# **Case Study 8: United Arab Emirates**

# Al Wathbah-2 wastewater treatment plant and Abu Dhabi irrigation scheme

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### Acronyms

AADC	Al Ain Distribution Company		
ADDC	Abu Dhabi Distribution Company		
ADSSC	Abu Dhabi Sewerage Services Company		
DOE	Department of Energy		
RSB	Regulation and Supervision Bureau		
SCAD	Statistical Center – Abu Dhabi		
UAE	United Arab Emirates		
WWTP	Wastewater Treatment Plant		

# History and project justification

In the Emirate of Abu Dhabi, continued population growth, combined with rapid economic development, has increased wastewater production. This has created an urgent need for sustainable wastewater management to be included in the government's integrated water resource management plans.

In 2021, the estimated population of the Abu Dhabi metropolitan area was 1,512,000, which represents an increase of almost 2% from 2020 (Figure 1). Until 2021, the whole area was served by the Al Mafraq Wastewater Treatment Plant (Al Mafraq WWTP), which had a capacity of 66,902,867 m<sup>3</sup>/year (ADSSC 2020). The plant was old, overloaded and not able to cope with the increased wastewater coming from the city and the newly developed surrounding settlements.

In 2011, two new treatment plants and facilities were constructed to boost wastewater treatment services in Abu Dhabi city and the surrounding areas and to eventually replace the Al Mafraq WWTP. Al Wathbah-1 and Al Wathbah-2 Wastewater Treatment Plants (hereinafter Al Wathbah-1 and Al Wathbah-2 WWTPs) were designed to fill gaps in existing treatment facilities caused by the increased volume of wastewater and to produce recycled water to use as irrigation water for farms, parks, green areas and similar around Abu Dhabi as part of sustainable water resource management activities. Each plant has a design capacity of 109,500,000 m<sup>3</sup>/year increasing potential capacity from 124,100,000 m<sup>3</sup>/year to 219,000,000 m<sup>3</sup>/day. In addition, the Al Mafraq WWTP continued to operate, albeit with limited capacity, up to 2021.



FIGURE 8.1 Metro area population of the Emirate of Abu Dhabi (1950-2030). SOURCE: SCAD 2021.

Al Wathbah-2 WWTP (Figure 8.2, Image 8.1) treats a significant part of the wastewater coming from Abu Dhabi City. It has a treatment capacity of 300,000 m<sup>3</sup>/day and is designed to serve a population of 1,500,000. Production at the plant increased from 65,000,000 m<sup>3</sup>/year in 2012 to more than 82,600,000 m<sup>3</sup>/year in 2020 (Figure 8.3).

Challenges facing Al Wathbah-2 WWTP include but are not limited to:

- Wastewater discharge to the environment: after the completion of the project, only 45% of the treated water was being recycled and reused. The remaining 55% was discharged to the Al Musaffah Channel on the Arabian Gulf, causing negative economic and environmental impacts. This water can be reused as irrigation water.
- Treated wastewater quality: the catchment area for Al Wathbah-2 is below sea level. This has led to seepage of seawater into the collection network and results in high levels of salinity (between 3,000-4,000 ppm), which is reflected in the salinity levels of water produced at the plant. Water with high salinity levels has reduced reuse potential.



FIGURE 8.2 Al Wathbah-2 WWTP: location map and layout. *SOURCE*: Google Earth.



IMAGE 8.1 Al Wathbah-2 WWTP. SOURCE: ADSSC.



FIGURE 8.3 Al Wathbah-2 WWTP: Production 2012-2020.

## Reuse case description at a glance

Water reuse for irrigation, especially for food production, is central to the Emirate of Abu Dhabi's strategy to increase food security and food self-sufficiency. It is also central to its integrated water resource management plans, which include an ambitious target to reach zero discharge of recycled water into the environment by 2020.

To this end, in 2016, the Abu Dhabi government approved two mega projects to reuse 55% of treated water, which was being discharged into the environment. These projects, which include the completion of the required transmission and distribution networks and pumping stations for the recycled water to reach end-users, started in 2020 with an expected completion date of August 2022 and an investment cost of almost USD 0.3 billion. The works had originally been scheduled to be completed by 2020 but were delayed due to the COVID-19 pandemic.

In addition to the 105,000 m<sup>3</sup>/day of recycled water from Al Wathbah-2 WWTP currently used for irrigating landscaped areas and green spaces around local amenities, there is significant potential for its use in agricultural irrigation that could contribute to both food and environmental strategies. In 2014, 185 farms were supplied with 27,000 m<sup>3</sup>/day of recycled water from the plant. By August 2022, it was anticipated that an additional 390,000 m<sup>3</sup>/day of recycled water from Al Wathbah-1 and -2 WWTPs will be used to irrigate 4,200 farms, with half of this recycled water coming from Al Wathbah-2 WWTP (Dawoud 2017) (Figure 8.4).

In environmental terms, a preliminary assessment by the Department of Energy (DOE) found that aquifer recharge using recycled water from the plant could also be used as a means to enhance the quality of brackish groundwater and that excess irrigation wastewater during non-peak seasons could be recharged to the aquifer system to be used later. A big advantage of aquifer recharge using recycled water from wastewater treatment plants is that it breaks the pipe-to-pipe connection of direct reuse. This reuse project will make a significant contribution toward replacing the use of desalinated water by 125,000 m<sup>3</sup>/day and the costs of maintaining and operating more than 1,000 groundwater wells.

# National institutional and policy environment

Wastewater collection, treatment, discharge and reuse in the Emirate of Abu Dhabi have all historically sat under the responsibility of the Regulation and Supervision Bureau (RSB), which is part of the Abu Dhabi Executive Office. However, this changed in 2018 when a new governmental structure was established which included a new Department of Energy (DOE). The DOE was created to drive the Emirate's energy and water transition efforts toward creating a sector that promotes economic development, demographic growth, social development and environmental sustainability (in accordance with Law No. 11 of 2018).

In 2010, the RSB issued the Emirate of Abu Dhabi Trade Effluent Control Regulations Framework (Figures 8.5 and 8.6), to protect public health and regulate various aspects of wastewater treatment, management and monitoring.

# Stakeholders involved and management model



Abu Dhabi Sewerage Services Company (ADSSC) manages and operates both the Al Wathbah

**FIGURE 8.4** Al Wathbah-2 WWTP and reuse project: Schematic diagram and management model. *SOURCE*: DOE 2019.

*NOTES*: Al Ain Distribution Company (AADC), Abu Dhabi Distribution Company (AADC), Abu Dhabi Sewerage Services Company (ADSSC), Independent Sewage Treatment Plant (ISTP), Recycled Water and Biosolids (RW&B).

WWTPs and is responsible for different parts of the chain including collection and treatment. The Abu Dhabi Distribution Company (ADDC) and the Al Ain Distribution Company (AADC) have recently been given the responsibility for the transmission and distribution of recycled



FIGURE 8.5 Emirate of Abu Dhabi Trade Effluent Control Regulations 2010 Framework. *SOURCE*: QCC 2010.



FIGURE 8.6 Trade effluent discharge characterization chart in the Emirate of Abu Dhabi. *SOURCE*: QCC 2010.



**FIGURE 8.7** Structure of the recycled wastewater collection, treatment and reuse for Al Wathbah-2. *SOURCE*: DEO 2019. *NOTES*: Al Ain Distribution Company (AADC), Abu Dhabi Distribution Company (ADDC), Abu Dhabi Sewerage Services Company (ADSSC).

water for non-potable use, the majority of which is for irrigation, while the Department of Energy is responsible for monitoring and regulation. In terms of recycled water business assets in Abu Dhabi, which had a distribution network of 1,050 km and 494 interface points in January 2018, management was separated across different entities (Figure 8.7).

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## Funding and financial outlook and cost recovery

Al Wathbah-2 WWTP was constructed in 2012 with a capacity of 109,500,000 m<sup>3</sup>/year. It is a Build-Own-Operate-Transfer (BOOT) project – a project delivery mechanism in which the government grants a private sector party the right to finance, design, construct, own and operate a project for a set number of years. Al Wathbah-1 and Al Wathbah-2 WWTPs are BOOT projects, owned by the Abu Dhabi government and represented by Abu Dhabi Sewerage Services Company (ADSSC).

Al Wathbah-2 WWTP was designed and constructed by Al Wathbah Veolia Besix Wastewater for USD 280 million (AED 1.029 billion). It has an annual operation cost of USD 35 million (AED 128.6 million). Currently, there is a recycled water tariff with all capital (CAPEX) and operating (OPEX) expenditures paid by a government subsidy. Recycled water is given to the municipalities and end-users at no cost.

Currently, Al Wathbah-2's costs are not covered, but a wholesale tariff for recycled water, which will be enforced from January 2023, is intended to cover ADSSC's costs related to the production of recycled water. The tariff is a result of a proposal by ADSSC to allocate its costs between activities related to wastewater and recycled water and implement a mechanism to recover costs through a wholesale tariff. The Department of Energy (DOE) approved the proposal to have a recycled water tariff of USD 0.46/m<sup>3</sup> (AED 1.7).

	Wastewater collection and transport	Wastewater treatment	Transport of recycled water	Additional treatment for reuse	Distribution of recycled water to end-users
Construction and equipment services (de- scription and dimensions)	Collection network in- cluding Stra- tegic Tunnel Enhancement Program	Inlet Pumping Station Submersible pumps lift the sewage approxi- mately 23 m into the headwork from where the sewage gravitates through the plants Preliminary Treatment: Fine screens remove all particles with a size larger than 6 mm. In the next step, sand, grit, stones and broken glass settle down in the tanks. Lastly, surface skimmers remove oil and grease from the sewage Secondary Treatment: Removes majority of BOD5 and ammonia from the wastewater through two processes Tertiary Treatment: Ensures that the effluent complies with regulatory standards for irrigation purpos- es. Dual media filters (pumice stone and sand) are used for the filtration process. Then, the water is disinfected by injecting sodium hy- pochlorite produced on site. Finally, the recycled water is pumped to a reservoir with a capacity of 50,000 m <sup>3</sup> from where it is distributed to consumers to be used as water for irrigation purposes	Two main transmission pipelines with a diameter of 1,200 mm - One along Al Ain Road with a daily capac- ity of 250,000 m <sup>3</sup> (75 km) and one along Dubai Road with a capacity of 140,000 m <sup>3</sup> (length 45 km) Three pumping stations and ground reser- voirs	No additional treatment for reuse	Distribution network for 4,200 farms
Stakeholder that delivers the service	ADSSC	ADSSC	ADDC	NA	ADAFSA
CAPEX (in USD)	5,700 million	550 million	300 million	NA	50 million
CAPEX recov- ery and % of subsidy	100% subsidy by the gov- ernment	100% subsidy by the government	100% subsidy by the govern- ment	NA	100% sub- sidy by the government
Operation and maintenance services (de- scription)	25 years duration of the operation contract	25 years duration of the operation contract	Operation and maintenance contract by ADDC	NA	Operation and main- tenance by ADAFSA
Stakeholder that delivers the service	ADSSC	ADSSC	ADDC	NA	ADAFSA
OPEX (in USD/ year)	530 million	55 million	30 million	NA	5 million
OPEX recovery and % of subsidy	100% subsidy by the gov- ernment	100% subsidy by the government	100% subsidy by the govern- ment	NA	The newly approved tariffs will be USD 0.46 (1.7 AED)/ m <sup>3</sup> starting January 1, 2023.

#### TABLE 8.1 Funding and financial outlook and cost recovery.

NOTES: Abu Dhabi Agriculture and Food Security (ADAFSA), Abu Dhabi Distribution Company (ADDC), Abu Dhabi Sewerage Services Company (ADSSC), Biological Oxygen Demand (BOD), Capital Expenditure (CAPEX), Operating Expenditure (OPEX).

The CAPEX and OPEX costs for the reuse infrastructures to irrigate 4,200 farms are fully covered by the municipalities account which pays the Abu Dhabi Distribution Company (ADDC).

Full details are set out in Table 8.1.

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# Socioeconomic, health and environmental benefits and impacts

The Emirate of Abu Dhabi is witnessing one of the fastest-growing populations and economies in the world, with a projected population of almost 7 million by 2030. The government needed to take action to ensure its wastewater infrastructure needs are met now and in the future.

Although the old Al Mafraq WWTP had been continuously upgraded over its history, including an upgrade in capacity to 260,625 m<sup>3</sup>/day in 1997 and new systems for odor control and biosolids management, it became overloaded, leading to raw wastewater discharge into the environment and inefficient treatment of the collected volumes of wastewater. The construction of Al Wathbah-2 WWTP was part of planned activities carried out in the Emirate of Abu Dhabi between 2010 and 2013 to serve the wastewater needs of 3 million inhabitants.

Al Wathbah-2 WWTP is already providing socio-economic, health and environmental benefits including reduced discharge of raw sewage water to the environment, fewer odors and improved biosolids management. Raw sewage discharge has negative health and environmental impacts. The quality of the treated wastewater has improved increasing its reuse potential as irrigation water for both green and landscaped areas and for agricultural areas to replace the present use of desalinated water. This is saving USD 2.77 (AED 10.2)/m<sup>3</sup> of desalinated water and reduces energy consumption, which is also minimizing carbon emissions from the desalination plants. It is also more cost-efficient. Recycled water costs USD 0.051 (AED 1.9)/m<sup>3</sup> compared with expensive desalinated water.

Using recycled water from Al Wathbah-2 WWTP is also helping to improve and enhance deteriorated groundwater quality and increase reserves for future uses. By April 2022, it is expected that 4,200 farms will be irrigated with reused water, which will replace about 250,000 m<sup>3</sup>/day of brackish groundwater farms. In addition, the total dry mass of biosolids produced at the plant will be recycled for producing compost. In 2020 this amounted to 13,859 t.

# **Gender equality**

In March 2015, Her Highness Sheikha Fatima bint Mubarak, Chairwoman of the General Women's Union, Supreme Chairwoman of the Family Development Foundation and President of the Supreme Council for Motherhood and Childhood, launched the National Strategy for Empowerment of Emirati Women in the UAE (2015–2021). The strategy provides a framework for all federal and local government entities, the private sector, as well as social organizations, to set plans that will provide a decent living for women and make them creative in all sustainable and developmental fields. The strategy is the framework for setting up work plans, which would contribute to positioning the UAE among the advanced countries in the area of women's empowerment including in the water industry.

Wastewater development offers huge potential for women's employment even if currently they are under-represented. Only 0.6% of the women workforce are currently employed in the water supply, sewerage and waste management sector although the number of women working in the wastewater sector, including at Al Wathbah-2 WWTP, has increased by 30% since 2015.

The Abu Dhabi government is also dedicated to increasing the number of women in water reuse-related enterprises. Almost a quarter of the farms that will be supplied by treated wastewater from Al Wathbah-1 and Al Wathbah-2 WWTPs are owned by women with the potential to increase their livelihoods and food security. During focus group studies carried out by the government, women showed a high acceptance level in terms of using recycled water from wastewater treatment plants for agricultural purposes.

### **Resilience to COVID-19**

Treated wastewater samples from Al Wathbah-2 WWTP were collected in May and June 2021 and tested for COVID-19 (SARS-CoV-2) viral loads to track the prevalence of the virus and as an early-warning tool for predicting outbreaks in the future. Composite samples collected over 24 hours were made safe and then tested using a variety of different methods. None of the samples tested from Al Wathbah-2 WWTP were positive during the entire sampling period, indicating that the treatment technologies used at the plants are efficient and that the treated water was safe to reuse.

# Scalability and replicability potential

The smart management of wastewater treatment plants in the Emirate of Abu Dhabi Emirate including Al Wathbah-2 and the sustainable management of treated wastewater combined are expected to form a cornerstone to achieving Abu Dhabi's sustainability goals. The Abu Dhabi experience is scalable and can be applied throughout the region and beyond. Examples of water reuse achievements that could be replicated include:

Technology and Service Solutions: To control and manage the big assets and infrastructures, ADSSC has inaugurated a remote control and monitoring system for its wastewater treatment plants including Al Wathbah-2. The system enables means a comprehensive database can be maintained that enables supervisors to analyze data and submit reports to make informed decisions. Data from the system also helps develop and plan maintenance programs.

- Reuse and Achieving Zero Discharge to Environment: Abu Dhabi Government will reach zero discharge of wastewater to the environment by April 2022 by utilizing 390,000 m<sup>3</sup>/ day in irrigation. All produced treated wastewater, including from Al Wathbah-2 WWTP, will be fully utilized to irrigate 4,200 farms in addition to present use, and future production increases will be used for groundwater aquifer recharge to enhance the groundwater quality and reserve in areas near the existing farms to be used later for irrigation.
- Advanced Treatment Plants: In 2015, ADSSC in collaboration with the Environment Agency constructed the first advanced treatment plant with a capacity of 27,000 m<sup>3</sup>/day to irrigate 230 farms that use Al Wathbah-2 tertiary treated water.
- Food Security: The use of recycled water from Al Wathbah-2 WWTP will help the government improve its food self-sufficiency ratio. The ratio is currently 14% with a government target to reach 25% by 2030.

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## **SWOT** analysis

An analysis of the strengths, weaknesses, opportunities and threats (SWOT) of the Al Wathbah-2 WWTP and Abu Dhabi water reuse project is shown in Table 8.2 including an overview of serious setbacks it could face during its overall life cycle owing to institutional, economical, technical and social pressures and constraints.

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# Key factors for success along the project and lessons learned

Key factors for success along the project include:

- Understanding the role that tertiary treated water from the Al Wathbah-2 WWTP can play in an arid region with very limited renewable freshwater resources, as part of integrated water resource management plans and sustainability measures. In addition to being an additional water source, it can also relieve pressure on deteriorated groundwater aquifers and costly desalinated water, reduce energy use and associated carbon dioxide emissions from desalination plants and minimize the environmental impacts of desalination.
- The supply and installation of environmentally friendly bio trickling filters in the wastewater pumping stations have provided an environmentally friendly upgrade to the existing chemical scrubbers for the removal of odorous gas compounds in the recycled water.
- Using recycled water for irrigation in wetlands such as Al Wathbah Wetlands has environmental and ecological positive impacts.

Lessons learned include:

- Reuse of tertiary treated wastewater in irrigation can save using costly desalinated water and safe groundwater.
- Emerging and state-of-the-art technologies can help to reduce both CAPEX and OPEX.
- There are many treatment options for the direct reuse of reclaimed water in developing countries.
- Direct reuse of recycled water from wastewater treatment plants in the Emirate of Abu Dhabi is the most technical and economically feasible solution when compared to other options such as aquifer recharge of district cooling.

TABLE 8.2 Al Wathbah-2 WWTP and Abu Dhabi water reuse project: SWOT analysis.

	HELPFUL TO ACHIEVING THE OBJECTIVES	HARMFUL TO ACHIEVING THE OBJECTIVES
INTERNAL ORIGIN ATTRIBUTES OF THE ENTERPRISE	<ul> <li>STRENGTHS</li> <li>Enabling legislative framework</li> <li>Training on operation and management.</li> <li>Construction of collection tunnels to minimize the seepage of seawater into the collection network</li> <li>Wastewater tariffs will be enforced by 1 January 2023 as part of cost recovery</li> </ul>	<ul> <li>WEAKNESSES</li> <li>Discharge of stormwater to the wastewater collection network</li> <li>Only 45% of produced water from the Al Wathbah-2 WWTP is reused</li> <li>Discharge of 55% of recycled water produced is discharged into shallow and closed Al Musaffah marine channels causing negative environmental impacts</li> <li>Lack of wastewater transmission and distribution infrastructures.</li> <li>Seepage of seawater to the collection network is increasing the salinity of raw wastewater to 3,000-4,000 ppm that is not removed by Al Wathbah-2 during the treatment process</li> <li>Discharge of 13,859 tons of biosolids to the environment</li> <li>Wastewater tariffs could be a threat to reuse</li> </ul>
EXTERNAL FACTORS ATTRIBUTES OF THE ENVIRONMENT	<ul> <li>OPPORTUNITIES</li> <li>Raising awareness of the environmental aspects of wastewater treatment plants</li> <li>Construction of transmission and distribution infrastructures to reach 100% utilization of produced treated wastewater</li> <li>Increasing and empowering women's employment in operational roles at the Al Wathbah-2 WWTP, which are currently low</li> <li>Development of legislation related to recycled water use in farming</li> <li>Recycling of 13,859 tons of biosolids for producing compost</li> <li>Establishing agricultural measures to monitor agricultural land that uses recycled water for irrigational purposes</li> <li>Stakeholder involvement and engagement in water reuse for irrigation</li> <li>Enhance cost recovery for reuse in farming</li> </ul>	THREATS CAPEX needed to implement and maintain proper treatment or mitigation measures to solve the salinity level of treated wastewater from Al Wathbah-2

# **Methods and resources**

To collect and review all the required data on the Al Wathbah-2 WWTP Plant, a data collection form designed by Mohamed Dawoud was sent to the Abu Dhabi Sewerage Services Company (ADSSC). In addition, two interviews were conducted including one with the Abu Dhabi Municipality team and one with the Al Wathbah-2 WWTP operation team.

Other methods used during data collection and analysis included the design of data and output forms regarding the status of Al Wathbah-2 WWTP including capacity, production, reused quantities and quality in alignment with Department of Energy guidelines.

Data were collected and analyzed from different sources as follows:

- UAE Annual Statistical Report 2021 Federal Competitiveness and Statistics Centre (FCSC 2021)
- Data collection sheets and Annual Report, Abu Dhabi Sewerage Services Company (ADSSC)
- Official meetings with the Abu Dhabi Municipality and ADSSC
- Abu Dhabi Annual Statistical Report 2020 (SCAD 2021)
- Interviews with stakeholders involved in the operation of Al Wathbah-2 WWTP, the reuse of recycled water from the plant and wastewater regulation in the Emirate of Abu Dhabi.

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### References

- ADSSC (Abu Dhabi Sewerage Services Company). 2020. Abu Dhabi annual wastewater production and reuse statistical report. Abu Dhabi, United Arab Emirates (UAE): ADSSC.
- Dawoud, M. 2017. Feasibility of using treated wastewater in groundwater aquifer recharge in Abu Dhabi. The Gulf Water Science and Technology Association (WSTA). 12th WSTA Gulf Water Conference, March 28-30, 2017, Bahrain. WSTA. https://www.researchgate.net/publication/323476712\_Feasibility\_of\_Using\_Treated\_Wastewater\_in\_Groundwater\_Aquifer\_Recharge\_in\_Abu\_Dhabi
- DOE (Department of Energy). 2019. *Recycled water first regulatory control*. Abu Dhabi, United Arab Emirates (UAE): DOE. 43p.
- FCSC (Federal Competitiveness and Statistics Center). 2021. Annual statistics report. Abu Dhabi, United Arab Emirates (UAE): United Arab Emirates Ministry of Cabinet Affairs.
- QCC (Abu Dhabi Quality and Conformity Council). 2010. *Trade effluent control regulations 2010*. Abu Dhabi, United Arab Emirates (UAE). The Regulation and Supervision Bureau for the Water, Wastewater and Electricity Sector in the Emirate of Abu Dhabi. 30p. https://jawdah.qcc.abudhabi.ae/en/. Registration/QCCServices/SETD/ISGL/ISGL-LIST/WA-721.pdf
- SCAD (Statistics Centre Abu Dhabi). 2021. *Statistical yearbook of Abu Dhabi 2020*. Abu Dhabi, United Arab Emirates (UAE): SCAD. 272p. https://www.scad.gov.ae/Release%20Documents/Statistical%20. Yearbook%200f%20Abu%20Dhabi\_2020\_Annual\_Yearly\_en.pdf