Reinvented Toilets: New Technology and Policy for Non-Sewered Sanitation

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Today's Presentation

- The imperative to "Reinvent the Toilet"
- Development of an ISO Product Standard
- Performance requirements for RTs in the new ISO Standard
- Main technology paths
- Likely applications of RTs in North America
- The emerging regulatory framework

The materials being presented are not an endorsement of any specific product.

The Global Sanitation Problem

- 1 in 10 people live without clean water – that's 844 million people
- 1 in 3 people, 2.3 billion, do not have regular access to a decent toilet
- 800 children under 5 die *every day* from diarrheal diseases caused by poor water and sanitation

From Concept to International Standard

- 2011: Initial challenge to "Reinvent the Toilet"
- 2014-2015: B&MGF drafted private standard for RTs
- May 2016: ISO International Workshop Agreement (IWA 24:2016): Singapore
- Sept 2016: ISO Project 30500 Committee organized
- May 2018: Final ISO PC 30500 plenary: Katmandu
- Oct 2018: ISO 30500 published
- Dec 2019: US & Canada adopt ANSI/CAN/IAPMO/ISO 30500-2019

What is a non-sewered sanitation system (NSSS) under the ISO Standard?

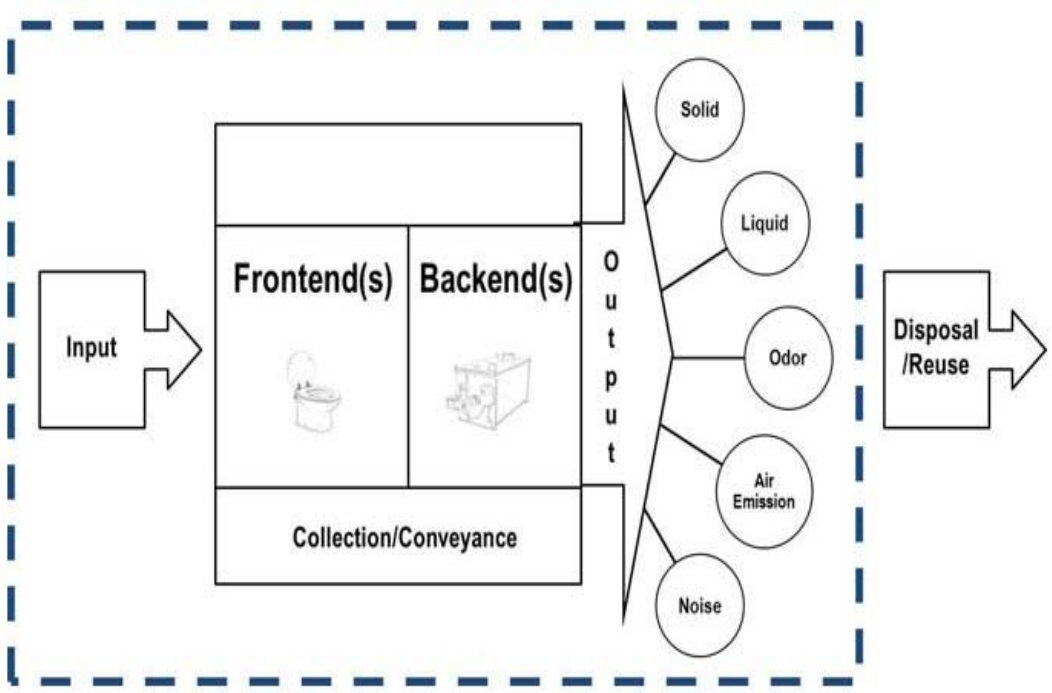
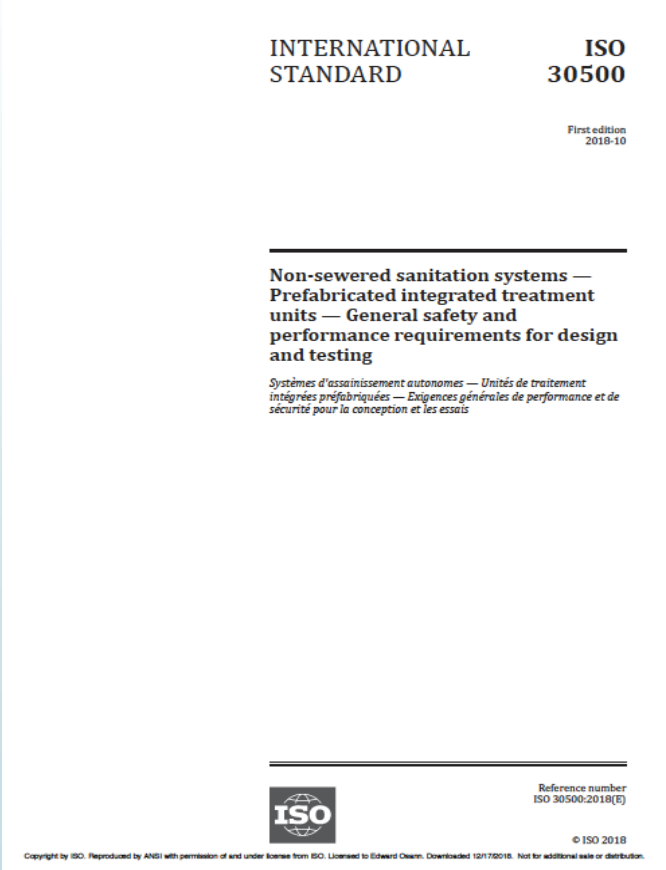


Figure 1: Scope of standard

- A device that isn't connected to a sewage system and collects and fully treats the input (human excrement) into a safely reusable or disposable output
- Packaged, not site-built
- How do they work?
  - combustion
  - wet oxidation
  - electrochemical oxidation
  - biological treatment
  - combos of the above

ISO 30500 : Performance Requirements and Test Procedures



INTERNATIONAL STANDARD

ISO 30500

First edition
2018-10

Non-sewered sanitation systems — Prefabricated integrated treatment units — General safety and performance requirements for design and testing

Systèmes d'assainissement autonomes — Unités de traitement intégrées préfabriquées — Exigences générales de performance et de sécurité pour la conception et les essais

Reference number
ISO 30500:2018(E)

- Product definition
- Performance Requirements:
  - Solid output and effluent
  - Odor
  - Noise
  - Air emissions
- Requirements for components and materials
- Requirements for safety and reliability
- Test procedures
- User interface requirements

ISO 30500 :Performance Requirements for Solid Output

Table 4 — Solid output validation thresholds and log reduction values (LRVs) for human health protection

Parameter (Pathogen class)	Human enteric bacterial pathogens	Human enteric viruses	Human enteric Helminths	Human enteric Protozoa
Surrogate	using *E. coli*[b] as surrogate, measured in CFU or MNP	using MS2 Coliphage as surrogate, measured in PFU	using *Ascaris suum* viable ova as surrogate	using viable *Clostridium perfringens* spores as surrogate, measured in CFU
Max. concentration in solids [number/g (dry solids)]	100	10	< 1	< 1
Overall LRV for solid[a]	≥ 6	≥ 7	≥ 4	≥ 6

[a] Log-reduction values (LRVs) were derived from a quantitative microbial risk assessment (QMRA) as described by WHO 2016, assuming 1 g of faecal solids contains approximately the same range of reference pathogens as in 1 l of liquid effluent (for LRVs derived in Table 5). For further information, see Reference [61] and Reference [72].

[b] *E. coli* strain KO11 (ATCC 55124) is selected because it is chloramphenicol resistant. Therefore, this antibiotic may be added to the plating medium to suppress the growth of other, interfering bacteria.

Other Key Requirements

- Odor – Using pre-screened panelists, a max of 10% of reports are rated “unpleasant” and a max of 2% are “unacceptable”
- Noise – an average of 60 dbA over 24 hrs and a max of 85 dbA at any time
- Visibility – No visibility of any accumulation of feces from previous users
- User manual – required, along with any specialized tools needed for maintenance
- Maintenance – product designed to allow users without technical expertise to perform routine user maintenance

ISO 30500: Test Procedure Overview -- Laboratory and Field Testing Required

Laboratory Testing

- 32-day test period
- Use of actual human waste, spiked as necessary with surrogates for human pathogens
- Normal loading and challenge loading
- Includes stop and start sequences simulating usage patterns
- Energy shut-off
- Overload protection

Field Testing

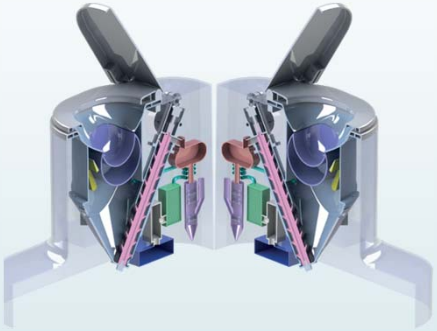
- 30 days for non-biological systems
- 5 months for biologically-based systems
- Input to be collected and analyzed for one week in advance of testing for reference
- Tested weekly while in actual use by intended users
- Testing for three pathogens: helminth requirements deemed met by protozoa requirements

Core Processing Technologies

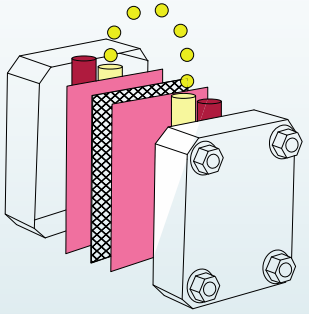
- **ELECTROCHEMICAL**

- **WET OXIDATION**

- **DRY COMBUSTION**



- **BIOLOGICAL**



Caltech

helbling

eawag aquatic research

Duke University

University of Toronto

Duke University RTI International

Cranfield University

SEDRON TECHNOLOGIES

USF University of South Florida

UWE Bristol

Stanford University

Columbia University in the City of New York

SELF-CONTAINED WATER-RECYCLING ECOLOGICAL TOILET

(Toilet of the Future)

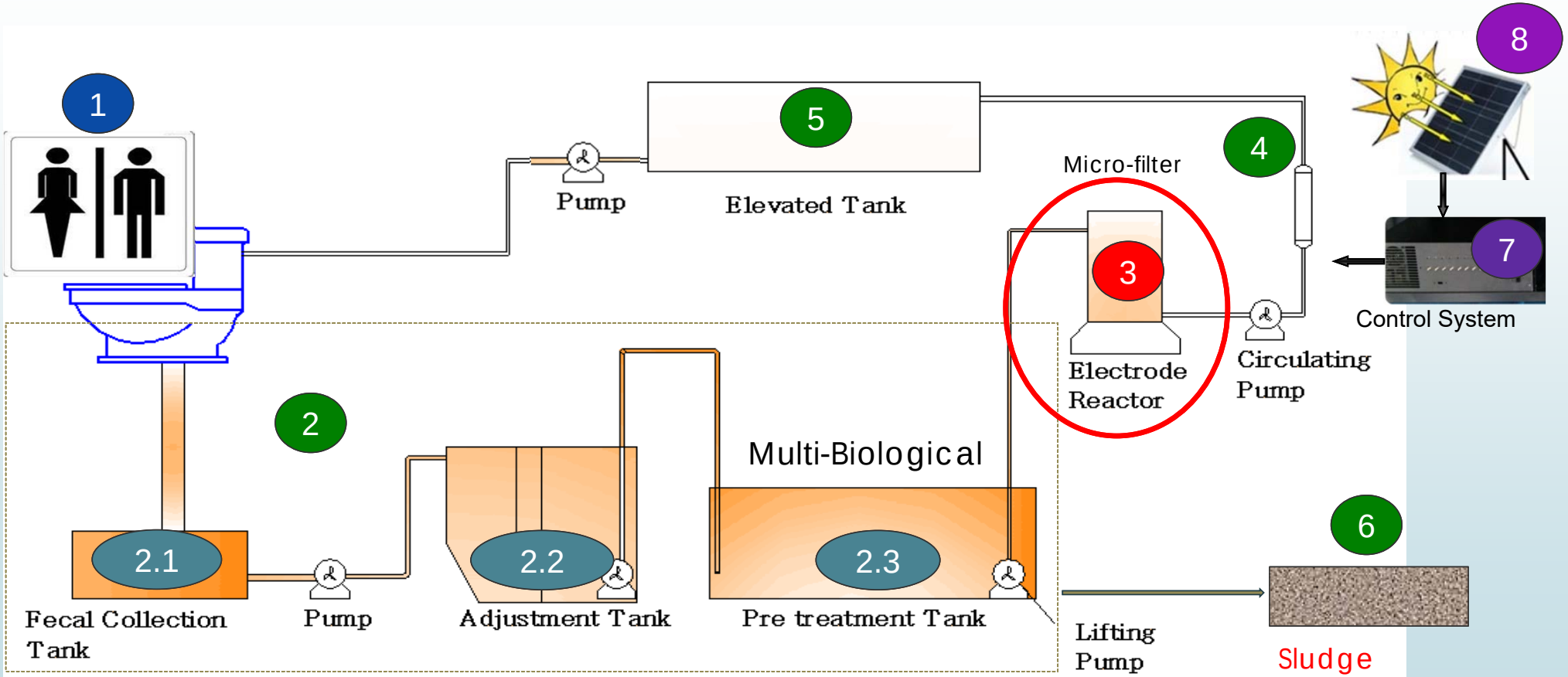
NG ECO-SANITARY MANUFACTURE CO.,LTD.

宜兴艾科森生态环卫设备有限公司 中国

Product Introduction

Typical Process of Eco-san Ecological Toilet

Eco-san



Process of ECO-SAN

Product Introduction

Treated Water quality (disinfection)

Eco-san

Solid output validation thresholds and log reduction values (LRVs) for human health protection

Parameter (Pathogen class)	Max. concentration in solids [number/g (dry solids)]		Overall LRV for solid		
Human enteric	ISO	Measured	ISO	Measured	Surrogate
Bacterial pathogens	100	100	>= 6	>=6	using E. coli as surrogate, measured in CFU or MNP
Viruses	10	10	>= 7	>=7	using MS2 Coliphage as surrogate, measured in PFU
Helminths	<1	<1	>= 4	>=4	using Ascaris sum viable ova as surrogate
Protozoa	<1	<1	>= 6	>=6	using viable Clostridium perfringens spores as surrogate,

Liquid effluent validation thresholds and log-reduction values (LRVs) for human health protection

Parameter (Pathogen class)	Max. concentration in liquids (number/l)		Overall LRV for liquid		
Human enteric	ISO	Measured	ISO	Measured	Surrogate
Bacterial pathogens	100	100	>= 6	>=6	using E. coli as surrogate, measured in CFU or MNP
Viruses	10	10	>= 7	>=7	using MS2 Coliphage as surrogate, measured in PFU
Helminths	<1	<1	>= 4	>=4	using Ascaris sum viable ova as surrogate
Protozoa	<1	<1	>= 6	>=6	using viable Clostridium perfringens spores as surrogate,

Product Introduction

Treated Water quality (environment)

Eco-san

Effluent performance thresholds for environmental parameters

		COD (mg/l)		TSS (mg/l)	
		ISO	Measured	ISO	Measured
Category A usage: Threshold for unrestricted urban uses		<= 50	4	<= 10	<= 10
Category B usage: Threshold for discharge into surface		<= 150	<= 150	<= 30	<= 30

Effluent performance load reduction percentage for nutrients (Environmental requirement)

		Total nitrogen		Total phosphorus	
		ISO	Measured	ISO	Measured
Minimum load reduction percentage		70%	0.05mg/L	80%	0.01mg/L

Effluent performance range for pH (Environmental requirement)

		pH	
		ISO	Measured
Range for all reuse purposes		6 to 9	6 to 9

Index	Value of Treated Water
pH	6～9
CODcr	≤50mg/l
SS	≤10mg/l
NH_3-N	≤5mg/l
TN	>70% removal rate
TP	>80% removal rate
Number of E.Coli	0
Number of fecal coliforms	0

- ✓ Fast treatment to organic contaminants
- ✓ Excellent disinfection and de-coloring performance
- ✓ Stable treatment result without influence of temperature

Cape Cod Community College

New Science and Engineering Center

PAYETTE

Cape Cod Community College

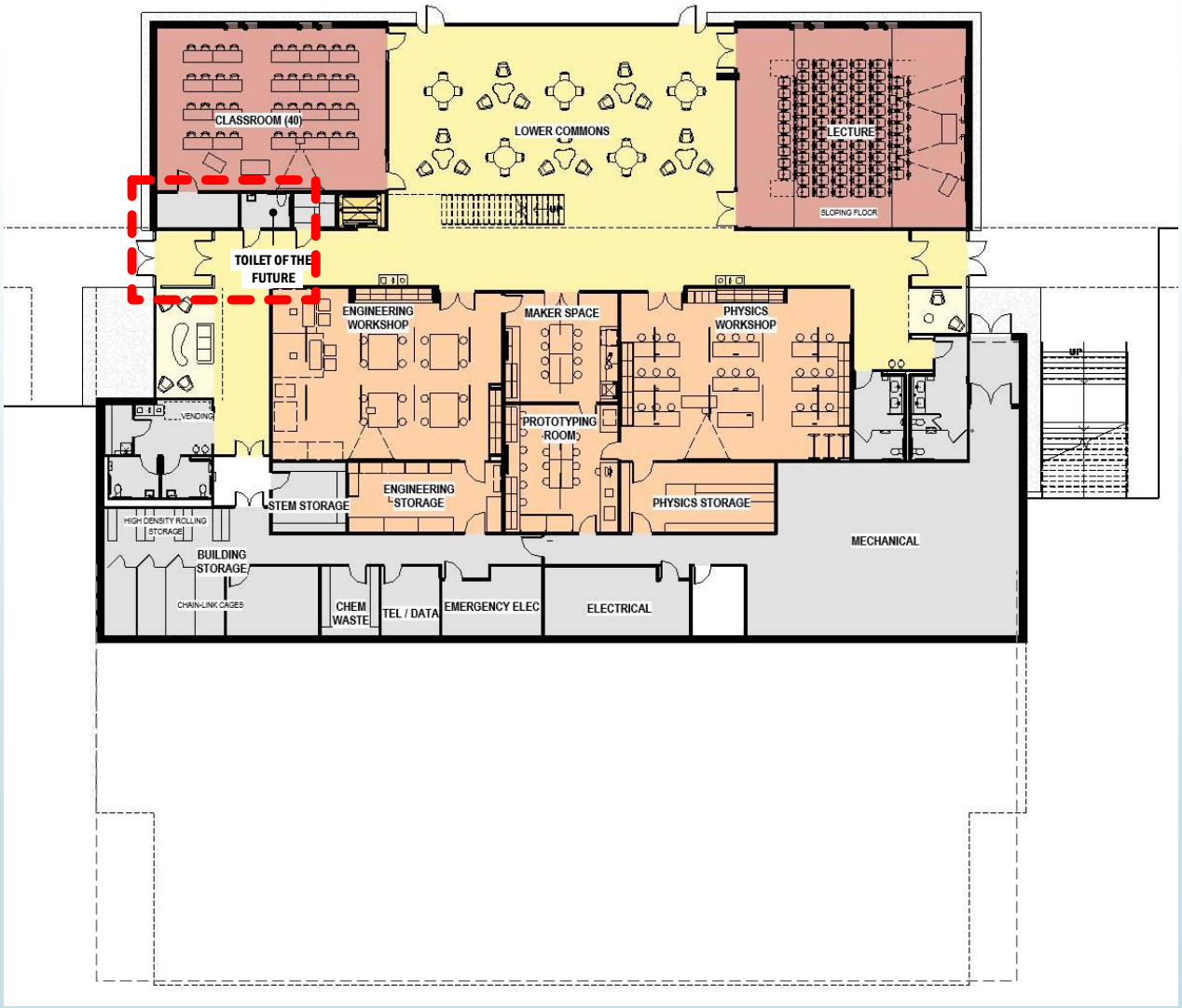
Program, Level 0

Single Occupancy Demonstration toilet

Highlighting regional water treatment issues

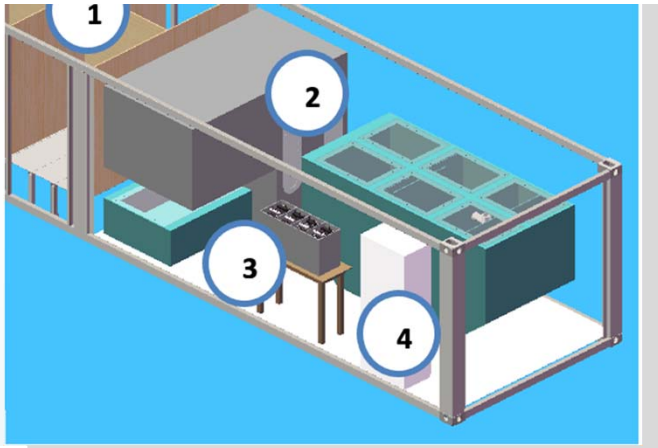
10-15 flush/day Design capacity

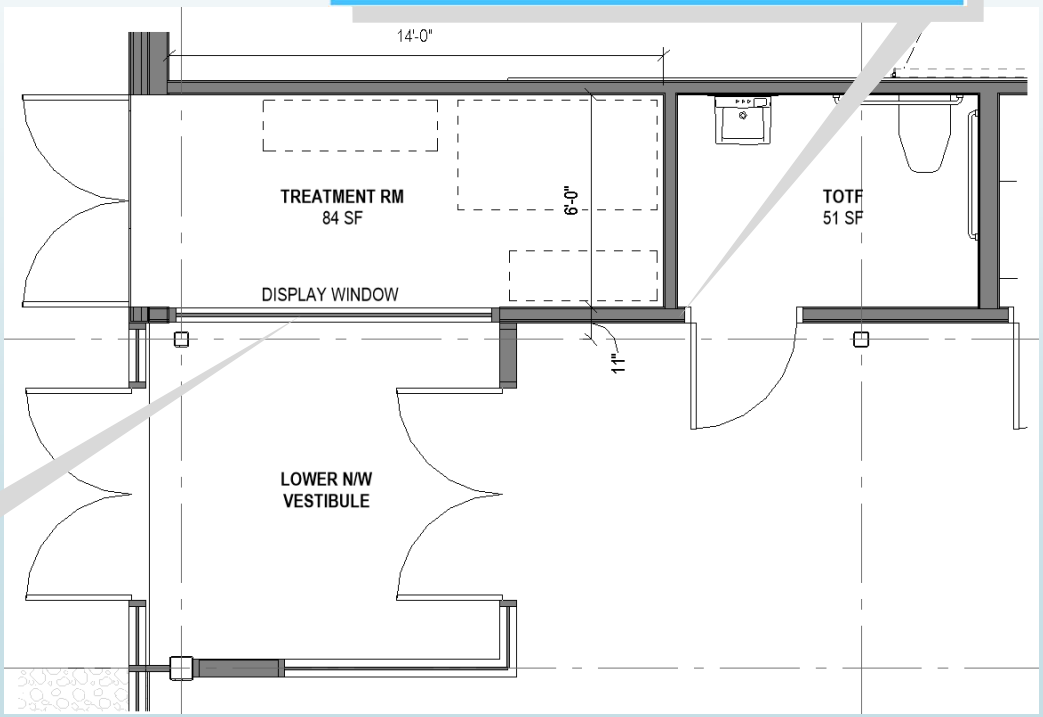
In addition to code-required restroom fixtures



Cape Cod Community College

Toilet of the Future





Potential Early Applications in North America

- National and provincial/state parks and forests
- Mobile/temporary sanitation at construction sites or public events
- Rural/low density populations in
  - Arid lands
  - Poorly drains soils
  - Permafrost areas
- Any jurisdiction prone to water curtailment or sewage treatment capacity constraints
- Any home not served by sanitary sewers

ISO 30500-Compliant Systems: Overcoming Septic System Limitations

Removes blackwater from the waste stream --

- Fecal solids removed
- Fecal pathogens removed
- Hydraulic loading from toilets removed

Extends service interval

“Known Unknowns” about RTs

- Availability
- Price
- Warranty
- Consumer acceptance
- Servicing requirements
- Repair history
- Business model for sales and installation
- Business model for maintenance and replacement

Progress on Policy in 2021: Model Plumbing Codes

2024 editions of national model plumbing codes are likely to be RT ready.

Technical committees have approved language allowing installation of ISO-compliant RTs in the major model codes, including --

- Uniform Plumbing Code (IAPMO)
- International Plumbing Code (ICC)
- International Residential Code (ICC)
- International Private Sewage Development Code (ICC)

ICC publication is expected in mid-2022. IAPMO balloting to be competed in late 2022.

Next Steps Toward Commercialization

- Expand the testing and certification infrastructure
- State and local adoption of RT-ready plumbing codes
- Identify demonstration sites and stakeholders in the US
- Encourage state agency leadership (3 to 5 states) in policy development
- Develop model language for health agency permitting, by use case.

Questions and Comments.

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