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Memorandum

Date: 17 April 2009

To:

From: Eric Strecker and Aaron Poresky, Geosyntec Consultants

Subject: Response to *Assessment Of Evaporation Potential With Low-Impact Development Practices*

PURPOSE

The purpose of this memorandum is to provide critical review and response to *Assessment Of Evaporation Potential With Low-Impact Development Practices,* Submitted by Dr. Richard Horner as an appendix to his letter to the Los Angeles Regional Water Quality Control Board, dated April 10th, 2009.

SUMMARY OF ASSESSMENT

The Assessment by Dr. Horner is based on the following methods and data:

- Monthly normal (i.e. long-running averages by month) precipitation and reference evapotranspiration (ETo) data were compiled for 5 regions around the country and 5 cities within California from a variety of sources.

- The five cities were selected because they represent locations where *"surface discharge limitations are found, or are being considered by regulatory authorities."*

- The wettest three-month and six-month periods were identified based on long-term monthly normal precipitation and ETo.

- Overall balance between precipitation and ETo were summarized for the wettest three-month and six-month periods in each local.

The assessment offers the following arguments and conclusions:

1) Because the water balance for the wettest three months in some parts of California show a minor surplus of ET compared to a deficit of ET potential in the east coast locales considered, LID will likely perform better in southern California.

   "..even though southern California's wet season coincides with its period of lowest evaporation, its generally warm, sunny winters give it an advantage over other locations in the nation that have ***adopted*** *runoff retentive LID measures."* [Emphasis added][1]

2) A greenroof study in State College, Pennsylvania *"..found over 50 percent of annual stormwater volume to be retained and not discharged, even with as little as 20 mm (under 1 inch) of storage capacity, and peak discharge rate attenuation to no more than the pre-development level for the 2-, 25-, and 100-year frequency events."* Dr. Horner's Assessment extends this finding to conclude that greenroofs in southern California *"…would be expected to increase runoff retention to well over 50 percent with this LID technique."* This statement is not supported by any additional data or discussion.

3) The Assessment concludes that the California Regional Boards can feasibly require capture and full retention for all new and redevelopment for the following reasons:

   a. ET and precipitation are better balanced in California than other areas that have adopted or are considering such requirements. This is supported by comparisons of monthly normals.

   b. Infiltration will be possible in most cases. This statement is not supported anywhere in the document.

   c. Water reuse infrastructure is already in place in the form of reclaimed water systems. This is mentioned only once within the document and no elaboration is provided.

4) Exceptions should be granted in extenuating circumstances, in which case mitigation should be provided off-site.

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[1] It is noted elsewhere in the Assessment that some of the requirements cited are currently under consideration and have not been adopted. Comments on the details and status of these regulations are contained in a separate memorandum by Geosyntec Consultants titled "NRDC comments on Draft NPDES Stormwater Permit for the County of Orange, Tentative Order No. R8-2008-0030" dated 4/9/2009.

GEOSYNTEC RESPONSE

The Assessment used very simple metrics and anecdotal evidence to support the conclusions summarized above. In general, we believe that the definitive nature of the claims is not supported by the evidence presented. A summary of our primary comments are below:

1) The use of monthly normal data masks the actual patterns of rainfall that are observed in southern California. We believe that this is not an appropriate technical method by which to extrapolate conclusions about the effectiveness of evapotranspirative BMPs.

2) Comparing the wettest three- and six-month periods does not consider fundamental differences between west coast and east coast climatic patterns. Precipitation in southern California is highly seasonal, while precipitation in the other areas studies is far less so. In addition, storms in southern California come back-to-back in many cases.

3) Irrigation demand during dry summer months in southern California is a very important aspect of evapotranspirative BMPs (especially greenroofs) that is not addressed by the Assessment. Likewise the Assessment does not consider different (lower) ET rates from plant palates that could potentially be adapted to survive in vegetated BMPs in southern California without irrigation.

4) The Assessment does not discuss important differences between greenroof systems and systems that capture rainwater for subsequent irrigation use. We believe these factors are important to consider in this context.

<u>Use of Monthly Normal ET and Precipitation</u>

The use of monthly normal data masks the actual patterns of rainfall and ET that are observed in southern California. Monthly normals are calculated as the average of many monthly totals (i.e. the January monthly normal is the average of all individual January total in the period of consideration). The occurrence of a year in which all months receive their “normal” rainfall would be extremely rare, yet this is the theoretical year upon which the Assessment’s conclusions are based. The use of monthly normals is especially deceptive in evaluating the balance of ET versus precipitation as it maskshow storms actually occur in short sequences.

In the figures below, we provide a comparison between a monthly-normal analysis, and a weekly analysis of some representative individual years. Data supporting the weekly analysis were obtained from the California Irrigation Management Information System, California’s statewide authority on evapotranspiration data. At the CIMIS Irvine gage (CIMIS #75), more than 20 years of co-located precipitation and ETo data are available at hourly intervals. This dataset represents an ideal opportunity to evaluate patterns of ETo and precipitation at high resolution. This gage is located adjacent to the retired El Toro Marine Corp Air Station (33^{o}41'19"N, 117^{o}43'14"W). To support the monthly normal comparison, long term monthly normals were obtained from the Western Regional Climate Center for a daily gage known as “Tustin-Irvine

Ranch" (COOP ID: 049087, 1902-2003). The annual normal rainfall is 12.9 inches per these records.

Water year precipitation totals were extracted from the CIMIS gage data to identify average years, wet years, and dry years as shown in Table 1.

Table 1: Total Precipitation by Water Year at Irvine, CA (CIMIS gage

Water Year	Precipitation Depth, inches	Years Selected for Detailed Analysis
1988	12.72	
1989	9.33	
1990	8.34	
1991	14.08	
1992	Gage Malfunction	
1993	20.96	Moderately Wet
1994	8.16	
1995	14.21	
1996	11.29	
1997	12.32	Near Average
1998	31.9	
1999	7.74	
2000	7.26	Moderately Dry
2001	12.31	Near Average
2002	4.18	
2003	14.52	
2004	8.59	
2005	28.83	Very Wet
2006	8.93	
2007	3.12	Very Dry
2008	8.44	
2009	8.21	

Figure 1 shows the monthly normal water balance for Irvine, CA. Figures 2 through 7 provide weekly summaries for actual years as identified in Table 1.

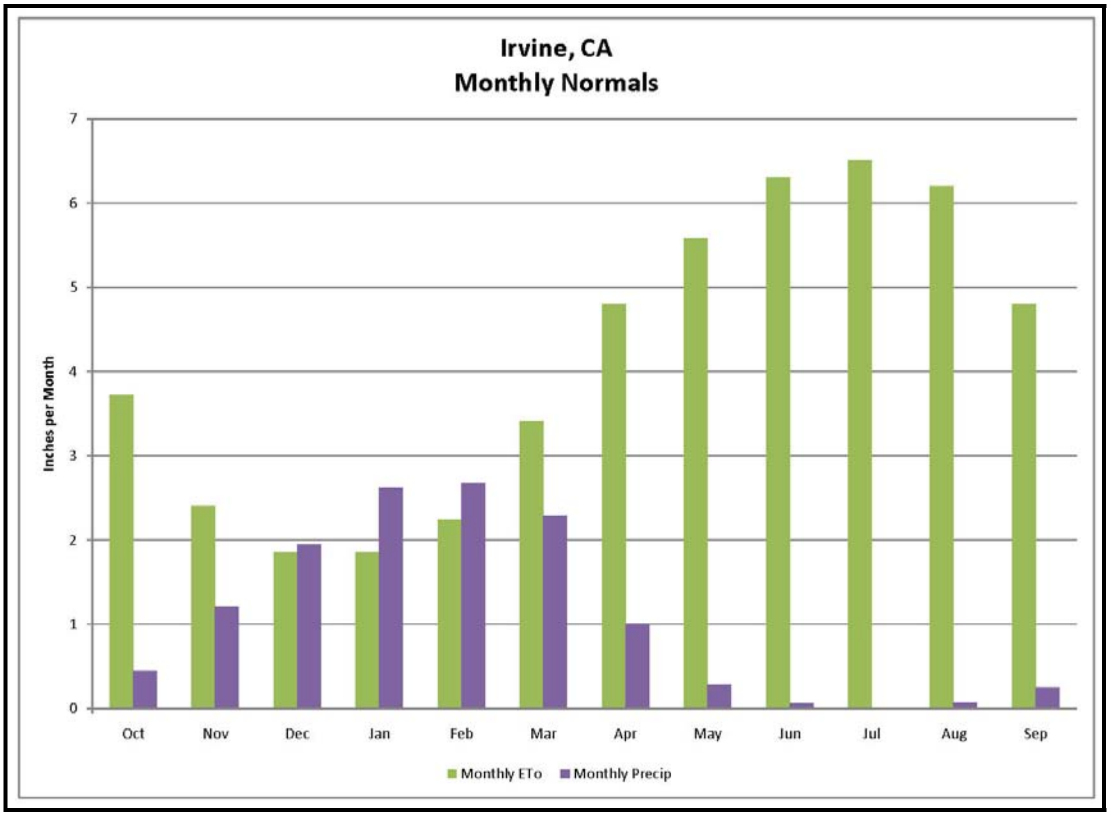


Figure 1. Monthly Normal Rainfall and Evapotranspiration at Tustin Irvine Ranch, Irvine, CA.

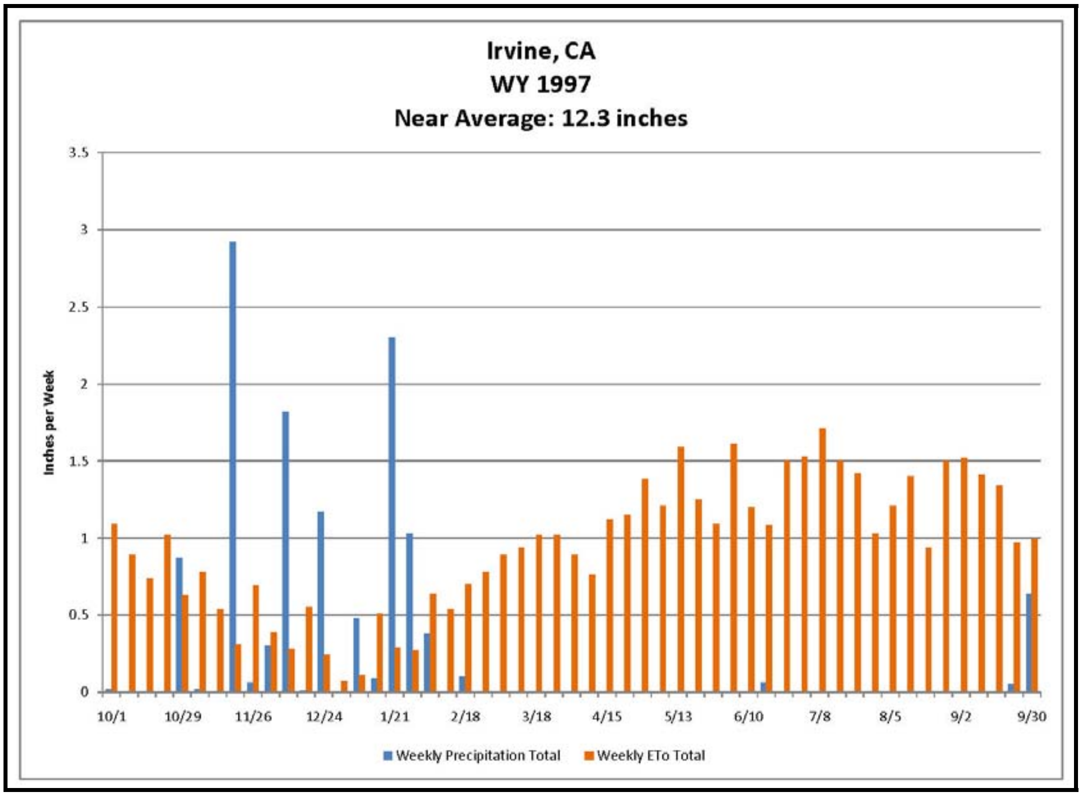


Figure 2. Weekly measured ETo and precipitation at CIMIS Irvine Station – WY 1997

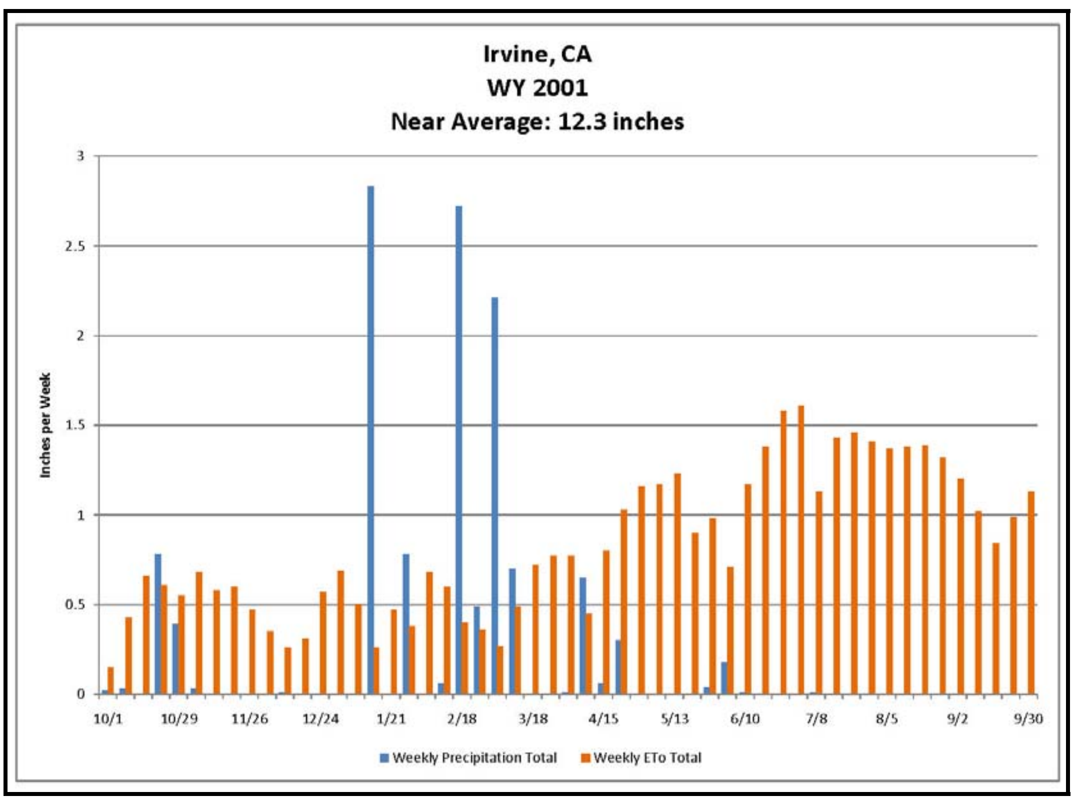


Figure 3. Weekly measured ETo and precipitation at CIMIS Irvine Station – WY 2001

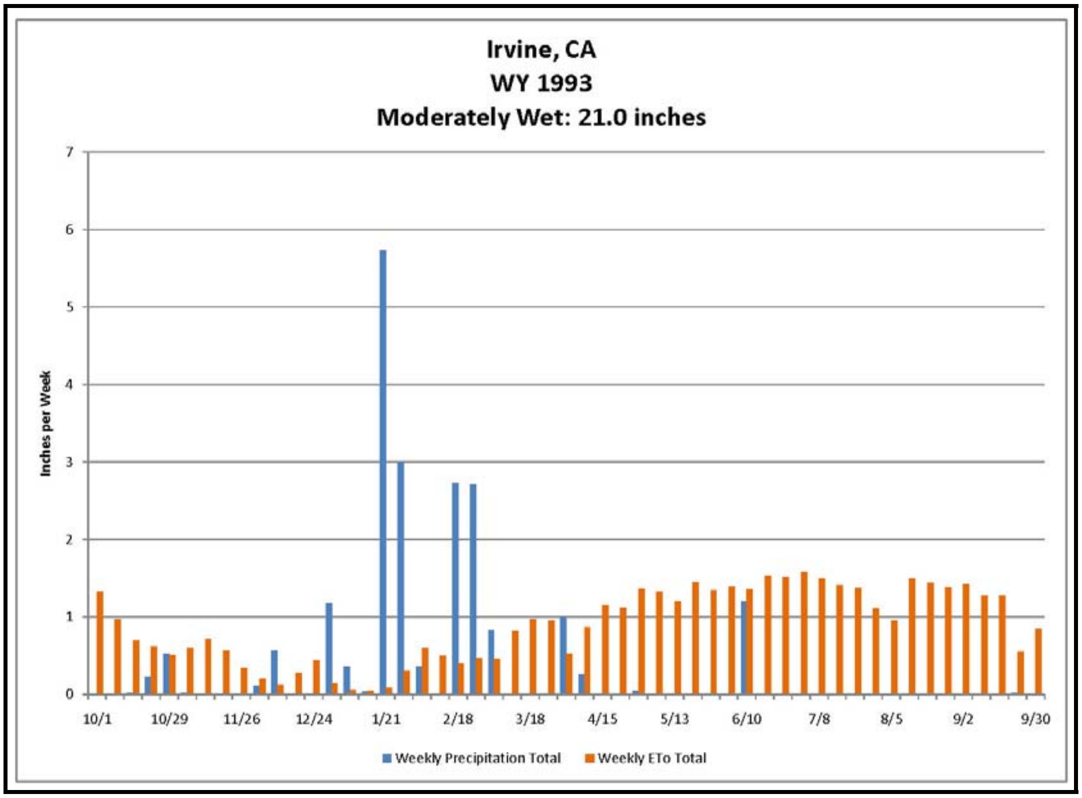


Figure 4. Weekly measured ETo and precipitation at CIMIS Irvine Station – WY 1993

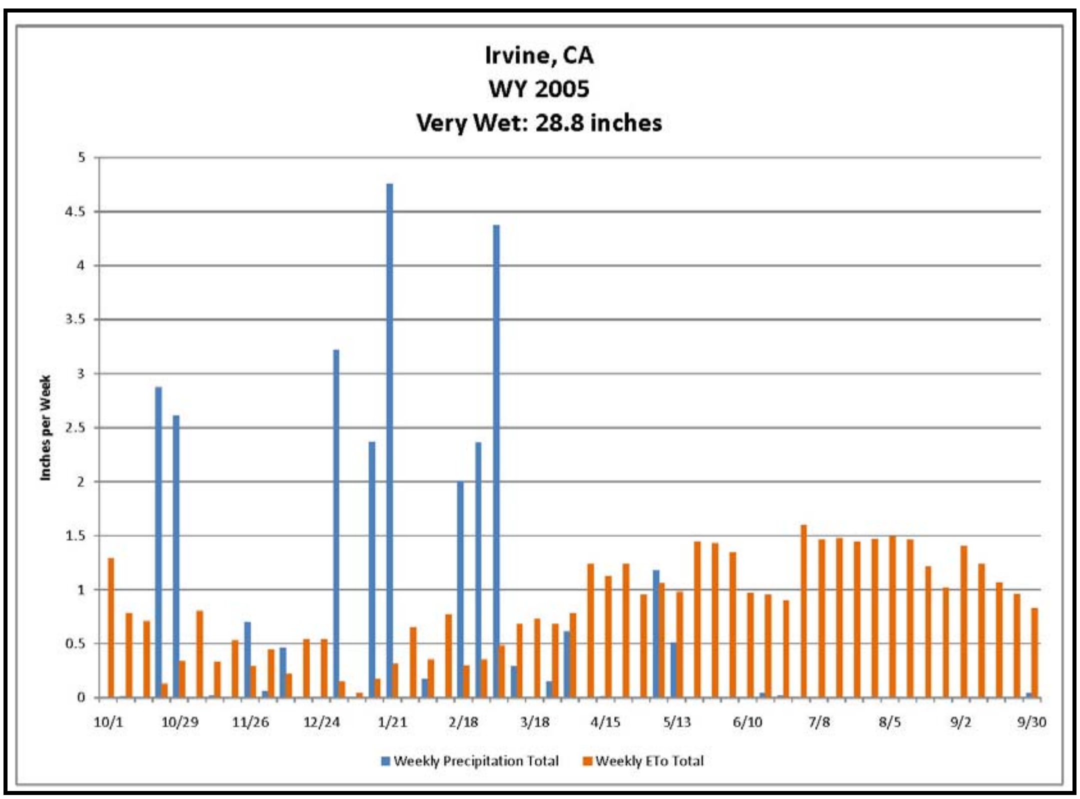


Figure 5. Weekly measured ETo and precipitation at CIMIS Irvine Station – WY 2005

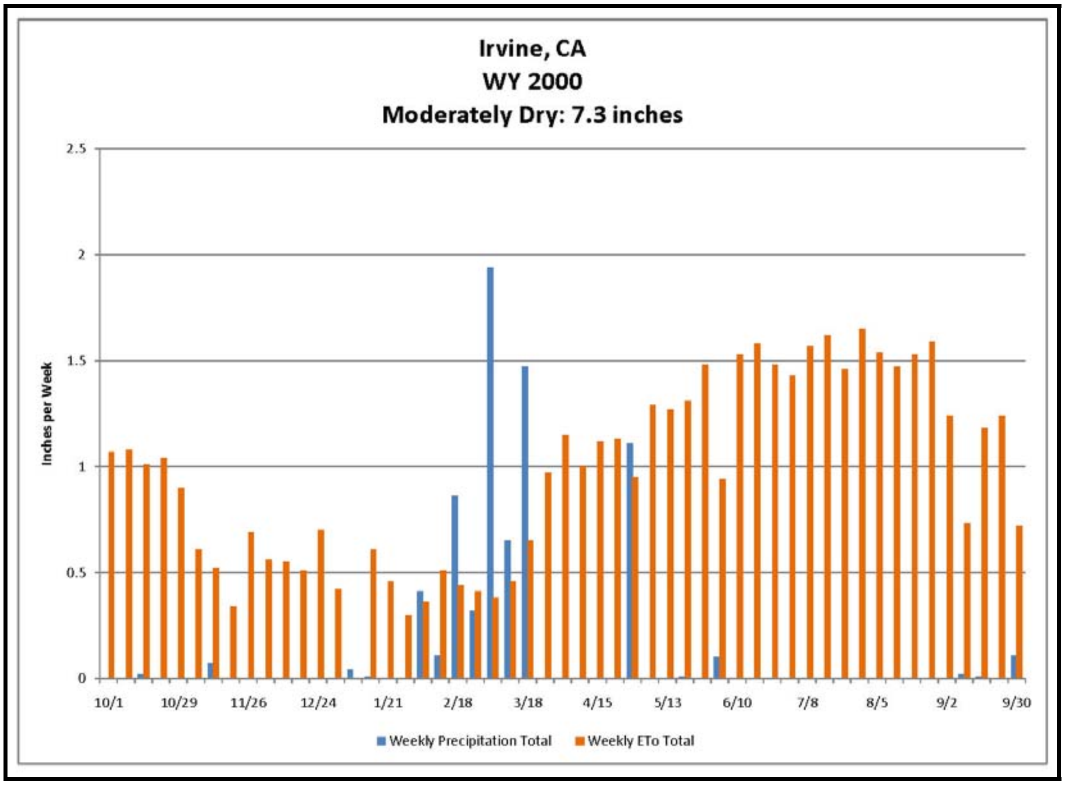


Figure 6. Weekly measured ETo and precipitation at CIMIS Irvine Station – WY 2000

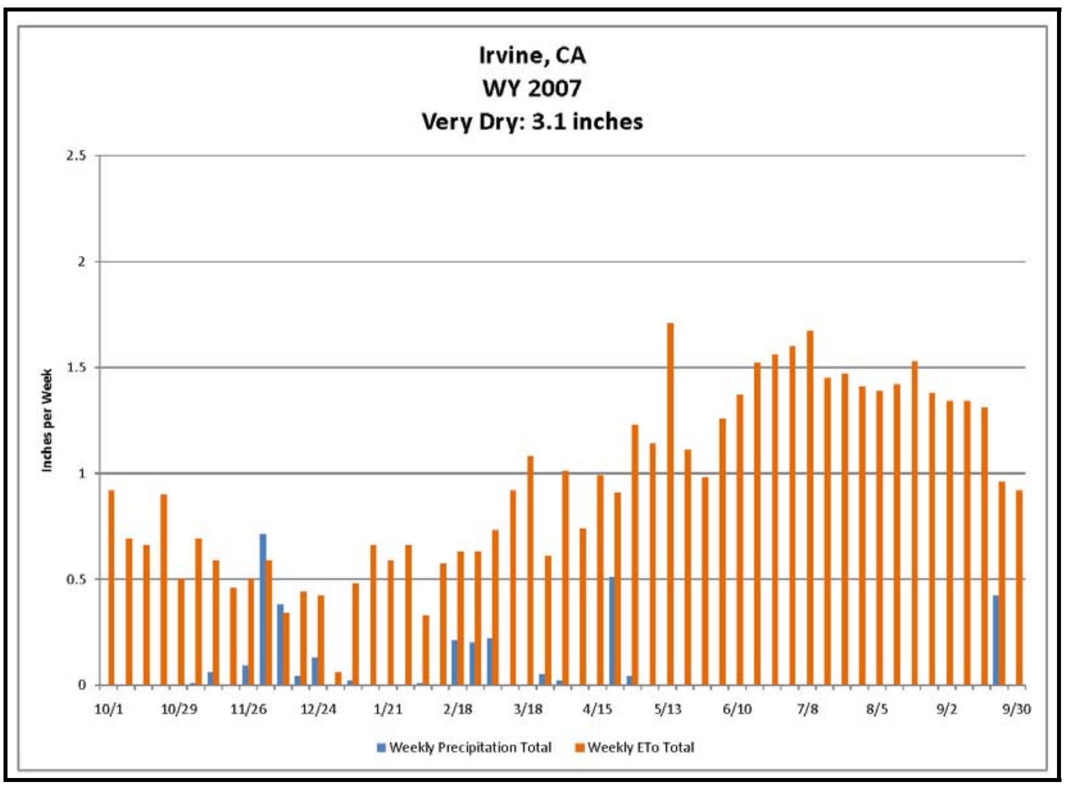


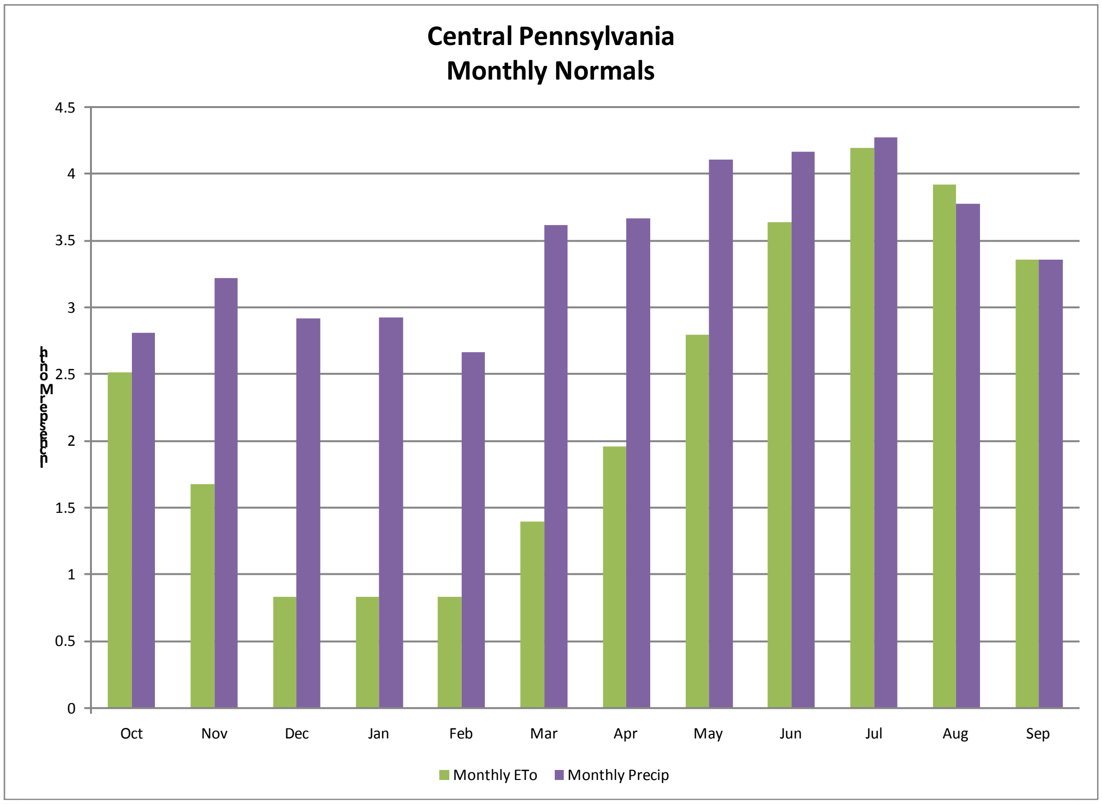
Figure 7. Weekly measured ETo and precipitation at CIMIS Irvine Station – WY 2007

Based on the figures above, it is apparent that monthly averages significantly mask the precipitation and ET patterns that occur within given months in the period of record. Monthly normals suggest that nearly all rainfall could be captured and evapotranspired, which was generally what the Assessment concluded for southern California. When summarized by actually weekly totals, the data suggest that rainfall during critical weeks and months in the period of record would far outpace evapotranspiration potential. This is especially of concern in southern California where the majority of annual rainfall can occur during periods in which evapotranspirative BMPs would tend to be largely ineffective. Finally direct comparisons between precipitation and evapotranspiration may be misleading due to the fact that rarely will an entire site be available for evapotranspirating storm water, especially on dense infill sites. Even with green roofs, it is unlikely that a full site would contain evapotranspiration area. On the other hand precipitation falls over the whole site.

The charts do suggest that ET is better paced to match precipitation in the "transition seasons" (i.e. late fall and early spring) when ET is higher and storm events tend to be smaller. The more complete capture of these storms would contribute to a moderate overall capture efficiency, but these charts suggest that more rigorous and technically appropriate analysis of the data would be required to support the Assessment's claims that greenroofs in southern California *"…would be expected to increase runoff retention to well over 50 percent with this LID technique."*

<u>**Fundamental Differences between East Coast and West Coast Climates**</u>

The differences between seasonality of rainfall are illustrated in a comparison between Central Pennsylvania (based on data sources cited by the Assessment) and Tustin Irvine Ranch (WRCC). The rainfall and precipitation for Central Pennsylvania were considered by the Assessment to represent a large area of the east coast.



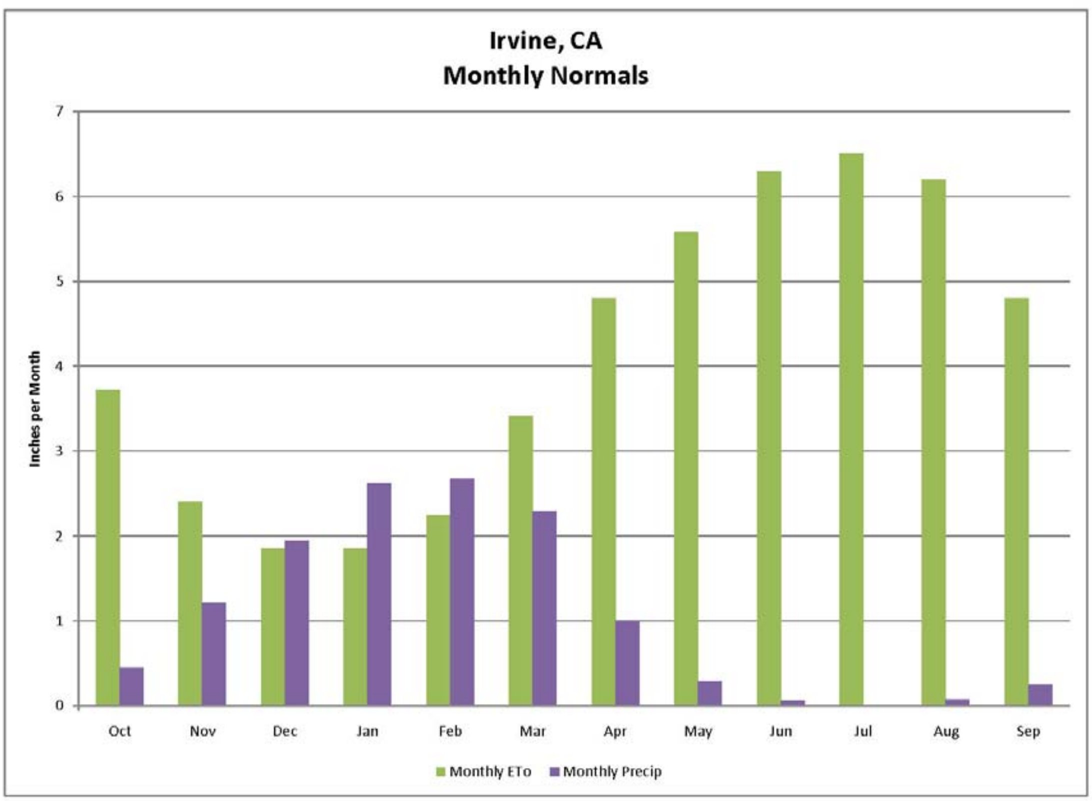


Figure 8. Monthly Normal Rainfall and Evapotranspiration in Central Pennsylvania and at Tustin Irvine Ranch

Two key points can be made from this comparison:

1) The seasonal variability of rainfall in central Pennsylvania is much less dramatic than that of southern California. The wettest three month period in central Pennsylvania is 12.4 inches while the driest is approximately 8.5 inches. By comparison, the wettest three months at Irvine receive approximately 7.5 inches of rain total while the driest receive less than 0.2 inches of rain total. The presence of rainfall during higher periods of ET in the east coast will inherently yield better capture efficiency in these months, thus tending to increase long-term capture efficiency despite a deficit in ET potential in the wettest and coldest months. Thus simply evaluating the wettest three months is over-simplified and has different ramifications for east coast compared to west coast locations.

2) The long, hot, dry summers in southern California necessitate irrigation of evaporation-based, vegetated BMPs or the use of extremely drought tolerant plants. On the first point, the current shortage of water in southern California requires a close evaluation of BMPs that would exert additional demand on water supplies (be they potable or reclaimed) to be confident that widespread implementation of these BMPs would not result in unintended consequences of increased irrigation needs.

   On the second point, it is likely that the same plants that can withstand several months of drought (i.e. require limited irrigation) would not likely be able to achieve evapotranspiration rates approaching the reference ETo (which is based on a well-irrigated cover crop) during the winter rainy season. All comparison contained in the Assessment and herein, assume that vegetated BMPs will achieve the reference ETo. In actuality, drought tolerant vegetation may achieve only half of ETo or less.

   By contrast, in Pennsylvania, rainfall is fairly consistent year round and would permit the use of more water-loving plants in vegetated BMPs without necessitating irrigation. These types of plants would be more likely to achieve a higher fraction of ETo, or potentially even exceed ETo in favorable locations.

<u>Difference Between Greenroofs and Other ET-based BMPs</u>

The Assessment provides a rough quantification of expected performance by reference of a greenroof study conducted in State College, PA. We find it relevant to identify certain important differences between greenroofs and other BMPs that rely on ET to dispose of water.

1) **Ratio of tributary to ET area.** Greenroofs typically ET from the same area from which they collect rainfall; in some cases additional roof area is routed to green roofs. By contrast, systems that capture water for irrigation may capture runoff from an area twice as large or much more than the area intended to be irrigated. Systems that concentrate runoff in on-site vegetated BMPs at typical ratio of between 4 and 10 percent of the

tributary area cannot hope to match ET to precipitation rates. This ratio is perhaps more important than the respective rates of ET and precipitation.

2) **Timing of Discharge.** Greenroofs represent the storage unit and the ET surface, thus would inherently begin to drawdown the storage as soon as a storm subsided and potential ET rates returned. By contrast, systems that capture water from impervious areas and use it to irrigate pervious areas would not be able to begin drawing down immediately. It would be necessary to wait until soil moisture in the pervious area had dissipated before irrigating with the captured water.

CONCLUSION

We have identified specific technical issues related to Dr. Horner's Assessment of ET Potential that suggest more rigorous analysis would be necessary to support the claims made by the Assessment. We have also identified other considerations with greenroofs, storage and reuse systems, and other evaporation-based BMPs that we believe should be better understood before issuing requirements that would tend to promote these BMPs above other options.

Our position is not that ET-based BMPs will not work in southern California. In fact, we believe that in the right situations, they may be well-suited to meet or partially meet the goals of a project. However, we believe that more robust analyses will be necessary to determine the benefits and costs of these types of BMPs and the limits on their effectiveness. Further, we do not believe they are necessarily the best or only types of BMPs to achieve water quality protection goals.