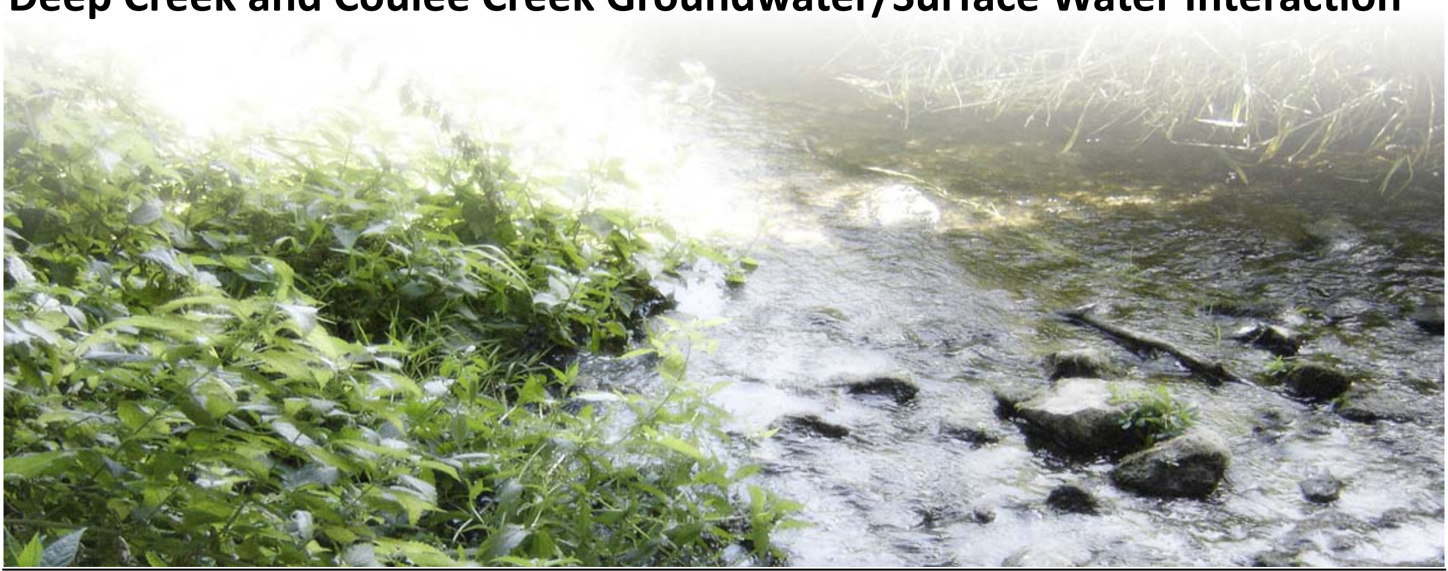
West Plains Hydrogeology

Deep Creek and Coulee Creek Groundwater/Surface Water Interaction



June 30, 2013

Prepared by Spokane County Water Resources

Washington Department of Ecology

Grant G1200159

SPOKANE COUNTY
WATER RESOURCES

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Introduction

This report describes the work completed for the *Deep Creek and Coulee Creek Ground/Surface Water Interaction Study* (project). The project was funded by grant G1200159 from the Washington Department of Ecology's (Ecology) Watershed Planning Program. The project scope was developed from recommendations included in the Water Resource Inventory Area (WRIA 54) Watershed Plan and WRIA 54 Detailed Implementation Plan (DIP). The WRIA 54 DIP includes the following recommendation

> **Recommendation TI-1: West Plains Hydrogeology Study**
>
> *Basalt Aquifer Groundwater Study-The Columbia River Basalt Group aquifers that underlie the West Plains area are used for water supply. Groundwater levels have declined in some areas, indicating the groundwater resource is potentially strained. These aquifers are not well understood. Elsewhere in the Pacific Northwest, basalt aquifers are used extensively for water supply, indicating that a better understanding of the Columbia River Basalt Group aquifers in the West Plains area would be beneficial to understand how this resource can be used in a sustainable way. (Tetra Tech, 2010)*

An important component of the Columbia River Basalt Group (CRBG) aquifers in the West Plains is the interaction of groundwater and surface water in the vicinity of Deep Creek and Coulee Creek. A valuable tool in understanding this interaction is a seepage run.

Groundwater/surface water interaction is an integral component of a hydrogeologic system. Stream segments can be gaining (water is moving from the groundwater system to the stream), or losing (water is moving from the stream to the groundwater system). During late summer and fall groundwater is often the only source of water for a gaining segment of a stream, and is essential to maintaining aquatic habitat. Alternatively, losing segments of a stream can be an important and significant groundwater recharge pathway. A seepage run identifies the locations and quantifies the impacts of gaining and losing reaches in a stream.

A seepage run is a set of multiple stream discharge (aka, flow) measurements taken in different locations on a stream and its tributaries within a short time frame, typically hours or days depending on the size of the study area. Once tributary contributions have been accounted for, the net change in flow between two locations can be inferred to be either a gain or loss to the groundwater system. Seepage runs are usually conducted in late summer or early fall after a period with no precipitation, so that contributions to the stream from overland run off or bank storage are minimized.

Background Information

Deep Creek and Coulee Creek both originate in the steptoes that are present north of the Town of Reardan. The creeks are approximately three miles apart where they originate; they converge approximately 0.75 miles before entering the Spokane River. The creeks originate in rolling hills that are predominately used for agriculture, and descend into narrow valleys with

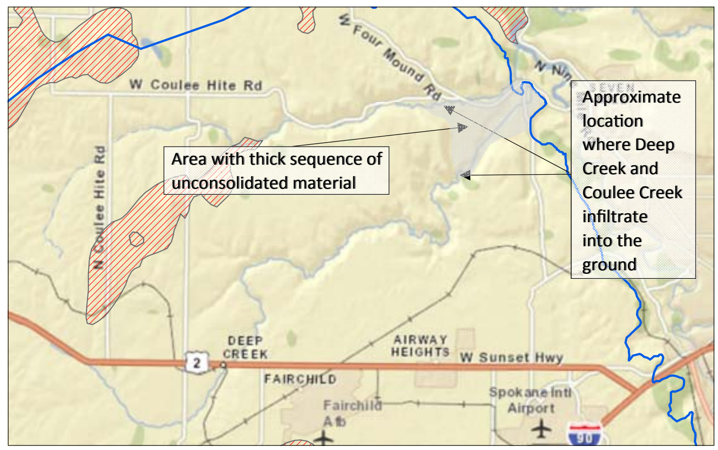

Figure 1— General Location where Deep Creek & Coulee Creek Infiltrate to ground.

steep walls that are incised into basalt plateaus. Approximately 4 miles from the Spokane River both creeks enter into a valley that has a thick sequence of unconsolidated material (sand and gravel) , exceeding 200 ft. in many locations, overlying basalt. Surface flow of both creeks quickly infiltrates into the unconsolidated material upon entering the valley most times of the year. Under certain climactic conditions, such as rain on snow events or significant precipitation on frozen or saturated ground, surface flow of the creeks will extend the entire distance to the Spokane River. This does not occur for an extended period of time and many years it does not occur at all. There is also a portion of Deep Creek between its crossing with Rambo Rd. and its crossing with Euclid Rd. that local residents report is often dry during the summer months.

Historical Flow Data

Very little stream flow data exists for either creek. Stream flow measurements on both creeks were taken in August 2006 as part of a fish habitat study (EES Consulting, 2007) and stream flow measurements were taken in May, June, and July of 2010 as part of a water quality study (GeoEngineers, 2010). Three locations on Deep Creek and two locations on Coulee Creek from the water quality study correspond with measurement locations of this study. A comparison of the data from the water quality study and data from this study are presented in Table 1.

Table 1: Deep Creek & Coulee Creek Stream Flow

Date	Deep Creek 2	Deep Creek 8	Deep Creek 13	Coulee Creek 1	Coulee Creek 2
	Water Quality Study				
5/23/10	1.9	3.8	1.4	0	1.8
6/6/10	4.7	8.9	3.7	2.6	3.1
6/22/10	4.5	6.2	1.8	1.6	2.4
7/12/10	0.5	2.7	0.9	0.2	0.5
7/25/10	0.3	1.5	0.6	0.1	0.3
	Deep & Coulee Creek Seepage Run				
9/24/12	0.23	2.15	0.38	-	-
10/1/12	-	0	-	0	0.1

stream flow values in CFS

Seepage Run

Field Activities

Stream flow measurements were collected on September 24 & 25, 2012 for Deep Creek and October 1, 2012 for Coulee Creek. Field work was conducted according to the Quality Assurance Project Plan (Spokane County, 2012) developed for the project and approved by Ecology. Measurements were taken at 18 locations on Deep Creek and 7 locations on Coulee Creek. Four of the locations on Deep Creek, and two of the locations on Coulee Creek had no flow at the time of the measurements. There was no measureable precipitation in the study area between August 22nd and October 13th , so there was negligible, if any, direct surface runoff entering either creek.

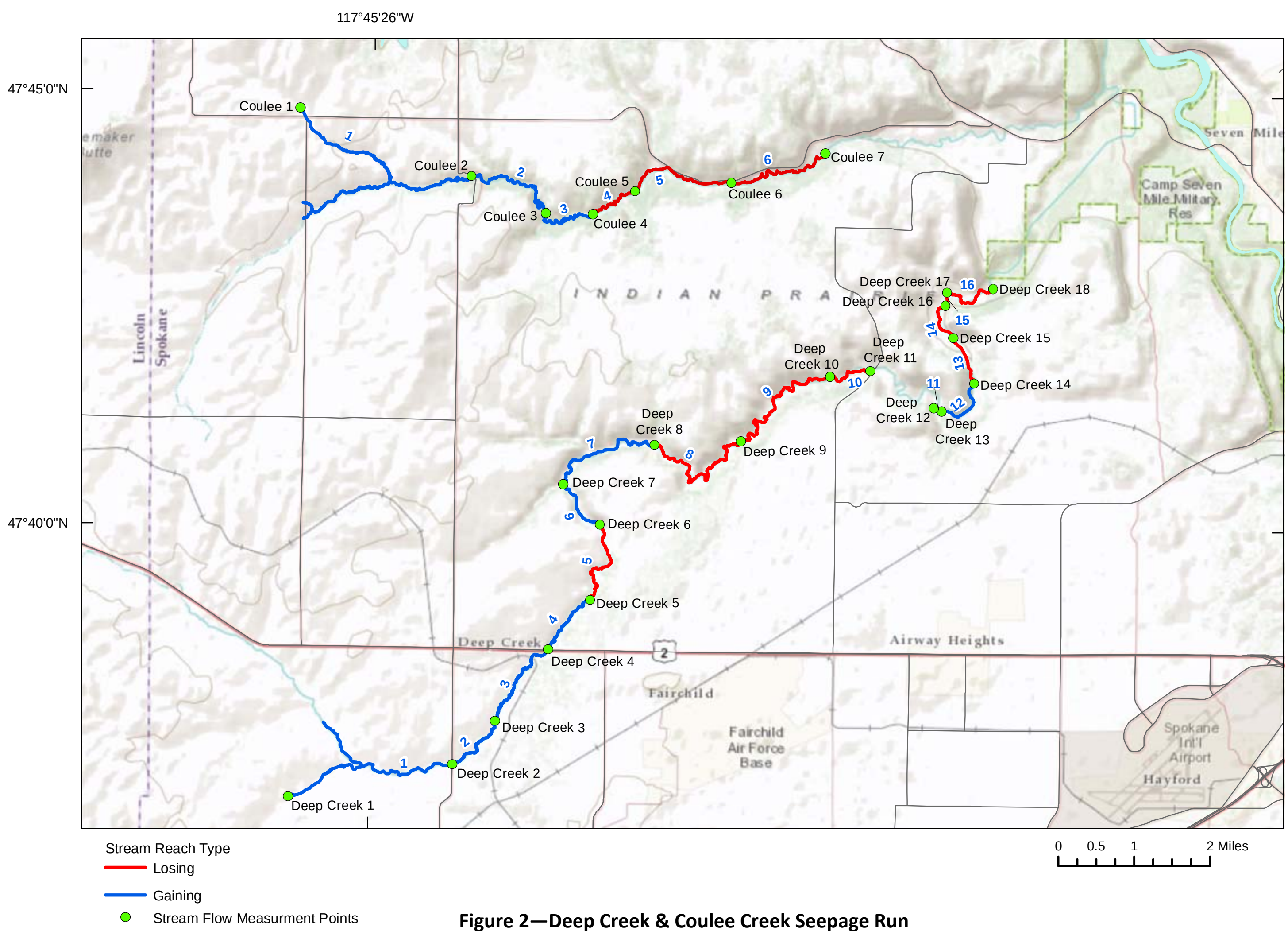

Figure 2—Deep Creek & Coulee Creek Seepage Run

Table 2- Deep Creek Seepage Run Data

Stream Reach	Beginning Flow (cfs)	Ending Flow (cfs)	Gain/Loss (cfs)	Beginning Elevation (ft)	Ending Elevation (ft)	Change (ft)	Length (mi.)	Gradient (ft/ft)	cfs/mile
1	0.00	0.23	0.23	2346	2318	28	2.74	0.0019	0.08
2	0.23	1.33	1.10	2318	2297	21	1.06	0.0038	1.04
3	1.33	2.08	0.75	2297	2243	54	1.59	0.0064	0.47
4	2.08	2.16	0.08	2243	2216	27	1.08	0.0047	0.07
5	2.16	1.83	-0.33	2216	2201	15	1.46	0.0019	-0.23
6	1.83	2.09	0.26	2201	2180	21	0.85	0.0047	0.31
7	2.09	2.15	0.06	2180	2158	22	1.86	0.0022	0.03
8	2.15	1.73	-0.42	2158	2100	58	2.34	0.0047	-0.18
9	1.73	0.14	-1.59	2100	2060	40	2.38	0.0032	-0.67
10	0.14	0.00	-0.14	2060	2047	13	0.72	0.0034	-0.19
11	0.00	0.38	0.38	1982	1979	3	0.15	0.0038	2.51
12	0.38	2.03	1.65	1979	1952	27	0.84	0.0061	1.96
13	2.03	1.49	-0.54	1952	1916	36	0.72	0.0094	-0.75
14	1.49	1.34	-0.15	1916	1910	6	0.64	0.0018	-0.23
15	1.34	1.08	-0.26	1910	1895	15	0.19	0.0151	-1.38
16	1.08	0.00	-1.08	1895	1878	17	0.85	0.0038	-1.28

Results

Tables 2 & 3 present the results for Deep Creek and Coulee Creek, respectively. The tables present results by stream reach which are defined by two stream flow measurement locations. The beginning flow, ending flow, and change in flow for each stream reach are included along with stream gradient and change in flow per mile. Figure 2 shows the location of each stream measurement location and the stream reach number. The stream reaches shown in Figure 2 are those that had flow at the time the data was collected; portions of the creek that are not designated gaining or losing did not have any flow at the time the measurements were collected.

Both creeks gain water in the upper portion of their respective basins. Coulee Creek gains water through the first half of the flowing portion of the creek and loses water for the second half of the flowing portion before completely infiltrating into the ground.

Deep Creek gains water through the first 4 stream reaches. Reach 5 is a losing reach, but if reaches 5, 6, and 7 are taken together there is essentially no net change in flow. Reaches 8, 9, and 10 all lose water and the creek completely infiltrates at the end of reach 10. Following reach 10 there is a dry portion of the creek. Through reach 11 and 12 the creek gains a similar quantity as was lost by the end of reach 10. Reach 11 and 12 have the highest gaining rate per mile of any other reaches of both Deep Creek and Coulee Creek. Through reaches 13, 14, 15 and

Table 3- Coulee Creek Seepage Run Data

Stream Reach	Beginning Flow (cfs)	Ending Flow (cfs)	Gain/Loss (cfs)	Beginning Elevation (ft.)	Ending Elevation (ft.)	Change (ft.)	Length (mi.)	Gradient (ft/ft)	cfs/mile
1	0.00	0.10	0.10	2496	2258	238	3.75	0.0120	0.03
2	0.10	0.25	0.15	2258	2191	67	1.81	0.0070	0.08
3	0.25	0.59	0.34	2191	2140	51	1.17	0.0082	0.29
4	0.59	0.32	-0.27	2140	2117	23	0.84	0.0052	-0.32
5	0.32	0.08	-0.24	2117	2052	65	1.59	0.0078	-0.15
6	0.08	0.00	-0.08	2052	1975	77	1.73	0.0084	-0.05

16, the entire flow gained in reaches 11 and 12 infiltrate into the ground.

Groundwater/Surface Water Interaction

West Plains Hydrogeology Overview

The geologic setting of the West Plains area of Spokane County is well described in many publications, including *Hydrogeology of the West Plains Area of Spokane County, Washington* (Deobald and Buchanan, 1995), and *WRIA 54 Phase 2, Level 1 Data Compilation and Assessment* (Tetra Tech, 2007). The important aspects of West Plains hydrogeology to this investigation are:

1. There are two primary basalt formations in the West Plains—The Wanapum Formation and the underlying Grande Ronde Formation. Each formation has a distinct aquifer.

2. The Wanapum aquifer is located above the Grande Ronde aquifer. The potentiometric surface of the Wanapum aquifer ranges in elevation from approximately 2440 to 2300 ft. msl. The groundwater flow direction is influenced by surface and near surface basement rock, and the flow directions tend to follow the topography of ground surface.

3. The Grande Ronde aquifer is located below the Wanapum aquifer. The potentiometric surface ranges in elevation from approximately 2200 to 2000 ft. msl in most of the West Plains. There is one area of the Grande Ronde, located where Deep Creek and Coulee Creek infiltrate into the ground, that may be hydraulically distinct from the other portions of the Grande Ronde. The potentiometric surface of this portion of the Grande Ronde aquifer ranges from approximately 1780 to 1690 ft. msl. The Grande Ronde does not appear to follow the surface topography and has a more regional flow direction that is generally to the east.

4. There are areas of the West Plains where unconsolidated surficial deposits, consisting primarily of glaciofluvial and lacustrine deposits, overlie the basalt formations. In some areas the unconsolidated material is over 200 ft. thick. These deposits are comprised of coarse grained sands and gravel that infiltrate water readily.

5. Both Deep Creek and Coulee Creek flow through areas with minimal unconsolidated surficial deposits and areas with thick sequences of unconsolidated surficial deposits.

Figure 3 & 6 present the general groundwater potentiometric surface of the Wanapum and Grande Ronde aquifers respectively. These figures were developed in an associated project—*West Plains Groundwater Elevation Monitoring and Mapping Project* (Spokane County Water Resources, 2013). The figures also include the location and elevation of each stream flow measurement point.

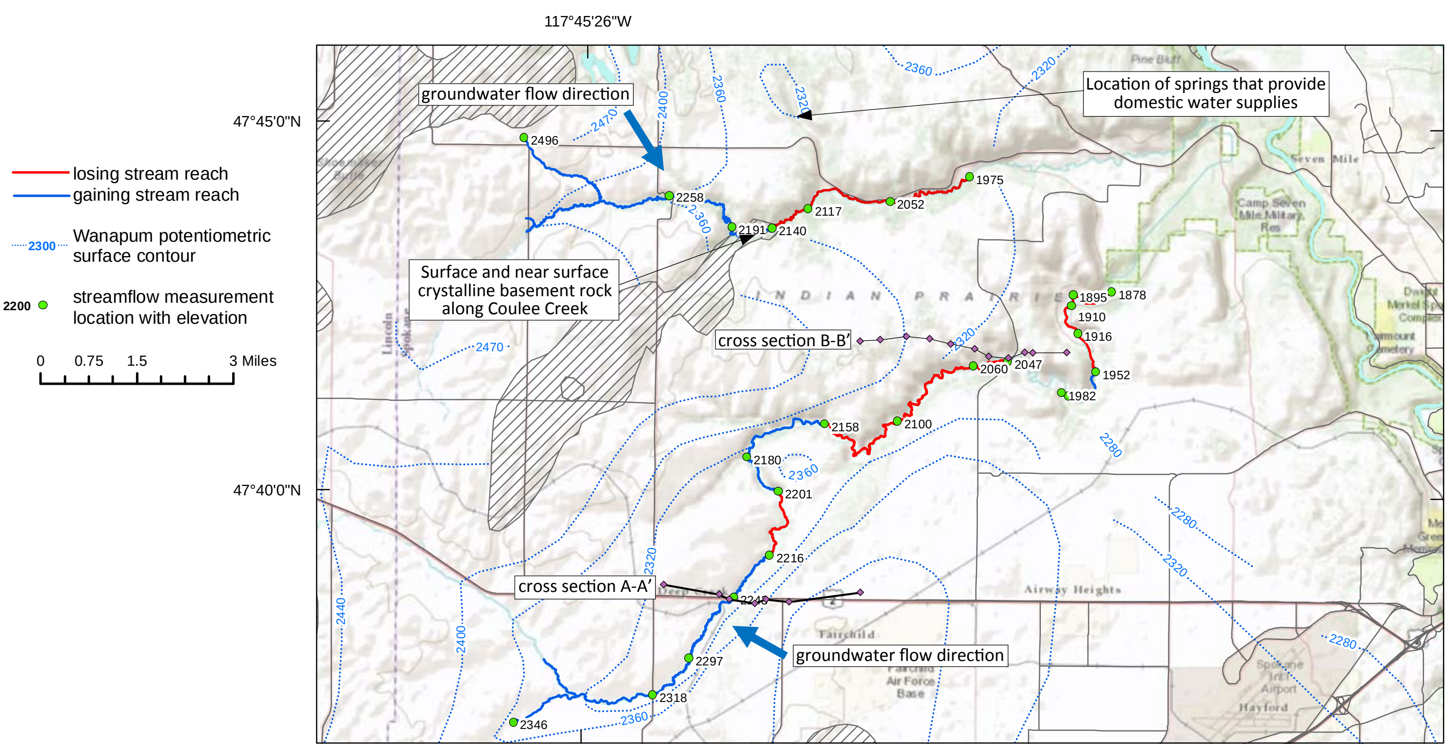

Figure 3— Deep Creek and Coulee Creek Seepage Run & Wanapum Aquifer Contours

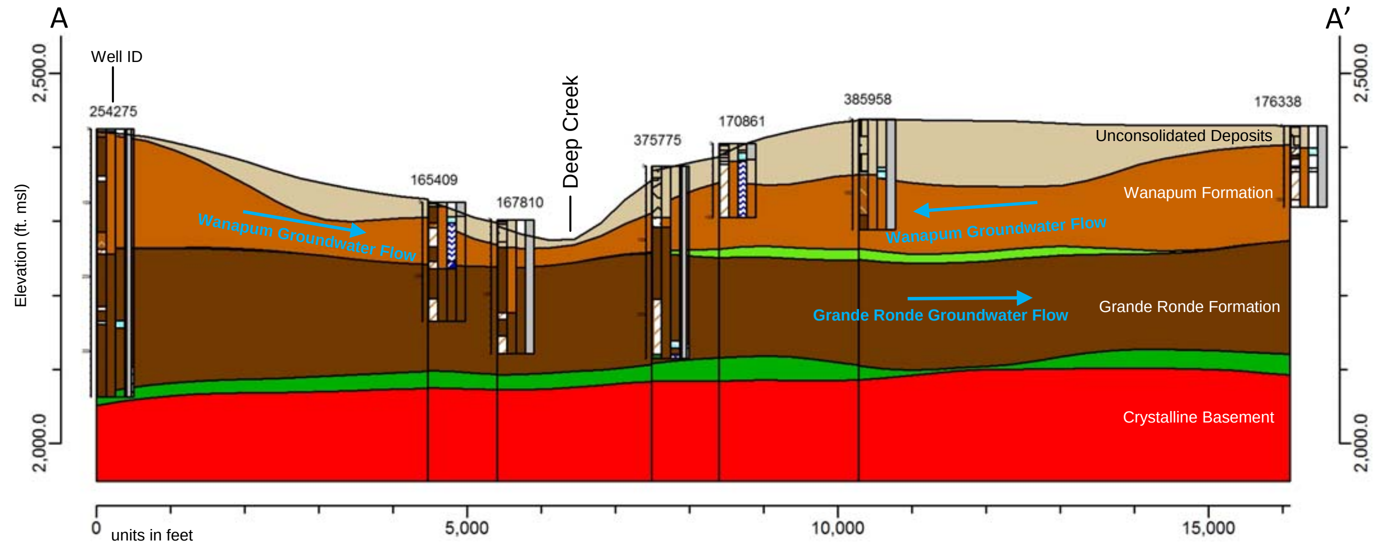

Figure 4— Geologic Cross Section A, Deep Creek Gaining Reach

note: Well ID refers to Ecology Well

Deep Creek Groundwater/Surface Water Interaction

The first four reaches of Deep Creek likely receive the majority of its flow from the Wanapum aquifer. The seepage run indicates the majority of stream flow that occurs in the upper portion of Deep Creek is gained in reaches 2 and 3. As shown in Figure 3 the Wanapum aquifer groundwater flow direction in the vicinity of reaches 2 and 3 is toward Deep Creek and the gradient in this location is relatively steep in comparison to other areas in the West Plains.

Figure 4 presents a cross section of the geology near the end of reach 3. The cross section was developed from stratigraphic surfaces developed as part of the *West Plains Hydrogeologic Database Project* (Spokane County Water Resources, 2011). The cross section shows two important hydrogeologic features in this location: 1) the potentiometric surface of the Wanapum aquifer is above Deep Creek, and 2) there is minimal unconsolidated deposits in the valley in which Deep Creek Runs. As a result of these features, the Wanapum aquifer is expressed as surface flow in Deep Creek. The Grande Ronde aquifer is also shown in Figure 4. The potentiometric surface of the Grande Ronde aquifer in this location is below the creek, and the flow direction is east.

In reaches 5 through 6 there area minimal gains and losses. The potentiometric surface of the Wanapum aquifer is between 150 and 180 ft. above Deep Creek in this area, and is likely disconnected and does not contribute groundwater to the creek. Surface springs can occur in this type of setting depending on the groundwater flow direction, but there are no visual indicators of springs such as flowing water, saturated soils, or vegetation,

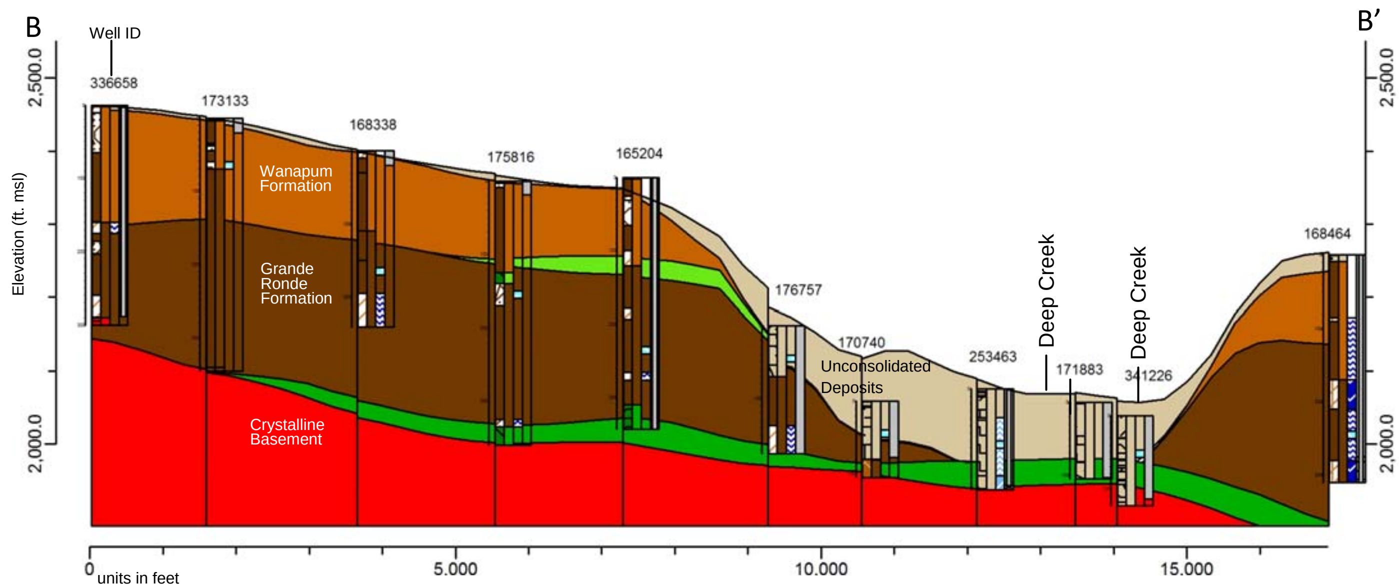

Figure 5— Cross Section B. Deep Creek Losing Reach

note: Well ID refers to Ecology Well Log ID such as cottonwood trees, that thrive in areas were groundwater is near the surface.

At reach 8 Deep Creek begins to lose water to the groundwater system. In this area the unconsolidated deposits are over 150 ft. thick in some areas, as shown in Figure 5. Water level measurements in wells adjacent to the creek indicate that the groundwater potentiometric surface is below the creek, and therefore the creek loses water through the unconsolidated deposits to the groundwater. Groundwater in the unconsolidated deposits may move laterally along the creek valley or vertically into the Grande Ronde aquifer which is also below the elevation of the creek in reaches 8, 9, and 10.

After a dry section of the creek the creek gains over 2 cfs in 1 mile. At this location the potentiometric surface of the Grande Ronde aquifer is at or above the surface of the creek (Figure 6) Also, at the beginning of reach 12 the valley becomes narrow, which may cause groundwater in the unconsolidated deposits to be expressed at the surface. There is limited water elevation data for the unconsolidated deposits in the vicinity of reaches 10, 11, and 12 so the interaction of the Grande Ronde aquifer, the unconsolidated deposits, and Deep Creek is not well understood. The reemergence of Deep Creek may be from the unconsolidated deposits or the Grande Ronde aquifer.

After reach 12 Deep Creek begins to lose water to the unconsolidated deposits and/or the Grande Ronde aquifer that underlie the creek. During most times of the year Deep Creek does not reemerge before the Spokane River.

Coulee Creek Ground/Surface Water Interaction

As with Deep Creek, Coulee Creek gains through its upper reaches and loses in its lower reaches. The potentiometric surface of the Wanapum aquifer is above the creek through out its entire length. At the beginning of reach 1 the potentiometric surface of the Wanapum aquifer is near the elevation of the creek; at the end of reach 6 the potentiometric surface of the Wanapum aquifer is over 300 feet above the surface of the creek (Figure 3).

The groundwater flow direction in the upper reaches trends toward the creek, but adjacent to reaches 4, 5, and 6 the groundwater flow direction moves toward a draw located on Coulee Hite Rd. Some residents along this portion of Coulee Hite Rd. utilize springs as their primary domestic water supply (shown in Figure 3). The springs are likely a surface expression of the Wanapum aquifer. There is no visual indication that water from the springs along Coulee Hite Rd. enter Coulee Creek, a conclusion which is supported by the seepage run data.

Another factor in the ground/surface water interaction of Coulee Creek may be surface and near surface crystalline basement rock that is present toward the end of reach 3. Throughout the West Plains surface and near surface crystalline basement rock extends above both the Wanapum and Grande Ronde basalt for-

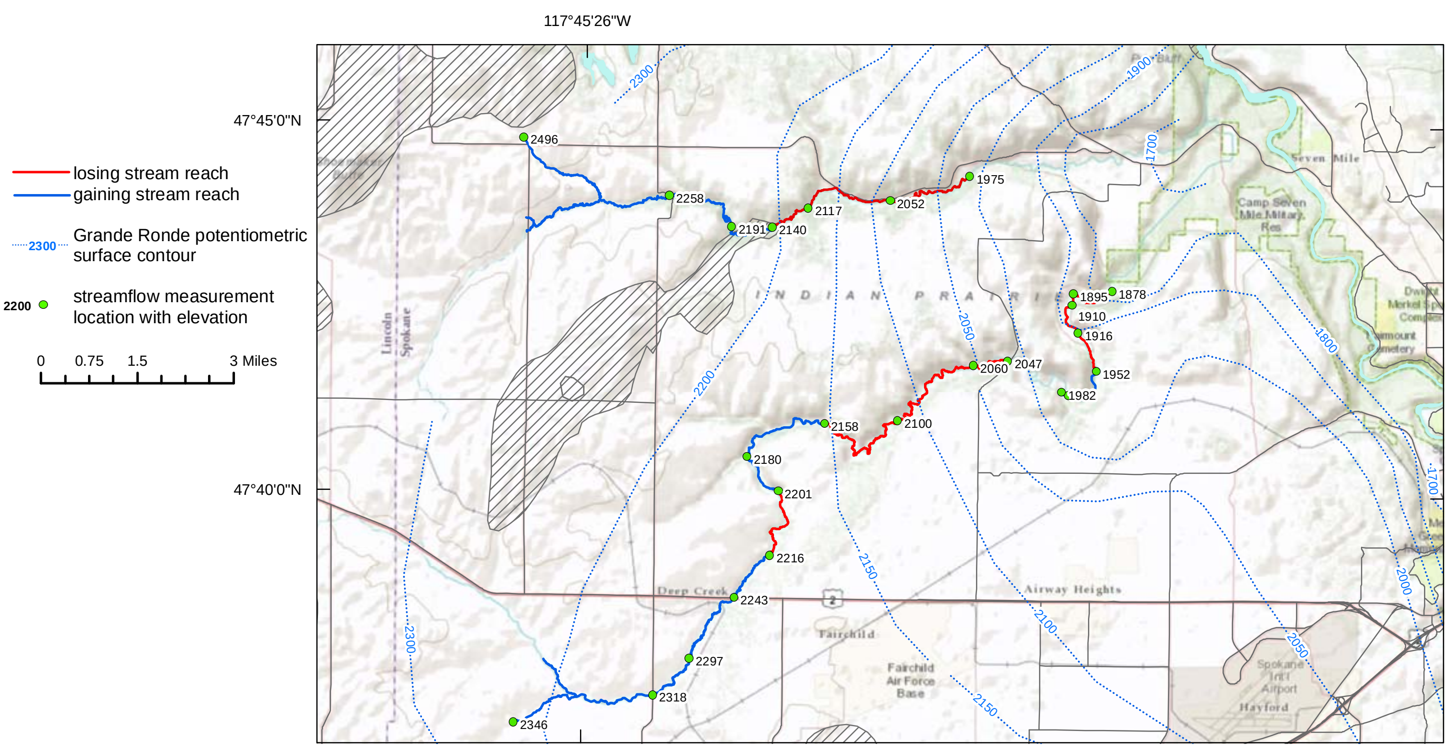

Figure 6— Deep Creek and Coulee Creek Seepage Run & Grande Ronde Aquifer Contours

mations, interrupting the continuity of the formation and the groundwater system. An area of surface and near surface crystalline basement rock begins near the end of reach 3 and extends southwest three miles. This crystalline basement may interrupt the Wanapum aquifer and change the groundwater flow direction towards Coulee Creek.

Throughout reaches 4, 5, and 6 the valley widens and the quantity of valley fill unconsolidated deposits increase. Throughout the last three reaches Coulee Creek infiltrates into the unconsolidated deposits until there is no longer any surface water. During most times of the year Coulee Creek does not reemerge before the Spokane River.

Summary and Conclusions

A seepage run was conducted on Deep Creek and Coulee Creek in the Fall of 2012. The purpose of the project was to gain a better understanding of the surface/groundwater interaction of each creek and the aquifers of the West Plains, and add to the limited amount of flow data available for each creek.

The maximum flow measured on Deep Creek was 2.16 cfs and on Coulee Creek was 0.59 cfs. Both creeks gained water in the upper portions of each creek basin, and infiltrated completely into unconsolidated material in the lower portions of each basin prior to the Spokane River. Deep Creek also completely infiltrated and reemerged in one other section of the creek. Approximately 9 miles upstream of the Spokane River where Deep Creek crosses Rambo Rd. the creek completely infiltrated and reemerged two miles downstream.

Both creeks likely gain water in the upper portions of each basin from the aquifers found in the Wanapum Basalt Formation, and lose water to the aquifers found in the Grande Ronde Basalt Formation and the unconsolidated material that overlie the Grande Ronde Basalt Formation. Since the upper portions of each creek are supplied by aquifers found in the Wanapum Basalt Formation, withdrawals from this formation can potentially impact flows in either creek. Also each creek is an important recharge mechanism for the aquifers found in the Grande Ronde Basalt Formation and unconsolidated materials located in the lower portions of each creek basin.

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