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Memorandum

Date: 9 April 2009

To: Mary Anne Skorpanich, Director, OC Watersheds Program

cc: Jeff Pratt, Public Works Director, County of Ventura

From: Eric Strecker, P.E. and Aaron Poresky, E.I.T Geosyntec Consultants
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Subject: Response to Critical Comments on "Low Impact Development Metrics in Stormwater Permitting"

This document contains Geosyntec response to elements of "Critique of Certain Elements of 'Low Impact Development Metrics in Stormwater Permitting'" (Dr. Richard Horner, February 2009 (paper not dated))

Dr. Horner's paper is referenced in a subsequent memorandum from the Natural Resources Defense Council (NRDC) to Ms. Carolyn Beswick and Members of the Santa Ana RWQCB titled: *Draft NPDES Stormwater Permit for the County of Orange, Tentative Order R8-2008-0030*. Comments on Dr. Horner's critique expressed herein apply to the NRDC memorandum by extension.

1 Overview

1.1 Dr. Horner's paper critiques elements of "Low Impact Development Metrics in Stormwater Permitting" prepared by Geosyntec Consultants and Larry Walker Associates (Geosyntec and LWA, 2009). The critique questions several assumptions and assertions made in the case studies contained therein, disagrees with the recommendations of the study, and selects elements from the study that support the assertion that a 5% effective impervious area (EIA) standard is both widely feasible and effective.

2 General Responses

2.1 It appears that all parties are in agreement that an appropriate LID standard must be linked to a volumetric standard. One of the objectives of the Metric paper was to determine the practicality and environmental outcomes of the LID metrics proposed in the draft April 2008 Ventura Countywide permit and the November 2008 Orange Countywide permit. The Metrics paper addressed the lack of such a volumetric standard in the Draft Ventura County permit. Without a volumetric standard the EIA metric may be abused. It is acknowledged that a volumetric standard is included in the Draft Orange County permit.

2.2 Geosyntec and LWA do not agree with, nor does the Metrics paper support, the validity or effectiveness of a 5% EIA limit. While values in the range of 5% EIA have been found to correspond to a "threshold" for channel degradation in some studies, the use of these findings to support a 5% EIA standard for new development and redevlopment projects relies on two tenuous links. First, the definition of EIA contained in the two draft permits does not necessarily correspond to the definition employed by studies of the impacts of EIA. Second, the studies finding approximate thresholds of 5% EIA were based on watershed averages, not individual projects or parcels. The Metrics paper states that a volumetric criterion for LID implementation does not need to be linked to a specific spatial extent of disconnection and/or compliance on a lot-by-lot basis to be protective, and that establishing a lot-by-lot criterion could inadvertently cause adverse impacts to receiving water quality (e.g., could lead to sprawl or preclude infill/redevelopment projects from occurring).

2.3 From the arguments provided in the critique, it appears that Dr. Horner misinterpreted the context in which the LID provisions of the draft MS4 permits are proposed. The critique argues against a "delta volume" approach and for a "full volume approach" to LID sizing. We fully support the component of the draft permits that require <u>treatment</u> of the entire "water quality volume." The critique's apparent misunderstanding is to confuse the LID design standard with the water quality design standard. The bulk of the argument against a delta-volume as a LID sizing metric is based on this apparent misunderstanding and the resulting assumption that any volume above the delta volume would be allowed to discharge without treatment or hydrologic control. This is not the case for either the Ventura or Orange Countywide draft permits. Both the water quality treatment and hydromodification elements of the draft permits would prohibit this from occurring. This item is discussed further in Section 3.1 below.

2.4 Geosyntec and LWA do not agree with, nor does the Metrics paper support, the critique's assertion that infiltration and reuse are feasible in all densities and types of development. A variety of limitations can prevent infiltration on a project site which are typical in southern California. Dr. Horner's study "Investigation of the Feasibility and Benefits for Low-Impact Site Design Practices ("LID") for Ventura County" (Horner, 2007) does not consider site specific infiltration rates and other limitations on infiltration; rather, it relies on a modeling study that assumed rather high infiltration rates based on San Fernando Valley soil types and applied those results in a rather simplified way to different case studies for example projects from San Diego County. Geosyntec has previously prepared a critique of this study (Geosyntec, 2008) that found various misrepresentations of findings and problematic assumptions that tended to result in uncertainty about claims of feasibility and effectiveness of an EIA standard at all project densities.

2.5 Horner (2007) relies on capture and reuse as a fall-back strategy where infiltration is not feasible. Stormwater reuse for the purpose of stormwater management requires a sufficient demand during the wet season to replenish the capacity of storage units to be effective as a stormwater management device. Horner (2007) does not attempt to demonstrate the effectiveness of capture and reuse. It is well understood that if sufficient water demand does not exist during the rainy season, the volume of storage that can be made available for subsequent storms is minimized. This would result in overall poor performance of capture and reuse to achieve stormwater management goals. Furthermore the Metric paper would be remised if it did not acknowledge the "practicality" challenges that are associated with the implementation of capture and reuse options, such as building and health code compliance.

2.6 We appreciate the detailed comments the critique offers on the case studies contained in the Metrics paper. Several were well-founded and could be used to make the case studies more robust. However, it is apparent that several others were made without consideration for the stated purposed of the case studies and thus unfairly misrepresent the findings of these studies. The findings of the Metrics paper do not support a lot-by-lot EIA criterion. In fact, the case studies demonstrate that lot-by-lot EIA limits are not the only, nor necessarily the best, way to realize the benefits of LID. The scope of the studies is not broad enough to dismiss the feasibility of this criterion nor did it attempt to do so. The critique takes this lack of dismissal as support for a lot-by-lot EIA limit and labels important constraints identified by the case studies as simply "negative". The critique's detailed comments on specific assumptions are tangential to the underlying discussion of whether a lot-by-lot EIA limit is superior to more appropriate watershed-scale metrics that may be better linked to the resources they are attempting to protect, as well as supported by the research on the impacts of impervious area on riparian ecology.

3 Specific Responses to the Critique

3.1 **Selection of an LID Design Storm.** On pages 1 through 3, the critique references a variety of studies that have found that the "full water quality volume" (calculated in a variety of ways across the country) represents the "point of diminishing returns" for water quality improvement. While we believe that this assumption should always be confirmed through analysis of site-specific rainfall patterns, we are in general agreement. The recommendations of the Metrics paper are not to replace the established water quality treatment criteria with the LID criteria. Rather, the Metrics paper recommends that the LID criteria should be less than the full water quality criteria and allow for natural condition runoff potential to be factored into calculations.

It appears that Dr. Horner erroneously treats the LID and water quality provisions of the draft permits interchangeably. Among the various regulatory standards that the critique cites (Georgia, Washington, Maine, Pennsylvania, North Carolina), only one standard appears to require retention of a specific design storm (Pennsylvania). This standard requires treatment of the first 2" of runoff from all impervious surfaces and permanent removal (i.e., infiltration, ET, or reuse) of 1" of runoff from new impervious surfaces. This does not seem to represent a "full volume" standard, nor does it seem to be consistent with the logic that the critique uses to support a full retention standard. Note that this "standard" is in a guidance document that is a draft form and has not been adopted to date. The other standards that were mentioned only require treatment of the design storm. It is not clear how these example regulations support a standard that would require capture and infiltration or reuse of the entire water quality volume. .

3.2 **Performance of LID vs. WQ Design Storm.** The critique relies on an event-based methodology to illustrate the difference between a "delta volume" and "full volume" approach, which inherently over-states the difference between these two standards. The critique claims that a "delta volume" design storm would result in significant impacts while a full volume design storm would result in none. (P 2)

> *"When managing water quality, in contrast, any untreated volume (in the delta volume scenario, this would be the amount that originally flowed from the undeveloped land) would deliver to the receiving water the many pollutants characteristic of urban runoff. There, these pollutants would create negative physical, chemical, and biological effects. On the other hand, if the appropriate water quality volume is used (i.e. no less than the 85th percentile event)* ***the LID-based stormwater management BMPs should deliver no pollutants to the receiving water****, since the retention and reuse or infiltration of that volume is practicable and achievable, as I have demonstrated separately by analyzing a range of development scenarios in southern California."* [Emphasis added]

This excerpt shows an apparent misunderstanding of BMP performance factors. BMPs are not designed to capture all of the runoff volume from every storm, but only that volume up to the design storm volume (e.g., 0.75 inches). Thus, the argument above applies only to a specific storm depth for which the difference in performance for "full volume" BMPs and for "delta volume" BMP would be greatest. Long term performance of a BMP depends on the patterns of rainfall and the drawdown rate of the BMP in addition to the storage volume provided. All other factors equal, the use of a "delta volume" approach (i.e., a smaller storage volume) would indeed infiltrate a lower portion of the overall runoff than a "full volume" approach, but the difference may be something on the order of capturing 70% versus 80% of the average annual runoff volume, not an "all or nothing" outcome. As the critique points out, the difference between the "delta volume" and the "full volume" is small for the cases considered. The runoff that is between the difference of the "delta volume" and the "full volume" would still require treatment to remove pollutants before discharge, which is not considered in the critique.

3.3 **Use of Horner, 2007 as a Basis for Assumption of Feasibility**. Dr. Horner's critique refers to his study entitled "Investigation of the Feasibility and Benefits for Low-Impact Site Design Practices ("LID") for Ventura County" as evidence of the benefits and feasibility of LID implementation at all densities. Geosyntec has already provided a critique of this study (Geosyntec, 2008) in which we found:

- Three of the six case studies assumed a lower imperviousness than typical of their land use category. For example, the restaurant case study assumed an imperviousness of 49%, although the Ventura County Hydrology Manual lists an average imperviousness of 85% for this land use. Lower imperviousness yields less runoff-generating surface and more area available for infiltration.

- The study assumed that all of the pervious area would be available for infiltration; no reduction was made to account for necessary building setbacks or to account for scenarios in which some pervious area is upgradient of impervious area or otherwise not suitable for infiltration.

- Dr. Horner's study made questionable use of a study of the benefit of infiltration basins in the San Fernando Valley. Geosyntec's critique identifies issues with this study as well as issues in the applicability of this study to Dr. Horner's findings for Ventura County. For example, the San Fernando Valley study assumed infiltration rates of 0.5 to 2 inches per hour and made use of daily rainfall totals from a San Fernando gage. The 2007 study did not attempt to validate or adjust these assumptions for the range of rainfall and soil conditions present in Ventura County.

- In higher density development and in areas of Ventura County that experience larger rainfall events, the conclusions of Dr. Horner's study were not supported by his calculations. The 2007 study relied on a fall-back strategy of capture and reuse where infiltration would not be sufficient to mitigate stormwater runoff; however, the study did not evaluate the effectiveness or feasibility of this concept.

Overall, the findings of the Horner (2007) study do not appear to fully support the stated conclusions related to volume reduction and feasibility of meeting an EIA standard. Considering the simplifications that the study relied upon, we believe that there should be more qualifications of, or limitations on, the findings.

3.4 **Benefits of LID in Case Studies**. Dr. Horner's critique asserts that the case studies contained in the Metrics paper do not address the benefits of LID. First, the stated intent of the studies was to evaluate the feasibility of implementation of a variety of interpretations of an EIA standard for LID implementation. It was not to perform a cost-benefit analysis. The primary benefits of LID lie in the volume reduction it can achieve on suitable sites. In fact, each scenario was linked to the volume retained on-site, thereby implicitly describing the benefits of implementation. The studies identified different ways in which equivalent benefit could be achieved.

3.5 **Walnut Village assumption of infiltration rate**. The critique contends that an assumption of 0.2 inches per hour for B soils is too low, and that the study ignores a basic tenant of LID: that soils should not be compacted during development. This case study was of an actual redevelopment project in Anaheim that included underground parking under the majority of the site and landscaped areas typically measuring 4-8 feet in width between the adjacent roadways and building foundations. We would like to make several comments related to this contention:

- In redevelopment projects, the condition of underlying soils may be out of the control of the site design engineer. While it is considered a "best practice" to recondition soil through soil amendments, this practice can only be feasibly implemented to a certain depth. If a low permeability soil layer lies below this depth, whether due to prior site compaction or natural site conditions, then reconditioning the surface, while increasing moisture storage capacity, would not necessarily increase the rate at which moisture storage capacity can be regenerated by infiltration.

- Both roadways and building foundations require compaction of underlying soils for structural stability. In an ideal scenario, the soil underlying the thin strips of landscaping would not be compacted, however it may very well be within the practical influence area of adjacent compacted areas.

- In cases where the landscaped area is proximate to the foundation of the underlying garage, compaction may be required for structural purposes, and in fact, infiltration may be prohibited for structural reasons.

- Typical guidance in the design of infiltrative BMPs suggests a factor of safety to account for long-term degradation of infiltration rates. For example, the Stormwater Management Manual of Western Washington (WADOE, 2005) recommends a factor of safety of 4 for BMPs relying primarily on infiltration in soils with unadjusted infiltration rates from 0.5 to 8.0 inches per hour. Such guidance seems prudent where the result of failure is the discharge of greater volumes of runoff to receiving waters and/or long durations of standing water potentially leading to public health concerns. The critique cites a range from 0.57 in/hr to 1.4 in/hr for B soils from the NRCS soil survey, a source which generally considers soils in their natural state (NRCS, 2007). Quoting from this source (Section 630.0702):

  "As a result of construction or other disturbances, the soil profile can be altered from its natural state and the listed group assignments generally no longer apply, nor can any supposition based on natural soils be made that will accurately describe the hydrologic properties of the disturbed soil. In these circumstances, an onsite investigation should be made to determine the hydrologic soil group."

Factoring the effects of incidental compaction in the urban environment and a prudent factor of safety, the assumption of 0.2 inches per hour as a design infiltration rate for B soils is consistent with the critique's citations. While the critique accurately points out that a slightly higher assumption would indeed reduce the drawdown time to less than 72 hours, this does not negate the fact that with relatively deep BMPs over soils with low infiltration rates, limited storage capacity would be regenerated for sequential storms. Such sequential storm sets are responsible for a large fraction of total precipitation in Southern California.

3.6 **Walnut Village – "non-essential hardscape".** Geosyntec and LWA agree that in some cases more hardscape is used in development than necessary. However, it should not be taken as a given that landscaping is less expensive. The statement in the case study should have been "apparently non-essential hardscape". The case studies explicitly state that not all site-specific constraints could be evaluated. It is likely that some of the hardscape that was removed for the 0% EIA case could have been needed for ADA access or to meet parking standards, if the case study were to be evaluated more closely.

3.7 **60 California – appropriateness of greenroofs and cisterns.** We appreciate the critiques's perspective on the trend of BMPs towards greenroofs and reuse. We fully embrace these technologies in places where they can be demonstrated to have a good chance of success. However, the critique does not demonstrate that the use of greenroofs and stormwater reuse are commonplace. Currently, greenroofs have been implemented primarily in a few large cities and primarily on public buildings.

The critique refers to an established program of rainwater harvesting and reuse in Texas. While eastern Texas receives greater rainfall than Southern California, the critique states that western Texas "has rainfall conditions very much like southern California's". A detailed review of the Texas Rainwater Harvesting Guidelines (TWDB, 2005) showed that this program is primarily targeted toward using harvesting to meet water demands, not to control stormwater. It should also be noted that large parts of Texas receive summer rainfall in the form of thunderstorms which rarely, if ever, occur during the summer in Southern California. Figure 1 provides a summary comparison between precipitation and evapotranspiration patterns in western Texas versus southern California.

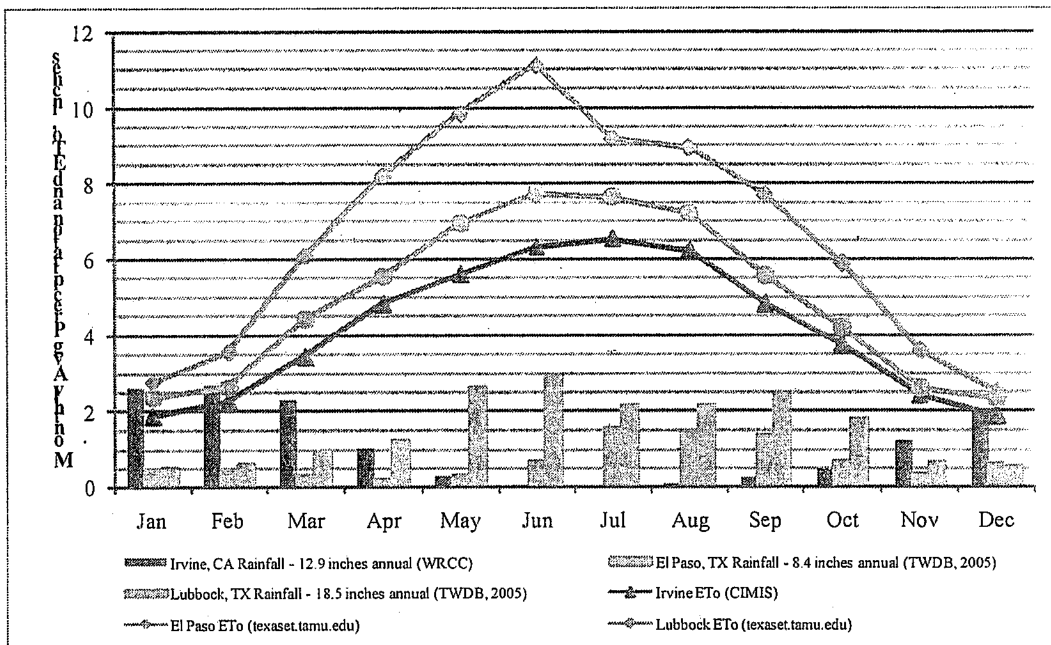

Figure 1: Comparison of precipitation and ET patterns between western Texas and southern California

Based on this preliminary comparison, western Texas appears to be a more favorable location than southern California for rainwater harvesting to manage stormwater impacts and meeting water demands. First, periods of higher rainfall are coincident with periods of higher ETo in west Texas, while the opposite is true in southern California. Second, rainfall occurs more steadily throughout the year in west Texas compared to the normally dry spring, summer and fall months of southern California.

3.8 **60 California – anticipated performance of greenroofs and cisterns.** The critique provides a somewhat vague defense for the performance of greenroofs in Southern California. One cited study found that a greenroof in Pennsylvania could reduce average annual runoff volumes by 50 percent. This study was compared to Southern California by saying that pan evaporation rates are between 3.3 and 4.2 inches per month in Pennsylvania from June to September (presumably a wet season in that locale) while November – February pan evaporation ranges from 3.5 to 4.0 in Los Angeles. A review of local ET data in Los Angeles County showed that this comparison is not valid. Monthly ET rates in Southern California range from about 1.5 to 2.5 from November through February. Also, rainfall is more seasonally concentrated in Southern California than in the mid-Atlantic region. Figures 2 and 3 below provide a comparison between Irvine, CA and the Washington, DC vicinity, for example.

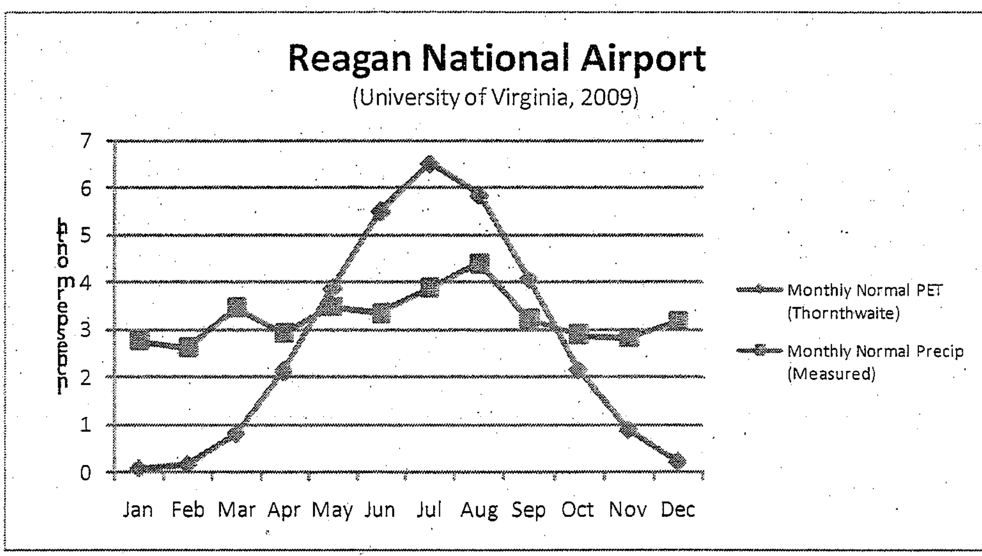

Figure 2: Monthly normal patterns of ET and precipitation at Reagan National Airport

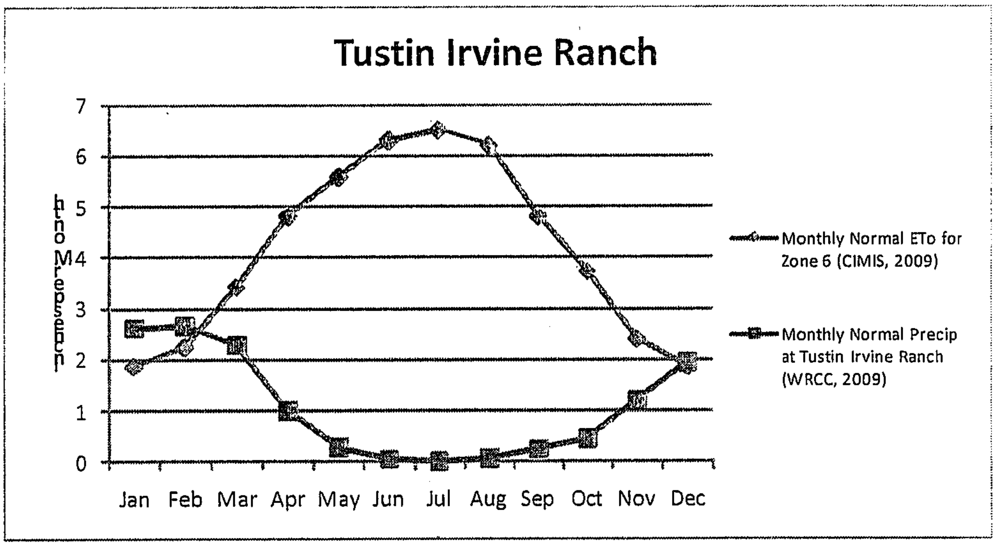

Figure 3: Monthly normal patterns of ET and precipitation in Irvine, CA

Dr. Horner states: "Therefore, Los Angeles has as much evaporation potential in the months when it most needs that potential as locations with successful green roofs elsewhere." Figure 2 shows that ET rates in December, January, and February are lower than the average precipitation. As precipitation is rarely average, on frequent occasions rainfall rates will significantly exceed ET rates. Thus Dr. Horner's conclusion does not seem to be supported by the examples provided.

Dr. Horner's critique does not address anticipated performance and feasibility of capture and reuse systems.

3.9 **60 California – regulatory barriers to indoor reuse**. We agree that codes should not be regarded as unbending. However, we feel it would not be responsible to discuss indoor reuse and its current feasibility without mentioning the current limitations and considering the time that may be needed to get code changes in place. We do not state that this should be basis for dismissing this approach.

3.10 **Ventura K-mart – scope of study**. We agree that the scope of this case study was too narrow to draw wide-ranging conclusions about cost. Likewise, the study did not "reject" tree boxes, bioretention, pervious pavement, green roofs, or water harvesting as the critique indicates. The study simply stated that two typical BMPs were chosen for evaluation. This is an issue of scope, not logic.

Dr. Horner himself took a simplified approach to costs by relying on the EPA report entitled: *Reducing Stormwater Costs through LID Strategies and Practices* (EPA 841-F-07-006, December 2007 - available for download at www.epa.gov/nps/lid). This report generally found that LID could result in cost savings. It is well understood that design criteria play a large factor in the cost of BMPs, however only two of 17 case studies contained in the EPA 2007 reported design criteria. Likewise, only three of 17 estimated performance. It is not clear whether these sites were designed to similar standards. It is also unclear whether these sites represent opportunistic examples (i.e., sites that had a natural fit for LID-type BMPs) or whether they are a true cross-section of development sites with the various inherent constraints.

Some of the studies contained in EPA (2007) relied on BMPs, such as narrowing street width and downspout disconnection, which would not be widely applicable to many high-density redevelopment projects. Of the BMPs contained in the case studies that would likely be used for higher-density projects (bioretention, permeable pavement, green roofs, and cisterns), permeable pavement was considered in only two of 17 case studies, and green roofs were considered in only one of the 17 studies (cost-benefit analysis showed substantially greater costs than benefits for this study). Cisterns with reuse were not considered in any of the 17 studies. Considering these factors, this source should not be relied upon solely in evaluating the costs of implementing the proposed permit requirements.

3.11 **Ventura K-mart – method of runoff estimation.** We agree that the NRCS curve number is not the best method to use for small storms, however the critique of this method is tangential to overall results, and use of the NRCS curve number method would actually tend to under-predict infrastructure requirements (i.e., cost). We appreciate this comment. It is noted that in Dr. Horner's previous evaluation of feasibility and effectiveness (Horner, 2007), the curve number method was used to establish the volume that would need to be infiltrated on-site.

3.12 **Ventura K-mart – assumption of infiltration rate.** We appreciate this correction. It appears that an adjustment factor was not applied as described in Section 3.5 to account for long-term decline in infiltration rate. Correction of this error would result in substantially increased infrastructure requirements (i.e., cost).

4 References

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