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Breeding Trouble: West Nile on the Willamette?

by Merilee Karr

A potential brew of stormwater, its uneven management, and mosquitoes could be a headache (or worse) for the Metroscape

From the Roman aqueducts to Bonneville Dam, humans have built structures to moderate the extremes of natural water flow. Some of these structures, from Roman cisterns to the catch basins under modern city streets, have inadvertently supplied mosquitoes with the standing water in which they thrive and multiply. Even more mosquito habitat may have been created in the last decade by a change in the Clean Water Act.

The original drive behind the Act, in 1972, was the elimination of point-source pollution: sewage and industrial discharge into waterways. In the 1990s new regulations aimed to prevent non-point-source pollution, due to urban stormwater runoff. There are two basic methods of cleaning stormwater: filtering, through earth, vegetation or manufactured filters; and settling, retaining the water behind a barrier to let particulates sink to the bottom. New studies show that water retention methods, such as the familiar catch basin, may breed mosquitoes. Even if retention structures are designed to minimize mosquito habitat by draining quickly, they may clog and accumulate standing water without regular maintenance.

West Nile virus has given mosquitoes a new importance, beyond imperiling picnics. Not since the 1930s, when Portland had regular malaria outbreaks, has a mosquito-borne disease threatened this area. West Nile virus is native to Africa, but turned up in sick people and birds in New York City in 1999. Each summer since then infections came to a few more contiguous states, marching toward the West Coast. The virus picked up speed in the summer of 2002, achieving unprecedented infection counts in the Midwest and reaching California. California counted in 2004 710 cases and 20 deaths, mostly in southern California. Oregon experienced its first few infections, of birds, horses, and humans, in the summer of 2004, in eastern and southern parts of the state. Increased numbers of infections are expected in Oregon and northern California this summer.

The Virus Surprises

This virus came to North America with a mild reputation, based on its behavior in its native Africa. Eighty percent of people with the infection do not notice they have it. Less than one percent have serious, life-threatening neurological consequences such as meningitis, encephalitis, and a polio-like paralysis. The remaining nineteen percent have been told to expect a mild flu, called “West Nile fever,” lasting about a week. “The reputation was of a mild illness, lasting three to six days,” said John
Watson, medical director of outbreak investigations at the Chicago Department of Public Health. It bothered Watson that there were never any references cited for this traditional account.

Then the Chicago outbreak of 2002, with 884 known cases and 66 deaths, sent an unexpectedly large number of unexpectedly sick people to the hospital. Watson and his colleagues interviewed one hundred of them, ranging in age from under 25 to over 65. These were West Nile fever patients, sick enough to notice but not sick enough for meningitis. More than a third still had muscle weakness and fatigue when they were interviewed three to six months after their initial diagnosis. A third had been hospitalized. Two-thirds had missed work or school, for a median of ten days. While the older patients were more likely to need hospitalization, prolonged weakness and fatigue were just as likely at any age. “It was a surprise,” Watson said. “It had been portrayed as more benign.” Other researchers have pointed to genetic differences among people as a factor.

“With West Nile, the big lesson is don’t make any assumptions,” said David Turner, field supervisor of Multnomah County Vector and Nuisance Control. The intimate ecological connection between urban mosquitoes and stormwater, obvious in retrospect, was brought to light in 2002 in the journal Stormwater by a group of scientists associated with the California Department of Health Services. They surveyed public works agencies nationwide on their experience with mosquitoes. Fully 86 per cent of the reporting agencies had seen mosquito production in stormwater structures.

A follow-up study showed mosquitoes’ preference for certain styles of stormwater management architecture. Those that maintained standing water in ponds or sumps (the retention space below a flow outlet) for more than a few days supported mosquito hatcheries. Those that drained rapidly, such as vegetated swales and other filtration devices, rarely harbored mosquitoes as long as their drains were kept open. (Mosquito eggs take about seven days to hatch and molt into flying adults.)

Mosquitoes grow in stormwater structures in the Portland area, too. Chris Wirth, supervisor of Multnomah County Vector and Nuisance Control, and David Turner, field supervisor in the same department, reported on their study in 2003 in Stormwater Treatment Northwest. Of over ten thousand sedimentation manholes (vertical cylinders with porous walls, common in the sandy soils of east Multnomah County), 99 per cent harbored mosquito larvae. Of almost two thousand catch basins, 75 per cent supported mosquito larvae. After treatment with microbial larvicide, all structures remained free of larvae for up to four weeks.

Safer, Cleaner Stormwater

The water manager’s traditional objective for stormwater is to keep it from turning into floodwater. This was easier in the times when most of a city’s acreage was water-absorbing earth, open to the sky. Soil is an effective flow moderator, a sponge that absorbs water and releases it slowly. After a storm, a city of dirt streets would be muddy, but probably not flooded.

In modern times, urban development has covered the land area of a city with an impermeable crust of asphalt and concrete. Stormwater landing on this hardscape turns into potentially enormous amounts of runoff, with flood potential if not controlled. The engineering approach to urban stormwater runoff is twofold. First, shunt it through the built environment to the nearest waterway as fast as possible. This can backfire, though, by flooding the waterway under a high stormwater load. Hence the first approach is balanced by the second: retain some of the water for later, slower flow into the waterway.

Structures such as the classic catch basin, a settling basin (or “sump”) that overflows into a pipe, perform both of these water management objectives. There are two side effects of the catch basin, however—one good, one bad. It retains silt and pollutants in the settling basin, keeping this material out of the waterway. The retained water also, unfortunately, provides mosquitoes with excellent breeding habitat.

Stormwater management in most of human history has aimed at quantity management, the moderation of extreme water flows. The 1990s broadening of the Clean Water Act took on quality management as well. The body of regulation implementing this goal is the National Pollutant Discharge Elimination System (NPDES). These federal rules are administered in Oregon by the Department of Environmental Quality. The first phase of the NPDES regulations, issued in 1990, required large cities to clean up their stormwater before discharging it into a waterway. Oregon’s largest municipalities received Phase I permits for stormwater discharge in 1995. Phase II federal regulations, for smaller municipalities, were issued in 1999. Their application to smaller cities in Oregon is still under discussion.
Mosquito surveillance and control are performed by Multnomah County Vector and Nuisance Control, part of the Environmental Health division of the Health Department. Since the 1930s, when Portland faced regular outbreaks of malaria, this department or its predecessors has quietly worked to prevent diseases carried by mosquitoes (or by other vectors, such as rats). Multnomah County’s may be one of the oldest continuously active mosquito control programs in the western United States.

Multnomah County catch basins and manholes were monitored in 2002 for mosquito larvae. Chris Wirth, entomologist and Supervisor of Multnomah County Vector and Nuisance Control, and David Turner, Supervisor of Field Operations in the same department, reported on that study in Stormwater Treatment Northwest. Of over ten thousand sedimentation manholes (vertical cylinders with porous walls, a common stormwater structure in the sandy soils of east Multnomah County), 99 per cent harbored mosquito larvae. Of almost two thousand catch basins, 75 per cent supported mosquito larvae. After treatment with microbial larvicide, all structures remained free of larvae for up to four weeks.

Stormwater facilities monitored by Clean Water Services in unincorporated Washington County, Tigard, and other municipalities.

Both stormwater facilities and known mosquito breeding sites are mapped on Multnomah County GIS systems. No other unit in the six-county metropolitan area has a comparable database facility to use for deploying scarce environmental health resources. The lack of such information in the Chicago area, where over a thousand catch basins that had been lost to history were rediscovered producing mosquitoes, may have contributed to that epidemic.

Complete as this database is, it only includes mosquito habitat on public land. Water structures on private property are only monitored if they have elicited a complaint about mosquito production. This is the limitation of most vector control databases. “Every 7-11 parking lot might have one catch basin,” said Wirth. “Every Fred Meyer parking lot might have a half dozen. I like Fred Meyer, but they’re open both dawn and dusk (the prime mosquito biting times).” None of the sources for this article would even guess how many more catch basins and ponds there are in the ground, beyond those listed in department databases. Twice as many? Half as many? Ten times as many? No one knows. And the mosquitoes don’t care.

“They’re making catch basins, but they’re not thinking of mosquito habitat,” said Wirth. “The planning isn’t there.” He estimates that it costs $12 to monitor and treat one manhole or catch basin for a year. “Multnomah County is absorbing all that work.”

The City of Portland Bureau of Environmental Services maintains the largest collection of sumped stormwater structures in the world, 45,794 catchbasins and 14,848 manholes, according to Linda Dartsch, Collection System manager. In contrast to Chicago, this system is unusually well mapped and inventoried, because in the 1980s, the bureau took over responsibility for the maintenance of about one hundred miles of roads in east Multnomah County. Inventory crews went out through this new territory “to find every ditch and culvert,” Dartsch said. Each of these structures needs the accumulated sediment vacuumed out periodically, or the basin fills up with silt and no longer functions as intended. Vector control programs that treat these structures with larvicide must coordinate with water managers to make sure the larvicide is not vacuumed out as well.
Maintenance

Stormwater facilities on private property present another set of problems, according to a recent study by Michael J. Pronold, City of Portland Environmental Program manager. Since the late 1990s, developers of new construction projects in Portland have been required to incorporate onsite stormwater facilities. One to two thousand such permits are issued per year, 80 per cent to residential construction. However, there is no requirement for maintenance or inspection to ensure that the facilities continue to function.

Pronold randomly selected residential, commercial and industrial sites, most less than two years old. Of 33 facilities, only 18 owners or responsible parties knew of the stormwater facility on their property, or of its function. Only six had a copy of the approved maintenance plan for their facility, and were performing that maintenance. At several sites, different stormwater structures had been built than the ones for which the permit had been issued. Since these sites were all relatively new, they were all still in good condition, undamaged by the lack of maintenance.

Pronold recommends an inspection program for stormwater facilities on private property. But with available staff and resources, he writes, "It is apparent that the majority of the residential properties will not be inspected."

Another category of stormwater facility which may experience poor maintenance is the federal mitigated wetland. Mel Franklin, manager of the Columbia Drainage Vector Control District, pointed to Dalton Lake as an example. It was built with federal highway funds as part of the highway project mitigation, but...
Washington County

Washington County does not have a vector control district. Jill Townzen, beginning her third year as the county’s entomologist, insists that the county does not have a vector control program, either. In fact, Washington County seems to be improvising a different organizational model, a cooperative relationship among municipalities, coordinated by Townzen from the county Environmental Health department. Townzen, a well-regarded entomologist with five years experience at the Multnomah County vector control program, was hired by the Washington County Environmental Health department at the beginning of the 2003 mosquito season. She works as a resource with nine municipalities, Tualatin Hills Park and Recreation, and Clean Water Services, the county water district. This level of cooperation “is not something you see in a lot of places,” said Townzen.

“Education is one of the biggest parts of my job,” she said. She trained staff to locate mosquito larvae and habitat, and has begun to map the mosquitoes. A good surveillance database of the breeding locations and mosquito species is the foundation of cost-effective, environmentally safe mosquito control.

Clean Water Services, a special service district, is responsible for water management in unincorporated Washington County. Its stormwater structures include 4500 catch basins, 400 manholes, and 400 other structures such as ponds and swales. Another 400-500 known stormwater structures of various kinds lie on private lands. As one of the largest water systems in Oregon, it holds a NPDES Phase I stormwater discharge permit.

The challenge of West Nile virus created some new interagency collaborations. “All the water quality jurisdictions came together on this issue,” said Craig Dye, a watershed manager at Clean Water Services who came here from Florida. “It was a lot more difficult in Florida to get local governments to work together.”

The potential environmental risk of mosquito control was debated early on in Washington County. Any product used for mosquito control bears a stigma to generations that grew up with the environmental damage done by DDT. But the facts of mosquito control are that there are several environmentally safe biological controls, natural enemies of the mosquito. These issues were settled long ago in the well-established mosquito control program in Multnomah County, but they were new to Washington County. Dye said, “It’s a real forward-thinking group. I’ve got to say, coming from Florida. There’s a real environmental ethic here.”

Clean Water Services chose an environmentally safe, mosquito-specific soil bacterium called Bacillus thuringiensis israelensis (Bti) that works by destroying the larval mosquito’s digestive system. Eighty percent of the district’s manholes and all of the ponds were treated with pellets of Bti, similar to the “mosquito dunks” available in hardware stores. It is safer, more effective and cheaper to eliminate larval mosquitoes—called “larviciding”—than to spray for flying adult mosquitoes—called “adulticiding.” Dye recalled, “We pretty much decided we weren’t going to adulticide, period.”

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this funding source is not followed by an operating budget, and the responsibility for maintenance is ambiguous. Dalton Lake was modified with a coffer dam about eight years ago, but local beavers have further modified it by blocking the coffer dam with their own dam. When the water level rises, the banks and shallows of the lake produce mosquitoes. If Franklin’s staff removes the beavers’ work, they restore it overnight. The man-made and beaver-made dams can hold back 100,000 gallons of water, so water release has to be done carefully.

Data Flow

The Chicago Tribune, in a literally post-mortem analysis of the 2002 West Nile epidemic there, reported that the failure to make the connection between stormwater management facilities and mosquito habitat was a major contributor to the epidemic. The south suburban mosquito control district did not begin to treat mosquito-producing catch basins with mosquito larvicide until August, when Chicagoans were already dying and streets and yards were littered with dead crows. (Crows and other corvid birds are hit hard by the virus.) By the end of that summer, Chicago had seen 884 human infections and 66 deaths. Over a thousand catch basins, excellent mosquito habitat, were also rediscovered in wet backyards, where they had been built decades before and never recorded in any database.

In the next mosquito season, 2003, Chicago catch basins were treated with larvicide early and often, and Illinois only recorded 50 infections and one death due to the virus.

Controlling mosquitoes in largely invisible stormwater structures, pinning disease outbreaks to nearby structures, and deploying environmental health resources call for a systematic approach. Maps and databases can be difficult to compile since these facilities have been built in various historical eras, often without adequate records. The stormwater system of Worcester, Massachusetts, goes back to the Civil War era. Some municipalities do have good databases for stormwater equipment within their borders, but no communication with adjacent communities about nearby mosquito-breeding catch basins. The mosquitoes themselves have no such civic limitations.

Both stormwater structures and known mosquito breeding sites are mapped on Multnomah County GIS systems. No other unit in the six-county Portland metropolitan area has a comparable database facility to use for efficiently applying scarce environmental health resources.

“That’s probably the most antiquated technology we have,” said Louis A. Dooley, administrator of the Southwest Washington Mosquito Control District. His district has new equipment for maintaining catch basins, but the mapping of mosquito and stormwater sites is manual. Field staff has hand-held GPS units for locating sites, but they do not link to a map.

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A few weeks (not days) of misery. Some in public health they have it. Most of the rest will recover completely after which is. Eighty percent of those infected won’t even know fatal as influenza, which is not mosquito-borne, or malaria, is for most a tolerable disease. West Nile virus is not as to the relatively few humans who have serious infections, West Nile virus, though fatal or permanently disabling mosquito protection, are all inherently dramatic. The sweep of the virus across the increasing pace of emerging diseases, as it is to North America immune systems. The headlines accorded newly diagnosed American immune systems. The arrival in North America of West Nile virus and its opportunistic sweep across the continent is part of a worldwide resurgence and redistribution of infectious diseases since the 1970s. Some scientists, notably Paul Epstein of Harvard’s Center for Health and the Global Environment, think this pattern may be related to global climate change. If so, West Nile won’t be the last new disease to come this way. The virus is as novel to public awareness, jittery over the increasing pace of emerging diseases, as it is to North American immune systems. The sweep of the virus across the country, the headlines accorded newly diagnosed neighbors, horses, and birds, and the pervasive advice on mosquito protection, are all inherently dramatic.

West Nile virus, though fatal or permanently disabling to the relatively few humans who have serious infections, is for most a tolerable disease. West Nile virus is not as fatal as influenza, which is not mosquito-borne, or malaria, which is. Eighty percent of those infected won’t even know they have it. Most of the rest will recover completely after a few weeks (not days) of misery. Some in public health

**Conclusion: Reality Bites**

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**WEST NILE CASES IN OREGON**

2004

Source: Multnomah County Vector and Nuisance Control.

Metroscape
The Southwest Washington Mosquito Control District includes all of Clark County and all its municipalities. When new construction plans include stormwater facilities, the district is notified. Many Oregon vector control managers wish they had this kind of communication. “We have a good working relationship with Planning and Public Works,” said Louis A. Dooley, the district’s administrator. The land use section of the county health department also keeps vector control in the loop. “Anything requiring a Health Department permit, we hear about it.” He has talked to developers about planned construction, but has never suggested modifications.

Clark County has a Phase I stormwater discharge permit under the NPDES. New equipment has enabled the district to test and treat 13,000 catch basins in 2004, up from 300 to 400 in previous years. However, information technology is limited. “That’s probably the most antiquated technology we have,” Dooley said. District mapping is manual, on paper, not GIS. Field techs have hand-held GPS units for locating stormwater and mosquito habitat sites, but the GPS units do not link to a map. Data bases of dead bird pick-up calls are on Excel spreadsheets, not a map.

The county includes several wildlife refuges under the U.S. Department of Fish and Wildlife, at Ridgefield, Camas, Washougal, and Franz Lake. “We get raked over the coals every year on mosquito issues,” said Joe Engler, wildlife biologist at the Ridgefield National Wildlife Refuge. “We don’t want a lot of treatment.” Engler does not feel that the untreated wildlife refuges could become regional reservoirs of the disease. He rationalizes the threat of West Nile virus to the birds in his refuge, and the large die-offs of birds elsewhere in the country, by citing several other bird diseases that have passed through this sanctuary.

Engler also feels that mosquito larvae are a significant part of the aquatic food chain and should not be removed, though he cannot cite any data or scientific papers supporting this view.

“There’s a distinct lack of cooperation,” said Dooley of the Mosquito Control District. “And this is a bird disease. We’ve never been able to find any source of data for their claims.”

West Nile virus has given a new visibility to largely underground stormwater structures. New designs will be modified to prevent mosquito production. In the meantime, much can be done with what is already in the ground. Studies demonstrate that mosquito production is likely in catch basins and manholes, with which most cities and towns are well supplied. These studies do not prove that all catch basins and manholes are hatching out mosquitoes, or that even if they are, that the mosquitoes carry disease. Municipalities should look at their stormwater systems with new concern, but they must still do mosquito surveillance to focus their resources efficiently. That said, the discovery of mosquitoes in stormwater offers a larvicidal opportunity. Stormwater structures, ubiquitous as they are under urban and suburban streets, may be significant contributors to summer mosquito swarms. If so, focusing vector control resources on stormwater systems may significantly reduce mosquito populations at their source.

This opportunity could be wasted, however, if agencies cannot locate all of their stormwater. Information management did not matter as much when most sumps were built. They could be trusted to do their underground water control work without human attention—so many are unmapped because once it was thought adequate to build them and walk away. But vector control will require regular staff attention, for mosquito surveillance, larvicide application, sediment removal, and maintenance. To accomplish that efficiently, databases will need to be compiled, with information technology that is compatible with that of regional partners within a mosquito’s flight range.

Preventing both vector-borne disease and water pollution will take collaboration, both interdisciplinary and interagency, between vector control, stormwater, and public health professionals. All of these newly related fields stand to gain new skills, new tools, and new understanding from each other.

Merilee Karr is a physician, an assistant professor of family medicine at OHSU, and medical journalist living in Portland, Oregon.