Monitoring for Source Water Protection in the North Santiam River Basin, Oregon, in Response to Harmful Algal Blooms and Recent Wildfires

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Background Information

The Beachie Creek and Lionshead wildfires affected nearly 400,000 acres of federal and private forestland, rural residential, and urban lands in the North Santiam River Canyon and surrounding watersheds upstream and down from Detroit and Bigg Cliff Lakes. The fire is by far the largest in modern history, threatening the drinking water supplies for communities along the river including Gates and Mill City, Lyons and Mehama, and the Cities of Stayton and Salem that all utilize the North Santiam River for municipal supply (**Figure 1**). The fires destroyed homes, businesses, and infrastructure including USGS streamflow gages and water-quality monitoring stations that municipalities rely upon to gage and anticipate water quality coming downstream to water intakes.

The existing continuous discharge and water-quality monitoring station in the North Santiam at Niagara (USGS 14181500) — downstream from Detroit Lake and Big Cliff Dams — stopped transmitting when the fire passed through, taking out one a critical early warning station. While this location foretells potential impacts from algal blooms in Detroit Lake, it does not capture inputs from many of the burned urban areas downstream. As a result, the USGS, North Santiam Watershed Council, and the City of Salem found a suitable location and rapidly deployed a real-time water-quality monitoring station in the North Santiam River downstream from Stout Creek (USGS 14183020), is one of the new stations (red circles in **Figure 1**), that provides lead time to downstream water users about water-quality conditions (see *https://waterdata.usgs.gov/nwis/uv/?site_no=14183020*).

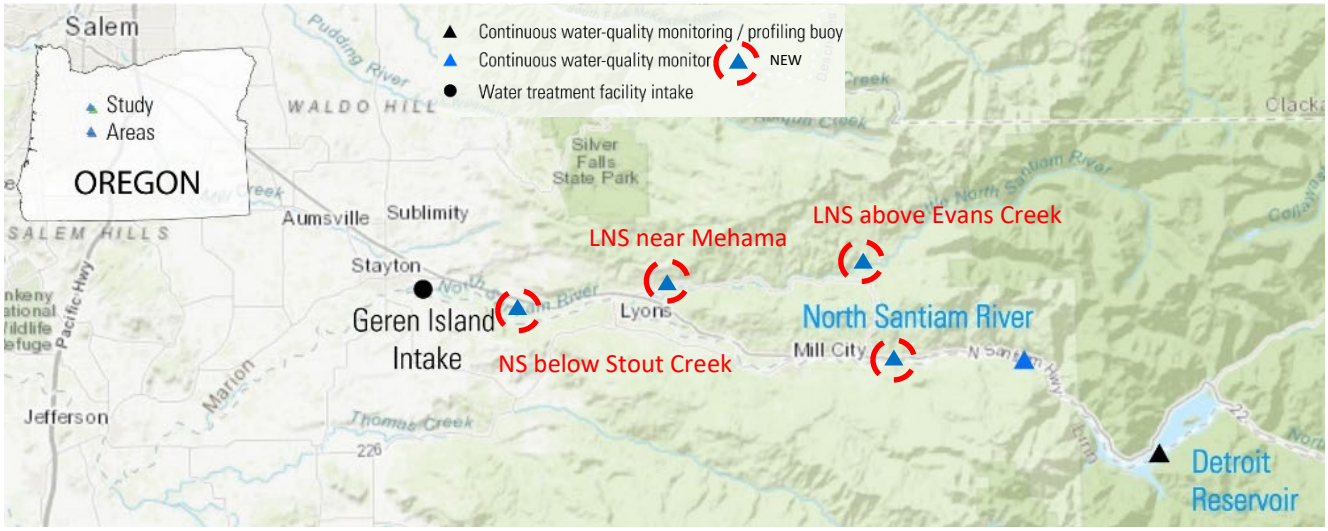

Figure 1. Map of the North Santiam River study area.

Initial data from that monitor captured a mid-October storm, the first to produce turbidity levels that are of concern for the Cities of Salem and Stayton and other water users along the North Santiam. The NS below Stout Creek station location incorporates both the upper mainstem and the Little North Santiam R. ("LNS"), where much of the high severity burned areas are located and where a previous USGS study (Bragg and Uhrich, 2010) found to contribute two-thirds of the sediment transported past Geren Island. This station is also influenced to some degree by Stout Creek upstream, which can have turbid flows and whose upper watershed

also burned to some degree. While outflows from Detroit and Big Cliff Lakes comprise most of the flow in the North Santiam River, storms can produce flows of several thousand CFS in the LNS (**Figure 2**).

Photographs showing storm runoff from a fire-impacted forest in the North Santiam River Basin, and the downstream effects on the Little North Santiam River. (Photographs by Lacey Goeres-Priest, City of Salem.)

The North Santiam R. below Stout Creek is 4.5 miles upstream from the City of Salem's Geren Island Slow Sand Drinking Water Treatment Plant, which provided about 30 minutes warning to the City of Salem, a bit more for Stayton, during the mid-October storm. The upstream station at Niagara was not operating leaving Gates and other municipal suppliers without advance warning but has since been repaired.

This second storm series produced substantial runoff from the LNS (about 6,000 CFS), with turbidity peaking in the North Santiam River below Stout Creek shortly after the suggest that much of this likely came from the LNS (**Figure 2**). Dilution from Big Cliff reservoir partly suppressed turbidity, which still exceeded ~50 FNUs in the North Santiam River and at the Geren Island Middle Intake (Data from USGS and City of Salem).

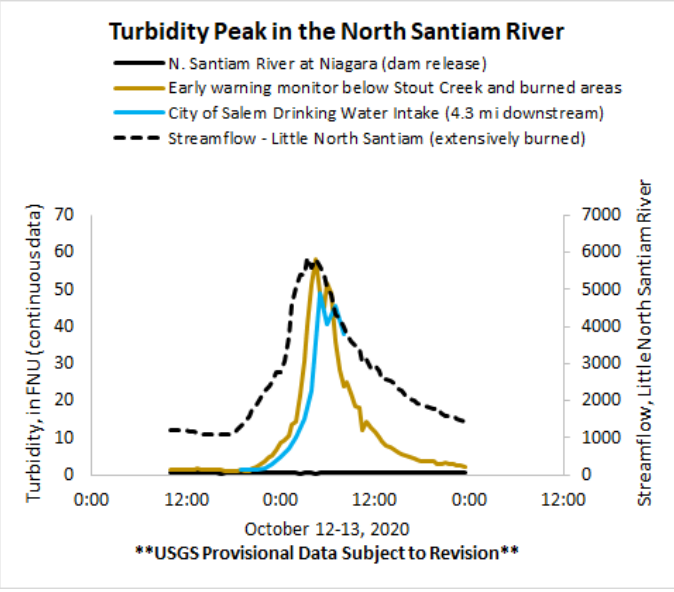

Figure 2. Streamflow and turbidity response in the North Santiam River during an October 2020 storm.

Work Plan for Federal Fiscal Years 2021-22 (October 2020-September 2022)

Task 1. Construction and Installation of Two Water-Quality Monitoring Stations

Task 1—Construction and installation of two new real-time water-quality monitoring stations—includes deployment of GOES satellite communications systems, running of orifice lines, and placement of waterproof enclosures to house the electronics. Also includes time for modem and datalogger programming, set up of DCODES, and entry of stations into the Aquarius database system. This "early warning" network of sensors (**Figure 1**) provides crucial lead time for drinking water treatment plant operators and identifies the primary sources of turbidity and organic carbon during storm events. The installation and the monitoring costs for real-time river stage at the upstream site on the LNS upstream of Evans Creek is covered in the agreement with the U.S. Army Corp of Engineers, with collection of continuous turbidity is included in this new program funded jointly by Salem and USGS.

Task 2. Operation and Maintenance of Five Continuous Water-Quality Monitors

Operation and maintenance of five continuous water quality monitors, in: (#1) Detroit Lake, to span the harmful algal bloom seasons in 2022 (this is not planned for 2021, but beginning as soon as the log boom is in place); (#2) North Santiam River at Niagara, which is operated year round; and (#'s 3–5) the North Santiam River below Stout Creek (*https://waterdata.usgs.gov/nwis/uv/?site_no=14183020*), the Little North Santiam River ("LNS") near Mehama (USGS station 14182500, *https://waterdata.usgs.gov/nwis/uv/?site_no=14182500*), and the Little North Santiam River upstream of Evans Creek (USGS 14181900, *https://waterdata.usgs.gov/nwis/uv?site_no=14181900*), would be operated through June 2022, covering all of 2021 and the most active storm-runoff period (through June) in 2022.

Most of these stations (except the LNS upstream of Evans Creek) will collect the full suite of YSI EXO2 parameters, including water temperature, specific conductance, pH, dissolved oxygen, turbidity, fluorescing dissolved organic matter (fDOM), total chlorophyll, and phycocyanin (8 parameters), with measurements every 30 minutes. The LNS upstream of Evans Creek monitoring station includes river stage (funded through a separate agreement with the U.S. Army Corp of Engineers), and turbidity via a stand-alone Analite sensor (*https://analite.com.au/product/nep-5000-digital-sensors/*). Note that these types of sensors are in use at other monitoring stations in Oregon; after the Riverside Fire, the U.S. Forest Service deployed one in Fish Creek in the Clackamas Basin (Todd Parker, U.S. Forest Service, written communication). They are known to produce somewhat higher turbidity values compared with YSI EXO turbidity sensors, but the relative magnitudes of the responses of the different sensors, and the timing of peaks, can be helpful for deciphering a stream's response to storm events, landslides, and slope failures that might occur in the upstream watershed.

These water-quality data are available in near-real time, transmitted via GOES satellite to USGS servers, with data and graphs available on the UGSS National Water Information System (NWIS) and the USGS Data Grapher. Data are corrected, checked, approved, and published on a regular basis, 3-4 times each year.

Table 1. Total Budget, October 1, 2020 to September 30, 2022.

The costs for each of the tasks are outlined below. The USGS can contribute federal matching funds amounting to 40% of the total cost.

	City of Salem	USGS	TOTAL COST
	Oct 1, 2020 - June 30, 2022		
Tasks:			
1. New WQ Monitor Construction[1]	$6,000	$4,000	$10,000
2. WQ Monitor Operations[2]			
Detroit Lake (Mar 2022 - June 2022)[3]	$0	$15,567	$15,567
N. Santiam R. at Niagara (July 2021-June 2022)[3]	$30,000	$20,000	$50,000
N. Santiam R. below Stout Ck (Oct 2020-June 2022)	$49,035	$32,690	$81,725
L.N. Santiam River near Mehama (July 2021-June 2022)	$30,000	$20,000	$50,000
L.N. Santiam River ab Evans Ck (Dec 2020-June 2022)	$24,600	$16,400	$41,000
Grand Totals	$139,635	$108,657	$248,292

[1] One-time cost for materials and labor for installing 2 new real-time water-quality monitoring stations: the North Santiam R. below Stout Creek and the Little North Santiam R. near Mehama; installation of the Little North Santiam R. above Evans Creek site was funded by the Army Corp of Engineers.

[2] Data collection in the North Santiam R. at Niagara and other sites extends through June 30, 2022 to cover the active winter and spring storm runoff periods.

[3] The previous Agreement between USGS and the City of Salem covered operations of two water-quality monitors, in Detroit Lake and downstream at Niagara, (12 months each) through June 2021; the proposed modified agreement starts July 1, 2021 and extends through June 2022, and includes operation of the profiler at Detroit Lake at no additional cost to Salem.

Reference Cited

Bragg, H.M., and Uhrich, M.A., 2010, Suspended-sediment budget for the North Santiam River basin, Oregon, water years 2005–08: U.S. Geological Survey Scientific Investigations Report 2010–5038, 26 p.

Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors: station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods Report 1-D3, 51 p.
(Also available at *https://pubs.usgs.gov/tm/2006/tm1D3/*.)