Global Decentralisation or "Scalping" Wastewater Treatment Can Help Solve Water Shortages and Environmental Issues

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ABSTRACT

Decentralised wastewater treatment is frequently used worldwide in those locations where additional water supply and shortages of potable water make reuse of highly treated wastewater more acceptable. Treating wastewaters is often are less costly than developing other potable water supplies. In addition, decentralised facilities can reduce the overall cost of transporting sewage and provide for localized treatment of industrial and agricultural wastes.

Historically, centralization of wastewater treatment has been driven by the need to ensure compliance with regulatory requirements. Recognizing that the numerous treatment facilities that have been constructed over time were either not meeting current standards or were creating a financial burden to operate and maintain, the industry moved towards consolidation. However, the decision to centralize facilities to meet environmental goals did not anticipate, in most instances, the ever increasing resource value of wastewater effluent.

While this subject may not be directly relevant to the NZ environment these global trends demonstrate factors which may be useful for smaller communities in NZ and will provide an insight into issues being faced in other parts of the world. These learnings could be adapted for the NZ environment. This paper will discuss several drivers for decentralised wastewater treatment, and present several case histories of various wastewater treatment plants around the world, including design criteria, effluent standards, and other descriptive information.

KEYWORDS: Sewer mining, decentralization, reclaimed water, water supply augmentation, advanced treatment

INTRODUCTION

Historically, centralization of wastewater treatment has been driven by the need to insure compliance with regulatory requirements. Recognizing that numerous treatment facilities had been constructed over time were neither meeting current standards or were creating a financial burden to operate and maintain prompted the industry to move towards consolidation. However, the decision to centralize facilities to meet environmental goals did not anticipate, in most instances, the ever increasing resource value of the wastewater effluent.

Several unique projects will be discussed in the presentation and include:

- JD Phillips Water Reclamation Facility, Colorado Springs, CO, USA
- Iowa Hill WWTP, Breckenridge, CO, USA.
- Everest WRF, Southwest WRF, and North Cape WRF, Cape Coral, FL, USA.
- Northern Water Plant, Barwon Water, Australia
- Jebel Ali STP, Dubai, UAE

Background details and other process information of these wastewater treatment plants will be presented in the following sections, including design criteria, effluent standards, and other descriptive information. The drivers for decentralized wastewater treatment, such as irrigation, water supply augmentation, stream flow augmentation, and industrial reuse will be discussed, including cost information.

BACKGROUND

Decentralized wastewater treatment is frequently used worldwide in those locations where additional water supply and shortages of potable water make reuse of highly treated wastewater more acceptable. Often locating a 'scalping' or 'sewer mining' treatment plant can offer are significant cost advantages to locating the wastewater processing facilities in remote locations, essentially reducing the distribution and other transport costs. Treated wastewaters often are less costly than development of other potable water supplies, and if located near end-users, reclaimed water reuse can be an extremely cost-effective alternative. Other indirect and direct potable water schemes, such as industrial or non-potable direct or indirect reuse require very extensive process configurations, including treatment processes such as ultra-filtration, reverse osmosis, and advanced oxidation.

Historically, centralization of wastewater treatment has been driven by the need to ensure compliance with regulatory requirements. Recognizing that the numerous treatment facilities that have been constructed over time were either not meeting current standards or were creating a financial burden to operate and maintain, the industry moved towards consolidation. However, the decision to centralize facilities to meet environmental goals did not anticipate, in most instances, the ever increasing resource value of wastewater effluent.

CASE HISTORIES OF DENTRALIZED WATER TREATMENT FACILTIES

Background details and other process information of several 'scalping' wastewater treatment plants will be presented in the following sections, including design criteria, effluent standards, and other descriptive information. The drivers for incorporating the "decentralized" wastewater treatment approach, such as irrigation, water supply augmentation, stream flow augmentation, and industrial reuse will be discussed, including regulatory requirements, treatment processing, and general cost information.

JD Phillips Water Reclamation Facility (WRF), Colorado Springs, USA – Colorado Springs Utilities

The JD Philips WRF is located in a semi arid climate which has also been subjected to drought conditions over the past decade. The Utilities, based upon a master planning effort completed by MWH, recognized the inherent value of utilizing recycled water in their long-term water resource plan. The desire to provide a distributed source of recycled water in the City resulted in the design of the JD Phillips Water Reclamation Facility. The facility basically "scalps" wastewater from the interceptor, returning solids to the system to be treated at a downstream facility. The decentralized aspect of this treatment scheme provides the Utility with reliable and flexible wastewater management. While the distribution of the valuable recycled water has proven to be cost effective, this facility has allowed for expansion of the wastewater system to meet the demands of new customers at the lowest capital and social costs.

Drivers for Decentralization. The JD Phillips Water Reclamation Facility, which has been operational for three years, was built in the northern (upstream) part of the City of Colorado Springs, Colorado service area and provides a significant source of recycled water. The 88 ML/d (22 mgd) facility basically "scalps" wastewater from the interceptor, returning solids to the system to be treated at a downstream WWTP facility. The decentralized aspect of this treatment scheme provides the Utility with reliable and flexible highly treated effluent for usage in the local area without the need for an extensive and costly distribution system from the City's centralized Las Vegas Street WWTP located in the southern part of the service area. While the distribution of the valuable recycled water has proven to be cost effective, this facility has allowed for expansion of the wastewater system to meet the demands of new reclaimed water customers at a very reasonable cost. Treated effluent from this plant is used for:

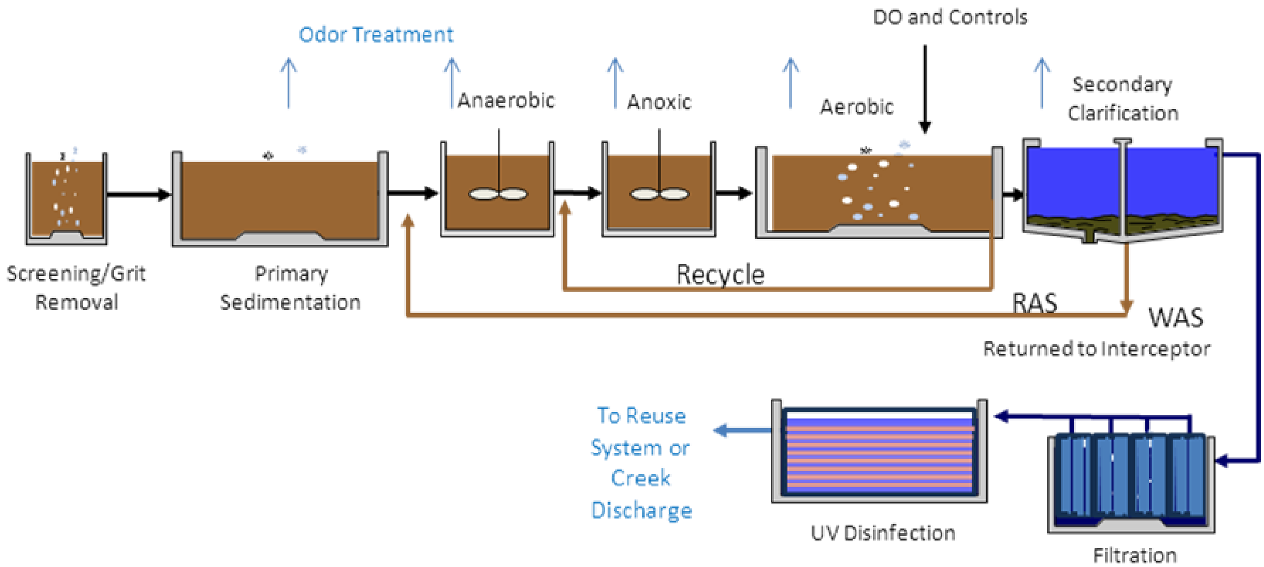
- Irrigation reuse
- Stream flow augmentation
- Canal water augmentation.

During the concept design phase, a cost-effectiveness evaluation was conducted to compare the advantages and disadvantage of centralized versus decentralized treatment. An extensive public involvement program was developed to obtain valuable input into non-monetary costs parameters such as traffic disruptions, odor concerns, use of reclaimed water for local irrigation, etc. Although the decentralized treatment approach was determined the most cost-effective project the public involvement process actually endorsed the decentralized wastewater treatment plant concept.

An interesting aspect of the City's wastewater facilities is that waste sludge generated from the liquid treatment processes is conveyed 30 km to a 'centralized' biosolids management facility in the southern portions of the city. This biosolids management facility is remotely located from major population centers, and provides a low cost method of biosolids disposal.

Treatment System Description. The JD Phillips WRF is designed to achieve a high level of TSS, BOD, and ammonia removal, and then receive filtration and ultraviolet disinfection prior to distribution. Plant capacities is currently 88 ML/d (22 mgd) and expandable to 120 ML/d (30 mgd). Space for additional tankage is provided in the design layout.

Wastewater enters the facility is subjected to preliminary treatment (screening and grit removal); nitrogen removal using the Modified Ludwig-Ettinger (MLE) activated sludge process; filtration, and UV disinfection. The following figure presents a simplified schematic of the treatment processes at the JD Phillips WRF.



Schematic of JD Phillips WRF, City of Colorado Springs, CO, USA

All the treatment facilities are covered and provided with odor treatment. Although the plant is located in a semi-industrial area, the local residents wanted the facility to be architectural pleasing and not contribute odors. The following figures show some of the odor containment and treatment facilities.

Current Permit Requirements. Discharge water quality requirements for each of the plants studied are regulated by the Colorado Department of Environmental Protection (CDEP). **Table 1** presents a summary of the permit requirements for each plant.

Table 1 Summary of Discharge Standards for the JD Phillips WRF

Plant	**JD Phillips WRF**
Location	Colorado Springs, Colorado, USA
Surface Water Discharge:	
Total Suspended Solids	• <5 mg/l TSS
Ammonia Nitrogen	• Seasonal, 2.0 to 8.0 mg/l NH3, varies
CBOD	• < 20 mg/l
Reclaimed/Reuse Water (Public Access):	
Fecal Coliform Bacteria	• single sample < 126/100mL • 30 day average
Chlorine Residual	> 1.0 mg/L

Iowa Hill WWTP, Breckenridge, USA.

The Iowa Hill WWTP is located in the Colorado Mountains, in the Town of Breckenridge, a very beautiful ski area. In the early 1990's the Breckenridge Sanitation District recognized the value of utilizing recycled water near the Town itself, as a 'second' source of usable water. MWH assisted the District in planning, design, and construction of a unique "underground" water reclamation facility actually constructed within the Town of Breckenridge city limits. The facility, which has been operational since 2000, provides a significant source of recycled water for local usage and steam flow augmentation. The facility basically "scalps" wastewater from the interceptor, returning solids to the system to be treated at a downstream facility.

The Iowa Hill WWTP is an underground facility, specifically designed to minimize visual and odor impacts to the Town. This plant produces a very high quality effluent, where wastewater is treated to very low levels of total nitrogen and total phosphorus prior to reuse.

Drivers for Decentralization. While the distribution of the valuable recycled water for snowmaking and other local uses has proven to be cost effective, this facility was designed specifically for stream flow augmentation of the Blue River system. The Blue River in the vicinity of the WWTP was historically hydraulically mined for gold and silver, leaving significant opportunities for restoration. The highly treated effluent helps to maintain minimum stream flows for the restored sections of the Blue River, and promotes for year round trout fishing.

This highly treated effluent is used for:

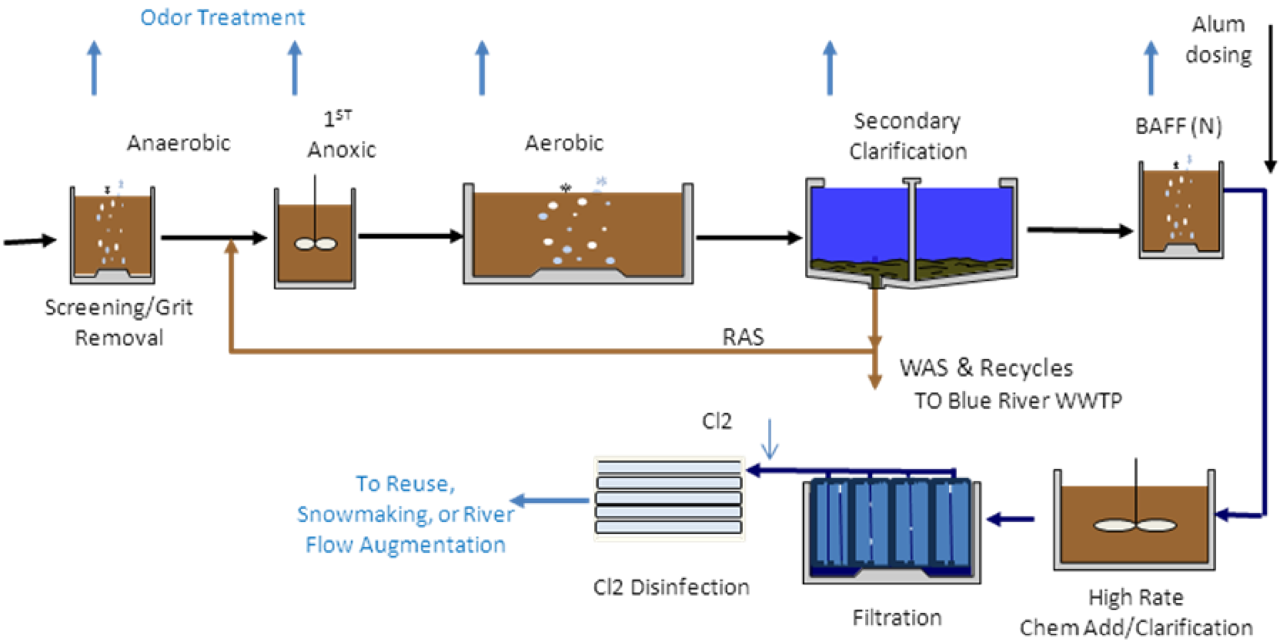
- Local reuse - irrigation
- Snowmaking
- Stream flow augmentation.

All generated solids are returned to the collection interceptor for further treatment at a downstream wastewater treatment plant.

The final location of the Iowa Hill WWTP was chosen due to its proximity to the Town of Breckenridge and the adjacent ski fields. This site eliminated the need for a cost prohibitive reuse water pumping and piping system that would have been required if effluent from the lower wastewater treatment plant approximately 16 kilometers downstream and roughly 300 metres in elevation drop was used for the reuse purposes.

Treatment System Description. The Iowa Hill WWTP is designed to achieve a high level of ammonia removal (<2.0 mg/L ammonia nitrogen), and extremely low levels of Total Phosphorus (< 0.02 mg/L) in the plant effluent prior to discharge into the reclaimed water system or to the Blue River steam discharge. Plant capacity is designed for 12 ML/d (3.0 mgd) on a maximum month daily flow basis.

Wastewater is pumped from a local interceptor to the treatment facility which includes preliminary treatment, high rate activated sludge, ammonia removal by biological aerated filters, phosphorus removal using a high rate chemical removal process (using alum), followed by effluent filtration and chlorine disinfection. The following figure presents a simplified schematic of the treatment processes at the Iowa Hill WWTP.



Schematic of Iowa Hill WWTP, Breckenridge, CO, USA

Current Permit Requirements. Discharge water quality requirements for each of the plants studied are regulated by the Florida Department of Environmental Protection (FDEP). **Table 2** presents a summary of the permit requirements for each plant.

Table 3 Summary of Discharge Standards for Iowa Hill WWTP

Plant	**Iowa Hill WWTP**
Location	Breckenridge, Colorado, USA
Surface Water Discharge:	
Total Suspended Solids	• <5 mg/l TSS
Ammonia Nitrogen	• < 2 mg/l
Total Phosphorus	• < 0.02 mg/l TP
Reclaimed/Reuse Water (Public Access):	
Fecal Coliform Bacteria	• single sample < 25/100mL

	• 30 day average
Chlorine Residual	> 1.0 mg/L

Everest, Southwest, and North Cape WRFs, Cape Coral, Florida, USA.

The City of Cape Coral, Florida, USA current has three decentralized water reclamation facilities, where the effluent is highly treated for nutrients (TN <3 mg/l, TP< 0.5 mg/l), filtration for solids removal, and high level disinfection for reclamation purposes. The City of Cape Coral is primary a large residential community facility located in the sunny west coast of Florida, USA, where many homes have direct access to the Gulf of Mexico or surrounded by numerous canals for open water access.

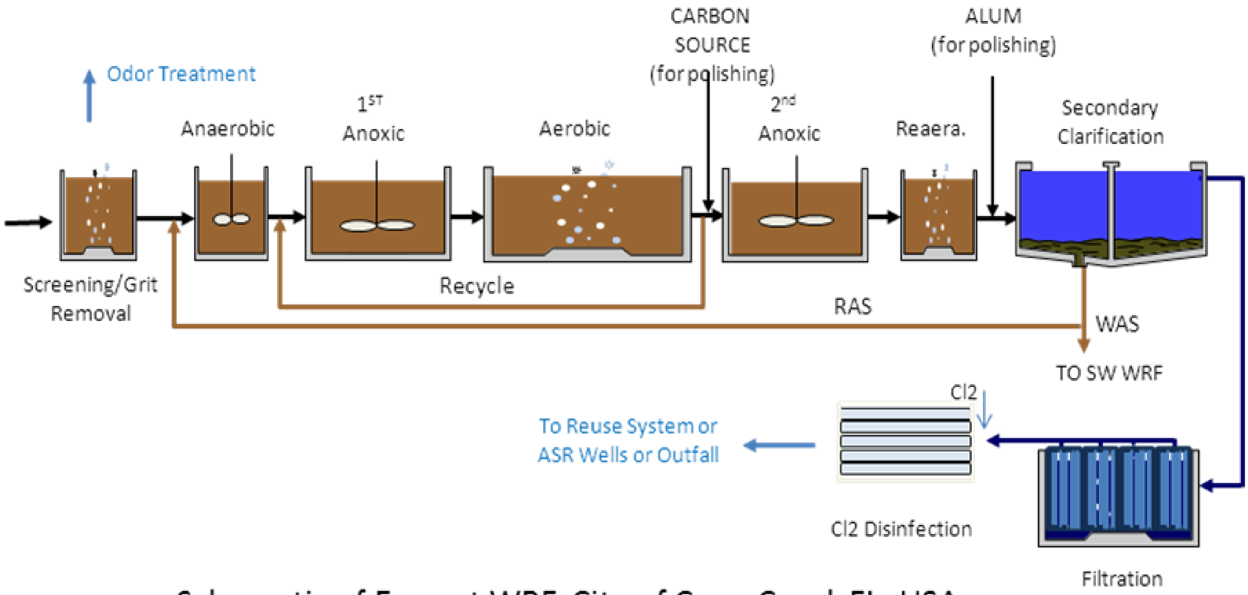
Drivers for Decentralization. The Southwest and North Cape WRFs are designed as non-surface water discharging facilities, where effluent is generated for reuse purposes. The Everest WRF also has an outfall pipeline that is primary used as a backup during wet weather periods. Treated effluent from all these facilities is used for:

- Irrigation reuse
- Ground water recharge (and recovery potential)
- Canal water augmentation

Each of the Cape Coral WRF's are designed for unlimited public access reuse to assist in augmenting the local water supply, and to avoid discharge into sensitive estuary receiving waters. A project objective was to essentially use all treated waters, even during wet weather periods. A number of aquifer and storage, and recovery (ASR) wells were installed to pump treated plant effluent into brackish groundwater during wet weather periods when irrigation reuse demand is low, and then pump this effluent from the ground during dry periods in order to augment the reuse supply. The local fresh water canals can also be used for seasonal storage of excess reuse waters.

Treatment System Description. The three WRF's in Cape Coral are designed to achieve a high level of nutrient removal (<3 mg/L TN and, 0.5 mg/L TP) in their plant effluents, and each receive filtration and 'high level' disinfection. Plant capacities range from 10.0 to 15.0 mgd on an average daily flow basis.

Wastewater enters the facility is subjected to preliminary and secondary treatment, nitrogen removal; filtration, and chlorination. The following figure presents a simplified schematic of the treatment processes at the Everest WRF.



Schematic of Everest WRF, City of Cape Coral, FL, USA

Current Permit Requirements. Discharge water quality requirements for each of the plants studied are regulated by the Florida Department of Environmental Protection (FDEP). Table 4 presents a summary of the permit requirements for each plant.

Table 4 Discharge Requirements for City of Cape Coral WRF's

Plant	**Everest WRF, Southwest WRF, and North Cape WRF**
Location	Cape Coral, Florida USA
Surface Water Discharge: (Everest WRF only)	
Total Suspended Solids	• <5 mg/l
Total Nitrogen	• <3 mg/l TN
Total Phosphorus	• <0.5 mg/l TP
Fecal Coliform Bacteria	• single sample < 2.2/100mL • 30 day average: 75% < detectable limit
Reclaimed Water (Public Access:	
Total Suspended Solids	• <5 mg/l TSS
BOD	• <20 mg/l CBOD
Fecal Coliform Bacteria	• single sample < 2.2/100mL • 30 day average: 75% < detectable limit
Chlorine Residual	> 1.0 mg/L

Each plant is required to provide "high level" disinfection prior to surface water discharge or distribution to reclaimed water customers, as defined by FDEP regulations. . In the event that any reclaimed water is injected to an ASR well for below ground storage, it must meet both primary and secondary federal and state drinking water standards.

Northern Water Plant, Barwon Water, Australia.

Innovative public private partnership was used to deliver region-wide benefits through potable water substitution. The Northern Water Plant will significantly increase recycled water use and deliver region-wide environmental, economic and social benefits through potable water substitution. In 2003, Barwon Water began major investigations into managing the increasing sewerage flows from catchments in northern Geelong. At the same time the Shell Refinery were investigating options to increase treatment of waste water discharged to sewer and reduce reliance on potable water use. Trade waste from the Shell Refinery and sewage from Barwon Water's domestic catchments will be treated to generate Class A recycled water for supply to the Shell Refinery and local community sporting fields.

Drivers for Decentralization. The Northern Water Plant has been scoped and designed to provide the following functionality:

- Biological treatment of 1.8ML/day of trade waste and spent caustic from the Refinery.
- Transfer and treatment of 5.6 ML/d of sewerage from Barwon Water's network to make up the volume required to meet the recycled water demand.
- Transfer and biological treatment up to 240L/sec of wet weather flow to provide hydraulic relief of
- Barwon Water's downstream sewerage system.
- Temporarily store excess biologically treated water following wet weather events
- Supply 4.7 ML/day of Class A recycled water to Refinery for boiler feed, and 0.25 ML/day for fire service make up
- Supply 30KL/day of Class A water to Stead Park for irrigation.

Treatment System Description. The Northern Water Plant is designed to achieve a high level of treatment in their plant effluents, and each receives biological treatment followed by filtration, RO, and UV and chlorine disinfection. Processes include:

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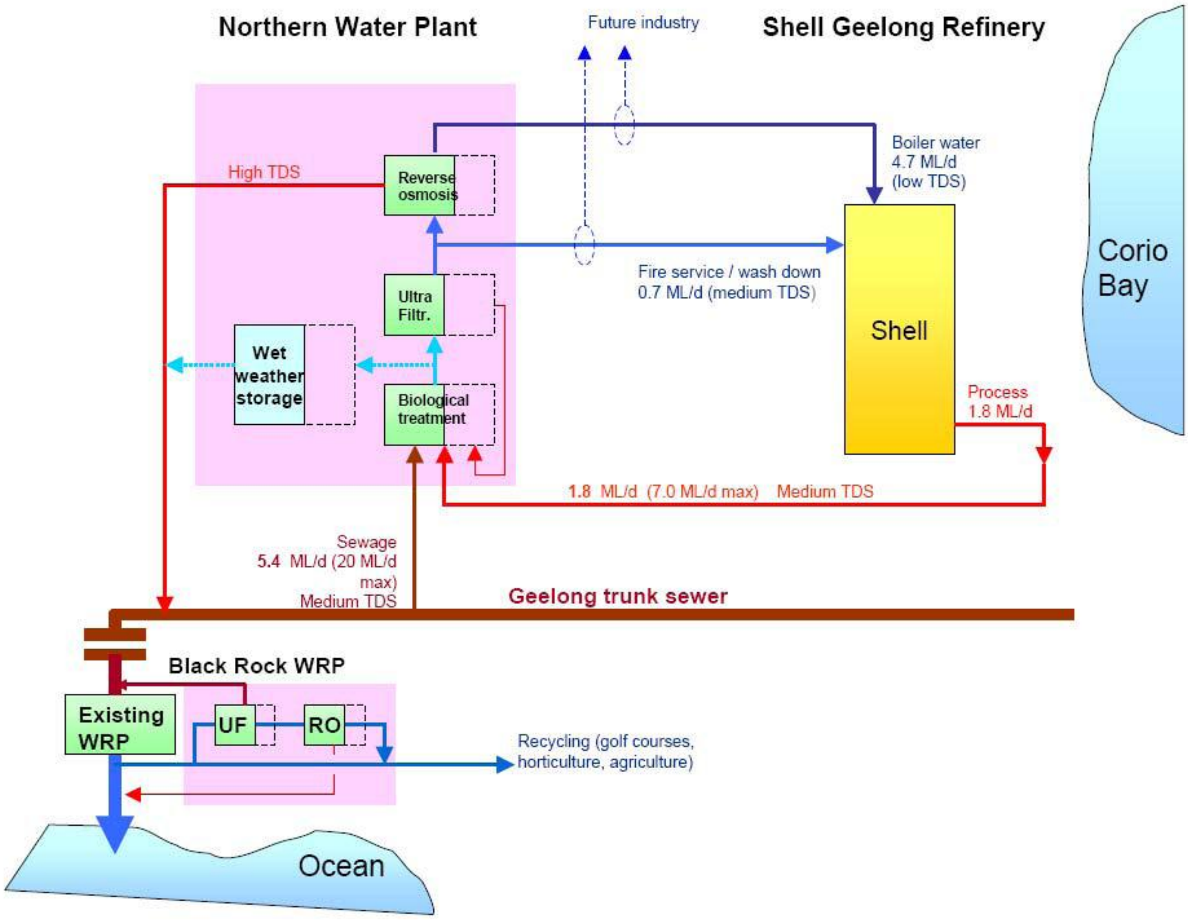
- • New pumping stations from two catchments
- • Inlet works (Band screen and Grit removal system)
- • Biological treatment (Modified Ludzack Ettinger),
- • Clarifiers
- • Ultra filtration membranes
- • UV disinfection
- • Reverse osmosis,
- • Chlorination
- • Wet weather and permeate storage lagoons
- • Onsite sludge thickening
- • Odour control



Benefits. The Project is will deliver the following benefits:

- Substitution of potable water with approximately 1,800 million litres of recycled water – equivalent to 5% of Geelong's supply
- Significantly contribute to Barwon Water's water re-use targets of 25% by 2015
- Provide irrigation water to local recreational and sports complex
- Compliance with regulatory requirements to contain wet weather flows
- Remove safety protocols on Barwon Water's sewers associated with Shell's trade waste
- 10% reduction in ocean discharge of treated wastewater from Black Rock WRP
- Allow future expansion of recycled water services to address climate change

As the industry moves in the direction of "One Water", where technology essentially erases the distinction between water and wastewater, so have many water companies moved to mine the wastewater as a social, economic, and environmental benefit.

Jebel Ali STP, Dubai, UAE.

Although wastewater is currently flowing to the Jebel Ali SPT, as a centralised plant, the palnt will be provided with a three pipe integrated system (sewerage, potable water and irrigation water) that will be servicing the whole of Dubai. The Al Awir STP feeds into one side of the irrigation system and then Jebel Ali feeds into the other side (30KM apart). In the future Dubai Municipality will look at decentralised RO plants (taking a reclaimed water feed from this irrigation system), treating though an advanced wastewater treatment system prior to usage for aquifer recharge, industrial applications or district cooling opportunities.

Drivers for Decentralization. As the need for additional water resources increases in the future, the Dubai Municipality will look at constructing several decentralised Advanced Water Reclamation Plants spread throughout the District. These Advances STPs will 'mine' a reclaimed water feed from the effluent irrigation system, treating though an advanced wastewater treatment system prior to offsite usage. This highly treated effluent would be used for:

- irrigation reuse
- aquifer recharge,
- industrial applications
- district cooling opportunities.

ADDITIONAL CONSIDERATIONS

Locating and designing a decentralized wastewater treatment facility will require special attention to the surrounding area and structures, and must follow a "good neighbor" policy with issues such as no odors and special architectural features. Design considerations include:

Instrumentation and Controls. Decentralized treatment facilities can be designed to be monitored and operate remotely, often from a centralized facility. SCADA and other on-line systems are typically used to minimize staffing at these facilities. Routine O&M can usually be accomplished during daytime shifts.

Odor Mitigation. Decentralized treatment facilities are often located in residual or light commercial areas depending on end usage of the treated effluent, and will typically require extensive odor control and treatment facilities. Raw sewage is often septic and will require containment and treatment, especially at the preliminary treatment processes and any solids handling or storage facilities.

Architecture and Landscaping. New wastewater treatment plants must blend in with the surrounding areas, and often require architectural features and landscaping that is normally not provided at wastewater treatment facility. New tankage is often completely covered, and even buried to lower the visual 'footprint' of the facility. Many of the facilities cited in this paper use architecturally pleasing structure and facades, and use trees and other landscaping to screen open tankage.

Sustainability. Energy efficiency and low carbon footprint must be designed into all new wastewater treatment facilities, including efficient buildings, state-of-the-art blower and aeration systems, and low power fixtures. The US EPA has created four classifications of sustainable practices. These are:

- Built Environment – The places where we live, work, shop, and play affect human health and the natural environment. How and where construction and development occurs can affect energy use, outdoor and indoor air quality, ecosystem quality and services, and natural and animal habitat protection. Planning development to preserve open space and critical habitat, revitalize and reuse land, and protect water supplies and air quality are key factors in building for a sustainable environment..

- Water, Ecosystems and Agriculture – Sustainable management practices are crucial in ensuring that our natural environment is protected for the present and for future generations. This is especially true in balancing economic, social, industrial, and recreational interests.

- Energy and the Environment – Fossil fuels - such as coal, natural gas, and oil - provide most of the energy used in the United States and impact the environment across geographical scales. Achieving sustainable and secure energy use requires that energy be developed from renewable and biological resources, be produced by cleaner and more efficient technologies, and be used more efficiently and with greater conservation. Sustainable energy practices reduce greenhouse gas emissions, incorporate efficient energy use and improvement of environmental quality without disrupting energy supplies, and minimize the affects of global change for the people, the environment, and the economy and of the United States.

- Materials and Toxics – The intergenerational dimension of sustainability means that society must be particularly mindful of the long-term threat posed by chemical and biological impacts on the environment. To protect humans and the environment from toxic chemicals to seek to promote the use of cleaner materials and to reduce material waste and chemical contamination.

SUMMARY

Decentralized wastewater treatment is frequently used worldwide in those locations where additional water supply and shortages of potable water make reuse of highly treated wastewater more acceptable. Often locating a ‘scalping’ or ‘sewer mining’ treatment plant can offer are significant cost advantages to locating the wastewater processing facilities in remote locations, essentially reducing the distribution and other transport costs. Treated wastewaters often are less costly than development of other potable water supplies, and if located near end-users, reclaimed water reuse can be an extremely cost-effective alternative.

This paper discussed several of the drivers for decentralized wastewater treatment, such as irrigation, water supply augmentation, stream flow augmentation, and industrial reuse. Several case histories of various wastewater treatment plants around the world were presented, including design criteria, effluent standards, and other descriptive information.

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