1.0 INTRODUCTION

In its entirety, the hydrologic cycle consists of water moving from ocean to atmosphere, precipitation on land, and runoff on land and rivers back to the ocean. Locally, the hydrologic cycle consists of precipitation and water leaving an area via evaporation, transpiration, infiltration, and runoff. As land cover changes with development, the movement of water into, out of, and across the land changes. Stormwater runoff increases as land is converted from natural conditions to a built condition (Figure 1). Increased impervious surfaces and increased channelization of flow paths increase the volume and flow rate of stormwater runoff. Alteration of watershed hydrology can lead to increased flooding, destabilization of river channel and more bank and bed erosion, reduction of water quality, and impacts to instream habitat.

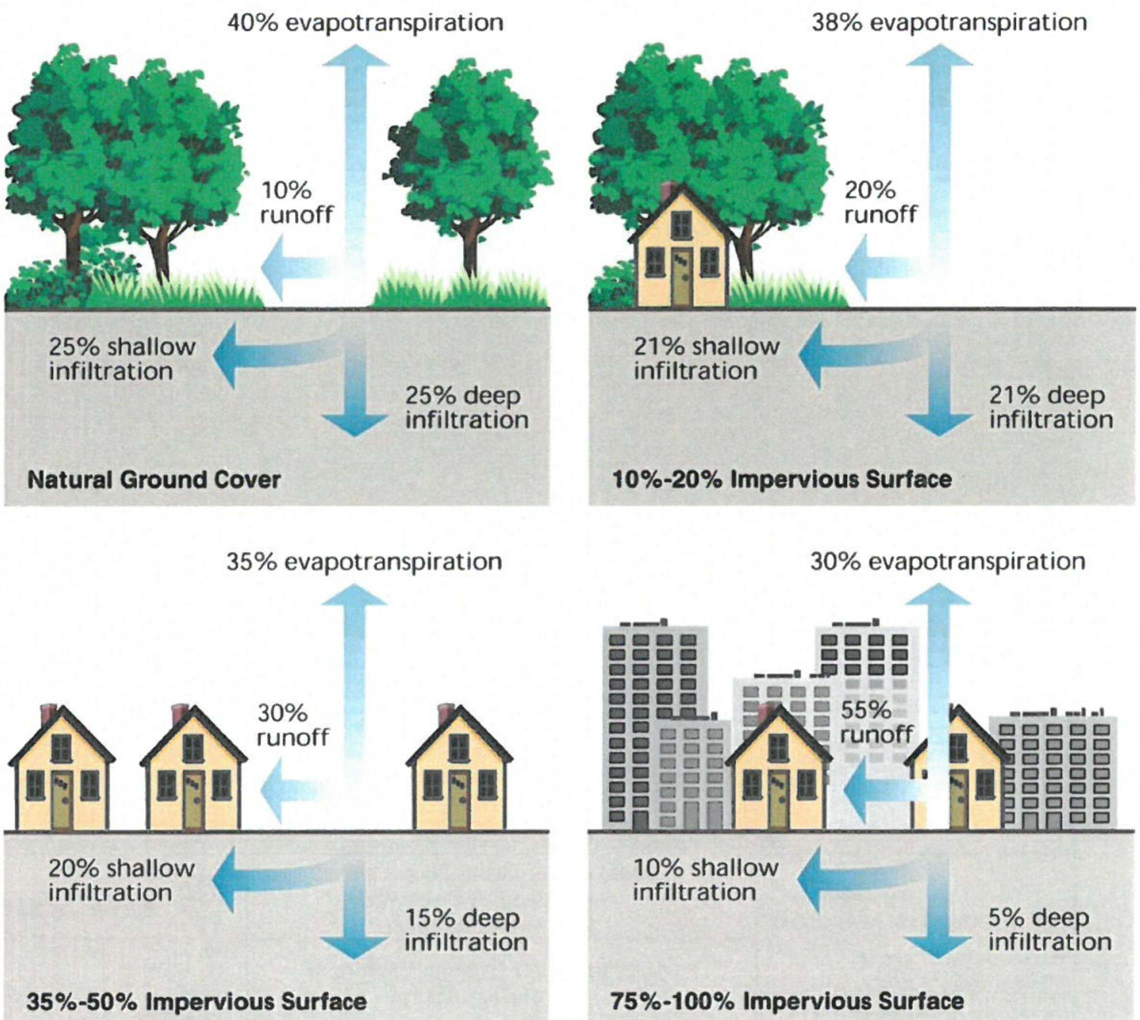
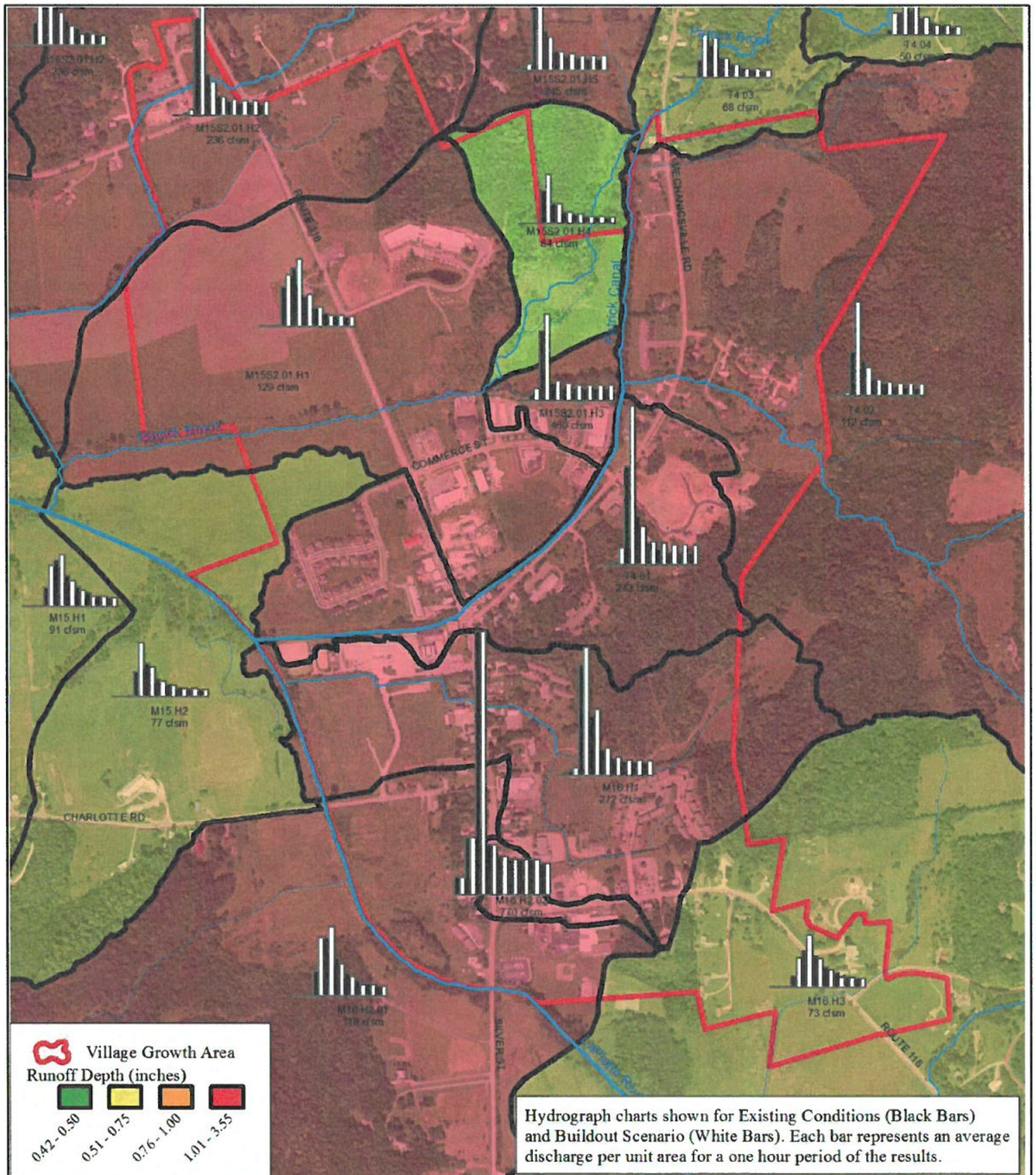


Figure 1: Alterations to the hydrologic cycle as impervious surface increases (FISRWG 1998).



Engineering, Landscape Architecture and Environmental Science **MILONE & MACBROOM®**	**Buildout Scenario Village Center Subwatershed Discharge 2-year Storm Estimate**	N W E S 0 250 500 1,000 Feet	
1233 Shelburne Road, Suite 150 South Burlington, VT 05403 (802) 864-1600 Fax: (802) 864-1601 www.miloneandmacbroom.com	**Growth Center Existing Conditions Hydrology Study**	**DATE:** **December 2011** **SCALE:** **see scale bar**	**SHEET:** **Figure 15**

PHASE 1: SMALL PATCHES WITHIN A LARGE FOREST MATRIX.

PHASE 2: INCREASED PARCELIZATION RESULTING IN THE EXPANSION OF PATCHES.

PHASE 3: CONVERSION FROM FOREST TO HUMAN LAND USE.

VTANR, 2015

EXECUTIVE SUMMARY

Existing conditions hydrology modeling of the LaPlatte River Watershed has been completed for the Town of Hinesburg, Vermont, with special focus on the Village Growth Area and upstream contributing areas. The hydrology model has created a baseline for addressing stormwater runoff in the Town. Low-impact design and proper stormwater handling can be planned and designed starting with the existing conditions hydrology model. For example, the model can help identify priority treatment areas where existing development is causing excessive stormwater runoff relative to other areas in the watershed. Results of this analysis can guide where development takes place and how it can be best implemented to protect water resources. The modeling can also be used to develop regulations for future development that explicitly considers stormwater treatment. A proactive approach to stormwater treatment is essential for smart growth that both protects water quality and reduces flood and erosion risks.

Existing conditions hydrographs were modeled showing the flow, volume, and timing during a range of floods. Runoff patterns, both volume and peak discharge, follow watershed land use trends that can generally be described as developed with high runoff in the Village Growth Area, forested with lower runoff to the east, and agricultural with moderate runoff to the west. Hydrographs showed a trend of higher peak discharge values occurring earlier in the storm in the agricultural lands with clay soils in the western section of town compared to forested subwatersheds in the eastern part of town. The six subwatersheds contributing the highest peak runoff and the highest runoff depth are located in and immediately upstream of the Village Growth Area.

A buildout scenario was modeled where land use was modified to reflect a theoretical full development condition based on current zoning regulations and likely developable land. Full buildout increased runoff peak flow rate and volume throughout the watershed for all modeled storm events. For example, the first flush of runoff that typically carries the most pollutants and is targeted for treatment (i.e., the water quality volume that is taken as the runoff volume generated from 0.9 inches of rainfall in Vermont) increased 35% at the downstream Town Boundary, from 38 cubic feet per second (cfs) to 52 cfs. The 100-year peak flow increased 17% at the downstream Town Boundary, from 7,797 cfs to 9,151 cfs. Increased peak flows will increase chances of flooding and damage to infrastructure, reduce water quality, and present a future stormwater management need as development expands.

The modeled 2-year storm runoff volume increased between 0 and 65% under the full watershed buildout scenario indicating that increased development will increase the amount of water travelling in stormwater infrastructure and in need of treatment. The water will also be moving faster as the peak flow rate increased 0 to 142% under the buildout scenario and thus there is more potential for erosion. Flood flows move through the watershed faster and can cause increased flooding, impacts to habitat, and reduced water quality. Increased peak discharge values were on average 50% higher than existing conditions, with Village Growth Area subwatersheds increasing on average the same as non- Growth Area subwatersheds. Stormwater treatment for future development is a priority across the watershed, not just in high density development areas.

The existing conditions model illustrates that the small subwatershed in the Village Growth Area containing the intersection of Route 116 and Silver Street generates a large runoff volume in small area due to large amounts of impervious cover and limited storage and infiltration. The model has been used to create a conceptual design for a tiered rain garden to introduce stormwater storage and treatment lost as the area was developed and land was converted to impervious cover. The installation is proposed on the Town owned land where the Masonic Hall is located along Silver Street where a ditch and lawn currently exist. The rain garden captures and detains runoff from three pipes that now flow to a ditch and directly to the LaPlatte River without treatment. Installation of the rain garden would result in the removal of 87% of the total suspended solids from the water quality volume and removal of 34% of Total Phosphorus. Beyond improving local water quality, the rain garden design will enhance local aesthetics, be easy to maintain, and serve as a public demonstration of simple measures that can be used to treat stormwater in the built environment. A ballpark cost opinion for final design, permitting, and construction of the rain garden is $60,000 based on typical construction and material costs.

8.3 General Stormwater Recommendations

This study has demonstrated that stormwater runoff is an issue within the LaPlatte River watershed. Many of the specific areas experiencing the most problems are focused in and around the village centers of Shelburne and Hinesburg. Older stormwater conveyance systems without any treatment are now handling increased volumes of runoff as properties in village centers converted land use to impervious cover and the already limited infiltration capacity was reduced. Data suggest that receiving waters are showing signs of impairment from stormwater discharge.

The areas that have been identified for mitigation projects add treatment to the existing system and seek to expand capacity at the village center where growth is likely to take place since municipal infrastructure (sidewalks, water and sewer, schools) and services already exist. Although rural areas do not have the same permitted development density or amount of impervious cover, stormwater impacts do exist from field and road ditch runoff that influences downstream channels. These areas will have different approaches to stormwater mitigation as there are not obvious collection systems to target projects.

Recommended strategies for improving water quality through stormwater treatment.

- Begin implementation of the projects identified during this study to eliminate discharge of untreated stormwater to receiving waters. Community and school hands-on demonstration projects are recommended to gain public support for minimizing stormwater impacts from village centers.

- Require all properties submitting an application for a building permit to demonstrate stormwater mitigation using Low Impact Development (LID) techniques. The ultimate goal is mimicking pre-development hydrology by reducing runoff volume for future development (Smith 2010). This strategy would specifically target small developments that are under the threshold for obtaining a state stormwater permit, but have a cumulative impact by joining the existing stormwater systems with such little treatment facilities. Innovative design approaches would be required to size and construct best management practices to reduce runoff (e.g., Hirschman and Collins 2008).

- Fund and implement a low impact development (LID) outreach program to promote and support single lot-scale stormwater reduction and re-use methods such as rain barrels, cisterns, and rain gardens. This would include adoption and distribution of an LID guidance manual such as that used by the South Burlington Stormwater Utility (Utility 2009) or VTDEC's *The Small Sites Guide for Stormwater Management* (VTDEC 2009). An important message is that LID techniques reduce stormwater runoff (Bedan and

Clausen 2009), improves the quality of receiving waters, is often aesthetically pleasing in village centers, and is cost-effective design approach (USEPA 2007).

- Building on the findings presented here, use stormwater treatment potential to guide future development and plans for growth in the village centers. The potential exists for infiltration-based stormwater mitigation in select locations in most of the priority watersheds. These possible treatment sites should be investigated further for verification of infiltration capacity based on soil mapping, proximity to potential development sites, and identification of parcel information.

- Revise planning and zoning ordinances to include specific strategies for stormwater improvement. Create a green infrastructure overlay district to reserve prime areas for infiltration and groundwater recharge based on soils and surficial geology. This type of overlay would allow for natural infiltration as well as locations for sighting engineered stormwater management areas.

There are many ways to reduce and re-use stormwater. A summary of popular approaches that could be incorporated into standard practices, master plans, or municipal code follow.

- Limit the amount of impervious surface and preserve open space
    - Cluster development for to share drives and roads
    - Minimizing pavement widths
    - Reduce setbacks from property lines to limit driveway lengths
    - Reduce necessary property frontages to reduce main road length per property
    - Encourage minimal disturbance practices during construction to preserve natural vegetation, heterogeneous land surface, and soil permeability
    - Use permeable pavement or pavers where possible
    - Use green roof tops
    - Increase infiltration capacity of lawns, sports fields and parks by mowing high and over seeding bare spots.

- Disconnect impervious surfaces from collection systems and receiving waters
    - Install rain barrels or cisterns for rainwater collection at roof downspouts for irrigation.
    - Install rain gardens to collect runoff from driveways and medians. Technical guidance for design and building is provided by the Vermont Rain Garden Manual created by the Winooski Natural Resource Conservation District (District 2009). Assistance is also available through UVM extension services.
    - Install infiltration systems such as infiltration trenches, basins, or underground galleys where soils are permeable.

- Eliminate use of curbing where possible to promote overland flow of runoff from impervious surfaces.

- Preserve river corridor natural stormwater functions
  - Restrict new development from designated floodplain areas. These areas are critical for water storage during flood events and sediment and nutrient removal.
  - Maintain and expand vegetated buffers to filter stormwater runoff.

- Improve stormwater treatment function of roadside ditches
  - Encourage natural vegetation for reduction of water velocity, improved settling of solids, and reduction of erosion.
  - Include small depressions to promote settling of solids and collection of gravel in road runoff.
  - Install sediment forebays and check dams where appropriate along existing ditches to increase water storage, promote infiltration, and allowing settling of solids.
  - Stone lined ditches raise water temperatures due to sun exposure and ultimately raise temperatures in streams that is harmful to many aquatic species.

- Improve stormwater runoff from agricultural areas
  - Encourage landowners to take advantage of USDA fencing and buffer programs to protect riparian areas.
  - Promote soil protection using cover crops and other methods.
  - Reduce pollutant load from fields.

Future considerations for the Towns.

- There is value in planning for stormwater mitigation on a watershed and town-wide basis instead of a site by site level as required by current state regulations. How can this more efficient level of planning be incorporated into policy?

- The benefits of being proactive in mitigating effects of stormwater are numerous and more economical in the long run. Could implementation of a stormwater management plan avoid state and federal mandated regulation?

- Minimizing ecological impacts in the watershed should be a priority for towns. Our health and that of the ecosystem depend on it.

- Should a green infrastructure overlay be created to conserve infiltration areas and describe their priority for stormwater mitigation and groundwater aquifer recharge?

- Due to the rural nature of the towns, development is often dispersed and small scale. Should new development of this type be required to meet a town stormwater treatment standard? How easily can the town implement low-impact design approaches?

- Are the costs and benefits for stormwater discharge appropriately shared between rural and urban areas?

- Would the town foster partnership with LaPlatte Watershed Partnership to facilitate outreach to property owners to provide education and technical advice on improved stormwater management?

- Many municipalities are moving towards tougher development standards where rather than no increase in peak flow rate no increase in stormwater runoff volume leaving the site is allowed. Is this standard a fair burden on future development?

- Roadside ditches contribute untreated stormwater directly to streams in the majority of the watershed. Is there a way to target specific areas for improvement during scheduled ditch maintenance? Will the town agree to change ditch practices to improve stormwater treatment and formalize these approaches in a policy?

8.4 Growth Center Considerations

The Town of Shelburne has taken steps to implement stormwater improvement strategies as part of MS4 permit requirements. A floodplain overlay has been incorporated into municipal zoning that includes stream buffers and stormwater overlay districts (Figure 23). Details and standards for stormwater treatment have been included in the Town Public Works Specifications. The Town has passed a Stormwater Ordinance. All of these steps have worked towards improved stormwater treatment and protection of the river corridors.

The Town of Shelburne's stormwater overlay district includes the majority of the developed area in and around the village center that has been discussed as high risk in this study. It requires that any new or redevelopment project exceeding 10,000 square feet (approximately ¼ acre) may be subject to individual permit requirements from the DEC Water Quality Division. The focus on stormwater has been on developed areas with designated stormwater impaired rivers. This report illustrates the need for prevention of future impacts and provides suggestions for refinement of the designated stormwater overlay district to preserve important infiltration areas or protect open space.

The Hinesburg Zoning districts include a Village Growth Area (Figure 24). This Growth Area designates a significant amount of currently undeveloped land to be part of future development. These areas are within many subwatersheds that were identified to be stormwater hot spots including LaPlatte River (M16) and Patrick Brook and Canal (M15.S02, T4.01, T4.02). The Patrick Brook and Canal reaches have already been identified as contributing to degraded conditions in the LaPlatte River reach (M15). Stream buffers have been included as part of the designated Growth Area. These buffers begin to set priority for stream functions and decrease pollutants in runoff, but may benefit from being extended to include more of the adjacent areas shown to have high infiltration capacity to support current and future stormwater treatment.

It is recommended that the Hinesburg Village Growth area be refined based on a village-wide stormwater management plan. This plan would strategize mitigation of current stormwater problems and set guidance for future development. Mitigation of stormwater runoff from public infrastructure would be addressed in the plan. A few areas with soils conducive to infiltration should be designated for infiltration type stormwater treatment and be incorporated in site planning.

Charlotte remains mostly rural within the LaPlatte River watershed. Town zoning designated most of the area as rural (Figure 25). Conservation areas show stream buffers and a few large areas adjacent to streams. East Charlotte village, including a small section of Village Commercial zoning is included in the watershed. This area of concentrated development is located at the headwaters of a few tributaries that appear to have adequate open space to provide stormwater treatment before discharge to a receiving water.

(3) Encroachment into Class II wetland buffers, Class III wetlands and Class III wetland buffers, may be permitted by the DRB upon finding that the proposed project's overall development, erosion control, stormwater treatment system, provisions for stream buffering, and landscaping plan achieve the following standards for wetland protection:

(a) The encroachment(s) will not adversely affect the ability of the property to carry or store flood waters adequately;

(b) The encroachment(s) will not adversely affect the ability of the proposed stormwater treatment system to reduce sedimentation according to state standards;

(c) The impact of the encroachment(s) on the specific wetland functions and values identified in the field delineation and wetland report is minimized and/or offset by appropriate landscaping, stormwater treatment, stream buffering, and/or other mitigation measures.

12.03 Stormwater Management Standards

A. Purpose. The purpose of this section is:

(1) To promote stormwater management practices that maintain pre-development hydrology through site design, site development, building design and landscape design techniques that infiltrate, filter, store, evaporate and detain stormwater close to its source;

(2) To protect water resources, particularly streams, lakes, wetlands, floodplains and other natural aquatic systems on the development site and elsewhere from degradation that could be caused by construction activities and post-construction conditions;

(3) To protect other properties from damage that could be caused by stormwater and sediment from improperly managed construction activities and post-construction conditions on the development site;

(4) To reduce the impacts on surface waters from impervious surfaces such as streets, parking lots, rooftops and other paved surfaces; and

(5) To promote public safety from flooding and streambank erosion, reduce public expenditures in removing sediment from stormwater drainage systems and natural resource areas, and to prevent damage to municipal infrastructure from inadequate stormwater controls.

B. Scope and Applicability

(1) These regulations shall apply to all land development within the City of South Burlington where one-half acre or more of impervious surface area exists or is proposed to exist on an applicant's lot or parcel.

(2) If the combination of new impervious surface area created and the redevelopment or substantial reconstruction of existing impervious surfaces is less than 5,000 s.f. then the application is exempt from requirements in this Section 12.03.

(3) Applications meeting the criteria set forth in section 12.03(B)(1) and not exempt under section 12.03(B)(2) shall meet the requirements in section 12.03(C) as follows:

(a) If the area of the lot or parcel being redeveloped or substantially reconstructed is less than 50% of the lot's existing impervious surface area, then only those portions of the lot or parcel that are being redeveloped or substantially reconstructed must comply with all parts of Section 12.03(C). All new impervious surface area must meet the requirements of section 12.03(C).

(b) If the area of the lot or parcel that is being redeveloped or substantially reconstructed exceeds 50% of the lot or parcel's existing impervious surface area then all of the lot or parcel's impervious surfaces must comply with all parts of Section 12.03(C). All new impervious surface area must meet the requirements of Section 12.03(C).

C. Site Design Requirements For New Development

(1) The Water Quality Volume (WQv) as defined in the Vermont Stormwater Management Manual for the lot or parcel's impervious surfaces shall not leave the lot via overland runoff, and shall be infiltrated using Low Impact Development (LID) practices including, but not limited to, practices detailed in the "South Burlington Low Impact Development Guidance Manual".

(a) If it is not possible to infiltrate the volume of stormwater runoff specified in Section 12.03(C)(1) due to one or more of the following constraints:

(i) Seasonally high or shallow groundwater as defined in Appendix D1 of the Vermont Stormwater Management Manual,

(ii) Shallow bedrock as defined in Appendix D1 of the Vermont Stormwater Management Manual,

(iii) Soil infiltration rates of less than 0.2 inches per hour,

(iv) Soils contaminated with hazardous materials, as that phrase is defined by 10 V.S.A. §6602(16), as amended,

(v) The presence of a "stormwater hotspot" as defined in Section 2.6 of the Vermont Stormwater Management Manual, or

(vi) Other site conditions prohibitive of on-site infiltration runoff subject to the review and approval of the Development Review Board,

then the WQv shall be retained on the lot using other LID strategies and practices such as those detailed in the "South Burlington Low Impact Development Guidance Manual", or treated by stormwater treatment practices meeting the Water Quality Treatment Standard as described in the most recently adopted version of the Vermont Stormwater Management Manual.

(2) The post-construction peak runoff rate for the one-year, twenty-four hour (2.1 inch) rain event shall not exceed the existing peak runoff rate for the same storm event from the site under conditions existing prior to submittal of an application. LID practices shall be incorporated into the design as necessary to achieve the maximum allowed runoff rate. If constraints prevent the use of LID practices (see Section 12.03(C)(1)(a)), stormwater treatment practices detailed in the Vermont Stormwater Management Manual may be used to achieve the required post construction runoff rate.

(3) Applicants who demonstrate that the required control and/or treatment of stormwater runoff per section 12.03(C)(1) and 12.03(C)(2) cannot be achieved for areas subject to these regulations per section 12.03(B) may utilize "site balancing".

D. Additional Site Plan Requirements

(1) Applicants required to comply with Section 12.03(C) must include the following information in their site plan submission: