An Integrated Approach to the Management of Stormwater Water Quality Within the Sub-Watersheds of Onota Lake Pittsfield, Massachusetts

Prepared For:

The City of Pittsfield

Massachusetts Department of Environmental Protection

US Environmental Protection Agency

Massachusetts Executive Office of Environmental Affairs

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Berkshire Regional Planning Commission

Lake Onota Preservation Association, Inc.

AN INTEGRATED APPROACH TO THE MANAGEMENT OF STORMWATER WATER QUALITY WITHIN THE SUB-WATERSHEDS OF ONOTA LAKE PITTSFIELD, MASSACHUSETTS

City of Pittsfield Onota Lake Long Range Management Project
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1.0 INTRODUCTION

The genesis for the development of the following report is a Diagnostic / Feasibility Study of Onota Lake, conducted in 1991 (IT, 1991). In that study, the overall ecology of Onota Lake was investigated. This included an examination of the lake's watershed, the quantification of the lake's pollutant load and recommendations for its long-term management. The Diagnostic / Feasibility Study concluded that some of the most significant problems and threats to the lake's water quality could be traced to the watershed. These included faulty septic systems, a potentially compromised sanitary sewer line, and the influx of nutrient and sediment rich stormwater runoff. With respect to the later, specific recommendations were provided concerning the control and reduction of these influxes. The report suggested that attention be given to decreasing the pollutant load entering the northern end of the lake by specifically targeting the inflow from Churchill, Daniels and Parker Brooks. Although these watersheds are relatively undeveloped, as compared to some of the lake's other sub-watersheds, they are large and therefore, the total suspended sediments and total phosphorus loads associated with both sub-watersheds comprise a significant component of the lake's total annual pollutant load. The general lack of a stormwater collection and conveyance system throughout these watersheds largely precludes the ability of implementing some of the more typical stormwater quality enhancement techniques.

Regardless of how stormwater management is accomplished, the need for the management of stormwater entering the lake was, and continuers to be obvious. In the decade since the Diagnostic / Feasibility Study was completed the northern basin of Onota Lake has become increasingly impaired. These impairments include more frequent algae blooms, increased occurrence and growth of non-native, invasive macrophytes (weeds), the expansion of sediment deltas and increased scour and erosion of the lake's tributaries. The need for action is therefore evident.

The overall goal of the integrated assessment report is to generate a prioritized plan for stormwater management activities in the Onota Lake Watershed. In order to prioritize future stormwater management activities it is prudent to reevaluate the recommendations for stormwater management within the Diagnostic / Feasibility Study. The Diagnostic / Feasibility Study report recommended that stormwater quality management be accomplished in part through the construction of low gabion weirs in Parker Brook, Churchill Brook, Daniels Brook, and the small tributary which passes under Blythewood Drive. The function of the weirs would be to temporarily impound inflow in easily accessed areas, for the purpose of intercepting sediment and particulate phosphorus. These "sediment traps" could then be periodically inspected and the accumulated sediment, debris and particulate matter removed. An objective of this assessment is to generate a preliminary design, including cost estimates, for the construction of gabion weirs, or similar technique, to provide nutrient and sediment reduction at the major tributaries feeding the lake. The project calls for the site analysis and design work for preliminary design of the gabion weir. In addition, an objective of this assessment is to inventory the stormwater infrastructure within the Onota Lake Watershed. The Diagnostic / Feasibility Study did not include water quality data for stormwater runoff entering the watershed through stormwater conveyances and did not include recommendations for stormwater management that included retrofit of existing stormwater infrastructure. However, the existence of stormwater collection and conveyance systems presents the ability of implementing some of the more typical stormwater quality enhancement techniques. The assessment includes stormwater infrastructure as a factor in prioritizing the stormwater management activities for the Onota Lake Watershed.

2.0 PROJECT SETTING

Located in the Berkshire Mountains in the City of Pittsfield, Massachusetts is Onota Lake a 617-acre waterbody. A headwater impoundment of Onota Brook, a tributary to the West Branch of the Housatonic River, Onota Lake consists of two, physically interlinked basins. The south basin, which is glacial in its origin, is deep (approximately 60 feet maximum depth), whereas the north basin, formed by the construction of the dam, is a flooded wetland/riparian area characteristically no deeper than 8 feet. Given this configuration, the lake has been defined as "two lakes in one" (IT, 1991). The *Housatonic River Basin 1997/1998 Water Quality Assessment Report* classified Onota Lake as mesotrophic. (DEP, 1998) Onota Lake is listed on the *Massachusetts Year 2004 Draft Integrated List of Impaired Waters* as being impaired by exotic species (EOEA, 2004).

The lake's overall watershed totals 6,345 acres in area. The majority of inflow to the lake occurs via the three tributaries that drain to the northern basin; Daniels Brook, Churchill Brook and Parker Brook. As detailed in the lake's Diagnostic/Feasibility Study (IT, 1991), pollutants entering the lake by means of stormwater runoff have caused, and will continue to contribute to, the degradation of the lake's overall quality. This non-point source (NPS) pollution originates largely from the existing development that occurs throughout the watershed. Future land disturbance and development will add to this problem and further exacerbate the lake's water quality. The most obvious impacts to date have been the accretion of sediment deltas, overall lake in-filling, periodic reductions in water clarity, the destruction of aquatic habitat, and the introduction of nutrients which in turn facilitates the development of algal blooms and the further growth of the invasive weed colonies. Overall, this NPS pollution threatens the ecological, community and economic resources of Onota Lake.

Past studies have documented that a majority of the NPS load to the lake is contributed by the Daniels, Parker and Churchill sub-watersheds (IT, 1991). This is in part due the size of these watersheds and their overall hydrologic contribution to the lake. However, some of this is a function of land disturbance and development, the steeper slopes characteristic of these sub-watersheds and the lack of any true stormwater management infrastructure. As such, this report focuses on the stormwater management measures that could potentially be implemented with the Parker Brook, Daniels Brook and Churchill Brook sub-watersheds. It should be noted that in the Diagnostic / Feasibility Study another recommended pollutant reduction measure was the construction of a "flow short-circuit" that would re-route spring flows and large storm flows through a channel and modification of Pomeroy Pond (an embayment of Onota Lake) to the lake's dam. The concept was to decrease sediment and phosphorus loading to the shallow, impacted north basin of the lake by "short-circuiting" the existing flow path. The "short-circuit" project is currently funded through a Section 319 Nonpoint Source Grant by the Massachusetts Department of Environmental Protection (Project 00-01/319). In the mean time, as previously noted, the lake continues to suffer the consequences of inadequate stormwater management and the north basin's problems continue to intensify and worsen.

In 1996, the Massachusetts Department of Environmental Protection (MADEP) adopted new rules and regulations pertaining to the management of the volume and quality of stormwater runoff. The result of three years of work by a State Stormwater Advisory Committee, the "Stormwater Management Policy" (the Policy) included nine specific Stormwater Performance Standards, which are to be met by new development in order to achieve compliance with the regulations. The goal of the Committee was to provide a cohesive set of performance standards that addressed key issues associated with stormwater runoff control. As such, the Policy consists of two separate volumes. Volume One, the *Stormwater Policy Handbook*, contains a description of the policy, how it is to be implemented, and the nine individual stormwater management standards that are to be met. Volume Two, the S*tormwater Technical Handbook*, contains detailed information and design criteria for the stormwater Best Management Practices (BMPs) used to manage the quantity, rate and quality of stormwater discharges. Volume Two served as the basis for the majority of the recommendations contained herein, although additional information has been obtained through the stormwater management design manuals of New Jersey (NJDEP, 2004), Connecticut (CTDEP, 2003) and New York (NYDEC, 1993).

The nine performance standards presented in the Policy are as follows:

1. No new stormwater conveyances may discharge untreated stormwater directly to, or cause erosion in wetlands or waters of the Commonwealth.
2. Post-development peak discharge rates must not exceed predevelopment conditions for the 2-year and 10-year storm events under all conditions. The l00-year event must be analyzed to determine impacts and must be controlled if necessary.

3. Loss of annual recharge to groundwater should be minimized through the use of infiltration measures, to the maximum extent practicable. The recharge "requirement" which is to mimic existing annual recharge on sites to the maximum extent practical, has not been changed. However, a design methodology for estimating existing annual recharge at a site, and for designing recharge systems has been developed. The methodology uses soil classifications, soil gradation analyses and specific Massachusetts regional rainfall data as data inputs.
4. Stormwater management systems must be designed to remove 80% of the average annual (post development) load of total suspended solids (TSS). It is presumed that this standard is met when; (a) suitable nonstructural practices for source control and pollution prevention are implemented; (b) stormwater management BMPs are sized to capture the prescribed runoff volume; and (c) stormwater management BMPs are maintained and designed as specified in Volume Two. The Policy provides estimates of the percent TSS removal for individual BMPs when designed in accordance with the specified guidelines. Water quality treatment volume is 0.5 inches of runoff from impervious areas (1.0 inch if discharge is to critical environmental area).
5. Stormwater discharges from areas that are defined as having "higher potential pollutant loads" (as defined in the Policy) require specific stormwater BMPs. Infiltration of stormwater from these areas without pretreatment is prohibited.
6. Specific BMPs must be used for discharges to critical areas and the water quality treatment volume is 1.0 inch of runoff.
7. Redevelopment projects must meet the performance standards to the maximum extent practicable. It must be clearly stated why full compliance cannot be achieved and such projects must, at a minimum, improve existing conditions.
8. Erosion and sedimentation controls are required during construction.
9. An Operation and Maintenance Plan (O&M Plan) for Stormwater Management is required.

Of the nine performance standards, those immediately germane to this study, given the fact that its focus is on the improvement of runoff controls from existing development, are points 1,4, 6 and 9. However, it is recognized that all the above points are critical to the successful long-term management of non-point source (NPS) loading to Onota Lake. As illustrated in point 4 above, the MADEP recognizes that reducing the total suspended solids component of stormwater runoff results in the reduction of other pollutants including nutrients, heavy metals and petroleum hydrocarbons. It is for that reason that the performance efficiency of most BMPs is defined by its ability to remove total suspended solids (TSS).

Given that the focus of this project was the correction of existing stormwater problems, emphasis is placed on those BMPs having the ability to unobtrusively and economically decrease sediment (total suspended solids) and nutrient (phosphorus and nitrogen) loading, and mitigate to some extent peak flows of storm events. Site constraints, including the lack of existing stormwater infrastructure, limited right-of-way distances, wetlands, steep slope and ledge rock had to be factored into the analysis in order to maintain some degree of cost control. An overview of potentially effective retrofit type BMPs is provided in Appendix A. A detailed assessment of the performance, capabilities and constraints associated with a wider array of BMPs is available in MADEP, 1997 and Schueler, 1994.

3.0 THE NEED FOR STORMWATER MANAGEMENT

Most native soils, by nature, have the ability to absorb and infiltrate rainfall (precipitation). The amount of infiltration will vary based on the composition of the soil, the type of vegetative cover it supports, the slope of the land and the depth to bedrock or to the groundwater table. Conversely, impervious cover, by nature, inhibits the infiltration of precipitation and encourages the generation of runoff. Thus, in general, as lands are developed, the amount of impervious cover increases thereby resulting in an increase in stormwater runoff. With this increase in runoff comes the likelihood of an increase in non-point source (NPS) pollution. Some of this is a function of land development. Alteration of the landscape from undeveloped to developed condition increase the types, amounts and availability of pollutants. The additional runoff erodes soils or mobilizes and transports those pollutants deposited on both impervious and pervious surfaces.

As such, the implications of development, as it applies to stormwater, are as follows:

- Hydrology - Increased impervious cover, without adequate mitigation, reduces the infiltration of precipitation, thereby increasing surface runoff and decreasing groundwater recharge. The added volume and energy associated with the resulting storm runoff has the potential to mobilize and transport an increased amount of pollutants. If not adequately mitigated, development related alterations in the hydrology of the watershed can result in lower base flows, storm flows of greater volume, velocity and duration, and an increase in pollutant loading.

- Pollutant generation - The types of pollutants present in surface runoff vary with land use. Typically, the more intense land is developed (i.e., the greater the amount of impervious cover) the greater the export of pollutants. Pollutants most often associated with land development are nutrients (nitrogen and phosphorus) and suspended sediments. Following development, nitrogen and phosphorus loads increase primarily from the fertilization of lawns, but soil erosion and decomposition of vegetation are other sources. Suspended sediments originate primarily as a result of the erosion of exposed, insufficiently vegetated land surfaces. The generation of heavy metals and petroleum hydrocarbons can also increase as land becomes increasingly developed. The majority of these pollutants are associated with the servicing or maintenance of vehicles or with vehicular emissions.

The MADEP has concluded that the proper long-term management of surface water, wetland and groundwater resources requires an integrated approach to the management of stormwater runoff (MADEP, 1997). This integrated approach involves the implementation of measures and design features that reduce the potential hydrologic and pollutant load impacts associated with site development. Commonly referred to as Best Management Practices (BMPs), these measures are both endorsed and now required by MADEP as part of any residential or commercial development. Whether structural (e.g., retention ponds, water quality basins, etc.) or nonstructural (e.g., low impact development planning strategies, wetland and waterway buffers, etc.), BMPs can be very effective in reducing the pollutant load of stormwater runoff and mitigating the effects of increased stormwater volumes and increased stormwater flow rates.

In the past, before a good understanding existed of the impacts of development and the consequences of impervious cover on stormwater flow, volume and quality, there were no rules, requirements or mandates in place to regulate the discharge of stormwater runoff. Rather, the typical approach was to collect it and release it to a stream, wetland or lake as quickly as possible, thereby averting localized flooding problems. When examining the stormwater collection and conveyance systems (or lack thereof) in the Onota Lake watershed, it becomes obvious that this has been the basic approach taken to date in the management of stormwater runoff. However, through the integration of properly sized and constructed BMPs it is possible to significantly reduce the impacts of land disturbance and develop, and approach a condition where no measurable impact to the quality of the surface waters, wetlands and riparian corridors are experienced as a result of land development.

To accomplish this, stormwater quality management measures need to be designed in a manner that correctly mitigates a development’s potential impacts to surface water, wetland and groundwater resources. This is accomplished by following these general precepts:

1. Design with consideration of the natural resource attributes and limitations of the site,
2. Promote, where feasible, stormwater recharge, and
3. Combine the pollutant removal benefits of multiple stormwater quality Best Management Practices.

To accomplish this entails approaching stormwater management and NPS pollution control through using a combination of structural and non-structural BMPs. Although this report focuses on existing stormwater impacts and the retrofit of the existing stormwater collection and conveyance system emphasis is placed in the report on structural BMPs. However, it is worthwhile to summarize some non-structural approaches, which should come into play when dealing with future development activities within the Onota Lake watershed.

3.1 NON-STRUCTURAL STORMWATER MANAGEMENT MEASURES

Source reduction controls, resource conservation, resource preservation and land use planning are all highly effective methods of minimizing both short and long-term development related water quality impacts. These measures reduce or eliminate environmental impacts <u>before they occur</u> given their inherently preventative nature. Limiting the entry of pollutants into the environment or avoiding the disturbance of sensitive habitats are ultimately preferable to implementing cleaning up, mitigation or restoration activities. While there exists many ways to reduce the pollutant loading of runoff, by reducing the amount and number of chemicals entering the environment in the first place, the level of protection provided the environment is that much greater. The following are conservation, preservation and source control measures that are applicable to the Onota Lake watershed.

3.1.1 PROTECTION OF SENSITIVE WETLAND AND AQUATIC FEATURES

As part of any future development process, the surface water and wetland features of a specific site within the Onota Lake watershed will need to be identified and delineated in accordance with MADEP wetland regulations. Through this process wetlands, streams, vernal pools and other surface water features will be formally located and identified, and subsequently preserved and protected in accordance with the provisions of the wetland regulations. For those water and wetland resources requiring a buffer or transition area, such will be provided, with the dimensions of the transition area or riparian buffer in keeping with the provisions of local, State and Federal wetland regulations. Through this review process should be possible to avoid excessive, unnecessary or damaging clearing along or within stream corridors.

3.1.2 MINIMIZATION OF DISTURBANCE AND USE OF ALTERNATIVE LANDSCAPING

Minimizing disturbance and utilizing alternative landscaping is an impact preventative technique that decreases erosion, eliminates the need for continual fertilization of lawn areas, decreases pesticide applications and conserves water. Such measures should be promoted by the BRPC and the Onota Lake Preservation Association (LOPA) for existing and future development located throughout the Onota Lake watershed.

For example, clearing and grading should be conducted only within prescribed areas and conducted in accordance with local regulations governing site clearing and soil disturbance. Measures should be taken to reduce the amount of clearing along the lake's shoreline and along any of the lake's feeder tributaries. This will decrease the opportunity for erosion while promoting the infiltration and/or evapotranspiration of runoff. The promotion of post-development landscaping of new large sub-division with site-appropriate, native vegetation and minimization of lawns could decrease pesticide and fertilizer use, thereby further protecting the lake and its tributaries from such impacts.

For existing developed areas within the watershed, the BRPC and LOPA should encourage the use of native plantings and the maintenance of an aquascaped edge along the lake's shoreline. This may involve the natural colonization of plants or the use of supplemental plantings. The intent of this is to facilitate groundwater recharge and minimize the generation of runoff, while foregoing to the need for the extensive use of fertilizers and pesticides.

3.1.3 FERTILIZER AND PESTICIDE MANAGEMENT

Integrated Pest Management (IPM) is a common sense approach to pesticide and fertilizer application that follows environmentally conservative methods to maintain pests below pre-defined, acceptable densities and encourage the healthy growth of turf and landscaping. It is now a standard practice for golf courses, nurseries and even some farms. The concept that if "a little is good, more is better" leads to over-application of product and an increased potential for the off-site transport of fertilizers and pesticides. By applying the minimum quantity of fertilizer necessary for optimum plant growth, the amount of fertilizer potentially lost to surface and groundwater resources is minimized. Within any lake community, especially for developed areas near the lake its tributaries, LOPA should promote the use of slow release fertilizers and the designation of landscaped areas adjacent to the lake as well as streams and wetlands as "no fertilizer" zones. Similarly, the limited or controlled use of pesticides in these same areas can reduce the amount of product being applied, thereby preventing surface and groundwater contamination. Careful selection of pesticide products can also reduce the likelihood of impacts to non-target organisms.

3.1.4 ROADWAY DE-ICING/SALT REDUCTION

This management practice promotes the "wise use" of road salts. Options include minimizing salt applications in areas that are not extensively utilized and maintaining stringent application controls in sensitive areas. Levels of service and application rates for various locations throughout the Onota Lake watershed can be determined prior to the winter season. Depending on the required level of access and public safety concerns, the road de-icing options could include no salt use, plowing and sanding, or the controlled use of salt or other de-icing agents. We are especially concerned about sanding operations as quite frequently during our inspections of the watershed we observed sand deposits in stream corridors at the mouth of stormwater outfalls. This was especially true throughout the Daniels Brook and Churchill Brook watersheds.

Although not always practical because of their cost and availability, there are alternative deicing compounds available on the market. For example, calcium magnesium acetate, a combination of dolomitic limestone and acetic acid, as well as other products, are used in other lake watersheds, for example in the watershed of Lake Tahoe, CA. These salt alternatives contribute little, if any, to the degradation of water quality. LOPA and BRPC should evaluate the use of these alternative products should be promoted. Emphasis should be given to roads or parking areas located in close proximity to the lake, its tributaries, wetlands or potable wells.

3.2 STRUCTURAL STORMWATER MANAGEMENT MEASURES

As per local and State regulations concerning the management of storm water runoff, any new development occurring within the Onota Lake watershed will need to be conducted in accordance with MADEP's stormwater Policy. The State regulations are designed to prevent flooding problems, minimize the off-site transport of pollutants and protect groundwater, surface water and wetland resources from impact. The previous section of this report provided a list of non-structural measures that could be used to protect the lake and its tributaries from direct and indirect NPS impacts attributable to development. This section address structural BMPs. Whereas non-structural BMPS are termed "source control" measures, structural BMPs are considered "delivery control" measures. This is because these measures are designed to intercept and treat runoff before it is discharged into a receiving wetland, stream or lake. Further within this report, details are provided of exact locations where specific types of BMPs should be used to minimize NPS pollution from the Parker, Daniels and Churchill watersheds. This section of the report deals with some of the specific types of stormwater quality management and polishing techniques that could be useful elsewhere in the watershed, especially in terms of dealing with stormwater discharges from new developments.

In dealing with runoff from any developed site, it is advisable that an attempt be made to integrate the following site planning, construction and BMP treatment measures into the project:

1. Do not directly discharge stormwater from any impervious components of the site to any stream or wetland without some degree of treatment.
2. Avoid "end of the pipe" treatment practices. Rather, deal with small stormwater catchment areas and attempt to treat and manage runoff as close to its point of origin as possible. Managing smaller volumes of runoff increase the BMP options that can be

successfully utilized.

3. Post-development peak flows for the 2, 5, 10, 25, 50 and 100-year storms should not be increased beyond that which existed under the pre-development condition of the site, and preferably should be deceased to peak rates that are actually less than the site's pre-developed rates.
4. Sumped catch basins and manufactured treatment devices should be used where practical to pre-treat runoff.
5. Roof top areas should be directed to an infiltration structures to encourage groundwater recharge and minimize the volume of stormwater runoff.
6. A combination of vegetated Best Management Practices (BMPs), having high pollutant removal efficiencies, should be functionally linked together, in what is commonly referred to as a "pollutant removal train" to maximize the removal of pollutants prior to the off-site discharge of runoff.
7. Stormwater infiltration should be promoted within individual BMPs. That is, avoid BMPs that simply hold or detain runoff.
8. All storm water structures and appurtenances should be sized in accordance with the guidance of the USEPA and as required by MADEP regulations and local ordinances.

4.0 QUANTIFICATION OF THE ONOTA LAKE WATERSHED NPS POLLUTANT LOAD

4.1 INTRODUCTION

As part of the Lake's Diagnostic Feasibility Study of the lake (IT, 1991) a pollutant load analysis was conducted for the entire Onota Lake Watershed. The results of that analysis, as summarized in Table 4.1, show that sub-watersheds VI, VII and VIII are responsible for the bulk of the lake's nutrient and sediment loading. These watersheds correspond respectively to the Parker/Lulu Brook, Churchill and Daniels Brook watersheds. However, these are the two largest sub-watersheds, and as such, their loading in itself is biased due to the size of the contributing watershed. Evidence of this is also found in the Diagnostic/Feasibility Report, I a subsequent table that shows the predominant land cover type in all of the above three sub-watersheds is forested land. As such, although these data are useful in understanding from where the lake's pollutant loading originates, it is somewhat misrepresentative with respect to determining where BMP retrofits should be implemented.

As such, one of the objectives of this study was to conduct a revised stormwater loading analysis that could be used in a more concerted manner to direct BMP installations and retrofits. The assessment conducted as part of this effort involved:

1. Quantification of non-point source pollutant loads on a sub-watershed specific basis.

2. Normalization of these data using weighting parameters that address the size of the contributing sub-watershed and the predominance of existing land cover by forested and undeveloped land.
3. Evaluation of Best Management Practices (BMPs) utility, practicality, performance and cost to address the corrected loads.
4. Identification of those BMPs applicable for implementation.

4.2 METHODOLOGY

The watershed's existing pollutant loads were calculated using the ArcView Generalized Watershed Loading Functions (AVGWLF) model, a GIS based pollutant load assessment tool. The AVGWLF model is well suited to the prediction of water quality improvements arising from stormwater quality management initiatives. This model has been recommended by the USEPA and State water resource agencies for several reasons. First, it directly links land use, land development and pollutant loads. This information is critical in projecting the cost/benefit improvements associated with any of the proposed stormwater management projects. Second, model results can be easily, and visually, demonstrated through the production of GIS maps.

The selected loading coefficients (Table 4.2) are consistent with those previously generated through the USEPA's National Urban Runoff Pollution (NURP) studies of the 1970's (Reckhow, et al., 1980). These are essentially the same coefficients that appear in Volume 2 of the MADEP Stormwater Technical Handbook (1997), the NJDEP Stormwater Best Management (BMP) Manual (NJDEP, 2002), and various publications from the Center for Watershed Protection.

4.3 RESULTS

The results of the pollutant loading calculations are presented in Table 4.3. Comparison of the 1992 and 2003/2004 data (Tables 4.1 and 4.3) reveals only minor differences in the overall loads computed for each sub-watershed. These are likely due to the more refined nature of the GIS based modeling tool used in this study as well as minor changes in land use that have occurred over the past decade. It should also be emphasized that neither the loads presented in Tables 4.1 nor 4.2 have been adjusted for existing BMPs. That is, these data represent raw loading, unmitigated in any manner. However, this appears to be correct based on Princeton Hydro's inspections of the watershed and the information contained in the stormwater infrastructure inventory conducted by BRPC and LOPA. (see Section 4)

Table 4.4 is an analysis of the relative percent of TN, TP and TSS loading attributable to each sub-watershed as defined by the sub-watershed load divided by the total land area associated with the given sub-watershed. The data presented in Table 4.5 shows the relative percentage of the lake's respective TN, TP and TSS total loads presented on a sub-watershed basis. As such, Table 4.5 shows how much of the load (%) originates from a given sub-watershed, and Table 4.4 shows how much pollutant loading is originating on a per/acre basis from each sub-watershed.

As stated above, the loads presented in these tables 4.1 and 4.3 are inherently biased due to the overall size of the respective watersheds. In order to correct for this, the base load for each sub-watershed was calculated. The base load represents the amount of pollutants that would be generated from a sub-watershed even it was not developed. In essence, pollutant load is generated under a 100% forested scenario. From a BMP and NPS management perspective, this load may be considered unmanageable, in that it is the natural pollutant load. This does not mean that it is not significant, but rather may be difficult to cost-effectively reduce. The base loads for each sub-watershed are presented in Table 4.6.

Table 4.7 shows for each sub-watershed, the extent to which the impact load exceeds the base load. The greater the exceedance value the more the pollutant load to the lake is a function of land development and watershed disturbance. Those sub-watersheds have higher values should be targeted for management. To better illustrate the relative NPS loading importance of each sub-watershed, they were ranked in Table 4.8 by their corrected computed loads. The higher the rank (the lower the number) the greater emphasis needed with respect to NPS load reduction.

Table 4.1
Summary of Pollutant Onota Lake Watershed Pollutant Loading
As Reported in the 1991 Diagnostic Feasibility Report

Sub-watershed	Area (acres)	Annual Load kg/yr		
		Total Nitrogen	Total Phosphorus	Total Suspended Solids
I	553.25	780.0	85.8	187,200
II	109.31	352.4	46.1	103,095
III	67.26	78.3	7.8	13,824
IV	102.38	56.3	5.6	5,625
V	172.50	192.5	15.4	19,019
VI	2,104.54	2,508.5	190.3	275,935
VII	763.82	1023.0	74.4	121,830
VIII	1,768.83	1914.0	151.6	255,270
IX	105.47	192.0	28.2	55,200
X	257.52	200.2	27.7	43,120
Total	6004.88	7297.0	632.9	1,080,118

Table 4.2
Loading Coefficients Utilized in the Computation of the
2003/2004 Onota Lake Watershed Pollutant Loads

Loading Coefficients	TN	TP	TSS
Forest	2.5	0.2	250
Agriculture	10.0	0.6	1600
High Density Res (includes commercial)	5	0.8	2000
Low Density Res	2	0.25	200
Open-Covered	5	0.3	400
Open-Disturbed	10	0.6	1600
Base Load Coefficient	2.5	0.2	250

Table 4.3
2003/2004 Onota Lake Watershed Pollutant Loads

Sub-watershed ID	**Area**		**TN**	**TP**	**TSS**
	Acres	Hectares			
I	385.48	156	780	85.8	187200
II	214.98	87	352.4	46.1	103095
III	66.72	27	78.3	7.8	13824
IV	61.78	25	56.3	5.6	5625
V	190.27	77	192.5	15.4	19019
VI	2137.46	865	2508.5	190.3	275935
VII	766.03	310	1023	74.4	121830
VIII	1569.12	635	1914	151.6	255270
IX	148.26	60	192	28.2	55200
X	190.27	77	200.2	27.7	43120
Total	5730.37	2319.00	7297.20	632.90	1080118.00

Table 4.4
2003/2004 Onota Lake Watershed Pollutant Loads
Loading Per Unit Area

	% Load (kg/yr) / % Area		
	TN	**TP**	**TSS**
I	158.9	201.5	257.6
II	128.7	194.2	254.4
III	92.2	105.9	109.9
IV	71.6	82.1	48.3
V	79.4	73.3	53.0
VI	92.2	80.6	68.5
VII	104.9	87.9	84.4
VIII	95.8	87.5	86.3
IX	101.7	172.2	197.5
X	82.6	131.8	120.2

Table 4.5
2003/2004 Onota Lake Watershed Pollutant Loads
Percent of Total Loading Per Sub-Watershed

	% Load (kg/yr) of Total		
	TN	**TP**	**TSS**
I	10.7	13.6	17.3
II	4.8	7.3	9.5
III	1.1	1.2	1.3
IV	0.8	0.9	0.5
V	2.6	2.4	1.8
VI	34.4	30.1	25.5
VII	14.0	11.8	11.3
VIII	26.2	24.0	23.6
IX	2.6	4.5	5.1
X	2.7	4.4	4.0

Table 4.6 **2003/2004 Onota Lake Watershed Pollutant Loads** **Base Load Per Sub-Watershed**					
Sub-watershed ID	**Area**		**Pollutant**		
	Acres	**Hectares**	**TN**	**TP**	**TSS**
I	385.48	156	390	31.2	39000
II	214.98	87	217.5	17.4	21750
III	66.72	27	67.5	5.4	6750
IV	61.78	25	62.5	5	6250
V	190.27	77	192.5	15.4	19250
VI	2137.46	865	2162.5	173	216250
VII	766.03	310	775	62	77500
VIII	1569.12	635	1587.5	127	158750
IX	148.26	60	150	12	15000
X	190.27	77	192.5	15.4	19250
Total	5730.37	2319.00	5797.50	463.80	579750.00

Table 4.7
2003/2004 Onota Lake Watershed Pollutant Loads
Total Load - Base Load And % Exceedence Per Sub-Watershed

Sub-Watershed	Impacted Load (Total Load – Base load kg/yr)				% Exceedence		
	TN	TP	TSS		TN	TP	TSS
I	390	54.6	148200		100.00	175.00	380.00
II	134.9	28.7	81345		62.02	164.94	374.00
III	10.8	2.4	7074		16.00	44.44	104.80
IV	-6.2	0.6	-625		-9.92	12.00	-10.00
V	0	0	-231		0.00	0.00	-1.20
VI	346	17.3	59685		16.00	10.00	27.60
VII	248	12.4	44330		32.00	20.00	57.20
VIII	326.5	24.6	96520		20.57	19.37	60.80
IX	42	16.2	40200		28.00	135.00	268.00
X	7.7	12.3	23870		4.00	79.87	124.00
Total	1499.7	169.1	500368				

Table 4.8
2003/2004 Onota Lake Watershed Pollutant Loads
Ranking of Sub-Watersheds By Corrected Pollutant Loads

	Rank		
Watershed	**TN**	**TP**	**TSS**
I	1	1	1
II	6	2	8
III	8	8	2
IV	7	6	6
V	2	9	7
VI	9	7	9
VII	3	10	10
VIII	10	3	3
IX	5	4	5
X	4	5	4

5.0 STORMWATER INFRASTRUCTURE INVENTORY

5.1 INTRODUCTION

For the purposes of this study the Onota Lake watershed has been divided into ten sub-watersheds (see Map 1) and numbered to be consistent with those described in the Diagnostic Feasibility Study (IT, 1991). BRPC staff and LOPA volunteers completed an inventory of the municipal stormwater infrastructure within the Onota Lake watershed in the City of Pittsfield. The stormwater infrastructure inventoried included the subsurface stormdrain systems and associated discharge pipes, catch basins and roadside drainage swales. BRPC staff and LOPA volunteers collected existing information from City of Pittsfield engineering maps through, Burbank Park Improvement Plans (Okerstrom-Lang Landscape Architects, 1998) and through field verification. Ultimately, each catch basin and discharge pipe was assigned a unique identifier. An alpha-numeric nomenclature system was utilized. All discharge pipes and catch basins were numbered. In some instances both catch basins and discharge pipes have a subcategory, such as 7A, 7B, 7C. All discharge pipes end with the suffix P, while all catch basins end with the suffix SD. The location of all identified discharge pipes and catch basins within the Onota Lake watershed was recorded and mapped. In addition, the type of pipe and diameter was recorded along with any other observations. Photographs were taken of the discharge pipes whenever possible. Table 5.0 displays the discharge pipe and catch basin inventory.

5.2 SUB-WATERSHED I

Sub-watershed I is a 385.48 acre sub-basin within the Onota Lake watershed. This sub-watershed is the fourth largest sub-watershed and drains to the lake via overland flow and rainfall. The land use within this sub-basin is a mixture of pasture, forest, urban open land, and mixed residential (predominantly lots larger than ½ acre). Burbank Park, a municipally owned park is located within this sub-watershed. Burbank Park serves as the primary access point for Onota Lake and includes a public boat launch, fishing pier, restrooms, parking areas, and the Controy Pavilion..

Pipe 10AP & 10BP

This sub-watershed contributes 13.6% of the annual total phosphorus load, 10.7% of the annual total nitrogen load and 17.3% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number one priority watershed for nutrient loading in all three categories, as displayed in Table 4.8.

There are eight separate catchment areas within Sub-watershed I. In addition to the eight catchment areas, there are 2 pipes (5P & 6P) located on private property, which discharge into the lake. No further information on these pipes exists. Thirteen (13) catch basins (90SD-101SD & 104SD) are located in the southern section of Sub-watershed I along West Street. These catch basins drain a single catchment area but do not discharge into the Onota Lake watershed.

Six separate catchment areas were identified within Burbank Park. There are 8 pipes (7AP-7CP, 8P, 9P, 10AP, 10BP, & 19P) and 8 catch basins (1SD-8SD) within Burbank Park. Information on stormwater infrastructure for Burbank Park was obtained through field investigations and through Burbank Park Improvement Plans. (Okerstrom-Lang Landscape Architects, 1998) In the vicinity of Lakeway Drive there are 3 pipes (11P, 12P & 12AP) and 6 catch basins (9SD-14SD). (see Map 2) Pipe 8P discharges into a vegetated area between the north and south parking lots of Burbank Park in an area with no identified catchbasins. Catch basins 3SD-6SD drain a catchment area along Lakeway Drive and discharge into pipe 19P, which discharges into a wooded area, and into pipe 7AP, which discharges directly into the lake.

Catch basins 1SD and 2SD, within a parking the south parking lot of Burbank Park, drain a single catchment area into pipe 7BP. Pipe 7BP discharges into a vegetated area within the 100ft buffer zone of the lake. Catch basins 7SD and 8SD are also located within the south parking lot of Burbank Park and drain a single catchment area to pipe 7CP, which discharges directly into the lake.

Pipe 9P discharges directly to the lake, and is located within an area of Burbank Park with no identified catchbasins. Pipes 10AP and 10BP discharge directly to the lake, and are located in the north parking lot of Burbank Park where there are no identified catchbasins.

Catch basins 9SD-14SD drain a catchment area in a residentially developed portion of Sub-watershed I along Lakeway Drive. Catch basins 9SD and 12SD drain into pipe 12AP, which discharges into a wetland. Catch basins 10SD and 11SD drain into 11P, which discharges directly into the lake. Catch basins 13SD and 14SD drain into pipe 12P, which also discharges directly into the lake.

5.3 SUB-WATERSHED II

Sub-watershed II is a 214.98 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the fifth largest sub-watershed and drains to the lake via the unnamed Blythewood Drive tributary and a combination of overland flow and rainfall. This basin is characterized by forest, pasture, and residential lots larger than ½ acre. A large horse farm borders the tributary, and serves as the single largest land use other than forest within this sub-watershed.

This sub-watershed contributes 7.3% of the annual total phosphorus load, 4.8% of the annual total nitrogen load and 9.5% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number two priority watershed for total phosphorus loading. However, this sub-watershed did not rank evenly through all categories, ranking as the sixth priority for total nitrogen and the eighth propriety for total suspended solids, as displayed in Table 4.8. The D/F Study reported bacteria and nitrate peaks at the unnamed tributary. Total phosphorus and total suspended solids were elevated in samples collected at the tributary during storm events. (IT, 1991)

The bridges over Parker and the unnamed Blythewood Drive tributary on Churchill Road allow runoff directly into these brooks. In addition, paved swales direct runoff from the road directly into Parker Brook. There are 5 catch basins (110SD-114SD) draining a single catchment area within this sub-watershed. These catch basins are believed to discharge into a wetland at the headwaters of the tributary that flows under Blythewood Drive. City of Pittsfield engineering designs show no evidence of a pipe and no pipe was identified during field assessments. However, the wetland allows for limited access for field inspection. (see Map 3)

5.4 SUB-WATERSHED III

Sub-watershed III is a 66.72 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the smallest sub-watersheds and drains to the lake via overland flow and rainfall. Forest and residential lots larger than ½ acre characterize this sub-watershed.

This sub-watershed contributes 1.2% of the annual total phosphorus load, 1.1% of the annual total nitrogen load and 1.3% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number eight priority watershed for total phosphorus and total nitrogen loading. However, this sub-watershed did not rank evenly through all categories, ranking as the second priority for total suspended solids, as displayed in Table 4.8.

Pipe 4P

There is 1 pipe (4P) that discharges to the lake within this sub-watershed. The pipe is located on private property. No information regarding the pipe was available through the City of Pittsfield engineering records and no connections were obvious in the field. There are no catch basins located within this sub-watershed. (see Map 4)

5.5 SUB-WATERSHED IV

Sub-watershed IV is a 61.78 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the one of the smallest sub-watersheds and drains to the lake via overland flow and rainfall. Only Sub-watershed III is smaller. Forest and participation recreation (golf courses) characterize this sub-watershed.

This sub-watershed contributes 0.9% of the annual total phosphorus load, 0.8% of the annual total nitrogen load and 0.5% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number seven priority watershed for total nitrogen loading. This sub-watershed ranked closely through all categories, ranking as the sixth priority for total phosphorus and total suspended solids, as displayed in Table 4.8.

There are 2 pipes (26P & 27P) that discharge to the lake within this sub-watershed. These pipes are located on private property. No information regarding theses pipes was available through the City of Pittsfield engineering records and no connections were obvious in the field. There are no catch basins located within this sub-watershed. (see Map 5)

5.6 SUB-WATERSHED V

Sub-watershed V is a 190.27 acre sub-watershed within the Onota Lake watershed. This sub-watershed is tied as the sixth largest sub-watershed with Sub-watershed X. This sub-watershed drains to the lake via overland flow and rainfall. Forest, cropland, and residential lots greater than ½ acre characterize this sub-watershed. (see Map 6)

This sub-watershed contributes 2.4% of the annual total phosphorus load, 2.6% of the annual total nitrogen load and 1.8% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number two priority watershed for total nitrogen loading. This sub-watershed did not rank evenly through all categories, ranking as the ninth priority for total phosphorus and the seventh priority for total suspended solids, as displayed in Table 4.8.

There is a single catchment area within this sub-watershed that drains 6 catch basins on Churchill Street (123SD-128SD). These six catch basins are located in the south western portion of this sub-watershed and discharge via 2 pipes (23P & 24P). Both pipes discharge into heavily vegetated wetland areas along the westerly side of Churchill Street. The vegetated wetland areas appear to be bordering vegetated wetlands (BVW) of Onota Lake.

5.7 SUB-WATERSHED VI

Sub-watershed VI is a 2,137.46 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the largest sub-watershed and drains to the lake via Parker Brook and a combination of overland flow and rainfall. This sub-watershed is made up of a variety of land uses including forest and residential lots greater than ½ acres.

This sub-watershed contributes 30.1% of the annual total phosphorus load, 34.4% of the annual total nitrogen load and 25.5% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number seven priority watershed for total phosphorus loading. This sub-watershed ranked closely through all categories, ranking as the ninth priority for total nitrogen and total suspended solids, as displayed in Table 4.8. The D/F Study reported bacteria and nitrate peaks at the tributary. Total phosphorus and total suspended solids were elevated in samples collected at the tributary during storm events. (IT, 1991)

There is a single catchment area within this sub-watershed. There are 4 catch basins on Churchill Street (115SD & 120SD-122SD). These catch basins are located in the western portion of this sub-watershed south of the intersection of Churchill Street and Cascade Street. The catch basins drain to pipe 22P, which discharges directly into Parker Brook. In addition, three paved swales direct runoff from the road directly into the brook. (see Map 7)

5.8 SUB-WATERSHED VII

Sub-watershed VII is a 766.03 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the third largest sub-watershed and drains to the lake via Churchill Brook and a combination of overland flow and rainfall. This sub-watershed is made up of a variety of land uses including forest, mining (gravel pit) and residential lots greater than ½ acres.

This sub-watershed contributes 11.8% of the annual total phosphorus load, 14.0% of the annual total nitrogen load and 11.3% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number three priority watershed for total nitrogen loading. However, this sub-watershed did not rank evenly through all categories, ranking as the tenth priority for total nitrogen and total suspended solids, as displayed in Table 4.8. The D/F Study reported bacteria and nitrate peaks at the tributary. Total phosphorus and total suspended solids were elevated in samples collected at the tributary during storm events. (IT, 1991)

The bridge over Churchill Brook allows runoff from the road to flow directly into the brook. LOPA volunteers have reported that, during significant rain events an alluvial fan of sediment has been traced back from the brook to an ATV trail. (see Map 8)

5.9 SUB-WATERSHED VIII

Sub-watershed VIII is a 1,569.12 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the second largest sub-watershed and drains to the lake via Daniels Brook and a combination of overland flow and rainfall. This sub-watershed is made up of a variety of land uses including forest, cropland and residential lots greater than ½ acres.

This sub-watershed contributes 24.0% of the annual total phosphorus load, 26.2% of the annual total nitrogen load and 23.6% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number ten priority watershed for total nitrogen loading. However, this sub-watershed did not rank evenly through all categories, ranking as the third priority for total nitrogen and total suspended solids, as displayed in Table 4.8. The D/F Study reported bacteria and nitrate peaks at the tributary. Total phosphorus and total suspended solids were elevated in samples collected at the tributary during storm events. (IT, 1991)

There are two separate catchment areas within this sub-watershed. There are 3 pipes (20P, 21AP & 22AP) that drain 12 catch basins along Pecks Road (31SD-42SD). Catch basins 31SD-34SD drain to pipe 20P, which discharges into a wetland on the westerly side of Pecks Road just east of Daniels Brook. Catch basins 35SD-42SD drain to pipes 21AP and 21BP. When water levels are high pipe 21AP discharges directly into Daniels Brook. However, under normal conditions this pipe discharges into a vegetated area within the 200’ regulated Riverfront protection Area. Pipe 21BP is not accessible, but is believed to discharge into a wetland on the easterly side of Pecks Road north of Pipes 20P and 21AP. (see Map 9) In addition, the bridge over Daniels Brook allows runoff from the road to flow directly into the brook. Two paved swales, at the bridge, allow runoff to flow from the road directly into the brook.

5.10 SUB-WATERSHED IX

Sub-watershed IX is a 148.26 acre sub-watershed within the Onota Lake watershed. This sub-watershed is the one of the smaller sub-watersheds, with only three sub-watersheds smaller in size. This sub-watershed drains to the lake via a combination of overland flow and rainfall. This sub-watershed is made up of a variety of land uses including forest, cropland and residential lots less than ¼ acres. This sub-watershed contains the most densely developed portion of the watershed.

This sub-watershed contributes 4.5% of the annual total phosphorus load, 2.6% of the annual total nitrogen load and 5.1% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number four priority watershed for total phosphorus loading. This sub-watershed ranked closely through all categories, ranking as the fifth priority for total nitrogen and total suspended solids, as displayed in Table 4.8.

Pipe 1P

There are 8 pipes (1P, 2AP, 2P, 3P, & 15P-18P) within this sub-watershed that discharge 11 catch basins (19SD-30SD). There are four separate catchment areas within this sub-watershed. Three catch basins along Pecks Road (28SD-30SD) drain a single catchment area and discharge directly into Onota Lake via pipe 3P. Nine catch basins (19SD-27SD) are located along Pecks Road and Kellie Drive. All nine catch basins drain a single catchment area and discharge via pipe 2AP. Pipe 2AP discharges directly into Onota Lake. Pipe 2AP is of particular concern since it drains a densely developed are, the heavily trafficked Pecks Road, and steeply sloped Kellie and Crown roads.

Thomas Island is the most densely developed area of the Onota Lake watershed. There are two separate catchment areas on Thomas Island. There was no information available through the City of Pittsfield engineering plans regarding the stormwater infrastructure for Thomas Island. Two catch basins (50SD &51SD) on Thomas Island drain a single catchment area. These catch basins are believed to drain to pipe 2P, which discharges directly to Onota Lake. A single catch basin on Thomas Island Road (52SD) drains the southern portion of Thomas Island. It is believed that this catch basin drains to pipe 18P, which discharges directly into Onota Lake.

Pipe 1P also discharges directly into Onota Lake. However, no information was available through the City of Pittsfield engineering plans, no connections were obvious during field observations, and no water has been observed flowing from the pipe. Pipe 16P discharges directly to Onota Lake from Thomas Island at the end of Shore Drive. No information was available through the City of Pittsfield engineering plans and no connections were obvious during field observations. The pipe is suspected to be used for flushing of the nearby fire hydrant. Pipe 17P discharges directly to Onota Lake on Thomas Island at the end of Thomas Road. No information was available through the City of Pittsfield engineering plans and no connections were obvious during field observations. According to residents of Shore Drive, the pipe is used for flushing of the nearby fire hydrant. (see Map 10)

5.11 SUB-WATERSHED X

Sub-watershed X is a 190.27 acre sub-watershed within the Onota Lake watershed. This sub-watershed is tied as the sixth largest sub-watershed with Sub-watershed V. This sub-watershed drains to the lake via overland flow and rainfall. This sub-watershed is made up of a variety of land uses including forest, participation recreation (golf courses) and mixed residential (predominantly lots less than ¼ acres).

This sub-watershed contributes 4.4% of the annual total phosphorus load, 2.7% of the annual total nitrogen load and 4.0% of the annual load of total suspended solids to the lake, as displayed in Table 4.5. When ranking sub-watersheds based on their corrected pollutant loads, this sub-watershed has been ranked as the number five priority watershed for total phosphorus loading. This sub-watershed ranked closely through all categories, ranking as the fourth priority for total nitrogen and total suspended solids, as displayed in Table 4.8.

Pipe 13P, 14AP, & 14BP

There are three separate catchment areas within this sub-watershed. There are five catch basins along Pecks Road (15ASD, 15SD, 16SD, 17SD & 18SD) that drain a single catchment area. These catch basins drain to one of three pipes that discharge directly into Onota Lake (13P, 14AP & 14BP). No information was available through the City of Pittsfield engineering plans and no connections were clear during field observations. A dye test would be required to determine the discharge point(s) of these five catch basins. In addition, it is suspected that these three pipes (13P, 14AP & 14BP) carry spring run-off from the vicinity of Knesset Israel Cemetery.

Two catch basins located on Bromback Street (58SD & 59SD) drain a single catchment area within this sub-watershed and discharge into a wetland between Bromback Street and Toronita Avenue. An additional 22 catch basins along Pecks Road (15ASD, 15SD-18SD & 60SD- 83SD) discharge to a pipe (25P) that drains outside of the Onota Lake watershed. (see Map 11)

Table 5.0 Onota Lake Watershed Discharge Pipe and Catch Basin Inventory

PIPE#	CATCH BASIN(S) THAT EMPTY INTO PIPE	SUB-WATERSHED	PARCEL#	OWNERS NAME	PARCEL ADDRESS	MAILING ADDRESS	TYPE OF PIPE	PIPE DIAMETER	NOTES
1P	Not able to be determined.	IX	E130008022	Ouilette, William F.	2 Thomas Rd. Pittsfield, MA 01201	same	corrugated metal	12" est.	Couldn't find on engineering maps.
2AP	19SD-27SD	IX	unknown	unknown	unknown	unknown	vitreous clay pipe	12" est.	Couldn't find on engineering maps.
2P	50SD, 51SD	IX	E130008022	Ouilette, William F.	2 Thomas Rd. Pittsfield, MA 01201	same	corrugated metal	12" est.	Probably connects to 2 storm drains on Thomas Road Couldn't find on engineering maps.
3P	28SD, 29SD, 30SD	IX	E140002020	Kelly, Daniel D.	649 Pecks Rd. Pittsfield, MA 01201	same	vitreous clay	30"	Connects to 3 storm drains on Pecks Road, at the junction w/Dan Casey Memorial Drive.
4P	Not able to be determined.	III	E120001010	Conte Family Nominee Trust	11 Appletree Pt. Pittsfield, MA 01201	PO Box 182 Hardwick, MA 01201	corrugated metal	12" est.	Couldn't find on engineering maps.
5P	Not able to be determined.	I	E090001010	Onota Heights Trust No. 2	826 West St. Pittsfield, MA 01201	same	black plastic	12"est.	None
6P	Not able to be determined	I	E090001011	Onota Heights Trust No. 3	827 West St. Pittsfield, MA 01201	same	Not able to be determined.	Not able to be determined.	None
7AP	3SD, 4SD, 5SD, 6SD	I	E110001001	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	vitreous clay	12"	Cement "wall" around drain falling into lake.
7BP	1SD, 2SD	I	E110001002	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	vitreous clay	12"est.	None
7CP	7SD, 8SD	I	E110001003	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	black plastic	18" est.	Both drains in south parking lot of Burbank Park have retention basins with raised drains. They were put in during the most recent renovation. Parks dept. has plans. Okerstrom & Lang for Burbank Park.
8P	Not able to be determined	I	E110001004	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	vitreous clay	18" est.	The storm drain along the road in Burbank Park no longer exists. See Park Dept. plans 1998 Okerstrom & Lang for Burbank Park.
9P	Not able to be determined	I	E110001005	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	vitreous clay	14" est.	This is an old drainage pipe. The storm drain along the road in Burbank Park no longer exists. . See Park Dept. plans 1998 Okerstrom & Lang for Burbank Park.
10AP&BP	Not able to be determined	I	E110001006	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	a - black plastic b - black plastic	both 10"	2 pipes run from a "retention" area in the southwest corner of the north parking lot at Burbank Park to these pipe ends. There is not a lot of retention in this spot. Most of the parking lot run-off goes away form this area. It does get a lot of run-off during the spring melt.
11P	Not able to be determined	I	F130001019	Rosen, Robert J.	625 Lakeway Dr. Pittsfield, MA 01201	same	vitreous clay	10"	At the engineering office this drain no longer appears to be connected to anything.
12AP	Not able to be determined	I	Unknown	Unknown	Unknown	Unknown	blue PVC	15" est.	Couldn't find on engineering maps.
12P	Not able to be determined	I	F130001020	Rosen, Robert J.	625 Lakeway Dr. Pittsfield, MA 01201	same	Cast iron	10"	At the engineering office this drain no longer appears to be connected to anything.
13P	14SD, 15SD, 16SD, 17SD, 18SD	X	F130012026	Viilot, Stephen M.	467 Pecks Rd. Pittsfield, MA 01201	same	Corrugated metal	18"	One of three pipes. Connects to grassy area across Pecks road and possibly several storm drains.
14P	14SD, 15SD, 16SD, 17SD, 18SD	X	F130012027	Viilot, Stephen M.	468 Pecks Rd. Pittsfield, MA 01201	same	Corrugated metal	18"	One of three pipes. Connects to grassy area across Pecks road and possibly several storm drains.
14AP	14SD, 15SD,	X	F130012028	Viilot, Stephen M.	469 Pecks Rd.	same	Corrugated metal	36"x22"	One of three pipes. Connects to grassy area across Pecks road and possibly several storm drains.

Table 5.0 Onota Lake Watershed Discharge Pipe and Catch Basin Inventory

PIPE#	CATCH BASIN(S) THAT EMPTY INTO PIPE	SUB-WATERSHED	PARCEL#	OWNERS NAME	PARCEL ADDRESS	MAILING ADDRESS	TYPE OF PIPE	PIPE DIAMETER	NOTES
	16SD, 17SD, 18SD				Pittsfield, MA 01201			asphalt coated	
15P	pump	IX	F140001002	Lief, Philip D.	65 Thomas Island Rd. Pittsfield, MA 01201	14 Seymour Pl. White Plains, NY 10605	black plastic	4" est.	Pump station located on Thomas Island Road near this pipe.
16P	hydrant	IX	F130013003	Goerlach, Katheryn A.	93 Thomas Island Rd. Pittsfield, MA 01201		vitreous clay	12" est.	Probably for flushing fire hydrant at end of Shore Drive, if location is different (couldn't find on engineering maps).
17P	hydrant	IX	flushes hydrant				PVC	8" est.	Used to flush the hydrant at end of Thomas Road.
18P	52SD	IX	E130008001	Baumli, Gregory	84 Shore Dr. Pittsfield, MA 01201	94 Lovers Lane New Lebanon, CT 12125	PVC	12" est.	Probably connects t6o a single storm drain (couldn't find on engineering maps).
19P	Not able to be determined.	I	E110001001	City of Pittsfield Burbank Park	Lakeway Dr. Pittsfield, MA 01201	874 North St. Pittsfield, MA 01201	corrugated metal	12"	Doesn't open near lake. This is an old drainage pipe. The storm drain along the road in Burbank Park no longer exists. (Okerstrom-Lang, 1998)
20P	31SD, 32SD, 33SD, 34SD	VIII	pipe does not drain into Onota Lake	Unknown	Unknown	Unknown	vitreous clay	12"	Pipe from storm drains on Peck's Road. Enter wetland west of Peck's Road then joins Daniels Brook.
21AP	35SD – 42SD	VIII	pipe does not drain into Onota Lake	Unknown	Unknown	Unknown	reinforced concrete	24"	Pipe carries water from Pecks Road as well as from a low area on the east side of Pecks Road, to Daniels Brook, south of the dam on Hancock Road.
21BP	35Sd – 42SD	VIII	pipe does not drain into Onota Lake	Unknown	Unknown	Unknown	reinforced concrete	24"	Intake? Connects low area east of Pecks Road, north of Hancock Road, to storm drains that empty into Daniels Brook at pipe #21 on the south side of the little bridge on Hancock Road.
22P	120SD, 121SD, 122SD	VI	pipe does not drain into Onota Lake	Unknown	Unknown	Unknown	reinforced concrete	12"	Pipe from storm drains on Churchill near northern end of Cascade. Empties into Parker Brook on east side of Churchill.
23P	123SD – 125SD	V	E140001001	Winadu Real Estate Co. LLC	Churchill St. Pittsfield, MA 01201	4 New King St. White Plains, NY 10604	Unknown	Unknown	According to engineering maps, pipe on east side pf Churchill at northern end of lake.
24P	126SD – 128SD	V	E140001002	Winadu Real Estate Co. LLC	Churchill St. Pittsfield, MA 01201	4 New King St. White Plains, NY 10604	Unknown	Unknown	Should be a pipe on the other side of Churchill at north end of lake.
26P	Unknown	IV	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Located on private property. Discharges directly into Onota Lake.
27P	Unknown	IV	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Located on private property. Discharges directly into Onota Lake.

6.0 PRIORITIZATION OF ONOTA LAKE SUB-WATERSHEDS

6.1 INTRODUCTION

The prioritization component of this Integrated Stormwater Management Report is intended to provide direction for stormwater management within the Onota Lake Watershed by:

- Prioritizing each of the sub-watersheds based on pollutant load
- Prioritizing each of the sub-watersheds based on the stormwater infrastructure inventory
- Identifying management options for improved stormwater management
- Identifying steps that the City of Pittsfield toward stormwater management

In characterizing each sub-watershed, information was provided to identify stormwater issues, impacts and options, the sum total of which will form the basis for the formulation of stormwater management recommendations. The Onota Lake watershed and its sub-watersheds are illustrated in Map 1. At the watershed level, the prioritization establishes priorities for stormwater management and outlines steps that the City of Pittsfield and LOPA can take to educate, regulate and maintain stormwater management.

6.2 METHODOLOGY

The sub-watersheds were prioritized based on five factors: total phosphorus loading, total nitrogen loading, total suspended solids loading, number of direct discharges, and number of catch basins draining to direct discharges. Each sub-watershed is prioritized as low priority, low/medium priority, medium priority, medium/high priority, or high priority. Priority categories were assigned a numerical equivalent: low priority equals 1, medium priority equals 2 and high priority equals 3. Each of the five factors were first placed into the categories of low, medium or high before being evaluated at the sub-watershed level. Three or more direct discharges were categorized as high, while 1-2 direct discharges were categorized as medium and 0 direct discharges were categorized as low. Three or more catch basins draining to direct discharges were categorized as high, while 1-2 catch basins draining to direct discharges were categorized as medium and 0 catch basins draining to direct discharges were categorized as low. Each of the three factors for nutrient loading, total nitrogen, total phosphorus, and total

Factor	Low	Medium	High
Direct Discharges	0	1-2	3+
Catch Basin to Direct Discharges	0	1-2	3+
Rank	8-10	4-7	1-3

suspended solids, were ranked 1-10 within Table 4.8. Rankings of 1-3 were assigned a high priority. Rankings of 4-7 were assigned a medium priority, while rankings of 8-10 were assigned a low priority.

Each of the five factors were given equal weight. The sum total of each factor was combined for each sub-watershed and averaged resulting in a single priority value for each of the ten sub-watersheds.

6.3 RESULTS

The results of the prioritization clearly indicate that Sub-watershed I is the highest priority sub-watershed. Sub-watershed I received high priority values for having greater than 3 direct discharges, greater than 3 catch basins draining to direct discharges, and ranking as the number one priority for nutrient loading in all three categories.

Sub-watershed VIII resulted as a medium/high priority sub-watershed with an average value of 2.4. Sub-watershed VIII has greater than 1-2 direct discharges and greater than 3 catch basins draining to direct discharges. This sub-watershed was prioritized as a high priority sub-watershed for total phosphorus loading, and loading of total suspended solids. However, this sub-watershed received a low priority for total nitrogen loading. Sub-watershed IX resulted as a medium/high priority sub-watershed with an average value of 2.4. Sub-watershed IX has greater than 3 direct discharges and greater than 3 catch basins draining to direct discharges. This sub-watershed was prioritized as a medium priority for nutrient loading in all three categories. Sub-watershed X resulted as a medium/high priority sub-watershed with an average value of 2.4. Sub-watershed X has greater than 3 direct discharges and greater than 3 catch basins draining to direct discharges. This sub-watershed was prioritized as a medium priority for nutrient loading in all three categories.

Sub-watershed II resulted as a medium priority sub-watershed with an average value of 1.8. Sub-watershed II has 1-2 direct discharges, but no catch basins within this sub-watershed drain to direct discharges. This sub-watershed was prioritized as a high priority sub-watershed for total phosphorus loading, and a medium priority sub-watershed for total nitrogen loading. However, this sub-watershed received a low priority for loading of total suspended solids. Sub-watershed IV resulted as a medium priority sub-watershed with an average value of 1.8. Sub-watershed IV has 1-2 direct discharges, but no catch basins within this sub-watershed drain to direct discharges. This sub-watershed was prioritized as a medium priority nutrient loading in all three categories. Sub-watershed VI resulted as a medium priority sub-watershed with an average value of 1.8. Sub-watershed VI has 1-2 direct discharges with greater than three catch basins draining to direct discharges. This sub-watershed was prioritized as a low priority sub-watershed for total nitrogen loading, and loading of total suspended solids. However, this sub-watershed received a high priority for total phosphorus loading.

Sub-watershed III resulted as a low/medium priority sub-watershed with an average value of 1.6. Sub-watershed III has 1-2 direct discharges, but no catch basins within this sub-watershed drain to direct discharges. This sub-watershed was prioritized as a low priority sub-watershed for total phosphorus loading, and total nitrogen loading. However, this sub-watershed received a medium priority for loading of total suspended solids. Sub-watershed V resulted as a low/medium priority sub-watershed with an average value of 1.6. Sub-watershed V has 1-2 direct discharges, but no catch basins within this sub-watershed drain to direct discharges. This sub-watershed was prioritized as a low priority sub-watershed for total phosphorus loading. However, this sub-watershed received a medium priority for loading of total suspended solids and a high priority for total nitrogen loading. Sub-watershed VII resulted as a low/medium priority sub-watershed with an average value of 1.6. Sub-watershed VII has 1-2 direct discharges, but no catch basins within this sub-watershed drain to direct discharges. This sub-watershed was prioritized as a low priority sub-watershed for total phosphorus loading and for loading of total suspended solids. However, this sub-watershed received a high priority for total nitrogen loading.

Table 6.0
Onota Lake Sub-watershed Prioritization

Sub-Watershed	Direct Discharges	Catch Basins to Direct Discharges	TN	TP	TSS	Priority
I	High	High	High	High	High	High
II	Med	Low	Med	High	Low	Med
III	Med	Low	Low	Low	Med	Low/Med
IV	Med	Low	Med	Med	Med	Med
V	Low	Low	High	Low	Med	Low/Med
VI	Med	High	Low	Med	Low	Med
VII	Med	Low	High	Low	Low	Low/Med
VIII	Med	High	Low	High	High	Med/High
IX	High	High	Med	Med	Med	Med/High
X	High	High	Med	Med	Med	Med/High

6.3 STORMWATER MANAGEMENT OPTIONS

Stormwater management must consider the feasibility of implementation. Feasibility includes such factors as community acceptance, cost-benefit ratio, and ease of maintenance. Some of the considerations for stormwater management include:

- Anticipated water quality impacts
- Land use
- Soil type and topography
- Human health
- Recreational uses
- Aesthetic considerations.

Stormwater can be addressed by a wide means of both structural and non-structural best management practices. Several options have been identified and considered for Onota Lake.

It is essential that stormwater management is based on considerations of environmental protection including stormwater quality, aquatic habitat management, stream flow, riparian vegetation, and channel morphology. In addition to structural best management practices, source control should form a basis for stormwater management. This involves the prevention of stormwater problems rather than the treatment of these problems at a later stage. If this is done, the management options identified will be consistent with the accepted stormwater management.

These categories provide a framework for the identification of stormwater management options and for the formulation of more comprehensive implementation plans. The general stormwater management options identified for Onota Lake are divided into categories of on-ground works and rehabilitation activities, maintenance and research, and education and regulatory activities. Specific recommendations for each of the sub-watersheds are provided in Tables 6.1 and 6.2.

6.3.1 ON-GROUND WORKS AND REHABILITATION ACTIVITIES

- Implement mandatory reductions in stormwater runoff from new development as part of the approval process.
- Undertake bank stabilization and revegetation works in identified erosion areas
- Identify opportunities to retrofit existing pollution control devices to improve capture/treatment efficiency and to incorporate water quality treatment features.

6.3.2 MAINTENANCE, MONITORING AND RESEARCH

- Identify options and resources for programs, which monitor the efficiency of stormwater devices. For example, evaluate/monitor water quality before and after treatment and record capture volumes.
- Monitor maintenance requirements, improve maintenance efficiency of stormwater devices and establish a sustainable maintenance strategy.
- Emphasize the need for stormwater devices to be maintained and managed correctly as a means of retaining efficiency.
- Research and monitor community attitudes and behaviors to ensure that education programs are well targeted and effective.
- Provide environmental information including water quality data to the community through LOPA, the Lakes and Ponds Association of Western Massachusetts (LAPA-West), and the Massachusetts Water Watch Partnership.

6.3.3 EDUCATIONAL AND REGULATORY ACTIVITIES

- Develop and implement education programs to develop skills and knowledge in watershed and management. Programs may focus on the protection and enhancement of riparian areas and vegetated buffers, and stormwater pollution prevention.
- Develop and implement specialist education programs for municipal officials to develop skills and knowledge in environmental protection and management. Programs may focus on the importance of riparian areas and wetland ecosystems, stormwater pollution prevention, best management practices, environmental pollution legislation and erosion and sediment control.
- Provide environmental information including water quality data to the community through LOPA, the Lakes and Ponds Association of Western Massachusetts (LAPA-West), and the Massachusetts Water Watch Partnership.
- Improve the regulation of erosion and sediment controls

Table 6.1 Sub-watershed Prioritization & Problem Identification

Sub-watershed ID#	Direct Discharges	Catch Basins Draining to Direct Discharges	Land Uses	Type of Problem	Priority	Feasibility of Implementation
I	9	9	Pasture Forest Urban Open Land (Burbank Park) Residential (> ½ acre)	Multiple direct discharges at Burbank Park, a heavily used area containing two parking lots Runoff from parking lot to boat ramp	High	High feasibility due to location of infrastructure on municipally owned land[1]
II	2	0	Pasture (large horse farm) Forest Residential (> ½ acre)	Runoff into brook from bridge and potential impacts from horse farm	Med	Subject to availability of land and cost
III	1	0	Forest Residential (> ½ acre)	1 pipe, on private property, discharges into lake	Low/Med	Subject to availability of land and cost
IV	2	0	Forest Participation Recreation (golf courses)	2 pipes, on private property, discharge into lake	Med	Subject to availability of land and cost
V	0	0	Cropland Forest Residential (> ½ acre)	No identified problems	Low/Med	No identified problems
VI	1	4	Forest Residential (> ½ acre)	Pipe discharges into brook plus paved channels direct runoff into brook	Med	Subject to availability of land and cost
VII	2	0	Forest Mining Residential (> ½ acre)	Paved runoff at bridge and ATV trail eroding into brook Potential impacts of gravel pit	Low/Med	Subject to availability of land and cost
VIII	2	8	Cropland Forest Residential (> ½ acre)	When water levels are high 1 pipe discharges directly to brook	Med/High	Subject to availability of land and cost
IX	8	12	Cropland Forest Residential (< ¼ acre)	Drains densely populated, steeply sloped sub basin with multiple catch basins and pipes discharging directly into Onota Lake	Med/High	Subject to availability of land and cost
X	3	5	Participation recreation (golf courses) Forest Residential (< ¼ acre)	3 pipes drain multiple catch basins along Pecks Road and spring runoff from vicinity of Knesset Israel Cemetery	Med/High	Subject to availability of land and cost

[1] The City of Pittsfield has been awarded $26,963 in Fiscal Year 2005 by the Berkshire Environmental fund to begin improvements within this sub-watershed.

Table 6.2 Management Options & Action Strategy

Sub-watershed	Type of Problem	Type of Solution (BMP)	Priority	Actions
I	Direct discharges at Burbank Park, a heavily used area with two parking lots Runoff from parking lot to boat ramp	• Install a trench grate drainage structure and a deep sump catch basin with an oil hood at the public boat ramp at Burbank Park. • Replace six existing catch basins at Burbank Park with deep sump catch basins with oil hoods. • Retrofit two existing sedimentation basins with oil hoods and improved drainage. • Repair the outlet structures and headwalls for two of the stormwater discharge pipes. • Install two new deep sump catch basins with oil hoods at the southern end of Lakeway Drive with a drainage manhole on Lakeway Drive and a drainage manhole in the vegetated area northwest of Lakeway Drive. • Install a Stormceptor© device, or other proprietary stormwater treatment system to work with the catch basins and trench grate at the south parking lot. • Install a third deep sump catch basin with an oil hood, pipe and outlet structure on the northern end of Lakeway Drive between the north and south parking lots.	High	Determine funding source for design, permitting and construction of recommended BMPs. These efforts recommendations could be implemented through a City of Pittsfield budget appropriation or through grant funding.
II	Runoff into brook from bridge and potential impacts from horse farm	• Monitor the water quality of the brook • Provide educational materials to owners/operators of horse farm	Med	Determine if improvements to the bridge are feasible through the City of Pittsfield Public Works Department Work with the owners of the horse farm and the Natural Resource Conservation Service for potential grant funding to assist agricultural operations in reducing nonpoint source pollution Permission may need to be sought for further implementation
III	1 pipe discharges into lake it is unclear what the purpose is of this pipe	• Contact residents of area for further information • NPS Education for property owners	Low/Med	Private property Permission may need to be sought for further implementation
IV	2 pipes discharge into lake it is unclear what the purpose is of these pipes	• Contact landowner for more information • NPS Education for property owners	Med	Private property Permission may need to be sought for further implementation
V	No identified problems	• NPS Education for property owners	Low/Med	Distribute NPS educational materials for property owners
VI	Pipe discharges into brook plus 3 paved channels direct runoff into brook	• Create roadside drainage ditches and vegetated swales to capture and infiltrate runoff • Create an infiltration trench to capture and infiltrate runoff	Med	Determine amount of land available for alternative treatments

Table 6.2 Management Options & Action Strategy

Sub-watershed	Type of Problem	Type of Solution (BMP)	Priority	Actions
		• Install new subsurface stormwater treatment systems		Work with City of Pittsfield Department of Public Works
VII	Paved runoff at bridge and ATV trail eroding into brook	• Create roadside drainage ditches and vegetated swales to capture and infiltrate runoff • Create an infiltration trench to capture and infiltrate runoff • Block trail stabilize banks and create vegetated buffer • Provide educational materials to ATV users • Work with ATV groups to stabilize and maintain trail or relocate trail to preferable location	Low/Med	Determine amount of land available for alternative treatments Work with City of Pittsfield Department of Public Works Distribute educational materials Work with ATV groups
VIII	3 pipes drain 6 catch basins more information is needed to determine connections	• Conduct water quality monitoring of discharge from pipes	Med/High	Pipes can be monitored without accessing private property. Work with City of Pittsfield Department of Public Works for potential retrofit of existing catch basins
IX	Drain densely populated, steeply sloped sub basin	• Retrofit existing catch basins to provide pre-treatment	Med/High	Work with City of Pittsfield Department of Public Works
X	Need to confirm connections	• Conduct water quality monitoring of discharge from pipes	Med/High	Pipes can be monitored without accessing private property. Work with City of Pittsfield Department of Public Works for potential retrofit of existing catch basins

7.0 DISCUSSION AND RECOMMENDATIONS FOR SPECIFIC BMPS

7.1 SUB-WATERSHED 1

As illustrated in Tables 4.7 and 4.8, sub-watershed I is actually the sub-watershed that should be targeted first for stormwater management. That sub-watershed parallels the lake's eastern shoreline and includes the boat launch area and Burbank Park. It is by area the fourth largest of the lake's sub-watersheds, encompassing 385 acres (Table 4.3). Interestingly, the Diagnostic Feasibility study did not consider this an important sub-watershed upon which to focus management funds or restoration attention. The results of this study suggest otherwise. The modeled data shows that it is responsible for 10.7%, 13.6% and 17.3% respectively of the lake's TN, TP and TSS loads.

Stormwater is discharged to the lake from this sub-watershed by both overland flow and specific pipes and catch basins. The stormwater infrastructure inventory identified a total of 27 catch basins and pipes flowing into the lake from this watershed. None of these structures appeared to have any degree of water quality management.

Proper management of runoff from the catch basins along Lakeway Drive may require the installation of chambered basins or pre-manufactured treatment devices (See Appendix A) at nodes where multiple catch basins converge and are directed to a discharge pipe. Princeton Hydro installed a SunTree Nutrient Box at Harvey's Lake in Pennsylvania. That structure, which managed the inflow from a 30 acre sub-watershed, characterized by relatively steep slope, removed eight tons of sediment and debris within the first six months of its operation. On a smaller scale, the stormwater discharged from these catch basins could also be managed through the installation of catch basin insets (Appendix A). Much cheaper and easier to install that the larger baffle boxes and pre-manufactured treatment devices, the utility of these BMPs will be largely limited by their need for frequent inspection, maintenance and cleanout. Foresight Lnad Services, Inc. prepared conceptual designs for specific areas of Burbank Park on behalf of BRPC and the City of Pittsfield through the *Eurasian Watermilfoil Re-growth Control Project at Onota Lake* funded by a Massachusetts Department of Conservation and Recreation Lake and Pond Grant. Funding has been awarded to the City of Pittsfield through the Berkshire Environmental Fund to begin to implement the first phase of the recommendations provided by Foresight Land Services.

7.2 SUB-WATERSHED VI

Again referring to Tables 4.3, 4.7 and 4.8, although the total load contributed to the lake from sub-watershed VI is significant, and overall the greatest, the data do not support the need to prioritize this sub-watershed for management. Draining the land tributary to Parker and Lulu Brook, this is the lake's largest sub-watershed by area. However, because the watershed is largely forested, there its base load represents a large percentage of its total load.

The Diagnostic / Feasibility Study report recommend that stormwater quality management be accomplished within these watersheds in part through the construction of low gabion weirs in each stream. Although sound in concept, with the adoption of the Rivers Protection Act and recent amendments to the Wetland Protection Act it would be difficult, if not impossible, to obtain the required environmental permits for the construction of such "on-line" sedimentation traps. Recognizing the change in the regulatory environment in 2004 relative to 1988, an approach similar in concept but different in application to the gabion weir solution would be needed. It was also recognized that with the passage of time, there would be the need to revisit the pollutant loading calculations of the Diagnostic / Feasibility Study, and update these data to better reflect existing conditions and improvements in diagnostic and modeling tools.

During Princeton Hydro's inspection of the drainage area along this section of Churchill Street, it was noted that there were few catch basins or inlet pipes. The stormwater infrastructure inventory reported the occurrence of only a single outfall. Inspection of this outfall and the connected catch basins showed that a significant amount of debris, sediment and leaf litter collect on the catch basin grates. This debris clogs the basins and may create flooding problems. However, because these structures manage only a small portion of the sub-watershed's total acreage, it is should not be prioritized for retrofit. However, it should be better maintained.

During volunteer water quality monitoring conducted by LOPA, elevated phosphorus and sediment concentrations have been measured in those streams. (LOPA Annual Report, 2003) These elevated concentrations may actually be a function of the stables located within this sub-watershed as opposed to runoff from impervious areas.

7.3 SUB-WATERSHED VII

Sub-watershed VII is associated with Churchill Brook. It is not only one of the largest watersheds by area, but contributes a significant amount of the lakes NPS load (Table 4.3). Analysis of the load (Tables 4.6 and 4.7) show that due to the slope, land cover and extent of development (although admittedly relatively small), this sub-watershed, along with sub-watersheds I and VII should be prioritized for stormwater management.

The Diagnostic / Feasibility Study report recommend that stormwater quality management be accomplished within these watersheds in part through the construction of low gabion weirs in each stream. Although sound in concept, with the adoption of the Rivers Protection Act and recent amendments to the Wetland Protection Act it would be difficult, if not impossible, to obtain the required environmental permits for the construction of such "on-line" sedimentation traps. Recognizing the change in the regulatory environment in 2004 relative to 1988, an approach similar in concept but different in application to the gabion weir solution would be needed. It was also recognized that with the passage of time, there would be the need to revisit the pollutant loading calculations of the Diagnostic / Feasibility Study, and update these data to better reflect existing conditions and improvements in diagnostic and modeling tools.

Examination of the stormwater collection system along the section of Churchill Drive that transects this sub-watershed showed evidence of flooding, scour and sediment deposition. This was most apparent at the intersection of Churchill Drive and Hancock Road. An attempt had in fact been made by the DPW to correct an erosion problem by excavating a large pit on the south side of the intersection. This excavation, as well as being in violation of wetland rules, was not having any apparent benefit from the perspective of water quality enhancement. Pollutant loading to the stream at this location is exacerbated by the steep hill to the north of the intersection. Evidence of heavy sanding of this roadway was observed. This sand and grit runs into the stream and eventually in to the lake, transporting with it a variety of contaminants.

A preliminary routing assessment of this area suggests that a relatively large pre-manufactured treatment device will be needed to manage the runoff generated by this intersection and adjacent lands. This could be a unit such as the 9400 Vortechnic or the larger version of the SunTree Nutrient Removing baffle box. It may be possible to install such a structure within the road right-of-way, specifically along the eastern shoulder of Churchill Drive, immediately north of the Hancock Road intersection. Doing so would likely alleviate or at least minimize any wetland disturbance, thereby reducing permit related issues.

Care will need to be taken with respect to the design of any such structure. Although some of these structures come equipped with flow by-pass devices, it will likely be necessary to construct or install a high-flow bypass. This can be a simple flow splitter installed in a manhole that directs low flows into the treatment unit, but bypasses larger flows (for example those associated with storms larger than the 2-year event) around the treatment device. Bypassing the larger storm

flows will decrease the likelihood for the resuspension and release of previously trapped contaminants and sediment.
As with any BMP, maintenance will be key to its success and longevity. It is recommend that any such device be inspected after any storm that generates more than 0.5 inches of runoff, and cleaned out at least four times per year, especially after the spring thaw as well as in the fall after leaf fall is completed.

It should be noted that at this same location consideration was given to creating a wetland type basin. However, the preliminary routing analysis suggested the size of the basin would be greater than what appears to be the amount of available land within the road right-of-way.

The stormwater infrastructure inventory refers to runoff entering the brook at the bridge over Churchill Brook. Apparently, runoff from a nearby ATV trail can result in the transport and loading to the brook of significant amounts of sediment. This has been so bad at times to create an alluvial fan of sediment in this portion of the brook. Princeton Hydro did not inspect the ATV trails. If this is a confirmed source of sediment loading to the brook and the lake, it must be corrected. This may be possible through some simple berming or the implementation of soil and sediment control practices similar to those sued at construction sites.

7.4 SUB-WATERSHED VIII

The data in Tables 4.3 and 4.7 show as was the case for sub-watershed VII, that sub-watershed VIII is worthy of prioritization for stormwater management. This is the Daniels Brook sub-watershed, the lake's second largest watershed. As shown in Table 4.8, although its TN rank is low (10), its TP and TSS ranks are high (3 for both). It also has relatively large exceedences for TP and TSS as so illustrated by the data contained in Table 4.7.

The Diagnostic / Feasibility Study report recommend that stormwater quality management be accomplished within these watersheds in part through the construction of low gabion weirs in each stream. Although sound in concept, with the adoption of the Rivers Protection Act and recent amendments to the Wetland Protection Act it would be difficult, if not impossible, to obtain the required environmental permits for the construction of such "on-line" sedimentation traps. Recognizing the change in the regulatory environment in 2004 relative to 1988, an approach similar in concept but different in application to the gabion weir solution would be needed. It was also recognized that with the passage of time, there would be the need to revisit the pollutant loading calculations of the Diagnostic / Feasibility Study, and update these data to better reflect existing conditions and improvements in diagnostic and modeling tools.

The stormwater infrastructure inventory notes that along Daniels Brook there are 3 pipes (20P, 21AP & 22AP) that drain 12 catch basins (31SD-42SD) within this sub-watershed. When water levels are high, one pipe (21AP) discharges directly into Daniels Brook. The inventory also makes note of drainage to the brook that occurs at the Hancock Road bridge over Daniels Brook that appears to allow runoff from the road to flow directly into the brook. During Princeton Hydro's inspection of the sub-watershed, it was noted that there are two paved swales designed to collect runoff from the road and the bridge decking, and convey that runoff into the brook with no mitigation or treatment. This is an unacceptable condition. However, there is limited space and opportunity for treatment either along the road or on the bridge. The right-of-way is especially narrow and there is no roadside swale or other structure that could be modified to collect and treat runoff. Correction of this problem will likely require the installation of a below grade pre-manufactured treatment device. Installation of such a structure will require the excavation of the road and its placement within the road itself. This can be done, however it will be costly.

8.0 CONCLUSIONS

The data show that sub-watershed II, VII and VIII should be the focus of any future stormwater management efforts conducted by the BRPC or LOPA. The types of BMPs most suitable for use in these areas are the retrofit type of BMPs exemplified by the pre-manufactured treatment devices. In some cases, for example along Lakeview Drive, it will likely be possible to decrease NPS loading through the implementation of some simple catch basin retrofits or the installation of relatively low cost chambered basins (< $2,000). However, given the scope of the problem and the magnitude of both the volume and rate of runoff (Churchill Drive/Hancock Road), the retrofit and correction will be more expensive, likely in excess of $100,000. This is the same for Daniels Brook at the Hancock Road overpass, where site constraints will make it difficult to easily install any BMP.

For the remainder of the watershed, emphasis needs to be placed on NPS load reduction at the local level. This can be accomplished through educational initiatives. This is especially true for the Blythewood Drive and Thomas Island sections of the watershed. For example, some stormwater management attention should be given to sub-watershed II. Although not as significant a contributor as I, VII or VIII, it is on a unit area a large contributor of NPS pollution to the lake. Unfortunately, there are few opportunities to manage road runoff or runoff from impervious areas in common land or right-of-ways. In addition, al large amount of the watershed drains to the lake independent of the road. Both of these areas are location where the non-structural measures discussed in Section 2 of the report would be applicable.

Overall, the data shows that a large percentage of the lake's NPS load is in fact base load. This conclusion is arrived at by comparing the loads in Table 4.3 to those in Table 4.6 and the data in Table 4.7. Although this means that existing pollutant loads are mostly "natural" in their origin, development of the watershed, even to a moderate level, could significantly jeopardize the quality of the lake, especially if conducted without proper and adequate stormwater quality management.

9.0 REFERENCES CITED

Claytor, R.A. and T.R. Schueler. 1996. Design of Stormwater Filtering Systems. The Center for Watershed Protection. Silver Spring, Maryland.

Harper, H.H. 1994. Stormwater Loading Rate Parameters for Central and South Florida. Environmental Research & Design, Inc. Orlando, Florida.

IT Corporation. 1991. Diagnostic /Feasibility Study for Onota Lake, Pittsfield, MA, Principal Investigator, Dr. Stephen J. Souza.

New Jersey Department of Environmental Protection. 2004. Stormwater and Non-Point Source Pollution Control. Best Management Practices Manual.

New York State Department of Environmental Conservation. 1993. Reducing the Impacts of Stormwater Runoff from New Development. Syracuse, New York.

Reckhow, K. H., M. N. Beaulac, and J. T. Simpson. 1980. Modeling phosphorus loading and lake response under uncertainty: A manual and compilation of export coefficients. Report No. EPA-440/5-80-011. U. S. EPA, Washington, D.C.

Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Metropolitan Information Center. Washington, D.C.

Schueler, T.R. 1995. Pollutant Removal Pathways in Florida Swales. Watershed Protection Techniques. 2(1): 299-301.

Schueler, T.R. 1996. A Workshop on Innovative Watershed Restoration and Protection Techniques. Garrett-Jacobs Mansion. Baltimore, Maryland. June 5-6, 1996.

Souza, S.J., R.L. Conner, and B. Krinsky. 1991. Development of a management plan for Onota Lake, a dual ecosystem waterbody. The Eleventh Annual International Symposium, North American Lake Management Society. Denver, Colorado.

Wu, J. 1989. Evaluation of detention basin performance in the Piedmont region of North Carolina. North Carolina Water Resources Research Institute. Report No. 89-248. Raleigh. North Carolina.

APPENDIX A

DESCRIPTION OF BEST MANAGEMENT PRACTICES OPTIONS

As part of Princeton Hydro's analysis of stormwater management options for the Lake Onota watershed, a list of potentially feasible best management practices (BMPs) were compiled. We have had first hand experience with the construction, installation and/or performance of the majority of the identified BMPs. The identified BMPs work particularly well in retrofit situations. Many do not require the extensive installation of new piping, but rather can be used with the existing stormwater collection system. Many of these devices also are relatively small and thus fit into the available right-of-way. Finally, the majority of these structures and devices are easy to maintain.

The general approach recommended in the above report calls for addressing stormwater problems at the individual catch basin level. Attempting to address stormwater problems on a regional scale, for instance through the installation or construction of a BMP at the terminal point where stormwater is discharged into a stream or the lake itself is usually not practical because of the required size of the structure. Rather than attempting to manage runoff at "the end of the pipe", by dealing with smaller catchments it becomes more feasible and less costly to correct existing stormwater loading problems. Furthermore, this approach often leads to more effective control and greater pollutant removal. The negative aspect with this approach is that because the retrofit structures tend to be relatively small, frequent inspections, cleanout and maintenance are required in order to ensure that the installed structures function effectively.

The following provides an overview of the types of BMP solutions that are most appropriate for the Lake Onota watershed. It should be noted that this is not an exhaustive list of BMPs. It is also apparent that the list does not include some of the more frequently sued BMPs such as detention basin and wet ponds. However, it was concluded following our inspection of the watershed and specific problem areas that such BMPs, because of their size requirements, would likely not be practical.

Catch Basin Inserts

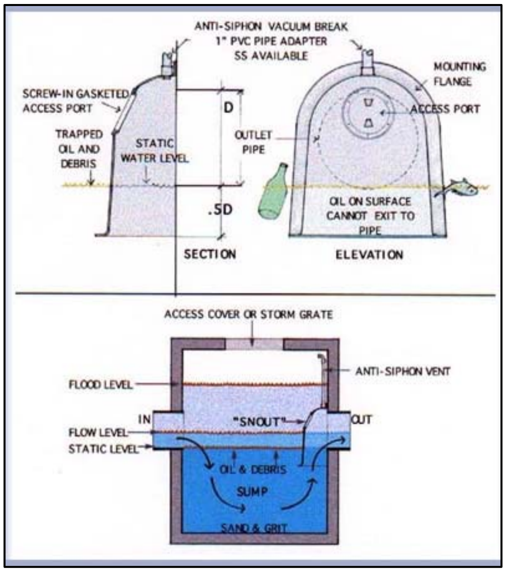
The role of a standard catch basin is to collect and transport stormwater as quickly as possible to the lake or its tributaries to avoid localized flooding. As a result, standard catch basins have little, if any, positive impact on water quality. In contrast, catch basins retrofitted with water quality inserts can convey stormwater yet provide some degree of pollutant reduction. Water quality insert modified catch basins can be used as stand alone BMPs or linked with other BMPs as a pre-treatment device. Typically, they are most effective when used as part of a linked BMP system.

Catch basin inserts are installed into existing catch basins, eliminating the cost of physically removing the existing basins and the cost of new construction. In some cases, even the existing grates can be reused. There are a number of catch basin insert designs, but in effect, they all function similarly. These units are intended to filter out sediment, leaves, debris and particulate material as stormwater flows into the catch basin. Some of these units have oil absorbent collars or pads that aid in the removal of petroleum hydrocarbons and one manufacturer even has a ferric (iron) filter designed to adsorb and remove dissolved phosphorus.

Although relatively inexpensive ($500 - $1,500 per installation), these devices require frequent inspection, service and/or replacement. If there is no maintenance commitment, these units will likely clog and fail within six-months of installation. None-the-less, these units have their place in the Lake Onota watershed. Some of the devices being considered for Lake Onota include:

1. The SNOUT
2. Fossil Filter
3. Aqua Guard
4. Envirodrains

The diagrams and photographs of some of these catch basin inserts are presented below. Such inserts could be installed along the road network of Thomas Island Cove.



Figures 1 and 2 - Installation schematic and photo of SNOUT basin insert device

Figures 3 and 4 - SNOUT during and after installation in an existing catch basin

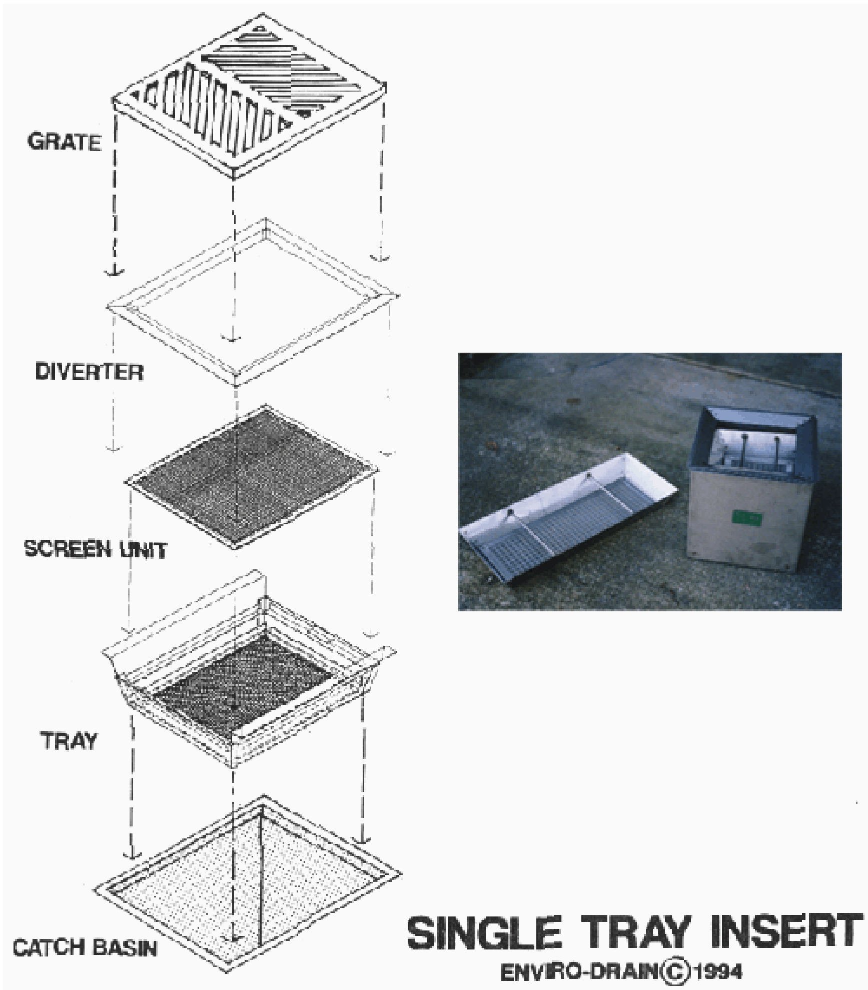
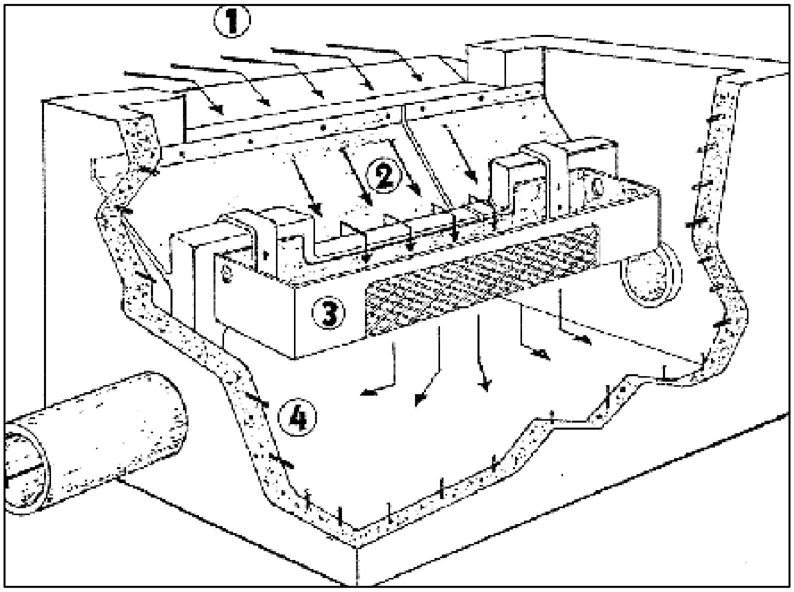
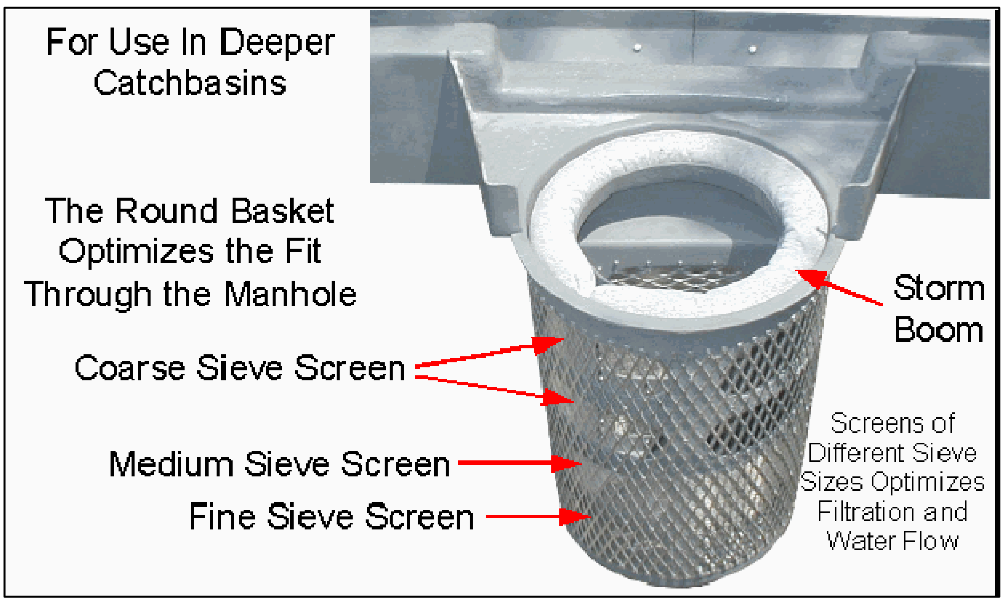


Figure 5 - Typical Enviro-Drain catch basin insert
Screen and baskets function to filter and trap particulate material. Although this is a drop inlet design, there are designs that work with cut curb inlets



Figures 6 and 7 - Catch basin inserts manufactured by Suntree Technologies for shallow and deep cut-curb installations. The storm boom shown in Figure 7 is intended to adsorb petroleum hydrocarbons.



Sumped and/or Hooded Water Quality Inlets

Essentially, it is possible to improve the water quality treatment capabilities of standard catch basins by constructing them with a hooded outlet invert pipe, sumped bottom (>2 ft), or interior baffles. Each of these modifications helps to trap sediments, leaf litter and urban debris by slowing storm surges and reducing the velocity of the intercepted runoff. Slowing stormwater flow allows for the settling of coarse and medium-sized sediment particles. We have made extensive use of this type of BMP in other lake communities. The retrofit process involves the removal of the exiting catch basin and its replacement with the modified design basin. In most cases, the existing inlet and outlet pipes can be reused. These BMPs could feasibly be used anywhere in the watershed. The following are examples of sumped and hooded water quality inlets or retrofit applications that can be used to improve pollutant removal effectiveness.

1. Baffled basins
2. Sumped Basins
3. Porous bottom sumped basins

Although sumped basins are effective in trapping sediments, they present a problem in the retained stormwater must be allowed to exfiltrate from the basin into the sub-soil. If not, the basin sump will retain water between storm events. This retained water may generate odors and could possibly provide mosquito-breeding habitat. To counter this, most sumped basins are constructed with an open bottom or perforations in the bottom of the basin to allow the captured water to infiltrate into a crushed stone sub-base or the underlying soils. Although this alleviates the problems with water retention, it may create an equally significant problem with respect to the transmission of petroleum hydrocarbons and dissolved contaminants into the groundwater. As such, care must be taken with the installation of such basins, especially in applications where there exists the opportunity for fuel spills and/or substantial runoff from roads and parking lots, or where the seasonal groundwater table is elevated..

The baffled basins provide a very good means of managing particulate pollutants without the inherent problems of the sumped basins. The baffled basins may consist of two or more chambers, separated by a weir. Each weir has weep holes at the base of the weir to enable captured water to slowly drain from the basin, out the discharge pipe, between storm events. A cross-section of a typical baffled basin that we installed around Lake Mohawk, Greenwood Lake, Cranberry Lake and Lake Hopatcong is supplied on the following page. Access to the baffled basin, for inspection and cleanout, may be via a grate or manhole cover. The typical installed cost of these basins is in the range of $3,000-$9,000 per basin, although some of the larger units installed in the Lake Mohawk watershed cost in the range of $75,000 (refer to Figure 9). We envision the use of the baffled basins within the Lake Onota watershed both as independent installations or in series, in advance of one of the manufactured treatment devices discussed below.

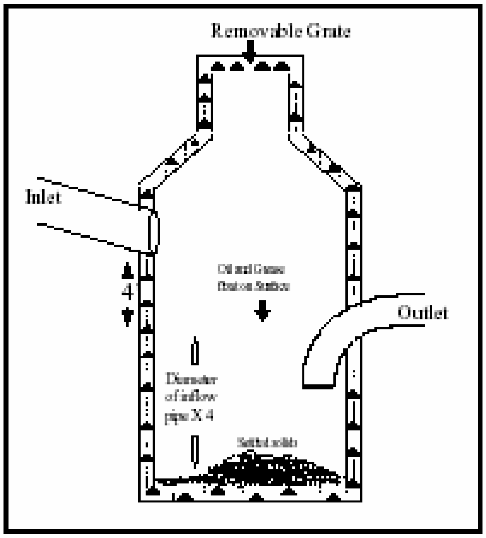
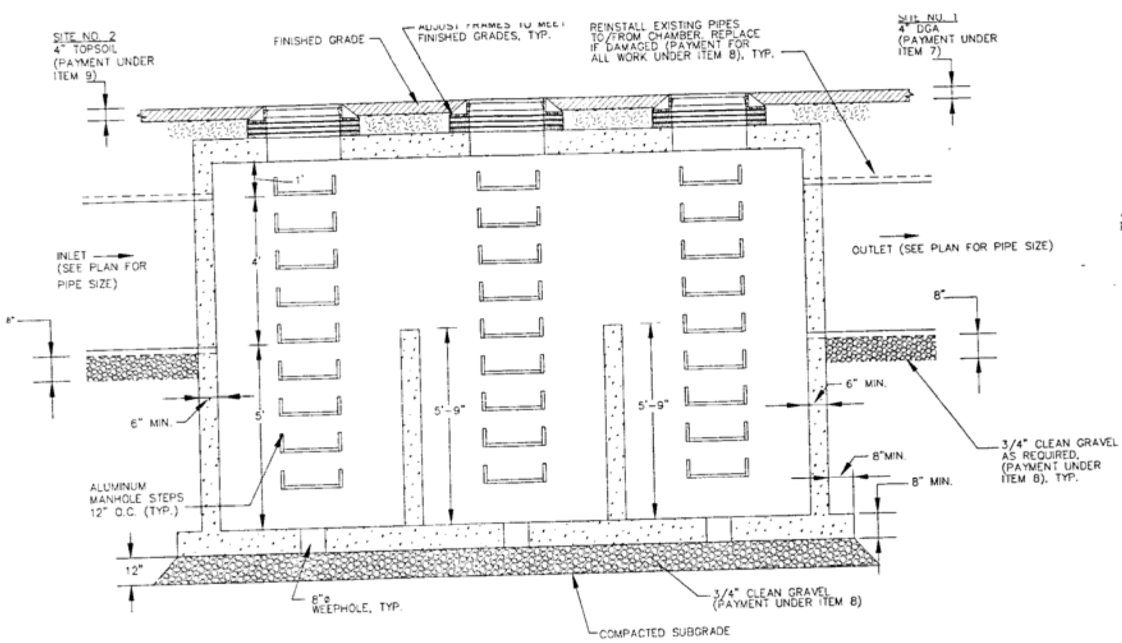


Figure 7 - General schematic of a deep-sump water quality inlet (as from MADEP, Stormwater Management, Volume 2, Stormwater Technical Manual, 1997)



NOTE:

1. BACKFILL WITH EXCAVATED MATERIAL OR SELECT FILL AS DIRECTED BY THE ENGINEER. ALL MATERIAL TO BE COMPACTED IN 12" LIFTS TO AT LEAST 98% OF MAXIMUM DENSITY. PAYMENT FOR SELECT FILL UNDER ITEM 5.

2. SHOP DRAWINGS, SEALED BY A PROFESSIONAL ENGINEER, SHALL BE PROVIDED FOR EACH TANK. EACH TANK SHALL CONFORM TO HS20 LOADING REQUIREMENTS AND BE DESIGN BASED ON FULL GROUNDWATER SUBMERGENCE WITHOUT PROPOSED WEEPHOLES.

Figure 8 - Typical cross-section of a multi-chambered, baffled sedimentation basin as installed in the Lake Mohawk watershed.

Figure 9 - An approximately 80' long, 8' deep, multi-baffled sedimentation chamber located in the Meadow Brook sub-watershed of Lake Mohawk

Figure 10 - An approximately 10' long, 3' deep, double-baffled sedimentation chamber located in the Sleepy Lagoon watershed of Lake Mohawk

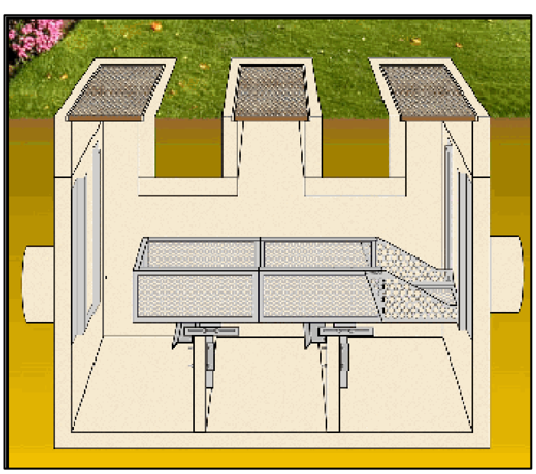
Manufactured Treatment Devices

Manufactured treatment devices are considered particularly effective for the management and treatment of runoff from highly impervious areas. There are numerous types of manufactured stormwater treatment devices, each with their own unique application, limitations and maintenance needs. The MADEP recognizes the role and the ability of many of these structures to effectively treat NPS loading and encourages their use as part of an integrated stormwater management and non-point source (NPS) pollution control strategy. There are a number of these units being routinely utilized, throughout New England and the Mid-Atlantic States.

It is recognized that the pollutant removal capabilities of these structures are limited largely to the removal of total suspended solids and floatables, and to some extent, particulate pollutants, including particulate phosphorus and the heavy metals and petroleum hydrocarbons that adhere to sediments. MTDs are commonly used to pre-treat runoff prior to its discharge to a wet pond, created wetland, infiltration basin or extended detention basin. The USDOT Federal Highway Administration, report bench scale testing for such units achieved sand and grit removal rates in excess of 90%. Examples of the types of manufactured treatment devices being considered for Lake Onota include:

1. Suntree Technologies Baffle Boxes
2. Vortechnic
3. Stormceptor
4. Stormfilter

MTDs can work well independently or in concert with baffled basins, water quality inlets, vegetated bioretention swales (see below) or as a pre-treatment measure for detention, retention and infiltration basins. As noted above, MTDs can be very effective. The Suntree Technologies unit installed at Harvey Lake, Pennsylvania, and subsequently monitored by Princeton Hydro, removed over eight-tons of sediments in the first six months of its installation. The negative aspects of MTDs are their size, cost and maintenance needs. Because these units are typically on the order of 20-30 feet in length and 6-10 feet in depth, a sizable excavation is needed for their installation. Issues may arise in creating the excavation relative to depth to bedrock, depth to seasonal groundwater and exceedence of the available right-of-way. The typical cost of MTDs varies with manufacturer and size, but range from $30,000 to $100,000 per unit installed. Most MTDs, because of their performance and efficiency require bi-annual cleanout. The Stormfilter units, the ones with pollutant removal media cartridges, require cartridge replacement on the order of once every 2-3 years. As the cartridges are a proprietary device, the maintenance costs associated with these units may be much greater than those that can be services with a simple clam-shell or vac-all device. MTDs are especially well suited for the Lake Onota watershed, especially if used in conjunction with the previously discussed baffled basins.



Figures 11, 12 and 13 – Suntree Technologies Baffle Basin with Nutrient Removal Basket. Lower photo is of Princeton Hydro supervised installation at Harveys Lake for which pre- and post-installation water quality monitoring data available.

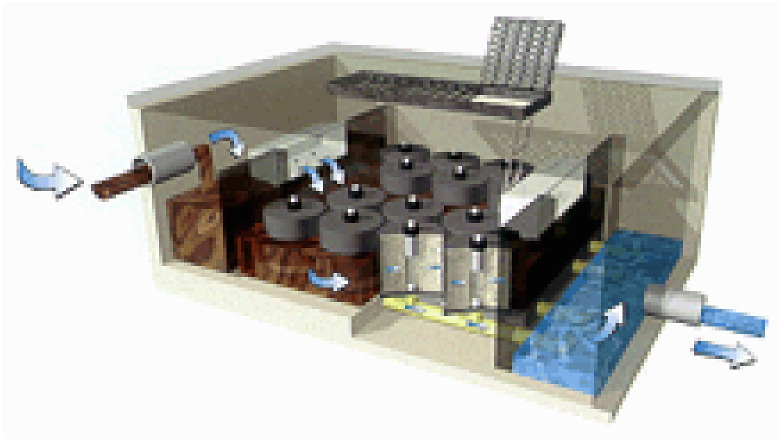


Figure 14 - Stormfilter MTD. Stormwater is treated by a series of filter cartridges. The cartridges can be supplied with different types of filter media to address and treat different types of pollutants. The cartridges need to be replaced typically once every 2-3 years.

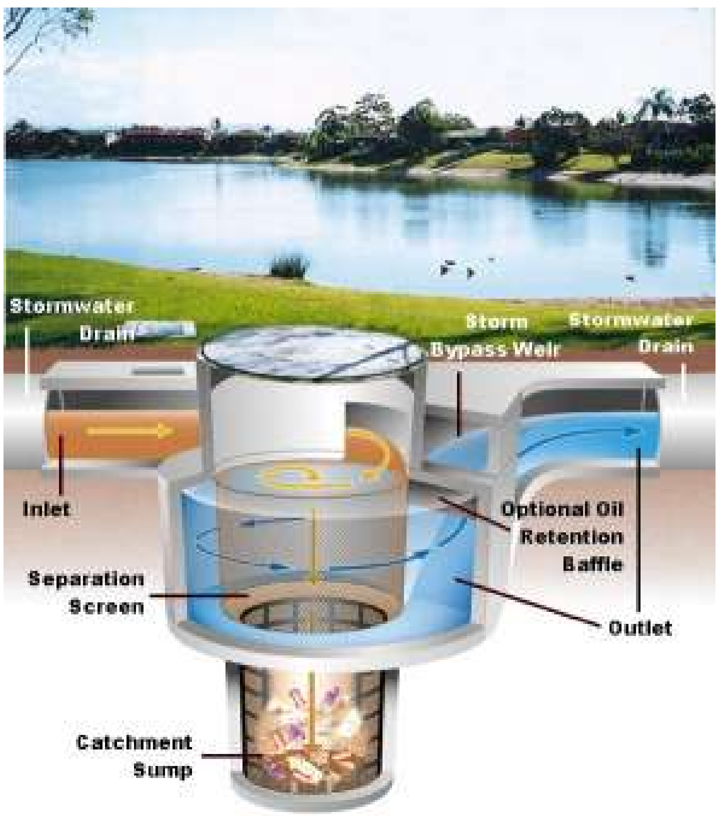
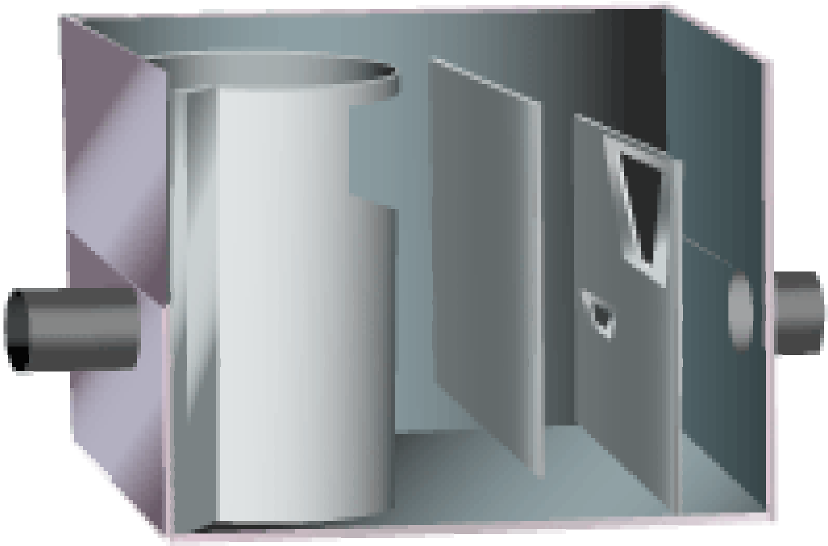


Figure 15 - CDS MTD. These can be installed on or off-line. Uses a helical swirl device to separate particulate contaminants from stormwater. Design by passes flow from larger storms thereby decreasing the chances for the resuspension and discharge of previously trapped material. Maintenance required 1-2 times per year.



Bioretention Swales and Basins

A swale is a natural depression or wide, man-made shallow ditch used to temporarily store, route or filter runoff. Swales are primarily used to intercept, route and control stormwater discharge. Because of the semi-rural nature of much of the Lake Onota watershed, roadside swales have been extensively used to convey stormwater from roads to the lake or the lake's tributaries. For the most part, swales designed or constructed as stormwater conveyance features have a limited capacity to treat stormwater runoff. In fact, in many situations, they can add to the problem because they are undersized, too steeply graded, eroded and improperly vegetated or maintained.

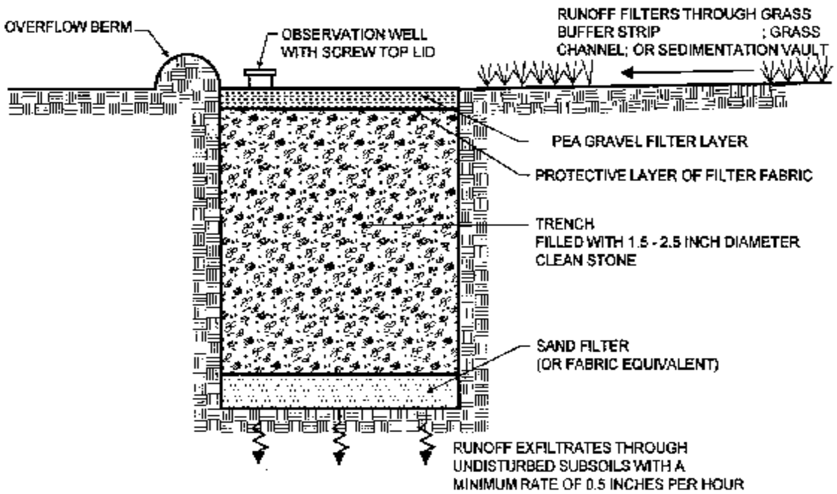
However, when properly designed and used in combination with other structural stormwater measures, swales can substantially improve the quality of stormwater. This is accomplished in two ways. First, when properly designed, the vegetation present in the swale will reduce runoff velocity. The extent to which this occurs is dependent on the length, depth and gradient of the swale, as well as the density of the vegetation. Second, a portion of the runoff discharged to a swale, will infiltrate into the soil, thus reducing the magnitude of the surface runoff. The extent to which this occurs is dependent on soil moisture conditions, the gradient of the swale, and the velocity of the runoff.

The existing stormwater conveyance systems in the Lake Onota watershed make extensive use of roadside swales to collect and transport runoff from paved areas to streams or the lake itself. During our inspection of the watershed, it was observed that most of these swales are eroded and inadequately maintained. In addition, because of the steepness grade in given areas of the watershed (e.g., along portions of Churchill Street, Peck Road and Daniels Road), the existing swales have limited capability in the management of runoff, either from the perspective of infiltration or pollutant removal.

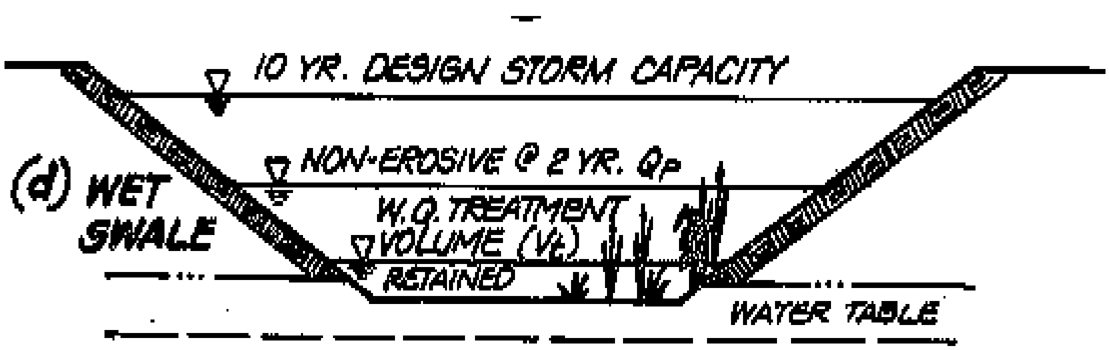
It appears possible to upgrade or retrofit existing swales along portions of Blythewood Drive, Churchill Street, Daniels Road and Hancock Road with some form of stone filled or vegetated swale, such as those illustrated on the following page. However, swales constructed with a bottom grade of greater than 5% slope should be avoided as they will have limited pollutant removal capability and will likely be erosion prone. Massachusetts, New Jersey and New York DEP guidance for the construction of water quality treatment capable swales share the following specifications:

- Swales should be designed using Manning's formula
- Swale bottom should be graded as close to zero as drainage will permit.
- Side slopes should be no greater than 3:1 (h:v).
- A water tolerant, erosion resistant grass should be established as a dense cover on the bottom of the swale. Swale grasses should not be mowed close to the ground since this impedes the filtering and hydraulic functions of the swale. In addition, if the swale is adjacent to a roadway, grass species that are relatively tolerant to road salts should be used.
- Maximum ponding time for captured runoff should not exceed 96 hours and preferable drain within 24 hours.
- Underlying soils should have a percolation rate of > 0.5 inches/hour. The soil should be tilled before the grass cover is established to maximize infiltration capacity.

The costs of bioretention and infiltration swales are highly variable.



Figures 18 and 19 – Cross-sections of an infiltration type swale (18 above) and typical vegetated swale (19 below).



Terminal Pipe and Headwall Solutions

Although MADEP and others recommend that drainage and stormwater problems be dealt with as close to the point of the generation of runoff as possible, there will always be situations where an “end-of-pipe” solution is inescapable. This happens quite frequently in lake communities where development has encroached close to the water’s edge and there is little opportunity to treat runoff before its discharge into the lake. We observed a number of such instances in Lake Onota and its tributaries.

There are measures that can be used to address such pollutant sources through the modification of the headwall or pipe that discharge into the lake. This is best exemplified by the treatment device manufactured by Fresh Creek (Figure 20).

Essentially a concrete wing wall extension of an existing headwall, the unit is equipped with easily accessible “baskets” that trap course sediment, litter, leaves and urban debris. The units require servicing at least twice per year, and perhaps after every major storm event. Although such structures have limited ability to remove nutrients and dissolved contaminants, they can be fairly effective in removing road grit, sand and leaf litter. As with the MTDs, the cost of these units is again highly variable, but typically begins in the range of $20,000 per unit installed.

At this point in time, as noted above, we are completing pollutant loading analyses and our feasibility evaluations of the various BMPs. However, based on our inspection of the watershed we suggest that consideration be given at this time to prioritizing improvements of the stormwater collection system along Churchill Street, specifically near the Hancock Road intersection. We observed eroded swales on both sides of the road, evidence of sediment and litter deposition and erosion of the receiving stream (Churchill Brook) in this area. Although we are still in the process of working out the details, we suggest that the swales be repaired and equipped and set locations with baffled catch basins. At the northeast side of the intersection, in what appear to be public right-of-way, a Suntree Technologies baffle box should be sized and installed. This installation is similar in context to that servicing a 28-acre sub-watershed at Harvey Lake. The cost of that installation, including materials and labor was in the vicinity of $180,000. If it appears that the Pomeroy Pond “flow short-circuiting” project is not likely to obtain the required MADEP permits, consideration should be given to re-appropriating those funds for this project. It does not appear that the Churchill Street drainage improvement require MADEP permits as they appear to be limited to non-wetland areas.

As mentioned at the beginning of this letter report, we are in the final stages of completing Task 1 of the Lake Onota Stormwater and Management Options Study. Additional details and recommendations will be provided in that report concerning other locations in the watershed where stormwater management upgrades appear to have a suitable cost-benefit ratio.