CITY OF SPOKANE

West Plains Geology & Hydrology

Stormwater Management Planning of the West Plains Subarea of Spokane

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4/11/2013

This report documents previous and ongoing studies of the unique geologic conditions and resulting variable drainage patterns of the West Plains area of Spokane County. The report also summarizes the political and financial realities of West Plains stormwater management. The West Plains is characterized by political boundaries and geologic features that have made comprehensive and regional stormwater management solutions difficult. This study compiles work from the last three decades into a written and visual synopsis of the issues the City of Spokane and other jurisdictions on the West Plains will have to manage while planning drainage in the area.

West Plains Geology & Hydrology

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1. Geological Conditions

The geology and hydrology of the West Plains Subarea of Spokane result from Eastern Washington's unique geological history of volcanic activity and immense floods. Except for a few hills—called steptoes—and other isolated areas, West Plains bedrock is covered by two layers of basalt from different periods of widespread volcanic flows. To varying degrees, silt, pebbles, boulders and other aggregate were deposited by cataclysmic floods during the last ice age, resulting in a fairly level surface covering a patchwork of underground aquifers, drainage channels, and differing bedrock levels.

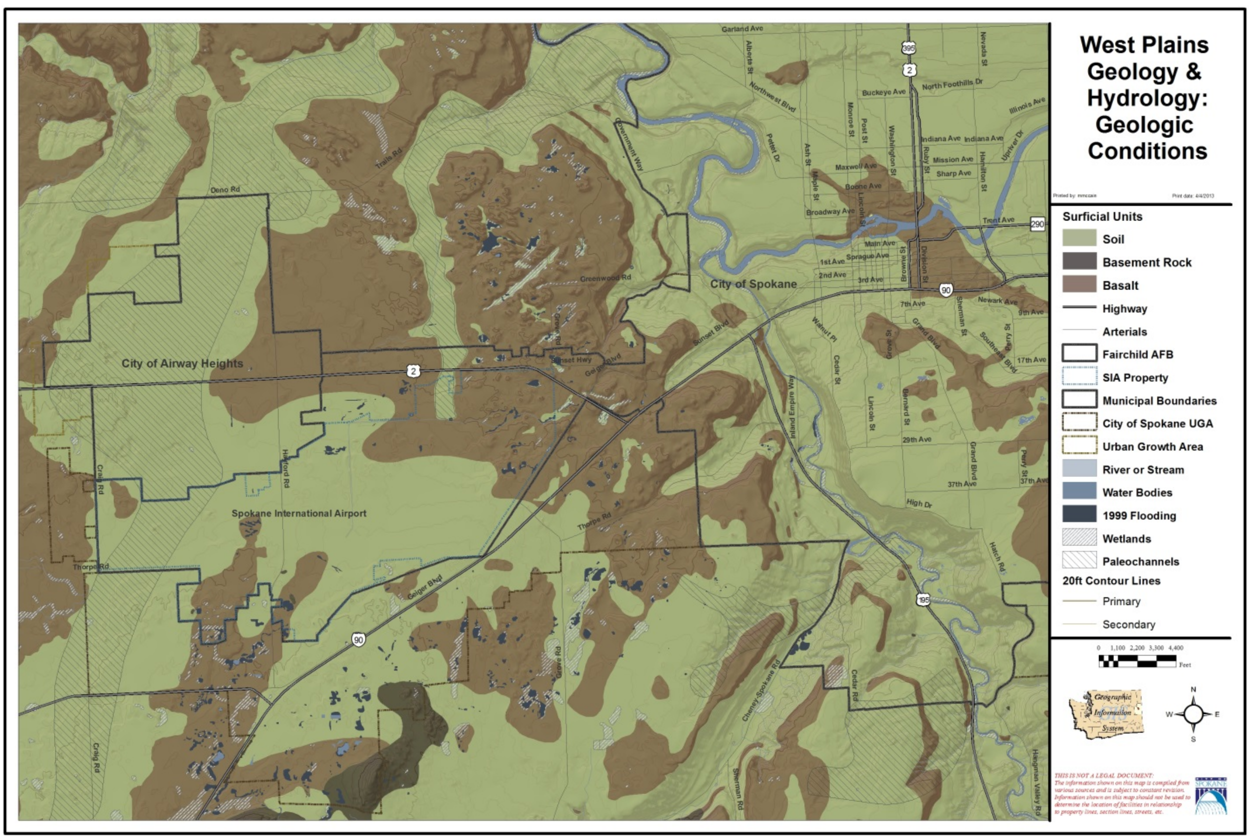


Figure 1: Engineering Firm Brown and Caldwell generalized a Surficial Unit Map from Washington State Department of Natural Resources

The West Plains gently slopes in a northeast direction toward the Spokane River. Many areas of the West Plains have shallow top soil covering impermeable basalt rock. Areas with very shallow basalt and basement rock usually contain numerous rock outcroppings and tend to be characterized by standing water and wetlands due to the impermeability of the rock below. Despite the gradual grade of the West Plains, the area is still too flat to effectively drain stormwater from areas with poor drainage, especially around Medical Lake and Cheney.

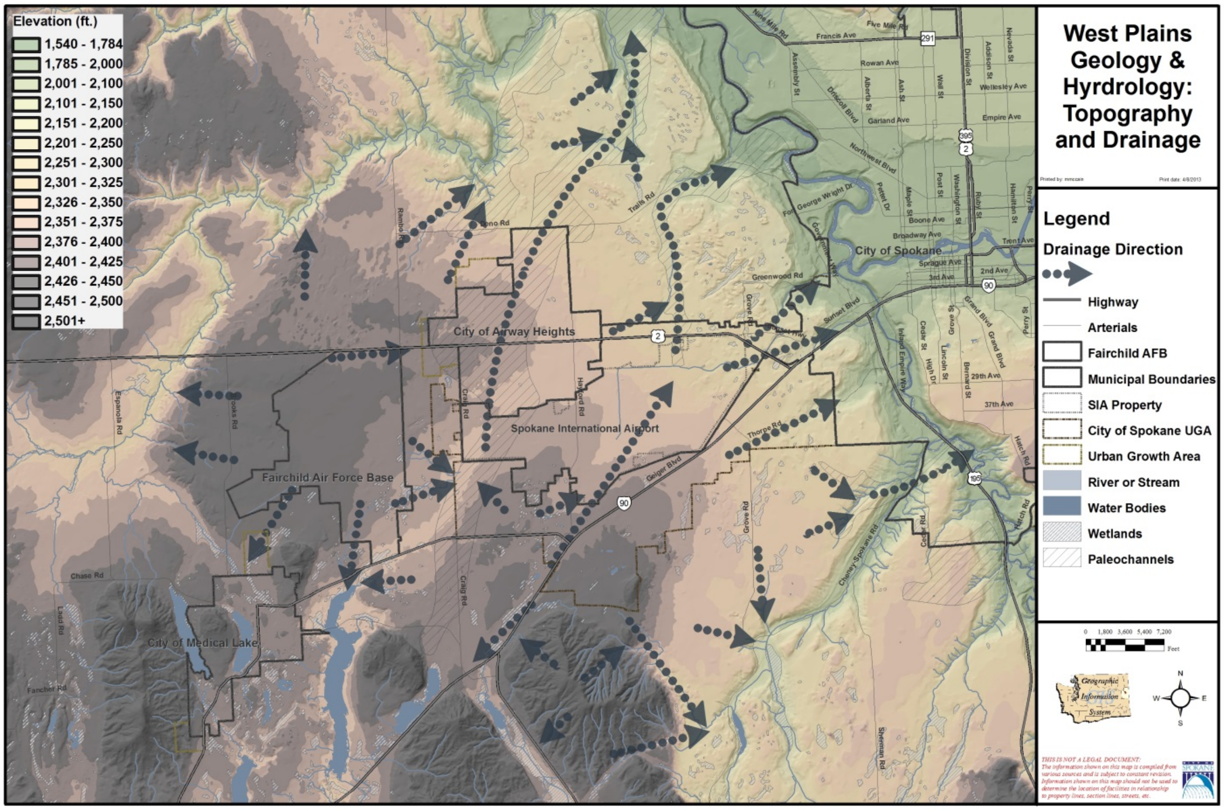


Figure 2: Topography and Drainage Directions on the West Plains

Geologists have found several underground drainage channels—called paleochannels—traversing parts of the West Plains, mainly in a north-south direction. Paleochannels are underground watersheds filled with aggregate. Water drains into the channels and slowly filters through the permeable material until it reaches a body of water in the Spokane River drainage system. Paleochannels are not readily apparent, but geologists use well data and seismic testing to detect their existence and path. Spokane International Airport directs most if its stormwater to a paleochannel starting north of Airport property near U.S. Route 2 and Spotted Road. A larger paleochannel has been discovered paralleling Craig road south of Airway Heights. This discovery is factored into recent ideas to address drainage challenges in the area. Two smaller paleochannels emptying further south in the Latah Creek watershed were mapped by URS Corporation and Brown and Caldwell for study commissioned by Spokane County completed in 2003.

2. Previous Studies and Proposals

Officials long ago recognized the potential for development in West Plains. The area is accessed by excellent transportation facilities including rail, Interstate 90, Spokane International Airport. Proximity to major employment centers like downtown Spokane and Fairchild AFB, also make it very attractive for home buyers and developers. For these reasons, Spokane County has been working for more than a decade to solve one of the biggest challenges to building on the West Plains—stormwater. Top soil across the area is generally shallow and impermeable bedrock is close to the surface. Occupants of numerous housing and commercial projects have firsthand experience with perennial flooding of basements and parking lots that result from developing in areas with poor drainage. Despite recurring drainage problems and several studies over the last two decades, the complexity of the geologic and political landscape of the West Plains has made a regional solution elusive.

Timeline of Studies

- 1990's: In depth geological data is generated for the West Plains, mainly by EWU faculty William Deobald and John Buchanan
- Late 1990's and early 2000's: URS Corporation, Brown and Caldwell, and Geoengineers hired by Spokane County to create a stormwater management plan for the West Plains. And interim solution is proposed to allow property owners to combine efforts to manage stormwater until a regional system is built.
- 2001-2003: Spokane County hires engineering firms URS Corp. and Brown and Caldwell to propose Stormwater Management solutions for the West Plains. The final report for that study, titled *Stormwater Management Plans for the West Plains Planning Area*[i], calls for linking drainage channels to SIA stormwater infrastructure, ultimately discharging to a paleochannel currently used by Spokane International Airport (SIA) that empties into Deep Creek area. SIA chooses to not be involved in the plan and does not allow non-SIA property to drain into its stormwater infrastructure. As a result, the plan is shelved (*See Figure 3).*
- 2006-2008: Renewed interest in a plan develops as further study of a north flowing paleochannel, starting south of Airway Heights and curving around the city's west side, continues. Solutions become focused on regional stormwater management facility in "Craig Road Sub-basin"
- 2008-Present: Spokane County is unable to

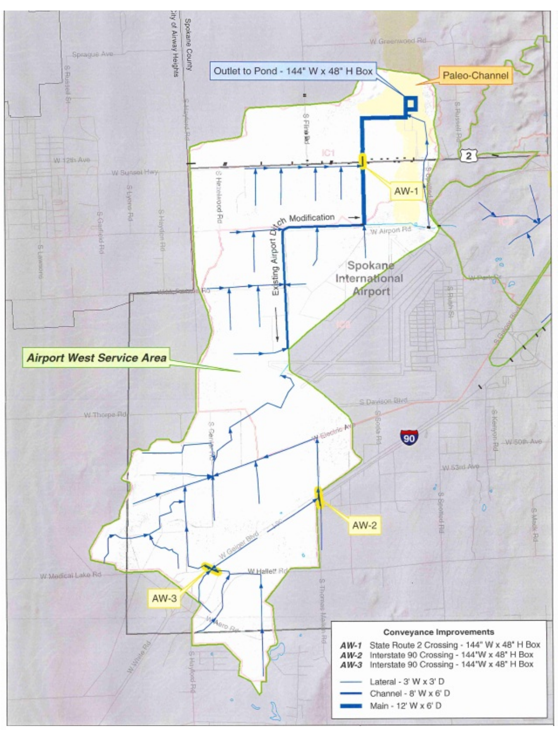


Figure 3: 2003 stormwater management plan using SIA infrastructure

acquire necessary land to tap into the Craig Road Sub-basin. Regional plans remain uncertain and developers continue to build a patchwork of onsite drainage systems. More detailed mapping of West Plains paleochannels is ongoing[ii].

Sub-basins

In the previously mentioned 2003 report, *Stormwater Management Plans for the West Plains Planning Area*, (henceforth called *2003 URS, Brown and Caldwell Plan*), engineers divided the West Plains into four basins—Deep Creek, Airway Heights, I-90, and Marshall Creek. The northern, western, and southern edges of the basins delineate a focus area for a previous study, but the area of concern for the City of Spokane is well within those borders. While the drainage basins of the West Plains are difficult to determine due to complex geology and generally flat topography, these borders provide a useful tool to physically and conceptually address stormwater issues. *Figure 4* below shows a fifth sub-basin called the Craig Road Sub-basin which is discussed on the next page.

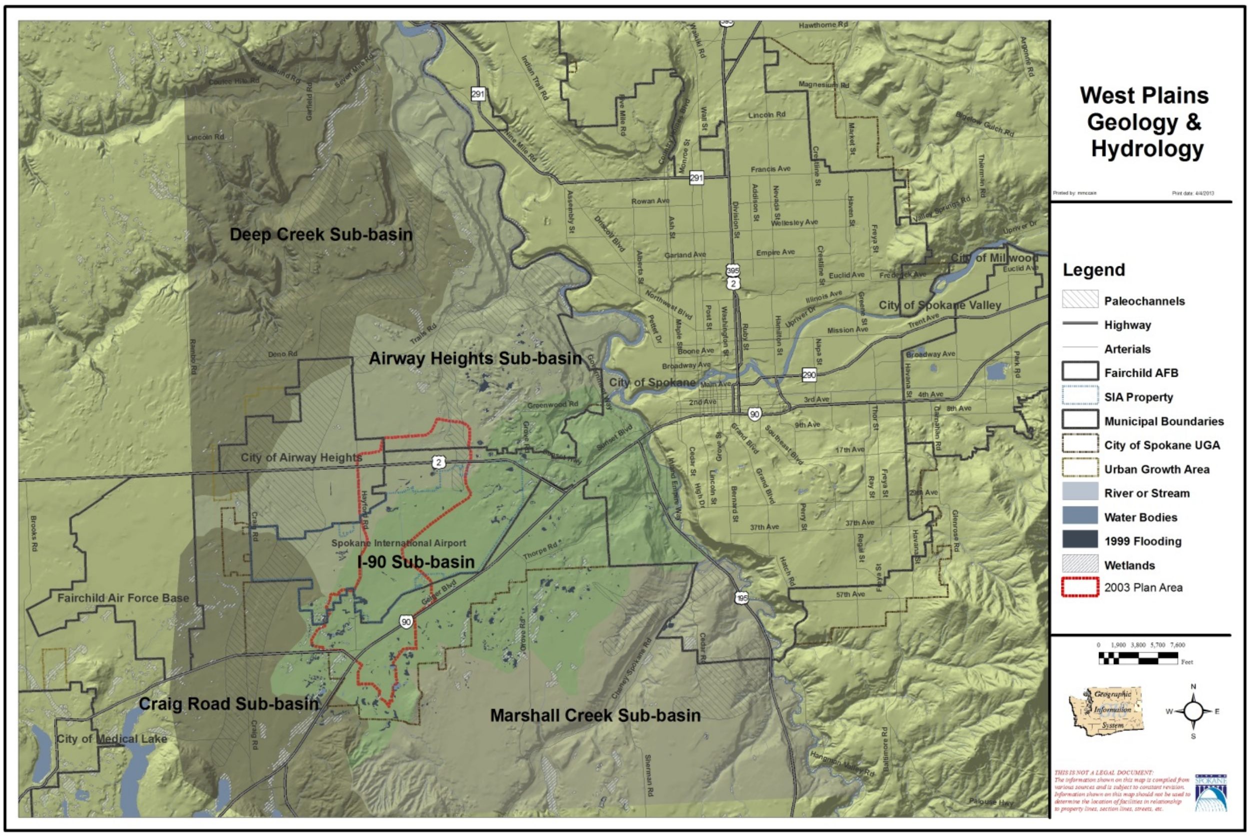


Figure 4: West Plains Sub-basins as defined by URS Corp. and Brown & Caldwell Engineers and the borders for the 2003 stormwater solution plan. The Craig Road Sub-basin was developed for this report for planning purposes.

Deep Creek Sub-basin

Stormwater in Deep Creek Sub-basin drains effectively. The *2003 URS, Brown and Caldwell Plan* discusses only minor drainage problems. Most of Airway Heights current Urban Growth Area is in the Deep Creek Sub-basin.

Airway Heights Sub-basin

Stormwater problems mainly exist in the eastern third of the Airway Heights Sub-basin and along the border with the I-90 Sub-basin.

I-90 Sub-basin

The I-90 Sub-basin experiences the most flooding due to shallow permeable soil, high water table, and high or protruding bedrock. The authors of the *2003 URS, Brown and Caldwell Plan* loosely divided the Sub-basin into two to further regions—East, generally east of the Airport, and West I-90—due to differing drainage characteristics. The Red line in *Figure 4* shows the solution area border of the *2003 URS, Brown and Caldwell Plan*. The plan mainly drains the West I-90 Sub-area, and while the authors are vague about the east-west divide, it can be assumed the eastern boundary line separates the basin.

East I-90 Sub-basin stormwater problems are characterized by seasonal “nuisance” flooding of some streets and basements. Seasonally high water table and undersized or blocked culverts or drainage ditches exacerbates flooding.

Drainage problems in West I-90 Sub-basin are more extensive and perennial than the eastern portion. Permeable depth to bedrock averages less than ten feet, but bedrock height fluctuates significantly, topping out above grade as rock outcroppings or dropping several “tens of feet” below the surface soil. Flat surface topography and rolling, but shallow bedrock prevents water from infiltrating or having an underground course to slowly drain elsewhere. As several commercial and large housing developments have experienced, managing stormwater in the West I-90 Sub-basin is difficult.

Figure 5: A Housing Development near the intersection of Hallet and Thomas Mallen Roads is located just north of a flooded area which is also depicted in the 1999 flood map in the *2003 URS, Brown and Caldwell Plan*. Flooding is characteristic of the West I-90 Sub-basin.

Much of the border of the City of Spokane and adjoining urban growth areas surround major problem areas within the I-90 Sub-basin. The proximity to I-90, SIA, and various rail links makes this sub-basin a desirable West Plains location for development, but the significant drainage problem must be addressed.

Marshall Creek Sub-basin

Located south of the Urban Growth Area, the Marshall Creek Sub-basin is relatively well drained.

Craig Road Sub-basin

While not designated in the *2003 URS, Brown and Caldwell Plan* as a sub-basin, the Craig Road Sub-basin could be an effective drainage destination for parts of the Western I-90 Sub-basin. A large paleochannel flowing south to north begins near the Highway 904 I-90 interchange, roughly paralleling Craig Road before it jogs around the city of Airway Heights. The eastern edge of the Craig Road Sub-basin should be defined by the spine of a wide shallow ridge west of the Highway 902/Medical Lake interchange of I-90. The ridge divides drainage between the Airport Paleochannel, and the Craig Road Basin/Airway Heights Paleochannel.

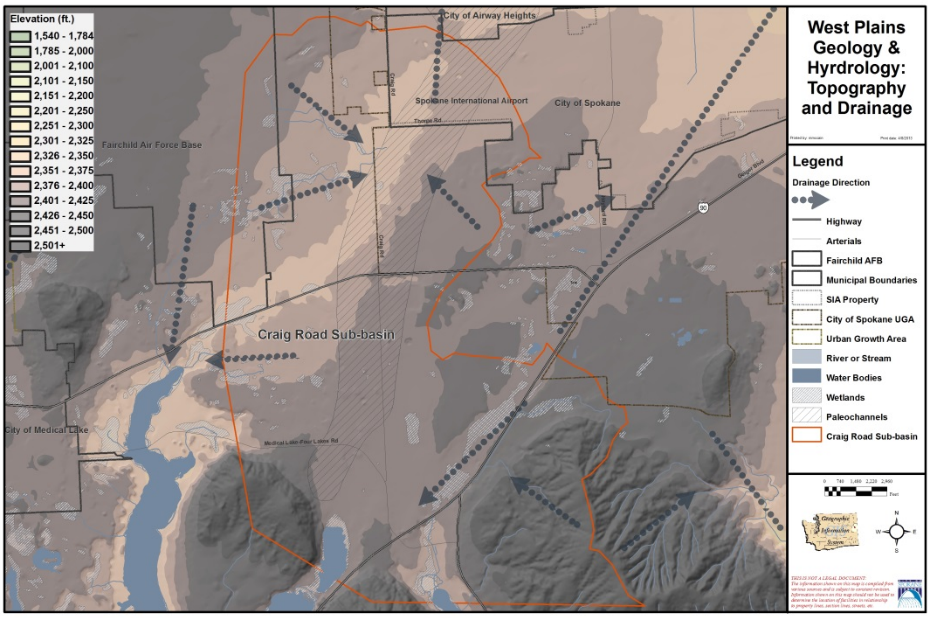


Figure 6: The Craig Road Sub-basin

3. Challenges/Opportunities

The geology, hydrology, and political realities of the West Plains are complicated, but enough momentum exists to overcome challenges and maximize the area's potential.

Geology

Paleochannels

Geologists hired by Spokane County have encountered several opportunities while researching drainage solutions for the West Plains. While impermeable shallow bedrock holds water near the surface, 5 paleochannels have been discovered that effectively drain water. SIA, for example, channels stormwater north into a paleochannel that flows toward Deep Creek.

Airport Paleochannel

SIA drains stormwater on its property to the Airport Paleochannel. As seen in *figure 3*, the first regional stormwater plan proposed funneling stormwater to SIA drainage infrastructure, which would connect a large area of the West Plains.

Spokane County has experienced several road blocks when trying to utilize the paleochannels drainage potential. SIA manages all of its own stormwater and would prefer not to have shared facilities. This reduces the geography available to transport stormwater since the airport has vetoed any plan to use or build infrastructure on SIA property.

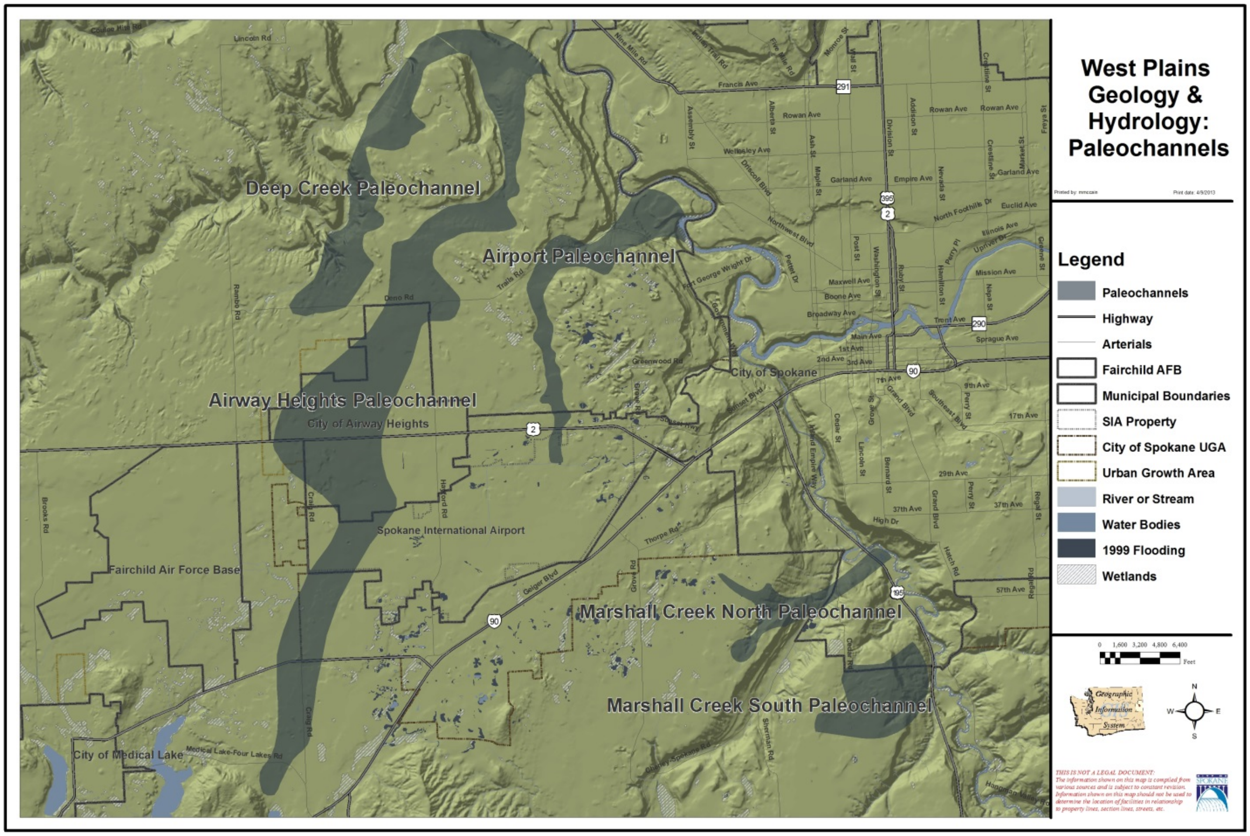


Figure 7: Paleochannels in the West Plains

Airway Heights Paleochannel

The Airway Heights Paleochannel runs through a limited strip of land between SIA and Fairchild AFB, and below Airway Heights municipal boundary, before draining into the Deep Creek basin. Much of the southern portion of Fairchild AFB is thought to drain into this Paleochannel.

After the *2003 URS, Brown and Caldwell Plan,* which recommended using SIA infrastructure to channel stormwater to the Airport Paleochannel, was shelved, the County focused on creating a regional drainage facility utilizing the Airway Heights Paleochannel, but was unable to acquire a suitable piece of land. Nevertheless, the paleochannel needs to be considered when planning for a smaller scale drainage facility for the Craig Road Sub-basin. A wide ridge of basalt, running south from SIA property and roughly paralleling Hayford Road, prevents gravity-fed drainage systems to the east from using the large Airway Heights Paleochannel, but a system west of the Medical Lake I-90 Interchange could utilize the natural drainage.

Marshall Creek Paleochannels

The *2003 URS, Brown and Caldwell Plan* depicts two small paleochannels on either side of Marshall Creek before the topography plunges into the Latah Creek Valley. The actual locations of these Paleochannels need to be further explored, as some engineering documents seem to slightly disagree with others. Nevertheless, the northern Paleochannel, while relatively shallow, should be considered as a possible drainage area for the I-90 Sub-basin. Topographically, this paleochannel might present an effective gravity-fed destination to drain large areas around I-90.

Thin Permeable Surfaces and Impervious Soils

Figure 8 below shows surface layers of permeable soil and aggregate less than 20 feet thick. Underneath the permeable layers are impervious layers of basalt and bedrock. Thinner pervious layers will hold water and flood more often.

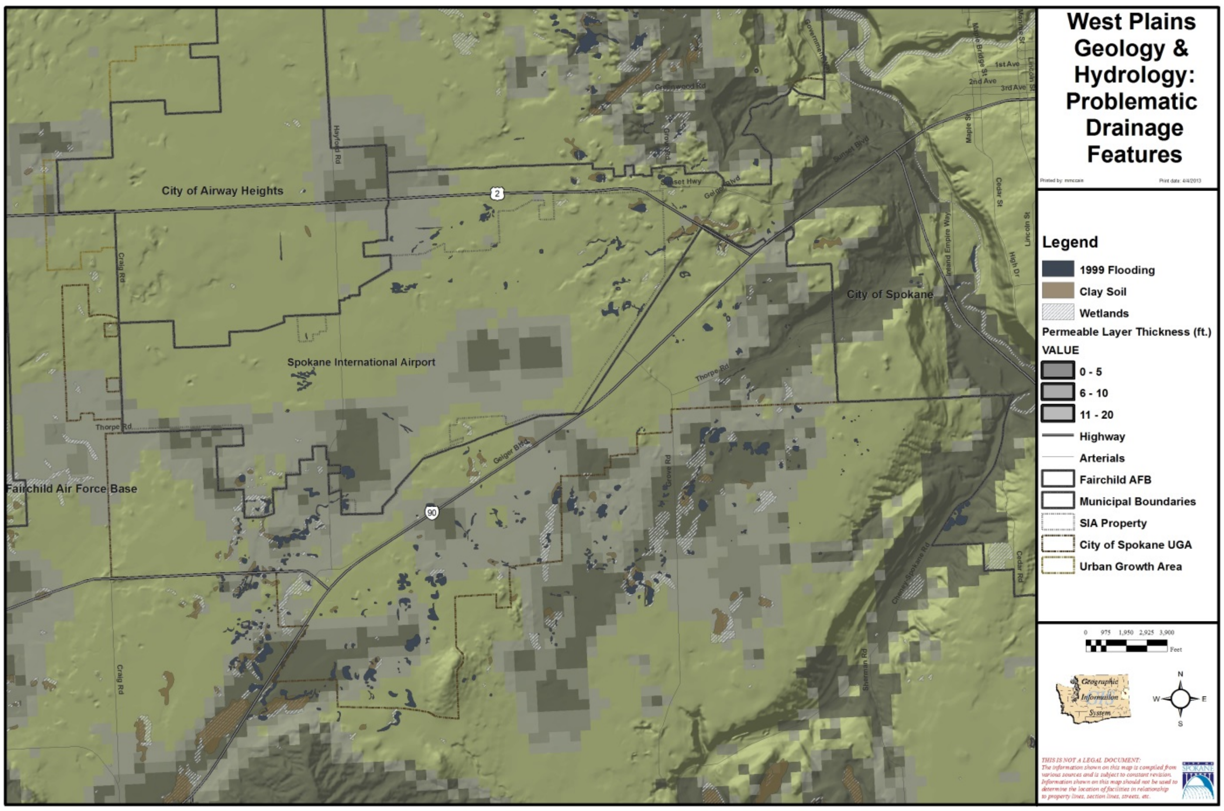


Figure 8: Poor drainage areas in the West Plains Sub-area. Clay, flooding, wetland buffers, and areas of shallow soil depict problem drainage areas.[iii iv]

The map also identifies areas with Clay soils. Clay has very poor drainage qualities and can act as an impermeable surface. Due to flat topography on the West Plains, evaporation is generally the only method water can escape areas with thin or clay soils. *Figure 8* demonstrates the general correlation between flat areas, thin/clay soils, and flooding and wetlands.

Hydrology

Flooding

Flooding is a frequent occurrence in the West Plains due to high water table and shallow bedrock. While limiting impervious surface is important, many areas already are naturally impervious. To the extent possible, these areas should be identified so stormwater treatment and development standards can be carefully managed.

Figure 9: Flooding on I-90 near the Medical Lake interchange

Engineers traced aerial photographs of flooding in 1999 for the *2003 URS, Brown and Caldwell Plan*. *Figure 8* above shows the flooded areas and wetlands. Flooded areas often result from poor drainage and are an easy identifier where problems will exist. Continued monitoring of flooding as development progresses is important.

Retention Ponds

Figure 10: Aerial photograph of Caterpillar stormwater retention pond, golf course intended to manage stormwater, and housing development with frequent flooding

Retention ponds are not an ideal solution for stormwater problems on the West Plains. In addition to being attractions for wildlife hazardous to aviation, they also attract mosquitos and can be aesthetically poor in design—two issues that will slow development. More importantly the large areas of land needed for the ponds detract from the development value of the land.

Retention ponds are inappropriate stormwater solutions in large swaths of the West Plains. Many current water retention facilities experience standing water beyond recommended time limits. The recently opened Caterpillar plant, seen in *Figure 10*, has a problem retention pond that does not properly drain and occasionally overflows.

Recreation Stormwater Solutions

A large housing development, seen in *Figure 10*, uses an adjacent golf course to manage stormwater. The results have been mixed due to equipment problems, continued flooding of nearby basements, and stormwater surges not corresponding seasonally with irrigation needs. Nevertheless, creative engineering, like using stormwater to irrigate a golf course, will improve the feasibility of the West Plains and create attractive amenities.

Water Conservation

Two aquifers sit below the West Plains, but the water contained is limited. Development in the area has led to a noticeable decline in existing well production. Engineers in the past ruled out directing stormwater into aquifers due to contamination concerns. However, aquifer recharge needs to be considered when drainage solutions are proposed.

Topography

While the West Plains is relatively flat, the gentle southwest to northeast slope provides some challenges. The most recently proposed solutions by the county focus on directing stormwater into the Craig Road Sub-basin. As demonstrated in *Figure 11*, a ridge starts on SIA property and rises to the south. The ridge separates the Craig Road Sub-basin from downward sloping grades to the east. Stormwater south of I-90 and east of the ridge would have to be conveyed against gravity to get to the Craig Road Sub-basin. The ridge is only 40 feet above I-90 at Spotted Road, but geography continues to drop to the east. The interchange of Route 2 and I-90, for example, is nearly 150 feet below the ridge. Engineering water over or through the ridge to the Craig Road Sub-basin is potentially cost prohibitive. As previously stated, the Marshall Creek Paleochannels might offer a solution.

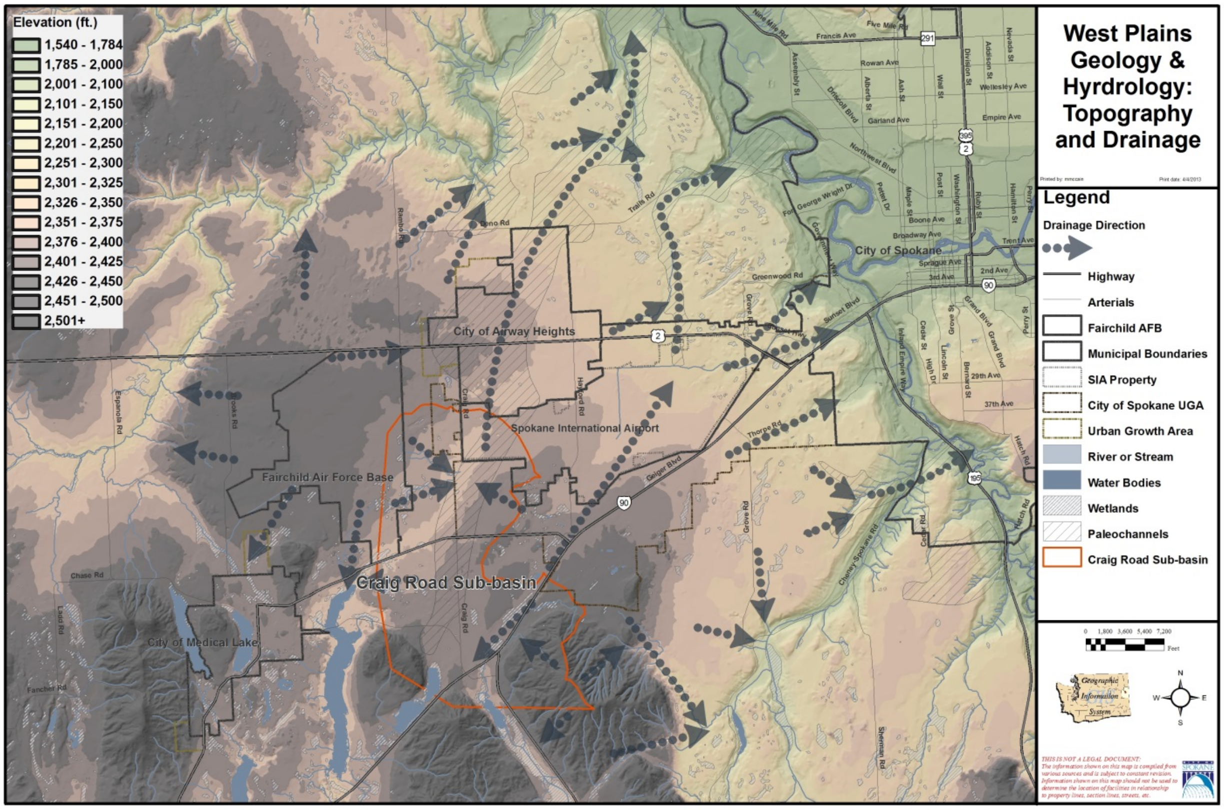


Figure 11: Land elevation on the West Plains and Watershed directions

Aviation

Spokane International Airport

SIA is largely independent from local governing authorities, and compared to nearby municipalities, has a much narrower mission and set of regulations it must adhere to. Airports, for example are discouraged by FAA advisories to allow non-airport property drain to stormwater onto airport land stormwater because it may attract hazardous wildlife. Nevertheless, the unique safety and land use needs surrounding an airport are always necessary to consider.

Fairchild Air Force Base

Fairchild is a very reliable partner in planning processes, but military bases are expected to keep high levels of self-sustainment and independence to ensure security and operability in emergency situations. The base has a stormwater management system in place and engineers to monitor the system. Base leaders must consider unique circumstances when choosing to join regional initiatives and municipalities on the West Plains should assume Fairchild will not participate in a regional stormwater solution.

Federal Aviation Administration (FAA) Recommendations

Waterfowl present real dangers to airport operations. According to FAA Advisory 150/5200-33B, in order to protect airport departure, approach, and circling airspace, the FAA recommends a five mile distance between the Airport Operation Area (AOA) and the nearest water management facility that can attract hazardous wildlife. Any surface stormwater management facility within the five mile radius is recommended to contain water no more than 48 hours after a storm incident and remain dry between rains. Furthermore, new or existing water retention facilities should be steep sided, engineered to limit surface water, or fenced to keep hazardous wildlife out. The FAA also discourages the creation of artificial wetlands or marshes within the five mile radius and airport. Using airport property to drain off-airport land is not recommended because doing so increases vegetation, attracting more wildlife. Washington State Transportation has adopted these recommendations for non-airport land.

Financial

According to a Spokane County engineer, complex geology on the West Plains creates a landscape where an effective stormwater solution for one development may have opposite results for another nearby. The intent of the *2003 URS, Brown and Caldwell Plan* was to build a regional stormwater system to replace the practice of approving a patchwork of small systems on a case by case basis. This has proved to be an elusive goal. The political reality prevents the 2003 study recommendations from implementation and the Craig Road Sub-basin solution would require extensive boring through basalt and/or pumping water against the natural slope. Engineers familiar with the plan note pumping stormwater against gravity or excavating for pipes and channels is probably cost prohibitive. Furthermore, SIA not contributing funds or infrastructure, as planners originally thought in the 2003 study, significantly lessens the finances available for a comprehensive solution.

A single regional solution is probably not politically or financially feasible, but a series of sub-regional systems that take advantage of existing topography and drainage into paleochannels is realistic. In the *2003 URS, Brown and Caldwell Plan*, engineers concluded 20 acres of land is necessary to infiltrate stormwater into the Airport Paleochannel from areas west of SIA (see *Figures 3* and *4*). Conversely, 800 acres of evaporation ponds is required to effectively manage water from the same area (see *Appendix*). The 2003 study concluded using paleochannels instead of evaporation ponds would save more than $2 million in construction and purchasing costs and require a fraction of the land (see *Appendix*). These numbers are based on the Airport Paleochannel and do not reflect the drainage abilities of the others.

Nevertheless, utilizing the several paleochannels under the West Plains may be the most cost and land efficient path to creating sub-regional systems. The *URS, Brown and Caldwell Plan* calls for draining a 4,228 acre (6.6 square miles) section, called Airport West Service Area (see *Figures 3* and *4)*. In this scenario, 20 acres of land and conduit infrastructure is required to drain 4,228 acres, far less land, according to the authors, than depending on evaporation ponds (see *Appendix*).

Stakeholders

Possible interested stakeholders in a comprehensive stormwater solution are the City of Spokane, Spokane County, City of Medical Lake, City of Airway Heights, Washington State Department of Transportation, SIA, Fairchild AFB, Spokane Tribe, Kalispel Tribe, developers, residents, landowners, and commercial/industrial companies.   As the West Plains develops and more small-scale stormwater solutions are created, the complexity of creating a regional system will increase as more and smaller groups of stakeholder build on the West Plains.

Role of the City of Spokane

The complicated hydrology and geology of the West Plains became an important issue for the City of Spokane after it annexed a large portion of land surrounding the airport. Most of the non-SIA property of the annex has easy access to the same paleochannel draining the airport. The Urban Growth Areas (UGA) which are planned for eventual annexation by the City, bordering both sides of I-90, have significant drainage issues with no easy means of conveyance. As the City continues to annex areas of the UGA on the West Plains, the incentive for Spokane County to create a regional stormwater solution will decrease. In order for economic goals of the annexation to be met, the City will have to play a leading role in forming a coalition of governments and stakeholders to find a comprehensive solution. Creating a Stormwater Special District will probably be one of the first steps. This is discussed later.

Urban Growth Areas

In early 2013, The Spokane County commissioners unanimously voted to extend the Urban Growth Area. Should these changes stand up to likely appeals, the UGA will eventually extend the borders of the Cities of Spokane and Airway Heights to Fairchild AFB. In addition, most of the area southeast of Grove and Thorp road was removed, while two small areas south of the current UGA and another north of Route 2 were added.

Anticipating these and future additions to the UGA is important to proper stormwater planning. Airway Heights, for example, may eventually grow east of Hayford Road, increasing the importance of the Airport Paleochannel as a possible joint stormwater solution between Airway Heights and Spokane.

4. Recommendations

The complexity of geology and political boundaries of the West Plains points away from a single regional system to several smaller systems. Solutions should be based on topography, geography, zoning, and land use.

Classify Areas

Sub-basins in *figure 3* provide a useful approach to dividing the regional systems. For example, the Airway Heights paleochannel can drain the Craig Road Sub-basin , while stormwater in the I-90 Sub-basin potentially can drain to the Marshall Creek Paleochannel if engineers find it to be a useful conduit.

Areas for development need to be targeted based upon best drainage. The Map in *Figure 6* provides useful information to determine those areas. Engineers compiled data from hundreds of wells connected in lines across the West Plains Subarea to create cross sections of the subsurface several hundred feet thick[v]. This data provides a comprehensive look at areas with thick drainable soils or

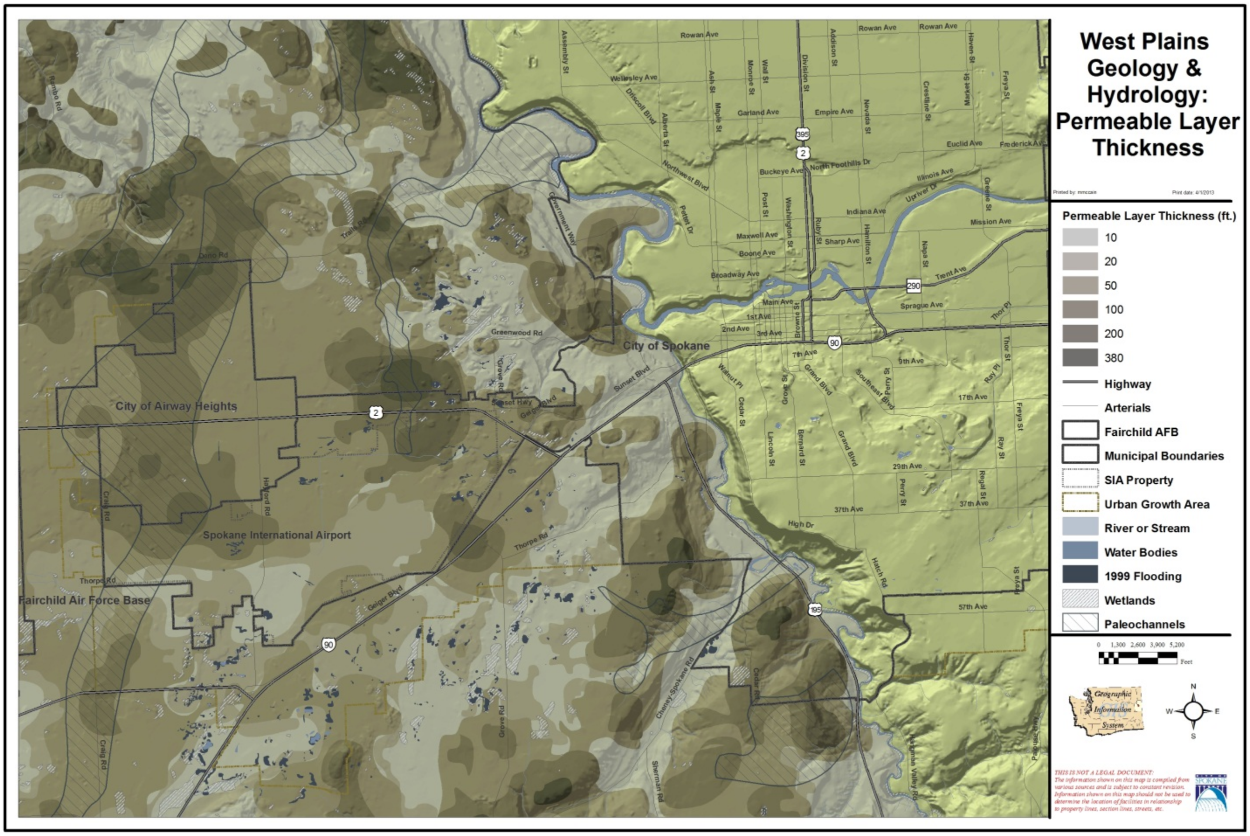


Figure 12: Thickness of permeable top layers. Except for clay, thicker topsoil, sediment, or aggregate results in better drainage. Map was traced and generalized from a more detailed map for clarity purposes. *Figure 5* reflects some of the detail of the original map.

aggregate. As f*igure 12* shows, areas of the map in dark shades of gray and brown represent thicker permeable layers. *Figure 12* also demonstrates the path of Paleochannels generally following sections of greater permeability.

Flooding and wetlands generally occur on light gray and brown areas. Dark gray to brown areas have the best drainage and could be targeted for the development of infiltration facilities.

Stormwater District

An intergovernmental special district to manage stormwater should be established to help pay development costs for the sub-regional systems. The State of Washington allows governments to create a Special Purpose District (SPD) focusing on drainage (Chapter 85.06 RCW), where only properties within the SPD boundary are taxed to pay for improvements. Dozens of drainage SPDs exist around the state of Washington, and most are established at the County level. Several governments can jointly create the SPD, which will increase the pool of revenue and produce better results for boundary-defying stormwater management.

Low Impact Development

Low Impact Development (LID) is an emerging development trend that, in the context of stormwater, emphasizes reducing impervious surface, while preserving or creating areas that serve historical drainage patterns. This is done though development practices that have the least impact on watersheds; catching and infiltrating water on site through bioswales, green roofs, and pervious parking; or creating new forests or wetlands. LID, whether using new or retrofitted infrastructure, can reduce efforts necessary for municipalities and property owners to effectively manage stormwater. However, results can vary substantially depending on geography. LID principles should be encouraged to lessen the negative impacts development will have on stormwater drainage, but the effectiveness will not be uniform throughout the West Plains. Areas with thin permeable soil over shallow bedrock (*see figure 12*) already pool water similar to an impervious parking lot. Many LID measures will be ineffective in mitigating stormwater problems in these areas.

Two approaches should be considered while specific land use regulations are developed. The first approach encourages building on existing well-drained areas where water will better infiltrate. The second option reserves highly permeable areas for draining larger stormwater systems.

The first scenario would produce quicker development, but could potentially make it more difficult to drain the vast sections with near-impermeable surface. Nevertheless, normal stormwater management features would work well in these areas.

The second approach would encourage development in poorly-drained areas and engineer stormwater to well-drained surfaces. This would fit into a regional LID method for the West Plains by building on poorly-drained surfaces and preserving the opposite for drainage. Secondly, required distances to move stormwater to perhaps dozens of carefully vetted retention/infiltration sites might be less than creating a few sub-regional systems. Lastly, fewer wetlands and flooded areas would exist near the airport by transferring stormwater from poor to well-drained areas.

5. Conclusion

The West Plains has a very interesting and complex geology that must be understood before development can prosper. More studies are needed of the water table, paleochannel, and drainage patterns, but geologist and engineers will soon be releasing more precise conclusions as the area is experiencing flurry of interest from geologists, developers, and municipalities. These studies will hone future planning, but enough information already exists to make smart development decisions that will maximize investments.

[i] *Final Report: Stormwater Management Plans for the West Plains Planning Area,* Prepared by URS Corp and Brown and Caldwell for Spokane County Utility, Feb 2003

[ii] Current Hydrology analysis compiled by Spokane County can be found at http://www.spokanecounty.org/WQMP/project54/asp/Home.asp

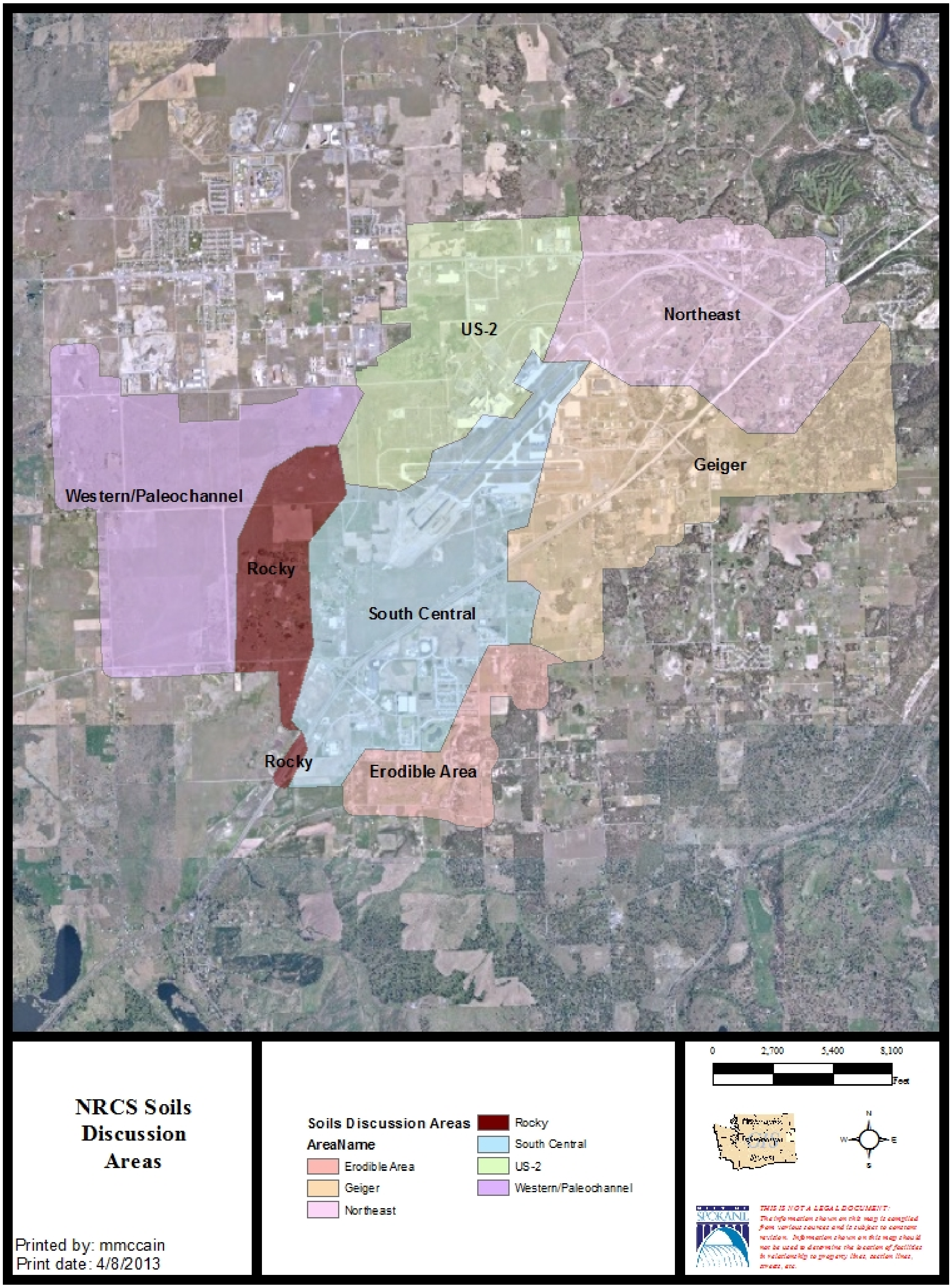
[iii] *1999 Flooding* in *Figure 5* is a trace of the 2003 trace of aerial photographs

[iv] *Clay* layer in Figure 5 comes from USDA, Natural Resource Conservation Service

[v] A document showing all the cross sections can be downloaded from http://www.spokanecounty.org/WQMP/project54/documents/Cross%20Sections.pdf

Appendix

1. Soils



US-2
Northeast
Geiger
Western/Paleochannel
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South Central
Rocky
Erodible Area
NRCS Soils Discussion Areas
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Soils Discussion Areas
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(a) The western area of the subarea is dominated by Cheney (CgB and ChB) and Cheney and Uhlig Silt Loams (CnB) over the Airway Heights paleochannel with some Cheney very rocky complex (CkC) and Bong and Phoebe fine sandy loams (BpB) on its western flank.

(b) The transition to the east of the Airway Heights paleochannel (the scabland area) is generally Cheney-Uhlig complex (CoB) with some Cheney and Uhlig silt loams (CnB), Cheney stony silt loam (ChB), and Cocolala silty clay loam (Cw and Cy) ephemeral wetlands.

(c) The south central area of consists mainly of Cheney and Uhlig silt loams (CnB) and Cheney gravelly and stony silt loams (CgB and ChB).

(d) The areas south and east of the intersection of Thomas Mallen and Hallett Roads includes erodible soil types including Dragoon silt loam (DrC), Dragoon stony silt loam (DsC), Reardan silt loam (RdB2), and Hesseltine silt loam (HoB), and Hesseltine gravelly silt loam (HrB).

(e) The area surrounding and to the south and east of the Geiger Interchange is dominated by Hesseltine stony silt loam (HsB) with some Cheney and Uhlig silt loams (CnB).

(f) The northeastern portion of the subarea is dominated by Hesseltine very rocky complex (HvC) with isolated Cheney and Uhlig silt loams (CnB), Hesseltine stony silt loam (HtB), and Hardesty silt loam (HhA).

(g) The area adjacent to US-2 transitions westward from Hesseltine extremely rocky complex (HxC) to Bong and Phoebe fine sandy loams (BpB) then to the Uhlig silt loam (UhA) and Cheney and Uhlig silt loams (CnB) that dominate the eastern part of the City of Airway Heights.

The Hesseltine series and the original type location are no longer recognized in Spokane County. The type location was moved to Stevens County in 03/2012 because that is the largest remaining acreage extent. Significant acreage (more than 71,000 acres) of the Hesseltine series and its associated phases (varying depth classes, surface stoniness - both on and in the soil, etc.) in Spokane County was remapped in the update (extensive revision) using numerous series. See United States Department of Agriculture. March 2012. Official Series Description – Hesseltine Series.

Others soil types may be searched by name at https://soilseries.sc.egov.usda.gov/osdname.asp. Maps from that search tool are from 2007, and still include Hesseltine soils.

2. On site retention compared to regional filtration*:

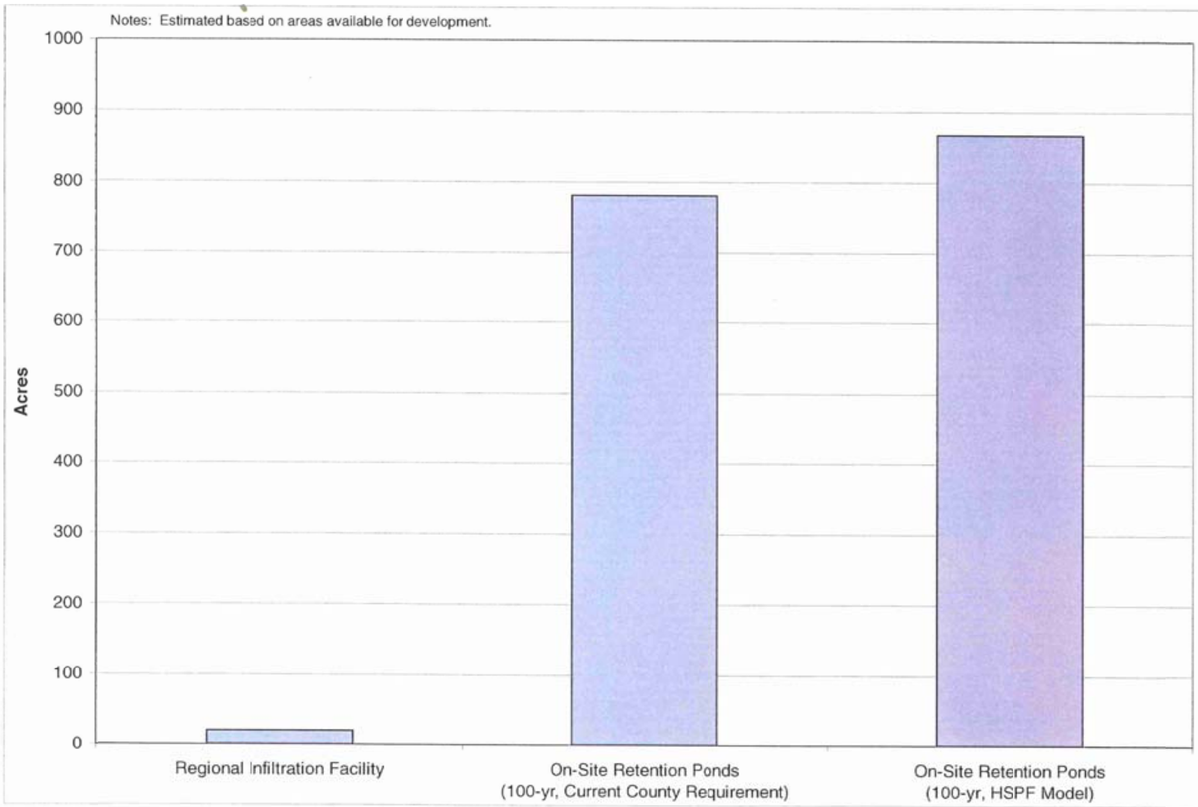

Figure 3-10 Total Surface Area - Paleo-Channel Infiltration vs. On-Site Retention

* *Final Report: Stormwater Management Plans for the West Plains Planning Area,* Prepared by URS Corp and Brown and Caldwell for Spokane County Utility, Feb 2003

3. Costs of On-site Retention and Regional Infiltration Facility*:

Table 3-5. Estimated Capital Costs of Structural Alternatives

West Plains Area Structural Alternatives	Total Cost	Cost Per Imperv. Acre	Regional Component /Public Share
Airport West Service Area:			
On-site Retention Ponds			
(100-yr, Current County Requirements)	$27,400,000	$52,000	NA
(100-yr, HSPF Model)	$30,700,000	$62,000	NA
Regional Infiltration Facility			
(20 iph, 5 ft deep)	$25,170,000	$12,000	$13,950,000
Garden Springs Creek Service Area:			
Channel/Culvert Improvements	$1,955,000	$14,000	$1,340,000
Indian Canyon Creek Service Area:			
Channel/Culvert Improvements	$2,825,000	$14,000	$1,900,000

* *Final Report: Stormwater Management Plans for the West Plains Planning Area,* Prepared by URS Corp and Brown and Caldwell for Spokane County Utility, Feb 2003