

Fact Sheet on PUB’s Open Request for Proposal (RFP) 23/01 on Innovative Technologies across the Water Loop

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Background

1. The Competitive Funding for Water Research (CWR) is a competitive funding scheme under the Urban Solutions & Sustainability (USS) domain. The aim of the CWR is to develop innovative and high-impact solutions to meet national water needs and ensure water security, sustainability, and resilience. At the same time, the CWR will support basic, applied and translational R&D to pre-position the water sector to meet future challenges, such as those brought about by climate change.

Present call

2. PUB manages the entire water loop and has developed the Four National Taps, i.e., water from local catchments, imported water, desalinated water and NEWater. All aspects of the water cycle are managed in an integrated manner – from the collection of rainwater from catchments, drains, canals and ponds for storage in the reservoirs; the treatment and distribution of drinking water; the island-wide sewerage system which collects all used water for treatment; to the reclamation of used water to produce NEWater, and the desalination of seawater. The concept of PUB's closed water loop, typical water/used water treatment processes and typical water quality are shown in [Appendix A](#).
3. While PUB has built up a robust and diversified water supply through its Four National Taps, Singapore's water demand is projected to almost double by 2065. In tandem, energy consumption and sludge generation will increase, and these are expected to be significant based on the current state-of-the-art water technologies. As such, the overarching goals of PUB's R&D are to reduce our energy and chemical consumption, waste production and reliance on manpower, while at the same time increase Singapore's water resources and improve our water quality. It is critical to ensure that Singapore's water supply remains resilient and sustainable to support the nation's growth amidst the projected increase in water demand and uncertainties such as climate change.
4. Over the years, PUB has been supporting various research ideas and technology developments to address the above water challenges and objectives. Moving forward, PUB has identified several R&D focus areas in the Technology Roadmap shown in [Appendix B](#).
5. This Open Call for Water Technologies has two tracks: 1) To advance new ideas and develop breakthrough technologies in the water loop, and 2) To translate or scale-up promising technologies in the water field.

Track 1: Advance new ideas and develop breakthrough technologies in the water loop

6. The aim of Track 1 is to solicit novel ideas and technologies that can address any of the focus areas in the Technology Roadmap shown in [Appendix B](#). Nascent technologies and ideas for fundamental research that are potentially game-changing are welcome. Below are other considerations and requirements for proposals submitted under Track 1:

Proposals should be innovative and challenge the current state-of-the-art technologies.

- i. Ideas and technologies that have already been funded or proposals targeting incremental improvements, and/or tweaks or enhancements to existing technologies will not be considered favourably.
 - ii. The Technology Readiness Level (TRL) of the proposed technology in the proposal should be clearly defined, and technologies having a TRL of less than 4 shall either entail or culminate in the demonstration of the technology using a bench-scale system/prototype with real water feeds. Appendix C shows the definitions of TRLs.
7. While proposals in any of the focus areas in Appendix B are welcome, PUB has particular interest in ideas and technologies in the following areas for Track 1:
- a) Seawater Desalination, Water Reuse and Used Water Treatment: Reduce energy consumption of Singapore's water sector by driving down energy consumption of seawater desalination and NEWater production and improving energy self-sufficiency of used water treatment.
 - For seawater desalination, the current state-of-the-art seawater desalination plant consumes about 3.5 kWh/m³ (at about 50% recovery). PUB aims to reduce the energy consumption to achieve the long-term goal of below 2.0 kWh/m³ at the system level. The areas of interest include low energy, alternative desalination processes (beyond SWRO), process and system optimisation, boron removal and energy recovery systems etc.
 - For NEWater production, the current state-of-the-art NEWater Factory consumes about 0.4 kWh/m³ (at about 75% recovery). PUB aims to reduce the energy consumption to achieve the long-term goal of below 0.2 kWh/m³ (at about 90% recovery) at the system level.
 - For used water treatment, the current state-of-the-art used water plant consumes approximately 0.3 kWh/m³ (net process energy). PUB aims to reduce the net process energy to achieve an energy self-sufficient or even energy-positive plant.
 - b) Waste Reduction and Resource Recovery: Reduce the amount of sludge produced in water and used water treatment, or to recover resources from sludge to reduce the amount sent to landfill. For resources derived from such sludges, the proposals shall address the leaching potential of toxic substances, and study their possible end use applications (e.g. in construction).

For seawater desalination brine, the resources, metals or minerals recovered should be valuable to industry or can be used as chemicals in PUB's water or used water treatment plants. The level of purity of these recovered resources shall be examined in relation to their intended end use application.

- c) Decarbonisation: Capture, remove and utilise carbon dioxide from the environment using technologies that can be integrated with PUB's operations. The proposals shall address the intended end use case for the sequestered carbon and the permanence of the sequestration.
 - d) Water Quality and Security: Maintain high water quality standards and more secure water resources for the nation's needs through protection of source water (e.g. seawater, used water, reservoir water), monitoring of water quality in treatment, distribution and sewers, and management of contaminants of emerging concern.
8. Research proposals that fall outside the focus areas stated in the Technology Roadmap shown in Appendix B may be considered if the proposal presents clear long-term targets that align with PUB's interest. The proposed scope of research should articulate how these targets will be achieved.

Track 2: Translate and scale-up of promising technologies in the water field

9. The aim of Track 2 is to increase the TRL of previously funded upstream research towards pilot- or demonstration-scale, in order to validate these technologies under real operating conditions, with the vision of implementing or commercialising these technologies. Proposals submitted under Track 2 shall build upon projects listed in Appendix D or other projects previously funded by NRF or PUB (including in-house and test-bedding projects) that have a minimum TRL of 4 and can advance PUB's R&D goals outlined in para 7. Below are other considerations and requirements for proposals submitted under Track 2:
- i. Proposals submitted by Technology Providers¹ who undertake to work with the current IP owners to develop the technology further will be considered favourably. The Technology Provider should have relevant track records or capabilities in the proposed technology area, and should have an experienced management team to guide the technology development towards commercialisation. The proposal should include a clear description of the business plan that addresses, but is not limited to, items such as target market, comparative advantage of proposed technology, revenue model, commercialisation plan, as well plans and potential partners for manufacturing and up-scaling.
 - ii. Applicants should work with the current Principal Investigator (PI) as a team to define the current research gaps in commercialising the research and to describe clearly how the proposed project will advance the technology's TRL to support commercialisation in the next few years.
 - iii. Proposals in a specific water focus area should be engineering-focused and directed towards optimising and validating the technology under continuous real operating conditions (for example, the capacity of water treatment technologies under pilot scale shall be at least 50 m³/day and 1,000 m³/day under demonstration

¹ Technology Provider refers to a company or business entity that owns a technology by either developing it or acquiring it from others and provides the technology through a commercial deal to technology users that form its market.

scale) to demonstrate the potential of the technology to meet the long-term targets of the focus area. At the same time, due consideration must be given to understand the system impact (i.e. both upstream and downstream impacts) to operation and product water quality (where relevant).

- iv. All proposed translation of technologies outside of the list of projects in Appendix D should be justified based on alignment to national water needs and the commercial potential of the technology.
10. All the proposals submitted shall articulate the advancement of the proposed technology against the current global state-of-the-art at the system level. The starting TRL of the proposed technology has to be stated in the proposal. At the end of the project, the TRL is expected to progress by at least two levels, unless otherwise justified in the proposal.

Data Management

11. The Urban Solutions and Sustainability (USS) domain agencies are compiling a metadata catalogue to improve data discoverability for researchers. It seeks to encourage early (i.e., pre-award) data-related discussions between agencies and investigators and will serve as a central reference for datasets available within agencies for request, to be used exclusively for the research.
12. Investigators from public institutions who are interested in making use of the data may approach their respective research offices who will assist to write in to request for the metadata catalogue. Other investigators may write in to PUB_Research@pub.gov.sg to request for the metadata catalogue. Please note that access to the metadata catalogue requires the signing of non-disclosure undertaking as a pre-requisite.
13. PUB will assess all requests based on the grant call topics and may request for further justifications. PUB reserves the right to approve or reject any requests for the metadata catalogue, and subsequent datasets. Please note that a separate non-disclosure agreement (NDA) is required for each request of datasets.
14. To facilitate data sharing, Host Institutions are required to submit cleaned data that is collected or generated in the research as identified by PUB. Please note that data may be shared with other publicly funded projects in the future through the metadata catalogue, unless they are commercial data or bounded by NDAs, to maximise synergies across projects and minimise duplicative works.

General Requirement

15. All research activities must be carried out in Singapore. Cross-disciplinary and multi-disciplinary research proposals are strongly encouraged, as well as proposals from research consortia involving partners drawn from different private and public organisations and academic institutions, including international collaborations with renowned experts to introduce new research capabilities and transfer of technical expertise to Singapore. Proposals with industry collaborators and commitments in the form of industry spending will be viewed favourably.

16. R&D proposals already funded by other agencies or being considered for funding by other agencies will not be considered under the present call. Applicants will need to declare other funding sources in the application.

Eligibility Information

17. This call is open to Institutes of Higher Learning (IHLs), public sector entities and private sector entities based in Singapore and overseas. Overseas entities must be registered in Singapore. Under this Open RFP, local IHLs and public research performers will qualify for 100% funding support of approved qualifying costs and 30% overheads. Funding support for non-Singapore entities is up to 30% whereas the support for Large Local Enterprises (LLEs), Singapore Small Medium Enterprises (SMEs), start-ups and not-for-profits is up to 50%. Please refer to Appendix E for the definitions of different enterprise segments.
18. Funding for private sector entities will be conditional on collaboration with a public research performer. This is applicable for research projects with grant amount >\$500K and demonstration/scale-up projects with grant amount >\$2M².
19. Funding for non-Singapore entities will be conditional on the appointment of a local Science Technology Licensing Office (STLO) to manage the foreground Intellectual Property, if any, in Singapore for maximum utility, and also help to provide fair access to Singapore entities in the public and private sector. This is regardless of whether a public research performer is involved in the project.

Application Procedure

20. To apply, the Applicant must submit the proposal using the 'CWR Research Proposal Form', which can be downloaded from the online Integrated Grant Management System (IGMS)³. Please refer to **Annex A** for detailed guidelines for the submission of the Proposal and **Annex B** for guidance on creation of account in IGMS.
21. The proposal shall include, but not limited to:
- i. Scientific principles
 - ii. State-of-the-art comparison, including a technical review of the technology proposed against the latest technologies.
 - iii. Full technical details on the methodology and technological development of the proposal, e.g., whether the technology will be developed starting from bench-, to pilot-, or demonstration-scale, and/or to eventual commercialisation. The applicant should also consider the proposed technology holistically from a system

² Grant amount refers to the total qualifying cost of the project, exclusive of in-kind contribution.

³ <https://researchgrant.gov.sg>

perspective (i.e., the requirements of the technology as a system if it is to be implemented).

- iv. Commercial viability of the project, including target markets for application of the technology or findings from the project.
 - v. Clear description of a general business plan that addresses items, such as, but not limited to, competitive analysis, go-to-market strategy, revenue model, commercialisation plan, as well as manufacturing and validation at scale. The plan should also highlight how the Intellectual Property (IP) created will be owned and commercialised, and how the benefits from these commercialisation plans can be accrued to Singapore.
 - vi. The proposed team members' expertise, previous related work and experience (2-page CVs shall be submitted for the Principal Investigator (PI), as well as for all co-Investigators and team members.
 - vii. Detailed budget required for the project (broken down into individual categories of manpower, equipment, consumables, travel, consultancy services, and others).
 - viii. Timeline for the project, showing intermediate milestones to be achieved.
 - ix. Expected research outputs and outcomes, and proposed key performance indicators (KPIs) for the project.
 - x. Other relevant information as determined by the PI.
22. The deadline for the Proposal submission is on **2 Feb 2024, 4:00 pm** (Singapore time, GMT +08:00).

Evaluation Criteria

23. Proposals received may be sent to peer reviewers for technical/scientific merit review. If appropriate, proposals from academia may also be sent to Industry Resource Persons (for commercial viability) and relevant national agencies (for national relevancy) for review. This is then followed by evaluation by CWR's Project Evaluation Panel (PEP), which comprises local and international experts as members. The PEP shall evaluate the proposal based on the criteria given in Para 23, referencing reviews from international peer reviewers, and make a recommendation whether to fund it.
24. All proposals are evaluated against the following criteria:
- i. Excellent science and cutting-edge technology with proposed activity involving innovative and cutting-edge research that seeks to bring together the best R&D talent available.
 - ii. Significant economic or social benefits to be accrued to Singapore through either tangible measures (creation of intellectual property, start-up companies, spin-out enterprises, etc), intangible measures (new capabilities or competencies, transfer

of technical expertise, etc), carbon mitigation or potential for commercialisation into new products, services or technologies deployed to solve national needs.

- iii. Robust management and governance with project team having adequate research experience and necessary expertise/knowledge, as well as reasonable milestones and deliverables.
- iv. Reasonableness of the proposed budget.

25. PUB is under no obligation to award the research grant in whole or in part to any proposal. PUB may require proposals to be revised as it sees fit to enhance research outcomes, facilitate integration of research concepts and technologies, and optimise funding resources. PUB's decision on the proposals selected and the funding support will be final and shall be abided by the applicants.

Estimated Budget

26. Funding support for each Research Proposal awarded under Track 1 and Track 2 will not exceed **S\$1.5 million** and **S\$2 million** respectively (excluding overheads). The Applicant should contribute in-kind services, cash, or a combination of the two towards the proposed project. In-kind services can include labour, materials, and other services. In-kind contributions demonstrate the participation and commitment of the applicants to the project.

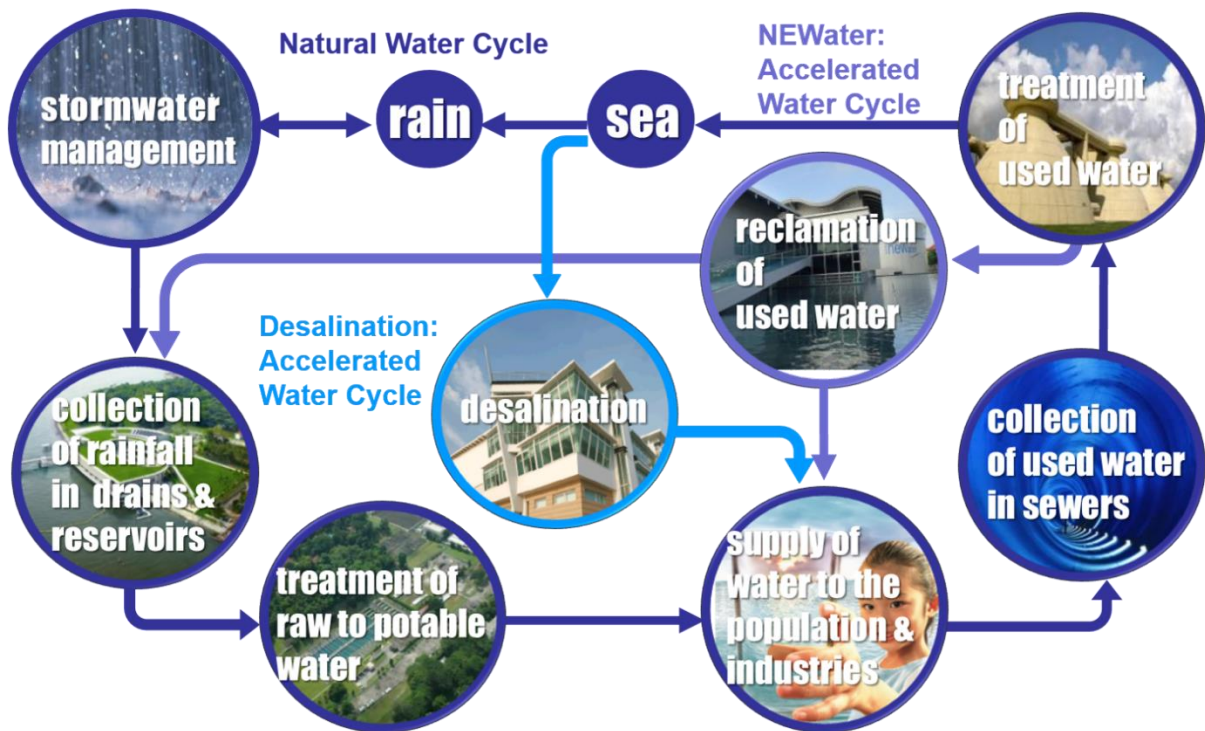
Maximum Project Duration

27. The maximum funding period for each Research Proposal is **3 years**.

Point of Contact

28. For more information, please contact Ms Felinia (felinia@pub.gov.sg) or Mr Tan Zi Peng (tan_zi_peng@pub.gov.sg) or Ms Weng YiQi (weng_yiqi@pub.gov.sg) from PUB Singapore.

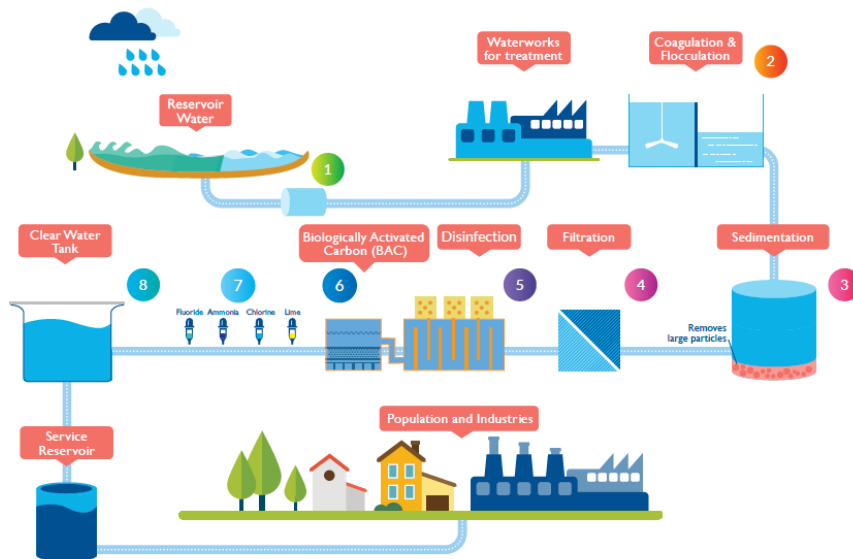
Appendix A: PUB's Water Loop, Typical Water/Used Water Treatment Processes and Typical Water Quality



The Concept of a Closed Water Loop

1. Treatment of Raw (local catchment water, imported water) to Potable Water

The product water quality shall meet the Environmental Public Health (EPH) (Water Suitable for Drinking) (No.2) Regulations 2019, with details to be found in following website: https://www.pub.gov.sg/Documents/Singapore_Drinking_Water_Quality.pdf. The typical treatment process in PUB's Water Supply Plant (WSP) are shown below.



① Screening:

Water is pumped through self-cleaning screens to remove particles greater than 1mm.

② Coagulation & Flocculation:

Coagulants and coagulant-aids like alum (aluminium sulphate) are added to bind or “flocculate” smaller suspended matter and particles, such as silt and sand, to form larger and heavier clumps. Lime is added to adjust pH prior to coagulation in some plants.

③ Sedimentation:

Particles combine into larger clumped particles that settle to the bottom of the tank and are removed.

④ Filtration:

The water then passes through either rapid sand filter or membranes to remove the finer residual particles of up to 0.02 microns.

⑤ Disinfection:

After filtration, the water is disinfected with chlorine (sodium hypochlorite) or ozone to kill all harmful bacteria and viruses.

⑥ Biological Activated Carbon (BAC):

Biological activated carbon filters further polish the water by removing natural organic matter, making the water biologically-stable.

⑦ Residual Treatment:

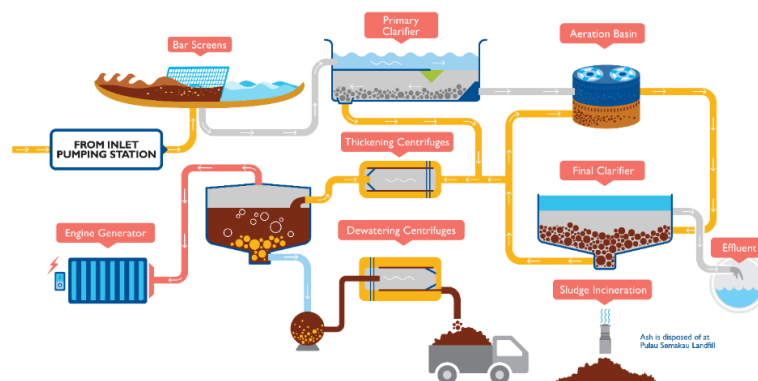
The water is dosed with lime (to balance the pH of water), chlorine and ammonium sulphate (to maintain the water quality in the distribution system), as well as fluoride (to prevent tooth decay).

⑧ Clear Water Tank:

After residual treatment, water is stored in the clear water tank, before pumping to the service reservoirs for distribution to customers.

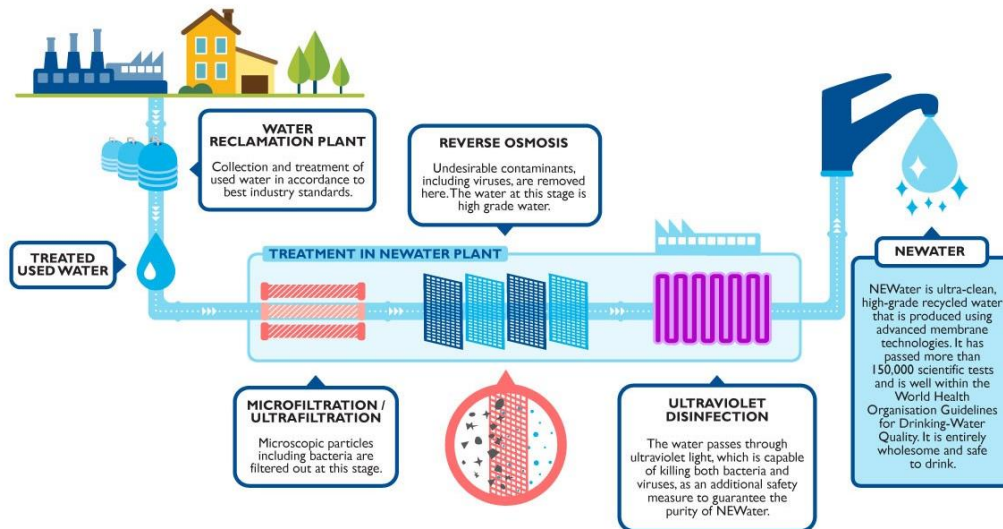
2. Treatment of Used Water

Used water from both domestic and non-domestic sources is treated at four water reclamation plants. Refer to the illustration below for the typical used water treatment process.



3. NEWater

The NEWater process recycles the treated used water into ultra-clean, high-grade reclaimed water, cushioning Singapore’s water supply against dry weather and moving Singapore towards water sustainability.



4. Desalination

As Singapore is surrounded by sea, PUB has turned seawater into drinking water. PUB continues to invest in research and technology to find more efficient ways to desalinate seawater. The typical desalination process is shown below.

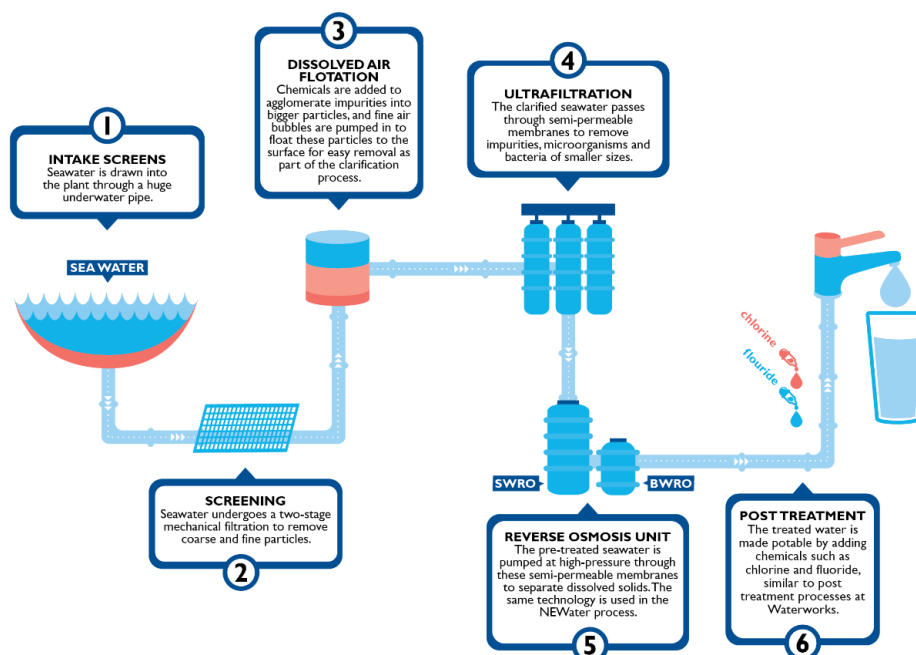


Table 1 Typical Seawater Quality

S/N	Parameter	Unit	Value
1.	pH	-	8.0 – 8.3
2.	Total Dissolved Solids	mg/L	30,600 – 35,700
3.	Specific Conductivity	μS/cm	47,089
4.	Total Suspended Solids	mg/L	2.8 – 49.3
5.	Turbidity	NTU	0.4 – 27.2
6.	Chemical Oxygen Demand	mg as O ₂ /L	6.0 – 72.0
7.	5-day, 20°C Biochemical Oxygen Demand	mg as O ₂ /L	2.00 – 10.00
8.	Total Organic Carbon	mg/L	0.08 – 4.22
9.	Dissolved Organic Carbon	mg/L	1.60
10.	Total Nitrogen	mg/L	< 1.00
11.	Nitrite	mg as N/L	< 0.02
12.	Nitrate	mg as N/L	0.50 – 4.97
13.	Total Phosphate	mg as P/L	0.13 – 1.00
14.	Dissolved Phosphate	mg as P/L	0.06 – 0.82
15.	Total Alkalinity	mg/L	101 – 116
16.	Total Hardness	mg/L as CaCO ₃	5,360 – 7,910
17.	Bicarbonate	mg/L as CaCO ₃	99 – 114
18.	Oil & Grease (via method infrared absorption)	-	0.3 – 3.3
19.	UV absorbance (254 nm)	-	< 0.05
20.	Aluminum	mg/L	0.70 – 2.33
21.	Ammonia	mg/L as N	< 0.05 – 0.11
22.	Barium	mg/L	< 0.01 – 0.515
23.	Boron	mg/L	1.81 – 7.44
24.	Calcium	mg/L	366 – 552
25.	Chloride	mg as Cl ⁻ /L	14,300 – 19,200
26.	Fluoride	mg as F ⁻ /L	0.42 – 1.00
27.	Iron	mg/L	< 0.19 – 0.74
28.	Manganese	mg/L	< 0.05 – 0.58
29.	Magnesium	mg/L	1060 – 1620
30.	Potassium	mg/L	352 – 593
31.	Silica	mg/L as SiO ₂	0.11 – 1.05
32.	Sodium	mg/L	8,290 – 13,400
33.	Strontium	mg/L	6.3 – 10.3
34.	Sulfate	mg as SO ₄ ²⁻ /L	2,350 – 3,450
35.	HPC	cfu/mL	10 – 16,100
36.	Total coliforms	cfu/mL	46 – 37,000
37.	Fecal coliforms	cfu/mL	6 – 79
38.	<i>Escherichia coli</i>	cfu/L	< 416

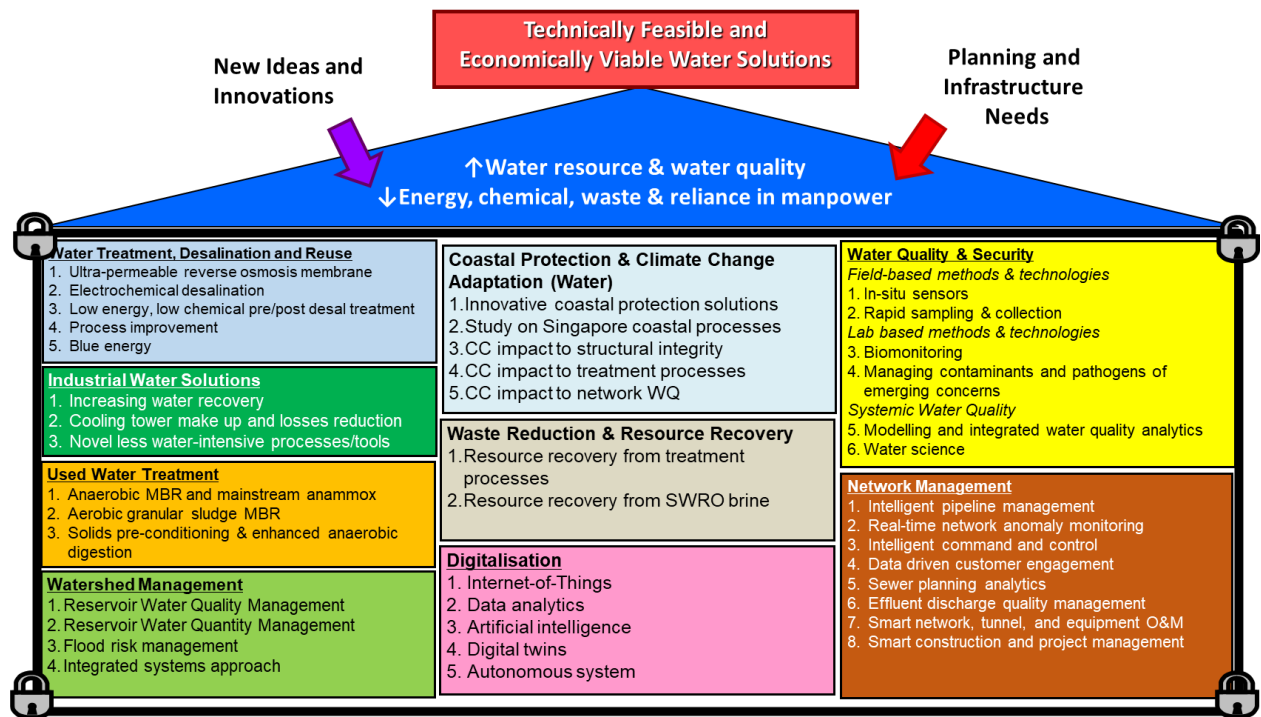
Table 2 Typical NEWater Quality

S/N	Parameter	Unit	Value
1.	Turbidity	NTU	< 0.2
2.	Conductivity	µS/cm	< 100 (if Feed Water Conductivity ≤ 1580) < 150 (if Feed Water Conductivity ≤ 2100)
3.	pH Value	-	7.0 – 8.5
4.	Total Organic Carbon	mg/L	< 0.1
5.	Ammoniacal Nitrogen	as N mg/L	< 0.5
6.	Aluminium	as Al mg/L	< 0.05
7.	Barium	as Ba mg/L	< 0.02
8.	Boron	as B mg/L	< 0.2
9.	Calcium	as Ca mg/L	< 1
10.	Chloride	as Cl mg/L	< 10 (if Feed Water Chloride ≤ 350) < 20 (if Feed Water Chloride ≤ 550)
11.	Total Residual Chloride	as Chloramine (mg/L)	1 to 2
12.	Colour	Hazen Unit	< 5
13.	Copper	as Cu mg/L	< 0.05
14.	Fluoride	as F mg/L	< 0.5
15.	Heterotrophic Plate Count (35°C, 48 hrs)	CFU/mL	< 100
16.	Iron	as Fe mg/L	< 0.01
17.	Manganese	as Mn mg/L	< 0.05
18.	Nitrate	as N mg/L	< 2.26
19.	Silica	as SiO ₂ (mg/L)	< 0.5
20.	Sodium	as Na mg/L	< 20
21.	Strontium	as Sr mg/L	< 0.1
22.	Sulphate	as SO ₄ mg/L	< 1
23.	Total Coliform Bacterial	Counts/100 mL	Not Detectable
24.	Total Dissolved Solids	mg/L	< 60 (if Feed Water TDS ≤ 1000) < 90 (if Feed Water TDS ≤ 1300)
25.	Total Hardness	as CaCO ₃ mg/L	< 5
26.	Total Trihalomethanes	mg/L	< 0.02
27.	Zinc	as Zn mg/L	< 0.1
28.	Formaldehyde	mg/L	< 0.1
29.	Enterovirus	mg/L	Not Detectable
30.	Total Alkalinity	as CaCO ₃ mg/L	< 50

Table 3 Typical Membrane Bioreactor Permeate Quality

S/N	Parameter	Unit	Value
1.	pH	-	6.7 – 6.9
2.	Turbidity	NTU	0.02 – 0.1
3.	Ammonia Nitrogen	as N mg/L	0.1 – 0.5
4.	Total Organic Carbon	mg/L	5 – 6
5.	Nitrate	as N mg/L	6 – 15
6.	Total Phosphate	as P mg/L	3 – 4
7.	Total coliforms (before disinfection)	CFU 100/mL	1-10
8.	Total coliforms (after disinfection)	CFU 100/mL	< 1
9.	Biological Oxygen Demand (5days@20°C)	mg/L	< 2
10.	Chemical Oxygen Demand	mg/L	15 – 20
11.	Total Dissolved Solids	mg/L	350 – 450
12.	Fluoride	as F mg/L	0.5 – 4
13.	Chloride	as Cl mg/L	80 – 120
14.	Sulphate	as SO ₄ mg/L	35 – 55
15.	Arsenic	as As mg/L	< 0.01
16.	Barium	as Ba mg/L	0.009
17.	Aluminium	as Al mg/L	0.04
18.	Iron	as Fe mg/L	0.04
19.	Boron	as B mg/L	0.05 – 0.1
20.	Manganese	as Mn mg/L	0.07
21.	Chromium	as Cr mg/L	< 0.005
22.	Copper	as Cu mg/L	0.03
23.	Lead	as Pb mg/L	< 0.01
24.	Mercury	as Hg mg/L	< 0.001
25.	Nickel	as Ni mg/L	< 0.02
26.	Zinc	as Zn mg/L	< 0.05
27.	Calcium	as Ca mg/L	30 – 40
28.	Magnesium	as Mg mg/L	8 – 15
29.	Bicarbonate	as CaCO ₃ (mg/L)	40 – 55
30.	Sodium	as Na mg/L	50 – 90
31.	Silica	as SiO ₂ (mg/L)	8 – 10
32.	Strontium	(as Sr) mg/L	0.04 – 0.07
33.	Potassium	(as Sr) mg/L	10 – 15

Appendix B: PUB Water Technology Roadmap



Appendix C: Technology Readiness Level (TRL) Definitions

Technology Readiness Level (TRL) is a widely used indicator of degree of development of a technology toward deployment on a scale of 1-9.

TRL	Definition	PUB's Context
1	Basic research: basic principles observed and reported. Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include fundamental investigations and paper studies.	The project is completed with formulations of basic theories / principles which have the potential to be further developed into applied research. The project may be limited to <u>literature review and fundamental investigations</u> .
2	Applied research: Technology concept and/or application formulated. Once basic principles are observed, practical applications can be formulated. Examples are limited to analytic studies and experimentation.	The project is completed with the conceptual development of application and technology. The project may involve <u>analytic studies such as numerical simulations</u> to support the basic theories.
3	Critical function: proof of concept established. Active research and development is initiated. Laboratory studies aim to validate analytical predictions of separate components of the technology. Examples include components that are not yet integrated or representative.	The project is completed with the <u>proof of concept established through laboratory studies</u> . The project may include laboratory studies on separate components of the overall technology that are not integrated.
4	Laboratory testing of prototype component or process. Design, development and lab testing of technological components are performed. Here, basic technological components are integrated to establish that they will work together. This is a relatively “low fidelity” prototype in comparison with the eventual system.	The project is completed with <u>lab-scale tests on the prototype</u> where separate components of the technology have been integrated.
5	Laboratory testing of integrated system. The basic technological components are integrated together with realistic supporting elements to be tested in a simulated environment. This is a “high fidelity” prototype compared to the eventual system.	The project is completed with <u>bench-scale tests</u> in a simulated environment (e.g., laboratories or other environment under controlled conditions) for optimisation/performance enhancement of the technology/prototype.
6	Prototype system verified. The prototype, which is well beyond that of level 5, is tested in a relevant environment. The system or process demonstration is carried out in a relevant operational environment.	The project is completed with <u>pilot-scale tests</u> in a relevant operational environment and the prototype system verified.
7	Integrated pilot system demonstrated. Prototype is near, or at, planned operational system level. The final design is virtually complete. The goal of this stage is to remove engineering and manufacturing risk.	The project is completed with <u>demo-scale tests</u> in the actual operational environment.

TRL	Definition	PUB's Context
8	<p>System incorporated in commercial design. Technology has been proven to work in its final form under the expected conditions. In most of the cases, this level represents the end of true system development.</p>	<p>The project is completed with <u>successful implementation of demo-scale tests</u> where true system development is achieved.</p>
9	<p>System ready for full-scale deployment. The technology in its final form is ready for commercial deployment.</p>	<p>The project is completed with <u>spin-offs / commercial deployment</u>.</p>
N/A		<p>E.g. scientific studies, literature reviews or development of toolboxes.</p>

Appendix D: List of Projects for Translation

Project Reference no.	Technology Developed	Host Institution
Innovative Membrane Technologies for Seawater Desalination and Water Treatment & Reuse		
1501-IRIS-05	Ultra-wetting graphene-based ultrafiltration (UF) membranes	Ngee Ann Polytechnic
1601-CRPW-T20	Pilot scale HAOPs (heated aluminum oxide particles) pre-treatment system for MBR filtrate to remove organics and scalants to mitigate RO fouling	NTU
1601-CRPW-T21	Flat sheet biomimetic membranes containing synthetic channels for selective transport of water or ions	NUS
1601-CRPW-T49	NF-MBR + RO hybrid system to increase recovery of the water reclamation process	NTU
PUB-1801-0008	4-inch highly permeable, anti-fouling, thin film, nanocomposite hollow fiber membranes for brackish water applications	NUS
PUB-1801-0010	4-inch Aquaporin based spiral wound biomimetic membranes for seawater desalination	NTU
PUB-1901-0001	Thin-film nanocomposite flat sheet membranes with high boron rejection with no pH adjustment for post-treatment of seawater desalination	NUS
P18-09-01	High permeability, thin film, nanocomposite flat sheet membranes embedded with porous and non-porous nano particles for brackish water and seawater desalination	NUS
Used Water Treatment Processes		
PUB-1801-0007	Pilot demonstration of an anaerobic membrane bioreactor (AnMBR) integrated with mainstream anammox-MBR process or electrodialysis reversal process	NTU
Water Quality Analysis		
PUB-1804-0076	An online heavy metal analyser using ions-imprinted polymers for use in rivers, catchments & sewers; and a portable mini analyser using the same technology for handheld detection of heavy metals	NUS
PUB-1804-0082	An integrated optofluidic system for concentration and detection of E. coli in water based on optical imaging	NTU

Appendix E: Definitions of Different Enterprise Segments

S/N	Type	Criteria
1	Non-SG entities	<ul style="list-style-type: none"> • <30% local shareholding, determined by the ultimate individual ownership
2	LLEs	<ul style="list-style-type: none"> • \geq30% local shareholding; and • More than \$100M in annual turnover
3	SMEs	<ul style="list-style-type: none"> • Have Group Annual Sales Turnover of not more than \$100M, or maximum employment of 200 employees • To qualify as an SG entity, they must also have at least 30% local shareholding, i.e. local equity held directly or indirectly by Singaporean(s) and/or Singapore PR(s)
4	Start-ups	<ul style="list-style-type: none"> • Registered for less than 5 years at time of grant application • Has individual ownership of more than 50% at reference year; and • Employs at least 1 worker • To qualify as an SG entity, they must also have at least 30% local shareholding
5	Not-for-profits	<ul style="list-style-type: none"> • Registered as a public Company Limited by guarantee, society or charity trust • Main purpose is to support or engage in activities of public or private interest without any commercial or monetary profit, and are prohibited from distributing monetary residual to their own members • To qualify as an SG not-for-profit, the entity must meet all 3 of the following criteria: (1) Registered and physically present in Singapore; (2) Core funding (i.e. excl. competitive grant funding) is derived entirely/mostly from SG entities; (3) Managed by a Board, which is at least half appointed by SG entities

Annex A: Guidelines for Submission of Proposal on IGMS

Closing Date: 2 Feb 2024, 4:00 pm (Singapore time, GMT +08:00).

1. The preparation of the proposal should be done using the 'CWR Research Proposal Form' which can be downloaded from the online IGMS. The proposal should be submitted in MS Word document or Adobe PDF format, 12-point font size, single-spaced, and the details of the proposal should not be longer than 20 full pages.
2. Applicants are required to lodge the application via the online IGMS before the stipulated closing date and time for the Request-for-Proposal (RFP). Separate submission outside of IGMS will not be considered. All relevant sections of the IGMS proposal online application form should be filled out completely, with the CWR Research Proposal Form and supporting documents uploaded as separate attachments. **The online application process may take time and hence please refer to IGMS website for full details of the application process. For new IGMS user from private sector entities, account registration is required for first time application. Please refer to Annex B below. New users would need to ensure his/her CorpPass account has been set-up, using his/her SingPass account.**
3. For submission of the proposal, only representatives from the Host Institution are required to apply for IGMS accounts. 3 distinct roles are required from any company or institution to endorse the proposal, namely: Principal Investigator (PI), Office of Research (ORE) and Director of Research (DOR) to complete a proposal submission.
4. Please note that applicants can only submit multiple files with maximum file size of 2MB each in the IGMS.
5. Should there be revisions to the submitted proposal, PI is to delete previous submission(s) and only keep the final proposal in the system. Failing to do so may lead to evaluation of wrong version of the proposal.
6. The link to the online IGMS is given here: <https://researchgrant.gov.sg>

Annex B: IGMS Account Creation

1. Before you begin, please familiarise yourself with the various training guides on navigating the IGMS system.
2. The various guides and manuals will help you understand the roles of various users in the IGMS and the application process. These documents can be downloaded from: <https://researchgrant.gov.sg/Pages/TrainingGuides.aspx>
3. The registration of the company or institution within IGMS is mandatory as part of the proposal submission workflow.
4. Please refer to the steps below for the creation of a new company/institution within IGMS.

Creation of account for local users

Step 1:

To register a new entry in IGMS, companies/institutions will need to send an e-mail to Ms Noby Ang or Ms Chay Peck Si at PUB_GLOBALHYDROHUB@pub.gov.sg, by **1 Dec 2023**, with the following details:

Subject: Creation of new Company/Institution in IGMS for RFP2301

Details of the New Company/Institution to be Created in IGMS

- Full Name of Company:
- Indicate Local Company or Foreign Company:
- Indicate Public Company or Private Company:
- UEN (for local company) or Entity ID (for foreign Company):
- For Foreign Company, please provide the screenshot from CorpPass profile page indicating the Entity ID (for Foreign Company), for verification purpose.

The Secretariat will inform the companies/institutions when their accounts have been created.

Step 2:

For PI who will be submitting the application under their company/institution, the role of HI Admin is necessary for the assignment of relevant roles (“ORE” and “DOR”)⁴ to other IGMS users in the company/institution.

After the company/institution has been created in IGMS, IGMS would grant him/her the Principal Investigator (PI) role by default. The Secretariat will inform them to nominate an HI Admin and arrange with IGMS to change the role of the person from a Principal Investigator (PI) to an HI Admin. The following steps will apply:

1. The company/institution will need to nominate an HI Admin. The HI Admin (including all other intended IGMS users) will need to ensure that his/her CorpPass account has been setup.
2. The HI Admin will need to login to IGMS using his/her CorpPass account to register/update his/her profile inside IGMS.

⁴ Note: To complete a proposal submission, 3 distinct roles are required from any company or institution to endorse the proposal, namely: Principal Investigator (PI), Office of Research (ORE) and Director of Research (DOR).

3. After the HI Admin has been successfully registered in IGMS, the HI Admin will notify the Secretariat with the information below:

- Full Name of HI Admin:
- E-mail Address of HI Admin:
- Designation of HI Admin in his/her company:

Once granted the role as an HI Admin, he/she can proceed to assign the relevant roles (e.g. “DOR”, “ORE”, etc.) to the various users within his/her organisation.

Since an HI Admin can concurrently hold the role of PI, he/she will be able to select different profiles upon login to IGMS:

- Login as HI Admin – to maintain institution & user profiles
- Login as PI – to apply for grant call

Creation of account for foreign users

For local companies/institutions with foreign staffs without access to CorpPass/SingPass. The following steps apply:

1. All foreign users from the company (i.e. HI Admin, DOR, ORE, PI) will “Register” themselves in IGMS via “Login for overseas users without CorpPass/SingPass”.

For overseas users without Singpass

Please enter user name.

Please enter password.

Verification *

I'm not a robot

reCAPTCHA
Privacy - Terms

This is a security feature that will prevent automated programs from attacking our website and protects your information.

Enter

Reset password Register Forgot your password?

2. After all the foreign users have been successfully registered in IGMS, the HI Admin will notify the Secretariat with the information below:

- Full Name of HI Admin:
- E-mail Address of HI Admin:
- Designation of HI Admin in his/her company:
- Full Name of DOR (if DOR is foreign user):

- E-mail Address of DOR (if DOR is foreign user):
- Designation of DOR in his/her company (if DOR is foreign user):
- Full Name of ORE (if ORE is foreign user):
- E-mail Address of ORE (if ORE is foreign user):
- Full Name of Foreign PI/Co-I(s)*:
- E-mail Address of Foreign PI/Co-I(s)*:

**list down all the foreign users that requires tagging to a company/institution*

3. The Secretariat will follow up with IGMS to tag the foreign user to your company.
4. Once the above foreign users have been added, tagged and assigned in IGMS, they can then proceed to login to IGMS via the “Login for overseas users without CorpPass/SingPass” section.

Note: The HI Admin cannot add a new foreign user. However, the HI Admin can change the role of a user or delete an existing user in his/her company.