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ANALYSIS OF THE ENVIRONMENTAL ADVANTAGES

OF THE BLUEWATER RECYCLER TRUCK

Final
Report

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Abstract

The objective of this study was to investigate and quantify the magnitude of the following advantages of the bluewater[TM] Recycler Truck -- a unique pumping and liquid-solid separating system called the Juggler[TM]: 1) increased productivity and decreased "carbon footprint", and 2) reduced export of local water resources. These objectives were met through literature review, data compilation and quantitative analysis. Of these two effects, the biggest environmental benefit of the Juggler[TM] technology over that of a conventional pumper is in the reduction in CO_2 emissions, the so-called "carbon footprint". Compared with traditional septic-pumping technology, Juggler[TM] technology was estimated to reduce the carbon emission for residential operations by 49 to 54% (from 58.89 kilograms of CO_2 per site for a conventional pumper to 30.14 or 26.85 kilograms of CO_2 per site, depending on the length of the work day, for the Juggler[TM]), and for commercial operations, by 60% (from 51.96 to 20.79 kilograms of CO_2 per site). Juggler[TM] technology, because it returns more than 95% of the extracted supernatant to the septic tank, also retains an estimated 24 to 33.5 million gallons of water in local aquifers that is now removed on Cape Cod (the geographic area considered in this study).

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1.0 Introduction

Nearly one in four households in the United States depends on an individual septic system or small community cluster system to treat wastewater. An estimated 10 to 20 percent of those systems malfunction each year causing pollution problems and public health threats. The difference between failure and success is the implementation of an effective wastewater management program. Such a program, if properly executed, can protect public health, preserve valuable water resources, and maintain economic vitality in a community (USEPA, 2008).

1.1. The Septic System

A septic tank is an underground engineered tank consisting of single or multiple units, together with one or more connecting piping systems installed in appropriate soils to receive wastewater flow from one or more residences or public buildings. Primary treatment of wastewater occurs in the septic tank and includes both physical and biological processes. Physical processes involve the decantation of larger solid particles from the wastewater; the denser solids sink to the bottom and form sludge, while the lighter solids float to the surface, forming a scum. Biological processes occur in the anaerobic (oxygen-deficient) zone within the septic tank. A microbiological community of anaerobic digesters develops within the septic tank and degrades the organic waste. Secondary treatment processes occur outside of the tank after the wastewater has been discharged into the receiving soils. Secondary treatment is not discussed in this report.

Primary wastewater treatment efficiency is directly related to the length of time that the wastewater is detained within the septic tank (known as detention or contact time). A properly sized tank should have at least a 24-hour fluid detention time at maximum sludge depth and scum accumulation (USEPA, 1980). A three-bedroom house with four occupants and no water-saving fixtures would require a 1,000-gallon septic tank (USEPA, 2000). Up to 50 percent of the solids retained in the tank decomposed, while the remainder accumulate as sludge at the tank bottom and must be removed periodically by pumping the tank (USEPA, 2000). Sludge and scum accumulate in the septic tank at rates of about 40 liters (11 gallons)/person/year (Wilhelm et al., 1994). As the sludge level increases, wastewater detention time decreases, and solids are more likely to escape into the absorption area and cause clogging and eventual failure of the septic system. To keep a septic tank system operating efficiently, the tank should be pumped periodically.

1.2. The bluewater^{TM} Recycler Truck

The conventional method for septic tank maintenance involves the complete removal of both floating and settled solids, as well as the liquid supernatant, from the septic tank into a single-compartment vacuum truck. As a consequence, the microbial community is also removed and the treatment efficiency hampered until a new community of anaerobic digesters can grow and acclimate within the tank. Additionally, by these conventional methods, the entire contents of each tank are transported to and discharged at a wastewater treatment facility (WWTF). The bluewater^{TM} Recycler Truck utilizes an innovative new technology that returns more than 95% of the supernatant to the septic tank and transports and discharges a more concentrated septage to the WWTF.

Leblanc and Blais (2002) described several on-site process technologies that have been developed to increase the efficiency of septic tank maintenance by returning the supernatant to the tank. They reported that these technologies ranged from the unnecessarily complex (centrifugal dehydration) to the inadequate (manual separation of solids and liquids into a dual-compartment truck). The primary purpose of this 2002 study, however, was to quantify the performance efficiency of the emerging technology utilized by the bluewater™ Recycler Truck -- a unique pumping and liquid-solid separating system called the Juggler™. Juggler™ technology is built upon a dual-compartment configuration, but also includes an integrated physical and mechanical treatment unit (Michaud, 2003). Reductions of biological and chemical oxygen demand, suspended material and total kjeldahl nitrogen in the supernatant returned to the septic tank using the Juggler™ technology were reported to be 92 to 98% by Leblanc and Blais (2002) and Blais et al. (2003). Recent innovations have reportedly increased the removal efficiency of to 99.98% (Labrie, 2008).

The Juggler™ is the first system to be approved by the National Sanitation Foundation International to meet its stringent Protocol P340 for septic tank or grease trap solid and liquid separating devices (NSF International, 2008). The Juggler™ has also been approved by the Massachusetts Department of Environmental Protection for use in maintaining Title 5 septic systems that are not in failure (Ferris, 2007).

1.3. Juggler™ Technology

The core of Juggler™ technology is a specialized filter that provides the final polishing of the supernatant as it is returned to the septic tank. This filter, formerly known as the Ultrasonic Solid Separation Unit (USSU™), was invented by Tony Vachon in the mid 1990s. This rotating self-cleaning filter operated at approximately 130 gallons per minute (GPM) and rejected solids greater than 60 microns while allowing microbial flora to remain in the filtrate (personal communication, Lamarche, 2008).

Tony and Erik Vachon, operating as Groupe SNS (Service Nettoyage Sanitaire) Inc., applied the USSU™ technology to various configurations of dual-compartment vacuum trucks with increasing success. By 2002, the Juggler™ had evolved into a viable and award winning technology. Groupe SNS received several awards for the Juggler™ including the Concours québécois en entrepreneurship (Quebec Entrepreneurship Contest) in 1999, Grand Prix québécois de l'invention (Quebec Inventors Grand Prize) in 2000, and Prix de l'Innovation du Carrefour des nouveautés at the Salon des technologies environnementales du Québec (Crossroads of Innovations Prize) in 2002 (Michaud, 2003).

In 2003, Groupe SNS began collaboration with, and eventually was purchased by, Labrie Environmental Group (Labrie), a solid waste equipment manufacturer. Prior to this, aside from filter-specific improvements, Juggler™ technology had evolved by adapting existing vacuum truck configurations to support the potential of the filter. By combining Labrie's truck building experience with Juggler™ technology, a new paradigm emerged which allowed the filter's potential to drive the design of the vehicle (personal communications, Vachon, 2008 and Lamarche, 2008). Juggler™ technology in 2008 is both robust and mature, and manifests throughout the vehicle and its complimentary components. Specific Juggler™ features related to the study objectives are discussed throughout this report. Pictures obtained during a February 2008 plant visit are presented in Appendix A.

2.0 Objectives of this report

The objective of this proposed study was to investigate and quantify the magnitude of the following advantages of the Juggler™ system as well as to demonstrate other advantages and/or potential disadvantages that may be discovered.

- **Increase productivity and decreased "carbon footprint"**

  Compared to a single-compartment septage storage vehicle, more septic tanks can be serviced per truckload because 50-70% of the contents are returned to the septic tank thereby reducing the cost of transporting the waste, the "carbon footprint" of bluewater™ and the septage load at the wastewater treatment facility.

- **Reduced export of local water resources**

  Less water is removed from the septic tank and transported to a wastewater treatment facility, potentially meaning that less water is exported from the local watershed.

These objectives were met through literature review, data compilation and quantitative analysis. This report outlines the results of this evaluation.

3.0 Analysis of Carbon Footprint

The carbon footprint of an activity is a measure of the total mass of carbon dioxide (CO_2) emissions that is directly and indirectly caused by the activity (Wiedmann and Minx, 2007). Direct emissions of CO_2 caused by Juggler™ technology are smaller than those directly caused by conventional technologies because Juggler™ requires fewer trips to the WWTF. Fewer trips results in less distance driven, less fuel consumed, and lower CO_2 emissions.

3.1. Objectives

The goal of this study was to quantify and compare the carbon footprints due to the daily activities of the Juggler™ septic pumper and a conventional pumper. Two operational scenarios were evaluated: residential septic tank maintenance and commercial fats, oil and grease (FOG) interceptor maintenance. Hypothetical study areas were developed to provide simplified and standardized, yet realistic, representations of typical operational activities for a single day. Total daily emissions were normalized by the number of sites serviced in a day to provide a carbon footprint for the typical operation at one residence or one food service facility. Although not quantified, other features of the Juggler™ that potentially serve to decrease it's carbon footprint are also presented, including the “RPM manager,” the ability to utilize the maximum capacity of the sludge tank, increased payload due to aluminum materials (rather than steel), and the hydraulically-powered jetter. The potential for lower indirect emissions from the Juggler's positive-displacement blower are also considered.

3.2. Scenarios

Two hypothetical scenarios were used for this evaluation. For the residential operations, the characteristics representing a generic suburban town are shown in Table 1. For the commercial operations, the characteristics representing a generic suburban retail mall are also presented in Table 1. Mileage and time estimates and other details are provided in Tables 2 through 6.

Table 1: Summary of Hypothetical Scenarios Characteristics

Characteristic	Residential	Commercial	Comments
Study Area	Suburban Community	Retail Mall	Septic tanks in residential areas; FOG interceptors associated with food service businesses in mall
Distance from Motor Pool (Shop)	25 miles	25 miles	Assumes all sites are located the same distance from shop
Location of WWTF	25 miles	25 miles	Assumes WWTF is located 25 miles away from sites in opposite direction from shop
Tank Contents	Septage	FOG	
Site to Site Travel distance	5 miles	n/a	Assumes all residential sites are located the same distance from each other. Assumes all commercial sites are adjacent.

3.3. Methods

Time and mileage estimates were based on suggestions by Robert Lamarche, Juggler™ National Sales and Product Manager of Labrie (personal communication, Jan 30, 2008) and are based on business experience. Total distance traveled in one work day was calculated for each technology (Juggler™ vs. conventional) for each scenario. For both technologies, 30 minutes was allowed on-site for each residential tank and 10 minutes (5 miles at 30 miles per hour) was allowed for travel from one residential site to the next. For commercial sites, a total of 35 minutes was allowed at each interceptor; this time includes nominal travel time between traps. Commercial activities were assumed to occur between 2AM and 9AM, which is typically downtime for food service establishments and a time when traffic interference is minimal.

We assumed that a conventional pumper could service a maximum of 3 sites per trip to the WWTF (three 1,000 gallon septic tanks completely full), whereas the Juggler™ could service a maximum of 12 sites (3,600 gallon sludge tank with 300 gallons retained per site; Robert Lamarche, personal communication, March 28, 2008). Because the maximum of 12 sites serviced by the Juggler™ does not allow for any incidental additional volume of sludge at any site, calculations were also performed for a residential scenario that assumes a more conservative 10-site capacity of the Juggler™ system. Commercial activities were limited primarily by the shorter 2AM to 9AM opportunity window. For both technologies, one hour was allowed for discharge and queued idle time at the WWTF. CO_2 emissions during idle time and during on-site pumping were not quantified.

3.4. Results

The total distance traveled in a day for each technology was used to calculate the daily CO_2 emissions for each scenario. Fuel mileage for the Juggler™ and the conventional pumper was assumed to be a constant 5 miles per gallon of diesel fuel. A conversion factor of 10.39 kilograms CO_2 per gallon (Cross, 2005) was used to convert the volume of diesel fuel used into the mass of CO_2 emitted. This conversion factor was based on a published emissions factor for transportation fuels (IPCC, 1997). Daily CO_2 totals were normalized by the number of sites serviced in a day. Mileage and time estimates for each technology and each scenario are tabulated in Tables 2 through 6.

Table 2: Operational Times and Mileage for Residential Septic Tank Service using Juggler™ Technology

Activity	Start Time	Minutes	Miles	Comments
Mobilization	7:00 AM	20	0	
Travel to first customer	7:20 AM	30	25	Assumes entire trip on highway @ 50 mph
Customer 1 + travel to next	7:50 AM	40	5	Assumes 30 minutes per site + 10 minutes between sites @ 30 mph average
Customer 2 + travel to next	8:30 AM	40	5	
Customer 3 + travel to next	9:10 AM	40	5	
Customer 4 + travel to next	9:50 AM	40	5	
Customer 5 + travel to next	10:30 AM	40	5	
Customer 6 + travel to next	11:10 PM	40	5	
1/2 hour lunch break	11:50 PM	30	0	Assumes no additional travel miles
Customer 7 + travel to next	12:20 PM	40	5	
Customer 8 + travel to next	1:00 PM	40	5	
Customer 9 + travel to next	1:40 PM	40	5	
Customer 10	2:20 PM	30	0	
Travel, queue and discharge to WWTF	2:50 PM	90	25	Assumes entire trip on highway @ 50 mph average and one hour for queue and discharge at WWTF, and WWTF is located in opposite direction from shop
Return to shop from WWTF	4:20 PM	60	50	Assumes entire trip on highway @ 50 mph average
Demobilization	5:20 PM	10	0	
End of 10-hour work day	5:30 PM	n/a	n/a	
	TOTALS	**10 hrs**	**145**	

Table 3: Operational Times and Mileage for Residential Septic Tank Service using Juggler™ Technology and maximizing Juggler™ storage capacity

Activity	Start Time	Minutes	Miles	Comments
Mobilization	7:00 AM	20	0	
Travel to first customer	7:20 AM	30	25	Assumes entire trip on highway @ 50 mph
Customer 1 + travel to next	7:50 AM	40	5	Assumes 20 minutes per site + 10 minutes between sites @ 30 mph average
Customer 2 + travel to next	8:30 AM	40	5	
Customer 3 + travel to next	9:10 AM	40	5	
Customer 4 + travel to next	9:50 AM	40	5	
Customer 5 + travel to next	10:30 AM	40	5	
Customer 6 + travel to next	11:10 AM	40	5	
1/2 hour lunch break	11:50 PM	30	0	Assumes no additional travel miles
Customer 7 + travel to next	12:20 PM	40	5	
Customer 8 + travel to next	1:00 PM	40	5	
Customer 9 + travel to next	1:40 PM	40	5	
Customer 10 + travel to next	2:20 AM	40	5	
Customer 11 + travel to next	3:00 PM	40	5	
Customer 12	3:40 PM	30	0	
Travel, queue and discharge to WWTF	4:10 PM	90	25	Assumes entire trip on highway @ 50 mph average, one hour for queue and discharge at WWTF, and WWTF is located in opposite direction from shop
Return to shop from WWTF	5:40 PM	60	50	Assumes entire trip on highway @ 50 mph average
Demobilization	6:40 PM	20	0	10 additional minutes added to round out workday to 7:00PM; does not affect calculations
End of 10.5-hour work day	7:00 PM	n/a	n/a	
	TOTALS	**11.5 hrs**	**155**	

Table 4: Operational Times and Mileage for Residential Septic Tank Service using Conventional Technology

Activity	**Start Time**	**Minutes**	**Miles**	**Comments**
Mobilization	7:00 AM	20	0	
Travel to first customer	7:20 AM	30	25	Assumes entire trip on highway @ 50 mph
Customer 1 + travel to next	7:50 AM	40	5	Assumes 30 minutes per site + 10 minutes between sites @ 30 mph average
Customer 2 + travel to next	8:30 AM	40	5	
Customer 3	9:10 AM	30	0	Assumes maximum 3 sites to reach sludge tank capacity
Travel, queue and discharge to WWTF	9:40 AM	90	25	Assumes entire trip on highway @ 50 mph average, one hour for queue and discharge at WWTF, and WWTF is located in opposite direction from shop
1/2 hour lunch break	11:10 PM	30	0	Assumes no additional travel miles
Return to fourth customer from WWTF	11:40 PM	30	25	Assumes entire trip on highway @ 50 mph
Customer 4 + travel to next	12:10 PM	40	5	
Customer 5 + travel to next	12:50 PM	40	5	
Customer 6	1:30 PM	30	0	
Travel, queue and discharge to WWTF	2:00 PM	90	25	
Return to shop from WWTF	3:30 PM	30	50	Assumes entire trip on highway @ 50 mph
Demobilization	4:30 PM	30	0	20 additional minutes added to round out workday to 6:00PM; does not affect calculations
End of 9.5-hour work day	5:00 PM	n/a	n/a	
	TOTALS	**9.5 hrs**	**170**	

Table 5: Operational Times and Mileage for Commercial FOG Interceptor Service using Juggler™ Technology

Activity	Start Time	Minutes	Miles	Comments
Mobilization	1:30 AM	20	0	
Travel to mall	1:50 AM	30	25	Assumes entire trip on highway @ 50 mph average
Customer 1	2:20 AM	35	0	Assumes 35 minutes per site and nominal travel time to next site
Customer 2	2:55 AM	35	0	
Customer 3	3:30 AM	35	0	
Customer 4	4:05 AM	35	0	
Customer 5	4:40 AM	35	0	
1/2 hour food break	5:15 AM	30	0	Assumes no additional travel miles
Customer 6	5:45 AM	35	0	
Customer 7	6:20 AM	35	0	
Customer 8	6:55 AM	35	0	
Customer 9	7:30 AM	35	0	
Customer 10	8:05 AM	35	0	
Travel, queue and discharge to WWTF	8:40 AM	90	25	Assumes entire trip on highway @ 50 mph average, one hour for queue and discharge at WWTF, and WWTF is located in opposite direction from shop
Return to shop from WWTF	10:10 AM	60	50	Assumes entire trip on highway @ 50 mph average
Demobilization	11:10 AM	20	0	10 additional minutes added to round out workday to 11:30AM; does not affect calculations
End of 9.5-hour work day	11:30 AM	n/a	n/a	
	TOTALS	**9.5 hrs**	**100**	

Table 6: Operational Times and Mileage for Commercial FOG Interceptor Service using Conventional Technology

Activity	**Start Time**	**Minutes**	**Miles**	**Comments**
Mobilization	1:30 AM	20	0	
Travel to mall	1:50 AM	30	25	Assumes entire trip on highway @ 50 mph average
Customer 1	2:20 AM	35	0	Assumes 35 minutes per site and nominal travel time to next site
Customer 2	2:55 AM	35	0	
Customer 3	3:30 AM	35	0	Assumes maximum 3 sites to reach sludge tank capacity
Travel, queue and discharge to WWTF	4:05 AM	90	25	Assumes entire trip on highway @ 50 mph average, one hour for queue and discharge at WWTF, and WWTF is located in opposite direction from shop
1/2 hour food break	5:35 AM	30	0	Assumes no additional travel miles
Return to fourth customer from WWTF	6:05 AM	30	25	
Customer 4	6:35 AM	35	0	
Customer 5	7:10 AM	35	0	
Customer 6	7:45 AM	35	0	
Travel, queue and discharge to WWTF	8:20 AM	90	25	
Return to shop from WWTF	9:50 AM	60	50	Assumes entire trip on highway @ 50 mph average
Demobilization	10:50 AM	10	0	
End of 9-hour work day	11:00 AM	n/a	n/a	
	TOTALS	**9 hrs**	**150**	

For the residential scenario, the Juggler™ services 10 sites and travels 145 miles, or services 12 sites and travels 155 miles, and the conventional pumper services 6 sites and travels 170 miles. For the commercial scenario, the Juggler™ services 10 sites and travels 100 miles, while the conventional pumper services 6 sites and travels 150 miles. For all scenarios, the Juggler™ makes only one trip per day to the WWTF while the conventional pumper makes two trips per day.

The scenario results are tabulated and compared in Table 7. Compared with traditional septic-pumping technology, Juggler™ technology was estimated to reduce the carbon emission for residential operations by 49% to 54%, and for commercial operations, by 60%.

Table 7: Comparison of Carbon Dioxide Emissions for Juggler™ and Traditional Septic Pumping Technologies

	Residential			Commercial	
	Juggler™		Conventional	Juggler™	Conventional
Daily travel miles	145	155	170	100	180
Daily sites visited	10	12	6	10	6
Mileage per site	14.5	12.9	28.3	10	25
CO_2 Emitted (kilograms) per site	30.14	26.85	58.89	20.79	51.96
Reduction in CO_2 emission for Juggler™ over conventional	49%	54%		60%	

3.5. Other Juggler™ "carbon friendly" features

Other features of the Juggler™ that serve to reduce carbon emissions include the "RPM manager," the ability to utilize the maximum capacity of the sludge tank, and an increased payload through the use of aluminum. Although carbon emissions are not quantified, the potential benefits of each of these features are discussed below (personal communications, Vachon, 2008 and Lamarche, 2008).

3.5.1. The RPM Manager

A positive-displacement blower (blower) is a pneumatic device designed for moving large volumes of air at either pressure or vacuum. The Juggler™ uses a blower primarily for vacuum-powered operations, and occasionally for pressure-powered operations. The Juggler's blower is powered by a driveshaft connected to the vehicle's engine; the speed of an engine is typically measured in revolutions per minute (RPM). The RPM manager is an electromechanical control device that varies the engine speed during blower operation. Using feedback from the blower system, the Juggler's RPM manager raises or lowers the engine speed appropriately. During operational periods when the RPM manager has lowered the idle speed of the vehicle's engines, less CO_2 is emitted compared to periods where the idle speed is increased to maintain sufficient vacuum or pressure. A conventional pumper system does not typically have an RPM manager and hence runs at high RPM during the entire pumping process.

3.5.2. Maximizing the Capacity of the Sludge Tank

Juggler™ technology includes two specific design features that allow the vehicle operator to utilize the maximum capacity of the sludge tank: the location of the primary shut-off valve and the externally-mounted visual sludge-level indicators. The primary shut-off valve is a normally-open floating ball valve located at the top of the sludge tank that functions as a mechanical safety device. When the height of sludge in the tank increases to a certain level, the ball floats up and mechanically blocks the valve orifice, thus placing the valve into a closed state. When closed, the valve effectively disables the vacuum pumping of sludge and, more importantly, prevents the sludge from overflowing the tank. Under typical operating conditions, this safety valve is rarely activated. However, the sludge height necessary to close this valve represents the absolute maximum capacity of the sludge tank. On conventional septage-pumping vehicles, the primary shutoff valve is mounted inside the sludge tank, below the top of the tank. Therefore, when the sludge is high enough to close the valve, the top of the sludge is located at a distance from the top of the tank approximately equal to the height of the mounted valve mechanism. With this type of configuration, there is a volume of at the top of the tank that is unusable. The primary shutoff valve on the Juggler™ is mounted outside, above the top of the tank. Therefore, the Juggler's primary shutoff valve will typically only engage when the tank has reached full capacity. Anytime this extra sludge volume capacity is utilized, the Juggler's carbon emissions are lower than the conventional pumper because the Juggler™ can collect larger volumes of sludge before traveling to the WWTF.

The externally-mounted visual sludge-level indicators are small removable transparent windows mounted on the top of the front sidewall of the sludge tank. One window is located at a height that allows the operator to judge if the sludge tank is near full. The other window allows the operator to judge if the tank is completely full. This design feature can potentially lower the Juggler's carbon emissions by facilitating the maximization of the Juggler's sludge carrying capacity.

3.5.3. Aluminum Vehicle Construction

The Juggler's pressure vessel (collectively the sludge and supernatant tanks) is constructed with aluminum. Many other components of the Juggler™ are constructed with aluminum as well. Compared to a conventional steel pressure vessel of equal size, the Juggler™ tank is lighter due to the lower density of aluminum. This lowers the weight of the vehicle, and therefore CO_2 emissions due to better fuel economy. Alternately, a larger-volume aluminum pressure vessel could be installed and the end product would be a vehicle with the same weight as a conventional pumper, but with increased sludge capacity, also meaning fewer trips to the WWTF. Each of these design features serve to lower the Juggler's carbon emissions.

3.5.4. Hydraulically-Powered Jetter

Conventional septage-pumping vehicles are equipped with a gasoline-powered high-volume pressure washer (jetter). A jetter is used to clean the sidewalls of the septic tank after pumping is complete. The Juggler's jetter is powered by hydraulic power generated whenever the vehicle's engine is operating. Although the hydraulic power is generated indirectly by the combustion of diesel fuel, there may be a quantifiable difference in CO_2 emissions between these two technologies and that difference may serve to lower the Juggler's carbon emissions. Emissions from either type of jetter technology were not quantified in this study.

3.5.5. "Environmentally Friendly" Blower Emissions

Conventional septic-pumping vehicles generate vacuum power using a rotary vane pump. However, rotary vane pumps operate at high temperature and require a constant flow of lubricating oil that also functions as a pneumatic seal. When these pumps are operated on conventional septage-pumpers, blue smoke is generated (personal communication, Tony Vachon, Feb 2008). This smoke is likely generated by the incomplete combustion of the lubricating oil and represents an emission source. Although these emissions may be primarily particulate in nature, there is likely a quantifiable mass of CO_2 being emitted, as well as other greenhouse gases and pollutants. The Juggler's blower requires only a nominal volume of lubricating oil and the design of the blower does not allow combustion of the lubricating oil.

3.6. Conclusions

Representative carbon footprints due to the direct activates of Juggler™ technology and conventional technology were quantified. These values were used to compare the technologies for residential septic tank maintenance and commercial FOG interceptor maintenance. Typical operational activities for a single day were represented using simplified and standardized yet realistic hypothetical study areas. Total daily emissions were normalized by the number of sites serviced to provide a carbon footprint for a typical operation at one residential or commercial site. Juggler™ technology was estimated to decrease the carbon footprint of residential operations by 49 to 54%% and of commercial operations by 60%.

Other features of the Juggler™ that serve to decrease it's carbon footprint were discussed, including the “RPM manager,” the ability utilize the maximum capacity of the sludge tank, increased fuel efficiency due to aluminum construction, and the hydraulically-powered jetter. The Juggler's use of a regenerative blower compared to a standard vane pump likely lowers the quantity of environmental pollutants.

4.0 Supernatant recycling

Wastewater recycling is a water saving technique that is gaining acceptance, especially in water-stressed regions. The transport of septic tank supernatant to a WWTF can remove water from local water resources if the WWTF is outside of the source watershed or aquifer system or when it discharges effluent into rivers or bays. Because Juggler™ technology returns more than 95% of the extracted supernatant to the septic tank, water is recycled and remains within the source area.

4.1. Objectives

The goal of this study was to quantify the potential water saving benefits of the Juggler™ technology. This was done by estimating the total volume of water removed by conventional septic pumping and transported to a local wastewater treatment facility (WWTF). Secondary benefits associated with Juggler™ technology are also discussed including lowering the total volume of material discharged at a WWTF and eliminating the need for potable water as part of the septic tank maintenance activity.

4.2. Study Area

Cape Cod, Massachusetts (the Cape), was selected as the study area because it is well defined geographically and because of the unique and sensitive groundwater resources on the Cape. The aquifer system on the Cape is comprised of six individual groundwater flow cells (GFC) as presented on Figure 1. Each of these GFCs is an isolated lens of fresh groundwater bounded laterally by saltwater (Masterson and Barlow, 1997). Current concerns regarding these cells include lowering of the water table leading to, among other threats, an increased risk of saltwater intrusion into the groundwater aquifer.

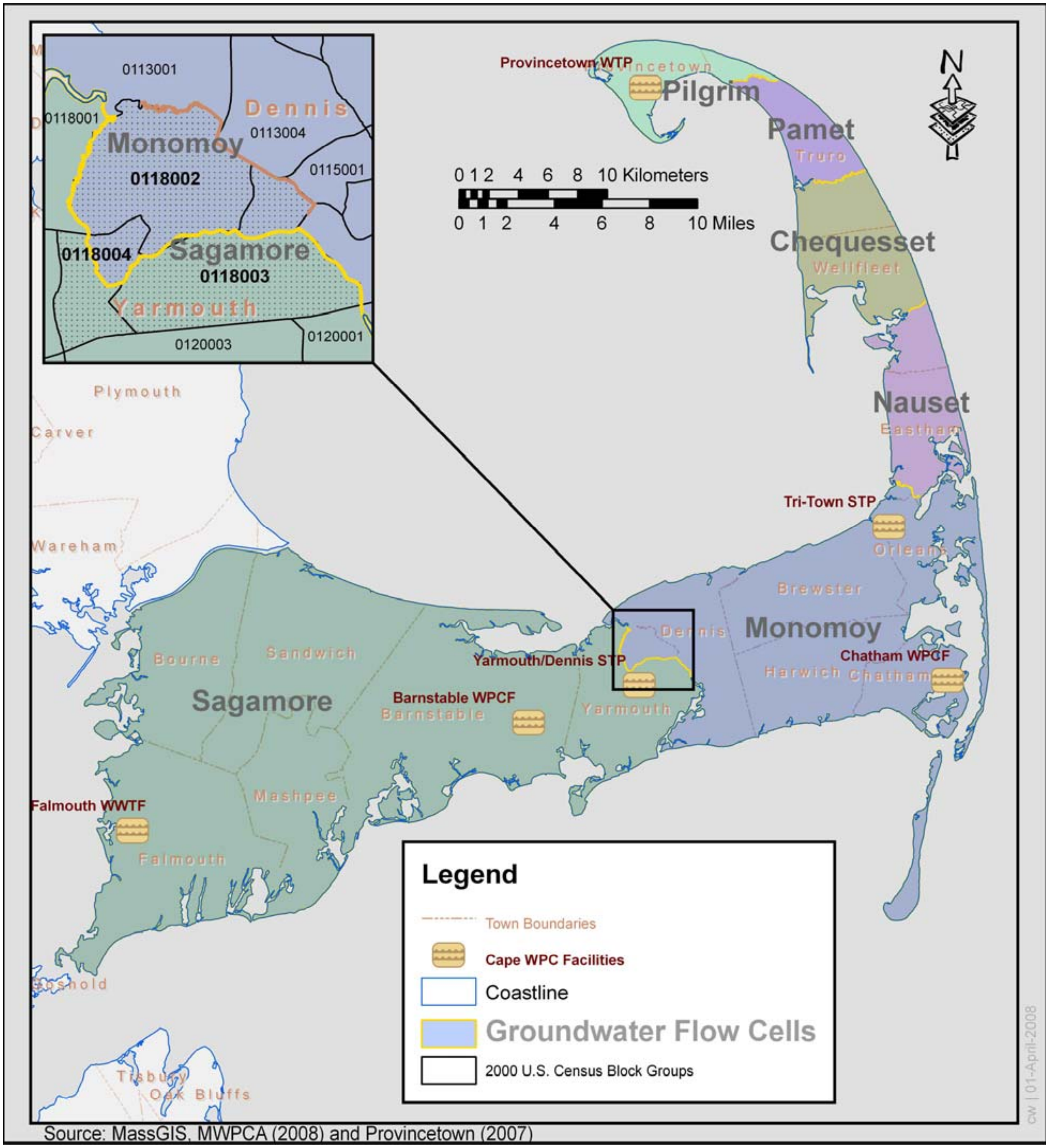

Figure 1 - Groundwater Flow Cells on Cape Cod, Massachusetts

4.3. Methods

A quantitative analysis was performed using Geographic Information Science (GIS) techniques to estimate the annual volume of supernatant pumped out of septic tanks within each GFC using conventional septic pumping technology. The volume pumped currently was estimated and the annual volume of supernatant that could potentially be retained in local aquifers was also estimated. Datasets used for this analysis were obtained from the Commonwealth of Mass. Executive Office of Environmental Affairs' Office of Geographic and Environmental Information (MassGIS) and included Administrative Boundaries, Physical Resources, Water Features and the 2000 United States Census.

The GFCs that comprise the Cape Cod Major Drainage Basin are presented on Figure 1 and listed below in Table 8. Table 8 also lists the towns that are located either entirely or partially within each GFC and the known WWTFs located within each GFC (MWPCA, 2008 and Provincetown, 2007).

Table 8: Groundwater Flow Cells (GFC) and Wastewater Treatment Facilities (WWTF) in the Cape Cod Major Drainage Basin

Groundwater Flow Cell	Size (miles)	Towns within GFC	Wastewater Treatment Facilities within GFC
Pilgrim	12.2	Provincetown, Truro	Provincetown STP[1]
Pamet	11.1	Truro	None
Chequesset	23.4	Truro, Wellfleet	None
Nauset	19.1	Wellfleet, Eastham	None
Monomoy	104	Eastham, Orleans, Brewster, Chatham, Harwich, Dennis	Tri-Town (Eastham, Orleans, Brewster) STP
			Chatham WPCF[1]
Sagamore	232	Yarmouth, Barnstable, Sandwich, Bourne, Mashpee, Falmouth	Yarmouth/Dennis STP
			Barnstable WPCF
			Falmouth WWTF

[1]STP denotes sewage treatment plant; WPCF denotes water pollution control facility.

The annual volume of supernatant pumped from septic tanks within each GFC using conventional methods was estimated by assuming that each housing unit in each GFC has one 1,000 gallon septic tank that is emptied once every three years. This assumption does not consider whether or not a specific housing unit is connected to a regional sewer system. A summary of the estimated annual volumes pumped is presented in Table 9. Of the total 47.9 million gallons (MG) that would be removed by conventional pumper technology, 50 to 70% (24 to 33.5 MG) is retained locally using Juggler™ technology.

Table 9: Comparison of annual volumes of supernatant pumped using conventional technology vs. annual volume of water processed by WWTFs in the Cape Cod Major Drainage Basin

Groundwater Flow Cell(s)	WWTF(s) In GFC	Total Housing Units	Supernatant Pumped (MGY)[1]
Pilgrim, Pamet, Chequesset	Provincetown WTP	9,498	3.17
Nauset, Monomoy	Tri-Town STP Chatham WPCF	50,527	16.8
Sagamore	Yarmouth/Dennis STP Barnstable WPCF Falmouth WWTF	83,636	27.9
		Total	**47.9**

[1]MGY denotes million gallons per year

4.4. Secondary benefits

As discussed in the carbon footprint evaluation, Juggler™ technology generates approximately one third fewer trips to the WWTF when compared to conventional methods. Due to the relatively high water content (95 to 97.5%) of the sludge collected using Juggler™ technology, the overall consistency and density of the material discharged at the WWTF is not considered by WWTF operators to be significantly different than that discharged by conventional methods (personal communication, Robert Lamarche, Jan 30, 2008). By normalizing the volume of material delivered by the number of septic tanks serviced, conventional technologies deliver approximately three times the volume of material to the WWTF per septic tank. If this multiplier is considered by, for example, a town planner or engineer, the use of Juggler™ technology within that town could potentially lower the need for the expansion of WWTF capacity.

The Juggler's high-volume pressure washer (jetter) technology also contributes to the water efficiency of the technology. The source of water for the Juggler's jetter is the treated supernatant. Therefore, each time the jetter is used to clean the walls of the septic tank after pumping, water is being retained within the local groundwater system. On a conventional septage-pumping vehicle, the water-supply source for the jetter is a portable fresh-water reservoir attached to the vehicle

4.5. Conclusions

A quantitative evaluation of supernatant pumping was performed to determine if Juggler™ technology provides significant water saving value compared to the annual volume of water processed at the individual waste treatment plants in the study area. The results of this evaluation were that an estimated 47.9 million gallons of supernatant pumping volumes are now removed from Cape Cod aquifers annually using traditional methods, whereas 24 to 33.5 million gallons (50 to 70%) of this total would be left in the aquifers using Juggler™ technology.

Secondary benefits associated with Juggler™ technology include the potential value of a threefold decrease of total volume per septic tank of material discharged at a wastewater treatment facility. Another water recycling capability of the Juggler™

technology is the elimination of potable water as a requirement for septic tank maintenance activities.

5.0 Summary and Conclusions

The objective of this study was to investigate and quantify the magnitude of the following advantages of the bluewater™ Recycler Truck -- a unique pumping and liquid-solid separating system called the Juggler™: 1) increased productivity and decreased "carbon footprint", and 2) reduced export of local water resources. These objectives were met through literature review, data compilation and quantitative analysis. Of these two effects, the biggest environmental benefit of the Juggler™ technology over that of a conventional pumper is in the reduction in CO_2 emissions, the so-called "carbon footprint". Compared with traditional septic-pumping technology, Juggler™ technology was estimated to reduce the carbon emission for residential operations by 49 to 54% (from 58.89 kilograms of CO_2 per site for a conventional pumper to 30.14 or 26.85 kilograms of CO_2 per site, depending on the length of the work day, for the Juggler™), and for commercial operations, by 60% (from 51.96 to 20.79 kilograms of CO_2 per site). Juggler™ technology, because it returns more than 95% of the supernatant pumped from septic systems back to those systems, also retains an estimated 24 to 33.5 million gallons of water in local aquifers that is now being removed on Cape Cod (the geographic area considered in this study).

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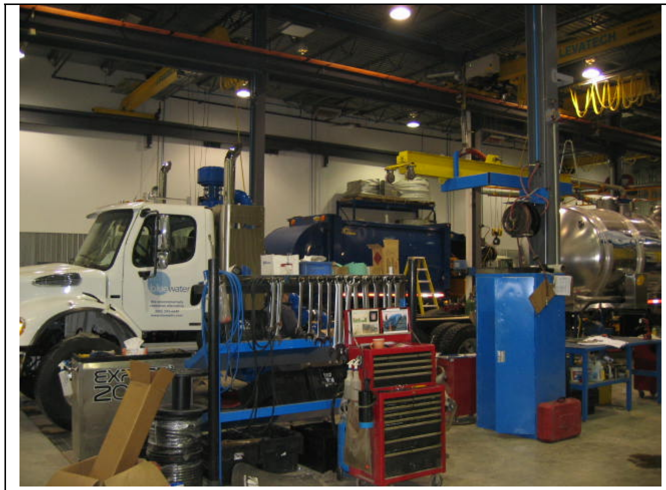
Appendix A

Juggler™ Plant Tour

Labrie Environmental Group, Saint-Nicolas, Canada

February 7, 2008



bluewater™ Recycler Truck in construction at Labrie's Juggler™ plant

bluewater™ Recycler Truck chassis and cab

The Juggler™ Filter

The Juggler™ Blower

The Juggler™ Pressure Vessel (front view)

The Juggler™ Pressure Vessel
(left side)

The Juggler™ Pressure Vessel
(rear view)

The Juggler™ Pressure Vessel
(right side)

The Juggler™ Team