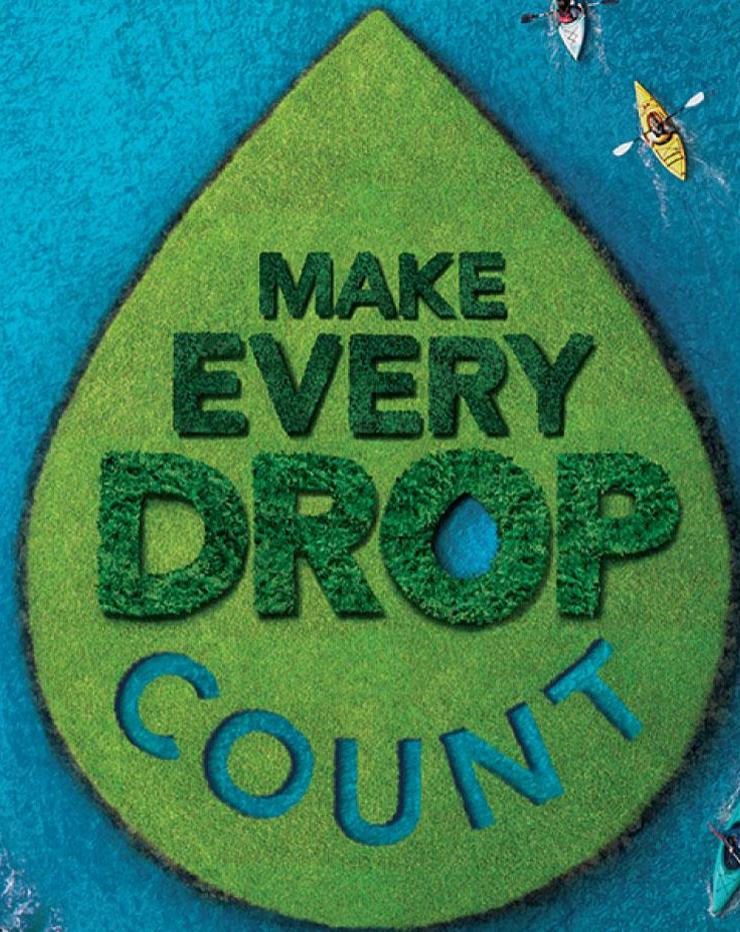
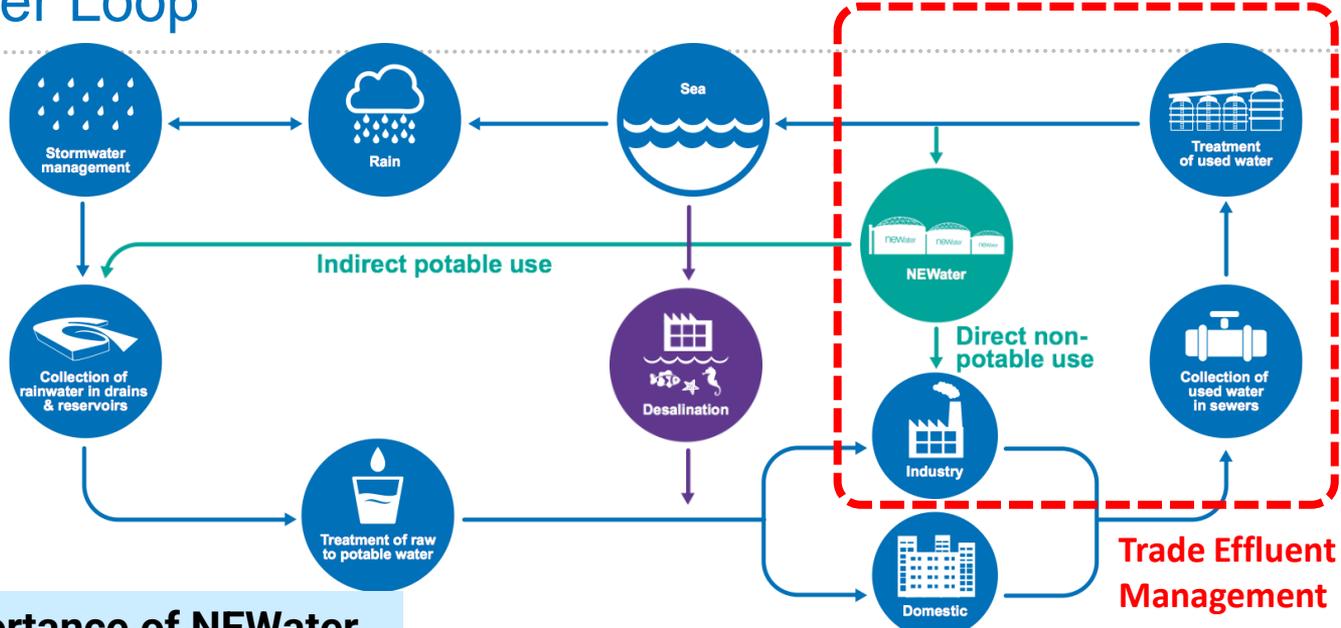


# Sewer Sampling Robot

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# Our Water Loop



## Importance of NEWater

- Water is scarce and precious resource in Singapore
- NEWater allows us to re-use every drop of water
- Multipronged approach placed to safeguard downstream treatment

# Background & Current Practice

## Trade effluent discharged from factories needs to comply with requirements

Prohibited substances or excessive concentrations of regulated substances:

- Affects health and safety of maintenance workers
- Disrupts downstream treatment processes in our plants

## Current Practice

### **Risk based regulatory approach:**

- Categorise factories based on risk profile
- Higher risk factories are required to install additional water quality monitoring instruments in last inspection chambers and are also inspected more frequently

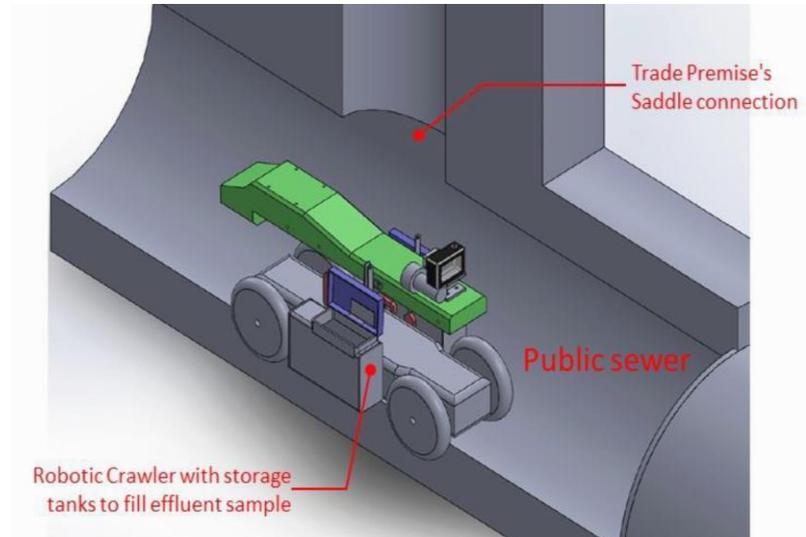
### **Special operations:**

- Conducted at factories suspected to carry out illegal discharge activities
- PUB monitors trade effluent discharge into public sewers from these factories at manholes

# Current Practice

## Monitoring trade effluent discharge in special operations

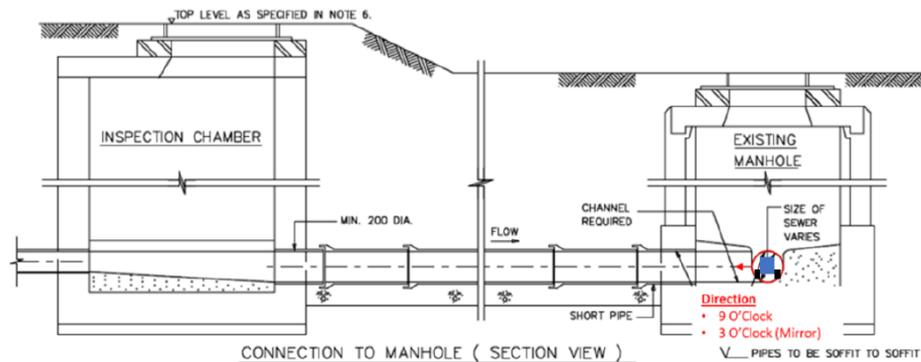
- Deployed in manholes up to 400m away
- Sample collection from sanitary connection with vertical effluent flow at the connection point.
- Existing robotic crawler is unable to collect samples from other types of sanitary connections due to the design of its collection tanks.



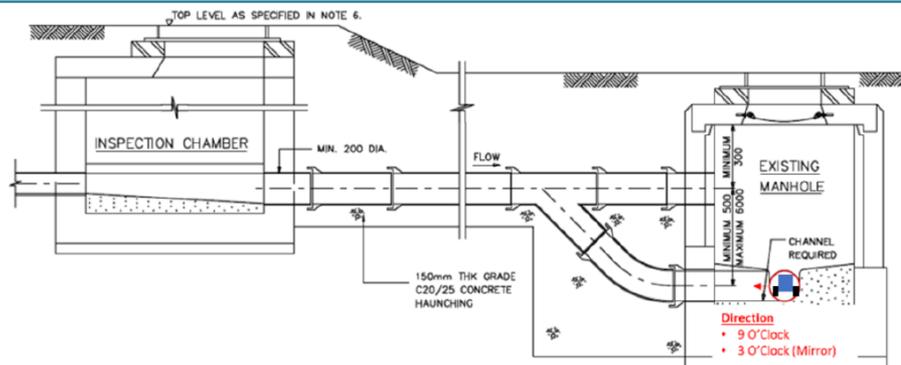
*Robotic crawler in sewer with saddle connection*

# Types of sanitary connections

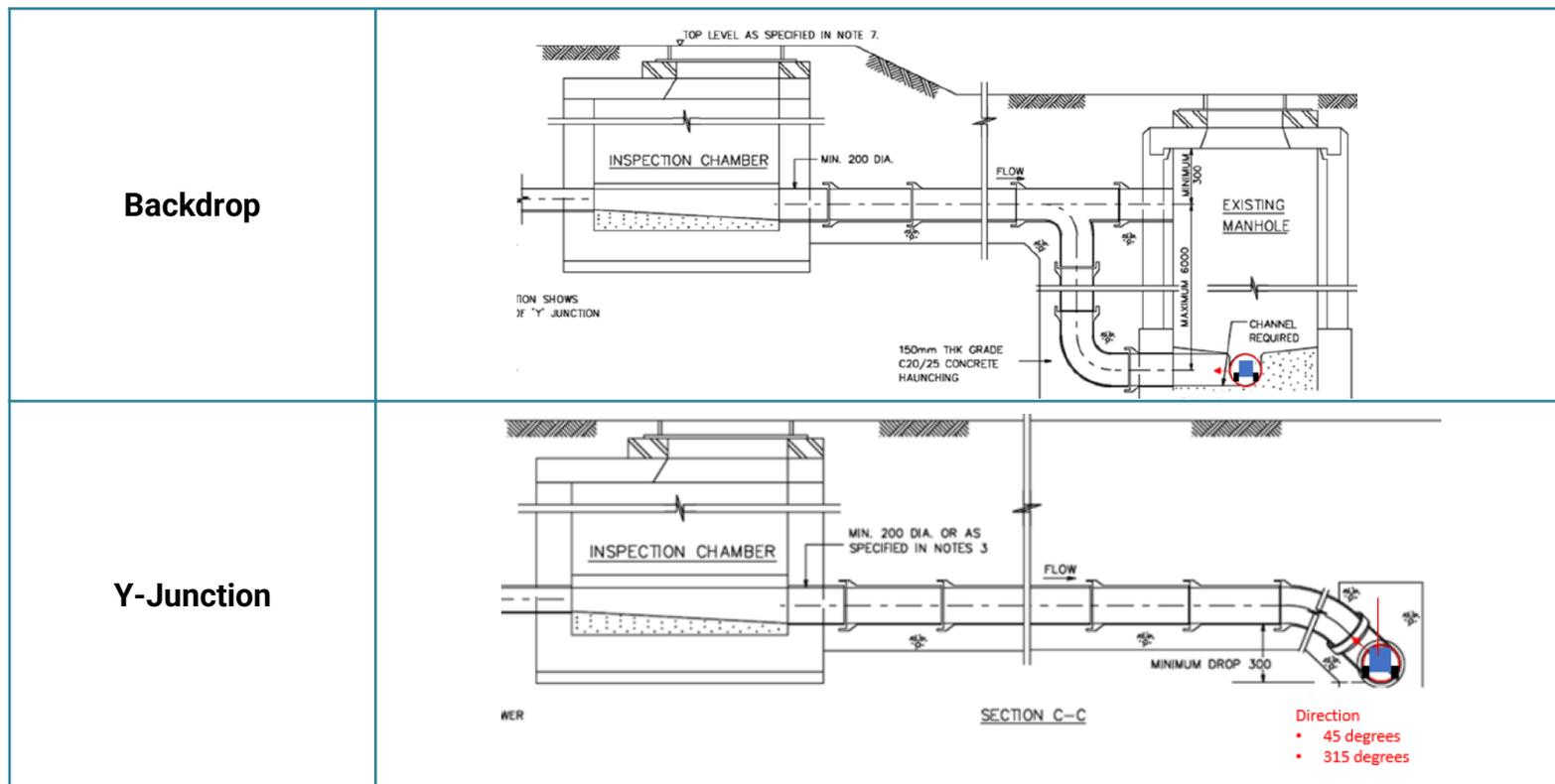
**Straight**



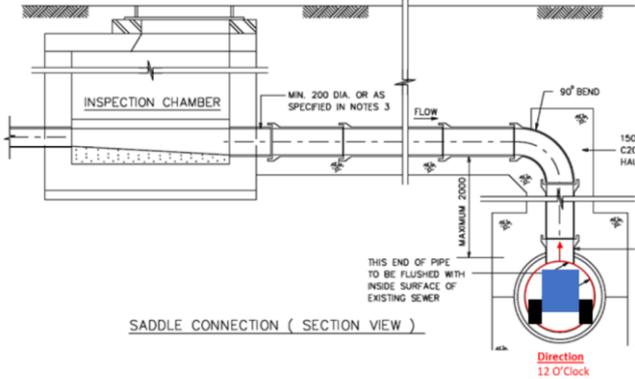
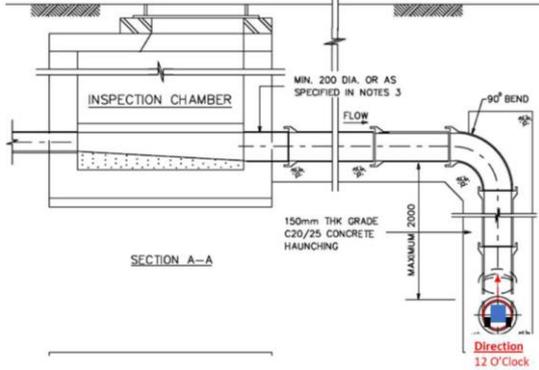
**Tumble Bay**



# Types of sanitary connections



# Types of sanitary connections

<p><b>Saddle</b></p>	 <p>SADDLE CONNECTION ( SECTION VIEW )</p>
<p><b>Raised</b></p>	 <p>SECTION A-A</p>

# Areas of Opportunity

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A customised robotic system that can be deployed in sewers up to 400m away to discreetly monitor trade effluent discharge and collect representative effluent samples from the various types of sanitary connections.

## The robotic platform shall be able to

- ✓ Deploy without the need for man-entry into the sewers
- ✓ Be remotely controlled by a human operator from the ground
- ✓ Manoeuvre up to 400m in sewer environments and conditions
- ✓ Visually inspect sewage pipe sanitary connection and sample collection process
- ✓ Monitor for hazardous gases

## Operational Requirements – Robotic Crawler

The robotic platform shall be suitable for use in sewerage environment and shall be equipped with suitable:

- **Traction to manoeuvre:** Traction wheels/treads to manoeuvre in sewers with water level up to half bore and pipe invert filled with soft sediments.
- **Record and display distance transverse:** Odometer to record and display to the operator, the real-time distance travelled by the crawler in the sewer.
- **Observe activities visually and record evidence:** 360° view, high resolution cameras with adequate lighting to record and display to the operator, the real-time observations as seen by the crawler in the sewer. Recorded video footages shall be stored in high definition (HD) quality.
- **Measure hazardous gas at source:** Gas meters to record and indicate to the operator, the real-time concentration of sewage gases and hazardous gases (e.g., volatile organic compounds, hydrogen sulphide, carbon monoxide and oxygen). Lower explosive limit (LEL) meters shall also be provided.
- **Sufficient length & minimize drag:** Suitable winch with neutral buoyant tether cables of sufficient length to traverse up to 400 m horizontal distance in sewers (excluding manhole depth).

# Operational Requirements – Sampling Mechanism

The robotic platform shall have a customised sampling mechanism that is

- **Suitable actuator arm:** to collect effluent samples from all types of lateral sanitary connections indicated in the Code of Practice (Sewerage and Sanitary works)
- **Effluent sample collected to be representative:** meaning collecting only the effluent discharged from the targeted sanitary connection, without cross-contamination from other streams in the public sewer. To ensure that the collected samples are representative, the containers shall always be capped/covered unless samples are being collected.
- **Storage of effluent samples:** Equipped with 250ml container(s) to store effluent samples. The material of the container shall be compatible with the discharge effluent and shall be break-resistant.
- **Designed to collect up to 5 discrete effluent samples** from the sanitary connection remotely operated by the operator.
- **Equipped with suitable electronics and sensing technologies** for automation of tasks requiring human intervention such as controlling actuator to collect samples, capping of samples or blocking other sewage stream, etc. (e.g., high-resolution cameras for imaging and LIDAR sensors for depth perception)

# Physical Requirements to Fit Working Environment

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## The robotic platform shall be:

- Designed for use in sewers with diameters ranging from 300 to 600 mm, and manholes with depth of up to 10 m.
- Designed as a whole or modular to fit into 600 x 600 mm opening (standard sewage manhole).
- Designed to function in hazardous environment and comply with relevant standards.

## Expected Outcomes

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- ✓ Develop a customised robotic system that allows operators to monitor suspected factories' effluent discharges on-site, from the public sewer, and collect representative effluent samples from the various types of lateral sanitary connections remotely, without the need for man-entry into the sewers.
- ✓ If the pilot is successful, the solution would be provided to PUB through a service model where the equipment is owned, operated, and maintained by the company.

**Thank You**



**MAKE  
EVERY  
DROP  
COUNT**