Geosyntec consultants

2566 Overland Avenue, Suite 670
Los Angeles, California 90064
PH 310.839.6040
FAX 310.839.6041
www.geosyntec.com

Memorandum

Date: May 28, 2008

To: Mark Grey, Building Industry Association of Southern California

From: Lisa Austin, Felicia Federico, Aaron Poresky, and Eric Strecker, Geosyntec Consultants

Subject: Review of Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for Ventura County
Geosyntec Project: LA0157

INTRODUCTION

The third draft Ventura County MS4 Permit contains the following provision:

III. New Development/ Redevelopment Performance Criteria

1. *Integrated Water Quality/ Resources Management Criterion*

   *(a) Permittees shall require that all New Development and Redevelopment projects identified in subsection 5.E.II control pollutants, pollutant loads, and runoff volume emanating from impervious surfaces through percolation, infiltration, storage, or evapo-transpiration, **by reducing the percentage of Effective Impervious Area (EIA) to less than 5 percent of total project area*** [emphasis added].

   (b) Impervious surfaces may be rendered "ineffective" if the storm water runoff is:

   (1) Drained into a vegetated cell, over a vegetated surface, or through a vegetated swale, having soil characteristics either as native material or amended medium using approved soil engineering techniques; or

   (2) Collected and stored for beneficial use such as irrigation, or other reuse purpose; or

   (3) Discharged into an infiltration trench.

Richard Horner[1] investigated the practicability of the effective impervious area (EIA) permit requirement, modified to include a lower, three percent EIA requirement, using six development project case studies. Results of the investigation are contained in the study Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for Ventura County (provided in PDF format, unpublished). One of the findings of the investigation was that typical development categories, ranging from single family residential to large commercial, can feasibly implement low-impact post-construction BMPs design in compliance with the draft permit's requirements.

Geosyntec was asked to review this study to assess the assumptions used in the analysis related to runoff volume control and the findings of feasibility related to capping EIA. As such, we have not evaluated the pollutant removal assumptions, calculations, or findings also contained in the study in this memo.

It should be noted that Geosyntec advocates the use of LID features and the disconnection of impervious areas where appropriate, and we routinely rely on these principles in stormwater management planning and design. The findings of our review contained in this memorandum are not intended to challenge the value of LID as a tool in stormwater management, as we believe it is indeed a useful tool. However, we also believe that the effectiveness of LID is markedly influenced by project site and watershed conditions and that the concepts behind LID are not universally appropriate and effective in mitigating stormwater impacts. LID is a site by site approach. We believe that watershed considerations are critical in determining whether LID, and in particular infiltration, are the best approach. Finally, what has been lacking in most LID assessments is a water balance that looks at the resulting changes in evapotranspiration (usually the most changed water balance component when developing an undeveloped site), deeper infiltration, and runoff.

REVIEW FINDINGS

The study tested the feasibility of capping EIA at three percent (rather than at five percent as stated in the draft Ventura County permit). The reason for using three percent instead of five

[1] Research Associate Professor, University of Washington Department of Civil and Environmental Engineering and Landscape Architecture

percent was based on a study conducted by Coleman, *et al.*,[2] that found that the ephemeral / intermittent streams in southern California appear to be more sensitive to changes in percent impervious cover than streams in other areas. This study estimated that the threshold of response is approximately two percent to three percent impervious cover, as compared to seven percent to ten percent for other portions of the U.S. But, as was also emphasized in the Horner study, it is important to note that the conclusion in the Coleman study applies specifically to streams with a catchment drainage area of less than five square miles. Therefore, to use a three percent (or five percent) EIA threshold for all projects, without consideration of the size of the watershed that they are located in, is not correctly based on the findings of the Coleman study. The implications for projects in Ventura County are significant, as there are several large river systems (*i.e.*, the Ventura River, the Santa Clara River, and Calleguas Creek) whose watersheds are much larger than five square miles. Attached to this memorandum are further comments on the use of impervious area as a hydromodification control criteria.

Case Studies

Six development project case studies were examined in the Horner study. Four of the case studies were based on building permit records from the City of San Marcos in San Diego County (the multi-family residential, small single family residential, restaurant, and office building case studies), with additional assumptions used to estimate the areas for roadways, walkways, and landscaping. The large single family residential development and retail commercial development case studies were hypothesized based on the other four cases. The land use, project area, and imperviousness for the six case studies are summarized in Table 1 below. Imperviousness is equal to the percentage of the total project area comprised of roof, parking, roadway, walkway, and driveway area. Also provided in Table 1 is the average imperviousness listed in Appendix A, Exhibit 14b, of the Ventura County Hydrology Manual for the corresponding case study land use type.

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[2] Coleman, D., C. MacRea, and E. D. Stein (2005). *Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams*. Southern California Coastal Water Research Project Technical Report #450, Westminster, CA.

Table 1: Case Study Characteristics, Land Use, and Areas

Case Study	Description	Project Area (acres)			Imperviousness (percent)	
		Impervious Area	Landscape Area	Total Area	Case Study	Ventura Hydrology Manual [1]
Multi-Family Residential	11 buildings 438 parking spaces	7.29	3.66	10.95	67	69 [2]
Small Single Family Residential	23 homes	1.36	1.67	3.04	45	65 [3]
Restaurant	1 building 33 parking spaces	0.38	0.39	0.77	49	85 [4]
Office	1 building 37 parking spaces	0.52	1.61	2.13	24	85 [4]
Large Single Family Residential	1,000 homes	59.29	72.69	131.98	45	65 [3]
Retail Commercial	1 building 500 parking spaces	4.73	0.47	5.20	91	85 [4]

[1] Hydrology Manual, Ventura County Watershed Protection District, Updated December 2006.
[2] Average imperviousness for residential – condominiums.
[3] Average imperviousness for residential – 1/8 acre lot. Case studies are 7.7 lots/acre (small project) and 7.6 lots/acre (large project).
[4] Average imperviousness for commercial and business.

Comparison of the Hydrology Manual average imperviousness to the case study imperviousness values shows that the multi-family residential and retail commercial case studies' imperviousness assumptions were reasonably close to the Hydrology Manual. The remaining case studies (small and large single family residential, restaurant, and office) analyzed scenarios with a lower imperviousness than the average value from the Hydrology Manual. In other words, these four case studies assumed a larger landscaped area than perhaps may be typical in Ventura County projects. The two single family residential case studies assumed the same density (approximately 7.6 – 7.7 houses per acre), but the assumed imperviousness corresponds to a lower density in the Hydrology Manual (approximately 5 houses per acre). The office building imperviousness assumption appears to be particularly low, as this case study assumes that 76 percent of the lot is landscaped. The restaurant case study is also quite low. These assumptions are important because they establish the post-development pervious area available for infiltration and other LID techniques.

Infiltration Capacity

The Horner study attempted to determine if the pervious portion of each case study site would provide sufficient area for infiltration of the site's annual runoff from the pervious area and the "Not-connected Impervious Area" (the 97 percent of the site's impervious area that is not EIA).

For this determination, the study calculated the average annual runoff volume for each case study and compared this volume to the infiltration capacity of the pervious area of the site. The study assumed that all of the pervious area would be available for infiltration; no reduction was made to account for necessary building setbacks. Also, the assumption that all pervious area is available for infiltration assumes that the drainage from the impervious area must be able to flow to all of the pervious area, which is not typically the case in actual development projects. On sloping sites, there is usually some pervious area which is upgradient of the impervious areas and therefore unavailable for infiltration. Finally the study assumed that there are no geotechnical or high groundwater issues associated with infiltration in estimating achievable volume reductions.

The infiltration capacity for the case studies was estimated based on the findings of Chralowicz *et al.* (2001).[3] The Chralowicz study developed infiltration basin sizes using simple assumptions about infiltration capacity of San Fernando Valley soils, SCS-method estimates of runoff for various urban land uses, and ten years of precipitation data from a rain gauge in the City of Northridge. This project did not involve any field testing, monitoring, verification or basin construction. The Chralowicz report calculated the average annual volume of stormwater runoff that could be captured from a five-acre drainage area in the Northridge area by infiltration basins of four sizes (surface area of 0.1 and 0.5 acres, depths of 2 and 3 feet) under a range of infiltration rates (0.5, 1.0, and 2.0 inches per hour).

The Horner study analysis method calculated average annual runoff volume for the case study sites using the following equation:

$$\text{Average annual runoff volume} = C \times RD \times A$$

Where,

C = runoff coefficient, RD = average annual rainfall depth, and A = project area.

The methods used to calculate the runoff coefficient and the average rainfall depth are important to the outcome of the analysis. Runoff volumes for pervious areas were based on an NRCS

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[3] Chralowicz, Donna, Alvaro Dominguez, Tessa Goff, Melissa Mascali, and Emily Taylor. *Infiltration of Urban Stormwater Runoff to Recharge Groundwater Used for Drinking Water: A Study of the San Fernando Valley, California.* A Group Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management, University of California Santa Barbara. Committee in charge: Professor Thomas Dunne and Professor Charles Kolstad. June 2001.

method that uses a variable called the "Curve Number" (CN) and an average rainfall event to calculate the runoff coefficient. The CN method is simplistic and does not account for variations in rainfall intensity at smaller time steps that would impact basin sizing. The Horner study assumed a CN of 83 for undeveloped pervious area, citing a study by American Forests on a watershed in San Diego (see the link in the footnote on page 5). The American Forests publication states that the CN was determined to be 83, but does not show the calculations or describe the data used to derive that number. A CN of 83 seems quite high. As a point of comparison, curve numbers for undeveloped land uses are provided in Appendix A, Exhibit 14a, of the Ventura County Hydrology Manual. The CN for narrow leaf chaparral in fair condition with low permeability soils (the most conservative soil type assumption) is listed as 75. The effect of using a higher CN is that this assumption will estimate a higher runoff volume from the pervious area. A CN of 83 yields a runoff coefficient of 0.07. In contrast, if an undeveloped CN of 75 were used, then the runoff coefficient would be 0.003 – an order of magnitude less. The curve number for impervious areas was assumed to be 95; the Ventura County Hydrology Manual value for impervious surfaces is 98. Thus the runoff volume from the impervious area may be slightly under predicted using this methodology. Together with overpredicted runoff from pervious areas, the estimated difference in pre- and post-runoff volumes is less than may actually be the case.

The second assumption in estimating annual runoff volume used in the Horner study was the rainfall assumption, which was based on the City of Ventura rain gauge. In the footnote on the bottom of page 6, the Horner study states that there are locations in the County with higher rainfall averages than this, especially the Ojai area. Thus the study, when accounting for the effect of the higher average rainfall in the Ojai area, found that two of the case studies were not able to meet the EIA performance standard (the multi-family residential and retail commercial sites). Attachment 2 provides a map that illustrates soil types and rainfall contours (10-year, 1-hour rainfall) for Ventura County. This map illustrates the variation in rainfall across the County and shows that other urban areas within the County also have higher rainfall patterns than the City of Ventura.

The Horner study relied on the infiltration basin sizing developed in Chralowicz *et al.* in order to determine the infiltration capacity of the case study sites. The Chralowicz study assumed infiltration rates between 0.5 and 2.0 in/hr, representing soils with various loam textures. There are two issues related to this soil infiltration rate assumption. First is whether the selected infiltration rates are representative, even for the San Fernando Valley soils. Chralowicz cites the USDA/SCS 1980 Soil Survey, but these values may be very different from tested infiltration rates. For example, on a project located in northern Los Angeles County, the NRCS soils data cited infiltration rates of 0.6 to 2 in/hr, however, nearby infiltration testing found 0.16 – 0.25

in/hr infiltration rates. Additionally, soil infiltration rates are greatly reduced when compacted. The second is whether it is appropriate to apply the San Fernando Valley soils assumptions to Ventura County. The Horner study states that soils in Ventura County "at least relatively near the Coast" are similar in texture, "thus making the conclusions of the San Fernando Valley study applicable." However, although the soils in Ventura County are somewhat similar to San Fernando Valley near the coast, they differ in other areas of the County.

A map that illustrates Ventura County soil types is provided in Attachment 2. Soils have been grouped by the County into seven classifications ranging from a very low infiltration rate (Soil Type 1) to a very high infiltration rate (Soil Type 7). The map in Attachment 2 shows that the soils in the coastal portion of the County (City of Ventura and Oxnard) are predominately Type 3 soils, which have a relatively slow infiltration rate (0.5 inches per hour) when thoroughly wetted, are chiefly soils that have a layer impeding downward movement of water, or are moderately fine textured soils that have a slow infiltration rate when dry. The eastern portion of the County (Thousand Oaks, Simi Valley, and Moorpark) appear to have predominately Type 1 soils, which are soils with a very low infiltration rate (0.25 inches per hour) when wetted. They are chiefly clays that have a high shrink-swell potential, soils that have a high permanent water table, soils that have a claypan clay layer at or near the surface, or soils that are shallow over nearly impervious material. Type 1 soils will have very, very low infiltration rates when compacted. By comparison, the Chralowicz study analyzed scenarios with infiltration rates between 0.5 and 2.0 inches per hour.

The infiltration basin sizing developed in Chralowicz *et al.* was based on ten years of precipitation data from a rain gauge in the City of Northridge. Chralowicz *et al.* assumed that precipitation in Northridge was representative of precipitation in the entire San Fernando Valley and that ten years was a sufficient timeframe to represent precipitation patterns. The sizing accounted for storms that occurred over more than one day by restricting the maximum volume that may be captured the second day by the volume that remained in the basin from the previous day. Thus the precipitation patterns in the rain gauge data were reflected on a daily time step in the basin sizing. The Northridge rain gauge is not representative of precipitation patterns for all of the urban portions of Ventura County. Table 2 below shows the mean precipitation and the 85th percentile rainfall depth for several National Climatic Data Center (NCDC) rain gauges in Ventura County and one in San Fernando (in close proximity to Northridge) using an inter-event dry period of 6 hours for storms greater than 0.1 inch. These rainfall statistics for Ventura County show that the depth of the average event and 85^{th} percentile rainfall vary greatly across the County and that the San Fernando rainfall data falls within this range.

Table 2: NCDC Hourly Gauge Summaries

Station Name	Available Period of Record	Number of Events[1]	Average Event Rainfall Depth [1] (in)	85th Percentile Rainfall Depth [1] (in)
Ventura Gauges				
Apache Camp	1948 - 1971	405	0.41	0.6
Chuchupate Ranger Stn	1948 - 2002	836	0.65	1.0
Simi Sanitation Plant	1975 - 2002	436	0.83	1.4
Ozena Guard Station	1972 - 2002	501	0.92	1.6
Piru Telemetering	1971 - 2002	495	0.93	1.7
Wheeler Springs 7 N	1948 - 1965	257	1.18	2.1
Pine Mountain Inn	1965 - 2002	637	1.28	2.1
Wheeler Springs 2 Ssw	1948 - 1969	333	1.28	2.4
Matilija Dam	1969 - 2002	597	1.53	2.5
San Fernando Gauge				
San Fernando Phase 3	1948 - 2003	850	0.98	1.8

[1] Statistics were determined using an inter-event time of 6 hours and storm events greater than 0.1 inch.

Another consideration in the use of the basin sizing results of Chralowicz *et al.* is that daily rainfall totals tend to smooth individual event peaks considerably, so using daily rainfall totals to size an infiltration basin may overpredict infiltration capacity and undersize the basin.

In summary, the Horner study relies on a study on infiltration of urban stormwater runoff in the San Fernando Valley with one soil type and rainfall pattern to estimate the infiltration capacity required for the case studies. The combination of assumptions related to the available pervious area, the infiltration capacity of this pervious area, and the infiltration basin sizing may have lead to inaccurate findings of feasibility when applied to all of the urban areas of Ventura County.

Horner Study Statement of Findings

The summary of results in the Horner study states that "typical development categories, ranging from single family residential to *large commercial*, can feasibly implement low-impact post-construction BMPs designed in compliance with the draft permit's requirements, as modified to include a lower, three percent EIA requirement" [emphasis added]. There are contradictions to this statement in the findings of the paper.. The results in Table 7 on page 13 show that the retail commercial land use case study had capacity to infiltrate only 26 percent of what would be required to meet the three percent EIA limit. At the higher Ojai rainfall level, the multi-family residential case study had the capacity to infiltrate only 78 percent of the annual runoff volume needed, and the retail commercial site had the capacity to infiltrate only 18 percent of the annual runoff volume needed.

The Horner study includes the following statement on page 13:

> "For any development project at which infiltration-oriented BMPs are considered, it is important that infiltration potential be carefully assessed using site-specific soils and hydrogeologic data. In the event such an investigation reveals a marginal condition (e.g., hydraulic conductivity, spacing to groundwater) for infiltration basins, soils could be enhanced to produce bioretention zones to assist infiltration."

Although bioretention areas are typically designed with highly amended sandy soils to promote the soil moisture holding capacity and evapotranspiration, the capacity of bioretention facilities to dispose of water, assuming no underdrain is provided, is most strongly influenced by the permeability of the underlying soils. Even in fairly low infiltration soils, for example 0.1 inches per hour, loss rate due to evaporation (from the ponded water surface and pores of the amended soil) is on the order of 10 to 15 times less than infiltration during summer months and 20 to 30 times less than infiltration during winter months. The combined loss rate, which is critical in determining the available storage capacity in subsequent storms, is predominantly controlled by the underlying soil infiltration rate, not the infiltration rate of the amended soil. Where combined loss rates are low, LID features must be designed with shallower ponding depths and consequently greater area requirements to achieve the same volume reductions.

In general, bioretention areas have a smaller runoff storage volume capacity than a basin and therefore the surface area required for bioretention is typically larger than an infiltration basin. In order for a bioretention area to be functionally equivalent to the infiltration basins in Chralowicz *et al.*, the bioretention area would require a four to six feet amended soil media depth with 12 to 18 inches of surface ponding. The statement also does not account for areas of Ventura County that are known to have groundwater levels near or at the surface (*e.g.*, Simi Valley), which precludes the use of infiltration techniques completely.

Additional discussion is provided in the Horner study related to the use of water harvesting or infiltration trenches for roof runoff management. Underground techniques for storage (cisterns) or infiltration (infiltration galleries under parking) may be an option in space limited projects (assuming there is a consumptive use available during periods of rainfall for the stored water on the project or site conditions are amenable to infiltration), but the costs associated with the implementation of these types of practices are much greater and therefore may not be economically feasible for some projects.

Finally, the study concludes that because the estimated volume reductions are possible, then the feasibility of capping EIA at 3 percent is demonstrated. This conclusion neglects the typical development scenario in which EIA results of impervious area located down gradient of available pervious area. To a certain extent, this can be limited by site design measures; however, it is common for competing project constraints such as right-of-way width, existing utilities, etc., to render it infeasible to "disconnect" some impervious areas. The study does not address this important consideration in developing findings of feasibility.

Summary

Geosyntec evaluated the study Investigation of the Feasibility and Benefits of Low-Impact Site Design Practices ("LID") for Ventura County to assess the assumptions used in the analysis related to runoff volume control and the findings of feasibility related to capping EIA. Key findings of this review are listed below. The applicability of the EIA goal assumed for the study has not been supported by literature for watersheds with large tributary areas.

- On a whole, the imperviousness of the case studies analyzed are likely lower than typical development projects in Ventura County. The result is that more landscaped area is assumed to be available for LID features.

- 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 the typical scenario in which some pervious area is upgradient of impervious area or otherwise not suitable for infiltration.

- Study findings regarding volume reduction apply only where geotechnical issues and high groundwater do result in statutory limits on infiltration. Simply providing amended soil to compensate for these conditions is not expected to provide the benefit that the study suggests, as the underlying soils control ultimate infiltration loss rates.

- The method used to develop the required infiltration volume potentially over predicts pre-development runoff and under predicts post-development runoff, thereby potentially biasing required infiltration volumes below what they would actually need to be to achieve the desired results.

- The Chralowicz study, which was used as the primary basis for estimating infiltration capacity, is based on assumptions that are not necessarily representative of typical conditions in Ventura County. Assumed infiltration rates are notably higher than typical Ventura County soils. Rainfall patterns are within the range of Ventura County conditions, but notably lower than some parts of Ventura County. Assumed infiltration basin design standards are not representative of typical LID features.

- The study relies on the logic that if the estimated volume reductions are met, the feasibility of the lower EIA standard is demonstrated. This finding does not consider the typical scenario in which EIA results from impervious area that is unavoidably down gradient of pervious area.

Overall, the findings of the study do not appear to fully support the stated conclusions related to volume reduction and feasibility of meeting an EIA standard lower than that proposed by the draft permit. Considering the simplifications that the study relied upon, we believe that there should be more qualifications of, or limitations on, the findings. For example, the study might more reasonably support the conclusion that LID is feasible in new development up to a certain level of density, where pervious area is appropriately located on the development site, native infiltration rates are sufficient, and where statutory limitations on infiltration are not present. From these findings, it may logically follow that most impervious area upgradient of pervious area could be feasibly disconnected. With proper site design practices, a low EIA is feasible in many project scenarios.

Suggested Additional Analyses

The study relies upon quantitative analyses that may require more simplification than appropriate and may be based on assumptions that are not representative of typical development scenarios in Ventura County. Geosyntec suggests an alternative analysis that would attempt to address the study questions more explicitly and directly. We recommend that a series of continuous simulations be performed using the EPA Stormwater Management Model (SWMM) or another appropriate continuous simulation model. The analysis would evaluate LID performance over a historically-representative period of record using hourly (or 15 minute) rainfall records available in various parts of Ventura County. The key components of the analysis would include:

- Continuous simulation with 5 or more precipitation records and corresponding ET estimates representative of the range of hydrologic patterns observed in Ventura County;
- A range of native soil infiltration rates in logical increments;
- Max ponding depth and total storage depth defined by permissible drawdown rates and soil pore space recovery time;
- A range of degrees of implementation of LID features in logical increments;
- Tracking of runoff volumes in pre-development conditions, developed conditions without treatment controls, and developed conditions with LID features; and

- Tracking and accounting for changes in deeper infiltration rates/volumes to evaluate whether the approaches could result in a change in the water balance that may not be appropriate.

Such an analysis would provide a range of expected performance based on inputs that are directly representative of typical Ventura County conditions.

A supplemental analysis of actual site plans to understand cases in which EIA is unavoidable, even with site design measures, would be appropriate to support findings of the feasibility of capping EIA for all cases.

* * * * *

ATTACHMENT 1

THE USE OF IMPERVIOUS AREA AS A HYDROMODIFICATION CONTROL CRITERIA

Studies Find Gross Measures are Inadequate

In 2003, the Water Environment Research Foundation published a report entitled "Physical Effects of Wet Weather Flows on Aquatic Habitats: Present Knowledge and Research Needs" (Roesner and Bledsoe 2003). This report emphasized the limitations of current attempts to link stream impacts to gross measures of development such as total imperviousness, observing that these measures provide little meaningful information to understand key processes and to create practical strategies for mitigation. The authors contended that flow controls in urban drainage systems have strong influence on runoff hydrology, but this fact is not recognized in studies that attempt to relate stream impacts to gross imperviousness only. They stressed that predictive models of reach-scale habitat changes must account for the connectivity and conveyance of the drainage system and relevant stormwater controls.

Subsequent papers have also highlighted the difference between total impervious area, which they argue need not be specifically limited, and effective impervious area, which is more meaningful (Walsh et al, 2005; Walsh, Fletcher and Ladson, 2005). This further supports the idea that it is the drainage design which is most important, rather than specific limits on impervious area. Studies by Booth *et al* (2004) also demonstrate that impervious area alone is a flawed surrogate of river health.

These conclusions make sense in light of the current scientific understanding of the mechanisms by which land use changes translate to stream impacts, summarized briefly as follows.

Land Use Alters Hydrologic and Geomorphic Processes

Natural hydrologic and geomorphic processes are changed by the introduction of impervious surfaces, connectivity of these surfaces to efficient drainage systems, increase in drainage density, compaction of soil, and removal of vegetation. The natural proportions of infiltration, runoff and evapotranspiration are altered in such a way as to increase runoff volumes, frequency of runoff events, long-term cumulative duration of runoff and peak flows. Sediment supply to streams is also reduced, compounding the effects of increased flows. The current state of scientific knowledge indicates that observed impacts to streams, such as channel enlargement, decreased bank stability, and simplification of stream habitat features, are mechanistically linked to the long-term increase in volumes, durations and frequencies of the entire range of sediment transporting flows and the resulting increase in work done on the channel boundary.

ATTACHMENT 1

However, both the process alterations and the resultant impacts to streams are highly variable for a given percent impervious surface area. These variations are due to local watershed influences and the nature of the development site, as described in the next two sub-sections.

Local Watershed Influence

Both regional climate and local watershed characteristics have a strong influence on the extent to which land use changes alter hydrologic processes (Chin 2006; Poff et al 2006; Gregory 2006; Konrad and Booth 2005). For example, where soils have high infiltration capacity, the conversion of open space to impervious surfaces will cause greater increases in runoff and stream flows compared to development on soils with low infiltration characteristics. The resulting in-stream effects can therefore also be more severe.

Site Drainage Design Influence

New approaches, including incorporation of BMPs, both on site and in-stream, and the use of watershed protection and low impact development (LID) strategies as required by Section 5.E.III.2 of the second draft Ventura County MS4 Permit, are changing the nature of developments with respect to the characteristics that cause alteration of hydrologic processes. Treatment control BMPs are now required components of new developments and re-developments, in accordance with the current Ventura County MS4 Permit. Some treatment control BMPs have the capacity to infiltrate a significant portion of runoff volumes; Strecker et al (2004) summarized data for BMPs which showed that biofilters and dry-extended detention basins provide an average of approximately 40% and 30% reduction, respectively, in the volume of captured runoff. Flow duration control basins are currently being incorporated into new development projects to address hydromodification. These hydromodification control facilities will also provide water quality benefits and can be applied at multiple scales, from an individual project scale to a regional scale, to address both proposed and existing flows.

Recent modeling studies show urban cluster design to be one of the most effective at reducing runoff volume (Brander et al, 2004). USEPA (2000) summarized a literature review on the application of LID in new development and existing urban areas, as well as studies of LID projects which provide evidence of effectiveness in reducing runoff volumes. The report found that LID offers both economic and environmental benefits, but may still necessitate structural BMPs in conjunction with the LID techniques in order to achieve watershed objectives; appropriateness depends on site conditions such as soil permeability, slope and water table depth, in addition to spatial limitations.

ATTACHMENT 1

Alternative Quantitative Criteria

These new approaches for managing stormwater, when designed using quantitative analyses based on continuous long-term simulations, have the potential to significantly reduce, and in some cases perhaps completely eliminate, those changes to hydrologic processes which took place through traditional development practices. Furthermore, changes in site design, coupled with the effects of local watershed characteristics, mean that gross measures of imperviousness are unsuitable for either predicting or controlling development impacts.

However, related metrics such as "effective impervious" or "connected impervious," are not viable alternative control metrics either, especially in the absence of quantitative criteria establishing a ratio of impervious area allowed for a given pervious area to which it drains (see further discussion in the following section). Instead, these metrics are only superficial assessments of those aspects of a development that we know have a directional relationship with changes in hydrologic processes and stream impacts, but for which there are poor quantitative relationships due to the number of influencing variables.

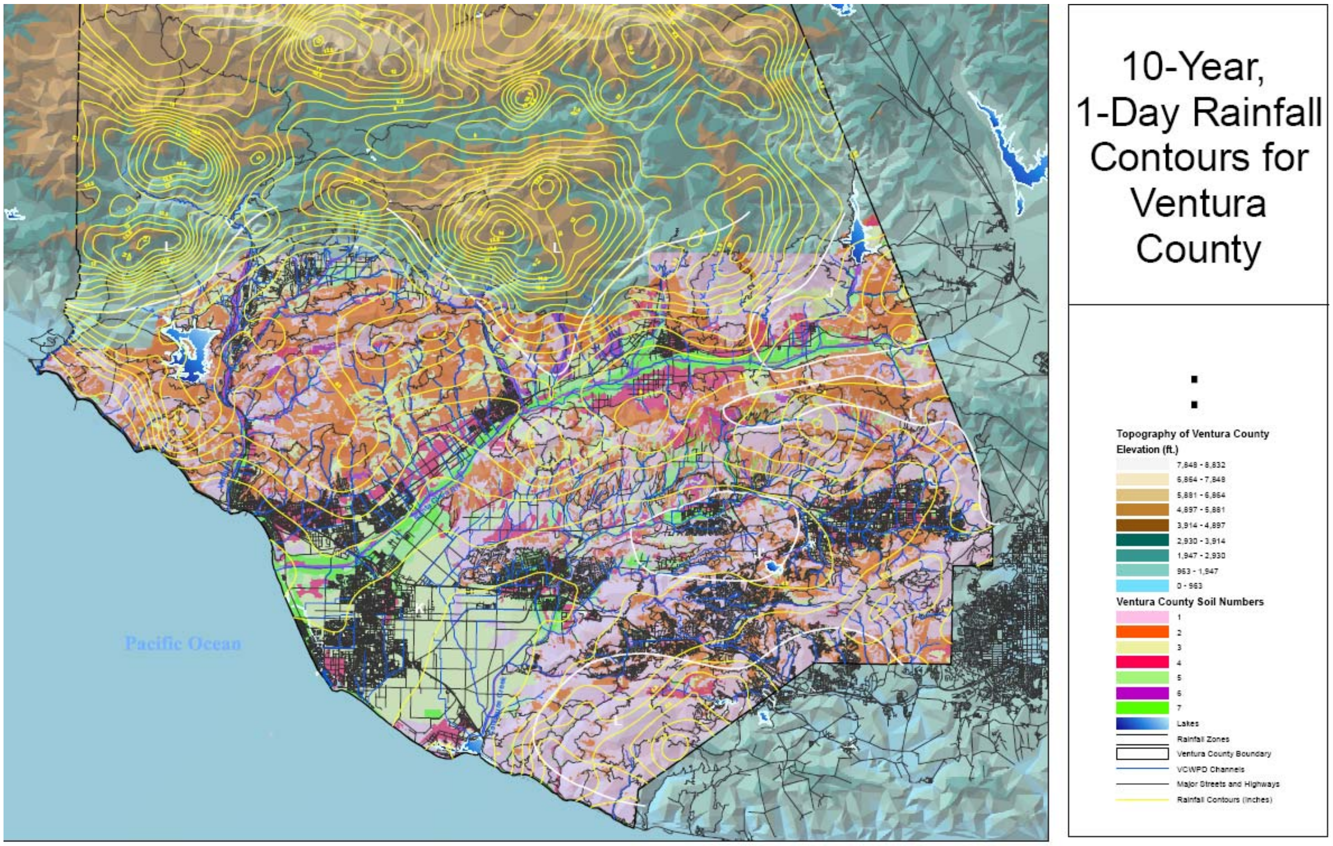
A simple analogy that might help clarify this important point is as follows: if a chemical reaction depended on having water at 100°C, then that exact temperature should be identified in any manufacturing or production process specifications. It would clearly not be appropriate to simply require that the water be "boiled", as this might result in water at various temperatures, depending on the elevation at which the process was taking place. A requirement to boil water would be fine for making tea, where the exact temperature is not critical, but would not be acceptable for a chemical process that is sensitive to the exact temperature. In other words, requirements should be specified in a way that is linked most directly to the required characteristic, when that characteristic is critical to the desired outcome, rather than to some other feature that is only generally associated with that characteristic. To take the analogy further, a requirement to boil the water would also preclude the use of other equipment such a pressure cooker, which could bring the water to the desired temperature without actually "boiling" it. By specifying requirements other than the truly relevant characteristic, innovative and potentially more cost effective solutions may be precluded, and effort may be spent to meet criteria that will not necessarily achieve the desired outcome. In the case of hydromodification control, the current scientific understanding indicates that the change in the long-term runoff flow duration series is the most critical hydrologic alteration, and the change in total work done on the channel boundary is the most critical effect to control, in order to prevent stream instability.

It is understood that there are logistical and practical considerations involved in the translation of scientific understanding into workable public policy. However, in this case, efforts undertaken over the past five years provide workable solutions. The specification of an Erosion Potential

ATTACHMENT 1

(Ep) is an example of such an implementable solution, which addresses the critical alterations discussed above, and is already incorporated into Section 5.III.3 of the second draft Ventura County Permit. Therefore, the EIA limits are unnecessary.

ATTACHMENT 2



This map, which includes the boundaries of hydrologic soil groups for the southern portion of Ventura County outside of the Los Padres National Forest, was created for reference purposes to show general hydrologic soil categories. The soils map was digitized from 1975 Soil Survey maps in 1997. The characteristics of the soils are one of the major factors affecting the rate of runoff and subsequent planning of storm drain facilities. Original data is based on 1970 publication by the Soil Conservation Service, U.S. Department of Agriculture in cooperation with the University of California Agriculture Experiment Station. Flood Control Staff reclassified the hundred of detailed hydrologic soil groups into seven general groups for drainage identification purposes. These soils groups are described below.

Soil Type 1 (NRCS Hydrologic Group D): Soils have a very low infiltration rate (0.25 inches per hour) when wetted. They are chiefly clays that have a high shrink-swell potential, soils that have a high permanent water table, soils that have a claypan clay layer at or near the surface, or soils that are shallow over nearly impervious material. Rate of transmission is very slow; thus, runoff potential is very high.

Soil Type 2 and 3 (NRCS Hydrologic Group C): Soils have slow infiltration rate (0.4 to 0.5 inches per hour respectively) when thoroughly wetted; chiefly soils that have a layer impeding

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downward movement of water, or moderately fine textured soils that have slow infiltration when dry. Rate of water transmission is low.

Soil Type 4 and 5 (NRCS Hydrologic Group B): Soils have moderate infiltration rate (0.75 to 1.0 inches per hours respectively) when thoroughly wetted; chiefly soils that are moderately deep to deep, moderately well drained to well drained, and moderately coarse textured. Rate of water transmission is moderate.

Soil Type 6 and 7 (NRCS Hydrologic Group A): Soils have a high infiltration rate (1.5 to 2.0 inches per hours respectively) when thoroughly wetted; chiefly deep, well drained to excessively drained sand, gravel or both. Rate of water transmission is high; thus, runoff potential is low.