WATER QUALITY EFFECTS OF WAPATO LAKE DRAINAGE IN 2008

By Bernie Bonn and Jan Miller, Clean Water Services
in consultation with Stewart Rounds, U.S. Geological Survey

The former Wapato Lake bed southeast of Gaston, Oregon, normally is drained during spring so that it can be farmed during the summer. The Wapato Lake area (page 29) has been leveed and drained since the 1930s by the Wapato Improvement District to support local agricultural activities. A levee protects the former lake bed from severe flooding during the winter, thus allowing easier drainage in the spring. The water pumped out of Wapato Lake in springtime typically has a minimal downstream water-quality effect as a result of high river flow and ample dilution. Some increased difficulties in treating municipal drinking water at the Joint Water Commission's plant downstream, however, have been reported to coincide with these springtime discharges from Wapato Lake

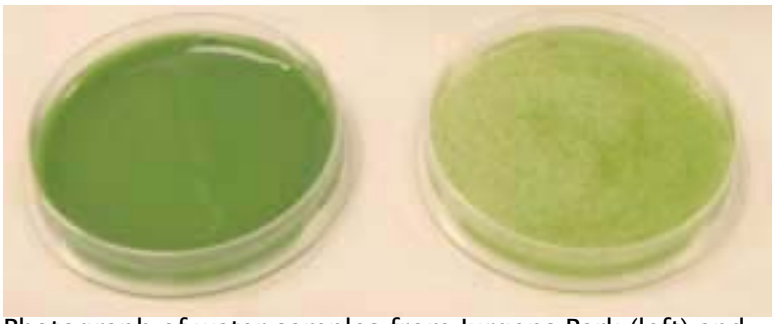
A Levee Breach

On December 2-3, 2007, more than 6 inches of total rainfall were recorded at several weather stations across the Tualatin River basin. By December 3rd, the Tualatin River at Gaston and at Dilley was cresting at near-flood levels. The peak streamflow recorded at the USGS gage at Dilley (site 14203500) was just under 10,000 cfs, almost identical to the peak streamflow recorded during the large flood of February 1996. During these high-water conditions, a small section of the levee on the west side of Wapato Lake failed (page 29), causing flood water to inundate the lake bed to a depth of approximately 8 feet, although no reliable measurements were taken.

Without first repairing or temporarily patching the levee, Wapato Improvement District personnel could not pump flood waters out of the lake. Any water pumped out would simply re-enter the lake through the levee breach. The levee, however, could not be patched because flood water prevented access. Consequently, the lake could not be drained in the springtime, and water remained ponded in the Wapato Lake bed until early summer when river levels finally receded below the levee breach. Once the levee was patched, pumps were turned on to transfer the ponded water into Wapato Creek, which discharges to the Tualatin River just upstream of the mouth of Scoggins Creek. While ponded on the peat soils of the lake bed, however, the water had a chance to warm up, pick up nutrients, and grow a substantial population of algae and zooplankton. The water-quality effects of this discharge were not discovered until weeks later.

Downstream Water-Quality Problems

Algae: On July 7, 2008, a sampling crew from Clean Water Services noticed unusual algal conditions and what might have been floating algal mats at RM 16.2 (Elsner). On July 9, 2008, U.S. Geological Survey (USGS) and Tualatin Riverkeeper (TRK) personnel independently discovered floating mats of blue-green algae in the lower Tualatin River at Tualatin's Jurgens Park (RM 10.8) and Tigard's Cook Park (RM 9.9). Floating mats of nuisance algae had not occurred in the Tualatin River since the early 1970s.



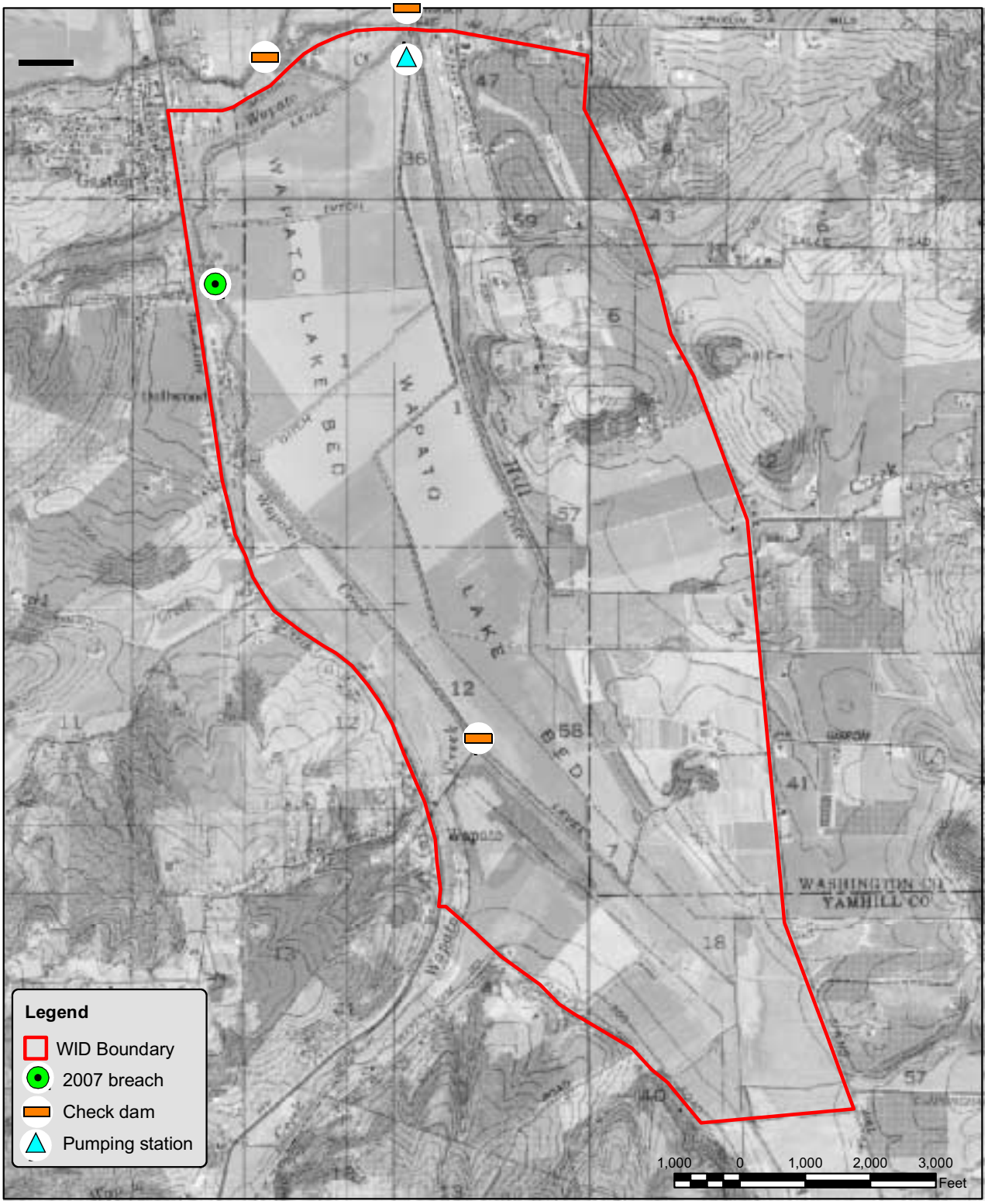
Photograph of water samples from Jurgens Park (left) and Cook Park (right) from July 9, 2008, showing the high concentrations of algae. The sample from Jurgens Park appears more concentrated partly because it was sampled directly from a floating algal mat.

Microscopic examination of water samples by USGS revealed the mats to be composed primarily of *anabaena flos aquae*, a blue-green algae (or cyanobacteria) that is capable of producing toxins and therefore can be a public health hazard. Water samples were sent to a laboratory (Aquatic Analysts) for cell counts, and USGS staff tested samples for microcystins, a class of toxin that can be produced by *anabaena.*

T1N, R3W, S19
Forest Grove Quad

Wapato Lake Improvement District
Site Plan Map

Map from Dean P. Moberg
USDA-NRCS



Map of Wapato Lake showing location of levee breach.

Results showed microcystin concentrations of 2.4, 0.19, and 0.14 µg/L for samples collected from three locations on July 9th. The World Health Organization's drinking water standard for microcystins is 1 µg/L, and Oregon's recreational health-hazard guideline concentration is 8 µg/L. Results of cell counts revealed *anabaena* concentrations at less than 30,000 cells/mL; Oregon's public health action level is 100,000 cells/mL. Despite most measurements being below guideline or action levels, the presence of floating mats of a potentially toxin-producing blue-green algae was sufficient for the Public Health Division of the Oregon Department of Human Services to issue a public health advisory on July 12th for the Tualatin River from Jurgens Park (RM 10.8) to the river's mouth. Clean Water Services increased their releases of water from Hagg Lake to help mitigate the problem and speed the river's recovery. The health advisory was lifted about two weeks later, on July 25th, after further sampling showed that the *anabaena* bloom had diminished.

Geosmin: At the same time that nuisance algae were present in the lower Tualatin River, the Joint Water Commission (JWC) was having unusual problems at its drinking water treatment plant near Forest Grove. Although JWC has rights to water in Scoggins and Barney Reservoirs, that water is delivered to the JWC plant via the Tualatin River. The withdrawal point near Forest Grove is downstream of Wapato Creek. During June and July of 2008, water withdrawn by JWC from the Tualatin River was more turbid than usual, and water users complained about taste and odor in the finished water. Tests on the river water by JWC staff showed unusually high levels of total organic carbon and of geosmin, a substance produced by blue-green algae that often accounts for an "earthy" taste and odor in water. In response, JWC modified its treatment processes, including the use of powdered activated carbon to help remove the higher load of organic materials, and initiated an investigation to determine the source of the water-quality problems. JWC also increased their releases from Barney Reservoir and Hagg Lake to help dilute geosmin and related substances. More information about JWC's taste and odor event are on page 17.

Other water quality measurements: Routine water-quality monitoring by Clean Water Services includes weekly sample collection from many sites along the Tualatin River as well as samples from many of its tributaries. Samples collected in late June and throughout July showed anomalously high concentrations of chlorophyll, turbidity, suspended solids, particulate and dissolved phosphorus, and chemical oxygen demand in the upper reaches of the Tualatin River, but downstream of Cherry Grove. These concentrations were much higher than those that were measured in previous years.

Tracking the Problems to Their Source

Clean Water Services data from June and July of 2008 indicated that a source rich in particulate material, phosphorus, algae, and organic matter was discharging to the Tualatin River upstream of their sampling location at Dilley (Spring Hill Road, USGS RM 58.8) but downstream of Cherry Grove (South Road, USGS RM 67.8). Samples from Scoggins Creek, the largest tributary in that reach, showed that it (and Hagg Lake) was not the source of the problem.

JWC expanded its monitoring program during June and July of 2008 in an attempt to identify the source of the high organic matter concentrations in the Tualatin River. Samples and field readings taken from multiple locations in the upper Tualatin River basin identified the pump discharge from Wapato Lake as the potential source of organic carbon and geosmin to the Tualatin River.

Water samples were collected by USGS on July 19, 2008, just downstream of the Wapato Improvement District's pump house at Gaston Road and analyzed for a variety of constituents. The water was turbid and had a low dissolved oxygen concentration (3.0 mg/L). Samples were sent to the Clean Water Services laboratory for chemical analyses and to other laboratories for species identification and enumeration of algae and zooplankton. Results showed high concentrations of oxygen demand (BOD5, 25 mg/L), organic nitrogen (6.6 mg/L), suspended solids (74 mg/L), chlorophyll (>300 µg/L), total phosphorus (2.5 mg/L), and phosphate (0.47 mg/L as P). Concentrations of algae and zooplankton in the pump discharge water also were very high, compared to concentrations that typically occur in the Tualatin River.

Putting the Pieces Together

USGS staff analyzed the results of the chemical tests to determine whether the Wapato Lake pump discharge could account for the anomalously high concentrations measured in the Tualatin River downstream. Using an estimated discharge rate based on the pumps' rated capacity (13,000 gal/min) and measured streamflows in Scoggins Creek (site 14202980) and the Tualatin River at Gaston (site 14202510), the downstream measured concentrations at Dilley were compared to estimated concentrations based on a mass balance of upstream sources. Results showed that the Wapato Lake source was sufficient to account for the elevated downstream concentrations of phosphorus, suspended solids, and oxygen demand in the Tualatin River.

In addition to the chemical data, results from algae samples collected from various sites in the upper Tualatin River basin showed that elevated algae concentrations at the JWC intake in July 2008 were largely coming from Wapato Lake. The available chemical and biological data from Clean Water Services, JWC, and USGS suggest that Wapato Lake pump discharge waters were responsible for the June and July 2008 water-quality problems at the JWC treatment plant as well as the anomalously high phosphorus, algae, and particulate concentrations in the Tualatin River at and downstream of Dilley (USGS RM 58.8).

A further analysis of streamflow and continuous monitor data was undertaken by USGS to determine whether the nuisance *anabaena* bloom that occurred in the lower Tualatin River in July 2008 could have been caused by discharges from Wapato Lake. Elevated dissolved oxygen measurements at three USGS continuous water-quality monitors at RMs 24.5 (downstream of Scholls), 9.9 (Cook Park), and 3.4 (Oswego Dam) were well correlated with the presence of large algae populations, and those data clearly showed the movement of a mass of algae from one site to the next in early July. The *anabaena* bloom, therefore, did not originate in the lower Tualatin River but was transported from an upstream source. Algae and zooplankton samples from RM 24.5 were also present at unusually high concentrations, illustrating that an upstream source must have been present.

The USGS analysis of streamflow data in the upper Tualatin River basin suggest that the greatest discharges from Wapato Lake might have occurred between June 30 and July 30, 2008. That timing is entirely consistent with known travel times from the Forest Grove area to the lower Tualatin River and the elevated dissolved oxygen concentrations that were measured at RM 24.5. That timing also is consistent with the available algae and zooplankton data in the lower Tualatin River. Those data suggest that a large bloom of *anabaena* had grown in Wapato Lake and was discharged along with a large population of zooplankton on or about June 30th. Many blue-green algae such as *anabaena* are resistant to grazing by zooplankton, and the zooplankton likely fed on other diatom and green algae, thus reducing the population of those algae and further favoring the presence of blue-greens. Data are not available to prove that the nuisance *anabaena* bloom came from Wapato Lake, but the available streamflow, chemical, and biological data all are consistent with that hypothesis. A USGS report is being drafted that will document the available data and explore the upstream/downstream connections associated with the Tualatin River's water-quality problems during the summer of 2008.

Clean Water Services, JWC, USGS, and other agencies are working to collaborate on future monitoring plans in the upper Tualatin River basin.