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DOMESTIC STRENGTH REALLY ?

An analysis and discussion of present-day onsite wastewater systems design criteria

Image source : www.aerofloat.com.au/processes/wastewater-treatment-plant-water-reuse/

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From Research to Applied Design Criteria

From Research to Applied Design Criteria

Applied Research

Published papers

Scientific consensus (peer review)

Integration in design manuals, handbooks, textbooks

Policy review process (opportunity to integrate new science, criteria, etc.)

Pre-publication for Public and industry consultation (seen in many jurisdictions)

Final version

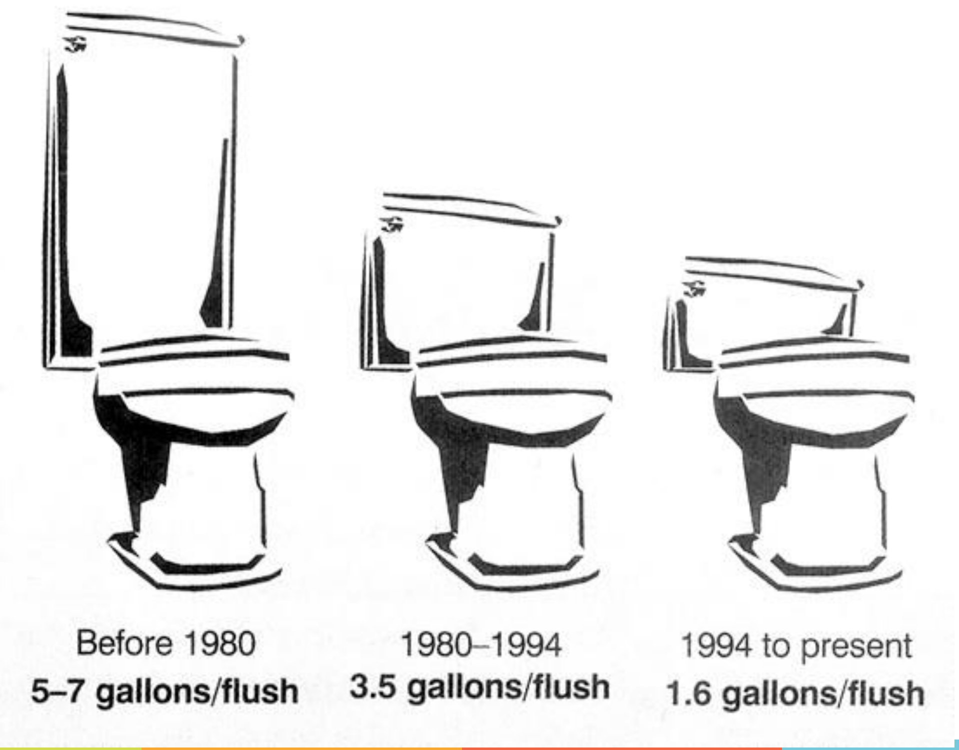
Adoption and implementation

Transitory measures (seen for major changes)

Full Enforcement

From Research to Applied Design Criteria

Knowing the gap that exists between state of knowledge (moving fast) and policies (moving slow), are we certain our current design criteria are always representative of today's reality ?



Review of actual Onsite Design Criteria

Review of actual onsite design criteria

Examples of design flow rates (residential applications) :

	Missouri	Minnesota	Texas	New York	Ontario (Can)
2 bedrooms	240 gpd	225 gpd	225 gpd	260 gpd	240 gpd
3 bedrooms	360 gpd	300 gpd	300 gpd	390 gpd	350 gpd
4 bedrooms	480 gpd	375 gpd	375 gpd	520 gpd	440 gpd
5 bedrooms	600 gpd	450 gpd	450 gpd	650 gpd	550 gpd
6 bedrooms	720 gpd	525 gpd	525 gpd	780 gpd	660 gpd
	Missouri Department of Health and Senior Services	Chapter 7080, Individual Subsurface Sewage Treatment Systems. Class II dwellings in example	On-Site Sewage Facility Rules Compilation §285.91(3). House without water saving devices in example	Wastewater Treatment Standards – Residential Onsite Systems 130 gpdpb	Ontario Building Code Part 8

Review of actual onsite design criteria

Examples of Wastewater Strength used in Standards (residential applications):

	Missouri	Minnesota	Texas	New York	Ontario (Can)
BOD_5	- 210 mg/l (PE)	300 mg/l (raw) 170 mg/l (PE)	- 140 mg/l (PE)	100-300 mg/l (raw) -	100-300 mg/l (raw) (200 mg/l average raw)
TSS	-	200 mg/l (raw) 60 mg/l (PE)	-	100-350 mg/l (raw)	100-350 mg/l (raw) (200 mg/l average raw)
TKN	-	-	-	-	35-70 mg/l (raw)
	Derived from buried sand filter organic loading rate	Chapter 7080, Individual Subsurface Sewage Treatment Systems	On-Site Sewage Facility Rules Compilation §285.91(3)	Adheres to NSF Standard 40	Adheres to CAN/BNQ 3680-600

PE = Primary effluent (septic tank effluent)

Any technology can get NSF or BNQ certified with a raw sewage BOD_5 average of 200 mg/l

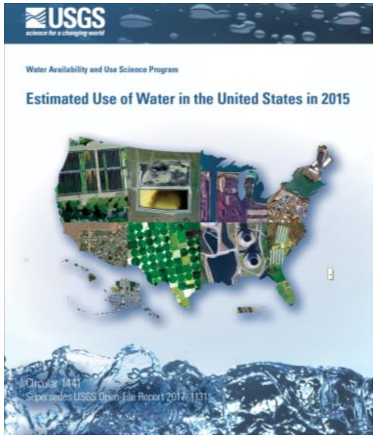
Most testing facilities get sewage from a public collection system (infiltration is very likely)

Evolution of the Domestic Water Use

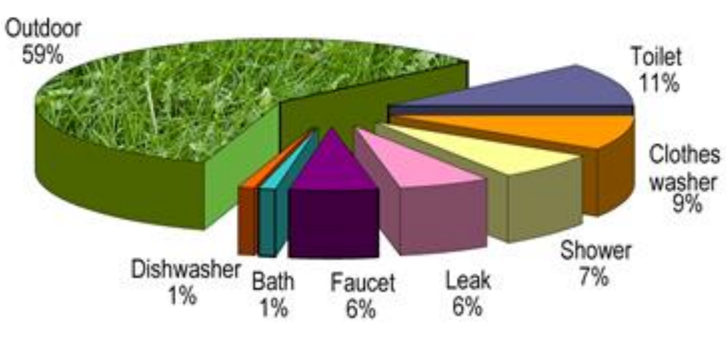
Evolution of the Domestic Water Use

US Domestic water use (gal per capita per day)

	Missouri	Minnesota	Texas	New York	USA
2005	**88**	**68**	**137**	**97**	**98**
2010	**88**	**62**	**92**	**79**	**88**
2015	**89**	**58**	**82**	**71**	**82**
+/- 2005-2015	**+1%**	**-15%**	**- 40%**	**-27%**	**- 16%**
Source:	**USGS Estimated Use of Water in the United States (report every 5 years) (Includes outdoor use and losses in public supply networks)**				

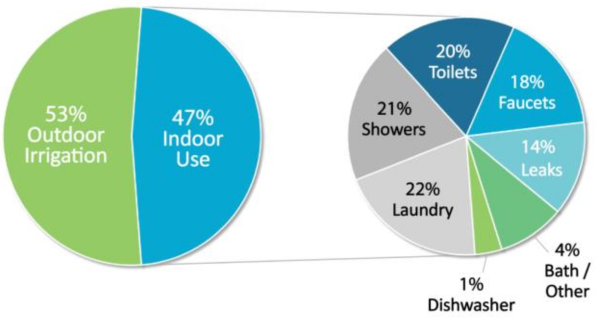


Residential Average Water Use



Source: American Water Works Association Research Foundation, End Uses of Water

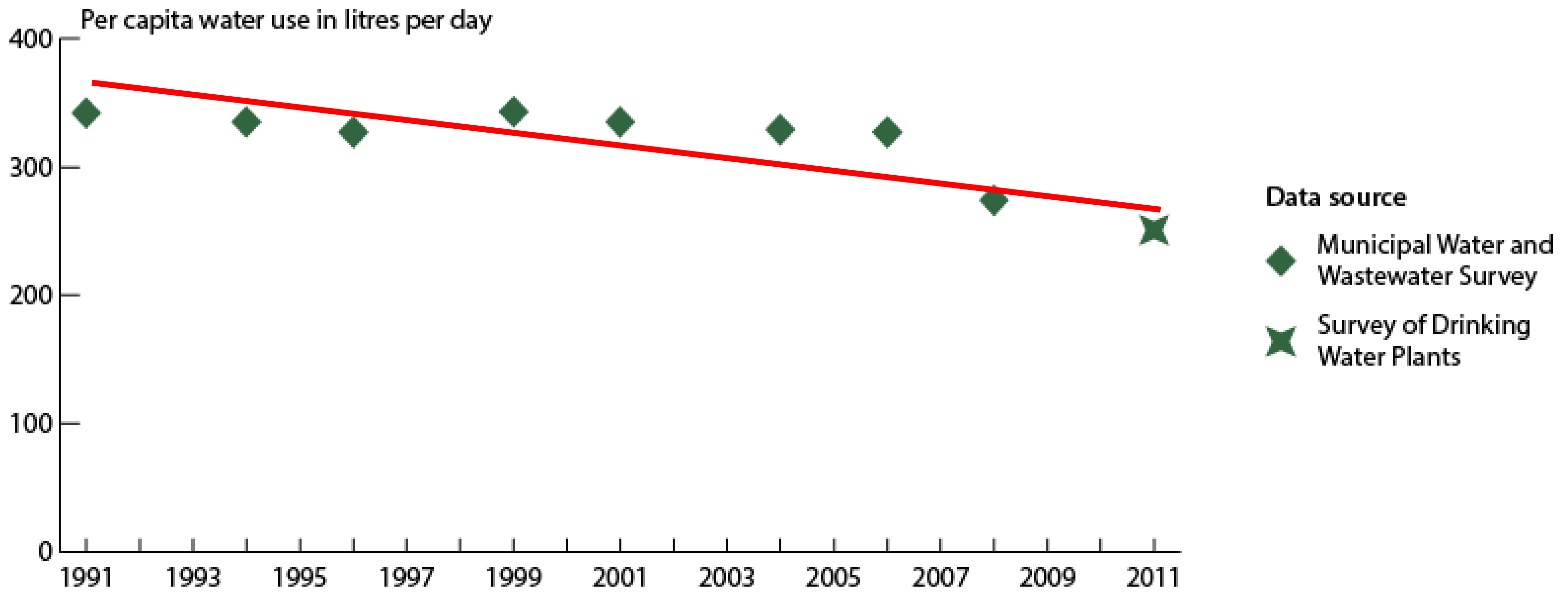
Understanding your water use:



Source: California Single Family Water Use Efficiency Study

Domestic water use

Canada residential water use



Highlights :

✓ 2011 per capita value of 251 L/pers.d (66 gpcd). -27% from 1991 (344 L/pers.d or 91 gpcd).

✓ 2017 per capita value of 220 L/pers.d (58 gpcd). -12% from 2011 (251 L/pers.d or 66 gpcd)

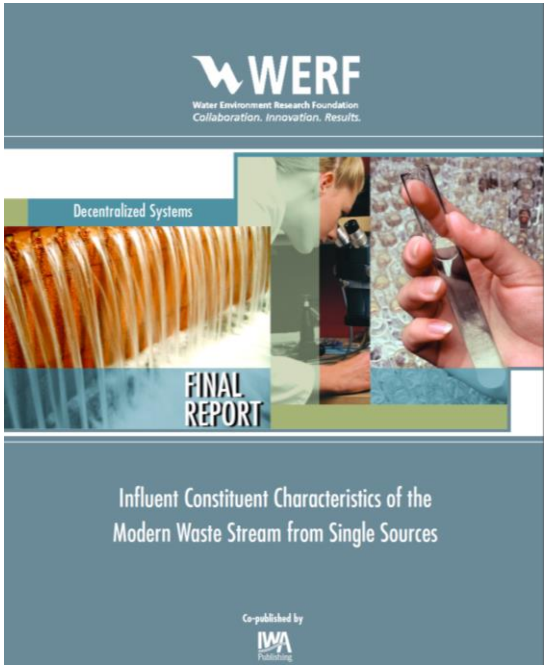
Source: StatCan.

Evolution of the Domestic Water Use

WERF: Influent Constituent Characteristics of the Modern Waste Stream from Single Sources, 2009

Highlights - Flows :

- ✓ Median value of indoor water use is 171 L/pers.d (45 gal)
  - ✓ Average per capita use for occupants >65 years old = 297 L/pers.d (78 gal)
  - ✓ Average per capita use for occupants <65 years old = 148 L/pers.d (39 gal)
- ✓ Study done in 1999 by AWWA (1100 households monitored): : median of 229 L/pers.d (60 gal): median decreased 25% between AWWA in 2009 and WERF in 2009



Impacts of reduced water use on sewage strength

Impacts of reduced water use

Raw sewage BOD_5, Nitrogen and phosphorus :

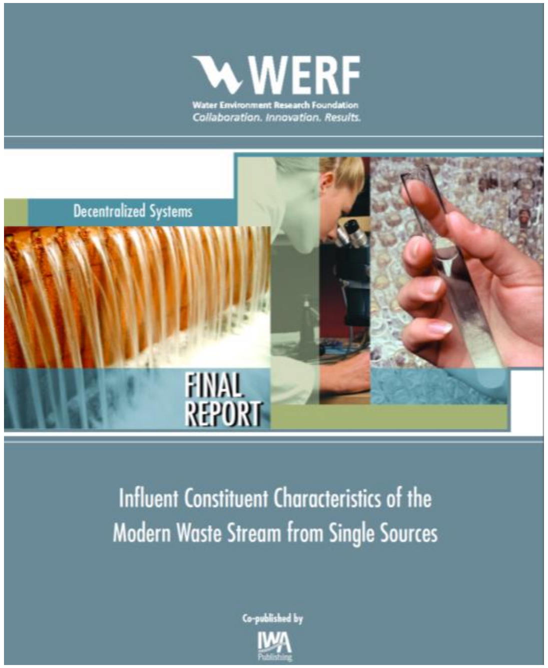
	Expected concentration From policies or certification protocols	Expected concentration for 15 % daily sewage volume reduction	Expected concentration for 30% daily sewage volume reduction
BOD_5	200 to 300 mg/l	235 to 353 mg/l	286 to 429 mg/l
TKN	35 to 70 mg/l	41 to 82 mg/l	50 to 100 mg/l
Phosphorus	4 to 15 mg/l	5 to 18 mg/l	6 to 21 mg/l

Septic tank effluent BOD_5 :

	Expected concentration From policies or certification	Expected concentration for 15 % daily sewage volume reduction	Expected concentration for 30% daily sewage volume reduction
BOD_5	140 to 200 mg/l	165 to 235 mg/l	200 to 286 mg/l

Impacts of reduced water use

WERF: Influent Constituent Characteristics of the Modern Waste Stream from Single Sources, 2009



Highlights Sewage strength :

- ✓ TSS range from 22 to 1690 mg/l (median of 232 mg/l).
- ✓ TSS in septic tank effluent: median value of 61 mg/l
- ✓ $cBOD_5$ ranged from 112 to 1101 mg/l (average of value 443 mg/l)
- ✓ $cBOD_5$ in Septic tank effluent ranged from 44 to 833 mg/l (average of 252 mg/l)

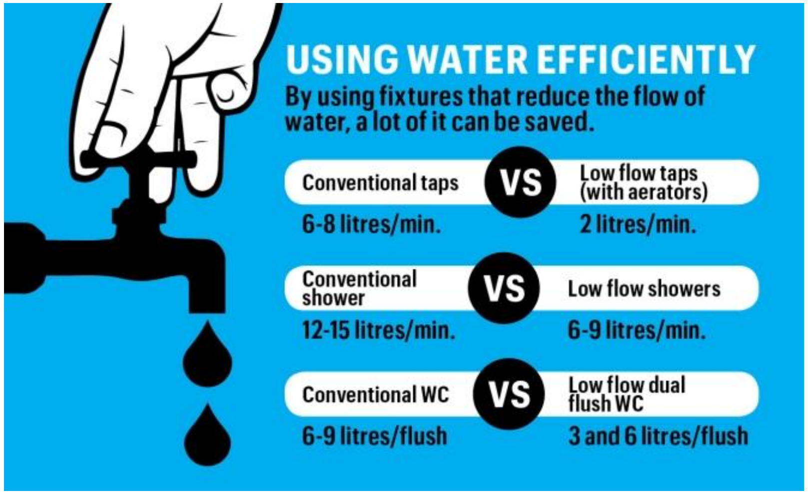
Observations

- ✓ Septic tanks appears to perform well their duty of removing solids. Effluent filter is an added safety factor.
- ✓ BOD_5 from recent data is higher than values used in standards (200 to 300 mg/l vs 443 mg/l for raw sewage. 140 to 210 mg/l versus 252 mg/l for septic tank effluent)

Impacts of reduced water use

- There is a global trend of reduced indoor domestic water use (water saving fixtures and appliances, social awareness, taxation $, etc.);
- Design criteria are frequently overestimating actual daily sewage flows while mass loading are likely stable;
- Consequently, septic systems are often receiving more concentrated sewage;

SO WHAT NOW ?



Impacts of smaller flows / higher strength on Onsite Treatment Systems

Impacts : 6 Legitimate Questions

1. **If the effluent concentration is higher but flow is lower, will the septic system or treatment unit perform the same ?**

   Biological treatment processes involve complex interactions between microorganisms, oxygen availability, retention time, temperature, etc. Those reactions are not following linear relationships. Performances are very likely to be impacted by strength. Some types of systems will have greater impacts than others.

Impacts : 6 Legitimate Questions

2. **If the soil receives higher strength, will it clog faster ? will it reduce its life expectancy ? will it increase the risk of effluent ponding over time ?**

In any types of systems and especially in soil-based systems, when effluent distribution is not perfect (which is almost always the case when using gravity distribution) the actual loading rate on the soil is much greater than the design loading rate and oxygen may become limited. This can lead to premature clogging, reduced life expectancy and higher risk of ponding (especially on sloped site and trench systems)

Impacts : 6 Legitimate Questions

3. **If the soil receives stronger effluent, is the separation distance from water table enough to remove the pollutants to the desired levels ?**

   Considering that most gravity fed septic systems are overloading portions of the bed, the residence time in the unsaturated layer of the soil before mixing with water table is shorter. Consequently, the filtration distances required to achieve proper treatment levels should be greater with higher effluent concentrations.

Impacts: 6 Legitimate Questions

4. **If sewage volume is less but it is stronger in concentration, knowing that most of our systems are fed using gravity should we pay more attention to the quality of effluent distribution ? In pumped systems, does that impact the way we should dose effluent ?**

   The quality of effluent distribution in often the weakest point in a design. Even distribution over the entire contact area (or between treatment units) is critical in achieving the desired performances.

   All soil-based systems are design on a hydraulic loading rate that implicitly consider effluent distribution to be perfect. Stronger effluent combined with imperfect distribution is likely to result in negative impacts such as premature clogging, water table contamination, reduced life expectancy.

   In any septic design and even more importantly when dealing with stronger effluent, trench system or single pass systems, the quality of effluent distribution should become a priority.

   With pumped system dealing with stronger effluent, we should aim for more frequent doses of smaller volumes and go low pressure dsitribution;

Impacts: 6 Legitimate Questions

5. **If we design septic systems using the approved criteria but something goes wrong such as premature clogging or effluent exceeding limits in surface discharge systems, who is responsible ?**

The most adequate question would probably be: How much will it cost to prove that we are not responsible ?

Impacts: 6 Legitimate Questions

6. **Can we adapt / improve a design to account for (or at least mitigate) the risks associated with lower flows and stronger effluent concentrations ?**

Definitely. Some design best practices can be implemented to reduce the risks associated with stronger effluent concentrations. Some will be discussed in the next section.

Suggested readings:

A Comparison of Gravity Distribution Devices Used in On-Site Domestic Wastewater Treatment Systems
T. Patel & N. O'Luanaigh & L. W. Gill, 2007

Comparison of Pressurized and Gravity Distribution Systems for Wastewater Treatment
Gross, Neal, Ederington, Muldoon, 1990

Adapting Onsite Designs

Adapting Onsite Designs

Adapting how we approach design:

- Recognizing that being proactive is better than being reactive;
- Recognizing the impacts of sewage flows and strength on our designs and the limitations of some of the concepts and techniques we are using.
- Recognizing that technologies may have been certified/tested with conditions different from those encountered in some situations. Do not hesitate to ask the manufacturers for advices. This will protect your client and yourself;
- Making your clients realizing (even if it is often difficult) that their septic system is one of the most expensive infrastructure on their property and a key feature in protecting their health and the environment…for the next 20 years or more. This reason alone should justify taking good care of it (periodic sludge pump outs, annual inspection, implementing best practices).

Adapting Onsite Designs

Couple of things worth considering:

- Evaluating design flow: going further than flow rate tables. Do you have access to water meter reading ? Does you client mostly use water saving devices ? Nb of bedrooms vs actual people living in the house, etc.;
- For any types of soil-based system or technology, always comply with both hydraulic (gal/ft^2/d) and organic loading criteria (lb BOD/ft^2/d);
- The quality of effluent distribution over the treatment area is one of the most important design aspect. This is the only way to avoid overloading, assure adequate levels of treatment and get longer life expectancy. This is even more important in soil-based systems and “single pass” technologies;
- BOD removal needs oxygen. More BOD = more oxygen demand. Adequate air flow through the system is critical to performance and longevity;
- When dosing stronger effluent, small is beautiful. Use more frequent smaller doses over fewer larger doses;

Conclusion

Conclusion

Volume of sewage impacts its strength and this should affect the way we approach design;

Proper site/flow evaluation is critical;

Being aware of the strength and weaknesses of the systems and components we use;

Every septic system should have some sort of periodic maintenance/inspection

QUESTIONS

End of presentation

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