



Decentralized Wastewater Management: An Evolving Paradigm for Sustainable Water Resources

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What is DWM?



- Modern Decentralized Wastewater Management (DWM) involves:
 - Onsite and clustered wastewater treatment systems
 - Treatment of wastewater at or near the point of generation
 - Centralized management, sensors and SCADA technology
- DWM moves beyond the historical use of “privies, cesspools, and septic systems” in rural areas
- DWM involves use of new technologies, resulting in higher treatment levels, greater reliability, and more flexibility
- In many settings, DWM is the most appropriate, least costly approach, and allows maximum flexibility in planning for future growth

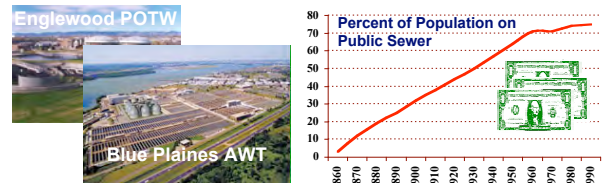
- DWM can contribute to achieving sustainable water resource management, because it enables:
 - Water recharge near the point of water extraction and avoid water export and depletion of local water resources
 - Reduction in the use of potable water to support waste transport to remote treatment plants
 - Beneficial recovery and reuse of water and nutrients
 - Prevention of catastrophic pollutant discharges from sanitary sewer overflows (SSOs) and combined sewer overflows (CSOs)
 - Lower consumption of energy and chemicals and reduced release of greenhouse gases



Some Perspectives



- Wastewater collection and transport away from people in dense urbanized areas was essential to public health
- Treatment was needed to protect receiving waters and prevent public health and ecosystem impacts
- Centralized wastewater management (CWM) became the goal and construction of POTW's was heavily subsidized by USEPA during the late 1900's



- Unfortunately, sewerage and CWM became a *de facto* goal for suburban and rural America as well
- Yet, this goal is flawed and imprudent
 - CWM can be costly, particularly for low density applications (e.g., ~70% of CWM cost can be due to sewerage)
 - CWM can lead to export of water from hydrologic basins (declining GW levels, depleted stream flows,...)
 - CWM can consume large amounts of energy and chemicals
 - CWM can actually lead to water quality degradation
 - Poor treatment due to deficiencies in O&M
 - Bypassing of raw sewage into the environment
 - ✓ Sanitary Sewer Overflows (SSO)
 - ✓ Combined Sewer Overflows (CSO)
 - Leakage of raw sewage from sewers

- Sewers can lead to problems with CWM
 - “Million-mile network” of sewage collection pipes that conveys ~50 trillion gpd of sewage to 20,000 treatment plants
 - SSOs and CSOs are prevalent and serious:
 - EPA estimates on an annual basis (2001):
 - 40,000 sanitary sewer overflows (SSOs)
 - 400,000 backups into basements
 - 1.3 trillion gallons/year of sewage discharged by CSOs
 - Roughly 1.8 to 3.5 million people get sick each year by swimming in waters contaminated by SSOs



- Leakage of raw sewage from sewers can be substantial and have far-reaching effects

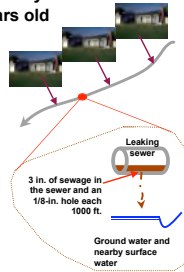
- Design criteria often specify limits on infiltration and exfiltration (e.g., 200 gpd per in. diameter per mile of sewer)

- Some key factors contributing to leakage

- ✓ Deterioration due to aging of sewers
 - ✗ Average age of sewer systems is 33 years
 - ✗ Some sewers are almost 200 years old
- ✓ Poor construction of newer sewers

- The volume of raw sewage that can leak from a length of sewer in a subdivision is substantial:

- ✓ ~500 gpd per 1000 ft. of sewer, or
- ✓ 15 to 20% of the raw wastewater flow

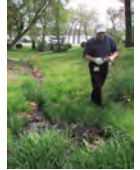


- Decentralized wastewater management (DWM) has many positive attributes, since it:

- ✗ Avoids excessive use of sewerage and the associated cost and problems (CSOs, SSOs, leakage)
- ✗ Relies on natural systems for treatment instead of chemical- and energy-intensive, tank-based technologies

- But, DWM is not flawless

- ✗ There have been poor performance experiences
- ✗ Key contributing factors?
 - Many older, disposal based systems
 - Old and new systems that are poorly designed, constructed, and maintained
 - Ineffective management and O&M



Status and Future of DWM



- Level of use

- ✗ In Colorado there are over 600,000 onsite wastewater systems (OWS, or ISDS in Colorado), which handle ~75 million gpd of wastewater
- ✗ In the U.S., 25% of the population is served by OWS and ~35% of new housing is served by such systems

- Purpose and performance expectations

- ✗ Years ago, OWS were designed as temporary waste disposal systems and only intended for use until sewers and centralized treatment plants were installed
- ✗ Since the 1980's, OWS and DWM have been viewed as necessary and appropriate for wastewater treatment and reuse, and been designed for long-term use

- In 1997, USEPA prepared a report to Congress describing the benefits of decentralized approaches to wastewater management and concluded that:

"Adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals."

www.epa.gov/owm/mtb/decent/response/index.htm

USEPA identified 5 major barriers to the successful implementation of decentralized wastewater technologies:

- ✓ Misinformation and limited knowledge about onsite systems
- ✓ Legislative and regulatory constraints
- ✓ Lack of system management
- ✓ Existing engineering practices
- ✓ Restricted access to funding

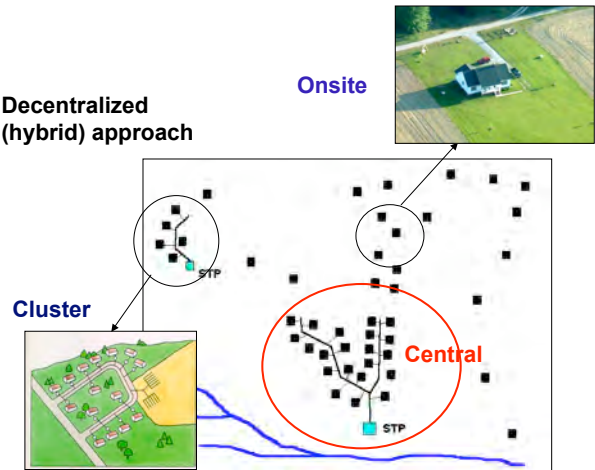


- USEPA stated that modern DWM can provide reliable treatment, be flexible, and cost-effective

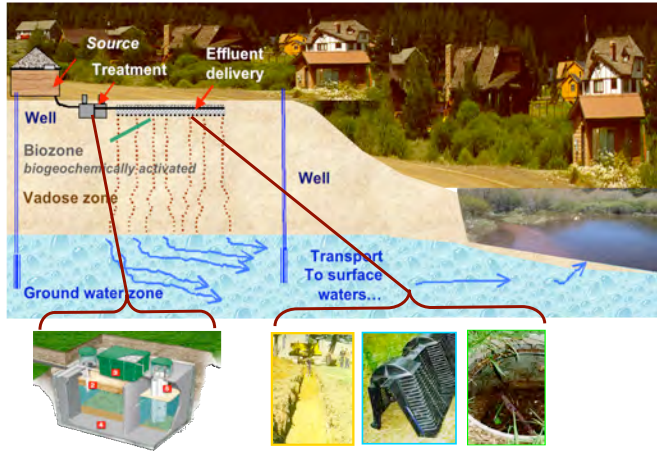
Simple centralized approach



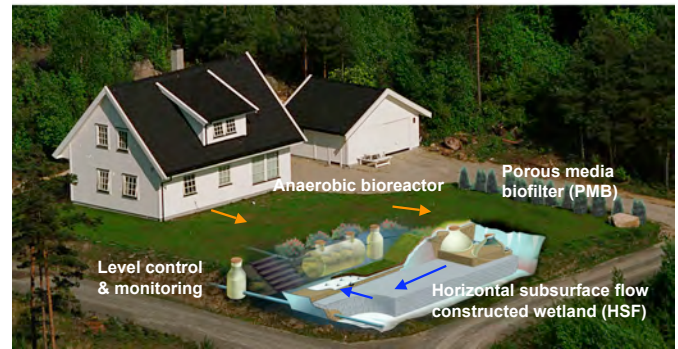
Decentralized (hybrid) approach



Conventional OWS can provide advanced treatment



Innovative OWS can enable reuse and provide additional benefits for some sites



Hybrid systems can be cost-effective for higher density developments



CASE STUDY Diamond Lake, Washington

Diamond Lake, Washington: 12,000 Year Old Effluent from Aquifer (Lakelse Nation)

SUMMARY OF SPECIFICATIONS

- Diamond Lake, WA
- 533 homes and businesses
- "Lake being destroyed by leaking septic tanks and failing drainfields"
- DWM for 68,000 gpd installed in 1987 using
 - Effluent sewers
 - 3-cell aerated lagoon
 - Effluent reuse by summer irrigation of alfalfa fields
- Costs
 - ✓ \$2.9M (excl. lagoon)
 - ✓ \$15/mon residential
 - ✓ \$25/mon commercial

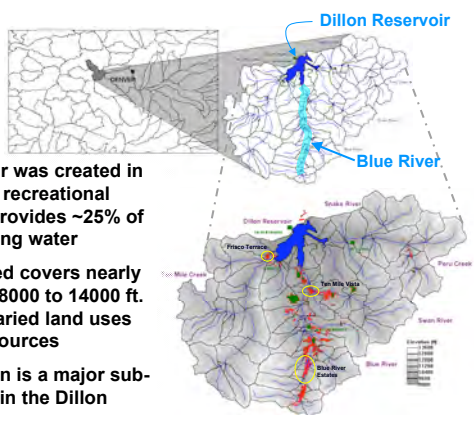
Eldorado Springs, Colorado



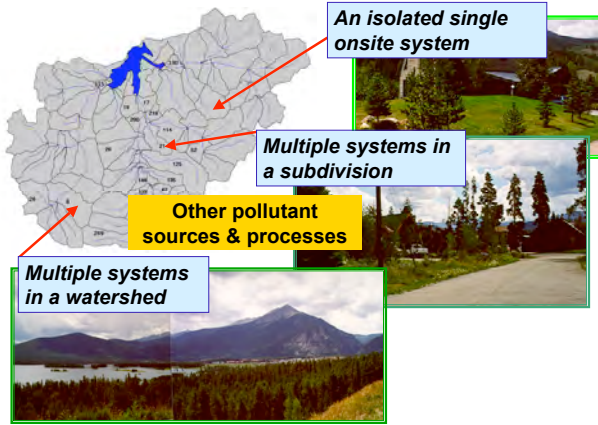
- 121 homes and businesses
- Old ISDS and difficult
- Concern over S. Bou private drinking water
- Planning studies con to date and CWM pro
 - ✓ Gravity sewers treatment plant discharge
 - ✓ Costs est. at \$2 \$3.6M to pay off
 - ✓ Users to pay \$1 mon for 20 year
- Nov. 2003 Ballot vote



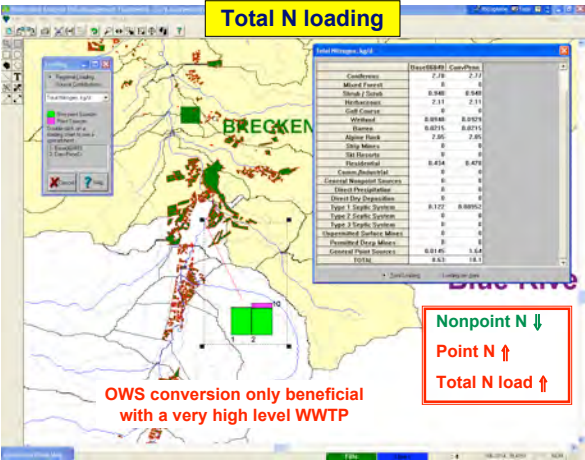
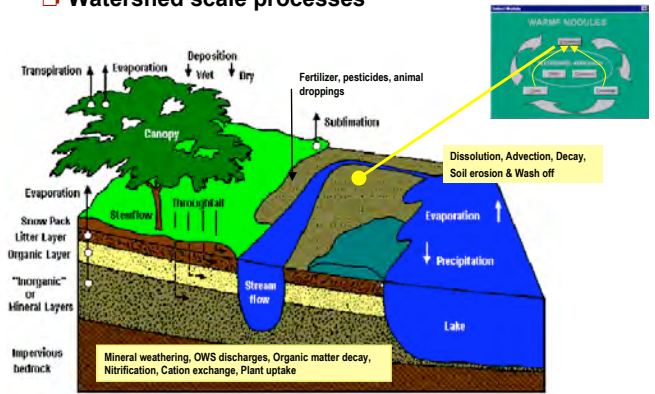
Blue River basin and Dillon watershed



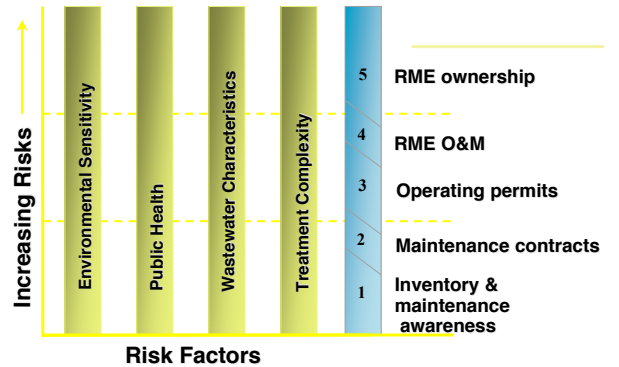
- ◆ Dillon Reservoir was created in 1963; supports recreational activities and provides ~25% of Denver's drinking water
- ◆ Dillon watershed covers nearly 325 sq. mi. at ~8000 to 14000 ft. and includes varied land uses and pollutant sources
- ◆ Blue River basin is a major sub-watershed within the Dillon watershed



Watershed scale processes



Management is essential to successful DWM and model frameworks have been developed by USEPA

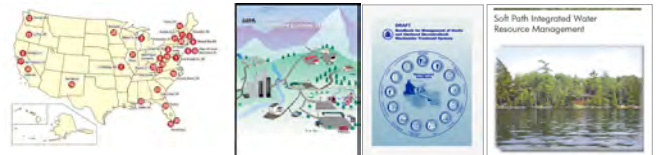


Recent DWM Developments

Recent U.S. Programs and Activities

- 1993 - National Onsite Demonstration Program (NODP) was initiated by USEPA with \$8.5M in funding to demonstrate new onsite technologies and management techniques http://www.nesc.wvu.edu/nodp/nodp_index.htm
- 1996 - Consortium of Institutes for Decentralized Wastewater Treatment was initiated and now consists of 24 universities <http://www.onsiteconsortium.org/>
- 1997 - Congress required USEPA to prepare a report describing the benefits of OWS and highlighting key barriers to overcome to enable effective and sustainable use
- 1997 - Congress with USEPA, initiated the National Decentralized Water Resources Capacity Development Project (NDWRCDP) with \$8.2M in funding to overcome the barriers identified in the 1997 USEPA report <http://www.ndwrcdp.org/>

- 2000's - Congress provides \$15.6M for projects in 6 areas to demonstrate DWM technologies and management concepts
- 2003 - USEPA published a new Onsite Systems Design Manual <http://www.epa.gov/ORD/NRMRL/Pubs/625R00008/625R00008.htm>
- 2003 - USEPA published an Onsite Systems Mgmt. Handbook <http://www.epa.gov/owm/mtb/decent/handbook.htm>
- 2003 - NDWRCDP sponsors Soft Path Integrated Water Resource Management workshops



Recent Colorado Programs & Activities

- 1997 - The Small Flows Program was initiated at CSM
<http://www.mines.edu/research/smallIQ/>
- 1997 - Formation of the ISDS Technical Advisory Committee by the State Board of Health, CDPHE, to review alternative ISDS for use in Colorado
- 2001 - Formation of ISDS Steering Committee by the CDPHE to review ISDS practices, assess water quality impacts and recommend changes for Colorado
<http://www.cdphe.state.co.us/op/wqcc/SpecialTopics/ISDS/isdswork.html>
- 2003 - Formation of the Colorado Professionals in Onsite Wastewater (CPOW) chapter of the National Onsite Wastewater Recycling Association <http://www.nowra.org/>

CSM Small Flows Program Context and need

- In Colorado there are over 600,000 onsite systems that handle ~30 billions gal/yr. of wastewater
- In the U.S., 25% of the population is served by onsite wastewater systems (OWS) and 35% of new housing is supported by such systems
- In the world 2.6 billion people lack basic sanitation and OWS could help achieve UN Millennium Goals
- To protect public health and environmental quality, OWS performance must be reliable and predictable
- Research and education can produce and disseminate new understanding, methods, and technologies to enhance current applications and enable improvements and innovations

CSM Small Flows Program Purpose and Scope

- Gain quantitative understanding and develop models and decision-support tools for existing and new OWS, including micro- to macro-scales
- Research includes: (1) basic and applied lab studies; (2) controlled field testing and evaluation; (3) field monitoring; and (4) mathematical modeling.




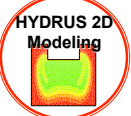
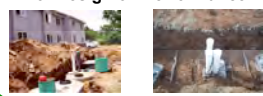





Research team

- CSM faculty/staff (~8) and students (~12) from multiple departments at CSM
- Other universities, national labs, industry, govt.

Program sponsors

- CSM, USEPA NDWRCDP, WERF, Dept. Education, Natl. Science Foundation, U.S. Geological Survey, Colorado government, Infiltrator Systems, Inc. and private industry

CSM recent and ongoing research

Hydraulic & Purification in Soil 	Pathogen Fate in Soil 	Soil Effects on Performance 	
HYDRUS 2D Modeling 	Mines Park Test Site ~ Effects of Design on Performance 	WARMF Modeling 	
OWS monitoring 	Pretreatment Unit Monitoring 	Source tracking 	Occurrence & fate of EOCs 

Selected journal papers

- McCray, J.E., S.L. Kirkland, R.L. Siegrist, G.D. Thyne (2005). Model Parameters for Simulating Fate and Transport of Onsite Wastewater Nutrients. *Ground Water*. Accepted and in press.
- Beach, D.N., J.E. McCray, K.S. Lowe, R.L. Siegrist (2005). Temporal Changes in Hydraulic Conductivity of Sandy Porous Media Biofilters during Wastewater Infiltration: Experimental Evaluation. *J. Hydrology*. Accepted and in press.
- Siegrist, R.L., J.E. McCray, K.S. Lowe (2004). Wastewater Infiltration into Soil and the Effects of Infiltrative Surface Architecture. *Small Flows Journal*, 5(1):29-39.
- Van Cuyk, S., R.L. Siegrist, K.S. Lowe, R.W. Harvey (2004). Evaluating Microbial Purification during Soil Treatment of Wastewater with Multicomponent Tracer and Surrogate Tests. *J. Environmental Quality*, 33:316-329.
- Mansell, J. and J.E. Drewes (2004). Fate of Steroidal Hormones During Soil-Aquifer Treatment. *Ground Water Monitoring and Remediation*, 24(2):94-101.
- Albert, J., J. Munakata-Marr, L. Tenorio, R.L. Siegrist (2003). Statistical Evaluation of Bacterial Source Tracking Data Obtained by rep-PCR DNA Fingerprinting of *Escherichia coli*. *Environ. Science and Technol.* 27:4554-4560.
- Beach, D.N., J.E. McCray (2003). Numerical Modeling of Unsaturated Flow in Wastewater Soil Absorption Systems. *Ground Water Monitoring and Remediation*, 23(2):64-72.
- Logan, A.L., T.K. Stevik, R.L. Siegrist, G. Ausland (2001). Transport and Fate of Cryptosporidium Parvum through Intermittent Sand Filters during Water and Wastewater Treatment. *Water Research*, 35(16):4359-4369.
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- Van Cuyk, S., R.L. Siegrist, A. Logan, S. Masson, E. Fischer, L. Figueroa (2001). Hydraulic and Purification Behaviors and their Interactions during Wastewater Treatment in Soil Infiltration Systems. *Water Research*, 35(4):953-964.



Concluding Remarks



- DWM is still evolving, but it is here to stay and is critical to wastewater infrastructure in the USA and abroad
- Further information about:
 - CSM Small Flows Program can be found at: www.mines.edu/research/smallIQ/
 - USEPA DWM programs can be found at: www.epa.gov/owm/onsite
- Thank you for listening
- Questions...???

