This report summarizes conditions in Cienega Creek Preserve: A regionally important lowland stream contributing to the Tucson basin and representing local drought conditions in a shallow groundwater-dependent riparian area; Managed by Pima County.
# REGIONAL COUNCIL

<table>
<thead>
<tr>
<th>Chair</th>
<th>Vice Chair</th>
<th>Treasurer</th>
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<tr>
<td>Ramón Valadez</td>
<td>Duane Blumberg</td>
<td>Satish Hiremath</td>
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<td>Chair</td>
<td>Mayor</td>
<td>Mayor</td>
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<td>Town of Oro Valley</td>
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<td>Jonathan Rothschild</td>
<td>Catalina Alvarez</td>
<td>Edward Manuel</td>
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<tr>
<td>Mayor</td>
<td>Vice Chairwoman</td>
<td>Chairman</td>
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<td>Pascua Yaqui Tribe</td>
<td>Tohono O’odham Nation</td>
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<td>Miguel Rojas</td>
<td>Ed Honea</td>
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<td>Representative</td>
<td>Mayor</td>
<td>Mayor</td>
</tr>
<tr>
<td>AZ State Transportation Board</td>
<td>City of South Tucson</td>
<td>Town of Marana</td>
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## MANAGEMENT COMMITTEE
- Michael Ortega, City Manager, City of Tucson
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- Manny Rosas

### Watershed Planning Interns
- Dylan Huber-Heidorn, Amanda Smith
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Executive Summary

Streams and rivers in the arid landscape of Arizona are rare, exceptionally productive systems that are especially sensitive to changes in water availability. Stressors, such as drought, have the ability to critically impact these delicate systems and the habitats and rural residents that depend upon them as a water source. The Cienega Creek Natural Preserve, located outside of Tucson, Arizona, is an example of one such system that has been experiencing the pressures of drought since 2001. This preserve is the site of a rare, low-elevation perennial stream of regional importance for its environmental and recreational value, and it has been designated as an “Outstanding Water” by the State of Arizona. Pima Association of Governments (PAG) has consistently monitored the shallow groundwater-dependent riparian area of Cienega Creek on a monthly and quarterly basis since 1989. The findings from monitoring indicate localized drought impacts in terms of four primary areas of hydrologic monitoring and analysis: streamflow volume, groundwater levels, extent of surface flow, and water quality.

In monitoring year (MY) 2015, PAG’s analysis documented the continuation of historic drought conditions that indicate a heightened level of risk to the ecosystem, especially during the driest times of the year. Results show that drought continues to affect the watershed and threaten the viability of its riparian habitat, but several measured conditions have improved since the record lows of previous years. PAG’s measurements indicate the possibility of stabilization in several critical measures of the health of the shallow groundwater system. Specifically, multi-year declines in average streamflow volume for the year showed signs of arrest. In June, typically the driest month, analysis showed a stabilization of flow extent from previous declines, but also the lowest ever recorded flow volume at Marsh Station, 0.013 cubic feet per second. During this monitoring year, the shortest recorded total length of flow in the creek system, 0.88 miles of the total 9.5 miles, was measured in June, while the longest flows, totaling 3.81 miles, were measured in September.

Negative trends in water resources cause concern among land managers for the long-term health of the region’s rare aquatic and shallow groundwater dependent ecosystems, especially during the driest seasons of the year. Increased coordination among water and land-use planners as well as well owners is recommended to ensure conservation strategies are implemented near vulnerable shallow groundwater areas of Cienega Creek. This will help the residents’ water supply as well as sustain the nearby habitat they enjoy. Additionally, PAG has provided drought analyses and conservation recommendations to the Local Drought Impact Group (LDIG) which were incorporated into the LDIG annual report to the Arizona Department of Water Resources. Working with the Arizona Department of Water Resources and the Safe Yield Task force, PAG is promoting strategies to protect vulnerable areas from groundwater overdraft by balancing sub-basin use and recharge. The Tucson Active Management Area is using Pima County and PAG’s delineated shallow groundwater areas to consider sub-regional water accounting analysis. PAG is also working with water providers and watershed groups to reach well owners with conservation and restoration strategies.

<table>
<thead>
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<th>Summary of Recommendations (MY14-15):</th>
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<td>Continued riparian habitat monitoring</td>
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<tr>
<td>- Ecological research to assess habitat viability and water needs in order to establish thresholds</td>
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<tr>
<td>- Support periodic detailed analysis by Pima County and others</td>
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<tr>
<td>- Prioritize management goals and conservation strategies based on watershed assessment</td>
</tr>
<tr>
<td>Water Conservation</td>
</tr>
<tr>
<td>- Promote conservation practices throughout the Cienega Creek Watershed</td>
</tr>
<tr>
<td>- Include both reactive efforts to restore watershed health and preventative action to reduce water consumption through outreach and education</td>
</tr>
</tbody>
</table>
Key Findings (MY14-15):
Streamflow Volume
- Annual average streamflow volume in MY14-15 increased to levels not seen since MY11-12
- The lowest streamflow volume ever recorded at Marsh Station, .013cfs, was measured in June

Groundwater Levels
- Average groundwater levels rose slightly, breaking a multi-year downward trend

Extent of Surface Flow
- PAG noted a minimal increase in June flow extent compared to last year’s record low with 0.88 miles of flow in June 2015. However creek flow extent remains well below the historic levels.
- Upper Davidson Canyon had substantial return of surface flow and pools during the September assessment

Introduction
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 document hydrologic conditions to establish baseline flow rates for Pima County’s in-stream water rights to flow and to detect groundwater development or land use changes in the vicinity of the Creek, and to determine long-term trends. 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 statewidedrought assessment. The data is valuable for informing groundwater pumping models and relationships for surface flows.

Beginning in July 2015, monthly well and streamflow monitoring will be taken over by the Pima County Regional Flood Control District (PC RFCD). PAG will continue to conduct quarterly assessments on the extent of flow and habitat notations. Extent of flow is particularly valuable for portraying seasonal character of the creek, and understanding potential vulnerabilities in this regionally valued lowland stream.

This report describes work completed by PAG as part of its 2014-2015 Overall Work Program, which includes monitoring in lower Cienega Creek and Davidson Canyon within the Cienega Creek Natural Preserve (Preserve). PAG’s monitoring is consistent with Pima County’s management plan for the Preserve, which includes goals to maintain in-stream flows, tree-sustaining shallow groundwater, and native flora and fauna. PAG has monitored the hydrology in the Preserve since 1989 in coordination with the PC RFCD. This report contains data collected during Fiscal Year (MY)14-15, which extended from July 1, 2014 through June 30, 2015, consisting of streamflow volume, groundwater levels, streamflow length (through the extent of the preserve), and water chemistry. Photographs were also taken to document conditions. This report also includes notes on additional PAG observations and studies. Data tables and figures in this report focus on results from the 2014-2015 monitoring year, but they also show data from previous years for comparison purposes. The fiscal year defines the dates of the Monitoring Year (MY).
The Cienega Creek Natural Preserve, which is owned by PC RFCD and co-managed by PC RFCD and Pima County Natural Resources Parks and Recreation (PC NRP&R), includes lower Cienega Creek and portions of lower Davidson Canyon (Figure 1A). For ease of reading, the following geographically distinct areas are referred to 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, just 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 northward, eventually reaching the preserve area.
- **Lower Davidson Canyon** - This section of Davidson extends north from Interstate 10 to the confluence with Cienega Creek and includes a historically perennial stream reach. It is included in the Preserve and is counted in the 9.5 mile figure for the total length of the creek system.
- **Upper Davidson Canyon** - South of Interstate 10, this reach begins at a spring with a historical pool. It is not included in the Preserve or in the 9.5 miles of monitored Cienega Creek. However, PAG does monitor Upper Davidson Canyon for streamflow on a quarterly basis.

The locations of all of the monitoring sites are shown in Figures 1A and 1B. During this monitoring year, monitoring methods and locations remained essentially the same as in past years, with any exceptions for this year explained in this report. Further documentation for project purpose, background, important findings, protocols, forms, metadata, and reports from previous years are available in the PAG online library: http://apps.pagnet.org/paglibrary/. The specific methodology for each aspect of monitoring and results are described in this report but more specific methodology descriptions may also be found in past reports and updated in PAG internal documents available upon request.
Figure 1A. PAG Monitoring Site Locations in the Cienega Creek Watershed
Water Quality Sampling Sites

- Water Quality Sample Site
- Monitoring Sites
- Water Courses
- Streets
- Dirt roads
- Railroad

Referred to as site 1/3 to reflect sites Davidson 1 (measured 2002-2003) and Davidson 3 (2007-current, approximately 30ft downstream from historical Davidson 1 site).
Streamflow Volume

Methods
PAG takes monthly streamflow volume measurements at two sites using a USGS Pygmy Flow Meter and calculates the discharge (Q) in cubic feet per second (CFS). When flow is too low for the Pygmy Meter to function, a bucket collection method is used. The flow is all directed to create a waterfall through a weir shape into a bucket of known volume. The amount of time to fill it is recorded. 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, following the methodology of the program. Base flows comprise discharges from the shallow aquifer into the stream channel without the direct influence of surface runoff. Flow volume in June 2015 was measured using a standardized bucket collection method, as an exception to our regular pygmy meter method, to measure the extremely low flow.

Discussion of Results
Since monitoring began in 1993, results show average streamflow volumes have declined and PAG has recorded all-time lows for Lower Cienega Creek in recent years. In MY13-14, the annual average streamflow decreased to the lowest on record at 0.21 cfs (Figure 2). PAG has been monitoring consistently since MY 96-97, providing reliable data for evaluating long term trends such as annual averages.

In MY14-15, annual average streamflow was 0.47 cfs, an increase from the previous two years. MY14-15 broke a recent downward trend, but this may not be significant. Only continued testing will reveal how this will impact long-term drought conditions.

Notably, the lowest flow volume measurement at Marsh Station was taken this year, with just 0.013 cfs of water flowing at the test site.
Figure 2. Annual Mean Streamflow Volume Trends at Marsh Station (MY93-94 to MY14-15)

The yearly averaged flow has fluctuated within the overall long-term downward trend of streamflow volume, which declined in MY13-14 to a record low.

Streamflow volume data for MY14-15 are shown in Table 1. To provide a longer term perspective on flow trends, Figure 3 shows discharge data from 1993 to the present. Figure 4 shows the streamflow trends since 2008, which better displays annual patterns and includes the last year that flow was recorded at the Tilted Beds site. Figure 4 shows the annual mean for Marsh Station, which has been a perennially flowing site. Specific field monitoring dates are available upon request.

In MY14-15, August, September, and December each saw greater flow volume at Marsh Station than had been recorded for those months since the wet 2008-2009 fiscal year. The Tilted Beds site exhibited no baseflow for the sixth year in a row (Figure 2). Tilted Beds previously had a pattern of ephemeral flow for 2-3 years followed by absence of flow for 2-3 years (Figure 2). PAG continues to monitor the site, but has observed no flow since 2010.
Table 1. Monthly Streamflow Volumes (July 2014 - June 2015)

<table>
<thead>
<tr>
<th>DATE</th>
<th>FLOW (cfs)[(1)]</th>
<th>FLOW (cfs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Marsh Station</td>
<td>Tilted Beds</td>
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<tr>
<td>July 2014</td>
<td>.27</td>
<td>0.00</td>
</tr>
<tr>
<td>August 2014</td>
<td>.57</td>
<td>0.00</td>
</tr>
<tr>
<td>September 2014</td>
<td>.82</td>
<td>0.00</td>
</tr>
<tr>
<td>October 2014</td>
<td>.40</td>
<td>0.00</td>
</tr>
<tr>
<td>November 2014</td>
<td>NoData</td>
<td>NoData</td>
</tr>
<tr>
<td>December 2014</td>
<td>.77</td>
<td>0.00</td>
</tr>
<tr>
<td>January 2015</td>
<td>.83</td>
<td>0.00</td>
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<tr>
<td>February 2015</td>
<td>.69</td>
<td>0.00</td>
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<td>March 2015</td>
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<td>April 2015</td>
<td>.24</td>
<td>0.00</td>
</tr>
<tr>
<td>May 2015</td>
<td>.1</td>
<td>0.00</td>
</tr>
<tr>
<td>June 2015</td>
<td>.013</td>
<td>0.00</td>
</tr>
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</table>

(1) “NoData” does not indicate lack of flow. Flow was observed in November, but no measurement is available.
The yearly seasonal pattern indicates that the highest base level streamflow volume is generally recorded in the winter months. However, recorded monthly flows have diminished over time. Streamflow volumes from PAG’s pre-drought data (MY93-94 to MY99-00) show an average of 1.32 cfs. No monthly measurement has matched or passed this threshold since MY08-09.

Figure 3. Monthly Streamflow Volume at Tilted Beds and Marsh Station Sites (1993 -2015)

A decline in streamflow volume has been especially evident over the last six years.
The highest streamflow volume is generally recorded in the winter and early spring. Since 2001, the months with the highest average flows, from highest to lowest, are February (1.187 cfs), March (1.181 cfs), January (1.06 cfs), September (.905 cfs), and April (.864 cfs).

PAG recommends further analyzing streamflow data for evidence of shifts in seasonal patterns.

Figure 4. Monthly Streamflow Volume at Tilted Beds and Marsh Station Sites (July 2008 – June 2015)

Since MY08-09, no monthly measurement has exceeded the average streamflow volume of 1.32 cfs recorded across pre-drought monitoring years (through June 2000).
Groundwater Levels

Methods
Depths to groundwater are measured at eight wells with either a Solinst Water Level Meter or with in situ transducers. The wells are distributed throughout the preserve length (Figure 1A and Appendix II). On a monthly basis and when accessible, PAG monitored the Jungle, Cienega, Del Lago1, and Empirita 2 well sites. PAG began using the same methods to monitor Davidson 2 on a monthly rather than quarterly basis in the fall of 2013. The PS-1 and PN-2 wells are monitored four times a day by ADWR transducers, so PAG notes the mid-day measurements for our databases to match when the other wells are measured. If any monitor dates fell outside of this schedule, it is noted in Table 2. The O’Leary was not monitored this year.

Beginning in July 2015, monthly well monitoring will be conducted by the Pima County Regional Flood Control District (PC RFCD). PAG will collaborate with the County and will continue to issue annual reports.

Discussion of Results
In 2001, drought began to noticeably impact the Cienega Creek Natural Preserve, with water levels averaging below pre-drought levels. In MY09-10, annual mean water levels dropped appreciably at all wells, reaching one of the most severe drought stages on PAG record due to the lack of summer monsoons that year. Groundwater levels remained stable for a couple years, but marked declines have been observed more recently. Table 2 provides a closer look at the monthly results from MY14-15, while Table 3 presents depth to groundwater (dwt) averages for the last seven years.

Overall, groundwater levels at PAG shallow groundwater monitoring sites dropped an average of 2.84 feet from MY07-08 (the earliest year with full data on the currently monitored wells) to MY14-15. Earlier annual reports included data from deeper wells. These data may not specifically reflect conditions of the shallow groundwater system, but the calculated average drop in the water table across all wells—roughly 18 feet from MY08-09 to MY13-14—is important to the broader analysis of hydrologic conditions in the area. Table 3 shows the change in a subset of wells that reflects the conditions of Cienega Creek’s shallow groundwater system, generally defined as ~50 feet or less depth to water. Specific field monitoring dates for wells are available upon request.

The shallow groundwater system shows high seasonal variability. The shortest depth to groundwater measurements for several wells are regularly recorded in the months during and immediately after the two monsoons, demonstrating a connection between the region’s seasonal rain patterns and the hydrologic systems that support Cienega Creek’s riparian habitat.
Table 2. Depth to Groundwater at Cienega Creek Natural Preserve Monitor Well Sites, Monthly Monitoring in Fiscal Year (July 2014-June 2015)

<table>
<thead>
<tr>
<th>Date</th>
<th>Cienega</th>
<th>Jungle</th>
<th>Empirita(2)</th>
<th>Del Lago</th>
<th>PS-1(1)</th>
<th>PN-2(1)</th>
<th>Davidson</th>
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<tr>
<td>Jul-14</td>
<td>20.48</td>
<td>46.6</td>
<td>88.23</td>
<td>73.78</td>
<td>57.94</td>
<td>249.9</td>
<td>20.49</td>
</tr>
<tr>
<td>Aug-14</td>
<td>18.5</td>
<td>46.07</td>
<td>88.2</td>
<td>68.37</td>
<td>48.28</td>
<td>251.59</td>
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<tr>
<td>Sep-14</td>
<td>17.88</td>
<td>45.67</td>
<td>NA</td>
<td>63.31</td>
<td>41.89</td>
<td>249.82</td>
<td>18.05</td>
</tr>
<tr>
<td>Oct-14</td>
<td>17.83</td>
<td>44.66</td>
<td>NA</td>
<td>62</td>
<td>41.02</td>
<td>226.84</td>
<td>18.71</td>
</tr>
<tr>
<td>Nov-14</td>
<td>19.32</td>
<td>44.61</td>
<td>87.65</td>
<td>69.31</td>
<td>48.47</td>
<td>225.7</td>
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<tr>
<td>Dec-14</td>
<td>19.41</td>
<td>44.3</td>
<td>87.53</td>
<td>72.62</td>
<td>51.38</td>
<td>226.84</td>
<td>25.28</td>
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<tr>
<td>Jan-15</td>
<td>18.95</td>
<td>43.68</td>
<td>87.59</td>
<td>74.48</td>
<td>53.37</td>
<td>227.81</td>
<td>27.45</td>
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<td>Feb-15</td>
<td>18.5</td>
<td>43.32</td>
<td>87.56</td>
<td>63.87</td>
<td>45.23</td>
<td>228.93</td>
<td>26.16</td>
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<td>Mar-15</td>
<td>18.71</td>
<td>42.9</td>
<td>87.48</td>
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<td>47.45</td>
<td>229.25</td>
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<td>Apr-15</td>
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<td>87.45</td>
<td>73.5</td>
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<td>May-15</td>
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<td>42.61</td>
<td>NA</td>
<td>75.46</td>
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<td>Jun-15</td>
<td>21.7</td>
<td>42.8</td>
<td>87.4</td>
<td>71.7</td>
<td>54.06</td>
<td>230.16</td>
<td>27.8</td>
</tr>
</tbody>
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Note: All depths are feet below land surface.

*Due to fluctuation in well water depth levels from pumping, PAG is no longer monitoring the O’Leary well regularly. For the most recent O’Leary well data, reference the MY13-14 report available on PAG’s website.

(1) Monitored by ADWR  (2) Inconsistently accessible

Table 3. Annual Average Depth to Groundwater (MY08-09 to MY14-15)

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Del Lago-1</th>
<th>Cienega</th>
<th>Jungle</th>
<th>Davidson-2</th>
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<tbody>
<tr>
<td>2008-09</td>
<td>73.79</td>
<td>14.45</td>
<td>31.02</td>
<td>19.17</td>
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<tr>
<td>2009-10</td>
<td>74.71</td>
<td>18.20</td>
<td>35.56</td>
<td>24.37</td>
</tr>
<tr>
<td>2010-11</td>
<td>74.92</td>
<td>18.47</td>
<td>38.33</td>
<td>23.64</td>
</tr>
<tr>
<td>2011-12</td>
<td>72.11</td>
<td>17.55</td>
<td>38.79</td>
<td>22.99</td>
</tr>
<tr>
<td>2012-13</td>
<td>76.34</td>
<td>19.28</td>
<td>39.93</td>
<td>23.50</td>
</tr>
<tr>
<td>2013-14</td>
<td>75.84</td>
<td>20.90</td>
<td>43.67</td>
<td>27.69</td>
</tr>
<tr>
<td>2014-15</td>
<td>69.37</td>
<td>19.34</td>
<td>44.16</td>
<td>23.86</td>
</tr>
</tbody>
</table>
Figure 5A. Cienega Creek Natural Preserve Monthly Depth to Groundwater (July 1994 - June 2015)

Water level declines in recent years are discernible for most wells shown here. See Figure 5B to see PN-2, which fell below the scale of this graph and displays data from 2006 onward.
Figures 5a, 5b and 5c illustrate long-term trends, showing water level data from 1994 to the present for many of our well-monitoring sites (note that Figure 5b and 5c are displayed at a different time scale than 5a).

The PN-2 well experienced an increase in water levels for the first time in several years, but was not included in Table 3 because it is located downstream from the PAG monitoring area and in a position where bedrock is considerably deeper. The graphs appear to depict a rise and fall in groundwater levels between 2006 and 2011 that coincided with the increased incidence of precipitation during fall and winter seasons as compared to the dry spring and summer months. This seasonal pattern was not observed in 2012 or 2013 (Figure 5c), which may be a result of the record low precipitation seen in these years (as reported by the Pima County Local Drought Impact Group). Water levels at several wells displayed evidence of a return to seasonal rhythms during MY14-15. Further investigation is needed to assess long term fluctuations and the impacts of drought on seasonal variability.

Figure 5B. Cienega Creek Natural Preserve Monthly Depth to Groundwater (July 2013 - June 2015)

*This graph shows a closer look at the seasonal pattern of groundwater levels in the last two years. Note the return to distinctive seasonal fluctuation in 2014. Data not available for some months due to inaccessibility. Note: See Figure 5B to see PN-2, which falls below the scale of this graph.*
For several years after 2011, seasonal patterns were not evident, indicating a lack of seasonal recharge to the system. A steady downward trend in water levels at this well was interrupted in the later months of 2014.

**Note:** PAG began monitoring the PN-2 well in 2006.
**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 using a Global Positioning System (GPS) unit. For this report, the term “length of flow” refers to the distance of stream that has flow extent, not the span of time over which flow is occurring. Quarterly mapping is conducted during the months of September, December, March and June. GPS data is collected along the length of the stream. The raw waypoints are then used to clip a standard stream line in ArcGIS in order to determine the lengths of each segment of surface flow. The length of surface flow for each quarterly walk-through is calculated by totaling the extent of each flowing segment. Flowing extent is compared to the total length of 9.5 miles of creek channel within the preserve. This includes the section of creek that begins at the I-10 crossing and flows northwest to Del Lago Dam as well as the lower reach of Davidson Canyon (Figure 1a). 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 baseflow impacted seasonally by precipitation and sediment fluctuation.

The flowing reaches of upper Davidson Canyon are located at a spring next to a bedrock outcrop south of the I-10 crossing (Figure 1a). This is the ninth year that these surface flows were systematically mapped, but the streamflows along this reach were also noted during earlier PAG studies.

**Discussion of Results**
Analyzing PAG’s consistently recorded surface flow data over time illustrates that our region has experienced significant drought since 2001, which is in concurrence with many statewide and U.S. Drought Monitor declarations. The tables and figures in this section depict the variation in seasonal and annual distances of streamflow, which can change dramatically in short periods of time and reflect the impact of water availability for the health of riparian systems in Arizona. When analyzed over time, the low streamflow extents seen in recent years provide a measurement of severe drought in this riparian system.

In MY14-15, PAG measured a June flow length of 0.88 miles—just 9% of the 9.5 mile creek—a marginal increase from the historical low of 0.86 miles recorded last fiscal year (Table 4). Summer flow extents have declined substantially since the 1980s (Table 5). In July 1984, during a wet period, the creek flowed continuously for the full distance of 9.5 miles (Montgomery & Associates 1993). Monitoring the perennial stretches of streamflow during the driest time of the year is important to understanding the overall health of the ecosystem, especially for the aquatic and riparian species that rely on the presence of surface water.

In Upper Davidson Canyon, flow was seen almost every quarter between when monitoring began in September 2005 through September 2009. In MY09-10, MY10-11, and MY12-13, flow was observed in the reach only during September monitoring visits and was absent during all other quarters.¹ This September, flow was observed in Davidson Canyon for the first time since 2012 with 0.35 miles of flow and pools.²

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¹ Clear pools under 20 ft each were present in most months during these years. Total pool lengths can be provided at request.
² Flows are not inspected in between quarterly surveys, so flow presence is unknown.
Table 4. Cienega Creek, Lower Davidson Canyon and Upper Davidson Canyon, Quarterly Data for Flow Extent Monitoring (Sep. 2014 - June 2015)

<table>
<thead>
<tr>
<th></th>
<th>Quarterly Flow Extent Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>September</td>
</tr>
<tr>
<td>Cienega Creek and Lower Davidson</td>
<td></td>
</tr>
<tr>
<td>TOTAL FLOW EXTENT</td>
<td>3.81</td>
</tr>
<tr>
<td>(miles)</td>
<td></td>
</tr>
<tr>
<td>Upper Davidson Canyon</td>
<td></td>
</tr>
<tr>
<td>TOTAL FLOW EXTENT**</td>
<td>.35</td>
</tr>
<tr>
<td>(miles)</td>
<td></td>
</tr>
</tbody>
</table>

Total flow extent is calculated by adding together the GPSed lengths of each segment of flow.
*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 added to the “total flow extent” in this 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 -2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>Length of Cienega Creek*</th>
<th>Length of Upper Davidson**</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jul-84</td>
<td>50,000 ft. (9.5 miles)</td>
<td></td>
<td>Errol L. Montgomery &amp; Associates, Inc.</td>
</tr>
<tr>
<td>May-85</td>
<td>50,000 ft. (9.5 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-86</td>
<td>43,140 ft. (8.2 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-87</td>
<td>43,200 ft. (8.2 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-88</td>
<td>41,500 ft. (7.9 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-89</td>
<td>34,640 ft. (6.6 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-90</td>
<td>37,400 ft. (7.1 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-91</td>
<td>42,160 ft. (8.0 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>May-92</td>
<td>37,740 ft. (7.1 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No data 1993-1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun-99</td>
<td>14,290 ft. (2.7 miles)</td>
<td></td>
<td>PAG</td>
</tr>
<tr>
<td>Jun-00</td>
<td>14,290 ft. (2.7 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun-01</td>
<td>24,950 ft. (4.7 miles)</td>
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</tr>
<tr>
<td>Jun-02</td>
<td>17,220 ft. (3.3 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun-03</td>
<td>10,630 ft. (2.0 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun-04</td>
<td>8,145 ft. (1.5 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun-05</td>
<td>7,865 ft. (1.5 miles)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jun-06</td>
<td>12,025 ft. (2.3 miles)</td>
<td>170 ft. (0.03 miles)</td>
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<tr>
<td>Jun-07</td>
<td>15,860 ft. (3.0 miles)</td>
<td>483 ft. (0.09 miles)</td>
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<tr>
<td>Jun-08</td>
<td>15,312 ft. (2.9 miles)</td>
<td>0 ft. (0 miles)</td>
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<tr>
<td>Jun-09</td>
<td>16,127 ft. (3.1 miles)</td>
<td>1,187 ft. (0.22 miles)</td>
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</tr>
<tr>
<td>Jun-10</td>
<td>12,566 ft. (2.4 miles)</td>
<td>3 ft (0 miles)</td>
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<tr>
<td>Jun-11</td>
<td>6,653 ft. (1.26 miles)</td>
<td>20 ft. (0.004 miles)</td>
<td></td>
</tr>
<tr>
<td>Jun-12</td>
<td>6653 ft. (1.26 miles)</td>
<td>49 feet (0.009 miles)</td>
<td></td>
</tr>
<tr>
<td>Jun-13</td>
<td>5016 ft. (0.95 miles)</td>
<td>0 ft (0 miles)</td>
<td></td>
</tr>
<tr>
<td>Jun-14</td>
<td>4517 ft. (0.86 miles)</td>
<td>0 ft (0 miles)</td>
<td></td>
</tr>
<tr>
<td>Jun-15</td>
<td>4621 ft. (0.88 miles)</td>
<td>0 ft (0 miles)</td>
<td></td>
</tr>
</tbody>
</table>

*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.

Note: Pools were used when calculating total length for Davidson Canyon in this table.
Figure 6. Maps of Cienega Creek and Davidson Canyon, Quarterly Flow Extent (Sept. 2014 - June 2015)

All quarters in MY14-15 saw marked increases over flow extents recorded in the previous year. Most notably, the lengths of September and December flows were 1.4 and 2.0 times longer than those of MY13-14, respectively.
Declining perennial reaches have far-reaching implications for the health of the ecosystem as a whole. Mapping streamflow during the driest part of the year conservatively identifies the perennial reaches (i.e. those stretches of flow that are likely present throughout the year) in the preserve. As seen in Figure 8, the total flow extent in the preserve is consistently lowest pre-monsoon, in June. Although PAG expects to find perennial flow in certain parts of the watercourse, the locations and extents of flow can be altered by the unpredictable shifting of sediment. While the recurring surface flows are generally seen near bedrock highs, deposition of even a few inches of sediment can be the difference between a flowing creek, a pool, or subsurface flow invisible to casual observation. For example, flow in the easternmost recurring segment fluctuated to a downstream location in 2004 and 2010 only to “migrate” upstream in subsequent years.

The extent of baseflow in Cienega Creek varies greatly between seasons (Figure 8). During drought, even the seasons with above-average flow extents no longer flow the entire stretch of the preserve. In PAG’s quarterly monitoring, March is most often the month of greatest flow extent, with an average of 4.6 miles since 2002 and a maximum length of 7.2 miles seen within the current drought period that began in 2002. The contrast in flow extent lengths between wet and dry seasons has gradually been decreasing: the difference between March and June flow distance was 3.9 miles in 2002 compared to 2 miles in 2015.

Figure 7. Cienega Creek Quarterly Flow Extent Graph (1999-2015)

As this graph shows, the extent of baseflow varies greatly between seasons with decreasing peaks and lows for the respective wet and dry seasons in recent years.
Since monitoring began in 1975, the annual extent of surface flow in the Cienega Creek Preserve has decreased dramatically (Figure 9). Seasonal fluctuation of extent of surface flow is more evident since 2001 as compared to 1984-1992.

Lower observed flow extents in the 1970s increased to full-length flow in the early 1980s – potentially an indication of cyclical drought patterns. The 1970 levels were higher than almost all recent observations, which may hint at the compounding impacts of both cyclical drought and increased well withdrawals, as found in the well and pumping inventory in the PAG 2012 Shallow Groundwater Report.

Figure 8. Cienega Creek Flow Extent Graph (1975-2015)

PAG data collection began after 1993. Earlier data is from the Fonseca 1993 report with data from Montgomery and Associates’ 1993 report. From 1984-92 flow extent was usually measured quarterly within the same seasons as PAG data, providing valuable comparison, but it was not measured consistently. Flow extent was estimated from aerial photos dating from October 1974, September 1978, December of 1979 and 1982. All other measurements were taken quarterly. Length was not measured from 1993-1998.
Figure 9. Map of Cienega Creek’s June Flowing Reaches (1999-2015)

The bars shown above represent the flow extent (wet reaches) recorded in Cienega Creek for each June from 1999 to 2015. The bars in the lower half of the page are spatially distributed to correspond to 8 miles of actual flowing creek length shown in the map. The colors alternate by year for visual aid with the most recent year, with the smallest total flow extent, in blue. Mile markers are shown in dashed lines for reference.
MY14-15 broke a 3-year trend of consistently diminishing June flow distances with a modest increase to 0.88 miles from a record low of 0.86 last year. All 9.5 miles of creek referenced for this study were flowing fully in the mid-1980s. Data is available from the 1970s which reveal less than 100% flow.
**Water Chemistry**

**Methods**
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 both exhibit ephemeral flow conditions. Cienega 1, just upstream of the confluence with Davidson Canyon, is a perennial site. Cienega 2, 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 using an Ultrameter. 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 analyzed by the Test America laboratory twice a year, usually in March and September. A complete list of constituents analyzed by the lab is available upon request. PCRFCD maintains a summary of the sampling results. Water quality measurements are only gathered during clear baseflow conditions three days or more after the last rain when minimal stormwater runoff is influencing the creek. Streamflow volume is measured to accompany all sampling efforts if enough flow is present to be measurable. Detailed protocols are available upon request. Documentation of additional water chemistry data from various sources is available at PAG.

**Discussion of Results**
PAG data shows the seasonal variation and differences in water chemistry between sites, but long-term trends are inconclusive. The following graphs provide the trends and/or averages for conductivity, pH, and temperature (Figures 12-14).

Conductivity declines during the fall season and fluctuates by about 200 μS within a year (Figure 12) illustrating the importance of consistent monitoring. The seasonal drop in conductivity was not as dramatic in MY13-14 as in previous years, but MY14-15 saw a return to seasonal oscillation. Drought may be having a significant impact on conductivity and its seasonal patterns, but more evidence is needed to reach conclusions. It’s possible that this trend can be explained by the influence of greater runoff contributing to the baseflows in wetter years, as opposed to greater reliance on older groundwater for baseflows in drier years. Further study could also include investigation of the apparent lag between flow and conductivity as well as the nature of the possible inverse relationship between the two.

In previous years, the Cienega site downstream of the Davidson confluence (Cienega 2) had lower conductivity than the site upstream of the confluence (Cienega 1) (Figure 12). This supports PAG studies that demonstrated the significant contribution from Davidson Canyon to baseflows of Cienega Creek. However, due to the low levels of flow in Davidson Canyon, comparisons between conductivity of the two sites are not possible for MY14-15. The historical data is still shown for reference and the Cienega sites have been updated with water quality sampling data from MY13-14 (Figures 13-14).
Figure 11. Cienega Watershed Conductivity (2002 - 2015)

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.
Figure 12. Cienega Watershed – Average pH per site (2002 - 2015)

Figure 13. Cienega Watershed – Average Temperature per Site (2002 - 2015)
Additional Related Monitoring, Outreach and Coordination

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 sites throughout Cienega Creek based on sites with historic photos or those known to be currently experiencing changes. PAG modified the frequency of photography in MY 13-14 to an as-needed basis if significantly changed conditions were encountered while in the field during monthly hydrologic monitoring. Photographic records, methodology, and site locations are available upon request.

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, and the final report is available on PAG’s website. PAG continues to note erosion and sedimentation patterns along the watercourse, but the change of form of erosion makes continued analysis difficult. The headcut has changed from a nickpoint with a steep drop in elevation within the three stream channels to a more gradual incline and a destabilized flood plain as it continues to move upstream. Cross sectional transects have not been measured since May 2011. New research would be needed to understand the details of this erosive feature’s recent development.

Wildlife Observations
PAG regularly documents wildlife observations and habitat characteristics during field work in Cienega Creek. Observations of flora and fauna are noted during quarterly walk-throughs. In order to communicate habitat and wildlife information, PAG reports incidental observations of species of concern on Pima County properties to the Office of Conservation Science in support of its 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 cataloged for future use by Pima County.

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. Contact PAG for detailed reporting.

Public Outreach
PAG continues to raise public awareness about the unique habitat, wildlife, and water resources of Cienega Creek via website, invitations for partners to join wet/dry mapping events, participation in local watershed groups, and presentations at meetings and conferences.

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 takes place, in part, through participation in the Cienega Watershed Partnership (CWP). PAG also coordinates with the Bureau of Land Management (BLM) and The Nature Conservancy (TNC) on methods of water quality monitoring, piezometer 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.
Summary of Results

Fiscal Year 2014-2015 (MY14-15) monitoring and analysis indicated continued severe drought in the Cienega Creek watershed with notable impacts to streamflow volume, groundwater levels, and streamflow distance. Brief summaries of the findings from MY14-15 are given below.

Streamflow Volume
Since monitoring began in 1993, streamflow volume has declined over time and PAG has recorded all-time lows for Lower Cienega Creek in recent years. In MY13-14, the annual average, monthly-recorded streamflow at Marsh Station was recorded as the all-time historical low of 0.21 cfs (cubic feet per second).

The MY14-15 data shows that base streamflow has seen a moderate rebound from MY13-14, with a monitoring year average streamflow volume at Marsh Station of 0.47 cfs. In addition to exceeding the recorded annual average streamflow for MY13-14, this year’s figure is also greater than the 5-year annual average of 0.38 cfs. For comparison to recent drought period measurements, however, average streamflow volume was 1.35 cfs in the 1990s (PAG’s streamflow data for the 1990s begin with MY93-94).

Although the average annual flow volume was higher than in the previous year, the record low June flow volume is an important indicator of drought conditions that are especially threatening to riparian ecosystems in the driest and more vulnerable time of the year.

Groundwater Levels
Since the beginning of the drought period in 2001, PAG has observed a general downward trend in groundwater levels, with appreciable drops in some years and minimal recoveries in other years. Annual monitoring year averages are based on a subset of wells from which we have been able to consistently collect and catalog data on a monthly basis. After several years of steady decline in the annual average, including large drops in the previous two years, the MY14-15 average was only marginally changed from the previous year. Groundwater levels rose slightly in four of the seven monitored wells in MY14-15, with an average rise of 2.84 feet.

Extent of Surface Flow
PAG recorded 0.88 miles of streamflow in June 2015, which is roughly 9% of the 9.5 mile stretch that is regularly monitored. Although this flow length is an increase over June 2014, it is only 100 ft longer than the all-time low recorded during that walkthrough. The extent of surface flow has steadily declined since 2001, with annual average streamflow extents never reaching pre-drought levels of the 1990s.

In Upper Davidson Canyon, flow was seen in almost every quarter from when monitoring began in September 2005 through September 2009. In MY09-10 and MY10-11, the reach had flow only in the September monitoring. No flow was observed in any visit of MY13-14, but this year, long reaches of flow returned in Davidson Canyon in September. The watercourse remained dry during other visits.

Water Quality
PAG’s data indicates seasonal variation and differences in water chemistry between sites, but no significant long-term trends have been identified.
**Recommendations**

PAG recognizes the ongoing importance of integrating watershed and land use planning, vital for quality of life, access to green space, aquatic and riparian health, and shallow groundwater sustainability. These recommendations were formed by experience in various Watershed Program studies and as a partner on watershed wide efforts with diverse stakeholders. PAG encourages hydrologic studies that inform sound policy. PAG will work with partners in an advisory, collaborative and/or outreach role to pilot sample strategies to support riparian areas, such as well owner engagement and coordination of low impact design standards. By maintaining a long term consistent monitoring program for Cienega Creek, PAG will continue to utilize this data as proxy for regional riparian health conditions and partner on sustainability indicator efforts to reflect the value of supporting these areas and the impact on our community vitality and long-term water reliability. PAG supports regional partners to explore restoration funding options.

**Research and Monitoring**

- Conduct further ecological study to develop critical thresholds for species habitat and water needs in Cienega Creek Preserve
- Support Pima County’s watershed threat assessment process
- Continue methodologically consistent monitoring of Cienega Creek testing sites
- Create an updated long-term statistical analysis of Cienega data every 3 to 5 years
- Monitor riparian areas and aquifer status in areas that are targeted for groundwater and watershed restoration
- Foster regional coordination between land managers and scientists
- Monitor riparian areas in other regions for localized drought impact reporting to the Local Drought Impact Group and the statewide Drought Impact Reporting System

**Outreach and Education**

- Increase coordination with land use planners and well owners to promote conservation
- Engage with water users in the Cienega Watershed
- Provide tools for private well owners to assess water availability, choose effective conservation strategies, share information
- Provide education and outreach regarding water hauling practices, aquifer status, and impacts of groundwater pumping on the local environment
- Make efforts to reach rural well owners who may not be receiving conservation messaging
- Provide the public with a report of the Cienega Watershed’s watershed health status in a digestible format, taking cues from the Lower Santa Cruz Living River Project

**Regional Planning and Conservation**

- Prioritize management goals based on ranked conservation strategies presented in watershed assessments
- Consider strategic land acquisition as a means to reduce additional groundwater withdrawal
- Support the Arizona Water Banking Authority and the Groundwater Replenishment District in closing gaps in reserves of Long Term Storage Credits
- Recharge water as close to the site of withdrawal as possible
➢ Update analysis of the Groundwater Replenishment District maps (see past PAG reports)
➢ Update the Shallow Groundwater report, to assess un-delineated shallow groundwater concerns
➢ Develop physical water supplies, especially considering infrastructure for the renewable local supply of stormwater
➢ Coordinate updates to Drought Preparedness Plans to reduce incongruity while addressing local conditions, and create coordinated outreach

**Watershed Restoration**

➢ Repair and prevent gullies originating at roadways
➢ Construct earthworks in upland areas to increase infiltration and control erosion or induce meander
➢ Implement conservation practices at nearby wells
➢ Implement watershed restoration techniques identified in the Pima County Regional Flood Control District’s Low Impact Development and Green Infrastructure Guidance Manual, the updated Design Standards for Stormwater Detention and Retention Basins, and the PAG Regional Council’s Low Impact Development / Green Infrastructure Resolution

**Arizona Department of Water Resources**

➢ Incorporate environmental benefits from recharging and/or reducing groundwater pumping near shallow groundwater dependent ecosystems when designing and developing criteria for Special Enhancements Areas and similar efforts
➢ Encourage and promote a study evaluating the effectiveness of managed stormwater recharge throughout Arizona, as recommended by the Blue Ribbon Panel, and evaluate potential for recharge credits
➢ Utilize the PAG CAGRD and Shallow Groundwater Reports’ recommendations to improve gaps in reported data
Acknowledgements

PAG would like to acknowledge the people and agencies that have assisted and participated in the Cienega Creek monitoring program. Pima County’s long-term interest and support of the Cienega Creek and this monitoring program has been vital in the continuance of the program. We greatly appreciate the Pima County staff for sharing data, providing input, and coordinating their research efforts.

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, especially consistent partners including Don Carter and Rachel Loubeau. The project could not have been maintained without the help of former intern Ashley Hullinger or that of former Sustainable Environment Director Claire Zucker. Additional thanks go to Tom Helfrich, David Scalero, Frank Postillion, Doug Siegel, Iris Rodden, Julia Fonseca, and Brian Powell.
Appendix I

Bird’s-Eye-View of Cienega Watershed
Bibliography

This section provides information for accessing various reports and studies that have provided data that supports PAG’s research and coordination efforts.

The following documents (and many others) are available at PAG’s [online Water Resources center](#).


Pima Association of Governments (PAG). “PAG Cienega Creek Annual Report.” Multiple years available.


Other resources