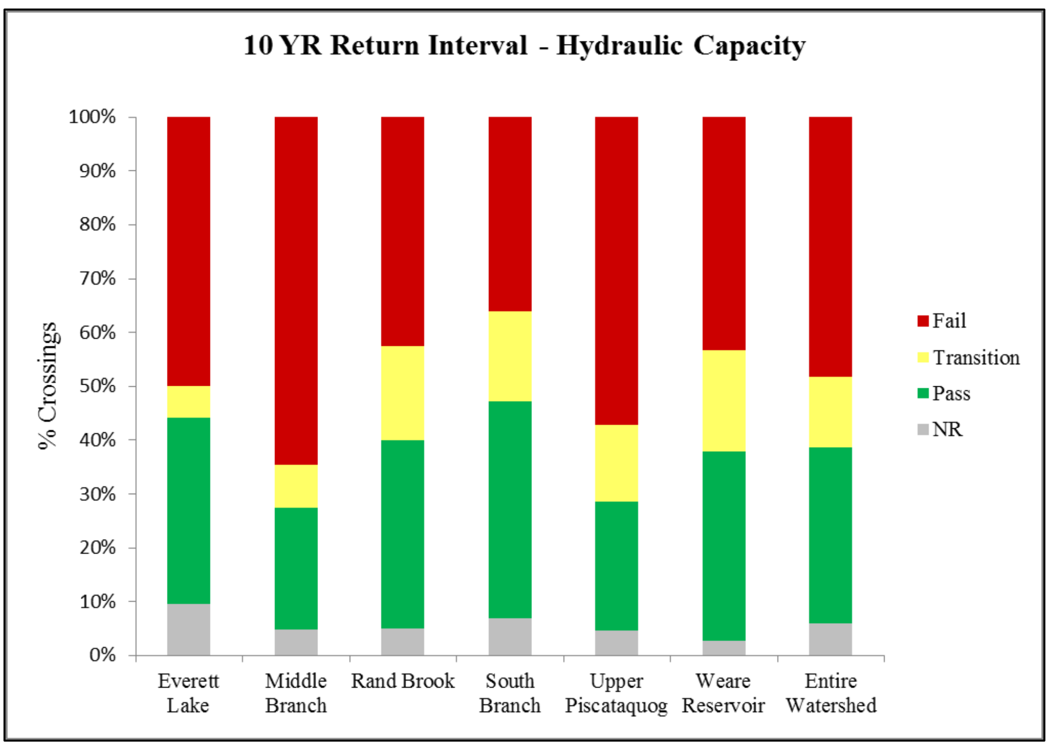


Figure 3. Results of all crossings by catchment for the 10-year return interval.

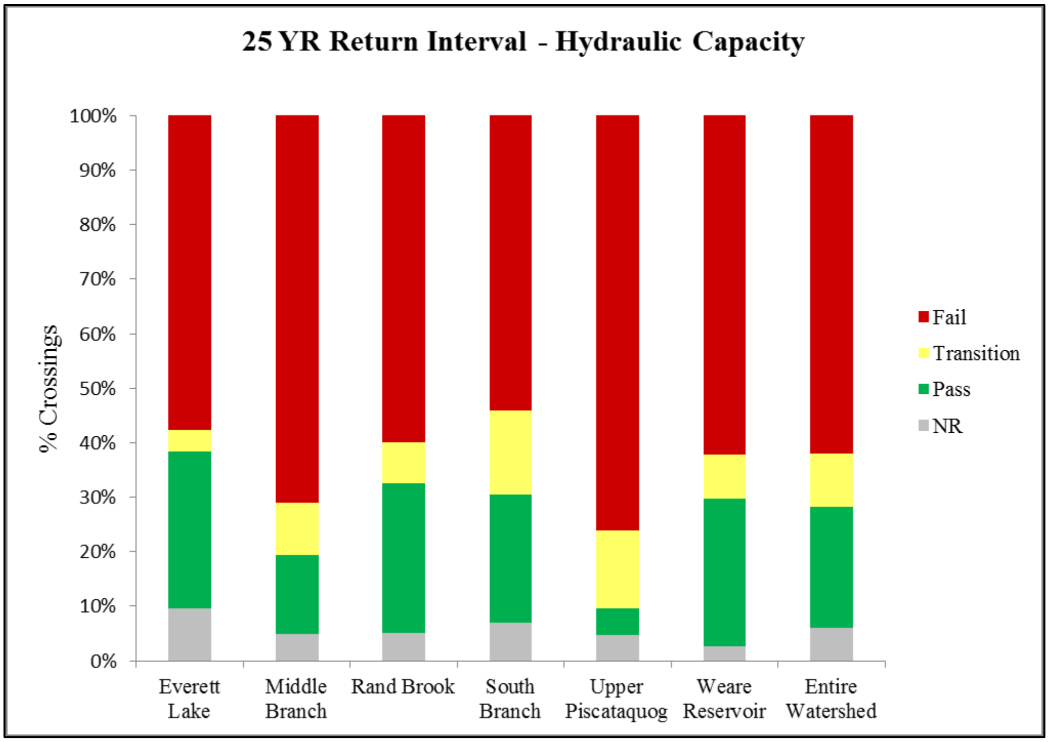


Figure 4. Results of all crossings by catchment for the 25-year return interval.

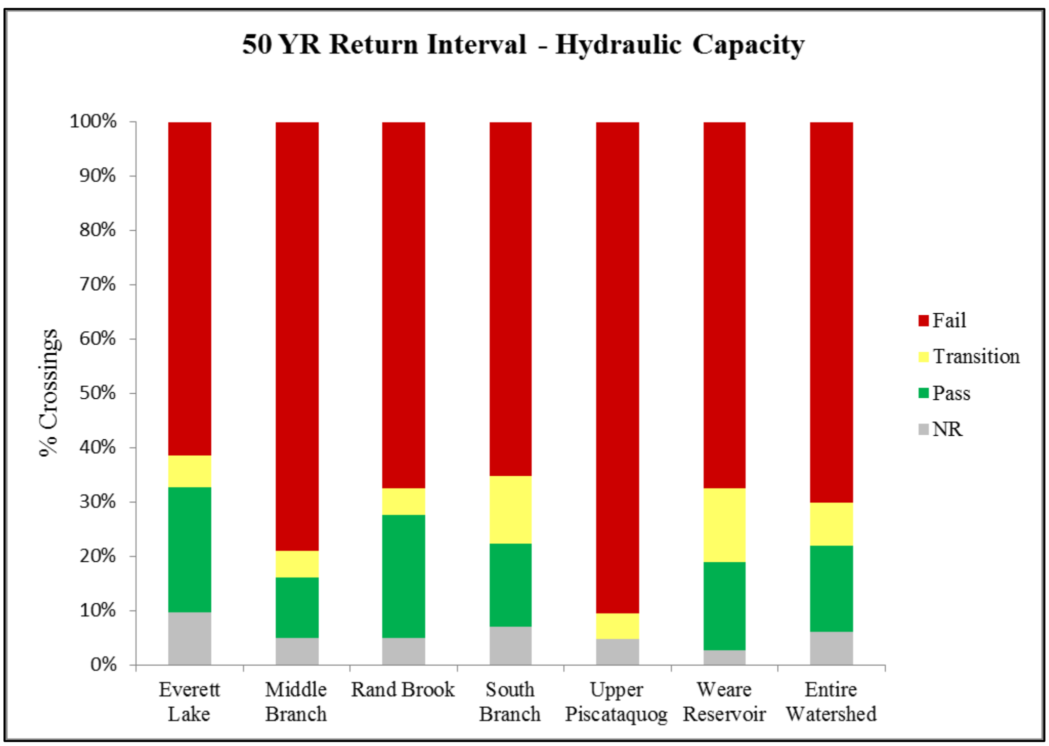


Figure 5. Results of all crossings by catchment for the 50-year return interval.

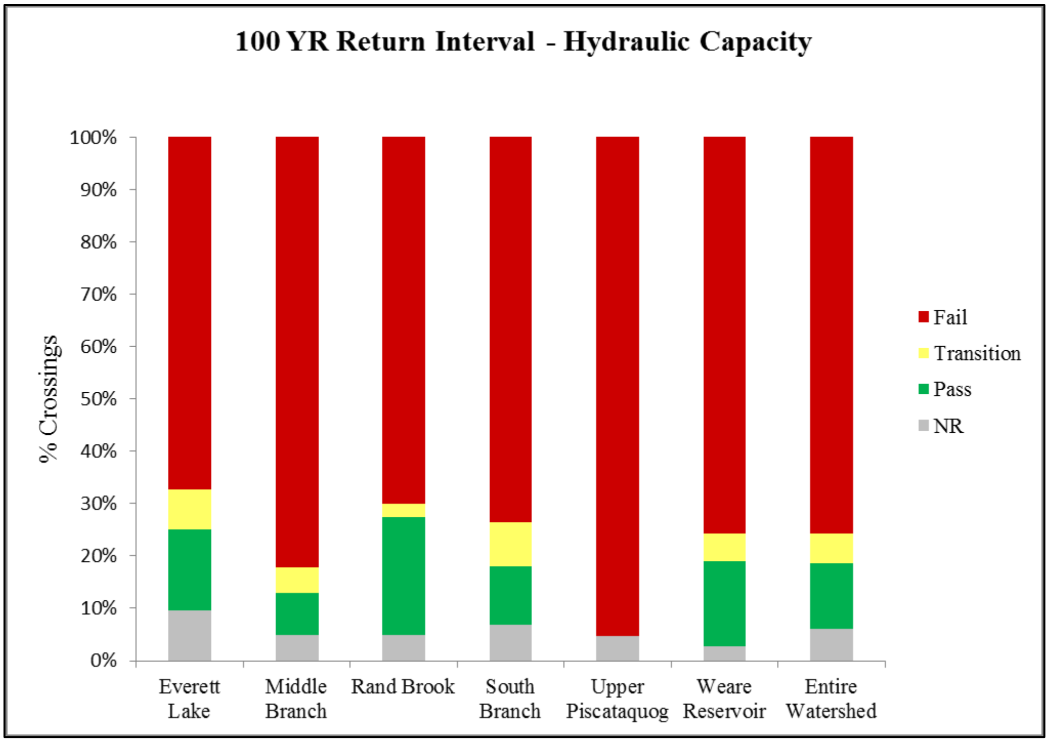


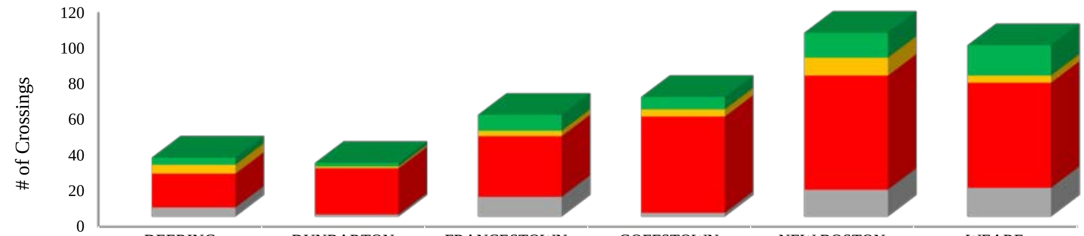
Figure 6. Results of all crossings by catchment for the 100-year return interval.

A tabular display of all results, grouped by town and organized by road name, is provided in Appendix 6. These tables include all crossings evaluated by the model and list the unique identification code for each crossing as well as additional geomorphic compatibility details. Both AOP and the HC are categorized and color coded for easy identification.

The Excel model results also include proposed culvert dimensions for each stream crossing. Dimensions are provided for two theoretical culverts, 1) a proposed rectangular culvert and 2) a proposed 25% imbedded circular culvert. For instance, when a culvert is assigned a transitional or failed category for a specific storm recurrence interval, these proposed culverts can be used to provide a general sense of what could be built in place of the existing culvert to pass all projected stream flows. These proposed culvert details are provided in the Results tab of the Excel model, at the bottom of the tab just above the statistic summaries.

It should be noted that, as discussed in the Hydrologic and Hydraulic methodology, these proposed culvert hydraulic designs use approximate equations and general assumptions. Proposed culvert sizes are not intended to be used as an exact design; rather, they should be used as a guide to estimating the conceptual size of required openings. More detailed modeling and analysis should be performed to develop a final design that incorporates a specific culvert modification or replacement size. See the suggested list of hydraulic tools available in Appendix 8 for more details.

Greater than 96 percent of all the stream crossings assessed are located in the following six towns identified in Figure 7: Deering, Dunbarton, Francestown, Goffstown, New Boston and Weare. This graph provides a summary of the HC rating for all of the crossings within each town.



	DEERING	DUNBARTON	FRANCESTOWN	GOFFSTOWN	NEW BOSTON	WEARE
GREEN	4	2	9	7	14	17
ORANGE	5	1	3	4	10	4
RED	19	26	34	54	64	59
NO RESULTS	5	1	11	2	15	16

Figure 7. HC conditions in the major towns in the study area.

Town-specific maps, with crossings identified geospatially, are included in Appendix 3 and 4 and color coded for the HC condition related to each storm recurrence interval. Figure 8 below provides an example of these maps; in this example, the town of Weare offers a visual outline of the HC condition for each crossing relative to the 2-year storm interval.

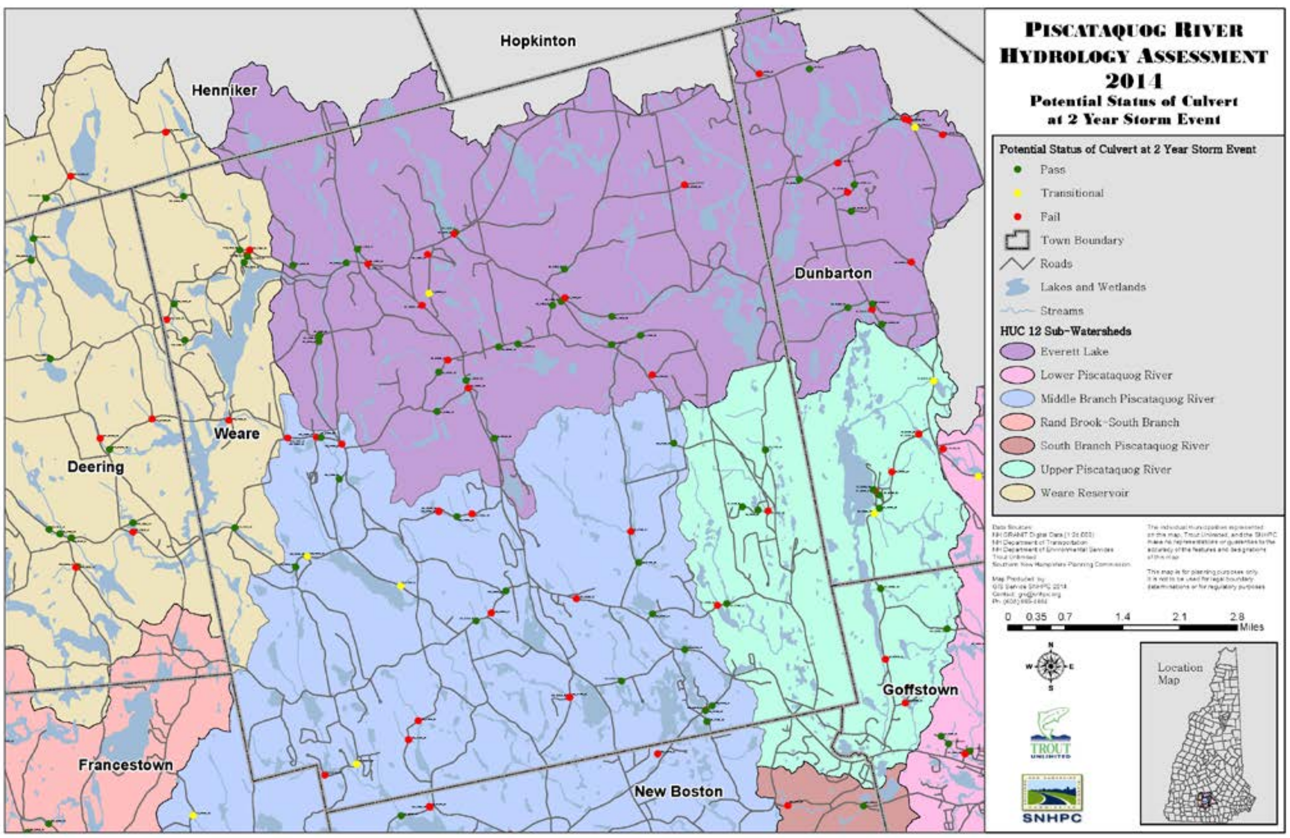


Figure 8. HC conditions in the town of Weare for the 2-year return interval.

Discussion of the Results

The reader should understand that results for this hydraulic capacity assessment have been run through a computer model designed for assessing hydraulic capacity and should not be viewed as final design criteria. Further assessment and evaluation of hydraulically inefficient crossings would provide a more accurate final design. However, this initial screening level assessment can be used as a first step in evaluating stream crossings for hydraulic capacity that might be a threat to municipal infrastructure and property, and aid in the prioritization of crossings to either be improved upon or replaced. The results for the entire watershed show that 73 percent of the 400 culverts assessed via the model are categorized as either transitional or failed during a 50 year storm event. A number of factors could be utilized to attempt to provide insight to the high percentage of crossings that are not passing certain storm flows efficiently, however reviewing data from the initial field data collection effort provides some preliminary insight. Some of the findings from the field assessment (TU 2012) that could indicate poor hydraulic capacity are summarized as follows:

- Of all crossings assessed, 87% were culverts, 7% were arches and 7% were bridges; on average, culverts are more likely to be undersized and fail than arches or bridges;
- Of the 358 culverts (87% of the total crossings), 67% were categorized as either old, rusting, collapsing or eroding;
- Of the 400 crossings 312 were measured for geomorphic conditions including bankfull width; and only 2% of the 312 had crossings that were sized at greater than 100% bankfull width (i.e. the target being 120%).

Considering the various types of structures that have served as stream crossings in the recent past, older culverts often times do not convey storm flows efficiently due to being undersized. Culverts built in the 1970s through the early 1990s are subject to hydraulic inefficiencies because they were typically built to the 25-year recurrence interval storm. Today, they are built to either the 50-year or 100-year recurrence interval storm, depending on the order of the stream or river and the drainage area associated with the crossing, and designers are using the most current rainfall data. As previously stated, information obtained during the initial field data collection effort indicates 87% of the crossings were culverts.

In addition to older culverts being commonly undersized with a low HC, two-thirds of the culverts assessed were in some degree of disrepair. Structurally compromised culverts could potentially lead to reduced flowable area, blockage, and lower HCs.

A primary design metric for newly installed culverts includes designing the culvert span to 1.2 times the bankfull width of the channel at the site. This allows for the channel to maintain its natural condition through the structure; allows for some geomorphic adjustment and does not 'harden' the banks. Data from the field effort indicated that only 2% of the crossings assessed for geomorphic parameters were sized greater than 1 times the bankfull width of the channel.

The model also provides results pertaining to potential crossings that would provide the proper HC for a given recurrence interval. Again, although not a final design, this portion of the results provides a general sense for what could work during a specific storm event. A rectangular culvert and a 25% embedded circular culvert are proposed. One advantage to box culverts and circular imbedded culverts are the opportunity to upsize culvert capacity and to embed these crossings into the stream bed to eliminate the potential to develop perched conditions. Natural substrate in a crossing greatly enhances both AOP and HC, as well as reducing instream velocity of stream flows due to the roughness coefficient. This feature greatly enhances AOP, giving migrating fish a chance to rest in naturally forming eddies. Data from the field effort indicated that 43 percent of the crossings assessed were considered to be New or in relatively good condition. This is slightly better than what has been observed in many other watershed assessments. Although the percent of “New” crossings would ideally be much higher, the reality is this is an expensive proposition to undertake and an excellent long-term goal for a community to work toward. The immediate and ongoing challenge for many Piscataquog River communities is the 42 percent of crossings found to be in Old condition, with the remaining 15 percent falling into rusted, collapsing or eroded categories. This failing infrastructure will present a significant financial investment for communities over the next couple of decades. One suggestion is for communities to consider creating a restructuring / replacement schedule based on a combination of assessments and results consisting of this HC assessment, the AOP and geomorphic assessment completed in 2012 as well as recommendations from their department of public works.

Summary

By developing this model and evaluating the HC of stream crossings within the Piscataquog River drainage, watershed communities will be able to easily evaluate potential road and infrastructure hazard risks associated with undersized road stream crossings. Having access to this critical data, municipal road agents and department of public works staff can take advantage of updated information to assist in prioritizing and restoring inadequate and undersized crossings. These actions will not only help to enhance HC, it will also potentially improve AOP. In the end, this proactive approach to addressing infrastructure needs within the watershed will help reduce maintenance and repair costs, safeguard against road safety issues, as well as protect critical environmental habitat associated with stream fragmentation.

Additionally, this model can be used by other organizations and municipalities within other watersheds to perform similar work. The Excel model and GIS methodology was created for non-engineers, such that someone with a moderate amount of Excel experience along with someone with a low to moderate level of GIS experience, can utilize this model to evaluate stream crossings within another watershed. An initial field data collection effort similar to what was performed for this project would of course be required; however, once the field data is complete, a community will have all the tools necessary to run an AOP, geomorphic and HC evaluation on all of their assessed road stream crossings.

Additionally, this project will assist: (1) municipal conservation commissions in identifying and developing important connectivity habitat restoration projects for aquatic organisms; (2) assist NH Fish & Game Department and NH Department of Environmental Services in prioritizing funding for future restoration projects and other actions designed to protect the water quality within a river system; (3) support NH Geological Survey in supplementing the fluvial geomorphic assessment study of all NH rivers; and (4) support each designated River's Local Advisory Committee (RLAC) in implementing an important goal of their River Management Plan which is to improve water quality and protect the natural flow of the river for fish and wildlife habitat and public water uses. The Piscataquog River watershed is presently a healthy combination of urban and rural landscapes. To maintain water quality for all of the eleven communities, it is extremely important that towns work across political lines to protect this valuable natural resource.

Provided below is an example of a road stream crossing that, if replaced, would greatly improve both HC and AOP. The investment and choice of culvert replacement and/or retrofit is ultimately a local and/or state decision. The authors of this document realize the significant financial commitment to address these issues. However, in the long run, if crossings are resilient to extreme flooding, there is a proven financial advantage to proactively restoring natural flows to our river systems. The second photograph is a crossing proven to withstand the 100-year flows associated with Tropical Storm Irene. If a community replaces undersized crossings with these designs, their community will not only protect their road infrastructure and residents, they will also save on the high costs associated with emergency repairs and avoid the disruption of critical emergency services at the same time. Upgrading any infrastructure is costly; however, if costs can be managed, then there is less unknowns into the future.

Left photograph above is an example of an impassable, undersized and incompatible stream crossing. Right photograph depicts a geomorphically compatible road stream crossing allowing for proper sediment transport, aquatic organism passage, and channel migration.

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Appendices

* (CD available upon request from SNHPC)

Appendix 1

GIS Methodology

Introduction

The objective of this GIS model is to generate watershed characteristics such as area, slope, longest flow path, SCS curve numbers, coverage by wetlands, ponds and lakes, and precipitation distribution for any given storm event. These parameters are necessary for the computation of runoff and are essential for running a hydraulic model. The overall goal of the GIS modeling is to assess the hydraulic capacity of existing road stream crossings within the watershed.

Data Requirements for the Model

Data from NH Granit:

- Digital Elevation Model (DEM): 1m resolution (http://lidar.unh.edu/map/)
- Soil Survey Geographic (SSURGO) database for New Hampshire (last revised in 2009)
- New Hampshire Land Cover Assessment - 2001: 30m resolution
- NH DOT Road Network (Scale: 1:24,000)
- New Hampshire Hydrologic Dataset (NHHD) (Scale: 1:24,000): New Hampshire Hydrography Dataset - CU 01070006 - Merrimack. It is a geodatabase; from Hydrography feature dataset, select a layer named " **NHDFlowline**" for streams, and **Watershed** and **Subwatershed** from **HydrologicUnits** feature dataset.

Other datasets include:

- 30-year normals (the normals are baseline datasets describing average monthly **precipitation** over the period 1981-2010. We chose monthly values in **April** which correspond to maximum precipitations for this model. Data can be downloaded at http://www.prism.oregonstate.edu/normals/.
- 2-10-25-50-100-year rainfall ascii files from Cornell (0.8 km resolution); units are in mm.
- Wetlands, ponds, and lakes from National Wetlands Inventory (U.S. Fish and Wildlife Service) (http://www.fws.gov/wetlands/Data/State-Downloads.html): Shapefile for New Hampshire (**CONUS_wet_poly** layer); units are in inches x1000.

Software requirements

- ArcGIS 10 or 10.1 (with Spatial Analyst)
- ArcHydro tools 10 or 10.1
- HEC-GeoHMS 10.1

Note:
Arc Hydro Tools are free with your ArcGIS software license. You may download version 2.0 of Arc Hydro Tools from
http://resources.arcgis.com/en/communities/hydro/01vn00000010000000.htm

GIS Model Workflow

Data preparation

1. Use ArcCatalog to create a project folder (create a specific name for this project) directly onto your C drive. Within this folder, you will create five other folders and a file geodatabase according to the following:

FOLDER NAME		CONTENT
Hydro_Project (Main folder)	Precipitation (Folder)	• 30-year April normal • 2-year precipitation • 10-year precipitation • 25-year precipitation • 50-year precipitation • 100-year precipitation
	Flowline (Folder)	• Streams
	Wetlands (Folder)	• Wetlands • Wet_Sqft.dbf table
	Runoff_CN (Folder)	• CN standalone and merged tables • Soils • Land cover
	Watershed (Folder)	• Watershed • Point-data • Roads
	Final_Output (Folder)	• Merge_Final (all tables merged)
	Hydro_Project (File geodatabase)	This geodatabase is reserved to ArcHydro and HEC-GeoHMS's processing output. It will store the LongestFlowPath, AdjointCatchment, Catchment, DrainageLine and WatershedPoint

Notice: ArcHydro will create its own additional folder named "Layers" once you start using Arc Hydro tools. This folder will store ArcHydro output raster data, i.e. agreedem, cat, cngrid, fac, fdr, fil, str, strlnk.

2. Create a file geodatabase within this project folder.
3. Save your map document into the folder you just created for the project (File > Save as.....)
4. Open windows explorer and unzip compressed files (you can freely download 7-zip and install it on your computer) into your project folder you just created.

5. Set the coordinate system of all data to NAD_1983_StatePlane_New_Hampshire_FIPS_2800_Feet

6. Clip data (use the **Clip tool** for vector data and **Extract by Mask** for raster data) to the extent (shapefile) of the watershed of your interest.

Watersheds delineation and characteristics (area, slope, flow path, basin length)

7. If an inventory of culverts was done, the data set collected should be used instead of steps 7-12. Otherwise add stream and road shapefiles and proceed through step 12.
8. Add DEM which corresponds to your watershed of interest; make sure you always use the original DEM.
9. Create a 10-feet buffer for stream.
10. Create a 10-feet buffer for roads.
11. Use the Intersect tool (Analysis tools.tbx > Overlay > Intersect) to intersect stream buffer and road buffer.
12. Create a points layer (name = Culverts) from the resulting shapefile using a **Feature to Point** tool (Data Management Tools.tbx > Features > Feature To Point) you will need an advanced (ArcInfo) license of ArcGIS, in order to create points. These points should technically correspond to the locations of culverts. In the next steps you will use these points with Arc Hydro Tools to delineate watersheds.
13. Activate ArcHydro Tools toolbar extension of ArcGIS and set Target Location (ApUtilities > Set Target Locations > Select HydroConfig as a node to set target location >). Notice that a window opens up which shows the target location (Figure 1). Here P_mb refers to the folder created for the project and P_mb.gdb is a database created in step 1.

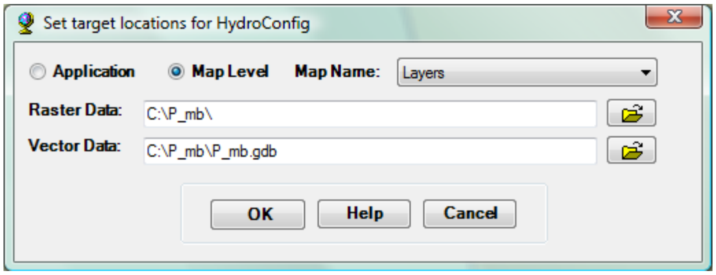


Figure 1. ArcHydro tools dialogue window showing the target location for geoprocessing output.

Terrain preprocessing (Using ArcHydro tools)

In this step, we use a Digital Elevation Model (DEM) and a stream network (stream network, the DEM and the map document must be stored in the same project folder at the same level in the project folder). The overall goal of terrain processing is to delineate the watershed of interest, calculate watershed characteristics (slope, longest flow path, sub-watersheds area, basin length, etc.) necessary for the calculation or runoff. This process involves eight steps: a) DEM reconditioning, b) Fill Sinks, c) Flow

Direction, d) Flow Accumulation, e) Stream Definition, f) Stream Segmentation, g) Catchment Grid Delineation, h) Drainage Line Processing.

The DEM Reconditioning function modifies Digital Elevation Models (DEMs) by imposing linear features onto them (burning/fencing). This function is an implementation of the AGREE method developed by Ferdi Hellweger at the University of Texas at Austin in 1997. For a full reference to the procedure refer to the web link http://www.ce.utexas.edu/prof/maidment/GISHYDRO/ferdi/research/agree/agree.html.

14. From Arc Hydro Tools Toolbar > Terrain Preprocessing > DEM Manipulation > DEM Reconditioning. (For the input: Raw DEM is the DEM you extracted by mask to the extent of your area of interest; AGREE Stream is the stream network you clipped earlier to the extent of your area of interest). Set Sharp drop/rise = 10 (Figure 2).

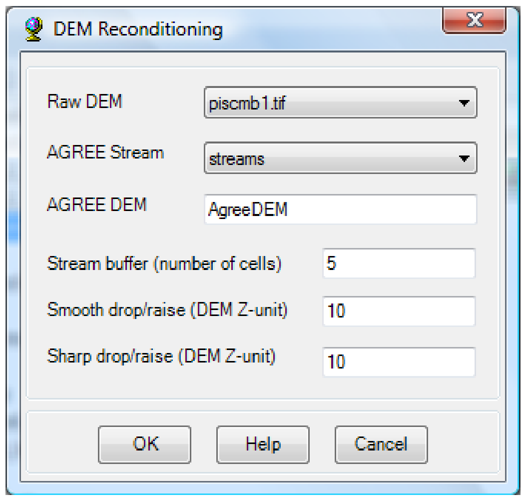


Figure 2. DEM Reconditioning dialogue window.

15. From **Arc Hydro Tools** toolbar: Terrain Preprocessing > DEM Manipulation > **Fill Sinks** (leave defaults).
16. From Arc Hydro Tools toolbar: Terrain Preprocessing > **Flow Direction** (Leave defaults).
17. From Arc Hydro Tools toolbar: Terrain Preprocessing > **Flow Accumulation** (leave defaults).
18. From Arc Hydro Tools toolbar: Terrain Preprocessing > **Stream Definition**. In the Area (square km) field, type 05 after decimal place and then delete everything else after 0.05. Never clear the field or leave only zeros. Leave the rest set to the defaults.
19. From Arc Hydro Tools toolbar: Terrain Preprocessing > **Stream Segmentation** (leave defaults).
20. From Arc Hydro Tools toolbar: Terrain Preprocessing > **Catchment Grid Delineation** (Leave defaults).
21. From Arc Hydro Tools toolbar: Terrain Preprocessing > **Drainage Line Processing** (leave defaults).
22. From Arc Hydro Tools toolbar: Terrain Preprocessing > Adjoint Catchment Processing (leave defaults).

23. Add river and road crossing point layer you created in step 12 or a layer of points you collected from the field if you have any.

Watershed processing

In this process, you will create Batch Points based on rivers_roads crossings **(Culverts** layer you processed earlier in step 8) and then you will delineate the watershed based on those points considered as potential locations for culverts. After watersheds are delineated, you will calculate watershed characteristics (area, slope, and longest flow path).

24. Turn off all layers except the Culvert layer and the **Drainage Line** layer.
25. Use the Snap Pour Point tool from ArcGIS toolbox (Spatial analyst Tools.tbx > Hydrology > Snap Pour Point) to snap river-roads crossing to the nearest point of the drainage line where the flow accumulation is maximal (a snap distance of 15 feet is chosen here). The Snap Pour Point tool is used to ensure the selection of points of high accumulation flow when delineating drainage basins using the Watershed tool. Snap Pour Point will search within a snap distance around the specified pour points for the cell of highest accumulated flow and move the pour point to that location.
26. Open the attribute table of the crossings point layer.
27. Select the first record from the attribute table and zoom to it.
28. From Arc Hydro Tools toolbar, click the Point Delineation tool as indicated by a red arrow in Figure 3. This tool allows watershed delineation for interactively defined points.

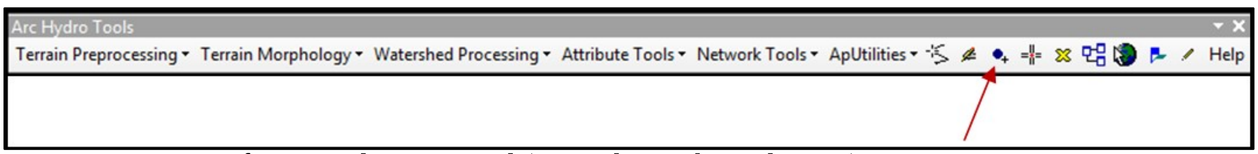


Figure 3. Location of Point Delineation tool (pointed to with a red arrow)

29. Leave defaults when the Point Delineation dialogue window (Figure 4) opens and click OK.

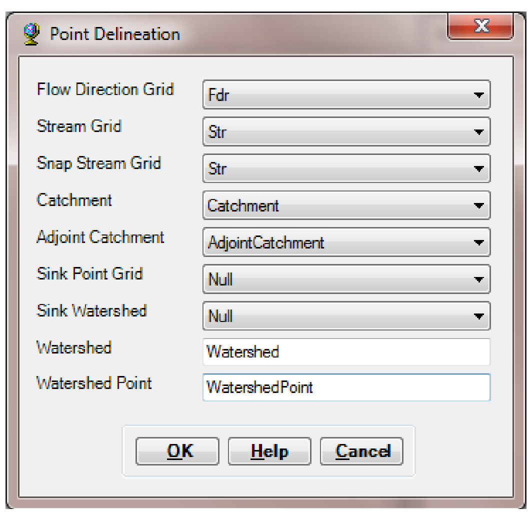


Figure 4. A dialogue window that shows the input for interactive watershed delineation and corresponding output layer names.

30. Click the nearest location to the first crossing point on the drainage line layer. When prompted to a dialog window shown in Figure 5, hit Cancel and restart until your click snaps to the drainage line.

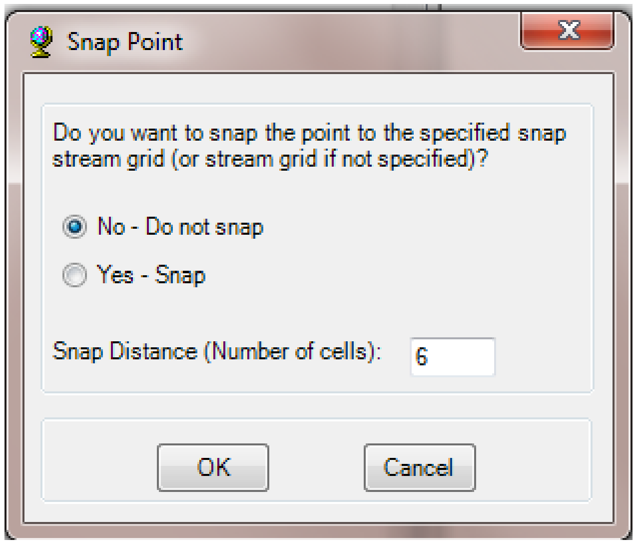


Figure 5. Snap Point window.

31. Click Yes when prompted to a question "Do you want to save the watershed?" and type the name of a culvert following an example given in Figure 6. For Description, you can type in the road name or stream name.

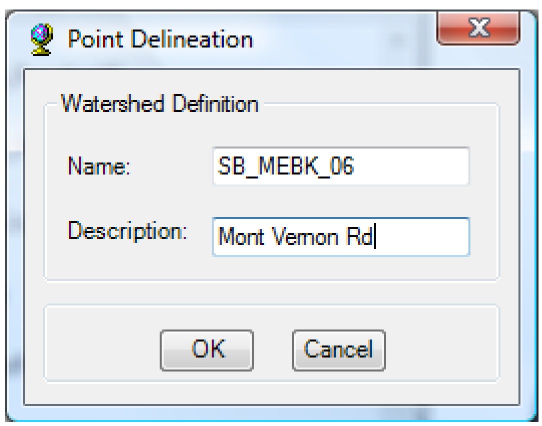


Figure 6. Point delineation dialogue window.

Notice: If a point lies half way between two drainage lines, it is useful to add an aerial photo of the area in the background so that you can see the point on top and make your judgment to decide which drainage line the point should naturally belong to. Also, if you want to remove any point you do not need, you need to start an edit session remove the record corresponding to the point from the attribute table.

32. Continue delineating watersheds until you have completed all the crossings. When finished, notice that the software has created two layers. One called "Watershed" and another one called "WatershedPoint". What you need to know is the Watershed layer has a field called " HydroID" which is the same as the field "DrainID" from the WatershedPoint layer.

Longest flow path for watersheds

33. From HEC-GeoHMS Toolbar, set parameters for data management (Preprocessing > Data Management) as shown in Figure 7. You do not need to type in anything. For Raw DEM, the name is the one you gave to your DEM; all else are named as shown.

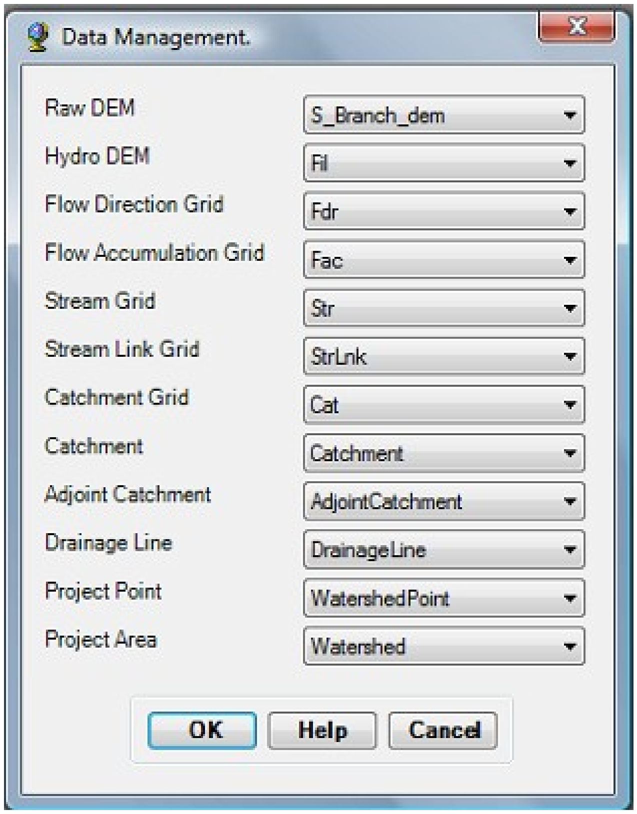


Figure 7. Data management window for HEC-GeoHMS extension.

34. Compute the longest flow path for each watershed (ft). From HEC-GeoHMS toolbar select Characteristics > Longest Flow Path.

    Notice the resulting layer is automatically named **Longestflowpath** (Figure 8). You will add 1 after the name to make it Longestflowpath1 since you will compute for Longestflowpath2, Longestflowpath3, and so on depending on the number of runs to make for this calculation. Make sure the Input Raw DEM is your **original DEM** and the Input Sub-basin the **Watershed** layer; leave **fdr** as the default for Input Flow Direction Grid (Figure 8).

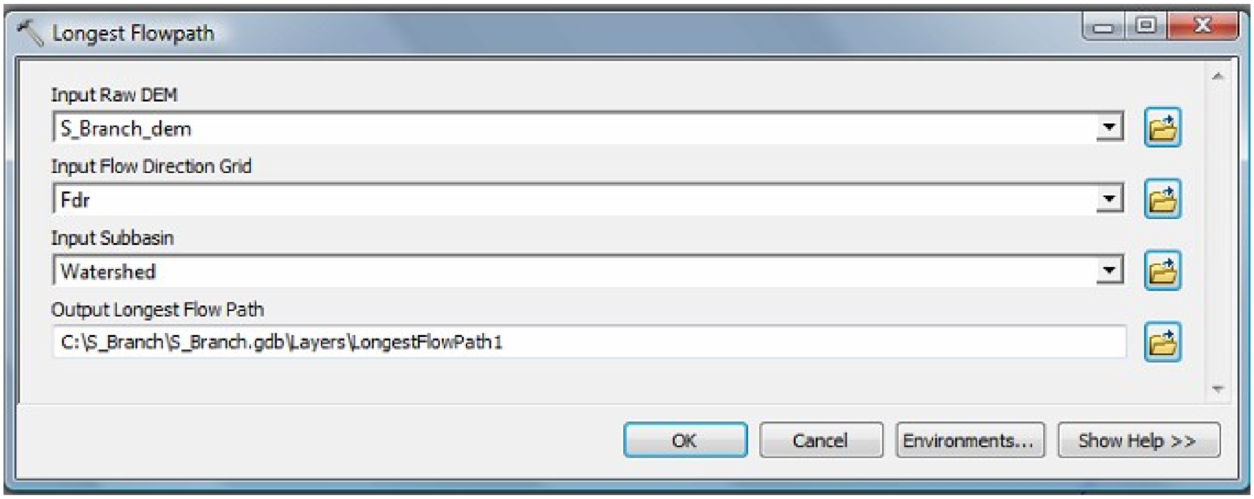


Figure 8. Window dialog for the computation of longest flow paths for watersheds.

Notice that the tool will calculate only a certain number of watersheds. You will need to run the tool multiple times to complete all watersheds in the next steps.

35. Use Joins and Relates to Join the LongestFlowPath layer you just created to the Watershed layer (Select HydroID from the drop down list for Choose the field in this layer that the join will be based on; for Choose the table to join to this layer, browse to the longest flow path layer you just created to add it; then select DrainID for Choose the field in the table to base the join on) (Figure 9).

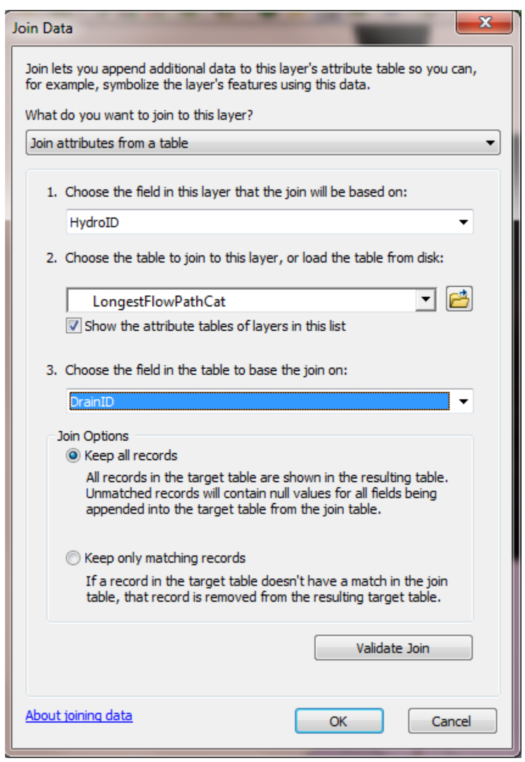


Figure 9. Join by attribute window.

36. Open Watershed layer's attribute table to select records for which the LongestFlowPath has not been calculated yet.
37. Run the longest flow path tool again (for Output Longest Flow Path, change the default name of LongestFlowPath to LongestFlowPath2). Every time you run iteration, make sure you change the output name.
38. Merge the first and the second LongestFlowPath layers.
39. From Watershed layer, clear all joins, then join merged layers.
40. Select records for which the longest flow path has not been calculated yet and run the tool again. Continue running steps until all records have a calculated LongestFlowPath.
41. Merge all the LongestFlowPath output layers into one layer called "LongestFlowPath_Merge". Join all merged and the longest flow path layers to the Watershed layer. Set the output location to the Flowline folder you created earlier.
42. Open LongestFlowPath_Merge layer properties and click Field tab to uncheck all fields except DrainID, Slp, Slp1085 and LongestFL. In later steps, these are the only fields we will use for the output.

Area of wetlands/ponds in watershed (ft^2)

You will use a wetland layer from National Wetlands Inventory (U.S. Fish and Wildlife Service) (http://www.fws.gov/wetlands/Data/State-Downloads.html): Shapefile for New Hampshire (**CONUS_wet_poly** layer). This data will later be used for a hydraulic model.

43. Clip the layer to the extent of the watershed you delineated (Using the Clip tool in ArcGIS).
44. Open the attribute table of the clipped layer and add a new field (Name: Wet_Sqft, Type: Double, Precision = 10, Scale = 2) (Figure 10).

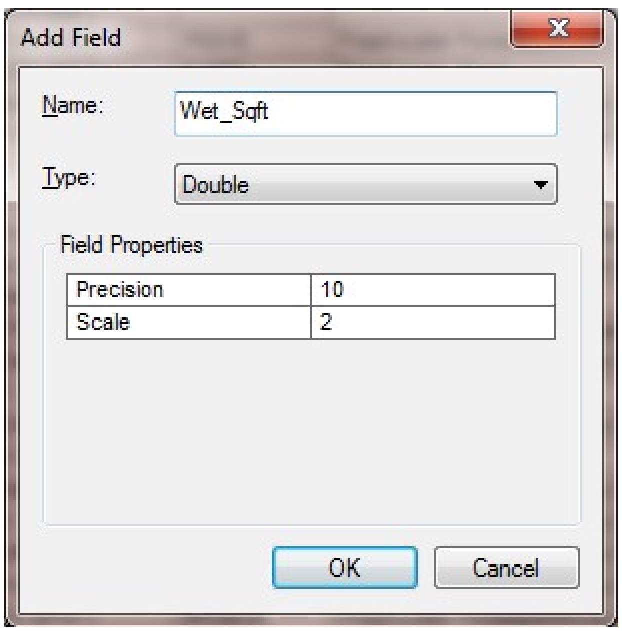


Figure 10. Input parameters for area calculation.

45. Right click Wet_Sqft and use Calculate Geometry and set necessary parameters (Figure 11). The output is computed in square feet for each watershed.

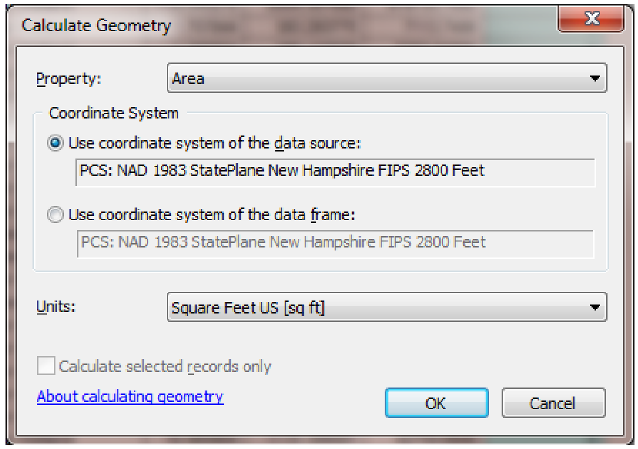


Figure 11. Context menu for calculating geometry (area in US feet).

46. To calculate how much (square feet) of wetlands, ponds, and lakes is in each watershed, use Spatial Join tool (ArcToolbox > Analysis Tools.tbx > Overlay > Spatial Join) to join the wetland layer you clipped in step 6 to the Watershed layer (Target Features = **Watershed**, Join Features = **Wetlands** layer, Join Operation: JOIN_ONE_TO_MANY. Set the output location to the **Wetlands** folder you created earlier) (Figure 12).

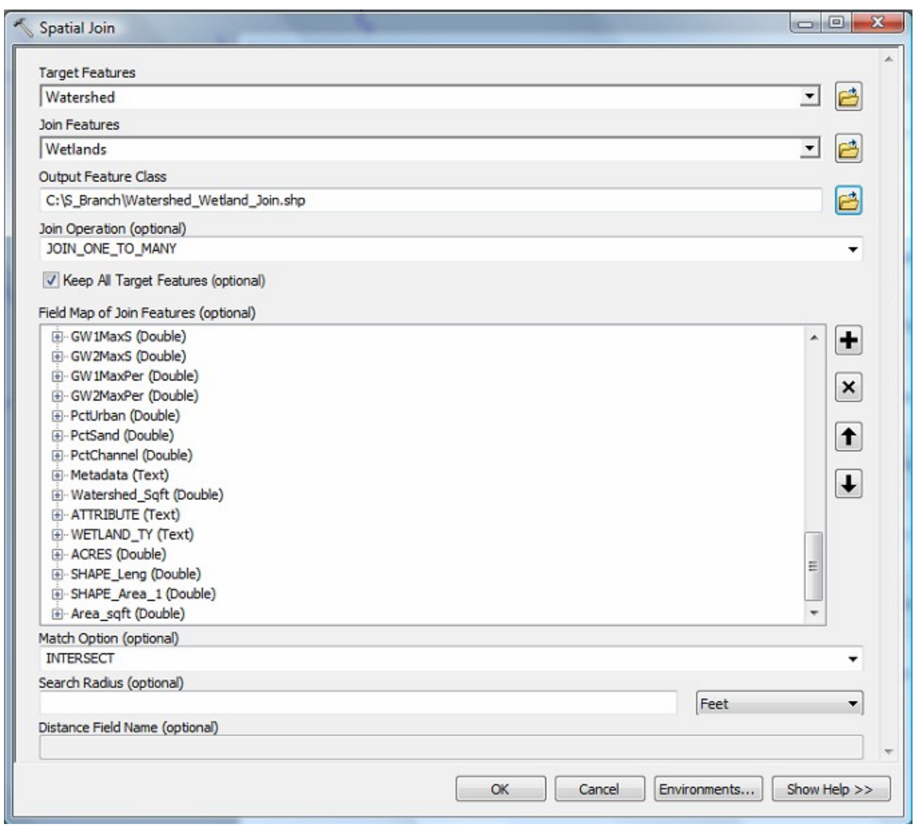
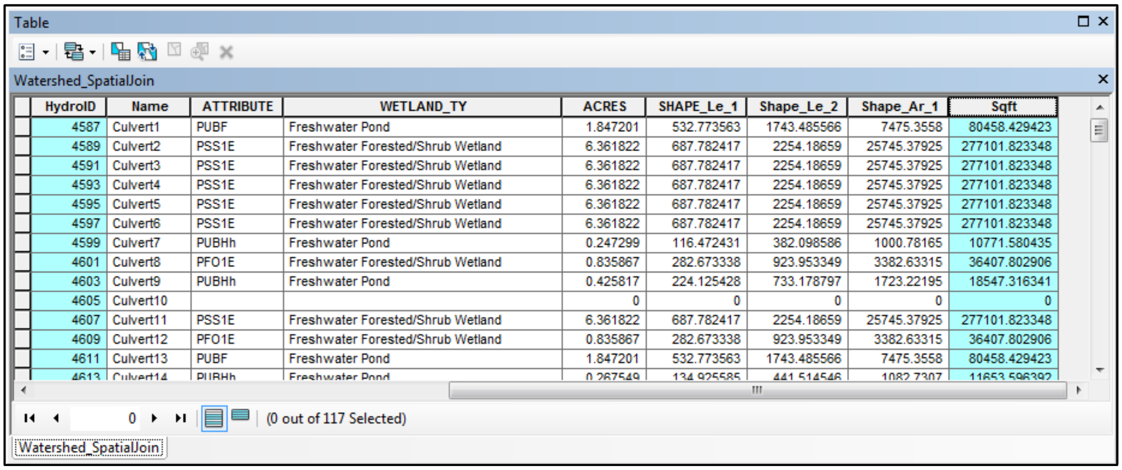


Figure 12. Spatial Join tool's input parameters.

Notice that the output contains HydroID field (which originates from the **Watershed** layer) and Sqft (which originates from the wetlands layer) (Figure 13).



HydroID	Name	ATTRIBUTE	WETLAND_TY	ACRES	SHAPE_Le_1	Shape_Le_2	Shape_Ar_1	Sqft
4587	Culvert1	PUBF	Freshwater Pond	1.847201	532.773563	1743.485566	7475.3558	80458.429423
4589	Culvert2	PSS1E	Freshwater Forested/Shrub Wetland	6.361822	687.782417	2254.18659	25745.37925	277101.823348
4591	Culvert3	PSS1E	Freshwater Forested/Shrub Wetland	6.361822	687.782417	2254.18659	25745.37925	277101.823348
4593	Culvert4	PSS1E	Freshwater Forested/Shrub Wetland	6.361822	687.782417	2254.18659	25745.37925	277101.823348
4595	Culvert5	PSS1E	Freshwater Forested/Shrub Wetland	6.361822	687.782417	2254.18659	25745.37925	277101.823348
4597	Culvert6	PSS1E	Freshwater Forested/Shrub Wetland	6.361822	687.782417	2254.18659	25745.37925	277101.823348
4599	Culvert7	PUBHh	Freshwater Pond	0.247299	116.472431	382.098586	1000.78165	10771.580435
4601	Culvert8	PFO1E	Freshwater Forested/Shrub Wetland	0.835867	282.673338	923.953349	3382.63315	36407.802906
4603	Culvert9	PUBHh	Freshwater Pond	0.425817	224.125428	733.178797	1723.22195	18547.316341
4605	Culvert10			0	0	0	0	0
4607	Culvert11	PSS1E	Freshwater Forested/Shrub Wetland	6.361822	687.782417	2254.18659	25745.37925	277101.823348
4609	Culvert12	PFO1E	Freshwater Forested/Shrub Wetland	0.835867	282.673338	923.953349	3382.63315	36407.802906
4611	Culvert13	PUBF	Freshwater Pond	1.847201	532.773563	1743.485566	7475.3558	80458.429423
4613	Culvert14	PUBHh	Freshwater Pond	0.267549	134.925585	441.514546	1082.7307	11653.596392

Figure 13. Output attribute table for the Watershed_SpatialJoin layer.

47. Right click HydroID > Summarize > When prompted to a dialog window, scroll down to expand **Wet_Sqft** field and check **Sum** in the Choose one or more summary statistics to be included in the output table box. The output table will show how much of total area (lakes, ponds, and wetlands combined) found in every watershed (the output table can be named "**wat_wetl.dbf**").
48. Open **wat_wetl.dbf** table properties and click Fields tab to uncheck all fields except HydroID and Wet_Sqft.

SCS Curve Numbers (CN) generation

A widely used method of calculating storm runoff developed by the Soil Conservation Service (SCS) uses storm rainfall and a curve number. A curve number is a quantitative descriptor of the land cover/soil complex and is commonly assigned based on information acquired from field surveys and interpretations of aerial photographs (Slack & Welch, 1980). Curve numbers have been tabulated by the Soil Conservation Service on the basis of soil type and land use. Four soil groups are defined:

- Group A: Deep sand, deep loess, aggregated silts
- Group B: Shallow loess, sandy loam
- Group C: Clay loams, shallow sandy loam, soils low in organic content, and soils usually high in clay
- Group D: Soils that swell significantly when wet, heavy plastic clays, and certain saline soils (Chow, Maidment, & Mays, 1988).

To generate CN values requires three steps: Land cover data preparation, soil data preparation and creation of SCS curve number grid. SCS curve number grid is used by many hydrologic models to extract the curve number for watersheds. We will use HEC-Geo-HMS for ArcGIS 10.1. There are also versions compatible with ArcGIS 10 as well.

Land cover data preparation

49. Add land cover data to ArcMap. Notice that the layer does not have a spatial reference.

Use the Define projection tool to assign spatial reference to the raster data (ArcToolbox > Data Management Tools.tbx > Projections and Transformations > Define Projection). You will then choose WGS84 for Coordinate System.

50. Set the land cover layer to NAD_1983_StatePlane_New_Hampshire_FIPS_2800_Feet projected coordinate system using the Project Raster tool (ArcToolbox > Data Management Tools.tbx > Projections and Transformations > Raster > Project Raster) (Figure 14).

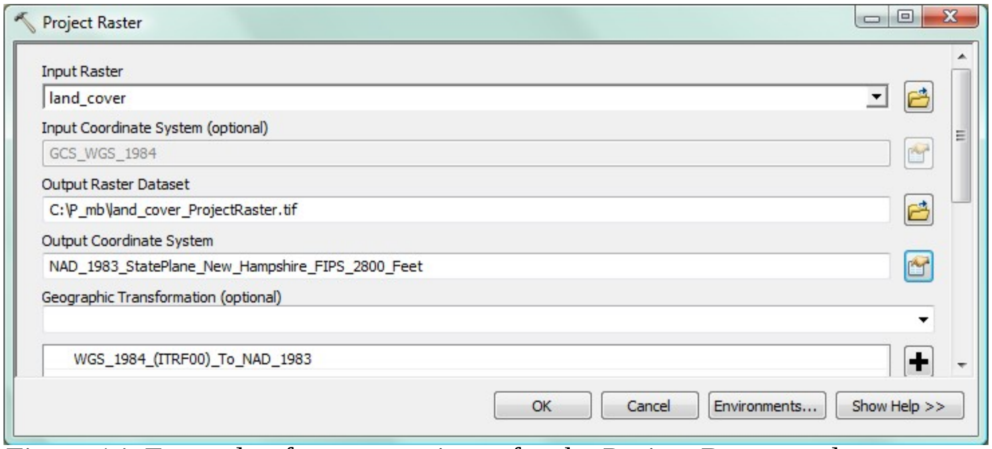


Figure 14. Example of parameter input for the Project Raster tool

51. Reclassify land use into classes that have the same general characteristics (From ArcGIS ArcToolbox > Spatial Analyst Tools. tbx > Reclass > Reclassify). You will use the following table to replace old values with new values (Table 1).

Table 1. Reclassification of land cover.

Old classes	**New classes**
110: Residential/commercial/industrial	1
140: Transportation	2
211: Row crops	3
212: Hay/Pasture	4
221: Orchards	5
412: Beach/Oak	6
414: Paper Birch/Aspen	
419: Other Hardwoods	
421: White/Red Pine	
422: Spruce/Fir	
423: Hemlock	
424: Pitch Pine	
430: Mixed Forest	
500: Open water	7
610: Forested wetlands	
620: Open wetlands	
630: Tidal wetlands	
710: Disturbed land	8
790: Other cleared	
No Data	No Data

The reclassify shows only eight classes (Figure 15). These same classes will be used later on for the creation of a LookUpTable in steps 60 through 63.

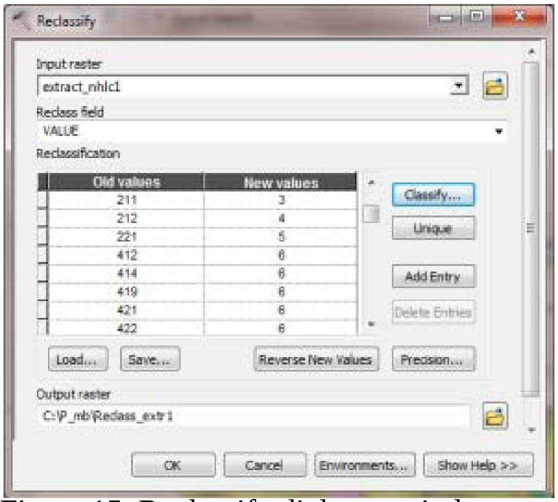


Figure 15. Reclassify dialogue window.

52. Convert the newly reclassified landcover from raster to polygon (ArcGIS Toolbox > Conversion Tools.tbx > From Raster > Raster to Polygon). Notice that the Simplify polygon box is unchecked. The output name is **RasterT_reclass1** (Figure 16).

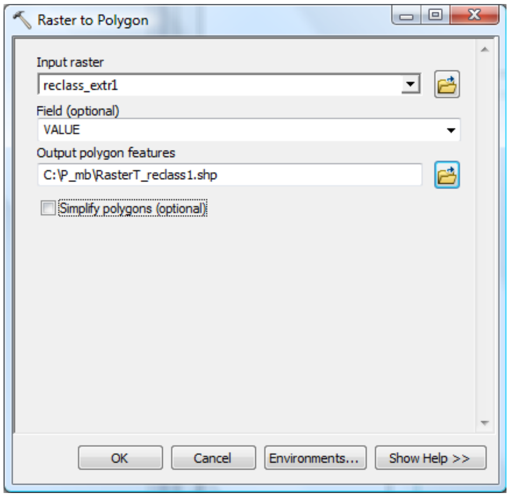


Figure 16. Raster to Polygon tool interface
(notice the Simplify polygon box is unchecked)

You will open the attribute table of land use layer (**RasterT_reclass1)** and add a new field (Name = **LandUse**; Type = Short Integer). Use Field Calculator to compute **LandUse** field values from **GRIDCODE** field values (Figure 17).

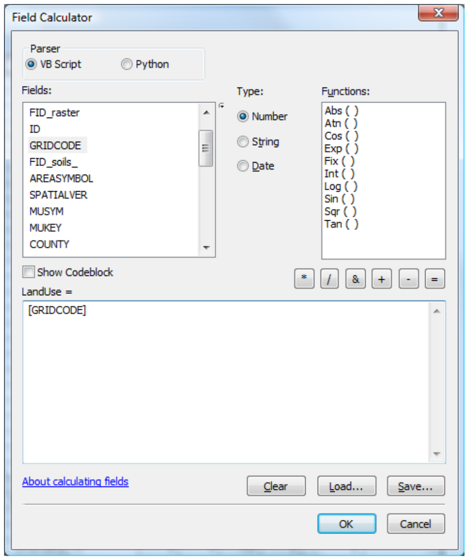


Figure 17. Calculation of Land Use values from GRIDCODE field.

Preparing Soil data

53. Open the attribute table of Soil data and add a new field named "SoilCode", Type = Text, Length = 5.
54. Right click the SoilCode field and click Field Calculator. Use Field Calculator and select HydrolGrp field name in the field calculator > OK (Figure 18).

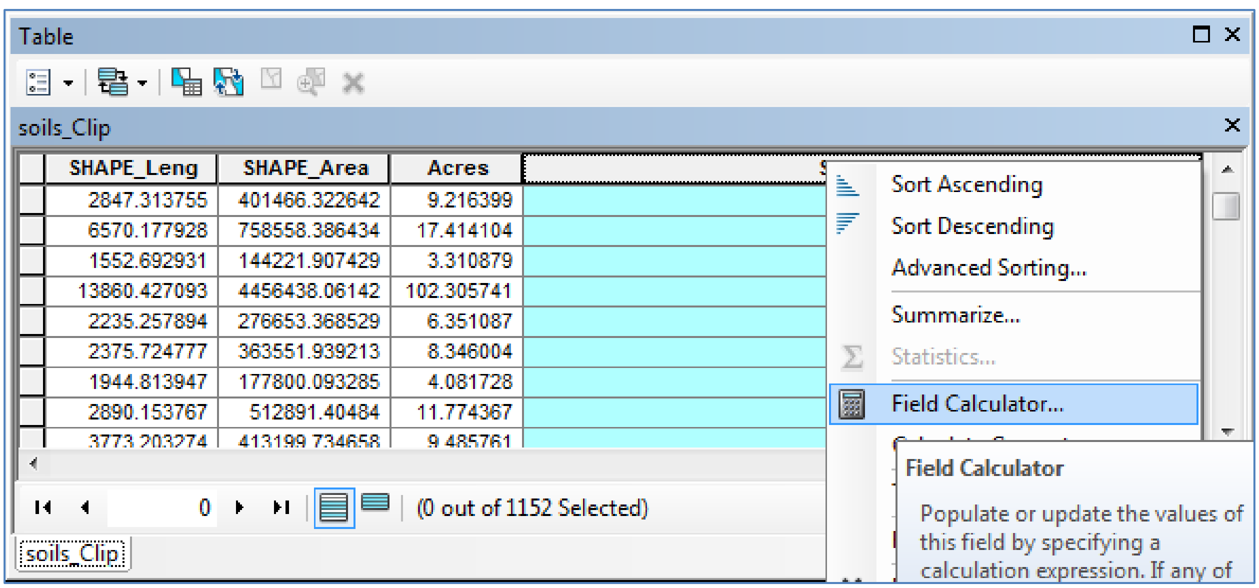


Figure 18. Soil layer attribute table with SoilCode field added to it.

When the Field Calculator window opens, double click **HydrolGrp** field. The window should now show that SoilCode = [HydrolGrp] (Figure 19).

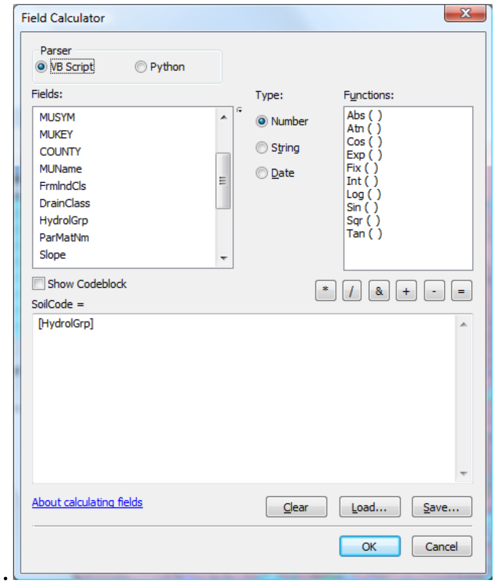


Figure 19. Field Calculator.

55. Hit OK. You will notice that some values in the new field are missing. This is because HydrolGrp field did not have any either. Therefore, you will use the DrainClass field to determine which class corresponds to each description. For example “Very poorly drained” would correspond to D, well drained to B, Excessively drained to A and poorly drained to C (Table 2).

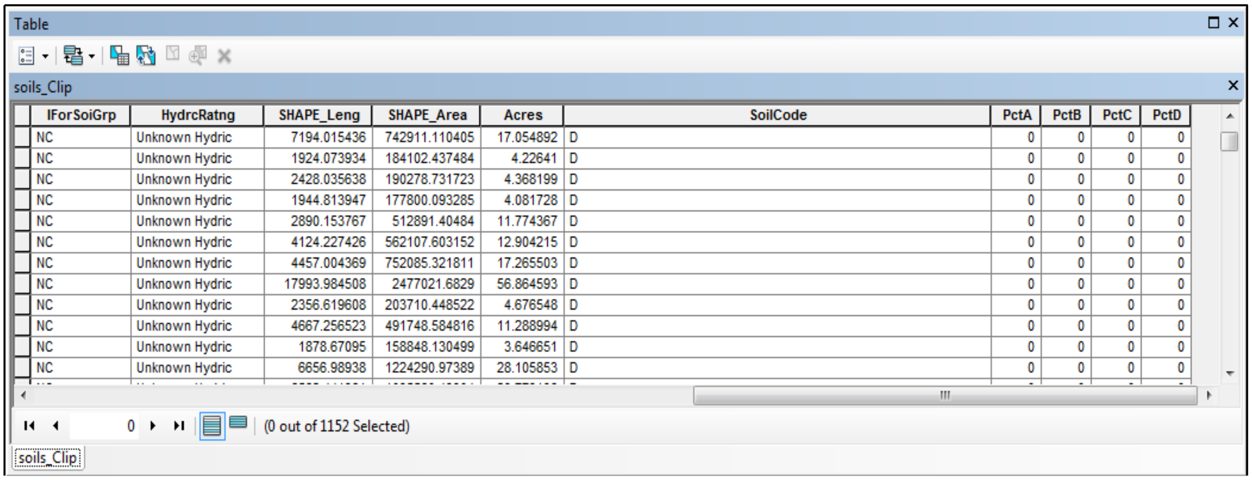
Table 2. Soil code based on soil drainage characteristics.

Soil Description	Soil Code
Excessively drained	A
Well drained	B
Poorly drained	C
Very poorly drained (including water)	D
No description	C

56. Select records that correspond to Very poorly drained of the DrainClass field > Right click SoilCode field to select Field Calculator > Type "D" under Soil Code = > OK.

Proceed with the rest of the classes. For those which do not have any description, you should refer to MUName field to decide which group to assign every record. For our case, since the rest of records consists mostly of water, we will consider the soil to be very poorly drained (D category).

57. Create four attribute fields with names "**PctA**", "**PctB**", "**PctC**" and "**PctD**". Data type is **short integer** for the four fields (Figure 20).



IForSoiGrp	HydrcRatng	SHAPE_Leng	SHAPE_Area	Acres	SoilCode	PctA	PctB	PctC	PctD
NC	Unknown Hydric	7194.015436	742911.110405	17.054892	D	0	0	0	0
NC	Unknown Hydric	1924.073934	184102.437484	4.22641	D	0	0	0	0
NC	Unknown Hydric	2428.035638	190278.731723	4.368199	D	0	0	0	0
NC	Unknown Hydric	1944.813947	177800.093285	4.081728	D	0	0	0	0
NC	Unknown Hydric	2890.153767	512891.40484	11.774367	D	0	0	0	0
NC	Unknown Hydric	4124.227426	562107.603152	12.904215	D	0	0	0	0
NC	Unknown Hydric	4457.004369	752085.321811	17.265503	D	0	0	0	0
NC	Unknown Hydric	17993.984508	2477021.6829	56.864593	D	0	0	0	0
NC	Unknown Hydric	2356.619608	203710.448522	4.676548	D	0	0	0	0
NC	Unknown Hydric	4667.256523	491748.584816	11.288994	D	0	0	0	0
NC	Unknown Hydric	1878.67095	158848.130499	3.646651	D	0	0	0	0
NC	Unknown Hydric	6656.98938	1224290.97389	28.105853	D	0	0	0	0

Figure 20. Attribute table of soil_clip layer with new fields (SoilCode, PctA, PctB, PctC and PctD) added to it.

58. You will use the Select by Attributes (from the drop-down arrow of the top left corner of the table) to select Soil Code that corresponds to category A (Figure 21).

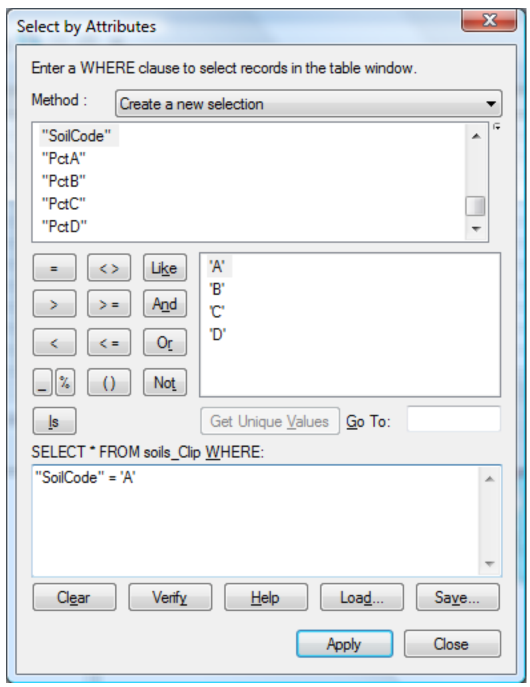


Figure 21. Selection by Attribute window.

59. Use Field Calculator to populate the Pct A field with the value of 100 leave a value of 0 for other fields, i.e. PctB, PctC, and PctD (e.g. Figure 22).

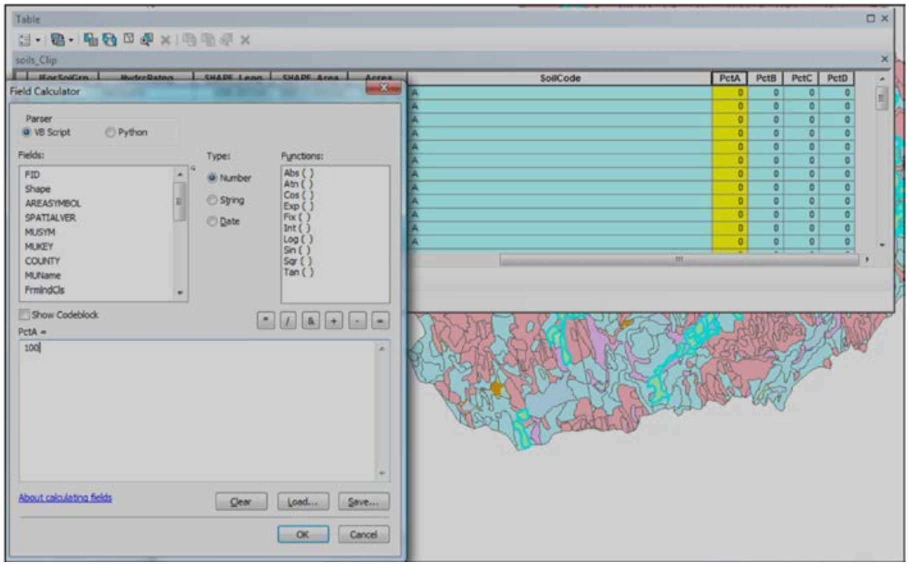
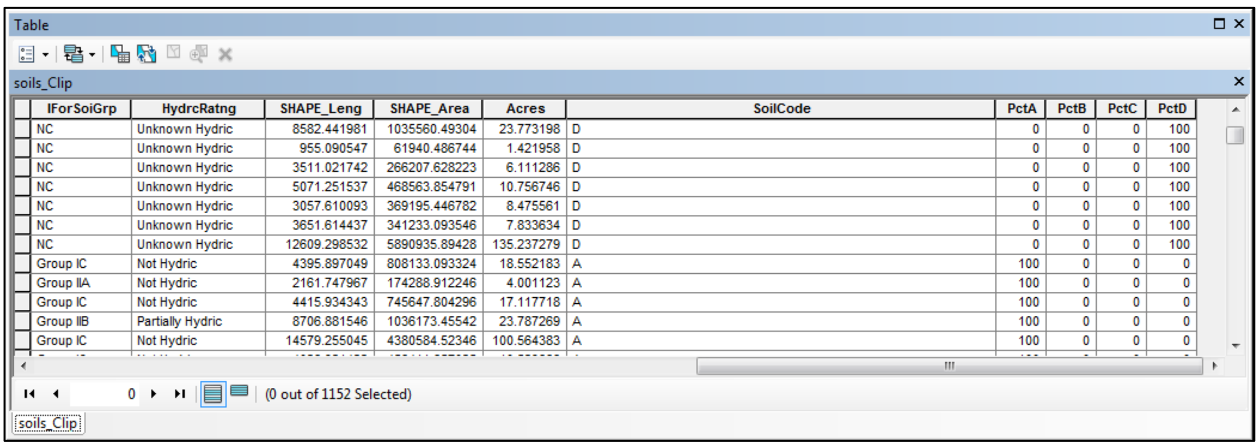


Figure 22. Example of the Use of Field Calculator for PctA field.

The resulting table should look like the example in Figure 23.



IForSoiGrp	HydrcRatng	SHAPE_Leng	SHAPE_Area	Acres	SoilCode	PctA	PctB	PctC	PctD
NC	Unknown Hydric	8582.441981	1035560.49304	23.773198	D	0	0	0	100
NC	Unknown Hydric	955.090547	61940.486744	1.421958	D	0	0	0	100
NC	Unknown Hydric	3511.021742	266207.628223	6.111286	D	0	0	0	100
NC	Unknown Hydric	5071.251537	468563.854791	10.756746	D	0	0	0	100
NC	Unknown Hydric	3057.610093	369195.446782	8.475561	D	0	0	0	100
NC	Unknown Hydric	3651.614437	341233.093546	7.833634	D	0	0	0	100
NC	Unknown Hydric	12609.298532	5890935.89428	135.237279	D	0	0	0	100
Group IC	Not Hydric	4395.897049	808133.093324	18.552183	A	100	0	0	0
Group IIA	Not Hydric	2161.747967	174288.912246	4.001123	A	100	0	0	0
Group IC	Not Hydric	4415.934343	745647.804296	17.117718	A	100	0	0	0
Group IIB	Partially Hydric	8706.881546	1036173.45542	23.787269	A	100	0	0	0
Group IC	Not Hydric	14579.255045	4380584.52346	100.564383	A	100	0	0	0

Figure 23. Fields **PctA**, **PctB**, **PctC**, **PctD** filled with value **100** in records corresponding to their soil hydrologic group depicted in SoilCode field.

Creating CN LookUp table

60. Create a **CnLookUp** table using **Create Table** tool (ArcToolBox > Data Management Tools.tbx > Table > Create Table). Table Location should be your project folder's geodatabase. Give the name "CnLookUp" to the table (Figure 24), then hit OK.

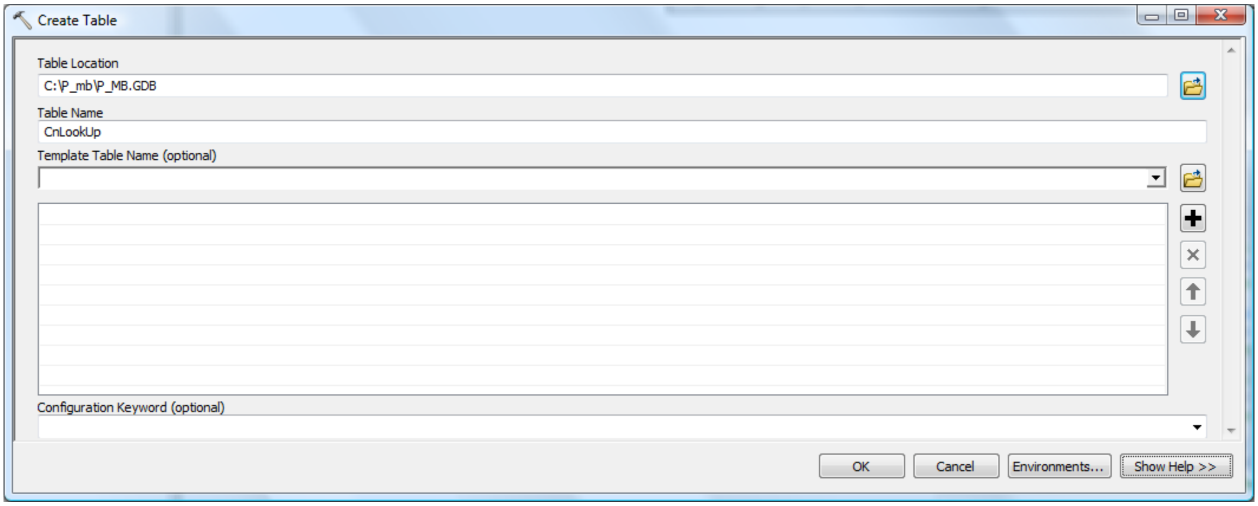


Figure 24. Create Table tool dialog window.

You should see the CnLookUp table you just created in the TOC (Table of Contents) under List By Source (Figure 25).

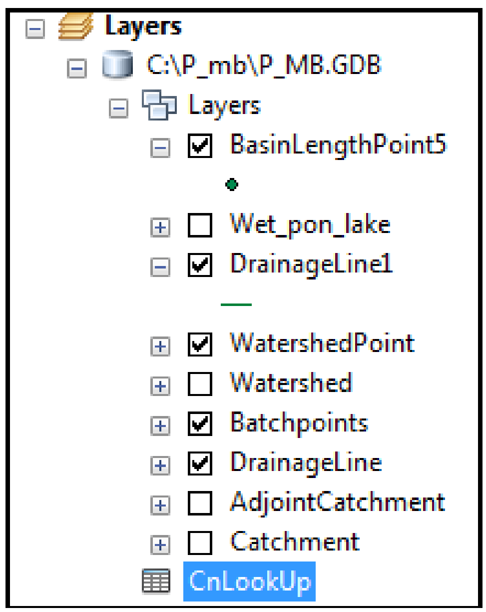


Figure 25. CnLookUp table created and added to the project database.

61. Right click the table > Open. Click the top left drop-down arrow and select Add Field (Field Name: **LUvalue**, Type: Short Integer, Allow Null Values: Yes). Add another field (Name: **Description**, Type: text, lenth: 30).

62. Add four more fields (Type = short integer) and name them "**A**", "**B**", "**C**", "**D**" respectively as illustrated in Figure 26.

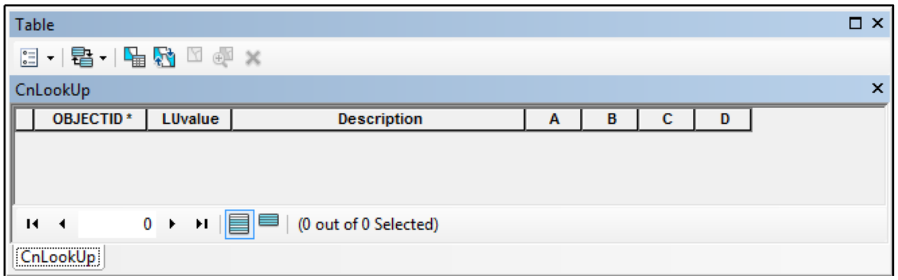
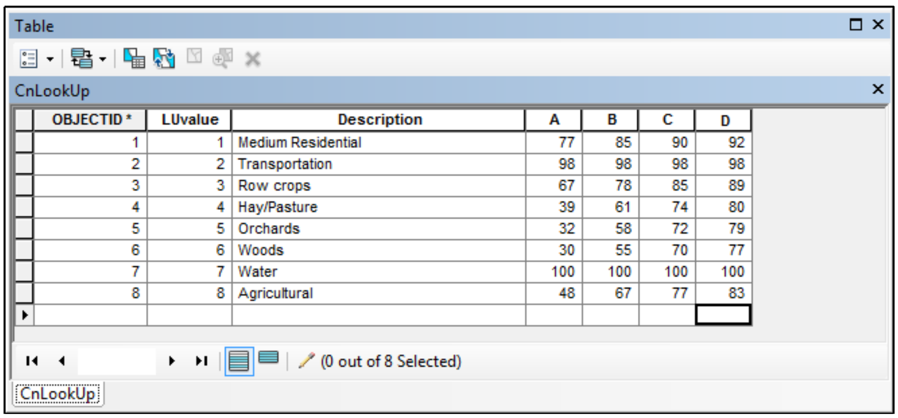


Figure 26. LuValue, Description, A, B, C and D new fields added to CnLookUp table.

63. Right click the table in the TOC, then click Edit Features > Start Editing. You will populate the table with CN values (Figure 27), then you will save edits before closing the editing session. These values have been retrieved from Soil Conservation Service (SCS) technical release 55 (Cronshey, 1986).



OBJECTID *	LUvalue	Description	A	B	C	D
1	1	Medium Residential	77	85	90	92
2	2	Transportation	98	98	98	98
3	3	Row crops	67	78	85	89
4	4	Hay/Pasture	39	61	74	80
5	5	Orchards	32	58	72	79
6	6	Woods	30	55	70	77
7	7	Water	100	100	100	100
8	8	Agricultural	48	67	77	83

Figure 27. CnLookUp table attribute values.

Union of Soil and Landuse Data

64. In this step, we will union Soil and Landuse Data using the Union tool (ArcToolbox > Analysis Tools > Overlay > Union). Name the output layer "**LC_Soils_Union**" (Figure 28).

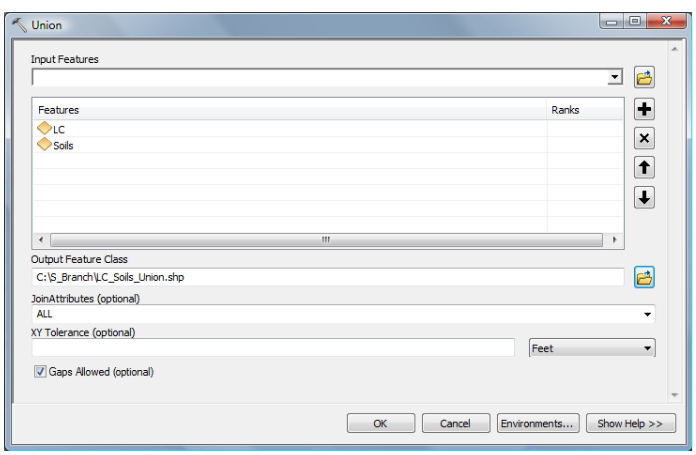


Figure 28. Dialogue window for the Union tool.

65. Open the attribute table of **LC_Soils_Union** layer and click the drop down arrow from top left corner of the attribute table > Click Select by Attributes. Set parameters as follows when a dialogue window opens (Figure 29).

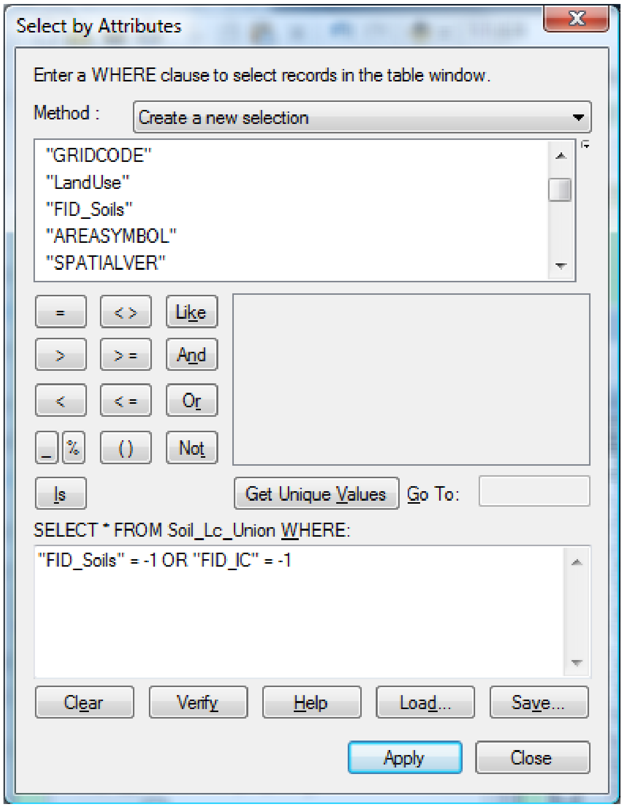


Figure 29. Select by Attribute dialogue window.

Now you have created a new layer that has both soil attributes and land use attributes. This layer is necessary for the computation of SCS runoff curve numbers (CN) which will be performed in the next step using the HEC-GeoHMS toolbar.

Creating CN Grid

66. Activate the HEC-GeoHMS extension toolbar by right clicking an empty space next to the main menu tool bar and checking the HEC-GeoHMS toolbar. The toolbar appears in ArcMap (Figure 30).

Figure 30. HEC-GeoHMS toolbar

67. You will now compute a CN Grid using Generate CN Grid tool (from the HEC-GeoHMS tool bar, click the drop-down arrow next to Utility > Click Generate CN Grid > OK).

Leave **fil** as default for Input Hydro DEM; set the Input soil Landuse Polygon to the new layer you created in steps 62 – 65; leave CNLookUp as default for Input Curve Number Lookup; Make sure the output corresponds to where you want it and leave CNGrid as default name for the output layer as shown (Figure 31).

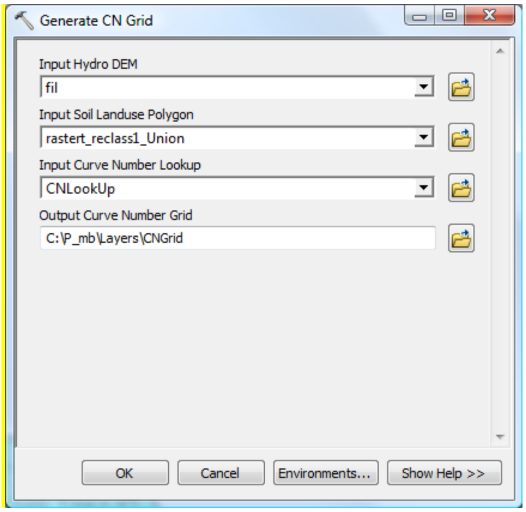


Figure 31. Interface for the Generate CN Grid tool.

The output from this step is a raster data that shows the distribution of CN values across the Middle Branch of the Piscataquog watershed.

68. In order to determine the average CN value for each of the watersheds, we will use the Zonal Statistics as Table tool (ArcToolBox > Spatial Analyst Tools.tbx > Zonal > Zonal Statistics asTable) (Figure 32).

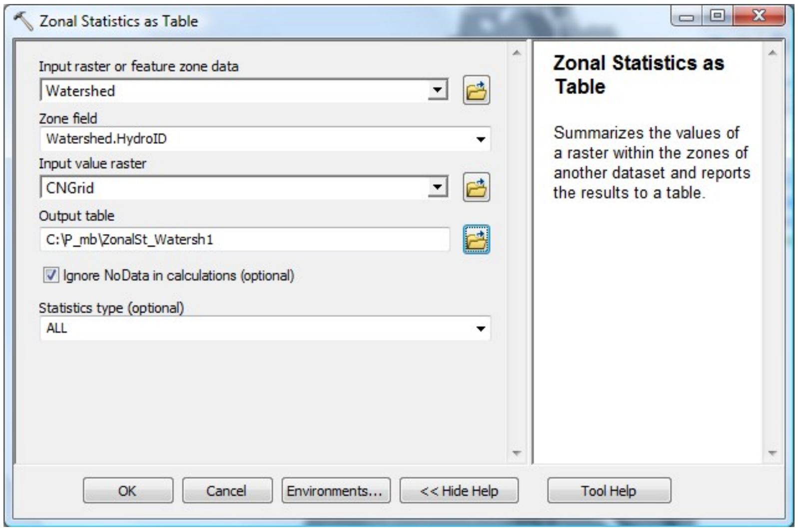


Figure 32. The interface of the Zonal Statistics as Table tool, with input parameters set.

The resulting table shows a field named "MEAN". This field stores averaged CN values for each watershed (Figure 33).

Table

ZonalSt_Watersh1

Rowid	HYDROID *	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	4623	111680	1202109	70	74	4	70.1	0.5	7826068
2	4625	3015146	32454630	30	100	70	68.6	9.5	206974400
3	4627	2867358	30863860	30	100	70	68.8	11.1	197229500
4	4629	2029801	21848510	70	98	28	72.6	6.8	147288000
5	4631	2342	25208.98	39	98	59	88.5	13.3	207365
6	4633	1150102	12379550	39	98	59	70.6	3.2	81223280
7	4635	2253340	24254650	55	100	45	68.9	7.5	155185600
8	4637	570683	6142756	70	98	28	70.6	3.2	40281510
9	4639	4160887	44787240	30	100	70	68.7	7.2	285944700

Figure 33. Table with averaged CN values for each watershed.

69. Join the new ZonalSt_Watershed1 to the Watershed layer using Join and Relates.
70. From the Watershed layer's attribute table, sort **MEAN** field by ascending order and then select records that have null values. Close the attribute table and run zonal statistics as table again. Merge the first and second ZonalSt_Watershed tables and join to the watershed layer. Continue this iterative process until you have calculated the average CN for the last record. (Tip: Every time before joining table, remove all joins and selections from Watershed layer).

71. Merge final ZonalSt_Watershed table to the second to last ZonalST_Watersed table generated in step 70 to make a final table named "**CN_Merge**" that shows mean runoff CN numbers for each watershed.

Precipitation Data

72. Add precipitation data you downloaded from http://www.prism.oregonstate.edu/normals/. Those are 2-10-25-50-100-year rainfall ascii files from Cornell (0.8 km resolution).

73. Convert ASCII data into raster format using ASCII to Raster tool (ArcToolBox > Conversion Tools.tbx > To Raster > ASCII to Raster) (Figure 34).

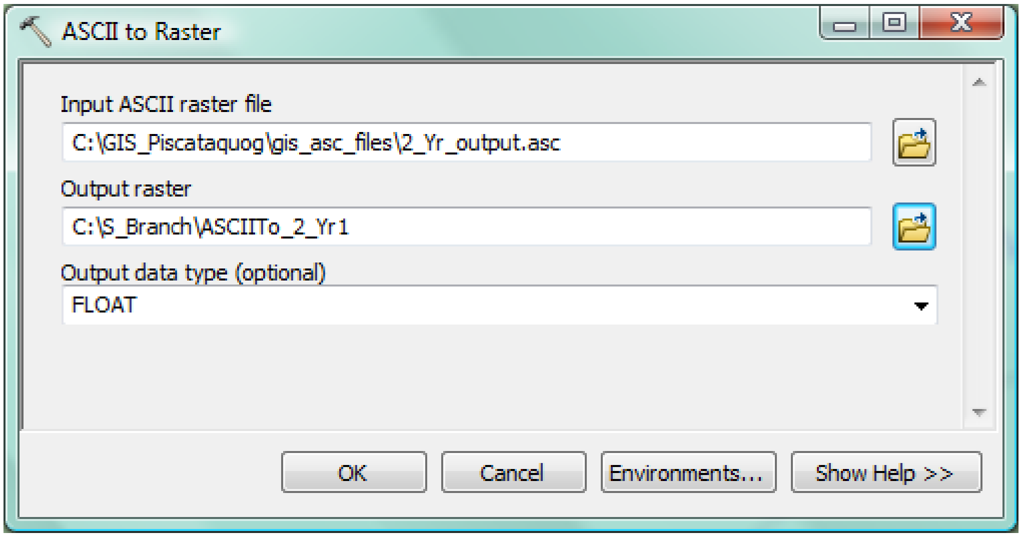


Figure 34. Interface for ascii to raster conversion tool.

74. Define the projection as WGS-72 using the Define Projection Tool (ArcToolBox > Data Management Tools.tbx > Projections and Transformations > Define Projection). For input data set, browse to add **ASCIITo_2_Yr1** layer > for coordinate system choose WGS 1972 (Figure 35).

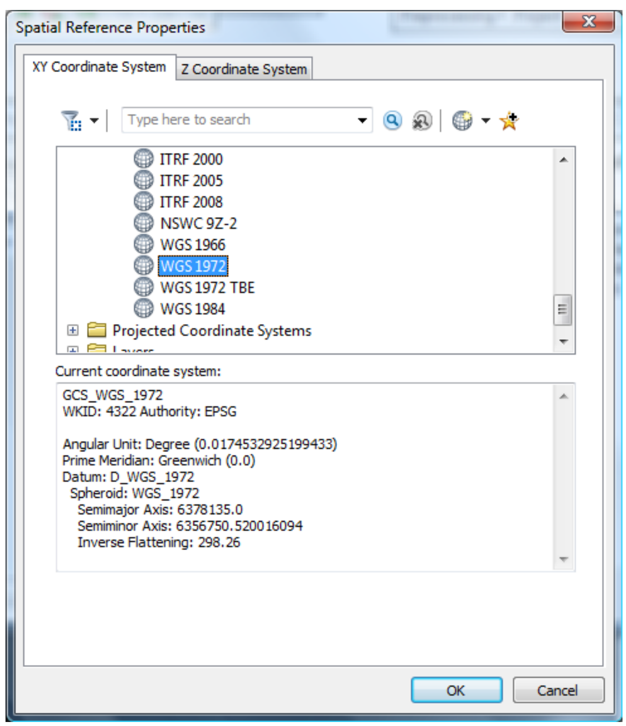


Figure 35. Spatial reference properties setting.

Project raster and choose **NAD_1983_StatePlane_New_Hampshire_FIPS_2800_Feet** for the output coordinate system and output name to be **prec_2yr**. This table name needs to be carried through the rest of this section to step 85.

To calculate the average precipitation (inches) for each watershed, you will use the Zonal Statistics as Table tool (ArcToolBox > Spatial Analyst Tools.tbx > Zonal > Zonal Statistics as Table) where the input raster of feature zone data is the watershed of interest, the zone field is the HydroID, the Input value raster is the precipitation raster data. The output table should be stored into the file geodatabase you created (for example it could be named ZonalSt_Water13 as in the tool dialogue below). For Statistics type, choose MEAN (Figure 36).

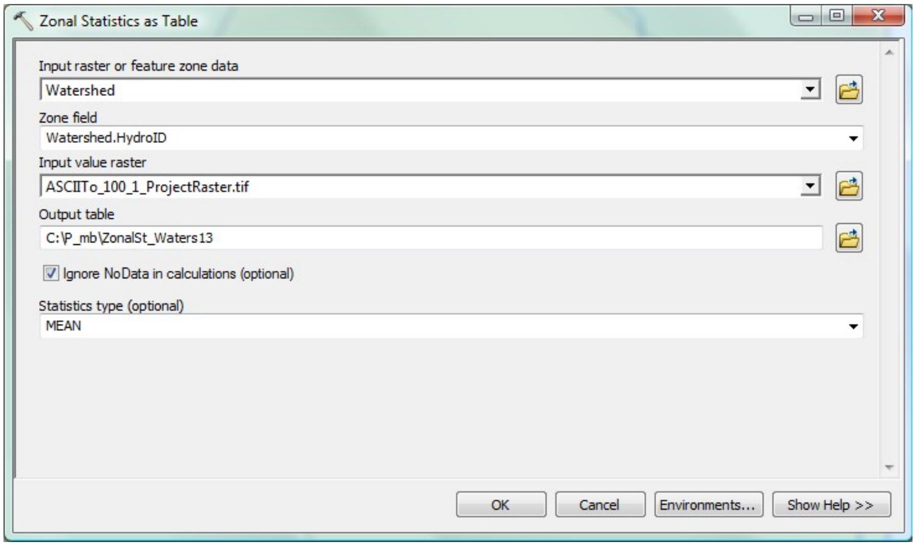


Figure 36. Zonal Statistics as Table tool dialogue window.

The Zonal Statistics as Table tool is used through iterations until mean precipitation is computed for all watersheds. Before each iteration, make sure all records for which mean precipitation has not been calculated yet are selected.

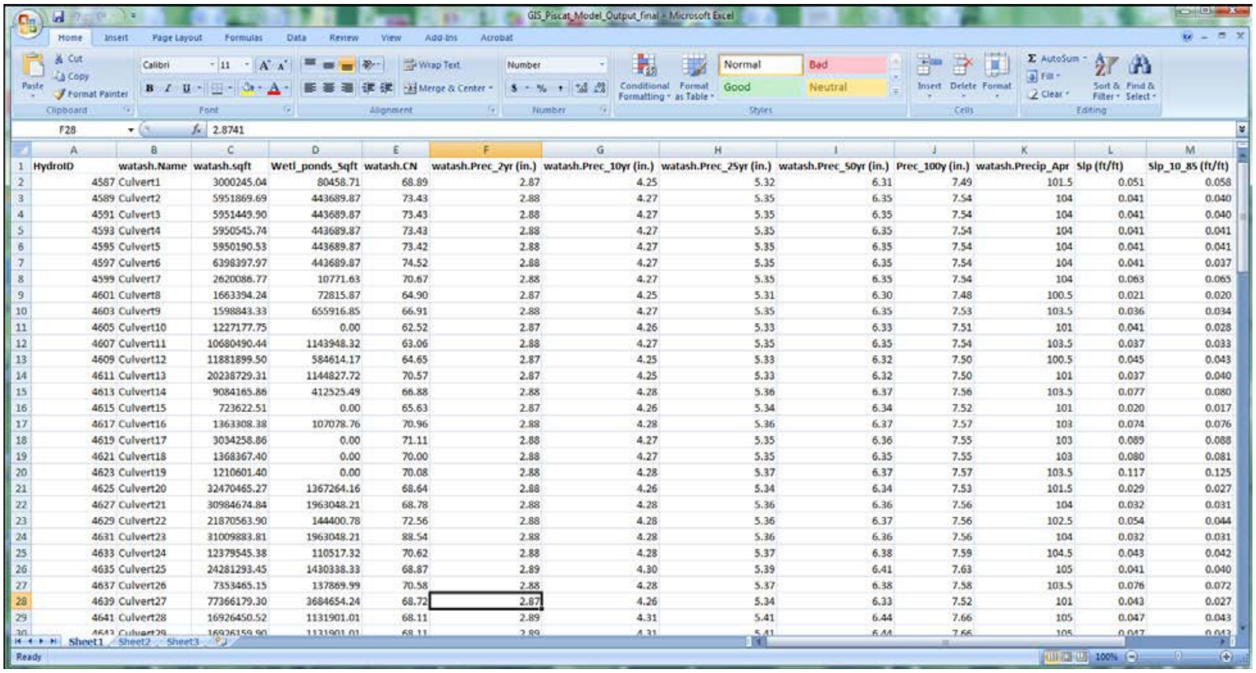
75. Join the table you just created to the watershed shapefile based on HydroID.
76. Open Watershed attribute table to sort Mean field by ascending field to select records for which Mean precipitation has not been calculated yet and run the Zonal Statistics as Table again.
77. Merge the first and the second mean precipitation tables, then join them to Watershed layer; sort mean field by ascending order and select null values to run the tool again.
78. Proceed with necessary iterations until you get to a point where you are prompted with an error message (**before you join the last table to the Watershed layer, always remember to merge that table with the newly merged one**). Open the attribute tables for both the Watershed Shapefile and the final merged table.
79. Sort the Watershed table on Mean to get the ones that are missing data on top.
80. Start editing the final merged table.
81. From the Watershed attribute table select, one at a time, each of the records missing their mean number and zoom to it.
82. Identify with the identify tool the watershed and precipitation raster to show the hydro ID and Pixel Value in the identify window.

83. On the final merged attribute table add a record and enter the Hydro ID into the Hydro id attribute and the Pixel Value into the Mean value.
84. Look at the Watershed attribute table and select the next record missing its mean number and zoom to it. Repeat steps 81– 83 until all records have a value in the mean attribute.
85. Save the Final merged table and stop editing.
86. Use the same process for ascii files of 2, 10, 25, 50 and 100 year storm events. When data processing is complete, all the tables containing precipitation data for the 2, 10, 25, 50 and 100 year storm events should be joined in GIS to get the final output that is shown in Table 3. Once completed, you only have to export to CSV file once and pull them into excel. All precipitation values need to be divided by 1000 to get the actual values (in inches).
87. Add Mean April Precipitation you downloaded from http://www.prism.oregonstate.edu/normals/ into ArcMap and process the data the same way you processed the other precipitation data (from step 73 through 85). Remember, however, that data is in mm. You will need to convert millimeters into inches using the formula (1Millimeter = 0.0393701 Inch).

The final output should be comprised of the following results (Table 3) and exported in Excel format for input into the model (Figure 37).

Table 3. Final output to be exported in Excel format.

GIS Output	**Units**	**When generated (step #)**
Watersheds area	ft^2	32
24 hour Precipitation, 2-yr	in	86
24 hour Precipitation, 10-yr	in	86
24 hour Precipitation, 25-yr	in	86
24 hour Precipitation, 50-yr	in	86
24 hour Precipitation, 100-yr	in	86
Mean April Precipitation	in	87
Area of Wetlands / Ponds	ft^2	48
Watershed Length, Flow Path	ft	41
Flow path slope	ft/ft	41
Flow path slope 1085 Method	ft/ft	41
SCS Runoff Curve Numbers (CN)		71



	HydroID	watash.Name	watash.sqft	Wetl_ponds_Sqft	watash.CN	watash.Prec_2yr (in.)	watash.Prec_10yr (in.)	watash.Prec_25yr (in.)	watash.Prec_50yr (in.)	Prec_100y (in.)	watash.Precip_Apr	Slp (ft/ft)	Slp_10_85 (ft/ft)
2	4587	Culvert1	3000245.04	80458.71	68.89	2.87	4.25	5.32	6.31	7.49	101.5	0.051	0.058
3	4589	Culvert2	5951869.69	443689.87	73.43	2.88	4.27	5.35	6.35	7.54	104	0.041	0.040
4	4591	Culvert3	5951449.90	443689.87	73.43	2.88	4.27	5.35	6.35	7.54	104	0.041	0.040
5	4593	Culvert4	5950545.74	443689.87	73.43	2.88	4.27	5.35	6.35	7.54	104	0.041	0.041
6	4595	Culvert5	5950190.53	443689.87	73.42	2.88	4.27	5.35	6.35	7.54	104	0.041	0.041
7	4597	Culvert6	6398397.97	443689.87	74.52	2.88	4.27	5.35	6.35	7.54	104	0.041	0.037
8	4599	Culvert7	2620086.77	10771.63	70.67	2.88	4.27	5.35	6.35	7.54	104	0.063	0.065
9	4601	Culvert8	1663394.24	72815.87	64.90	2.87	4.25	5.31	6.30	7.48	100.5	0.021	0.020
10	4603	Culvert9	1598843.33	655916.85	66.91	2.88	4.27	5.35	6.35	7.53	103.5	0.036	0.034
11	4605	Culvert10	1227177.75	0.00	62.52	2.87	4.26	5.33	6.33	7.51	101	0.041	0.028
12	4607	Culvert11	10680490.44	1143948.32	63.06	2.88	4.27	5.35	6.35	7.54	103.5	0.037	0.033
13	4609	Culvert12	11881899.50	584614.17	64.65	2.87	4.25	5.33	6.32	7.50	100.5	0.045	0.043
14	4611	Culvert13	20238729.31	1144827.72	70.57	2.87	4.25	5.33	6.32	7.50	101	0.037	0.040
15	4613	Culvert14	9084165.86	412525.49	66.88	2.88	4.28	5.36	6.37	7.56	103.5	0.077	0.080
16	4615	Culvert15	723622.51	0.00	65.63	2.87	4.26	5.34	6.34	7.52	101	0.020	0.017
17	4617	Culvert16	1363308.38	107078.76	70.96	2.88	4.28	5.36	6.37	7.57	103	0.074	0.076
18	4619	Culvert17	3034258.86	0.00	71.11	2.88	4.27	5.35	6.36	7.55	103	0.089	0.088
19	4621	Culvert18	1368367.40	0.00	70.00	2.88	4.27	5.35	6.35	7.55	103	0.080	0.081
20	4623	Culvert19	1210601.40	0.00	70.08	2.88	4.28	5.37	6.37	7.57	103.5	0.117	0.125
21	4625	Culvert20	32470465.27	1367264.16	68.64	2.88	4.26	5.34	6.34	7.53	101.5	0.029	0.027
22	4627	Culvert21	30984674.84	1963048.21	68.78	2.88	4.28	5.36	6.36	7.56	104	0.032	0.031
23	4629	Culvert22	21870563.90	144400.78	72.56	2.88	4.28	5.36	6.37	7.56	102.5	0.054	0.044
24	4631	Culvert23	31009883.81	1963048.21	88.54	2.88	4.28	5.36	6.36	7.56	104	0.032	0.031
25	4633	Culvert24	12379545.38	110517.32	70.62	2.88	4.28	5.37	6.38	7.59	104.5	0.043	0.042
26	4635	Culvert25	24281293.45	1430338.33	68.87	2.89	4.30	5.39	6.41	7.63	105	0.041	0.040
27	4637	Culvert26	7353465.15	137869.99	70.58	2.88	4.28	5.37	6.38	7.58	103.5	0.076	0.072
28	4639	Culvert27	77366179.30	3684654.24	68.72	2.87	4.26	5.34	6.33	7.52	101	0.043	0.027
29	4641	Culvert28	16926450.52	1131901.01	68.11	2.89	4.31	5.41	6.44	7.66	105	0.047	0.043
30	4643	Culvert29	16926159.90	1131901.01	68.11	2.89	4.31	5.41	6.44	7.66	105	0.047	0.043

Figure 37. GIS Model output.

Literature cited:

Chow, V. T., Maidment, D. R., & Mays, L. W. (1988). *Applied hydrology*. Retrieved from http://documentatiecentrum.watlab.be/imis.php?module=ref&refid=127685&basketaction=add

Cronshey, R. (1986). *Urban hydrology for small watersheds. 2nd edition* (Technical Report). U.S. Dept. of Agriculture, Soil Conservation Service, Engineering Division. Retrieved from http://repositories.tdl.org/tamug-ir/handle/1969.3/24438

Slack, R. B., & Welch, R. (1980). Soil Conservation Service Runoff Curve Number Estimates from Landsat Data1. *JAWRA Journal of the American Water Resources Association*, *16*(5), 887–893.

Appendix 2

Instructions for Using Excel Model

Appendix 2

Instructions for Using the Excel Hydro Model

The Excel model is designed to be user-friendly. The goal of the model is to provide the user with estimates of how selected culverts will perform during storm events without the user having the engineering and mathematic experience needed to perform calculations. The results should be used as a preliminary analysis of culvert performances; it is recommended that this information not be used for final design.

The model has four tabs visible to the user: *Instructions*, *GIS Input*, *User Input*, and *Results*. These four tabs contain all the information and data entry locations that are required to run the analysis. There are additional hidden tabs that contain equations and lookup tables. The four visible tabs, and instructions on how to use them, are described below.

In order to run and obtain results from the model, two types of input data are required: 1) hydrology input data (refer to the GIS portion of the report); and 2) hydraulic input data (i.e. the field-collected culvert data).

I. Instructions

The first tab contains an introduction to the project, a legal disclaimer, an explanation regarding the limitations of the model and methods, instructions, and some quick navigation buttons. All of this information should be reviewed and thoroughly understood before entering any data or running the model. The information contained on this sheet has implications as to the effectiveness of the model. When all of this information has been read, proceed to the *GIS Input* tab.

II. Hydrology Input

The *GIS Input* tab houses information obtained from GIS or another source that is used to characterize the hydrologic portion of the analysis. This data can be imported from file created in GIS or entered manually.

To import the data from a GIS file, it is important to have the correct format. The first row in the file should have the following data headers for the column: Column A is the *Culvert ID*; Column B is the *Latitude*; Column C is the *Longitude*; Column D is *Notes*; Column E is the *Drainage Area*; Columns G, H, I, J, and K are all *the 24-hour Storm Precipitation Depths for the 2-, 10-, 25-, 50-, and 100-yr storms*, respectively; Column L is the *Average April Precipitation*, Column M is the *Watershed Slope*, Column N is the *Area of Ponds and Wetlands*, and finally Column O is the *Watershed Length*. See the included Example *GIS Output* data file for reference.

If there are multiple scenarios to be analyzed, it may be easiest to have separate folders for each scenario, with each folder containing its own model file and *GIS Input* file.

Upon completion of GIS applications and creation of the spreadsheet, click on the *Import Data from File* button. This data may be edited by clicking the *Edit Imported Data* button.

If the user would like to insert the data manually, just click the *Insert Data Manually* button and enter the respective information.

If the values for *Mean April Precipitation*, *Watershed Slope*, or *Area of Wetlands and Ponds* are outside of the recommended ranges of values for the calculations, they will display in *orange and italics text*. As such, all the calculations will still be performed but note that the calculated results should not be used as conclusive outcomes. When either of the two options to enter the data is completed, the tables in the next tabs will match the number of culverts being hydrologically modeled.

III. Hydraulic Input

The *User Input* tab is for entering the hydraulic field-collected data. The portion of the worksheet where data for each culvert is input begins at Column Q.

With the exception of the first value in the table (*Culvert Type Reference Number*, Column L), other required values are self-explanatory based on the Culvert Property needed. The *Culvert Type Reference Number* is a value that the program uses to assign the correct coefficients to the equations used in the calculations. These coefficients are given based on the culvert type, shape, material, inlet condition, and edge condition. As a check, the user can look below each column in the generated table and find the culvert shape, material, and end and edge type, as defined by the culvert type reference number entered.

Data Reference #9 and #10 are optional and they will be grayed out if they are not necessary or appear as the other cells for input information.

IV. Results

Upon completion of two input tabs, the outcome is generated and displayed in the *Results* tab. The selected return period may be changed by the user at the top- left corner of the sheet using the drop-down selection box. Table values will update when the return period is changed.

The first seven rows display calculated hydrology and existing culvert crossing properties. The resulting culvert rating will indicate *Pass*, *Transitional*, or *Fail*. Both the *Culvert ID* and the rating will show as green, yellow, or red, respectively.

The next three rows offer proposed geomorphic properties calculated for the crossing based on the peak flows. These were calculated using equations from the Regional Regression Equations or SCS methodology, depending on sub-watershed drainage area. The remaining eight rows show results for proposed rectangular and 25% embedded circular culverts that could potentially be required to pass the flows. To reiterate, the proposed culvert results are programmed calculations and should not be used for final design. The purpose of this screening level design information is to give the user an initial idea of what might be required in comparison to what currently exists on-site. Further design and engineering is recommended if replacement of a crossing is pursued.

Below the table of results, some statistics are included that show the total number of culverts that are passing, transitional, or failing, as well as the overall percentage of each. To the right of this, a pie chart can be found representing these statistics.

Appendix 3 & 4

Appendix 3: Individual town maps showing results for modeled 2 year storm event.

List of Town Maps

- Deering
- Dunbarton
- Francestown
- Goffstown
- Greenfield
- Lyndeborough
- New Boston
- Weare

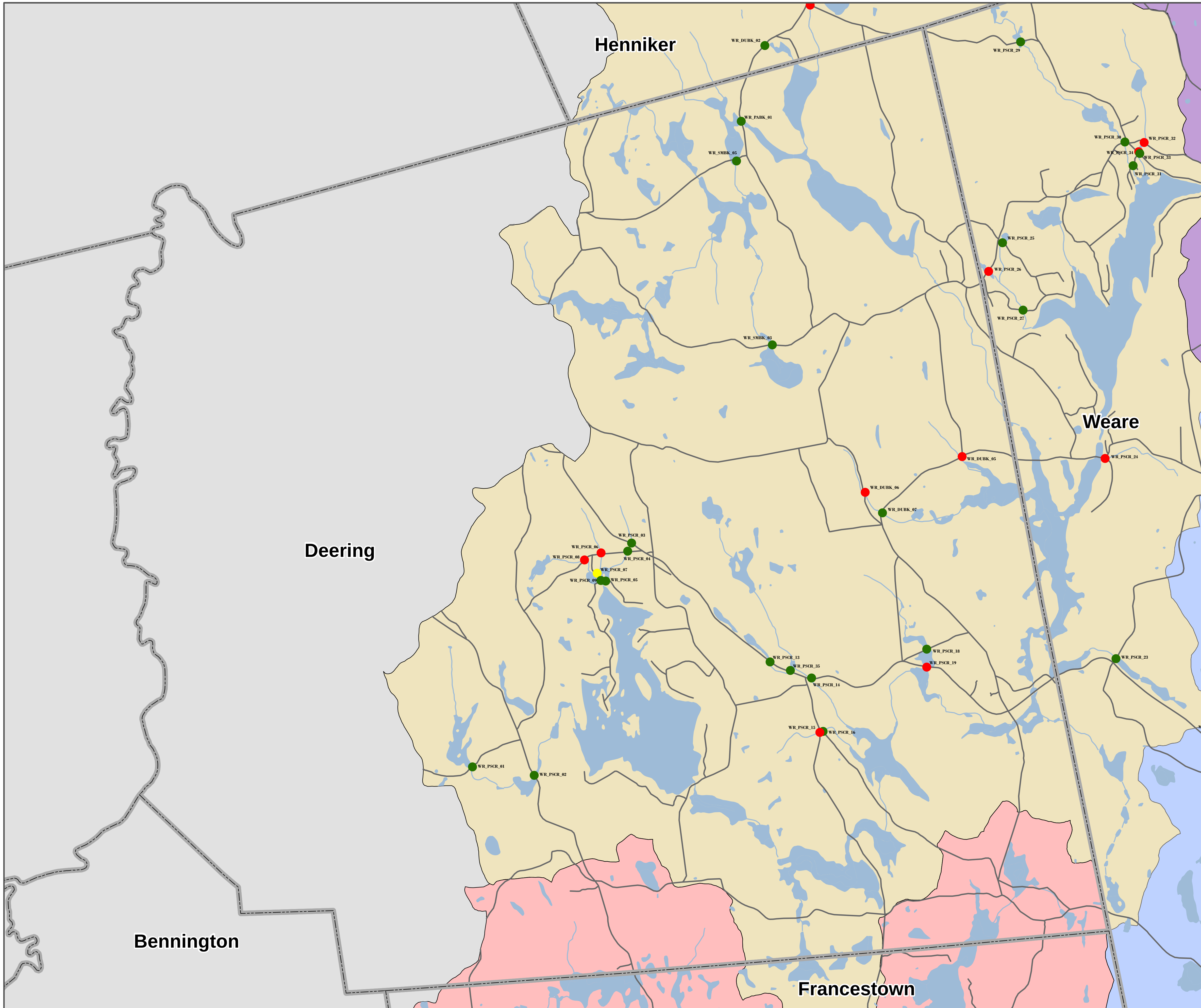
Appendix 4: Grid maps of individual towns showing results for the 10, 25, 50, & 100 year storm events.

Town	# of Maps
- Deering	5
- Dunbarton	4
- Francestown	7
- Goffstown	7
- Greenfield	1
- Lyndeborough	1
- New Boston	9
- Weare	12

(CD of maps available upon request from SNHPC)

Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event



Potential Status of Culvert at 2 Year Storm Event

- Pass
- Transitional
- Fail
- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

- Everett Lake
- Lower Piscataquog River
- Middle Branch Piscataquog River
- Rand Brook-South Branch
- South Branch Piscataquog River
- Upper Piscataquog River
- Weare Reservoir

Data Sources:
NH GRANIT Digital Data (1:24,000)
NH Department of Transportation
NH Department of Environmental Services
Trout Unlimited
Southern New Hampshire Planning Commission

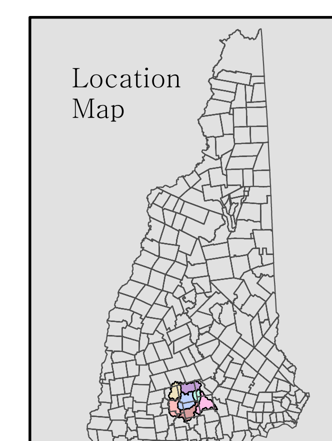
Map Produced by
GIS Service SNHPC 2014.
Contact: gis@snhpc.org
Ph: (603) 669-4664

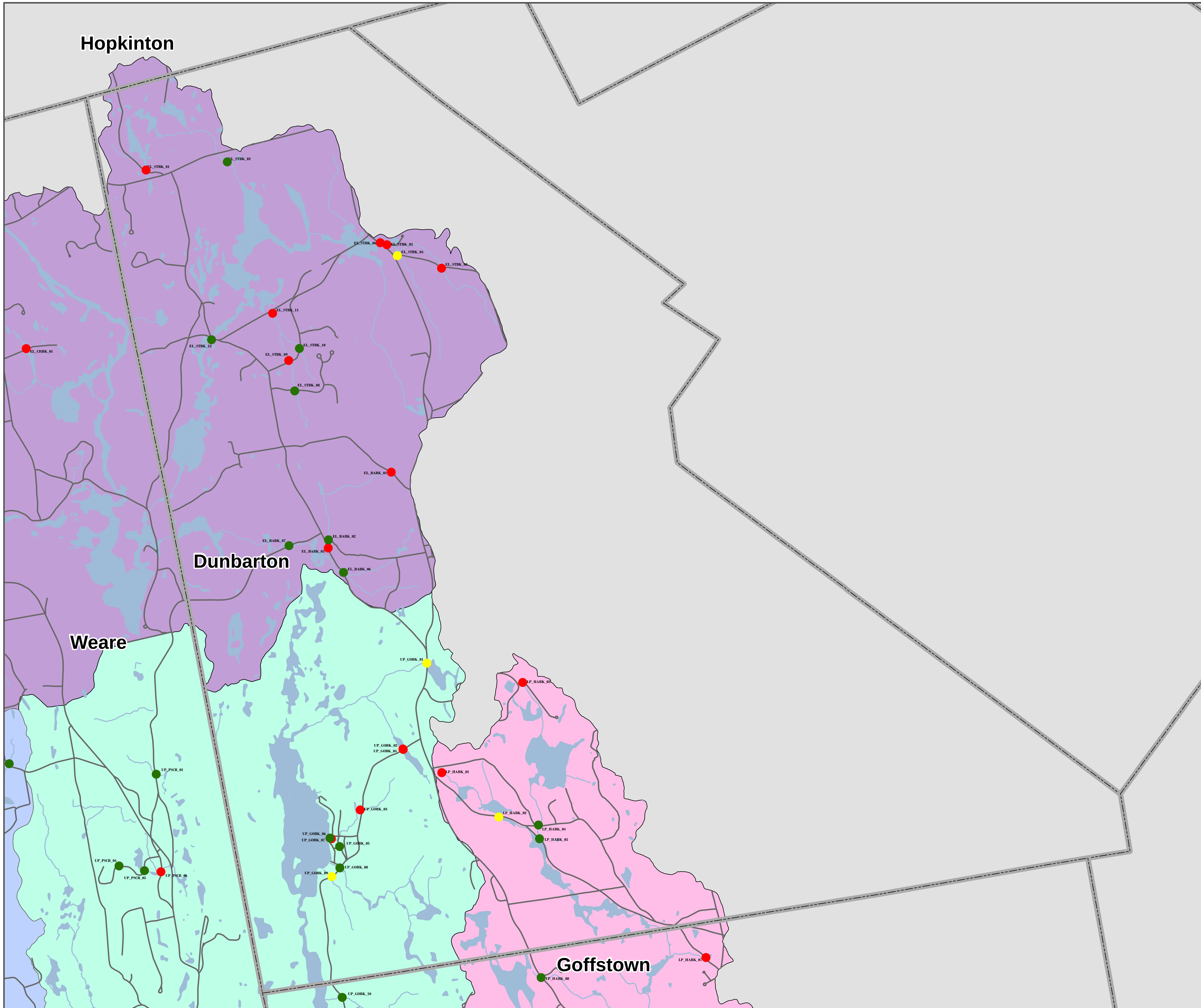
The individual municipalities represented on this map, Trout Unlimited, and the SNHPC make no representations or guaranties to the accuracy of the features and designations of this map.

This map is for planning purposes only. It is not to be used for legal boundary determinations or for regulatory purposes.

0 0.225 0.45 0.9 1.35 1.8 Miles

N W E S





Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event

Potential Status of Culvert at 2 Year Storm Event

- Pass
- Transitional
- Fail
- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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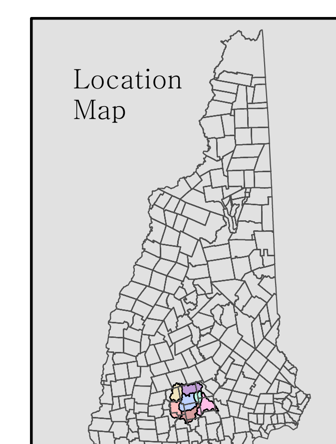
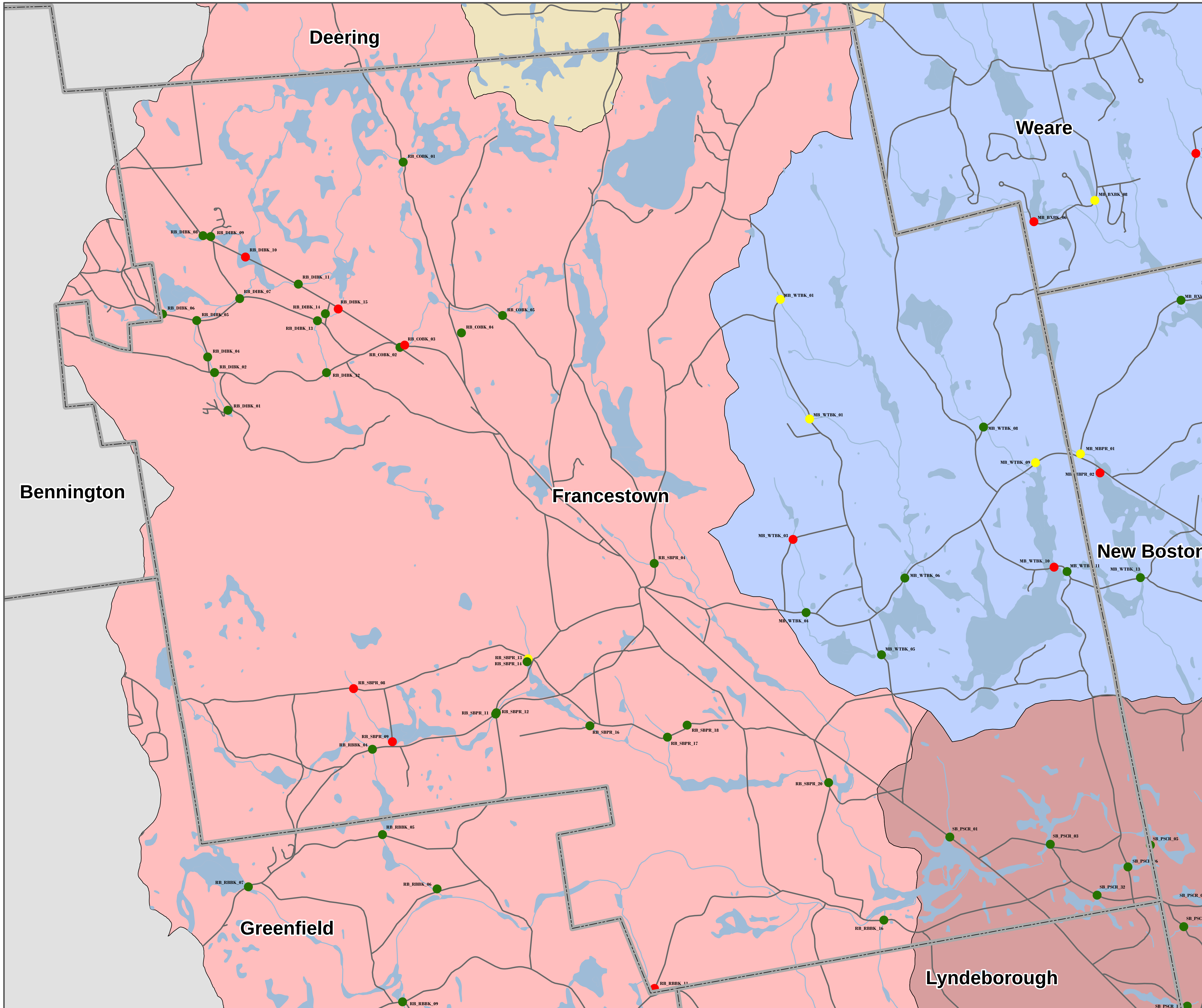
0 0.25 0.5 1 1.5 2 Miles

N S W E



Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event



Potential Status of Culvert at 2 Year Storm Event

- Pass
- Transitional
- Fail
- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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0 0.225 0.45 0.9 1.35 1.8 Miles

N W E S

Location Map

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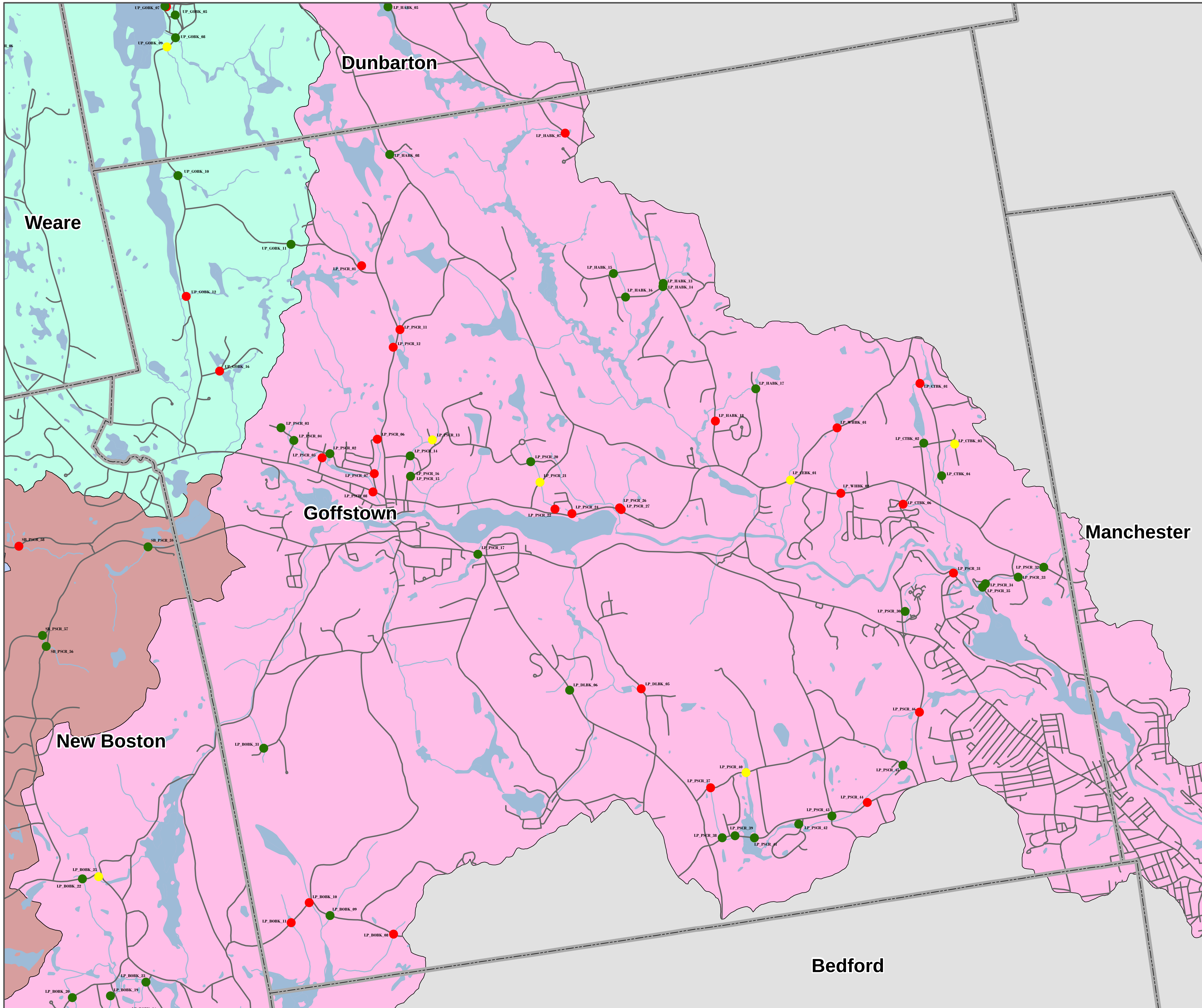
SNHPC

Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event



Potential Status of Culvert at 2 Year Storm Event

- Pass
- Transitional
- Fail
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- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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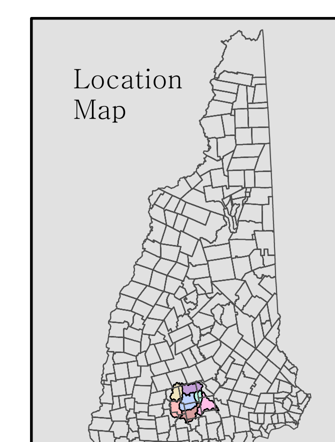
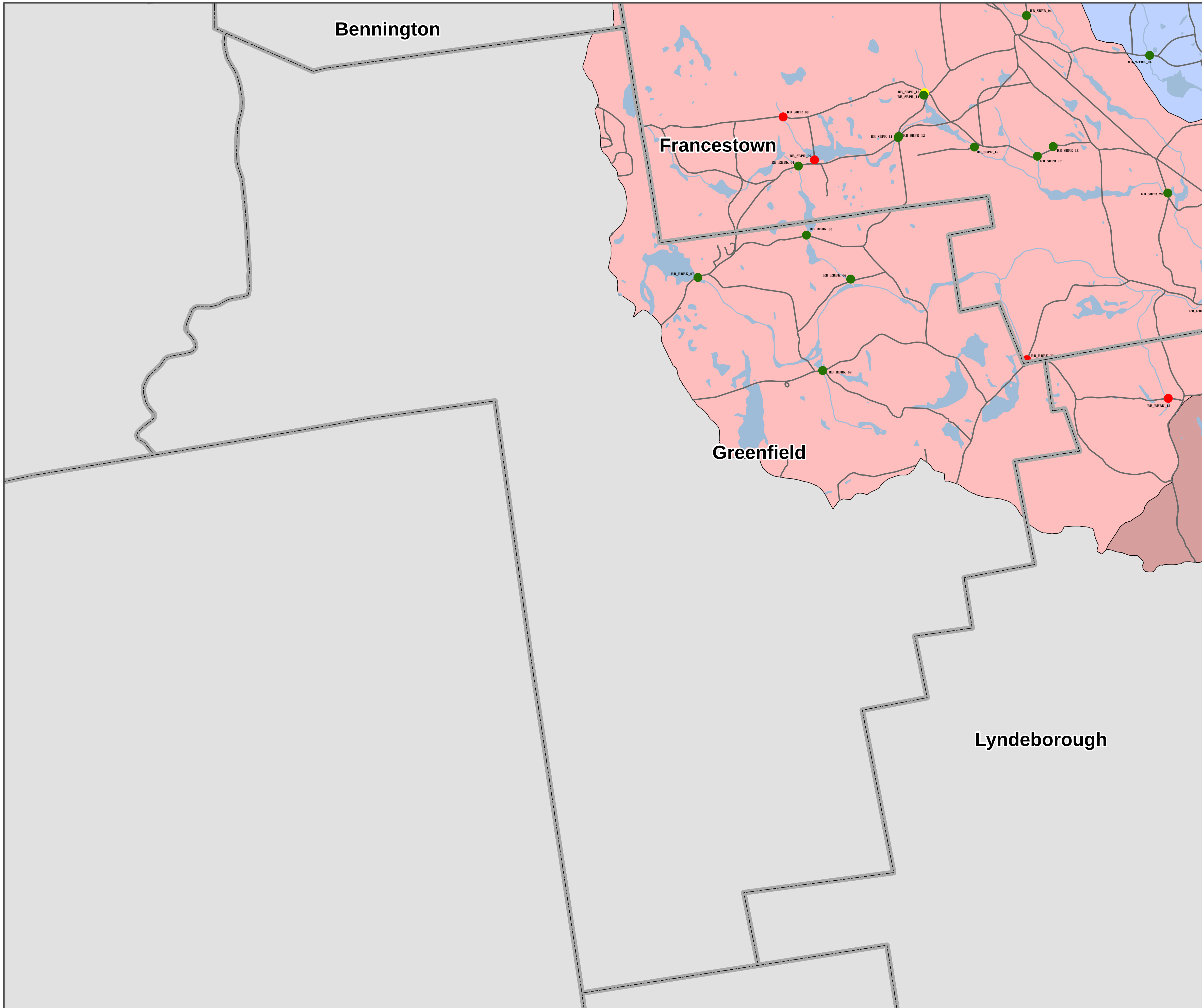
0 0.25 0.5 1 1.5 2 Miles



Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event



Potential Status of Culvert at 2 Year Storm Event

- Pass
- Transitional
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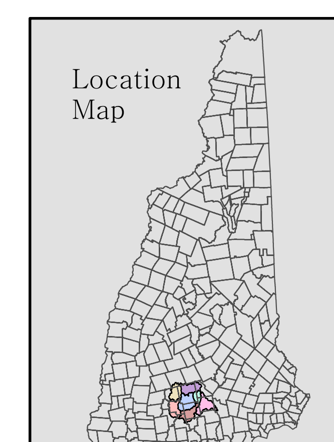
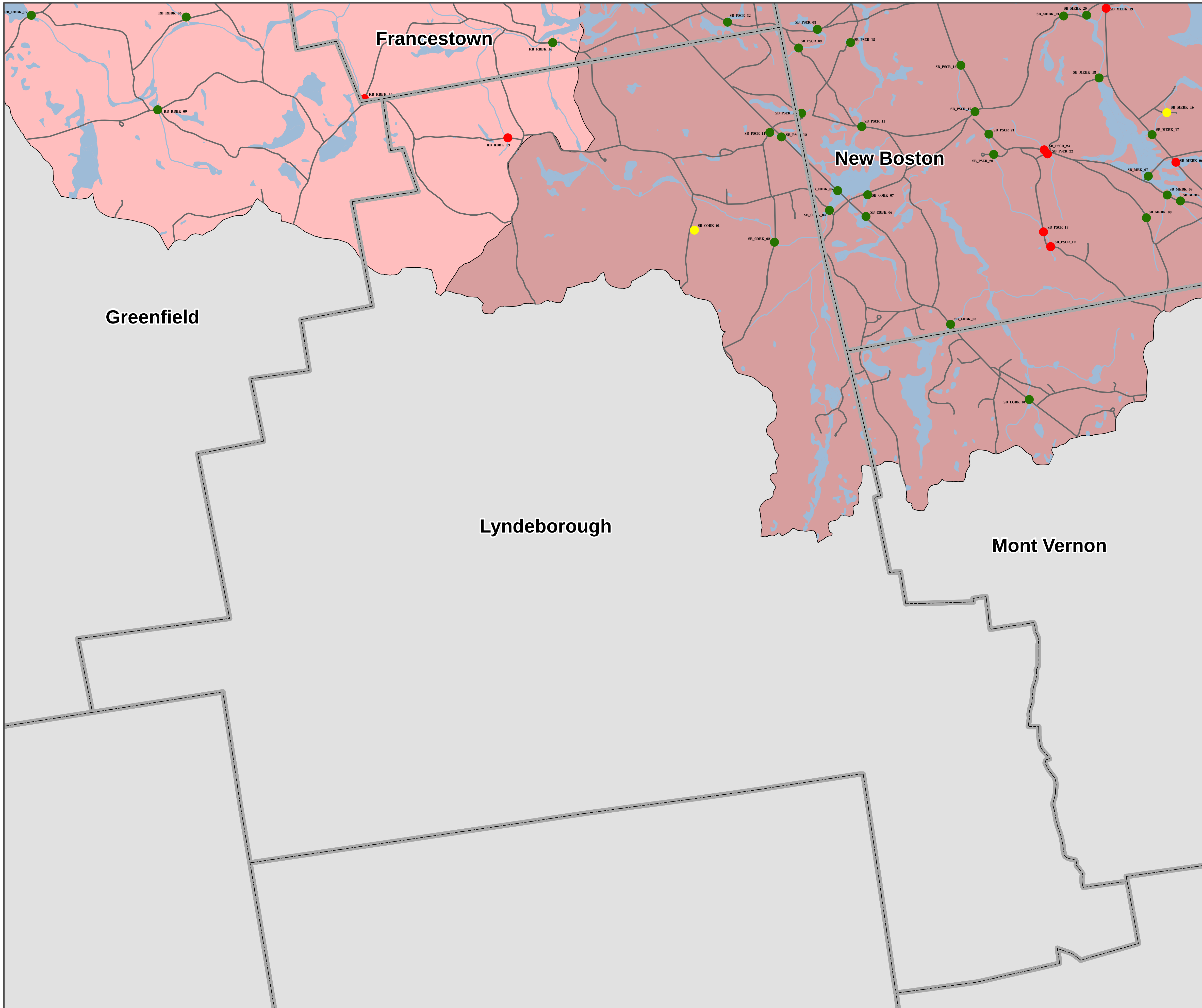
0 0.275 0.55 1.1 1.65 2.2 Miles

N W E S





Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event

Potential Status of Culvert at 2 Year Storm Event

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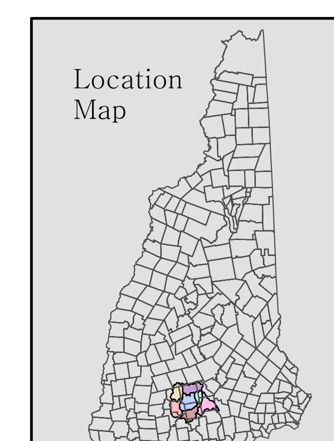
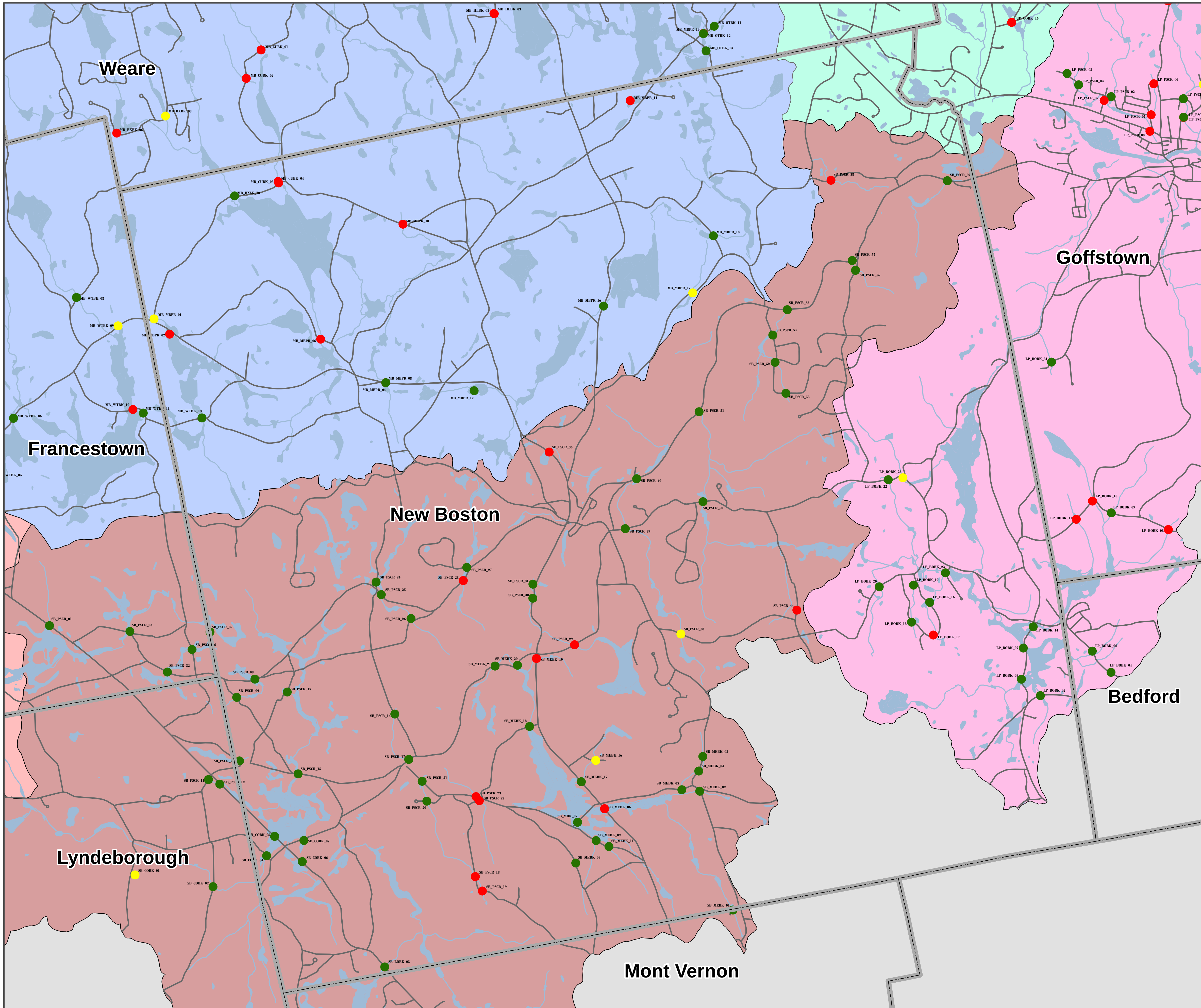
0 0.275 0.55 1.1 1.65 2.2 Miles

N W E S



TROUT UNLIMITED

SNHPC



Piscataquog River Hydrology Assessment 2014

Potential Status of Culvert at 2 Year Storm Event

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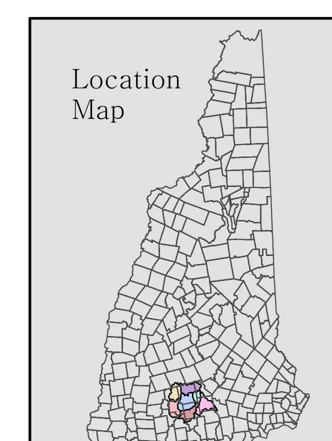
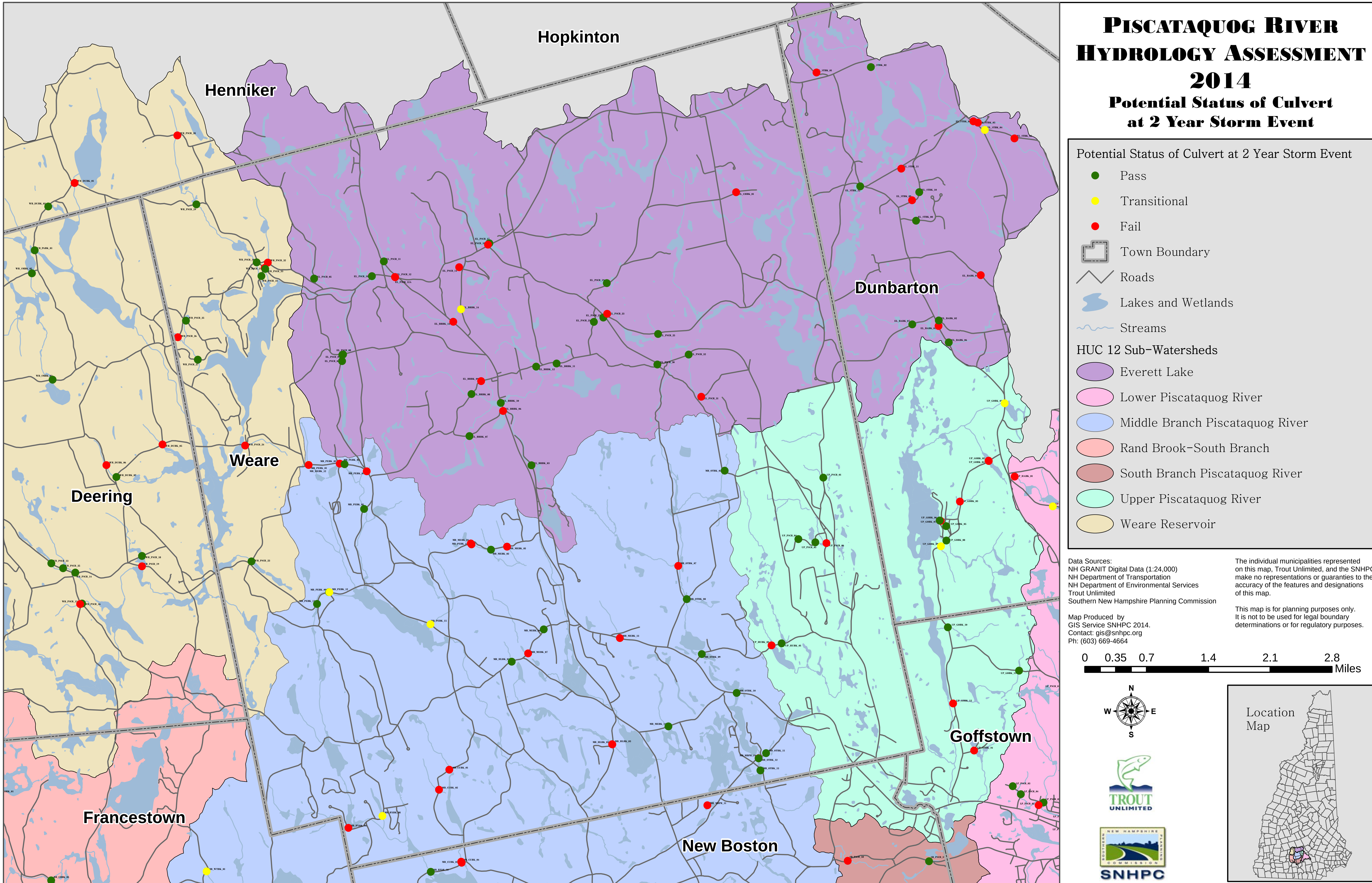
0 0.275 0.55 1.1 1.65 2.2 Miles

N W E S



TROUT UNLIMITED

SNHPC


PISCATAQUOG RIVER HYDROLOGY ASSESSMENT 2014
Potential Status of Culvert at 2 Year Storm Event
Potential Status of Culvert at 2 Year Storm Event
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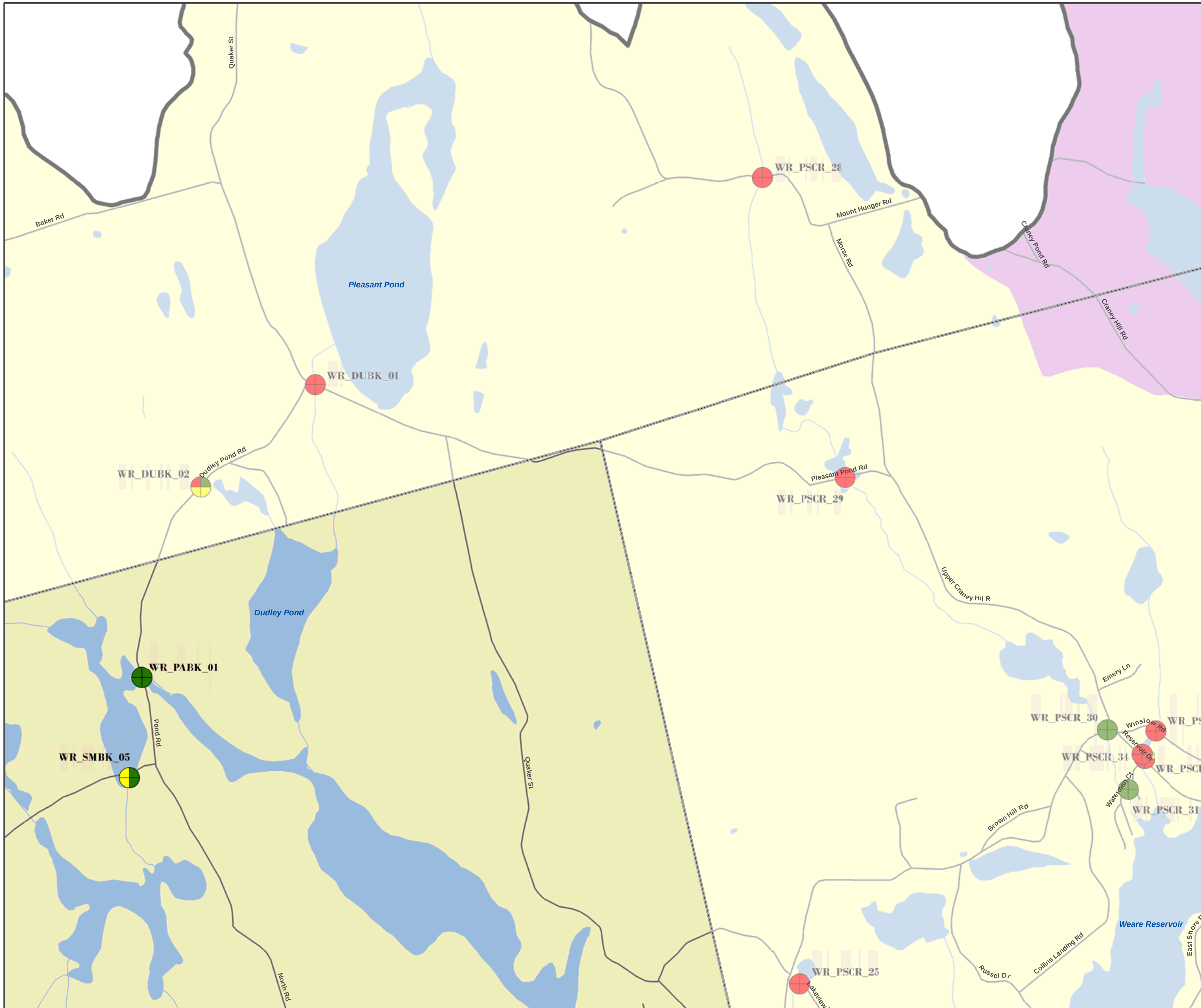
0 0.35 0.7 1.4 2.1 2.8 Miles
N
W E
S
Location Map
TROUT UNLIMITED
SNHPC
Hopkinton
Henniker
Dunbarton
Weare
Deering
Goffstown
Francestown
New Boston

Piscataquog River Hydrology Assessment 2014

Deering

Map 1 of 5



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year: 100 | 10 | 50 | 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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- Weare Reservoir

0 0.125 0.25 0.5 Miles

Data Sources:
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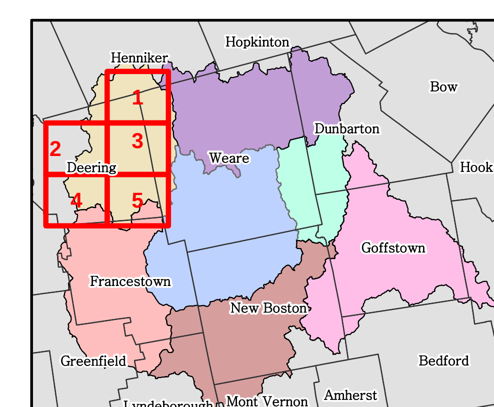
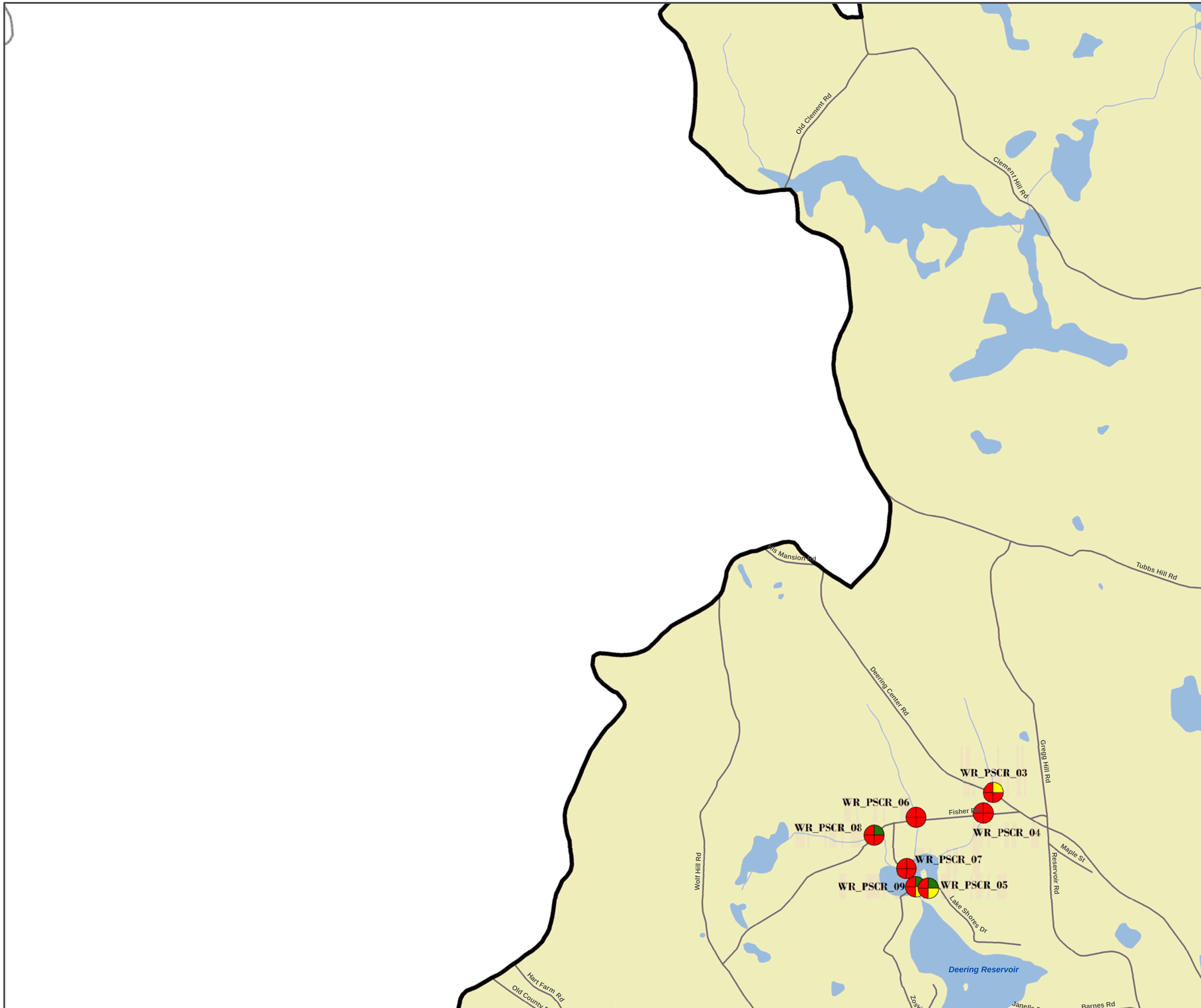


TROUT UNLIMITED

SNHPC



Piscataquog River Hydrology Assessment 2014

Deering

Map 2 of 5

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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- South Branch Piscataquog River
- Upper Piscataquog River
- Weare Reservoir

0 0.125 0.25 0.5 Miles

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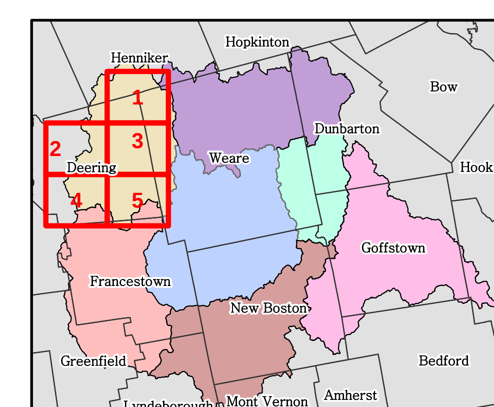
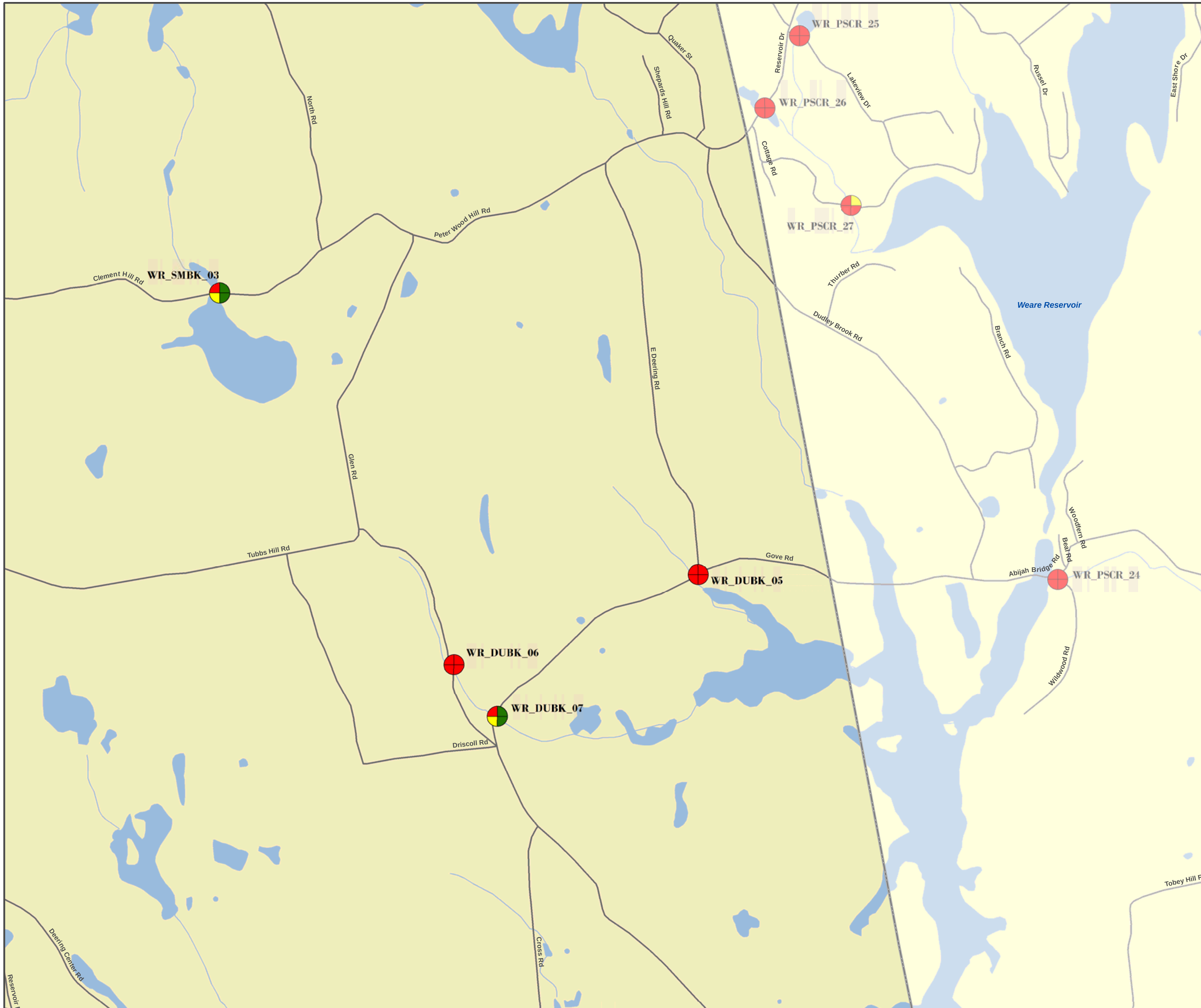


Piscataquog River Hydrology Assessment 2014

Deering

Map 3 of 5



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

- Everett Lake
- Lower Piscataquog River
- Middle Branch Piscataquog River
- Rand Brook-South Branch
- South Branch Piscataquog River
- Upper Piscataquog River
- Weare Reservoir

0 0.125 0.25 0.5 Miles

Data Sources:
NH GRANIT Digital Data (1:24,000)
NH Department of Transportation
NH Department of Environmental Services
Trout Unlimited
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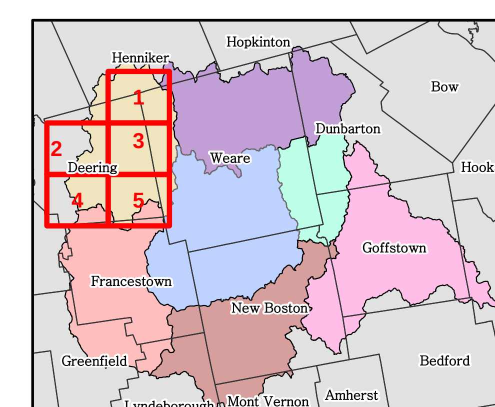

TROUT UNLIMITED

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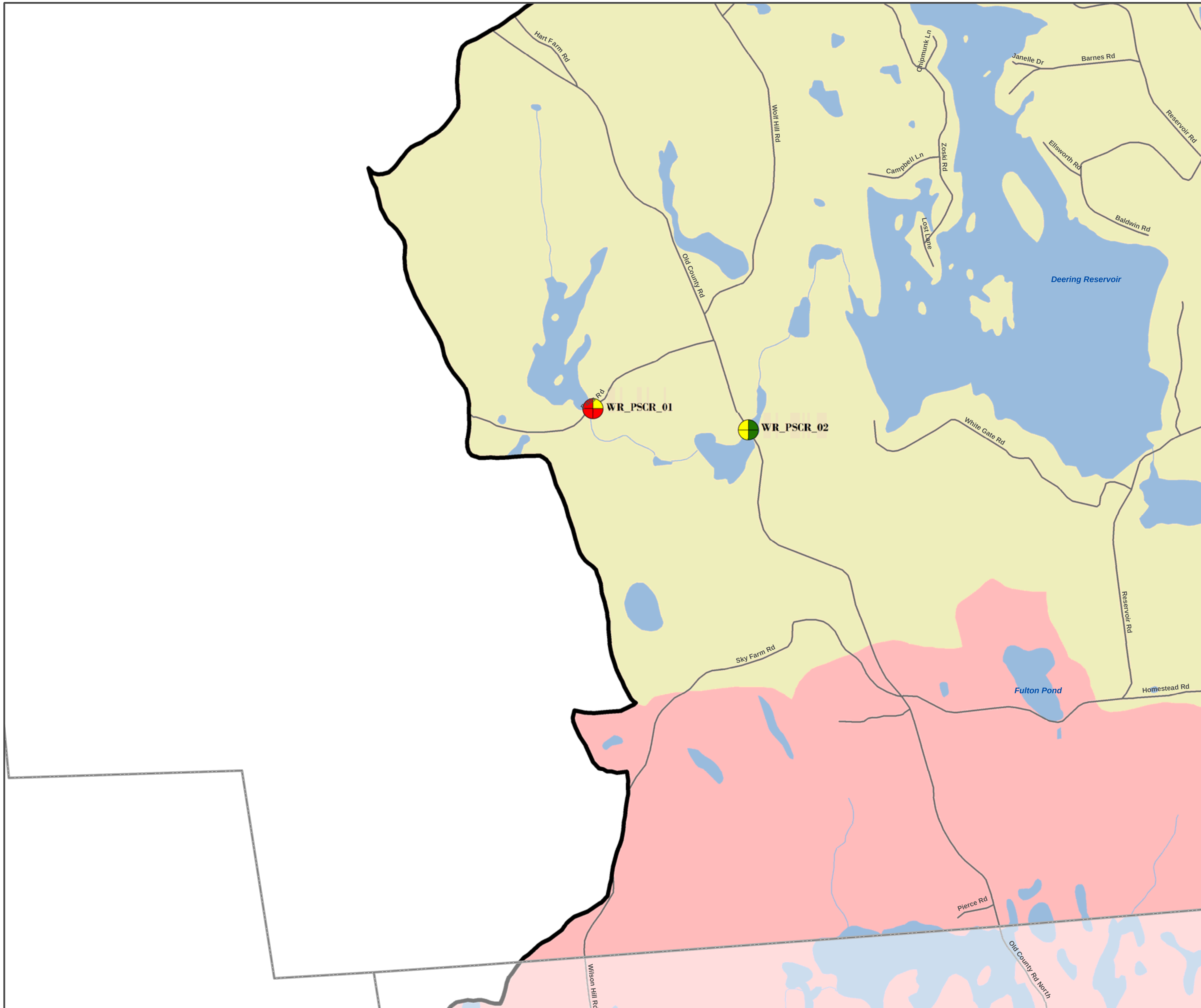
Piscataquog River Hydrology Assessment 2014

Deering

Map 4 of 5



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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0 0.125 0.25 0.5 Miles

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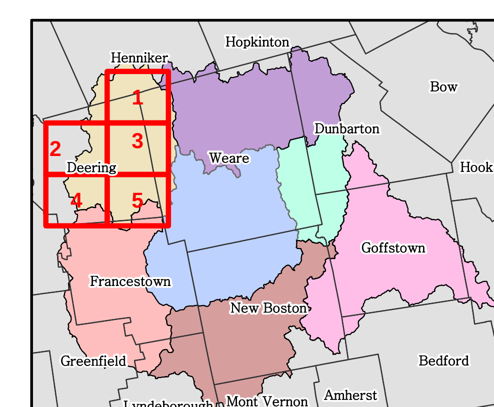
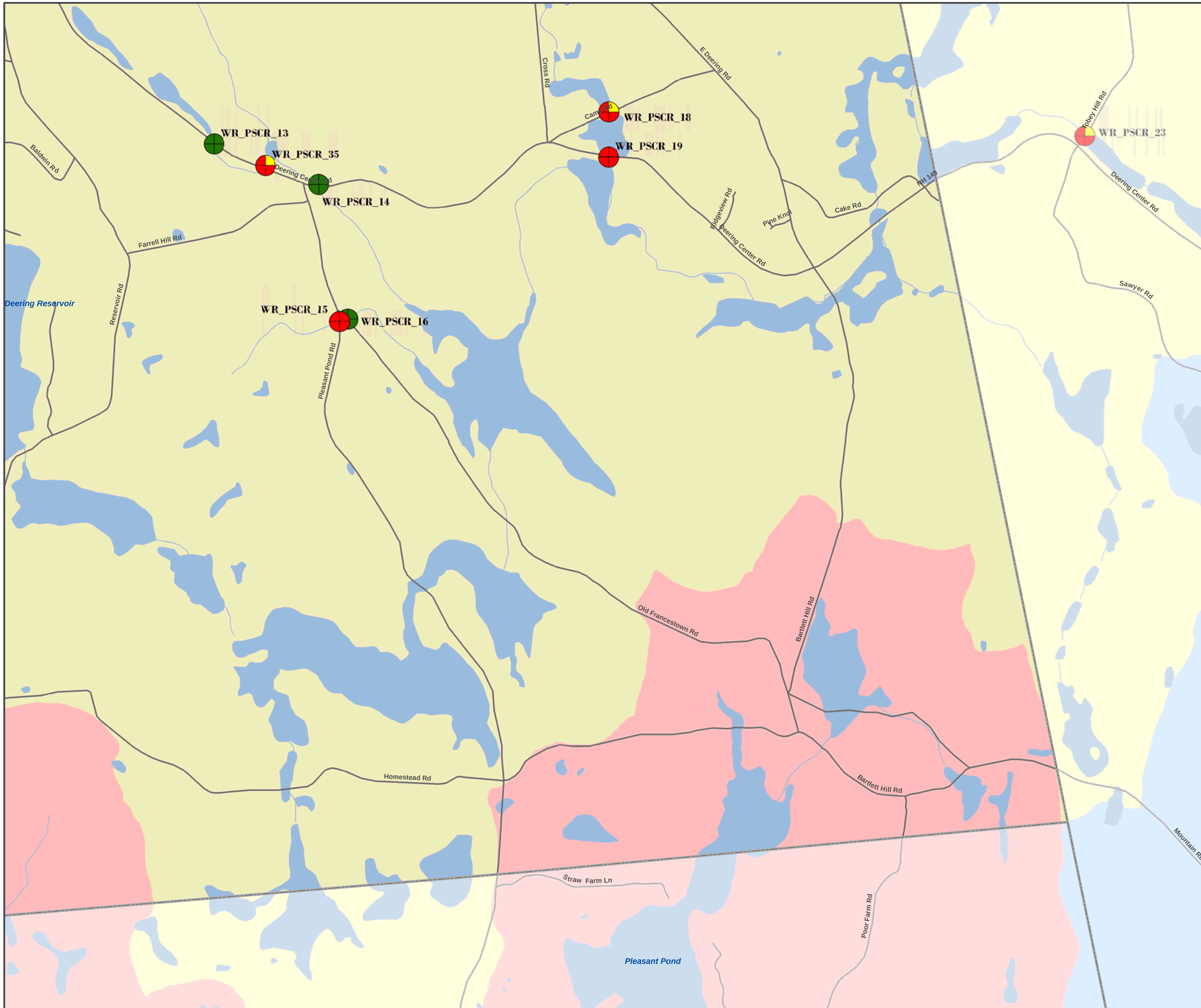


Piscataquog River Hydrology Assessment 2014

Deering
Map 5 of 5



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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0 0.125 0.25 0.5 Miles

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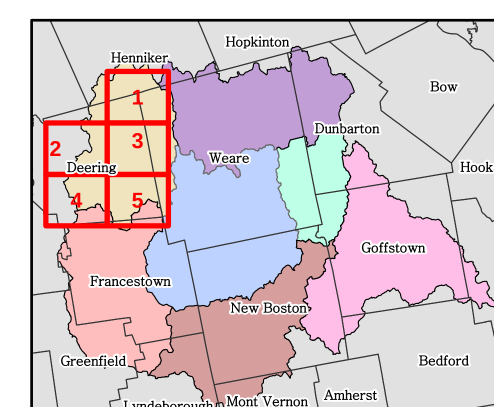

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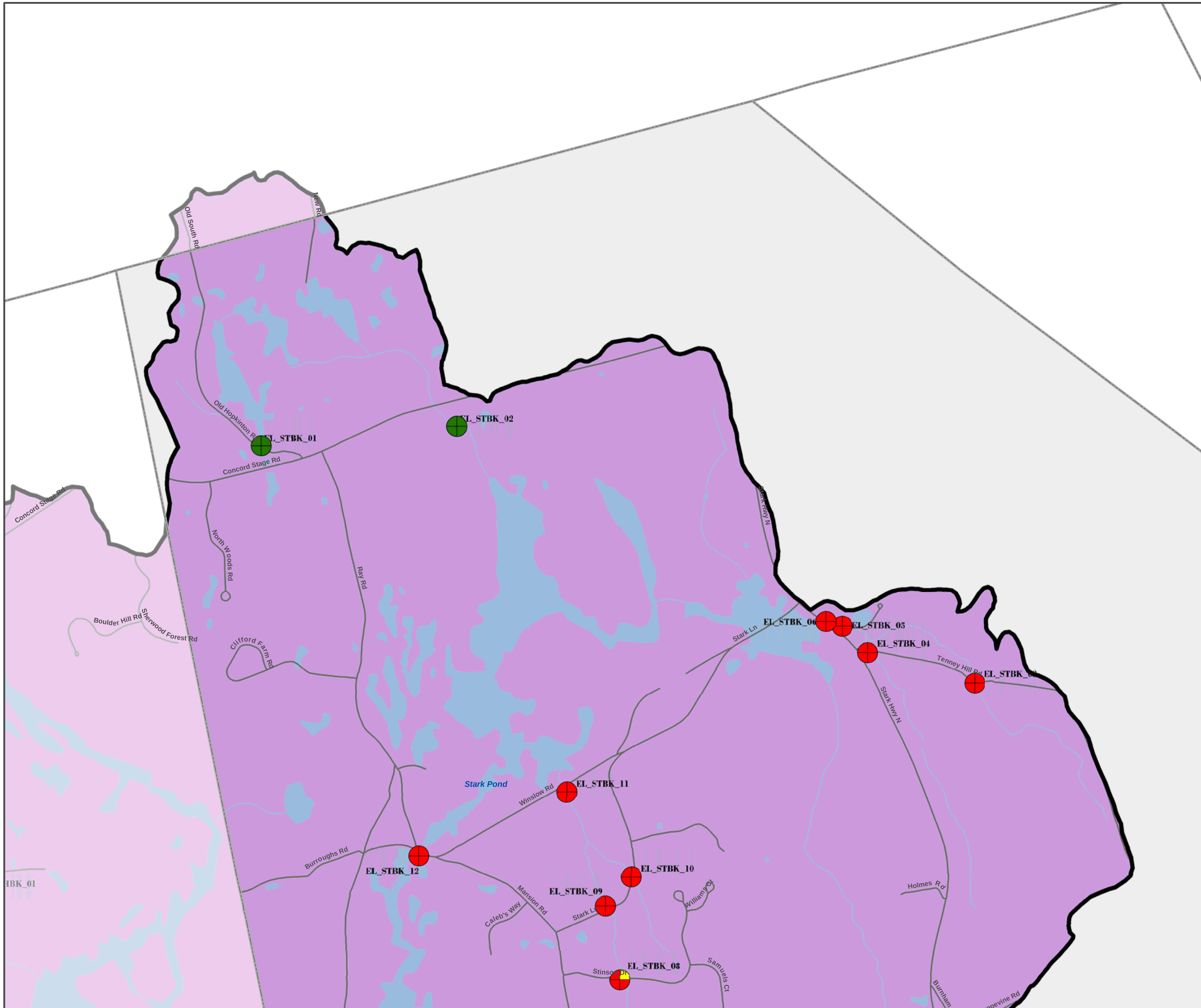

Piscataquog River Hydrology Assessment 2014

Dunbarton

Map 1 of 4

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

- Everett Lake
- Lower Piscataquog River
- Middle Branch Piscataquog River
- Rand Brook-South Branch
- South Branch Piscataquog River
- Upper Piscataquog River
- Weare Reservoir

0 0.15 0.3 0.6 Miles

Data Sources:
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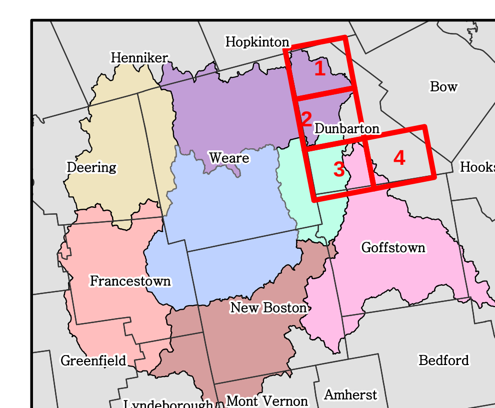

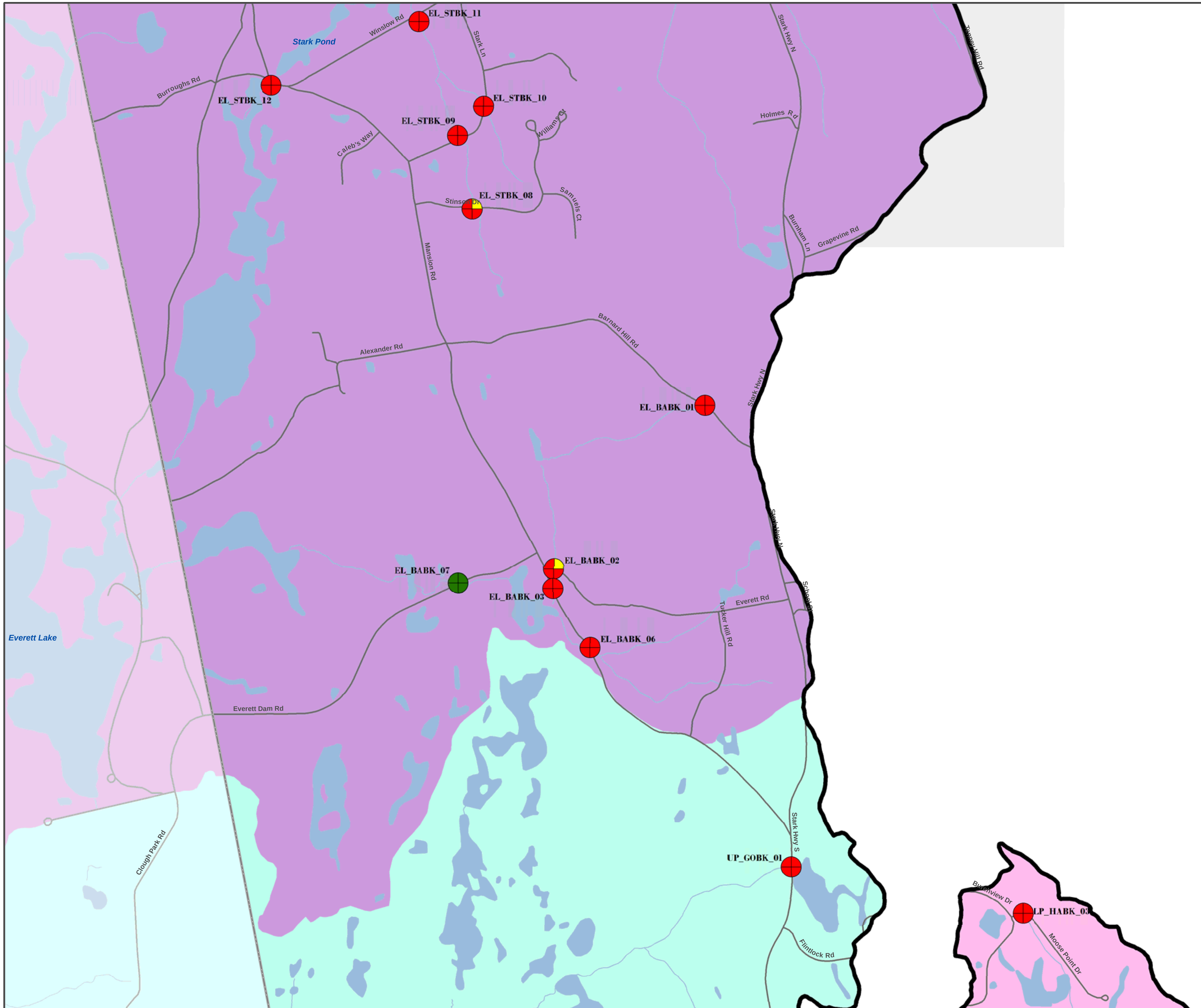

Piscataquog River Hydrology Assessment 2014

Dunbarton

Map 2 of 4

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

- Everett Lake
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- Weare Reservoir

0 0.15 0.3 0.6 Miles

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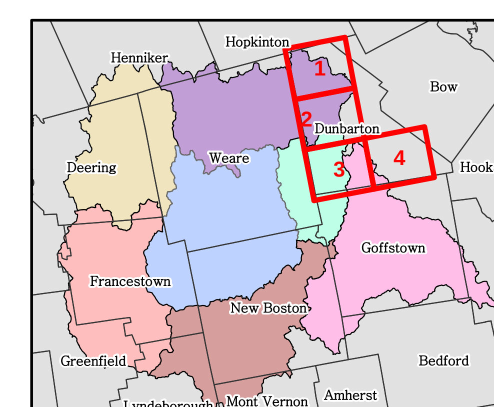
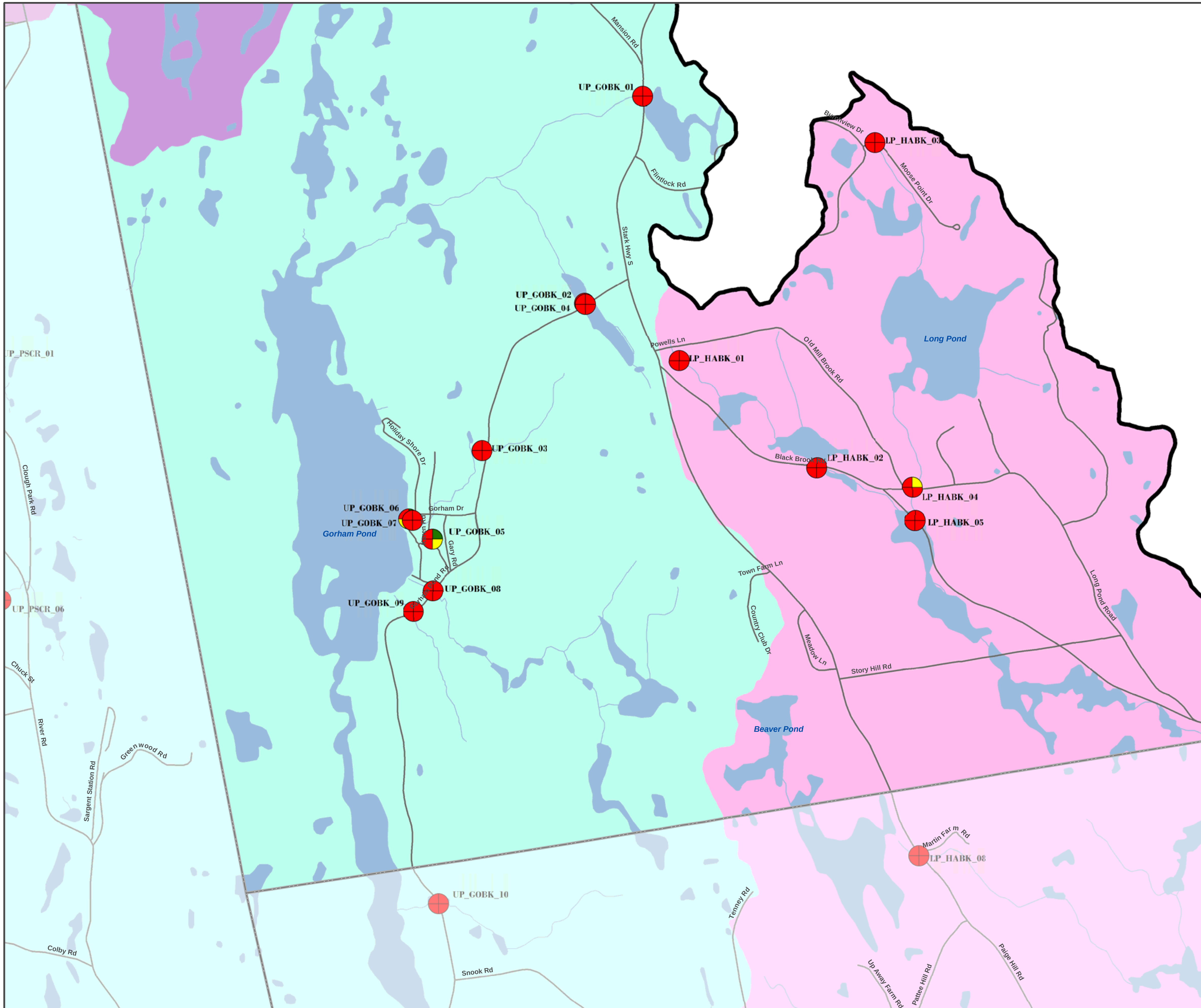


Piscataquog River Hydrology Assessment 2014

Dunbarton

Map 3 of 4



Potential Status of Culvert at Given Storm Event

Storm Year

100 | 10
50 | 25

Pass

Transitional

Fail

Town Boundary

Roads

Lakes and Wetlands

Streams

HUC 12 Sub-Watersheds

Everett Lake

Lower Piscataquog River

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Upper Piscataquog River

Weare Reservoir

0 0.15 0.3 0.6 Miles

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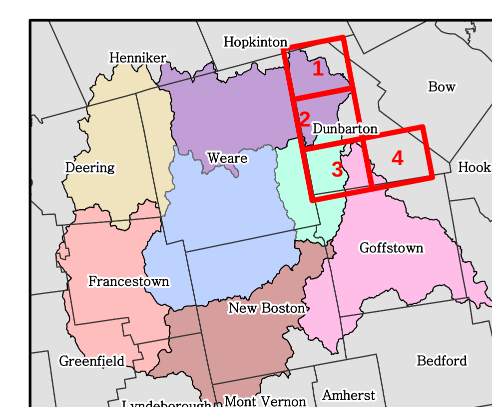

TROUT UNLIMITED

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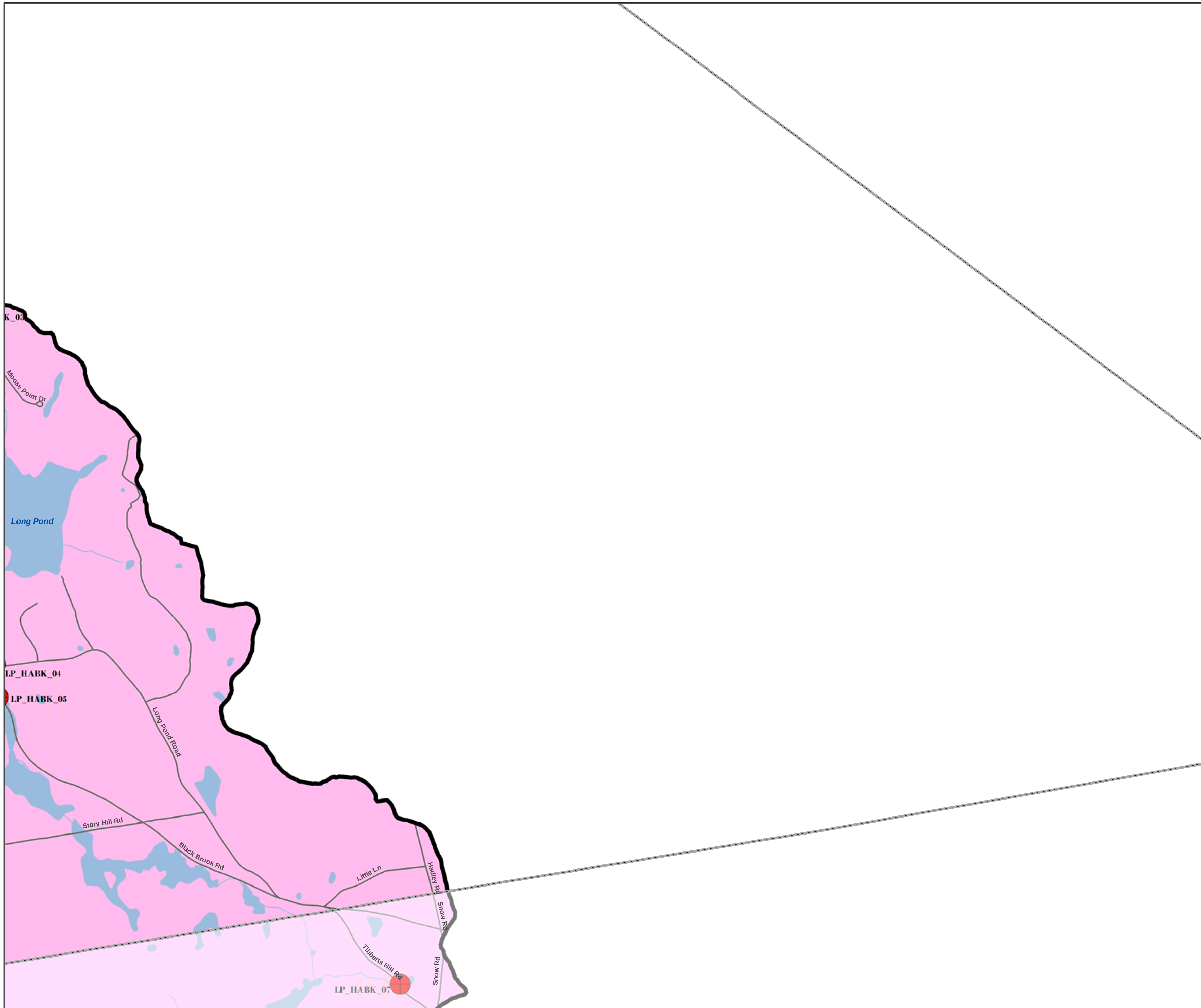
Piscataquog River Hydrology Assessment 2014

Dunbarton

Map 4 of 4



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
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- Streams

HUC 12 Sub-Watersheds

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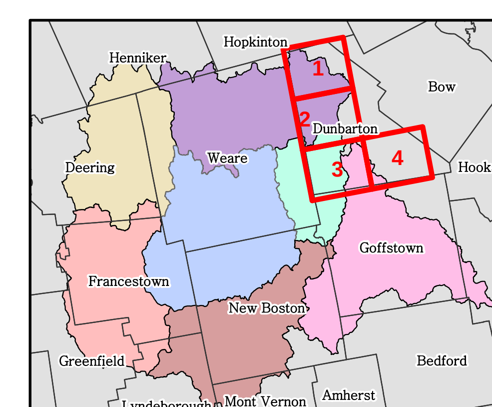
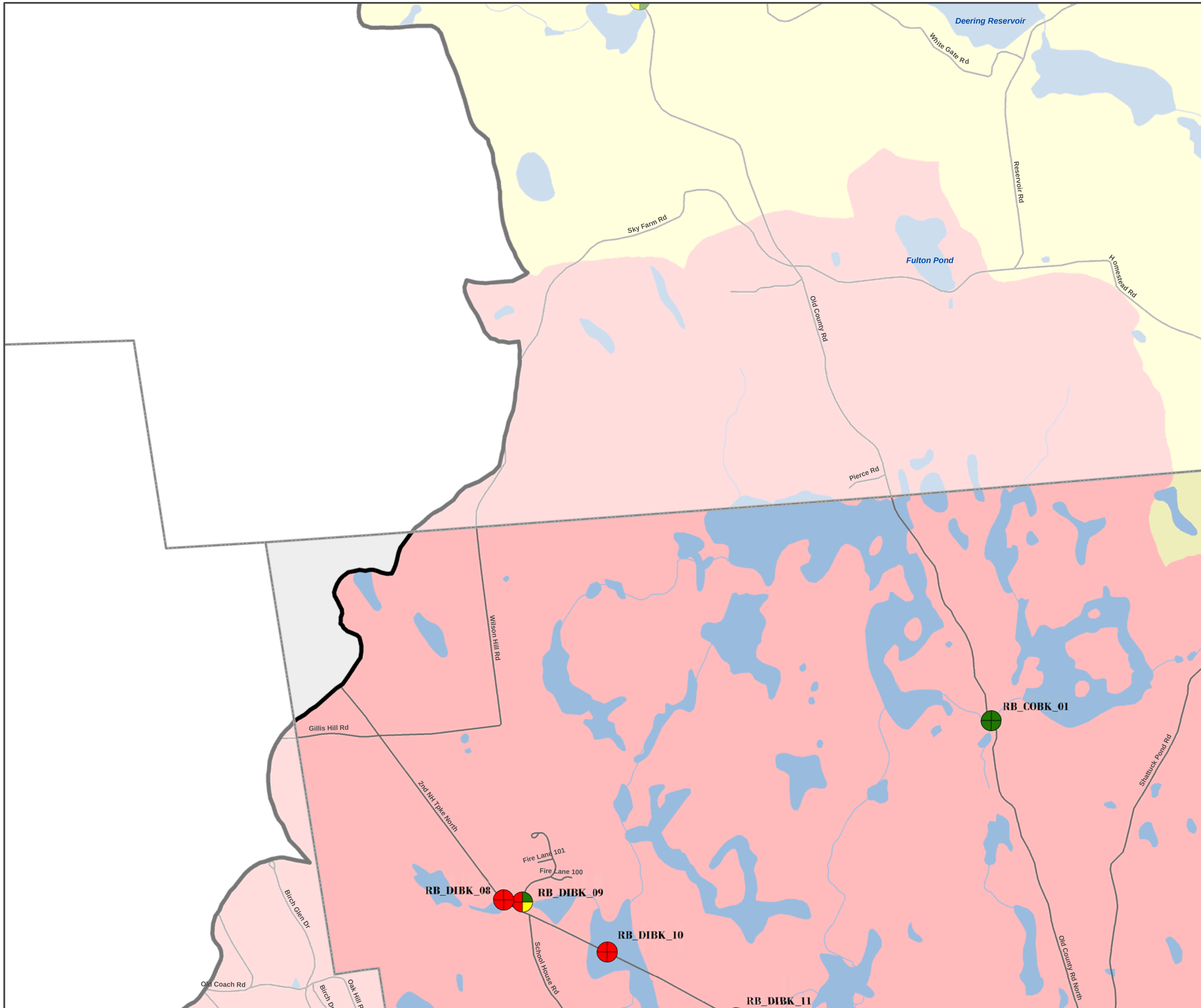


Piscataquog River Hydrology Assessment 2014

Francestown
Map 1 of 7



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
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0 0.125 0.25 0.5 Miles

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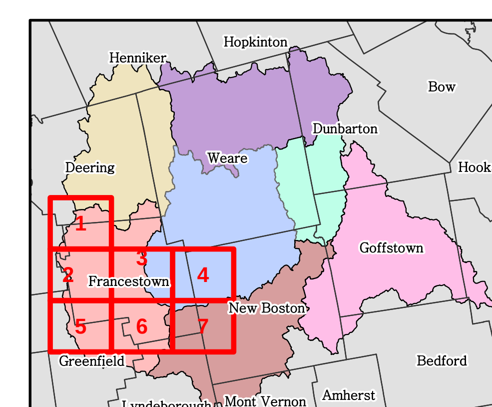

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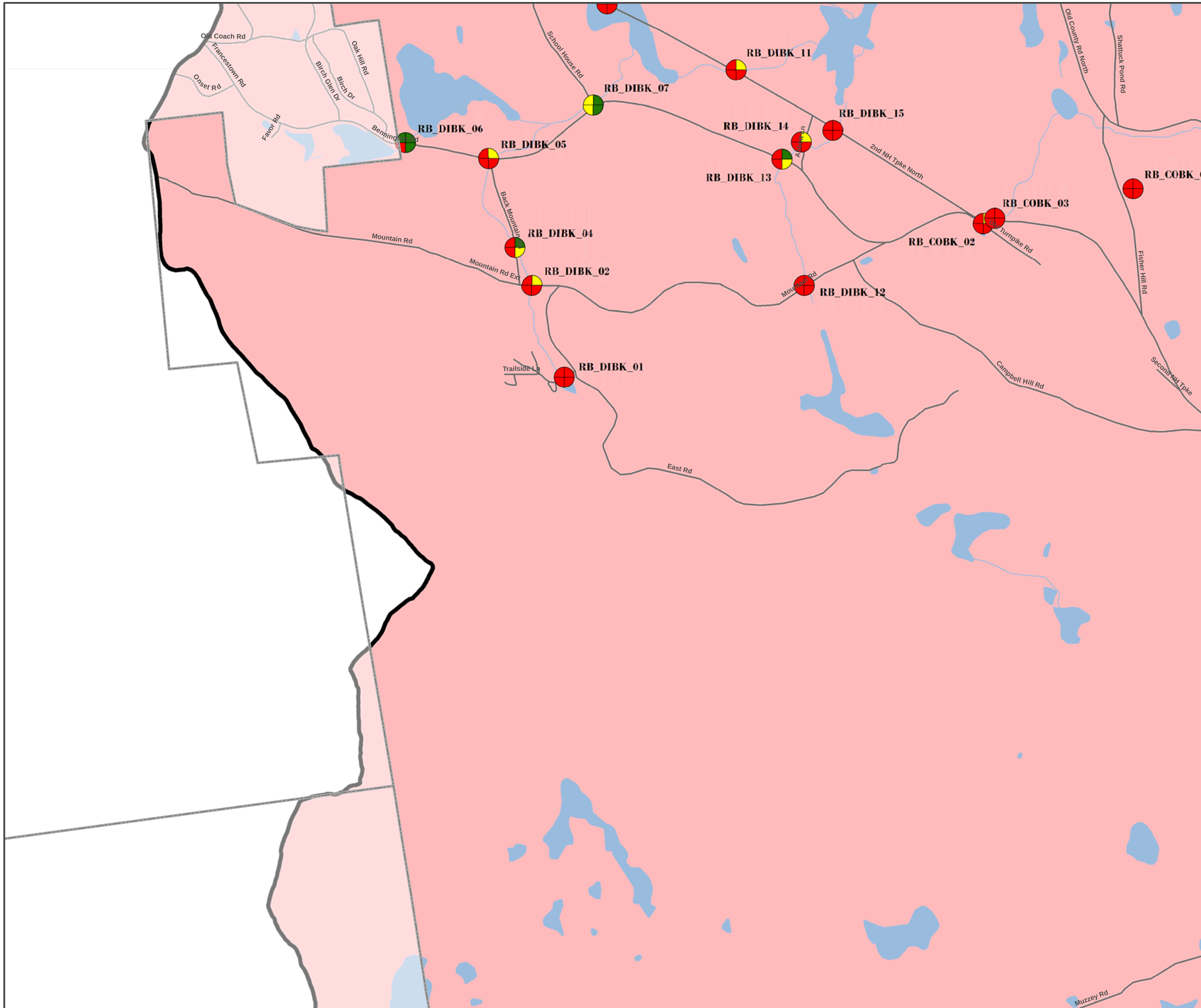

Piscataquog River Hydrology Assessment 2014

Francestown

Map 2 of 7

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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0 0.125 0.25 0.5 Miles

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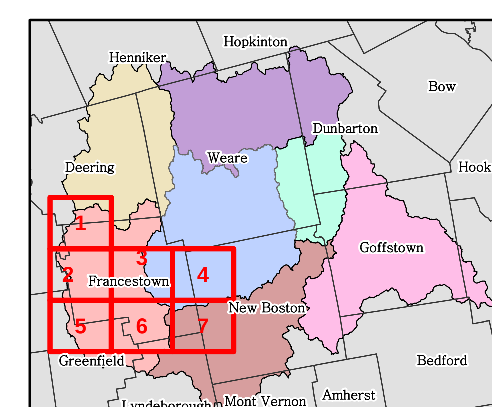
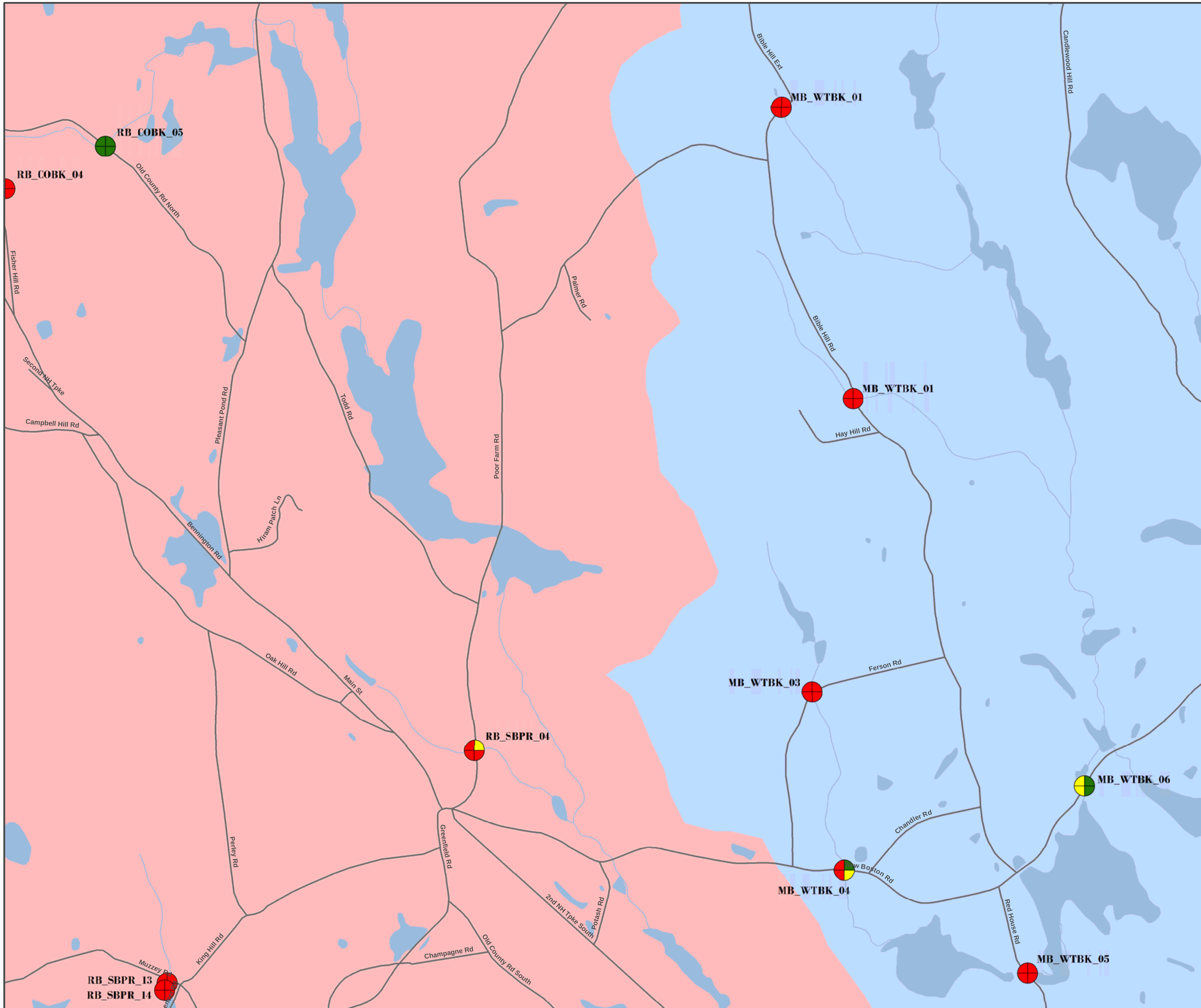


Piscataquog River Hydrology Assessment 2014

Francestown

Map 3 of 7



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

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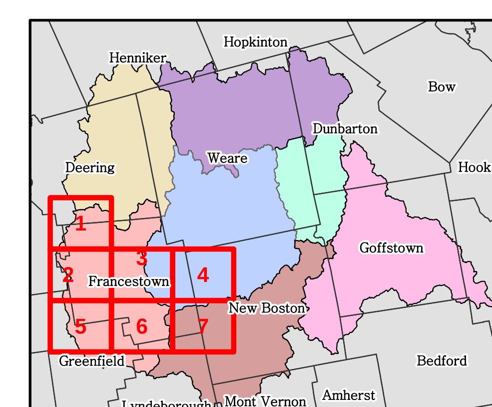

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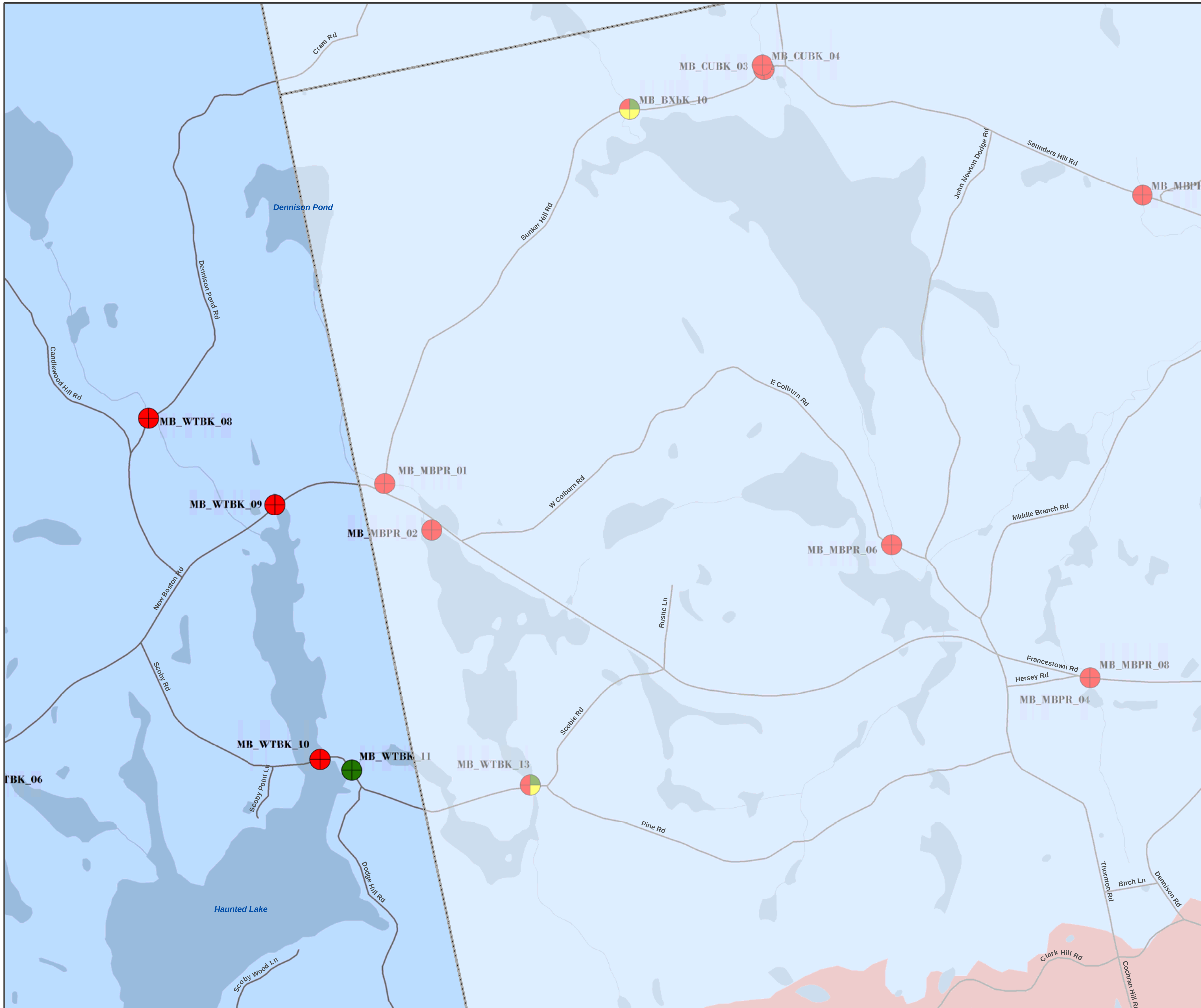

Piscataquog River Hydrology Assessment 2014

Francestown

Map 4 of 7

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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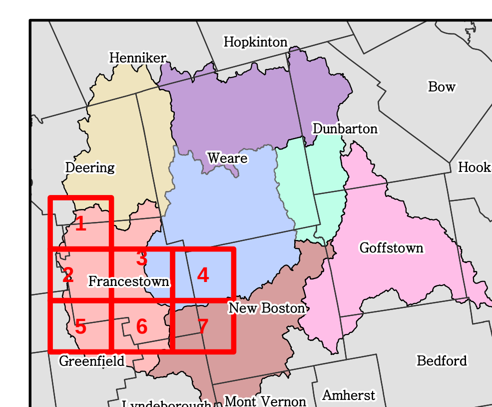
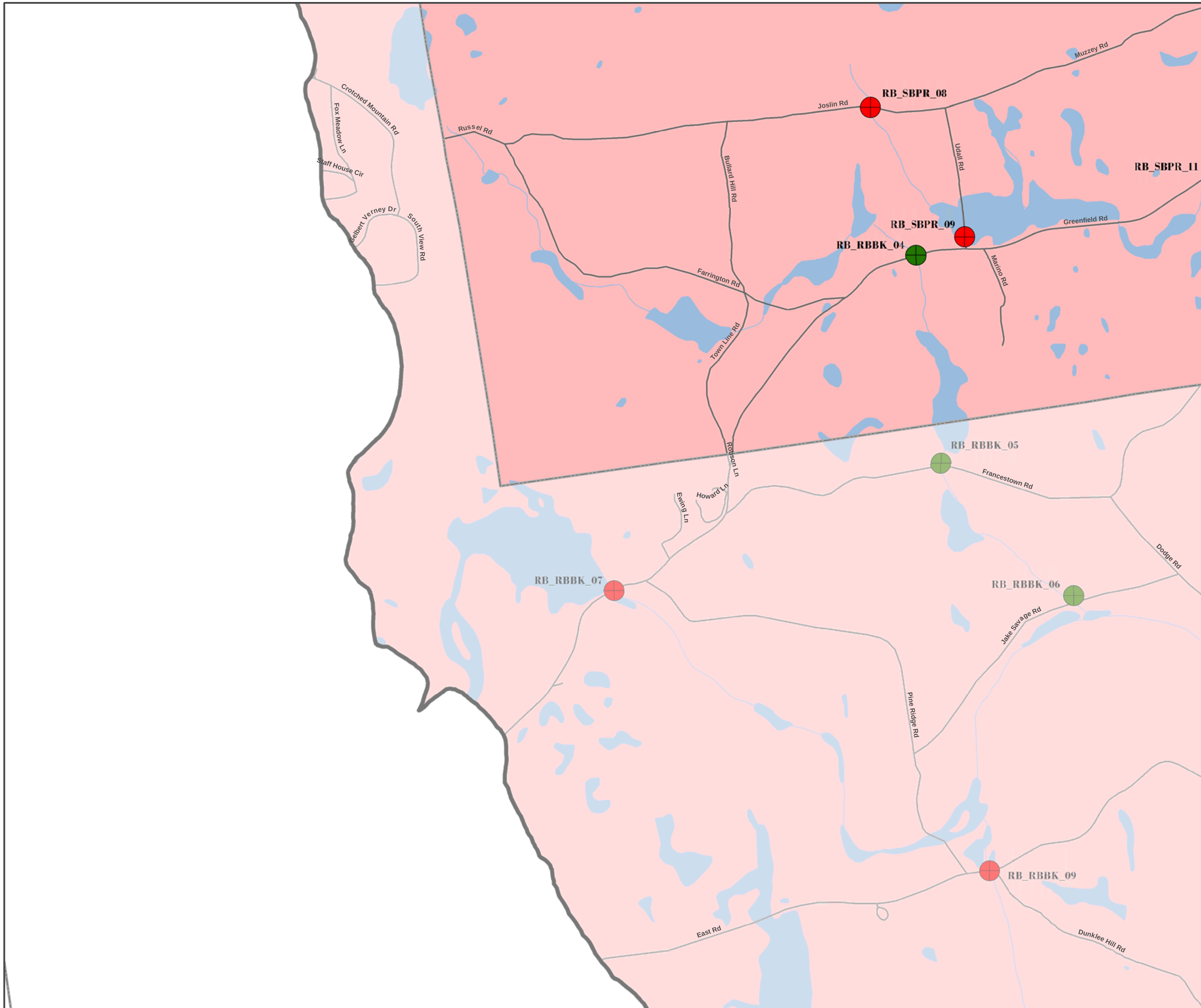


Piscataquog River Hydrology Assessment 2014

Francestown
Map 5 of 7



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

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- Roads
- Lakes and Wetlands
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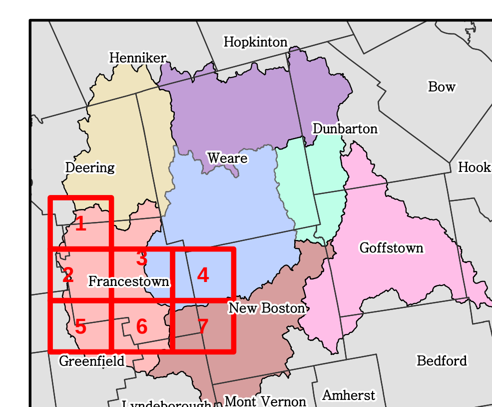

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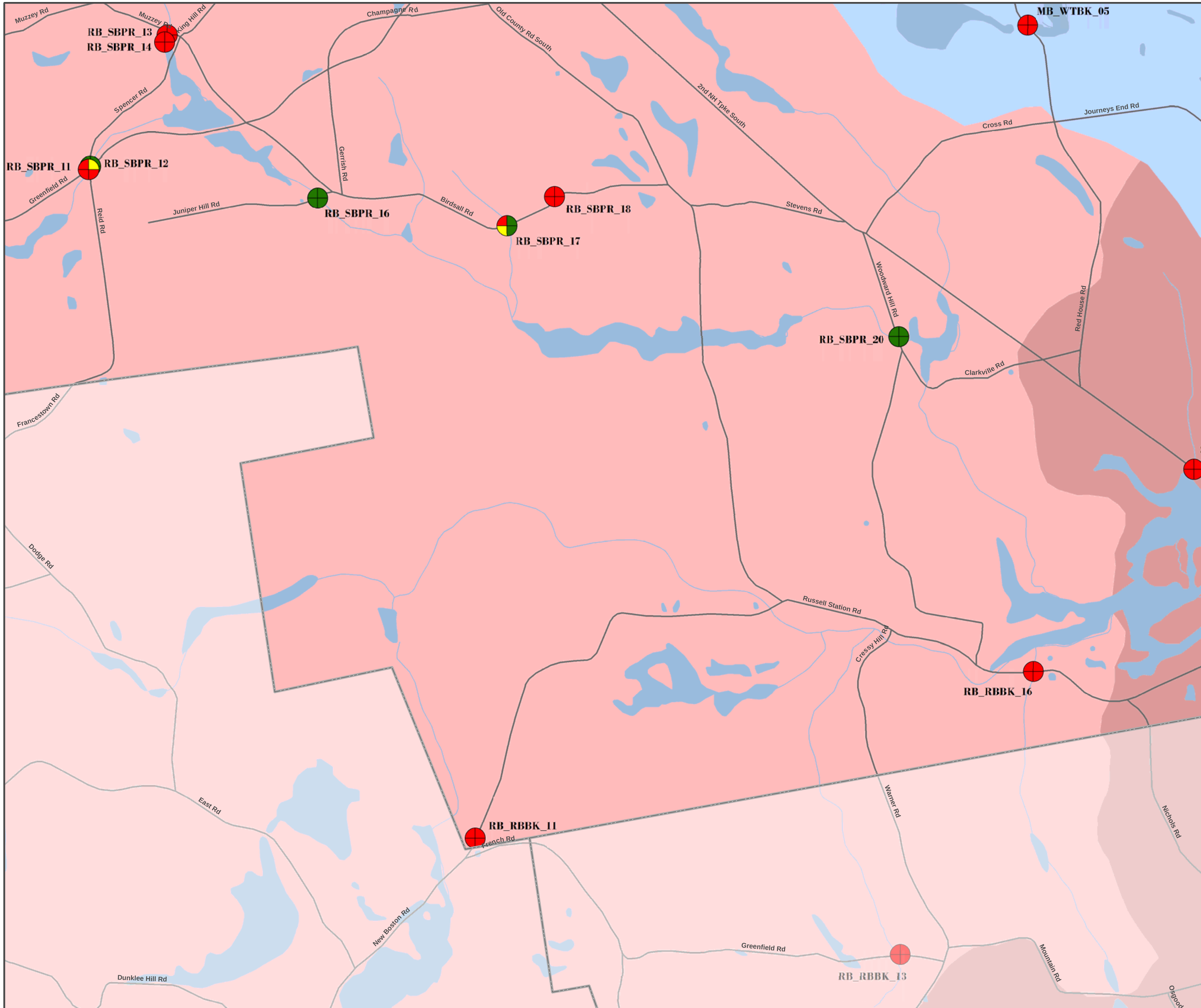

Piscataquog River Hydrology Assessment 2014

Francestown

Map 6 of 7

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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- Upper Piscataquog River
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0 0.125 0.25 0.5 Miles

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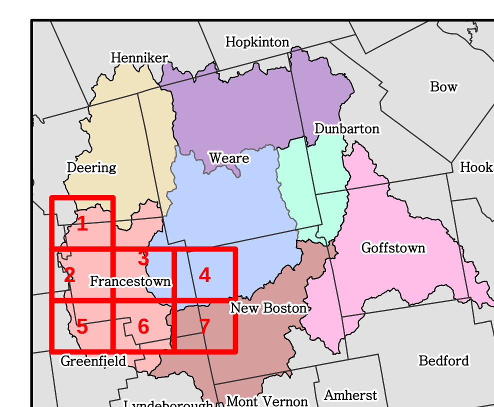
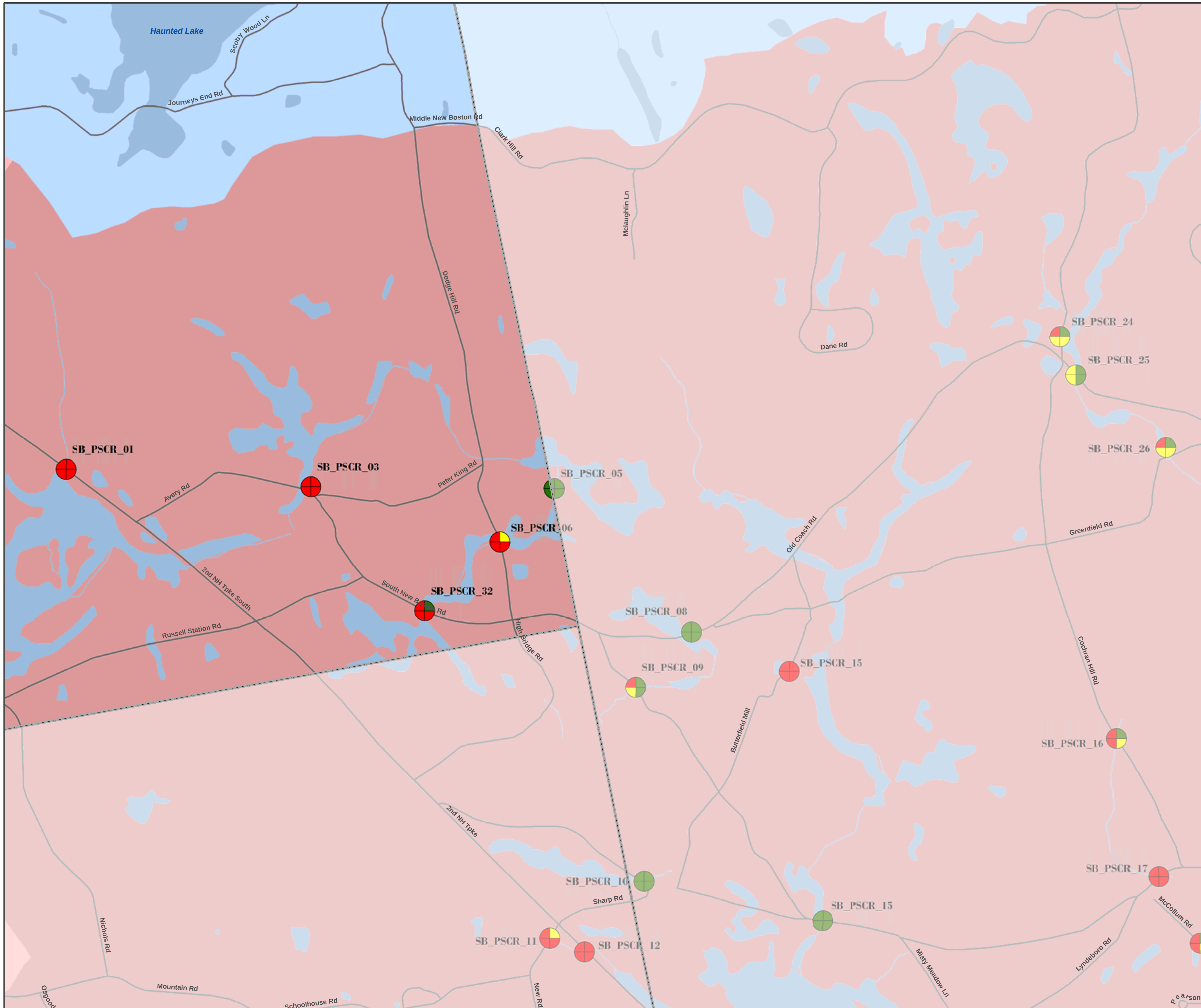


Piscataquog River Hydrology Assessment 2014

Francestown
Map 7 of 7



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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0 0.125 0.25 0.5 Miles

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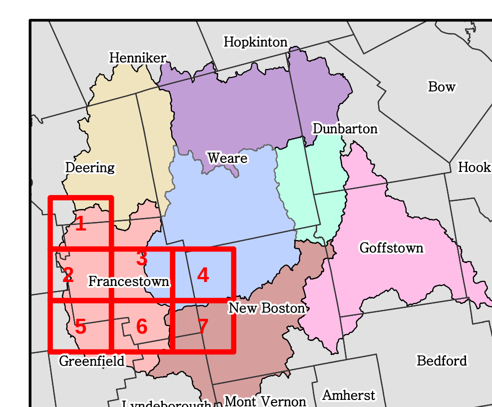

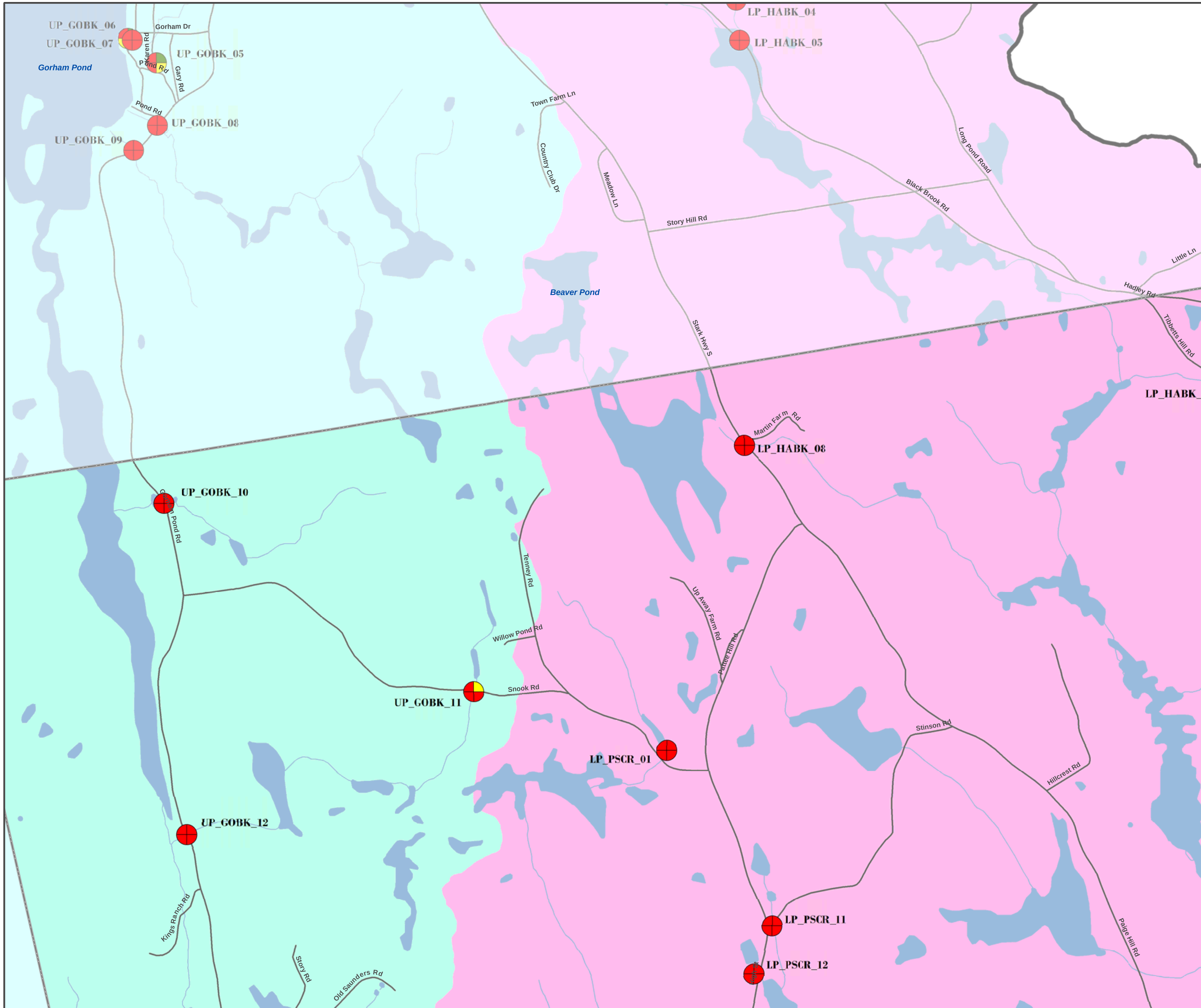

PISCATAQUOG RIVER HYDROLOGY ASSESSMENT 2014

Goffstown

Map 1 of 7

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year: 100, 10, 50, 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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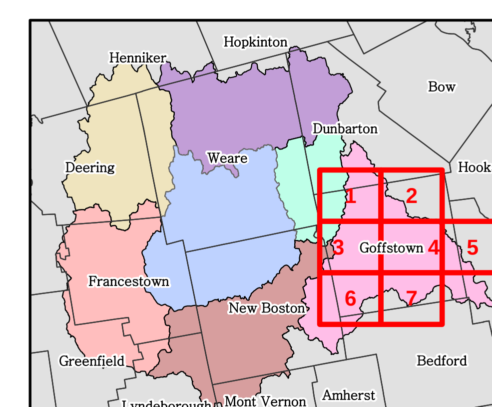

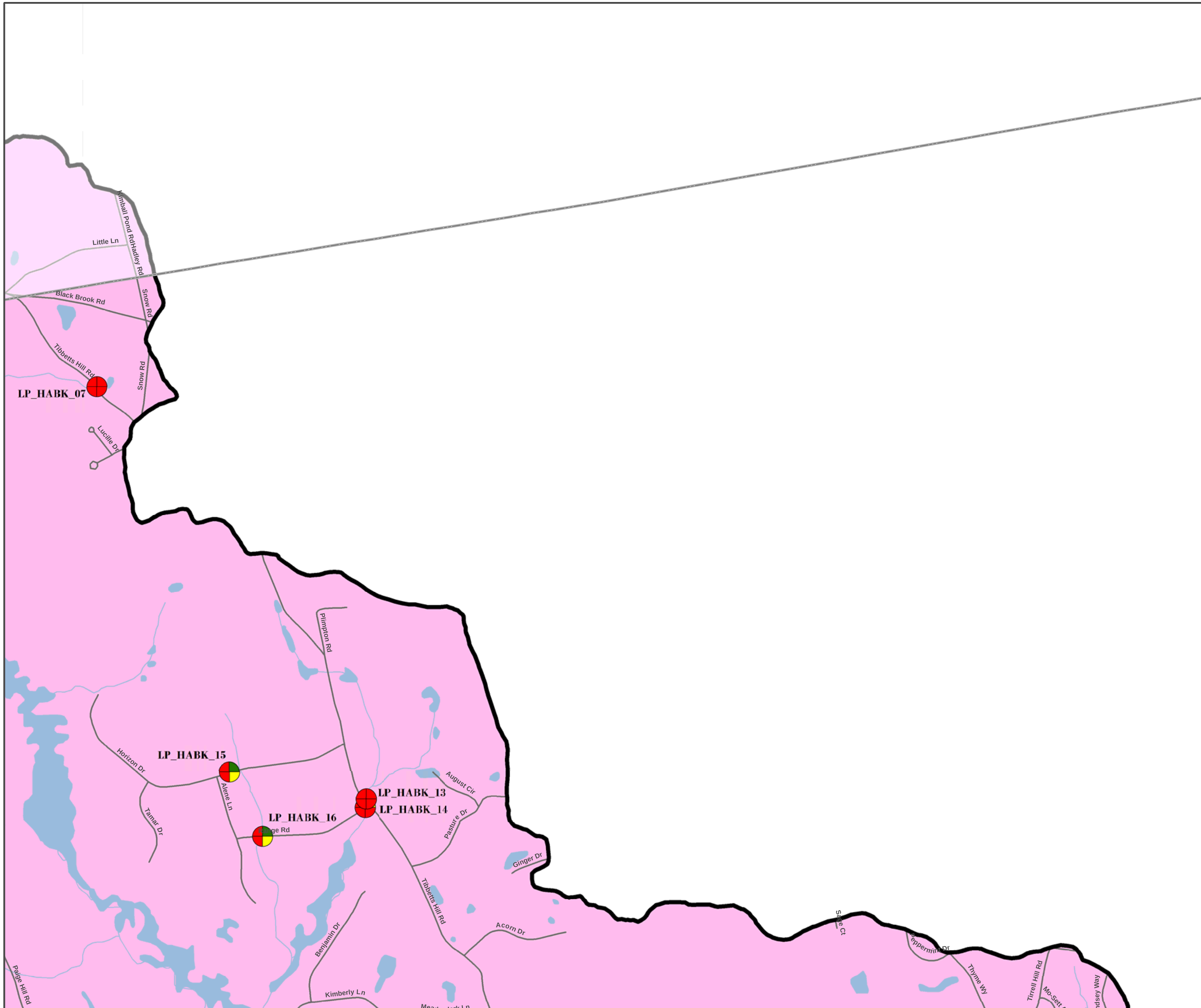

Piscataquog River Hydrology Assessment 2014

Goffstown

Map 2 of 7

Potential Status of Culvert at Given Storm Event

Storm Year: 100, 10, 50, 25

- Pass
- Transitional
- Fail

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

- Everett Lake
- Lower Piscataquog River
- Middle Branch Piscataquog River
- Rand Brook-South Branch
- South Branch Piscataquog River
- Upper Piscataquog River
- Weare Reservoir

0 0.125 0.25 0.5 Miles

Data Sources:
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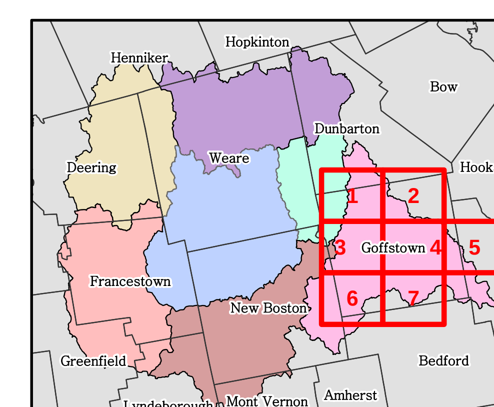

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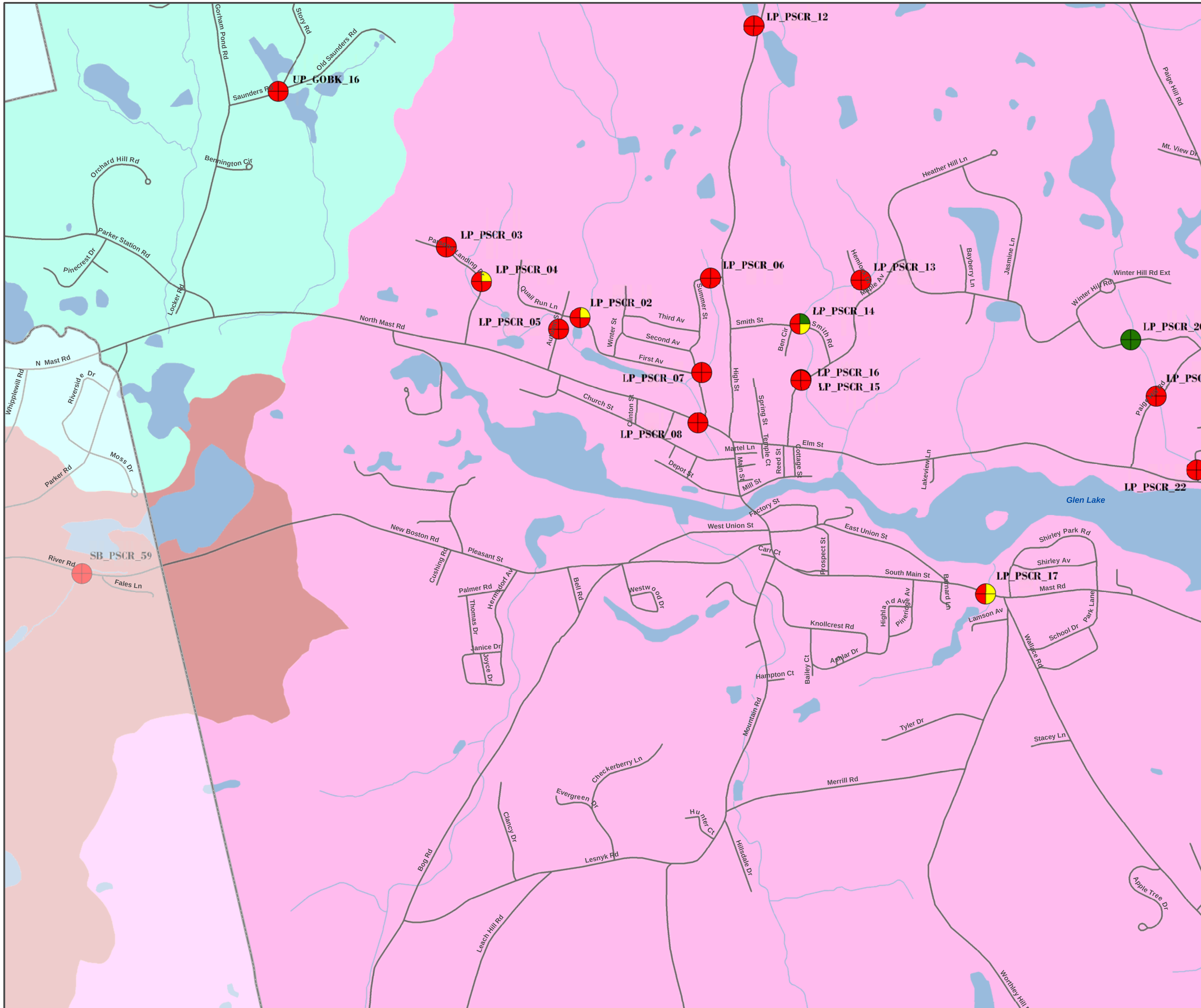
Piscataquog River Hydrology Assessment 2014

Goffstown

Map 3 of 7



Potential Status of Culvert at Given Storm Event

Storm Year

100 | 10
50 | 25

Pass

Transitional

Fail

Town Boundary

Roads

Lakes and Wetlands

Streams

HUC 12 Sub-Watersheds

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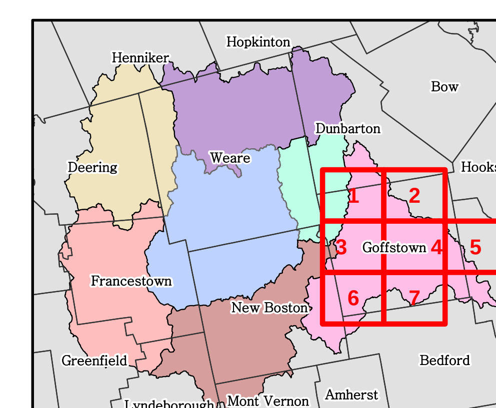
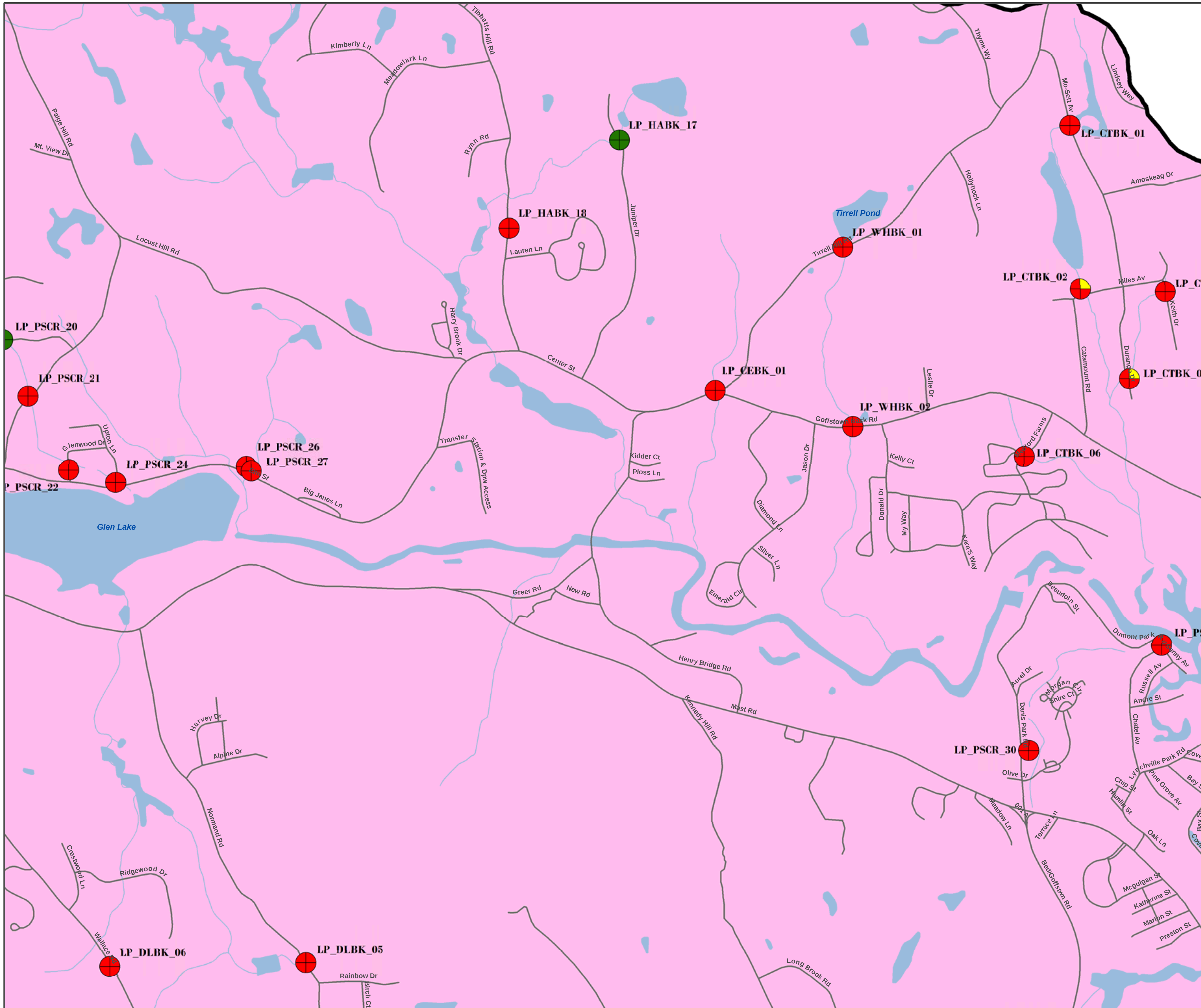


Piscataquog River Hydrology Assessment 2014

Goffstown

Map 4 of 7



Potential Status of Culvert at Given Storm Event

Storm Year

100	10
50	25

- Pass
- Transitional
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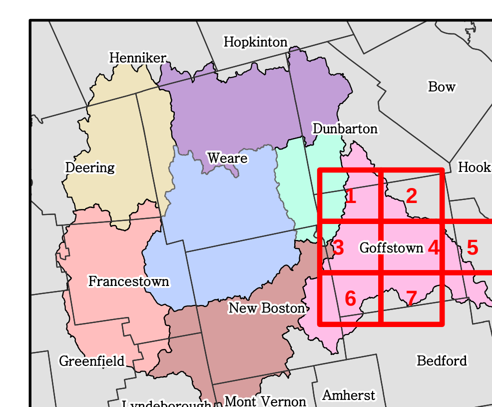
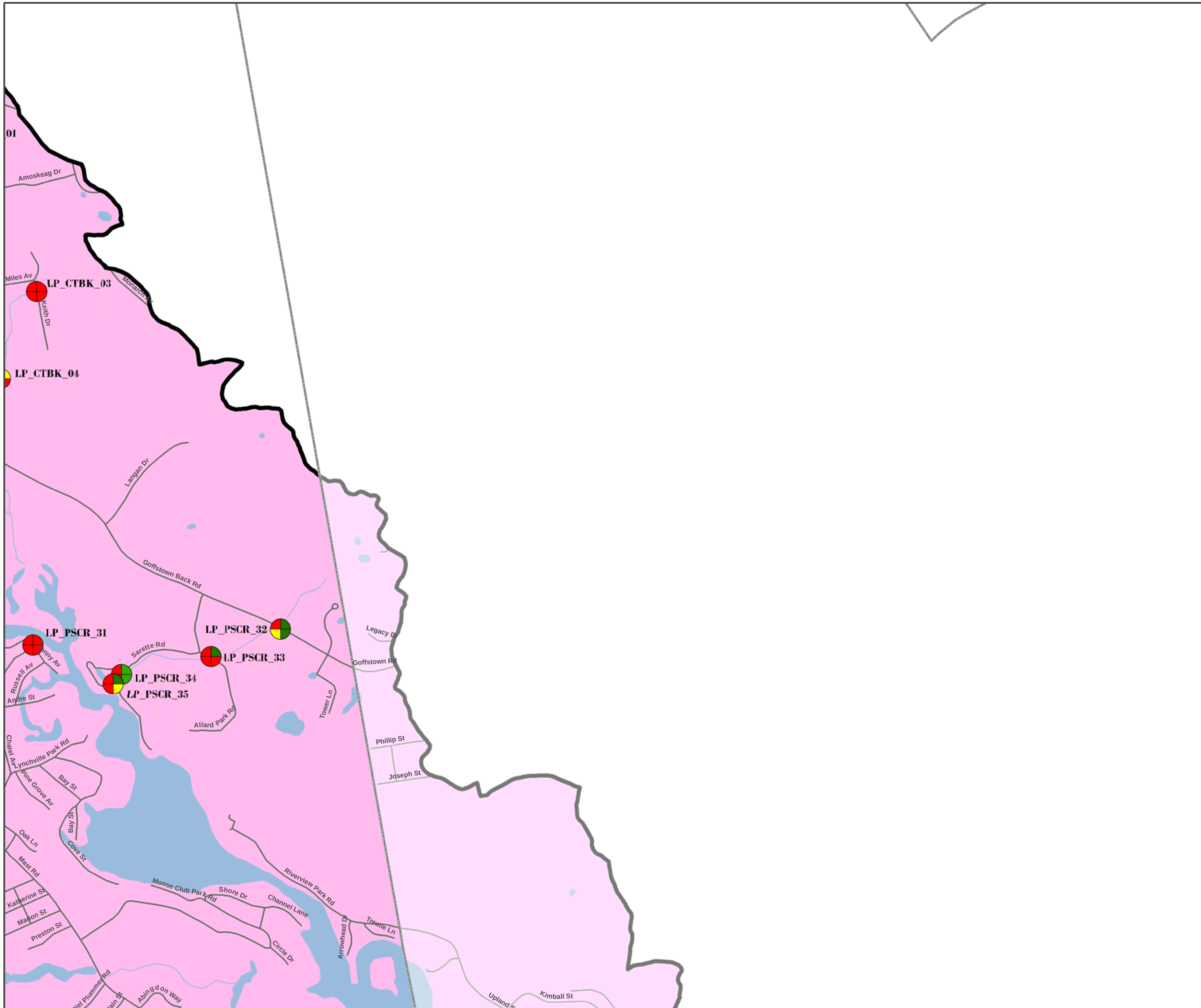


Piscataquog River Hydrology Assessment 2014

Goffstown

Map 5 of 7



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
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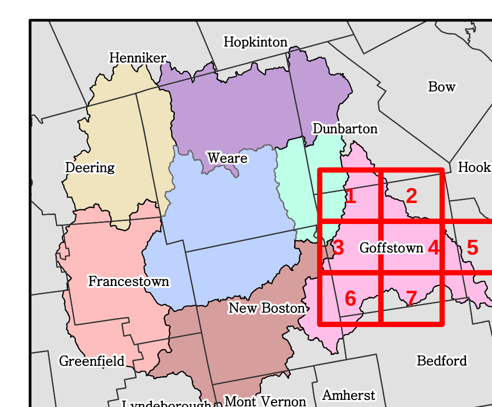

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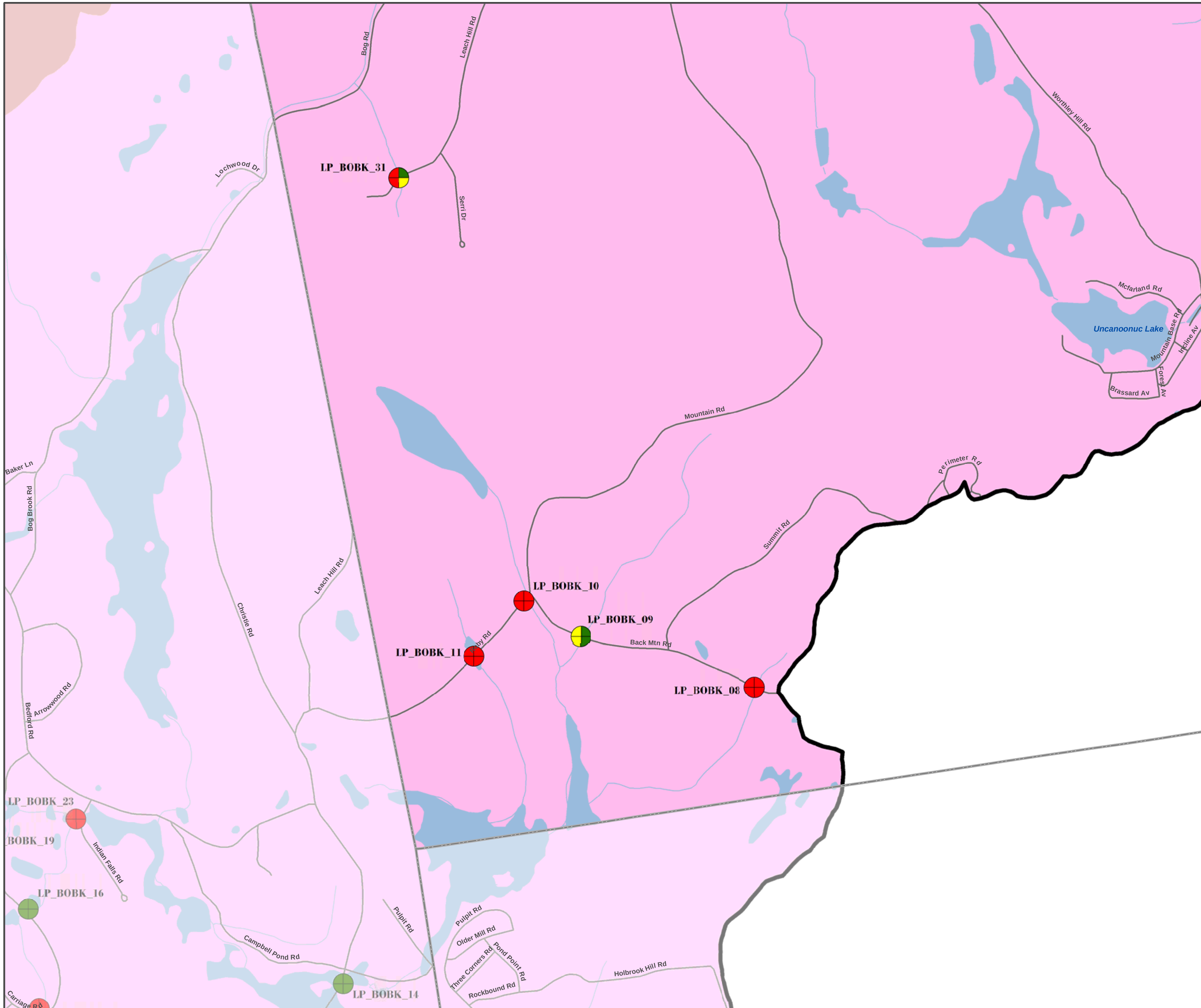

Piscataquog River Hydrology Assessment 2014

Goffstown

Map 6 of 7

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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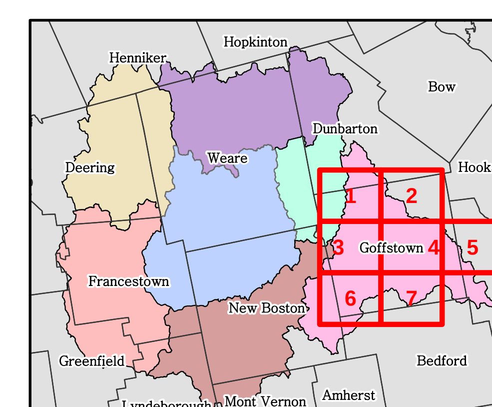

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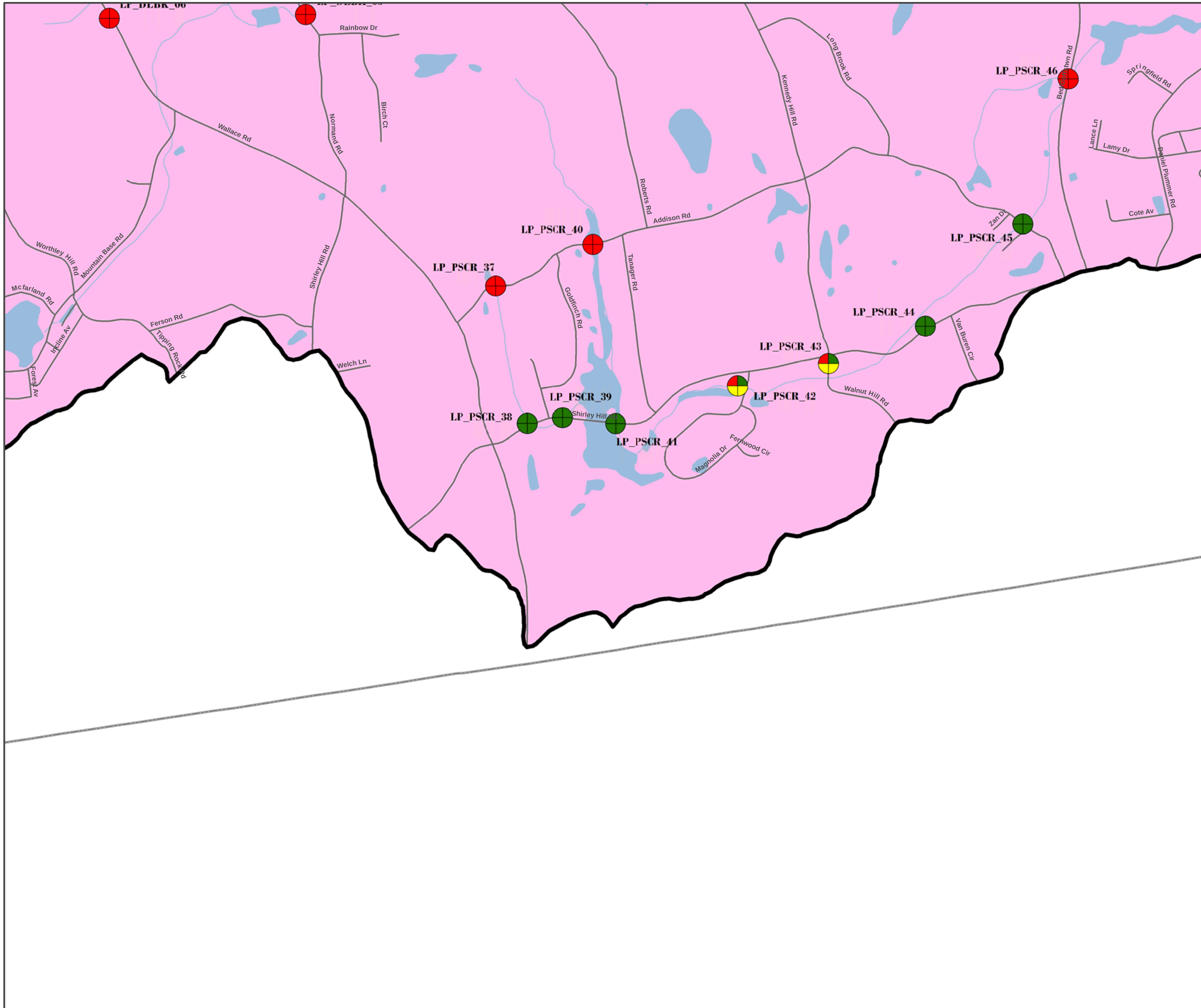

Piscataquog River Hydrology Assessment 2014

Goffstown

Map 7 of 7

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

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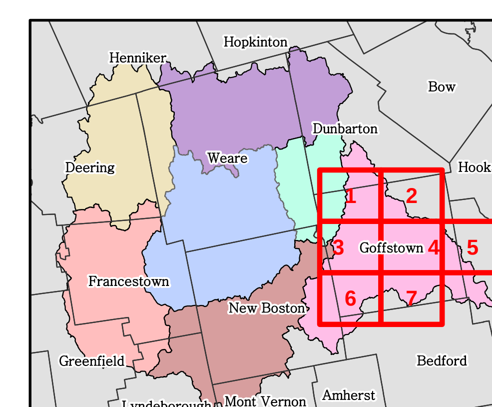

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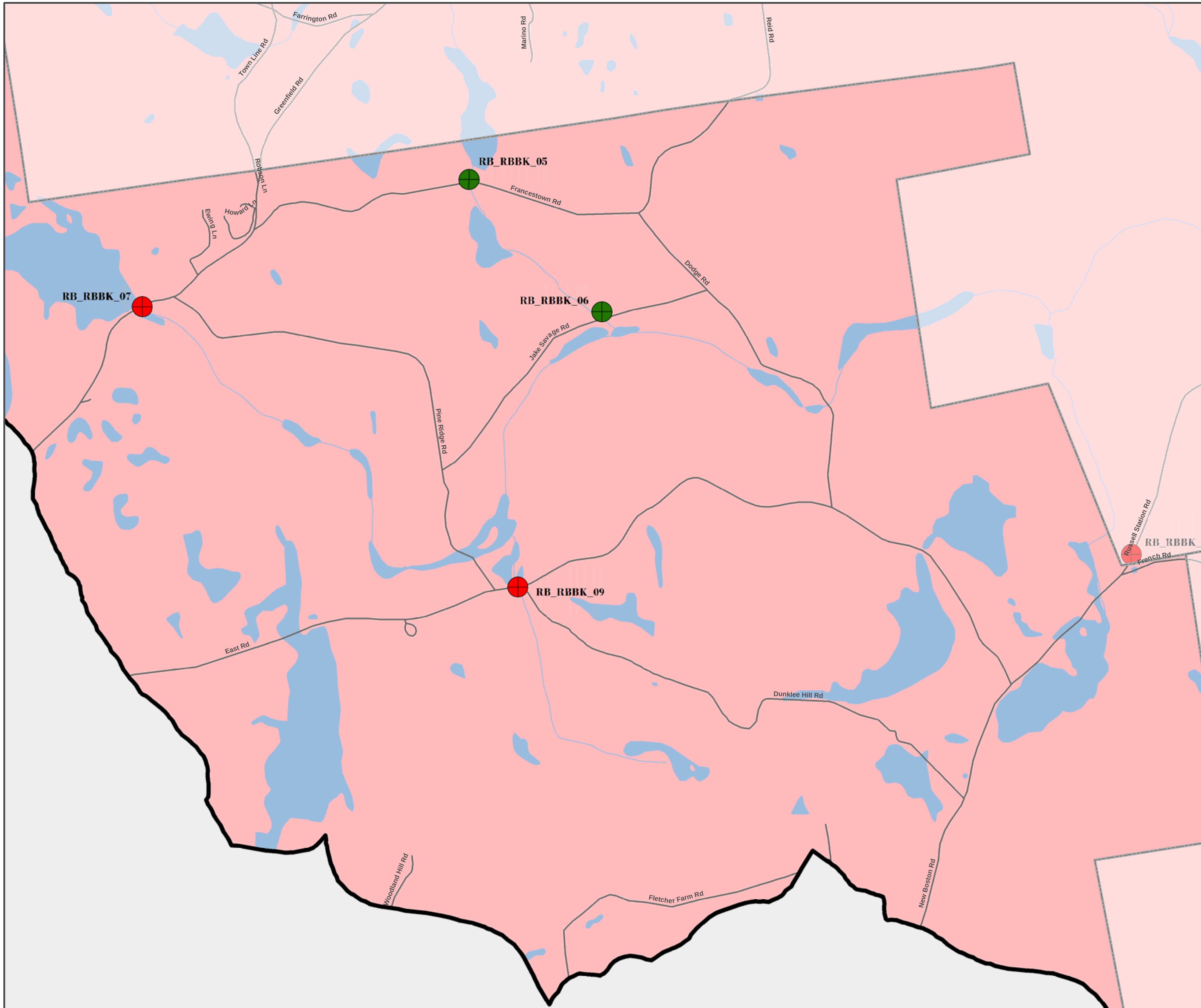

Piscataquog River Hydrology Assessment 2014

Greenfield

Map 1 of 1

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

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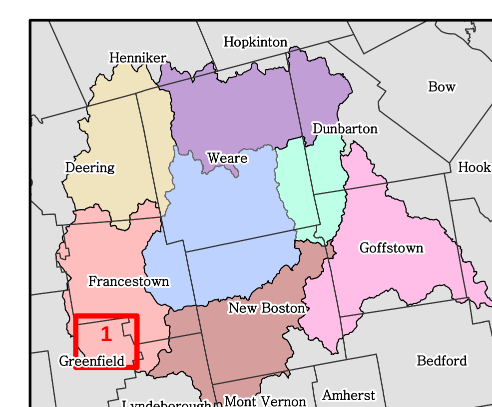

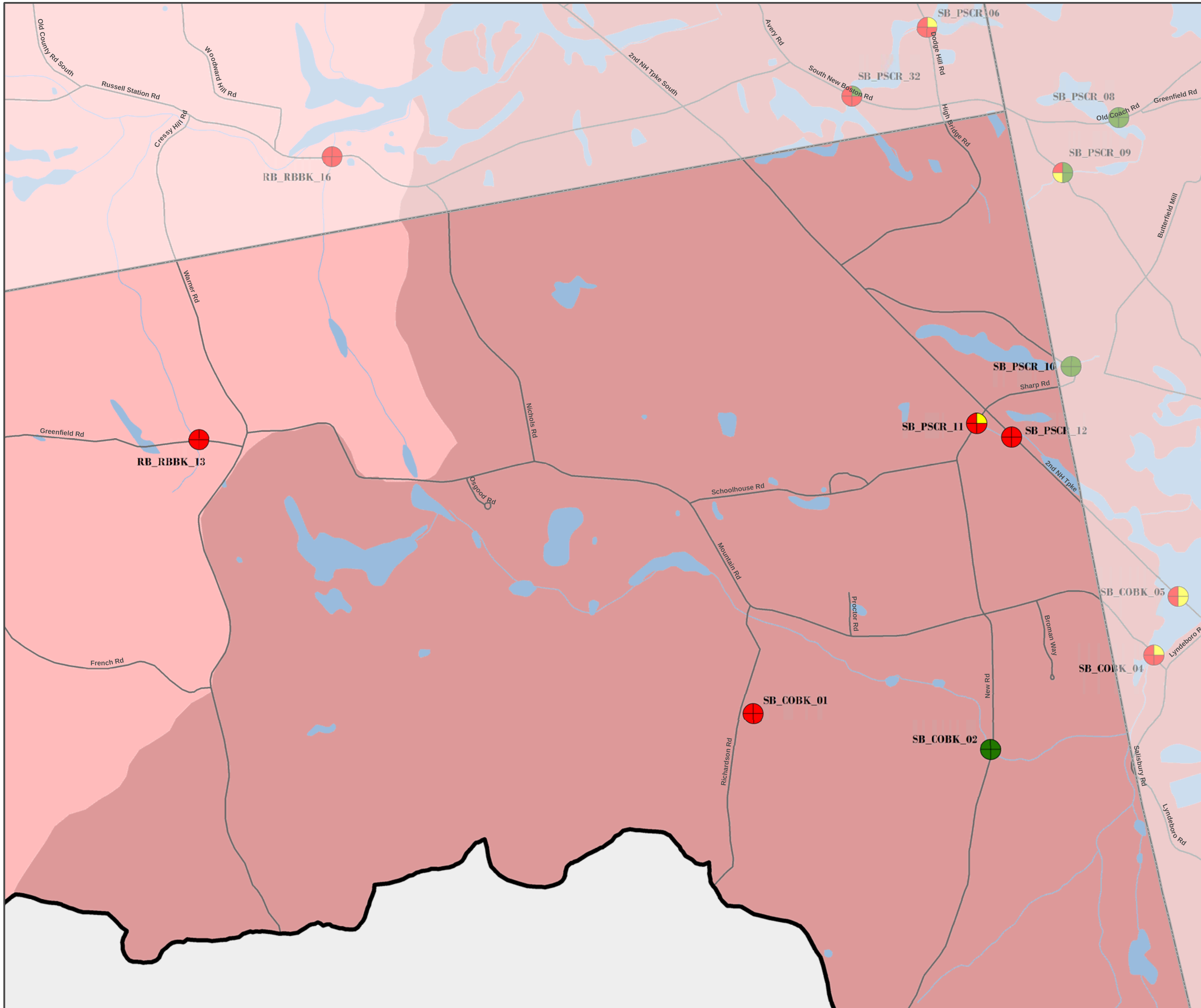

Piscataquog River Hydrology Assessment 2014

Lyndeborough

Map 1 of 1

Potential Status of Culvert at Given Storm Event

- Pass
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Storm Year

100 | 10
50 | 25

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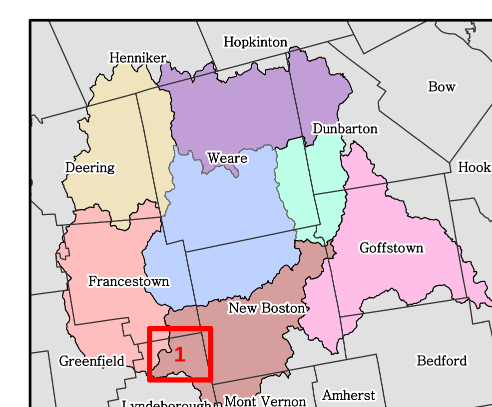

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Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 1 of 9

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

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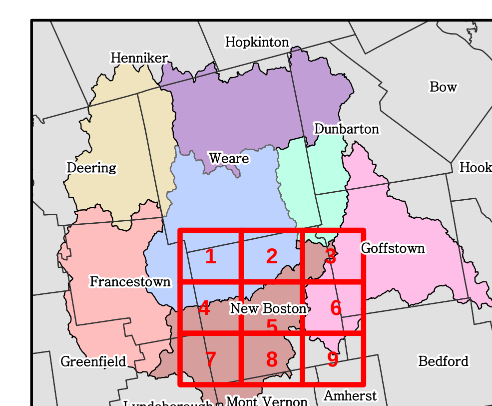

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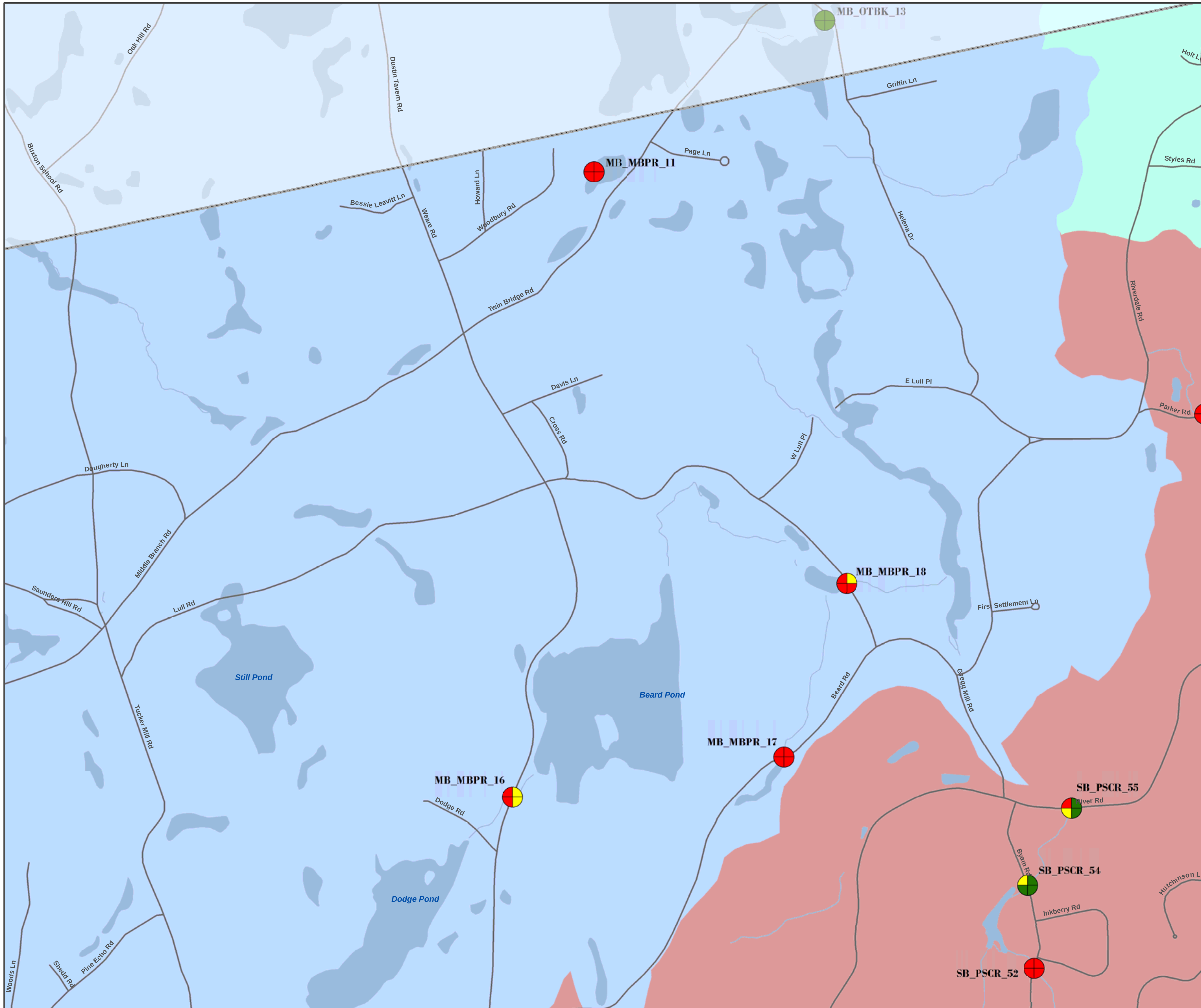

Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 2 of 9

Potential Status of Culvert at Given Storm Event

Pass

Transitional

Fail

Storm Year

100 | 10

50 | 25

Town Boundary

Roads

Lakes and Wetlands

Streams

HUC 12 Sub-Watersheds

Everett Lake

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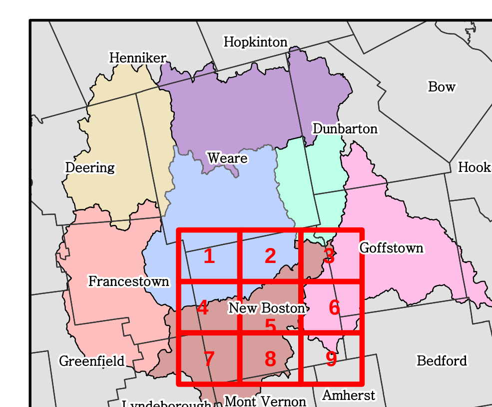

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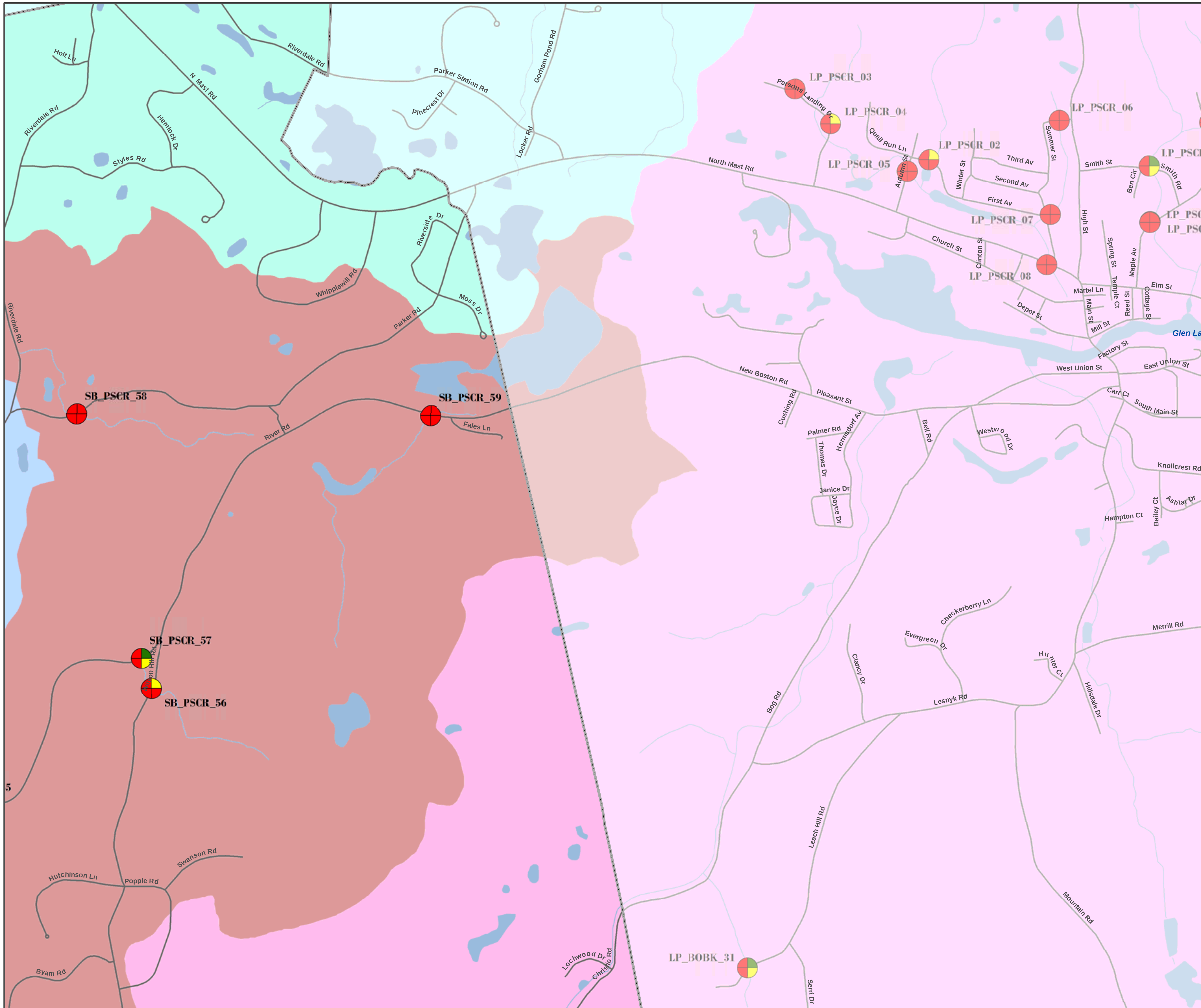
Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 3 of 9



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- Pass
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Storm Year

100	10
50	25

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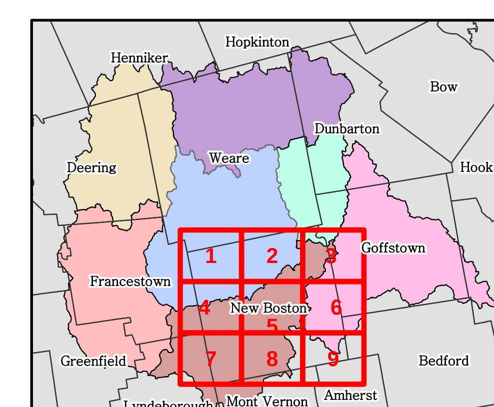
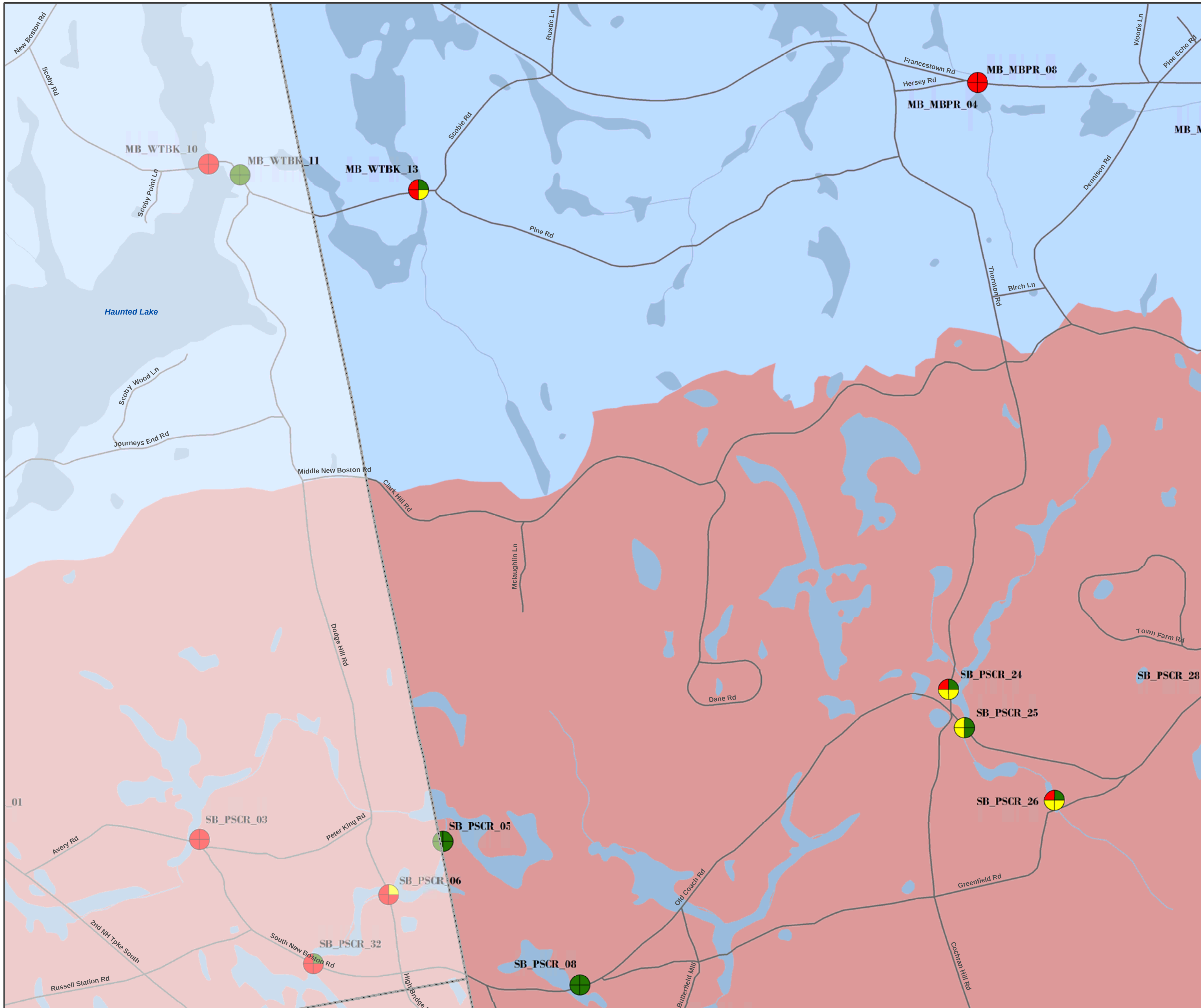


Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 4 of 9



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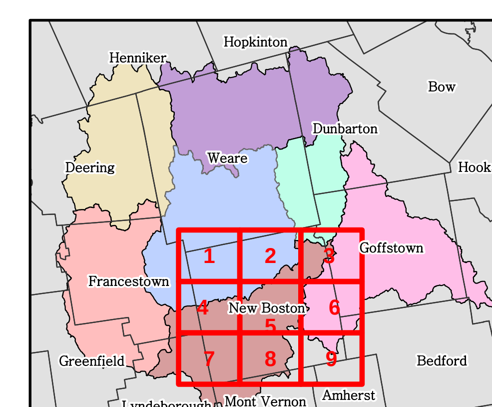
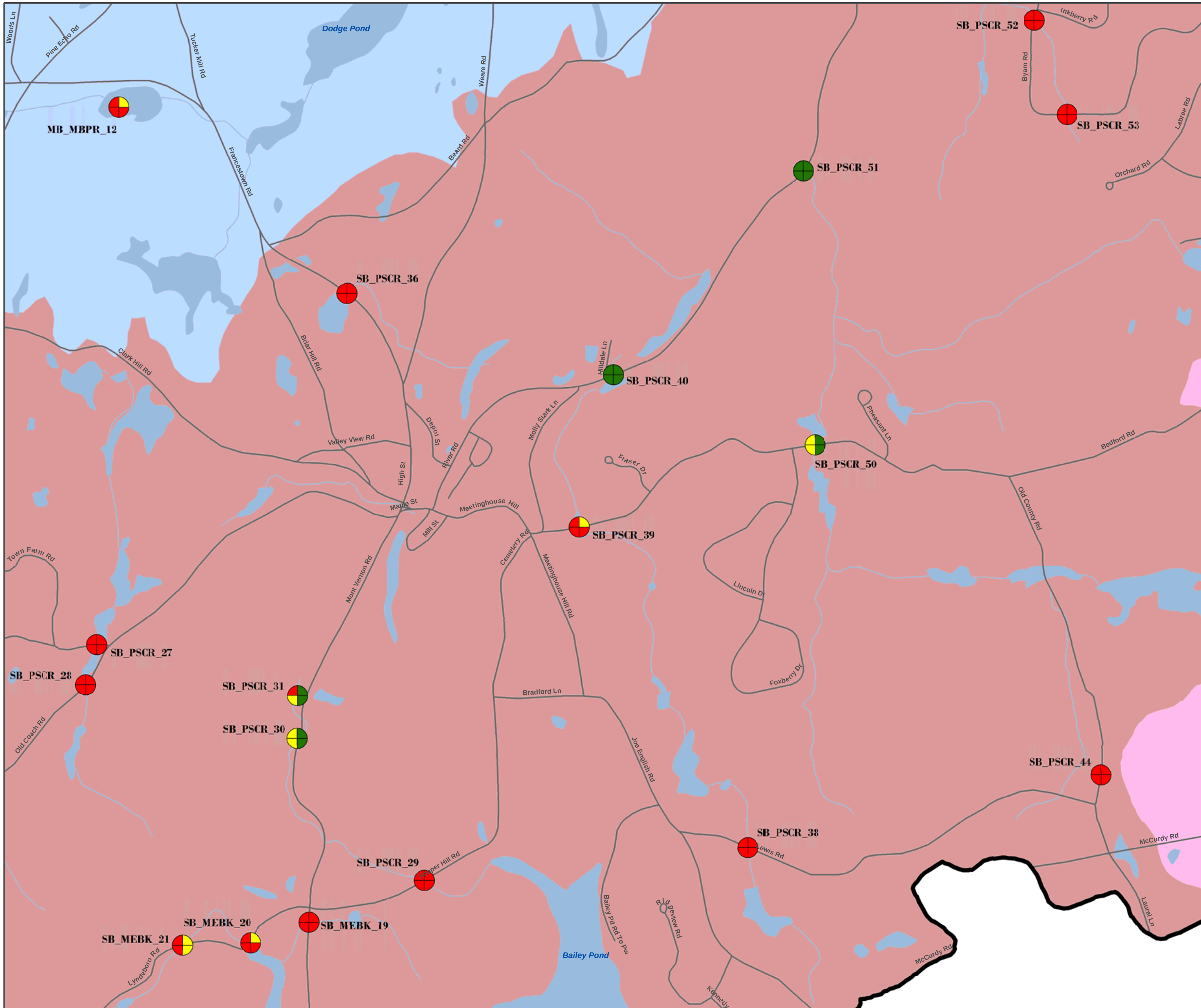


Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 5 of 9



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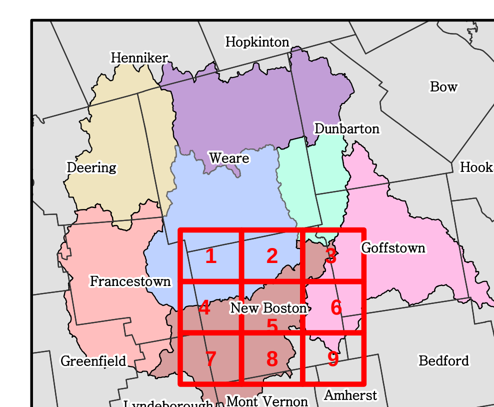
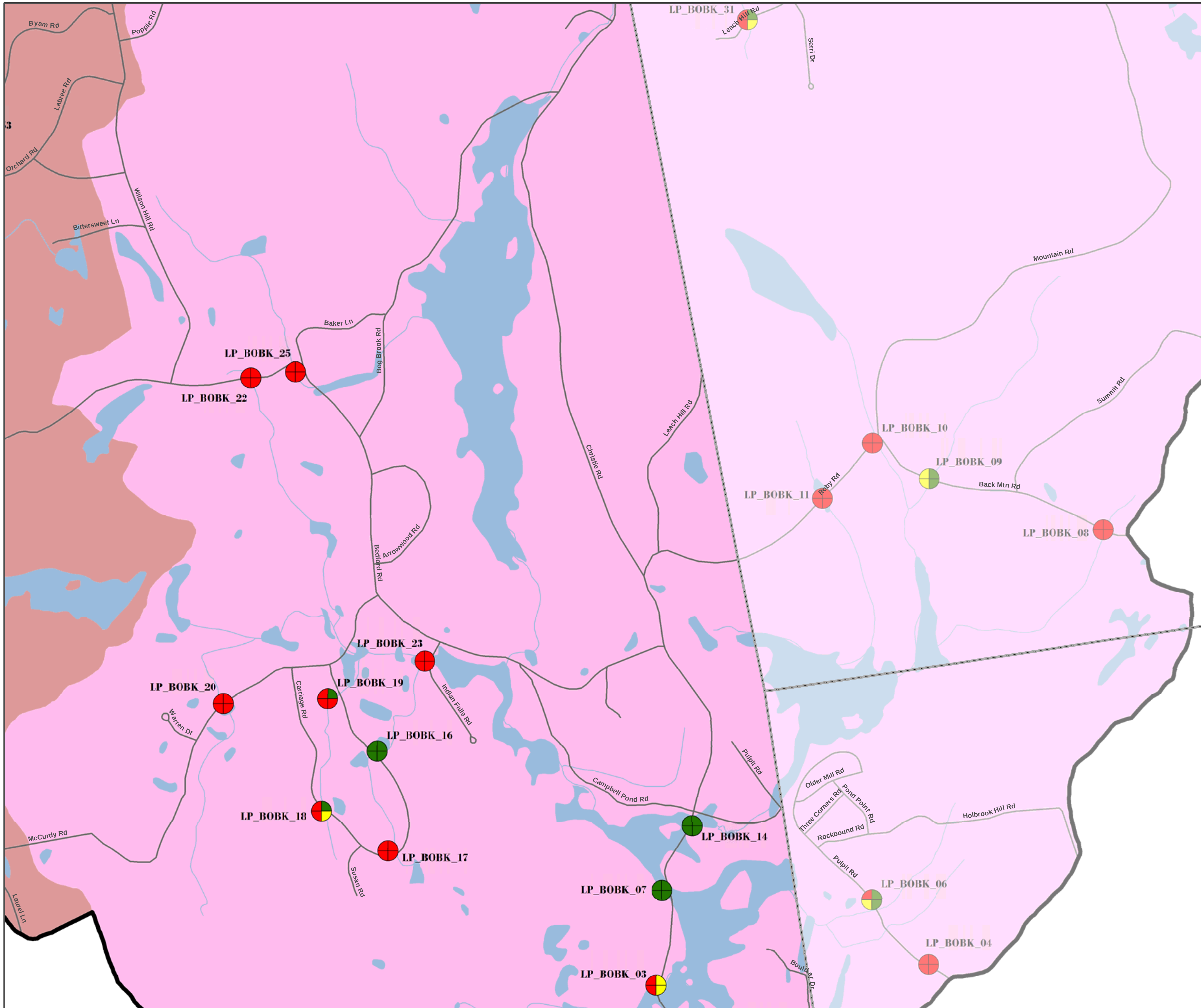


Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 6 of 9



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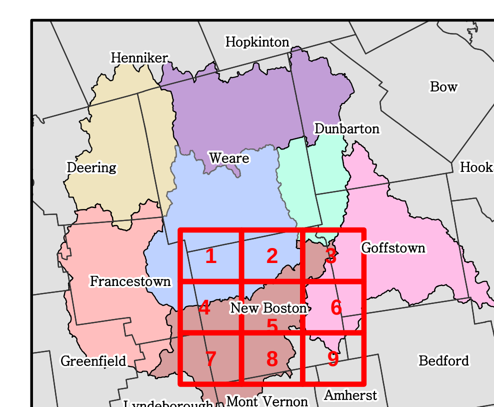

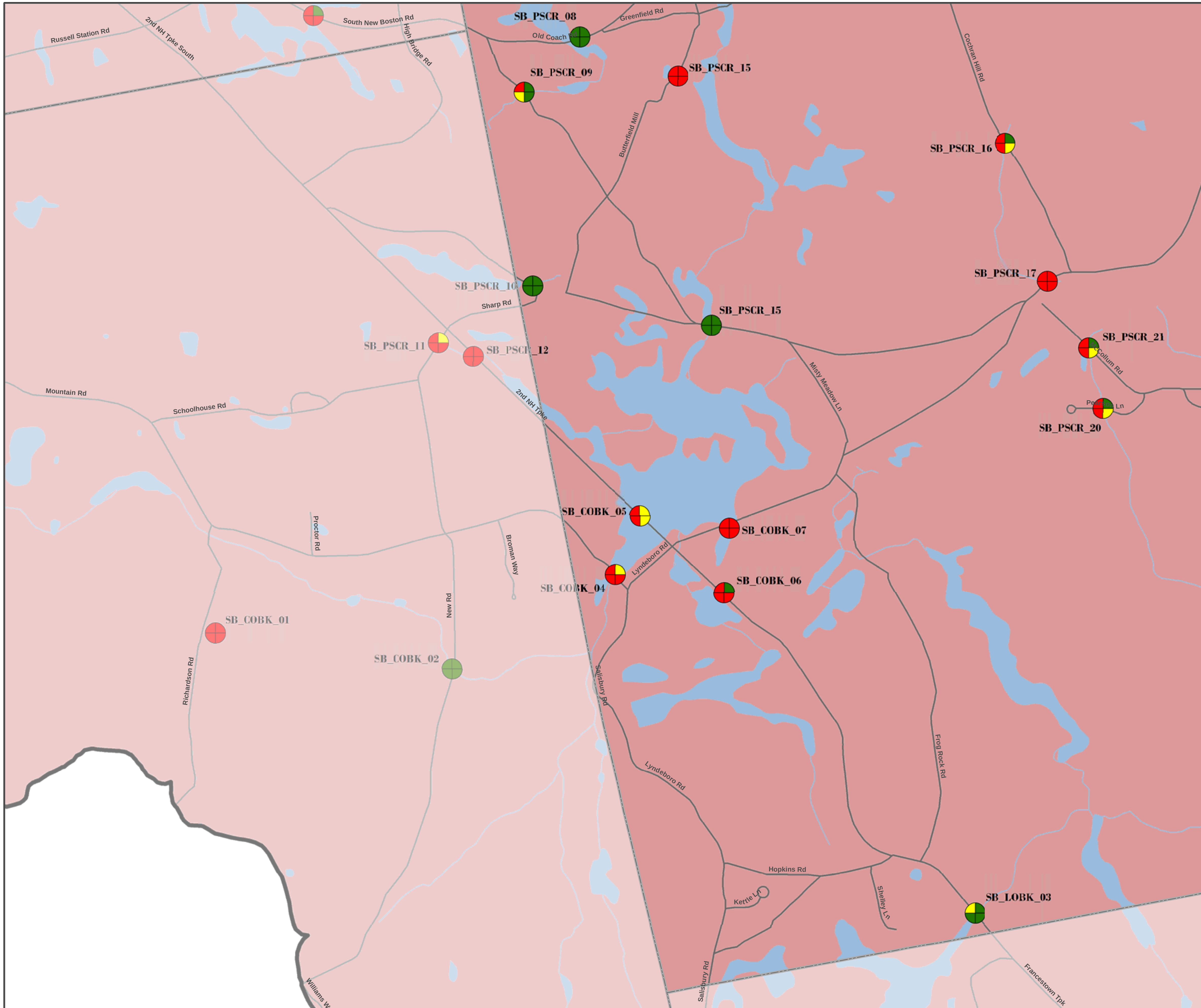

Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 7 of 9

Potential Status of Culvert at Given Storm Event

Pass
Transitional
Fail

Storm Year

100	10
50	25

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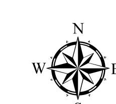

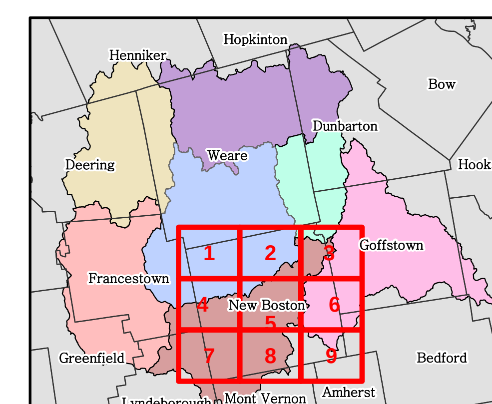

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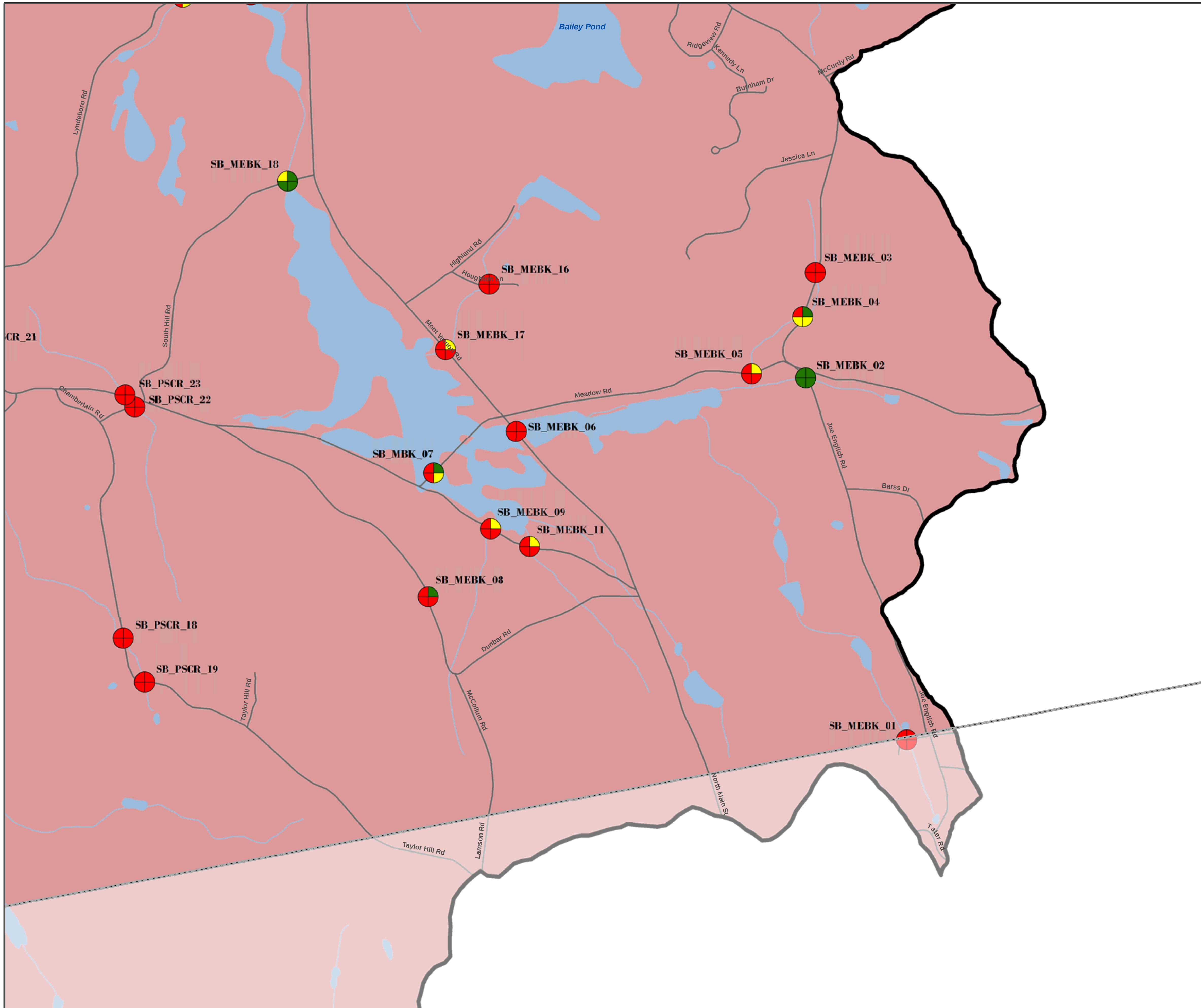

Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 8 of 9

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

- Everett Lake
- Lower Piscataquog River
- Middle Branch Piscataquog River
- Rand Brook-South Branch
- South Branch Piscataquog River
- Upper Piscataquog River
- Weare Reservoir

0 0.125 0.25 0.5 Miles

Data Sources:
NH GRANIT Digital Data (1:24,000)
NH Department of Transportation
NH Department of Environmental Services
Trout Unlimited
Southern New Hampshire Planning Commission

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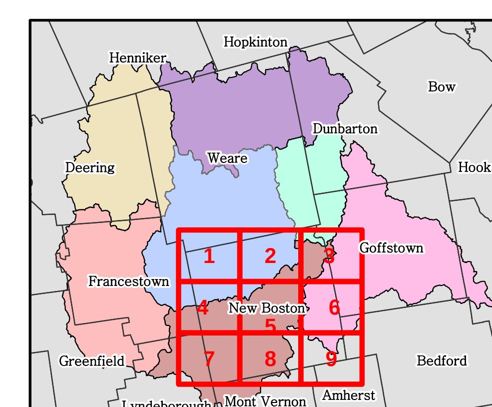

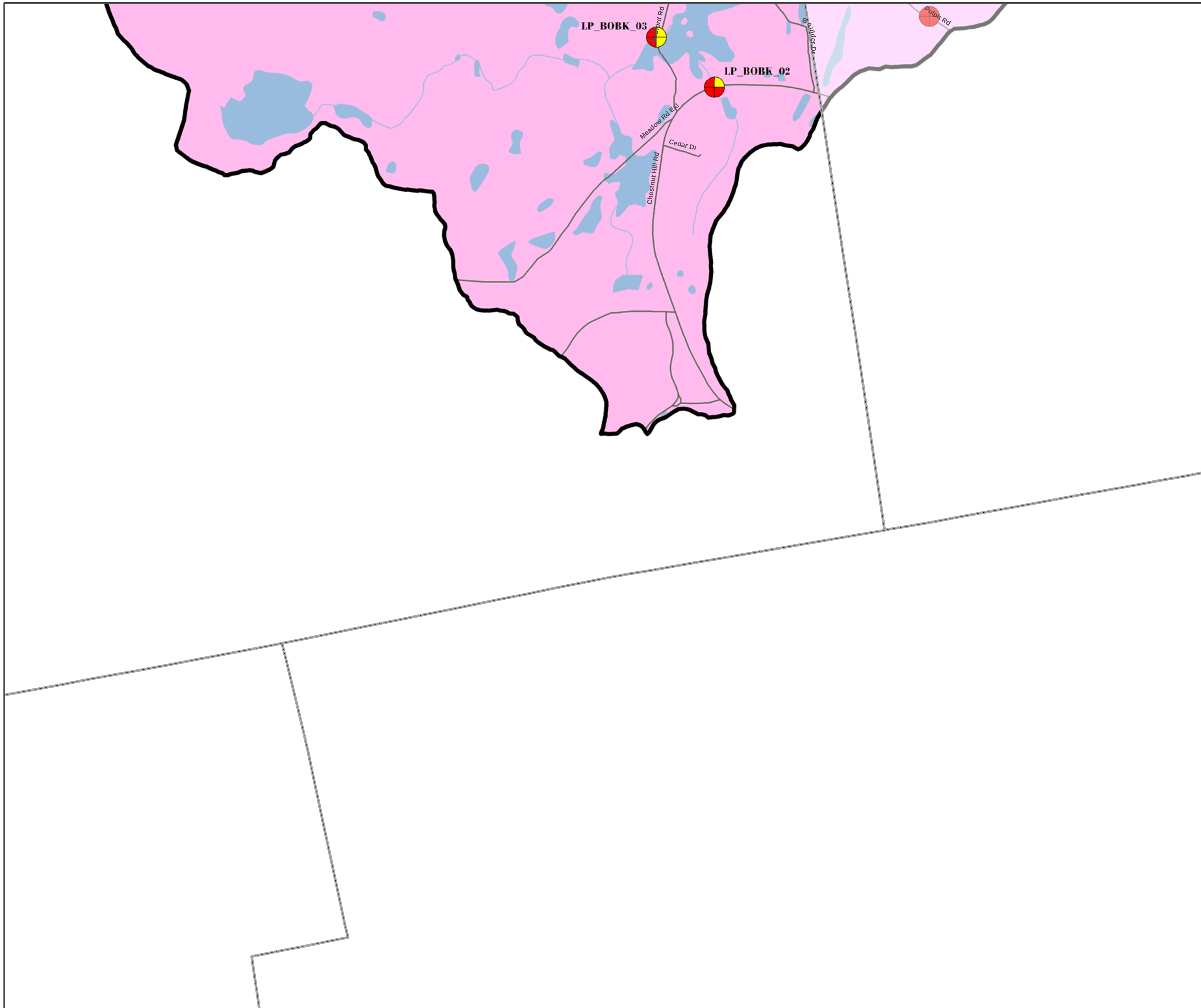

Piscataquog River Hydrology Assessment 2014

Town of New Boston

Map 9 of 9

Potential Status of Culvert at Given Storm Event

Storm Year

100 | 10
50 | 25

- Pass
- Transitional
- Fail

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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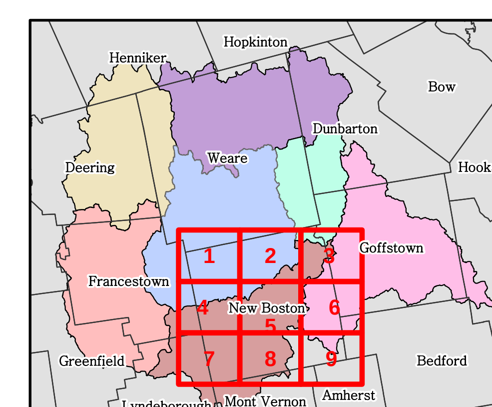

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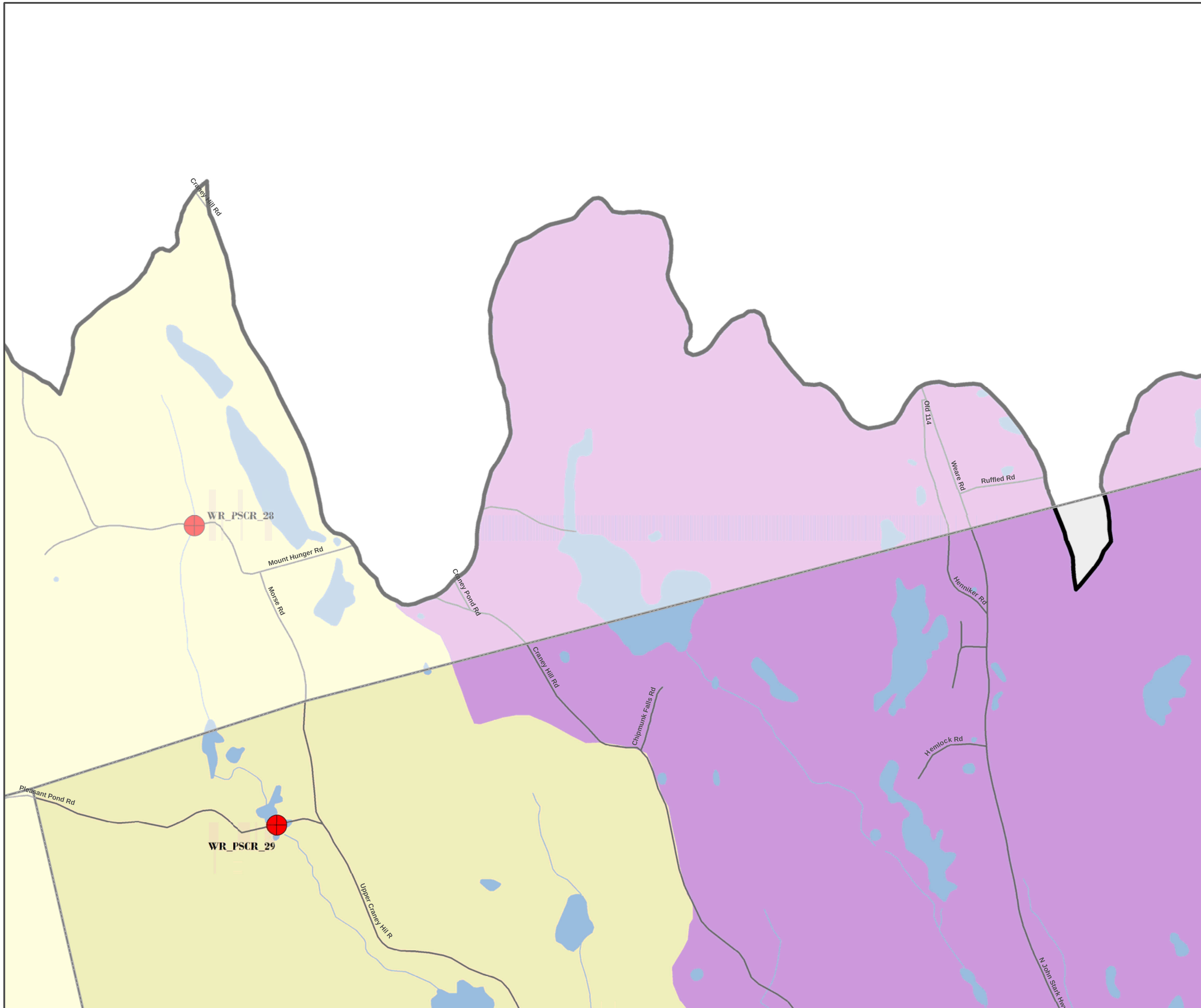

Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 1 of 12

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

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- Roads
- Lakes and Wetlands
- Streams

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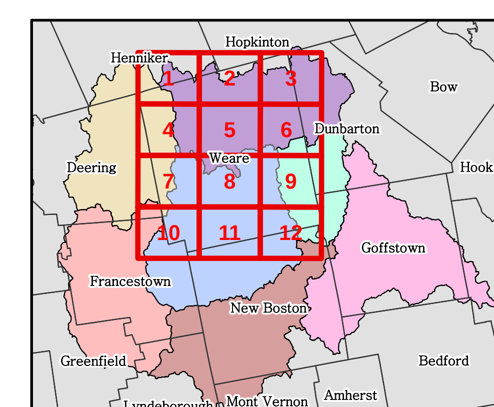

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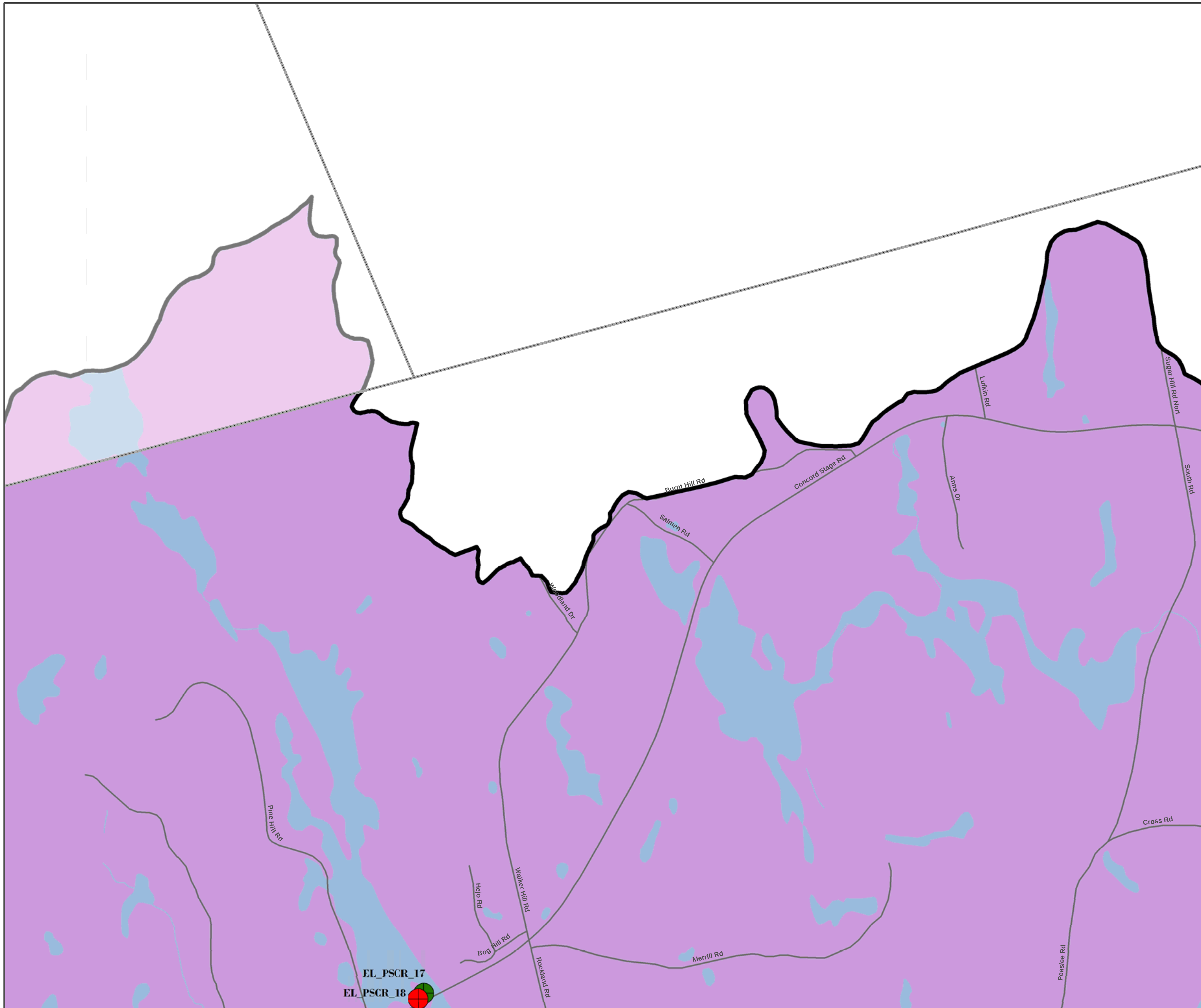

Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 2 of 12

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

HUC 12 Sub-Watersheds

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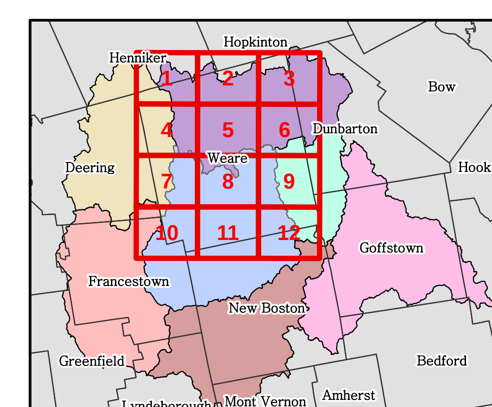
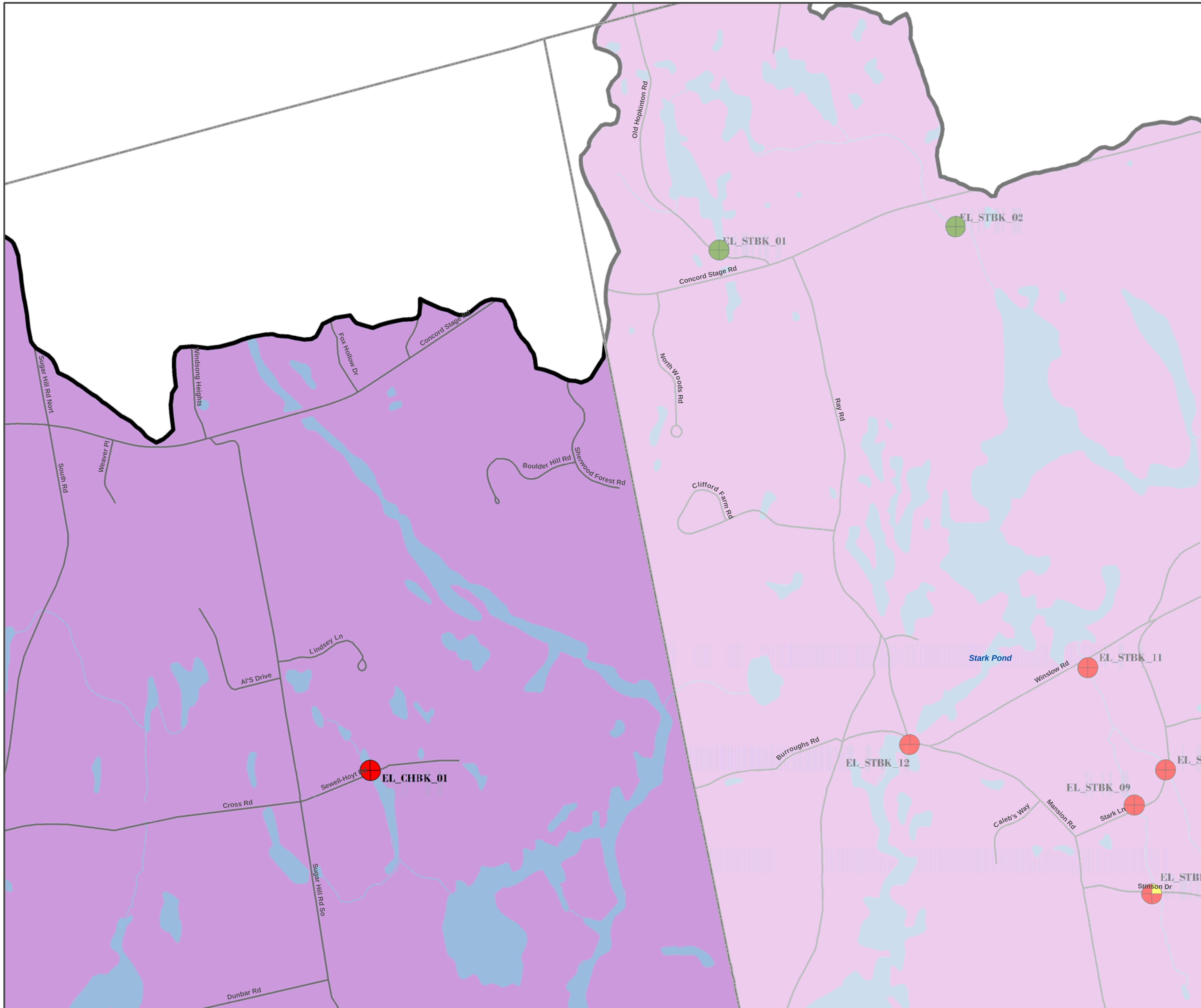


Piscataquog River Hydrology Assessment 2014

Town of Weare
Map 3 of 12



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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0 0.125 0.25 0.5 Miles

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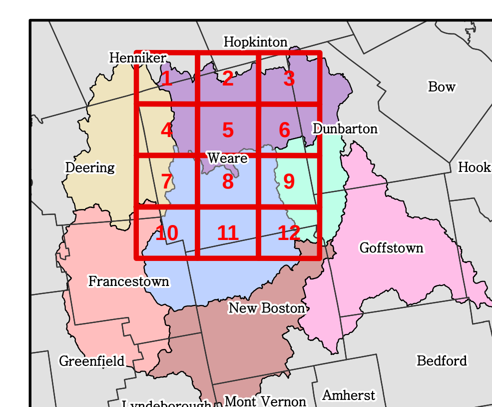

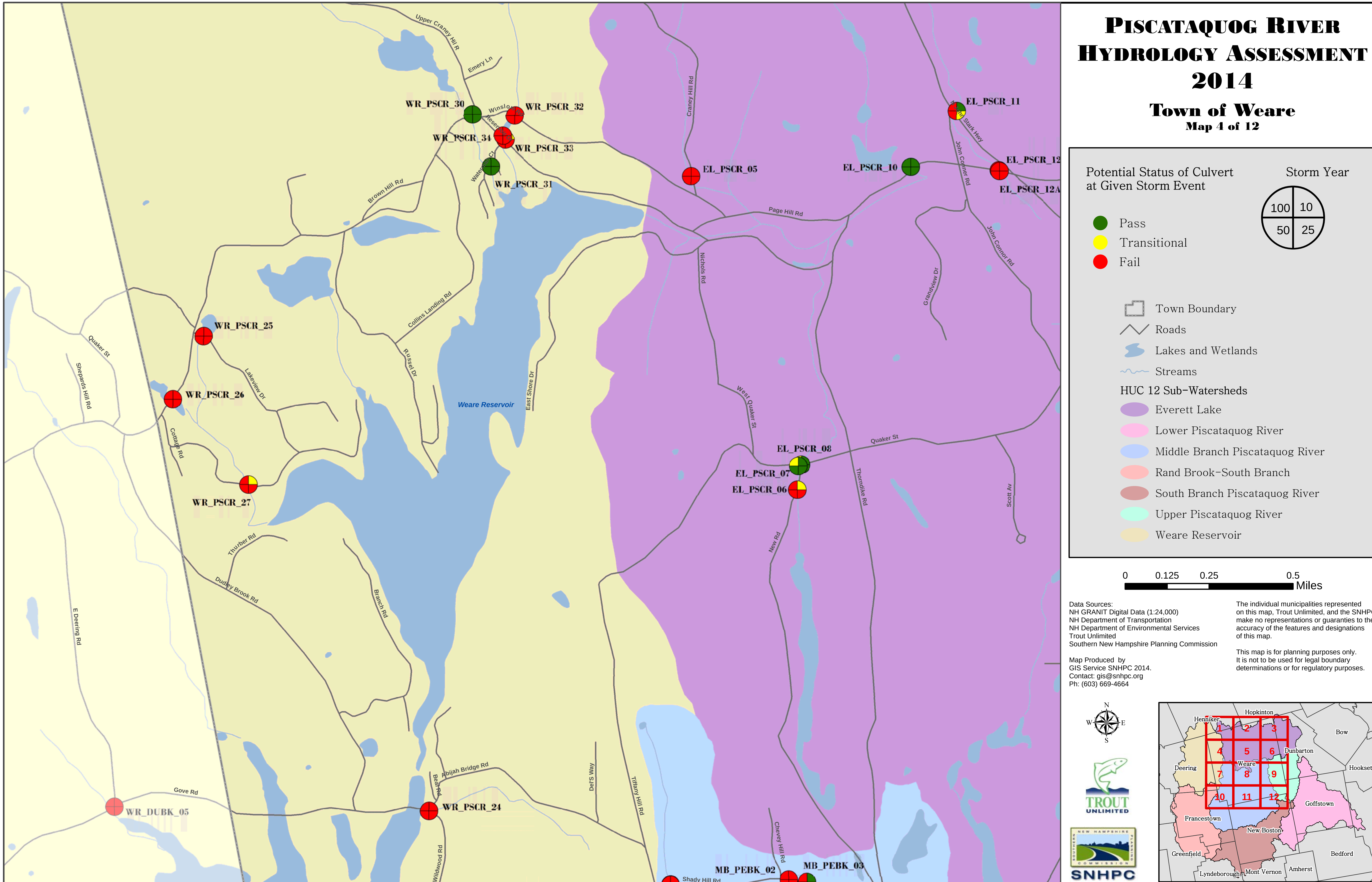

Piscataquog River Hydrology Assessment 2014
Town of Weare
Map 4 of 12
Potential Status of Culvert at Given Storm Event
Pass
Transitional
Fail
Storm Year
100
10
50
25
Town Boundary
Roads
Lakes and Wetlands
Streams
HUC 12 Sub-Watersheds
Everett Lake
Lower Piscataquog River
Middle Branch Piscataquog River
Rand Brook-South Branch
South Branch Piscataquog River
Upper Piscataquog River
Weare Reservoir
0
0.125
0.25
0.5
Miles
Data Sources:
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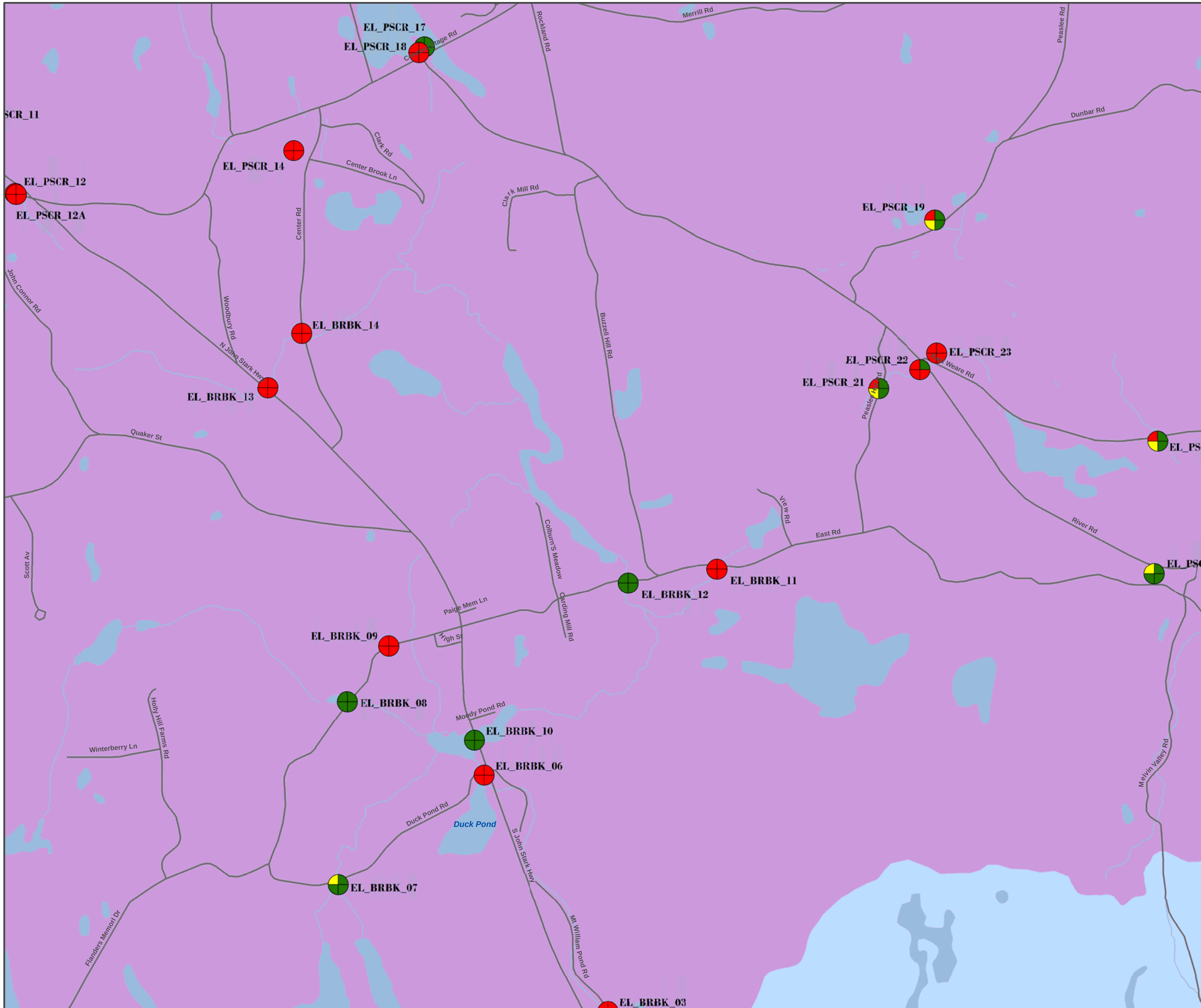
WR_PSCR_30
WR_PSCR_32
WR_PSCR_34
WR_PSCR_33
WR_PSCR_31
WR_PSCR_25
WR_PSCR_26
WR_PSCR_27
WR_PSCR_24
WR_DUBK_05
EL_PSCR_05
EL_PSCR_10
EL_PSCR_11
EL_PSCR_12
EL_PSCR_12A
EL_PSCR_08
EL_PSCR_07
EL_PSCR_06
MB_PEBK_02
MB_PEBK_03
Weare Reservoir
Upper Craney Hill R
Emery Ln
Brown Hill Rd
Collins Landing Rd
Quaker St
Shepards Hill Rd
Lakeview Dr
Russel Dr
East Shore Dr
Cottage Rd
Thurber Rd
Dudley Brook Rd
Branch Rd
E Deering Rd
Gove Rd
Abijah Bridge Rd
Bear Rd
Wildwood Rd
Del'S Way
Tiffany Hill Rd
Shady Hill Rd
Chevey Hill Rd
New Rd
Thorndike Rd
Scott Av
West Quaker St
Nichols Rd
Page Hill Rd
Craney Hill Rd
John Conner Rd
John Connor Rd
Stark Hwy
Grandview Dr
Hopkinton
Henniker
Bow
Dunbarton
Weare
Deering
Hooksett
Goffstown
Francestown
New Boston
Greenfield
Bedford
Lyndeborough
Mont Vernon
Amherst



Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 5 of 12

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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0 0.125 0.25 0.5 Miles

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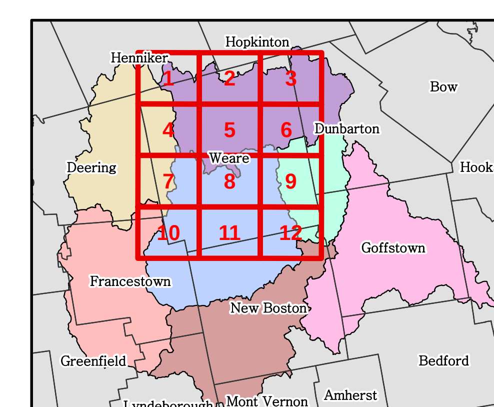
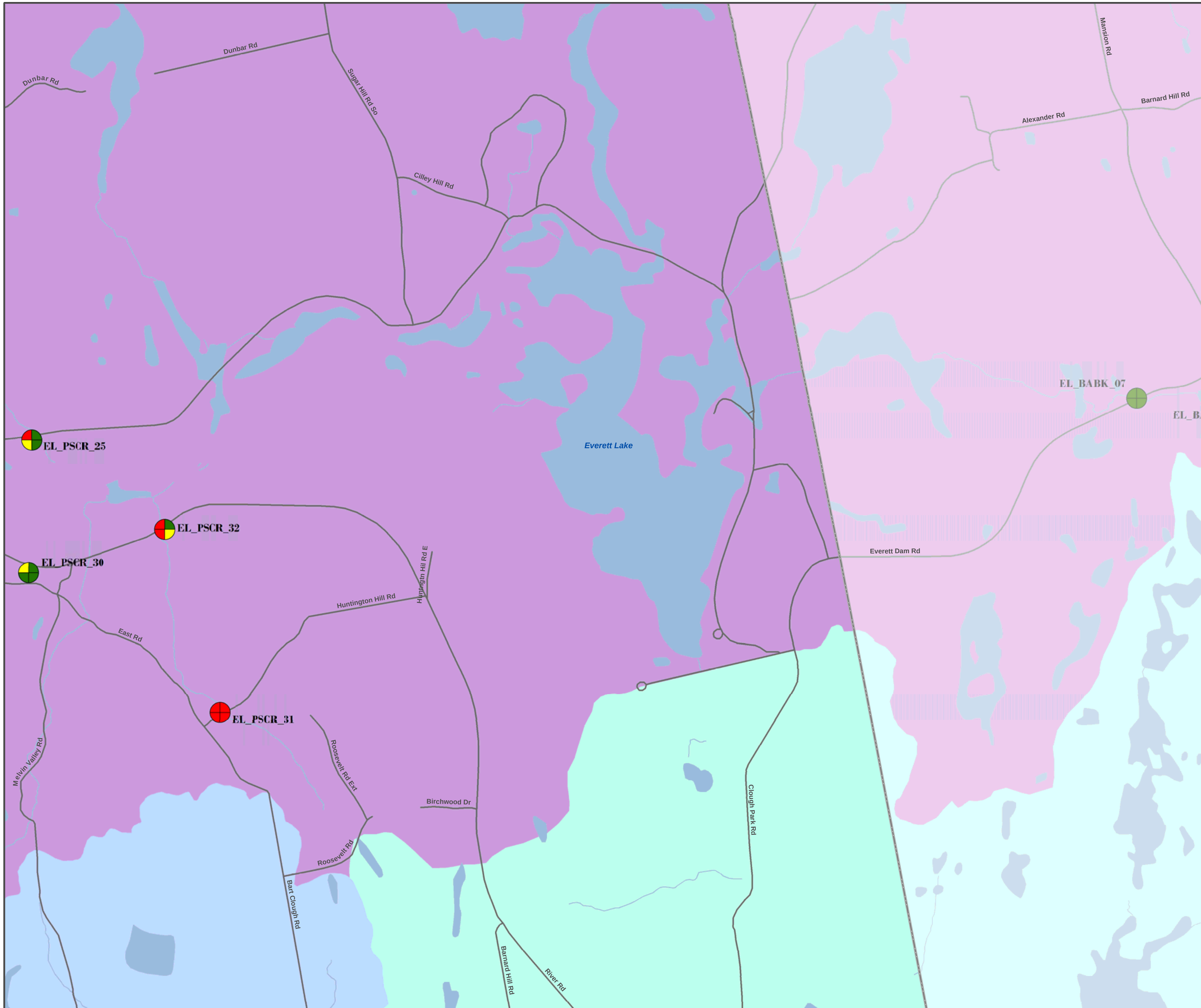


Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 6 of 12



Potential Status of Culvert at Given Storm Event

Storm Year

100 | 10
50 | 25

- Pass
- Transitional
- Fail

- Town Boundary
- Roads
- Lakes and Wetlands
- Streams

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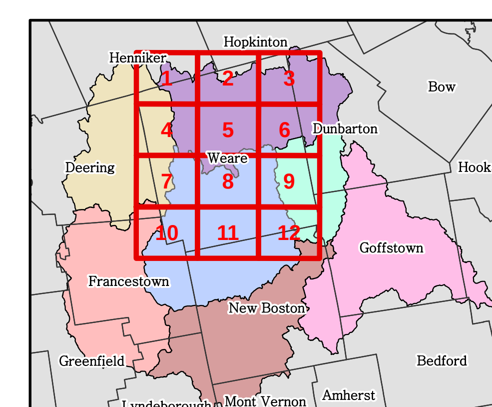

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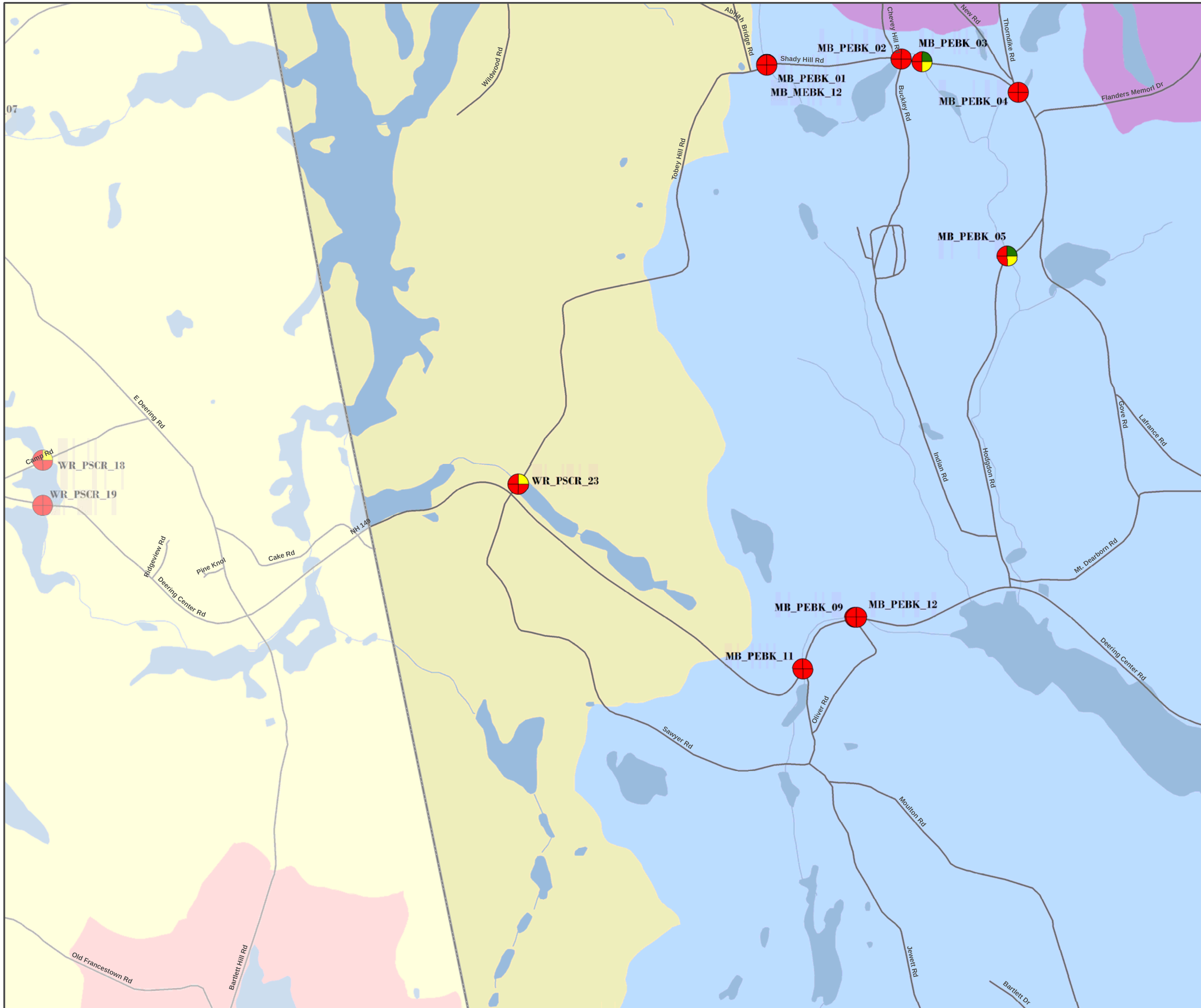

Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 7 of 12

Potential Status of Culvert at Given Storm Event

Storm Year

100 | 10
50 | 25

Pass

Transitional

Fail

Town Boundary

Roads

Lakes and Wetlands

Streams

HUC 12 Sub-Watersheds

Everett Lake

Lower Piscataquog River

Middle Branch Piscataquog River

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South Branch Piscataquog River

Upper Piscataquog River

Weare Reservoir

0 0.125 0.25 0.5 Miles

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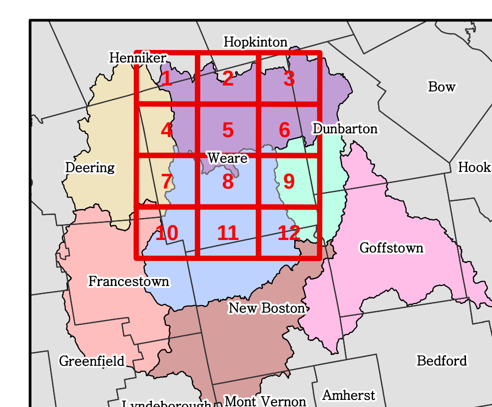
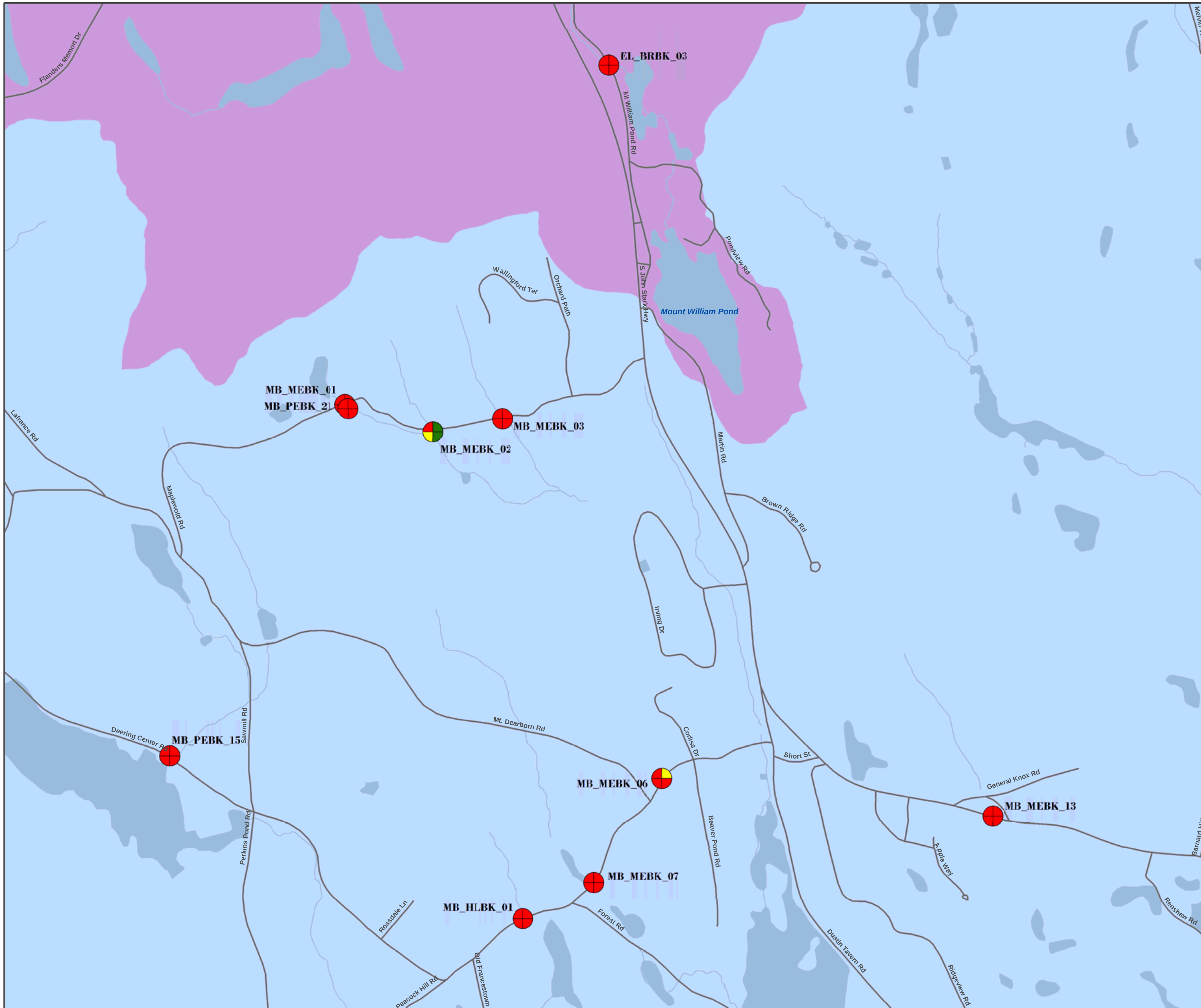


Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 8 of 12



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100 | 10
50 | 25

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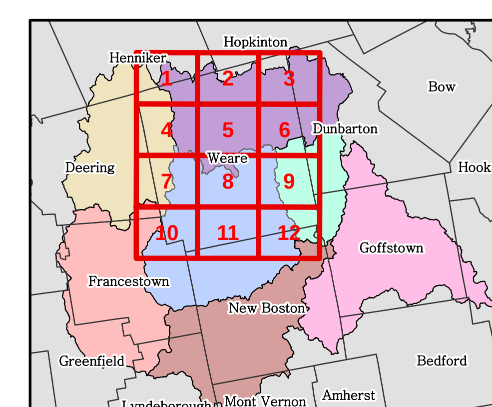

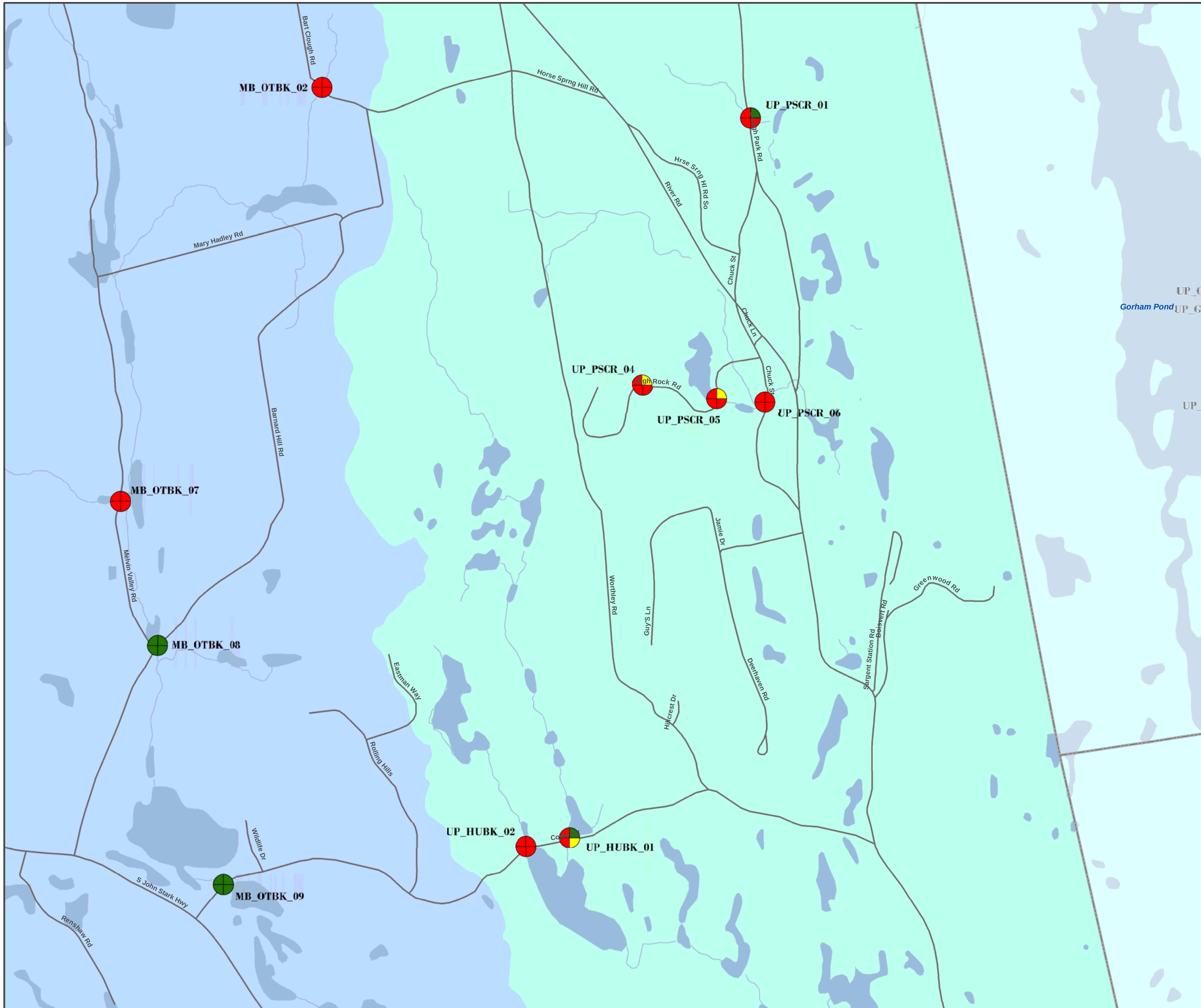

Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 9 of 12

Potential Status of Culvert at Given Storm Event

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- Fail

Storm Year

100 | 10
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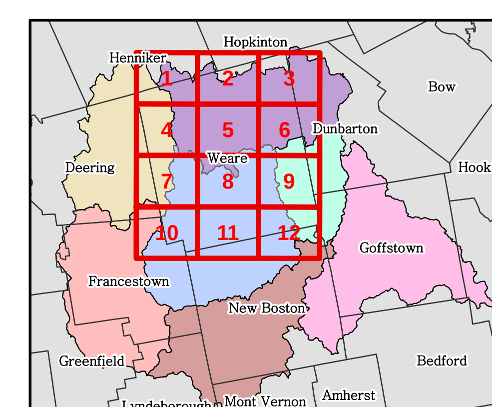
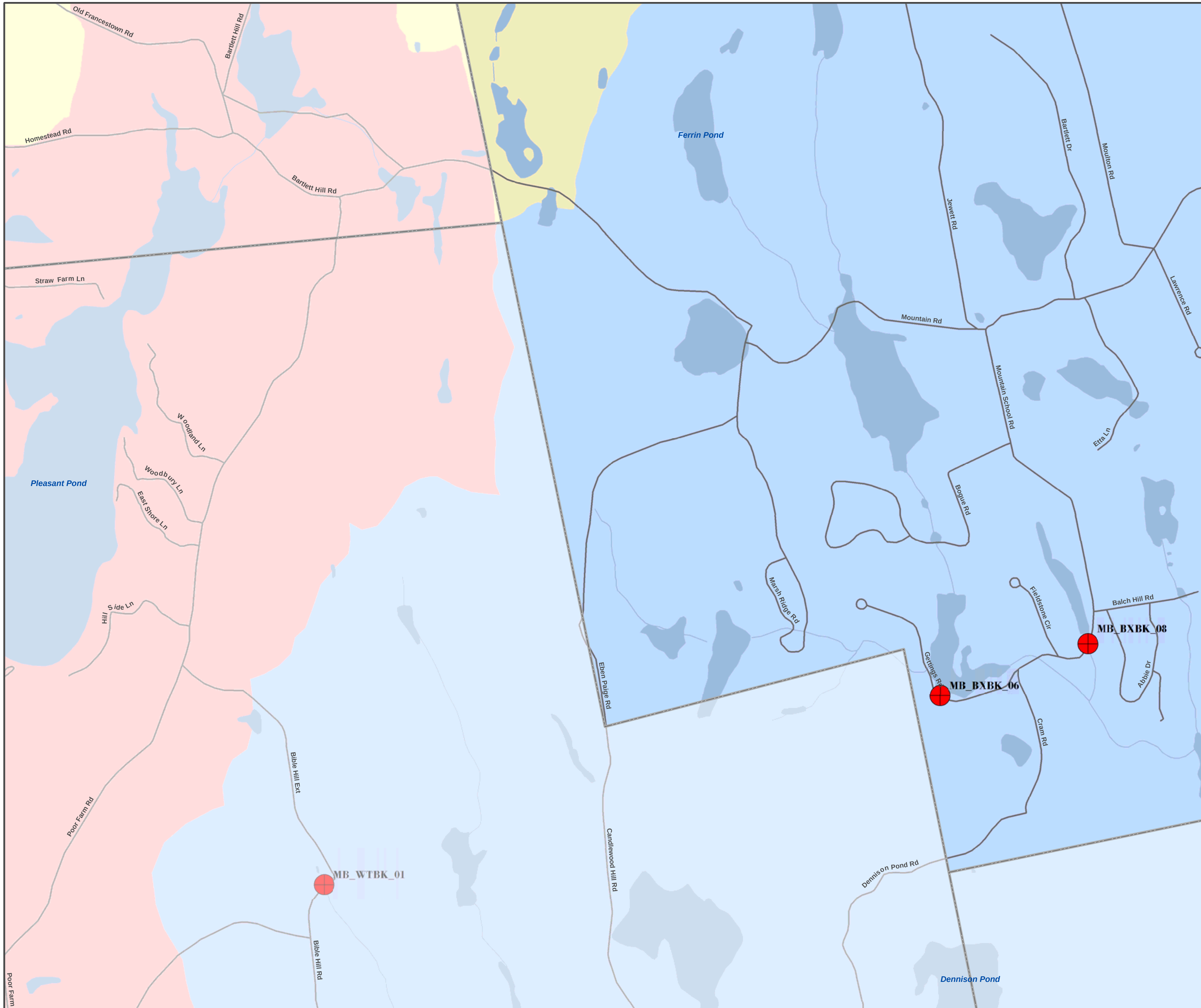


Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 10 of 12



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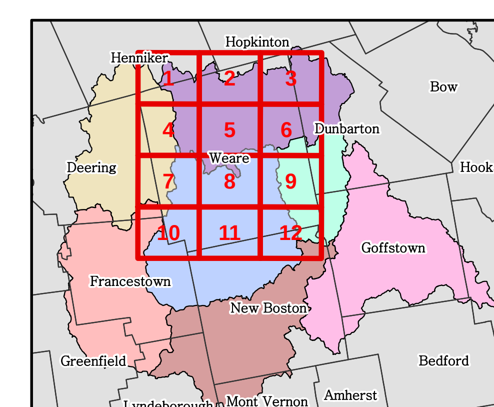

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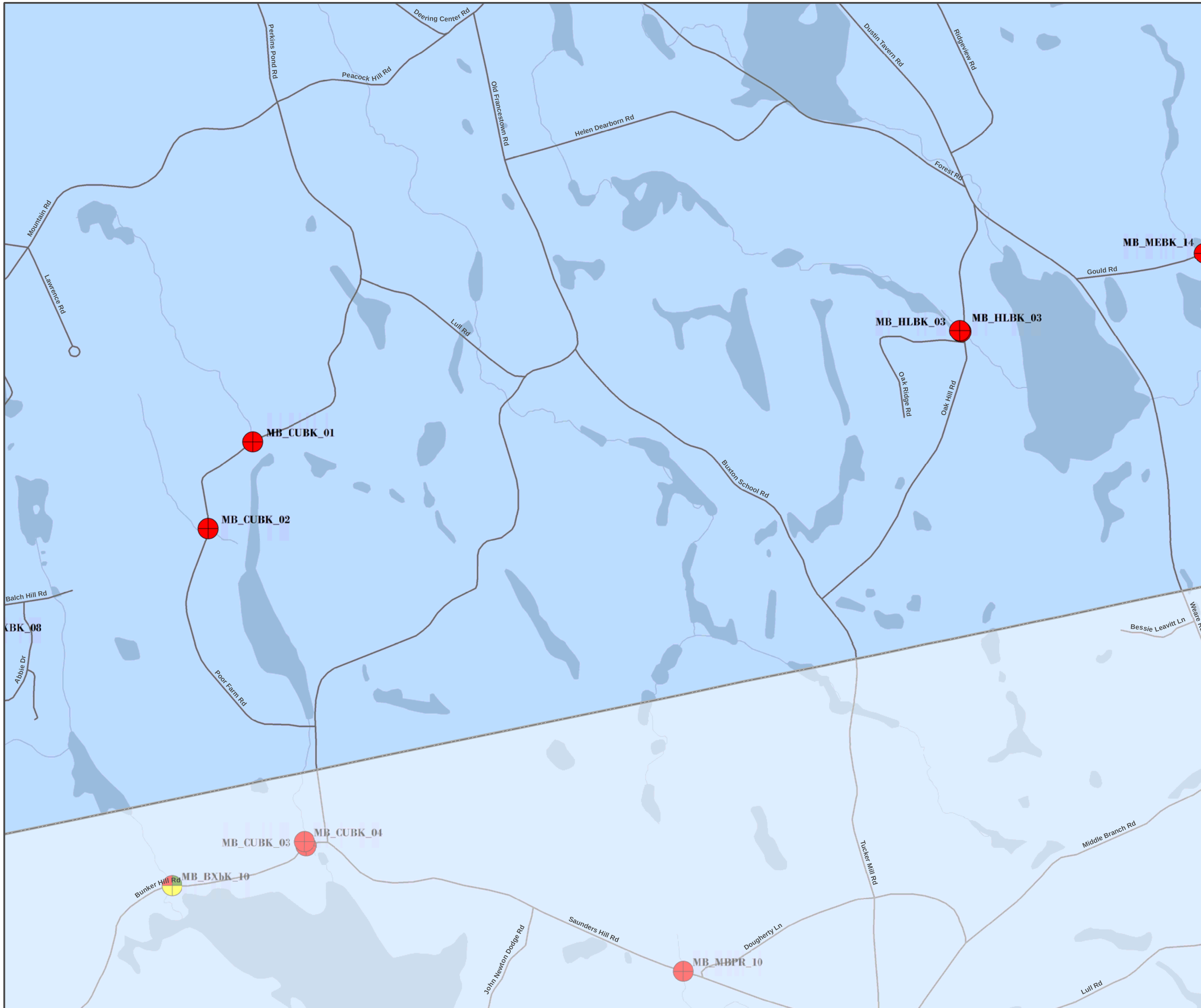

Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 11 of 12

Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100 | 10
50 | 25

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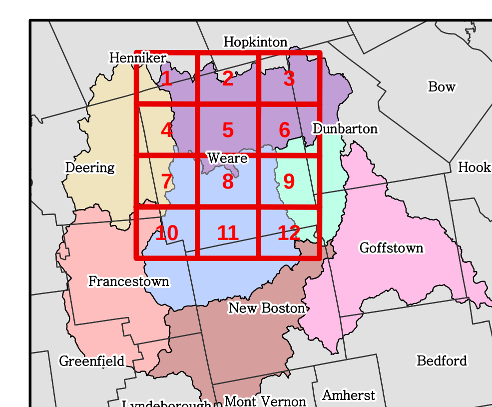

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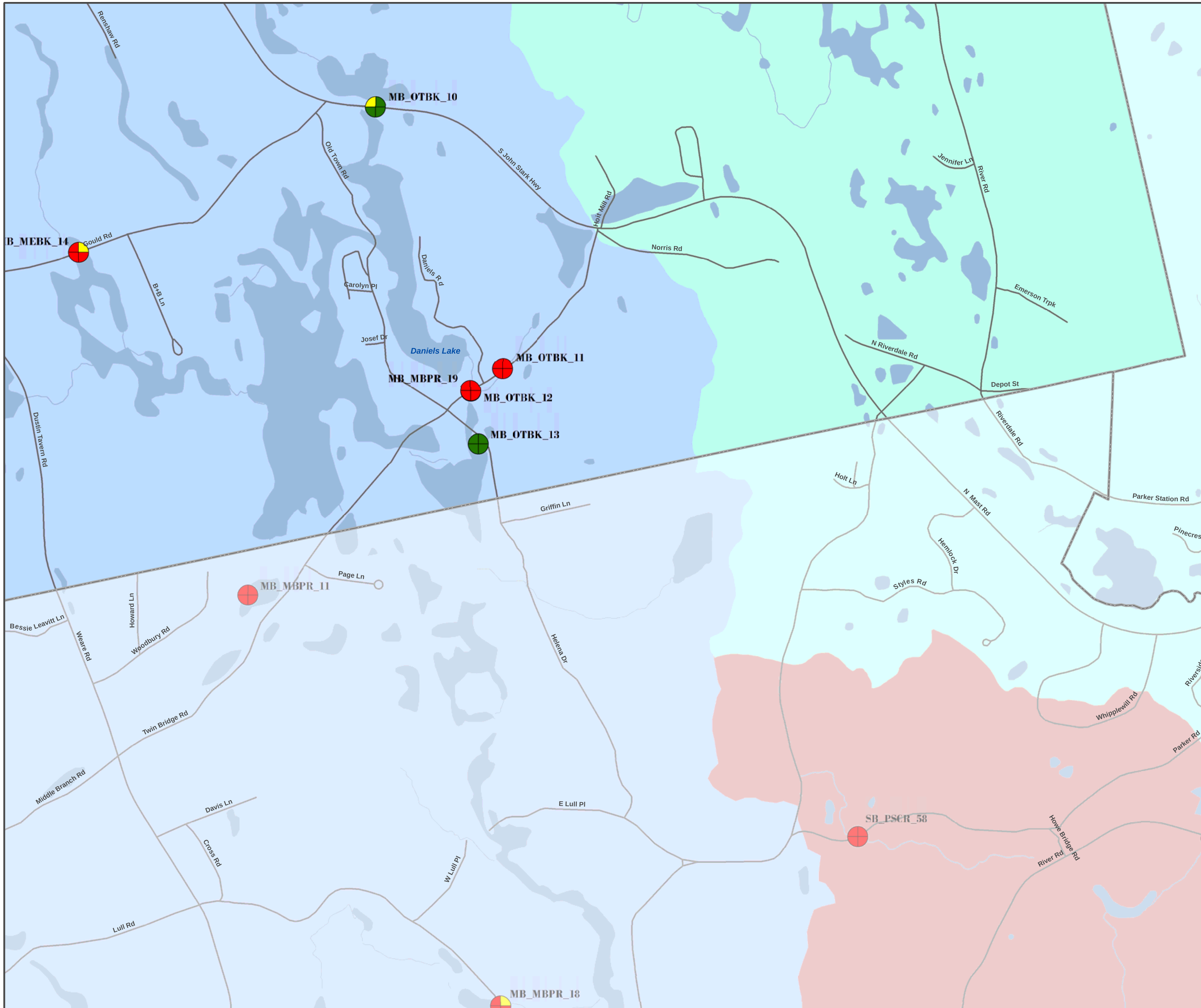
Piscataquog River Hydrology Assessment 2014

Town of Weare

Map 12 of 12



Potential Status of Culvert at Given Storm Event

- Pass
- Transitional
- Fail

Storm Year

100	10
50	25

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- Roads
- Lakes and Wetlands
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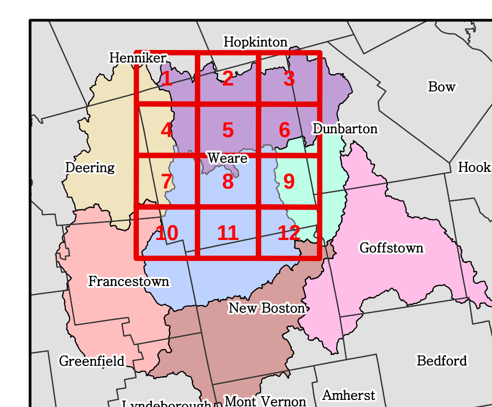

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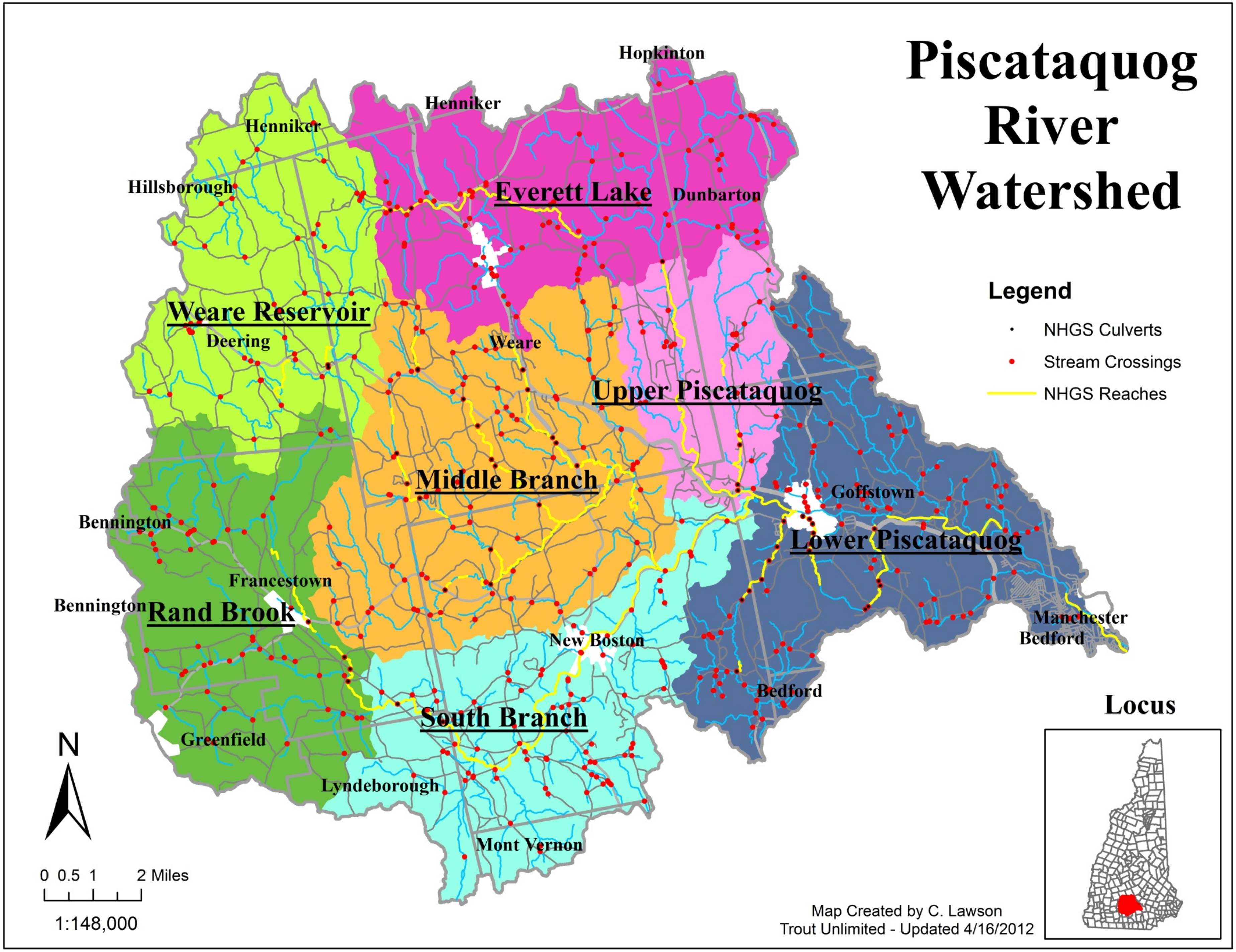
Appendix 5

Piscataquog River Drainage

Overview Map of HUC 12 Basins


Piscataquog River Watershed
Legend
NHGS Culverts
Stream Crossings
NHGS Reaches
Hopkinton
Henniker
Henniker
Hillsborough
Everett Lake
Dunbarton
Weare Reservoir
Deering
Weare
Upper Piscataquog
Middle Branch
Goffstown
Bennington
Lower Piscataquog
Francestown
Bennington
Rand Brook
New Boston
Manchester
Bedford
Bedford
South Branch
Greenfield
Lyndeborough
Mont Vernon
N
0 0.5 1 2 Miles
1:148,000
Locus
Map Created by C. Lawson
Trout Unlimited - Updated 4/16/2012

Appendix 6

Excel Model ~ Tabular Results by Town

Appendix 6

Tabular Results of Hydraulic Modeling by Town

Town of Bedford

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
BEDFORD	Pulpit	Bog Brook	LP_BOBK_04	Culvert	42.95898	-71.60807	New	2	7.3	Free Fall	0.1	57	18.9	RED	P	F	F	F	F
BEDFORD	Pulpit	Bog Brook	LP_BOBK_06	Culvert	42.96147	-71.61105	New	2.5	3.2	At Grade	0	41	23.6	GRAY	P	P	P	T	F

Town of Deering

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
DEERING	Camp Rd	Piscataquog Trib	WR_PSCR_18	Culvert	43.06532	-71.80962	New	2.7	1	At Grade	0	30		GRAY	P	T	F	F	F
DEERING	Clement Hill	Smith Brook	WR_SMBK_02	Culvert	43.09745	-71.8461	Old	2	2	Backwatered	0	20		GRAY	-	-	-	-	-
DEERING	Clement Hill Rd	smith brook	WR_SMBK_03	Culvert	43.09423	-71.82984	New	3	2	Free Fall	2	28		RED	P	P	P	T	F
DEERING	Cross Rd	Piscataquog	WR_PSCR_17	Culvert	43.07043	-71.81368	New	3	5	Free Fall	0.6	40	23.3	ORANGE	-	-	-	-	-
DEERING	Deering Rd	Piscatatquog	WR_PSCR_19	Culvert	43.06354	-71.80912	Rusted	5	0.2	At Grade	0	41		GREEN	F	F	F	F	F
DEERING	Dudley Pond rd	Dudley Brook	WR_DUBK_02	Culvert	43.12263	-71.83088	Rusted	4	1	At Grade	0	23	34.5	GRAY	P	P	T	T	F
DEERING	E Deering	Piscataquog Trib	WR_PSCR_14	Culvert	43.0624	-71.82488	New	6.5	2	Free Fall	0.1	78	42.3	RED	P	P	P	P	P
DEERING	E deering	Piscataquog	WR_PSCR_35	Culvert	43.06324	-71.82751	New	3	0.2	At Grade	0	42	24.8	GRAY	P	T	F	F	F
DEERING	E Deering Rd	Dudley Brook	WR_DUBK_04	Bridge	43.08327	-71.79591	New	27.5	2	At Grade	0	26.7	81.4	GRAY	-	-	-	-	-
DEERING	E Deering Rd	Dudley Brook	WR_DUBK_07	Culvert	43.07826	-71.81564	New	4	7	At Grade	0	58	18.3	GRAY	P	P	P	T	F
DEERING	E Deering Rd	Piscataquog Trib	WR_PSCR_03	Culvert	43.0753	-71.8479	New	2.5	6	Free Fall	2.9	54	12.6	RED	P	T	F	F	F
DEERING	E Deering Rd	Piscataquog Trib	WR_PSCR_13	Culvert	43.06407	-71.82979	Old	3	5	At Grade	0	34.5	39.8	GRAY	P	P	P	P	P
DEERING	Falls Rd	Piscataquog	WR_PSCR_01	Culvert	43.05421	-71.86857	New	3	1	Free Fall	0.8	30		RED	P	T	F	F	F
DEERING	Fisher	Piscataquog Trib	WR_PSCR_04	Culvert	43.07446	-71.84828	Rusted	3	3	Free Fall	0.6	37.5	22.4	ORANGE	P	F	F	F	F
DEERING	Fisher	Piscataquog Trib	WR_PSCR_06	Culvert	43.07433	-71.85207	Old	2	1	Free Fall	1	38	33.4	RED	F	F	F	F	F
DEERING	Fisher	Piscataquog Trib	WR_PSCR_08	Culvert	43.07413	-71.8536	Collapsing	3.3	5	Free Fall	0.3	20	28.3	RED	F	F	F	F	F
DEERING	Glenn Rd	Dudley Brook	WR_DUBK_06	Culvert	43.07903	-71.81767	New	1.4	2	Free Fall	1.3	29.5	13.8	RED	F	F	F	F	F
DEERING	Gove Rd	Dudley Brook	WR_DUBK_05	Culvert	43.08352	-71.8055	Collapsing	2	5	Free Fall	1	46	23.5	RED	F	F	F	F	F
DEERING	Lake Shore Rd	Piscataquog	WR_PSCR_05	Culvert	43.07181	-71.85101	New	1.9	2	At Grade	0	27	20.1	GRAY	P	P	T	F	F
DEERING	Lakeview	Piscataquog	WR_PSCR_25	Arch	43.10398	-71.80003	Old	1.7	5	At Grade	0	23.5		GRAY	P	F	F	F	F
DEERING	North Rd	Smith Brook	WR_SMBK_04	culvert	43.11009	-71.83965	Old	5.5	0.7	At Grade	0	40	52.6	GRAY	-	-	-	-	-
DEERING	North Rd	Smith Brook	WR_SMBK_05	Culvert	43.11163	-71.83509	Old	5.5	2	At Grade	0	49	37.0	GRAY	P	P	P	T	T
DEERING	Old County	Piscataquog	WR_PSCR_02	Culvert	43.05313	-71.86038	Rusted	5.5	2	Backwatered	0	40		GRAY	P	P	P	T	T
DEERING	Old Francestown	Piscataquog Trib	WR_PSCR_16	Bridge	43.05757	-71.82323	Old	3	13	Free Fall		28	29.6	GRAY	P	P	P	P	P

Town of Deering, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
DEERING	Peterwood	Dudley Brook	WR_DUBK_03	Bridge	43.09982	-71.80852	Old			At Grade	0	21.4	0.0	GRAY	-	-	-	-	-
DEERING	Pleasant Pond Rd	Piscataquog Trib	WR_PSCR_15	Bridge	43.05729	-71.82349	New	1.6	10	Free Fall	0.8	27	15.9	RED	F	F	F	F	F
DEERING	Pond	Patten Brook	WR_PABK_01	Culvert	43.1154	-71.83379	New	3.3	1.5	At Grade	0	27		GRAY	P	P	P	P	P
DEERING	Quaker	Dudley Brook	WR_DUBK_01	Culvert	43.12522	-71.82655	Rusted	2	3	At Grade	0	22	21.7	GRAY	F	F	F	F	F
DEERING	Reservoir Rd	Piscataquog	WR_PSCR_26	Arch	43.10122	-71.80196	Old	2.7	0.7	At Grade	0	36		GRAY	F	F	F	F	F
DEERING	Tobey Hill Rd	Piscataquog	WR_PSCR_23	Bridge	43.06467	-71.78526	Old	2.8	0	At Grade	0	16	18.1	GRAY	P	T	F	F	F
DEERING	Wildwood Rd	Piscatatquog River	WR_PSCR_24	Culvert	43.08384	-71.78665	New	2.7	2	At Grade	0	40.5	23.8	GRAY	F	F	F	F	F
DEERING	Zoski	Piscataquog	WR_PSCR_07	Culvert	43.07238	-71.85246	New	3	1	Free Fall	0.4	29.5	29.0	RED	T	F	F	F	F
DEERING	Zoski	Piscataquog	WR_PSCR_09	Culvert	43.07119	-71.85194	New	4	2	Free Fall	0.4	33	36.2	ORANGE	P	P	T	F	F

Town of Dunbarton

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
DUNBARTON	Barnard Hill Rd	Barnard Brook	EL_BABK_01	Culvert	43.11141	-71.62222	Rusted	1	3	Cascade	1.7	31		GRAY	F	F	F	F	F
DUNBARTON	Black Brook Rd	Harry Brook	LP_HABK_02	Culvert	43.07354	-71.60581	New	3	1	At Grade	0	40		GRAY	T	F	F	F	F
DUNBARTON	Black Brook Rd	Harry Brook	LP_HABK_05	Culvert	43.0711	-71.59972	Old	3	0.3	At Grade	0	58	20.9	GRAY	P	F	F	F	F
DUNBARTON	Everett Dam Rd	Barnard Brook	EL_BABK_07	Culvert	43.10332	-71.6373	New	6	3	At Grade	0	44	25.9	GRAY	P	P	P	P	P
DUNBARTON	Gorham Lake Rd	Gorham Brook	UP_GOBK_02	Culvert	43.0809	-71.62035	Old	1	6	Cascade	0.2	47		GRAY	F	F	F	F	F
DUNBARTON	Gorham Lake Rd	Gorham Brook	UP_GOBK_03	Culvert	43.0743	-71.62659	Rusted	2	2	At Grade	0	40	19.9	GRAY	F	F	F	F	F
DUNBARTON	Gorham Pond Rd	Gorham Brook	UP_GOBK_04	Culvert	43.08091	-71.62016	Old	1.1	9	Free Fall	0.4	47		RED	F	F	F	F	F
DUNBARTON	Gorham Pond Rd	Gorham Brook	UP_GOBK_08	Culvert	43.06791	-71.62965	Old	1.3	1.5	At Grade	0	50		GRAY	F	F	F	F	F
DUNBARTON	Gorham Pond rd	Gorham Brook	UP_GOBK_09	Culvert	43.06695	-71.63087	Old	2	3	Free Fall	0.5	63	12.6	RED	T	F	F	F	F
DUNBARTON	Holiday Shore	Gorham Brook	UP_GOBK_07	Culvert	43.07118	-71.63113	Old	2.5	5	At Grade	0	25	27.6	GRAY	P	P	P	T	F
DUNBARTON	Karen Rd	gorham Brook	UP_GOBK_05	Culvert	43.07018	-71.62985	New	3	6.4	At Grade	0	25	34.2	GRAY	P	P	T	F	F
DUNBARTON	Long Pond Rd	Harry Brook	LP_HABK_04	Culvert	43.07261	-71.59988	Old	3	3	Free Fall	0.8	72	20.0	ORANGE	P	T	F	F	F
DUNBARTON	Mansion	Stark Brook	EL_STBK_12	Arch	43.12619	-71.64899	Old	13	0.2	At Grade	0	28	61.8	GREEN	P	P	P	P	P
DUNBARTON	Mansion Rd	Barnard Brook	EL_BABK_03	Culvert	43.10308	-71.63137	Old	2.4	3.5	At Grade	0	38	17.2	GRAY	F	F	F	F	F
DUNBARTON	Mansion Rd	Barnard Brook	EL_BABK_06	Culvert	43.10042	-71.62929	Old	3	8	Free Fall	5.4	58	18.8	RED	P	F	F	F	F
DUNBARTON	MoosePoint Rd	Harry Brook	LP_HABK_03	Culvert	43.08823	-71.60207	Rusted	1.5	0.5	At Grade	0	70		GREEN	F	F	F	F	F
DUNBARTON	no name	Stark Brook	EL_STBK_05	Culvert	43.13624	-71.62258	Rusted	3	2	At Grade	0	62	30.5	GRAY	F	F	F	F	F
DUNBARTON	Old Hopkinton	Stark Brook	EL_STBK_01	Culvert	43.14456	-71.65884	Rusted	1.5	2	At Grade	0	40	13.4	GRAY	F	F	F	F	F
DUNBARTON	Powell Ln	Harry Brook	LP_HABK_01	Culvert	43.07903	-71.61525	Old	1	5	At Grade	0	21		GRAY	F	F	F	F	F
DUNBARTON	Rte 13	Gorham Brook	UP_GOBK_01	Culvert	43.0904	-71.61658	Old	2	1.6	At Grade	0	50		GRAY	T	F	F	F	F
DUNBARTON	Stark	Stark Brook	EL_STBK_09	Culvert	43.12349	-71.6375	Old	2	3	Free Fall	0.2	30	15.9	ORANGE	F	F	F	F	F
DUNBARTON	Stark	Stark Brook	EL_STBK_10	Culvert	43.12494	-71.63572	New	2	2.5	At Grade	0	30	11.0	GRAY	P	F	F	F	F
DUNBARTON	Stark Hwy N	Stark Brook	EL_STBK_06	Culvert	43.13655	-71.62357	New	3.9	2	At Grade	0	82	36.1	GRAY	F	F	F	F	F
DUNBARTON	Stark Lane	Stark Brook	EL_STBK_07	Culvert	43.13618	-71.62782	Rusted	4.5	0	Backwatered	0	65		GRAY	-	-	-	-	-

Town of Dunbarton, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
DUNBARTON	Stephanie Rd	Gorham Brook	UP_GOBK_06	Culvert	43.07111	-71.63091	Old	2	4.3	At Grade	0	28.5	20.0	GRAY	F	F	F	F	F
DUNBARTON	Stephanie Rd	Gorham Brook	UP_GOBK_07	Culvert		0	Old	2	4.3	At Grade	0	28.5	20.0	GRAY	P	P	T	F	F
DUNBARTON	Stinson	Stark Brook	EL_STBK_08	Culvert	43.12035	-71.63635	New	3	4	At Grade	0	57	19.6	GRAY	P	T	F	F	F
DUNBARTON	Tenney Hill	Stark Brook	EL_STBK_03	Culvert	43.1338	-71.61427	Collapsing	3.5	3	Free Fall	1.3	60	20.6	RED	F	F	F	F	F
DUNBARTON	Tenney Hill Rd	Stark Brook	EL_STBK_04	Culvert	43.13527	-71.6208	New	3	5	Free Fall	0.2	32	24.5	RED	T	F	F	F	F
DUNBARTON	Winslow	Stark Brook	EL_STBK_11	Culvert	43.12931	-71.63976	Old	3	1.5	At Grade	0	33	18.3	GRAY	F	F	F	F	F

Town of Francestown

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
FRANCESTOWN	2nd NH Turnpike	unk	RB_DIBK_08	Culvert	43.0194	-71.8674	New	3	5	At Grade	0	32.6	28.6	GREEN	P	F	F	F	F
FRANCESTOWN	2nd NH Turnpike	Dinsmore Brook	RB_DIBK_10	Culvert	43.01745	-71.86208	Old	1.25	1	Backwatered	0	40		GRAY	F	F	F	F	F
FRANCESTOWN	2nd NH Turnpike	Dinsmore Brook	RB_DIBK_11	Culvert	43.01498	-71.85546	Rusted	5	0.2	At Grade	0	31	39.7	GRAY	P	T	F	F	F
FRANCESTOWN	2nd NH Turnpike	Dinsmore Brook	RB_DIBK_15	Arch	43.01271	-71.85046	collapsing	1.2	1.5	At Grade	0	30.5	8.2	GRAY	F	F	F	F	F
FRANCESTOWN	2nd NH Turnpike	Piscataquog	SB_PSCR_01	Culvert	43.14875	-71.35823	Old	2	0.2	Cascade	0.25	49	53.2	GRAY	P	F	F	F	F
FRANCESTOWN	Abbott Ln	Dinsmore Brook	RB_DIBK_14	Culvert	43.01227	-71.85207	New	3	2.5	Free Fall	2	31	47.7	RED	P	T	F	F	F
FRANCESTOWN	Avery Rd	Piscataquog	SB_PSCR_03	Culvert	42.96376	-71.76141	Old	3	1.3	At Grade	0	30.8		GRAY	P	F	F	F	F
FRANCESTOWN	Back Mtn Rd	Dinsmore Brook	RB_DIBK_04	Culvert	43.00828	-71.86678	New	4	2.5	Free Fall	1.5	40	33.4	RED	P	P	T	F	F
FRANCESTOWN	Bennington	Dinsmore Brook	RB_DIBK_05	Culvert	43.01162	-71.86816	New	4	1	Backwatered	0	64	29.4	GREEN	P	T	F	F	F
FRANCESTOWN	Bennington Rd	Collins Brook	RB_COBK_03	Culvert	43.00941	-71.84214	New	1.5	2.5	Free Fall	0.5	49	19.6	RED	F	F	F	F	F
FRANCESTOWN	Bennington Rd	Dinsmore brook	RB_DIBK_06	Culvert	43.01221	-71.87244	New	5	0.7	At Grade	0	49	34.8	GRAY	P	P	P	P	P
FRANCESTOWN	Bennington Rd	Dinsmore Brook	RB_DIBK_13	Culvert	43.01162	-71.85306	Eroding	4	1.5	At Grade	0	34	48.5	GRAY	P	P	T	F	F
FRANCESTOWN	Bible Hill Rd	Whiting Brook	MB_WTBK_02	Culvert	43.00277	-71.79145	Old	3	4	Cascade	0.7	47.7	21.5	GRAY	T	F	F	F	F
FRANCESTOWN	Bible Hill Rd Ext	Whiting Brook	MB_WTBK_01	Culvert	43.01365	-71.79518	Eroding	2	5	At Grade	0	23.7		GRAY	T	F	F	F	F
FRANCESTOWN	Birdsall	South Branch Piscataquog	RB_SBPR_17	Culvert	42.97351	-71.80918	Rusted	3	3	At Grade	0	32		GRAY	P	P	P	T	F
FRANCESTOWN	Birdsall	So. Branch Piscataquog	RB_SBPR_18	Culvert	42.97461	-71.80673	Old	1.3	0.8	At Grade	0	30	4.3	GRAY	P	F	F	F	F
FRANCESTOWN	Cressey Hill Rd	Rand Brook	RB_RBBK_14	Bridge	42.95793	-71.78953	New	30	0.4	At Grade	0	15	76.9	GRAY	-	-	-	-	-
FRANCESTOWN	Dennison Pond Rd	Whiting Brook	MB_WTBK_08	Culvert	43.00211	-71.76964	Old	3	0.5	At Grade	0	20.8	16.2	GRAY	P	F	F	F	F
FRANCESTOWN	Dodge Hill Rd	Piscataquog	SB_PSCR_04	Culvert	42.96848	-71.7368	Old	2.5	3.6	Cascade	0.4	28.7	40.5	GRAY	-	-	-	-	-
FRANCESTOWN	Dodge Rd	piscataquog	SB_PSCR_05	Culvert	42.96361	-71.75111	Old	4	0.8	At Grade	0	38.5		GRAY	P	P	P	P	P
FRANCESTOWN	Farrington	Rand Brook	RB_RBBK_03	Bridge	42.9706	-71.85379	Old	3.5	1	At Grade	0	16	19.9	GRAY	-	-	-	-	-
FRANCESTOWN	Ferson	Whiting Brook	MB_WTBK_03	Arch	42.99161	-71.7936	Old	1.4	7	At Grade	0	26.8	6.0	GRAY	F	F	F	F	F
FRANCESTOWN	Fisher Hill	Collins Brook	RB_COBK_04	Culvert	43.01054	-71.83504	New	1.5	2	At Grade	0	21	13.8	GRAY	P	F	F	F	F
FRANCESTOWN	Greenfield Rd	rand brook	RB_RBBK_04	Arch	42.97235	-71.84607	New	8	0.2	At Grade	0	30	33.3	GRAY	P	P	P	P	P
FRANCESTOWN	Greenfield Rd	So. Branch Piscataquog	RB_SBPR_15	Bridge	42.97724	-71.82342	New	18	0	At Grade	0	37		GRAY	-	-	-	-	-
FRANCESTOWN	Greenfield Rd	unk	RB_SBPR_12	Bridge	42.97572	-71.83058	New	9.2	7	At Grade	0	37.5	46.4	GRAY	P	P	P	P	P
FRANCESTOWN	Juniper Hill	So. Branch Piscataquog	RB_SBPR_16	Culvert	42.97454	-71.81889	New	12.5	2.5	At Grade	0	27	59.2	GRAY	P	P	P	P	P

Town of Francestown, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
FRANCESTOWN	Mountain Rd	Dinsmore Brook	RB_DIBK_02	Culvert	43.00685	-71.86592	Old	3	3	Free Fall	0.3	46	37.7	RED	P	T	F	F	F
FRANCESTOWN	Mountain Rd	Dinsmore Brook	RB_DIBK_12	Culvert	43.00687	-71.85191	Old	2	7	Free Fall	0.4	33	20.2	RED	P	F	F	F	F
FRANCESTOWN	Muzzey	So. Branch Piscataquog	RB_SBPR_13	Culvert	42.98067	-71.82662	Old	3	0.7	At Grade	0	25	18.4	GRAY	T	F	F	F	F
FRANCESTOWN	Muzzey Rd	south branch trib	RB_SBPR_08	Culvert	42.97791	-71.84844	New	1.5	4	At Grade	0	16	37.3	GRAY	F	F	F	F	F
FRANCESTOWN	no name	Dinsmore Brook	RB_DIBK_01	Culvert	43.0034	-71.86424	New	2	6	Free Fall	0.3	200		RED	T	F	F	F	F
FRANCESTOWN	no name	Dinsmore Brook	RB_DIBK_09	Culvert	43.01932	-71.86644	Old	3.5	2.5	Free Fall	0.6	41	27.3	RED	P	P	T	F	F
FRANCESTOWN	Old County	collins Brook	RB_COBK_05	Culvert	43.01222	-71.02998	Old	12.5		Cascade	0.2		111.6	GRAY	P	P	P	P	P
FRANCESTOWN	Old County	Piscataquog South Branch	RB_SBPR_19	Bridge	42.96931	-71.79913	New	23	7.5	At Grade	0	21		GRAY	-	-	-	-	-
FRANCESTOWN	Old Cty Rd	Collins Brook	RB_COBK_01	Culvert	43.02618	-71.84238	New	3.5	0.1	At Grade	0	32	24.9	GRAY	P	P	P	P	P
FRANCESTOWN	Old Turnpike Rd	collins Brook	RB_COBK_02	Culvert	43.00921	-71.84273	New	2	3	Free Fall	1	20	33.6	RED	P	T	F	F	F
FRANCESTOWN	Pleasant Pond Rd	Collins Brook	RB_COBK_06	Bridge	43.01689	-71.82214	New	22	0.1	At Grade	0	30	68.4	GRAY	-	-	-	-	-
FRANCESTOWN	Poor Farm	South Branch Piscataquog	RB_SBPR_04	Culvert	42.98944	-71.81088	New	3	3	Free Fall	0.3	39	12.0	RED	P	T	F	F	F
FRANCESTOWN	Red House Rd	Whiting Brook	MB_WTBK_05	Culvert	42.98101	-71.78222	New	4	0.5	At Grade	0	40		GRAY	P	F	F	F	F
FRANCESTOWN	Reid Rd	South Branch Piscataquog	RB_SBPR_11	Culvert	42.9756	-71.83067	New	5.8	0.5	Free Fall	0.8	48	26.5	RED	P	T	F	F	F
FRANCESTOWN	Rt 136	Whiting Brook	MB_WTBK_06	Arch	42.98813	-71.77956	Old	4	2	At Grade	0	39	22.7	GRAY	P	P	P	T	T
FRANCESTOWN	Rt 136	Whiting Brook	MB_WTBK_07	Bridge	42.98947	-71.77778	Old	11	2	At Grade	0	32.5	57.1	GRAY	-	-	-	-	-
FRANCESTOWN	Rt 136	Whiting Brook	MB_WTBK_04	Culvert	42.98493	-71.79176	Old	4	2	At Grade	0	33	30.8	GRAY	P	P	T	F	F
FRANCESTOWN	Rt 136	Whiting Brook	MB_WTBK_09	Culvert	42.99869	-71.76316	Old	1.5	2	Free Fall	0.3	48		ORANGE	T	F	F	F	F
FRANCESTOWN	Russell Station	Rand Brook	RB_RBBK_12	Bridge	42.95916	-71.79565	New	28	7.1	At Grade	0	19	83.2	GRAY	-	-	-	-	-
FRANCESTOWN	Russell Station	Rand Brook	RB_RBBK_15	Bridge	42.95665	-71.78388	New	44.8	5.5	At Grade	0	29	111.1	GRAY	-	-	-	-	-
FRANCESTOWN	Russell Station	Rand Brook	RB_RBBK_16	Culvert	42.95677	-71.7821	Old	1.6	1.5	#1 at grade #2Free Fall	0.4	40	21.1	GRAY	T	F	F	F	F
FRANCESTOWN	S New Boston Rd	Piscataquog	SB_PSCR_06	Culvert	42.96164	-71.75154	Old	2.5	0.9	At Grade	0	40.8	8.9	GRAY	P	T	F	F	F
FRANCESTOWN	School House Rd	Dinsmore Brook	RB_DIBK_07	Culvert	43.01364	-71.86279	New	5	3.5	At Grade	0	51	52.4	GRAY	P	P	P	T	T
FRANCESTOWN	Scobie Rd	Whiting Brook	MB_WTBK_11	Culvert	42.98883	-71.75933	Rusted	7.5	3	Free Fall	0.5	29.5	58.0	ORANGE	P	P	P	P	P
FRANCESTOWN	Scobie Rd	Whiting Brook	MB_WTBK_10	Culvert	42.98905	-71.76131	Old	1.3	0.4	At Grade	0	30		GREEN	F	F	F	F	F
FRANCESTOWN	Spencer	South Branch Piscataquog	RB_SBPR_14	Arch	42.9804	-71.82675	Old	2.8	4.5	At Grade	0	16	19.1	GRAY	P	F	F	F	F
FRANCESTOWN	town line	rand brook	RB_RBBK_02	Bridge	42.96941	-71.85485	Old	3	4	At Grade	0	14		GRAY	-	-	-	-	-
FRANCESTOWN	Udall Rd	unk	RB_SBPR_09	Culvert	42.97305	-71.84357	Rusted	2	1.2	Free Fall	0.3	30		ORANGE	F	F	F	F	F
FRANCESTOWN	Udall Rd	Piscataquog Trib	SB_PSCR_09A	Culvert	42.97305	-71.84357	Rusted	2	1	Free Fall	0.3	30		ORANGE	-	-	-	-	-
FRANCESTOWN	Woodward Hill	Piscataquog	RB_SBPR_20	Culvert	42.96936	-71.78903	Rusted	12.5	2	At Grade	0	32	46.7	GRAY	P	P	P	P	P

Town of Goffstown

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
GOFFSTOWN	1st Ave	Piscataquog	LP_PSCR_02	Culvert	43.02493	-71.60793	Rusted	3.6	0.7	Backwatered	0	40	37.9	GREEN	P	T	F	F	F
GOFFSTOWN	Addison	Piscataquog	LP_PSCR_37	Culvert	42.99047	-71.55456	New	1	0.9	Free Fall	0.15	41		RED	F	F	F	F	F
GOFFSTOWN	Addison	Piscataquog	LP_PSCR_40	Culvert	42.99207	-71.54931	New	2.3	0.7	Free Fall	0.6	41		RED	T	F	F	F	F
GOFFSTOWN	Addison	Piscataquog	LP_PSCR_45	Arch	42.99279	-71.52742	Old	3.3	0.2	Cascade	0.4	57	35.8	GRAY	P	P	P	P	P

Town of Goffstown, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
GOFFSTOWN	Allard Park Rd	Piscataquog	LP_PSCR_33	Culvert	43.0122	-71.51105	Old	2	1.7	Cascade	0.8	22		GRAY	P	P	F	F	F
GOFFSTOWN	Autumn	Piscataquog	LP_PSCR_05	Culvert	43.02467	-71.60906	New	1.3	0.7	At Grade	0	42	21.7	GREEN	F	F	F	F	F
GOFFSTOWN	Back Mtn Rd	Bog Brook	LP_BOBK_08	Culvert	42.97534	-71.59885	Old	1	2.6	At Grade	0	44		GRAY	F	F	F	F	F
GOFFSTOWN	Back Mtn Rd	Bog Brook	LP_BOBK_09	Arch	42.97734	-71.60807	Old	3.5	8.4	At Grade	0	32	22.4	GRAY	P	P	P	T	T
GOFFSTOWN	Bog Brook Rd	Bog Brook	LP_BOBK_28	Culvert	42.98979	-71.63177	New	1.5	3.8	Cascade		40		GRAY	-	-	-	-	-
GOFFSTOWN	Center Street	Cemetary Brook	LP_CEBK_01	Culvert	43.02221	-71.54323	New	2.25	3	Free Fall	0.6	67	42.0	RED	T	F	F	F	F
GOFFSTOWN	Dumont Park Rd	Piscataquog	LP_PSCR_31	Culvert	43.01257	-71.52031	Old	1.3	1.7	At Grade	0	42.7	8.1	GRAY	F	F	F	F	F
GOFFSTOWN	Durango Dr	Catamount Brook	LP_CTBK_04	Culvert	43.02258	-71.52194	New	3	3.4	Cascade	0	51	19.7	GRAY	P	T	F	F	F
GOFFSTOWN	Elm	Piscataquog	LP_PSCR_16	Culvert	43.02268	-71.59665	New	6	6	Free Fall	0.2	70	56.2	RED	P	P	F	F	F
GOFFSTOWN	Elm st	Piscataquog	LP_PSCR_24	Culvert	43.01885	-71.57381	Old	2	3.2	Free Fall	1.9	132	27.8	RED	F	F	F	F	F
GOFFSTOWN	Elm St	Piscataquog	LP_PSCR_26	Culvert	43.0191	-71.56728	Old	1.3		Free Fall	0.6	60	7.9	RED	F	F	F	F	F
GOFFSTOWN	Elm St	Piscataquog	LP_PSCR_27	Culvert	43.01908	-71.5671	New	1	1.8	At Grade	0	43.5	23.4	GRAY	F	F	F	F	F
GOFFSTOWN	Glenwood Dr	Piscataquog	LP_PSCR_22	Culvert	43.01947	-71.57632	Old	2	1	Free Fall	0.3	41	22.0	RED	F	F	F	F	F
GOFFSTOWN	Goffstown Back Rd	Piscataquog	LP_PSCR_32	Culvert	43.01319	-71.50752	Old	3	4	At Grade	0	100	11.8	GRAY	P	P	P	T	F
GOFFSTOWN	Goffstown Back Rd	Whiting brook	LP_WHBK_02	Culvert	43.02091	-71.53599	New	1.5	1.8	At Grade	0	67	3.1	GRAY	F	F	F	F	F
GOFFSTOWN	Gorham Pond Rd	Gorham Brook	UP_GOBK_10	Culvert	43.05367	-71.62934	New	2.5	2.1	At Grade	0	38		GRAY	P	F	F	F	F
GOFFSTOWN	Gorham Pond Rd	Gorham Brook	UP_GOBK_12	Culvert	43.04127	-71.6282	New	1.3	2.7	Free Fall	1	40.6	10.1	RED	F	F	F	F	F
GOFFSTOWN	Hemlock	Piscataquog	LP_PSCR_13	Culvert	43.02644	-71.59356	New	2.6	1.4	Cascade	2	83	10.0	GRAY	T	F	F	F	F
GOFFSTOWN	Horizon Dr	Henry Brook	LP_HABK_15	Culvert	43.04351	-71.56799	New	3	2.1	At Grade	0	70.4	25.1	GRAY	P	P	T	F	F
GOFFSTOWN	Juniper Dr	Henry Brook	LP_HABK_17	Culvert	43.03186	-71.54821		6	1.6	Free Fall	1.5	88.8	61.2	RED	P	P	P	P	P
GOFFSTOWN	Keith Dr	Catamount Brook	LP_CTBK_03	Culvert	43.02595	-71.52005	New	1.8	1.5	At Grade	0	48.5		GRAY	T	F	F	F	F
GOFFSTOWN	Leach Hill Rd	Bog brook	LP_BOBK_31	Culvert	42.99462	-71.61729	New	4	13.4	Free Fall	2.5	30	45.7	RED	P	P	T	F	F
GOFFSTOWN	Magnolia	Piscataquog	LP_PSCR_42	Culvert	42.98655	-71.54173	New	4	3	Cascade	3	69	21.6	GRAY	P	P	T	T	F
GOFFSTOWN	Maple	Piscataquog	LP_PSCR_15	Culvert	43.02264	-71.59662	Old	2.5	2.3	At Grade	0	75	29.9	GRAY	F	F	F	F	F
GOFFSTOWN	Mast	Gorham Brook	UP_GOBK_17	Culvert	43.02529	-71.62272	Rusted			At Grade	0			GRAY	-	-	-	-	-
GOFFSTOWN	Medford Farm Rd	Catamount Brook	LP_CTBK_06	Culvert	43.01979	-71.52711	Old	2	3.8	Free Fall	0.3	48.4	21.9	RED	F	F	F	F	F
GOFFSTOWN	Miles Ave	Catamount Brook	LP_CTBK_02	Culvert	43.02582	-71.5248	New	4	2.4	Free Fall	0.9	39.1	30.3	RED	P	T	F	F	F
GOFFSTOWN	Morgan Circle	Piscataquog	LP_PSCR_30	Culvert	43.00762	-71.52687	Old	1.9	1	At Grade	0	63	21.0	GRAY	P	F	F	F	F
GOFFSTOWN	Mosett	Catamount Brook	LP_CTBK_01	Culvert	43.03235	-71.5248	New	1.9	0.1	At Grade	0	50.1		GRAY	F	F	F	F	F
GOFFSTOWN	N Mast Rd	Piscataquog	LP_PSCR_08	Culvert	43.02106	-71.60194	New	4.3	0.4	At Grade	0	70	33.7	GRAY	F	F	F	F	F
GOFFSTOWN	Norman	Dan Little Brook	LP_DLBK_05	Culvert	43.0007	-71.56417	Old	1.5	3.2	At Grade	0	43		GRAY	F	F	F	F	F
GOFFSTOWN	Paige Hill Rd	Piscataquog	LP_PSCR_21	Culvert	43.02206	-71.57832	Old	2	6.7	At Grade	0	37	28.6	GRAY	T	F	F	F	F
GOFFSTOWN	Parsons Dr	Piscataquog	LP_PSCR_04	Culvert	43.02574	-71.61332	Old	2.5	0.5	Backwatered	0	60	23.1	GRAY	P	T	F	F	F
GOFFSTOWN	Pasrsons Dr	Piscataquog	LP_PSCR_03	Culvert	43.02753	-71.61494	New	1.6	5.1	Free Fall	1	80	19.8	RED	P	F	F	F	F
GOFFSTOWN	Range Rd	Henry Brook	LP_HABK_14	Culvert	43.0422	-71.56104	Eroding	3.3	4.3	Free Fall	1.2	53		RED	P	T	F	F	F
GOFFSTOWN	Range Road	Henry Brook	LP_HABK_16	Culvert	43.04111	-71.56669	New	3	3.9	At Grade	0	98.2	41.3	GRAY	P	P	T	F	F
GOFFSTOWN	Roby	Bog Brook	LP_BOBK_11	Culvert	42.97656	-71.61346	New	1.5	3.5	At Grade	0	47	22.1	GRAY	F	F	F	F	F
GOFFSTOWN	Roby Rd	Bog Brook	LP_BOBK_10	Culvert	42.97866	-71.61109	Old	2	2.7	Free Fall	1.5	46	25.0	RED	F	F	F	F	F

Town of Goffstown, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
GOFFSTOWN	Rt 114	Piscataquog	LP_PSCR_46	Culvert	42.99826	-71.52508	New	3	0.7	At Grade	0	130	7.5	GRAY	F	F	F	F	F
GOFFSTOWN	Rte 13	Piscataquog	LP_PSCR_12	Culvert	43.03598	-71.59882	New	2	2.5	Free Fall	0.2	85	23.5	RED	F	F	F	F	F
GOFFSTOWN	S Main St	Piscataquog	LP_PSCR_17	Culvert	43.01471	-71.587	New	5	1.9	At Grade	0	56.5	11.8	GREEN	P	T	T	F	F
GOFFSTOWN	Sarette	Piscataquog	LP_PSCR_34	Culvert	43.0116	-71.51562	Old	3	4.7	Cascade	0.8	28.5	32.0	GRAY	P	P	P	F	F
GOFFSTOWN	Saunders Rd	Gorham Brook	UP_GOBK_16	Culvert	43.03353	-71.62355	New	1.5	0.5	At Grade	0	22		GRAY	F	F	F	F	F
GOFFSTOWN	Shirley Hill	Piscataquog	LP_PSCR_44A	Culvert	42.98785	-71.53448	New	7	1.9	Free Fall	0.6	50	62.6	RED	P	P	P	P	P
GOFFSTOWN	Shirley Hill Rd	Piscataquog	LP_PSCR_38	Bridge	42.98529	-71.55281	New	8.4	0.7	At Grade	0	25.6	45.6	GRAY	P	P	P	P	P
GOFFSTOWN	Shirley Hill Rd	Piscataquog	LP_PSCR_39	Bridge	42.98556	-71.55106	New	7.7	3.8	At Grade	0	24	77.2	GRAY	P	P	P	P	P
GOFFSTOWN	Shirley Hill Rd	Piscataquog	LP_PSCR_41	Bridge	42.98531	-71.54825	New	6	5.6	At Grade	0	25		GRAY	P	P	P	P	P
GOFFSTOWN	Shirley Hill Rd	Piscataquog	LP_PSCR_44	Culvert	42.98887	-71.53226	New	1.3	0.3	At Grade	0	44	9.7	GRAY	F	F	F	F	F
GOFFSTOWN	Smith	Piscataquog	LP_PSCR_14	Culvert	43.02475	-71.59676	Rusted	5.3	0.6	Free Fall	0.5	70	44.3	RED	P	P	T	F	F
GOFFSTOWN	Snook	Piscataquog	LP_PSCR_01	Culvert	43.04426	-71.60384	New	1.5	0.7	Cascade	0.3	40	5.4	GRAY	F	F	F	F	F
GOFFSTOWN	Snook Rd	Gorham Brook	UP_GOBK_11	Culvert	43.04663	-71.6134	New	2.3	2.4	Free Fall	1.6	52	21.4	RED	P	T	F	F	F
GOFFSTOWN	Stark Hwy	Harry Brook	LP_HABK_08	Culvert	43.0559	-71.59949	Old	3	1.1	Free Fall	0.4	57	11.4	RED	P	F	F	F	F
GOFFSTOWN	Stinson	Piscataquog	LP_PSCR_11	Culvert	43.03777	-71.5982	New	1	2	At Grade	0	52		GRAY	F	F	F	F	F
GOFFSTOWN	Summer st	Piscataquog	LP_PSCR_07	Culvert	43.02296	-71.60193	New	2.2	3.8	At Grade	0	55.5	33.8	GRAY	F	F	F	F	F
GOFFSTOWN	Tibbett Hilll Rd	Henry Brook	LP_HABK_18	Culvert	43.02833	-71.55363	Old	2	2.2	Free Fall	0.5	40	14.2	RED	F	F	F	F	F
GOFFSTOWN	Tibetts Hill Rd	Henry Brook	LP_HABK_07	Culvert	43.05779	-71.57465	New	1	6.3	At Grade	0	36.7		GRAY	F	F	F	F	F
GOFFSTOWN	Tibetts Hill Rd	Henry Brook	LP_HABK_13	Culvert	43.04257	-71.56109	New	3	4.5	Free Fall		60	18.2	GRAY	P	F	F	F	F
GOFFSTOWN	Tirrell Hill Rd	Whiting brook	LP_WHBK_01	Culvert	43.02758	-71.5365	New	1.5	3.7	At Grade	0.1	58	4.3	GRAY	F	F	F	F	F
GOFFSTOWN	Wallace	Dan Little Brook	LP_DLBK_06	Culvert	43.00057	-71.57415	Old	1.5	3.5	Cascade	1.9	41	24.8	GRAY	P	F	F	F	F
GOFFSTOWN	Walnut Hill	Piscataquog	LP_PSCR_43	Culvert	42.98701	-71.53738	New	7		Cascade	0.7		57.4	GRAY	P	P	T	T	F
GOFFSTOWN	Water St	Piscataquog	LP_PSCR_35	Culvert	43.01103	-71.51611	Old	3	1.8	Backwatered	0	42	38.1	GRAY	P	P	T	F	F
GOFFSTOWN	Whipple	Piscataquog	LP_PSCR_06	Culvert	43.02651	-71.60142	Old	2	2.7	At Grade	0	34	16.1	GRAY	F	F	F	F	F
GOFFSTOWN	Winter Hill Rd	Piscataquog	LP_PSCR_20	Culvert	43.02416	-71.57967	New	4	1	At Grade	0	60	46.5	GRAY	P	P	P	P	P

Town of Greenfield

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
GREENFIELD	East rd	Rand Brook	RB_RBBK_09	Culvert	42.9492	-71.84224	Rusted	3.5	1.2	At Grade	0	42	32.6	GRAY	P	F	F	F	F
GREENFIELD	Francestown Road, Rte 136	Rand Brook	RB_RBBK_07	Culvert	42.95971	-71.86153	New	3	1	Free Fall	0.5	69	6.0	RED	P	F	F	F	F
GREENFIELD	Greenfield Rd	Rand Brook	RB_RBBK_11	Culvert	42.95047	-71.81075	New	1.3	2.2	Free Fall	0.3	25	15.8	RED	F	F	F	F	F
GREENFIELD	Jake Savage	Rand Brook	RB_RBBK_06	Arch	42.95956	-71.83794	Old	3.8	5.3	At Grade	0	19	19.1	GRAY	P	P	P	P	P
GREENFIELD	Pine Ridge	Rand brook	RB_RBBK_08	Bridge	42.95039	-71.84484	Old	149		At Grade	0	4		GRAY	-	-	-	-	-
GREENFIELD	So. Francestown Road	Rand Brook	RB_RBBK_05	Bridge	42.96453	-71.84479		7.3	2	At Grade	0	19	44.2	GRAY	P	P	P	P	P

Town of Henniker

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
HENNIKER	Bartlett Hill Rd	unk	WR_PSCR_20	Bridge	43.05847	-71.79824	New	24	3	At Grade	0	22.3		GRAY	-	-	-	-	-
HENNIKER	Mt Hunger	unk	WR_PSCR_28	Culvert	43.1343	-71.80189	Rusted	1.5	2	Free Fall	0.2	41	6.7	RED	F	F	F	F	F

Town of Lyndeborough

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
LYNDEBOROUGH	Richardson	cold brook	SB_COBK_01	Culvert	42.93593	-71.7607	New	2	3.9	Free Fall	0.4	28		ORANGE	T	F	F	F	F

Town of Mount Vernon

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
MONT VERNON	Pvt road	Meadow	SB_MEBK_01	Culvert	42.93185	-71.66692	New	1.5	2.3	Free Fall	0.3	21		RED	P	F	F	F	F
MONT VERNON	Tarn Rd	Cold Brook	SB_COBK_03	Culvert	42.91526	-71.74037	New	4	0	At Grade	0	28		GRAY	-	-	-	-	-

Town of New Boston

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
NEW BOSTON	2nd NH Turnpike	Piscataquog	SB_PSCR_12	Culvert	42.9463	-71.74728	Old	2	3.7	At Grade	0	54	22.3	GRAY	P	F	F	F	F
NEW BOSTON	Beard Rd	Piscataquog Trib	MB_MBPR_17	Culvert	43.00261	-71.67329	New	1.5	1.5	Free Fall	0.6	39.6		RED	T	F	F	F	F
NEW BOSTON	Bedford	Bog Brook	LP_BOBK_03	Culvert	42.95827	-71.62199	New	3	0.8	At Grade	0	51	26.7	GRAY	P	T	T	F	F
NEW BOSTON	Bedford	Bog Brook	LP_BOBK_07	Culvert	42.96191	-71.62139	New	4.5	0.3	At Grade	0	50	12.4	GREEN	P	P	P	P	P
NEW BOSTON	Bedford	Bog Brook	LP_BOBK_25	Culvert	42.98127	-71.6405	Old	2	1.5	Free Fall	0.7	57	11.3	RED	T	F	F	F	F
NEW BOSTON	Bedford Rd	Piscataquog	SB_PSCR_39	Culvert	42.97552	-71.68389	Old	4.7	0.9	Free Fall	2.1	41	50.8	RED	P	T	F	F	F
NEW BOSTON	bedford rd	Piscataquog	SB_PSCR_50	Culvert	42.97862	-71.67207	New	5.5	1.1	At Grade	0	42	46.3	GRAY	P	P	P	T	T
NEW BOSTON	Bedford rd	Bog Brook	LP_BOBK_14	Culvert	42.96455	-71.62032	New	8	0.1	At Grade	0	42		GREEN	P	P	P	P	P
NEW BOSTON	Bedford Rd	Bog Brook	LP_BOBK_22	Culvert	42.98112	-71.64297	Old	2	7.2	Free Fall	0.2	69		RED	P	F	F	F	F
NEW BOSTON	Bog Brook Rd	Bog Brook	LP_BOBK_27	Culvert	42.98708	-71.63252	New	5	0.1	Backwatered	0	35	34.2	GRAY	-	-	-	-	-
NEW BOSTON	Bunker Hill Rd	Bukston Brook	MB_BXBK_10	Culvert	43.0136	-71.7451	Rusted	5.5	3	At Grade	0	24.3	25.3	GRAY	P	P	T	T	F
NEW BOSTON	Bunker Hill Rd	Currier brook	MB_CUBK_04	Culvert	43.0151	-71.7386	Old	2.5	2	Free Fall	0.2	36.5	9.4	ORANGE	F	F	F	F	F
NEW BOSTON	Bunker Hill Road	Middle Branch Trib	MB_MBPR_01	Culvert	42.9995	-71.7576	Old	2.5	5.7	At Grade	0	33	12.6	GRAY	T	F	F	F	F
NEW BOSTON	Butterfield Mill Rd	Piscataquog Trib	SB_PSCR_15	Culvert	42.95696	-71.73693	Old	1	1.3	Free Fall	0.15	32		RED	P	F	F	F	F
NEW BOSTON	Butterfield Mill Rd	Piscataquog Trib	SB_PSCR_15A	Culvert	40.94083	-71.73472	New	4	0.7	Free Fall	0.9	40.5		RED	P	P	P	P	P
NEW BOSTON	Byam	Piscataquog	SB_PSCR_52	Culvert	42.99483	-71.66048	New	2.3	10	Free Fall	1.2	200	28.1	RED	P	F	F	F	F
NEW BOSTON	Byam	Piscataquog	SB_PSCR_54	Culvert	42.99775	-71.66093	New	3.9	1.5	At Grade	0	200	41.2	GRAY	P	P	P	P	T
NEW BOSTON	Byam Rd	Piscataquog Trib	SB_PSCR_53	Culvert	42.99106	-71.65884	New	1.5	4.4	Free Fall	1.6	53.4	21.4	RED	P	F	F	F	F

Town of New Boston, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
NEW BOSTON	Carriage rd	Bog Brook	LP_BOBK_16	Culvert	42.96695	-71.63638	New	6	0.2	At Grade	0	77.5	37.0	GRAY	P	P	P	P	P
NEW BOSTON	Carriage Rd	Bog Brook	LP_BOBK_17	Culvert	42.96325	-71.63523	New	1.5	1.3	At Grade	0	70	7.0	GRAY	F	F	F	F	F
NEW BOSTON	Carriage Rd	Bog Brook	LP_BOBK_18	Culvert	42.96523	-72.63947	New	3	0.7	Free Fall	0.8	113.5	32.7	RED	P	P	T	F	F
NEW BOSTON	Carriage Rd	Bog Brook	LP_BOBK_19	Culvert	42.96898	-71.6382	New	3	1	Cascade	0.4	136	24.2	GRAY	P	P	F	F	F
NEW BOSTON	Chestnut Hill Rd	Bog Brook	LP_BOBK_02	Culvert	42.95642	-71.61906	Old	2	1	Free Fall	0.2	85	23.3	RED	P	T	F	F	F
NEW BOSTON	Clark Hill Rd	Piscataquog	SB_PSCR_33	Culvert	42.97641	-71.69361	Old					600		GRAY	-	-	-	-	-
NEW BOSTON	Cochran	Piscataquog	SB_PSCR_24	Culvert	42.96947	-71.72279	Old	2	0.8	At Grade	0	29	8.9	GRAY	P	P	T	T	F
NEW BOSTON	Cochran Hill Rd	Piscataquog	SB_PSCR_16	Culvert	42.9543	-71.7198	New	3.5	4	Free Fall	1.3	42	38.0	RED	P	P	T	F	F
NEW BOSTON	Colburn	Middle Branch Trib	MB_MBPR_06	Culvert	42.99724	-71.73145	Old	1.2	1	At Grade	0	23.2		GRAY	F	F	F	F	F
NEW BOSTON	Dennison Road	Piscataquog Trib	MB_MBPR_12	Culvert	42.9913	-71.7071	Old	2	2	Cascade	0.16	30.9		GRAY	P	T	F	F	F
NEW BOSTON	Dodge rd	Piscataquog Trib	MB_MBPR_15	Culvert	42.9992	-71.68938	Old	2.9	2	At Grade	0	35.5	16.0	GRAY	-	-	-	-	-
NEW BOSTON	Dunbar	Meadow Brook	SB_MEBK_10	ford	42.93711	-71.68363	Old			At Grade	0	31	0.0	GRAY	P	T	F	F	F
NEW BOSTON	Dunbar	Meadow Brook	SB_MEBK_13	ford	42.93736	-71.68134	Old		7	At Grade	0	38	0.0	GRAY	-	-	-	-	-
NEW BOSTON	Francestown Rd	Piscataquog	SB_PSCR_36	Culvert	42.98425	-71.69576	Old	1.3	2	Backwatered	0	60		GRAY	F	F	F	F	F
NEW BOSTON	Francestown Road	Middle Branch Trib	MB_MBPR_02	Culvert	42.99818	-71.75494	Collapsing	2	1	At Grade	0	43	33.9	GRAY	F	F	F	F	F
NEW BOSTON	Francestown Road	Piscataquog River	MB_MBPR_05	Culvert	42.9938	-71.7289	Old	4	2	Backwatered	0	44.7		GRAY	-	-	-	-	-
NEW BOSTON	Francestown Road	Piscataquog Trib	MB_MBPR_08	Culvert	42.99237	-71.72173	Collapsing	7	2	At Grade	0	170		GRAY	P	P	P	P	T
NEW BOSTON	Francestown Road	Piscataquog River	MB_MBPR_13	Culvert	42.99076	-71.70297	Old	3	2	At Grade	0	80	16.7	GRAY	-	-	-	-	-
NEW BOSTON	francestown road	Piscataquog Trib	MB_MBPR_14	Culvert	42.98977	-71.70251	Collapsing	2.2	3	At Grade	0	84		GRAY	-	-	-	-	-
NEW BOSTON	Francestown Tpk	Cold Brook	SB_COBK_05	Culvert	42.94028	-71.73861	New	4	1.6	At Grade	0	32	25.2	GRAY	P	T	T	F	F
NEW BOSTON	Francestown Tpk	Cold Brook	SB_COBK_06	Culvert	42.93722	-71.73444		1	1.7	At Grade	0	41.5	5.9	GRAY	P	P	F	F	F
NEW BOSTON	Francestown Tpk	Lords Brook	SB_LOBK_01	Culvert	42.91714	-71.70986	New	3	3.8	Free Fall	0.1	49	22.4	RED	P	P	T	F	F
NEW BOSTON	Francestown Turnpike	Lords Brook	SB_LOBK_03	Culvert	42.92535	-71.72163	New	4	0.8	At Grade	0	45	58.3	GRAY	P	P	P	P	T
NEW BOSTON	Greenfield Rd	Rand Brook	RB_RBBK_13	Culvert	42.94612	-71.78891	Rusted	3.3	2.3	Free Fall	0.3	40	26.1	RED	F	F	F	F	F
NEW BOSTON	Greenfield Rd	Piscataquog	SB_PSCR_26	Culvert	42.96523	-71.71752	Old	4	1	At Grade	0	40	13.0	GRAY	P	P	T	T	F
NEW BOSTON	Hooper Hill Road	Piscataquog Trib	SB_PSCR_29	Culvert	42.96253	-71.69175	New	2.5	2	Cascade	1.5	38	23.8	GRAY	F	F	F	F	F
NEW BOSTON	Houghton	Meadow Brook	SB_MEBK_16	Culvert	42.94884	-71.68847	New	2	4	At Grade	0	50	14.7	GRAY	T	F	F	F	F
NEW BOSTON	Indian Falls Rd	Bog Brook	LP_BOBK_23	Culvert	42.97035	-71.63364	Old	3	1.5	At Grade	0	47	23.9	GRAY	P	F	F	F	F
NEW BOSTON	Joe English Rd	Meadow Brook	SB_MEBK_02	Culvert	42.94551	-71.67226	New	5.3	9.9	Free Fall	3	43	58.8	RED	P	P	P	P	P
NEW BOSTON	Joe English Rd	Meadow Brook	SB_MEBK_03	Culvert	42.94943	-71.6717	New	2.5	2.5	Free Fall	1.3	53	31.5	RED	P	F	F	F	F
NEW BOSTON	Joe English Rd	Meadow Brook	SB_MEBK_04	Culvert	42.9475	-71.67269	Collapsing	5	2.3	Cascade	0.4	56	49.3	GRAY	P	P	T	T	F
NEW BOSTON	Lewis Rd	Piscataquog	SB_PSCR_38	Arch	42.96357	-71.67525	Old	3	5.3	At Grade	0	18	21.5	GRAY	T	F	F	F	F
NEW BOSTON	Lewis Rd	Piscataquog	SB_PSCR_41	ford	42.96547	-71.65922	Old		4.6	Cascade	0.4	9.4	0.0	GRAY	-	-	-	-	-
NEW BOSTON	Lull Rd	Piscataquog Trib	MB_MBPR_18	Culvert	43.00919	-71.67029	Old	4	5	At Grade	0	31.5		GRAY	P	T	F	F	F
NEW BOSTON	Lyndborough	Cold Brook	SB_COBK_07	Culvert	42.93972	-71.73389	Old	1.3	0.7	Free Fall	0.5	41	2.6	RED	P	F	F	F	F
NEW BOSTON	Lyndeborough Rd	Meadow Brook	SB_MEBK_20	Arch	42.9596	-71.7008	New	8	3	At Grade	0	30.5	21.6	GREEN	P	T	F	F	F
NEW BOSTON	Lyndeborough Rd	Piscataquog	SB_PSCR_17	Culvert	42.94902	-71.71784	Rusted	2	2	Free Fall	2.5	60	27.4	RED	P	F	F	F	F
NEW BOSTON	Lyndeborough Road	Meadow Brook	SB_MEBK_21	Culvert	42.95983	-71.70425	Eroding	4	1	At Grade	0	30	69.8	GRAY	P	T	T	F	F
NEW BOSTON	Mc Collum	Piscataquog	SB_PSCR_21	Culvert	42.94653	-71.71555	New	2	5	Free Fall	1	21	20.8	RED	P	P	T	F	F

Town of New Boston, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
NEW BOSTON	McCollum	Meadow Brook	SB_MEBK_08	Culvert	42.93708	-71.69168	New	2.5	7	Free Fall	0.5	40	24.0	RED	P	P	F	F	F
NEW BOSTON	McCollum	Piscataquog	SB_PSCR_23	Culvert	42.9448	-71.70721	New	2	1.5	Cascade	0.4	30	26.3	GRAY	F	F	F	F	F
NEW BOSTON	McCurdy	Bog Brook	LP_BOBK_20	Culvert	42.96887	-71.64442	Old	2	0.3	At Grade	0	41		GRAY	P	F	F	F	F
NEW BOSTON	McCurdy Rd	Bog Brook	LP_BOBK_21	Culvert	42.97013	-71.6966	Old	5	0.4	At Grade	0	41	24.7	GRAY	-	-	-	-	-
NEW BOSTON	Meadow Rd	Meadow Brook	SB_MEBK_05	Culvert	42.94567	-71.67516	Eroding	4	3.1	At Grade	0	45	36.2	GRAY	P	T	F	F	F
NEW BOSTON	Meadow Rd	Meadow Brook	SB_MEBK_07	Culvert	42.94184	-71.69148	Old	3.5	0	At Grade	0	21		GRAY	P	P	T	F	F
NEW BOSTON	Meadow Rd	Meadow Brook	SB_MEBK_15	Culvert	42.9435	-71.69924	New	1.4	1	At Grade	0	34	12.2	GRAY	-	-	-	-	-
NEW BOSTON	Middle Branch Rd	Piscataquog Middle Branch	MB_MBPR_09	Culvert	43.02411	-71.68183	Old	4	0.2	At Grade	0	20	31.3	GRAY	-	-	-	-	-
NEW BOSTON	Mont Vernon	Meadow Brook	SB_MEBK_12	Culvert	42.93826	-71.68125	Old	3	3	Free Fall	2.7	200	21.2	RED	-	-	-	-	-
NEW BOSTON	Mont Vernon	Meadow Brook	SB_MEBK_17	Arch	42.9465	-71.69082	Old	2	2	At Grade	0	47	9.9	GRAY	P	T	F	F	F
NEW BOSTON	Mont Vernon	Meadow Brook	SB_MEBK_19	Culvert	42.96052	-71.69764	New	1.3	7	At Grade	0	55	12.8	GRAY	F	F	F	F	F
NEW BOSTON	Mont Vernon	Piscataquog	SB_PSCR_30	Culvert	42.96755	-71.69824	Eroding	4	5.5	At Grade	0	48	34.0	GRAY	P	P	P	T	T
NEW BOSTON	Mont Vernon	Piscataquog	SB_PSCR_31	Culvert	42.96911	-71.69794	Old	2	3.1	Free Fall	1.3	17	52.4	RED	P	P	P	T	F
NEW BOSTON	Mont Vernon Rd	Meadow brook	SB_MEBK_06	Culvert	42.94366	-71.68748	Old	2.5	0.9	At Grade	0	40		GRAY	F	F	F	F	F
NEW BOSTON	Mtn Rd	Cold Brook	SB_COBK_04	Culvert	42.93816	-71.74001	Old	4	1.9	Backwatered	0	17	56.5	GRAY	P	T	F	F	F
NEW BOSTON	New Rd	Cold Brook	SB_COBK_02	Culvert	42.93453	-71.74827	New	6	5.6	At Grade	0	39	36.9	GRAY	P	P	P	P	P
NEW BOSTON	New Rd	Piscataquog	SB_PSCR_11	Culvert	42.94672	-71.74901	New	1.5	5.8	Free Fall	2.2	43		RED	P	T	F	F	F
NEW BOSTON	Newman Wilson	Piscataquog Trib	MB_MBPR_19	Culvert	43.03228	-71.67162	Rusted	2	8	Cascade	4.3	60	33.4	GRAY	F	F	F	F	F
NEW BOSTON	no name	Meadow Brook	SB_MEBK_09	Arch	42.93985	-71.6885	Old	2.7	1	At Grade	0	25	22.5	GRAY	P	T	F	F	F
NEW BOSTON	no name	Meadow Brook	SB_MEBK_11	Arch	42.93925	-71.68672	Old	1.9	1.6	At Grade	0	24	13.8	GRAY	-	-	-	-	-
NEW BOSTON	no name	Meadow Brook	SB_MEBK_14		42.93867	-71.68365						29		GRAY	-	-	-	-	-
NEW BOSTON	no name	Piscataquog	SB_PSCR_09	Arch	42.95656	-71.74503	Old	2	4.5	At Grade	0	17	29.0	GRAY	P	P	P	T	F
NEW BOSTON	Old Coach	Piscataquog	SB_PSCR_08	Culvert	42.95833	-71.74167	New	2.2	1.6	At Grade	0	39.5		GRAY	P	P	P	P	P
NEW BOSTON	Old Coach	Piscataquog	SB_PSCR_28	Culvert	42.9695	-71.70921	New	1.3	0.2	At Grade	0	40		GRAY	F	F	F	F	F
NEW BOSTON	Old Coach Rd	Piscataquog	SB_PSCR_25	Culvert	42.9679	-71.72199	Rusted	5	1.6	Free Fall	0.4	60	34.4	ORANGE	P	P	P	T	T
NEW BOSTON	Old Cty Rd	Piscataquog	SB_PSCR_44	Culvert	42.96606	-71.65715	New	1.2	0.2	Free Fall	0.8	21	18.1	RED	F	F	F	F	F
NEW BOSTON	Parker	Piscataquog	SB_PSCR_58	Culvert	43.01552	-71.6515	New	1.2	0.5	Free Fall	0.5	42	4.9	RED	F	F	F	F	F
NEW BOSTON	Pearson Ln	Piscataquog	SB_PSCR_20	Culvert	42.94429	-71.71492	New	4	6.5	At Grade	0	120	35.6	GRAY	P	P	T	F	F
NEW BOSTON	Pine Road	Middle Branch Trib	MB_MBPR_04	Culvert	42.99237	-71.72173	Old	1.5	3	At Grade	0	20.5	12.0	GRAY	F	F	F	F	F
NEW BOSTON	River Rd	Piscataquog	SB_PSCR_40	Culvert	42.98126	-71.68214	Old	3	2.8	Cascade	0.4	41.3	35.6	GRAY	P	P	P	P	P
NEW BOSTON	River Rd	Cochrane Brook	SB_PSCR_51	Culvert	42.9885	-71.67223		6	0	At Grade	0	66.4	54.7	GRAY	P	P	P	P	P
NEW BOSTON	River Rd	Piscataquog	SB_PSCR_55	Culvert	43.00063	-71.65861	Old	4	2.1	Free Fall	0.9	40.7	39.2	RED	P	P	P	T	F
NEW BOSTON	Rte 13	Piscataquog	SB_PSCR_32	Culvert	42.95914	-71.75553	New	2	9	Cascade	0.7	41	38.3	GRAY	P	P	F	F	F
NEW BOSTON	Rte 13	Piscataquog	SB_PSCR_57	Culvert	43.00629	-71.64836	New	3	0.9	Free Fall	0.4	56	58.8	RED	P	P	T	F	F
NEW BOSTON	Rte 13	Piscataquog	SB_PSCR_59	Culvert	43.01539	-71.63364	Old	2	1.7	Free Fall	1.2	56	15.6	RED	P	F	F	F	F
NEW BOSTON	Rte 77	Piscataquog Trib	MB_MBPR_16	Culvert	43.00137	-71.68764	Old	4	0.5	At Grade	0	40.8	27.9	GRAY	P	T	T	F	F
NEW BOSTON	S Hill Rd	Meadow Brook	SB_MEBK_18	Arch	42.95274	-71.69907	Old	3.5	1	At Grade	0	38		GRAY	P	P	P	P	T

Town of New Boston, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
NEW BOSTON	S Hill rd	Piscataquog	SB_PSCR_18	Culvert	42.93558	-71.70731	New	1.7	1.8	Free Fall	0.4	40	10.0	RED	F	F	F	F	F
NEW BOSTON	S Hill Rd	Piscataquog	SB_PSCR_19	Culvert	42.93402	-71.70628	Old	1.3	3.1	At Grade	0	19.5	8.2	GRAY	F	F	F	F	F
NEW BOSTON	S Hill Rd	Piscataquog	SB_PSCR_22	Culvert	42.94436	-71.70677	Rusted	2	2	At Grade	0	30	24.0	GRAY	F	F	F	F	F
NEW BOSTON	Saunders Hill Road	Piscataquog Trib	MB_MBPR_10	Culvert	43.0106	-71.7182	Collapsing	1	3	At Grade	0	26.9	2.1	GRAY	F	F	F	F	F
NEW BOSTON	Scobie Rd	Whiting brook	MB_WTBK_12	Culvert	42.98745	-71.75423	Old							GRAY	-	-	-	-	-
NEW BOSTON	Scobie Rd	Whiting brook	MB_WTBK_13	Culvert	42.9882	-71.75008	Old	6	0.6	At Grade	0	30	29.4	GRAY	P	P	T	F	F
NEW BOSTON	Sharp	Piscataquog	SB_PSCR_10	Arch	42.949	-71.74432	Old	3	4.3	At Grade	0	22	63.8	GRAY	P	P	P	P	P
NEW BOSTON	Town Farm	Piscataquog	SB_PSCR_27	Culvert	42.97107	-71.70871	Rusted	2	1.3	Free Fall	1	41		RED	P	F	F	F	F
NEW BOSTON	Wilson Hill	Piscataquog	SB_PSCR_56	Arch	43.00517	-71.648	Old	3.8	1.3	At Grade	0	20	27.4	GRAY	P	T	F	F	F

Town of Weare

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
WEARE	Barnard Hill Rd	Otter brook	MB_OTBK_03	Culvert	43.0714	-71.68037	Collapsing							GRAY	-	-	-	-	-
WEARE	Barnard Hill Rd	Otter brook	MB_OTBK_08	Culvert	43.05841	-71.68768	New	6.9	0.1	Free Fall	0.6	40.5	57.0	RED	P	P	P	P	P
WEARE	Bart Clough Rd	Otter Brook	MB_OTBK_02	Culvert	43.07927	-71.67924	Old	1.5	8.3	At Grade	0	32	14.3	GRAY	P	F	F	F	F
WEARE	Center Brook	Piscataquog	EL_PSCR_14	Culvert	43.11217	-71.73735	Old	1	0	At Grade	0	40	6.7	GRAY	F	F	F	F	F
WEARE	Center Rd	Breed Brook	EL_BRBK_14	Culvert	43.10578	-71.73832	New	2.4	3	Cascade	0.4	59.5	22.4	GRAY	T	F	F	F	F
WEARE	Chuck	Piscataquog	UP_PSCR_06	Culvert	43.06748	-71.6564	Rusted	2	4	Cascade	0.4	30	13.9	GRAY	F	F	F	F	F
WEARE	Clough Park Rd	Piscataquog	UP_PSCR_01	Culvert	43.07823	-71.65736	New	3	3.5	At Grade	0	47	40.5	GRAY	P	P	F	F	F
WEARE	Colby	Huse Brook	UP_HUBK_01	Culvert	43.05104	-71.66649	Rusted	4	2.6	At Grade	0	60		GRAY	P	P	T	F	F
WEARE	Colby	Huse Brook	UP_HUBK_02	Culvert	43.05077	-71.66869	Old	1.8	1	Backwatered	0	100		GRAY	F	F	F	F	F
WEARE	Colby Rd	Otter Brook	MB_OTBK_09	Culvert	43.04916	-71.68467	New	9.3	0.5	At Grade	0	40	20.9	GRAY	P	P	P	P	P
WEARE	Concord Stage Rd	Piscataquog Trib	EL_PSCR_13	Bridge	43.11293	-71.74229	New	10	0.3	At Grade	0	33.7	66.7	GRAY	-	-	-	-	-
WEARE	Concord Stage Rd	Piscataquog River	EL_PSCR_16	Culvert	43.11408	-71.73843	Old			Cascade	35	100	0.0	GRAY	-	-	-	-	-
WEARE	Concord Stage Rd	Piscataquog Trib	EL_PSCR_17	Culvert	43.11634	-71.73175	New	5	6	At Grade	0	82.2		GRAY	P	P	P	P	P
WEARE	Cottage Rd	Piscataquog	WR_PSCR_27	Culvert	43.09742	-71.79716	New	2.6	3.9	Free Fall	0.8	21	17.0	RED	P	T	F	F	F
WEARE	Cram	Buxton Brook	MB_BXBK_08	Culvert	43.02271	-71.75602	Old	2	3.5	At Grade	0	64	14.5	GREEN	T	F	F	F	F
WEARE	Craney Hill rd	Piscataquog	EL_PSCR_01	Culvert	43.11668	-71.77219	Collapsing	1.2	4	Free Fall	0.9	34	11.3	RED	-	-	-	-	-
WEARE	Craney Hill Road	Piscataquog	EL_PSCR_05	Culvert	43.11076	-71.7712	New	2.5	4	Free Fall	0.4	30.8	30.0	RED	P	F	F	F	F
WEARE	Cross Rd	Peaslee Meadow Bk	EL_PMBK_02	Arch	42.97057	-71.68559	Old	4	4	At Grade	0	27.5	5.3	GRAY	-	-	-	-	-
WEARE	Deering Center Rd	Peacock Brook	MB_PEBK_09	Culvert	43.05952	-71.76785	New	2.5	3.4	At Grade	0.7	52	44.5	GRAY	P	F	F	F	F
WEARE	Deering Center Road	Peacock Brook	MB_PEBK_11	Culvert	43.0572	-71.77072	Old	2.5	0.5	At Grade	0	62		GRAY	P	F	F	F	F
WEARE	Deering Center Road	Peacock Brook	MB_PEBK_12	Culvert	43.0594	-71.76778	New	2.5	2	Free Fall	1	49	47.6	RED	T	F	F	F	F
WEARE	Deering Center Road	Peacock Brook	MB_PEBK_15	Culvert	43.05425	-71.74525	Old	3	0.2	At Grade	0	41.3	35.1	GREEN	T	F	F	F	F

Town of Weare, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval 2	10	25	50	100
WEARE	Duck Pond	Breed Brook	EL_BRBK_07	Culvert	43.08502	-71.7364	Old	3	1	Free Fall	0.9	34	13.5	RED	P	P	P	P	T
WEARE	Duck Pond Rd	Breed Brook	EL_BRBK_06	Culvert	43.08917	-71.72887	Collapsing	2	2.5	At Grade	0	66.5	17.4	GRAY	F	F	F	F	F
WEARE	E Shore Rd	Piscataquog	EL_PSCR_04	Culvert	42.95041	-71.81074	Old	2.5	11.9	At Grade	0	27	22.7	GRAY	-	-	-	-	-
WEARE	E Weare	Peaslee Meadow Bk	EL_PMBK_03	Bridge	43.10567	-71.68279	New	10.7	0.4	At Grade	0	41	30.5	GRAY	-	-	-	-	-
WEARE	E Weare Rd	Piscataquog	EL_PSCR_25	Culvert	43.10177	-71.69395	Old	3	1	At Grade	0.35	58	33.5	GRAY	P	P	P	T	F
WEARE	East	Breed Brook	EL_BRBK_12	Culvert	43.09635	-71.72153	New	8	2.6	Free Fall	0.2	30		ORANGE	P	P	P	P	P
WEARE	East Rd	Breed Brook	El_BRBK_11	Culvert	43.09691	-71.71683	Old	3	4	Free Fall	0.6	38	25.5	ORANGE	P	F	F	F	F
WEARE	East Shore DR	Piscataquog Trib	EL_PSCR_08	Culvert	43.09844	-71.76497	Old	4	0.2	At Grade	0	23.5	26.1	GRAY	P	P	P	P	T
WEARE	East Weare Rd	Piscataquog	EL_PSCR_23	Culvert	43.10475	-71.70583	Old	1.9	1.5	At Grade	0	45	19.7	GREEN	F	F	F	F	F
WEARE	Flanders Memorial Hwy	Breed Brook	EL_BRBK_08	Culvert	43.09185	-71.73597	New	4	1	Free Fall	0.8	51		RED	P	P	P	P	P
WEARE	Flanders Memorial Hwy	Breed Brook	EL_BRBK_09	Culvert	43.09392	-71.73378	Old	1.3	2	At Grade	0	45		GRAY	F	F	F	F	F
WEARE	Gen Knox Rd	Meadow Brook	MB_MEBK_12	Culvert	43.08019	-71.77295	New	2.2	1	Free Fall	0.2	40	35.9	RED	T	F	F	F	F
WEARE	Gettings	Buxton Brook	MB_BXBK_06	Culvert	43.02084	-71.76342	Rusted	1.3	1.8	At Grade	0	40	13.5	GRAY	F	F	F	F	F
WEARE	Gould Rd	Meadow Brook	MB_MEBK_14	Culvert	43.03743	-71.69183	Old	5.8	1.5	Free Fall	0.3	50.7		ORANGE	P	T	F	F	F
WEARE	Helen Dearborn Road	Hillside brook	MB_HLBK_02	Culvert	43.04168	-71.7252	Collapsing		2	At Grade	0	40	0.0	GRAY	-	-	-	-	-
WEARE	High Rock Rd	Piscataquog	UP_PSCR_04	Culvert	43.06802	-71.66228	Collapsing	2	4	At Grade	0	140	18.5	GRAY	P	T	F	F	F
WEARE	High Rock Rd	Piscataquog	UP_PSCR_05	Culvert	43.06778	-71.65887	New	3	0.8	Cascade	0.2	79	25.9	GRAY	P	T	F	F	F
WEARE	Hodgdon Rd	Peacock brook	MB_PEBK_05	Culvert	43.07317	-71.75996	New	4	3	Free Fall	0.7	36.2	31.9	RED	P	P	T	F	F
WEARE	Hodgdon Road	Peacock Brook	MB_PEBK_04	Culvert	43.07918	-71.75958	Old	1.5	3	At Grade	0	41.2		GRAY	F	F	F	F	F
WEARE	Huntington Hill	Piscataquog	EL_PSCR_31	Culvert	43.09155	-71.68419	Old	1.25	0.3	Free Fall	0.7	21	11.9	RED	F	F	F	F	F
WEARE	John Stark Hwy	Breed Brook	EL_BRBK_10	Arch	43.09043	-71.7294	New	7	5.8	At Grade	0	63		GRAY	P	P	P	P	P
WEARE	MapleWold	Meadow Brook	MB_MEBK_01	Culvert	43.06752	-71.73589	New	1.3	2	Free Fall	0.4	29.6	14.1	RED	F	F	F	F	F
WEARE	Maplewold Rd	Peacock Brook	MB_PEBK_21	Culvert	43.06739	-71.7358	New	1.1	9	Cascade	0.5	25	14.2	GRAY	F	F	F	F	F
WEARE	Maplewold Road	Meadow Brook	MB_MEBK_02	Culvert	43.0664	-71.73163	New	4.5	4	Free Fall	0.2	24	56.0	RED	P	P	P	T	F
WEARE	Maplewold Road	Meadow Brook	MB_MEBK_03	Culvert	43.06687	-71.72804	Old		4.7	At Grade	0	33	0.0	GRAY	F	F	F	F	F
WEARE	Melvin Valley Rd	Otter Brook	MB_OTBK_07	Culvert	43.06379	-71.68965	Eroding	1.8	6	At Grade	0	21.8		GRAY	F	F	F	F	F
WEARE	Mount Dearborn Road	Meadow Brook	MB_MEBK_06	Culvert	43.05257	-71.72056	New	2	1	Cascade	0.8	41.6	21.5	GRAY	P	T	F	F	F
WEARE	Mt Dearborn Road	Peacock Brook	MB_PEBK_13	Culvert	43.05837	-71.74033	New	5		Free Fall	4.4	42		RED	-	-	-	-	-
WEARE	Mt William Pond Rd	Breed Brook	EL_BRBK_02	Culvert	43.08269	-71.72437	Eroding	4	2	Free Fall	0.4	60	43.2	RED	P	T	F	F	F
WEARE	Mt. William Pond Rd	Breed Brook	EL_BRBK_03	Culvert	43.08025	-71.72251	Old	3	1	At Grade	0	30	21.1	GRAY	P	F	F	F	F
WEARE	N John Stark Highway	Breed Brook	EL_BRBK_13	Culvert	43.10371	-71.74014	rusted	1.5	3	At Grade	0	51	6.1	GRAY	F	F	F	F	F
WEARE	New Rd	Piscataquog	EL_PSCR_06	Culvert	43.09724	-71.76501	Old	3.5	3	Free Fall	0.5	65	28.8	RED	P	T	F	F	F
WEARE	Newman Wilson Rd	Otter Brook	MB_OTBK_13	Arch	43.03044	-71.67056	New	22	1	At Grade	0	32.5	47.1	GRAY	P	P	P	P	P
WEARE	no name	Stark Brook	EL_STBK_13	Bridge	43.10715	-71.65843	New	13.6	0.8	At Grade	0	24	52.3	GREEN	-	-	-	-	-
WEARE	Oak Hill RD	Hillside Brook	MB_HLBK_03	Culvert	43.0345	-71.7045	New	3	1	Cascade	4	75	7.9	GRAY	F	F	F	F	F
WEARE	Oak Hill Rd	Hillside Brook	MB_HLBK_03	Culvert	43.03464	-71.7044	Old	3	2	Free Fall	0.5	67	10.1	RED	-	-	-	-	-
WEARE	page hill rd	Piscataquog	WR_PSCR_33	Culvert	43.11261	-71.78262	Old	3	1	At Grade	0	41	27.4	GRAY	P	T	F	F	F
WEARE	Page Hill Road	Piscataquog Trib	EL_PSCR_03	Bridge	43.10929	-71.76781	Old	6	15	At Grade	0	23	43.3	GRAY	-	-	-	-	-

Town of Weare, cont.

Town	Road Name	Stream Name	Crossing ID	Structure Type	Latitude	Longitude	Condition	Culvert Width (ft)	Culvert Slope	Culvert Outlet	Culvert Drop (ft)	Length (ft)	Bankfull %	AOP Status	Return Interval				
															2	10	25	50	100
WEARE	Peaslee	Piscataquog	EL_PSCR_19	Culvert	43.1098	-71.7057	Rusted	1.5	1.5	At Grade	0	28	7.6	GRAY	P	P	P	T	F
WEARE	Peaslee	Piscatquog	EL_PSCR_20	ford	43.11026	-71.70495				At Grade	0	24		GRAY	-	-	-	-	-
WEARE	Peaslee Hill rd	Piscataquog	EL_PSCR_21	Culvert	43.1037	-71.7084	New	3	8	Free Fall	0.7	60	38.7	RED	P	P	P	T	F
WEARE	pleasant pond rd	Piscataquog Trib	WR_PSCR_29	Culvert	43.12304	-71.79752	New	3.5	2	At Grade	0	41	58.7	GRAY	P	F	F	F	F
WEARE	Pond View	Breed Brook	EL_BRBK_04	Culvert	42.97006	-71.69661	New	2	3	Free Fall	0.4	33	17.8	RED	-	-	-	-	-
WEARE	PondView Rd	Breed Brook	EL_BRBK_01	Culvert	43.07647	-71.71923	New	2	3.7	Free Fall	0.7	31	16.6	RED	F	F	F	F	F
WEARE	Poor Farm Rd	Currier Brook	MB_CUBK_01	Culvert	43.03035	-71.74098	Old	2	3	At Grade	0	30	14.3	GRAY	F	F	F	F	F
WEARE	Poor Farm Rd	Currier Brook	MB_CUBK_02	Culvert	43.02708	-71.74318	Old	2	7	Free Fall	1.3	41	11.6	RED	F	F	F	F	F
WEARE	Poor Farm Rd	Currier brook	MB_CUBK_03	Culvert	43.01504	-71.73829	Old	1.5	0.2	At Grade	0	30		GRAY	F	F	F	F	F
WEARE	Quaker	Piscataquog	EL_PSCR_07	Culvert	43.09843	-71.76484	Rusted	3.9	3	At Grade	0	25	25.7	GRAY	P	P	P	P	T
WEARE	Reservoir Rd	Piscataquog Trib	EL_PSCR_12	Culvert	43.11105	-71.75321	Old	1.3	1	At Grade	0	59.4		GRAY	F	F	F	F	F
WEARE	Reservoir Rd	Piscataquog Trib	EL_PSCR_10	Arch	43.11115	-71.75829	Old	6	1	At Grade	0	25	74.1	GRAY	P	P	P	P	P
WEARE	Reservoir Rd	Piscataquog Trib	EL_PSCR_12A	Culvert	43.11109	-71.75301	New	2		At Grade	0	122		GRAY	F	F	F	F	F
WEARE	River Rd	Piscataquog Trib	EL_PSCR_18	Culvert	43.11635	-71.73168	Old	3	2	At Grade	0	42.6		GRAY	F	F	F	F	F
WEARE	River Rd	Piscataquog	EL_PSCR_22	Culvert	43.10445	-71.70619	Old	2	6	Free Fall	3.5	63	20.4	RED	P	P	F	F	F
WEARE	River Rd	Piscataquog	EL_PSCR_30	Culvert	43.09713	-71.69145	Old	4.5	4	At Grade	0	216	18.1	GRAY	P	P	P	P	T
WEARE	River Rd	Piscataquog	EL_PSCR_32	Culvert	43.09831	-71.68773	Old	4	5	Cascade	4.5	125	22.6	GRAY	P	P	T	F	F
WEARE	River/Clough Park Rd	Piscataquog	UP_PSCR_07	Culvert	43.06805	-71.65508	New	1.5	3.6	Free Fall	0.9	130	12.1	RED	-	-	-	-	-
WEARE	Rt 114	Meadow Brook	MB_MEBK_13	Culvert	43.05196	-71.70273	Old	2	5	Cascade	0.2	128.8	19.1	GRAY	F	F	F	F	F
WEARE	Rt 114	Piscataquog Trib	EL_PSCR_11	Culvert	43.11357	-71.7559	Old	3	1	At Grade	0	49.9	16.0	GRAY	P	P	T	F	F
WEARE	Rt 114	Otter Brook	MB_OTBK_10	Culvert	43.04299	-71.67738	Rusted	5.5	0.4	At Grade	0	46		GRAY	P	P	P	P	T
WEARE	Rte 149	Hillside brook	MB_HLBK_01	Culvert	43.04805	-71.72685	Old	2	0.8	Free Fall	0.9	48.5	7.5	RED	P	F	F	F	F
WEARE	Rte 149	Meadow Brook	MB_MEBK_07	Culvert	43.04919	-71.72347	Old	2	2	Cascade	0.4	53.8	28.7	GRAY	F	F	F	F	F
WEARE	Rte 77	Stark Brook	EL_STBK_02	Culvert	43.14646	-71.64809	New	3.5	3	Cascade	0.4	200	21.0	GRAY	P	P	P	P	P
WEARE	Sewell-Hoyt	Choate Brook	EL_CHBK_01	Culvert	43.12492	-71.6769	New	1.3	4.5	At Grade	0	31	6.7	GRAY	F	F	F	F	F
WEARE	Shady Hill Rd	Peacock Brook	MB_PEBK_01	Culvert	43.08012	-71.77261	Old	1.2	1	Free Fall	0.9	52		RED	F	F	F	F	F
WEARE	Shady Hill Rd	Peacock Brook	MB_PEBK_02	Culvert	43.0804	-71.76585	New	2.5	0.2	At Grade	0	60		GRAY	F	F	F	F	F
WEARE	Shady Hill Road	Peacock Brook	MB_PEBK_03	Culvert	43.08039	-71.76467	Old	4	2	Cascade	0.3	40.4	36.4	GRAY	P	P	T	F	F
WEARE	Twin Bridge Rd	Piscataquog	MB_MBPR_11	Culvert	43.02411	-71.68179	New	1.25	0.5	At Grade	0	39.5		GRAY	F	F	F	F	F
WEARE	Twin Bridge Rd	Otter Brook	MB_OTBK_11	Culvert	43.0331	-71.67006	Rusted	2.8	3	Free Fall	0.6	59.3	22.3	ORANGE	P	F	F	F	F
WEARE	Twin Bridge Rd	Otter Brook	MB_OTBK_12	Culvert	43.03227	-71.67158	Old	7.3	2	At Grade	0	40.5	28.0	GRAY	P	P	P	P	P
WEARE	unk	Piscataquog	EL_PSCR_24	Arch	43.10307	-71.70251	collapsing			At Grade	0	36.6		GRAY	-	-	-	-	-
WEARE	Waterman Rd	Piscataquog River	WR_PSCR_31	Culvert	43.11116	-71.78315	Old	4	2	Free Fall	0.2	20	42.0	ORANGE	P	P	P	P	P
WEARE	Waterman Rd	Piscataquog	WR_PSCR_34	Culvert	43.11224	-71.78252	Rusted	1.5	3	At Grade	0	29	3.0	GRAY	F	F	F	F	F
WEARE	Winslow Rd	Piscataquog	WR_PSCR_30	Culvert	43.11329	-71.78426	Old	5.7	5	At Grade	0	50	23.6	GREEN	P	P	P	P	P
WEARE	Winslow Rd	Piscataquog	WR_PSCR_32	Culvert	43.1133	-71.7817	Rusted	1.9	1	Free Fall	2.3	40	9.3	RED	F	F	F	F	F

Appendix 7

Modeling Tools ~ Resources

Appendix 7

Hydrology and Hydraulic Resources

Hydrology

StreamStats – StreamStats for New Hampshire incorporates regression equations that can be used to estimate the long-term flood discharges at recurrence intervals of 2-, 5-, 10-, 25-, 50-, 100-, and 500-years. http://water.usgs.gov/osw/streamstats/new_hampshire.html

HEC-HMS – The Hydrologic Modeling System (HEC-HMS) is designed to simulate the complete hydrologic processes of dendritic watershed systems.
http://www.hec.usace.army.mil/software/hec-hms/

Hydraulics

HEC-RAS – HEC-RAS is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. In can perform one-dimensional steady flow, unsteady flow, sediment transport/mobile bed computations, and water temperature modeling.
http://www.hec.usace.army.mil/software/hec-ras/

HY-8 – HY-8 enables users to perform hydraulic computations to assess the performance of culverts, roadway overtopping at a culvert, evaluate multiple barrels at a single crossing, and documentation such as tables and graphs summarizing model results.
http://www.fhwa.dot.gov/engineering/hydraulics/software/hy8/

Road-Stream Crossing Design

US Forest Service Stream Simulation Method – The Stream Simulation Method is a method for designing and building road-stream crossings intended to permit free and unrestricted movements of any aquatic species; SSM structures have a continuous streambed that mimics the slope, structure, and dimensions of the natural streambed.
http://www.fs.fed.us/eng/pubs/pdf/StreamSimulation/

Appendix 8

Culvert Assessment Protocol Survey Form

Culvert Field Form

Piscataquog River Project - ver. 4/20/2012

Structure ID	Unknown ☐			Structure Number	
Observer(s)/ Organization(s)				Date & Time	
Town		Datum		Latitude (N/S)	
Location				Longitude (E/W)	
SGA Reach ID				Stream Name	
Road Name				Road Type	**paved gravel trail railroad**
# of shoulder lanes				Crossing Condition	**new old eroding collapsing rusted**
# of travel lanes		Structure Materials	**Concrete Plastic-Corrugated Plastic-Smooth Tank Stone Steel-Corrugated Steel-Smooth Aluminum-Corrugated Other: ____________**	Structure skewed to roadway	**yes no**
# of culverts at crossing				Flow Conditions	**unusually low typical low higher than average flood conditions**
Overflow pipe(s)	**yes no**				

Geomorphic and Fish Passage Data

General

Floodplain filled by roadway approaches: **entirely** (> 3/4 of floodplain) **partially** (1/4 – ¾ of floodplain) **not significant**
Structure within ⅓ mile downstream of a significantly steeper segment of stream: **yes no unsure**
Culvert slope as compared with the channel slope is: **higher lower about the same**
Water depth in the crossing matches that of stream: **yes no (significantly deeper) no (significantly shallower)**
Water velocity in crossing matches that of stream: **yes no (significantly faster) no (significantly slower)**

Upstream

Structure opening partially obstructed by (circle all that apply): **wood sediment wood & sediment deformation of culvert none other: _________**

Steep riffle present immediately upstream of structure: **yes no**
If channel avulses, stream will: **cross road follow road cross and follow road unsure**
Estimated distance avulsion would follow road: _______________ **(ft.)**
Angle of stream flow approaching structure: **sharp bend (45° - 90°) mild bend (5° - 45°) naturally straight channelized straight**
Evidence of streambed erosion or aggradation immediately upstream of culvert: **erosion aggradation none**
Culvert inlet: **at grade cascade free fall**
Upstream bankfull widths: 1.)__________ 2.)___________ 3.)__________ 4.)__________ 5.)__________ (ft.)

Reference bankfull widths: 1.)__________ 2.)___________ 3.)__________ 4.)__________ 5.)__________ (ft.)

Downstream

Water depth in culvert (at outlet): _______________ **(0.0 ft.)**
Culvert outlet: **at grade cascade free fall backwatered _____ (ft.)** Stepped footers: **yes no**
Outlet drop (invert to water surface): _______________ **(0.0 ft.)**
Pool present immediately downstream of structure: **yes no**
Pool depth at point of streamflow entry: _______________ **(ft.)**
Maximum pool depth: _______________ **(0.0 feet)**
Downstream bank heights are substantially higher than upstream bank heights: **yes no**
Hydraulic control type: **bedrock boulders cobble gravel sand wood other:_______________**
Distance from downstream end of culvert to hydraulic control: _______________ **(ft.)**
Evidence of streambed erosion or aggradation immediately downstream of culvert: **erosion aggradation none**
Downstream bankfull widths: 1.)_________ 2.)__________ 3.)_________ 4.)_________ 5.)_________ (ft.)

	Upstream	**Downstream**	**In Structure**	
Dominant bed material (substrate) at structure (use codes below)	**1 2 3 4 5 6 UNK**	**1 2 3 4 5 6 UNK**	**NONE 1 2 3 4 5 6 UNK**	
Bedrock present	**yes no**	**yes no**	Depth of Substrate	**< 1 foot 1-2feet >2 feet UNK N/A**
Sediment Deposit Type	**none delta side point mid-channel**	**none delta side point mid-channel**	**none delta side point mid-channel**	
Elevation of sediment deposits is greater than or equal to ½ bankfull elevation	**yes no**	**yes no**	**yes no**	
			Substrate Throughout? **yes no**	
Beaver dam near structure Distance from structure to dam	**yes no distance: _____ (ft.)**	**yes no distance: _____ (ft.)**	**Bed Material Codes** **1 –** bedrock **2 –** boulder **3 –** cobble **4 –** gravel **5 –** sand **6** – silt/clay **UNK -** unknown	
Hard bank armoring	**intact failing none UNK**	**intact failing none UNK**		
Bank erosion	**high low none**	**high low none**		
Stream bank scour causing undermining around/under structure (circle all that apply)	**none culvert footers wing walls**	**none culvert footers wing walls**		

Wildlife Data (left/right bank determined facing downstream)	**Upstream LEFT**	**Upstream RIGHT**	**Downstream LEFT**	**Downstream RIGHT**	**Vegetation Type Codes**
Dominant vegetation type (use codes to the right)					**C –** coniferous forest **D –** deciduous forest **M –** mixed forest **S –** shrub/sapling **H –** herbaceous/grass **B –** bare **R –** road embankment
Does a band of shrub/forest vegetation that is at least 50' wide start within 25' of structure and extend 500' or more up/downstream?	**yes no**	**yes no**	**yes no**	**yes no**	

<table>
<tr><td>Road-killed wildlife within ¼ mile of structure (circle none or list species)</td><td colspan="3">species: none</td><td></td></tr>
<tr><td rowspan="5">Wildlife sign and species observed near (up/downstream) and inside structure
(circle none or list species and sign types)</td><td colspan="2">Outside Structure</td><td colspan="2">Inside Structure</td></tr>
<tr><td>species (none)</td><td>sign</td><td>species (none)</td><td>sign</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Spatial data collected with GPS: **yes** **no** **Comments/Drawings:**

Photos taken: **yes** **no**

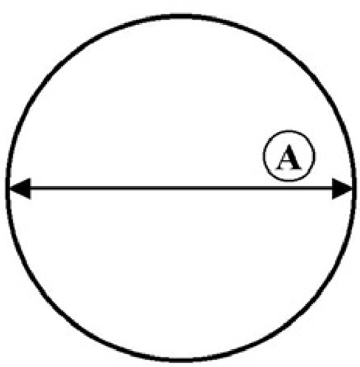
Please fill out photo log below

Folder Name:	Culvert Opening	Stream Channel	Above Crossing
Photo View - Upstream	☐	☐	☐
Photo View - Downstream	☐	☐	☐

Record the file name for each photo taken in the appropriate box

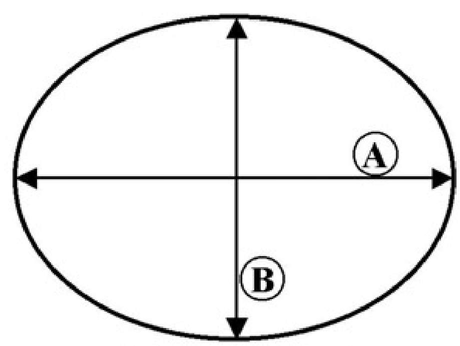
Crossing Dimensions

1.



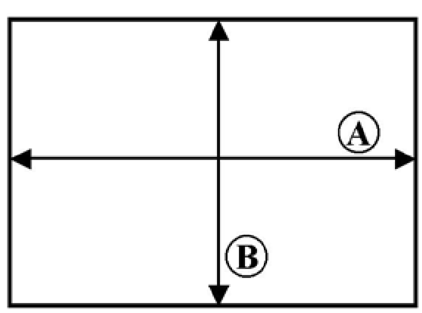
Round Culvert

2.



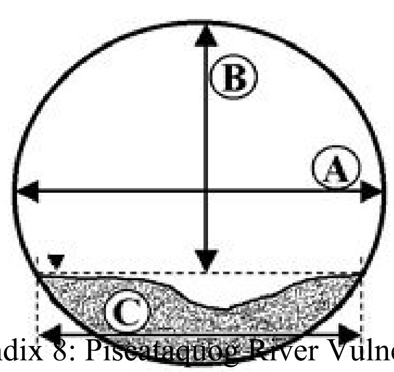
Elliptical Culvert

3.



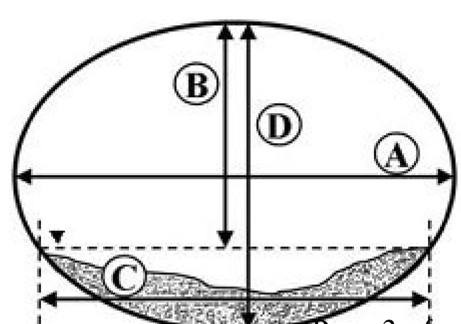
Box Culvert

4.



Embedded Round Culvert

5.



Embedded Elliptical Culvert

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.** ☐ **Ford**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): ____________________
~~Crossing Slope (%):~~__________________

Note: When inventorying multiple culverts, label left culvert 1 and go in increasing order from left to right from downstream end (outlet) to looking upstream.

Culvert Cell 2 of _______

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): ____________________
~~Crossing Slope (%):~~__________________

Culvert Cell 3 of _______

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): ____________________
~~Crossing Slope (%):~~__________________

Culvert Cell 4 of ________

Crossing Type (from above): ☐ **1.** ☐ **2.** ☐ **3.** ☐ **4.** ☐ **5.**

	Ⓐ	Ⓑ	Ⓒ	Ⓓ
Upstream Dimensions (ft.)				
Downstream Dimensions (ft.)				

Length of stream through crossing (ft.): ____________________
~~Crossing Slope (%):~~__________________

Culvert # 1: Road Elevations (1/10 ft.):

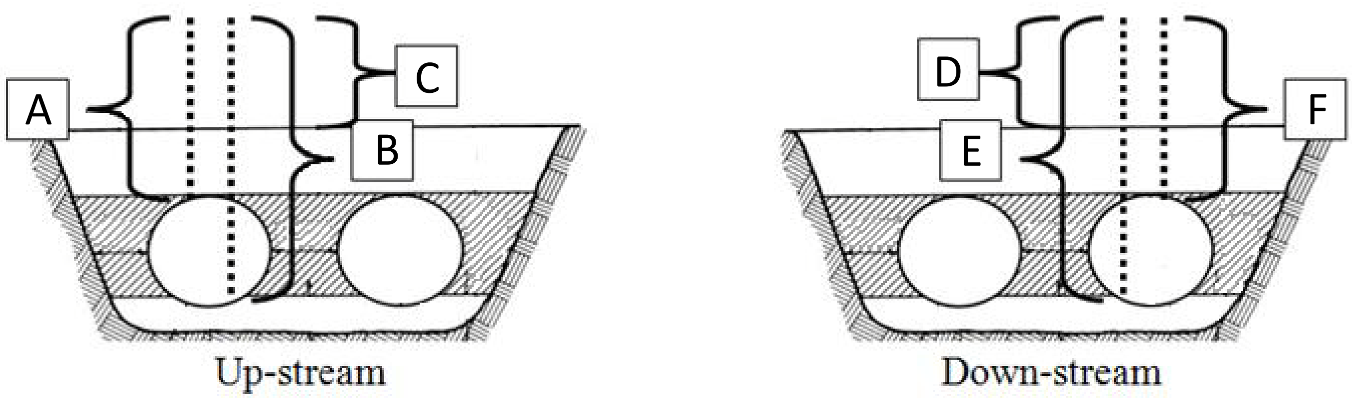
Upstream: A) ______________ B) ______________ C) ______________

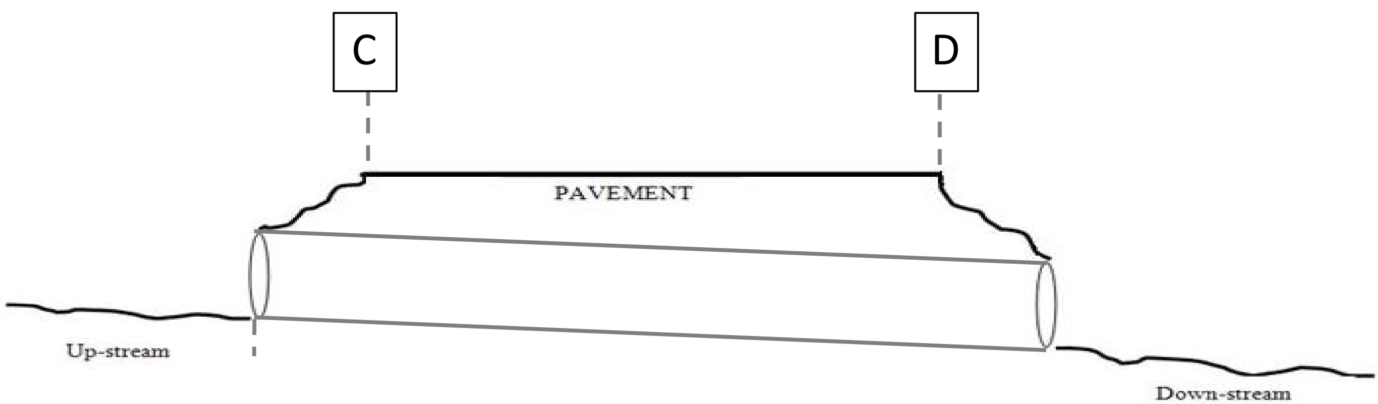
Downstream: D)_______________ E) ______________ F) ______________

Culvert # 2: Road Elevations (1/10 ft.):

Upstream: A) ______________ B) ______________ C) ______________

Downstream: D)_______________ E) ______________ F) ______________





<u>Other NOTES:</u>