MEMORANDUM

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SUBJECT: **Cienega Creek Natural Preserve Surface Water and Groundwater Monitoring Annual Report for the 2010-2011 Fiscal Year**

DATE: July 22, 2013

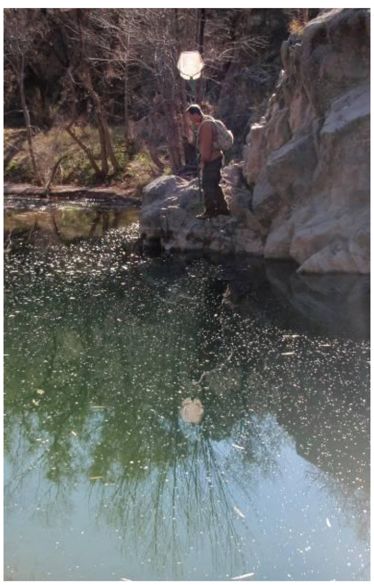
Please find the enclosed 2010-2011 Fiscal Year annual report for the Cienega Creek Natural Preserve Monitoring Project. This technical report summarizes PAG's groundwater and surface water monitoring between July 2010 and June 2011. The report has been shortened to include a simpler analysis and less detailed methodology. Detailed methods are available upon request, separately.

If you have any questions and/or would like any additional information, please feel free to call me at 792-1093.

Pima County's Cienega Creek Natural Preserve

Surface Water and Groundwater Monitoring Project – PAG Annual Report

Fiscal Year 2010-2011



Pima Association of Governments

Prepared for the Pima County Regional Flood Control District
by Pima Association of Governments

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Introduction

This report describes work completed by Pima Association of Governments (PAG) as part of its 2010-2011Overall Work Program, which includes monitoring in lower Cienega Creek and Davidson Canyon. The purpose of PAG's monitoring program is to establish baseline hydrologic conditions for comparison purposes, so that long-term trends and conditions are documented and changes can be detected. This monitoring is consistent with the management plan for the preserve in which the goals include to maintain in-stream flows, preserve tree-sustaining shallow groundwater and preserve native plant and animal species. PAG has monitored the hydrology in the Cienega Creek Natural Preserve (Preserve) since 1989, in coordination with the Pima County Regional Flood Control District (PCRFCD). This report contains data collected between July 1, 2010 and June 31, 2011 (the fiscal year, i.e. monitoring year) consisting of streamflow volume, groundwater levels, streamflow length (through the extent of the Preserve), water chemistry and photography. It also includes notes on additional PAG observations and studies. Data tables and figures in this report focus on results from the 2010-2011monitoring year, but they also show some data from previous years for comparison purposes.

The Cienega Creek Natural Preserve, which is owned by PCRFCD and co-managed by PCRFCD and Pima County Natural Resources Parks and Recreation (PCNRP&R), includes lower Cienega Creek and portions of lower Davidson Canyon. For ease of reading, the following geographically distinct areas are referred to in these terms throughout the report.

- Cienega Creek
  This area is defined as reach of lower Cienega Creek between Interstate 10 and the diversion dam east of Vail, Arizona. This area is the main focus of PAG's hydrologic monitoring program.
- Cienega Creek Natural Preserve
  This area includes lower Cienega Creek, Empirita Ranch south of I-10, and monitoring sites in lower Davidson Canyon.
- Cienega Watershed
  This area includes the Preserve area and monitoring sites in upper Davidson Canyon (not in the Preserve, south of I-10)
- Upper Cienega Creek
  The report does not include upper Cienega Creek which includes the Las Ciénegas Natural Conservation Area, managed by the U.S. Bureau of Land Management (BLM). Las Ciénegas is where the headwaters begin and flow north.

The locations of all of the monitoring sites are shown in Figures 1A and1B. During FY 10-11, monitoring methods and locations remained essentially the same as in past years, with any exceptions for this year explained in this report. PAG has further documentation for project purpose, background, important findings, protocols, forms and metadata available in-house, as well as reports from previous years available in the PAG on-line library. The specific methodology for each aspect of monitoring is described in past reports and updated in PAG internal documents, available upon request.

Figure 1A. PAG Monitoring Site Locations in the Cienega Creek Watershed

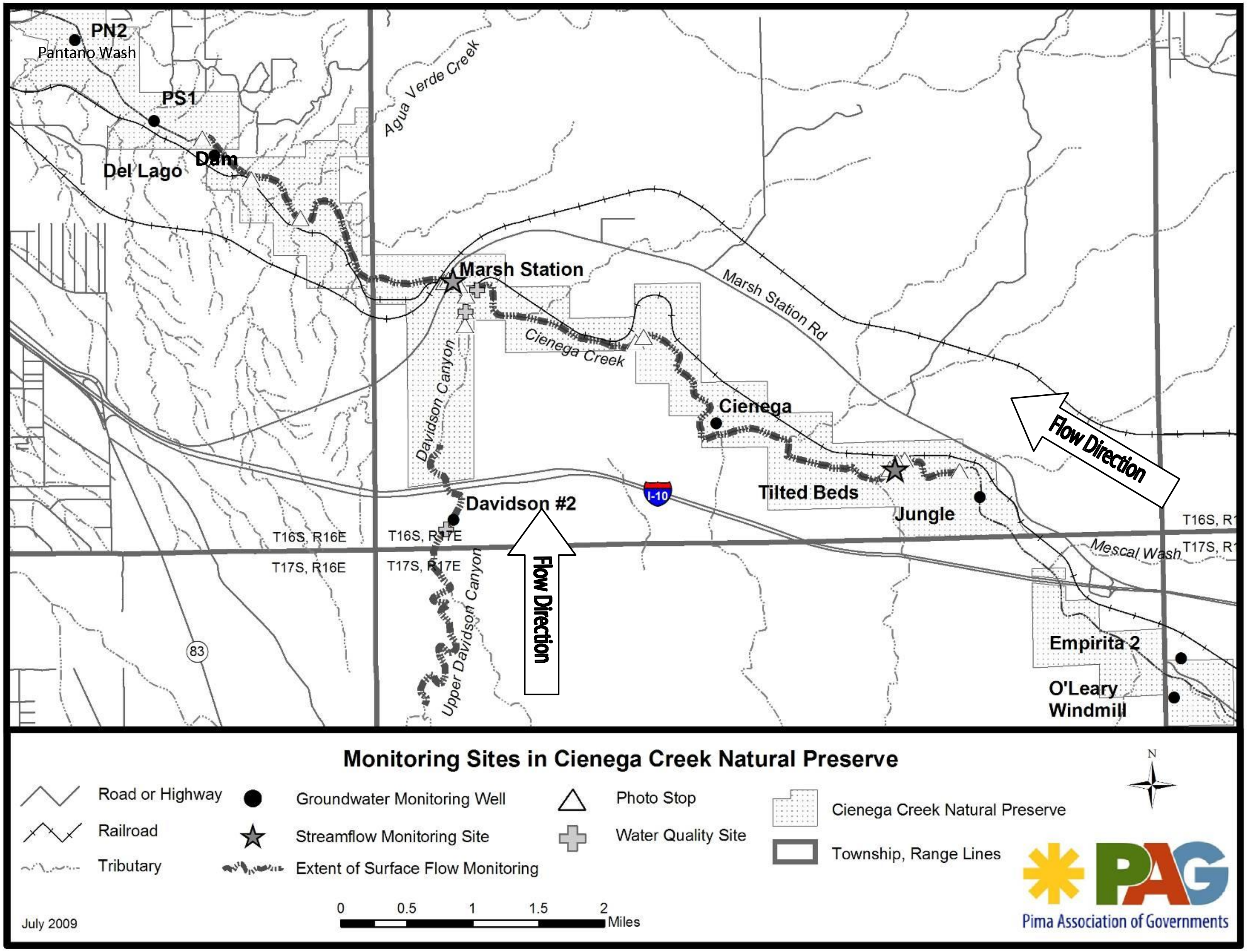
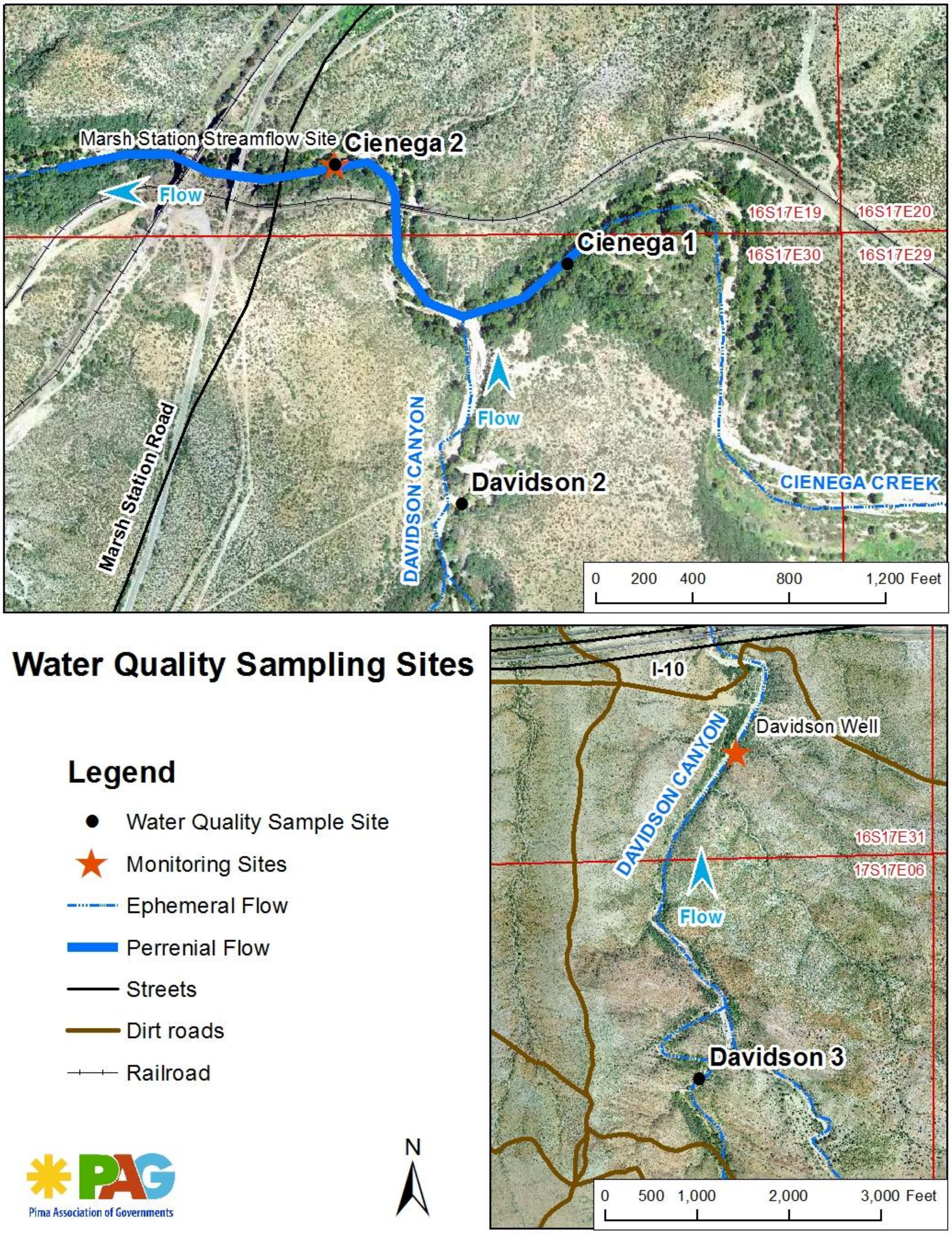


Figure 1B. PAG Water Quality Monitoring Site Locations



Streamflow Volume

Methods

In Fiscal Year (FY) 2010-2011, PAG took monthly streamflow volume measurements at two sites using a USGS Pygmy Flow Meter and calculated the discharge (Q) in cubic feet per second (cfs). The sites are Marsh Station Road Bridge, downstream from the Cienega/Davidson confluence, and Tilted Beds, several miles upstream from Marsh Station (Figure 1A). PAG monitors the streamflow during baseflow conditions, as required in the methodology of the program. Baseflows are produced by discharges from the shallow aquifer into the stream channel without the direct influence of surface runoff.

Results

FY 2010-2011Results

The range in seasonal fluctuation at Marsh Station was notably small this monitoring year. The difference between the high flow month and low flow month was 0.63 cfs, whereas the FY2008-2009 monitoring year fluctuated by 1.78 cfs. In the previous monitoring year we found that September 2009 had the lowest flow record for any September due to lack of monsoon rains (Figure 2). This monitoring year, June 2011, was the lowest June record with 0.05 cfs flow. The lowest flow on record for any month was 0 cfs in July 2004.

Tilted Beds exhibited no baseflow for the second year in a row (Table 1). Tilted Beds has a pattern of winter flow for 2-3 years, followed by absence of flow for 2-3 years (Figure 3). From 2007 to 2009, Tilted Beds exhibited nearly consistent flow throughout the year. This site's flow may be ephemeral because it is more impacted by sedimentation and erosion processes than the Marsh Station site. This demonstrates the complexity behind determining whether a site is ephemeral or intermittent during drought.

Historical Trends

Annual average streamflow remained lower than last year's levels at the streamflow sites. Streamflow data for this fiscal year for both sites are shown in Table 1, while Figure 2 graphically presents the streamflow trends for the past two fiscal years. To provide a longer term perspective on flow trends, Figure 3 shows discharge data from 1993 to the present.

Since monitoring began in 1993, annual average flow has declined over time. The annual average streamflow at Marsh Station was at its lowest this year with 0.32 cfs average flow volume. This is similar to last year, lower by only 0.07 cfs (Table 1). Annually averaged flow has fluctuated up and down within the long-term downward trend of streamflow volume at our perennial streamflow measuring site, Marsh Station (Figure 4). The two upward swings in annual average flow became lower each time (around 2001 and around 2008). Low periods of flow similarly became lower during 1996-2000, 2002- 2006, and 2010..

Table 1. Monthly Streamflow Volumes (July 2010 - June 2011)

DATE	FLOW (cfs) Marsh Station	FLOW (cfs) Tilted Beds
Monthly Monitoring Data		
July 2010	0.20	0.00
August 2010	0.10	0.00
September 2010	0.34	0.00
October 2010	0.27	0.00
November 2010	0.25	0.00
December 2010	0.48	0.00
January 2011	0.68	0.00
February 2011	0.59	0.00
March 2011	0.51	0.00
April 2011	0.33	0.00
May 2011	0.09	0.00
June 2011	0.05	0.00
Recent Annual Mean Flows (cfs)		
2006-2007 AVERAGE	1.06	0.00
2007-2008 AVERAGE	0.99	0.07
2008-2009 AVERAGE	1.16	0.09
2009-2010 AVERAGE	0.39	0.00
2010-2011 AVERAGE	0.32	0.00
Flow Change Per Specified Period (cfs)		
06-07 to 07-08 CHANGE (1)	- 0.07	+ 0.07
07-08 to 08-09 CHANGE (1)	+ 0.17	+ 0.02
08-09 to 09-10 CHANGE (1)	- 0.77	- 0.09
09-10 to 10-11 CHANGE (1)	- 0.07	- 0.00

Table Notes

PAG measured all flows with a USGS Pygmy Flow Meter.

(1) = "CHANGE" is defined as the difference between annual averages

"+" = Increase in discharge

"-" = Decrease in discharge

Figure 2. Monthly Streamflow Volume at Tilted Beds and Marsh Station Sites (July 2008 -June 2011)

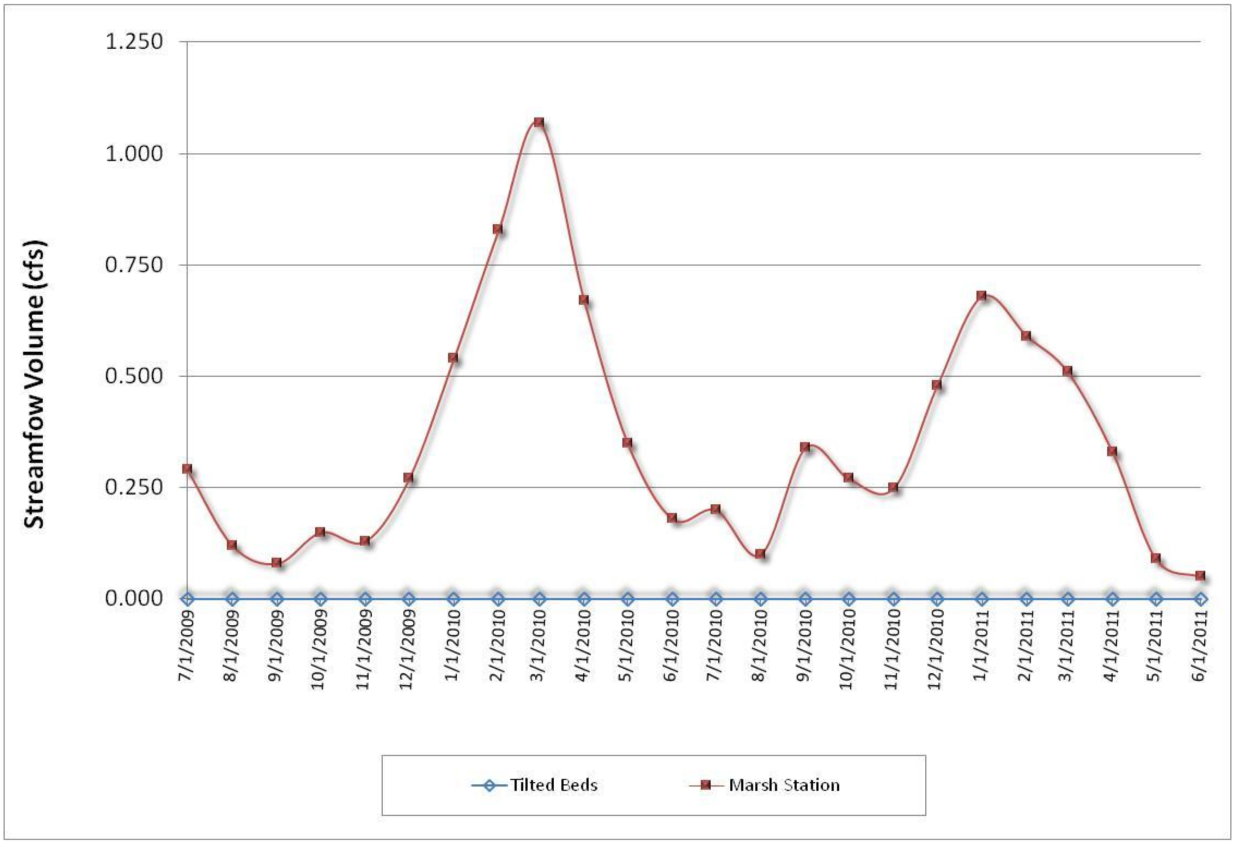


Figure 3. Monthly Streamflow Volume at Tilted Beds and Marsh Station Sites (1993 – 2011)

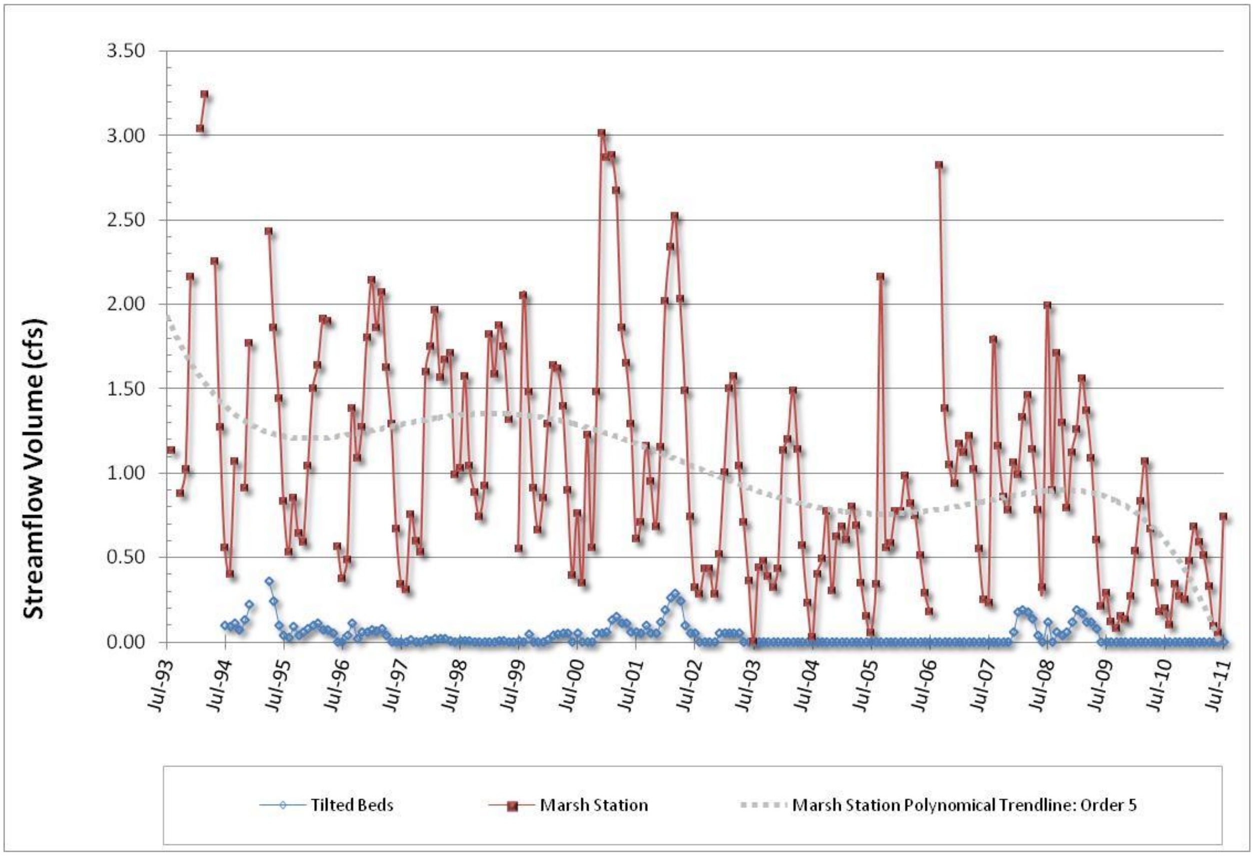
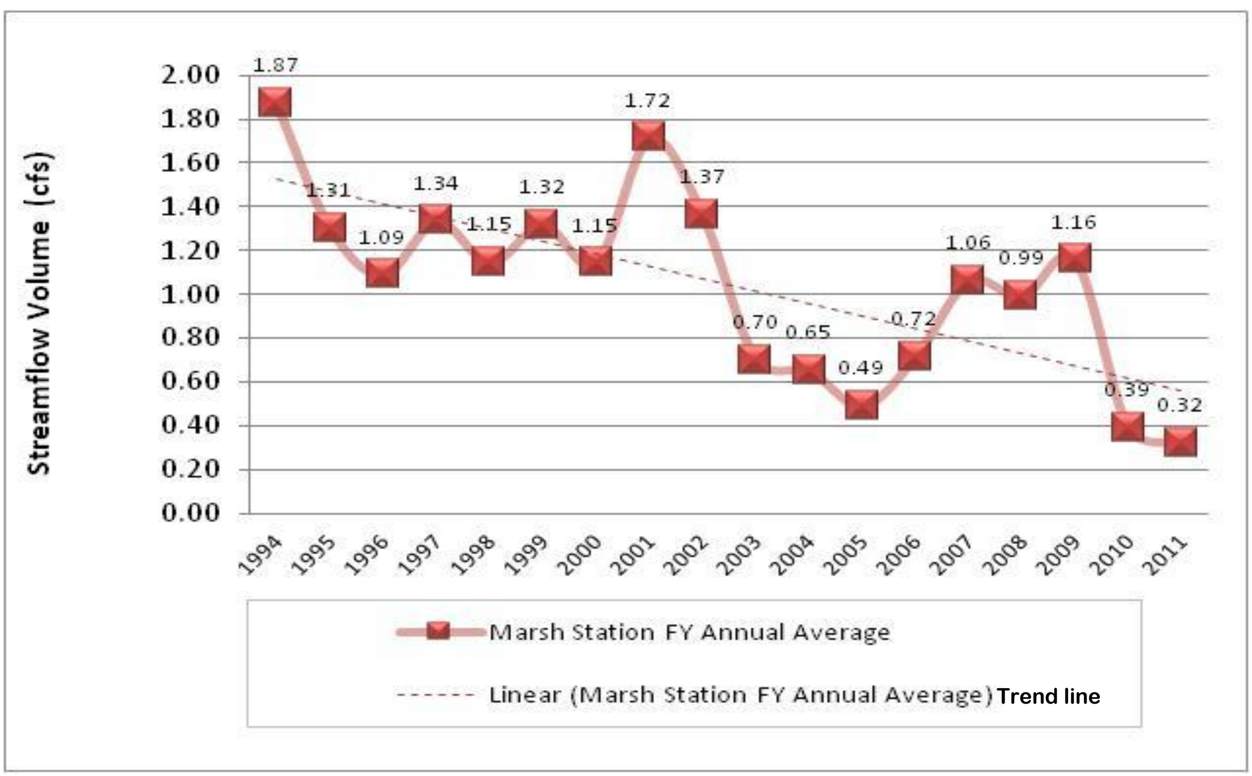


Figure 4. Annual Mean Streamflow Volume Trends at Marsh Station (FY 93-94 to FY 10-11)



Groundwater Levels

Methods

Depths to groundwater were measured at eight wells with either a Solinst Water Level Meter or with *in situ* transducers. The wells are distributed throughout the preserve length and are named (Figure 1A). On a monthly basis, PAG monitored the Jungle, Cienega, Del Lago 1and Empirita 2 (when accessible) well sites. Davidson 2 continued to be monitored on a quarterly schedule. The PS-1 and PN-2 wells were monitored four times a day by ADWR transducers. If any monitor dates fell outside of this schedule, it is noted in Table 2. Because the O'Leary well had a pump installed in June 2007, which influenced subsequent water levels, it has been monitored irregularly and has been removed from several calculations.

Results

Trends in groundwater levels follow trends of streamflow closely. Recent mean annual changes are displayed in Figure 5 and Table 3, while Figure 6A exhibits the long-term trends, showing water level data from 1994 to the present. Figure 6B shows 2005-2011 depth to groundwater for PN-2. In FY 10-11 average depth-to groundwater continued to increase (i.e. dropping water table).

Yearly declines in groundwater levels have been exhibited since 1994, with the exception of a brief rise in 2001 and a more prolonged rise from June 2006 to June 2009.. In 2002, drought began to appreciably impact the Cienega Creek Natural Preserve with wells never averaging above pre-drought levels. In FY 09-10, annual mean water levels dropped appreciably at all wells, reaching one of the most severe drought stages on our records because of the lack of summer monsoons. The average change for the 6 wells listed in Table 3 (selected for their consistently available data) was 7.17 feet lower in depth to groundwater (Table 3). In FY 10-11groundwater levels decreased in most wells, but less drastically than the prior year, averaging 0.66 feet lower(Figure 4).

Table 2. Depth to Groundwater and Streamflow Presence at Cienega Creek Natural Preserve Monitor Well Sites

Monthly Monitoring in FY 10-11

Date	Del Lago	Cienega	Jungle	Empirita[3]	O'Leary*	Davidson[1]	PS-1[2]	PN-2[2]
7/20/10	76.32	20.20	38.65	88.10			56.77	192.39
8/12/10	66.75	17.80	38.24	88.65			47.06	195.34
9/14/10	70.43	16.70	38.12	89.30		16.18	45.72	195.18
10/22/10	76.40	19.22	39.00	89.60			52.76	194.07
11/9/10	76.80	19.80	39.13	89.50			54.51	195.13
12/21/10	74.91	19.53	38.61	88.70	61.48	25.17	56.38	199.13
1/28/11	75.67	18.08	38.12	88.69			55.09	203.61
2/18/11	76.10	17.25	37.87	88.40			55.96	206.10
3/10/11	74.69	16.60	37.66	88.20		26.05	55.64	208.43
4/21/11	76.83	17.15	37.60	87.80			57.53	212.99
5/19/11	76.94	18.80	38.06				58.87	215.77
6/20/11	77.22	20.55	38.92	87.43		27.17	60.09	218.34

Note: *All depths are feet below land surface. Streamflow is observed in the closest streambed location: "y" = streamflow was present, "n" = no streamflow was present. Streamflow presence is accompanied by maximum stream depth data.*

**Due to fluctuation in well water depth levels from pumping, PAG is no longer monitoring the O'Leary well regularly.*

(1) *Measured quarterly*
(2) *Monitored by ADWR*
(3) *Inconsistently accessible*

Table 3. Annual Average Depth to Water and Cumulative Change

	Annual Average Depth to Water (ft.)					Annual Change (ft.)			
DATE	06-07	07-08	08-09	09-10	10-11	06-07 to 07-08	07-08 to 08-09	08-09 to 09-10	09-10 to 10-11
DEL LAGO-1	69.47	72.21	70.68	74.71	74.92	-2.74	1.53	-2.07	-0.21
CIENEGA	15.95	16.27	14.45	18.20	18.47	-0.32	1.82	-3.76	-0.27
JUNGLE	33.99	30.98	31.02	35.56	38.33	3.01	-0.04	-4.54	-2.77
DAVIDSON-2	20.30	22.55	19.17	24.37	23.64	-2.25	-3.38	-5.20	0.73
PS-1	46.88	50.38	46.71	54.91	54.70	-3.50	3.67	-8.20	0.21
PN-2	192.50	183.65	182.10	201.36	203.04	8.85	1.55	-19.26	-1.68

Note:
All depths are feet below land surface.
Davidson is measured quarterly.
PS-1 and PN-2 are monitored by ADWR.
Empirita-2 and O'Leary were inconsistently available, so they are not included.

Figure 5. Annual Change in Average Depth to Water

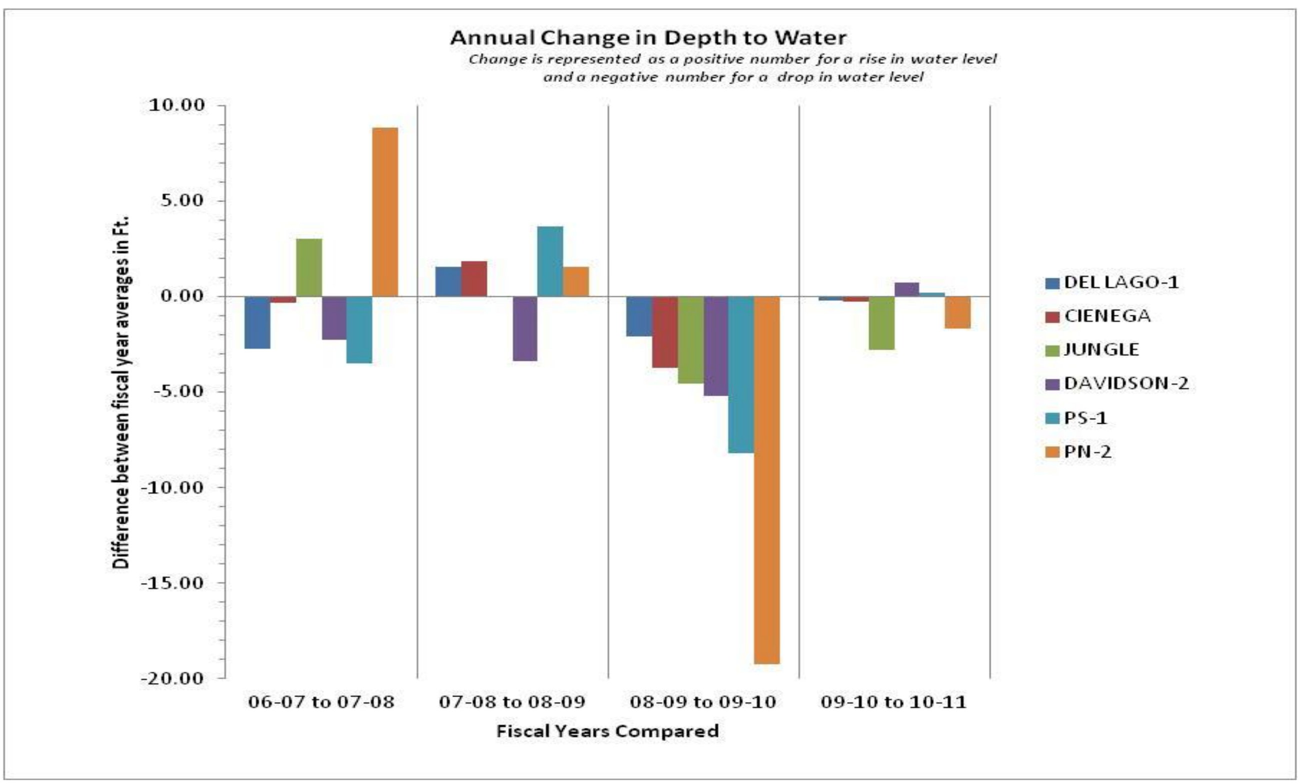
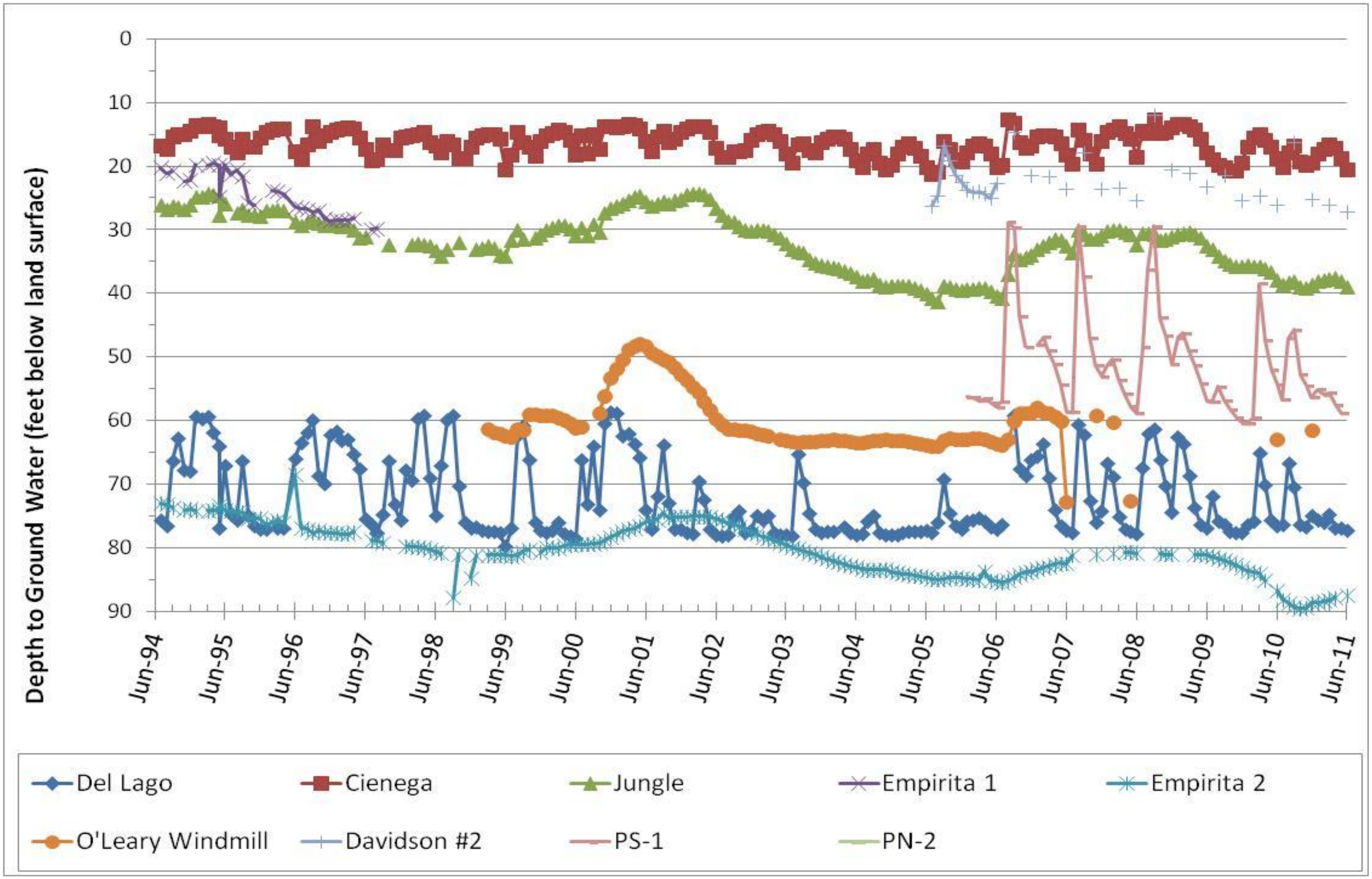


Figure 6A. Cienega Creek Natural Preserve Monthly Depth to Groundwater (June 1994 - June 2011)



See Figure 6B to see PN-2, which fell below the scale of this graph.

Figure 6B. PN-2 Monthly Depth to Groundwater (June 2005 - June 2011)

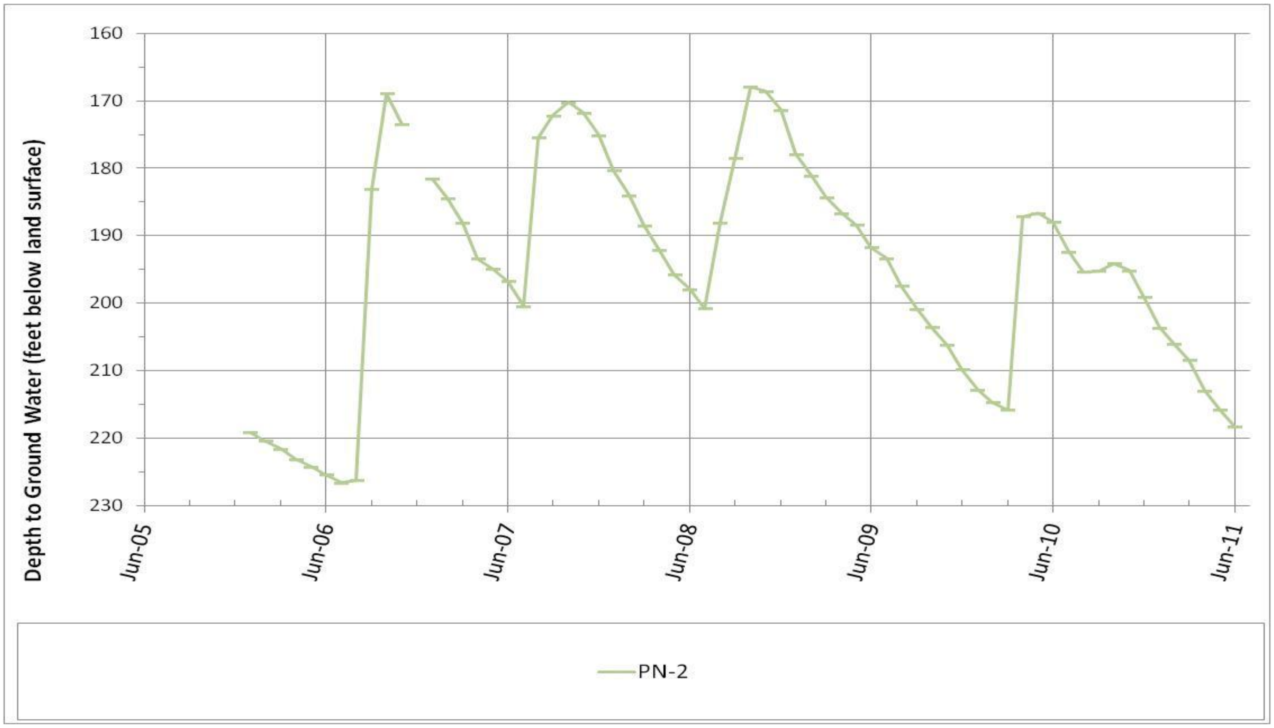
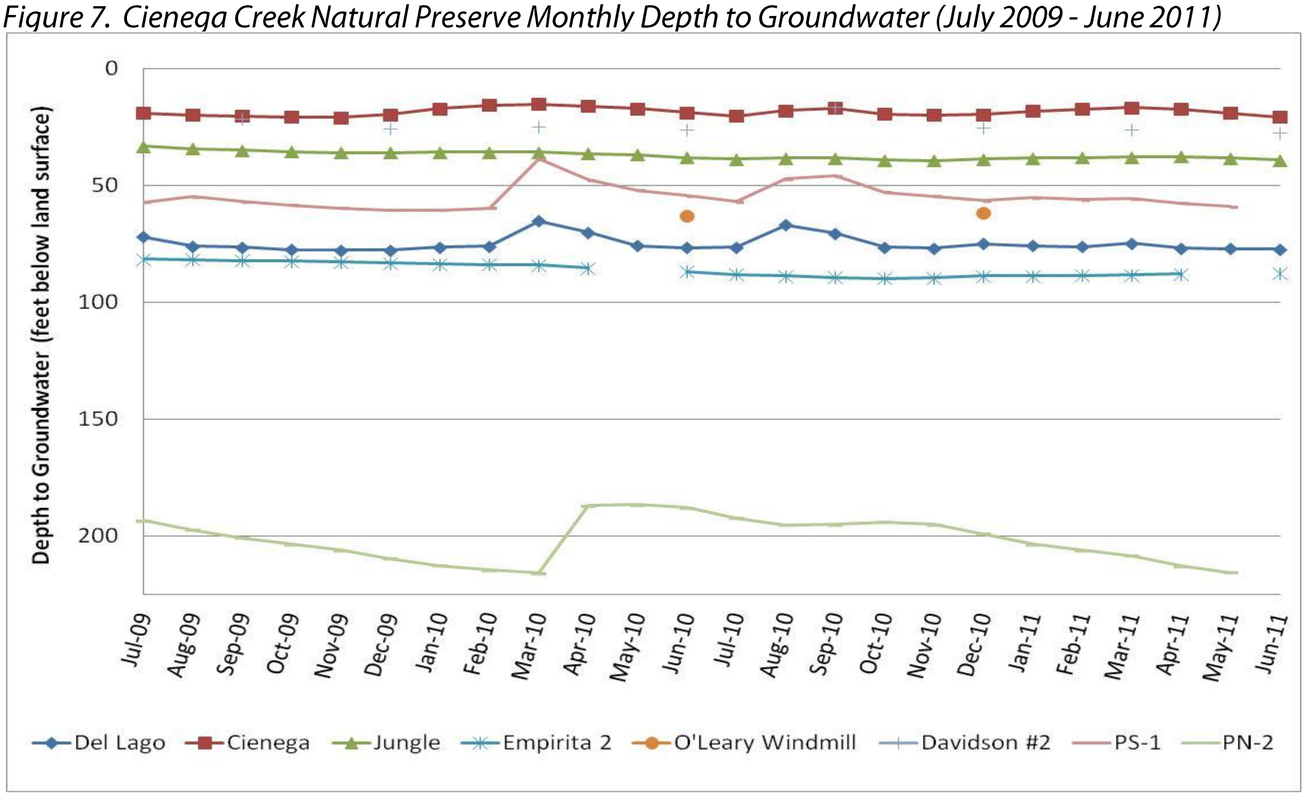


Figure 7. Cienega Creek Natural Preserve Monthly Depth to Groundwater (July 2009 - June 2011)



Data are not available for some months due to inaccessibility.

Extent of Surface Flow (Wet/Dry Mapping Walk-Throughs)

Methods

The extent of surface flow was mapped by walking the length of the creek channels and marking the location of the flows by GPS. For this report, when the length of flow is referred to, the topic is the distance of stream that has flow extent, not the span of time that it is flowing. Quarterly mapping is conducted during the months of September, December, March and June. The length of surface flow for each quarterly walk-through is calculated by totaling the extent of each flowing segment. These flowing segments are located near bedrock highs that bring groundwater to the surface and are separated by dry segments that vary in size with seasonal rains and sediment fluctuations. The total length of creek channel within the preserve is 9.5 miles. This includes the section of creek that begins at the I-10 crossing and flows northwest to the dam. The mapping results are shown in Figure 8 and Figure 11. Located outside the Preserve, the sum of flow length for upper Davidson Canyon (Figure 1A) is calculated and presented separately.

Results

Cienega Flow Extent:
These data are evaluated for trends of average annual total distance of the surface flow length, seasonal variation, intermittency of segments and minimal perennial flow trends.
The annual average total distance of surface flow extent in the Cienega Creek Preserve since 1975 has decreased over time (Figure 10). PAG considers the time period since 2001 to be a drought period.

Mapping streamflow during the driest part of the year conservatively identifies the perennial reaches in the Preserve. As seen in Figure 8, the total flow extent in the Preserve is consistently lowest pre-monsoon, in June. Summer flow extents have declined substantially since the 1980s (Table 5, Figure 12). In July 1984, during a wet period, the creek flowed continuously from I-10 to the Pantano Dam, a distance of 9.5 miles (Montgomery & Associates 1993). PAG noted the lowest flow length in our historical record at 1.26 miles in June 2011. This is about half of the flow length in the previous June. This is 0.24 miles less flow than the previous record low in 2004 and 2005. These records all occur in June.

The wettest seasons have not followed common seasonal trends the last two monitoring years. The month with the longest total flow extent is usually either March or September following summer monsoons or winter rains. Calendar Year 2009 had the lowest September flow length on record. This fiscal year the highest flow was in December 2010 with flow length at 3.89 miles, slightly above September and March of the same fiscal/monitoring year since neither of these normally wet months had great flows. The result, seen in Figure 8 and Table 4 is a low peak in the seasonal fluctuations.

Lower Davidson Canyon Flow Extent:
Since 2001, when mapping began in lower Davidson Canyon near the confluence with Cienega Creek, the extent of surface flow has considerably varied both annually and seasonally. The reach alternates between near year-round flow and near year-round dryness.

Upper Davidson Canyon Flow Extent:
The flowing reaches of upper Davidson Canyon are located at a spring next to a bedrock outcrop south of the I-10 crossing (as seen on the map in Figure 8). This is the sixth year that these surface flows were systematically mapped, but the streamflows along this reach were also noted during earlier PAG studies. In FY 09-10 and FY10-11 the reach had flow only in the September monitoring. Since flows are only inspected on a quarterly basis, there may have been periods where surface flow was present during non-inspection months. Prior to September 2009, flow was seen almost every quarterly month back to when this monitoring began in September 2005.

Table 4. Cienega Creek, Lower Davidson Canyon and Upper Davidson Canyon, Quarterly Data for Flow Extent Monitoring (Sep. 2009 - June 2011)

	Quarterly Flow Extent Monitoring			
	September	**December**	**March**	**June**
Cienega Creek				
FY 10-11 DATE *	9/9/2010	12/14/2010	3/31/11	6/8/2011
FY 10-11 TOTAL FLOW EXTENT (miles)	*3.51*	*3.89*	*3.58*	*1.26*
FY 09-10 TOTAL FLOW EXTENT (miles)	*1.95*	*3.22*	*5.68*	*2.38*
Upper Davidson Canyon				
FY 10-11 date**	9/14/2010	12/21/2010	3/10/11	6/20/2011
FY 10-11 TOTAL FLOW EXTENT (miles)	*.62*	*0****	*0****	*0****
FY 09-10 TOTAL FLOW EXTENT (miles)	*0.58*	*0****	*0****	*0****

Total flow extent is calculated by adding together the GPSed lengths of each segment of flow.
**For specific dates in FY09-10, see the FY09-10 annual report.*
***Upper Davidson Canyon reaches are mapped on different dates than Cienega Creek and lower Davidson Canyon reaches due to the length of time required to complete both creeks.*
****Pools smaller than 20 feet are not considered "flowing extent " in thi s graph, but may have been present and, if so, points were captured by GPS . These points are available upon request.*

Table 5. Cienega Creek and Upper Davidson Canyon, Summer Months' Total Length of Flow Extent, (1984 -2011)

Year	Length of Cienega Creek	Length of Upper Davidson	Source
Jul-84	50,000 ft. (9.5 miles)	No data	Errol L. Montgomery & Associates, Inc.
May-85	50,000 ft. (9.5 miles)		
May-86	43,140 ft. (8.2 miles)		
May-87	43,200 ft. (8.2 miles)		
May-88	41,500 ft. (7.9 miles)		
May-89	34,640 ft. (6.6 miles)		
May-90	37,400 ft. (7.1 miles)		
May-91	42,160 ft. (8.0 miles)		
May-92	37,740 ft. (7.1 miles)		
No data 1993-1998			
Jun-99	14,290 ft. (2.7 miles)	No data	PAG
Jun-00	14,590 ft. (2.8 miles)		
Jun-01	24,950 ft. (4.7 miles)		
Jun-02	17,220 ft. (3.3 miles)		
Jun-03	10,630 ft. (2.0 miles)		
Jun-04	8,145 ft. (1.5 miles)		
Jun-05	7,865 ft. (1.5 miles)		
Jun-06	12,025 ft. (2.3 miles)	170 ft. (.03 miles)	
Jun-07	15,860 ft. (3.0 miles)	483 ft. (.09 miles)	
Jun-08	14,831 ft. (2.8 miles)	0 ft. (0 miles)	
Jun-09	16,127 ft. (3.1 miles)	1,187 ft (.22 miles)	
Jun-10	12,566 ft. (2.4 miles)	0 ft (0 miles)	
Jun-11	6,653 ft. (1.26 miles)	0 ft (0 miles)	

The length of the Cienega Creek channel from Interstate 10 to the Pantano Dam equals 50,000 ft. (9.5 miles) and includes 1,100 ft. (0.21 miles) of Lower Davidson near the confluence with Cienega in this calculation. Upper Davidson includes 22,700 ft. of creek channel (4.3 miles) from the spring south of the I-10 crossing down to the beginning of the Lower Davidson Reach. Data were collected by Errol L. Montgomery & Associates from 1984 to 1993. Data were not collected from 1993 through 1998.

Figure 8. Maps of Cienega Creek and Davidson Canyon, Quarterly Flow Extent (Sep. 2010 - June 2011)

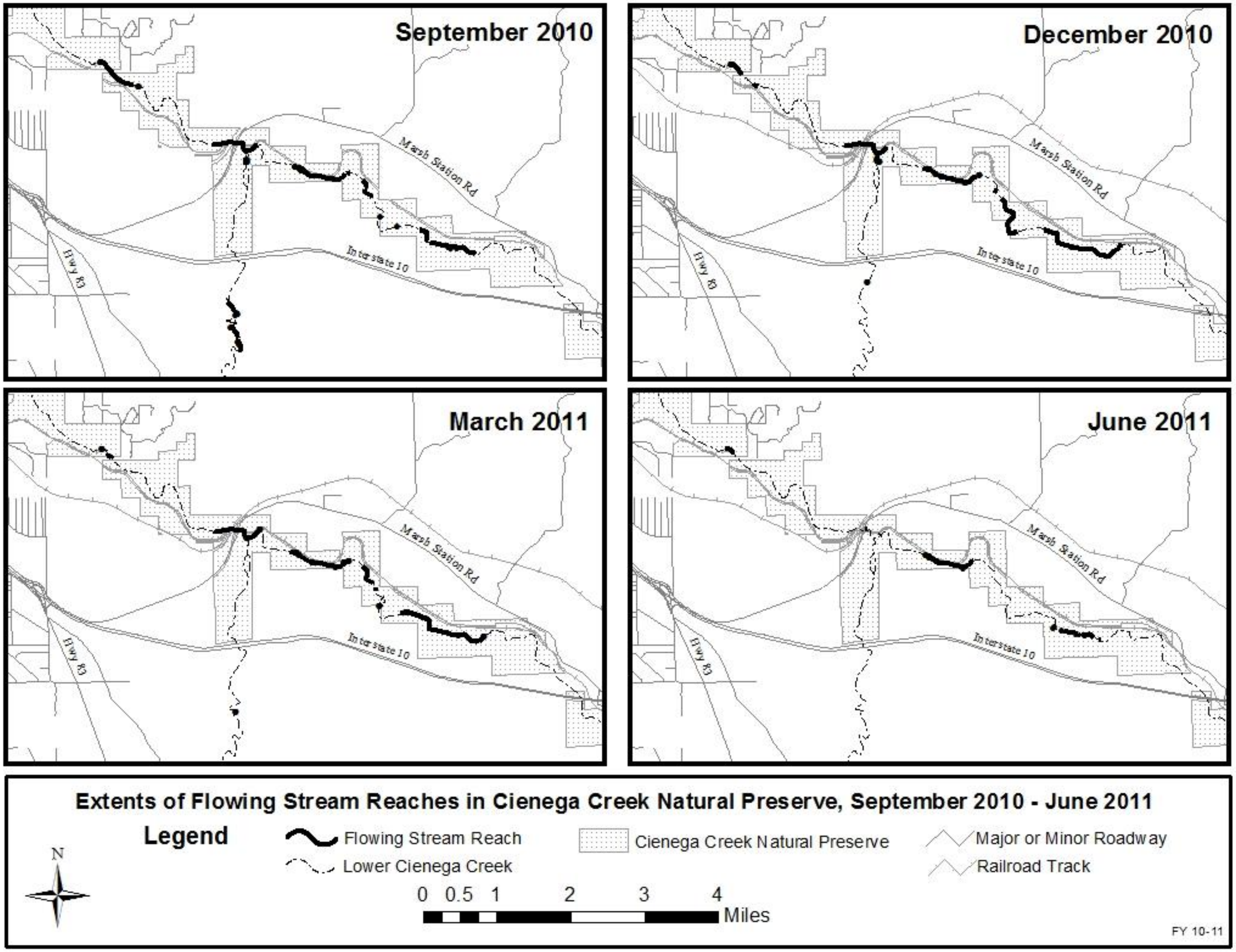


Figure 9. Cienega Creek Quarterly Flow Extent, 1999 to 2011

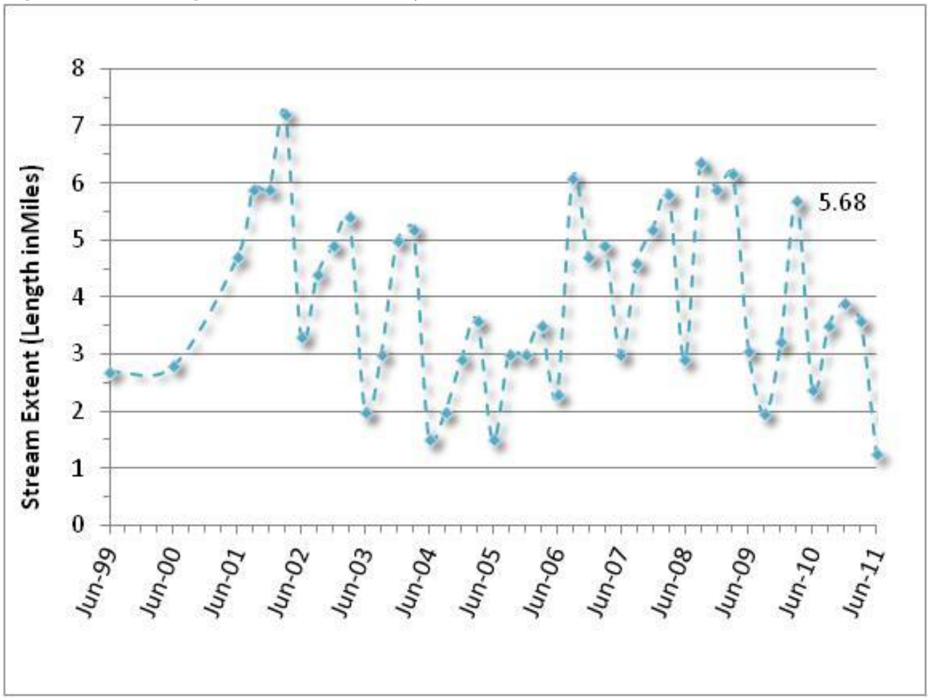
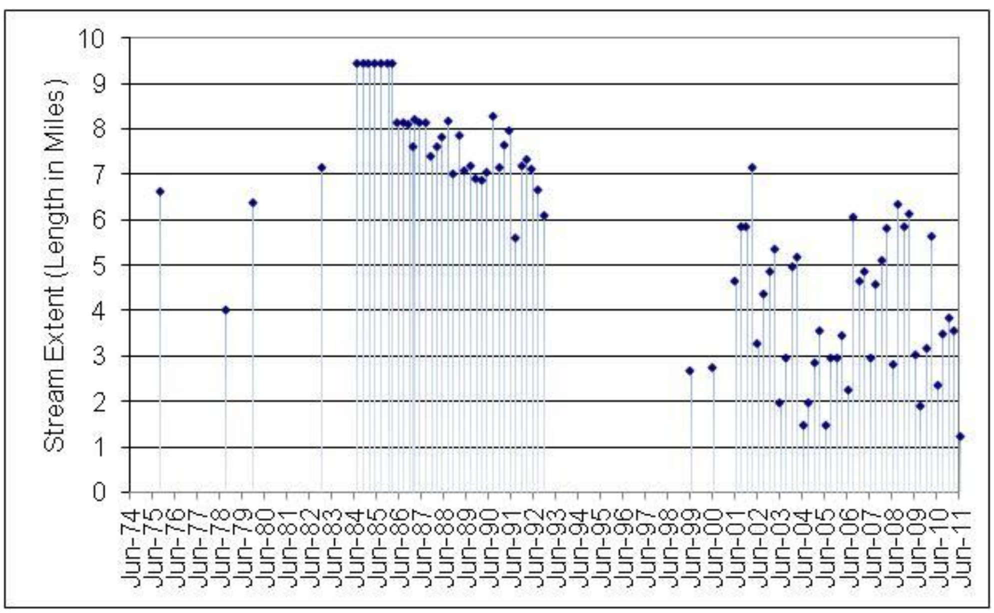
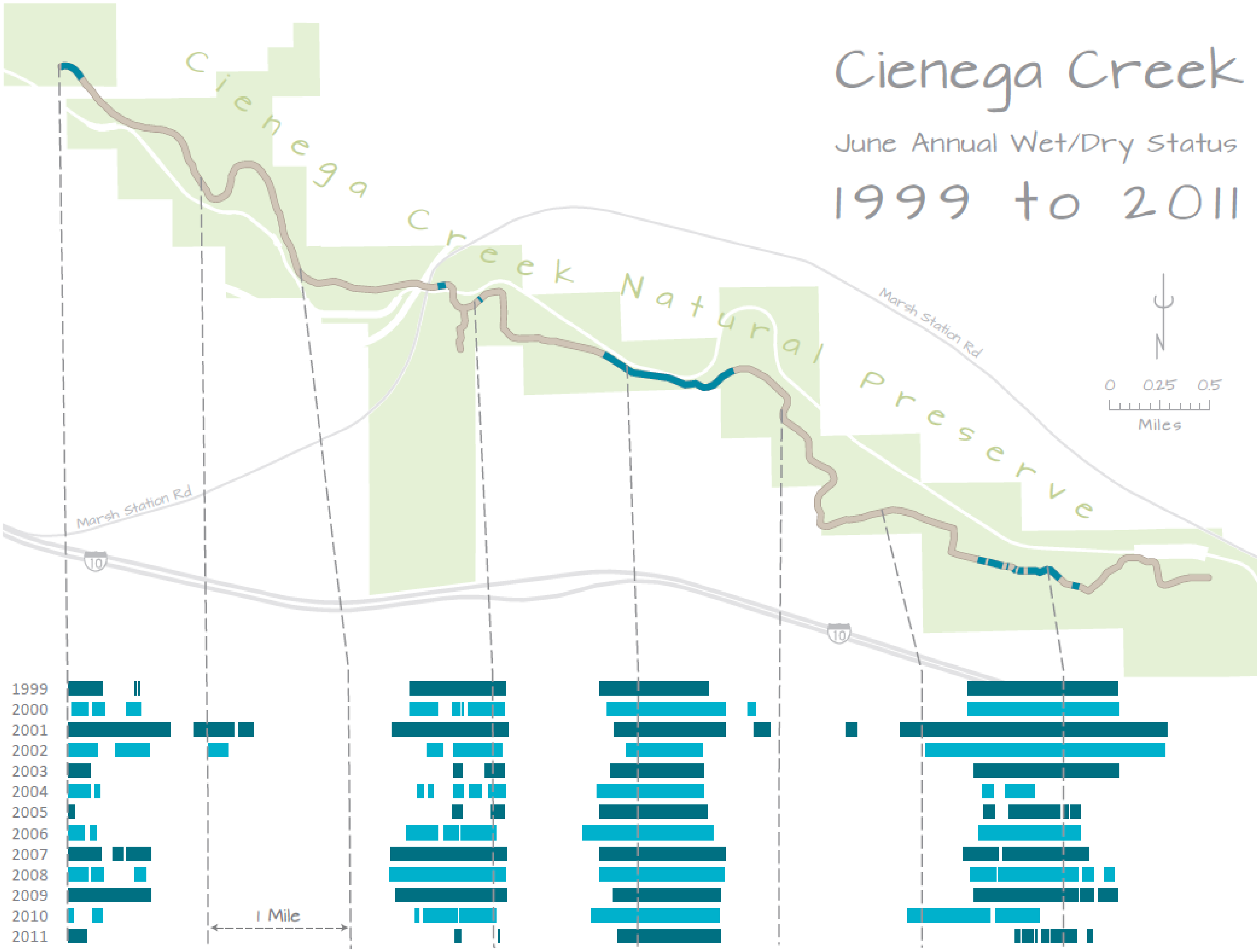


Figure 10. Cienega Creek Flow Extent, 1975 to 2011



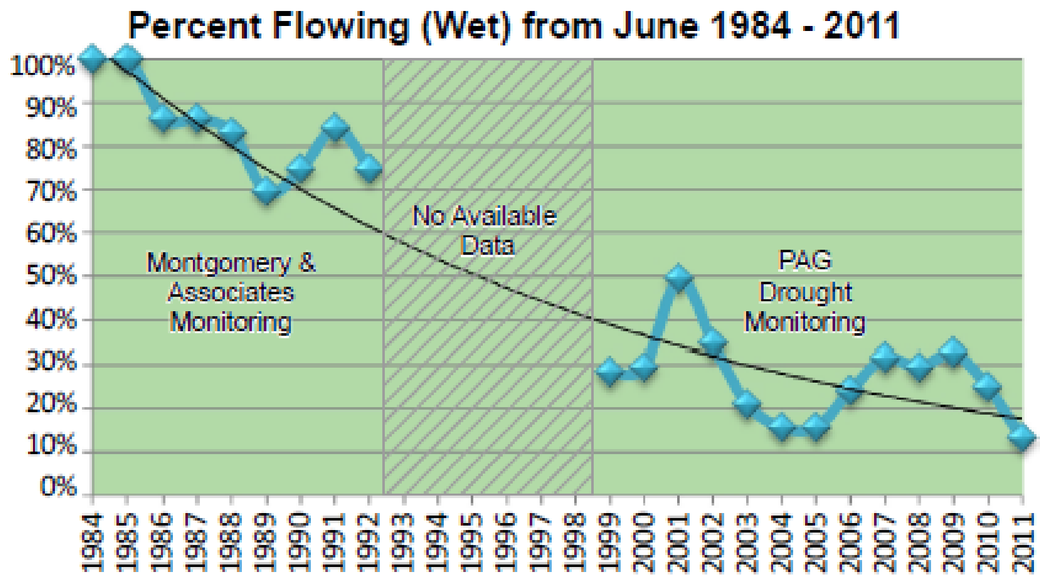
Data prior to 1993 is from Errol L. Montgomery & Associates, (Montgomery & Associates 1993). Prior to 1984, and between 1999 -2000, flow extent was measured but not consistently. Extent length was measured in October 1974, September 1978, December of 1979 and 1982, and June of 1999 and 2000, typically during the drier months. Length was not measured from1993-1998. All other measurements were taken quarterly.

Figure 11. Map of Cienega Creek's June Flowing Reaches -1999 to 2011



Bars represent wet reaches in a linear fashion for each June, 1999-2011. The bars are spatially distributed to correspond to 8 miles of mapped creek length. The colors alternate by year for visual aid. Using GPS technology, teams walk the creek to map where it intermittently flows.

Figure 12. Graph of Percent of Creek Length Flowing in June: Perennial Flow



100% flow refers to the 9.5 miles of creek flow that were present in the wet years of the mid 1980's. This 9.5miles of creek channel starts at the I-10 overpass at the upstream end of the preserve down to the dam and the downstream end of the preserve. Data is available from the 1970s which reveal less than 100% flow, but that monitoring did not take place in June and so is not included in this graph. Since June is typically the driest time of year, but it can be stated regardless that 100% did not flow perennial those years.

Water Chemistry

Methods

The locations of the monitoring sites for water chemistry are displayed in Figure 1B. Current monitoring stations, Davidson 1/3 and Davidson 2 are both located in Davidson Canyon upstream from its confluence with Cienega Creek, and prior to drought both exhibited spatially intermittent baseflow throughout the reach, but now exhibit ephemeral baseflow conditions during this drought. Cienega 1, located just upstream of the confluence with Davidson Canyon is a perennial site. Cienega 2, located downstream from the confluence at Marsh Station Bridge, is also a perennial streamflow monitoring site.

Water quality field parameters are measured quarterly at the four water quality sites. In addition, Cienega 2 field parameters are measured monthly. Field parameters include Total Dissolved Solids, temperature, conductivity and pH. At two sites, samples are collected and processed twice a year, in March and September. A complete list of analytes included in sampling is not included in this report but is available upon request. PCRFCD analyzes the sampling results. Water quality measurements are only gathered during baseflow conditions when clear, non-storm runoff water is flowing in the creek.. Streamflow volume is measured to accompany all sampling efforts. Detailed protocols are available upon request. Documentation of additional water chemistry data from various sources is available at PAG.

Results

Our data shows the seasonal variation and differences in water chemistry between sites, but we did not detect any significant long term trends. The seasonal trend for conductivity is a drop in the fall, fluctuating by about 200 µS within a year (Figure 13). Future isotope tests will help to explain if recent stormwater recharge explains this seasonal variation.

The average conductivity of the Davidson Canyon sites is lower than the Cienega sites. The contribution of Davidson Canyon to baseflows of Cienega Creek possibly plays a role in creating the lower conductivity found at the Cienega site downstream of the Davidson confluence (Cienega 2) when compared to the site upstream of the confluence (Cienega 1) (Figure 13). The long term trend is illustrated in Figure 14, comparing the last few years' data with 2002-2003 data.

Over the last ten years, we found that average conductivity increased slightly at all sites, except for a slight decrease at Davidson 2 (Figure 14).

The pH was highest at Davidson 1/3 and Cienega 2 (located below the confluence) (Figure 15).

The temperature was lowest at Cienega 1 (located upstream of the confluence)(Figure 16).

Davidson 3 serves as a replacement for the Davidson 1 site since March 2007. Depending on the site, readings were measured every 1-3 months, when sites had available flow. No data was collected from 2004-2006.

Figure 13. Cienega Watershed – Seasonal Fluctuation of Conductivity with data available from January 2007 to June 2011

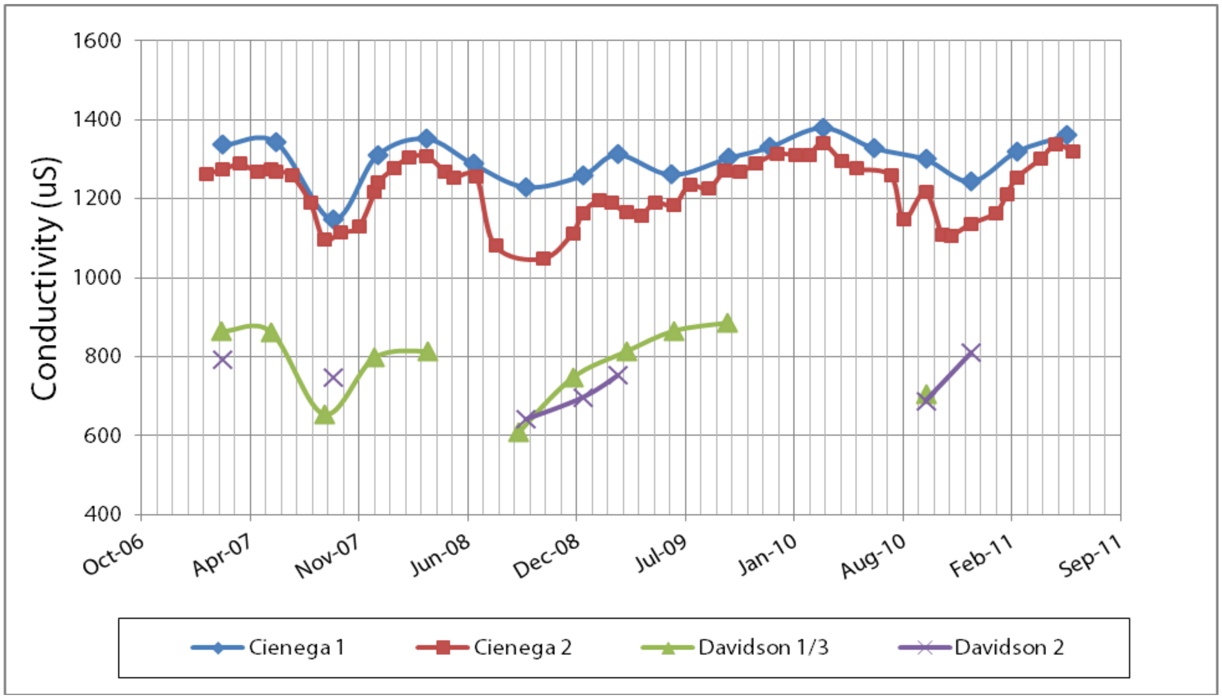
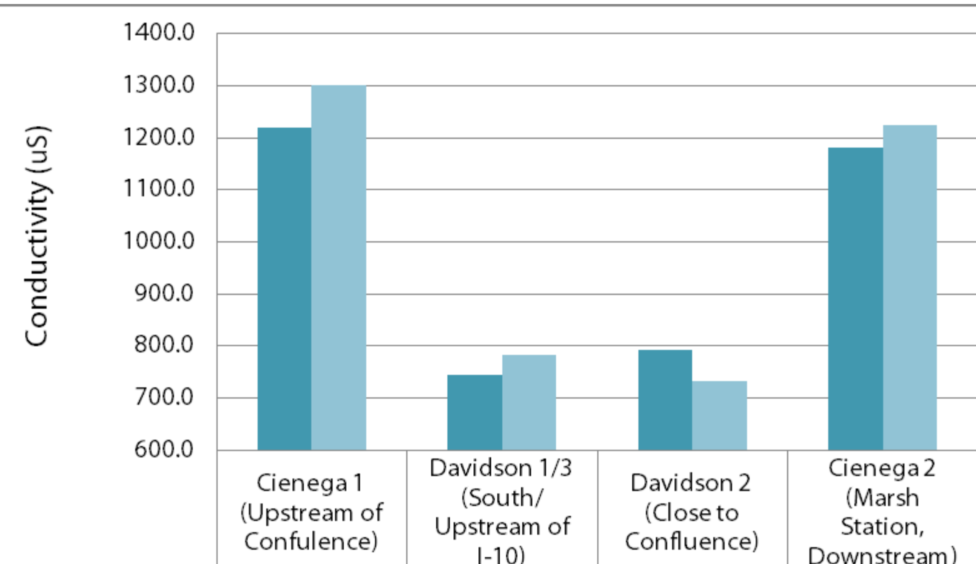


Figure 14. Cienega Watershed – Comparison of Average Conductivity of 2002-2003 to 2007-2011 Time Periods per Site



	Cienega 1 (Upstream of Confulence)	Davidson 1/3 (South/ Upstream of I-10)	Davidson 2 (Close to Confluence)	Cienega 2 (Marsh Station, Downstream)
Average Conductivity (uS) 2002-2003	1219.4	744.4	792.8	1180.7
Average Conductivity (uS) 2007-2011	1300.3	783.7	732.5	1225.7

Figure 15. Cienega Watershed – Average pH - 2002 through 2011

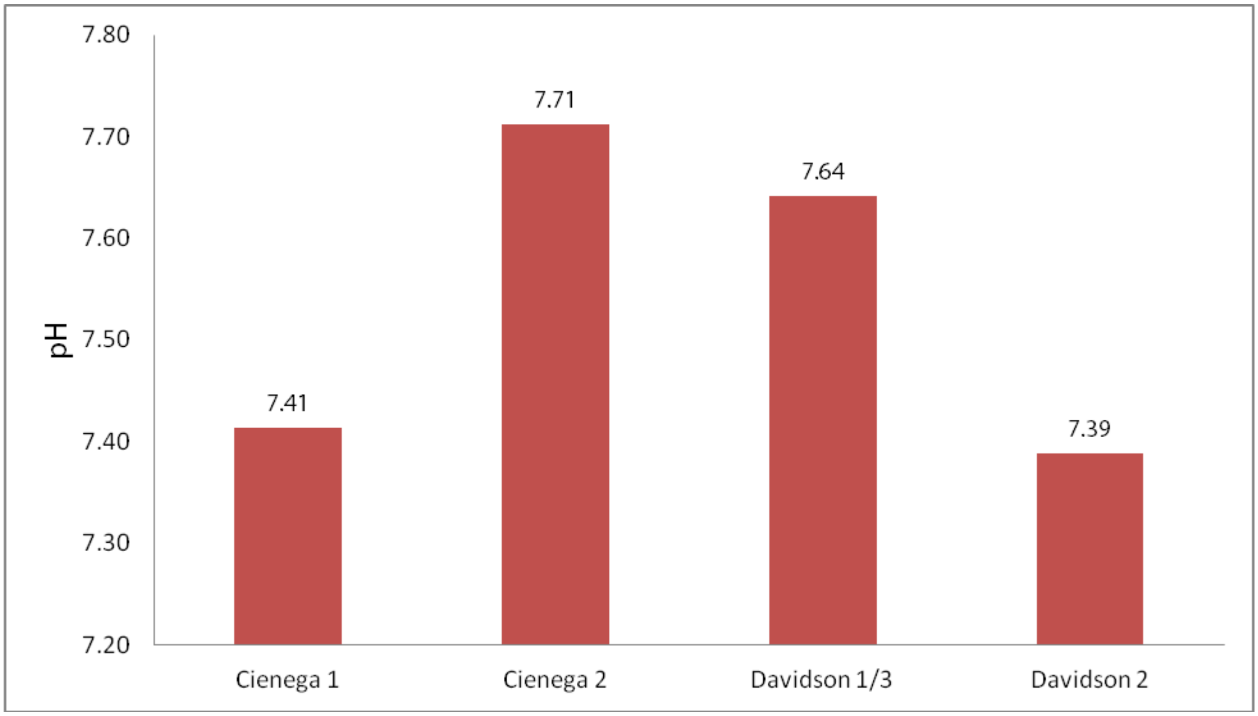
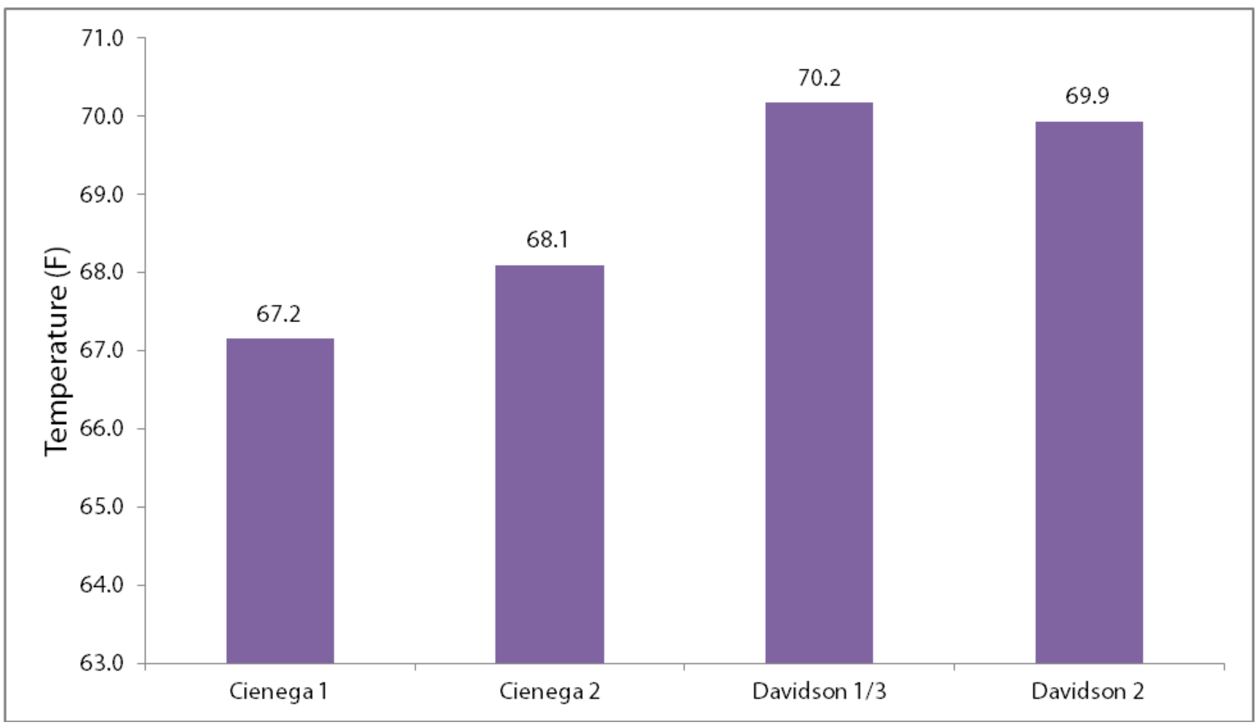


Figure 16. Cienega Watershed –Average Temperature per Site - 2002 through 2011



Repeat Photography

Repeat photography is a valuable tool for assessing the change along the creek and for sharing information with others. In 2006, PAG established eight repeat photography areas and methodology for documentation and has modified the methods as needed. PAG continued photographing established photo areas in FY 10-11 on a quarterly basis, or more often if extreme conditions were encountered while in the field during monthly hydrologic monitoring. Many photo locations include several different repeat photographs so that different view directions can be documented.

Photo sites were initially selected in 2006 by reviewing a collection of photos with a history of recorded site conditions and by adding sites as needed in order to capture dynamic conditions, or to get a better distribution throughout the creek. The site locations are shown in Table 6 and Figure 1A. GPSed locations are stored in a GIS shapefile and are available upon request. Care is taken to photograph at the same location each time, adjusting the frame slightly if needed to accommodate conditions. Photos are stored digitally at PAG and, for record-keeping, photos are named according to a photo site number, description and view direction, and filed by date.

In FY 08-09, we created an initial review of these photo sites to assess the methodology of the program and see if there is evidence of site morphology, flow or vegetation change recorded within the images of this large set of baseline data. Since then, the following area photo assessments have been included in the annual reports:

- Vegetative changes near Del Lago Dam
- Scour pool below Del Lago Dam
- Canopy cover and sedimentation at Jungle Road
- Erosion at Tilted Beds
- Streamflow Volume Changes at Marsh Station

Review of repeat photography shows that site changes that might go unnoticed in the field are often revealed by comparing historical photos. PAG's photo catalogue now contains numerous photo sites distributed throughout the creek. This baseline data is valuable because of the unpredictability of geomorphic alterations along the creek. The photographs have also been used in newsletters, presentations, data requests and other forms of communication to demonstrate seasonal change, drought and erosion. PAG has created and placed the following virtual tours of Cienega Creek on-line.

- Headcut virtual field trip
- 3D Photosynth view of Marsh Station

For this FY 10-11 report, we have selected photos from repeat photography sites Headcut A and Headcut B (HCa and HCb), to demonstrate the pronounced erosion and sedimentation changes that have occurred (Figures 17 and 18). In Figure1A, this location has a triangle symbol near the middle of the preserve where the railroad makes a horseshoe turn around a large wash and wetlands. These two locations are within 30 feet of one another, and are distinguished primarily by the direction they face.

Table 6. Cienega Walk-Through Photo Points (from upstream to downstream)

Photo Stop ID (Site name)	**Photo Name**	**Description**
#1	Jungle Road - A	Stand on road in middle of channel. *Look Downstream.*
	Jungle Road - B	Stand on road in middle of channel. *Look Upstream.*
#2	Jungle Tunnel	Stand downstream of beginning of flow (by tunnel). Capture some of banks of tributary. *Look Downstream.*
#5	Upstream of Tilted Beds	Stand 30 paces from barbed wire fence. *Look Upstream.*
#3	Tilted Beds A	Measuring site in foreground. *Look Downstream.*
#4	Tilted Beds B	Standing atop sandstone outcrop looking upon bucket measuring site. *Look Upstream.*
Bend	Headcut original channel in horseshoe bend	Stand a ways upstream of RR Wash. *Look Downstream.*
HCa	Head Cut - A	At Major headcut plunge pool where headcuts split, slightly upstream of pool, on bank. *Look Downstream.*
HCb	Head Cut - B	At Major headcut plunge pool where headcuts split, standing slightly downstream of pool, in headcut. *Look Upstream*.
#8	Confluence - Upstream from railroad bridge	Downstream of confluence of Cienega Creek and Davidson Creek. *Look Upstream.Take another to include bedrock, standing more downstream, depending on conditions.*
Dav	Davidson - Deer Grass - A	Up Davidson Canyon to most extreme possibility of beginning of flow. *Look Upstream.*
	Davidson - Deer Grass - B	Same as above, but *Look Downstream.*
#9	Sharp bend in creek upstream in Davidson Creek	Walk upstream from confluence to end of flow, *Look Downstream.*
#10	Just downstream from sharp bend in creek	Just downstream from Point #9, take picture with end of flow included - *Turn around to Look Upstream.*
#7	Upstream from Marsh Station	Through the railroad bridge (with bridge support structure in photo). Vertical shot. *Look Upstream. Take extra photos if you need to see stream beds and banks closer up (less bridge).*
#6a	Marsh Station - A	Bedrock on left, with bridge in picture. Standing downstream of flow measurement site. *Look Downstream.*
#6b	Marsh Station - B	Flow measurement site in photo. *Look Upstream.*
Sediment Plug	Sediment Plug	Stand downstream of stream bend where it is cutting into sediment (duck spot). Capture wide new banks. *Look Upstream.*
#11a	SP 1006 (Southern Pacific mile marker) - A	Stand downstream from beginning of flow with hill present ahead on right (may not be visible). *Look Upstream.*
#11b	SP 1006 (Southern Pacific mile marker) - B	Stand upstream from beginning of flow with hill present ahead on left (may not be visible). *Look Downstream.*
#12a	Del Lago Dam - A	Focus on dam. Stand a bit upstream on N side of creek. *Look Downstream.* Make sure you can see the distance of flow over dam or get another shot.
#12b	Del Lago Dam - B	Focus on dam. Stand a bit downstream on N side of creek. *Look Upstream.*
#12c	Del Lago Dam - C	Look across dam from south bank. Capture flow over dam and the pools.

Photography Assessment Figures

Figure 17. Erosion and sedimentation changes in the headcut
Repeat photography at site HCb, looking upstream along Cienega Creek. These photographs show the original headcut channel on the left and the second fork on the right, with its entrance hidden by a sand berm.

Note: The tree is highlighted in red, so that the reader can match the photographs.


Sept. 2007


Sept. 2008


Sept. 2009


Sept. 2010

Photography Assessment Figures

Figure 18. Channel width and vegetation cover changes
Repeat photography at site HCa, looking downstream along Cienega Creek. These photographs document the change in channel width over time due to the breakdown of the banks upstream and sedimentation infill. Note that the vegetation also changed from year to year in September.

Note:
The tree is highlighted in red, so that the reader can match the photographs.


Sept. 2006


Sept. 2007


Sept. 2008


Sept. 2009


Sept. 2010

Additional Related Monitoring

Headcut Study
Headcutting in the Cienega Creek watershed is a dramatic demonstration of sediment fluctuation within the stream system. The headcut at the railroad horseshoe area was studied through a two-year Arizona Water Protection Fund Grant (AWPF Grant No. 07-144) completed in 2010[1]. PAG continues to measure 2 cross-section transects annually and GPS the location of nick points along the stream during quarterly walk-throughs.

Wildlife Observations
PAG regularly documents wildlife observations and habitat characteristics during field work in Cienega Creek. Observations of flora and fauna were noted during quarterly walk-throughs. The native threatened and endangered fish and frog species observed by PAG in pools and other flowing reaches consisted of Gila Topminnow and Gila Chub. Lowland Leopard Frogs were also present within the creek. Longfin Dace is the most abundant native fish in lower Cienega Creek and though Topminnow is less dominant, it is commonly seen in most reaches. Pool habitats were present at various locations along Cienega Creek during each quarterly walk-through this year.

PAG has created an informal guide for common species in the Preserve, which will be published on our Web site. PAG reports incidental observations of species of concern on Pima County properties to the Office of Conservation Science with the goal to record observations of species for the Multi Species Conservation Plan, for the forthcoming U.S. Fish and Wildlife Service (USF&WS) Section 10 permit. Coordinates for location and species data from this effort is entered into an intranet database at Pima County.

Outreach and Coordination

Drought Watch
PAG uploads reports on the impact and trends of drought on lower Cienega Creek to the statewide reporting Arizona Drought Watch Web site: http://azdroughtwatch.org. Two wells with consistently available month to month data and one streamflow site contribute to this monthly analysis. The gradual drying trend exhibited by theCienega flow lengths since 1984 (Table 5) is probably due in part to the current drought, but PAG cannot completely rule out all other contributing factors, such as water withdrawals from nearby wells or upstream land uses. Contact PAG for detailed reporting.

Public Outreach
PAG continues to raise public awareness about the unique habitat, wildlife, and water resources of Cienega Creek especially with researchers and conservation groups in the region so that County Preservation efforts are known, PAG monitoring efforts are supported, and value of the Creek is understood. This outreach is conducted via website, active invitations to partners to join wet/dry mapping events, participation in local watershed groups, and presentations at meetings, conferences and media interviews. Concerns about visitation impacts on the creek and the need request permits to access this rare and protected resource are emphasized.

Coordination
In addition to coordination with Pima County, PAG continues to connect with other agencies and professionals to facilitate, coordinate and support collaborative projects in the region. Information exchange and coordination take place in part through participation in the Cienega Corridor Conservation Council (4Cs) and the Cienega Watershed Partnership (CWP). Toward that end, PAG coordinates with the Bureau of Land Management (BLM) and The Nature Conservancy (TNC) on

methods of water quality monitoring, piezometers usage, and surface flow mapping to ensure that our hydrologic monitoring programs are consistent with those of the upper reaches of Cienega Creek within the Las Cienegas National Conservation Area. To organize a single week for Arizona rivers mapping, PAG also coordinates with additional groups who map other creeks throughout Arizona.

Conclusions and Recommendations

Cienega Creek is a unique Sonoran Desert low-elevation perennial stream with critical water, recreation and wildlife resources in southeastern Arizona. Since the mid 1980s, PAG has conducted research to firmly establish baseline hydrologic conditions for comparison purposes, in the event that future groundwater development or land use changes occur in the vicinity of Cienega Creek. Originally focusing solely on groundwater and streamflow monitoring over the years, PAG's work has evolved into a multifaceted monitoring program that includes many more aspects of the creek system, thus becoming an important part of regional and statewide drought assessment.

Fiscal Year 2010-2011monitoring indicated continued severe drought in the Cienega Creek watershed. Streamflows decreased and groundwater levels dropped slightly at all wells during this year from the previous year's levels, creating some record lows. Greater drops were observed the year prior.

Notable Findings This Monitoring Year:

- PAG noted the lowest flow length in our historical record at 1.26 miles in June 2011. This is about half of the flow length in the previous June. This is 0.24 miles less flow than the previous record low in 2004 and 2005. These records all occurred in June.
- June 2011 streamflow volume at Marsh Station was the lowest June record with 0.05 cfs flow, although other months in prior years have been lower.
- The annual average streamflow volume at Marsh Station was at its lowest this year with a 0.32 cfs average flow volume.

PAG recommends continued investigation into measures that will maintain or restore native riparian habitat, water levels, stream geomorphology, and floodplain functions. PAG hopes to continue aiding PCRFCD and PCNRP&R in their management of the Cienega Creek Natural Preserve. Continued groundwater and surface water monitoring, water quality analysis, and habitat and wildlife documentation are critical tools toward achieving integrated resource management for the system.

Acknowledgements

PAG would like to acknowledge the following people who have assisted with the Cienega Creek monitoring program. Pima County has provided long-term support of the Cienega Creek monitoring program as a part of PAG's annual work plan. We greatly appreciate Pima County staff for supporting the monitoring, initiating program elements as needed, sharing data, providing input and coordinating. The coordination efforts of the Cienega Watershed Partnership have been greatly valued and we also appreciate all the volunteers who joined us for wet/dry monitoring this year.

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