APPENDIX B

Effect of Increases in Peak Flows and Imperviousness on the Morphology of Southern California Streams Executive Summary

EXECUTIVE SUMMARY

Urbanization in southern California has resulted in direct and indirect effects on natural stream courses that have altered their physical and biological character. Development typically increases impervious surfaces on formerly undeveloped (or less developed) landscapes and reduces the capacity of remaining pervious surfaces to capture and infiltrate rainfall. The result is that as a watershed develops, a larger percentage of rainfall becomes runoff during any given storm. In addition, runoff reaches the stream channel much more efficiently, so that the peak discharge rates for floods are higher for an equivalent rainfall than they were prior to development. This process has been termed *hydromodification*.

Although the effects of increased impervious cover on stream flow have been well documented (Bledsoe, 2001; Booth, 1990; 1991; MacRae, 1992; 1993; 1996), the majority of past studies have focused on perennial streams. Until recently, few comparable studies have evaluated the impacts of urbanization on ephemeral or intermittent streams of arid or semi-arid climates. This had made it difficult to effectively manage stormwater impacts on southern California's natural streams. In response, the Stormwater Monitoring Coalition (SMC) conducted this study to assess the relationship between stream erosion and urbanization. It is anticipated that the results of this study will be useful in developing peak flow criteria for Los Angeles County as well as future stormwater regulations or management strategies.

The goal of this study is to assess relationships between stream channel type and resistance that will allow prediction of channel response under changed conditions associated with increased impervious cover. The specific study objectives are to:

- Establish a stream channel classification system for southern California streams;
- Assess stream channel response to watershed change, and attempt to develop deterministic or predictive relationships between changes in impervious cover and stream channel enlargement; and
- Provide a conceptual model of stream channel behavior that will form the basis for future development of a numeric model.

The intent of this study was to use multiple watersheds (each containing a single site) studied in broad scope rather than a single watershed (with many sites) studied in great detail. Consequently a total of 11 separate sites were selected in 8 distinct watersheds.

The study approach was to evaluate the changes in stream channel configuration over time and compare them to the changes in total basin impervious cover (TIMP) over the same time period. Data collection occurred in two phases. In the first phase background and historic information was gathered on each site and its contributing drainage area. In the second phase detailed field data was collected on the geomorphic condition of each study reach. The combinations of historic and contemporary data were used to develop predictive relationships between changes in impervious cover and channel form.

This study resulted in the following general conclusions regarding the relationship between impervious cover and stream channel form for ephemeral streams in southern California:

1. Southern California streams exhibit deterministic relationships between bankfull discharge (Qbfl), and measures of channel geometry such as cross section area (Abfl). Of the field measures calculated, the greatest consistency in relationship to the discharge rate at the bankfull stage, also termed the *Dominant Discharge* (Qbfl), was with the channel cross-sectional area (Abfl). Dominant Discharge exhibited a clear, predictable (or deterministic) relationship with features of channel geometry, such as channel width and cross-section area, i.e. as discharge increases, predictable increases in channel size are observed.

2. The ephemeral/intermittent streams in southern California appear to be more sensitive to changes in TIMP than streams in other areas. Stream channel response can be represented using an *enlargement curve*, which relates the percent of impervious cover (TIMP) to a change in cross-sectional area. The data for southern California streams forms a relationship very similar in shape to the enlargement curves developed for other North American streams. However, the curve for southern California streams is above the general curve for streams in other climates. This suggests that a specific enlargement ratio is produced at a lower value of impervious surface area in southern California than in other parts of North America. Specifically, the estimated threshold of response is approximately 2-3% TIMP, as compared to 7-10% for other portions of the U.S. It is important to note that this conclusion applies specifically to streams with a catchment drainage area less than 5 mi^2.

3. There is a natural background level of channel degradation that is occurring in all stream channels studied, even in the absence of development within the drainage area. A minimal rate of change in channel bottom elevation was observed in all sites, regardless of whether the watershed has experienced an increase in impervious cover. Control sites exhibited a state of dynamic equilibrium where downcutting was observed, but channel morphology did not change appreciably over time. In contrast, the developed sites exhibited instability, where one or more measures of channel morphology changed over time. In addition, the rate of change in downcutting was greater in the developed sites than in the control sites. For example, at the Dry Canyon control site downcutting was estimated to be 0.7 ft/yr, while the rate at the developing Plum Canyon site was estimated to be 1.7 ft/yr. These results demonstrate poor channel resistance to increased flow in all stream channels except those subject to bedrock control, such as Topanga Creek.

4. Streams are sensitive to both peak discharge and duration of discharge. The ephemeral and intermittent streams investigated in this study appear to be highly sensitive to changes in flow rates associated with increased impervious cover. Additionally, they appear to have a low resistance to erosion, which results in increased susceptibility to channel enlargement in response to increases in the duration of high flows. The predictive relationships established in this study can be used to evaluate potential effects of proposed development on the stability of natural streams. There are ranges of strategies that can be used to help reduce the potential effects of increased TIMP. However, the selection of a management strategy is dependent upon the extent to which a stream channel has been impacted by development within the watershed, the nature of the stream channel reach under consideration, and the anticipated future watershed conditions (i.e. expected increases in TIMP). Three general strategies should be considered when attempting to manage increases in peak flow:

> **a. Limit Impervious Area.** Although the focus of this study was necessarily on TIMP, disconnecting impervious areas from the drainage network and adjacent impervious areas is a key approach to protecting channel stability. Utilizing this strategy can make it practical to keep the effective impervious cover (i.e. the amount hydrologically connected to the stream) equal to or less than the identified threshold of 2-3%.
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> **b**. **Control Runoff.** Hydrograph matching is not recommended for a single “design” storm with a specific return period, but rather for a range of return periods from 1 year to 10 years. Accomplishing such hydrograph matching will be challenging, and undoubtedly require a combination of techniques to prevent (retain), as well as to delay or attenuate (detain) runoff and/or stream flow.
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> **c. Stream Channel Movement.** Allow the greatest freedom possible for “natural stream channel” activity. This includes establishing buffer zones and maintaining setbacks to allow for channel movement and adjustment to changes in energy (associated with runoff). However, where instream controls are required consider all potential management options.

It is important to keep in mind that the choice of a management approach or approaches should be dictated by the strategies that are appropriate given the conditions of each stream reach and its contributing watershed. Consequently a suite of management approaches may need to be applied to provide a comprehensive solution to managing potential increases in runoff due to land use change.

Stream channels respond to changes in basin imperviousness in complex ways, and specific responses will vary based on the characteristics of the stream and watershed. An exhaustive analysis of these issues was beyond the scope of this study; nevertheless, the present study represents an important first step in understanding the response of ephemeral streams to increases in impervious cover.