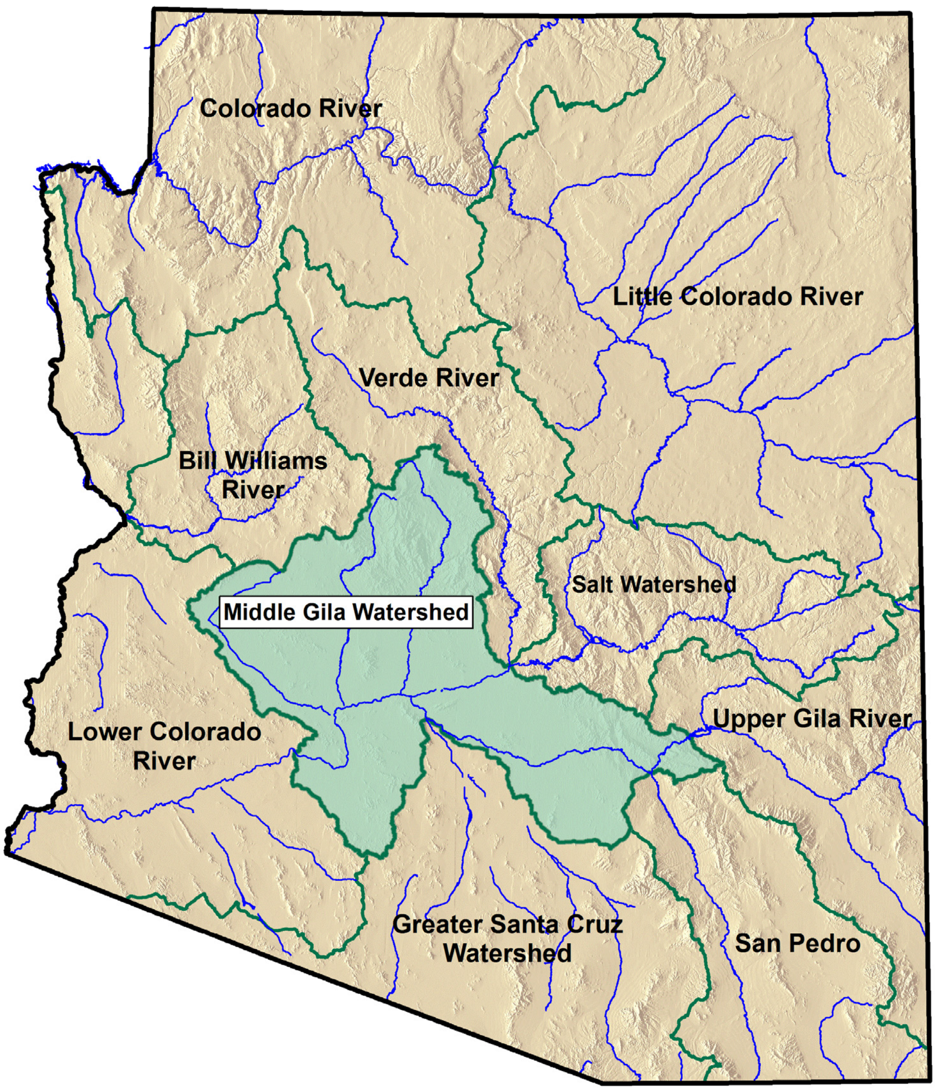
NEMO Watershed-Based Plan
Middle Gila Watershed


Photo: Channah Rock

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Arizona Cooperative Extension

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The NEMO website is www.arizonanemo.org

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Section 1: Introduction

Background: Nonpoint Source Pollution and NEMO

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 Nonpoint Education for Municipal Officials 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 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 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.

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, stakeholder-group local watershed-based plans 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, strategies and projects to be implemented by the partnership.

Based on 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 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 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 loading 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 Middle Gila Watershed. The watershed characterization (Sections 2 through 8) will include the entire Middle Gila Watershed.

The Middle Gila Watershed is located in the central portion of the state of Arizona, south of the city of Prescott, and north including the cities of Phoenix, Gila Bend and Hayden, 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 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(Draft) – 2006: Arizona's Integrated 305(b) Assessment and 303(d) Listing Report* (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: www.adeq.state.az.us/environ/water/assessment/assess.html.

The watershed classification includes identifying and mapping important resources, and ranking 10-digit HUC

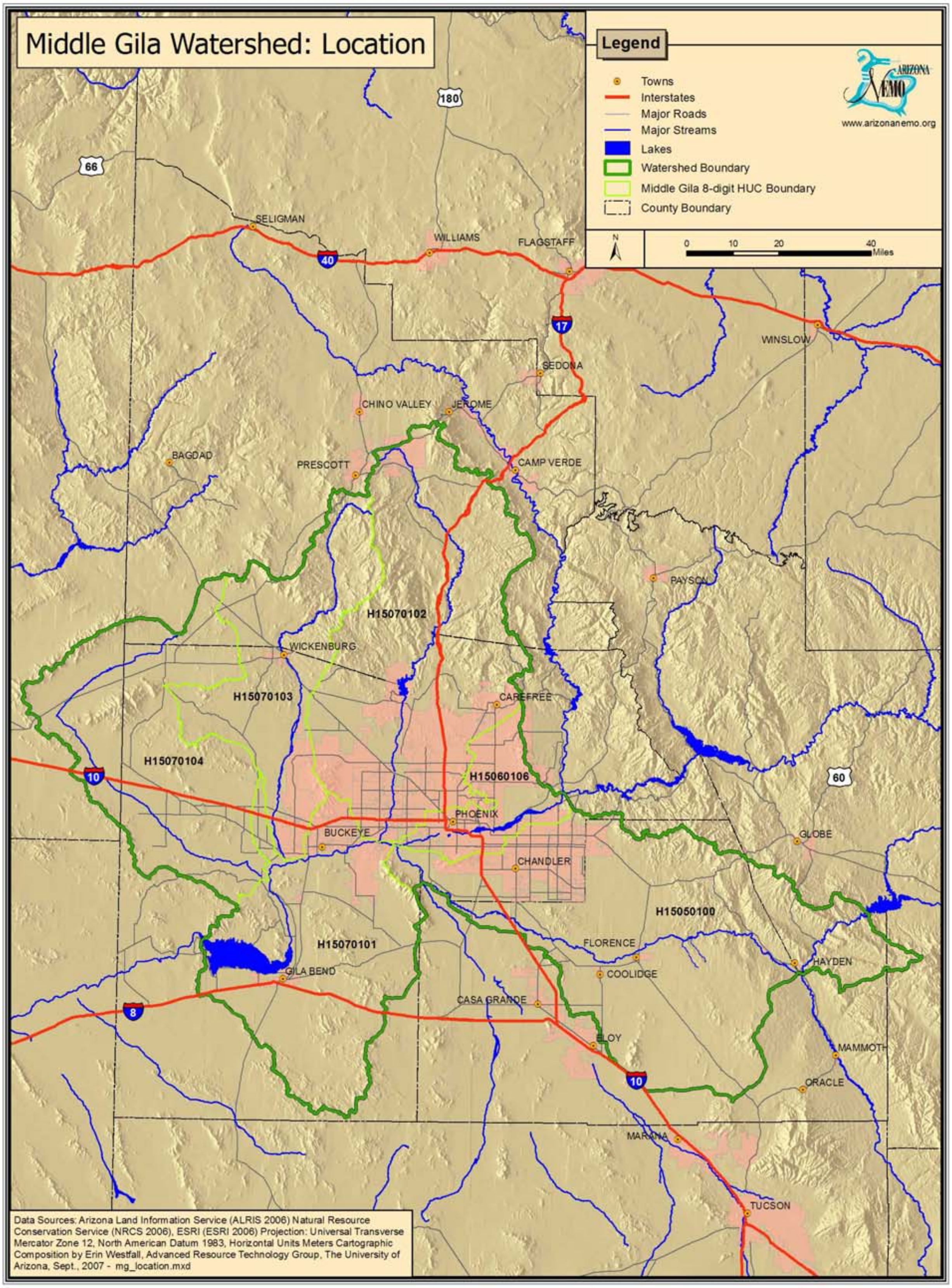

Figure 1-1: Location

(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 Upper Middle Gila Watershed include AGWA, SWAT, 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., 2004), 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 an ESRI ArcGIS 8.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 Middle Gila 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 Middle Gila watershed is a six-digit HUC watershed. Within the Middle Gila, smaller subwatershed areas are delineated using the eight-digit cataloging HUC. These eight-digit HUCs were used for the characterizations, classifications and GIS modeling.

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

H150701 Middle Gila Watershed

15070102 - Agua Fria River
15070104 - Centennial Wash
15070103 - Hassayampa River
15070101 - Lower Gila River above Painted Rock Dam
15060106B - Lower Salt River
15050100 - Middle Gila 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.

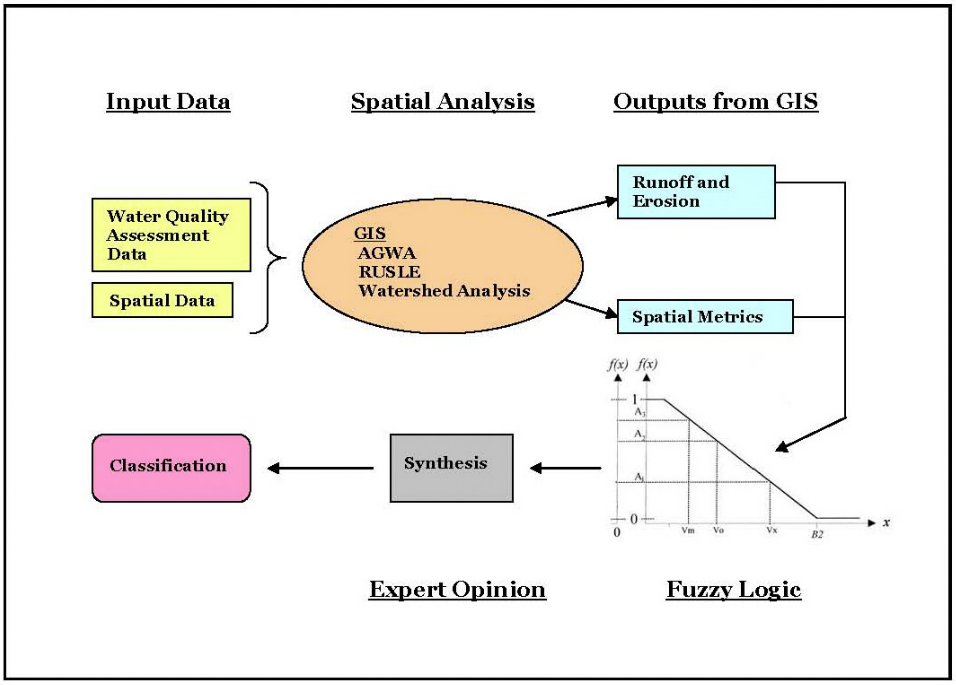

Figure 1-2: Transformation of Input Data via a GIS, Fuzzy Logic Approach, and Synthesis of Results into a Watershed Classification.

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, 2006);

    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.

<u>Structure of this Watershed-Based Plan</u>

Watershed characterizations, including physical, biological, and social characteristics, are discussed in Sections 2 through 4. Important environmental resources are discussed in Section 5. These sections will address the entire Middle Gila Watershed (all eight eight-digit HUCs).

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 Middle Gila 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 Middle Gila Watershed in Arizona is defined as the area drained by the Gila River below Coolidge Dam in the east to Painted Rock Dam in the west. It includes the Lower Salt River drainage below Roosevelt Dam. The watershed is located in the central part of the state, from the southern part of Phoenix, north to the Prescott area, as shown in Figure 2-1.

Elevations range from 7,979 feet above sea level at Mt. Union, to 541 feet above sea level, near Gila Bend.

Watershed Size

The Middle Gila Watershed covers approximately 12,056 square miles, representing about 9% of the state of Arizona. The watershed has a maximum width of about 100 miles east-west, and a maximum length of about 150 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 Middle Gils is a 6-digit HUC, and the subwatershed areas for this watershed-based plan were delineated on the basis of the 8-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: Middle Gila Watershed HUCs and Subwatershed Areas.

Subwatershed Name and HUC Designation	Area (square miles)
Agua Fria River H15070102	2,785
Centennial Wash H15070104	1,946
Hassayampa River H15070103	1,454
Lower Gila River above Painted Rock Dam H15070101	2,012
Lower Salt River H15060106B	505
Middle Gila River H15050100	3,354
Middle Gila River Watershed	*12,056*

The Phoenix AMA is located in central Arizona and is one of the five Active Management Areas mandated by the Groundwater Code. The Phoenix AMA covers 5,646 square miles and consists of seven groundwater basins. The AMA is characterized by a diverse mix of water uses, with a heavy and increasing emphasis on municipal and industrial uses. Multiple sources of water (CAP, Salt and Verde surface water, effluent and groundwater) are available and are being used to meet demand.

Approximately 2.3 million acre feet of water is used annually in the Phoenix AMA, comprised of 1.4 million acre feet of renewable water (CAP, Salt and Verde surface water, and effluent) and 900,000 acre feet of groundwater.

The Phoenix AMA is drained by the Gila River and four principal tributaries: the Salt, the Verde, the Agua Fria, and the Hassayampa Rivers. Other tributaries include Queen Creek, New River, Skunk Creek, Cave Creek,

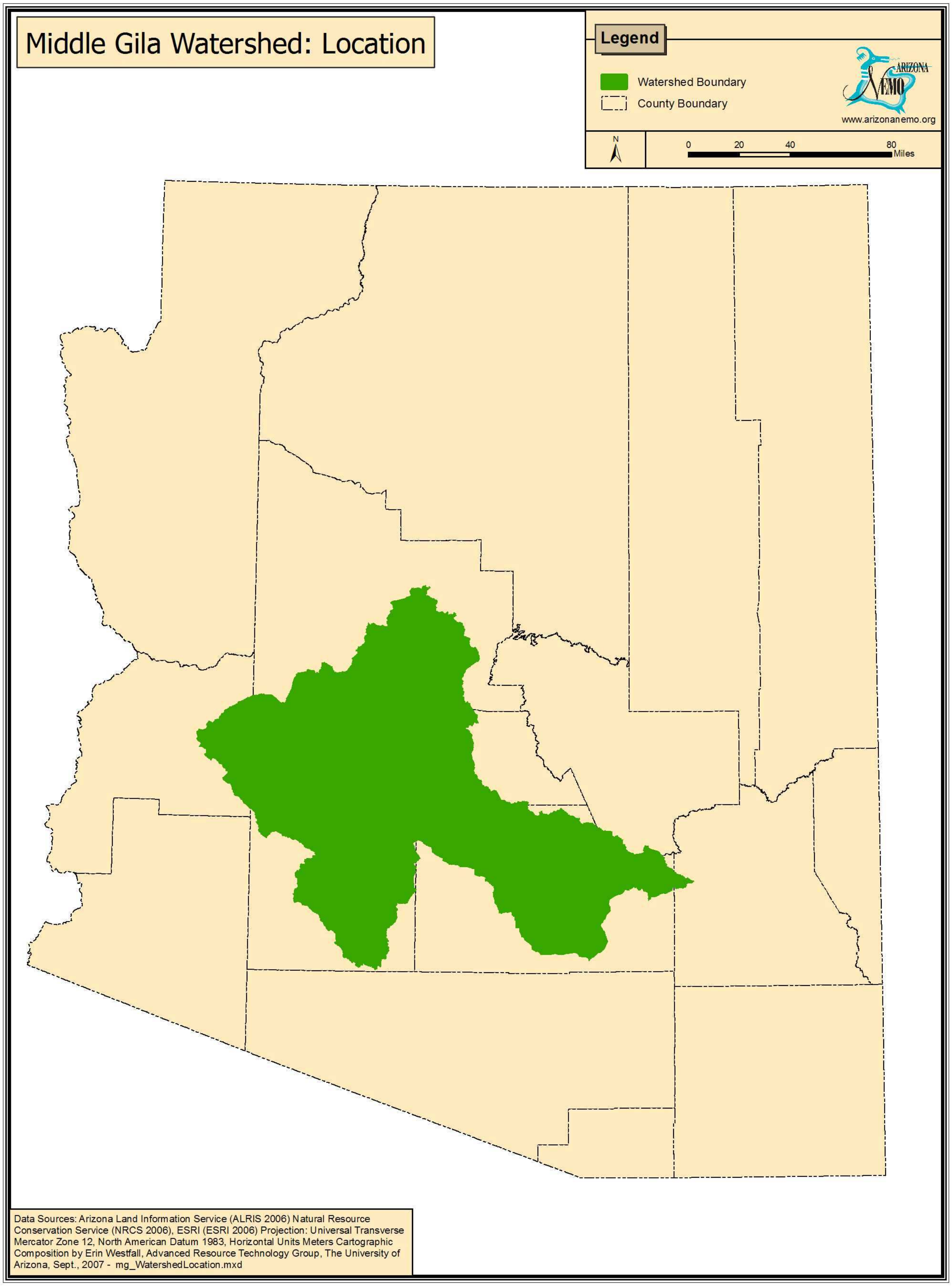

Figure 2-1: Watershed Location

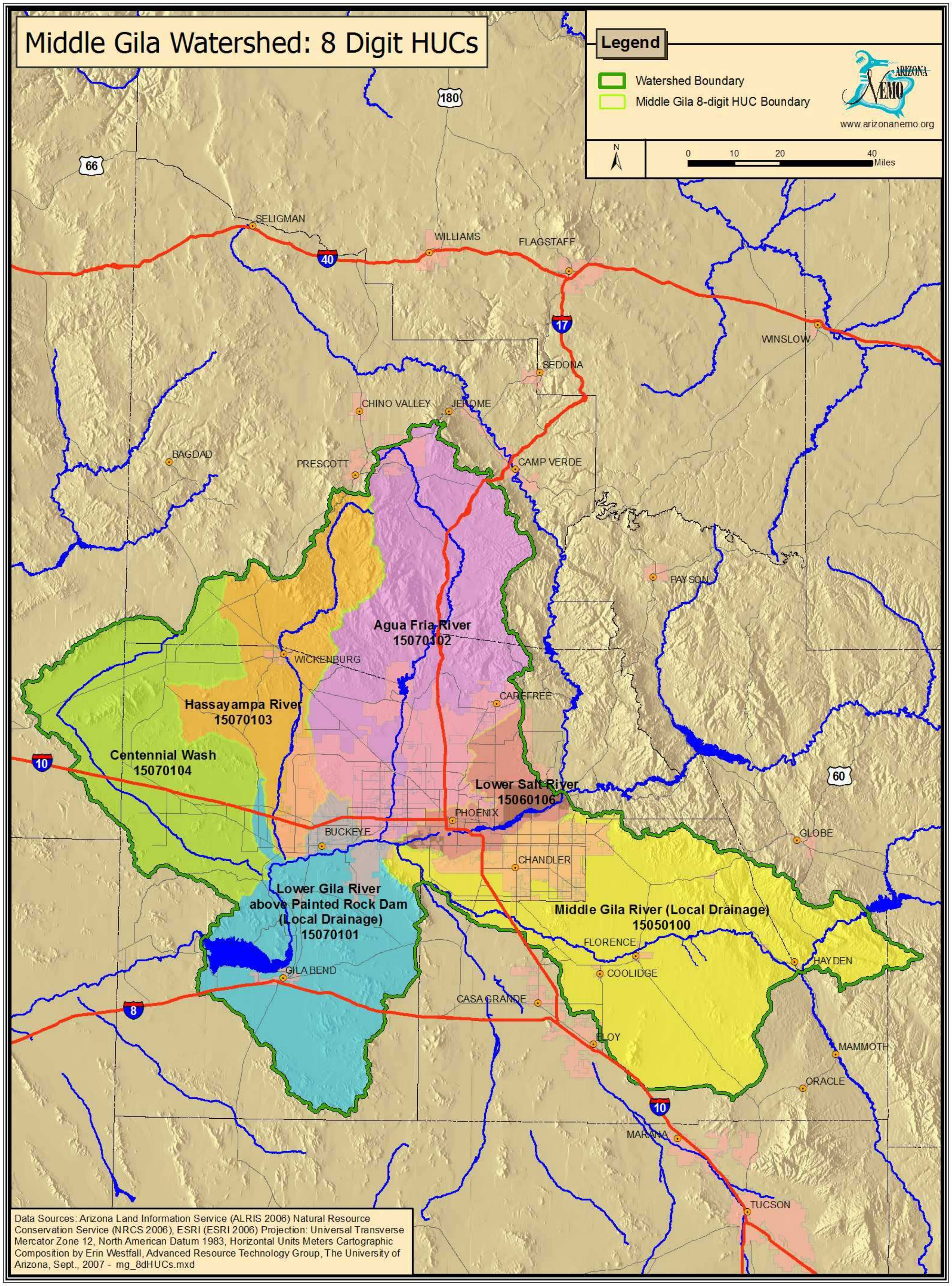

Figure 2-2: 8 Digit HUCs

Waterman Wash, and Centennial Wash. Regulatory water storage reservoirs have been constructed on the Salt, Verde, and Gila Rivers and on the Agua Fria River, allowing for a relatively high proportion of surface water use in some areas of the Phoenix AMA. The climate of the Phoenix AMA is semi arid receiving an average of seven inches of annual precipitation.

The Phoenix AMA goal is to achieve safe-yield by the year 2025 through the increased use of renewable water supplies and decreased groundwater withdrawals in conjunction with efficient water use. (ADWR, 2007).

Topography

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

The land surface elevation of the Middle Gila Watershed ranges between 541 and 7,979 feet above sea level. The tallest feature in the watershed is Mt. Union at 7,979 feet. The lowest point in the watershed is the near where the Gila River exits the watershed about 20 miles west/northwest of the town of Gila Bend.

Mean elevation for the whole Middle Gila Watershed is 4,151 feet (Table 2-2). Lower Gila River above Painted Rock Dam (H15070101) is lower than the rest of the watershed with a mean elevation of 2,436 feet, about 1,800 feet lower than the mean for the entire watershed (Figure 2-3).

Approximately 26% of the Middle Gila Watershed has a slope greater than 15%, while 60% of the watershed has a slope less than 5%. The Centennial Wash subwatershed is flatter than the watershed mean with only 14% of its area over 15% slope, and 76% less than 5% slope. The Agua Fria River is the steepest, with 40% of the area greater than 15% slope, (Table 2-3 and Figure 2-4).

Table 2-2: Middle Gila River Watershed Elevation Range.

Subwatershed Name	Min(feet)	Max(feet)	Mean (feet)
Agua Fria River H15070102	970	7,797	4,334
Centennial Wash H15070104	778	5,643	3,156
Hassayampa River H15070103	801	7,799	4,275
Lower Gila River above Painted Rock Dam H15070101	541	4,331	2,436
Lower Salt River H15060106B	984	3,998	2,385
Middle Gila River H15050100	970	7,721	2,308
Middle Gila River Watershed	*541*	*7,797*	*4,151*

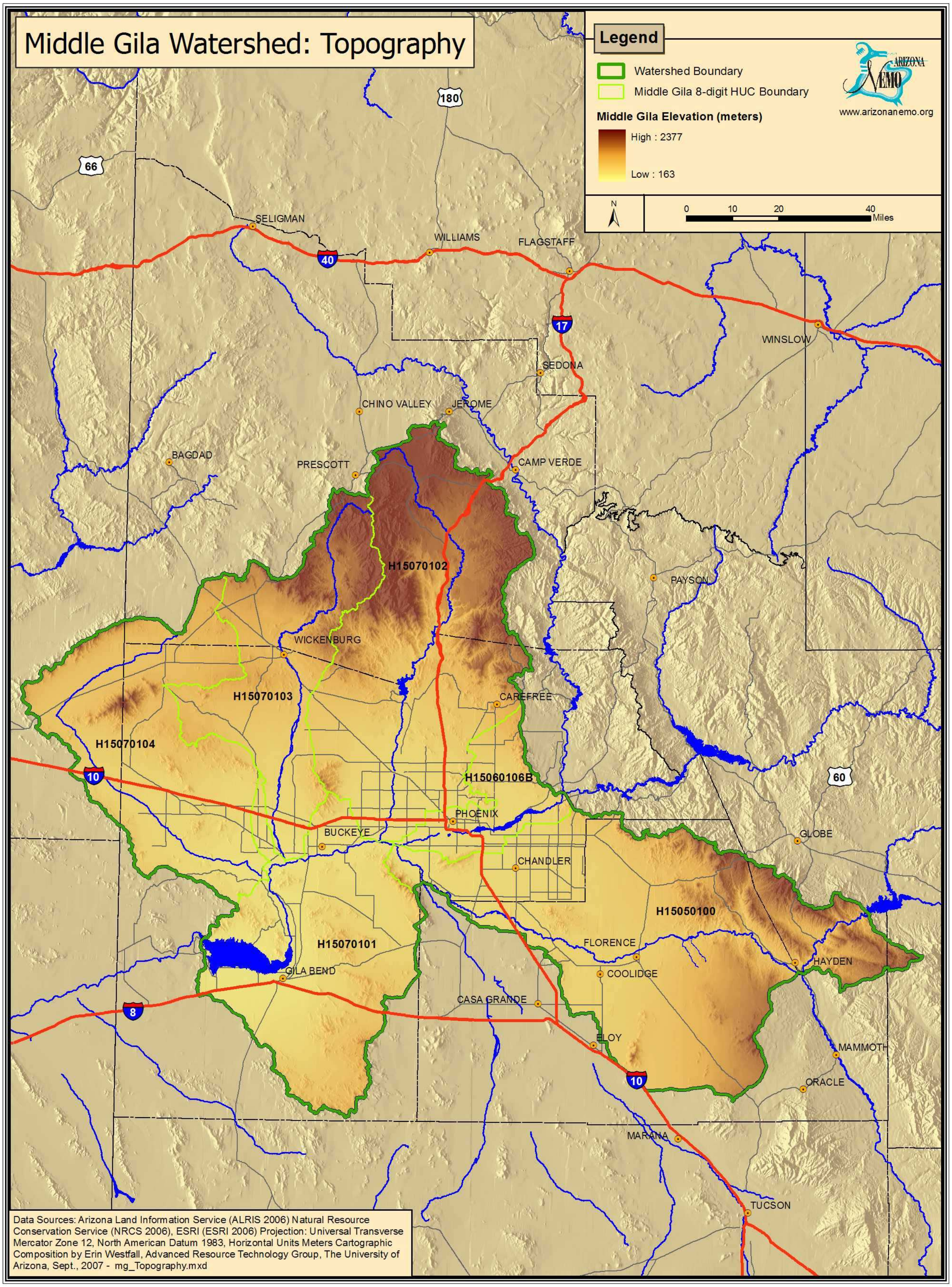

Figure 2-3: Topography

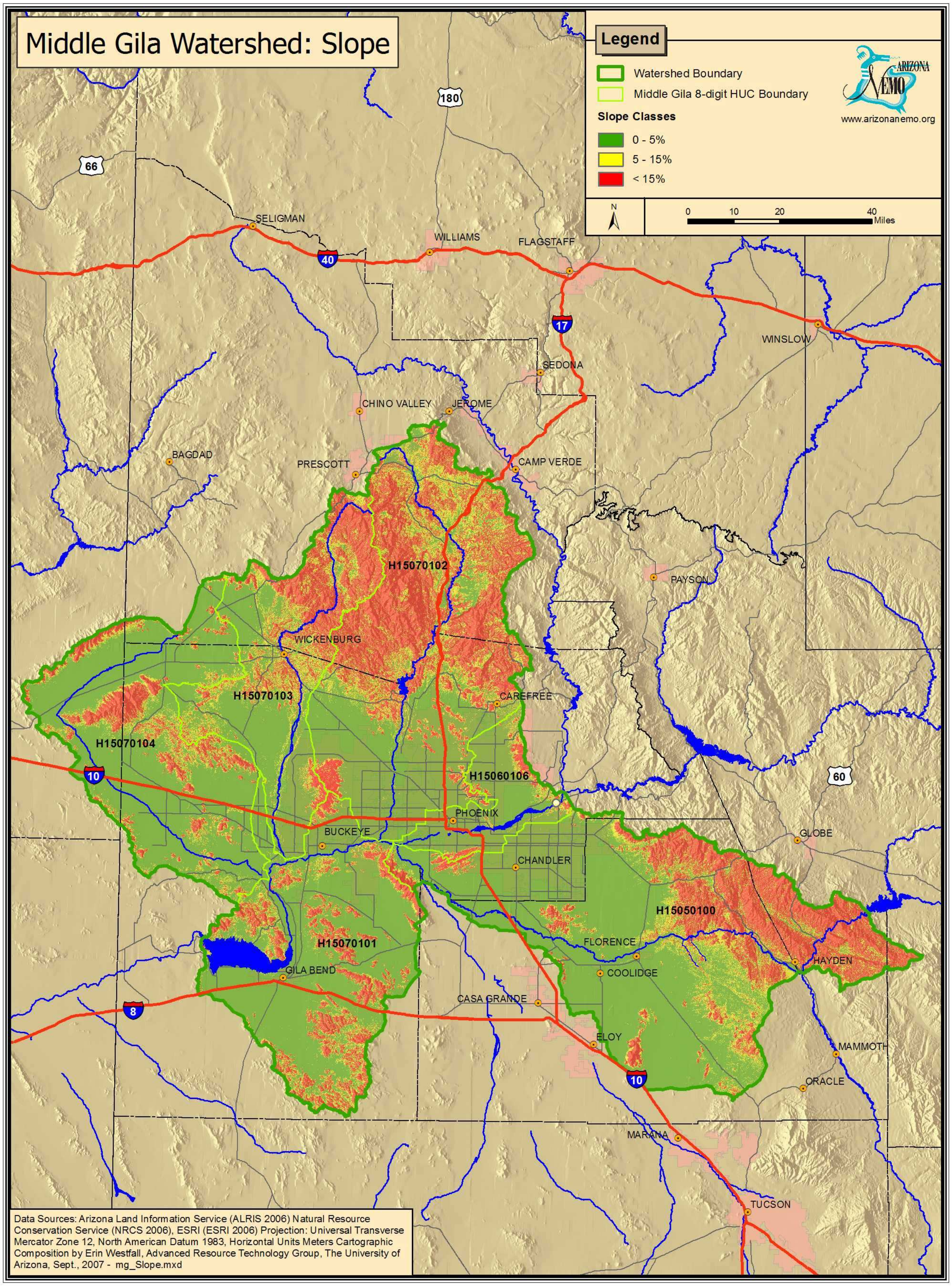

Figure 2-4: Slope Classes

Table 2-3: Middle Gila River Watershed Slope Classes.

Subwatershed Name	Area (sq. mi.)	Percent Slope		
		0-5%	5-15%	>15%
Agua Fria River H15070102	2,785	40%	20%	40%
Centennial Wash H15070104	1,946	76%	10%	14%
Hassayampa River H15070103	1,454	48%	20%	32%
Lower Gila River above Painted Rock Dam H15070101	2,012	72%	10%	18%
Lower Salt River H15060106B	505	92%	5%	2%
Middle Gila River H15050100	3,354	61%	12%	27%
Middle Gila River Watershed	*12,056*	*60%*	*14%*	*26%*

Water Resources

Lakes and Reservoirs

There are 10 mapped lakes and other water features in the Middle Gila Watershed. Painted Rock Reservoir is by far the largest potential surface water body with an area of 53,641 acres. However, Painted Rock Reservoir is dry. The next largest water bodies are Lake Pleasant with an area of 2,042 acres and Tempe Town Lake at 221 acres. Table 2-4 lists the major surface water bodies and their associated areas. Figure 2-5 shows the major lakes and streams.

Stream Types

The Middle Gila Watershed contains a total of 1,786 miles of major streams and canals (streams having a cartographic order of 3 or less). Table 2-5 lists the major streams and their lengths. The Gila River is the longest river in the watershed at 263 miles.

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, as when it receives water from a seasonal spring or from another source, such as melting spring snow.
- Ephemeral streams are at all times above the elevation of the ground water table, has no base flow, and flows 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).

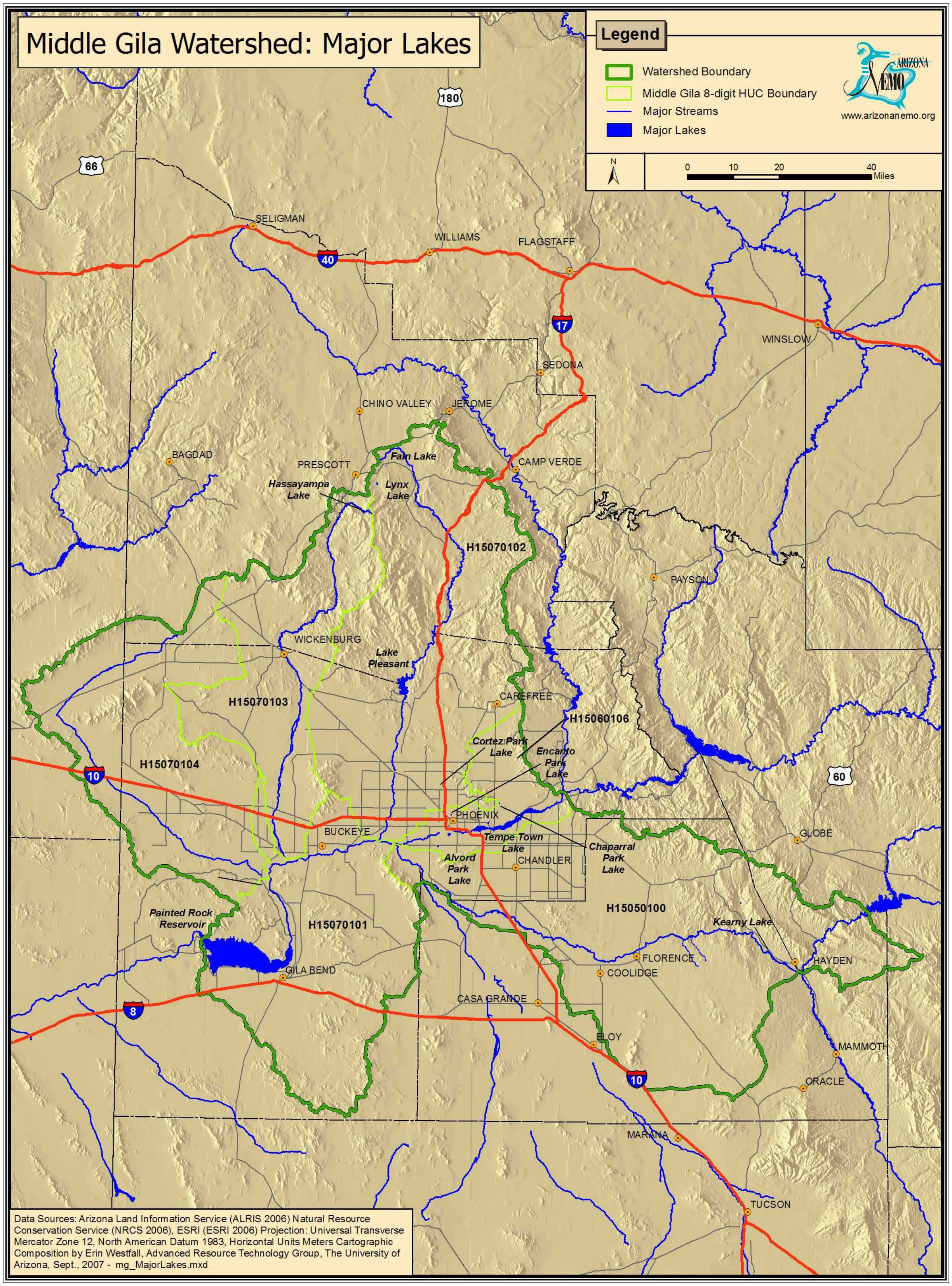

Figure 2-5: Major Lakes

Approximately 82% of the streams in the Middle Gila Watershed are intermittent or ephemeral (Figure 2-6). Only18% of streams are perennial. Table 2-6 shows the percent perennial and intermittent/ephemeral streams in the Middle Gila Watershed.

Table 2-4: Middle Gila River Watershed Major Lakes and Reservoirs.

Lake Name (if known)	**Subwatershed**	**Surface Area (acre)**	**Elevation (feet above mean sea level)**	**Dam Name (if known)**
Alvord Park Lake	Lower Salt River	57	1,066	
Chaparral Park Lake	Lower Salt River	13	1,257	
Encanto Park Lake	Lower Salt River	8	1,092	
Lake Pleasant	Agua Fria River	2,042	1,568	Carl Pleasant Dam
Little Box Lake	Middle Gila River	18	2,191	Little Box Canyon Dam
Lower Lake	Agua Fria River	78	1,434	Camp Dyer Division Dam
Lynx Lake	Agua Fria River	49	5,531	Lynx Lake Dam
Painted Rock Reservoir	Lower Gila River above Rock Dam	53,641	607	Painted Rock Dam
Papago Park Ponds	Lower Salt River	21	1,234	
Tempe Town Lake	Lower Salt River	221	1,148	

Table 2-5: Middle Gila River Watershed Major Streams, Canals and Lengths.

Stream Name	**Subwatershed**	**Stream Length (miles)**
Unnamed Stream	Hassayampa River	8
Agua Fria River	Agua Fria River	168
Antelope Creek	Hassayampa River	16
Arizona Canal	Agua Fria River, Lower Salt River	30
Arlington Canal	Centennial Wash, Lower Gila River above Painted Rock Dam	7
Ash Creek	Agua Fria River	34
Beardsley Canal	Agua Fria River, Lower Gila River above Painted Rock Dam	33
Big Bug Creek	Agua Fria River	29
Big O Wash	Middle Gila River	26
Black Canyon Creek	Agua Fria River	19
Blind Indian Creek	Agua Fria River, Hassayampa	15
Boulder Creek	Agua Fria River	17
Box Wash	Hassayampa River	18
Castle Creek	Agua Fria River	22
Cave Creek	Agua Fria River	46
Centennial Wash	Centennial Wash	102
Connelly Wash	Middle Gila River	18

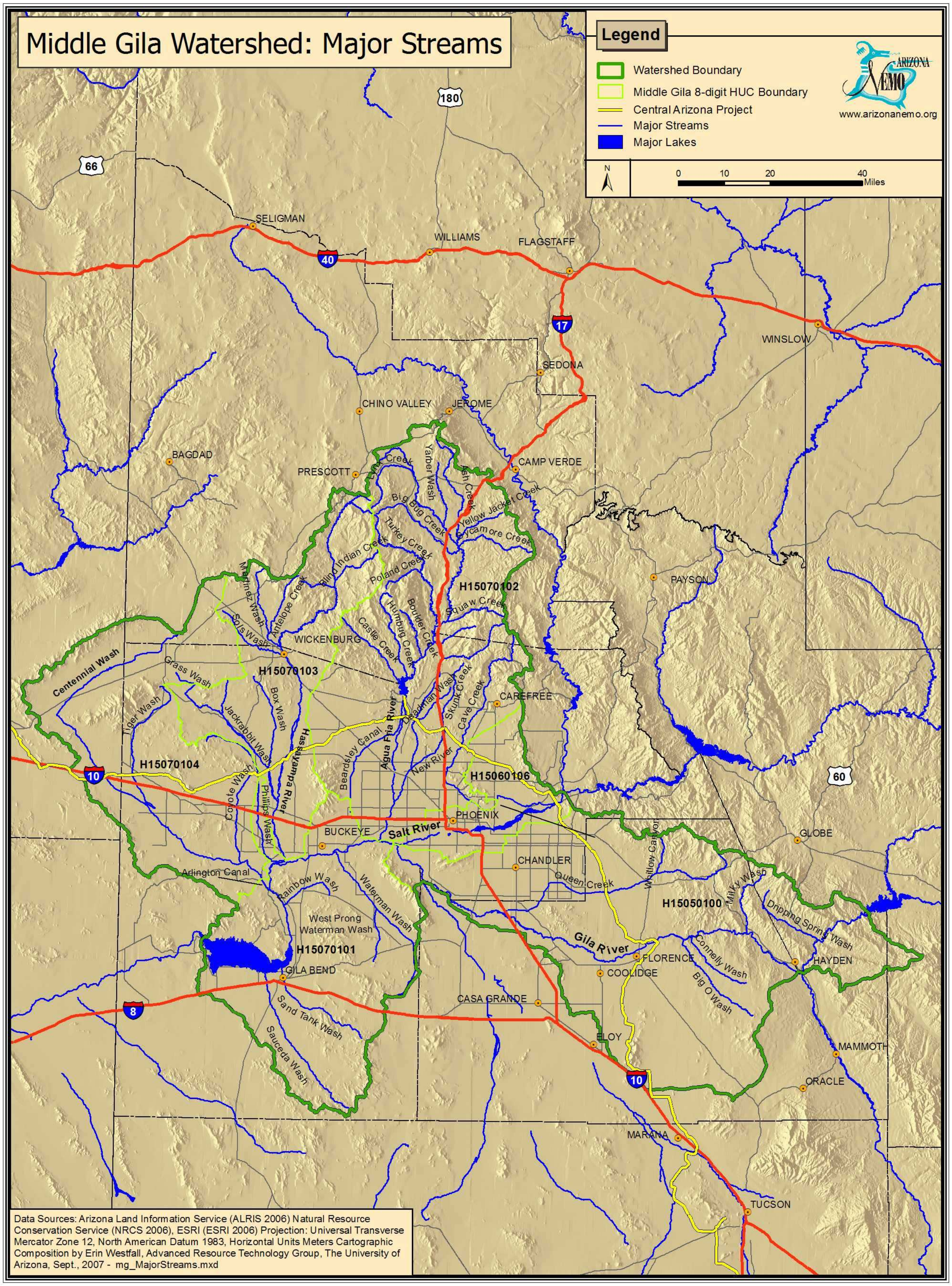

Figure 2-6: Major Streams

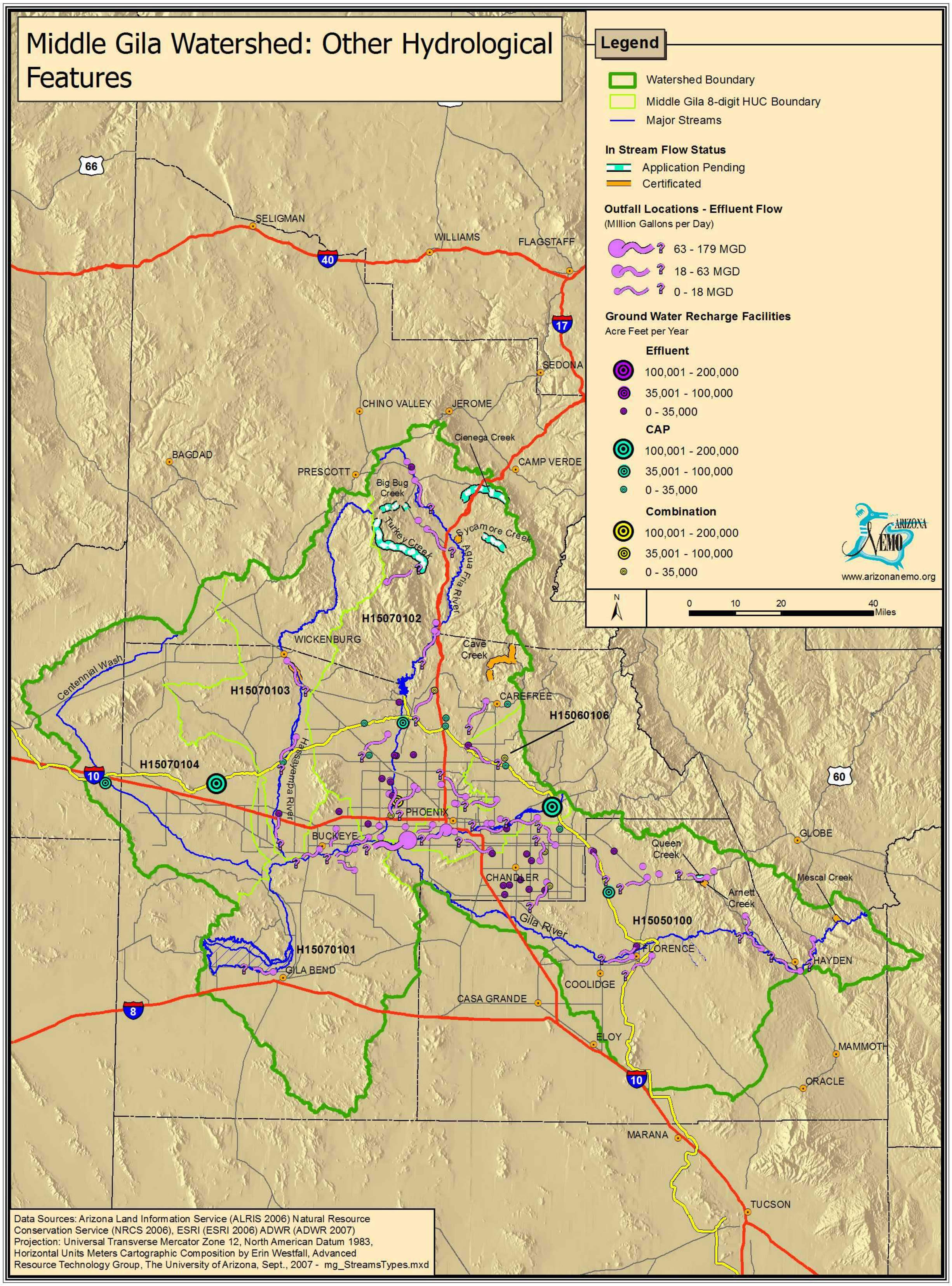

Figure 2-6.2: Other Hydrological Features

Stream Name	Subwatershed	Stream Length (miles)
Coyote Wash	Centennial Wash	32
Deadman Wash	Agua Fria River	12
Dripping Spring Wash	Middle Gila River	20
Gila River	Middle Gila River, Lower Gila River above Painted Rock Dam	263
Grass Wash	Centennial Wash	5
Groom Creek	Hassayampa River	6
Hassayampa River	Hassayampa River, Lower Gila River above Painted Rock Dam	140
Humbug Creek	Agua Fria River	28
Jackrabbit Wash	Hassayampa River	52
Little Ash Creek	Agua Fria River	5
Little Squaw Creek	Agua Fria River	12
Luke Wash	Lower Gila River above Painted Rock Dam	7
Lynx Creek	Agua Fria River	7
Martinez Wash	Hassayampa River	23
Milky Wash	Middle Gila River	20
New River	Agua Fria River	58
Phillips Wash	Lower Gila River above Painted Rock Dam	12
Poland Creek	Agua Fria River	12
Queen Creek	Middle Gila River	62
Rainbow Wash	Lower Gila River above Painted Rock Dam	14
Salt River	Lower Salt River	45
Sand Tank Wash	Lower Gila River above Painted Rock Dam	31
Sauceda Wash	Lower Gila River above Painted Rock Dam	41
Skunk Creek	Agua Fria River	30
Sols Wash	Hassayampa River	20
Squaw Creek	Agua Fria River	18
Star Wash	Hassayampa River	5
Sycamore Creek	Agua Fria River	21
Tiger Wash	Centennial Wash	38
Turkey Creek	Agua Fria River	30
Waterman Wash	Lower Gila River	44
West Prong Waterman Wash	Lower Gila River	13
Whitlow Canyon	Middle Gila River	9
Winters Wash	Centennial Wash	8
Yarber Wash	Agua Fria River	17
Yellow Jacket Creek	Agua Fria River	8

Table 2-6: Middle Gila River Watershed
Stream Types and Length for Major Streams.

Stream Type	Stream Length (miles)	Percent of Total Stream Length
Perennial	322	18%
Intermittent/Ephermal	1,464	82%
Total Length	1,786	100%

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 2-7 shows stream network for the Middle Gila Watershed, and Table 2-7 gives the stream density for each subwatershed in feet of stream length per acre. The average stream density for the Middle Gila Watershed is 11 feet/acre. The Middle Gila River subwatershed has the highest drainage density at 14 feet/acre. The Centennial Wash subwatershed has the lowest drainage density at 9 feet/acre.

Annual Stream Flow

Annual stream flows for twenty three gages were obtained for the Middle Gila Watershed. These gages were selected based on their location, length of date record, and representativeness of watershed response. Figure 2-8 shows the locations of these gages. The gage at the Gila River below Gillespie Damhad the highest measured annual mean stream flow with 1,375 cubic feet per second (cfs), for the period from 1993 through 2006.

Figures 2-10 through 2-22 show hydrographs for five 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 Gila River at Kelvin gage there were a series of years where there was little or no flow, and the five year moving average (Figure 2-11) shows a downward trend in stream flow. This gage is located west of Phoenix, near the confluence with the Gila River.

Figure 2-12 shows that the mean daily stream flow of the Gila River Below Coolidge Dam has less variation than at Kelvin, but also shows a similar decreasing trend for the five year moving average (Figure 2-13).

Figure 2-16 shows a large amount of variability for the Gila Bend Canal at Gillespie Dam, and also shows a downward trend for the five year moving average (Figure 2-15).

Figure 2-18 shows long periods of little or no flow at the Gila River Near Goodyear, and Figure 2-19 shows a

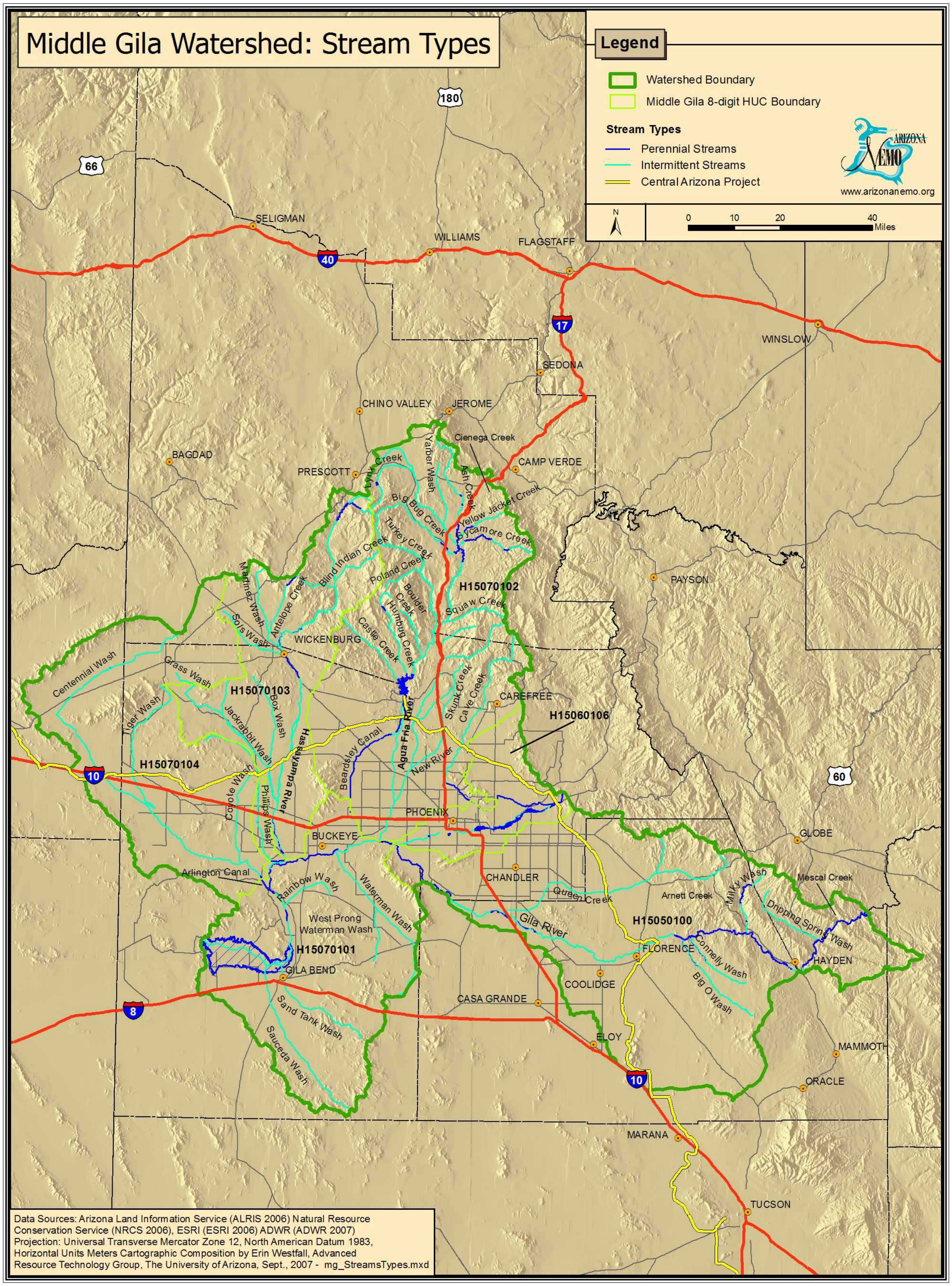

Figure 2-7: Stream Types

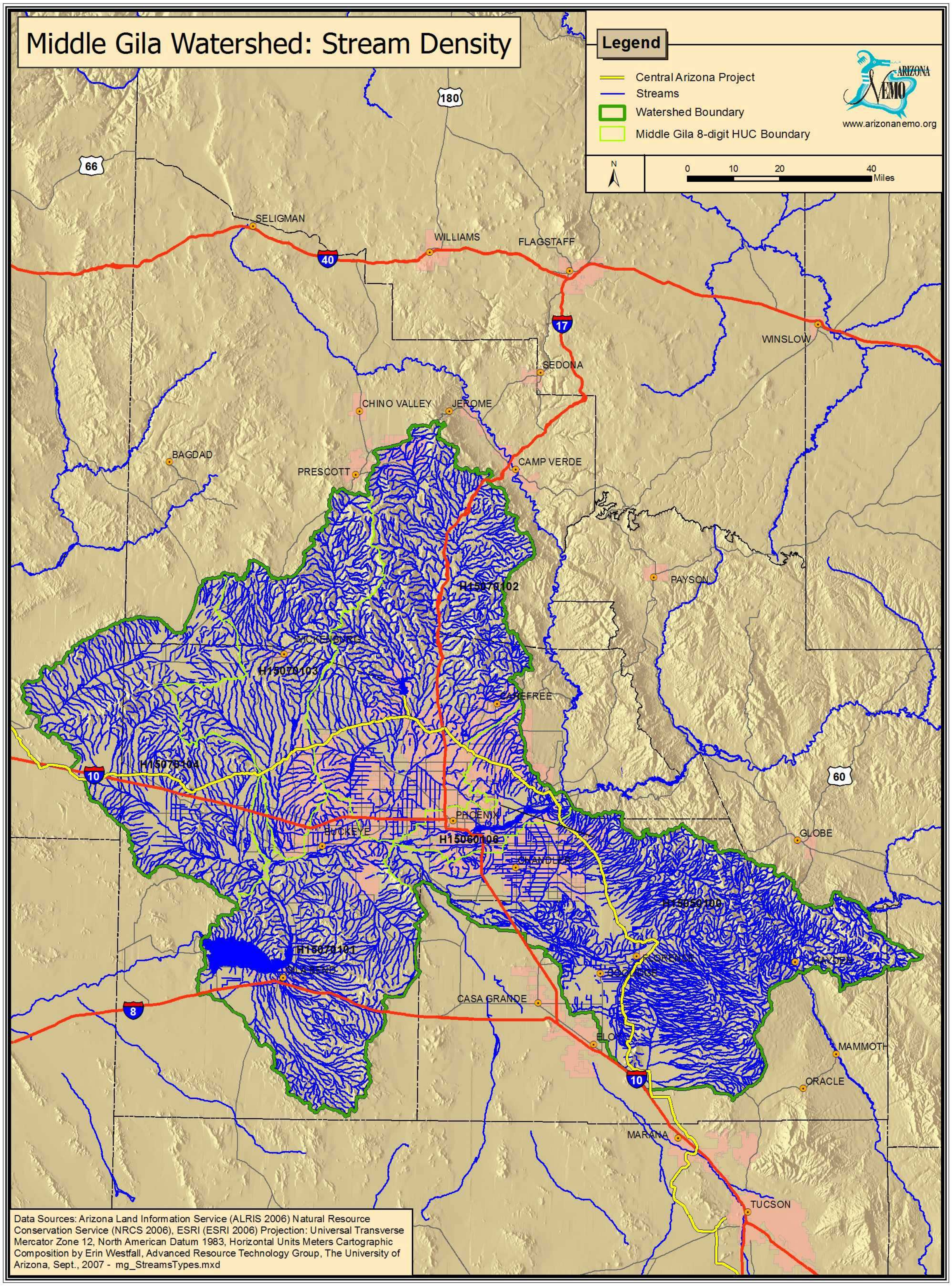

Figure 2-8: Stream Density

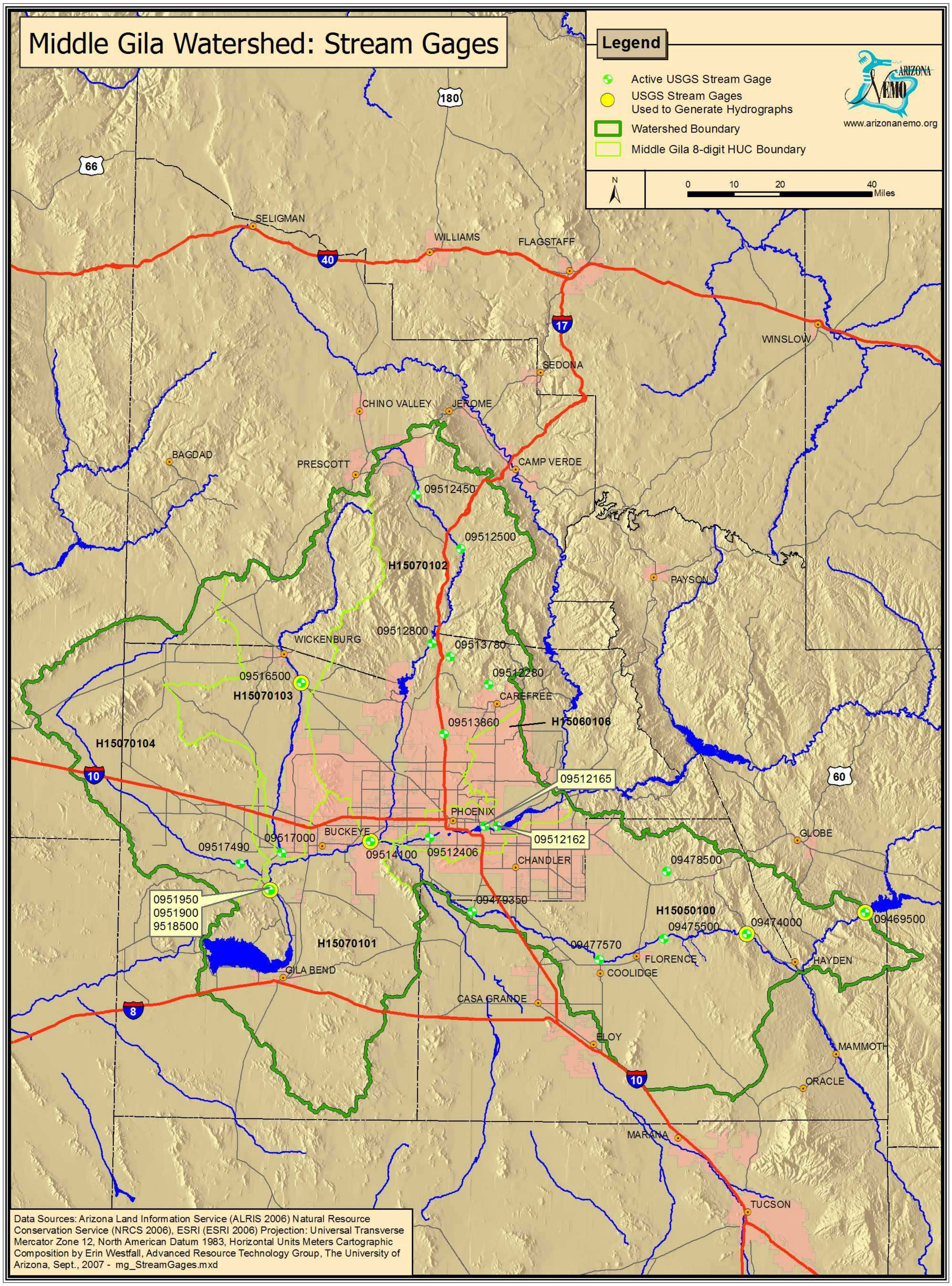

Figure 2-9: USGS Stream Gages

very gradual downward trend for the five year moving average.

Figure 2-20 illustrates the variable flows at the Hassayampa River near Morristown, and Figure 2-21 and Figure 2-22 show a downward trend in the five year moving average.

Table 2-7: Middle Gila River Watershed Stream Density.

Subwatershed Name	Area (acres)	Stream Length (feet)	Stream Density (feet / acre)
Agua Fria River H15070102	1,782,503	17,827,615	10
Centennial Wash H15070104	1,245,518	11,342,721	9
Hassayampa River H15070103	930,408	9,657,885	10
Lower Gila River above Painted Rock Dam H15070101	1,287,952	13,673,460	11
Lower Salt River H15060106B	323,335	3,471,789	11
Middle Gila River H15050100	2,146,407	29,168,209	14
Middle Gila River Watershed	*7,716,124*	*85,141,678*	*11*

Table 2-8: Middle Gila River Watershed USGS Stream Gages and Annual Mean Stream Flow.

USGS Gage ID	Site Name	Begin Date	End Date	Annual Mean Stream Flow (cfs)
09477570	Gila River at Attaway	2003	2006	21
09475500	Florence-Casa Grande Canal, Near Florence	1984	2006	391
09474000	Gila River at Kelvin	1911	2006	510
09469500	Gila River Below Coolidge Dam*	1901	2006	368
09479350	Gila River Near Maricopa	1995	2006	0.45
09518500	Gila Bend Canal at Gillespie Dam	1976	2006	74
09519501	Gila River Below Gillespie Dam (Low-Water-Gage)*	1993	2006	1,375
09519000	Enterprise Canal at Gillespie Dam	1974	2006	12
09478500	Queen Creek Below Whitlow Dam Near Superior	2001	2006	7
09517490	Centennial Wash at Southern Pacific Railroad Bridge*	1978	2006	2
09517000	Hassayampa River Near Arlington	1991	2006	62
09514100	Gila River at Estrella Parkway, Near Goodyear	1993	2006	779
09512406	Salt River at 57st Avenue	2003	2006	295
09512165	Salt River at Priest Drive Near Phoenix	1995	2006	202
09512162	Indian Bend Wash at Curry Road	1993	2006	4
09513860	Skunk Creek Near Phoenix	1968	2006	1
09512280	Cave Creek Below Cottonwood Creek Near Cave Creek	1981	2006	6

USGS Gage ID	Site Name	Begin Date	End Date	Annual Mean Stream Flow (cfs)
09516500	Hassayampa River Near Morristown*	1939	2006	29
09513780	New River Near Rock Springs*	1966	2006	13
09512800	Agua Fria River Near Rock Springs*	1971	2006	83
09512500	Agua Fria River Near Mayer	1941	2006	23
09512450	Agua Fria River Near Humboldt	2001	2006	6

* Discontinuous years of data

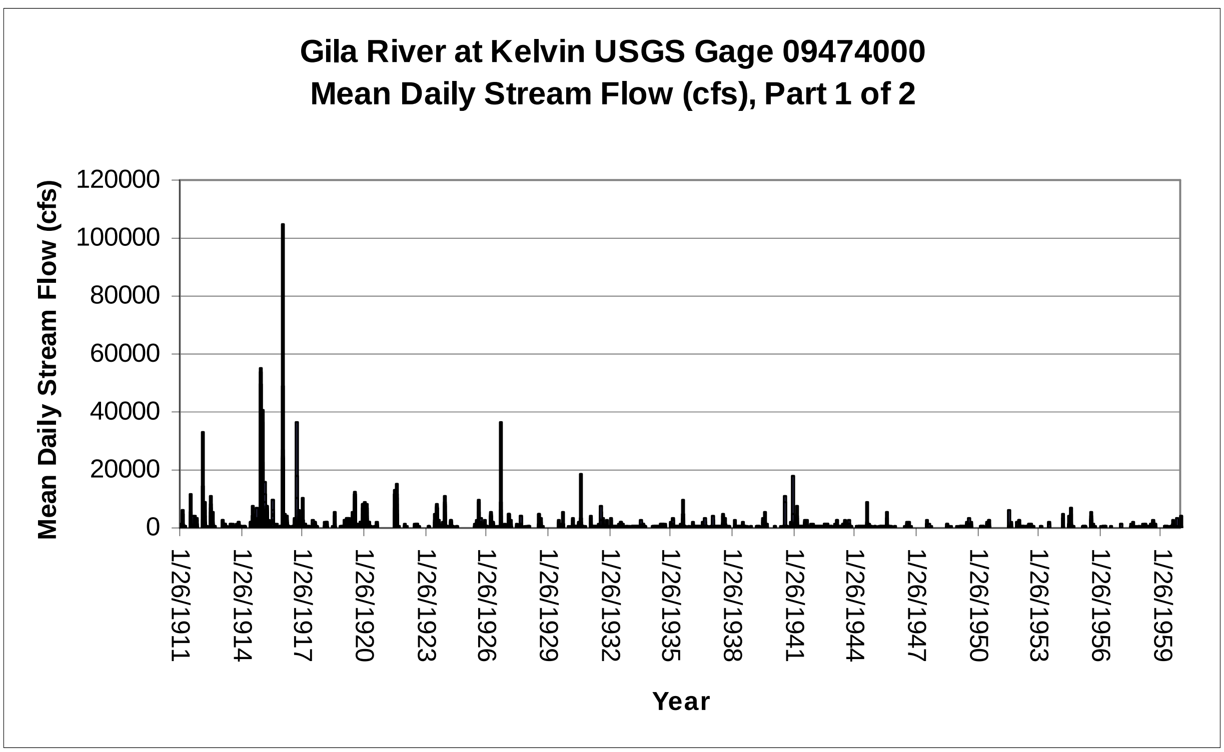

Figure 2-10: Gila River at Kelvin USGS Gage 09474000, Mean Daily Stream Flow (cfs) Hydrograph (Part 1 of 2).

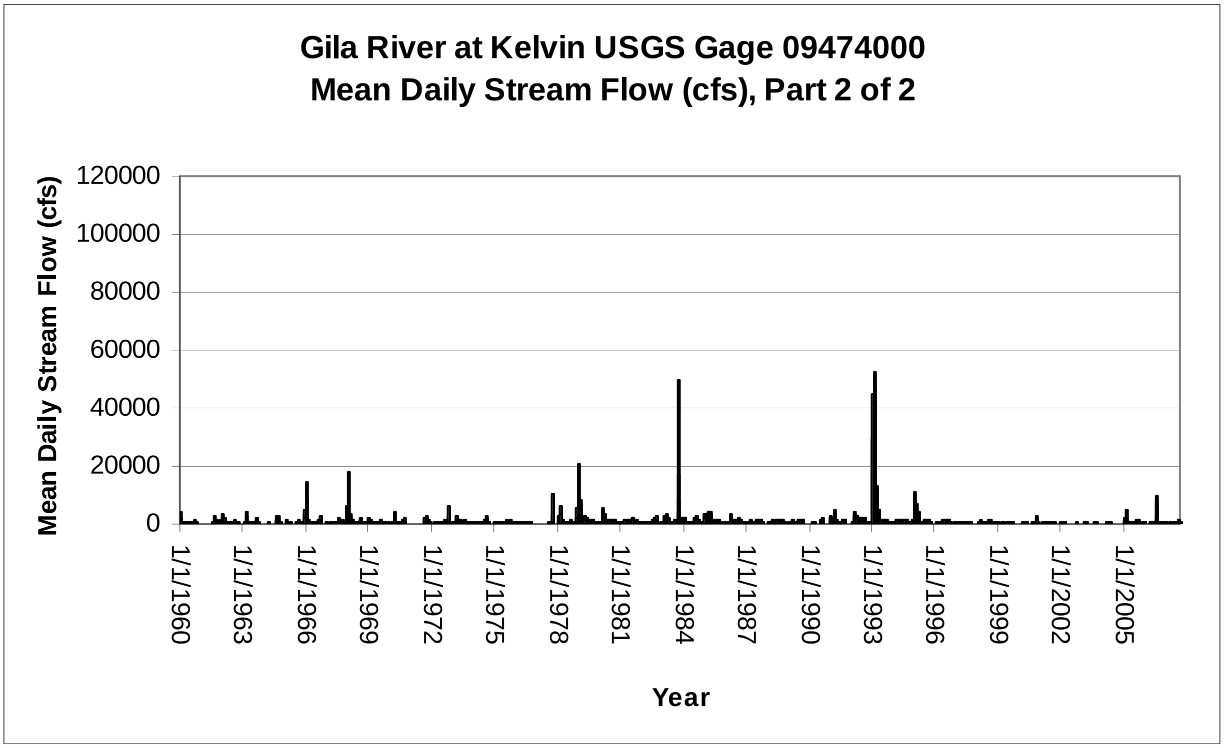

Figure 2-11: Gila River at Kelvin USGS Gage 09474000, Mean Daily Stream Flow (cfs) Hydrograph (Part 2 of 2).

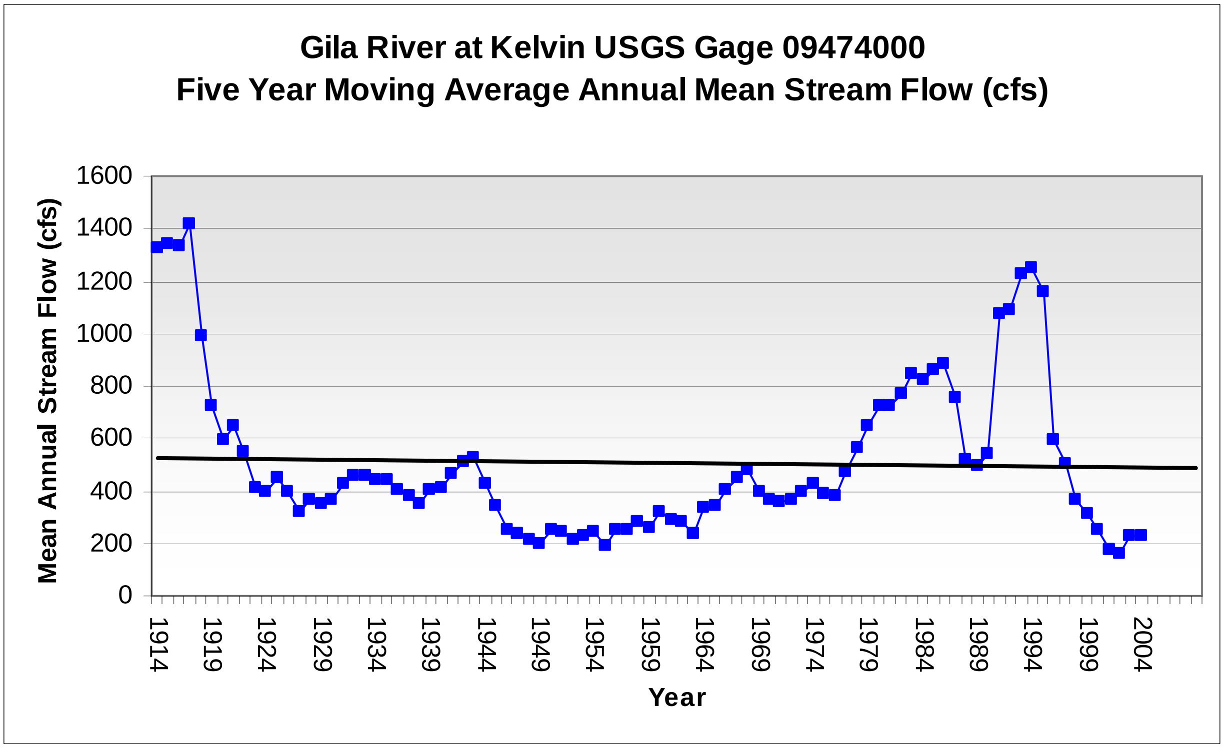

Figure 2-12: Gila River at Kelvin USGS Gage 09474000, Five Year Moving Average Annual Mean Stream Flow (cfs) Hydrograph.

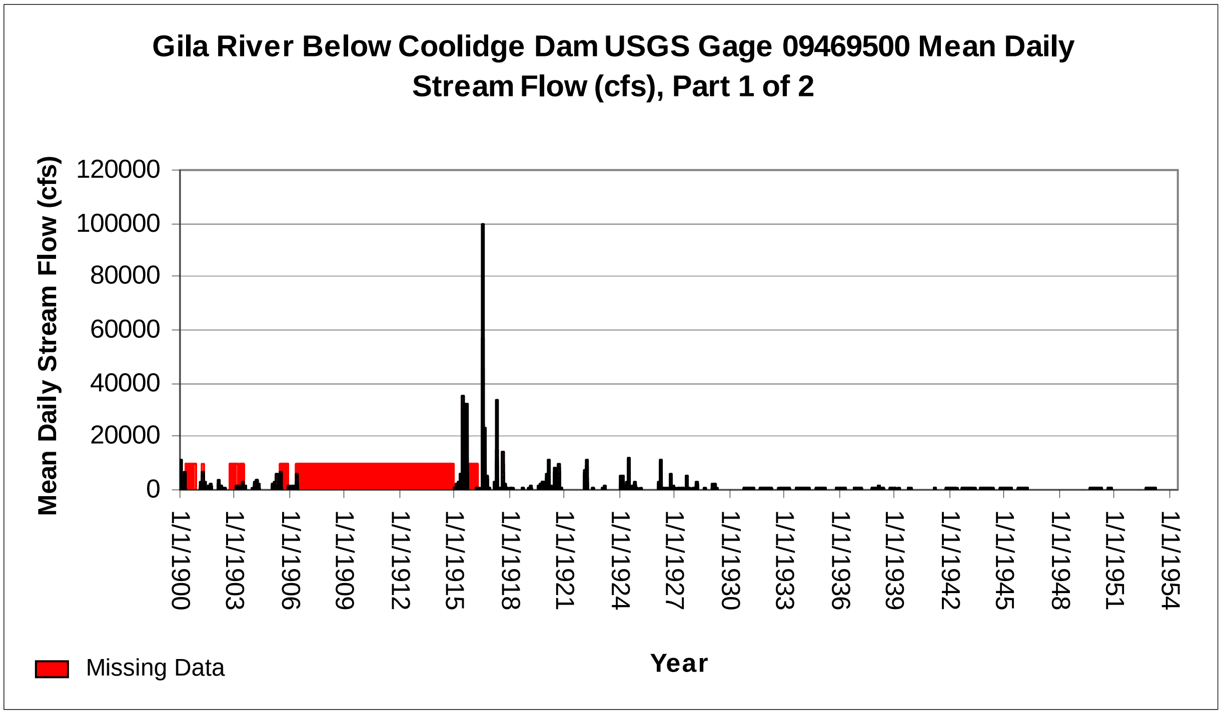

Figure 2-13: Gila River Below Coolidge Dam USGS Gage 09469500, Mean Daily Stream Flow (cfs) Hydrograph (Part 1 of 2).

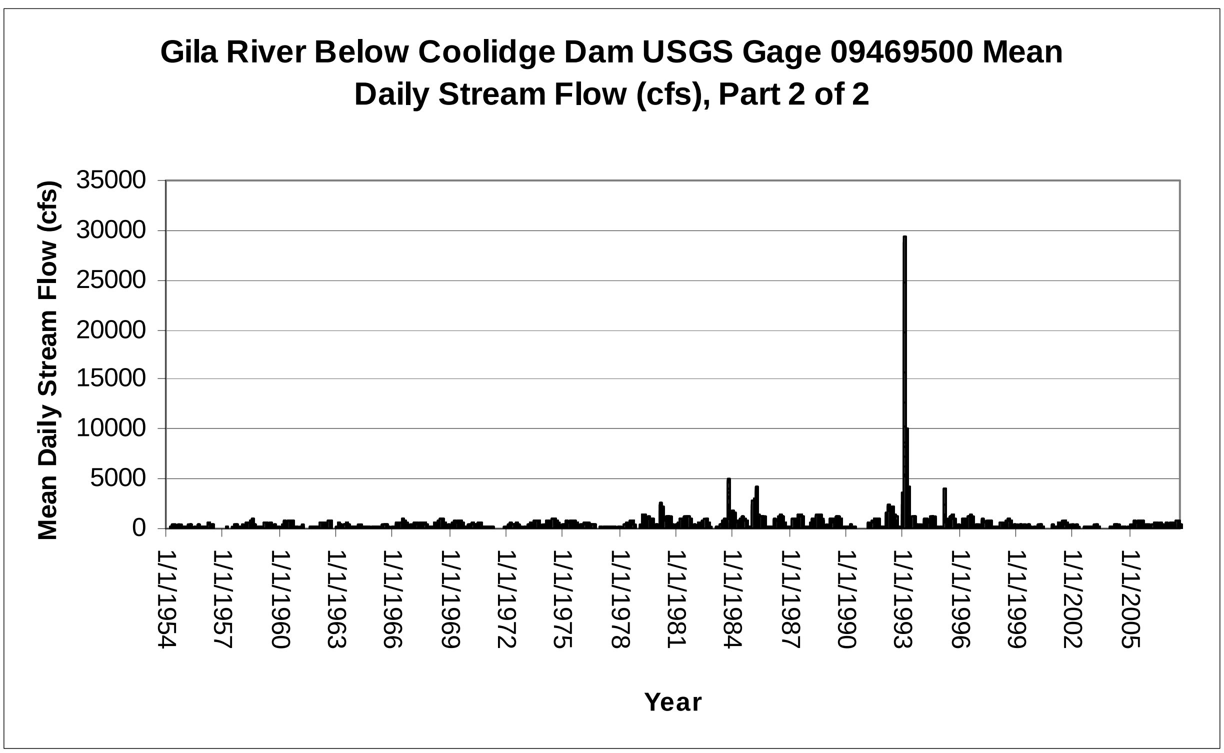

Figure 2-14: Gila River Below Coolidge Dam USGS Gage 09469500, Mean Daily Stream Flow (cfs) Hydrograph (Part 2 of 2).

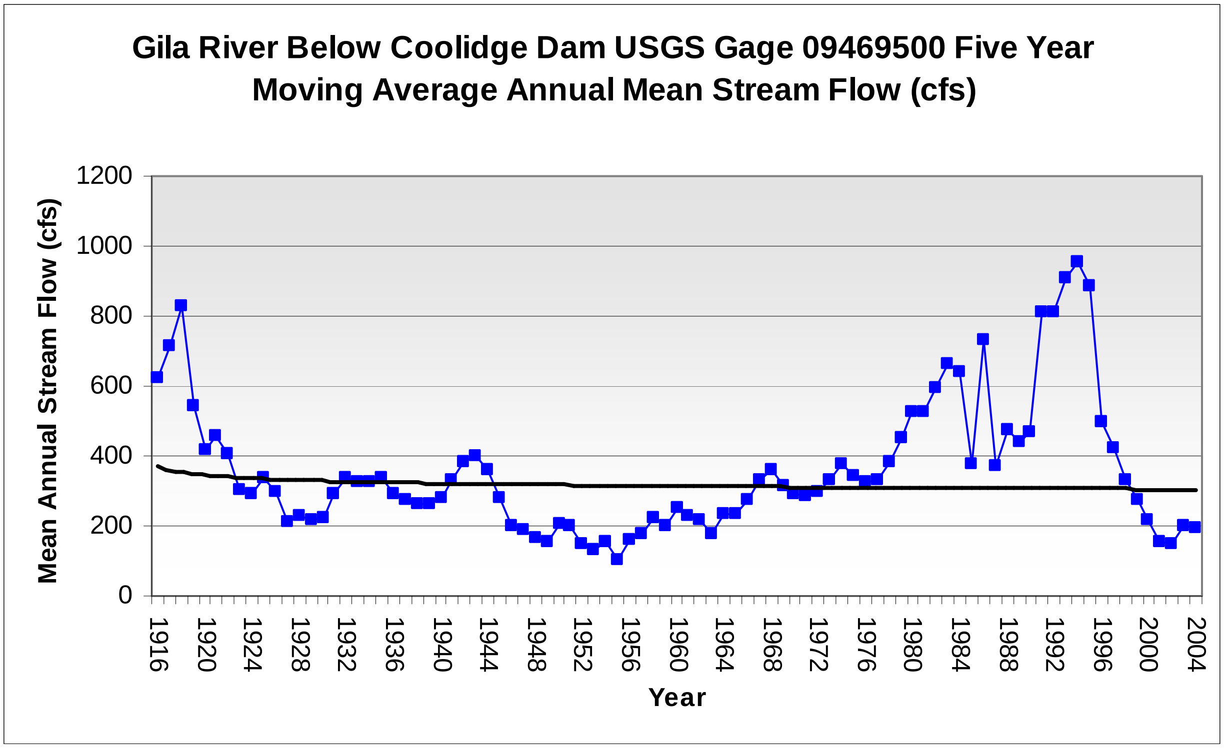

Figure 2-15: Gila River Below Coolidge Dam USGS Gage 04969500, Five Year Moving Average Annual Mean Stream Flow (cfs) Hydrograph.

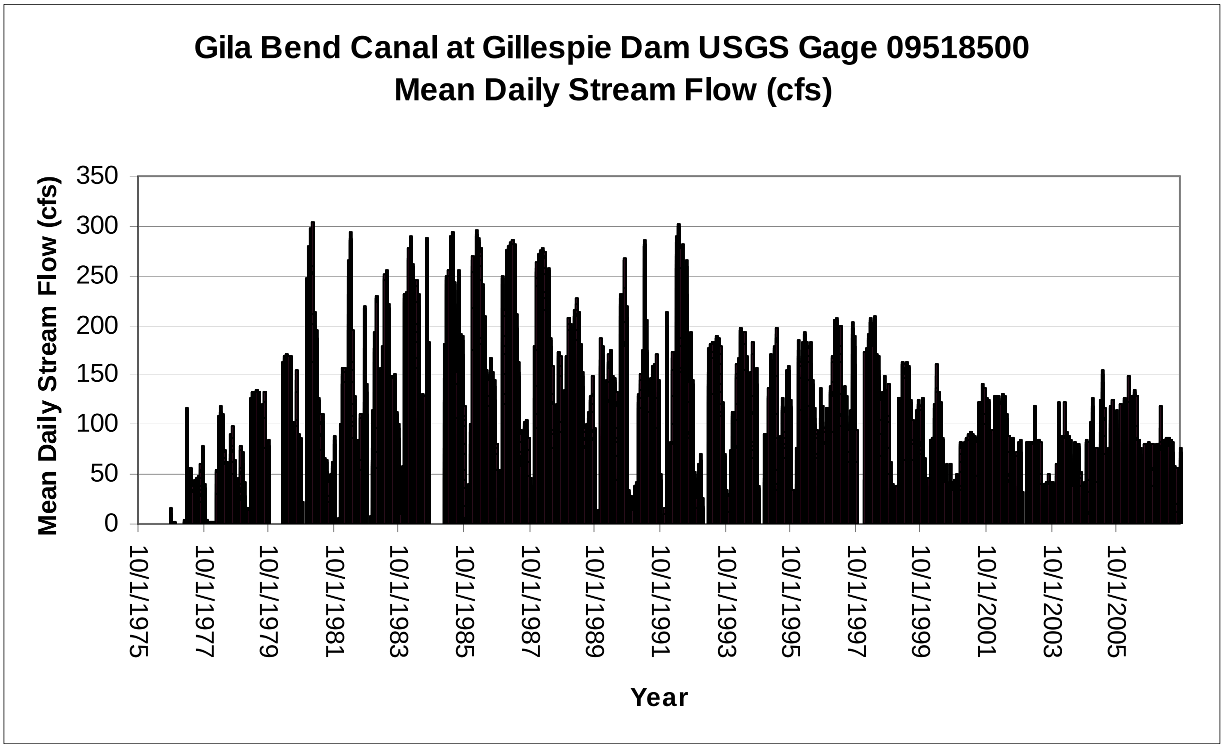

Figure 2-16: Gila Bend Canal at Gillespie Dam USGS Gage 09518500, Mean Daily Stream Flow (cfs) Hydrograph.

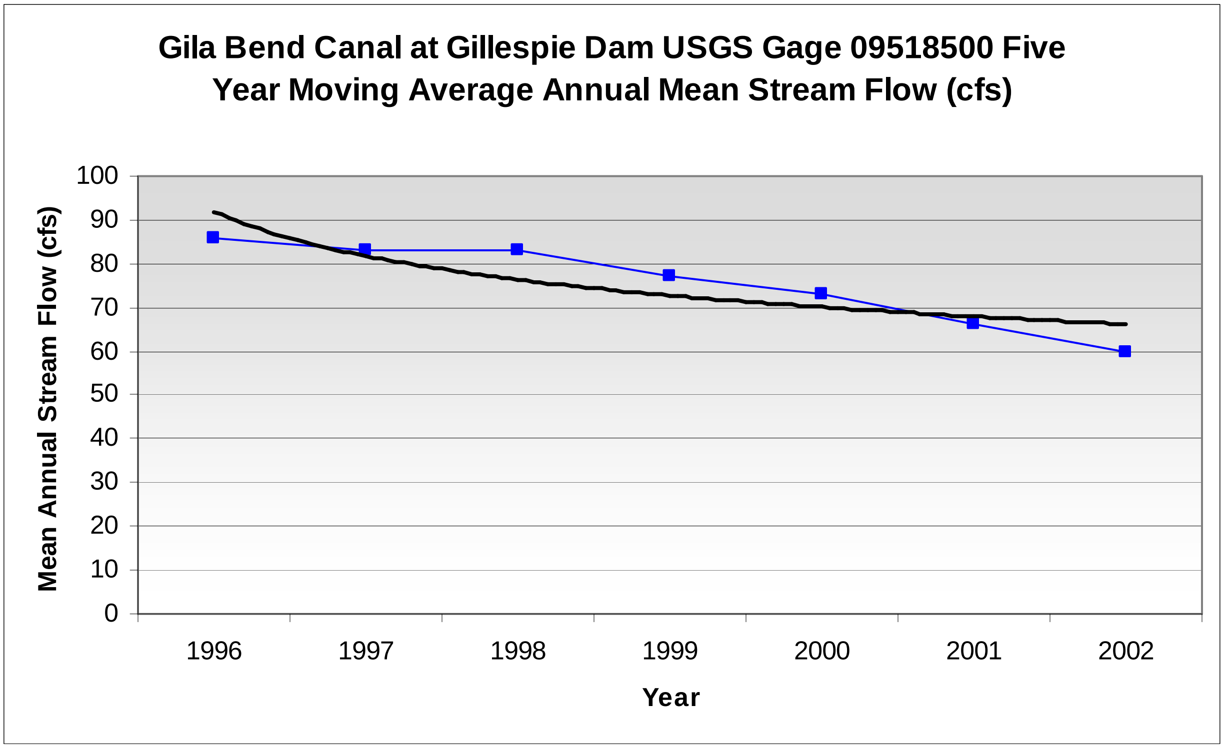

Figure 2-17: Gila Bend Canal at Gillespie Dam USGS Gage 09518500, Five Year Moving Average Annual Mean Stream Flow (cfs) Hydrograph.

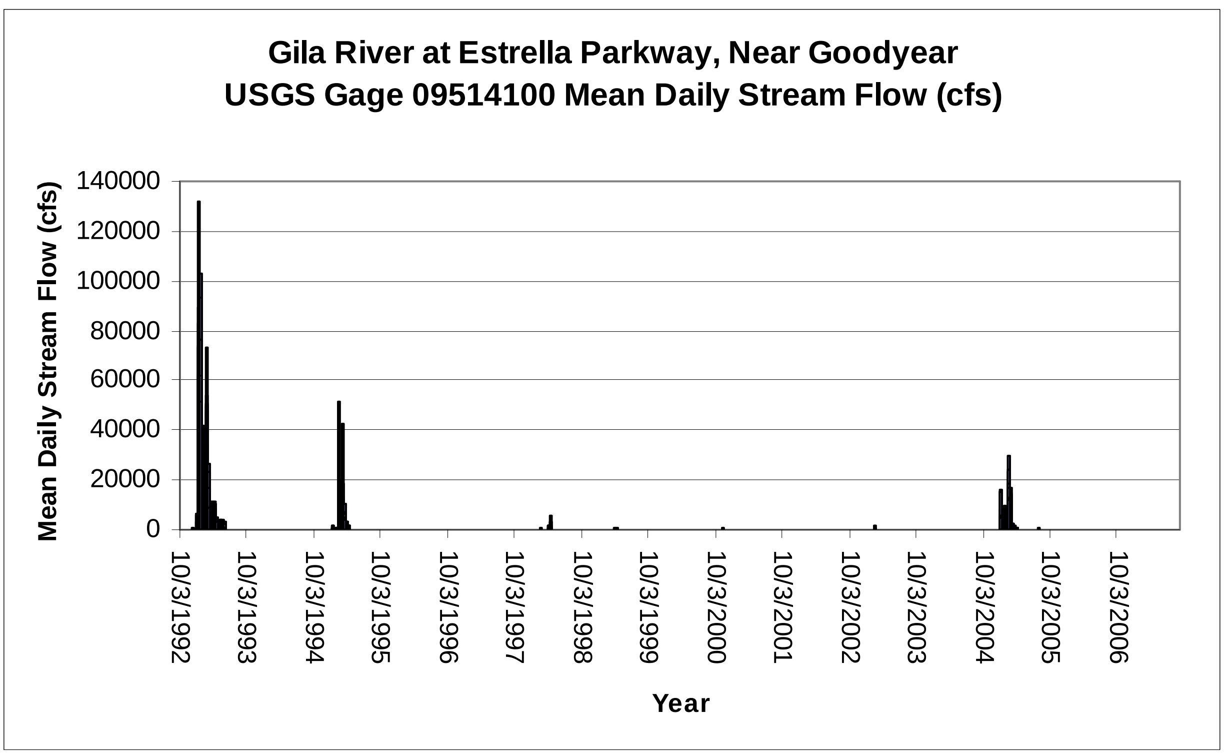

Figure 2-18: Gila River at Estrella Parkway, Near Goodyear USGS Gage 09514100, Mean Daily Stream Flow (cfs) Hydrograph.

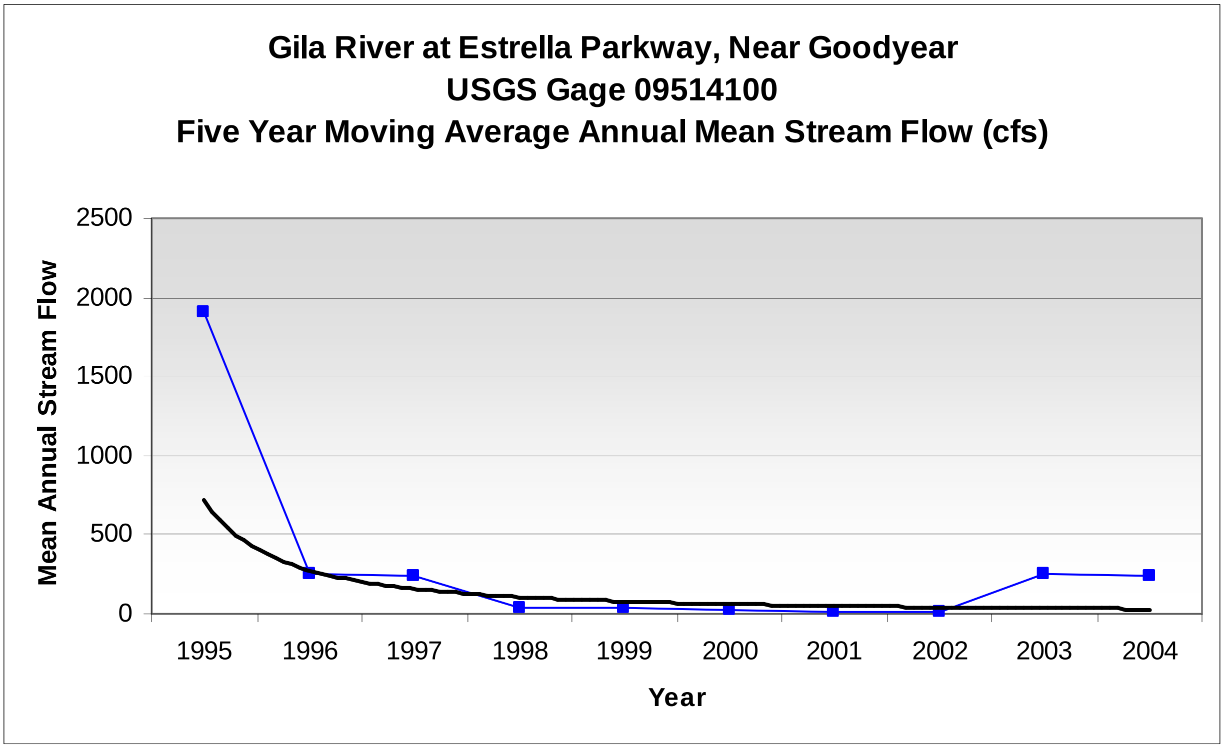

Figure 2-19: Gila River at Estrella Parkway, Near Goodyear USGS Gage 09514100, Five Year Moving Average Annual Mean Stream Flow (cfs) Hydrograph.

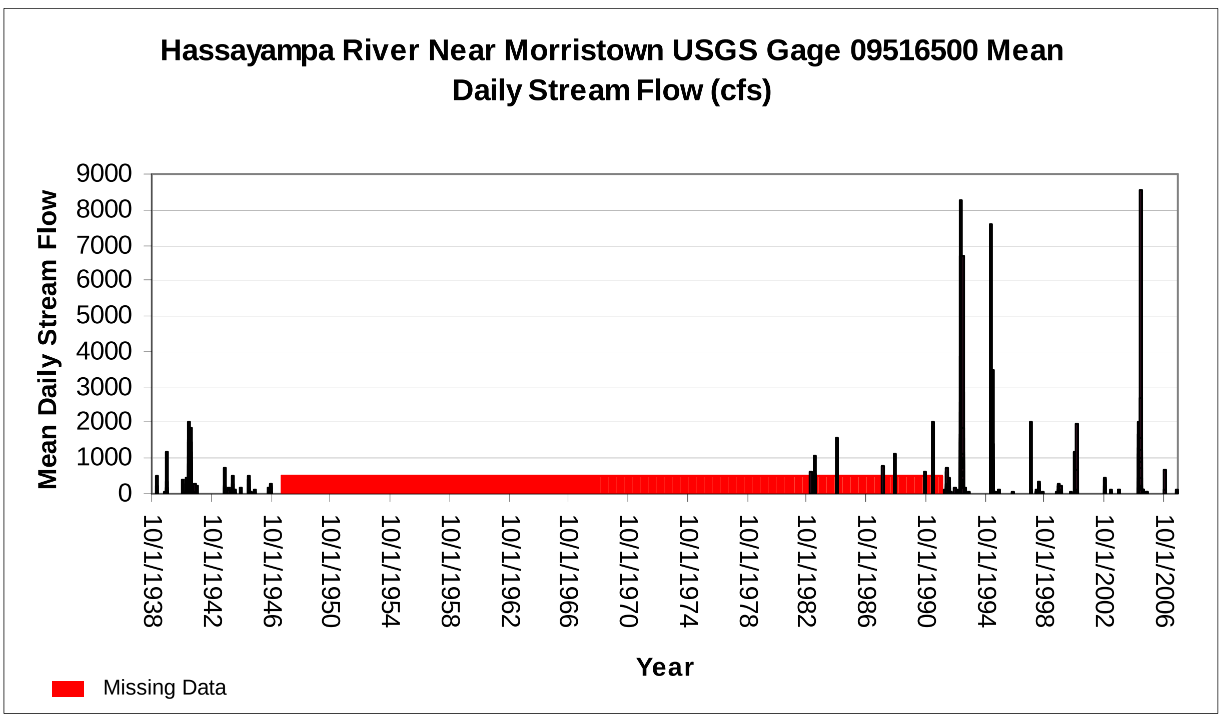

Figure 2-20: Hassayampa River Near Morristown USGS Gage 09516500, Mean Daily Stream Flow (cfs) Hydrograph.

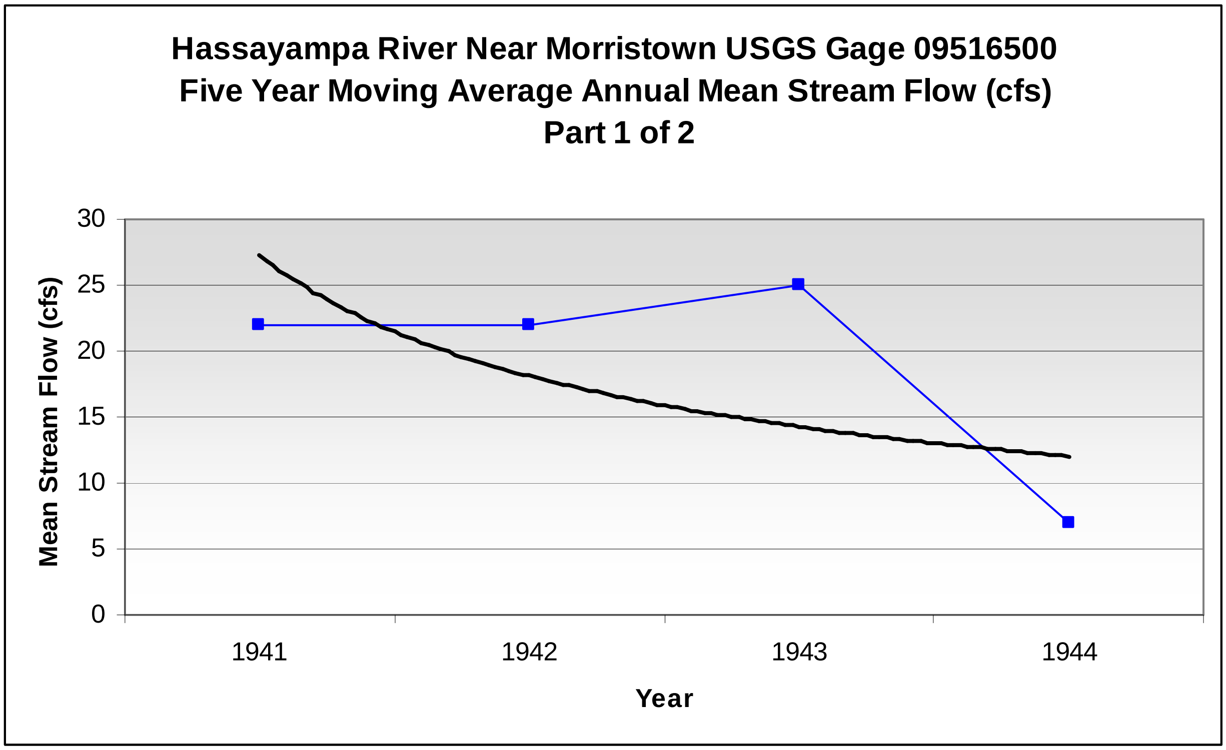

Figure 2-21: Hassayampa River Near Morristown USGS Gage 09516500, Five Year Moving Average Annual Mean Stream Flow (cfs) Hydrograph (Part 1 of 2).

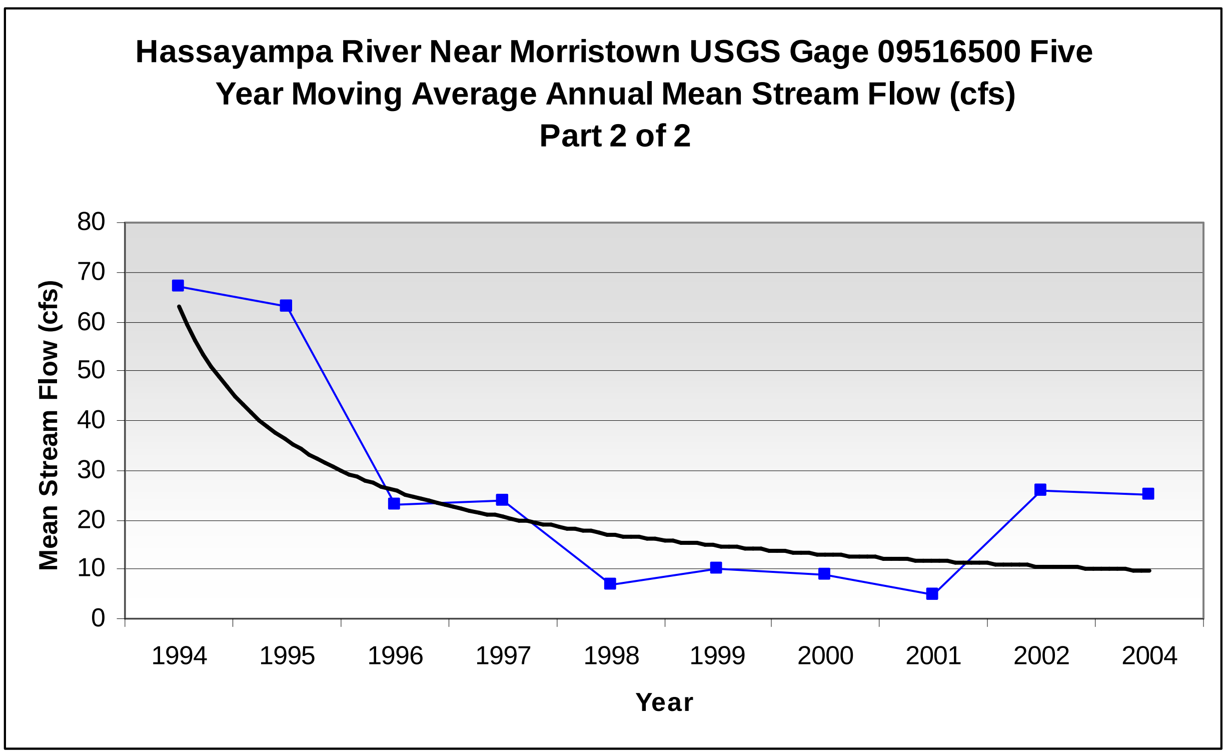

Figure 2-22: Hassayampa River Near Morristown USGS Gage 09516500, Five Year Moving Average Annual Mean Stream Flow (cfs) Hydrograph (Part 2 of 2).

Water Quality

The Middle Gila Watershed has nine water bodies assessed as impaired in Arizona's 303(d) List of Impaired Waters (ADEQ, 2006) (Figure 2-23):

• Alvord Park Lake in south Phoenix is impaired due to ammonia. Elevated ammonia may represent a risk to aquatic life. This lake is an important urban recreational area. The TMDL investigation is scheduled to be initiated in 2007.

• Chaparral Lake in Scottsdale is impaired due to low dissolved oxygen and bacteria (*Escherichia coli*). Swimming or wading in the lake is prohibited; therefore, public health risk due to the presence of *E. coli* is reduced. Low dissolved oxygen may pose problems for aquatic life. Both low dissolved oxygen and high *E. coli* are likely related to ducks and other wildlife that congregate at this lake.
Both TMDLs are scheduled to be initiated in 2007.

• Cortez Park Lake in Phoenix is impaired due to low dissolved oxygen and high pH. Low dissolved oxygen and high pH are frequently associated with excess nutrient loadings and eutrophic conditions which may lead to algal blooms and even fish kills. The narrative nutrient implementation guidance being developed by ADEQ may be used in developing these TMDLs as numeric nutrient standards have not been established. Both TMDLs are scheduled to be initiated in 2007.

• Gila River from the San Pedro River to Mineral Creek is impaired due to suspended sediment. A TMDL is planned to be initiated in 2009.

• Gila River from Centennial Wash to Gillespie Dam is impaired due to selenium and boron. A TMDL is expected to be initiated in 2008.

• Hassayampa River from headwaters to Copper Creek is impaired due to low pH. Mine remediation actions are expected to also address low pH.

• Mineral Creek, from Devil's Canyon to the Gila River, is impaired due to copper, selenium, and low dissolved oxygen. Both copper and selenium concentrations may pose a risk to aquatic life and wildlife. Recent remediation efforts have been effective in mitigated copper contamination, as exceedances only occur during extreme flow events; however, those methods have not reduced the selenium loads.

• Queen Creek from headwaters to mining discharge is impaired due to copper. Copper concentrations may pose a risk to aquatic life and wildlife. A TMDL was initiated in 2005 and is scheduled to be completed in 2007

•Queen Creek from mining WWTP discharge to Potts Canyon is also impaired due to Copper.

• Turkey Creek,from unnamed tributary to Poland Creed, is impaired due to copper and lead. Metals concentrations may represent a risk to aquatic life and wildlife. A TMDL, completed in 2006, indicate that the primary sources of metals are inactive and abandoned mines, such as Golden Turkey Mine and Golden Belt Mine.

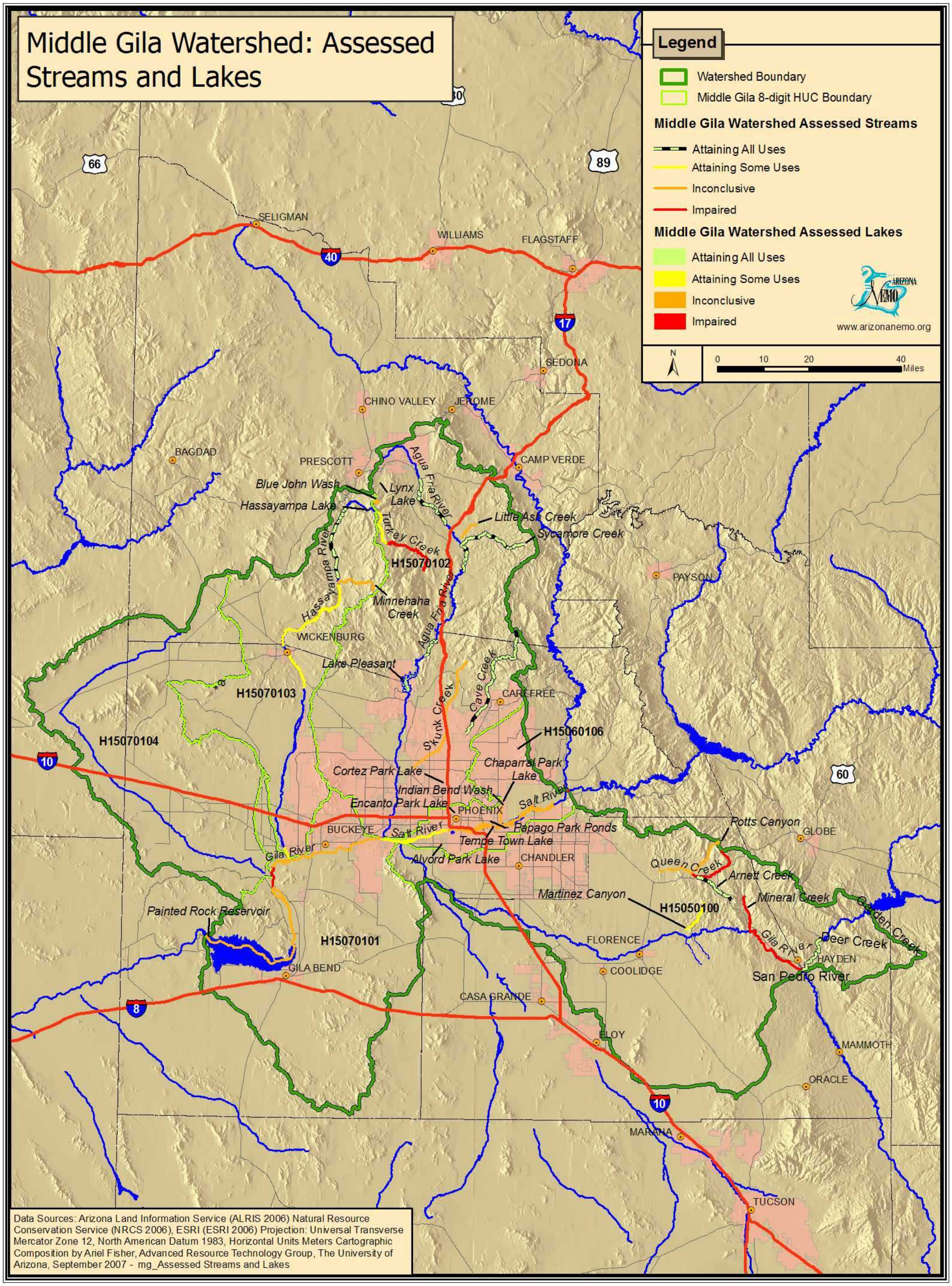

Figure 2-23: 303d Assessed Streams and Lakes

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 Middle Gila Watershed straddles the margin of the Basin and Range and the Transition Zone, two of the three geologic provinces found in the state of Arizona. The geology of the watershed is complex, varying widely in age, lithology, and structure (Figure 2-24).

The Agua Fria National Monument (AFNM) is located in the transition zone of central Arizona, between the Colorado Plateau Province to the Northeast and the Basin and Range Province to the Southwest. It is situated between the New River Mountains (Moore Gulch shear zone) to the East and the Bradshaw Mountains (Shylock shear zone) to the West. Just north of the monument is the Estler basalt volcanic center (Estler peak area) and south is the Black Canyon Dispositional Basin (Chalk Canyon & Hickey Formations) (from http://www.geocities.com/afnmus/Geology.html).

The Precambrian rocks in this area consist primarily of granite that weathers to rounded boulders and knobs, and flaky, silvery schist. Flat-lying layers of whitish limestone, siltstone, and water-laid volcanic ash are found in Tertiary-age lake sediments, and Quaternary and Tertiary lava flows cap the higher mesas.

The dark metamorphic rocks that form a skin around the Bradshaw Mountains are about 1.7 million years old, are also present in Black Canyon to the east. The Bradshaws have at their core a Precambrian mass of granite that intruded the metamorphic rocks (Chronic 1983).

The northwestern section of the Middle Gila Watershed contains several mountain ranges comprised of Precambrian and late Cretaceous granite; these mountain ranges, which include the Vulture Mountains and the White Tank Mountains, are heavily faulted and bear remnants of a vast lava plateau that once dominated the area.

Located in the heart of the watershed, the floor of the Phoenix Basin is nearly level. It contains deposits of salt and anhydrite that suggest the existence, at some time, of a large saline lake similar to the Salton Sea.

To the east of Phoenix, the Superstition Mountain Range is composed almost entirely of mid-Tertiary volcanic rocks. The Superstition volcanic field contains five partially overlapping calderas, the result of the collapse of emptied magma chambers following a series of violent explosions that shaped the geology of the area.

Figure 2-24 and Table 2-9 illustrate and document the geology of the Middle Gila Watershed. Table 2-10 lists the percentage of each rock type. The most common rock type is alluvium which comprises 50% of the watershed.

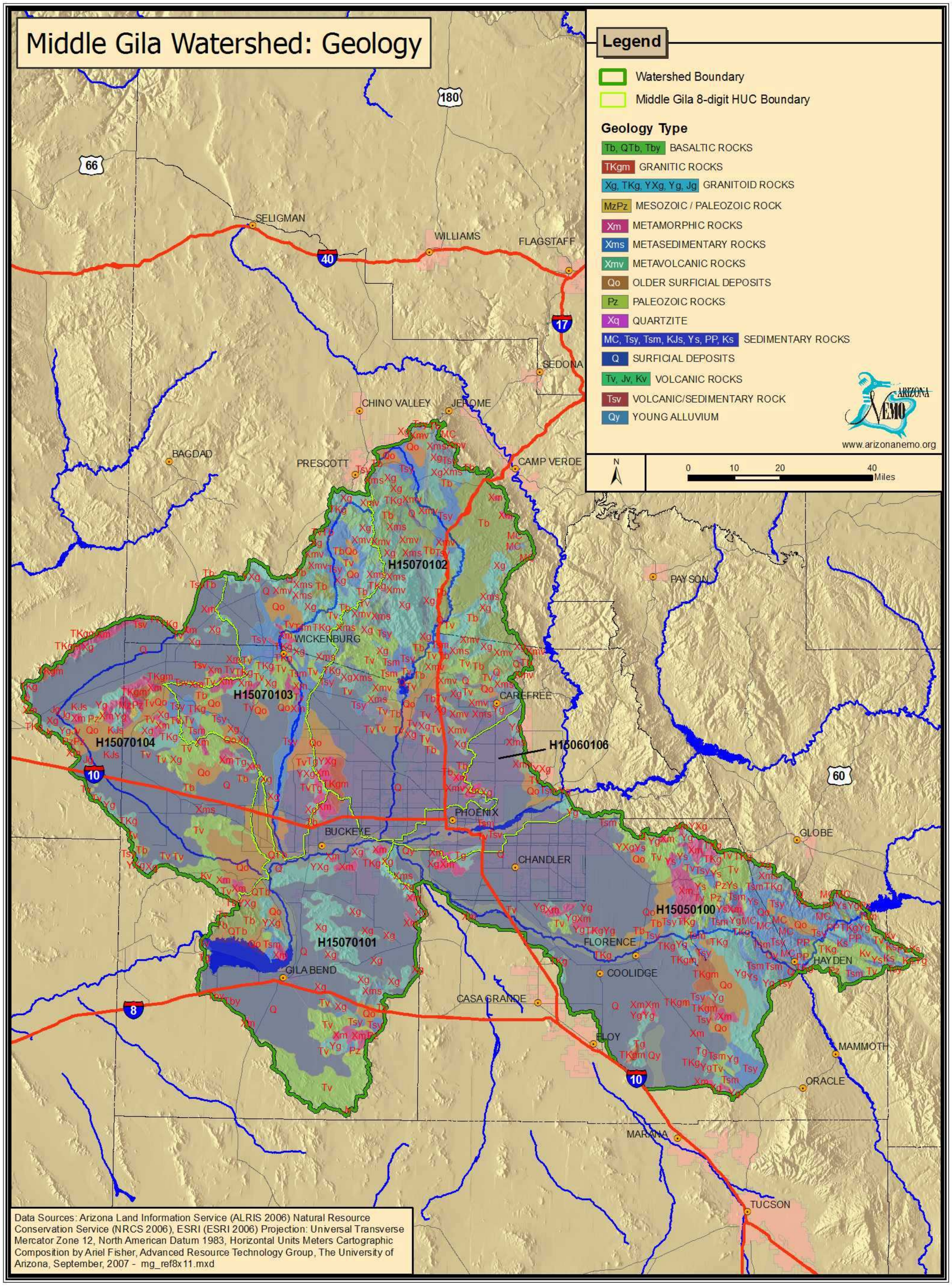

Figure 2-24: Geology

Alluvial Aquifers

Much of the younger Quaternary stream alluvium consists of unconsolidated sand, gravel, and silt deposited within narrow and shallow stripes of the present stream channels as floodplain alluvium and channel fill (Figure 2-25).

Table 2-9: Middle Gila River Watershed Geology (part 1 of 2).

Geologic Unit	Geologic Code	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
BASALTIC ROCKS (Holocene to Late Pliocene)	QTb	-	-	0.08%	1.17%	-
BASALTIC ROCKS (late to middle Miocene)	Tb	19.03%	0.76%	2.86%	2.42%	-
BASALTIC ROCKS (Pliocene to late Miocene;)	Tby	-	-	-	0.13%	-
GRANICTIC ROCKS (early Tertiary to late Cretaceous)	TKgm	0.84%	1.34%	>0.00%	0.38%	-
GRANITOID ROCKS (early Miocene to Oligocene)	Tg	0.19%	0.49%	0.42%	0.02%	2.0%
GRANITOID ROCKS (early Proterozoic)	Xg	21.32%	2.54%	17.74%	10.27%	0.6%
GRANITOID ROCKS (early Tertiary to late Cretaceous)	TKg	1.85%	2.34%	2.77%	0.03%	-
GRANITOID ROCKS (Jurassic)	Jg	-	0.15%	-	-	-
GRANITOID ROCKS (middle or early Proterozoic)	YXg	0.13%	0.35%	3.25%	3.81%	0.7%
GRANITOID ROCKS (Middle Proterozoic)	Yg	0.36%	2.91%	-	0.92%	4.6%
MESOZOIC AND PALEOZOIC ROCKS	MzPz	-	0.17%	-	-	-
METAMORPHIC ROCKS (early Proterozoic)	Xm	1.36%	7.19%	3.71%	3.49%	1.7%
METASEDIMENTARY ROCKS (early Proterozoic)	Xms	9.65%	0.16%	1.37%	1.00%	1.2%
METAVOLCANIC ROCKS (early Proterozoic)	Xmv	8.73%	-	3.66%	-	1.8%
OLDER SURFICIAL DEPOSITS (middle Pleistocene to late Pleistocene)	Qo	26.73%	12.10%	10.06%	5.39%	4.0%

Geologic Unit	Geologic Code	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
PALEOZOIC ROCKS (undifferentiated)	Pz	-	0.56%	-	0.35%	-
SEDIMENTARY ROCKS (Cretaceous)	Ks	-	-	-	-	-
SEDIMENTARY ROCKS (middle Miocene to Oligocene)	Tsm	1.88%	0.05%	2.42%	1.10%	3.1%
SEDIMENTARY ROCKS (middle Proterozoic)	Ys	-	-	-	-	-
SEDIMENTARY ROCKS (Mississippian to Cambrian)	MC	0.73%	-	-	-	-
SEDIMENTARY ROCKS (Permian and Pennsylvanian)	PP	-	-	-	-	-
SEDIMENTARY ROCKS (Pliocene to middle Miocene)	Tsy	2.93%	0.73%	18.05%	0.56%	-
SEDIMENTARY ROCKS WITH LOCAL VOLCANIC UNITS	KJs	-	0.36%	-	-	-
SURFICIAL DEPOSITS (Holocene to middle Pleistocene)	Q	1.03%	55.37%	24.67%	49.37%	63.0%
VOLCANIC AND SEDIMENTARY ROCKS (middle Miocene)	Tsv	-	0.32%	0.09%	-	0.4%
VOLCANIC ROCKS (Jurassic; locally latest Triassic)	Jv	-	0.28%	-	0.07%	-
VOLCANIC ROCKS (late Cretaceous; early Tertiary)	Kv	-	1.27%	-	-	-
VOLCANIC ROCKS (middle Miocene to Oligocene)	Tv	3.02%	10.47%	8.15%	11.89%	0.5%
YOUNG ALLUVIUM (Holocene to latest Pleistocene)	Qy	0.20%	0.11%	0.72%	7.61%	16.6%
Area (Sq. Miles)		2,785	1,946	1,454	2,012	505

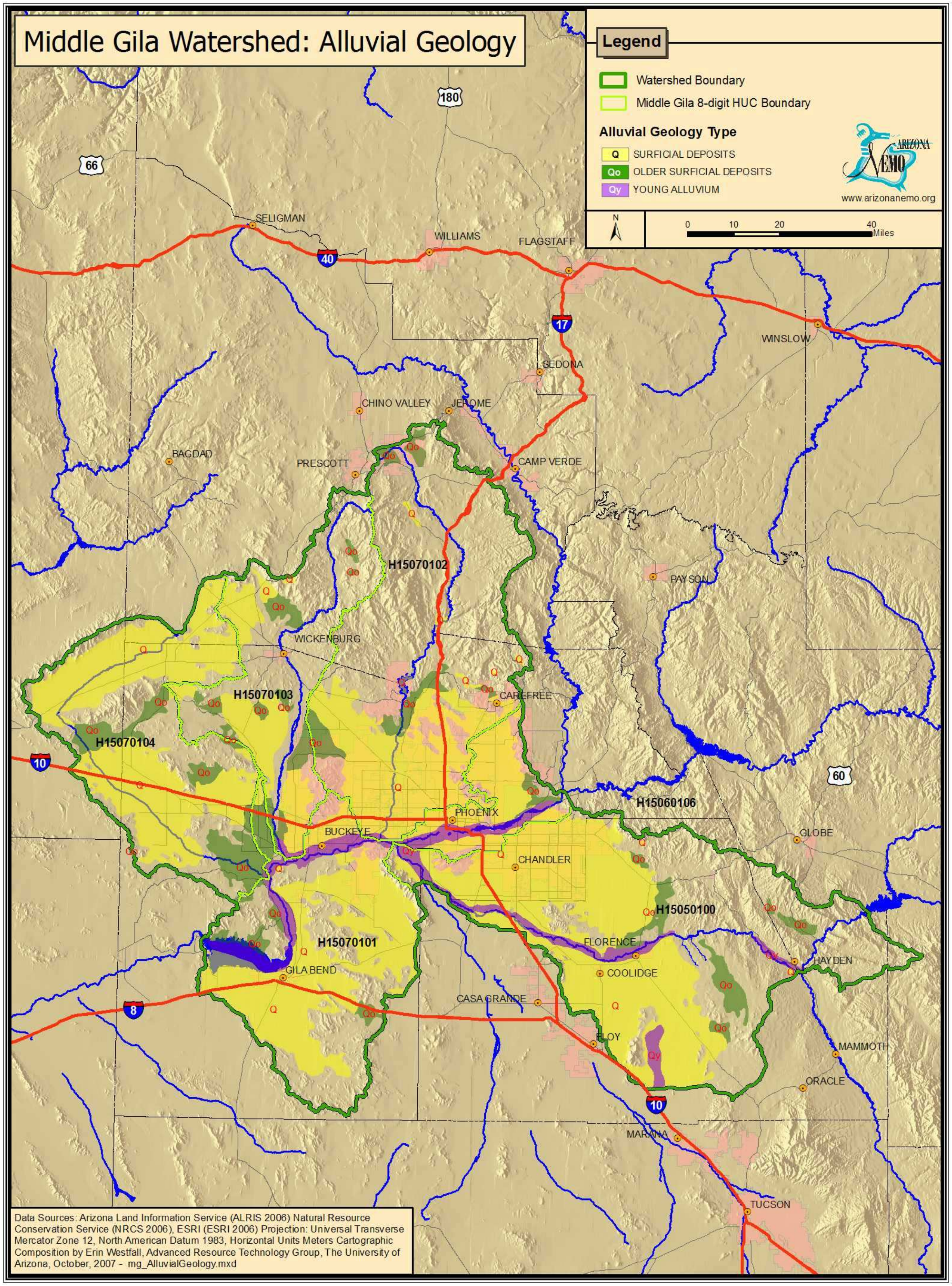

Figure 2-25: Alluvial Geology

Table 2-9: Middle Gila River Watershed Geology (part 2 of 2).

Geologic Unit	**Geologic Code**	**Middle Gila River H15050100**	**Middle Gila River Watershed**
BASALTIC ROCKS (Holocene to Late Pliocene)	QTb	-	0.2%
BASALTIC ROCKS (late to middle Miocene)	Tb	0.21%	4.9%
BASALTIC ROCKS (Pliocene to late Miocene;)	Tby	-	0.02%
GRANICTIC ROCKS (early Tertiary to late Cretaceous)	TKgm	1.60%	0.9%
GRANITOID ROCKS (early Miocene to Oligocene)	Tg	0.99%	0.5%
GRANITOID ROCKS (early Proterozoic)	Xg	0.75%	8.3%
GRANITOID ROCKS (early Tertiary to late Cretaceous)	TKg	2.63%	1.6%
GRANITOID ROCKS (Jurassic)	Jg	-	0.02%
GRANITOID ROCKS (middle or early Proterozoic)	YXg	0.12%	1.2%
GRANITOID ROCKS (Middle Proterozoic)	Yg	7.70%	3.1%
MESOZOIC AND PALEOZOIC ROCKS	MzPz	-	0.03%
METAMORPHIC ROCKS (early Proterozoic)	Xm	4.66%	3.8%
Geologic Unit	Geologic Code	River H15050100	River Watershed
METASEDIMENTARY ROCKS (early Proterozoic)	Xms	0.93%	2.3%
METAVOLCANIC ROCKS (early Proterozoic)	Xmv	-	2.9%
OLDER SURFICIAL DEPOSITS (middle Pleistocene to late Pleistocene)	Qo	4.60%	6.7%
PALEOZOIC ROCKS (undifferentiated)	Pz	0.72%	0.4%
SEDIMENTARY ROCKS (Cretaceous)	Ks	0.45%	0.13%
SEDIMENTARY ROCKS (middle Miocene to Oligocene)	Tsm	3.20%	1.8%
SEDIMENTARY ROCKS (middle Proterozoic)	Ys	3.05%	0.9%
SEDIMENTARY ROCKS (Mississippian to Cambrian)	MC	1.56%	0.5%
SEDIMENTARY ROCKS (Permian and Pennsylvanian)	PP	1.18%	0.3%
SEDIMENTARY ROCKS (Pliocene to middle Miocene)	Tsy	5.05%	5.0%
SEDIMENTARY ROCKS WITH LOCAL VOLCANIC UNITS	KJs	-	0.06%

SURFICIAL DEPOSITS (Holocene to middle Pleistocene)	Q	45.45%	41.7%
VOLCANIC AND SEDIMENTARY ROCKS (middle Miocene)	Tsv	-	0.08%
VOLCANIC ROCKS (Jurassic; locally latest Triassic)	Jv	-	0.06%
VOLCANIC ROCKS (late Cretaceous; early Tertiary)	Kv	1.86%	0.7%
VOLCANIC ROCKS (middle Miocene to Oligocene)	Tv	8.00%	8.5%
YOUNG ALLUVIUM (Holocene to latest Pleistocene)	Qy	5.28%	3.6%
Area (Sq. Miles)		3,354	12,056

Table 2-10: Middle Gila Watershed Rock Types.

Geologic Unit	Middle Gila River (Local Drainage) 15050100	Lower Gila River above Painted Rock Dam (Local Drainage) 15070101	Agua Fria River 15070102	Hassayampa River 15070103	Centennial Wash 15070104	Lower Salt River 15060106B	*Middle Gila Watershed*
Basaltic and Volcanic Rocks	10.1%	15.7%	22.1%	11.2%	13.1%	22.0%	*16.0%*
Granitic Rocks	13.8%	15.4%	24.7%	24.2%	10.1%	19.1%	*17.0%*
Sedimentary Rocks	6.3%	1.7%	5.6%	20.5%	1.1%	10.5%	*9.0%*
Metamorphic Rocks	14.5%	4.8%	19.7%	8.7%	8.1%	3.2%	*9.0%*
Alluvium	55.3%	62.4%	28.0%	35.4%	67.6%	45.4%	*50.0%*
Area (Sq. Miles)	*3,354*	*2,012*	*2,785*	*1,454*	*1,946*	*505*	*12,056*

Soils

Based on the soil characteristics for the Middle Gila Watershed two types of maps were created: a soil texture map (Figure 2-26) and a soil erodibility factor map (Figure 2-27). Soil erodibility is generated from the soil texture characteristics.

There are 26 different soil textures in the Middle Gila Watershed (Table 2-11). Extremely gravelly loam is the most common soil texture, covering 14% of the watershed. Loam and very gravely clay loam are the next most common soil textures, covering 13% and 10% 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, 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

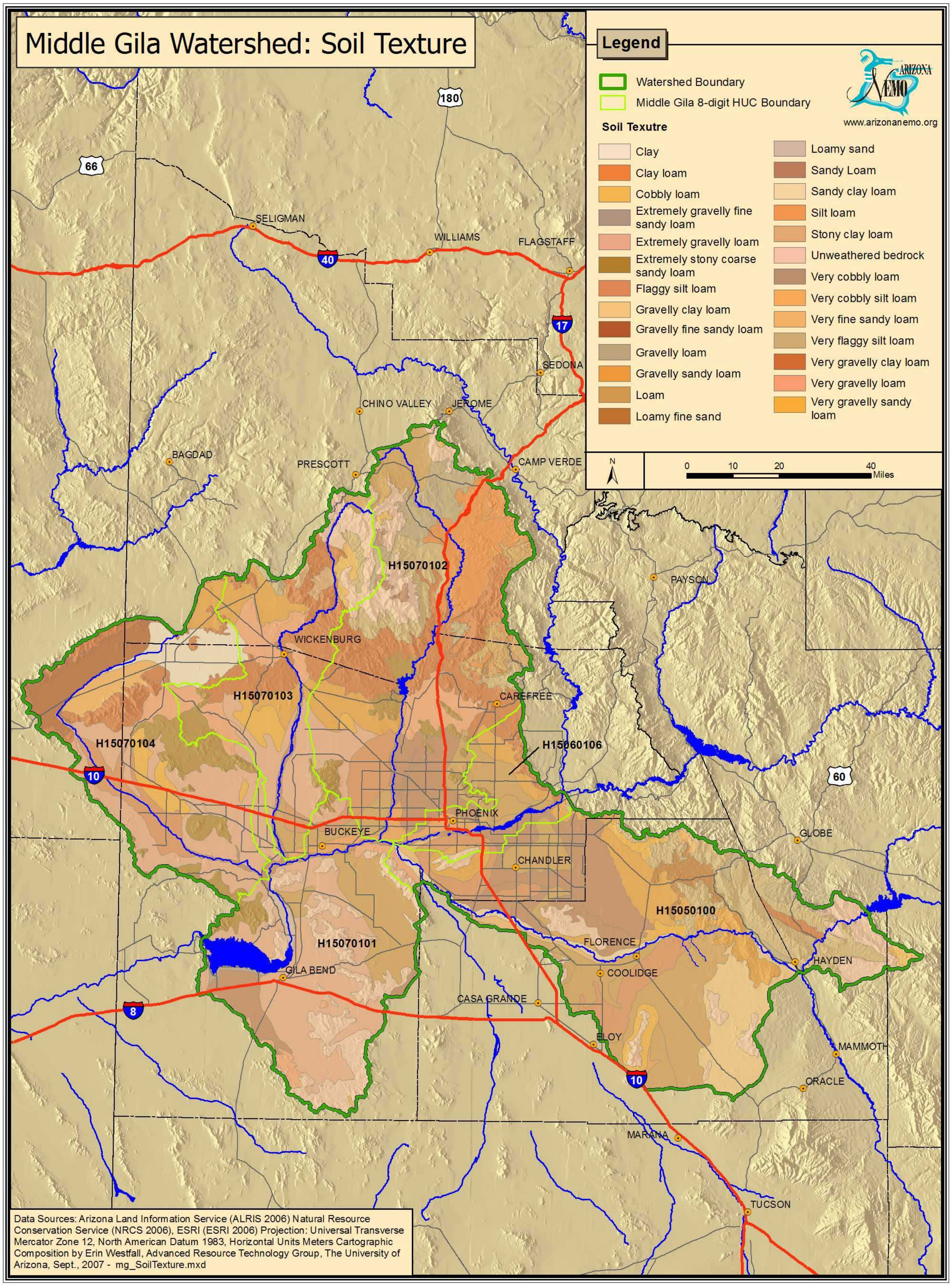

Figure 2-26: Soil Texture

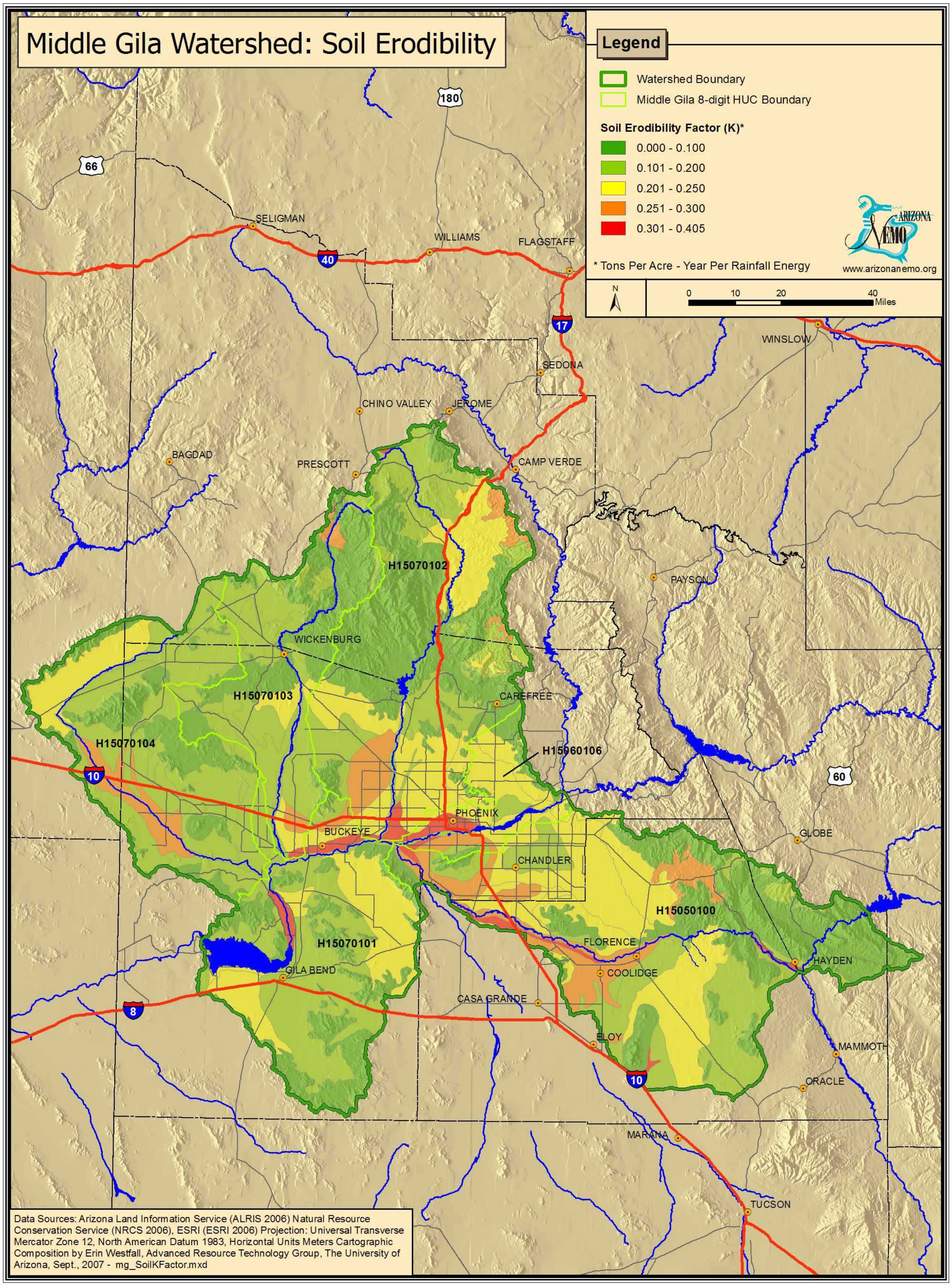

Figure 2-27: Soil Erodibility

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 Middle Gila River subwatershed and the Lower Salt River subwatershed had the highest weighted mean Soil Erodibility Factors, with K = 0.161 and 0.207 respectively. The Hassayampa River subwatershed had the lowest weighted mean K at 0.123. The weighted mean K for the whole Middle Gila Watershed is 0.146.

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

Soil Texture	**Agua Fria River H150470102**	**Centennial Wash H15070104**	**Hassayampa River H15070103**	**Lower Gila River above Painted Rock Dam H15070101**	**Lower Salt River H15060106B**
Clay	-	10%	0.8%	-	-
Clay Loam	13%	-	-	-	-
Cobbly Loam	0.4%	-	2%	-	-
Extremely Gravelly Fine Sandy Loam	-	-	-	0.9%	-
Extremely Gravelly Loam	4%	29%	15%	40%	-
Extremely Stony Coarse Sandy Loam	5%	12%	4%	3%	1.1%
Flaggy Silt Loam	5%	9%	2%	1%	7.3%
Gravelly Clay Loam	-	-	-	-	-
Gravelly Fine Sandy Loam	-	11%	-	-	-
Gravelly Loam	6%	-	2%	-	-
Gravelly Sandy Loam	5%	3%	12%	-	18.2%
Loam	13%	-	4%	17%	29.4%
Loamy Fine Sand	-	-	-	-	-
Loamy Sand	-	-	-	5%	-
Sandy Loam	9%	0.8%	3%	8%	19.9%
Sandy Clay Loam	-	-	-	>0.0%	-
Silt Loam	1%	-	0.4%	1%	8.4%
Stony Clay Loam	-	-	2%	-	-
Unweathered Bedrock	7%	-	9%	20%	2.0%
Very Cobbly Loam	-	-	-	-	-
Very Cobbly Silt Loam	-	5%	-	0.1%	-
Very Fine Sandy Loam	-	-	-	-	1.3%
Very Flaggy Silt Loam	7%	-	2%	-	0.6%
Very Gravelly Clay Loam	21%	11%	24%	-	12.0%
Very Gravelly Loam	5%	3%	14%	3%	-

Soil Texture	Agua Fria River H150470102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Very Gravelly Sandy Loam	0.4%	5%	5%	-	-

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

Soil Texture	Middle Gila River H15050100	Middle Gila River Watershed
Clay	-	*1.8%*
Clay Loam	-	*2.9%*
Cobbly Loam	0.6%	*0.5%*
Extremely Gravelly Fine Sandy Loam	-	*0.1%*
Extremely Gravelly Loam	-	*14.0%*
Extremely Stony Coarse Sandy Loam	-	*4.2%*
Flaggy Silt Loam	3%	*5.3%*
Gravelly Clay Loam	10%	*2.7%*
Gravelly Fine Sandy Loam	-	*1.8%*
Gravelly Loam	2%	*2.2%*
Gravelly Sandy Loam	10%	*6.6%*
Loam	21%	*13.3%*
Loamy Fine Sand	2%	*0.7%*
Loamy Sand	-	*0.9%*
Sandy Loam	3%	*8.9%*
Sandy Clay Loam	15%	*0.8%*
Silt Loam	0.3%	*1.0%*
Stony Clay Loam	-	*0.3%*
Unweathered Bedrock	9%	*8.7%*
Very Cobbly Loam	>0.0%	*> 0.0%*
Very Cobbly Silt Loam	0.4%	*0.9%*
Very Fine Sandy Loam	1%	*0.4%*
Very Flaggy Silt Loam	14%	*5.7%*
Very Gravelly Clay Loam	0.9%	*10.2%*
Very Gravelly Loam	0.5%	*3.8%*
Very Gravelly Sandy Loam	3%	*2.3%*

*Table 2-12: Middle Gila River Watershed Soil Erodibility Factor K.**

Subwatershed Name	**Min K**	**Max K**	**Weighted Average**
Agua Fria River H15070102	0.013	0.405	0.139
Centennial Wash H15070104	0.013	0.264	0.135
Hassayampa River H15070103	0.013	0.405	0.123
Lower Gila River above Painted Rock Dam H15070101	0.013	0.405	0.144
Lower Salt River H15060106B	0.000	0.405	0.207
Middle Gila River H15050100	0.000	0.405	0.161
Middle Gila River Watershed	*0.000*	*0.405*	*0.146*

Climate

Precipitation

For the 30 years (1961-1990) of precipitation data used in this report, the average annual precipitation for the Middle Gila Watershed is 12 inches. The Agua Fria River subwatershed receives the most rainfall with 15 inches of rain in an average year, while the Lower Gila River above Painted Rock Dam subwatershed typically receives only 8 inches. Figure 2-28 shows the distribution of precipitation over the watershed, and Table 2-13 shows the average annual precipitation in inches per year.

Table 2-13: Middle Gila River Watershed
Average Annual Precipitation (in/yr)

Subwatershed Name	**Min (in/yr)**	**Max (in/yr)**	**Weighted Average**
Agua Fria River H15070102	7	31	15
Centennial Wash H15070104	7	17	10
Hassayampa River H15070103	7	31	14
Lower Gila River above Painted Rock Dam H15070101	5	13	8
Lower Salt River H15060106B	7	19	10
Middle Gila River H15050100	7	31	13
Middle Gila River Watershed	*5*	*31*	*12*

Temperature

One hundred and nineteen weather stations in the Middle Gila Watershed are shown in Figure 2-29. Thirty-one of these locations were used for watershed modeling (Table 2-14) because of consistency and duration of the data.

For the 30 years (1961 – 1990) of temperature data, the average annual temperature for the Middle Gila Watershed is 67° Fahrenheit (Table 2-15). The Lower Gila River above Painted Rock Dam, and the Middle Gila River subwatersheds both have the highest annual average temperature of

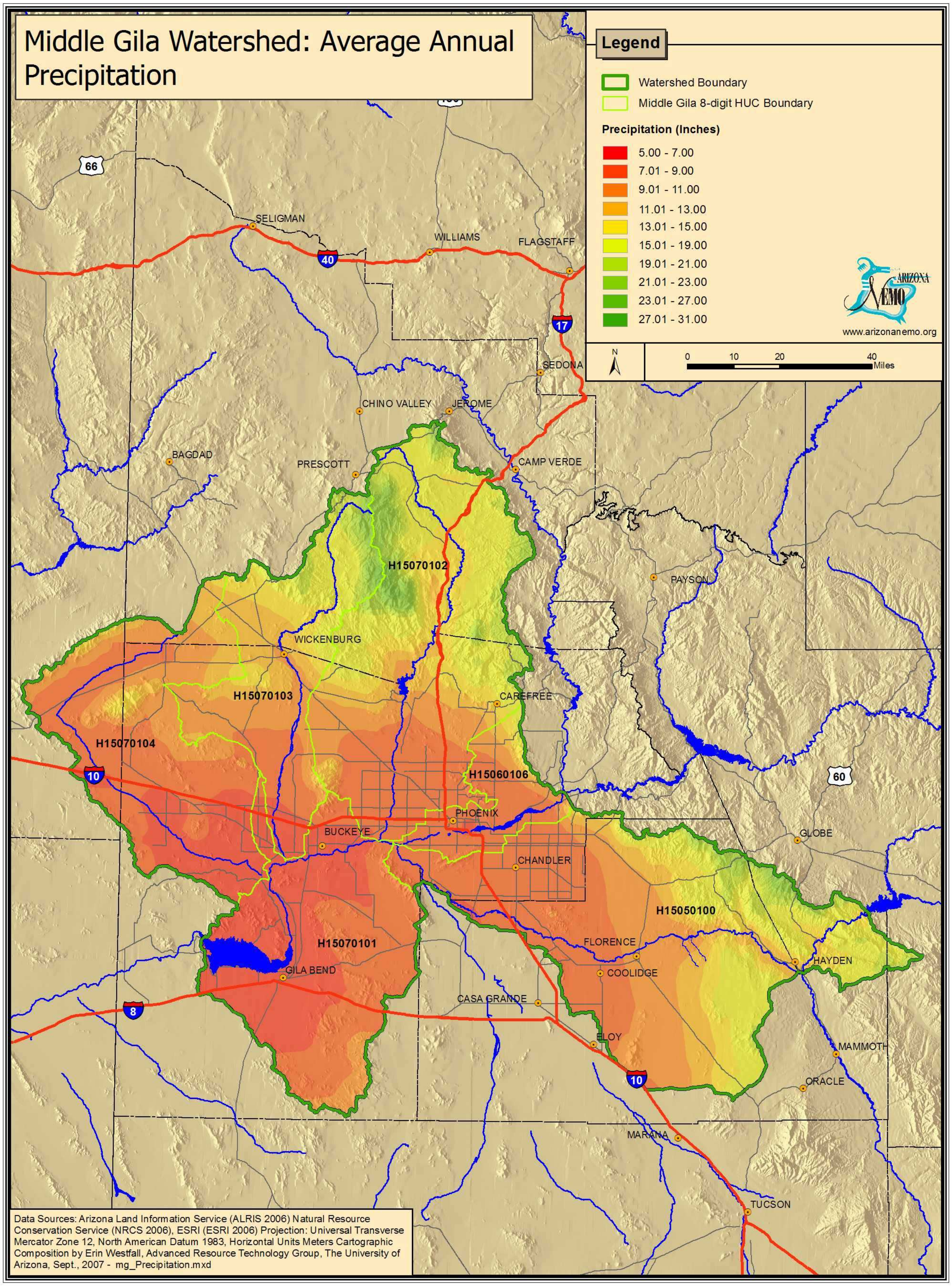

Figure 2-28: Average Annual Precipitation

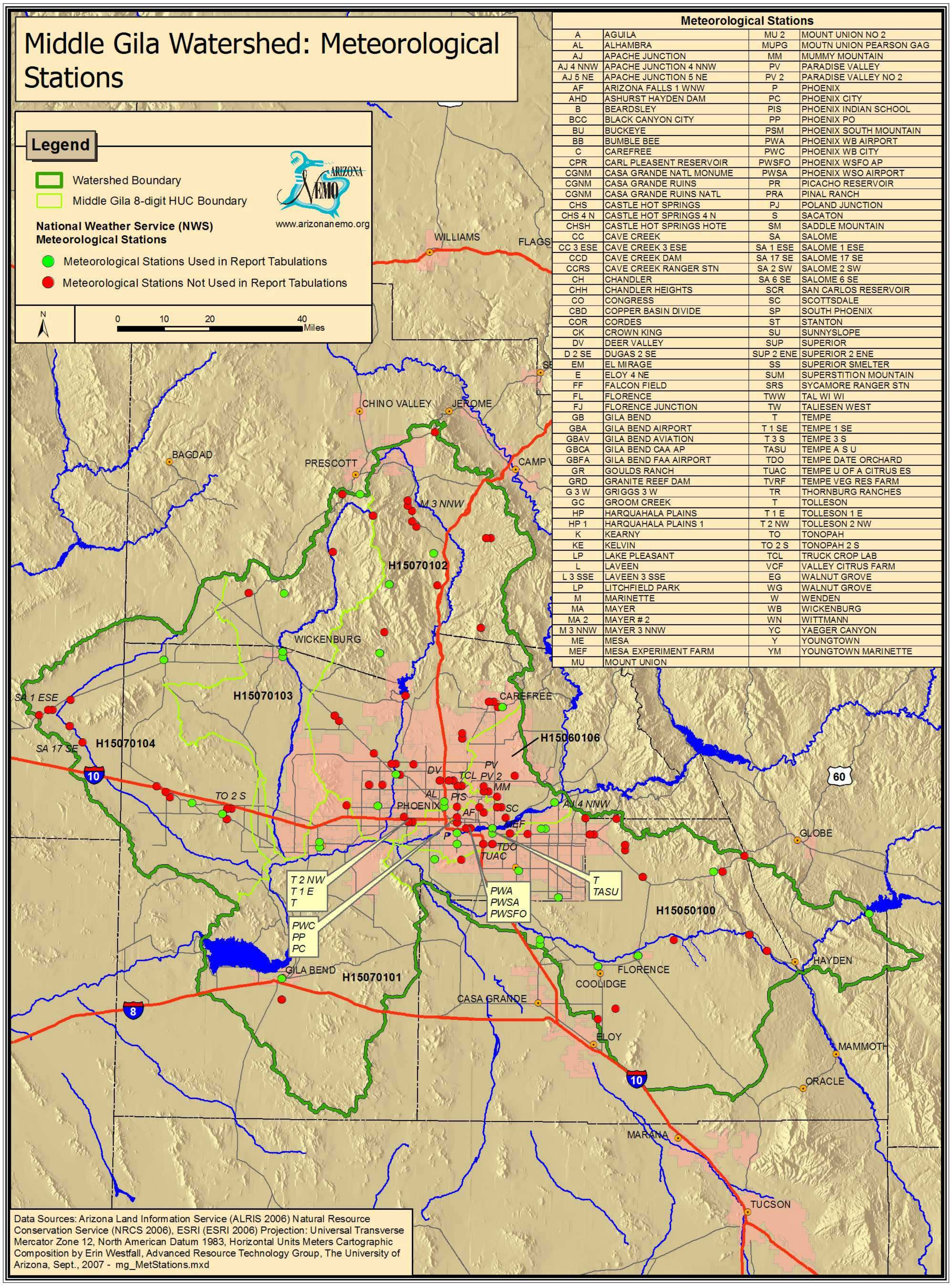

Figure 2-29: Meteorological Stations

70°. Table 2-15 shows the annual average temperatures for each subwatershed and Figure 2-30 is a map of the temperature ranges.

Table 2-14: Middle Gila River Watershed Summary of Temperature Data for 31 Weather Stations with Sufficient Data.

ID	Gage	Average Annual Max. Temperature (F)	Average Annual Min Temperature (F)	Average Annual Temperature (F)
020060-6	Aguila	82	49	66
020104-6	Alahambra	87	52	70
021026-6	Buckeye	88	52	70
021282-6	Carefree	82	57	70
021314-6	Casa Grande Ruins National Monument	87	52	70
021353-3	Castle Hot Springs Hotel	84	56	70
021511-6	Chandler	85	52	69
021514-6	Chandler Heights	85	56	71
022109-3	Cordes	76	47	62
022329-3	Crown King	68	39	54
022927-6	Falcon Field	85	50	68
023027-6	Florence	87	54	71
023393-6	Gila Bend	89	56	73
023621-6	Granite Reef Dam	86	54	70
023713-3	Groom Creek	66	35	51
023852-6	Haraquahala Plains 1	86	50	68
024829-6	Laveen 3 SSE	87	56	72
024977-6	Litchfield Park	87	54	71
026474-6	Phoenix	86	60	73
027370-6	Sacaton	86	52	69
027480-4	San Carlos Reservoir	80	52	66
028112-6	South Phoenix	85	54	70
028184-3	Stanton	77	53	65
028348-6	Superior	79	59	69
028489-6	Tempe	85	53	69
028499-6	Tempe ASU	87	55	71
028641-6	Tonopah	86	54	70
029287-6	Wickenburg	84	48	66
029634-6	Youngtown	87	57	72

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

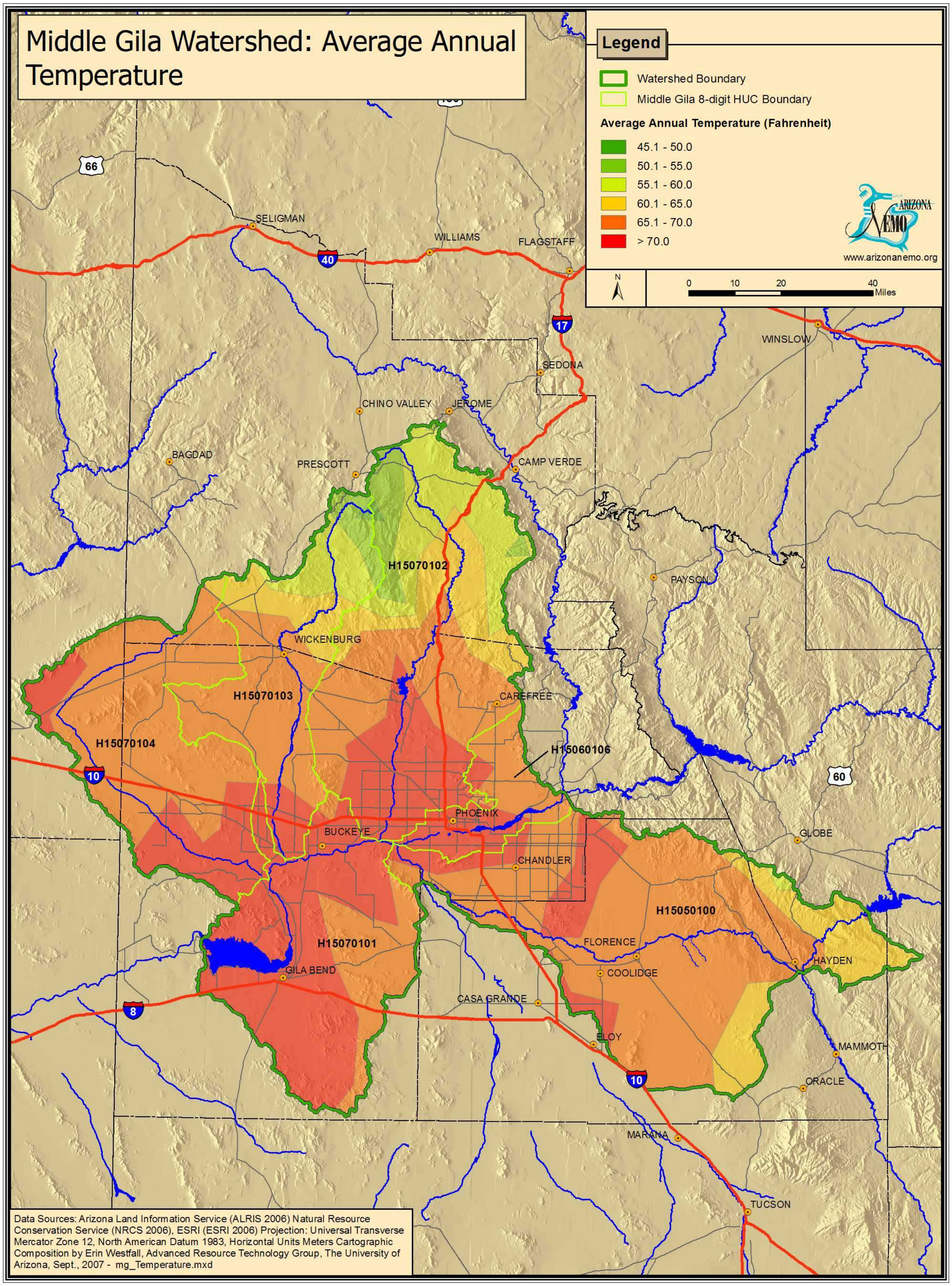

Figure 2-30: Average Annual Temperature

Table 2-15: Middle Gila River Watershed Average Annual Temperature (°F).

Subwatershed	**Avg Annual Temp (°F)**
Agua Fria River H15070102	67
Centennial Wash H15070104	68
Hassayampa River H15070103	66
Lower Gila River above Painted Rock Dam H15070101	70
Lower Salt River H15060106	68
Middle Gila River H15050100	70
Middle Gila River Watershed	*67*

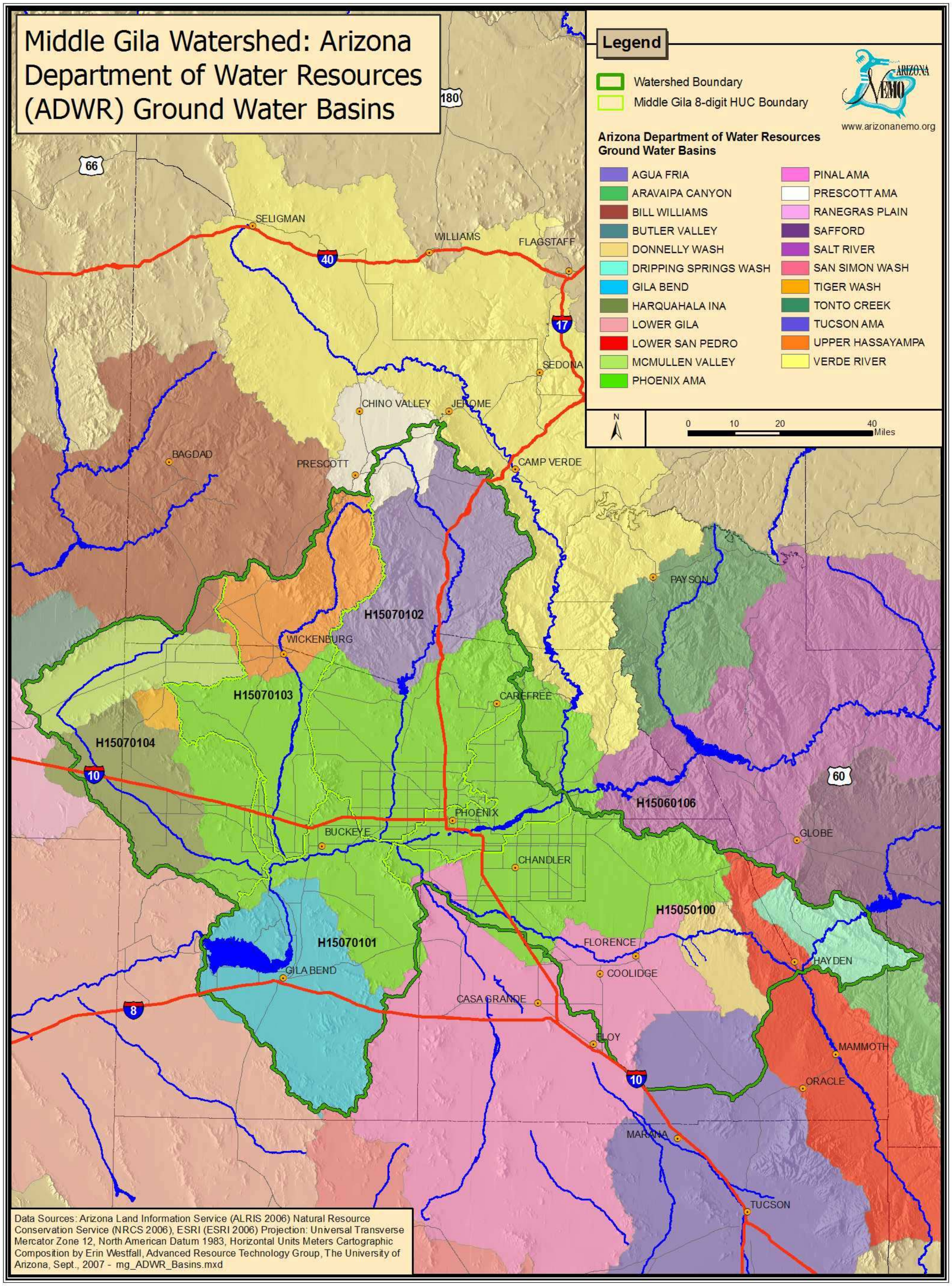

Figure 2-31: ADWR Ground Water Basins

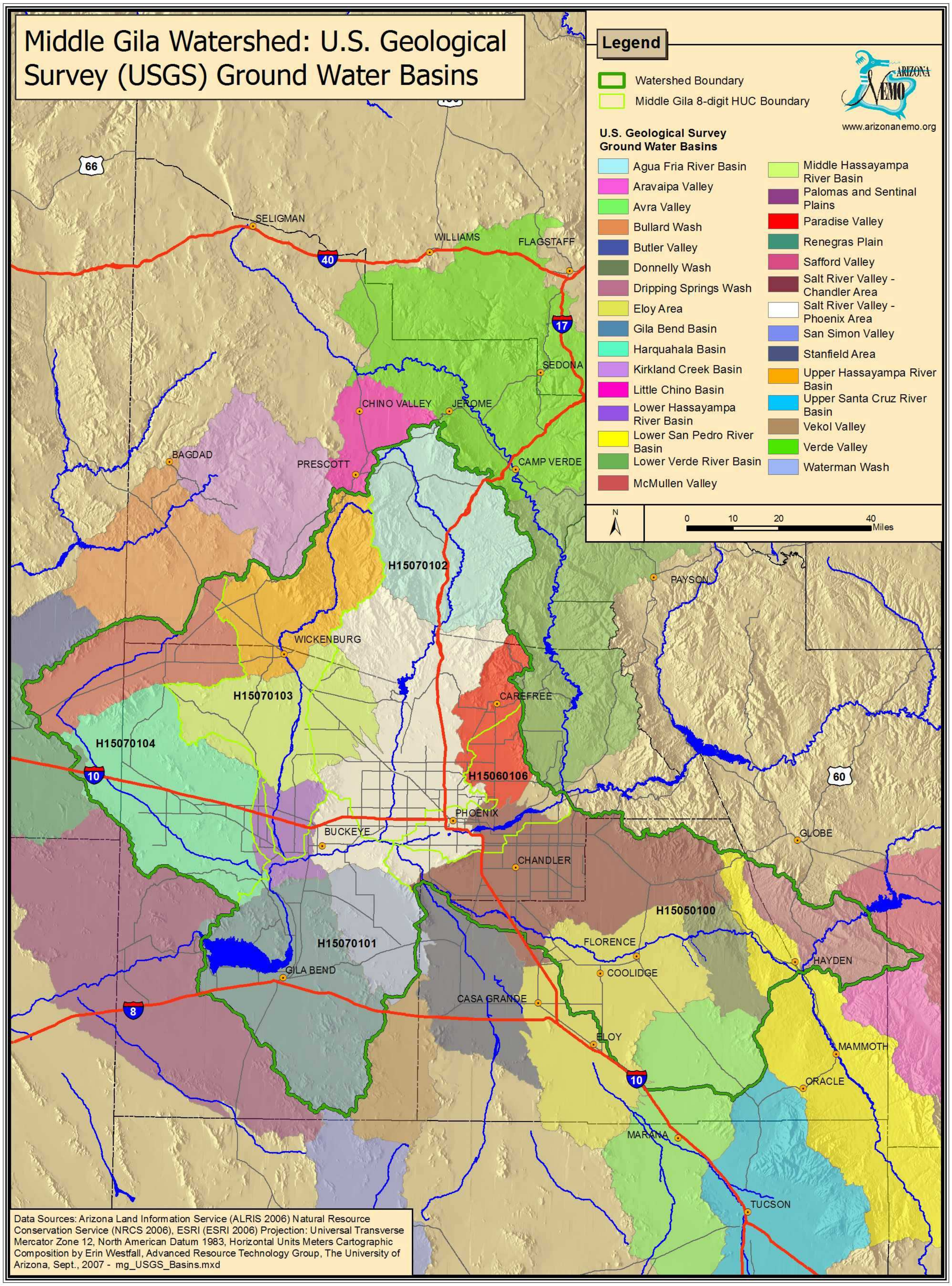

Figure 2-32: USGS Ground Water Basins

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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 an ecosystem region or ecoregion. 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 Middle Gila 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 Middle Gila Watershed in the dry domain, with 81% in the Tropical/Subtropical Desert Division, and 19% in the Tropical/Subtropical Steppe Division. For the provinces, 81% is in the American Semi-Desert and Desert Province and 19% is in the Colorado Plateau Semi-Desert Province, corresponding respectively to the Sonoran Mohave Desert and the Tonto Transition Sections. 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 describes 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 two Divisions present in the Middle Gila Watershed are the Tropical/Subtropical Desert Division and the Tropical/Subtropical Steppe Division.

The Tropical/Subtropical Desert Division occurs in the southern 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. Annual precipitation can be less than 8 in (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

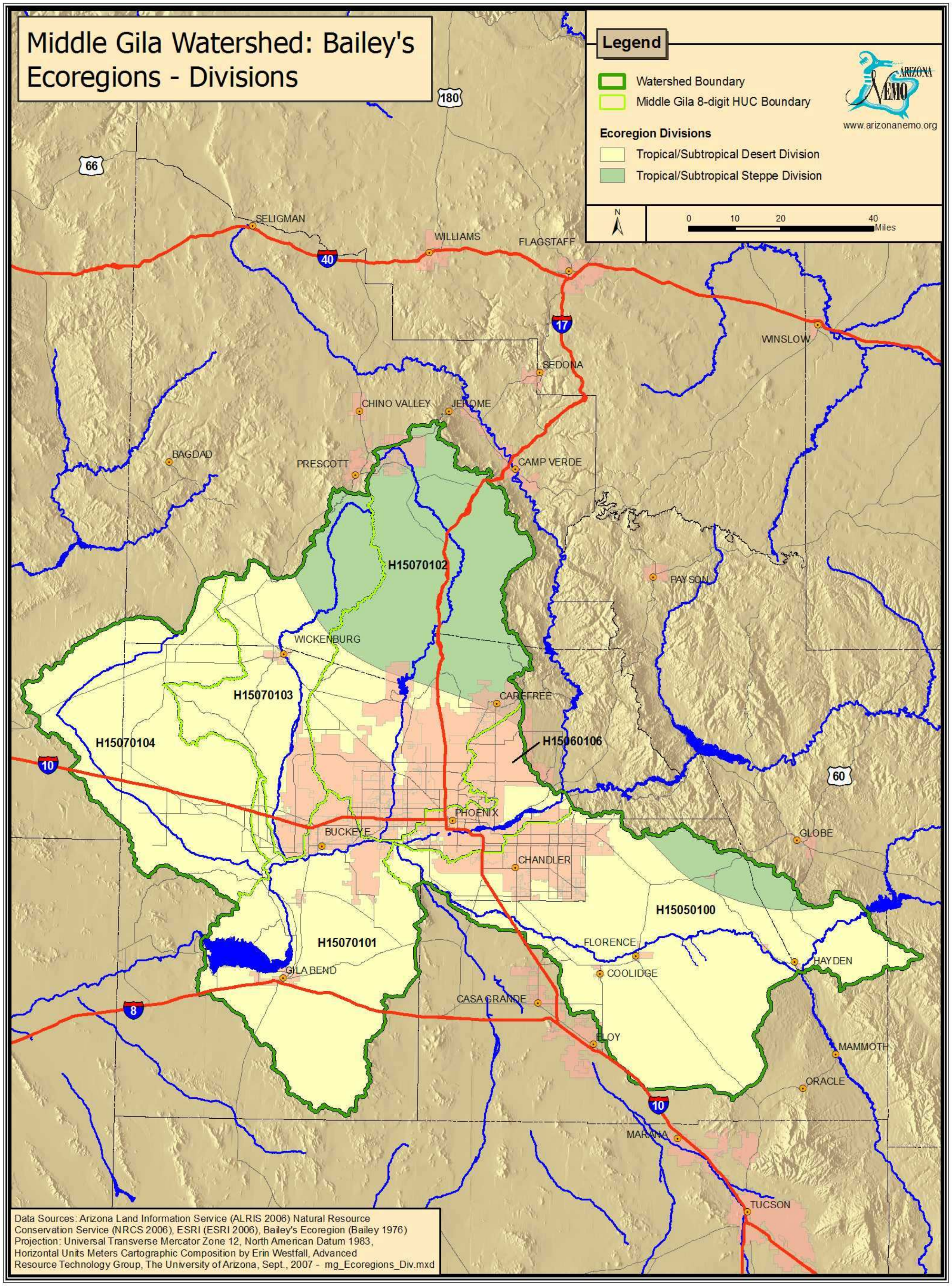

Figure 3-1: Bailey's Ecoregions – Divisions

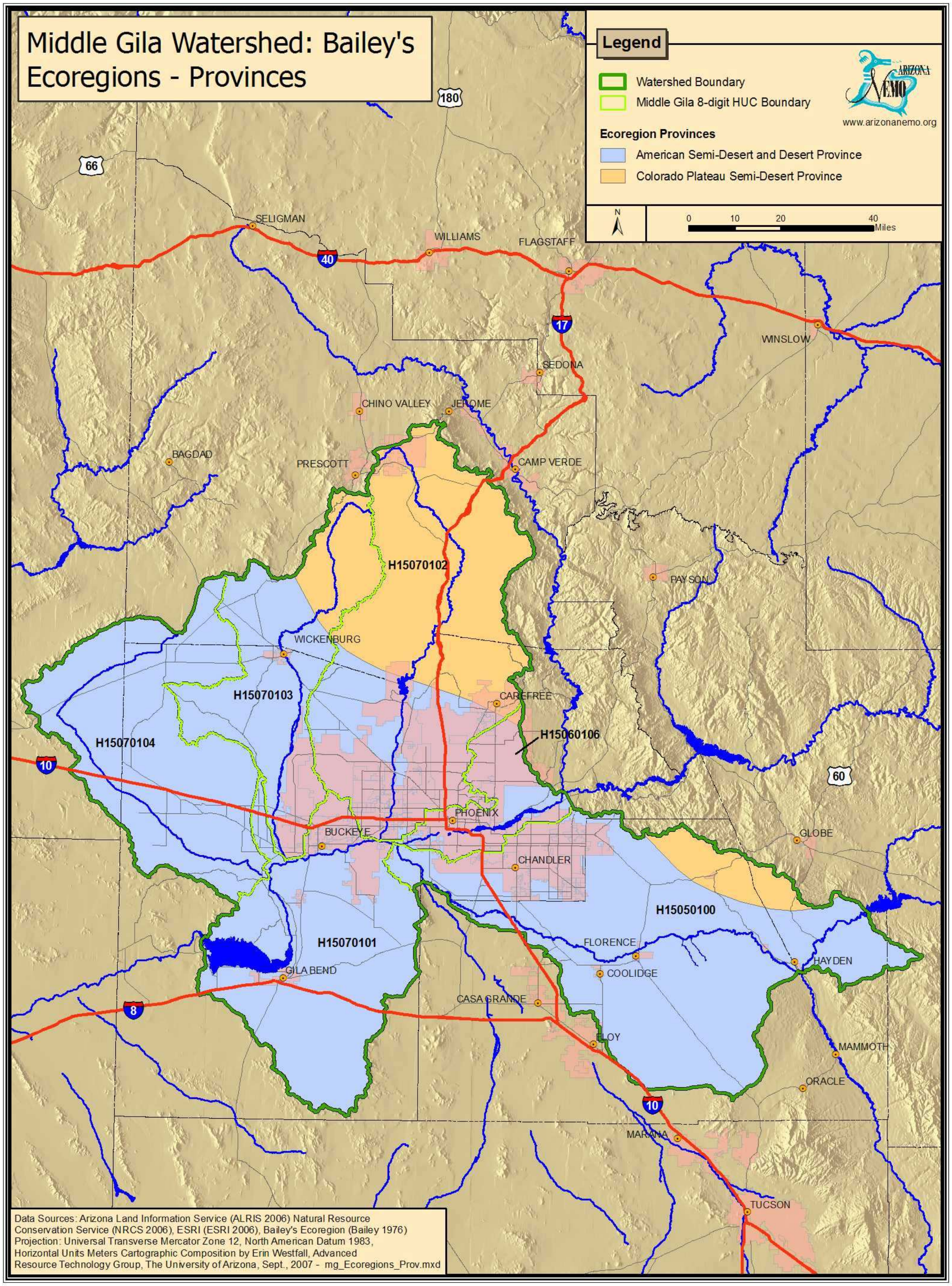

Figure 3-2: Bailey's Ecoregions – Provinces

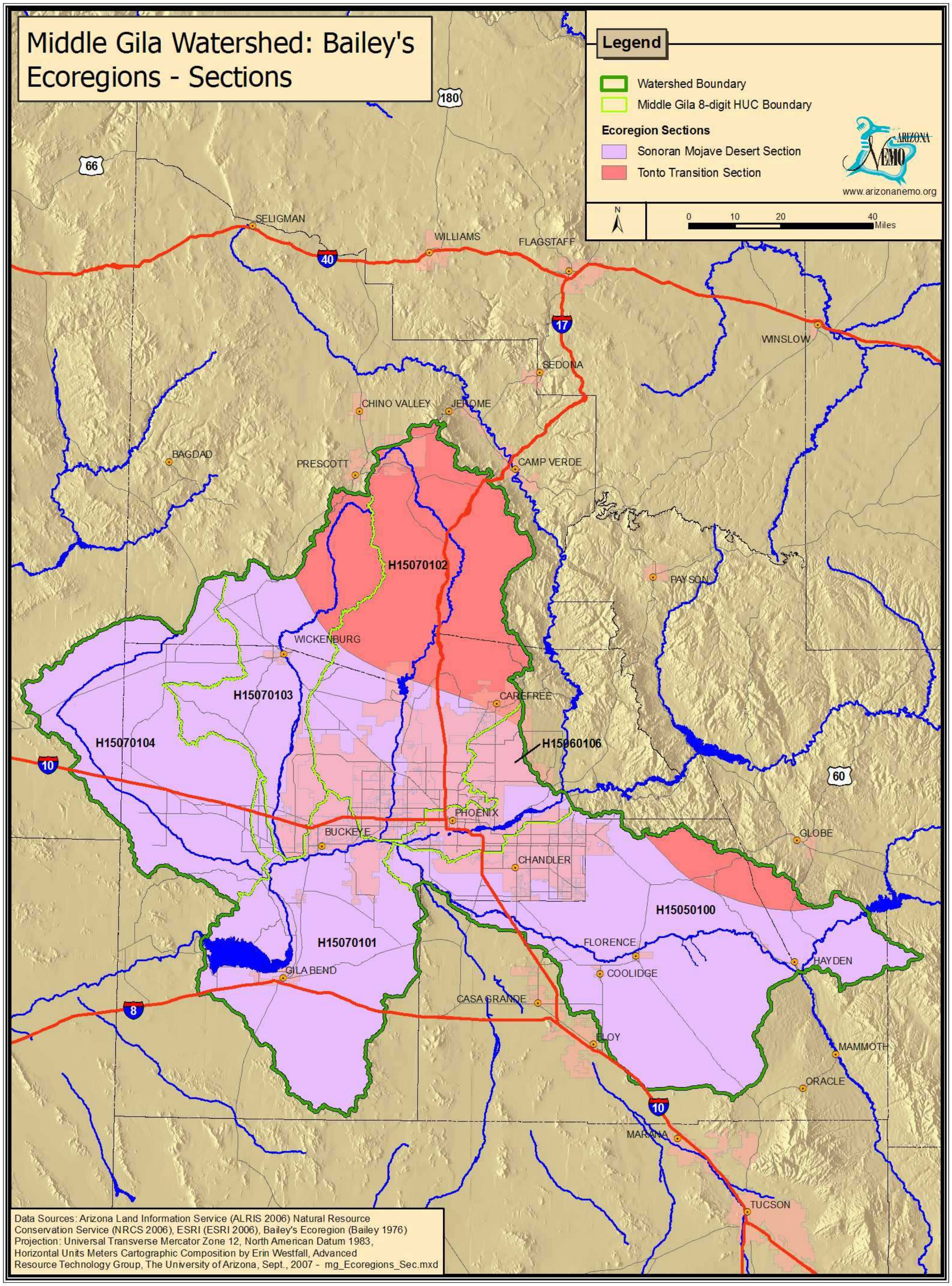

Figure 3-3: Bailey's Ecoregions - Sections

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 Tropical/Subtropical Steppe Division occurs in the northern portion of the watershed (Figure 3-1). This is a hot, semiarid climate where potential evaporation exceeds precipitation, and where all months have temperatures above 32°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 two Provinces in the Middle Gila Watershed: the Colorado Plateau Semi-Desert Province, and the American Semi-Desert and Desert Province, corresponding respectively to the Tonto Transition, and the Sonoran Mohave Desert Sections.

The Colorado Plateau Semi-Desert Province and Tonto Transition Section is found in the northern 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). Summer rains are thunderstorms, with gentler rains during the winter.

The American Semi-Desert and Desert Province and Sonoran Mohave Desert Section (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 places have a near-woodland appearance, due to the treelike saguaro cactus, prickly pear cactus, ocotillo, creosote bush, and smoke tree.

Table 3-1: Middle Gila River Watershed Ecoregions - Divisions.

Subwatershed	**Tropical/ Subtropical Desert Division**		**Tropical/ Subtropical Steppe Division**		***Middle Gila River Area (sq. miles)***
	percent	**area (sq. miles)**	**percent**	**area (sq. miles)**	
Agua Fria River H15070102	40%	1,105	60%	1,680	2,785
Centennial Wash H15070104	100%	1,946	-	-	1,946
Hassayampa River H15070103	75%	1,089	25%	365	1,454
Lower Gila River above Painted Rock Dam H15070101	100%	2,012	-	-	2,012
Lower Salt River H15060106B	98%	496	2%	9	505
Middle Gila River H15050100	92%	3,070	8%	284	3,354
Middle Gila River Watershed	*81%*	*9,718*	*19%*	*2,338*	*12,056*

Table 3-2: Middle Gila River Watershed Ecoregions - Provinces.

Subwatershed	**American Semi-Desert and Desert Province**		**Colorado Plateau Semi-Desert Province**		***Middle Gila River Area (sq. miles)***
	percent	**area (sq. miles)**	**percent**	**area (sq. miles)**	
Agua Fria River H15070102	40%	1,105	60%	1,680	2,785
Centennial Wash H15070104	100%	1,946	-	-	1,946
Hassayampa River H15070103	75%	1,089	25%	365	1,454
Lower Gila River above Painted Rock Dam H15070101	100%	2,012	-	-	2,012
Lower Salt River H15060106B	98%	496	2%	9	505
Middle Gila River H15050100	92%	3,070	8%	284	3,354
Middle Gila River Watershed	*81%*	*9,718*	*19%*	*2,338*	*12,056*

Table 3-3: Middle Gila River Watershed Ecoregions - Sections.

Subwatershed	Sonoran Mojave Desert Section		Tonto Transition Section		*Middle Gila River Area (sq. miles)*
	percent	area (sq. miles)	percent	area (sq. miles)	
Agua Fria River H15070102	40%	1,105	60%	1,680	2,785
Centennial Wash H15070104	100%	1,946	-	-	1,946
Hassayampa River H15070103	75%	1,089	25%	365	1,454
Lower Gila River above Painted Rock Dam H15070101	100%	2,012	-	-	2,012
Lower Salt River H15060106B	98%	496	2%	9	505
Middle Gila River H15050100	92%	3,070	8%	284	3,354
Middle Gila River Watershed	*81%*	*9,718*	*19%*	*2,338*	*12,056*

Vegetation

Two different vegetation maps were created for the Middle Gila 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 nine different biotic communities in the Middle Gila Watershed. The primary community type over the entire watershed is the Lower Colorado River Sonoran Desert Scrub (43%), followed by the Arizona Upland Sonoran Desert Scrub (39%), with Interior Chaparral comprising 10%. 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, 32 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 Sonoran Paloverde-Mixed Cacti Desert Scrub encompassing 35.4% of the watershed. The next most common types are Sonora-Mojave Creosote bush – White Bursage Desert Scrub

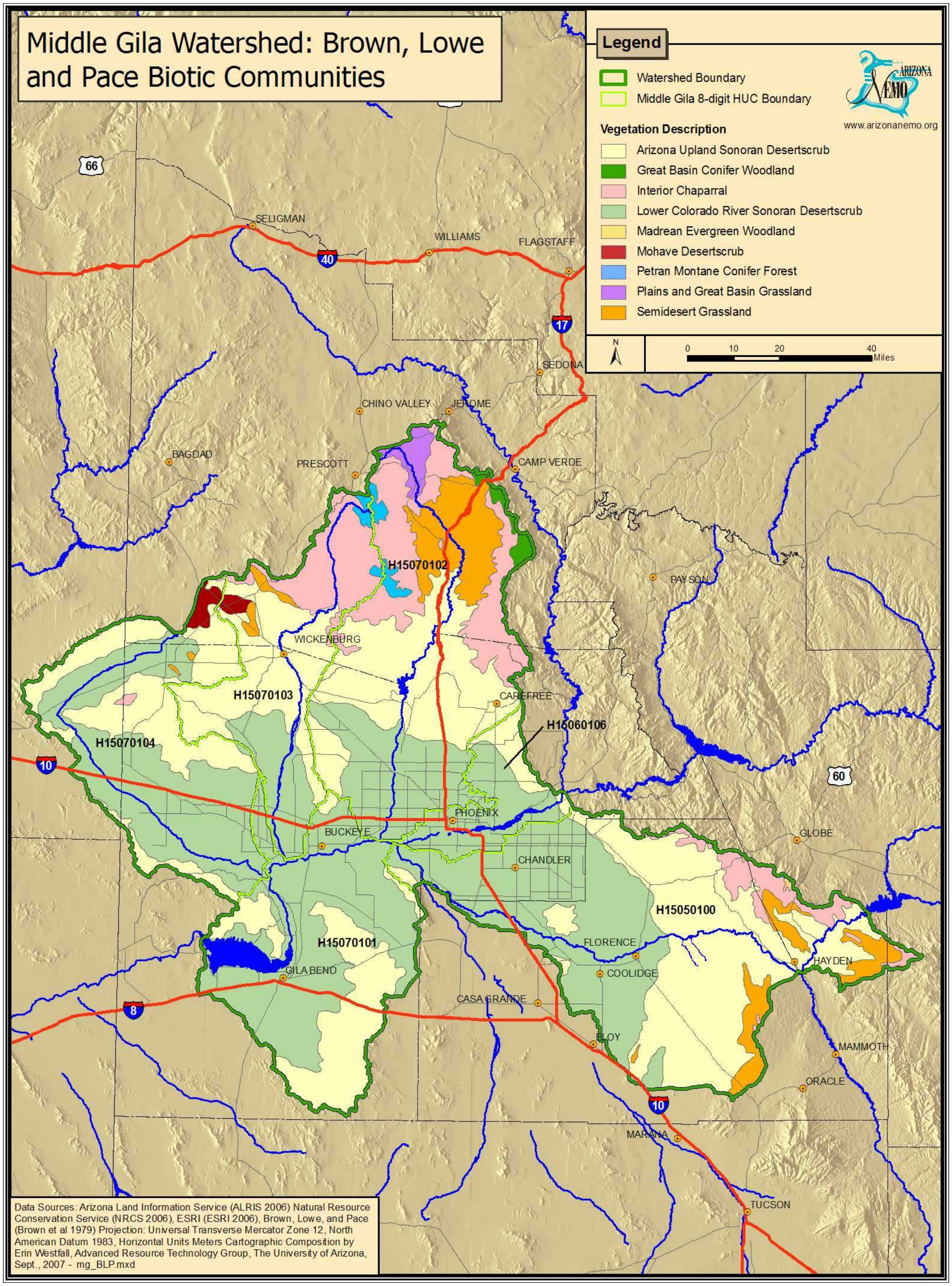

Figure 3-4: Brown, Lowe, and Pace Biotic Communities

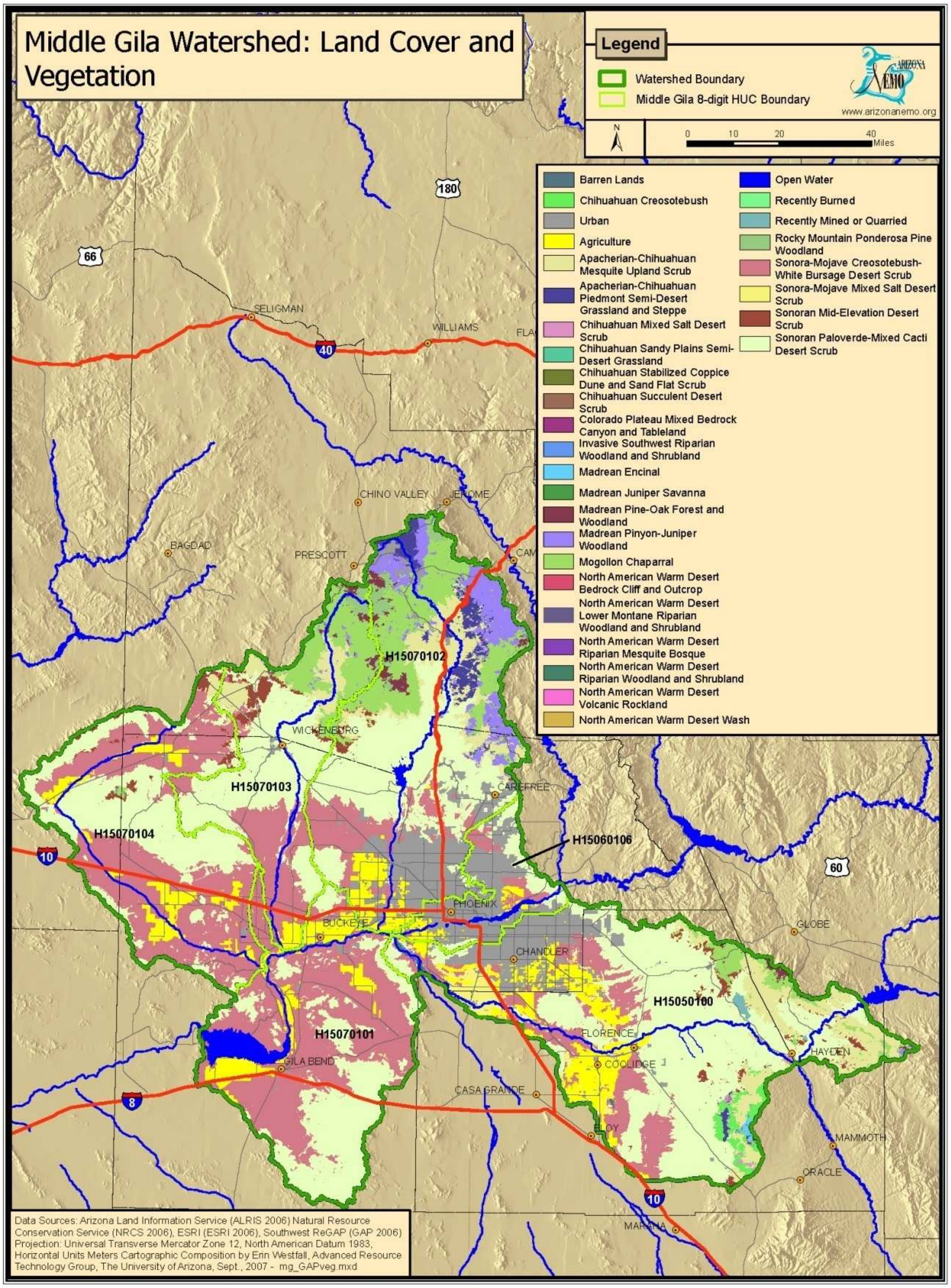

Figure 3-5: Land Cover and Vegetation

(24.9%), agriculture (7.2%), and Developed - High Intensity (7.1%). Figure 3-5 is a map of the Southwest Regional GAP Land Cover for the Middle Gila Watershed.

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

Biotic Community	**Agua Fria River H15070102**	**Centennial Wash H15070104**	**Hassayampa River H15070103**	**Lower Gila River above Painted Rock Dam H15070101**	**Lower Salt River H15060106B**
Arizona Upland Sonoran Desert Scrub	36%	39%	46%	33%	23%
Great Basin Conifer Woodland	2%	-	-	-	-
Interior Chaparral	22%	0.6%	26%	-	-
Lower Colorado River Sonoran Desert Scrub	22%	58%	22%	67%	77%
Madrean Evergreen Woodland	-	-	-	-	-
Mohave Desert Scrub	-	2%	1%	-	-
Petran Montane Conifer Forest	2%	-	2%	-	-
Plains and Great Basin Grassland	3%	-	-	-	-
Semidesert Grassland	14%	0.2%	3%	-	-
Area (square miles)	*2,785*	*1,946*	*1,454*	*2,012*	*505*

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

Biotic Community	**Middle Gila River H15050100**	***Middle Gila River Watershed***
Arizona Upland Sonoran Desert Scrub	46%	*39%*
Great Basin Conifer Woodland	-	*0.5%*
Interior Chaparral	6%	*10%*
Lower Colorado River Sonoran Desert Scrub	41%	*43%*
Madrean Evergreen Woodland	0.2%	*0.05%*
Mohave Desert Scrub	-	*0.5%*
Petran Montane Conifer Forest	0.05%	*0.6%*
Plains and Great Basin Grassland	-	*0.7%*
Semidesert Grassland	7%	*5.5%*
Area (square miles)	*3,334*	*12,056*

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

Land Cover	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101
Agriculture	3.8%	8.7%	1.9%	10.2%
Apacherian-Chihuahuan Mesquite Upland Scrub	9.0%	1.5%	8.8%	0.1%
Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	4.6%	-	0.1%	-
Barren Lands	0.04%	0.3%	0.2%	0.02%
Chihuahuan Creosotebush	0.02%	>0.00%	0.01%	-
Chihuahuan Mixed Salt Desert Scrub	-	-	-	-
Chihuahuan Sandy Plains Semi-Desert Grassland	-	-	-	-
Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	-	-	-	-
Chihuahuan Succulent Desert Scrub	-	-	-	-
Colorado Plateau Mixed Bedrock Canyon and Tableland	0.07%	-	0.04%	-
Developed – Low Intensity	2.7%	0.1%	0.6%	0.6%
Developed – High Intensity	12.3%	0.3%	0.4%	0.9%
Invasive Southwest Riparian Woodland and Shrubland	0.01%	0.05%	0.01%	0.4%
Madrean Encinal	0.01%	-	>0.00%	-
Madrean Juniper Savanna	0.6%	>0.00%	0.2%	-
Madrean Pine-Oak Forest and Woodland	2.6%	>0.00%	2.4%	-
Madrean Pinyon-Juniper Woodland	10.7%	0.2%	3.1%	0.01%
Mogollon Chaparral	13.6%	0.3%	14.6%	0.01%
North American Warm Desert Bedrock Cliff and Outcrop	-	0.2%	0.1%	-
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	0.3%	-	-	-
North American Warm Desert Riparian Mesquite Bosque	0.06%	-	0.1%	0.7%
North American Warm Desert Riparian Woodland and Shrubland	0.1%	0.1%	0.1%	0.5%
North American Warm Desert Volcanic Rockland	-	-	-	-
North American Warm Desert Wash	0.01%	0.01%	0.03%	>0.00%

Land Cover	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101
Open Water	0.5%	0.1%	0.01%	0.05%
Recently Burned	0.02%	-	0.01%	-
Recently Mined or Quarried	0.02%	-	0.03%	-
Rocky Mountain Ponderosa Pine Woodland	1.9%	-	1.9%	-
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	9.3%	46.8%	20.5%	51%
Sonora-Mojave Mixed Salt Desert Scrub	0.08%	0.3%	0.2%	0.5%
Sonoran-Mojave Mid-Elevation Desert Scrub	1.3%	3.8%	4.4%	0.2%
Sonoran Paloverde-Mixed Cacti Desert Scrub	26.2%	37.2%	40.3%	34.8%
Area (square miles)	*2,785*	*1,946*	*1,454*	*2,012*

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

Land Cover	Lower Salt River H15060106B	Middle Gila River H15050100	*Middle Gila River Watershed*
Agriculture	8.91%	9.3%	*7.2%*
Apacherian-Chihuahuan Mesquite Upland Scrub	0.04%	8.5%	*5.8%*
Apacherian-Chihuahuan Piedmont Semi-Desert Grassland and Steppe	-	0.4%	*1.2%*
Barren Lands	0.04%	0.2%	*0.1%*
Chihuahuan Creosotebush	-	2.5%	*0.7%*
Chihuahuan Mixed Salt Desert Scrub	-	0.6%	*0.2%*
Chihuahuan Sandy Plains Semi-Desert Grassland	-	0.01%	*> 0.00%*
Chihuahuan Stabilized Coppice Dune and Sand Flat Scrub	-	0.02%	*0.01%*
Chihuahuan Succulent Desert Scrub	-	0.04%	*0.01%*
Colorado Plateau Mixed Bedrock Canyon and Tableland	-	0.04%	*0.03%*
Developed – Low Intensity	7.13%	2.5%	*1.8%*
Developed – High Intensity	50.5%	6.8%	*7.1%*
Invasive Southwest Riparian Woodland and Shrubland	0.2%	0.2%	*0.1%*
Madrean Encinal	-	0.2%	*0.06%*
Madrean Juniper Savanna	-	0.05%	*0.2%*

Land Cover	**Lower Salt River H15060106B**	**Middle Gila River H15050100**	***Middle Gila River Watershed***
Madrean Pine-Oak Forest and Woodland	-	0.6%	*1.1%*
Madrean Pinyon-Juniper Woodland	-	0.8%	*3.1%*
Mogollon Chaparral	0.01%	3.3%	*5.9%*
North American Warm Desert Bedrock Cliff and Outcrop	-	0.03%	*0.01%*
North American Warm Desert Lower Montane Riparian Woodland and Shrubland	-	0.02%	*0.07%*
North American Warm Desert Riparian Mesquite Bosque	0.12%	0.4%	*0.3%*
North American Warm Desert Riparian Woodland and Shrubland	0.2%	0.3%	*0.2%*
North American Warm Desert Volcanic Rockland	-	>0.00%	*> 0.00%*
North American Warm Desert Wash	> 0.00%	0.04%	*0.02%*
Open Water	0.4%	0.04%	*0.2%*
Recently Burned	-	-	*0.01%*
Recently Mined or Quarried	-	0.4%	*0.1%*
Rocky Mountain Ponderosa Pine Woodland	-	0.04%	*0.7%*
Sonora-Mojave Creosotebush-White Bursage Desert Scrub	11.5%	13.2%	*24.9%*
Sonora-Mojave Mixed Salt Desert Scrub	0.1%	3.4%	*1.1%*
Sonoran-Mojave Mid-Elevation Desert Scrub	0.2%	3.8%	*2.5%*
Sonoran Paloverde-Mixed Cacti Desert Scrub	20.6%	42.4%	*35.4%*
Area (square miles)	*505*	*3,354*	*12,056*

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 Middle Gila Watershed (Figure 3-6).

Seven of the ten different types of riparian areas occur within this watershed (Table 3-6). Riparian areas

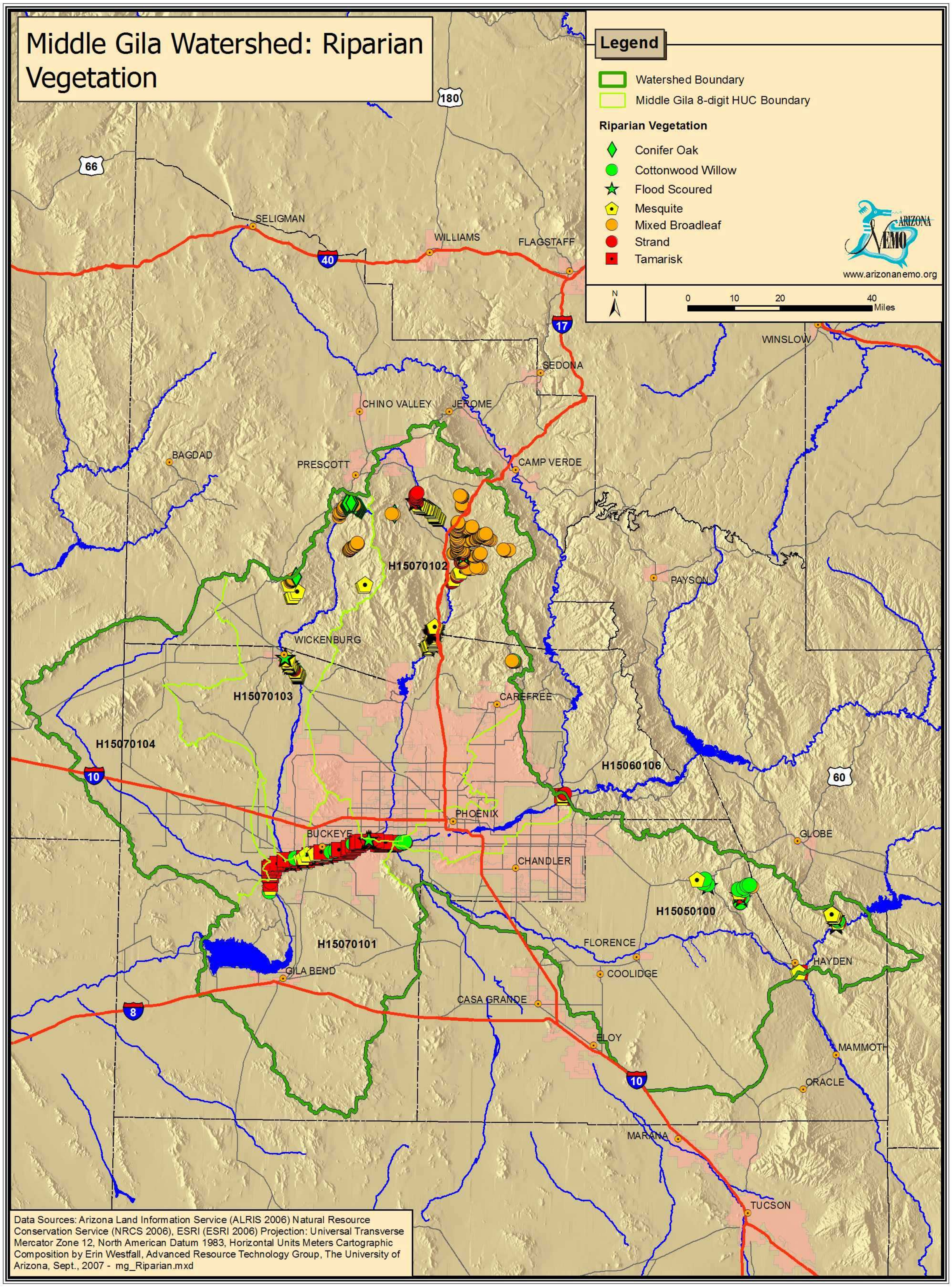

Figure 3-6: Riparian Vegetation

encompass approximately 24,657 acres (39 square miles) or 0.32% of the entire watershed. Tamarisk comprises about 11,339 acres (18 square miles, or 43% of the riparian areas), and Strand (the area alongside the stream channel) comprises about 8,691 acres (14 square miles, or 33% of the riparian areas).

The Lower Gila River above Painted Rock Dam subwatershed has the greatest amount of riparian vegetation with 19,619 acres (31 square miles). The Agua Fria and the Middle Gila River subwatersheds have the next largest amounts of riparian vegetation with 1,715 acres and 809 acres respectively. Table 3-6 contains the list of riparian vegetation types and areas for each subwatershed.

Critical Habitats

Critical habitats for four species (Gila Chub, Mexican Spotted Owl, Spike Dace, and Southwest Willow Flycatcher) are identified in the Middle Gila Watershed (Figure 3-7).

Major Land Resource Areas (MLRAs)

Major Land Resource Areas, or MLRA's, are ecosystem divisions in Arizona. There are five different MLRA's in the Middle Gila Watershed (Figure 3-8): Arizona and New Mexico Mountains, Central Arizona Basin and Range, Colorado and Green River Plateaus, Sonoran Basin and Range, and Southeastern Arizona Basin and Range (Table 3-7).

The Central Arizona Basin and Range MLRA has the largest representation with 58% (6,992 square miles) of the watershed. Sonoran Basin and Range is the next largest with 23% (2,773 square miles) of the entire watershed. The Lower Salt River subwatershed lies entirely within the Arizona and New Mexico Mountains and Central Arizona Basin and Range MLRAs (Cassady, 2000).

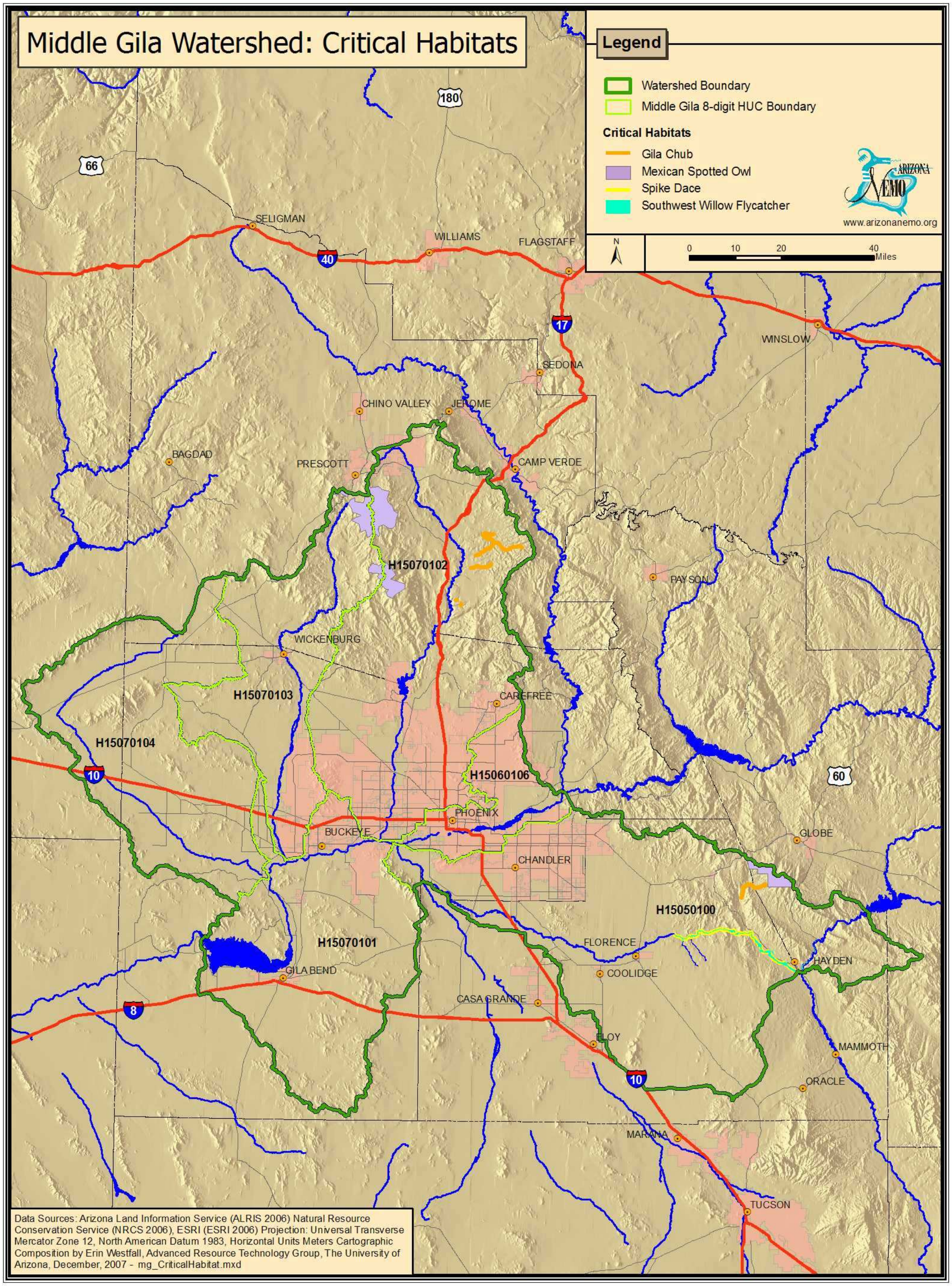

Figure 3-7: Critical Habitats

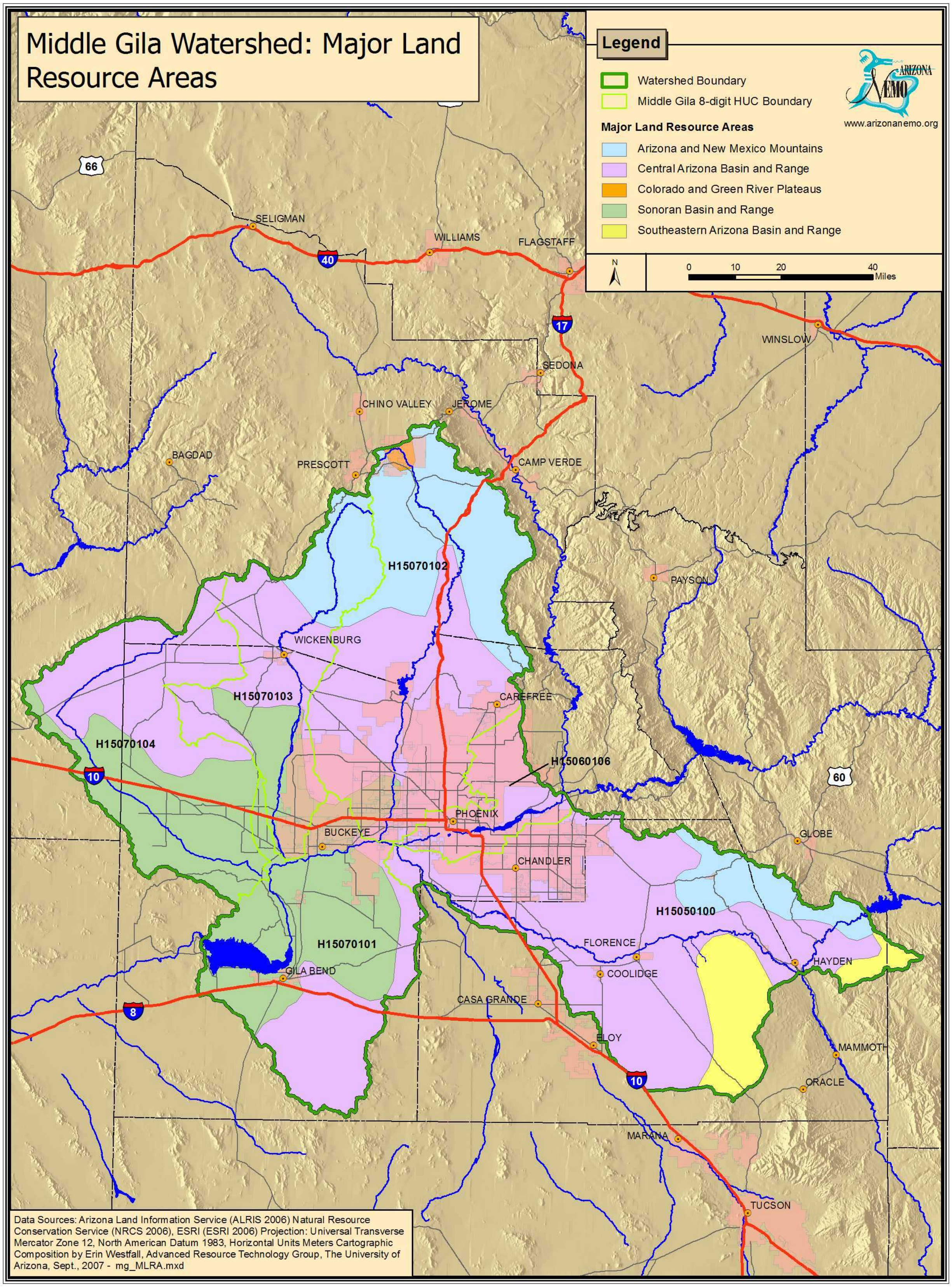

Figure 3-8: Major Land Resource Areas

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

Riparian Vegetation Community	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106b
Conifer Oak	2	-	81	-	-
Cottonwood Willow	3	-	176	112	38
Flood Scoured	161	-	52	515	-
Mesquite	185	-	241	784	20
Mixed Broadleaf	1,026	-	120	-	-
Strand	338	-	112	7,338	680
Tamarisk	1	228	149	10,870	71
Total Area (acres)	*1,715*	*228*	*931*	*19,619*	*809*

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

Riparian Vegetation Community	Middle Gila River H15050100	***Middle Gila River Watershed***
Conifer Oak	-	*83*
Cottonwood Willow	688	*1,017*
Flood Scoured	122	*850*
Mesquite	197	*1,427*
Mixed Broadleaf	105	*1,251*
Strand	223	*8,691*
Tamarisk	20	*11,339*
Total Area (acres)	*1,355*	*24,657*

Table 3-7: Middle Gila River Watershed - Major Land Resource Areas (percent per Subwatershed) (Part 1 of 2).

Subwatershed	Major Land Resource Areas (percent per subwatershed)			Middle Gila River Watershed Area (square miles)
	Arizona and New Mexico Mountains	Central Arizona Basin and Range	Colorado and Green River Plateaus	
Agua Fria River H15070102	37.6%	58.5%	1.1%	2,785
Centennial Wash H15070104	-	50%	-	1,946
Hassayampa River H15070103	26.2%	47.8%	-	1,454
Lower Gila River above Painted Rock Dam H15070101	-	35.3%	-	2,012
Lower Salt River H15060106B	-	100%	-	505
Middle Gila River H15050100	11.3%	73.7%	-	3,354
Middle Gila River Watershed (percent)	15%	58%	0.25%	12,056

Table 3-7: Middle Gila River Watershed - Major Land Resource Areas (percent per Subwatershed) (Part 2 of 2).

Subwatershed	Major Land Resource Areas (percent per subwatershed)		Middle Gila River Watershed Area (square miles)
	Sonoran Basin and Range	Southeastern Arizona Basin and Range	
Agua Fria River H15070102	3.1%	-	2,785
Centennial Wash H15070104	50%	-	1,946
Hassayampa River H15070103	26%	-	1,454
Lower Gila River above Painted Rock Dam H15070101	64.7%	-	2,012
Lower Salt River H15060106	-	-	505
Middle Gila River H15050100	-	15.0%	3,354
Middle Gila River Watershed (percent)	23%	4%	12,056

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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 Middle Gila Watershed is located in six counties: Gila, Graham, La Paz, Maricopa, Pinal and Yavapai as shown in Figure 4-1. The majority of the watershed lies in three counties, with 53% in Maricopa, 21% in Pinal and 19% in Yavapai County (Table 4-1).

Two of the subwatersheds are located at or near 100% in Maricopa County. These are the Lower Gila River above Painted Rock Dam (99.9%) and the Lower Salt River (100%) subwatersheds.

Council of Governments (COGs)

Five Councils of Governments (COGs) are present in the Middle Gila Watershed, the Central Arizona Association of Governments (CAAG), Maricopa Association of Governments (MAG), the Northern Arizona Council of Governments (NACOG), Southeastern Arizona Governments Organization (SEAGO) and the Western Arizona Council of Governments (WACOG). (Figure 4-2). These five COGs correspond to the counties described above. The MAG represents 53% of the watershed, or the Maricopa County portion, CAAG represents the Pinal County portion, or 23%, and NACOG represents the Yavapai County portion, or 19%. WACOG, represents the La Paz portion, or 4%, and SEAGO, represents the Graham County portion, or 0.2% of the watershed (Table 4-2).

Table 4-1: Middle Gila Watershed Percent of Subwatershed by County (Part 1 of 2).

Subwatershed and HUC Middle Gila River Watershed	Area (sq. mi.)	Gila	Graham	La Paz	Maricopa
Agua Fria River H15070102	2,785	-	-	-	48.9%
Centennial Wash H15070104	1,946	-	-	27.7%	63.7%
Hassayampa River H15070103	1,454	-	-	-	52.7%
Lower Gila River above Painted Rock Dam H15070101	2,012	-	-	-	99.9%
Lower Salt River H15060106B	505	-	-	-	100%
Middle Gila River H15050100	3,354	6.8%	0.8%	-	15.8%
Total Middle Gila River Watershed	*12,056*	*1.9%*	*0.2%*	*5%*	*53%*

Table 4-1: Middle Gila Watershed Percent of Subwatershed by County (Part 2 of 2).

Subwatershed and HUC Middle Gila River Watershed	**Area (sq. mi.)**	**Pinal**	**Yavapai**
Agua Fria River H15070102	2,785	-	51.1
Centennial Wash H15070104	1,946	-	8.7%
Hassayampa River H15070103	1,454	-	47.3%
Lower Gila River above Painted Rock Dam H15070101	2,012	0.1%	-
Lower Salt River H15060106B	505	-	-
Middle Gila River H15050100	3,354	76.6%	-
Total Middle Gila River Watershed	*12,056*	*21%*	*19%*

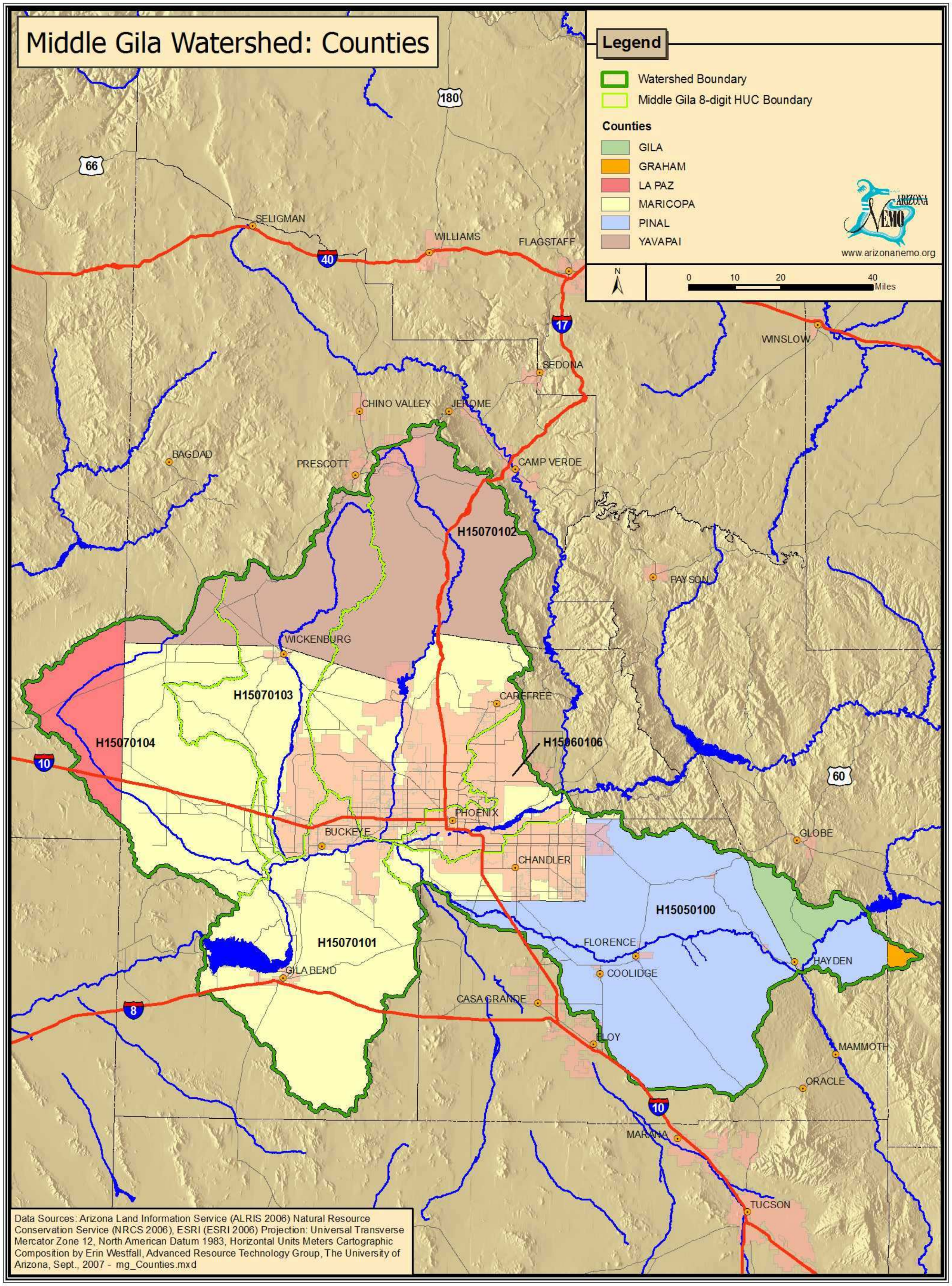

Figure 4-1: Counties

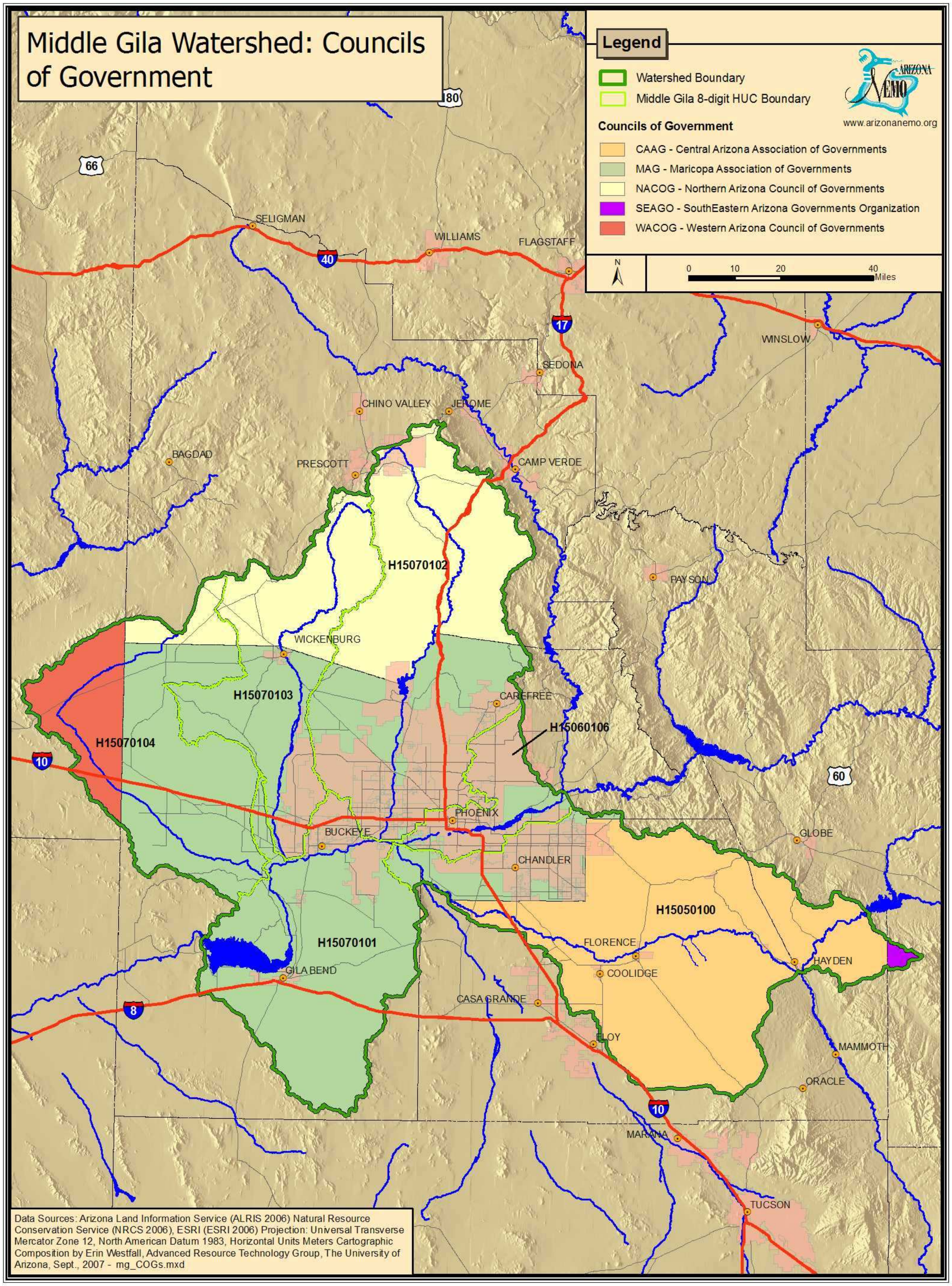

Figure 4-2: Councils of Government

Table 4-2: Middle Gila Watershed Councils of Governments, Percent by Subwatershed.

Subwatershed Name and HUC	**Councils Of Governments**				
	CAAG[1]	**MAG[2]**	**NACOG[3]**	**SEAGO[4]**	**WACOG[5]**
Agua Fria River H15070102	-	48.9%	51.1%	-	-
Centennial Wash H15070104	-	63.7%	8.7%	-	27.7%
Hassayampa River H15070103	-	52.7%	47.3%	-	-
Lower Gila River above Painted Rock Dam H15070101	0.2%	99.8%	-	-	-
Lower Salt River H15060106B	-	100%	-	-	-
Middle Gila River H15050100	83.4%	15.8%	-	0.8%	-
Total Middle Gila River Watershed	*23%*	*53%*	*19%*	*0.2%*	*4%*

1 CAAG – Central Arizona Association of Governments
2 MAG – Maricopa Association of Governments
3 NACOG – Northern Arizona Council of Governments
4 SEAGO – SouthEastern Arizona Governments Organization
5 WACOG – Western Arizona Council of Governments

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 ten major urban areas that lie partially within the Middle Gila Watershed: Avondale, Chandler, Gilbert, Glendale, Mesa, Peoria, Phoenix, Scottsdale, Surprise, and Tempe (Figure 4-3). Each of these urban areas lies partially within the Middle Gila Watershed. Phoenix has the largest area with 329,817 acres (515 square miles), most of which lies within the Middle Gila River subwatershed. Table 4-3 tabulates these areas.

A population density map was created using 2000 census block population data. Areas with a population density greater than 1,000 persons per square mile were determined (Figure 4-4). This classification yielded seventeen urban areas (Table 4-4). Guadalupe had the greatest density with 4,634 persons per square mile.

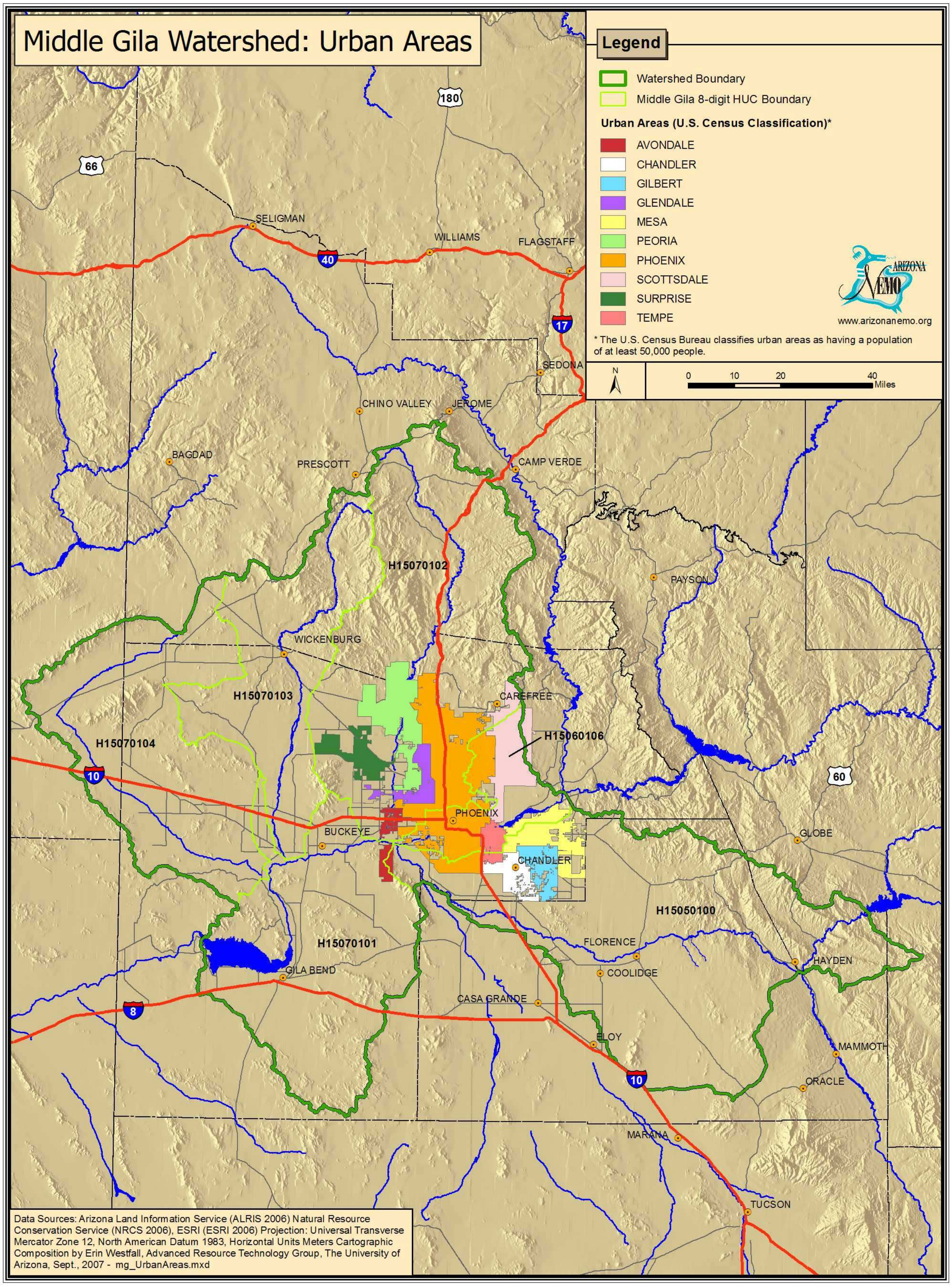

Figure 4-3: Urban Areas

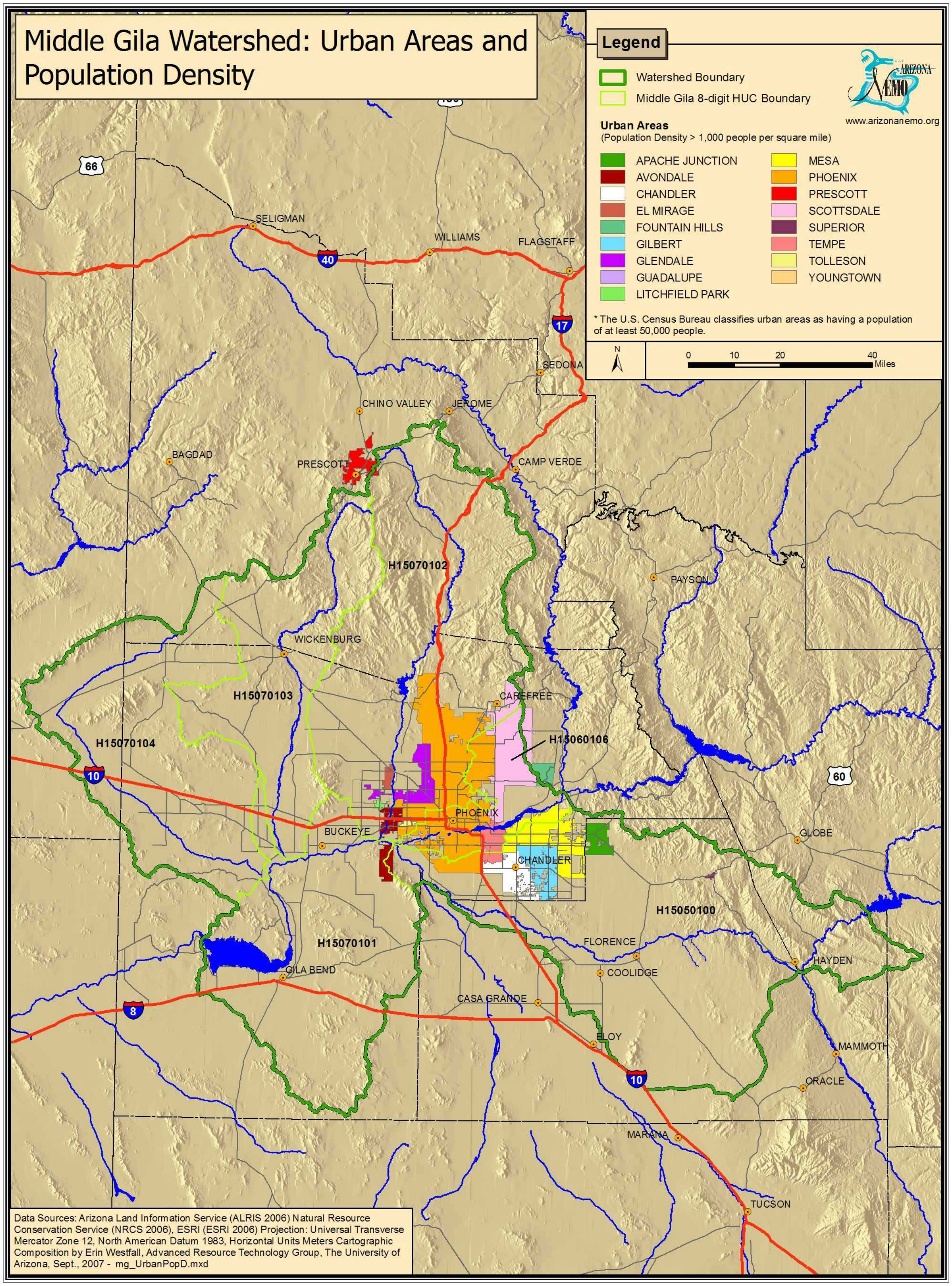

Figure 4-4: Urban Areas and Population Density

Table 4-3: Middle Gila Watershed Urban Areas (acres) (Part 1 of 2).

Sub-watershed Name	**Urban Area (acres)**				
	Avondale	**Chandler**	**Gilbert**	**Glendale**	**Mesa**
Agua Fria River H15070102	13,809	-	-	37,889	-
Centennial Wash H15070104	-	-	-	-	-
Hassayampa River H15070103	-	-	-	-	-
Lower Gila River above Painted Rock Dam H15070101	10,556	-	-	-	-
Lower Salt River H15060106B	25	-	-	-	20,120
Middle Gila River H15050100	4,003	40,997	41,508	-	63,898
Middle Gila River Watershed	*28,393*	*40,997*	*41,508*	*37,889*	*84,018*

Table 4-3: Middle Gila Watershed Urban Areas (acres) (Part 2 of 2).

Sub-watershed Name	**Urban Area (acres)**				
	Peoria	**Phoenix**	**Scottsdale**	**Surprise**	**Tempe**
Agua Fria River H15070102	113,855	177,476	19,775	53,138	-
Centennial Wash H15070104	-	-	-	-	-
Hassayampa River H15070103	-	-	-	-	-
Lower Gila River above Painted Rock Dam H15070101	-	-	-	-	-
Lower Salt River H15060106B	-	126,217	81,928	-	19,302
Middle Gila River H15050100	-	26,124	-	-	6,149
Middle Gila River Watershed	*113,855*	*329,817*	*101,703*	*53,138*	*25,451*

Table 4-4: Middle Gila Watershed Urban Areas Based on 2005 Population Density

Urban Areas	Population	Area (square miles)	Urban Area Density persons / sq. mi.
Apache Junction	34,070	34	1,002
Avondale	66,110	44	1,490
Chandler	231,785	64	3,618
El Mirage	29,630	10	2,957
Fountain Hills	23,105	20	1,141
Gilbert	178,000	65	2,745
Glendale	236,030	59	3,987
Guadalupe	5,425	1	4,634
Litchfield Park	4,265	3	1,288
Mesa	452,355	131	3,446
Phoenix	1,452,825	515	2,819
Prescott	40,770	39	1,056
Scottsdale	223,835	185	1,210
Superior	3,170	2	1,612
Tempe	160,735	40	4,042
Tolleson	5,460	5	1,182
Youngtown	4,055	1	3,464

* 2005 population estimate data obtained from the U.S. Census Bureau

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 used to create a density map (Figure 4-5), through a normalization process using a grid composed of 1 square mile grid cells. 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 4-5 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 175 persons per square mile. The Lower Salt River subwatershed had the highest population density with an average of 1,484 persons per square mile, and a maximum of 10,274. The Centennial Wash subwatershed had an average of only 1.0 person per square mile.

Table 4-5: Middle Gila Watershed 1990 Population Density (persons/square mile).

Sub-watershed Name	Area (sq. miles)	Min	Max	Mean
Agua Fria River H15070102	2,785	0	8,746	330
Centennial Wash H15070104	1,946	0	160	1
Hassayampa River H15070103	1,454	0	1,105	6
Lower Gila River above Painted Rock Dam H15070101	2,012	0	2,073	8
Lower Salt River H15060106B	505	0	10,274	1,484
Middle Gila River H15050100	3,354	0	8,570	163
Total Middle Gila River Watershed	*12,056*	*0*	*10,274*	*175*

Note: Adjacent watersheds may share a grid square.

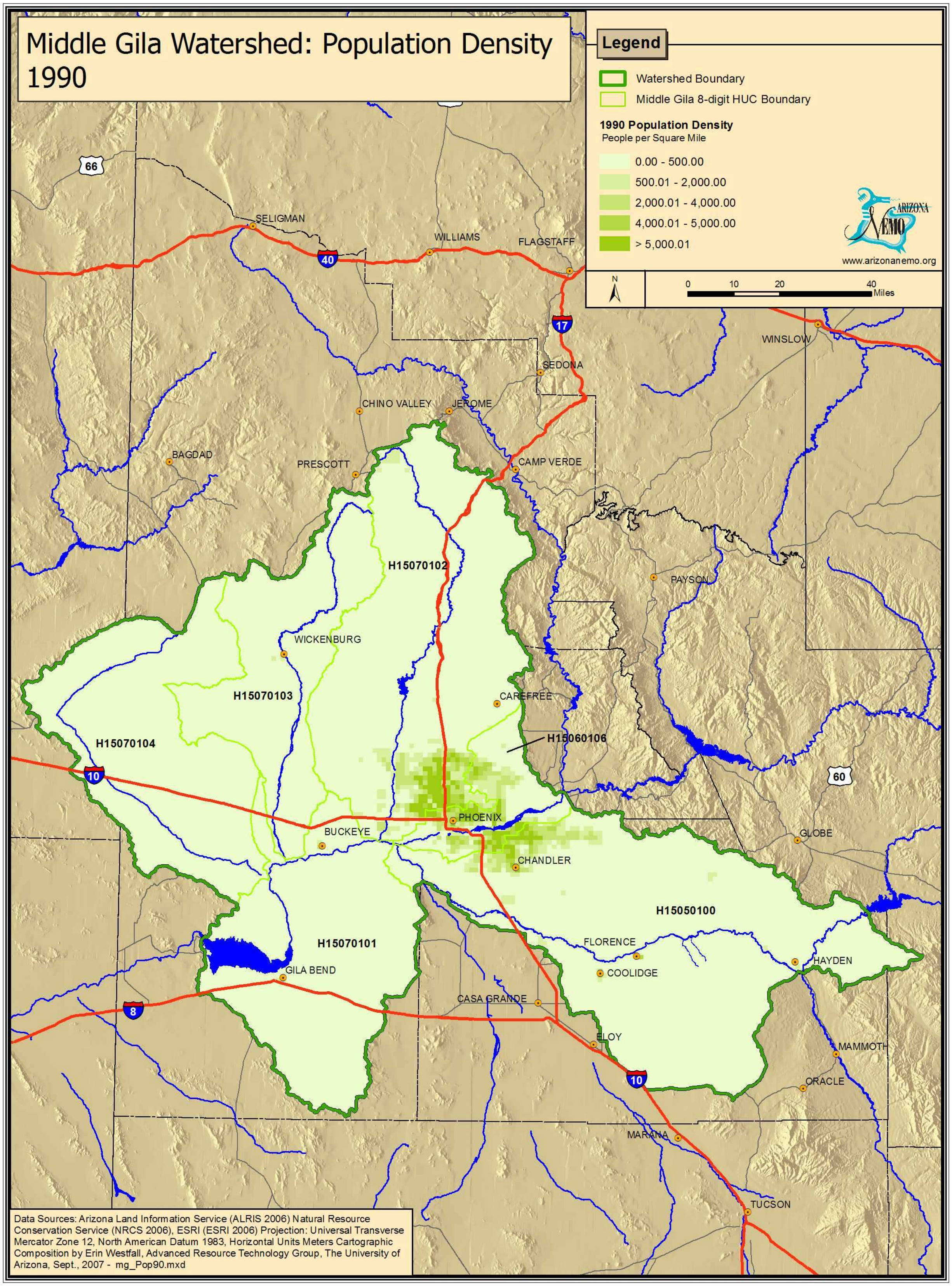

Figure 4-5: Population Density 1990

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 4-6. A population density map (Figure 4-6) was created from these data. The average population density in 2000 was 255 persons per square mile. The Lower Salt River subwatershed had the highest population density with 1,922 average persons per acre.

Population Change

The 1990 and 2000 population density maps were used to create a population density change map. The resulting map (Figure 4-7) shows population increase or decrease over the ten year time frame. Overall, population density increased by an average of 80 persons per square mile during this ten year time period. Three subwatersheds had fairly large increases in average population: Lower Salt River (438 persons/sq. mile), Agua Fria River (145 persons/sq. mile) and Middle Gila River (104 people/sq. mile). Table 4-7 shows the change in population density from 1990 to 2000 in persons per square mile.

Table 4-6: Middle Gila Watershed 2000 Population Density (persons/square mile).

Sub-watershed Name	**Area (sq. miles)**	**Min**	**Max**	**Mean**
Agua Fria River H15070102	2,785	0	13,565	475
Centennial Wash H15070104	1,946	0	600	3
Hassayampa River H15070103	1,454	0	1,224	9
Lower Gila River above Painted Rock Dam H15070101	2,012	0	2,846	14
Lower Salt River H15060106B	505	0	12,913	1,922
Middle Gila River H15050100	3,354	0	10,793	267
Total Middle Gila River Watershed	*12,056*	*0*	*13,565*	*255*

Note: Adjacent watersheds may share a grid square.

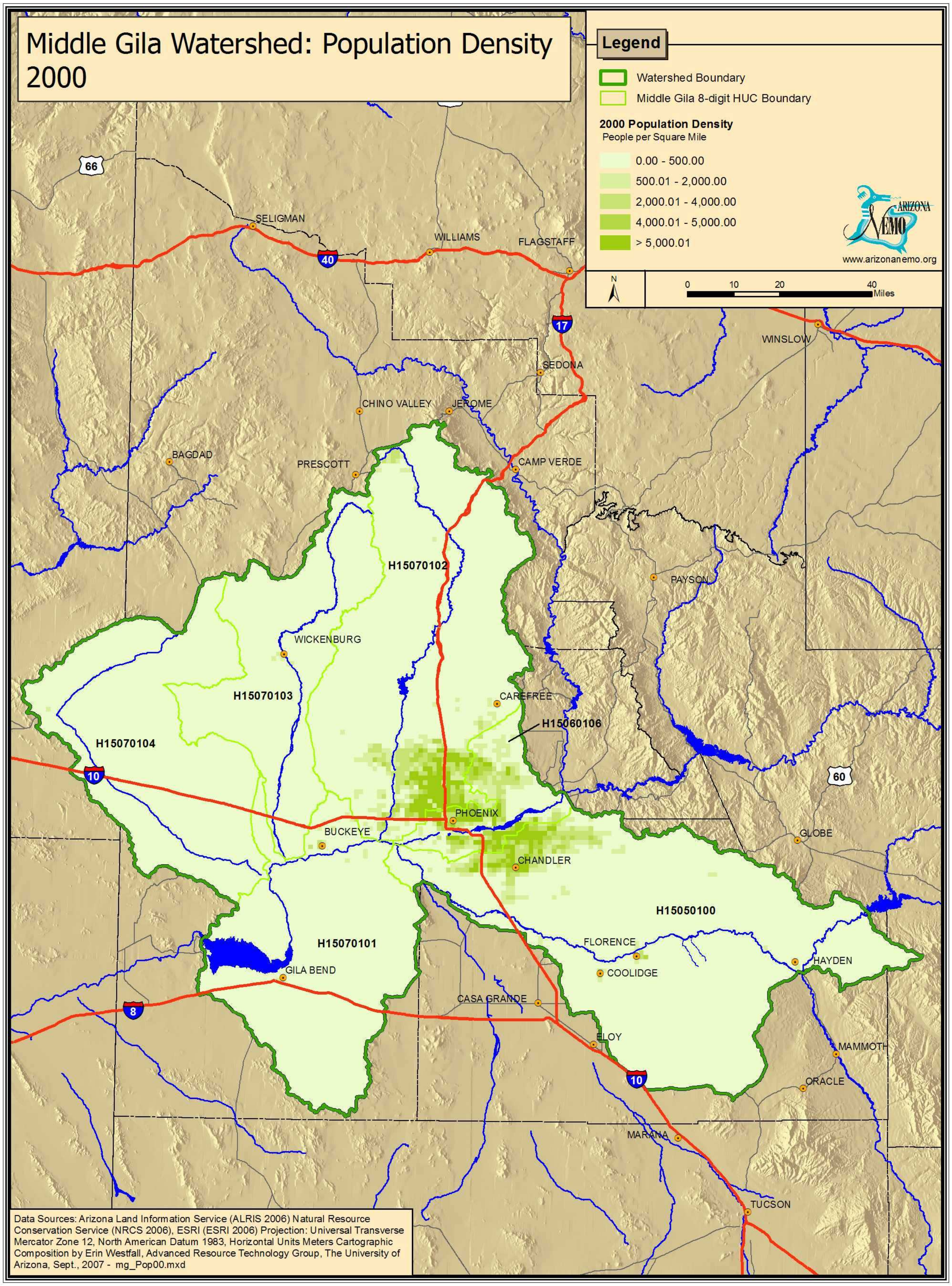

Figure 4-6: Population Density 2000

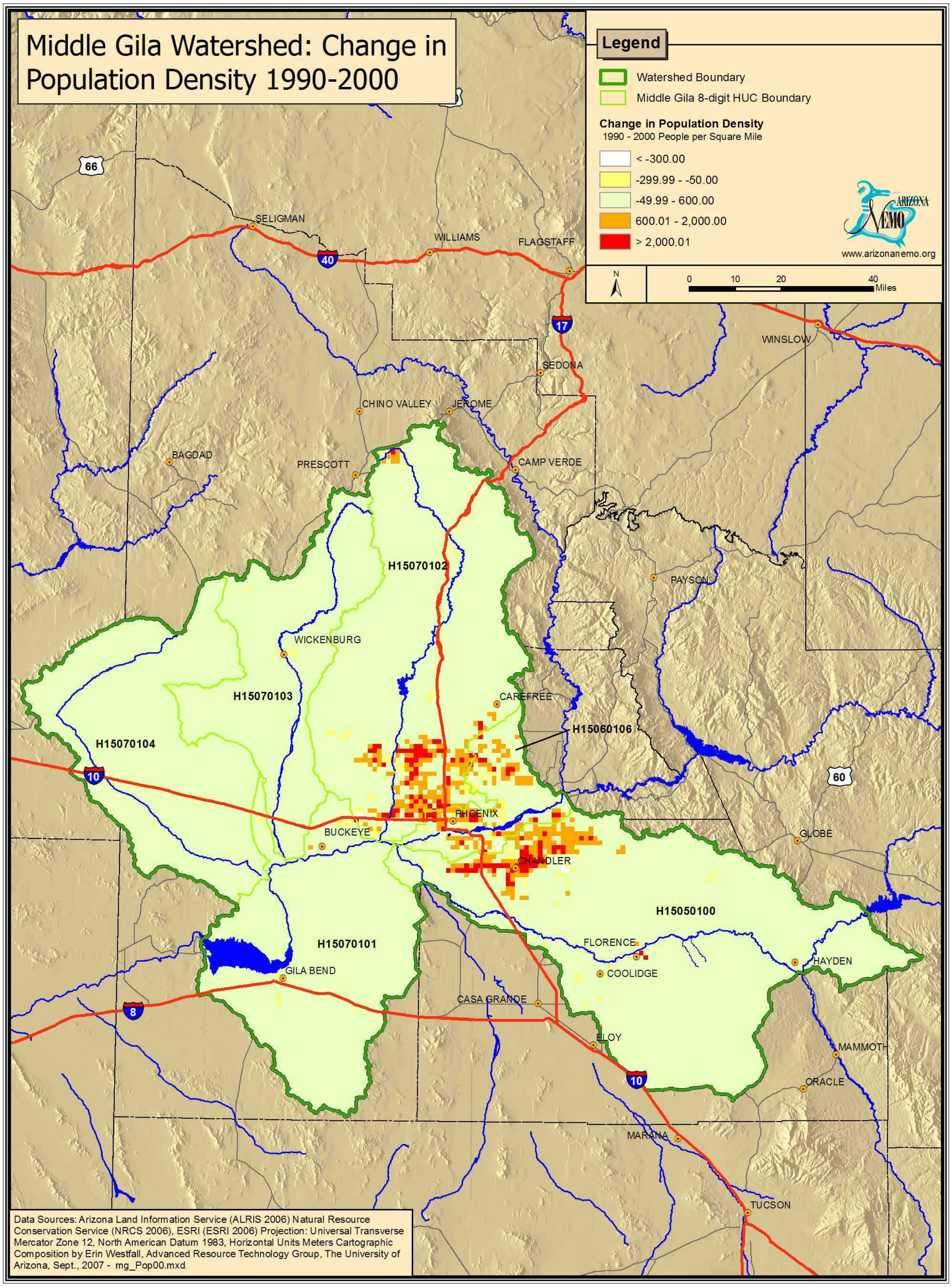

Figure 4-7: Change in Population Density 1990-2000

Table 4-7: Middle Gila Watershed Population Density Change 1990-2000 (persons/square mile).

Sub-watershed Name	Area (sq. miles)	Min	Max	Mean
Agua Fria River H15070102	2,785	-803	5,070	145
Centennial Wash H15070104	1,946	-61	567	2
Hassayampa River H15070103	1,454	-173	452	3
Lower Gila River above Painted Rock Dam H15070101	2,012	-687	2,542	6
Lower Salt River H15060106B	505	-780	6,413	438
Middle Gila River H15050100	3,354	-780	4,935	104
Total Middle Gila River Watershed	*12,056*	*-803*	*6,413*	*80*

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 developed 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.

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 more 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 4-8 and Table 4-8, Middle Gila River Watershed Housing Density for 2000, identifies that 75.1% of housing is located in "undeveloped private" areas, while 4.0% is located in "exurban" areas. Figure 4-9 and Table 4-9, Housing Density for 2030, projects "undeveloped private" areas decreasing to 46.8% and "exurban" areas increasing to 5.2%.

Table 4-8: Middle Gila Watershed 2000 Housing Density (Percent of Watershed) (part 1 of 2).*

Housing Density	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Undeveloped Private	56.4%	95.8%	89.1%	90.0%	37.8%
Rural	22.6%	4.0%	10.3%	9.3%	26.5%
Exurban	7.2%	0.2%	0.4%	0.6%	12.1%
Suburban	13.3%	0.05%	0.2%	0.2%	22.1%
Urban	0.5%	0.01%	0.01%	> 0.00%	1.5%

** 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 4-8: Middle Gila Watershed 2000 Housing Density (Percent of Watershed) (part 2 of 2).*

Housing Density	Middle Gila River H15050100	Middle Gila River Watershed
Undeveloped Private	78.9%	75.1%
Rural	12.0%	14.0%
Exurban	3.4%	4.0%
Suburban	5.5%	6.7%
Urban	0.2%	0.3%

** 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/

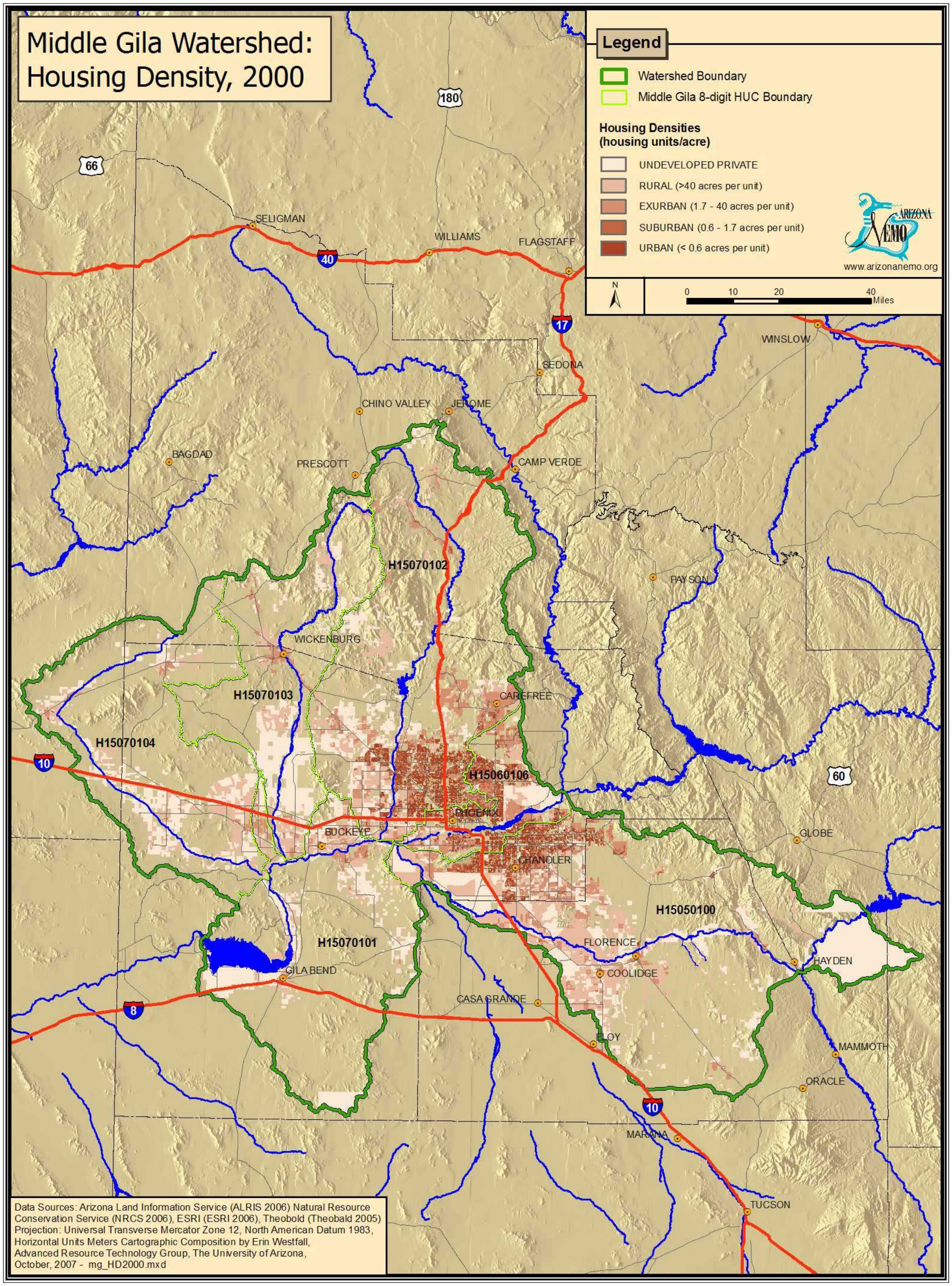

Figure 4-8: Housing Density 2000

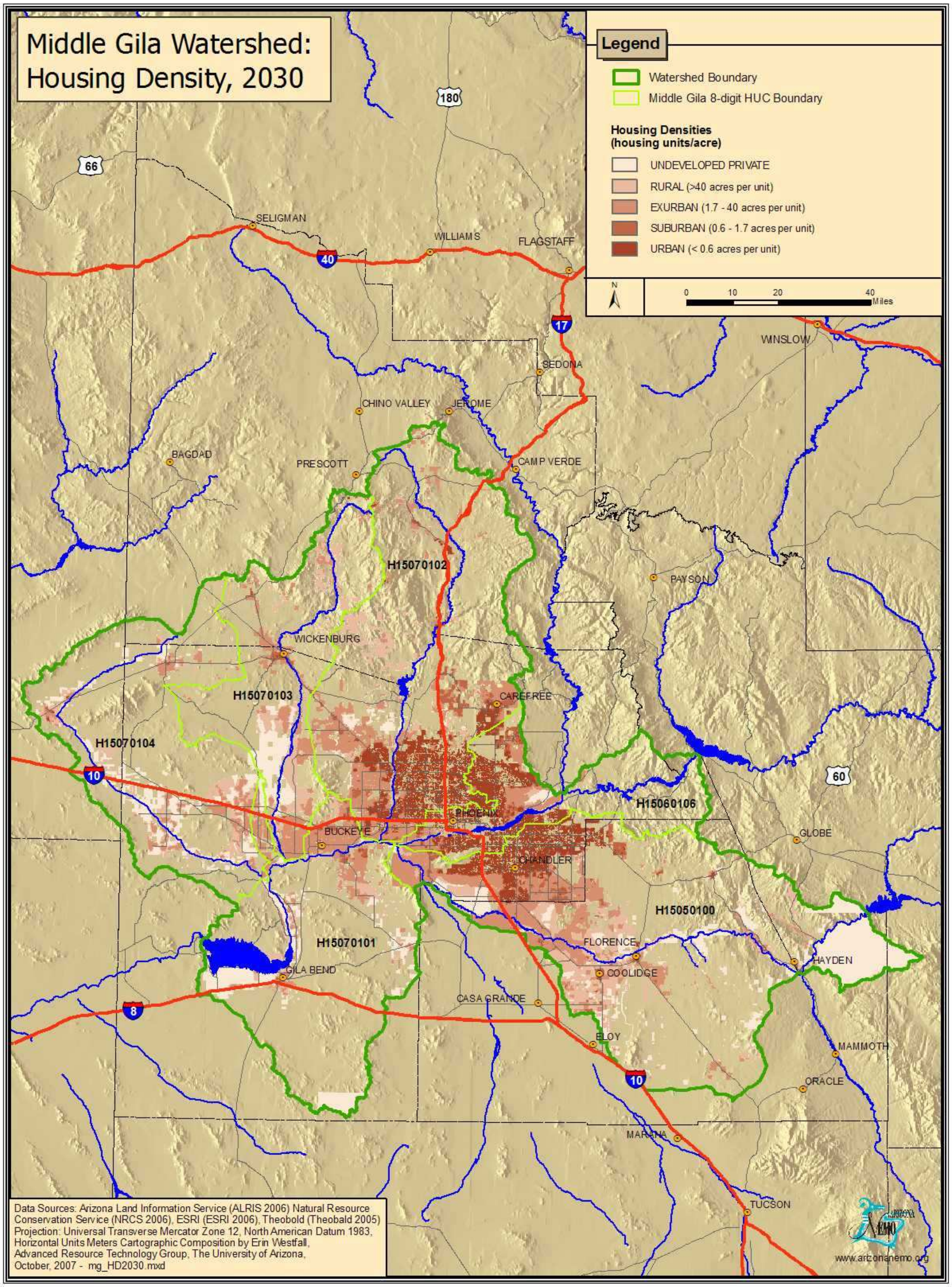

Figure 4-9: Housing Density 2030

Table 4.9: Middle Gila Watershed 2030 Housing Density (Percent of Watershed) (part 1 of 2).*

Housing Density	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Undeveloped Private	20.2%	77.0%	58.9%	62.2%	7.1%
Rural	39.1%	22.1%	37.9%	34.4%	27.2%
Exurban	9.3%	0.7%	2.6%	3.0%	11.7%
Suburban	30.3%	0.2%	0.7%	0.5%	51.3%
Urban	1.1%	0.01%	0.01%	> 0.00%	2.7%

** 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 4.9: Middle Gila Watershed 2003 Housing Density (Percent of Watershed) (part 2 of 2).*

Housing Density	Middle Gila River H15050100	Middle Gila River Watershed
Undeveloped Private	53.1%	46.8%
Rural	29.5%	31.9%
Exurban	4.3%	5.2%
Suburban	12.6%	15.4%
Urban	0.5%	0.7%

** 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/

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. Figure 4-10 shows the road types.

The total road length in the Middle Gila Watershed is 2,546 miles (Table 4-10).

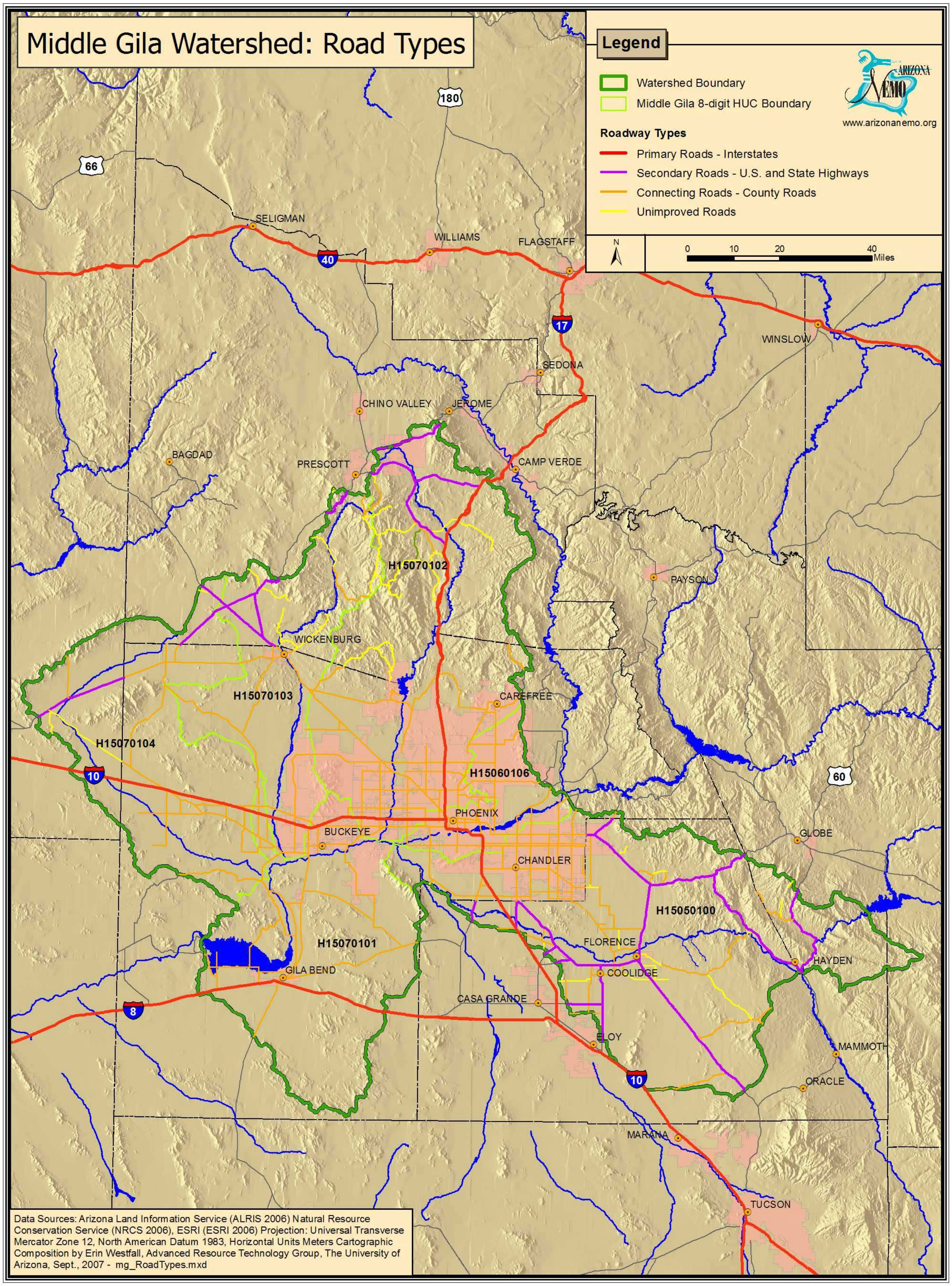

Figure 4-10: Road Types

The predominant road type, based on the Census Classification, is "county road" with 1,794 miles, or 70% of the total roads length. The Middle Gila River subwatershed has the greatest accumulated length of roads with 732 miles, or 29% of the total roads length. Table 4-11 lists road types and lengths in each subwatershed.

Table 4-10: Middle Gila Watershed Road Types.

Census Classification Code Middle Gila River Watershed	Road Length (miles)	Percent of Total Length
Interstate	64	2.5%
U.S. and State Hwys	383	15%
County Roads	1,794	70%
Unimproved Roads	305	12%
Total Road Length (miles)	*2,546*	*100%*

Table 4-11: Middle Gila Watershed Road Types and Lengths by Subwatershed.

Subwatershed Name	Road Length (miles)	Percent of Total Length
Agua Fria River H15070102	657	26%
Centennial Wash H15070104	299	12%
Hassayampa River H15070103	300	12%
Lower Gila River above Painted Rock Dam H15070101	346	14%
Lower Salt River H15060106B	212	8%
Middle Gila River H15050100	732	29%
Total Middle Gila River Watershed	*2,546*	*100%*

<u>Mines</u>

There are 2,699 mineral extraction mines recorded with the Office of the Arizona State Mine Inspector in the Middle Gila Watershed. The Agua Fria River subwatershed has the highest number of mines (1,061), while the Lower Gila River above Painted Rock Dam subwatershed has the fewest with only 89 mines.

There are eleven different types of mines reported of which the largest number are underground mines with 731 (27%) (Table 4-12 and Figure 4-11).

Mine activity status is shown in Table 4-13 and Figure 4-12, listing seven different types of mines. The largest category of mine status is "unknown" with 894 (33%) mines listed. Six hundred and seventy-nine (25%) are "explored prospect", and 663 (24%) are "past producer".

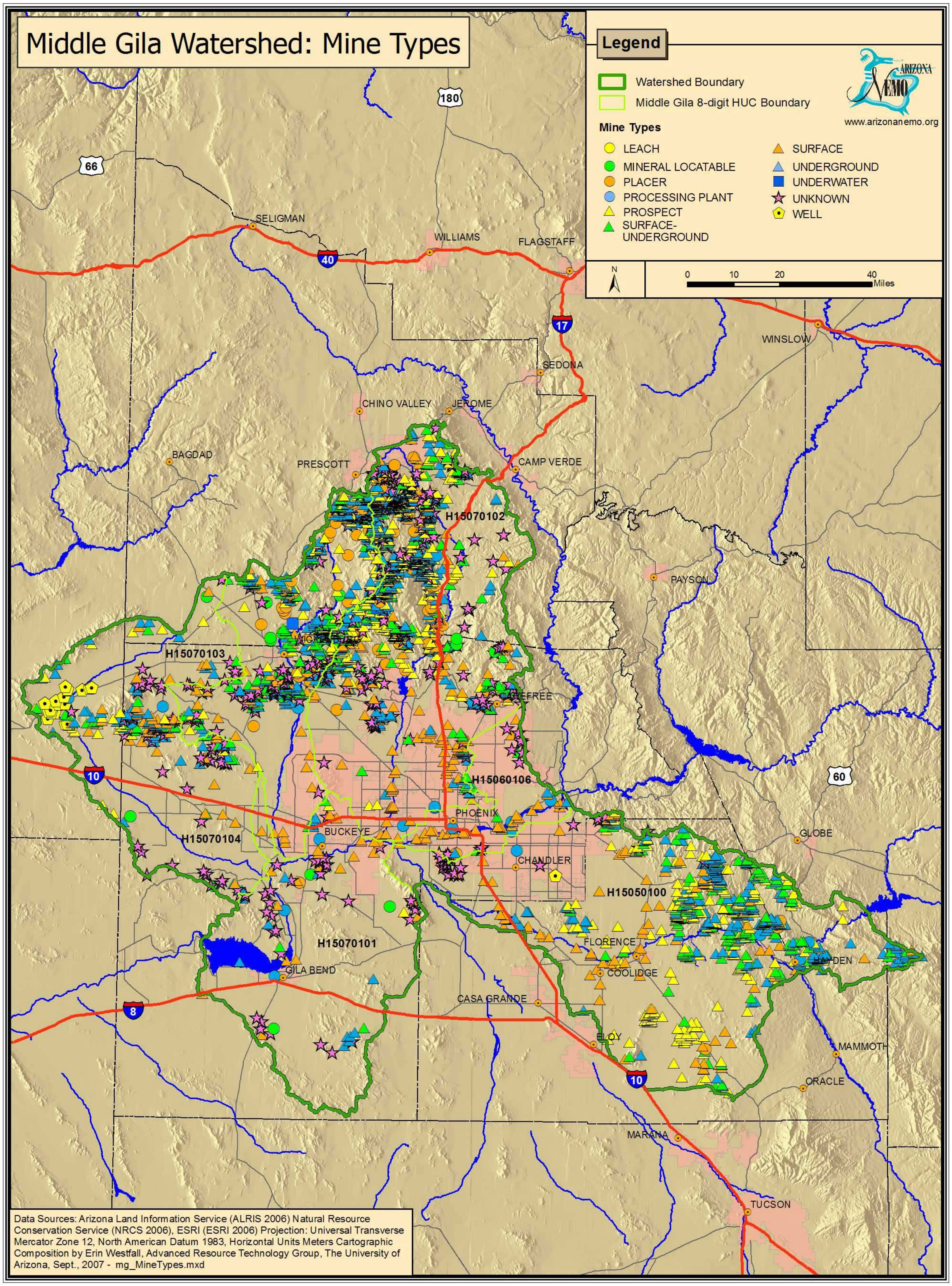

Figure 4-11: Mine Types

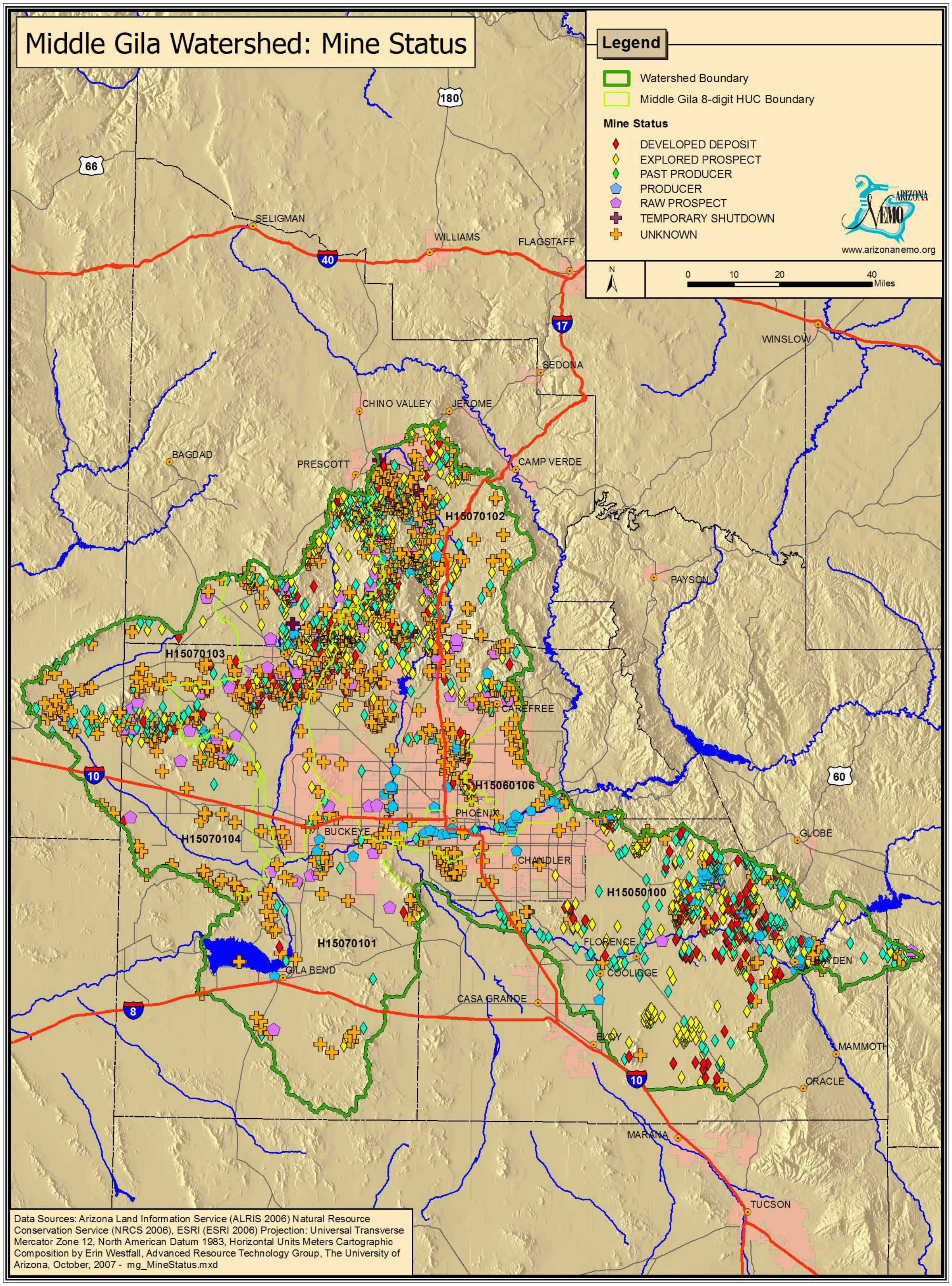

Figure 4-12: Mine Status

Table 4-14 and Figure 4-13 show the types of ores being mined in the Middle Gila Watershed. The most common known ore types (after "unknown") are gold, copper, sand, and silver.

Table 4-12: Middle Gila Watershed Mine Types (part 1 of 2).

Mine Types	**Agua Fria River H15070102**	**Centennial Wash H15070104**	**Hassayampa River H15070103**	**Lower Gila River above Painted Rock Dam H15070101**	**Lower Salt River H15060106B**
Leach	1	-	3	-	-
Mineral Locatable	6	3	11	3	-
Placer	55	-	40	2	1
Processing Plant	9	3	3	3	4
Prospect	228	28	85	2	-
Surface-Underground	108	25	100	3	6
Surface	124	52	47	21	35
Underground	295	48	164	17	3
Underwater	2	-	1	-	-
Unknown	233	56	103	38	18
Well	-	20	-	-	-
Total Mines	*1,061*	*235*	*557*	*89*	*67*

Table 4-12: Middle Gila Watershed Mine Types (part 2 of 2).

Mine Types	**Middle Gila River H15050100**	**Middle Gila River Watershed**
Leach	3	7
Mineral Locatable	-	23
Placer	4	102
Processing Plant	19	41
Prospect	206	549
Surface-Underground	136	378
Surface	95	374
Underground	204	731
Underwater	-	3
Unknown	22	470
Well	1	21
Total Mines	*690*	*2,699*

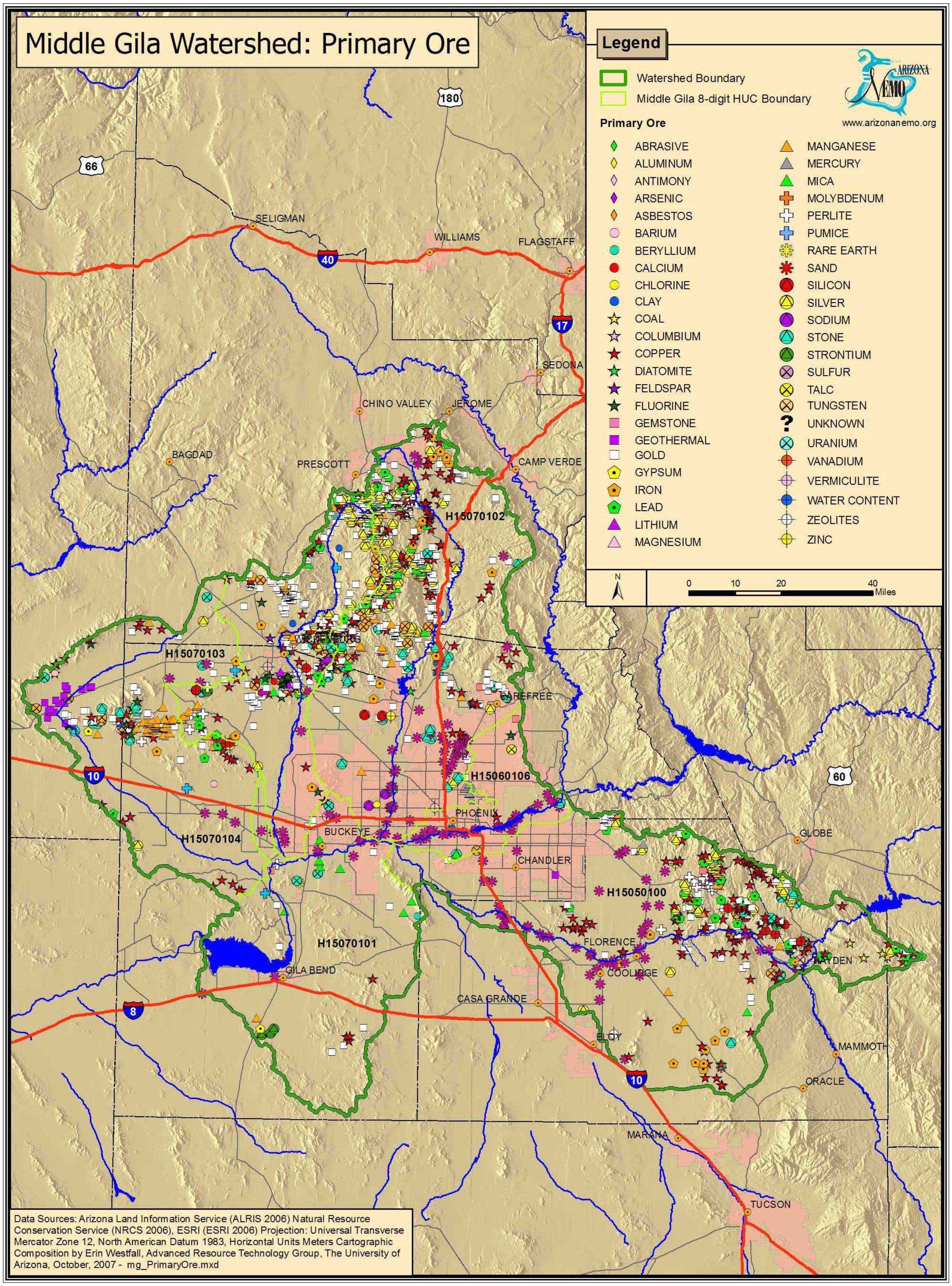

Figure 4-13: Primary Ore Types

Table 4-13: Middle Gila Watershed Mine Status (part 1 of 2).

Mine Types	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Developed Deposit	60	18	60	2	1
Explored Prospect	273	25	156	5	1
Past Producer	229	63	137	14	6
Producer	33	1	8	5	25
Raw Prospect	23	12	22	8	-
Temporary Shutdown	5	-	4	-	-
Unknown	438	116	170	55	34
Total Mines	*1,061*	*235*	*557*	*89*	*67*

Table 4-13: Middle Gila Watershed Mine Status (part 2 of 2).

Mine Types	Middle Gila River H15050100	Middle Gila River Watershed
Developed Deposit	136	277
Explored Prospect	219	679
Past Producer	214	663
Producer	45	117
Raw Prospect	4	69
Temporary Shutdown	1	10
Unknown	71	884
Total Mines	*690*	*2,699*

Table 4-14: Middle Gila Watershed Mines – Ore Type.

Ore Type	Total Number of Mines	Ore Type	Total Number of Mines
Abrasive	1	Manganese	83
Aluminum	1	Mercury	8
Antimony	1	Mica	23
Arsenic	1	Molybdenum	4
Asbestos	5	Perlite	25
Barium	9	Pumice	7
Beryllium	10	Rare Earth	1
Calcium	5	Sand	132
Chlorine	1	Silicon	3
Clay	6	Silver	150
Coal	4	Sodium	3
Columbium	2	Stone	33
Copper	369	Strontium	5
Diatomite	1	Sulfur	2
Feldspar	11	Talc	0
Fluorine	27	Tungsten	40
Gemstone	7	Unknown	930
Geothermal	22	Uranium	21
Gold	555	Vanadium	11
Gypsum	4	Vermiculite	3
Iron	42	Water Content	1
Lead	75	Zeolites	2
Lithium	6	Zinc	6
Magnesium	2		

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 4-14 and Table 4-15). 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 82% of the watershed. Urban is the next most common type with 9% of the total area.

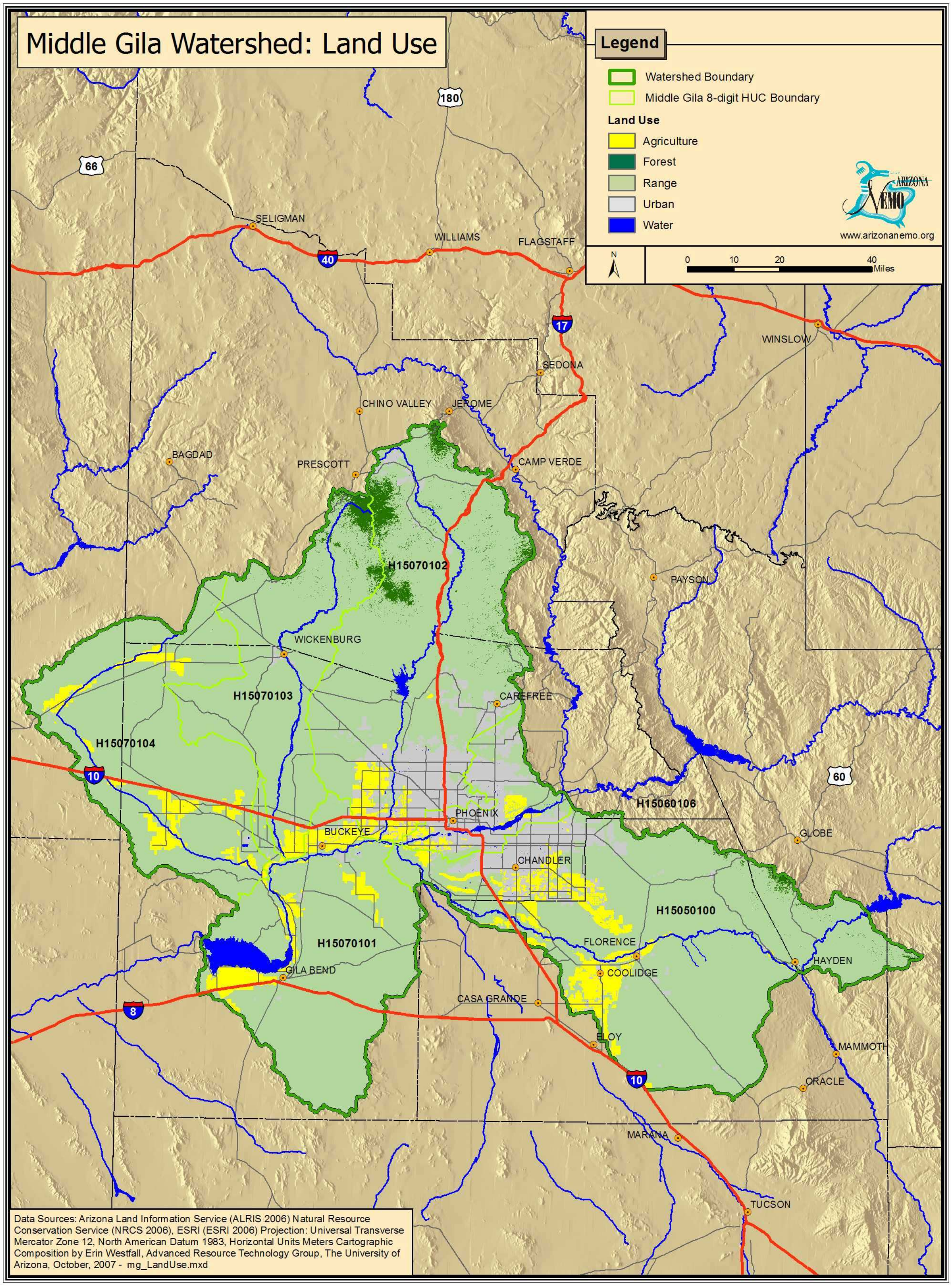

Figure 4-14: Land Use

Land Ownership

In the Middle Gila Watershed, there are 8 different land ownership entities (Figure 4-15 and Table 4-16). "Private" is the largest category of land owners, representing 29% of the watershed. State Lands and National Forest Service are the next most significant land owners with 22% and 10% of the watershed, respectively.

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 4-16 shows the boundaries of the preserve lands within the Middle Gila Watershed. The State Trust lands within these 3,281 square miles or 2,098,480 acres are eligible for conservation purposes. Table 4-17 show the API areas for each subwatershed.

Wilderness Areas:

There are 18 different Wilderness Areas within the Middle Gila watershed. Table 4-18 lists each one and the acreage in each subwatershed. Figure 4-17 shows where each wilderness area is located.

There are a total of 539,487 acres (843 square miles) of Wilderness Areas, or approximately 7% of the watershed. The largest wilderness area is the North Maricopa Mountains Wilderness Area with approximately 63,120 acres of area, within the Lower Gila River Above Painted Rock Dam subwatershed.

Golf Courses:

There are 60 mapped golf courses within the Middle Gila Watershed, shown as green squares in Figure 4-18 (ESRI Data and Maps, 2003). Most are located in the Phoenix metropolitan area. The data from the 2001 GIS data layer used in this analysis under reports the number of golf courses. PhoenixArizona.com reports over 250 golf courses in the Phoenix area alone.

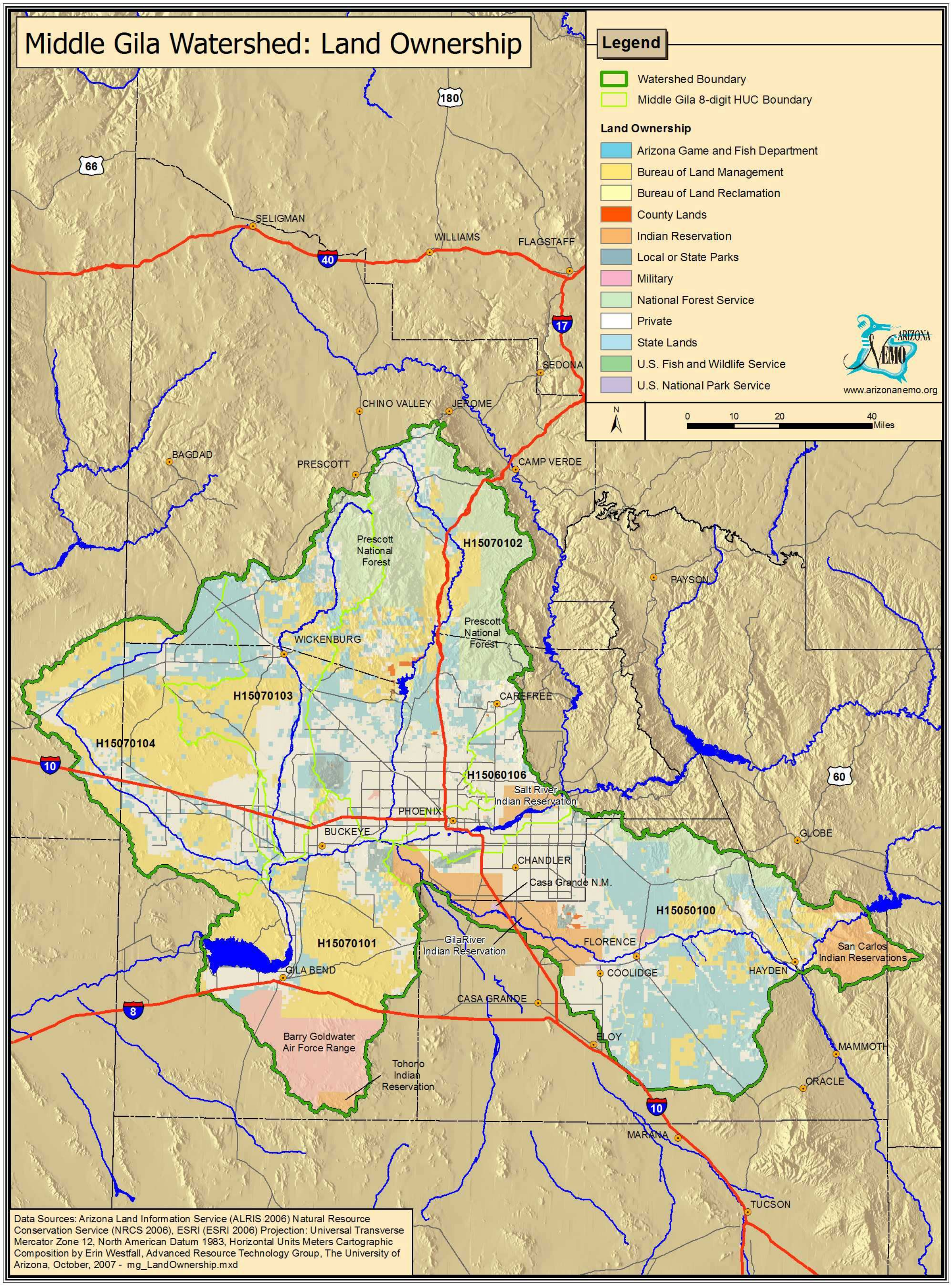

Figure 4-15: Land Ownership

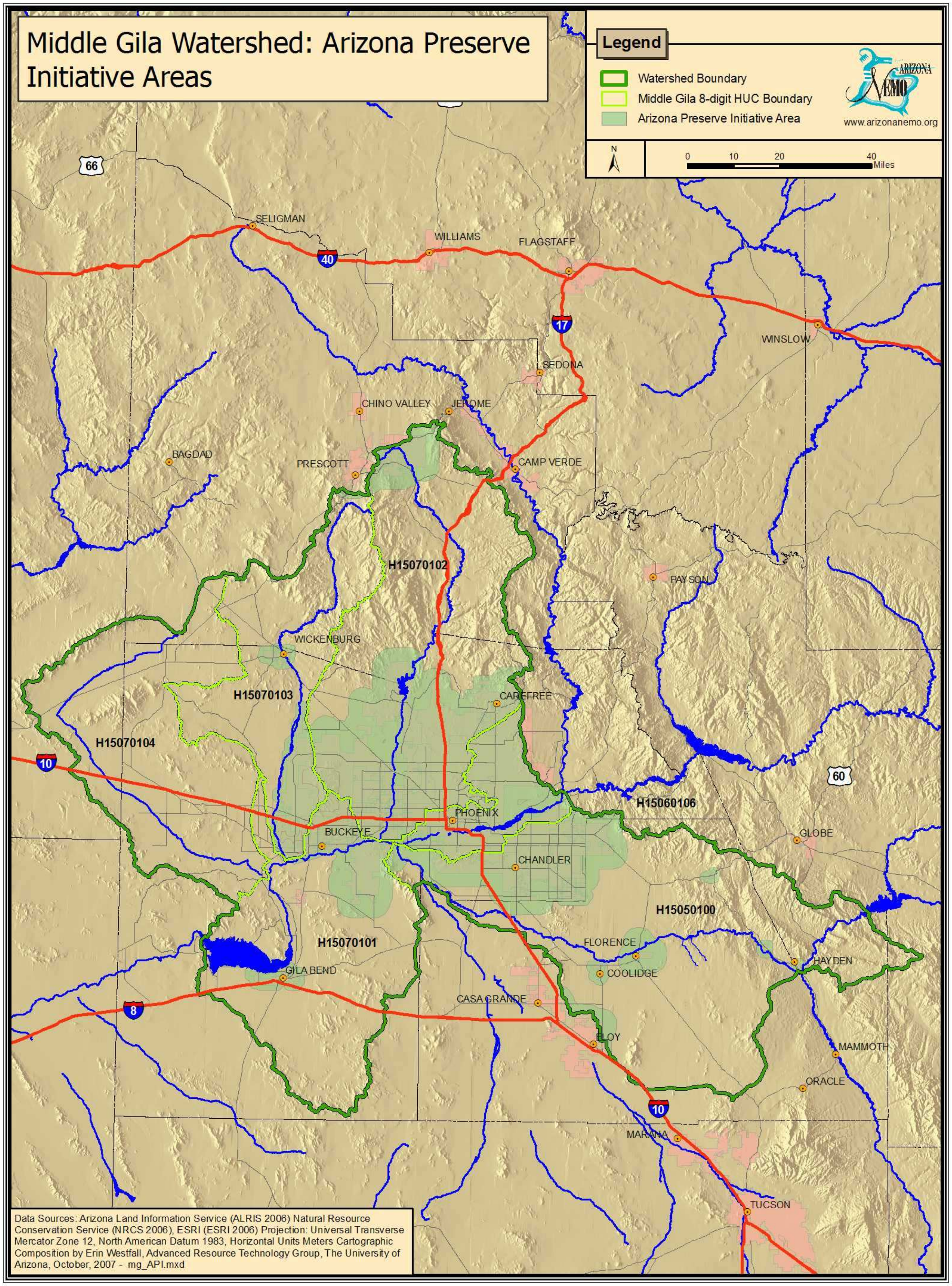

Figure 4-16: Arizona Preserve Initiative Areas

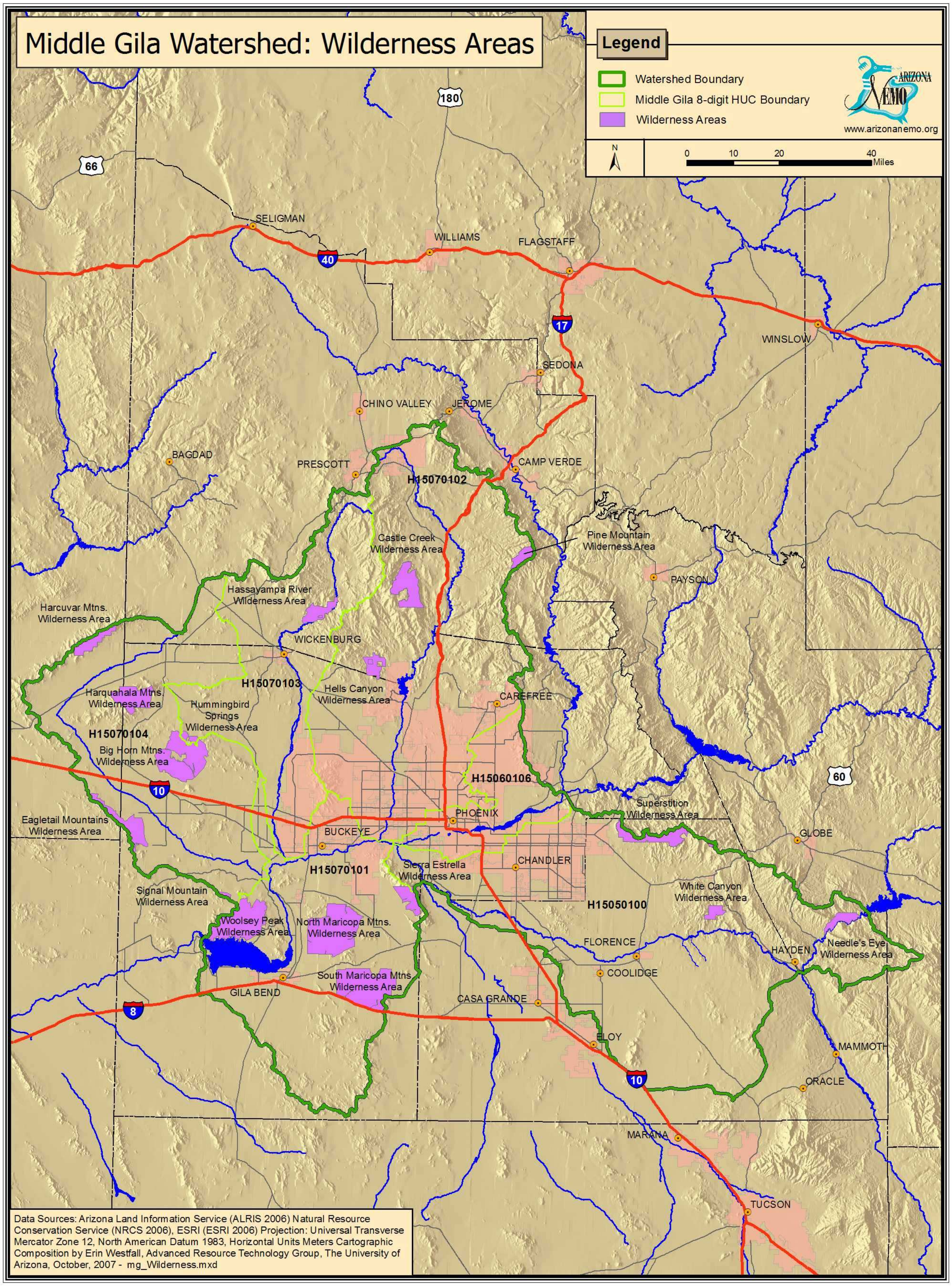

Figure 4-17: Wilderness Areas

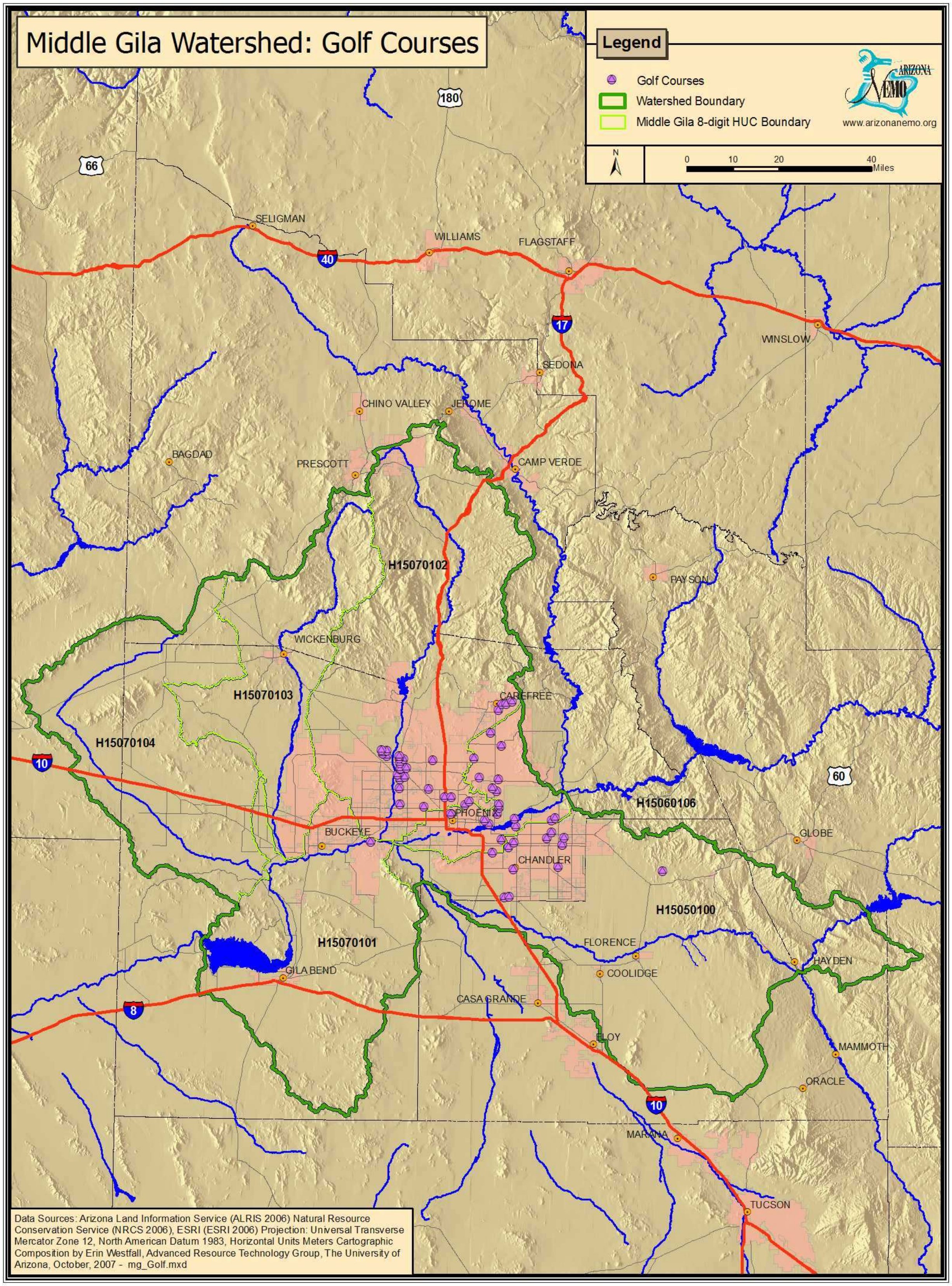

Figure 4-18: Golf Courses

Table 4-15: Middle Gila Watershed Land Use (part 1 of 2).

Land Cover	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Agriculture	3.8%	8.7%	1.9%	10.2%	9%
Forest	4.6%	>0.00%	4.4%	-	-
Range	76.0%	90.8%	92.8%	88.3%	33%
Urban	15.1%	0.5%	1.0%	1.5%	58%
Water	0.5%	0.1%	0.01%	0.05%	0.4%
Total Area (square miles)	*2,785*	*1,946*	*1,454*	*2,012*	*505*

Table 4-15: Middle Gila Watershed Land Use (part 2 of 2).

Land Cover	Middle Gila River H15050100	*Middle Gila River Watershed*
Agriculture	9.3%	*7%*
Forest	0.7%	*1.8%*
Range	80.7%	*82%*
Urban	9.3%	*9%*
Water	0.04%	*0.2%*
Total Area (square miles)	*3,354*	*12,056*

Table 4-16: Middle Gila Watershed Land Ownership (Percent of each Subwatershed) (part 1 of 2).

Land Owner	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Arizona Game and Fish Department	0.1%	0.01%	-	0.3%	0.04%
Bureau of Reclamation	1.1%	0.04%	0.05%	-	0.8%
Bureau of Land Management	15.8%	55.7%	31.1%	44.1%	0.4%
County Lands	0.5%	-	0.02%	-	0.1%
National Forest Service	28.6%	-	13.2%	-	1.5%
Indian Reservation	-	-	-	2.1%	16%
Local or State Parks	1.6%	-	0.9%	1.5%	3%
Military	0.1%	-	0.1%	21.1%	-

Land Owner	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
U.S. National Park Service	-	-	-	-	-
Private	34.3%	22.6%	27.4%	23.9%	70%
State Lands	17.9%	21.6%	27.3%	6.6%	9%
U.S. Fish and Wildlife Service	-	-	-	0.4%	-
Area (square miles)	*2,785*	*1,946*	*1,454*	*2,012*	*505*

Table 4-16: Middle Gila Watershed Land Ownership (Percent of each Subwatershed) (part 2 of 2).

Land Owner	Middle Gila River H15050100	*Middle Gila River Watershed*
Arizona Game and Fish Department	0.01%	*0.07%*
Bureau of Reclamation	1.8%	*0.8%*
Bureau of Land Management	11.6%	*27%*
County Lands	0.2%	*0.2%*
National Forest Service	7.6%	*10%*
Indian Reservation	18.0%	*6%*
Local or State Parks	1.2%	*1%*
Military	0.3%	*4%*
U.S. National Park Service	0.1%	*0.02%*
Private	26.3%	*29%*
State Lands	33.0%	*22%*
U.S. Fish and Wildlife Service	-	*0.07%*
Area (square miles)	*3,354*	*12,056*

Table 4-17: Middle Gila Watershed Areas of Arizona Preserve Initiative Lands.

Subwatershed Name	Subwatershed Area (square miles)	Preserve Areas (square miles)	Preserve Areas (acre)	Percent of Subwatershed
Agua Fria River H15070102	2,785	1,301	832,333	46.7%
Centennial Wash H15070104	1,946	-	-	-
Hassayampa River H15070103	1,454	275	175,461	18.9%
Lower Gila River above Painted Rock Dam H15070101	2,012	389	248,687	19.3%
Lower Salt River H15060106B	505	505	323,200	100%
Middle Gila River H15050100	3,354	811	518,799	24.2
Total Middle Gila River Watershed	*12,056*	*3,281*	*2,098,480*	*27%*

Table 4-18: Middle Gila Watershed Wilderness Areas (acres) (part 1 of 2).

Wilderness Area	Agua Fria River H15070102	Centennial Wash H15070104	Hassayampa River H15070103	Lower Gila River above Painted Rock Dam H15070101	Lower Salt River H15060106B
Big Horn Mountains	-	21,001	-	-	-
Castle Creek	-	-	-	-	-
Cedarbench	-	-	-	-	-
Eagletail Mountains	-	23,008	-	-	-
Harcuvar Mountains	-	13,224	-	-	-
Harquahala Mountains	-	22,861	-	-	-
Hassayampa River Canyon	-	-	12,186	-	-
Hells Canyon	-	0.13	-	-	-
Hummingbird Springs	-	26,615	3,521	-	-
Needle's Eye	-	-	-	-	-
North Maricopa Mountains	-	-	-	63,120	-
Pine Mountain	-	-	-	-	-
Sierra Estrella	-	-	-	11,903	-
Signal Mountain	-	1,705	-	-	-
South Maricopa Mountains	-	-	-	56,865	-
Superstition	-	-	-	-	-
White Canyon	-	-	-	-	-
Woolsey Peak	-	373	-	46,463	-
Total Wilderness Area (acre)	-	*108,787*	*15,707*	*178,351*	-

Table 4-18: Middle Gila Watershed Wilderness Areas (acres) (part 2 of 2).

Wilderness Area	**Middle Gila River H15050100**	***Middle Gila River Watershed***
Big Horn Mountains	-	*21,001*
Castle Creek	-	*25,536*
Cedarbench	-	*160*
Eagletail Mountains	-	*23,008*
Harcuvar Mountains	-	*13,224*
Harquahala Mountains	-	*22,861*
Hassayampa River Canyon	-	*12,286*
Hells Canyon	-	*9,971*
Hummingbird Springs	-	*30,136*
Needle's Eye	8,768	*8,768*
North Maricopa Mountains	-	*63,120*
Pine Mountain	-	*8,605*
Sierra Estrella	603	*12,507*
Signal Mountain	-	*1,705*
South Maricopa Mountains	-	*56,865*
Superstition	23,673	*23,673*
White Canyon	5,764	*5,764*
Woolsey Peak	-	*46,837*
Total Wilderness Area (acre)	*38,808*	*539,487*

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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 a general description of the data.*

Section 5: Important Resources

The Middle Gila Watershed contains extensive and important natural resources, with national, regional and local significance. The watershed contains critical riparian habitat for the Mexican Spotted Owl, the Gila Chub, the Spike Dace, 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 (outstanding 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.

The NRAs have been categorized within the 10-digit HUC subwatershed area where they are located. Several 10-digit contiguous HUCs have been combined to form unique NRAs The significance of each area is discussed in the following paragraphs. The two identified Natural Resource Areas consist of the following groupings of 10-digit HUCS:

1. *Northern Middle Gila River NRA*: Lower Salt River, Agua Fria River, Hassayampa River, and Centennial Wash.

2. *Southern Middle Gila River NRA*: Lower Gila River and the Middle Gila River.

<u>Northern Middle Gila River NRA</u>

The Northern Middle Gila River NRA contains extensive riparian vegetation along the Salt River and its tributaries, important perennial streams, three Arizona Preserve Initiative areas, critical wildlife habitat, a national forest, parts of three Indian reservations, and eight wilderness areas.

The Northern NRA has Arizona Preserve Initiative land in the Agua Fria River Subwatershed, the Centennial Wash Subwatershed, the Hassayampa River Subwatershed, and in the Lower Salt River Subwatershed (Figure 4-14 and Table 4-15). Critical habitat exists in the Northern NRA for the Gila Chub and the Mexican Spotted Owl (Figure 3-7). Prescott National Forest occupies the northwest section of the NRA. The Salt River Indian Reservation lies just north of the Salt River in Phoenix eastern Phoenix.

The Wilderness Areas for the Northern NRA are:

<u>Big Horn Mountains</u>
(http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/bighorn.html)

This 21,000-acre wilderness lies 60 miles west of Phoenix in western Maricopa County. The precipitous 1,800-foot-high Big Horn Peak and neighboring desert plain escarpments give the wilderness exceptional scenic value, especially noticeable along Interstate Highway 10 south of the area. The Hummingbird Spring Wilderness, northeast of this area, is separated from the Big Horn Wilderness by a jeep trail.

Nine miles of the jumbled Big Horn Mountains ridgeline cross the wilderness. The central mountainous core is surrounded by smaller hills, fissures, chimneys, narrow canyons, and desert plains. This wilderness offers many recreation opportunities such as hiking, backpacking, rock climbing, photography and nature study. Rugged ridges challenge expert climbers, while side canyons and plains offer easier hiking.

This wilderness contains many desert species, such as the desert bighorn sheep, Gila monster, kit fox and desert tortoise. Golden eagles, prairie falcons, barn owls and great horned owls nest in the cliffs.

Castle Creek
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=104

On the stark eastern slopes of the Bradshaw Mountains, with a total of 25,215 acres, Castle Creek Wilderness stands between Phoenix and Flagstaff, easily accessible from both. Extremely rugged topography rises to granite peaks that top off at 7,000 feet on Juniper Ridge, offering overlooks of the Agua Fria River. In the Wilderness' southeastern corner the elevation drops to 2,800 feet. Saguaro cactus, paloverde, mesquite, jojoba, catclaw, and grasslands dominate the lower elevations. Up higher you'll find chaparral communities of scrubby live oak, mountain mahogany, and manzanita with pinyon and juniper on southern slopes. Dense populations of mule deer and javelina inhabit this area, along with a few mountain lions, bobcats, black bears, elk, coyotes, rabbits, foxes, skunks, and badgers. Snakes and lizards live here, and numerous birds soar overhead, including doves, quail, hawks, owls, ravens, jays, and many smaller species.

Eagletail Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Eagletail%20Mountains%20Wilderness

Fifteen miles of the Eagletail Mountains' rough ridgeline run through the northern section of this 97,880 acres Wilderness, including 3,300-foot Eagletail Peak. Cemetery Ridge lies along the southern border. Geology buffs can examine several distinct rock strata throughout these mountains, and everyone can marvel at such geologic wonders as natural arches, high spires and monoliths, jagged sawtooth ridges, and numerous washes between six and eight miles long. Courthouse Rock, a huge granite monolith, stands over 1,000 feet above the desert floor near the northern border and attracts technical rock climbers. Between the two main ridges stretches a vast desert plain of ocotillo, cholla, creosote, ironwood, saguaro cactus, barrel cactus, Mormon tea, mesquite, and sand. Summer temperatures rage and send up thermals upon which raptors ride as they scan the landscape for a desert rodent snack. The great horned owl and the coyote live here, but they keep themselves well hidden from backpackers, campers, and horseback riders.

Harcuvar Mountains

http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Harcuvar%20Mountains%20Wilderness

This desert encompasses over 10 miles of the Harcuvar Mountains' ridgeline, from an elevation of 2,400 feet on the bajadas to more than 5,100 feet on the mountainous crest. Plant and animal communities thrive on diverse landforms, including a 3,500-acre "island" of interior chaparral habitat on the northern ridgeline that hides a few species of wildlife cut off from their parent populations: rosy boas, Gilbert's skinks, and desert night lizards. Desert bighorn sheep live alongside mountain lions, desert tortoises, golden eagles, and several species of hawks. Isolated from the rest of the world, the 20,050 Harcuvar Mountains Wilderness offer splendid and lonely backpacking in the canyons and on the ridges.

Harquahala Mountain
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Harquahala%20Mountains%20Wildernessuntains

Harquahala means "running water high up" in the language of one early native tribe. This 22.880 acre elevated region, set on one of western Arizona's largest desert ranges, was so named for its numerous perennial seeps and springs. The Harquahalas reach a high point on the western side on Harquahala Peak at 5,691 feet, the uppermost elevation in the southwestern part of the state. From the summit of the peak the panorama includes surrounding desert and mountains up to 100 miles away. Natural mountain springs support a rare habitat among Sonoran Desert mountains, a screened interior canyon system with exceptional natural diversity. Rare cacti live here among relict "islands" of chaparral and desert grasslands. Here you'll find high peaks and foothills, deep rocky canyons and valleys, and ridges dropping to bajadas. Sunset Canyon falls 1,600 feet from the steep east rim of the mountains. Brown's Canyon, which stretches for nine miles across the northeastern portion, houses the endangered desert tortoise and is seldom visited. This area also sustains the largest mule deer herd in western Arizona, a sizable raptor population, and one of the few increasing desert bighorn sheep herds.

Hassayampa River Canyon
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Hassayampa%20River%20Canyon%20Wilderness

The Hassayampa River flows freely for several miles along the southern and eastern portions of this 12,300 acre Wilderness, supporting a riparian habitat. The area reaches a high point on Sam Powell Peak at 4,015 feet in the western portion, where you'll also discover a striking geological monolith called The Needle. Side canyons and uplands are covered in chaparral, paloverde, and saguaro.

Hells Canyon
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=239

A 9,311 acre scenic portion of the Hieroglyphic Mountain Range, this area is home to numerous peaks, mostly over 3,000 feet, encircling and isolating Burro Flats from the rest of the world. Hells Canyon is further isolated by private land on its southern, eastern, and northern sides. The most prominent of the peaks are Garfias Mountain at 3,381 feet and Hellgate Mountain at 3,339 feet. Several cliffs on the mountains attract climbers, and the canyons make for relatively easy hiking. Most of this Wilderness is covered by Sonoran Desert vegetation: saguaro, paloverde, barrel cactus, ocotillo, and desert grasses.

Hummingbird Springs
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=251&tab=General

Northeast of Hummingbird Springs, which sits near the middle of this 31,200 acre Wilderness, a colorful escarpment, Sugarloaf Mountain, climbs steeply from the Tonopah Desert to 3,418 feet and lends this area remarkable scenic value. Over eight miles of the Big Horn Mountains are included in this Wilderness. Here one finds hills and washes and bajadas abounding with saguaro, ocotillo, cholla, paloverde, and mesquite, habitat for desert bighorn sheep, mule deer, and desert tortoise. Kit foxes and Gila monsters race along the ground while Cooper's hawks, prairie falcons, and golden eagles rule the skies.

Pine Mountain
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Pine%20Mountain%20Wilderness

At 6,814 feet, Pine Mountain is the highest point on the Verde River Rim, which slashes across this 20,061 acre area from northeast to southwest. Steep and rocky southeastern slopes fall toward the Verde, Arizona's only Wild & Scenic River Area. On the rim you'll find an "island" of tall ponderosa pine and Douglas fir surrounded by desert mountains and hot dry mesas covered in pinyon and juniper, cut by rugged canyons. The rim overlooks the Verde River with fine views out across the desert. Despite scant water, wildlife abounds here on forested slopes and in the canyons, especially game animals. Pine Mountain Wilderness straddles the boundary between Prescott and Tonto National Forests. Not far to the north lies Cedar Bench Wilderness.

Southern Middle Gila River NRA

The Southern Middle Gila River NRA contains one national historical park, seven wilderness areas, extensive riparian vegetation along the Salt River and its tributaries, important perennial streams, six Arizona Preserve Initiative areas, critical wildlife habitat, a national forest, Barry Goldwater Air Force Range, and three Indian Reservations.
The Southern NRA has Arizona Preserve Initiative land in both the Lower Gila River Subwatershed, and in the Middle Gila River Subwatershed (Figure 4-14 and Table 4-15). Critical habitat exists in the Southern NRA for the Southwest Willow Flycatcher, Spike Dace and the Mexican Spotted Owl (Figure 3-7). Tonto National Forest occupies the eastern section of the NRA. The Salt River Indian Reservation lies just north of the Salt River in Phoenix eastern Phoenix. The San Carlos Indian Reservation lies in the southeastern tip of the watershed. The Gila River Indian Reservation is located along the Gila River in the southern part of the watershed, and the Tohono Indian Reservation is

south of the Barry Goldwater Air Force Range.

The Southern NRA parks and wilderness areas are:

Casa Grande Ruins National Historical Park (http://www.desertusa.com/cas/index.html)

For more than a thousand years, prehistoric farmers inhabited much of present-day southern Arizona. When the first Europeans arrived, all that remained of the ancient cultures were the ruins of villages, irrigation canals and various artifacts.

In 1694, Father Eusebio Francisco Kino described his visit to Casa Grande, or "Big House," as a 4-story structure built by the Hohokam in the mid-1300s. Constructed with layers of caliche mud, the walls of the tower are 4 1/2 feet thick at the base. This mysterious structure, with holes in 3 walls, is believed to have been used for astronomical observation. Casa Grande is the largest structure built by the Hohokam and represents the height of their architecture.

Casa Grande Ruins, the nation's first archeological preserve, protects the Casa Grande and other archeological sites within its boundaries, including remains of a walled village near the Big House and vestiges of other villages nearby.

Needle's Eye
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Needle's%20Eye%20Wilderness

The Mescal Mountains cut across the middle of this 8,760 acre Wilderness, their southwestern flank forming a spectacular striped slope of Paleozoic limestone that looms more than 2,500 feet high. The Gila River flows through this country and forms the Wilderness's southern border. The river threads through a marvelous section of steep-walled canyon so narrow it's earned the name Needle's Eye. Several small slickrock side canyons wind down to the Gila, bisecting the area. The narrow river channel lies tangled in dense riparian growth, often making travel difficult. The San Carlos Apache Indian Reservation occupies the territory to the north and south, and private land surrounds the rest of this Wilderness, eliminating open public access; one must obtain permission to enter here.

North Maricopa Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=North%20Maricopa%20Mountains%20Wilderness

Ranging from about 1,000 feet to 2,813 feet, the North Maricopa Mountains are a jumble of isolated summits and long ridges separated by washes and bajadas (desert slopes). As one would expect, they're not far north of South Maricopa Mountains Wilderness. About 10 miles of the North Maricopas stand in the 63,200 acre Wilderness surrounded by vast desert plains that support saguaro, cholla, ocotillo, and other typical Sonoran plant species. One may sight a desert bighorn sheep, desert tortoise, coyote, bobcat, fox, and deer here, or see a Gambel's quail dart away at your approach while a raptor soars overhead. The old Butterfield Stage Road forms a portion of the southern boundary, and beyond the road backpackers and horsepackers find an ample supply of solitude.

South Maricopa Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=South%20Maricopa%20Mountains%20Wilderness

A low-elevation Sonoran mountain range, the Maricopas stretch for 13 miles across this 60,100 acre Wilderness of extensive desert plains. The eastern portion of the area contains an isolated and screened interior formed by long ridges and lone peaks separated by washes and plains. The western portion is primarily flat desert. Vegetation consists of cholla, saguaro, ocotillo, paloverde, and mesquite. Desert bighorn sheep, coyotes, bobcats, foxes, deer, Gambel's quail, various raptors, desert tortoises, and numerous reptiles live here.

Superstition
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=583

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 159,757 acre 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.

White Canyon
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=White%20Canyon%20Wilderness

Intricately carved and scenically splendid White Canyon runs north-south through the middle of this 5,790 acre Wilderness. Narrow in places, this canyon's walls rise as much as 800 feet above the bottom. Throughout you'll find delicate, eroded formations and numerous side canyons. Sand, slickrock, and willows cover the canyon's bottom. The Rincon, an enormous, amphitheater-like escarpment, stands near the southern boundary. Set in the rugged southeast portion of the Mineral Mountains, this Wilderness features a perennial stream that supports a variety of vegetation from saguaro cacti to chaparral. When rainstorms flood the area, especially during summer "monsoons," waterfalls pour over the rim of White Canyon, or form quiet pools within sculpted terraces. Wildlife includes a myriad of birds, thanks to the steady presence of water, often scarce in other regions. Black bears and mountain lions are permanent residents.

Woolsey Peak
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Woolsey%20Peak%20Wilderness

Woolsey Peak stands at 3,270 feet above sea level and approximately 2,500 feet above the Gila River (to the south). It is a geographical landmark visible from much of southwestern Arizona. The Painted Rock Dam blocks the Gila River not far from the southwestern corner of the 64,000 acre area. Encompassing a major portion of the Gila Bend Mountains, it is just barely separated from the smaller Signal Mountain Wilderness to the north. You'll find sloping lava flows, basalt mesas, ragged peaks, and broken ridges dotted with saguaro, cholla, paloverde, creosote, and bursage. Desert mesquite, paloverde, and ironwood grow in the washes throughout this rugged and expansive desert Wilderness. Desert bighorn sheep, mule deer, bobcats, mountain lions, hawks, and owls are inhabitants of the area.

References:

Casa Grande Ruins National Historical Park.
http://www.desertusa.com/cas/index.html

U.S. Fish & Wildlife Service. 2007.
http://www.fws.gov/southwest/es/arizona/Threatened.htm#CountyList

Wilderness Areas:
Big Horn Mountains
(http://www.blm.gov/az/st/en/prog/blm_special_areas/wildareas/bighorn.html)
Castle Creek
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=104
Eagletail Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Eagletail%20Mountains%20Wilderness
Harcuvar Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Harcuvar%20Mountains%20Wilderness
Harquahala Mountain
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Harquahala%20Mountains%20Wildernessuntains
Hassayampa River Canyon
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Hassayampa%20River%20Canyon%20Wilderness
Hells Canyon
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=239
Hummingbird Springs
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=251&tab=General
Needle's Eye
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Needle's%20Eye%20Wilderness
North Maricopa Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=North%20Maricopa%20Mountains%20Wilderness
Pine Mountain
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Pine%20Mountain%20Wilderness
South Maricopa Mountains
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=South%20Maricopa%20Mountains%20Wilderness
Superstition
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&WID=583

White Canyon
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=White%20Canyon%20Wilderness

Woolsey Peak
http://www.wilderness.net/index.cfm?fuse=NWPS&sec=wildView&wname=Woolsey%20Peak%20Wilderness

Section 6: Watershed Classification

This watershed classification was conducted on the forty-one 10-digit HUC subwatersheds that comprise the Middle Gila Watershed.

In this watershed classification, each 10-digit subwatershed 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 Middle Gila Watershed include AGWA, SWAT, and SEDMOD/RUSLE, as described below and in Appendices C and D.

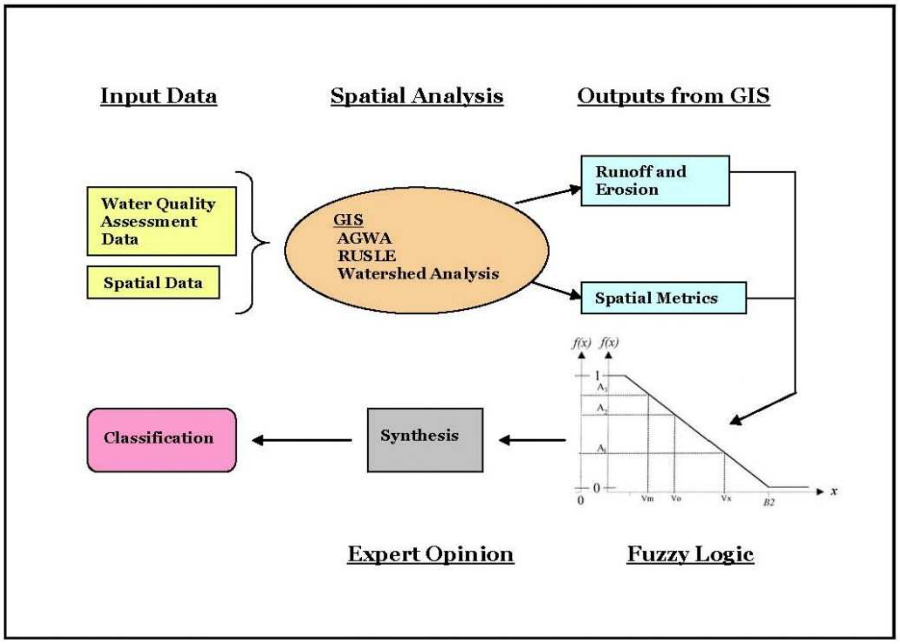

Figure 6-1: Transformation of Input Data via a GIS, Fuzzy Logic Approach, and Synthesis of Results into a Watershed Classification.

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., 2006), 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 forty-one 10-digit HUC subwatersheds in the Middle Gila River Watershed.

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

HUC 10	Subwatershed Name
1505010001	Dripping Springs Wash-Middle Gila River
1505010002	Mineral Creek-Middle Gila River
1505010003	Box O Wash-Middle Gila River
1505010004	Upper Queen Creek
1505010005	Upper McClellan Wash
1505010006	Brady Wash-Picacho Reservoir
1505010007	Paisano Wash-Middle Gila River
1505010008	Middle Queen Creek
1505010009	Lower Queen Creek
1505010010	Lower McClellan Wash-Middle Gila River
1505010011	Middle Gila River below Queen Creek
1506010602	Indian Bend Wash
1506010603B	Lower Salt River below Saguaro Lake
1507010101	Waterman Wash
1507010102	Luke Wash-Lower Gila River
1507010103	Sand Tank Wash
1507010104	Rainbow Wash-Lower Gila River
1507010105	Quilotosa Wash
1507010106	Sauceda Wash
1507010107	Lower Gila River-Painted Rock Reservoir
1507010201	Ash Creek and Sycamore Creek
1507010202	Big Bug Creek-Agua Fria River
1507010203	Black Canyon Creek
1507010204	Bishop Creek
1507010205	Agua Fria River-Lake Pleasant

HUC 10	Subwatershed Name
1507010206	Cave Creek-Arizona Canal Diversion Channel
1507010207	Trilby Wash-Trilby Wash Basin
1507010208	New River
1507010209	Agua Fria River below Lake Pleasant
1507010301	Upper Hassayampa River
1507010302	Sols Wash
1507010303	Middle Hassayampa River
1507010304	Jackrabbit Wash
1507010305	Lower Hassayampa River
1507010401	Aguila Valley Area-Centennial Wash
1507010402	McMullen Valley Area-Centennial Wash
1507010403	Tiger Wash
1507010404	Upper Harquahala Plains Area-Centennial Wash
1507010405	Middle Harquahala Plains Area-Centennial Wash
1507010406	Winters Wash
1507010407	Lower Harquahala Plains Area-Centennial Wash

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 Middle Gila 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 Middle Gila 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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	Classified as moderate risk, drains to Mineral Creek-Middle Gila River that is classified as extreme.
Mineral Creek-Middle Gila River 1505010002	1.0	Classified as extreme risk, drains to Box O Wash-Middle Gila River that is classified as high.

Subwatershed Name	Metals WQA FMV	Justification
Box O Wash-Middle Gila River 1505010003	0.7	Classified as high risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Upper Queen Creek 1505010004	1.0	Classified as extreme risk, drains to Middle Queen Creek that is classified as moderate.
Upper McClellan Wash 1505010005	0.5	Classified as moderate risk, drains to Brady Wash-Picacho Reservoir that is classified as moderate.
Brady Wash-Picacho Reservoir 1505010006	0.5	Classified as moderate risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Paisano Wash-Middle Gila River 1505010007	0.5	Classified as moderate risk, drains to Lower McClellan Wash-Middle Gila River that is classified as moderate.
Middle Queen Creek 1505010008	0.5	Classified as moderate risk, drains to Lower Queen Creek that is classified as moderate.
Lower Queen Creek 1505010009	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Lower McClellan Wash-Middle Gila River 1505010010	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Middle Gila River below Queen Creek 1505010011	0.5	Classified as moderate risk, drains to Lower Salt River below Saguaro Lake that is classified as moderate.
Indian Bend Wash 1506010602	0.7	Classified as high risk, drains to Lower Salt River below Saguaro Lake that is classified as moderate.
Lower Salt River below Saguaro Lake 1506010603B	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.
Waterman Wash 1507010101	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.
Luke Wash-Lower Gila River 1507010102	1.0	Classified as extreme risk, drains to Rainbow Wash-Lower Gila River that is classified as moderate.
Sand Tank Wash 1507010103	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Rainbow Wash-Lower Gila River 1507010104	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Quilotosa Wash 1507010105	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Sauceda Wash 1507010106	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	Classified as moderate risk, drains out of the watershed.
Ash Creek and Sycamore Creek 1507010201	0.5	Classified as moderate risk, drains to Big Bug Creek-Agua Fria River that is classified as moderate.
Big Bug Creek-Agua Fria River 1507010202	0.5	Classified as moderate risk, drains to Bishop Creek that is classified as moderate.
Black Canyon Creek 1507010203	1.0	Classified as extreme risk, drains to Agua Fria River-Lake Pleasant that is classified as moderate.
Bishop Creek 1507010204	0.0	Classified as low risk, drains to Agua Fria River-Lake Pleasant that is classified as moderate.
Agua Fria River-Lake Pleasant 1507010205	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.

Subwatershed Name	Metals WQA FMV	Justification
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0	Classified as low risk, drains to Indian Bend Wash that is classified as high.
Trilby Wash-Trilby Wash Basin 1507010207	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
New River 1507010208	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
Agua Fria River below Lake Pleasant 1507010209	0.0	Classified as low risk, drains to Luke Wash-Lower Gila River that is classified as extreme.
Upper Hassayampa River 1507010301	1.0	Classified as extreme risk, drains to Middle Hassayampa River that is classified as moderate.
Sols Wash 1507010302	0.5	Classified as moderate risk, drains to Middle Hassayampa River that is classified as moderate.
Middle Hassayampa River 1507010303	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Jackrabbit Wash 1507010304	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Lower Hassayampa River 1507010305	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.
Aguila Valley Area-Centennial Wash 1507010401	0.5	Classified as moderate risk, drains to McMullen Valley Area-Centennial Wash that is classified as moderate.
McMullen Valley Area-Centennial Wash 1507010402	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Tiger Wash 1507010403	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	Classified as moderate risk, drains to Middle Harquahala Plains Area-Centennial Wash that is classified as moderate.
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Winters Wash 1507010406	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.

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**
Dripping Springs Wash-Middle Gila River 1505010001	1	1
Mineral Creek-Middle Gila River 1505010002	1	1
Box O Wash-Middle Gila River 1505010003	1	1
Upper Queen Creek 1505010004	1	1
Upper McClellan Wash 1505010005	1	1
Brady Wash-Picacho Reservoir 1505010006	1	1
Paisano Wash-Middle Gila River 1505010007	0.75	1
Middle Queen Creek 1505010008	1	1
Lower Queen Creek 1505010009	1	1
Lower McClellan Wash-Middle Gila River 1505010010	1	1
Middle Gila River below Queen Creek 1505010011	1	1
Indian Bend Wash 1506010602	1	1
Lower Salt River below Saguaro Lake 1506010603B	1	1
Waterman Wash 1507010101	1	1
Luke Wash-Lower Gila River 1507010102	1	1
Sand Tank Wash 1507010103	1	1
Rainbow Wash-Lower Gila River 1507010104	1	1
Quilotosa Wash 1507010105	1	0
Sauceda Wash 1507010106	1	0
Lower Gila River-Painted Rock Reservoir 1507010107	0.75	0
Ash Creek and Sycamore Creek 1507010201	1	1
Big Bug Creek-Agua Fria River 1507010202	1	1
Black Canyon Creek 1507010203	1	1
Bishop Creek 1507010204	1	1
Agua Fria River-Lake Pleasant 1507010205	1	1

Subwatershed	FMV #mines /HUC	FMV #mines/ riparian
Cave Creek-Arizona Canal Diversion Channel 1507010206	1	1
Trilby Wash-Trilby Wash Basin 1507010207	1	1
New River 1507010208	1	1
Agua Fria River below Lake Pleasant 1507010209	1	1
Upper Hassayampa River 1507010301	1	1
Sols Wash 1507010302	1	1
Middle Hassayampa River 1507010303	1	1
Jackrabbit Wash 1507010304	1	1
Lower Hassayampa River 1507010305	1	1
Aguila Valley Area-Centennial Wash 1507010401	1	1
McMullen Valley Area-Centennial Wash 1507010402	1	1
Tiger Wash 1507010403	1	1
Upper Harquahala Plains Area-Centennial Wash 1507010404	1	1
Middle Harquahala Plains Area-Centennial Wash 1507010405	1	1
Winters Wash 1507010406	1	1
Lower Harquahala Plains Area-Centennial Wash 1507010407	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)
Dripping Springs Wash-Middle Gila River 1505010001	6823
Mineral Creek-Middle Gila River 1505010002	8607
Box O Wash-Middle Gila River 1505010003	4050
Upper Queen Creek 1505010004	9641
Upper McClellan Wash 1505010005	1237
Brady Wash-Picacho Reservoir 1505010006	1133
Paisano Wash-Middle Gila River 1505010007	1256
Middle Queen Creek 1505010008	2422
Lower Queen Creek 1505010009	960

Subwatershed	RUSLE Soil Loss “A” (kg/ha/yr)
Lower McClellan Wash-Middle Gila River 1505010010	472
Middle Gila River below Queen Creek 1505010011	501
Indian Bend Wash 1506010602	1060
Lower Salt River below Saguaro Lake 1506010603B	762
Waterman Wash 1507010101	1015
Luke Wash-Lower Gila River 1507010102	786
Sand Tank Wash 1507010103	1239
Rainbow Wash-Lower Gila River 1507010104	734
Quilotosa Wash 1507010105	805
Sauceda Wash 1507010106	871
Lower Gila River-Painted Rock Reservoir 1507010107	1217
Ash Creek and Sycamore Creek 1507010201	9994
Big Bug Creek-Agua Fria River 1507010202	4551
Black Canyon Creek 1507010203	4872
Bishop Creek 1507010204	8684
Agua Fria River-Lake Pleasant 1507010205	4500
Cave Creek-Arizona Canal Diversion Channel 1507010206	4288
Trilby Wash-Trilby Wash Basin 1507010207	1057
New River 1507010208	3291
Agua Fria River below Lake Pleasant 1507010209	910
Upper Hassayampa River 1507010301	5089
Sols Wash 1507010302	1967
Middle Hassayampa River 1507010303	4394
Jackrabbit Wash 1507010304	766
Lower Hassayampa River 1507010305	996
Aguila Valley Area-Centennial Wash 1507010401	1531
McMullen Valley Area-Centennial Wash 1507010402	2539
Tiger Wash 1507010403	2232
Upper Harquahala Plains Area-Centennial Wash 1507010404	1493
Middle Harquahala Plains Area-Centennial Wash 1507010405	647
Winters Wash 1507010406	720
Lower Harquahala Plains Area-Centennial Wash 1507010407	409

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

Subwatershed	Erosion Category	FMV
Dripping Springs Wash-Middle Gila River 1505010001	5	0.8
Mineral Creek-Middle Gila River 1505010002	6	1.0
Box O Wash-Middle Gila River 1505010003	5	0.8
Upper Queen Creek 1505010004	6	1.0
Upper McClellan Wash 1505010005	3	0.4
Brady Wash-Picacho Reservoir 1505010006	3	0.4
Paisano Wash-Middle Gila River 1505010007	3	0.4
Middle Queen Creek 1505010008	4	0.6
Lower Queen Creek 1505010009	2	0.2
Lower McClellan Wash-Middle Gila River 1505010010	1	0.0
Middle Gila River below Queen Creek 1505010011	1	0.0
Indian Bend Wash 1506010602	2	0.2
Lower Salt River below Saguaro Lake 1506010603B	2	0.2
Waterman Wash 1507010101	2	0.2
Luke Wash-Lower Gila River 1507010102	2	0.2
Sand Tank Wash 1507010103	3	0.0

Subwatershed	Erosion Category	FMV
Rainbow Wash-Lower Gila River 1507010104	2	0.2
Quilotosa Wash 1507010105	2	0.2
Sauceda Wash 1507010106	2	0.2
Lower Gila River-Painted Rock Reservoir 1507010107	3	0.4
Ash Creek and Sycamore Creek 1507010201	6	1.0
Big Bug Creek-Agua Fria River 1507010202	5	0.8
Black Canyon Creek 1507010203	5	0.8
Bishop Creek 1507010204	6	1.0
Agua Fria River-Lake Pleasant 1507010205	5	0.8
Cave Creek-Arizona Canal Diversion Channel 1507010206	5	0.8
Trilby Wash-Trilby Wash Basin 1507010207	2	0.2
New River 1507010208	4	0.6
Agua Fria River below Lake Pleasant 1507010209	2	0.2
Upper Hassayampa River 1507010301	5	0.8
Sols Wash 1507010302	4	0.6
Middle Hassayampa River 1507010303	5	0.8
Jackrabbit Wash 1507010304	2	0.2
Lower Hassayampa River 1507010305	2	0.2

Subwatershed	Erosion Category	FMV
Aguila Valley Area-Centennial Wash 1507010401	3	0.4
McMullen Valley Area-Centennial Wash 1507010402	4	0.6
Tiger Wash 1507010403	4	0.6
Upper Harquahala Plains Area-Centennial Wash 1507010404	3	0.4
Middle Harquahala Plains Area-Centennial Wash 1507010405	1	0.0
Winters Wash 1507010406	2	0.2
Lower Harquahala Plains Area-Centennial Wash 1507010407	1	0.0

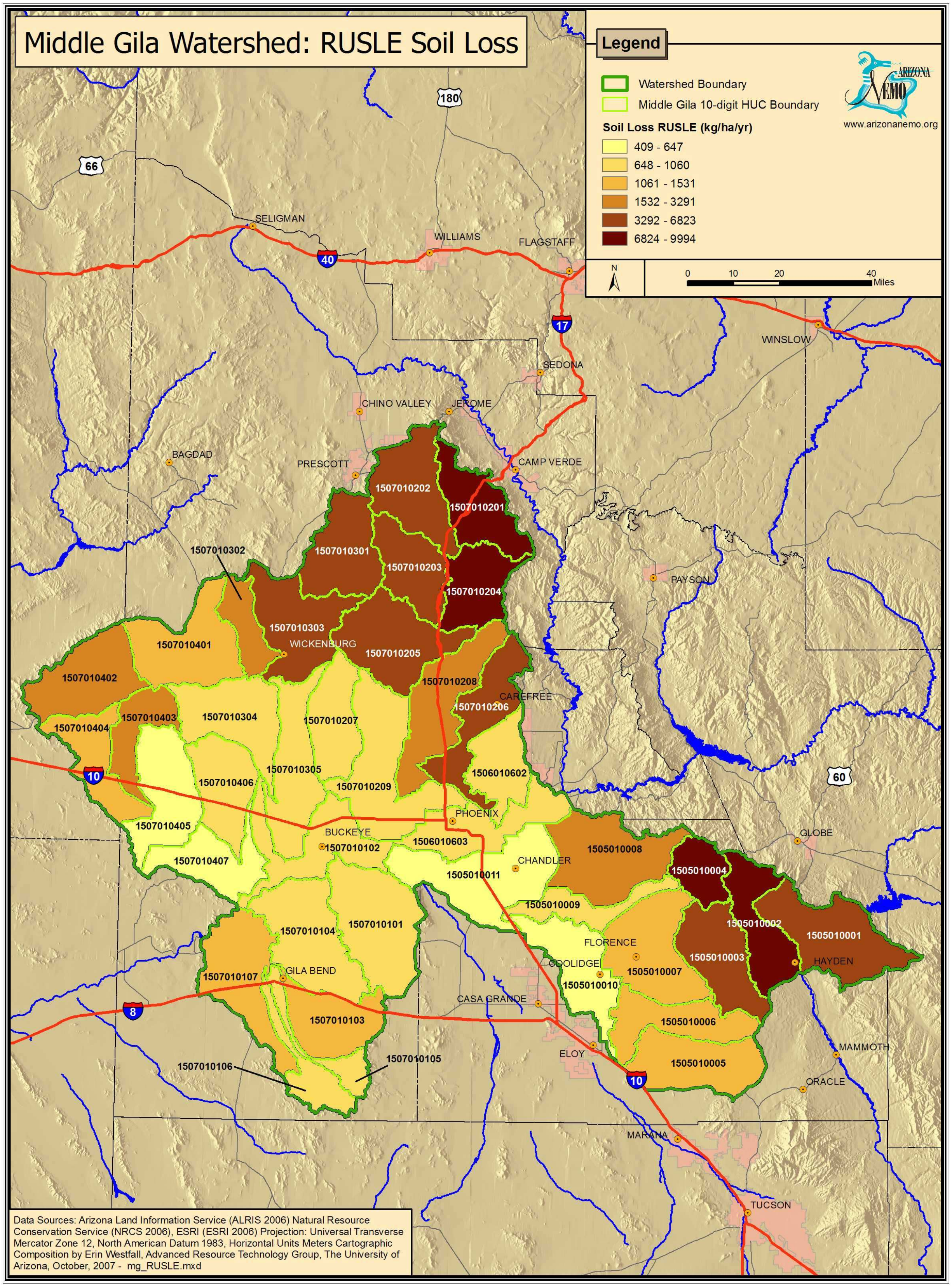

Figure 6-2: RUSLE Soil Loss "A" (kg/ha/yr) by Subwatershed

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 and Table 6-7 shows the results for each subwatershed.

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
Dripping Springs Wash-Middle Gila River 1505010001	0.10%	0
Mineral Creek-Middle Gila River 1505010002	0.46%	0
Box O Wash-Middle Gila River 1505010003	0.00%	0
Upper Queen Creek 1505010004	1.54%	0
Upper McClellan Wash 1505010005	0.62%	0
Brady Wash-Picacho Reservoir 1505010006	0.19%	0
Paisano Wash-Middle Gila River 1505010007	2.94%	0
Middle Queen Creek 1505010008	23.66%	1
Lower Queen Creek 1505010009	8.92%	0.7
Lower McClellan Wash-Middle Gila River 1505010010	3.75%	0
Middle Gila River below Queen Creek 1505010011	38.70%	1
Indian Bend Wash 1506010602	56.78%	1
Lower Salt River below Saguaro Lake 1506010603B	48.98%	1
Waterman Wash 1507010101	0.35%	0
Luke Wash-Lower Gila River 1507010102	6.29%	0.5
Sand Tank Wash 1507010103	0.76%	0
Rainbow Wash-Lower Gila River 1507010104	0.68%	0
Quilotosa Wash 1507010105	1.58%	0
Sauceda Wash 1507010106	0.07%	0
Lower Gila River-Painted Rock Reservoir 1507010107	0.57%	0
Ash Creek and Sycamore Creek 1507010201	0.58%	0
Big Bug Creek-Agua Fria River 1507010202	9.56%	0.8
Black Canyon Creek 1507010203	0.61%	0
Bishop Creek 1507010204	1.69%	0
Agua Fria River-Lake Pleasant 1507010205	0.35%	0
Cave Creek-Arizona Canal Diversion Channel 1507010206	43.33%	1
Trilby Wash-Trilby Wash Basin 1507010207	2.06%	0
New River 1507010208	26.90%	1
Agua Fria River below Lake Pleasant 1507010209	33.60%	1
Upper Hassayampa River 1507010301	0.26%	0
Sols Wash 1507010302	2.51%	0
Middle Hassayampa River 1507010303	2.00%	0
Jackrabbit Wash 1507010304	0.00%	0
Lower Hassayampa River 1507010305	0.79%	0
Aguila Valley Area-Centennial Wash 1507010401	0.55%	0
McMullen Valley Area-Centennial Wash 1507010402	0.39%	0
Tiger Wash 1507010403	0.11%	0

Subwatershed	Percent Urban	FMV
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.42%	0
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.25%	0
Winters Wash 1507010406	0.23%	0
Lower Harquahala Plains Area-Centennial Wash 1507010407	1.23%	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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	1	1	0.8	0	0.76
Mineral Creek-Middle Gila River 1505010002	1.0	1	1	1.0	0	0.90
Box O Wash-Middle Gila River 1505010003	0.7	1	1	0.8	0	0.76
Upper Queen Creek 1505010004	1.0	1	1	1.0	0	0.90
Upper McClellan Wash 1505010005	0.5	1	1	0.4	0	0.60
Brady Wash-Picacho Reservoir 1505010006	0.5	1	1	0.4	0	0.60
Paisano Wash-Middle Gila River 1505010007	0.5	1	1	0.4	0	0.60
Middle Queen Creek 1505010008	0.5	1	1	0.6	1	0.75
Lower Queen Creek 1505010009	0.5	1	1	0.2	0.7	0.62
Lower McClellan Wash-Middle Gila River 1505010010	0.5	1	1	0.0	0	0.50

Subwatershed	FMV WQA[1]	FMV # Mines / HUC	FMV # Mines / Riparian	FMV Erosion Category	FMV Urban Areas	FMV Weighted
Middle Gila River below Queen Creek 1505010011	0.5	1	1	0.0	1	0.60
Indian Bend Wash 1506010602	0.7	1	1	0.2	1	0.71
Lower Salt River below Saguaro Lake 1506010603B	0.7	1	1	0.2	1	0.71
Waterman Wash 1507010101	0.7	1	1	0.2	0	0.61
Luke Wash-Lower Gila River 1507010102	1.0	1	1	0.2	0.5	0.75
Sand Tank Wash 1507010103	0.5	0.875	1	0.0	0	0.50
Rainbow Wash-Lower Gila River 1507010104	0.5	1	1	0.2	0	0.55
Quilotosa Wash 1507010105	0.5	0	0	0.2	0	0.20
Sauceda Wash 1507010106	0.5	0	0	0.2	0	0.20
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	0.75	0	0.4	0	0.29
Ash Creek and Sycamore Creek 1507010201	0.5	1	1	1.0	0	0.75
Big Bug Creek-Agua Fria River 1507010202	0.5	1	1	0.8	0.8	0.78
Black Canyon Creek 1507010203	1.0	1	1	0.8	0	0.85
Bishop Creek 1507010204	0.0	1	1	1.0	0	0.60
Agua Fria River-Lake Pleasant 1507010205	0.3	1	1	0.8	0	0.64
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0	1	1	0.8	1	0.65
Trilby Wash-Trilby Wash Basin 1507010207	0.3	1	1	0.2	0	0.49
New River 1507010208	0.3	1	1	0.6	1	0.69
Agua Fria River below Lake Pleasant 1507010209	0.0	1	1	0.2	1	0.50
Upper Hassayampa River 1507010301	1.0	1	1	0.8	0	0.85
Sols Wash 1507010302	0.5	1	1	0.6	0	0.65
Middle Hassayampa River 1507010303	0.5	1	1	0.8	0	0.70
Jackrabbit Wash 1507010304	0.5	1	1	0.2	0	0.55
Lower Hassayampa River 1507010305	0.7	1	1	0.2	0	0.61
Aguila Valley Area-Centennial Wash 1507010401	0.5	1	1	0.4	0	0.60
McMullen Valley Area-Centennial Wash 1507010402	0.5	1	1	0.6	0	0.65
Tiger Wash 1507010403	0.5	1	1	0.6	0	0.65
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	1	1	0.4	0	0.60
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	1	1	0.0	0	0.50
Winters Wash 1507010406	0.5	1	1	0.2	0	0.55
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.7	1	1	0.0	0	0.56

Subwatershed	FMV WQA[1]	FMV # Mines / HUC	FMV # Mines / Riparian	FMV Erosion Category	FMV Urban Areas	FMV Weighted
Weights	*0.30*	*0.05*	*0.30*	*0.25*	*0.10*	

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

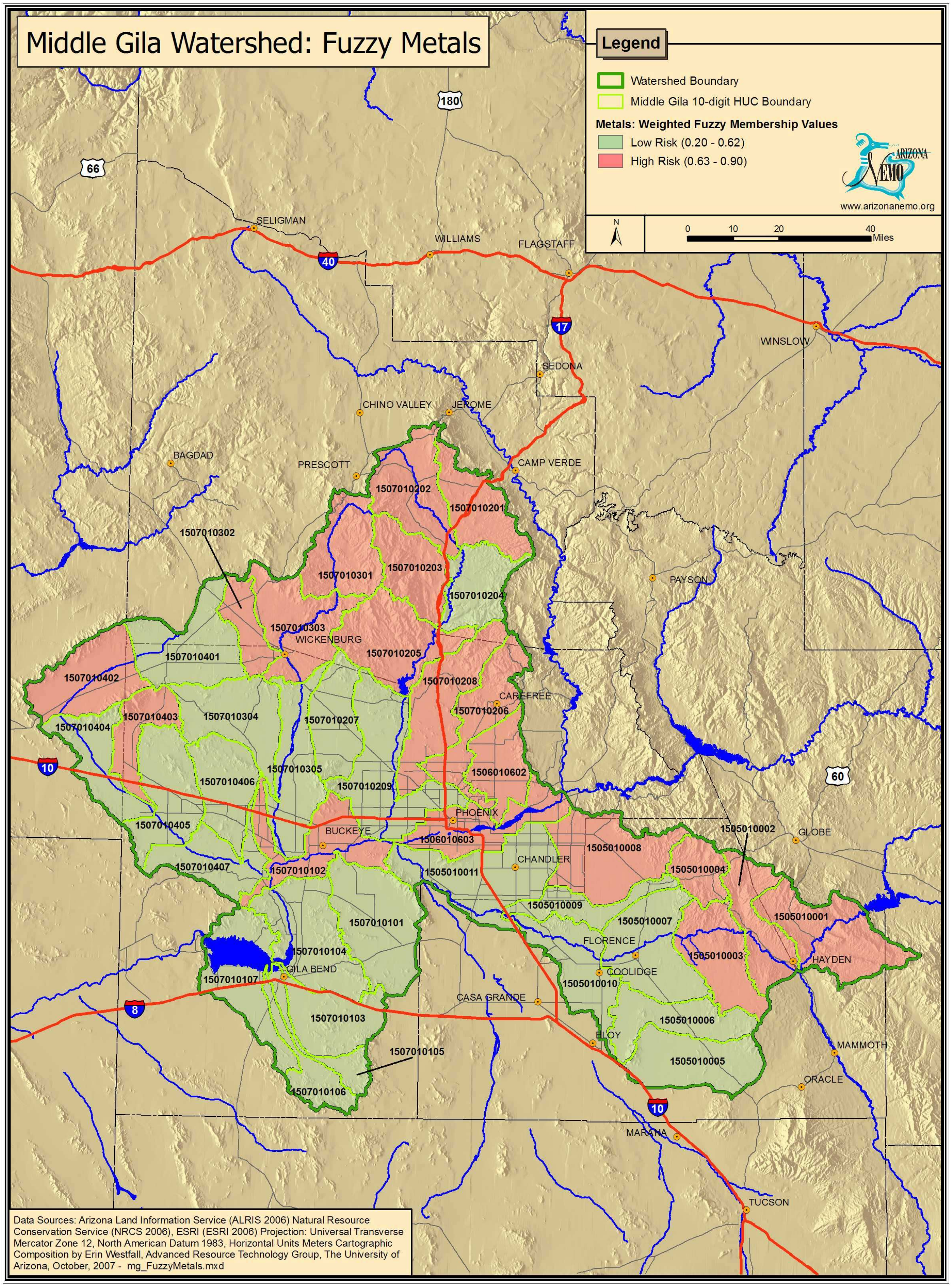

Figure 6-3: Results for the Fuzzy Logic Classification for Metals

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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	Classified as moderate risk, drains to Mineral Creek-Middle Gila River that is classified as extreme.
Mineral Creek-Middle Gila River 1505010002	1.0	Classified as extreme risk, drains to Box O Wash-Middle Gila River that is classified as low.
Box O Wash-Middle Gila River 1505010003	0.0	Classified as low risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Upper Queen Creek 1505010004	0.5	Classified as moderate risk, drains to Middle Queen Creek that is classified as moderate.
Upper McClellan Wash 1505010005	0.5	Classified as moderate risk, drains to Brady Wash-Picacho Reservoir that is classified as moderate.
Brady Wash-Picacho Reservoir 1505010006	0.5	Classified as moderate risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Paisano Wash-Middle Gila River 1505010007	0.5	Classified as moderate risk, drains to Lower McClellan Wash-Middle Gila River that is classified as moderate.
Middle Queen Creek 1505010008	0.5	Classified as moderate risk, drains to Lower Queen Creek that is classified as moderate.

Subwatershed Name	FMV	Justification
Lower Queen Creek 1505010009	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Lower McClellan Wash-Middle Gila River 1505010010	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Middle Gila River below Queen Creek 1505010011	0.5	Classified as moderate risk, drains to Lower Salt River below Saguaro Lake that is classified as moderate.
Indian Bend Wash 1506010602	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 1506010603B	0.5	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as moderate.
Waterman Wash 1507010101	0.5	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as moderate.
Luke Wash-Lower Gila River 1507010102	0.5	Classified as moderate risk, drains to Rainbow Wash-Lower Gila River that is classified as moderate.
Sand Tank Wash 1507010103	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Rainbow Wash-Lower Gila River 1507010104	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Quilotosa Wash 1507010105	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Sauceda Wash 1507010106	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	Classified as moderate risk, drains out of the watershed.
Ash Creek and Sycamore Creek 1507010201	0.5	Classified as moderate risk, drains to Big Bug Creek-Agua Fria River that is classified as moderate.
Big Bug Creek-Agua Fria River 1507010202	0.5	Classified as moderate risk, drains to Bishop Creek that is classified as moderate.
Black Canyon Creek 1507010203	0.7	Classified as high risk, drains to Agua Fria River-Lake Pleasant that is classified as moderate.
Bishop Creek 1507010204	0.0	Classified as low risk, drains to Agua Fria River-Lake Pleasant that is classified as moderate.
Agua Fria River-Lake Pleasant 1507010205	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0	Classified as low risk, drains to Indian Bend Wash that is classified as moderate.
Trilby Wash-Trilby Wash Basin 1507010207	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
New River 1507010208	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
Agua Fria River below Lake Pleasant 1507010209	0.0	Classified as low risk, drains to Luke Wash-Lower Gila River that is classified as moderate.
Upper Hassayampa River 1507010301	0.3	Classified as moderate risk, drains to Middle Hassayampa River that is classified as low.
Sols Wash 1507010302	0.3	Classified as moderate risk, drains to Middle Hassayampa River that is classified as low.
Middle Hassayampa River 1507010303	0.0	Classified as low risk, drains to Lower Hassayampa River that is classified as moderate.

Subwatershed Name	FMV	Justification
Jackrabbit Wash 1507010304	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Lower Hassayampa River 1507010305	0.5	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as moderate.
Aguila Valley Area-Centennial Wash 1507010401	0.5	Classified as moderate risk, drains to McMullen Valley Area-Centennial Wash that is classified as moderate.
McMullen Valley Area-Centennial Wash 1507010402	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Tiger Wash 1507010403	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	Classified as moderate risk, drains to Middle Harquahala Plains Area-Centennial Wash that is classified as moderate.
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Winters Wash 1507010406	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.5	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as moderate.

Land ownership - Sediment

One of the principal land uses in the Middle Gila Watershed is livestock grazing. Livestock grazing occurs primarily on land owned by the federal government (Bureau of Land Management (BLM), U.S. Forest Service (USFS), Wildlife Refuges, and National Parks), which comprises approximately 37.4% of the total watershed area. The remaining lands where grazing occurs are Arizona State Trust Lands (approximately 21.6%), tribal lands (approximately 6.0%), and privately owned land (approximately 29.2%). The remaining lands are military (approximately 3.7%), state and local parks (approximately 1.1%), and "other" (approximately 1.0%), which are not likely grazed. 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 Middle

Gila Watershed based on land ownership.

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

Subwatershed	% State + Private	FMV
Dripping Springs Wash-Middle Gila River 1505010001	23%	1
Mineral Creek-Middle Gila River 1505010002	49%	1
Box O Wash-Middle Gila River 1505010003	57%	1
Upper Queen Creek 1505010004	7%	0
Upper McClellan Wash 1505010005	83%	1
Brady Wash-Picacho Reservoir 1505010006	86%	1
Paisano Wash-Middle Gila River 1505010007	80%	1
Middle Queen Creek 1505010008	82%	1
Lower Queen Creek 1505010009	69%	1
Lower McClellan Wash-Middle Gila River 1505010010	49%	1
Middle Gila River below Queen Creek 1505010011	49%	1
Indian Bend Wash 1506010602	88%	1
Lower Salt River below Saguaro Lake 1506010603B	59%	1
Waterman Wash 1507010101	32%	1
Luke Wash-Lower Gila River 1507010102	67%	1
Sand Tank Wash 1507010103	5%	0
Rainbow Wash-Lower Gila River 1507010104	27%	1
Quilotosa Wash 1507010105	16%	0.4
Sauceda Wash 1507010106	3%	0
Lower Gila River-Painted Rock Reservoir 1507010107	35%	1
Ash Creek and Sycamore Creek 1507010201	7%	1
Big Bug Creek-Agua Fria River 1507010202	60%	1
Black Canyon Creek 1507010203	5%	0
Bishop Creek 1507010204	5%	0
Agua Fria River-Lake Pleasant 1507010205	38%	1
Cave Creek-Arizona Canal Diversion Channel 1507010206	73%	1
Trilby Wash-Trilby Wash Basin 1507010207	83%	1
New River 1507010208	72%	1
Agua Fria River below Lake Pleasant 1507010209	89%	1
Upper Hassayampa River 1507010301	30%	1
Sols Wash 1507010302	98%	1
Middle Hassayampa River 1507010303	53%	1
Jackrabbit Wash 1507010304	33%	1
Lower Hassayampa River 1507010305	85%	1
Aguila Valley Area-Centennial Wash 1507010401	79%	1
McMullen Valley Area-Centennial Wash 1507010402	30%	1
Tiger Wash 1507010403	25%	1
Upper Harquahala Plains Area-Centennial Wash 1507010404	38%	1
Middle Harquahala Plains Area-Centennial Wash 1507010405	39%	1
Winters Wash 1507010406	45%	1

Subwatershed	% State + Private	FMV
Lower Harquahala Plains Area-Centennial Wash 1507010407	39%	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 Middle Gila 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 Middle Gila 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
Dripping Springs Wash-Middle Gila River 1505010001	0	0
Mineral Creek-Middle Gila River 1505010002	0.2	1
Box O Wash-Middle Gila River 1505010003	0	0
Upper Queen Creek 1505010004	0.4	0.1
Upper McClellan Wash 1505010005	0	0
Brady Wash-Picacho Reservoir 1505010006	0	0
Paisano Wash-Middle Gila River 1505010007	1	1
Middle Queen Creek 1505010008	1	1
Lower Queen Creek 1505010009	1	1
Lower McClellan Wash-Middle Gila River 1505010010	1	1
Middle Gila River below Queen Creek 1505010011	1	1
Indian Bend Wash 1506010602	1	1
Lower Salt River below Saguaro Lake 1506010603B	1	1
Waterman Wash 1507010101	0.5	1
Luke Wash-Lower Gila River 1507010102	1	1
Sand Tank Wash 1507010103	0	0
Rainbow Wash-Lower Gila River 1507010104	0.3	1
Quilotosa Wash 1507010105	0.2	1
Sauceda Wash 1507010106	0	0
Lower Gila River-Painted Rock Reservoir 1507010107	1	1
Ash Creek and Sycamore Creek 1507010201	0	0

Subwatershed	FMV - HUI Watershed	FMV - HUI Riparian
Big Bug Creek-Agua Fria River 1507010202	1	1
Black Canyon Creek 1507010203	0	0
Bishop Creek 1507010204	0	0
Agua Fria River-Lake Pleasant 1507010205	0	0
Cave Creek-Arizona Canal Diversion Channel 1507010206	1	1
Trilby Wash-Trilby Wash Basin 1507010207	0	0.2
New River 1507010208	1	1
Agua Fria River below Lake Pleasant 1507010209	1	1
Upper Hassayampa River 1507010301	0	0
Sols Wash 1507010302	0	0.1
Middle Hassayampa River 1507010303	0	0
Jackrabbit Wash 1507010304	0	0
Lower Hassayampa River 1507010305	0.3	1
Aguila Valley Area-Centennial Wash 1507010401	0.3	1
McMullen Valley Area-Centennial Wash 1507010402	0.3	1
Tiger Wash 1507010403	0	0
Upper Harquahala Plains Area-Centennial Wash 1507010404	0	0.4
Middle Harquahala Plains Area-Centennial Wash 1507010405	1	1
Winters Wash 1507010406	0.5	1
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.3	1

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
Dripping Springs Wash-Middle Gila River 1505010001	4	0.6
Mineral Creek-Middle Gila River 1505010002	5	0.8
Box O Wash-Middle Gila River 1505010003	2	0.2
Upper Queen Creek 1505010004	3	0.4
Upper McClellan Wash 1505010005	1	0.0
Brady Wash-Picacho Reservoir 1505010006	1	0.0
Paisano Wash-Middle Gila River 1505010007	2	0.2
Middle Queen Creek 1505010008	3	0.4

Subwatershed	Runoff Category	FMV
Lower Queen Creek 1505010009	2	0.2
Lower McClellan Wash-Middle Gila River 1505010010	3	0.4
Middle Gila River below Queen Creek 1505010011	5	0.8
Indian Bend Wash 1506010602	2	0.2
Lower Salt River below Saguaro Lake 1506010603B	5	0.8
Waterman Wash 1507010101	4	0.6
Luke Wash-Lower Gila River 1507010102	6	1.0
Sand Tank Wash 1507010103	3	0.4
Rainbow Wash-Lower Gila River 1507010104	4	0.6
Quilotosa Wash 1507010105	3	0.4
Sauceda Wash 1507010106	1	0.0
Lower Gila River-Painted Rock Reservoir 1507010107	2	0.2
Ash Creek and Sycamore Creek 1507010201	3	0.4
Big Bug Creek-Agua Fria River 1507010202	3	0.4
Black Canyon Creek 1507010203	4	0.6
Bishop Creek 1507010204	4	0.6
Agua Fria River-Lake Pleasant 1507010205	5	0.8
Cave Creek-Arizona Canal Diversion Channel 1507010206	4	0.6
Trilby Wash-Trilby Wash Basin 1507010207	4	0.6
New River 1507010208	5	0.8
Agua Fria River below Lake Pleasant 1507010209	5	0.8
Upper Hassayampa River 1507010301	4	0.6
Sols Wash 1507010302	2	0.2
Middle Hassayampa River 1507010303	4	0.6
Jackrabbit Wash 1507010304	5	0.8
Lower Hassayampa River 1507010305	4	0.6
Aguila Valley Area-Centennial Wash 1507010401	2	0.2
McMullen Valley Area-Centennial Wash 1507010402	1	0.0
Tiger Wash 1507010403	3	0.4
Upper Harquahala Plains Area-Centennial Wash 1507010404	2	0.2
Middle Harquahala Plains Area-Centennial Wash 1507010405	3	0.4
Winters Wash 1507010406	3	0.4
Lower Harquahala Plains Area-Centennial Wash 1507010407	3	0.4

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

Subwatershed	Erosion Category	FMV
Dripping Springs Wash-Middle Gila River 1505010001	5	0.8
Mineral Creek-Middle Gila River 1505010002	6	1.0
Box O Wash-Middle Gila River 1505010003	2	0.2
Upper Queen Creek 1505010004	5	0.8
Upper McClellan Wash 1505010005	1	0.0
Brady Wash-Picacho Reservoir 1505010006	1	0.0
Paisano Wash-Middle Gila River 1505010007	2	0.2
Middle Queen Creek 1505010008	5	0.8
Lower Queen Creek 1505010009	2	0.2

Subwatershed	Erosion Category	FMV
Lower McClellan Wash-Middle Gila River 1505010010	2	0.2
Middle Gila River below Queen Creek 1505010011	4	0.6
Indian Bend Wash 1506010602	4	0.6
Lower Salt River below Saguaro Lake 1506010603B	6	1.0
Waterman Wash 1507010101	2	0.2
Luke Wash-Lower Gila River 1507010102	4	0.6
Sand Tank Wash 1507010103	2	0.2
Rainbow Wash-Lower Gila River 1507010104	2	0.2
Quilotosa Wash 1507010105	2	0.2
Sauceda Wash 1507010106	1	0.0
Lower Gila River-Painted Rock Reservoir 1507010107	1	0.0
Ash Creek and Sycamore Creek 1507010201	6	1.0
Big Bug Creek-Agua Fria River 1507010202	5	0.8
Black Canyon Creek 1507010203	5	0.8
Bishop Creek 1507010204	6	1.0
Agua Fria River-Lake Pleasant 1507010205	5	0.8
Cave Creek-Arizona Canal Diversion Channel 1507010206	4	0.6
Trilby Wash-Trilby Wash Basin 1507010207	3	0.4
New River 1507010208	6	1.0

Subwatershed	Erosion Category	FMV
Agua Fria River below Lake Pleasant 1507010209	3	0.4
Upper Hassayampa River 1507010301	5	0.6
Sols Wash 1507010302	2	0.2
Middle Hassayampa River 1507010303	3	0.4
Jackrabbit Wash 1507010304	2	0.2
Lower Hassayampa River 1507010305	2	0.2
Aguila Valley Area-Centennial Wash 1507010401	2	0.2
McMullen Valley Area-Centennial Wash 1507010402	1	0.0
Tiger Wash 1507010403	2	0.2
Upper Harquahala Plains Area-Centennial Wash 1507010404	1	0.0
Middle Harquahala Plains Area-Centennial Wash 1507010405	2	0.2
Winters Wash 1507010406	1	0.0
Lower Harquahala Plains Area-Centennial Wash 1507010407	1	0.0

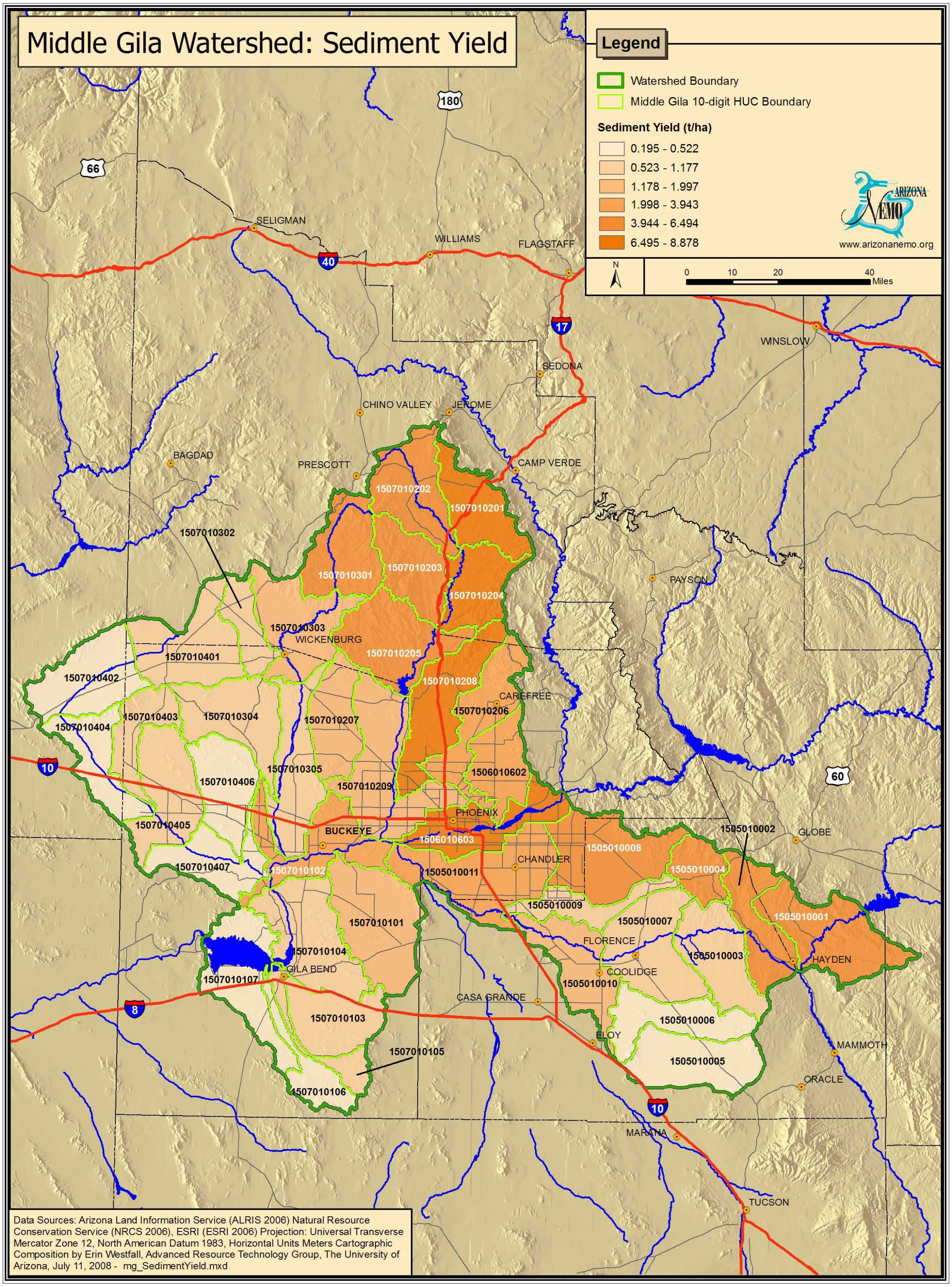

Figure 6-4: Sediment Yield by subwatershed

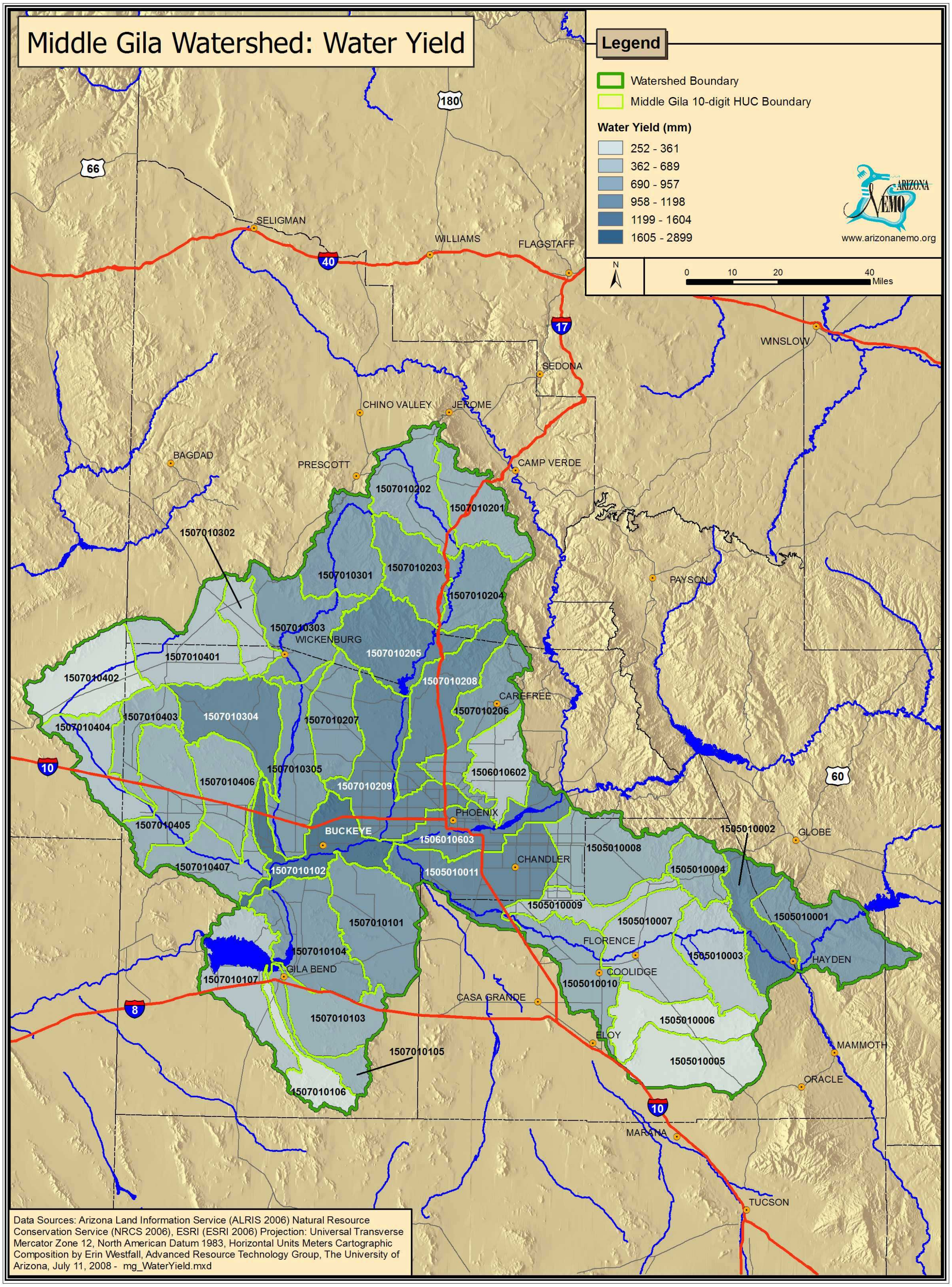

Figure 6-5: Water Yield by subwatershed

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, and Table 6-14 shows the results.

$\text{FMV} = 0 \text{ if } (\% \text{ Urban} < 5)$
$\text{FMV} = (5 <= \% \text{ Urban} < 12) / 12$
$\text{FMV} = 1 \text{ if } (\% \text{ Urban} >= 12)$

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

Subwatershed	Percent Urban	FMV
Dripping Springs Wash-Middle Gila River 1505010001	0.10%	0
Mineral Creek-Middle Gila River 1505010002	0.46%	0
Box O Wash-Middle Gila River 1505010003	0.00%	0
Upper Queen Creek 1505010004	1.54%	0
Upper McClellan Wash 1505010005	0.62%	0
Brady Wash-Picacho Reservoir 1505010006	0.19%	0
Paisano Wash-Middle Gila River 1505010007	2.94%	0
Middle Queen Creek 1505010008	23.66%	1
Lower Queen Creek 1505010009	8.92%	0.7
Lower McClellan Wash-Middle Gila River 1505010010	3.75%	0
Middle Gila River below Queen Creek 1505010011	38.70%	1
Indian Bend Wash 1506010602	56.78%	1
Lower Salt River below Saguaro Lake 1506010603B	48.98%	1
Waterman Wash 1507010101	0.35%	0
Luke Wash-Lower Gila River 1507010102	6.29%	0.5
Sand Tank Wash 1507010103	0.76%	0
Rainbow Wash-Lower Gila River 1507010104	0.68%	0
Quilotosa Wash 1507010105	1.58%	0
Sauceda Wash 1507010106	0.07%	0
Lower Gila River-Painted Rock Reservoir 1507010107	0.57%	0
Ash Creek and Sycamore Creek 1507010201	0.58%	0
Big Bug Creek-Agua Fria River 1507010202	9.56%	0.8
Black Canyon Creek 1507010203	0.61%	0
Bishop Creek 1507010204	1.69%	0
Agua Fria River-Lake Pleasant 1507010205	0.35%	0
Cave Creek-Arizona Canal Diversion Channel 1507010206	43.33%	1
Trilby Wash-Trilby Wash Basin 1507010207	2.06%	0
New River 1507010208	26.90%	1
Agua Fria River below Lake Pleasant 1507010209	33.60%	1
Upper Hassayampa River 1507010301	0.26%	0
Sols Wash 1507010302	2.51%	0
Middle Hassayampa River 1507010303	2.00%	0
Jackrabbit Wash 1507010304	0.00%	0

Subwatershed	Percent Urban	FMV
Lower Hassayampa River 1507010305	0.79%	0
Aguila Valley Area-Centennial Wash 1507010401	0.55%	0
McMullen Valley Area-Centennial Wash 1507010402	0.39%	0
Tiger Wash 1507010403	0.11%	0
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.42%	0
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.25%	0
Winters Wash 1507010406	0.23%	0
Lower Harquahala Plains Area-Centennial Wash 1507010407	1.23%	0

Sediment Results

The weighted combination approach was used to create combined fuzzy scores to rank sediment results, as shown in Table 6-15. 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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	1	0	0	0.6	0.8	0	0.51
Mineral Creek-Middle Gila River 1505010002	1.0	1	0.2	1	0.8	1.0	0	0.80
Box O Wash-Middle Gila River 1505010003	0.0	1	0	0	0.2	0.2	0	0.17
Upper Queen Creek 1505010004	0.5	0	0.4	0.1	0.4	0.8	0	0.42
Upper McClellan Wash 1505010005	0.5	1	0	0	0.0	0.0	0	0.08
Brady Wash-Picacho Reservoir 1505010006	0.5	1	0	0	0.0	0.0	0	0.08
Paisano Wash-Middle Gila River 1505010007	0.5	1	1	1	0.2	0.2	0	0.40
Middle Queen Creek 1505010008	0.5	1	1	1	0.4	0.8	1	0.74
Lower Queen Creek 1505010009	0.5	1	1	1	0.2	0.2	0.7	0.47
Lower McClellan Wash-Middle Gila River 1505010010	0.5	1	1	1	0.4	0.2	0	0.46
Middle Gila River below Queen Creek 1505010011	0.5	1	1	1	0.8	0.6	1	0.80
Indian Bend Wash 1506010602	0.5	1	1	1	0.2	0.6	1	0.62
Lower Salt River below Saguaro Lake 1506010603B	0.5	1	1	1	0.8	1.0	1	0.92

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
Waterman Wash 1507010101	0.5	1	0.5	1	0.6	0.2	0	0.49
Luke Wash-Lower Gila River 1507010102	0.5	1	1	1	1.0	0.6	0.5	0.81
Sand Tank Wash 1507010103	0.5	0	0	0	0.4	0.2	0	0.21
Rainbow Wash-Lower Gila River 1507010104	0.5	1	0.3	1	0.6	0.2	0	0.48
Quilotosa Wash 1507010105	0.5	0.4	0.2	1	0.4	0.2	0	0.39
Sauceda Wash 1507010106	0.5	0	0	0	0.0	0.0	0	0.03
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	1	1	1	0.2	0.0	0	0.34
Ash Creek and Sycamore Creek 1507010201	0.5	1	0	0	0.4	1.0	0	0.50
Big Bug Creek-Agua Fria River 1507010202	0.5	1	1	1	0.4	0.8	0.8	0.72
Black Canyon Creek 1507010203	0.7	0	0	0	0.6	0.8	0	0.46
Bishop Creek 1507010204	0.0	0	0	0	0.6	1.0	0	0.48
Agua Fria River-Lake Pleasant 1507010205	0.3	1	0	0	0.8	0.8	0	0.55
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0	1	1	1	0.6	0.6	1	0.71
Trilby Wash-Trilby Wash Basin 1507010207	0.3	1	0	0.2	0.6	0.4	0	0.40
New River 1507010208	0.3	1	1	1	0.8	1.0	1	0.91
Agua Fria River below Lake Pleasant 1507010209	0.0	1	1	1	0.8	0.4	1	0.71
Upper Hassayampa River 1507010301	0.3	1	0	0	0.6	0.6	0	0.43
Sols Wash 1507010302	0.3	1	0	0.1	0.2	0.2	0	0.20
Middle Hassayampa River 1507010303	0.0	1	0	0	0.6	0.4	0	0.35
Jackrabbit Wash 1507010304	0.5	1	0	0	0.8	0.2	0	0.38
Lower Hassayampa River 1507010305	0.5	1	0.3	1	0.6	0.2	0	0.48
Aguila Valley Area-Centennial Wash 1507010401	0.5	1	0.3	1	0.2	0.2	0	0.36
McMullen Valley Area-Centennial Wash 1507010402	0.5	1	0.3	1	0.0	0.0	0	0.24
Tiger Wash 1507010403	0.5	1	0	0	0.4	0.2	0	0.26
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	1	0	0.4	0.2	0.0	0	0.20
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	1	1	1	0.4	0.2	0	0.46
Winters Wash 1507010406	0.5	1	0.5	1	0.4	0.0	0	0.37
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.5	1	0.3	1	0.4	0.0	0	0.36

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
Weights	*0.05*	*0.05*	*0.05*	*0.15*	*0.3*	*0.3*	*0.1*	

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

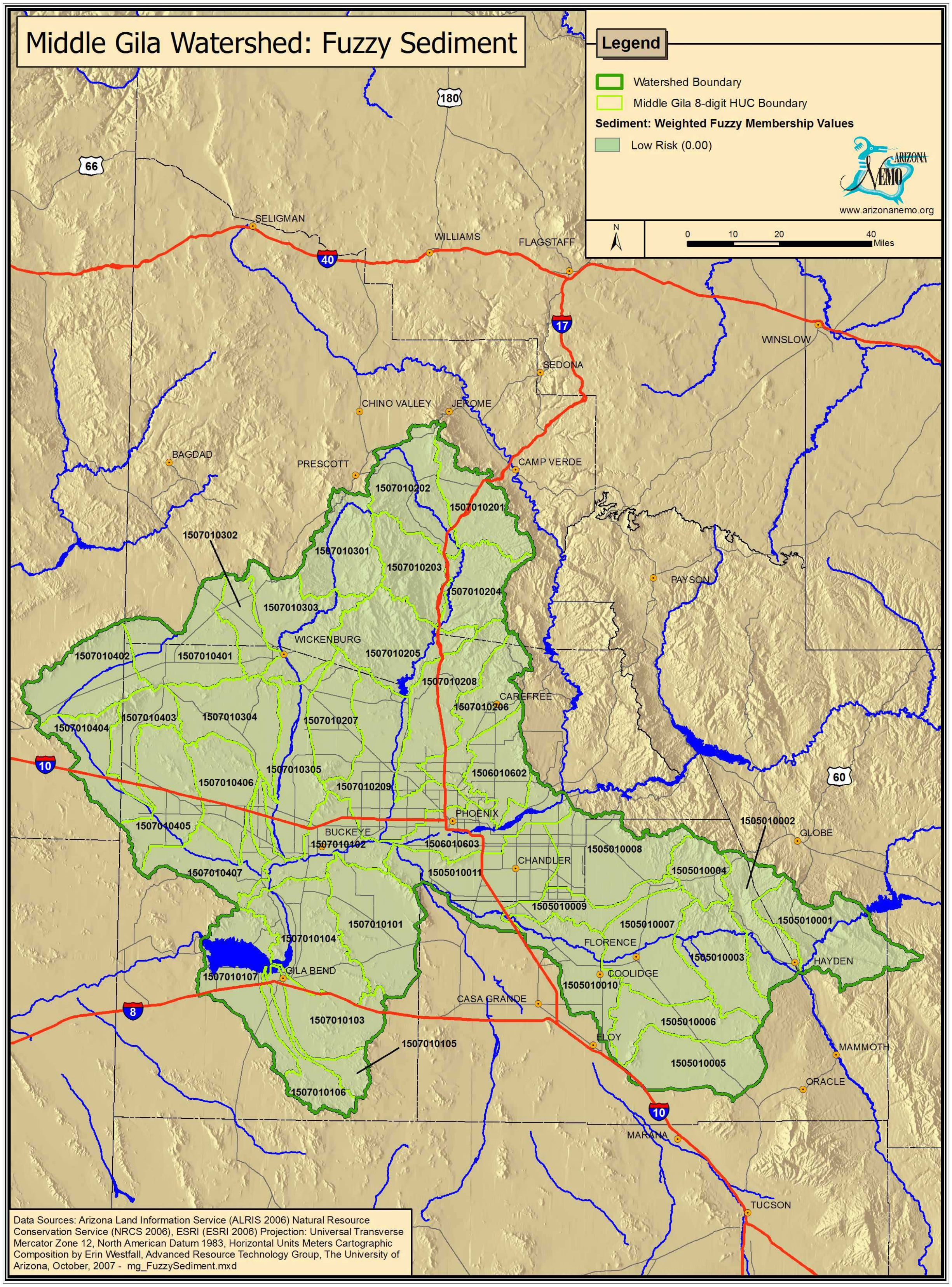

Figure 6-6: Results for the Fuzzy Logic Classification for Sediment

Organics

Several water quality parameters that have been identified as concerns in the Middle Gila 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 water bodies 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 Middle Gila 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 Middle Gila 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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	Classified as moderate risk, drains to Mineral Creek-Middle Gila River that is classified as extreme.
Mineral Creek-Middle Gila River 1505010002	0.5	Classified as moderate risk, drains to Box O Wash-Middle Gila River that is classified as moderate.
Box O Wash-Middle Gila River 1505010003	0.5	Classified as moderate risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Upper Queen Creek 1505010004	0.5	Classified as moderate risk, drains to Middle Queen Creek that is classified as moderate.
Upper McClellan Wash 1505010005	0.5	Classified as moderate risk, drains to Brady Wash-Picacho Reservoir that is classified as moderate.
Brady Wash-Picacho Reservoir 1505010006	0.5	Classified as moderate risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Paisano Wash-Middle Gila River 1505010007	0.5	Classified as moderate risk, drains to Lower McClellan Wash-Middle Gila River that is classified as moderate.
Middle Queen Creek 1505010008	0.5	Classified as moderate risk, drains to Lower Queen Creek that is classified as moderate.
Lower Queen Creek 1505010009	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Lower McClellan Wash-Middle Gila River 1505010010	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Middle Gila River below Queen Creek 1505010011	0.7	Classified as moderate risk, drains to Lower Salt River below Saguaro Lake that is classified as extreme.
Indian Bend Wash 1506010602	1.0	Classified as extreme risk, drains to Lower Salt River below Saguaro Lake that is classified as extreme.
Lower Salt River below Saguaro Lake 1506010603B	1.0	Classified as extreme risk, drains to Luke Wash-Lower Gila River that is classified as high.
Waterman Wash 1507010101	0.6	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as high.
Luke Wash-Lower Gila River 1507010102	0.7	Classified as high risk, drains to Rainbow Wash-Lower Gila River that is classified as moderate.
Sand Tank Wash 1507010103	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Rainbow Wash-Lower Gila River 1507010104	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Quilotosa Wash 1507010105	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Sauceda Wash 1507010106	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	Classified as moderate risk, drains out of the watershed.
Ash Creek and Sycamore Creek 1507010201	0.5	Classified as moderate risk, drains to Big Bug Creek-Agua Fria River that is classified as moderate.
Big Bug Creek-Agua Fria River 1507010202	0.5	Classified as moderate risk, drains to Bishop Creek that is classified as low.

Subwatershed Name	FMV	Justification
Black Canyon Creek 1507010203	0.7	Classified as moderate risk, drains to Agua Fria River-Lake Pleasant that is classified as extreme.
Bishop Creek 1507010204	0.0	Classified as low risk, drains to Agua Fria River-Lake Pleasant that is classified as extreme.
Agua Fria River-Lake Pleasant 1507010205	1.0	Classified as extreme risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0	Classified as low risk, drains to Indian Bend Wash that is classified as moderate.
Trilby Wash-Trilby Wash Basin 1507010207	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
New River 1507010208	0.3	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as low.
Agua Fria River below Lake Pleasant 1507010209	0.0	Classified as low risk, drains to Luke Wash-Lower Gila River that is classified as high.
Upper Hassayampa River 1507010301	0.0	Classified as low risk, drains to Middle Hassayampa River that is classified as moderate.
Sols Wash 1507010302	0.5	Classified as moderate risk, drains to Middle Hassayampa River that is classified as moderate.
Middle Hassayampa River 1507010303	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Jackrabbit Wash 1507010304	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Lower Hassayampa River 1507010305	0.6	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as high.
Aguila Valley Area-Centennial Wash 1507010401	0.5	Classified as moderate risk, drains to McMullen Valley Area-Centennial Wash that is classified as moderate.
McMullen Valley Area-Centennial Wash 1507010402	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Tiger Wash 1507010403	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	Classified as moderate risk, drains to Middle Harquahala Plains Area-Centennial Wash that is classified as moderate.
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Winters Wash 1507010406	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.6	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as high.

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 Middle Gila 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
Dripping Springs Wash-Middle Gila River 1505010001	0	0.0
Mineral Creek-Middle Gila River 1505010002	1	1.0
Box O Wash-Middle Gila River 1505010003	0	0.0
Upper Queen Creek 1505010004	0.2	0.4
Upper McClellan Wash 1505010005	0.2	0.0
Brady Wash-Picacho Reservoir 1505010006	1	0.0
Paisano Wash-Middle Gila River 1505010007	1	1.0
Middle Queen Creek 1505010008	1	1.0
Lower Queen Creek 1505010009	1	1.0
Lower McClellan Wash-Middle Gila River 1505010010	1	1.0
Middle Gila River below Queen Creek 1505010011	1	1.0
Indian Bend Wash 1506010602	1	1.0
Lower Salt River below Saguaro Lake 1506010603B	1	1.0
Waterman Wash 1507010101	1	0.8
Luke Wash-Lower Gila River 1507010102	1	1.0
Sand Tank Wash 1507010103	0	0.3
Rainbow Wash-Lower Gila River 1507010104	1	1.0
Quilotosa Wash 1507010105	1	1.0
Sauceda Wash 1507010106	0.1	0.3
Lower Gila River-Painted Rock Reservoir 1507010107	1	1.0
Ash Creek and Sycamore Creek 1507010201	0	0.0
Big Bug Creek-Agua Fria River 1507010202	1	1.0
Black Canyon Creek 1507010203	0	0.0
Bishop Creek 1507010204	0.2	0.3
Agua Fria River-Lake Pleasant 1507010205	0	0.0
Cave Creek-Arizona Canal Diversion Channel 1507010206	1	1.0
Trilby Wash-Trilby Wash Basin 1507010207	0.4	0.5
New River 1507010208	1	1.0
Agua Fria River below Lake Pleasant 1507010209	1	1.0
Upper Hassayampa River 1507010301	0	0.0
Sols Wash 1507010302	0.5	0.5

Subwatershed	FMV HU Index Watershed	FMV HU Index Riparian
Middle Hassayampa River 1507010303	0.3	0.3
Jackrabbit Wash 1507010304	0	0.0
Lower Hassayampa River 1507010305	1	1.0
Aguila Valley Area-Centennial Wash 1507010401	1	1.0
McMullen Valley Area-Centennial Wash 1507010402	1	1.0
Tiger Wash 1507010403	0	0.0
Upper Harquahala Plains Area-Centennial Wash 1507010404	1	0.8
Middle Harquahala Plains Area-Centennial Wash 1507010405	1	1.0
Winters Wash 1507010406	1	1.0
Lower Harquahala Plains Area-Centennial Wash 1507010407	1	1.0

Land Use - Organics

The major land uses in the Middle Gila Watershed are agriculture, livestock grazing, and urban lands, which all 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
Dripping Springs Wash-Middle Gila River 1505010001	0.10%	0
Mineral Creek-Middle Gila River 1505010002	0.46%	0
Box O Wash-Middle Gila River 1505010003	0.00%	0
Upper Queen Creek 1505010004	1.54%	0
Upper McClellan Wash 1505010005	0.62%	0
Brady Wash-Picacho Reservoir 1505010006	0.19%	0
Paisano Wash-Middle Gila River 1505010007	2.94%	0
Middle Queen Creek 1505010008	23.66%	1
Lower Queen Creek 1505010009	8.92%	0.7
Lower McClellan Wash-Middle Gila River 1505010010	3.75%	0

Subwatershed	Percent Urban	FMV
Middle Gila River below Queen Creek 1505010011	38.70%	1
Indian Bend Wash 1506010602	56.78%	1
Lower Salt River below Saguaro Lake 1506010603B	48.98%	1
Waterman Wash 1507010101	0.35%	0
Luke Wash-Lower Gila River 1507010102	6.29%	0.5
Sand Tank Wash 1507010103	0.76%	0
Rainbow Wash-Lower Gila River 1507010104	0.68%	0
Quilotosa Wash 1507010105	1.58%	0
Sauceda Wash 1507010106	0.07%	0
Lower Gila River-Painted Rock Reservoir 1507010107	0.57%	0
Ash Creek and Sycamore Creek 1507010201	0.58%	0
Big Bug Creek-Agua Fria River 1507010202	9.56%	0.8
Black Canyon Creek 1507010203	0.61%	0
Bishop Creek 1507010204	1.69%	0
Agua Fria River-Lake Pleasant 1507010205	0.35%	0
Cave Creek-Arizona Canal Diversion Channel 1507010206	43.33%	1
Trilby Wash-Trilby Wash Basin 1507010207	2.06%	0
New River 1507010208	26.90%	1
Agua Fria River below Lake Pleasant 1507010209	33.60%	1
Upper Hassayampa River 1507010301	0.26%	0
Sols Wash 1507010302	2.51%	0
Middle Hassayampa River 1507010303	2.00%	0
Jackrabbit Wash 1507010304	0.00%	0
Lower Hassayampa River 1507010305	0.79%	0
Aguila Valley Area-Centennial Wash 1507010401	0.55%	0
McMullen Valley Area-Centennial Wash 1507010402	0.39%	0
Tiger Wash 1507010403	0.11%	0
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.42%	0
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.25%	0
Winters Wash 1507010406	0.23%	0
Lower Harquahala Plains Area-Centennial Wash 1507010407	1.23%	0

Nutrients

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

1. Alvord Lake, for ammonia
2. Chaparral Park Lake, for *E. coli* and low dissolved oxygen
3. Cortez Park Lake, for high pH and low dissolved oxygen
4. Hassayampa River from headwaters to Copper Creek, for high pH
5. Mineral Creek, for low dissolved oxygen

In addition, there were insufficient monitoring data for many of the water bodies, 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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	0	0.0	1	0	0.31
Mineral Creek-Middle Gila River 1505010002	0.5	1	1.0	1	0	0.75
Box O Wash-Middle Gila River 1505010003	0.5	0	0.0	1	0	0.25
Upper Queen Creek 1505010004	0.5	0.2	0.4	1	0	0.41

Subwatershed	FMV WQA[1]	FMV HUI / subws	FMV HUI / riparian	FMV Land Use	FMV Urban Areas	FMV Weighted
Upper McClellan Wash 1505010005	0.5	0.2	0.0	1	0	0.29
Brady Wash-Picacho Reservoir 1505010006	0.5	1	0.0	1	0	0.45
Paisano Wash-Middle Gila River 1505010007	0.5	1	1.0	1	0	0.75
Middle Queen Creek 1505010008	0.5	1	1.0	1	0	0.75
Lower Queen Creek 1505010009	0.5	1	1.0	1	0	0.75
Lower McClellan Wash-Middle Gila River 1505010010	0.5	1	1.0	1	0	0.75
Middle Gila River below Queen Creek 1505010011	0.7	1	1.0	1	0	0.81
Indian Bend Wash 1506010602	1.0	1	1.0	1	0	0.90
Lower Salt River below Saguaro Lake 1506010603B	1.0	1	1.0	1	0	0.90
Waterman Wash 1507010101	0.6	1	0.8	1	0.45	0.77
Luke Wash-Lower Gila River 1507010102	0.7	1	1.0	1	0	0.81
Sand Tank Wash 1507010103	0.5	0	0.3	1	0	0.34
Rainbow Wash-Lower Gila River 1507010104	0.5	1	1.0	1	0	0.75
Quilotosa Wash 1507010105	0.5	1	1.0	1	0	0.75
Sauceda Wash 1507010106	0.5	0.1	0.3	1	0	0.36
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	1	1.0	1	0	0.75
Ash Creek and Sycamore Creek 1507010201	0.5	0	0.0	1	0	0.25
Big Bug Creek-Agua Fria River 1507010202	0.5	1	1.0	1	0	0.75
Black Canyon Creek 1507010203	0.7	0	0.0	1	0	0.31
Bishop Creek 1507010204	0.0	0.2	0.3	1	0	0.23
Agua Fria River-Lake Pleasant 1507010205	1.0	0	0.0	1	0	0.40
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0	1	1.0	1	0	0.60
Trilby Wash-Trilby Wash Basin 1507010207	0.3	0.4	0.5	1	0	0.42
New River 1507010208	0.3	1	1.0	1	0	0.69
Agua Fria River below Lake Pleasant 1507010209	0.0	1	1.0	1	0	0.60
Upper Hassayampa River 1507010301	0.0	0	0.0	1	0	0.10
Sols Wash 1507010302	0.5	0.5	0.5	1	0	0.50
Middle Hassayampa River 1507010303	0.5	0.3	0.3	1	0	0.40
Jackrabbit Wash 1507010304	0.5	0	0.0	1	0	0.25
Lower Hassayampa River 1507010305	0.6	1	1.0	1	0	0.78

Subwatershed	FMV WQA[1]	FMV HUI / subws	FMV HUI / riparian	FMV Land Use	FMV Urban Areas	FMV Weighted
Aguila Valley Area-Centennial Wash 1507010401	0.5	1	1.0	1	0	0.75
McMullen Valley Area-Centennial Wash 1507010402	0.5	1	1.0	1	0	0.75
Tiger Wash 1507010403	0.5	0	0.0	1	0	0.25
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	1	0.8	1	0	0.69
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	1	1.0	1	0	0.75
Winters Wash 1507010406	0.5	1	1.0	1	0	0.75
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.6	1	1.0	1	0.45	0.83
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 mining 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).

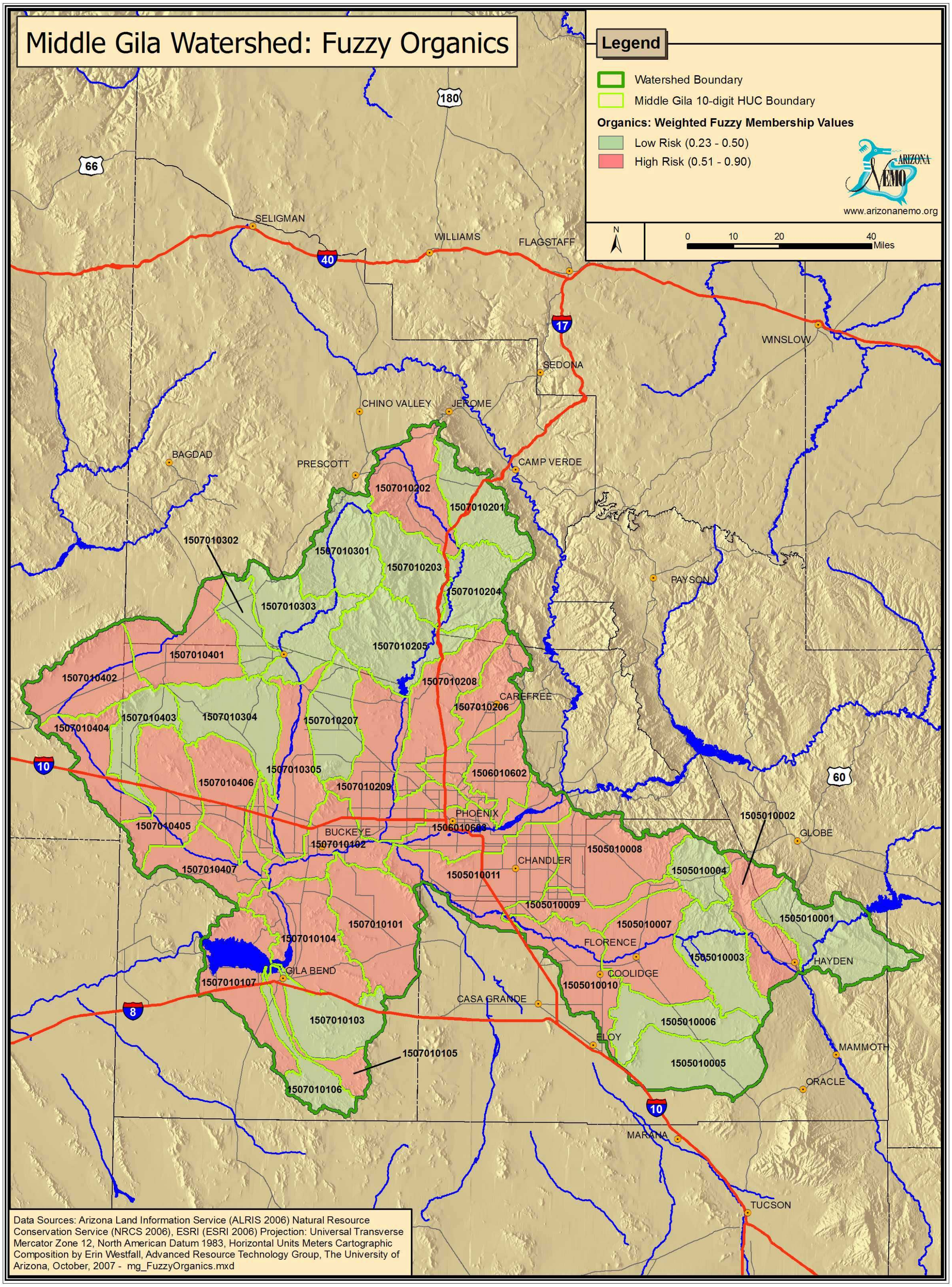

Figure 6-7: Results for the Fuzzy Logic Classification for Organics

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 6-17 contains the fuzzy membership values for selenium for each subwatershed based on the water quality assessment results.

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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	Classified as moderate risk, drains to Mineral Creek-Middle Gila River that is classified as extreme.
Mineral Creek-Middle Gila River 1505010002	1.0	Classified as extreme risk, drains to Box O Wash-Middle Gila River that is classified as moderate.
Box O Wash-Middle Gila River 1505010003	0.5	Classified as moderate risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Upper Queen Creek 1505010004	0.5	Classified as moderate risk, drains to Middle Queen Creek that is classified as moderate.
Upper McClellan Wash 1505010005	0.5	Classified as moderate risk, drains to Brady Wash-Picacho Reservoir that is classified as moderate.
Brady Wash-Picacho Reservoir 1505010006	0.5	Classified as moderate risk, drains to Paisano Wash-Middle Gila River that is classified as moderate.
Paisano Wash-Middle Gila River 1505010007	0.5	Classified as moderate risk, drains to Lower McClellan Wash-Middle Gila River that is classified as moderate.
Middle Queen Creek 1505010008	0.5	Classified as moderate risk, drains to Lower Queen Creek that is classified as moderate.
Lower Queen Creek 1505010009	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Lower McClellan Wash-Middle Gila River 1505010010	0.5	Classified as moderate risk, drains to Middle Gila River below Queen Creek that is classified as moderate.
Middle Gila River below Queen Creek 1505010011	0.5	Classified as moderate risk, drains to Lower Salt River below Saguaro Lake that is classified as moderate.
Indian Bend Wash 1506010602	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 1506010603B	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.
Waterman Wash 1507010101	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.

Subwatershed Name	FMV	Justification
Luke Wash-Lower Gila River 1507010102	0.5	Classified as moderate risk, drains to Rainbow Wash-Lower Gila River that is classified as moderate.
Sand Tank Wash 1507010103	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Rainbow Wash-Lower Gila River 1507010104	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Quilotosa Wash 1507010105	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Sauceda Wash 1507010106	0.5	Classified as moderate risk, drains to Lower Gila River-Painted Rock Reservoir that is classified as moderate.
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	Classified as moderate risk, drains out of the watershed.
Ash Creek and Sycamore Creek 1507010201	0.5	Classified as moderate risk, drains to Big Bug Creek-Agua Fria River that is classified as moderate.
Big Bug Creek-Agua Fria River 1507010202	0.5	Classified as moderate risk, drains to Bishop Creek that is classified as moderate.
Black Canyon Creek 1507010203	0.5	Classified as moderate risk, drains to Agua Fria River-Lake Pleasant that is classified as moderate.
Bishop Creek 1507010204	0.5	Classified as moderate risk, drains to Agua Fria River-Lake Pleasant that is classified as moderate.
Agua Fria River-Lake Pleasant 1507010205	0.5	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as moderate.
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.5	Classified as moderate risk, drains to Indian Bend Wash that is classified as moderate.
Trilby Wash-Trilby Wash Basin 1507010207	0.5	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as moderate.
New River 1507010208	0.5	Classified as moderate risk, drains to Agua Fria River below Lake Pleasant that is classified as moderate.
Agua Fria River below Lake Pleasant 1507010209	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.
Upper Hassayampa River 1507010301	0.7	Classified as high risk, drains to Middle Hassayampa River that is classified as moderate.
Sols Wash 1507010302	0.5	Classified as moderate risk, drains to Middle Hassayampa River that is classified as moderate.
Middle Hassayampa River 1507010303	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Jackrabbit Wash 1507010304	0.5	Classified as moderate risk, drains to Lower Hassayampa River that is classified as moderate.
Lower Hassayampa River 1507010305	0.5	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as moderate.
Aguila Valley Area-Centennial Wash 1507010401	0.5	Classified as moderate risk, drains to McMullen Valley Area-Centennial Wash that is classified as moderate.
McMullen Valley Area-Centennial Wash 1507010402	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.
Tiger Wash 1507010403	0.5	Classified as moderate risk, drains to Upper Harquahala Plains Area-Centennial Wash that is classified as moderate.

Subwatershed Name	FMV	Justification
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	Classified as moderate risk, drains to Middle Harquahala Plains Area-Centennial Wash that is classified as moderate.
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Winters Wash 1507010406	0.5	Classified as moderate risk, drains to Lower Harquahala Plains Area-Centennial Wash that is classified as moderate.
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.7	Classified as moderate risk, drains to Luke Wash-Lower Gila River that is classified as extreme.

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 Middle Gila 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
Dripping Springs Wash-Middle Gila River 1505010001	0.0%	0
Mineral Creek-Middle Gila River 1505010002	1.4%	0.1
Box O Wash-Middle Gila River 1505010003	0.0%	0
Upper Queen Creek 1505010004	0.0%	0
Upper McClellan Wash 1505010005	1.0%	0.1
Brady Wash-Picacho Reservoir 1505010006	1.4%	0.1
Paisano Wash-Middle Gila River 1505010007	11.5%	1
Middle Queen Creek 1505010008	8.0%	0.8
Lower Queen Creek 1505010009	24.0%	1
Lower McClellan Wash-Middle Gila River 1505010010	38.8%	1
Middle Gila River below Queen Creek 1505010011	16.2%	1
Indian Bend Wash 1506010602	4.0%	0.4
Lower Salt River below Saguaro Lake 1506010603B	10.4%	1
Waterman Wash 1507010101	6.8%	0.7

Subwatershed Name	% Agricul. Land	FMV Agricul. Land
Luke Wash-Lower Gila River 1507010102	19.0%	1
Sand Tank Wash 1507010103	0.3%	0
Rainbow Wash-Lower Gila River 1507010104	8.4%	0.8
Quilotosa Wash 1507010105	4.7%	0.5
Sauceda Wash 1507010106	1.3%	0.1
Lower Gila River-Painted Rock Reservoir 1507010107	21.0%	1
Ash Creek and Sycamore Creek 1507010201	0.1%	0
Big Bug Creek-Agua Fria River 1507010202	0.3%	0
Black Canyon Creek 1507010203	0.0%	0
Bishop Creek 1507010204	0.0%	0
Agua Fria River-Lake Pleasant 1507010205	0.0%	0
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.0%	0
Trilby Wash-Trilby Wash Basin 1507010207	0.0%	0
New River 1507010208	1.1%	0.1
Agua Fria River below Lake Pleasant 1507010209	21.8%	1
Upper Hassayampa River 1507010301	0.1%	0
Sols Wash 1507010302	0.0%	0
Middle Hassayampa River 1507010303	0.0%	0
Jackrabbit Wash 1507010304	0.0%	0
Lower Hassayampa River 1507010305	8.2%	0.8
Aguila Valley Area-Centennial Wash 1507010401	8.4%	0.8
McMullen Valley Area-Centennial Wash 1507010402	8.6%	0.9
Tiger Wash 1507010403	0.5%	0
Upper Harquahala Plains Area-Centennial Wash 1507010404	3.9%	0.4
Middle Harquahala Plains Area-Centennial Wash 1507010405	18.9%	1
Winters Wash 1507010406	7.6%	0.8
Lower Harquahala Plains Area-Centennial Wash 1507010407	8.0%	0.8

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
Dripping Springs Wash-Middle Gila River 1505010001	83	1

Subwatershed Name	Number of mines	FMV mines/HUC
Mineral Creek-Middle Gila River 1505010002	132	1
Box O Wash-Middle Gila River 1505010003	102	1
Upper Queen Creek 1505010004	89	1
Upper McClellan Wash 1505010005	35	0.66
Brady Wash-Picacho Reservoir 1505010006	47	0.66
Paisano Wash-Middle Gila River 1505010007	73	1
Middle Queen Creek 1505010008	61	1
Lower Queen Creek 1505010009	15	0.33
Lower McClellan Wash-Middle Gila River 1505010010	28	0.66
Middle Gila River below Queen Creek 1505010011	25	0.33
Indian Bend Wash 1506010602	14	0.33
Lower Salt River below Saguaro Lake 1506010603B	53	1
Waterman Wash 1507010101	12	0.33
Luke Wash-Lower Gila River 1507010102	41	0.66
Sand Tank Wash 1507010103	9	0
Rainbow Wash-Lower Gila River 1507010104	18	0.33
Quilotosa Wash 1507010105	1	0
Sauceda Wash 1507010106	0	0
Lower Gila River-Painted Rock Reservoir 1507010107	8	0
Ash Creek and Sycamore Creek 1507010201	34	0.66

Subwatershed Name	Number of mines	FMV mines/HUC
Big Bug Creek-Agua Fria River 1507010202	293	1
Black Canyon Creek 1507010203	248	1
Bishop Creek 1507010204	25	0.33
Agua Fria River-Lake Pleasant 1507010205	223	1
Cave Creek-Arizona Canal Diversion Channel 1507010206	95	1
Trilby Wash-Trilby Wash Basin 1507010207	46	0.66
New River 1507010208	34	0.66
Agua Fria River below Lake Pleasant 1507010209	63	1
Upper Hassayampa River 1507010301	186	1
Sols Wash 1507010302	12	0.33
Middle Hassayampa River 1507010303	215	1
Jackrabbit Wash 1507010304	84	1
Lower Hassayampa River 1507010305	60	1
Aguila Valley Area-Centennial Wash 1507010401	24	0.33
McMullen Valley Area-Centennial Wash 1507010402	41	0.66
Tiger Wash 1507010403	59	1
Upper Harquahala Plains Area-Centennial Wash 1507010404	31	0.66
Middle Harquahala Plains Area-Centennial Wash 1507010405	31	0.66
Winters Wash 1507010406	35	0.66
Lower Harquahala Plains Area-Centennial Wash 1507010407	14	0.33

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
Dripping Springs Wash-Middle Gila River 1505010001	0.7	1	0	0.60
Mineral Creek-Middle Gila River 1505010002	1.0	1	0.1	0.78
Box O Wash-Middle Gila River 1505010003	0.5	1	0	0.50
Upper Queen Creek 1505010004	0.5	1	0	0.50
Upper McClellan Wash 1505010005	0.5	0.66	0.1	0.44
Brady Wash-Picacho Reservoir 1505010006	0.5	0.66	0.1	0.44
Paisano Wash-Middle Gila River 1505010007	0.5	1	1	0.75
Middle Queen Creek 1505010008	0.5	1	0.8	0.70
Lower Queen Creek 1505010009	0.5	0.33	1	0.58
Lower McClellan Wash-Middle Gila River 1505010010	0.5	0.66	1	0.67
Middle Gila River below Queen Creek 1505010011	0.5	0.33	1	0.58
Indian Bend Wash 1506010602	0.5	0.33	0.4	0.43
Lower Salt River below Saguaro Lake 1506010603B	0.7	1	1	0.85
Waterman Wash 1507010101	0.7	0.33	0.7	0.61
Luke Wash-Lower Gila River 1507010102	0.5	0.66	1	0.67
Sand Tank Wash 1507010103	0.5	0	0	0.25
Rainbow Wash-Lower Gila River 1507010104	0.5	0.33	0.8	0.53
Quilotosa Wash 1507010105	0.5	0	0.5	0.38
Sauceda Wash 1507010106	0.5	0	0.1	0.28

Subwatershed Name	FMV WQA[1]	FMV mines/HUC	FMV % Agricultural Land	FMV Weighted
Lower Gila River-Painted Rock Reservoir 1507010107	0.5	0	1	0.50
Ash Creek and Sycamore Creek 1507010201	0.5	0.66	0	0.42
Big Bug Creek-Agua Fria River 1507010202	0.5	1	0	0.50
Black Canyon Creek 1507010203	0.5	1	0	0.50
Bishop Creek 1507010204	0.5	0.33	0	0.33
Agua Fria River-Lake Pleasant 1507010205	0.5	1	0	0.50
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.5	1	0	0.50
Trilby Wash-Trilby Wash Basin 1507010207	0.5	0.66	0	0.42
New River 1507010208	0.5	0.66	0.1	0.44
Agua Fria River below Lake Pleasant 1507010209	0.7	1	1	0.85
Upper Hassayampa River 1507010301	0.7	1	0	0.60
Sols Wash 1507010302	0.5	0.33	0	0.33
Middle Hassayampa River 1507010303	0.5	1	0	0.50
Jackrabbit Wash 1507010304	0.5	1	0	0.50
Lower Hassayampa River 1507010305	0.5	1	0.8	0.70
Aguila Valley Area-Centennial Wash 1507010401	0.5	0.33	0.8	0.53
McMullen Valley Area-Centennial Wash 1507010402	0.5	0.66	0.9	0.64
Tiger Wash 1507010403	0.5	1	0	0.50
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.5	0.66	0.4	0.52
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.5	0.66	1	0.67
Winters Wash 1507010406	0.5	0.66	0.8	0.62
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.7	0.33	0.8	0.63
Weights	*0.5*	*0.25*	*0.25*	

1WQA = Water Quality Assessment results

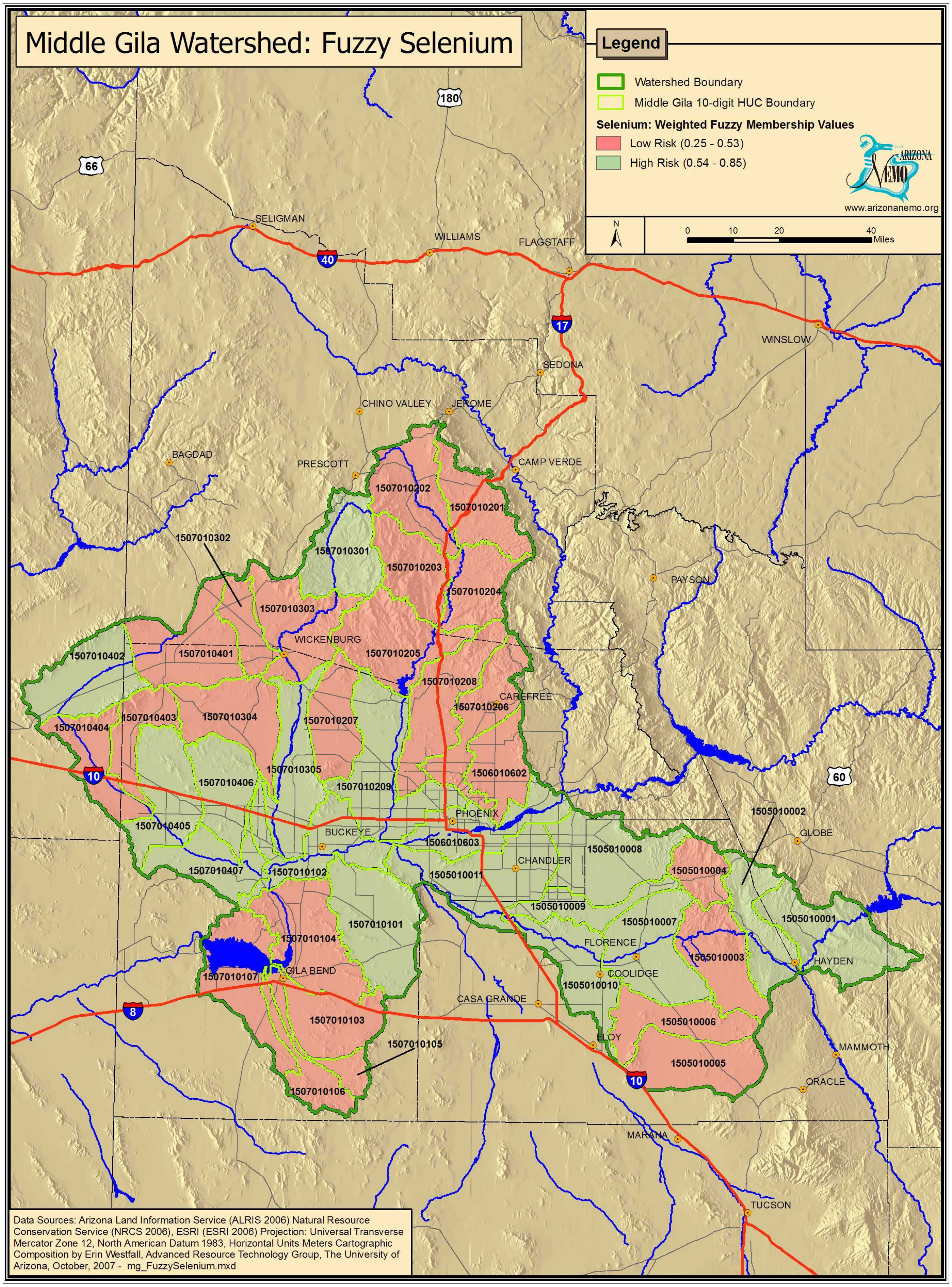

Figure 6-8: Results for the Fuzzy Logic Classification for Selenium

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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, its 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 Middle Gila 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 Alfove Park Lake, Chaparral Lake, Cortez Park Lake, French Gulch, Hassayampa River, Mineral Creek, Queen Creek, Turkey Creek, and several reaches of the Gila River, Painted Rocks Reservoir, the reaches of the Salt River and the Hassayampa River that flow into the Gila River 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 Middle Gila 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 Middle Gila 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 Middle Gila 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 Middle Gila 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 Middle Gila 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 Middle Gila 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.

French Gulch TMDL for Cadmium, Copper and Zinc

French Gulch, a tributary to the Hassayampa River near Walnut Grove, is impaired due to cadmium, copper, and zinc. Metal concentrations may represent a risk to aquatic and wildlife communities. TMDLs were completed for this stream in 2005 and identified the Zonia Mine as the primary source of these pollutants, although natural background and other inactive and abandoned mine workings may also be contributing loads. Currently the mine is operating three production wells to draw down the water table and reduce metal loading to the surface water from the ground water. ADEQ will be working with the owners of Zonia Mine and other stakeholders to develop and implement management measures to further reduce loadings and pollutant risks to the environment.

Hassayampa River TMDL for Cadmium, Copper and Zinc

Hassayampa River is impaired due to cadmium, copper, and zinc. Metal concentrations may pose a risk to aquatic and wildlife communities. TMDLs were approved in 2002. Several abandoned mine tailings were identified as primary sources of these contaminants including: McCleur tailings, Senator Golf Mine adit and tailings, and the Wetland tailings. The U.S. Forest Service has initiated several remediation projects, and ADEQ is working with interested stakeholders to prepare a TMDL Implementation Plan to identify other actions and watershed management measures.

Mineral Creek TMDL for Copper and Selenium

Mineral Creek, at tributary to the Gila River near Kelvin, is impaired due to copper and selenium. Both copper and selenium concentrations may pose a risk to aquatic life and wildlife. Recent remediation efforts have been effective in mitigating copper contamination, as exceedances only occur during extreme flow events; however, those methods have not reduced the selenium loads.

Queen Creek TMDL for Copper

Queen Creek near Superior is impaired due to copper. Copper concentrations may pose a risk to aquatic life and wildlife. A TMDL was initiated in 2005 and is scheduled to be completed in 2007.

Turkey Creek TMDL for Copper and Lead

Turkey Creek, a tributary to the Agua Fria, is impaired due to copper and lead. Metals concentrations may represent a risk to aquatic life and wildlife. TMDLs, anticipated to be completed in 2006, indicate that the primary sources of metals are inactive and abandoned mines, such as Golden Turkey Mine and Golden Belt Mine. ADEQ has been coordinating with the U.S. Forest Service in identifying remediation actions for mines on Forest

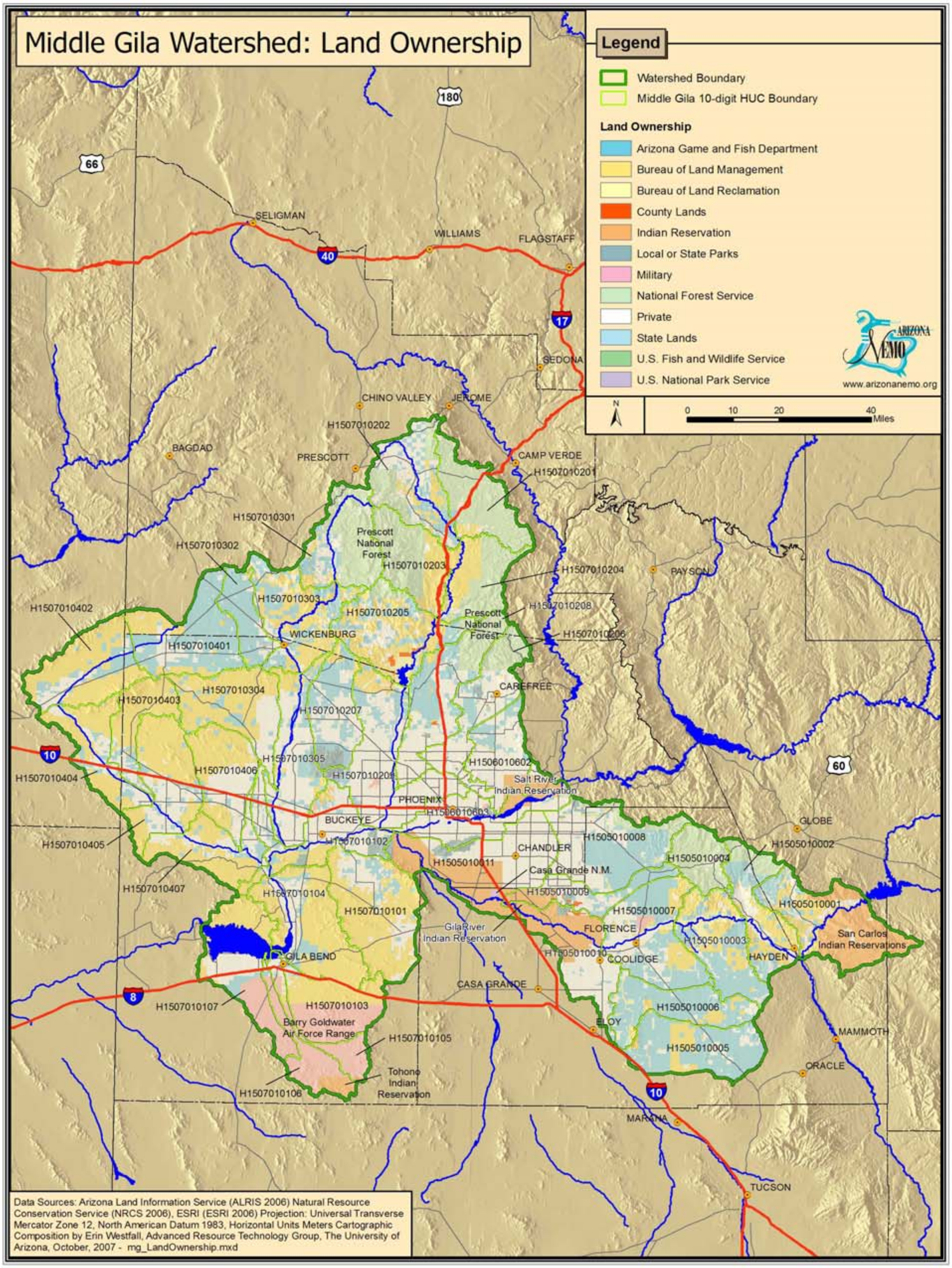

Figure 7-1: Land Ownership

Service land. ADEQ has been working with stakeholders to identify and implement strategies or actions that would bring Turkey Creek back into compliance with its standards.

Sediment

Erosion and sedimentation are major environment problems in the western United States, including the Middle Gila 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 Middle Gila 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:

Implementing grazing management practices to improve or maintain the health and vigor of plant communities will lead to reductions in surface runoff and erosion in the Middle Gila Watershed. 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.

Table 7-3: Middle Gila Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 1 of 2).

Subwatershed	Arizona Game and Fish	Bureau of Land Management	Bureau of Land Reclamation	County Lands	Indian Reservation	Local or State Parks
Dripping Springs Wash-Middle Gila River 1505010001	-	20%	0.1%	-	56%	-
Mineral Creek-Middle Gila River 1505010002	-	30%	-	-	-	-
Box O Wash-Middle Gila River 1505010003	-	30%	12%	-	-	-
Upper Queen Creek 1505010004	-	0.2%	-	-	-	-
Upper McClellan Wash 1505010005	-	16%	0.6%	-	-	0.3%
Brady Wash-Picacho Reservoir 1505010006	-	11%	2%	-	-	-
Paisano Wash-Middle Gila River 1505010007	-	15%	2%	-	< 0.0%	-
Middle Queen Creek 1505010008	< 0.0%	1%	2%	< 0.0%	-	-
Lower Queen Creek 1505010009	-	< 0.0%	0.4%	2%	24%	3%
Lower McClellan Wash-Middle Gila River 1505010010	-	< 0.0%	< 0.0%	0.8%	48%	2%
Middle Gila River below Queen Creek 1505010011	< 0.0%	0.3%	-	-	46%	5%
Indian Bend Wash 1506010602	-	0.1%	0.9%	< 0.0%	10%	0.3%
Lower Salt River below Saguaro Lake 1506010603	< 0.0%	0.6%	0.8%	-	21%	4%
Waterman Wash 1507010101	< 0.0%	66%	-	-	2%	0.5%
Luke Wash-Lower Gila River 1507010102	2%	23%	-	-	< 0.0%	8%
Sand Tank Wash 1507010103	-	43%	-	-	0.2%	-
Rainbow Wash-Lower Gila River 1507010104	-	73%	-	-	< 0.0%	0.2%
Quilotosa Wash 1507010105	-	5%	-	-	3%	-

Subwatershed	Arizona Game and Fish	Bureau of Land Management	Bureau of Land Reclamation	County Lands	Indian Reservation	Local or State Parks
Sauceda Wash 1507010106	-	< 0.0%	-	-	21%	-
Lower Gila River-Painted Rock Reservoir 1507010107	-	36%	-	-	< 0.0%	-
Ash Creek and Sycamore Creek 1507010201	-	5%	-	-	-	-
Big Bug Creek-Agua Fria River 1507010202	-	12%	-	< 0.0%	-	-
Black Canyon Creek 1507010203	-	31%	-	-	-	-
Bishop Creek 1507010204	-	40%	-	-	-	-
Agua Fria River-Lake Pleasant 1507010205	-	43%	6%	3%	-	< 0.0%
Cave Creek-Arizona Canal Diversion Channel 1507010206	< 0.0%	0.3%	< 0.0%	0.1%	-	3%
Trilby Wash-Trilby Wash Basin 1507010207	-	6%	0.1%	< 0.0%	-	11%
New River 1507010208	0.7%	3%	0.3%	0.3%	-	0.5%
Agua Fria River below Lake Pleasant 1507010209	-	8%	0.9%	< 0.0%	-	2%
Upper Hassayampa River 1507010301	-	7%	-	-	-	-
Sols Wash 1507010302	-	2%	-	0.1%	-	-
Middle Hassayampa River 1507010303	-	47%	-	16%	-	0.1%
Jackrabbit Wash 1507010304	-	67%	0.1%	-	-	-
Lower Hassayampa River 1507010305	-	12%	0.2%	-	-	3%
Aguila Valley Area-Centennial Wash 1507010401	-	22%	-	-	-	-
McMullen Valley Area-Centennial Wash 1507010402	-	70%	-	-	-	-
Tiger Wash 1507010403	-	75%	-	-	-	-

Subwatershed	Arizona Game and Fish	Bureau of Land Management	Bureau of Land Reclamation	County Lands	Indian Reservation	Local or State Parks
Upper Harquahala Plains Area-Centennial Wash 1507010404	-	61%	0.3%	-	-	-
Middle Harquahala Plains Area-Centennial Wash 1507010405	-	61%	-	-	-	-
Winters Wash 1507010406	-	55%	-	-	-	-
Lower Harquahala Plains Area-Centennial Wash 1507010407	< 0.0%	61%	-	-	-	-
Middle Gila Watershed	*0.1%*	*27%*	*0.8%*	*0.2%*	*6%*	*1%*

Table 7-3: Santa Cruz Watershed Land Ownership (Percent of each 10 Digit HUC Subwatershed) (part 2 of 2).

Subwatershed	Military Lands	National Forest Service	Private Land	State Lands	U.S. Fish and Wildlife	U.S. National Park Service
Dripping Springs Wash-Middle Gila River 1505010001	-	1%	12%	11%	-	-
Mineral Creek-Middle Gila River 1505010002	-	21%	24%	26%	-	-
Box O Wash-Middle Gila River 1505010003	-	1%	6%	51%	-	-
Upper Queen Creek 1505010004	-	93%	7%	0.1%	-	-
Upper McClellan Wash 1505010005	-	-	9%	73%	-	-
Brady Wash-Picacho Reservoir 1505010006	-	-	9%	77%	-	-
Paisano Wash-Middle Gila River 1505010007	2%	0.4%	32%	48%	-	-
Middle Queen Creek 1505010008	0.2%	14%	41%	42%	-	-
Lower Queen Creek 1505010009	-	1%	38%	31%	-	-
Lower McClellan Wash-Middle Gila River 1505010010	-	-	45%	3%	-	0.2%

Subwatershed	Military Lands	National Forest Service	Private Land	State Lands	U.S. Fish and Wildlife	U.S. National Park Service
Middle Gila River below Queen Creek 1505010011	-	-	49%	0.3%	-	0.6%
Indian Bend Wash 1506010602	-	0.5%	69%	19%	-	-
Lower Salt River below Saguaro Lake 1506010603	0.2%	2%	70%	0.9%	-	-
Waterman Wash 1507010101	-	-	23%	9%	-	-
Luke Wash-Lower Gila River 1507010102	0.5%	-	57%	10%	-	-
Sand Tank Wash 1507010103	52%	-	4%	2%	-	-
Rainbow Wash-Lower Gila River 1507010104	-	-	17%	10%	-	-
Quilotosa Wash 1507010105	77%	-	15%	1%	-	-
Sauceda Wash 1507010106	75%	-	2%	1%	-	-
Lower Gila River-Painted Rock Reservoir 1507010107	26%	-	30%	5%	2%	-
Ash Creek and Sycamore Creek 1507010201	-	89%	5%	2%	-	-
Big Bug Creek-Agua Fria River 1507010202	-	28%	37%	23%	-	-
Black Canyon Creek 1507010203	-	65%	4%	0.7%	-	-
Bishop Creek 1507010204	-	55%	3%	2%	-	-
Agua Fria River-Lake Pleasant 1507010205	-	10%	14%	24%	-	-
Cave Creek-Arizona Canal Diversion Channel 1507010206	-	24%	60%	12%	-	-
Trilby Wash-Trilby Wash Basin 1507010207	0.2%	-	38%	44%	-	-
New River 1507010208	23%	-	40%	32%	-	-
Agua Fria River below Lake Pleasant 1507010209	0.7%	-	75%	14%	-	-

Subwatershed	Military Lands	National Forest Service	Private Land	State Lands	U.S. Fish and Wildlife	U.S. National Park Service
Upper Hassayampa River 1507010301	-	63%	17%	13%	-	-
Sols Wash 1507010302	-	-	15%	82%	-	-
Middle Hassayampa River 1507010303	-	0.8%	-	37%	-	-
Jackrabbit Wash 1507010304	-	-	22%	12%	-	-
Lower Hassayampa River 1507010305	0.3%	-	62%	22%	-	-
Aguila Valley Area-Centennial Wash 1507010401	-	-	13%	65%	-	-
McMullen Valley Area-Centennial Wash 1507010402	-	-	13%	18%	-	-
Tiger Wash 1507010403	-	-	14%	11%	-	-
Upper Harquahala Plains Area-Centennial Wash 1507010404	-	-	24%	14%	-	-
Middle Harquahala Plains Area-Centennial Wash 1507010405	-	-	29%	10%	-	-
Winters Wash 1507010406	-	-	39%	5%	-	-
Lower Harquahala Plains Area-Centennial Wash 1507010407	-	-	29%	11%	-	-
Middle Gila Watershed	*4%*	*10%*	*29%*	*22%*	*0.1%*	*< 0.0%*

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

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.

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.

<u>Organics</u>

At several locations within the Middle Gila 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

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.

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.

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.

Alvord Park Lake TMDL for Ammonia

Alvord Park Lake in south Phoenix is impaired due to ammonia. Elevated ammonia may represent a risk to aquatic life. This lake is an important urban recreational area. The TMDL investigation is scheduled to be initiated in 2007.

Chapparral Lake TMDL for Dissolved Oxygen and Bacteria

Chaparral Lake in Scottsdale is impaired due to low dissolved oxygen and bacteria (*Escherichia coli*). Swimming or wading in the lake is prohibited; therefor, public health risk due to the presence of *E. coli* is reduced. Low dissolved oxygen may pose problems for aquatic life. Both low dissolved oxygen and high *E. coli* are likely related to ducks and other wildlife that congregate at this lake. Both TMDLs are scheduled to be initiated in 2007.

Cortez Park Lake TMDL for Dissolved Oxygen and pH

Cortez Park Lake is Phoenix is impaired due to low dissolved oxygen and high pH. Low dissolved oxygen and high pH are frequently associated with excess nutrient loadings and eutrophic conditions which may lead to algal blooms and even fish kills. The narrative nutrient implementation guidance being developed by ADEQ may be used in developing these TMDLs as numeric nutrient standards have not been established. Both TMDLs are scheduled to be initiated in 2007.

Gila River, Painted Rocks Reservoir, Salt River and Hassayampa River TMDL for Pesticides

Several reaches of the Gila River, Painted Rocks Reservoir, the reaches of the Salt River and the Hassayampa River that low into the Gila River are all impaired by pesticides in fish tissue – specifically, DDT, metabolites, toxaphene, and chlordane. (See also Painted Rocks Borrow Pit in the Colorado-Lower Gila Watershed). Although these pesticides have been banned from use for at least 20 years, these pesticides remain at concentrations that may pose a high risk to aquatic life and species that prey on them, including humans who may eat the fish. Fish consumption advisories have been set for these waters for more than 10 years. This is a complex TMDL due to the size of the drainage and vast area where these pesticides were historically applied.

<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.

<u>Strategy for Channel and Riparian Protection and Restoration</u>

Riparian areas are one of the most critical resources in the Middle Gila 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 Northern Middle Gila River NRA and the Southern Middle Gila 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

Arizona Department of Environmental Quality, ADEQ. 2006. Arizona's Integrated 305(b) Water Quality Assessment and 303(d) Listing Report, Middle Gila Watershed Assessment. http://www.azdeq.gov/environ/water/assessment/download/303-04/mg.pdf

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 Middle Gila Watershed. This methodology ranked forty-one subwatersheds for four key nonpoint source water quality concerns:

1. Metals originating from abandoned mine sites;
2. Stream sedimentation due to urban issues;
3. Organic and nutrient pollution due to urban issues;
4. Selenium pollution due to urban issues.

Table 8-1 lists the forty-one 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**
Dripping Springs Wash-Middle Gila River 1505010001	0.76	0.51	0.31	0.60
Mineral Creek-Middle Gila River 1505010002	0.90	0.80	0.75	0.78
Box O Wash-Middle Gila River 1505010003	0.76	0.17	0.25	0.50
Upper Queen Creek 1505010004	0.90	0.42	0.41	0.50
Upper McClellan Wash 1505010005	0.60	0.08	0.29	0.44
Brady Wash-Picacho Reservoir 1505010006	0.60	0.08	0.45	0.44
Paisano Wash-Middle Gila River 1505010007	0.60	0.40	0.75	0.75
Middle Queen Creek 1505010008	0.75	0.74	0.75	0.70
Lower Queen Creek 1505010009	0.62	0.47	0.75	0.58
Lower McClellan Wash-Middle Gila River 1505010010	0.50	0.46	0.75	0.67
Middle Gila River below Queen Creek 1505010011	0.60	0.80	0.81	0.58
Indian Bend Wash 1506010602	0.71	0.62	0.90	0.43
Lower Salt River below Saguaro Lake 1506010603B	0.71	0.92	0.90	0.85
Waterman Wash 1507010101	0.61	0.49	0.77	0.61
Luke Wash-Lower Gila River 1507010102	0.75	0.81	0.81	0.67
Sand Tank Wash 1507010103	0.50	0.21	0.34	0.25
Rainbow Wash-Lower Gila River 1507010104	0.55	0.48	0.75	0.53
Quilotosa Wash 1507010105	0.20	0.39	0.75	0.38
Sauceda Wash 1507010106	0.20	0.03	0.36	0.28
Lower Gila River-Painted Rock Reservoir 1507010107	0.29	0.34	0.75	0.50
Ash Creek and Sycamore Creek 1507010201	0.75	0.50	0.25	0.42
Big Bug Creek-Agua Fria River 1507010202	0.78	0.72	0.75	0.50
Black Canyon Creek 1507010203	0.85	0.46	0.31	0.50
Bishop Creek 1507010204	0.60	0.48	0.23	0.33
Agua Fria River-Lake Pleasant 1507010205	0.64	0.55	0.40	0.50
Cave Creek-Arizona Canal Diversion Channel 1507010206	0.65	0.71	0.60	0.50
Trilby Wash-Trilby Wash Basin 1507010207	0.49	0.40	0.42	0.42
New River 1507010208	0.69	0.91	0.69	0.44
Agua Fria River below Lake Pleasant 1507010209	0.50	0.71	0.60	0.85
Upper Hassayampa River 1507010301	0.85	0.43	0.10	0.60
Sols Wash 1507010302	0.65	0.20	0.50	0.33
Middle Hassayampa River 1507010303	0.70	0.35	0.40	0.50

Subwatershed	FMV Weighted			
	Metals	Sediment	Organics	Selenium
Jackrabbit Wash 1507010304	0.55	0.38	0.25	0.50
Lower Hassayampa River 1507010305	0.61	0.48	0.78	0.70
Aguila Valley Area-Centennial Wash 1507010401	0.60	0.36	0.75	0.53
McCullen Valley Area 1507010402	0.65	0.24	0.75	0.64
Tiger Wash 1507010403	0.65	0.26	0.25	0.50
Upper Harquahala Plains Area-Centennial Wash 1507010404	0.60	0.20	0.69	0.52
Middle Harquahala Plains Area-Centennial Wash 1507010405	0.50	0.46	0.75	0.67
Winters Wash 1507010406	0.55	0.37	0.75	0.62
Lower Harquahala Plains Area-Centennial Wash 1507010407	0.56	0.36	0.83	0.63

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

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

- Mineral Creek-Middle Gila River Subwatershed and Upper Queen Creek Subwatershed, for metals pollution due to mining;
- Lower Salt River below Saguaro Lake Subwatershed, for sediment pollution derived from urban issues;
- Indian Bend Wash Subwatershed and Lower Salt River below Saguaro Lake Subwatershed, for organics pollution due to urban issues; and,
- Lower Salt River below Saguaro Lake Subwatershed and Agua Fria River below Lake Pleasant Subwatershed, for selenium due to urban issues.

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. Mineral Creek-Middle Gila River Subwatershed and Upper Queen 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 Mineral Creek-Middle Gila River Subwatershed and the Upper Queen Creek Subwatershed ranked as the most critical areas in the Middle Gila 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 land owners within the Mineral Creek- Middle Gila Subwatershed are the U.S. Bureau of Land Management (30%) National Forest Service (21%), private landowners (24%), and state lands (26%) (Table 7-3). The major land owners within the Upper Queen Creek Subwatershed are the National Forest Service (93%), and private landowners (7%) (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. Lower Salt River below Saguaro Lake Subwatershed Example Project

Pollutant Type and Source: Sediment pollution due to urbanization.

The Lower Salt River below Saguaro Lake Subwatershed of the Middle Gila River Watershed ranked as the most critical subwatershed impacted by land use activities, and for the purposes of outlining an example project, implementation of best management practices related to stormwater management is recommended. In rapidly growing urban areas, such as Phoenix, new construction and increasing population growth result in increased soil disturbance and stormwater sediment loading.

The major land owners within the Lower Salt River below Saguaro Lake Subwatershed (Table 7-3) are Indian Reservations (21%), local or state parks (4%), National Forest Service (2%), and private land (70%). 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:
The goal of this example is to reduce

sediment pollution to the Lower Salt River below Saguaro Lake subwatershed. Because increased sediment load is assumed to be the result of increased urban stormwater concerns, some background information on current stormwater regulations is necessary.

The Environmental Protection Agency (EPA) has estimated that about 30 percent of known pollution to our nation's waters is attributable to stormwater runoff. In 1987, Congress directed EPA to develop a regulatory program to address the stormwater problem. EPA issued regulations in 1990 authorizing the creation of a National Pollution Discharge Elimination System (NPDES) permitting system for stormwater discharges. In Arizona, this program is called AZPDES, which stands for Arizona Pollutant Discharge Elimination System. Because stormwater runoff can transport pollutants to either a municipal storm sewer system or to a water of the United States, permits are required for those discharges.

Stormwater discharges generated during construction activities can also cause an array of physical, chemical, and biological water quality impacts. Water quality impairment occurs, in part, because a number of pollutants are preferentially absorbed onto mineral or organic particles found in fine sediment. The interconnected process of erosion (detachment of soil particles) and sediment transport during storm events results in water quality degradation. Stormwater runoff from construction sites can include pollutants other than sediment, which may become mobilized when land surfaces are disturbed. These include phosphorous, nitrogen, pesticides, petroleum derivatives, construction chemical and solid wastes.

ADEQ stormwater regulations address both small and large construction sites. Large construction activity refers to the disturbance of 5 or more acres. It also refers to the disturbance of less than 5 acres of total land area that is a part of a larger common plan of development or sale if the large common plan will ultimately disturb five acres or more (see 40 CFR 122.26(b)(14)(x)).

Small construction activity refers to the disturbance of 1 or more, but less than 5, acres of land. It also refers to the disturbance of less than 1 acre of total land area that is part of a larger common plan of development of sale if the larger common plan will ultimately disturb 1 or more, but less than 5 acres (see 40 CFR 122.26(b0(15)).

To obtain authorization for discharges of stormwater associated with construction activity, the operator must comply with all the requirements of the general permit and submit a Notice of Intent (NOI) and a Stormwater Management Plan (SWMP). More information about Arizona Stormwater Regulations and permitting can be found at http://azdeq.gov/environ.water/permits/stormwater.html.

Management Measures:
Municipal Ordinances addressing stormwater retention / detention, construction site management, housing density, drainage buffers, impermeable surfaces, and grading are the most effective management measures to address sediment pollution due to stormwater runoff. New ordinance proposals can be initiated by citizen

groups within the jurisdiction of the municipality, such as the stakeholdergroup local watershed partnership.

Generally, properly implemented and enforced construction site ordinances effectively reduce sediment pollution. In many areas, however, the effectiveness of ordinances in reducing pollutants is limited due to inadequate information or incomplete compliance with local ordinances by construction site operators. Report of obvious construction site violations or local ordinances, for example, failure to manage site waste (messy housekeeping) and tracking of mud onto roadway can be performed by local citizens.

In addition to ordinances as a best management practices to address stormwater sediment ADEQ Stormwater Regulations require an outreach education component of the Stormwater Management Plans. Stakeholder-group local watershed partnerships can play an important role in educating the public about individual property owner responsibilities in protecting stream water quality.

3. Indian Bend Wash Subwatershed and Lower Salt River below Saguaro Lake Subwatershed Example Project

Pollutant Type and Source: Organics pollution due to human use of urban lakes.

Chaparral Lake in Indian Bend Wash Subwatershed and Alvord Lake the Lower Salt River below Saguaro Lake Subwatershed are urban lakes affected by organics. Chaparral Lake is impaired due to low dissolved oxygen and bacteria, while Alvord Lake is impaired by ammonia. Both lakes are scheduled for TMDLs.

Land owners within Indian Bend Wash Subwatershed (Table 7-3) are private land (69%), state land (19%), and Indian Reservations (10%). The major land owners within the Lower Salt River below Saguaro Lake Subwatershed (Table 7-3) are Indian Reservations (21%), local or state parks (4%), National Forest Service (2%), and private land (70%). 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:
Total Maximum Daily Load (TMDL) is a term used to describe the amount of a pollutant that a stream or lake can receive and still meet water quality standards. A TMDL study identifies sources of pollution and potential reductions needed to attain standards. Point sources (such as municipal or industrial discharges) and nonpoint sources (such as runoff from urban or agricultural lands, and natural background) are considered in calculating the TMDL. The study must also account for seasonal variation and include a margin of safety.

The objective of the federal Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. To fulfill this objective, states assess their surface waters and identify which waters do not meet state surface water quality standards. A TMDL must be completed for each pollutant "impairing" (or not meeting surface water quality standards) these waterbodies.

The TMDL study examines the source(s) and the extent of the water quality impairment, and provides the appropriate information necessary for planning and implementation actions designed to achieve surface water quality standards. Whereas the TMDL study establishes a pollution budget for an impaired surface water body, the accompanying TMDL implementation plan provides an action plan outlining affordable, efficient, and effective alternatives to restore water quality.

During both the TMDL study and implementation planning processes, the Arizona Department of Environmental Quality (ADEQ) involves stakeholders by coordinating public meetings and encouraging comments and input. Additionally, ADEQ will help stakeholders identify funding sources (such as Water Quality Improvement Grants) that can help pay for water quality improvements.

Management Measures:
Implementing management practices to improve or maintain riparian health will help reduce organic pollutants in urban lakes. Management may include such actions as dredge the lake, add an aeration system, treat with algaecides prior to bloom period, manage lake level (drop during spring to minimize filamentous algae growth), use of well water or alternate source of water, e.g., CAP water, treat stormwater runoff to remove TSS/settleable solids using settling ponds, constructed wetlands in wash using a membrane curtain designed to remove some nutrients and solids, institute residential and golf course Best Management Practices (BMPs).

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.

4. Lower Salt River below Saguaro Lake Subwatershed and Agua Fria River below Lake Pleasant Subwatershed Example Report

Pollutant Type and Source:
Selenium naturally occurring.

The Lower Salt River below Saguaro Lake Subwatershed and Agua Fria River below Lake Pleasant Subwatershed of the Middle Gila Watershed ranked as the most critical subwatershed impacted by selenium, however agricultural land use is limited throughout the watershed. Because selenium is naturally occurring, no best management practice is recommended to address selenium in this watershed. It should be understood, however, that evaporation of flood irrigation water will exacerbate selenium loading in the stream and for this reason it should be avoided. In addition, evaporation in reservoirs will increase selenium concentrations.

The major land owners within the Lower Salt River below Saguaro Lake Subwatershed (Table 7-3) are Indian Reservations (21%), local or state parks (4%), National Forest Service (2%), and private land (70%). The land owners within the Agua Fria River below Lake Pleasant Subwatershed are the U.S. Bureau of Land Management (8%), local or state parks (2%), private landowners (75%), and state lands (14%) (Table 7-3). 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 onsite treatment.

As an example of a situation where drainage water must be managed, some watersheds in California have agricultural drainage water containing 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, 1999).

Currently, Arizona is not considering such extreme measures, but selenium remains an important nonpoint source contaminant and 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, microalgalbacterial treatment, biological precipitation, and constructed wetlands. Engineered water treatment systems, however, may beyond the scope of a proposed best management practices project, and technologies are still in the research stage.

Section 7 briefly discusses load reduction potential, maintenance, and anticipated costs associated with the installation of mechanized irrigation systems. These types of systems allow for improved water conservation and improved management of limited water resources. 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.

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 Middle Gila Watershed, Mineral Creek-Middle Gila River, Upper Queen Creek, Indian Bend Wash, Lower Salt River below Saguaro Lake, Agua Fria River below Lake Pleasant 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**
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**

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 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
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			

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 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 Middle Gila Watershed, the Mineral Creek-Middle

Gila River, Upper Queen Creek, Indian Bend Wash, Lower Salt River below Saguaro Lake, Agua Fria River below Lake Pleasant 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 forty-one 10-digit HUC subwatersheds within the Middle Gila 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 Middle Gila Watershed (ADEQ 2006).

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 forty-one subwatersheds included in this assessment, the watersheds with the highest risk of water quality degradation are:

1. Mineral Creek-Middle Gila River Subwatershed and Upper Queen Creek Subwatershed, for metals pollution;

2. Lower Salt River below Saguaro Lake Subwatershed, for sediment pollution;

3. Indian Bend Wash Subwatershed and Lower Salt River Below Saguaro Lake Subwatershed, for pollutants due to organics; and

4. Lower Salt River below Saguaro Lake Subwatershed and Agua Fria River below Lake Pleasant 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.

References

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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, Middle Gila 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 Middle Gila 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.

<table>
<tr><th colspan="3">Subwatershed</th></tr>
<tr><td colspan="3">Dripping Springs Wash – Middle Gila River
HUC 1505010001
Combined Classification for Risk of Impairment:
• Metals: Moderate
• Sediment: Extreme
• Organics: Moderate
• Selenium: Moderate</td></tr>
<tr><th>Surface Waterbody</th><th colspan="2">Water Quality Data:
Sampling and Assessment Status[1,2,3]</th></tr>
<tr><td>Gila River
From San Pedro River to Mineral Creek

ADEQ ID: 15050100-008

One sampling site at this surface waterbody.</td><td>Sampling</td><td>• Metals: (d&t 12-13): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, zinc; fluoride (13).
• Sediment: total dissolved solids (13), suspended sediment concentration (13), turbidity (12).
• Organics: Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen and pH (12-13); E. coli (13).
• Selenium: selenium.</td></tr>
</table>

	Status	Parameters exceeding standards: *E. coli*, lead, suspended sediment concentration, selenium. Currently assessed as Category 5, "Impaired" due to suspended sediment exceedances. Surface Waterbody risk classification: • **Metals:** Moderate due to some exceedances. • **Sediment:** Extreme due to suspended sediment exceedances. • **Organics:** Moderate due to some exceedances and insufficient data. • **Selenium:** Moderate due to some exceedances and insufficient data.
Gila River from Dripping Springs Wash to San Pedro River ADEQ ID: 15050100-009 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4) boron, lead, manganese, mercury, nickel; fluoride (4). • **Sediment:** total dissolved solids (4), suspended sediment (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (4). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1, "Attaining". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Mineral Creek – Middle Gila River
HUC 1505010002

Combined Classification for Risk of Impairment:

- **Metals:** Extreme
- **Sediment:** Extreme
- **Organics:** Moderate
- **Selenium:** Extreme

Surface Waterbody	Water Quality Data: Sampling and Assessment Status[1,2,3]

Gila River From San Pedro River to Mineral Creek ADEQ ID: 15050100-008 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 12-13): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, zinc; fluoride (13). • **Sediment:** total dissolved solids (13), suspended sediment concentration (13), turbidity (12). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen and pH (12-13); *E. coli* (13). • **Selenium:** selenium.
	Status	Parameters exceeding standards: *E. coli*, lead, suspended sediment concentration, selenium. Currently assessed as Category 5, "Impaired" due to suspended sediment exceedances. Surface Waterbody risk classification: • **Metals:** Moderate due to some exceedances. • **Sediment:** Extreme due to suspended sediment exceedances. • **Organics:** Moderate due to some exceedances and insufficient data. • **Selenium:** Moderate due to some exceedances and insufficient data.
Gila River from Dripping Springs Wash to San Pedro River ADEQ ID: 15050100-009 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4) boron, lead, manganese, mercury, nickel; fluoride (4). • **Sediment:** total dissolved solids (4), suspended sediment (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (4). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1, "Attaining". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Mineral Creek from Devil's Canyon to Gila River ADEQ ID: 15050100-012 Five sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 217-218): Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, selenium, silver, thallium, zinc; fluoride (217). • **Sediment:** total dissolved solids (217), turbidity (217). • **Organics:** dissolved oxygen, pH, nitrite/nitrate, (218). • **Selenium:** selenium.
	Status	Parameters exceeding standards: dissolved copper, dissolved oxygen, selenium. Currently assessed as Category 5 (selenium, low dissolved oxygen), Category 4B (copper), "Impaired". Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances and detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate, low DO due to hydromodification. • **Selenium:** Extreme due to exceedances.
Kearny Lake ADEQ ID: 15050100-6666 Three sampling sites at this surface waterbody.	Sampling	• **Metals:** (t 3-9): arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, zinc; fluoride (5). • **Sediment:** total dissolved solids (9). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (4-9). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough and insufficient data. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough and insufficient data.

Subwatershed		
Box O Wash – Middle Gila River **HUC 1505010003** **Combined Classification for Risk of Impairment:** • **Metals:** High • **Sediment:** Low • **Organics:** Moderate • **Selenium:** Moderate		
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Martinez Canyon from headwaters to Box Canyon ADEQ ID: 15050100-080 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 5): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t5 & d 0-1) boron, lead, manganese, mercury; fluoride (5). • **Sediment:** total dissolved solids (5), suspended sediment concentration (4), turbidity (5). • **Organics:** Ammonia, total nitrogen, nitrite/nitrate, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (5); *E. coli* (5). • **Selenium:** none.
	Status	Parameters exceeding standards: lead, 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:** High due to some exceedances and insufficient data. • **Sediment:** Low. • **Organics:** Moderate due to some exceedances. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed	
Upper Queen Creek **HUC 1505010004** **Combined Classification for Risk of Impairment:** • **Metals:** Extreme • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate	
Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**

Arnett Creek from headwaters to Queen Creek ADEQ ID: 15050100-1818 Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 4-8): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4-8 & d 0-2) boron, lead, mercury, silver; fluoride (6); cyanide (1). • **Sediment:** total dissolved solids (6), turbidity (6). • **Organics:** Ammonia, total nitrogen, nitrite/nitrate, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (4-6); *E. coli* (6). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved oxygen (due to natural conditions of low flow and ground water upwelling). Currently assessed as Category 1, "Attaining". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough for mercury. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Potts Canyon from headwaters to Queen Creek ADEQ ID: 15050100-1856 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 1): cadmium, chromium, copper, mercury, zinc; (t1) arsenic, lead, manganese; fluoride (1). • **Sediment:** total dissolved solids (1), suspended sediment concentration (1). • **Organics:** dissolved oxygen, pH (1). • **Selenium:** none.
	Status	Parameters exceeding standards: arsenic, dissolved copper, lead, mercury, suspended sediment concentration. Currently assessed as Category 3, "Inconclusive". Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough for mercury. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.

Queen Creek from headwaters to mining WWTP discharge ADEQ ID: 15050100-014A Eight sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 11-26): Antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, zinc; (t12 & d 4-5): barium, boron, selenium; (t 26 & d 1): manganese; fluoride (13). • **Sediment:** total dissolved solids (15), suspended sediment (5), turbidity (13). • **Organics:** dissolved oxygen, pH, nitrite/nitrate (15-25); *E. coli* (7). • **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:** Low. • **Organics:** Low. • **Selenium:** Low.
Queen Creek from mining WWTP discharge to Potts Canyon ADEQ ID: 15050100-014B Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 4-7): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-2 & t 5-7): boron, lead, manganese, mercury; fluoride (6); chlorine (2); selenium (2). • **Sediment:** total dissolved solids (4), suspended sediment (5), turbidity (4). • **Organics:** ammonia, total nitrogen, nitrite/nitrate, total phosphorus, dissolved oxygen, pH (4-7); *E. coli* (4). • **Selenium:** selenium (2).
	Status	Parameters exceeding standards: dissolved copper, chlorine, dissolved oxygen, selenium. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances. • **Sediment:** Low. • **Organics:** Moderate due to some exceedances and detection limits not low enough. • **Selenium:** Moderate due to some exceedances and detection limits not low enough.
Queen Creek ADEQ ID: 15050100-014C One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 1): cadmium, chromium, copper, mercury, zinc; (t1): arsenic, lead, manganese; fluoride (1). • **Sediment:** total dissolved solids (1), suspended sediment concentration (3). • **Organics:** dissolved oxygen, pH (1). • **Selenium:** none.

	Status	Parameters exceeding standards: arsenic, dissolved copper, mercury, suspended sediment concentration. Currently assessed as Category 3, "Inconclusive", due to detection limits not low enough for dissolved mercury and 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

Upper McClellan Wash
HUC 1505010005

Combined Classification for Risk of Impairment:

- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Subwatershed

Brady Wash-Picacho Reservoir
HUC 1505010006

Combined Classification for Risk of Impairment:

- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Subwatershed

Paisano Wash-Middle Gila River
HUC 1505010007

Combined Classification for Risk of Impairment:

- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Subwatershed		
Middle Queen Creek **HUC 1505010008** **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]**	
Queen Creek ADEQ ID: 15050100-014C One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 1): cadmium, chromium, copper, mercury, zinc; (t1): arsenic, lead, manganese; fluoride (1). • **Sediment:** total dissolved solids (1), suspended sediment concentration (3). • **Organics:** dissolved oxygen, pH (1). • **Selenium:** none.
	Status	Parameters exceeding standards: arsenic, dissolved copper, mercury, suspended sediment concentration. Currently assessed as Category 3, "Inconclusive", due to detection limits not low enough for dissolved mercury and 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 Queen Creek
HUC 1505010009

Combined Classification for Risk of Impairment:
- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Subwatershed

Lower McClellan Wash-Middle Gila River
HUC 1505010010

Combined Classification for Risk of Impairment:
- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Subwatershed

Middle Gila River below Queen Creek
HUC 1505010010

Combined Classification for Risk of Impairment:
- **Metals:** Moderate.
- **Sediment:** Moderate.
- **Organics:** Moderate.
- **Selenium:** Moderate.

Subwatershed

Indian Bend Wash
HUC 1506010602

Combined Classification for Risk of Impairment:
- **Metals:** High
- **Sediment:** Moderate
- **Organics:** Extreme
- **Selenium:** Moderate

Surface Waterbody	**Water Quality Data: Sampling and Assessment Status**[1,2,3]	
Indian Bend Wash from headwaters to Salt River ADEQ ID: 15060106B-179 One sampling site at this surface waterbody.	Sampling	• **Metals:** (t 4): cadmium, copper, lead, mercury, zinc. • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4). • **Selenium:** none.

	Status	Parameters exceeding standards: lead. 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 some exceedances and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Low. • **Selenium:** Moderate due to insufficient data.
Salt River From Granite Reef Dam for 2 kilometers ADEQ ID: 15060106B-001A One sampling site at this surface waterbody.	Sampling	• **Metals:** (t 3-4): arsenic, barium, cadmium, chromium, copper, lead, manganese, selenium, zinc. • **Sediment:** total dissolved solids (6), turbidity (2). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (5-7). • **Selenium:** selenium.
	Status	Parameters exceeding standards: chromium, lead. Currently assessed as Category 2, "Attaining some uses". Surface Waterbody risk classification: • **Metals:** High due to limited data and some exceedances. • **Sediment:** Low. • **Organics:** Moderate due to insufficient data. • **Selenium:** Low.
Salt River from 2 kilometers below Granite Reef Dam to Interstate 10 bridge ADEQ ID: 15060106B-001B One sampling site at this surface waterbody.	Sampling	• **Metals:** (t 2): antimony, arsenic, beryllium, cadmium, chromium, copper, lead, zinc; (t2): boron, manganese, selenium. • **Sediment:** total dissolved solids (2), turbidity (2). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (2); *E. coli* (2). • **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.
Chaparral Park Lake ADEQ ID: 15060106B-0300 Two sampling sites at this surface waterbody. *E. coli* bacteria and low dissolved oxygen were added to 303(d) list in 2004.	Sampling	• **Metals:** (d3 & t2): barium, cadmium, chromium, copper, lead, manganese, mercury, zinc; (t2 & d0-2): antimony, arsenic, beryllium, boron, selenium, silver; fluoride (2). • **Sediment:** total dissolved solids (5), turbidity (1). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (7). • **Selenium:** selenium.
	Status	Parameters exceeding standards: *E. coli* bacteria and dissolved oxygen. Currently assessed as Category 5, “Impaired” due to *E. coli* bacteria and low dissolved oxygen. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to exceedances. • **Selenium:** Moderate due to insufficient data.
Tempe Town Lake ADEQ ID: 15060106B-1588 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 0-1 & t 72): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc; fluoride (6). • **Sediment:** total dissolved solids (11), turbidity (1317). • **Organics:** ammonia, total nitrogen, nitrite/nitrate, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen (280); pH (1332); *E. coli* (352). • **Selenium:** selenium.

	Status	Parameters exceeding standards: low numbers of exceedances for *E. coli*, dissolved oxygen, pH (high), mercury. Currently assessed as Category 2, “Attaining some uses”. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough for dissolved mercury. • **Sediment:** Low. • **Organics:** Moderate due to some exceedances for *E. coli*. • **Selenium:** Low.
Subwatershed		
Lower Salt River below Saguaro Lake **HUC 1506010603B** **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]**	
Salt River from 2 kilometers below Granite Reef Dam to Interstate 10 bridge ADEQ ID: 15060106B-001B One sampling site at this surface waterbody.	Sampling	• **Metals:** (t 2): antimony, arsenic, beryllium, cadmium, chromium, copper, lead, zinc; (t2): boron, manganese, selenium. • **Sediment:** total dissolved solids (2), turbidity (2). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (2); *E. coli* (2). • **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.
Salt River from Interstate 10 bridge to 23rd Avenue WWTP discharge ADEQ ID: 15060106B-001C One sampling site at this surface	Sampling	• **Metals:** no current data. • **Sediment:** total dissolved solids (1). • **Organics:** ammonia, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (1). • **Selenium:** none.

waterbody.	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.
Salt River from 23rd Avenue WWTP discharge to Gila River ADEQ ID: 15060106B-001D One sampling site at this surface waterbody. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** (d&t 48): Antimony, arsenic, beryllium, cadmium, chromium, copper, mercury, zinc; (t4): boron, lead, manganese; fluoride (4); chlorine (3). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (4). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, “Attaining some uses”. EPA assessed as Category 5, “Impaired” due to DDT, toxaphene, and chlordane in fish tissue. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to insufficient data and detection limits not low enough.
Alvord Lake ADEQ ID: 15060106B-0050 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (4d & 2t): cadmium, chromium, copper, lead, manganese, mercury, zinc; (2t & 0-2d): antimony, arsenic, beryllium, boron, lead, selenium; fluoride (2). • **Sediment:** total dissolved solids (12), turbidity (6). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (11-21). • **Selenium:** selenium.

	Status	Parameters exceeding standards: Ammonia Currently assessed as Category 5, "Impaired" due to exceedances. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough for mercury. • **Sediment:** Low. • **Organics:** Extreme due to exceedances. • **Selenium:** Low.
Encanto Park Lake ADEQ ID: 15060106B-0510 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d1): cadmium, chromium, copper, lead, manganese, mercury, zinc. • **Sediment:** total dissolved solids (2). • **Organics:** Ammonia, dissolved oxygen, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (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 or dissolved mercury. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough for dissolved mercury. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Papago Park Ponds ADEQ ID: 15060106B-1030 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 2): antimony, arsenic, barium, beryllium, boron, cadmium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc; (d 0-1 & t2): chromium; fluoride (2). • **Sediment:** turbidity (2). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (2), *E. coli* (2). • **Selenium:** selenium.

	Status	Parameters exceeding standards: none. Currently assessed as Category 3, “Inconclusive”. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough for dissolved mercury. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.
Tempe Town Lake ADEQ ID: 15060106B-1588 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 0-1 & t 72): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc; fluoride (6). • **Sediment:** total dissolved solids (11), turbidity (1317). • **Organics:** ammonia, total nitrogen, nitrite/nitrate, total phosphorus, total Kjeldahl nitrogen; dissolved oxygen (280); pH (1332); *E. coli* (352). • **Selenium:** selenium.
	Status	Parameters exceeding standards: low numbers of exceedances for *E. coli*, dissolved oxygen, pH (high), mercury. Currently assessed as Category 2, “Attaining some uses”. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough for dissolved mercury. • **Sediment:** Low. • **Organics:** Moderate due to some exceedances for *E. coli*. • **Selenium:** Low.

Subwatershed

Waterman Wash
HUC 1507010101

Combined Classification for Risk of Impairment:

- **Metals:** Extreme
- **Sediment:** Moderate
- **Organics:** High
- **Selenium:** Extreme

<table>
<tr><td colspan="3">Subwatershed</td></tr>
<tr><td colspan="3">Luke Wash – Lower Gila River
HUC 1507010102
Combined Classification for Risk of Impairment:
• Metals: Extreme
• Sediment: Moderate
• Organics: High
• Selenium: Extreme</td></tr>
<tr><td>Surface Waterbody</td><td colspan="2">Water Quality Data:
Sampling and Assessment Status[1,2,3]</td></tr>
<tr><td rowspan="2">Gila River
From Gillespie Dam to Rainbow Wash

ADEQ ID: 15070101-007

Fish consumption advisory due to pesticides in fish tissue.

DDT, toxaphene, and chlordane were re-listed by EPA in 2002.</td><td>Sampling</td><td>• Metals: no current data.
• Sediment: no current data.
• Organics: no current data.
• Selenium: no current data.</td></tr>
<tr><td>Status</td><td>Parameters exceeding standards: no current data.

Currently assessed as Category 3, “Inconclusive” due to lack of data.

EPA assessed as Category 5, “Impaired” due to DDT, toxaphene, and chlordane in fish tissue.

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.</td></tr>
<tr><td>Gila River
From Centennial Wash to Gillespie Dam

ADEQ ID: 15070101-008

One sampling site at this surface waterbody.</td><td>Sampling</td><td>• Metals: (d&t 18): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, thallium, zinc; fluoride (18).
• Sediment: total dissolved solids (18), suspended sediment concentration (18), turbidity (18).
• Organics: Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (18); E. coli (18).
• Selenium: selenium (18).</td></tr>
</table>

	Status	Parameters exceeding standards: boron, selenium in the water column, *E. coli.* Currently assessed as Category 5, "Impaired" due to exceedances. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances. • **Sediment:** Low. • **Organics:** High due to one exceedance. • **Selenium:** Extreme due to exceedances.
Gila River From Hassayampa River to Centennial Wash ADEQ ID: 15070101-009 Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.
	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.
Gila River From Waterman Wash to Hassayampa River ADEQ ID: 15070101-010 Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.
	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.

Gila River From Agua Fria River to Waterman Wash ADEQ ID: 15070101-014 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, beryllium, cadmium, copper, lead, manganese, mercury, zinc; (t2): boron, chromium; 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. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Gila River From Salt River to Agua Fria River ADEQ ID: 15070101-015 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4): boron, lead, manganese, mercury; fluoride (4); chlorine (2). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (4). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining all uses". EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Salt River from 23rd Avenue WWTP discharge to Gila River ADEQ ID: 15060106B-001D One sampling site at this surface waterbody. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** (d&t 48): Antimony, arsenic, beryllium, cadmium, chromium, copper, mercury, zinc; (t4): boron, lead, manganese; fluoride (4); chlorine (3). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (4). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining some uses". EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to insufficient data and detection limits not low enough.

Subwatershed

Sand Tank Wash
HUC 1507010103

Combined Classification for Risk of Impairment:

- **Metals:** Extreme
- **Sediment:** Moderate
- **Organics:** High
- **Selenium:** Extreme

Subwatershed

Rainbow Wash – Lower Gila River
HUC 1507010104

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]	
Gila River From Rainbow Wash to Sand Tank ADEQ ID: 15070101-005	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.

Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.
Gila River From Gillespie Dam to Rainbow Wash ADEQ ID: 15070101-007 Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.
	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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

Quilotosa Wash
HUC 1507010105

Combined Classification for Risk of Impairment:

- **Metals:** Moderate
- **Sediment:** Moderate
- **Organics:** Moderate
- **Selenium:** Moderate

Subwatershed
Sauceda Wash **HUC 1507010106** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate

Subwatershed
Lower Gila River – Painted Rock Reservoir **HUC 1507010107** **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]	
Gila River From Sand Tank to Painted Rocks Reservoir ADEQ ID: 15070101-001 Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.
	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.
Gila River From Rainbow Wash to Sand Tank ADEQ ID: 15070101-005	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.

Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.
Painted Rocks Reservoir ADEQ ID: 15070101-1020A This is a flood retention basin.	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.
	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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

Ash Creek and Sycamore Creek
HUC 1507010201

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]

Little Ash Creek From headwaters to Ash Creek ADEQ ID: 15070102-039 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 1): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t1): boron, lead, manganese, mercury; fluoride (1). • **Sediment:** total dissolved solids (1), turbidity (1). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (1), *E. coli* (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 detection limits not low enough and insufficient data.
Sycamore Creek From Tank Canyon to Agua Fria River ADEQ ID: 15070102-024B One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, beryllium, cadmium, copper, zinc; (d 0-2 & t 4): boron, chromium, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (4); *E. coli* (3). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 1 "Attaining". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed		
Big Bug Creek – Agua Fria River **HUC 1507010202** **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]	
Agua Fria River From Sycamore Creek to Big Bug Creek ADEQ ID: 15070102-023 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (4t) 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". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Agua Fria River From State Route 169 to Yarber Wash ADEQ ID: 15070102-031B One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (4t & 0-1d) boron, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), suspended sediment (4), turbidity (4). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (4); *E. coli* (4). • • **Selenium:** none

	Status	Parameters exceeding standards: none. Currently assessed as Category 1, “Attaining”. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough for mercury. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Blue John Wash From headwaters to unnamed tributary of Lynx Creek ADEQ ID: 15070102-471 One sampling site at this surface waterbody.	Sampling	• **Metals:** (1d): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; (2t & 0-2d); fluoride (1) • **Sediment:** total dissolved solids (1). • **Organics:** none. • **Selenium:** none.
	Status	Parameters exceeding standards: zinc (dissolved). Currently assessed as Category 3, “Inconclusive” due to zinc exceedances, insufficient core parameters and sampling events. 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:** Moderate due to detection limits not low enough.
Sycamore Creek From Tank Canyon to Agua Fria River ADEQ ID: 15070102-024B One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, beryllium, cadmium, copper, zinc; (d 0-2 & t 4): boron, chromium, lead, manganese, mercury; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** ammonia, total nitrogen, total phosphorus, total Kjeldahl nitrogen, dissolved oxygen, pH (4); *E. coli* (3). • **Selenium:** none.

	Status	Parameters exceeding standards: none. Currently assessed as Category 1 “Attaining”. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Unnamed tributary to Lynx Creek From headwaters to Lynx Creek ADEQ ID: 15070102-124 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (d6): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, thallium, zinc; fluoride (6). • **Sediment:** total dissolved solids (6). • **Organics:** none. • **Selenium:** none.
	Status	Parameters exceeding standards: cadmium, copper, zinc. Currently assessed as Category 3, “Inconclusive”. 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:** Moderate due to insufficient data and detection limits not low enough.
Fain Lake ADEQ ID: 15070102-0005 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 2): Antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc; fluoride (2). • **Sediment:** total dissolved solids (3), turbidity (2). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (2-3); *E. coli* (3). • **Selenium:** selenium.

	Status	Parameters exceeding standards: dissolved oxygen. Currently assessed as Category 2, "Attaining some uses", due to insufficient core parameters and sampling events, and detection limits not low enough for dissolved mercury. 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.
Lynx Lake ADEQ ID: 15070102-0860 Four sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 3-6): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, selenium, silver, zinc; fluoride (8). • **Sediment:** total dissolved solids (2), turbidity (6). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (3-7), *E. coli* (1). • **Selenium:** selenium.
	Status	Parameters exceeding standards: lead, manganese. Currently assessed as Category 2, "Attaining some uses". Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough for dissolved mercury. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Low.

Subwatershed

Black Canyon Creek
HUC 1507010203

Combined Classification for Risk of Impairment:

- **Metals:** Extreme
- **Sediment:** High
- **Organics:** Moderate
- **Selenium:** Moderate

Surface Waterbody	Water Quality Data: Sampling and Assessment Status[1,2,3]

Turkey Creek From headwaters to unnamed tributary at 341928/1122128 ADEQ ID: 15070102-036A Five sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 3-9): arsenic, beryllium, cadmium, chromium, copper, lead, zinc; (d 0-2 & t 3): boron; (d 0-2 & t 1-2): antimony, manganese, mercury. • **Sediment:** suspended sediment concentration (1). • **Organics:** ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (1); dissolved oxygen, pH (7-9). • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved oxygen due to low flow and ground water upwelling. Currently assessed as Category 2, "Attaining some uses". 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:** Moderate due to detection limits not low enough.
Turkey Creek From unnamed tributary at 341928/1122138 to Poland Creek ADEQ ID: 15070102-036B Ten sampling sites at this surface waterbody. TMDL out for public review and comment. When approved by EPA, Water will be moved to Category 4. D list cadmium and zinc.	Sampling	• **Metals:** (d&t 17-46): arsenic, boron, cadmium, chromium, copper, lead, manganese, zinc; (t37 & d5): mercury; (t 3-6): beryllium; (d&t 1): antimony; cyanide (9). • **Sediment:** suspended sediment concentration (4). • **Organics:** dissolved oxygen (20); pH (46); total phosphorus (17); nitrite/nitrate (10); total nitrogen, total Kjeldahl nitrogen (1). • **Selenium:** none.
	Status	Parameters exceeding standards: copper, lead; low number of exceedances: arsenic, cadmium, chromium, dissolved oxygen due to natural conditions of low flow and ground water upwelling, mercury, suspended sediment concentration. Currently assessed as Category 5, "Impaired" due to copper and lead exceedances. Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances. • **Sediment:** High due to exceedances and insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to insufficient data.

Subwatershed

Bishop Creek
HUC 1507010204

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]	
Agua Fria River From Sycamore Creek to Big Bug Creek ADEQ ID: 15070102-023 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (4t) 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". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Agua Fria River – Lake Pleasant
HUC 1507010205

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]

Agua Fria River From Little Squaw Creek to Cottonwood Creek ADEQ ID: 15070102-017 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, boron, cadmium, chromium, copper, zinc; (4t) 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* (4). • **Selenium:** none
	Status	Parameters exceeding standards: dissolved oxygen due to low flow and ground water upwelling. Currently assessed as Category 1, "Attaining". Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.
Lake Pleasant ADEQ ID: 15070102-1100 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (d 7-10 & t 15-23): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc; fluoride (31). • **Sediment:** total dissolved solids (9), turbidity (26). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (35-45); benzene, ethylbenzene, toluene, xylene (10-15); *E. coli* (3). • **Selenium:** selenium.
	Status	Parameters exceeding standards: dissolved oxygen (2 in 15 samples), pH (1 in 15 samples). Currently assessed as Category 1, "Attaining All Uses". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Moderate due to some exceedances. • **Selenium:** Moderate due to detection limits not low enough.

Cortez Park Lake ADEQ ID: 15060106B-0410 Two sampling sites at this surface waterbody. High pH and low dissolved oxygen we added to 303(d) list in 2004.	Sampling	• **Metals:** (d&t 2): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, zinc; fluoride (2). • **Sediment:** total dissolved solids (2), 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: pH, dissolved oxygen. Currently assessed as Category 5, “Impaired”. Surface Waterbody risk classification: • **Metals:** Moderate due to insufficient data and detection limits not low enough for dissolved mercury. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to exceedances and insufficient data. • **Selenium:** Moderate due to insufficient data.

Subwatershed

Cave Creek – Arizona Canal Diversion Channel
HUC 1507010206

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]	
Cave Creek from headwaters to Cave Creek Dam ADEQ ID: 15060106B-026A Two sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 5-8): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4-8 & d0-2): boron, lead, manganese, mercury; fluoride (8). • **Sediment:** total dissolved solids (8), suspended sediment concentration (1), turbidity (8). • **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”.

Surface Waterbody risk classification:
• Metals: Low
• Sediment: Low.
• Organics: Low.
• Selenium: Moderate due to detection limits not low enough.</td></tr>
<tr><td colspan="3">Subwatershed</td></tr>
<tr><td colspan="3">Trilby Wash-Trilby Wash Basin
HUC 1507010207
Combined Classification for Risk of Impairment:
• Metals: Low
• Sediment: Low
• Organics: Low
• Selenium: Moderate</td></tr>
<tr><td colspan="3">Subwatershed</td></tr>
<tr><td colspan="3">New River
HUC 1507010208
Combined Classification for Risk of Impairment:
• Metals: Moderate
• Sediment: Moderate
• Organics: Moderate
• Selenium: Moderate</td></tr>
<tr><td>Surface Waterbody</td><td colspan="2">Water Quality Data:
Sampling and Assessment Status[1,2,3]</td></tr>
<tr><td rowspan="2">Skunk Creek
From headwaters to Agua Fria River

ADEQ ID: 15070102-003

One sampling site at this surface waterbody.</td><td>Sampling</td><td>• Metals: (t 3): cadmium, copper, lead, mercury, zinc.
• Sediment: none.
• Organics: ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (3).
• Selenium: none.</td></tr>
<tr><td>Status</td><td>Parameters exceeding standards: lead.

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.</td></tr>
<tr><td colspan="3">Subwatershed</td></tr>
</table>

Agua Fria River below Lake Pleasant **HUC 1507010209** **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]	
Gila River From Salt River to Agua Fria River ADEQ ID: 15070101-015 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 4): Antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (t4): boron, lead, manganese, mercury; fluoride (4); chlorine (2). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** Ammonia, dissolved oxygen, pH, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen (4); *E. coli* (4). • **Selenium:** none.
	Status	Parameters exceeding standards: none. Currently assessed as Category 2, "Attaining all uses". EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. Surface Waterbody risk classification: • **Metals:** Low. • **Sediment:** Low. • **Organics:** Low. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Upper Hassayampa River **HUC 1507010301** **Combined Classification for Risk of Impairment:** • **Metals:** Extreme • **Sediment:** Moderate • **Organics:** Extreme • **Selenium:** High	
Surface Waterbody	**Water Quality Data:** **Sampling and Assessment Status**[1,2,3]

Cash Mine Creek From headwaters to Hassayampa River ADEQ ID: 15070103-349 Two sampling sites at this surface waterbody. The Hassayampa River TMDL include loadings for cadmium, copper, and zir from this tributary.	Sampling	• **Metals:** (3d & 2t): antimony, arsenic, beryllium, cadmium, chromium, copper, lead, nickel, silver, zinc; (2t & d0-2d): barium, boron, manganese, mercury; fluoride (1). • **Sediment:** total dissolved solids (4. • **Organics:** dissolved oxygen, pH (2). • **Selenium:** none.
	Status	Parameters exceeding standards: copper (dissolved), pH, lead (dissolved), zinc (dissolved). Currently assessed as Category 4A, "Not Attaining" (impaired) due to cadmium, copper and zinc exceedances. Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances, insufficient data and detection limits not low enough. • **Sediment:** Moderate due to insufficient data. • **Organics:** Extreme due to exceedances and insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
French Gulch From headwaters to Hassayampa River ADEQ ID: 15070103-239 Twelve sampling sites at this surface waterbody. TMDL completed and approved in 2004 for cadmium, copper and zinc.	Sampling	• **Metals:** (d&t 36-45): cadmium, chromium, copper, zinc; (d4 & 43t): manganese; (d 0-2 & t36-38): arsenic, boron, lead, mercury; (d&t3): beryllium; fluoride (4). • **Sediment:** total dissolved solids (4), turbidity (4). • **Organics:** dissolved oxygen (19), pH (38). • **Selenium:** none.
	Status	Parameters exceeding standards: cadmium, copper, zinc, arsenic, dissolved oxygen due to low flow and ground water upwelling, lead. Currently assessed as Category 4A, "Not Attaining" (impaired). Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.

Hassayampa River From Cottonwood Creek to Martinez Wash ADEQ ID: 15070103-004 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 16-24): antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, zinc; (d&t 8): barium, nickel, silver, thallium; (d 0-1 & t 8-20): boron, manganese; fluoride (21). • **Sediment:** total dissolved solids (19), suspended sediment concentration (11), turbidity (21). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (21-22); *E. coli* (21). • **Selenium:** none.
	Status	Parameters exceeding standards: *E. coli* (1 in 3 year period). Currently assessed as Category 2, "Attaining Some Uses". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Moderate due to one exceedance. • **Selenium:** Moderate due to detection limits not low enough.
Hassayampa River From headwaters to Copper Creek ADEQ ID: 15070103-007A Fifteen sampling sites at this surface waterbody. Add pH. TMDL completed and approved in 2002 for cadmium, copper and zinc.	Sampling	• **Metals:** (d&t 58-69): cadmium, copper, zinc; (d&t 3-7): antimony, arsenic, barium, beryllium, chromium, manganese, nickel, silver; (d 0-2 & t 1-2): boron, selenium, thallium; (t 6 & d 2): mercury; fluoride (7). • **Sediment:** total dissolved solids (7). • **Organics:** dissolved oxygen (41), pH (62), total nitrogen (8), total phosphorus (1), nitrite/nitrate (8). • **Selenium:** selenium.
	Status	Parameters exceeding standards: cadmium, copper, zinc, pH, lead, selenium. Currently assessed as Category 5 (pH), "Impaired", Category 4A (cadmium, copper, zinc), "Not Attaining". Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances. • **Sediment:** Moderate due to insufficient data. • **Organics:** Low due to acid rock drainage. • **Selenium:** Moderate due to detection limits not low enough.

Hassayampa River From Copper Creek to Blind Indian Creek ADEQ ID: 15070103-007B Seven sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 8-42): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, silver, thallium, zinc; (d 0-1 & t 8-20): boron, manganese; fluoride (20). • **Sediment:** total dissolved solids (18), suspended sediment concentration (10), turbidity (18). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (20-39). • **Selenium:** none.
	Status	Parameters exceeding standards: none in last 3 years of monitoring. Currently assessed as Category 1, "Attaining All Uses". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.
Minnehaha Creek From headwaters to Hassayampa Creek ADEQ ID: 15070103-029 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 1): antimony, arsenic, barium, beryllium, boron, cadmium, chromium, copper, manganese, mercury, silver, zinc; (t1): lead, nickel. • **Sediment:** total dissolved solids (1). • **Organics:** dissolved oxygen, pH (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 and dissolved metals. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough and insufficient data.

Unnamed tributary to Cash Mine Creek From headwaters to Cash Mine Creek ADEQ ID: 15070103-415 Six sampling sites at this surface waterbody.	Sampling	• **Metals:** (d&t 4-5): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, silver, thallium, zinc; (t&d 1): boron; (1) selenium; fluoride (4). • **Sediment:** total dissolved solids (4). • **Organics:** dissolved oxygen, pH (2). • **Selenium:** selenium (1).
	Status	Parameters exceeding standards: cadmium, copper, zinc, beryllium, lead, pH, selenium. Currently assessed as Category 4A, "Not Attaining" (impaired). Surface Waterbody risk classification: • **Metals:** Extreme due to exceedances, detection limits not low enough and insufficient data. • **Sediment:** Moderate due to insufficient data. • **Organics:** High due to one exceedance, and insufficient data. • **Selenium:** High due to one exceedance, insufficient data, and detection limits not low enough.
Hassayampa Lake ADEQ ID: 15070103-3160 One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 1): antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver, zinc; (t1): mercury; fluoride (1). • **Sediment:** total dissolved solids (1). • **Organics:** none. • **Selenium:** none.
	Status	Parameters exceeding standards: dissolved copper, lead. Currently assessed as Category 3, "Inconclusive" due to insufficient core parameters and sampling events. Surface Waterbody risk classification: • **Metals:** High due to one dissolved copper and one lead exceedance. • **Sediment:** Moderate due to insufficient data. • **Organics:** Moderate due to insufficient data. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Sols Wash
HUC 1507010302

Combined Classification for Risk of Impairment:

- **Metals:** Moderate
- **Sediment:** Low
- **Organics:** Moderate
- **Selenium:** Moderate

Subwatershed

Middle Hassayampa River
HUC 1507010303

Combined Classification for Risk of Impairment:

- **Metals:** Moderate
- **Sediment:** Low
- **Organics:** Moderate
- **Selenium:** Moderate

Surface Waterbody	**Water Quality Data: Sampling and Assessment Status[1,2,3]**	
Hassayampa River From Sols Wash to 8 miles below Wickenburg ADEQ ID: 15070103-002A One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-1 & t 3): boron, manganese, lead, mercury; (d&t 1): barium, nickel, silver, thallium; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (3); *E. coli* (3). • **Selenium:** none.
	Status	Parameters exceeding standards: *E. coli* (1 in 3 year period), dissolved oxygen due to low flow and ground water upwelling. Currently assessed as Category 2, “Attaining Some Uses”. Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Moderate due to low dissolved oxygen, and one *E. coli* exceedance. • **Selenium:** Moderate due to detection limits not low enough.

<table>
<tr><td rowspan="2">Hassayampa River
From Cottonwood Creek to Martinez Wash

ADEQ ID: 15070103-004

One sampling site at this surface waterbody.</td><td>Sampling</td><td>• Metals: (d&t 16-24): antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, zinc; (d&t 8): barium, nickel, silver, thallium; (d 0-1 & t 8-20): boron, manganese; fluoride (21).
• Sediment: total dissolved solids (19), suspended sediment concentration (11), turbidity (21).
• Organics: Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (21-22); E. coli (21).
• Selenium: none.</td></tr>
<tr><td>Status</td><td>Parameters exceeding standards: E. coli (1 in 3 year period).

Currently assessed as Category 2, “Attaining Some Uses”.

Surface Waterbody risk classification:
• Metals: Moderate due to detection limits not low enough.
• Sediment: Low.
• Organics: Moderate due to one exceedance.
• Selenium: Moderate due to detection limits not low enough.</td></tr>
<tr><td colspan="3">Subwatershed</td></tr>
<tr><td colspan="3">Jackrabbit Wash
HUC 1507010304
Combined Classification for Risk of Impairment:
• Metals: Moderate
• Sediment: Moderate
• Organics: Moderate
• Selenium: Moderate</td></tr>
<tr><td colspan="3">Subwatershed</td></tr>
<tr><td colspan="3">Lower Hassayampa River
HUC 1507010305
Combined Classification for Risk of Impairment:
• Metals: Moderate
• Sediment: Moderate
• Organics: Moderate
• Selenium: Moderate</td></tr>
<tr><td>Surface Waterbody</td><td colspan="2">Water Quality Data:
Sampling and Assessment Status[1,2,3]</td></tr>
</table>

Gila River From Hassayampa River to Centennial Wash ADEQ ID: 15070101-009 Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** no current data. • **Sediment:** no current data. • **Organics:** no current data. • **Selenium:** no current data.
	Status	Parameters exceeding standards: no current data. Currently assessed as Category 3, "Inconclusive" due to lack of data. EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.
Hassayampa River From Buckeye Canal to Gila River ADEQ ID: 15070103-001B One sampling site at this surface waterbody. Fish consumption advisory due to pesticides in fish tissue. DDT, toxaphene, and chlordane were re-listed by EPA in 2002.	Sampling	• **Metals:** (d&t 4): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-1 & t 4): boron, manganese, lead, mercury; (d 0-1 & t 1): barium, nickel, silver, selenium, thallium; 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:** selenium.
	Status	Parameters exceeding standards: selenium. Currently assessed as Category 2, "Attaining some uses". EPA assessed as Category 5, "Impaired" due to DDT, toxaphene, and chlordane in fish tissue. 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.

Hassayampa River From Sols Wash to 8 miles below Wickenburg ADEQ ID: 15070103-002A One sampling site at this surface waterbody.	Sampling	• **Metals:** (d&t 3): antimony, arsenic, beryllium, cadmium, chromium, copper, zinc; (d 0-1 & t 3): boron, manganese, lead, mercury; (d&t 1): barium, nickel, silver, thallium; fluoride (3). • **Sediment:** total dissolved solids (3), turbidity (3). • **Organics:** Ammonia, total nitrogen, total phosphorus, nitrite/nitrate, total Kjeldahl nitrogen, dissolved oxygen, pH (3); *E. coli* (3). • **Selenium:** none.
	Status	Parameters exceeding standards: *E. coli* (1 in 3 year period), dissolved oxygen due to low flow and ground water upwelling. Currently assessed as Category 2, "Attaining Some Uses". Surface Waterbody risk classification: • **Metals:** Moderate due to detection limits not low enough. • **Sediment:** Low. • **Organics:** Moderate due to low dissolved oxygen, and one *E. coli* exceedance. • **Selenium:** Moderate due to detection limits not low enough.

Subwatershed

Aguila Valley Area-Centennial Wash
HUC 1507010401

Combined Classification for Risk of Impairment:

- **Metals:** Moderate
- **Sediment:** Moderate
- **Organics:** Moderate
- **Selenium:** Moderate

Subwatershed

McMullen Valley Area-Centennial Wash
HUC 1507010402

Combined Classification for Risk of Impairment:

- **Metals:** Moderate
- **Sediment:** Moderate
- **Organics:** Moderate
- **Selenium:** Moderate

Subwatershed
Tiger Wash **HUC 1507010403** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate

Subwatershed
Upper Harquahala Plains Area-Centennial Wash **HUC 1507010404** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate

Subwatershed
Middle Harquahala Plains Area-Centennial Wash **HUC 1507010405** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate

Subwatershed
Winters Wash **HUC 1507010406** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate

Subwatershed
Lower Harquahala Plains Area-Centennial Wash **HUC 1507010407** **Combined Classification for Risk of Impairment:** • **Metals:** Moderate • **Sediment:** Moderate • **Organics:** Moderate • **Selenium:** Moderate

[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:
Agl: 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
Middle Gila 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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**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.

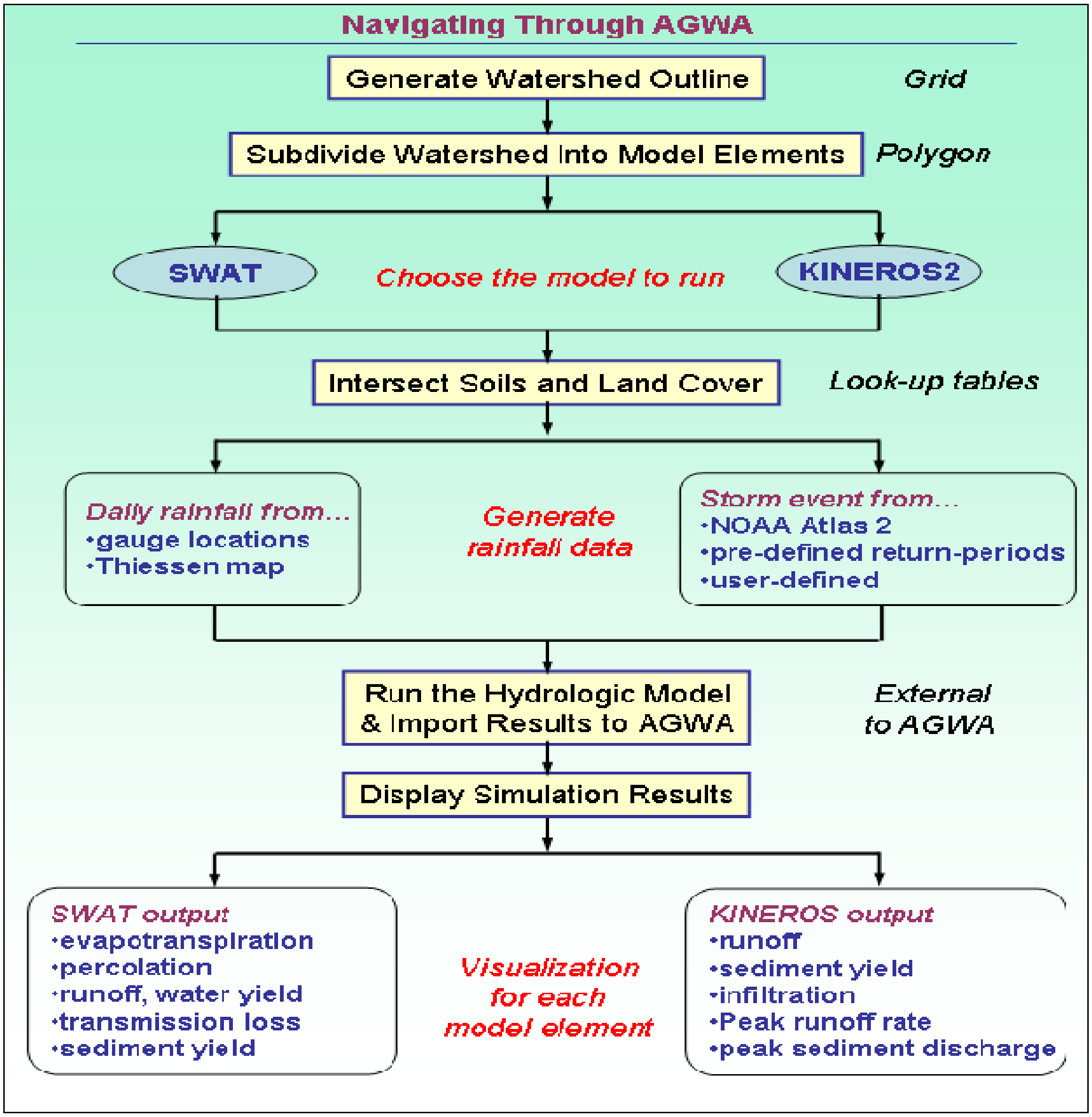

Figure D-1: Flow chart showing the general framework for using KINEROS2 and SWAT in AGWA.

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.

References:

Arnold, J.G., J. R. Williams, R. Srinivasan, K.W. King, and R. H. Griggs. 1994. SWAT-Soil & Water Assessment Tool. USDA, Agricultural Research Service, Grassland, Soil and Water Research Laboratory, Temple, Texas.

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RS/GIS Laboratory, 2004. Southwest Gap Regional Provisional Landcover. http://earth.gis.usu.edu/swgap Land cover / land use. Sept. 24, 2004.

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