Runoff Analysis for the Malibu Creek Watershed

by Bradley Owens
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Introduction

This analysis is undertaken as part of a water quality monitoring program of Heal the Bay, funded by the California Coastal Conservancy, and created by the 606 Studio as a degree fulfillment masters project for the Graduate Department of Landscape Architecture at California Polytechnic State University, Pomona.

This document is prepared as an appendix to the main document called “A Framework for Monitoring and Enhancement of the Malibu Creek Watershed”.

Timothy Kovacs, Lance Nielsen, and Christopher Smemoe of EMRL have been instrumental in the development of this analysis, as well as Mark Abramson of Heal the Bay. Their willingness to help, and attention to detail is greatly appreciated.

Software used for modeling the watershed is called Watershed Modeling System (WMS) created by Environmental Modeling Research Laboratory (EMRL) of Brigham Young University. With this model, runoff was estimated utilizing data supplied by Los Angeles County and digital elevation data from DEM's. The watershed was modeled for two conditions, pre-development and current developed conditions. Results show approximately a 100% increase in runoff from the pre-developed condtion to the current developed condtion.

Background

The Malibu Creek watershed is located in Los Angeles and Ventura counties in southern California. The creek drains approximately 109 square miles and empties into Santa Monica Bay at Malibu Lagoon; elevations range from sea level to greater than 3,000 feet. The watershed has seven main subsheds and each has varying degrees of development ranging from rural low density to urban medium density. Also included in the watershed are many industrial, agricultural, and recreational developments. For a more in-depth description of the watershed, see the main document called "A Framework for Monitoring and Enhancement of the Malibu Creek Watershed".

Increasing the amount of impervious surfaces in a watershed can result in increased runoff and increased stream discharge; this can have a deleterious effect on habitats in the watershed and at the outflow, as well as on downstream development due to flooding and erosion.

A working model of runoff in the watershed is helpful in evaluating the impact of development on Santa Monica Bay, as well as for identifying suitable locations for future development. The runoff model is also used predictively when analyzing impact of potential development in the watershed.

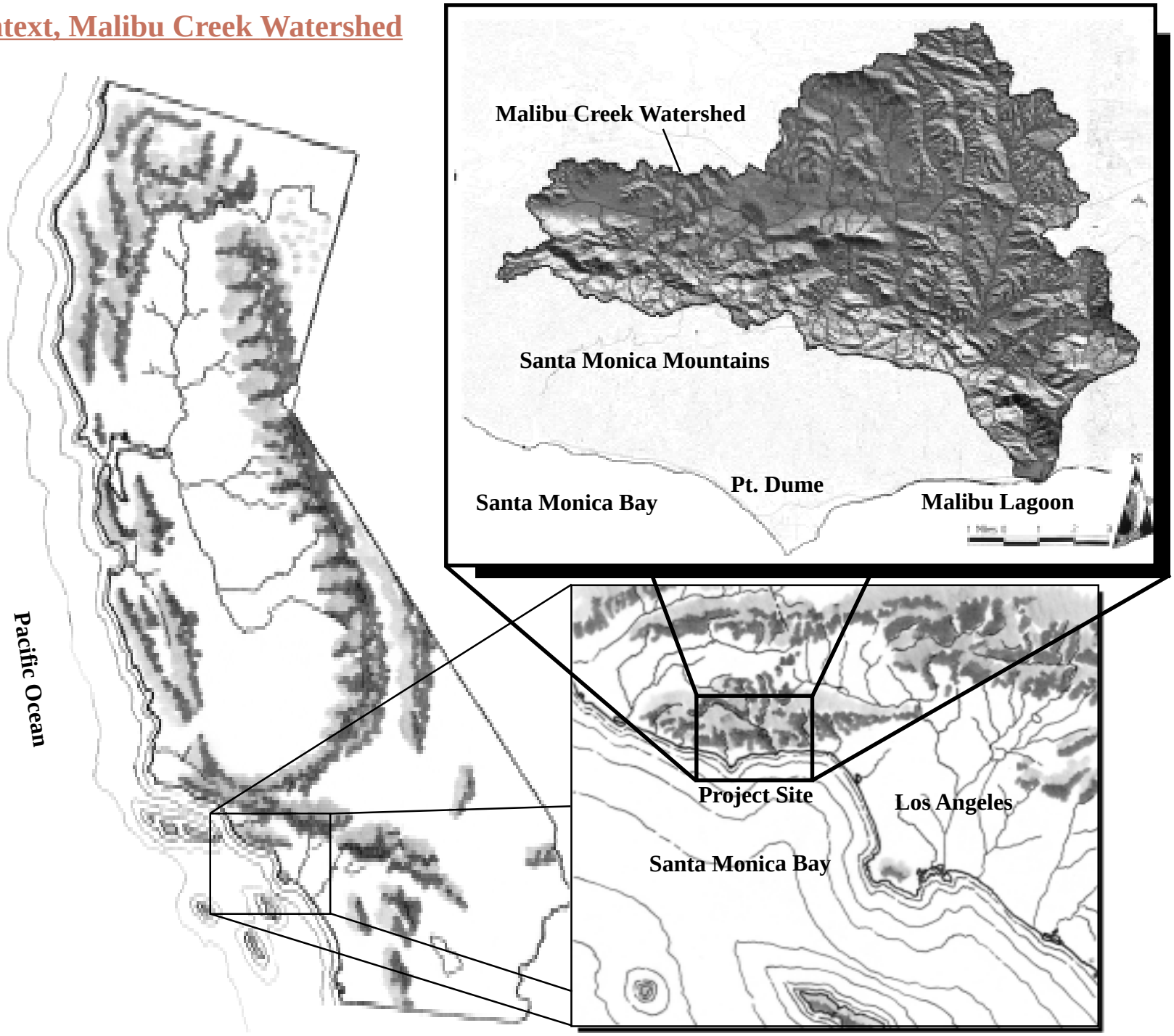
The modeling tool chosen for this task is a modeling software called Watershed Modeling System (WMS) developed by Environmental Modeling Research Laboratory (EMRL) of Brigham Young University in Provo, Utah.

WMS provides a graphical interface for standard computer models such as HEC-1 and TR-20; HEC was developed by the United States Army Corps of Engineers, and TR-20 was developed by the Soil Conservation Service (SCS, now the National Resource Conservation Service or NRCS). In addition to the graphical interface, WMS provides many utilities for computing and converting data inputs required for the standard models. When using this software program, the model can be updated and refined as new information becomes available, thus adding to the effectiveness with which analyzing and predicting changes in the watershed can occur.

Model Inputs and Methods

The WMS software requires that certain data sets are available depending on the model type and accuracy desired. A typical model would be developed based on Digital Elevation Models (DEM's) that are readily available on the World Wide Web. A DEM is spatial data that provides gridded elevation for a given land area and usually corresponds to a USGS quad map.

Site Context, Malibu Creek Watershed



Malibu Creek Watershed,
Boundaries and Area
Agoura Hills
21.62 sq. miles
Las Virgenes
24.34 sq. miles
Westlake
16.86 sq. miles
Hidden Valley
16.86 sq. miles
Malibou Lake
13.15 sq. miles
Malibu Cyn
12.81 sq. miles
Cold Creek
8.16 sq. miles
Malibu Watershed
Outlet

Model Inputs and Methods (con't)

For this model, data was provided by LA County Dept. of Public Works; this included land use, soil types, vegetation, and watershed and subshed boundaries. This data was modified by the Cal Poly team to reflect the latest conditions using digital aerial photography and 3D modeling and input into the model in GIS shapefile format (except for the vegetation data, which is not used directly by the model; this will be discussed later in this document). In addition to the shapefiles, DEM's were also utilized in the model for elevation dependent computations such as slope and subshed curve number averaging.

There are several dams within the Malibu watershed. Of these, four were used in the model due to their size and/or location within the watershed. Information about the dams is available on the World Wide Web (see references), and the dams used for this model (with the DWR number) are Lake Sherwood (765-000) in Hidden Valley, Westlake Lake (786-000) in Westlake, Lindero Lake (785-000) in Agoura Hills, and Malibou Lake (771-000) in the Malibou Lake subshed.

HEC-1 was chosen as the hydrograph method within WMS due to its ability to utilize the landuse and soils data, thus providing more precision than other models such as TR-20; within HEC-1, the SCS curve number method was chosen to compute losses (runoff) for the same reason. The curve number method was developed by the SCS (now NRCS) as a way to index various surface runoff conditions based on land use conditions and soil characteristics.

A hydrograph is a representation of a volume surface flow in a given time period (cubic feet per second). For this model, a 24 hour storm was used as the time period. After the initial infiltration of rain into the topsoil, overland flow, or runoff, will occur and a peak will also occur at some point when the flows are greatest due to factors such as subshed geometry (area, slope), soil types, cover (land use, vegetation), and storm pattern. The hydrograph is a graphical representation of the collection of runoff at a common point (such as at a stream gage).

The model was run for intervals of 2-5-20-25-50-100 year storms based on rain data available from the National Oceanic Atmospheric Agency (NOAA) and applied to two conditions- current developed conditions, and pre-development conditions based on a vegetation survey from 1930-1934 by AE Wieslander of the United States Forestry Service. For pre-development land use conditions, the Wieslander survey was area averaged visually in order to input subshed curve numbers into the model

Model Data Sources

Primary Data	Source	Notes
Rainfall	NOAA	24hr, 2-5-10-25-50-100 year storms
Soils	Los Angeles County	Department of Public Works
Land Use	Los Angeles County	Department of Public Works
Watershed, Subshed Boundary's	Los Angeles County	Department of Public Works
Vegetation, Current Condition	Los Angeles County	Modified and updated by Cal Poly 606 Studio team
Vegetation, Pre-developed Condition	USFS	Survey by A.E. Wieslander
Elevation	Cal St. Northridge	Digitial Elevation Models (DEM)

The following table lists the primary data sets used for the model and the source for the information. Additional source information is available in the reference section at the end of this document.

Assumptions, Limitations

This model is dependent on the available primary data; it is assumed that this is the best available at this time. It is known that the soil survey on which the GIS shapefile was based is an interim survey by the NRCS and is currently being updated for official release due in year 2001 (personal communication, Al Wasner, NRCS). In addition, the land use categories supplied did not have direct correlation to the SCS curve number table and this was manually interpolated.

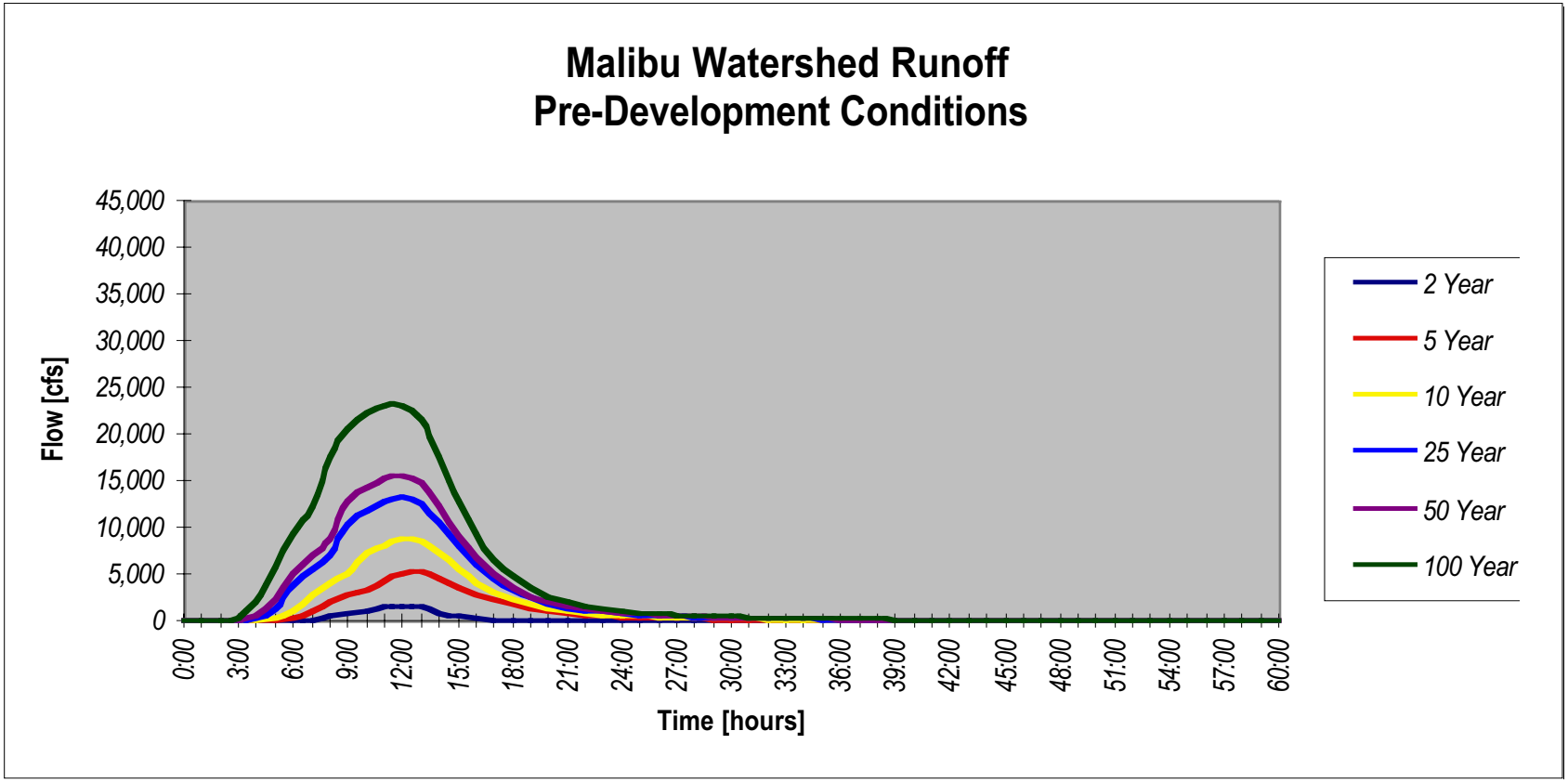
As stated previously, this model has many inputs so modification and refinement over a long period of time will return the best results. Additional information to add would be channel geometry, reservoir geometry and conditions, and more exact soils data. Hydrologic modeling is both art and science so the results are assumed to be estimates and will differ from actual conditions.

Results

The runoff analysis resulted in two primary results, pre-development and current developed conditions with modeled estimates of peak runoff (cubic feet per second) for each subshed and a total at the ocean outlet for each storm interval. The data is presented below in tabular form with a hydrograph representing the outlet.

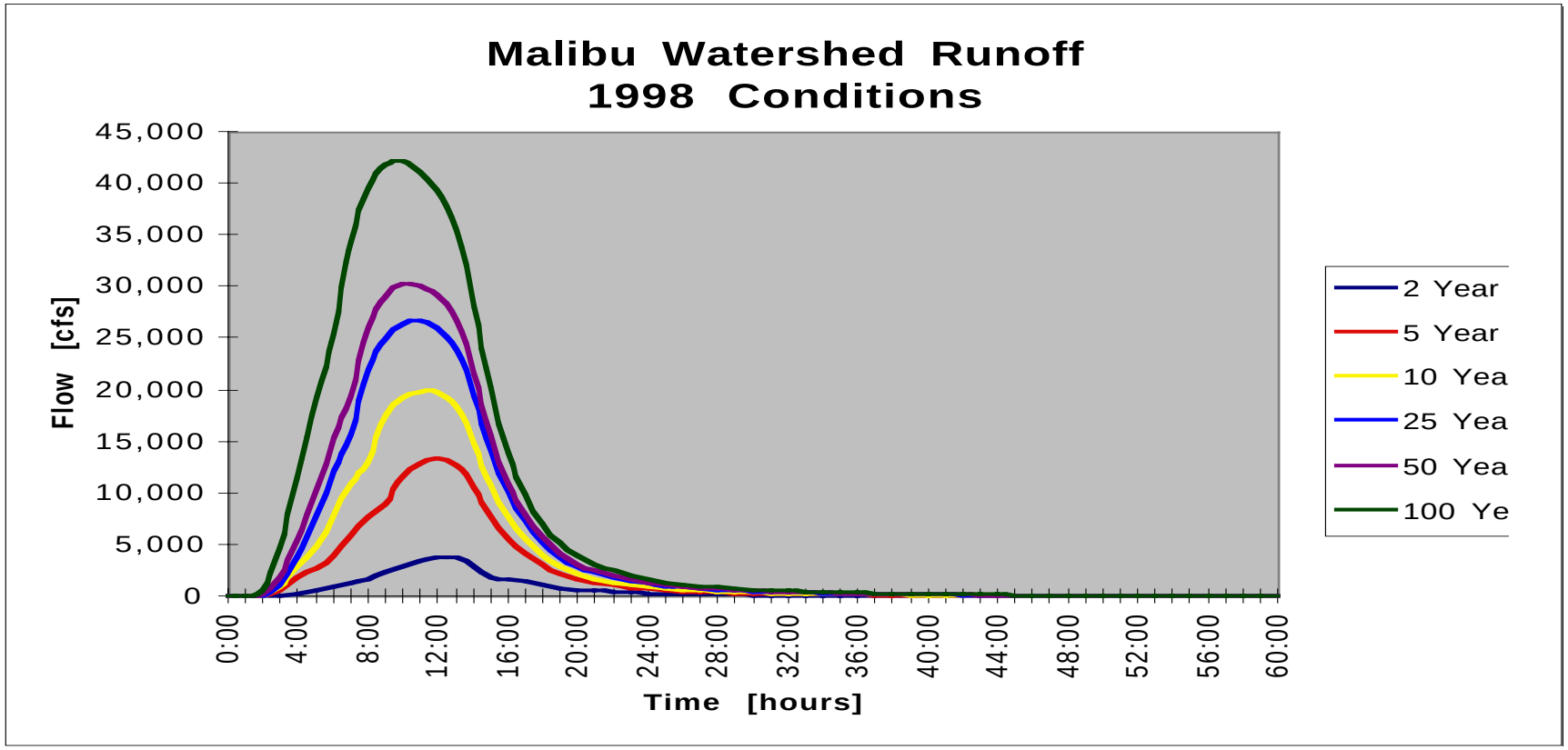
Malibu Creek Watershed Outflow, Pre-Development Conditions [cfs]

Storm Interval	**Malibu Creek Outlet**	Malibu Cyn	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
2yr/24hr	**1,601**	229	97	260	248	278	159	340
5yr/24hr	**5,247**	635	483	522	1,702	856	901	1,175
10yr/24hr	**8,663**	964	681	841	2,762	1,856	1,001	1,768
25yr/24hr	**13,130**	1,829	1,177	1,285	4,064	2,109	1,308	2,965
50yr/24hr	**15,427**	2,393	1,289	1,533	4,581	2,652	1,761	3,284
100yr/24hr	**23,056**	3,398	1,908	2,545	6,463	4,175	2,498	4,631



Malibu Creek Watershed Outflow, 1998 Conditions [cfs]

Storm Interval	**Malibu Creek Outlet**	Malibu Canyon	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
2yr/24hr	**3,766**	573	270	702	693	921	1,307	939
5yr/24hr	**13,255**	1,365	1,074	1,265	3,646	2,311	3,162	2,668
10yr/24hr	**19,821**	1,950	1,432	1,888	5,454	4,305	3,907	3,738
25yr/24hr	**26,616**	3,342	2,249	2,682	7,469	4,784	3,982	5,708
50yr/24hr	**30,161**	3,735	2,433	3,109	8,762	5,751	4,814	6,189
100yr/24hr	**42,090**	5,596	3,356	4,699	10,948	8,221	6,559	8,146



Conclusions

The modeling has shown that the watershed is yielding a large increase in runoff since predevelopment conditions have changed into the current state of development. Increases greater than 100% are seen in every subshed, most approaching 200% for a two year storm, and the Westlake subshed showing an over 700% increase. Not only is the increase dramatic, but the relationship between the increase in mapped impervious surface and the runoff increase is interesting as well because of the logarithmic relationship borne out by the data.

Impervious Area Comparison, Pre-development v. Current Development

Category	Malibu Canyon	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
Total Area [mi^2]	12.81	8.16	24.34	13.15	21.62	12.99	16.86
Mapped Impervious (current) [mi^2]	0.48	0.16	1.73	0.44	3.98	2.97	0.94
Percent Impervious (PreDev)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Percent Increased Impervious (Current)	3.71	2.01	7.11	3.38	18.39	22.89	5.56
PreDev. Runoff (2yr/24hr) [cfs]	229	97	260	248	278	159	340
Current Dev. Runoff (2yr/24hr) [cfs]	573	270	702	693	921	1,307	939
Percent Increased Runoff	150	178	170	179	231	722	176

Percent Increase, Impervious Area and Increased Runoff

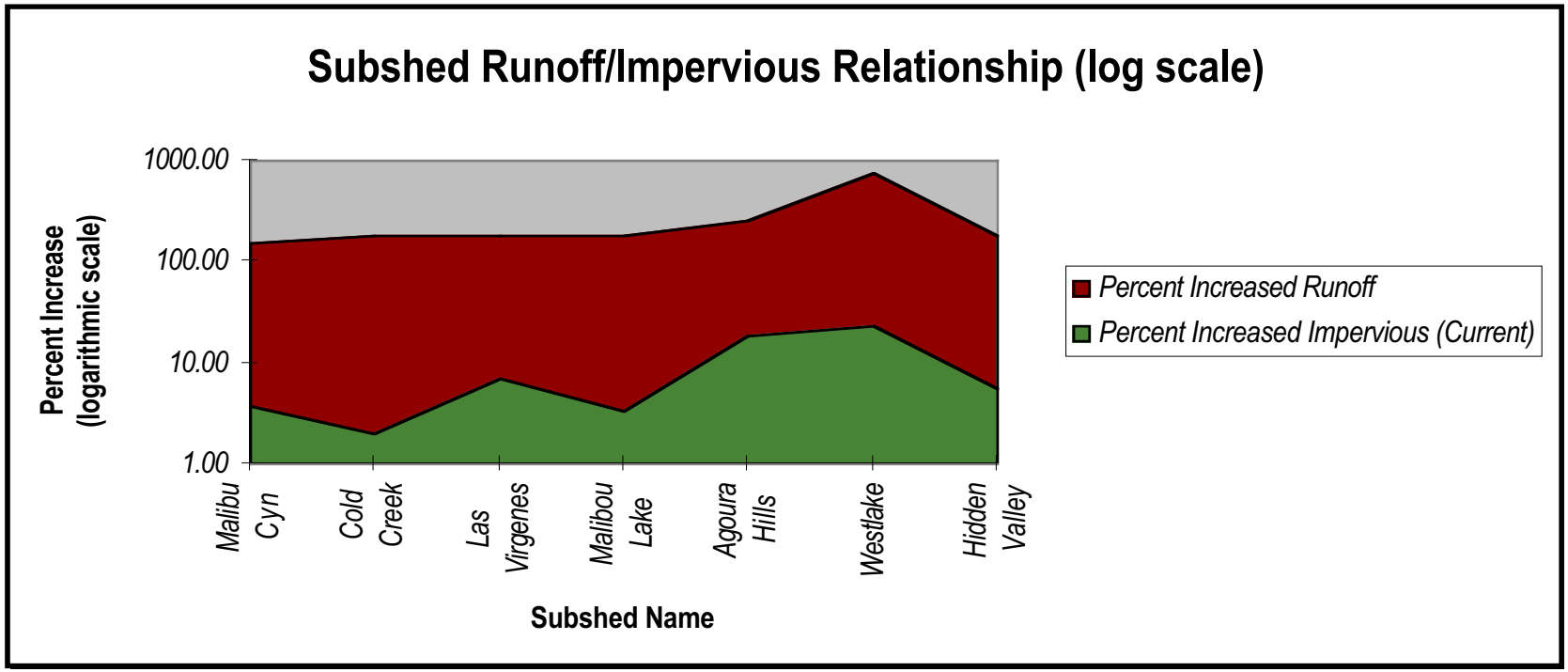
Category	Malibu Canyon	Cold Creek	Las Virgenes	Malibou Lake	Agoura Hills	Westlake	Hidden Valley
Percent Increase Impervious (Current)	3.71	2.01	7.11	3.38	18.39	22.89	5.56
Percent Increased Runoff	150.22	178.35	170.00	179.44	231.29	722.01	176.18

The tables above show that the increase in impervious surface area in each subshed has dramatically increased the runoff into Malibu Creek (with the assumptiion being that the predeveloped condition had zero impervious surface). The clearest example is in the Westlake

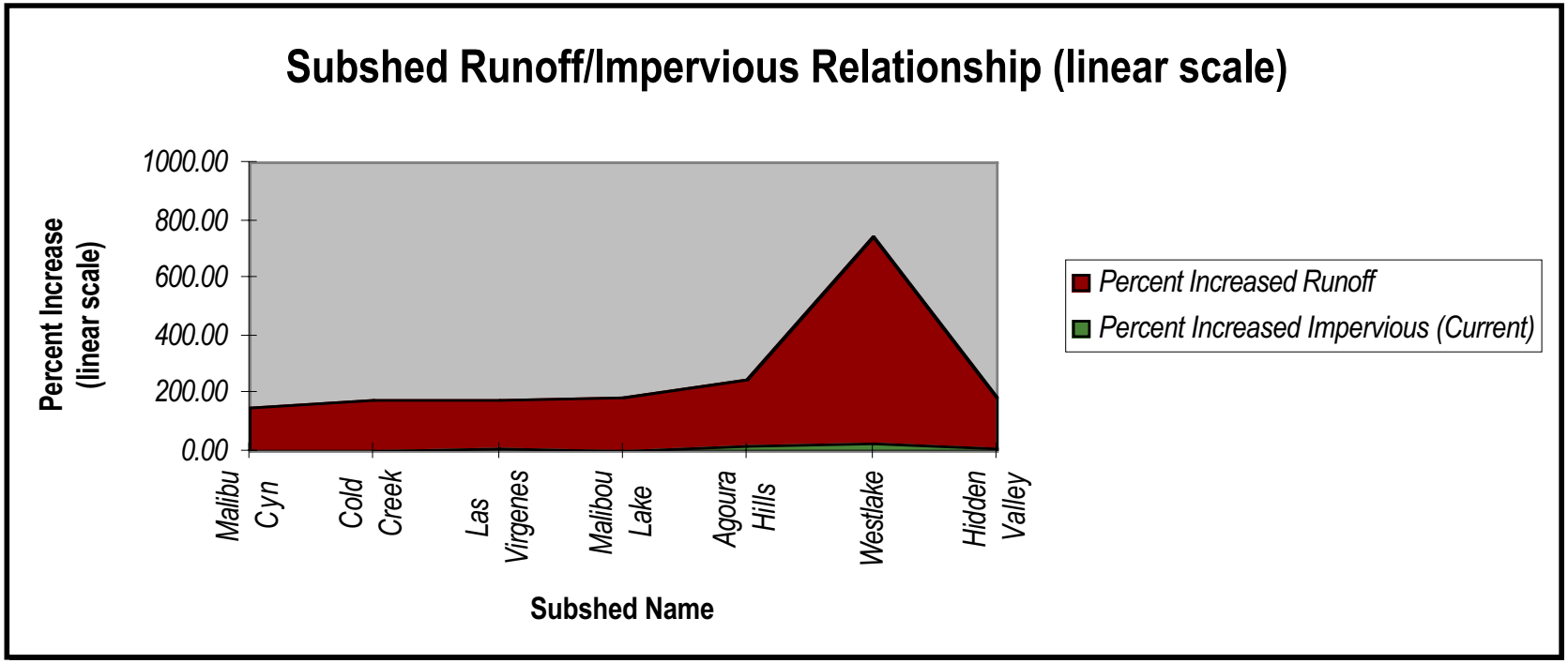
Conclusions (con't)

subshed where a 22.89% increase in impervious surface has led to a 722.01% increase in runoff.

The following graphs demonstrate that a small increase in impervious area within a watershed will result in large increases in runoff; two scales, logarithmic and linear, are shown in order to bring out the relationship visually. For instance, the linear graph (second graph) shows that the increase has a logarithmic relationship; small incremental increases of impervious surface leads to greater and greater amounts of runoff.



Conclusions (con't)



Although typical (and costly) structural devices such as dams and weirs can be used to control runoff, it is clear that this watershed will yield extreme amounts of runoff as impervious surfaces increase and, due to the erosive nature of the soils, will render these devices largely ineffective in relatively short periods of time as seen with Rindge Dam which has completely filled with sediment. It would seem that a more comprehensive management of the watershed resources will result in a cost effective and habitat conserving condition.

References

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