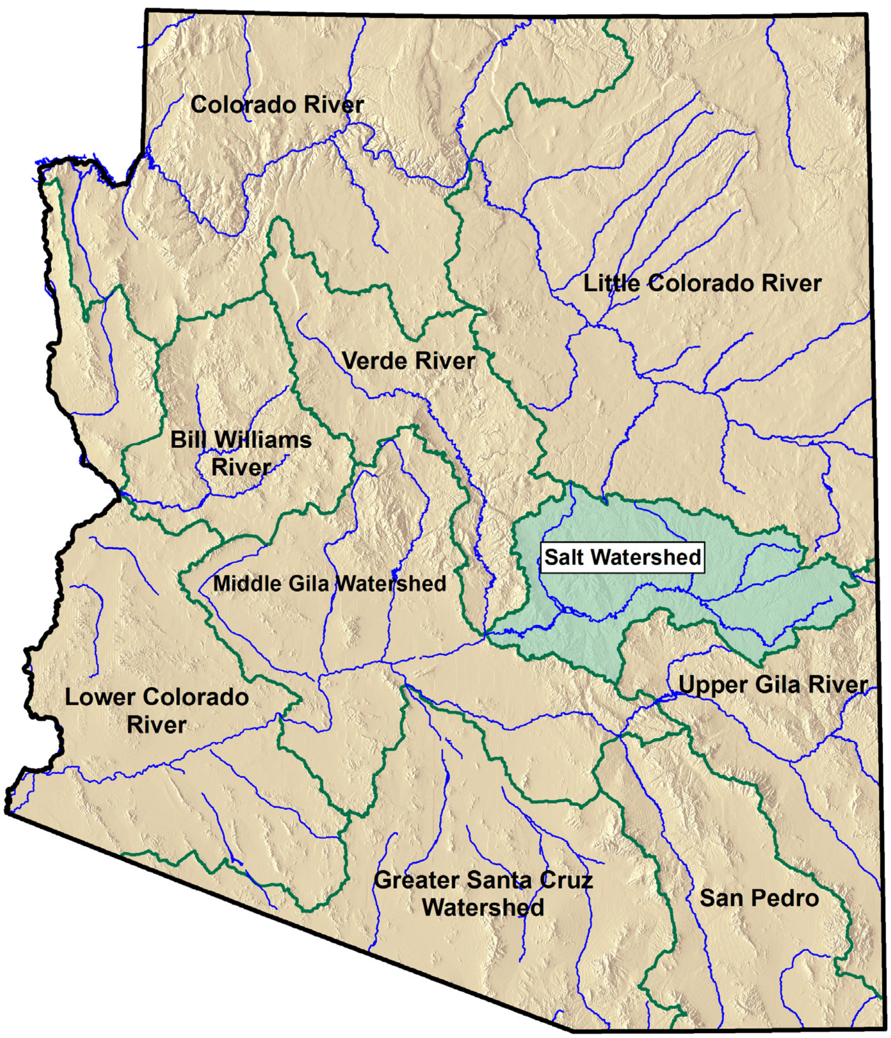
ARIZONA NEMO

NEMO Watershed-Based Plan
Salt Watershed

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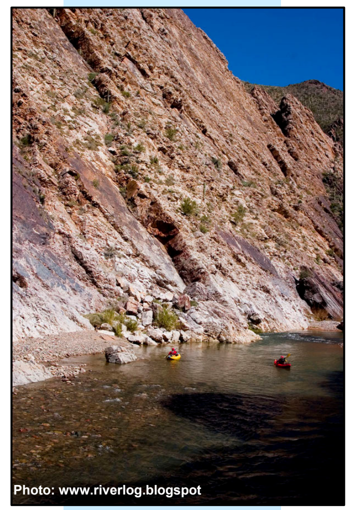
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Water Resources Research Center

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The NEMO website is www.arizonanemo.org

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Section 1: Introduction

<u>Background: Nonpoint Source Pollution and NEMO</u>

The Southwestern United States, including the state of Arizona, is the fastest growing region in the country. Because the region is undergoing rapid development, there is a need to address health and quality of life issues that result from degradation of our water resources.

Water quality problems may originate from both “point” and “nonpoint” sources. The Clean Water Act (CWA) defines "point source” pollution as "any discernable, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft from which pollutants are or may be discharged" (33 U.S.C. § 1362(14)). Point source discharge is regulated through provisions in the CWA.

Although nonpoint source pollution is not defined under the CWA, it is widely understood to be the type of pollution that arises from many dispersed activities over large areas, and is not traceable to any single discrete source. Nonpoint source pollution may originate from many different sources, usually associated with rainfall runoff moving over and through the ground, carrying natural and manmade pollutants into lakes, rivers, streams, wetlands and ground water. In contrast to point source pollution, nonpoint source pollution is addressed primarily through non-regulatory means under the CWA.

Nonpoint source pollution is the leading cause of water quality degradation across the United States, and is the water quality issue that NEMO, the <u>N</u>onpoint <u>E</u>ducation for <u>M</u>unicipal <u>O</u>fficials program, and this watershed based plan will address.

Nationally, NEMO has been very successful in helping to mitigate nonpoint source pollution. The goal of NEMO is to educate land-use decision makers to take proactive voluntary actions that will mitigate nonpoint source pollution and protect natural resources. In the eastern United States (where the NEMO concept originated), land use authority is concentrated in municipal (village, town and city) government. In Arizona, where nearly 80% of the land is managed by state, tribal and federal entities, land use authorities include county, state and federal agencies, in addition to municipal officials and private citizens.

In partnership with the Arizona Department of Environmental Quality (ADEQ) and the University of Arizona (U of A) Water Resources Research Center, the Arizona Cooperative Extension at the U of A has initiated the Arizona NEMO program. Arizona NEMO attempts to adapt the original NEMO program to the conditions in the semiarid, western United States, where water supply is limited and many natural resource problems are related to the lack of water, as well as water quality.

Working within a watershed template, Arizona NEMO includes: comprehensive and integrated watershed planning support, identification and publication of Best Management Practices (BMP), and education on water conservation and riparian water quality restoration. Arizona NEMO maintains a website, http://www.ArizonaNEMO.org that contains these watershed based plans, Best Management Practices fact sheets, and other educational materials.

Watershed-Based Plans

Watershed-based plans are holistic documents designed to protect and restore a watershed. These plans provide a careful analysis of the sources of water quality problems, their relative contributions to the problems, and alternatives to solve those problems. Furthermore, watershed-based plans present proactive measures that can be applied to protect water bodies.

In watersheds with developed or drafted Total Maximum Daily Load (TMDL) studies for specific waterbodies, the watershed-based plan must be designed to achieve the load reductions identified in the TMDL. The CWA requires each state to perform a TMDL on waterbodies that are identified as impaired due to exceedances of state surface water quality standards. As point sources and nonpoint sources of pollution are determined through TMDL analysis, subsequent load reductions are assigned to each source as necessary for the purposes of improving water quality to meet state standards.

In collaboration with the local watershed partnerships and ADEQ, NEMO will help improve water quality by developing a realistic watershed-based plan to achieve water quality standards and protection goals. This plan will identify:

- Areas that are susceptible to water quality problems and pollution;
- Sources that need to be controlled; and
- Management measures that should be implemented to protect or improve water quality.

The first component of the planning process is to characterize the watershed by summarizing all readily available natural resource information and other relevant data for that watershed. As seen in Sections 2 though 5 of this document, these data are at a broad-based, large watershed scale and include information on water quality, land use and cover, natural resources and wildlife habitat.

The second component of the watershed planning process is to identify nonpoint source pollutants that need to be managed. This is done by ranking and prioritizing areas within the watershed based on water quality concerns and other physical attributes. Hydrologic modeling supports the ranking of the watershed areas, as seen in Section 6. Finally, example watershed management practices addressing water pollution due to metals, sediment, organics, and selenium are discussed in Section 7. Example project planning, budgeting, and scheduling, as well as the EPA Guidelines for water quality improvement grant applications to implement watershed management projects, are presented in Sections 8 and 9.

It is anticipated that stakeholder-groups will develop their own detailed planning documents. That document may cover a subwatershed area within the NEMO Watershed-based Plan, or include the entire watershed area. In addition, local watershed-based plans generated by stakeholder-groups will incorporate local knowledge and concerns gleaned from stakeholder involvement and will include:

- A description of the stakeholder / partnership process;
- A well-stated, overarching goal aimed at protecting, preserving, and restoring habitat and water quality, and encouragement of land stewardship;
- A plan to coordinate natural resource protection and planning efforts;
- A detailed and prioritized description of natural resource management objectives; and
- A detailed and prioritized discussion of Best Management Practices (BMPs), strategies and projects to be implemented by the partnership.

Based on the EPA's *2003 Guidelines for the Award of Section 319 Nonpoint Source Grants*, a watershed-based plan should include all nine of the elements listed below. This NEMO watershed-based plan addresses each of these elements (except for Element 2: Expected Load Reductions); however, the watershed group must determine the final watershed plan and actions.

- Element 1: *Causes and Sources* - Clearly define the causes and sources of impairment (physical, chemical, and biological).
- Element 2: *Expected Load Reductions* - An estimate of the load reductions expected for each of the management measures or Best Management Practices (BMPs) to be implemented (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time).
- Element 3: *Management Measures* - A description of the management measures or Best Management Practices (BMPs) and associated costs that will need to be implemented to achieve the load reductions estimated in this plan and an identification (using a map or a description) of the critical areas where those measures are needed.
- Element 4: *Technical and Financial Assistance* - An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.
- Element 5: *Information / Education Component* - An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing management measures.

- Element 6: *Schedule* - A schedule for implementing management measures identified in this plan that is reasonably expeditious.

- Element 7: *Measurable Milestones* - A schedule of interim, measurable milestones for determining whether the management measures, Best Management Practices, or other control actions are being implemented.

- Element 8: *Evaluation of Progress* - A set of criteria that can be used to determine whether load reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised or, if a Total Maximum Daily Load (TMDL) has been established, whether the TMDL needs to be revised.

- Element 9: *Effectiveness Monitoring* - A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established in the Evaluation of Progress element.

These nine elements help provide reasonable assurance that the nonpoint source of pollution will be managed to improve and protect water quality and to assure that public funds to address impaired waters are used effectively.

Purpose and Scope

This watershed-based plan includes a watershed characterization and a watershed classification for the Salt Watershed. The watershed characterization is found in Sections 2 through 5. The watershed classification is located in Sections 6 through 9.

The Salt Watershed is located in the central portion of the state of Arizona, east of the city of Phoenix, as shown in Figure 1-1.

The watershed characterization in Sections 2 through 5 includes physical, biological, and social/economic data in a geographic information system (GIS) database format, as both mapped and tabulated data, that has been collected from available existing and published data sources. No new field data were collected for this plan. This characterization represents an inventory of natural resources and environmental conditions that affect primarily surface water quality. It provides educational outreach

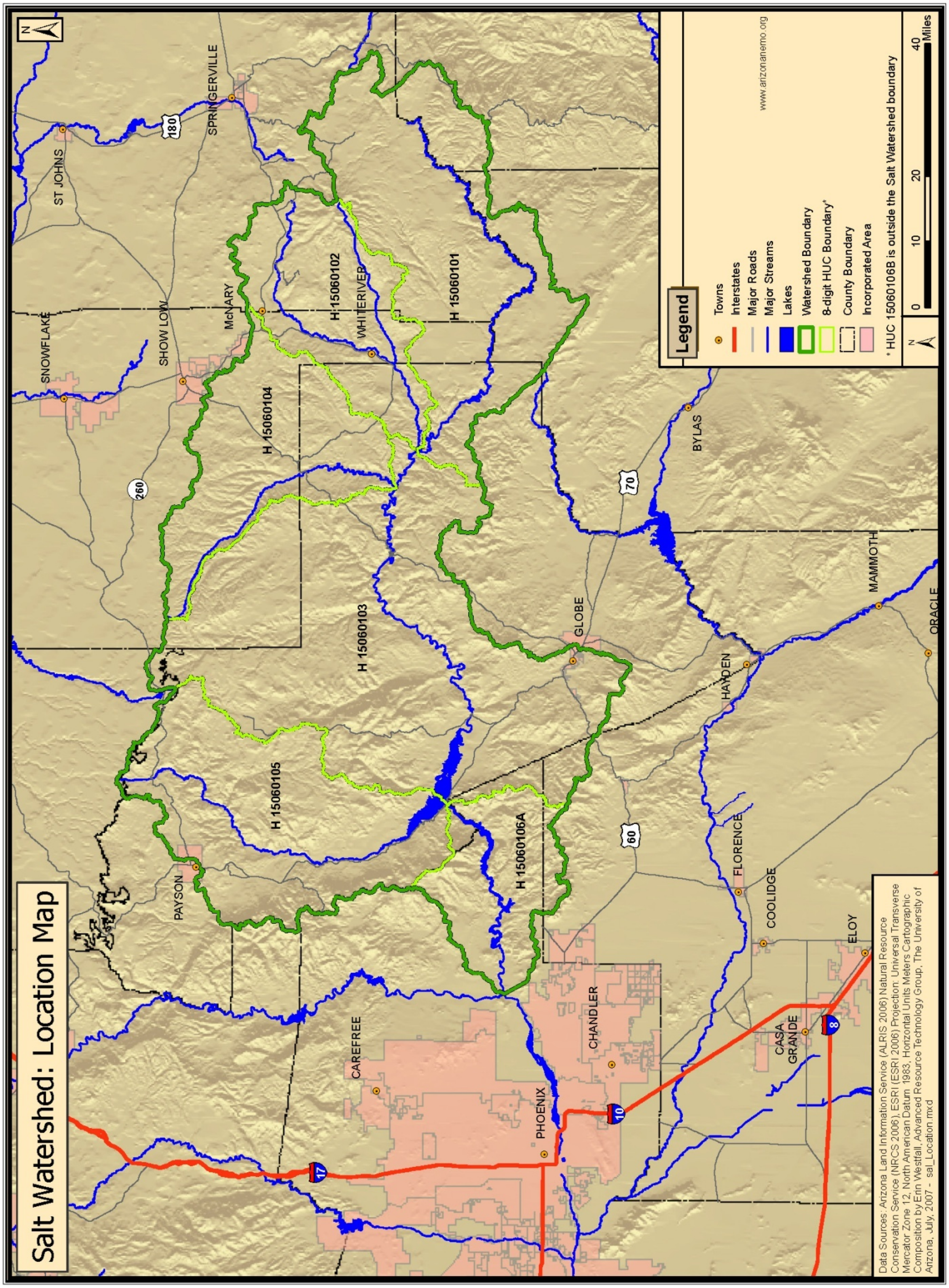

Figure 1-1: Location

material to stakeholders and watershed partnerships.

The watershed classification identifies water quality problems by incorporating water quality data reported in *The Status of Water Quality in Arizona – 2006: Arizona's Integrated 305(b) Assessment and 303(d) Listing Report, Draft* (ADEQ, 2006), ADEQ's biennial report consolidating water quality reporting requirements under the federal Clean Water Act. The ADEQ water quality data, TMDL definitions, and further information for each stream reach and the surface water sampling sites across the state can be found at: http://lists.azdeq.gov/environ/water/assessment/download/2006/integrated.pdf.

The watershed classification includes identifying and mapping important resources, and ranking 10-digit HUC (hydrologic unit codes) subwatersheds (discussed later in this section) based on the likelihood of nonpoint source pollutant contribution to stream water quality degradation.

In addition to the watershed characterization and classification, this plan includes general discussions of recommended nonpoint source Best Management Practices (BMP) that may be implemented to achieve pollutant load reductions and other watershed goals. It provides methods and tools to identify problem sources and locations for implementation of BMPs to mitigate nonpoint source pollution.

These watershed management activities are proposed with the understanding that the land-use decision makers and stakeholders within the watershed can select the BMPs they feel are most appropriate and revise management activities as conditions within the watershed change. Although these chapters are written based on current information, the tools developed can be used to update this plan and reevaluate water quality concerns as new information becomes available.

Methods

The methods used to develop this watershed-based plan include GIS analysis and hydrologic modeling to classify and characterize the subwatersheds, and fuzzy logic to rank them.

GIS and Hydrologic Modeling

GIS and hydrologic modeling were the major tools used to develop this watershed-based plan. In a GIS, two types of information represent geographic features: locational and descriptive data. Locational (spatial) data are stored using a vector (line) or a raster (grid) data structure. Vector data are object based data models which show spatial features as points, lines, and/or polygons. Raster data models represent geographical space by dividing it into a series of units or cells, each of which is limited and defined by an equal amount of the earth's surface. These cells may be triangular or hexagonal, although the square is the most common.

Corresponding descriptive (attribute) data for each geographic feature are stored in a set of tables. The spatial and descriptive data are linked in the GIS so that both sets of information are always available.

Planning and assessment in land and water resource management requires spatial modeling tools to incorporate complex watershed-scale attributes into the assessment process. Modeling tools applied to the Salt Watershed include AGWA, SWAT, SEDMOD, and RUSLE, as described below.

The Automated Geospatial Watershed Assessment Tool (AGWA) is a GIS-based hydrologic modeling tool designed to evaluate the effects of land use change (Burns et al., 2004). AGWA provides the functionality to conduct all phases of a watershed assessment. It facilitates the use of the Soil and Water Assessment Tool (SWAT), a hydrologic model, by preparing the inputs, running the model, and presenting the results visually in the GIS. AGWA has been used to illustrate the impacts of urbanization and other landscape changes on runoff and sediment load in a watershed.

AGWA was developed under a joint project between the Environmental Protection Agency (EPA), Agricultural Research Service (ARS), and the University of Arizona. SWAT was developed by the ARS, and is able to predict the impacts of land management practices on water, sediment and chemical yields in complex watersheds with varying soils, land use and management conditions (Arnold et al., 1994).

The SEDMOD model (Van Remortel et al., 2006), which uses the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997), was applied in this plan to estimate soil erosion and sediment delivery from different land use types. This procedure involves a series of automated Arc Macro Language (AML) scripts and two supported programs that run on an ESRI ArcGIS 9.x Workstation platform.

The watershed classification within this plan incorporates GIS-based hydrologic modeling results and other data to describe watershed conditions upstream from an impaired stream reach identified within Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2006).

In addition, impacts due to mine sites (erosion and metals pollution) and grazing (erosion and pollutant nutrients) are simulated.

The Salt Watershed is defined and mapped by the U.S. Geological Survey using the eight-digit Hydrologic Unit Code (HUC). The United States is divided and sub-divided into successively smaller hydrologic units of surface water drainage features, which are classified into four levels, each identified by a unique hydrologic unit code consisting of two to eight digits: regions (2 digit), sub-regions (4 digit), accounting units (6 digit), and cataloging units (8 digit) (Seaber et al., 1987).

The Salt Watershed is an eight-digit HUC watershed. Within the Salt River, smaller subwatershed areas are delineated using the ten-digit cataloging HUC. These ten-digit HUCs were used for the characterizations, classifications and GIS modeling.

For purposes of this planning document, the western-most portion of the watershed, which covers the urban area of Phoenix, is incorporated into the Middle Gila Watershed-Based Plan. The split was made because land-use characteristics and the extent of urbanization of the western-most portion of the Salt Watershed is more consistent with that of the Middle Gila.

The following six and eight HUC units and subwatershed names are used to clarify locations in this plan.

H150601 Salt River Watershed

15060101 Black River
15060102 – White River
15060103 – Upper Salt River
15060104 - Carrizo Creek
15060105 - Tonto Creek
15060106A – Lower Salt River

Fuzzy Logic

To rank the 10-digit HUC subwatershed areas that are susceptible to water quality problems and pollution, and to identify sources that need to be controlled, a fuzzy logic knowledge-based methodology was applied to integrate the various spatial and non-spatial data types (Guertin et al., 2000; Miller et al., 2002; Reynolds et al., 2001). This methodology has been selected as the basis by which subwatershed areas and stream reaches are prioritized for the implementation of BMPs to assure nonpoint source pollution is managed.

Fuzzy logic is an approach to set theory that handles vagueness or uncertainty, and has been described as a method by which to quantify common sense. In classical set theory, an object is either a member of the set or excluded from the set. Fuzzy logic allows for an object to be a partial member of a set.

For example, classical set theory might place a man into either the tall or short class, with the class of tall men being those over the height of 6’0”. Using this method, a man who is 5’ 11” tall would not be placed in the tall class, although he would not be considered ‘not-tall’. This is unacceptable, for example, for describing or quantifying an object that may be a partial member of a set. In fuzzy logic, membership in a set is described as a value between 0 (non-membership in the set) and 1 (full membership in the set). For instance, the individual who is 5’ 11” is not classified as short or tall, but is classified as tall to a degree of 0.8. Likewise, an individual of height 5' 10" would be tall to a degree of 0.6.

In fuzzy logic, the range in values between different data factors are converted to the same scale (0-1) using fuzzy membership functions. Fuzzy membership functions can be discrete or continuous depending on the characteristics of the input. In the illustration above, the degree of tallness was iteratively added in intervals of 0.2, creating a discrete data set. A continuous data set would graph the heights of all individuals and correlate a continuous fuzzy member value to that graph. A user defines their membership functions to describe the relationship between an individual factor and the achievement of the stated goal.

A benefit of using a fuzzy membership function is that it can be based on published data, expert opinions, stakeholder values or institutional policy, and can be created in a data-poor environment. Another benefit is that it provides for the use of different methods for combining individual factors to create the final classification, and the goal set. Fuzzy membership functions and weighting schemes can also be changed based on watershed concerns and conditions.

The general approach used in this plan was to integrate watershed characteristics, water quality measurements, and modeling results within a multi-parameter ranking system based on the fuzzy logic knowledge-based approach, as shown schematically in Figure 1-2.

This approach requires that a goal be defined according to the desired outcome, and that the classification be defined as a function of the goal and is therefore reflective of the management objective. For this watershed classification, the goal is to identify critical subwatersheds in which BMPs should be implemented to reduce nonpoint source pollution.

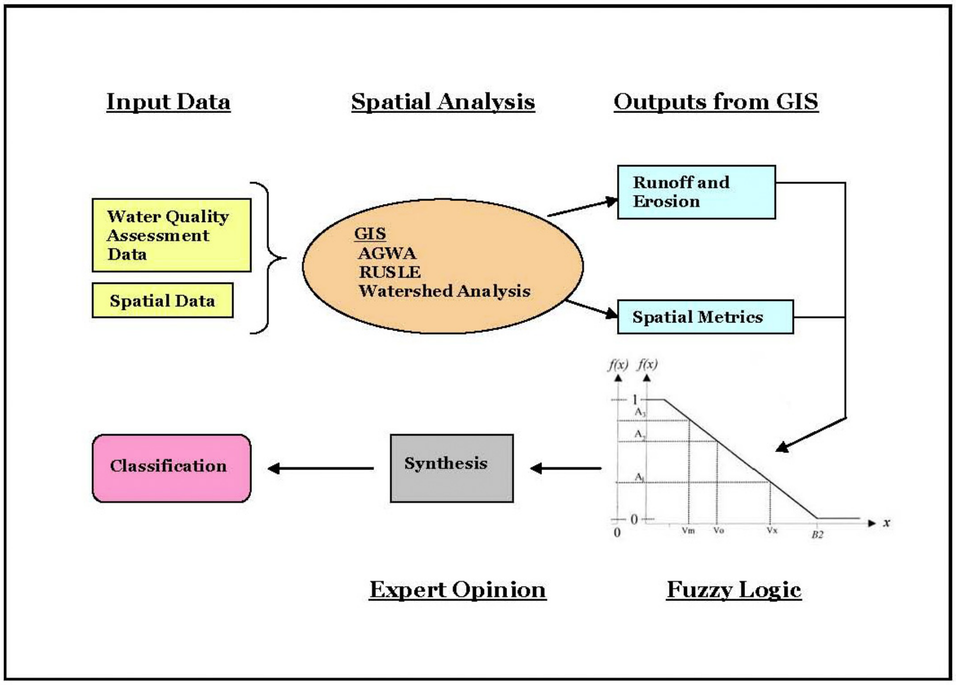

Figure 1-2: Transformation of Input Data via a GIS, Fuzzy Logic Approach, and Synthesis of Results into a Watershed Classification.

The classification process was implemented within a GIS interface to create the subwatershed classifications using five primary steps:

1. Define the goal of this watershed classification: Classify water quality impairment due to dissolved total metals from mining activity;

2. Assemble GIS data and other observational data;

3. Define watershed characteristics through:

    a. Water quality data provided in Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2004);

    b. GIS mapping analysis; and

    c. Modeling and simulation of erosion vulnerability and potential for stream impairment (i.e. from soils at mine sites and proximity to abandoned mine sites).

4. Use fuzzy membership functions to transform the vulnerability and impairment metrics into fuzzy membership values; and

5. Determine a composite fuzzy score representing the ranking of the combined attributes for each subwatershed, and interpret the results.

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2006), was used to classify each monitored stream reach based on its relative risk of impairment for each of the chemical constituent groups.

The constituent groups include metals, organics, nutrients, and turbidity/sediment.

Two final levels of risk were defined: high and low. For example, if elevated concentrations of metals, such as copper and mercury, are found above standards, the water body would be classified as 'high' risk if ADEQ has currently assessed it as being "impaired" for that constituent group. Conversely, a water body is classified as 'low' risk if there are no exceedances in a constituent group and there are sufficient data to make a classification.

Classifications were conducted at the 10-digit HUC subwatershed scale, resulting in the ranking of the 27 subwatershed areas.

Structure of this Watershed-Based Plan

Watershed characterizations, including physical, biological, and social characteristics, are discussed in Sections 2 through 4. Important environmental resources are discussed in Section 5.

The subwatershed classifications based on water quality attributes including concentrations of metals, sediment/turbidity, organics, and nutrients are found in Section 6. Watershed management strategies and BMPs are provided in Section 7, the Watershed Plan is presented in Section 8, and a summary of EPA's 9 Key Elements is provided in Section 9.

The full tabulation of the ADEQ water quality data and assessment status is provided in Appendix A. Suggested technical references of studies completed across the Salt Watershed are included in Appendix B, a description of RUSLE is in Appendix C, and a description of AGWA is in Appendix D.

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Section 2: Physical Features

The Salt Watershed in Arizona extends from the area near the New Mexico border to the town of Avondale. For purposes of this planning document, the western-most portion of the watershed, which covers the urban area of Phoenix, is incorporated into the Middle Gila Watershed-Based Plan. The split was made because land-use characteristics and the extent of urbanization of the western-most portion of the Salt Watershed are more consistent with that of the Middle Gila Watershed. The Lower Salt River 8-digit HUC is split at the Granite Reef Dam, as shown in Figure 1-1, and is designated as H15060106A.

Elevations range from 11,420 feet above sea level at Mt. Baldy, located southwest of Springerville, to 1,397 feet above sea level just south of Granite Reef, near the confluence of the Verde and Salt Rivers.

Watershed Size

The Salt Watershed has an area of approximately 6,243 square miles, representing about 5% of the state of Arizona. The watershed has a maximum approximate width of 130 miles east-west, and a maximum length of 80 miles north-south.

All watersheds in the U.S. were originally delineated by the U.S. Geological Survey into 8-digit HUC cataloging units, and were later subdivided into 10 or 11-digit HUC subwatersheds by the NRCS (http://cain.nbii.gov/calwater/calhist.html). Each drainage area has a unique hydrologic unit code number, or HUC, and a name based on the primary surface water feature within the HUC.

The Salt is an 8-digit HUC, and the subwatershed areas for this watershed-based plan were delineated on the basis of the 10-digit HUC. The classifications and GIS modeling were conducted on the ten-digit HUC subwatershed areas.

The subwatersheds are listed in Table 2-1 with both the unique HUC digital classification and the subwatershed basin name. The subwatershed areas are delineated in Figure 2-2.

Table 2-1: Salt Watershed HUCs and Subwatershed Areas.

Subwatershed Name and HUC Designation	Area (square miles)
Black River H15050101	1,251
White River H15060102	638
Upper Salt River H15060103	2,152
Carrizo Creek H15060104	709
Tonto Creek H15060105	1,048
Lower Salt River H15060106A	445
Salt Watershed	*6,243*

The Phoenix Active Management Area (AMA) is located in the Phoenix metropolitan portion of the watershed. An AMA is managed by the State to provide long-term management and conservation of ground water resources. The Phoenix AMA covers 5,646 square miles and consists of seven groundwater basins. The mission of this AMA is to achieve safe-yield by promoting conservation and through the use of renewable water sources.

The Phoenix AMA is drained by the Gila River and four principal tributaries: the Salt, the Verde, the Agua Fria and the Hassayampa Rivers (ADWR, 2007).

Topography

Topography and land slope, as well as soil characteristics, are important when assessing the vulnerability of a subwatershed to erosion, as will be discussed later in this document.

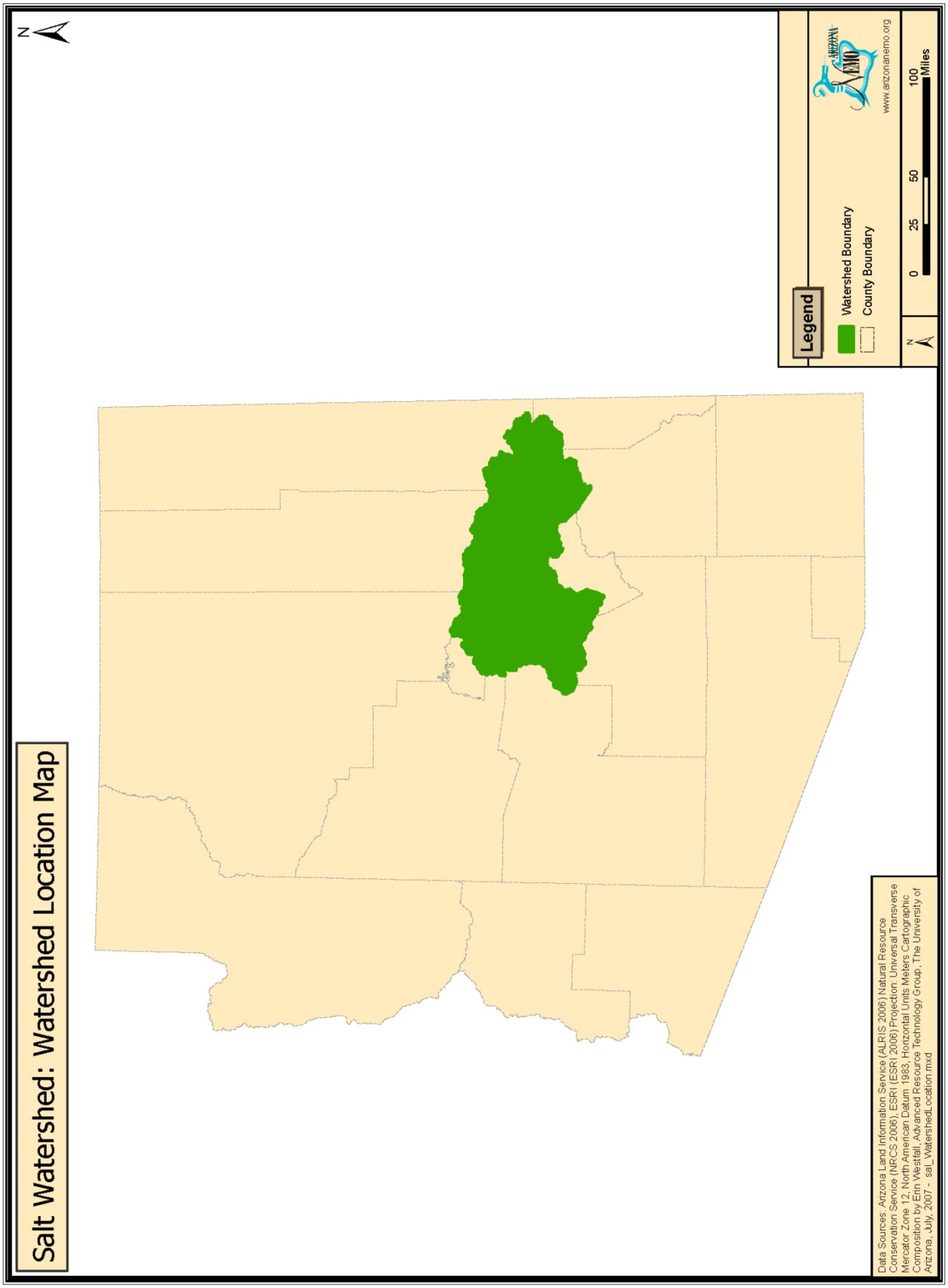

Figure 2-1: Watershed Location Map

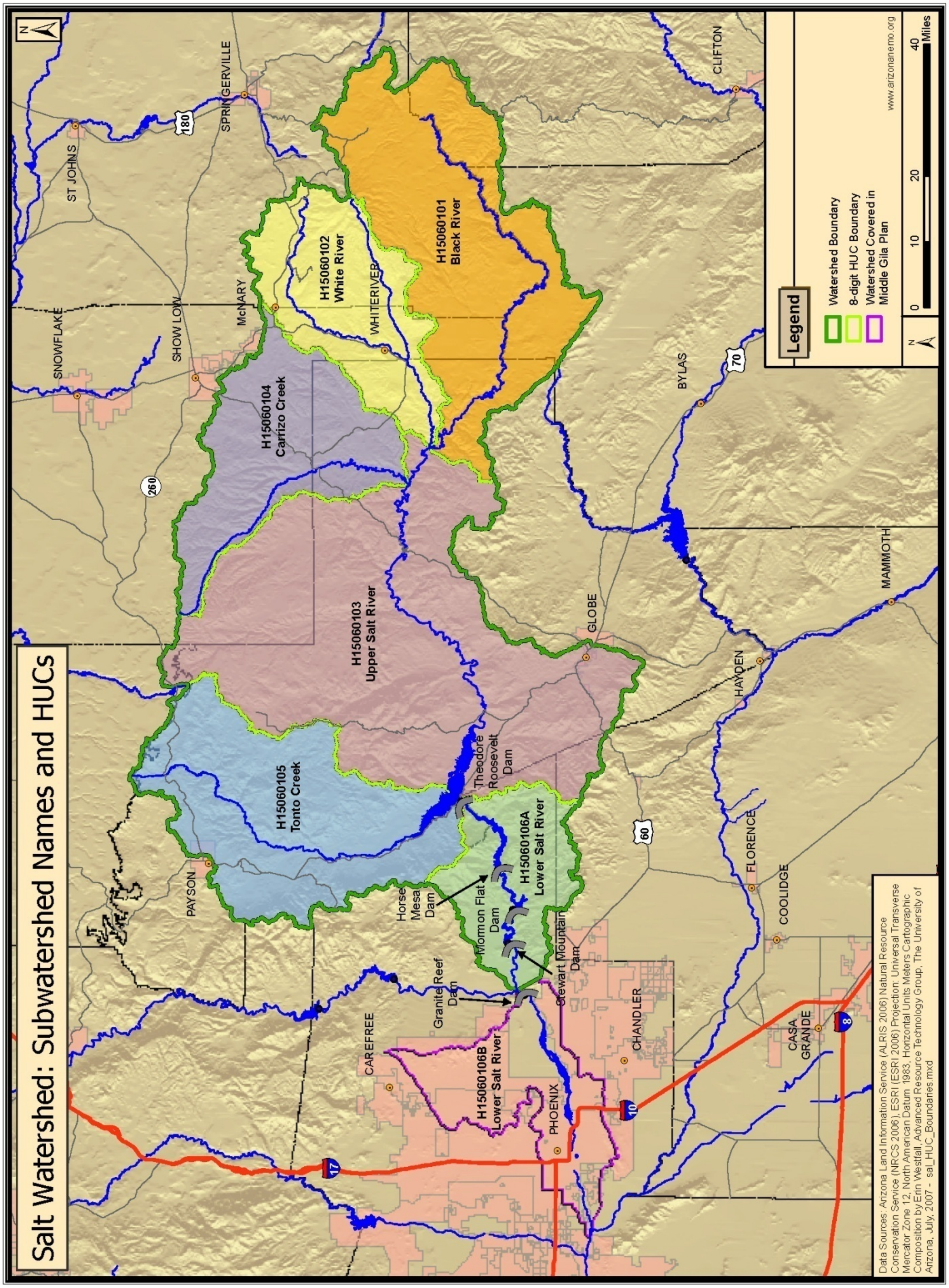

Figure 2-2: Subwatershed Names and HUCs

The land surface elevation of the Salt Watershed ranges between 1,397 and 11,420 feet above sea level.

The tallest feature in the watershed is Mt. Baldy at 11,420 feet. The lowest point in the watershed is located just south of Stewart Mountain dam. Mean elevation for the whole Salt Watershed is 5,531 feet (Table 2-2). The Lower Salt River subwatershed (HUC 15060106A), just East of the Phoenix area, is lower than the rest of the watershed with a mean elevation of 1,397 feet, about 4,000 feet lower than the mean for the entire watershed (Figure 2-3).

Approximately 51% of the Salt Watershed has a slope greater than 20%, while about 49% of the watershed has a slope less than 20%. The Lower Salt River subwatershed is flatter than the watershed average with only 33% of its area under 20% slope, and 67% greater than 20% slope. The Upper Salt River and Tonto River subwatersheds are the steepest, each with 23% of the area greater than 40% slope (Table 2-3 and Figure 2-4).

Table 2-2: Salt Watershed Elevation Range.

Subwatershed Name	Min (feet)	Max (feet)	Mean (feet)
Black River H15060101	4222	11414	7185
White River H15060102	4222	11414	7205
Upper Salt River H15060103	2093	7844	4852
Carrizo River H15060104	4055	7677	6063
Tonto River H15060105	2093	7969	4600
Lower Salt River H15060106A	1397	7596	4618
Salt Watershed	1397	11195	5531

Table 2-3: Salt Watershed Slope Classes.

Subwatershed Name	Area (sq. mi.)	Percent Slope		
		0-20%	20-40%	>40%
Black River H15060101	1,251	66.7%	22.4%	10.9%
White River H15060102	638	60.5%	28.9%	10.7%
Upper Salt River H15060103	2,152	42.1%	34.6%	23.3%
Carrizo River H15060104	709	48.9%	33.8%	17.3%
Tonto River H15060105	1,048	43.5%	33.4%	23.1%
Lower Salt River H15060106A	445	33%	31%	36%
Salt Watershed	6243	49%	31%	20%

Surface Water Resources

Lakes and Reservoirs

There are 4 mapped lakes and other water features in the Salt Watershed. Theodore Roosevelt Lake is by far the largest surface water body with an area of 18,594 acres. The next largest water

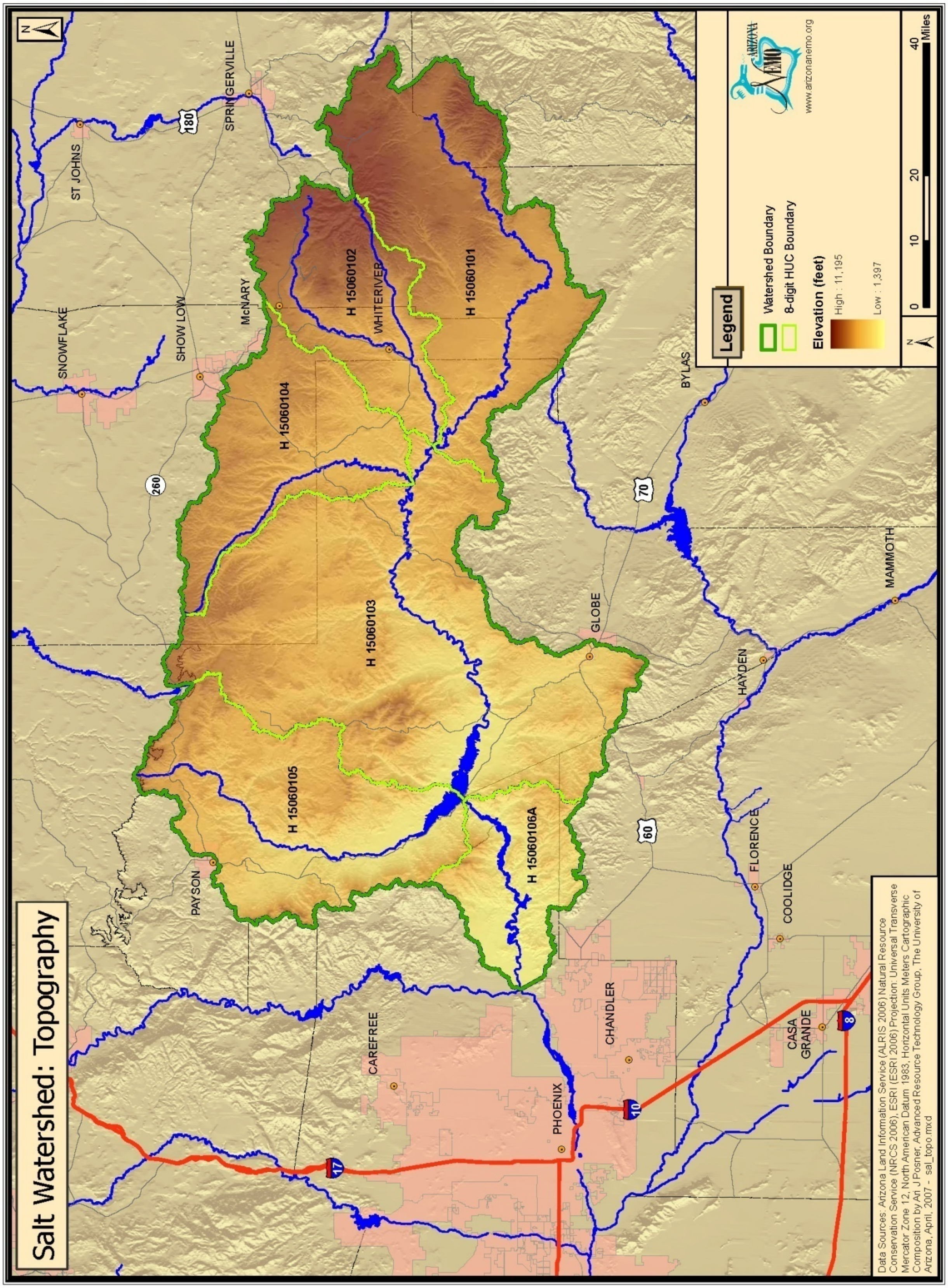

Figure 2-3: Topography

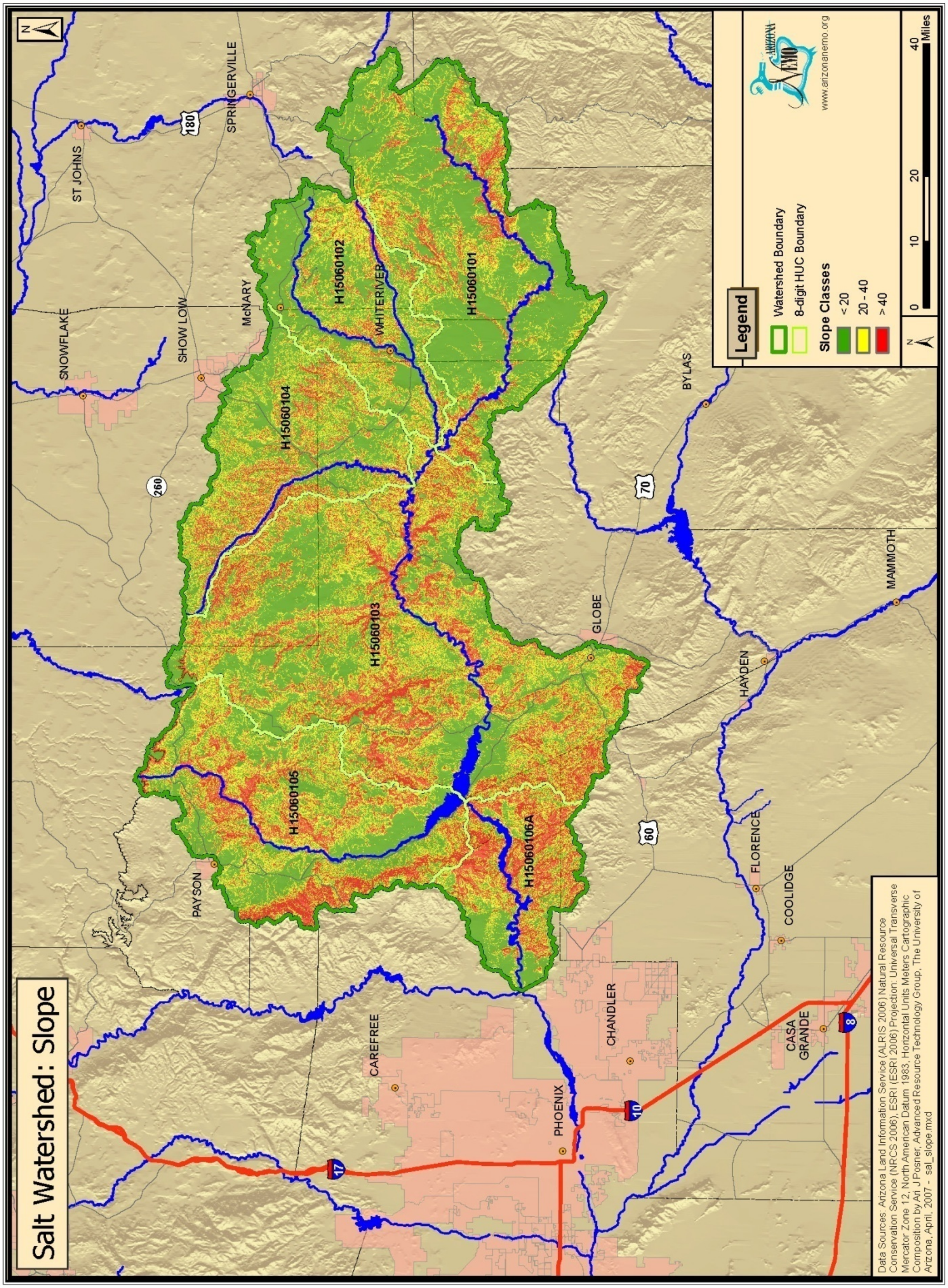

Figure 2-4: Slope

body is Apache Lake which covers 2,191 acres. The Salt is the largest river in the watershed with 1,598 miles of major streams. Table 2-4 lists the major surface water bodies and their associated areas, and Table 2-5 lists their lengths. Figure 2-5.1 shows the major lakes and streams.

Outstanding Arizona Waters

The Arizona Department of Environmental Quality (ADEQ) recognizes state resource waters of unique value as Outstanding Arizona Waters (OAW), a designation which affords such waters a Tier 3 level of antidegradation protection, meaning no degradation of current water quality can be tolerated. As stated in

Table 2-4: Salt Watershed Major Lakes and Reservoirs.

Lake Name (if known)	Subwatershed	Surface Area (acre)	Elevation (feet above mean sea level)	Dam Name (if known)
Apache Lake	Lower Salt River	2,191	1,916	Horse Mesa Dam
Canyon Lake	Lower Salt River	448	1,660	Mormon Flat Dam
Saguaro Lake	Lower Salt River	1,022	1,505	Stewart Mountain Dam
Theodore Roosevelt Lake	Lower Salt River, Tonto Creek, Upper Salt River	18,594	2,093	Theodore Roosevelt Dam

Table 2-5.1: Salt Watershed Major Streams and Lengths.

Stream Name	Subwatershed	Stream Length (miles)
Unnamed Stream	Black River	5
Amos Wash	White River	16
Bear Wash	White River	15
Beaver Creek	Black River	13
Big Bonito Creek	Black River	41
Black River	Black River	122
Canyon Creek	Upper Salt River	52
Carrizo Creek	Carrizo Creek	63
Cedar Creek	Carrizo Creek	14
Cherry Creek	Upper Salt River	61
Cibecue Creek	Upper Salt River	47
Corduroy Creek	Carrizo Creek	37
Corn Creek	Black River	9
Cottonwood Creek	Lower Salt River	16
Cottonwood Wash	White River	5
Crooked Creek	Black River	8
Deer Springs Canyon	Carrizo Creek	11
Diamond Creek	White River	21
East Cedar Creek	Carrizo Creek	19

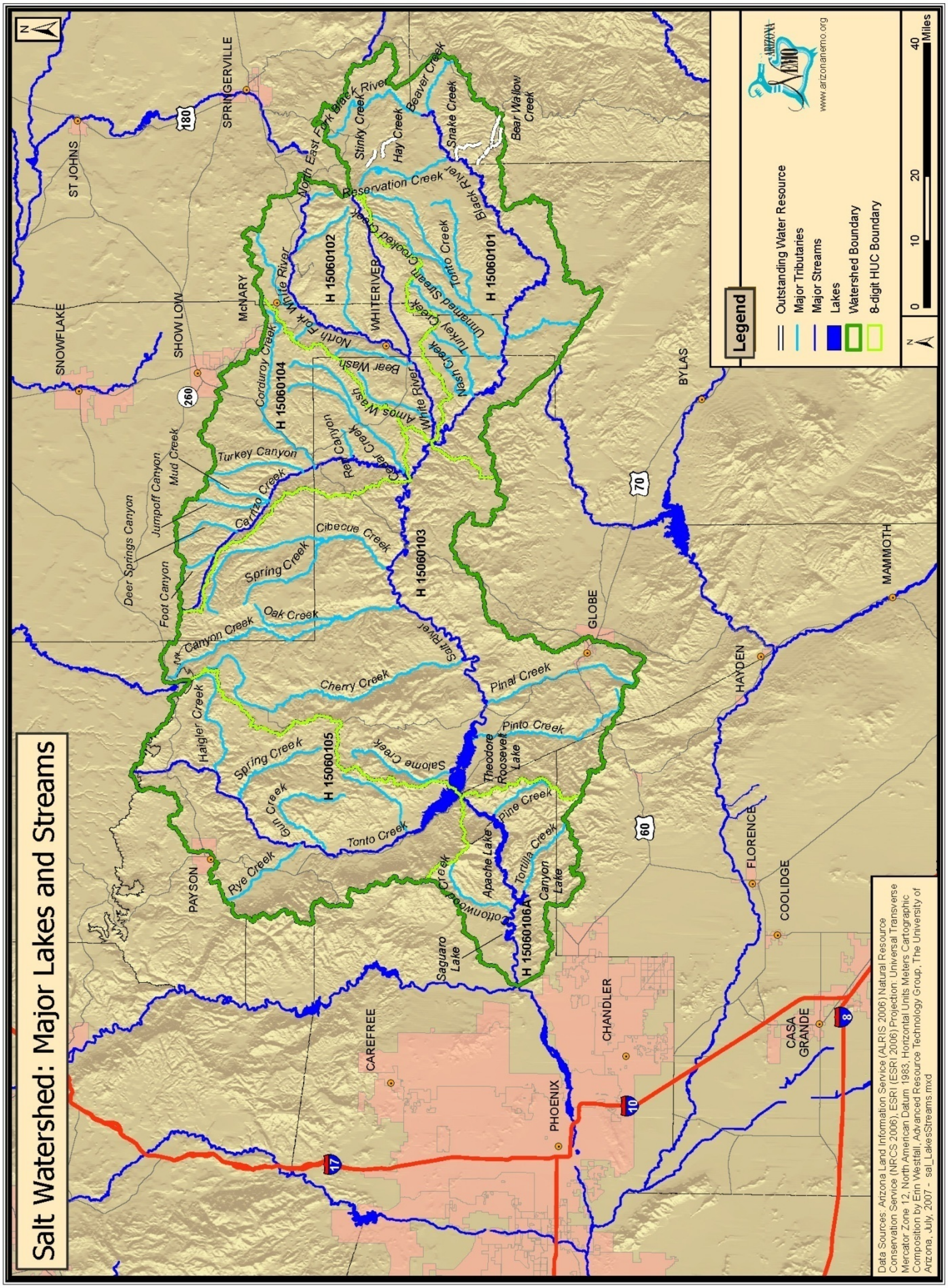

Figure 2-5: Major Lakes and Streams

Stream Name	Subwatershed	Stream Length (miles)
East Fork Black River	Black River	5
East Fork White River	White River	31
Foot Canyon	Carrizo Creek	6
Gooseberry Creek	White River	17
Greenback Creek	Tonto Creek	16
Gun Creek	Tonto Creek	26
Haigler Creek	Tonto Creek	23
Indian Creek	Black River	17
Jumpoff Canyon	Carrizo Creek	12
Little Bonito Creek	Black River	10
Middle Cedar Creek	Carrizo Creek	14
Mud Creek	Carrizo Creek	12
Nash Creek	Black River	17
North East Fork Black River	Black River	23
North Fork White River	White River	51
Oak Creek	Upper Salt River	16
Paradise Creek	White River	12
Pinal Creek	Upper Salt River	14
Pine Creek	Lower Salt River	12
Pinto Creek	Upper Salt River	36
Red Canyon	Carrizo Creek	5
Reservation Creek	Black River	23
Russell Gulch	Upper Salt River	12
Rye Creek	Tonto Creek	18
Salome Creek	Upper Salt River	21
Salt River	Upper Salt River, Lower Salt River	239
Sawmill Creek	Black River	16
Spring Creek	Upper Salt River, Tonto Creek	42
Tonto Creek	Black River, Tonto Creek	122
Tortilla Creek	Lower Salt River	16
Turkey Canyon	Carrizo Creek	16
Turkey Creek	Black River	25
White River	White River	18

Antidegredation Implementation Procedures (ADEQ 2007), a body of water is eligible to be considered for OAW classification if the following criteria are met:

- The surface water is a perennial water and is in a free-flowing condition;
- The surface water has good water quality. For the purpose of this regulation, “good water quality” means that the surface water has water quality that meets or is better than applicable water quality standards; and
- The surface water meets one or both of the following conditions: (a) is of

exceptional recreational or ecological significance because of its unique attributes; (b) threatened or endangered species are known to be associated with the surface water and maintenance of existing water quality is essential to maintenance or propagation of said species or the surface water provides critical habitat for a threatened or endangered species.

Site-specific water quality standards may be implemented to maintain and protect existing water quality conditions for an OAW. ADEQ may consider the following factors when evaluating waters nominated for OAW classification:

- Whether there is the ability to manage the OAW and its watershed to maintain and protect existing water quality;

- The social and economic impact of Tier 3 antidegradation protection;

- Public comments in support of or opposition to the OAW classification;

- The timing of the OAW nomination relative to the triennial review of surface water quality standards;

- The consistency of an OAW classification with applicable water quality management plans; and

- Whether the nominated surface water is located within a national or state park, national monument, national recreation area, wilderness area, riparian conservation area, area of critical environmental concern, or has another special use designation (for example, Wild and Scenic River designation).

ADEQ currently recognizes 20 reaches of various water bodies throughout the state as Outstanding Arizona Waters, and is reviewing two additional streams for possible OAW classification. Within the Salt Watershed, portions of six rivers are currently protected as Outstanding Arizona Waters (Figure 2-5). As Table 2-5.2 shows, these OAW include 4 miles of Bear Wallow Creek (from its headwaters to the San Carlos Indian Reservation), 4 miles of both the North and South Forks of Bear Wallow Creek (from their headwaters to where they join Bear Wallow Creek), 5 miles of Hay Creek (from its headwaters to the West Fork of Black Creek), 6 miles of Snake Creek (from its headwaters to Black River), and 3 miles of Stinky Creek (from White Mountain Apache Indian Reservation to the West Fork of Black River) (ADEQ 2007).

Stream Types

There are three different stream types: perennial, intermittent and ephemeral.

- Perennial streams have surface water that flows continuously throughout the year.

- Intermittent streams are streams or reaches that flow continuously only at certain times of the year when it receives water from a seasonal spring or from another source, such as melting spring snow.

- Ephemeral streams are above the elevation of the ground water table at all times, have no base flow, and flow only in direct response to precipitation.

Most streams in desert regions are intermittent or ephemeral. Some channels are dry for years at a time, but are subject to flash flooding during high-intensity storms (Gordon et al., 1992).

Approximately 60% (922 miles) of the major streams in the Salt Watershed are intermittent. Figure 2-5.2 and Table 2-6.1 show the percent perennial and intermittent streams in the Salt Watershed. Only 40% (603 miles) of streams are perennial. No ephemeral streams are listed for the Salt Watershed.

Table 2-5.2: Salt River Watershed Outstanding Water Resources.

Stream Name	**Subwatershed**	**Stream Length (miles)**
Bear Wallow Creek	Upper Black River	4
Bear Wallow Creek South Fork	Upper Black River	4
Hay Creek	Upper Black River	5
North Fork Bear Wallow Creek	Upper Black River	5
Snake Creek	Upper Black River	6
Stinky Creek	Upper Black River	3

Table 2-6.1: Salt Watershed
Stream Types and Length for Major Streams.

Stream Type	**Stream Length (miles)**	**Percent of Total Stream Length**
Perennial	603	40%
Intermittent	922	60%
Total Length	1525	100%

Instream Flow

Instream flow is the maintenance flow necessary to preserve instream values such as aquatic and riparian habitats, fish and wildlife and riparian-based recreation related to a particular stream or stream segment(s) (ADWR 1997).

Three rivers in the Salt Watershed have certified in stream flow rights: Christopher Creek, Pinto Creek, and Reynolds Creek. Seven other creeks have applications pending (Table 2-6.2). Figure 2-7 identifies the instream status of streams, outfall locations of effluent flow, and locations of dams in the Salt Watershed.

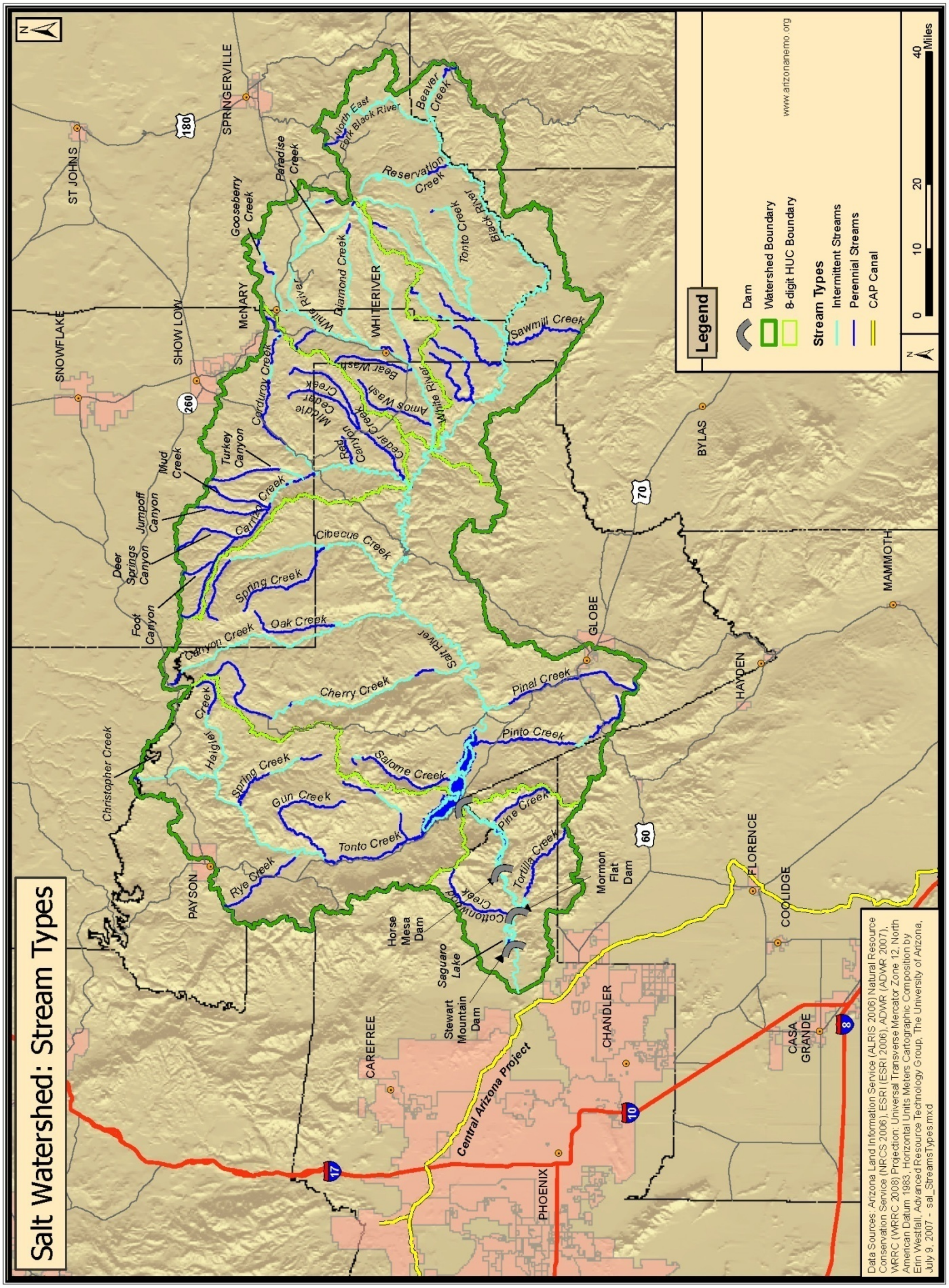

Figure 2-6: Stream Types

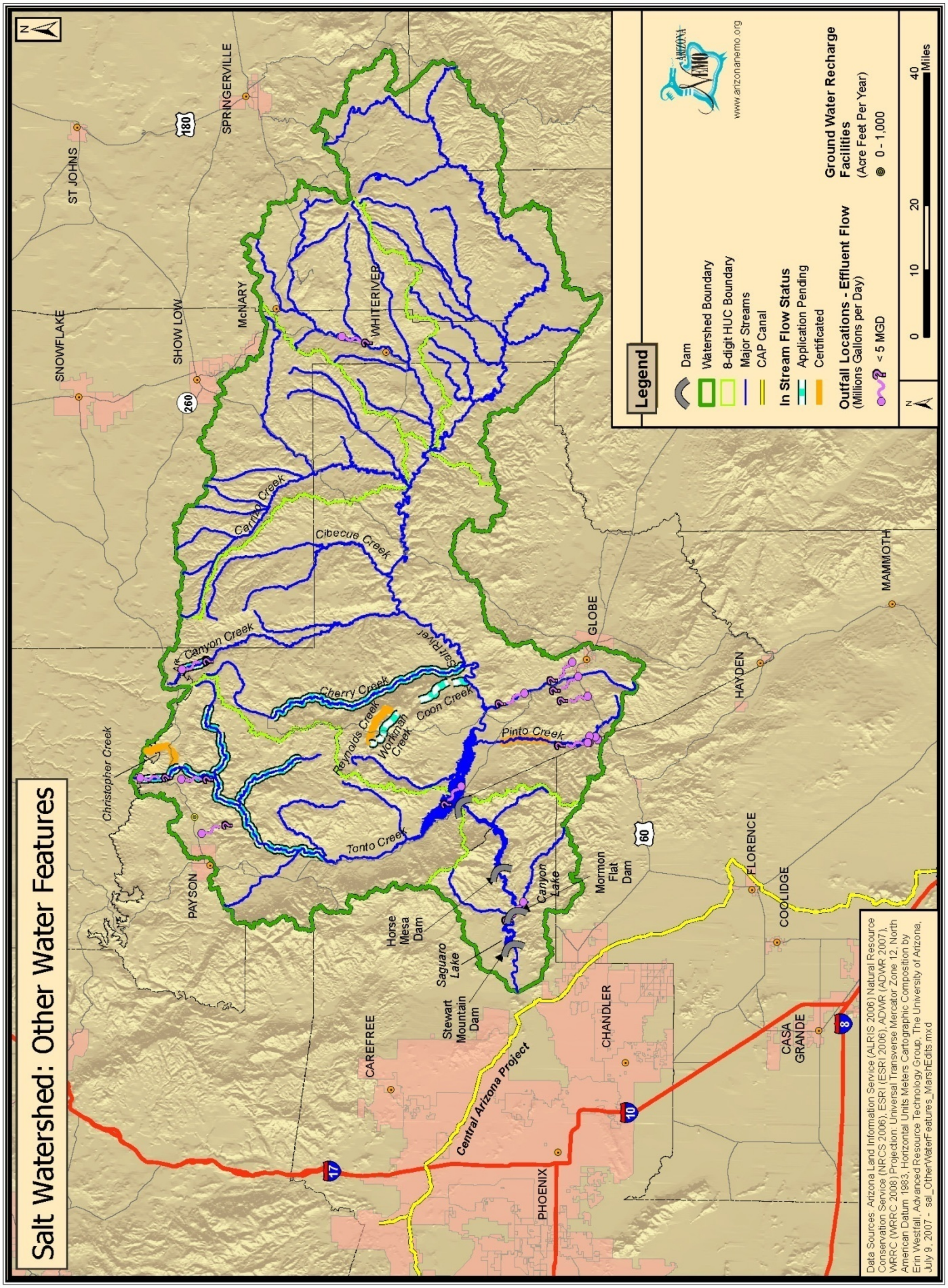

Figure 2-7: Other Water Features

Table 2-6.2: Salt Watershed In Stream Flow Status and Length.

Stream Name	In Stream Flow Status	Permit Holder(s)	In Stream Flow Length (miles)
Canyon Creek	Application Pending	Tonto National Forest	5.1
Cherry Creek	Application Pending	Tonto National Forest	40.9
Christopher Creek	Certificated	Tonto National Forest	5.7
Coon Creek	Application Pending	Tonto National Forest	7.5
Haigler Creek	Application Pending	Tonto National Forest	14.4
Pinto Creek	Certificated	Tonto National Forest	9.2
Reynolds Creek	Certificated	Tonto National Forest	6.9
Spring Creek	Application Pending	Tonto National Forest	16.7
Tonto Creek	Application Pending	Tonto National Forest	39.6
Workman Creek	Application Pending	Tonto National Forest	5.2

Stream Density

The density of channels in the landscape is a measure of the dissection of the terrain. The stream density is defined as the length of all channels in the watershed divided by the watershed area. Areas with high stream density are associated with high flood peaks and high sediment production, due to increased efficiency in the routing of water from the watershed. Since the ability to detect and map streams is a function of scale, stream densities should only be compared at equivalent scales (Dunne and Leopold, 1978).

Figure 2-8 shows stream network for the Salt Watershed, and Table 2-7 gives the stream density for each subwatershed in feet of stream length per acre (for all streams in the watershed). The average stream density for the Salt Watershed is 12.1 feet/acre. The Lower Salt River subwatershed has the highest drainage density at 15.0 feet/acre. The Carrizo Creek subwatershed has the lowest drainage density at 11.1 feet/acre.

Annual Stream Flow

Annual stream flows for fourteen gages were obtained for the Salt Watershed. These gages were selected based on their location, length of date record, and representativeness of watershed response. Figure 2-9 shows the locations of these gages. The gage at the Salt River below Stewart Mountain Dam had the highest measured annual mean stream flow with 981 cubic feet per second (cfs) (1941 to 2006) (Table 2-8). The Salt River near the town of Roosevelt had the next greatest annual

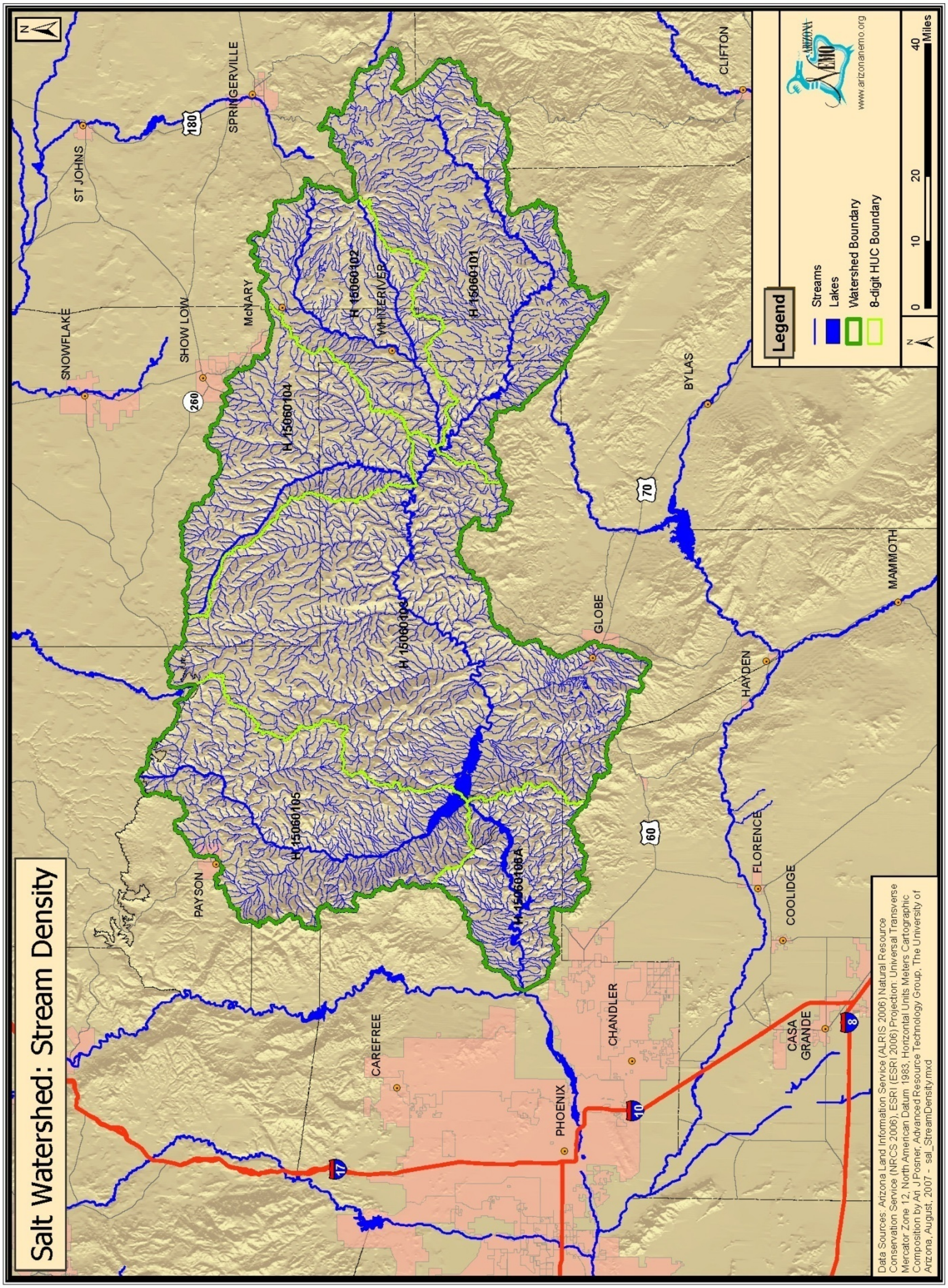

Figure 2-8: Stream Density

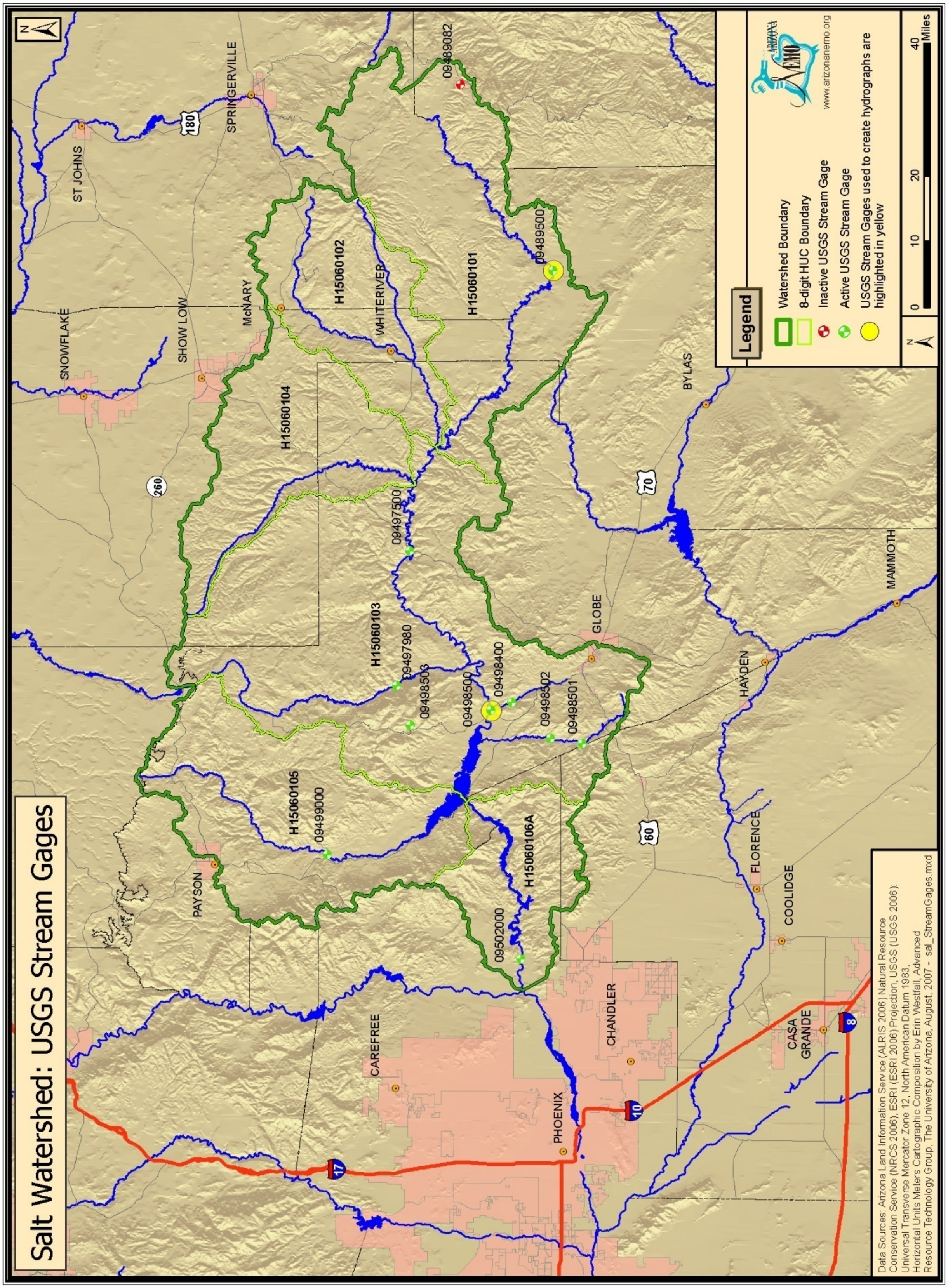

Figure 2-9: USGS Stream Gages

mean stream flow with 882 cfs, for the period from1914 through 2006.

Figures 2-10 through 2-15 show hydrographs for three selected U.S. Geological Survey stream gages for mean daily flow and for a five-year moving average mean annual flow. These graphs show the variability in streamflow over time and space in this watershed.

For example, Figure 2-10 shows that at the Black River near Point of Pines USGS Gage there were series of years where there was little or no flow, but the five year moving average (Figure 2-11) shows an increasing trend in stream flow until about 1993 followed by a downturn in flow. This gage is located west of Phoenix, near the confluence with the Gila River.

Figure 2-14 shows that the 5-year moving average stream flow at the Salt River near Roosevelt USGS Gauge has the same flat trend line as the Black River for the periods 1956-2004. This gage is located just east of Phoenix.

Table 2-7: Salt Watershed Stream Density, All Streams.

Subwatershed Name	**Area (acres)**	**Stream Length (feet)**	**Stream Density (feet / acre)**
Black River H15060101	800,579	9,816,996	12.3
White River H15060102	408,265	4,685,832	11.5
Upper Salt River H15060103	1,377,570	15,985,445	11.6
Carrizo Creek H15060104	454,075	5,020,633	11.1
Tonto Creek H15060105	670,569	8,457,571	12.6
Lower Salt River H15060106A	284,708	4,263,577	15.0
Salt Watershed	*3,995,770*	*48,230,054*	*12.1*

Table 2-8: Salt Watershed USGS Stream Gages and Annual Mean Stream Flow.

USGS Gage ID	Site Name	Begin Date	End Date	Annual Mean Stream Flow (cfs)
09489500	BLACK RIVER BLW PUMPING PLANT, NR POINT OF PINES	1954	2006	205
09497980	CHERRY CREEK NEAR GLOBE, AZ	1966	2006	33
09512162	INDIAN BEND WASH AT CURRY ROAD, TEMPE, AZ	1993	2006	4
09489082	NORTH FORK THOMAS CREEK NEAR ALPINE, AZ	1986	1991	0.12
09498400	PINAL CREEK AT INSPIRATION DAM, NR GLOBE, AZ	1981	2006	12
09498501	PINTO CREEK BLW HAUNTED CANYON NR MIAMI, AZ	1996	2006	4
09498502	PINTO CREEK NEAR MIAMI, AZ	1995	2006	11
09512406	SALT RIVER AT 51ST AVENUE, PHOENIX, AZ	2003	2006	295
09512165	SALT RIVER AT PRIEST DRIVE NEAR PHOENIX, AZ	1996	2006	202
09502000	SALT RIVER BLW STEWART MOUNTAIN DAM, AZ	1941	2006	981
09497500	SALT RIVER NEAR CHRYSOTILE, AZ	1925	2006	650
09498500	SALT RIVER NEAR ROOSEVELT, AZ	1914	2006	882
09498503	SOUTH FORK PARKER CREEK NEAR ROOSEVELT, AZ	1987	2006	0.4
09499000	TONTO CREEK ABV GUN CREEK, NEAR ROOSEVELT, AZ	1942	2006	152

* Discontinuous years of data

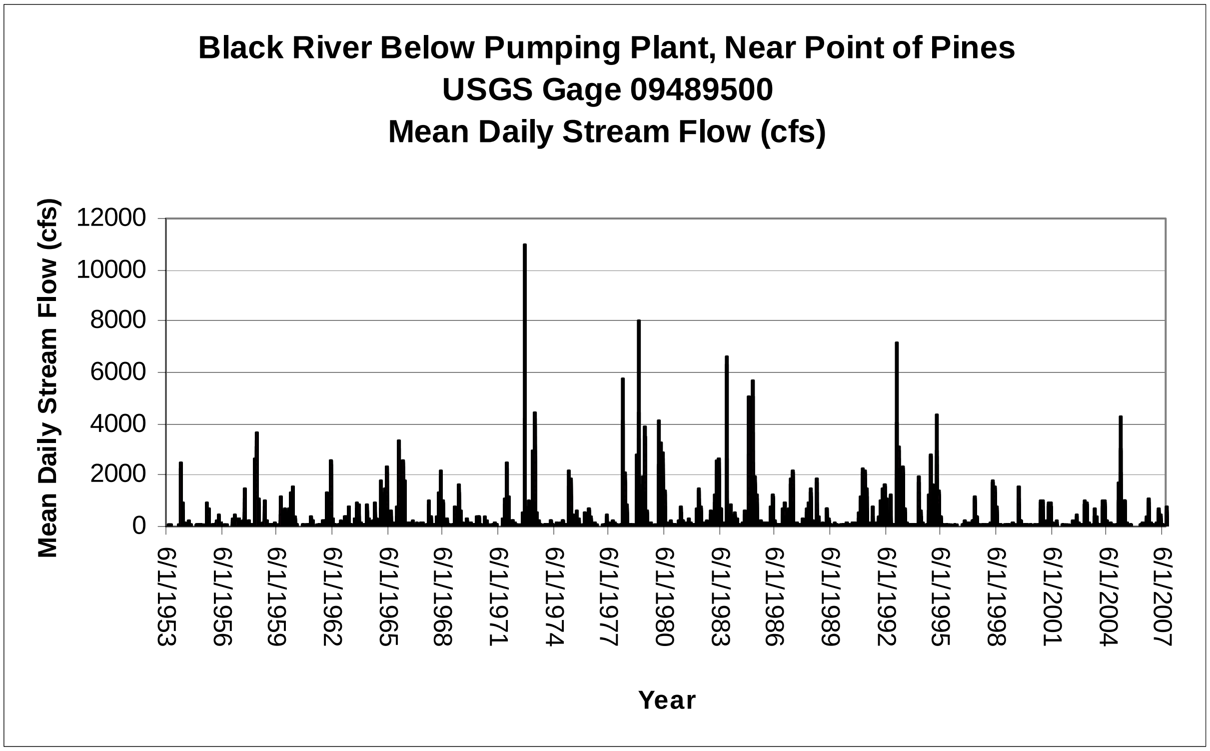

Figure 2-10: Black River Below Pumping Plant, Near Point of Pines USGS Gage 09489500, Mean Daily Stream Flow (cfs) Hydrograph.

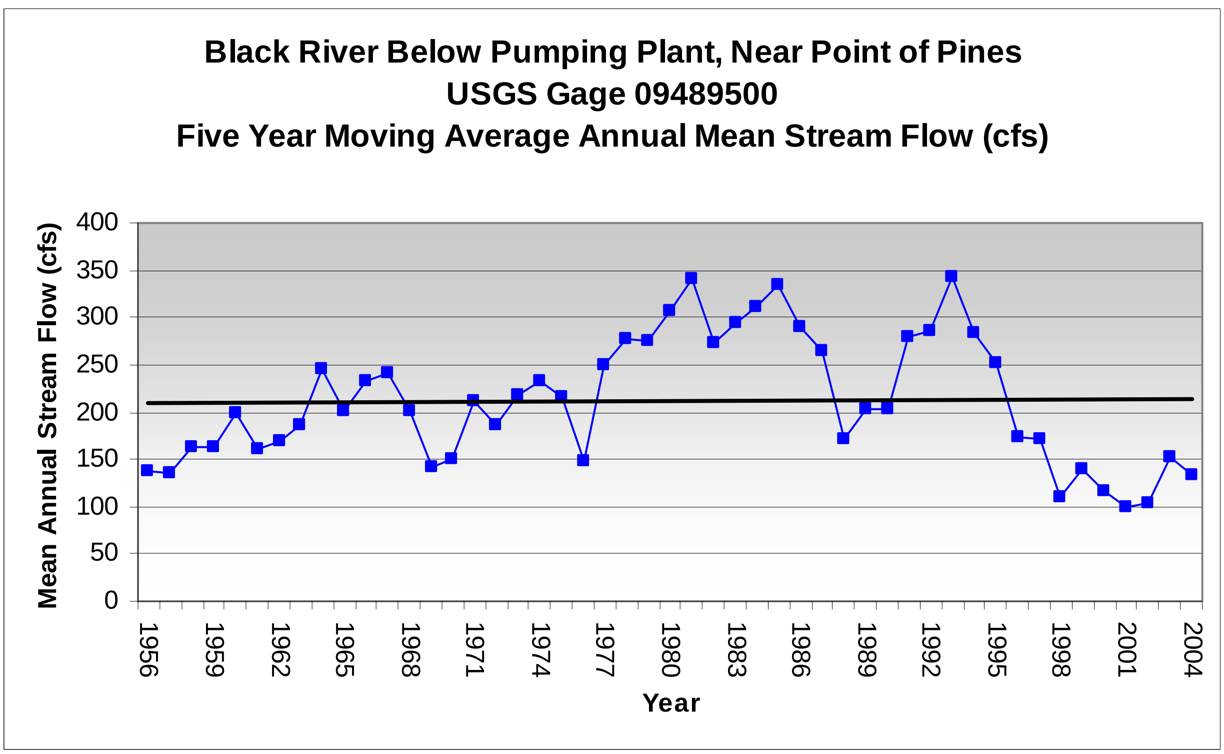

Figure 2-11: Black River Below Pumping Plant, Near Point of Pines USGS Gage 09489500, Five Year Moving Average Annual Stream Flow (cfs) Hydrograph.

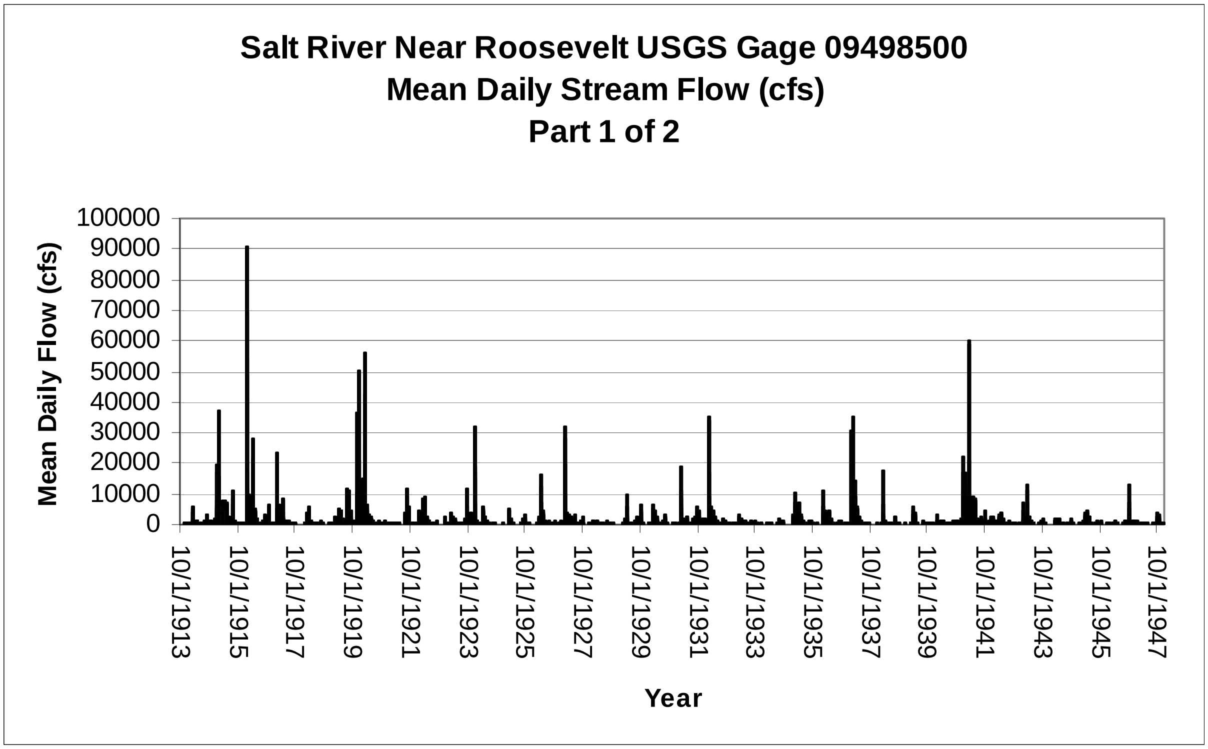

Figure 2-12: Salt Near Roosevelt USGS Gage 09498500, Mean Daily Stream Flow (cfs) Hydrograph (Part 1 of 2).

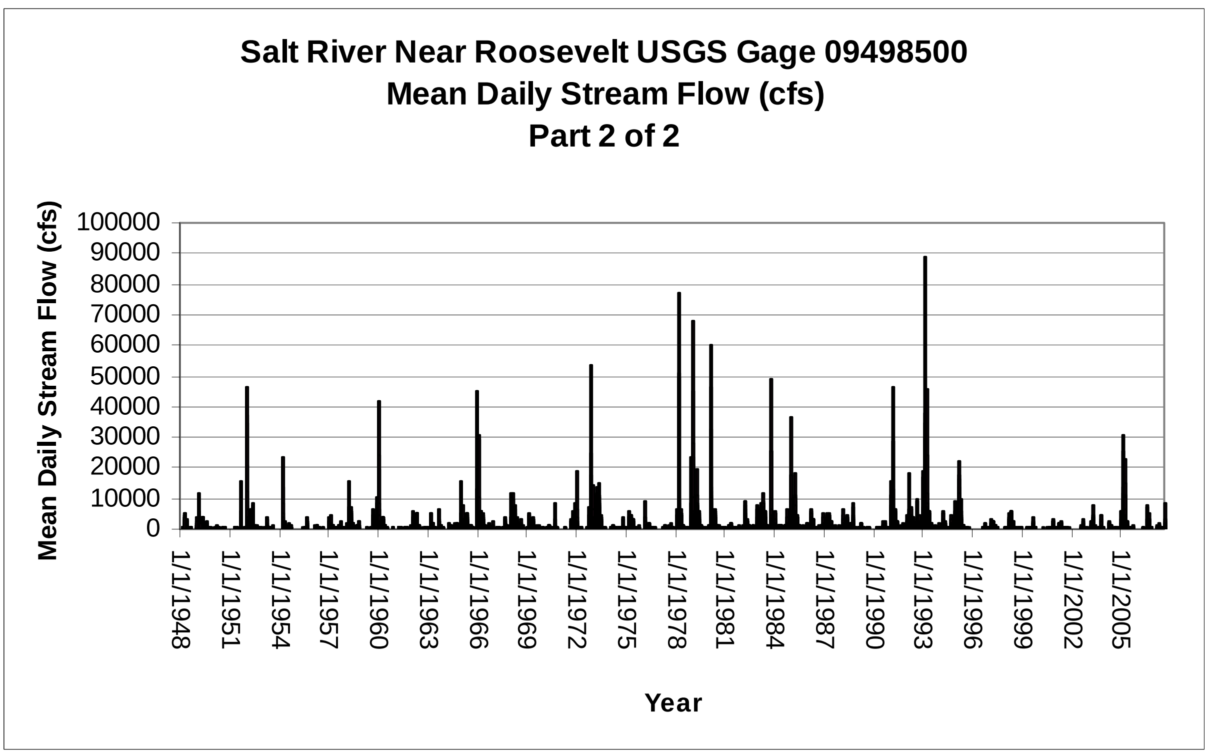

Figure 2-13: Salt Near Roosevelt USGS Gage 09498500, Mean Daily Stream Flow (cfs) Hydrograph (Part 2 of 2).

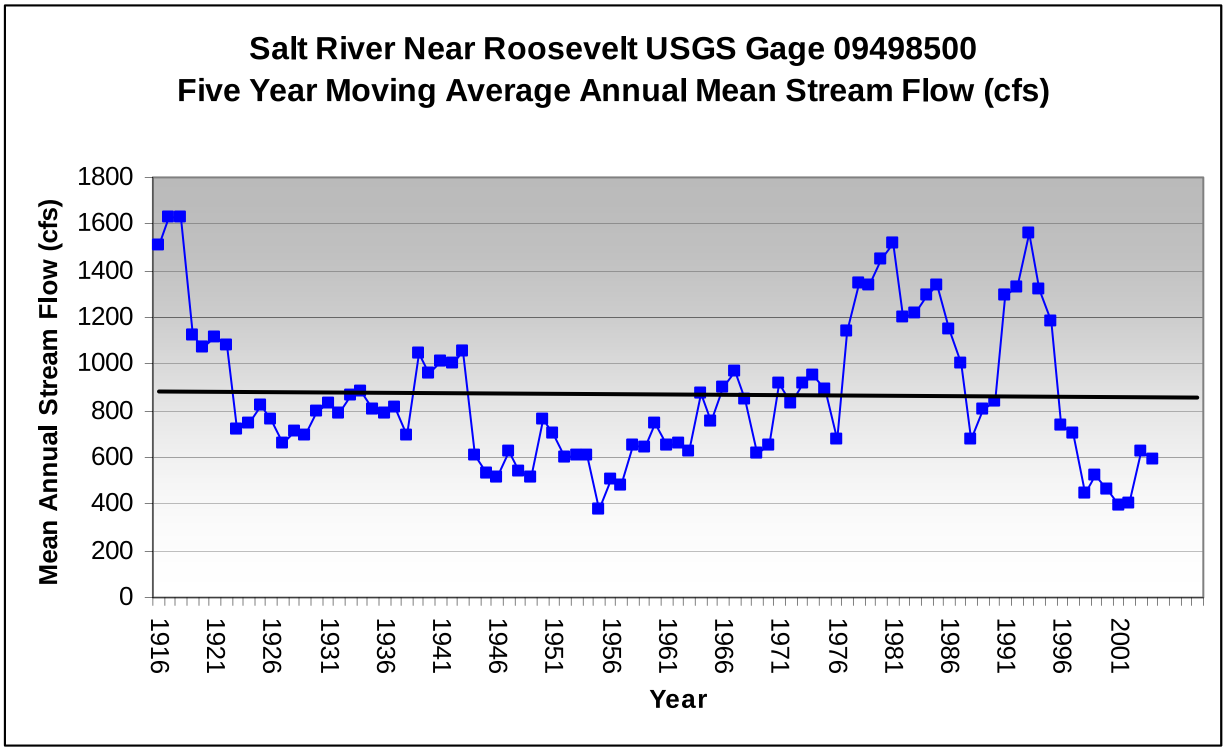

Figure 2-14: Salt Near Roosevelt USGS Gage 09498500, Five Year Moving Average Annual Stream Flow (cfs) Hydrograph.

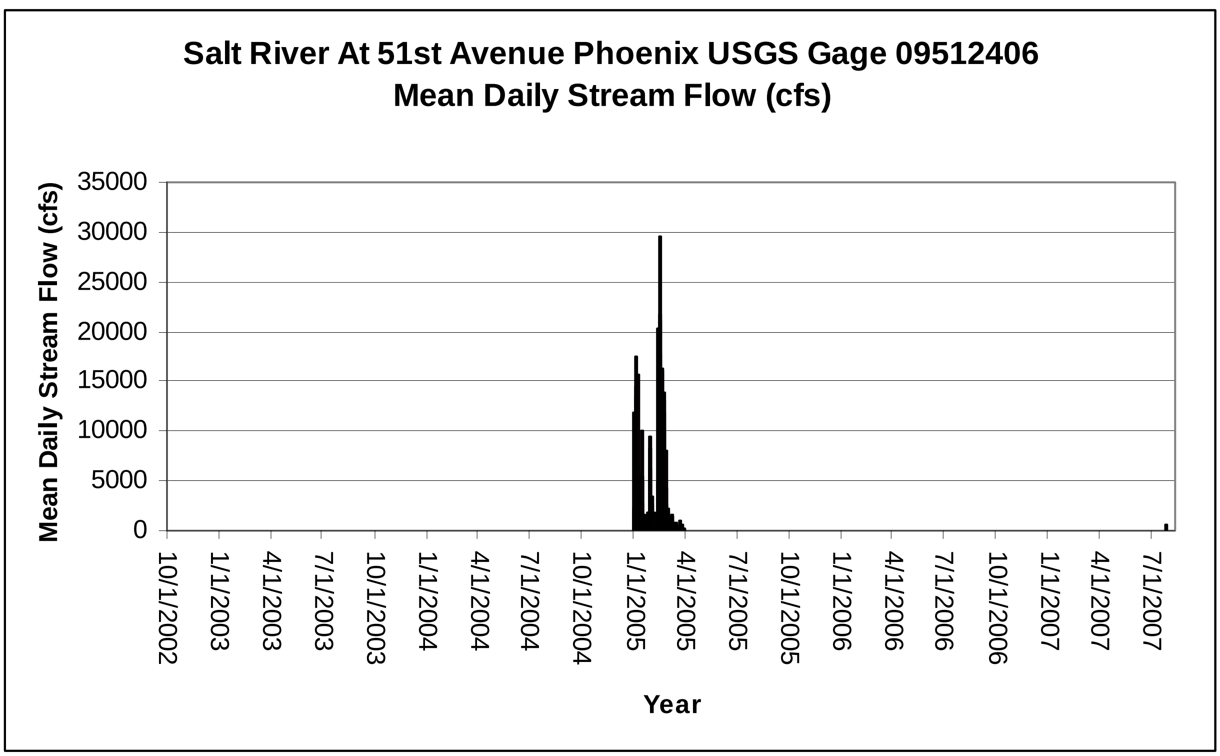

Figure 2-15: Salt River At 51st Avenue Phoenix USGS Gage 09512406, Mean Daily Stream Flows (cfs). *Several records in this data set have a value of zero.

Water Quality

The Arizona Department of Environmental Quality (ADEQ) assesses surface water quality to identify which surface waters are impaired or attaining designed uses and to prioritize future monitoring (ADEQ, 2006). Impaired waters, as defined by Section 303(d) of the federal Clean Water Act, are those waters that are not meeting the state's water quality standards for designated uses. Attaining waters meet state water quality standards for designated uses. Strategies are implemented on impaired waters to reduce pollutant loadings so that surface water quality standards will be met, unless impairment is *solely* due to natural conditions.

Once a surface water stream or lake has been identified as impaired, activities in the watershed that might contribute further loadings of the pollutant are not allowed (ADEQ, 2006). Agencies and individuals planning future projects in the watershed must ensure that activities will not further degrade these impaired waters and are encouraged through grants to implement strategies to reduce loading. One of the first steps is the development of a Total Maximum Daily Load (TMDL) analysis to empirically determine the load reduction needed to meet ADEQ standards.
The Salt Watershed has eleven stream reaches assessed as impaired in Arizona's 303(d) List of Impaired Waters (ADEQ, 2006) (Figure 2-16):

- Canyon Lake is impaired by low dissolved oxygen
- Apache Lake is impaired by low dissolved oxygen
- Christopher Creek from headwaters to Tonto Creek is impaired by phosphorus
- Five Point Tributary from headwaters to Pinto Creek is impaired by copper
- Pinto Creek from West Fork Pinto Creek to Roosevelt Lake is impaired by copper and selenium
- Salt River from Pinal Creek to Roosevelt Lake is impaired by suspended sediment
- Salt River from Stewart Mountain Dam to Verde River is impaired by low dissolved oxygen
- Tonto Creek from headwaters to unnamed tributary is impaired by phosphorus

An explanation of the 303(d) listing process is found in Section 1, Introduction, and a tabulation of the water quality attributes can be found in Section 6, Watershed Assessment. The constituents analyzed for each stream and lake are listed in Appendix A, Table 1.

Geology

The following is from the ADWR Webpage (http://www.adwr.state.az.us/dwr/Content/Find_by_Category/ABCs_of_Water/Rural_AZ/CentralHighlands/saltriver.pdf)

Salt River Lakes Sub-Basin

The Salt River Lakes sub-basin contains mostly igneous granitic, metamorphic, and sedimentary rocks. Unconsolidated sediments are basin-fill materials that accumulated in the larger valleys in the

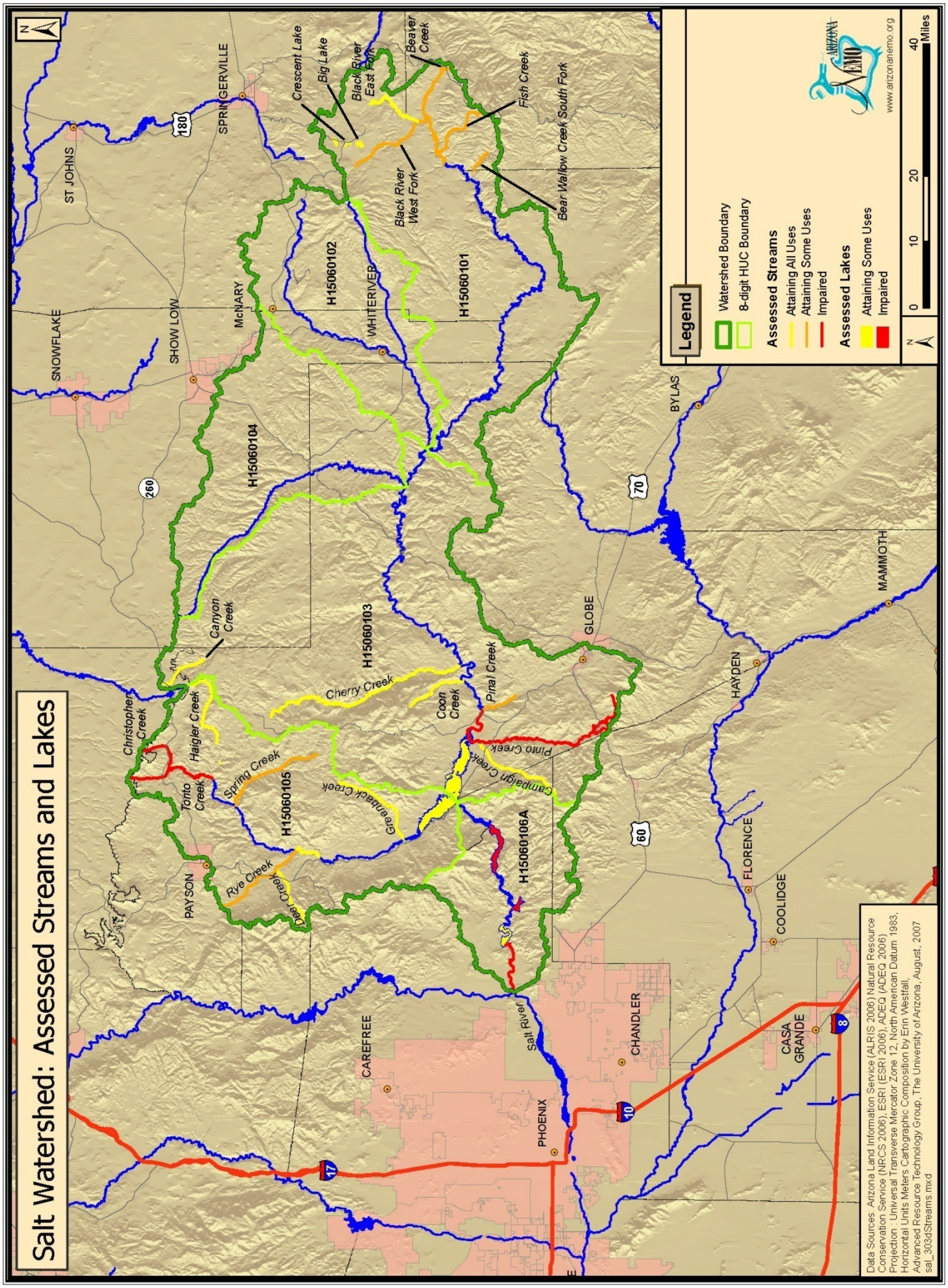

Figure 2-16: Assessed Streams and Lakes

sub-basin. Ground water occurs to some extent in all of these rock units (Figure 2-17 and Table 2-9.)

Unconsolidated sands and gravel occur within the floodplains of streams and washes and are generally the most productive aquifer. Semi-consolidated to consolidated basin-fill sediments known as the Gila Conglomerate occur in the Globe-Miami area where they form a local aquifer in the tectonic graben of Pinal Creek. In this area, the Gila Conglomerate is up to 4,000 feet thick, and provides the bulk of both domestic and industrial water supplies. The City of Globe operates several public-supply wells in the adjacent San Carlos Valley sub-basin of Safford basin. A limestone aquifer also provides public supply and industrial water in the Globe-Miami area. Where fractured and faulted, the limestone aquifer can produce large amounts of good quality water. The igneous granitic rocks provide only minor amounts of water because of their very low primary permeability. Most of this water is derived from fractured, fissured, and faulted or decomposed sequences. Other than the industrial and public supply wells in the Globe-Miami areas, most water production is from low-demand domestic and stock wells. There also are numerous springs and seeps that flow in direct response to precipitation.

Acidic water that drains from areas disturbed by mining activities has created a contaminant plume in the alluvial aquifer along Pinal Creek and Miami Wash. This alluvial aquifer exhibits elevated levels of heavy metals such as aluminum, barium, copper, manganese, and iron. High sulfate levels are also present and precede the front of elevated metal concentrations in groundwater.

Salt River Canyon Sub-Basin

The western section of the Salt River Canyon sub-basin is composed of sedimentary and igneous granitic rocks similar to those in the Salt River Lakes sub-basin. The rest of the sub-basin consists primarily of consolidated sedimentary rocks. These rocks include flat-lying limestones, sandstones, siltstones, shales, and thin conglomerates.

The sedimentary rocks are cut by the Salt River Canyon which is the major drainage feature of the sub-basin. Because of a lack of well data not much is known about potential aquifers in this area. Springs in the area may produce up to 900 gallons per minute. Rock units that may produce useable quantities of water in the sub-basin include the Supai Formation, Redwall Limestone, Coconino Sandstone, and the undivided sandstones. These units are producing aquifers in the Plateau uplands province, and potentially could provide useable quantities of water within the sub-basin. Near the Salt River Canyon all upper rock units are dewatered; lower units discharge groundwater to the Salt River thereby supporting base flow of the river.

White River Sub-Basin

The southwestern part of the White River sub-basin contains the same consolidated sedimentary rocks as the

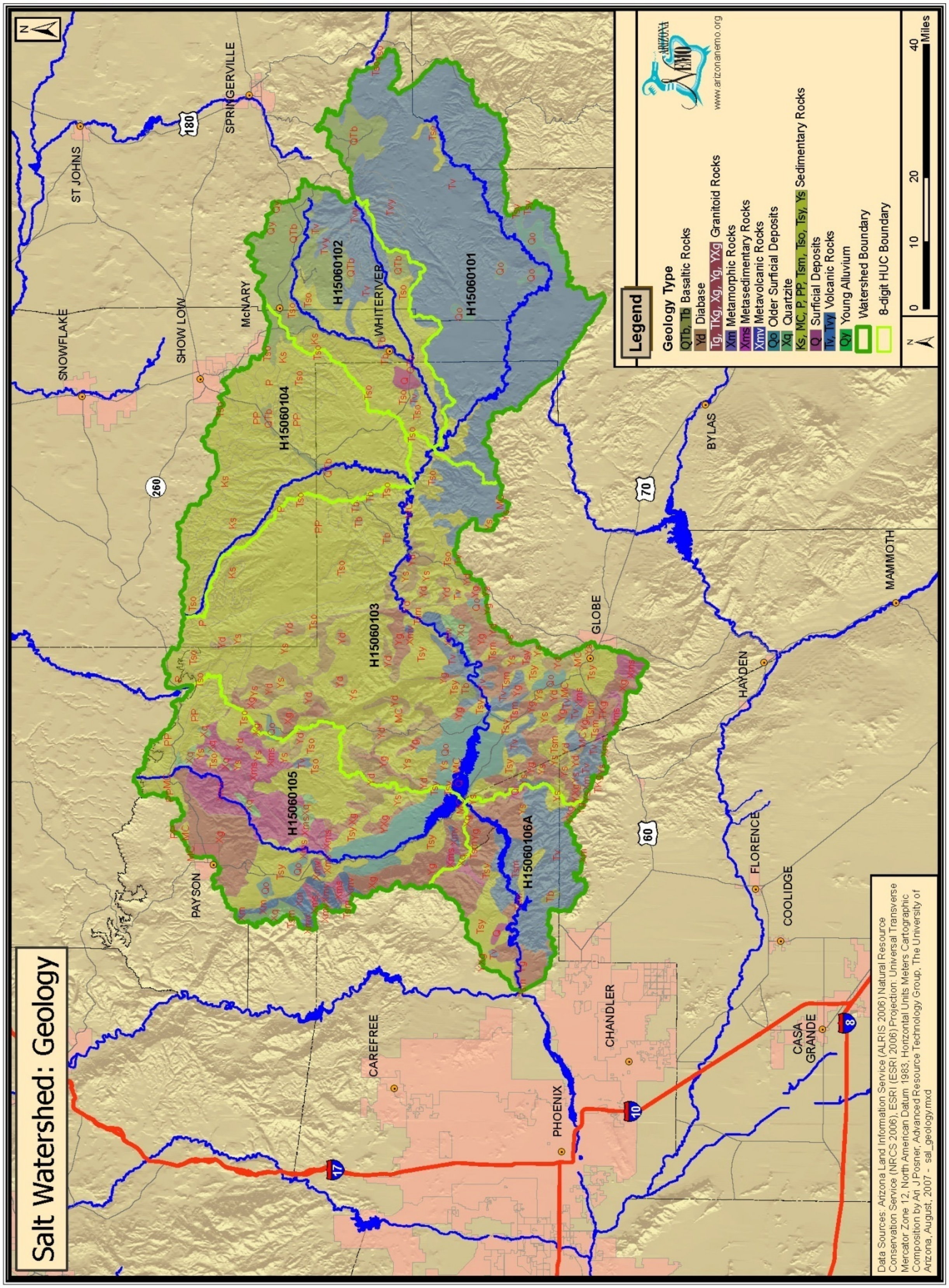

Figure 2-17: Geology

Salt River Canyon sub-basin. However, the eastern part of the sub-basin is covered with volcanics. The volcanics consist of basaltic lava flows, cinder beds, and tuffaceous agglomerates.

Groundwater occurs in the various volcanic flows in cinder beds, weathered zones, and fracture zones. Water is produced from seeps, springs, and shallow, low-yield wells. In the Pinetop-Lakeside-Show Low area, similar basalts form part of an aquifer locally known as the Pinetop-Lakeside aquifer where production rates may exceed 300 gallons per minute.

Black River Sub-Basin

The Black River sub-basin is almost entirely covered by volcanics. Basalt flows, rhyolitic ash flows, tuffs, and tuffaceous agglomerates form layers in excess of 3,000 feet thick in places. Water is available from low-yield wells, springs, and seeps.

The few wells completed in these basalts are widely scattered and used for stock and domestic consumption. Well depths of 400 to 800 feet deep are common; cinder beds, fracture zones, and weathered zones provide the best well yields. Wells in the Natanes Plateau show no water-level declines, therefore, groundwater on the plateau may be at or near steady-state conditions.

Alluvial Geology

Most older surficial deposits in the Salt Watershed are located in the western part of the watershed. Younger alluvium is found in the eastern part of the watershed. See Figure 2-18 for alluvial geology types of deposits.

Groundwater Basins

There are 11 ground water basins identified by ADWR in the Salt Watershed (Figure 2-19), while USGS lists four groundwater basin in the watershed (Figure 2-20).

Rock Types

Sedimentary rocks (45.0%) and volcanic rocks (31.5%) comprise the largest categories of rock types in the Salt Watershed (Table 2-10). Surficial deposits (4.4%), alluvium (0.4%), granitoid rocks (13.1%) and metamorphic rocks (5.9%) make up the remaining rock classifications.

Table 2-9: Salt Watershed Geology.

Geologic Unit	**Geologic Code**	**Black River H15060101**	**White River H15060102**	**Upper Salt River H15060103**	**Carrizo River H15060104**	**Tonto River H15060105**	**Lower Salt River H15060106A**	***Salt Watershed***
BASALTIC ROCKS (Holocene to late Pliocene: 0 to 4 Ma.)	QTb	4.6%	31.7%	-	4.0%	-	-	4.6%
BASALTIC ROCKS (late to middle Miocene; 8 to 16 Ma.)	Tb	-	0.5%	0.6%	0.1%	-	0.8%	0.3%
DIABASE (middle Proterozoic; 1100 Ma.)	Yd	-	-	10.5%	-	3.3%	-	4.2%

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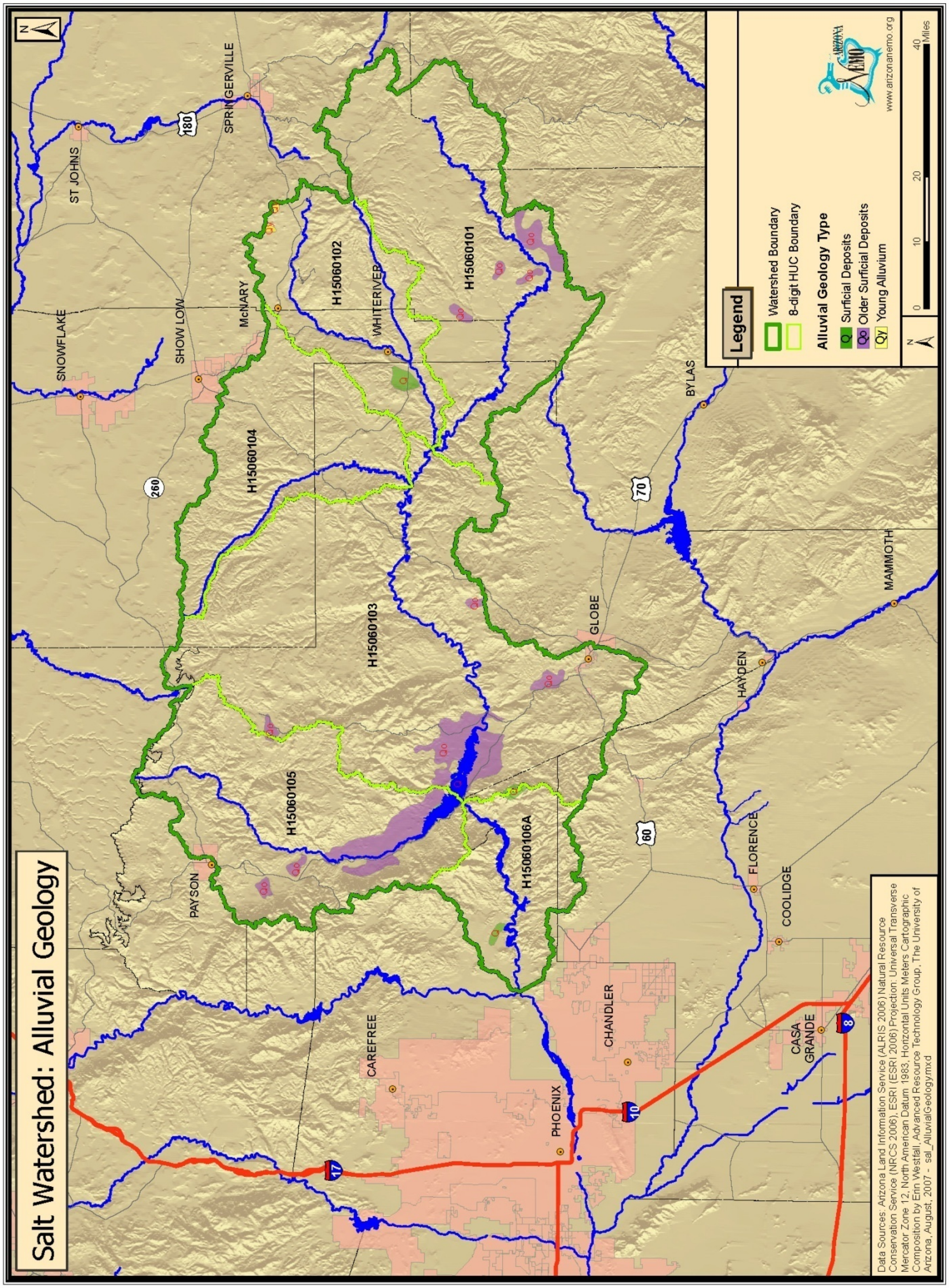

Figure 2-18: Alluvial Geology

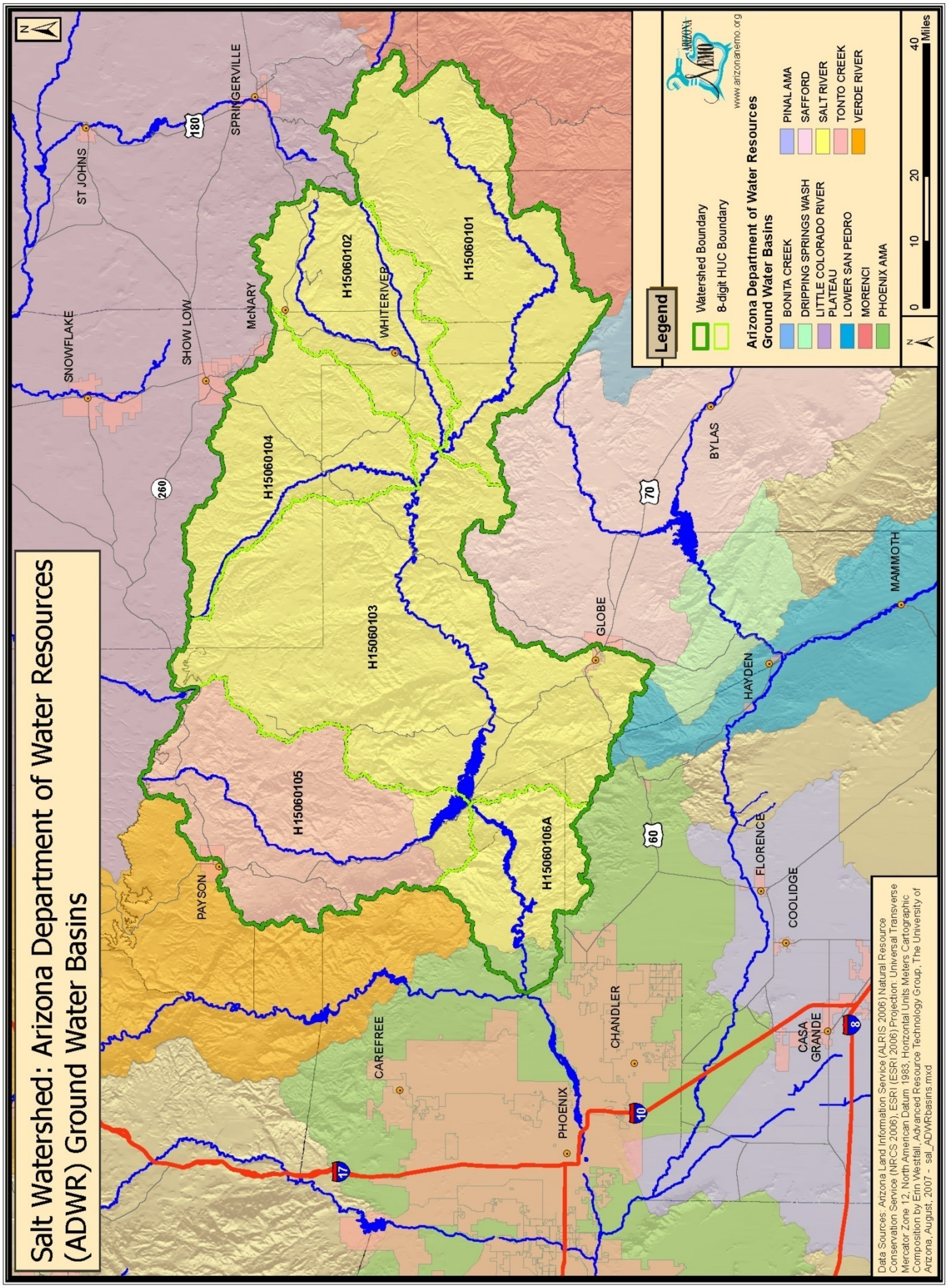

Figure 2-19: Arizona Department of Water Resources (ADWR) Ground Water Basins

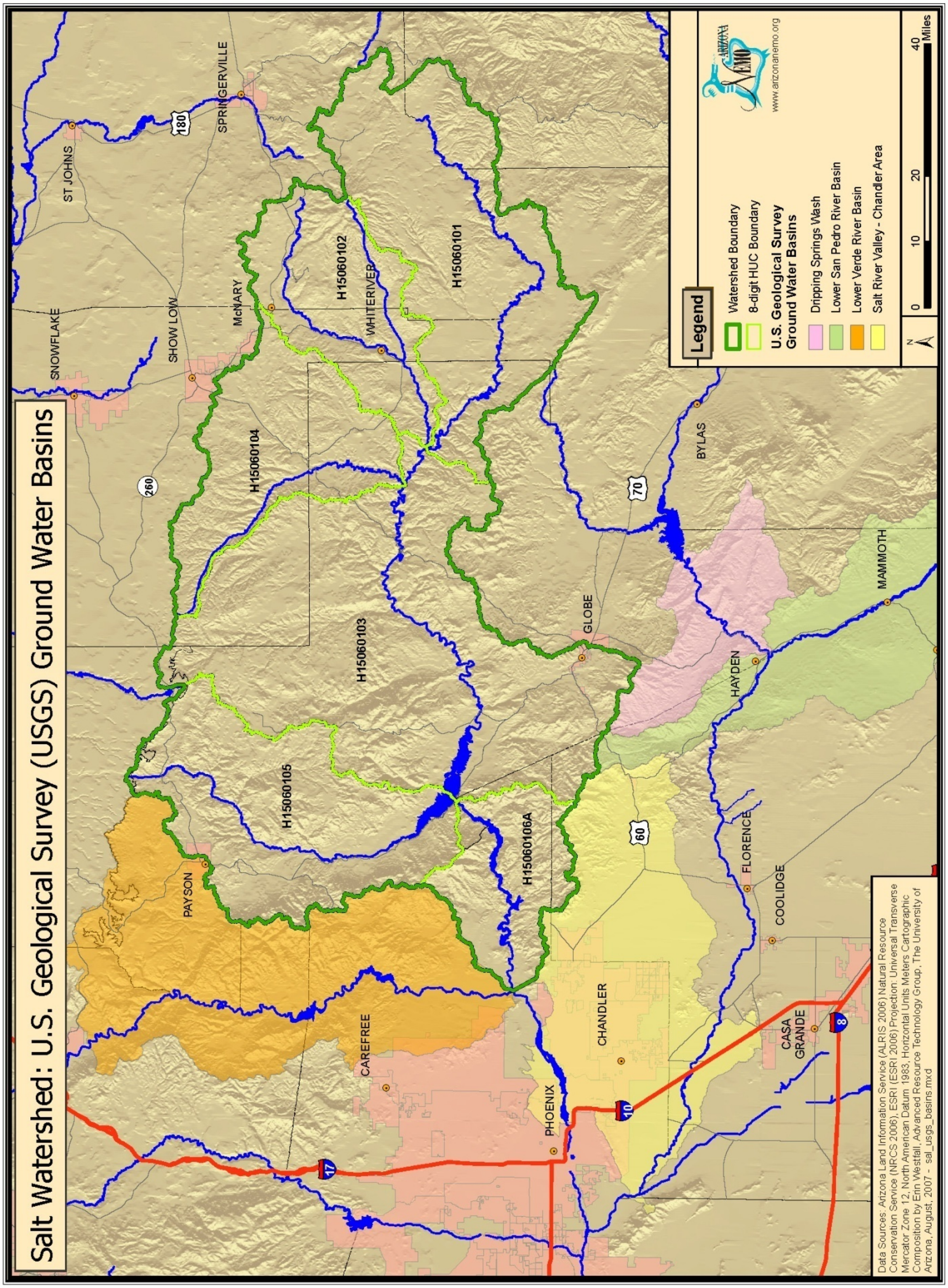

Figure 2-20: U.S. Geological Survey (USGS) Ground Water Basins

Geologic Unit	Geologic Code	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo River H15060104	Tonto River H15060105	Lower Salt River H15060106A	*Salt Watershed*
GRANITOID ROCKS (early Proterozoic; 1400 Ma. Or 1650 to 1750Ma.)	Xg	-	-	1.8%	-	13.6%	1.3%	3.1%
GRANITOID ROCKS (early Tertiary to late Cretaceous; 55 to 85 Ma.)	TKg	-	-	0.8%	-	-	-	0.3%
GRANITOID ROCKS (middle or early Proterozoic; 1400 Ma.)	YXg	-	-	0.1%	-	1.0%	0.6%	0.3%
GRANITOID ROCKS (middle Proterozoic; 1400 Ma.)	Yg	-	-	7.6%	-	3.8%	30.0%	5.4%
METAMORPHIC ROCKS (early Proterozoic; 1650 to 1800 Ma.)	Xm	-	-	0.1%	-	1.7%	> 0.0%	0.3%
METASEDIMENTARY ROCKS (early Proterozoic; 1650 to 1800 Ma.)	Xms	-	-	1.4%	-	19.7%	1.3%	3.9%
METAVOLCANIC ROCKS (early Proterozoic; 1650 to 1800 Ma.)	Xmv	-	-	0.8%	-	2.8%	-	0.8%
OLDER SURFICIAL DEPOSITS (middle Pleistocene to latest Pliocene)	Qo	3.2%	-	4.8%	-	8.7%	-	3.8%
QUARTZITE (early Proterozoic; 1700 Ma.)	Xq	-	-	0.7%	-	4.0%	0.2%	0.9%
SEDIMENTARY ROCKS (Cretaceous)	Ks	-	2.3%	0.1%	20.7%	-	-	2.6%
SEDIMENTARY ROCKS (middle Miocene to Oligocene; 15 to 38 Ma.)	Tsm	-	-	1.7%	-	0.2%	3.7%	0.9%
SEDIMENTARY ROCKS (middle Proterozoic)	Ys	-	-	23.6%	-	15.3%	-	10.9%
SEDIMENTARY ROCKS (Mississippian to Cambrian)	MC	-	-	5.1%	0.4%	4.0%	0.01%	2.5%
SEDIMENTARY ROCKS (Oligocene to Eocene)	Tso	2.0%	17.7%	6.2%	10.1%	3.3%	-	6.0%
SEDIMENTARY ROCKS (Permian and Pennsylvanian)	PP	0.7%	22.6%	16.6%	41.0%	3.6%	-	13.4$
SEDIMENTARY ROCKS (Permian)	P	-	-	1.9%	23.7%	1.5%	-	3.6$
SEDIMENTARY ROCKS (Pliocene to middle Miocene)	Tsy	0.0%	-	6.0%	-	12.3%	12.0%	5.0%

Geologic Unit	Geologic Code	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo River H15060104	Tonto River H15060105	Lower Salt River H15060106A	*Salt Watershed*
SURFICIAL DEPOSITS (Holocene to middle Pleistocene)	Q	-	1.7%	0.7%	-	0.9%	1.7%	0.7%
VOLCANIC ROCKS (middle Miocene to Oligocene; 15 to 38 Ma.)	Tv	85.4%	11.3%	8.7%	-	0.3%	45.0%	24.5%
VOLCANIC ROCKS (Pliocene to middle Miocene)	Tvy	4.1%	11.7%	-	-	-	-	2.0%
YOUNG ALLUVIUM (Holocene to latest Pleistocene)	Qy	-	0.5%	-	-	-	-	0.06%
Area (Sq. Miles)		*1,251*	*638*	*2,152*	*709*	*1,048*	*445*	*6,243*

Table 2-10: Salt Watershed Rock Types.

Geologic Unit	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo River H15060104	Tonto River H15060105	Lower Salt River H15060106A	*Salt Watershed*
Volcanic Rocks	80.3%	83.0%	39.7%	45.2%	0.1%	45.8%	31.5%
Granitoid Rocks	-	-	6.4%	-	13.3%	32.1%	13.1%
Metamorphic Rocks	-	-	1.4%	-	8.2%	1.5%	5.9%
Sedimentary Rocks	18.9%	16.7%	50.3%	54.8%	74.0%	18.8%	45.0%
Surficial Deposits	0.8%	0.2%	2.2%	-	4.4%	1.7%	4.4%
Alluvium	-	0.1%	-	-	-	-	0.4%
Area (Sq. Miles)	*1,251*	*638*	*2,152*	*709*	*1,048*	*445*	*6,243*

Soils

Based on the soil characteristics for the Salt Watershed two types of maps were created: a soil texture map (Figure 2-21) and a soil erodibility factor map (Figure 2-22). Soil erodibility is generated from the soil texture characteristics.

There are 20 different soil textures in the Salt Watershed (Table 2-11). Cobbly loam is the most common soil texture, covering 27% of the watershed. Unweathered bedrock and very flaggy silt loam are the next most common soil textures, covering 19% and 14% respectively.

Soil erosion is a naturally occurring process, however, accelerated erosion occurs when soils are disturbed by agriculture, mining, construction, or when natural ground cover is removed and the soil is left unprotected. Erosion and sedimentation in streams are major environmental problems in the western United States.

Soils differ in their susceptibility to disturbance by water due to different inherent physical, chemical and mineralogical properties. Properties known to affect erodibility include particle size distribution, organic matter content, soil structure, texture,

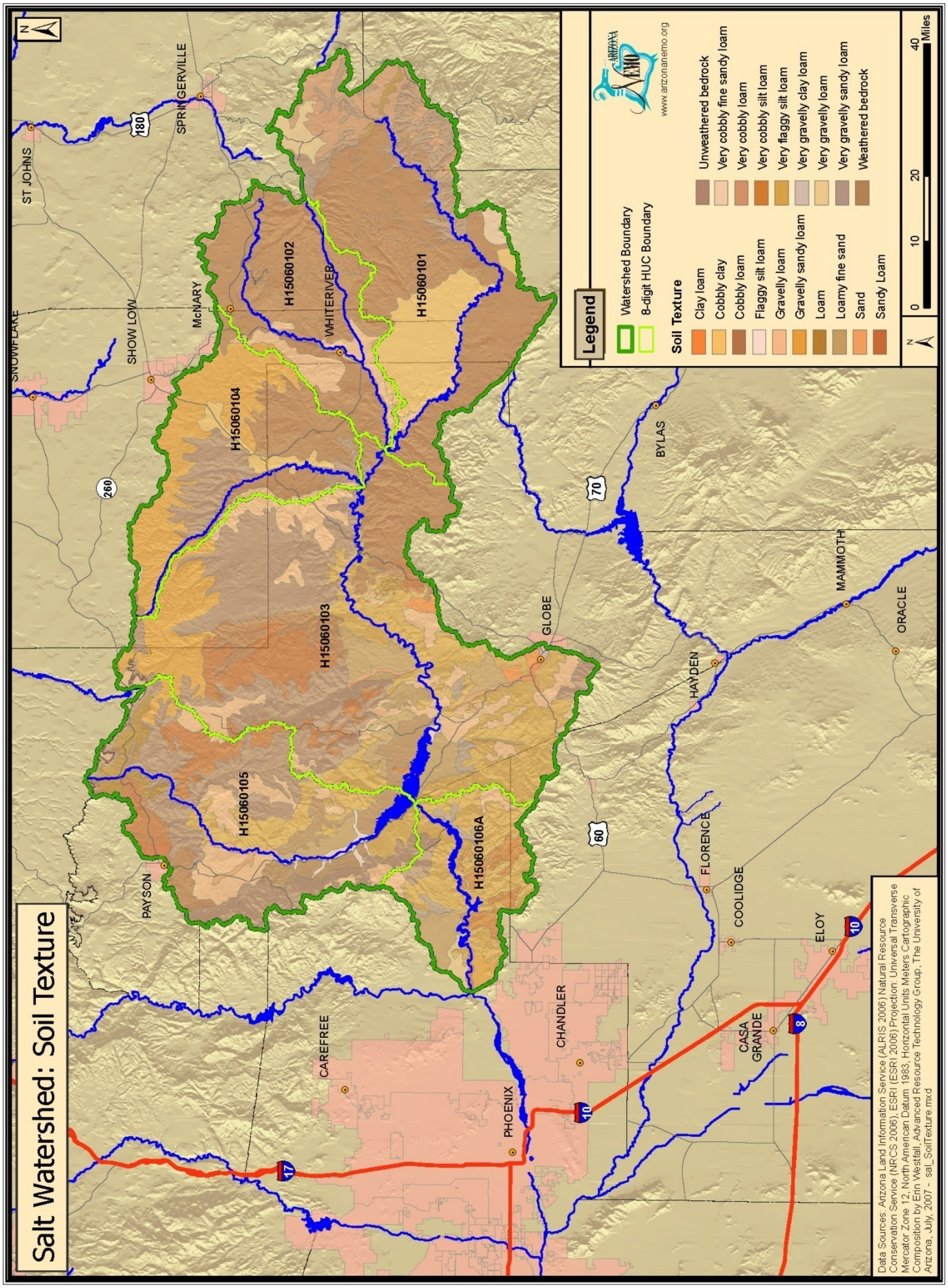

Figure 2-21: Soil Texture

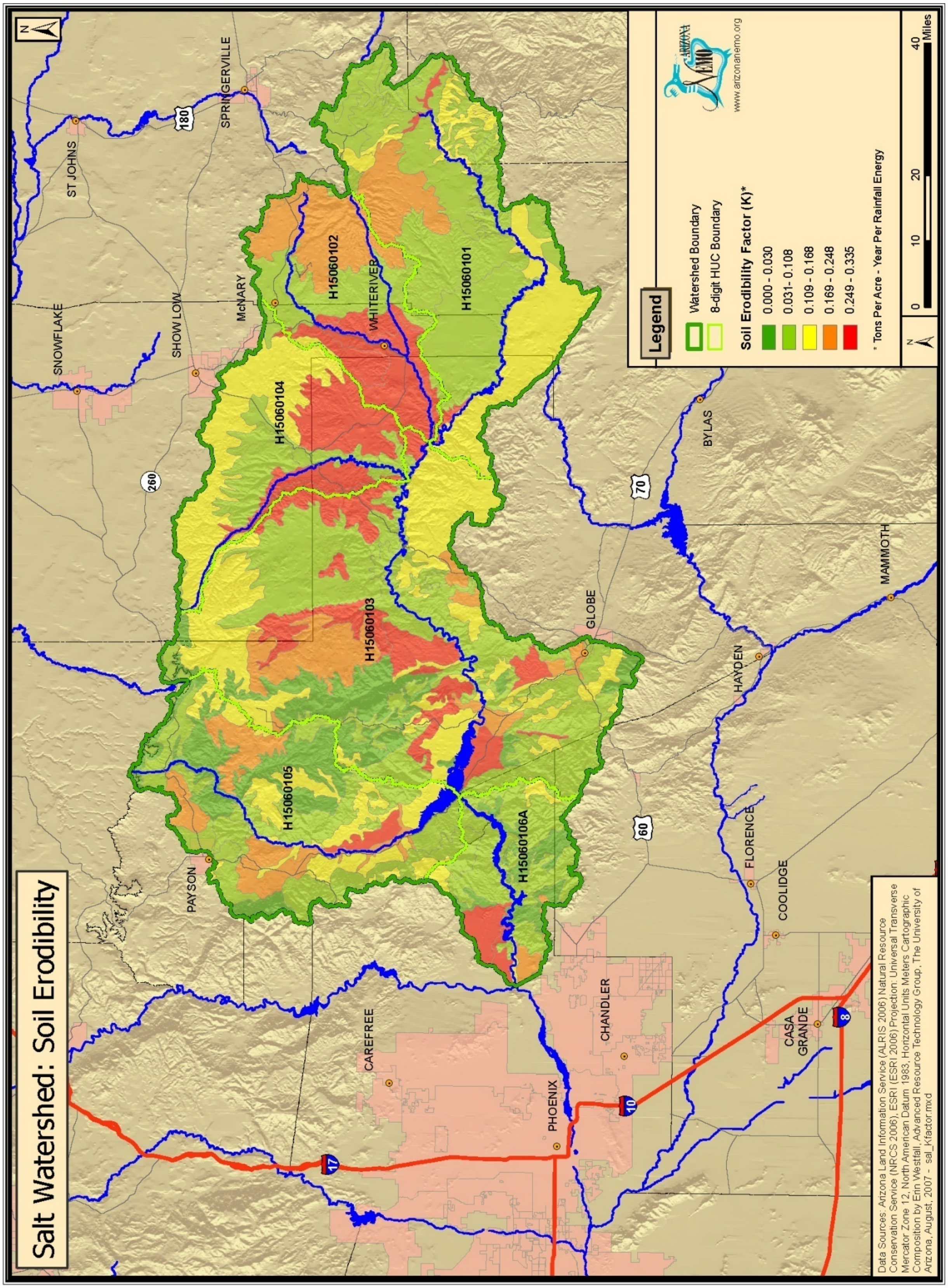

Figure 2-22: Soil Erodibility

moisture content, vegetation cover, and precipitation amount and intensity.

Erosion caused by precipitation and running water and the factors affecting soil loss have been summarized in the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). The USLE is a model for predicting long-term average soil losses based in part on factors of slope and erosive energy. It has been revised to reflect updates in the calculations, and additional analysis of the research data, and is now referred to as the Revised Universal Soil Loss Equation, or RUSLE.

Within the RUSLE equation, the Soil Erodibility Factor (K) represents the rate of soil loss per rainfall erosion index unit. Soil erodibility can be thought of as the ease with which soil is detached by splash during rainfall or by surface flow or both. It is estimated in the units of mass per unit area, or tons per acre per year, and is based on soil texture, with a range of values between 0.0 (no erosion potential) to 1.0 (USDA, 1997). Table 2-12 shows these values for each subwatershed.

The White River subwatershed and the Carrizo Creek subwatershed had the highest weighted mean Soil Erodibility Factors, with K = 0.214 and 0.189 respectively. The Black River subwatershed had the lowest weighted mean K at 0.109. The weighted mean K for the entire Salt Watershed is 0.122.

Table 2-11: Salt Watershed Soil Texture – Percent by Subwatershed (part 1 of 2).

Soil Texture	Black River H15050101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104	Tonto Creek H15060105
Clay loam	-	-	1%	-	-
Cobbly clay	17%	2%	-	6%	-
Cobbly loam	52%	81%	13%	31%	3%
Flaggy silt loam	-	-	0.2%	-	2%
Gravelly loam	0.5%	15%	12%	3%	15%
Gravelly sandy loam	-	1%	8%	42%	2%
Loam	1%	-	0.4%	-	6%
Loamy fine sand	-	-	7%	-	2%
Sand	-	-	0.6%	-	1%
Sandy loam	-	-	9%	-	12%
Silt loam	-	-	-	-	-
Unweathered bedrock	13%	-	24%	17%	33%
Very cobbly fine sandy loam	1%	-	0.2%	-	-
Very cobbly loam	11%	1%	-	-	-
Very cobbly silt loam	-	-	-	-	-
Very flaggy silt loam	-	-	22%	-	14%
Very gravelly clay loam	-	-	0.1%	0.4%	-
Very gravelly loam	3%	-	-	-	-
Very gravelly sandy loam	0.5%	0.4%	0.6%	-	-
Weathered bedrock	-	-	2%	-	9%

Table 2-11: Salt Watershed Soil Texture – Percent by Subwatershed (part 2 of 2).

Soil Texture	Lower Salt River H15060106A	Salt Watershed
Clay loam	-	0.4%
Cobbly clay	-	4%
Cobbly loam	-	27%
Flaggy silt loam	-	0.4%
Gravelly loam	4%	9%
Gravelly sandy loam	4%	8%
Loam	-	1%
Loamy fine sand	9%	3%
Sand	-	0.4%
Sandy loam	1%	5%
Unweathered bedrock	5%	*19%*
Very cobbly fine sandy loam	-	*0.3%*
Very cobbly loam	-	*2%*
Very cobbly silt loam	13%	*1%*
Very flaggy silt loam	56%	*14%*
Very gravelly clay loam	-	*0.1%*
Very gravelly loam	3%	*0.8%*
Very gravelly sandy loam	4%	*0.7%*
Weathered bedrock	-	*2%*

*Table 2-12: Salt Watershed Soil Erodibility Factor K.**

Subwatershed Name	Min K	Max K	Weighted Average
Black River H15060101	0.050	0.335	0.109
White River H15060102	0.050	0.331	0.214
Upper Salt River H15060103	0.000	0.335	0.141
Carrizo Creek H15060104	0.064	0.331	0.189
Tonto Creek H15060105	0.000	0.282	0.110
Lower Salt River H15060106A	0.000	0.320	0.096
Salt River Watershed	0.00	0.335	0.122

Climate

Precipitation

For the 30 years (1961-1990) of precipitation data used in this report, the average annual precipitation for the Salt Watershed is 22 inches. The White River subwatershed receives the most rainfall with 26 inches of rain in an average year, while the Lower Salt River subwatershed typically receives only 18 inches. Figure 2-23 shows the distribution of precipitation over the watershed, and Table 2-13 shows the average annual precipitation in inches per year.

Table 2-13: Salt Watershed Average Annual Precipitation (in/yr)

Subwatershed Name	Min (in/yr)	Max (in/yr)	Weighted Average
Black River H15060101	17	35	24
White River H15060102	17	35	26
Upper Salt River H15060103	15	37	22
Carrizo Creek H15060104	17	33	22
Tonto Creek H15060105	15	37	22
Lower Salt River H15060106A	9	31	18
Salt Watershed	9	37	22

Temperature

Fifty-six weather stations in the Salt Watershed are shown in Figure 2-24. Fifteen of these locations were used for watershed modeling (Table 2-14) because of consistency and duration of the data.

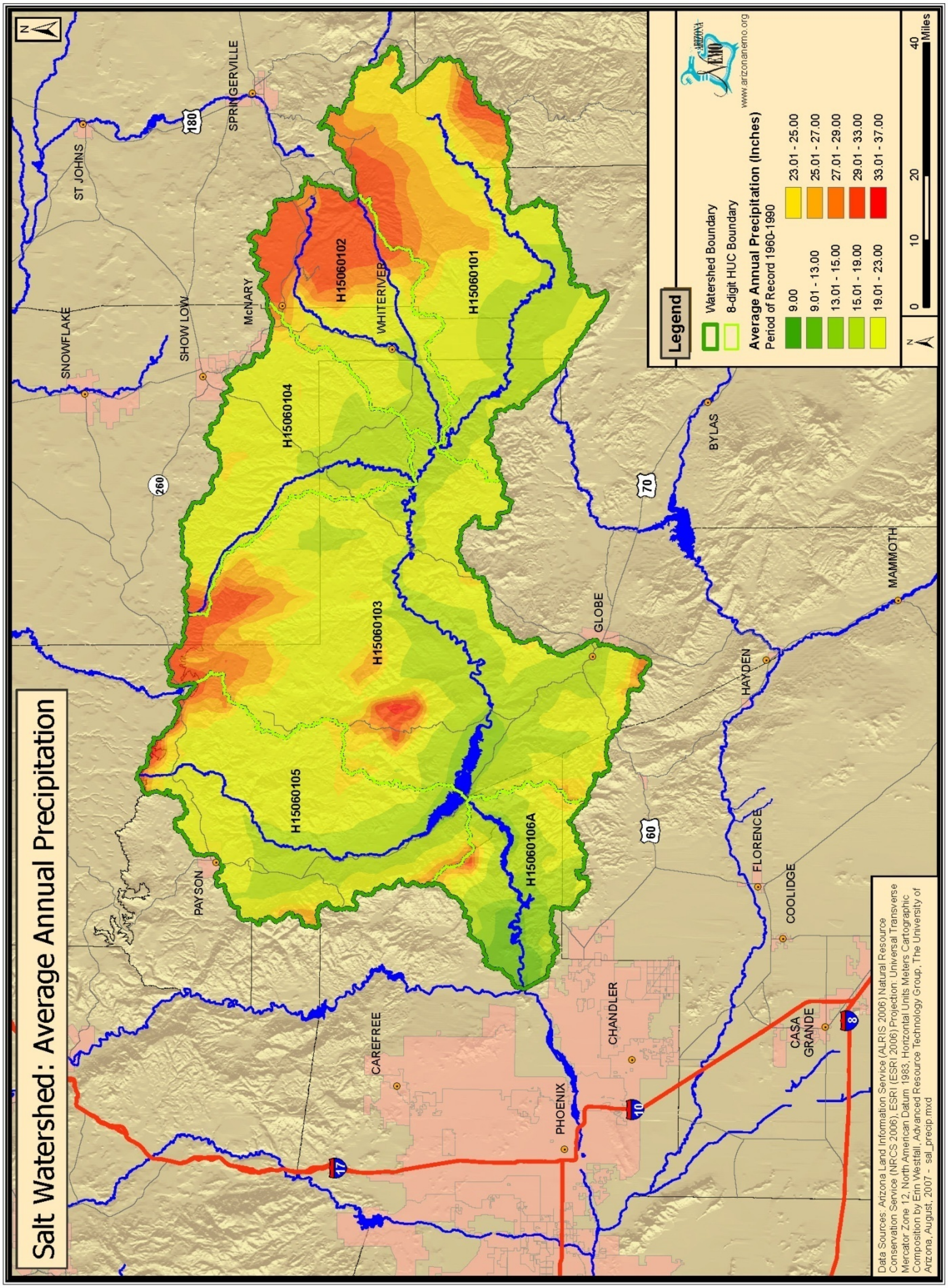

Figure 2-23: Average Annual Precipitation

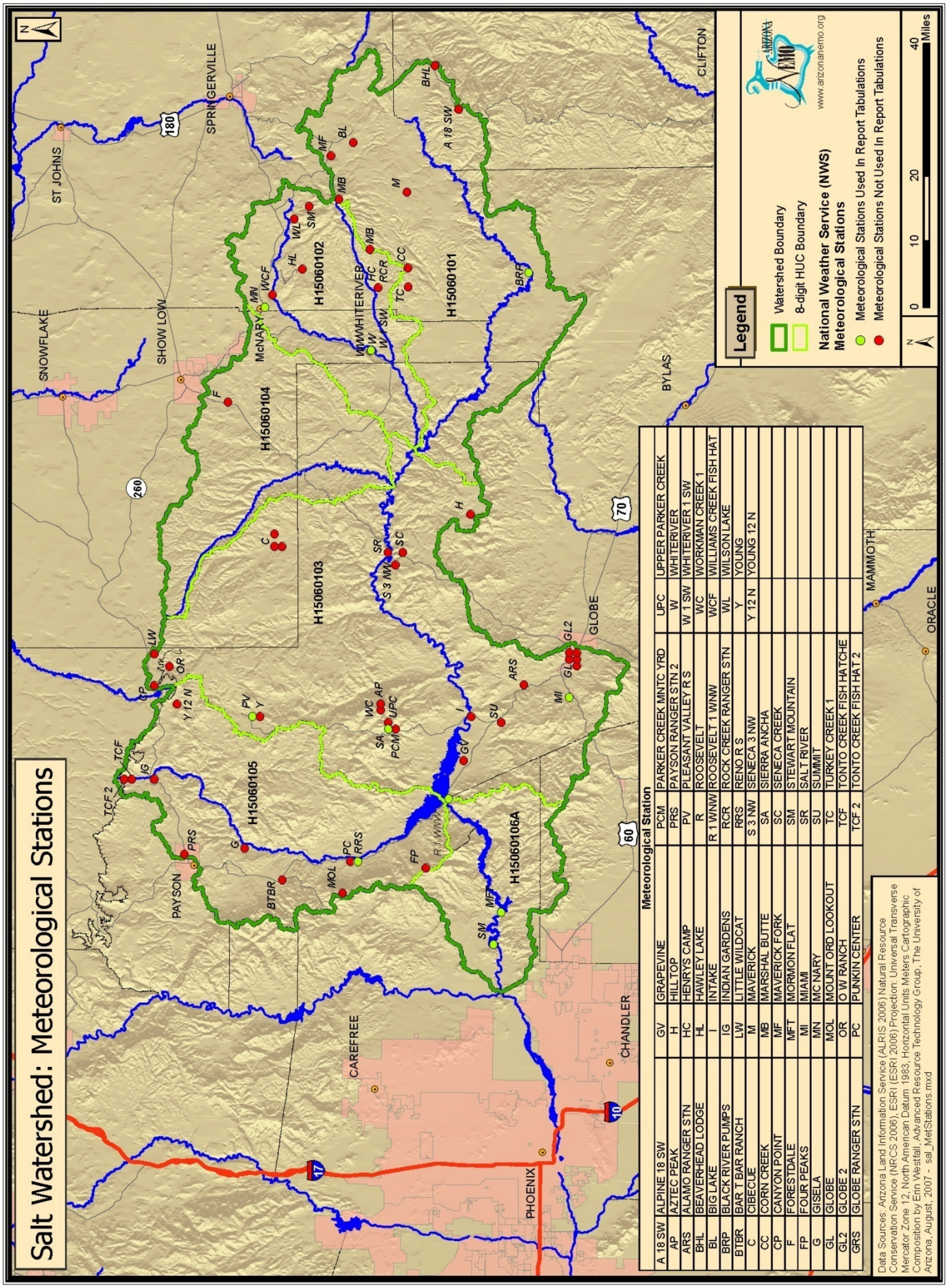

Figure 2-24: Meteorological Stations

Table 2-14: Salt Watershed Summary of Temperature Data for 15 Weather Stations with Sufficient Data.

ID	Gage	Average Annual Max. Temperature (F)	Average Annual Min Temperature (F)	Average Annual Temperature (F)
020808-7	BLACK RIVER PUMPS	68.0	36.9	52.5
023621-6	GRANITE REEF DAM	85.5	54.1	69.8
025412-2	MC NARY	62.4	32.1	47.3
025467-6	MESA EXPERIMENT FARM	84.7	52.9	68.8
036623-4	MIAMI	76.7	50.9	63.8
025700-6	MORMON FLAT	83.9	58.8	71.4
026474-6	PHOENIX	86.3	60.3	73.3
026653-4	PLEASANT VALLEY	71.7	35.0	53.4
027081-4	RENO R S	80.5	49.7	65.1
027281-4	ROOSEVELT 1 WNW	80.9	54.8	67.9
027876-4	SIERRA ANCHA	72.2	45.6	58.9
028112-6	SOUTH PHOENIX	84.7	54.2	69.5
028214-6	STEWART MOUNTAIN	84.9	53.7	69.3
028489-6	TEMPE	85.1	52.6	68.9
029271-2	WHITERIVER	71.7	38.1	54.9

http://www.wrcc.dri.edu/summary/climsmaz.html

For the 30 years (1961 – 1990) of temperature data, the average annual temperature for the Salt Watershed is 55° Fahrenheit (Table 2-15). The Lower Salt River subwatershed has the highest annual average temperature (67°).

Table 2-15 shows the annual average temperatures for each subwatershed and Figure 2-25 is a map of the temperature ranges.

Table 2-15: Salt Watershed Average Annual Temperature (°F).*

Subwatershed	Avg Annual Temp (°F)
Black River H15060101	49
White River H15060102	48
Upper Salt River H15060103	58
Carrizo River H15060104	47
Tonto River H15060105	55
Lower Salt River H15060106A	67
Salt Watershed	55

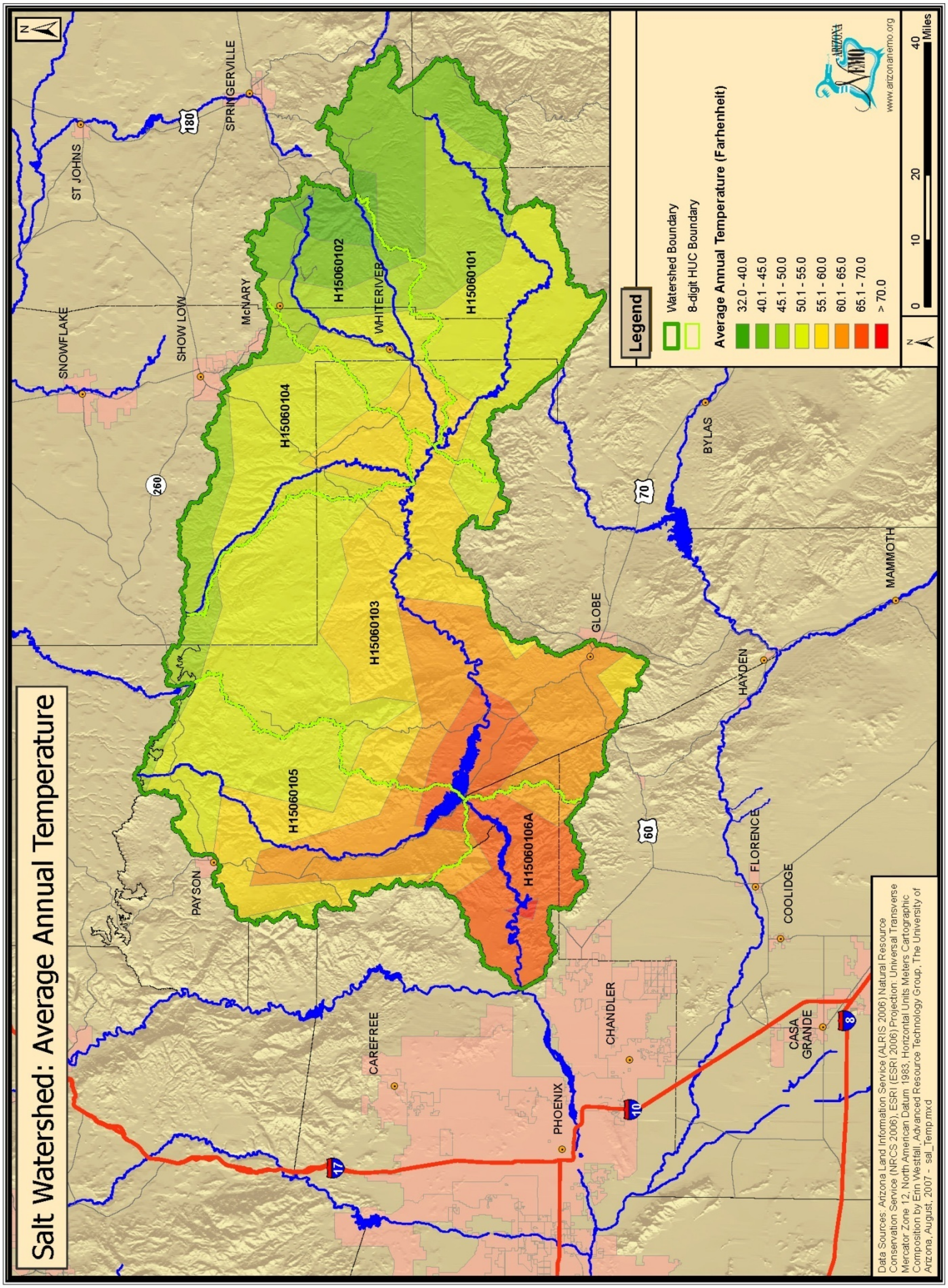

Figure 2-25: Average Annual Temperature

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*Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases. Metadata includes the original source of the data, when it was created, its geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.

Section 3: Biological Resources

Ecoregions

The effects of latitude, continental position, and elevation, together with other climatic factors, combine to form the world's ecoclimatic zones, which are referred to as ecosystem regions or ecoregions. Ecoregion maps show climatically determined ecological units. Because macroclimates are among the most significant factors affecting the distribution of life on earth, as the macroclimate changes, the other components of the ecosystem change in response.

Bailey's Ecoregion classification (Bailey, 1976) provides a general description of the ecosystem geography of the United States. This classification system was applied to the Salt Watershed, based on subwatersheds, which are identified using the USGS eight digit Hydrologic Unit Codes (HUC).

In Bailey's classification system, there are four *Domains*: polar, humid temperate, humid tropical and dry. The first three are differentiated based on humidity and thermal characteristics. The fourth, the dry domain, is defined on the basis of moisture alone. Each domain is divided into divisions, which are further subdivided into provinces, on the basis of macrofeatures of the vegetation.

This classification places all of the Salt Watershed in the dry domain, with 1% in the Tropical/Subtropical Desert Division, 53% in the Tropical/Subtropical Regime Mountains, and 46% are located in the Tropical/Subtropical Steppe Division. For the provinces, 46% is in the Colorado Plateau Semi-Desert Province, 53% is in the Arizona-New Mexico Semi-Desert – Open Woodland – Coniferous Forest – Alpine Meadow Province and 1% is in the American Semi-Desert and Desert Province, corresponding respectively to the Tonto Transition Section, the White Mountain-San Francisco Peaks Section, and the Sonoran Mohave Desert Section. Figures 3-1, 3-2 and 3-3, and Tables 3-1, 3-2 and 3-3 show these divisions.

The following descriptions are from Bailey's Ecosystem Classification (Bailey, 1995). The Dry Domain characterizes a dry climate where annual losses of water through evaporation at the earth's surface exceed annual water gain from precipitation. Due to the resulting water deficiency, no permanent streams originate in dry climate zones. Dry climates occupy one-fourth or more of the earth's land surface.

The three Divisions present in the Salt Watershed are the Tropical/Subtropical Desert Division, Tropical/Subtropical Regime Mountains, and the Tropical/Subtropical Steppe Division.

The Tropical/Subtropical Desert Division occurs in the western portion of the watershed (Figure 3-1). It is characterized by extreme aridity, extremely high air and soil temperatures, with extreme variations between day and night temperatures.

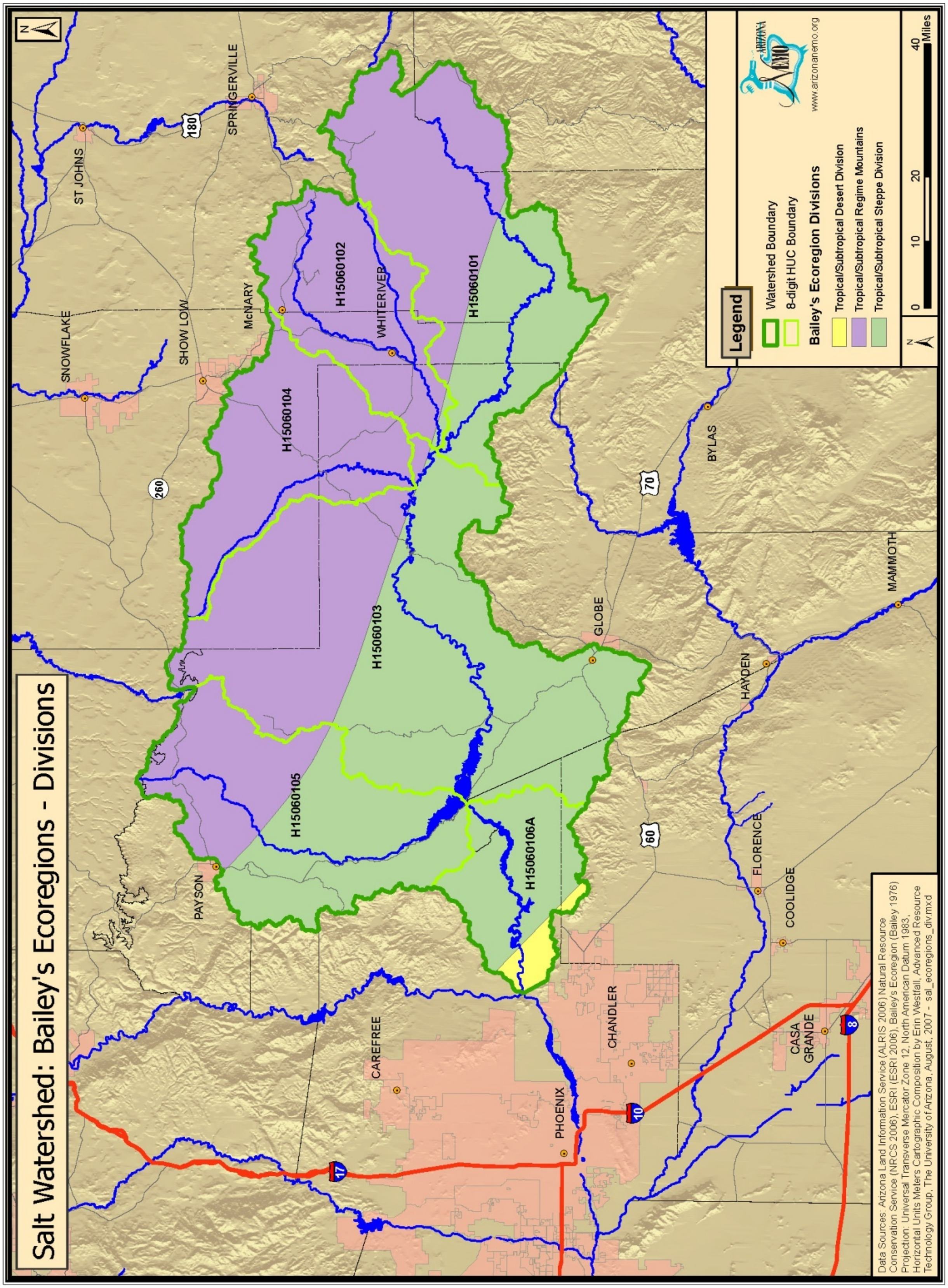

Figure 3-1: Bailey's Ecoregions - Divisions

Annual precipitation can be less than 8 inches (200 mm) in many places. The dry-desert vegetation, a class of xerophytic plants, is widely dispersed and provides negligible ground cover.

A dominant pedogenic process is salinization, which produces areas of salt crust where only salt-loving (halophytic) plants can survive. Calcification is conspicuous on well-drained uplands, where encrustations and deposits of calcium carbonate (caliche) are common. Humus is lacking and soils are mostly Aridisols (dry, high in calcium-carbonate, clays and salts, not suitable for agriculture without irrigation), and dry Entisols (young, diverse, some suitable for agriculture).

The region is characterized by dry-desert vegetation, a class of xerophytic plants that are widely dispersed and provide negligible ground cover. In dry periods, visible vegetation is limited to small hard-leaved or spiny shrubs, cacti, or hard grasses. Many species of small annuals may be present, but they appear only after the rare but heavy rains have saturated the soil.

In the Mojave-Sonoran Deserts (American Desert), plants are often so large that some places have a near-woodland appearance. Well known are the treelike saguaro cactus, the prickly pear cactus, the ocotillo, creosote bush, and smoke tree. But much of the desert of the Southwestern United States is in fact scrub, thorn scrub, savanna, or steppe grassland. Parts of this region have no visible plants; they are made up of shifting sand dunes or almost sterile salt flats.

The northeastern portion of the Salt watershed exhibits characteristics of the Tropical/Subtropical Regime Mountains Division. Temperate deserts of continental regions have low rainfall and strong temperature contrasts between summer and winter. In the intermountain region of the Western United States between the Pacific coast and Rocky Mountains, the temperate desert has characteristics of a sagebrush (Artemisia) semidesert, with a very pronounced drought season and a short humid season. Most precipitation falls in winter, despite a peak in May.

Temperate desert climates support the sparse xerophytic shrub vegetation typical of semidesert. One example is the sagebrush vegetation of the Great Basin and northern Colorado Plateau. Recently, semidesert shrub vegetation seems to have invaded wide areas of the Western United States that were formerly steppe grasslands, due to overgrazing and trampling by livestock. Soils of the temperate desert are Aridisols low in humus and high in calcium carbonate. Poorly drained areas develop saline soils, and dry lake beds are covered with salt deposits.

The Tropical/Subtropical Steppe Division occurs in the middle portion of the watershed. This is a hot, semiarid climate where potential evaporation exceeds precipitation, and where all months have temperatures above 32^{o}F.

Steppes are typically grasslands with short grasses and other herbs, and with locally developed shrubland and woodland. Pinyon-juniper woodland occurs on the Colorado Plateau, while to the east, in Texas, the grasslands grade into savanna woodland or semi deserts composed of xerophytic shrubs, cactus or trees, and the climate becomes semiarid-subtropical. These areas are able to support limited grazing, but generally require supplemental irrigation for crop cultivation. Soils are commonly Mollisols and Aridisols, containing some humus.

Bailey's Ecoregion classification defines three Provinces in the Salt Watershed: the Colorado Plateau Semi-Desert Province, the American Semi-Desert and Desert Province, and the Arizona-New Mexico Mountains Semi-Desert – Open Woodland – Coniferous Forest – Alpine Meadow Province, corresponding respectively to the Tonto Transition, Sonoran Mojave Desert, and White Mountain San Francisco Peaks Sections.

The Colorado Plateau Semi-Desert Providence and the Tonto Transition Section are found in the central portion of the watershed (Figures 3-2 and 3-3). The area is characterized as tablelands with moderate to considerable relief, and generally high elevations which keep the temperatures cooler than in other parts of Arizona. Precipitation averages about 20 inches (510 mm) per year, with some areas receiving less than 10 inches (260 mm). Precipitation falls as intense thunderstorms in summer, with gentler rains during the winter.

The American Semi-Desert and Desert Province and the Sonoran Mojave Desert (Figures 3-2 and 3-3) occur in the southern portion of the watershed, and are characterized by extensive plains, most gently undulating, from which isolated mountains and buttes rise abruptly. Summers are long and hot, with convective thunderstorms. Winters are moderate, with gentle, widespread rains. Washes generally flow only after rains.

Vegetation consists of cactus and shrubs such as the creosote bush, and Mesquite trees. Some areas have a near-woodland appearance, due to the treelike saguaro cactus, prickly pear cactus, ocotillo, creosote bush, and smoke tree.

The Arizona-New Mexico Mountains Semi-Desert – Open Woodland – Coniferous Forest – Alpine Meadow Province and the White Mountain San Francisco Peaks Section occur in the northeastern portion of the watershed. This area has a cool to cold climate with most precipitation occurring during late summer (as thunderstorms) and early winter. Landscape is mostly steep foothills and mountains. Vegetation varies by zones of altitude and, from low to high elevations, ranges from herbaceous and shrubland, woodland, to forest.

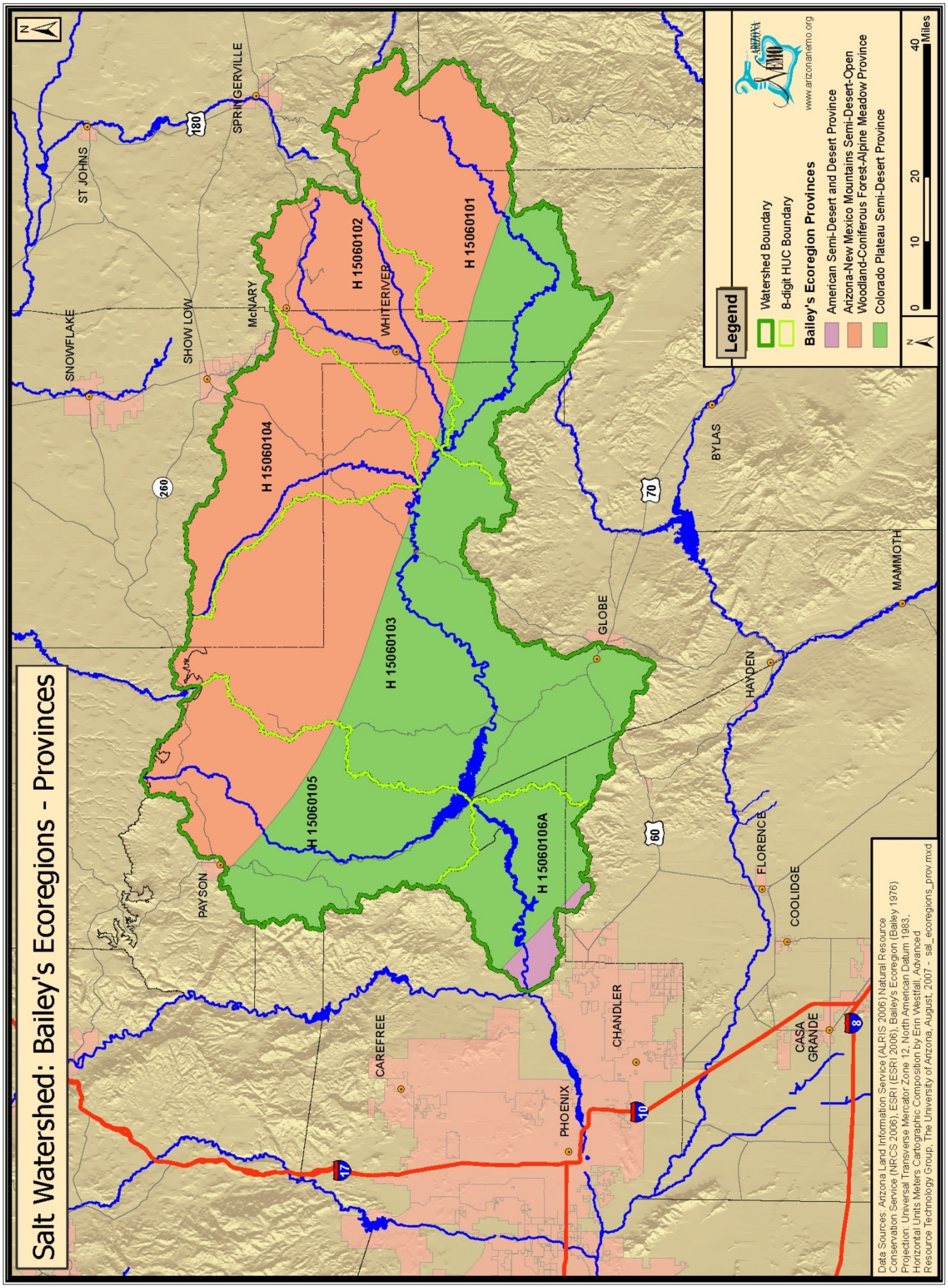

Figure 3-2: Bailey's Ecoregions - Provinces

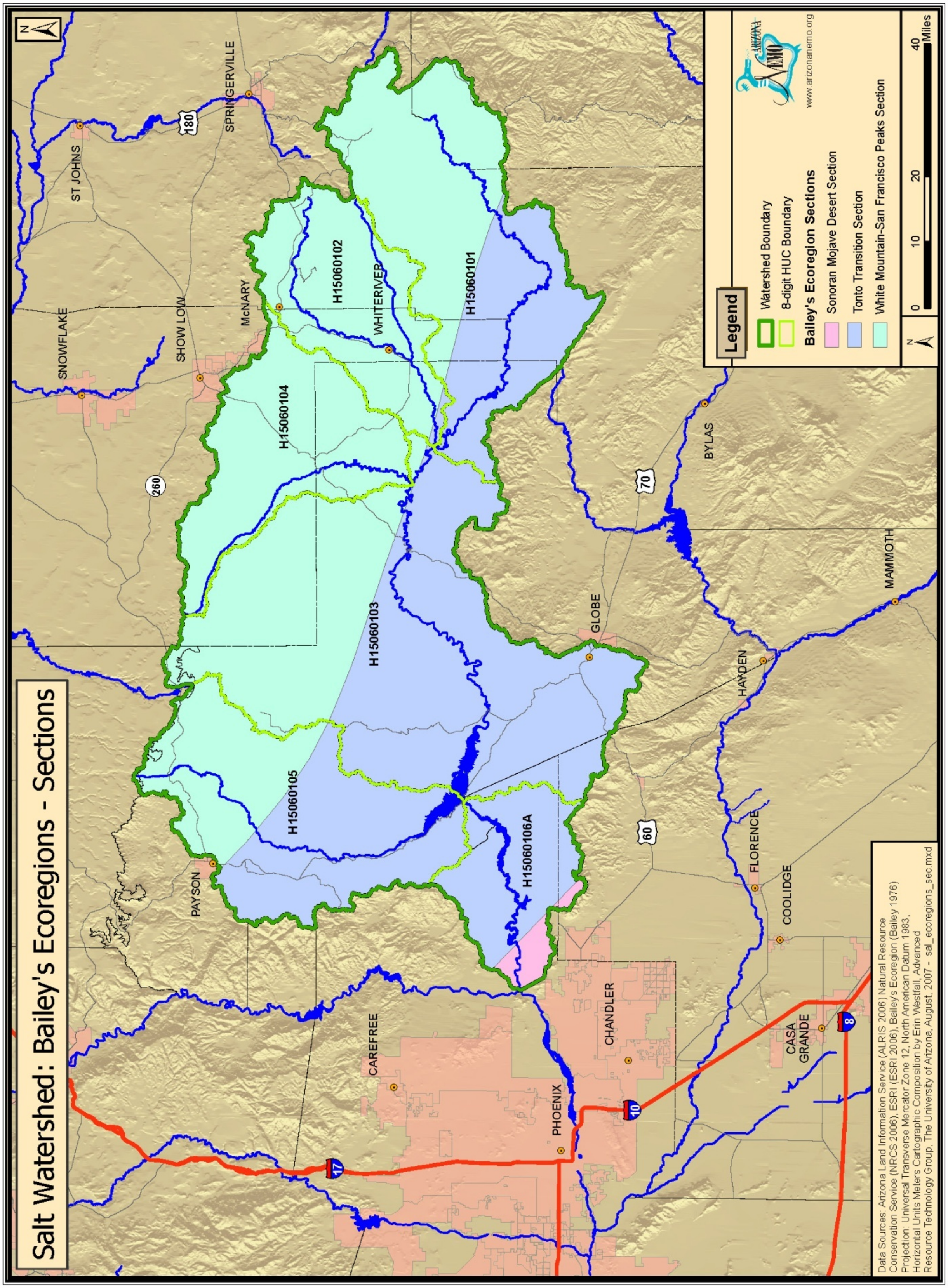

Figure 3-3: Bailey's Ecoregions - Sections

Table 3-1: Salt Watershed Ecoregions - Divisions.

Subwatershed	Tropical/ Subtropical Desert Division		Tropical/ Subtropical Regime Mountains		Tropical/ Subtropical Steppe Division		***Salt River Area (sq. miles)***
	percent	**area (sq. miles)**	**percent**	**area (sq. miles)**	**percent**	**area (sq. miles)**	
Black River H15060101	-	-	58%	721	42%	530	1,251
White River H15060102	-	-	98%	626	2%	12	638
Upper Salt River H15060103	-	-	39%	834	61%	1,318	2,152
Carrizo Creek H15060104	-	-	100%	709	-	-	709
Tonto Creek H15060104	-	-	40%	424	60%	624	1,048
Lower Salt River H15060106A	14%	65	-	-	86%	380	445
Salt River Watershed	*1%*	*65*	*53%*	*3314*	*46%*	*2864*	*6,243*

Table 3-2: Salt Watershed Ecoregions - Provinces.

Subwatershed	American Semi-Desert and Desert Province		Arizona-New Mexico Mountains Semi-Desert – Open Woodland – Coniferous Forest – Alpine Meadow Province		Colorado Plateau Semi-Desert Province		***Salt River Area (sq. miles)***
	percent	**area (sq. miles)**	**percent**	**area (sq. miles)**	**percent**	**area (sq. miles)**	
Black River H15060101	-	-	58%	721	42%	530	1,251
White River H15060102	-	-	98%	626	2%	12	638
Upper Salt River H15060103	-	-	39%	834	61%	1,318	2,152
Carrizo Creek H15060104	-	-	100%	709	-	-	709
Tonto Creek H15060104	-	-	40%	424	60%	624	1,048
Lower Salt River H15060106A	14%	65	-	-	86%	380	445
Salt River Watershed	1%	65	53%	3314	46%	2874	6,243

Table 3-3: Salt River Watershed Ecoregions - Sections.

Subwatershed	**Sonoran Mojave Desert Section**		**White Mountain – San Francisco Peaks Section**		**Tonto Transition Section**		***Salt River Area (sq. miles)***
	percent	**area (sq. miles)**	**percent**	**area (sq. miles)**	**percent**	**area (sq. miles)**	
Black River H15060101	-	-	58%	721	42%	530	1,251
White River H15060102	-	-	98%	626	2%	12	638
Upper Salt River H15060103	-	-	39%	834	61%	1,318	2,152
Carrizo Creek H15060104	-	-	100%	709	-	-	709
Tonto Creek H15060104	-	-	40%	424	60%	624	1,048
Lower Salt River H15060106A	59%	65	-	-	86%	380	445
Salt River Watershed	1%	65	53%	3314	46%	2874	6,243

Vegetation

Two different vegetation maps were created for the Salt watershed, one based on biotic (vegetation) communities and the other based on land cover.

The first map is based on the classification of biotic communities that was published by Brown, Lowe, and Pace (Brown et al., 1979). These biotic zones are general categories indicating where vegetation communities would most likely exist (Figure 3-4). Under this classification there are ten different biotic communities in the Salt Watershed. The primary community types over the entire watershed is Petran Montane Conifer Forest (31%) and Great Basin Conifer Woodland (31%) with Interior Chaparral comprising 15%. Table 3-4 shows the percentage of each biotic community in each subwatershed.

The second vegetation map was created from the Southwest Regional Gap Analysis Project land cover map (Lowry et. al, 2005). According to this map, 40 different land cover types are found within the watershed, including vegetation communities, developed land, open water, and agriculture (Table 3-5). The most common land cover type over the entire watershed is Rocky Mountain Ponderosa Pine Woodland encompassing 22% of the watershed. The next most common types are Mandrean Pinyon-Juniper Woodland (21%), Mandrean Pine-Oak Forest and Woodland (11%), and Mogollon Chaparral (10%). Figure 3-5 identifies land cover and vegetation locations in the Salt Watershed.

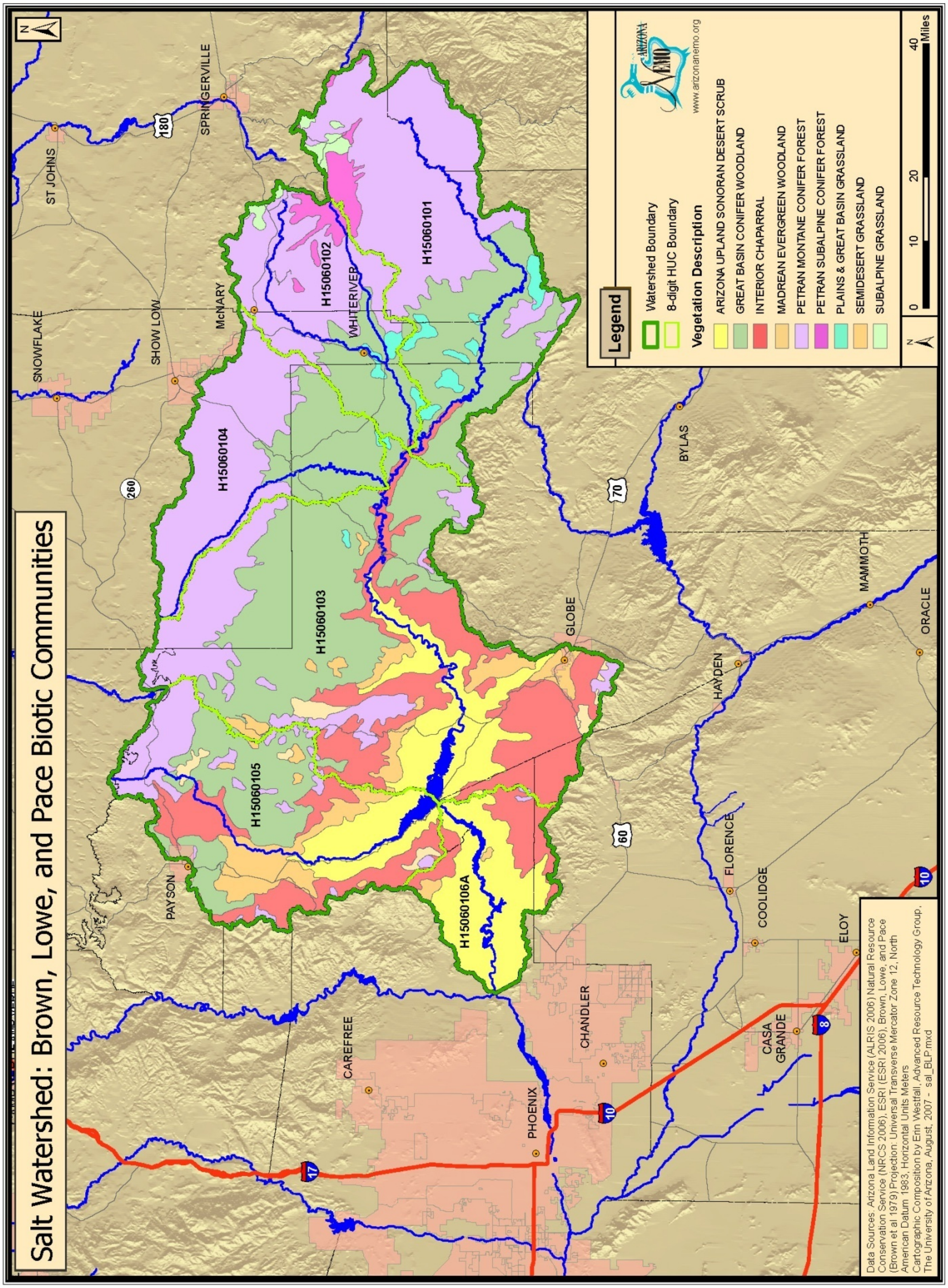

Figure 3-4: Brown, Lowe, and Pace Biotic Communities

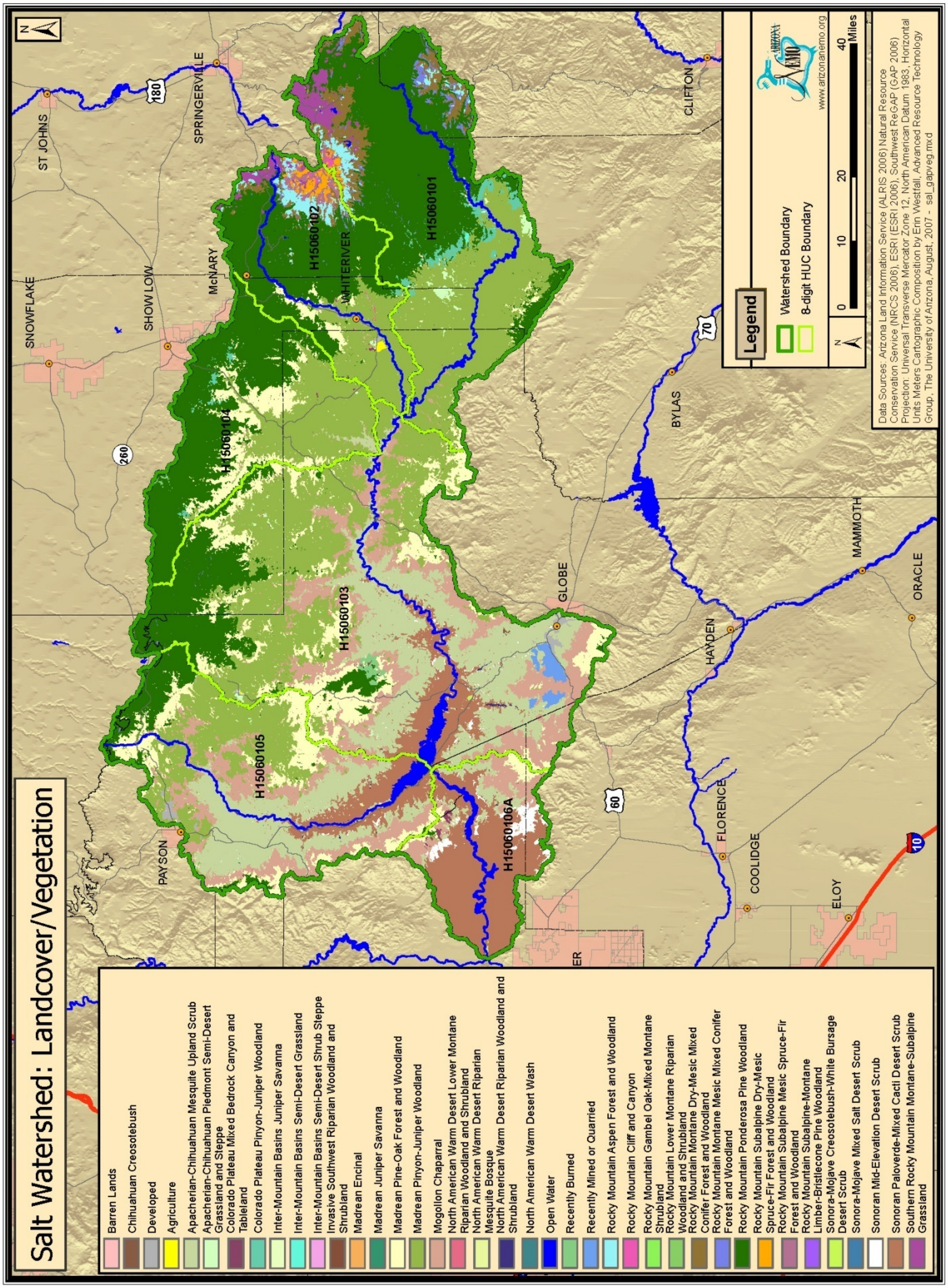

Figure 3-5: Landcover/Vegetation

Table 3-4: Salt Watershed Brown, Lowe and Pace Biotic Communities, Percent by Subwatershed (part 1 of 2).

Biotic Community	**Black River H15060101**	**White River H15060102**	**Upper Salt River H15060103**	**Carrizo Creek H15060104**	**Tonto Creek H15060105**
Arizona Upland Sonoran Desert Scrub	-	-	14%	-	6%
Great Basin Conifer Woodland	33%	28%	36%	34%	12%
Interior Chaparral	1%	0.2%	26%	0.02%	9%
Madrean Evergreen Woodland	>0%	-	1%	-	0.8%
Petran Montane Conifer Forest	56%	59%	16%	66%	67%
Petran Subalpine Conifer Forest	4%	7%	-	-	-
Plains Great Basin Grassland	4%	4%	0.2%	0.3%	-
Semidesert Grassland	-	-	6%	-	6%
Subalpine Grassland	2%	2%	-	-	-
Area (square miles)	1,251	638	2,152	709	1,048

Table 3-4: Salt Watershed Brown, Lowe and Pace Biotic Communities, Percent by Subwatershed (part 2 of 2).

Biotic Community	**Lower Salt River H15060106A**	***Salt River Watershed***
Arizona Upland Sonoran Desert Scrub	71%	13%
Great Basin Conifer Woodland	-	31%
Interior Chaparral	26%	15%
Madrean Evergreen Woodland	-	1%
Petran Montane Conifer Forest	0.6%	31%
Petran Subalpine Conifer Forest	-	2%
Plains Great Basin Grassland	-	1%
Semidesert Grassland	2%	5%
Subalpine Grassland	-	0.6%
Area (square miles)	445	6,243

Table 3-5: Salt River Watershed Southwest Regional GAP Analysis Project Land Cover, Percent of Subwatershed (Part 1 of 2).

Land Cover	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104
Agriculture	-	0.3%	0.01%	-
Apacherian-Chihuahuan Mesquite Upland Scrub	0.2%	0.3%	18%	1%
Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	2%	0.3%	0.8%	0.4%
Barren Lands, Non-specific	-	-	-	-
Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	>0.00%	-	0.2%	0.02%
Colorado Plateau Mixed Bedrock Canyon and Tabeland	0.2%	0.4%	0.4%	0.8%
Colorado Plateau Pinyon-Juniper Woodland	5%	0.8%	0.2%	3%
Developed, Medium – High Intensity	-	0.6%	0.6%	0.04%
Developed, Open Space – Low Intensity	-	-	0.01%	-
Inter-Mountain Basins Juniper Savanna	0.06%	-	-	-
Inter-Mountain Basins Semi-Desert Grassland	0.1%	>0.00%	-	>0.00%
Inter-Mountain Basins Semi-Desert Shrub Steppe	>0.00%	0.01%	>0.00%	>0.00%
Invasive Southwest Riparian Woodland and Shrubland	-	-	0.2%	-
Madrean Encinal	0.01%	>0%	0.06%	>0.00%
Madrean Juniper Savanna	0.01%	0.02%	0.04%	0.01%
Madrean Pine-Oak Forest and Woodland	3%	5.3%	16%	18%
Madrean Pinyon-Juniper Woodland	29%	21%	23%	25%
Mogollon Chaparral	1%	2%	17%	3%
North American Warm Desert Lower Montane Riparian Woodland and Shrub	0.02%	-	0.1%	0.05%
North American Warm Desert Riparian Mesquite Bosque	0.02%	-	0.05%	-
North American Warm Desert Riparian Woodland and Shrubland	-	0.3%	0.2%	-
North American Warm Desert Wash	-	-	0.04%	>0.00%
Open Water	0.1%	0.2%	0.4%	>0.00%
Recently Burned	-	-	0.4%	0.4%
Recently Mined or Quarried	-	0.01%	1%	>0.00%
Rocky Mountain Aspen Forest and Woodland	2%	5%	>0.00%	-
Rocky Mountain Cliff and Canyon	0.2%	0.3%	>0.00%	>0.00%
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	0.06%	0.08%	0.02%	0.05%
Rocky Mountain Lower Montane Riparian Woodland and Shrubland	0.01%	>0.00%	-	-
Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	7%	4%	0.2%	0.3%
Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland	4%	3%	0.3%	0.2%

Land Cover	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104
Rocky Mountain Ponderosa Pine Woodland	41%	48%	12%	47%
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	0.7%	2%	-	-
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	0.6%	3%	>0.00%	-
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	0.01%	>0%	-	-
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	-	-	0.1%	-
Sonora-Mojave Mixed Salt Desert Scrub	-	-	-	-
Sonoran Mid-Elevation Desert Scrub	>0.00%	>0.00%	2%	>0.00%
Sonoran Paloverde-Mixed Cacti Desert Scrub	-	-	7%	>0.00%
Southern Rocky Mountain Montane-Subalpine Grassland	4%	3%	>0.00%	0.01%
Area (square miles)	1,251	638	2,152	709

Table 3-5: Salt River Watershed Southwest Regional GAP Analysis Project Land Cover, Percent of Subwatershed (Part 2 of 2).

Land Cover	Tonto Creek H15060105	Lower Salt River H15060106A	Salt River Watershed
Agriculture	0.02%	-	0.7%
Apacherian-Chihuahuan Mesquite Upland Scrub	21%	9%	10%
Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	0.4%	0.1%	0.7%
Barren Lands, Non-specific	-	> 0.00%	> 0%
Chihuahuan Creosotebush, Mixed Desert and Thorn Scrub	0.04%	0.1%	0.06%
Colorado Plateau Mixed Bedrock Canyon and Tabeland	0.3%	1%	0.4%
Colorado Plateau Pinyon-Juniper Woodland	0.1%	-	1%
Developed, Medium – High Intensity	0.8%	-	4%
Developed, Open Space – Low Intensity	>0.00%	-	0.5%
Inter-Mountain Basins Juniper Savanna	>0.00%	-	0.01%
Inter-Mountain Basins Semi-Desert Grassland	-	-	0.03%
Inter-Mountain Basins Semi-Desert Shrub Steppe	>0.00%	-	> 0.00%
Invasive Southwest Riparian Woodland and Shrubland	0.2%	0.1%	0.09%
Madrean Encinal	0.03%	0.03%	0.03%
Madrean Juniper Savanna	0.1%	0.02%	0.04%
Madrean Pine-Oak Forest and Woodland	16%	5%	11%
Madrean Pinyon-Juniper Woodland	22%	1%	21%

Land Cover	Tonto Creek H15060105	Lower Salt River H15060106A	Salt River Watershed
Mogollon Chaparral	18%	12%	10%
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	0.2%	0.05%	0.1%
North American Warm Desert Riparian Mesquite Bosque	0.2%	0.2%	0.06%
North American Warm Desert Riparian Woodland and Shrubland	0.4%	> 0.0%	0.1%
North American Warm Desert Wash	0.1%	>0.00%	0.03%
Open Water	0.7%	2%	0.4%
Recently Burned	>0.00%	-	0.2%
Recently Mined or Quarried	>0.00%	-	0.4%
Rocky Mountain Aspen Forest and Woodland	0.02%	-	0.9%
Rocky Mountain Cliff and Canyon	0.01%	-	0.06%
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	0.06%	-	0.04%
Rocky Mountain Lower Montane Riparian Woodland and Shrubland	-	-	> 0.00%
Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	0.2%	-	1%
Rocky Mountain Montane Mesic Mixed Conifer Forest and Woodland	0.1%	-	1%
Rocky Mountain Ponderosa Pine Woodland	9%	0.2%	22%
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	>0.00%	-	0.3%
Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland	-	-	0.4%
Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	-	-	>0.00%
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	0.1%	0.7%	0.9%
Sonora-Mojave Mixed Salt Desert Scrub	-	> 0.0%	0.01%
Sonoran Mid-Elevation Desert Scrub	2%	9%	2%
Sonoran Paloverde-Mixed Cacti Desert Scrub	9%	60%	9%
Southern Rocky Mountain Montane-Subalpine Grassland	>0.00%	-	1%
Area (square miles)	1,048	445	6,243

Habitats (Riparian and Wetland Areas)

The Arizona Game & Fish Department has identified riparian vegetation associated with perennial waters and has mapped the data in response to the requirements of the state Riparian Protection Program (July 1994). This map was used to identify riparian areas in the Salt Watershed (Figure 3-6).

Eleven of the thirteen different types of riparian areas occur within this watershed (Table 3-6). Riparian areas encompass approximately 14,638 acres (22.9 square miles) or 0.4% of the entire watershed. Mesquite comprises about 4,308 acres (6.7 square miles, or 27.5% of the riparian areas), and Mixed Broadleaf comprises about 2,544 acres (4.0 square miles, or 16.2% of the riparian areas).

The Upper Salt River and Tonto Creek subwatersheds have the greatest amount of riparian vegetation with about 6,623 acres (10.3 square miles) and 4,585 acres (7.2 square miles), respectively. The Lower Salt River and Black River subwatersheds also have large amounts of riparian vegetation with 1,523 acres (2.4 square miles) and 1,907 acres (3.0 square miles) respectively. The White River subwatershed has less then 1.0 acre of riparian vegetation, and Carrizo Creek has no riparian vegetation associated with perennial waters. Table 3-6 contains the list of riparian vegetation types and areas for each subwatershed.

The Salt Watershed contains areas of critical habitat for the Loach Minnow, the Mexican Spotted Owl and the Southwest Willow Flycatcher (Figure 3-7)

Major Land Resource Areas (MLRAs)

Major Land Resource Areas, or MLRA's, are ecosystem divisions in Arizona. There are two different MLRA's in the Salt Watershed (Figure 3-8): Arizona and New Mexico Mountains, Central Arizona Basin and Range (Table 3-7).

The Arizona and New Mexico Mountains MLRA has the largest representation with 90% (5619 square miles) of the watershed. Central Arizona Basin and Range MLRA is the next largest with 10% of the entire watershed (624 square miles). Trilby Wash – Trilby Wash Basin is entirely within the Central Arizona Basin and Range MLRA (Cassady, 2000).

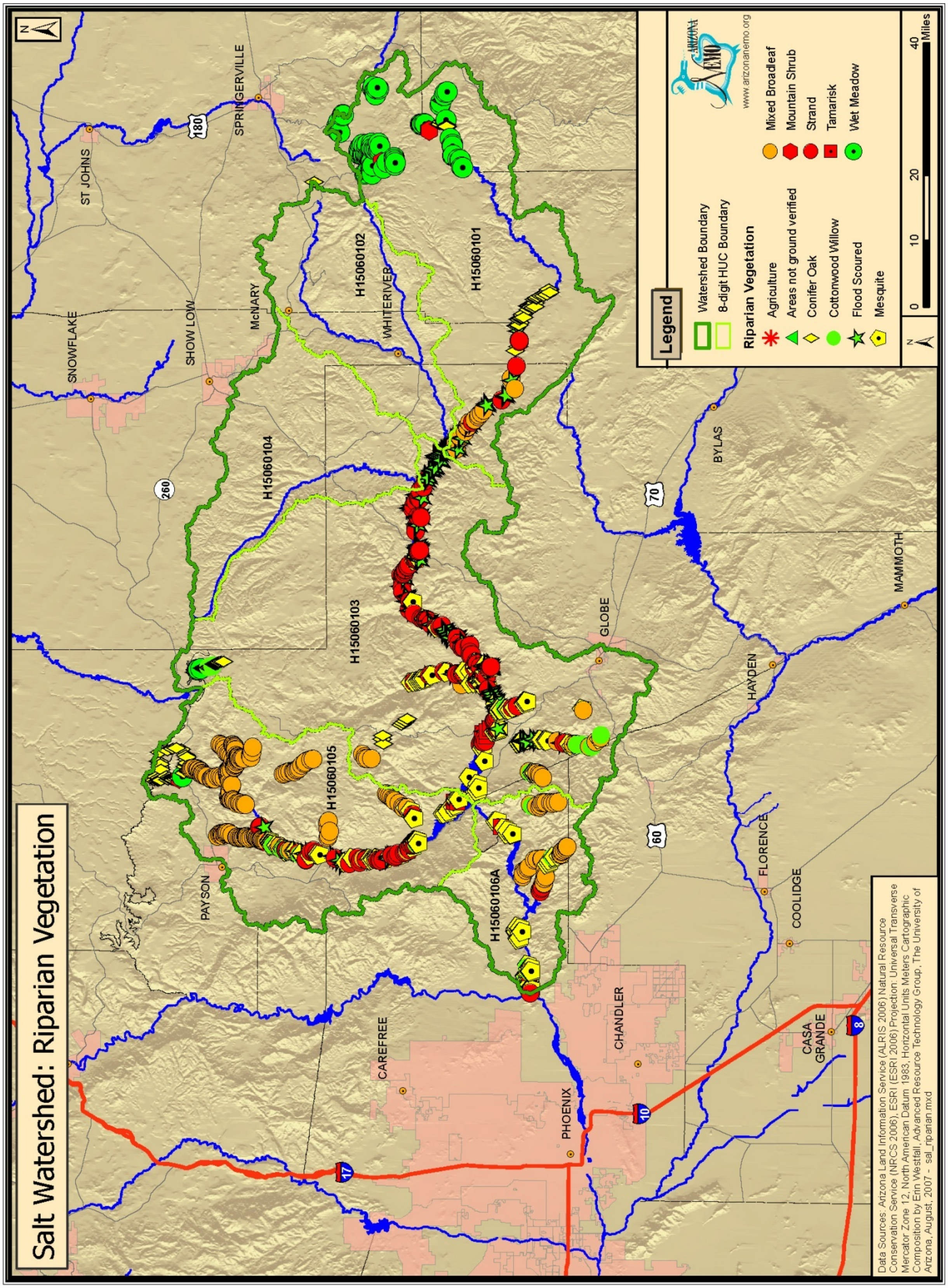

Figure 3-6: Riparian Vegetation

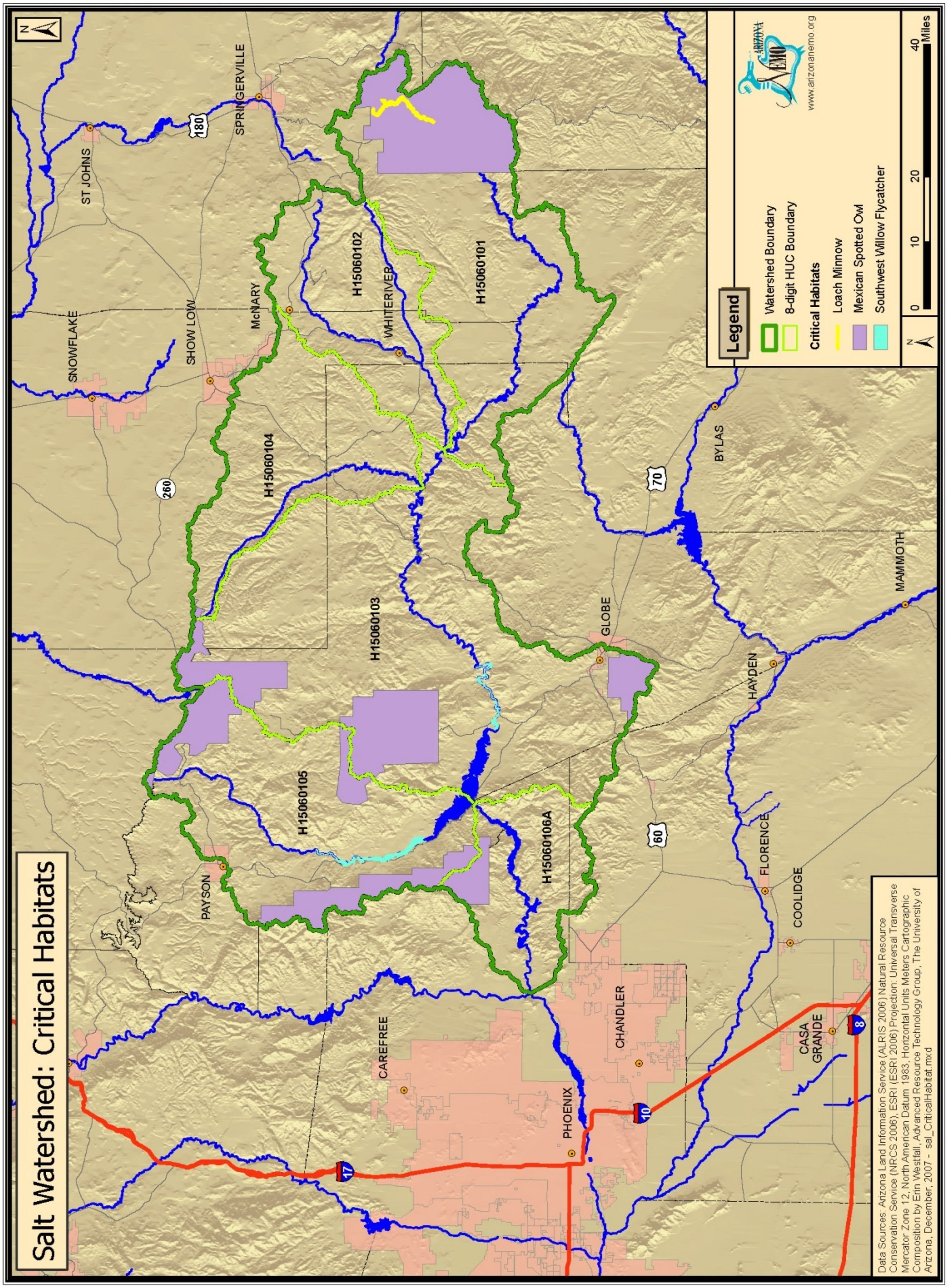

Figure 3-7: Critical Habitat

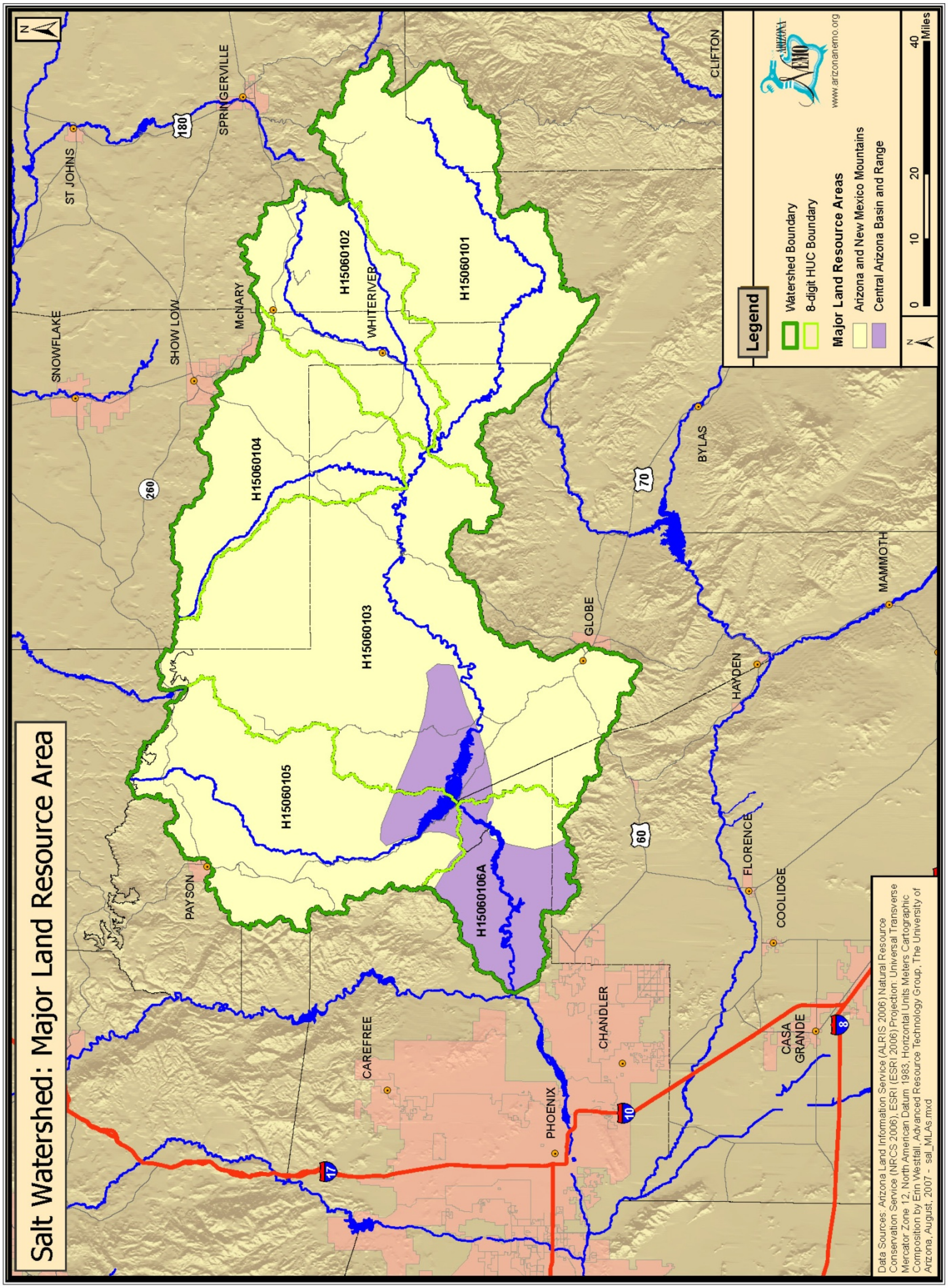

Figure 3-8: Major Land Resource Area

Table 3-6: Salt River Watershed Riparian and Wetland Areas (acres) by Subwatershed (Part 1 of 2).

Riparian Vegetation Community	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104	Tonto Creek H15060105
Agriculture	-	-	-	-	10
Areas Not Ground Verified	-	-	-	-	0
Conifer Oak	543	0.12	269	-	507
Cottonwood Willow	-	-	671	-	12
Flood Scoured	246	-	992	-	340
Mesquite	-	-	1,451	-	2,055
Mixed Broadleaf	302	-	536	-	1,301
Mountain Shrub	55	-	-	-	20
Strand	115	-	682	-	303
Tamarisk	-	-	1,990	-	25
Wet Meadow	646	-	32	-	12
Total Area (acres)	1,907	0.12	6,623	-	4,585

Table 3-6: Salt River Watershed Riparian and Wetland Areas (acres) by Subwatershed (Part 2 of 2).

Riparian Vegetation Community	Lower Salt River H15060106A	Salt River Watershed
Agriculture	-	10
Areas Not Ground Verified	3	3
Conifer Oak	-	1,319
Cottonwood Willow	233	916
Flood Scoured	8	1,586
Mesquite	802	4,308
Mixed Broadleaf	405	2,544
Mountain Shrub	-	75
Strand	61	1,161
Tamarisk	11	2,026
Wet Meadow	-	690
Total Area (acres)	1,523	14,638

Table 3-7: Salt River Watershed - Major Land Resource Areas (percent per Subwatershed).

Subwatershed	Major Land Resource Areas, Area (percent per subwatershed)		Salt River Watershed Area (square miles)
	Arizona and New Mexico Mountains	Central Arizona Basin and Range	
Black River H15060101	100%	-	1,251
White River H15060102	100%	-	638
Upper Salt Rivr H15060103	92%	8%	2,152
Carrizo Creek H15060104	100%	-	709
Tonto Creek H15060105	93%	7%	1,048
Lower Salt River H15060106A	22%	78%	445
Salt River Watershed (percent)	90%	10%	6,243

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**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases. Metadata includes the original source of the data, when it was created, its geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.*

Section 4: Social/Economic Characteristics

County Governments

Understanding which governmental entities hold jurisdiction over the land in a given watershed helps a watershed partnership understand the significance of each stakeholder's influence on the watershed. The Salt Watershed is located in eight counties: Apache, Coconino, Gila, Graham, Greenlee, Maricopa, Navajo, and Pinal, as shown in Figure 4-1. The watershed lies primarily in Gila County, (53% of the area), and also overlaps with Navajo and Apache counties (17% and 16% of the area respectively), and Maricopa county (7% of the area) (Table 4-1).

Council of Governments (COGs)

Four Councils of Governments (COGs) are present in the Salt Watershed: the Central Arizona Association of Governments (CAAG), the Maricopa Association of Governments (MAG), the Northern Arizona Council of Governments (NACOG), and the Southeastern Arizona Governments Organization (SEAGO) (Figure 4-2). The CAAG represents the Gila County and Pinal portions of the watershed (55%). The NACOG represents the Navajo, Coconino, and Apache counties (33% of the watershed). The MAG represents the Maricopa County portion, or 7% of the watershed. The SEAGO represents the Graham and Greenlee portions (6% of the watershed).

Table 4-1: Salt Watershed, Percent of Subwatershed by County (part 1 of 2)

Subwatershed and HUC Salt Watershed	Area (sq. mi.)	Apache	Coconino	Gila	Graham	Greenlee
Black River H15060101	1,251	51%	-	14%	17%	12%
White River H15060102	638	56%	-	19%	-	-
Upper Salt River H15060103	2,152	-	0.8%	81%	-	-
Carrizo Creek H15060104	709	0.4%	-	31%	-	-
Tonto Creek H15060105	1,048	-	1%	99%	-	-
Lower Salt River H15060106A	445	-	-	4%	-	-
Total Salt River Watershed	6,243	16%	0.4%	53%	3%	2%

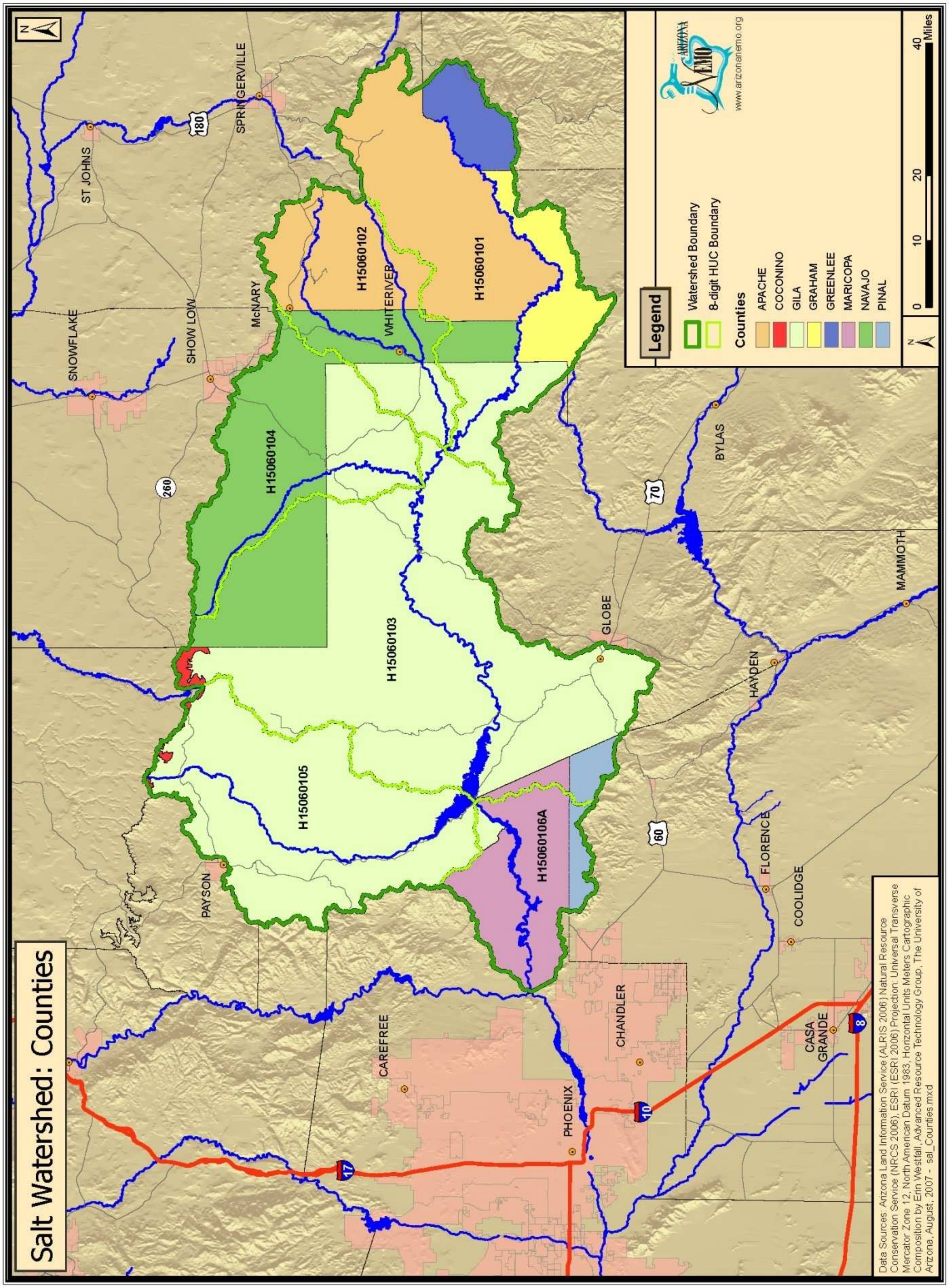

Figure 4-1: Counties

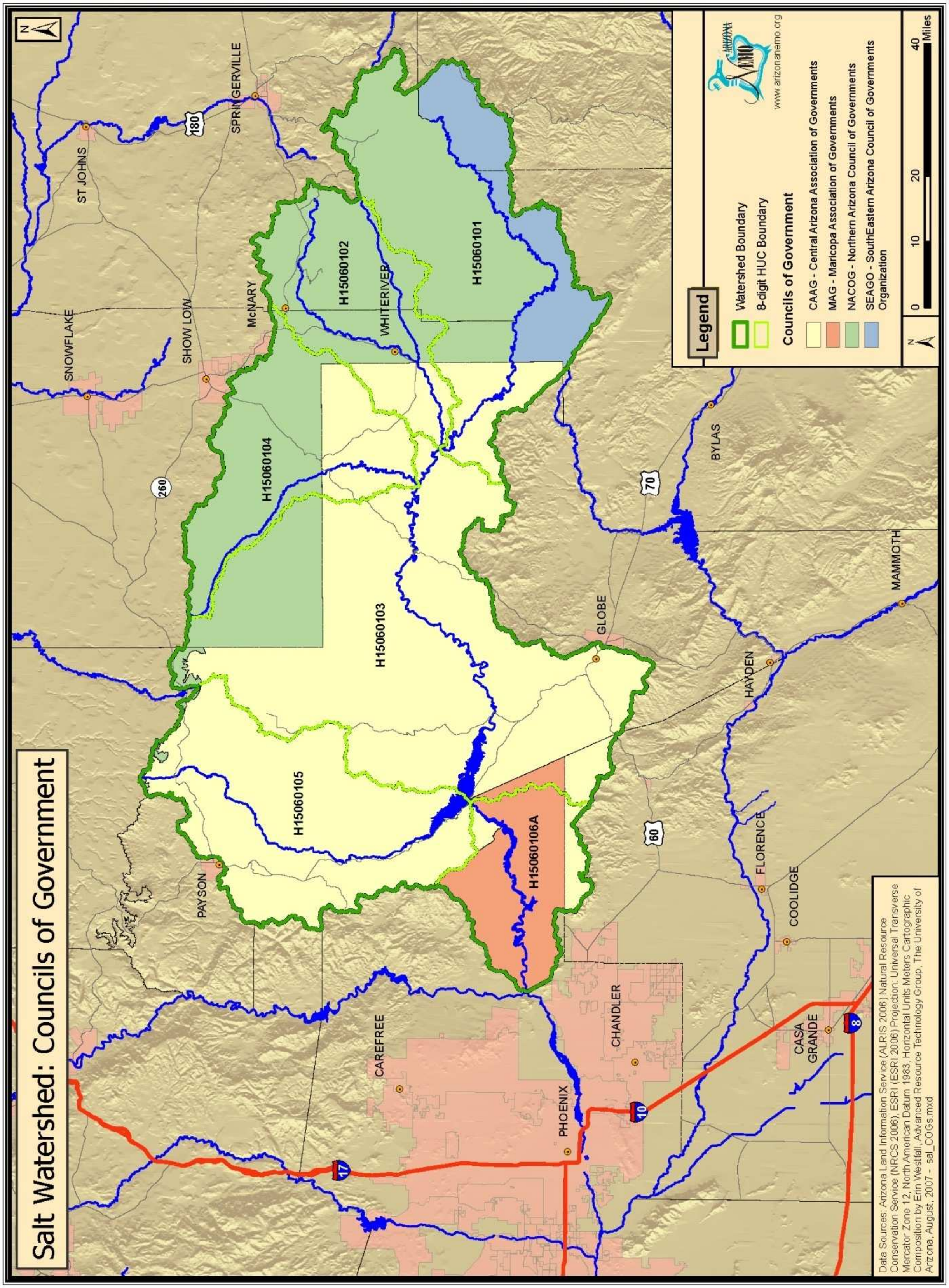

Figure 4-2: Councils of Government

Table 4-1: Salt Watershed, Percent of Subwatershed by County (part 2 of 2)

Subwatershed and HUC Salt Watershed	Area (sq. mi.)	Maricopa	Navajo	Pinal
Black River H15060101	1,251	-	6%	-
White River H15060102	638	-	25%	-
Upper Salt River H15060103	2,152	2%	15%	2%
Carrizo Creek H15060104	709	-	69%	-
Tonto Creek H15060105	1,048	>0.00%	-	-
Lower Salt River H15060106A	445	85%	-	11%
Total Salt Watershed	6,243	7%	17%	2%

Table 4-2: Salt Watershed Councils of Governments, Percent by Subwatershed

Subwatershed Name and HUC	Councils Of Governments			
	CAAG[1]	MAG[2]	NACOG[3]	SEAGO[4]
Black River H15060101	29%	-	12%	59%
White River H15060102	19%	-	81	-
Upper Salt River H15060103	83%	2%	15%	-
Carrizo Creek H15060104	31%	-	69%	-
Tonto Creek H15060104	99%	0.04%	0.96	-
Lower Salt River H15060106A	15%	85%	-	-
Total Salt River Watershed	55%	7%	33%	6%

1 Central Arizona Association of Governments
2 Maricopa Association of Governments
3 Northern Arizona Council of Governments
4 SouthEastern Arizona Governments Organization

Urban Areas

The U.S. Census Bureau categorizes various types of population centers based on population figures and density. Densely settled territory that contains 50,000 or more people is defined as an urban area (www.census.gov/geo/www/geo_defn.html). Based on that definition and Census Bureau data, there are no major urban areas that lie within the Salt Watershed, as defined by ADEQ (Figure 4-3).

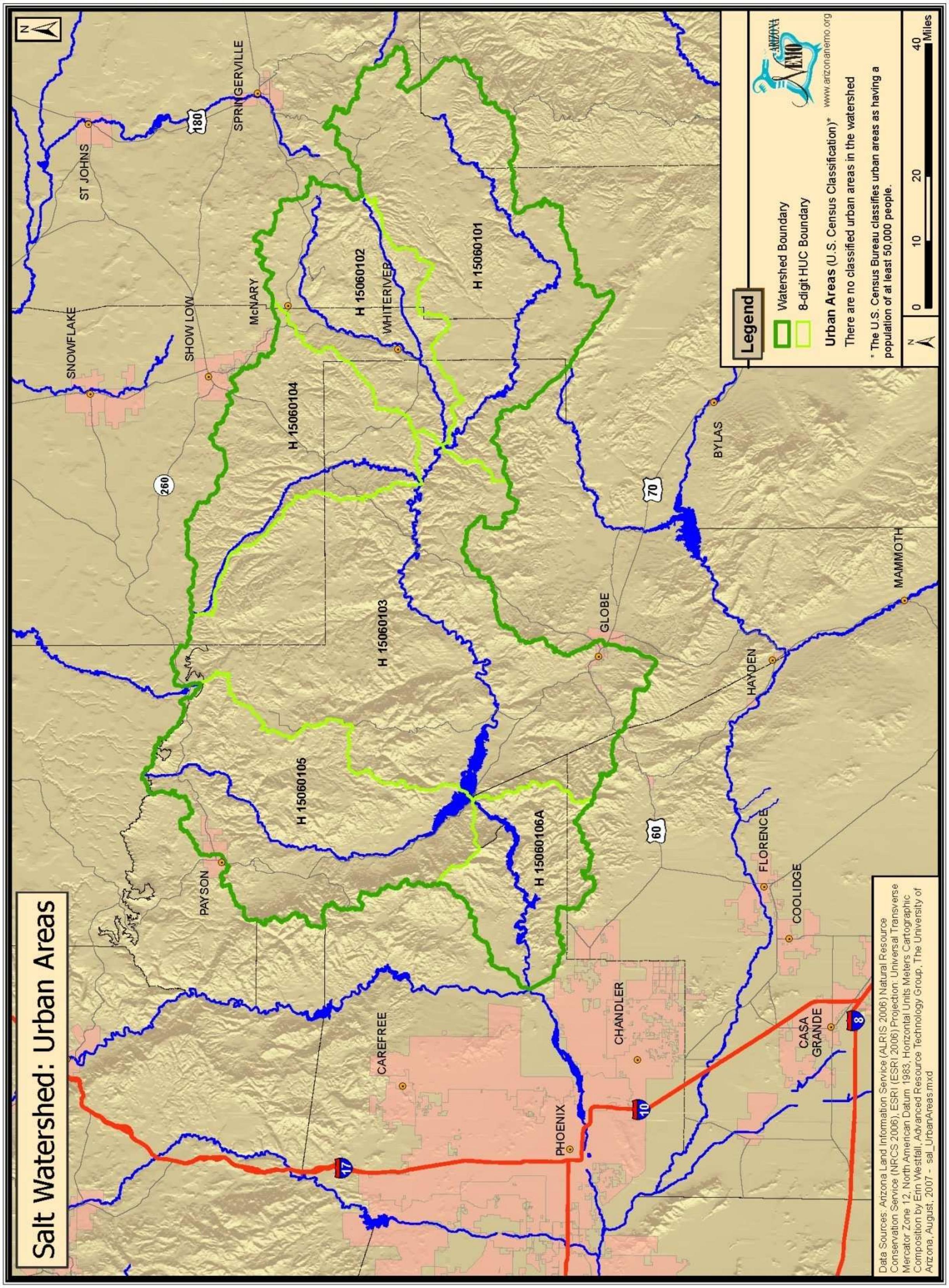

Figure 4-3: Urban Areas

Population

Census Population Densities in 1990

Census block statistics for 1990 were compiled from a CD prepared by Geo-Lytics (Geo-Lytics, 1998). These data were linked with census block data and a normalization process using a grid composed of 1 square mile cells was used to create a density map (Figure 4-4). This process involves calculating density per census block and intersecting it with the grid, which is then used to calculate the number of people and thus density per grid square.

Table 4-3 shows the tabulated minimum, maximum and mean number of persons per square mile in 1990 for each subwatershed. In 1990, the mean population density for the entire watershed was 5 persons per square mile. The White River subwatershed had the highest population density with an average of 12 persons per square mile, and a maximum of 638. The sparsely populated Black River subwatershed had an average of only 0.1 persons per square mile.

Table 4-3: Salt Watershed 1990 Population Density (persons/square mile).

Sub-watershed Name	Area (sq. miles)	Min	Max	Mean
Black River H15060101	1,251	0	29	0.1
White River H15060102	638	0	638	12
Upper Salt River H15060103	2,152	0	2,434	9
Carrizo Creek H15060104	709	0	160	2
Tonto Creek H15060105	1,048	0	441	5
Lower Salt River H15060106A	445	0	15	0.2
Total Salt River Watershed	6,243	0	2,434	5

Note: Adjacent watersheds may share a grid square.

Census Population Densities in 2000

The Census Block 2000 statistics data were downloaded from the Environmental Systems Research Institute (ESRI) website (ESRI Data Products, 2003) and are shown in Table 4-4. A population density map (Figure 4-5) was created from these data. The average population density in 2000 was 6 persons per acre. The White River subwatershed had the highest population density with 14 average persons per square mile. The Black River had the lowest average density with 0.3 persons per square mile.

Population Change

The 1990 and 2000 population density maps were used to create a population density change map. The resulting map (Figure 4-6) shows population increase or decrease over the ten year time frame. Overall, population density increased by an average of 1 person per square mile during this ten year time period. The subwatersheds all had increases in average population. Table 4-5 shows the change in population density from 1990 to 2000 in persons per square mile. The Tonto Creek subwatershed experienced the most growth with an average increase

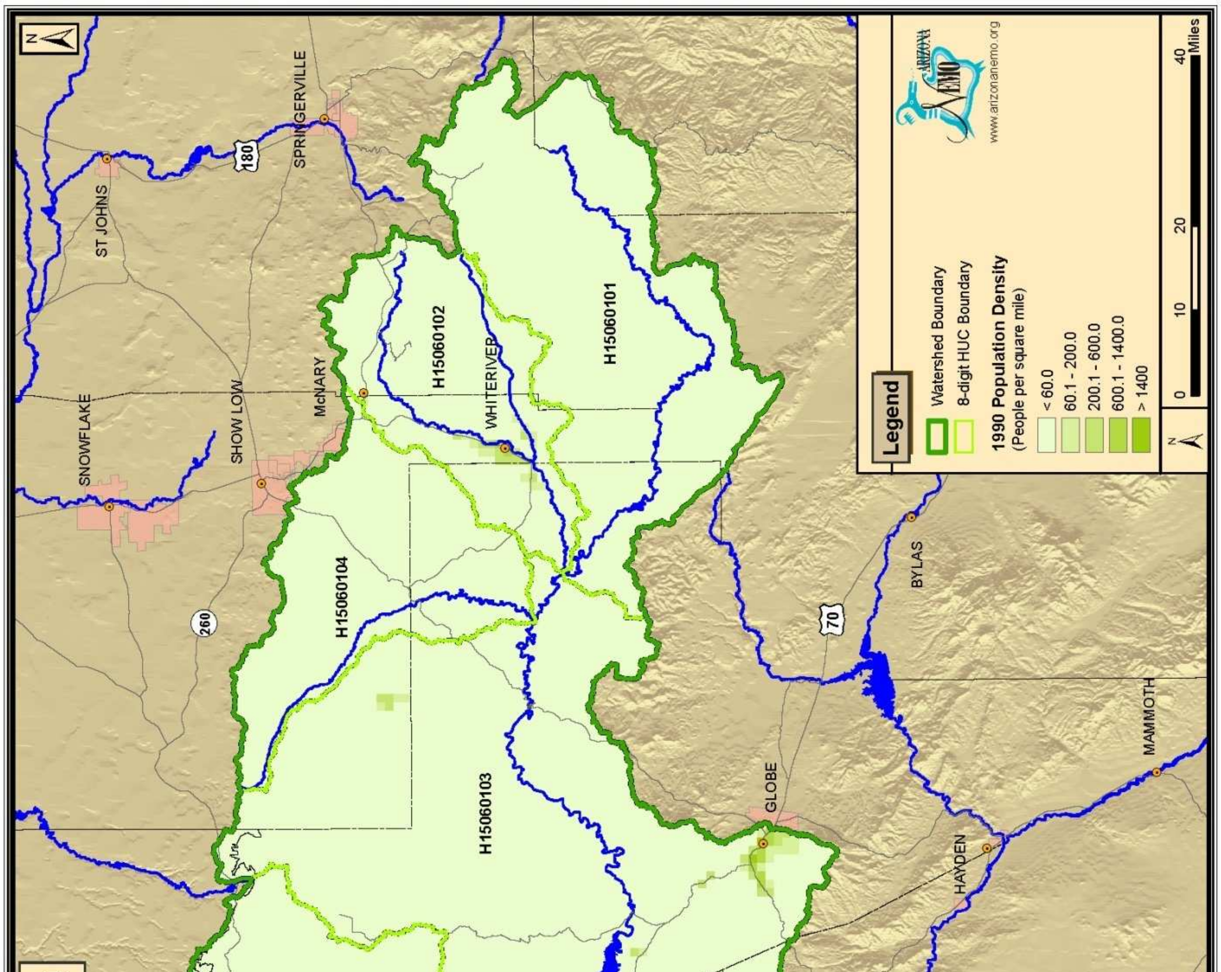

Figure 4-4: Population Density 1990

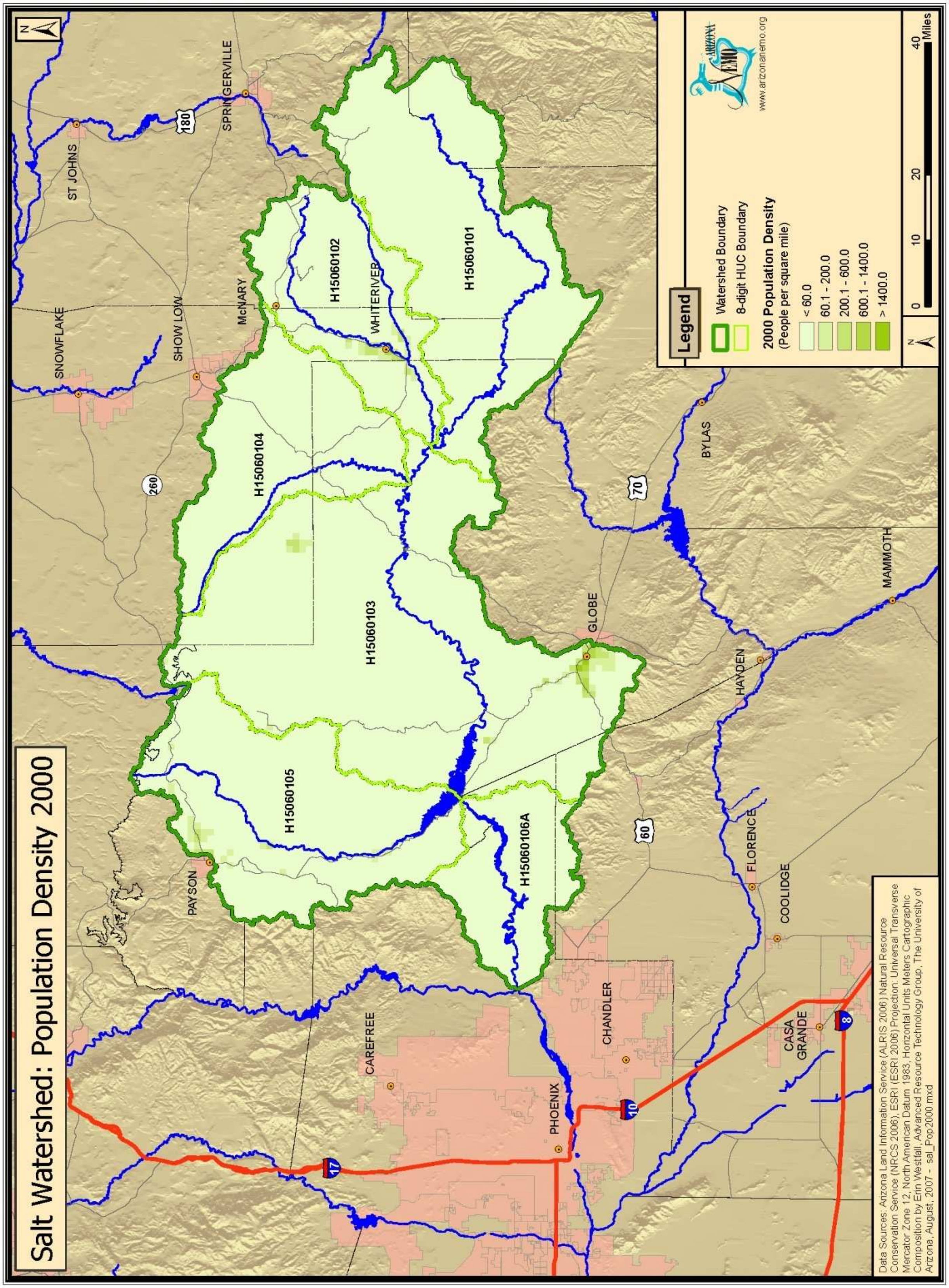

Figure 4-5: Population Density 2000

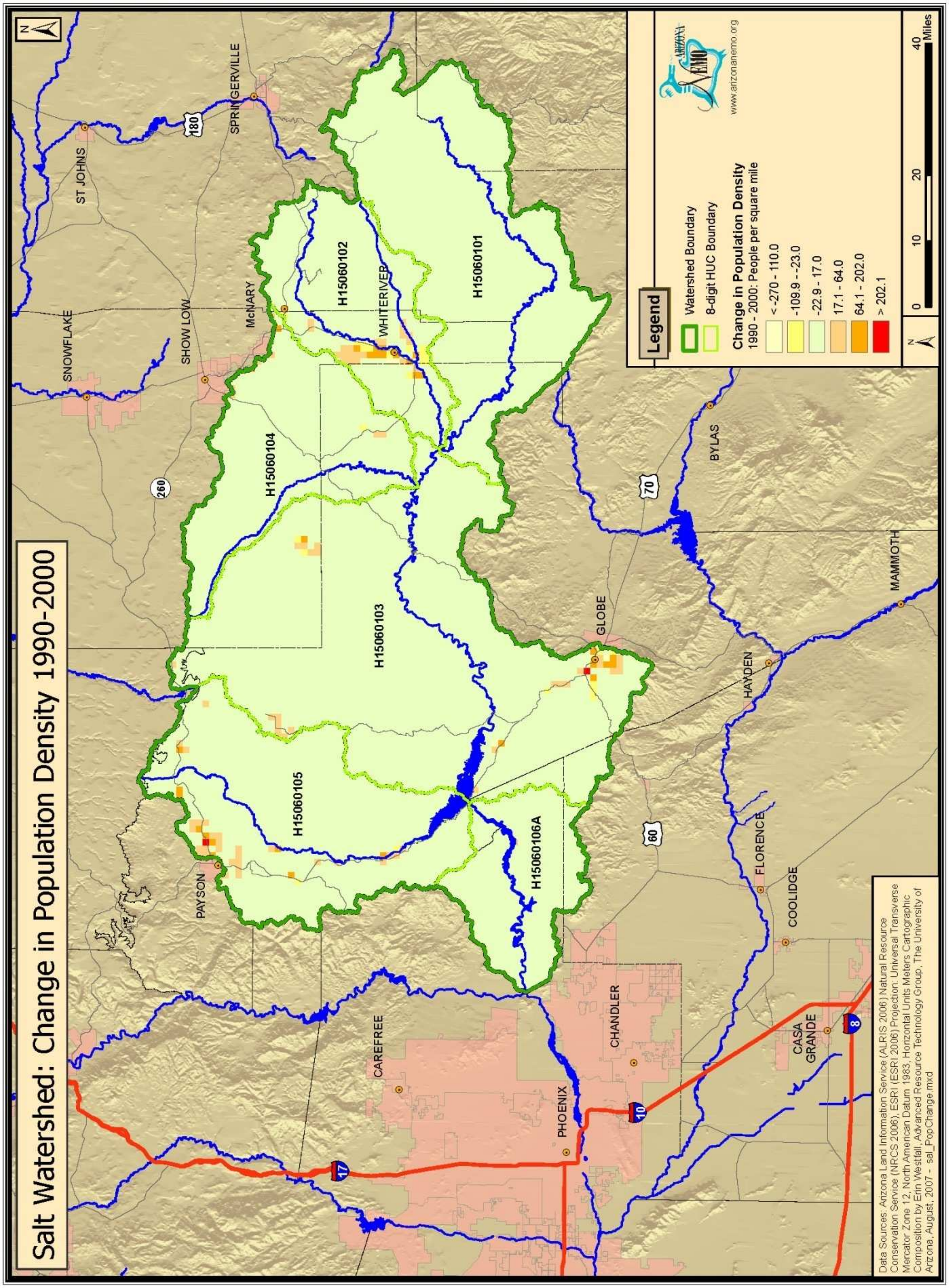

Figure 4-6: Change in Population Density 1990-2000

of 3 persons per square mile. The Black River subwatershed had the smallest increase in population density with an increase of only 0.1 persons per square mile.

Table 4-4: Salt Watershed 2000 Population Density (persons/square mile).

Sub-watershed Name	Area (sq. miles)	Min	Max	Mean
Black River H15060101	1,251	0	11	0.3
White River H15060102	638	0	794	14
Upper Salt River H15060103	2,152	0	2,302	9
Carrizo Creek H15060104	709	0	256	3
Tonto Creek H15060105	1,048	0	813	7
Lower Salt River H15060106A	445	0	18	0.2
Total Salt River Watershed	6,243	0	2,302	6

Note: Adjacent watersheds may share a grid square.

Housing Density, 2000 and 2030

The Watershed Housing Density Map for the years 2000 and 2030 were created with data developed by David M. Theobald (Theobald, 2005). Theobald created a nationwide housing density model that incorporates a thorough way to account for land-use change beyond the "urban fringe."
Exurban regions are the "urban fringe", or areas outside suburban areas, having population densities greater than 0.68 – 16.18 ha (1.68 – 40 acres) per unit. Theobald stresses that exurban areas are increasing at a much faster rate than urban sprawl, are consuming much more land, and are having a greater impact on ecological health, habitat fragmentation and other resource concerns.

Table 4-5: Salt Watershed Population Density Change 1990-2000 (persons/square mile).

Sub-watershed Name	Area (sq. miles)	Min	Max	Mean
Black River H15060101	1,251	-27	10	0.1
White River H15060102	638	-269	202	2
Upper Salt River H15060103	2,152	-174	431	0.5
Carrizo Creek H15060104	709	-80	101	1
Tonto Creek H15060105	1,048	-55	389	3
Lower Salt River H15060106A	445	-12	18	0.01
Total Salt River Watershed	6,243	-270	431	1

Note: Adjacent watersheds may share a grid square.

Theobald estimates that the exurban density class has increased at a much faster rate than the urban/suburban density classes. Theobald's model forecasts that this trend will continue and may even accelerate by 2030. This indicates that development patterns are shifting more towards exurban, lower density, housing units, and are thereby consuming more land. He suggests that exurban development has a greater overall effect on natural resources because of the larger footprint and disturbance zone, a higher percent of impervious surfaces, and higher pollution because of more vehicle miles traveled to work and shopping.

Figure 4-7 and Table 4-6 Salt Watershed Housing Density for 2000, identifies that 47% of housing is located in "undeveloped private" areas, while 0.9% is located in "exurban" areas. Figure 4-8 and Table 4-7 Housing Density for 2030, projects "undeveloped private" areas remained the same and "exurban" areas increasing to 4.0%.

Table 4-6: Salt Watershed 2000 Housing Density (Percent of Watershed) (part 1 of 2).*

Housing Density	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo River H15060104	Tonto River H15060105
Undeveloped Private	68%	79%	42%	93%	0.6%
Rural	3%	15%	1%	6%	0.4%
Exurban	0.02%	3%	1%	0.3%	1%
Suburban	-	0.2%	0.2%	0.01%	0.2%
Urban	-	0.05%	0.1%	>0.00%	0.06%

** These figures report the percent of the watershed that contains housing density data, and does not take into account null values. Some areas of the watershed do not contain data due to the modeling techniques utilized by the creator of the data.*
Data Sources: Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art32/

Table 4-6: Salt Watershed 2000 Housing Density (Percent of Watershed) (part 2 of 2).*

Housing Density	Lower Salt River H15060106A	Salt River Watershed
Undeveloped Private	0.3%	47%
Rural	1%	3%
Exurban	> 0.0%	0.9%
Suburban	-	0.1%
Urban	-	0.05%

** These figures report the percent of the watershed that contains housing density data, and does not take into account null values. Some areas of the watershed do not contain data due to the modeling techniques utilized by the creator of the data.*
Data Sources: Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art32/

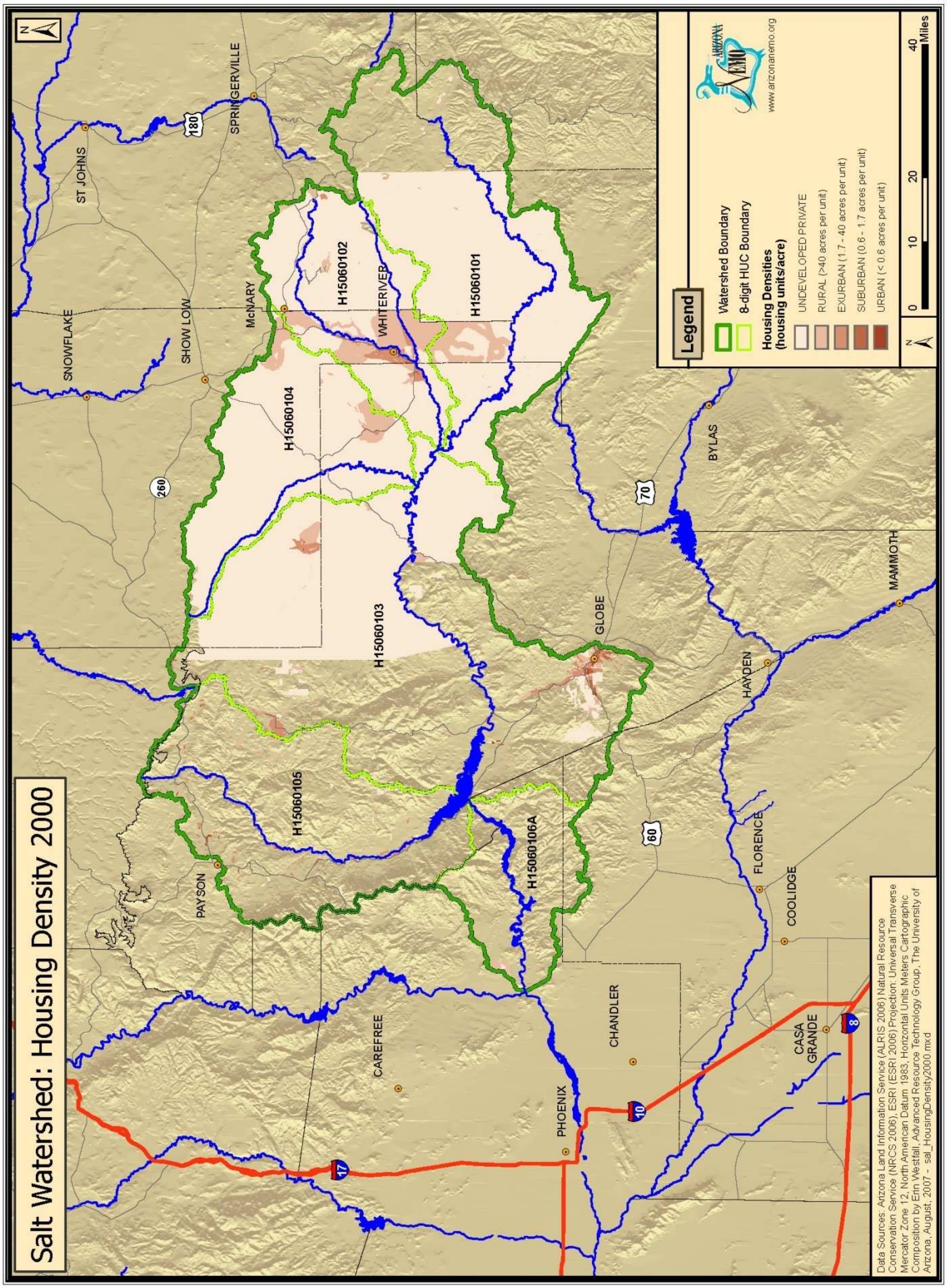

Figure 4-7: Housing Density 2000

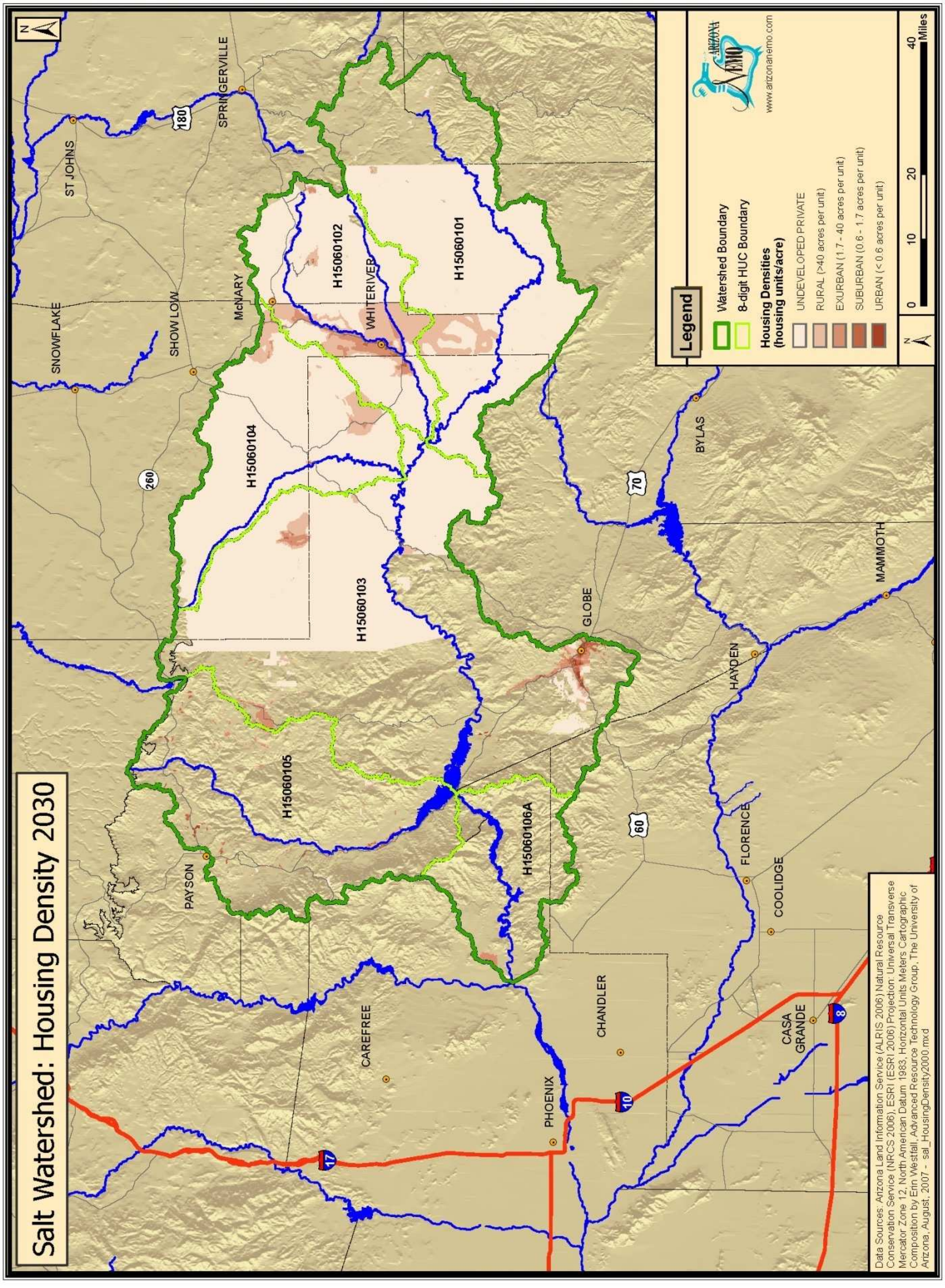

Figure 4-8: Housing Density 2030

Table 4-7: Salt Watershed 2030 Housing Density (Percent of Watershed) (part 1 of 2).*

Housing Density	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo River H15060104	Tonto River H15060105
Undeveloped Private	68%	78%	72%	92%	0.4%
Rural	4%	16%	1%	6%	0.4%
Exurban	0.03%	5%	1%	0.4%	0.9%
Suburban	-	0.3%	0.4%	0.03%	0.5%
Urban	-	0.06%	0.1%	>0.00%	0.1%

** These figures report the percent of the watershed that contains housing density data, and does not take into account null values. Some areas of the watershed do not contain data due to the modeling techniques utilized by the creator of the data.*
Data Sources: Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1): 32. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art32/

Table 4-7: Salt Watershed 2030 Housing Density (Percent of Watershed) (part 2 of 2).*

Housing Density	Lower Salt River H15060106 A	Salt Watershed
Undeveloped Private	0.2%	47%
Rural	0.07%	4%
Exurban	0.9%	1%
Suburban	-	0.2%
Urban	-	0.06%

** These figures report the percent of the watershed that contains housing density data, and does not take into account null values. Some areas of the watershed do not contain data due to the modeling techniques utilized by the creator of the data.*
Data Sources: Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and 10(1): 32. [online] URL: http://www.ecologyandsociety.org/vol10/iss1/art32/

Roads

Roads are important to consider in a watershed classification because they can impact water quality by increasing runoff and, especially in construction areas or where the roads are unpaved, can increase sediment yield.

The total road length in the Salt Watershed is 1,033 miles (Table 4-8). The predominant road type, based on the Census Classification, is "unimproved road" with 555 miles, or 54% of the total roads length. The Upper Salt River subwatershed has the greatest accumulated length of roads with 303 miles, or 24% of the total roads length. Table 4-9 lists road types and lengths in each subwatershed. Figure 4-9 shows the road types.

Table 4-8: Salt Watershed Road Types

Census Classification Code Salt Watershed	Road Length (miles)	Percent of Total Length
Interstate	-	-
U.S. and State Whys	371	36%
County Roads	107	10%
Unimproved Roads	555	54%
Total Road Length (miles)	1,033	100%

Table 4-9: Salt Watershed Road Lengths by Subwatershed

Subwatershed Name	Road Length (miles)	Percent of Total Length
Black River H15060101	291	23%
White River H15060102	126	11%
Upper Salt River H15060103	303	24%
Carrizo Creek H15060104	84	7%
Tonto Creek H15060105	166	13%
Lower Salt River H15060106A	63	6%
Total Salt River Watershed	1,033	100%

<u>Mines</u>

There are 590 mineral extraction mines recorded with the Office of the Arizona State Mine Inspector in the Salt Watershed. The Upper Salt River subwatershed has the highest number of mines (381), while the Carrizo Creek subwatershed has only 10 mines.

There are ten different types of mines reported (including "unknown"), of which 163 (28%) are prospect and 158 (27%) are underground mines (Table 4-10 and Figure 4-10).

Mine activity status is shown in Table 4-11 and Figure 4-11, listing seven different types of mines ranging from active to inactive production, or unknown status. The highest number of mine types are 217 (37%) mines listed as "past producer" and 187 (32%) listed as "explored prospect".

Table 4-12 and Figure 4-12 show the types of ores being mined in the Salt watershed. The most common ore types are copper, asbestos, sand, uranium, gold and iron. Ten percent of all mines have an "unknown" ore type.

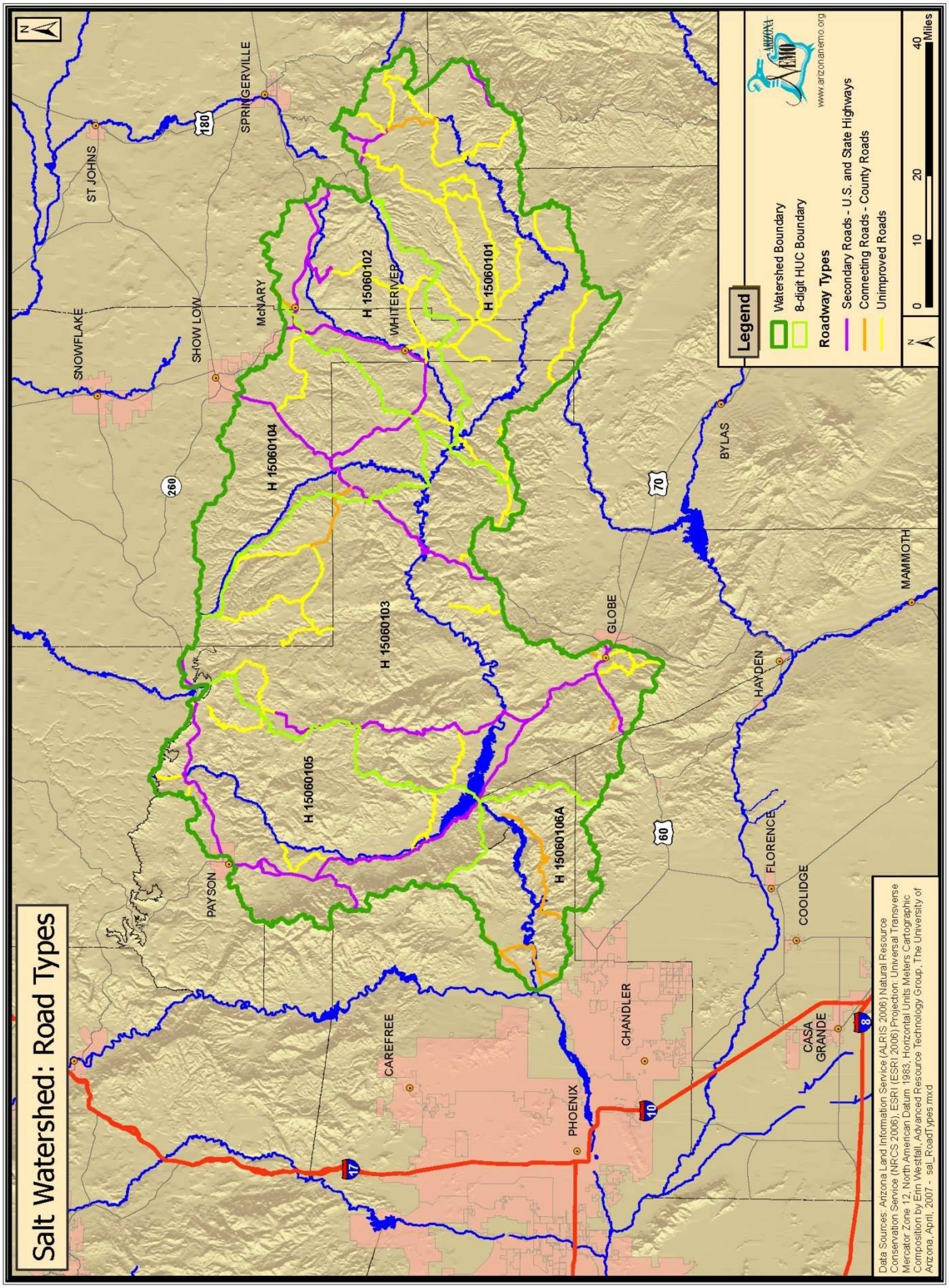

Figure 4-9: Road Types

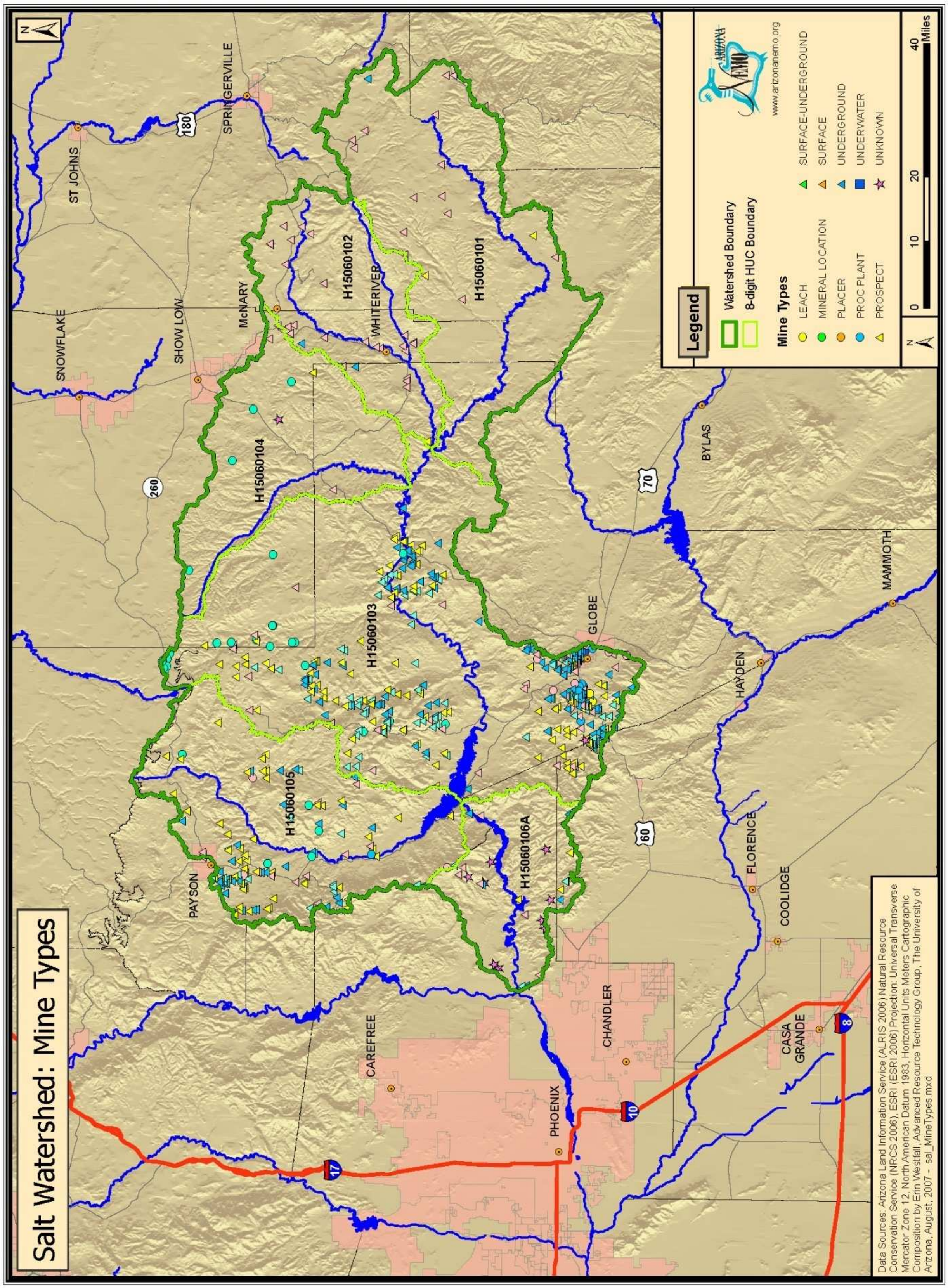

Figure 4-10: Mine Types

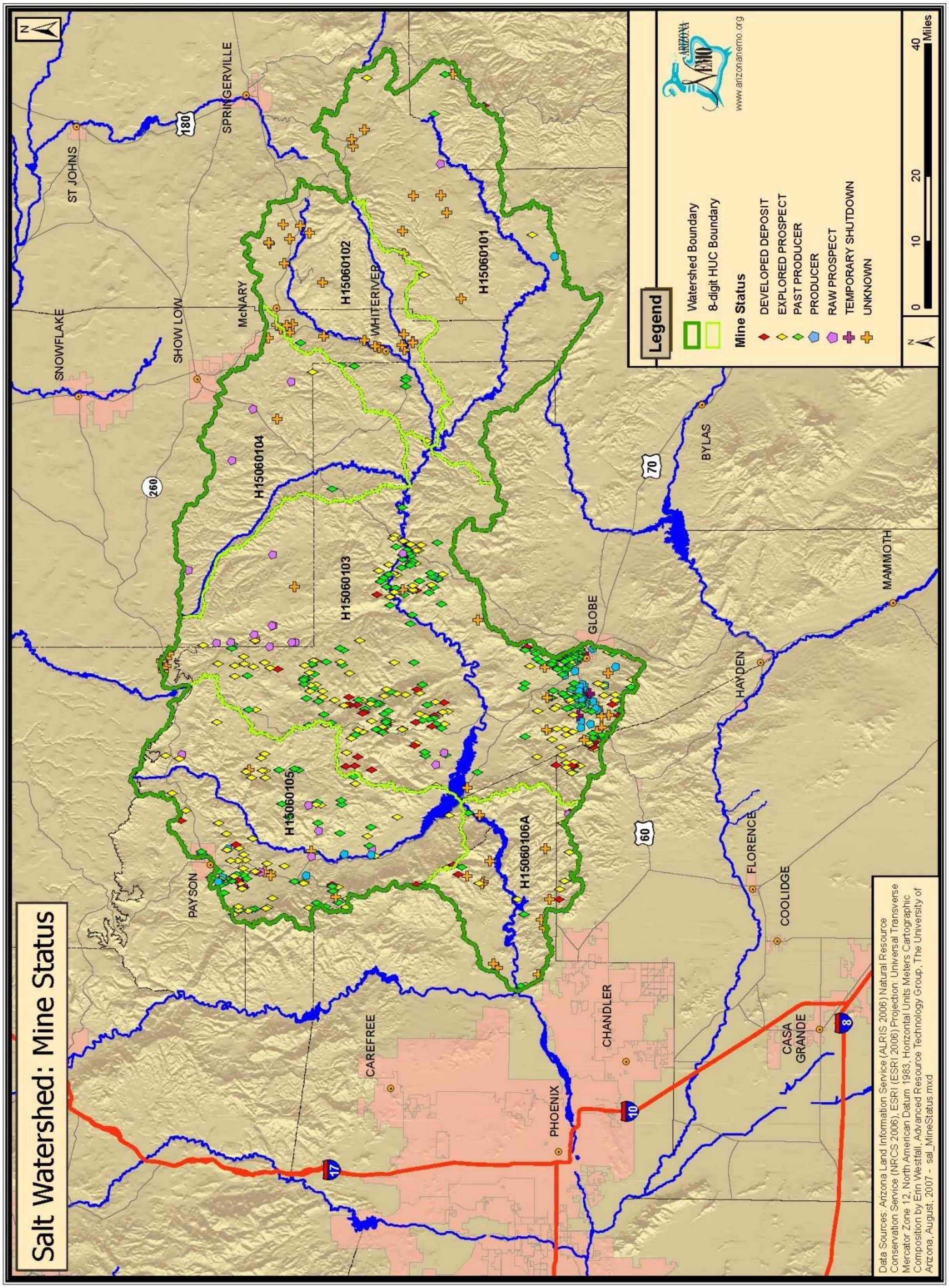

Figure 4-11: Mine Status

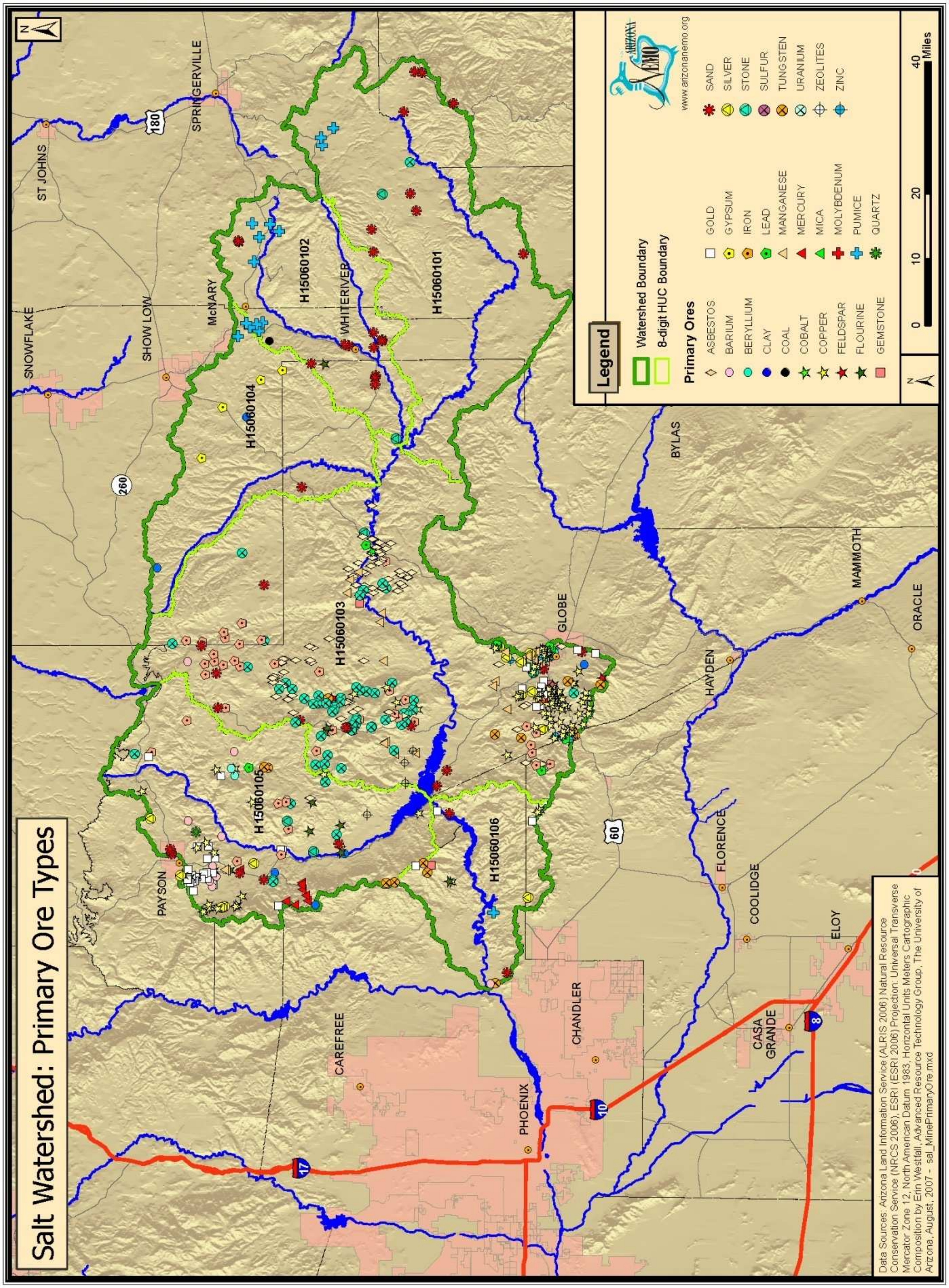

Figure 4-12: Primary Ore Types

Table 4-10: Salt Watershed Mine Types (part 1 of 2).

Mine Types	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104	Tonto Creek H15060105
Leach	-	-	3	-	-
Mineral Locatable	-	-	21	4	5
Placer	-	-	6	-	3
Processing Plant	-	-	12	-	1
Prospect	2	1	103	1	51
Surface/Underground	-	-	72	-	17
Surface	14	25	48	4	13
Underground	1	2	114	-	36
Underwater	-	-	1	-	-
Unknown	-	-	1	1	-
Total Mines	17	28	381	10	126

Table 4-10: Salt Watershed Mine Types (part 2 of 2).

Mine Types	Lower Salt River H15060106A	Salt Watershed
Leach	-	3
Mineral Locatable	-	30
Placer	-	9
Processing Plant	-	13
Prospect	5	163
Surface/Underground	3	92
Surface	6	110
Underground	5	158
Underwater	-	1
Unknown	9	11
Total Mines	28	590

Table 4-11: Salt Watershed Mine Status (part 1 of 2).

Mine Types	**Black River H15060101**	**White River H15060102**	**Upper Salt River H15060103**	**Carrizo Creek H15060104**	**Tonto Creek H15060105**
Developed Deposit	1	-	32	-	7
Explored Prospect	3	1	118	1	56
Past Producer	2	6	160	1	44
Producer	1	-	32	-	6
Raw Prospect	1	-	13	4	6
Temporary Shutdown	-	-	4	-	1
Unknown	9	21	22	4	6
Total Mines	*17*	*28*	*381*	*10*	*126*

Table 4-11: Salt Watershed Mine Status (part 2 of 2).

Mine Types	**Lower Salt River H15060106A**	**Salt Watershed**
Developed Deposit	3	43
Explored Prospect	8	187
Past Producer	4	217
Producer	-	39
Raw Prospect	1	25
Temporary Shutdown	-	5
Unknown	12	74
Total Mines	28	590

Table 4-12: Salt Watershed Mines – Ore Type.

Ore Type	Total Number of Mines	Ore Type	Total Number of Mines
Asbestos	84	Mercury	8
Barium	10	Mica	0
Beryllium	2	Molybdenum	1
Clay	6	Pumice	15
Coal	1	Quartz	1
Cobalt	1	Sand	42
Copper	109	Silver	14
Feldspar	2	Stone	8
Flourine	11	Sulfur	1
Gemstone	3	Talc	0
Gold	42	Tungsten	16
Gypsum	4	Unknown	60
Iron	41	Uranium	59
Lead	8	Zeolites	5
Manganese	30	Zinc	6

Note: If a mine contains more than one ore, only the major ore is noted.

Land Use

The land use classifications were determined utilizing the Southwest Regional GAP Vegetation data (Lowry et. Al, 2005). The Southwest Regional GAP classification contains 40 different land cover categories; however, these categories were consolidated into five land use types (Figure 4-13 and Table 4-13). The five groupings for the land use categories are:

1. *Agriculture*: Cropland.
2. *Forest*: Forest land.
3. *Rangeland*: Herbaceous rangeland; Mixed rangeland; Shrub and brush rangeland.
4. *Urban*: Mixed urban or built-up land; Other urban or built-up land; Strip mines quarries and gravel pits; Transportation, communication and utilities.
5. *Water*: No change in category.

The most common land cover type is Range which makes up 59% of the Salt Watershed. Forest land is the next most common type with 40% of the total area.

Land Ownership

In the Salt Watershed, there are 8 different land ownership entities (Figure 4-14 and Table 4-14). Indian reservations are the largest land owners, representing 50% of the watershed. The Forest Service is the next most significant land owner representing 48% of the watershed.

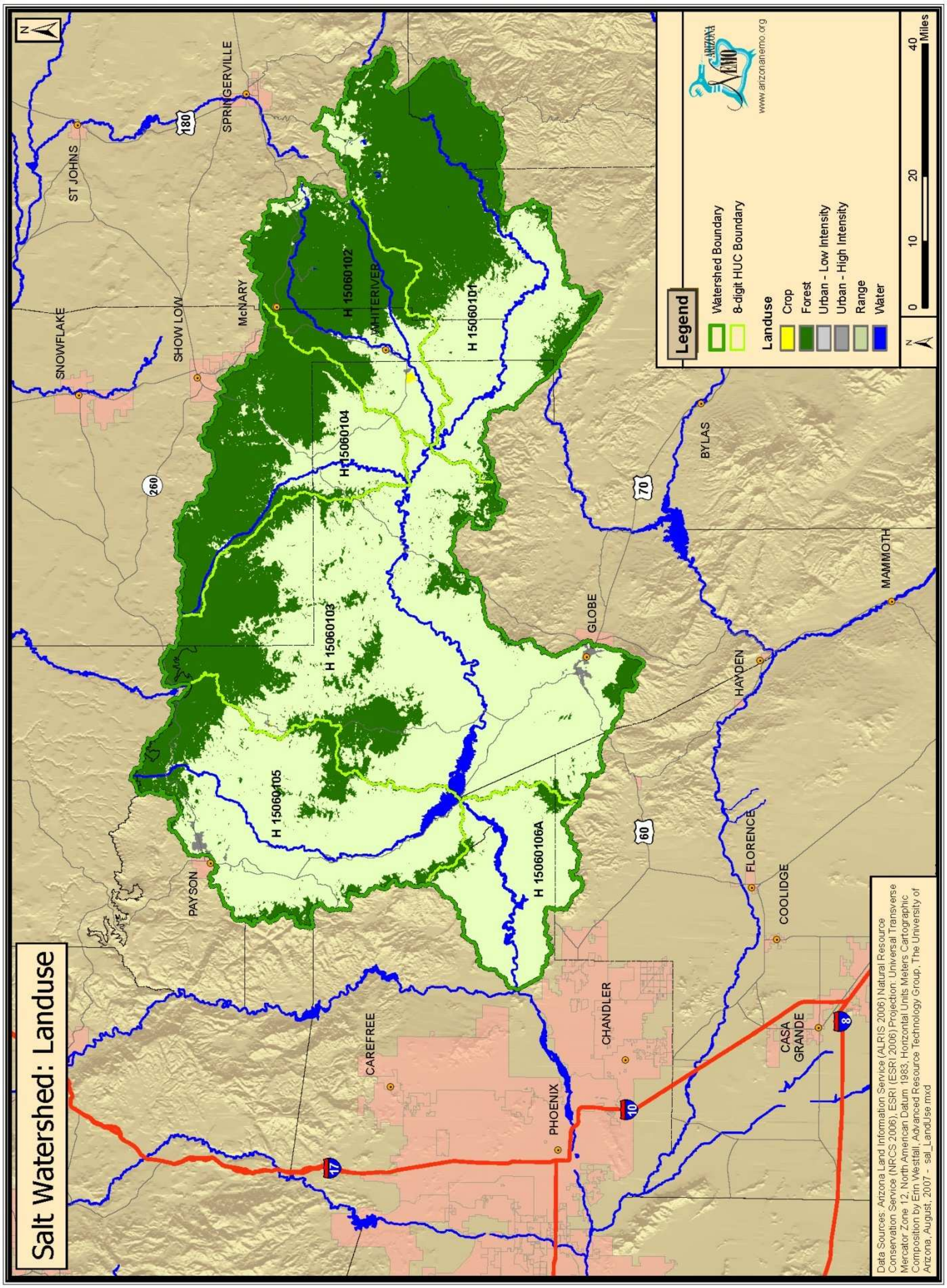

Figure 4-13: Land Use

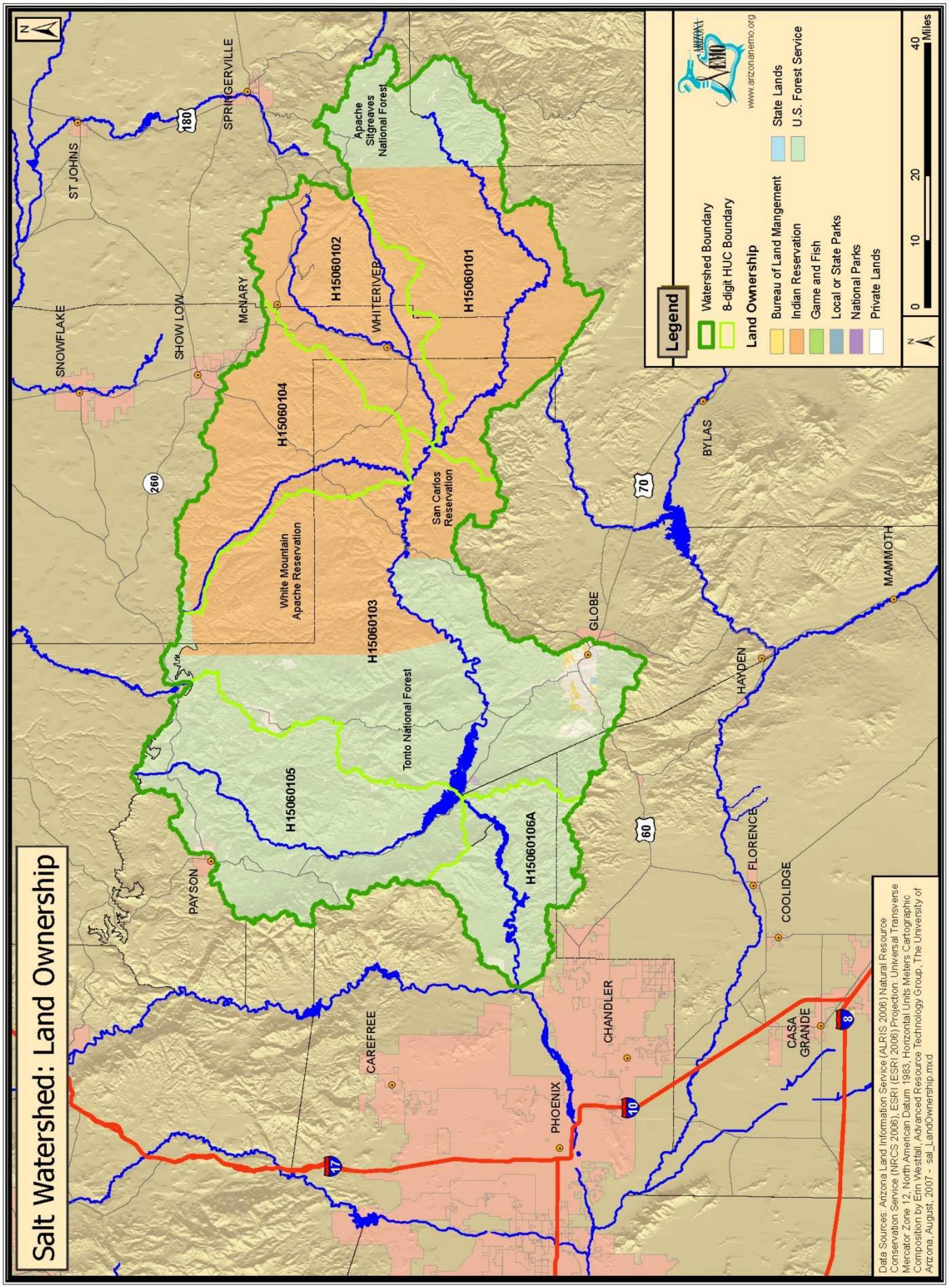

Figure 4-14: Land Ownership

Special Areas

Preserves:

Preserves listed here are part of the Arizona Preserve Initiative (API). The API was passed by the Arizona State Legislature as HB 2555 and signed into law by the Governor in the spring of 1996. It is designed to encourage the preservation of select parcels of state Trust land in and around urban areas for open space to benefit future generations. The law lays out a process by which Trust land can be leased for up to 50 years or sold for conservation purposes. Leases and sales must both occur at a public auction (http://www.land.state.az.us/programs/operations/api.htm).

Figure 4-15 shows the boundaries of the preserve lands within the Salt Watershed. The State Trust lands within these 119 square miles or 76,033 acres are eligible for conservation purposes. Table 4-15 show the API areas for each subwatershed.

Wilderness Areas:

There are 10 different Wilderness Areas within the Salt Watershed. Table 4-16 lists each one and the acreage in each subwatershed. Figure 4-16 shows where each wilderness area is located.

There are a total of 331,766 acres (519 square miles) of wilderness in the Salt Watershed, or approximately 8% of the watershed. The largest wilderness area is the Superstition Wilderness Area with 136,461 acres, located within the Lower and Upper Salt River subwatersheds.

Golf Courses:

There are no mapped golf courses within the Salt Watershed. Additional golf courses may exist in the Salt watershed that were not included in the 2001 GIS data layer used in this analysis (ESRI Data and Maps, 2003).

Table 4-13: Salt Watershed Land Use (part 1 of 2).

Land Cover	**Black River H15060101**	**White River H15060102**	**Upper Salt River H15060103**	**Carrizo Creek H15060104**	**Tonto Creek H15060105**
Agriculture	-	0.3%	0.01%	-	0.02%
Forest	58%	70%	28%	66%	25%
Range	42%	29%	71%	34%	74%
Urban	-	0.5%	0.6%	0.04%	0.8%
Water	0.1%	0.2%	0.4%	>0.00%	0.6%
Total Area (square miles)	1,251	638	2,152	709	1,048

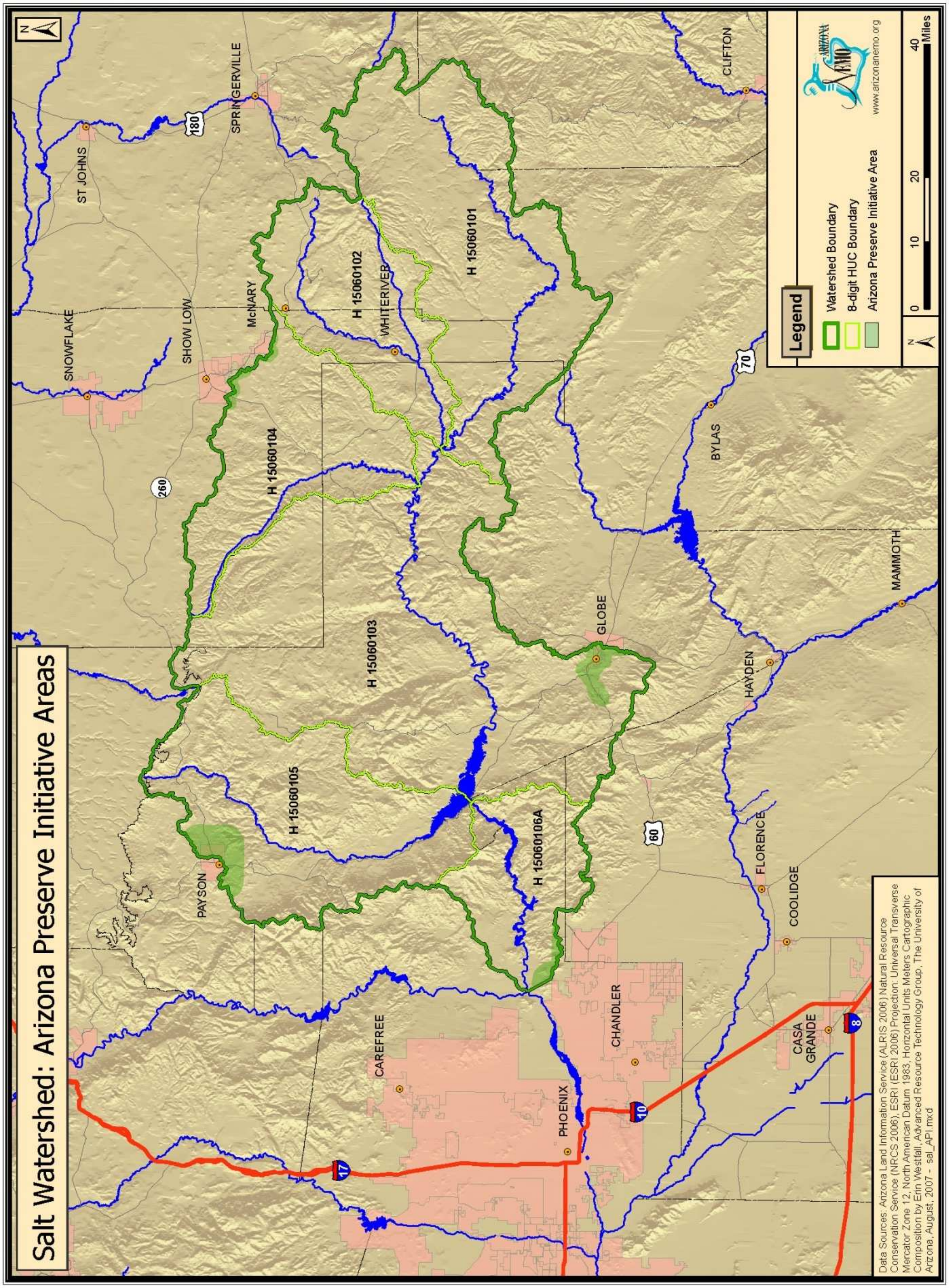

Figure 4-15: Arizona Preserve Initiative Areas

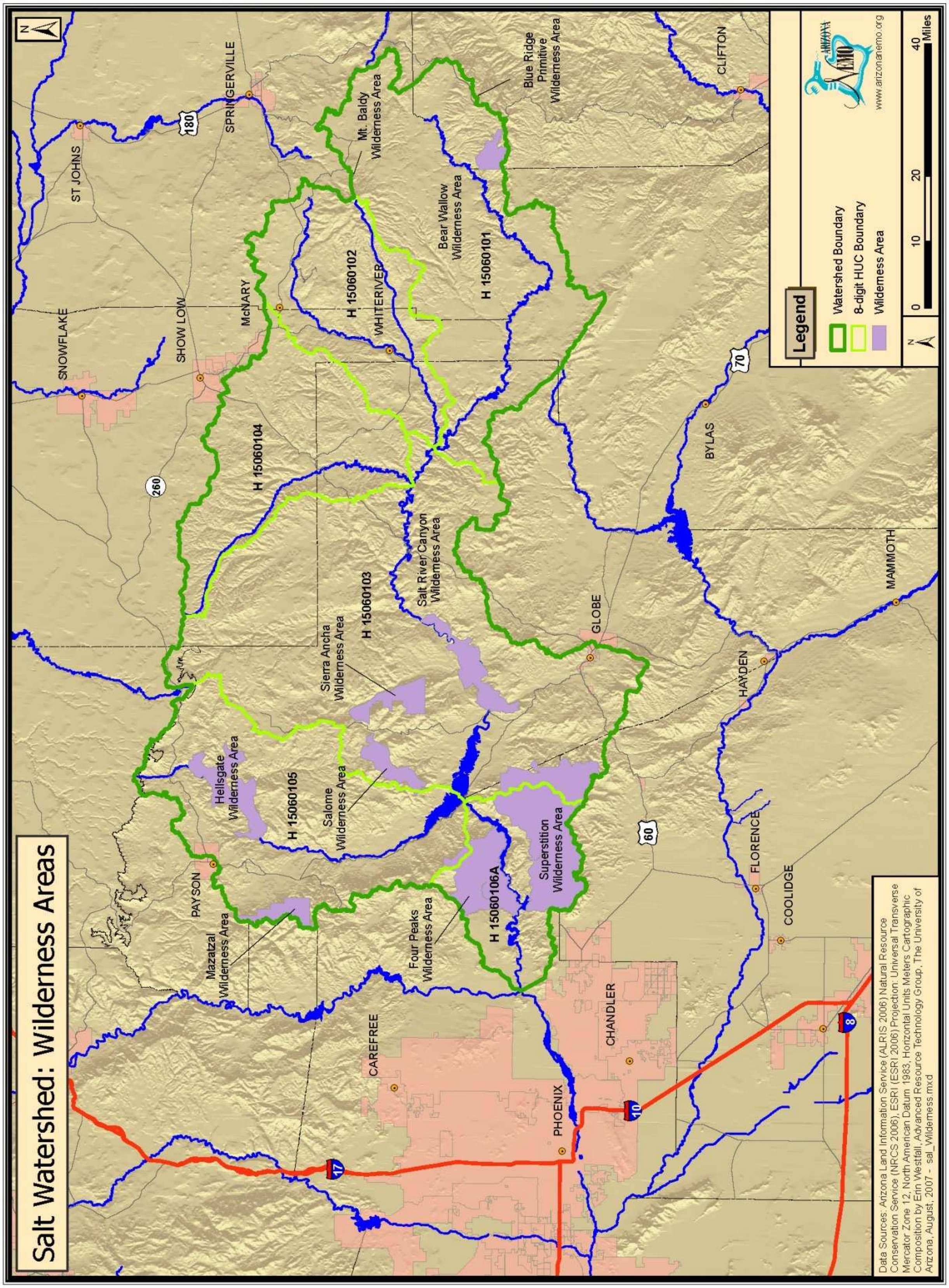

Figure 4-16: Wilderness Areas

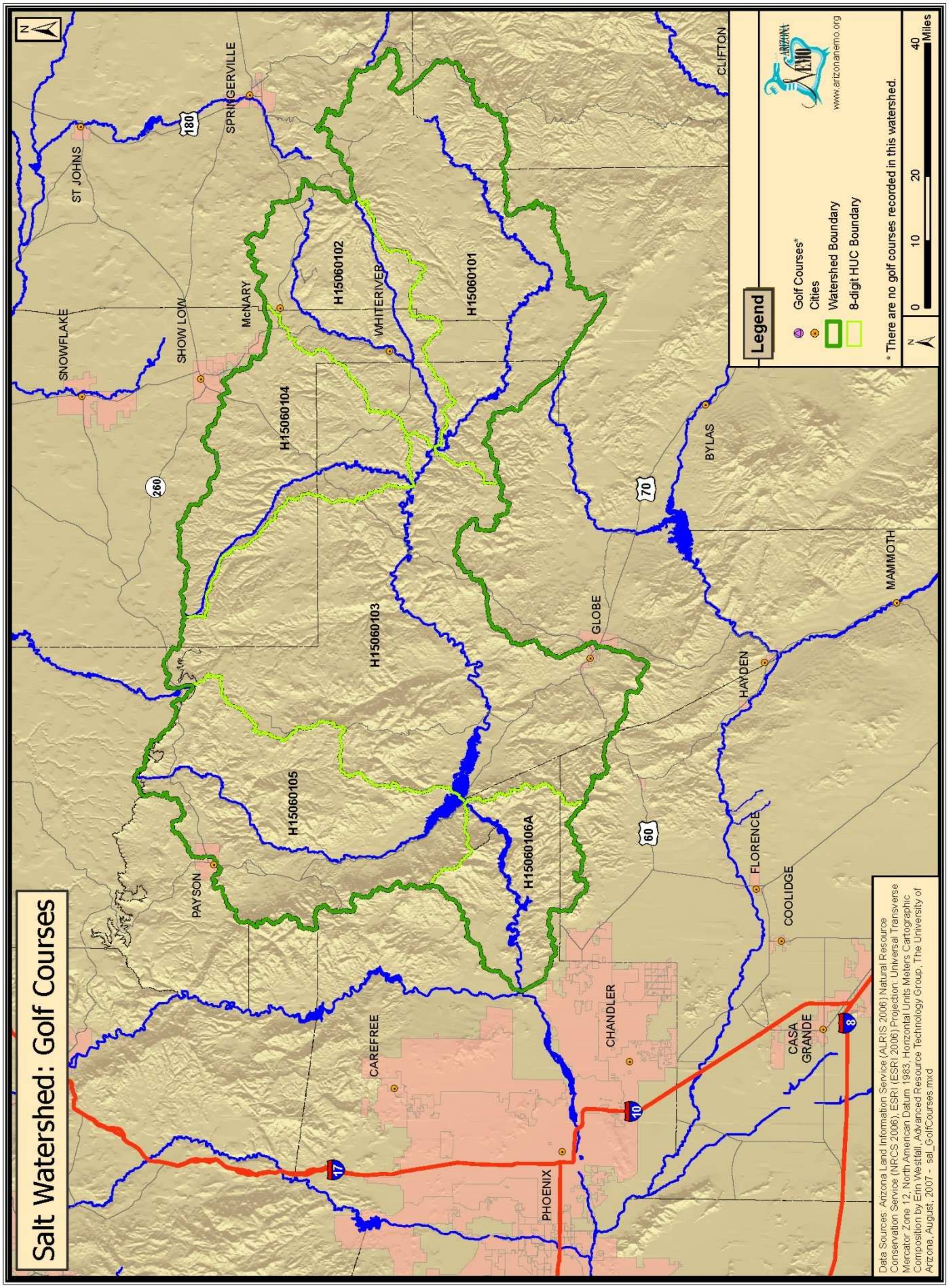

Figure 4-17: Golf Courses

Table 4-13: Salt Watershed Land Use (part 2 of 2).

Land Cover	Lower Salt River H15060106A	***Salt Watershed***
Agriculture	-	0.03%
Forest	5%	40%
Range	93%	59%
Urban	-	0.4%
Water	2%	0.4%
Total Area (square miles)	445	6,243

Table 4-14: Salt Watershed Land Ownership (Percent of each Subwatershed) (part 1 of 2).

Land Owner	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104	Tonto Creek H15060105
BLM	-	-	0.4%	-	-
US Forest Service	29%	0.8%	55%	1%	98%
Game and Fish	0.03%	-	0.01%	-	-
Indian Reservation	71%	99%	41%	99%	0.01%
National Park Service	-	-	0.08%	-	-
Parks and Recreation	-	-	-	-	-
Private Land	0.2%	0.12	4%	0.03%	2%
State Land	-	-	0.06%	-	-
Area (square miles)	1,251	638	2,152	709	1,048

Table 4-14: Salt Watershed Land Ownership (Percent of each Subwatershed) (part 2 of 2).

Land Owner	Lower Salt River H15060106A	***Salt Watershed***
BLM	-	0.2%
US Forest Service	99%	48%
Game and Fish	-	0.01%
Indian Reservation	9%	50%
National Park Service	-	0.03%
Parks and Recreation	0.01%	0.2%
Private Land	1%	2%
State Land	-	> 0.0%
Area (square miles)	950	6,748

Table 4-15: Salt Watershed Areas of Arizona Preserve Initiative Lands.

Subwatershed Name	Subwatershed Area (square miles)	Preserve Areas (square miles)	Preserve Areas (acre)	Percent of Subwatershed
Black River H15060101	1,251	-	-	-
White River H15060102	638	-	-	-
Upper Salt River H15060103	2,152	34	21,708	2%
Carrizo River H15060104	709	13	8,340	2%
Tonto River H15060105	1,048	56	36,047	5%
Lower Salt River H15060106A	445	16	9,938	4%
Total Salt Watershed	6,243	119	76,033	2%

Table 4-16: Salt Watershed Wilderness Areas (acres) (part 1 of 2).

Wilderness Area	Black River H15060101	White River H15060102	Upper Salt River H15060103	Carrizo Creek H15060104	Tonto Creek H15060105
Bear Wallow	11,237	-	-	-	-
Blue Ridge Primitive	168	-	-	-	-
Four Peaks	-	-	-	-	3,710
Hellsgate	-	-	-	-	37,399
Mazatzal	-	-	-	-	17,135
Mt. Baldy	207	45	-	-	-
Salome	-	-	18,213	-	302
Salt River Canyon	-	-	32,088	-	-
Sierra Ancha	-	-	21,007	-	-
Superstition	-	-	36,793	-	-
Total Wilderness Area (acre)	11,612	45	108,101	-	58,546

Table 4-16: Salt Watershed Wilderness Areas (acres) (part 2 of 2).

Wilderness Area	**Lower Salt River H15060106A**	***Salt Watershed***
Bear Wallow	-	11,237
Blue Ridge Primitive	-	168
Four Peaks	53,793	57,504
Hellsgate	-	37,399
Mazatzal	-	17,135
Mt. Baldy	-	252
Salome	-	18,515
Salt River Canyon	-	32,088
Sierra Ancha	-	21,007
Superstition	99,668	136,461
Total Wilderness Area (acre)	153,461	331,766

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Land use. July 21, 2003.

**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases. Metadata includes the original source of the data, when it was created, its geographic projection and scale, the name(s) of the contact person and/or organization, and a general description of the data.*

Section 5: Important Resources

The Salt Watershed has extensive and important natural resources, with national, regional and local significance. The watershed contains critical riparian habitat for the Mexican Spotted Owl, the Loach Minnow and the Southwest Willow Flycatcher (U.S. Fish & Wildlife Service, 2004). The watershed also contains important recreational resources including extensive wilderness areas with hiking, bird watching and fishing.

As a result of our analysis, two Natural Resource Areas (NRAs) have been identified for protection based on the combination of natural resource values. Factors that were considered in delineating these areas include: legal status (unique waters, critical habitat for threatened and endangered species, national monument areas and wilderness), the presence of perennial waters and riparian areas, the presence of state parks and forests, recreational resources and local values.

Several 10-digit contiguous HUCs have been combined to form a unique NRAs. The two identified Natural Resource Areas consist of the following groupings of 10-digit HUCs:

1. *Western Salt River NRA*: Upper Salt River, Tonto Creek, and Lower SALT River.

2. *Eastern SALT River NRA*: Black River, White River and Carrizo Creek

Western Salt River NRA

The Western Salt River NRA contains Tonto National Monument, extensive riparian vegetation along the Salt River and its tributaries, important perennial streams, seven wilderness areas, three Arizona Preserve Initiative areas, critical wildlife habitat, a national forest, and parts of two Indian reservations.

Critical habitat exists in the Western Salt River NRA for the Southwest Willow Flycatcher and the Mexican Spotted Owl (Figure 3-7)

Tonto National Monument

The following description of Tonto National Monument is from the National Park Service website (http://www.nps.gov/tont/naturescience/index.htm)

Situated within rugged terrain at the northeastern boundary of the Sonoran Desert, Tonto National Monument preserves cliff dwellings and other prehistoric archeological sites. For three hundred years, a vast culture lived within Tonto Basin, surviving and adapting to the arid environment. Built in shallow caves, perched over a thousand feet above the river valley, the cliff dwellings are representative of the final phase of occupation in this area.

The river valley below, once a thriving settlement with farm fields and stone dwellings, is now covered by Roosevelt Lake. The surrounding mountains, built by sedimentary layers and then uplifted, are continually being shaped through erosion and weathering. From the valley rising 2000 feet to the mountain tops, spreading through open areas, sheltered among rocks, nestled in canyons, and hidden among washes are different local environments, each with their own community of wildlife. This is the tremendous diversity and interconnection of life that is the Sonoran Desert.

Wilderness Areas

There are seven wilderness areas in the Western Salt River NRA, all administered by the U.S. Forest Service. These wilderness areas are:

Hellsgate Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=240)

The United States Congress designated the Hellsgate Wilderness in 1984 and it has a total of 37,440 acres.

Lying at the base of the Mogollon Rim, upper Tonto Creek has incised a 1,000-foot-deep canyon that runs entirely through the center of this Wilderness. A perennial waterway, Tonto Creek creates deep emerald pools sometimes separated by impassable falls. The area also contains Haigler Creek with its impressive rock formations. Elevations range from 6,440 feet atop Horse Mountain in the northeast corner to 2,960 feet where Tonto Creek leaves the area in the southwest. Trout, catfish, and smallmouth bass inhabit both creeks, popular destinations with anglers. Available water helps to support a variety of wildlife: black bears, mountain lions, mule deer, coyotes, gray foxes, javelinas, beavers, and many small mammals and birds.

Sierra Ancha Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Sierra%20Ancha).

The United States Congress designated the Sierra Ancha Wilderness in 1964 and it has a total of 20,850 acres.

Centuries ago the Salado Indians built and lived in cliff dwellings in this region, and the ruins of many of them still stand today. An "original" Arizona Wilderness, Sierra Ancha was established as a Primitive Area in 1933 and as a Wilderness in 1964. Uranium exploration carved a few roads into this area in the 1950s, roads now being reclaimed by natural processes.

Exceptionally rough, scenic, and often inaccessible, Sierra Ancha consists of precipitous box canyons, towering vertical cliffs, and pine-covered mesas. Elevations range from 4,000 feet near Cherry Creek to more than 7,400 feet on several high peaks, with the highest point on Aztec Peak at 7,733 feet. Chaparral covers lower elevations with turbinella oak, manzanita, and mountain mahogany. Some pinyon and juniper cloak the east side of the Wilderness, dropping to semidesert brush and grassland below. Several springs usually offer water year-round.

Salome Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Salome).

The United States Congress designated the Salome Wilderness in 1984 and it now has a total of 18,531 acres.

Salome Canyon is the major canyon that runs almost the entire length of this Wilderness. You won't encounter many human being in the area but you will see remnants of the Salado Indians, who lived here until vanishing about 700 years ago.

In the north area, the land becomes increasingly rugged with many bedrock outcroppings. It culminates in Hell's Hole, a region of precipitous bluffs. Water is sometimes available from several small springs. Elevations range from 2,600 feet at lower Salome Creek to 6,500 feet on Hopkins Mountain. Semidesert grasslands and chaparral dominate the vegetation. Winters usually freeze, and summer temperatures often exceed 100 degrees Fahrenheit.

Salt River Canyon Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Salt%20River%20Canyon)

The United States Congress designated the Salt River Canyon Wilderness in 1984 and it has a total of 32,101 acres.

Many describe the vista where U.S. 60 crosses the Salt River Canyon as the most dramatic in Arizona. Here the highway descends 2,000 feet of steep switchbacks, crosses a bridge, and ascends the opposite side of the canyon. About 20 miles below the bridge, the spectacular steep-walled canyon bisects Salt River Canyon Wilderness. Within the area elevations range from 2,200 feet at the canyon's lower end to 4,200 feet on White Ledge Mountain. More than 200 species of wildlife have been identified along the river.

About half of the area's human visitors are skilled white-water navigators, who venture down the Salt River during the short and dangerous river-running season from March to May.

Superstition Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Superstition).

The United States Congress designated the Superstition Wilderness in 1964 and it now has a total of 159,757 acres.

Although there is no guarantee that you'll find buried treasure, you are sure to discover miles and miles of desolate and barren mountains, seemingly endless and haunting canyons, raging summer temperatures that can surpass 115 degrees Fahrenheit, and a general dearth of water. Even the area's earliest known inhabitants, the hardy Hohokam and Salados peoples, established only very small villages and cliff dwellings in this harsh and fabulous country between 800 and 1400 A.D.

The Wilderness value of the Superstitions has long been recognized. Established as a Primitive Area in 1939, it was named a pre-Wilderness Act "wilderness" in 1940, and became an official Wilderness in 1964. Elevations range from approximately 2,000 feet on the western boundary to 6,265 feet on Mound Mountain. In the western portion rolling land is surrounded by steep, even vertical terrain. Weaver's Needle, a dramatic volcanic plug, rises to 4,553 feet. The central and eastern portions are less topographically severe.

Vegetation is primarily that of the Sonoran Desert, with semidesert grassland and chaparral higher up. Dense brushland covers hundreds of acres. A few isolated pockets of ponderosa pine may be found at the highest elevations.

Four Peaks Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Four%20Peaks).

The United States Congress designated the Four Peaks Wilderness in 1984 and it now has a total of 61,074 acres.

Rising from desert foothills near the center of the Wilderness, a major mountain with four peaks can be seen from great distances in all directions. From the craggy summits the land drops down a complex series of ridges and drainages to bluffs and deep gorges. Elevations vary from around 1,600 feet to 7,657 feet on Brown's Peak, the highest of the four peaks.

Ponderosa pine and some Douglas fir grow in the highlands. A few aspen stand on the north side of Brown's Peak. Intermediate elevations have produced impenetrable thickets of manzanita, Gambel oak, and pinyon pine. Below 4,000 feet, grasslands blend into the Upper Sonoran Desert and impressively huge saguaro cacti thrive. The narrow canyons are pleasingly shaded with cottonwoods and sycamores.

One of the densest black bear populations in Arizona lives in this Wilderness. Other mammals include ring-tailed cats, skunks, coyotes, deer, javelinas, and mountain lions. Keep your eyes open for rattlesnakes, scorpions, black widow spiders, centipedes, and millipedes.

Atop the mountain temperatures are noticeably cooler than down below. Lightning storms occur regularly during "desert monsoon season" (July and August) and flash floods are common. Snow accumulates here in winter.

Springs and streams are seasonal, and water is often impossible to find.

Tonto National Forest

(text from the Forest Service Webpage, 2008, http://www.fs.fed.us/r3/tonto/about/history.shtml).

The Tonto National Forest, Arizona, embraces almost 3 million acres of rugged and spectacularly beautiful country, ranging from Saguaro cactus-studded desert to pine-forested mountains beneath the Mogollon Rim. This variety in vegetation and range in altitude (from 1,300 to 7,900 feet) offers outstanding recreational opportunities throughout the year, whether it's lake beaches or cool pine forest.

As the fifth largest forest in the United States , the Tonto National Forest is one of the most-visited “urban” forests in the U.S. (approximately 5.8 million visitors annually). Its boundaries are Phoenix to the south, the Mogollon Rim to the north and the San Carlos and Fort Apache Indian reservations to the east.

In the winter, national and international visitors flock to Arizona to share the multi-hued stone canyons and Sonoran Desert environments of the Tonto’s lower elevations with Arizona residents. In the summer, visitors seek refuge from the heat at the Salt and Verde rivers and their chain of six man-made lakes. Visitors also head to the high country to camp amidst the cool shade of tall pines and fish the meandering trout streams under the Mogollon Rim.

One of the primary purposes for establishing the Tonto National Forest in 1905 was to protect its watersheds around reservoirs. The forest produces an average of 350,000 acre-feet of water each year. Six major reservoirs on the forest have the combined capacity to store more than 2 million acre-feet of water. Management efforts are directed at protecting both water quality and watershed and riparian area conditions.

Eight Wilderness Areas, encompassing more than 589,300 acres, are managed to protect the unique natural character of the land and to assure the public recreation areas where one is only a visitor. In addition, portions of the Verde River have been designated by Congress as Arizona’s first and only Wild and Scenic River Area.

Fish and wildlife are abundant on the Tonto; more than 400 vertebrate species are represented, including 21 listed among federal and state Threatened and Endangered Species. Maintaining quality habitat to support and improve wildlife diversity is a primary management consideration.

Approximately 26,000 head of cattle are permitted to graze on the forest. Because of its year-round availability, permitted use is extremely high and land allotments must be carefully managed to avoid over-utilization and declining productivity of the range. Currently, long-term drought conditions across the Southwest have limited our ability to sustain more than 20 percent of the permitted numbers on the forest.

The Tonto has a rich history of producing copper, gold, silver, lead, zinc, uranium, molybdenum, manganese, asbestos, mercury and many other metals and minerals. This history spans over 150 years and includes 38 mineral districts with recorded production.

Although the Tonto is not heavily timbered, about 4 million board feet total of saw logs, fuel wood and other forest wood products are selectively harvested each year.

The critical fire season is relatively short, usually lasting from May to mid-July. During that period, natural and human-caused fires often threaten the timber, chaparral, grass and light shrub vegetative zones. The Tonto has averaged 330 wildfires a year over the last ten years.

With some of the state's more prominent peaks located on the Tonto, the forest supports an important communication link for Arizona. Radio, television and telephone networks use the electronic sites on these mountains to facilitate state and national communications. Many of the high-capacity transmission lines that bring Phoenix its power also crisscross the Tonto.

Arizona Preserve Institute Areas

There are three preserve lands within the Western Salt River NRA, encompassing a total of 611 square miles. The largest preserve is in the Lower Salt River Watershed (15060106) which covers 520 square miles near Payson. The other two preserves are located near Globe and Chandler, respectively. Figure 4-14 shows the boundaries of the preserve lands within the Salt Watershed.

Eastern Salt River NRA

The Eastern Salt River NRA contains extensive riparian vegetation along the Salt River and its tributaries, important perennial streams, three wilderness areas, six areas protected as Outstanding Arizona Waters, critical wildlife habitat, a national forest, and parts of two Indian reservations.

Critical habitat exists in the Eastern Salt River NRA for the Loach Minnow and the Mexican Spotted Owl (Figure 3-7)

Mount Baldy Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Mount%20Baldy)

The United States Congress designated the Mount Baldy Wilderness in 1970 and it has 7,079 acres.

Captain George Wheeler, who surveyed much of the American Southwest in the 1870s, wrote that the view from Mount Baldy was "the most magnificent and effective of any among the large number that have come under my observation." In other words, he liked it . . . he really liked it. So do the scores of day hikers who visit Mount Baldy Wilderness today, making it one of the most popular hiking areas in Arizona.

An extinct volcano rising to 11,403 feet, Mount Baldy stands within the White Mountain Apache Reservation; the Wilderness occupies its eastern slope. Most of the forest covering the mountain is mixed conifers with ponderosa pine in the lower elevations and fir and spruce higher up. Large meadows break open the forest, carpeted in summer with wildflowers such as Indian paintbrush, columbine, penstemon, iris, and lupine. Until winter cloaks the area in snow, elk and deer are commonly seen. Beavers, mountain lions, coyotes, bobcats, and black bears live here with a variety of smaller mammals. Bald eagles, falcons, and hawks circle beneath the sun. Summer thunderstorms are frequent, as are lightning strikes on the mountain.

Bear Wallow Wilderness

(text from Wilderness Institute, University of Montana College of Forestry and Conservation, 2008, http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Bear%20Wallow)

The United States Congress designated the Bear Wallow Wilderness in 1984 and it now has a total of 11,080 acres.

Some of the largest acreage of virgin ponderosa pine in the Southwest stands on Bear Wallow Wilderness, venerable reminders of a once extensive forest of these giants. Down the length of the area, through a blanket of pine, fir, and spruce, beautiful Bear Wallow Creek flows year-round, shaded by green riparian hardwoods. The creek provides a habitat for the endangered Apache trout; anglers can try for other species in the creek and its north and south forks. Early explorers were impressed by the large number of well-used wallows, which revealed how plentiful the area's population of black bears was. Black bears still abound, and you may see elk, deer, squirrels, and a diverse community of smaller mammals, birds, and reptiles. Wildflowers bloom in profusion, especially during the summer rains. Poison ivy grows tall and dangerously abundant.

Blue Ridge Primitive Wilderness Area

(text from Apache Sitgreaves National Forest Webpage, 2008, http://www.fs.fed.us/r3/asnf/recreation/trails/alpine_trails/trl_blu_list.shtml).

In 1933 the Secretary of Agriculture proclaimed the Blue Range should be managed for primitive uses to maintain the wildness of that area. Its 173,762 acres are indeed wild and it is the last designated Primitive Area in the United States. The Blue Range remains one of Arizona's untouched and little known jewels. This is a land of rugged mountains, steep canyons, and stark ridges that is at the same time remote and accessible through an extensive trail system. Trails are open to non-motorized and non-mechanized use only within the primitive area.

Apache - Sitgreaves National Forest

The Apache and the Sitgreaves National Forests were administratively combined in 1974 and are now managed as one unit from the Forest Supervisor's Office in Springerville. The two million acre Forest encompasses magnificent mountain country in east-central Arizona along the Mogollon Rim and the White Mountains.

What makes this Forest so special? It's the water...lots of it...draining the high mountains and forming numerous lakes and streams...a fisherman's paradise in the arid Southwest.

The Apache-Sitgreaves has 34 lakes and reservoirs and more than 680 miles of rivers and streams - more than can be found in any other Southwestern National Forest. The White Mountains contain the headwaters of several Arizona rivers including the Black, the Little Colorado, and the San Francisco.

The Sitgreaves was named for Captain Lorenzo Sitgreaves, a government topographical engineer who conducted the first scientific expedition across Arizona in the early 1850's. On the Sitgreaves, the major attractions for visitors from the hot valleys of Phoenix or Tucson are the Mogollon Rim and the string of man-made lakes. From the Rim's 7600-foot elevation, vista points provide inspiring views of the low country to the south and west.

In the last century, the US Army established a series of forts in New Mexico and Arizona. To supply these forts and settlements, a military road was built linking Santa Fe, New Mexico and Camp Verde near Prescott. Part of this road, called the General Crook Trail, runs almost the length of the Sitgreaves and in many places follows the brink of the Rim.

The Apache National Forest is named after the tribes that settled in this area. It ranges in elevation from 3500 feet near Clifton to nearly 11,500 feet on Mount Baldy. The congressionally proclaimed Mount Baldy, Escudilla, and Bear Wallow wildernesses and the Blue Range Primitive Area make the Apache one of America's premier backcountry Forests. The Apache is also noted for its trout streams and high-elevation lakes and meadows.

The management concerns on the Apache-Sitgreaves include the health and restoration of the watersheds, sustaining the Forest's ecosystems, reducing the dangers associated with wildfire in the urban interface, and maintaining the National Forest road system.

Outstanding Arizona Waters

Within the Eastern Salt NRA, portions of six areas are currently protected as Outstanding Arizona Waters. OAW include 4.25 miles of Bear Wallow Creek (from its headwaters to the San Carlos Indian Reservation), 3.8 miles of both the North and South Forks of Bear Wallow Creek (from their headwaters to where they join Bear Wallow Creek), 5.5 miles of Hay Creek (from its headwaters to the West Fork of Black Creek), 6.2 miles of Snake Creek (from its headwaters to Black River), and 3 miles of Stinky Creek (from White Mountain Apache Indian Reservation to the West Fork of Black River) (Figure 2-5) (ADEQ 2007).

References:

Apache Sitgreaves National Forest Webpage, 2008, http://www.fs.fed.us/r3/asnf/recreation/trails/alpine_trails/trl_blu_list.shtml).

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Section 6: Watershed Classification

This watershed classification was conducted on the twenty-seven subwatersheds that comprise the Salt Watershed.

In this watershed classification, each 10-digit subwatershed in the Salt Watershed is classified or ranked based on susceptibility to water quality problems and pollution sources that need to be controlled through implementation of nonpoint source Best Management Practices (BMPs). This classification also prioritizes subwatersheds for available water quality improvement grants, based on known water quality concerns.

Methods

The general approach used to classify subwatersheds was to integrate watershed characteristics, water quality measurements, and results from modeling within a multi-parameter ranking system based on the fuzzy logic knowledge-based approach (described below), as shown schematically in Figure 6-1.

The process was implemented within a GIS interface to create the subwatershed classifications using five primary steps:

1. Define the goal of the watershed classification: to prioritize which 10-digit subwatersheds are most susceptible to known water quality concerns, and therefore, where BMPs should be implemented to reduce nonpoint source pollution;
2. Assemble GIS data and other observational data;
3. Define watershed characteristics through:
    a. Water quality assessment data provided by Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a);
    b. GIS mapping analysis; and
    c. Modeling / simulation of erosion vulnerability and potential for stream impairment (in this case, from soils in mine site areas and proximity of mines sites to riparian areas).
4. Use fuzzy membership functions to transform the potential vulnerability / impairment metrics into fuzzy membership values with scales from 0 to 1; and
5. Determine a composite fuzzy score representing the ranking of the combined attributes, and interpret the results.

GIS and Hydrologic Modeling

GIS and hydrologic modeling were the major tools used to develop this watershed-based plan. Planning and assessment in land and water resource management require spatial modeling tools so as to incorporate complex watershed-scale attributes into the assessment process. Modeling tools applied to the Salt Watershed include AGWA, SWAT, and SEDMOD/RUSLE, as described below and in Appendices C and D.

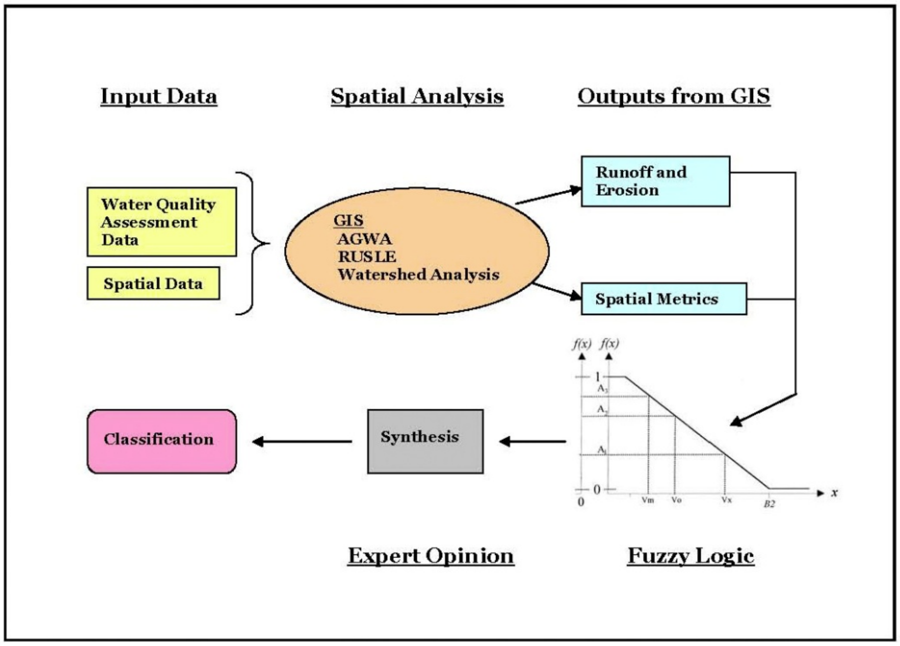

Figure 6-1: Transformation of Input Data via a GIS, Fuzzy Logic Approach, and Synthesis of Results into a Watershed Classification.

The Automated Geospatial Watershed Assessment Tool (AGWA) is a GIS-based hydrologic modeling tool designed to evaluate the effects of land use change (Burns et al., 2004). AGWA provides the functionality to conduct all phases of a watershed assessment. It facilitates the use of the Soil and Water Assessment Tool (SWAT), a hydrologic model, by preparing the inputs, running the model, and presenting the results visually in the GIS. AGWA has been used to illustrate the impacts of urbanization and other landscape changes on runoff and sediment load in a watershed. AGWA was developed under a joint project between the Environmental Protection Agency (EPA), Agricultural Research Service (ARS), and the University of Arizona. SWAT was developed by the ARS, and is able to predict the impacts of land management practices on water, sediment and chemical yields in complex watersheds with varying soils, land use and management conditions (Arnold et al., 1994). The SEDMOD model (Van Remortel et al., 2004), which uses the Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997), was used to estimate soil erosion and sediment delivery from different land use types.

The watershed classification within this plan incorporates GIS-based hydrologic modeling results and other data to describe watershed conditions upstream from an impaired stream reach identified within Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a). In addition, impacts due to mine sites (e.g. erosion and metals pollution) and grazing (e.g. erosion and pollutant nutrients) are simulated.

Fuzzy Logic

To rank the 10-digit HUC subwatershed areas that are susceptible to water quality problems and pollution, and to identify sources that need to be controlled, a fuzzy logic knowledge-based methodology was applied to integrate the various spatial and non-spatial data types (Guertin et al., 2000; Miller et al., 2002; Reynolds et al., 2001). This methodology has been selected as the basis by which subwatershed areas and stream reaches are prioritized for the implementation of BMPs to assure nonpoint source pollution is managed.

Fuzzy logic is an approach to set theory that handles vagueness or uncertainty, and has been described as a method by which to quantify common sense. In classical set theory, an object is either a member of the set or excluded from the set. Fuzzy logic allows for an object to be a partial member of a set, and converts the range in values between different data factors to the same scale (0.0 -1.0) using fuzzy membership functions. Fuzzy membership functions can be discrete or continuous depending on the input characteristics.

The development of a fuzzy membership function can be based on published data, expert opinions, stakeholder values or institutional policy, and can be created in a data-poor environment. A benefit of this approach is that it provides for the use of different methods for combining individual factors to create the final classification and the goal set. Fuzzy membership functions and weighting schemes can also be changed based on watershed concerns and conditions.

Subwatershed Classifications

This classification was conducted at the 10-digit HUC subwatershed scale. Table 6-1 lists the 10-digit HUC numerical identifications and subwatershed names for all twenty-seven 10-digit HUC subwatersheds in the Salt River Watershed.

Table 6-1: HUC 10-Digit Designation and Subwatershed Name.

HUC 10	**Subwatershed Name**
H1506010101	Upper Black River
H1506010102	Big Bonito Creek
H1506010103	Middle Black River
H1506010104	Lower Black River
H1506010201	Upper North Fork White River
H1506010202	Lower North Fork White River
H1506010203	East Fork White River
H1506010204	White River
H1506010301	Cibecue Creek
H1506010302	Sawmill Creek–Upper Salt River
H1506010303	Canyon Creek
H1506010304	Cherry Creek
H1506010305	Salt River Draw–Upper Salt River
H1506010306	Pinal Creek
H1506010307	Pinto Creek
H1506010308	Salome Creek
H1506010309	Upper Salt River – Theodore Roosevelt Lake
H1506010401	Corduroy Creek
H1506010402	Cedar Creek
H1506010403	Carrizo Creek
H1506010501	Spring Creek
H1506010502	Haigler Creek – Tonto Creek
H1506010503	Rye Creek – Tonto Creek
H1506010504	Gun Creek – Tonto Creek
H1506010505	Tonto Creek – Theodore Roosevelt Lake
H1506010601	Lower Salt River – Apache, Canyon, and Saguaro Lake
H1506010603 A	Lower Salt River Below Saguaro Lake

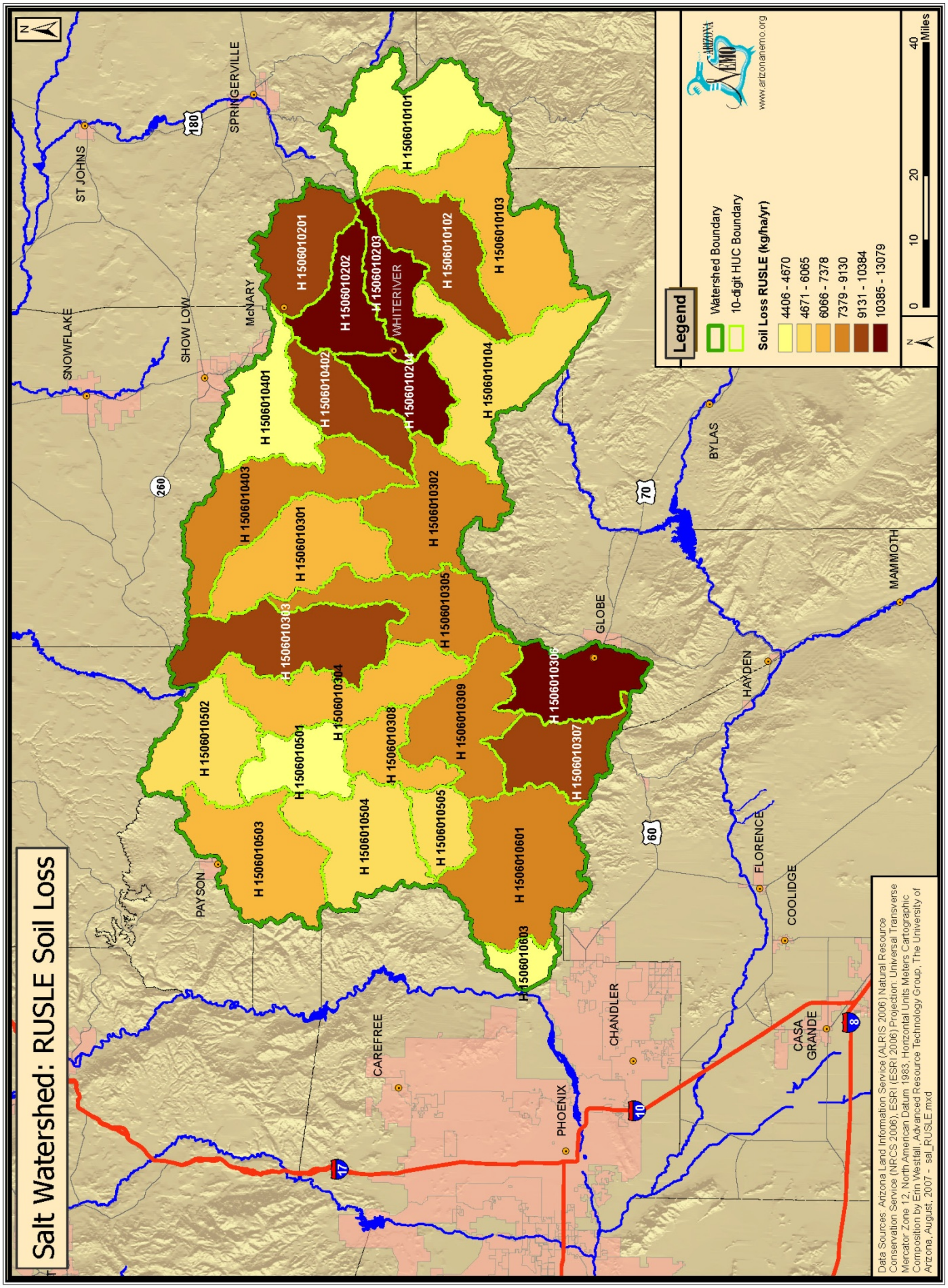

Figure 6-2: Salt Watershed, RUSLE Soil Loss "A" (kg/ha/yr) by Subwatershed

Classifications were conducted on individual or groups of water quality parameters, and potential for impairment for a water quality parameter based on the biophysical characteristics of the watershed. Constituent groups were evaluated for the Salt Watershed. The constituent groups are:

- Metals (cadmium, mercury, copper, zinc, lead, arsenic), with cadmium used as an index since it is the most common parameter sampled in the watershed;
- Sediment (turbidity is used as an index since it was the previous standard and represents most of the sampling data);
- Organics (concerns include *Escherichia coli (E. coli)*, nutrients, high pH and dissolved oxygen, and are related to organic material being introduced into the aquatic system); and
- Selenium.

The development of the fuzzy logic approach for each constituent is described below.

Water Quality Assessment Data

ADEQ's water quality assessment criteria and assessment definitions are found in Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a). These data were used to define the current level of impairment of each HUC-10 subwatershed using fuzzy membership values. For more information see the ADEQ website: http://www.azdeq.gov/environ/water/assessment/assess.html.

Surface waters assessed as "impaired" and included in the 303(d) List of Impaired Waters are scheduled for completion of a Total Maximum Daily Load (TMDL) quantitative and analysis plan. A TMDL is the maximum amount (load) of a water quality parameter which can be carried by a surface water body, on a daily basis, without causing an exceedance of surface water quality standards (ADEQ. 2006b). Although all monitored water bodies will be reviewed in this watershed-based plan, only those assessed as impaired will be discussed for best management practices (Section 7 of this Watershed-Based Plan).

Appendix A Table 1 is a summary of the ADEQ water quality monitoring data (ADEQ. 2006a) and 10-digit HUC subwatershed classification results for the Salt Watershed. The water quality data were used to classify each monitored stream reach or water body based on its relative risk of impairment for the constituent groups. It should be noted that not every 10-digit HUC subwatershed contained a water quality sampling site.

The four levels of risk used to classify each water body are: Extreme, High, Moderate and Low.

- Extreme risk - If a surface water body within the subwatershed is currently assessed as being "impaired" by ADEQ for one of the constituent groups.

- High risk - If a surface water body within the subwatershed is assessed as "inconclusive" because of limited data, but the available sampling indicates water quality exceedances occurred.

- Moderate risk - If either:
  - A surface water body within the subwatershed was assessed as “inconclusive” or “attaining”, but there are still a low number of samples exceeding standards for a constituent group (i.e. less than 10% of samples); or
  - There were no water quality measurements available for a constituent group at any site within the subwatershed.
- Low risk - If no exceedances exist in a constituent group and there were sufficient data to make an assessment.

An overall risk classification is assigned to the 10-digit HUC subwatershed based on the worst case risk classification of the water bodies in that subwatershed (see Appendix A, Table 1). Fuzzy membership values (FMV) were assigned to each subwatershed using the criteria in Table 6-2.

The FMVs in Table 6-3 are based on two considerations: 1) Subwatershed relative risk of impairment (described above), and 2) Downstream subwatershed risk of impairment.

The status of downstream surface waters provides a way to evaluate the possibility that the subwatershed is contributing to downstream water quality problems. This is particularly important where water quality data is limited and few surface water quality samples may have been collected within the subwatershed.

Water bodies classified as either extreme (impaired) or low (no exceedances) risk had a higher influence than high or moderate classified water bodies in determining downstream water quality condition because they were less ambiguous than the other levels of risk. For example, if a water body was classified as extreme risk, it was used to define the water quality condition, and the subwatershed was given an FMV of 1.0. Likewise, if a water body along the pathway was classified as low risk, that water body was used to define the downstream water quality condition (see Table 6-2).

Table 6-2: Fuzzy Membership Values (FMV) for HUC-10 Subwatersheds Based on ADEQ Water Quality Assessment Results

Subwatershed Classification	Downstream Subwatershed Classification	FMV
Extreme	N/A	1.0
High	Extreme	1.0
High	High	0.8
High	Moderate/Low	0.7
Moderate	Extreme	0.7
Moderate	High	0.6
Moderate	Moderate	0.5
Moderate	Low	0.3
Low	N/A	0.0

Metals

Metals are one of the most significant water quality problems in these watersheds because of the potential toxicity to aquatic life. Parts of the region have a long history of metal mining, and this use has left many stream segments and lakes with elevated levels of total and dissolved metals. Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a) has designated several streams or lakes as Category 4 or 5, Impaired for metals (see Appendix A, Table 1). However, some stream reaches have not been sampled for metals.

The primary sources for metals are probably runoff and erosion from active and abandoned mines since there are a high number of mines in the area. However, developed urban areas are also considered to be a nonpoint source for metals pollutants.

The factors used for the metals classification were:

- ADEQ water quality assessment results;
- Presence of mines within a watershed;
- Presence of mines within the riparian zone; and
- Potential contribution of mines to sediment yield.
- Percent urbanized areas

Water Quality Assessment - Metals

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a) was used to define the current level of impairment for metals for each stream reach. Each subwatershed was then assigned a risk level based on the worst case stream reach. The FMV was assigned based on the location of the subwatershed relative to an impaired water (Table 6-2).

Table 6-2 lists the fuzzy membership values used for different watershed conditions based on watershed location and water quality assessment results. Table 6-3 contains the fuzzy membership values assigned to each 10-digit HUC subwatershed for metals, based on the criteria defined in Table 6-2. The justification used to determine the FMV is also included in Table 6-3.

Table 6-3: Fuzzy Membership Values (FMV) Assigned to each 10-digit HUC Subwatershed, Based on Water Quality Assessment Results for Metals.

Subwatershed Name	Metals WQA FMV	Justification
Upper Black River 1506010101	0.5	Classified as moderate risk, drains to Middle Black River that is classified as moderate.
Big Bonito Creek 1506010102	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Middle Black River 1506010103	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Lower Black River 1506010104	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Upper North Fork White River 1506010201	0.5	Classified as moderate risk, drains to Lower North Fork White River that is classified as moderate.
Lower North Fork White River 1506010202	0.5	Classified as moderate risk, drains to White River that is classified as moderate.

Subwatershed Name	Metals WQA FMV	Justification
East Fork White River 1506010203	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
White River 1506010204	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Cibecue Creek 1506010301	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Sawmill Creek – Upper Salt River 1506010302	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Canyon Creek 1506010303	0.0	Classified as low risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Cherry Creek 1506010304	0.0	Classified as low risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salt River Draw – Upper Salt River 1506010305	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinal Creek 1506010306	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinto Creek 1506010307	1.0	Classified as extreme risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salome Creek 1506010308	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Upper Salt River – Theodore Roosevelt Lake 1506010309	1.0	Classified as extreme risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as moderate.
Corduroy Creek 1506010401	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Cedar Creek 1506010402	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Carrizo Creek 1506010403	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Spring Creek 1506010501	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.
Haigler Creek – Tonto Creek 1506010502	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.
Rye Creek – Tonto Creek 1506010503	0.3	Classified as moderate risk, drains to Gun Creek – Tonto Creek that is classified as low.
Gun Creek – Tonto Creek 1506010504	0.0	Classified as low risk, drains to Tonto Creek – Theodore Roosevelt Lake that is classified as moderate.
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.5	Classified as moderate risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as moderate.
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.5	Classified as moderate risk, drains to Lower Salt River Below Saguaro Lake that is classified as moderate.
Lower Salt River Below Saguaro Lake 1506010603A	0.5	Classified as moderate risk, drains out of the watershed.

Location of Mining Activities

The type and location of a mine within a watershed and in relation to a riparian zone determines its potential for impact on nearby water quality. Mining generally causes soil disturbance, which results in erosion and sediment yield to streams. In addition, since mines by definition occur in mineralized areas, it is assumed that the eroded soil is also high in metals. More thorough discussions of the geologic conditions and location of mine sites and mine types across the watershed are found in Section 2, Physical Characteristics and Section 4, Social/Economic Characteristics. The spatial data described in those sections were used along with the ADEQ water quality assessment data to classify each subwatershed for susceptibility to erosion and risk for metals pollution using the methodology described below.

The number of mines in a subwatershed and within the riparian zone (<= 250 m from a stream) were determined in the GIS. The results were used to assign an FMV to each subwatershed based on the following criteria.

Number of mines per watershed:

FMV = 0 if (# of mines <= 2)
FMV = (# of mines – 2) / 8
FMV = 1 if (# of mines >= 10)

Number of mines in riparian zone:

FMV = 0 if (# of mines < 1)
FMV = (# of mines) / 5
FMV = 1 if (# of mines >= 5)

Table 6-4 contains the fuzzy membership values assigned to each 10-digit HUC subwatershed based on the number of and location of mines. These values were used in the summary analysis to assess the relative impact of mining on the concentration of dissolved and total metals in the subwatershed.

Table 6-4: FMV for each Subwatershed Based on the Number and Location of Mines.

Subwatershed	FMV #mines /HUC	FMV #mines/ riparian
Upper Black River 1506010101	0.75	0.6
Big Bonito Creek 1506010102	0.25	0.2
Middle Black River 1506010103	0.375	0.4
Lower Black River 1506010104	0	0
Upper North Fork White River 1506010201	0.625	0.6
Lower North Fork White River 1506010202	0.875	1
East Fork White River 1506010203	0.5	1
White River 1506010204	0.5	0.2
Cibecue Creek 1506010301	0.125	0.2
Sawmill Creek – Upper Salt River 1506010302	1	1
Canyon Creek 1506010303	1	1
Cherry Creek 1506010304	1	1
Salt River Draw – Upper Salt River 1506010305	1	1
Pinal Creek 1506010306	1	1
Pinto Creek 1506010307	1	1
Salome Creek 1506010308	1	1
Upper Salt River – Theodore Roosevelt Lake 1506010309	1	1
Corduroy Creek 1506010401	0.5	0

Subwatershed	FMV #mines /HUC	FMV #mines/ riparian
Cedar Creek 1506010402	0	0.4
Carrizo Creek 1506010403	0	0.2
Spring Creek 1506010501	1	1
Haigler Creek – Tonto Creek 1506010502	0.375	0.8
Rye Creek – Tonto Creek 1506010503	1	1
Gun Creek – Tonto Creek 1506010504	1	1
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.125	0.4
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	1	1
Lower Salt River Below Saguaro Lake 1506010603A	1	1

Potential Contribution of Mines to Sediment Yield

Gross soil erosion in kg/ha/yr was determined for each subwatershed using the SEDMOD model (Van Remortel et al., 2006), which is based on RUSLE (Renard et al., 1997; see Appendix C). Since this watershed based plan assumes that mine sites contribute to erosion and the resulting sediments are high in metals, the potential for erosion from mines to contribute to the risk for metals impairment for a subwatershed was evaluated.

The model results for soil loss (RUSLE "a" value) were imported into the GIS and reclassified into 6 categories. Table 6-5 tabulates the values for soil loss in kg/ha/yr for each subwatershed.

Table 6-6 shows the erosion category and fuzzy membership value for each subwatershed. The range of erosion values were classified into six erosion categories, where category 1 represents zero potential for metals contribution (i.e. low sediment yield), and category 6 represents a high potential (i.e. high sediment yield). The fuzzy membership values ranged from 0.0 to 1.0, and were increased by 0.20 for each higher erosion category and Figure 6-2 shows these results

Table 6-5: RUSLE Calculated Soil Loss "A" (kg/ha/yr)

Subwatershed	RUSLE Soil Loss "A" (kg/ha/yr)
Upper Black River 1506010101	4,516
Big Bonito Creek 1506010102	9,613
Middle Black River 1506010103	6,541
Lower Black River 1506010104	5,302
Upper North Fork White River 1506010201	10,384
Lower North Fork White River 1506010202	11,359
East Fork White River 1506010203	12,699
White River 1506010204	11,898
Cibecue Creek 1506010301	7,378
Sawmill Creek – Upper Salt River 1506010302	8,653
Canyon Creek 1506010303	9,598
Cherry Creek 1506010304	6,452
Salt River Draw – Upper Salt River 1506010305	7,699
Pinal Creek 1506010306	13,079
Pinto Creek 1506010307	10,325
Salome Creek 1506010308	6,621
Upper Salt River – Theodore Roosevelt Lake 1506010309	9,130
Corduroy Creek 1506010401	4,670

Subwatershed	RUSLE Soil Loss "A" (kg/ha/yr)
Cedar Creek 1506010402	9,486
Carrizo Creek 1506010403	8,436
Spring Creek 1506010501	4,597
Haigler Creek – Tonto Creek 1506010502	5,482
Rye Creek – Tonto Creek 1506010503	6,282
Gun Creek – Tonto Creek 1506010504	6,065
Tonto Creek – Theodore Roosevelt Lake 1506010505	5,786
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	8,692
Lower Salt River Below Saguaro Lake 1506010603A	4,406

Table 6-6: Fuzzy Membership Values per Erosion Category.

Subwatershed	Erosion Category	FMV
Upper Black River 1506010101	1	0.00
Big Bonito Creek 1506010102	5	0.80
Middle Black River 1506010103	3	0.40
Lower Black River 1506010104	2	0.20
Upper North Fork White River 1506010201	5	0.80
Lower North Fork White River 1506010202	6	1.00
East Fork White River 1506010203	6	1.00
White River 1506010204	6	1.00
Cibecue Creek 1506010301	3	0.40
Sawmill Creek – Upper Salt River 1506010302	4	0.60
Canyon Creek 1506010303	5	0.80

Subwatershed	Erosion Category	FMV
Cherry Creek 1506010304	3	0.40
Salt River Draw – Upper Salt River 1506010305	4	0.60
Pinal Creek 1506010306	6	1.00
Pinto Creek 1506010307	5	0.80
Salome Creek 1506010308	3	0.40
Upper Salt River – Theodore Roosevelt Lake 1506010309	4	0.60
Corduroy Creek 1506010401	1	0.00
Cedar Creek 1506010402	5	0.80
Carrizo Creek 1506010403	2	0.20
Spring Creek 1506010501	1	0.00
Haigler Creek – Tonto Creek 1506010502	2	0.20
Rye Creek – Tonto Creek 1506010503	3	0.40
Gun Creek – Tonto Creek 1506010504	2	0.20
Tonto Creek – Theodore Roosevelt Lake 1506010505	2	0.20
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	4	0.60
Lower Salt River Below Saguaro Lake 1506010603A	1	0.00

Urbanized Areas

Various studies have shown that semiarid stream systems become irreparably impaired once the impervious surfaces within the watershed exceed about 10%, and will experience dramatic morphological changes once that percentage exceeds about 20% (Coleman et. al., 2005; Miltner et al., 2003). The final values for the fuzzy membership functions (FMV) were selected based on these studies. The FMVs for the percentage of urban land within a 10-digit HUC subwatershed is shown below.

FMV = 0 if (% Urban < 5)
FMV = (5 < = % Urban < 12) / 12
FMV = 1 if (% Urban >= 12)

Table 6-7: Fuzzy Membership Values for Urbanized Areas.

Subwatershed	Percent Urban	FMV
Upper Black River 1506010101	0.00	0
Big Bonito Creek 1506010102	0.00	0
Middle Black River 1506010103	0.00	0
Lower Black River 1506010104	0.00	0
Upper North Fork White River 1506010201	0.21	0
Lower North Fork White River 1506010202	1.30	0
East Fork White River 1506010203	0.22	0
White River 1506010204	0.55	0
Cibecue Creek 1506010301	0.00	0
Sawmill Creek – Upper Salt River 1506010302	0.11	0
Canyon Creek 1506010303	0.06	0
Cherry Creek 1506010304	0.39	0
Salt River Draw – Upper Salt River 1506010305	0.00	0
Pinal Creek 1506010306	5.50	0.45
Pinto Creek 1506010307	0.00	0
Salome Creek 1506010308	0.08	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0.12	0
Corduroy Creek 1506010401	0.14	0
Cedar Creek 1506010402	0.00	0
Carrizo Creek 1506010403	0.00	0
Spring Creek 1506010501	0.09	0
Haigler Creek – Tonto Creek 1506010502	0.19	0
Rye Creek – Tonto Creek 1506010503	2.40	0
Gun Creek – Tonto Creek 1506010504	0.28	0
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.04	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.00	0
Lower Salt River Below Saguaro Lake 1506010603A	0.00	0

Metals Results

The fuzzy membership values for the number of mines, urbanized area, and for the erosion category were used to create a combined fuzzy score for each subwatershed using the weighted combination method.

This method uses a weighting scheme (weighted combination method) which was developed in cooperation with ADEQ. The weights consider the proximity of mines to the riparian area, the percent urbanized area, the susceptibility to erosion, and the ADEQ water quality results. The overall number of mines within the subwatershed (but removed from the riparian area) was not considered as pertinent to the classification, so this weight was set at 0.05, as opposed to 0.3 for mines in the riparian area.

The results are found in Table 6-8, and the weights are listed at the bottom of the table. Each of the assigned weights were multiplied with the FMV, and then added to produce the weighted FMV ranking.

Using the weighted FMV values, the subwatershed areas were classified into 'high' or 'low" risk for impairment due to metals based on natural breaks. Figure 6-3 shows the results of the weighted combination method classified into high and low risk for metals.

Table 6-8: Summary Results for Metals Based on the Fuzzy Logic Approach – Weighted Combination Approach.

Subwatershed	**FMV WQA[1]**	**FMV # Mines / HUC**	**FMV # Mines / Riparian**	**FMV Erosion Category**	**FMV Urban Areas**	**FMV Weighted**
Upper Black River 1506010101	0.5	0.75	0.6	0.00	0	0.37
Big Bonito Creek 1506010102	0.5	0.25	0.2	0.80	0	0.42
Middle Black River 1506010103	0.5	0.375	0.4	0.40	0	0.39
Lower Black River 1506010104	0.5	0	0	0.20	0	0.20
Upper North Fork White River 1506010201	0.5	0.625	0.6	0.80	0	0.56
Lower North Fork White River 1506010202	0.5	0.875	1	1.00	0	0.74
East Fork White River 1506010203	0.5	0.5	1	1.00	0	0.73
White River 1506010204	0.5	0.5	0.2	1.00	0	0.49
Cibecue Creek 1506010301	0.5	0.125	0.2	0.40	0	0.32
Sawmill Creek – Upper Salt River 1506010302	0.5	1	1	0.60	0	0.65
Canyon Creek 1506010303	0.0	1	1	0.80	0	0.55
Cherry Creek 1506010304	0.0	1	1	0.40	0	0.45
Salt River Draw – Upper Salt River 1506010305	0.7	1	1	0.60	0	0.71
Pinal Creek 1506010306	0.7	1	1	1.00	0.45	0.86
Pinto Creek 1506010307	1.0	1	1	0.80	0	0.85
Salome Creek 1506010308	0.7	1	1	0.40	0	0.66
Upper Salt River – Theodore Roosevelt Lake 1506010309	1.0	1	1	0.60	0	0.80
Corduroy Creek 1506010401	0.5	0.5	0	0.00	0	0.18

Subwatershed	FMV WQA[1]	FMV # Mines / HUC	FMV # Mines / Riparian	FMV Erosion Category	FMV Urban Areas	FMV Weighted
Cedar Creek 1506010402	0.5	0	0.4	0.80	0	0.47
Carrizo Creek 1506010403	0.5	0	0.2	0.20	0	0.26
Spring Creek 1506010501	0.5	1	1	0.00	0	0.50
Haigler Creek – Tonto Creek 1506010502	0.5	0.375	0.8	0.20	0	0.46
Rye Creek – Tonto Creek 1506010503	0.3	1	1	0.40	0	0.54
Gun Creek – Tonto Creek 1506010504	0.0	1	1	0.20	0	0.40
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.5	0.125	0.4	0.20	0	0.33
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.5	1	1	0.60	0	0.65
Lower Salt River Below Saguaro Lake 1506010603A	0.5	1	1	0.00	0	0.50
Weights	*0.30*	*0.05*	*0.30*	*0.25*	*0.10*	

[1]Water Quality Assessment results, from Table 6-3.

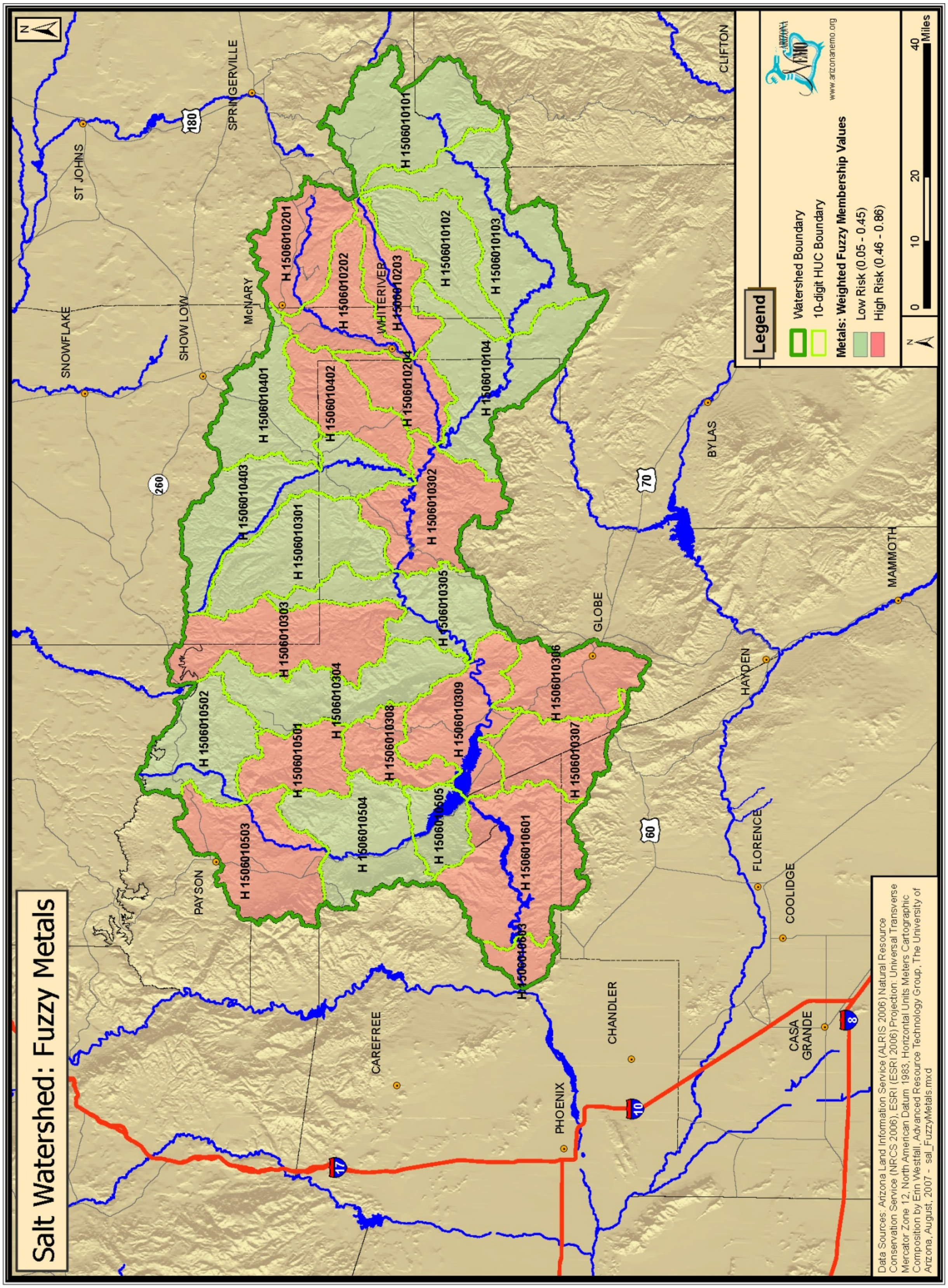

Figure 6-3: Salt Watershed, Results for the Fuzzy Logic Classification for Metals

Sediment

Erosion and sedimentation are major environmental concerns in arid and semiarid regions. Sediment is the chief source of impairment in the southwestern United States, not only to our few aquatic systems, but also to our riparian areas which are at risk from channel degradation.

The factors used for the sediment classification are:

- ADEQ water quality assessment results (turbidity data is used where sediment results are not available);
- Land ownership;
- Human use within a subwatershed and riparian area;
- Estimated current runoff and sediment yield; and
- Percent urbanized area.

Because available water quality data are limited, more weight was placed on subwatershed characteristics and modeling results when performing the classification.

Water Quality Assessment Data - Sediment

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2006a) was used to define the current water quality based on water monitoring results. In assigning fuzzy membership values, the location of a subwatershed relative to an impaired water was considered. As discussed under the metals classification section, Table 6-2 contains the fuzzy membership values used for different subwatershed conditions based on the water quality classification results. Table 6-9 contains the fuzzy membership values assigned to each 10-digit HUC subwatershed based on turbidity data.

Table 6-9: Fuzzy Membership Values for Sediment, Assigned to each 10-Digit HUC Subwatershed, Based on Water Quality Assessment Results.

Subwatershed Name	FMV	Justification
Upper Black River 1506010101	0.5	Classified as moderate risk, drains to Middle Black River that is classified as moderate.
Big Bonito Creek 1506010102	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Middle Black River 1506010103	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Lower Black River 1506010104	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Upper North Fork White River 1506010201	0.5	Classified as moderate risk, drains to Lower North Fork White River that is classified as moderate.
Lower North Fork White River 1506010202	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
East Fork White River 1506010203	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
White River 1506010204	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.

Subwatershed Name	FMV	Justification
Cibecue Creek 1506010301	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Sawmill Creek – Upper Salt River 1506010302	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Canyon Creek 1506010303	0.0	Classified as low risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Cherry Creek 1506010304	0.0	Classified as low risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salt River Draw – Upper Salt River 1506010305	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinal Creek 1506010306	0.0	Classified as low risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinto Creek 1506010307	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salome Creek 1506010308	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Upper Salt River – Theodore Roosevelt Lake 1506010309	1.0	Classified as extreme risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as moderate.
Corduroy Creek 1506010401	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Cedar Creek 1506010402	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Carrizo Creek 1506010403	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Spring Creek 1506010501	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.
Haigler Creek – Tonto Creek 1506010502	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.
Rye Creek – Tonto Creek 1506010503	0.3	Classified as moderate risk, drains to Gun Creek – Tonto Creek that is classified as low.
Gun Creek – Tonto Creek 1506010504	0.0	Classified as low risk, drains to Tonto Creek – Theodore Roosevelt Lake that is classified as moderate.
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.5	Classified as moderate risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as moderate.
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.3	Classified as moderate risk, drains to Lower Salt River Below Saguaro Lake that is classified as low.
Lower Salt River Below Saguaro Lake 1506010603A	0.0	Classified as low risk, drains out of the watershed.

Land ownership - Sediment

One of the principal land uses in the Salt Watershed is livestock grazing. Livestock grazing occurs primarily on land owned by the federal government (Bureau of Land Management (BLM), and U.S. Forest Service (USFS)), which comprises approximately 44.88% of the total watershed area. The remaining lands where grazing occurs are Arizona State Trust Lands (approximately 0.67%), tribal lands (approximately 47.35%), and privately owned land (approximately 6.8%). Section 4, Social Characteristics, contains a brief discussion of land ownership, with more detail provided in Section 7, Watershed Management, where individual management practices and target stakeholders are discussed.

Given that Federal lands must have management plans that include best management practices, the following classification will highlight State and private lands that may not have a water management plan in place. The fuzzy membership function for the percentage of land in state or private ownership within a 10-digit HUC subwatershed is shown below.

FMV = 0 if (%State + private <= 10)
FMV = (%State + private – 10) / 15
FMV = 1 if (%State + private >= 25)

Table 6-10 contains the fuzzy membership values assigned to each 10-digit HUC subwatershed in the Salt Watershed based on land ownership.

Table 6-10: Fuzzy Membership Values for Sediment Based on Land Ownership.

Subwatershed	% State + Private	FMV
Upper Black River 1506010101	0.93	0
Big Bonito Creek 1506010102	0.00	0
Middle Black River 1506010103	0.00	0
Lower Black River 1506010104	0.00	0
Upper North Fork White River 1506010201	0.06	0
Lower North Fork White River 1506010202	0.00	0
East Fork White River 1506010203	0.00	0
White River 1506010204	0.00	0
Cibecue Creek 1506010301	0.00	0
Sawmill Creek – Upper Salt River 1506010302	0.04	0
Canyon Creek 1506010303	1.30	0
Cherry Creek 1506010304	4.30	0
Salt River Draw – Upper Salt River 1506010305	0.49	0
Pinal Creek 1506010306	24.6	0.97
Pinto Creek 1506010307	7.53	0
Salome Creek 1506010308	0.87	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0.29	0
Corduroy Creek 1506010401	0.08	0
Cedar Creek 1506010402	0.00	0
Carrizo Creek 1506010403	0.00	0

Subwatershed	% State + Private	FMV
Spring Creek 1506010501	2.31	0
Haigler Creek – Tonto Creek 1506010502	2.00	0
Rye Creek – Tonto Creek 1506010503	3.02	0
Gun Creek – Tonto Creek 1506010504	2.70	0
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.22	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.03	0
Lower Salt River Below Saguaro Lake 1506010603A	62.6	1

Human Use Index - Sediment

The Human Use Index was used to assess the relative impact of urban development on sediment load in streams. The Human Use Index is defined as the percentage of a subwatershed that is characterized as developed for human use. In the Salt Watershed, human use consists of developed areas as defined by the Southwest Regional GAP land cover data set as residential land use, agriculture, mining and roads (RS/GIS Laboratory, 2004).

Human use was assessed at both the subwatershed and riparian scale (<= 250 meters from a stream). The fuzzy membership functions for both conditions are:

Human Use Index (HUI)/watershed:

FMV = 0 if (HUI <= 5%)
FMV = (HUI – 5) / 15
FMV = 1 if (HUI >= 20%)

Human Use Index/riparian:

FMV = 0 if (HUI <= 1%)
FMV = (HUI - 1) / 4
FMV = 1 if (HUI >= 5%)

Table 6-11 contains the fuzzy membership values assigned to each 10-digit HUC subwatershed in the Salt Watershed based on the Human Use Index.

Table 6-11: Fuzzy Membership Values for Sediment Based on the Human Use Index (HUI).

Subwatershed	FMV - HUI Watershed	FMV - HUI Riparian
Upper Black River 1506010101	0	0
Big Bonito Creek 1506010102	0	0
Middle Black River 1506010103	0	0
Lower Black River 1506010104	0	0
Upper North Fork White River 1506010201	0	0
Lower North Fork White River 1506010202	0	0
East Fork White River 1506010203	0	0
White River 1506010204	0	0
Cibecue Creek 1506010301	0	0
Sawmill Creek – Upper Salt River 1506010302	0	0
Canyon Creek 1506010303	0	0
Cherry Creek 1506010304	0	0

Subwatershed	FMV - HUI Watershed	FMV - HUI Riparian
Salt River Draw – Upper Salt River 1506010305	0	0
Pinal Creek 1506010306	0.6	1
Pinto Creek 1506010307	0	1
Salome Creek 1506010308	0	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0	0
Corduroy Creek 1506010401	0	0
Cedar Creek 1506010402	0	0
Carrizo Creek 1506010403	0	0
Spring Creek 1506010501	0	0
Haigler Creek – Tonto Creek 1506010502	0	0
Rye Creek – Tonto Creek 1506010503	0	0.75
Gun Creek – Tonto Creek 1506010504	0	0
Tonto Creek – Theodore Roosevelt Lake 1506010505	0	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0	0
Lower Salt River Below Saguaro Lake 1506010603A	0	0

AGWA/SWAT Modeling

Runoff, Erosion and Sediment Yield

AGWA/SWAT was used to evaluate the potential runoff and sediment yield (see Appendix D for a description of AGWA/SWAT) for a subwatershed area. Runoff can be used to evaluate potential sediment yield, which is a measure of the rate of erosion. Both runoff and sediment yield depend on a combination of soil properties, topography, climate and land cover.

The modeling results were reclassified into 6 categories, with the first category given a fuzzy membership value of 0.0. The fuzzy membership values were increased by 0.2 for each higher category. Table 6-12 shows the runoff categories and associated FMV, and Table 6-13 shows the erosion categories and associated FMV. Figure 6-4 shows erosion as sediment yield for each subwatershed. Figure 6-5 shows runoff as water yield for each of the subwatersheds.

Table 6-12: Fuzzy Membership Values and Runoff Categories.

Subwatershed	Runoff Category	FMV
Upper Black River 1506010101	2	0.2
Big Bonito Creek 1506010102	3	0.4
Middle Black River 1506010103	3	0.4
Lower Black River 1506010104	4	0.6
Upper North Fork White River 1506010201	2	0.2
Lower North Fork White River 1506010202	2	0.2
East Fork White River 1506010203	3	0.4
White River 1506010204	2	0.2
Cibecue Creek 1506010301	5	0.8
Sawmill Creek – Upper Salt River 1506010302	6	1.0
Canyon Creek 1506010303	5	0.8
Cherry Creek 1506010304	6	1.0
Salt River Draw – Upper Salt River 1506010305	5	0.8

Subwatershed	Runoff Category	FMV
Pinal Creek 1506010306	3	0.4
Pinto Creek 1506010307	4	0.6
Salome Creek 1506010308	3	0.4
Upper Salt River – Theodore Roosevelt Lake 1506010309	6	1.0
Corduroy Creek 1506010401	4	0.6
Cedar Creek 1506010402	4	0.6
Carrizo Creek 1506010403	6	1.0
Spring Creek 1506010501	2	0.2
Haigler Creek – Tonto Creek 1506010502	2	0.2
Rye Creek – Tonto Creek 1506010503	2	0.2
Gun Creek – Tonto Creek 1506010504	2	0.2
Tonto Creek – Theodore Roosevelt Lake 1506010505	2	0.2
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	3	0.4
Lower Salt River Below Saguaro Lake 1506010603A	1	0.0

Table 6-13: Fuzzy Membership Values and Erosion Categories.

Subwatershed	Erosion Category	FMV
Upper Black River 1506010101	3	0.4
Big Bonito Creek 1506010102	3	0.4
Middle Black River 1506010103	3	0.4
Lower Black River 1506010104	5	0.8
Upper North Fork White River 1506010201	2	0.2
Lower North Fork White River 1506010202	4	0.6
East Fork White River 1506010203	3	0.4
White River 1506010204	5	0.8
Cibecue Creek 1506010301	5	0.8
Sawmill Creek – Upper Salt River 1506010302	6	1.0
Canyon Creek 1506010303	4	0.6
Cherry Creek 1506010304	3	0.4
Salt River Draw – Upper Salt River 1506010305	4	0.6
Pinal Creek 1506010306	3	0.4
Pinto Creek 1506010307	3	0.4
Salome Creek 1506010308	2	0.2
Upper Salt River – Theodore Roosevelt Lake 1506010309	4	0.6
Corduroy Creek 1506010401	6	1.0
Cedar Creek 1506010402	6	1.0
Carrizo Creek 1506010403	6	1.0
Spring Creek 1506010501	1	0.0
Haigler Creek – Tonto Creek 1506010502	1	0.0
Rye Creek – Tonto Creek 1506010503	1	0.0
Gun Creek – Tonto Creek 1506010504	2	0.2
Tonto Creek – Theodore Roosevelt Lake 1506010505	2	0.2
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	2	0.2
Lower Salt River Below Saguaro Lake 1506010603A	1	0.0

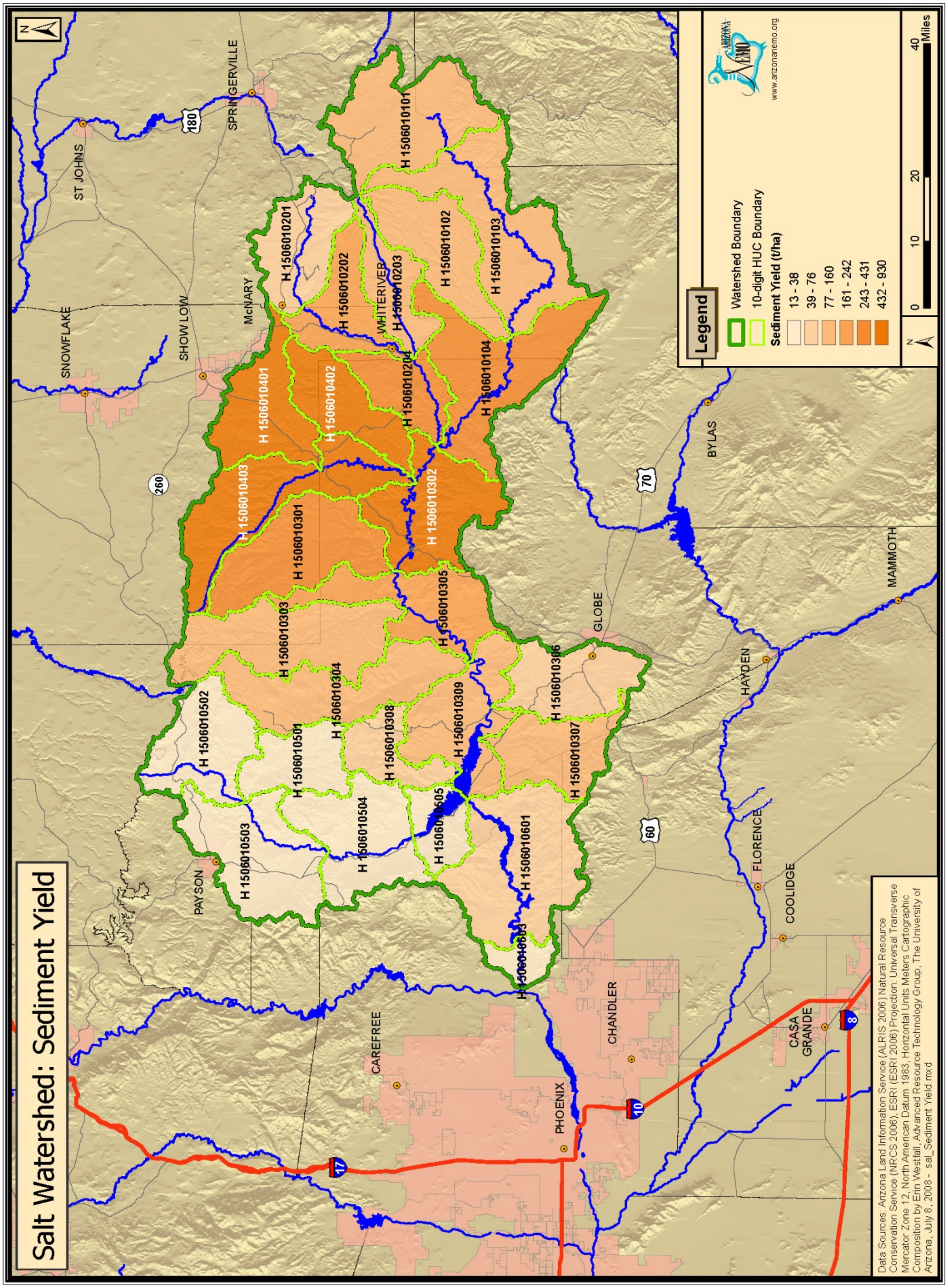

Figure 6-4: Salt Watershed, Sediment Yield by subwatershed

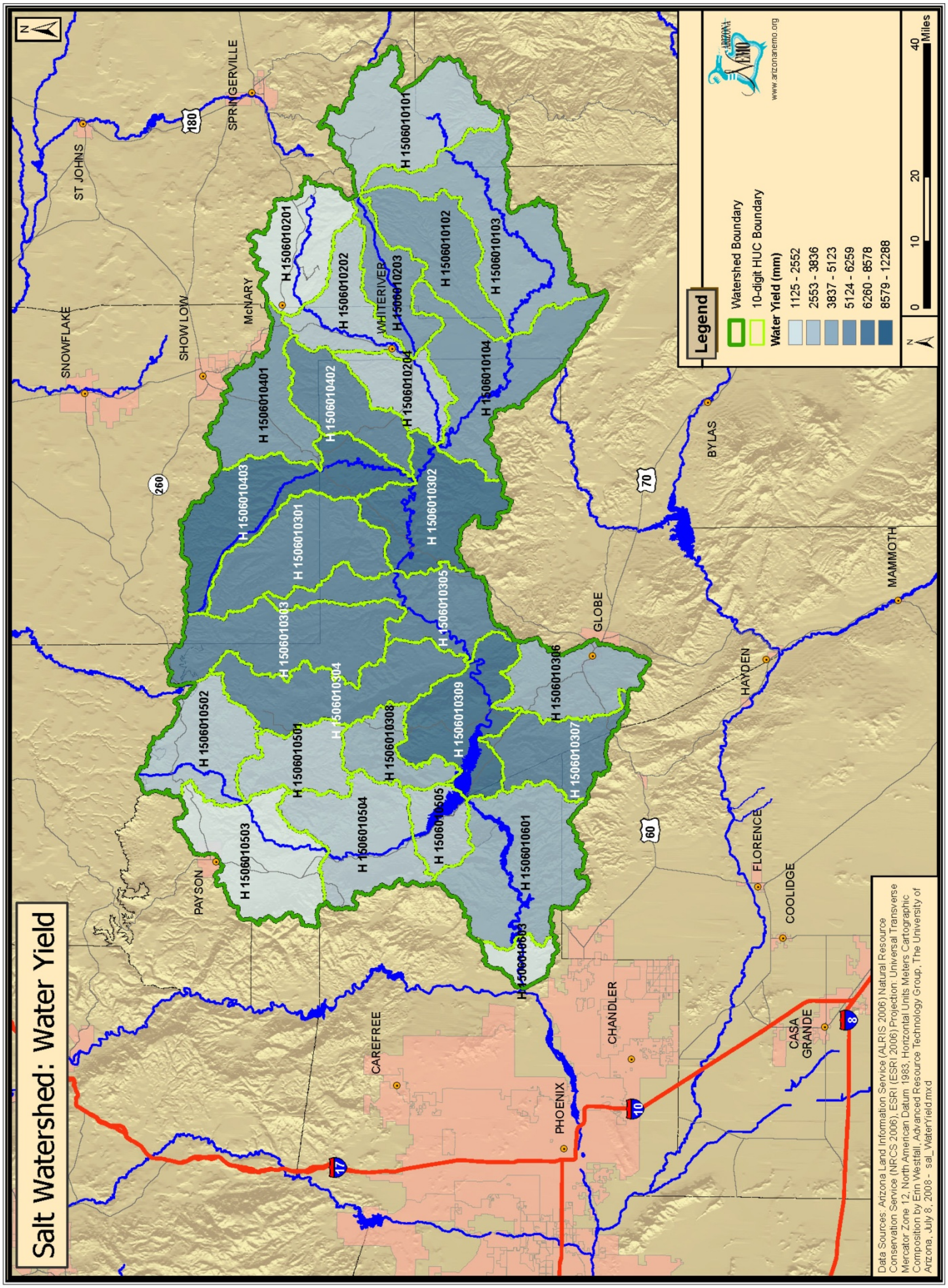

Figure 6-5: Salt Watershed, Water Yield by subwatershed

Urbanized Areas - Sediment

Urbanized areas can increase sediment content in stream systems in various ways. For example, new construction of roads and buildings causes increased sediment in runoff. In addition the runoff from impervious surfaces is sediment starved, and when this water reaches the streams, increased erosion results (Booth, 1990; Chin and Gregory, 2004). Various studies have shown that semiarid stream systems become irreparably impaired once the impervious surfaces within the watershed exceed about 10%, and will experience dramatic morphological changes once that percentage exceeds about 20% (Coleman et. al., 2005; Miltner et al., 2003). The final values for the fuzzy membership functions (FMV) were selected based on these studies. The FMVs for the percentage of urban land within a 10-digit HUC subwatershed is shown below.

FMV = 0 if (% Urban < 5)
FMV = (5 < = % Urban < 12) / 12
FMV = 1 if (% Urban >= 12)

Table 6-14: Fuzzy Membership Values for Urbanized Areas for Sediment.

Subwatershed	Percent Urban	FMV
Upper Black River 1506010101	0.00	0
Big Bonito Creek 1506010102	0.00	0
Middle Black River 1506010103	0.00	0
Lower Black River 1506010104	0.00	0
Upper North Fork White River 1506010201	0.21	0
Lower North Fork White River 1506010202	1.30	0
East Fork White River 1506010203	0.22	0
White River 1506010204	0.55	0
Cibecue Creek 1506010301	0.00	0
Sawmill Creek – Upper Salt River 1506010302	0.11	0
Canyon Creek 1506010303	0.06	0
Cherry Creek 1506010304	0.39	0
Salt River Draw – Upper Salt River 1506010305	0.00	0
Pinal Creek 1506010306	5.50	0.45
Pinto Creek 1506010307	0.00	0
Salome Creek 1506010308	0.08	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0.12	0
Corduroy Creek 1506010401	0.14	0
Cedar Creek 1506010402	0.00	0
Carrizo Creek 1506010403	0.00	0
Spring Creek 1506010501	0.09	0
Haigler Creek – Tonto Creek 1506010502	0.19	0
Rye Creek – Tonto Creek 1506010503	2.40	0
Gun Creek – Tonto Creek 1506010504	0.28	0
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.04	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.00	0
Lower Salt River Below Saguaro Lake 1506010603A	0.00	0

Sediment Results

The weighted combination approach was used to create combined fuzzy scores to rank sediment results, as shown in Table 6-14. Figure 6-6 shows the results of the weighted combination method classified into high and low priority for sediment. The weights used in the classification are also found in Table 6-15.

Table 6-15: Summary Results for Sediment Based on the Fuzzy Logic Approach – Weighted Combination Approach.

Subwatershed Name	FMV WQA[1]	FMV Land Ownership	FMV HU Index / Watershed	FMV HU Index / Riparian	FMV Runoff	FMV Erosion	FMV Urban Area	FMV Weighted
Upper Black River 1506010101	0.5	0	0	0	0.2	0.4	0	0.21
Big Bonito Creek 1506010102	0.5	0	0	0	0.4	0.4	0	0.27
Middle Black River 1506010103	0.5	0	0	0	0.4	0.4	0	0.27
Lower Black River 1506010104	0.5	0	0	0	0.6	0.8	0	0.45
Upper North Fork White River 1506010201	0.5	0	0	0	0.2	0.2	0	0.15
Lower North Fork White River 1506010202	0.5	0	0	0	0.2	0.6	0	0.27
East Fork White River 1506010203	0.5	0	0	0	0.4	0.4	0	0.27
White River 1506010204	0.5	0	0	0	0.2	0.8	0	0.33
Cibecue Creek 1506010301	0.5	0	0	0	0.8	0.8	0	0.51
Sawmill Creek – Upper Salt River 1506010302	0.5	0	0	0	1	1	0	0.63
Canyon Creek 1506010303	0	0	0	0	0.8	0.6	0	0.42
Cherry Creek 1506010304	0	0	0	0	1	0.4	0	0.42
Salt River Draw – Upper Salt River 1506010305	0.7	0	0	0	0.8	0.6	0	0.46
Pinal Creek 1506010306	0	0.97	0.60	1.0	0.4	0.4	0.45	0.51
Pinto Creek 1506010307	0.7	0	0	1.0	0.6	0.4	0	0.49
Salome Creek 1506010308	0.7	0	0	0	0.4	0.2	0	0.22
Upper Salt River – Theodore Roosevelt Lake 1506010309	1	0	0	0	1	0.6	0	0.53
Corduroy Creek 1506010401	0.5	0	0	0	0.6	1	0	0.51
Cedar Creek 1506010402	0.5	0	0	0	0.6	1	0	0.51
Carrizo Creek 1506010403	0.5	0	0	0	1	1	0	0.63
Spring Creek 1506010501	0.5	0	0	0	0.2	0	0	0.09

Subwatershed Name	FMV WQA[1]	FMV Land Ownership	FMV HU Index / Watershed	FMV HU Index / Riparian	FMV Runoff	FMV Erosion	FMV Urban Area	FMV Weighted
Haigler Creek – Tonto Creek 1506010502	0.5	0	0	0	0.2	0	0	0.09
Rye Creek – Tonto Creek 1506010503	0.3	0	0	0.75	0.2	0	0	0.19
Gun Creek – Tonto Creek 1506010504	0	0	0	0	0.2	0.2	0	0.12
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.5	0	0	0	0.2	0.2	0	0.15
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.3	0	0	0	0.4	0.2	0	0.20
Lower Salt River Below Saguaro Lake 1506010603A	0	1.0	1.0	1.0	0	0	0	0.25
Weights	*0.05*	*0.05*	*0.05*	*0.15*	*0.3*	*0.3*	*0.1*	

[1]WQA = Water Quality Assessment results, Table 6-8

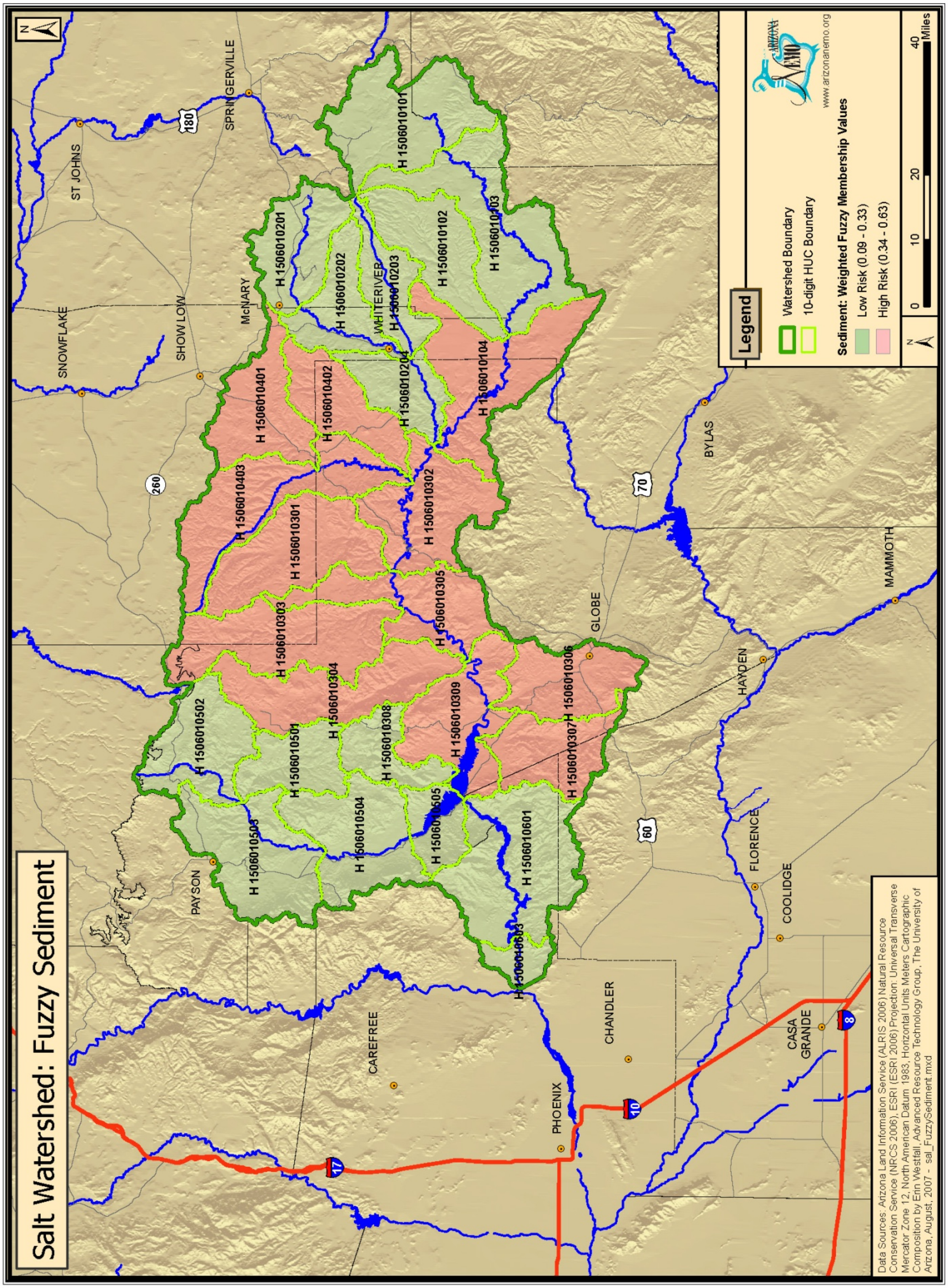

Figure 6-6: Salt Watershed, Results for the Fuzzy Logic Classification for Sediment

Organics

Several water quality parameters that have been identified as concerns in the Salt Watershed are related to the introduction of organic material to a water body. Several monitored reaches had past pH exceedances associated with metals exceedances from historic mining activity. Several reaches had dissolved oxygen exceedances due to natural low flow conditions and ground water upwelling. Several reaches had *E. coli* or phosphorus exceedances. Several other waterbodies had limited or insufficient data for organics.

The factors that were used for organic material classification are:

- ADEQ water quality assessment results for organic parameters, including dissolved oxygen, nitrates and TDS;
- Human use index within both the overall subwatershed and within the riparian area; and
- Land use, including grazing and agriculture.

Water Quality Assessment - Organics

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2006a) was used to define the current water quality conditions based on water quality measurements. In assigning fuzzy membership values, the location of the 10-digit HUC subwatershed relative to an impaired water or reach was considered. Table 6-2 contains the fuzzy membership values used for different subwatershed conditions based on the water quality assessment results. Table 6-16 contains the fuzzy membership values assigned to each 10-digit HUC subwatershed for organics classification.

Human Use Index - Organics

The Human Use Index was used to assess the relative impact of urban development on the presence of organics in stream water. The Human Use Index is defined as the percentage of a subwatershed that is disturbed by development and human use. In the Salt Watershed, human use consists of developed areas as defined by the Southwest Regional GAP land cover data as residential land use, mining and roads (RS/GIS Laboratory, 2004).

Human activity can introduce organic material to a water body by disposal of organic compounds, waste and sewage. Most of the residential developments outside of urban areas in the Salt Watershed utilize onsite septic sewage systems. Currently, the construction of new septic systems requires a permit from ADEQ in the State of Arizona (some exemptions apply), and an inspection of the septic system is required when a property is sold if it was originally approved for use on or after Jan. 1, 2001 by ADEQ or a delegated county agency (http://www.azdeq.gov/environ/water/permits/wastewater.html).

However, there are no requirements for regular inspections of older septic systems and as a result, rural areas may have a significant impact on the introduction of organic material to the environment.

Table 6-16: Fuzzy Membership Values for Organics, Assigned to each 10-digit HUC Subwatershed Based on Water Quality Assessment Results for Organics.

Subwatershed Name	FMV	Justification
Upper Black River 1506010101	0.7	Classified as high risk, drains to Middle Black River that is classified as moderate.
Big Bonito Creek 1506010102	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Middle Black River 1506010103	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Lower Black River 1506010104	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Upper North Fork White River 1506010201	0.5	Classified as moderate risk, drains to Lower North Fork White River that is classified as moderate.
Lower North Fork White River 1506010202	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
East Fork White River 1506010203	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
White River 1506010204	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Cibecue Creek 1506010301	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Sawmill Creek – Upper Salt River 1506010302	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Canyon Creek 1506010303	0.0	Classified as low risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Cherry Creek 1506010304	0.0	Classified as low risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salt River Draw – Upper Salt River 1506010305	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinal Creek 1506010306	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinto Creek 1506010307	1.0	Classified as extreme risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salome Creek 1506010308	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Upper Salt River – Theodore Roosevelt Lake 1506010309	1.0	Classified as extreme risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as extreme.
Corduroy Creek 1506010401	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Cedar Creek 1506010402	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Carrizo Creek 1506010403	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Spring Creek 1506010501	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.
Haigler Creek – Tonto Creek 1506010502	1.0	Classified as extreme risk, drains to Rye Creek – Tonto Creek that is classified as moderate.

Subwatershed Name	FMV	Justification
Rye Creek – Tonto Creek 1506010503	0.3	Classified as moderate risk, drains to Gun Creek – Tonto Creek that is classified as low.
Gun Creek – Tonto Creek 1506010504	0.0	Classified as low risk, drains to Tonto Creek – Theodore Roosevelt Lake that is classified as moderate.
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.7	Classified as moderate risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as extreme.
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	1.0	Classified as extreme risk, drains to Lower Salt River Below Saguaro Lake that is classified as low.
Lower Salt River Below Saguaro Lake 1506010603A	1.0	Classified as extreme risk, drains out of the watershed.

Human use has been assessed at both the subwatershed and riparian area scale (<= 250 meters from a stream). The fuzzy membership functions for both conditions are as follows:

Human Use Index (HUI)/ HUC watershed:

FMV = 0 if (HUI <= 1%)
FMV = (HUI – 1) / 3
FMV = 1 if (HUI >= 4%)

Human Use Index/Riparian:

FMV = 0 if (HUI <= 0%)
FMV = (HUI - 0) / 4
FMV = 1 if (HUI >= 4%)

Table 6-17 contains the fuzzy membership values assigned to each 10- digit HUC subwatershed in the Salt Watershed for organics based on the Human Use Index.

Table 6-17: Fuzzy Membership Values for Organics Based on the Human Use Index.

Subwatershed	FMV HU Index Watershed	FMV HU Index Riparian
Upper Black River 1506010101	0	0
Big Bonito Creek 1506010102	0	0
Middle Black River 1506010103	0	0
Lower Black River 1506010104	0	0
Upper North Fork White River 1506010201	0	0
Lower North Fork White River 1506010202	0	0
East Fork White River 1506010203	0	0
White River 1506010204	0	0.2
Cibecue Creek 1506010301	0	0
Sawmill Creek – Upper Salt River 1506010302	0	0
Canyon Creek 1506010303	0	0
Cherry Creek 1506010304	0	0

Subwatershed	FMV HU Index Watershed	FMV HU Index Riparian
Salt River Draw – Upper Salt River 1506010305	0	0
Pinal Creek 1506010306	1	1
Pinto Creek 1506010307	1	1
Salome Creek 1506010308	0	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0	0
Corduroy Creek 1506010401	0	0
Cedar Creek 1506010402	0	0
Carrizo Creek 1506010403	0	0
Spring Creek 1506010501	0	0
Haigler Creek – Tonto Creek 1506010502	0	0
Rye Creek – Tonto Creek 1506010503	2	1
Gun Creek – Tonto Creek 1506010504	0	0
Tonto Creek – Theodore Roosevelt Lake 1506010505	0	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0	0
Lower Salt River Below Saguaro Lake 1506010603A	0	0

Land Use - Organics

The major land uses in the Salt Watershed are livestock grazing and urban lands, which both contribute to organics in the watershed. Livestock grazing occurs on most land ownership types, including federal government land (BLM and USFS), Arizona State Trust Land, tribal lands and privately owned land. Therefore, each 10-digit HUC watershed was assigned a fuzzy membership value based on its primary land use relative to livestock grazing.

All subwatersheds were initially assigned a value of 1.0 as most of the land is state, federal, tribal or privately owned, and was assumed to be used for livestock grazing, agriculture, or urban areas.

Urbanized Areas – Organics

Urbanized areas can contribute to an increase in organics in stream systems from human activities such as the use of fertilizers or leaking septic systems. Because these contributions can be significant, urbanized areas were included as an additional category in these calculations. The FMVs for the percentage of urban land within a 10-digit HUC subwatershed is shown below.

FMV = 0 if (% Urban < 5)
FMV = (5 < = % Urban < 12) / 12
FMV = 1 if (% Urban >= 12)

Table 6-18: Fuzzy Membership Values for Urbanized Areas for Organics.

Subwatershed	Percent Urban	FMV
Upper Black River 1506010101	0.00	0
Big Bonito Creek 1506010102	0.00	0
Middle Black River 1506010103	0.00	0
Lower Black River 1506010104	0.00	0
Upper North Fork White River 1506010201	0.21	0
Lower North Fork White River 1506010202	1.30	0

Subwatershed	Percent Urban	FMV
East Fork White River 1506010203	0.22	0
White River 1506010204	0.55	0
Cibecue Creek 1506010301	0.00	0
Sawmill Creek – Upper Salt River 1506010302	0.11	0
Canyon Creek 1506010303	0.06	0
Cherry Creek 1506010304	0.39	0
Salt River Draw – Upper Salt River 1506010305	0.00	0
Pinal Creek 1506010306	5.50	0.45
Pinto Creek 1506010307	0.00	0
Salome Creek 1506010308	0.08	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0.12	0
Corduroy Creek 1506010401	0.14	0
Cedar Creek 1506010402	0.00	0
Carrizo Creek 1506010403	0.00	0
Spring Creek 1506010501	0.09	0
Haigler Creek – Tonto Creek 1506010502	0.19	0
Rye Creek – Tonto Creek 1506010503	2.40	0
Gun Creek – Tonto Creek 1506010504	0.28	0
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.04	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.00	0
Lower Salt River Below Saguaro Lake 1506010603A	0.00	0

Nutrients

According to Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a), seven waterbodies had exceedances for nutrients:

1. Apache Lake, for dissolved oxygen
2. Canyon Lake, for dissolved oxygen
3. Christopher Creek from headwaters to Tonto Creek, for *E. coli* and phosphorus
4. Crescent Lake, for high pH (EPA)
5. Salt River from Stewart Mountain Dam (Saguaro Lake) to Verde River, for low dissolved oxygen
6. Tonto Creek, from headwaters to unnamed tributary at 341810/1110414, for *E. coli*, phosphorus and low dissolved oxygen
7. Tonto Creek, from unnamed tributary at 341810/1110414 to Haigler Creek, for *E. coli*

In addition, there were insufficient monitoring data for many of the waterbodies, resulting in "inconclusive" assessments. Nutrient exceedances can be caused by runoff from residential areas where landscapes are fertilized, or from animal waste where grazing is prevalent.

pH

According to Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a), several waterbodies have exceedances for pH levels. Non-compliant pH measurements can be an indication of lake eutrophication, or can be associated with past mining activities (acid mine drainage). Typical unpolluted flowing water will have pH values ranging from 6.5 to 8.5 (unitless); however, where photosynthesis by aquatic organisms takes up dissolved carbon dioxide during daylight hours, a diurnal pH fluctuation may occur and the maximum pH value may sometimes reach as high as 9.0. Studies have found that in poorly buffered lake water, pH fluctuations occur with maximum pH values exceeding 12 (Hem, 1970). The fluctuation in pH has been found to be more pronounced in warm, arid lakes.

Some mine sites may produce acid mine drainage, or low pH conditions, due to the exposure of sulfates to oxygen and water. The acid mine drainage dissolves naturally occurring metals in the soils, increasing the dissolved metal concentrations to sometimes toxic levels. Low pH in aquatic systems can be fatal to many organisms, including fish, or may affect reproduction, causing deformities. In addition, low pH can result in the release of heavy metals, which oxidize and accumulate in the gills of fish, causing asphyxiation (des.nh.gov/wet/Aug04Institute/chemical.pdf).

Organics Results

The weighted combination approach was used to create the combined fuzzy score, and the results are found in Table 6-19, along with the weights used in the classification. Figure 6-7 shows the results of the weighted combination method classified into high and low priority for organics.

Table 6-19: Summary Results for Organics Based on the Fuzzy Logic – Weighted Combination Approach.

Subwatershed	FMV WQA[1]	FMV HUI / subws	FMV HUI / riparian	FMV Land Use	FMV Urban Areas	FMV Weighted
Upper Black River 1506010101	0.7	0	0	1	0	0.31
Big Bonito Creek 1506010102	0.5	0	0	1	0	0.25
Middle Black River 1506010103	0.5	0	0	1	0	0.25
Lower Black River 1506010104	0.5	0	0	1	0	0.25
Upper North Fork White River 1506010201	0.5	0	0	1	0	0.25
Lower North Fork White River 1506010202	0.5	0	0	1	0	0.25
East Fork White River 1506010203	0.5	0	0	1	0	0.25
White River 1506010204	0.5	0	0.2	1	0	0.31
Cibecue Creek 1506010301	0.5	0	0	1	0	0.25
Sawmill Creek – Upper Salt River 1506010302	0.5	0	0	1	0	0.25
Canyon Creek 1506010303	0	0	0	1	0	0.10
Cherry Creek 1506010304	0	0	0	1	0	0.10
Salt River Draw – Upper Salt River 1506010305	0.7	0	0	1	0	0.31
Pinal Creek 1506010306	0.7	1	1	1	0.45	0.86
Pinto Creek 1506010307	1	1	1	1	0	0.90
Salome Creek 1506010308	0.7	0	0	1	0	0.31

Subwatershed	FMV WQA[1]	FMV HUI / subws	FMV HUI / riparian	FMV Land Use	FMV Urban Areas	FMV Weighted
Upper Salt River – Theodore Roosevelt Lake 1506010309	1	0	0	1	0	0.40
Corduroy Creek 1506010401	0.5	0	0	1	0	0.25
Cedar Creek 1506010402	0.5	0	0	1	0	0.25
Carrizo Creek 1506010403	0.5	0	0	1	0	0.25
Spring Creek 1506010501	0.5	0	0	1	0	0.25
Haigler Creek – Tonto Creek 1506010502	1	0	0	1	0	0.40
Rye Creek – Tonto Creek 1506010503	0.3	2	1	1	0	0.89
Gun Creek – Tonto Creek 1506010504	0	0	0	1	0	0.10
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.7	0	0	1	0	0.31
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	1	0	0	1	0	0.40
Lower Salt River Below Saguaro Lake 1506010603A	1	0	0	1	0	0.40
Weights	*0.3*	*0.2*	*0.3*	*0.1*	*0.1*	

[1]WQA = Water Quality Assessment results

Selenium

There were insufficient selenium data to assess most waterbodies, although in locations where monitoring occurred, two exceedances were noted in Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a).

- Pinto Creek from West Fork Pinto Creek to Roosevelt Lake
- Pinto Creek from unnamed tributary at 331927/1105456 to West Fork Pinto Creek

High values for selenium may be associated with high values for metals, and are likely to be naturally occurring in highly mineralized soils, or after a severe fire. In addition, high values may be associated with evaporation or tailing ponds, where evaporation would increase the relative concentration of selenium, as well as other constituents. One common source of elevated selenium in the western United States is agricultural drainage water ("tail water") from seleniferous irrigated soils (Hem, 1970).

Water Quality Assessment Data-Selenium

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ. 2006a) results were used to define the current water quality based on water monitoring results. In assigning fuzzy membership values, the location of a subwatershed relative to an impaired water was considered. Table 6-20 contains the fuzzy membership values for selenium for each subwatershed based on the water quality assessment results.

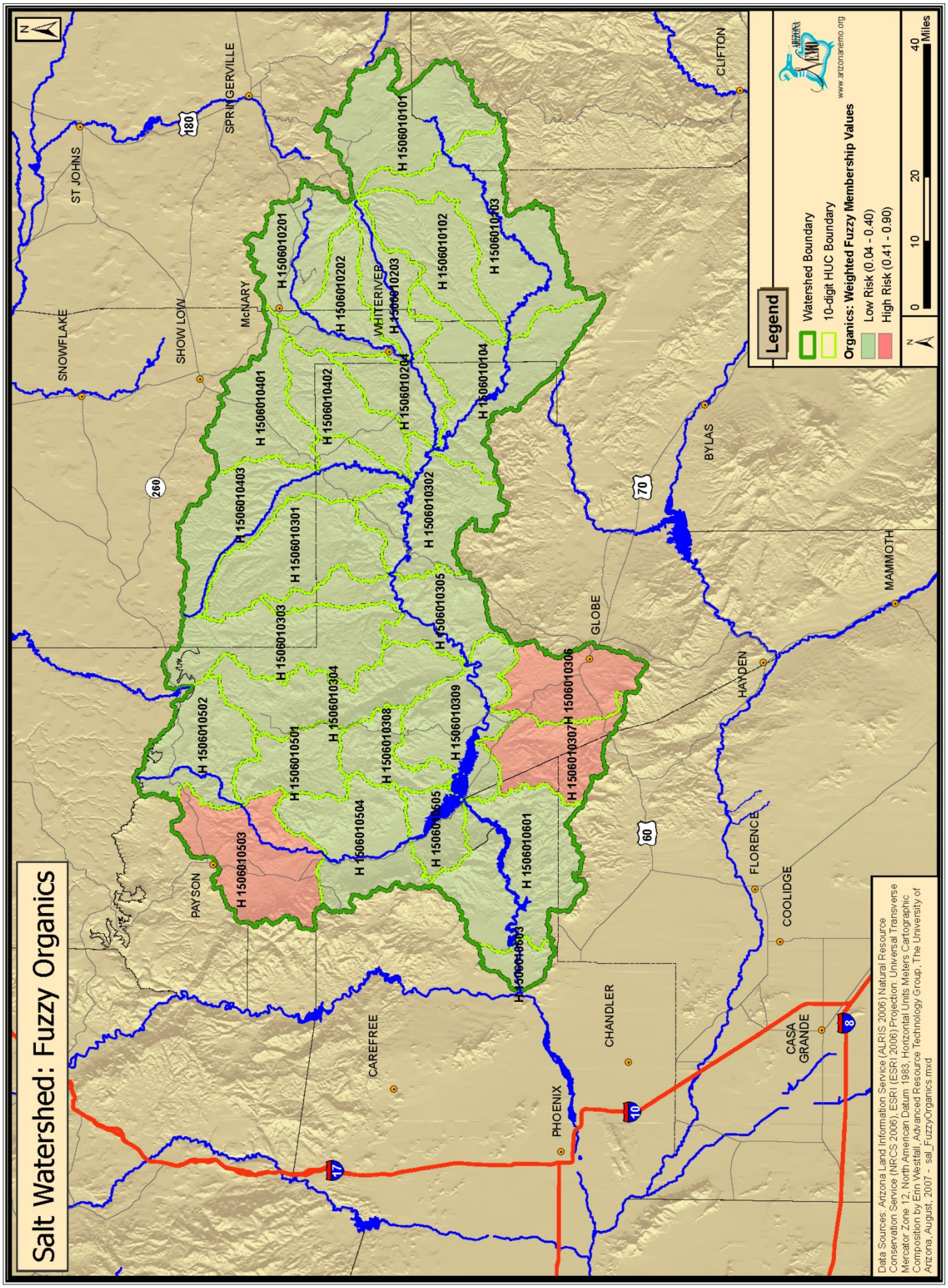

Figure 6-7: Salt Watershed, Results for the Fuzzy Logic Classification for Organics

Table 6-20: Fuzzy Membership Values for Selenium Assigned to each 10-digit HUC Subwatershed Based on Water Quality Assessment Results.

Subwatershed Name	FMV	Justification
Upper Black River 1506010101	0.5	Classified as moderate risk, drains to Middle Black River that is classified as moderate.
Big Bonito Creek 1506010102	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Middle Black River 1506010103	0.5	Classified as moderate risk, drains to Lower Black River that is classified as moderate.
Lower Black River 1506010104	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Upper North Fork White River 1506010201	0.5	Classified as moderate risk, drains to Lower North Fork White River that is classified as moderate.
Lower North Fork White River 1506010202	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
East Fork White River 1506010203	0.5	Classified as moderate risk, drains to White River that is classified as moderate.
White River 1506010204	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Cibecue Creek 1506010301	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Sawmill Creek – Upper Salt River 1506010302	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Canyon Creek 1506010303	0.5	Classified as moderate risk, drains to Salt River Draw – Upper Salt River that is classified as moderate.
Cherry Creek 1506010304	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salt River Draw – Upper Salt River 1506010305	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinal Creek 1506010306	0.0	Classified as low risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Pinto Creek 1506010307	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Salome Creek 1506010308	0.7	Classified as moderate risk, drains to Upper Salt River – Theodore Roosevelt Lake that is classified as extreme.
Upper Salt River – Theodore Roosevelt Lake 1506010309	1.0	Classified as extreme risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as moderate.
Corduroy Creek 1506010401	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Cedar Creek 1506010402	0.5	Classified as moderate risk, drains to Carrizo Creek that is classified as moderate.
Carrizo Creek 1506010403	0.5	Classified as moderate risk, drains to Sawmill Creek – Upper Salt River that is classified as moderate.
Spring Creek 1506010501	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.
Haigler Creek – Tonto Creek 1506010502	0.5	Classified as moderate risk, drains to Rye Creek – Tonto Creek that is classified as moderate.

Subwatershed Name	FMV	Justification
Rye Creek – Tonto Creek 1506010503	0.5	Classified as moderate risk, drains to Gun Creek – Tonto Creek that is classified as moderate.
Gun Creek – Tonto Creek 1506010504	0.5	Classified as moderate risk, drains to Tonto Creek – Theodore Roosevelt Lake that is classified as moderate.
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.5	Classified as moderate risk, drains to Lower Salt River – Apache, Canyon, and Saguaro Lake that is classified as moderate.
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.5	Classified as moderate risk, drains to Lower Salt River Below Saguaro Lake that is classified as moderate.
Lower Salt River Below Saguaro Lake 1506010603A	0.5	Classified as moderate risk, drains out of the watershed.

Agricultural Lands

The percentage of the agricultural lands in each 10-digit HUC subwatershed was calculated as shown in Table 6-21.

The fuzzy membership function was defined as follows:

FMV = 0 if (% Agricultural land = 0)
FMV = (% Agricultural land / 10)
FMV = 1 if (% Agric. land >= 10)

Number of Mines per Watershed

Elevated concentrations of selenium in the waters of the Salt Watershed are likely due to naturally occurring selenium in the metal-rich soils and rocks. To classify subwatersheds likely to exhibit exceedance in selenium, the number of mines in each 10-digit HUC subwatershed was calculated and a fuzzy membership value assigned as shown in Table 6-22.

Table 6-21: Percentage of Agricultural Lands in each Subwatershed.

Subwatershed Name	% Agricul. Land	FMV Agricul. Land
Upper Black River 1506010101	0%	0
Big Bonito Creek 1506010102	0%	0
Middle Black River 1506010103	0%	0
Lower Black River 1506010104	0%	0
Upper North Fork White River 1506010201	0%	0
Lower North Fork White River 1506010202	0%	0
East Fork White River 1506010203	0%	0
White River 1506010204	1.5%	0.15
Cibecue Creek 1506010301	0%	0
Sawmill Creek – Upper Salt River 1506010302	0%	0
Canyon Creek 1506010303	0%	0
Cherry Creek 1506010304	0.07%	
Salt River Draw – Upper Salt River 1506010305	0%	0

Subwatershed Name	% Agricul. Land	FMV Agricul. Land
Pinal Creek 1506010306	0%	0
Pinto Creek 1506010307	0%	0
Salome Creek 1506010308	0%	0
Upper Salt River – Theodore Roosevelt Lake 1506010309	0%	0
Corduroy Creek 1506010401	0%	0
Cedar Creek 1506010402	0%	0
Carrizo Creek 1506010403	0%	0
Spring Creek 1506010501	0%	0
Haigler Creek – Tonto Creek 1506010502	0%	0
Rye Creek – Tonto Creek 1506010503	0.03%	0.003
Gun Creek – Tonto Creek 1506010504	0.01%	0.001
Tonto Creek – Theodore Roosevelt Lake 1506010505	0%	0
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0%	0
Lower Salt River Below Saguaro Lake 1506010603A	0%	0

Table 6-22: Fuzzy Membership Values Based on Number of Mines in each 10-digit HUC Subwatershed.

Number of Mines in Each Subwatershed	FMV
0-10	0.0
11-25	0.33
26-50	0.66
> 50	1.00

Table 6-23 shows the fuzzy membership values for each 10-digit HUC subwatershed based on the number of mines.

Table 6-23: Fuzzy Membership Values for Selenium for each 10-digit HUC Subwatershed Based on the Number of Mines.

Subwatershed Name	Number of mines	FMV mines/HUC
Upper Black River 1506010101	8	0.00
Big Bonito Creek 1506010102	4	0.00
Middle Black River 1506010103	5	0.00
Lower Black River 1506010104	0	0.00
Upper North Fork White River 1506010201	7	0.00
Lower North Fork White River 1506010202	9	0.00
East Fork White River 1506010203	6	0.00
White River 1506010204	6	0.00
Cibecue Creek 1506010301	3	0.00
Sawmill Creek – Upper Salt River 1506010302	25	0.33
Canyon Creek 1506010303	40	0.66
Cherry Creek 1506010304	48	0.66
Salt River Draw – Upper Salt River 1506010305	32	0.66
Pinal Creek 1506010306	128	1.00
Pinto Creek 1506010307	53	1.00
Salome Creek 1506010308	25	0.33
Upper Salt River – Theodore Roosevelt Lake 1506010309	27	0.66
Corduroy Creek 1506010401	6	0.00
Cedar Creek 1506010402	2	0.00

Subwatershed Name	Number of mines	FMV mines/HUC
Carrizo Creek 1506010403	2	0.00
Spring Creek 1506010501	13	0.33
Haigler Creek – Tonto Creek 1506010502	5	0.00
Rye Creek – Tonto Creek 1506010503	71	1.00
Gun Creek – Tonto Creek 1506010504	34	0.66
Tonto Creek – Theodore Roosevelt Lake 1506010505	3	0.00
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	23	0.33
Lower Salt River Below Saguaro Lake 1506010603A	5	0.00

Selenium Results

The weighted combination approach was used to create the combined fuzzy score, and the results are found in Table 6-24, along with the weights used in the classification. Figure 6-8 shows the results of the weighted combination method classified into high and low priority for selenium.

Table 6-24: Summary Results for Selenium Based on the Fuzzy Logic - Weighted Combination Approach.

Subwatershed Name	FMV WQA[1]	FMV mines/HUC	FMV % Agricultural Land	FMV Weighted
Upper Black River 1506010101	0.5	0.00	0	0.25
Big Bonito Creek 1506010102	0.5	0.00	0	0.25
Middle Black River 1506010103	0.5	0.00	0	0.25
Lower Black River 1506010104	0.5	0.00	0	0.25
Upper North Fork White River 1506010201	0.5	0.00	0	0.25
Lower North Fork White River 1506010202	0.5	0.00	0	0.25
East Fork White River 1506010203	0.5	0.00	0	0.25
White River 1506010204	0.5	0.00	0.15	0.29
Cibecue Creek 1506010301	0.5	0.00	0	0.25
Sawmill Creek – Upper Salt River 1506010302	0.5	0.33	0	0.33
Canyon Creek 1506010303	0.5	0.66	0	0.42
Cherry Creek 1506010304	0.7	0.66		0.52
Salt River Draw – Upper Salt River 1506010305	0.7	0.66	0	0.52
Pinal Creek 1506010306	0.0	1.00	0	0.25
Pinto Creek 1506010307	0.7	1.00	0	0.60
Salome Creek 1506010308	0.7	0.33	0	0.43
Upper Salt River – Theodore Roosevelt Lake 1506010309	1.0	0.66	0	0.67
Corduroy Creek 1506010401	0.5	0.00	0	0.25
Cedar Creek 1506010402	0.5	0.00	0	0.25
Carrizo Creek 1506010403	0.5	0.00	0	0.25
Spring Creek 1506010501	0.5	0.33	0	0.33
Haigler Creek – Tonto Creek 1506010502	0.5	0.00	0	0.25
Rye Creek – Tonto Creek 1506010503	0.5	1.00	0.003	0.50
Gun Creek – Tonto Creek 1506010504	0.5	0.66	0.001	0.42
Tonto Creek – Theodore Roosevelt Lake 1506010505	0.5	0.00	0	0.25
Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601	0.5	0.33	0	0.33
Lower Salt River Below Saguaro Lake 1506010603A	0.5	0.00	0	0.25
Weights	*0.5*	*0.25*	*0.25*	

1WQA = Water Quality Assessment results

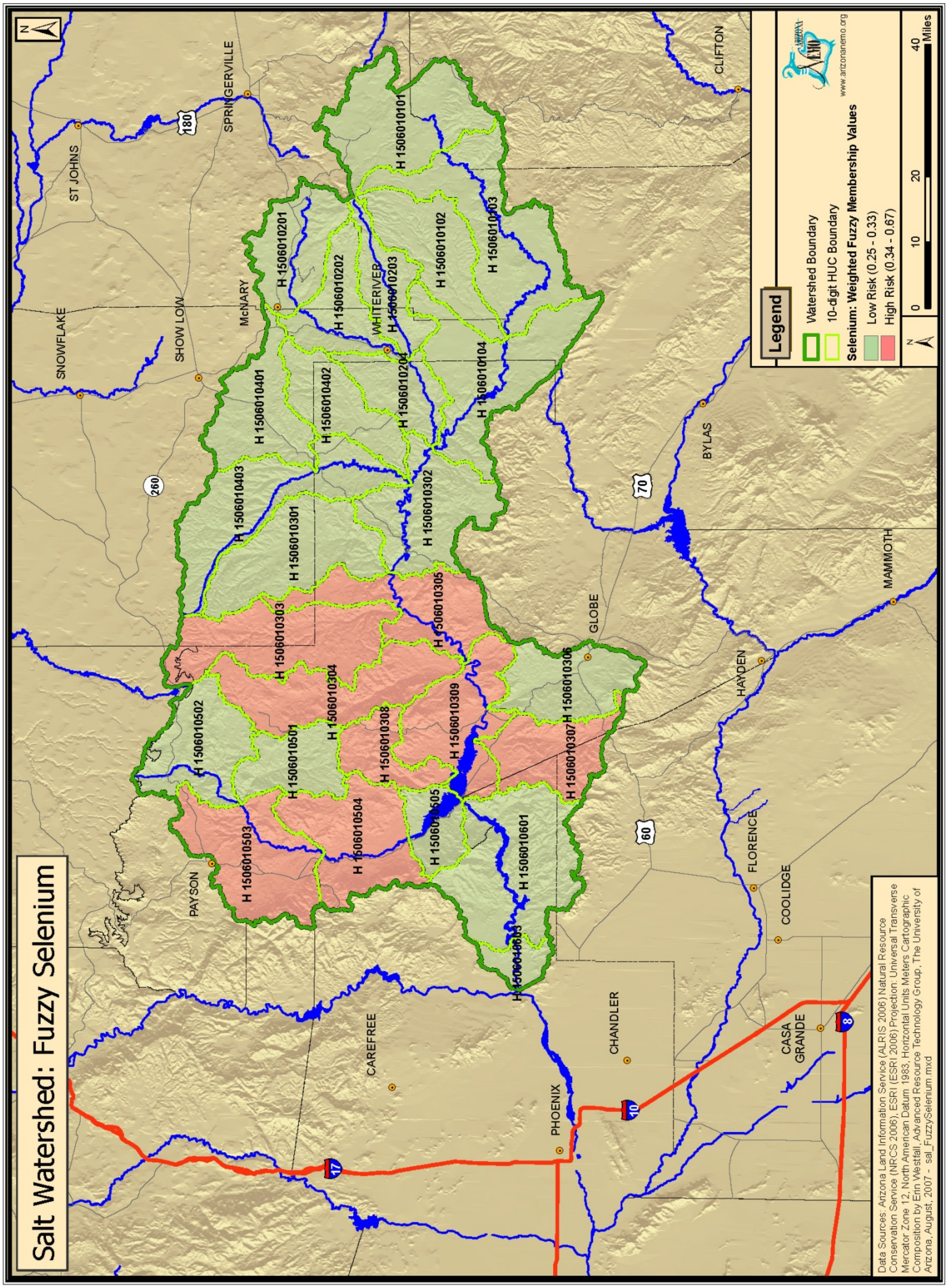

Figure 6-8: Salt Watershed, Results for the Fuzzy Logic Classification for Selenium

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**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases. Metadata includes the original source of the data, when it was created, it's geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.*

Section 7: Watershed Management

This section discusses the recommended watershed management activities to address nonpoint source pollution concerns in the Salt Watershed. These recommendations are subject to revision by land use decision makers and stakeholders, and may be revised based on new data as it becomes available. It is understood that the application of any management activities will require site-specific design and may require licensed engineering design. These recommendations are only general in nature and are presented herein so as to allow land use decision makers and watershed stakeholders to conceptualize how best to address watershed management.

Total Maximum Daily Load (TMDL) plans for Canyon Lake, Crescent Lake, Christopher Creek, Tonto Creek, the Salt River, Apache Lake and Five Point Mountain are also summarized within this section. A TMDL plan is a study for an impaired water body that defines the maximum amount of a specified water quality parameter or pollutant that can be carried by a waterbody without causing an exceedance of water quality standards.

Management Methods

The section includes general watershed management methods, recommended strategies for addressing existing impairment in the watershed, stream channel and riparian restoration, and proposed education programs. The general watershed management methods include:

- Site management on new development;
- Monitoring and enforcement activities;
- Water quality improvement and restoration projects; and
- Education.

Each of these methods is defined further below, and is addressed within each of the three classifications: metals, organics, and nutrient nonpoint source pollutant water quality concerns.

Site Management on New Development:

Control the quantity and quality of water run-off from new development sites. The primary sources for future development in the Salt Watershed include the mining industry, new housing developments and increased urbanization, and new road construction.

Although it is recognized that ADEQ requires Aquifer Protection Permitting and the issuance of Stormwater Management Plans for active mine sites, new mine development in the watersheds should continue to be monitored. It is important to promote the application of nonpoint source management measures on all new development sites through cooperation with local government, developers and private land owners.

Monitoring and Enforcement Activities:

- Continue and expand water quality monitoring programs in the watershed to measure the effectiveness of management practices on protecting and restoring the waters of the Salt Watershed.

- Promote septic tank inspections and certification of septic systems by local government entities.
- Promote construction site inspection and enforcement action for new development.

Water Quality Improvement and Restoration Projects:

- Promote efforts to protect and restore the natural functions and characteristics of impaired water bodies. Potential projects are discussed below.
- Integrate adaptive management methods and activities across the watershed to address existing and future problems.

Education:

- Develop programs to increase the awareness and participation of citizens, developers and local decision makers in the watershed management efforts. Education programs are discussed below.

Strategy for Addressing Existing Impairment

The major sources of water quality impairment and environmental damage in the Salt Watershed are elevated concentrations of dissolved and particulate metals, sediment and organics. The high priority 10-digit HUC subwatersheds were identified for each constituent group in the previous section on Watershed Classification (Section 6).

The goal of this section is to describe a strategy for dealing with the sources of impairment for each constituent group. The management measures discussed herein are brief and meant to provide initial guidance to the land use decision makers and watershed stakeholders.

Detailed descriptions of the following management measures, in addition to a manual of nonpoint source best management practices (BMPs), can be found at the NEMO website www.ArizonaNEMO.org.

Metals

The primary nonpoint source of anthropogenic metals in the Salt Watershed is abandoned or inactive mines, although it is recognized that naturally occurring metals originating from local highly mineralized soils may contribute to elevated background concentrations in streams and lakes. Industrial and urban sources of metals are also important due to the amount of development in the watershed. Portions of the Salt Watershed have a long history of mining, with many abandoned and several active mines found across the watershed. In most cases the original owner or responsible party for an abandoned mine is unknown and the responsibility for the orphaned mine falls to the current landowner.

Abandoned / orphaned mines are found on all classes of land ownership in the Salt Watershed, including federal, state and private lands, with a majority of the mines located on land administered by the Federal government and the State of Arizona. Surface runoff and erosion from mine waste / tailings is the principal source of nonpoint source contamination. Subsurface drainage from mine waste / tailings can also be a concern. The recommended actions include:

- Inventory of existing abandoned mines;
- Revegetation of disturbed mined lands;
- Erosion control;
- Runoff and sediment capture;
- Tailings and mine waste removal; and
- Education.

Load reduction potential, maintenance, cost and estimated life of revegetation and erosion control treatments for addressing metals from abandoned mines are found in Table 7-1.

Inventory of Existing Abandoned Mines:

All existing abandoned mines are not equal sources for elevated concentrations of metals. One of the difficulties in developing this assessment is the lack of thorough and centralized data on abandoned mine sites. Some of the mapped abandoned mine sites are prospector claims with limited land disturbance, while others are remote and disconnected from natural drainage features and represent a low risk pollutant source.

Table 7-1. Proposed Treatments for Addressing Metals from Abandoned Mines.

Action	Load Reduction Potential	Estimated Time Load Reduction	Expected Maintenance	Expected Cost	Estimated Life of Treatment
Revegetation	Medium	< 2 years	Low	Low-Medium	Long
Erosion Control Fabric	High	Immediate	Low	Low-Medium	Short
Plant Mulch	Low	Immediate	Low	Low	Short
Rock Mulch	High	Immediate	Medium	Low-High	Long
Toe Drains	High	Immediate	Medium	Medium	Medium
Detention Basin	High	Immediate	High	High	Medium-Long
Silt Fence	Medium	Immediate	Medium	Low	Short-Medium
Straw Roll/bale	Medium	Immediate	High	Low	Short
Removal	High	Immediate	Low	High	Long

NOTE: The actual cost, load reduction, or life expectancy of any treatment is dependent on site specific conditions. The terms used in this table express relative differences between treatments to assist users in evaluating potential alternatives. Only after a site-specific evaluation can these factors be quantified more rigorously.

At sites where water and oxygen are in contact with waste rock containing sulfates, sulfuric acid is formed. As the water becomes more acidic, metals are leached from the soils and rock, generating toxic concentrations of heavy metals in the water. Acid rock drainage, also known as acid mine drainage, can be a significant water quality concern. Management of this important source of watershed impairment begins with compiling available information from the responsible agencies. This information can be used to conduct an onsite inventory to clarify the degree of risk the site exhibits towards discharging elevated concentrations of metals to a water body.

Risk factors to be assessed include: area and volume of waste/tailings; metal species present and toxicity; site drainage features and metal transport characteristics (air dispersion, sediment transport, acid mine drainage, etc.); distance to a water body; and evidence of active site erosion. Abandoned mine sites can then be ranked and prioritized for site management and restoration.

Revegetation:

Revegetation of the mine site is the only long-term, low maintenance restoration alternative in the absence of funding to install engineered site containment and capping. In semi-arid environments, revegetation of a disturbed site is relatively difficult even under optimal conditions. The amount of effort required to revegetate an abandoned mine site depends on the chemical composition of the mine waste/tailings, which may be too toxic to sustain growth.

The addition of soil amendments, buffering agents, or capping with top soil to sustain vegetation often approaches the costs associated with engineered capping. If acid mine drainage is a significant concern, intercepting and managing the acidic water may necessitate extensive site drainage control systems and water treatment, a significant increase in cost and requiring on-going site operation and maintenance.

Reclaimed Mine Site
(Dept. of the Interior, Office of Surface Mining, http://www.osmre.gov/awardwy.htm)

Erosion Control:

If revegetation of the mine site is impractical, site drainage and erosion control treatments are alternatives. Erosion control actions can also be applied in combination with revegetation to control erosion as the vegetation cover is established. Erosion control fabric and plant mulch are two short-term treatments that are usually applied in combination with revegetation.

Rock mulch (i.e. rock riprap) is a long-term treatment, but can be costly and impractical on an isolated site. Rock mulch can be an inexpensive acid buffering treatment if carbonate rocks (limestone) are locally available. As the acidic mine drainage comes in contact with the rock mulch, the water looses it’s acidity and dissolved metals precipitate out of the water column. A disadvantage of erosion control treatments is that they do not assist in dewatering a site and may have little impact on subsurface acidic leaching.

Rock Rip-Rap Sediment Control
(Dept. of the Interior, Office of Surface Mining, http://www.osmre.gov/ocphoto.htm)

Rock Structure for Runoff Control
(Dept. of the Interior, Office of Surface Mining, http://www.osmre.gov/ocphoto.htm)

Runoff and Sediment Capture:

The capture and containment of site runoff and sediment, and prevention of the waste rock and tailings from contact with a water body are other management approaches. Short-term treatments include installing straw roll/bale or silt fence barriers at the toe of the source area to capture sediment.

Long-term treatments include trenching the toe of the source area to capture the runoff and sediment. If the source area is large, the construction of a detention basin may be warranted.

Disadvantages of runoff and sediment capture and containment treatments are that they may concentrate the contaminated material, especially if dissolved metals are concentrated by evaporation in retention ponds. Structural failure can lead to downstream transport of pollutants. The retention / detention of site runoff can also escalate subsurface drainage problems by ponding water.

Load reduction potential, maintenance, cost and estimated life of runoff and sediment control treatments such as toe drains, basins, and silt fences are found in Table 7-2.

Table 7-2. Proposed Treatments for Addressing Erosion and Sedimentation.

Action	Load Reduction Potential	Estimated Time to Load Reduction	Expected Maintenance	Expected Cost	Estimated Life of Treatment
Grazing Mgt.	Medium	< 2 years	Low	Low	Long
Filter Strips	High	< 2 years	Low	Low	Long
Fencing	Low	Immediate	Low	Low	Medium
Watering Facility	Medium	Immediate	Low	Low-Medium	Medium
Rock Riprap	High	Immediate	Medium	Medium-High	Long
Erosion Control Fabric	High	Immediate	Low	Low-Medium	Short
Toe Rock	High	Immediate	Low	Medium	Long
Water Bars	Medium	Immediate	Medium	Medium	Medium
Road Surface	High	Immediate	Medium	High	Long

Note: The actual cost, load reduction, or life expectancy of any treatment is dependant on site specific conditions. Low costs could range from nominal to $10,000, medium costs could range between $5,000 and $50,000, and high costs could be anything greater than $25,000. The terms used in this table express relative differences between treatments to assist users in evaluating potential alternatives. Only after a site-specific evaluation can these factors be quantified more rigorously.

Removal:

The mine waste/tailing material can be excavated and removed for pollution control. This treatment is very expensive and infeasible for some sites due to lack of accessibility.

Education:

Land use decision makers and stakeholders need to be educated on the problems associated with abandoned mines and the available treatments to mitigate the problems. In addition, abandoned mine sites are health and safety concerns and the public should be warned about entering open shafts that may collapse, or traversing unstable slopes. Due to the financial liability associated with site restoration, legal and regulatory constraints must also be addressed.

The target audiences for education programs are private land owners, watershed groups, local officials and land management agencies (U.S. Forest Service, Bureau of Land Management, and Tribal entities).

Figure 7-1 shows land ownership across the 10-digit HUCs, and Table 7-3 provides a listing of percentage of land ownership as distributed across the subwatershed areas. This table provides a basis from which to identify stakeholders pertinent to each subwatershed area, and is repeated here in more detail after a brief discussion of land ownership in Section 4, Social and Economic Characteristics of the watershed.

Subwatershed areas prioritized for educational outreach to address metals based on Section 6 analysis are Pinto Creek and Pinal Creek.

Pinto Creek TMDL for Copper and Selenium

Pinto Creek is impaired by copper, and the segment of Pinto Creek downstream of Ripper Spring is also impaired by selenium. Both copper and selenium concentrations pose a risk to aquatic life and wildlife. Selenium was added on the 2004 Impaired Waters List for the downstream segment of Pinto Creek and a selenium TMDL is scheduled to be initiated in 2007.

The Pinto Creek Phase II TMDL Modeling Report, written by Malcolm Pirnie, Inc. for ADEQ (2006), describes the hydrology and pollutant transport for Pinto Creek basin in support of allocation of copper from discharges to the creek. Natural mineralization in the area has resulted in numerous historic and active mining related disturbances. This model scenario results lead to the following major conclusions:

- Gibson Mine is the single largest source of copper loads to Pinto Creek – over 90% of the copper load. Remediation efforts are necessary at this mining site;
- Remediation at other mining sources is expected to reduce copper;
- Much of upper Pinto Creek would exceed copper criteria even after remediation;
- The Carlotta Copper project (a new mine site being established on Pinto Creek) is not predicted to cause large changes in copper loads or concentrations.

Aggressive remediation activities are being scheduled for the Gibson Mine, an abandoned mine (see Water Quality Improvement Grants below). Site specific standards are also being developed for copper in Pinto Creek because the natural background concentration is higher than the standard in this copper rich mining area.

Five Point Mountain Tributary TMDL for Copper

Five Point Mountain Tributary is impaired due to dissolved copper exceedences from its headwaters to Pinto Creek. Copper concentrations pose a risk to aquatic life and wildlife. A TMDL is currently being developed.

<u>Sediment</u>

Erosion and sedimentation are major environment problems in the western United States, including the Salt Watershed. In semiarid regions, the primary source of sediment is from channel scour. Excessive channel scour and down-cutting can lead to deterioration of riparian systems' extent and condition. Increases in channel scour are caused by increased surface runoff produced by changing watershed conditions. Restoration of impaired channel riparian areas can also mitigate erosion damage.

The primary land uses in the Salt Watershed that can contribute to erosion are livestock grazing and mining. Development, which also contributes to erosion, is increasing in some portions of the watershed. Impervious land surfaces accelerate surface runoff, increase flow velocity, and exacerbates channel scour. Dirt roads can be an important source of sediment as well. The recommended sediment management actions (see Table 7-2) are:

- Grazing Management
- Filter Strips
- Fencing
- Watering Facilities
- Rock Riprap
- Erosion Control Fabrics
- Toe Rock
- Water Bars
- Erosion Control on Dirt Roads
- Education

Grazing Management:

Livestock grazing is currently the primary land use in the Salt Watershed. Implementing grazing management practices to improve or maintain the health and vigor of plant communities will lead to reductions in surface runoff and erosion. Sustainable livestock grazing can be achieved in all plant communities by changing the duration, frequency and intensity of grazing.

Management may include exclusion of land such as riparian areas from grazing, seasonal rotation, rest or some combination of these options. Proper grazing land management provides for a healthy riparian plant community that stabilizes stream banks, creates habitat and slows flood velocities.

Filter Strips:

A filter strip along a stream, lake or other waterbody will retard the movement of sediment, and may remove pollutants from runoff before the material enters the body of water. Filter strips will protect channel and riparian systems from livestock grazing and tramping. Fencing the filter strip is usually required when livestock are present. Filter strips and fencing can be used to protect other sensitive ecological resources.

Fencing:

Restricting access to riparian corridors by fencing will allow for the reestablishment of riparian vegetation. Straw bale fencing slows runoff and traps sediment from sheet flow or channelized flow in areas of soil disturbance.

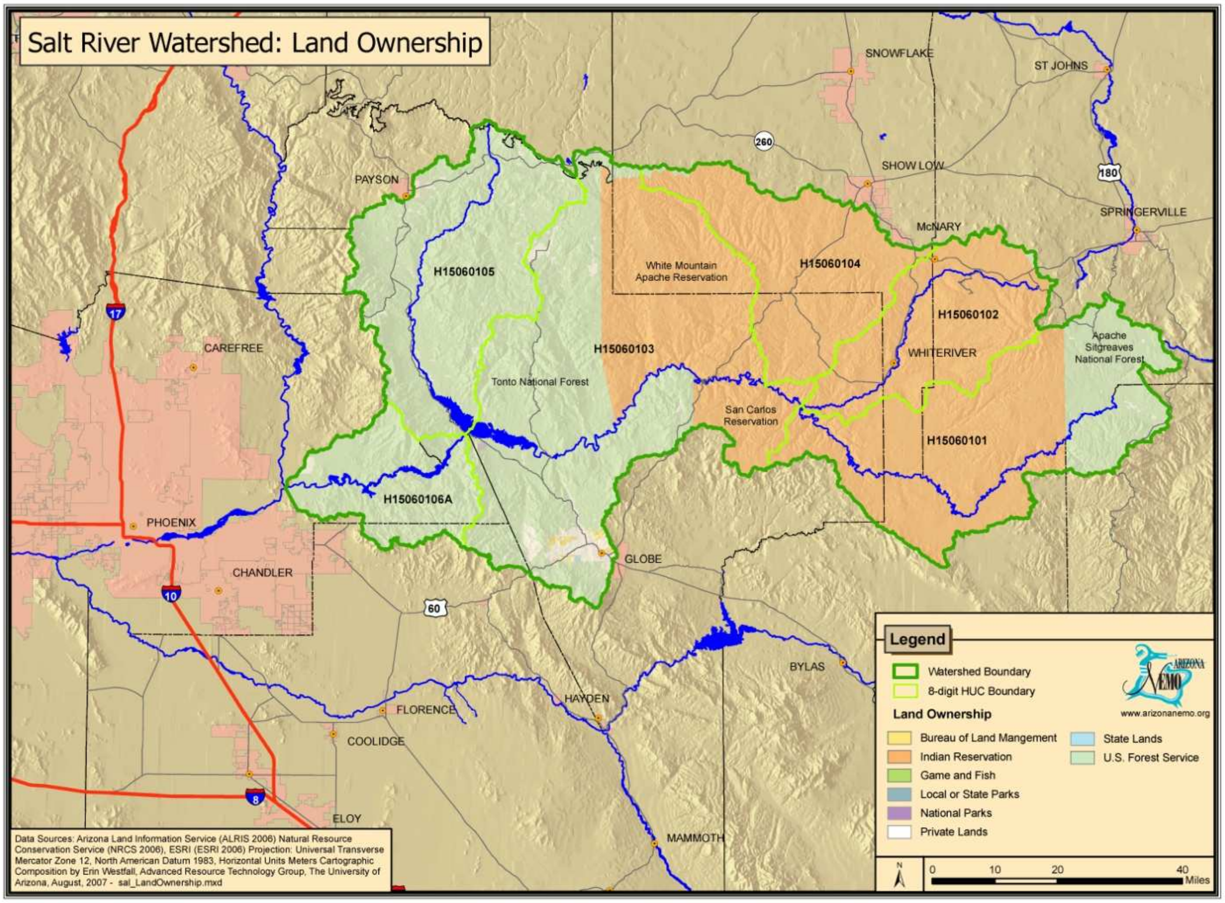

Figure 7-1: Salt Watershed Land Ownership by Subwatershed

Table 7-3: Salt River Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 1 of 6).

Land Owner	**Upper Black River 1506010101**	**Big Bonito Creek 1506010102**	**Middle Black River 1506010103**	**Lower Black River 1506010104**	**Upper North Fork White River 1506010201**
BLM	0.0%	0.0%	0.0%	0.0%	0.0%
US Forest Service	96.21%	0.0%	14.75%	0.0%	2.49%
Game and Fish	0.12%	0.0%	0.0%	0.0%	0.0%
Indian Reservation	2.73%	100%	82.25%	100%	97.45%
National Park Service	0.0%	0.0%	0.0%	0.0%	0.0%
Parks and Recreation	0.0%	0.0%	0.0%	0.0%	0.0%
Private Land	0.0%	0.0%	0.0%	0.0%	0.0%
State Land	0.0%	0.0%	0.0%	0.0%	0.0%
Area (square miles)	*312*	*221*	*375*	*342*	*195*

Table 7-3: Salt River Watershed Land Ownership (Percent of each Subwatershed) (part 2 of 6).

Land Owner	**Lower North Fork White River 1506010202**	**East Fork White River 1506010203**	**White River 1506010204**	**Cibecue Creek 1506010301**	**Sawmill Creek – Upper Salt River 1506010302**
BLM	0.0%	0.0%	0.0%	0.0%	0.0%
US Forest Service	0.0%	0.01%	0.0%	0.0%	6.15%
Game and Fish	0.0%	0.0%	0.0%	0.0%	0.0%
Indian Reservation	100%	99.99%	100%	100%	93.81%
National Park Service	0.0%	0.0%	0.0%	0.0%	0.0%
Parks and Recreation	0.0%	0.0%	0.0%	0.0%	0.0%
Private Land	0.0%	0.0%	0.0%	0.0%	0.0%
State Land	0.0%	0.0%	0.0%	0.0%	0.0%
Area (square miles)	*168*	*138*	*137*	*290*	*267*

Table 7-3: Salt River Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 3 of 6).

Land Owner	**Canyon Creek 1506010303**	**Cherry Creek 1506010304**	**Salt River Draw – Upper Salt River 1506010305**	**Pinal Creek 1506010306**	**Pinto Creek 1506010307**
BLM	0.0%	0.0%	0.0%	4.69%	0.0%
US Forest Service	27.60%	91.51%	55.33%	71.19%	93.02%
Game and Fish	0.0%	0.06%	0.0%	0.0%	0.0%
Indian Reservation	71.16%	4.72%	44.18%	0.0%	0.0%
National Park Service	0.0%	0.0%	0.0%	0.0%	0.0%
Parks and Recreation	0.0%	0.0%	0.0%	0.0%	0.0%
Private Land	1.23%	3.71%	0.49%	23.45%	6.97%
State Land	0.0%	0.0%	0.0%	0.0%	0.0%
Area (square miles)	*318*	*278*	*236*	*200*	*186*

Table 7-3: Salt River Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 4 of 6).

Land Owner	**Salome Creek 1506010308**	**Upper Salt River – Theodore Roosevelt Lake 1506010309**	**Corduroy Creek 1506010401**	**Cedar Creek 1506010402**	**Carrizo Creek 1506010403**
BLM	0.0%	0.0%	0.0%	0.0%	0.0%
US Forest Service	*99.12%*	99.04%	0.16%	0.0%	1.92%
Game and Fish	0.0%	0.0%	0.0%	0.0%	0.0%
Indian Reservation	0.0%	0.0%	99.76%	100%	98.08%
National Park Service	0.0%	0.67%	0.0%	0.0%	0.0%
Parks and Recreation	0.0%	0.0%	0.0%	0.0%	0.0%
Private Land	0.88%	0.29%	0.08%	0.0%	0.0%
State Land	0.0%	0.0%	0.0%	0.0%	0.0%
Area (square miles)	*119*	*259*	*212*	*176*	*321*

Table 7-3: Salt River Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 5 of 6).

Land Owner	**Spring Creek 1506010501**	**Haigler Creek – Tonto Creek 1506010502**	**Rye Creek – Tonto Creek 1506010503**	**Gun Creek – Tonto Creek 1506010504**	**Tonto Creek – Theodore Roosevelt Lake 1506010505**
BLM	0.0%	0.0%	0.0%	0.0%	0.0%
US Forest Service	98.58%	98.00%	96.97%	97.37%	99.82%
Game and Fish	0.0%	0.0%	0.0%	0.0%	0.0%
Indian Reservation	0.0%	0.0%	0.03%	0.0%	0.0%
National Park Service	0.0%	0.0%	0.0%	0.0%	0.0%
Parks and Recreation	0.0%	0.0%	0.0%	0.0%	0.0%
Private Land	0.0%	2.0%	3.01%	2.63%	0.18%
State Land	0.0%	0.0%	0.0%	0.0%	0.0%
Area (square miles)	*321*	*224*	*301*	*274*	*102*

Table 7-3: Salt River Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 6 of 6).

Land Owner	**Lower Salt River – Apache, Canyon, and Saguaro Lake 1506010601**	**Lower Salt River Below Saguaro Lake 1506010603A**	***Salt River Watershed***
BLM	0.0%	0.0%	*0.2%*
US Forest Service	99.98%	90.75%	*48%*
Game and Fish	0.0%	0.0%	*0.01%*
Indian Reservation	0.0%	1.68%	*50%*
National Park Service	0.0%	0.0%	*0.03%*
Parks and Recreation	0.0%	0.09%	*>0.00%*
Private Land	0.02%	7.48%	*2%*
State Land	0.0%	0.0%	*0.2%*
Area (square miles)	388	56	*6,243*

Watering Facilities:

Alternative watering facilities, such as a tank, trough, or other watertight container at a location removed from the waterbody, can provide animal access to water, protect and enhance vegetative cover, provide erosion control through better management of grazing stock and wildlife, and protect streams, ponds and water supplies from biological contamination. Providing alternative water sources is usually required when creating filter strips.

Alternative cattle watering facilities
(http://www.2gosolar.com/typical_installations.htm)

Rock Riprap:

Large diameter rock riprap reduces erosion when installed along stream channels and in areas subject to head cutting. Regrading may be necessary before placing the rocks, boulders or coarse stones, and best management practices should be applied to reduce erosion during regrading.

Erosion Control Fabric:

Geotextile filter fabrics reduce the potential for soil erosion as well as volunteer (weed) vegetation, and are often installed beneath rock riprap.

Rock Riprap and Jute Matting

Erosion Control along a stream.
(Photo: Lainie Levick)

Toe Rock:

Placement of rock and riprap along the toe of soil slopes reduces erosion and increases slope stability.

Water Bars:

A water bar is a shallow trench with mounding long the down-slope edge that intercepts and redirects runoff water in areas of soil disturbance. This erosion control method is most frequently used at tailings piles or on dirt roads.

Erosion Control on Dirt Roads:

In collaboration with responsible parties, implement runoff and erosion control treatments on dirt roads and other disturbed areas. Dirt roads can contribute significant quantities of runoff and sediment if not properly constructed and managed. Water bars and surfacing are potential treatments. When a road is adjacent to a stream, it may be necessary to use engineered road stabilization treatments.

The stabilization of roads and embankments reduces sediment input from erosion and protects the related infrastructure. Traditional stabilization relied on expensive rock (riprap) treatments. Other options to stabilize banks include the use of erosion control fabric, toe rock and revegetation.

Bank Stabilization and Erosion Control along a highway
(Photo: Lainie Levick)

Channel and Riparian Restoration:

Restoration or reconstruction of a stream reach is used when the stream reach has approached or crossed a threshold of stability from which natural recovery may take too long or be unachievable. This practice significantly reduces sediment input to a system and will promote the riparian recovery process. Channel and riparian restoration will be discussed in more detail below.

Education:

The development of education programs will help address the impact of livestock grazing and promote the implementation of erosion control treatments. Education programs should address stormwater management from land development and target citizen groups, developers and watershed partnerships.

Based on the sediment and erosion classification completed in Section 6, subwatershed areas prioritized for educational outreach to address erosion control include Big Bug Creek-Salt River, and Black Canyon Creek.

Organics

At several locations within the Salt Watershed, water quality problems associated with the introduction of animal waste were observed. The two primary sources of animal waste in the watershed are livestock grazing in riparian areas and failing septic systems. Livestock grazing is common across the entire watershed.

The recommended actions (see Table 7-4) for management of organics are:

- Filter Strips
- Fencing
- Watering Facilities
- Septic System Repair
- Education

Table 7-4. Proposed Treatments for Addressing Organics.

Action	Load Reduction Potential	Estimated Time to Load Reduction	Expected Maintenance	Expected Cost	Estimated Life of Treatment
Filter Strips	High	< 2 years	Low	Low	Long
Fencing	Low	Immediate	Low	Low	Medium
Watering Facility	Medium	Immediate	Low	Low-Medium	Medium
Septic System Repair	High	Medium	High	High	Medium

Note: The actual cost, load reduction, or life expectancy of any treatment is dependant on site specific conditions. Low costs could range from nominal to $10,000, medium costs could range between $5,000 and $20,000, and high costs could be anything greater than $15,000. The terms used in this table express relative differences between treatments to assist users in evaluating potential alternatives. Only after a site-specific evaluation can these factors be quantified more rigorously.

Filter Strips:

Creating a filter strip along a water body will reduce and may remove pollutants from runoff before the material enters a body of water. Filter strips have been found to be very effective in removing animal waste due to livestock grazing, allowing the organics to bio-attenuate (i.e. be used by the plants) and degrade. Fencing the filter strip is usually required when dealing with livestock.

Fencing:

Restricting access to riparian corridors by fencing will allow for the reestablishment of riparian vegetation. Straw bale or silt fencing slows runoff and traps organics from sheet flow or channelized flow in areas of soil disturbance.

Filter strip near waterbody (http://jasperswcd.org/practices.htm)

Watering Facilities:

Alternative watering facilities, such as a tank, trough, or other watertight container at a location removed from the waterbody, can provide animal access to water and protect streams, ponds and water supplies from biological contamination by grazing cattle. Providing alternative water sources is usually required when creating filter strips.

Septic System Repair:

One of the difficulties in assessing the impact of failing septic systems to streams is the lack of thorough and centralized data on septic systems. Although it can be assumed that residential development in areas not served by sanitary sewers will rely on private on-site septic systems, the condition of the systems are usually unknown until failure is obvious to the home owner.

Currently, the construction of new septic systems requires a permit from ADEQ in the State of Arizona (some exemptions apply). In addition, ADEQ requires that the septic system be inspected when a property is sold if it was originally approved for use on or after Jan. 1, 2001 by ADEQ or a delegated county agency. This is to help selling and buying property owners understand the physical and operational condition of the septic system serving the home or business. The ADEQ website with more information on permitting septic systems is: http://www.azdeq.gov/environ/water/permits/wastewater.html.

Although not required by ADEQ, older septic systems should be inspected when purchasing a home with an existing system.

At a minimum, conduct an inventory of locations where private septic systems occur to clarify the degree of risk a stream reach may exhibit due to failure of these systems. Risk factors can be assessed with GIS mapping tools, such as: proximity to a waterbody, soil type, depth to the water table, and density of development. Septic system sites can then be ranked and prioritized for further evaluation.

Education:

Develop educational programs that explain the sources of organics, address the impacts of livestock grazing, and promote the implementation of filter strips, fencing and alternative watering facilities. In addition, the programs should promote residential septic system maintenance, septic tank inspections and certification of septic systems by local municipalities or government entities.

Canyon Lake TMDL for Low Dissolved Oxygen

Canyon Lake is impaired by low dissolved oxygen. Low dissolved oxygen is generally associated with nutrient loading and eutrophic conditions which can lead to algal blooms and even fish kills. A TMDL is to be initiated in 2008 to determine the cause and controllable sources of the low dissolved oxygen and recommend strategies to meet surface water quality standards.

Canyon Lake TMDL for pH

•Crescent Lake is impaired due to high pH (alkalinity). High pH readings are also frequently associated with nutrient loading (see Canyon Creek comments). High pH values may represent concerns for most designated uses, but pose the biggest risk to aquatic life. A TMDL is scheduled to be initiated in 2008.

Christopher Creek and Tonto Creek TMDL for Bacteria

Christopher Creek and Tonto Creek, above Haigler Creek confluence, are impaired by bacteria (Escherichia coli) contamination. Bacteria contamination may pose a risk to humans swimming or even wading in the water. A bacteria TMDL was completed in 2004 for both Christopher Creek and Tonto Creek. Septic and waste disposal systems were identified as the primary source of bacterial loading. The TMDL recommended inspection, repair, and upgrading of these systems, and improving facilities at heavily used recreational sites. The U.S. Forest Service and Gila County Health Department were encouraged to initiate routine bacterial monitoring.

A TMDL is comprised of the sum of individual waste load allocations within the receiving water body for point sources, load allocations for nonpoint sources, and natural background levels. In the TMDL analysis, a targeted loading capacity is first calculated, which is the maximum pollutant load that the system can handle and still meet the surface water quality standards. Then this load is allocated among all sources, including an allocation set aside as a margin of safety to handle natural variation.

The Tonto Creek and Christopher Creek TMDL implementation plan makes recommendations for the cleanup of the identified source areas. The Forest Service conducted their own research and hired an engineering consultant to identify and design solutions towards restoring surface water quality located on Forest Service land. Proposed management measures, anticipated load reductions, measurable milestones, and costs of implementation of selected measures are included in the Implementation Plan. The major management measures selected include consolidating and capping the tailings onsite, removal of some of the tailings, and surface control measures (ADEQ, 2006).

Tonto Creek, above Haigler Creek confluence, is also impaired by nitrogen (nutrients). Excess nitrogen can lead to eutrophic conditions and algal blooms. A nitrogen TMDL was approved in 2005. Three sources of excess nutrients were identified: septic systems, insufficient restroom facilities at recreational sites along Tonto Creek, and the Tonto Creek Fish Hatchery. ADEQ will work with the Arizona Game and Fish Department to determine new permit discharge limits for the hatchery and the means for achieving these limits. Inspection, repair, and upgrading of septic systems, along with improving waste facilities at recreational sites, were also recommended actions so that nutrient standards will be met.

The three reaches that currently have Implementation Plans are:

- Tonto Creek, from the headwaters to tributary at 34°48'10"/111°04'14”, for Nitrogen and *E. coli*,

- Tonto Creek, from the tributary at 34°48'10"/111°04'14" to Haigler Creek, for Nitrogen and *E. coli*, and
- Christopher Creek, from the headwaters to Tonto Creek, for *E. coli*

These three reaches were combined into one TMDL Implementation Plan (http://www.azdeq.gov/environ/water/assessment/download/tonto.pdf).

Salt River TMDL for Dissolved Oxygen

The Salt River, from Stewart Mountain Dam (Saguaro Lake) to the Verde River, is impaired by low dissolved oxygen which poses a threat to aquatic life. More data is needed to identify sources and TMDLs have been scheduled to be initiated in 2008. (http://www.azdeq.gov/environ/water/assessment/download/salt.pdf)

Apache Lake TMDL for Dissolved Oxygen

Apache Lake is impaired by low dissolved oxygen. Low dissolved oxygen is generally associated with nutrient loading and eutrophic conditions which can lead to algal blooms and even fish kills. ADEQ is collecting more dissolved oxygen samples to support a TMDL.

<u>Selenium</u>

Selenium occurs naturally in the environment; however, it can enter groundwater or surface water from hazardous waste-sites or irrigated farmland. The recommended action for the management of selenium is to avoid flood irrigation of croplands, and install a mechanized irrigation system.

Mechanized irrigation systems include center pivot, linear move, gated pipe, wheel line or drip irrigation. Based on a 1998 study (Hoffman and Willett, 1998) costs range from a low of $340 per acre for the PVC gated pipe to a high of $1,095 per acre for the linear move. The center pivot cost per acre is $550, and wheel line is $805 per acre.

Education:

Develop educational programs that explain the sources of selenium, and illustrate the various alternative irrigation systems.

Agriculture represents a very small portion of the land use in the Salt Watershed. Based on the results of the selenium classification and ranking in Section 6, the subwatershed areas that are prioritized for educational outreach to address selenium are Big Bug Creek-Salt River, Ash Creek and Sycamore

Creek, Black Canyon Creek and Salt River-Lake Pleasant.

Strategy for Channel and Riparian Protection and Restoration

Riparian areas are one of the most critical resources in the Salt Watershed. Healthy riparian areas stabilize stream banks, decrease channel erosion and sedimentation, remove pollutants from surface runoff, create wildlife habitat, slow flood velocities, promote aquifer recharge and provide recreational opportunities.
As ground water resources are tapped for water supply, many riparian areas across the watershed are in danger of being dewatered as the water table drops below the base of the stream channel. A large portion of the riparian systems in the watershed are managed by federal agencies, principally the Bureau of Land Management and the Forest Service. In cooperation with responsible management agencies, riparian protection and restoration efforts should be implemented across the watershed.

The creation of filter strips should be considered surrounding all important water bodies and riparian systems within the three natural resource areas, including the extensive riparian forests and perennial streams of the Upper Salt River NRA, Salt River-Lake Pleasant NRA, and the Lower Salt River NRA.

This will require fencing and, in many cases, providing alternative water sources for livestock and wildlife. Riparian areas have been an important source of forage for most livestock growers, but to protect these delicate ecosystems, low impact riparian grazing systems should be developed and applied where feasible.

In impaired stream reaches restoration treatments maybe necessary. Treatments may involve engineered channel re-alignment, grade control and bank stabilization structures and a variety of revegetation and other bio-engineering practices.

Additional information will need to be collected on the existing impairment of stream reaches and riparian areas to better understand which stream segments should be prioritized for restoration projects. Data needs include:

- Studying the existing stream corridor structure, function and disturbances.
- Determining the natural stream conditions before disturbance. This entails identifying a "reference site" that illustrates the potential pristine stream conditions.
- Identifying the causes for the impairment and restoration alternatives.
- Identifying stream reaches that have a high potential to successfully respond to restoration treatments.

This watershed classification is one method used to identify stream impairment and restoration alternatives, but other data needs may also include identifying important issues, examining historic conditions, evaluating present conditions and processes, and determining the effects of human activities. It can mean describing the parts and processes of the whole watershed and analyzing their functions in general or relative to some standard (such as a water quality standard or historic condition). It also can mean focusing on particular concerns about human activities, conditions or processes in the watershed.

Stream and riparian restoration projects are costly and should be viewed as a long-term endeavor. Stream and riparian restoration projects cannot be conducted in isolation from other watershed activities. If the root cause of channel and riparian impairment is due to upstream watershed conditions, onsite restoration efforts are likely to fail unless the overall watershed conditions are also improved. This requires an integrated approach that addresses the entire watershed.

Citizen groups also have a role in the restoration efforts. Volunteers can be used in the tree planting and seeding treatments, and can also be used for grade control and bank stabilization construction. Education programs, such as "Adopt A Stream", should be developed to encourage public understanding of the importance of maintaining natural riparian systems and restoration of degraded streams.

Education Programs:

The education effort will be partly conducted by the Arizona Nonpoint Education of Municipal Officials (NEMO) program. Arizona NEMO works through the University of Arizona Cooperative Extension Service, in partnership with the Arizona Department of Environmental Quality (ADEQ) Water Quality Division, and the Water Resources Research Center. The goal of Arizona NEMO is to educate land use decision-makers to take voluntary actions that will mitigate nonpoint source pollution and protect our natural resources.

Education needs:

Education programs need to be developed for land use decision makers and stakeholders that will address the various sources of water quality degradation and present management options. The key sources of concern for educational programs are:

- *Abandoned Mines* (control of runoff and sediment)
- *Grazing Management* (erosion control treatments and riparian area protection)
- *Streamside Protection* (filter strips and alternative watering facilities)
- *Riparian Management* (bank stabilization, filter strips and livestock fencing)
- *Septic Systems* (residential septic system maintenance, licensing and inspection programs)
- *Stormwater Management* (control of stormwater runoff from urbanized and developing areas)
- *Water Conservation* (for private residents and to prevent dewatering of natural stream flow and riparian areas)

Target Audiences:

The targeted audiences will include developers, private land owners and managers, livestock growers, home owners and citizen groups. Several programs, including those addressing mine reclamation, septic systems, stormwater management and water conservation, will be considered. Development of an "Adopt a Stream" Program will also be considered.

References

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Hoffman, T.R. and G.S. Willett. 1998. The Economics of Alternative Irrigation Systems in the Kittitas Valley of Washington State. Cooperative Extension, Washington State University, pub. EB1875. http://cru84.cahe.wsu.edu/cgi-bin/pubs/EB1875.html

Data Sources*:

Arizona State Land Department, Arizona Land Resource Information System (ALRIS), http://www.land.state.az.us/alris/index.html
Land ownership. February 7, 2002.

**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases. Metadata includes the original source of the data, when it was created, its geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.*

Section 8: Local Watershed Planning

The first component of the watershed-based planning process is to summarize all readily available natural resource information and other data for a given watershed. As seen in sections 2 through 5 of this document, these data are at a broad-based, large watershed scale and include information on water quality, land use and cover, natural resources and wildlife habitat.

It is anticipated that stakeholder-groups will develop their own planning documents. The stakeholder-group watershed-based plans may cover a subwatershed area within the NEMO Watershed-based Plan, or include the entire 8-digit HUC watershed area.

In addition, stakeholder-group local watershed-based plans should incorporate local knowledge and concerns gleaned from stakeholder involvement and could include:

- A description of the stakeholder/ partnership process;
- A well-stated, overarching goal aimed at protecting, preserving, and restoring habitat and water quality, and encouragement of land stewardship;
- A plan to coordinate natural resource protection and planning efforts;
- A detailed and prioritized description of natural resource management objectives; and
- A detailed and prioritized discussion of best management practices, strategies and projects to be implemented by the partnership.

EPA's *2003 Guidelines for the Award of Section 319 Nonpoint Source Grants* (EPA, 2003) suggests that a watershed-based plan should include all nine elements listed in Section 1 of this document to be considered for funding. These elements are discussed again in Section 9 and the corresponding sections in the Plan are noted. The nine planning elements help provide reasonable assurance that the nonpoint source of pollution will be managed to improve and protect water quality, and to assure that public funds to address impaired waters are used effectively.

<u>Potential Water Quality Improvement Projects</u>

GIS, hydrologic modeling, and fuzzy logic were used to rank and prioritize the 10-digit HUC subwatersheds for known water quality concerns (Section 6, Watershed Classification). These rankings are used to identify where water quality improvement projects should be implemented to reduce nonpoint source pollution in the Salt River Watershed. This methodology ranked twenty-seven subwatersheds for four key nonpoint source water quality concerns:

1. Metals originating from abandoned mine sites;
2. Stream sedimentation due to land use activities;
3. Organic and nutrient pollution due to land use activities;
4. Selenium pollution due to lake evaporation.

Table 8-1 lists the twenty-seven subwatersheds and their final weighted fuzzy membership value for each of these four constituents. Values highlighted with a shaded box indicate high risk for water quality degradation. The highest ranking value in each category is highlighted with a bold cell outline. The rankings range from a low risk of 0.0 to higher risk values approaching 1.0. See Section 6 for a full discussion on the derivation of these values.

Table 8-1. Summary of Weighted Fuzzy Membership Values for Each Subwatershed.

Subwatershed	**FMV Weighted**			
	Metals	**Sediment**	**Organics**	**Selenium**
Upper Black River H1506010101	0.37	0.21	0.31	0.25
Big Bonito Creek H1506010102	0.42	0.27	0.25	0.25
Middle Black River H1506010103	0.39	0.27	0.25	0.25
Lower Black River H1506010104	0.20	0.45	0.25	0.25
Upper North Fork White River H1506010201	0.56	0.15	0.25	0.25
Lower North Fork White River H1506010202	0.74	0.27	0.25	0.25
East Fork White River H1506010203	0.73	0.27	0.25	0.25
White River H1506010204	0.49	0.33	0.31	0.29
Cibecue Creek H1506010301	0.32	0.51	0.25	0.25
Sawmill Creek–Upper Salt River H1506010302	0.65	**0.63**	0.25	0.33
Canyon Creek H1506010303	0.55	0.42	0.10	0.42
Cherry Creek H1506010304	0.45	0.42	0.10	0.52
Salt River Draw–Upper Salt River H1506010305	0.71	0.46	0.31	0.52
Pinal Creek H1506010306	**0.86**	0.51	0.86	0.25
Pinto Creek H1506010307	0.85	0.49	**0.90**	0.60
Salome Creek H1506010308	0.66	0.22	0.31	0.43
Upper Salt River – Theodore Roosevelt Lake H1506010309	0.80	0.53	0.40	**0.67**
Corduroy Creek H1506010401	0.18	0.51	0.25	0.25
Cedar Creek H1506010402	0.47	0.51	0.25	0.25
Carrizo Creek H1506010403	0.26	**0.63**	0.25	0.25

Subwatershed	FMV Weighted			
	Metals	Sediment	Organics	Selenium
Spring Creek H1506010501	0.50	0.09	0.25	0.33
Haigler Creek – Tonto Creek H1506010502	0.46	0.09	0.40	0.25
Rye Creek – Tonto Creek H1506010503	0.54	0.19	0.89	0.50
Gun Creek – Tonto Creek H1506010504	0.40	0.12	0.10	0.42
Tonto Creek – Theodore Roosevelt Lake H1506010505	0.33	0.15	0.31	0.25
Lower Salt River – Apache, Canyon, and Saguaro Lake H1506010601	0.65	0.20	0.40	0.33
Lower Salt River Below Saguaro Lake H1506010603A	0.50	0.25	0.40	0.25

Based on these fuzzy membership values, the subwatershed that ranked the highest for each of the nonpoint sources was selected for an example water quality improvement project.

The five example subwatershed projects that will be discussed here are:

- Pinal Creek Subwatershed, for metals pollution due to mining;
- Sawmill Creek – Upper Salt River Subwatershed and Carrizo Creek Subwatershed, for sediment pollution derived from overgrazing;
- Pinto Creek Subwatershed, for organics pollution due to failing septic systems and livestock grazing; and,
- Upper Salt River – Theodore Roosevelt Lake Subwatershed, for selenium due naturally occurring lake evaporation.

Example projects with Best Management Practices to reduce metals, sediment, organic, nutrient, and selenium pollution are discussed below. Management measures and their associated costs must be designed and calculated based on site-specific conditions; however, sample costs are included in Section 7.

Methods for calculating and documenting pollutant reductions for sediment, sediment-borne phosphorous and nitrogen, feedlot runoff, and commercial fertilizer, pesticides and manure utilization can be found on the NEMO website in the Best Management Practices (BMP) Manual, under Links (www.ArizonaNEMO.org). It is expected that the local stakeholder partnership watershed-based plan will identify projects and locations important to their community, and may differ from the example project locations proposed here.

1. Pinal Creek Subwatershed Example Project

Pollutant Type and Source: Metal-laden sediment originating from an abandoned tailings or spoil pile at a mine site within the riparian area.

The Pinal Creek Subwatershed ranked as the most critical area in the Salt River Watershed impacted by metals related to a mine site (i.e. highest fuzzy membership value for metals), and a project to control the movement of metal-laden sediment is recommended. The major land owners within both the Pinal Creek Subwatershed are the U.S. Forest Service (71%), private land (23%), and the Bureau of Land Management (5%) (Table 7-3). Projects implemented on private, federal, or state lands must obtain the permission of the owner and must comply with all local, state and federal permits.

Load Reductions:
Calculate and document sediment delivery and pollutant reductions for sediment-borne metals using Michigan DEQ (1999) methodology (found in the NEMO BMP Manual under "Links"). Although this manual addresses sediment reduction with respect to nutrients, the methods can be applied when addressing metals. Particulate metals that generate dissolved metals in the water column and dissolved metals have a tendency to behave like nutrients in the water column.

Management Measures:
Various options are available to restore a mine site, ranging from erosion control fabrics and revegetation to the removal and relocation of the tailings material. Section 7 and Table 7-2 present these management measures along with associated load reduction potential, maintenance, and anticipated costs. It should be recognized that only after a site-specific evaluation can the best treatment option be identified and that the installation of engineered erosion control systems and/or the relocation of the tailings will necessitate project design by a licensed engineer.

2. Sawmill Creek – Upper Salt River Subwatershed and Carrizo Creek Subwatershed

Pollutant Type and Source: Sediment pollution due to overgrazing.

Sawmill Creek – Upper Salt River Subwatershed and Carrizo Creek Subwatershed ranked as the most critical subwatersheds impacted by land use activities, and for purposes of outlining an example project it will be assumed that cattle grazing in the uplands and within the riparian area have exacerbated erosion. The major land owners within the Sawmill Creek – Upper Salt River Subwatershed (Table 7-3) are Indian Reservations (94%) and the U.S. Forest Service (6%).
The major land owners within the Carrizo Creek Subwatershed (Table 7-3) are Indian Reservations (98%) and the U.S. Forest Service (2%). Projects implemented on private, federal, or state lands must obtain the permission of the owner and must comply with all local, state, and federal permits.

Load Reductions:
In the Sawmill Creek – Upper Salt River Subwatershed and Carrizo Creek Subwatershed, sediment is assumed to most likely originate from grazing practices because rangeland livestock grazing is one of the land uses in this portion of the Salt River Watershed. Load reductions can be calculated and documented for sediment using Michigan DEQ (1999) methodology (see the NEMO BMP Manual).

Management Measures:

Implementing grazing management practices to improve or maintain upland and riparian health will help reduce excess surface runoff and accelerated erosion. Management may include exclusion of the land from grazing and/or restricting access to riparian corridors by fencing, which will also reduce the introduction of fecal matter to the stream.

Alternative water facilities at a location removed from the water body may be necessary. Section 7 includes information on alternative watering facilities. Table 7-2 presents load reduction potential, required maintenance, and anticipated costs associated with each project option. It should be recognized that only after a site-specific evaluation can the best treatment option be identified and that the installation of the engineered erosion control systems and the installation of an alternative water source may necessitate project design by a licensed engineer.

3. Pinto Creek Subwatershed Example Project

Pollutant Type and Source: Organics pollution due to failing septic systems and livestock grazing.

The rural areas of the Pinto Creek Subwatershed generally do not have access to public waste water treatment and for this reason organic pollutants are assumed to originate from failing septic systems. However, livestock grazing and cattle watering in the stream channel may also contribute to the pollution concern. The land owner within the Pinto Creek Subwatershed is the U.S. Bureau of Land Management (Table 7-3). The major land owners within the Lower Salt River below Saguaro Lake Subwatershed (Table 7-3) are the U.S. Forest Service (93%) and private land (7%). Projects implemented on private, state, or federal lands must obtain the permission of the owner and must comply with all local, state, and federal permits.

Load Reductions:
Prior to initiating a project to address bacteria pollution, it may benefit the watershed partnership to determine the source of bacterial contamination. Implementation of DNA fingerprinting technology will identify the actual sources of bacteria and clarify how best to target an implementation plan and project.

The field of bacteria source tracking continues to evolve rapidly and there are numerous methods available, each which has its limitations and benefits. Despite the rapid and intensive research into existing methods, EPA recommends that bacteria source tracking "should be used by federal and state agencies to address sources of fecal pollution in water…[because it] represents the best tools available to determine pathogen TMDL load allocations and TMDL implementation plan development" (EPA 2001).

As an example, the results of a study funded from Section 319 Nonpoint Source Grant funds for Oak Creek Canyon within the Verde Watershed found that most of the fecal pollution came from natural animal populations with sporadic and seasonal impacts from human, dog, cattle, house, and llama sources (NAU 2002). The Oak Creek Task Force (a locally led watershed group) suggested implementing locally approved grazing modifications to decrease the inflow of sediment carrying fecal material, as well as public education and increased toiled facilities within the canyon to reduce nonpoint source bacterial pollutants.

In the Pinto Creek Subwatershed, pathogens are assumed to most likely originate from a combination of failing septic systems and/or grazing practices because rangeland livestock grazing is observed in the area. Load reductions can be calculated and documented for grazing runoff using Michigan DEQ (1999) methodology (see the NEMO BMP Manual).

Management Measures:
Implementing grazing management practices to improve or maintain riparian health will help reduce organic pollutants. Management may include exclusion of the land from grazing and/or restricting access to riparian corridors by fencing, which will also reduce the introduction of fecal matter to the stream.

Alternative watering facilities at a location removed from the water body may be necessary. Section 7 and Table 7-2 present load reduction potential, required maintenance and anticipated costs associated with each project option. It should be recognized that only after a site-specific evaluation can the best treatment option be identified.

Failing septic systems can also result in partially treated or untreated surface wastewater containing fecal coliform bacteria and nutrients, causing nonpoint source pollution in drainage ways, streams, and lakes. The only practical long-term Best Management Practice would be to either upgrade individual septic systems by redesigning and replacing part or all of them, or requiring hook-up to a public wastewater treatment facility. This work must be done by a registered contractor or a business licensed to design and install individual sewage treatment systems, but the greatest constraint to this practice is the significant cost to the homeowner. The Arizona Water Infrastructure Finance Authority (WIFA) could be a source of low interest financing to rural communities seeking to upgrade their wastewater disposal systems to protect water supply, however requiring hook-up still results in costs to the homeowner.

Some locations experiencing rapid development across the state are putting into place ordinances requiring new development to install wastewater treatment facilities, but this does little to address existing systems. Constructed wetland systems have been successfully applied in more humid regions of the country; in Arizona, shallow ground water would be necessary to sustain a constructed wetland treatment system. The constructed wetland system would consist of two shallow basins about 1 foot in depth and containing gravel, which supports emergent vegetation. The first of the two cells is lined to prevent seepage, while the second is unlined and acts as a disposal field. The water level is maintained below the gravel surface, thus preventing odors, public exposure, and vector problems. In an alternative design, a standard septic drain-tile field drain system could be used in place of the second cell.

4. Upper Salt River – Theodore Roosevelt Lake Subwatershed Example Project

Pollutant Type and Source: Selenium pollution due to naturally occurring lake evaporation.

The Upper Salt River – Theodore Roosevelt Lake Subwatershed of the Salt River Watershed ranked as the most critical area impacted by agricultural land use practices that exacerbate the concentration of naturally occurring selenium (i.e. highest fuzzy membership value for Selenium. Selenium concentrations may also be the result of excessive evaporation from the surface of the reservoir. The major land owner within this subwatershed (Table 7-3) is the U.S. Forest Service which manages 99% of the land. Projects implemented on private, state, or federal lands must obtain the permission of the owner and must comply with all local, state, and federal permits.

Load Reductions:
Naturally occurring selenium is concentrated in water by evaporation, and also when irrigation water leaches selenium from the soil. To calculate the load reduction resulting from implementation of a Best Management Practice, an estimate of the reduction in volume of irrigation tail water that returns to the stream is required.

Support for calculating load reductions can be obtained from the local Agricultural Research Service or County Cooperative Extension office (http://cals.arizona.edu/extension/).

Management Measures:
Implementing agricultural irrigation practices to reduce tail water pollution will necessitate dramatic changes from the typical practice of flood irrigation. This may involve the installation of mechanized irrigation systems or on-site treatment.

In some watersheds in California, agricultural drainage water contains levels of selenium that approach the numeric criterion defining hazardous waste (above 1,000 parts per billion). This situation is being considered for permit regulation to manage drainage at the farm level (San Joaquin Valley Drainage Implementation Program).

Currently, Arizona is not considering such extreme measures, but selenium remains an important nonpoint source contaminant and is a known risk to wildlife. The use of treatment technologies to reduce selenium concentrations include ion exchange, reverse osmosis, solar ponds, chemical reduction with iron, microalgal-bacterial treatment, biological precipitation, and constructed wetlands. Engineered water treatment systems may be beyond the scope of a proposed Best Management Practices project, and technologies are still in the research stage.

Section 7 outlines load reduction potential, maintenance, and anticipated costs associated with the installation of mechanized irrigation systems. It should be recognized that only after a site-specific evaluation can the best treatment option be identified and that the installation of mechanized irrigation systems involve capital expense and may necessitate project design by a licensed engineer. Mechanized irrigation, however, allows for improved water conservation and improved management of limited water resources.

Technical and Financial Assistance

Stakeholder-group local watershed-based plans should identify specific projects important to their partnership, and during the planning process should estimate the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement the plan. Technical support services include NEMO, University of Arizona Cooperative Extension, government agencies, and other environmental professionals. Funding sources may include:

- Clean Water Act Section 319(h) funds;
- State revolving funds through the Arizona Department of Environmental Quality;
- Central Hazardous Materials Fund;
- USDA Environmental Quality Incentives Program and Conservation Security Program;
- Arizona Water Protection Fund through the Arizona Department of Water Resources;
- Water Infrastructure Finance Authority;
- Arizona Heritage Fund through Arizona State Parks and Arizona Game and Fish; and
- Private donations or non-profit organization donations.

In addition to the extensive listing of funding and grant sources on the NEMO website (www.ArizonaNEMO.org), searchable grant funding databases can be found at the EPA grant opportunity website (www.grants.gov or www.epa.gov/owow/funding.html)

In Arizona, Clean Water Act Section 319(h) funds are managed by ADEQ and the funding cycle and grant application can be found at www.azdeq.gov/environ/water/watershed/fin.html.

The Arizona legislature allocates funding to the Arizona Water Protection Fund. In addition, the fund is supplemented by income generated by water-banking agreements with the Central Arizona Project. Information can be found at www.awpf.state.az.us.

Most grants require matching funds in dollars or in-kind services. In-kind services may include volunteer labor, access to equipment and facilities, and a reduction on fee schedules/rates for subcontracted tasks. Grant matching and cost share strategies allow for creative management of limited financial resources to fund a project.

Education and Outreach

An information/education component is an important aspect of the stakeholder-group local watershed-based plan that will be used to enhance public understanding of the project and encourage early and continued participation in selecting, designing, and implementing management measures.

Outreach and public education activities in the watershed might include sponsoring a booth at the County Fair. Working with Cooperative Extension programs, such as Project WET (Water Education for Teaches, K-12 classroom education), a group might provide displays, posters, and fact sheets on important water topics in addition to individual water quality improvement projects. The NEMO program offers each watershed partnership the opportunity to post fact sheets and status reports on the NEMO website, and to announce important events on the NEMO calendar (www.ArizonaNEMO.org). In addition, a partnership can obtain guidance and technical support in designing an outreach program through the University of Arizona Cooperative Extension.

Implementation Schedules and Milestones

A schedule for project selection, design, funding, implementation, reporting, operation, maintenance, and closure are necessary to the watershed planning process. In the Salt River Watershed, Pinal Creek, Carrizo Creek, Pinto Creek, and Upper Salt River – Theodore Roosevelt Lake 10-digit HUC subwatershed areas have been prioritized for potential water quality improvement projects, but other locations across the watershed may hold great interest by the stakeholders for project implementation. Private land owners, or partnerships or stakeholders, may propose discreet projects to respond to immediate water quality concerns, such as stream bank erosion exacerbated by a recent flooding event.

After project selection, implementation may be dependent on the availability of funds, and because of this most watershed partnerships find themselves planning around grant cycles. Table 8-2 depicts the planning process, and suggests that the stakeholder group may want to revisit the listing and ranking of proposed projects on a regular basis, giving the group the opportunity to address changing conditions.

Table 8-2: Example Watershed Project Planning Schedule

Watershed Project Planning Steps	**Year**				
	1	**2**	**3**	**4**	**5**
Stakeholder-Group 319 Plan Development	X				
Identify and rank priority projects	X				
Grant Cycle Year 1: Select Project(s)	X				
Project(s) Design, Mobilization, and Implementation	X	X			
Project(s) Reporting and Outreach		X			

Project(s) Operation and Maintenance, Closure		X	X		
Grant Cycle Year 2: Select Project(s)		X			
Project(s) Design, Mobilization, and Implementation		X	X		
Project(s) Reporting and Outreach			X		
Project(s) Operation and Maintenance, Closure			X		
Revisit Plan, Identify and Re-Rank Priority Projects			X		
Grant Cycle Year 3: Select Project(s)			X		
Project(s) Design, Mobilization, and Implementation			X	X	
Project(s) Reporting and Outreach				X	
Project(s) Operation and Maintenance, Closure				X	X

As shown in the table, a 'short' one-year project may actually take as many as three years from conception, to implementation, and ultimate project closure. With the number of grants currently available in Arizona for water quality improvement projects, the watershed partnership may find themselves in a continual cycle of grant writing and project reporting, overlapping and managing several aspects of several projects simultaneously.

Most funding agencies operate on a reimbursement basis and will require reporting of project progress and reimbursement on a percent completion basis. In addition, the individual project schedule should be tied to important measurable milestones which should include both project implementation milestones and pollutant load reduction milestones. Implementation milestones may include interim tasks, such as shown in Table 8-3, and can be tied to grant funding-source reporting requirements.

Based on funding availability, the activities outlines in Table 8-3 could be broken down into three separate projects based on location (Stream Channel, Stream Bank, and Flood Plain), or organized into activity-based projects (Wildcat Dump Cleanup, Engineered Culverts, etc).

Table 8-3: Example Project Schedule

Management Measures and Implementation Schedule Streambank Stabilization and Estimated Load Reduction					
			Water Quality Milestone Target Load Reduction: 100% Hazardous Materials 75% Sediment Load		
Milestone	**Date**	**Implementation Milestone**	**Area 1 Stream Channel**	**Area 2 Stream Bank**	**Area 3 Flood Plain**

Management Measures and Implementation Schedule Streambank Stabilization and Estimated Load Reduction					
			Water Quality Milestone Target Load Reduction: 100% Hazardous Materials 75% Sediment Load		
Milestone	**Date**	**Implementation Milestone**	**Area 1 Stream Channel**	**Area 2 Stream Bank**	**Area 3 Flood Plain**
Task 1: Contact Administration	04/01/05 Thru 09/31/06	Contract signed Quarterly reports Final report			
Task 2: Wildcat Dump Clean-up	04/01/05 Thru 07/05/05	Select & advertise clean- up date Schedule containers and removal	Remove hazardous materials from stream channel 100% hazardous material removal	Remove tires and vehicle bodies from stream bank 100% hazardous material removal	
Task 3: Engineering Design	04/01/05 Thru 08/15/05	Conceptual design, select final design based on 75% load reduction		Gabions, culverts, calculate estimated load reduction	Re-contour, regrade, berms, water bars, gully plugs Calculate estimated load reduction
Task 4: Permits	04/01/05 Thru 09/01/05	Confirm permit requirements and apply for necessary permits	US Army Corps of Engineers may require permits to conduct projects within the stream channel	Local government ordinances as well as the US Army Corps and State Historical Preservation may be needed	In addition to local and state permits, the presence of listed or endangered species will require special permitting and reporting
Task 5: Monitoring	07/05/05 Thru 10/31/06	Establish photo points and water quality sample locations	Turbidity sampling, baseline and quarterly, compare to anticipated 75% load reduction	Photo points, baseline and quarterly Calculate sediment load reduction	Photo points, baseline and quarterly Calculate sediment load reduction

Management Measures and Implementation Schedule Streambank Stabilization and Estimated Load Reduction					
			Water Quality Milestone Target Load Reduction: 100% Hazardous Materials 75% Sediment Load		
Milestone	**Date**	**Implementation Milestone**	**Area 1 Stream Channel**	**Area 2 Stream Bank**	**Area 3 Flood Plain**
Task 6: Revegetation	08/15/05 Thru 09/15/05	Survey and select appropriate vegetation			Willows, native grasses, cotton wood, mulch
Task 7: Mobilization	09/01/05 Thru 10/31/05	Purchase, delivery, and installation of engineered structures and revegetation material		Install gabions, resized culverts Professional and volunteer labor	Regrade, plant vegetation with protective wire screens around trees Install gully plugs and water bars Volunteer labor
Task 8: Outreach	04/01/05 Thru 10/31/06	Publication of news articles, posters, monthly reports during stakeholder-group local watershed meetings			
Task 9: Operation and Maintenance	09/01/05 Thru 10/31/06	Documentation of routine operation and maintenance in project quarterly reports during contract period Continued internal record keeping after contract/project closure		Maintenance and routine repair of engineered structures	Maintenance and irrigation of new plantings until established Removal of weeds and invasive species

Evaluation

The evaluation section of a watershed plan will provide a set of criteria that can be used to determine whether progress toward individual project goals is being achieved and/or the effectiveness of implementation in meeting expectations. These criteria will help define the course of action as milestones and monitoring activities are being reviewed.

The estimate of the load reductions expected for each of the management measures or best management practices to be implemented is an excellent criterion against which progress can be measured. Prior to project implementation, baselines should be established to track water quality improvements, and standard measurement protocols should be established so as to assure measurement methodology does not change during the life of the project.

To evaluate the example project outlined in Table 8-2, the following key evaluation attributes must be met:

- Schedule and timeliness: Grant applications, invoices and quarterly reports must be submitted to the funding source when due or risk cancellation of contracts. If permits are not obtained prior to project mobilization, the project crew may be subject to penalties or fines.

- Compliance with standards: Engineered designs must meet the standards of the Engineering Board of Licensing; water quality analytical work must be in compliance with State of Arizona Laboratory Certification. Excellent evaluation criteria would include engineer-stamped 'as-built' construction diagrams and documentation of laboratory certification, for example. Methods for estimating load reduction must be consistent with established methodology, and the means by which load reductions are calculated throughout the life of the plan must be maintained.

- Consistency of measurement: The plan should identify what is being measured, the units of measurement, and the standard protocol for obtaining measurements. For example, turbidity can be measured in 'Nephlometric Units' or more qualitatively with a Siche disk. Water volume can be measured as Acre/feet, gallons, or cubic feet. Failure to train project staff to perform field activities consistently and to use comparable units of measurement can result in project failure.

- Documentation and reporting: Field note books, spreadsheets, and data reporting methodology must remain consistent throughout the project. Photo point locations must be permanently marked so as to assure changes identified over the life of the project are comparable. If the frequency of data collection changes or the methodology of reporting changes in the midst of the project, the project and overall plan loses credibility.

The project is a near success if the reports are on time, the engineered structures do not fail, data are reported accurately, and an independent person reviewing your project a year after project closure understands what was accomplished. The project is a full success if water quality improvement and load reductions have been made.

The criteria for determining whether the overall watershed plan needs to be revised are an appropriate function of the evaluation section as well. For example, successful implementation of a culvert redesign may reduce the urgency of a stream bank stabilization project downstream from the culvert, allowing for reprioritization of projects.

It is necessary to evaluate the progress of the overall watershed plan to determine effectiveness, project suitability, or the need to revise goals, BMPs, or management measures. The criteria used to determine whether there has been success, failure, or progress will also determine if objectives, strategies, or plan activities need to be revised, as well as the watershed-based plan itself.

<u>Monitoring</u>

Monitoring of watershed management activities is intrinsically linked to the evaluation performed within the watershed because both track effectiveness. While monitoring evaluates the effectiveness of implementation measures over time, the criteria used to judge success/failure/progress is part of the evaluation process.

Watershed monitoring will also include the water quality data reported in Arizona's Integrated 305(b) Assessment Report (ADEQ 2006), but the overall stakeholder-group watershed plan will identify additional data collection activities that are tied to stakeholder concerns and goals. For the Salt Watershed, the Pinal Creek, Carrizo Creek, Pinto Creek, and Upper Salt River – Theodore Roosevelt Lake subwatersheds are identified as vulnerable to water quality impairment due to metals, sediment, organics, and selenium. Monitoring of stream reaches for these constituents requires standard water sample collection methodology and sample analysis by a certified laboratory. If routine monitoring of these reaches is to be conducted, sample collection and analysis must be consistent with data collection by ADEQ to support the 305(b) Assessment Report.

Following the example of the project outlined in Table 8-2, other water quality and watershed health constituents to be monitored include:

- Turbidity. Measuring stream turbidity before, during, and after project implementation will allow for quantification of load reduction.

- Stream flow and volume, presence or absence of flow in a wash following precipitation. Monitoring of these attributes is important especially after stream channel hydromodification.

- Presence/absence of waste material. This can be monitored with photo-points.

- Riparian health, based on diversity of vegetation and wildlife. Monitoring can include photo-points, wildlife surveys and plant mapping.

The monitoring section will determine if the partnership's watershed strategies/management plant is successful, and/or the need to revise implementation strategies, milestones, or schedules. It is necessary to evaluate the progress of the plan to determine effectiveness, suitability, or the need the revise goals or BMPs.

Water quality monitoring for chemical constituents that may expose the sampler to hazardous conditions will require appropriate health and safety training and the development of a Quality Assurance Project Plan (QAPP). Monitoring for metals derived from abandoned mine sites, pollutants due to organics, nutrients derived from land use, and selenium will require collection and preservation techniques, in addition to laboratory analysis. Monitoring for sediment load reductions may be implemented in the field without extensive protocol development.

Resources to design a project monitoring program can be found at the EPA water quality and assessment website: www.epa.gov/owow/monitoring as well as through the Master Watershed Steward Program available through the University of Arizona Cooperative Extension's local county office. In addition, ADEQ will provide assistance in reviewing a QAPP and monitoring program.

Conclusions

This watershed-based plan ranked or classified all twenty-seven 10-digit HUC subwatersheds within the Salt River Watershed for vulnerability to water quality degradation from nonpoint source pollutants (Section 6 and Table 8-1). This ranking was based on Arizona's Integrated 305(b) Water Quality Assessment and 303(d) Listing Report for the Salt River Watershed.

In addition to the subwatershed classifications, this plan contains information on the natural resources and socio-economic characteristics of the watershed (Sections 2 through 5). Based on the results of the Classification in Section 6, example Best Management Practices and water quality improvement projects to reduce nonpoint source pollutants are also provided (Section 7).

The subwatershed rankings were determined for the four major constituents (metals, sediment, organics, and selenium) using fuzzy logic (see Section 6 for more information on this methodology and the classification procedure). The final results are summarized in this section and are shown in Table 8-1. In addition, technical and financial assistance to implement the stakeholder-group local watershed-based plans are outlined in this section.

Of the twenty-seven subwatersheds included in this assessment, the four watersheds with the highest risk of water quality degradation are:

1. Pinal Creek Subwatershed, for metals pollution;

2. Sawmill Creek – Upper Salt River Subwatershed and Carrizo Creek Subwatershed for sediment pollution;

3. Pinto Creek Subwatershed, for pollutants due to organics; and

4. Upper Salt River – Theodore Roosevelt Lake Subwatershed, for selenium due to agricultural practices.

This NEMO Watershed-Based Plan is consistent with EPA guidelines for CWA Section 319 Nonpoint Source Grant funding. The nine planning elements required to be eligible for 319 grant funding are discussed, including education and outreach, project scheduling and implementation, project evaluation, and monitoring.

Some basic elements are common to almost all forms of planning: data gathering, data analysis, project identification, implementation and monitoring. It is expected that local stakeholder groups and communities will identify specific projects important to their partnership, and will rely on the NEMO plan for developing their own plans.

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Section 9: Summary of EPA's 9 Key Elements for Section 319 Funding

Introduction

All projects that apply for Section 319 funding under the Clean Water Act and administered through the Arizona Department of Environmental Quality must include nine key elements in their watershed-based plans. These elements are listed in Section 1 of this Watershed-Based Management Plan and are also discussed in the Nonpoint Source Guidance Document by the US EPA (http://www.epa.gov/owow/nps/319/index.html).

The nine key elements are described below and the corresponding Sections of this NEMO Watershed-Based Plan are noted. Information and data to support this requirement can be found in these sections of this plan.

Element 1: Causes and Sources

NEMO Sections 6 and 7.

The watershed-based plan must identify the sources that will need to be controlled to achieve load reductions established in the nonpoint source TMDL.

In addition, pollutants of concern must be identified, and the causes and sources (primary and secondary) of water body impairment (physical, chemical, and biological, both point and nonpoint sources) must be linked to each pollutant of concern.

Section 6 of this NEMO Watershed-Based Plan prioritizes the subwatersheds for risk of impairment due to metals, sediment, organics, and selenium nonpoint source pollution. In addition, the potential causes for each constituent are described so that the watershed group can begin identifying the source of the risk.

Section 7 of the NEMO plan discusses existing TMDLs in the watershed that identify known sources of water body impairment.

Element 2: Expected Load Reductions

Not included in the NEMO Plan.

The plan must contain an overview of TMDL load reductions expected for each Best Management Practice, linked to an identifiable source (only required for sediment (tons/year), nitrogen, or phosphorous (lbs/year)).

Element 3: Management Measures

NEMO Sections 7 and 8.

The plan must contain a description of the nonpoint source Best Management Practices or management measures and associated costs needed to achieve load reductions for the critical areas identified in which the measures will need to be implemented to achieve the nonpoint source TMDL.

Section 7 of the NEMO plan describes a variety of nonpoint source BMPs that may be applied for load reduction and management of metals, sediment, organics, and selenium pollution.

Section 8 includes an example water quality improvement project for each of the four constituents (metals, sediment, organics, and selenium) with specific example management measures.

Element 4: Technical and Financial Assistance

NEMO Sections 7 and 8, and NEMO website (www.ArizonaNEMO.org).

The plan must include an estimate of the technical and financial assistance needed, including associated costs, and funding strategies (funding sources), and authorities the stakeholder-group anticipates having to rely on to implement the plan.

Section 7 includes several tables that include various management measures and their relative costs, life expectancy and load reduction potential.

Section 8 includes a list of possible funding sources and links for water quality improvement projects. In addition, the NEMO website (www.ArizonaNEMO.org) has an extensive list of links to a wide variety of funding sources.

Element 5: Information/Education Component

NEMO Section 8.

The information/education component is intended to enhance public understanding and participation in selecting, designing, and implementing the nonpoint source management measures, including the outreach strategy with long and short term goals, and the funding strategy.

Section 8 lists local resources that may be valuable in education and outreach to the local community or other targeted audiences. In addition, examples of local educational outreach projects are presented.

Element 6: Schedule

NEMO Section 8.

The plan must include a schedule for implementing, operating, and maintaining the nonpoint source Best Management Practices identified in the plan.

Section 8 describes the importance of schedules in a water quality improvement project and presents an example schedule.

Element 7: Measurable Milestones

NEMO Section 8.

The plan must include a schedule of interim, measurable milestones for determining whether nonpoint source Best Management Practices or other control actions are being implemented and water quality improvements are occurring.

Section 8 describes some measurable milestones and presents an example schedule that includes milestones.

Element 8: Evaluation of Progress

NEMO Section 8.

The plan must contain a set of criteria used to determine whether load reductions are being achieved and substantial progress is being made towards attaining water quality standards, including criteria for determining whether the plan needs to be revised or if the TMDL needs to be revised.

Section 8 describes how to evaluate the progress and success of a water quality improvement project and describes the key attributes that must be met for a successful project.

Element 9: Effectiveness Monitoring

NEMO Section 8.

The plan must include a monitoring plan to evaluate the effectiveness of implementation efforts over time, measured against the set of criteria established in the Evaluation of Progress element (8).

Section 8 discusses the importance of project monitoring, and presents several example water quality and health constituents that should be monitored.

Conclusions

The NEMO Watershed-Based Plans are structured to be a watershed wide, broad evaluation of the nine key elements. The community watershed groups, as they apply for Section 319 Grant funds to implement projects, will need to readdress each of these 9 key elements for their specific watershed project.

Table 1: Subwatershed Classification for Risk of Impairment, Salt Watershed.

Arizona's Integrated 305(b) Assessment and 303(d) Listing Report (ADEQ, 2007) includes water quality data and assessments of water quality in several surface waterbodies across the Salt Watershed. This table summarizes the surface waterbody data used to assess the risk of impairment for each 10-digit HUC subwatershed; some HUCs may have more than one surface waterbody assessed within the watershed, some have none. Some surface water bodies are present in more than one 10-digit HUC. The table includes the ADEQ water quality data (sampling and assessment status) and the NEMO risk classification assigned to individual surface waterbodies within each subwatershed. It also includes the NEMO risk classification for each subwatershed, which is determined by the highest risk level of the surface waterbodies within that subwatershed.

The four levels of NEMO risk classification are defined in Section 6: extreme; high; moderate; and low. This table is organized to determine the relative risk of nonpoint source water quality degradation due to metals, sediment, organics and selenium for each 10-digit HUC subwatershed based on existing ADEQ water quality data. See the footnotes at the end of the table for more information and definitions of abbreviations, and Section 6 for the NEMO ranking values assigned to each risk classification.

Subwatershed		
Upper Black River **HUC 1506010101** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate. • **Sediment:** Moderate. • **Organics:** High. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Beaver Creek From headwaters to Black River ADEQ ID: 15060101-008 Five sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 3): Antimony, arsenic, beryllium, cadmium, copper, zinc; (3t & 0-1d): boron, lead, manganese, mercury; (d&t 1): barium, nickel, silver, thallium; fluoride (3). • **Sediment:** total dissolved solids (7), suspended sediment concentration (22), turbidity (22). • **Organics:** Ammonia, total nitrogen, total nitrite/nitrate, total Kjeldahl nitrogen (3); phosphorus, dissolved oxygen and pH (7); *E. coli* (3). • **Selenium:** none.

	Status	Parameters exceeding standards: dissolved oxygen due to low flow conditions and groundwater upwelling, phosphorus, suspended sediment concentration. Currently assessed as Category 2, “Attaining some uses” due to detection limits not low enough for selenium and dissolved mercury. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Moderate due to some exceedances. • **Organics:** High due to exceedances and insufficient data. • **Selenium:** Moderate due to insufficient data.
Black River from Beaver Creek to Reservation Creek ADEQ ID: 15060101-007 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (3t & 0-1d) boron, manganese, lead, mercury; (d&t 1) barium, nickel, silver, thallium; fluoride (3). • **Sediment:** total dissolved solids (3), suspended sediment (3), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (3); *E. coli* (2). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, “Attaining some uses” due to insufficient *e. coli* to assess FBC, and detection limits not low enough for selenium and dissolved mercury. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Low.
East Fork Black River from headwaters to Black River ADEQ ID: 15060101-009 Three sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 8): Antimony, arsenic, beryllium, cadmium, copper, zinc; (t8 & d0-2): boron, lead, manganese, mercury; (d&t 2) barium, nickel, silver, thallium; fluoride (8). • **Sediment:** total dissolved solids (8), suspended sediment (4), turbidity (12). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (8); *E. coli* (8). • **Selenium:** none.

<table>
<tr><td></td><td>Status</td><td>Parameters exceeding standards: none.

Currently assessed as Category 1, “Attaining all uses.

Surface Waterbody risk classification:
• Metals: Moderate due to detection limits not low enough.
• Sediment: Low.
• Organics: Low.
• Selenium: Moderate due to detection limits not low enough.</td></tr>
<tr><td rowspan="2">West Fork Black River
from Indian Reservation to Black River

ADEQ ID: 15060101-048

Six sampling sites at this surface waterbody.</td><td>Sampling</td><td>• Metals: (d&t 8): Antimony, arsenic, beryllium, cadmium, copper, zinc; (t8 & d0-1): boron, lead, manganese, mercury; (d 1 & t 2) barium, nickel, silver, thallium; fluoride (8).
• Sediment: total dissolved solids (7), suspended sediment (69); turbidity (95).
• Organics: ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (8); E. coli (8).
• Selenium: none.</td></tr>
<tr><td>Status</td><td>Parameters exceeding standards: suspended sediment concentration.

Currently assessed as Category 2, “Attaining some uses.

Surface Waterbody risk classification:
• Metals: Moderate due to detection limits not low enough.
• Sediment: Moderate due to some exceedances.
• Organics: Low.
• Selenium: Moderate due to detection limits not low enough.</td></tr>
<tr><td>Fish Creek

ADEQ ID: 15060101-032

One sampling site at this surface waterbody.</td><td>Sampling</td><td>• Metals: (d&t 3): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, zinc; (t3 & d 0-1): boron, lead, manganese, mercury; (d&t 1) barium, nickel, silver, thallium; fluoride (3).
• Sediment: total dissolved solids (3), turbidity (3).
• Organics: Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (3); E. coli (2).
• Selenium: none.</td></tr>
</table>

	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses", due to detection limits not low enough for dissolved mercury and selenium Surface Waterbody risk classification: • **Metals:** Low • **Sediment:** Low. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Hannagan Creek from headwaters to Beaver Creek ADEQ ID: 15060101-034 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** none. • **Sediment:** total dissolved solids (7), suspended sediment (4), turbidity (4). • **Organics:** dissolved oxygen, pH, total phosphorus (5-7). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved oxygen due to low flow and ground water upwelling, phosphorus, suspended sediment concentration. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to some exceedances. • **Organics:** Moderate due to some exceedances. • **Selenium:** Moderate due to insufficient data.
Hay Creek from headwaters to West Fork Black River ADEQ ID: 15060101-353 Two sampling sites at this surface waterbody. Unique Water	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (2t & 0-1d) boron, lead, manganese, mercury; fluoride (2). • **Sediment:** total dissolved solids (2), suspended sediment (8), turbidity (8). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (2); *E. coli* (1). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events, and detection limits not low enough for selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Home Creek from headwaters to West Fork Black River ADEQ ID: 15060101-339 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** none. • **Sediment:** total dissolved solids (2), suspended sediment (6), turbidity (6). • **Organics:** dissolved oxygen, pH (4); total phosphorus (1). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Horton Creek from headwaters to Beaver Creek ADEQ ID: 15060101-036 One sampling site at this surface waterbody.	Sampling	• **Metals:** none. • **Sediment:** total dissolved solids (1), suspended sediment (3), turbidity (3). • **Organics:** dissolved oxygen, pH, total phosphorus (2). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Stinky Creek from headwaters to Fort Apache Reservation ADEQ ID: 15060101-352A One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (2t & 0-1d) boron, lead, manganese, mercury; fluoride (2). • **Sediment:** total dissolved solids (2), turbidity (2). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (2); *E. coli* (1). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved oxygen due to low flow and ground water upwelling. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events, and detection limits not low enough for selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to some exceedances. • **Selenium:** Moderate due to insufficient data.
Thomas Creek from headwaters to Beaver Creek ADEQ ID: 15060101-285 Three sampling sites at this surface waterbody.	Sampling	• **Metals:** none. • **Sediment:** total dissolved solids (1), suspended sediment (3), turbidity (3). • **Organics:** dissolved oxygen, pH, total phosphorus (2). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved oxygen due to low flow and ground water upwelling. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Willow Creek from headwaters to Beaver Creek ADEQ ID: 15060101-049 One sampling site at this surface waterbody.	Sampling	• **Metals:** none. • **Sediment:** total dissolved solids (1), suspended sediment (3), turbidity (3). • **Organics:** dissolved oxygen, pH, total phosphorus (2). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Big Lake ADEQ ID: 15060101-0160 Five sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 3): antimony, arsenic, barium, boron, beryllium, chromium, selenium, zinc; (t3 & d0-1): cadmium, copper, lead, manganese, mercury, silver; fluoride (3). • **Sediment:** total dissolved solids (4), turbidity (3). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (3-4); *E. coli* (2). • **Selenium:** selenium.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses" due to missing core parameters. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Low.
Crescent Lake ADEQ ID: 15060101-0420 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 3): antimony, arsenic, barium, boron, beryllium, chromium, manganese, nickel, silver, selenium, zinc; (t3 & d 0-2): cadmium, copper, lead, mercury; fluoride (3). • **Sediment:** total dissolved solids (4), turbidity (2). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (3); *E. coli* (2). • **Selenium:** selenium.

	Status	Parameters exceeding standards: none. Currently assessed as Category 2, “Attaining some uses” due to missing core parameters. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. EPA listed as impaired due to high pH. • **Selenium:** Low.
Subwatershed		
Big Bonita Creek **HUC 1506010102** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate due to lack of monitoring data. • **Sediment:** Moderate due to lack of monitoring data • **Organics:** Moderate due to lack of monitoring data. • **Selenium:** Moderate due to lack of monitoring data.		
Subwatershed		
Middle Black River **HUC 1506010103** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate. • **Sediment:** Moderate. • **Organics:** Moderate. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Bear Wallow Creek from North and South Forks of Bear Wallow to Indian Reservation boundary. ADEQ ID: 15060101-023A One sampling site at this surface waterbody. Unique Water.	Sampling	• **Metals:** (d&t 3): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, zinc; (t3 & d0-1): boron, lead, manganese, mercury; (d&t 1): nickel, silver, thallium; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (3); *E. coli* (2). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses" due to insufficient *E. coli* samples to assess FBC, and detection limits not low enough for selenium and dissolved mercury. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Low. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
South Fork Bear Wallow Creek from headwaters to Bear Wallow Creek ADEQ ID: 15060101-258 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t2 & d0-1): boron, lead, manganese, mercury; fluoride (2). • **Sediment:** total dissolved solids (2), turbidity (2). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (2); *E. coli* (2). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive" due to insufficient sampling events and insufficient core parameters, and detection limits not low enough for selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Black River from Beaver Creek to Reservation Creek ADEQ ID: 15060101-007 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (3t & 0-1d) boron, manganese, lead, mercury; (d&t 1) barium, nickel, silver, thallium; fluoride (3). • **Sediment:** total dissolved solids (3), suspended sediment (3), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (3); *E. coli* (2). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses" due to insufficient *e. coli* to assess FBC, and detection limits not low enough for selenium and dissolved mercury. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Low.
North Fork Bear Wallow Creek from headwaters to Bear Wallow Creek ADEQ ID: 15060101-022 One sampling site at this surface waterbody. Unique Water.	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, manganese, mercury, zinc; (t2 & d0-1): boron, lead, manganese, mercury; fluoride (2). • **Sediment:** total dissolved solids (2), turbidity (2). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (2); *E. coli* (2). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events, and detection limits not low enough for selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Snake Creek from headwaters to Black River ADEQ ID: 15060101-045 One sampling site at this surface waterbody. Unique Water.	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, beryllium, cadmium, chromium, copper, mercury, zinc; (t2 & d0-1): boron, lead, manganese, mercury; fluoride (2). • **Sediment:** total dissolved solids (2), turbidity (2). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (2); *E. coli* (2). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive", due to insufficient core parameters and sampling events, and detection limits not low enough for selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Subwatershed

Lower Black River
HUC 1506010104

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Upper North Fork White River
HUC 1506010201

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Lower North Fork White River
HUC 1506010202

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

East Fork White River
HUC 1506010203

Combined Classification for Risk of Impairment:
- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

White River
HUC 1506010204

Combined Classification for Risk of Impairment:
- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Cibecue Creek
HUC 1506010301

Combined Classification for Risk of Impairment:
- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Sawmill Creek – Upper Salt River
HUC 1506010302

Combined Classification for Risk of Impairment:
- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed		
Canyon Creek **HUC 1506010303** **Combined Classification for Risk of Impairment:** • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Canyon Creek from headwaters to White Mountain Apache Reservation ADEQ ID: 15060103-014 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, zinc; (t4): boron, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (3). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1, “Attaining all uses”. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Cherry Creek
HUC 1506010304

Combined Classification for Risk of Impairment:

- **Metals:** Low.
- **Sediment:** Low.
- **Organics:** Low.
- **Selenium:** Moderate.

Surface Waterbody	Water Quality Data: Sampling and Assessment Status[1,2,3]	
Cherry Creek from tributary at 340509 / 11056004 to Salt River ADEQ ID: 15060103-015B Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 8): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, zinc; (t8): boron, lead, manganese, mercury; fluoride (8). • **Sediment:** total dissolved solids (8), turbidity (8). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (8); *E. coli* (7). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1, “Attaining all uses”. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Salt River Draw – Upper Salt River
HUC 1506010305

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed		
Pinal Creek **HUC 1506010306** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate. • **Sediment:** Low. • **Organics:** Moderate. • **Selenium:** Low.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Pinal Creek From Lower Pinal Creek WWTP discharge to Salt River ADEQ ID: 15060103-280D Fourteen sampling sites at this surface waterbody (11 USGS special studies, and 3 USGS Pinal Group Effectiveness).	Sampling	• **Metals:** (d&t 93-173): beryllium, cadmium, chromium, copper, manganese, nickel, zinc; (d&t 25-60): antimony, arsenic, barium, boron, lead, thallium; (d&t 17-25): selenium, silver; (d4 & t25): mercury; fluoride (11). • **Sediment:** total dissolved solids (8), suspended sediment (22), turbidity (22). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (22); *E. coli* (22); dissolved oxygen (109); pH (27). • **Selenium:** selenium
	Status	Parameters exceeding standards: cadmium (dissolved), chromium, dissolved oxygen, pH, zinc (dissolved). Currently assessed as Category 2, "Attaining some uses" due to some dissolved cadmium and zinc exceedances, and detection limits not low enough for dissolved metals and total selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Low. • **Organics:** Moderate due to insufficient data. • **Selenium:** Low.
Subwatershed		
Pinto Creek **HUC 1506010307** **Combined Classification for Risk of Impairment:** • **Metals:** Extreme. • **Sediment:** Moderate. • **Organics:** Extreme. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	

Campaign Creek From headwaters to Pinto Creek ADEQ ID: 15060103-037 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, barium, beryllium, cadmium, chromium, copper, zinc; (t 4): Boron, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (3). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1, "Attaining all uses". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Cottonwood Gulch From headwaters to Pinto Creek ADEQ ID: 15060103-891 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 9-19): arsenic, beryllium, cadmium, copper, magnesium, selenium, zinc. • **Sediment:** turbidity (9). • **Organics:** dissolved oxygen (9), pH (19). • **Selenium:** selenium.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Ellis Ranch Tributary From headwaters to Pinto Creek ADEQ ID: 15060103-888 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 27): copper; (d&t 5): selenium, zinc. • **Sediment:** none. • **Organics:** pH (4). • **Selenium:** selenium.
	Status	Parameters exceeding standards: Copper due to natural background conditions (not considered a violation of copper criteria); low pH. Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** High due to exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Five Point Mountain Tributary From headwaters to Pinto Creek ADEQ ID: 15060103-885 Four sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 6): copper; (d&t 5): selenium, zinc; (d&t 1): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, lead, manganese, mercury; nickel, silver, thallium; fluoride (1). • **Sediment:** none. • **Organics:** pH (6). • **Selenium:** selenium.
	Status	Parameters exceeding standards: dissolved copper. Currently assessed as Category 5, "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Gibson Mine Tributary From headwaters to Pinto Creek ADEQ ID: 15060103-887 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 31-50): copper, zinc; (d&t 1): antimony, arsenic, barium, beryllium, cadmium, chromium, lead, manganese, mercury, nickel, silver, thallium; fluoride (1). • **Sediment:** turbidity (1). • **Organics:** dissolved oxygen (4); pH (17. • **Selenium:** none.

Add copper to 303(d) list. Moving from Category 4A to Category 5 until Phase II is completed.	Status	Parameters exceeding standards: dissolved copper, low pH. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to pH exceedances. • **Selenium:** Moderate due to insufficient data.
Gold Gulch From headwaters to Pinto Creek ADEQ ID: 15060103-894 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 3 & t 33): copper, selenium, zinc; (d&t 23-33): arsenic, beryllium, cadmium, magnesium. • **Sediment:** turbidity (30). • **Organics:** dissolved oxygen (21), pH (42). • **Selenium:** selenium.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, “Inconclusive”. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Haunted Canyon From headwaters to Pinto Creek ADEQ ID: 15060103-879 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 61 &t 19): copper; (d&t 3-15); antimony, arsenic, barium, beryllium, cadmium, chromium, lead, nickel, selenium, silver, thallium, zinc; (d 0-2 d & t 8): boron, manganese, mercury; fluoride (9). • **Sediment:** total dissolved solids (5), turbidity (6). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (5-7); *E. coli* (4); dissolved oxygen (10); pH (26). • **Selenium:** selenium.
	Status	Parameters exceeding standards: dissolved copper. Currently assessed as Category 3, “Inconclusive”. Surface Waterbody risk classification: • **Metals:** Extreme due to dissolved copper exceedances. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

JK Mountain Tributary From headwaters to West Fork Pinto Creek ADEQ ID: 15060103-873 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 2): copper, selenium, zinc. • **Sediment:** none. • **Organics:** pH (2). • **Selenium:** selenium.
	Status	Parameters exceeding standards: dissolved copper. Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Extreme due to dissolved copper exceedances. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Mead Canyon From headwaters to Pinto Creek ADEQ ID: 15060103-889 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 2): copper, zinc. • **Sediment:** none. • **Organics:** pH (2). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved copper due to natural background conditions (not considered a violation of copper criteria); low pH. Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** High due to pH exceedances in 1 of 2 samples. • **Selenium:** Moderate due to detection limits not low enough.
Pinto Creek From headwaters to unnamed tributary at 331927/1105456 ADEQ ID: 15060103-018A One sampling site at this surface waterbody. Conducting a Phase II copper TMDL. (Moving from Category 4A to 5 while completing Phase II Copper TMDL.)	Sampling	• **Metals:** (d 7 & t 6): copper; (d 3 & t 2) zinc. • **Sediment:** none. • **Organics:** pH (7); dissolved oxygen and pH (2). • **Selenium:** none.
	Status	Parameters exceeding standards: copper, dissolved copper, pH. Currently assessed as Category 5, "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to pH exceedances. • **Selenium:** Moderate due to detection limits not low enough.

Pinto Creek From unnamed tributary at 331927/1105456 to West Fork Pinto Creek ADEQ ID: 15060103-018B Eleven sampling sites at this surface waterbody. Add selenium to the 303(d) list. Moved from Category 4A to 5 while conducting a Phase II copper TMDL.	Sampling	• **Metals:** (d 96 &t 80): copper; (d 38 & t 58) zinc; (d 8 & t 33): arsenic, beryllium, cadmium, manganese; (t26): selenium; (d&t 8-9): antimony, barium, boron, chromium, lead, nickel, silver, thallium; (t 8): mercury; fluoride (9). • **Sediment:** turbidity (7). • **Organics:** pH (112). • **Selenium:** selenium (26).
	Status	Parameters exceeding standards: copper, selenium, pH, zinc (dissolved). Currently assessed as Category 5, "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to copper and zinc exceedances, and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Extreme due to exceedances and detection limits not low enough.
Pinto Creek From West Fork Pinto Creek to Roosevelt Lake ADEQ ID: 15060103-018C Four sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 35 &t 31): copper; (d 25 & t 26) zinc; (d&t 22-23): antimony, arsenic, beryllium, cadmium, chromium, lead, manganese; (d&t 9-10): barium, nickel, silver, thallium; (d 0-2 & t 22-23): boron, manganese; (d 4 & t 22): mercury; (d&t 1-2): selenium; fluoride (23). • **Sediment:** total dissolved solids (20), turbidity (21), suspended sediment concentration (10). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate (20-21); *E. coli* (19); dissolved oxygen (24); pH (33). • **Selenium:** selenium (1-2).
	Status	Parameters exceeding standards: copper, selenium, cadmium (1 in 23 samples), dissolved oxygen due to natural conditions of low flow and ground water upwelling. Currently assessed as Category 5, "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** High due to exceedances and detection limits not low enough.

Powers Gulch From headwaters to Haunted Canyon ADEQ ID: 15060103-884 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 8-9): copper, selenium, zinc; (t 8): arsenic, beryllium, cadmium, manganese. • **Sediment:** turbidity (8). • **Organics:** pH (9). • **Selenium:** selenium (d&t 8-9).
	Status	Parameters exceeding standards: copper (dissolved). Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances, and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
West Fork Pinto Creek From headwaters to Pinto Creek ADEQ ID: 15060103-066 Three sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 4-5): copper, selenium, zinc; (d&t 1): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, lead, manganese, mercury, nickel, silver, thallium; fluoride (1). • **Sediment:** none. • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (1); dissolved oxygen (2), pH (7). • **Selenium:** selenium (d&t 4-5).
	Status	Parameters exceeding standards: copper (dissolved). Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** High due to copper exceedances, and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Roosevelt Lake ADEQ ID: 15060103-1240 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 3-6 & t 9-25): arsenic, cadmium, chromium, copper, lead, nickel, silver, zinc; (d 0-2 & t 9-25): antimony beryllium, boron, manganese, selenium, thallium; fluoride (24). • **Sediment:** total dissolved solids (61), turbidity (21). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, nitrite/nitrate (69-90); total phosphorus (18); *E. coli* (3). • **Selenium:** selenium.

	Status	Parameters exceeding standards: one or two exceedances of copper, dissolved oxygen, lead, manganese, pH. Currently assessed as Category 2, "Attaining some uses" due to missing composite data. Surface Waterbody risk classification: • **Metals:** Moderate. • **Sediment:** Moderate. • **Organics:** Moderate due to missing composite data. • **Selenium:** Low.

Subwatershed

Salome Creek
HUC 1506010308

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Upper Salt River – Theodore Roosevelt Lake
HUC 1506010309

Combined Classification for Risk of Impairment:

- **Metals:** Extreme.
- **Sediment:** Extreme.
- **Organics:** Extreme.
- **Selenium:** Extreme.

Surface Waterbody	Water Quality Data: Sampling and Assessment Status[1,2,3]	
Coon Creek From tributary at 334642 / 1105425 to Salt River ADEQ ID: 15060103-039B One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, zinc; (t 4): boron, lead, manganese, mercury; fluoride (4). • **Sediment:** turbidity (4) total dissolved solids (4), *E. coli* (4). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (4). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 1, "Attaining All Uses". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Pinal Creek From Lower Pinal Creek WWTP discharge to Salt River ADEQ ID: 15060103-280D Fourteen sampling sites at this surface waterbody (11 USGS special studies, and 3 USGS Pinal Group Effectiveness).	Sampling	• **Metals:** (d&t 93-173): beryllium, cadmium, chromium, copper, manganese, nickel, zinc; (d&t 25-60): antimony, arsenic, barium, boron, lead, thallium; (d&t 17-25): selenium, silver; (d4 & t25): mercury; fluoride (11). • **Sediment:** total dissolved solids (8), suspended sediment (22), turbidity (22). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (22); *E. coli* (22); dissolved oxygen (109); pH (27). • **Selenium:** selenium
	Status	Parameters exceeding standards: cadmium (dissolved), chromium, dissolved oxygen, pH, zinc (dissolved). Currently assessed as Category 2, "Attaining some uses" due to some dissolved cadmium and zinc exceedances, and detection limits not low enough for dissolved metals and total selenium. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Low. • **Organics:** Moderate due to insufficient data. • **Selenium:** Low.
Pinto Creek From headwaters to unnamed tributary at 331927/1105456 ADEQ ID: 15060103-018A	Sampling	• **Metals:** (d 7 & t 6): copper; (d 3 & t 2) zinc. • **Sediment:** none. • **Organics:** pH (7); dissolved oxygen and pH (2). • **Selenium:** none.

One sampling site at this surface waterbody. Conducting a Phase II copper TMDL. (Moving from Category 4A to 5 while completing Phase II Copper TMDL.)	Status	Parameters exceeding standards: copper, dissolved copper, pH. Currently assessed as Category 5, "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to pH exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Pinto Creek From unnamed tributary at 331927/1105456 to West Fork Pinto Creek ADEQ ID: 15060103-018B Eleven sampling sites at this surface waterbody. Add selenium to the 303(d) list. Moved from Category 4A to 5 while conducting a Phase II copper TMDL.	Sampling	• **Metals:** (d 96 &t 80): copper; (d 38 & t 58) zinc; (d 8 & t 33): arsenic, beryllium, cadmium, manganese; (t26): selenium; (d&t 8-9): antimony, barium, boron, chromium, lead, nickel, silver, thallium; (t 8): mercury; fluoride (9). • **Sediment:** turbidity (7). • **Organics:** pH (112). • **Selenium:** selenium (26).
	Status	Parameters exceeding standards: copper, selenium, pH, zinc (dissolved). Currently assessed as Category 5, "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to copper and zinc exceedances, and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Extreme due to exceedances and detection limits not low enough.
Pinto Creek From West Fork Pinto Creek to Roosevelt Lake ADEQ ID: 15060103-018C Four sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 35 &t 31): copper; (d 25 & t 26) zinc; (d&t 22-23): antimony, arsenic, beryllium, cadmium, chromium, lead, manganese; (d&t 9-10): barium, nickel, silver, thallium; (d 0-2 & t 22-23): boron, manganese; (d 4 & t 22): mercury; (d&t 1-2): selenium; fluoride (23). • **Sediment:** total dissolved solids (20), turbidity (21), suspended sediment concentration (10). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate (20-21); *E. coli* (19); dissolved oxygen (24); pH (33). • **Selenium:** selenium (1-2).

	Status	Parameters exceeding standards: copper, selenium, cadmium (1 in 23 samples), dissolved oxygen due to natural conditions of low flow and ground water upwelling. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Extreme due to copper exceedances. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** High due to exceedances and detection limits not low enough.
Salt River from Pinal Creek to Roosevelt Dam ADEQ ID: 15060103-004 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 27-28): antimony, arsenic, barium, boron, beryllium, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, thallium, zinc. • **Sediment:** total dissolved solids (28), turbidity (27), suspended sediment concentration (28), cyanide (13). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (22-28); *E. coli* (23). • **Selenium:** selenium (d&t 27-28).
	Status	Parameters exceeding standards: suspended sediment concentration; and others related to the Rodeo-Chediski Fire in 2002. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Moderate due to some exceedances. • **Sediment:** Extreme due to exceedances. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Subwatershed

Corduroy Creek
HUC 1506010401

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Cedar Creek
HUC 1506010402

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Carrizo Creek
HUC 1506010403

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Spring Creek
HUC 1506010501

Combined Classification for Risk of Impairment:

- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Surface Waterbody	**Water Quality Data: Sampling and Assessment Status**[1,2,3]	
Spring Creek from headwaters to Tonto Creek ADEQ ID: 15060105-010 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3-4): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-2 & t3): boron, lead, manganese, mercury; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (4); *E. coli* (2). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, “Attaining some uses”. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Subwatershed		
Haigler Creek – Tonto Creek **HUC 1506010502** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate. • **Sediment:** Moderate. • **Organics:** Extreme. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status**[1,2,3]	
Christopher Creek From headwaters to Tonto Creek ADEQ ID: 15060105-353 Nine sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 3-4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t 3-4): barium, boron, lead, manganese, mercury; (t1): nickel, silver, thallium; fluoride (4) • **Sediment:** total dissolved solids (3), turbidity (72), suspended sediment concentration (163). • **Organics:** Ammonia (4); dissolved oxygen, pH, total nitrogen, total phosphorus, total Kjeldahl nitrogen (95-102); *E. coli* (68). • **Selenium:** none.
	Status	Parameters exceeding standards: *E. coli*, phosphorus. Currently assessed as Category 4A (*E. coli*) “Not Attaining” (Impaired), Category 5 (phosphorus) Impaired. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Moderate due to some exceedances. • **Organics:** Extreme due to exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Haigler Creek From headwaters to unnamed tributar at 341223 / 1110011 ADEQ ID: 15060105-012A One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t 4): boron, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (4); *E. coli* (3). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 1, "Attaining All Uses". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Tonto Creek From headwaters to unnamed tributary at 341810 / 1110414 ADEQ ID: 15060105-013A Fourteen sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 5-26): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, nickel, manganese, mercury, silver, thallium, zinc; (t 25-26): boron, manganese; fluoride (26). • **Sediment:** total dissolved solids (23), suspended sediment concentration (124), turbidity (167). • **Organics:** total nitrogen, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (156-166); ammonia (26); *E. coli* (103). • **Selenium:** none.
	Status	Parameters exceeding standards: *E. coli* bacteria, phosphorus, and low dissolved oxygen. Currently assessed as Category 4A (*E. coli*) "Not Attaining" (Impaired), Category 5 (phosphorus and low dissolved oxygen) "Impaired". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Extreme due to exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Tonto Creek From tributary at 341810 / 1110414 to Haigler Creek ADEQ ID: 15060105-013B Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-2 & t 4): boron, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), suspended sediment concentration (24); turbidity (34). • **Organics:** ammonia (4); total nitrogen, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (32-35); *E. coli* (23). • **Selenium:** none.

	Status	Parameters exceeding standards: *E. coli*. Currently assessed as Category 4A, "Not Attaining" (Impaired). Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Extreme due to exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Subwatershed		
Rye Creek – Tonto Creek **HUC 1506010503** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate. • **Sediment:** Moderate. • **Organics:** Moderate. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status[1,2,3]**	
Deer Creek From headwaters to Rye Creek ADEQ ID: 15060105-018 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t 3): boron, lead, manganese, mercury; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** ammonia, total nitrogen, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH. total phosphorus (3); *E. coli* (3). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1, "Attaining all uses". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Rye Creek From headwaters to Tonto Creek ADEQ ID: 15060105-014 Three sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4): boron, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, nitrite/nitrate, total Kjeldahl nitrogen, total phosphorus (4); *E. coli* (2). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved oxygen due to natural conditions of low flow and ground water upwelling. Currently assessed as Category 2, "Attaining some uses". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Moderate due to missing some core parameters. • **Selenium:** Moderate due to detection limits not low enough.
Spring Creek from headwaters to Tonto Creek ADEQ ID: 15060105-010 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3-4): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-2 & t3): boron, lead, manganese, mercury; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (4); *E. coli* (2). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses". Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Tonto Creek From Rye Creek to Gun Creek ADEQ ID: 15060105-008 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 7-20): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, silver, thallium, zinc; (d 0-2 & t 20): boron, manganese; fluoride (20). • **Sediment:** total dissolved solids (20), suspended sediment concentration (10), turbidity (21). • **Organics:** ammonia, total nitrogen, nitrite/nitrate, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (20-21); *E. coli* (20). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1 "Attaining all uses". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Subwatershed		
Gun Creek – Tonto Creek **HUC 1506010504** **Combined Classification for Risk of Impairment:** • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate.		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Greenback Creek From headwaters to Tonto Creek ADEQ ID: 15060105-005 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3): antimony, arsenic, beryllium, cadmium, copper, zinc; (d0-2 & t3): boron, lead, manganese, mercury; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, nitrite/nitrate, total Kjeldahl nitrogen, total phosphorus (3); *E. coli* (3). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 1 "Attaining all uses". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Tonto Creek – Theodore Roosevelt Lake
HUC 1506010505

Combined Classification for Risk of Impairment:

- **Metals:** Moderate due to lack of monitoring data.
- **Sediment:** Moderate due to lack of monitoring data.
- **Organics:** Moderate due to lack of monitoring data.
- **Selenium:** Moderate due to lack of monitoring data.

Subwatershed

Lower Salt River – Apache, Canyon, and Saguaro Lake
HUC 1506010601

Combined Classification for Risk of Impairment:

- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Extreme.
- **Selenium:** Moderate.

Surface Waterbody	Water Quality Data: Sampling and Assessment Status[1,2,3]	
Apache Lake ADEQ ID: 15060106A-0070 Eight sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 5 & t 9-14): cadmium, chromium, copper, lead, nickel, silver, zinc; (d 0-2 & t 6-15): antimony, arsenic, barium, boron, beryllium, manganese, selenium, mercury, thallium; fluoride (11). • **Sediment:** total dissolved solids (14), turbidity (24). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (42-45); *E. coli* (11). • **Selenium:** selenium.

	Status	Parameters exceeding standards: low dissolved oxygen. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Extreme due to exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Canyon Lake ADEQ ID: 15060106A-0250 Seven sampling sites at this surface waterbody.	Sampling	• **Metals:** (t7-11 & d 7): cadmium, chromium, copper, lead, nickel, silver, zinc; (t7 & d0-2): antimony, arsenic, barium, boron, beryllium, manganese, selenium, mercury, thallium; fluoride (16). • **Sediment:** total dissolved solids (6), turbidity (11). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (28-30); *E. coli* (8). • **Selenium:** selenium.
	Status	Parameters exceeding standards: low dissolved oxygen. Currently assessed as Category 5, “Impaired. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to exceedances. • **Selenium:** Moderate due to detection limits not low enough.
Saguaro Lake ADEQ ID: 15060106A-1290 Eight sampling sites at this surface waterbody.	Sampling	• **Metals:** (t 6-16 & d 5): antimony, arsenic, barium, boron, beryllium, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, zinc; (t 15): mercury; (t 4): thallium; fluoride (25). • **Sediment:** total dissolved solids (14), turbidity (19). • **Organics:** ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (40-44); *E. coli* (16). • **Selenium:** selenium.

	Status	Parameters exceeding standards: dissolved oxygen, fluorine, pH. Currently assessed as Category 2, “Attaining some uses”. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to exceedances. • **Selenium:** Low.

Subwatershed

Lower Salt River below Saguaro Lake
HUC 1506010603A

Combined Classification for Risk of Impairment:

- **Metals:** Moderate.
- **Sediment:** Low.
- **Organics:** Extreme.
- **Selenium:** Moderate.

Surface Waterbody	Water Quality Data: Sampling and Assessment Status[1,2,3]	
Salt River from Stewart Mountain Dam (Saguaro Lake) to Verde River ADEQ ID: 15060106A-003 Four sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 21-22): antimony, arsenic, barium, boron, beryllium, cadmium, chromium, copper, lead, manganese, nickel, selenium, silver, thallium, zinc; (t22): mercury; fluoride (1, d22). • **Sediment:** total dissolved solids (22), turbidity (21), suspended sediment concentration (22). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (22-23); *E. coli* (22). • **Selenium:** selenium (d&t 21-22).
	Status	Parameters exceeding standards: low dissolved oxygen. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Extreme due to exceedances. • **Selenium:** Low.

Notes:
[1] All water quality constituents had a minimum of three samples unless otherwise indicated by numbers in parenthesis. For example, arsenic (2) indicates two samples have been taken for arsenic on this reach.
[2] The number of samples that exceed a standard is described by a ratio. For example, the statement “Exceedances reported for E. coli (1/2),” indicates that one from two samples has exceeded standards for E. coli.

[3] The acronyms used for the water quality parameters are defined below:
(d) = dissolved fraction of the metal or metalloid (after filtration), ug/L
(t) = total metal or metalloid (before filtration), ug/L
cadmium (d): Filtered water sample analyzed for dissolved cadmium.
cadmium (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) cadmium content.
chromium (d): Filtered water sample analyzed for dissolved chromium.
chromium (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) chromium content.
copper (d): Filtered water sample analyzed for dissolved copper.
copper (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) copper content.
dissolved oxygen: O2 (mg/L)
E. coli: Escherichia coli bacteria (CFU/100mL)
lead (d): Filtered water sample analyzed for dissolved lead.
lead (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) lead content.
manganese (d): Filtered water sample analyzed for dissolved manganese.
manganese (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) manganese content.
mercury (d): Filtered water sample analyzed for dissolved mercury.
mercury (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) mercury content.
nickel (d): Filtered water sample analyzed for dissolved nickel.
nickel (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) nickel content.
nitrite/nitrate: Water sample analyzed for Nitrite/Nitrate content.
n-kjeldahl: Water sample analyzed by the Kjeldahl nitrogen analytical method which determines the nitrogen content of organic and inorganic substances by a process of sample acid digestion, distillation, and titration.
pH: Water sample analyzed for levels of acidity or alkalinity.
selenium (d): Filtered water sample analyzed for dissolved selenium.
selenium (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) selenium content.
silver (d): Filtered water sample analyzed for dissolved silver.
silver (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) silver content.
suspended sediment concentration: Suspended Sediment Concentration
temperature: Sample temperature
total dissolved solids: tds, (mg/L)
total solids: (t) Solids
total suspended solids: (t) Suspended Solids
turbidity: Measurement of suspended matter in water sample (NTU)
zinc (d): Filtered water sample analyzed for dissolved zinc.
zinc (t): Unfiltered water sample and sediment/particulates suspended in the water sample analyzed for (t) zinc content.

Designated Uses:
AgI: Agricultural Irrigation. Surface water is used for the irrigation of crops.
AgL: Agricultural Livestock Watering. Surface water is used as a supply of water for consumption by livestock.
A&Ww: Aquatic and Wildlife Warm water Fishery. Surface water used by animals, plants, or other organisms (excluding salmonid fish) for habitation, growth, or propagation, generally occurring at elevations less than 5000 feet.
FC: Fish Consumption. Surface water is used by humans for harvesting aquatic organisms for consumption. Harvestable aquatic organisms include, but are not limited to, fish, clams, crayfish, and frogs.
FBC: Full Body Contact. Surface water use causes the human body to come into direct contact with the

water to the point of complete submergence (e.g., swimming). The use is such that ingestion of the water is likely to occur and certain sensitive body organs (e.g., eyes, ears, or nose) may be exposed to direct contact with the water.

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Appendix B: Suggested Readings
Salt Watershed

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Appendix C: Revised Universal Soil Loss Equation (RUSLE) Modeling

The Revised Universal Soil Loss Equation (RUSLE) was used to model erosion potential. RUSLE computes average annual erosion from field slopes as (Renard, 1997):

$$A = R*K*L*S*C*P$$

Where:

A = computed average annual soil loss in tons/acre/year.
R = rainfall-runoff erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover-management factor
P = Conservation Practice

The modeling was conducted in the ArcInfo Grid environment using SEDMOD, Van Remortel's (2006) Soil & Landform Metrics program. This is a series of Arc Macro Language (AML) programs and C++ executables that are run sequentially to prepare the data and run the RUSLE model. A 30-meter cell size was used to correspond to the requirements of the program.

All of the required input spatial data layers were converted to the projection required by the program (USGS Albers NAD83) and placed in the appropriate directories. The input data layers include:

- USGS Digital Elevation Model (DEM). The DEM was modified by multiplying it by 100 and converting it to an integer grid as prescribed by the program.
- Master watershed boundary grid (created from USGS DEM).
- National Land Cover Dataset (NLCD) land cover grid.
- Land mask grid for open waters, such as oceans or bays, derived from the NLCD land cover data. No oceans or bays are present in this watershed, so no cells were masked.

The first component AML of the program sets up the 'master' soil and landform spatial datasets for the study area. This includes extracting the STATSGO soil map and attributes as well as the R, C, and P factors, from datasets that are provided with the program. The R-factor is rainfall-runoff erosivity, or the potential of rainfall-runoff to cause erosion. The C-factor considers the type of cover or land management on the land surface. The P-factor looks at conservation practices, such as conservation tillage.

Additionally, a stream network is delineated from the DEM using the default threshold of 100 30x30 meter cells as the contributing area for stream delineation. The AML also creates the K factor grid. The K factor considers how susceptible a soil type is to erosion.

The second component AML sets up additional directory structures for any defined subwatersheds. In this use of the model the entire Salt Watershed was modeled as a single unit, with 27 subwatersheds.

The third component AML iteratively computes a set of soil parameters derived from the National Resource Conservation Service's State Soil Geographic (STATSGO) Dataset.

The fourth component AML calculates the LS factor according to the RUSLE criteria using DEM-based elevation and flow path. The L and S factors take into account hill slope length and hill slope steepness.

The fifth component AML runs RUSLE and outputs R, K, LS, C, P factor grids and an A value grid that contains the modeled estimate of erosion in tons/acre/year for each cell.

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U.S. Geological Survey.
National Elevation Dataset 30-Meter Digital Elevation Models (DEMs). April 8, 2003. http://gisdata.usgs.net/NED/default.asp

**Note: Dates for each data set refer to when data was downloaded from the website. Metadata (information about how and when the GIS data were created) is available from the website in most cases. Metadata includes the original source of the data, when it was created, its geographic projection and scale, the name(s) of the contact person and/or organization, and general description of the data.*

Appendix D: Automated Geospatial Watershed Assessment Tool – AGWA

The Automated Geospatial Watershed Assessment (AGWA) tool is a multipurpose hydrologic analysis system for use by watershed, water resource, land use, and biological resource managers and scientists in performing watershed- and basin-scale studies (Burns et al., 2004). It was developed by the U.S.D.A. Agricultural Research Service's Southwest Watershed Research Center. AGWA is an extension for the Environmental Systems Research Institute's (ESRI) ArcView 3.x or ArcMap 9.x, widely used geographic information system (GIS) software packages.

AGWA provides the functionality to conduct all phases of a watershed assessment for two widely used watershed hydrologic models: the Soil and Water Assessment Tool (SWAT); and the KINematic Runoff and EROSion model, KINEROS2.

The watershed assessment for the Salt Watershed was performed with the Soil and Water Assessment Tool. SWAT (Arnold et al., 1994) was developed by the USDA Agricultural Research Service (ARS) to predict the effect of alternative land management decisions on water, sediment and chemical yields with reasonable accuracy for ungaged rural watersheds. It is a distributed, lumped-parameter model that will evaluate large, complex watersheds with varying soils, land use and management conditions over long periods of time (> 1 year). SWAT is a continuous-time model, i.e. a long-term yield model, using daily average input values, and is not designed to simulate detailed, single-event flood routing. Major components of the model include: hydrology, weather generator, sedimentation, soil temperature, crop growth, nutrients, pesticides, groundwater and lateral flow, and agricultural management. The Curve Number method is used to compute rainfall excess, and flow is routed through the channels using a variable storage coefficient method developed by Williams (1969). Additional information and the latest model updates for SWAT can be found at http://www.brc.tamus.edu/swat/.

Data used in AGWA include Digital Elevation Models (DEMs), land cover grids, soil data and precipitation data.

For this study data were obtained from the following sources:

- DEM: United States Geological Survey Seamless Data Distribution System, National Elevation Dataset, 30-Meter Digital Elevation Models (DEMs). April 10, 2008. http://seamless.usgs.gov/website/seamless/index.htm

- Soils: USDA Natural Resource Conservation Service, STATSGO Soils. April 17, 2003. http://www.soils.usda.gov/survey/geography/statsgo/

- Land cover: Southwest GAP Analysis Project Regional Provisional Land Cover dataset. September, 2004. http://earth.gis.usu.edu/swgap/

- Precipitation Data: Cooperative Summary of the Day TD3200: Includes daily weather data from the Western United States and the Pacific Islands. Version 1.0. August 2002. National Oceanic and Atmospheric Administration/National Climatic Data Center, Asheville, North Carolina.

The AGWA Tools menu is designed to reflect the order of tasks necessary to conduct a watershed assessment, which are broken out into five major steps, as shown in Figure 1 and listed below:

1. Watershed delineation and discretization;
2. Land cover and soils parameterization;
3. Writing the precipitation file for model input;
4. Writing the input parameter file and running the chosen model; and
5. Viewing the results.

When following these steps, the user first creates a watershed outline, which is a grid based on the accumulated flow to the designated outlet (pour point) of the study area. The user then specifies the contributing area for the establishment of stream channels and subwatersheds (model elements) as required by the model of choice.

From this point, the tasks are specific to the model that will be used, which in this case is SWAT. If internal runoff gages for model validation or ponds/reservoirs are present in the discretization, they can be used to further subdivide the watershed.

The application of AGWA is dependent on the presence of both land cover and soil GIS coverages. The watershed is intersected with these data, and parameters necessary for the hydrologic model runs are determined through a series of look-up tables. The hydrologic parameters are added to the watershed polygon and stream channel tables.

For SWAT, the user must provide daily rainfall values for rainfall gages within and near the watershed. If multiple gages are present, AGWA will build a Thiessen polygon map and create an area-weighted rainfall file. Precipitation files for model input are written from uniform (single gage) rainfall or distributed (multiple gage) rainfall data.

In this modeling process, the precipitation file was created for a 10-year period (1990-2000) based on data from the National Climatic Data Center. In each study watershed multiple gages were selected based on the adequacy of the data for this time period. The precipitation data file for model input was created from distributed rainfall data.

After all necessary input data have been prepared, the watershed has been subdivided into model elements, hydrologic parameters have been determined for each element, and rainfall files have been prepared, the user can run the hydrologic model of choice. SWAT was used in this application.

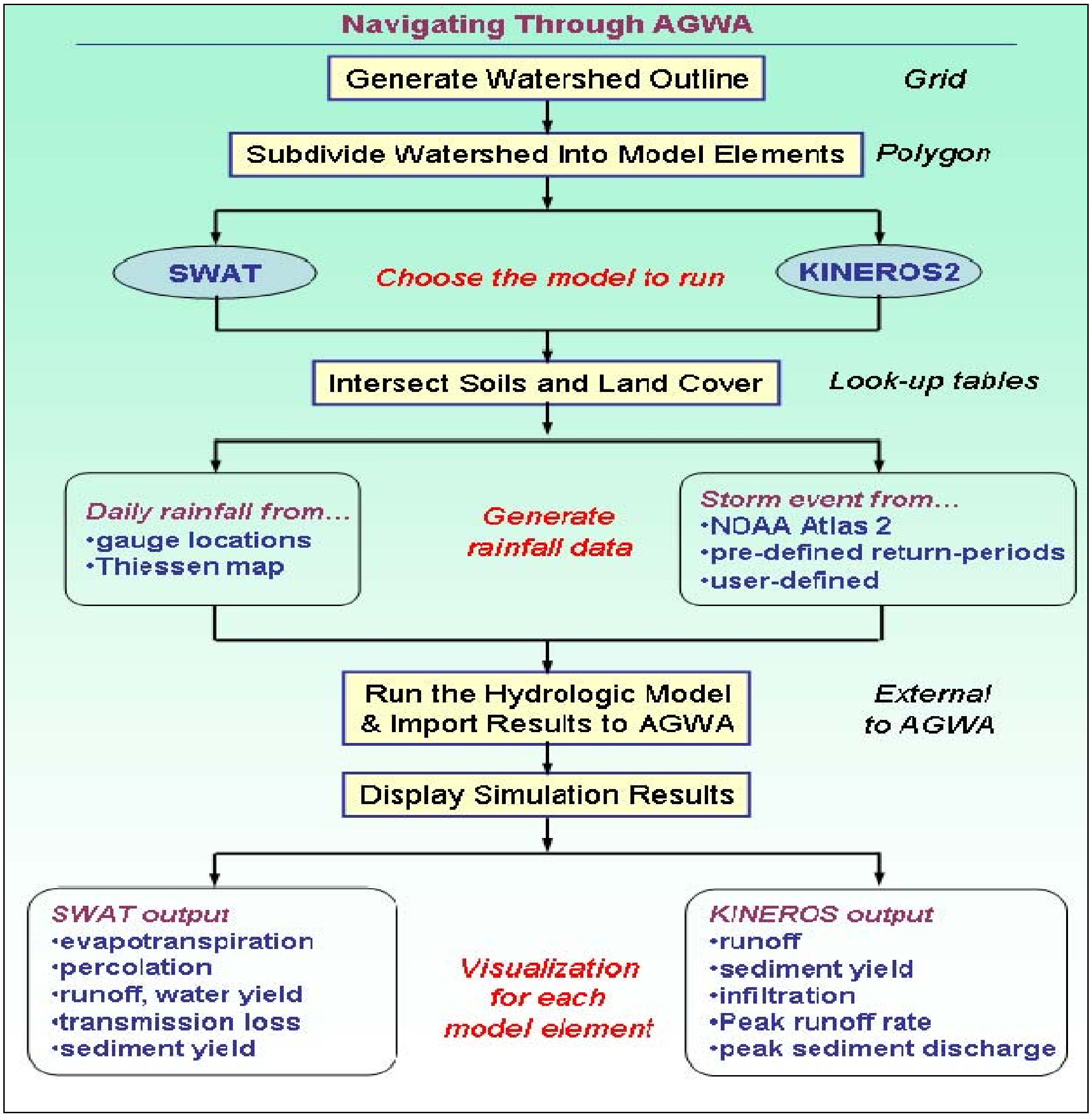

Figure D-1: Flow chart showing the general framework for using KINEROS2 and SWAT in AGWA.

After the model has run to completion, AGWA will automatically import the model results and add them to the polygon and stream map tables for display. A separate module within AGWA controls the visualization of model results. The user can toggle between viewing the total depth or accumulated volume of runoff, erosion, and infiltration output for both upland and channel elements. This enables problem areas to be identified visually so that limited resources can be focused for maximum effectiveness. Model results can also be overlaid with other digital data layers to further prioritize management activities. Output variables available in AGWA/SWAT are:

- Channel Discharge (m^3/day);

- Evapotranspiration (ET) (mm);
- Percolation (mm);
- Surface Runoff (mm);
- Transmission loss (mm);
- Water yield (mm);
- Sediment yield (t/ha); and
- Precipitation (mm).

It is important to note that AGWA is designed to evaluate relative change and can only provide qualitative estimates of runoff and erosion. It cannot provide reliable quantitative estimates of runoff and erosion without careful calibration. It is also subject to the assumptions and limitations of its component models, and should always be applied with these in mind.

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