Subwatershed Planning

Americana and
Main Street Subwatersheds
Ada County, Idaho

June 29, 2016

Prepared for:
Ada County Highway District and Partners for Clean Water

Prepared by:
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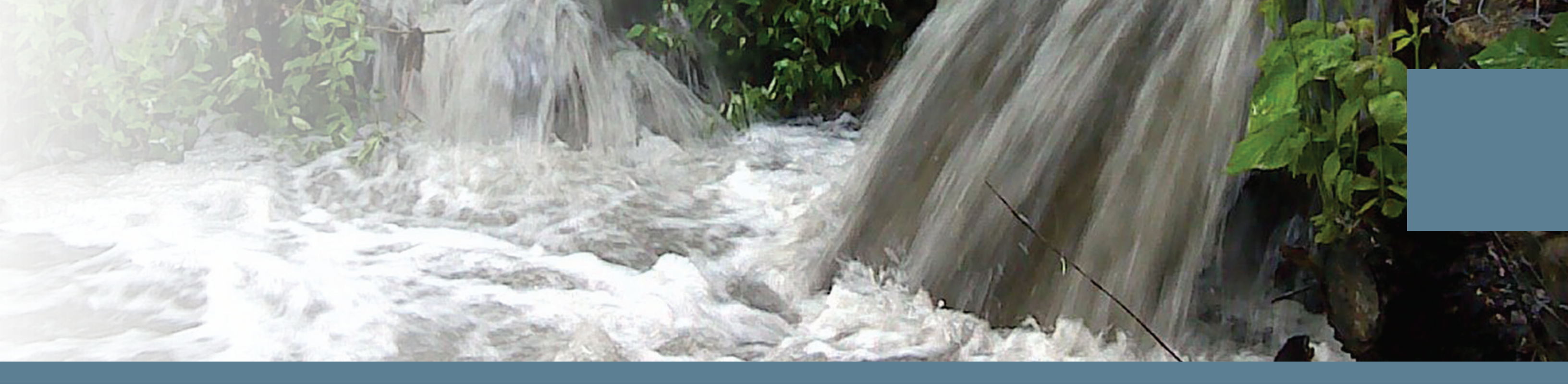
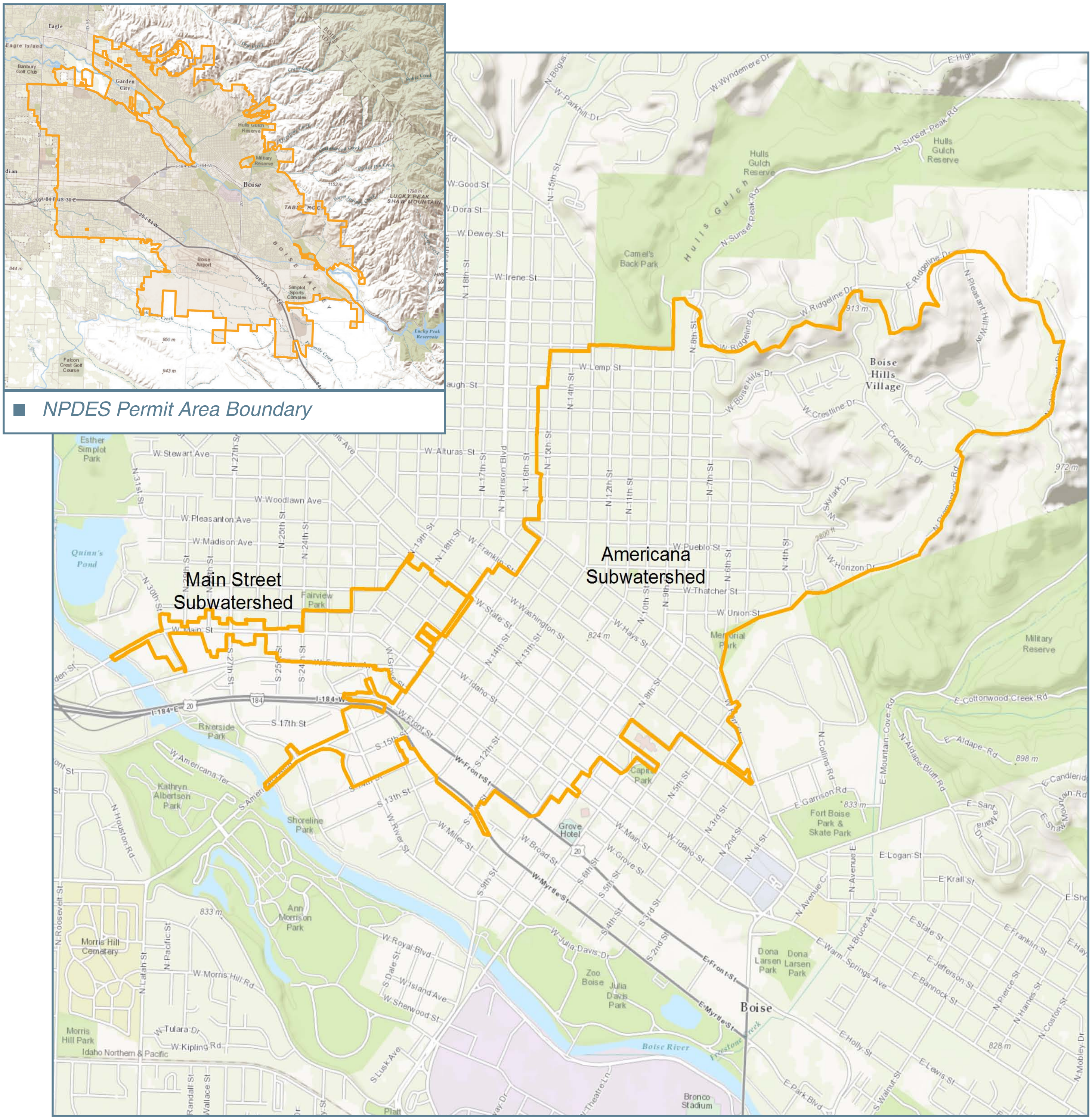
Contents





■ NPDES Permit Area Boundary

■ Project Area Map - Americana and Main Street Subwatersheds. Boise, Ada County, Idaho.

Americana and Main Street Subwatersheds

Stormwater events in the subwatersheds

Subwatershed Planning

Executive Summary

The goal of the Subwatershed planning project is to develop strategic subwatershed-scale plans for the Main Street and Americana subwatersheds. The plan prioritizes areas to implement Green Stormwater Infrastructure (GSI). GSI, when implemented, will reduce stormwater runoff and pollutant loading to the Boise River (the two subwatersheds' receiving waters).

Often, GSI is implemented opportunistically based on a willing landowner or as part of a redevelopment or new development project, or recommended through regulation. This project aims to be proactive in GSI implementation by setting forth a process based on quantitative data for determining appropriate locations for GSI within the project area. The prioritization process described in this project is replicable in other subwatersheds within ACHD's and their co-permittees (permittees) purview. Additionally, the GSI prioritization method is flexible, allowing project managers to optimize opportunities for implementation as they arise.

The subwatershed planning project fulfills a portion of permittees NPDES Permit (IDS-027561), specifically section II. A. 4 of their Storm Water Management Program Requirements (EPA 2013).

The Main Street and Americana subwatersheds are located in Ada County and both are within the City of Boise. The two subwatersheds drain to the Boise River, and their outfalls contribute pollutant loads to the river. The two subwatersheds differ in size and land use configuration. The Main Street Subwatershed is approximately 79 acres, of which 51 acres (65%) is commercial land use. The Americana Subwatershed is roughly 960 acres, of which 584 acres (61%) is in a residential type land use category (residential high, medium and low). Such differences in size and land use effect stormwater runoff and pollutant loads.

Subareas, the land surface that drains to a stormwater structure (e.g. catch basin), of the subwatershed's were delineated in ArcGIS. The Main Street Subwatershed contained 35 subareas (used in analysis - see subarea results for more information). The Americana Subwatershed is home to 393 subareas (used in analysis - see subarea results for more information). These subareas were prioritized for GSI implementation by categorizing them into high priority, moderate priority, and low priority classes. Subarea prioritization was based on quantitative data derived in PCSWMM, a stormwater modeling software package, as well as other pertinent data related to successful GSI such as groundwater depth, and percent Right-of Way. Project pitfalls (groundwater contamination) to GSI implementation and capitalizing on opportunities (redevelopment) are also factored into the final prioritization.

The prioritization methodology identified 8 subareas in the Main Street Subwatershed as high priority and 57 subareas in the Americana Subwatershed as high priority. Important considerations for successful GSI implementation are discussed in the document. These considerations are primarily based on ACHD's and the City of Boise's stormwater management guidelines and best management practices.

Introduction

The Subwatershed Plan project fulfills a portion (II. A. 4) of ACHD and their co-permittees (permittees) NPDES Permit's (IDS-027561) Storm Water Management Program Requirements (EPA 2013). The Main Street and Americana subwatersheds are located in Ada County and are both within the City of Boise. Both subwatersheds drain to the Boise River, and their outfalls contribute pollutant loads to the river.

The goal of the Subwatershed planning project is to develop strategic subwatershed-scale plans for the Main Street and Americana subwatersheds that prioritize areas to implement Green Stormwater Infrastructure (GSI) which when implemented will reduce stormwater runoff and water quality impairment to the Boise River (receiving waters).

The objectives of the subwatershed planning process are to:

1. Meet the requirements outlined in the permittees' USEPA NPDES MS4 Permit, No: IDS-027561, primarily section II.A.4. (EPA 2013)
2. Define the existing conditions of the Main Street and Americana subwatersheds.
3. Delineate subareas within the two subwatersheds.
4. Select and run a model that quantifies pollutant loads discharging from the subareas within the two subwatersheds.
5. Create a prioritization methodology, based on model results and other pertinent data, that rank subareas in terms of importance for Green Stormwater Infrastructure (GSI) implementation.
6. Ensure prioritization aligns with permittees redevelopment and transportation plans.
7. Create subwatershed plans that are available to a broad audience and facilitate implementation of GSI within the two Main Street and Americana Subwatersheds.

The subwatershed plan development process relies on model data to inform prioritization of subareas for GSI implementation. It must be stated the modeling effort for this project is not a regulatory requirement but rather is strictly voluntary to assist the subwatershed planning process. Existing GSI projects that the permittees have installed or will install as a result of this project are evaluated separately using onsite monitoring and modeling techniques specific to those projects.

Existing Conditions and Subwatershed Characterization

Introduction

This section provides a thorough understanding of the subwatersheds, their characteristics (land cover, land use, outfall flows and water quality), subareas, priority aquatic resources and beneficial uses. This section also provides an overview of the available GIS data and a synthesis of existing plans that govern stormwater management within the two subwatersheds.

Project Goal

The goal of the ACHD Subwatershed planning project is to develop strategic subwatershed-scale implementation plans for the Main Street and Americana subwatersheds that provide direction on how and where to reduce stormwater runoff and water quality impairment to the Boise River (receiving waters) using Green Stormwater Infrastructure (GSI).

Geographic Information System Data & Background Information

Geographic information system (GIS) data is an important component of the subwatershed planning process. GIS data provides the medium from which to derive the subareas of each subwatershed as well as the metrics to perform modelling of pollutant loads. Existing (created prior to project initiation) and derived (created during the course of the project) GIS data have been compiled into two geodatabases: Main Street Subwatershed and Americana Subwatershed. Table 1 lists the data layers found in each database and notes regarding where data was compiled from and the differences between the two subwatersheds.

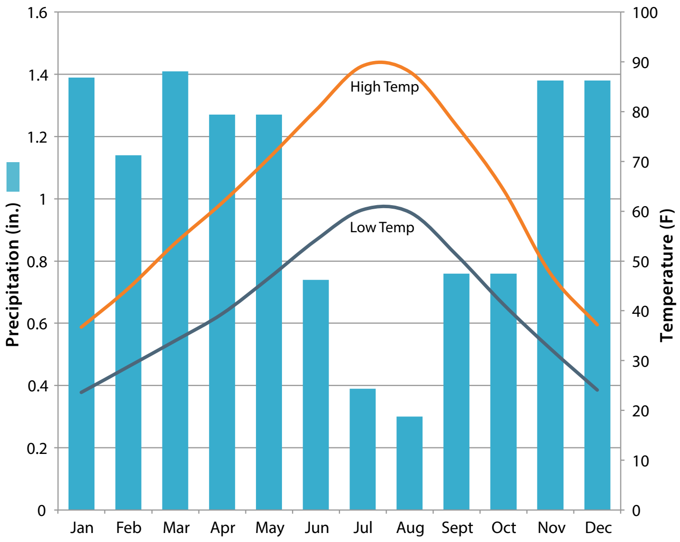
Climatic Conditions

Boise resides in a semi-arid climate, marked by hot dry summers and cold winters. Rainfall is generally infrequent and light with an average of 12 inches per year (Figure 1) (NWS 2014). Snowfall occurs between November and March averaging approximately 19 inches per year (US Climate Data). Climate is an important factor when implementing GSI, especially in an arid climate like Boise. For example, plant selection for GSI installations should consider tolerance for drought conditions, periods of infrequent inundation, extreme heat, and winter conditions including snow cover and freezing (Washington State Department of Ecology 2013).

The quantity of precipitation and seasonal distribution must be understood prior to implementing any model and such data is integral to modelling accuracy and precision. The intensity, duration and frequency curves for precipitation events within the project area are shown in Figure 2. ACHD's continuous flow and rain measurement data for Americana and Main Street subwatersheds provides a more discrete foundation for understanding the climatic conditions in Boise, as the continuous data provides real-time background flow and storm water runoff response to storm events (Brown and Caldwell 2014a). The continuous monitoring data is integral to the modeling phase of this project.

Existing Plans

Existing documents that govern stormwater management and GSI within the Municipal Separate Storm Sewer System (MS4) that discharges to the Boise River are summarized in Figure 3. The documents ensure that ACHD and other Permittees

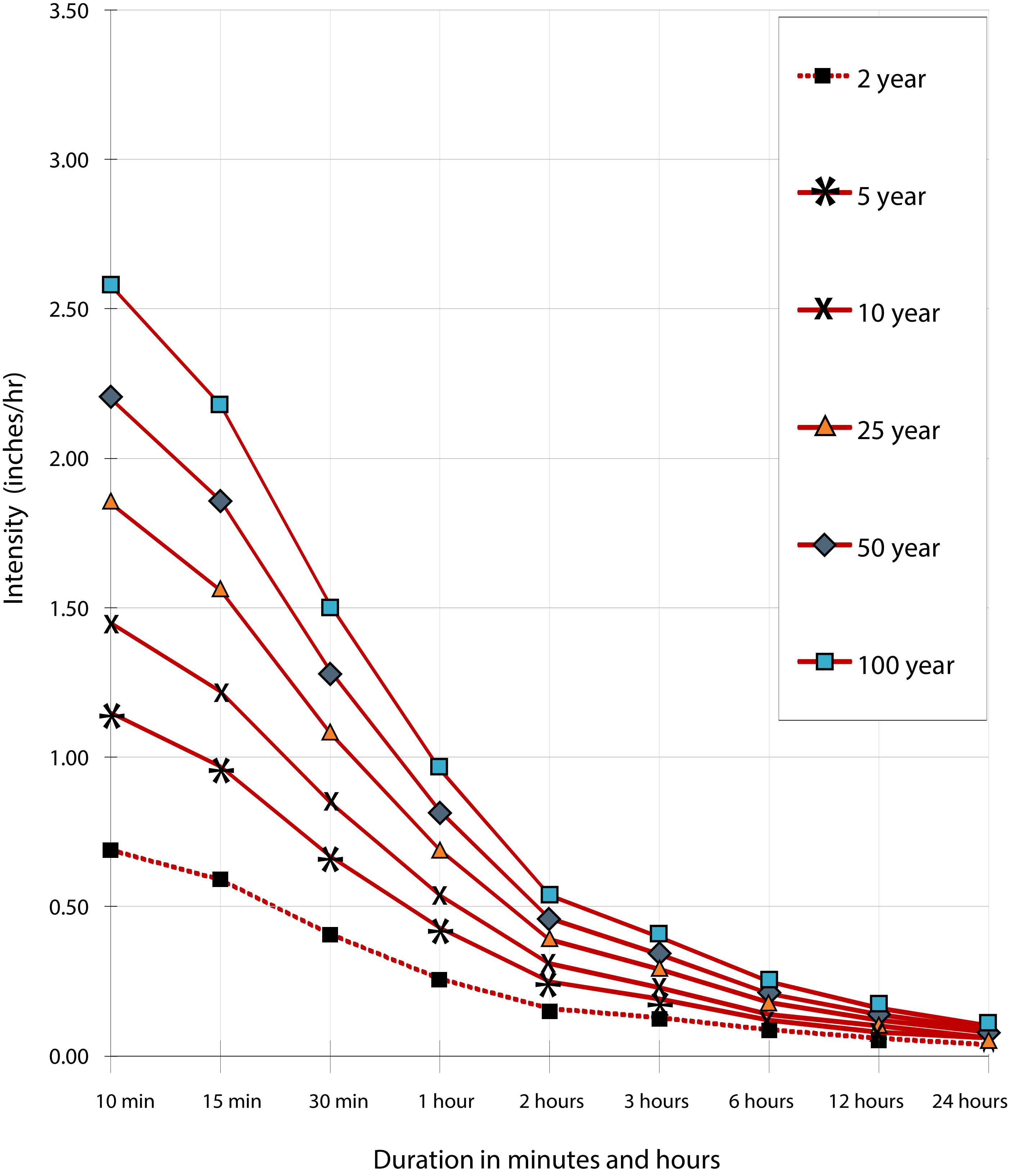


■ *Figure 1. Boise Climate Data (NWS 2014)* are in compliance with their National Pollutant Discharge Elimination System (NPDES) permit (No. IDS-02756-1). The NPDES permit outlines how the co-permittees must work together to reduce pollutant loads to the Boise River as well as many other aspects of controlling stormwater within Boise and Garden City. Many of the documents in the matrix below can be found on the Partner's for Clean Water website (http://www.partnersforcleanwater.org/), ACHD's website (http://achdidaho.org/Departments/TechServices/Drainage.aspx) and the City of Boise's website (http://publicworks.cityofboise.org/services/water-quality/stormwater/). ACHD, The Partners for Clean Water, and the City of Boise websites provide fact sheets and synopses of the documents in Figure 3.

These documents provide insight into the feasibility of GSI opportunities within the Americana and Main Street Subwatersheds. In general, the Boise City/Garden City Area MS4 NPDES Permit (No. IDS-027561) governs and guides the permittees' actions regarding stormwater in the project area. Subsequent documents (e.g. Phase I Stormwater Management Plan, Storm Water Outfall Monitoring Plan, and NPDES Phase I Annual Storm Water Monitoring Report for 2014) were developed to document program compliance.

■ *Table 1. GIS Data per Subwatershed (available in Geodatabase format).*

Data	Main	Americana	Notes
Subwatershed Boundaries	X	X	Subwatershed boundaries were provided by ACHD Staff.
Land Cover	X	X	Nine class Urban Tree Canopy (UTC) data
Parking Lots	X	X	Clipped from UTC to extent of each subwatershed
Building Foot Prints	X	X	Clipped from UTC to extent of each subwatershed
Tree Canopy	X	X	UTC data
Parcel Ownership	X	X	UTC data
ACHD Right-of-Way	X	X	From ACHD
NHD Data	X	X	Boise River and Boise City Canal
NPDES Permit Area	X	X	NPDES Permit boundary
Storm Drain Structures	X	X	From ACHD
Storm Drain Pipes	X	X	From ACHD
Ponds	-	X	No ponds occur in the Main Street Subwatershed
Wetlands	X	X	Under bridges confined to Boise River Channel
Floodplains	X	X	FEMA designated floodways and flood zones
Lidar	X	X	Partial Lidar dataset for Americana
Street Centerlines	X	X	ACHD Data
2ft Contour Lines	-	X	Only Americana subwatershed used to create Digital Elevation Models (DEM) (Ada County)
Sub Areas	X	X	68 sub areas in Main St; 684 sub areas in Americana
GeoPDFs	X	X	PDFs from ACHD detailing flow dir. and no outlet areas
2ft Contour Line DEM	-	X	Derived using 2ft Contour Lines



■ *Figure 2.* *Precipitation intensity, duration and frequency for Boise (ACHD 2015)*

	Stormwater Subwatershed Planning Element			Jurisdictional Purview	EPA Permitting	Water Quality	BMP Structural and Non-Structural	Stormwater Infrastructure	Green Stormwater Infrastructure (GSI)	Revegetation	Modeling	Monitoring	Flooding
	Subwatershed Planning Document	Date	Author	*Jurisdictional boundaries, MS4 Permittee requirements, annual action items*	*Document assists MS4 permittees in meeting NPDES permit requirements*	*Describes water quality standards or provides data on MS4 outflows and pollutant loads*	*Describes Stormwater BMP installations, design, efficiencies, and problems*	*Describes stormwater infrastructure or problems with existing infrastructure*	*Addresses aspects of GSI, allowable interventions, standards and potential flow and pollutant load reductions*	*Addresses revegetation for GSI and non-GSI stormwater infrastructure*	*Addresses aspects of stormwater modeling and, pollutant/flow reductions from BMPs and GSI*	*MS4 permittee outfall/ stormwater monitoring data, requirements or procedures*	*Addresses potential flooding areas within the MS4, locations and causes*
1	Preliminary Hydrologic & Hydraulic Analysis for the Downtown Boise Master Drainage Plan	2000	Keller Assoc.	⬛	☐	⬛	⬛	🟦	⬛	☐	🟦	🟦	🟦
2	30th Street Area Master Plan	2011	COB, CCDC, COBPDS	⬛	☐	⬛	⬛	🟦	⬛	☐	☐	⬛	☐
3	Boise City\Garden City MS4 Permit, Permit No.: IDS-027561	2013	EPA	🟧	🟧	🟧	🟧	🟦	🟧	☐	🟧	🟧	⬛
4	Pollutants of Concern (PoC) Guide For ACHD's NPDES Phase 1 Permit Area: Water Quality Controls and Effectiveness Assessment	2013	ACHD	🟧	🟧	🟧	⬛	⬛	⬛	⬛	☐	🟧	⬛
5	Fairview Avenue Greenstreet Concept design; Evaluating Offset Mitigation through Green Infrastructure within a Public ROW.	2014	Tetra Tech	⬛	⬛	⬛	🟦	🟦	🟦	☐	⬛	⬛	☐
6	Phase I Stormwater Management Plan	2014	ACHD	🟧	🟧	🟧	🟧	🟧	🟧	⬛	⬛	🟧	⬛
7	Stormwater Management Pond Revegetation Guidance Manual	2014	For ACHD, By EPG	⬛	⬛	⬛	🟦	🟦	🟦	🟧	⬛	🟦	☐
8	Boise City Instream Water Quality Data	2014	City of Boise	☐	☐	🟦	☐	☐	☐	☐	☐	🟦	☐
9	Green Stormwater Infrastructure Guidance Manual	2014	ACHD	🟦	🟦	⬛	⬛	⬛	🟧	🟦	⬛	🟦	☐
10	City of Boise Stormwater Management Program	2014	City of Boise	🟧	🟧	🟦	🟧	🟧	🟧	🟦	⬛	🟦	☐
11	Boise City MS4 Program Development and Implementation Services; Green Stormwater Infrastructure Issue Paper	2014	HDR	🟧	🟧	🟦	🟦	🟦	🟧	🟦	⬛	🟦	☐
12	Storm Water Outfall Monitoring Plan	2014	Brown and Caldwell	🟧	🟧	🟧	⬛	⬛	⬛	☐	⬛	🟧	☐
13	Water Year 2014 Phase I Outfall Monitoring, Technical Memorandum: Structural Controls Context Review	2014	Brown and Caldwell	🟦	🟧	🟦	🟧	🟧	⬛	⬛	⬛	🟦	☐
14	NPDES Phase I Annual Storm Water Monitoring Report for Water Year 2014	2014	Brown and Caldwell	🟧	🟧	🟧	⬛	🟦	☐	☐	⬛	🟧	⬛

Indicator Assessment Legend

Governs	Addresses	Mentions	N/A
🟧	🟦	⬛	☐

🟧 **Governs** - document mandates ACHD/MS4 Permittee action pertinent to stormwater management, this could be ordinances, permits or Permittee initiatives.

🟦 **Addresses** - document supplies information pertinent to stormwater management through suggested actions, desired outcomes or monitoring data.

⬛ **Mentions** - document mentions community stormwater planning elements but does not provide data, set mandated goals or actions for the MS4 permittees.

☐ **Not Applicable** - document is not applicable to the stormwater planning element.

Figure 3. *Stormwater Document Synthesis*

Priority Aquatic Resources and Beneficial Uses

Aquatic resources in the two subwatersheds are scarce. In general aquatic resources are restricted to the Boise River. The Americana and Main Street subwatersheds are primarily urban environments and thus the opportunity for aquatic resources to be present throughout each subwatershed is limited.

Beneficial uses of the Boise River are determined by IDEQ in the development of water quality standards. Further discussion of beneficial uses and pollutants of concern are provided in the *Lower Boise TMDL – Pollutant and Beneficial Uses* section (Table 2).

Wetlands and Floodplains - National Wetland Inventory Data

A search of the United States Fish and Wildlife's (USFWS) National Wetlands Inventory (NWI) revealed that jurisdictional wetlands do occur within the Americana and Main Street subwatersheds, but they are limited to the Boise River (Table 3). These wetlands occur within or adjacent to the Boise River channel under the Main Street and Americana bridges and therefore only intersect each subwatershed near their outfalls. Within the Main Street subwatershed, a total of 0.21 acres (9,188 sq ft) of wetlands occur, with Riverine type encompassing the majority (Table 3). In the Americana Subwatershed, the Riverine type is the only wetland encountered and it encompasses 0.25 acres (10,890 sq ft) (Table 3). The Riverine wetland type (R3UBH) found in the two subwatersheds is described as a deepwater habitat contained to natural channels that are continuously flowing, characterized by a high gradient and fast water velocity, consisting of an unconsolidated bottom that is permanently flooded (USFWS NWI 2015). The other wetland type that occurs in the Main Street Subwatershed is Freshwater Forested/Shrub Wetland (PFO1A). This wetland type (PFO1A) is characterized as a palustrine system dominated by trees and shrubs, with woody vegetation (broad-leaved deciduous) that is 6m tall or taller that sheds their leaves during the cold season, and are temporarily flooded.

Similar to wetlands, floodplains occur within each subwatershed but are restricted to areas adjacent to the Boise River channel. Floodplain and flood hazard information for each subwatershed is garnered from the National Flood Hazard Layer, which is a digital database that contains flood hazard map information from the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program. This data is derived from Flood Insurance Rate Map databases and Letters of Map Revision (FEMA 2014). The wetland and floodplain extents are located in each subwatershed's geodatabase.

Lower Boise River TMDL- Pollutants and Beneficial Uses

Water quality standards are set by the Idaho Department of Environmental Quality (IDEQ) and established under Idaho Code IDAPA §58.01.02 to protect the beneficial uses of the state's waters. For the mainstem lower Boise River, beneficial uses are designated as: cold water aquatic life, salmonid spawning, primary contact recreation (swimming), domestic water supply, agriculture, wildlife habitats, and aesthetics. Waters that do not meet standards or support beneficial uses are added to the 303(d) list and a Total Maximum Daily Load (TMDL) pollutant management plan is developed, as required by the Clean Water Act (US EPA 2015).

■ *Table 2. Beneficial uses, use support, 303(d) listed pollutants and causes, and TMDL establishment (IDEQ 2009) for Assessment Unit ID17050114SW011a_06.*

Assessment Unit Name	Assessment Unit Number	Beneficial Uses [a]	Use Support [b]	Pollutants/Causes	Listed Pollutant
Diversion Dam to Veterans Memorial Parkway	011a_06	CWAL SS DWS PCR	NFS NFS NA FS	Low flow alterations; Physical Substrate Habitat Alterations; Water Temperature	Water Temperature

a: CWAL – cold water aquatic life, SS-salmonid spawning, DWS- domestic water supply, PCR-primary contact recreation

b: NFS = not fully supporting, FS = fully supporting NA = not assessed

In January 2000, the Environmental Protection Agency (EPA) approved TMDL allocations for sediment and bacteria for the lower Boise River (IDEQ 1999). An addendum to sediment and bacteria allocations was approved in 2008 (LBWC and IDEQ 2008). Since the original TMDL was approved, bacteria targets were also revised from measuring for fecal coliform levels to measuring Escherichia coli (*E. coli*) concentrations. A sediment and bacteria TMDL for lower Boise River tributaries was approved in September 2015. In 2011, a phosphorus TMDL was developed for Lake Lowell in the Lower Boise River watershed. As a tributary to the Snake River, the Boise River at the confluence must reach target concentrations as set by the Snake River-Hells Canyon TMDL, which establishes a seasonal (May 1 to September 30) instream total phosphorus target of 0.07 mg/L for the Snake River-Hells Canyon reach upstream from Brownlee Reservoir (IDEQ and ODEQ 2004). The 2015 total phosphorus TMDL addendum has similar targets for the lower Boise River with a year round stormwater allocation that requires a 42% reduction in wet weather runoff phosphorus loads and an 84% reduction in dry weather runoff phosphorus loads. (IDEQ 2015). Temperature TMDL for select reaches of the Boise River and its tributaries are in the process of being established (IDEQ 2014).

The ultimate receiving water for all stormwater discharges monitored in this program is the Lower Boise River, either directly or indirectly (see Table 3). Therefore, water quality targets and/or criteria for phosphorus, sediment, *E. coli* and temperature must be monitored (and best management practices implemented) as part of the National Pollutant Discharge Elimination System (NPDES) permit. Beneficial uses for the reach between the Lucky Peak and Veterans Memorial Parkway (RM 50), as pertinent to this report, include cold water aquatic life, salmonid spawning, domestic water supply and primary contact recreation (Table 3). Additionally, this reach is designated as a Special Resource Water (SRW) affording the reach protection from pollutants discharged by point sources (IDEQ 2001). A five year review by IDEQ determined that temperature criteria for salmonid spawning within this reach are exceeded every spring and most fall months (IDEQ 2009).

Stormwater samples from the Americana and Main Street subwatersheds were collected during four storm events from November 2013 to May 2014 (Brown and Caldwell 2014b). Samples were collected from within stormwater pipes near each subwatertshed outfall. Non-stormwater (during dry weather conditions) water quality monitoring was also conducted. Stormwater runoff samples were analyzed according to the analytical requirements listed in the NPDES Permit. Table 4 summarizes the measured pollutant concentrations at the time of sampling for the Americana and Main Street subwatersheds. Results showed that single sample *E. coli* measurements exceeded instream targets during some storm events in both the Americana and Main Street subwatersheds. Instream targets for total suspended sediment (TSS) were exceeded during the spring samples in 2014 for both subwatersheds. All samples for total phosphorus (TP) exceeded target concentrations, with the highest concentrations measured during storm events. Temperature targets were exceeded mostly in the Americana subwatershed during both dry and wet events. Targets are based on instream water quality standards.

Monitoring data is integral to the modelling component of this project. ACHD's continuous monitoring of flow and pollutant load estimates provide baseline data from which to compare modeling results. The data, presented in Table 4, enables model verification which ensures that model results are consistent with real world conditions.

■ *Table 3. USFWS Designated Wetlands within the Main and Americana Subwatersheds*

Subwatershed	USFWS Code	Wetland Type	Acres	SQ FT
Main Street	PFO1A	Freshwater Forested/Shrub Wetland	0.00	40.2
	R3UBH	Riverine	0.21	9147.5
Americana	R3UBH	Riverine	0.25	10889.9

■ *Table 4.* *Select Analytical Sampling Data for Americana and Main Subwatersheds (Brown and Caldwell, 2014).*

Event Date	Monitoring Station	*E. coli* (mpn/ 100 mL)	Target[1] *E. coli* (mpn/ 100 mL)	TSS (mg/L)	Target[2] TSS (mg/L)	TP (mg/L)	Instream Target[3] TP (mg/L)	Temp (°C)	Target Max Temp[4] (°C)	Sample Type[5]
Dry Samples										
11/15/13	Americana	2.0	406	<1	50/80	0.102	0.07	15.4	22/13	G
2/11/14	Americana	52	406	2.1	50/80	0.078	0.07	12.6	22/13	G
4/22/14	Americana	6.3	406	2.0	50/80	0.084	0.07	17.3	22/13	G
5/8/14	Americana	-	406	15.4	50/80	0.112	0.07	-	22/13	G
Wet Samples										
11/16/13	Americana	27.2	406	22.4	50/80	0.631	0.07	10.4	22/13	G, C
	Main	6.3	406	21.5	50/80	0.218	0.07	5.6	22/13	G, C
2/12/14	Americana	908.4	406	148.0	50/80	0.328	0.07	6.0	22/13	G, C
	Main	4.1	406	68.6	50/80	0.161	0.07	6.7	22/13	G, C
4/22/14	Americana	96	406	90.9	50/80	0.466	0.07	15.0	22/13	G, C
	Main	1299.7	406	97.3	50/80	0.323	0.07	13.5	22/13	G, C
5/8/14	Americana	-	406	77.9	50/80	0.679	0.07	-	22/13	G, C

1: Represents the single-sample *E. coli* action level target (State Water Quality Standards). (BC 2014b)

2: Total suspended sediment TMDL targets for the mainstem Boise River are set at 50 mg/L for < 60 days and 80 mg/L for < 14 days. (IDEQ 1999)

3: IDEQ 2015, IDEQ 2001; Instream Target

4: Cold Water State Water Quality Criteria / Salmonid Spawning State Water Quality Criteria. (BC 2014b)

5: Type of Sample: G= Grab, C = Composite

Subareas of the Subwatersheds

Subarea delineation is an essential step for stormwater modelling studies and GSI implementation. Subareas provide the boundaries and extent of drainage areas within the urban environment defining how much land area drains to ACHD's existing stormwater infrastructure. Subarea delineation within the urban environment is challenging because flow direction can be altered by roads and road geometry, artificial surfaces (curbs, medians, etc.) and storm drains, resulting in a drainage network that does not always align with the local topography.

Subareas within the Main Street and Americana subwatersheds are defined by stormwater infrastructure. Delineated subareas represent the drainage area to ponds, catch basins, sand/grease traps, siphon drains, etc. Subareas are further grouped by stormwater pipe network entering the larger system.

Subarea Delineation Methodology

Subareas within the two subwatersheds were delineated in ESRI's ArcGIS 10.3 using ArcHydro, an extension to ArcMap. Resultant ArcHydro model results were hand edited to ensure accuracy. Arc Hydro tools are very straightforward to employ, and enable the user to delineate sub-catchments using high resolution (2m pixel size) Digital Elevation Models (DEM). High resolution DEMs (<10m resolution) improve the quality of hydrological features extracted from elevation models, especially in urban environments (X 2005).The Main Street subwatershed subareas were delineated using a high resolution DEM derived from Light Detection and Ranging (LIDAR) data (2007). The Americana subareas were delineated using a high resolution DEM created from 2ft contour data (Community Planning Association of Southwest Idaho 2001).

The workflow used to create the subareas is graphically expressed in Appendix A. Each high resolution DEM was preprocessed by filling sinks (holes or low points in the DEM) to accurately reflect the drainage network.

Once the DEMs were preprocessed, ArcHydro computed flow direction (direction water would flow to from each pixel) and flow accumulation (volume of water flowing to each pixel) grids (raster files) employing Maidment's methods (Maidment 2002). The flow direction and flow accumulation grids provide the medium for further ArcHydro tools; stream segmentation, stream definition, and drainage line delineation and catchment grid delineation. The resultant data from these tools enable ArcHydro to define catchments, adjoint catchments (accumulation of adjacent catchments), drainage lines and drainage points (low points per catchments). The feature classes (shapefiles) created through the ArcHydro process, catchments, adjoint catchments, drainage lines and drainage points, were used to delineate the subareas within the two subwatersheds. Final subareas were delineated by hand editing the catchments and adjoint catchments based on stormwater infrastructure (pipes and structures), road geometry, other urban infrastructure and GeoPDF provided by ACHD that document how water drained through the urban environment. This step ensured that the resultant subarea drainage network was based in reality.

The ArcHydro methodology identified areas within the subwatersheds that were interior drainages; areas where water did not drain to a stormwater structure, or drained to the middle of a property. These interior drainage areas were removed from the data set. Additionally, the delineation process identified areas of each subwatershed where water drained out of a subwatershed, and these areas were removed from the data set as well.

The final step in the delineation process was to field edit the subarea feature class. Ecosystem Sciences personnel visited the field on four occasions during storms to ensure that the subareas were delineated correctly: March 14th (Main Street subareas), April 8th (Americana), April 11th (Americana), and May 15th (Main and Americana). Small edits were made to the subarea feature classes due to field visits.

Main Street Subwatershed & Subareas

The Main Street Subwatershed comprises approximately 79.4 acres. The subwatershed extends from east to west, with 16th Street forming the eastern border and the Boise River the western border and outfall location. The subwatershed is bordered by State Street to the north and Fairview Avenue to the south. The majority of the subwatershed is centered on the parcels adjacent to Main Street, which runs from east to west.

Land Cover/Land Use

Land cover in the Main Street Subwatershed is dominated by impervious surfaces (buildings, parking lots, roads and other impervious surfaces), which encompass over 61 acres (77%) of the watershed (Figure 4). Tree canopy occupies roughly 14% (11 acres) of the subwatershed with pervious surfaces (Soil and Dry Veg, Irrigated Veg, and Non-irrigated Veg) encompassing only 9% (7.1 acres) (Figure 4).

The Main Street Subwatershed is dominated by Commercial (65%, 51 acres) and Residential (23%, 18 acres) land uses (Figure 5). Often the commercial land use has high impervious surface cover, which is the case in the Main Street Subwatershed (Figure 4). Land uses associated with pervious surfaces, such as Public and Residential (high, medium and low) encompass 31% of the Main Street Subwatershed (Figure 5).

Planimetric Land Cover

The 9 class land cover data (Figure 4), represent the Main Street Subwatershed from an aerial perspective in spring or summer, when trees are leaved out. Unfortunately, this is not the case in Boise year-round. Since the majority of the precipitation in the region occurs between December and March, when trees are barren, a different view of impervious cover is needed to understand its effect on stormwater runoff. For this perspective, planimetric data is employed to understand what the true impervious cover is per subwatershed.

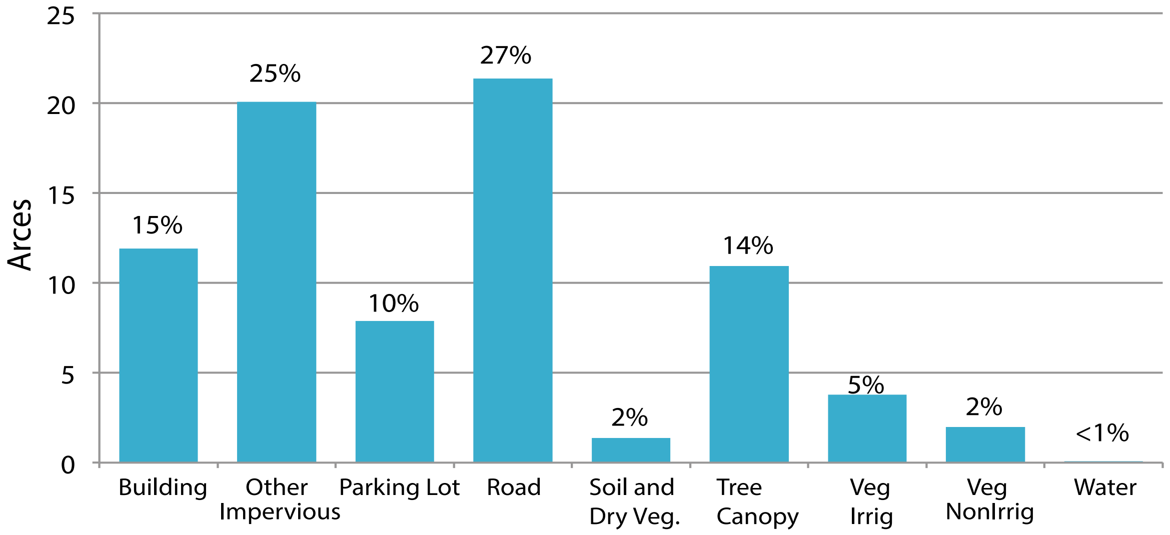
Planimetrics allows a planner to view data from a different perspective from which to evaluate a particular problem. The problem to be examined is what the actual land cover is when trees are bare, especially related to impervious surface cover. The Urban Tree Canopy (UTC) Assessment (Plan-it Geo 2013) data provides planimetric impervious surface data per subwatershed (Figure 6). When trees are bare the total impervious surface cover in the Main Street Subwatershed is 81% (64.4 acres), compared to 77% (61.3 acres) when trees have leaves. Overall, the planimetric data demonstrates an impervious surface cover increase of 3.1 acres in the Main Street Subwatershed, evenly distributed (~1 acre increase) between Buildings, Roads, and Parking Lots. Planimetric data and the 9 class land cover data are both important as each data represents the seasonality of Boise and ensures accurate data for modelling applications.

Outfall Flows

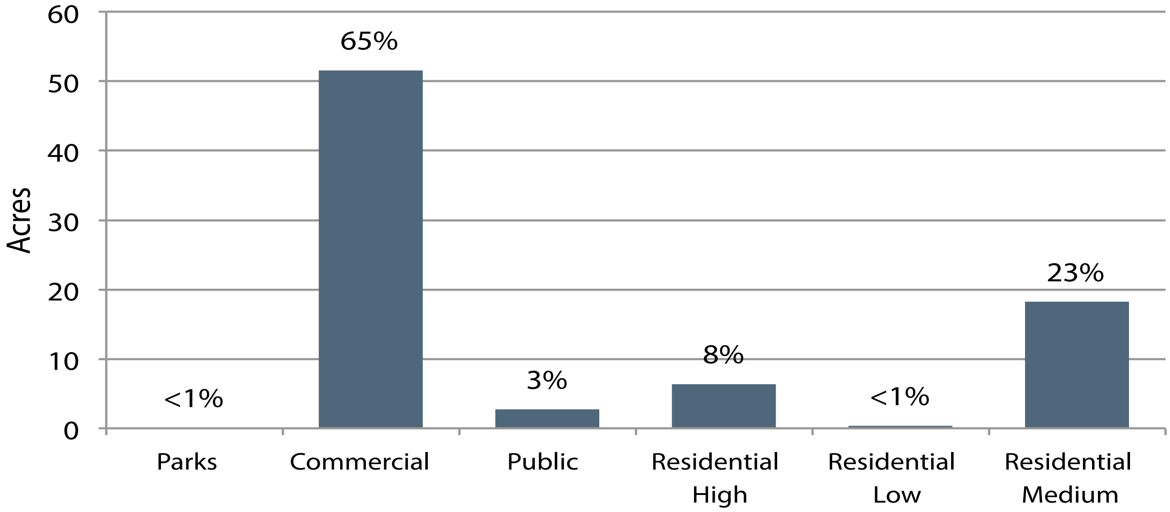
Outfall flows within the Main Street Subwatershed are monitored continuously (Brown and Caldwell 2014b). Additionally, discharge from storm events are monitored for pollutant concentrations. Flows ranged from 0 cfs to over 19 cfs near the Main Street Outfall. The greater than 19 cfs high flow event is not associated with a greater than 0.1 inch storm event (Brown and Caldwell 2014a). Data collected to date suggest storm events generally produce flows of less than 4 cfs from the Main Street Outfall, although, the May 9th, 2014 storm event yielded a maximum flow of over 5.5 cfs for a very short duration (approximately 30 minutes). This high flow occurred shortly after a cloud burst that produced greater than 0.08 inches of rain. As noted in the Phase I Monitoring Report, "the hydrograph for the Main Street monitoring station responds quickly to measured rain by showing less separation between the beginning of rainfall and the rise and peak of the hydrograph. This drainage area is small and contains some of the highest percent of impervious surfaces of the monitored drainage areas" (Brown and Caldwell 2014a).

Subareas

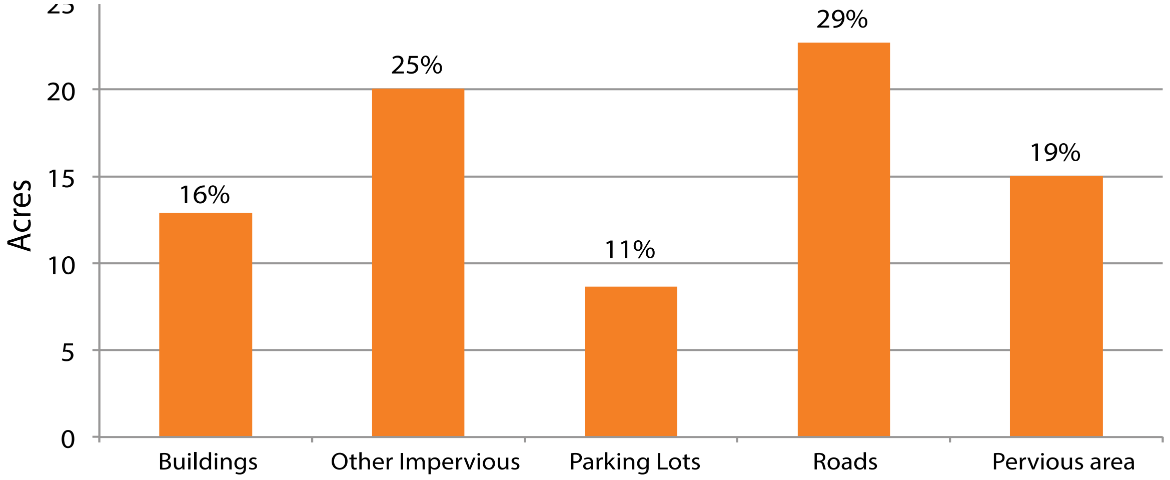
The subarea delineation process (ArcHydro model with hand editing) for Main Street Subwatershed identified a total of 68 individual subareas (Table 5). Most of the 68 subareas drain to a stormwater structure (e.g. catch basin) and are labeled using the structures, "Structure ID" from the GIS data (ID in Table 5). As noted above, interior drainage areas where water drains away from the pipe network or out of the Subwatershed were removed from the data set. The 68 subareas are grouped into 35 subareas based on how water flows through the system (Table 5 and Figure 7). A grouping of subareas represents water flowing through several storm drain structures (e.g. catch basins) before entering a storm drain pipe. For example, subarea ID 16592, in Table 5, initially had 10 subareas. This demonstrates that there are ten contributing subareas to Structure ID 16592, at which point all the water from the 10 subareas enters a storm drain pipe (Table 5 and Figure 7). Grouping subareas facilitated the modeling portion of this project. Subareas that did not drain directly to a stormwater pipe caused routing issues and reduced overall accuracy of modeling results.



■ *Figure 4.* *Main Street Subwatershed Land Cover (9 class) (Plan-it Geo 2013)*



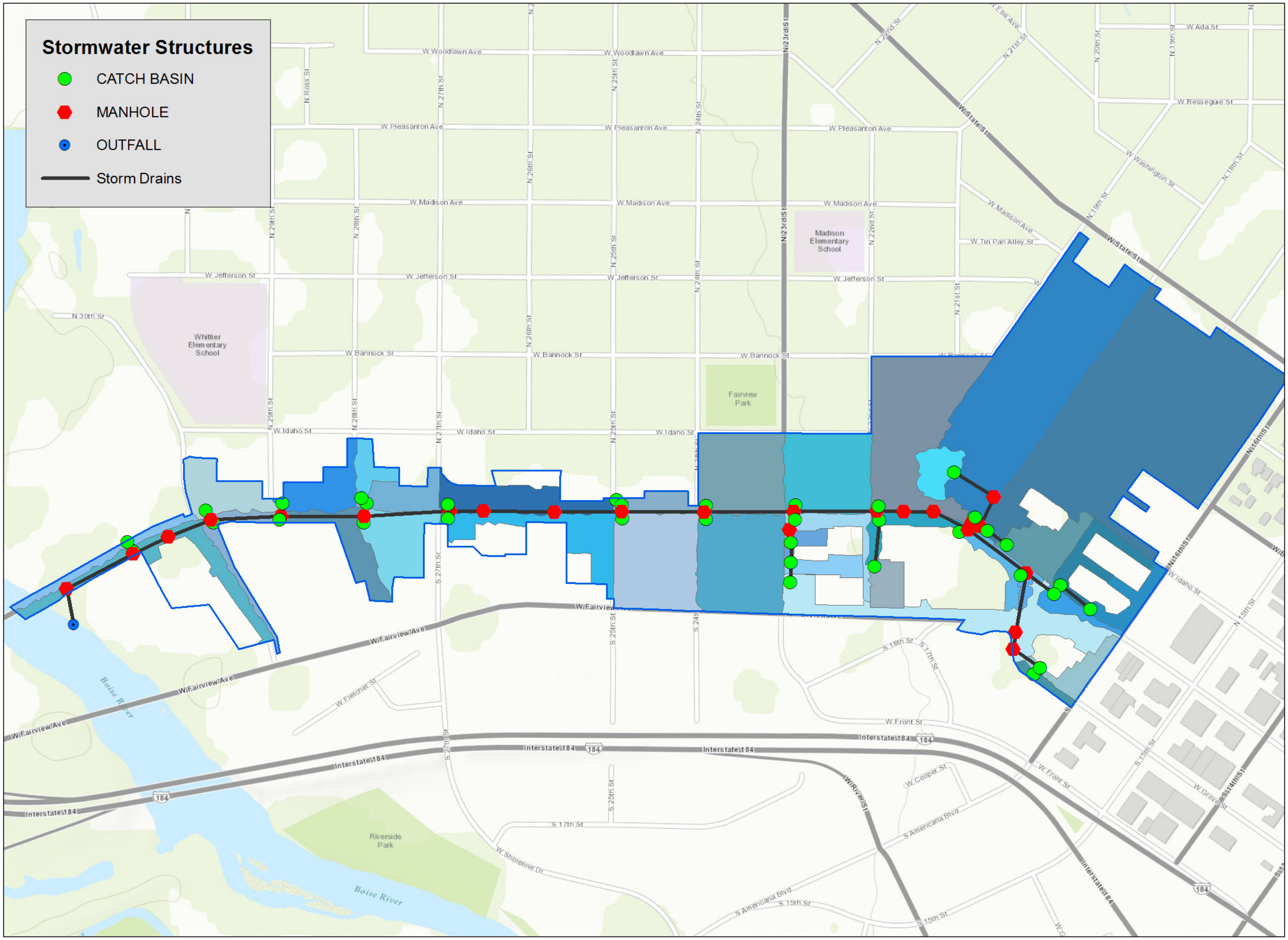
■ *Figure 5.* *Main Street Subwatershed Land Use (Plan-it Geo 2013).*



■ *Figure 6.* *Main Street Subwatershed Planimetric Land Cover (Plan-it Geo 2013).*

Table 5. Main Street Subwatershed subareas (ID), % impervious acres and % land use.

Name	Acres	% Impervious	Commercial	Open Space	Public	Residential High	Residential Low	Residential Medium
S33443	0.66	89.3	90.3	0.0	9.7	0.0	0.0	0.0
S2282	1.40	89.2	88.1	0.0	11.9	0.0	0.0	0.0
S11369	0.72	35.1	11.5	0.0	88.5	0.0	0.0	0.0
S29180	1.22	89.4	87.6	0.0	11.7	0.0	0.0	0.7
S3049	1.22	8.6	6.5	0.0	93.5	0.0	0.0	0.0
S9261	1.67	57.0	83.9	0.0	16.1	0.0	0.0	0.0
S7929	0.95	83.0	100.0	0.0	0.0	0.0	0.0	0.0
S32837	1.69	85.6	100.0	0.0	0.0	0.0	0.0	0.0
S41421	1.89	72.4	100.0	0.0	0.0	0.0	0.0	0.0
S28884	0.61	86.7	100.0	0.0	0.0	0.0	0.0	0.0
S8621	3.38	89.3	100.0	0.0	0.0	0.0	0.0	0.0
S23308	2.90	46.0	60.3	2.7	0.0	0.0	0.0	37.0
S20166	3.59	82.8	100.0	0.0	0.0	0.0	0.0	0.0
S9126	2.90	45.3	64.6	0.0	0.0	0.0	0.0	35.4
S14401	5.14	32.4	22.7	0.0	0.0	13.2	0.0	64.1
S40406	0.75	42.7	41.6	0.0	0.0	35.8	0.0	22.6
S803	0.65	74.5	100.0	0.0	0.0	0.0	0.0	0.0
S3	0.68	88.8	100.0	0.0	0.0	0.0	0.0	0.0
S29678	0.79	76.8	100.0	0.0	0.0	0.0	0.0	0.0
S4167	3.08	89.3	100.0	0.0	0.0	0.0	0.0	0.0
S13330	0.58	80.7	100.0	0.0	0.0	0.0	0.0	0.0
S5013	0.29	86.5	100.0	0.0	0.0	0.0	0.0	0.0
S34413	0.17	31.5	100.0	0.0	0.0	0.0	0.0	0.0
S1619	0.66	80.9	100.0	0.0	0.0	0.0	0.0	0.0
S898	0.24	75.8	100.0	0.0	0.0	0.0	0.0	0.0
S32412	0.71	72.3	100.0	0.0	0.0	0.0	0.0	0.0
S15432	0.71	74.7	100.0	0.0	0.0	0.0	0.0	0.0
S2461	0.93	74.0	98.5	0.0	1.5	0.0	0.0	0.0
S13464	0.47	79.0	100.0	0.0	0.0	0.0	0.0	0.0
S16592	15.06	50.6	38.7	0.0	0.8	18.7	0.7	41.1
S7495	1.34	76.8	76.4	0.0	0.0	22.3	1.3	0.0
S34081	9.56	30.4	11.2	0.0	0.0	23.3	0.2	65.4
S2450	0.01	92.2	100.0	0.0	0.0	0.0	0.0	0.0
S22475	1.74	84.1	88.7	0.0	11.3	0.0	0.0	0.0
S10219	0.56	49.2	60.0	0.0	0.0	0.0	0.0	40.0



■ *Figure 7. Main Street Subareas (Grouped) with Storm Drains and Stormwater Infrastructure*

Americana Subwatershed & Subareas

The Americana Subwatershed comprises approximately 959 acres. The watershed extends from northeast to southwest with the Boise Foothills forming the northeast boundary and the outlet of the subwatershed, the Boise River, marking the southwest boundary.

Land Cover/Land Use

Land cover in the Americana Subwatershed is much different than the Main Street Subwatershed, mostly due to the abundance of residential land uses in the area (Figure 8 and Figure 9). Americana is less dominated by impervious surfaces (Buildings, Parking Lots, Roads and Other Impervious Surfaces) than Main Street (50% compared to 77%, respectively) (Figure 8). Tree canopy is much more abundant in the Americana Subwatershed occupying roughly 22% (207 acres) of the subwatershed. Pervious surfaces (Soil and Dry Veg, Irrigated Veg, and Non-irrigated Veg) encompass 29% (277 acres) of the Americana Subwatershed (Figure 8).

The Americana Subwatershed is dominated by residential land uses (high, medium and low) occupying approximately 61% (584 acres) of the land area. Land uses associated with impervious surfaces (e.g. Commercial) account for 24% (225 acres) of the watershed (Figure 9). The remaining 15% of the Americana Subwatershed's land use includes Public Land (9%, 86 acres), Agriculture (3%, 30 acres), Schools (2%, 22 acres), with Open Space, Parks, and Industrial each accounting for less than 1% (Figure 9).

Planimetric Land Cover

Similar to the Main Street Subwatershed, Figure 8 represents the Americana Subwatershed when trees are leaved out (9 class land cover data). To examine the actual impervious surface cover within the subwatershed planimetric data is employed (Figure 10). When trees lose their leaves the impervious surface cover in the Americana Subwatershed increases to 55% (530 acres), compared to 50% (475 acres) when trees have leaves. Overall, the planimetric data demonstrates an impervious surface cover increase of 55 acres in the Americana Subwatershed. Road impervious surface cover increases 4% when trees are bare, while building impervious surface cover increases almost 2%. Parking lot impervious surface cover increased less than 1% when viewing the subwatershed from a planimetric perspective.

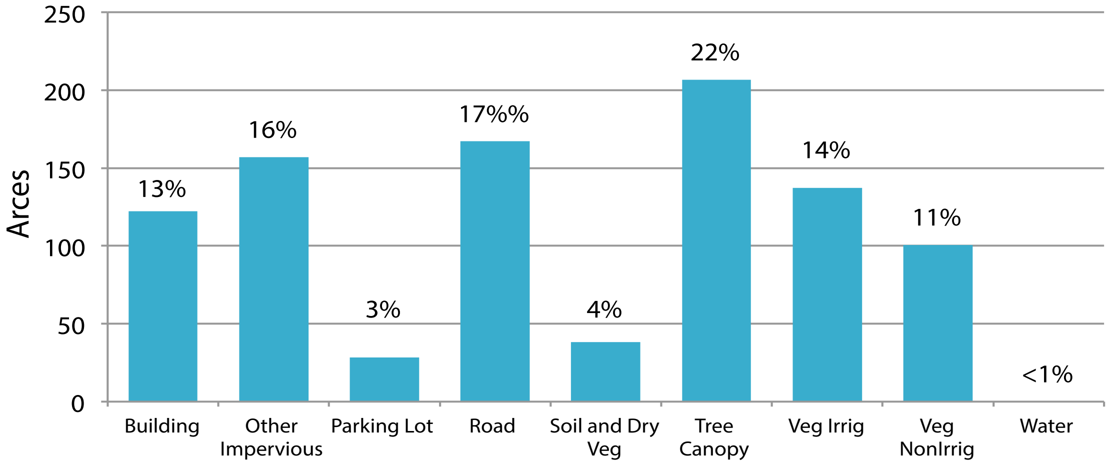
Outfall Flows

Outflows from the Americana Subwatershed are monitored continuously (Brown and Caldwell 2014b). Additionally, storm events are monitored throughout the year. Flows from the Americana Outfall ranged from 0 cfs to over 15 cfs. The Americana Outfall generally has continuous flow (non-stormwater flows), with 0.2 to 0.8 cfs draining to the Boise River throughout the year (Brown and Caldwell 2014b). The source for the dry-weather flow is postulated to be intermittent creeks, groundwater, detention ponds, and infiltration and diversion from the Boise City Canal (Brown and Caldwell 2014a). Based on data collected, storm events (rain fall with greater than 0.1 inches of precipitation) produce a range of flows (2 cfs to 15 cfs) near the Americana Outfall, depending on storm intensity (Brown and Caldwell 2014a). The May 9th, 2014 storm event yielded a maximum flow of over 18 cfs for a very short duration (30 minutes), which occurred shortly after a cloud burst that produced 0.09 inches of rain (Brown and Caldwell 2014a). The Americana Subwatershed is large; it contains a mix of impervious and pervious cover, but its outfall flows are still very much linked to the size and intensity of precipitation events.

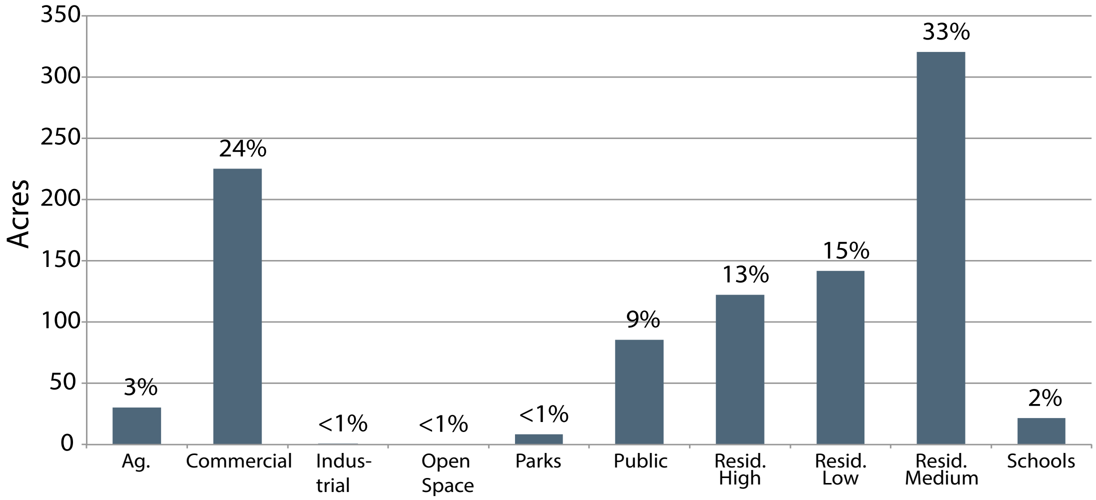
Subareas

Six hundred and eighty-four (684) subareas were initially delineated in the Americana Subwatershed. Most of the 684 subareas drain to a stormwater structure (e.g. catch basin) and are labeled using the structures "Structure ID" from the GIS data. As noted previously, interior drainage areas and areas where water drains away from stormdrain pipes or out of the Americana Subwatershed were removed from the data set. In the Americana Subwatershed the 684 subareas were grouped into 393 subareas based on how water flows through the system (Figure 11, and Appendix B).

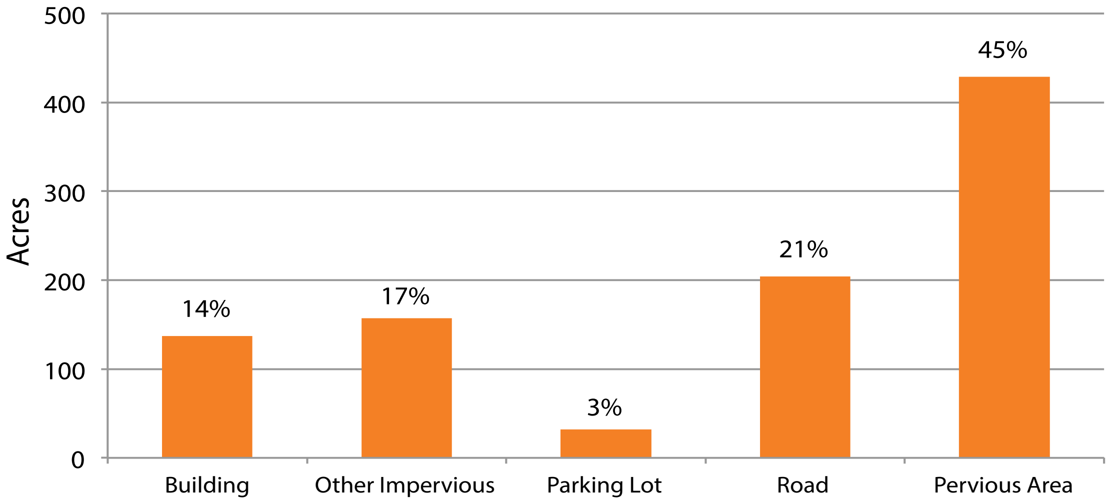
A grouping of subareas in the Americana Subwatershed represents water flowing through several storm drain structures (e.g. catch basins) before entering a storm drain pipe. Grouping subareas facilitated the modeling portion of the project. Subareas that did not drain directly to a stormwater pipe caused routing issues and reduced the overall accuracy of the model results. Percent impervious and percent land use data for the 393 Americana subareas is found in Appendix B.



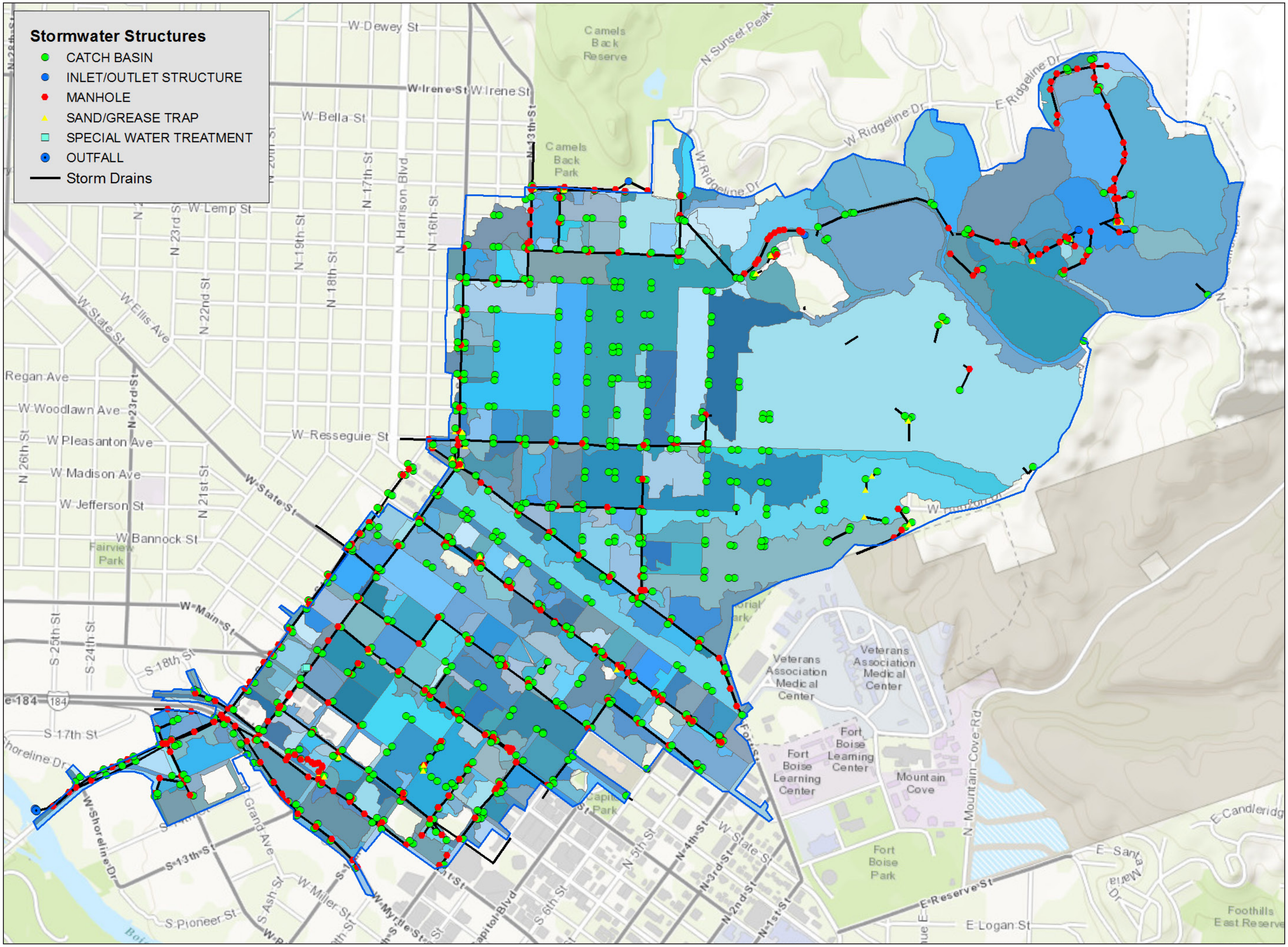
■ *Figure 8. Americana Subwatershed Land Cover (Plan-it Geo 2013)*



■ *Figure 9. Americana Subwatershed Land Use (Plan-it Geo 2013).*



■ *Figure 10. Americana Subwatershed Planimetric Land Cover (Plan-it Geo 2013).*



■ *Figure 11. Americana Subwatershed Subareas (Grouped) with Storm Drains and Stormwater Infrastructure*

Selecting Appropriate Stormwater Model

The goal of this section is to determine the most appropriate model that supports ACHD's watershed planning process. The model must be able to determine pollutant loads per subarea and support the prioritization process.

Important elements of the stormwater model or suite of models are that it/they can estimate pollution loads originating from subareas based on existing land use. This need drives the type of model that is needed to support this project. Based on the requirements listed above, the subwatershed planning process requires a single model or suite of models that simulates hydrologic information (rainfall, peak flows and drainage area discharge), location, and water quality in subareas and throughout the entire subwatershed. The selected model should ideally be able to effectively assess the following pollutants: Escherichia coli (*E. coli*), Sediment (TSS), and Phosphorus (TP) (Brown and Caldwell 2014a). Additionally, the recommended model must be consistent with ACHD's technical expertise and computer infrastructure (i.e. operating systems, applicable software and network).

Frequently cited stormwater models include: EPA SWMM, WinSLAMM, HSPF, and SUSTAIN, but there are many others (NRC 2009). Stormwater models range from the watershed scale (e.g. HSPF) to the site scale (e.g. Rational Method) or BMP specific (e.g. Oregon State University's LID infiltration Facility Calculator). Stormwater models have been applied in the Boise area to determine peak discharge in sizing stormwater facilities, such as the Rational Method and TR-55 (BPWD 2010), but no models have been implemented locally that examine the impact land use in subareas of these two subwatersheds has on pollutant loading and runoff volumes. Found within this technical memorandum is a review of existing stormwater models and tools (i.e. excel based spreadsheet calculations). The final section of the memorandum includes a recommendation of the most applicable model/models and the rationale for selecting that model or suite of models, as well as a proposed modeling approach.

Purpose of Stormwater Models

Stormwater models are important to municipalities, highway districts, developers and planners for two primary reasons: to assist in understanding the impact of land use on water quantity and quality (NRC 2009).

Models are used to understand the impacts of land use on water quantity and quality by associating specific water quality impairments (i.e. high total phosphorus or suspended sediments), or quantity of flow, with surrounding land use. Does an area with a high impervious surface cover contribute more pollutants and flow to a receiving water body than an area with less impervious surface cover? There is a considerable body of literature quantifying impacts of land use on flow duration curves, event mean concentrations (EMCs), and loading rates for a number of pollutants (NRC 2009, Maestre and Pitt 2005); such data are critical to effective models.

Stormwater models are also employed to quantify the effect a Stormwater Control Measure (SCM) has on flow quantity and pollutant loads. Within the literature it has been shown that there is large variability in the effectiveness of SCMs (GSI) due to land use, historical legacies (previous land use), climate and hydrogeology (NRC 2009). Quantifying flow and pollutant load reductions from a single parcel (small area) of land based on an implemented SCM is a common task and in such cases the Rational Method and TR-55 models are frequently employed to estimate volume (NRC 2009). Sometimes a more complex model that incorporates flow routing (how water flows through the system) and the cumulative water quality effects of multiple SCMs throughout an entire subwatershed or urban area is required. Such models necessitate greater data inputs, assumptions and computational procedures, but generate results that can guide decision making over a much larger area or complex system.

In general, models provide guidance for managers and designers for things like the sizing of BMP facilities (GSI/LID or traditional) to protect the quality of receiving waters, identification of source areas for pollutants, and for information during the design and review of new and redevelopment projects in urban areas (WDOE 2004). Models also provide knowledge of comparative pollutant loads to help managers target resources to priority subwatersheds or predict the water quality response of a receiving water body to urbanization (CWP 1995).

Boise Precipitation, Peak Flows, Regulatory Setting and Models

The EPA analyzed average rainfall depth in the Boise area based on 48 years of 24-hour precipitation data obtained from NOAA and collected at the Boise Airport. These data indicate that approximately 95% of all storms in the Boise area result in a rainfall volume of 0.6 inches or less; 90% of all storms result in a rainfall volume of 0.47 inches or less (Boise MS4 Permit 2012). Such data demonstrate that Ada County, and all of Idaho, reside in Type II rainfall distribution. There are four different types of rainfall distributions throughout the U.S. – Type I, Type 1A, Type II and Type III, and they relate to the intensity, duration and frequency (IDF) of precipitation events (Figure 2). Type II rainfall distribution curves generally follow a similar pattern in which 45 to 55% of the event depth (precipitation) occurs within 10% of the storm duration (Figure 2) (USSCS 1986).

With regional precipitation in mind, the City of Boise requires that new and redevelopment projects manage (retain on-site) the peak flow of runoff to match the predevelopment hydrology for each site. For areas that are <15% slope and new development acres <10 acres, the primary conveyance system must accommodate a 50-year storm event while the secondary conveyance system be able to handle a 100-year event. Areas with >15% slope or new development >10 acres (primarily foothill developments) both the primary and secondary conveyance systems must accommodate the 100-year storm event (BPWD 2015). Essentially, the City of Boise requirement attempts to ensure that new and redevelopment retain all stormwater onsite rather than discharge to the storm sewer system and subsequently the Boise River. Commercial development areas within the City of Boise are required to provide treatment for at least 80% of the storms annually (80% of daily storm events are estimated to have a depth of 0.34" or less) (BPWD 2010). The primary application of the proposed runoff reduction requirement of 0.6" will be for redevelopment in areas with existing storm drain systems where the developer is unable to meet local jurisdictions' on-site retention requirements. They may be allowed the discharge runoff off site once the 0.6" threshold is met.

Projects in ACHD right of way that exceed 5000 sq. ft. are required to be designed to retain 0.6" onsite and 100-yr flood control event. If a project site is located in area with an existing storm drain system, the 100-yr event can be by-passed to this system.

The requirements listed above, found in the NPDES permit, City ordinances, management plans, and ACHD policies and resolutions, drive modelling needs. The selected model or suite of models must be able to simulate the pollutant load and flow, as well as reductions resulting from GSI BMPs, based on the precipitation data presented above.

Seasonality of Stormwater Loads

Boise's climate has two distinct periods: wet (October through April) and dry (May through September) (Figure 2). The wet period corresponds to the months when the region receives the majority of its precipitation, conversely the dry period summarizes the time of year where rainfall is scarce. Storm events do occur during the dry period (summer thunderstorms) and often result in a higher accumulation (load and concentration) of pollutants in stormwater, due to a lack of previous rainfall and subsequent runoff. This information pertains to movement of pollutants over land surfaces, or the accumulation and wash-off of street particles, which are important considerations in many stormwater models such as SWMM, HSPF, and SLAMM (NRC 2009). Storm events that occur following a long dry period often discharge higher sediment and pollutant loads than events that occur shortly after a previous rainfall (NRC 2009). For this reason, stormwater filtration goals often target filtering the volume of runoff from the "first flush," initial flow of water into SCM or pipe system following precipitation event, since the highest concentration of contaminates are contained in that event. ACHD monitors pollutants in their stormwater drains through grab samples (*E. Coli* and field parameters) and event-based continuously monitored flow weighted composites.

Models in Practice – City of Boise and ACHD

ACHD and the City of Boise employ the Rational Method and the NRCS TR-55 to determine sizing needs for stormwater facilities (Table 6) (Brown and Caldwell n.d.). ACHD employed WinSLAMM in an Integrated Modeling approach to develop pollutant unit loads per 100 acres for local land use and soil type combinations. More information on ACHD's use of WinSLAMM can be found in Section 8 of the NPDES Phase I Annual Stormwater Monitoring Report for Water Year 2015 (Brown and Caldwell 2015g).

Computer Infrastructure

Since models are run on computers it is imperative to ensure that ACHD's computer infrastructure comports with any recommended models hardware and software needs. Some models, like GIS analyses, are best done locally instead of over a network. Presented here is a synopsis of ACHD's computer infrastructure which must meet stormwater model computational needs. ACHD employs Microsoft Windows 7 Pro operating system, on 64-bit computers with Intel core I5 processors (I5-3470 @ 3.20 GHz) with 8GB Ram. ACHD retains licenses for ESRI's ArcGIS 10.2.2. Generally, models will be run locally rather than over a network. ACHD's computer infrastructure comports with all models reviewed in this document.

Existing Data

Stormwater models require data to simulate water quantity and water quality. ACHD retains the following data for modelling purposes: drainage area (watersheds), land cover (impervious/pervious surface cover), land use (parcel unit level descriptions), soil data, continuous precipitation data for storm events, continuous flow monitoring of outfalls, and continuous and grab water quality samples of storm events (Brown and Caldwell 2014b).

ACHD retains the baseline data needed to simulate water quantity and quality discharging from the two subwatersheds for most, if not all, stormwater models. Additionally, ACHD's existing data provides a sound foundation from which to accurately model stomwater in the project area and meet the needs of the subwatershed planning process.

Review of Urban Stormwater Models

Stormwater models are often cited in the literature (NRC 2009). Models range from simple (not to be confused with the Simple Method) to complex, with simple types being derived in an excel spreadsheet, or similar environment, while complex models are run in a graphical user interface (GUI) or standalone program. Model outputs can be vastly different (CWP 1995); even with similar data inputs, differences are often associated with model assumptions and load coefficients (CWP 1995). The appropriate stormwater model's output should mirror real-world conditions when compared to ACHD's continuous monitoring data.

Simple models generally rely on limited data requirements (drainage area, land use, impervious cover, and precipitation). Complex models require statistically derived information such as flow curves, time series data, solar radiation and pollution concentration coefficients (e.g. HSPF). Some models can complete a continuous analysis while others are event based. Continuous models include simulation of a full time domain composed of storm and inter-storm periods (NRC 2009). Continuous models incorporate data that describes pollutant loads on streets and impervious surfaces prior to a storm event, enabling the simulation of dry period pollutant accumulation. Event-based models limit simulation time domains to a storm event, covering the time of rainfall and runoff generation and routing, and initial conditions need to be estimated on the basis of antecedent moisture or precipitation conditions (NRC 2009, WDOE 2013).

The scale of the analysis area is an important consideration in stormwater model selection. The selected model should be appropriate to the size of the area being simulated. For example, the computational needs to simulate a site less than 10 acres (e.g.

Rational Method) is much different compared to that of an entire watershed (e.g. HSPF). Scale is an important factor in the analysis of the Americana and Main Street subwatersheds, as the two subwatersheds are vastly different ranging from approximately 560 acres to less than 80 acres, respectively. Subareas in the Americana Subwatershed range in size from 0.07 acres to over 100 acres. Subareas in the Main Street Subwatershed range in size from 0.006 acres to over 15 acres (Subarea Results section).

Additionally, one must consider the end use of the model. Will the model be used to estimate runoff discharge from a small parcel in an effort to identify the appropriate sizing of a BMP to retain the discharge onsite (Simple or Rational Method)? Or is the model expected to include a time series of pollutant discharges throughout a storm event and be able to simulate flow and pollutant load reductions based on BMPs (SWMM and Win SLAMM)? Understanding the end use of the model will drive the selection of an appropriate model for ACHD. Finally, what output information is desired? Is the model expected to generate peak flow, runoff volumes and/or event hydrograph calculations only (TR-55 and Rational method)? Or does the model need to incorporate hydraulic information and water quality simulations (EPA SWMM)? Also, many stormwater models can incorporate BMP effectiveness and the cost of implementing and maintaining the BMP (WinSLAMM) (MPCA 2015).

Continuous Versus Event-Based Approaches

Another aspect of stormwater modeling is the time domain of the simulation. Event-based models limit simulation time domains to a storm event, covering the time of rainfall and runoff generation and routing (NRC 2009). Initial conditions need to be estimated on the basis of antecedent moisture or precipitation conditions. For catchments in which runoff is dominated by impervious surfaces, this is a reasonable approach. In landscapes dominated by variable source area runoff dynamics in which runoff is generated from areas that actively expand and contract on the basis of soil moisture conditions, a fuller accounting of the soil moisture budget is required (NRC 2009). Event-based modeling is often considered inappropriate for water quality purposes because it will not reproduce the full distribution of receiving water problems (NRC 2009). Continuous models are more robust and include simulation of a full time domain composed of storm and inter-storm periods (dry periods). SWMM and WinSLAMM are two frequently used continuous stormwater models, but each model can perform event based simulations as well.

■ *Table 6.* *Design Storm Frequencies - Water Quantity and Water Quality.*

Type of Development	**Method**	
	Rational Method (For areas <= 10 acres)	**NRCS TR-55**
New Development <10 acres and in areas with < 15% slope	Peak Flow Rates	
	Based on time of concentration and associated intensity for a 24 hour, 50 year design storm frequency. The time of concentration cannot be less than ten minutes.	Based on a 24 hour, 100 year storm with a Type II Distribution.
	Peak Volumes	
	Based on a one hour, 50 year design storm frequency (e.g., an intensity of approximately 1" per hour).	Based on a 24 hour, 50 year storm with a Type II Distribution.
New Development >10 acres and in areas with > 15% slope	Peak Flow Rates	
	– – – –	Based on a 24 hour, 100 year storm with a Type II Distribution.
	Peak Volumes	
	– – – –	Based on a 24 hour, 50 year storm with a Type II Distribution.

(Adopted from BPWD 2010 – Stormwater Management a Design Manual, Boise Public Works Department)

Hydrologic (Rainfall-Runoff) Models

Hydrologic models are used to estimate runoff volumes, peak flows, and the temporal distribution of runoff at a particular location resulting from a given precipitation record or event. Essentially, hydrologic models are used to predict how the site topography, soil characteristics and land cover will cause runoff either to flow relatively unhindered through the system to a point of interest or to be delayed or retained. Many hydrologic models also include relatively simple procedures to route runoff hydrographs through storage areas or channel, and to combine hydrographs from multiple watersheds (MPCA 2015).

Hydraulic Models

Hydraulic models simulate the flow (velocity and depths) of water in rivers and open channels. Hydraulic models compute one-dimensional water surface profiles for steady or unsteady flow and are intended for flood plain studies and floodway encroachment evaluations (MPCA 2015). Simple hydraulic models, such as HEC-2 and HEC-RAS, are not needed in this project because water surface profiles will not be generated. ACHD is currently collecting flow and volume data at the outfalls of Americana and Main Street subwatersheds through it's monitoring program. If this data were not available then a hydraulic model would be required to quantify the contribution of stormwater to the Boise River.

Combined Hydraulic and Hydrologic Models

Several models incorporate hydraulic and hydrologic information. Such models enable the user to simulate hydrology (peak flows, runoff, volumes and temporal distribution of runoff) and hydraulics within the urban environment. Combined models are often more complex than simple hydrologic or hydraulic models, but the results offer a greater understanding of stormwater effects throughout the urban environment. Combined models are comprehensive computer models that simulate quantity and quality problems associated with urban runoff (EPA SWMM). Both single-event and continuous simulation can be performed on catchments having storm sewers, or combined sewers and natural drainage, for prediction of flows and pollutant concentrations (MPCA 2015).

Water Quality Models

Water quality models are used to evaluate the effectiveness of a BMP, simulate water quality conditions in a lake, stream, or wetland, and to estimate the loadings to water bodies. Often the goal is to evaluate how some external factor (such as a change in land use or land cover, the use of best management practices) will affect water quality. Parameters that are frequently modeled include total phosphorus, total suspended sediment, and dissolved oxygen (MPCA 2015).

Combined Hydraulic, Hydrologic and Water Quality Models

Several stormwater models include hydraulic, hydrologic and water quality components. These models simulate representative hydrologic and hydraulic conditions in the watershed, subwatershed, and stream system and estimate stormwater pollutant loads through consideration of a variety of factors including soil type, infiltration, and exponential wash off (CWP 1995). SWMM, HSPF and WinSLAMM are examples of such models.

Stormwater model comparison analyses have been undertaken and are documented online and in the Literature Cited section of this document (NRC 2009, MPCA 2015, Brown and Caldwell n.d.). For this reason, descriptions of all potential models are not provided. Table 7 offers a comparative analysis of potential models focusing on those that can effectively simulate hydrologic (rainfall-runoff volume) information, includes a water quality component, and evaluates BMP effectiveness in a standalone fashion or through a lumped analysis. The goals of ACHD's subwatershed planning process model requirements (e.g. accurately estimate pollution loads based on land use in the subareas and subwatershed) warrant limiting the review of existing stormwater models to those that simulate representative hydrologic, hydraulic, water quality conditions and, if needed, the evaluation of BMP effectiveness (e.g. flow reductions) in a standalone or lumped analysis. Table 7 also delves into the cost of each model and whether or not the model is GIS compatible. GIS compatibility is an important component as much of ACHD's pertinent modelling data is housed in a GIS format.

Stormwater Model

The selection of a stormwater modeling tool, or tools, for ACHD and the Permittees is based on this projects goals and objectives, available data and available resources (modeling expertise and computer infrastructure). The key to choosing the appropriate model lies in a clear understanding of the drainage area scale (individual subarea to entire subwatershed), availability of water quality and hydrologic data (continuous and grab monitoring data), resources (funding) and personnel (modeling expertise) (CWP 1995). When evaluating potential models decision makers should consider the type of information desired from the modeling effort, the specific conditions to be modeled, the required level of accuracy and reliability of the model, and the further use of the model and model results (NRC 2009). With this information in mind, and to help facilitate the model selection, the following questions were considered during the model selection process:

1. Does the model meet the subwatershed planning process goals (estimate pollutant loads in subareas and the subwatershed) and minimizes assumptions regarding outcomes?
2. Does existing data (GIS and ACHD's monitoring data; water quality and water quality) meet the requirements of the model, or will resources need to be devoted to generate the necessary data?
3. Does the model support the appropriate scale of the two subwatersheds (minimum site scale [0.006 acres] to subwatershed scale [560 acres])?
4. Is the model complex enough to meet project goals? Or will the model require support from other models to achieve desired results?

Answers to these questions limit the suite of available models and facilitates the final decision on the appropriate model. It is imperative that the selected model provide managers with the guidance for targeting areas in need of protection and for predicting the magnitude and risks associated with pollutant loads (CWP 1995). The results of the selected model will facilitate identifying pollutant reduction strategies (GSI BMPs) and assessing a potential strategy's results.

Selected Model

Based on the literature review, the goals and objectives of the project and the existing GIS and monitoring data it became evident that three models appeared to be most applicable to the subwatershed planning process: 1) Hydrologic Simulation Program (Fortran) (HSPF) coupled with the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS); 2) EPA's Storm Water Management Model (SWMM and PCSWMM), and 3) Source Loading and Management Model for Windows (WinSLAMM), including the ArcGIS extension ArcSLAMM. These three models were thoroughly evaluated to determine which was most appropriate.

HSPF is a watershed-scale model for simulation of watershed hydrology and water quality. HSPF is used extensively in the development of TMDL's at the watershed scale and is appropriate for stormwater modeling. HSPF is compatible with GIS data and integrates well with ACHD's existing data. Importantly, HSPF and Basins were developed by the EPA and are thus acceptable for meeting permit requirements. The drawback for HSPF is the scale that the model works on. It is generally used for watershed-wide scale studies, such as the entire lower Boise River. A major drawback of HSPF is that it does not include a GSI component. HSPF calculates pollutant loads to receiving waters (reservoirs and streams) and thus would need to be coupled with another model, such as SELECT V2.0, to evaluate placement and effectiveness of GSI control measures. Due to the scale differences and lack of GSI control measure evaluation HSPF is not recommended.

Table 7. Stormwater Model Comparative Analysis (Water Quality models highlighted).

Model	Common Use (Type)	Typical Scale	Complexity	Data Requirements	LID BMP Location & Effectiveness	Water Quality	Continuous or Event Based	User Interface	GIS Capable
EPA SWMM (PC SWMM) (INFO SWMM)	Urban runoff, pollutant loading, hydraulic design	Site to Watershed	Medium to Complex	Land use, soil, meteorological time series, drainage systems SCM type and sizing	Yes, including street cleaning	Yes	Yes – Can be used for both	GUI - Stand alone	Yes
HSPF (BASINS)	Combined water quality, hydraulics and hydrologic	Site to Watershed	Complex	Land cover/ land use, soil, precipitation, temperature, humidity, solar radiation etc.	Only as loading to reservoirs (receiving waters)	Yes - receiving waters	Yes	Stand alone - Fortran	Yes
Select V2.0	Evaluate SCM scenarios	Site to Watershed	Medium	Hourly rainfall data, runoff coefficients, drainage area, impervious cover, EMC	Yes – Seven SCMs available	Yes, six pollutants	Event	Excel/ Spread sheet	No
Watershed Treatment Tool (WTM)	Estimate the efficacy of SCMs	Site to Watershed	Simple (Simple method)	Pollutant concentrations, runoff	Yes	Yes	Continuous	Excel/ Spread sheet	No
MUSIC	Urban runoff, pollutant loading, hydraulic design, simple receiving waters	Site to Watershed	Simple to medium	Land use, soil, precipitation, drainage system, SCM type and sizing	Yes	Yes	Event	GUI - Stand alone	No
WWHM (2012)	HSPF engine with regional modification	Site to Watershed	Complex	Land cover/ land use, soil, precipitation, temperature, humidity, solar radiation etc.	Yes	Yes	Continuous	GUI - Stand alone	No
WinSLAMM with ArcSLAMM	Urban runoff, pollutant loads	Site to Watershed	Medium	Land cover/land use, development characteristics, soil, rainfall (event, monthly), evaporation, SCM sizing and type	Yes	Yes	Continuous	GUI - Stand alone	Yes

WinSLAMM (with ArcSLAMM) and EPA SWMM (PCSWMM) are two of the most widely applied stormwater modeling software packages available, and meet EPA permit requirements. As its name suggests, EPA SWMM was developed by the EPA and PCSWMM, which is based on EPA SWMM, was developed by Computational Hydraulics International (CHI). WinSLAMM was developed by PV & Associates. Since PCSWMM and WinSLAMM are developed by private entities they require purchasing licenses, which would be additional cost for future modeling. PCSWMM costs $120 per month or $1,440/year. WinSLAMM costs $375/year for a single license.

Both software packages work at scales consistent with the Main Street and Americana subwatersheds and both have the ability to evaluate GSI control measures. Although the names of the GSI controls that can be modeled in each software package differ, all potential ACHD and City of Boise GSI accepted controls can be modeled in WinSLAMM and PCSWMM (Table 8). The difference between the two software packages, in terms of modeling GSI controls, is in how the specifications of each potential control are described within the software package.

Either software package would meet the needs of of the project, but PCSWMM is recommended for this project due to the ease of incorporating existing data into the model. GIS, hydrologic and water quality data are easily incorporated into PCSWMM. The ease of importing data into PCSWMM reduces modeling time and expenditures considerably. WinSLAMM requires more data manipulation to incorporate existing datasets into the model. For example, ArcSLAMM is an extension for ArcGIS that is used to create data for incorporation into WinSLAMM. ArcSLAMM works with a predefined geodatabase which facilitates the creation of subareas and other pertinent model parameters. Much of the data that would be created through ArcSLAMM already exists in ACHD's databases, thus adding redundancy to the modeling effort. For these reasons, PCSWMM is the recommended modeling package for the Subwatershed Planning Project.

■ *Table 8. GSI controls that can be modeled in PCSWMM and WinSLAMM*

Potential LID Controls	**PCSWMM**	**WinSLAMM**
Permeable Pavers*	X	X
Tree Systems*	X	X
Bioretention*	X	X
Bio-swale*	X	X
Rain Barrel	X	X
Rain Garden	X	X
Green Roof	X	X

*ACHD accepted GSI controls (ACHD 2014 – Green Stormwater Infrastructure Guidance manual)

Model Methodology

The following approach (steps) was employed to build the PCSWMM model, ensure the model was functioning correctly, calibrate the model to existing conditions, and then utilize the model to evaluate pollutant contributions from the each subwatersheds' (Main Street and Americana) subareas:

1. Set up model by importing existing data (e.g. subareas, pipes, storm drains, ACHD monitored precipitation and monitored flow data).
2. Run initial model to ensure that flow continuity and runoff continuity errors were acceptable. This step ensures that water is flowing correctly in PCSWMM's simulated environment.
3. Calibrate the model to existing conditions. ACHD's monitoring data (flow, pollutant concentration and pollutant load) were used to ensure model results are commensurate with real world conditions. Three water-quality event models were derived to compare model output to ACHD monitoring data. The three water-quality events were; October 21st, 2014 (23 hours), December 19th 2014 (13 hours), and May 5th, 2015 (19 hours).
4. Evaluate the accuracy of the model. Answer the question; how accurate are the model's simulated data (output) compared to real world conditions? The Nash-Sutcliffe Efficiency (NSE) statistic was relied on to evaluate simulated model result accuracy (Moriasi et al. 2007). See section below on the Nash-Sutcliffe Efficiency statistic for more information.
5. Model future conditions to estimate possible impacts to water quality. A fourth model was run for each subwatershed that evaluated the EPA issued NPDES Permit's runoff reduction standard of 0.6" in 24-hours (95th percentile storm) (ACHD 2015c). The model was run using the average washoff and buildup values from the three water quality events. This storm is used to evaluate the runoff reduction needed for development and redevelopment projects that disturb more than 5,000 square feet. This event is referred to herein as the "code storm."

The modeling results from the code storm were used in the Prioritization Methodology, which identified priority subareas for GSI implementation within the two subwatersheds.

PCSWMM Model Inputs

The following section describes several of the PCSWMM model inputs. It must be noted that not all variables are described below, as there are many. The information presented below focuses on the variables that effect model function and results the most.

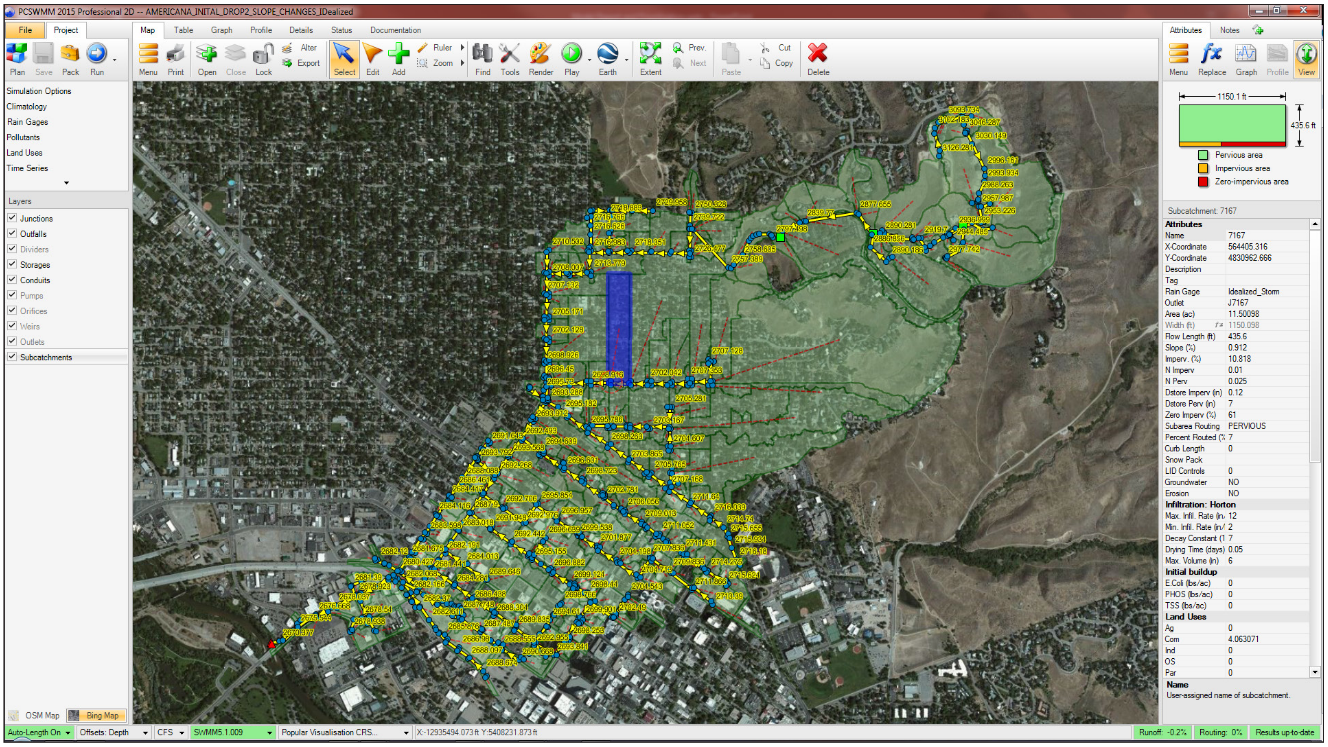
GIS data (subarea, pipes, structures) built the foundation of the model. Precipitation drives the model, as rain causes stormwater events. But as important as precipitation is, the attributes of the subareas are equally important, as these variables determine how much and how fast water moves through each subarea to the storm drain system.

GIS Data

The GIS data described in the Existing Conditions section of this report documents much of the base input data that is imported into the PCSWMM model. The primary data imported into PCSWMM includes; ACHD's storm drain pipes, ACHD's storm drain structures (catch basin's, siphon drains, outfalls, manholes, sand/grease traps, etc.), derived subareas, and land use data (Brown and Caldwell 2015a). A view of much of the GIS data in the PCSWMM environment is provided in Figure 12. Also in Figure 12, found along the right side of the image are the attributes that describe the subareas many of which are explained below.

Climate Data (Precipitation and Evaporation)

Rainfall is the primary driver of stormwater in Ada County and ACHD has monitoring stations throughout Boise that collect rainfall information. For this project rainfall data collected by ACHD at their Front Street Rain Gauge was used to determine precipitation events for the PCSWMM model (Figure 13). Front Street Rain Gauge).



Subcatchment: 7167

Attributes	
Name	7167
X-Coordinate	564405.316
Y-Coordinate	4830962.666
Description	
Tag	
Rain Gage	Idealized_Storm
Outlet	J7167
Area (ac)	11.50098
Width (ft)	1150.098
Flow Length (ft)	435.6
Slope (%)	0.912
Imperv. (%)	10.818
N Imperv	0.01
N Perv	0.025
Dstore Imperv (in)	0.12
Dstore Perv (in)	7
Zero Imperv (%)	61
Subarea Routing	PERVIOUS
Percent Routed (%	7
Curb Length	0
Snow Pack	
LID Controls	0
Groundwater	NO
Erosion	NO
Infiltration: Horton	
Max. Infil. Rate (in/	12
Min. Infil. Rate (in/	2
Decay Constant (1	7
Drying Time (days)	0.05
Max. Volume (in)	6
Initial buildup	
E.Coli (lbs/ac)	0
PHOS (lbs/ac)	0
TSS (lbs/ac)	0
Land Uses	
Ag	0
Com	4.063071
Ind	0
OS	0
Par	0

Name
User-assigned name of subcatchment.

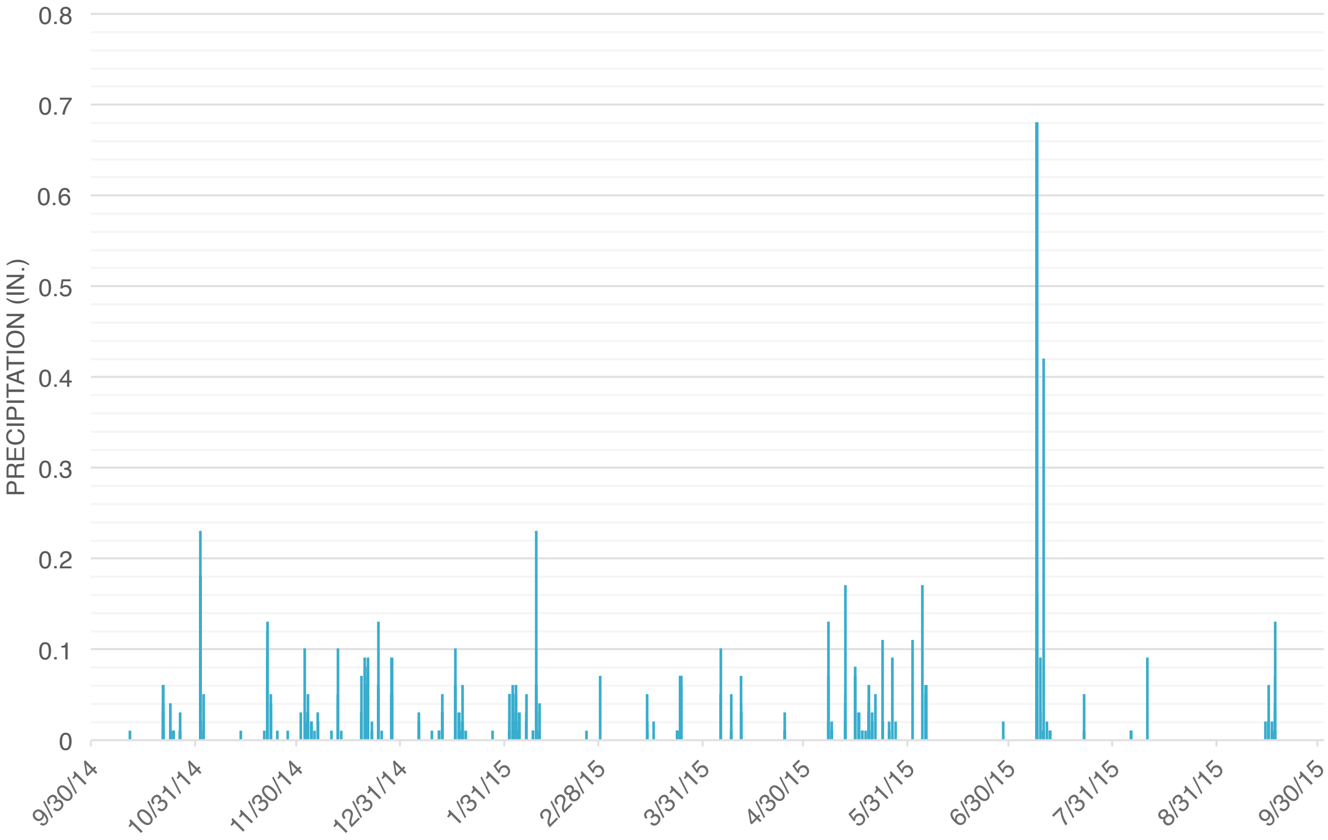
Auto-Length On
Offsets: Depth
CFS
SWMM5.1.009
Popular Visualisation CRS...
X:-12935494.073 ft Y:5408231.873 ft
Runoff: -0.2%
Routing: 0%
Results up-to-date

■ *Figure 12. Americana Subwatershed in PCSWMM environment. Subareas (green polygons), storm drain pipes (yellow lines) and storm drain infrastructure (blue points), red lines indicate storm drain structure that subarea drains to.*

Evaporation rates have a considerable effect on stormwater. Warm spring and hot summer days have greater evaporation rates than winter and fall rates in Ada County. Appropriate evaporation rates for Boise are documented in NOAA Technical Report NWS 34, Mean Monthly, Seasonal and Annual Pan Evaporation for the United States (NOAA 1982). Quantified monthly evaporation rates for the Boise Airport were used for the three WQ event PCSWMM models. Mean monthly evaporation rates are as follows; October 3.90 in/day, December 1.09in/day, and May 7.39 in/day. For the code storm model run an average of the evaporation rates from the three WQ storms was used (4.13 in/day) (NOAA 1982).

Impervious Area or Directly Connected Impervious Area (DCIA)

Impervious surfaces such as roadways, parking lots, rooftops, sidewalks, driveways, and other pavements impede stormwater infiltration and generate surface runoff. Research has shown that total watershed impervious area is correlated with a number of negative impacts on water resources such as increased runoff, increased sediment, nutrient, and other pollutant levels, and reduced recharge to groundwater (CWP 2003). In Boise and Ada County studies have shown that this relationship exists but is not a direct correlation, as estimated impervious areas were substantially higher than the impervious estimates derived from ACHD's measured runoff (Brown and Caldwell 2015b, Impervious Area Connectivity Evaluation). Brown and Caldwell (2015b) noted that runoff coefficients based on current total

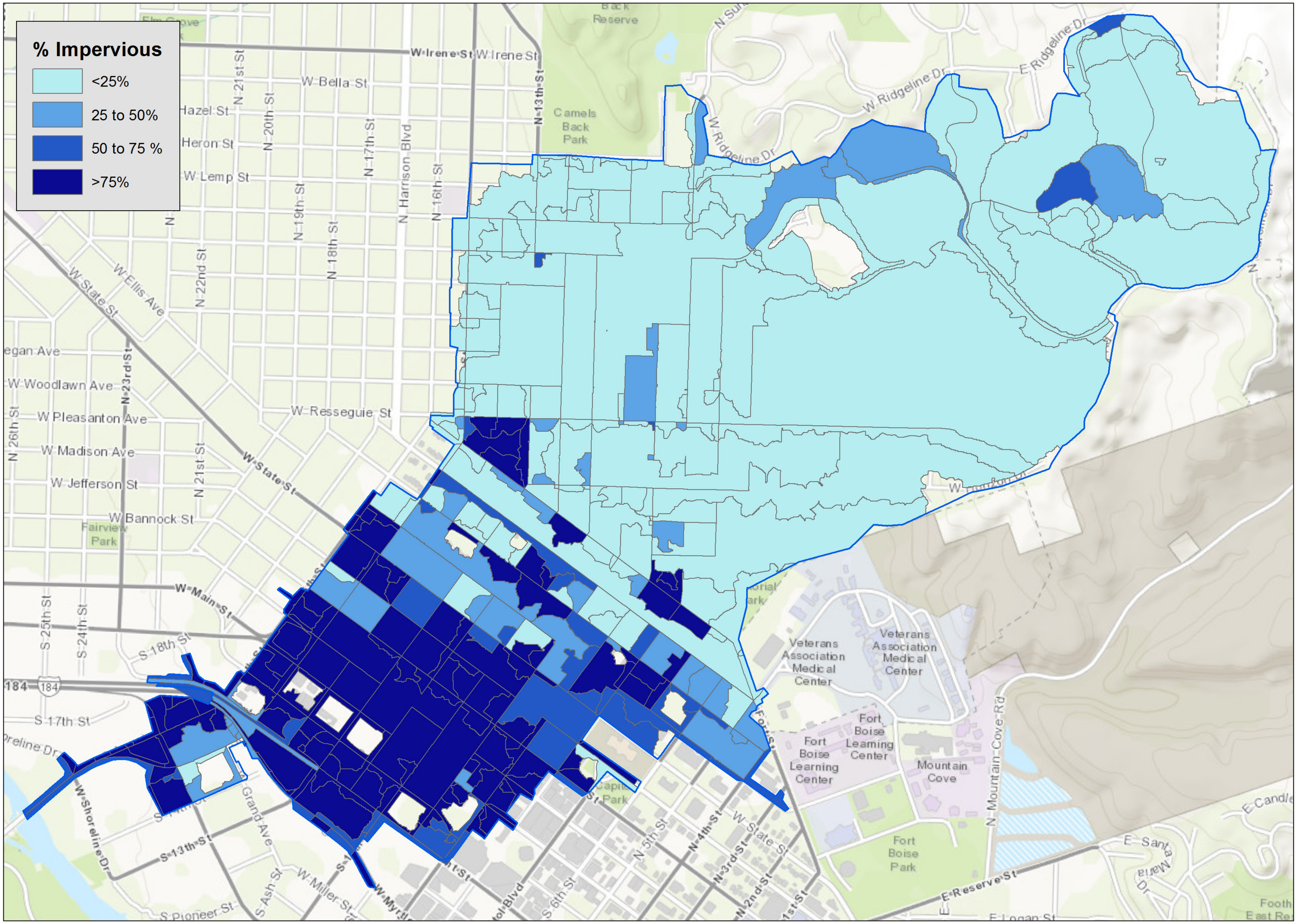


■ *Figure 13. Water Year 2015 Precipitation data for the Front Street Rain Gauge*

impervious area estimates within ACHD's monitored subwatersheds consistently yield runoff estimates that are 2.3 to 7.6 times higher than the measured runoff volumes (Brown and Caldwell 2015b). The rationale for this is that an area may have a high impervious cover but the entire impervious area may not be connected to the stormwater system. For example, rooftops that drain to lawns do not contribute stormwater to the overall system, as that runoff infiltrates into the grass area. The rooftop areas are not "directly" connected to the stormwater system and are thus not contributing runoff. To determine applicable impervious area percentages, or directly connected impervious area (DCIA), for the Boise area, Brown and Caldwell performed an Impervious Area Connectivity Evaluation (Brown and Caldwell 2015b). Brown and Caldwell's analysis quantified DCIA per land use type by developing empirical relationships between a land use's total impervious area and its directly connected impervious areas (Brown and Caldwell 2015b). Brown and Caldwell's analysis results were used to derive DCIA for the following land use types for this study; Agriculture, Commercial, Industrial, Open Space, Parks, Public, Schools, Residential Medium, Residential High and Residential Low. Figure 14 (Americana Impervious Area Map) depicts the DCIA per subarea in the Americana Subwatershed.

Manning's n Impervious/Pervious

Manning's n values describe the roughness or friction applied to water by the medium it is flowing over. In many flow conditions the selection of a Manning's roughness coefficient can greatly affect computational results (Chow 1959). Therefore, within PCSWMM it is essential to select a n value that accurately reflects real world conditions. In PCSWMM users apply an n value to pervious (e.g. grass, bare soil) and impervious (e.g. asphalt) areas per subarea. N values for impervious and pervious areas were selected from Chow's (1959) *Reference tables for Manning's n values for channels, closed conduits flowing partially full and corrugated metal pipes*.



■ *Figure 14. Directly Connected Impervious Area (DCIA) per Subarea within the Americana Subwatershed*

Infiltration Rates

Pervious areas within the two subwatersheds enable precipitation to infiltrate into the ground rather than runoff and contribute to stormwater discharge. Within the project area surface soils are underlain by alluvium of the Boise River consisting primarily of sandy cobble gravel, which grades to sandy pebble gravel with no clay (TetraTech 2014). Soils investigations of sites within the two subwatersheds revealed soil permeability (infiltration rates) approaching 12 inches per hour (Brown 2013; Wright 2002 from TetraTech 2014). Therefore, maximum infiltration rates used in the PCSWMM model was 12 inches per hour.

Pipe Size

Storm drain pipe size is an important component of stormwater management and effects the results of models. Storm drain pipe size should increase in a downstream direction. Pipe sizes ranged from 10 inches to 48 inches in diameter. ACHD reviewed the storm drain pipe GIS data to ensure sizing was correct.

Pipe Manning's n

As mentioned above, Manning's n values describe the roughness or friction applied to water by the medium it is flowing over. In PCSWMM users must enter a n value for each type of pipe. Within the storm drain system there are several types of pipes; Corrugated Metal Pipe (CMP), High Density Polyethylene (HDPE) Pipe, PVC, Reinforced Concrete Pipe (RCP) and Steel Pipe. Chow (1959) documents the n values for CMP, RCP, and Steel. HDPE and PVC n values were obtained from Barfuss et al. (1994) and Bishop and Jeppson (1975), respectively.

Stormwater Structure Depth and Invert Elevations

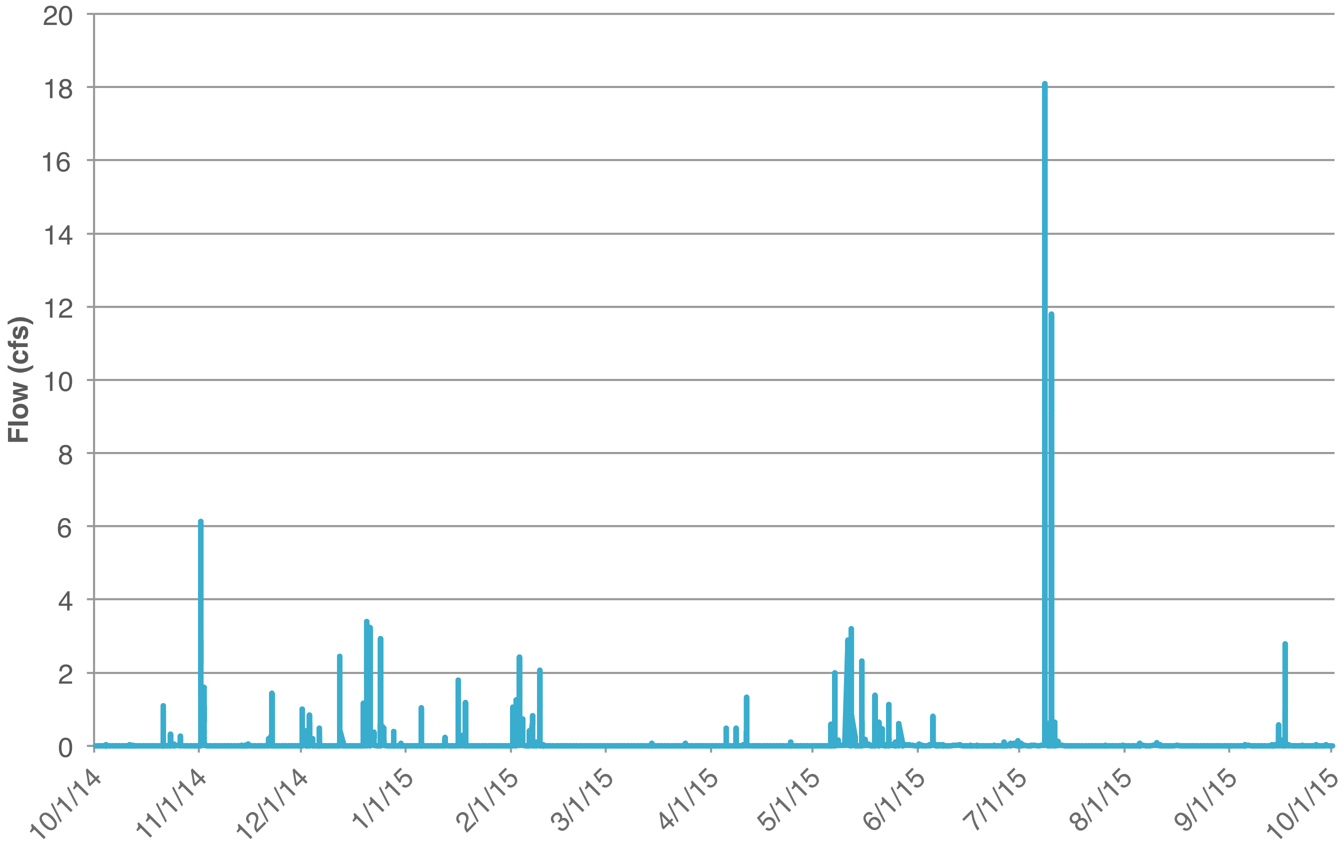
ACHD does not have a complete survey of their storm drain infrastructure's rim elevations and invert elevations. Therefore, rim elevations and invert elevations were derived in GIS. Each stormwater structure's (e.g. catch basin, sand and grease trap, manhole) GIS point was intersected with a digital elevation model (DEM). Thus, rim elevations represent the mean elevation above sea level at the location of each stormwater structure point. Initial invert elevations were derived by subtracting the ACHD standard depth of the stormwater structure from the rim elevation (ACHD 2015b). For example, manholes are generally 6 feet deep, sand and grease traps are 4 feet deep and catch basins are 3 feet deep (ACHD 2015b). These initial invert elevations were edited in PCSWMM to ensure that pipe slopes (e.g. pipe connecting catch basin invert elevation to manhole invert elevation) were sufficient to allow flow and not cause surcharge.

ACHD Flow Monitoring Data

One of the most important PCSWMM model inputs is actual flow data. As mentioned above, ACHD continuously monitors flow in the Americana and Main Street Subwatersheds in the storm drain just upstream from each outfall. Figure 15 depicts continuous flow monitoring data in the Main Street Subwatershed for the 2015 water year. These data are very important because it enables PCSWMM users to calibrate each model and statistically analyze how well the simulated PCSWMM results matched real-world conditions (ACHD continuous flow monitoring data). Figure 16 depicts the PCSWMM simulated results of flow in conduit (storm drain pipe) C2 compared to ACHD monitoring data in the same location during the December 19th, 2014 modeled storm event. Figure 16 also contains the rainfall for the December 19th 2014 event, which demonstrates how stormwater flow is dependent on precipitation and responds to precipitation.

Nash-Sutcliffe Efficiency Statistic (NSE)

Goodness of fit, or how well simulated model results match real-world conditions, was derived by using the Nash Sutcliffe Efficiency (NSE) statistic. NSE values range from negative infinity to 1.0. A NSE value of 1.0 is optimal fit of a model. Generally, for surface runoff model simulation, values greater than 0.5 are deemed satisfactory, meaning the simulated results are closely matching real-world conditions (Moriasi et. al



■ *Figure 15. 2015 Water Year Flow Monitoring near the Main Street Watershed Outfall*

2007). Figure 16 shows the NSE value (0.82) for the Main Street Subwatershed's model from 12/19/2014. NSE values for the three Main Street Subwatershed models ranged from 0.727 – 0.82(Table 9). NSE values for the three Americana Subwatershed models ranged from 0.76 to 0.797 (Table 9). These values indicate that the PCSWMM models created for the Main Street and Americana subwatersheds were closely matching real-world conditions.

Modeled Storm Events

As mentioned in the Monitoring Methodology section above three WQ events were modeled in PCSWMM (Table 9). The three modeled events were chosen because all three had monitoring data for both subwatersheds (Brown and Caldwell 2015c). Modeling these events allowed for the comparison of PCSWMM simulated results to actual real-world data. Table 9 provides detailed information on each storm event (duration and precipitation) as well as the NSE statistic for each event.

■ *Table 9. Simulated (PCSWMM) storm events and error statistics. Duration and precipitation data are from Brown and Caldwell 2015c.*

Storm Event	Duration (hr)*	Precip. (in)	NSE Main St.	NSE Americana
10/21/2014	8	0.27	0.727	0.797
12/19/2014	8.5	0.13	0.082	0.783
05/15/2015	15	0.33	0.766	0.76

Code Storm (0.6 in. precipitation event in 24 hours)

Based on the results of the three WQ modeled storm events it was determined that the PCSWMM model was adequately simulating real-world conditions in the two subwatersheds. Therefore, to assist in the prioritization of subareas for GSI implementation, a hypothetical fourth model was created. The hypothetical fourth model evaluated the EPA issued NPDES Permit's runoff reduction standard of 0.6-inch precipitation event 24-hours (95th percentile storm) (ACHD 2015c). The model used the average values for many of the input parameters mentioned above and below, primarily buildup and washoff values from the three water quality models. The results of the code storm model were used to determine runoff and pollutants loads per subarea of the two subwatersheds. The runoff and pollutant load data per subarea were applied to the prioritization schema described below.

Pollutants of Concern

Three pollutants were modeled in PCSWMM; Total Suspended Solids (TSS), Phosphorus (TP), and bacteria in the form of Escherichia Coli (*E. coli*). These pollutants are identified as sources of water quality impairment for the lower Boise River and are monitored by ACHD (IDEQ 1999, IDEQ 2001, IDEQ 2009, USEPA 2013, IDEQ 2015). Monitoring stations are located in a storm drain pipe just upstream of the outfall. ACHD's pollutant monitoring data was vital to model calibration. ACHD's pollutant monitoring data does not provide a time series of pollutant concentrations during a monitored storm event. Rather their monitoring methodology results in an event mean concentration (EMC). An EMC is a value determined by compositing (in proportion to flow rate) a set of samples, taken at various points in time during a runoff event, into a single sample for analysis (NRDC 2016).

To calibrate the PCSWMM model, ACHD's monitored EMCs were compared to the simulated EMC for each pollutant. If the simulated EMC's were not consistent with ACHD's monitored EMCs, PCSWMM model parameters were altered. The primary PCSWMM model parameters altered were buildup and washoff, which are explained in more detail below. Buildup and washoff parameters were altered until a good fit was achieved between real-world (ACHD monitoring data) and simulated conditions (PCSWMM output).

More information about each pollutant is available in the Existing Conditions section of this report, but provided below is a brief description of each.

Total Suspended Solid (TSS)

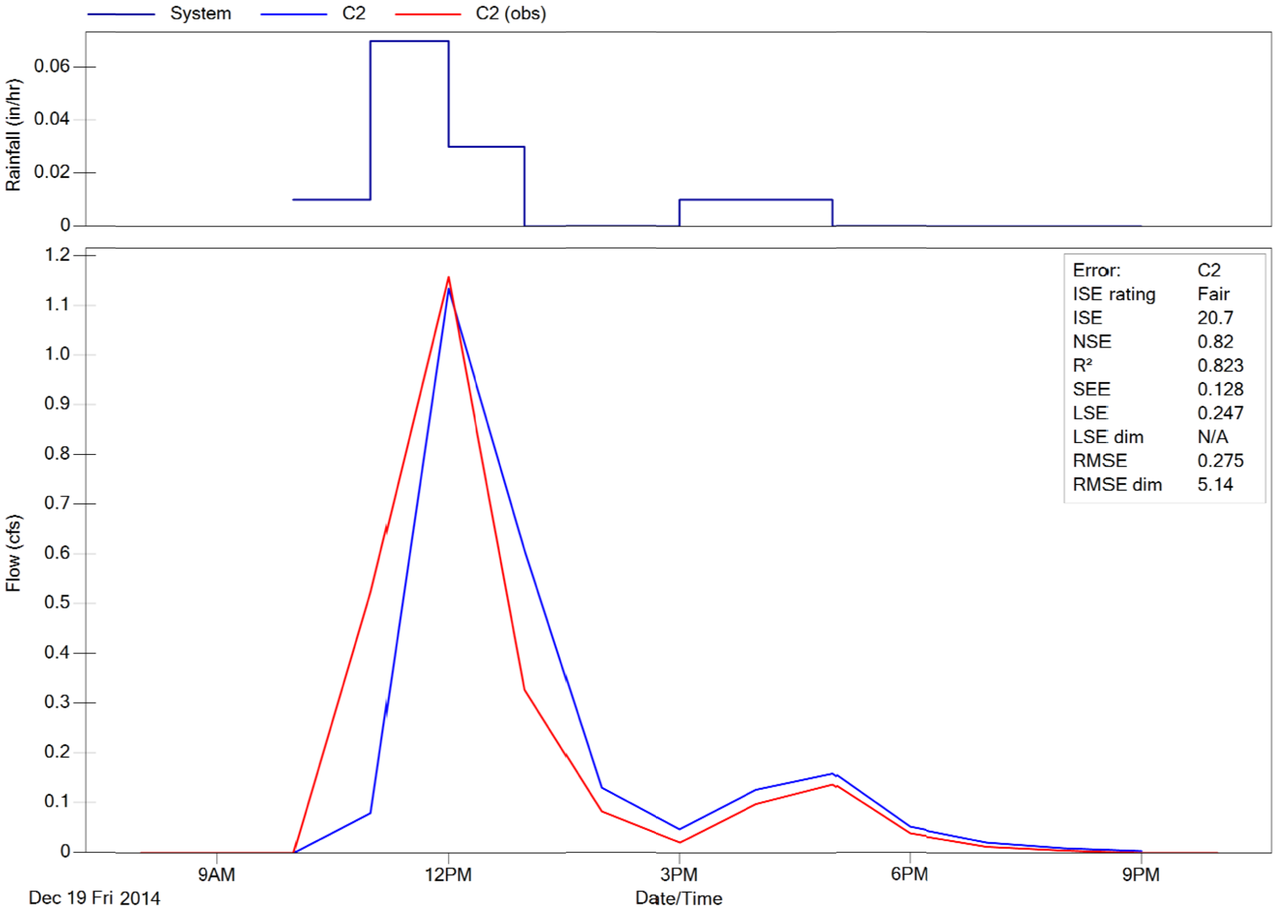
Point sources, which stormwater outfalls are one type, contribute suspended solids (TSS) to the lower Boise River. Stormwater runoff that contains sediment can deposit harmful amounts of silt and other material in stream, harming habitat needed by aquatic insects and plants (Brown and Caldwell 2014b). Stormwater TSS is generally the result of accumulated debris on roads, soil erosion from construction sites, lawns and landscaping/gardening activities (Brown and Caldwell 2014b).

Phosphorus

Phosphorus is a nutrient that promotes weed and algae growth in water bodies. Excessive concentrations of phosphorus in aquatic environments has been known to reduce dissolved oxygen content harming fish and other aquatic organisms. Sources of phosphorus in stormwater have been linked to fertilizer runoff from urban/suburban lawns, human and animal waste and detergents (Brown and Caldwell 2014b).

Bacteria - Escherichia coli (*E. coli*)

Bacteria is a common constituent in lakes and streams. Fecal coliform is a type of bacteria that by themselves are usually not pathogenic; they are indicator organisms, which means they may indicate the presence of other pathogenic bacteria. Pathogenic bacteria are linked to illness in humans and animals. Escherichia coli (*E. coli*), which are a type of fecal coliform, are known to cause disease in humans and animals when present in drinking water and contact recreation water bodies (IDEQ 2001). Bacteria (*E. coli*) contaminants come from organic matter, animal waste and litter (Brown and Caldwell 2014b). Unlike TSS and phosphorus concentrations which are linked to certain land uses, data accumulated by the Nationwide Urban Runoff Program (NURP) found that concentrations of fecal coliform (bacteria) exhibited a large degree of variability, and did not indicate any distinctions based on land use (EPA, 1983). For this reason, the *E. coli* results presented below are contain a degree of uncertainty.



■ *Figure 16. Simulated flow (blue line) compared to monitored flow in conduit (storm drain) C2 in the Main Street Subwatershed. Storm event rainfall depicted in top graph. NSE statistic (error) in inset box.*

Washoff and Buildup

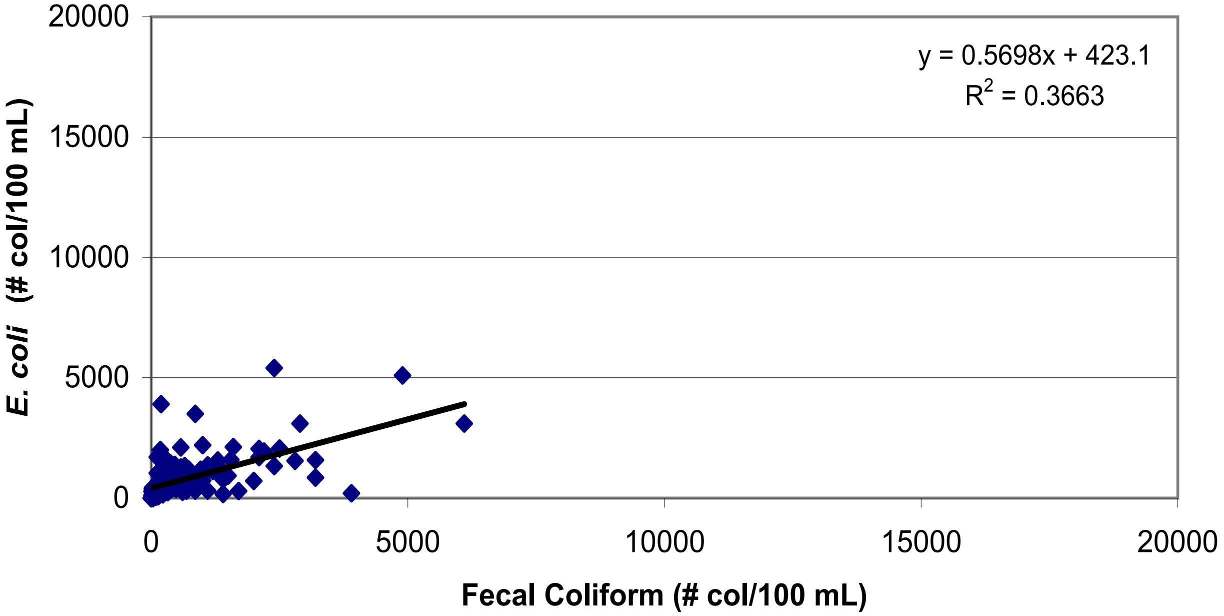
Simulating pollutant loads and concentrations within PCSWMM is accomplished by entering buildup and washoff values for each land use, as land use types account for the spatial variation in pollutant buildup and washoff rates (CHI-Water 2015). Associating buildup and washoff rates with land uses is a common practice in stormwater and pollutant modeling. The National Stormwater Quality Database retains a wealth of information related to pollutant buildup and washoff rates from land uses (EPA 2015). For example, Table 10 depicts washoff rates (EMCs) from selected land uses for several pollutants including the three simulated in this study (EPA 2015). High TSS washoff rates are generally associated with areas characterized by high impervious areas (i.e. industrial and freeways) (Table 10). Residential areas generally contribute greater concentrations of phosphorus than all other land uses in urban areas, as fertilizer use is associated with the presence of lawns (Table 10).

Initial PCSWMM water quality models relied on values from the National Stormwater Quality Database, to determine appropriate washoff and buildup values. Such data provided initial estimates of the mean event concentrations originating from the different land uses found in the two subwatersheds.

E. coli buildup and washoff rate data is not as straight forward as phosphorus and TSS. Often, such as in Table 10, bacteria buildup and washoff rates are attributed to fecal coliform. Fecal coliform and *E. coli* are not the same, and their concentrations differ in water quality samples.

■ *Table 10. Pollutant washoff rates for selected landuses (Pitt et al. 2004).*

Parameter	Overall	Residential	Commercial	Industrial	Freeways	Open Space
Area (acres)	56	57.3	38.8	39	1.6	73.5
% Imperv.	54.3	37	83	75	80	2
Precip. Depth (in)	0.47	0.46	0.39	0.49	0.54	0.48
TSS (mg/L)	58	48	43	77	99	51
BOD5 (mg/L)	8.6	9	11.9	9	8	4.2
COD (mg/L)	53	55	63	60	100	21
Fecal Coliform (mpn/100 mL)	5081	7750	4500	2500	1700	3100
NH3 (mg/L)	0.44	0.31	0.5	0.5	1.07	0.3
N02+NO3 (mg/L)	0.6	0.6	0.6	0.7	0.3	0.6
Nitrogen, Total Kjeldahl (mg/L)	1.4	1.4	1.6	1.4	2	0.6
Phos., filtered (mg/L)	0.12	0.17	0.11	0.11	0.2	0.08
Phos., total (mg/L)	0.27	0.3	0.22	0.26	0.25	0.25
Cd, total (ug/L)	1	0.5	0.9	2	1	0.5
Cd, filtered (ug/L)	0.5	ND	0.3	0.6	0.68	ND
Cu, total (ug/L)	16	12	17	22	35	5.3
Cu, filtered (ug/L)	8	7	7.6	8	10.9	ND
Pb, total (ug/L)	16	12	18	25	25	5
Pb, filtered (ug/L)	3	3	5	5	1.8	ND
Ni, total (ug/l)	8	5.4	7	16	9	ND
Ni, filtered (ug/L)	4	2	3	5	4	ND
Zn, total (ug/L)	116	73	150	210	200	39
Zn, filtered (ug/L)	52	33	59	112	51	ND
ND = not detected, or insufficient data to present as a median value.						



■ *Figure 17. Relationship between E.Coli and Fecal Coliform concentrations in the Boise River (CH2MHILL 2003).*

Therefore, initial buildup and washoff concentrations relied on data from the Lower Boise River Coliform Bacteria DNA Testing report (CH2MHILL 2003). This report provided data that showed the relationship between Fecal Coliform and E.Coli concentrations in the Boise River (Figure 17). To complicate matters, PCSWMM does not use MPN per 100 ml as the concentration unit. PCSWMM determines concentrations in liters, and therefore the results from PCSWMM for *E. coli* seem much higher. Note that when viewing the results below, PCSWMM concentrations are represented as the most probable number (MPN) or colony forming units per liter, not per 100ml as seen in Table 10.

The NSQD data and the Lower Boise Coliform report provided initial estimates for buildup and washoff rates to enter into the PCSWMM model. ACHD's monitoring data provided target EMCs. To meet the target EMCs from ACHD's monitoring data, the initial buildup and washoff rates were edited in PCSWMM. Buildup and washoff values area presented in Appendix C.

Running the PCSWMM model involves many other variables and inputs. The information presented above explains some of the most important variables that have a significant effect on model function and accuracy.

Results

PCSWMM Model results are presented by subwatershed below. Since the Americana Subwatershed contains 393 subareas, most of its results are presented in spatial form, while the 35 subareas in the Main Street Subwatershed are presented in graphical form.

Main Street Subwatershed Results

Pollutant concentrations from the three modeled water quality storms events for the Main Street Subwatershed are presented in Table 11. Table 11 also contains ACHD's monitoring data for comparison. Overall, modeled pollutant concentrations were very similar to ACHD's monitored pollutant concentrations (Table 11), which along with the sufficient NSE values discussed earlier, indicates that the PCSWMM model is adequately simulating real-world conditions in the Main Street Subwatershed.

Main Street Subwatershed – Loads Per Subarea

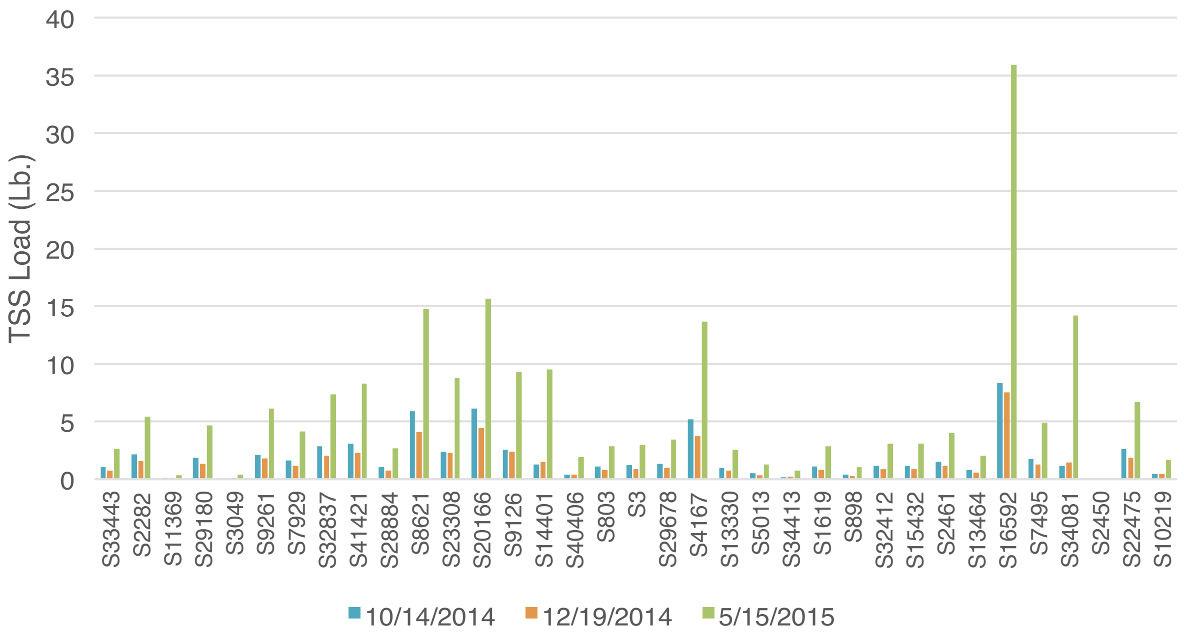
In the Main Street Subwatershed pollutants loads vary by storm event and time of year, which is dependent on many factors including seasonality (e.g. evaporation), size of storm (amount of precipitation), and buildup and washoff rates in which the number of antecedent dry days factors heavily. Table 12 displays the simulated (modeled) min, max and mean pollutants loads (TSS, phosphorus and *E. Coli*) per the 35 subareas for the three storm events in the Main Street Subwatershed. In the Main Street subwatershed TSS and phosphorus pollutant loads display a significant size related trend, in which the largest subareas generate the greatest load (Figure 18 and Figure 19). For example, subarea S16592 is the largest subarea (15.1 acres) and contributes the greatest TSS (10/21/2014 – 8.34lbs; 12/19/2014 – 7.52lbs; 5/15/2015 – 35.93lbs) and phosphorus (10/21/2014 – 0.267lbs; 12/19/2014 – 0.089lbs; 5/15/2015 – 0.13lbs) loads for the three storms (Figures 18 and 19).

■ *Table 11. Comparison of Main Street WQ results (simulated PCSWMM EMCs and Monitored ACHD EMCs)*

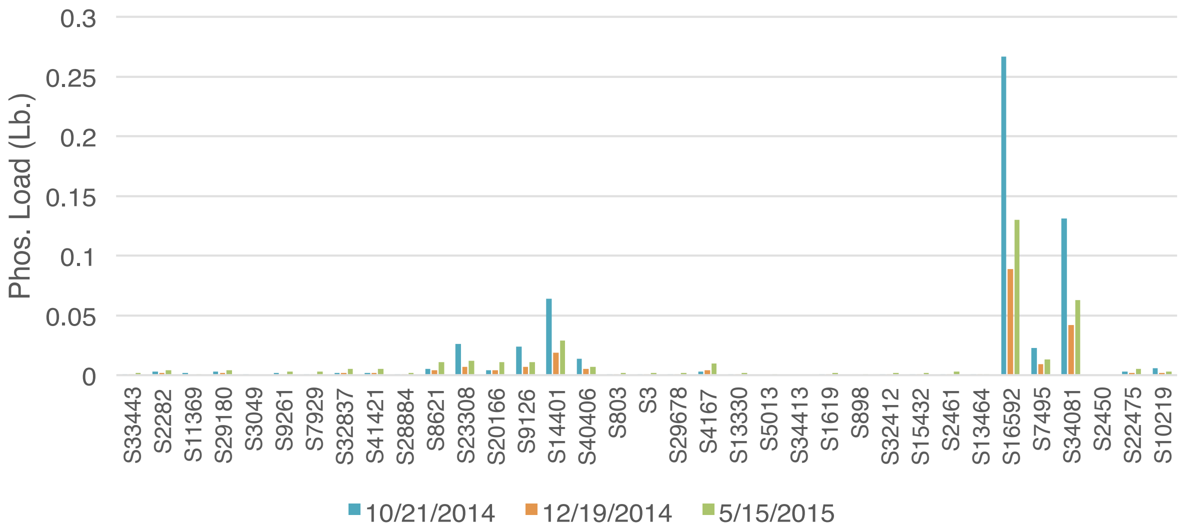
	PCSWMM			ACHD		
Date	*E. coli* (mpn/L)	Phosph (mg/l)	TSS (mg/l)	*E. coli* (mpn/L)	Phosph (mg/l)	TSS (mg/l)
10/21/14	NA	0.6	60.6	NA	0.62	63.9
12/19/14	6947	0.27	131.6	6867	0.26	130.0
5/15/15	3749	0.24	79.9	3873	0.25	83.2

■ *Table 12. Minimum, Mean, and Maximum Pollutant Loads per Subarea in the Main Street Subwatershed*

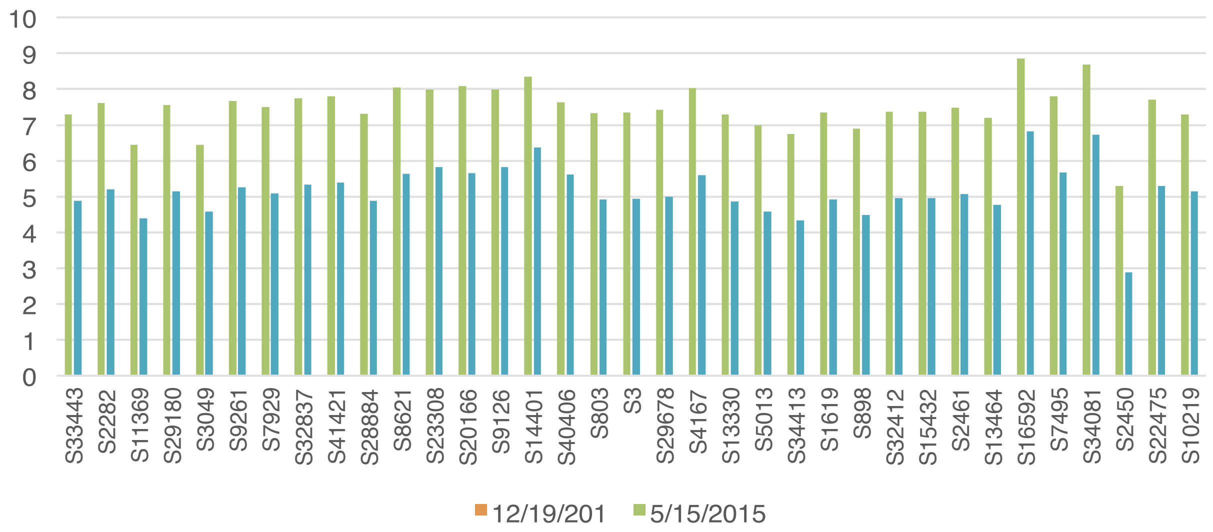
Storm Event	Statistic	TSS (lbs)	Phosph (lbs)	E.Coli (mil. Col.)
10/21/14	Min.	0.031	0	NA
	Mean	1.88	0.017	NA
	Max.	8.34	0.267	NA
12/19/14	Min.	0.086	0	5.3
	Mean	1.48	0.006	7.484
	Max.	7.52	0.089	8.686
5/15/14	Min.	0.373	0	2.887
	Mean	5.98	0.01	5.173
	Max.	35.93	0.13	6.819



■ *Figure 18. TSS load per subarea from three modeled (PCSWMM) WQ storm events*



■ *Figure 19. Phosphorus load per subarea from three modeled (PCSWMM) WQ storm events*



■ *Figure 20. E.coli load (mil. Col.) from two modeled (PCSWMM) WQ storms*

Another trend in the Main Street monitoring results is that subareas consisting of a high percentage of residential area have higher phosphorus loads. For example, the second largest subarea in the Main Street Subwatershed is S34081 (9.56 acres), which is nearly 89% residential (Table 5). S34081 contributed the second largest phosphorus load in the subwatershed (Figure 19). Conversely, S34081 did not contribute as large a sediment (TSS) load as some smaller subareas, such as S8621 (3.38 acres) and S20166 (3.59 acres), which are 100% commercial land use (Table 5). Commercial land use is characterized by high impervious area, which is known to contribute a high TSS load during storm events (Brown and Caldwell 2015b).

As mentioned above *E. coli* results presented herein contain a degree of uncertainty, as research indicates that bacteria monitoring exhibits variability, and does not indicate any distinctions based on land use (EPA 1983). Only two of the three ACHD monitored storms contained *E. coli* data in the Main Street Subwatershed (12/19/2014 and 5/15/2015). Similar to the TSS and phosphorus results, subarea size is a factor in the *E. coli* results, as S16592 and S34081 contribute the greatest colony forming units or load for both simulated storms (Figure 20). Unlike TSS and phosphorus there is no significant trend in the *E.coli* results per land use, as the majority of subareas contribute 6 to 8 million colonies for the 12/19/2014 storm, and 4 to 6 million colonies for 5/15/2015 storm regardless of land use.

Americana Subwatershed Results

Pollutant concentrations from the three modeled water quality storms events for the Americana Subwatershed are presented in Table 13. Table 13 also contains ACHD's monitoring data for comparison. Overall, modeled pollutant concentrations were very similar to ACHD's monitored pollutant concentrations (Table 13), which along with the high NSE values discussed earlier, indicate that PCSWMM is adequately simulating real-world conditions in the Americana Subwatershed.

Americana Subwatershed – Loads Per Subarea

Table 14 displays the simulated (modeled) min, max and mean pollutants loads (TSS, phosphorus and *E. Coli*) per the 393 subareas for the three storm events in the Americana Subwatershed. The Americana Subwatershed has much greater variability in the size and land use configuration of its subareas compared to the Main Street Subwatershed. Americana includes large residential areas and open space in the foothills (see Existing Conditions Section), which is a stark contrast to the Main Street Subwatershed. For example, the largest subarea in the Americana Subwatershed is 107 acres (subarea 38243), which is roughly 30 acres larger than the entire Main Street Subwatershed. Americana's smallest subarea is only 0.007 acres. These large differences in subarea size and land use must be considered when interpreting the results presented herein.

Similar to the Main Street subwatershed, modeled polluted loads in the Americana Subwatershed display area and land use related trends. TSS loads are highest in the subareas of downtown Boise which are primarily commercial land use with a high percent impervious area (Figure 21). The largest Americana subarea, 38243, ranks in the top 3 percent of TSS load in the subwatershed, but is dominated by residential and open space land uses and also has a very low impervious area (<10%) (Figure 21). The TSS load from subarea 38243 can be attributed to its size.

Simulated phosphorus loads in the Americana Subwatershed are primarily related to land use with the highest contributing areas being dominated by residential (Figure 22). The top 10% of phosphorus load contributing subareas in the Americana Subwatershed all consist of greater than 40% residential land use (residential high, medium and low) (Appendix B, Figure 22).

As is the case in the Main Street Subwatershed, only two of the three ACHD monitored storms contained *E. coli* data in the Americana Subwatershed (10/21/2014 and 12/19/2014). Similar to the TSS results, subarea size is a factor in the *E. coli* loads in the Americana Subwatershed. The five highest *E. coli* load contributing subareas are also the five largest subareas (Figure 23).

Unlike TSS and phosphorus, there is no significant trend in the *E. coli* results per land use in the Americana Subwatershed, as the majority of subareas contribute 7 to 9 million colonies for both simulated storm events (10/21/2014 and 12/19/2014) regardless of land use.

Code Storm (0.6 in precipitation event in 24 hr) Results

Due to the area related pollutant load trends in the two subwatersheds mentioned above, the results of the code storm are presented as pollutant load per acre. The pollutant load per acre is also used in the prioritization methodology below.

Table 13. Comparison of Americana WQ results (simulated PCSWMM EMCs and Monitored ACHD EMCs)

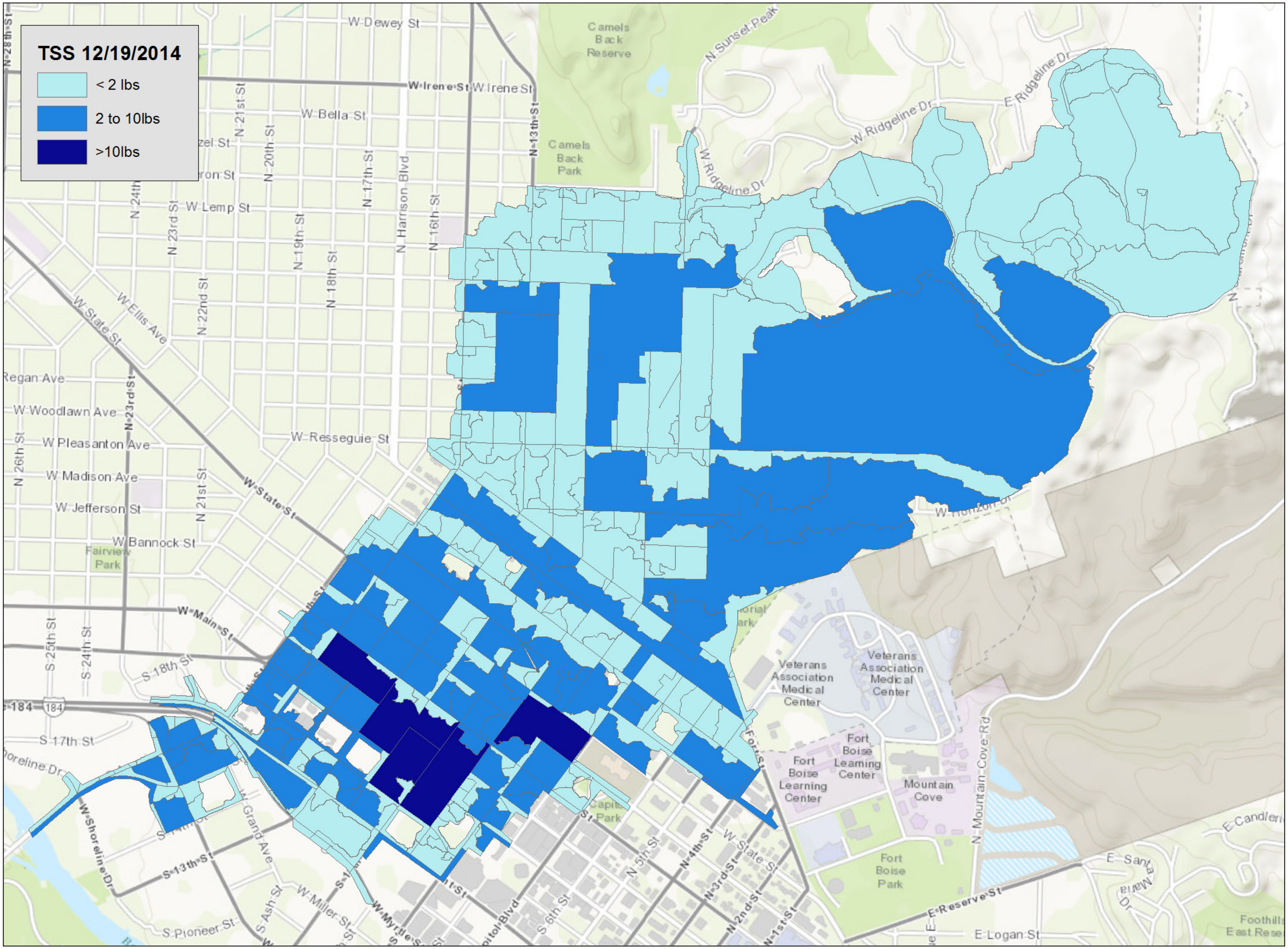
	PCSWMM			ACHD		
Date	*E. coli* (mpn/L)	Tot. Phosph (mg/l)	TSS (mg/l)	*E. coli* (mpn/L)	Phosph (mg/l)	TSS (mg/l)
10/21/14	14260	0.85	98.1	14136	0.84	97.2
12/19/14	12523	0.43	95.9	12515	0.43	95.7
5/15/15	NA	0.43	118.7	NA	0.42	119.0

Table 14. Minimum, Mean, and Maximum Pollutant Loads per Subarea in the Americana Subwatershed

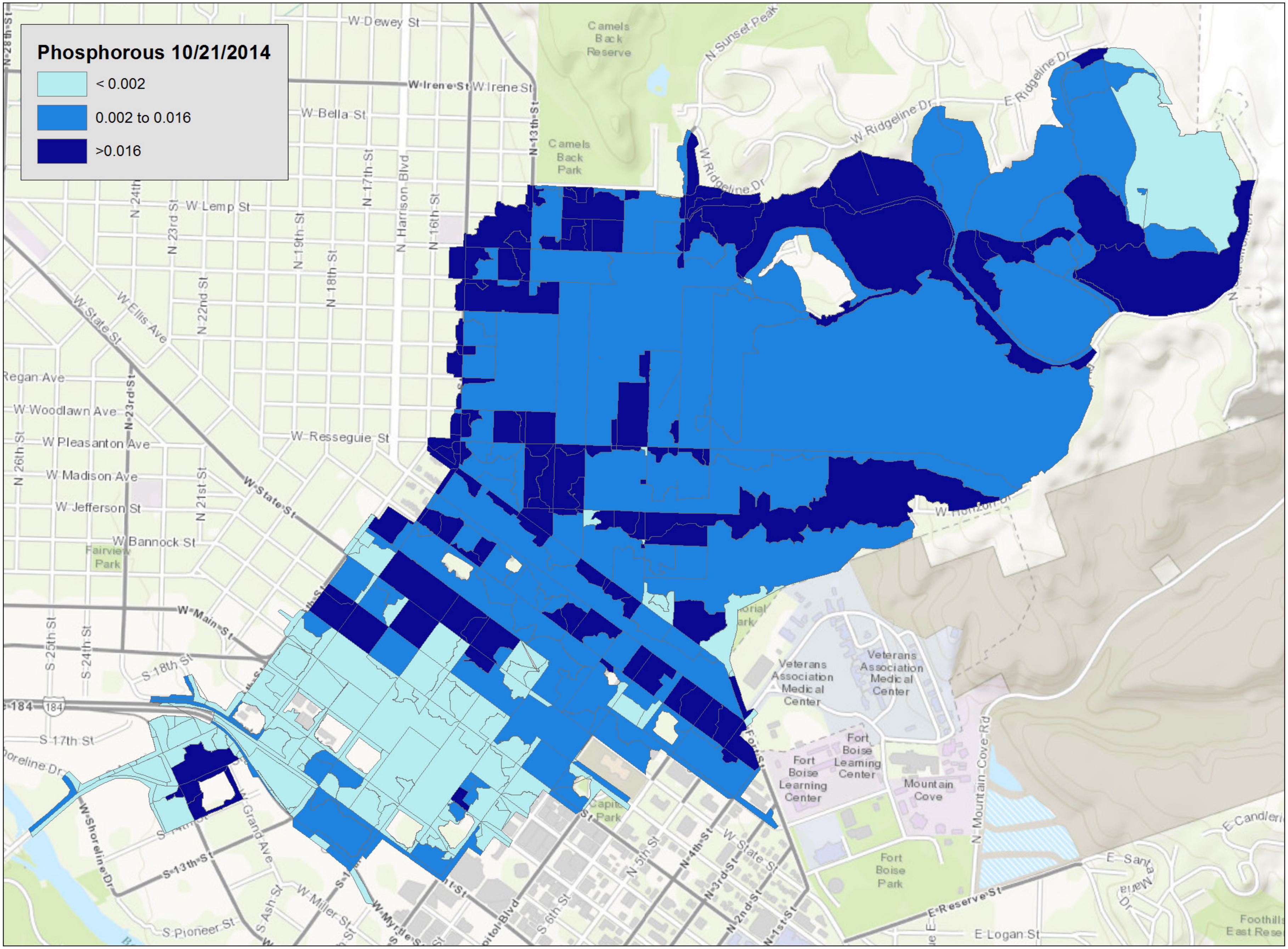
Storm Event	Statistic	TSS (lbs)	Phosph (lbs)	*E. coli* (mil. Col.)
10/21/14	Min.	0	0	0
	Mean	2.38	0.017	7.27
	Max.	35.11	0.267	9.73
12/19/14	Min.	0	0	0
	Mean	1.46	0.008	7.056
	Max.	19.84	0.257	9.73
5/15/14	Min.	0	0	NA
	Mean	1.54	0.01	NA
	Max.	17.78	0.2	NA

Table 15. Minimum, Mean, and Maximum Pollutant Loads per Acre for Subareas in the Main Street and Americana Subwatershed for the Code Storm

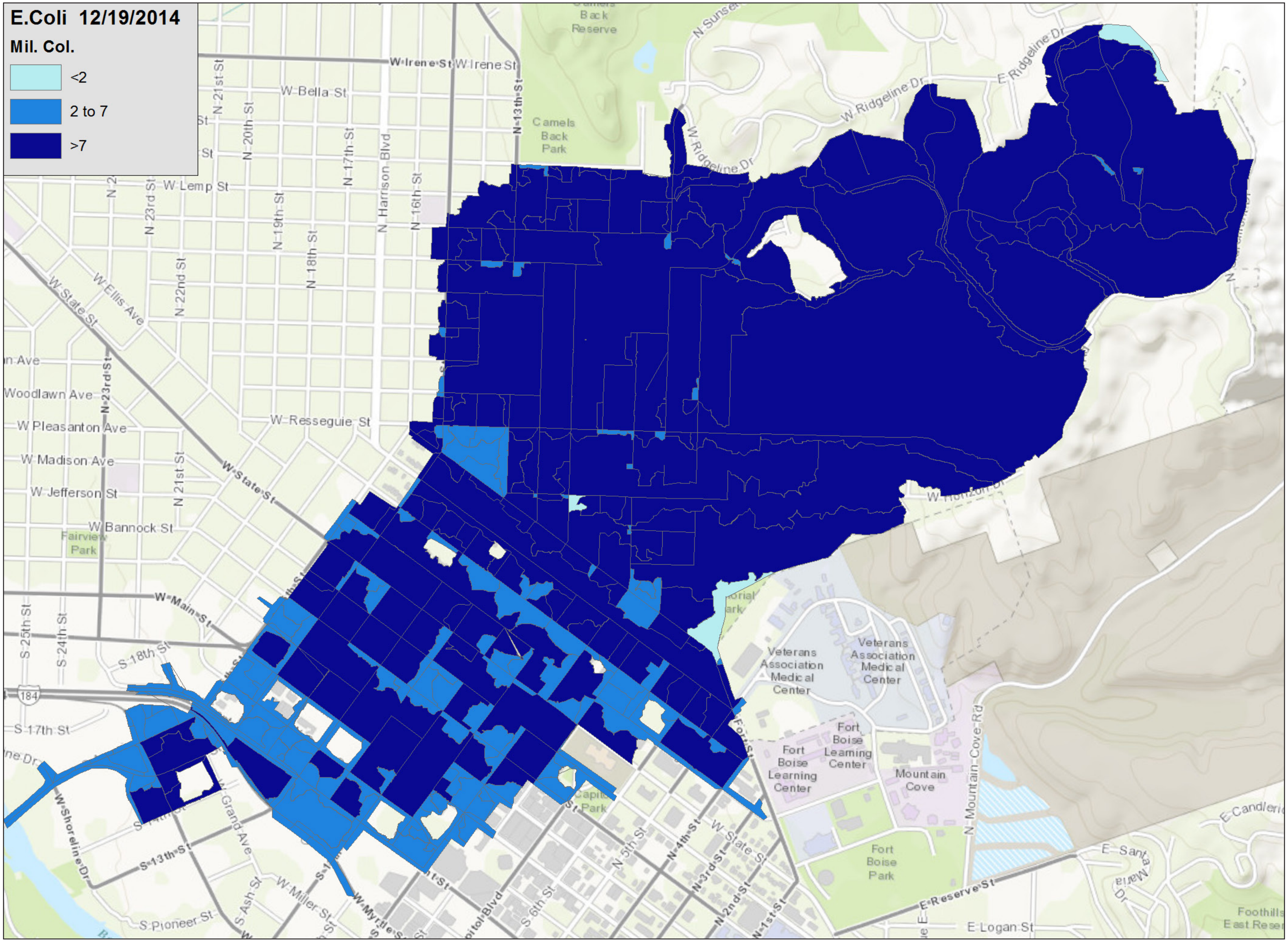
Storm Event	Statistic	TSS (lbs/acre)	Phosphorus (lbs/acre)	*E.coli* (mil. Col./acre)
Main Street	Min.	0.08	0	0.39
	Mean	2.9	0.007	5.07
	Max.	3.6	0.014	335.3
Americana	Min.	0	0	0
	Mean	1.33	0.027	13.17
	Max.	2.5	0.19	98.6



■ *Figure 21. TSS load (lbs.) per subarea from modeled 12/19/2014 storm event*



■ *Figure 22. Phosphorus load (lbs.) per subarea from modeled 10/21/2014 storm event*



■ *Figure 23. E. coli load (million colonies.) per subarea from modeled 12/19/2014 storm event*

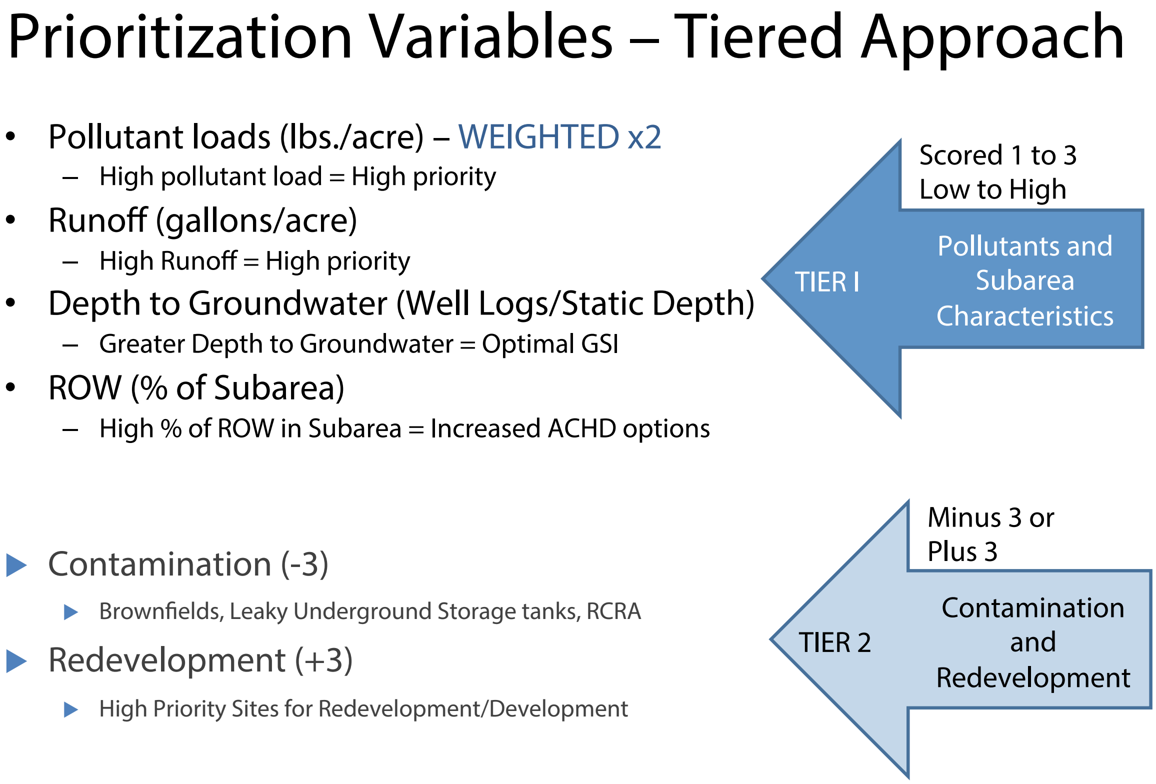
Prioritization

The over arching goal of this project is to provide ACHD and the co-permittees with a method to prioritize areas to implement GSI. Often, GSI is implemented opportunistically based on a willing landowner or as part of a redevelopment or new development project, or recommended through regulation. In such events GSI, is installed and resources are spent. The GSI provides storm water benefits by mitigating runoff and pollutant loads, but is the GSI installed in the location that provides the greatest benefit for the resources spent? Is the GSI providing the most efficient pollutant treatment or flow reduction?

This project aims to be proactive in GSI implementation by setting forth a process based on quantitative data for determining appropriate locations for GSI within the Main Street and Americana subwatersheds. The prioritization methodology outlined below relies on quantitative pollutant load data (e.g. lbs/acre) and runoff data (gallons per acre) derived in PCSWMM as well as other metrics important to successful GSI (e.g. depth to groundwater) installations.

The methodology takes into consideration ACHD's area of jurisdiction by incorporating the percent of right-of-way (ROW) per subarea. The methodology also considers opportunities to install GSI based on development; therefore new and redevelopment locations are given a higher score. And lastly, GSI is intended to mimic natural hydrology. . It is important that infiltrated stormwater not mix with underground contamination, which could potentially spread contamination through groundwater to a nearby receiving water body. Proximity to underground contamination is also built into the model. Figure 24 presents the overall methodological approach to prioritizing subareas in the two subwatersheds.

The prioritization of subareas is accomplished through a simple equation (Figure 25). The variables in Tier 1 of the approach are scored from 1 to 3 points. For example, a subarea with a low volume of runoff would get a score of 1.



Prioritization Variables – Tiered Approach

- Pollutant loads (lbs./acre) – WEIGHTED x2
  - High pollutant load = High priority
- Runoff (gallons/acre)
  - High Runoff = High priority
- Depth to Groundwater (Well Logs/Static Depth)
  - Greater Depth to Groundwater = Optimal GSI
- ROW (% of Subarea)
  - High % of ROW in Subarea = Increased ACHD options

Scored 1 to 3
Low to High

TIER I

Pollutants and Subarea Characteristics

- Contamination (-3)
  - Brownfields, Leaky Underground Storage tanks, RCRA
- Redevelopment (+3)
  - High Priority Sites for Redevelopment/Development

Minus 3 or
Plus 3

TIER 2

Contamination and Redevelopment

Figure 24. Tiered GSI prioritization variables and approach

Conversely, a score of 3 would indicate that subarea contributes a high volume of runoff to the overall system. Treatment of pollutant loads is paramount to ACHD in their consideration of GSI implementation. Therefore, pollutants are weighted higher (multiplied by 2) than all other Tier 1 variables. Pollutant loads are then on a scale of 2 (low pollutant load) to 6 (high pollutant load) (Figure 24). This step ensures that higher pollutant load contributing subareas are prioritized.

Tier 2 acknowledges the opportunistic (redevelopment) aspect of GSI and potential pitfalls (groundwater contamination) to implementation. Subareas that contain a known redevelopment project are given an additional score of 3. Subareas containing a known contamination site lose 3 points. The overall prioritization methodology is relatively simple and is repeatable in other subwatersheds.

Tier 1 Variables

Presented below is a description of each of the Tier 1 variables. Tier 1 consists of 6 parameters; TSS (lbs/acre), Phosphorus (lbs/acre), *E. coli* (mil. Col./acre), Runoff Volume (gallons/acre), Depth to Groundwater (feet), and percent of Right-of-Way.

Pollutant Loads (TSS, Phosphoruos, *E. coli*)

TSS, Phosphorus, and *E. coli* are the pollutants of concern and their pollutant loads for the prioritization were generated in PCSWMM based on the results of Code Storm model (0.6in precipitation event in 24hrs).

Runoff (gallons per acre)

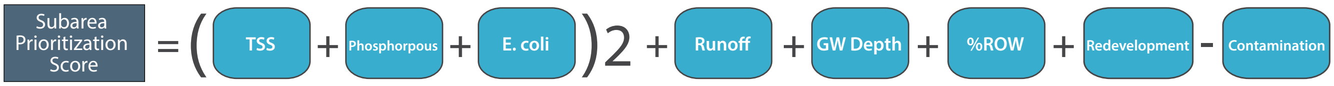
GSI is often used to increase capacity in storm drains by reducing flow to the system by infiltrating stormwater into the ground. Although treatment is paramount for ACHD and their co-permittees, increasing the capacity of the storm drain system through runoff reduction is important as well. Runoff volume per subarea was generated in PCSWMM based on the results of the Code Storm model (0.6 in precipitation event in 24 hrs).

Depth to Groundwater

Depth to groundwater is an important component of the site selection and design process for GSI implementation. The greater the depth to groundwater the greater potential for infiltration of stormwater and pollutant absorption. Conditions in the project area provide an ideal environment for GSI due to the area's groundwater being generally 10ft below the surface (TetraTech 2015). Depth to groundwater was calculated for this project in ArcGIS by creating a groundwater grid based on Idaho Department of Water Resources permitted well GIS data (IDWR 2016). Over 700 well points containing static water level data were used to create a depth to groundwater grid covering the two subwatersheds. The static water level is the distance from the land surface (or the measuring point) to the water in the well under non-pumping (static) conditions. Depth to groundwater ranged from 3ft to over 100ft in the project area.

Percent of Right-of-Way

ACHD's area of influence in the project area is primarily limited to the Right-of-Way (ROW). A greater percentage of the ROW per subarea indicates that ACHD has greater options for, and control of, GSI implementation. Percent ROW per subarea was calculated in ArcGIS. Percent ROW in the Main Street Subwatershed ranged from 8 to 100% and from 0 to 100% in the Americana Subwatershed.



■ *Figure 25. Simple equation to determine priority subareas.*

Tier 2 Variables

Tier 2 variables consist of redevelopment opportunities and potential project pitfalls in the form of potential underground contamination.

Redevelopment Opportunities

Redevelopment opportunities were identified by ACHD through discussions with developers and looking at development applications. Vacant lots were also included as redevelopment opportunities.

Potential Contamination Sites

Potential contamination data is from the Idaho Department of Environmental Quality's Brownfield Inventory from their Waste Management & Remediation Division Facility Mapper (IDEQ 2016). The points in the dataset used for the prioritization include leaky underground storage tanks (LUST) and RCRA (Resources Conservation and Recovery Act) which are considered potential contamination sites (IDEQ 2016).

Prioritization Results

To aid in the understanding of the prioritization process, the Tier 1 subarea variable results for the Americana Subwatershed are spatially depicted in Figure 26. Tables 16 and 17 depict the actual values used to score the two subwatershed subareas.

The maximum potential value for the prioritization equation is 30 (Figure 25). Defining the cut off points for classifying subareas into high, moderate and low priority classes is subjective based on natural breaks in the data sets. Subareas that scored equal to or greater than 21 are considered high priority, moderate priority subareas range from 20 to 17, while low priority subareas scored 16 and below. Classifying the subareas into high, moderate and low priorities is subjective and dependent on project goals and resources. When it comes time to actual implementation, ACHD and their co-permittees can select any break. For example, the permittees may want to include an aesthetic component, such as tree canopy, and looking for opportunities in an area that has low percent tree canopy. In such a case, project goals may be better served by being more inclusive in the high priority category including subareas scored equal to or greater than 20. Then, project managers would have a greater range of priority subareas to choose from and match those with neighborhoods with a low percent tree canopy. Alternatively, project resources may necessitate only choosing one subarea in which to implement GSI, and thus only the highest scoring subarea would be selected.

The Main Street Subwatershed has only 35 subareas. Such a small number facilitates examining the subarea scoring and results in tabular form (Table 18). In the Main Street Subwatershed prioritization values ranged from 12 to 24. The high priority category included 8 subareas, the moderate category 19 subareas, and the low category 8 subareas (Table 18). The Main Street Subwatershed subarea prioritization is displayed in Figure 27. Figure 27 includes the redevelopment and potential contamination sites in the Main Street Subwatershed.

The Americana Subwatershed contains 393 subareas, and therefore is not displayed in tabular form but in spatial form (Figure 28). In the Americana Subwatershed prioritization values ranged from 11 to 24. The high priority category included 57 subareas, the moderate category 208 subareas, and the low category 128 subareas. The Americana Subwatershed subarea prioritization is displayed in Figure 28. Figure 28 includes the redevelopment and potential contamination sites in the Americana Subwatershed.

Table 16 Main Street Prioritization Criteria Values and Scoring

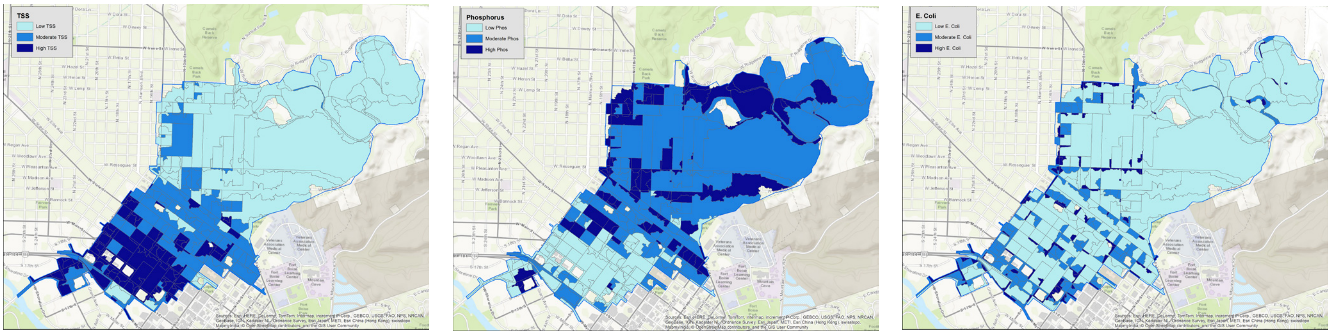
Variable	High (3)	Moderate (2)	Low (1)	N/A (0)
TIER I				
TSS (lbs/acre)*	>3.0	1.5 to 3	<1.5	-
Phos (lbs/acre)*	>0.009	0.006 to 0.009	<0.006	-
E.coli (Counts/acre)*	>10	5 to 10	<5	-
Runoff (Gal/Acre)	>13,000	7,000 to 13,000	<7,000	-
Depth to Groundwater (ft)	>15	10 to 15	5 - 10 ft	<5
% ROW	>80%	40 to 80%	<40%	-
TIER 2				
Contamination	Present (-3)		Absent (0)	
Redevelopment Opportunity	Present (+3)		Absent (0)	

** Weighted Variable (score multiplied by 2)*

Table 17. Americana Subwatershed Prioritization Criteria Values and Scoring

Variable	High (3)	Moderate (2)	Low (1)	N/A (0)
TIER I				
TSS (lbs/acre)*	>2.35	0.45 to 2.35	<0.45	-
Phos (lbs/acre)*	>0.04	0.006 to 0.004	<0.006	-
E. coli (Counts/acre)*	>14	5.3 to 14	<5.3	-
Runoff (Gal/Acre)	>10,000	5,000 to 10,000	<5,000	-
Depth to Groundwater (ft)	>15	10 to 15	5 - 10 ft	<5
% ROW	>80%	40 to 80%	<40%	-
TIER 2				
Contamination	Present (-3)		Absent (0)	
Redevelopment Opportunity	Present (+3)		Absent (0)	

** Weighted Variable (score multiplied by 2)*

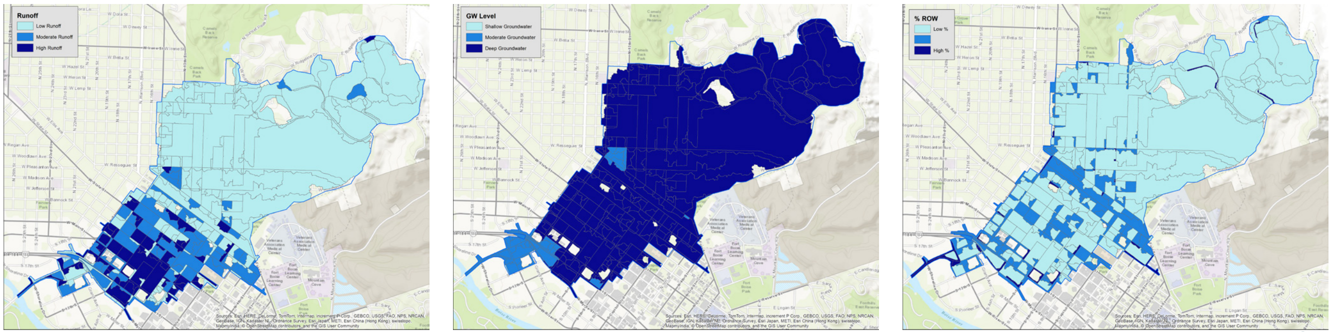


TSS *Phosphorus* *E.coli*

Figure 26. Americana Tier 1 Variables and Results.

■ *Table 18. Prioritization methodology and results for the Main Street Subwatershed.*

Subarea Name	Runoff Gallons per Acre	Runoff Score	TSS lbs/acre	TSS Score	PHOS lbs/acre	PHOS Score	E. Coli (mil. Col.)	E. coli Score	GW Depth (ft)	GW Depth Score	% ROW	% ROW Score	Redevel. Score	Contam. Score	Priority Score
S33443	15120.0	3	3.3	6	0.009	6	6.1	4	13.8	2	1.0	3	0	0	24
S898	0.0	1	3.5	6	0.008	4	15.1	6	15.1	3	1.0	3	0	0	23
S803	15389.1	3	3.5	6	0.006	4	6.3	4	14.6	2	0.9	3	0	0	22
S1619	15206.9	3	3.5	6	0.006	4	6.2	4	15.0	2	0.8	3	0	0	22
S29180	8223.7	2	3.2	6	0.009	6	3.5	2	15.5	3	0.5	2	0	0	21
S28884	16304.0	3	3.6	6	0.008	4	6.6	4	11.5	2	0.6	2	0	0	21
S29678	12688.6	2	3.5	6	0.006	4	5.3	4	13.5	2	0.8	3	0	0	21
S7495	7463.9	2	3.1	6	0.014	6	3.4	2	15.6	3	0.4	2	0	0	21
S2282	14252.5	3	3.2	6	0.009	4	3.1	2	15.4	3	0.5	2	0	0	20
S13330	17187.0	3	3.5	6	0.007	4	6.9	4	13.6	2	0.3	1	0	0	20
S5013	0.0	1	3.6	6	0.007	4	12.6	6	12.2	2	0.2	1	0	0	20
S32412	14159.8	3	3.5	6	0.006	2	5.8	4	15.1	3	0.7	2	0	0	20
S15432	14139.1	3	3.5	6	0.006	2	5.8	4	15.3	3	0.7	2	0	0	20
S2461	10761.1	2	3.5	6	0.006	4	4.5	2	16.0	3	0.8	3	0	0	20
S13464	0.0	1	3.5	6	0.006	4	8.3	4	15.1	3	0.8	2	0	0	20
S2450	0.0	1	3.6	6	0.000	2	335.3	6	11.6	2	1.0	3	0	0	20
S7929	10519.4	2	3.5	6	0.007	4	4.4	2	15.1	3	0.5	2	0	0	19
S22475	11520.1	2	3.2	6	0.008	4	2.6	2	15.4	3	0.7	2	0	0	19
S11369	0.0	1	0.5	2	0.004	2	5.2	4	15.8	3	1.0	3	3	0	18
S32837	11852.3	2	3.6	6	0.007	4	2.7	2	14.3	2	0.6	2	0	0	18
S40406	0.0	1	1.9	4	0.012	6	6.0	4	14.5	2	0.1	1	0	0	18
S4167	12996.5	2	3.6	6	0.007	4	1.5	2	14.5	2	0.7	2	0	0	18
S34413	0.0	1	2.6	4	0.000	2	20.3	6	15.0	2	1.0	3	0	0	18
S16592	6638.3	1	2.0	4	0.013	6	0.4	2	16.9	3	0.4	2	0	0	18
S10219	0.0	1	2.3	4	0.009	4	7.6	4	15.3	3	0.5	2	0	0	18
S8621	11847.8	2	3.6	6	0.008	4	1.4	2	11.7	2	0.4	1	0	0	17
S3	14787.6	3	3.6	6	0.007	4	6.0	4	14.8	2	0.3	1	0	3	17
S41421	10554.8	2	3.5	6	0.006	2	2.4	2	14.6	2	0.5	2	0	0	16
S34081	4184.9	1	0.9	2	0.009	6	0.6	2	15.2	3	0.4	2	0	0	16
S9126	6890.4	1	2.4	4	0.007	4	1.7	2	13.0	2	0.4	2	0	0	15
S20166	11156.9	2	3.6	6	0.007	4	1.3	2	11.8	2	0.4	1	0	3	14
S3049	0.0	1	0.1	2	0.001	2	3.3	2	14.9	2	0.3	1	3	0	13
S14401	3894.5	1	1.2	2	0.009	4	1.1	2	14.0	2	0.4	2	0	0	13
S9261	5992.3	1	2.9	4	0.005	2	2.7	2	14.2	2	0.2	1	0	0	12
S23308	6897.6	1	2.3	4	0.008	4	1.7	2	11.6	2	0.4	2	0	3	12

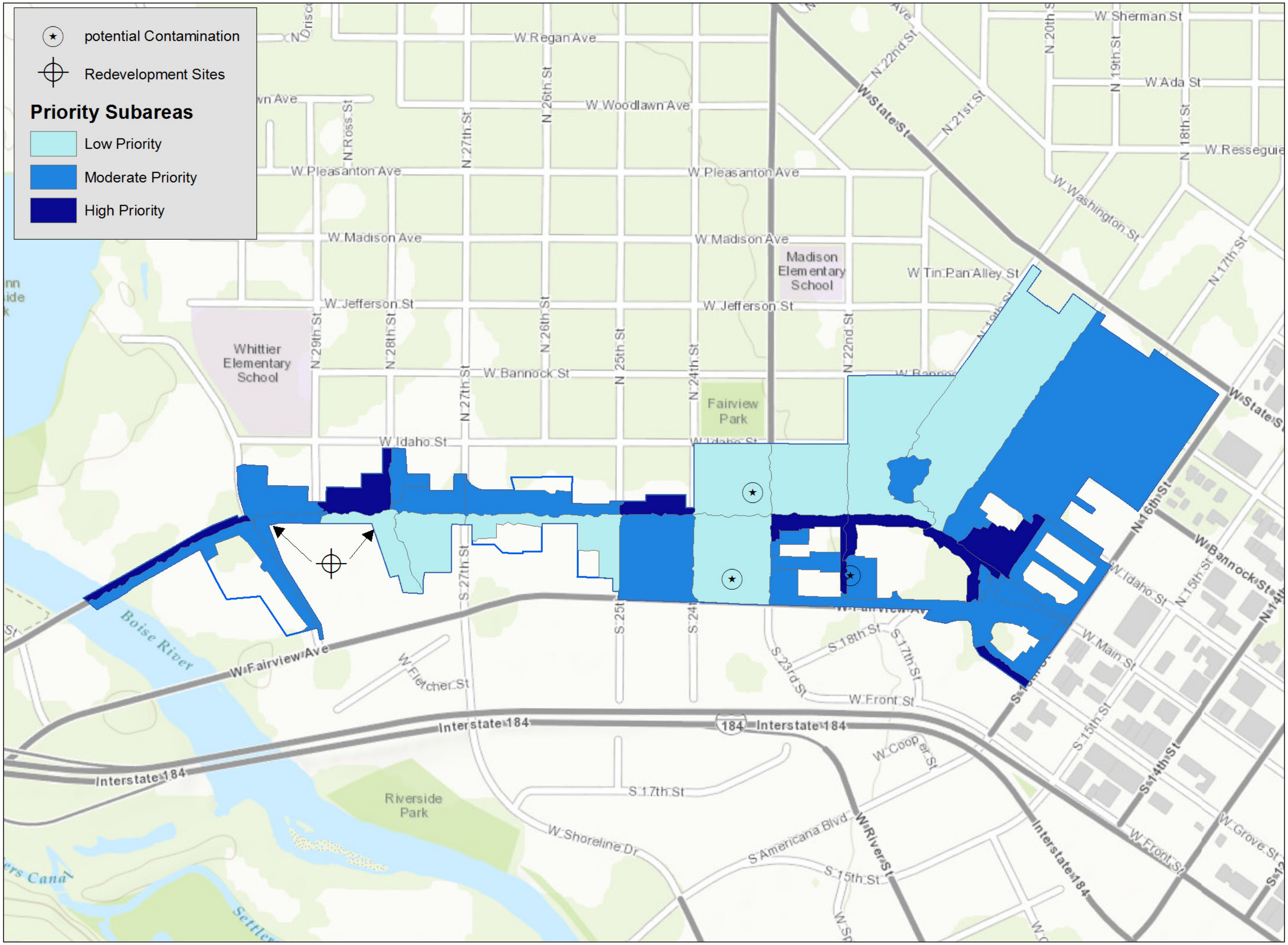


Runoff

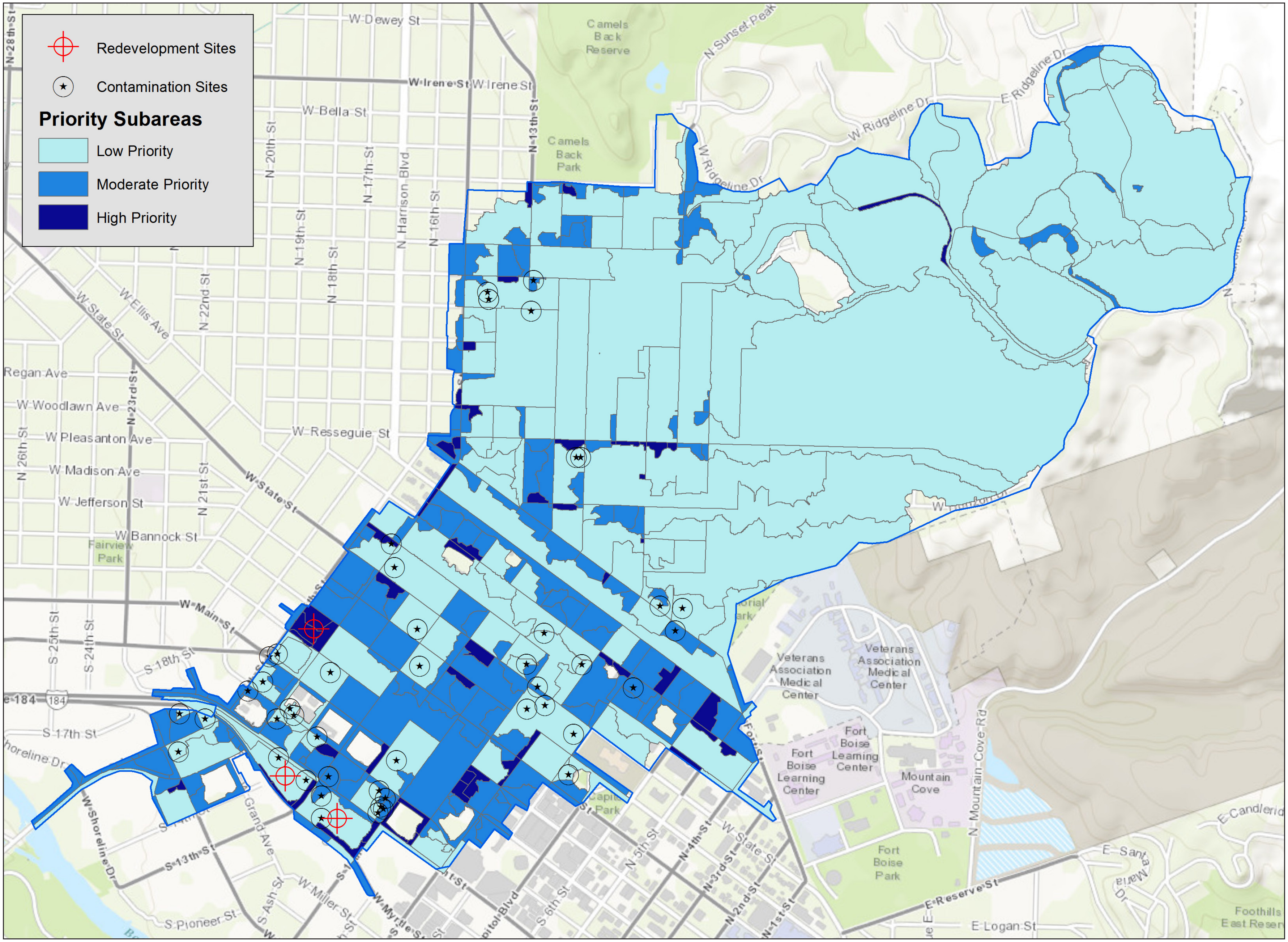
Groundwater Depth

% ROW

■ *Figure 26 Continued. Americana Tier 1 Variables and Results.*



■ *Figure 27. Main Street Subwatershed Prioritized Subareas*



■ *Figure 28. Americana Subwatershed Prioritized Subareas*

GSI Implementation Considerations

After prioritizing the subareas of the two subwatersheds for GSI, the next step is to decide which GSI BMP to implement. This section presents a brief list of design considerations for matching the appropriate GSI BMPs (including Bioretention Swales, Bioretention Planters, Stormwater Tree Cells, and Permeable Pavers) to specific sites (ACHD 2104).

While all four GSI BMPs provide similar stormwater management benefits such as promoting infiltration, reducing runoff peak rates, and improving water quality, they are not all created equal. The performance requirements and standards for stormwater management are documented in ACHD code section 8000 – Drainage and Stormwater Management and these requirements should be consulted as a first step in selecting GSI BMPs. New development sites and redevelopment sites are required to retain stormwater onsite and have more flexibility related to selecting GSI BMPs. Areas that lack stormwater BMPs and are slated for retrofit without substantial redevelop will need to identify how to integrate GSI BMPs with existing site features such as buildings, parking lots, right-of-way, and sidewalks.

GSI projects may be initiated by private development and redevelopment or agency initiated on public roadways, parking lots or buildings. Project motivations may be regulatory driven through runoff reduction and retention or voluntary multipurpose infrastructure improvements.

Site specific design constraints such as infiltration feasibility, maintenance concerns, available space, topography, and cost may inform the selection of GSI BMPs. Overall, the Main Street and Americana subwatersheds are considered to have well-draining soil with satisfactory infiltration rates (Tetra Tech 2014). However, prior to implementing a GSI BMP for the purpose of infiltration, developers need to verify the design infiltration rates. The testing involves a certified professional to dig multiple test pits or bore holes on a site to establish the soil profile, infiltration rate, water table, and/or depth to bedrock. A partial list of considerations are:

1. There shall be a minimum separation between the bottom of the GSI BMP and seasonal high groundwater of at least 3-feet; except for bio-swales which only require 2-feet of separation. The designer will need to further evaluate site specific conditions including potential detrimental effects of groundwater mounding or low permeability/ impervious soil layers.
2. GSI BMPs are generally focused on stormwater infiltration. An infiltration rate of 0.5 inches per hour is consider the minimum allowable.
3. The infiltration system shall not be located in fill unless the fill is clean sand or gravel and a geotechnical engineer certifies that the fill slopes are stable.

Once the site's infiltration feasibility is known, a conceptual stormwater management plan can be developed utilizing the pre-approved GSI BMPs to meet the stormwater management requirements of the manual. Guidance for implementing stormwater GSI BMPs is contained in section 8200 - ACHD Stormwater Design Tools and Approved BMPs. The advantage of utilizing an approved GSI BMP is under review, as ACHD is evaluating thier performance and maintenance costs. ACHD has also produced a spreadsheet that certified designers use to determine the size of each BMP, as needed. The following is a summary of design guidelines developed by ACHD, documented in the "ACHD Stormwater Design Tools and Approved BMPs," governing the implementation of each GSI BMP. First and foremost, the area draining to a bioretention device shall not exceed 2 acres, and pre-treatment in the form of shallow catch basins or other approaches is required.

Bioretention swales are BMPs approved for pretreatment, treatment, and storage. The implementation of this BMP requires prior written approval from ACHD. They are not allowed on residential streets for new development except for rural lots greater than 1 acre. They are most commonly installed at the back of a curb in the median or along the side of arterials, collectors, or in subdivision common areas. Limitations to adjacent roadway grading includes 6% maximum longitudinal slopes. The width of the swale requires a minimum allowable space of 7.5 feet from the back of the curb or 8 feet from the edge of the roadway (roadway section without a curb). Aesthetically, bioretention swales are susceptible to lack of irrigation, causing grass and shrubs to die during dry arid weather periods.

Bioretention planters provide stormwater benefits similar to bioretention swales; however, as an alternative they are designed as flat (no slope) facilities enclosed with a vertical planter wall. The planter walls, in lieu of side slopes, allows greater flexibility to modify the length and width of the planter over the bioretention swale to fit specific site geometry limitations.

Stormwater Tree Cells are approved for treatment and storage. They consist of tree planters, generally located in road-side pedestrian walkways, connected to an underground modular soil block system. The soil is specifically designed to promote tree growth, filter and detain/retain stormwater. Typically, tree cell treatment systems consist of pre-engineered modular components rather than being custom designed like bioretention swales and planters. Silva Cells are a product that has been approved for use by ACHD. The stormwater tree planters provide aesthetic and shade benefits of street trees for parked cars and street pedestrians. Additionally, the geometry of storage can be customized based on underground space available.

Permeable pavers are approved for treatment and storage. They consist of interlocking concrete pavers set on a bed of crushed stone. Pavers can be installed in parking zones and areas with low vehicle traffic and lower speed vehicle areas. Permeable paver facilities may receive run-off from adjacent areas such as building roofs and conventional pavement, but not vegetated or landscaped areas. Ideally, they are implemented in areas with less than a 2% slope. However, sub-grade terracing improvements can allow them to be installed in areas sloping up to 6%.

As implied above, each GSI BMP has limitations and ideal applications. If there is more than one GSI BMP that meets site suitability criteria designers will frequently provide a conceptual plan to compare each suitable alternative. From that, cost estimates can be provided to inform the final decision.

During construction of the GSI BMPs, the designer needs to verify the actual site conditions are consistent with design assumptions. The ACHD Stormwater Design Guidelines identify numerous items to confirm and monitor during construction. Some items must be inspected by Ada County during construction before the facilities are approved for operation.

GSI BMPs achieve treatment of stormwater via a range of physical and biological processes, and therefore require regular maintenance. Facilities that are not maintained will not function effectively. GSI BMPs require regular cleaning of sediment from pre-treatment basins. If sediment is allowed to flow into GSI BMPs, it often plugs them, reducing the ability of stormwater to enter them and/or reducing their ability to infiltrate stormwater to groundwater. Vegetation management includes watering during dry periods, replacement of vegetation that dies or isn't thriving, and periodic trimming to remove overgrowth. Treatment media may need to be periodically replaced. If regular maintenance occurs and the installed GSI follows ACHD's guidelines, then the four approved GSI BMPs described above provide an aesthetic means of treating stormwater in Ada County.

Conclusion

Green Stormwater Infrastructure (GSI) provides an alternative, and often aesthetic, means to reduce the negative impacts of stormwater on receiving water bodies compared to conventional grey stormwater infrastructure. GSI has been shown to be cost effective compared to traditional methods (Hjerpe 2015, TetraTech 2015). GSI offers additional benefits to the community in the form of ecosystem services, such as shade from trees and aesthetics by beautification of local streets. The U.S. Environmental Protection Agency (EPA) encourages communities to use green stormwater infrastructure to help manage stormwater runoff and improve water quality. Therefore, it is expected that the use of GSI to manage stormwater will grow in the future.

Agencies with jurisdiction in the subwatersheds will implement and encourage use of GSI and the related development principles through enforcement of policy and respective stormwater management programs.

The goal of this project was to develop strategic subwatershed-scale plans for the Main Street and Americana subwatersheds that prioritizes areas to implement GSI to reduce stormwater runoff and water quality impairment to the Boise River. The prioritization methodology created through this project identified 8 high priority subareas in the Main Street Subwatershed and 57 high priority subareas in the Americana Subwatershed. The tiered prioritization methodology is based on quantitative data derived in PCSWMM, but also includes criteria that enable ACHD and their co-permittees to be opportunistic with GSI as redevelopment or new development projects arise. The prioritization methodology is easily transferable to other subwatersheds in Ada County as it is based on data ACHD currently collects and easily accessible public datasets. Lastly, and of importance to ACHD and their co-permittees, the subwatershed planning and prioritization presented in this document meets the requirements outlined in their NPDES permit (IDS-027561) (EPA 2013).

Literature Cited

ACHD. 2014. Green Stormwater Infrastructure Guidance Manual.

ACHD 2015a. ACHD Section 8000 – Drainage and Stormwater Management

ACHD. 2015b. ACHD Section 8200 – Stormwater Design Tools and Approved BMPs

ACHD. 2015c. Frequently Asked Questions (FAQs) Policy Manual Revisions (Sections 8000/8200).

Barfuss, Steven and J. Paul Tullis. 1994. Friction factor test on high density polyethylene pipe. Hydraulics Report No. 208. Utah Water Research Laboratory, Utah State University. Logan, Utah. 1994.

Bishop, R.R. and R.W. Jeppson. 1975. Hydraulic characteristics of PVC sewer pipe in sanitary sewers. Utah State University. Logan, Utah. September 1975

Brown and Caldwell. n.d. Urban Stormwater Runoff and Pollution Models – Which One Should I Choose? The First Step Towards a Larger Effort.

Brown and Caldwell. 2014a. NPDES Phase I Annual Storm Water Monitoring Report for Water Year 2014. Prepared for Ada County Highway District.

Brown and Caldwell. 2014b. Pollutants of Concern (PoC) Guide for ACHD's NPDES Phase I Permit Area: Water Quality Controls and Effectiveness Assessment. Prepared for Ada County Highway District.

Brown and Caldwell. 2014c. Stormwater Management Plan. Prepared for Ada County Highway District.

Brown and Caldwell 2015 – Urban Tree Canopy Land Use GIS data. Adopted from Plan-it Geo 2013.

Brown and Caldwell. 2015d. MS4 Phase I support 2015; Impervious Area Connectivity Evaluation – Draft. Prepared for Ada County Highway District.

Brown and Caldwell. 2015g. DRAFT - NPDES Phase I Annual Stormwater Monitoring Report for Water Year 2015. Prepared for ACHD.

Center for Watershed Protection (CWP). 1995. Simple and Complex Stormwater Pollutant Load Models Compared. Article 13 in Watershed Protection Techniques 2(2):364-368

Center for Watershed Protection. 2003. The Impacts of Impervious Cover on Aquatic Systems. Watershed Protection Research Monograph No. 1. Ellicott City, MD. www.cwp.org/Resource_Library/Center_Docs/IC/Impacts _IC_Aq_Systems.pdf

CH2MHILL. 2003. Lower Boise River Coliform Bacteria DNA Testing; Final Summary Report. Prepared for the Lower Boise River Water Quality Plan.

CHI-Water. 2015. CHI online support. Accessed September 25th, 2015 via http://support.chiwater.com/support/search?term=washoof+buildup&authenticity_token=XVwzlArR3UGiCmw%2FSh1bdND2nxDgdhSCrfalnwAx%2FNU%3D

Chow, V.T., 1959, Open-channel hydraulics: New York, McGraw-Hill, 680 p.

City of Boise Public Works Department (BPWD). 2010. Stormwater Management, A Design Manual. August 2010. Boise, Idaho

City of Boise Public Works Department (BPWD). 2015. City of Boise Stormwater Management Plan. In coordination with the City of Boise Environmental Division. Boise, Idaho

City of Boise Public Works Department. 2015b. Stormwater Management; A Design Manual. September 2015. Boise, Idaho

Community Planning Association of Southwest Idaho. 2001. Two foot contours of Ada County. Prepared by 3Di, LLC.

FEMA. 2014. FEMA Flood Hazard Zone, DFIRM Database for Boise City and unincorporated Areas. Digital Maps.

HDR. 2014. Boise City MS4 Program Development and Implementation Services; Green Stormwater Infrastructure Issue Paper.

Idaho Department of Environmental Quality (IDEQ). 1999. Lower Boise River TMDL: Subbasin Assessment Total Maximum Daily Loads. Idaho Department of Environmental Quality, Boise

IDEQ, 2001. Lower Boise River Nutrient & Tributary Subbasin Assessments. Idaho

IDEQ. 2009. Lower Boise River TMDL five-year review. Idaho Department of Environmental Quality, Boise

IDEQ. 2014. Idaho's 2012 integrated report, final. Idaho Department of Environmental Quality, Boise

IDEQ. 2015. Draft 2015 Total Phosphorus TMDL Addendum for the Lower Boise River, Mason Creek, and Sand Hollow Creek. Idaho Department of Environmental Quality, Boise

IDEQ and ODEQ. 2004. Snake River-Hells Canyon total maximum daily load (TMDL): Idaho Department of Environmental Quality and Oregon Department of Environmental Quality

IDEQ. 2016. Brownfields Inventory. Data downloaded from IDEQ's Waste Management a& Remediation Division Facility Mapper. http://wastesites.deq.idaho.gov/

IDWR. 2015. All Permitted Wells, GIS data. Accessed November 11th 2015 via http://research.idwr.idaho.gov/index.html#GIS-Data

Keller Associates. 2000. Preliminary Hydrologic& Hydraulic Analysis for the Downtown Boise Master Drainage Plan. Prepared for Ada County Highway District. ACHD Project SD 1199-001.

LBWC and IDEQ. 2008. Sediment and bacteria allocations addendum to the Lower Boise River TMDL. Lower Boise Watershed Council and Idaho Department of Environmental Quality, Boise

Maidment, David R. 2002. Arc Hydro: GIS for Water Resources. Redlands. CA, ESRI.

Maestre, A., and R. Pitt. 2005. The National Stormwater Quality Database, Version 1.1. A Compilation and Analysis of NPDES Stormwater Monitoring Information. EPA Office of Water, Washington, DC

Moriasi, D.N., Arnold, J.G., Van Liew, M.W., Bingner, R.L., Harmel, R.D., and T.L. Veith. 2007. Model evaluation guidelings for systematic quantification of accuracy in watershed simulations. Transactions of the ASABE. Vol. 50(3).

Minnesota Pollution Control Agency (MPCA). 2015. Available Stormwater models and selecting a model. Accessed February 25, 2015 from http://stormwater.pca.state.mn.us/index.php?title=Main_Page&oldid=21948

National Research Council. 2009. Urban Stormwater Management in the United States. Washington, DC: The National Academies Press, Washington, DC

National Weather Service, 2014. Boise, Idaho, Total Monthly Precipitation for each Year of Record, Boise Air Terminal Data October 1940 through September 2014.

NOAA. 1982. NOAA Technical Report NWS 34; Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States. United States Department of Commerce, Washington D.C.

NRDC. 2016. Stormwater Strategies; community responses to runoff pollution. Accessed February 2, 2016. http://www.nrdc.org/water/pollution/storm/gloss.asp

Pitt Robert Pitt, R. Maestre, A., Morquecho, A., Brown, T., Schueler, T., Cappiella, K., and P.Sturm. 2004. Research Progress Report; Findings from the National Stormwater Quality Database (NSQD).

Plan-it Geo. 2013. Treasure Valley Urban Tree Canopy Assessment; October 2013 Update. Prepared for: Idaho Department of Lands, Idaho Community Forestry Program.

Tetra Tech. 2014. Fairview Avenue Greenstreet Concept Design: Evaluating Offset Mitigation through Green Infrastructure within a Public Right-of-Way. Prepared for the Ada County County Highway District, Garden City, Idaho

US Climate Data 2014. Website http:www.usclimatedata.com/climate/boise/Idaho/united-states/usid0025. Accessed on April 18, 2015.

U.S Environmental Protection Agency (EPA). 1983. Results of the Nationwide Urban Runoff Program, Volume I Final Report. Water Planning Division. WH-554. Washington, DC

U.S. Environmental Protection Agency (EPA). 2013. Authorization to Discharge Under the National Pollutant Discharge Elimination System. Boise/Garden City Area MS4 Permint. No. IDS-027561.

U.S Environmental Protection Agency (EPA). 2015. National Stormwater Quality Database (NSQD). Version 4.02. Updated March 17th 2015.

U.S. Soil Conservation Service (USSCS). 1986. A Method for Estimating Volume and Rate of Runoff for Urban Watersheds. SC-TP-55. U.S. Department of Agriculture, Washington, DC

U.S.Fish and Wildlife Service (USFWS). 2015. National Wetlands Inventory Data for HU8, 17050114 (Lower Boise River). Digital map data.

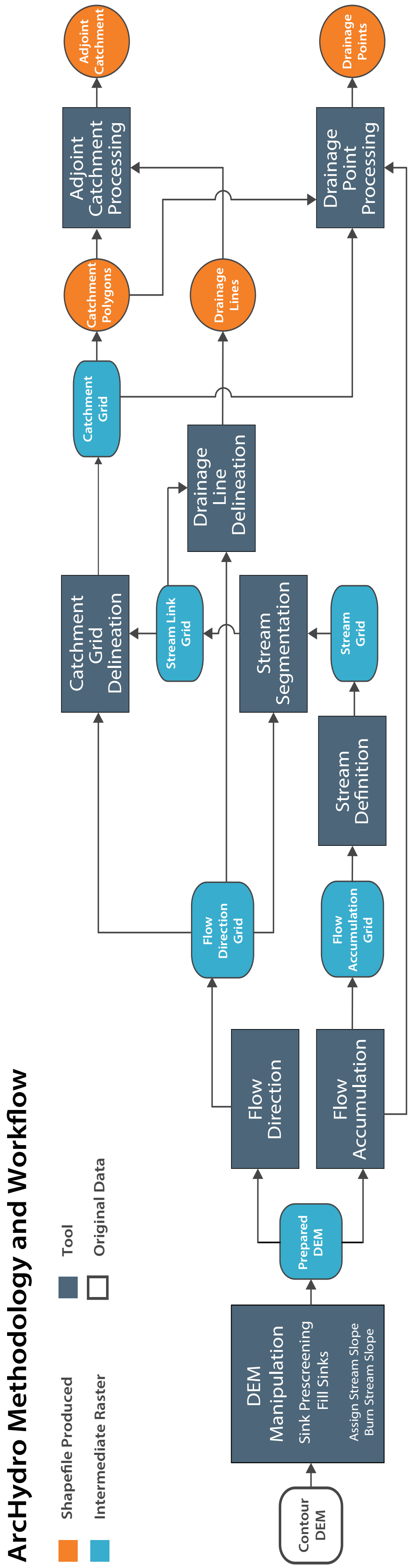
Washington State Department of Ecology (WDOE) 2004. Stormwater Management Manual for Eastern Washington. Publication Number 04-10-076. Olympia, Washington

Washington State Department of Ecology. 2013. Eastern Washington Low Impact Development Guidance Manual. Prepared by AHBL & HDR.

X, Liu, J. Peterson, and Z. Zhang. “High-Resolution DEM Generated from LiDAR Data for Water Resource Management.” (2005): 1402-408. Web.

Appendix A

Figure. Subarea Delineation Methodology and Workflow (at left).



Appendix B

Americana Subarea Information

% Land Use

Subarea	Acres	% Impervious	Agriculture	Commercial	Industrial	Open Space	Park	Public	Residential High	Residential Low	Residential Medium	School
1022	0.9	23.8	0.0	0.0	0.0	0.0	0.0	23.8	0.0	0.8	75.4	0.0
10449	0.5	66.7	0.0	70.5	0.0	0.0	0.0	29.5	0.0	0.0	0.0	0.0
10477	0.4	11.5	0.0	0.0	0.0	0.0	0.0	0.0	48.6	0.0	51.4	0.0
10541	5.9	10.4	0.0	0.0	0.0	0.0	0.0	0.0	34.9	0.0	65.1	0.0
10580	1.1	18.0	0.0	0.0	0.0	0.0	0.0	0.0	64.7	0.0	35.3	0.0
10671	1.4	86.8	0.0	95.3	0.0	0.0	0.0	0.0	2.8	0.0	0.0	1.9
10714	1.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11005	0.2	10.4	0.0	0.0	0.0	0.0	0.0	0.0	45.8	0.0	54.2	0.0
1112	1.9	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.6	69.4	0.0
1120	1.4	26.9	0.0	0.0	0.0	0.0	0.0	32.5	0.0	9.2	58.3	0.0
11247	1.0	41.8	0.0	29.9	0.0	0.0	23.1	47.0	0.0	0.0	0.0	0.0
11268	0.1	12.8	0.0	0.0	0.0	0.0	0.0	0.0	24.8	0.0	75.2	0.0
11343	3.0	47.7	0.0	67.4	0.0	0.0	0.0	0.0	15.6	0.0	17.1	0.0
11441	2.5	90.6	0.0	97.9	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
11568	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11587	7.3	48.7	0.0	43.1	0.0	0.0	0.0	0.0	6.3	0.0	7.4	43.3
11802	2.9	9.9	0.0	19.9	0.0	0.0	0.0	0.0	41.7	0.0	38.3	0.0
11945	1.4	80.3	0.0	89.6	0.0	0.0	0.0	0.0	0.0	0.0	1.8	8.6
11953	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	1.3	87.3	0.0	95.8	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0
12085	0.2	33.0	0.0	0.0	0.0	0.0	0.0	0.0	79.3	0.0	0.0	20.7
12147	0.4	81.6	0.0	92.1	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0
12247	2.3	12.6	0.0	0.0	0.0	0.0	0.0	0.0	51.3	0.0	48.7	0.0
12817	8.3	45.0	0.0	0.0	0.0	0.0	0.0	60.4	0.0	19.1	20.5	0.0
12973	5.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13089	1.1	72.2	0.0	85.5	0.0	0.0	0.0	0.0	9.3	0.0	3.1	2.1
13319	27.5	14.6	0.0	0.0	0.0	0.0	0.0	0.0	14.2	4.2	81.6	0.0
13527	0.9	81.3	0.0	5.5	0.0	0.0	2.7	91.8	0.0	0.0	0.0	0.0
13716	1.4	37.6	0.0	58.6	0.0	0.0	0.0	0.0	31.1	0.0	10.3	0.0
13790	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13826	1.1	14.8	0.0	7.9	0.0	0.0	0.0	9.9	56.8	0.0	25.4	0.0
13872	0.5	88.4	0.0	96.5	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0
13939	0.9	86.7	0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	96.4
13940	3.0	63.4	0.0	62.5	0.0	0.0	0.0	37.5	0.0	0.0	0.0	0.0
14138	1.9	19.4	0.0	28.5	0.0	0.0	0.0	1.3	13.8	0.0	56.4	0.0
14197	0.5	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
14249	0.7	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14273	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14522	0.5	82.1	0.0	92.4	0.0	0.0	0.0	0.0	7.6	0.0	0.0	0.0
14559	1.0	13.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.1	68.9	0.0
14669	0.4	84.3	0.0	92.5	0.0	0.0	0.0	7.5	0.0	0.0	0.0	0.0
14694	0.6	22.6	0.0	31.4	0.0	0.0	0.0	0.0	23.4	0.0	24.3	20.9
14699	3.9	57.8	0.0	74.7	0.0	0.0	0.0	0.0	0.4	0.0	24.9	0.0
14821	0.2	33.5	0.0	49.4	0.0	0.0	0.0	0.0	50.3	0.0	0.4	0.0
14835	1.0	13.5	0.0	13.2	0.0	0.0	0.0	1.6	20.3	0.0	64.9	0.0
15245	0.9	93.9	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1527	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15346	24.2	10.7	0.0	4.2	0.0	0.1	4.8	0.3	26.1	0.0	64.5	0.0
15477	0.7	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15833	2.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15857	1.9	18.1	0.0	3.6	0.0	0.0	0.0	0.0	66.7	0.0	27.8	1.9
16104	0.9	92.4	0.0	97.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16133	0.4	18.1	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	97.6	0.0
16269	0.9	92.9	0.0	99.3	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
16361	0.4	23.2	0.0	0.0	0.0	0.0	0.0	31.8	51.6	0.0	16.6	0.0
16416	0.3	23.3	0.0	0.0	0.0	0.0	0.0	0.0	77.8	0.0	22.2	0.0
16474	3.6	0.4	0.0	2.8	0.0	2.9	61.9	1.3	26.7	0.0	4.4	0.0
16595	7.9	93.6	0.0	99.8	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0
1660	1.0	18.0	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	94.7	0.0
167	1.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16820	2.6	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.8	61.2	0.0
16930	0.0	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
16951	2.1	20.3	0.0	31.0	0.0	0.0	0.0	0.0	14.2	0.0	52.8	2.0
17156	17.8	17.3	0.0	29.6	0.0	0.0	0.0	1.4	24.1	0.0	39.3	5.6
17290	1.9	14.3	0.0	30.9	0.0	0.0	0.0	0.0	40.4	0.0	28.6	0.0
17502	1.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17585	1.8	31.9	0.0	43.2	0.0	0.0	0.0	0.0	56.8	0.0	0.0	0.0
17631	0.3	44.5	0.0	15.8	0.0	0.0	26.6	57.6	0.0	0.0	0.0	0.0
17700	6.8	43.0	0.0	0.0	0.0	0.0	0.0	56.1	0.0	8.0	35.9	0.0
17701	0.0	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
17702	5.6	8.8	0.0	0.0	0.0	0.0	0.0	2.3	0.0	96.7	1.0	0.0
17703	0.1	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	71.6	28.4	0.0
17901	1.9	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18210	2.5	35.1	0.0	51.9	0.0	0.0	0.0	7.3	7.5	0.0	28.8	4.6
18324	1.5	6.5	52.9	0.0	0.0	0.0	0.0	0.8	0.0	0.0	46.2	0.0
18463	0.9	60.3	0.4	0.0	0.0	0.0	0.0	74.8	0.0	8.9	16.0	0.0
18714	1.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18735	10.9	23.3	0.0	0.0	0.0	0.0	0.0	31.9	0.0	31.0	37.0	0.0
18831	0.3	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
18932	0.3	23.0	0.0	0.0	0.0	0.0	0.0	21.5	0.0	0.0	78.5	0.0
19013	0.2	28.1	0.0	0.0	0.0	0.0	0.0	39.8	0.0	54.1	6.1	0.0
19097	7.0	64.5	0.0	65.5	0.0	0.0	0.0	34.5	0.0	0.0	0.0	0.0
19507	0.8	80.7	0.0	91.5	0.0	0.0	0.0	0.0	2.7	0.0	5.8	0.0
19639	0.7	20.0	0.0	0.0	0.0	0.0	0.0	0.0	69.6	0.0	30.4	0.0
19712	3.9	7.9	80.9	0.0	0.0	0.0	0.0	17.7	0.0	1.4	0.0	0.0
19745	0.8	64.9	0.0	80.6	0.0	19.4	0.0	0.0	0.0	0.0	0.0	0.0
19838	0.4	10.1	0.0	0.0	0.0	0.0	0.0	8.5	0.0	89.2	2.3	0.0

Subarea	Acres	% Impervious	Agriculture	Commercial	Industrial	Open Space	Park	Public	Residential High	Residential Low	Residential Medium	School
19881	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20012	1.7	90.5	0.0	97.6	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0
20133	2.0	0.9	81.6	0.0	0.0	0.0	0.0	0.8	0.0	0.0	17.6	0.0
20223	2.9	7.0	0.0	0.0	0.0	0.0	0.0	2.2	0.1	76.1	21.6	0.0
20226	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20292	0.8	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20566	0.6	17.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.1	93.9	0.0
20759	3.8	70.4	0.0	0.0	0.0	0.0	0.0	82.6	0.0	17.1	0.3	0.0
20833	0.1	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
20883	0.2	12.9	0.0	3.6	0.0	0.0	0.0	12.0	50.5	0.0	33.8	0.0
21257	3.4	15.1	0.0	0.0	0.0	0.0	0.0	0.0	15.1	0.0	84.9	0.0
21393	0.3	13.6	0.0	0.0	0.0	0.0	11.1	0.0	60.4	0.0	28.5	0.0
2140	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21418	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21651	1.2	88.1	0.0	95.9	0.0	0.0	0.7	3.4	0.0	0.0	0.0	0.0
21848	5.9	40.3	0.0	60.6	0.0	0.0	0.0	2.7	24.9	0.0	11.7	0.0
21906	0.4	11.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.6	53.4	0.0
21993	0.7	19.0	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.0	92.0	0.0
2202	0.4	13.4	0.0	22.4	0.0	0.0	0.0	2.0	49.0	0.0	26.6	0.0
22047	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22128	2.1	27.3	0.0	26.3	0.0	0.0	0.0	0.0	69.5	0.0	4.2	0.0
2234	4.0	50.9	0.0	39.8	0.0	0.0	0.0	36.4	0.0	0.0	0.0	23.9
22491	0.7	52.2	0.0	46.3	0.0	0.0	0.0	43.9	5.2	0.0	4.6	0.0
2253	0.7	18.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	92.5	7.5
2256	4.2	14.2	0.0	6.7	0.0	0.0	0.1	0.0	16.0	0.0	77.2	0.0
22709	1.1	16.6	0.0	0.0	0.0	0.0	0.0	0.0	8.7	0.0	91.3	0.0
22820	6.4	10.3	0.0	0.0	0.0	0.0	0.0	1.5	33.9	0.0	60.3	4.3
2315	0.2	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
23249	4.4	15.8	0.0	0.0	0.0	0.0	0.0	0.0	11.5	0.0	87.1	1.4
2331	0.4	72.7	0.0	18.7	0.0	0.0	0.0	81.3	0.0	0.0	0.0	0.0
23368	10.4	20.7	0.0	0.0	0.0	0.0	0.0	31.4	1.0	45.3	22.4	0.0
23415	1.4	16.5	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.0	90.6	0.0
23437	0.8	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23443	3.0	87.0	0.0	95.6	0.0	0.0	0.0	0.0	0.9	0.0	3.5	0.0
23707	1.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23717	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2393	3.7	22.3	0.0	32.9	0.0	0.0	12.0	19.7	29.3	0.0	6.0	0.0
23973	5.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2412	0.7	28.6	0.0	0.0	0.0	0.0	0.2	0.0	86.4	0.0	13.4	0.0
24400	1.8	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24431	0.6	87.2	0.0	95.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0
24519	1.1	88.4	0.0	96.5	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0
24548	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2459	0.8	13.8	0.0	0.0	0.0	0.0	13.9	0.0	62.4	0.0	23.7	0.0
2464	0.7	20.4	0.0	0.0	0.0	0.0	0.0	25.7	18.7	0.0	55.6	0.0
2473	0.6	36.5	0.0	55.6	0.0	0.0	0.0	0.0	14.1	0.0	23.7	6.5
2513	0.2	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
25306	1.2	88.4	0.0	0.1	0.0	0.0	0.0	0.0	1.6	0.0	0.6	97.7
25365	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25407	0.4	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	99.6	0.0
25423	0.5	68.9	0.0	74.6	0.0	0.0	0.0	25.4	0.0	0.0	0.0	0.0
2543	2.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2564	0.6	73.8	0.0	86.8	0.0	0.0	0.0	0.0	0.0	0.0	12.2	1.0
25706	1.0	82.9	0.0	92.9	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.0
25716	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2582	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25895	9.7	34.4	0.0	0.0	0.0	0.0	0.0	47.6	0.6	21.8	30.0	0.0
25956	0.5	31.3	0.0	40.5	0.0	0.0	0.0	0.0	59.5	0.0	0.0	0.0
26277	1.1	91.3	0.0	98.3	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0
26280	0.4	12.8	0.0	0.0	0.0	0.0	0.0	0.0	24.9	0.0	75.1	0.0
26300	0.3	15.7	0.0	0.0	0.0	0.0	0.0	0.0	12.4	0.0	87.6	0.0
26425	0.5	93.3	0.0	99.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0
26481	31.0	9.7	0.0	1.9	0.0	0.0	0.0	0.1	36.1	0.0	61.9	0.0
26559	1.8	61.5	0.0	49.7	0.0	0.0	0.0	50.3	0.0	0.0	0.0	0.0
26607	2.1	11.3	0.0	0.0	0.0	0.0	0.0	0.0	31.2	0.0	68.8	0.0
26663	0.6	12.5	0.0	1.7	0.0	0.0	0.0	0.0	51.9	0.0	46.5	0.0
27092	0.7	84.5	0.0	94.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0
2714	1.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27491	0.9	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27677	4.1	80.9	0.0	90.1	0.0	0.0	0.0	8.0	1.8	0.0	0.0	0.0
2769	0.3	69.8	0.0	22.9	0.0	0.0	0.0	77.1	0.0	0.0	0.0	0.0
27800	0.4	16.5	0.0	0.0	0.0	0.0	9.1	0.0	0.0	0.0	90.9	0.0
27881	1.9	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28071	0.1	60.2	0.0	59.5	0.0	0.0	0.0	37.8	2.8	0.0	0.0	0.0
2820	0.7	85.4	0.0	94.6	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0
28214	1.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	15.7	0.0	84.3	0.0
28226	0.9	88.5	0.0	96.1	0.0	0.0	0.0	3.9	0.0	0.0	0.0	0.0
28277	1.4	10.2	0.0	0.0	0.0	0.0	0.0	0.0	35.6	0.0	64.4	0.0
28289	1.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28307	0.4	89.0	0.0	96.4	0.0	0.0	0.0	3.6	0.0	0.0	0.0	0.0
28349	0.5	12.6	0.0	0.3	0.0	0.0	0.0	0.0	25.5	0.0	74.2	0.0
28546	0.3	80.0	0.0	91.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0
28599	0.9	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28694	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2913	4.9	16.7	0.0	0.0	0.0	0.0	0.0	25.1	0.1	52.2	22.6	0.0
29216	0.4	10.6	0.0	0.0	0.0	0.0	0.0	0.0	34.2	0.0	65.8	0.0
29250	4.8	89.4	0.0	1.7	0.0	0.0	0.0	98.3	0.0	0.0	0.0	0.0
29483	0.6	27.8	0.0	0.0	0.0	0.0	0.0	0.0	85.0	0.0	13.8	1.2
29492	0.5	23.5	0.0	30.4	0.0	0.0	0.0	0.0	0.0	0.0	64.9	4.7

% Land Use

Subarea	Acres	% Impervious	Agriculture	Commercial	Industrial	Open Space	Park	Public	Residential High	Residential Low	Residential Medium	School
2955	0.8	66.9	0.0	28.0	0.0	0.0	0.0	72.0	0.0	0.0	0.0	0.0
29557	1.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29584	0.1	10.1	0.0	0.0	0.0	0.0	9.2	0.0	26.9	0.0	63.9	0.0
29688	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29821	0.9	12.4	0.0	0.0	0.0	0.0	0.0	17.0	0.0	66.3	16.7	0.0
29874	15.7	10.6	0.0	0.0	0.0	0.0	0.0	9.4	0.0	90.6	0.0	0.0
29886	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
29957	0.1	22.9	0.0	43.9	0.0	56.1	0.0	0.0	0.0	0.0	0.0	0.0
30025	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30178	1.7	41.4	0.0	47.6	0.0	0.0	0.0	28.7	0.0	0.0	23.6	0.0
30190	1.1	73.0	0.0	18.3	0.0	0.0	0.0	81.7	0.0	0.0	0.0	0.0
30322	1.2	79.7	0.0	10.5	0.0	0.0	0.0	89.5	0.0	0.0	0.0	0.0
30612	1.5	9.2	0.0	0.0	0.0	0.0	0.0	0.0	39.3	0.0	59.2	1.6
30682	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30755	1.0	92.6	0.0	99.1	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
30922	0.7	16.1	0.0	3.3	0.0	0.0	0.0	0.0	8.6	0.0	88.1	0.0
31022	1.6	88.6	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	1.2	97.9
31053	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31065	3.4	14.5	0.0	0.0	0.0	0.0	0.0	0.0	56.0	0.0	44.0	0.0
31095	3.0	10.6	0.0	13.9	0.0	0.0	0.0	0.0	33.5	0.0	52.6	0.0
311	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31194	0.3	24.3	0.0	31.8	0.0	0.0	0.0	0.0	0.0	0.0	68.2	0.0
31433	2.2	13.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	0.0	75.9	0.0
31548	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31607	3.4	37.7	0.0	55.7	0.0	0.0	0.0	0.4	8.8	0.0	35.1	0.0
31662	0.0	37.3	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
31682	1.5	82.2	0.0	92.2	0.0	0.0	0.0	2.8	1.6	0.0	3.5	0.0
31705	1.7	55.6	0.0	69.2	0.0	0.0	15.6	15.1	0.0	0.0	0.0	0.0
31755	1.5	17.8	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.4	95.5	0.0
32012	0.0	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
32423	0.4	17.1	0.0	0.0	0.0	0.0	0.0	0.0	62.4	0.0	37.6	0.0
32430	0.2	44.6	0.0	61.2	0.0	0.0	0.0	0.0	0.0	0.0	38.8	0.0
32536	0.5	78.9	0.0	87.4	0.0	0.0	0.0	12.6	0.0	0.0	0.0	0.0
32595	3.3	80.8	0.0	91.5	0.0	0.0	0.0	1.0	7.5	0.0	0.0	0.0
32612	1.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32686	1.7	89.3	0.0	96.7	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0
32739	1.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32806	0.1	16.6	0.0	13.7	0.0	0.0	0.0	0.0	8.3	0.0	78.0	0.0
3289	4.4	19.4	0.0	0.0	0.0	0.0	0.0	10.8	0.5	0.0	88.7	0.0
33417	0.3	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
33444	1.1	27.9	0.0	44.2	0.0	0.0	0.0	0.0	14.1	0.0	41.7	0.0
33460	0.8	16.6	0.0	0.0	0.0	0.0	0.0	0.0	8.9	0.0	91.1	0.0
33499	4.4	16.9	0.0	0.0	0.0	0.0	0.0	2.0	5.5	1.3	91.2	0.0
33531	2.7	89.0	0.0	1.5	0.0	0.0	0.0	0.0	0.5	0.0	0.0	98.1
33602	11.9	9.4	0.0	0.0	0.0	0.0	0.0	0.0	37.1	2.1	60.8	0.0
33689	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33872	0.6	29.6	0.0	44.8	0.0	0.0	0.0	0.9	25.1	0.0	13.6	15.6
33888	1.9	12.7	0.0	0.0	0.0	0.0	0.0	0.0	24.9	0.0	74.4	0.7
33894	0.6	22.1	0.0	26.7	0.0	0.0	0.0	0.0	0.0	0.0	73.3	0.0
3400	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34063	3.2	11.7	0.0	0.0	0.0	0.0	0.0	0.0	29.2	0.0	70.8	0.0
34146	1.9	9.2	0.0	0.0	0.0	0.0	0.0	10.3	0.0	69.4	20.3	0.0
34406	0.3	78.3	0.0	89.9	0.0	0.0	0.0	0.0	3.9	0.0	6.2	0.0
34412	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3474	0.8	61.5	0.0	48.9	0.0	0.0	0.0	51.1	0.0	0.0	0.0	0.0
34743	0.0	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
34789	1.2	15.3	0.0	0.2	0.0	0.0	0.0	5.8	58.2	0.0	35.8	0.1
3480	1.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3482	0.6	17.6	0.0	4.2	0.0	27.3	0.0	0.0	68.5	0.0	0.0	0.0
3510	1.9	12.1	0.0	16.8	0.0	0.0	0.0	0.0	28.8	0.0	52.3	2.1
35129	1.0	25.6	0.0	0.0	0.0	0.0	0.0	37.6	47.9	0.5	14.0	0.0
35157	0.7	85.5	0.0	93.6	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0
35190	0.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35218	0.8	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35244	0.2	11.7	0.0	0.0	0.0	0.0	0.0	0.0	29.3	0.0	70.7	0.0
35306	5.6	8.6	0.0	3.9	0.0	0.0	0.0	0.0	40.1	0.0	55.9	0.0
35402	1.5	75.0	0.0	87.7	0.0	12.3	0.0	0.0	0.0	0.0	0.0	0.0
35522	0.2	14.1	0.0	0.0	0.0	0.0	18.6	0.0	0.7	0.0	80.7	0.0
35606	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
35881	0.9	17.4	0.0	0.9	0.0	0.0	0.0	0.0	63.7	0.0	35.4	0.0
36008	0.3	16.5	0.0	0.0	0.0	0.0	0.0	0.0	60.8	0.0	39.2	0.0
3611	5.6	8.9	0.0	0.0	0.0	0.0	0.0	0.0	41.0	0.0	59.0	0.0
36156	1.6	36.7	0.0	52.5	0.0	0.0	0.0	0.0	2.6	0.0	44.9	0.0
36223	1.0	30.8	0.0	0.0	0.0	0.0	0.0	38.6	54.9	0.0	6.6	0.0
36243	1.5	84.9	0.0	94.2	0.0	0.0	0.0	0.0	4.6	0.0	1.2	0.0
36262	0.2	86.2	0.0	95.1	0.0	0.0	0.0	0.0	0.0	0.0	4.9	0.0
36270	1.9	80.3	0.0	9.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.2
36320	1.6	13.6	0.0	11.0	0.0	0.0	0.0	0.0	55.0	0.0	34.0	0.0
36395	5.2	47.5	0.0	52.8	0.0	0.0	0.0	30.8	0.0	0.0	16.4	0.0
36402	0.2	73.5	0.0	86.7	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0
36443	22.6	9.2	0.0	2.1	0.0	0.0	0.4	0.0	37.7	0.0	59.7	0.0
36495	1.0	90.4	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.6	99.2
3654	0.6	12.0	0.0	22.3	0.0	0.0	0.0	0.0	36.1	0.0	41.6	0.0

% Land Use

Subarea	Acres	% Impervious	Agriculture	Commercial	Industrial	Open Space	Park	Public	Residential High	Residential Low	Residential Medium	School
36557	21.1	17.6	39.9	0.0	0.0	0.0	0.0	29.9	0.0	21.7	8.5	0.0
36578	1.1	31.1	0.0	43.9	0.0	0.0	0.0	0.0	0.0	0.0	56.1	0.0
36611	1.5	93.8	0.0	99.9	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
36772	0.3	58.1	0.0	74.9	0.0	0.0	0.0	0.0	0.0	0.0	25.1	0.0
36958	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37046	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37055	0.4	64.0	0.0	64.3	0.0	0.0	0.0	35.7	0.0	0.0	0.0	0.0
37058	0.4	11.9	0.0	0.0	0.0	0.0	0.0	0.0	28.6	0.0	71.4	0.0
37079	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37103	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37144	0.6	88.0	0.0	2.7	0.0	0.0	0.0	97.3	0.0	0.0	0.0	0.0
37260	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37320	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37504	0.3	14.3	0.0	0.0	0.0	0.0	0.0	0.0	18.6	0.0	81.4	0.0
37526	0.6	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
37580	1.5	27.9	0.0	49.3	0.0	0.0	50.7	0.0	0.0	0.0	0.0	0.0
3778	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37942	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37950	6.9	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37959	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38052	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38079	0.9	93.6	0.0	99.8	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
38138	0.4	26.9	0.0	44.1	0.0	0.0	0.0	0.0	18.5	0.0	37.4	0.0
38243	107.4	9.2	0.0	0.0	0.0	0.0	0.0	0.1	2.6	58.2	39.1	0.0
38519	18.0	17.3	0.0	0.0	0.0	0.0	0.0	15.4	0.0	22.8	61.8	0.0
38567	2.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38585	0.1	5.6	57.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.6	0.0
38627	6.2	23.3	0.0	33.6	0.0	0.0	0.0	0.0	7.9	0.0	58.5	0.0
38751	1.8	68.7	0.0	24.8	0.0	0.0	0.0	75.2	0.0	0.0	0.0	0.0
38809	1.4	42.3	0.0	0.0	0.0	0.0	0.0	54.0	0.0	1.3	44.7	0.0
39034	2.9	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39226	1.6	76.6	0.0	13.8	0.0	0.0	0.0	86.2	0.0	0.0	0.0	0.0
39297	25.5	12.0	0.6	0.0	0.5	0.0	0.0	3.2	56.6	18.0	21.1	0.0
39318	29.3	3.0	51.6	0.0	0.0	0.0	0.0	0.1	0.0	29.4	18.9	0.0
39382	2.8	10.1	0.0	0.0	0.0	0.0	0.0	12.1	0.0	64.6	23.3	0.0
39524	0.5	80.0	0.0	89.5	0.0	0.0	0.0	0.0	0.0	0.0	2.0	8.5
3964	0.4	68.9	0.0	83.4	0.0	0.0	0.0	0.0	0.0	0.0	16.6	0.0
39864	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39919	0.7	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
39979	0.6	14.1	0.0	0.0	0.0	0.0	0.0	0.3	18.7	0.0	80.0	1.1
40215	1.2	89.8	0.0	97.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
40255	0.1	91.5	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
40400	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4045	1.1	20.2	0.0	0.0	0.0	0.0	0.0	13.5	0.0	0.0	86.5	0.0
40455	1.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40584	1.3	10.3	0.0	0.0	0.0	0.0	0.0	0.0	35.5	0.0	64.5	0.0
40603	0.8	15.5	0.0	0.0	5.6	0.0	0.1	13.2	0.0	64.4	16.8	0.0
40613	1.3	23.5	0.0	0.0	0.0	0.0	60.2	39.8	0.0	0.0	0.0	0.0
40641	1.3	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
40772	3.0	64.2	0.0	80.1	0.0	0.0	0.0	0.0	19.9	0.0	0.0	0.0
41083	0.3	85.7	0.0	93.8	0.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0
41117	1.3	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.1	4.9
41147	0.5	67.8	0.0	79.2	0.0	0.0	0.0	13.6	7.2	0.0	0.0	0.0
4144	0.4	61.7	0.0	63.1	0.0	0.0	0.0	34.6	2.3	0.0	0.0	0.0
4154	0.7	90.9	0.0	97.9	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.0
4156	8.7	12.9	0.0	0.0	0.0	0.0	0.0	0.0	6.1	28.6	65.3	0.0
4165	0.5	21.3	0.0	27.8	0.0	0.0	0.0	0.0	5.2	0.0	67.0	0.0
41652	1.1	20.2	0.0	25.4	0.0	0.0	0.0	0.0	5.9	0.0	68.7	0.0
4184	1.6	85.2	0.0	1.0	0.0	0.0	0.0	0.0	2.7	0.0	1.1	95.2
4336	1.2	33.3	0.0	49.1	0.0	0.0	0.0	6.5	6.3	0.0	38.1	0.0
45273	1.1	86.2	0.0	86.6	13.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4699	1.5	65.6	0.0	68.3	0.0	0.0	0.0	31.7	0.0	0.0	0.0	0.0
4763	0.3	41.7	0.0	57.8	0.0	0.0	0.0	0.0	0.0	0.0	42.2	0.0
4803	0.9	37.6	0.0	53.1	0.0	0.0	0.0	0.0	0.0	0.0	45.4	1.5
4868	0.3	21.0	0.0	0.0	0.0	0.0	0.0	0.0	72.0	0.0	28.0	0.0
4888	1.8	9.2	0.0	0.0	0.0	0.0	0.0	0.0	40.1	0.0	59.9	0.0
4898	0.5	13.5	0.0	0.0	0.0	0.0	0.0	0.0	21.7	0.0	78.3	0.0
5143	2.4	8.7	0.0	2.6	0.0	0.0	0.6	0.0	39.7	0.0	57.2	0.0
5521	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5524	0.5	76.3	0.0	84.6	0.0	0.0	0.0	15.4	0.0	0.0	0.0	0.0
5526	0.5	0.0	0.0	0.0	0.0	0.0	83.9	0.0	10.6	0.0	5.6	0.0
57	2.3	93.0	0.0	99.4	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0
5779	0.4	76.9	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	88.9
6316	1.2	9.3	0.0	0.0	0.0	0.0	0.0	0.0	43.1	0.0	56.9	0.0
6428	16.1	14.8	0.0	20.3	0.0	0.0	0.0	0.0	21.4	0.0	58.3	0.0
6615	5.2	36.9	0.0	0.0	0.0	0.0	0.0	33.0	16.3	0.0	16.0	34.6
6626	1.4	33.6	0.0	33.1	0.0	0.0	0.0	35.2	23.1	0.0	8.6	0.0
6853	0.4	15.5	0.0	0.0	0.0	0.0	0.0	0.0	13.6	0.0	86.4	0.0
6859	0.4	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

% Land Use

Subarea	Acres	% Impervious	Agriculture	Commercial	Industrial	Open Space	Park	Public	Residential High	Residential Low	Residential Medium	School
6897	0.5	65.8	0.0	68.6	0.0	0.0	0.0	31.4	0.0	0.0	0.0	0.0
6936	0.1	37.3	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
6996	0.9	68.5	0.0	83.2	0.0	0.0	0.0	0.0	16.8	0.0	0.0	0.0
7135	0.7	11.0	0.0	0.0	0.0	0.0	0.0	0.0	47.3	0.0	52.7	0.0
7154	0.9	91.1	0.0	98.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
7167	11.5	10.8	0.0	4.1	0.0	0.0	0.0	0.0	30.7	0.0	65.3	0.0
719	0.5	11.1	0.0	0.0	0.0	0.0	0.0	0.0	47.6	0.0	52.4	0.0
7358	0.6	17.8	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	96.0	0.0
7451	1.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7471	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8125	0.2	4.3	0.0	16.7	0.0	70.4	0.0	0.0	12.9	0.0	0.0	0.0
8131	0.3	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
8176	3.0	82.9	0.0	91.3	0.0	0.0	0.0	8.7	0.0	0.0	0.0	0.0
8211	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8396	2.0	21.6	0.0	0.0	0.0	0.0	0.0	20.1	0.0	5.5	74.4	0.0
8489	0.1	60.8	0.0	77.6	0.0	0.0	0.0	0.0	22.4	0.0	0.0	0.0
8505	0.9	23.5	0.0	43.5	0.0	0.0	0.0	0.0	30.8	0.0	25.8	0.0
8563	0.5	14.8	0.0	0.0	0.0	0.0	0.0	0.0	16.4	0.0	83.6	0.0
86396	0.8	80.4	0.0	0.0	0.0	0.0	8.4	91.6	0.0	0.0	0.0	0.0
86523	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8696	0.6	63.0	0.0	38.1	0.0	0.0	0.0	61.9	0.0	0.0	0.0	0.0
8700	0.5	17.0	0.0	0.0	0.0	0.0	0.0	0.0	62.3	0.0	37.7	0.0
87399	0.7	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87482	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87495	0.3	92.1	0.0	98.8	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0
87871	0.6	88.8	0.0	96.3	0.0	0.0	0.0	3.7	0.0	0.0	0.0	0.0
87873	0.4	93.7	0.0	99.8	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
87874	0.5	91.2	0.0	98.3	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0
87875	0.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87876	0.0	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87877	0.1	44.9	0.0	65.0	0.0	0.0	35.0	0.0	0.0	0.0	0.0	0.0
87878	0.2	25.8	0.0	47.0	0.0	0.0	53.0	0.0	0.0	0.0	0.0	0.0
87879	0.5	38.4	0.0	59.4	0.0	0.0	40.6	0.0	0.0	0.0	0.0	0.0
87880	4.0	86.5	0.0	95.3	0.0	0.0	4.7	0.0	0.0	0.0	0.0	0.0
87881	0.1	28.9	0.0	50.3	0.0	0.0	49.7	0.0	0.0	0.0	0.0	0.0
87882	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
87976	0.1	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
88290	0.6	10.9	0.0	0.0	0.0	0.0	0.0	0.0	46.9	0.0	53.1	0.0
88317	0.2	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8881	1.5	16.8	0.0	0.0	0.0	0.0	0.0	0.0	61.6	0.0	38.4	0.0
8974	2.3	14.1	0.0	0.0	0.0	0.0	0.0	0.0	19.2	0.0	80.8	0.0
9057	0.1	18.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0
9224	0.5	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9242	0.3	8.5	0.0	8.0	0.0	0.0	0.0	0.0	40.1	0.0	51.9	0.0
928	2.2	30.6	0.0	43.0	0.0	0.0	0.0	0.0	0.0	0.0	57.0	0.0
9436	1.6	58.4	0.0	28.2	0.0	0.0	0.0	63.8	3.8	0.0	1.1	3.0
9515	0.3	18.0	0.0	0.0	0.0	0.0	0.0	0.0	64.8	0.0	35.2	0.0
9670	1.6	19.8	0.0	0.0	0.0	0.0	0.0	15.1	0.0	5.1	79.8	0.0
9755	1.5	14.7	0.0	18.5	0.0	0.0	0.0	0.0	20.0	0.0	56.3	5.1
9776	1.5	62.5	0.0	58.8	0.0	0.0	0.0	41.2	0.0	0.0	0.0	0.0
9789	3.0	63.6	0.0	35.9	0.0	0.0	0.0	64.1	0.0	0.0	0.0	0.0
9908	0.6	94.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S41513	1.6	25.0	0.0	97.9	0.0	0.0	0.0	1.1	0.0	0.0	0.0	1.0
1125	13.6	11.7	0.0	0.0	0.0	0.0	0.0	0.0	16.0	20.9	63.1	0.0
13327	2.2	89.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	98.3

Appendix C

Model input parameters – Washoff and Buildup

October 21 2014

	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
TSS	Commercial	POW	1000	0.4	0.6	AREA	EXP	22	1	0	25
	OpenSpace	POW	1000	0.05	0.3	AREA	EXP	4	1.8	0	25
	Public	POW	1000	0.05	0.3	AREA	EXP	4	1.8	0	25
	ResidenH	POW	1000	0.2	0.2	AREA	EXP	15	1.4	0	25
	ResidenL	POW	1000	0.18	0.15	AREA	EXP	12	1.7	0	25
	ResidenM	POW	1000	0.19	0.17	AREA	EXP	13	1.6	0	25

	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
E. Coli	Commercial										
	OpenSpace										
	Public			not applicable no E.COLI Monitoring Data							
	ResidenH										
	ResidenL										
	ResidenM										

	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
Phos.	Commercial	POW	100	0.1	0.55	AREA	EXP	0.06	1.2	0	10
	OpenSpace	POW	100	0.15	0.95	AREA	EXP	0.18	1.2	0	10
	Public	POW	100	0.15	0.75	AREA	EXP	0.12	1.2	0	10
	ResidenH	POW	100	0.27	0.95	AREA	EXP	0.4	1.2	0	10
	ResidenL	POW	100	0.23	0.95	AREA	EXP	0.21	1.2	0	10
	ResidenM	POW	100	0.24	0.95	AREA	EXP	0.25	1.2	0	10

12/19/14

	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
TSS	Commercial	POW	1000	0.5	0.6	AREA	EXP	22	0.5	0	25
	OpenSpace	POW	1000	0.1	0.3	AREA	EXP	4	1.8	0	25
	Public	POW	1000	0.1	0.3	AREA	EXP	4	1.8	0	25
	ResidenH	POW	1000	0.35	0.2	AREA	EXP	15	1.3	0	25
	ResidenL	POW	1000	0.2	0.15	AREA	EXP	12	1.5	0	25
	ResidenM	POW	1000	0.3	0.17	AREA	EXP	13	1.4	0	25

	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
E. Coli	Commercial	POW	100000000	2300	4.9	AREA	EXP	12500	0.05	0	0
	OpenSpace	POW	100000000	5000	1	AREA	EXP	15500	0.3	0	0
	Public	POW	100000000	10000	1	AREA	EXP	15500	0.3	0	0
	ResidenH	POW	100000000	20500	4.9	AREA	EXP	45000	0.1	0	0
	ResidenL	POW	100000000	15000	2.9	AREA	EXP	45000	0.2	0	0
	ResidenM	POW	100000000	17500	3.9	AREA	EXP	45000	0.15	0	0

	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
Phos.	Commercial	POW	100	0.1	0.55	AREA	EXP	0.06	0.9	0	10
	OpenSpace	POW	100	0.15	0.95	AREA	EXP	0.18	1.2	0	10
	Public	POW	100	0.15	0.75	AREA	EXP	0.12	1.2	0	10
	ResidenH	POW	100	0.27	0.95	AREA	EXP	0.4	1	0	10
	ResidenL	POW	100	0.23	0.95	AREA	EXP	0.21	1.2	0	10
	ResidenM	POW	100	0.24	0.95	AREA	EXP	0.25	1.1	0	10

TSS	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
	Commercia	POW	1000	0.5	3	AREA	EXP	22	0.5	0	25
	OpenSpace	POW	1000	0.1	0.5	AREA	EXP	4	1.1	0	25
	Public	POW	1000	0.1	0.5	AREA	EXP	4	1.1	0	25
	ResidenH	POW	1000	0.35	2	AREA	EXP	15	0.6	0	25
	ResidenL	POW	1000	0.2	1.8	AREA	EXP	12	0.8	0	25
	ResidenM	POW	1000	0.3	1.9	AREA	EXP	13	0.7	0	25

E. Coli	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
	Commercia	POW	100000000	2300	4.9	AREA	EXP	12500	0.05	0	0
	OpenSpace	POW	100000000	5000	1	AREA	EXP	15500	0.3	0	0
	Public	POW	100000000	10000	1	AREA	EXP	15500	0.3	0	0
	ResidenH	POW	100000000	20500	4.9	AREA	EXP	45000	0.1	0	0
	ResidenL	POW	100000000	15000	2.9	AREA	EXP	45000	0.2	0	0
	ResidenM	POW	100000000	17500	3.9	AREA	EXP	45000	0.15	0	0

Phos.	Name	Buildup Function	Max. Buildup	Buildup Rate Constant (Scaling Factor)	Buildup Power/Sat. Constant (Time Series)	Buildup Normalizer	Washoff Function	Washoff Coefficient	Washoff Exponent	Washoff Cleaning Effic.	Washoff BMP Effic.
	Commercia	POW	100	0.15	0.55	AREA	EXP	0.06	0.9	0	10
	OpenSpace	POW	100	0.2	0.95	AREA	EXP	0.18	1.2	0	10
	Public	POW	100	0.2	0.75	AREA	EXP	0.12	1.2	0	10
	ResidenH	POW	100	0.31	0.95	AREA	EXP	0.4	1	0	10
	ResidenL	POW	100	0.29	0.95	AREA	EXP	0.21	1.2	0	10
	ResidenM	POW	100	0.3	0.95	AREA	EXP	0.25	1.1	0	10