Placer County Stormwater TMDL Strategy

Placer County, CA

July 12, 2011

Final Technical Report

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TABLE OF CONTENTS

EXECUTIVE SUMMARY ES.1
CHAPTER 1. STRATEGY INTRODUCTION 1.1
BACKGROUND 1.1
OBJECTIVES AND APPROACH 1.2
CHAPTER 2. BASELINE POLLUTANT LOAD ESTIMATES 2.1
CONCEPTS APPLIED AND APPROACH 2.1
Selecting Urban Planning Catchments for PLRM Models 2.3
Developing Baseline PLRM Models 2.4
BASELINE POLLUTANT LOADS 2.5
Results From Selected Placer County Urban Planning Catchments 2.6
Extrapolating Results to all Urban Areas in Placer County 2.8
Urban Stormwater Baseline Pollutant Load Estimate for Placer County 2.10
CHAPTER 3. CONCEPTS FOR LOAD REDUCTION 3.1
POLLUTANT LOAD DISTRIBUTION ANALYSIS 3.1
Urban Planning Catchments (UPCs) 3.1
Land Uses and Land Use Conditions 3.3
CONCEPTS FOR POLLUTANT LOAD REDUCTION 3.7
Concept 1 – Intensive Improvements In UPCs with High Pollutant Loading Rates 3.7
Concept 2 – Advanced Pollutant Source Control for Road Operations 3.11
Concept 3 – Targeted Implementation of BMPs for Private Land Uses 3.20
SUMMARY OF RESULTS AND RECOMMENDATIONS 3.26
CHAPTER 4. ANALYSIS OF CAPITAL WQIP APPROACH TO ACHIEVE FIRST TMDL MILESTONE 4.1
FIRST LOAD REDUCTION MILESTONE ANALYSIS 4.1
Baseline Load Estimate for WQIPs 4.2
Individual WQIP Load Reduction Estimates Using PLRM 4.7
Jurisdictional Load Reduction Estimates 4.8
Comparison to First TMDL Load Reduction Milestone 4.10
PROJECT DELIVERY COSTS 4.10
ANALYSIS IMPLICATIONS AND LIMITATIONS 4.11
CHAPTER 5. MANAGEMENT STRATEGIES TO ACHIEVE TMDL MILESTONES 5.1
SUMMARY OF TMDL MILESTONES 5.1
RECOMMENDED STRATEGY TO MEET FIRST TMDL MILESTONE (2011-2016) 5.2
Uncertainty in Water Quality Performance Estimates 5.3
TMDL STRATEGY TO MEET CLARITY CHALLENGE (2017-2026) 5.4
Implementation Challenges to Meet Clarity Challenge 5.6
REFERENCES R.1
APPENDIX A – URBAN AREAS MODELED A.1
APPENDIX B – EXTRAPOLATION SPREADSHEET B.1
APPENDIX C – PLRM MODELS AND SUMMARY OF PLRM INPUTS C.1
APPENDIX D – CHAPTER 5 TECHNICAL ASSUMPTIONS D.1

LIST OF TABLES

ES.1 Lake Tahoe TMDL Load Reduction Milestones ES.1
ES.2 Placer County Baseline Condition Load Estimate ES.2
ES.3 Summary of Load Reductions and Costs by Concept ES.3
ES.4 Placer County Baseline Load Reduction Estimates ES.5
1.1 Lake Tahoe TMDL Load Reduction Milestones 1.1
2.1 PLRM Models Developed for Densest Urban Areas 2.3
2.2 PLRM Models Developed for Less Dense Urban Areas 2.3
2.3 Crediting Program Standard Assumptions for Baseline Condition PLRM Simulations 2.5
2.4 Average Annual Output from PLRM Models of Baseline Condition 2.6
2.5 Placer County Baseline Condition Load Estimate 2.10
2.6 Statistics on Modeled Area vs. Total Urban Area 2.10
3.1 UPCs for Water Quality Improvement in Concept 1 3.8
3.2 Summary of Load Reduction and Cost Estimates for Concept 1 3.10
3.3 General Road Conditions Modeled 3.12
3.4 Percent DCIA by Road Risk Category 3.14
3.5 Cost Assumptions for Advanced PSC Road Operations – Secondary High Risk Roads Only 3.15
3.6 Cost Assumptions for Advanced PSC Road Operations – Secondary High and Moderate Risk Roads 3.16
3.7 Summary of Load Reduction and Cost Estimates for Concept 2 3.17
3.8 Loading Rates with Private Property BMPs 3.23
3.9 Cost Estimates for Private Property BMPs 3.24
3.10 Summary of Load Reduction and Cost Estimates for Concept 3 3.24
3.11 Summary of Load Reductions and Costs by Concept 3.26
4.1 Placer County TMDL FSP Loads 4.1
4.2 Baseline FSP Loads for Placer County WQIPs, 2004-2016 4.2
4.3 Comparison of PLRM Baseline Results to UPC Unit Loads 4.7
4.4 PLRM Results for Three Completed Placer County WQIPs 4.8
4.5 Expected FSP Load Reductions for Placer County WQIPs, 2004-2016 4.9
4.6 Placer County Baseline Load Reduction Estimates 4.10
4.7 Project Delivery Costs Associated with WQIPs Likely to be Completed by 2016 4.10
5.1 Placer County TMDL FSP Loads 5.1
5.2 Load Reduction Estimates Associated with Recommended Actions to Achieve First TMDL Milestone 5.2
5.3 Cost Estimates Associated with Recommended Actions to Achieve First TMDL Milestone 5.3
5.4 Load Reduction Estimates Associated with Recommended Actions to Achieve Clarity Challenge Milestone 5.5
5.5 Cost Estimates Associated with Recommended Actions to Achieve Clarity Challenge Milestone 5.5
5.6 Summary of Estimated Costs to Achieve Clarity Challenge Milestone, 2004-2026 5.6

LIST OF FIGURES

2.1 Placer County Urban Boundary with Land Ownership Included in Analyses 2.2
2.2 Unit Area Loading of FSP and Surface Runoff for PLRM Models 2.7
2.3 Regression Relationships of Percent Impervious Area of UPCs 2.9
3.1 Urban Planning Catchment Fine Sediment Particle Loads 3.2
3.2 Catchment Area to FSP Loading Comparison by Land Use 3.4
3.3 Catchment FSP Loading – Secondary Road Land Use 3.5
3.4 Catchment FSP Loading – Commercial and Residential Land Uses 3.6
3.5 Secondary Road FSP Loading Rates by Percent DCIA 3.13
3.6 Average Annual Road Abrasive Application by Jurisdiction 3.18
3.7 FSP Loading Rates with Private Property BMPs 3.21
3.8 Surface Runoff with Private Property BMPs 3.22
4.1 Placer County Capital WQIPs overlain on Urban Planning Catchments 4.3

LIST OF TERMS

A&T Tool	TMDL Accounting & Tracking Tool; Data management tool that stores, tracks and reports credit information and load reduction achievement over time in association with the Crediting Program.
Baseline	Baseline Condition; Conditions present during TMDL baseline period, Oct 1, 2003 – May 1, 2004.
BMP RAM	Best Management Practice Maintenance Rapid Assessment Methodology; Tool for Tahoe Basin urban stormwater community to determine relative condition of an urban stormwater BMP.
CEC	Characteristic Effluent Concentration; Represents the effluent concentration typically achieved by a SWT facility in PLRM dependent upon the type of SWT facility specified.
CICU	Commercial/Industrial/Communications/Utilities; Land use designated in Tahoe Basin TMDL.
CRC	Characteristic Runoff Concentration; Representative concentration for a pollutant of concern in runoff from a specific land use and associated land use condition in PLRM.
Credit	Lake Tahoe Clarity Credit; Related to pollutant load reductions and used to evaluate progress towards TMDL.
Crediting Program	Lake Tahoe Clarity Crediting Program; Tahoe Basin program that defines system to track and evaluate pollutant load reductions and related credits within context of TMDL by urban catchment.
DCIA	Directly Connected Impervious Area; Impervious surfaces draining through a direct hydraulic connection to a surface water drainage system.
Existing	Existing Condition; Conditions present during the development of this Strategy Report, Oct 1, 2010 – May 1, 2011.
FSP	Fine Sediment Particle; Mass fraction of TSS concentration <16µm.
LRWQCB	Lahontan Regional Water Quality Control Board; California regulatory agency overseeing Tahoe Basin TMDL implementation.
MFR	Multi-Family Residential; Land use designated in Tahoe Basin TMDL.
NDEP	Nevada Division of Environmental Protection; Nevada regulatory agency overseeing Tahoe Basin TMDL implementation.
O&M	Operations & Maintenance; Practices to ensure proper function of urban stormwater infrastructure.
PLRM	Pollutant Load Reduction Model; Tool for Tahoe Basin urban stormwater community to estimate pollutant load reductions associated with catchment-scale water quality improvement actions.
Road RAM	Road Rapid Assessment Methodology; Tool for Tahoe Basin urban stormwater community to determine the condition of impervious road surfaces.
Road Risk	PLRM term that incorporates road characteristics to describe relative risk of pollutant generation and transport downslope from impervious road surfaces.
SFR	Single Family Residential; Land use designated in Tahoe Basin TMDL.
SWT	Stormwater Treatment Facility; Treatment BMP designed to reduce urban stormwater volumes and/or pollutant concentrations from a concentrated stormwater flow path.
TMDL	Tahoe Basin Total Maximum Daily Load; Implementation plan that establishes pollutant load reduction allocations for urban stormwater to improve Lake Tahoe clarity.
TSS	Total Suspended Sediment; Mass of sediment contained in a known volume of water.
UPC	Urban Planning Catchment; A contiguous area containing urban land uses with runoff draining to a surface waterbody. Any single square foot of land is included in only one urban catchment
WQIP	Water Quality Improvement Project; Typically a suite of improvements (pollutant source control, hydrologic source control, and stormwater treatment facilities) implemented within an urban catchment to reduce the pollutant loading to surface waters.

EXECUTIVE SUMMARY

The California Water Quality Control Board – Lahontan Region (LRWQCB) and Nevada Division of Environmental Protection (NDEP) have completed a Lake Tahoe TMDL analysis (LRWQCB and NDEP 2010) with the following key findings: 1) fine sediment particles (<16µm; FSP) are the primary pollutant of concern impacting lake clarity; and 2) stormwater runoff originating in urban areas is estimated to contribute 72% of the annual FSP pollutant load to Lake Tahoe.

The Lake Tahoe TMDL Implementation Plan (LRWQCB and NDEP 2010) establishes interim load reduction milestones for FSP, total phosphorus (TP), and total nitrogen (TN), with the most notable milestone being the Clarity Challenge (Table ES.1), which requires that all Tahoe Basin jurisdictions reduce FSP loading by 34% by the year 2026. Upcoming revisions to NPDES permits (California) and Memorandums of Agreement (Nevada) will require that each jurisdiction develop and commit to a load reduction plan formulated to meet these load reduction milestones.

Table ES.1. Lake Tahoe TMDL Load Reduction Milestones (LRWQCB and NDEP 2010)

Pollutant	5-Year Milestone	10-Year Milestone	Clarity Challenge (15-Year) Milestone	Transparency Standard (65-Year)
FSP	10%	21%	34%	71%
TP	7%	14%	21%	50%
TN	8%	14%	19%	46%

The 2NDNATURE Team (2NDNATURE, Northwest Hydraulic Consultants, Environmental Incentives, and Geosyntec Consultants) was contracted by the US Army Corps of Engineers (ACOE) to develop the Placer County Stormwater TMDL Strategy (Strategy Report). The goal of the Strategy Report is to: 1) assist Placer County to plan water quality improvements, strategies, and operations that will meet the Lake Tahoe TMDL pollutant load reduction milestones; and 2) provide information and insight for other jurisdictions as they develop their TMDL strategies. The Strategy Report is organized as follows:

Chapter 1. Provides the background, objectives and approach to developing the Strategy Report.
Chapter 2. Presents the approach used to calculate Placer County's jurisdictional baseline (2004) load estimate.
Chapter 3. Explores opportunities to cost-effectively reduce pollutant loads.
Chapter 4. Estimates and forecasts Placer County's ability to meet the first 5-Year load reduction milestone.
Chapter 5. Presents a recommended strategy, associated costs, and implementation challenges for meeting load reduction milestones up to the Clarity Challenge.

A detailed sensitivity analysis to quantify the level of uncertainty associated with the technical estimates of load reduction was beyond the scope of work for the Strategy Report. Qualitative discussions regarding the challenges and uncertainties associated with the technical estimates and future funding needs are provided throughout the document. Recognizing the level of uncertainty associated with many of the recommendations contained herein, the Strategy Report is intended to be revisited and adapted by Placer County and other Tahoe Basin jurisdictions as new policies are developed and more research is conducted to resolve current challenges and uncertainties.

CALCULATE BASELINE (2004) LOADING

Each jurisdiction will be required to estimate a baseline pollutant load to Lake Tahoe for FSP, TP, and TN and submit the estimate to its responsible TMDL regulator (Lahontan RWQCB for CA jurisdictions and NDEP for NV jurisdictions). The baseline loading report will need to include a description of the methodologies and analysis assumptions used to derive the baseline load estimate.

Chapter 2 of this document describes the methodology applied for Placer County, which used the Pollutant Load Reduction Model (PLRM; NHC et al. 2009) as the primary tool and technical basis for developing the insight needed for decision making and regulatory review. The PLRM can be applied to estimate catchment scale pollutant loads and evaluate potential load reductions for stormwater project alternatives. The PLRM was used to model a subset of urban planning catchments (UPC) within Placer County, and the modeling results were then extrapolated to the entire Placer County urban area in the Lake Tahoe Basin to estimate the total baseline load. Of the 35 Placer County UPCs delineated for the analysis, 14 UPCs representing a range of urban conditions in Placer County were modeled using PLRM. Using the modeling results, regression equations were developed to normalize pollutant loading for each pollutant of concern and surface runoff based on the percentage of impervious area within the modeled catchments. For the 21 UPCs that were not explicitly modeled, the regression equations were applied to estimate surface runoff and pollutant loading using the percentage of impervious area within each UPC and the size of the UPC. The results for all 35 UPCs were summed to determine the Placer County baseline pollutant loading estimate, which is presented in Table ES.2.

Table ES.2. Placer County Baseline Condition Load Estimate

Urban Area	Surface Runoff	Pollutant Loading						
(acres)	(ac-ft /year)	TSS	FSP	TP	SRP	TN	DIN	Units
5,738	1,491	875,000	516,000	2,450	550	10,220	1,260	lb/year
		397	234	1.1	0.2	4.6	0.6	metric tons/year
		-	2.6E+19	-	-	-	-	# particles/year[1]

[1] 1kg FSP = 1.1×10^{14} particles FSP (Equation 0.3; LRWQCB and NDEP 2009)

OPPORTUNITIES TO COST-EFFECTIVELY REDUCE POLLUTANT LOADING

Concepts for load reduction were formulated and analyzed to provide a framework to explore opportunities to cost-effectively reduce pollutant loads. Water quality improvement actions were grouped into one of three load reduction concepts: 1) implementation of public water quality improvement projects (WQIPs); 2) improved road maintenance operation for water quality; and 3) increased private parcel implementation. Below is a summary of each concept analyzed for water quality performance and costs:

- Concept 1 was formulated to be WQIPs that target all significant sources of pollutant loads within UPCs with the highest pollutant loading rates using a combination of stormwater quality improvements that include stormwater treatment facilities, hydrologic source controls, and pollutant source controls.
- Concept 2 was formulated to be advanced pollutant source controls on roads under the assumption that pollutant generation associated with road abrasive applications could be reduced throughout a jurisdiction without diminishing traffic safety. Abrasive application reductions would be achieved by improving operational efficiency and using more advanced equipment. Concept 2 would also target

recovery of pollutants on the road surface through frequent street sweeping using best available technology sweepers.

- Concept 3 was formulated to be private property BMP implementation and would prioritize BMP implementation for land use conditions with the highest pollutant loading rates.

Concept 1 is similar to current practices, while Concepts 2 and 3 represent changes in emphasis from public WQIPs. Table ES.3 summarizes the results of the concept analysis and presents: the estimated percent reduction in FSP loads relative to Placer County's estimated baseline load; cost estimates annualized over a 20-year period relative to the amount of FSP removed per year; and notes on confidence in performance and cost estimates. While the analysis uses Placer County stormwater conditions as its basis, the results and recommendations should be generally applicable to all Tahoe Basin jurisdictions regulated under the TMDL.

The effectiveness of various implementation levels for each of the three concepts were initially evaluated independently as a step in developing an overall strategy. As shown in Table ES.3, no single concept achieves the required 34% TMDL Clarity Challenge with a high degree of confidence. Note that the load reduction estimates shown in Table ES.3 for multiple concepts cannot be summed because they would not perform independently if implemented together in urban catchments. Therefore, this study recommends that the concepts be blended to develop a strategy for meeting TMDL load reduction targets. The estimated differences in annualized unit costs in Table ES.3 are subject to uncertainty, but even when allowing for this uncertainty the relative cost effectiveness of Concepts 2 and 3 provides a compelling reason to include them in an overall TMDL strategy.

Table ES.3. Summary of Load Reductions and Costs by Concept

Concept	Permutation of Concept	FSP Reduction as % of TMDL Baseline	Annualized Unit Cost ($/lb FSP removed/ year)[1]	Notes on Confidence in Performance and Cost Estimates
1	1a. Intensive water quality improvements in UPCs with "Highest" FSP loading rates[2]	18%	$70	Load Estimate: Source control is expected to improve WQIP treatment performance, thus increasing confidence that actions would achieve estimated load reductions. Requires a significant increase in maintenance commitments to ensure long-term achievement and sustainment of load reductions. Cost Estimate: Probably too conservative, actual design and operations would likely be more cost-effective.
	1b. Concept 1a + intensive water quality improvements in UPCs with "High" FSP loading rates[2]	26%	$88	
2	2a. Frequent sweeping on all High Risk roads	19%	$3.75	Load Estimate: Limited data on the effectiveness of road maintenance practices related to improvement in FSP characteristic runoff concentrations. Actions to reduce road abrasives not defined, quantified, or compared across jurisdictions. Cost Estimate: Actions associated with advanced sweeping cost are quantifiable. Advanced abrasive application controls are not yet defined.
	2b. Frequent sweeping plus abrasive controls on all High Risk roads	27%	$4.25	
	2c. Concept 2b + frequent sweeping plus abrasive controls on all Moderate Risk roads[3]	38%	$3.50	

Concept	Permutation of Concept	FSP Reduction as % of TMDL Baseline	Annualized Unit Cost ($/lb FSP removed/ year)[1]	Notes on Confidence in Performance and Cost Estimates
3	3a. BMP implementation on all CICU within UPCs with high FSP loading rates	12%	$20	Load Estimate: High confidence in ability of BMPs to reduce load, but lack of long-term private property maintenance or program to ensure maintenance could affect long-term sustainment of load reductions. Cost Estimate: Limited data available for costs of BMP implementation on CICU with space constraints. Heavily constrained sites could be very expensive. However, the cost estimate is considered reasonably conservative on an average basis.
	3b. Concept 3a + BMP implementation for all CICU and all MFR	20%	$26	
	3c. Concept 3b + BMP implementation for all SFR	23%	$41	

[1]Annualized unit cost estimates were developed from total cost estimates and do not attempt to divide costs by funding source (e.g., public grants, Placer County contributions, private contributions, etc.)

[2]See Figure 3.1 for definition and location of "Highest" and "High" UPCs.

[3]The unit cost estimate for Concept 2c is lower than Concepts 2a and 2b because cost estimates assume the miles of road swept per day under Concept 2c will increase (i.e., more roads swept = less travel time for sweeper between targeted roads).

FORECAST ABILITY TO MEET FIRST TMDL MILESTONE (10% LOAD REDUCTION BY 2016)

The Lake Tahoe TMDL set the baseline condition for all TMDL analyses as May 1, 2004, meaning that any water quality action occurring after May 2004 may be counted towards TMDL load reduction milestones. The first regulatory requirement of the TMDL for load reduction planning will require development of a 5-year load reduction plan that demonstrates how the first TMDL milestone (10% FSP load reduction from baseline loads) will be achieved by 2016.

For most jurisdictions in the Tahoe Basin, including Placer County, the primary approach to reducing stormwater pollutant loads has been the implementation of public WQIPs throughout the urban portion of their jurisdiction in accordance with TRPA's Environmental Improvement Program (EIP). Chapter 4 of this Strategy Report assesses Placer County's current progress towards the first TMDL milestone by estimating pollutant load reductions for completed WQIPs (2004-2010) and WQIPs planned for completion by the end of the first TMDL milestone (2011-2016) to determine if continuation of current practices is a viable approach to achieve the first TMDL milestone.

Table ES.4 summarizes the results of the analysis conducted in Chapter 4, which estimates that Placer County has achieved a 3% load reduction relative to its baseline pollutant load as of Spring 2011, and if all planned WQIPs are completed by 2016, an 8% reduction may be achieved by 2016. Based on this estimate, Placer County may not meet the first 10% load reduction milestone by 2016 through the implementation of WQIPs alone.

Table ES.4. Placer County Baseline Load Reduction Estimates

	WQIPs completed to date	WQIPs to be completed by 2016
Placer County Baseline Load Estimate (lb/year)	516,000	
Number of WQIPs	11	18
Total FSP Load Reduction Estimate (lb/year)	14,743	42,255
Baseline FSP Load Reduction (%)	3%	8%

Although actual load reductions could be higher than the Table ES.4 estimates, there is a low degree of confidence that Placer County could achieve a 10% FSP load reduction by 2016 with a strategy focused primarily on the implementation of WQIPs. In order to achieve the first TMDL milestone, and certainly to achieve subsequent milestones including the Clarity Challenge milestone (34% FSP load reduction in a 15-year timeline), Placer County will need to implement additional pollutant load reduction actions beyond WQIP implementation. Although the analysis in this report is for the Placer County urban area, the project team believes these results and implications will be generally applicable to all Tahoe Basin jurisdictions regulated under the TMDL.

RECOMENDED STRATEGY FOR MEETING TMDL MILESTONES

The recommended strategy to meet TMDL milestones discussed in Chapter 5 recognizes the need to shift away from reliance solely on implementation of public WQIPs to a more balanced program that emphasizes improvements in road operations for water quality and targeted implementation of private property BMPs. The recommended TMDL strategy for Placer County to meet the Clarity Challenge blends the following actions: 1) continuation of public WQIPs in urban catchments with the highest FSP loads; 2) advanced road operation actions to improve and protect water quality; and 3) implementation of private property BMPs targeting private land uses that typically generate the highest FSP loads. Based on the specific set of actions selected, the total cost to implement the recommended TMDL Strategy for Placer County is estimated to be approximately $130 million. Of this amount, approximately $28 million has already been expended on completed WQIPs and $11.5 million is estimated to be contributed from the private sector. This cost estimate includes annual operation and maintenance (O&M) and Crediting Program inspection and reporting costs from 2011-2026, which total roughly $16 million during that time period.

Below are brief summaries of the primary actions incorporated into the recommended strategy:

Continue Public WQIPs: Over the last few decades public WQIPs have been a common water quality improvement strategy employed throughout the Tahoe Basin to reduce pollutant loading to Lake Tahoe. The funding mechanism for these projects is well established and jurisdictions have experience in planning and implementing WQIPs to reduce pollutants loads. In the past, these projects have focused on a myriad of water quality concerns with varying effectiveness, and there may be some opportunity to improve the design of future projects to target the pollutants of concern in urban stormwater identified in the TMDL. For example, the cost of a project per FSP load reduced might be used to evaluate project priorities or the feasibility of a particular WQIP.

Improved Road Maintenance Practices for Water Quality: Roads have been identified as a significant FSP source by Tahoe Basin urban stormwater research studies (e.g., LRWQCB and NDEP 2008a). Improved pollutant source control practices can significantly reduce the generation and transport of pollutants of concern from roads. Improvements to current road abrasive control practices include: the use of the most advanced equipment to reduce the total amount of abrasives applied without compromising traffic

safety; applying abrasives with higher durability to reduce the generation of FSP from pulverization; and alternative deicing strategies such as brine pre-application. Improvements to pollutant recovery from roads include: increasing the frequency of sweeping; and the use of best available technology sweepers to target recovery of pollutants of concern.

Increase and Target Private Parcel BMP Implementation: BMP implementation on single-family residential (SFR), multi-family residential (MFR), and Commercial, Institutional, Communications, and Utilities (CICU) land uses can reduce pollutant concentrations generated from the land use and significantly reduce the volume of water leaving private parcels. As a first phase of targeted BMP implementation to maximize load reductions, it is recommended that BMP compliance be targeted for CICU and MFR land uses in the urban catchments identified with the highest FSP loading rates. In Placer County these areas are: Kings Beach, Lake Forest, Tahoe City, and Homewood.

Similar to this analysis for Placer County, other Tahoe jurisdictions will likely find that the most effective strategy to achieve the TMDL load reduction milestones blends the three water quality improvement actions described above. Source control of pollutants through improved road maintenance (decreasing pollutant concentrations) and increased BMP implementation on private parcels (decreasing stormwater volumes) will reduce the pollutant loading into the stormwater runoff system, which will improve the pollutant treatment capability of the stormwater treatment systems implemented as public WQIPs. The most effective strategies will also consider the spatial distribution of pollutant loading across the entire jurisdiction and will target those areas with the highest loading and therefore the greatest opportunity to realize load reductions.

A key strength of the recommended strategy is that it provides flexibility by identifying three separate water quality improvement actions that may be combined in various proportions, or on different timeframes, to meet the Clarity Challenge milestone. The recommended strategy includes a blend of actions with markedly different estimates of cost effectiveness (see Table ES.3). For example, the continued implementation of public WQIPs is estimated to be far less cost effective for pollutant load reductions relative to near-term improvements in road maintenance practices and targeted private property BMP implementation. This result suggests that a shift in jurisdictional stormwater quality improvement programs may be necessary to target load reductions with a stronger emphasis on cost effectiveness.

While some shift in emphasis among stormwater programs appears necessary based on the results of this analysis, it is worth noting that the cost-benefit estimates in Table ES.3 consider concepts independently and on average over an entire jurisdiction. Therefore, the singular concepts don't reflect the synergy that can be achieved by combining actions at the catchment scale; for example: 1) private BMPs and improved road operations can reduce the size (cost) of WQIP facilities and improve performance; 2) WQIPs can compensate for lapses in road operations for water quality (e.g., it is not possible to recover road abrasives from sweeping during certain winter conditions); 3) WQIPs can provide stable drainages to route runoff from source control areas and avoid secondary pollutant loading problems (e.g., roadside or channel erosion) that would undermine source control efforts, and 4) WQIPs are more effective buffers in large storm events, which may carry high episodic loads. For these reasons, and because continued implementation of public WQIPs will be necessary to meet load reductions targets beyond the Clarity Challenge, public WQIPs are included as a primary action in the recommended strategy.

CHALLENGES ASSOCIATED WITH THE RECOMENDED STRATEGY

At the present time Placer County is not in a position to immediately implement the recommended strategy due to constraints on program funding, institutional policy, and regulatory support. Rather than change the recommended strategy to match Placer County's current capabilities, the Strategy Report takes the approach of identifying challenges in need of resolution in the next five years, and recognizes that the Clarity Challenge strategy will be refined by 2016 to perhaps modify the blend of specific actions described in this document. Other Tahoe Basin jurisdictions will face similar challenges, and inter-agency collaboration over the next five years could provide significant benefits to Basin-wide stormwater planning. Resolution of the following challenges will be necessary for Placer County and other jurisdictions to successfully meet Clarity Challenge load reduction milestones.

UNCERTAINTY WITH FUNDING

WQIP Implementation – Planning, design, and construction of WQIPs is funded primarily through public grants. However, the present outlook for sustained allocation of significant grant funds to continue WQIP implementation is uncertain. Unless other sources of funding are identified, program costs may not be supported at the level necessary to meet milestones.

Significant Increases in Maintenance Costs – The approaches proposed require significant increases in water quality maintenance costs for improved road operations and for maintenance of stormwater treatment facilities constructed as part of WQIPs. Current grant funding policies do not allow for grant funds to be used for operations and maintenance. Placer County and all other Tahoe Basin jurisdictions will need to locate, secure, and sustain funding to pay for the additional water quality maintenance activities proposed.

Increases in Program Management Costs and Staffing – The process for registering and tracking load reductions outlined by the Crediting Program will require additional staff for each jurisdiction. An estimate of the additional staff time required is presented in this report. The recommended strategy also includes monitoring and evaluation to support the shift in program emphasis and the refinement of the Clarity Challenge strategy in 2016. These costs for additional staff will require additional grant funding or identification of other funding sources.

REGULATORY SUPPORT TO INCREASE PRIVATE BMP IMPLEMENTATION

While current TRPA regulatory code requires the implementation of BMPs on all private parcels, compliance has not been broadly enforced. To date, the policy has resulted in a low level of voluntary response by the private sector, and Tahoe Basin jurisdictions responsible for stormwater management currently have minimal resources and political support to enforce private property BMP implementation or maintenance. Placer County and other Tahoe Basin jurisdictions will need improved support from local agency policy makers and regulatory agencies such as TRPA to achieve private BMP implementation in priority areas, and to ensure private BMPs are maintained.

INSTITUTIONAL CHANGES

Road operations have traditionally been organized as part of public works and transportation safety activities of local agencies and have not been closely coordinated with watershed or water quality functions. Effective modification of road operations practices may require internal organizational changes and shifts in allocation of funds. These types of changes require development of proposed program and operations plans, and an approval at the highest level of governance (e.g., Board of Supervisors). Uncertainty exists regarding the nature and timing of institutional changes needed to implement some parts of the recommended strategy.

CHAPTER 1. STRATEGY INTRODUCTION

The 2NDNATURE Team (2NDNATURE, Northwest Hydraulic Consultants, Environmental Incentives, and Geosyntec Consultants) was contracted by the US Army Corps of Engineers (ACOE) to develop the Placer County Stormwater TMDL Strategy (Strategy). The goal of the Strategy is to assist Placer County and other implementing jurisdictions in the Lake Tahoe Basin in outlining future water quality improvements that will meet the Lake Tahoe TMDL pollutant load reduction allocations for urban stormwater. The Pollutant Load Reduction Model (PLRM; NHC et al. 2009) is the primary tool being used for these analyses to provide a technical basis for developing the insight needed for decision making and regulatory review. The PLRM can be applied to estimate pollutant loads and evaluate potential load reductions for stormwater project alternatives. This Technical Report provides the basis for Placer County to develop their Strategy for meeting Lake Tahoe TMDL pollutant load reduction allocations. The report will be shared with the other jurisdictions to be used for guiding development of their TMDL Strategy.

BACKGROUND

Lake Tahoe has been designated an "impaired water body" for 3 pollutants (fine sediment particles (FSP), nitrogen and phosphorous). As an impaired water body under the Clean Water Act, a Total Maximum Daily Load (TMDL) analysis is required. The California Water Quality Control Board – Lahontan Region (LRWQCB) and Nevada Division of Environmental Protection (NDEP) have completed a Lake Tahoe TMDL analysis which finds fine sediment particles (<16µm; FSP) is the primary pollutant of concern for lake clarity (p. 3-2; LRWQCB and NDEP 2010). Direct stormwater runoff originating in urban areas is estimated to contribute 72% of the total FSP, 38% of the total phosphorous, and 16% of the total nitrogen annual loading to the lake (p. 7-2; LRWQCB and NDEP 2010).

The Lake Tahoe TMDL set the baseline condition for all TMDL analyses as May 1, 2004, and establishes a 15-year interim load reduction milestone from the baseline condition, referred to as the Clarity Challenge (Table 1.1). Meeting the Clarity Challenge will mark a clear improvement in Lake Tahoe water clarity and is the focus for the TMDL Implementation Plan (p. 6-4; LRWQCB and NDEP 2010). The Final TMDL states that all urban upland jurisdictions, including Placer County, will need to reduce their FSP loading by 34% to meet the Clarity Challenge (Table 10.1; LRWQCB and NDEP 2010). Upcoming revisions to the Placer County Stormwater NPDES permit are expected to focus on requiring load reductions to be analyzed in project planning and annual reporting and making significant progress toward the Clarity Challenge load reduction target.

Table 1.1. Lake Tahoe TMDL Load Reduction Milestones

Pollutant	5-Year Milestone	10-Year Milestone	Clarity Challenge (15-Year) Milestone	Transparency Standard (65-Year)
FSP	10%	21%	34%	71%
TP	7%	14%	21%	50%
TN	8%	14%	19%	46%

The Lake Clarity Crediting Program (Crediting Program) Handbook (LRWQCB and NDEP 2009) has been developed to provide guidance to estimate and track pollutant load reductions within the context of the Lake Tahoe TMDL. The PLRM is the Crediting Program's recommended empirical model for jurisdictions to estimate catchment load reductions on an average annual basis. The initial version of the Pollutant Load Reduction Model (PLRM v1) was released in October 2009 by Northwest Hydraulic Consultants (NHC), 2NDNATURE, and Geosyntec Consultants through grants provided by the ACOE and the Nevada Division of Environmental Protection (NDEP) (NHC et al.

2009). The PLRM provides Lake Tahoe resource managers with a tool to compare urban stormwater quality improvement alternatives within a defined project area based on the predicted pollutant load reductions.

OBJECTIVES AND APPROACH

The specific objectives of this Technical Report are:

- Estimate baseline condition (2004) pollutant loads from the urban area of Placer County.
- Develop the technical basis for prioritizing approaches for pollutant load reductions in Placer County by assessing various load reduction strategies, including pollutant source control, hydrologic source control, passive stormwater treatment, and advanced stormwater treatment.
- Provide technical information to support Placer County's process for selecting a strategy for meeting anticipated Lake Tahoe TMDL pollutant load reduction allocations for urban stormwater that will be required in a future NPDES permit.
- Provide analyses for review by other Tahoe Basin urban jurisdictions to inform and support their development of a TMDL Strategy to meet load reduction allocations in their respective jurisdictions.

To meet the above objectives, the 2NDNATURE Team has developed the following phased approach to developing the Placer County Stormwater TMDL Strategy:

1. Use PLRM to develop baseline (2004) pollutant load estimates for Placer County urban area.
2. Use PLRM to screen potential pollutant load reduction approaches, based on the identification of high-priority urban planning catchments with relatively high load estimates, common contributing factors for pollutant loading among those urban planning catchments, and load reduction approaches that employ both catchment and land use based improvements.
3. Apply PLRM load reduction estimates of modeled pollutant load reduction scenarios, a cost/benefit analysis, and key implementation considerations to recommend priority actions.
4. Develop strategy recommendations for consideration by Placer County and other Tahoe Basin jurisdictions regarding the most cost-effective and timely actions that may meet Lake Tahoe TMDL pollutant load reduction allocations.

Throughout this Technical Report, the focus of the analysis has been on FSP, as that is the primary pollutant of concern indentified in the TMDL and currently the only pollutant used in the definition of a Lake Clarity Credit (LRWQCB and NDEP 2009). Based on the current recommendation from the LRWQCB (R. Larsen, pers. comm. Feb 24, 2011), all jurisdictions will be required to provide baseline (2004) load estimates for 3 key pollutants (FSP, TP, TN). As jurisdictions undertake the process of registering catchments for the Crediting Program, the expected load reductions for FSP, TP and TN will need to be entered into the TMDL Accounting & Tracking Tool and thus the % FSP, TP, and TN reductions will be tracked over time. However, regulatory compliance is based on Credit awards, which to date are solely equated to FSP load reductions (1 Credit = 1.0×10^{16} FSP particles; p. 0-7, LRWQCB and NDEP 2009). It is assumed that water quality improvement actions that result in FSP reductions will result in comparable TP and TN load reductions, and the calculation of the TP and TN % reduction milestones (see Table 1.1) were scaled by the TMDL Program based on the FSP load reduction targets desired. Jurisdiction actions to meet load reduction requirements should focus on maximizing expected FSP load reductions. In the future, should a jurisdiction demonstrate achievement of the FSP milestone, but TP and TN load reductions fail to meet corresponding targets, the TMDL Program will revisit the assumption that if FSP load reductions are met nutrient load reductions will follow.

CHAPTER 2. BASELINE POLLUTANT LOAD ESTIMATES

The 2NDNATURE Team developed the following approach to estimate baseline loads for the urban area of Placer County.

CONCEPTS APPLIED AND APPROACH

The following concepts were used to develop the Baseline Pollutant Load Estimates.

Baseline Loads – In order to provide a baseline consistent with TMDL requirements documented in the LRWQCB order (LRWQCB 2011), the baseline condition for all PLRM models reflects conditions present during the TMDL baseline period of October 1, 2003 to May 1, 2004. Additionally, PLRM input follows the standard baseline condition inputs defined in the Crediting Program Handbook - *Catchment Credit Schedule Technical Guidance and Instructions* (LRWQCB and NDEP 2009).

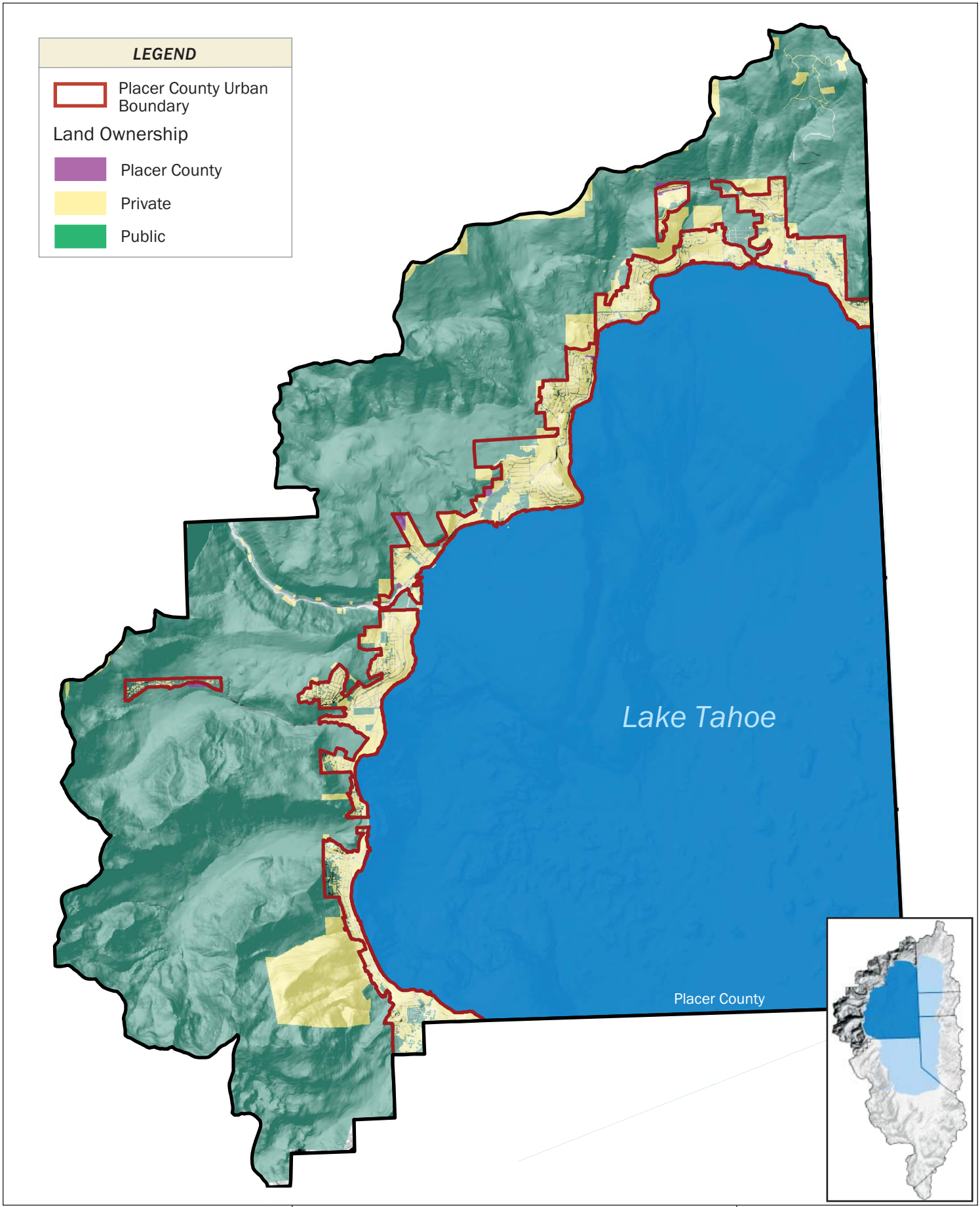
Placer County Urban Boundary – The baseline loading analysis assesses urban pollutant loading and the potential for load reductions in urban areas of Placer County. The urban boundary for Placer County, defined using TRPA Plan Area Statements, is the spatial extent of analyses for this work. Figure 2.1 displays the urban boundary for Placer County.

Urban Planning Catchments (UPCs) – The *Crediting Program Handbook* directs urban jurisdictions to estimate pollutant loads and load reductions using distinct urban catchments. The term "urban planning catchment" is used in this Technical Report and is synonymous with the Crediting Program term: "urban catchment". Urban Planning Catchments (UPCs) ensure that pollutant load estimates to Lake Tahoe are the sum of distinct input points (i.e., UPC outlets). A UPC delineation developed by Placer County and provided to the 2NDNATURE team was used to develop PLRM models and report pollutant loading for this Technical Report and is included as Figure 3.1.

PLRM Catchments – A PLRM catchment is a discrete drainage area where pollutant loading is evaluated in the PLRM. The term "PLRM catchment" is used in this Technical Report and is synonymous with the Crediting Program term: "modeling catchment". For urban areas modeled, pollutant loading is estimated using one or more PLRM catchments. Appendix A contains a series of exhibits showing the urban areas modeled, the specific PLRM catchments modeled, and the relationship of PLRM catchments to Placer County UPCs for the baseline loading analysis. PLRM catchments are typically smaller than an urban planning catchment or the boundaries of a water quality improvement project (WQIP). Therefore, multiple PLRM catchments are typically used to estimate pollutant loading from a UPC or a WQIP in this analysis.

Extrapolation of Model Output - Because the PLRM was developed for applications at the stormwater quality improvement project scale (e.g., projects roughly 10 -100 acres in size), it would be very resource intensive to develop PLRM models for the entire urban area of Placer County to estimate a total urban pollutant load. The approach described below extrapolates pollutant loading from a subset of Placer County UPCs modeled using the PLRM to other urban areas of Placer County not explicitly modeled to derive an estimate of total baseline pollutant loading.

The following sections outline the approach taken to 1) select Placer County UPCs to model using the PLRM and 2) develop the baseline PLRM models.



2NDNATURE LLC
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nhc
www.nhcweb.com

FIGURE 2.1 PLACER COUNTY URBAN BOUNDARY WITH LAND OWNERSHIP

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SELECTING URBAN PLANNING CATCHMENTS FOR PLRM MODELS

Two criteria were applied when selecting UPCs to model in the PLRM. Appendix A contains a series of exhibits showing the urban areas modeled, the specific PLRM catchments modeled, and the relationship of PLRM catchments to Placer County UPCs.

1. Criteria #1: Select UPCs that represent the densest urban areas. The densest urban areas of Placer County generally include unique opportunities and constraints for siting stormwater quality improvements that are site-specific and may not be representative of land use conditions for the less dense urban areas of Placer County. Therefore, PLRM models were developed for these areas to represent and explore these site-specific opportunities and constraints. Four (4) of the densest urban areas were developed into PLRM models as shown in Table 2.1.

Table 2.1. PLRM Models Developed for Densest Urban Areas

Name of Area Modeled	**Placer County UPCs ID** (modeled urban area only)
Kings Beach	PC3, PC32, PC33, and PC34
Lake Forest	PC18, PC19, PC22, and PC23
Tahoe City	PC25
Homewood	PC7

2. Criteria #2: Select UPCs that represent a range of conditions in less dense urban areas. Less dense urban areas in Placer County have relatively similar opportunities and constraints in terms of siting stormwater quality improvements. Therefore, a representative number of PLRM models were developed for a subset of these less dense UPCs to model the range of conditions. UPCs were selected based on the premise that pollutant loading for the less dense urban areas varies based on the setting. Settings are defined as either dispersed or concentrated, based on the TMDL Pollutant Reduction Opportunities Report (PRO Report) (LRWQCB and NDEP 2008b).

   Dispersed: Impervious area is distributed in a manner that generally does not impede construction of stormwater quality improvements. Available area for improvements is either commingled within the extents of the existing impervious area, downstream of the impervious area, or a combination of the two.

   Concentrated: Impervious area coverage is relatively dense, with a relatively high percentage of the impervious area directly connected to a catchment outlet and/or receiving water. Minimal pervious area is available for stormwater quality improvements both within the extent of the existing impervious area and downstream of the impervious area.

Four (4) of the less dense UPCs in Placer County were selected based on setting and through discussions with Placer County. The four areas modeled are shown in Table 2.2.

Table 2.2. PLRM Models Developed for Less Dense Urban Areas

Name of Area Modeled	**Placer County UPC ID** (modeled urban area only)	**TMDL Setting**
Sunny Ward	PC15	Concentrated
Dollar Point	PC20	Concentrated
Timber Pines	PC14	Dispersed
Watson	PC36	Dispersed

DEVELOPING BASELINE PLRM MODELS

The following describes common assumptions and methods used to develop all baseline PLRM models.

1. Existing Conditions Analysis Memorandums (ECAMs) provided by Placer County to the 2NDNATURE team were used to develop input parameters for PLRM models where the ECAMs covered all or a portion of the urban area being modeled.
2. GIS data was queried to develop input data necessary for each PLRM model (e.g., land use distribution, soil distribution, average slope, etc.). The following GIS data sets were used:
    a. ***TMDL Land Use GIS Layer***:
        i. Used to create a planning level estimate of land use distribution and impervious area by land use in the Land Use Editor of the PLRM.
        ii. The layer can be downloaded from the Lahontan RWQCB website at http://www.waterboards.ca.gov/lahontan/water_issues/programs/tmdl/lake_tahoe/index.shtml
    b. ***2006 Tahoe Basin Soil Survey***:
        i. Used to define the distribution of soils in the Soil Editor of the PLRM. The distribution of soils is used by the PLRM to recommended values for hydrologic properties of soil.
        ii. The layer can be downloaded from the NRCS website for Soil Survey Symbol = CA693 at http://soildatamart.nrcs.usda.gov/Survey.aspx?State=CA
    c. ***Default PLRM Road Risk Layer***:
        i. Used to define the distribution of Road Risk in the Land Use Conditions Editor of the PLRM. Road Risk categorizes the pollutant potential of roads (see Section 6.1 of the PLRM User's Manual for a complete description of Road Risk).
        ii. The layer can be downloaded from the Tahoe Integrated Information Management System (TIIMS) at: http://www.tiims.org/TIIMS-Sub-Sites/PLRM.aspx
    d. ***DEM of the Lake Tahoe Basin***:
        i. Used to calculate the average slope of each modeled drainage catchment for entry in the Catchment Properties Editor of the PLRM.
        ii. The layer can be downloaded from the USGS Lake Tahoe Clearinghouse at http://tahoe.usgs.gov/DEM.html
3. The baseline year for all models is 2004. Where applicable, assumptions of typical conditions for the Tahoe Basin as of May 1, 2004 are used. Standard assumptions defining the Baseline Condition using guidance provided in the *Crediting Program Handbook* is also used (Table 2.3). For example, the basin-wide average level of private property BMP implementation was used based on information defined in the *Crediting Program Handbook*.

Table 2.3. Crediting Program Standard Assumptions for Baseline Condition PLRM Simulations

PLRM Interface	PLRM Input	Crediting Program Standard Assumptions
Land Use Conditions Editor	**Degree of Private Property BMP Implementation**	***% Certificates***
	Single-Family Residential	7% BMP
	Multi-Family Residential	19% BMP
	CICU	5% BMP
	Vegetated Turf	0% Source Control
	Vegetated Turf with an Approved Fertilizer Management Plan	100% Source Control
Road Conditions Editor	**Road Abrasive Application Strategy**	**Strategy**
	Secondary Roads – All Risk Categories	None
	Primary Roads – All Risk Categories	Moderate
	Street Sweeper Type	**Type**
	Secondary Roads – All Risk Categories	Mechanical Broom
	Primary Roads – All Risk Categories	Mechanical Broom
	Street Sweeper Frequency	**Frequency**
	Secondary Roads – All Risk Categories	Winter = 0 times; Summer = 1-2 times
	Primary Roads – All Risk Categories	Winter and Summer = 1-2 times per season

Source: PLRM Applications Guides (NHC et al. 2010)

4. A limited amount of field inspection was used to validate the ECAMs developed by Placer County and the GIS data listed above.
5. Google Earth® Street View was used to refine estimates of road shoulder conditions and impervious area connectivity.
6. The period of simulation used to estimate average annual pollutant loads is Water Year 1989 through Water Year 2006. Specific time series of meteorological data used for each UPC vary based on the location of each UPC (NHC et al. 2009). However, differences in pollutant loading caused by spatial meteorological variability are relatively minor compared to differences caused by variable land uses conditions among UPCs. This is partly because the PLRM meteorological algorithms use the same Tahoe City SNOTEL gage for all urban areas in Placer County.

BASELINE POLLUTANT LOADS

This section presents the following:

1. Modeling results for runoff and FSP loading for the selected UPCs (see Tables 2.1 and 2.2).
2. The methods used to extrapolate results from selected UPCs to generate baseline pollutant load for all urban area in Placer County.
3. Estimates of baseline pollutant loading for Placer County.

Note that the PLRM estimates pollutant loading for all pollutants of concern (nutrient and sediment species) for lake clarity. To simplify the presentation of results, only the methods used to derive pollutant load estimates for Fine Sediment Particles (FSP) defined as total suspended sediment (TSS) <16µm and surface runoff are described in this section. Estimates of pollutant loading for all pollutants of concern are summarized at the end of the section as required in the LRWQCB order (2011).

RESULTS FROM SELECTED PLACER COUNTY URBAN PLANNING CATCHMENTS

Table 2.4 presents the average annual estimates for FSP loading and surface runoff derived for the urban areas of each UPC modeled using the PLRM. Key physiographic characteristics of the urban areas modeled are presented in Table 2.4 and include:

- Area – acreage of urban area of the UPC modeled in the PLRM.
- % Imp – the percentage of area that is impervious.
- % DCIA – the percentage of impervious area estimated to be directly connected to the drainage system.

Key outputs from the urban areas modeled are presented in Table 2.4 and include:

- % Surface Runoff - the percentage of precipitation that generates surface runoff on a unit area basis (calculated as volume of surface runoff expressed in terms of depth over the catchment area divided by rainfall depth).
- Surface Runoff – the average annual volume and depth (unit area) of surface runoff.
- FSP Loading – the average annual Fine Sediment Particle load as total load and unit area load.

Figure 2.2 presents average annual FSP loading and surface runoff normalized by area.

Table 2.4. Average Annual Output from PLRM Models of Baseline Condition

Placer County UPC ID	Area (acres)	% Imp	% DCIA	% Surface Runoff	Surface Runoff		FSP Loading	
					(ac-ft/yr)	(in/yr)	(lb/yr)	(lb/yr/acre)
PC14	205	14%	52%	5%	30	1.8	7,700	38
PC36	64	18%	66%	8%	15	2.8	2,000	43
PC18	19	19%	60%	8%	4	2.8	1,800	94
PC19	19	20%	60%	8%	4	2.7	1,700	92
PC15	830	21%	45%	7%	170	2.5	57,000	69
PC20	378	24%	76%	13%	140	4.5	33,400	88
PC34	187	25%	59%	11%	51	3.3	21,800	117
PC33	97	26%	72%	12%	30	3.8	11,400	93
PC23	47	27%	60%	10%	14	3.6	6,100	128
PC7	50	28%	85%	18%	27	6.5	11,600	235
PC22	283	29%	66%	13%	112	4.8	61,200	217
PC3	112	35%	72%	18%	50	5.4	19,700	176
PC32	82	43%	70%	22%	45	6.6	25,200	309
PC25	37	54%	67%	28%	31	9.8	14,900	400

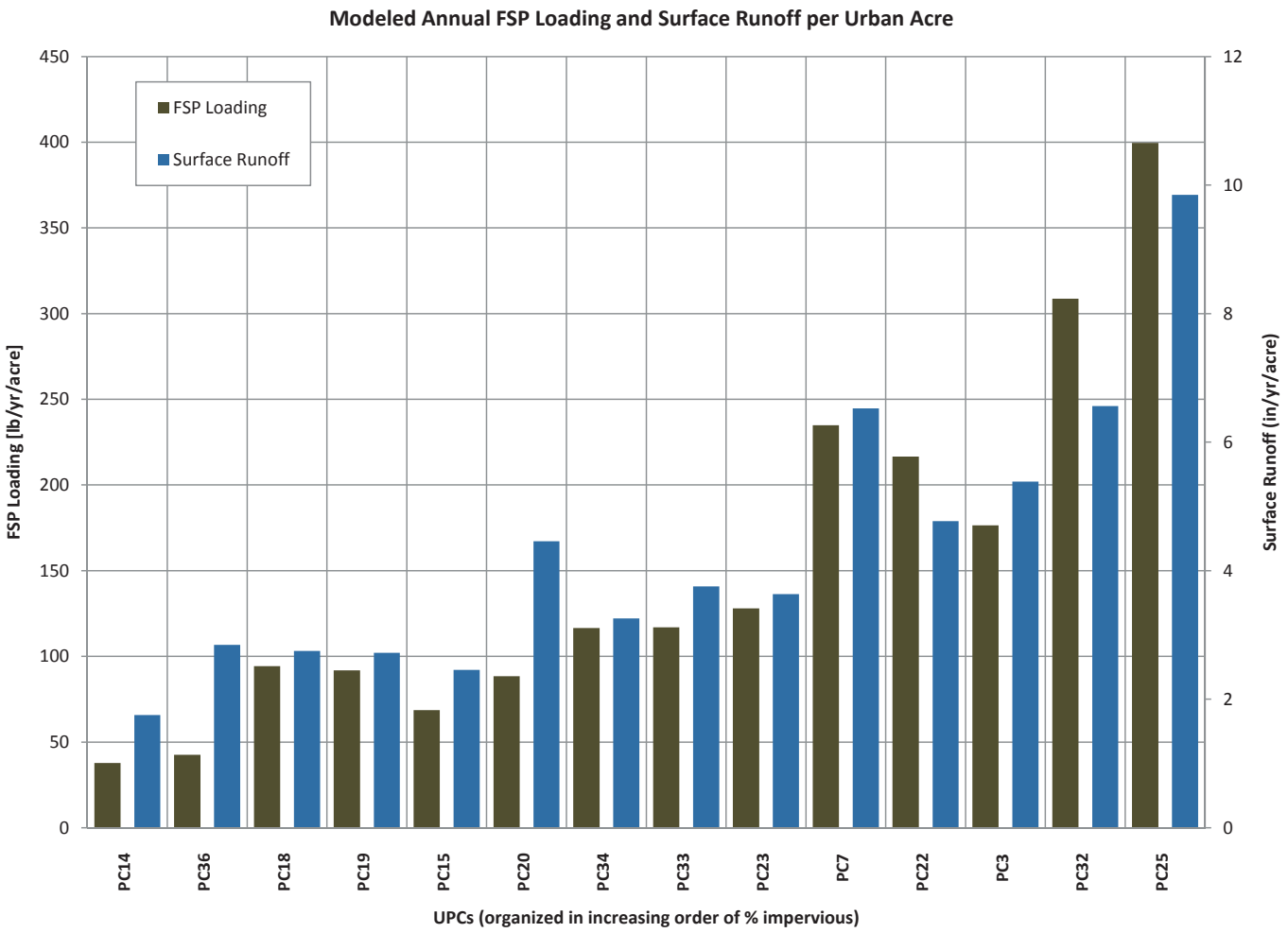


Figure 2.2. presents the average annual estimates for FSP loading and surface runoff derived for the urban areas of each UPC modeled using the PLRM. Because the PLRM was developed for applications at the storm water quality improvement project scale (e.g., projects roughly 10 -100 acres in size), it would be very resource intensive to develop PLRM models for the entire urban area of Placer County to estimate a total baseline pollutant load. To conserve resources, the approach described in the report extrapolates pollutant loading from the subset of Placer County UPCs shown in Figure 2.2 to other urban areas of Placer County not explicitly modeled to derive an estimate of total baseline condition (2004) pollutant loading.

FIGURE 2.2 UNIT AREA BASELINE LOADING OF FSP AND SURFACE RUNOFF FOR PLRM MODELS

EXTRAPOLATING RESULTS TO ALL URBAN AREAS IN PLACER COUNTY

Regression relationships for the data presented in Table 2.4 were explored to determine if reasonable correlations could be identified to extrapolate estimates of pollutant loading to UPCs without PLRM models. Two strong correlations were identified between FSP pollutant loading and 1) the percent impervious area in a UPC (R-value of 0.85) and 2) the percent of area occupied by high impact land uses in a UPC (R-value of 0.86), where high impact land uses are defined as commercial land uses and Placer County maintained roads. The regression between % impervious area of UPC and FSP Loading was selected for the extrapolation, because it is assumed the relationship will provide a better correlation for the least dense UPCs that might have a very low percentage of area occupied by high impact land uses. Figure 2.3 displays the regression for % Impervious Area of UPC vs. FSP Loading. Equation 2.1 is the regression equation developed from Figure 2.3 for FSP Loading.

Equation 2.1: $FSP\ Loading\ \left(\frac{lb}{year-acre}\right) = 1529 \times (\%\ Impervious\ Area\ of\ UPC)^{1.88}$

A similar regression with a strong correlation (R-value of 0.88) was identified between the percent impervious area of a UPC and the normalized surface runoff (in/year/acre). Figure 2.3 displays the regression for % Impervious Area of UPC vs. Surface Runoff. Equation 2.2 is the regression equation developed from Figure 2.3 for Surface Runoff.

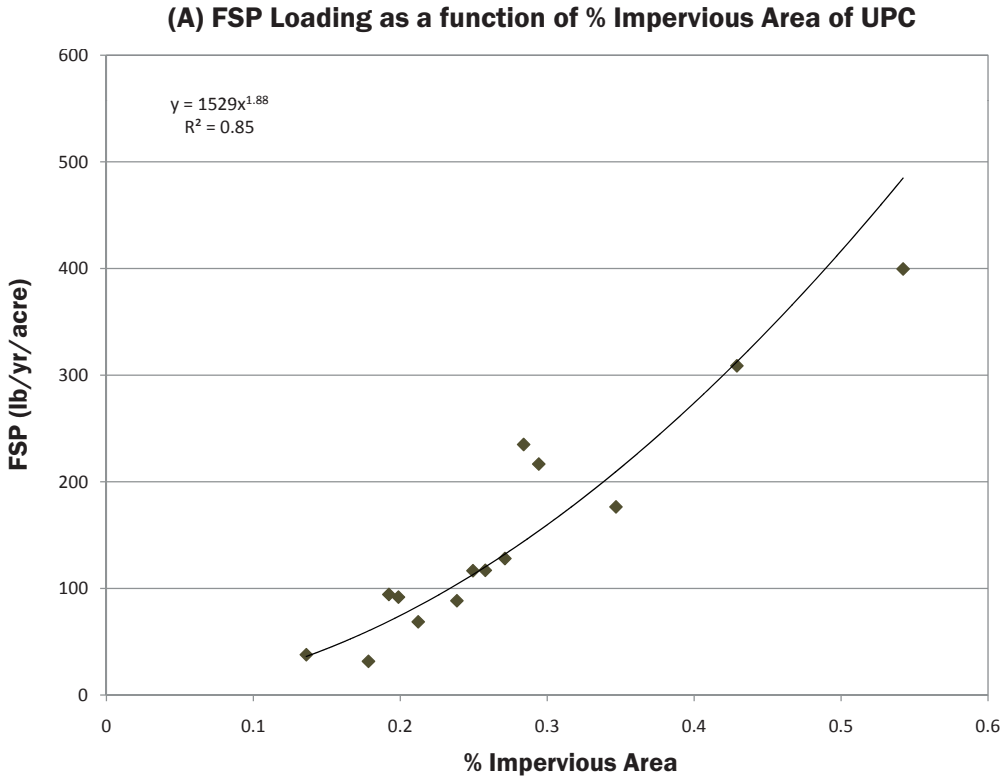
Equation 2.2: $Surface\ Runoff\ \left(\frac{in}{year-acre}\right) = 20.4 \times (\%\ Impervious\ Area\ of\ UPC)^{1.21}$

Extrapolation of pollutant loading and surface runoff to UPCs without PLRM models was accomplished using the following approach. Appendix B includes a spreadsheet displaying the extrapolated loads for surface runoff and all pollutants of concern.

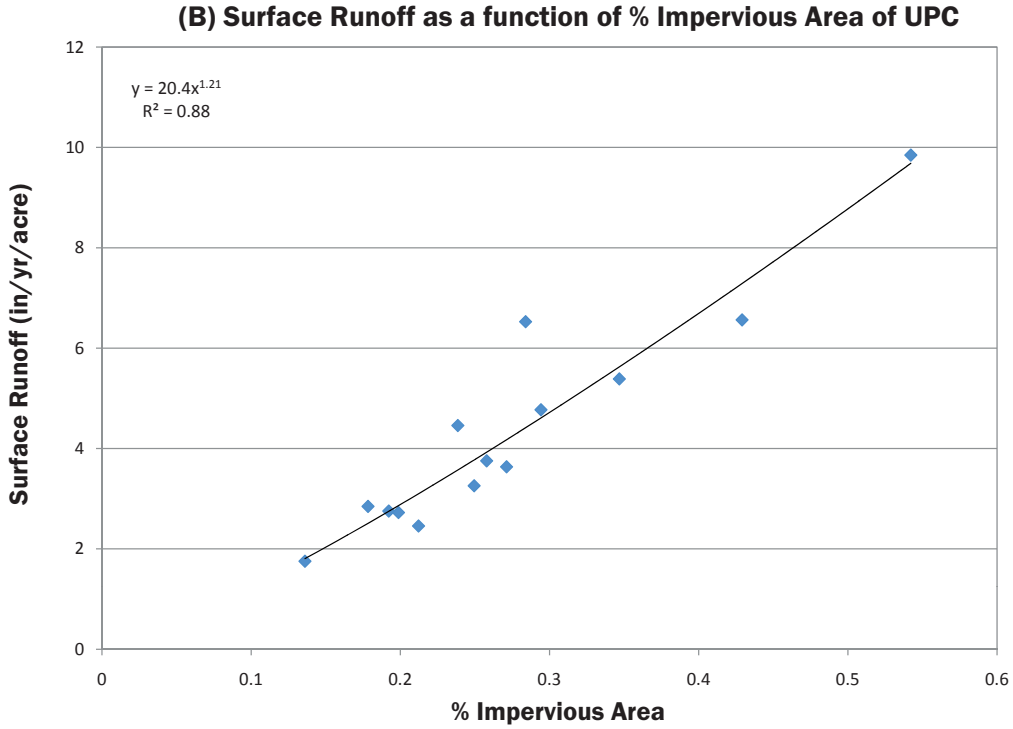
1. Key physiographic characteristics of each UPC not modeled in the PLRM were derived in GIS. This included a tabulation of the urban area of each UPC and the percentage of urban area that is impervious. The urban area of each UPC was estimated by intersecting the Placer County Urban Boundary with the Placer County UPC delineation. Impervious area was tabulated within the urban area of each UPC using the TMDL Land Use GIS Layer.
2. Equations 2.1 and 2.2 were applied to each UPC not modeled in the PLRM to estimate pollutant loading and surface runoff. Note that the regressions used are power functions, which were selected to avoid any negative values that could have been produced for UPCs with low amounts of impervious area had a linear regression been used.

The summation of extrapolated pollutant loads and surface runoff was combined with the estimates from PLRM models to produce an estimate of Placer County loading from the urban area.

Regression relationships were developed to extrapolate the PLRM modeling results of the selected Placer County UPCs to the Placer County UPCs that were not modeled. UPC % impervious area was selected because it is applicable to both the UPCs with the densest (see Table 2.1) and less dense urban areas (see Table 2.2). GIS analysis was performed on the unmodeled UPCs and the regression equations below were used to estimate the FSP pollutant loading and surface runoff for each Placer County UPC. The results of this extrapolation, as well as the PLRM modeling, were used to estimate Placer County baseline FSP loading from the urban area.



(A) Regression relationship of % Impervious Area of UPC versus average annual FSP Loading per unit area.



(B) Regression relationship of % Impervious Area of UPC versus average annual Surface Runoff per unit area.

FIGURE 2.3 REGRESSION RELATIONSHIPS OF PERCENT IMPERVIOUS AREA OF UPCS

URBAN STORMWATER BASELINE POLLUTANT LOAD ESTIMATE FOR PLACER COUNTY

Table 2.5 displays the urban stormwater baseline (2004) estimates of average annual surface runoff and pollutant loading for TSS, FSP, Total Phosphorus (TP), Soluble Reactive Phosphorus (SRP), Total Nitrogen (TN) and Dissolved Inorganic Nitrogen (DIN) for Placer County. Table 2.5 was generated by tabulating output from PLRM baseline models and applying the extrapolation techniques discussed above to UPCs without PLRM models. The total load estimate is the sum of the results of the PLRM baseline models (see Table 2.4) and the results of the extrapolation calculations for urban areas not explicitly modeled in PLRM.

Table 2.5. Placer County Baseline Condition Load Estimate

Urban Area (acres)	Surface Runoff (ac-ft/year)	% Surface Runoff	Pollutant Loading						
			TSS	FSP	TP	SRP	TN	DIN	Units
5,738	1,491	8.8%	875,000	516,000	2,450	550	10,220	1,260	lb/year
			397	234	1.1	0.2	4.6	0.6	metric ton (MT)/year
			-	2.6E+19	-	-	-	-	# particles/year[1]

[1] 1kg FSP = 1.1×10^{14} particles FSP (Equation 0.3; LRWQCB and NDEP 2009)

Table 2.6 displays relevant statistics for the total area of Placer County modeled in the PLRM vs. the total urban area of Placer County. Roughly 42% of the total Placer County urban area was modeled using PLRM for this effort.

Table 2.6. Statistics on Modeled Area vs. Total Urban Area

Parameter	Total Urban Area	Modeled Area
Urban Area (acres)	5,738	2,409
Impervious Area (acres)	1,234	589
% Impervious	21.5%	24.4%
% of Urban Area Modeled	42%	

The Lahontan RWQCB is requiring each urban jurisdiction on the California side of the Tahoe Basin to develop their own baseline pollutant load estimates for urban stormwater (LRWQCB 2011). The LRWQCB and NDEP will be responsible for reviewing and approving each jurisdictions methods and baseline load estimates for consistency with the requirements outlined in the Crediting Program Handbook (LRWQCB and NDEP 2009). The baseline estimates shown in Table 2.5 were developed to meet the requirements outlined in the Crediting Program Handbook and the LRWQCB order (2011).

For all urban jurisdictions, load reductions allocations will be determined using the same relative basis. Specifically, all urban jurisdictions will be required to reduce their loads to the same percent reduction from their baseline estimate. Notable regulatory goals include a 34% reduction in FSP baseline loads to meet the Clarity Challenge within a 15-year interim milestone (see Table 1.1), and a 71% reduction in FSP baseline loads to attain the clarity standard for Lake Tahoe.

CHAPTER 3. CONCEPTS FOR LOAD REDUCTION

Chapter 3 identifies: 1) urban planning catchments (UPCs) in Placer County with relatively high pollutant loading rates per unit area; 2) factors contributing to increased pollutant loading rates related to land uses and key land use conditions; and 3) general concepts for pollutant load reduction, including estimates of fine sediment particle (FSP) load reduction and planning level costs. At the end of the chapter, a summary of the results of the analysis and preliminary recommendations regarding approaches that Placer County may use to meet TMDL load reduction allocations are provided.

It is important to note that correlations and relationships discussed within Chapter 3 are based on analysis of modeling output that has been synthesized into average annual estimates of FSP loading and stormwater runoff from 18-year continuous PLRM simulations. The modeling output discussed in Chapter 3 will show less variability than annual or event-specific stormwater monitoring data.

POLLUTANT LOAD DISTRIBUTION ANALYSIS

The analysis described in this section identifies Placer County UPCs that contribute relatively high pollutant loads of FSP based on PLRM modeling results. As described in Chapter 2, the baseline estimate extrapolates pollutant loading from a subset of Placer County UPCs, which were modeled using the PLRM, to other urban areas of Placer County not explicitly modeled. This extrapolation produced an estimate of urban pollutant loading for all UPCs in Placer County. After presenting FSP loading by UPC, the analysis explores factors contributing to high pollutant loads among urban land uses.

URBAN PLANNING CATCHMENTS (UPCS)

Figure 3.1 illustrates the results of the Placer County baseline modeling for UPCs in Placer County. For comparative purposes, FSP loading per unit of area (lb/year/acre) is presented to identify UPCs that contribute relatively high FSP loads per unit area. The breakpoints in unit FSP loading in Figure 3.1 were selected using the following approach:

- Lowest (<44 lb/year/acre) – UPCs in the 0 to 25th percentile of unit FSP loads;
- Low (45-90 lb/year/acre) – UPCs in the 25th to 50th percentile of unit FSP loads;
- Moderate (91-116 lb/year/acre) – UPCs in the 50th to 75th percentile of unit FSP loads;
- High (117-167 lb/year/acre) – UPCs in the 75th to 90th percentile of unit FSP loads;
- Highest (>168 lb/year/acre) – UPCs in the top 10 percentile of unit FSP loads.

The following points are noted about Figure 3.1:

- The densest urban areas in Placer County have the highest unit FSP loads (Kings Beach, Lake Forest, Tahoe City, and Homewood).
- The UPCs in the "Highest" and "High" unit FSP load categories encompass roughly 18% of the urban area in Placer County (1,033 acres out of 5,738 acres designated as urban). Collectively these UPCs contribute roughly 43% of the total estimated FSP load from urban stormwater runoff.
- The UPCs in the "Lowest" FSP loading category encompass roughly 20% of the urban area in Placer County (1,168 acres out of 5,738 acres designated as urban). Collectively these UPCs contribute roughly 7% of the total estimated FSP load from urban stormwater runoff.

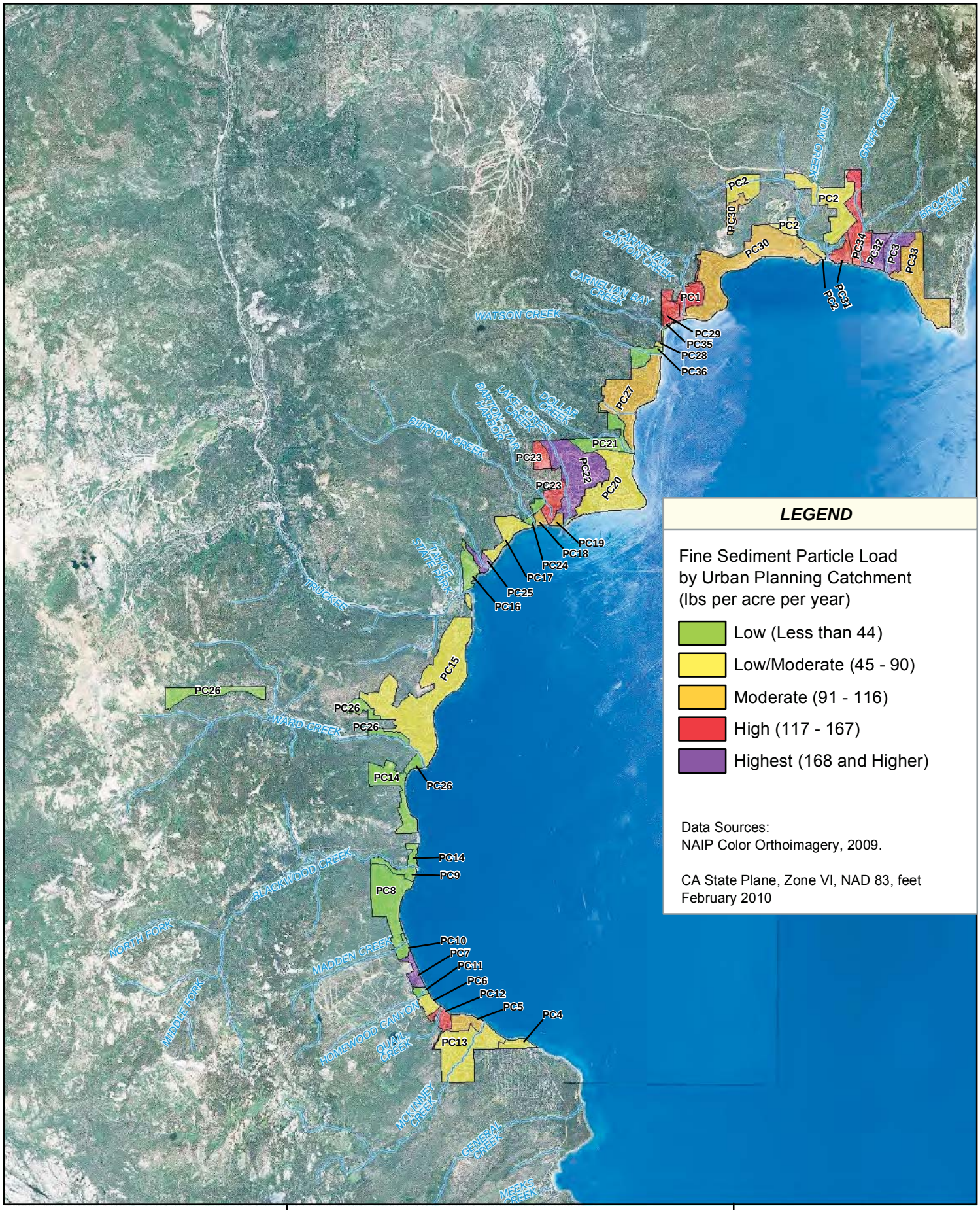


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FIGURE 3.1 URBAN PLANNING CATCHMENT FINE SEDIMENT PARTICLE LOADS

LAND USES AND LAND USE CONDITIONS

Output from the subset of UPCs modeled was examined to identify potential correlations between FSP loading and: 1) land use types; 2) road conditions, using Road Risk and directly connected impervious area (DCIA) as key factors; and 3) urban land uses, using impervious area and DCIA as key factors.

PLRM output does not presently report loads contributed by a specific land use within a PLRM catchment. The data analyzed below is based on post-processing PLRM output for several PLRM catchments to identify differences in pollutant generation rates by land use and key factors related to land use conditions. Note that a user of PLRM version 1.1 would not be able to reproduce the results in this section, which were post-processed using the PLRM's parent model: EPA SWMM 5.

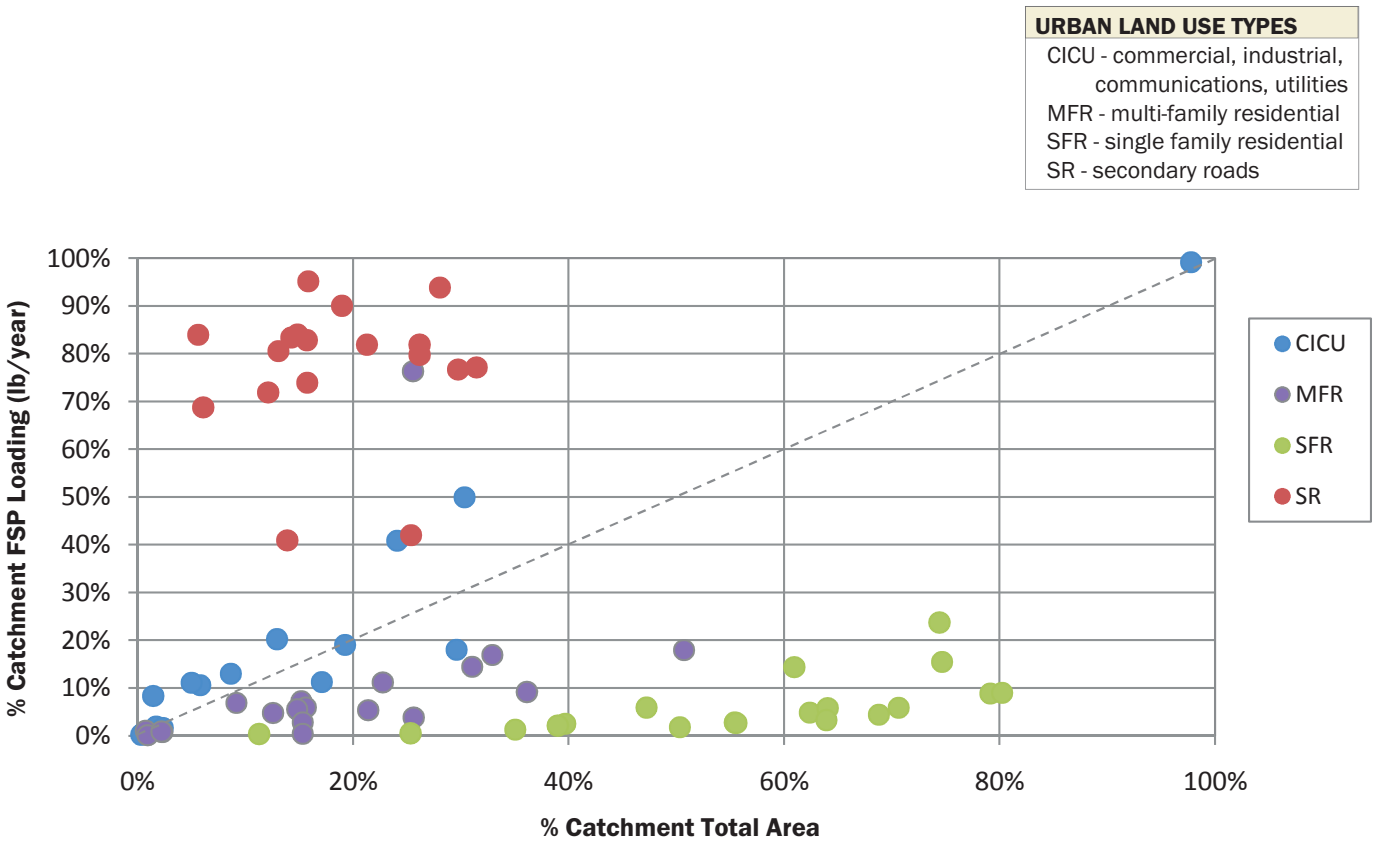
Figure 3.2 relates the percentage of area that an urban land use occupies within a PLRM catchment to its contribution of FSP load within the catchment. Urban land uses are defined to include the following: Single Family Residential (SFR); Multi-Family Residential (MFR); Commercial, Institutional, Communications, and Utilities (CICU). Secondary Roads (SR) are a special class of urban land termed a road land use in the PLRM. The following points are noted about Figure 3.2:

- The SR land use occupies a maximum area of roughly 30% of any PLRM catchment, but typically generates at least 70% or more of the estimated catchment FSP load.
- The CICU land use typically contributes more FSP loading than MFR or SFR land uses.
- The SFR and MFR land uses typically comprise the most total area and impervious area in any PLRM catchment. On average, SFR and MFR impervious area accounts for 36% and 18%, respectively, (or 54% collectively) of the total impervious area in any catchment. While the SFR and MFR land uses typically occupy the greatest area in any catchment, these land uses have relatively low pollutant generation rates and on average produce less that 20% of the estimated catchment FSP load. However, this finding does not negate the importance of implementing residential BMPs. The retention of water through private property BMP implementation reduces total catchment runoff volumes and peak flow rates.

Figure 3.3 displays annual average FSP loading generated by the SR land use within a PLRM catchment. Figure 3.3 relates the magnitude of FSP load to the distribution of Road Risk and the total area of directly connected impervious area (DCIA) for the SR land use within a catchment. The results shown in Figure 3.3 illustrate the function of PLRM algorithms; specifically, the highest FSP loads generated by a SR land use in PLRM are caused by high amounts of DCIA (highest amount of surface runoff) combined with a significant portion of secondary roads within the catchment defined as either High or Moderate Risk (poorest quality runoff).

Figure 3.4 explores potential correlations between FSP loading and urban land uses with variable amounts of impervious area and DCIA. Secondary roads are not included, as the land use was analyzed separately in Figure 3.3. The following points about Figure 3.4 are noted:

- Figure 3.4A illustrates an increase in the unit FSP load (lb/year/acre) as the amount of impervious area within an urban land use increases.
- Similarly, Figure 3.4B illustrates an increase in unit FSP load as the percentage of impervious area that is DCIA increases for each urban land use.
- The highest unit FSP loads for urban land uses are attributed to high amounts of impervious area combined with high amounts of the impervious area being DCIA.

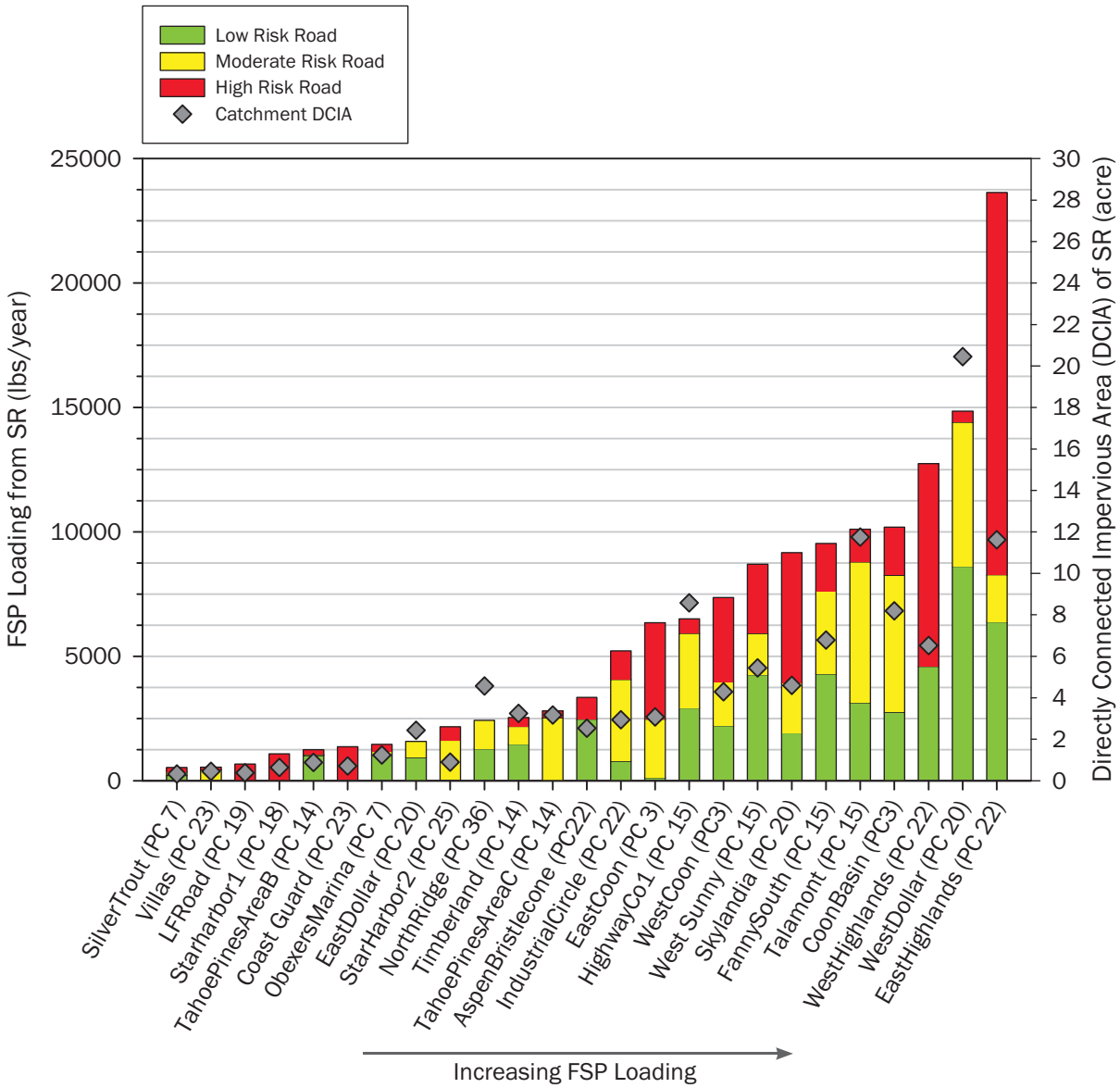


Within each of the 21 PLRM modeled catchments, the relative % contribution for each of the 4 urban land uses (CICU, MFR, SFR, SR) was determined for catchment area and catchment FSP Loading.

Figure 3.2 illustrates the relationship between % catchment area to % catchment FSP loading for each of the 4 urban land uses. The dashed line represents the 1:1 ratio where the loading would equate to the relative area contribution of the respective land use. Values above the line indicate a disproportionately higher loading per unit area contribution, while values below the line indicate a disproportionately lower loading per unit area contribution for each respective land use.

- Generally, CICU and SR contribute a greater proportion of the overall catchment FSP loading relative to the percent distribution within the catchment. MFR and SFR land uses contribute a smaller fraction to overall loading relative to their areal contribution.
- Secondary roads occupy no more than 30% of any catchment, but typically generate 70% - 90% of the total estimated annual catchment FSP load.
- Area of SFR within a catchment can be upwards of 60% of the total acreage, yet rarely accounts for more than 20% of the total FSP loading from the catchment.

FIGURE 3.2 CATCHMENT AREA TO FSP LOADING COMPARISON BY LAND USE

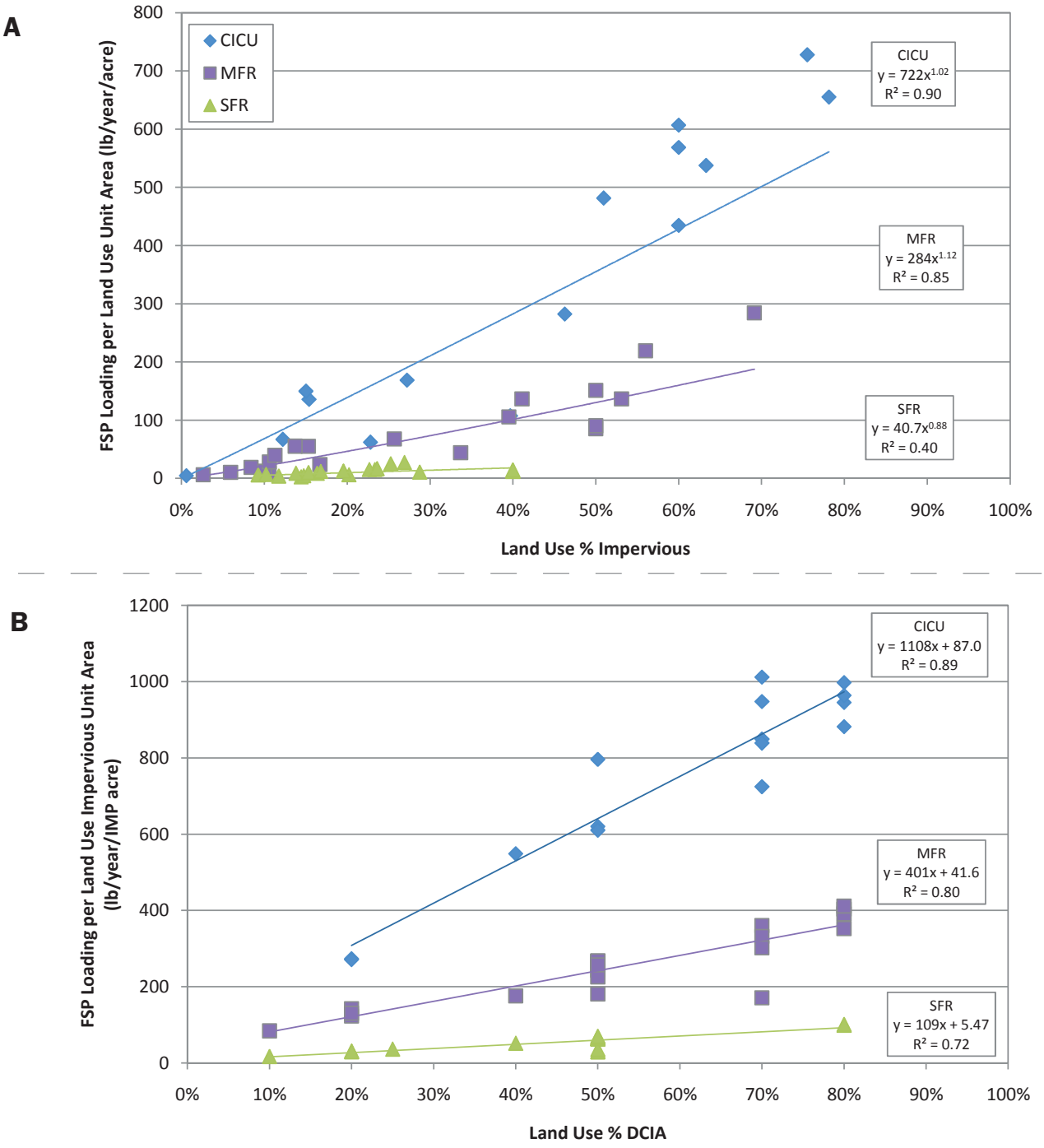


For each PLRM modeled catchment, the relationship between road risk, directly connected impervious area (DCIA) and FSP loading are displayed for the secondary road land use.

- PLRM catchments are presented in order of increasing FSP loading from left to right.
- The height of each stacked histogram indicates the total FSP loading (lbs/yr) by the secondary road land use.
- The green, yellow, and red bars display the relative contribution to the FSP loading by each road risk type (low, moderate, high).
- The DCIA (acres) of the secondary road land use is given for each catchment (grey diamond).

Figure 3.3 illustrates the function of the PLRM algorithms: the highest FSP loads generated by the SR land use are caused by high amounts of DCIA, typically combined with a significant portion of secondary roads within the catchment defined as either High or Moderate Risk.

FIGURE 3.3 CATCHMENT FSP LOADING - SECONDARY ROAD LAND USE



For each of the PLRM modeled catchments, the correlation between land use characteristics and FSP loading per unit land use area are provided for the catchment's commercial and residential land uses.

(A) The FSP loading per unit area of each land use (CICU, MFR, SFR) is plotted against the impervious area within that land use. For CICU and MFR, a strong relationship is shown: as % imperviousness increases, FSP loading per unit land use area increases.

(B) The FSP loading per unit of impervious area of each land use is plotted against the % directly connected impervious area (DCIA) of that land use. Each land use shows a strong correlation between increasing % DCIA and increasing FSP loading.

URBAN LAND USE TYPES
CICU - commercial, industrial, communications, utilities
MFR - multi-family residential
SFR - single family residential

Note: DCIA was estimated using limited field inspections and Google Earth® Street View.

FIGURE 3.4 CATCHMENT FSP LOADING - COMMERCIAL AND RESIDENTIAL LAND USES

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CONCEPTS FOR POLLUTANT LOAD REDUCTION

The concepts formulated in this section provide a framework to explore opportunities to cost-effectively reduce pollutant loads. Concepts have been formulated as the "building blocks" for a strategy that can achieve anticipated TMDL load reductions at a jurisdictional scale. The analysis uses Placer County to assess the extent to which each concept cost effectively achieves pollutant load reductions. However, the results and recommendations should be applicable to all Tahoe Basin jurisdictions regulated under the TMDL to reduce pollutant loads from urban stormwater runoff.

Placer County's current approach for reducing stormwater pollutant loads, which is similar to most jurisdictions in the Tahoe Basin, is to implement capital water quality improvements throughout the urban portion of their jurisdiction in accordance with TRPA's Environmental Improvement Program (EIP). Project prioritization and project area delineation typically targets urban areas that have not yet received EIP water quality improvements. Using the available grant funding, water quality improvements within a project area are located and designed to address the worst pollutant sources and to take advantage of opportunities such as available land for treatment facilities. To date, typical projects have focused on erosion control, pollutant and hydrologic source control of road shoulder runoff, and construction of treatment BMPs on public lands. Private property BMP implementation has been encouraged to provide erosion and hydrologic source control on a parcel scale. The intent of evaluating concepts is to explore whether shifts in the current approach could achieve TMDL load reductions more quickly or cost effectively.

Three different pollutant load reduction concepts are formulated below. Each concept is assessed for load reduction performance with results extrapolated to all locations where the concept was defined to apply to provide a comparison of relative load reductions across concepts.

The discussion and analysis of each concept is organized as follows:

- Concept Description and Opportunities for Load Reduction – provides a brief description of the concept for load reduction in terms of implementation and function. Links identified opportunities for load reduction in UPCs or land use conditions to the concept formulated.
- Analysis Methodologies – describes the approaches used to estimate pollutant loading and to derive planning level cost estimates for each concept.
- Pollutant Load Reduction and Planning Level Cost Estimate – presents estimates of FSP loading, stormwater runoff reductions (where applicable), and planning level cost estimates for a concept.
- Uncertainty in Estimates – describes factors contributing to uncertainty in load reduction performance estimates using the PLRM and the planning level cost estimates. Due to the limited scope of this analysis, sensitivity tests were not performed to quantify the level of uncertainty. Instead descriptions of data or research needs that may help reduce uncertainty in performance estimates are provided.
- Potential Implementation Constraints – discusses potential implementation constraints associated with a concept. However, implementation constraints are not used at this stage in the planning process to reject or modify a concept.

CONCEPT 1 – INTENSIVE IMPROVEMENTS IN UPCS WITH HIGH POLLUTANT LOADING RATES

CONCEPT DESCRIPTION AND OPPORTUNITIES FOR LOAD REDUCTION

Concept 1 uses intensive stormwater quality improvements in UPCs with high unit FSP loads as a potentially efficient approach to achieve a jurisdictional target for load reduction. The term "intensive" implies that

stormwater quality improvements would address all significant sources of FSP loads within the project area. The scope of the intensive projects would be similar to past and current Placer County projects, but would include additional focus on advanced stormwater treatment (SWT) facilities, pollutant source controls (PSCs), increased operations and maintenance, and private property BMP compliance. Recognizing that previous erosion control and water quality improvement projects have been constructed in portions of the UPCs identified with high unit FSP loads, intensive projects would also retrofit and improve existing SWT facilities to increase or maintain FSP load reductions from these facilities.

Table 3.1 displays the UPCs in the High and Highest categories of unit FSP load as described above and mapped in Figure 3.1. These UPCs collectively represent 18% of the total urban area in Placer County but are estimated to contribute 43% of the total average annual FSP load.

Table 3.1. UPCs for Water Quality Improvement in Concept 1

FSP Loading Category	UPC ID	Common Name	Estimated Baseline Unit FSP Load (lb/year/acre)
Highest	PC25	Tahoe City - Tahoe State Park	400
Highest	PC32	Kings Beach - Bear	309
Highest	PC7	Homewood	235
Highest	PC22	Lake Forest - Industrial	217
Highest	PC3	Kings Beach - Coon	176
High	PC12	Chambers Landing	137
High	PC23	Lake Forest - Coast Guard	128
High	PC1	Carnelian Bay	122
High	PC29	Carnelian Bay	121
High	PC33	Kings Beach - Fox	93
High	PC34	Kings Beach - Griff	117
High	PC31	Kings Beach (West of 267)	117

ANALYSIS METHODOLOGIES

The following steps outline the approach and assumptions used to estimate FSP load reductions for Concept 1.

1. A subset of the UPCs in Table 3.1 (PC32, PC25, and PC7) were modeled in PLRM to estimate unit FSP loading rates with intensive water quality improvements implemented. The following bullets provide a general description of theoretical water quality improvements incorporated into the PLRM models to represent Concept 1:
   a. All High and Moderate Risk road shoulders were Stable and Protected (PLRM terms).
   b. Hydrologic source controls were implemented on roads to reduce the amount of DCIA by 20% relative to the baseline condition.
   c. All runoff from Placer County roads is routed to stormwater treatment (SWT) facilities that target FSP removal. Specifically, all SWT facilities include filtration of stormwater prior to any discharge of treated stormwater (e.g., wet basins, cartridge media filters, bed filters). Assuming that filtration is a component of each SWT facility modeled, characteristic effluent concentrations (CECs) for FSP in treated effluent ranged between 13-20 mg/L dependent upon the SWT facility simulated in PLRM (NHC et al. 2009).

d. A very high level of private property BMP compliance was assumed. This approach was taken to test if targeted enforcement of private property BMPs commensurate with implementation of a WQIP is an effective strategy to reduce runoff volumes in UPCs with high pollutant loading rates. The following levels of BMP implementation were assumed. SFR implementation is lower than CICU and MFR assuming compliance would focus on the urban land uses with the highest loading rates.
   i. CICU = 100% Implementation
   ii. MFR = 100% Implementation
   iii. SFR = 70% implementation

e. Street sweeping using high efficiency sweepers occurs monthly in the winter with less frequent sweeping in other seasons on High Risk and Moderate Risk roads.

2. The selected UPCs for Concept 1 are the densest urban areas in Placer County. The modeling analysis assumes constraints associated with land availability make implementation of SWT facilities at uniform design standards cost-prohibitive. To account for this assumption the following steps were used:
   a. Without considering potential constraints, PLRM models were developed with SWT facilities that captured and treated 85%-90% of the average annual stormwater runoff. This threshold is similar to the performance expected for a SWT facility in Placer County sized to meet the 20-year 1-hour storage criterion (assumed as 1-inch of runoff from impervious area directly connected to SWT).
   b. UPCs designated in Table 3.1 as having the "Highest" FSP loading rates are assumed to have the most significant constraints. Key input parameters used to represent the performance of SWT facilities and infiltration facilities in the PLRM (e.g., water quality storage volume) were reduced to reflect these constraints. Specific reductions were as follows:
      i. The water quality storage volume and footprint of each SWT facility was reduced by 30%.
      ii. Total private property BMP implementation was reduced by 20% for all urban land uses:
         1. CICU = 80% Implementation
         2. MFR = 80% Implementation
         3. SFR = 50% implementation
      iii. No modifications to characteristic effluent concentrations (CECs) were made. The assumption being that land constraints limit the size of SWT facilities, which reduces the annual volumes of stormwater treated, but do not reduce the performance of the SWT facility for treating the stormwater it captures.
   c. UPCs designated in Table 3.1 as having "High" FSP loading rates were modeled in a similar manner to that described in 2b above. However, these UPCs are assumed to have less severe constraints relative to the "Highest" FSP loading UPCs. Specific reductions were as follows:
      i. The water quality storage volume and footprint of each SWT facility was reduced by 15%.
      ii. Total private property BMP implementation was reduced by 10% for all urban land uses:
         1. CICU = 90% Implementation
         2. MFR = 90% Implementation
         3. SFR = 60% implementation

3. PLRM models developed with these assumptions produced average unit FSP loading rates estimates of:
   - UPCs with "Highest" FSP Loading rates in Table 3.1 = 68 lb/year/acre of FSP, and
   - UPCs with "High" FSP Loading rates in Table 3.1 = 53 lb/year/acre of FSP.

   a. Average unit FSP loads above were multiplied by applicable UPC areas to estimate average annual FSP loads where Concept 1 is applied.

b. Estimated FSP loads derived in each UPC where Concept 1 is applied were subtracted from estimated FSP loads in the Baseline Condition (see Table 3.1) to calculate total FSP load reductions that might be achieved.

Planning level costs for Concept 1 were estimated using the approach below.

1. Planning level cost estimates were derived from information published in the Pollutant Reduction Opportunities (PRO) Report (LRWQCB and NDEP 2008b).
2. The approach for Concept 1 is similar to the intent of Tier 2 water quality improvements defined in the PRO Report. Therefore, the cost estimates for Tier 2 were adapted to this analysis to provide a planning level estimate of cost for Concept 1.
3. The average cost estimates for TMDL settings defined as Concentrated-Moderate and Concentrated-Steep in the PRO Report were used for this analysis, which equaled $158,000/acre. This unit area cost estimate includes costs for planning, design, construction, and construction oversight.
4. O&M costs were assumed to be 3% of capital cost. A linear increase in capital cost is used to estimate O&M costs in any given year to produce annualized cost estimates. All dollar amounts are 2011 dollars and are not adjusted for inflation or other factors.

POLLUTANT LOAD REDUCTION AND PLANNING LEVEL COST ESTIMATE

Table 3.2 summarizes the modeled FSP load reductions and associated planning level cost estimates for Concept 1. Two levels of implementation for water quality improvements are shown in Table 3.2:

- Near-Term – intensive water quality improvements are implemented over the next ten years in UPCs identified with the "Highest" unit FSP loading rates.
- Long-Term – after completion of the Near-Term approach, intensive water quality improvements are implemented in the following ten years in UPCs identified with "High" unit FSP loading rates (total of 20 years to complete implementation of all improvements). Costs shown for the Long-Term approach include costs for the Near-Term approach.

Table 3.2. Summary of Load Reduction and Cost Estimates for Concept 1

	Near-Term Water quality improvements in "Highest" UPCs	Long-Term Water quality improvements in "Highest" and "High" UPCs
Total Urban Area (acre)	563	1,164
Total Impervious Area (acre)	163	319
FSP Load Reduction (lb/year)	94,600	136,400
Capital Cost ($)	$89,000,000	$184,000,000
Time Period for O&M and Annualized Cost Calculation	10 Years	20 Years
Average O&M Cost Over Time Period ($/year)	$1,500,000	$2,900,000
Estimated % TMDL Load Reduction for FSP	18%	26%
Annualized Cost ($/year)	$10,400,000	$12,100,000
Notes/Assumptions	The densest urban areas (i.e., Kings Beach, Tahoe City [portion not currently routed to TCWTS], Homewood, and Lake Forest)	Simplifying Assumption for Cost Calculation: Near-Term approach completed in Year 10; remaining UPCs completed in Years 11-20.

UNCERTAINTY IN ESTIMATES

- Performance estimates in Concept 1 rely heavily on the implementation of SWTs that target FSP removal. The FSP Characteristic Effluent Concentrations (CECs) in PLRM are a source of uncertainty as minimal FSP data was available when the current CECs were derived. Tahoe-specific research is being conducted by the 2NDNATURE/NHC team to validate or revise FSP CECs in PLRM and results will be published in 2012.
- Regardless of the CEC values assigned in PLRM, continued and proactive SWT facility maintenance is necessary to maintain the treatment processes of each facility modeled in PLRM. Compared to current practices, Concept 1 assumes a significant increase in resources is needed for operation and maintenance of SWT facilities to produce and maintain the water quality performance estimated long-term.
- Dense urban development generating high FSP loads presents a number of significant constraints for locating and constructing effective stormwater quality improvements. At a project level, capital costs and land acquisition costs could vary significantly relative to the planning level costs estimates in Table 3.2 due to site-specific constraints.

POTENTIAL IMPLEMENTATION CONSTRAINTS

The following are implementation constraints for Concept 1:

- Capital cost – While funding is a general implementation constraint, the intensive water quality improvements under Concept 1 would target the densest urban areas and would comprehensively address all significant pollutant sources. Therefore, projects would have relatively high costs for planning, property acquisition and construction. Although projects can be phased to some degree, a very high level of funding would be needed to proceed with Concept 1.
- Maintenance cost – Concept 1 would require additional maintenance resources relative to current maintenance operations for Tahoe Basin jurisdictions.
- Implementation timeline – Water quality improvement projects planned and implemented in the densest Tahoe Basin urban areas typically involve multiple objectives and numerous stakeholder groups. These types of projects take a number of years to plan and implement. If Concept 1 is used as a primary approach to achieve load reductions, appropriate timelines for meeting TMDL milestones should be coordinated with regulatory agencies responsible for overseeing the implementation of the TMDL.
- Private BMP implementation – Concept 1 assumes a high level of private parcel BMP compliance. Currently, there is no certainty to reach the targeted levels assumed in the modeling for the various private property land uses. Although TRPA ordinances have existed for private BMP implementation for over 20 years, the implementation level remains on the order of 10% or lower in some areas of Placer County. A rigorous multi-agency effort will need to occur in order to forge a hard-line approach with respect to implementation. One example would be to require implementation through point of sale transactions similar to wood stove upgrade requirements that apply in the Basin. These constraints are discussed in more detail with Concept 3.

CONCEPT 2 – ADVANCED POLLUTANT SOURCE CONTROL FOR ROAD OPERATIONS

CONCEPT DESCRIPTION AND OPPORTUNITIES FOR LOAD REDUCTION

Concept 2 implements advanced pollutant source controls to minimize road abrasive applications while maintaining traffic safety and maximizing road abrasive recovery. Examples of actions to minimize the quantity of road abrasives might include: 1) improved abrasive specifications, such as pre-washing and sieving of abrasive

material to completely eliminate FSP in the supply prior to application; 2) use of best available technology, such as state-of-the-art bulk spreaders that more efficiently apply abrasives to the road surface; and 3) advanced management measures, such as temperature sensors or meteorological monitoring, to better target road abrasive applications to antecedent conditions and storm types and minimize the temporal frequency and spatial distribution of applications on an annual basis. Advanced road abrasive recovery actions might include: 1) acquisition of best available technology street sweepers that target FSP recovery (e.g., high-efficiency vacuum assisted sweepers; and 2) high-frequency street sweeping operations.

Concept 2 assumes road abrasive applications could be reduced throughout a jurisdiction without diminishing traffic safety by improving operational efficiency and applying best available technology. Concept 2 assumes road abrasive recovery will be most cost-effective in terms of FSP load reductions by targeting Secondary High Risk (SHR) and Moderate Risk (SMR) roads with a high degree of DCIA (see Figures 3.2-3.3). An additional benefit for Concept 2 not quantified as part of this analysis may be improved runoff quality to SWTs, which would likely reduce SWT maintenance costs and better maintain treatment performance.

ANALYSIS METHODOLOGIES

Stormwater runoff volumes were not analyzed as part of Concept 2 because they are not affected by Concept 2. The discussion below assumes the reader is familiar with PLRM terminology and PLRM concepts for modeling pollutant loading. In particular, the idea of Road Risk needs to be understood:

- The PLRM categorizes all roads in the Tahoe Basin by Road Risk, which is used to categorize the relative potential for a road to generate pollutants.
- In practical terms, a High Risk Road relative to a Moderate Risk Road is 1) steeper, 2) has higher average traffic volumes, and/or 3) has denser urban land uses adjacent to the road. A High Risk Road typically has the poorest quality runoff because it has the most road abrasives applied to maintain traffic safety and the most amount of disturbance because of traffic and adjacent land use density.

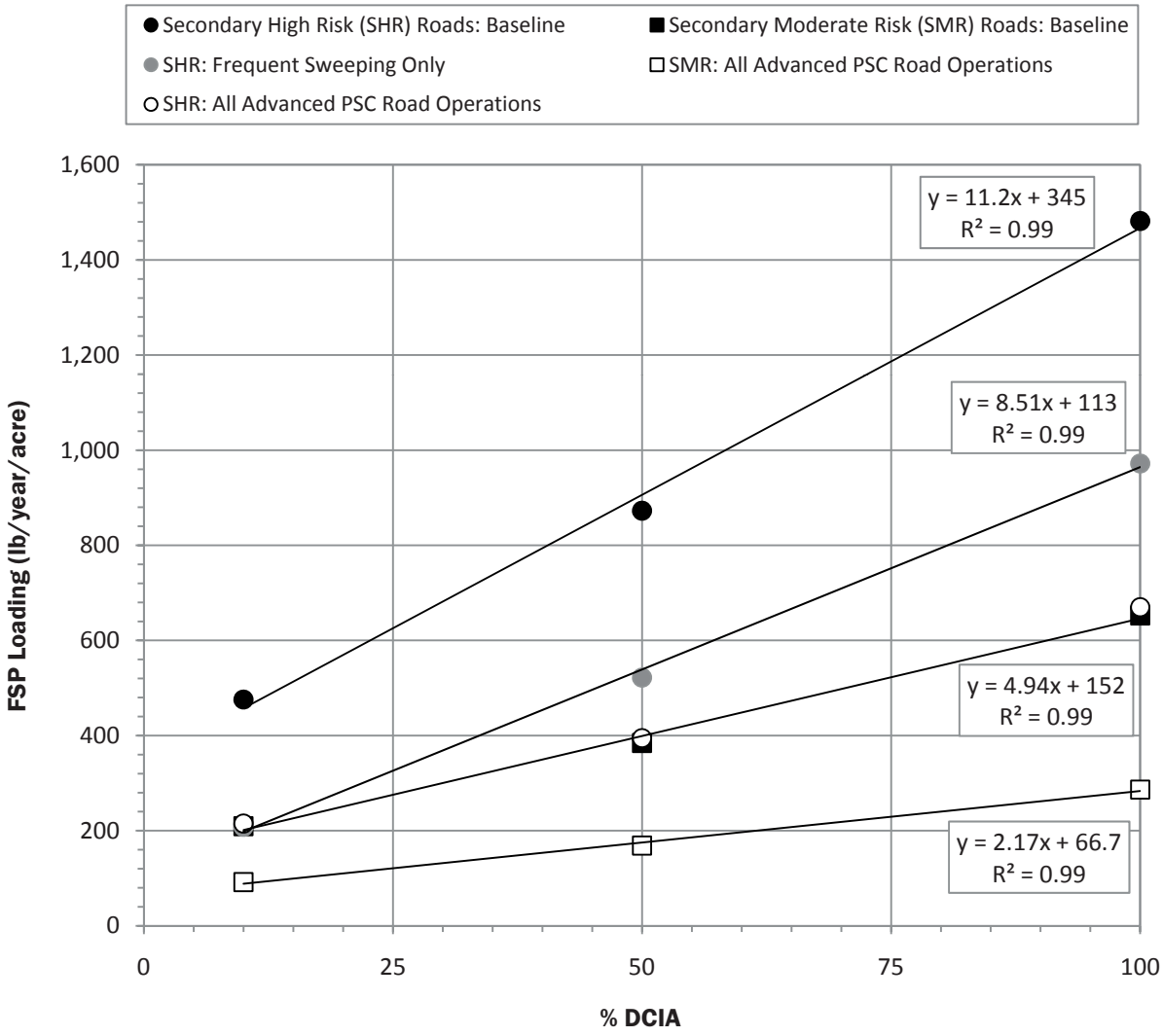
The following steps outline the approach used to estimate FSP load reductions for Concept 2.

1. Generalized road conditions were modeled in PLRM to develop estimates of FSP loads on a unit area basis for Secondary Roads under varying 1) Road Risk categories, 2) road operations, and 3) degrees of DCIA. Table 3.3 displays the generalized road conditions modeled for Concept 2. To simplify the modeling analysis for Concept 2, road shoulder condition did not vary across Road Risk categories. Specifically, all road shoulders were defined to be 50% Erodible and 50% Stable and Protected.

2. Each generalized road condition (see Table 3.3) was modeled for three different values of DCIA to generate a range of unit FSP loads (Figure 3.5).

Table 3.3. General Road Conditions Modeled

Generalized Road Condition	Abrasive Applications and Sweeping
High Road Risk: Baseline	Abrasives: Minimal Control Measures Sweeping: Minimal frequency with Mechanical Broom
High Road Risk: Frequent Sweeping Only	Abrasives: Minimal Control Measures Sweeping: High frequency with High-Efficiency Sweeper
High Road Risk: All Advanced PSC Road Operations	Abrasives: Advanced Control Measures Sweeping: High frequency with High-Efficiency Sweeper
Moderate Road Risk: Baseline	Abrasives: Minimal Control Measures Sweeping: Minimal frequency with Mechanical Broom
Moderate Road Risk: All Advanced PSC Road Operations	Abrasives: Advanced Control Measures Sweeping: High frequency with High-Efficiency Sweeper



Results from generalized PLRM models developed to estimate FSP loading rates based on (1) road risk categories, (2) road operations, and (3) percent of directly connected impervious area (DCIA). Note that road shoulder condition did not vary across road risk categories. All road shoulders were defined as 50% erodible and 50% stable and protected to simplify analysis.

Results are presented for Secondary High Risk (SHR) Roads and Secondary Moderate Risk (SMR) Roads with varying %DCIA (10%, 50%, and 100%) for baseline and advanced road operations, where

- Baseline conditions assume minimal abrasive control measures and minimal sweeping with a mechanical broom sweeper;
- Frequent sweeping assumes the use of a high-efficiency sweeper 12-14 times during the winter months and 3-6 times during the remaining times of year; and
- Advanced PSC road operations assumes frequent sweeping plus a reduction in the total volume of road abrasives applied on an average annual basis, as well as reduction in the volume of FSP directly applied as road abrasive.

FIGURE 3.5 SECONDARY ROAD FSP LOADING RATES BY PERCENT DCIA

3. To calculate an FSP load from the range of unit FSP loads, road area was categorized by % DCIA among Road Risk categories (Table 3.4). The following methods and assumptions were used:
   a. The total length of roads in Placer County for each Road Risk category was calculated in GIS using the default Road Risk Layer (2009) for PLRM.
   b. Total road area was calculated by multiplying total road length and a nominal right-of-way width of 40 feet (12.2 meters).
   c. The distribution of DCIA shown in Table 3.4 by Road Risk category was estimated using best professional judgment and experience gained when developing the Baseline PLRM models for Placer County.

Table 3.4. Percent DCIA by Road Risk Category

Road Risk Category	Miles	Acres	% of Roads		
			100% DCIA	50% DCIA	10% DCIA
High Risk	49.2	238	50%	25%	25%
Moderate Risk	46.7	227	33%	33%	34%
Low Risk	44.8	217	25%	25%	50%
Total	140.7	683	36%	28%	36%

4. The distribution of road area defined in Table 3.4 was multiplied by the estimated unit FSP loads (Figure 3.5) to estimate an average annual FSP load from each generalized road condition.

5. Modeled FSP loads for advanced PSC road operations were subtracted from estimated FSP loads from the Baseline Condition to calculate potential FSP load reductions that might be achieved from Concept 2.

Tables 3.5 and 3.6 present the assumptions used to estimate planning level costs for Concept 2.

1. Table 3.5 estimates the cost of advanced PSC road operations for all Secondary High Risk roads in Placer County. Two cost estimates are included in Table 3.5: with and without advanced road operations to minimize road abrasive applications.

2. Table 3.6 estimates the cost of advanced PSC road operations for all Secondary High Risk and Moderate Risk roads in Placer County.

3. The assumptions in Tables 3.5 and 3.6 were used to calculate an annualized O&M cost based on the level of effort for operations.

4. All dollar amounts are 2011 dollars and are not adjusted for inflation or other factors.

5. A nominal cost estimate of $250,000/year was added to the annual cost estimate assuming successful implementation of measures to reduce abrasive applications would require: 1) the equivalent of one additional staff person at $125,000/year; and 2) equipment purchasing, equipment maintenance, and material supply averaging $125,000/year.

6. The general equation used to estimate annualized cost from the assumptions in Table 3.5 and Table 3.6 is:

$$\frac{Cost}{year} = \left(\frac{days\ sweeping}{year}\right) * \left(\frac{cost\ sweeping}{day}\right) + \left(\frac{disposal\ cost}{ton}\right) * \left(\frac{tons\ removed}{year}\right) + \left(\frac{cost\ abrasive\ control}{year}\right)$$

Table 3.5. Cost Assumptions for Advanced PSC Road Operations – Secondary High Risk Roads Only

Item	Quantity	Units	Assumptions
Advanced FSP Sweeper Operation	5,200	$/day	1. Operating cost of $300k sweeper for cost recovery = ($250/hour) 2. One maintenance personnel ($75/hour) 3. 8 Hour Day 4. ($250 + $75)*8 = $2,600/day/sweeper 5. Two sweepers needed to allow for more abrasive recovery during limited periods when winter conditions allow for sweeper operation 6. FSP sweeper could be ineffective in areas with heavy debris - see General Sweeper Support Cost estimate
Target High Risk Roads	50	miles	1. High Risk roads are in reasonably close proximity, meaning sweeping only High Risk roads will be somewhat efficient
Miles Swept per Day (both sides)	20	miles/day	1. Average of 2 hours travel time per day not sweeping 2. Average of 2 hours per day for unloading material and general maintenance 3. Sweeping for 4 hours per day at 5 mph = 20 lane miles 4. 2 sides of a road swept = 20 lane miles / 2 lanes = 10 miles per day 5. Both sweepers operational = 2 sweepers * 10 miles per day = 20 miles per day
Frequency of Sweeping all High Risk Roads per Year	20	time/year	1. Average of 14 opportunities with winter conditions favorable for sweeping 2. After winter, swept Spring = 2; Summer =2; Fall =2
Material Disposal Cost	50	$/ton	1. Cost of disposal based on unit cost times triple the estimated FSP removed (to account for other solids and debris removed) 2. Tons removed linked back to performance estimate (not shown)
General Sweeper Support Cost	1,600	$/day	1. General sweeper support costs, which may include mechanical broom sweeping prior to FSP sweeping for heavy debris conditions 2. Mechanical broom sweeping required half-time relative to FSP sweeping 3. Operating costs of mechanical broom sweeper half the operating costs of FSP sweeping = ($125/hour) 4. ($125 + $75)*8 = $1,600/day
Advanced Control of Road Abrasive Applications	$250,000	$/year	1. Specific actions not yet defined, assuming $250,000/year
Cost: Frequent Sweeping Only	$360,000	$/year	
Cost: Frequent Sweeping and Advanced Control of Road Abrasive Applications	$610,000	$/year	

Table 3.6. Cost Assumptions for Advanced PSC Road Operations – Secondary High and Moderate Risk Roads

Item	Quantity	Units	Assumptions
Advanced FSP Sweeper Operation	5,200	$/day	1. Operating cost of $300k sweeper for cost recovery = ($250/hour) 2. One maintenance personnel ($75/hour) 3. 8 Hour Day 4. ($250 + $75)*8 = $2,600/day/sweeper 5. 2 sweepers needed to allow for more abrasive recovery during limited periods when winter conditions allow for sweeper operation 6. FSP sweeper could be ineffective in areas with heavy debris - see General Sweeper Support Cost estimate
Target High Risk Roads	96	miles	1. High Risk and Moderate Risk roads are in reasonably close proximity, meaning sweeping is reasonably efficient
Miles Swept per Day (both sides)	25	miles/day	1. Average of 1 hour travel time per day not sweeping 2. Average of 2 hours per day for unloading material and general maintenance 3. Sweeping for 5 hours per day at 5 mph = 25 lane miles 4. 2 sides of a road swept = 25 lane miles / 2 lanes = 12.5 miles per day 5. Both sweepers operational = 2 sweepers * 12.5 miles per day = 25 miles per day
Frequency of Sweeping all High Risk Roads per Year	15	time/year	1. Average of 12 opportunities with winter conditions favorable for sweeping 2. After winter, swept Spring = 1; Summer =1; Fall =1
Material Disposal Cost	50	$/ton	1. Annualized cost of disposal based on unit cost plus triple the estimated FSP removed (to account for other solids and debris removed) 2. Tons removed linked back to performance estimate (not shown)
General Sweeper Support Cost	1,600	$/day	1. General sweeper support costs, which may include mechanical broom sweeping prior to FSP sweeping for heavy debris conditions 2. Mechanical broom sweeping required half-time relative to FSP sweeping 3. Operating costs of mechanical broom sweeper half the operating costs of FSP sweeping = ($125/hour) 4. ($125 + $75)*8 = $1,600/day
Advanced Control of Road Abrasive Applications	$250,000	$/year	1. Specific actions not yet defined, assuming $250,000/year
Cost: Frequent Sweeping and Advanced Control of Road Abrasive Applications	$700,000	$/year	

POLLUTANT LOAD REDUCTION AND PLANNING LEVEL COST ESTIMATE

Table 3.7 presents modeled estimates of FSP pollutant load reductions and planning level cost estimates under varying advanced PSC road operations targeting either: 1) High Risk roads or 2) High and Moderate Risk roads.

Table 3.7. Summary of Load Reduction and Cost Estimates for Concept 2

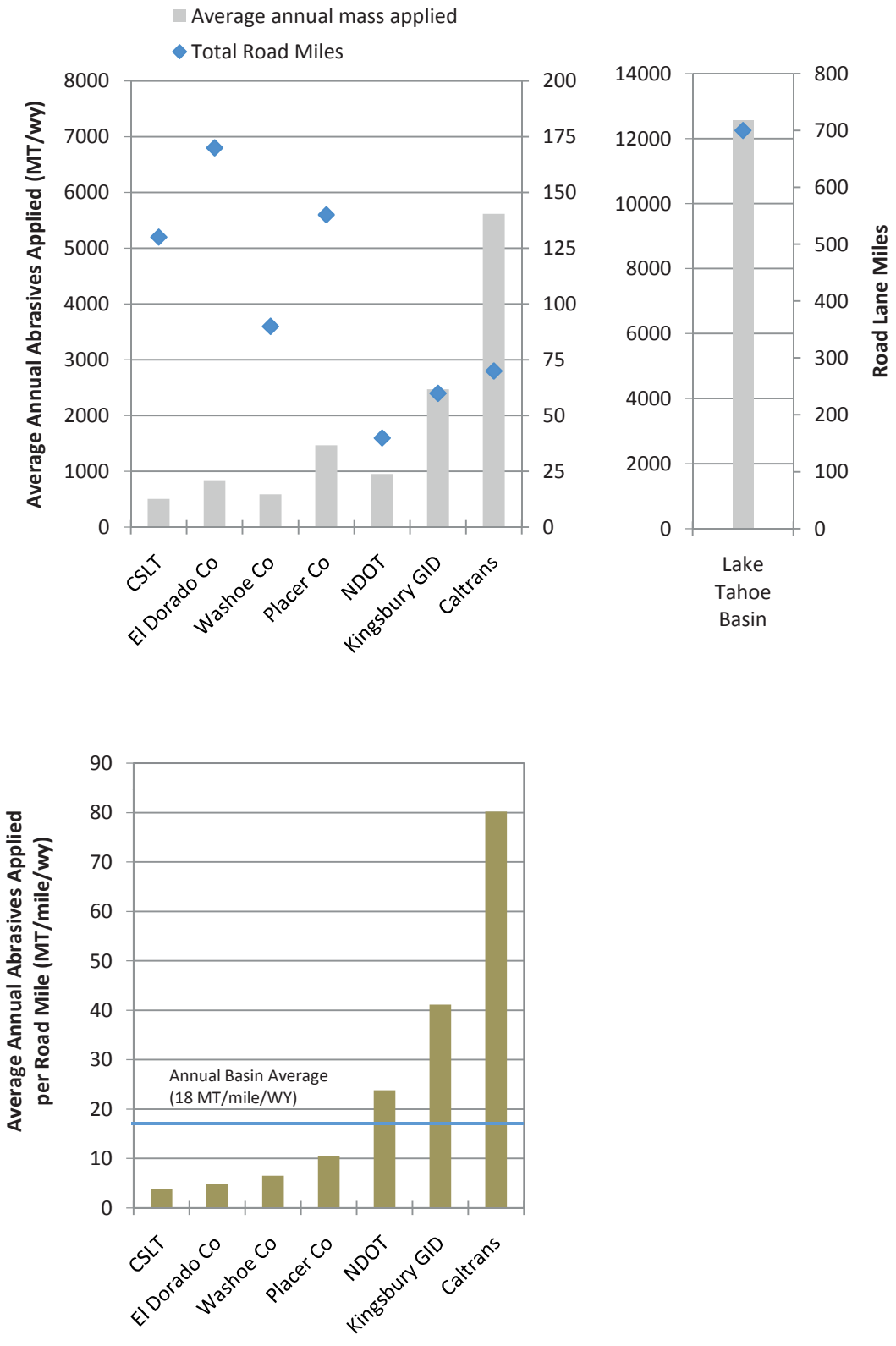
Parameter	Target All Secondary High Risk Roads		Target All Secondary High and Moderate Risk Roads
	Frequent Sweeping Only	Frequent Sweeping + Advanced Control of Road Abrasive Applications	Frequent Sweeping + Advanced Control of Road Abrasive Applications
Total Road Length (miles)	49	49	95.5
Total Road Area (acres)	237	237	465
FSP Load Reduction (lb/year)	99,000	143,000	198,000
Stormwater Runoff Reduction (ac-ft/year)	n/a - concept does not affect surface runoff		
Capital Cost ($)	n/a - all costs, including equipment, assumed in O&M costs		
Time Period for O&M and Annualized Cost Calculation	20 Years		
Average O&M Cost Over Time Period ($/year)	$360,000	$610,000	$700,000
Estimated % TMDL Load Reduction for FSP	19%	27%	38%
Annualized Cost ($/year)	$360,000	$610,000	$700,000

UNCERTAINTY IN ESTIMATES

Table 3.7 estimates significant FSP load reductions for Concept 2 at relatively low annualized cost. However, there are a number of uncertainties that limit confidence in performance estimates for Concept 2. Available water quality data and information on average annual loads under baseline conditions is extremely limited, and PLRM estimates of loads under advanced PSC road operations use algorithms developed from equally limited information and best professional judgment. Until specific advanced road operation actions can be defined and better quantified for achievable load reductions based on research and monitoring, predicting achievable FSP load reductions from advanced PSC road operations remains difficult and the results have notable uncertainty.

With the caveats above noted, the modeling analysis highlights a potentially significant opportunity to cost-effectively achieve long-term FSP load reductions from advanced PSC road operations. Additional supporting data that better defines road operations and additional research on sweeping effectiveness for removing FSP loads will improve confidence in performance estimates of Concept 2. The following lists some specific factors contributing to uncertainty.

1. Characterizing and quantifying road operations for water quality – Road operations vary among Tahoe Basin jurisdictions and detailed documentation and tracking of road operations that may affect water quality is limited. A summary of abrasive applications by total mass for Lake Tahoe jurisdictions from 2000-2009 based on annual regulatory reporting is shown in Figure 3.6. PLRM includes a function that



Data Sources:
NDOT: NDOT 2009
KGGID: M. Runtzel, pers. comm.
Caltrans: Caltrans 2009
Washoe: D. Minto, pers. comm.
CSLT: CSLT 2010 and B. Larsen, pers. comm.
Placer: N. Lance-Seghi, pers. comm.
El Dorado: R. Wigart, pers. comm.

FIGURE 3.6 AVERAGE ANNUAL ROAD ABRASIVE APPLICATION BY JURISDICTION

2NDNATURE ecosystem science + design
2ndnaturellc.com
ph 831.426.9119
nhc
nhcweb.com
ph 530.544.3788

assumes Tahoe Basin jurisdictions can implement better road operations through technological improvements and increased planning to reduce the quantity of road abrasives applied while maintaining traffic safety. However, the exact actions of advanced road abrasive operations remain undefined and therefore difficult to quantify.

2. PLRM performance estimates of road operations – PLRM algorithms relate specific actions for road operations to changes in the condition of the road, which in turn influences the characteristic runoff concentration (CRC) for the road. While this approach is considered a reasonable methodology to determine relative road conditions on an average annual basis, there are gaps in available supporting water quality data to confidently link specific PSC actions for road operations to a magnitude of water quality improvement. For example, sweeping effectiveness estimates in the PLRM are based on a variety of existing controlled studies conducted outside of the Lake Tahoe Basin. However, preliminary controlled experiments on Tahoe Basin roads suggest that the PLRMv1 CRCs used for roads are representative of actual conditions and the potential water quality benefit estimates of combined road maintenance practices to reduce abrasives and increase sweeping effectiveness are likely achievable (2NDNATURE and NHC 2010).

3. Cold climate effects on the operations of high efficiency street sweepers – Preliminary data on the effectiveness of high-efficiency sweepers for removing FSP is promising (2NDNATURE and NHC 2010). However, high efficiency street sweepers can only operate when roads are free of ice and snow and may perform poorly under freezing conditions and perhaps under high street loadings. The timing and effectiveness of sweeping prior to transport of roadway generated pollutants during spring rains is a critical component to minimize annual pollutant loading from roads. Opportunities for jurisdictions to optimize road conditions will vary each year and this variability may not be well represented in PLRM.

4. Road shoulder conditions and effectiveness of abrasive recovery – Field observations and operational experience reported by road maintenance personnel indicates that road shoulder condition has a significant effect on abrasive recovery. Uncertain relationships between road shoulder conditions and the efficiency of abrasive recovery through street sweeping creates uncertainty in performance estimates.

5. Equipment maintenance fluctuations – The higher technology sweepers, e.g., tend to have more moving parts and are likely susceptible to requiring a frequent maintenance and parts replacement program as compared to standard traditional broom sweepers. Actual data for maintaining such sweepers in an alpine climate is yet to be realized.

POTENTIAL IMPLEMENTATION CONSTRAINTS

Available maintenance resources are an implementation constraint for Concept 2. While funding sources may be available to purchase equipment to implement Concept 2 (e.g., sweepers, meteorological monitoring network, etc.), the operation and maintenance costs of Concept 2 would require additional resources beyond those currently available to road maintenance departments in the Tahoe Basin. Implementation of Concept 2 would require modifications to grant guidelines to allow water quality maintenance operations to be eligible for funding, or would require direct funding of operations by Tahoe Basin jurisdictions.

CONCEPT 3 – TARGETED IMPLEMENTATION OF BMPS FOR PRIVATE LAND USES

CONCEPT DESCRIPTION AND OPPORTUNITIES FOR LOAD REDUCTION

Concept 3 analyzes private property BMPs as a potentially cost-effective approach to meet jurisdictional pollutant load reduction targets. Private property is defined as any urban land use not owned or maintained by a Tahoe Basin jurisdiction, but included in the jurisdiction's TMDL allocation. Specifically, this definition includes the following urban land uses, which are consistent with TMDL categories (LRWQCB and NDEP 2009): Single Family Residential (SFR); Multi-Family Residential (MFR); Commercial, Institutional, Communications, and Utilities (CICU).

Concept 3 assumes the most efficient approach to reduce pollutant loads from urban land uses in the near-term is to target land use conditions with the highest loading rates. The evaluation of Concept 3 assumes the following implementation approach to estimate FSP load reductions and costs.

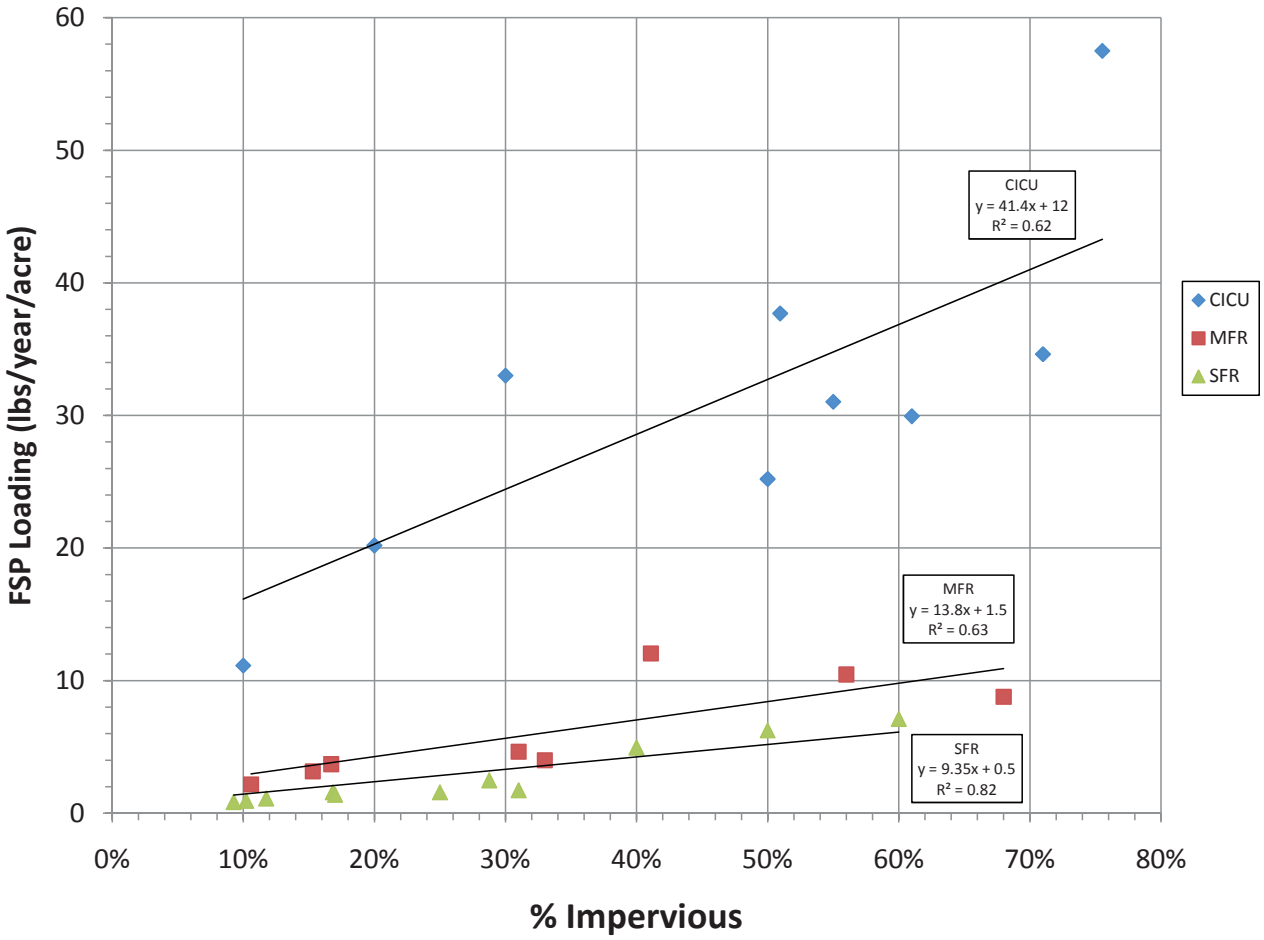
- Near-Term Implementation (Years 1 - 5) – Install BMPs on all CICU within UPCs estimated to have the poorest CICU land uses conditions. Specifically, UPCs where estimated FSP loading rates from CICU exceed 2,200 lb/year.
- Mid-Term Implementation (Years 6-10) – Install BMPs for all remaining CICU not addressed in the near-term plus install BMPs for all MFR in a jurisdiction.
- Long-Term Implementation (Years 11-20) – Install BMPs for all SFR in a jurisdiction

Water quality improvements could be achieved through individual private property BMP compliance or through community BMP systems that are funded by the parcels draining to the community BMP system. To simplify the analysis of Concept 3, performance estimates use PLRM modeling algorithms to analyze the performance of individual private property BMP compliance. Planning level cost estimates are based on available individual parcel-scale private property BMP cost data.

ANALYSIS METHODOLOGIES

The following steps outline the approach used to estimate FSP load reduction and stormwater runoff reductions for Concept 3.

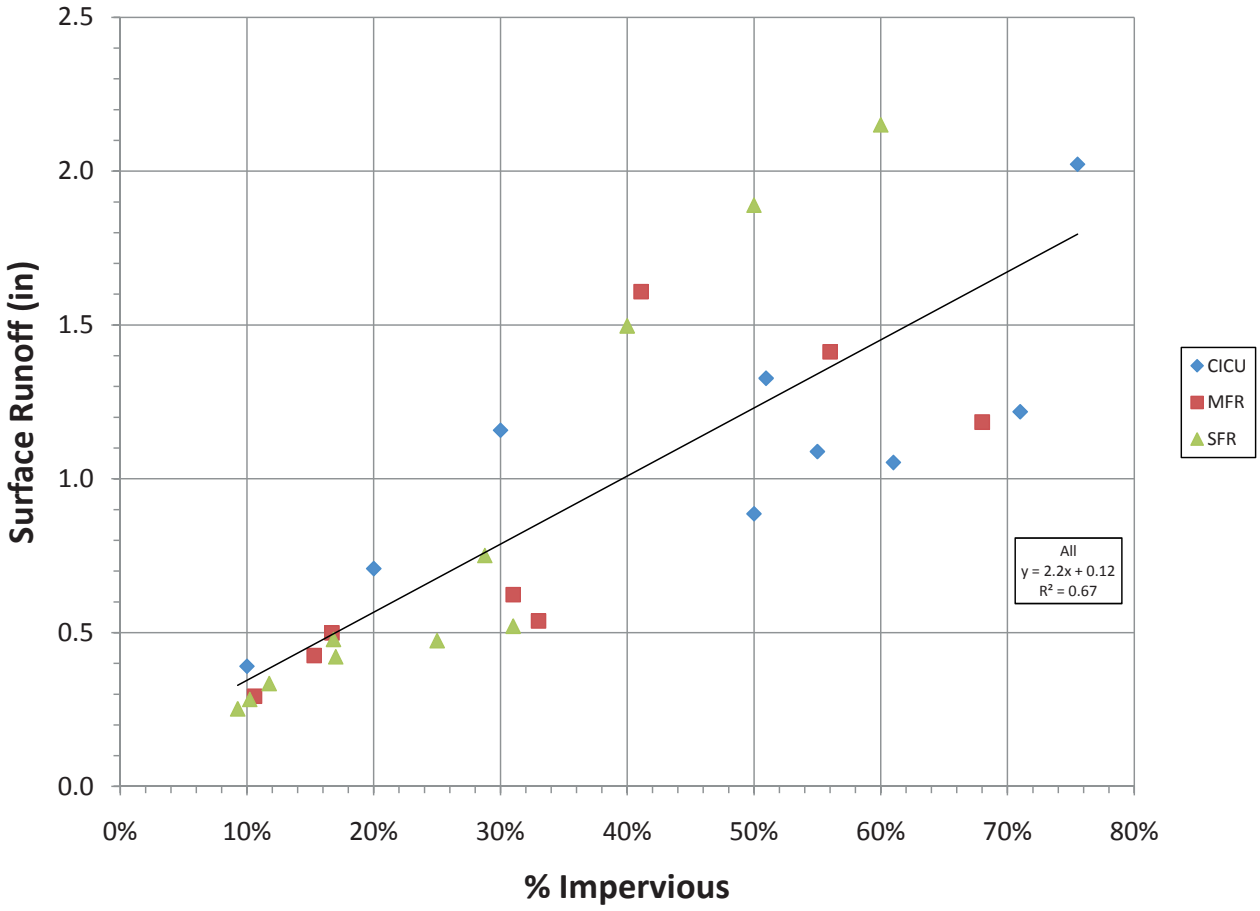
1. Using a subset of the Baseline PLRM models developed for Placer County, Concept 3 models were created in PLRM with 100% private property BMP implementation complying with TRPA code for all urban land uses. Baseline PLRM models for Placer County assume private property BMPs have been implemented at 2004 baseline levels as defined by the *Crediting Program Handbook* (LRWQCB and NDEP 2009):
   a. Single-Family Residential = 7% Implementation,
   b. Multi-Family Residential = 19% Implementation, and
   c. CICU = 5% Implementation.
2. PLRM models were selected for a range of impervious area conditions for each urban land use.
3. The output from each model run was analyzed on an urban land use basis to derive: 1) FSP loading per unit of area (lb/year/acre) and 2) stormwater runoff on a unit area basis (inches/year).
4. Regression equations for unit FSP loads and stormwater runoff (Table 3.8) were derived from the model output shown in Figures 3.7 and 3.8.
   a. Regression equations for unit FSP loads were derived for each urban land use to account for differences in runoff quality.
   b. As expected and as shown in Figure 3.8, differences in hydrologic function are primarily related to impervious area and not to the type of urban land use. Therefore, a single regression equation for stormwater runoff is used for all urban land uses.



A subset of PLRM baseline scenario models representing a range of % impervious area were selected to analyze Concept 3 scenarios with 100% private property BMP implementation.

Figure 3.7 presents the model output by urban land use (CICU, MFR and SFR), comparing land use % impervious to unit area annual FSP loading from that land use.

FIGURE 3.7 FSP LOADING RATES WITH PRIVATE PROPERTY BMPS



A subset of PLRM baseline scenario models representing a range of % impervious area were selected to analyze Concept 3 scenarios with 100% private property BMP implementation.

Figure 3.8 presents the model output by urban land use (CICU, MFR and SFR), comparing land use % impervious to surface runoff (in) from that land use. Because each land use has similar hydrologic function at 100% BMP implementation, where design criteria aim to retain all volumes generated during a 20-year 1-hour storm, a single regression equation is used for all land uses. The scatter in the PLRM modeling output is predominantly related to the percentage of impervious area that is DCIA.

FIGURE 3.8 SURFACE RUNOFF WITH PRIVATE PROPERTY BMPS

Table 3.8. Loading Rates with Private Property BMPs

Land Use	Unit FSP Loads (lb/year/acre)	Stormwater Runoff Rate (inches)
CICU	41.4*(%IMP) + 12	2.2(%IMP) +0.12
MFR	13.8*(%IMP) + 1.5	2.2(%IMP) +0.12
SFR	9.35*(%IMP) + 0.5	2.2(%IMP) +0.12

5. The regression equations were applied to a GIS tabulation of impervious area by urban land use, which produced total FSP pollutant load and stormwater runoff estimates with 100% private property BMP implementation.
6. For each urban land use, estimates of FSP loads and stormwater runoff volumes for Concept 3 were subtracted from estimates of FSP loads and stormwater runoff volumes from the Baseline Condition to estimate reductions attributed to Concept 3.

The following steps outline the approach used to estimate planning level costs for Concept 3.

1. Planning level cost estimates of private property BMP implementation are derived from information published in the Pollutant Reduction Opportunities (PRO) Report (LRWQCB and NDEP 2008b).
2. BMP cost data in the PRO Report is provided on a parcel basis. To develop a cost estimate in units of dollars/acre the following was assumed:
   a. CICU averages 1 parcel per acre,
   b. MFR averages 2 parcels per acre, and
   c. SFR averages 4 parcels per acre.
3. The following averages for the capital cost of BMPs were taken from the PRO Report:
   a. CICU averages $50,000 per parcel,
   b. MFR averages $12,000 per parcel, and
   c. SFR average $4,400 per parcel.
4. Baseline PLRM models and cost estimates assume private property BMPs have been implemented at 2004 baseline levels defined by the *Crediting Program Handbook* (LRWQCB and NDEP 2009). Capital costs for previous BMP implementation are not included in the estimate; however, O&M costs for previous BMP implementation are included in the estimate. The following levels of baseline BMP implementation are defined in the *Crediting Program Handbook* on a land-use basis:
   a. Single-Family Residential = 7% Implementation,
   b. Multi-Family Residential = 19% Implementation, and
   c. CICU = 5% Implementation.

Table 3.9 displays cost estimates in dollars/acre using the assumptions in #2 and #3 above.

1. O&M costs were assumed to be 3% of capital cost. A linear increase in capital cost is used to estimate O&M costs in any given year and to annualize costs. Annualized O&M costs include an additional yearly amount of $250,000 for two full-time Placer County positions to support planning and implementation of private property BMPs in Placer County
2. O&M costs are calculated for a 20-year period to annualize cost.
3. BMP planning and design are included in the capital cost estimate.
4. All dollar amounts are 2011 dollars and are not adjusted for inflation or other factors.

Table 3.9. Cost Estimates for Private Property BMPs

Land Use	Capital Cost ($/acre)	O&M Cost ($/year)
CICU	$50,000	3% of capital cost
MFR	$24,000	3% of capital cost
SFR	$17,000	3% of capital cost

POLLUTANT LOAD REDUCTION AND PLANNING LEVEL COST ESTIMATE

Table 3.10 presents estimates of FSP pollutant load and stormwater runoff reductions achieved using the step-wise implementation approach of BMPs for all urban land uses in Placer County. Capital costs shown in Table 3.10 are cumulative. In other words, the analysis estimates a capital cost of roughly $72,000,000 (2011 dollars) to implement BMPs on all private property parcels in Placer County.

Table 3.10. Summary of Load Reduction and Cost Estimates for Concept 3

	Near-Term Approach (5 years)	Mid-Term Approach (10 years)	Long-Term Approach (20 years)
	Implement BMPs on all CICU within UPCs with estimated FSP loading > 2,200 lb/year	Near-Term Approach + implement BMPs on all remaining CICU and all MFR in Placer County	Mid-Term Approach + implement BMPs for all SFR in Placer County
Total Urban Area (ha)	289	1,122	3,536
Total Impervious Area (ha)	89	267	684
2004 Baseline - Total Urban Area without BMPs (ha)	274	966	3,212
FSP Load Reduction (lb/year)	63,800	105,600	121,000
Surface Runoff Reduction (ac-ft/year)	162	397	689
Capital Cost ($)	$14,000,000	$34,000,000	$72,000,000
Average O&M Cost Over 20-Year Period ($/year)	$630,000	$1,060,000	$1,330,000
Estimated % TMDL Load Reduction for FSP	12%	20%	23%
Stormwater Runoff Reduction Relative to TMDL Baseline Estimate	11%	27%	46%
Annualized Cost ($/year)	$1,300,000	$2,760,000	$4,930,000
Notes/Assumptions	Primarily the densest urban areas (i.e., Kings Beach, Tahoe City [portion not currently routed to TCWTS], Homewood, and Lake Forest)	Simplifying Assumption for Cost Calculation: Near-Term approach completed in Year 5; remaining BMPs implemented in Years 6-10.	Simplifying Assumption for Cost Calculation: Mid-Term approach completed in Year 10; SFR BMPs implemented in Years 11-20.

As shown in Table 3.10, the model output and planning level cost estimate suggests the most efficient FSP load reductions can be achieved by targeting the CICU land use with the poorest land use conditions (Near-Term Approach). However, implementation of all private property BMPs in Placer County, including MFR and SFR, will provide additional FSP load reductions and significant stormwater runoff reductions. Pollutant load is the product of both the quality and quantity of stormwater runoff generated from an urban area. While the SFR and MFR land uses are estimated to have better quality runoff relative to CICU, they comprise a significant amount of the total urban area and impervious area within Placer County (54% of the urban area and 46% of the impervious area). Significant stormwater runoff reductions may be achieved from focusing on compliance of private property BMPs on MFR and SFR land uses that have high degrees of impervious area and DCIA.

UNCERTAINTY IN ESTIMATES

Because private property BMPs are predominantly constructed and maintained by individual parcel owners, improper construction and unreliable maintenance are potential performance issues. The PLRM estimate assumes that private BMPs are constructed correctly and are maintained to ensure proper function (e.g., continue to infiltrate at or above the design target). If a significant number of private property BMPs installed are not maintained over the long-term, the average load reduction for private property BMPs estimated by the PLRM may not be accurate.

The current version of the PLRM characterizes how variable conditions affect characteristic runoff concentrations (CRCs) generated by road land uses. However, the current version of the PLRM uses static CRCs for other urban land uses that only vary based on the presence or absence of BMPs. Because land use conditions will vary markedly across parcels in the Tahoe Basin for the same land use, existing contributions of loading from private property may be underestimated or overestimated for some locations and conditions. Because this analysis was conducted at the Placer County scale, this limitation of the current PLRM algorithms may not be a significant source of uncertainty for jurisdictional estimates of pollutant loading.

POTENTIAL IMPLEMENTATION CONSTRAINTS

The primary difficulty with implementing Concept 3 is providing incentive and/or funding for BMP compliance and maintenance. For example, Placer County has no regulatory authority for private property BMP implementation. Current TRPA regulations define private property BMPs as mandatory, but compliance has not been enforced. This policy has resulted in a voluntary level of response by the private sector (the 2004 Baseline defined by the Crediting Program Handbook [LRWQCB and NDEP 2009] are SFR = 7% Implementation; MFR = 19% Implementation; and CICU = 5% Implementation). Concept 3 would require an institutional shift potentially involving a combination of incentives, funding, and enforcement that ensures implementation and maintenance of private parcel BMPs. It should also be noted that the capital and maintenance costs for this concept would not come from Placer County. However, if this concept is pursued, there would likely be costs to be funded by the County for facilitating implementation (i.e., education, incentive programs, and involvement in developing regulatory programs).

Concept 3 would also require a fundamental shift in the prioritization process for private property BMP implementation. The current TRPA approach prioritized BMP implementation by watersheds in the Tahoe Basin, whereas Concept 3 would prioritize BMP implementation by land use and land use condition.

SUMMARY OF RESULTS AND RECOMMENDATIONS

For each of the pollutant load reduction concepts Table 3.11 summarizes: 1) the estimated percent reduction in FSP loads relative to Placer County's estimated baseline load; 2) cost estimates annualized over a 20-year period relative to the amount of FSP removed per year; and 3) a brief discussion on confidence in performance and cost estimates. As shown in Table 3.11, no single concept achieves the required 34% TMDL Clarity Challenge with a high degree of confidence. The concepts formulated and evaluated will need to be blended to develop a strategy for meeting TMDL load reduction targets. Note that there is some overlap in the actual improvements that would be implemented under the 3 concepts and the load reduction estimates for multiple concepts cannot be summed.

The three concepts presented above are intended to illustrate probable magnitudes of pollutant load reductions and costs. Concept 1 uses more of a watershed perspective and is based on intensifying current practice to build capital improvements in the UPCs that contribute the highest unit FSP loads in the County. In order for Concept 1 load reductions to be achieved long-term, committed maintenance to ensure SWT continued performance will need to be an integral part of future practices. Concepts 2 and 3 use more of a land use perspective and both would require some shift in institutional practice to implement along with additional personnel resources. Concept 2 requires a much higher focus on maintenance and operations of roads for water quality, with a corresponding shift in funding requirements. Concept 3 focuses on reducing pollutant loads and runoff volumes from private property, which has traditionally not been directly addressed by public water quality improvement projects. Similar to Concept 2, Concept 3 would require an institutional shift combining public outreach and coordination, incentive programs, funding, enforcement, and intensive collaboration with and amongst other Basin jurisdictions including TRPA, Lahontan and the California Tahoe Conservancy to formulate implementation regulations and incentives that translate into full private property BMP compliance.

All three concepts provide effective tools to meet TMDL targets and probably no single concept should be adopted as a preferred strategy. The estimated differences in annualized unit costs are subject to uncertainty, but even when allowing for this uncertainty the results provide compelling reasons to prioritize and implement water quality improvements to meet TMDL allocations at least partly on a land use basis rather than solely on a catchment basis.

Table 3.11. Summary of Load Reduction and Cost Estimates by Concept

Concept	Permutation of Concept	FSP Reduction as % of TMDL Baseline	Annualized Unit Cost ($/lb FSP removed/ year)[1]	Notes on Confidence in Performance and Cost Estimates
1	1a. Intensive water quality improvements in UPCs with "Highest" FSP loading rates	18%	$70	Load Estimate: Source control is expected to improve WQIP treatment performance, thus increasing confidence that actions would achieve estimated load reductions. Requires a significant increase in maintenance commitments to ensure long-term achievement and sustainment of load reductions. Cost Estimate: Probably too conservative, actual design and operations would likely be more cost-effective.
	1b. Concept 1a + intensive water quality improvements in UPCs with "High" FSP loading rates	26%	$88	

Concept	Permutation of Concept	FSP Reduction as % of TMDL Baseline	Annualized Unit Cost ($/lb FSP removed/ year)[1]	Notes on Confidence in Performance and Cost Estimates
2	2a. Frequent sweeping on all High Risk roads	19%	$3.75	Load Estimate: Limited data on the effectiveness of road maintenance practices related to improvement in FSP characteristic runoff concentrations. Actions to reduce road abrasives not defined, quantified, or compared across jurisdictions. Cost Estimate: Actions associated with advanced sweeping cost are quantifiable. Advanced abrasive application controls are not yet defined.
	2b. Frequent sweeping plus abrasive controls on all High Risk roads	27%	$4.25	
	2c. Concept 2b + frequent sweeping plus abrasive controls on all Moderate Risk roads[2]	38%	$3.50	
3	3a. BMP implementation on all CICU within UPCs with high FSP loading rates	12%	$20	Load Estimate: High confidence in ability of BMPs to reduce load, but lack of long-term private property maintenance or program to ensure maintenance could affect long-term sustainment of load reductions. Cost Estimate: Limited data available for costs of BMP implementation on CICU with space constraints. Heavily constrained sites could be very expensive. However, the cost estimate is considered reasonably conservative on an average basis.
	3b. Concept 3a + BMP implementation for all CICU and all MFR	20%	$26	
	3c. Concept 3b + BMP implementation for all SFR	23%	$41	

[1]Annualized unit cost estimates were developed from total cost estimates and do not attempt to divide costs by funding source (e.g., public grants, Placer County contributions, private contributions, etc.)

[2]The unit cost estimate for Concept 2c is lower than Concepts 2a and 2b because cost estimates assume the miles of road swept per day under Concept 2c will increase (i.e., more roads swept = less travel time for sweeper between targeted roads).

In addition to water quality benefits and cost, objectives such as community development, transportation, public safety, recreation, and environmental restoration may factor into developing a preferred strategy. In addition, the feasibility and potential implementation timelines for Concept 2 and Concept 3 depend on institutional or funding shifts. Development and adoption of a preferred strategy thus depends on policy decisions, but the analysis conducted here and summarized in Table 3.11 provides the following observations on developing an effective strategy to achieve the required 34% load reduction of FSP from urban stormwater (TMDL Clarity Challenge milestone; see Table 1.1). Note that while the analyses used Placer County as its basis - most of the following observations are applicable to all Tahoe Basin jurisdictions regulated under the TMDL for urban stormwater.

1. A high priority should be placed on improved road operations (Concept 2) to reduce FSP generation associated with abrasive application and to increase recovery of FSP prior to entry into drainage systems, particularly during the late winter/early spring. Given both the apparent cost effectiveness of this concept and present uncertainties associated with achievable load reductions, this concept should be a key element of any strategy but be combined with other concepts. When resources become available to gradually improve sweeping frequency with high efficiency sweepers, priorities should be UPCs with the "highest" FSP loading rate. Similarly opportunities to implement advanced abrasive application strategies

should be focused on priority UPCs, but may be more cost-effective (relative to sweeping strategies) if implemented jurisdiction-wide. Combined with implementation of advanced road operations, research and monitoring should be conducted to better understand how road operations affect pollutant loading to reduce uncertainty in the current load and load reduction estimates.

2. A high priority should be placed on implementation and maintenance of private property BMPs (Concept 3). Working with TRPA, approaches should be developed to accelerate private property BMP compliance targeting land use conditions identified to have high FSP loadings. In particular, improvements should be implemented on CICU land uses where CICU is responsible for a significant portion of the overall urban planning catchment FSP load (e.g., Tahoe City and Homewood). Although public jurisdictions have no obligation to pay for private BMP improvements, public outreach and incentive or cooperative funding programs should be considered as tools to reduce a public jurisdiction's long-term expenditures for achieving TMDL targets. Priorities should be given to UPCs with the "Highest" FSP loading rates.

3. Water quality improvement projects (WQIPs) planned or being designed in UPCs with the "Highest" unit FSP loads should be prioritized for future grant funding (Concept 1). Additionally, the potential to implement Concepts 2 and 3 in these UPCS should be fully explored, as discussed above. Besides providing additional load reductions, Concepts 2 and 3 have the potential to increase the effectiveness of public SWT facilities by reducing inflowing loads and/or runoff volumes.

4. Table 3.11 shows that relatively high unit costs may be associated with intensive water quality improvements in the UPCs with the "High" and "Highest" unit FSP loads. While improvements in these areas are still considered a cost-effective approach due to their relative contribution to the total baseline pollutant load, a balanced approach should be taken to planning and implementing water quality improvements in these UPCs. Where constraints make load reductions relatively expensive on a unit basis, application of source controls only (such as those identified in Concepts 2 and 3) or implementation of less intensive treatments may be the most cost-effective approach in some portions of the UPC.

5. Existing SWT facilities in UPCs identified by the analysis to have unit FSP loadings in the "Highest" and "High" categories should be retrofitted if significant performance improvements are achievable at reasonable cost (see #6 below).

6. In order to control cost while meeting TMDL load reductions, water quality improvements should be planned and designed based on cost-effectiveness. Criteria for assessing the cost-benefit of water quality improvements should be developed to assist in deciding on the type and degree of improvements in UPCs that have not received extensive water quality improvements.

In summary, the recommended strategy that appears most effective involves a combination of: 1) continuation of water quality improvement projects in UPCs with the highest unit FSP loads, tempered by considerations of cost-effectiveness where physical or cultural constraints make intensive water quality improvements impractical; 2) application of advanced road operations in areas with high levels of directly connected impervious area that also need frequent road abrasive applications for traffic safety; and 3) implementation of private property BMPs, with a focus on CICU land uses and catchments where CICU contributes high fractions of the total loads.

CHAPTER 4. ANALYSIS OF CAPITAL WQIP APPROACH TO ACHIEVE FIRST TMDL MILESTONE

Under the regulatory requirements of the Lake Tahoe TMDL, the future NPDES permits in California and Memoranda of Agreement in Nevada will require development of a 5-year load reduction plan that demonstrates how the first TMDL milestone (10% FSP load reduction from baseline loads) will be achieved by 2016. For most jurisdictions in the Tahoe Basin the primary approach to reducing stormwater pollutant loads has been the implementation of capital water quality improvement projects (WQIP) throughout the urban portion of their jurisdiction in accordance with TRPA's Environmental Improvement Program (EIP). Based on the limitations of available grant funding, typical WQIPs are implemented to address the worst pollutant sources while taking advantage of existing opportunities, such as available land for treatment facilities.

The analysis in Chapter 4 estimates load reductions achieved from Placer County WQIPs to determine if continuation of current practices is a viable approach to achieve the first TMDL milestone by 2016. The analysis in this chapter is not intended to be a specific recommendation for a 5-year load reduction plan for Placer County. Chapter 5 assesses a range of pollutant load reduction strategies, including the three concepts described in Chapter 3, to achieve all TMDL milestones, including the Clarity Challenge milestone (34% FSP load reduction) in a 15-year timeline (by 2026).

FIRST LOAD REDUCTION MILESTONE ANALYSIS

Based on the calculations described in Chapter 2, the Placer County baseline (2004) FSP load is estimated to be 516,000 lb/year. In order to meet the first load reduction milestone, Placer County must demonstrate a 10% (51,600 lb/year) reduction from the baseline load. The Placer County FSP load reductions associated with each of the TMDL milestones over the next 15 years are shown in Table 4.1.

Table 4.1. Placer County TMDL FSP Loads

Load	% Reduction	Year of measure	FSP Loading (lb/year)
Placer County Baseline	-	*2004*	*516,000*
First Load Reduction Milestone	10%	2016	464,400
Second Load Reduction Milestone	21%	2021	407,600
Clarity Challenge Milestone	34%	2026	340,600

Placer County continues to plan and implement WQIPs as their primary strategy for pollutant load reductions. To provide an estimate of Placer County's ability to achieve the first milestone through continued implementation of WQIPs, an analysis of the current practices was performed using the following steps:

1. Develop an estimate of baseline FSP loading for each WQIP using an estimate of FSP loading taken from the urban planning catchment(s) where the WQIP is located.
2. Using PLRM, estimate the % FSP load reduction for a subset of completed WQIPs in Placer County that are considered representative of typical WQIPs completed to date by Placer County
3. Develop an extrapolation approach of PLRM results to estimate the FSP load reduction for each completed or planned WQIPs not modeled in PLRM.
4. Calculate the expected Placer County FSP load reduction from WQIP implementation through 2016 and compare to the first TMDL milestone.

BASELINE LOAD ESTIMATE FOR WQIPS

Placer County identified 18 WQIPs that have either been completed since 2004, or have a high likelihood of being completed by 2016 (Figure 4.1 and Table 4.2). WQIP areas were calculated in GIS using a shapefile provided by Placer County and further refined working with County project managers. The baseline pollutant load was estimated as the product of the WQIP area and an estimate of the FSP load per unit area (lb/acre/year). The unit loading rate was taken from the baseline load estimate of the urban planning catchment (UPC) in which the WQIP is located (see Chapter 2), as shown in Figure 4.1.

Table 4.2. Baseline FSP loads for Placer County WQIPs Constructed or Planned for Implementation, 2004-2016. Highlighted projects have been completed.

Water Quality Improvement Project Name	Area (acres)	Year Implemented or Estimated	Baseline Unit FSP Loading Rate (lb/acre/year)	Baseline FSP Load (lb/year)
Timberland	60	2004	37	2,295
Upper Cutthroat	9	2004	117	1,021
Lake Tahoe Park	71	2005	48	3,496
Tahoe Pines - Area C	36	2007	123	4,464
Tahoe Pines - Area B	5	2007	37	185
Dollar Point	213	2008	66	14,087
Tahoe Estates	205	2009	64	13,121
Beaver Street	26	2009	93	2,380
West Sunnyside I	111	2010	48	5,438
Lake Forest I	51	2010	110	5,599
Fox Clean Water Pipe	n/a	2010	n/a	n/a
Tahoe City Residential	36	2011	117	4,213
Brockway	95	2011	93	8,791
Lake Forest II	103	2012	128	13,218
Tahoe Pines - Area A	162	2013	33	5,194
West Sunnyside II	74	2013	48	3,626
Lake Forest III	130	2014	165	21,450
Kings Beach CCIP	68	2015	310	21,017

It should be noted that urban planning catchments (UPC) are typically larger than WQIP areas. Consequently, the land use composition and impervious area within a WQIP might vary significantly from that of the UPC where it is located and affect pollutant loading estimates at the WQIP scale. Table 4.3 compares baseline loading rates for specific WQIPs modeled in PLRM to the estimation approach of baseline loads developed at the UPC spatial scale. As Table 4.3 indicates, the approximation method used to quantify the potential load reduction estimate for each WQIP could markedly vary from detailed PLRM modeling results of a WQIP. Recognizing this issue, the unit loading rate was revised for a WQIP if the land use distribution within a WQIP notably differed from the land use distribution of the UPC. Specific examples include:

- Lake Forest II and Lake Forest III projects are located within the same high pollutant loading UPC (PC22, 217 lb/acre/year); however Lake Forest II addresses a less densely populated portion of the catchment and Lake Forest III contains a mix of densely, and less densely populated land uses. Therefore the baseline

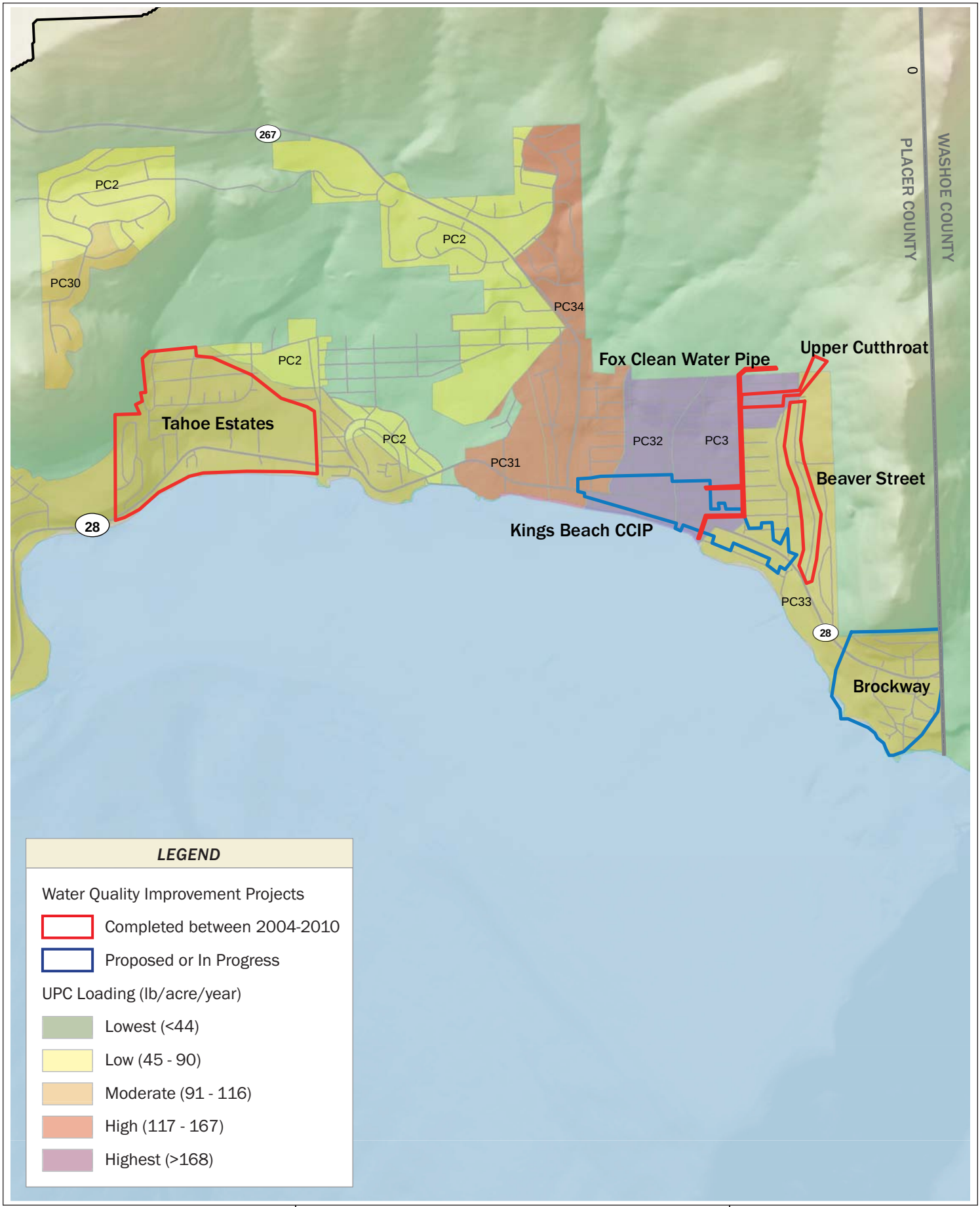


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FIGURE 4.1A PLACER COUNTY CAPITAL WQIPS OVERLAIN ON THE PLACER COUNTY URBAN PLANNING CATCHMENTS CATEGORIZED BY FSP LOADING RATE (SEE CHAPTER 3)

0 0.25 0.5 mi

N

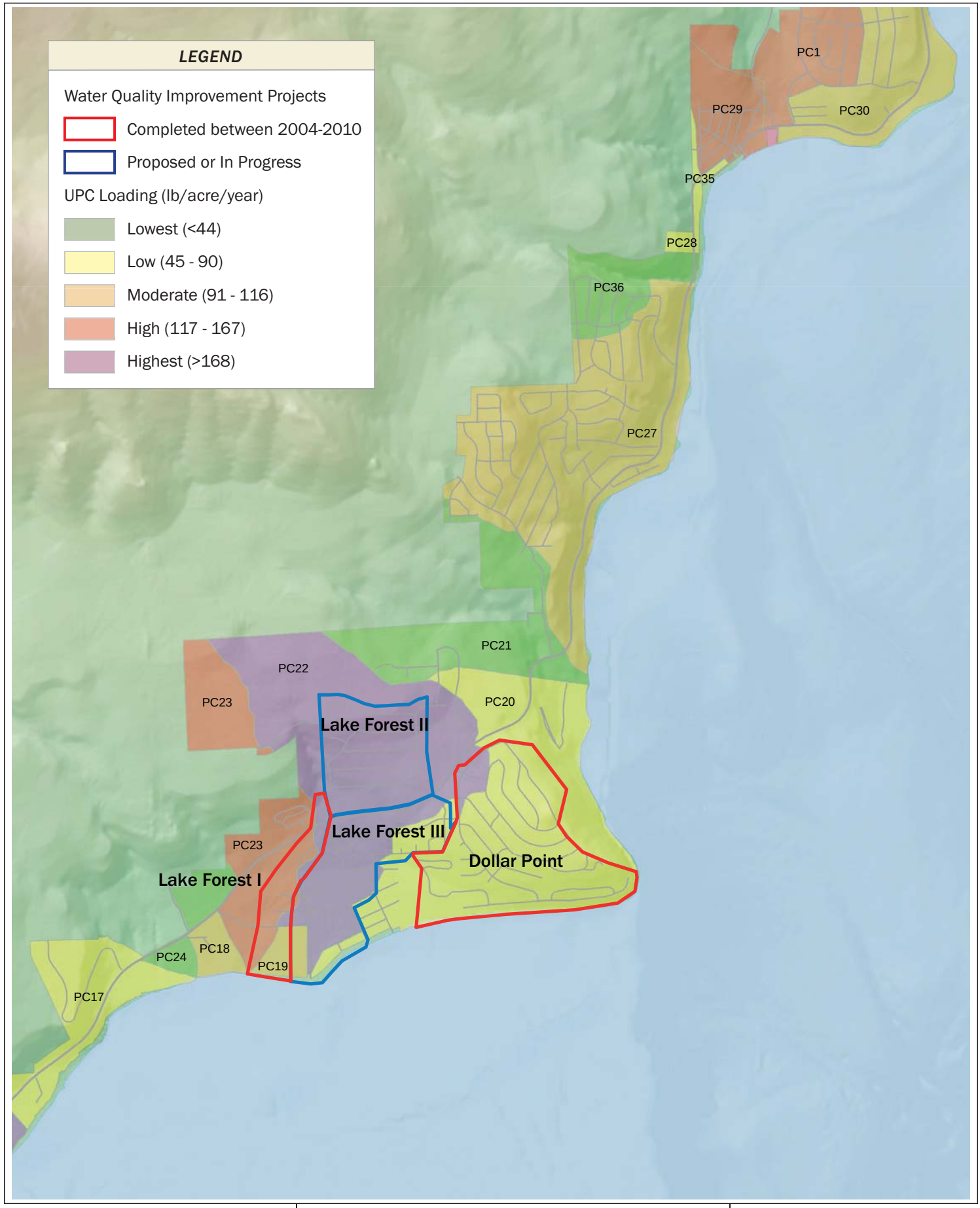

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FIGURE 4.1B PLACER COUNTY CAPITAL WQIPS OVERLAIN ON THE PLACER COUNTY URBAN PLANNING CATCHMENTS CATEGORIZED BY FSP LOADING RATE (SEE CHAPTER 3)

0 0.25 0.5 mi

N

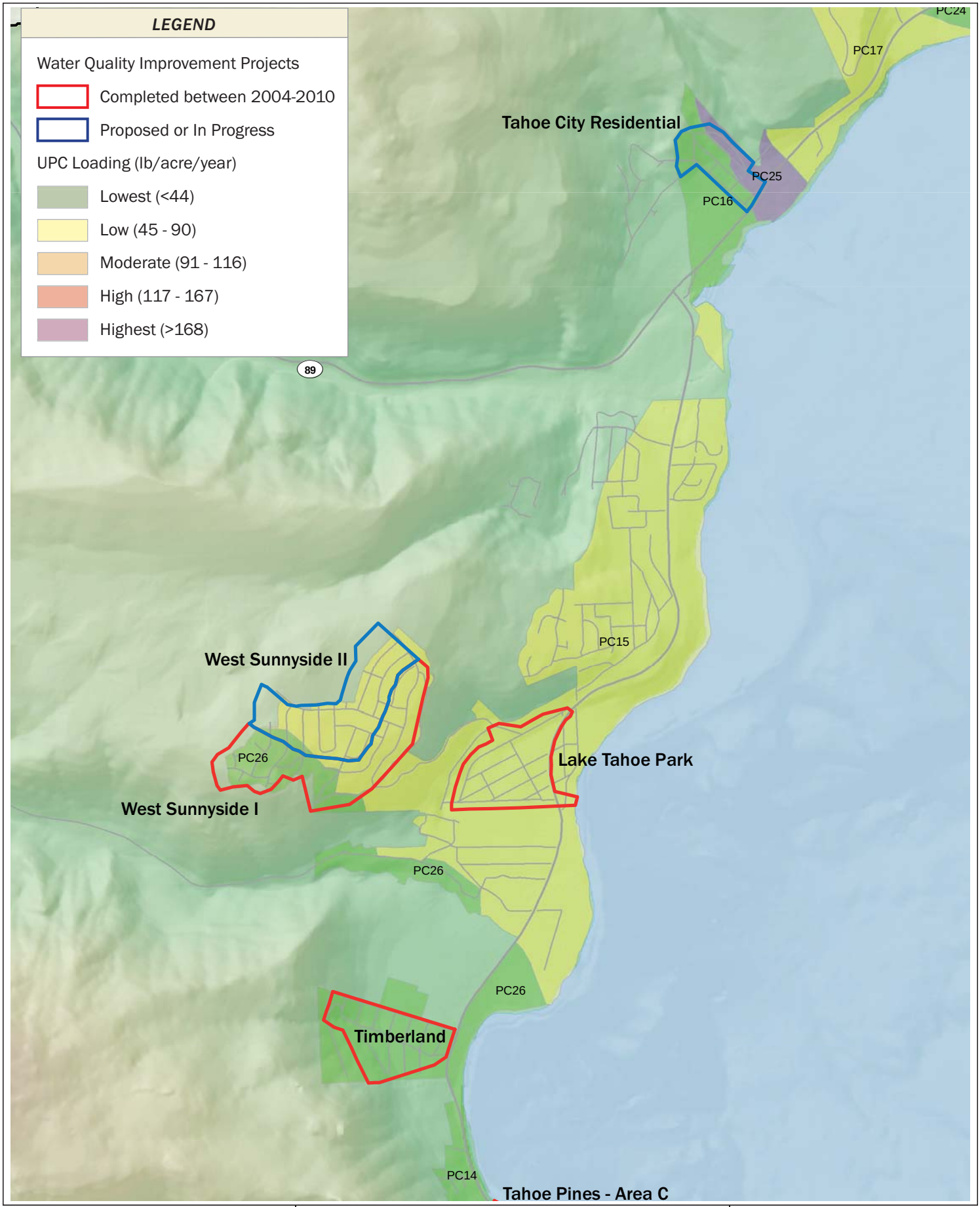

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FIGURE 4.1C PLACER COUNTY CAPITAL WQIPS OVERLAIN ON THE PLACER COUNTY URBAN PLANNING CATCHMENTS CATEGORIZED BY FSP LOADING RATE (SEE CHAPTER 3)

0 0.25 0.5 mi

N

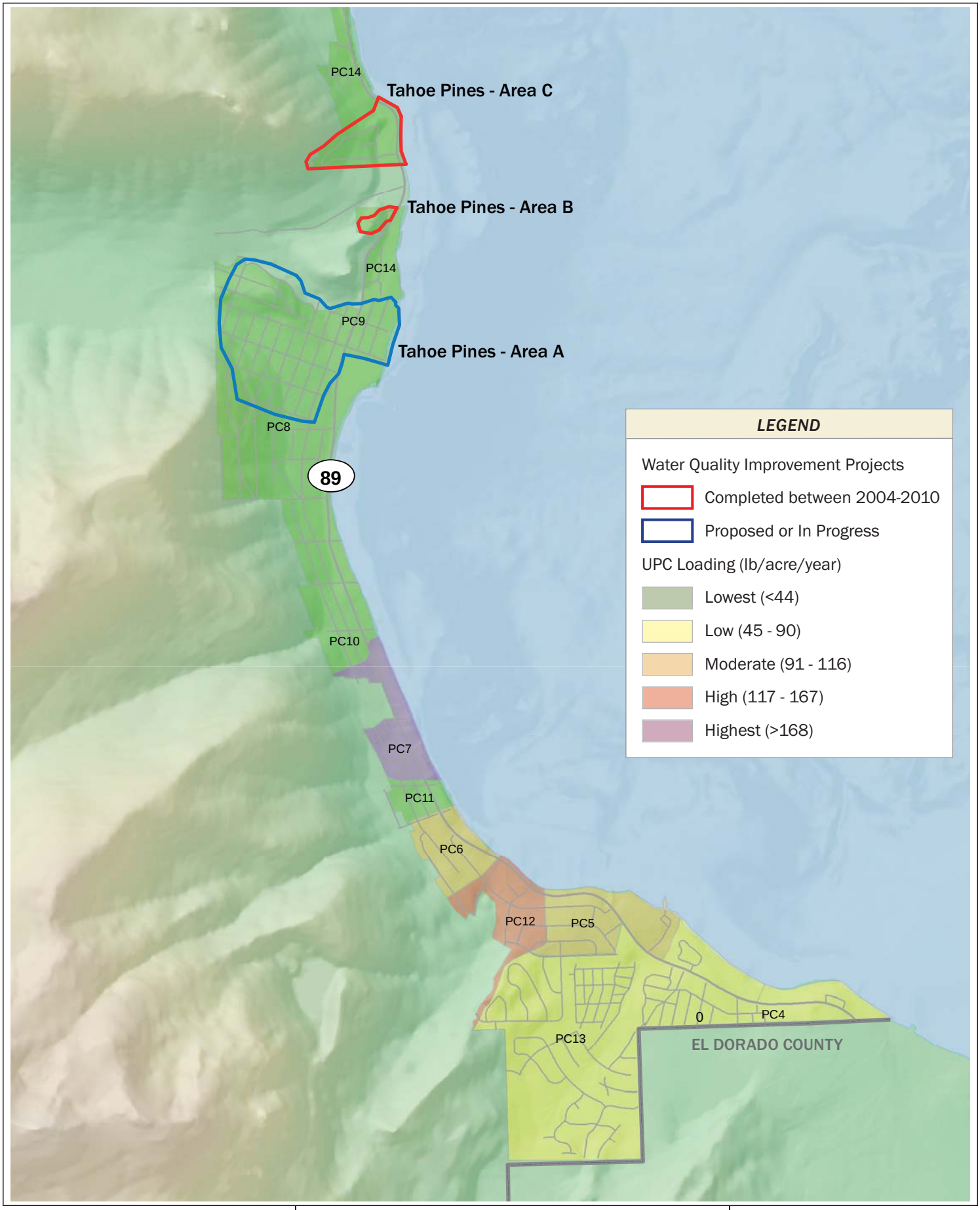

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FIGURE 4.1D PLACER COUNTY CAPITAL WQIPS OVERLAIN ON THE PLACER COUNTY URBAN PLANNING CATCHMENTS CATEGORIZED BY FSP LOADING RATE (SEE CHAPTER 3)

unit FSP loading rate for Lake Forest II was reduced to 128 lb/acre/year and the baseline unit FSP loading rate for Lake Forest III was reduced to 165 lb/acre/year.

- The Tahoe City Residential project uses a lower baseline FSP loading estimate (117 lb/acre/year) relative to the UPC because the project does not address the CICU land uses within the catchment, which are the primary source of FSP loading in the PC25 (400 lb/acre/year).

Table 4.3. Comparison of PLRM Baseline Results to UPC Unit Loads

WQIP	UPC ID	Area (acre)			Baseline FSP Load per unit area (lb/acre/year)	
		PLRM Project Area	UPC	% of UPC Modeled	PLRM Results	UPC Average Estimate
Tahoe Estates	PC30	205	587	35%	64	94
Dollar Point	PC20	213	378	56%	66	88
Tahoe Pines Area C	PC14	36	205	18%	123	38

INDIVIDUAL WQIP LOAD REDUCTION ESTIMATES USING PLRM

PLRM models were developed to estimate the expected FSP load reduction associated with three recently completed WQIPs: Tahoe Estates, Dollar Point, and Tahoe Pines Area C (see Figure 4.1). These 3 WQIPs were selected because (1) they represent typical stormwater runoff improvements implemented within the Placer County urban area, and (2) the necessary catchment and project data was readily available, reducing the level of effort associated with building each PLRM model. Table 4.4 summarizes the estimated FSP load reductions modeled in PLRM and Appendix C includes the PLRM models and summary of model inputs. The following provides a brief description of the main features of each WQIP:

Tahoe Estates WQIP

- The Tahoe Estates WQIP is located in the PC30 urban planning catchment, a "Moderate" FSP loading per unit area catchment (see Figure 4.1A). The 200-acre project area includes the following land uses: single family residential (35%), forested upland (27%), commercial (20%), multi-family residential (10%), and secondary roads (9%).
- The Tahoe Estates WQIP focuses on increased infiltration of stormwater runoff volumes in available urban lots and within Placer County's rights-of-way, as well as stabilization of significant erosional sources. Stormwater improvements associated with the project and modeled in PLRM include increases in road shoulder stabilization throughout most of the project area; routing a portion of road runoff to a 9,000 ft^3 infiltration basin; stabilization of an unpaved dirt road using porous concrete; and increases in the percentage of BMP certificates issued relative to the recommended Crediting Program baseline values.
- As modeled by PLRM, the post-project condition is estimated to provide a 24% reduction in FSP loading (see Table 4.4) and an 18% reduction in runoff volume relative to the baseline condition.

Dollar Point WQIP

- The Dollar Point WQIP is located in the PC20 urban planning catchment, a "Low" FSP loading per unit area catchment (see Figure 4.1B). The 216-acre project area is dominated by single family residential (63%) and secondary road (18%) land uses.
- The Dollar Point WQIP focuses on increased infiltration of stormwater runoff volumes within Placer County's rights-of-way. Stormwater improvements associated with the project and modeled in PLRM

include increases in road shoulder stabilization and increased stormwater routing from roads to infiltration facilities within the right-of-way.

- As modeled by PLRM, the post-project condition is estimated to provide a 23% reduction in FSP loading (see Table 4.4) and a 12% reduction in runoff volume relative to the baseline condition.

Tahoe Pines WQIP (Area C)

- The Tahoe Pines WQIP (Area C) is located in the PC14 catchment, which is designated a "Lowest" unit FSP loading catchment (see Figure 4.1D). The 36-acre project area is comprised of single family residential (55%) and secondary road (13.5%) land uses. Forested upland accounts for 30% of the catchment area.
- The Tahoe Pines Area C project focuses on increased infiltration of stormwater runoff volumes and road shoulder stabilization. Stormwater improvements associated with the project and modeled in PLRM include increases in stormwater routing of runoff to infiltration facilities in the right-of-way; diversion of secondary road runoff to forested land; and road shoulder stabilization improvements.
- As modeled by PLRM, the post-project condition is estimated to provide a 39% reduction in FSP loading (see Table 4.4) and a 12% reduction in runoff volume relative to the baseline condition.

Table 4.4. PLRM Results for Three Completed Placer County WQIPs

WQIP	Description	Area (acres)	FSP Loading (lb/year)		
			Baseline	Expected Load Reduction	% Reduction
Tahoe Estates	Load reduction primarily due to infiltration	200	13,158	3,113	24%
Dollar Point	Load reduction primarily due to infiltration	216	14,172	3,247	23%
Tahoe Pines Area C	Load reduction due to infiltration, road shoulder stabilization, and diversion of road runoff to forested land	36	4,451	1,738	39%

JURISDICTIONAL LOAD REDUCTION ESTIMATES

For each WQIP in Table 4.2 that was not modeled in detail in PLRM, the % FSP reduction as a result of WQIP implementation was estimated based on similarities to the modeled WQIPs based on best professional judgment (Table 4.5). Specifically, WQIPs assumed to be most similar to Dollar Point WQIP were assigned a 23% load reduction, Tahoe Estates a 24% reduction, and Tahoe Pines Area C a 39% reduction (see Table 4.4). The FSP load reduction (lb/year) for each expected condition is the product of the baseline FSP load and the estimated % FSP reduction (see Table 4.5). The following should be noted about the estimates of the FSP load reduction for certain WQIPs:

- Lake Forest I (aka Lake Forest SEZ Improvements) removed existing commercial land uses and restored the area to SEZ. A 39% reduction may underestimate the load reduction associated with this type of project; however a detailed PLRM model is necessary to develop a more appropriate estimate.
- The Fox Clean Water Pipe project diverts forested runoff to bypass the urban stormwater drainage system in Kings Beach. This improvement reduces the volume of forested runoff commingling with urban stormwater and improves the treatment capabilities of existing stormwater treatment facilities. Currently PLRM does not include a mechanism to calculate the load reduction associated with forested runoff. For

the purposes of this analysis, it was assumed that the clean water pipe project would improve the treatment efficiency of existing storm water treatment facilities by 10%. The load reduction of 400 lb/year is calculated from a PLRM model of Fox Basin with a current estimate of 4,004 lb/year of FSP removed.

- The Kings Beach CCIP includes water quality improvements for the commercial core area targeting the treatment of high pollutant loading runoff from roads and CICU land uses. The Kings Beach CCIP design is more similar to the improvements discussed in Concept #1 (see Chapter 3) compared to the WQIPs modeled in detail in PLRM. The Concept #1 analyses estimated a 75%-80% reduction in FSP loads. For this analysis, a 50% load reduction is assumed for the Kings Beach CCIP, recognizing that Concept #1 may represent a theoretical maximum in load reduction that may not be achievable for current projects without additional capital and maintenance resources.

Table 4.5. Expected FSP Load Reductions for Placer County WQIPs Constructed or Planned for Implementation, 2004-2016. Highlighted projects have been completed. The estimated % FSP reduction is based on PLRM results in Table 4.4 and best professional judgment.

Water Quality Improvement Project Name	Baseline FSP Load (lb/year)	*Estimated % FSP Reduction*	Expected FSP Load Reduction (lb/year)
Completed WQIP			
Timberland	2,295	*24%*	551
Upper Cutthroat	1,022	*39%*	398
Lake Tahoe Park	3,496	*23%*	804
Tahoe Pines – Area C	4,464	*39%*	1,741
Tahoe Pines – Area B	185	*23%*	43
Dollar Point	14,086	*23%*	3,240
Tahoe Estates	13,120	*24%*	3,149
Beaver Street	2,380	*39%*	928
West Sunnyside I	5,439	*24%*	1,305
Lake Forest I	5,599	*39%*	2,184
Fox Clean Water Pipe	n/a	*10%*	400
FSP Load Reduction Achieved (2010) = 14,743 lb/year			
Proposed or In Progress WQIP			
Tahoe City Residential	4,212	*23%*	969
Brockway	8,791	*23%*	2,022
Lake Forest II	13,217	*23%*	3,040
West Sunnyside II	3,626	*39%*	1,414
Lake Forest III	21,450	*39%*	8,366
Kings Beach CCIP	21,016	*50%*	10,508
Tahoe Pines - Area A	5,194	*23%*	1,195
FSP Load Reduction Planned (2011 - 2016) = 27,513 lb/year			
FSP Load Reduction Expected (2016) = 42,255 lb/year			

COMPARISON TO FIRST TMDL LOAD REDUCTION MILESTONE

Table 4.6 sums the estimated FSP load reduction for each WQIP shown in Table 4.5 and presents the total FSP load reduction (lb/year) for Placer County if all 18 WQIPs identified are implemented by 2016 . The analysis estimates an 8% reduction from the baseline FSP load for Placer County, which suggests that it unlikely that Placer County can achieve the first load reduction milestone by 2016 through implementation of WQIPs alone. To date, Placer County is estimated to have achieved a 3% reduction with the implementation of 11 WQIPs since 2004.

Table 4.6. Placer County Baseline Load Reduction Estimates

	WQIPs completed to date	WQIPs to be completed by 2016
Placer County Baseline Load Estimate (lb/year)	516,000	
Number of WQIPs	11	18
Total FSP Load Reduction Estimate (lb/year)	14,743	42,255
Baseline FSP Load Reduction (%)	3%	8%

PROJECT DELIVERY COSTS

Placer County provided actual and estimated costs (Table 4.7) for the 18 WQIPs listed in Table 4.5. Estimates include planning, environmental documentation, permitting, design, acquisitions and construction costs.

Table 4.7. Project Delivery Cost Associated with WQIPs Likely to be Completed by 2016. Projects are ordered by project status (highlighted projects are completed) and then by increasing costs.

Water Quality Improvement Project Name	Project Delivery Costs
Tahoe Pines - Area B	$500,000
Tahoe Pines - Area C	$1,000,000
Beaver Street	$1,000,000
Dollar Point	$1,500,000
Timberland	$1,500,000
Upper Cutthroat	$1,750,000
Fox Clean Water Pipe	$3,000,000
Tahoe Estates	$3,500,000
West Sunnyside I	$3,500,000
Lake Forest I	$5,000,000
Lake Tahoe Park	$5,300,000
Total (Completed Projects)	**$27,550,000**
Tahoe Pines - Area A	$1,500,000
Tahoe City Residential	$2,000,000
West Sunnyside II	$2,000,000
Brockway	$3,140,000
Lake Forest II	$3,750,000
Lake Forest III	$5,000,000
Kings Beach CCIP (Water Quality Component)	$17,500,000
Total (In Progress/Proposed Projects)	**$34,890,000**
TOTAL (All Projects)	**$62,440,000**

ANALYSIS IMPLICATIONS AND LIMITATIONS

Given the results of the analysis (see Table 4.6), it is unlikely Placer County will be able to achieve the first TMDL milestone of a 10% FSP load reduction by 2016 by maintaining a singular strategy focused on the implementation of WQIPs. In addition to the pollutant load reduction estimation indicating that the 18 WQIPs will only achieve an 8% reduction from the Placer County baseline load, there are a number of additional considerations regarding Placer County's ability to meet the first TMDL milestone:

- Placer County has constructed 11 WQIPs since 2004 at a rate of approximately 1.6 WQIPs per year and $2,500,000 per project. In order to have all WQIPs in Table 4.7 in the ground by 2016, 7 WQIPs will need to be constructed at the rate of 1.4 projects per year at an average of approximately $5,000,000 per project. The Kings Beach CCIP, with an estimated cost of $17,500,000 for water quality improvements, is 3 times more expensive than any other project, completed or planned. From a funding perspective, the 7 WQIPs indentified for implementation between 2011 and 2016 may not be feasible given the current uncertainties in future grant funding.

- The analysis estimates that as of 2010, completed WQIPs have achieved a 3% reduction in Placer County's 2004 baseline load. The remaining 7 WQIPs that have a high likelihood of implementation by 2016 are estimated to result in an additional 28,000 lb/year FSP load reduction, which is significant given the estimated performance of the 11 WQIPs implemented from 2004 to 2010. Specifically, two projects, Kings Beach CCIP and Lake Forest III, account for nearly 44% (or approximately 19,000 lb/year) of the total FSP load reduction expected by 2016. If these two projects are part of Placer County's strategy for meeting the first TMDL milestone and the projects are not completed by 2016, Placer County will fall significantly short of achieving the first TMDL milestone.

- As indicated by the comparison in Table 4.3, the extrapolation of PLRM results to UPC baseline loading rates has some degree of uncertainty. However, given the underlying assumptions in PLRM and the relative differences across projects, the analysis provides a reasonable estimation approach for Placer County to use for load reduction planning on a jurisdiction scale. Detailed PLRM baseline and project models must be developed to meet the catchment registration requirements of the Crediting Program. While detailed PLRM model results of individual WQIPs will likely vary from the load reductions shown in Table 4.5, the differences are not expected to be significant enough to indicate that Placer County would achieve the first TMDL milestone through WQIP implementation only.

In order to achieve the first TMDL milestone, and certainly to achieve subsequent milestones towards attainment of the Clarity Challenge milestone (34% FSP load reduction in a 15-year timeline), Placer County must implement additional pollutant load reduction strategies beyond WQIP implementation. The implementation of WQIPs will likely become more constrained in the future, given the high capital cost of projects and the obstacles to siting projects in densely populated urban areas. New strategies which blend a combination of the three concepts presented in Chapter 3 (Intensive Improvements in High Pollutant Loading UPCs, Advanced Pollutant Source Control for Road Operations, and Targeted Implementation of BMPs for Private Land Uses) to target all pollutant load sources will be necessary to achieve future TMDL load reduction milestones. Chapter 5 provides a general approach for jurisdictions to prioritize and select water quality improvement actions to meet the TMDL milestones within the allotted time while considering cost-effectiveness.

CHAPTER 5. MANAGEMENT STRATEGIES TO ACHIEVE TMDL MILESTONES

Chapter 5 provides the recommended implementation approach for Placer County's Lake Tahoe TMDL Strategy to meet TMDL milestones. The recommendations include specific courses of action, the suggested timeline for implementation of actions, and estimated costs associated with project delivery, O&M, and TMDL reporting.

Although this report provides specific recommendations, it is important to note that TMDL Strategy development will be an iterative process. The calculations within this document are based on informed assumptions and extrapolations. As Placer County moves forward with implementation, the actual load reductions realized by specific actions will need to be compared to baseline load estimates and milestone targets. Annual reviews of progress towards each milestone will likely result in strategy adjustments based on a variety of considerations, including expected load reductions associated with an action, cost-effectiveness of the action, and available resources. Additionally, the Lake Clarity Crediting Program (Crediting Program; LRWQCB and NDEP 2009) is designed to be flexible, allowing for updates as the science underlying the TMDL is improved with future research. The recommendations in this chapter should therefore be viewed as a starting point for Placer County's TMDL Strategy.

This section summarizes recommended actions and associated costs for meeting the first TMDL milestone (10% load reduction by 2016) and the Clarity Challenge milestone (34% load reduction by 2026). The technical assumptions and approaches used to estimate water quality performance and costs are provided in *Appendix D: Chapter 5 Technical Assumptions.*

SUMMARY OF TMDL MILESTONES

The Crediting Program establishes the system by which jurisdictions track Lake Clarity Credits and provide reports to TMDL regulators demonstrating progress towards pollutant load reduction milestones. Table 5.1 summarizes the Placer County TMDL baseline FSP load calculated in Chapter 2 and the first three load reduction milestones and associated Lake Clarity Credits.

Table 5.1. Placer County TMDL FSP Loads

Load	% Reduction	Year of Measure	FSP Loading (lb/year)	FSP Loading (MT/year)	FSP Loading[1] (# particle/ year)	Lake Clarity Credits[2] to Meet Milestone (Load Reduction)
Placer County Baseline	-	*2004*	*516,000*	*234*	*2.57E+19*	-
First Load Reduction Milestone	10%	2016	464,400	211	2.32E+19	257 (23 MT/year)
Second Load Reduction Milestone	21%	2021	407,600	185	2.03E+19	541 (49 MT/year)
Clarity Challenge Milestone	34%	2026	340,600	154	1.70E+19	875 (80 MT/year)

[1] 1kg FSP = 1.1×10^{14} particles FSP (Equation 0.3; LRWQCB and NDEP 2009

[2] 1 Lake Clarity Credit = 1.0×10^{16} FSP particles (Equation 0.2; LRWQCB and NDEP 2009)

RECOMMENDED STRATEGY TO MEET FIRST TMDL MILESTONE (2011-2016)

To date, Placer County has focused on implementation of capital WQIPs to reduce pollutant loads. The research team conducted an analysis to assess Placer County's current progress towards the first TMDL milestone by estimating pollutant load reductions for completed WQIPs (2004-2010) and WQIPs planned for completion by the end of the first TMDL milestone (2011-2016). Chapter 4 presents the results of this analysis, which is based on the spatial extrapolation of the results of three PLRM models. The analysis in Chapter 4 estimates that Placer County has achieved a 3% pollutant load reduction relative to its baseline pollutant load as of Spring 2011, and if all planned WQIPs are completed by 2016, an 8% reduction may be achieved by 2016 (see Table 4.6). Based on the Chapter 4 estimate, Placer County may not meet the first 10% load reduction milestone by 2016 through the implementation of WQIPs alone. The analysis in Chapter 3 (Concepts for Load Reduction) suggests that Placer County has opportunities to implement other pollutant load reduction actions to augment load reductions achieved through WQIP implementation to meet the first TMDL milestone.

Based on these findings, the following approach is recommended to meet the first TMDL milestone by 2016:

ACTION 1. Register Completed WQIPs (2004-2010): These are the completed WQIPs highlighted in Table 4.5 that can be registered as part of the Crediting Program to earn Lake Clarity Credits.

ACTION 2. Construct and Register New WQIPs (2011-2016): These are the "Proposed" or "In Progress" WQIPs shown in Table 4.5 that are in various stages of project development. Placer County anticipates completing these WQIPs by 2016.

ACTION 3. Conduct and Register Advanced Road Operations for Water Quality – Phase 1: These actions focus on reducing the average annual mass of abrasives and FSP applied to Placer County roads through the use of best available technology. Specific actions include:

- Retrofitting all sanding trucks/plows with best available technology bulk spreaders to increase the efficiency and control over the amount of road abrasives applied.
- Switching road abrasive supplies to documented sources with high durability (i.e., resists pulverization into FSP).
- Selecting and applying an abrasive source with no FSP.

Table 5.2 summarizes the FSP load reduction estimates associated with Actions 1-3. FSP load reductions are presented as both a % reduction relative to the Placer County baseline load estimate and the number of Lake Clarity Credits that would be awarded. Table 5.2 sums the total load reduction that may be achieved from the recommended actions and compares the estimate to the first TMDL milestone target (see Table 5.1). The technical assumptions used to calculate the water quality performance of each action are detailed in *Appendix D.*

Table 5.2. Load Reduction Estimates Associated with Recommended Actions to Achieve First TMDL Milestone.

Recommended Actions (2004-2016)	Estimated % FSP Load Reduction	Lake Clarity Credits
1. Register Previously Completed WQIPs (2004-2011)	2.9%	75
2. Construct and Register New WQIPs (2011-2016)	5.4%	140
3. Conduct and Register Advanced Road Operations for Water Quality – Phase 1	4.9%	126
First TMDL Milestone Estimated Totals (2004- 2016)	**13.3%**	**341**
First TMDL Milestone Target	**10%**	**257**

Table 5.3 provides the total action delivery costs and annualized costs associated with O&M and Crediting Program tasks for each recommended action. Of the roughly $66 million in total cost estimated to meet the first TMDL milestone, approximately $28 million has already been expended on completed WQIPs (Action 1 delivery costs). The average annual cost estimates associated with the recommended actions from 2011-2016 equals approximately $400,000, of which $320,000 per year is for O&M costs and $76,000 per year is associated with Crediting Program tasks. All projected costs used a 2011 cost-basis and are not adjusted for inflation. The technical assumptions and calculation methods used to estimate costs of each action are detailed in *Appendix D.*

Table 5.3. Cost Estimates Associated with Recommended Actions to Achieve First TMDL Milestone.

Recommended Actions (2004-2016)	Cost Estimates		
	Action Delivery Cost ($)	**Annualized[1] Increase in O&M Cost ($/year)**	**Annualized[1] Crediting Program Cost ($/year)**
1. Register Previously Completed WQIPs (2004-2011)	$27,600,000[2]	$110,000	$40,000
2. Construct and Register New WQIPs (2011-2016)	$34,900,000	$60,000	$20,500
3. Conduct and Register Advanced Road Operations for Water Quality – Phase 1	$750,000	$150,000[3]	$15,500
Annualized O&M and Crediting Program Costs (2011 - 2016)		*$320,000*	*$76,000*
	Total Delivery Cost ($)	**Total O&M Cost ($)**	**Total Crediting Program Cost ($)**
Progress from Existing Conditions (2011) to First TMDL Milestone (2016)	**$35,650,000**	**$1,920,000**	**$456,000**

[1] Costs are annualized over a six-year time frame (2011-2016).

[2] Action 1 Project Delivery Costs previously expended.

[3] Estimated grant funding for performance monitoring = $100,000/year; estimated Placer County cost = $50,000/year.

UNCERTAINTY IN WATER QUALITY PERFORMANCE ESTIMATES

Water quality performance estimates presented in this report rely on estimates developed from the PLRM, which contains a number of assumptions and uncertainties that can be reduced through continued stormwater monitoring and validation efforts. For example, the Action 3 estimates that relate reductions in road abrasive applications to FSP load reductions in PLRM are based on very limited data. Similar modeling uncertainties exist with the expected load reductions associated with the performance of WQIPs in Actions 1 and 2. In the near-term, the LRWQCB plans to accept the risk associated with these types of modeling uncertainties and will honor load reduction estimates produced by PLRM for the duration of catchment credit schedules, which are proposed by a jurisdiction and approved by the LRWQCB (B. Larsen, pers. comm. 21 April 2011).

The following are key considerations regarding the recommended actions related to current uncertainties:

- Additional research, monitoring, and evaluation are necessary to validate and improve modeling algorithms to increase confidence that the actions implemented are achieving the load reductions estimated. Catchment scale water quality monitoring of priority catchments would provide critical quantitative evidence to determine if pollutant loads decrease in concert with the implementation of water quality improvement actions. Catchment water quality monitoring would provide Placer County with data to evaluate the effectiveness of actions toward achieving TMDL milestones in select locations as well as provide data to verify model average annual loading estimates. Placer County can use the water

quality monitoring data to inform their strategy to meet the Clarity Challenge over time. The protocols and costs required to track catchment pollutant load reductions have yet to be fully developed, but costs are expected to be approximately $100,000 per catchment every 2-3 years with focused cost-effective monitoring. Monitoring costs are not included as part of this analysis.

- The PLRM is currently the only modeling tool pre-approved for use when registering pollutant load reductions with the Crediting Program. The PLRM was developed to estimate load reductions at the individual WQIP scale and was not developed to efficiently estimate and integrate load reductions that may be achieved from actions that affect an entire jurisdiction (e.g., Action 3: Advanced Road Operations for Water Quality). A defensible and efficient process for registering jurisdiction wide load reduction credits should be negotiated between the LRWQCB and the jurisdictions to allow for appropriate credits to be assigned.
- The actual achievement of estimated load reductions from WQIPs assumes that stormwater treatment BMPs within registered catchments are adequately maintained within an acceptable condition range.

TMDL STRATEGY TO MEET CLARITY CHALLENGE (2017-2026)

The recommended TMDL Strategy for Placer County to meet the Clarity Challenge blends the following actions: 1) continuation of public WQIPs in urban catchments with the highest FSP loads; 2) augmentation of Phase 1 advanced road operation actions to continue to improve and protect water quality; and 3) implementation of private property BMPs, with a focus on CICU land uses and catchments where CICU contributes high FSP loads. A key strength of the recommended TMDL strategy is that it provides flexibility by identifying three separate water quality improvement actions that may be combined in various proportions, or on different timeframes, to meet the Clarity Challenge milestone. The recommended TMDL Strategy recognizes the need to shift away from a heavy reliance on implementation of public WQIPs to a more balanced program that includes improvements in road operations for water quality and targeted implementation of private property BMPs. The following 3 actions are recommended for the TMDL Strategy to meet the Clarity Challenge. Actions 1-3 (implemented by 2016) will also need to be continually maintained to meet this and subsequent milestones.

ACTION 4. Conduct and Register Advanced Road Operations for Water Quality – Phase 2: This action augments the Phase 1 actions (Action 3) to include advanced and more frequent pollutant recovery actions (e.g., street sweeping) on Placer County roads. Specific actions include:

- Subscribing to a weather forecasting service or development of in-house meteorological expertise to increase the accuracy of storm forecasting to better target operational practices (e.g., deicing activities) to the type of storm and the timing of snowfall or rainfall.
- Increasing use of deicers and other advanced technology (e.g., pavement temperature sensors) to optimize the amount of road abrasive material applied based on the type of storm event and the antecedent conditions.
- Frequently sweeping streets particularly during winter and spring months with best available technology sweepers to improve road conditions for water quality.

ACTION 5. Increase Private Property BMP Implementation: Obtain 100% private property BMP implementation on CICU and MFR land uses in the urban catchments identified with the highest FSP loading rates, specifically Kings Beach, Lake Forest, Tahoe City and Homewood. This action includes redevelopment projects.

ACTION 6. Construct and Register New WQIPs (2017-2026): This action implements additional water quality improvement projects in high priority areas.

Table 5.4 summarizes the FSP load reduction associated with Actions 4-6, as well as the total FSP load reduction estimates associated with maintaining Actions 1-3 (see Table 5.2). The FSP load reductions are presented as both a % reduction relative to the Placer County baseline loading estimate and the number of Lake Clarity Credits that would be awarded. Table 5.4 sums the total load reduction that may be achieved from the recommended actions and compares the estimate to the Placer County Clarity Challenge TMDL milestone target (see Table 5.1). The technical assumptions used to calculate the water quality performance of each action are detailed in *Appendix D.*

Table 5.4. Load Reduction Estimates Associated with Recommended Actions to Achieve Clarity Challenge.

Recommended Actions (2017-2026)	Estimated % FSP Load Reduction	Lake Clarity Credits
1-3. Maintain Actions 1-3 Implemented Between 2004-2016	13.3%	341
4. Conduct and Register Advanced Road Operations for Water Quality – Phase 2	7.6%	196
5. Increase Private Property BMP Implementation	11.4%	294
6. Construct and Register New WQIPs (2017-2026)	3.7%	96
Clarity Challenge Estimated Totals (2004-2026)	**36.0%**	**927**
Clarity Challenge Target	**34%**	**875**

Table 5.5 provides a summary of the estimates for action delivery, O&M, and Crediting Program costs associated with implementing (or maintaining) all 6 actions from 2017-2026 to achieve the Clarity Challenge Milestone. The total cost for this time period is estimated to be roughly $64 million, including $13.5 million to cover O&M and Crediting Program costs. All projected costs used a 2011 cost-basis and are not adjusted for inflation. The technical assumptions and calculation methods used to estimate costs of each action are detailed in *Appendix D.*

Table 5.5. Cost Estimates Associated with Recommended Actions to Achieve Clarity Challenge Milestone.

Recommended Actions (2017-2026)	Action Delivery Cost ($)	Annualized[1] Increase in O&M Cost ($/year)	Annualized[1] Crediting Program Cost ($/year)
1-3. Maintain Actions 1-3 Implemented Between 2004-2016	Not Applicable	$321,000	$87,800
4. Conduct and Register Advanced Road Operations for Water Quality – Phase 2	$700,000	$550,000	$1,200
5. Increase Private Property BMP Implementation	$9,950,000[2]	$290,000[3]	$300
6. Construct and Register New WQIPs (2017-2026)	$40,000,000	$84,000	$17,700
Average Annual O&M and Crediting Program Costs (2017 - 2026)		*$1,250,000*	*$107,000*
	Total Delivery Cost ($)	**Total O&M Cost ($)**	**Total Crediting Program Cost ($)**
Progress from First TMDL Milestone to Clarity Challenge (2017-2026)	**$50,650,000**	**$12,500,000**	**$1,070,000**

[1] Costs are annualized over a ten-year time frame (2017-2026).

[2] Assumed to be private sector contribution.

[3] Estimated private sector maintenance = $165,000/year; estimated Placer County BMP support cost = $125,000/year.

When reviewing Tables 5.4 and 5.5 it is important to note that the analyses and recommendations contained in this report are intended to: 1) demonstrate to regulatory review agencies that achievement of load reduction milestones is technically feasible; and 2) provide implementing agencies with estimates of associated costs and levels of effort for achieving TMDL milestones. For this purpose, numeric estimates of load reductions associated with a particular blend of actions for water quality improvements are provided as a recommended TMDL Strategy, which is used as the basis for estimation of both load reductions and costs using best available information. However, given the uncertainties in the current numeric estimates and the challenges that Placer County may face in implementation and securing funding, a refinement of the strategy to meet the Clarity Challenge will likely be necessary prior to implementation. This refinement or update should occur by mid-2016.

The actual strategy Placer County implements to meet the Clarity Challenge may include a different blend of Actions 4, 5, and 6 relative to what is presented based on: 1) resolution of institutional or policy changes required to resolve key implementation challenges, which are highlighted in the next section; 2) available funding; and 3) the results of monitoring and lessons learned from implementation of the first 5-year load reduction plan. However, the analysis summarized in Tables 5.4 and 5.5 suggests that the cost/benefit of future WQIP implementation beyond 2016 may need to be reconsidered in light of the likelihood of siting and public resource limitations and the expected cost effectiveness of other load reduction concepts.

Table 5.6 summaries the estimated costs associated with achieving the Clarity Challenge milestone by 2026 for the Recommended Strategy. Total delivery, O&M, and Crediting Program costs are provided for 3 separate time periods: 2004-2011 (baseline to existing condition); 2011-2016 (existing condition to the first TMDL milestone); and 2017-2026 (first TMDL milestone to Clarity Challenge milestone). Based on the specific set of actions selected, the total cost to implement the recommended Placer County Stormwater TMDL Strategy is estimated to be approximately $130 million. Of this amount, approximately $28 million has already been expended on completed WQIPs, $11.5 million is estimated to be contributed from the private sector and $1.5 million is expected to be funded via research grants to conduct performance monitoring. This cost estimate includes annual operation and maintenance (O&M) and Crediting Program inspection and reporting costs from 2011-2026, which total roughly $16 million during that time period.

Table 5.6 Summary of Estimated Costs to Achieve Clarity Challenge Milestone, 2004-2026

Intervals Leading Up To TMDL Milestones	Total Delivery Cost ($)	Total O&M Cost ($)	Total Crediting Program Cost ($)	Total Cost ($)
Baseline Condition (2004) to Existing Condition (2011)	$27,600,000	$80,000	Not Applicable	**$28 million**
Existing Condition (2011) to First TMDL Milestone in 2016	$35,650,000	$1,920,000	$456,000	**$38 million**
First TMDL Milestone (2016) to Clarity Challenge (2026)	$50,650,000	$12,500,000	$1,070,000	**$64 million**
Achieve Clarity Challenge (2004-2026)	**$114 million**	**$14.5 million**	**$1.5 million**	**$130 million**

IMPLEMENTATION CHALLENGES TO MEET CLARITY CHALLENGE

The recommended strategy for meeting the Clarity Challenge was developed to be a cost-effective approach for Placer County to meet the TMDL Clarity Challenge milestone. However, at the present time Placer County is not in a position to immediately implement the recommended strategy due to constraints on program funding, institutional policy, and regulatory authority. Rather than change the recommended strategy to match Placer County's current capabilities, this report takes the approach of identifying these challenges for resolution in the

next five years, and recognizes that the Clarity Challenge strategy will be refined by 2016 perhaps to modify the blend of specific actions described in this chapter. Other Tahoe Basin jurisdictions will face similar challenges and collaboration over the next five years could provide significant benefits Basin-wide. Resolution of the following challenges will be necessary for Placer County and other jurisdictions to successfully meet Clarity Challenge load reduction milestones.

UNCERTAINTY WITH FUNDING

WQIP Implementation – Planning, design, and construction of WQIPs is funded primarily through public grants. However, the present outlook for sustained allocation of significant grant funds to continue WQIP implementation is uncertain. Unless other sources of funding are identified, program costs may not be supported at the level necessary to meet milestones.

Significant Increases in Maintenance Costs – The approaches proposed require significant increases in water quality maintenance costs for improved road operations and for maintenance of stormwater treatment facilities constructed as part of WQIPs. Current grant funding policies do not allow for grant funds to be used for operations and maintenance. Placer County and all other Tahoe Basin jurisdictions will need to locate, secure, and sustain funding to pay for the additional water quality maintenance activities proposed.

Increases in Program Management Costs and Staffing – The process for registering and tracking load reductions outlined by the Crediting Program will require additional staff for each jurisdiction. An estimate of the additional staff time required is presented in *Appendix D*. The recommended strategy also includes monitoring and evaluation to support the shift in program emphasis, and the refinement of the Clarity Challenge strategy in 2016. These costs for additional staff will require additional grant funding or identification of other sustainable funding sources.

REGULATORY SUPPORT TO INCREASE PRIVATE BMP IMPLEMENTATION

While current TRPA regulatory code requires the implementation of BMPs on all private parcels, compliance has not been broadly enforced. To date, the policy has resulted in a low level of voluntary response by the private sector, and Tahoe Basin jurisdictions responsible for stormwater management currently have minimal resources and political support to enforce private property BMP implementation or maintenance. Furthermore, the current regulatory code for appropriate maintenance practices is overly general. For example, TRPA's current Code of Ordinances requires that "BMPs shall be maintained to ensure their continued effectiveness" (Section 25.8). Placer County and other Tahoe Basin jurisdictions will need improved support from local agency policy makers and regulatory agencies such as TRPA to achieve private BMP implementation in priority areas, and to ensure private BMPs are maintained.

INSTITUTIONAL CHANGES

Road operations have traditionally been organized as part of public works and transportation safety activities of local agencies and have not been closely coordinated with watershed or water quality functions. Effective modification of road operations practices may require internal organizational changes and shifts in allocation of funds. These types of changes require development of proposed program and operations plans, and an approval at the Board of Supervisors level. Uncertainty exists regarding the nature and timing of institutional changes needed to implement some parts of the recommended strategy.

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APPENDIX A – URBAN AREAS MODELED

Provided Electronically: PlacerTMDLStrategy_AppendixA.pdf

APPENDIX B – EXTRAPOLATION SPREADSHEET

Provided Electronically: PlacerTMDLStrategy_AppendixB.xlsx

APPENDIX C – PLRM MODELS AND SUMMARY OF PLRM INPUTS

Provided Electronically: PlacerTMDLStrategy_AppendixC_PlacerBaselinePLRMmodels.zip and PlacerTMDLStrategy_AppendixC_PLRMInputs.zip

APPENDIX D – CHAPTER 5 TECHNICAL ASSUMPTIONS

Appendix D presents the technical assumptions and approaches for developing the water quality performance estimates and cost estimates summarized in *Chapter 5: Management Strategies to Achieve TMDL Milestones*.

APPROACH FOR ESTIMATING CREDITING PROGRAM WORK EFFORT

With the implementation of the Tahoe TMDL and adoption of the Crediting Program, the reporting requirements under Placer County's NPDES permit have changed significantly. Placer County must complete several tasks for each urban catchment where water quality improvement actions have been implemented and the County registers the catchment to receive Lake Clarity Credits for reducing pollutant loading to Lake Tahoe. Jurisdictions can register catchments and receive credits for load reduction actions completed since the baseline year of 2004. The Crediting Program defines the system to evaluate and track pollutant load reductions and related Lake Clarity Credits within the context of the TMDL by urban catchment. An urban catchment is defined as "a contiguous area containing urban land uses with runoff draining to a surface waterbody. Any single square foot of land is included in only one urban catchment." (LRWQCB and NDEP 2009). The Accounting and Tracking (A&T) Tool is a data management tool to store, track and report a jurisdiction's credit information and load reduction achievement over time. This tool will be revised over the next year to integrate the data management functions associated with registering catchments, documenting inspection results and producing annual report materials that show the number of credits generated. The A&T will standardize and significantly simplify the reporting effort as a result of automated annual report generation once the tool is populated with required information for each registered catchment.

The tasks associated with the Crediting Program are divided into 2 categories: Initial Tasks and Ongoing Annual Tasks. The initial tasks are completed one time as improvements are identified, designed, implemented and registered in the A&T Tool. As currently conceived in the Crediting Program, PLRM is used throughout the project design phase to evaluate pollutant load reduction alternatives and assist project designers in selecting the preferred alternative based on quantitative comparison of pollutant loads and runoff volumes. The approach to planning and design will change with the availability of new tools and shift in focus to optimize load reductions with new actions, but the cost of alternatives analyses , permitting and other pre-implementation costs are not included in the Crediting Program estimates herein.

Following project construction, the PLRM scenario is finalized based on actual construction and planned O&M implementation, and the catchment is registered in the A&T Tool. Ongoing annual tasks are completed every year following registration to demonstrate continued performance of the projects and actions within the registered catchments. The descriptions of the tasks associated with the Crediting Program are presented below, including the relative timing of task completion:

Initial Crediting Program Inspection and Reporting Tasks (completed one time for each new registered catchment)

- Post-action implementation: Based on the actual improvements constructed and the planned water quality maintenance actions within the catchment: finalize the PLRM model and associated expected load reduction estimate; complete the stormwater infrastructure inventory; complete the Catchment Credit Schedule (CCS) detailing load estimates and documentation, stormwater infrastructure inventory, and maintenance plans; and register the catchment with A&T Tool.

Ongoing Annual Crediting Program Inspection and Reporting Tasks (completed every year following catchment registration)

- Variable: Perform ongoing inspections using BMP RAM (2NDNATURE et al. 2009) and Road RAM (2NDNATURE et al. 2010) within the catchment in accordance with the accepted CCS.
- Winter: Submit the annual stormwater report for each catchment, including the annual credit declaration based on inspection and maintenance activities.

Water quality improvement actions implemented within a catchment may include water quality improvement projects (WQIPs or capital and redevelopment projects), private parcel BMP implementation, road maintenance practices for water quality, or any other pollutant control actions that can be shown to reduce pollutant loading from urban areas. WQIPs result in the construction of stormwater treatment BMPs that will require annual condition assessments using BMP RAM or an equivalent method to verify acceptable maintenance and performance over time. Road condition assessment tools have been developed for implementation on the jurisdictional scale and require a number of observations over the year using Road RAM or an equivalent method. These jurisdiction scale results can be directly used to fulfill road condition inspection requirements for all registered catchments.

Tables D.1 presents an estimated level of effort (staff hours) for completion of the tasks described above for a single catchment. Estimates in Table D.1 are separated by completed and planned WQIPs, recognizing that completed WQIPs (e.g., implemented pre-2011) will likely require more effort to perform the initial tasks than future WQIPs. Completed WQIPs may lack information in a format consistent with the Crediting Program requirements and in some cases current staff may not be familiar with past WQIPs, thus more time is expected to complete the initial tasks. The staff hours to complete the ongoing annual tasks of inspections (BMP RAM) and reporting are expected to be the same for both completed and planned WQIPs in Table D.1.

Table D.1. Per Catchment Hours Associated with Crediting Program Inspection and Reporting Tasks[1]

Timing	Description of Tasks	Frequency	Estimated Average Staff Hours per Catchment	
			Completed WQIPs (2004-2010)	Future WQIPs (2011-2016)
Registration	Finalize Inventory and Load Reduction Estimate; Complete CCS & Supporting Products including A&T Tool Data Entry; Complete Verification Meeting	1x	80	60
Total Personnel Hours for Initial Crediting Program Inspection and Reporting Tasks			**80**	**60**
Summer	BMP RAM observations	Every Year	15	15
Winter	Annual Stormwater Reporting	Every Year	10	10
Total Personnel Hours for Ongoing Annual Crediting Program Inspection and Reporting Tasks			**25**	**25**

[1] Time estimates modified from hours provided by Environmental Incentives and originally based on information from urban jurisdictions participating in the Crediting Program Support Services.

The following should be noted regarding the estimates shown in Table D.1:

- The level of staff effort per catchment is assumed to decrease as more catchments are registered by a jurisdiction and staff becomes more familiar with the Crediting Program process. The hours in Table D.1 are considered average levels of effort for experienced staff.
- Actual staff hours to complete Crediting Program tasks for a specific urban catchment may differ from the averages presented based on the size of the urban catchment. Larger catchments (>100 acres) will mean a larger area to analyze in GIS, likely more stormwater infrastructure to inventory, and a more complex PLRM model to create; all of which will increase the total data management requirements for the catchment. Smaller catchments (<50 acres) will likely require less staff hours to complete all associated Crediting Program tasks.
- The hours associated with initial Crediting Program inspection and reporting tasks are not all-inclusive of the hours required to identify, design, and construct a water quality improvement project. The estimates in Table D.1 represent the additional hours necessary to complete the work associated with the Crediting Program, and assume that PLRM is being used in the identification of the recommended project alternative.
- The hours associated with the ongoing annual Crediting Program tasks are all-inclusive and reflect the estimated time to complete the condition tracking and reporting requirements of the Crediting Program.
- Hour estimates assume the development of the Tahoe Stormwater Tools Integration System, which will improve the data input and output interface between the A&T Tool, BMP RAM, and Road RAM and reduce the need for data entry replication between these tools. The improved interaction between these tools will greatly improve the jurisdiction's efficiency at completing the tasks shown in Tables D.1 and D.2.

Road RAM is not included in Table D.1 because Road RAM is intended for implementation at a jurisdictional scale and not the urban catchment scale. Table D.2 presents the estimated staff hours associated with the implementation of Road RAM on the larger jurisdiction scale. As previously stated, PLRM was not developed to efficiently estimate and integrate load reductions that may be achieved on a jurisdiction-wide scale. A defensible and efficient process for registering jurisdiction wide load reduction credits will need to be negotiated between the LRWQCB and the jurisdictions to allow for appropriate credits to be assigned.

Table D.2. Estimated Staff Hours Associated with Jurisdiction-Wide Implementation of Road RAM

Timing	Description of Tasks	Frequency	Estimated Staff Hours
Registration	Finalize Inventory and Load Reduction Estimate; Complete CCS & Supporting Products including A&T Tool Data Entry; Complete Verification Meeting	1x	80
Total Personnel Hours for Initial Crediting Program Inspection and Reporting Tasks			**80**
Throughout Year	Road RAM observations	Every Year	125[1]
Winter	Annual Stormwater Reporting	Every Year	10
Total Personnel Hours for Ongoing Annual Crediting Program Inspection and Reporting Tasks			**135**

[1] Road RAM observations are averaged on 5-year increments to account for the level of effort associated with one calibration year and 4 check up years (see Part II of the Road RAM User Manual; 2NDNATURE et al. 2010).

In order to run a responsive and effective TMDL implementation program, it is recommended that two staff members within a jurisdiction devote a portion of their time assigned to TMDL activities with the following roles: 1) stormwater program manager; and 2) stormwater technical analyst. The following responsibilities are envisioned for each position:

- The stormwater program manager would be responsible for oversight and implementation of the TMDL Strategy, including facilitating the necessary programmatic shifts within a jurisdiction to ensure a successful program. The stormwater program manager would be responsible for overseeing jurisdictional progress towards meeting TMDL milestones, meeting with regulators as necessary to review the requirements of the TMDL, and adaptively managing the TMDL Strategy as implementation progresses to ensure the jurisdiction remains on track to meet TMDL milestones.
- The stormwater technical analyst would assist the program manager and would be proficient in GIS, Microsoft Access, PLRM, BMP RAM, Road RAM, and A&T Tool. The technical analyst would complete a majority of the initial tasks for each registered catchment, as well as oversee the work associated with the implementation of Road RAM and BMP RAM, including field verification of the infrastructure inventory and condition observations. The stormwater technical analyst would complete ongoing annual tasks, with assistance from the program manager, to ensure a tight feedback loop between management decisions and verification of acceptable conditions and credit award.

ACTIONS 1 AND 2 – REGISTER WQIPS (SEE TABLES 5.2 AND 5.3)

DESCRIPTION

Action 1 involves registering completed WQIPs from 2004-2011. Action 2 involves registering WQIPs planned for construction by 2016, where registration occurs after construction is completed. A total of 18 WQIPs are currently associated with Actions 1 and 2 for Placer County, as shown in Table 4.5 in Chapter 4.

WATER QUALITY PERFORMANCE ESTIMATE

The FSP load reduction estimates for Actions 1 and 2 were developed from the analyses contained in Chapter 4, which is summarized in Table 4.6.

PROJECT / ACTION DELIVERY COST ESTIMATE

Placer County provided actual and estimated costs for the 18 WQIPs associated with Actions 1 and 2, which are summarized in Table 4.7 in Chapter 4. Actual and estimated costs for project delivery include planning, environmental documentation, permitting, design, acquisitions and construction costs. Project delivery costs associated with Action 1 have been expended as of 2011, but are included in Tables 5.2 and 5.3 because the associated WQIPs are eligible for Lake Clarity Credits and therefore will be a cost associated with meeting TMDL milestones once these WQIPs are registered.

O&M COST ESTIMATE

Operations and Maintenance (O&M) costs were estimated using the approach described below, which is summarized in Table D.3.

1. The analysis adapted average annual O&M cost estimates available from the Pollutant Reduction Opportunities (PRO) Report (LRWQCB and NDEP 2008b), which are organized by TMDL Setting and Treatment Tier.
2. The location of each WQIP listed in Table D.3 was cross-referenced with the TMDL Setting layer in GIS to define the applicable TMDL Setting for each WQIP (see *TMDL Setting Designations* in Table D.3).

3. The designated TMDL Treatment Tier for each WQIP was based on the project team's knowledge of the improvements associated with each WQIP (see *Assumed Type of TMDL Project* in Table D.3). Only the Kings Beach Commercial Core project was designated a Tier 2 project based on its planned used of extensive stormwater filtration devices.
4. The average O&M cost estimates in the PRO Report were adapted for this analysis using the following approach:
    a. The PRO Report lumps cost estimates for street sweeping into the overall O&M estimate. Costs associated with street sweeping were removed from Actions 1 and 2 because water quality road operations are considered separate actions in this analysis.
    b. O&M cost estimates were uniformly increased by 10% to better reflect assumed 2011 costs. (The PRO Report uses 2007 as its cost basis). Note that all projected costs in this report use a 2011 cost-basis and are not adjusted for inflation.
5. The area of each WQIP was multiplied by the unit area O&M cost to estimate average annual O&M costs for each WQIP (see *Adjusted TMDL Estimate of O&M Cost ($/Year)* in Table D.3).
6. The year of construction, or planned construction, was used to estimate the total O&M cost for each WQIP for the time period: 2011-2016. The annualized cost of Action 1 and Action 2 were calculated by summing the total O&M costs for all WQIP associated with each Action and dividing by six years.

AVERAGE ANNUAL CREDITING PROGRAM INSPECTION AND REPORTING COSTS

Crediting Program costs for Actions 1 and 2 are calculated based on the estimated average staff hours shown in Table D.1.

- Staff hours for completed WQIPs were summed for all WQIPs associated with Action 1.
- Staff hours for planned WQIPs were summed for all WQIPs associated with Action 2.
- A rate of $150/hour was used calculate total costs for each Crediting Program task. Placer County provided this fully burdened employee hourly rate estimate to the team.

The approach for estimating annual Crediting Program Costs is based on an assumed timing of catchment registration, which is described in the section: Crediting Program Inspection and Reporting Cost Estimate (First TMDL Milestone).

Table D.3. Actions 1 and 2 O&M Cost Estimate Assumptions

Water Quality Improvement Project Name	TMDL Setting Designations	Assumed Type of TMDL Project	Adjusted TMDL Estimate of O&M Cost ($/Year/acre)	Estimated Project Size (acres)	Adjusted TMDL Estimate of O&M Cost ($/Year)	Year Constructed or Estimated	Total (2011-2016) O&M Cost ($)
Tahoe Pines - Area B	Dispersed Steep	Tier 1	$87	5	$400	2007	$2,400
Tahoe Pines - Area C	Dispersed Steep	Tier1	$87	36	$3,100	2007	$18,600
Beaver Street	Concentrated Steep	Tier 1	$186	26	$4,800	2009	$28,800
Dollar Point	Concentrated Steep	Tier 1	$186	213	$39,500	2008	$237,000
Timberland	Dispersed Steep	Tier 1	$87	60	$5,200	2004	$31,200
Upper Cutthroat	Concentrated Steep	Tier 1	$186	9	$1,700	2004	$10,200
Fox Clean Water Pipe	Concentrated Steep	Tier 1	$186	n/a	$2,500	2010	$15,000
Tahoe Estates	Dispersed Steep	Tier 1	$87	205	$17,800	2009	$106,800
West Sunnyside I	Concentrated Steep	Tier 1	$186	111	$20,600	2010	$123,600
Lake Forest I	Dispersed Moderate	Tier 1	$54	51	$2,700	2010	$16,200
Lake Tahoe Park	Concentrated Moderate	Tier 1	$180	71	$12,800	2005	$76,800
						Action 1 Total (2011-2016):	**$666,600**
						Annual Average for Action 1 over six years:	**$111,000**
Tahoe Pines - Area A	Dispersed Moderate	Tier 1	$54	162	$8,700	2013	$26,100
Tahoe City Residential	Concentrated Moderate	Tier 1	$180	36	$6,500	2011	$32,500
West Sunnyside II	Concentrated Steep	Tier 1	$186	74	$13,700	2013	$41,100
Brockway	Concentrated Steep	Tier 1	$186	95	$17,600	2011	$88,000
Lake Forest II	Dispersed Steep	Tier 1	$87	103	$8,900	2012	$35,600
Lake Forest III	Concentrated Moderate	Tier 1	$180	130	$23,400	2014	$46,800
Kings Beach CCIP (Water Quality Component)	Concentrated Moderate	Tier 2	$1,356	68	$92,200	2015	$92,200
						Action 2 Total (2011-2016):	**$362,300**
						Annual Average for Action 2 over six years:	**$60,000**

ACTION 3 – IMPLEMENT BEST AVAILABLE TECHNOLOGY FOR ABRASIVE APPLICATIONS (SEE TABLES 5.2 AND 5.3)

DESCRIPTION

Action 3 assumes there is significant opportunity to improve road abrasive application strategies in Placer County to reduce the average annual mass of road abrasives applied without compromising traffic safety. Specific actions include:

1. Retrofitting all sanding trucks/plows with best available technology bulk spreaders to increase the efficiency of road abrasive applications (e.g., Epoke bulk spreaders or functionally equivalent equipment).
2. Switching road abrasive supplies to documented sources with high durability (i.e., resists pulverization into FSP) and no FSP contained in the abrasive source.

Action 3 was formulated to minimize the increase in annual O&M costs by recommending actions that may improve water quality through integration of best available technology without requiring a significant increase in maintenance personnel resources. Action 3 represents only a small shift in current road maintenance practices that would require procurement and installation of new equipment and procurement of potentially more expensive sources of road abrasives.

WATER QUALITY PERFORMANCE ESTIMATE

The following describes the methods and assumptions used to estimate the FSP load reductions associated with Action 3 using PLRM. To follow the terminology used, the reader will need to be familiar with the PLRM.

- Action 3 is applied to all roads in Placer County defined as either High Risk or Moderate Risk. Action 3 is not applied to Low Risk roads assuming road abrasives are never, or very rarely, applied to Low Risk roads.
- In PLRM, the road abrasive application strategy input in the Road Conditions Editor was changed from “Minimal Abrasive Control Measures” to “Moderate Abrasive Control Measures” for High Risk and Moderate Risk roads. This change in PLRM adjusts characteristic runoff concentrations (CRC) assigned to roads, and improves the estimated water quality in stormwater runoff from the roads relative to the Baseline Condition.
- A significant constraint on the analysis is that PLRM load reductions associated with changes in road abrasive application strategies are difficult to extrapolate to the jurisdictional scale because water quality performance will depend upon the presence, absence, and/or function of storm water treatment facilities downstream of the roads being modeled. To account for this constraint, and as a “factor of safety”, the load reduction extrapolation for Placer County was applied only to High Risk and Moderate Risk roads not within WQIP areas identified in Actions 1 and 2 to estimate the water quality benefit.
    - There are roughly 141 miles of roads in Placer County in the Tahoe Basin, which was calculated in GIS.
    - Of the 141 miles of roads, 68 miles were estimated in GIS to be within the boundaries of WQIPs identified in Actions 1 and 2 (see Figure 4.1).
    - The load reduction extrapolation for Action 3 was only applied to the 73 miles of road outside the boundaries of the WQIPs indentified in Actions 1 and 2 for High Risk and Moderate Risk roads.
    - Note that the above assumptions were made to provide a conservative estimate of water quality benefit. In actual practice, and for cost calculations, Action 3 is assumed to be applied to all roads in Placer County defined as either High Risk or Moderate Risk.

PROJECT / ACTION DELIVERY COST ESTIMATE

Action 3 project delivery costs totaling $750,000 (see Table 5.3) were calculated from the following assumptions:

- 1 best available technology bulk spreader costs approximately $100,000.
- 5 sanding trucks/plows would be retrofitted with the new bulk spreader.
- $250k in associated costs would be incurred to install and retrofit with new equipment; train maintenance personnel on proper equipment operation; and integrate the new equipment into current road maintenance practices.

O&M COST ESTIMATE

Action 3 O&M costs averaging $150,000/year (see Table 5.3) were calculated from the following assumptions:

- Best available technology bulk spreaders would not be more expensive to maintain relative to the existing equipment used.
- Better road abrasive sources would cost $50k more annually to procure relative to current abrasive sources.
- Given current uncertainties associated with the linkage between road operation improvements and resultant pollutant load reductions to Lake Tahoe, $100k annually is assumed necessary for performance monitoring of Action 3. The $100k estimate is assumed to be a grant funded component of Placer County's TMDL strategy that would assist other jurisdictions and the TMDL to better quantify the benefits of road operations and potential pollutant load reductions.

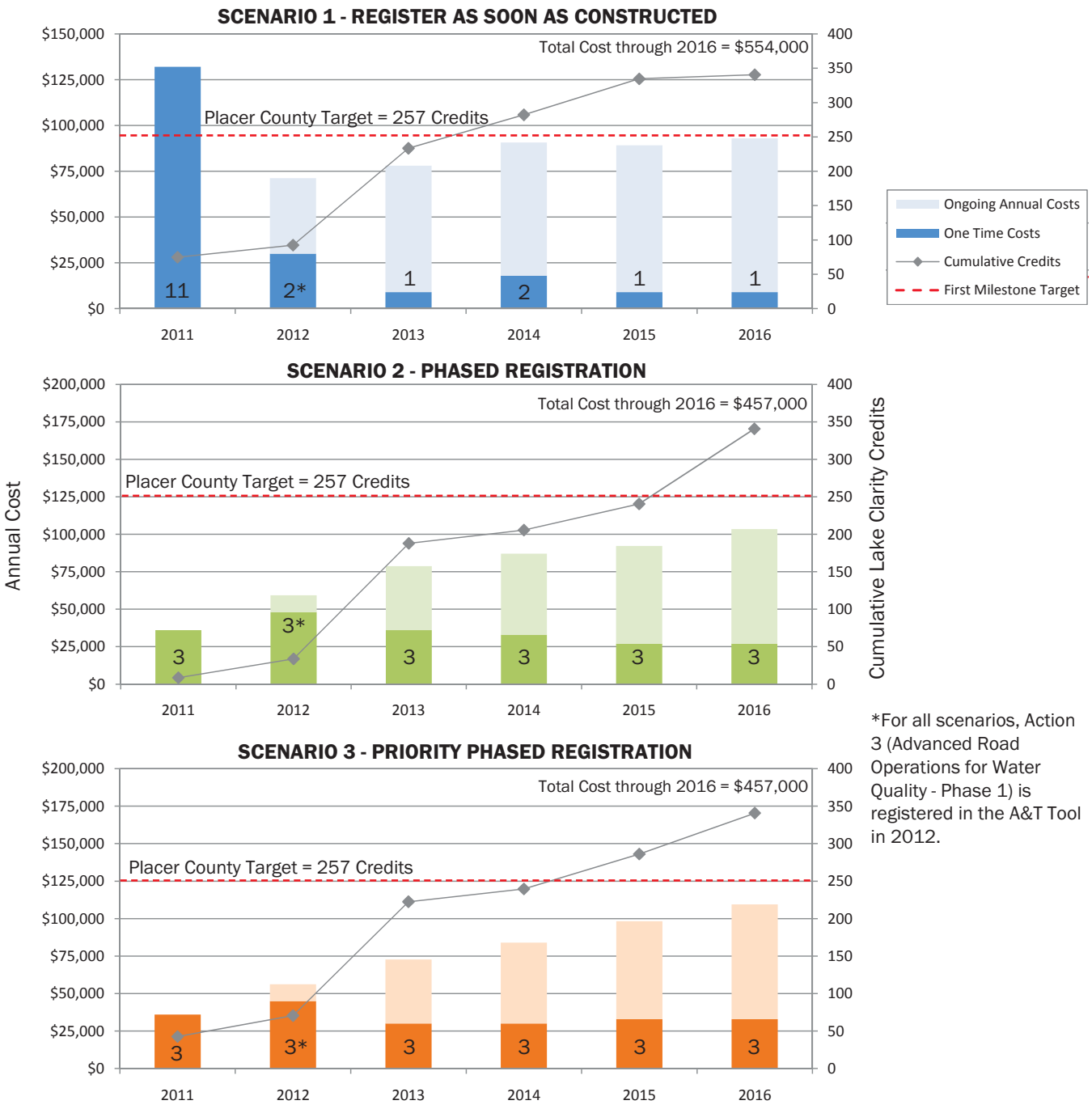
AVERAGE ANNUAL CREDITING PROGRAM INSPECTION AND REPORTING COSTS

Action 3 Crediting Program costs are calculated based on the hours associated with the implementation of Road RAM (see Table D.2). A rate of $150/hour was used calculate total costs for each Crediting Program task. Placer County provided this fully burdened employee hourly rate estimate to the team.

The approach for estimating annual Crediting Program Costs is based on an assumed timing of catchment registration, which is described in the section: Crediting Program Inspection and Reporting Cost Estimate (First TMDL Milestone).

CREDITING PROGRAM INSPECTION AND REPORTING COST ESTIMATE (FIRST TMDL MILESTONE; SEE TABLE 5.3)

The costs associated with implementation of the Crediting Program are highly dependent on the timing of catchment registration in the A&T Tool. Once a catchment is registered, the ongoing annual costs associated with condition tracking and annual stormwater report submission are incurred each subsequent year in which credits are awarded. Therefore Placer County must balance the need to demonstrate progress towards the TMDL load reduction milestones with the costs associated with the Crediting Program reporting requirements. To illustrate the cost and load reduction considerations, Figure D.1 presents 3 potential registration scenarios for Actions 1-3. For each scenario, total annual costs are shown as the sum of the initial costs associated with analyzing and registering new catchments (darker shade) and ongoing annual costs (lighter shade) and the number of catchments registered per year is provided. The cumulative credits over time associated with the each registered pollutant load reduction action are also shown, as well as the Placer County first TMDL milestone target of 257 Lake Clarity Credits.



*For all scenarios, Action 3 (Advanced Road Operations for Water Quality - Phase 1) is registered in the A&T Tool in 2012.

For each scenario the total annual costs and cumulative credits achieved are shown for 2011-2017. Annual costs include one-time costs (darker shade) and ongoing annual costs (lighter shade). Number of catchments registered per year (black text) and credits required by Placer County to meet the First TMDL Milestone (dashed red line) are shown for reference.

Scenario Descriptions

Note: All scenarios assume Action 3 (Advanced Road Operations for Water Quality - Phase 1) is implemented in 2012, and ongoing annual costs are incurred every year following catchment registration.

Scenario 1 - WQIPs are registered in the year following their construction (see Table 4.2). All currently completed projects are registered in 2011.

Scenario 2 - WQIP registration is evenly spaced over 6 years. Registration is prioritized chronologically in order of implementation (see Table 4.2) with older projects registered first.

Scenaro 3 - WQIP registration is evenly spaced over 6 years. Registration is prioritized by estimated load reduction (see Table 4.5) with higher load reductions registered first.

FIGURE D.1 HYPOTHETICAL FINANCIAL SCENARIOS TO REACH FIRST TMDL MILESTONE

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The following describes the 3 examples used to illustrate potential registration scenarios for Placer County's implementation of the TMDL Strategy:

Scenario 1 – All Action 1 WQIPs are registered in 2011 and Action 2 WQIPs are registered in the year following their construction (see Table 4.2). Action 3 is implemented in 2012. The total cost of this scenario through 2016 is $554,000, or an average annual cost of $92,000, and Placer County meets the first TMDL milestone in 2014.

Scenario 2 – Registration of the WQIPs is evenly spaced from 2011-2016 at a rate of 3 catchments per year and catchments are registered in chronological order based on construction completion (see Table 4.2). Action 3 is implemented in 2012. The total cost of this scenario through 2016 is $457,000, or an average annual cost of $76,000, and the first milestone is met in 2016.

Scenario 3 - Registration of the WQIPs is evenly spaced from 2011-2016 at a rate of 3 catchments per year and catchment registration is prioritized by estimated load reduction as projects are implemented. Action 2 WQIPs are registered in the year following their construction (see Table 4.2), while Action 1 WQIPs yielding higher load reductions are registered first (see Table 4.5). Action 3 is implemented in 2012. The total cost of this scenario through 2016 is $457,000, or an average of $76,000, and the first milestone is met in 2015.

Given these 3 scenarios, it is recommended Placer County follow Scenario 3 with respect to catchment registration due to the cost savings of the approach while demonstrating compliance 1 year prior to the requirement. The timing of Scenario 3 also allows flexibility should funding limitations or other constraints delay progress in the future, or should Placer County not receive a full credit award in any registered catchment.

To calculate the total Crediting Program costs associated with the implementation of Actions 1-3, it was assumed a catchment registration strategy similar to Scenario 3 was implemented. Total Action 1 costs under Scenario 3 from 2011-2016 are $241,000; Action 2 costs are $123,200; Action 3 costs are $93,000, equaling a total of $457,000. The total action costs are averaged over the 6-year time period (2011-2016) to determine the average annual Crediting Program costs shown in Table 5.3 of $40,100; $20,500; and $15,500 for Actions 1, 2, and 3 respectively. The average annual cost of Crediting Program inspection and reporting costs is $76,000, or approximately 500 staff hours (assuming $150/hour).

ACTION 4 – ADVANCED ABRASIVE CONTROLS AND ADVANCED/FREQUENT SWEEPING (SEE TABLES 5.4 AND 5.5)

DESCRIPTION

Action 4 builds upon Action 3 to further reduce the average annual mass of road abrasives applied to Placer County roads without compromising traffic safety. Additionally, Action 4 targets aggressive road abrasive recovery operations (i.e., street sweeping) using best available technology street sweepers. Specific actions include:

1. Subscribing to a weather forecasting service or development of in-house meteorological expertise to increase the accuracy of storm forecasting to better target operational practices (e.g., deicing activities) to the type of storm and the timing of snowfall or rainfall.
2. Increasing use of deicers and other advanced technology (e.g., pavement temperature sensors) to optimize the amount of road abrasive material applied based on the type of storm event and the antecedent conditions.
3. Frequently sweeping streets with best available technology sweepers:
    a. After abrasive applications in winter (when possible)
    b. Monthly in summer

It should be noted that Action 4 as formulated requires a significant increase in annual O&M costs relative to current levels because it requires a significant increase in maintenance personnel resources and equipment costs.

WATER QUALITY PERFORMANCE ESTIMATE

The approach used to estimate the FSP load reduction for Action 4 is similar to the approach used for Action 3. Specifically, Action 4 was applied only to High Risk and Moderate Risk roads on the 73 miles of roads not associated with WQIPs in Actions 1 and 2 to estimate the water quality benefit. Note that this assumption was made to provide a conservative estimate of water quality benefit. In actual practice, and for cost calculations, Action 4 is assumed to be applied to all roads in Placer County defined as either High Risk or Moderate Risk.

The following modeling inputs were adjusted in PLRM to estimate pollutant load reductions attributed to Action 4:

- The road abrasive application strategy input in the Road Conditions Editor was changed from "Moderate Abrasive Control Measures" to "Advanced Abrasive Control Measures" for High Risk and Moderate Risk roads. This change in PLRM adjusts characteristic runoff concentrations (CRC) assigned to roads, and improves the estimated water quality in stormwater runoff from the roads relative to the Action 3 simulation.
- The Sweeping Effectiveness inputs in the Road Conditions Editor of PLRM were changed from TMDL Baseline Condition assumptions to:
  - Type of Sweeper = High Efficiency Vacuum Assisted
  - Sweeping Frequency = winter after abrasive application; summer monthly
- Note that the load reduction estimate shown in Table 5.4 for Action 4 is the incremental increase in load reduction relative to Action 3 based on the PLRM inputs described above.

PROJECT / ACTION DELIVERY COST ESTIMATE

The action delivery cost assumes a one-time procurement of two best available technology street sweepers at a total cost of $700,000. Replacement costs of best available technology sweepers are factored into the O&M cost estimate.

O&M COST ESTIMATE

The annualized O&M estimate for street sweepers is taken from Table 3.6 in Chapter 3. The $250,000 annual cost shown for advanced abrasive controls in Table 3.6 was reduced to $100,000/year for the annualized O&M estimate shown in Table 5.5. This adjustment was made because the Action 3 cost estimate partially accounts for costs associated with advanced abrasive controls.

AVERAGE ANNUAL CREDITING PROGRAM INSPECTION AND REPORTING COSTS

Registration of Action 4 would replace registration of Action 3. Therefore initial Crediting Program tasks (i.e., redefining the road maintenance practices and remapping road class within the jurisdiction) would be repeated based on Table D.2. Ongoing annual costs for conducting jurisdictional Road RAM assessments are included as a cost for Action 3 and are not included as a cost for Action 4. A rate of $150/hour was used calculate total costs for each Crediting Program task. Placer County provided this fully burdened employee hourly rate estimate to the team. The approach for estimating annual Crediting Program Costs is based on an assumed timing of catchment registration, which is described in the section: Crediting Program Inspection and Reporting Cost Estimate (Clarity Challenge Milestone).

ACTION 5 – INCREASED PRIVATE PROPERTY BMP IMPLEMENTATION (SEE TABLES 5.4 AND 5.5)

DESCRIPTION

Action 5 assumes that 100% BMP Implementation (or very near 100% BMP implementation) can be achieved for the CICU and MFR land uses in the urban catchments identified with the highest FSP loading rates, specifically Kings Beach, Lake Forest, Tahoe City and Homewood (see Figure 3.1). It is assumed that BMP implementation would be completed in these areas through a combination of redevelopment projects, integration of improvements with public WQIPs and stormwater utility fees, and targeted regulatory enforcement.

WATER QUALITY PERFORMANCE ESTIMATE

Baseline Condition PLRM models for the four urban areas identified above were modified with inputs of 100% BMP Implementation for the CICU and MFR land uses. The resulting load reduction from the PLRM simulations was tabulated and is shown in Table 5.4. Issues associated with double-counting load reductions are unlikely with this modeling representation because the targeted CICU and MFR land uses are predominantly adjacent to the lake and existing storm water treatment facilities are not treating most of the CICU and MFR runoff targeted.

PROJECT / ACTION DELIVERY COST ESTIMATE

Project delivery costs were taken from Table 3.9 in Chapter 3, which estimates that:

- CICU averages $50,000/acre for BMP implementation
- MFR averages $25,000/acre for BMP implementation

The total area of CICU and MFR land uses within the targeted urban areas was tabulated in GIS and the product of the tabulated area and average unit area cost was used to estimate the total project delivery cost of $9,950,000, specifically:

- 129 acres of CICU in targeted urban areas X $50,000/acre = $6,450,000
- 140 acres of MFR in targeted urban areas X $25,000/acre = $3,500,000

Typically private parcel BMP implementation and maintenance is neither a public cost nor the responsibility of the jurisdictions. Future cost sharing programs could be explored to increase the implementation of these cost-effective water quality improvement actions.

O&M COST ESTIMATE

O&M costs were assumed to be 3% of project delivery cost. A linear increase was used to annualize costs assuming a linear implementation of BMPs from 2017 to 2026. Using this methodology, the annualized cost estimate for private sector maintenance of BMPs is $165,000. An additional yearly amount of $125,000 was added to the annualized O&M cost estimate for one full-time Placer County position to support planning and implementation of private property BMPs in Placer County.

Estimated flow and load reductions achieved through the implementation of Action 5 appear to be significant, and there may be a need for Placer County to demonstrate continued performance of these water quality improvements. Eventually, Placer County may need to expand its stormwater outreach and education program beyond the single staff person proposed in this estimate to ensure proper maintenance of private parcel BMPs is conducted.

AVERAGE ANNUAL CREDITING PROGRAM INSPECTION AND REPORTING COSTS

Action 5 assumes the re-registration of 4 catchments (Kings Beach, Lake Forest, Tahoe City and Homewood) to account for 100% implementation of private parcel BMPs on CICU and MFR land uses. This change to the Catchment Credit Schedule is assumed to be minimal and require little staff effort (less than 1 day). Currently, there are no additional inspection and reporting requirements associated with the Crediting Program with respect to private parcel BMP implementation and the ongoing annual tasks are included in the continued reporting for Actions 1-3. A fully-burdened staff rate of $150/hour was provided by Placer County and assumed for cost calculations.

The approach for estimating annual Crediting Program Costs is based on an assumed timing of catchment registration, which is described in the section below: Crediting Program Inspection and Reporting Cost Estimate (Clarity Challenge Milestone).

ACTION 6 – CONSTRUCT NEW WQIPS (SEE TABLES 5.4 AND 5.5)

DESCRIPTION

Action 6 assumes continued implementation of public WQIPs targeting high priority FSP loading areas in Placer County. The scope and nature of WQIPs implemented within the time period of 2017-2026 is assumed to shift towards more projects with improvements similar to the TMDL Treatment Tier 2 level of water quality improvement. For the basis of the estimates it is assumed that Placer County constructs eight new WQIPs from 2017-2016.

WATER QUALITY PERFORMANCE ESTIMATE

Specific water quality performance estimates for WQIPs that have not been scoped are difficult and additional modeling analyses would require numerous assumptions and have a high degree of uncertainty. To provide an order of magnitude load reduction estimate for Action 6, the following simple approach was used:

- The estimated load reduction for all 18 WQIPs associated with Actions 1 and 2 was averaged, yielding an average FSP load reduction of 0.46% per WQIP implemented relative to the estimated baseline load for Placer County.
- Action 6 assumes that eight new WQIPs will be constructed between 2017 and 2026.
- Multiplying the average FSP load reduction per WQIP implemented by the number of WQIPs implemented yields a total FSP load reduction of 3.7% relative to the estimated baseline load for Placer County.

PROJECT / ACTION DELIVERY COST ESTIMATE

Project delivery costs were estimate using the following approach and assumptions:

- Future WQIPs will likely be more expensive to plan and construct relative to past WQIPs because opportunities for significant load reductions will diminish and WQIPs will likely focus on more densely developed urban areas that have significant constraints. Based on this assumption, the average project delivery cost for all planned WQIPs for Action 2 (see Table 4.7) was used to estimate a future average WQIP cost, which yielded a cost of $5,000,000 per WQIP. Average project size was estimated at 40 acres, representing a unit cost of $125,000 per acre, consistent with the Pollutant Reduction Opportunity Report (LRWQCB and NDEP 2008b). Estimated project delivery costs on a per acre basis are thus significantly more expensive than pre-2011 projects and, on average, also more expensive than Action 2 WQIP unit costs.
- Action 6 assumes that eight new WQIPs will be constructed between 2017 and 2026.

- Multiplying the estimated average WQIP cost by the number of WQIPs implemented yields a total cost of $40,000,000.

O&M COST ESTIMATE

Operations and Maintenance (O&M) costs were estimated using the same approach used for Actions 1 and 2. For the eight WQIPs assumed to be implemented, four WQIPs were assumed to be Tier 1 type projects and four WQIPs were assumed to be Tier 2 type projects. Additional assumptions are shown in Table D.4.

Table D.4. Action 6 O&M Cost Estimate Assumptions

Water Quality Improvement Project Name	TMDL Setting Designations	Assumed Type of TMDL Project	Adjusted TMDL Estimate of O&M Cost ($/Year/acre)	Estimated Project Size (acres)	Adjusted TMDL Estimate of O&M Cost ($/Year)	Year Constructed or Estimated	Total (2011-2016) O&M Cost ($)
Project A	Dispersed Steep	Tier 1	$87	40	$3,500	2018	$28,000
Project B	Concentrated Steep	Tier 2	$1,169	40	$46,800	2019	$327,600
Project C	Concentrated Steep	Tier 1	$186	40	$7,400	2020	$44,400
Project D	Concentrated Moderate	Tier 2	$1,356	40	$54,200	2021	$271,000
Project E	Dispersed Steep	Tier 1	$87	40	$3,500	2022	$14,000
Project F	Dispersed Steep	Tier 2	$756	40	$30,300	2023	$90,900
Project G	Concentrated Steep	Tier 1	$186	40	$2,500	2024	$5,000
Project H	Concentrated Moderate	Tier 2	$1,356	40	$54,200	2025	$54,200
						Action 6 Total (2017-2026):	**$835,100**
						Annual Average for Action 6 over ten years:	**$84,000**

AVERAGE ANNUAL CREDITING PROGRAM INSPECTION AND REPORTING COSTS

Crediting Program costs are calculated based on the estimated average staff hours shown in Table D.1.

- Staff hours for planned WQIPs were summed for all WQIPs associated with Action 6 (see Table D.4).
- A rate of $150/hour was used calculate total costs for each Crediting Program task. Placer County provided this fully burdened employee hourly rate estimate to the team.

The approach for estimating annual Crediting Program Costs is based on an assumed timing of catchment registration, which is described in the section below: Crediting Program Inspection and Reporting Cost Estimate (Clarity Challenge Milestone).

CREDITING PROGRAM INSPECTION AND REPORTING COST ESTIMATE (CLARITY CHALLENGE MILESTONE)

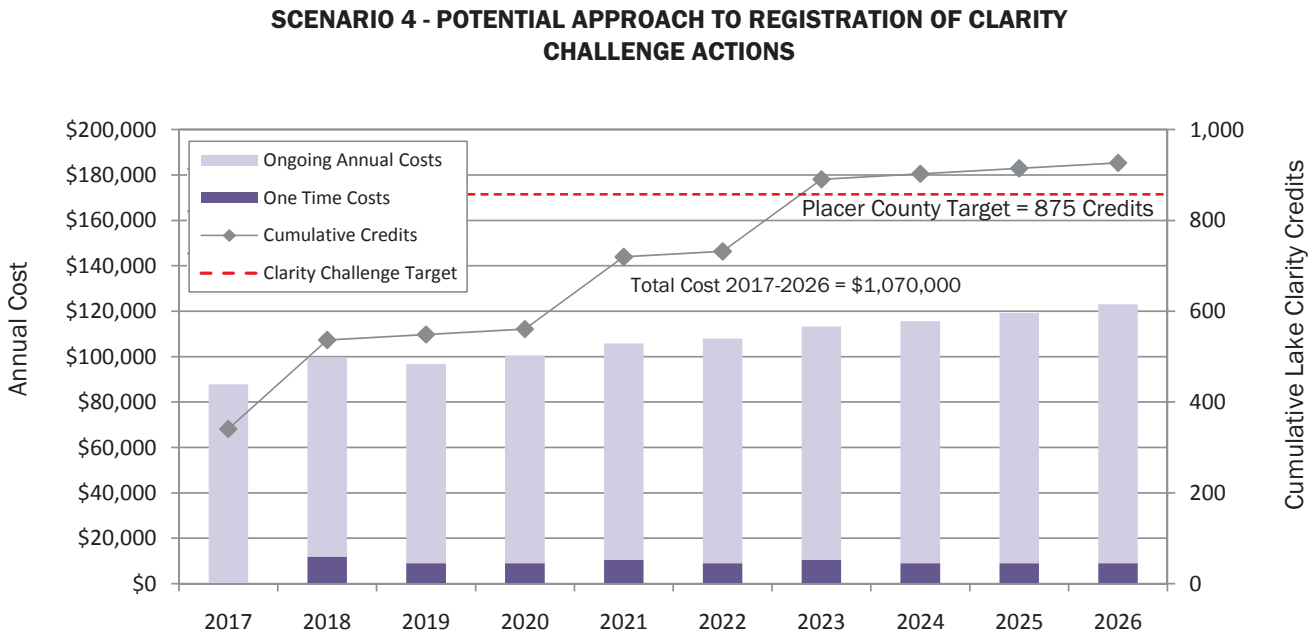
Figure D.2 presents a potential catchment registration strategy from 2017-2026 for Actions 4-6. Similar to Figure D.1, total annual costs are shown as the sum of the initial costs (darker shade) and ongoing annual costs (lighter shade) and the number of catchments registered per year is provided. The cumulative credits over time associated with the each registered pollutant load reduction action are also shown, as well as the Placer County Clarity Challenge TMDL milestone target of 875 Lake Clarity Credits.

The following describes the potential registration scenario shown in Figure D.2:

- The ongoing Crediting Program inspection and reporting tasks for Actions 1-3 will continue to be implemented annually in order for the jurisdiction to receive the full credit award each year from 2017 through 2026. The annual tasks associated with the Crediting Program requirements are estimated to average $87,800 per year. These costs reflect the ongoing Credit Program inspection and reporting costs associated with the implementation and registration of 18 WQIP catchments (see Table D.1) and jurisdiction-wide implementation of Road RAM (see Table D.2).
- Action 4 is implemented in 2018.
- Action 5 is implemented in 2 catchments in 2021 and 2 more in 2023. The 294 credits associated with the implementation of Action 5 are assumed to be equally divided across the 4 catchments.
- Action 6 is implemented at a pace of 1 catchment per year starting in 2019. It is assumed there would be some necessary lead time in planning these projects, given the increase site constraints. The 96 credits are assumed to be equally divided across the 8 WQIPs.

This registration strategy is presented for illustrative purposes only to assist Placer County with the long-term planning of its TMDL Strategy. If this hypothetical catchment registration strategy was implemented, Placer County would achieve the Clarity Challenge milestone in 2023. The total Crediting Program cost from 2017-2026 under this hypothetical scenario would be $1.1 million, or $107,000 annually over the 10-year time period (2017-2026), which is equivalent to approximately 700 staff hours per year (assuming $150/hour).

With this scenario, total Crediting Program inspection and reporting costs for the ongoing implementation of Actions 1-3 would be $878,000; Action 4 costs would be $12,000; Action 5 costs would be $3,000; and Actions 6 costs would be $177,000. These total Crediting Program inspection and reporting costs are averaged over the 10-year time period (2017-2026) to determine the average annual Crediting Program inspection and reporting costs for that time period and are shown in Table 5.5 at $87,800; $1,200; $300; and $17,700 for Actions 1-3, 4, 5, and 6 respectively. It is likely that cost efficiencies and streamlining will occur during the initial 5-year period that will reduce the Crediting Program inspection and reporting costs during this period and would thus reduce the overall and average costs.



Total annual costs and cumulative credits achieved are shown for 2017-2026. Annual costs include one-time costs (darker shade) and ongoing annual costs (lighter shade). Credits required by Placer County to meet the Clarity ChallengeTMDL Milestone (dashed red line) are shown for reference.

Description of Approach

Actions 1-3 are maintained throughout time frame.

Action 4: Advanced Abrasive Control and Advanced/Frequent Sweeping is implemented in 2018.

Action 5: Increased Private Property BMP Implementation is implemented in 2 catchments in 2021 and 2 more catchments in 2023.

Action 6: Construct New WQIPs is implemented at a pace of 1 catchment per year from 2019 through 2026.

FIGURE D.2 HYPOTHETICAL FINANCIAL SCENARIO TO REACH CLARITY CHALLENGE MILESTONE