

Pharmaceuticals and other contaminants in Groundwater and Surface Water

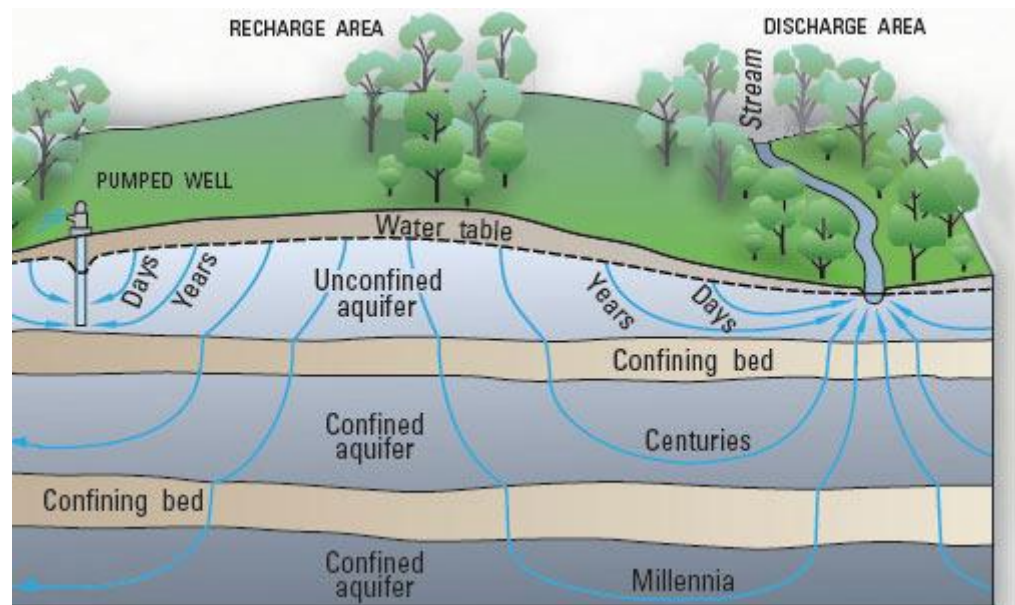
November 5, 2019 Barrington Area Council of Governments Prescription Drug
Take-back Event at The Garlands of Barrington

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Barrington Area Council of Governments
Prescription Drug Take-Back Event
November 5, 2015
The Garlands of Barrington

OVERVIEW

- How pharmaceuticals get into the groundwater, surface water, and potentially drinking water
- Microplastics - an emerging water contaminant
- Perfluoroalkanes



https://www.usgs.gov/special-topic/water-science-school/science/groundwater-flow-and-water-cycle?qt-science_center_objects=0#qt-science_center_objects

The Hydrologic Cycle and Groundwater Vulnerability

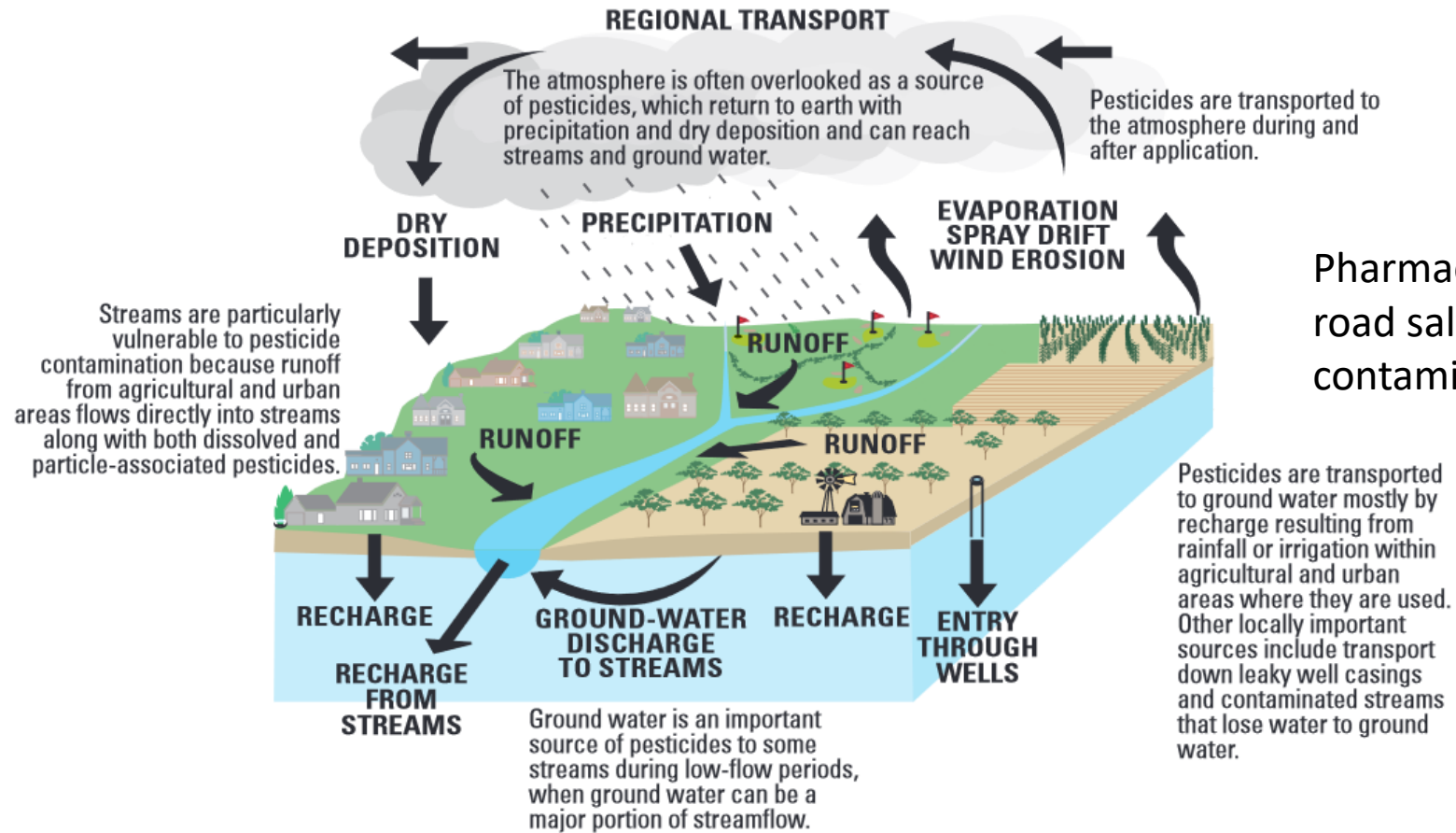
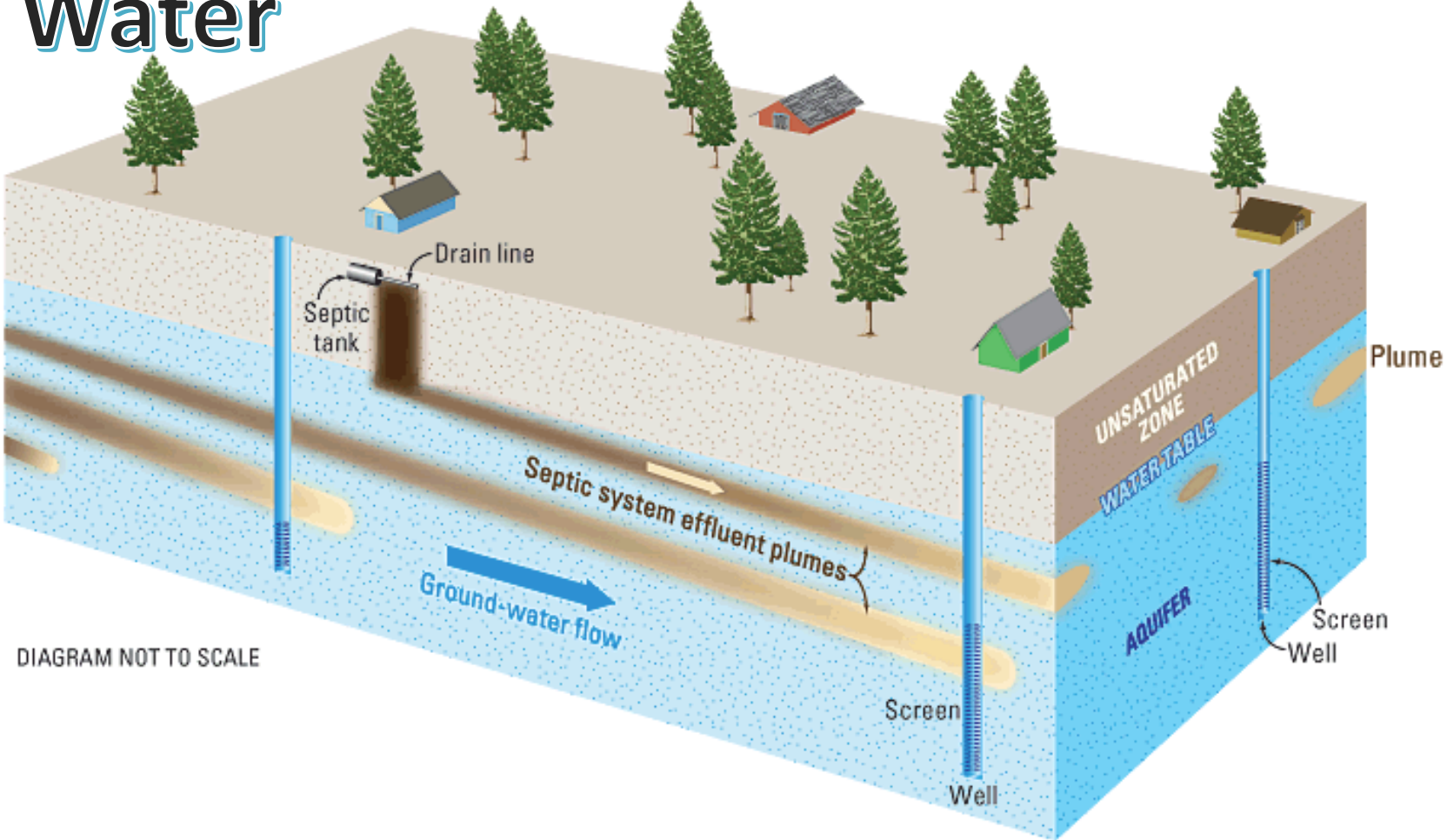


Figure 2-4. Pesticides are transported to streams and ground water primarily by runoff and recharge. Nonpoint sources of pesticides originating from areas where they were applied—rather than point sources such as wastewater discharges—are the most widespread causes of pesticide occurrence in streams and ground water. (Modified from Majewski and Capel, 1995.)

Source: Water Science School, Pesticides in Groundwater, https://www.usgs.gov/special-topic/water-science-school/science/pesticides-groundwater?qt-science_center_objects=0#qt-science_center_objects

Septic Systems as Sources of Contaminants to Drinking Water



Source: Williams and others, 2007 <https://pubs.usgs.gov/fs/2007/3103/>

What Utility Infrastructure does Barrington Area Council of Governments (BACOG) Area have?

- 7,840 drinking water wells, mostly private
- Nearly all in the shallow sand and gravel aquifer (<300 feet)
- Many areas have septic systems
- More populated communities have sewers
- 2 wastewater treatment plants

Pharmaceuticals



News Network

For Journalists

Mayo Clinic Radio

By mayonewsreleases

Nearly 7 in 10 Americans Take Prescription Drugs, Mayo Clinic, Olmsted Medical Center Find

June 19, 2013

CORRECTION: Corrects fourth most commonly prescribed drugs to drugs used to lower lipids rather than drugs to control blood pressure, and adds Olmsted Medical Center as study co-author.

ROCHESTER, Minn. — Nearly 70 percent of Americans are on at least one prescription drug, and more than half take two, Mayo Clinic and Olmsted Medical Center researchers say. [Antibiotics](#), [antidepressants](#) and [painkilling opioids](#) are most commonly prescribed, their study found. Twenty percent of patients are on five or more prescription medications, according to the findings, published online in the journal [Mayo Clinic Proceedings](#).

MULTIMEDIA ALERT: For audio and video of Dr. Jennifer St. Sauver talking about the study, visit the [Mayo Clinic News Network](#).

The findings offer insight into prescribing practices. The statistics from the [Rochester Epidemiology Project](#) in Olmsted County, Minn. are comparable to those elsewhere in the United States, says study author Jennifer St. Sauver, Ph.D., a member of the Mayo Clinic Population Health Program in the Mayo Clinic Center for the Science of Health Care Delivery.

"Often when people talk about health conditions they're talking about chronic conditions such as [heart disease](#) or [diabetes](#)," Dr. St. Sauver says. "However, the second most common prescription was for [antidepressants](#) — that suggests mental

WebMD

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Americans Taking More Prescription Drugs Than Ever

Consumer Reports says many may be doing more harm than good



FROM THE WEBMD ARCHIVES

By Robert Preidt

HealthDay Reporter

THURSDAY, Aug. 3, 2017 (HealthDay News) -- A new survey finds 55 percent of Americans regularly take a prescription medicine -- and they're taking more than ever.

Those who use a prescription drug take four, on average, and many also take over-the-counter [drugs](#), [vitamins](#) and other [dietary supplements](#), the survey done by Consumer Reports shows.

But many of those pills may be unnecessary and might do more harm than good, according to a special report in the September issue of *Consumer Reports* magazine.

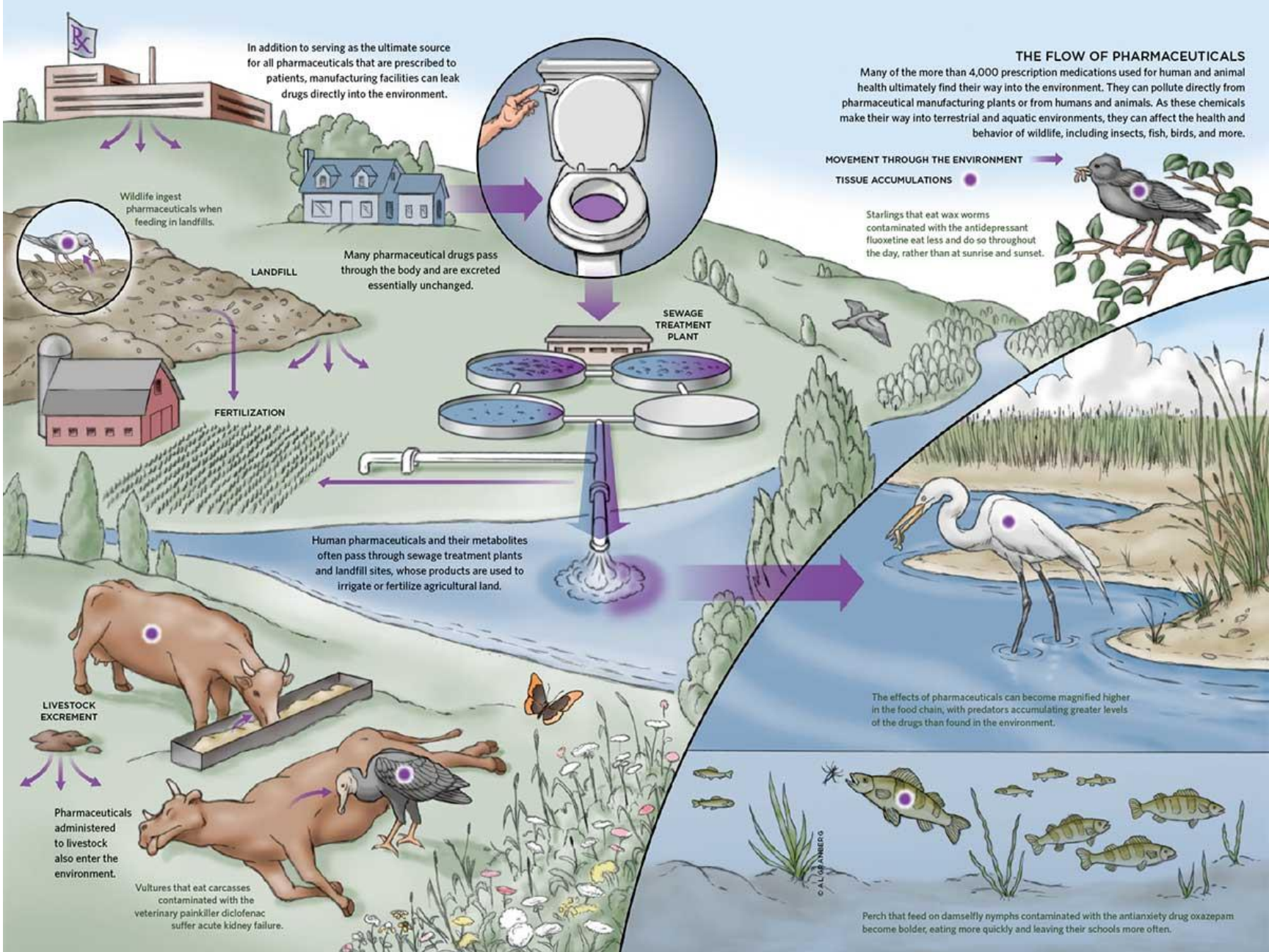
Among those who take prescription drugs, 53 percent get them from more than one health care provider, which increases the risk of adverse drug effects. More than a third say no provider has reviewed their medicines to see if all are necessary.

1. Vicodin
2. Simvastatin
3. Lisinopril
4. Levothyroxine
5. Azithromycin
6. Metformin
7. Lipitor
8. Amlodipine
9. Amoxicillin
10. Hydrochlorothiazide

https://www.medicinenet.com/top_drugs_prescribed_in_the_us/views.htm



Cycling of Pharmaceuticals in the Environment

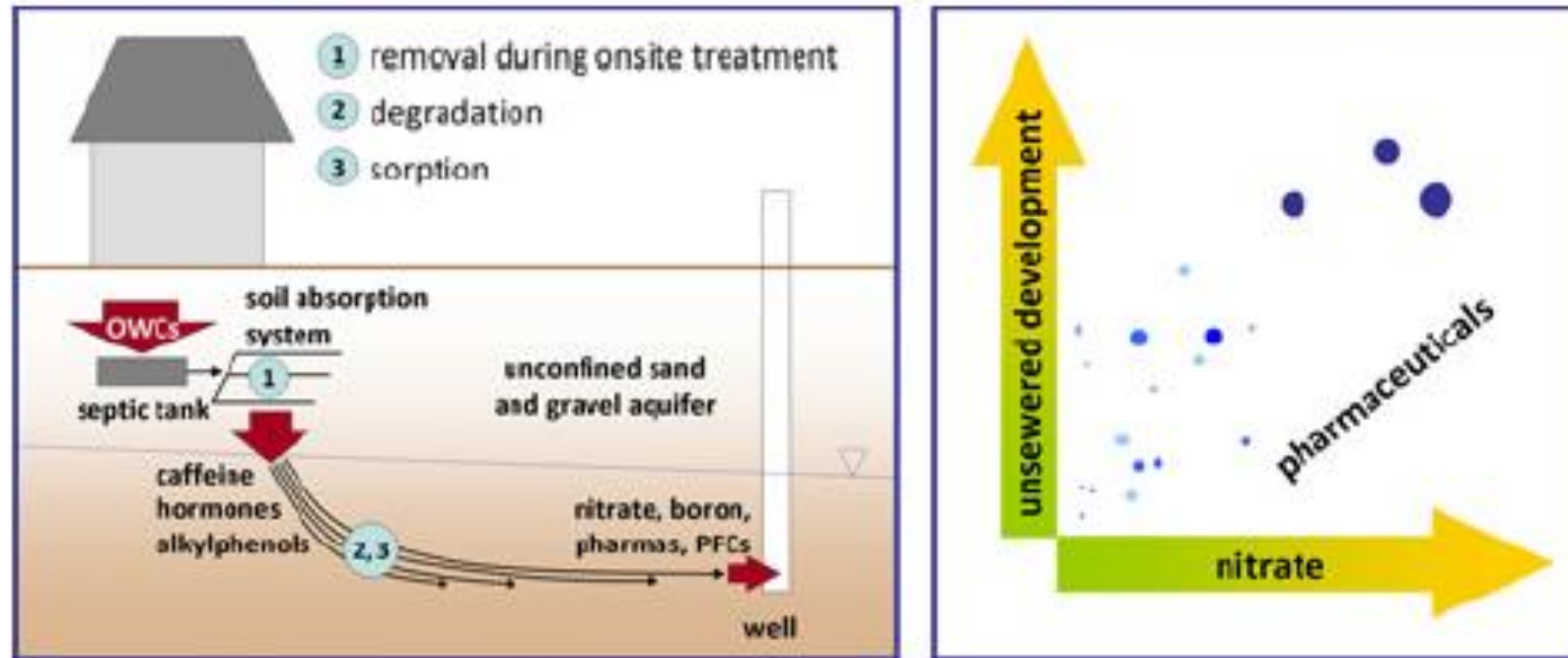


Source: Granberg,
<https://www.usgs.gov/media/images/pharmaceuticals-move-throughout-aquatic-environment>



Pharmaceuticals Detected in Public and Private Drinking Water Supplies in Shallow Aquifers

- Septic systems primary sources of pharmaceuticals in aquifer



SOURCE: Laurel A. Schaider, Janet M. Ackerman, Ruthann A. Rudel

Septic systems as sources of organic wastewater compounds in domestic drinking water wells in a shallow sand and gravel aquifer

Science of The Total Environment, Volume 547, 2016, pp. 470-481

Source: Laurel A. Schaider, Ruthann A. Rudel, Janet M. Ackerman, Sarah C. Dunagan, Julia Green Brody

Pharmaceuticals, perfluorosurfactants, and other organic wastewater compounds in public drinking water wells in a shallow sand and gravel aquifer

Science of The Total Environment, Volumes 468–469, 2014, pp. 384-393

Pharmaceuticals and Other Chemicals in Landfill Waste

Max Concentration	Percent Frequency of Detection	Chemical
7,020,000 ppt	55	para-cresol (plasticizer and flame-retardant, antioxidant in oils, rubber, polymers, and wood preservative)
4,080,000 ppt	95	bisphenol A (used in plastics, thermal paper, and epoxy resins)
705,000 ppt	65	ibuprofen (analgesic, antipyretic)
254,000 ppt	95	DEET (insect repellent)
147,000 ppt	90	lidocaine (local anesthetic, topical anti-itch treatment)
97,200 ppt	84	camphor (natural compound with medicinal uses and embalming)
51,200 ppt	95	cotinine (transformation product of nicotine)
2,590 ppt	75	carbamazepine (anticonvulsant and mood stabilizer)
168 ppt	55	estrone (natural estrogenic hormone)

SOURCE: [Contaminants of emerging concern in fresh leachate from landfills in the conterminous United States](#): Environmental Science--Processes and Impacts, 2014, v. 16, no. 10, p. 2335-2354, doi:10.1039/C4EM00124A. https://toxics.usgs.gov/highlights/2014-08-12-leachate_pharm.html

Pharmaceuticals in Landfill Leachate and Wastewater Treatment Plants

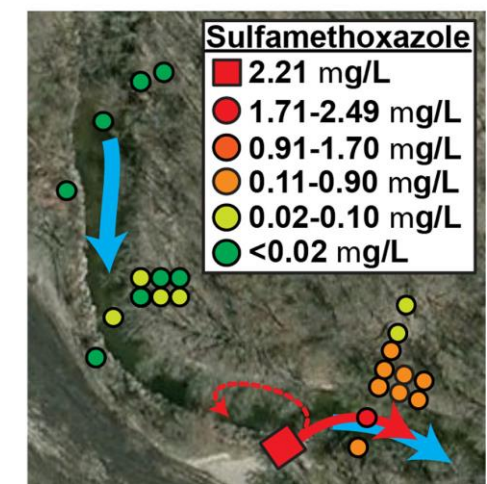
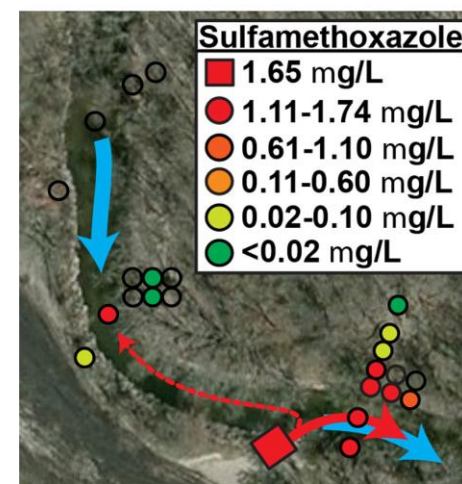
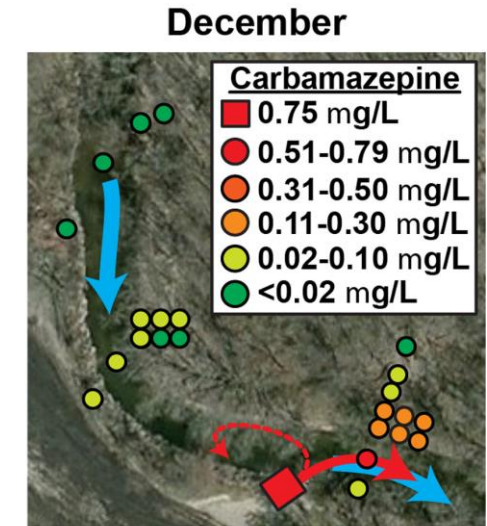
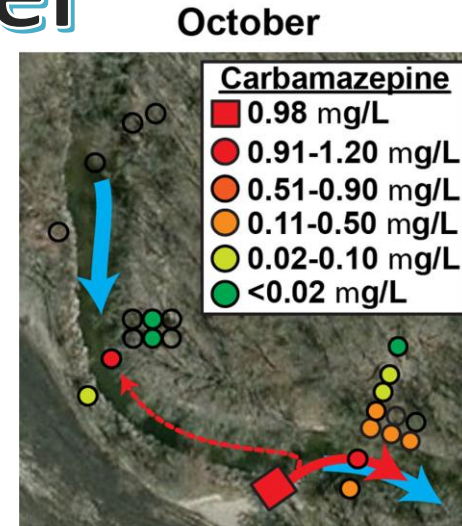
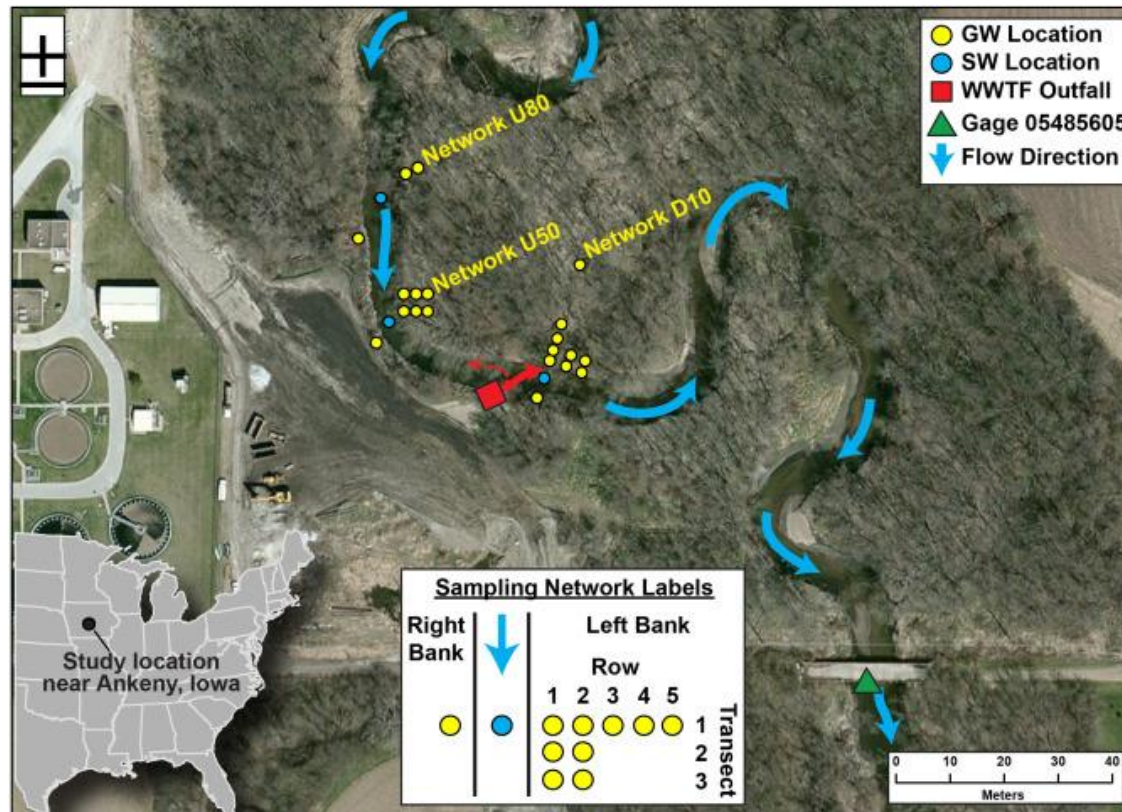
Most Frequent Detections:	
Lidocaine	Local anesthetic
Cotinine	Nicotine breakdown products
Carisoprodol	Muscle relaxant
Bisphenol A	Plastics component
carbamazepine	Anticonvulsant
DEET	Insect repellent

SOURCE: https://toxics.usgs.gov/highlights/2015-11-13-leachate_pathways.html

SOURCE: Masoner, J.R., Kolpin, D.W., Furlong, E.T., Cozzarelli, I.M., and Gray, J.L., 2015, [Landfill leachate as a mirror of today's disposable society--Pharmaceuticals and other contaminants of emerging concern in final leachate from landfills in the conterminous United States](#): Environmental Toxicology and Chemistry, doi:10.1002/etc.3219 (Advanced Web release).

Masoner, J.R., Kolpin, D.W., Furlong, E.T., Cozzarelli, I.M., Gray, J.L., and Schwab, E.A., 2014, [Contaminants of emerging concern in fresh leachate from landfills in the conterminous United States](#): Environmental Science--Processes and Impacts, v. 16, no. 10, p. 2335-2354, doi:10.1039/C4EM00124A.

Pharmaceuticals Found in Treated Wastewater can be Transported from Surface Water to Groundwater



USGS study: [Riverbank filtration potential of pharmaceuticals in a wastewater-impacted stream](#): Environmental Pollution, 2014, v. 193, p. 173-180, doi:10.1016/j.envpol.2014.06.028.



Microplastics are Everywhere!

- Plastic does not biodegrade or breakdown into simple, digestible components.
- Plastic simply breaks down into smaller and smaller plastic pieces, creating microplastics.
- Samples collected from the St. Croix and Mississippi Rivers from water, sediment, fish, and mussels ALL contained microplastics.
- Fibers were most abundant, 86 to 93 percent in the samples.

Microplastic Types and Sources

Microbeads

Soaps, scrubs, toothpastes, deodorants, sunscreen, lipstick, eye shadow, shaving cream, medical uses (drug delivery)

Pellets

Pre-production pellets and powders, bead blasting (boat hulls and engine parts)

Fibers/Lines

Synthetic clothing and textiles, cigarette butts, nets

Fragments

Degraded pieces of plastic litter such as bottles, manufacturing waste material (shavings), tire particles

Films

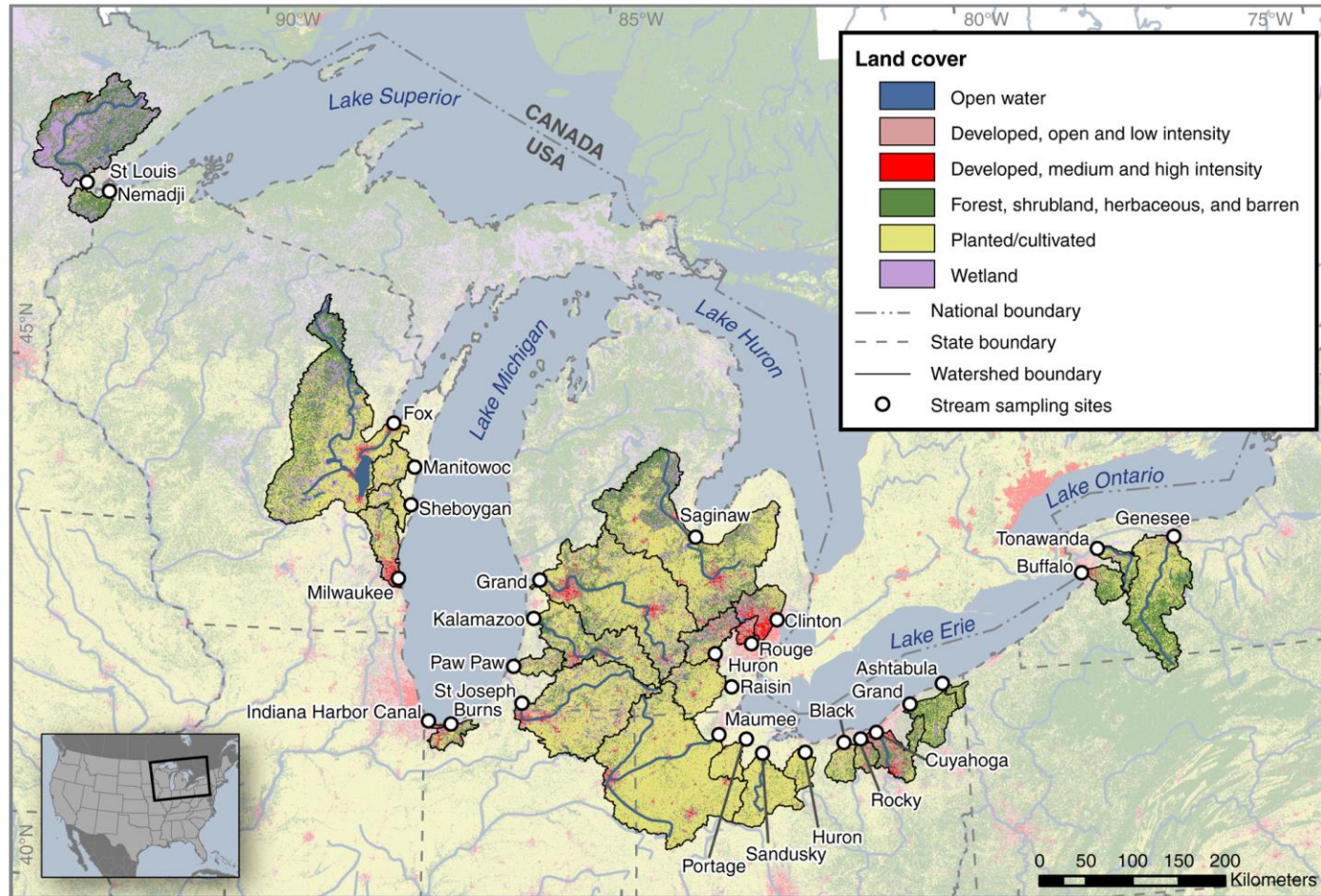
Bags and wrappers

Foams

Styrofoam™, rubber

<https://irma.nps.gov/DataStore/DownloadFile/577360>
<https://www.sciencebase.gov/catalog/item/58e7d00ae4b09da6799c0f8a>

Plastic Debris in 29 Tributaries to the Great Lakes



Sampling locations, watershed boundaries, and watershed land uses.



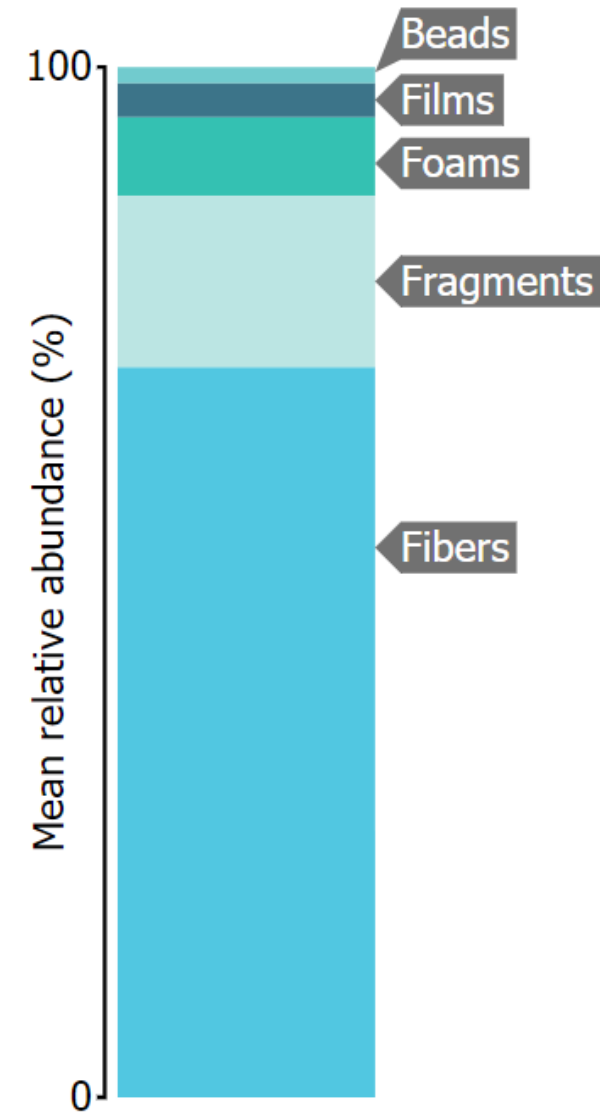
Published in: Austin K. Baldwin; Steven R. Corsi; Sherri A. Mason; *Environ. Sci. Technol.* **2016**, 50, 10377-10385.

DOI: 10.1021/acs.est.6b02917

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Microplastics in our Nation's Surface Water

- 12% of freshwater fish have ingested plastic particles
- 50 – 90 particles per serving of oysters and mussels
- Hazards are physical, carcinogenic, and endocrine disruption



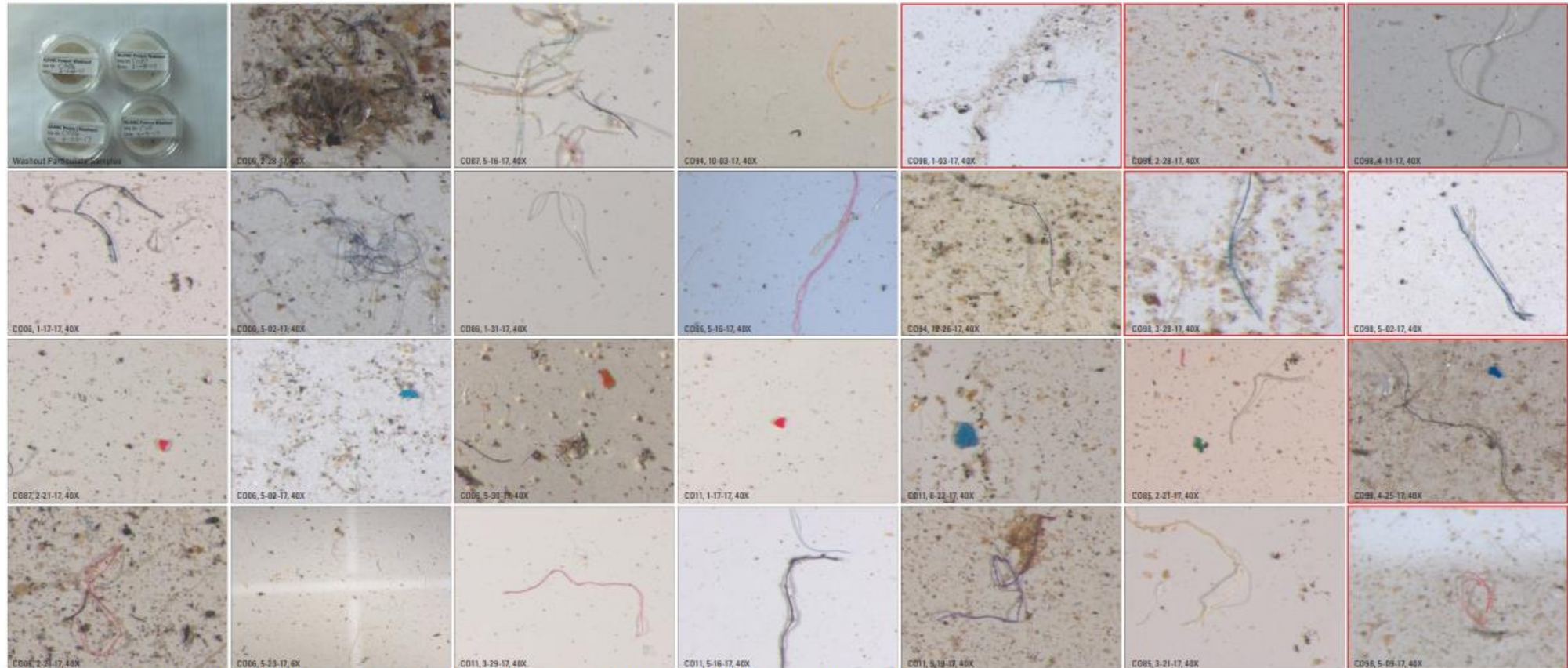
Source:

<https://owi.usgs.gov/vizlab/microplastics/>

Microplastics in the Rain

- Colorado Front Range peppered with microfibers and microparticles in >90 percent of samples

Photomicrographs of plastics collected at the NUANC NTN subnetwork, Sugarloaf, and Loch Vale sites in Colorado

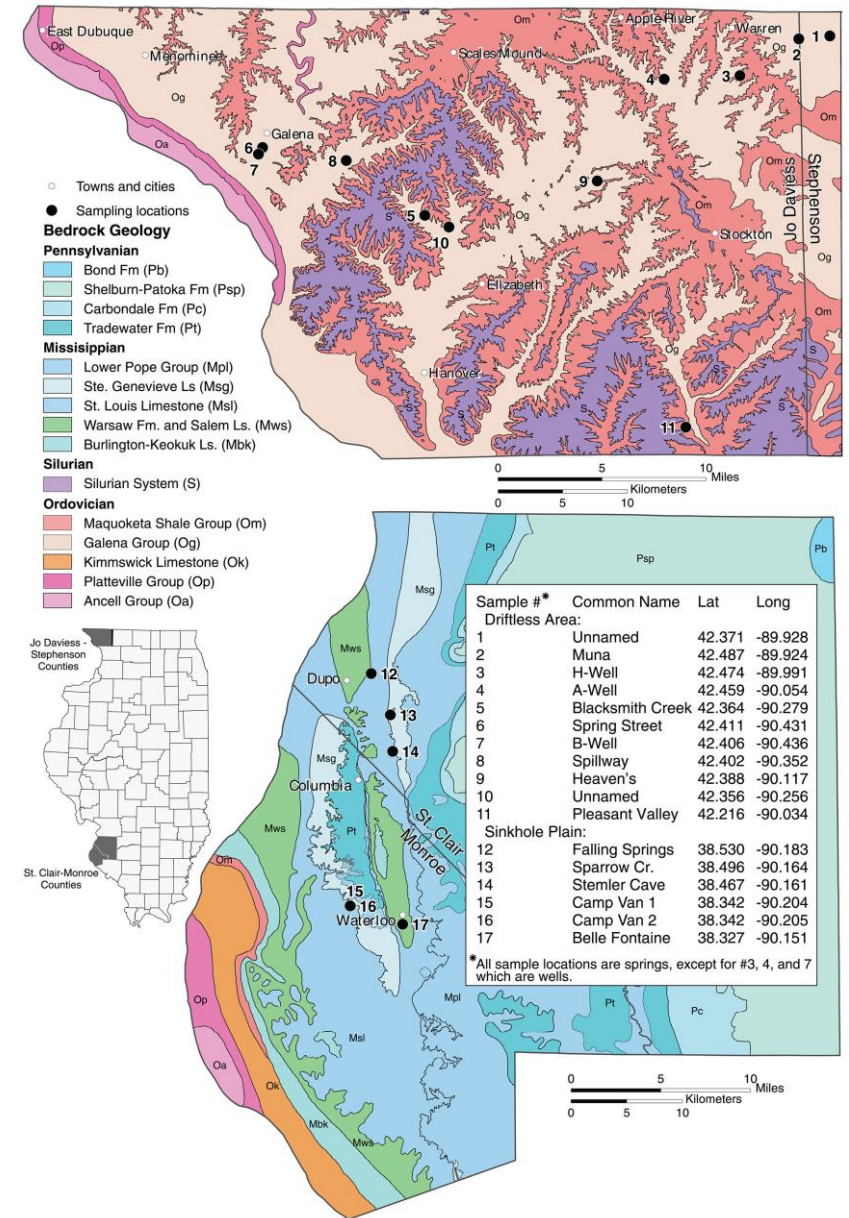


(Explanation of labels: CO06, site identification; 2-28-17, month-day-year; 40X, magnification; Red outline indicates Loch Vale samples.)

<https://pubs.usgs.gov/of/2019/1048/ofr20191048.pdf>

Microplastic in Groundwater

- Primarily in karst aquifers which have large voids
- Scientists have only just begun to explore microplastics in groundwater systems



Source: Samuel V. Panno, Walton R. Kelly, John Scott, Wei Zheng, Rachael E. McNeish, Nancy Holm, Timothy J. Hoellein, Elizabeth L. Baranski. **Microplastic Contamination in Karst Groundwater Systems.** *Groundwater*, 2019; DOI: [10.1111/gwat.12862](https://doi.org/10.1111/gwat.12862)

PerfluoroWhat?

- PFAS is a broad name for man-made industrial chemicals
 - Nonstick cookware, firefighting foams, food wrappers, stain and water resistant fabrics, household cleaners
- These chemicals are
 - Oil and water repellent
 - Extremely persistent
 - Bioaccumulate



Photo sources:

<https://www.rnz.co.nz/news/environment/397591/banned-firefighting-foam-found-at-port-taranaki-dunedin-airport>

<https://chemicalwatch.com/76146/precise-genx-mechanism-of-toxicity-eludes-epa-scientists>

Potential Health Effects

- Studies associate PFOS and PFOA in exposure with high cholesterol, thyroid disorders, preeclampsia, and testicular and kidney cancer, reproductive and developmental effects.
- Confirmed animal carcinogen at parts per trillion level
 - That is equivalent to 1 ounce in 7.5 billion gallons of water
- In blood of general human and wildlife population

USEPA Fact Sheet: https://www.epa.gov/sites/production/files/2017-12/documents/ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf

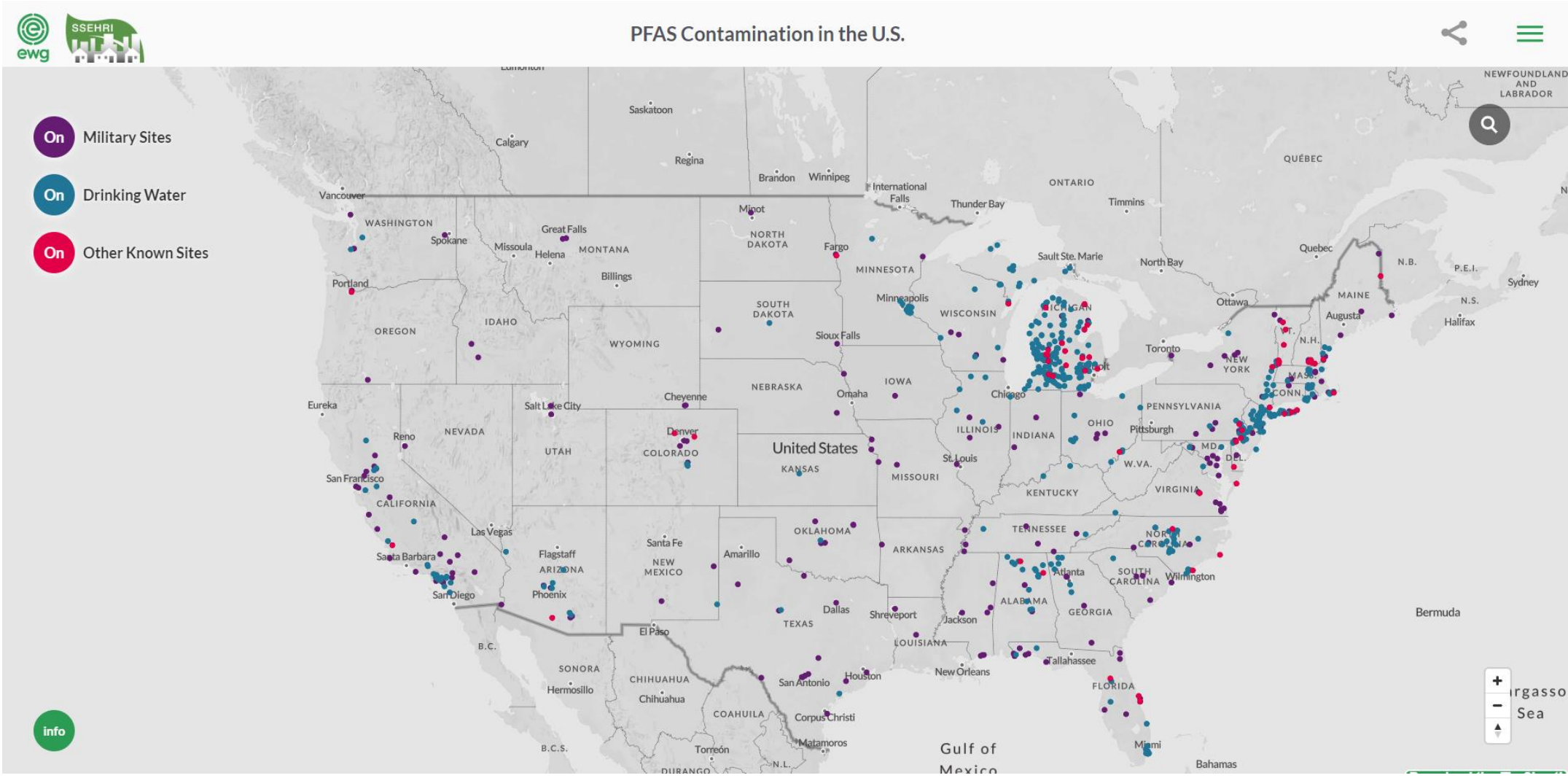
Are PFOS and PFOAs regulated?

Federally NOT regulated:
NO Maximum Contaminant
Level (MCL) established by
USEPA

Some States have
established drinking water
standards

State	Guideline (µg/L)		Source
	PFOA	PFOS	
Delaware	0.4	0.2	DNREC 2016
Maine	0.13	0.56	MDEP 2016
Michigan	0.42	0.011	MDEQ 2015
Minnesota	0.035	0.027	MDH 2017b
New Jersey	0.04	NA	NJDEP 2016
North Carolina	2	NA	NCDEQ 2013
Texas	0.3	0.6	TCEQ 2016
Vermont	0.02	NA	VTDEC 2016

PFAS Detected in Drinking Water and Groundwater



Source: https://www.ewg.org/interactive-maps/2019_pfas_contamination/map/

Illinois PFAS Study

- Illinois Environmental Protection Agency is testing municipal water supplies for PFAS compounds throughout the State (2019-2020).
- Illinois has not established a standard.
- Defer to USEPA Lifetime Health Advisory of 70 nanograms per liter (ng/L) or parts per trillion (ppt).

Source: https://pfas-1.itrcweb.org/wp-content/uploads/2018/01/pfas_fact_sheet_regulations_1_4_18.pdf

Groundwater and Surface Waters are Vulnerable

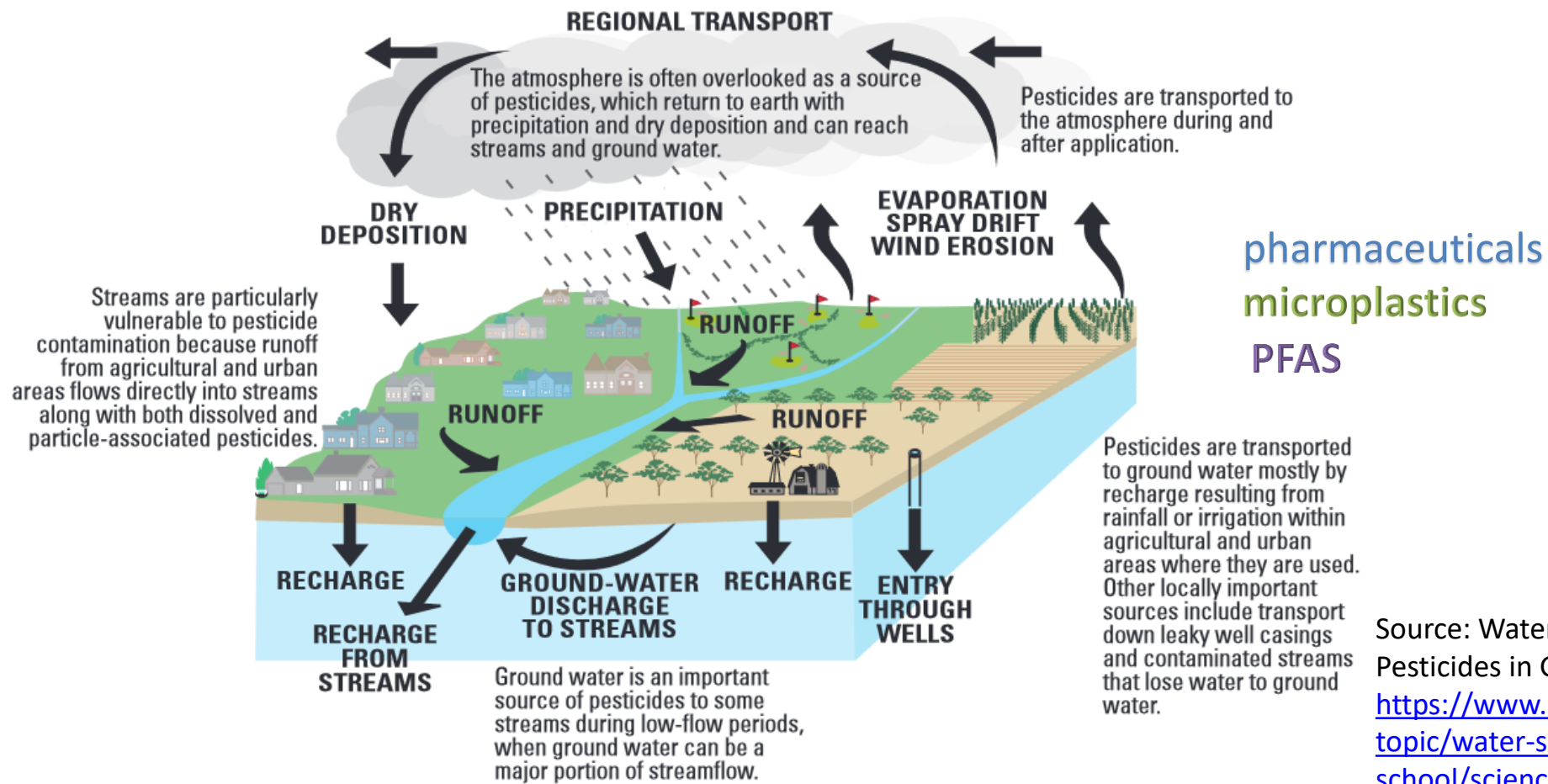


Figure 2-4. Pesticides are transported to streams and ground water primarily by runoff and recharge. Nonpoint sources of pesticides originating from areas where they were applied—rather than point sources such as wastewater discharges—are the most widespread causes of pesticide occurrence in streams and ground water. (Modified from Majewski and Capel, 1995.)

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USGS References

https://toxics.usgs.gov/investigations/cec/wastewater_treatment.html

<https://toxics.usgs.gov/highlights/2014-09-22-pharms2gw.html>

https://toxics.usgs.gov/highlights/2014-08-12-leachate_pharm.html

<https://pubs.usgs.gov/fs/2007/3103/>

<https://pubs.er.usgs.gov/publication/70142252>