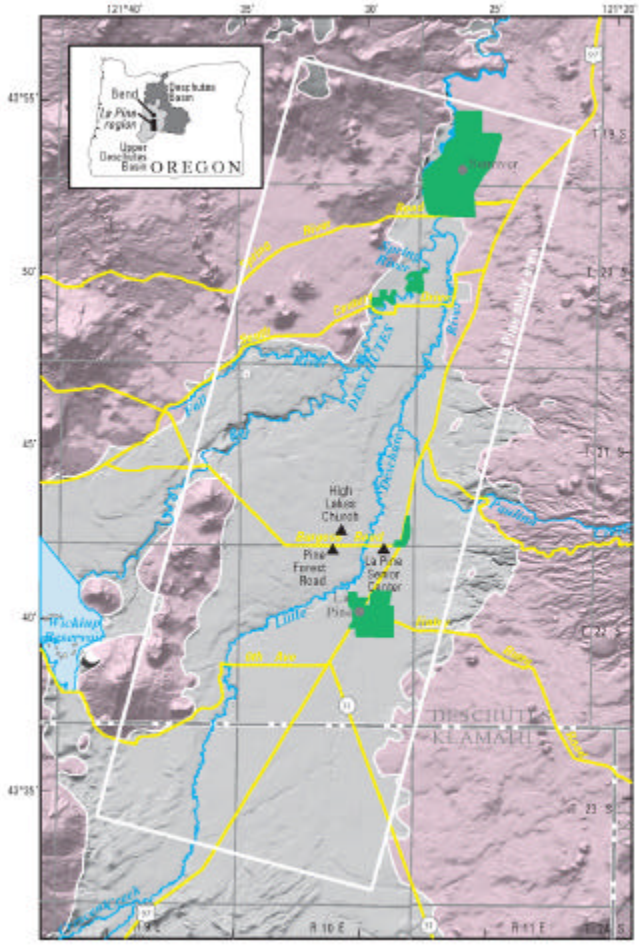
National Decentralized Water Resources Capacity Development Project

Executive Summary



Organic Wastewater Compounds, Pharmaceuticals, and Coliphage in Groundwater Receiving Discharge From Onsite Wastewater Treatment Systems Near La Pine, Oregon: Occurrence and Implications for Transport

Oregon Department of Environmental Quality
Portland, Oregon

April 2005

Organic Wastewater Compounds, Pharmaceuticals, and Coliphage in Groundwater Receiving Discharge From Onsite Wastewater Treatment Systems Near La Pine, Oregon: Occurrence and Implications for Transport

Submitted by Oregon Department of Environmental Quality
Portland, OR

NDWRCDP Project Number: **WU-HT-03-05**

National Decentralized Water Resources Capacity Development Project (NDWRCDP) Research Project

Final Report, April 2005

NDWRCDP, Washington University, Campus Box 1150
One Brookings Drive, Cupples 2, Rm. 11, St. Louis, MO 63130-4899

DISCLAIMER

This work was supported by the National Decentralized Water Resources Capacity Development Project (NDWRCDP) with funding provided by the U.S. Environmental Protection Agency through a Cooperative Agreement (EPA No. CR827881-01-0) with Washington University in St. Louis. This report has not been reviewed by the U.S. Environmental Protection Agency. This report has been reviewed by a panel of experts selected by the NDWRCDP. The contents of this report do not necessarily reflect the views and policies of the NDWRCDP, Washington University, or the U.S. Environmental Protection Agency, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

CITATIONS

This report was prepared by

Stephen R. Hinkle
US Geological Survey
10615 SE Cherry Blossom Dr.
Portland, OR 97216

Rodney J. Weick
Oregon Department of Environmental Quality
2020 SW 4th Ave.
Portland, OR 97201

Jill M. Johnson
Deschutes County Environmental Health Division
117 NW Lafayette Ave.
Bend, OR 97701

Jeffery D. Cahill
US Geological Survey
National Water Quality Laboratory
Denver Federal Center
P.O. Box 25046
Lakewood, CO 80225

Steven G. Smith
US Geological Survey
National Water Quality Laboratory
Denver Federal Center
P.O. Box 25046
Lakewood, CO 80225

Barbara J. Rich
Oregon Department of Environmental Quality
c/o Deschutes County Environmental Health Division
117 NW Lafayette Ave.
Bend, OR 97701

The final report was edited and produced by ProWrite Inc., Reynoldsburg, OH.

This report is available online at www.ndwrcdp.org. This report is also available through the

National Small Flows Clearinghouse
P.O. Box 6064
Morgantown, WV 26506-6065
Tel: (800) 624-8301
WWCDMG47

This report also is available as US Geological Survey Scientific Investigations Report 2005-5055, available on the World Wide Web at http://water.usgs.gov/pubs/sir/2005/5055/

This report should be cited in the following manner:

Hinkle, Stephen R., Weick, Rodney J., Johnson, Jill M., Cahill, Jeffery D., Smith, Steven G., and Rich, Barbara J. 2005. *Organic Wastewater Compounds, Pharmaceuticals, and Coliphage in Groundwater Receiving Discharge From Onsite Wastewater Treatment Systems Near La Pine, Oregon: Occurrence and Implications for Transport.* Project No. WU-HT-03-05. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by Oregon Department of Environmental Quality, Portland, OR.

ACKNOWLEDGEMENTS

Appreciation is extended to the following individuals for assistance in the preparation of this report:

The project benefited from close collaboration by numerous individuals. The staff at the La Pine Senior Center and the High Lakes Christian Church granted permission for the emplacement of 23 temporary monitoring wells on the two properties.

Dan Haldeman and Todd Cleveland (Deschutes County Environmental Health Division) provided key communications links between the United States Geological Survey (USGS) and owners of property where monitoring occurred, orchestrated many aspects of field efforts for monitoring of onsite wastewater treatment systems, and were a wealth of technical information.

Dave Anderson, Tracy England, Jim Glass, Don Hanson, Mark Pugh, and Bob Williams (Oregon Department of Environmental Quality) provided crucial drilling support.

Rebecca Bushon and Donna Francy (USGS) accommodated our need to drill five days a week by accepting weekend delivery of coliphage samples at their homes, transporting them to the laboratory facilities, and analyzing them immediately.

Appreciation is also expressed to the NDWRCDP for their support of this work:

Principal Investigator
Jay R. Turner, D.Sc., Washington University

Project Coordinator
Andrea L. Shephard, Ph.D.

NDWRCDP Project Steering Committee:

Coalition for Alternative Wastewater Treatment
Valerie I. Nelson, Ph.D.

Consortium of Institutes for Decentralized Wastewater Treatment
Ted L. Loudon, Ph.D., P.E.

Electric Power Research Institute
Raymond A. Ehrhard, P.E.
Tom E. Yeager, P.E.

National Onsite Wastewater Recycling Association
Jean Caudill, R.S.

National Rural Electric Cooperative Association
Scott Drake, P.E.

Water Environment Research Foundation
Jeff C. Moeller, P.E.

Members-At-Large:
James F. Kreissl
Richard J. Otis, Ph.D., P.E.
Jerry Stonebridge

CONVERSION FACTORS

Multiply	By	To Obtain
Length		
inch (in.)	25.4	millimeter (mm)
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
square mile (mi^2)	2.590	square kilometer (km^2)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows:

$°F = (1.8 \times °C) + 32$

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83). UTM refers to the Universal Transverse Mercator coordinate system; zone 10 in this report.

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L). One liter (L) is equal to 1,000 milliliters (mL). Nitrate concentrations are reported in units of milligrams nitrogen per liter (mg N/L), in contrast to the occasionally seen units of milligrams nitrate per liter (mg NO_3^-/L).

Disclaimer:
Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the US Government.

ABSTRACT

This project involved documenting the occurrence of organic wastewater compounds (components of “personal care products” and other common household chemicals), pharmaceuticals (human prescription and nonprescription medical drugs), and coliphage (viruses that infect coliform bacteria and that are found in high concentrations in municipal wastewater) in onsite wastewater (septic tank effluent). These contaminants were also documented in a shallow, unconfined, sandy aquifer that serves as the primary source of drinking water for most residents near La Pine, Oregon. Samples from two types of observation networks provided basic occurrence data for onsite wastewater and downgradient groundwater. One observation network was a group of 28 traditional and innovative (advanced treatment) onsite wastewater treatment systems and associated downgradient drainfield monitoring wells, referred to as the innovative systems network. The drainfield monitoring wells were located adjacent to or under onsite wastewater treatment system drainfield lines. Another observation network, termed the transect network, consisted of 31 wells distributed among three transects of temporary, stainless-steel-screened, direct-push monitoring wells installed along three plumes of onsite wastewater. The transect network, by virtue of its design, also provided a basis for increased understanding of the transport of analytes in natural systems.

Coliphage were frequently detected in onsite wastewater. Coliphage concentrations in 101 samples of raw and treated onsite wastewater were highly variable, and ranged from less than 1 to 3,000,000 plaque forming units per 100 milliliters (PFU/100 mL). Coliphage were occasionally detected at low concentrations in samples from wells located downgradient from onsite wastewater treatment system drainfield lines (eight occurrences among 110 samples). However, coliphage concentrations were below method detection limits in replicate or repeat samples collected from the eight sites. The consistent absence of coliphage detections in the replicate or repeat samples is interpreted to indicate that the detections reported for groundwater samples represented low-level field or laboratory contamination, and it would appear that coliphage were effectively attenuated to less than 1 PFU/100 mL over distances of several feet of transport in the La Pine aquifer and (or) overlying unsaturated zone.

Organic wastewater compounds were frequently detected in onsite wastewater. Of the 63 organic wastewater compounds in the analytical schedule, 45 were detected in the 21 samples of onsite wastewater. Concentrations of organic wastewater compounds reached a maximum of 1,300 µg/L (p-cresol). Caffeine was detected at concentrations as high as 320 µg/L. Fourteen of the 45 compounds were detected in more than 90 percent of onsite wastewater samples. Fewer (nine) organic wastewater compounds were detected in 51 groundwater samples, despite the presence of nitrate and chloride likely from onsite wastewater sources. The nine organic wastewater compounds that were detected in groundwater samples were:

- Acetyl-hexamethyl-tetrahydro-naphthalene (AHTN)
- Caffeine
- Cholesterol
- Hexahydrohexamethyl-cyclopentabenzopyran
- N,N-diethyl-meta-toluamide (DEET)
- Tetrachloroethene
- Tris (2-chloroethyl) phosphate
- Tris (dichloroisopropyl) phosphate
- Tributyl phosphate

Frequent detection of household-chemical type organic wastewater compounds in onsite wastewater provides evidence that some of these organic wastewater compounds may be useful indicators of human waste effluent dispersal in some hydrologic environments. The occurrence of organic wastewater compounds in groundwater downgradient from onsite wastewater treatment systems demonstrates that a subgroup of organic wastewater compounds is transported in the La Pine aquifer. The consistently low concentrations (generally less than 1 µg/L) of organic wastewater compounds in water samples collected from wells located no more than 19 feet from drainfield lines indicates that the reactivity (sorption, degradation) of this suite of organic wastewater compounds may limit their usefulness as tracers of onsite wastewater discharged into aquifers.

Groundwater samples from one of the three groundwater transects, along with one sample from the onsite wastewater treatment system associated with that transect, were analyzed for a suite of 18 pharmaceuticals. Eight pharmaceuticals were detected in the onsite wastewater at concentrations up to about 120 µg/L (acetaminophen). In downgradient groundwater samples, sulfamethoxazole (an antibacterial), acetaminophen (an analgesic), and caffeine (a stimulant, and not a medical drug) each were detected once, at concentrations between 0.10 µg/L and 0.18 µg/L—typical of the range of concentrations observed in other studies of wastewater-impacted groundwater. In addition to the readily identified pharmaceuticals, two pharmaceuticals—the anticonvulsant drugs primidone and phenobarbitol—were tentatively identified in three groundwater samples from one nest of wells at another transect. Tentative identification of primidone and phenobarbitol occurred during analysis of groundwater samples for organic wastewater compounds; chromatogram peaks not associated with the target organic wastewater compounds were observed and the mass spectra of the unidentified compounds were matched to known mass spectra in a mass spectral reference library. Estimated concentrations reached as high as 12 µg/L (primidone). As was the case with organic wastewater compounds, the pharmaceutical occurrence data indicate that some pharmaceuticals may be useful indicators of the presence of human waste in the environment, and a subset of pharmaceuticals is transported to groundwater from onsite wastewater treatment systems.

Printed on recycled paper in the United States of America.

WU-HT-03-05

NDWRCDP
Washington University, Campus Box 1150, One Brookings Drive, Cupples 2, Rm. 11, St. Louis, Missouri 63130-4899 • USA

This report is available online at www.ndwrcdp.org.This report is also available through the National Small Flows Clearinghouse • West Virginia University/NRCCE, P.O. Box 6064, Morgantown,WV 26506-6064 • USA Tel: (800) 624-8301 • WWCDMG47