Emerald Hills Urban Village
FOUNDATION RESEARCH BULLETIN

Design Centre for Sustainability at UBC

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WATER

1.0 Why is water a key theme?

Land development disturbs and alters the natural hydrological systems of the landscape, affecting the quality and quantity of water that falls on or flows through a particular site. As development paves over the land, its capacity to absorb and retain water on site is reduced, resulting in larger quantities of water flowing from the site. As the water flows over surfaces, it collects particles and contaminants that affect the health of aquatic environments downstream. The challenge for sustainable neighbourhoods is to manage stormwater so that a healthy and balanced hydrological cycle can be maintained.

This research bulletin will examine the issue of water from three perspectives:

- Water as a natural system (eg. rainwater, groundwater, water bodies);
- Water as a human need (eg. drinking water);
- Water as infrastructure (eg. supply and wastewater management).

Water as a natural system

Even within Canada where water is seemingly plentiful, there is an inherent carrying capacity for any natural system. While the potential supply of water is difficult to estimate, it is certainly finite, and this limit needs to be balanced between human interests and ecological necessity. As more water is withdrawn from the ground for consumption by endless subdivision developments, for example, less water becomes available to recharge the wells, irrigation ditches, and the sensitive ecosystems of creeks, rivers, and wetlands. In addition, the treatment of associated wastewater is not only costly but, in some cases, environmentally damaging.

Water as a human need

Urban land development places pressure on available fresh water supplies for potable water consumption (Fig. 1). Canadians in major urban city centres are among the largest water consumers in the world[1] and although the country has a plentiful supply, these supplies are feeling the stresses of population growth, an increased standard of living, urbanization, and the uncertain impacts of climate change. These major stress factors will likely increase water demands and decrease available water supplies in the future. Climate change impact studies, for example, suggest that the trends of earlier snowmelt runoffs, lower precipitation with warmer, wetter winters and longer, hotter and drier

[1] Environment Canada. 2002.

Fig. 1 Land development often compromises water resources.

summers will soon become the norm.

It is important to consider the impacts of urban development on water supplies during the planning and design phase of an urban subdivision. Implementing techniques to minimize the impacts of stormwater runoff and reducing the amount of potable water and wastewater consumed will promote the sustainability of a community and its resources.

Water as infrastructure

Water supply and quality is impacted by conventional engineering systems which contain and pipe water underground, and release it into treatment facilities and larger waterbodies. Creative, contextural designs combined with financial incentives can assist in developing low-impact designs for water infrastructure that balances the natural hydrological cycle, minimizing long term costs and sustaining this resource (Fig. 2).

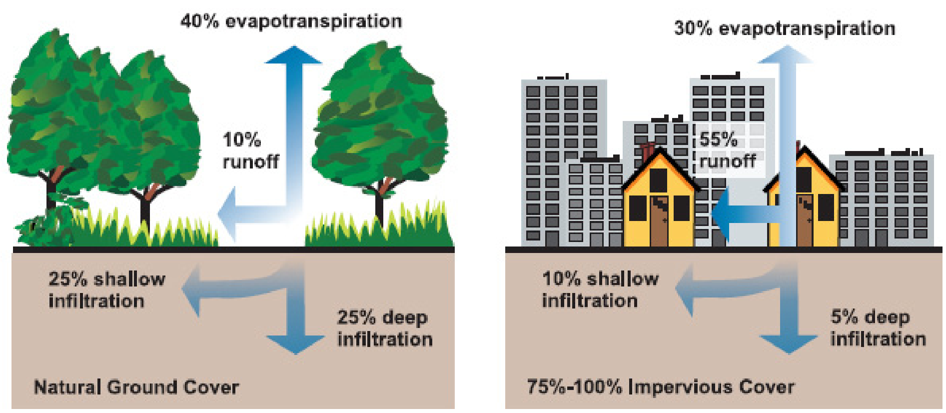

Fig. 2 Pre- and post- development runoff scenarios compared.

2.0 Why is water important to Emerald Hills Urban Village?

Strathcona County has committed to being part of Alberta's Water for Life Strategy. The Water for Life Strategy has outlined strategies committed to protecting the quality and quantity of Alberta's water resources including the maintenance of a safe, secure drinking water supply, a healthy aquatic ecosystem, and a reliable quality water supply for a sustainable economy.   In order to sustain the community's water resources and ecosystem, it is important that these strategies be incorporated into Emerald Hills Urban Village's stormwater, potable water and wastewater systems.

Strathcona County has taken great strides to improve its existing stormwater system. In 2005, Council passed a best practices guide for stormwater facilities. The guide offers many best practice for improving the existing storm system including the construction of wetlands, and the retention of natural wetlands in urban areas to improve water quality, the use of stormceptors to separate oil and solids prior to entering

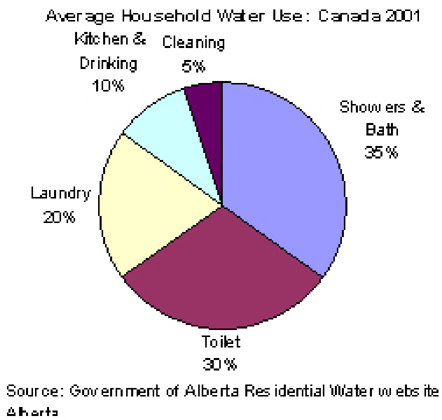

Fig. 3 Average household water use in Canada- 65% in the bathroom alone.

Fig. 4 An example of rainwater management integrated within a development plan.

stormwater treatment facilities, and the use of education to inform residents about the benefits of improving the stormwater system. It is important to incorporate stormwater best practices into the Emerald Hills Urban Village project because not only will they minimize the amount of stormwater runoff, but they will also improve the quality of water, minimize the impacts of flooding and erosion, and reduce the costs associated with treating runoff in a treatment facility.

Strathcona County is located within the Beaver Hills sub-watershed, which is part of the much larger North Saskatchewan Watershed. The community purchases its water from Epcor who withdraws it from the North Saskatchewan River. Recent water data suggests that the supply from the North Saskatchewan may be diminishing in supply. The natural volume of water in the North Saskatchewan River at Edmonton during the 2006 summer was much below average. In fact, it was the 12th lowest level on record (based on the 1912-2001 data[2]) . Considering for the impact that the residents of the Emerald Hills Urban Village will have on this existing water supply is important. The developer must design for the efficiency and conservation of potable water and wastewater.

Designing for water conservation can be very straightforward. For example, installing water efficient appliances can reduce indoor water consumption in the home by as much as 30%. Toilets alone account for 30% of the total water used within the home, and replacing older inefficient models can lead to significant reduction in potable water use and wastewater consumption[3]. In a study conducted by the American Water Works Association, important connections were made between water use and density. The results show that per person indoor water use in a multi-family dwelling is significantly less than in a single family house. According to that study, average indoor water use in single-family residential homes amounts to 318L per person per day. In multi-family dwellings, indoor water use totaled 273L per person per day, and in apartments, indoor water use was 250L per person per day[4]. Thus, it is important to consider both housing density and water conservation during the Emerald Hills design process.

From a municipal standpoint, designing and planning for water conservation makes financial sense. By reducing water demand and wastewater generation, it is possible for municipalities to defer expensive capital investment projects for water supply and wastewater treatment infrastructure. Conserving water today builds capacity into the existing Strathcona County infrastructure system, so that it can accommodate the future water demands of Emerald Hills.

3.0 How can EHUV impact on this theme?

Strathcona County has an opportunity to be a leader in water resources

2 Alberta Environment. 2006.

3 In a 1992 Pilot Program, the Regional Municipality of Waterloo and the City of Kitchener, ON showed that households with ultra low-flow (ULF) toilets saw water use fall between 20 and 30%. The annual savings for homes with ULF toilets was between $65 and $135. Environment Canada: National Action Plan to Encourage Municipal Water Use Efficiency.

4 Pacific Institute. 2003.

management. Designing and planning for sustainability now will lead to a healthier, more sustainable community for the future.

A few simple strategies will go a long way in reducing the amount and quality of stormwater runoff, and the amount of water consumed by residents of the Emerald Hills Urban Village. The incorporation of stormwater strategies that improve infiltration rates with water efficient technologies and a soft path approach to water management will reduce the ecological footprint that the Emerald Hills Urban Village makes in Strathcona County.

3.1 What strategies are relevant for EHUV?

Water as a natural system

Site Planning for Stormwater Strategies

Strathcona County envisions stormwater management moving toward low impact development (LID) which aims to reduce the impacts on land, water and air by conserving natural systems and the hydrologic functions of a site. Some of the LID practices outlined in the County's Best Management Practices Guide[5] include the use of:

- Permeable pavement blocks – porous concrete or asphalt allows water flow to an underground gravel area where it can be slowly released back into the soil.
- Open swales – used at the edge of parking lots to receive runoff, help treat pollutants and promote infiltration.
- Vegetated (green) rooftops – a combination of specialized planting media and vegetation that helps filter pollutants, store runoff and reduce energy consumption.
- Tree filter boxes – a bio-retention container that uses soil and crushed stone to store and slow down runoff and filter out pollutants.
- Specialized inlets – inlets that prevent the inflow of trash and debris or can store and detain stormwater to change the timing of runoff into the storm system.
- Soil amendments – sand and organic materials (e.g., mulch) are added to the soil to increase infiltration characteristics of soil and filter pollutants.
- Bio-retention – specialized landscaped areas used to filter and store runoff and promote groundwater recharge via infiltration.
- Disconnectivity – the practice of directing runoff from impervious areas onto landscaped and vegetated areas.

Fig. 5 A stormwater oriented site planning strategy for EHUV

Key features of a stormwater oriented site planning strategy for EHUV illustrated through a drainage diagram based on the Deep Green Scenario

[5] Strathcona County. 2005.

(Fig. 5) and includes:

A Natural Hydrologic Pattern

Prior to development, the natural topography of the EHUV site generally directed runoff to the north and northwest. Infiltration rates are slow, thus in large rainstorms water is detained in many kettle shaped basins. A sustainable stormwater management strategy for the study site would likely be based on a drainage pattern comparable to and compatible with this original natural pattern and connect each developed area to that larger pattern.

Within the EHUV project area, drainage basins similar to those found in the natural system are created on the west side of the site and integrated with neighbouring open spaces and proposed residential development adjacent to the park (leaving the park for more active recreational uses). Ultimately any runoff leaving the project area would be conveyed (naturally or mechanically as necessary) in the direction of other pathways and detention areas to the north and northwest.

'On Parcel' Load Reduction

A key strategy for reducing load on the system as a whole and increasing aquifer recharge is to shift some responsibility for infiltration or detention onto each development parcel to manage in a manner appropriate to the type of development (including streets and paved areas). Infiltrating 90% of rain events is achievable through a variety of best management practices such as green roofs, stormwater gardens, engineered soils, infiltration galleries, cisterns, etc.

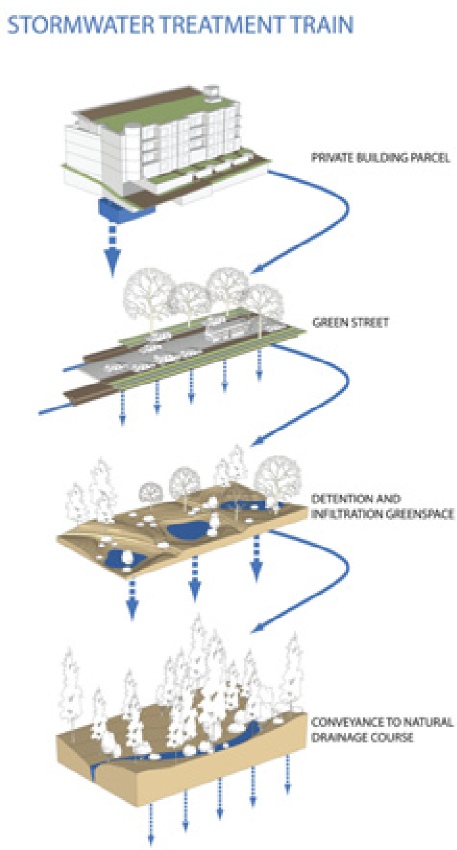

Fig. 6 A whole site treatment train.

A Whole Site Treatment Train

Drainage and stormwater management elements throughout the project area would be considered and engineered as one integrated system — a water treatment train (Fig. 6) that filters and infiltrates water in stages as moves onto and across the site.

'Green and Gray' Pathways

Water that cannot be infiltrated or detained would flow and infiltrate through two types of pathways that can be aligned with open space, street and path systems. 'Gray' pathways would be designed to manage water running off vehicular surfaces and likely to carry greater concentrations of pollutants. 'Green' pathways would be designed to manage water running off pedestrian and planted surfaces and likely to carry lower concentrations of pollutants.

3.2 What technologies are appropriate for EHUV?

Other LID technologies, not listed in the Best Practices guide include: the protection and restoration of natural areas, clustering development to maximize unpaved areas, planning at the regional scale to preserve open space, day-lighting creeks, using minimum width streets, reducing the area of parking lots, protecting and planting trees to reduce runoff, designing recreation areas that can hold runoff, and directing runoff from pavement and buildings to vegetation-lined channels or trenches[6]. These principles should be considered for the Emerald Hills Urban Village. Several of the large concepts are explained in more detail below.

Water as a human need

Water and Wastewater Conservation Strategies

Although Epcor has an abundant supply of water available, it is still important for Strathcona County to reduce its vulnerability to future water shortages. Strathcona County has been proactive in reducing water consumption. In fact, household water consumption dropped from 21,000 litres per month in 2003 to 19,000 litres per month in 2005 due to several water conservation initiatives[7]. However, there is more to potable water management than a couple of demand side management initiatives.

Planners and designers should consider the soft-path approach to water management for the Emerald Hills Urban Village. The soft-path approach seeks to provide water related services such as new forms of water sanitation, drought-resistant landscapes, urban design for conservation, and rain fed ways to grow crops[8]. Planners using the soft-path approach essentially model a sustainable future and then 'backcast' a community's water needs. Creating a plan to meet these needs will require innovation, conservation, water reallocation and a change in patterns of use[9]. Several of these innovations and conservation measures are addressed below. Incorporating these into the Emerald Hills Urban Village design will reduce potable water and wastewater consumption.

Reduce Demand

Fig. 7 An example of xeriscaping.

Landscape efficiency - Xeriscaping

The goal of a xeriscape is the creation of a visually attractive landscape that uses plants selected for their water efficiency (Fig. 7). Properly maintained, a xeriscape can easily use less than one-half the water of a traditional landscape. Once established, a xeriscape should require less maintenance than turf landscape[10]. Xeriscaping includes principles such as:

- The use of native, low maintenance plants to reduce water consumption.
- Grouping plants with similar water demands together.
- Mulching as soil cover to minimize evaporation, for cooling, reducing weed growth and slowing erosion.

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6 Land Government Commission (LGC). N/D.
7 Higgins, V. 2006.
8 Brandes, O & D. Brooks, 2005.
9 Ibid., and France, R., 2002.
10 Brandes, O. & T. Maas, E. Reynolds, 2006.

Water Efficient Technology

Water conservation fixtures and appliances in the home can save up to 30-70% of water use. Strathcona County planners must ensure that water efficiency fixtures are incorporated into the structural design. Such fixtures include:

- low flush toilets (Fig. 8);
- low flow faucets and showerheads;
- efficient washing machines and dishwashers.
- drip irrigation

Fig. 8 A dual-flush toilet with a low flush option.

Toilets in particular, have the largest potential for indoor water savings both in terms of potable and wastewater savings (conventional toilets use 13L/flush while ultra low flush toilets use 6L/flush).

Water Reuse and Recycling

Wherever possible, design for the reuse, recycling and reclamation of water for toilet flushing and outdoor irrigation. This practice is limited because most regulatory frameworks currently do not support the reuse of water. Other barriers to its implementation include social perception regarding the health risks associated with using reclaimed water, and the lack of financial incentives to assist in the development of water reuse technology[11].

Wastewater Treatment Strategies

The Capital Region treatment facility located on the North Saskatchewan River processes the wastewater from Strathcona County. The Emerald Hills Urban Village will likely be diverting its wastewater to this facility. However, there are a couple of alternatives worth considering in the subdivision design.

Biofilters

Biofilters are designed for the biological treatment of wastewater (Fig.9). The process involves spraying wastewater over a synthetic filter. As the medium drains by gravity, beneficial microbes degrade the organic pollutants, coliform bacteria, ammonium and other contaminants in the septic tank effluent. These systems can be used for residential units. A biofilter for a 3-4 bedroom home costs approximately $12,000-16,000[12].

Fig. 9 An example of biofilters.

Trickling Filters

Trickling filters (TFs) are used to remove organic matter from wastewater (Fig. 10). The TF is an aerobic treatment system that utilizes microorganisms attached to a medium to remove organic matter from wastewater. This type of system is common to a number of technologies such as rotating biological contactors and packed bed reactors (biotowers). These systems are known as attached-growth processes. In contrast, systems in which microorganisms

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[11] Ibid.
[12] Waterloo Biofilter System (WBS), 2006.

Fig. 10 Trickling filter sewage treatment bed.

Fig. 11 Dual-vortex hydrodynamic separator for stormwater treatment.

Fig. 12 Just one of many possible designs for bioretention.

are sustained in a liquid are known as suspended-growth processes[13].

Water as infrastructure

Hydrodynamic Separators

Hydrodynamic separators are flow-through structures that include a settling or separation unit to help remove sediments and other pollutants used in stormwater treatment (Fig. 11). The separators are most effective where the materials to be removed are heavy particulates or floatables rather than solids with poor settleability or dissolved pollutants. The technology may stand alone, or be applied with other stormwater initiatives[14].

Design Criteria - Separators can be placed in almost any specific location in a system, but are ideal for use in stormwater 'hotspots' such as a gas station, where higher concentrations of pollutants are likely to occur[15].

Bioretention

Bioretention is the use of soils and plants to remove pollutants from stormwater runoff (Fig. 12). The treatment area may consist of a grass buffer strip, a sand bed, ponding area, organic or mulch layer, planting soil, and plants which slow the runoff's velocity. Runoff it spread evenly along the length of the ponding area, which consists of the surface organic layer and ground cover and underlying planting soil. Water is ponded to a depth of 15 cm and gradually infiltrates the bioretention areas or evapotranspires[16].

Design Criteria - Each component of the area is designed to perform a specific function. For example, the buffer strip reduces incoming runoff, the sand bed reduces velocity, filters particulates and spreads the flow, while the organic layer filters the pollutants. The clay in the planting soil provides adsorption sites for heavy metals and nutrients. The layout is determined by the site constraints – underlying soils, existing vegetation, and drainage. The size is a function of the drainage area and the runoff generated from the area[17].

Wet Detention Ponds

A wet detention pond is a stormwater control structure that provides both retention and treatment of polluted storm runoff (Fig. 13). The detention pond consists of a permanent pool of water into which the stormwater runoff is directed. Runoff from each rain event is detained and treated in the pond until it is displaced by runoff from the next storm. Capturing storm runoff allows for control of water quantity and water quality. The pond's natural physical, biological and chemical processes then work to remove pollutants.[18]

Design Criteria - Each pond is unique to the site and application. The

[13] US Environmental Protection Agency (EPA), 1999.
[14] Ibid., Hydrodynamic Separators.
[15] Ibid.
[16] Ibid., Bioretention.
[17] Ibid.
[18] Ibid., Wet Detention Ponds.

Fig. 13 A wet detention pond.

Fig. 14 An infiltration trench surrounding a high density residential development in Burnaby, B.C.

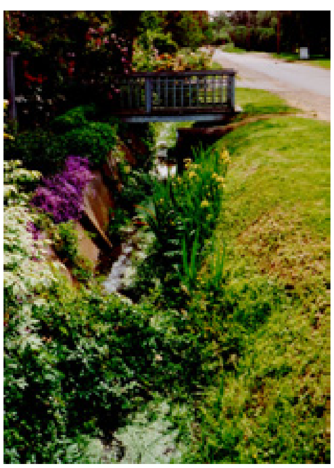

Fig. 15 A grass swale.

site must have adequate baseflow, and requires an underlying soil permeability of between 10^{-5} and 10^{-6} cm/sec. Stormwater must remain in the pool long enough to remove pollutants, which is determined by biological uptake and sedimentation processes.[19]

Infiltration and Percolating Trench

An infiltration trench is an excavated trench between 0.9 and 3.7 metres deep, backfilled with a stone aggregate, protected by a vegetated buffer strip which captures large sediment particles in the runoff and lined with filter fabrics (Fig. 14). A small portion of the runoff is directed at the trench and pollutants are filtered out of the runoff as it infiltrates the surrounding soils. The use of an infiltration trench also improves groundwater recharge and preserves baseflow in nearby streams. Trenches provide efficient removal of suspended solids, particulate pollutants, coliform bacteria, organics and nutrients from stormwater runoff[20].

Design Criteria – soils should have a low silt and clay content and have infiltration rates greater than 1.3 cm per hour. Trenches are suitable for drainage areas up to four hectares[21].

Grass Swales

Grass swales or channels are a highly effective and relatively inexpensive technique that can be used to reduce runoff velocity (Fig. 15). They are primarily used on residential streets or highways and can be adapted to suit a variety of sites. Grass swales are most effective when the channel depth is minimized and the detention time is maximized. Constructing grass swales in parking lots is less expensive than installing curb and gutter/storm drain inlets and drain pipes[22].

Design Criteria – Swales effectiveness is dependant upon the erodibility of the soils within the channel[23].

Green Roofs

Vegetative roof cover or green roofs can effectively reduce urban stormwater runoff by reducing the percentage of impervious surface space in an urban area (Fig. 16). They are especially effective in older urban areas with chronic combined sewer overflow problems where there are high levels of imperviousness. The green roof consists of a vegetative layer, growing medium, a filter layer, and drainage. Green roofs in urban areas offer a variety of benefits, such as extending the life of roofs by protecting it from wear, reducing energy costs and conserving valuable land that would otherwise be required for stormwater runoff controls. Green roofs have been used extensively in Europe and there are many opportunities to apply this measure in Canadian cities[24].

Design Criteria – roofs should be developed for the storm events that

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19 Ibid.
20 Ibid., Infiltration Trench.
21 Ibid.
22 Ibid., 2000. Low Impact Development.
23 Ibid.
24 Ibid.

Fig. 16 The green roof on the Silva residential building in North Vancouver has a 27% reduction in the rate and quantity of stormwater runoff.

most significantly contribute to combined sewer overflows, hydraulics overloads, and runoff problems[25].

Pervious Pavement

The use of pervious pavements increases the percent of infiltration in a drainage basin (Fig. 17). Increased infiltration leads to groundwater recharge, reduction in runoff volume and stormwater treatment for pollutants. There are several advantages to using pervious pavement, including water treatment, less need for costly curbs and stormwater infrastructure, improved road safety from better skid resistance, and recharge to local aquifers . Concrete unit pavers can also be used as a paving material that addresses stormwater management. Individual pavers rest upon a sand bed with an aggregate base. This produces drainage holes in 12% of the pavement area – these holes are filled with fine gravel but still allow for water infiltration[26].

Fig. 17 Pervious pavement along streets in Portland, Oregon.

Design Criteria - Pervious pavement is generally used in low traffic areas (parking areas, emergency vehicle lanes, and pedestrian areas). Soils should be tested to have permeability rates over 1.3 centimeters per hour. Concrete paving stones are durable and can be used in high traffic areas[27].

4.0 What policies and/or programs will add value?

In addition to physical design strategies, other initiatives can reduce water demand and control quantity. These can be created on the level of the municipality (via policies), development, the community, or be specific to selected parcels. These include[28]:

• Education and awareness-building on water use, with conservation tips and techniques around the home and workplace, including appliances and irrigation;

• Multi-level monitoring of water consumption that is ongoing, visible and widely accessible, with easily available comparisons to neighbouring communities and/or Canadian averages for water consumption;

• Community-designed water events and public art features that is participatorily inclusive in their design, and which involve a range of community members (ie. children to seniors, respected community and corporate leaders);

• Create Municipal and Developer partnerships with local NGOs working on water and ecology issues;

• Create community events, markets and support local businesses which provide knowledge of and access to native plants and techniques on specialized planting and outdoor water use techniques to reduce consumption and ensure water quality;

• Create a policy to plant native species, including native grasses, in all pub lic and open space areas, especially those close to or connected to Environ ment Management

[25] Ibid.
[26] France, R., 2002.
[27] US Environmental Protection Agency (EPA). Porous Pavement. 1999.
[28] One Planet Living (OPL), 2006. pp. 29-30.

Areas, and enforce xeriscaping techniques where required. Amend bylaw 7.4.1 a), b), d), and e) to reflect this;

• Mandate feasibility studies for all proposed developments for on-site waste water treatment and greywater re-use opportunities (eg. rainwater for toilets).

5.0 What other resources are available?

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