ALTERNATIVES ANALYSIS and FEASIBILITY REPORT

COMBINATION POND

Rutland, Vermont

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FINAL

Prepared for:
City of Rutland

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DuBois & King inc.

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ALTERNATIVES ANALYSIS and FEASIBILITY REPORT

COMBINATION POND

1.0 EXECUTIVE SUMMARY

Combination Pond is an onstream pond located on Moon Brook in Rutland, Vermont. The pond, based on multiple years of monitoring, is causing a significant increase in the temperature of the brook.

The City of Rutland hired the project team of Dubois & King, Inc. and Bear Creek Environmental, LLC to complete an alternatives analysis and feasibility study. The work was directed by a Steering Committee comprised of the City of Rutland, the Rutland Natural Resources Conservation District, and the Vermont Agency of Natural Resources.

The scope of work for the alternatives analysis included a review and summary of previous studies, property ownership research, a report, and public meetings.

Seven alternatives were identified to address temperature, water quality, and habitat issues in the vicinity of Combination Pond. The alternatives included doing nothing, updating the dam to current design standards, releasing colder water from the bottom of the pond, constructing a bypass channel or pipe, augmenting the pond water with colder groundwater, and removing the dam. These alternatives were evaluated for environmental benefit, cost effectiveness, changes to downstream hydrology, and landowner concerns.

Two public meetings, each attended by approximately 30 people were held to review the alternatives.

The Steering Committee concluded that removing the dam is the best ecological and public safety alternative. However, because of complex ownership issues, that alternative is unlikely at present to move forward.

The Steering Committee recommended moving forward with the modifications to the dam that would allow water to be released from the colder bottom of the pond.

The steering committee also recommended that property owners in the Charter Hills neighborhood work with the City of Rutland and the owner of Combination Pond to implement a maintenance plan for the dam.

2.0 INTRODUCTION

The City of Rutland retained the project team of DuBois & King, Inc (D&K) and Bear Creek Environmental, LLC (BCE) to perform an alternatives analysis of Combination Pond located on Moon Brook in Rutland, Vermont. The project includes legal research and the analysis of options to mitigate the pond's impact on water quality in the brook. Financial support for the project is provided by the Stormwater Impaired Restoration Fund.

A Steering Committee provided direction and review throughout the project. Members were Evan Pilachowski (Rutland City Engineer), Nanci McGuire (Rutland Natural Resources Conservation District), and Ethan Swift and Jim Pease (Vermont Department of Environmental Conservation).

2.1 Overview

Combination Pond is a 2.15 acre onstream pond located off of Sharon Drive in Rutland, Vermont that significantly elevates the water temperature of Moon Brook. The Pond is also affecting natural sediment transport, is impeding aquatic organism passage, and poses a potential flood hazard to downstream properties should the dam fail. The drainage area of the pond is 1.64 square miles.

Located within the Otter Creek watershed, Moon Brook is part of the larger Lake Champlain-St. Lawrence River basin (Figure 1). Moon Brook and its tributaries account for roughly 9 square miles of the entire 1,100 square mile Otter Creek watershed. The topography of Moon Brook is generally gentle, with the greatest changes in relief occurring in the uppermost headwaters of the basin (Bear Creek Environmental, 2008). Moon Brook is located in a highly urbanized area in Rutland County, Vermont (Figure 2). The upper portions of the watershed are predominately forested, but urban land use dominates throughout most of the mainstem reaches and lower reaches of the tributaries, with sparsely distributed agricultural parcels (Bear Creek Environmental, 2008).

As shown in Figure 3, Moon Brook from the outlet of Combination Pond downstream to the mouth has been identified by the State of Vermont as impaired, and is included in Part A of the 2008 303(d) List of Waters (October 2008, approved by USEPA September 24, 2008). Surface water quality problems are identified as stormwater runoff and erosion. Elevated summer water temperatures are another documented stressor on the aquatic biota of Moon Brook as described in the Total Maximum Daily Load to Address Biological Impairment in Moon Brook (October 2008, approved by EPA Region 1: February 19, 2009). The Vermont Agency of Natural Resources has identified private stormwater ponds and public recreational ponds in the Moon Brook watershed as contributing to stream temperature warming, thereby precluding a trout fishery (VTDEC, 2004). The only biological monitoring sites that met water quality standards between 1986 and 2005 are located above Combination Pond.

In addition to ecological concerns related to Combination Pond, aesthetics, recreation, and flooding hazard are likely to be primary concerns of residents and the community. Combination Pond is situated in a focal point in the Charter Hill neighborhood, and a number of the homes overlook the pond making aesthetics an important consideration. There is a parking area, located off of Sharon Drive providing easy access to the pond. There is no available information regarding the recreational importance of the pond; however, it is likely that some fishing and open water boating takes place. In May 2010, the Rutland Kiwanis Club held their annual fishing Derby at Combination Pond. During Tropical storm Irene in August 2011, flood waters overtoped Sharon Drive and downstream property owners were evacuated. That event has led to heightened awareness of dam safety issues and interest in reducing the potential for the dam to overtop and to fail.

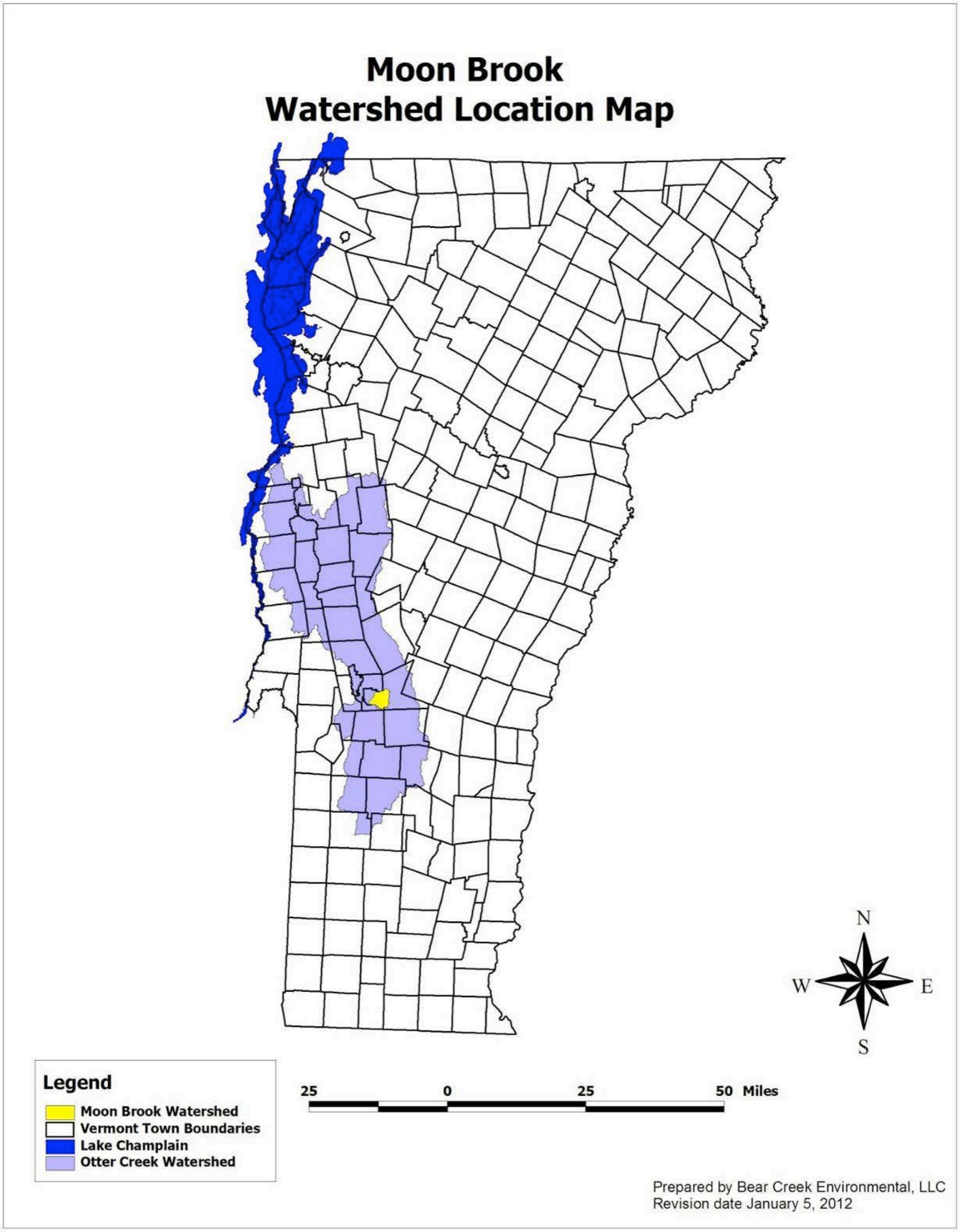

Figure 1. Moon Brook Watershed Location Map

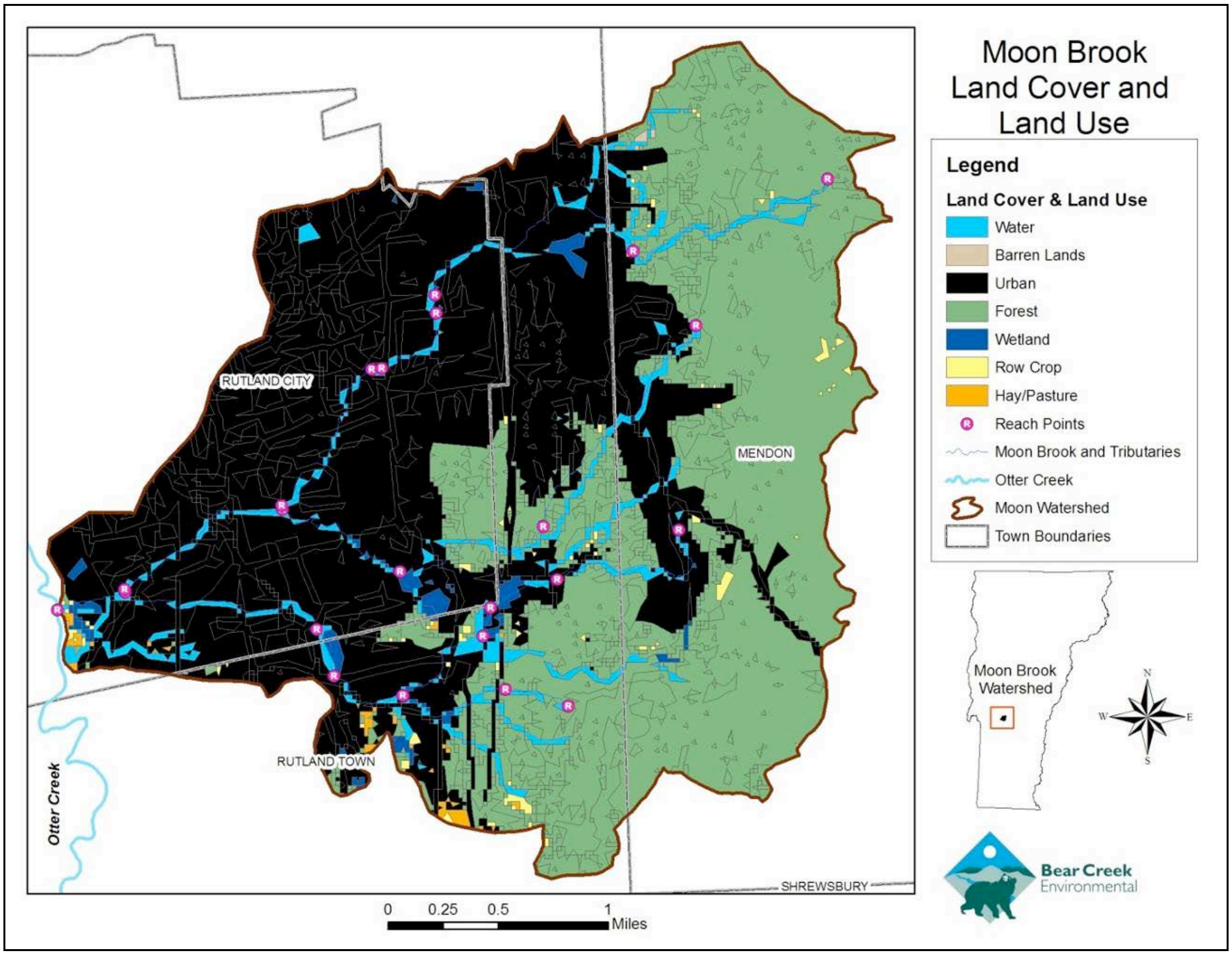

Figure 2. Land cover and land use in Moon Brook Watershed

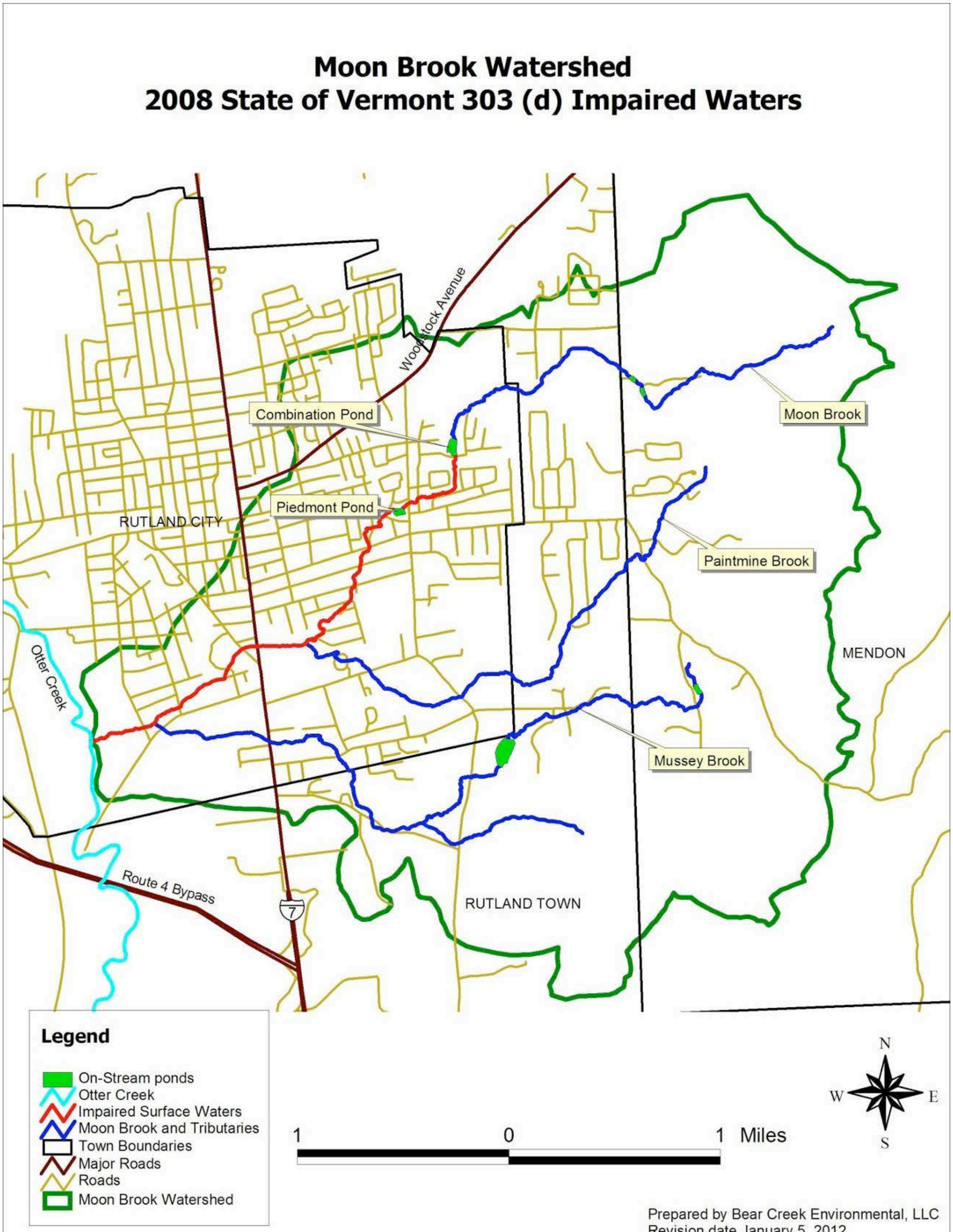

Figure 3. 303 (d) Impaired Section of Moon Brook

2.2 Scope of Work for Alternatives Analysis

The purpose of this report is to present and evaluate a number of alternatives to decrease water temperatures to improve habitat suitability for trout, allow natural migration of aquatic organisms, restore natural sediment transport, and reduce flood hazards associated with the dam. There are five primary components of the project:

Review and Summary of Previous Studies
Property Ownership Research
Site Assessment
Alternatives Analysis and Feasibility Report
Outreach Effort

3.0 REVIEW AND SUMMARY OF PREVIOUS STUDIES

3.1 Water Temperature Monitoring

The City of Rutland collected water temperature data within Moon Brook from 2005 through 2007. The City has continued monitoring temperature in subsequent years, including 2012. A summary of the 2005 – 2007 results and a plot of recent 2012 data are included in Attachment 1.

The monitoring results have shown a significant increase in water temperature of Moon Brook due to warming within Combination Pond. The temperature results for a 160 day period in 2007 (end of April through beginning of October) were evaluated using a coldwater fisheries criteria developed by the New Mexico Environmental Department that is based on brook trout as an indicator species. The coldwater criteria are as follows:

1. Instantaneous temperature below 75.2°F;
2. No single day with temperatures above 68°F for more than 8 hours;
3. No more than 3 days in a row with maximum temperature above 68°F.

According to Evan Pilachowski (Rutland City Engineer), the stations immediately below the pond exceeded the coldwater fishery criteria developed by the New Mexico Environmental Department on more than half of the days. In contrast, the monitoring station upstream of Combination Pond did not exceed the coldwater criteria on any of the monitoring days in 2007.

During 2006, the City of Rutland undertook a special temperature study to better understand if the pond is stratified. This information is useful for evaluating the effectiveness of a bottom release to reduce the water temperature in Moon Brook. Temperature data loggers were installed upstream of the pond, near the outlet structure at two depths (3 feet and 6 feet below the surface), and immediately downstream of the pond (assumed to be the same as the surface of the pond). Unfortunately, the temperature logger installed downstream of the pond may have been exposed to the air, and is not useful in understanding possible temperature stratification within the pond.

When water temperatures were at their highest in the pond during late July, as shown in Figure 4, temperatures at a depth of 6 feet were in the range of 1.5 to 3 degrees Fahrenheit colder than at a depth of 3 feet. This suggests there is some reduction in water temperature with depth. For the period July 19, 2006 through July 22, 2006, the temperature of the pond at both the 3 and 6 foot depths did not meet coldwater criteria #2 and #3.

Because no concurrent temperature data are available for the surface of the pond (from where water is released from the pond to the downstream channel) or from the bottom of the pond, the full range of temperatures in the pond are not well understood. However, if the 1.5 – 3 degree spread observed between the 3 and 6 foot depths is extrapolated linearly (an assumption which unfortunately cannot be verified with the available data), it suggests that the water at the pond bottom (depth of about 9 feet) may be another 1.5 to 3.0 degrees colder than measured at the 6 foot depth. If this is correct, then the temperature regime near the bottom of the pond may approach compliance with the coldwater criteria #2 and #3, though would not likely fully meet them.

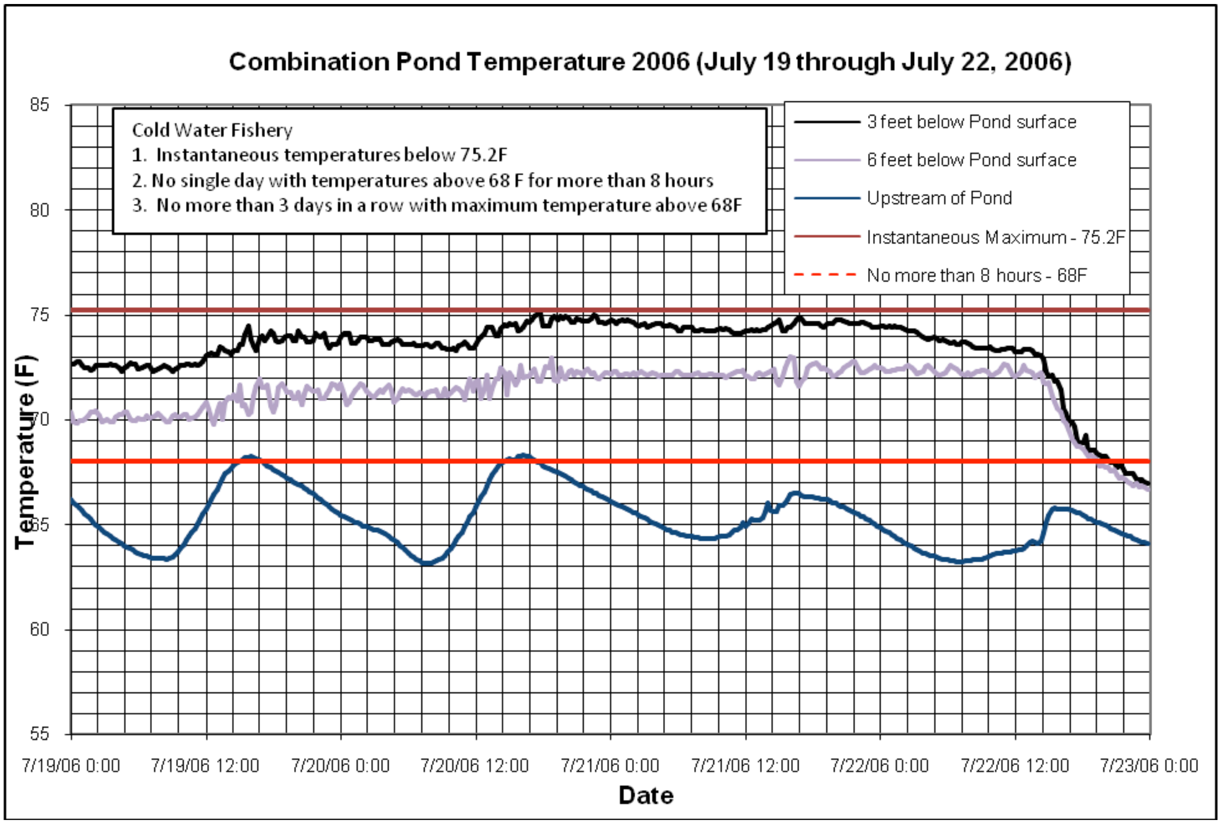

Figure 4. 2006 Water Temperature Data from Moon Brook above Combination Pond and Within Combination Pond at two depths (City of Rutland Study)

3.2 Analysis of Sediment from Combination Pond

Combination Pond is located downstream of the former Old City landfill (Figure 5), which was capped in 1990 and is no longer active. Approximately 300,000 tons of solid waste was deposited at the Old City landfill between the 1930s and 1988. Historical sampling of the site has revealed elevated levels of volatile organic carbons (VOCs), semi volatile organic compounds (SVOCs), and metals in the groundwater. Elevated levels of metals have also been found in the surface water path (drainage swale and Moon Brook) (USEPA, 2006).

In an effort to inform a feasibility analysis for Combination Pond, the Vermont Department of Conservation (VTDEC) conducted a sediment assessment of Combination Pond in October 2009. This sediment assessment provides important information regarding reuse of sediments that could potentially be removed from the pond as part of a project to address the biological impairment of Moon Brook. Based on information provided by Ethan Swift (VTDEC), stations were established every 30 feet along a 170 foot cross section, paralleling Sharon Drive approximately 100 feet off the southern shoreline. Three additional sampling locations were sited along longitudinal mid-points at the outlet, mid pond, and inlet. Information regarding the sampling locations is provided in Table 1 on page 1 of Attachment 2. The sediment samples were collected using an Ekman dredge, and were analyzed at the VTDEC laboratory in Waterbury, Vermont for typical landfill monitoring parameters. The sediment was tested for metals (arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead, and zinc) and total petroleum hydrocarbons (TPH), solids, and total volatile solids (TVS). The results of the laboratory analyses are included in Table 3 in Attachment 2.

VTDEC evaluated the laboratory results to determine if the sediments fall under the Resource Conservation and Recovery Act (RCRA) as clean fill. The results were compared to a number of thresholds including a sediment biological threshold effect concentration (TEC) and a probable effects concentration (PEC), which are recommended guidelines for protection of aquatic biota in freshwater ecosystems (VTDEC, not dated). The TEC is a concentration below which adverse effects are unlikely to occur. The PEC is a concentration above which adverse effect are likely to be observed. There are no TEC and PEC values listed for manganese and iron. For this reason, manganese and iron concentrations were compared to the lowest effect level (LEL) and the serious effects level (SEL) in the NOAA Screening Quick Reference Tables (Buckman 2008).

Although the Combination Pond sediments exceeded the TEC or LEL for cadmium, lead, zinc, iron and manganese, none of the concentrations exceeded the PEC or SEL. Therefore, there is not a high risk of impact to the aquatic biota from the sediment (personal communication Rick Levey, VTDEC).

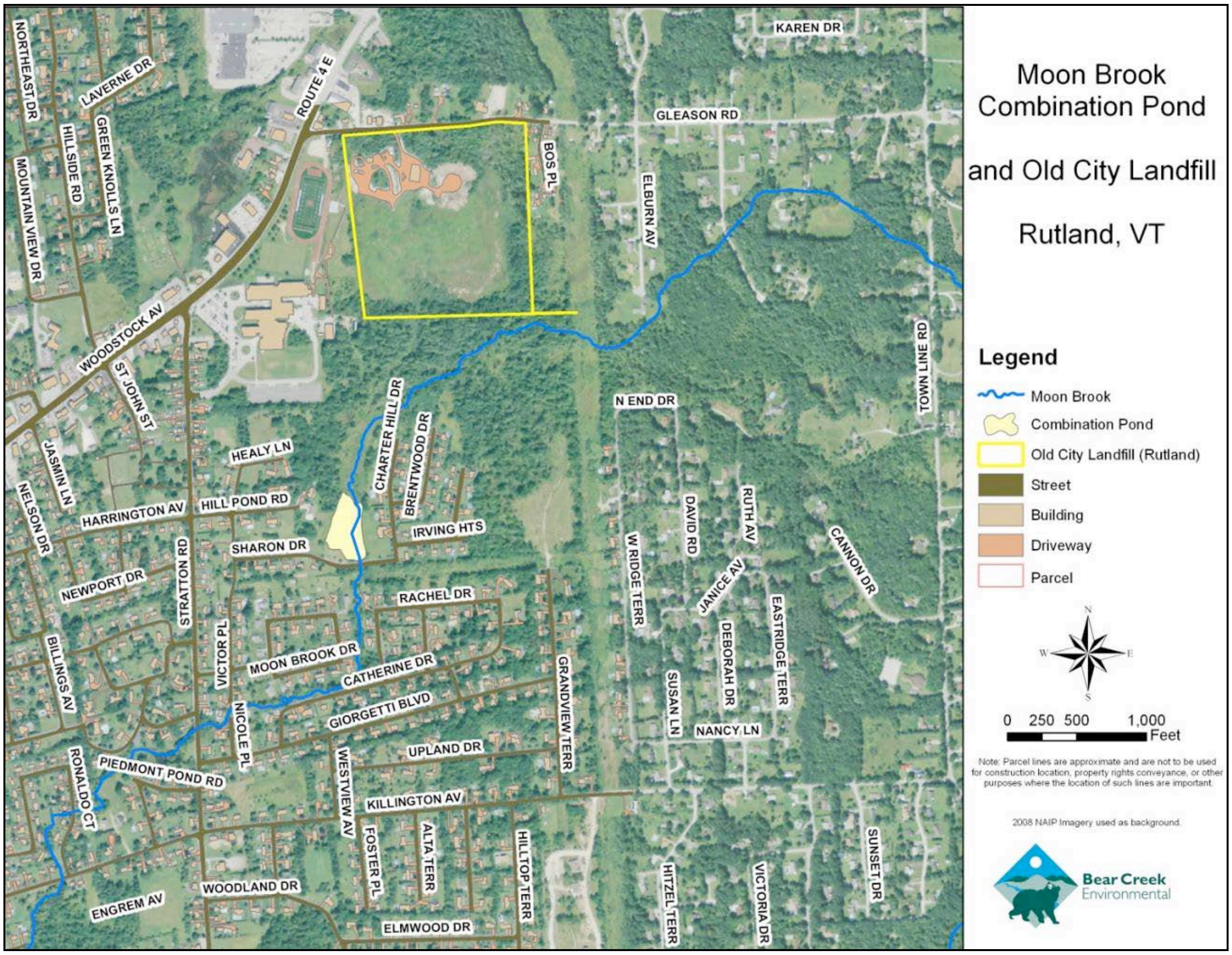

Figure 5. Site Location Map for Old City Landfill and Combination Pond

The results of the sediment analyses for Combination Pond were also compared to a soil Toxicity Characteristic Leaching Procedure (TCLP) value. TCLP values are available for cadmium, chromium and lead. The maximum concentration of all three of these analytes in the Combination Pond sediment was found to be below the TCLP. If no TCLP value was available for a certain parameter, the Regional Screening Levels (RSL) for chemical contaminants at superfund sites was evaluated. For arsenic, copper, nickel, zinc, iron and manganese, there is no TCLP value, so the regional screening levels for chemical contaminants at superfund sites were used as a comparison (VTDEC, not dated).

Neil Kamman of the VTDEC Monitoring, Assessment and Planning Program concluded from his initial review of the laboratory results in April 2010 (email communication of April 13, 2010) that the sediments could be treated as clean fill. He requested that Trish Coppolino verify his conclusion. Trish Coppolino with the VTDEC Waste Management Division (email communication of April 14, 2011 to Neil Kamman, Jim Pease, and Ethan Swift) stated that based on the analytical results the sediments appear clear for reuse. Trish wrote that arsenic is elevated above the RSL, but was within the normal background range for concentrations found in Vermont. She stated that the PAH (polycyclic aromatic hydrocarbons) data would be key to have. Based on an email dated April 22, 2010 from Jim Pease, Stormwater Section of the VTDEC, the VTDEC Wastewater Management Division would like to have sediment from Combination Pond tested for PCBs and PAHs. The sample collection can be done as a composite of the stockpiled soil, if the dam were to be removed.

3.3 Moon Brook Corridor Plan

Stream geomorphic assessment data collected in 2005 was used to prepare a river corridor plan (RCP) for the Moon Brook watershed (Bear Creek Environmental, LLC 2008). The river corridor planning effort was sponsored by the Rutland Natural Resources Conservation District (NRCD) with funding provided through a grant from the Agency of Natural Resources Clean and Clear Program (now called Ecosystem Restoration Grants). The primary objective of the RCP is to identify and prioritize corridor protection and restoration projects. The 2008 Corridor Plan for Moon Brook identified Combination Pond as an onstream pond that is affecting sediment transport, impeding aquatic organism passage, and resulting in thermal impacts to Moon Brook. The Plan recommended an alternatives analysis to address these issues. The alternatives analysis is listed as high priority in the project identification table.

4.0 PROPERTY OWNERSHIP RESEARCH

D&K reviewed selected deeds for parcels abutting and near the pond to determine what stated rights and obligations, if any, surrounding property owners may have to the pond. The Rutland City Attorney also reviewed the matter and provided his opinion. Documentation is included in Attachment 3.

The significant findings are as follows:

- The pond is on a parcel currently owned by Charter Hills Inc (a successor to Otter Valley Realty Corporation, which subdivided the surrounding land). The current owner's representative is Ms. Judy Barone, Esq.

- In 1958, Otter Valley Realty Corporation executed a document ("1958 Establishment Document") that granted rights to Combination Pond (then called Healy Pond) for recreational purposes to purchasers of the subdivided lots adjacent to and near the pond. This document is referenced in the deeds of the subdivided parcels.

- Approximately 70 parcels, based on D&K's preliminary review of selected deeds and subdivision records, are thought to have documented rights to the Pond. All are located to the east and west of the pond. No parcels south (downstream) of the pond have rights. A map showing these specific parcels is included in Attachment 3.

- The 1958 Establishment Document states that neither Otter Valley Realty Corp. nor its successors are under any obligation to maintain, repair, or replace the dam that creates the pond, or to maintain the pond at any particular level, or to maintain or improve the pond "for any purpose whatsoever".

- In the opinion of the City Attorney, modifications to the pond that preserved the pond in some form would not infringe upon the rights of the easement's owners. However, removal of the pond, unless done under the order of a regulatory agency, would make the owner "liable for interference with the easement, and in turn be liable for damages to the easement's owners." The full written opinion of the City Attorney is attached.

5.0 SITE ASSESSMENT

5.1 Topographic Survey

Based on a survey completed by D&K in June 2011, a base map, longitudinal profile, and stream cross sections were generated. The pond survey included the perimeter, a 25-foot buffer, corners of adjacent structures, the road, the spillway and outlet structure for the pond. LiDAR elevation information developed by FEMA for floodplain mapping purposes was used to define the topography outside of the survey limits. The existing conditions site plan, longitudinal profile, and cross sections are included in Attachment 4.

5.2 Site Geomorphic Summary

A four acre polygon that includes Combination Pond and extends upstream to above the end of Charter Hills Drive is included on the Vermont Significant Wetland Inventory as a Class 2 wetland (Figure 6). Photographs of the pond and wetlands are provided on pages 1 through 3 of Attachment 5. The cross sections and longitudinal profile from the D&K survey were used by BCE to determine the slope and stream type upstream and downstream of the existing pond.

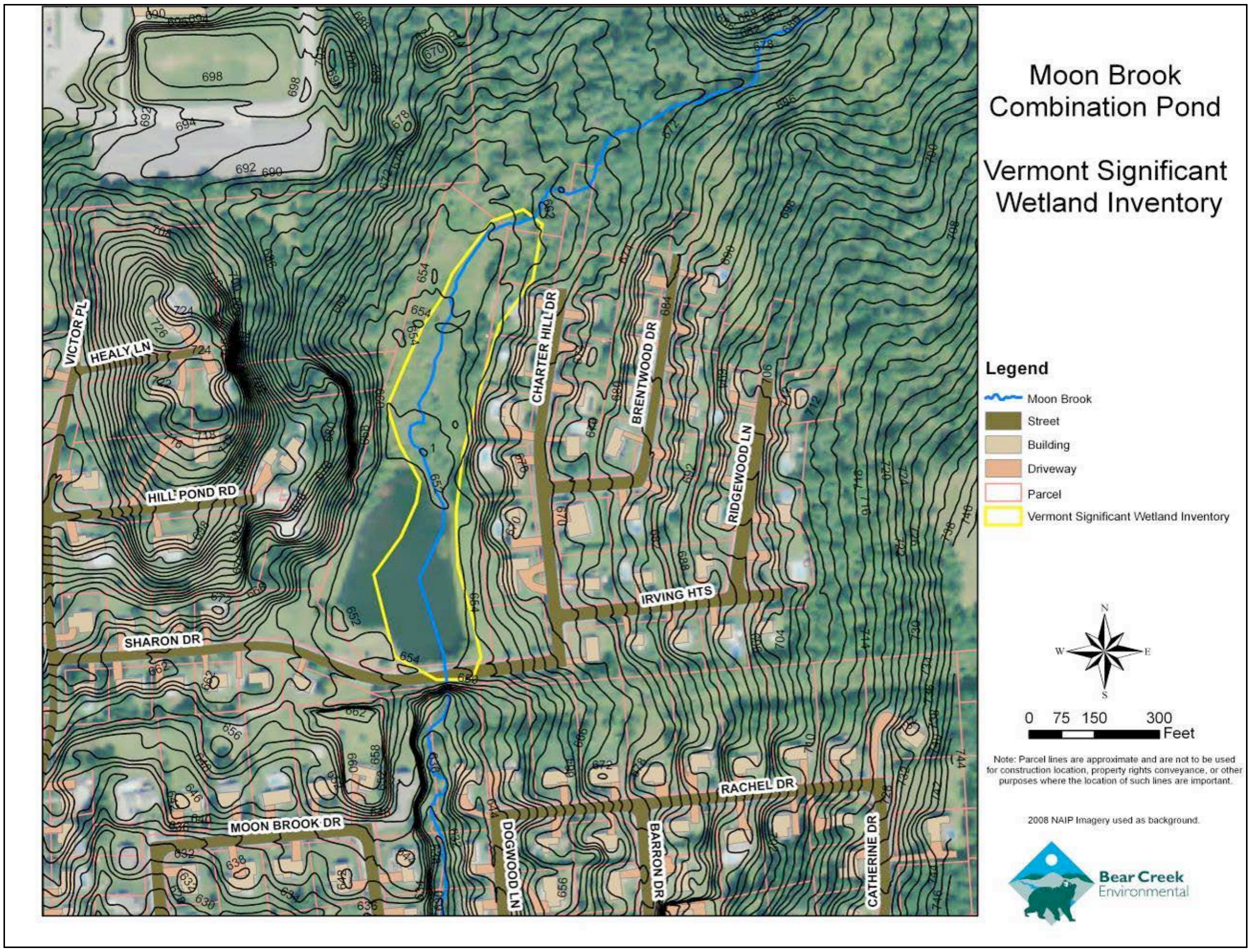

Figure 6. Vermont Significant Wetlands in Vicinity of Combination Pond

Upstream of the Pond

6). Photographs and cross section summary sheets for the three cross sections located upstream of the pond are included on pages 4 through 9 of Attachment 5. Based on the Vermont Regional Curve (Vermont River Management Program, 2006), the predicted bankfull cross-sectional area is 17.9 square feet. The average bankfull cross-sectional area based on examination of the three surveyed cross sections above the pond is similar to the regional curve and was found to be 16.6 square feet and to range from 11.9 to 19.4 square feet. The bankfull width calculated from the surveyed cross sections above the pond averaged 14.8 feet, which is slightly narrower than the bankfull width from the regional curve of 16.3 feet. The width to depth ratio of the cross sections are generally low (<12) with the exception of station 9+33, where the channel is braided. The Rosgen stream type for the channel above the pond is characterized as an "E" channel (slightly entrenched, low width to depth ratio, high sinuosity and gentle slope with sand and silt as the dominant substrate type).

Table 1. Channel Dimensions above the Pond

Cross section Location	Cross sectional Area (sq. feet)	Bankfull Channel Width (feet)	Width to Depth Ratio	Notes
Station 9+18	18.5	12.4	8.27	Low width to depth ratio
Station 9+33	11.9	17.3	25.22	Braided
Station 9+79	19.4	14.8	11.23	Low width to depth ratio
Average of 3 cross sections	**16.6**	**14.8**	**14.9**	
Vermont Regional Curve	17.9	16.3	NA	

Downstream of the Pond

Water flows out of the pond spillway through a 36 inch pipe and into the Moon Brook channel downstream of Sharon Drive. The west side valley wall is close to the channel and is extremely steep. The east valley wall in the vicinity of the downstream end of the pond is hilly. Photographs and cross section summary sheets for the three cross sections located below the pond are included on pages 10 through 14 of Attachment 5. The approximate bankfull elevation was marked in the field using flags, and these elevations were included in the D&K survey.

The predicted cross-sectional area and bankfull width from the Vermont Regional Hydraulic Geometry Curves for Moon Brook downstream of Combination Pond are included in Table 2. The cross-sectional area based on two measured riffle cross sections is 15.8 square feet, compared with the regional curve value of 17.9 square feet. The average bankfull channel width of the two measured riffle sections is 15.6 feet, which is slightly narrower than the regional curve of 16.3 feet. The Rosgen stream type downstream of the pond is "C". The channel is slightly entrenched, has a moderate width to depth ratio, and low sinuosity. The slope averages approximately 3.5 percent in the surveyed section below the pond, resulting in a sub class of "b".

Table 2. Channel Dimensions below the Pond

Cross section Location	Cross sectional Area (sq. feet)	Bankfull Channel Width (feet)	Width to Depth Ratio
Station 15+88 (Riffle)	14.3	15.7	17.2
Station 16+17 (Riffle)	17.4	15.4	13.7
Station 16+57 (Pool)	14.3	15.7	17.2
Average of Riffle cross sections	**15.8**	**15.6**	**15.4**
Vermont Regional Curve	17.9	16.3	NA

5.3 Dam Condition Assessment

DuBois & King conducted an inspection of the dam on June 13, 2011. The inspection included observations of the primary components including the upstream and downstream embankments, roadway crest, and spillway components. The inspection was based solely on visual observations, and did not include additional investigations such as video inspection or subsurface borings, which might reveal conditions not noted during the visual inspection.

Overall, the dam is in fair to good condition. However, several components of the dam show signs of deterioration that is typical of dams of this type. Regular maintenance that is necessary to reduce the risk of dam failure and prolong the service life of the dam is lacking.

The following summarizes the observations of the primary dam components made during the visual inspection:

Upstream embankment:

- Vegetation is comprised of brush and woody vegetation up to approximately 10" in diameter.
- Erosion at water-line was not observed, though inspection was limited due to vegetation.
- No sinkholes or animal holes were observed.
- Bare unprotected earth was observed at one location due to tree blow-down.
- Ground was generally firm and dry.
- Concrete wall near right abutment is rotating and at risk of falling into water.

Downstream embankment:

- Vegetation is comprised of brush and woody vegetation up to approximately 18" in diameter.

- Center of embankment over spillway pipe is armored with 36"-minus sub-angular stone fill.
- Smaller stone fill is present, particularly to the right (looking downstream) of the spillway outlet. The stone appears to include a variety of types suggesting it may represent multiple past maintenance efforts, possibly to address erosion events.
- 6"-minus crushed stone was observed in the upper portion of the embankment from the edge of road down to the stone fill, with the appearance that it was placed to address past erosion at that location.
- Voids were present between larger stones in the center of the embankment. Active seepage (which could be responsible for loss of the inter-stone material) was not observed, suggesting the lack of material is likely due to surface runoff either from overtopping or stormwater.
- The embankment is soft in some places and is not protected by stone. The growth of scouring rush suggests a regularly-moist surface.
- Water was observed trickling from a perforated storm drain pipe that discharges mid-way up the embankment and serves catch basins on either side of the road above.
- An animal burrow was observed near the right abutment on the upper portion of the abutment.

<u>Spillway/Outlet Works</u>

- The primary concrete drop inlet riser was observed only from the edge of water. Concrete appeared to be in reasonably good condition.
- A significant amount of woody debris was collected on all sides of the trash rack. The relatively low flow at the time of inspection was able to flow through the debris without an appreciable increase in water surface elevation, but the blockage would certainly impact capacity during storm flows.
- The secondary overflow drop inlet near the upstream edge of road was observed to be free of debris. However, the dense metal mesh cover would be prone to leaf blockage and the metal itself significantly reduces the capacity.
- The 36-inch corrugated metal outlet pipe was observed from the downstream end. Remnants of an original bituminous coating were noted. The pipe shape was generally intact with only minor signs of deformation. The bottom third of the pipe rust stained, though the invert appeared to be intact. The condition of the upstream portion of the pipe could not be observed.

<u>Dam Crest</u>

- Crest of dam is two-lane paved road. Asphalt in fair condition with some cracking noted, but no surficial indications of voids or otherwise compromised material under the pavement.

5.4 Hydrologic and Hydraulic Analysis

A report summarizing the hydrologic and hydraulic (H&H) evaluation of the dam is provided in a separate report prepared by D&K. in Attachment 6. The evaluation was conducted to determine the hydraulic capacity of the dam (i.e., how much water it can safely pass), compare the results to current State and industry standards, and evaluate alternatives for increasing the capacity.

The Vermont Dam Safety Program generally follows US Army Corps of Engineers guidelines for classifying dams and determining the required hydraulic capacity. The State currently classifies Combination Pond as a Low Hazard structure. By Corps guidelines, the potential water storage at the top of the dam (20 ac-ft) puts the dam in the Small Size (50-1,000 ac-ft of storage) category by default, although it is actually smaller than the threshold.

For a Low Hazard, Small Size structure, the Corps guidelines (which Vermont follows) recommends the spillway design flood be the 50 to 100-year frequency storm. In the latest State inspection report (2007), the Dam Safety Program suggested that the presence of houses downstream might warrant a change in hazard classification from Low to Significant. A detailed dam breach analysis would be required to determine with certainty whether the reclassification is warranted.

As a Low Hazard dam, the design storm is the 100-year flood event (1% annual chance). Specifically, the State standard calls for 1.5 feet of freeboard (the vertical distance from the peak water surface elevation to the top of the dam) during the 100-year flood. If the dam were to be reclassified to Significant Hazard based on the risk of downstream damages in the event of dam failure, then the design storm would likely increase to a larger event. The Corps guidelines, which the State generally follows, recommend for a Significant Hazard dam a design storm range from the 100-year to ½ Probable Maximum Flood (PMF) event.

The PMF is defined as the flood resulting from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible at a specific location. The ½ and ¼ PMF storms are simply smaller fractions of the full PMF storm. For comparison, a ½ PMF is typically on the order of 3 – 5 times larger than the 100-year flood event, and the full PMF is typically 5 – 10 times larger. Designing a dam to safely pass a larger storm, especially a storm as large as the ½ PMF or full PMF, requires either a relatively large spillway or a relatively large amount of available storage below the top of the dam.

The H&H evaluation considered eight storm events ranging from the 2-year (i.e., 5% annual chance) to the full PMF. The results are summarized in the table below. The dam does not meet current spillway capacity guidelines; the 100-year storm event, which is supposed to be contained within the pond with 1.5 feet of vertical freeboard to spare, instead overtops the dam by 1.1 feet.

Table 3. Existing Conditions Hydraulic Capacity

Storm Event	Top of Dam Elev. (ft)	Normal Pool Elev. (ft)	Inflow (cfs)	Outflow (cfs)	Peak WSEL (ft)	Freeboard (ft)
Primary drop inlet (4'x4') at elevation 647.2, second drop inlet (7'x4') at elevation 648.75, both connecting to one 36" CMP. Top of dam treated as broad crested weir.						
Q2	649.7	647.2	39	37	648.0	1.7
Q10	649.7	647.2	133	102	649.7	0.0
Q25	649.7	647.2	231	228	650.3	-0.6
Q50	649.7	647.2	337	335	650.6	-0.9
Q100	649.7	647.2	472	470	650.8	-1.1
¼ PMF	649.7	647.2	692	690	651.1	-1.4
½ PMF	649.7	647.2	2116	2114	652.3	-2.6
Full PMF	649.7	647.2	5199	5196	653.7	-4.0

Two possible replacement spillway scenarios were evaluated in detail, and a detailed discussion of each is presented in the H&H report (Attachment 6):

- The first (Alternative A) entails replacing the current spillway with substantially larger pipes and raising the top of dam to create more storage.
- The second (Alternative B) entails replacing the current spillway with moderately larger pipes and armoring the downstream embankment so that it is safe when overtopped.

Based on the H&H analysis, we offer the following conclusions and recommendations related to hydraulic capacity:

- The existing dam overtops during storms greater than the 10-year event. During the 100-year storm, the dam would overtop by 1.1 feet, falling well short of the current standard of 1.5 feet of vertical freeboard between the computed water surface and the top of dam.

- Erosion during overtopping of a dam is the single greatest cause of failure for earthen dams.

- The pond lacks the storage volume to provide any meaningful reduction in peak flows (inflow vs. outflow), and thus even removing the dam completely would have almost no perceptible impact on flows at downstream locations.

- A combination of a significantly larger spillway (8'x8' riser leading to a 6'x5' box culvert outlet pipe) plus raising the dam by 1.3' – the components of Alternative A – would allow the 100-year storm to pass with 1.5 feet of freeboard, thereby meeting current State requirements.

- Passing the ¼ PMF or larger storm events through a closed outlet system is not practical; excessively large components and significant raising of the dam would be necessary. Thus for safe passage of flows greater than the 100-year event (which would be necessary were the dam to be reclassified to Significant Hazard), modestly upsizing the existing spillway and protecting the downstream slope so that it is stable when overtopped – Alternative B -- is a more practical approach.

- If the dam is to remain and is to be brought into compliance with current hydraulic capacity standards, we would recommend implementing the components of Alternative B.

5.5 Dam Improvement Recommendations

Based on the condition observed during the inspection, DuBois & King offers the following recommendations to improve the integrity of the dam, reduce the risk of catastrophic failure, and prolong its functional service life. A suggested timeframe is also included for each physical measure.

General

1. Recognize that earthen dams do not safely impound water indefinitely; regular maintenance and periodic rehabilitation efforts are required to prolong functional service life and reduce the risk of failure.

2. Recognize that dams do fail, sometimes with serious consequences to downstream people and property. The first and second leading causes of earthen dam failure, respectively, are erosion during overtopping and uncontrolled seepage through the embankment.

Maintenance / Minor Improvements

3. Remove all trees and brush. Timeline: 0-3 months. The limits of clearing should extend fifteen feet beyond the toe and ends of the earthen embankment. This measure serves several primary purposes. First, it eliminates the potential for tree blow-down, which can result in a void on the embankment surface as soil is removed with the roots. Such voids shorten seepage paths and can contribute to dam failure. Second, the

roots of woody vegetation provide preferential flow conduits for water seeping through the dam, and when the roots die and decay, the resulting voids can dramatically exacerbate seepage. Third, it allows sunlight to keep the embankment drier, which increases stability. Finally, removing the vegetation allows for more complete inspection of the embankment.

4. Restore embankment surfaces. Timeline: 0-3 months. Following removal of woody vegetation, the embankment slopes should be regraded as necessary to a consistent slope. The animal burrow on the downstream right embankment and any others discovered should be filled with compacted embankment material. Similarly, any other depressions or holes left from stump removal should be filled with compacted embankment material. Finally, a hearty stand of grass should be established throughout.

5. Replace trash rack with one less prone to clogging. Timeline: 0-3 months. Replace the existing rack with one that forms a "halo" around the existing riser allowing water to flow through, under, and over the rack. The Natural Resource Conservation Service has a standard design (known as a Concentric Trash Rack) that could readily be adapted to this site. Such a design would help maintain the capacity of the existing spillway even with debris present, and would thus reduce the risk of overtopping.

6. Institute a trash rack cleaning plan. Timeline: 0-3 months. The trash rack should be cleaned periodically and whenever debris that is not expected to flush through is observed. This measure is critical to maintaining capacity of the spillway and reducing the potential for overtopping. This measure is recommended whether or not a new trash rack is installed.

<u>Improvements</u>

7. Plan for the replacement of the existing spillway. Timeline: 5-10 years. While the existing concrete riser and corrugated metal pipe (CMP) outlet are in fair condition, they will not last indefinitely. The CMP in particular, thought to be at least 40 years old, is approaching the end of its reliable service life. Sliplining of this pipe (as opposed to replacement) may be a cost effective option to extend its service life.

8. Plan for installation of seepage control measures. Timeline: 5-10 years. While excessive seepage through the dam is not currently a significant issue, the rate of seepage can be expected to increase over time as flow paths through the embankment become more developed. This is a potential problem because the seeping water erodes the inside of the

dam leaving preferential flow paths and voids that significantly increase the potential for dam failure. This is typical of earthen dams. A common and cost-effective solution is to install a sand filter and drain system on the downstream portion of the embankment. This system collects and discharges seeping water but prevents eroding sediment from exiting.

9. Consider replacing spillway to increase hydraulic capacity and bring into compliance with current standards. Timeline 5-10 years. As described in the H&H report (Attachment 6), this would entail replacing the existing riser and outlet barrel with larger structures, marginally raising the top of dam, and protecting the downstream embankment against erosion during overtopping events. This measure would negate the need for recommendations 7 and 8, which would be included with it.

6.0 POND ALTERNATIVES ANALYSIS

A number of alternatives have been identified to address water quality and habitat issues downstream of Combination Pond. The City of Rutland has requested that the alternatives analysis consider each of the following environmental concerns:

Effect on water temperature
Effect on in-stream and riparian habitat
Effect on aquatic organism passage
Effect on improved sediment transport
Effect on reduced flooding hazards
Effect on improved water quality

The alternatives will also be evaluated for cost effectiveness, changes to hydrology downstream of the existing pond, and landowner concerns. Conceptual level drawings in plan, profile, and section view have been prepared for each of the alternatives and are included in Attachment 7. Preliminary cost estimates for each alternative are included in Attachment 8.

In addition to the specific alternatives presented below, a host of others – often variations or combinations of the ones presented – could be identified. Some additional alternatives were deemed to have limited potential benefits or excessive drawbacks that they were not included as stand-alone alternatives. For instance, planting of additional trees around the pond would theoretically result in cooler water due to shading, but the expected benefits were deemed to be too limited and the timeframe for a mature tree canopy to develop too long to warrant inclusion as a stand-alone alternative. It is hoped that the list of alternatives presented below, while not exhaustive, provides a sufficiently broad coverage of all available options and will allow for the selection of a preferred alternative or at least selection of a general direction.

6.1 Alternative #1 - Do Nothing

One possible option is to leave the dam in the current configuration and make no physical improvements. This would be the least expensive option of all of the alternatives because no money will be invested in upgrading the dam or improving habitat or water quality. The drawback to this approach is the dam will continue to deteriorate and environmental problems (including elevated temperature and lack of aquatic organism passage) will persist.

6.2 Alternative #2 – Update Dam to Meet Current Dam Safety Standards

The primary objective of alternative #2 would be to bring the current dam into compliance with current dam safety standards. This alternative would improve the structural and geotechnical stability of the dam and would provide additional spillway capacity. Specific components of the alternative include:

- clearing all brush from the upstream and downstream sides,
- filling animal burrows on the downstream side,
- minor grading to restore a uniform embankment slope, and establishment of a hearty stand of grass cover.
- installing a new trash rack less prone to clogging
- installing a new primary spillway (riser and outlet pipe)
- armoring the downstream slope of the dam to protect it during overtopping events.

The estimated cost of this alternative is $179,000. This includes $149,000 for construction and $30,000 for engineering and permitting. As an interim measure, all but the last two components (up to and including an improved trash rack) could be implemented for $25,000 or less.

The primary benefits of this alternative are improved public safety and reduced liability for the owner of the dam. The recreational value of the pond would be unchanged, and the community would continue to be able to use the pond in its current configuration. Disadvantages include the significant cost and the fact that the work would do nothing to address the temperature and other ecological problems associated with the pond.

6.3 Alternative #3 – Bottom Release

Alternative # 3 would provide the release of cooler water downstream of the dam to mitigate elevated summer water temperatures. This would be accomplished by modifying the spillway so that under low flow conditions the water released from the pond would come from the bottom of the pond where the water is cooler during the summer months. The bottom release system would be constructed by attaching a relatively small pipe (e.g., 6 inches) to the outside of the existing riser. Ninety degree elbows with short pipe stubs of pipe would be attached to both ends. At the bottom end, the pipe stub and elbow would project into the pond and serve as the bottom water intake. At the top end, the elbow and stub pipe would be inserted through a notch or a hole in the side of the riser just below the riser crest. Exiting water from the new pipe would simply drop into the riser. More involved modifications could be done but would come with significantly higher costs than the relatively low-tech alternative described above.

Under no-flow conditions (i.e., nothing coming into the pond), the pond water level would be equal to the elevation of the pipe stub coming into the riser (which would be lower than the current pond elevation by approximately six inches, depending on the final design). Under low flow conditions, the pond level would rise marginally, and all outflow would be through the bottom-release system. The system would be designed to handle approximately 0.5 cubic feet per second per square mile (CSM) or the estimated August/September median flow. Based on a drainage area of 1.64 square mile, the design flow might be approximately 0.82 cubic feet per second. During higher flows, when the capacity of the bottom release system is exceeded, water would flow over the riser crest and exit the pond as it currently does.

As discussed in Section 3.1, the limited temperature monitoring data from the pond suggests that the water temperature is colder at the bottom than at the top, and may be cold enough to be in compliance with the temperature standards evaluated. However, the data is too limited to confidently estimate the impact of a bottom release system. Collection of additional temperature data at various depths within, upstream, and downstream of the pond during the summer months is recommended to better understand the benefits of Alternative #3. It is also recommended that an air temperature logger be used to monitor diel fluctuations.

The estimated cost of the bottom release is $18,000. This includes $15,000 for construction and $3,000 for engineering and permitting.

The primary benefits of this alternative include low cost and the potential for improved temperature conditions downstream in Moon Brook. Disadvantages include the lack of improvements to the dam for public safety, the continued barrier to aquatic organism passage, and the lower normal water surface elevation and corresponding reduction in surface area.

6.4 Alternative #4 – Bypass Channel

A bypass channel around the pond would reduce water temperatures by decreasing the residence time of the water through the site. The primary components of this alternative include:

- Diversion berm at the pond inlet;
- Bypass channel along the side of the pond (likely the west side);
- Smaller pond with the same outlet structure;
- New culvert from the downstream end of the bypass channel to either the existing pond outlet structure or under the road to the downstream side of the dam.

Under normal flow conditions, water would flow into the bypass channel rather than the pond, and then routed via culvert to Moon Brook. The channel would in fact be more of a drainage swale designed to accommodate relatively low flows than a functioning stream channel because the space needed to construct a larger, fully functioning stream channel would leave little room for the pond and would increase the risk of the pond water becoming stagnant. Based on orthophotos review, the location of the primary channel at the inlet of the pond has moved over time, and thus a low earthen berm across the valley at the upstream end of the pond would be needed to encourage the inflow channel to remain in its current location and feed water into the proposed diversion channel. Under storm flows, the berm would overtop and water would flow into both the diversion channel and directly into the pond.

The bypass channel could either lead to a new culvert routed to the existing spillway (as shown on the attached drawing), or could lead to a new culvert that goes under Sharon Drive and rejoins Moon Brook downstream of the dam. Neither would restore aquatic organism passage. The former is likely to be more cost effective, and thus is the option included with this alternative.

The estimated cost of the bypass channel is $80,000. This includes $66,000 for construction and $14,000 for engineering and permitting. Both the bypass channel and the diversion structure will likely require maintenance over time.

The primary benefit of this bypass channel alternative is the potential for significant reduction in water temperature downstream of the pond. Drawbacks include the smaller pond that may be less desirable for recreational use and is at risk of becoming stagnant, the potential for ongoing maintenance of the diversion berm and bypass channel, continued lack of aquatic organism passage, and failure to address any dam safety issues.

6.5 Alternative #5 – Bypass Pipe

A bypass pipe could be constructed around the pond or underneath the pond to reduce water temperatures during low to moderate flow conditions. This would maintain the current foot print of the pond and allow for existing recreational uses. The pond would overflow through the existing spillway under moderate to high flow conditions. The major components of Alternative #5 would be:

- Diversion berm at the pond inlet;
- Rigid structure to split flow between the bypass pipe and pond;
- Gate to adjust flow
- Bypass pipe on pond bottom from inlet to existing dam outlet structure

The estimated cost of the bypass pipe is $99,000. This includes $82,000 for construction and $17,000 for engineering and permitting. Both the bypass channel and the diversion structure will likely require maintenance over time.

The bypass pipe would be beneficial in reducing summer water temperatures in Moon Brook below the pond, but does not address the lack of aquatic organism passage or natural sediment transport. Similar to Alternative #5, the main inflow channel to the pond has not been a fixed location. A low berm would be needed to divert the flow into the bypass pipe, and berm and diversion structure would need to be maintained over time. There is a potential for the pond to become stagnant by diverting flow through the bypass pipe. It is recommended that the pond be monitored to assure the pond maintains sufficient oxygen levels to support fish and other aquatic life.

6.6 Alternative #6 – Groundwater Augmentation

A dug well at the upstream end of the pond could be constructed to augment the outflow from the pond to reduce the water temperature in Moon Brook. The primary components of this alternative include:

- Shallow well constructed of perforated concrete well tiles in the wetland upstream of the pond;
- A delivery pipe from the well across the pond bottom to the existing outlet structure.

The estimated cost of the groundwater augmentation is $84,000. This includes $70,000 for construction and $14,000 for engineering and permitting. Both the bypass channel and the diversion structure will likely require maintenance over time.

Although the footprint of the pond would be the same, the water level of the pond may be drawn down slightly by the removal of the groundwater in the wetland upstream of the pond. Additional studies would be needed to determine the amount and temperature of the groundwater that would be available. It seems likely that the groundwater augmentation would only have a beneficial effect under low flow conditions. It may be difficult to quantify the benefit of Alternative #6.

6.7 Alternative #7 – Remove dam and restore Moon Brook Channel and Floodplain

Alternative #7 entails removing the dam and restoring the stream channel through the site. The primary components of this alternative are:

- Remove existing dam spillway (riser and outlet barrel);
- Install new larger culvert or bridge over the channel on Sharon Drive;
- Restore the stream channel and riparian area through the former pond.

Because Sharon Drive crosses over the top of the dam, the embankment cannot simply be cut open to expose the former stream channel. Instead, the embankment would remain in place, but the existing spillway (riser and outlet pipe) would be replaced with a new larger culvert or a small bridge. The culvert or bridge would be large enough to fully span a natural channel. In theory, the existing culvert could be used (with the riser removed), but that scheme has significant limitations from flow capacity, sediment transport, and aquatic organism passage.

The estimated cost of the dam removal is $219,000. This includes $182,000 for construction and $37,000 for engineering and permitting. Ecosystem Restoration Funds and other restoration grants would likely be available due to the positive environmental gain.

The environmental benefits of implementing this alternative are the greatest of all the alternatives. It is the only alternative that allows for temperature reduction and full restoration of the ecosystem. The removal of dam would provide over 500 feet of restored stream channel and floodplain, and would provide continuity between upstream and downstream of the former pond. Alternative #7 would provide a significant reduction in water temperature and would restore natural sediment transport and aquatic organism passage. The concerns about the safety of the dam would be eliminated and the owner's liability for the dam would be addressed. Because the existing pond provides no meaningful reduction in peak flows, removing the dam would not have a significant impact on downstream flow regime.

There are a number of drawbacks to removing the dam. The primary negative aspect is the loss of open water recreation. The adjacent landowners may consider the removal of the pond to have a negative effect on property value and aesthetics, and it could prompt legal action on their part. It is possible that the restored channel may not be completely stable for several years until the vegetation establishes and the channel achieves a stable profile, dimension, and cross section. Given the slope of the channel, the portion of the wetland closest to the pond may dry out.

Table 4. Primary Components of Alternatives and Benefits and Drawbacks

Alternative	Primary Objective	Major Component	Approximate Cost	Primary Benefits	Primary Drawbacks	Additional Considerations
Do Nothing		No physical improvements No change in management of Dam	None	Community could continue to use the dam in its current configuration No expected costs	Dam will continue to deteriorate; Public safety not addressed; Environmental problems will persist	Current dam owner may not approve of this option
Update Dam to Meet Current Safety Standards	Bring into compliance with current standards	Improve integrity of dam Provide additional spillway capacity	High - $179,000	Improved public safety Reduced liability for dam owner Community could continue to use the dam in its current configuration	Environmental problems will persist; Cost for initial upgrade is moderate and additional costs will be incurred to maintain dam	
Bottom Release	Release cooler water from pond	Modification to spillway to provide bottom release	Low – $18,000	Some reduction in water temp; Low cost; Simple Community could continue to use the dam in its current configuration	Temperature data lacking to assess benefit of this alternative, but likely will not fully achieve desired temperature reduction; Natural sediment transport and aquatic organism passage is not addressed	Recommend collection of additional temperature data to better understand stratification of pond.
Bypass Channel	Decrease water temperature by reducing residence time of water through site	Smaller pond with same outlet structure; Bypass channel around side of pond; Diversion structure at pond inlet; New culvert or bring into existing outlet structure	Moderate – $80,000	Reduction in water temperature expected at outfall	Channel and diversion structure may require maintenance; Smaller pond is less desirable for recreational use; Pond may become stagnant; Will not allow aquatic organism passage;	Project may be on adjacent properties; Monitor pond to assure good water quality
Bypass Pipe	Decrease water temperature by diverting flow	Low berm to direct flow into bypass pipe; Rigid structure to split flow between pipe and pond; Gate to adjust flow	Moderate - $99,000	Reduce water temperature during low to moderate flows; Maintains footprint of pond	Maintenance of berm and diversion structure; Does not allow aquatic organism passage; Does not improve sediment transport; Pond may become stagnant	Monitor pond to assure good water quality
Groundwater Augmentation	Decrease water temperature by augmenting pond outflow with cool, groundwater	Dug well; Delivery pipe to existing outlet structure	Moderate - $84,000	Reduce water temperature during low flows; Maintains footprint of pond	May not have enough groundwater available to significantly lower water temperature; Difficult to predict and quantify benefit of groundwater augmentation; Does not address aquatic organism passage or natural sediment transport	Would require additional studies to determine amount and temperature of groundwater
Dam Removal and Restore Moon Brook Channel and Floodplain	Decrease water temperature by removing dam and allowing natural flow regime in restored channel and floodplain	Dam removal; Channel restoration; Floodplain and buffer restoration; Construct bridge or culvert at Sharon Drive	High – $219,000. *Public river restoration funding may be available.	Reduces summer water temperature under a range of flow conditions; Provides opportunity to restore ecosystem, aquatic organism passage and natural sediment transport; Eliminates need to upgrade to current dam safety standards	Pond is eliminated and no longer offers current recreational opportunities; Landowners may object to change in aesthetics; Wetland closest to restored channel may dry out; Restored channel may be unstable in the short term (0-5 years)	May be opposition from property owners with rights to the pond; Utility crossings would need to be investigated

Table 5. Qualitative Ranking of Alternatives against Project Objectives and Evaluation Criteria

Alternative	Environmental Concerns				Hydrology		Landowner Concerns			Cost		Number of Objectives Achieved/ Cost
	Water Temp.	Instream & Riparian Habitat	Aquatic Organism Passage	Sediment Transport	Dam Failure Potential	Flood Attenuation	Dam Owner	Abutting Owners of Pond	Downstream Landowners	Initial Design & Construction	Ongoing Maintenance	
Do Nothing	N	N	N	N	N	N	N	F	N	None	Low	1/Low
Update Dam to Meet Current Safety Standards	N	N	N	N	F	N	F	F	F	High	Low	4/Moderate
Bottom Release	P	N	N	N	N	N	N	F	N	Low	Low	1/Low
Bypass Channel	F	F	N	P	N	N	N	P	N	Moderate	Moderate	2/Moderate
Bypass Pipe	F	N	N	P	N	N	N	F	N	Moderate	Moderate	2/Moderate
Groundwater Augmentation	P	N	N	N	N	N	N	F	N	Moderate	Low	1/Moderate
Remove Dam & Restore Floodplain	F	F	F	F	F	N	F	N	F	High	Low	7/Moderate

Qualitative ratings:
F - Fully meets objective
P - Partially meets objective
N - Does NOT meet objective

Objectives:
Water Temperature – no significant increase in water temperature between wetland channel above Combination Pond and Moon Brook below Sharon Drive
Instream & Riparian Habitat – provides a natural stream channel with a functioning riparian buffer
Aquatic Organism Passage – provide passage for all species and life stages of resident fish
Sediment Transport – sediment is naturally transported through the site and provides for an equilibrium condition
Dam Failure Potential – risk of dam failure is minimal
Flood attenuation – provides attenuation of high flows
Concern from Dam Owner – owner does not have a significant liability for breach of dam
Abutting Pond Landowners – property value is not reduced and pond continues to provide recreational opportunities

Cost:
High – greater than $100,000; **Moderate** - $50,000 to $100,000; **Low** – less than $50,000

7.0 PUBLIC OUTREACH

DuBois & King, Inc. and Bear Creek Environmental, LLC led two public meetings to review and discuss a draft of this report. The meetings were held on May 1 and May 15, 2011 in the Fox Room of the Rutland Free Library. Both meetings offered the same format and content and were attended by approximately 30 people. Each of the alternatives was presented with conceptual drawings and a short narrative. A suhmmary of each meeting, sign in sheets, and newspaper articles that followed are included in Attachment 9.

8.0 CONCLUSIONS AND RECOMMENDTATIONS

On May 29, 2012, the Combination Pond Steering Committee met to discuss the next steps for the project.

- The steering committee believes removal of the dam is the best ecological and public safety option.
- Recognizing there are complex ownership issues, the bottom release is the next preferred alternative of the committee. The bottom release alternative provides cooler water below the dam in Moon Brook, continued recreational use of the pond in its current configuration, and avoids ownership issues.
- The steering committee also recommends that property owners in the Charter Hills neighborhood work with the City of Rutland and the owner of Combination Pond to implement a maintenance plan for the dam. Continued deferred maintenance will reduce the service life of the dam and increase public safety risks.

9.0 REFERENCES

Bear Creek Environmental, LLC. 2008. River Corridor Plan, Moon Brook Watershed (Rutland City, Rutland Town and Mendon, Vermont). Middlesex, Vermont.

Buckman, M.F. 2008 NOAA Screening Quick Reference Tables. NOAA OR&R Report 08-1. Office of Response and Restoration Division, National Oceanic and Atmospheric Administration, Seattle, WA. 34 pp. http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf

EPA. 2006. Waste Site Cleanup & Reuse in New England: Rutland City Landfill, Rutland Vermont. Last Modified August 9, 2006. Accessed January 10, 2012. http://yosemite.epa.gov/r1/npl_pad.nsf/701b6886f189ceae85256bd20014e93d/700520dbf614845b85256b4200606fc8!OpenDocument

Vermont Department of Environmental Conservation. (not dated). Investigation and Remediation of Contaminated Properties Procedures. Wastewater Management Division. http://www.anr.state.vt.us/dec/wastediv.

Vermont River Management Program. 2006. Vermont Regional Hydraulic Geometry Curves. Waterbury, Vermont