

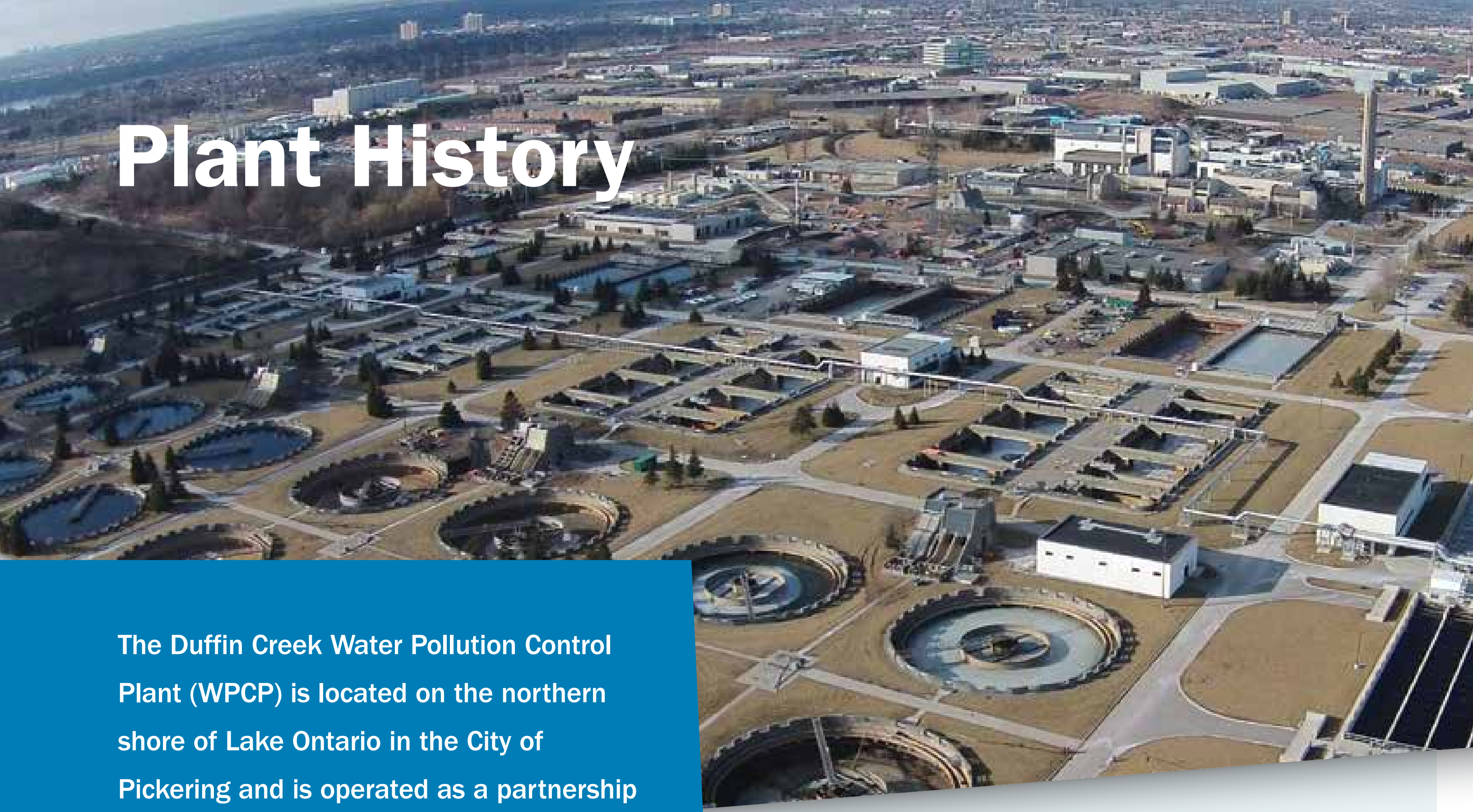

Duffin Creek Water Pollution Control Plant

Technical Information

York Region

DURHAM REGION

Plant History



The Duffin Creek Water Pollution Control Plant (WPCP) is located on the northern shore of Lake Ontario in the City of Pickering and is operated as a partnership between The Regional Municipality of York and The Regional Municipality of Durham. It is a highly engineered system of tanks, pipes, specialized equipment and buildings, covering the equivalent of 400 football fields. The facility treats wastewater collected from residential, institutional and industrial locations from communities within York Region and the Town of Ajax and the City of Pickering in Durham Region. Once the treatment process is complete, clear treated water is returned back into Lake Ontario.

The Duffin Creek WPCP is ISO 14001 certified and a Ministry of the Environment and Climate Change Class 4 conventional activated sludge treatment plant with a built capacity of **630,000** m^3/day, currently rated at 520,000 m^3/day average flow rate.

In the 1960s, the Province of Ontario faced two challenges. The first was the declining health of rivers and streams in the Greater Toronto Area (GTA) and the second was the growing economy and population.

The Province made the forward-thinking decision in 1969 to replace the smaller plants with one large, central facility – the Duffin Creek WPCP. Built with leading treatment technology, the Province showed its commitment to providing a higher standard of wastewater treatment and meeting the requirements of the first Canada-U.S. Great Lakes Water Quality Agreement. By releasing treated water into Lake Ontario, pressure was taken off of the smaller streams in the GTA, allowing them to recover and return to a healthier condition. Ownership of the facility was transferred from the province to the Municipalities of York Region and Durham Region in 1997. Since then, the two Regions and provincial and federal governments have invested more than $850 million to meet the demands of urban expansion while continuing to protect the environment.

View of Duffin Creek WPCP's aeration tanks

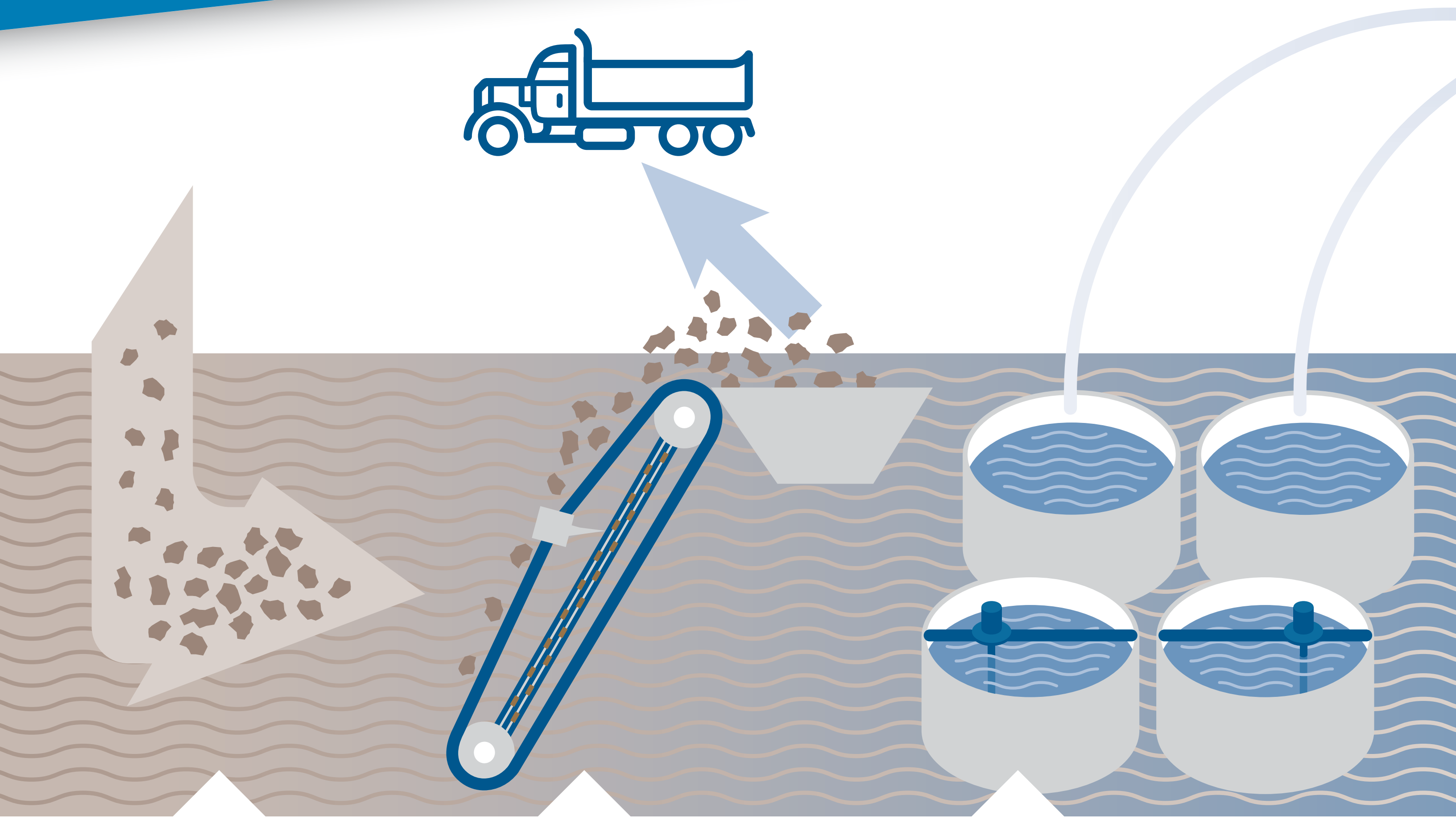
Duffin Creek Water Pollution Control Plant

The Duffin Creek WPCP has been specifically engineered to remove solid materials, nutrients and bacteria from wastewater. The Ministry of the Environment and Climate Change (MOECC) sets limits on the amount and types of substances in the water released into Lake Ontario for each wastewater treatment plant via Environmental Compliance Approvals. The treatment processes at the Duffin Creek WPCP go beyond these requirements by removing more solid material, nutrients and bacteria from the wastewater than is required by regulation.

In nature, certain types of bacteria clean water by consuming and breaking down organic waste into smaller and less harmful substances. The Duffin Creek WPCP uses this same mechanism of removal but on a much larger scale.

Treated effluent leaving disinfection phase

The Wastewater Treatment Process



1 INFLUENT WORKS

2 PRELIMINARY TREATMENT

3 PRIMARY TREATMENT

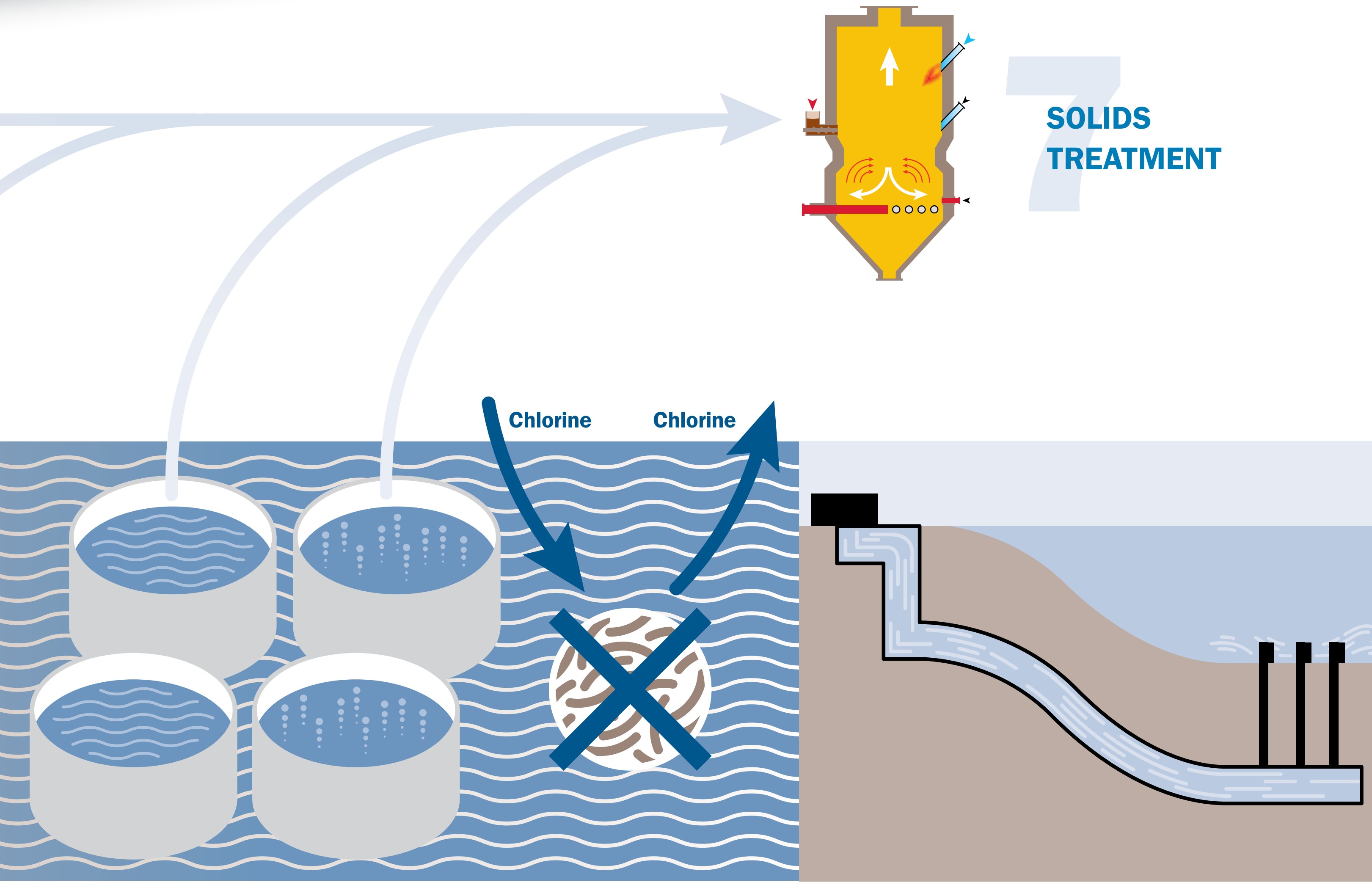
The Wastewater Treatment Process

Many processes are required to take out solid material, nutrients and bacteria from wastewater to ensure the effluent released into Lake Ontario will not harm the natural environment. The wastewater treatment process at the Duffin Creek WPCP can be broken down into seven stages of treatment using physical, chemical and biological mechanisms to remove contaminants. These stages include influent works, screening and grit removal, primary treatment, secondary treatment, disinfection and discharge. Additionally, the biological solids captured during the wastewater treatment process are removed and receive further treatment.

Flow meters at Duffin Creek WPCP

Upper surface of travelling bridge

7 SOLIDS TREATMENT



4 SECONDARY CLARIFICATION

5 DISINFECTION

6 DISCHARGE

There are three different mechanisms of removal: physical, biological and chemical. **Physical** removal involves gravity and a mechanical unit to actively remove the waste material. **Chemical** removal involves a reaction between two substances to form solid particles that are able to settle out of the water. **Biological** removal involves living bacterial organisms that break down or consume organic waste from the wastewater.

Steps in the Water Treatment Process

1. Influent Works

The wastewater enters the influent pumping station where 16 pumps direct the wastewater to the preliminary treatment stage. Wastewater flows by gravity through the remaining stages of treatment.

2. Preliminary Treatment

The preliminary treatment stage removes large solid materials from the wastewater using mechanical bar screens and grit tanks. Large materials or screenings are removed from the influent by 12 bar screens that are both mechanically and manually cleaned. Following this stage, eight grit tanks slow the flow of influent to allow large solids to settle out. Heavy suspended material such as sand and gravel settle to the bottom of the tank, where they are collected and dewatered through grit clarifiers.

Effluent: is the term used for the clear treated water released into a body of water after processing at a wastewater treatment plant.

Polymer: a substance that has a molecular structure consisting of a large number of similar units bonded together.

Hopper: a tapered container that collects waste and is able to discharge its contents.

Travelling bridge mechanism used in Primary Treatment

3. Primary Treatment (Clarifiers)

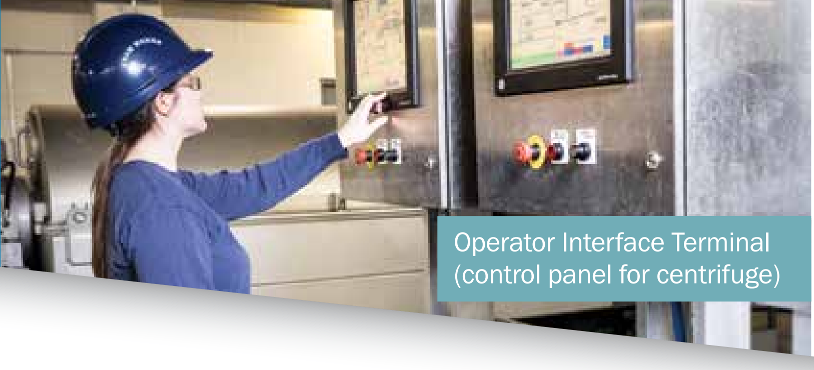
Any remaining solids from the preliminary phase settle by gravity in 14 large settling tanks. A slow-moving travelling bridge mechanism scrapes the bottom and pushes the settled sludge into hoppers before it is pumped into either anaerobic digester tanks or to sludge-blending tanks. Lighter particles such as fat, oil and grease float to the surface as scum where they are collected and directed to digester tanks. Primary treatment removes approximately 60 per cent of suspended solids and 30 per cent of the biochemical oxygen demand (BOD) in the wastewater.

Phosphorus is found naturally in the environment but is also found in animal and human waste, rotting plants and in common household products. Higher levels in rivers and lakes come from water that has run off from farms and urban areas, discharge from septic systems, and wastewater treatment plants. The Duffin Creek WPCP uses technology to ensure the clear treated water released into Lake Ontario achieves or surpasses regulatory requirements.

Enhanced Phosphorus Removal

Iron salts are used in the treatment process to help remove phosphorus and suspended solids. Iron salt reacts with phosphorus to form phosphate precipitates which can be settled out of the wastewater in the clarifiers. The facility has the ability to add iron salt at three locations; before primary clarification and before and after aeration. Polymers can also be used to improve the quality of the effluent by increasing the settlement of suspended solids.

Duffin Creek WPCP uses waste iron salts from the steel industry for reuse in phosphorus removal.



Operator Interface Terminal (control panel for centrifuge)

Aeration tank

4. Secondary Clarification

In secondary treatment, small organic material and nutrients are removed by pumping air into wastewater to promote the growth of bacteria. Fourteen aeration tanks, each containing anoxic and aerobic zones, are rich with microorganisms that break down and consume organic material. Each aeration tank contains an anoxic zone where no air has been added; this allows for denitrification to occur. The tank containing the aerobic zone is where air is diffused into the water and facilitates nitrification and the final breakdown of organic material.

Following aeration, broken down organic matter and microorganisms are directed to 22 secondary clarifiers where final settling of biosolids occurs. The settled material is called activated or living sludge. The majority of the activated sludge is pumped back to the head of the aeration process to be reused and is referred to as return activated sludge. The remaining portion is referred to as waste activated sludge and is pumped to the primary clarifiers where it will thicken with raw sludge before it is pumped to anaerobic digesters or sludge blending tanks. This is referred to as waste-activated sludge.

5. Disinfection

To kill pathogenic microorganisms in the final effluent, chlorine is added in the form of liquid sodium hypochlorite. Due to the toxic effects of chlorine on aquatic life, sodium bisulphite is then added to neutralize chlorine from the treated effluent before it enters Lake Ontario.

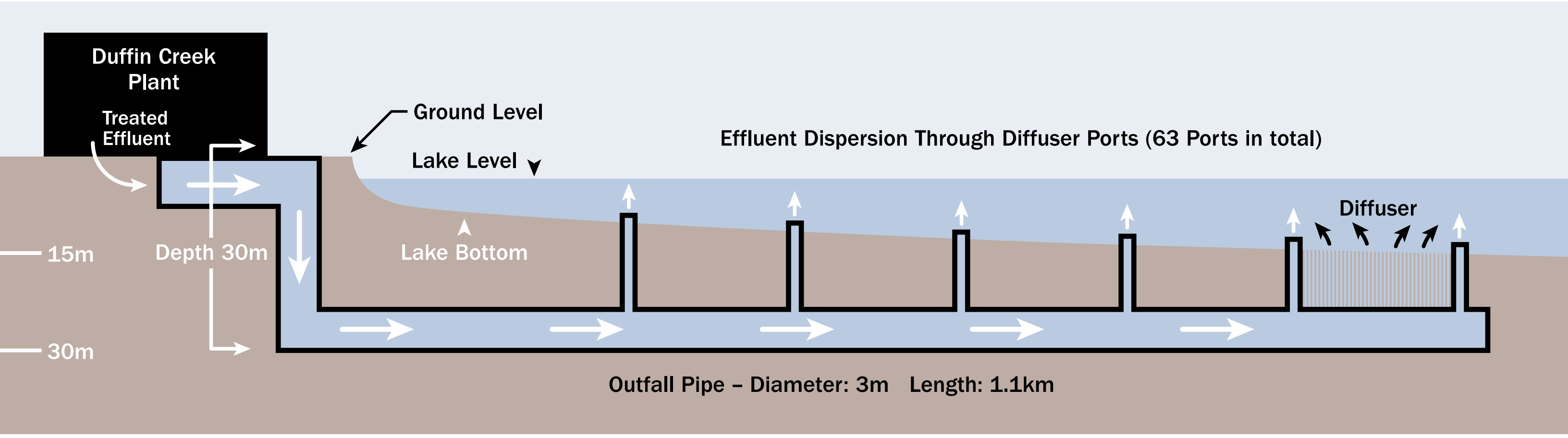
6. Discharge

The final step in the wastewater treatment process safely delivers clear treated water back into Lake Ontario. Clear treated water enters Lake Ontario through an outfall pipe that is approximately 3.05 metres in diameter and 1,100 metres long. The pipe is also equipped with 63 diffuser ports. This diffusion system allows for an even distribution of water into the lake with minimal disruption of the natural environment.

Denitrification is the process of converting nitrates to inactive nitrogen gas in wastewater treatment.

Anoxic zone is an area where no air has been added into the wastewater.

Aerobic zone is an area where air has been diffused into the water.



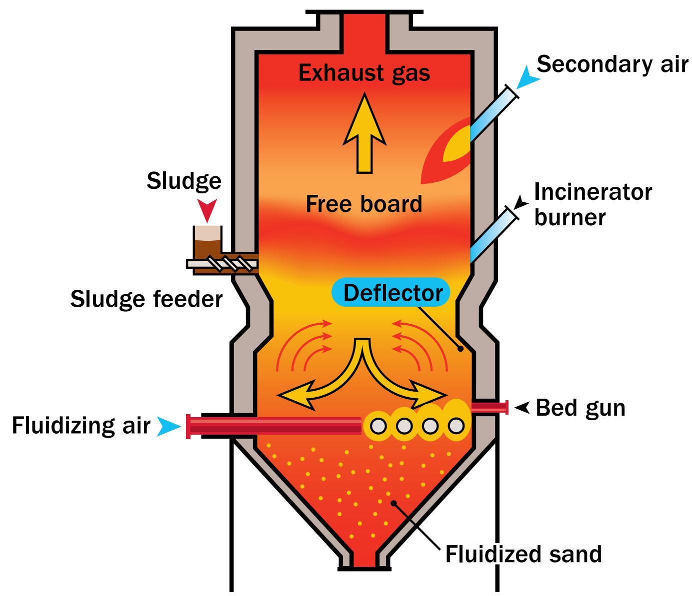
Centrifuge used in dewatering process

7. Solids Treatment

Biosolids or sludge is a product of the wastewater treatment process. Sludge produced at the plant is first dewatered and then burned in the plant's incinerators as fuel.

Dewatering: Duffin Creek WPCP uses eight dewatering solid bowl centrifuges to separate solids from liquid waste to create semi-solid sludge or a sludge cake. This process increases the solids content of sludge from approximately two per cent to 25 per cent. The dewatered sludge cake is incinerated.

Incineration: The incinerator consists of four fluidized bed reactors where the sludge cake is combusted into ash and flue gas. Each reactor has three main components: a windbox, a sand bed and a freeboard. The windbox provides sufficient air to fluidize the sand bed and begin the mixing process. Sand is used to break up the sludge cake into smaller pieces to ensure an efficient incineration process. The third part of the reactor, the freeboard, is located at the top of the reactor. This device removes process odours and contaminants in a final combustion process when water vapour and combustion by-products are destroyed. The material left over from burning biosolids is ash. The gases emitted by the waste heat boiler enter a wet scrubber where solid and liquid particles are removed while the activated carbon unit reduces emissions.



Meeting Environmental Standards

The Duffin Creek WPCP ensures protection of both human health and the environment by meeting or surpassing standards set by the MOECC. Treated water discharged to Lake Ontario meets the environmental protection requirements determined by the MOECC and Fisheries and Oceans Canada. Requirement for effluent are set out in legislation including the *Ontario Water Resources Act*, *Environmental Protection Act* and the Wastewater System Effluent Regulations under the federal government's *Fisheries Act*. The MOECC issue Environmental Compliance Approvals which set the specific limits of substances that can be released into Lake Ontario and the atmosphere.

Treatment Efficiency

The Duffin Creek WPCP meets or surpasses effluent quality standards with over 90 per cent treatment efficiency for the removal of wastewater contaminants.

	Raw Wastewater*	Treated Effluent*	ECA Limit	Percent Removed
Total Phosphorus (TP) mg/L	6.6	0.52	0.8	92.1%
Total Suspended Solids (TSS) mg/L	303	7.1	25.0	97.7%
Biochemical Oxygen Demand (BOD_5) mg/L	217	2.7	25.0	98.8%
Total Ammonia Nitrogen (TAN) Summer mg/L	36.3	0.78	6.0	97.9%
Total Ammonia Nitrogen (TAN) Winter mg/L	30.9	0.51	10.0	98.3%
Escherichia Coliform Sampling (Geometric Mean Density)	*N/A	52	200	*N/A

Values are representative of the 2016 MOECC Annual Plant Performance Report and are subject to change.

Total Phosphorus — All forms of phosphorus in wastewater (both solid and dissolved particles). Total phosphorus is used as an indicator of water quality and plant performance.

Total Suspended Solids — The amount of material suspended in a water sample. Total Suspended Solids is used as an indicator of water quality and plant performance.

Biochemical Oxygen Demand (BOD_5) — A measure of the amount of oxygen that is used by living organisms in wastewater to breakdown organic matter over a period of five days. When BOD_5 levels are high, dissolved oxygen in the water decreases; creating a difficult environment for fish and other aquatic organisms to survive.

Total Ammonia Nitrogen (Summer/Winter) — In wastewater, ammonia exists in two forms: NH_3 (unionized ammonia) and NH^{4+} (ionized ammonia). Ammonia will promote excess algae growth if discharged into Lake Ontario. High levels of unionized ammonia is also toxic to aquatic life.

Escherichia Coliform (E.coli) Sampling —A type of bacteria commonly found in wastewater at high concentrations. E.coli is removed from wastewater to keep the lake ecologically safe.

Dewatering building control room

Primary effluent from primary treatment

DUFFIN CREEK WPCP SPECIFICATIONS — Liquid Process

Stage 1 and 2 Average Design Capacity
— 330 MLD

Stage 3 Average Design Capacity
— 300 MLD

MLD – Mega litres per day

Influent Pumping Station

16 Submersible Pumps

Capacity of each: 180,835 m^3/day

Total Capacity: 1,446,682 m^3/day

Screening and Grit Removal

Eight Hydraulically Activated Bar Screens, 2.1 m long with 12 mm bar spaces and four Manual Bar Screens

Eight Aerated Grit Tanks: each 17 m x 7 m x 4.5 m

Primary Sedimentation

Stage 1 & 2

Eight Tanks: each 64 m x 24.5 m x 3.6 m

Volume: each 5,644.80 m^3

Surface Overflow Rate: 28.95 m^3/day/m^2

Hydraulic Retention Time: 2.98 h

Total Volume: 45,158.4 m^3

Stage 3

Six Tanks: each 65 m x 24 m x 3.7 m

Volume: each 5,772 m^3

Surface Overflow Rate: 33.12 m^3/day/m^2

Hydraulic Retention Time: 2.68 h

Total Volume: 34,632 m^3

*Hydraulic Retention Times are calculated at designed average daily flow.

Aeration — Fine Bubble Air Diffusion

Stage 1 & 2

Eight Tanks: each 22.75 m x 22.9 m x 5.8 m

Each containing four Cells per tank

Volume: each 12,086.62 m^3

Hydraulic Retention Time: 6.39 h

Total Volume: 96,692.96 m^3

Stage 3

Six Tanks: each 26.25 m x 24.9 m x 5.75 m

Each containing four Cells per tank

Volume: each 15,033.38 m^3

Hydraulic Retention Time: 6.98 h

Total Volume: 90,200.25 m^3

Secondary Clarification

Stage 1 & 2

16 Circular Tanks: each 41.2 m (dia.) x 3.7 m (deep)

Volume: each 4,932.71 m^3

Surface Overflow Rate: 17.03 m^3/day/m^2

Hydraulic Retention Time: 5.22 h

Total Volume: 78,923.38 m^3

Stage 3

Six Tanks: each 124 m x 25.8 m x 5.5 m

Volume: each 17,595.6 m^3

Surface Overflow Rate: 16.15 m^3/day/m^2

Hydraulic Retention Time: 8.17 h

Total Volume: 105,573.60 m^3

*Hydraulic Retention Times are calculated at designed average daily flow.

DUFFIN CREEK WPCP SPECIFICATIONS

Liquid Process

Chlorination

Stage 1 Contact Chamber

Volume of Tank: 2,463 m^3

Detention Time: 5.63 min

Stage 2 Contact Chamber

Volume of Tank: 2,735 m^3

Detention Time: 6.25 min

Stage 3 Contact Chamber

Two Chambers: 75 (l) x 30 (baffle width) x 4 m (d)

Total Volume: 18,000 m^3

Detention Time: 41.1 min

*Detention Times are calculated at designed average daily flow.

Discharge

Length of Overall Pipes: 1,100 m

Outfall Diameter: 3 m

63 diffusers total; only 35 open since 2007.

Solid Process

Raw Sludge Blending Tank

Two Tanks: each 33.5 m dia. x 9.1 m

Volume: each 8,020.85 m^2

Anaerobic Digesters

Four Primary Digesters and two Secondary Digesters

Each 33.5 m dia. x 9.1 m

Volume: each 8,020.85 m^2

Dewatering Centrifuges

Eight Centrifuges

Capacity: each 2.5 dry tonne/h

Total capacity of centrifuges: 20 dry tonne/h

Sludge Cake Pumps

Eight Sludge cake pumps

Capacity: each 15 m^3/h

Incineration

Four Reactors: each 105 dry tonne/d

Total Capacity: 420 dry tonne/d

Ash Thickening Tanks

Three Circular Tanks: 11 m in (dia.), 4.69 m (deep)

Capacity of Each: 445.706 m^3

Ash Vacuum Filters

Two Filters: each 4,100 kg TSS/h

Total Capacity: 8,200 kg TSS/h

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