







A Statewide Assessment of Arizona's Streams

July 2007 – June 2010









ADEQ
Arizona Department of Environmental Quality




A Statewide Assessment of Arizona's Streams

Fiscal Years 2008 to 2010

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ABBREVIATIONS

Abbreviation	Name	Abbreviation	Name
ALKCACO3	Total Alkalinity	Mn (T)	Total Manganese
ALKPHEN	Phenolphthalein Alkalinity		
ADEQ	Arizona Department of Environmental Quality	MRL	Minimum Reporting Level
As (D)	Arsenic Dissolved	MU	Monitoring Unit
As (T)	Arsenic Total	N (T)	Nitrogen Total
AZGF	Arizona Game and Fish Department	NA (D)	Sodium Dissolved
AZPDES	Arizona Pollutant Discharge Elimination System	Na (T)	Sodium Total
B (T)	Boron Total	NH3	Ammonia
Ca (D)	Calcium Dissolved	N03 + N02	Nitrate plus Nitrite
Ca (T)	Calcium Total	ntu	Nephelometric Turbidity Unit
CALCARB-T	Calcium Carbonate Total	P (T)	Phosphorous Total
CAL-D/T	Calcium Dissolved/Total	Pb (D	Lead Dissolved
Cd (D)	Cadmium Dissolved	Pb (T)	Lead Total
Cd (T)	Cadmium Total	PB-D	Lead Dissolved
CFS	Cubic Feet per Second	PFC	Proper Functioning Condition
Cl- (T)	Chloride Total		
CO3	Carbonate	QA	Quality Assurance
Cr (T)	Total Chromium	RBS	Relative Bed Stability
Cu (D)	Copper Dissolved	Se (T)	Selenium Total
Cu (T)	Copper Total	SO4	Sulfate Total
CWA	Clean Water Act	SSC	Suspended Sediment Concentration
DO (mg/l)	Dissolved Oxygen (mg/l)	su	Standard pH Units
DO %	Percent Dissolved Oxygen	TDS	Total Dissolved Solids
EC	Specific Conductivity		
E. COLI	Escherichia coli	TEMP-AIR	Air Temperature
F-	Fluoride Total	TEMP-WATER	Water Temperature
Ft	Feet	TKN	Total Kjeldahl Nitrogen
Ft/s	Feet per second	TMDL	Total Maximum Daily Load
HARDCACO3	Total Hardness	USGS	U.S. Geological Survey
HCO3	Bicarbonate	Zn (D)	Zinc Dissolved
Hg (D)	Mercury Dissolved	Zn (T)	Zinc Total
Hg (T)	Mercury Total	%IH	Percent Ideal Habitat
HUC	Hydrologic unit Code		
IBI	Index of Biological integrity		
K (D)	Potassium Dissolved		
K (T)	Potassium Total		
ml	Milliliters		
mm	Millimeters		
Mg (D)	Magnesium Dissolved		
Mg (T)	Magnesium Total		

TABLE OF CONTENTS

CHAPTER 1 – INTRODUCTION

OVERVIEW

This report discusses the condition of Arizona's wadeable perennial streams using a probabilistic monitoring design. A probabilistic design allows statistical inferences to be made about stream segments that were never visited. A targeted or census approach would require thousands of sites to adequately cover the state. Probabilistic monitoring provides a cost effective approach for answering statewide questions such as "What percentage of stream miles are in good condition for macroinvertebrates?". A targeted monitoring approach is still essential to provide the detailed work necessary for the Clean Water Act 305(b) assessment and Total Maximum Daily Loads (TMDLs).

WHY SHOULD YOU CARE?

Clean water is essential for the prosperity of nations and the livelihood of people. According to a 2010 United Nation's report, "over half of the world's hospitals beds are occupied with people suffering from illnesses linked with contaminated water and more people die as a result of polluted water than are killed by all forms of violence including wars." Addressing poor sanitation is still one of the greatest challenges we face at a global scale.

Developed countries like the United States do not experience the devastating effects from poor sanitation because of laws enacted in the 1970s to stop pumping raw sewage and industrial pollution into waterways. Many rivers and streams throughout the United States were used as open sewers until the Clean Water Act was enacted in 1972. The Clean Water Act addressed many of the major water pollution threats. Today we face problems of a more chronic nature such as long term exposure to new chemicals, non-point sources, and increased salinity. The purpose of this report is to provide a baseline of water quality data for Arizona's perennial streams so that water quality improvements or degradation can be analyzed over time.

ARIZONA WATER

Water is one of Arizona's most important resources. The importance of water will only grow as Arizona's population increases. The United States Census Bureau has ranked Arizona the second-fastest growing state after Nevada. Arizona's population as of the 2010 census was 6,392,017 and is expected to double by 2030. This increase will unquestionably place further demands on Arizona's water supply.

Groundwater is the primary source for Arizona's water (ADWR, 2006). Surface water, Central Arizona Project water and effluent from wastewater treatment plants make up the remaining 45 percent of the water that Arizona uses. The majority of Arizona's water is used for agriculture with smaller allotments being used for municipal and industrial uses (Figure 1).

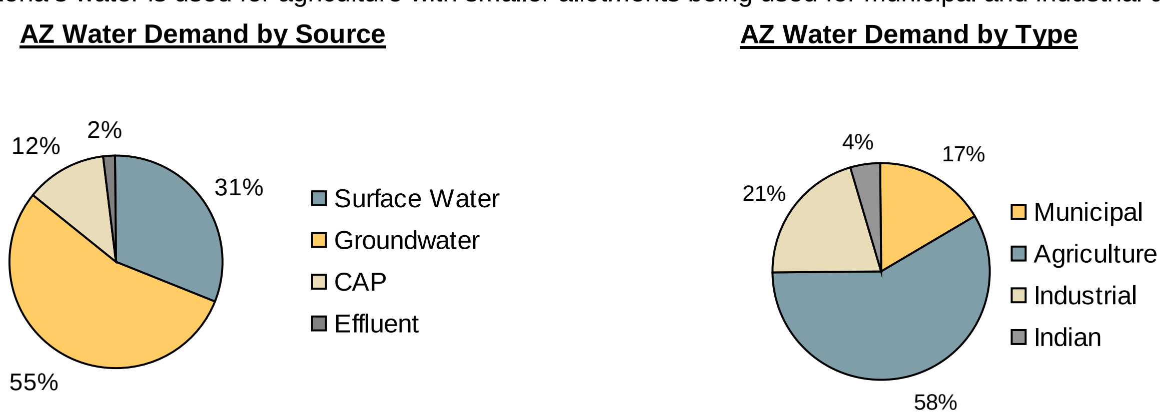


Figure 1. AZ Water Demand by Source and Type (ADWR, 2006)

MONITORING OBJECTIVES

ADEQ monitors lakes, streams and groundwater throughout the state to assess whether the water is safe to drink, safe for recreation, suitable for irrigation, and adequate to support aquatic life. Monitoring is used to meet state and federal goals of protecting human health and aquatic life. The Clean Water Act (CWA) and Arizona Revised Statutes (A.R.S.) § 49-225 gives ADEQ the authority to conduct ambient water monitoring.

The information that the Monitoring Unit in the Water Quality Division at ADEQ gathers is used by other government agencies such as the U.S. Environmental Protection Agency, Arizona Game and Fish Department, and the Arizona Department of Water Resources. The data is also used by land owners, universities, operators of drinking water systems and the public to make informed management decisions.

Figure 2 illustrates the relationship between water quality monitoring, assessments, Total Maximum Daily Load (TMDL) development, and the implementation of water quality improvement strategies. Water quality is monitored and the results are compared against the surface water quality standards. The results of the assessment are included in the CWA Section 305(b) report, while impaired waters are placed on the 303(d) list. TMDLs are developed for impaired surface waters on the 303(d) list. The National Pollutant Discharge Elimination System (NPDES) is a CWA permitting program which addresses point source discharges to surface waters. These permits are written to ensure discharges from facilities meet water quality standards. Arizona received delegation for the NPDES program from EPA in December 2002. The CWA 319 program addresses nonpoint source pollution and provides grants for projects to improve water quality.

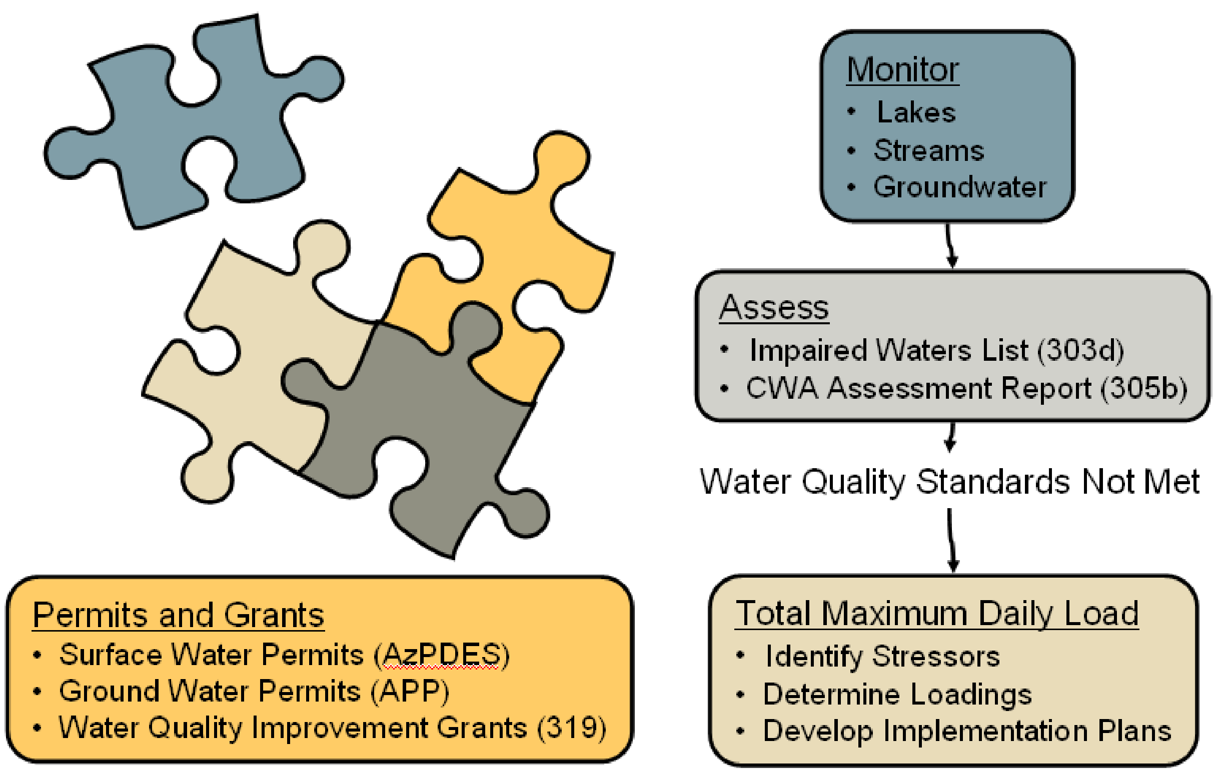


Figure 2. Relationships between Clean Water Act Programs.

This report is not associated with the 305(b) assessment report or the 303(d) impaired waters list. Please consult the most recent Integrated Assessment and Listing Report to determine if a stream reach is impaired or is attaining. The most recent version of the Integrated report can be found on ADEQ's Web site at: http://www.azdeq.gov/environ/water/assessment/assess.html .

PROBABILISTIC HISTORY

Section 305(b) of the Clean Water Act requires states to provide "a description of the water quality of all navigable waters…". In practice this is an impossible task either with a targeted or probabilistic monitoring design. Targeted designs fail to monitor all waters because it is impractical to monitor every stream and lake in the state. Probabilistic designs usually fall short of a 100% assessment because some streams cannot be accessed. Samplers may be denied access by property owners or they may encounter physical barriers such as canyons that prevent sampling (Figure 3).

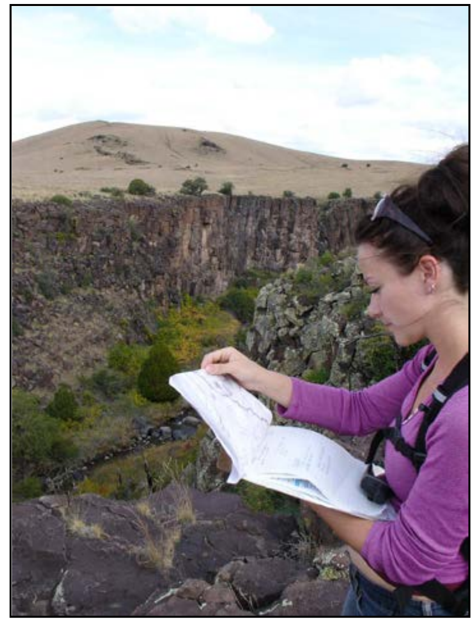


Figure 3. This site was rejected because of access issues. The Little Colorado River is at the base of an inaccessible canyon (2007).

States have historically chosen to use a targeted approach to monitor surface water. This approach allowed states to make specific assessment and listing decisions on a particular waterbody, but did not allow for a comprehensive assessment of a particular state. In 2000, the Government Accounting Office criticized the EPA and States for failing to monitor all waters of the state.

> *Assessment data in the 305(b) report are not complete because they do not represent all of the states' waters, either through a census (i.e., the monitoring of all waters in a state) or through statistical sampling that would yield data that are projectable to all state waters.*

EPA responded to this criticism by creating the National Aquatic Resource Surveys (NARS). NARS used probabilistic monitoring to provide a national picture of streams, rivers, lakes, coastal waters, and wetlands. EPA developed standardized methodology that was used consistently across the nation so that results collected by states could be compared across the nation. This is in stark contrast with the methodology developed by states since the passing of the CWA in 1972. Since that time, each state has created separate standards and methods to measure those standards as directed by the CWA. This disconnect between the state and national scale goals prompted the Office of Management and Budget to tie Section 106 funding to using statistical methodology to monitor the state using either the EPA's national methods or the state derived methods (Federal Register, 2008).

As of 2009, 45 states had adopted probabilistic monitoring for at least one waterbody (FIGURE 4). Assessing at least one waterbody and participating in the National Surveys is required by the EPA (2008, Federal Register).

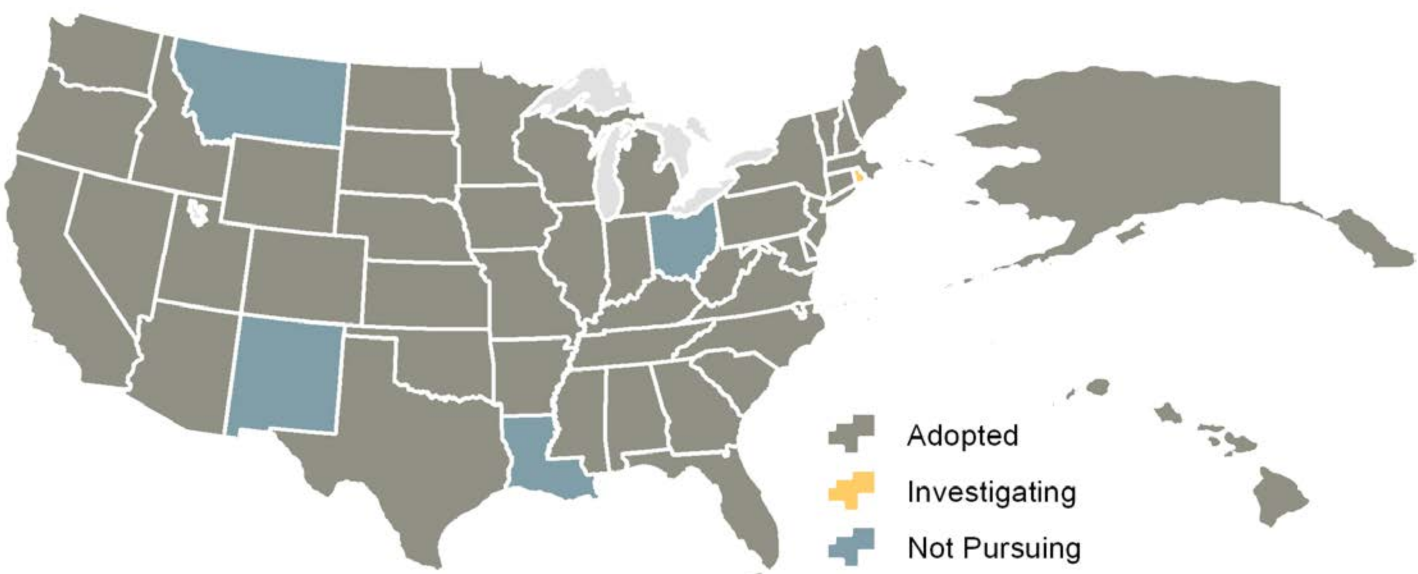


Figure 4. Map of states using or evaluating probabilistic methods to complete statewide condition assessments (USEPA, 2012)

WHY ARIZONA CHOSE THE STATE PATH TO STATEWIDE ASSESSMENT

Arizona has used statistical methods to assess the state's water quality by using both EPA and state methods. From 2000 to 2004, the Arizona Game and Fish Department (AZG&F) conducted the first statewide probabilistic assessment of Arizona's wadeable perennial streams using EPA's national protocols. AZG&F sampled 47 sites as part of a statewide intensification project of the Western Environmental Mapping and Assessment Program which later was published as the first national Wadeable Stream Assessment (EPA, 2006).

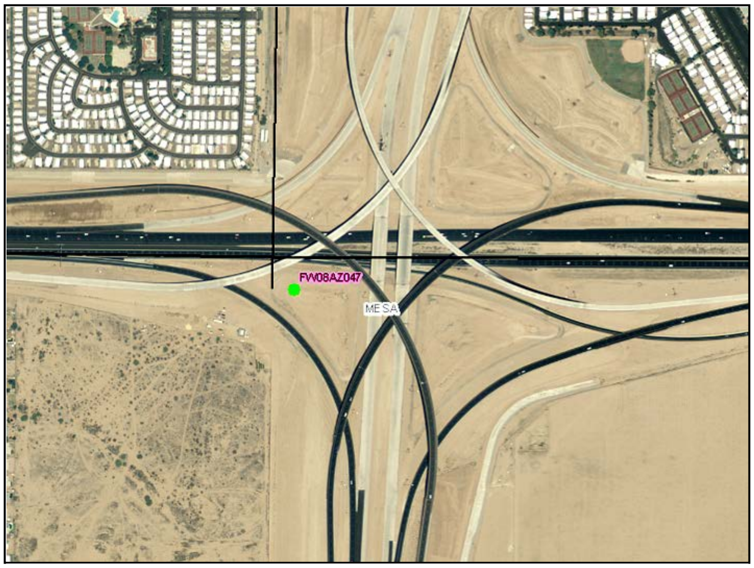


Figure 5. This interstate exchange in Phoenix showed up as a "stream" in EPA's target population.

AZDEQ was awarded a grant to compare EPA's national methods to the state specific methods for cold water streams (streams greater than 5,000 feet in elevation). Sampling was completed in the spring of 2007. AZDEQ wanted to know whether EPA's NARS data could be used in the 305(b) assessment and whether the data collected by using state methods could be used in the EPA's national survey.

The results of the survey were mixed. EPA and state methods were comparable for macroinvertebrates in cold water streams. EPA and state methods were only partly comparable for chemistry and habitat results. Differences in sample collection and methodology for habitat and chemistry samples meant that only some of the parameters and samples could be directly compared. An even bigger issue was the extremely poor target population used in NARS. 84% of Arizona sites in EPA's Wadeable Stream Assessment were non-target. In other words, roughly nine out of 10 streams were not streams at all (Figure 5). More than 250 sites had to be evaluated for the 2009/2010 National River and Stream Survey before 40 sampleable sites could be selected, which tied up several staff for months. In 2007, AZDEQ contracted with USGS to model perennial stream flow and created an updated map for Arizona streams (Anning, 2009). This new map decreased the error rate to 43%, which is less than half the error rate of the target population map that EPA created.

In the end, AZDEQ decided to use state methods to perform a statewide assessment of wadeable perennial streams. The incompatibility of the national survey with the 305(b) assessment and the out-of-date maps associated with the EPA target design were the main factors for choosing the state path to statewide assessment.

CHAPTER 2 – MONITORING DESIGN AND METHODS

PROBABILISTIC MONITORING DESIGN

Arizona utilizes a Generalized Random Tessellation Stratified (GRTS) survey design for a linear resource. The GRTS design includes reverse hierarchical ordering of the selected sites (Olsen, 2007). In this model, the computer arranges all of the streams of the state in one line and then randomly picked sites along that line. The randomly picked sites were further stratified into three geographic regions.

For the statewide assessment, 49 sites were selected to be sampled over a three-year cycle. The Central Monitoring Region is the first region to be sampled. Splitting the state into three regions enabled ADEQ to keep this rotating approach and minimize travel time. Figure 6 illustrates which watersheds make up each monitoring region and indicates the years each region was sampled.

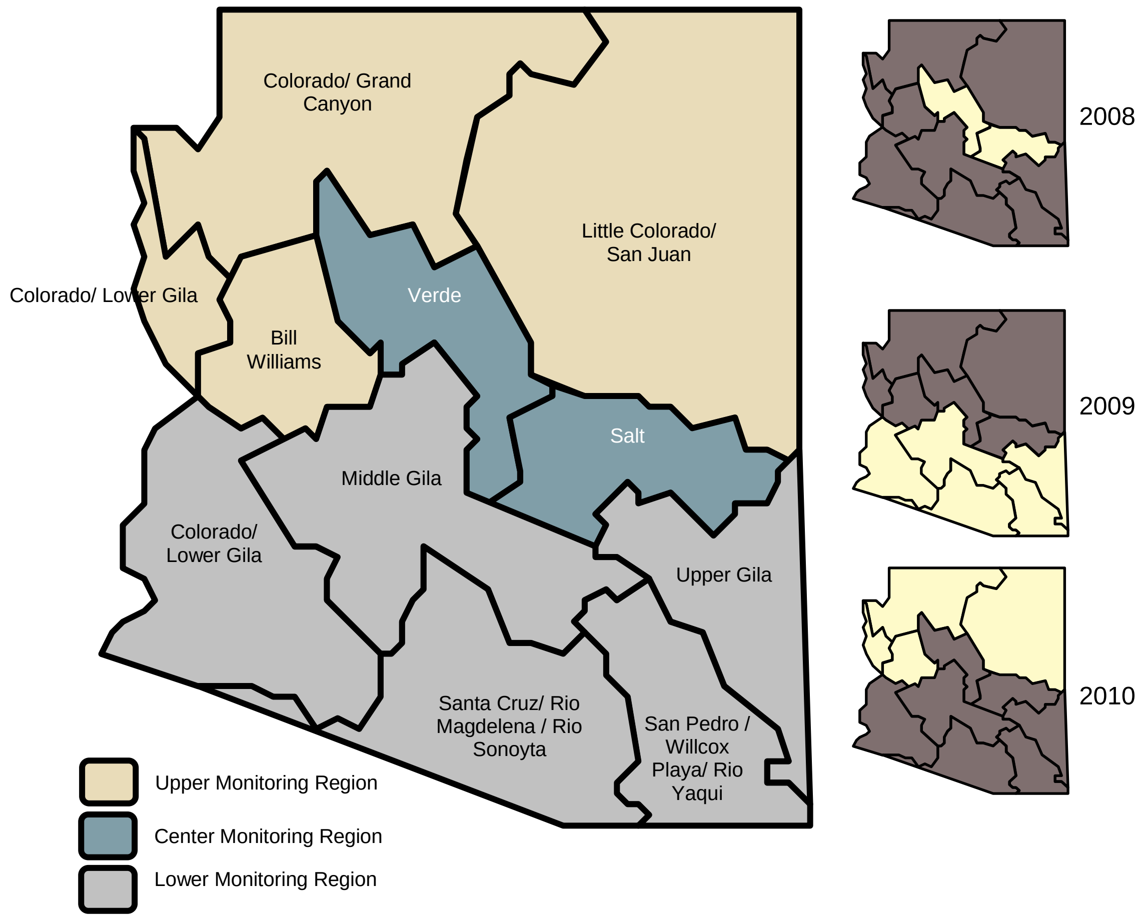


Figure 6. Monitoring Regions

In order to use the probability-based monitoring plan, EPA generated a random sampling site list with specific coordinates using the R-statistical program. The coordinates were then plotted on ADEQ's perennial stream map. This map was modified by ADEQ in 2007 from the original version created by the Arizona Game and Fish Department in 1993. ADEQ updated the map to include "predicted" perennial reaches based on USGS models, which used existing ADEQ flow records to predict the hydrological regime of ungaged streams in Arizona (Anning, 2009). The map was further modified to exclude stream reaches that were on Native American land, lake shorelines, canals, or ditches.

Next, the random sites were further evaluated by GIS and field reconnaissance, and categorized as "target" or "non-target". GIS and field reconnaissance validated the following criteria for the "target" sites:

1) Was the sample site wadeable and perennial?
2) Was the sample site accessible?

3) Was permission granted if the site was on private land?
4) Was the sample site on Native American Land?

TARGET POPULATION AND SITE EVALUATION RESULTS

The target population for this study is wadeable perennial streams that are not located on a Native American reservation, which make up 28 percent of the state (Figures 7 and 8). Arizona has 90,375 miles of streams (ADEQ 2011) and the vast majority of these streams are ephemeral or only flow due to precipitation (Figure 7). Roughly 4% of Arizona's streams are intermittent, which means that the stream flows continuously during certain times of the year, but does not flow year round. Only 4%, or 3,274 of the state's streams that are not on Native American land, are considered to be perennial (Figure 7). Perennial streams flow year round. This report only focuses on the 4% of streams that are considered to be perennial and not on Native American reservations.

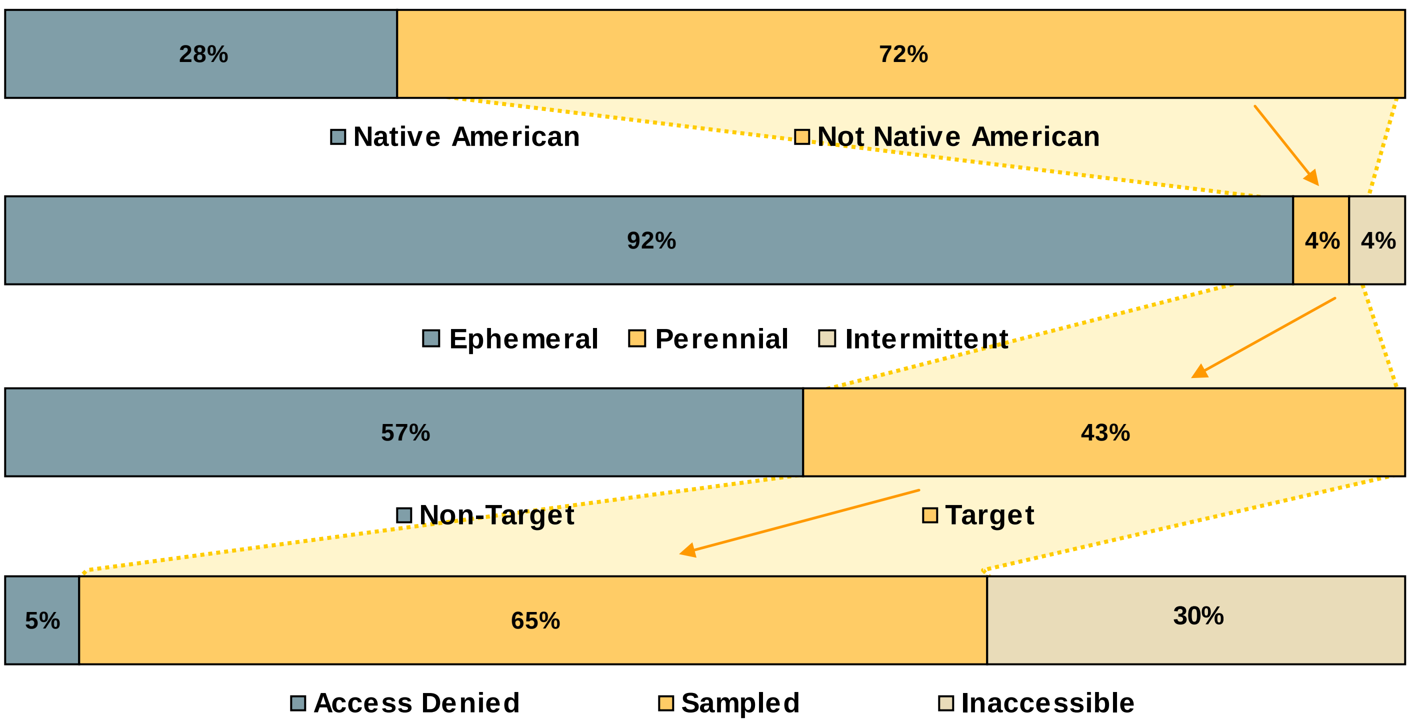
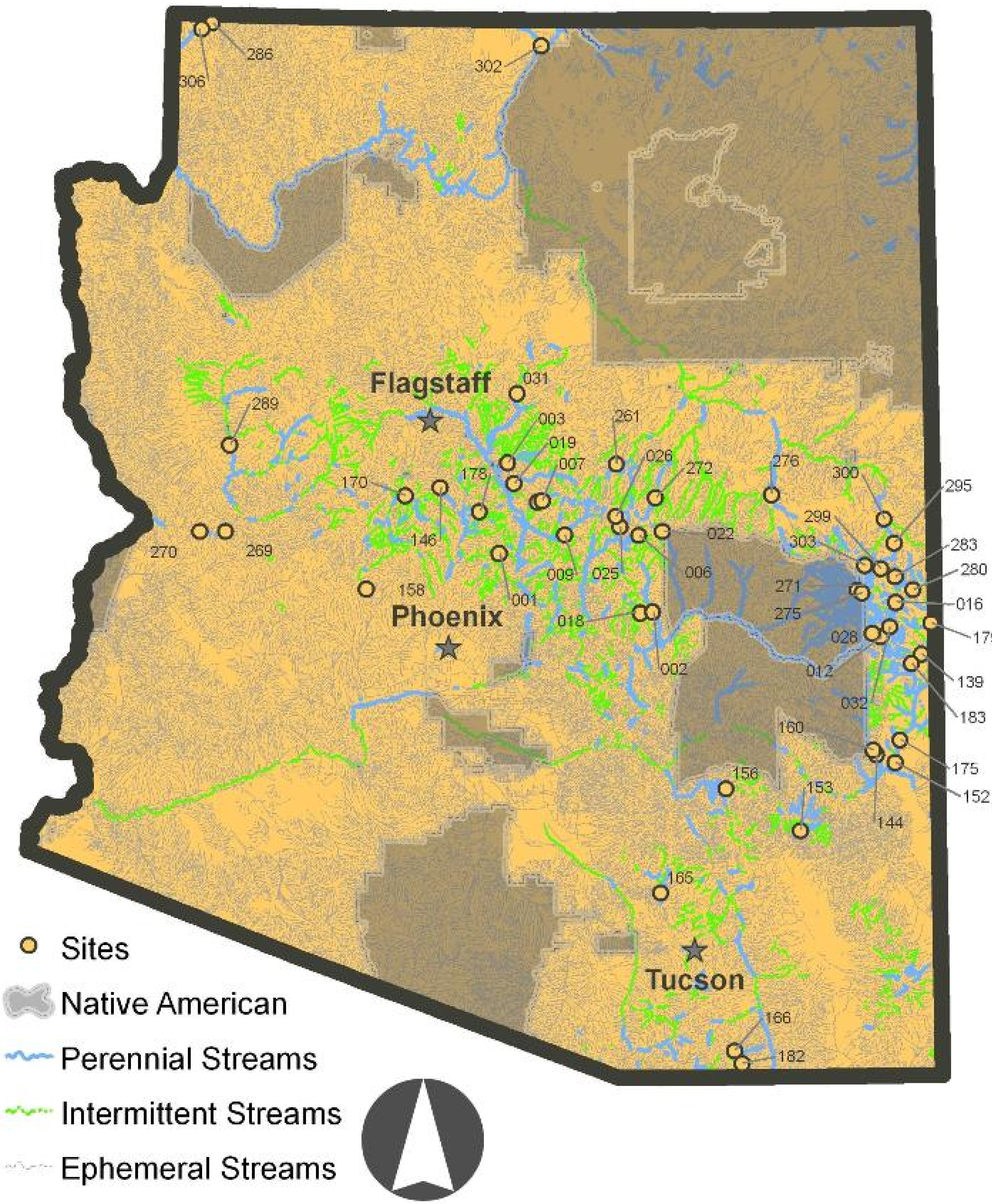


Figure 7. Assessing Sample Population

A total of 131 sites were evaluated, of which 49 sites were determined to be "target" sites or sites that are wadeable perennial streams. Fifty-seven percent of streams were "non-target". These non-target streams were dry, non-wadeable or map errors (Figure 7).

Thirty-five percent of the targeted sites (3,274 miles) could not be sampled because of access denials or because they were inaccessible due to barriers such as canyon walls. Inaccessible and access denied sites are still considered 'target' since they are wadeable and perennial. This leaves 2,128 river miles that were actually assessed for this report. The 2008, 2009, and 2010 site evaluation results were added as new attributes to the perennial stream map for future reference and to further improve the accuracy of selecting "target" monitoring sites.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Phoenix
018
275
028
179
002
012
139
032
183
160
175
156
153
152
144
165
Tucson
166
182
Sites
Native American
Perennial Streams
Intermittent Streams
Ephemeral Streams

Figure 8. Site Map.

REFERENCE SITE SELECTION

AZDEQ staff conducts bioassessments and habitat assessments at biocriteria reference sites, random sites, and outstanding water sites to develop Arizona's regional reference site network statewide and to monitor trends in reference conditions over time. Another purpose of the biocriteria monitoring effort is to test existing indices of biological integrity for warm and cold water streams over a range of impairment conditions and sources of stressors. A minimum of 10 biocriteria reference sites are selected in each watershed each year. Some of the random sites were also used as reference sites for the 2008 macroinvertebrate collection.

SITE LOCATION

Table 2 lists the random sites and site IDs that were sampled. Figure 8 shows the aerial location of all monitoring sites.

ADEQ gives each sample site a unique identification code. The first two letters correspond to the watershed code. For example, SRBON001.69, SR corresponds to the Salt River Watershed. The next three letters are chosen to correspond to the stream name. Using our example SRBON001.69, BON represents Boneyard Creek. Lastly, the values at the end of the identification code relate to the river miles that pinpoint the sample site on the stream (measured in river miles from the mouth of the stream to the site location). The site ID SRBON001.69 represents the specific sampling point 1.69 river miles from the mouth of Boneyard Creek located in the Salt River watershed.

Table 2. Site List

EPA Random Number	ADEQ Site ID	Latitude	Longitude	Designated Used
289	BWBSR037.79	34.69802	-113.59875	A&Ww, FBC, FC, AGL
270	BWBWR025.86	34.22929	-113.77753	A&Ww, FBC, FC, AGL
269	BWBWR038.52	34.23133	-113.61	A&Ww, FBC, FC, AGL
302	CGPAR000.49	36.86431	-111.59718	A&Ww, FBC, FC
306	CGVGR044.58	36.92139	-113.86056	A&Ww, FBC, FC, AGI, AGL
286	CGVGR052.23	36.95234	-113.78983	A&Ww, FBC, FC, AGI, AGL
272	LCCHC073.26	34.44045	-110.84027	A&Wc, FBC, FC, AGI, AGL
261	LCECL009.39	34.61961	-111.09361	A&Wc, FBC, FC, AGI, AGL
275	LCELR008.70	33.92245	-109.51178	A&Wc, FBC, FC, AGL
303	LCFIS003.86	34.06819	-109.49522	A&Wc, FBC, FC, AGL
300	LCLCR323.60	34.31572	-109.36278	A&Wc, FBC, FC, AGI, AGL
295	LCLCR336.72	34.18653	-109.30272	A&Wc, FBC, FC, AGI, AGL
280	LCNUT025.35	33.93481	-109.1861	A&Wc, FBC, FC, AGI, AGL
283	LCRUD008.43	34.00376	-109.29946	A&Wc, FBC, FC, AGL
276	LCSIL027.05	34.45506	-110.09041	A&Wc, FBC, FC, AGI, AGL
299	LCSLR003.72	34.04889	-109.39028	A&Wc, FBC, FC, AGL
271	LCWLR007.37	33.93506	-109.5426	A&Wc, FBC, FC
146	MGAFR110.01	34.4899	-112.23094	A&Ww, FBC, DWS, FC, AGI, AGL
158	MGHSR048.20	33.93794	-112.69969	A&Ww, FBC, FC, AGI, AGL
170	MGHSR110.58	34.44417	-112.4585	A&Wc, FBC, FC, AGI, AGL
178	MGLSY000.42	34.36344	-111.97436	A&Ww, FBC, FC
165	SCSAB005.09	32.32097	-110.81064	A&Ww, FBC, DWS, FC, AGI
156	SPARA026.35	32.87922	-110.39407	A&Ww, FBC, FC, AGL
166	SPGDN007.55	31.47358	-110.35006	A&Wc, FBC, FC
153	SPGRA007.71	32.65188	-109.92518	A&Wc, FBC, DWS, FC, AGL
182	SPMLC013.56	31.40539	-110.30369	A&Wc, FBC, DWS, FC, AGL
32	SRBEV001.40	33.73811	-109.34092	A&Wc, FBC, FC, AGI, AGL

EPA Random Number	ADEQ Site ID	Latitude	Longitude	Designated Used
28	SRBLR102.24	33.70403	-109.45258	A&Wc, FBC, DWS, FC, AGI, AGL
16	SRBON001.69	33.86981	-109.29889	A&Wc, FBC, FC, AGI, AGL
2	SRCHE013.65	33.82842	-110.8571	A&Ww, FBC, FC, AGI, AGL
22	SRCYN045.73	34.25836	-110.79568	A&Wc, FBC, DWS, FC, AGI, AGL
12	SRFIS004.49	33.68464	-109.39689	A&Wc, FBC, FC, AGI, AGL
6	SRHAG013.09	34.23894	-110.94906	A&Wc, FBC, FC, AGI, AGL
25	SRTON053.87	34.28333	-111.07083	A&Ww, FBC, FC, AGI, AGL
26	SRTON059.43	34.33897	-111.09592	A&Wc, FBC, FC, AGI, AGL
18	SRWRK007.97	33.8238	-110.93915	A&Wc, FBC, FC, AGI, AGL
183	UGBLR030.24	33.54061	-109.20342	A&Wc, FBC, FC, AGI, AGL
139	UGBLR036.37	33.59028	-109.13917	A&Wc, FBC, FC, AGI, AGL
144	UGEAG011.09	33.05542	-109.43581	A&Ww, FBC, DWS, FC, AGI, AGL
160	UGEAG015.23	33.07844	-109.45581	A&Ww, FBC, DWS, FC, AGI, AGL
152	UGSFR006.08	33.01139	-109.31889	A&Ww, FBC, FC, AGI, AGL
175	UGSFR019.04	33.13222	-109.28333	A&Ww, FBC, FC, AGI, AGL
179	UGTRY001.56	33.75614	-109.07472	A&Wc, FBC, FC, AGL
9	VREVR023.59	34.24086	-111.42892	A&Ww, FBC, DWS, FC, AGI, AGL
7	VRFOS014.33	34.42431	-111.57319	A&Ww, FBC, FC, AGL
31	VROAK048.36	34.99833	-111.73917	A&Wc, FBC, DWS, FC, AGI, AGL
1	VRROU002.93	34.13959	-111.84675	A&Ww, FBC, FC, AGL
3	VRWBV002.97	34.62642	-111.79894	A&Ww, FBC, FC, AGI, AGL
19	VRWCL005.10	34.51418	-111.75664	A&Ww, FBC, FC, AGI, AGL

[1]Coordinates in North American Datum 1983

SAMPLE METHODS

The ADEQ Standard Operating Procedures for Water Quality Sampling (Jones, 2012) describes the sample collection methods used for water chemistry, macroinvertebrate and habitat data.

CHAPTER 3 – SUMMARY OF DATA

HYDROLOGIC CONDITIONS

Hydrologic conditions varied considerably among the three years sampled (2008-2010). During 2008, there were high magnitude flood events from January to April 2008 in the Verde and Salt River basins where our water quality work was conducted. Flood maximums ranged from an eight-year return interval in the Verde (Figure 9; West Clear Creek) to a maximum 30-year return interval flood in Pinto Creek, Cherry Creek, Tonto Creek and others in the Salt River basin.

During 2009, there were spikes of high flows (one year return interval near bankfull) during the monsoon rain events of July-October 2008, but flows were slightly below to near normal 30-year averages through the spring sampling event of 2009 and for the remainder of the monitoring year (Figure 9; San Pedro River and Blue River).

During 2010, there were near-average conditions through monsoon and winter seasons, then high flows during April-May (two year return interval flood just above bankfull) in the Little Colorado River basin, and high magnitude floods from February to April in the Bill Williams River basin (three to five year return interval flood in excess of bankfull) (Figure 9).

These varied flows among sampling years pose some problems for a statewide water quality assessment. Flow and substrate conditions and the resulting macroinvertebrate community status were different depending on which region of the state ADEQ was sampling and in which year. While some variation in stream conditions are expected in any given year, the high flow conditions of monitoring year 2008 were extreme enough to exempt some macroinvertebrate samples from application of the biocriteria standard. ADEQ has developed a rule of thumb to help evaluate potentially flood affected samples. If a winter flood event of magnitude ≥10 year return interval has occurred in the basin or in the stream to be sampled for macroinvertebrates, then samples are not collected or the sample is flagged with a comment that it is likely disturbed due to flood conditions (Spindler, 2010).

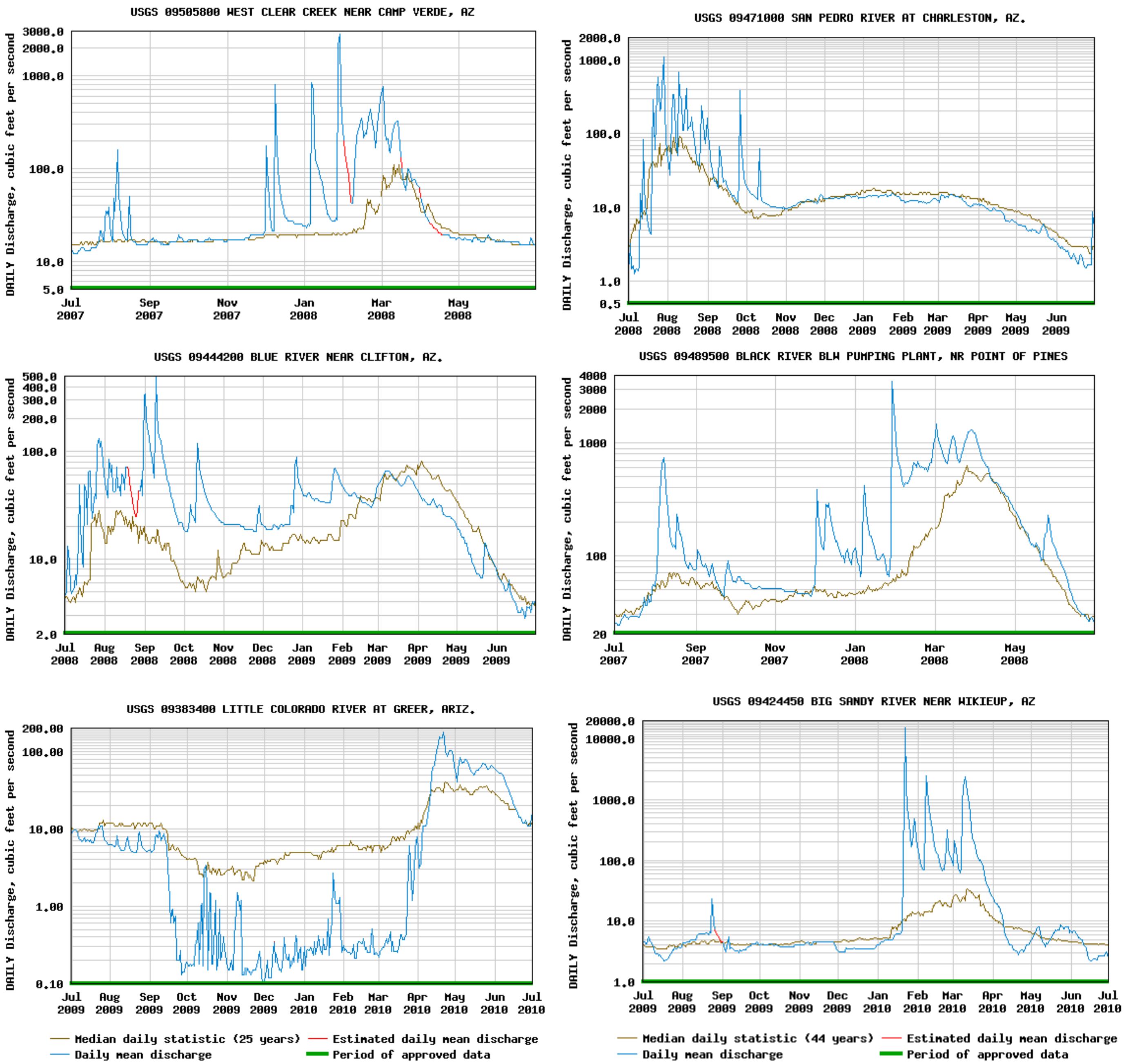


Figure 9. Inter-annual variations in surface water mean daily flows between stream gages and basins during the Arizona statewide probability survey sampling period, 2007-2010.

REGIONAL VARIATIONS IN WATER QUALITY PARAMETERS

Water quality parameters can vary significantly by location due to a number of factors such as human disturbance, geology, ecology and climate. Figures 10 to 17 indicate how parameters, such as discharge, vary from one site to another. These figures summarize the range and aerial distribution of a particular parameter. They are not intended to provide pinpoint measurements for each site. The EPA random numbers on the map correlate to ADEQ specific site ID numbers (see Table 2). Use Appendix A for specific results.

In Figures 10-17, each site is represented for the spring sample only. Ranges for each parameter (i.e., the size of each circle and the corresponding range) were chosen based on criteria such as water quality standards and the distribution of the results. Each parameter is discussed briefly below.

Discharge. The Little Colorado River (EPA 300/ADEQ LCLCR323.60) and The Virgin River (EPA 286/ADEQ CGVGR052.23) had the highest spring discharges statewide with values of 59 and 50 cfs respectively. The majority of the sampled streams were less than 4 cfs during the spring (Figure 10).

Specific Conductivity (SpCond). The highest conductivity was found in the two Virgin River sites (EPA 306/ADEQ CGVGR044.58 and EPS 286/ADEQ CGVGR052.23) located in the northern part of the state with values of 2981 and 2419 uS/cm. Multiple sites within the Little Colorado River watershed in eastern Arizona had the lowest conductivity results (Figure 11).

Dissolved Oxygen (DO). Aravaipa Creek (EPA 156/ADEQ SPARA026.35) had the lowest average DO for all of the sites (5.59 mg/L). The Agua Fria River (EPA 146/ADEQ MGAFR110.01) had the highest average DO concentration of 13.87 mg/L. The DO mg/L standard for the Aquatic and Wildlife Warm designated use is six mg/L, while the Aquatic and Wildlife Cold is seven mg/L. There were six DO exceedances during the spring (See Appendix A). The most common DO concentration through out the state was in the eight mg/l range (Figure 12).

E. Coli. The highest average E. coli count was the Bill Williams River (EPA 270/ADEQ BWBWR025.86) with a value of 212 colony forming units (cfu). The full body contact E. coli standard is 235 cfu and the partial body contact standard is 576 cfu. No full body or partial body contact E. coli exceedances were present in any of the spring samples. Twelve sites had non-detect E. coil samples (Figure 13).

Suspended Sediment Concentration (SSC). In 2002, ADEQ replaced the water quality standard for turbidity with suspended sediment concentration (SSC). The SSC standard for the Aquatic and Wildlife Warm designated use is 80 mg/L, while the Aquatic and Wildlife Cold is 25 mg/L. Silver Creek (EPA 276/ADEQ LCSIL027.05), a cold water stream, had the highest SSC value at 198 mg/L and exceeded the standard. In addition to Silver Creek, there were four other cold water streams that exceeded the SSC standard: The Little Colorado River (EPA 300/ADEQ LCLCR323.60) with a value of 61.4 mg/L, the Blue River (EPA 139/ADEQ UGBLR036.37) with a value of 58.8 mg/L, West Fork of the Little Colorado River (EPA 271/ADEQ LCWLR007.37) with a value of 35 mg/L, and Turkey Creek (EPA 179/ADEQ UGTRY001.56) with a value of 27 mg/L. No warm water SSC exceedances were present in any of the spring samples (Figure 14).

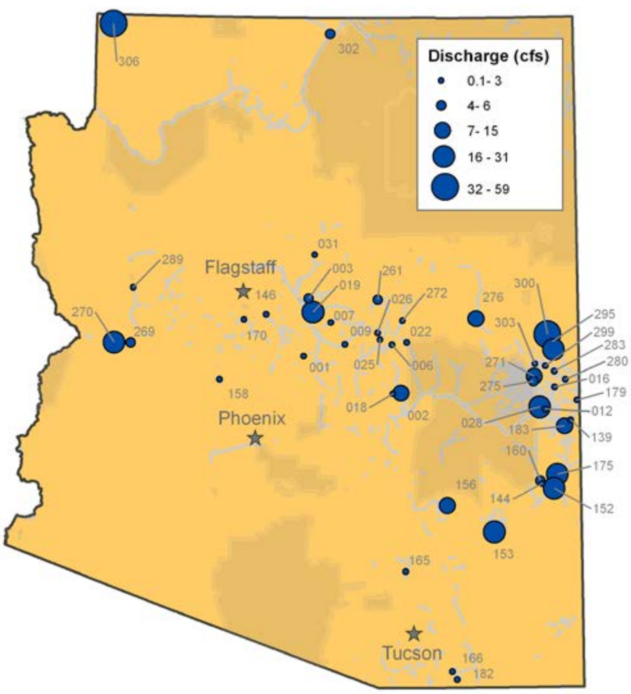
Proper Functioning Condition (PFC) Score

Proper Functioning Condition (PFC) is a qualitative method for assessing the condition of riparian-wetland areas (Prichard et al, 1993). The term PFC is used to describe both the assessment process, and a defined, on-the-ground condition of a riparian-wetland area. PFC is represented as a percent of the ideal score. A higher percentage indicates a higher quality riparian area. A threshold of 82% of ideal was developed from the 75th percentile of reference sites, a criterion for meeting basic riparian health as used in the probabilistic section of this report. There were 10 cold and seven warm water samples failing the 82% criteria. The overall mean of all 49 samples was 84% of ideal PFC score, with a mean of 85% for cold water streams and a mean of 83% for warm water streams. The range of values was 44-100% for all samples. Overall a large proportion of Arizona streams have good riparian health (65%), though a significant percentage (35%) are in less than ideal condition (Figure 15).

Percent Fines. The percentage of sand, silt and clay, sized <2 mm, found in a 100 count pebble count in the streambed constitutes the percent fines parameter. ADEQ methods and the bottom deposit standard require a measurement of 100 particles in riffle habitats in cold water streams. A result above 30 percent fines is considered to be detrimental to aquatic life in cold water streams. Pebble counts for warm water streams are conducted throughout the entire reach and a result above 50 percent fines is considered to be detrimental to aquatic life. There was one exceedance of the riffle threshold (1sample/24 total samples or 4%) in cold water streams, with a mean value of 9.4% fines and a range of 0-100% fines. There were 4 exceedances of the warm water bottom deposit standard threshold (4samples/22total samples or 18%) in warm water streams, with a mean of 25.2% and a range of 0-98%.(Figure 16). None of the samples violated the bottom deposit criteria, which requires for two samples to list a reach as impaired (Figure 16).

IBI Score. Seven metrics were used to calculate a macroinvertebrate Index of Biological Integrity (IBI) for cold water streams: total taxa, Diptera taxa, intolerant taxa, Hilsenhoff Biotic Index, percent Plecoptera, percent scrapers, and scraper taxa. Nine metrics are used for warm water streams: total taxa, Hilsenhoff Biotic Index, Ephemeroptera taxa, Trichoptera taxa, Chironomidae taxa, percent Ephemeroptera, percent individuals in the dominant taxon, number of scraper taxa, and percent scrappers. Table 5 describes the thresholds for IBI scores in warm and cold water streams.

Sites with inconclusive IBI scores require a verification sample to re-assess the condition of the site. If the verification sample results are in the 'poor' or 'inconclusive' ranges, the site is considered to be exceeding the aquatic and wildlife standard. During the spring index period, 42 percent of the 49 sites were violating the biocriteria standards (Figure 17). Biocriteria monitoring and results are discussed in more detail in the Biological and Habitat Assessment section in Chapter 3.



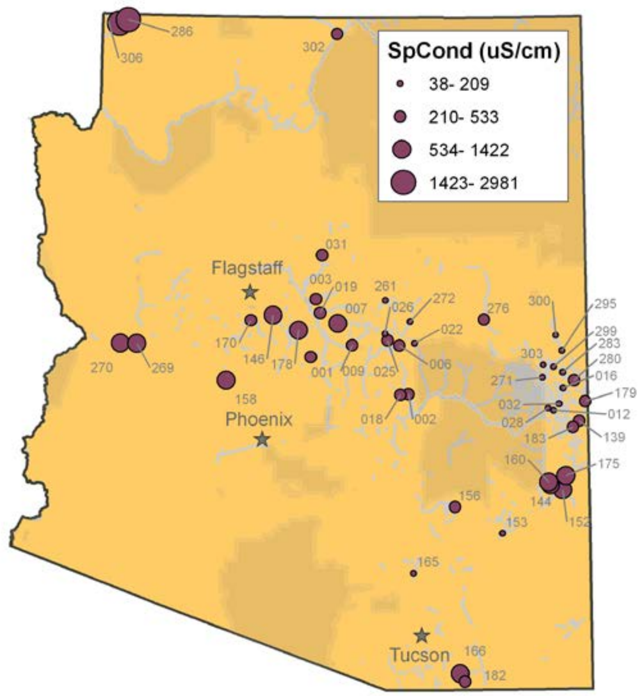


Figure 10. Discharge Results

Figure 11. Specific Conductivity Results

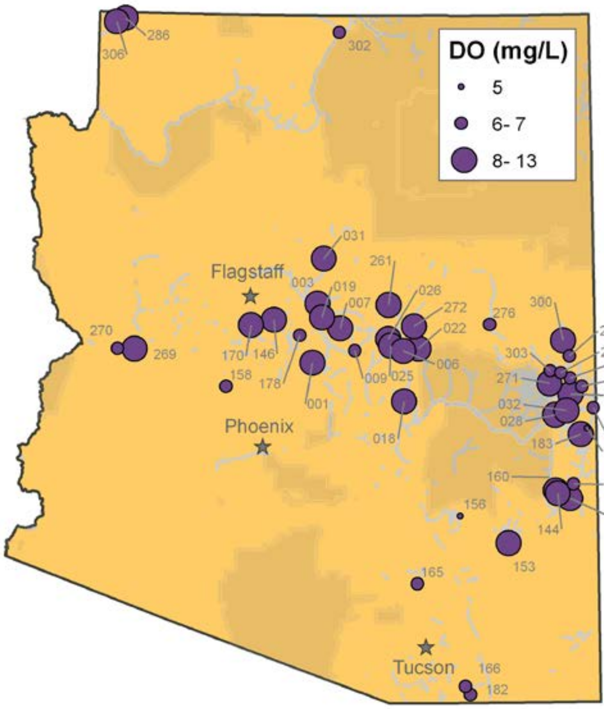


Figure 12. Dissolved Oxygen Level

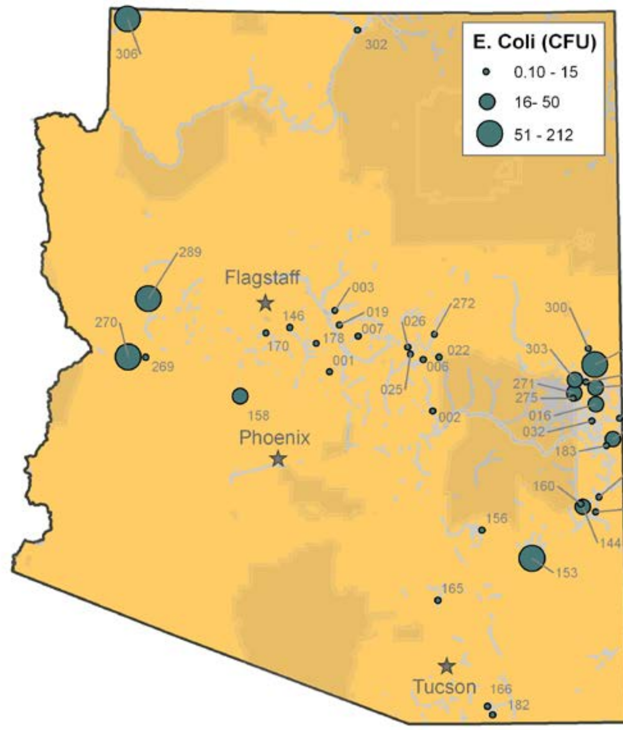


Figure 13. E. coli Concentrations

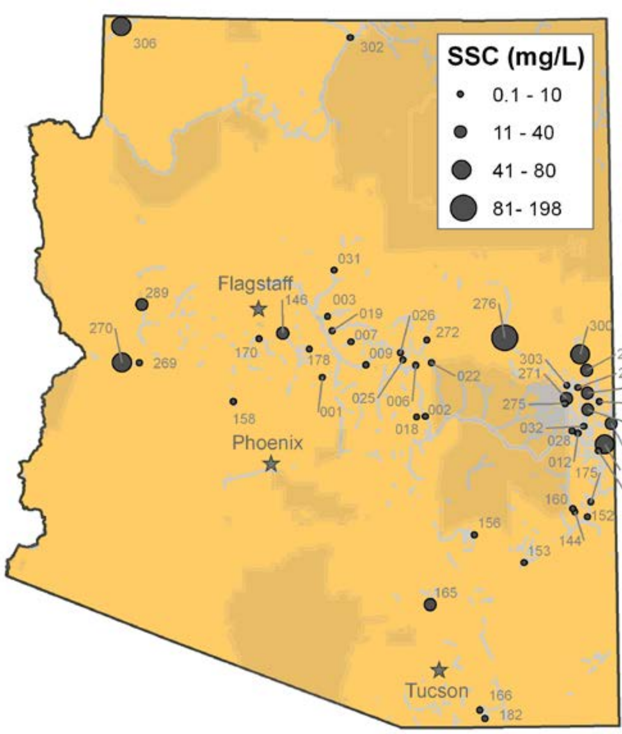


Figure 14. SSC Results

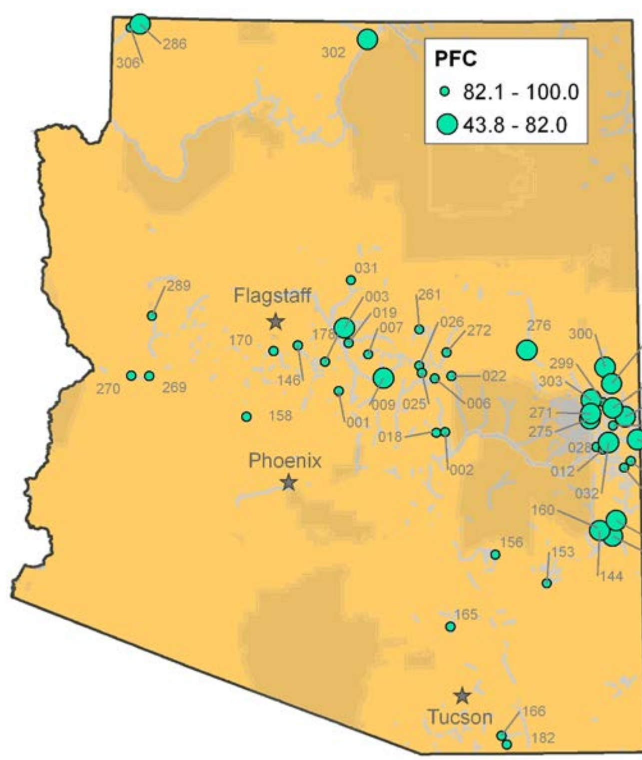


Figure 15. PFC Score

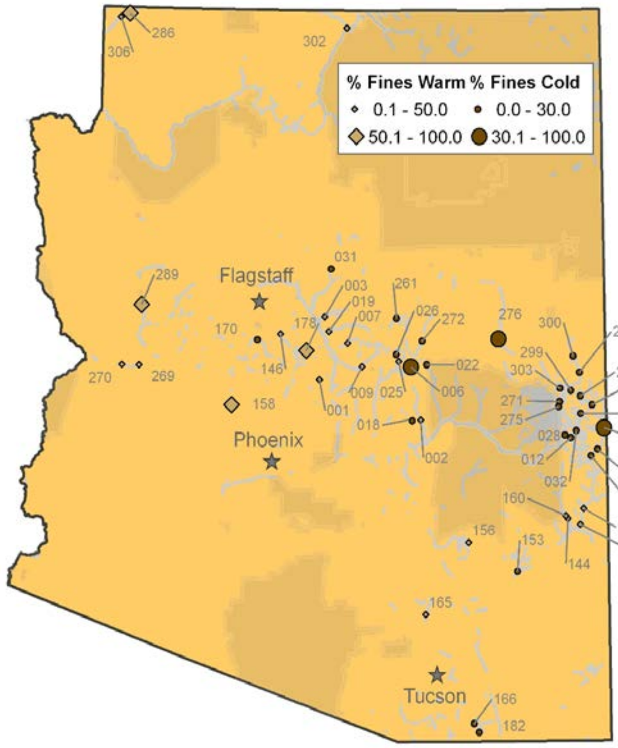


Figure 16. Percent Fines (Warm and Cold Water)

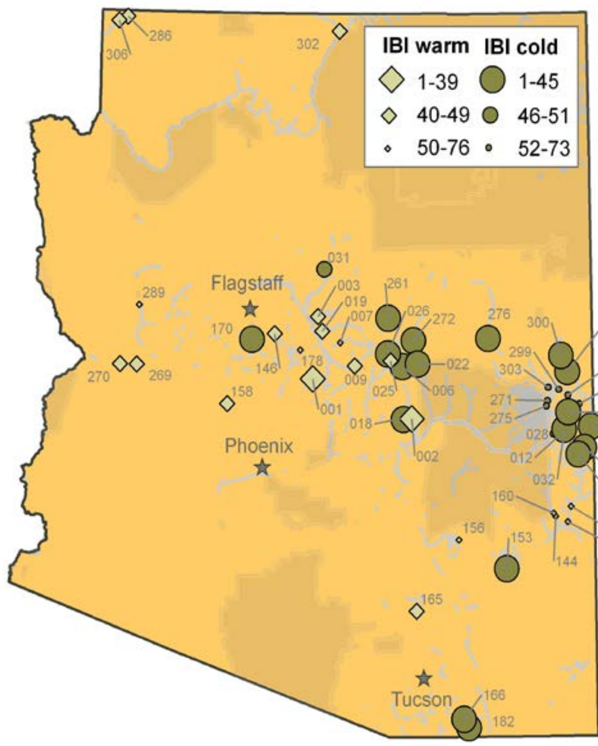


Figure 17. IBI Scores (Warm and Cold Water)

Water Quality Exceedances

Ten of the 49 sites had at least one exceedance during the spring sampling period in MY 2008-2010 (Table 3). The most common parameter not meeting water quality standards was the macroinvertebrate IBI score (see Macroinvertebrate Exceedances and Appendix D). Some of these violations are likely due to large magnitude floods that occurred in January 2008 (see Chapter 3 – Hydrologic Conditions). Dissolved oxygen was exceeded at six of the sample sites and was the second most common exceedance. For a complete list of chemistry exceedances that occurred during the entire 2008 – 2010 sampling period see Appendix B.

Table 3. Chemical Exceedances for sites sampled during the Spring Index Period (Monitoring Years 2008-2010)

Site ID	Designated Use[1]	Date	Analyte	Standard	Result
LCLCR323.60	A&Wc, FBC, FC, AgI, AgL	6/3/2010	SSC	> 25 mg/L	61.4 mg/L
LCLCR336.72	A&Wc, FBC, FC, AgI, AgL	6/30/2010	DO	> 7.0 mg/L	6.99 mg/L
LCRUD008.43	A&Wc, FBC, FC, AgL	7/1/2010	DO Cu(D)	> 7.0 mg/L .006 mg/L	6.73 mg/L 0.016 mg/L
LCSLR003.72	A&Wc, FBC, FC, AgL	6/30/2010	DO	> 7.0 mg/L	6.52 mg/L
SPARA026.35	A&Ww, FBC, FC, AgL	5/14/2009	DO	> 6.0 mg/L	5.59 mg/L
UGBLR036.37	A&Wc, FBC, FC, AgI, AgL	8/6/2009	DO SSC	> 7.0 mg/L >25 mg/L	5.71 mg/L 58.8 mg/L
CGVGR044.58	A&Ww, FBC, FC, AgI, AgL	6/16/2010	Se	> .002	.0029 mg/L
LCSIL027.05	A&Wc, FBC, FC, AgI, AgL	5/4/2010	DO SSC Ecoli	> 7.0 mg/L, > 80 mg/L 235 CFU	5.77 mg/L 87 mg/L 320 CFU
UGTRY001.56	A&Wc, FBC, FC, AgL	6/17/2009	SSC	> 25 mg/l	27 mg/L
MGHSR110.58	A&Wc, FBC, FC, AgI, AgL	4/7/2009	Cd(D) Cu(D) Zn (D)	0.001 mg/L 0.006 mg/L 0.085 mg/L	0.0058 mg/L 0.036 mg/L 0.29 mg/L
LCNUT025.35	A&Wc, FBC, FC, AGI, AGL	7/1/2010	Cu(D)	0.006 mg/L	0.011 mg/L
SPGDN007.55	A&Wc, FBC, FC	4/30/2009	DO	>7.0 mg/L	6.98 mg/L

MACROINVERTEBRATE EXCEEDANCES

In 2009, Arizona developed water quality standards for macroinvertebrates in warm and cold water streams throughout the state (Table 4). Guidelines for analysis of biological data and use of the biocriteria standard are presented in the draft "Narrative Biocriteria Standard Implementation Procedures for Wadeable, Perennial Streams" (Jones, 2012). The ADEQ narrative biocriterion reads as follows: "A wadeable, perennial stream shall support and maintain a community of organisms having a taxa richness, species composition, tolerance and functional organization comparable to that of a stream with reference conditions in Arizona." (A.A.C. R18-11-108.01). The numeric biocriteria thresholds for warm and cold water streams are shown in Table 4.

Table 4. Macroinvertebrate IBI Thresholds for Wadeable, Perennial Streams of Arizona

Macroinvertebrate bioassessment result	Index of Biological Integrity Score		Assessment category
	Cold water	Warm water	
Greater than the 25th percentile of reference condition	≥ 52	≥ 50	Meeting biocriterion
Between 10th and 25th percentile of reference	46 – 51	40 – 49	Inconclusive
Less than the 10th percentile of reference condition	≤ 45	≤ 39	Violating biocriterion

Overall, 42% of macroinvertebrate samples were violating, 27% inconclusive, and 31% meeting biocriteria (Table 5, Figure 18). IBI scores ranged from 19 - 72 in cold water streams and 32 - 73 in warm water streams, with an overall mean IBI of 47 for all 48 samples. When comparing cold versus warm water streams, there were a higher percentage of biocriteria violations in cold water samples (66%) than warm water samples (10%), during the study period of 2008-2010 (Figure 18).

Large floods, of a 10-50 year magnitude event, occurred in the Salt and Verde watersheds in early 2008. Extreme floods scoured streambeds and banks, degrading in-stream habitat conditions and reducing the abundance and diversity of the benthic macroinvertebrate population. As a result of the flood/scour effects on the macroinvertebrate community which are considered "natural background" conditions, these samples are exempted from being listed as "impaired". All of the bioassessment results and IBI scores are presented in Appendix D.

The difference in number of violating samples in cold water versus warm water streams was notably large (Table 5, Figure 18). Stressors potentially affecting the macroinvertebrate community and associated IBI scores included flooding/flow regime, crayfish/biological stressors, and sediment/habitat effects. Cold water streams had six times the number of violating samples (Figure 18). This is most likely due to the 2008 floods.

Table 5. Macroinvertebrate IBI data summary for samples collected 2008-2010 across Arizona

Bioassessment category	Cold water samples (%of cw samples)	Warm water samples (%of ww samples)	All samples (%)
Meeting biocriteria standard	8 (30%)	7 (33%)	15 (31%)
Inconclusive	1 (4%)	12 (57%)	13 (27%)
Violating biocriteria standard	18 (66%)	2 (10%)	20 (42%)
Total	27	21	48

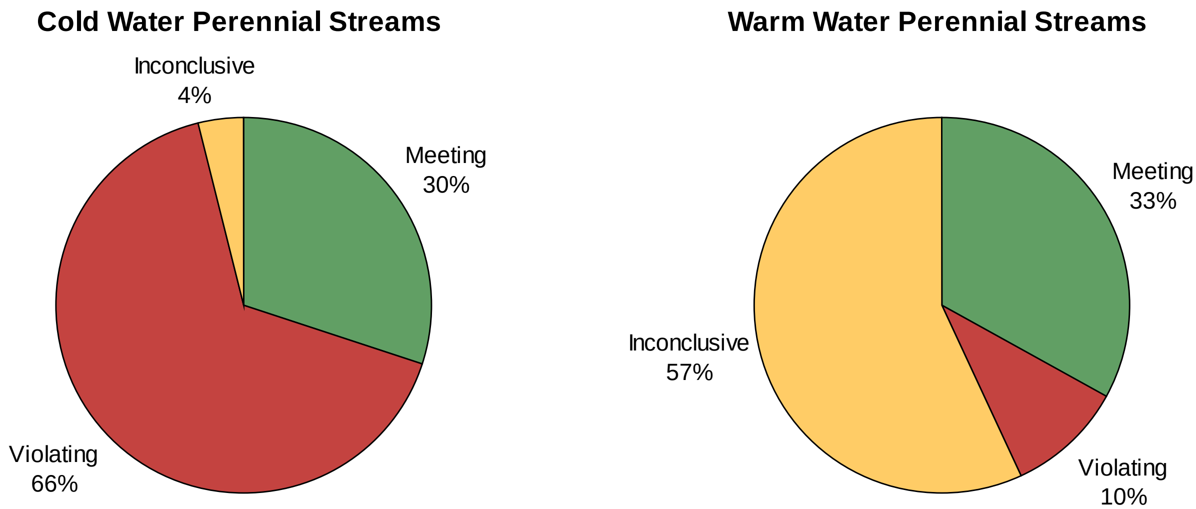


Figure 18. Bioassessment results for 48 samples from cold and warm water perennial, wadeable stream sites statewide in Arizona, July 2007-June 2010.

CHAPTER 4 – PROBABILISTIC ANALYSIS

Probabilistic assessments provide a different way of looking at the condition of the state than a targeted 305(b) assessment. Probabilistic methods rank each parameter as 'most disturbed', 'least disturbed' or 'intermediate' based on reference conditions. Reference sites are not necessarily pristine streams, rather they are the 'least disturbed' sites in the state. Appendix F describes the reference site selection process for chemical and habitat stressors and identifies the condition class thresholds for each of those thresholds.

One advantage of a probabilistic analysis over a traditional 305(b) assessment is the ability to identify stressors based on reference conditions. A 305(b) assessment is limited by standards that are currently in effect and do not typically account for all multitude of stressors that could impact a particular use. This study will analyze the impact of various stressors to water quality and the importance of each of those stressors to macroinvertebrates.

MACROINVERTEBRATE RESULTS

The assessment of aquatic life was based on 49 samples representing the 2,128 miles of assessed perennial stream length. The assessed stream length will simply be referred to as the 'stream length' in the following sections.

There were 899 miles of stream length or 42% in most disturbed condition, 29% in least disturbed condition, and 27% in intermediate condition according to IBI thresholds for warm and cold water streams. There were also 2% of stream miles in the no-data category because one sample was lost.

The percentage of streams in most disturbed condition during this survey (42%) was similar to the 41% found in the last statewide probabilistic survey conducted in 2000-2004 (Robinson, et al., 2006). Approximately 29% of stream length in this survey was in good condition (least disturbed) compared to 45% in the 2006 study, suggesting a decline in aquatic life conditions. There was a larger amount of stream length in intermediate condition in this survey (27%), compared with 14% in the 2006 survey.

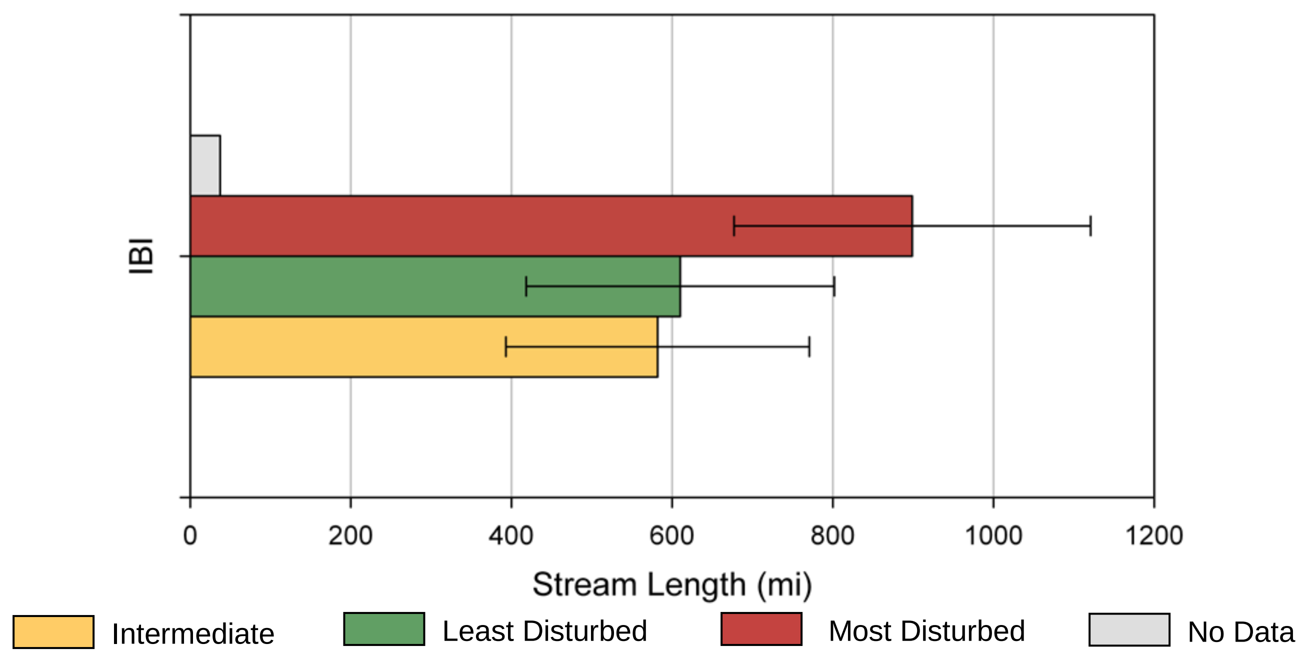


Figure 20. ADEQ Statewide Macroinvertebrate IBI Scores, 2008-10.

STRESSOR CONDITION

Chemical Stressors

The following chemical parameters were assessed because they are indicative of water quality overall and are important for macroinvertebrates. A summary of the results are depicted in Figure 21. Thresholds for each parameter are listed in Appendix F, Table 3.

Turbidity
Turbidity in the water column, especially over prolonged periods of time, can be harmful to aquatic life. Turbid water contains excess suspended particles, which decreases the amount of light in a stream. Excess turbidity can limit plant growth, abrade gills and make feeding difficult for fish and invertebrates. In this assessment, 1,606 miles or roughly 76 % of the assessed statewide stream length was in the least disturbed condition and 338 miles or 16% of stream length was in the most disturbed condition for turbidity.

Suspended Sediment Concentration (SSC)
Suspended sediment, like turbidity, is harmful to aquatic life. In this assessment, 1,739 miles or 82% was in the least disturbed condition and 316 miles or 15% was in the most disturbed condition.

pH
Extreme values of pH are harmful to aquatic life. Acidic conditions below a pH of 6.5 and caustic conditions above a pH of 9.0 are beyond the normal range and highly destructive for aquatic life. In this assessment, the entire assessed stream length (2,128 mi) was in the least disturbed condition for pH.

Dissolved Oxygen
Dissolved oxygen in the water column is necessary for respiration of all aquatic animal life, including invertebrates and fish. In this assessment, 1,947 miles or 92 % of stream length was in the least disturbed condition while 107 miles or 5% was in the most disturbed condition.

Specific conductance
Specific conductance measures the ionic content of water and thereby its ability to conduct an electrical current. This field measurement is akin to salinity. High conductivity is harmful to aquatic life. In this assessment, 984 miles or 46% was in the least disturbed condition while 513 miles or 24% was in the most disturbed condition.

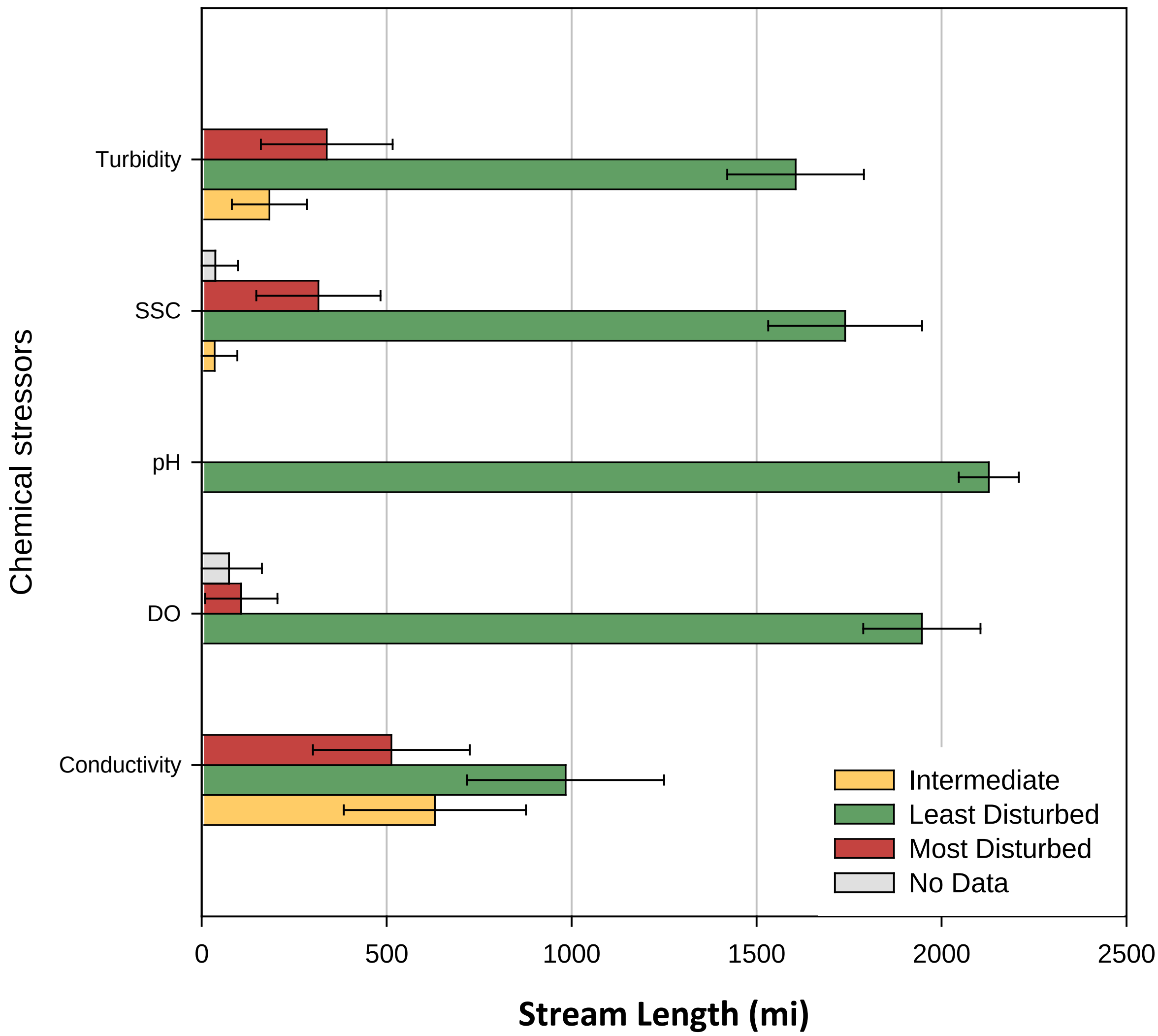


Figure 21. Summary of chemical indicator results for statewide assessed stream length (mi).

Physical Habitat Stressors

ADEQ collects more than 100 data points per sample related to habitat. The following parameters have been chosen because their excess abundance or absence are known to be habitat stressors and can be detrimental to aquatic life including macroinvertebrates. A summary of the results are depicted in Figure 22. Thresholds for each parameter are listed in Appendix F, Table 3.

Percent Riffle

In streams where sediment is accumulating, fine particles fill in the interval spaces between cobbles in riffles. Pools will fill with sediment and become shallow. Aggrading streams tend to have less riffle habitat and are dominated by runs, which reduces the diversity of habitat for macroinvertebrates. For percent riffle, 1,312 stream miles or 62% were in minimally disturbed condition indicating that riffle habitat is present and available for macroinvertebrate habitat in the majority of our streams in Arizona. The 256 stream miles or 12% that were categorized as most disturbed were mainly in warm water sites with finer substrates.

Proper Functioning Condition

The Proper Functioning Condition considers hydrology, vegetation, and erosion attributes of a stream. Approximately 1,441 stream miles (68%) were categorized to be in the least disturbed condition using the proper functioning condition procedures, indicating that the majority of the streams are resilient. There were 375 stream miles (18%) in the most disturbed category and 311 stream miles (15%) in the intermediate condition category.

Macrophytes
This field measurement of the quantity of macrophyte or vascular plants covering the stream bottom is an indicator of nutrient enrichment. A majority of the sampled stream miles (1,625 miles or 76%) were categorized to be in the least disturbed condition with regard to macrophytes (aquatic plant cover). 503 stream miles or 24% were categorized as most disturbed.

Habitat
The ADEQ habitat index includes five semi-quantitative measures of habitat diversity, sediment and substrate conditions that relate to macroinvertebrate habitat. In this assessment 1,180 stream miles (56%) were categorized as least disturbed in the state. This is indicative of good habitat for macroinvertebrates and fish including diversity of habitat (riffle, undercut banks, algal mats, etc.). 643 stream miles (30%) were in the most disturbed category.

Percent Fines
This field measurement is obtained by conducting a 100-count pebble count from the stream bottom within a study reach, and calculating the percentage of fine sediments (<2mm in size) that occur in the stream bottom. Approximately 886 stream miles (42%) were categorized as least disturbed, demonstrating the potential of good habitat for macroinvertebrates and fish in Arizona streams. Only 408 streams miles (19%) were determined to be in the most disturbed category. 419 stream miles were in the Intermediate category. Data was not collected on 20% of the sites (415 stream miles) due to different protocols required for warm and cold water streams.

Canopy
Canopy density is a quantitative measure of the degree to which riparian vegetation overhangs and shades the stream bottom. Shading makes a big difference in stream temperature, algae growth and organic processing time. In this assessment 781 stream miles (37%) were in least disturbed category and 745 stream miles were in most disturbed category (35%) Canopy cover is important for stream health because it has effects on soil and water temperature, and provides a food and habitat source for fish and macroinvertebrates.

Algae
This estimate of algae growth cover on the stream bottom within the study reach and may indicate nutrient enrichment. The majority of sampled stream miles (1,324 miles or 62%) were categorized to be in the least disturbed condition in regards to algae. There were 567 stream miles (27%) determined to be in the most disturbed category.

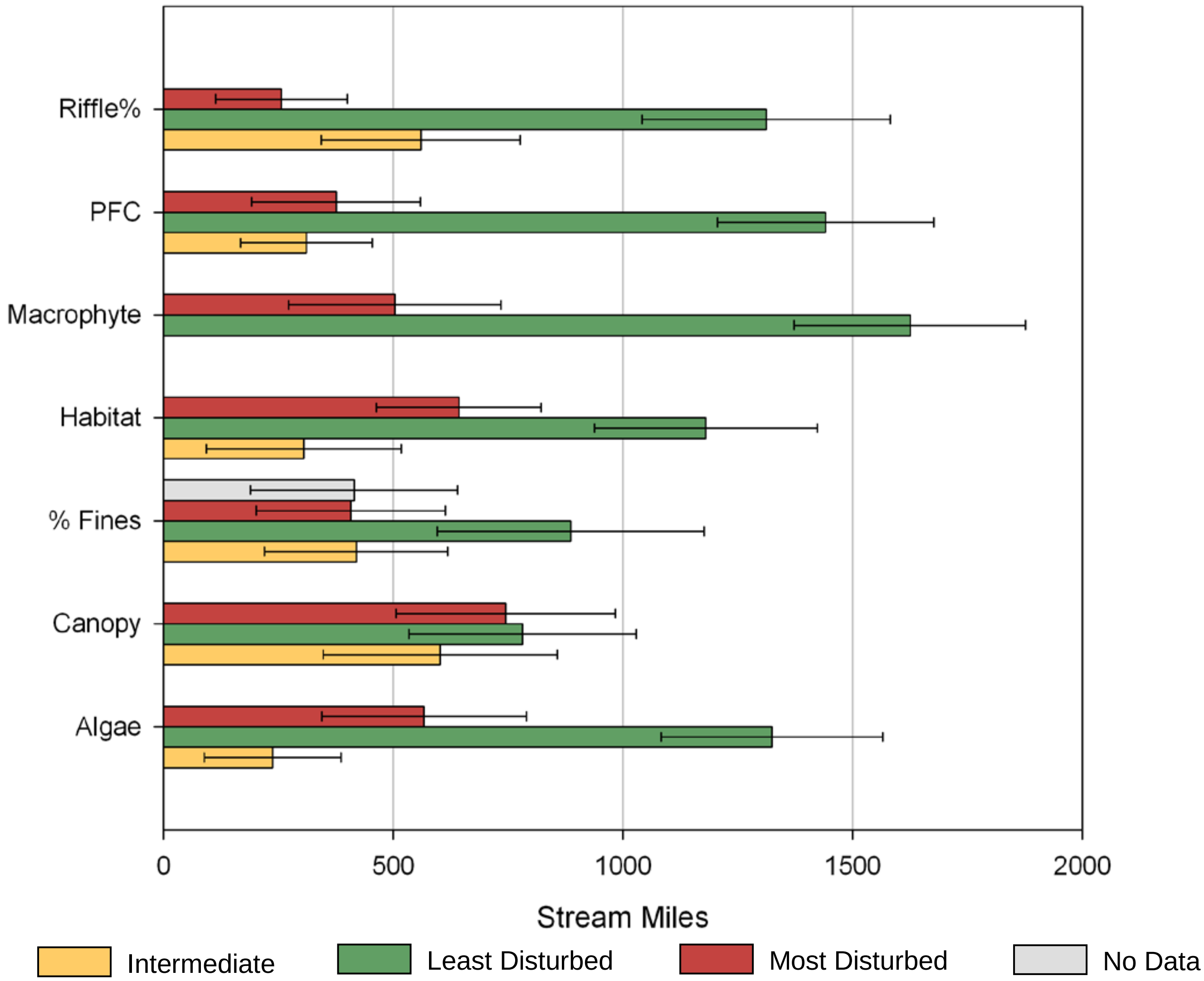


Figure 22. Physical Habitat Stressors.

RANKING OF STRESSORS

The identification of the importance and magnitude of stressors is one of the attributes that make probabilistic monitoring so powerful. The 305(b) assessment ranks stressors, but is limited to stressors that have a corresponding water quality standard. Probability surveys are able to identify stressors such as turbidity and then determine whether it will impact the biota, which only consists of macroinvertebrates in this study. The probabilistic assessment method first ranks the extent of the stressors in terms of stream miles in most disturbed condition and then examines the severity of each stressor on the biota using a relative risk calculation. The stressor extent and risk are used together to identify stressors with most impact to aquatic biota.

Relative Extent

Figure 23 illustrates the number of stream miles of each physical and chemical stressor that is in most disturbed condition. The most extensive stressors by far were the percent canopy cover over the streambed (35%), and habitat index (30%). Percent canopy cover is correlated with stream temperature, bank stability and excess sediment in the stream bottom and is indicative of multiple habitat stress factors related to nonpoint source pollution. The habitat index assesses suitable habitat for macroinvertebrates by scoring factors such as riffle and run habitat and substrate quality.

Intermediate stressors appeared to be nutrient and sediment related including algae cover on the streambed (27%), conductivity (24%), macrophyte cover (24%), percent fine sediment in the streambed (19%), and riparian condition (18%).

These stressors are reflective of nutrient enrichment, runoff and sedimentation from the watershed and degradation of riparian corridors.

Chemical stressors such as turbidity and SSC at baseflow, as well as percent riffle habitat and dissolved oxygen were of least importance in terms of relative extent across the state of Arizona (Figure 23). Since sampling is conducted typically during baseflow conditions, there are unlikely to be high turbidity or SSC values in the dataset. In addition, dissolved oxygen is typically high in flowing streams and standard exceedances are rare in Arizona streams. Lastly, although the loss of riffle habitat scored low in terms of relative extent, we understand that the condition of the substrate in the riffle habitat is more important than quantity of riffle.

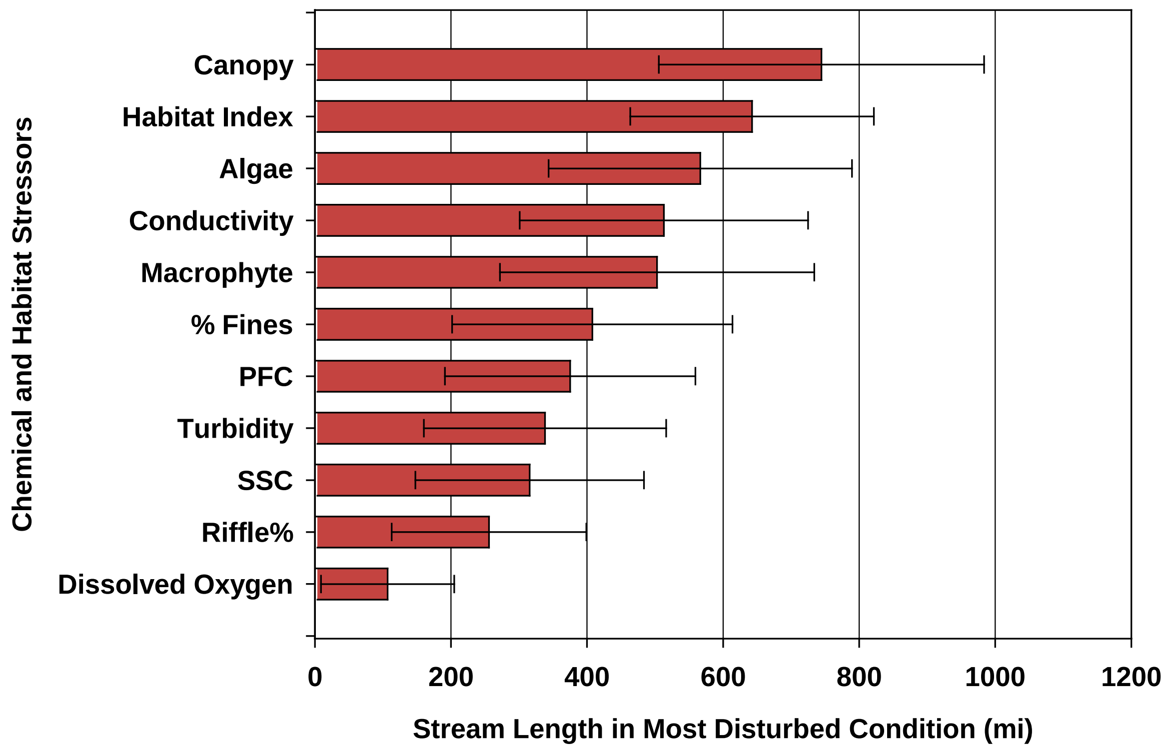


Figure 23. Summary of chemical and habitat stressor extents in most disturbed condition, in the Arizona statewide probabilistic assessment, July 2007-June 10

In comparison to the 2007 Little Colorado River (LCR) survey, the stressor ranking was very similar with the exception of exotic fish and crayfish in the 2007 survey (Condon, et al., 2010). This survey found the percent canopy cover and habitat condition as stressors with the greatest extent statewide, whereas the 2007 LCR survey found these factors 3rd and 4th most important after exotic fish and crayfish which are not included in this reports data set. With those two exceptions, the stressors with the greatest extent were similar between studies. Biological stressors such as crayfish, non-native vertebrates, or the Asian clam are important stressors. These data were not collected in this study due to the lack of methods that would allow for the accurate assessment of crayfish abundance.

In comparison to the previous statewide ecological assessment report (Robinson, et al., 2006), the ranking of stressors is somewhat different. This survey found riparian cover and habitat as most important stressors, while the 2006 study found riparian disturbance and percent cover were the 4th and 5th most important stressors, in terms of stream miles in most disturbed condition. However in the 2006 study exotic fish and nutrients were the top two stressors and none of these parameters were used in our stressor survey. Our survey indicated that habitat index score was second most important stressor, whereas the 2006 Western EMAP survey ranked it as sixth. Conductivity in this survey was a stressor for 24% of stream kilometers whereas it comprised approximately 17% in the 2006 survey.

Relative Risk

The relative risk is a statistic that measures the increase in the likelihood of finding a biological indicator (such as macroinvertebrates) in the most-disturbed condition while having a stressor in the most-disturbed condition at the same site (Stoddard, et al., 2005). A relative risk value of one or less indicates that there is no association between the stressor and the biological indicator and values greater than one indicate significant risk. The purpose of the relative risk statistic is to determine the severity of each stressor associated with each biological indicator.

Relative risk values are presented for the macroinvertebrate community and associated chemical and physical stressor data for perennial streams across Arizona in Figure 24. The stressors presenting the greatest relative risk for macroinvertebrates included fine sediment in the stream bottom, turbidity, SSC, habitat index score, respectively. Moderate risk stressors included conductivity, algae percent cover, percent riffle habitat, and dissolved oxygen content. Factors that did not rank as important stressors to the macroinvertebrates were macrophyte cover, Proper Functioning Condition of riparian areas, pH and canopy cover.

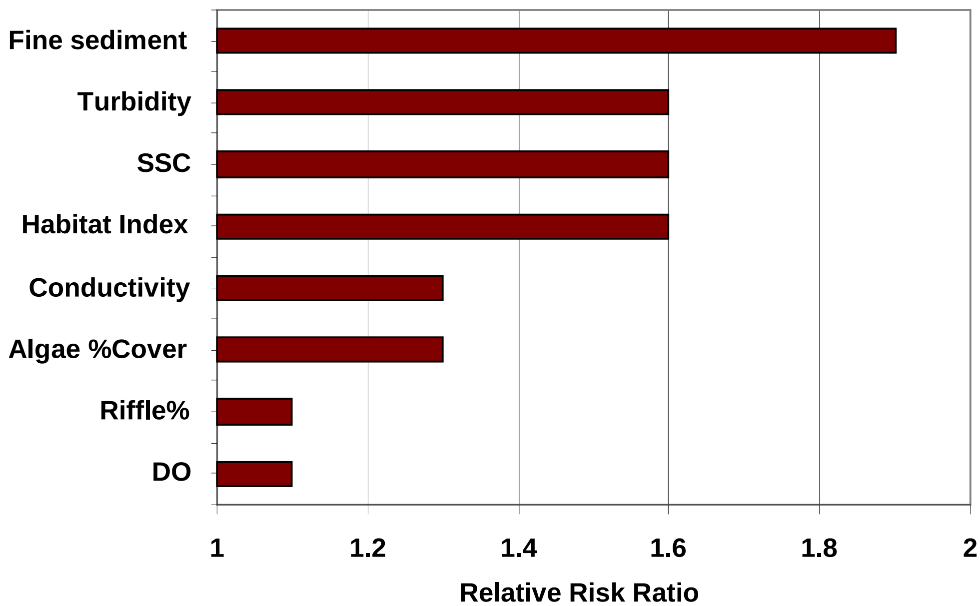


Figure 24. Relative Risk of Stressors.

APPENDIX A – CHEMISTRY RESULTS FOR SPRING INDEX PERIOD (2008 – 2010)

In addition to the parameters below, both Antimony and Beryllium (total and dissolved) were sampled but not included in the table because these parameters were non-detect (ND). Parameters not analyzed are denoted NA. Parameters that exceeded state standards are in bold type. Units are reported in milligrams per liter.

Site ID	Date	Alk, Pheno	NH3	As (D)	As (T)	B (T)	Cd (D)	Cd (T)	Hardness	Alkalinity	Ca (D)	Ca (T)	CO3	Cl- (T)
BWBSR037.79	4/21/2010	ND	ND	8.2	8.2	0.25	ND	ND	NA	280	NA	63	ND	55
BWBWR025.86	6/10/2010	ND	ND	7.6	7.9	0.23	ND	ND	NA	230	NA	39	ND	71
BWBWR038.52	6/10/2010	ND	0.1	7.7	8	ND	ND	ND	NA	180	NA	29	ND	52
CGPAR000.49	6/8/2010	ND	0.0375	2.2	2.25	ND	ND	ND	NA	110	NA	33	ND	9.4
CGVGR044.58	6/16/2010	ND	ND	12	11	0.89	ND	ND	NA	280	NA	260	ND	380
CGVGR052.23	4/27/2010	ND	ND	6.2	8.7	0.27	ND	ND	NA	170	NA	150	ND	99
LCCHC073.26	5/25/2010	ND	ND	3	3.1	ND	ND	ND	NA	91	NA	21	ND	ND
LCECL009.39	5/24/2010	ND	ND	1.9	1.4	ND	ND	ND	NA	110	NA	23	ND	ND
LCELR008.70	6/24/2010	ND	ND	ND	ND	ND	ND	ND	NA	17	NA	3.4	ND	ND
LCFIS003.86	6/29/2010	ND	0.05	ND	ND	ND	ND	ND	NA	50	NA	11	ND	14
LCLCR323.60	6/3/2010	ND	0.071	ND	1	ND	ND	ND	NA	83	NA	21	ND	3.5
LCLCR336.72	6/30/2010	ND	0.05	ND	ND	ND	ND	ND	NA	110	NA	23	ND	3.6
LCNUT025.35	7/1/2010	ND	0.12	ND	ND	ND	ND	ND	NA	130	NA	33	ND	14
LCRUD008.43	7/1/2010	ND	ND	ND	ND	ND	ND	ND	NA	100	NA	21	ND	2.7
LCSIL027.05	5/4/2010	ND	ND	1.4	1.8	ND	ND	ND	NA	140	NA	36	ND	7.5
LCSLR003.72	6/30/2010	ND	ND	ND	ND	ND	ND	ND	70	88	NA	16	ND	ND
LCWLR007.37	6/22/2010	ND	ND	ND	ND	ND	ND	ND	NA	12	NA	2.4	ND	ND
MGAFR110.01	4/6/2009	42	ND	5.6	ND	0.25	ND	ND	210	190	60	60	51	71
MGHSR048.20	6/4/2009	ND	ND	ND	ND	0.00014	ND	ND	240	240	64	65	ND	35
MGHSR110.58	4/7/2009	ND	ND	ND	ND	ND	0.0058	0.0066	130	57	37	38	ND	ND
MGLSY000.42	4/8/2009	ND	ND	ND	ND	ND	ND	ND	270	280	59	59	ND	11
SCSAB005.09	6/10/2009	ND	ND	ND	ND	ND	ND	ND	35	45.5	11	12	ND	6.1
SPARA026.35	5/14/2009	ND	ND	ND	ND	ND	ND	ND	130	160	47	44	ND	5.2
SPGDN007.55	4/30/2009	ND	ND	ND	ND	ND	ND	ND	345	320	99	96.5	ND	ND
SPGRA007.71	6/25/2009	ND	ND	NA	ND	ND	NA	ND	27	33	8.9	NA	ND	ND
SPMLC013.56	4/29/2009	ND	ND	ND	ND	ND	ND	ND	160	150	56	56	ND	ND
SRBEV001.40	6/18/2008	ND	ND	ND	ND	ND	ND	ND	51	52	12	NA	ND	ND
SRBLR102.24	7/10/2008	28	0.03	NA	ND	ND	ND	ND	41.5	61.5	11	NA	ND	ND
SRBON001.69	6/16/2008	4.4	ND	ND	ND	ND	ND	ND	51	74	13	NA	5.2	ND
SRCHE013.65	5/1/2008	7.4	ND	ND	ND	ND	ND	ND	220	210	51	NA	8.8	19

SRCYN045.73	5/13/2008	ND	ND	5.8	5.5	ND	ND	ND	110	100	34	NA	ND	ND

Site ID	Date	Alk, Pheno	NH3	As (D)	As (T)	B (T)	Cd (D)	Cd (T)	Hardness	Alkalinity	Ca (D)	Ca (T)	CO3	Cl- (T)
SRFIS004.49	6/24/2008	ND	0.09	ND	ND	ND	ND	ND	31	36	7.6	NA	ND	ND
SRTON053.87	5/15/2008	3.2	ND	ND	ND	ND	ND	ND	160	140	46	NA	3.8	5.5
SRTON059.43	5/14/2008	4.3	ND	ND	ND	ND	ND	ND	94	84	28	NA	5.2	ND
SRWRK007.97	6/16/2008	ND	0.05	ND	ND	ND	ND	ND	160	170	36	NA	ND	ND
UGBLR030.24	6/17/2009	7.55	ND	ND	ND	ND	ND	ND	160	180	44	44	9.05	ND
UGBLR036.37	8/6/2009	NS	ND	1.3	1.5	0.88	ND	ND	NA	230	NA	54	13	3.5
UGEAG011.09	4/28/2009	3.35	ND	ND	ND	ND	ND	ND	140	170	35	34.5	4.05	19
UGEAG015.23	4/29/2009	2.75	ND	ND	ND	ND	ND	ND	140	160	34	34	3.25	13
UGSFR006.08	4/29/2009	7.5	ND	ND	ND	ND	ND	ND	260	160	79	80	9	330
UGSFR019.04	5/12/2009	9.1	ND	ND	ND	ND	2.5	ND	140	160	43	42	11	65
UGTRY001.56	6/17/2009	10	ND	ND	ND	ND	ND	ND	160	220	46	46	12	ND
VREVR023.59	6/25/2008	3.2	0.0275	ND	ND	ND	ND	ND	200	200	38	NA	3.9	ND
VROAK048.36	7/8/2008	ND	0.07	ND	ND	ND	ND	ND	150	150	35	NA	ND	ND
VRROU002.93	4/30/2008	4.8	0.0125	10	10	ND	ND	ND	290	280	62	NA	5.7	10
VRWBV002.97	4/28/2008	4.3	ND	17	20	0.23	ND	ND	250	260	61	NA	5.1	17
VRWCL005.10	4/29/2008	3.7	ND	ND	ND	ND	ND	ND	190	200	44	NA	4.4	ND
VRFOS014.33	6/13/2008	ND	0.09	ND	5	ND	ND	ND	420	390	NA	100	390	7.1

Site ID	Date	Cr (T)	Cu (D)	Cu (T)	DO (mg/l)	DO %	E. coli	Flow (cfs)	F-	Calc Hardness	HCO3	TKN	Pb (D)	Pb (T)
BWBSR037.79	4/21/2010	ND	ND	ND	NA	NA	75	2	1.4	240	280	ND	ND	ND
BWBWR025.86	6/10/2010	0.01	ND	0.01	6.94	87.8	212	17	1.2	170	220	ND	ND	0.001
BWBWR038.52	6/10/2010	ND	ND	ND	11.55	113.4	2	5.2	0.84	130	180	ND	ND	ND
CGPAR000.49	6/8/2010	ND	ND	ND	6.27	93	1	4.9	ND	165	110	ND	ND	ND
CGVGR044.58	6/16/2010	ND	ND	ND	8.47	97.9	200	50	0.8	1000	280	ND	ND	ND
CGVGR052.23	4/27/2010	ND	ND	0.019	NA	NA	106	625	0.4	540	170	ND	ND	0.004
LCCHC073.26	5/25/2010	ND	ND	ND	8.25	105.2	1	3.6	ND	89	91	ND	ND	ND
LCECL009.39	5/24/2010	ND	ND	ND	8.4	107.4	NA	4.7	ND	110	110	ND	ND	ND
LCELR008.70	6/24/2010	ND	ND	ND	NA	NA	0	4	ND	6.5	17	ND	ND	ND
LCFIS003.86	6/29/2010	ND	ND	ND	7.54	101	20	0.44	ND	50	50	ND	ND	ND
LCLCR323.60	6/3/2010	ND	ND	ND	8.09	114.4	0	59	ND	85	83	ND	0.003	ND
LCLCR336.72	6/30/2010	ND	ND	ND	**6.99**	89.6	115	17	ND	93	110	1.2	ND	ND
LCNUT025.35	7/1/2010	ND	**0.011**	ND	7.23	87.7	NA	1	ND	120	130	ND	ND	ND
LCRUD008.43	7/1/2010	ND	**0.016**	ND	**6.73**	86.2	48	1.5	ND	88	100	2.1	ND	ND
LCSIL027.05	5/4/2010	ND	ND	ND	**5.77**	69.4	**320**	0	ND	150	140	ND	ND	0.002
LCSLR003.72	6/30/2010	ND	ND	ND	**6.52**	82.2	2	1	ND	ND	88	ND	ND	ND
LCWLR007.37	6/22/2010	ND	ND	ND	9.07	76.8	7	9.4	ND	6.5	12	ND	ND	ND
MGAFR110.01	4/6/2009	ND	0.0041	ND	13.87	172	2	3.7	0.43	220	120	0.88	2E-04	ND
MGHSR048.20	6/4/2009	ND	0.00074	ND	6.29	73.1	46	2.5	0.77	240	300	0.16	ND	ND
MGHSR110.58	4/7/2009	ND	**0.036**	0.1	9.67	113.6	4	1.7	0.18	140	69	ND	4E-04	ND
MGLSY000.42	4/8/2009	ND	0.00039	ND	7.62	83.5	4	NA	0.22	270	340	ND	ND	ND
SCSAB005.09	6/10/2009	ND	0.0015	ND	6.17	85	1	1	0.15	41	55.5	0.255	ND	ND
SPARA026.35	5/14/2009	ND	ND	ND	**5.59**	71.5	6	9.5	0.5	140	190	ND	ND	ND
SPGDN007.55	4/30/2009	ND	ND	ND	**6.98**	81.3	12	0.27	0.12	360	390	ND	ND	ND
SPGRA007.71	6/25/2009	ND	NA	ND	8.35	92	125	17.05	ND	32	40	0.17	ND	ND
SPMLC013.56	4/29/2009	ND	ND	ND	7.41	85.6	2	0.25	ND	170	190	0.12	ND	ND
SRBEV001.40	6/18/2008	ND	ND	ND	8.63	94.8	11	NA	0.11	55	63	0.01	ND	ND
SRBLR102.24	7/10/2008	ND	0.00043	ND	8.93	113.2	NA	26	0.11	46	34.5	0.2	ND	ND
SRBON001.69	6/16/2008	ND	0.0019	ND	10.16	118.3	26	1.1	0.13	55	79	0.1	ND	ND
SRCHE013.65	5/1/2008	ND	0.0004	ND	NA	NA	1	12	0.19	230	240	ND	ND	ND
SRCYN045.73	5/13/2008	ND	ND	ND	9.65	102.6	7	2.6	ND	120	130	ND	ND	ND
SRFIS004.49	6/24/2008	ND	ND	ND	NA	NA	NA	2	ND	35	44	0.3	ND	ND
SRTON053.87	5/15/2008	ND	0.000225	ND	8.84	97	0	3	ND	160	170	0.15	ND	ND

SRTON059.43	5/14/2008	ND	0.00023	ND	8.99	99.9	0	1.9	ND	98	91	0.12	ND	ND
SRWRK007.97	6/16/2008	ND	0.00067	ND	8.24	100.7	NA	0.273	ND	170	200	0.2	ND	ND

Site ID	Date	Cr (T)	Cu (D)	Cu (T)	DO (mg/l)	DO %	E. coli	Flow (cfs)	F-	Calc Hardness	HCO3	TKN	Pb (D)	Pb (T)
UGBLR030.24	6/17/2009	ND	0.002845	ND	8.51	98	2	8.7	0.17	170	200	ND	ND	ND
UGBLR036.37	8/6/2009	ND	ND	ND	**5.71**	78.3	42	0.8	ND	200	210	ND	ND	0.001
UGEAG011.09	4/28/2009	ND	0.0011	ND	9.75	104.7	26	2	1	145	190	ND	ND	ND
UGEAG015.23	4/29/2009	ND	NA	ND	9.78	95.9	8	6.3	0.48	150	190	ND	ND	ND
UGSFR006.08	4/29/2009	ND	0.0035	ND	10.26	117	2	19	0.77	250	170	ND	ND	ND
UGSFR019.04	5/12/2009	ND	ND	ND	7.76	110.4	15	31	0.73	150	170	ND	ND	ND
UGTRY001.56	6/17/2009	ND	0.00079	ND	7.03	92.6	12	1	0.32	170	240	ND	ND	ND
VREVR023.59	6/25/2008	ND	0.000268	ND	6.94	91.6	NA	1.9	0.15	210	240	0.06	ND	ND
VROAK048.36	7/8/2008	ND	ND	ND	9.24	87.9	NA	1.4	ND	160	190	0.2	ND	ND
VRROU002.93	4/30/2008	ND	0.000475	ND	8.1	77.1	1	0.3	0.3	270	330	0.1125	ND	ND
VRWBV002.97	4/28/2008	ND	0.00095	ND	8.73	104	8	5.9	0.12	260	310	0.083	ND	ND
VRWCL005.10	4/29/2008	ND	0.00046	ND	8.56	93	1	18	0.1	210	230	ND	ND	ND
VRFOS014.33	6/13/2008	ND	ND	ND	8.69	97.8	0	2.5	0.17	400	470	ND	ND	ND

Site ID	Date	Mg (D)	Mg (T)	Mn (T)	Hg (D)	Hg (T)	N (T)	PH	P (T)	K (D)	K (T)	Se (T)	Na (D)	Na (T)	EC	SO4 (T)	SSC
BWBSR037.79	4/21/2010	NA	20	0.00028	ND	0.0002	ND	8.04	0.14	NA	4.4	ND	NA	79	800	64	13.4
BWBWR025.86	6/10/2010	NA	17	0.12	ND	ND	ND	8.04	1.2	NA	7.1	ND	NA	75	744	57	46.7
BWBWR038.52	6/10/2010	NA	14	0.34	ND	ND	0.247	8.15	0.15	NA	5.7	ND	NA	51	579	44	2.76
CGPAR000.49	6/8/2010	NA	20	ND	ND	ND	0.835	8.72	ND	NA	3.15	ND	NA	30	474.3	130	9.95
CGVGR044.58	6/16/2010	NA	86	0.044	ND	ND	0.606	7.48	0.16	NA	26	**0.0029**	NA	260	2981	950	72.2
CGVGR052.23	4/27/2010	NA	40	0.48	ND	0.00023	0.489	8.43	0.8	NA	9.7	ND	NA	74	946.1	210	1100
LCCHC073.26	5/25/2010	NA	8.5	ND	ND	ND	ND	8.68	ND	NA	ND	ND	NA	2	137	ND	0.966
LCECL009.39	5/24/2010	NA	12	0.011	ND	ND	ND	9	ND	NA	ND	ND	NA	1	166.5	ND	NA
LCELR008.70	6/24/2010	NA	1	0.016	ND	ND	ND	7.45	ND	NA	ND	ND	NA	3.1	42	2.4	1.84
LCFIS003.86	6/29/2010	NA	5.2	ND	ND	ND	ND	8.71	ND	NA	ND	ND	NA	9.6	114.8	2.4	1.95
LCLCR323.60	6/3/2010	NA	8.1	0.087	ND	ND	ND	8.5	0.12	NA	2.4	ND	NA	9.8	145.7	6.2	**61.4**
LCLCR336.72	6/30/2010	NA	8.7	0.061	ND	ND	ND	8.37	ND	NA	2.3	ND	NA	12	186.6	3.8	21.3
LCNUT025.35	7/1/2010	NA	9	0.014	ND	ND	ND	8.2	ND	NA	ND	ND	NA	18	269.3	4.3	3.05
LCRUD008.43	7/1/2010	NA	8.5	0.027	ND	ND	359	8.27	0.11	NA	4.3	ND	NA	10	174.2	3.4	17.4
LCSIL027.05	5/4/2010	NA	14	0.11	ND	ND	ND	8.11	0.23	NA	4	ND	NA	11	290	8.4	**87**
LCSLR003.72	6/30/2010	NA	7.05	0.012	ND	0.00021	ND	8.47	ND	NA	ND	ND	NA	9.5	136	ND	1.03
LCWLR007.37	6/22/2010	NA	1	ND	ND	ND	0.193	8.98	ND	NA	ND	ND	NA	2.9	37	2.5	3.7
MGAFR110.01	4/6/2009	18	18	ND	0.00000078	ND	6.2	8.66	1.3	8.9	NA	ND	69	NA	747.6	62	12
MGHSR048.20	6/4/2009	20	20	ND	0.00000063	ND	1.2	NA	0.045	2.2	NA	ND	51	NA	686.4	46	2
MGHSR110.58	4/7/2009	10	11	0.22	0.00000245	ND	ND	7.73	ND	0.97	NA	ND	6.8	NA	305	80	2
MGLSY000.42	4/8/2009	31	31	ND	ND	ND	0.053	7.63	ND	1.5	NA	ND	17	NA	564.5	8.8	2
SCSAB005.09	6/10/2009	2.7	2.7	ND	0.0000046	ND	ND	7	ND	1.3	NA	ND	8.6	NA	110.3	0.5	11
SPARA026.35	5/14/2009	8.9	8.5	ND	ND	ND	0.62	7.69	0.03	2	NA	ND	19	NA	376	19	2
SPGDN007.55	4/30/2009	27	26.5	ND	ND	ND	0.105	7.33	ND	0.25	NA	ND	4.25	NA	638.9	27	2
SPGRA007.71	6/25/2009	2.4	NA	ND	NA	ND	ND	8.5	ND	0.64	NA	ND	4.3	NA	83	5.4	7
SPMLC013.56	4/29/2009	6.7	6.8	ND	ND	ND	ND	7.32	ND	0.25	NA	ND	4	NA	324	12	2
SRBEV001.40	6/18/2008	6	NA	ND	ND	ND	ND	8.16	0.159	0.94	NA	ND	3.7	NA	118	7.7	10
SRBLR102.24	7/10/2008	4.55	NA	ND	ND	ND	ND	8.71	0.058	1.6	NA	ND	6.4	6.4	107.1	0.5	8.5
SRBON001.69	6/16/2008	5.5	NA	ND	ND	ND	ND	8.64	0.07	1.8	NA	ND	9.4	NA	139	0.5	14
SRCHE013.65	5/1/2008	24	NA	ND	0.000000535	ND	ND	8.46	ND	2	NA	ND	16	NA	448	13	2
SRCYN045.73	5/13/2008	7.9	NA	ND	NA	ND	0.091	8.28	0.036	0.88	NA	ND	3	NA	209.7	8.4	2
SRFIS004.49	6/24/2008	4	NA	ND	ND	ND	ND	7.25	0.042	0.73	NA	ND	2.8	NA	79	4.1	2
SRTON053.87	5/15/2008	12	NA	ND	ND	ND	ND	8.47	0.043	0.89	NA	ND	3.8	NA	296	16	7
SRTON059.43	5/14/2008	6.8	NA	ND	0.00000062	ND	0.11	8.67	0.049	0.8	NA	ND	2.1	NA	176.2	14	9

SRWRK007.97	6/16/2008	19	NA	ND	0.0000006	ND	0.23	7.99	0.058	1.6	NA	ND	6.6	NA	318	7.5	2

Site ID	Date	Mg (D)	Mg (T)	Mn (T)	Hg (D)	Hg (T)	N (T)	pH	P (T)	K (D)	K (T)	Se (T)	Na (D)	Na (T)	EC	SO4 (T)	SSC
UGBLR030.24	6/17/2009	14	14	ND	ND	ND	ND	8.42	0.12	0.82	NA	ND	15	NA	350.5	9.15	2
UGBLR036.37	8/6/2009	NA	16	0.066	ND	ND	ND	8.21	0.17	NA	2.1	ND	NA	23	393.7	4.6	**58.8**
UGEAG011.09	4/28/2009	14	14.5	ND	ND	ND	ND	8.06	0.0655	3.5	NA	ND	29	NA	649	12	2
UGEAG015.23	4/29/2009	15	15	ND	ND	ND	ND	7.87	0.0575	3.1	NA	ND	20	NA	637	9	2
UGSFR006.08	4/29/2009	13	13	ND	ND	ND	ND	NA	0.047	10	NA	ND	17	NA	1422	20	2
UGSFR019.04	5/12/2009	12	12	ND	ND	ND	ND	8.53	0.058	3.6	NA	ND	53	NA	570	17	7
UGTRY001.56	6/17/2009	13	13	ND	NA	ND	ND	7.71	0.12	0.58	NA	ND	35	NA	425	11	**27**
VREVR023.59	6/25/2008	28	NA	0.052	0.00000034	ND	ND	8.3	0.014	1.2	NA	ND	5.8	NA	378.3	NA	2
VROAK048.36	7/8/2008	17	NA	ND	ND	ND	0.11	8.08	0.016	0.77	NA	ND	3.6	NA	277.2	1.2	2
VRROU002.93	4/30/2008	29	NA	ND	ND	ND	ND	8.07	0.015	1.4	NA	ND	21	NA	533	13	2
VRWBV002.97	4/28/2008	27	NA	ND	0.00000061	ND	ND	8.15	ND	2.6	NA	ND	22	NA	510.8	6.8	2
VRWCL005.10	4/29/2008	24	NA	ND	ND	ND	ND	8.53	ND	1.5	NA	ND	6.3	NA	347.6	1.6	2
VRFOS014.33	6/13/2008	NA	38	ND	ND	ND	0.1	7.25	0.02	NA	1.6	ND	NA	12	748	26	0.481

Site ID	Date	Air Temp	Water Temp	TDS	Turbidity	Zn (D)	Zn (T)
BWBSR037.79	4/21/2010	16.6	NA	490	2.32	ND	ND
BWBWR025.86	6/10/2010	38.4	27.4	483	52.5	ND	ND
BWBWR038.52	6/10/2010	31.7	14.47	376	66.1	ND	ND
CGPAR000.49	6/8/2010	39.1	29.81	303.6	4.51	ND	ND
CGVGR044.58	6/16/2010	29.7	22.19	1922	32.3	ND	ND
CGVGR052.23	4/27/2010	23.2	14.97	616.9	7.69	ND	ND
LCCHC073.26	5/25/2010	71.8	13.23	87.6	1.53	ND	ND
LCECL009.39	5/24/2010	20.8	16.6	106.7	1.14	ND	ND
LCELR008.70	6/24/2010	25.6	NA	40	3.01	ND	ND
LCFIS003.86	6/29/2010	23.8	14.56	73.5	1.91	ND	ND
LCLCR323.60	6/3/2010	32.7	17.18	93.3	40	ND	ND
LCLCR336.72	6/30/2010	22.4	16.07	119.4	19.4	ND	ND
LCNUT025.35	7/1/2010	NA	11.25	172.3	1.82	ND	ND
LCRUD008.43	7/1/2010	21	13.3	111.4	12.8	ND	ND
LCSIL027.05	5/4/2010	32.9	15.12	220	81.9	ND	ND
LCSLR003.72	6/30/2010	23.1	13.37	87.2	1.75	ND	ND
LCWLR007.37	6/22/2010	20.8	8.08	24	2.87	ND	ND
MGAFR110.01	4/6/2009	24.6	18.8	478.6	18.3	ND	ND
MGHSR048.20	6/4/2009	17.6	19.29	439	0.42	ND	ND
MGHSR110.58	4/7/2009	20	13.78	195.6	6.06	**0.29**	0.44
MGLSY000.42	4/8/2009	15.3	13.15	361.1	3.96	ND	ND
SCSAB005.09	6/10/2009	33.2	25.27	70.9	0.96	ND	ND
SPARA026.35	5/14/2009	16.8	17.11	200	1	ND	ND
SPGDN007.55	4/30/2009	NA	13.86	409.2	0.62	ND	ND
SPGRA007.71	6/25/2009	25.7	17.78	100	NA	NA	ND
SPMLC013.56	4/29/2009	23.8	17.25	207.4	0.13	ND	ND
SRBEV001.40	6/18/2008	NA	20.16	76	12	ND	ND
SRBLR102.24	7/10/2008	NA	16.22	68.6	4.75	ND	ND
SRBON001.69	6/16/2008	28.7	22.15	90	16.1	ND	ND
SRCHE013.65	5/1/2008	22.8	16.37	291	0.93	ND	ND
SRCYN045.73	5/13/2008	6.8	8.55	134.4	2.25	ND	ND
SRFIS004.49	6/24/2008	16	12.71	51	0.65	ND	ND
SRTON053.87	5/15/2008	NA	11.87	189.5	0.7	ND	ND
SRTON059.43	5/14/2008	NA	11.81	113	1.23	ND	ND

SRWRK007.97	6/16/2008	27.4	15.8	203	0.67	ND	ND

Site ID	Date	Air Temp	Water Temp	TDS	Turbidity	Zn (D)	Zn (T)
UGBLR030.24	6/17/2009	26.7	13.89	224.5	1.25	ND	ND
UGBLR036.37	8/6/2009	31.8	21.27	252	4.48	ND	ND
UGEAG011.09	4/28/2009	24.6	18.41	422	3.08	ND	ND
UGEAG015.23	4/29/2009	23	14.34	414	0.57	ND	ND
UGSFR006.08	4/29/2009	31	21.8	924	5.3	ND	ND
UGSFR019.04	5/12/2009	32.8	25.5	400	5.1	ND	ND
UGTRY001.56	6/17/2009	24	17.29	271.9	1.59	ND	ND
VREVR023.59	6/25/2008	28.3	23.6	242.1	3.23	ND	ND
VROAK048.36	7/8/2008	13.2	11.99	177.4	0.41	ND	ND
VRROU002.93	4/30/2008	22.6	13.99	346	0.68	ND	ND
VRWBV002.97	4/28/2008	30.9	19.6	327.1	NA	ND	ND
VRWCL005.10	4/29/2008	19.3	14.6	222.5	2.43	ND	ND
VRFOS014.33	6/13/2008	28.3	21.2	486	1.81	ND	ND

Bold = Exceedance

APPENDIX B – CHEMISTRY EXCEEDANCES DURING 2008 – 2010 MONITORING YEARS

Site ID	Date	Parameter	Result	Units		Site ID	Date	Parameter	Result	Units
BWBWR025.86	2/22/2010	Se (T)	0.0021	MG/L		MGHSR110.58	4/7/2009	Cu (D)	0.036	MG/L
CGPAR000.49	3/30/2010	As (T)	0.034	MG/L		MGHSR110.58	10/20/2008	Zn (D)	0.19	MG/L
CGPAR000.49	2/9/2010	Zn (T)	0.34	MG/L		MGHSR110.58	2/4/2009	Zn (D)	0.26	MG/L
CGVGR044.58	6/16/2010	Se (T)	0.0029	MG/L		MGHSR110.58	4/7/2009	Zn (D)	0.29	MG/L
CGVGR052.23	3/9/2010	E. COLI	460	CFU		MGHSR110.58	10/20/2008	Zn (T)	0.2	MG/L
CGVGR052.23	11/9/2009	Se (T)	0.0021	MG/L		MGHSR110.58	2/4/2009	Zn (T)	0.34	MG/L
LCLCR323.60	6/3/2010	SSC	61.4	MG/L		SCSAB005.09	9/11/2008	E. COLI	310	CFU
LCLCR336.72	6/30/2010	DO	6.99	MG/L		SPARA026.35	5/14/2009	DO	5.59	MG/L
LCNUT025.35	7/1/2010	Cu (D)	0.011	MG/L		SPGDN007.55	4/30/2009	DO	6.98	MG/L
LCRUD008.43	7/1/2010	Cu (D)	0.016	MG/L		SRTON053.87	7/7/2008	E. COLI	435.9	CFU
LCRUD008.43	9/30/2009	DO	6.45	MG/L		SRTON053.87	8/12/2008	E. COLI	866.4	CFU
LCRUD008.43	7/1/2010	DO	6.73	MG/L		SRTON053.87	9/3/2008	E. COLI	1299.7	CFU
LCSIL027.05	5/4/2010	DO	5.77	MG/L		SRWRK007.97	8/29/2007	DO	6.71	MG/L
LCSIL027.05	5/4/2010	E. COLI	320	CFU		UGBLR036.37	8/6/2009	SSC	58.8	MG/L
LCSIL027.05	5/4/2010	SSC	87	MG/L		UGBLR036.37	8/6/2009	DO	5.71	MG/L
LCSIL027.05	9/21/2009	E. COLI	494	CFU		UGEAG011.09	8/27/2008	E. COLI	660	CFU
LCSLR003.72	6/30/2010	DO	6.52	MG/L		UGSFR006.08	8/27/2008	E. COLI	620	CFU
MGAFR110.01	9/11/2008	E. COLI	690	CFU		UGSFR019.04	10/15/2008	E. COLI	640	CFU
MGHSR048.20	8/15/2008	DO	5.22	MG/L		UGSFR151.22	6/18/2009	DO	3.27	MG/L
MGHSR048.20	2/4/2009	DO	5.63	MG/L		UGSFR151.22	3/31/2009	DO	6.95	MG/L
MGHSR048.20	8/15/2008	Mn (T)	77	MG/L		UGTRY001.56	6/17/2009	SSC	27	MG/L
MGHSR110.58	10/20/2008	Cd (D)	0.0037	MG/L		VRWBV002.97	8/28/2007	As (T)	0.049	MG/L
MGHSR110.58	2/4/2009	Cd (D)	0.0039	MG/L		VRWBV002.97	11/6/2007	As (T)	0.032	MG/L
MGHSR110.58	4/7/2009	Cd (D)	0.0058	MG/L		VRWBV002.97	8/28/2007	E. COLI	480	CFU
MGHSR110.58	2/4/2009	Cu (D)	0.034	MG/L						

APPENDIX C - RAW STATISTICS

The summary statistics below include all variables where sufficient data was available for analysis. These statistics were compiled from the data presented in Appendix A. Half the mean reporting limit (MRL) was used for all non-detect values (ND). All values were calculated with a 95% confidence interval and an alpha = 0.05.

ALKPHEN	Q1	Q2	Q3	Q4		NH3	Q1	Q2	Q3	Q4
Mean	2.75	3.63	3.53	2.50		Mean	0.0158	0.0235	0.0286	0.0176
Standard Error	0.32	0.66	0.80	0.29		Standard Error	0.0033	0.0037	0.0076	0.0019
Median	1.00	3.10	1.00	1.00		Median	0.0100	0.0225	0.0150	0.0100
Standard Deviation	2.47	3.17	3.90	2.27		Standard Deviation	0.0262	0.0130	0.0322	0.0148
Count	61.00	23.00	24.00	62.00		Count	61.0000	12.0000	18.0000	60.0000
DO mg/l	Q1	Q2	Q3	Q4		CO3	Q1	Q2	Q3	Q4
Mean	8.04	11.05	10.00	8.55		Mean	3.19	4.23	4.15	2.88
Standard Error	0.28	0.36	0.51	0.16		Standard Error	0.39	0.79	0.98	0.36
Median	7.54	11.23	9.44	8.74		Median	1.00	3.70	1.00	1.00
Standard Deviation	2.03	1.76	2.21	1.24		Standard Deviation	3.04	3.81	4.80	2.86
Count	53.00	24.00	19.00	60.00		Count	61.00	23.00	24.00	62.00
HARDNESS	Q1	Q2	Q3	Q4		DO%	Q1	Q2	Q3	Q4
Mean	179.53	267.13	148.05	204.84		Mean	88.72	101.06	93.67	92.99
Standard Error	21.80	39.25	18.38	26.12		Standard Error	2.39	2.53	5.25	2.00
Median	180.00	220.00	145.00	180.00		Median	90.30	96.45	95.50	94.45
Standard Deviation	170.27	188.23	86.21	205.70		Standard Deviation	17.39	12.39	22.89	15.48
Count	61.00	23.00	22.00	62.00		Count	53.00	24.00	19.00	60.00
HCO3	Q1	Q2	Q3	Q4		HARDCACO3	Q1	Q2	Q3	Q4
Mean	189.38	234.61	160.88	189.74		Mean	182.38	266.52	152.61	209.73
Standard Error	14.94	20.55	19.20	14.91		Standard Error	22.10	39.70	18.15	27.75
Median	210.00	240.00	155.00	195.00		Median	180.00	220.00	155.00	185.00
Standard Deviation	116.70	98.55	94.06	117.40		Standard Deviation	172.59	190.40	85.12	218.47

Count	61.00	23.00	24.00	62.00
E. coli	Q1	Q2	Q3	Q4
Mean	44.06	8.45	45.37	9.42
Standard Error	14.94	2.15	27.01	3.21
Median	13.00	3.00	2.00	1.00
Standard Deviation	109.78	9.87	117.71	22.89
Count	54.00	21.00	19.00	51.00

Count	61.00	23.00	22.00	62.00
P-T	Q1	Q2	Q3	Q4
Mean	0.4813	0.0397	0.0425	0.0358
Standard Error	0.4351	0.0091	0.0093	0.0033
Median	0.0430	0.0255	0.0280	0.0280
Standard Deviation	1.8461	0.0427	0.0455	0.0270
Count	18.0000	22.0000	24.0000	66.0000

TKN	Q1	Q2	Q3	Q4
Mean	0.1716	0.2435	0.1457	0.1129
Standard Error	0.0380	0.0273	0.0137	0.0091
Median	0.1100	0.2000	0.1000	0.1000
Standard Deviation	0.1565	0.1308	0.0656	0.0736
Count	17.0000	23.0000	23.0000	66.0000

SO4-T	Q1	Q2	Q3	Q4
Mean	31.43	74.43	11.40	58.67
Standard Error	16.71	40.22	3.24	24.91
Median	4.40	11.00	8.80	8.05
Standard Deviation	130.55	192.87	15.89	192.93
Count	61.00	23.00	24.00	60.00

ALKCACO3	Q1	Q2	Q3	Q4
Mean	177.04	198.39	136.71	159.06
Standard Error	13.45	17.22	16.89	12.52
Median	190.00	200.00	125.00	165.00
Standard Deviation	97.00	82.59	82.76	98.60
Count	52.00	23.00	24.00	62.00

MN-T	Q1	Q2	Q3	Q4
Mean	0.0471	0.2569	0.0269	0.0338
Standard Error	0.0054	0.2202	0.0019	0.0067
Median	0.0250	0.0250	0.0250	0.0250
Standard Deviation	0.0424	1.0562	0.0092	0.0528
Count	61.0000	23.0000	24.0000	62.0000

F-TOTAL	Q1	Q2	Q3	Q4
Mean	0.19	0.34	0.22	0.23
Standard Error	0.05	0.15	0.11	0.05
Median	0.05	0.11	0.05	0.10
Standard Deviation	0.43	0.71	0.52	0.39
Count	61.00	23.00	24.00	62.00

TDS	Q1	Q2	Q3	Q4
Mean	220.83	332.77	4611.53	271.31
Standard Error	26.51	46.11	3734.17	31.92
Median	207.00	279.00	279.00	230.95
Standard Deviation	207.07	221.12	13463.73	251.35
Count	61.00	23.00	13.00	62.00

APPENDIX D - MACROINVERTEBRATE RESULTS

Site ID	Index Period	Sample Date	Total Taxa	Diptera Taxa	HBI	Percent Stoneflys	Percent Scraper	Scraper Taxa	Caddisfly Taxa	Mayfly Taxa	Percent Mayflies	Percent Dominant Taxon	IBI Score	ADEQ Narrative	EPA Narrative
BWBSR037.79	Spring	6/1/10	27	5	4.38	9.81	37.31	7	4	6	43.65	30.00	76	Meets	Least disturbed
BWBWR025.86	Spring	6/10/10	22	4	5.42	0.00	1.86	2	2	3	30.73	48.79	43	Inconclusive	Intermediate
BWBWR038.52	Spring	6/10/10	13	3	5.79	0.00	6.93	1	2	4	55.11	45.26	45	Inconclusive	Intermediate
CGPAR000.49	Spring	6/8/10	17	7	5.91	0.00	1.48	2	3	2	16.79	62.18	40	Inconclusive	Intermediate
CGVGR044.58	Spring	6/16/10	15	4	6.79	0.00	4.94	2	2	2	30.86	30.86	41	Inconclusive	Intermediate
CGVGR052.23	Spring	6/15/10	19	5	5.96	0.00	3.28	2	2	3	45.36	21.31	49	Inconclusive	Intermediate
LCCHC073.26	Spring	5/25/10	21	6	5.50	0.37	7.09	4	2	5	49.44	41.42	37	Violates	Most disturbed
LCECL009.39	Spring	5/24/10	18	5	6.04	0.00	1.39	2	2	3	2.19	71.17	26	Violates	Most disturbed
LCELR008.70	Spring	6/24/10	33	7	5.74	0.38	25.38	9	6	6	3.85	43.46	59	Meets	Least disturbed
LCFIS003.86	Spring	6/29/10	24	5	3.83	8.99	42.88	5	5	3	42.70	38.01	64	Meets	Least disturbed
LCLCR323.60	Spring	6/3/10	19	5	5.54	0.00	1.28	2	3	6	56.15	53.76	28	Violates	Most disturbed
LCLCR336.72	Spring	6/30/10	21	4	5.67	0.00	8.32	3	2	6	56.48	42.75	30	Violates	Most disturbed
LCNUT025.35	Spring	7/1/10	28	9	4.89	15.65	49.17	5	4	4	19.15	27.07	70	Meets	Least disturbed
LCRUD008.43	Spring	7/1/10	36	6	5.44	2.77	30.68	8	8	7	17.74	27.17	62	Meets	Least disturbed
LCSIL027.05	Spring	6/25/10	12	3	7.04	0.00	0.68	2	0	2	0.51	48.89	19	Violates	Most disturbed
LCSLR003.72	Spring	6/30/10	30	5	4.21	7.89	33.33	9	5	7	56.41	21.89	72	Meets	Least disturbed
LCWLR007.37	Spring	6/23/10	21	5	4.61	3.83	71.07	6	1	7	37.74	36.78	65	Meets	Least disturbed
MGAFR110.01	Spring	4/6/09	16	4	5.66	0.00	0.18	1	2	4	49.18	44.46	43	Inconclusive	Intermediate
MGHSR048.20	Spring	6/4/09	21	6	6.16	0.00	0.51	1	3	3	40.44	37.06	46	Inconclusive	Intermediate
MGHSR110.58	Spring	4/7/09	16	9	6.16	2.84	0.00	0	1	0	0.00	65.60	32	Violates	Most disturbed
MGLSY000.42	Spring	4/8/09	25	6	6.22	0.00	2.46	3	5	5	18.25	50.00	50	Meets	Least disturbed
SCSAB005.09	Spring	6/10/09	22	7	6.31	0.00	5.37	3	3	3	23.66	52.29	47	Inconclusive	Intermediate
SPARA026.35	Spring	5/14/09	29	7	6.15	0.00	11.07	4	8	6	48.16	17.86	72	Meets	Least disturbed
SPGDN007.55	Spring	4/30/09	24	8	6.11	0.00	1.95	3	4	4	15.43	37.70	34	Violates	Most disturbed
SPGRA007.71	Spring	6/25/09	31	7	6.31	0.00	2.80	5	9	5	6.20	43.80	40	Violates	Most disturbed
SPMLC013.56	Spring	4/29/09	23	8	5.85	0.00	1.51	2	5	2	1.51	80.60	37	Violates	Most disturbed
SRBEV001.40	Spring	6/18/08	23	3	5.26	2.61	11.04	4	4	7	56.22	25.70	42	Violates	Most disturbed
SRBLR102.24	Spring	7/10/08	36	6	5.44	2.04	19.07	10	6	11	53.89	22.04	60	Meets	Least disturbed
SRBON001.69	Spring	6/16/08	24	6	5.79	0.39	5.27	4	4	4	56.64	27.93	37	Violates	Most disturbed
SRCHE013.65	Spring	5/1/08	14	2	5.87	0.00	0.36	2	1	4	19.78	69.51	32	Violates	Most disturbed
SRCYN045.73	Spring	5/13/08	19	4	5.98	0.00	2.48	5	5	4	6.10	78.48	32	Violates	Most disturbed
SRFIS004.49	Spring	6/24/08	27	5	5.47	9.11	30.86	7	5	4	33.46	31.23	63	Meets	Least disturbed
SRHAG013.09	Spring	5/14/08	28	10	6.18	0.00	2.61	4	4	3	11.61	31.04	44	Violates	Most disturbed

Site ID	Index Period	Sample Date	Total Taxa	Diptera Taxa	HBI	Percent Stoneflys	Percent Scraper	Scraper Taxa	Caddisfly Taxa	Mayfly Taxa	Percent Mayflies	Percent Dominant Taxon	IBI Score	ADEQ Narrative	EPA Narrative
SRTON053.87	Spring	5/15/08	20	3	5.96	0.78	2.35	4	4	5	6.65	76.13	41	Inconclusive	Intermediate
SRTON059.43	Spring	5/14/08	17	5	5.83	0.38	2.29	5	4	3	13.14	58.86	38	Violates	Most disturbed
SRWRK007.97	Spring	6/16/08	16	4	5.58	2.46	2.46	2	2	3	37.31	33.90	27	Violates	Most disturbed
UGBLR030.24	Spring	6/17/09	25	7	6.24	0.00	2.58	5	6	8	25.13	25.47	35	Violates	Most disturbed
UGBLR036.37	Spring	8/6/09	29	9	5.84	0.00	2.29	5	5	6	50.29	18.16	42	Violates	Most disturbed
UGEAG011.09	Spring	4/28/09	33	3	5.96	0.00	11.30	5	9	8	25.80	22.79	71	Meets	Least disturbed
UGEAG015.23	Spring	4/28/09	29	4	6.69	0.00	7.25	5	7	8	30.40	15.54	66	Meets	Least disturbed
UGSFR006.08	Spring	4/29/09	28	3	6.29	0.00	9.64	4	8	9	49.53	11.53	71	Meets	Least disturbed
UGSFR019.04	Spring	5/13/09	35	5	6.04	0.20	8.66	5	11	10	27.76	29.92	73	Meets	Least disturbed
UGTRY001.56	Spring	6/17/09	30	11	6.60	0.19	2.27	5	8	3	7.56	32.70	44	Violates	Most disturbed
VREVR023.59	Spring	6/25/08	16	3	5.64	0.00	1.80	2	4	4	31.54	31.74	46	Inconclusive	Intermediate
VRFOS014.33	Spring	6/13/08	33	11	6.34	0.00	5.37	5	7	6	36.78	20.48	72	Meets	Least disturbed
VROAK048.36	Spring	7/8/08	25	7	5.32	0.00	6.11	7	4	3	64.07	62.22	46	Inconclusive	Intermediate
VRROU002.93	Spring	4/30/08	17	6	5.88	0.00	0.19	1	2	2	17.35	37.87	39	Violates	Most disturbed
VRWBV002.97	Spring	4/28/08	15	3	5.60	0.00	0.74	2	3	4	42.70	40.11	45	Inconclusive	Intermediate
VRWCL005.10	Spring	4/29/08	18	3	5.71	0.36	2.86	2	4	5	33.93	38.39	48	Inconclusive	Intermediate

Cold Water
Warm Water

APPENDIX E - SITE PHOTOS

BWBSR037.79 	BWBWR025.86 	BWBWR038.52 	CGPAR000.49 
CGVGR044.58 	CGVGR052.23 	LCCHC073.26 	LCECL009.39 
LCELR008.70 	LCFIS003.86 	LCLCR323.60 	LCLCR336.72 
LCNUT025.35 	LCRUD008.43 	LCSIL027.05 	LCSLR003.72 

LCWLR007.37 	MGAFR110.01 	MGHSR048.20 	MGHSR110.58 
MGLSY000.42 	SCSAB005.09 	SPARA026.35 	SPGDN007.55 

APPENDIX F – REFERENCE SITE SELECTION AND CONDITION THRESHOLDS

Thresholds used to assess habitat and some chemical stressors were based on percentiles obtained from the reference distribution. Non-probabilistic sites with samples collected between 2001 and 2010 were evaluated to determine if they qualify as reference sites. Biological, chemical, and land use screening criteria as well as the best professional judgment (BPJ) were used in the selection process.

For the habitat reference site selection, the following criteria were used to screen all candidate sites before the BPJ was applied. Some of the habitat stressor data were only available since 2008, so the final selection was also largely limited to the sites with at least one sample collected between 2008 and 2010.

- No Biocriteria violations between 2001 and 2010
- No A&W impairment in the 2010 water quality assessment
- No apparent land use impact on the macroinvertebrate community
- At least one full SEM sampling since 2008

Twelve cold reference and 14 warm reference sites were selected as a result (Table 1).

For the chemistry reference site selection, habitat rating scores were used in place of chemical assessment results to avoid circular referencing. All non-probabilistic sites with samples collected between 2001 and 2010 were considered as chemistry reference candidates. Candidate sites were screened based on the following criteria:

- No Biocriteria violations between 2001 and 2010
- Good rating on habitat scores
- No apparent land use impact on the macroinvertebrate community
- For suspended sediment concentration, storm runoff samples were excluded from the analysis.

Eighteen cold reference and 17 warm reference sites were selected as a result (Table 2).

Reference site data between 2001 and 2010 were compiled by taking an average value per site for each of the 7 habitat stressors and 3 chemical stressors. Box plots were constructed to determine the reference distribution. The 5th/95th and 25th/75th percentiles of the reference distribution were used as thresholds to distinguish the most-disturbed sites from the intermediate sites and the intermediate sites from the least-disturbed sites, respectively (Stoddard et al. 2005). The results are summarized in Table 3.

Table 1. Habitat Reference Sites

Station ID	Waterbody Name	County	Region	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
LCWLR004.09	WEST FORK LITTLE COLORADO RIVER	Apache	cold	33.9631111	-109.5006389
LCMAM002.05	MAMIE CREEK	Apache	cold	33.9671392	-109.0826272
LCRUD007.23	RUDD CREEK	Apache	cold	34.0110214	-109.2816122
LCPAD001.30	PADDY CREEK	Apache	cold	33.9179678	-109.1513286
SPCRC013.37	CARR CANYON	Cochise	cold	31.4269219	-110.3072308
SRWFB005.34	WEST FORK BLACK RIVER	Apache	cold	33.7941625	-109.4234019
SRHAY000.04	HAY CREEK	Apache	cold	33.8088889	-109.4221667
SRSTI000.38	STINKY CREEK	Apache	cold	33.8546667	-109.4585278
UGKPK011.18	KP CREEK	Greenlee	cold	33.5836111	-109.3430556
UGETK011.80	EAST TURKEY CREEK	Cochise	cold	31.9087297	-109.2531981
VRWCL036.37	WEST CLEAR CREEK	Coconino	cold	34.5531389	-111.4075278

Station ID	Waterbody Name	County	Region	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
VREVR051.15	EAST VERDE RIVER	Gila	cold	34.4211114	-111.2632925
CGBRA000.44	BRIGHT ANGEL CREEK	Coconino	warm	36.1023439	-112.0958631
CGSHI000.05	SHINUMO CREEK	Coconino	warm	36.2373222	-112.3486667
MGLAS004.52	LITTLE ASH CREEK	Yavapai	warm	34.3837786	-112.02585
SPARA026.35	ARAVAIPA CANYON CREEK	Graham	warm	32.8792189	-110.3940758
SPHSC010.67	HOT SPRINGS CANYON	Cochise	warm	32.3541164	-110.2679189
SRSPI011.63	SPRING CREEK	Gila	warm	34.0807361	-111.0763772
SRWPN004.47	West Fork Pinto Creek	Gila	warm	33.4394444	-111.0638889
UGSFR034.57	SAN FRANCISCO RIVER	Greenlee	warm	33.2009444	-109.1491389
UGBON006.41	BONITA CREEK	Graham	warm	32.9565628	-109.5318014
VRFOS014.33	FOSSIL CREEK	Yavapai	warm	34.4243056	-111.5731944
VRVER165.07	VERDE RIVER	Yavapai	warm	34.8936808	-112.2122158
VRWBV012.56	WET BEAVER CREEK	Yavapai	warm	34.6739211	-111.6701661
VRSYW001.72	SYCAMORE CREEK	Yavapai	warm	34.8822694	-112.0671

Table 2. Chemistry Reference Sites

Station ID	Waterbody Name	County	Region	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
LCWLR000.92	WEST FORK LITTLE COLORADO RIVER	Apache	cold	33.99375	-109.4651389
LCWLR004.09	WEST FORK LITTLE COLORADO RIVER	Apache	cold	33.9631111	-109.5006389
LCLCR360.06	LITTLE COLORADO RIVER	Apache	cold	34.0080781	-109.4544408
LCBEN002.57	BENTON CREEK	Apache	cold	33.9854333	-109.2916153
LCRUD007.23	RUDD CREEK	Apache	cold	34.0110214	-109.2816122
LCPAD001.30	PADDY CREEK	Apache	cold	33.9179678	-109.1513286
LCLCR350.32	LITTLE COLORADO RIVER	Apache	cold	34.0865744	-109.4032839
LCELR000.13	LITTLE COLORADO RIVER EAST FORK	Apache	cold	34.0020328	-109.4572189
LCSLR001.42	SOUTH FORK LITTLE COLORADO RIVER	Apache	cold	34.0707514	-109.4102656
SPCRC013.37	CARR CANYON	Cochise	cold	31.4269219	-110.3072308
SRWFB005.34	WEST FORK BLACK RIVER	Apache	cold	33.7941625	-109.4234019
SRHAY000.04	HAY CREEK	Apache	cold	33.8088889	-109.4221667
SRSTI000.38	STINKY CREEK	Apache	cold	33.8546667	-109.4585278
SRCRS005.68	CHRISTOPHER CREEK	Gila	cold	34.3373997	-111.0136472
SRNBE000.10	NORTH FORK BEAR WALLOW CREEK	Greenlee	cold	33.5983333	-109.4460833
UGKPK011.18	KP CREEK	Greenlee	cold	33.5836111	-109.3430556
UGETK011.80	EAST TURKEY CREEK	Cochise	cold	31.9087297	-109.2531981
VRWCL036.37	WEST CLEAR CREEK	Coconino	cold	34.5531389	-111.4075278
CGBRA001.36	BRIGHT ANGEL CREEK	Coconino	warm	36.1117883	-112.0889186
CGSHI000.05	SHINUMO CREEK	Coconino	warm	36.2373222	-112.3486667
MGSYD009.13	SYCAMORE CREEK	Yavapai	warm	34.3473903	-111.9514033
MGLAS004.52	LITTLE ASH CREEK	Yavapai	warm	34.3837786	-112.02585
SPHSC010.67	HOT SPRINGS CANYON	Cochise	warm	32.3541164	-110.2679189
SPBHC004.31	BUEHMAN CANYON CREEK	Pima	warm	32.4063333	-110.5407778
SRWPN004.47	West Fork Pinto Creek	Gila	warm	33.4394444	-111.0638889
UGSFR034.57	SAN FRANCISCO RIVER	Greenlee	warm	33.2009444	-109.1491389

Station ID	Waterbody Name	County	Region	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
UGBON006.41	BONITA CREEK	Graham	warm	32.9565628	-109.5318014
UGEAG040.33	EAGLE CREEK	Greenlee	warm	33.2943656	-109.4946633
UGDIX000.78	DIX CREEK	Greenlee	warm	33.1971944	-109.1579167
VRWBV012.35	WET BEAVER CREEK	Yavapai	warm	34.6744722	-111.6720833
VRFOS014.33	FOSSIL CREEK	Yavapai	warm	34.4243056	-111.5731944
VRWCL010.66	WEST CLEAR CREEK	Yavapai	warm	34.5386111	-111.6941667
VRVER165.07	VERDE RIVER	Yavapai	warm	34.8936803	-112.2122153
VRWBV012.56	WET BEAVER CREEK	Yavapai	warm	34.6739211	-111.6701661
VRSYW001.72	SYCAMORE CREEK	Yavapai	warm	34.8822694	-112.0671

Table 3. Condition Class Thresholds

Stressor	Region	Most-Disturbed	Least-Disturbed
Percent fines	cold	> 29%	≤ 16%
	warm	> 35%	≤ 20%
Canopy cover	cold	< 33%	≥ 55%
	warm	< 20%	≥ 37%
Macrophyte cover	cold	> 63%	≤ 29%
	warm	> 73%	≤ 46%
Algae cover	cold	> 21%	≤ 13%
	warm	> 65%	≤ 32%
Percent riffle	cold	< 14%	≥ 40%
	warm	< 15%	≥ 17%
Habitat rating % ideal	cold	< 81%	≥ 89%
	warm	< 70%	≥ 76%
PFC % ideal	cold	< 74%	≥ 83%
	warm	< 68%	≥ 82%
Turbidity	cold	> 10 NTU	≤ 5 NTU
	warm	> 54 NTU	≤ 20 NTU
Specific Conductivity	cold	> 338 uS/cm	≤ 173 uS/cm
	warm	> 662 uS/cm	≤ 543 uS/cm
SSC	cold	> 15 mg/L	≤ 9 mg/L
	warm	> 35 mg/L	≤ 16 mg/L
pH	cold	<6.5 or >9.0 SU	6.5 – 9.0 SU
	warm	<6.5 or >9.0 SU	6.5 – 9.0 SU
Dissolved Oxygen	cold	<90% or <7.0 mg/L	>90% or ≥7.0 mg/L
	warm	<90% or <6.0 mg/L	>90% or ≥6.0 mg/L

APPENDIX G – REFERENCES

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