Prepared in cooperation with the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service

Discharge and Sediment Concentration in the Bill Williams River and Turbidity in Lake Havasu During and Following High Releases from Alamo Dam, Arizona, in March and April 2010

Open-File Report 2011-1129

COVER

Lake Havasu near the mouth of the Bill Williams River, March 17, 2010. Turbid water caused by high releases from Alamo Dam is visible in the foreground. Photo taken by Jamie Macy, U.S. Geological Survey.

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By Stephen M. Wiele, Jamie P. Macy, Hugh L. Darling, Robert J. Hart, and
Andrew B. Hautzinger

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Contents

Abstract.....	1
Introduction.....	1
Acknowledgments.....	1
Methods and Results.....	1
Streamflow-Gaging Station Discharge Records and Measurements in the Bill Williams River.....	1
Suspended Sediment Sampling in the Bill Williams River.....	3
Turbidity and Water-Quality Field Measurements in Lake Havasu.....	3
References Cited.....	4

Appendix 1. Suspended sediment concentrations and discharge measurements on the Bill Williams River (Attached Excel file)

Appendix 2. Turbidity and other water-quality data for selected sites on Lake Havasu (Attached Excel file)

Figures

1. Map showing measurement and sampling locations on the Bill Williams River and in Lake Havasu.....	2
2. Discharge at the Bill Williams River below Alamo Dam and Bill Williams River near Parker streamflow gaging stations from the start of water year 2010 through the end of June.....	3
3. Discharge records at the Bill Williams River below Alamo Dam and Bill Williams near Parker streamflow gaging stations and discharge measurements at the Bill Williams River at Mineral Wash near Planet and Bill Williams River at Lake Havasu sites.....	3
4. Measured discharge at the Bill Williams River at Mineral Wash near Planet and Bill Williams River at Lake Havasu sites and total sediment concentrations derived from samples at those locations.....	4
5. A perspective view to the northwest of continuous turbidity measurements in Lake Havasu during the planned releases from Alamo Dam.....	5

Conversion Factors and Abbreviations

Inch/Pound to SI

Multiply	By	To obtain
Length		
foot (ft)	3.281	meter (m)
mile (mi)	1.609	kilometer (km)
Flow rate		
foot per second (ft/s)	0.3048	meter per second (m/s)
Discharge		
cubic foot per second (ft ³ /s)	0.0278	cubic meter per second (m ³ /s)

SI to Inch/Pound

Multiply	By	To obtain
Length		
centimeter (cm)	0.394	inch (in)
Flow rate		
meter per second (m/s)	3.281	foot per second (ft/s)
Concentration		
milligram per liter (mg/L)	1.0	part per million*

* Assuming that the density of water is 1 gram per milliliter (g/mL).

Vertical coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Vertical Datum of 1988 (NAVD 88)."

Horizontal coordinate information is referenced to the insert datum name (and abbreviation) here for instance, "North American Datum of 1983 (NAD 83)."

Altitude, as used in this report, refers to distance above the vertical datum.

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Abstract

Discharges higher than are typically released from Alamo Dam in west-central Arizona were planned and released in 2005, 2006, 2007, 2008 and 2010 to study the effects of these releases on the Bill Williams River. The Bill Williams River Wildlife Refuge is located above the mouth of the Bill Williams River on Lake Havasu, and the river is the subject of ongoing ecological studies. Sediment concentrations and water discharges were measured in the Bill Williams River and turbidity, water temperature, specific conductance, pH, dissolved oxygen, and Secchi depth were measured in Lake Havasu during and after experimental releases in 2005 and 2006 from Alamo Dam. Additional measurements of the same parameters in the Bill Williams River and Lake Havasu were made during releases in 2010, and these are the subject of this report.

Introduction

On March 7, 2010, the Army Corps of Engineers, which operates Alamo Dam (fig. 1), initiated a release of about 3,000 ft³/s that lasted for 36 hours (fig. 2). Another high release was initiated on March 15, 2010, that had a peak discharge of about 2,000 ft³/s lasting about 157 hours (fig. 2). The U.S. Geological Survey (USGS) measured discharge and sampled suspended sediment at two locations on the Bill Williams River during the peak and on the rising and falling limbs of the first release. The USGS also measured turbidity and other physiochemical properties in Lake Havasu during both releases and after the recession of the second release. The USGS currently operates two streamflow gaging stations on the Bill Williams River that provide discharge data at 15-minute intervals. This report describes the measurement methods for discharge, suspended sediment, turbidity, and other physiochemical parameters and documents the measurement results. Information about the study area, previous and related work,

and sediment, discharge, turbidity, and physiochemical data collected during high releases in 2005 and 2006 can be found in Wiele and others (2009).

The inlets to the Central Arizona Project (CAP) canal and Wilmer Pumping Plant operated by CAP are located in Lake Havasu, and consequently the turbidity of the water in Lake Havasu is a major concern for the CAP. The CAP made additional turbidity measurements during the same time period as this study and presented them along with a discussion of the impacts of increased turbidity on their operation (Central Arizona Project, written commun., 2010).

Acknowledgments

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Methods and Results

Streamflow Gaging Station Discharge Records and Measurements in the Bill Williams River

There are currently two active USGS streamflow gaging stations on the Bill Williams River (fig. 1): Bill Williams River below Alamo Dam (gage number 09426000) and Bill Williams River near Parker (09426620). The locations of two additional sites are used to indicate measurement locations: Bill Williams River at Mineral Wash near Planet (09426600) and Bill Williams River at Lake Havasu (09426630), which is located near the mouth of the Bill Williams River and was designated as a gaging site for the 2005 discharge measurements and sediment sampling (fig. 1). The Bill Williams River at Mineral Wash

2 Discharge and Sediment Concentration in the Bill Williams River and Turbidity in Lake Havasu, Arizona

Figure 1. Map showing measurement and sampling locations on the Bill Williams River and in Lake Havasu. The sampling locations on the Bill Williams River are below Alamo Dam (09426000), at Mineral Wash (09426600), near Parker (09426620), and at Lake Havasu (0926630). The discharge and sediment measurements are given in appendix 1. All of the sampling sites from 2005 and 2006 are shown. Sampling sites and measurements in 2010 are listed in appendix 2.

near Planet site is about 1 mile upstream from the Bill Williams River near Parker gage and about 3 miles downstream from the Bill Williams River at Planet site that was used for sampling in 2005 and 2006. More information about gaging and sampling sites was provided by Wiele and others (2009). During the 2010 releases, six discharge measurements were made at the site near

Planet and nine discharge measurements were made at Lake Havasu using the methods described by Rantz (1982) (figs. 2 and 3). Complete gage records and additional gage information can be found at <http://waterdata.usgs.gov/az/nwis/nwis>. Measured discharges at the Mineral Wash and Lake Havasu sites during the 2010 releases are provided in appendix 1.

Figure 2. Discharge records at the Bill Williams River below Alamo Dam and Bill Williams River near Parker streamflow gaging stations from the start of water year 2010 through the end of June.

Suspended Sediment Sampling in the Bill Williams River

Suspended sediment samples were collected at the Mineral Wash near Planet and the Lake Havasu (Bill Williams River mouth) sites (appendix 1 and fig. 4) during the 2010 releases. The samples at the river mouth were collected from a boat and integrated vertically and across the channel using standard methods as described by Edwards and Glysson (1999). Point samples were collected at the Mineral Wash near Planet site by wading. Discharges above 500 ft³/s were too swift to safely wade or operate a stationary boat at the Mineral Wash near Planet site. When the discharge was greater than 500 ft³/s, the suspended sediment was sampled with a point sampler about 5 to 10 feet from the bank and 4 feet below the surface.

The sediment samples were analyzed by the USGS sediment laboratory at the David A. Johnston Cascade Volcano Observatory, Vancouver, Washington. The analysis determined the sediment concentration and the percent finer for 10 size classes. Suspended sediment data are in appendix 1.

Turbidity and Water-Quality Field Measurements in Lake Havasu

The turbidity and water-quality field parameters were measured in Lake Havasu with the same methods employed in the 2006 study (Wiele and others, 2009). The sampling locations in Lake Havasu during this study were a subset of the sampling locations in 2005 and 2006 (fig. 1).

The study area extended from the mouth of Bill Williams River on the east, westward toward the forebay of Parker Dam. A numbering system consisting of 30 sampling points was designed for the area of study in Lake Havasu for the sampling in 2005 and 2006 (fig. 1; Wiele and others, 2009). Twenty-two of those locations were used for the 2010 sampling. The sites were georeferenced using a handheld Garmin global positioning

Figure 3. Discharge data during the March 2010 high release from Alamo Dam—discharge records at the Bill Williams River below Alamo Dam and Bill Williams near Parker streamflow gaging stations; discharge measurements at the Bill Williams River at Mineral Wash near Planet and Bill Williams River at Lake Havasu sites.

system (GPS) device. Depth-profile measurements of turbidity (fig. 5), specific conductance, water temperature, dissolved oxygen, and pH were made at the sampling points. The complete Lake Havasu data sets are given in appendix 2.

A Sea-Bird Electronics (<http://www.seabird.com/>) SBE25 was used to make water-parameter profile measurements. The pressure, water temperature, specific conductance, pH, dissolved oxygen, and turbidity sensors on the SBE25 are calibrated annually by the manufacturer. Calibration coefficients were updated in the Sea-Bird software following calibration. All measurements from the SBE25 are included in appendix 2.

The Sea-Bird SBE25 was programmed to scan the sensors at 8 Hz. At this frequency, the profiler scanned each sensor eight times per second. A descent rate (or downcast) of about 1 m/s was used. The data were logged as raw voltages from the sensors in hexadecimal format. Start time of the downcast and other information pertinent to the measurement site were recorded for site identification purposes. Data presented in this report are based on derived, converted, and bin-averaged values from the raw hexadecimal data files.

A 20-cm-diameter Secchi disk was used to measure the transparency of water. Secchi-disk measurements were made from the shaded side of the boat. The disk was lowered through the water column until it was no longer visible, and the depth of the disk was recorded. This process was repeated three times, and the average value recorded. In addition to water turbidity, Secchi-disk transparency depends on several

other factors, including the observer's eyesight, the contrast between the disk and the surrounding water, the reflectance of the disk, and the disk's diameter (Cole, 1975). The surface condition of the lake also can affect the readings.

References Cited

- Cole, G. A., 1994, Textbook of limnology: Saint Louis, C.V. Mosby Company, 283 p.
- Edwards, Thomas K., and Glysson, G. Douglas, 1999, Field methods for measurement of fluvial sediment: Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 3, Chap. C2, 89 p.
- Rantz, S.E., 1982, Measurement and computation of stream-flow-Volume 1. Measurement of stage and discharge: U.S. Geological Water-Supply Paper 2175, 284 p.
- Wiele, S.M., Hart, R.J., Darling, H.L., and Hautzinger, A.B., 2009, Sediment transport in the Bill Williams River and turbidity in Lake Havasu during and following two high releases from Alamo Dam, Arizona, in 2005 and 2006: U.S. Geological Survey Scientific Investigations Report 2009-5195, 22 p., accessed online December 15, 2010 at <http://pubs.usgs.gov/sir/2009/5195/>.

Figure 4. Measured discharge at Bill Williams River at Mineral Wash near Planet and Bill Williams River at Lake Havasu sites and total sediment concentrations derived from samples at those locations.

Figure 5

Figure 5. A perspective view to the northeast of continuous turbidity measurements in Lake Havasu during the planned releases from Alamo Dam in March and April, 2010. The scale is approximate because the perspective view is distorted. Vertical columns represent the turbidity values at depth for each measurement site. Black dots show the location and number of each measurement site. Site numbers correspond to those in figure 1 (and in appendixes). NTU stands for nephelometric turbidity unit.

Figure 5. — Continued.

Figure 5. — Continued.

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