CLEARFORD
WATER SYSTEMS INC.

Smart Sewage:
The Clearford One™

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Water Managed.

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1. Introduction

The vast majority of people in India live in rural villages, small towns and along the edges of India's ever growing cities. These places, despite appearing different, have many common features including:

1. Organic unplanned growth
2. Water supply below 70-90 Litres/Per Capita/Per Day (LPCD)

The reason wherever we go in India we see wastewaters flowing in open drains is that in the vast majority of India's Villages, Small Towns and along the peripheries of major cities there is inadequate water supply to move the solid component of sewage from its source to a sewage treatment facility.

A common solution - septic tanks and/or soak pits, are at best a short term solution as all they do is collect concentrated solid sewage in tanks while allowing the liquid component to either soak in and then travel underground or drain via open drains into nearby water bodies and nallahs (Figure 1).

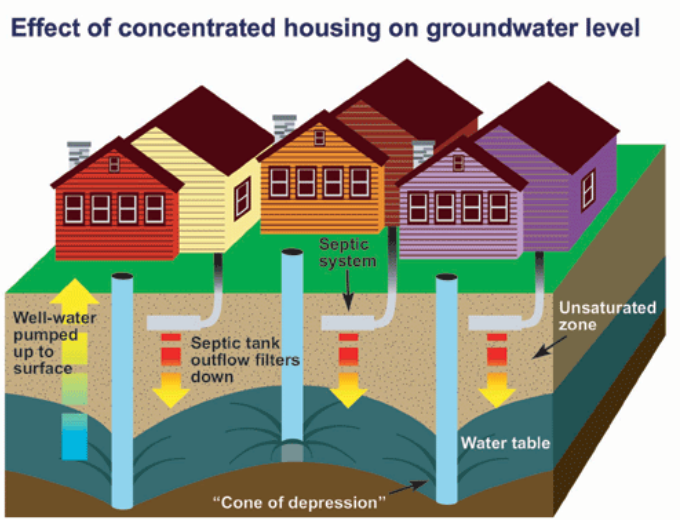

Figure 1: Sewage contamination caused by Septic Tanks/Soak Pits

In fact, even the solid sewage that is accumulated in them must frequently be drained (1-2 years) either via tankers or by the deplorable practice of manual scavenging and disposed of in fields or depressions from which rain or seepage will once again mix this concentrated sludge into water bodies. The idea that this waste can be reused as agricultural fertilizer ignores the fact that there are many social issues related to its handling which actively work against this solution. This in any case does not address the issue of other domestic wastewaters.

Clearford Water Systems Inc., a Canadian company, has spent twenty five years developing its unique, proprietary sewage collection, treatment and recycling system to tackle this very issue of how to deploy sewerage networks in areas of low water supply and help mitigate the tremendous loss of life and wastage of income earning opportunity caused by illness. The Clearford One solution works on the principle of decentralized sewage collection and has three major components: underground ClearDigest™ Smart Digester tanks, a ClearConvey™ network of HDPE piping and an end of the line ClearRecover™ Sewage Treatment Plant (STP) dedicated to recycling as much of the water as possible and thus augmenting available water resources.

This step-by-step decentralized process offers many advantages over traditional sewerage collection and treatment systems and for the first time allows the deployment of sewage collection and treatment across Rural India and on the outskirts of urban areas and allows development strategies to have a real impact in in terms of overall community health in a sustainable manner that does not have to be recreated every few years. It also minimizes disruption of the community during installation and saves on annual Operating Costs.

2. Description of Proposed Servicing Solution

Clearford India Pvt. Ltd. on behalf of the various private and government organizations Designs, Builds, Operates and Maintains the Clearford One™ system to fully respond to the sanitation requirements of communities. It is envisioned that this model can be replicated globally to address Sanitation collection, treatment and reuse of wastewaters.

Principal Components of Clearford One™

Clearford One™ is comprised of three principal components: ClearDigest™, ClearConvey™ and ClearRecover™ (refer to Figure 2). Following is a brief summary of key elements of each component.

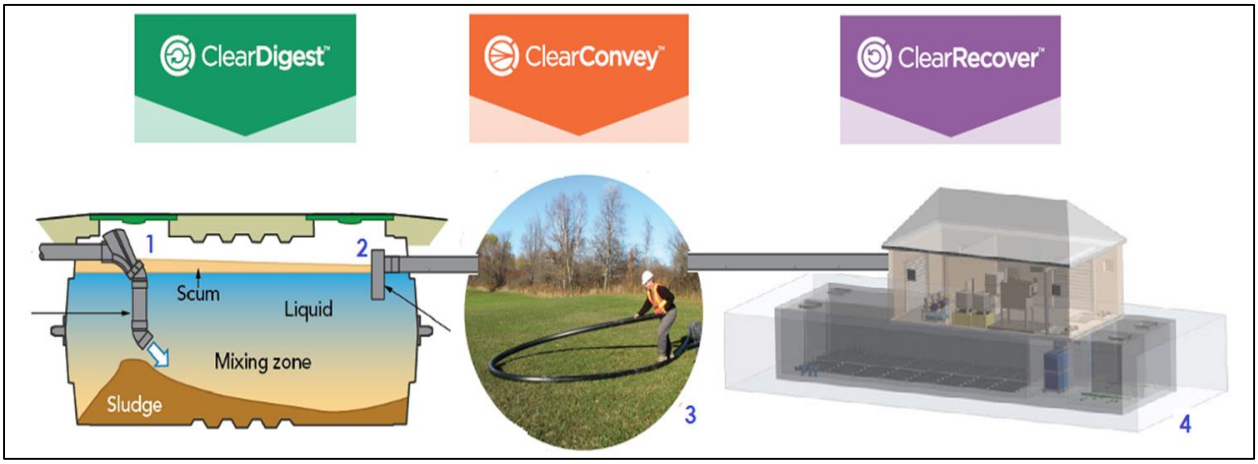

Figure 2: Clearford One™ Featuring ClearDigest™, ClearConvey™ and ClearRecover™

ClearDigest™ consists of interceptor tanks that receive all the wastewater from each connected source. ClearDigest™ tanks retain all solids, digest the biosolids, modulate the peak flow, and deliver solids-free effluent to the ClearConvey™ pipe network. A proprietary inlet device known as a Passive Hydraulic Mixer passively converts the hydraulic energy of the inflow entering the tank to maintain gentle mixing, which facilitates accelerated and extended digestion of biosolids. A proprietary outlet device known as a Peak Flow Attenuator allows the water level in the tank to increase during peak use while restricting the outflow from the tank to a predictable modulated rate.

Advantages of ClearDigest™:

- *Allow only solids-free effluent to enter ClearConvey™,*
- *Reduce system peak flows,*
- *Reduce maintenance cycle (extended period of operation prior to removal of undigested solids) of the ClearDigest™ tanks.*
- *Allows sewerage networks to be deployed in communities with low water supply below 135 LPCD.*
- *Eliminates sewage seeping into Groundwater and local water bodies as is common with currently used Soak Pits and Septic Tanks.*

ClearConvey™ is a network of small bore sewer (SBS®) pipes comprised of thermally-fused HDPE pipe and fittings forming a watertight system that connects ClearDigest™ with the ClearRecover™ treatment facility. ClearConvey™ is a small diameter variable grade gravity sewer system that if required can incorporate solids-free pumping stations as required by the local topography. ClearConvey™ maintenance is facilitated through system access points (SAPs) to allow flushing of the pipes, if required. Air circulation in the system is achieved through vented SAP caps. These SAP's are located at the start of every independent sewer line and thereafter at intervals of 80m – 250m as per requirements of the site.

Advantages of ClearConvey™:

- *Convey solids-free effluent to ClearRecover™,*
- *No manholes eliminating risk to life of sanitation staff,*
- *Quicker to install,*
- *Less staff required for maintenance,*
- *Thermally fused joint eliminating leakage and inflow and infiltration,*
- *Elimination of infiltration means that the STP size does not have to increase to handle the additional liquid load,*
- *Reduced peak flows means smaller diameter pipes,*
- *Protects groundwater, local water bodies and drinking water sources from contamination,*

ClearRecover™ receives the solids-free effluent from ClearConvey™ and treats it to the prescribed effluent discharge criteria of the Rajasthan Pollution Control Board and local reuse requirements. Here we are happy to offer you the option of either a Sequential Batch reactor (SBR) or a Soil Biotechnology Structured Wetland (SBT) type Wastewater Treatment Plant.

Advantages of ClearRecover™:

- *Effectively eliminate headworks and primary treatment process requirements,*
- *No Bar Screen requirement,*
- *Reduced Sludge Handling,*
- *Reduced consumption of electricity,*
- *Reduced consumption of chemicals,*
- *Reduced STP annual Operation and Maintenance costs.*

System Design Overview

Clearford One™ is designed as a complete wastewater servicing solution for communities. Each system is engineered to match the community's requirements based on site specific features like topography, local environment, soils and groundwater conditions and land use. Design parameters for ClearDigest™ and ClearConvey™ are established in the MOE NETE, Ontario, Canada Certificate for the Clearford SBS® system. Design of the ClearRecover™ treatment facilities also meets requirements as per the CPHEEO Guidelines in India.

Clearford One™ features two stages of wastewater treatment: decentralized primary and partial secondary treatment in distributed ClearDigest™ tanks, followed by final treatment at a centralized ClearRecover™ wastewater treatment plant (STP). Conveyance of wastewater is achieved through the ClearConvey™ small bore sewer network, which receives solids-free effluent from ClearDigest™ and delivers the effluent to ClearRecover™ with zero inflow and infiltration.

ClearDigest™ with primary settling and partial anaerobic digestion removes up to 80% of TSS and up to 75% of BOD from domestic wastewater. Nutrients and temperature of the effluent are similar to that of raw sewage conveyed by conventional gravity systems. Table 1 summarizes the estimated removal rates for pollutants resulting from pre-treatment in ClearDigest™ tanks.

Table 1: ClearDigest™ Performance – Removal Rates

Wastewater Quality Parameter	Percentage Removal(1)
COD	60-65%
BOD_5	65-75%
TSS	65-80%

Notes: (1) Based on range of operating data from existing Clearford installations

ClearDigest™ and ClearConvey™ deliver a consistent flow of pre-treated solids-free effluent to the ClearRecover™ STP, with significant reductions to peak and wet weather flows relative to conventional systems. These features allow for significant efficiencies in the treatment process, such as reduced headworks and primary treatment requirements and less organic loading for biological treatment than conventional systems. The result is reduced size of STP facilities and equipment, translating into capital cost savings and long term operating and maintenance cost efficiencies relative to conventional systems.

ClearDigest™ can be installed one tank per house or a shared tank between houses. Tanks can be located anywhere on the property or within the road allowance depending on municipal preference, space availability, house connections, and topography. As with conventional systems, ventilation is provided through the drainage pipe to the house connecting to the plumbing vent stack and there are no odours.

It is proposed to provide each household with a 2,000 litre ClearDigest™ tanks that will achieve greater than 2 days hydraulic retention time based on 5 persons/unit and the specified daily wastewater generation rates: 70-90 LPCD. The ClearDigest™ tank is designed to perform at-source primary treatment (solids removal) with partial secondary anaerobic treatment of sewage organics. Clearford will utilize either single-chamber manufactured tanks with proprietary inlet and outlet fittings or build the tanks in-situ at each location. The inlet fitting enhances digestion of organics, while the outlet fitting buffers the peak flow from the tank while also eliminating the passage of solid objects into the piping network. The volume of sludge production is expected to vary significantly from home to home based on occupancy and household habits. ClearDigest™ tanks digest organic solids at a higher rate than traditional septic tanks, minimizing sludge removal requirements. Depending on system design parameters, ClearDigest™ tanks typically operate between 10-20 years before requiring servicing.

A typical house connection consists of a standard sanitary drainage pipe (min. 2% slope) connecting to a ClearDigest™ tank, which is connected to the ClearConvey™ main via a lateral pipe (min. 0.20% slope). House connections are shallow (typically 0.3 to 1.2 m below grade) to accommodate the installation of the tank (refer to Figure 3).

Figure

Figure 3: Typical ClearDigest™ Service Cross-Section

ClearConvey™ pipes are not constrained by the minimum scouring velocity in conventional sewers because solids are removed at-source, effectively eliminating sewer blockages. Phasing of sanitary servicing is easily accommodated, as only the liquid portion of wastewater is conveyed through the pipe network. As a result, ClearConvey™ can be installed at very low gradients (minimum 0.20% slope) with a minimum cleansing velocity of 0.15 m/s, and with significantly smaller piping (minimum 90 mm diameter) than conventional gravity sewer systems. The depth for ClearConvey™ pipes is determined based on site conditions considerations as with conventional systems.

Access to the ClearConvey™ network is provided through System Access Points (SAPs) for flushing and CCTV inspection if desired. SAP's are small cleanout ports spaced throughout the collection network at approximately 100m intervals. Unlike conventional sewer systems, large concrete manholes are not required at pipe intersections and changes in pipe direction. SAPs are watertight to prevent inflow and infiltration, and allow for air circulation and venting in the pipe network to prevent the buildup of gases and hydraulic locks in the system.

Where pumping stations and forcemains are required, infrastructure requirements and operation are greatly simplified with solids-free effluent. Additionally, the sizing for pumps and forcemains is reduced as a result of smaller peak flows from the watertight ClearConvey™ network.

ClearRecover™ is an optimized treatment package that is designed to achieve site specific water recovery objectives. A key advantage of Clearford One™ is that the ClearRecover™ package is tailored for each project based on the site requirements and local availability of technologies. A number of wastewater treatment technologies are compatible with the Clearford One™ system; however, Clearford has identified several preferred treatment technologies that are reliable, effective, and cost efficient for the recovery of clean water.

The general selection criteria for wastewater treatment technologies are:

- Average, or typical, efficiency and performance of the treatment process: This is usually the criterion considered to be best in comparative studies. The possibility that the technology might remove other contaminants than those which were the prime target should also be considered an advantage.
- Reliability of the technology: The process should preferably be stable and resilient against shock loading, i.e., it should be able to continue operation and to produce an acceptable effluent under infrequent peak hydraulic and loading conditions.

- Application in reuse schemes: resource recovery contributes to environmental as well as to financial sustainability. It can include agricultural irrigation, industrial cooling and process water re-use, or low-quality applications such as toilet flushing. The use of generated sludges can only be considered as crop fertilisers or for reclamation if the micro-pollutant concentration is not prohibitive or the health risks acceptable.

- Regulatory determinants: local output standards as determined by reuse standards must be met.

Constructed wetlands are a promising technology for the removal of nutrients and certain pollutants from wastewaters, which utilizes the natural features of wetland vegetation, soil, substrate, and microbes to treat wastewater. Constructed wetlands are now widely accepted for use in treating a variety of wastewaters, including industrial and agricultural wastewater, landfill leachate, and stormwater runoff. A simple well-designed wetland can achieve a typical effluent quality of 30 mg/L of BOD and TSS, while even higher quality effluent can be achieved with more advanced designs.

Constructed wetlands are a cost effective and technically feasible approach to treating wastewater for several reasons:

- Wetlands can be less expensive to build than other wastewater treatment options;
- Operation and maintenance expenses are low in terms of energy and supplies;
- Operation and maintenance require only periodic, rather than continuous, on-site labour;
- Wetlands are able to tolerate fluctuations in flow rate;
- Wetlands can facilitate water reuse and recycling;
- Wetlands can be incorporated with landscaping and the natural environment;
- Wetlands are an environmentally sensitive approach to wastewater treatment that are viewed with favour by the general public.

There are two main configurations of constructed wetlands: free water surface wetlands and submerged flow wetlands. Free water surface wetlands have an exposed water surface above the filter media, as shown in Figure . This facilitates the transfer of oxygen from the atmosphere, which promotes aerobic biological treatment of the wastewater.

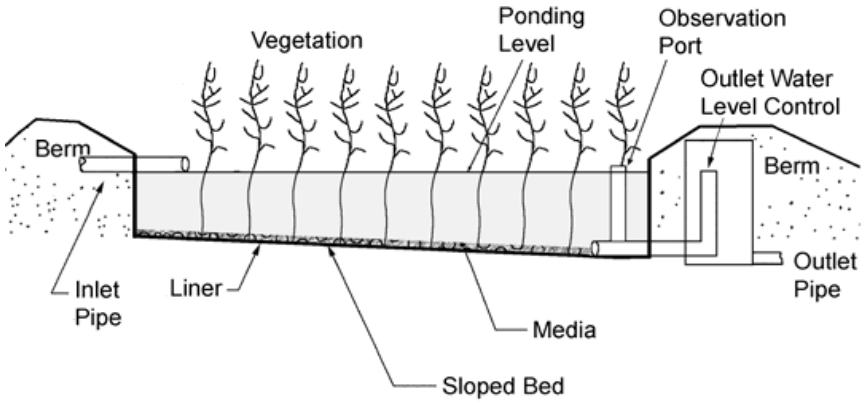

Figure 4: Typical Free Water Surface Constructed Wetland

Submerged or subsurface flow wetlands have the water surface below the top of the filter media, as shown in Figure 5. This configuration allows for maximum contact between the wastewater and microorganisms that grow attached to the submerged substrate surfaces.

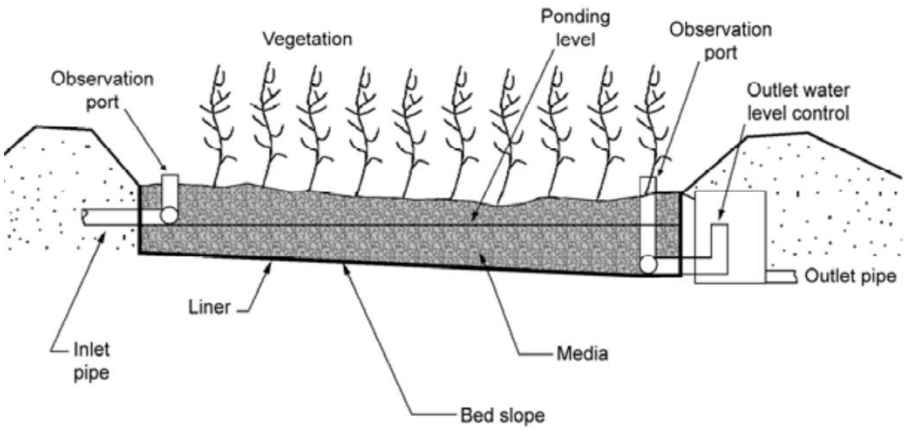

Figure 5: Typical Submerged Flow Constructed Wetland

Sequencing Batch Reactors (SBR) are a special form of activated sludge treatment in which all of the treatment process takes place in the same reactor tank, resulting in a compact and efficient treatment plant configuration. This process treats the wastewater in a batch mode, with each batch passing through a sequence of treatment steps, typically including fill, react, settle, decant and idle, as shown and described below. All phases of treatment are logically time-controlled. The actual cycle time will vary with the effluent results desired; for example, if only BOD reduction is desired, a cycle time of 3-6 hours may be used based on the organic loading rate. The effluent quality from a well-operated SBR plant is typically 20 mg/L of BOD and TSS with Total Nitrogen values as low as 10 mg/L. Additional filtering can reduce the TSS and BOD values to 10 mg/L.

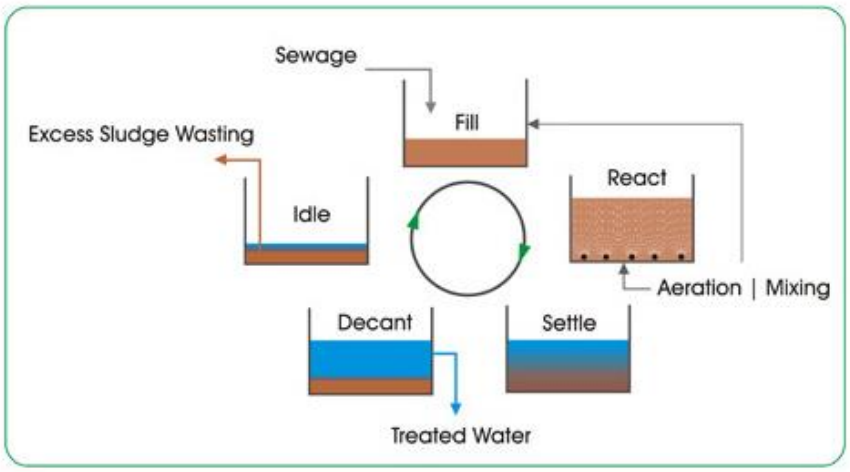

Figure 6: Sequencing Batch Reactor Typical Process Schematic

- ***Fill*:** The influent wastewater flows into the reactor vessel above the sludge blanket under anoxic or anaerobic conditions. Mixed liquor is drawn into the reactor through a manifold, and mixed with the influent wastewater. This initiates the rapid digestion period when the microorganisms are in contact with the substrate and a large amount of oxygen is provided to facilitate the substrate consumption. Nitrification and denitrification occur at the beginning of this stage. This period ends when the tank is either full or when a maximum time for filling is reached.

- ***React*:** This stage includes mixing and aeration. Aerated conditions serve to oxidize organic carbon. During this period aeration continues until complete biodegradation of BOD and nitrogen is achieved. The length of the aeration period determines the degree of BOD consumption.

- ***Settle*:** During this cycle, all mixing and aeration is turned off and the mixed liquor solids settle, allowing a clear supernatant to form in the upper part of the tank. As aeration is discontinued at this stage, solids separation leaves clear, treated effluent above the sludge blanket. During this clarifying period no liquids enter or leave the tank to avoid turbulence in the supernatant.

- ***Decant*:** The decant phase occurs after a substantial depth of supernatant has formed. Automatic valves are opened and supernatant is drawn off the upper portion of the tank. This phase is characterized by the withdrawal of treated effluent from approximately 600 mm below the surface of the supernatant to avoid extracting any floating solids. This removal is done without disturbing the settled sludge.

- ***Idle*:** This unique stage helps to acclimatize the biomass for the next fill stage. The time in this stage can be used to waste sludge or perform backwashing of the jet

aerator. Sludge wasting is efficient during this period because the settled sludge bed has attained a maximum concentration of solids. The wasted sludge is pumped to an anaerobic digester to reduce the volume of the sludge to be discarded. The frequency of sludge wasting ranges between once each cycle to once every two to three months depending on system design.

System Operational Overview

Clearford One™ does not require the level of maintenance of a conventional gravity collection system since solids, fats, oils, and greases (FOGs) are captured in the ClearDigest™ tanks. Routine inspections and maintenance ensure long-lasting effective operations. Visual inspections of covers, risers and tanks ensure that there is no structural damage to the system and water tightness is maintained. The only action required is measuring and pumping out the solids in the tank when the level reaches a predetermined height, typically specified as 50% of the water level in the tank. Solids removal is performed by a licensed septage hauler and disposed at approved location. The pump-out cycle for the ClearDigest™ tank varies based on occupancy and household habits. For typical households, ClearDigest™ has an average pump-out cycle of 10-20 years. A detailed ClearDigest™ maintenance program will be implemented for optimum system performance and minimal disruption to residents. ClearRecover™ will be operated similarly to other STP facilities, meeting all regulatory requirements.

Clearford will operate the Clearford One™ system for the term of the O&M contract, which includes:

- Routine repairs and preventative maintenance;
- Compliance with regulatory approvals and environmental legislation;
- Sampling and analysis as required to report compliance with site specific approvals; and
- Training of local staff for takeover.

Value Added Deliverables

Construction Value Added

Clearford One™ installation is adaptable with minimal disturbance to surrounding areas during construction. ClearConvey™ mains can be installed in back yards or within the road

allowance, and use narrow trenching techniques. Reinstatement and construction management costs (e.g., traffic) are minimized.

Trench excavation widths are minimized with ClearConvey™ as a result of flatter sewer pipe slopes. This difference provides the benefit of less excavation and less disruption to roadways during installation.

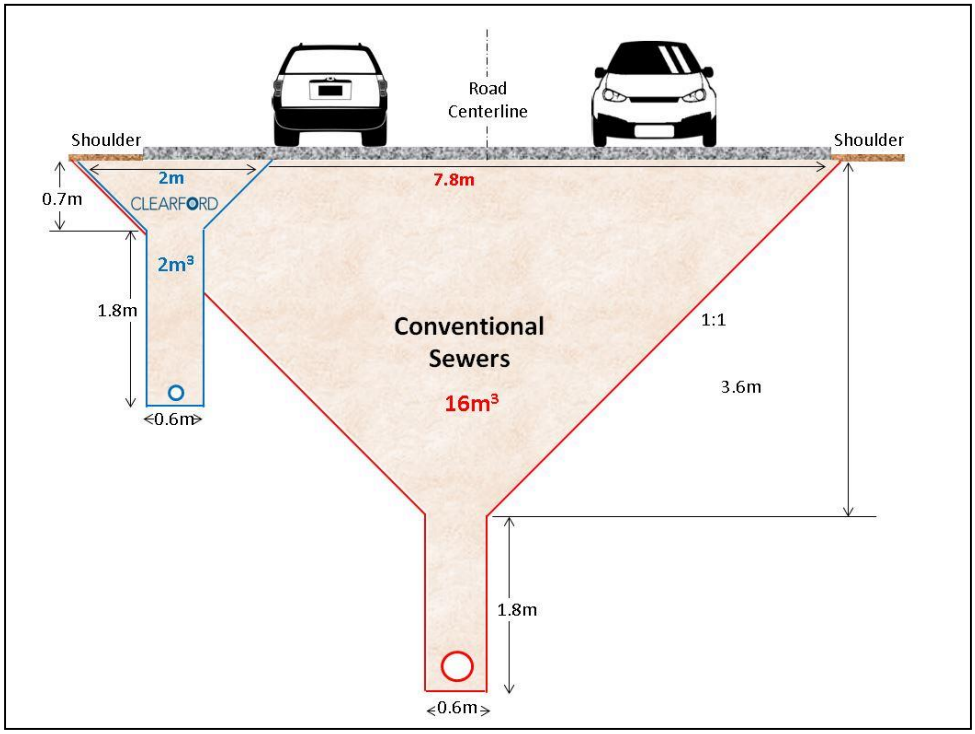

Figure 7: Excavation for ClearConvey™ Compared to Conventional Sewers

Clearford One™ systems discharge fewer pollutants than conventional facilities. The watertight ClearConvey™ network does not allow inflow/infiltration of storm and groundwater, thereby reducing the hydraulic loading to the ClearRecover™ STP while achieving the same treated effluent discharge concentrations. The resulting total mass of pollutants leaving the facility is reduced.

Clearford One™ is easily expandable to service outlying hamlets and rural areas outside of the main service areas. Solids-free effluent from ClearDigest™ can be conveyed over long distances through very flat gravity or low-pressure sewer mains, or via solids-free pump station and forcemains, to the central ClearRecover™ facility. This enables greater public health and environmental protection in vulnerable source water areas where contamination of groundwater is a concern.

The sewage from each home goes through a ClearDigest™ tank prior to entering the collection network. If any abuse of the sewage system occurs, the source of that abuse can be easily isolated to a particular homeowner and remedies undertaken to prevent further misuse.

Pump station operation is simplified because of solids-free effluent handling and reduced peak flows, resulting in more compact and easier to maintain pump stations than conventional sewage pump stations.

Clearford One™ Pump Station *Conventional Pump Station*

Figure 8: Pump Station Comparison

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https://www.youtube.com/watch?v=TeIjT0Q33zU