Water Management

Strategies & 2030 Goals	2019 Achievements	2020 Targets
Risk Management of Water Resources Enforce climate change mitigation policies, implement water conservation and water shortage adaptation measures		
Reduce unit water consumption (liter/8-inch equivalent wafer mask layer) by 30% (Base year: 2010)	Reduced water consumption per unit product by 5.2% (Base year: 2010)[Note 4] Target: 27%	Reduce unit water consumption (liter/8-inch equivalent wafer mask layer) to 10% (Base year: 2010)
Develop Diverse Water Sources Integrate internal and external company resources to develop regenerated water technology; implement water conservation and the use of regenerated water in the manufacturing process		
Increase the replacement rate of regenerated water by more than 30% [Note 1]	Saved an additional 3,280,000 metric tons of water through newly-adopted water conservation measures Target: 1.14 million metric tons	Commence the TSMC Tainan Science Park Reclaimed Water Plant tender project and start supplying water in 2021
Develop Preventive Measures Improve the efficiency of water pollution prevention and removal of water pollutants [Note 2]		
Water pollution composite indicator 30% above effluent standards [Note 3]	Average concentration of tetramethylammonium hydroxide (TMAH) in wastewater discharge was 7.86 ppm Average concentration of copper ions in wastewater discharge was 0.09 ppm Target: Tetramethylammonium hydroxide (TMAH) < 8 ppm; copper ion (Cu^{2+}) < 0.15 ppm	Discharge less than 6 ppm of tetramethylammonium hydroxide (TMAH) Water pollution composite indicator reduction rate of 20%

● Exceeded ○ Achieved ○ Missed Target

Note 1: Replacement rate of reclaimed water includes cumulative total of conserved water
Note 2: The scope of water pollution projects and data includes Taiwan facilities and VIsEra
Note 3: Water pollution composite indicator is an integration of TSMC's pollutants as compared to the average reduction rate of effluent standards: Including chemical oxygen demand (COD), villaumite, suspended solids, ammonia nitrogen, nitrate nitrogen, arsenic, boron, copper, NMP, and cobalt
Note 4: Due to test production in new fabs, water consumption per unit product did not meet standards. TSMC continues to commit to the development of water reclamation techniques. Its industrial water reclamation plant is expected to commence operation and supply water by 2021

Semiconductor processes have become complex as they advance from 2D structures to a 3D FinFET architecture, which in turn increases the types and quantity of the chemical materials used. Water is vital to cleaning wafers and maintaining a clean environment. TSMC has established various water recycling applications through water resource risk management, expansion of diverse water sources, and the development of pollution prevention techniques in order to maximize the efficiency water use throughout the water cycle in its facilities. In 2019, the Company took further steps to regulate the water management framework of its facilities to ensure the reasonable allocation of facility water resources in response to seasonal temperature changes.

Water Resource Risk Management

Comprehensive Information Network and Meticulous Water Balance Calculation

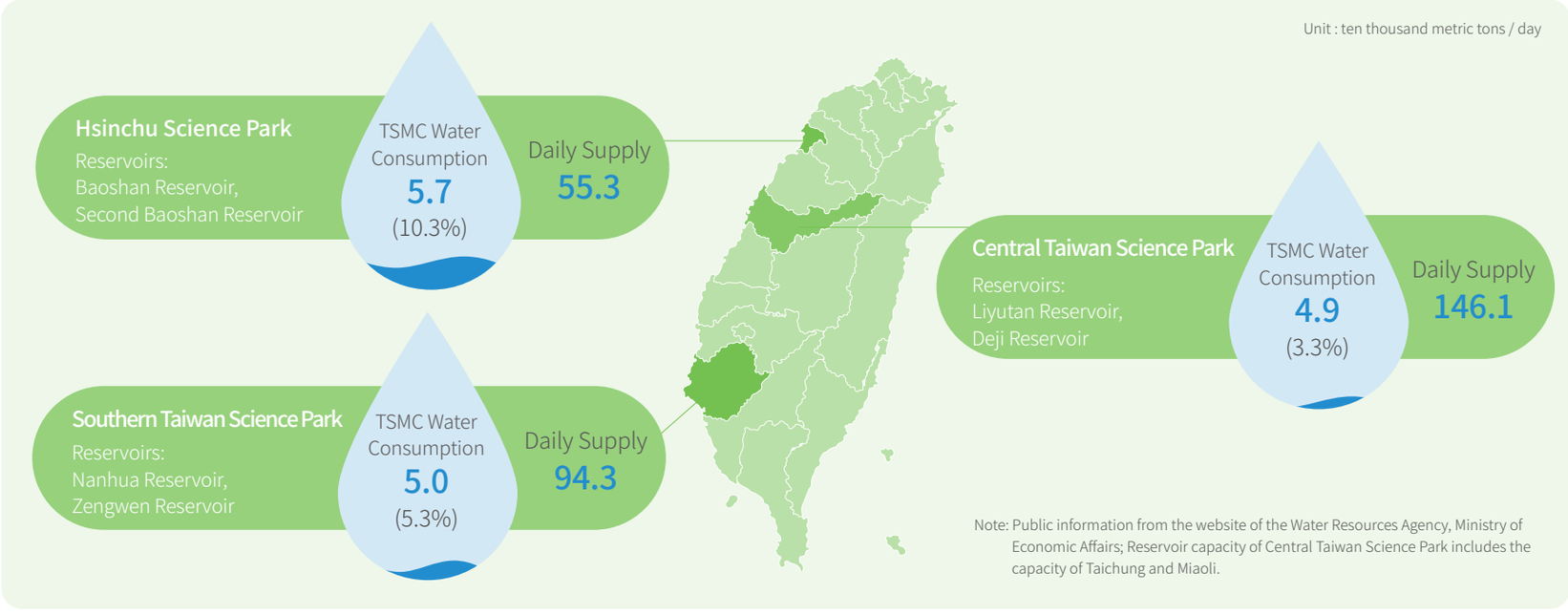
TSMC uses a comprehensive water reporting system for continuous monitoring of water levels in water reservoirs, and installs hundreds of water consumption monitoring points combined with water balance diagrams around its facilities to calculate process water consumption, recycled water, wastewater, and domestic water consumption in facilities, as well as to track the direction and quantity of water flow and water reclamation status. The data is used as the basis for calculating water recycling rates and water discharged rates, for estimating the volume of water allocated to each water-consuming unit, and for establishing an effective index for monitoring water use.

Smart Management of Recycled Water

The key to successful water resources allocation is detailed classification and comprehensive water reclamation mechanisms. TSMC categorizes wastewater from purification and processing equipment according to purity so that the cleanest water is given priority to be purified and recycled for use in the manufacturing process, and the second cleanest water is treated in water recycling facilities then supplied for use by water-consuming units other than production equipment. Finally, unrecyclable wastewater is discharged to an onsite wastewater treatment plant, where various wastewater recycling and treatment systems are used to enable continuous water purification and reuse in processes, cooling towers, and pollution prevention systems for better water resource efficiency.

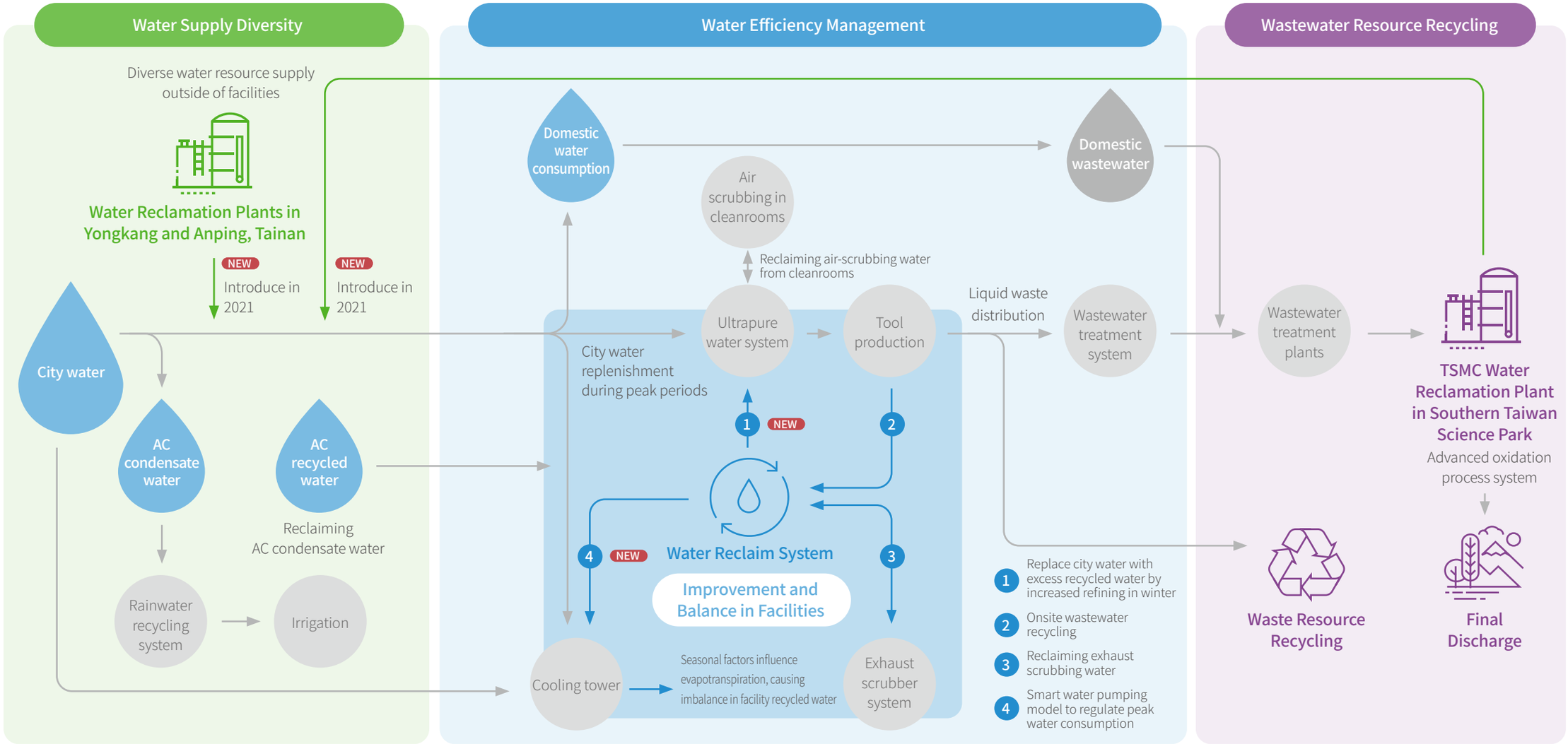
In 2019, TSMC took progressive measures to build smart mechanisms for managing recycled water. Based on seasonal changes and peak water consumption predictions, TSMC refined water reclamation techniques such as reverse osmosis membranes, resin columns, and UV lights to improve the quality of recycled water. Recycled water with improved quality can replace city water. For example, when the use of air-conditioning systems is reduced in winter, cooling towers require less water, causing an excess of recycled water. A smart recycled water management mechanism can dynamically allocate and supply recycled water, instead of city water, to other production units

TSMC Water Consumption Rate at Three Science Parks



Note: Public information from the website of the Water Resources Agency, Ministry of Economic Affairs; Reservoir capacity of Central Taiwan Science Park includes the capacity of Taichung and Miaoli.

Main Water Cell and On-site Recycling System

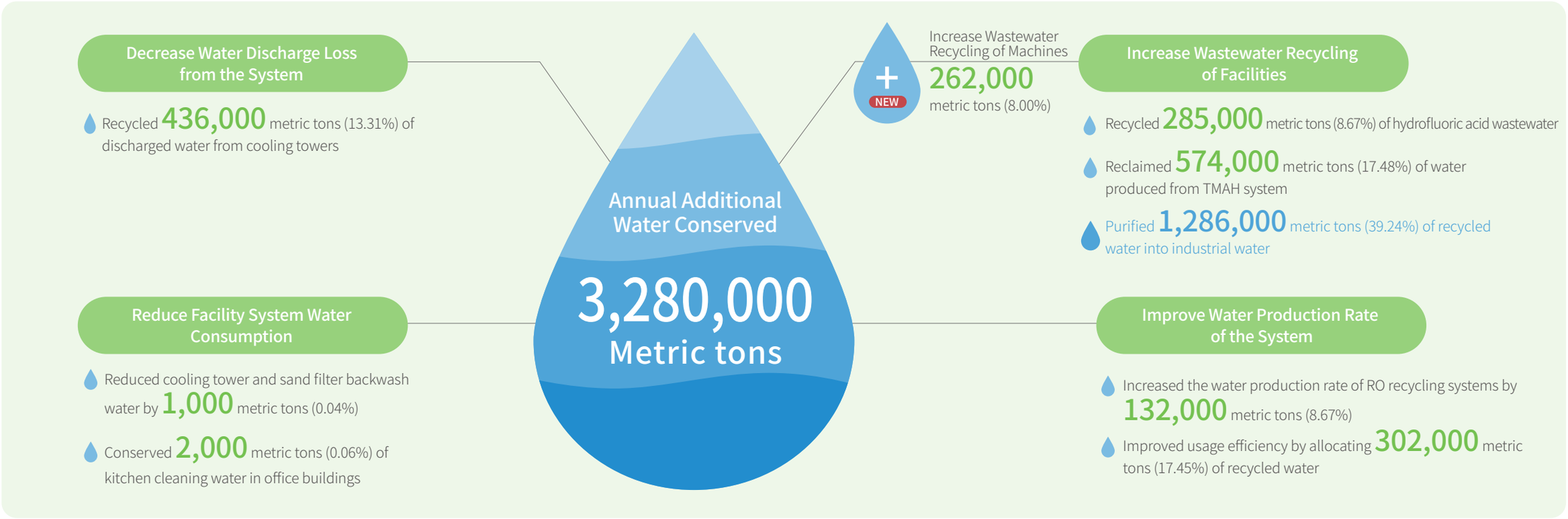


Improving Water Efficiency and Strengthening Facility Water Reclamation Measures

In 2019, TSMC has continuously increased the depth of its four water conservation measures: reduce water consumption by facility systems, increase wastewater recycling in facility systems, improve system water production rates, and decrease water discharge loss from the system. In addition to continuously enhancing the effectiveness and expanding the scale of the eight existing water-saving measures, TSMC also introduced wastewater recycling machines and took comprehensive measures in five of its facilities to "purify recycled water into industrial water", effectively saving 1,286,000 tons of water. The annual additional water conserved reached 3,280,000 metric tons in total.

Many newly-built TSMC fabs (Fab 15 Phase 7 and Fabs 19 Phases 1 and 2) began operating in 2019. Due to increased demand for process cleanliness and optimization of operating systems, unit water consumption was 59.3 (L/8-inch equivalent wafer mask layer) in 2019, a reduction of 5.2% as compared to the base year, which means the annual target was not achieved.

Water Conservation Measures and Results in 2019



Wastewater discharge is closely related to city water consumption and recycled water. Unit wastewater discharge in 2019 was 39.8 (L/8-inch equivalent wafer mask layer), an increase of 22.1% as compared to last year. TSMC actively conducts inventory of various water saving measures. By optimizing the water efficiency of advanced processes and introducing water reclamation techniques, the Company aims to improve the process water recycling rate, recycling volume, and use of reclaimed water and to reduce wastewater discharge.

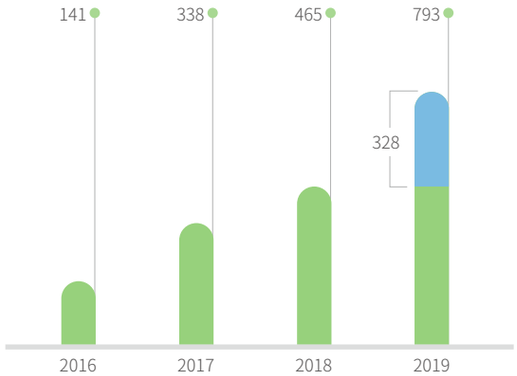
187%

Saved an additional 3,280,000 metric tons of water through newly-adopted water conservation measures, surpassing annual water saving targets by 187%

6 Years

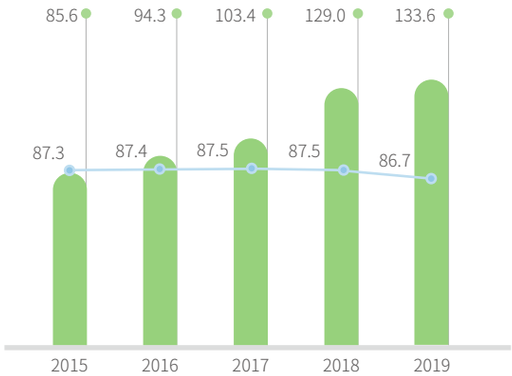
Cu^{2+} and NH_4-N concentration of effluent water achieved 2025 goals six years ahead of schedule

Annual Water Conservation Unit: ten thousand metric tons



- Annual Cumulative Water Conserved
- Annual Additional Water Conserved

Water Recycling and Usage Efficiency

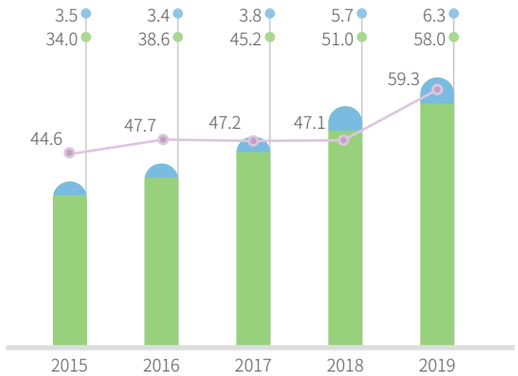


- Total amount of water recycling (million metric tons)
- Average process water recycling rate (%)

Note 1: Total amount of water recycled includes numbers from manufacturing process water treatment and recycling as well as manufacturing process water recycling in scrubber towers

Note 2: Total volume of water recycled and average recycling rate of water for manufacturing processes are calculated with data from TSMC's facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra

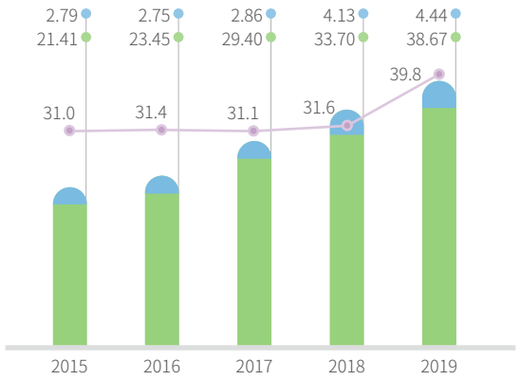
City Water Consumption and Water Consumption per Wafer-Layer



- Total city water consumption of Taiwan facilities (million ton)
- Total city water consumption of subsidiaries (million metric tons)
- Water consumption per wafer-layer (Liter / 8-inch equivalent wafer mask layer)

Note: City water consumption and unit water consumption intensity index are calculated with data from TSMC's facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra

Wastewater Discharge per Product Unit



- Wastewater discharge of Taiwan facilities (million metric tons)
- Wastewater discharge of subsidiaries (million metric tons)
- Discharge per product unit (Liter / 8-inch equivalent wafer mask layer)

Note: Wastewater discharge and unit wastewater intensity index are calculated with data from TSMC's facilities in Taiwan, WaferTech, TSMC (China), TSMC (Nanjing) and VisEra

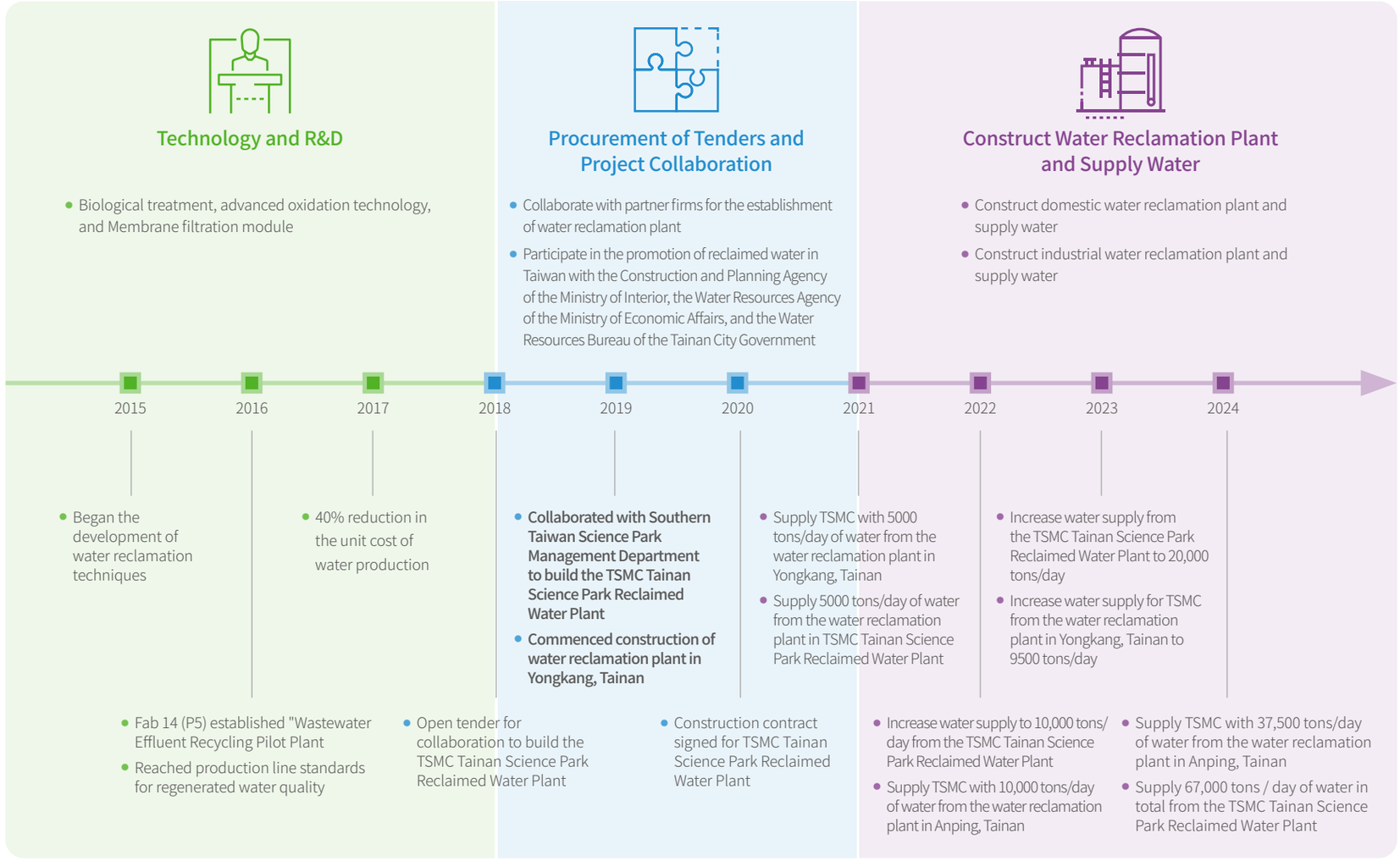
Develop Diverse Water Sources

Adopting Domestic & Industrial Reclaimed Water to Reduce City Water Consumption

As a leading global semiconductor company, TSMC began developing water reclamation techniques in 2015 by coordinating with government departments to plan the construction of industrial recycled water facilities and use of recycled domestic water. In line with the reclaimed water pipeline configurations in science parks, bidding for TSMC's Tainan Science Park Reclaimed Water Plant was successfully launched in 2019. This operation represents a concrete action by TSMC to expand water resource diversity.

Please refer to TSMC Fulfills Green Manufacturing by Supporting the Establishment of First Private-owned Reclaimed Water Plant in Taiwan on the TSMC Corporate Social Responsibility website for more details

Timeline of Highlights for Regenerated Water



Note: Water supply schedule and water supply volume for 2021 and thereafter are calculated from reclaimed water consumption contracts between TSMC and government departments (Southern Taiwan Science Park Administration and Tainan City Government)

Develop Preventive Measures

Effective Source Distribution Management and Treatment Facilities

A total of 38 distribution systems have been established based on the composition and concentration of wastewater from manufacturing processes. TSMC has built a comprehensive wastewater classification and resourcing system integrated with treatment equipment to effectively decompose pollutants. Following this, wastewater is condensed and reclaimed through the recycling system to further reduce the concentration of pollutants in line with the dual goals of pollutant reduction and reuse. In 2019, TSMC installed a new distribution and treatment system for wastewater containing high concentrations of cobalt and cobalt-containing CMP wastewater. Additionally, a cobalt-containing wastewater electroplating system was established to recycle cobalt-containing wastewater for making cobalt bars. In 2019, 150 kg of cobalt bars were produced.

Wastewater Quality Improvement

All TSMC fabs have installed equipment to continuously monitor water quantity and quality at effluent spouts of wastewater treatment facilities. By closely monitoring and recording changes in water quality and quantity, TSMC can respond appropriately when abnormalities occur.

TSMC actively assesses manufacturing raw materials by referencing domestic and international studies on aquatic toxicity, placing focus on pollutants in the semiconductor industry, such as TMAH (strong base), copper ions (heavy metal) and ammonia nitrogen, as well as suspended solids and chemical oxygen demands that strongly impact marine life, setting these as five key targets to be improved in the first phase. The Company has carried out various improvement measures, and established the second-phase goal of reducing the water pollution composite indicator of 10 substances by 30% by 2030, to demonstrate TSMC's determination to reduce the environmental impact of wastewater discharge. In 2019, TSMC enhanced distribution of copper-containing liquid waste and chemical dosage improvement, effectively reducing copper ions in discharged water by 0.09 ppm, which is far below the 1 ppm drinking water standard. The Company has reached the 2025 target ahead of schedule. The efficiency of ammonia nitrogen wastewater treatment was improved, as indicated by the reduction of discharge concentration to 17.31 ppm, which is better than the effluent standards.

Preventive Techniques on Key Pollutants of Wastewater Quality and Improvement Achievements

Unit: ppm

Item	Status in 2019	Standards Set by Science Park Administration	Targets in 2025	2019 Improvement Outcome (2014 as Baseline)	Preventive Techniques
TMAH	7.86	HSP: 30 CTSP: 20 STSP: 60	1.0	Reduced by 74% from the previous year	• Recycle low-concentration liquid waste • Establish anion exchange resin towers
Copper ion	0.09	HSP: 1 CTSP: 0.8 STSP: 1.5	0.1	Reduced by 76% from the previous year Achieved 2025 goals ahead of schedule	• Distribute copper-containing liquid waste and electroplating
NH_4-N	17.31	HSP: 30 CTSP: 20 STSP: 60	20	Reduced by 89% from the previous year Achieved 2025 goals ahead of schedule	• Expand ammonia treatment systems • Upgrade treatment facilities and improve treatment efficiency
Chemical oxygen demand	185.5	HSP: 500 CTSP: 500 STSP: 450	100	Reduced by 54% from the previous year	• Implement combustion treatment in strippers (Under assessment and planning) • Establish biological treatment systems (bioprocess) (Under assessment and planning)

Note: Hsinchu Science Park (HSP), Central Taiwan Science Park (CTSP), Southern Taiwan Science Park (STSP)
Note 2: Suspended solids reduction achieved 2025 goals ahead of schedule in 2018

Ammonia Analyzer

Wastewater Classification and Recycling System

	38 Different Types of Liquid Classified	9 Recycling Systems	13 Types of Wastewater Treatment	9 Products Recycled
Hydrofluoric (HF) Acid Wastewater	• HF acid wastewater (2 types) • Ozone-containing HF acid wastewater • Manufacturing process scrubbing water	• Hydrofluoric (HF) acid wastewater • Local scrubber wastewater recycling	• Chemical coagulation treatment of HF acid • HF (including ammonia) treatment • Biological treatment of HF acid wastewater	• Calcium fluoride • Fluorite
Acidic, Caustic, and Organic Wastewater	• Deionized water • Ozone-containing deionized water • Acidic wastewater (2 types) • Ozone-containing acidic wastewater • Caustic wastewater • Ozone-containing Caustic wastewater • TMAH wastewater • Organic wastewater (2 types)	• Acidic wastewater recycling • Ozone-containing acidic wastewater recycling • Caustic wastewater recycling • Caustic wastewater upcycling • Organic wastewater recycling	• Acidic and Caustic wastewater treatment • NH_4-N wastewater treatment and recycling • TMAH liquid waste recycling • Biological treatment system for organic wastewater	• Ammonium sulfate • Ammonia water • Gypsum • TMAH
CMP Wastewate	• Electroplating wastewater • CMP wastewater (2 types) • Copper-containing CMP wastewater • Cobalt-containing CMP wastewater	• Chemical coagulation recycling of CMP wastewater • Copper-containing CMP wastewater upcycling	• CMP wastewater treatment • Copper-containing CMP wastewater treatment • Cobalt-containing CMP wastewater treatment	
High-Concentration Liquid Waste	• Waste sulfuric acid • Waste copper sulfate • Cobalt-containing liquid • Other wastewater (16 types)		• Waste-H_2SO_4 reclaim • Copper-containing electroplating wastewater recycling • Cobalt-containing electroplating wastewater recycling NEW	• Sulfuric acid • Copper bar • Cobalt bar NEW

Note 1: TMAH stands for tetramethylammonium hydroxide
Note 2: Among all recycled products, sulfuric acid and electronic grade coating copper are reused in TSMC sites, while the rest are reused externally by other industries
Note 3: Cobalt-containing electroplating wastewater recycling was introduced in 2019

Case Study

First Semiconductor Company to Receive Platinum Certification from the Alliance for Water Stewardship with the Highest Rating in History

To mitigate climate change, implement green manufacturing, and continue to improve water efficiency, TSMC has introduced the world's only AWS Standard in 2019, using Fab 6 and Fab 14 Phases 5/6/7 as the initial demonstration site. In December of the same year, TSMC was officially certified by AWS, becoming the world's first semiconductor company to receive AWS certification. TSMC's evaluation score of 114 points not only surpasses the Platinum-level threshold (80 points) but it is also the highest score on record.

TSMC is committed to managing its water resources in an effort to fulfill the sixth UN Sustainable Development Goal—Clean Water and Sanitation— and to be the first in the industry to comply with AWS standards. TSMC has established a comprehensive and systematic sustainable water management organization. The AWS team that came to inspect the entire catchment in the certification process has recognized and praised TSMC for implementing the industry-leading copper extraction from waste copper sulfate program, creating a high-tech green factory with firefly habitat restoration, planning the recycling and reuse of general wastewater in the site, and working with external units to create green energy smart water control gates that help improve efficiency in domestic irrigation.

In 2019, the AWS Task Force summarized their experiences with a demonstration site in the AWS Blue Book. The Blue Book serves as a guideline for promoting Fab matching, and Fab 15 is expected to complete certification in 2020, in hopes that the company's operations can co-exist and prosper with the environment.

- **Continuous and Excellent Record of No Violations**
- **Active Participation in the Promotion of Governmental Policies**

- **Green Energy Smart Water Control Gates**
  - Provide the government with patented green energy smart water control gate technologies for free
  - Assessments show that 10% irrigation water can be saved
- **Copper Extraction System**
  - Establish copper wastewater recycling system that recycles and reuses copper sulfate-converted copper tubes and electronic-grade coating copper
- **Use of Reclaimed Water in Facilities**
  - Industrial and domestic reclaimed water is reused in manufacturing processes and will be supplied starting in 2022
- **The First "Firefly Enterprise" in Taiwan**
  - Build a world-class green factory and become the first facility in Taiwan to successfully restore firefly populations

Please refer to TSMC Receives Alliance for Water Stewardship Platinum Certification; Achieves Record Point Total on the TSMC Corporate Social Responsibility website for more details

- **Excellent Management System**
  - Comprehensive and continuous employee training mechanisms
  - Comprehensive processing procedures (risk assessment, system setup, operations, and emergency response standard operating procedures)
- **Healthy Water Environment**
  - Continuous monitoring and improvement of the environmental impact of sites on the water catchments
  - Conservation and rebuilding of biodiversity in catchment environment
- **Sustainable Water Balance**
  - Well-structured information platform
  - Open and measurable water operations standards
- **Good Water Quality**
  - The quality of discharged water is higher than the regulatory requirements, and is continuously improving
  - Creation of a sustainable cycle system to reduce the impact of operations on the water catchments
- **Safe Drinking Water and Sanitation Environment**
  - Provide employees in the areas near sites with safe and healthy environments and drinking water
  - Implementation of the commitment on drinking water and sanitation indicators for sites and catchments

Case Study

First Company to Recover Fireflies On-site

Dedicated to fulfilling our mission to strengthen environmental protection, we have adopted biodiversity conservation management and are the first business in Taiwan to successfully recover fireflies in our fab sites (For more detail, please go to "Successful Recovery of Fireflies in TSMC's Tainan Fab"). After four years of unremitting efforts, as of April, 2019, over 200 fireflies have been spotted in our Tainan Fab. The firefly habitat experience is now being replicated in our Hsinchu and Taichung fabs.

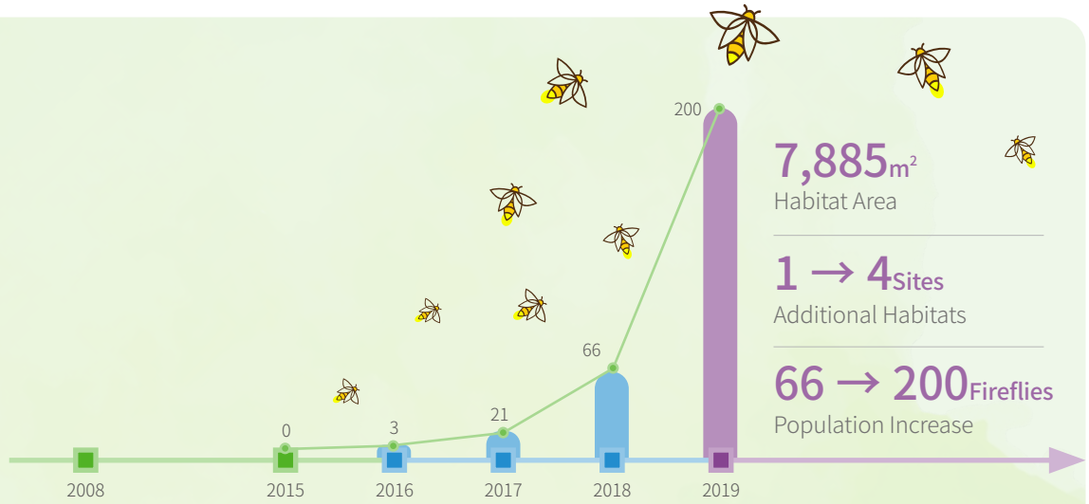
Establishment of the Best Habitat Building Process

To ensure that the fireflies are breeding steadily, in 2019, we placed more focus on managing water quality and vegetation cover. We also monitored the quantity and growth of snail prey so that Aquatica ficta larvae, which feed on snails, are able to enter the pupal stage. Moreover, we have always maintained our firefly habitats with minimal interference. Apart from simulating their natural habitat, we took further measures such as installing shorter street lights and LED 590nm firefly lamps to reduce light pollution and habitat disturbance.

A Larger Fireflies Habitat to Light up TSMC Fabs

Seeking to set up an eco-friendly fab, we collaborated with ecologists to select potential locations for firefly habitats in September 2019. In the future, we will be recovering three species on three newly-selected sites according to the respective environment, and gradually build up a habitat for the fireflies. With each step we take, TSMC is becoming greener, and one step closer to reaching a balance between technology and ecology.

For more information, please visit our CSR website "Bringing Back the Light-TSMC Firefly Habitat Restoration Initiative"



Planning Phase

- Habitat site construction
- Habitat restoration planning
- Monitor the site's environmental ecology
- Manage the ecological pool's water quality

Habitat Building Phase

- Build a habitat that suits the fireflies' life cycle
- Maintain stable long-term water quality
- Cultivate prey for larvae, build a pupation platform
- Improve vegetation cover management to prevent invasion of exotic species, maintain multi-layer vegetation, and control vegetation density

Sustainable Management Phase

- **Eco-friendly habitat management**
- **Focus on forming a firefly food chain**
- **Regularly change firefly lamps**
- **Select additional locations for new habitats**


Firefly Pool in Fab14A


Firefly Pool in Fab14A


Habitat Investigation