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Hydrogeologic Framework of the Chamokane Creek Basin, Stevens County, Washington

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Introduction

Chamokane Creek basin is a 179 square-mile area that borders and partially overlaps the Spokane Indian Reservation in southern Stevens County in northeastern Washington State (fig. 1). Primary aquifers within the basin are part of a sequence of glaciofluvial and glaciolacustrine fill within an ancient paleochannel eroded into Miocene basalt and Cretaceous to Eocene granite. Chamokane Creek has a mean annual discharge of 62.5 cubic feet per second (ft^3/s) and is tributary to the Spokane River.

In 1979, all water rights in the Chamokane Creek basin were adjudicated by the United States District Court requiring regulation in favor of the senior water right of the Spokane Tribe of Indians. A court-appointed Water Master regulates junior water rights when the mean daily 7-day low-flow falls below 24 ft^3/s in Chamokane Creek; regulation has been necessary in 2 of the past 10 years (2001 and 2008). Additionally, the basin is closed to further groundwater or surface-water appropriation, with the exception of permit-exempt uses of groundwater.

The Spokane Tribe, State of Washington, and Bureau of Indian Affairs are concerned about the effects of future groundwater development in the basin and the potential effects of this growth on Chamokane Creek. In order to evaluate these concerns, the U.S. Geological Survey (USGS) is conducting a study to describe the groundwater and surface-water system of the valley-fill deposits of the basin and to assess the effects of potential increases in groundwater withdrawals on groundwater and surface-water resources.

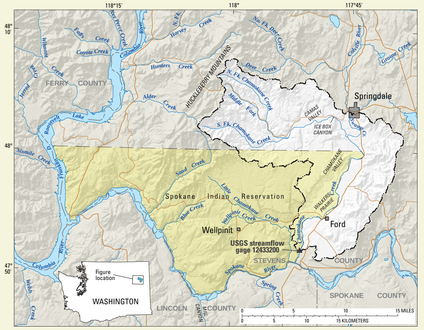

Figure 1. Location of the Chamokane Creek basin, Stevens County, Washington.

Methods

A two-part (Phases 1 and 2) investigation was designed (1) to characterize the hydrogeologic setting and groundwater and surface-water interactions in the basin, and to obtain hydrologic data sets to support subsequent computer modeling (Kahle and others, 2010), and (2) to build and apply a coupled groundwater and surface-water flow model, GSFLOW (Markstrom and others, 2008), in order to evaluate the possible regional effects of different groundwater-use alternatives on the surface-water system.

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Hydrogeologic Framework

Six hydrogeologic units were identified in the basin using well logs, geologic mapping, and field observations (figs. 2 and 3). The Upper outwash aquifer is an unconfined aquifer along the valley floors of the study area, and consists mostly of sand, gravel, and cobbles. The Landslide unit is composed of poorly sorted deposits of broken basalt and sedimentary interbeds along the basalt bluffs in Walkers Prairie. The Valley confining unit mostly is a low-permeability unit consisting of glaciolacustrine silt and clay at depth throughout the valley bottoms of the study area. The Lower aquifer is a confined aquifer consisting of sand and gravel at depth below the Valley confining unit. The Basalt unit is composed of Columbia River Basalt and sedimentary interbeds. Water is contained in cracks and fractures and from zones between lava flows. The Bedrock unit includes rocks older than the Columbia River Basalt and commonly includes granite and quartzite with small and often unreliable yields.

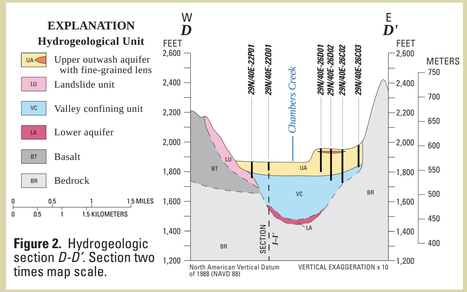
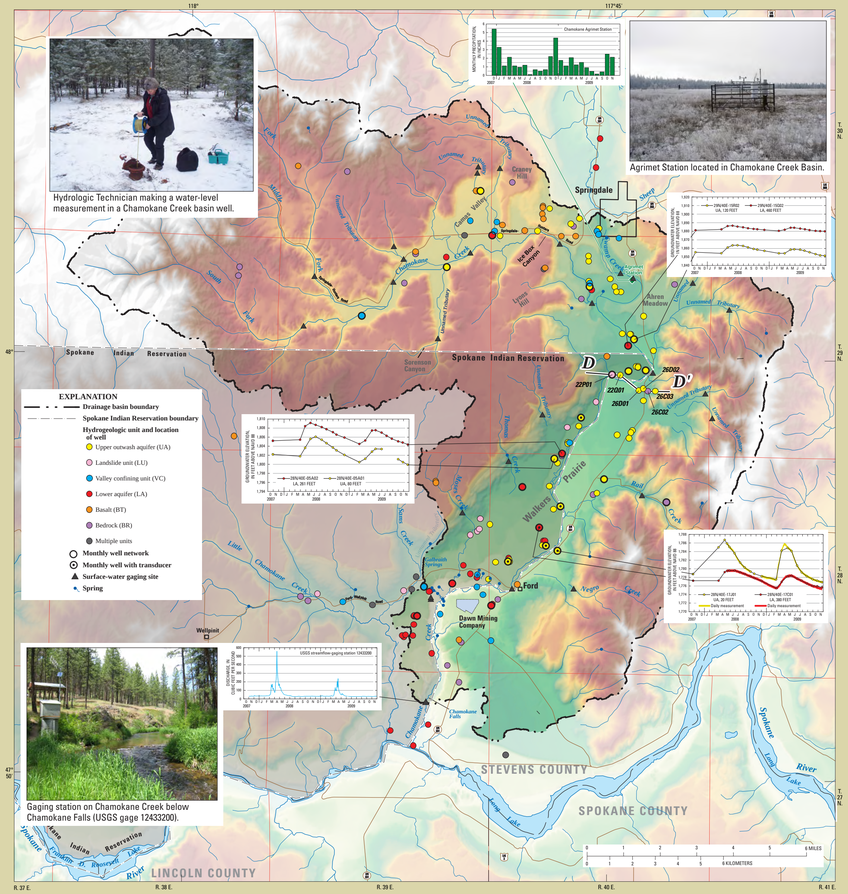


Figure 2. Hydrogeologic section *D-D'*. Section two times map scale.



Hydrologic Technician making a water-level measurement in a Chamokane Creek basin well.

Agrimet Station located in Chamokane Creek Basin.

Gaging station on Chamokane Creek below Chamokane Falls (USGS gage 12433200).

Figure 3. Location of project wells with hydrogeologic unit, surface-water measurement sites, and Agrimet station; graphs showing water levels in wells, precipitation measured at the Agrimet station, and discharge data from USGS streamflow-gaging station 12433200; Chamokane Creek basin, Stevens County, Washington.

Movement of Water

Based on water levels measured in wells (autumn 2007), horizontal groundwater flow in the Upper outwash aquifer moves from the topographically high tributary-basin areas toward the topographically lower valley floors (fig. 4A). Horizontal groundwater flow in the Lower aquifer is south to southwest from near Springdale to south of Ford. In the Camas Valley, flow in the Lower aquifer is east to near the end of the valley where flow likely discharges into overlying sediments and Chamokane Creek near the end of the valley at the head of Icebox Canyon (fig. 4B).

Water-level graphs for closely spaced wells completed in the Upper outwash aquifer and the Lower aquifer indicate a similar timing of the seasonal rise and decline in water levels with similar, but slightly greater magnitude in the fluctuations in the Upper outwash aquifer (fig. 3). The overall similarity of fluctuations in water levels indicate that these systems may be fairly well hydraulically connected.

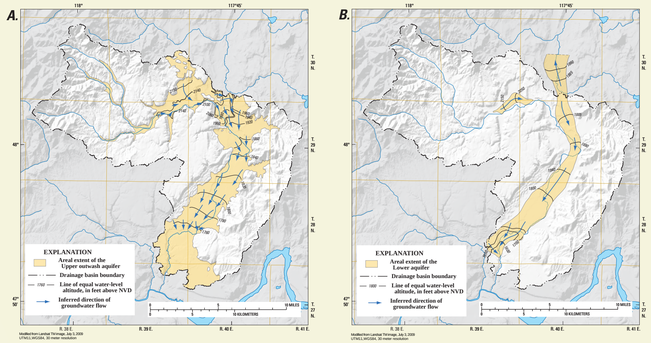


Figure 4. Areal extent, water-level altitudes, and inferred directions of groundwater flow in (*A*) the Upper outwash aquifer and (*B*) the Lower aquifer

During low-flow surface-water measurements (late summer/early autumn 2007 and 2008), many sites were at or near zero flow. The most notable exception to this was downstream from Ford where large springs discharge from the Upper outwash aquifer and support streamflow year round. During high-flow surface-water measurements (mid-April 2008), gains in streamflow occurred throughout the Camas Valley with the largest high-flow measurement made at the mouth of Ice Box Canyon. Large streamflow losses were recorded near the north end of Walkers Prairie where Chamokane Creek loses flow directly to the Upper outwash aquifer.

Land-Use/Land-Cover Change

Satellite data from 1987 and 2009 were used to conduct a land-use/land-cover (LULC) change analysis of the basin. Landsat Thematic Mapper data were acquired from the U.S. Geological Survey Earth Resources Observation and Science (EROS) Center. To classify LULC for the 1987 and 2009 images, a hybrid approach to image classification was used using ERDAS IMAGINE software. Results show that similar to the conditions in 1987 (fig. 5A), Chamokane Creek basin in 2009 (fig. 5B) was an area dominated by forests with some pasture and agricultural lands. Development is still relatively sparse. Logging activities seem to be the major cause of land-cover change in the basin between 1987 and 2009.

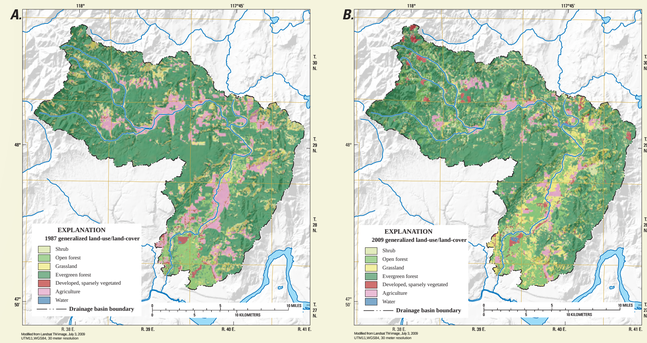


Figure 5. Generalized land use and land cover classification for (*A*) 1987 and (*B*) 2009

GSFLOW

GSFLOW is being used to investigate the aquifer-creek interactions, provide water budgets, and simulate the effects of potential groundwater withdrawals and climate scenarios on Chamokane Creek. The model is constructed using the hydrogeologic framework, stream geometry, and water-use estimates from Phase I (fig. 6). Measured precipitation and air temperature are the major factors used to compute evaporation, transpiration, sublimation, snowmelt, surface runoff, and infiltration. The model will be constrained by newly collected groundwater and surface-water data, and daily evapotranspiration data from the Agrimet station.

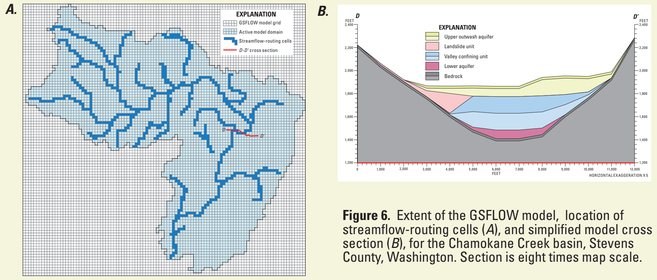


Figure 6. Extent of the GSFLOW model, location of streamflow-routing cells (*A*), and simplified model cross section (*B*), for the Chamokane Creek basin, Stevens County, Washington. Section is eight times map scale.

References Cited

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Markstrom, S.L., Niswonger, R.G., Regan, R.S., Prudic, D.E., and Barlow, P.M., 2008, GSFLOW-coupled ground-water and surface-water FLOW model based on the integration of the Precipitation-Runoff Modeling System (PRMS) and the Modular Ground-Water Flow Model (MODFLOW-2005): U.S. Geological Survey Techniques and Methods 6-D1, 240 p. (Also available at http://water.usgs.gov/nrp/gwsoftware/gsflow/gsflow.html).

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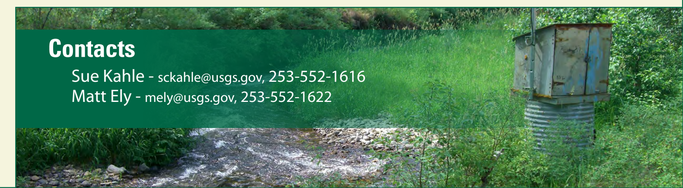

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