

GUELPH RESIDENTIAL GREYWATER FIELD TEST FINAL REPORT



Background

As one of Canada's largest communities reliant solely on a finite groundwater source for its drinking water needs, the City of Guelph's ability to achieve water and wastewater servicing capacity through conservation offers numerous benefits. In looking to water supply capacity, community conservation programming offers water resource sustainability and financial competitiveness of the City's water utility while meeting the water resource needs associated with significant community growth – an anticipated additional 50,000 persons by 2031 (Ontario Places to Grow Plan). When looking to wastewater servicing, as the assimilative capacity of the Speed River (the City's sole location for treated wastewater effluent discharge) to accept increasing volumes of treated wastewater effluent is limited, the ability to reduce the volume of liquid wastewater requiring treatment offers ecological benefits to the Grand River Watershed as well as capital and operation financial benefits to the City.

In 2006 Guelph City Council endorsed the *Water Supply Master Plan (WSMP)*. This detailed Master Plan evaluates the water demand associated with projected growth over a 50-year planning horizon as well as new water supply alternatives necessary to facilitate future community growth. This Master Plan identified water conservation and efficiency as the most cost-effective and immediately available source of new water supply and, as such, ranked water conservation and efficiency as the #1 water supply priority action. In support of this direction, the WSMP identified three time-based water reduction targets based on 2006 average daily water production volumes:

- Reduction of 10% (5,300 m³/day) in average day water use by 2010;
- Reduction of 15% (7,950 m³/day) in average day water use by 2017; and
- Reduction of 20% (10,600 m³/day) in average day water use by 2025

Further to the WSMP, both the *2007 Community Energy Initiative* and the *2007 Guelph Strategic Plan* set sustainability performance goals of using “less water and energy per capita than any comparable Canadian city.” These goals continue to guide the City's current water conservation activities and bring greater emphasis to the relationship between water supply, wastewater treatment, and energy demand.

To achieve these targets, an update to the City's *Water Conservation and Efficiency Strategy (WCES)* was initiated in February of 2008. This award winning 10-year strategy was endorsed by Council in May 2009 and identifies the preferred program, policy, and resource recommendations to achieve a further reduction of 8,773 m³/day by 2019, as well as to achieve the aggressive reduction targets of the *Water Supply Master Plan*, *Water and Wastewater Master Servicing Study*, *Wastewater Treatment Master Plan*, *Community Energy Initiative*, and *Council's Strategic Plan*.

Through development of the WCES it was noted that many long standing local municipal water conservation programs, such as toilet or clothes washers retrofit rebates, would reach saturation by the end of the 10-year planning horizon of this strategy. Therefore, in meeting the long-term reduction targets of the WSMP, further capacity development was required in the area of research and evaluation of new demand management alternatives. As part of public consultation completed through development of the WCES,

strong public and political support for decentralized demand substitution approaches, including greywater reuse and rainwater harvesting, was expressed. With this in mind, pilot programs for home-based greywater reuse and rainwater harvesting programs were approved by Guelph City Council as part of the final WCES to further investigate these technology alternatives and build the necessary technical and social capacity to ensure future readiness of these alternatives.

Residential Greywater Reuse Field Test

In May of 2009 the City of Guelph initiated the Residential Greywater Reuse Field Test to assess the feasibility of large scale adoption of home-based greywater reuse technologies. The study set a target of installing greywater systems in a total of 30 homes (both existing and new homes) to assess system performance in real world environments. Five core areas of study were chosen by the project team, including:

- System Operation and Performance
- Public Perception and Homeowner Satisfaction
- Household Water Use and Related Energy Monitoring
- Municipal Management Frameworks and Required Support Networks
- Premise Isolation Device Requirements

To solicit participation in the study, City staff completed consultations with interested members of the Guelph and District Home Builders Association in late 2008. As a result of these consultations, three local home builders, Fusion Homes, Reid's Heritage Homes, and Evolve Builders Group, agreed to participate in the Field Test and to market residential greywater reuse systems to their clientele.

To promote uptake of greywater reuse technology, Guelph offered an incentive of \$1500 to home owners installing an approved greywater system in either new or existing homes. Program participants were also provided at no charge with backflow prevention (premise isolation) devices as well as financial compensation towards the required annual testing of these devices over a five-year period. In exchange for receiving the incentives identified above, participants agreed to allow City representatives to monitor the water quality of the greywater produced by their system on a monthly basis for a period of 12 months, with a single final water quality sample to be taken 24 months after system installation. Additionally, participants were requested to provide feedback through social feedback forums, interviews, and surveys to share their experiences and attitudes towards the technology.

As of completion of this report, a total of 25 participants have installed home greywater reuse systems, including ten in new homes and fifteen in existing homes. Further findings of the Field Test are detailed in the following sections for reference. For additional information on the Guelph Residential Greywater Field Test please visit www.guelph.ca/greywater.

Greywater Field Test Project Team

A multi-stakeholder project team was established to direct the development, implementation, and evaluation of the Field Test. This project team included representatives from academia, the local home building and home renovation industry, water efficiency engineering consultants, and City staff. The project team is identified below:

Academia

- Matthew DeLuca, M.Sc., University of Guelph
- Khosrow Farahbakhsh, Ph.D., P. Eng., University of Guelph
- Benjamin Kelly, Ph.D., Nippissing University

City Staff:

- David Auliffe, City of Guelph
- Wayne Galliher, A.Sc.T, City of Guelph
- Jennifer Gilks, M.Sc., City of Guelph

Home Builders:

- Andy Oding, Reid's Heritage Homes
- Ben Polley, Evolve Builders Group
- Ron Thompson, Fusion Homes

Professional Engineering Consultants:

- Bill Gauley, P.Eng., Veritec Consulting Inc.

The City of Guelph would like to thank the members of project team and their respective organizations for their great significant contributions and overall value added to the Guelph Residential Greywater Field Test.

Federation of Canadian Municipalities Green Municipal Fund

In December 2008, Guelph received notice from the Federation of Canadian Municipalities (FCM) that \$72,524 in grant funding was to be provided through the FCM Green Municipal Fund for the Guelph Residential Greywater Reuse Field Test. FCM's gracious financial support has provided the necessary resources for the City and project team to effectively evaluate the social, economic, and environmental impacts associated with implementing home-based water reuse technologies as well as the considerations in establishing the appropriate municipal management frameworks for home water reuse technologies. The City of Guelph would like to sincerely thank FCM for their support of this initiative and it is hoped that the findings of this study will help to build further capacity and continue dialogue on water reuse amongst communities across Canada. For more information on the FCM Green Municipal Fund please visit:

www.fcm.ca.

Field Test Observations

Key findings of the Residential Field Test included the following:

- **Water Demand Reductions:** Home greywater systems were successful in reducing household water demand over the period of study with average water demands decreasing by 22.6 litres per capita per day. However, the volume of water saved (and therefore the financial savings) is directly related to the flush volume of the toilets in the home (at this time greywater can only be used for toilet or urinal flushing in the home). In other words, as toilets become more efficient and less greywater is used per flush, the potential for water savings in the home decreases. Conversely, water savings would be greater in homes fitted with inefficient toilets that would flush with more greywater.
- **Public Health and Safety:** The social research completed as part of this project concluded that both systems owners and members of the general public had minimal concerns regarding personal health and safety associated with general greywater exposure via system upkeep and general operation. Interestingly, aesthetic concerns (odour and colour of treated greywater, for example) were the dominant quality concerns.
- **Audience for Technology:** With limited public awareness of residential water reuse technologies, the audience for such systems is greatly limited at this time. With this in mind, the future marketing and promotion of such technologies may be best suited to partnerships with green renovators and/or showcase opportunities through “Green Building” demonstration projects. Separately, social research identified that the term “greywater reuse” may limit acceptance of such technologies/practices amongst members of the general public. With this in mind, it is anticipated that future marketing/promotion approaches seek opportunities for more suitable terminologies, such as “recycled water”, to increase the perceived accessibility/applicability of these technologies to broader audiences.
- **Cost Effectiveness:** At the current municipal water and wastewater user rates, and with the use of residential greywater limited to toilet or urinal flushing, residential greywater reuse systems had significant payback periods (+30 years) when taking into account all operational costs of the systems. While this payback period will decrease as rates increase and system costs diminish, it is difficult to make a business case for the installation of greywater reuse systems in single-family homes at this time. Perhaps the business case associated with installing large-scale or communal greywater reuse systems would be more attractive.
- **Maintenance Program Challenges:** Residential greywater systems require ongoing maintenance, e.g., homeowners are required to remove soap and debris from system filters and to add chlorine pucks for disinfection when required.. Although this maintenance program was achievable for most participating homeowners, many of the homeowners grew tired of the maintenance requirements over time and expressed their desire for more system automation to alleviate the manual maintenance requirements for the homeowner.
- **Treatment Approach vs. Water Quality Guidelines:** Overall, the quality of treated greywater produced by the systems included in this pilot project had only a limited overall compliance with the water quality objectives of the *2010 Health Canada Guidelines for Domestic Water Reuse*. Although

greywater quality is largely dependent on homeowner diligence regarding maintenance, quality is also related to the type of treatment employed by the greywater system (filtration and/or chlorination) and the high variability in inlet greywater quality, which is influenced by differences in soap/product use, duration of showers, and person hygiene habits amongst those studied. Most systems installed frequently met the guidelines for E.coli or fecal coliforms but failed to meet guidelines for turbidity and BOD.

Field Test Recommendations

Based on findings of Guelph's Field Test, the following recommendations have been developed for the implementation and enhancement of home water reuse system-based programming:

- 1. Need for Increased Communication & Public Education:** With system operation/performance contingent on the homeowner's ability and willingness to complete ongoing system maintenance, it is recommended that introductory educational and promotional elements of water reuse programming accurately reflect all duties/requirements of system ownership. Although this approach may work to effectively limit some audiences from participating, the added transparency provided through introduction of these requirements would be expected to promote a more robust and prepared participant base. Beyond introductory program marketing, it is also recommended that early educational opportunities be introduced to familiarize participating homeowners with their water reuse system as well as system maintenance and common troubleshooting requirements. Furthermore, in sustaining benefits to all parties via system use, it is recommended that vehicles for continued communication with program participants be implemented to offer reminders to homeowners about regular maintenance, to share lessons learned from participant peers, and to increase awareness of support resources available amongst participant groups.
- 2. Participant Support Networks:** In concert with homeowner educational requirements, it is also recommended that educational opportunities for local trades and contractors be developed to further the knowledge base and support network for program participants. An example of such educational opportunities would include the Green Plumbers Program, available in Australia and the United States of America, through which plumbing contractors may gain certification in water reuse system installation and servicing, amongst other environmental disciplines.

Separately, through defining technology eligibility standards for water reuse programming, it is recommended that consideration be given to the presence of necessary educational and customer support requirements through eligible technology selection. This may be limited to the presence of operational manuals and local-based customer service support representatives, but could be further defined to increase educational requirements to include instructional videos or other resources seen to best support the needs of program participants.

- 3. Affordability, Scale and Evaluation of Format:** With residential water reuse currently limited to end uses such as toilet flushing and the priming of traps, the business case for individual home-based water reuse systems will continue to be a challenge unless there is a significant increase in water/wastewater user rates. However, when looking to environments within which water reuse has gained significant uptake, such as in industry, the business case for such endeavors has been greatly aided by the overall scale of implementation and ability to offset significant

water/wastewater demands. In learning from these models, it is recommended that further evaluation of opportunities for increased scale and alternate service formats be investigated within residential environments. These format alternatives may range from a shared decentralized system within multi-residential type settings to more complex and large scale communal wastewater effluent systems, that are anticipated to enjoy the economies of scale realized within industry and provide the business case necessary for qualified personnel to manage ongoing operational and maintenance requirements of such systems. In working to define these preferred models, it is recommended that a community water reuse feasibility study be completed to assess opportunity by sector, through detailed stakeholder consultation and field process audits, to assess potable vs. non-potable water demands as well as the community appetite for subsequent programming and utility servicing models to best match local need.

4. **Backflow Prevention Policy Amendments:** A key challenge to making a business case for water reuse is the requirement for backflow prevention devices to be installed in homes with greywater systems and the associated cost of device testing on an annual basis. Although protection of public health is of paramount importance, there may be opportunities to manage the risk associated with the operation of greywater systems through alternate premise isolation service models and building practice requirements. In Guelph's Field Test, both testable and non-testable premise isolation devices were installed with field testing of all devices completed on annual basis. Both types of devices achieved the desired level of performance and no complete device failures were observed. In reference to these encouraging field results, and in having implemented system construction requirements prohibiting direct connection of potable and non-potable water systems in the home, it is recommended that City of Guelph Backflow Prevention requirements for such systems be revised to extend the duration at which such devices must be tested provided that redundancies are present within the home to limit cross-connections of the potable and non-potable systems (such as a premise isolation device and air gap for potable water addition to system). Furthermore, it is recommended that non-testable backflow prevention devices (such as Dual Check Valves) be considered for use with such systems with devices to be replaced (if needed) upon the revised inspection frequency to ensure ongoing working order. These recommendations are anticipated to significantly increase financial benefit to homeowners installing greywater systems by significantly reducing annual backflow device testing costs and reducing the costs associated with device replacement. However, with the public interest of mitigating potential risk, it is further recommended that greywater system and related plumbing system inspections be implemented on an annual basis in concert with this backflow policy revision to ensure proper working order of the systems and to manage the occurrence of private changes to household plumbing which may introduce potential threats following initial home plumbing inspections.
5. **Rebates and Incentives:** Based on the relatively high cost of system installation and the limited return on investment at this time, rebates and incentives continue to be an essential tool in promoting system uptake. However, in looking to municipal affordability, it is recommended that the financial value of municipal incentives be amended to reflect the value of water/wastewater serving capacity saved via system use on a municipality by municipality basis. Beyond the incentive amount, it is also recommended that the use of incentive programs create a linkage to desired community capacity building and knowledge development. For example, water reuse based programming noted in Southern Australia requires that systems be installed by a certified Green Plumber to ensure proper system installation/program eligibility. Such program models are seen to create an incentive for local

contractors to attain associated certifications as a matter of business development. They may also enhance a community's knowledge base for water reuse and associated support networks.

6. **Management Frameworks:** With reference to the limited of scale of the Field Test (25 homes) and associated management controls in place, the risk of system malfunction or failure was largely limited to the occurrence of individual private household servicing challenges (inability to flush household toilets) and/or premise based contamination events (wrongful connection of potable and greywater home plumbing systems). Although these risks do require ongoing attention and response strategies, the format and scale at which these technologies were implemented during the Field Test provided a manageable level of risk in comparison to a more extensive roll-out of greywater reuse technologies. However, in looking to legacy challenges around such technologies (such as home resale and technology management amongst new homeowners), staff/stakeholder consultation completed as part of this study offered some valuable suggestions with reference to system-based operational permitting which were not considered through initial implementation of the pilot. With this in mind, it is recommended that further evaluation of water reuse system operational permits be assessed in hope that the introduction of such controls would increase the level of information received regarding active systems on an ongoing basis as well as define the duty to disclose necessary operational requirements of system during events such as home resale and system decommissioning. Furthermore, in building upon consultation completed at a staff stakeholder level, it is recommended that greater dialogue with community stakeholders be completed to assess the full spectrum of service models alternatives, risk by model as well as related mitigation and service response strategies to best address community desire and need.
7. **Technology Performance Testing and Certification:** With homeowner feedback attained through the Field Test showing great support for more automated/passive greywater reuse technologies, it is essential that further technology enhancement be undertaken at this time to meet greater consumer appeal. Fundamental to such improvements is the introduction of a representative performance testing protocols and associated technology certification programs to make greater performance information available to consumers and reinforce credible technologies in the marketplace. In this regard, the Canadian Standards Association endorsed Standard B128.3 - *Performance of Non-Potable Water Treatment Systems* within the closing period of the Field Test. This Standard aims to evaluate and certify water reuse technologies (packaged plants) versus a series of common stresses/operational challenges confronted by such system in real world environments. With this standard recently approved, and certified testing facilities for such technologies still to be established, the presence of CSA B128.3 certified technologies is not anticipated in the short-term. However, in looking to the timing of the introduction of certified technologies, it is recommended that technology eligibility criteria for water reuse programming integrate this certification in the future to reinforce the use of robust technologies in the field.

Next Steps

The Greywater Field Testing project provided significant insight into the challenges and opportunities associated with residential water reuse practices, including greywater reuse. This insight provided impetus to undertake further research and development to develop appropriate technologies and public acceptance strategies to enable progressive implementation of residential water reuse and recycling practices. For example, more attention must be placed on technologies that can produce effluent of higher aesthetic

quality. Additionally appropriate technologies must minimize maintenance requirements and offer more cost-effective alternatives to homeowners. The process of technology development must also include shared and community-based systems. The University of Guelph in partnership with the City of Guelph, Viqua, Veritec Consulting, Guelph Chamber of Commerce and three builders, was recently awarded research funding for a two-year project to develop appropriate technology for residential water reuse in Ontario. This project will build on the outcome of the Greywater Field Testing project and will contribute to building capacity in developing and implementing sustainable water and wastewater management practices.

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This field test was carried out with assistance from the Green Municipal Fund, a Fund financed by the Government of Canada and administered by the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors, and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.