Appendix B: Parameter Ranges for Sensitivity Analysis.

The sensitivity analysis is focused on the key parameters that are both uncertain and likely to make a difference in the results. Infiltration rates, construction costs, and the required private rate of return are the parameters that meet these qualifications. For each of these parameters we define a low, baseline, and high value and examine our incentive results for all combinations of low and high values.

We do not include a range of values for the opportunity cost of parking area. While the difference in the total land costs is key to the comparison of the decentralized relative to the centralized strategy, the opportunity costs of parking are not a large component of the decentralized system costs. Table 7 of the paper shows that parking area opportunity costs are at most 8% of total costs for the Bid 2 index. This implies that the optimization rarely converts existing paved areas to infiltration pits. Therefore, higher costs for converting paved areas to infiltration pits would have little effect on costs at the lower capture levels, since it is already not optimal to convert pavement to infiltration pits. Lower land conversion costs would only reinforce our finding that decentralized, incentive-based implementation of BMPs appears to be an inexpensive option for meeting runoff reduction goals.

The infiltration rate is the single largest factor in determining BMP sizing and hence costs and also can vary greatly from one area to another. For our sensitivity analysis we decided to consider the range of infiltration rates in Los Angeles County because this is the broader area that may consider a decentralized incentive based approach to stormwater runoff. Because the soil maps for Los Angeles county are dated and probably do not reflect infiltration rates after properties are altered with new soils, it is better to operate from actual infiltration rate data. Data on infiltration rates at the various spreading grounds in Los Angeles County are not useful because they are not indicative of conditions in other areas. Instead we located hydrology information on five sites where BMPs were installed by the Los Angeles and San Gabriels Rivers Watershed Council (LASGRWC) in the course of its Water Augmentation Study. The Caltrans BMP retrofit study also includes one Los Angeles area site.

As Appendix table B1 shows, the infiltration rates at the LASGRWC study sites are in general high. This may be because most sites are in the San Fernando Valley area where soils generally have high infiltration rates. Based on these data, we chose the baseline estimate of 76.2 mm/hr, a low of 25.4 mm/hr and a high of 215.9 mm/hr. Our mid-range estimate is at the higher end of this distribution because Sun Valley, where many of these projects are located, has well drained alluvial soils that are not reflective of the entire area. It is unlikely there are many areas in Los Angeles or elsewhere with infiltration rates as high as the ones measured in Sun Valley.

The construction costs are the largest cost component in the analysis of the decentralized system. We used quantile regression to determine the coefficients that predict the 25th and 75th percentile of the log of costs (See Appendix table B2.) We use the relationship between cost and capacity at the 25th and 75th percentile of log costs as the upper and lower construction cost bounds.

We also include a low and high cost for porous pavement. The range of costs cited by Youngs (California Cement Council, verbal communication, 2006) is from \$48.44/m^2 on large installation with porous soils to \$96.88/m^2 on small installations and poor soils where asphalt must be removed to install porous pavement. We chose \$86.11/m^2 as the baseline estimate on the assumption that most installation in Sun Valley would be small but on porous soils. The lower end of the cost range when asphalt removal is included is $70/m^2 and we use $96.88/m^2 as the upper end of the cost range.

The cost estimates for centralized treatment are also inexact. They are based on national rather than the local cost data we used for the decentralized BMPs and do not take into account the variation in costs from project to project. We located actual or estimated cost and volume data on six local projects; three infiltration pits and three infiltration basins (the data sources are Department of Public Works, Los Angeles Count 2004 and Caltrans 2001). We then compared the actual or estimated cost of these projects to estimates derived from the cost curves. The costs of the actual projects range from 2 to 11 times the costs estimated by the FHWA(2003) cost curves (see Appendix Table 2). Part of the difference may be due to project costs that are not contemplated in the centralized infiltration basin and infiltration trench cost curves such as site access and preparation. These are costs that are likely to be particularly high in dense urbanized areas where roads and utilities have to be relocated in order to place infiltration structures or new stormwater conveyance. For example, the highest cost ratio is for the placement of infiltration basins below power lines. The median cost ratio is 5.6 times the FHWA (2003) cost estimate and the mean is similar at 5.75 the cost. In order to be conservative on the cost-comparison between centralized and decentralized alternatives we use the FHWA (2003) estimate as our low cost estimate (we use the low cost estimate as our baseline estimate), two times that curve as our middle cost estimate and 5.75 time the curve as our high cost estimate. We judge this range to be conservative because the FHWA (2003) curve seems to project costs lower than those ever observed in the Los Angeles area and some of the projects had higher cost ratios than our high estimate. For each of the three cost curves we estimates costs with our high, baseline, and low infiltration rate estimates. This results in a range of centralized costs to compare with our range of incentive-based costs.

The rate of return demanded by property owners hinges on their perception of the riskiness of the BMP investment and their degree of bid shading. It is unlikely that property owners will regard this as a completely safe investment. Because they would be installing BMPs on their own property, they may be worried that the BMPs would interfere with business operations or would malfunction. In addition, they would not be completely certain about maintenance costs. On the other hand, we expect that any incentive-based project would give a tax-free return because the payments would be structured as discounts on stormwater and other fees, and thus not taxable as income. Investors' expectations of after tax equity real returns are about 7.5-11.5% assuming a 2.5% inflation rate (personal conversation, Bowman Cutter III, Managing Director for Warburg, 5/31/2007). In contrast, safe returns on non-taxable municipal bonds are in the 2.5-3% range. A 2 percentage point advantage over municipal bonds would represent an expectation that the BMP investment is risky but less so than equities and would result in a required 5% rate of return. However, property owners may require a return in the (post-tax) equity range of perhaps 8%. We can then use 5-8% as the range of required return based on the perceived riskiness of the investment.

This range does not reflect the possibility of bid shading to gain returns above the minimum required level. Kirwan, Lubowski, and Roberts (2005) examine bid shading in the USDA's Conservation Reserve Program auctions that are similar to what we propose here and Crespi and Sexton (2005) estimate bid shading in cattle auctions. Kirwan et al. (2005) estimate bid shading between 10-40% (meaning that 10-40% of the payment received is excess profit) while Crespi and Sexton estimate bid shading around 7%. We account for bid shading by deriving a rate of return premium for our multi-period model based on some of the results from the single-period model of Kirwan et al. (2005). This derivation generates an additional 3 percentage point premium on top of the required rate of return. Adding this to the upper bound of our 5-8% range gives 11% as the new upper-bound rate of return with bid shading. Then 5% is our lower-bound rate of return if landowners view stormwater BMPs as a safe investment and there is no bid shading.

References

Kirwan, B., R.N. Lubowski, and M.J. Roberts. (2005). "How Cost-Effective are Land Retirement Auctions? Estimating the Difference Between Payments and Willingness to Accept in the Conservation Reserve Program." *American Journal of Agricultural Economics* 87(5): 1239-47.

Los Angeles County Department of Public Works. (2004). Sun Valley Watershed Management Plan. May.

Table B1: Infiltration Rates in Los Angeles.

Site	Sun Valley Area	Infiltration Rate (mm/hr)	Data Source
Elementary School	Yes	203.2	Estimated from soil reports.
Scrap Metal Yard	No	215.9	Percolation test
Veterans Park	No	114.3	Percolation test
Commercial Building	No	25.4	Estimated from soil reports.
Recycling Facility	Yes	215.9	Estimated from soil report.
Caltrans-Altadena	No	39.6	Caltrans *

* Table 6-1, Caltrans. 2004. "BMP Retrofit Pilot Program-Final Report." Report ID CTSW-RT-01-050.

Table B2: Comparison of Actual and Predicted Capital Costs for Centralized Infiltration ($M).

Project	Construction Cost	Predicted Cost	Cost Ratio
Infiltration Basins			
LADWP Steam Plant (Estimate*)	5.253	1.202	4.372
Powerline Easement (Estimate*)	0.946	1.901	11.018
Wentworth Park (Estimate*)	0.944	0.117	8.072
Infiltration Trenches			
Sun Valley Park (Estimate**)	3.240	1.709	1.896
Altadena MS (Adjusted**,#)	0.291	0.043	6.831
Carlsbad MS (Adjusted**)	0.116	0.050	2.329

* Sun Valley Watershed Plan. Los Angeles Department of Public Works.

** Caltrans. Third Party BMP Retrofit Pilot Study Cost Review. 2001

Adjusted downward by Caltrans for some expenses associated with monitoring and construction timeliness necessitated by litigation. Caltrans judged these were not costs that typical projects would face.