San Diego Region Bacteria Total Maximum Daily Loads

Cost-Benefit Analysis

Work Plan

Circulate for public review

Version 0.8

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INTRODUCTION AND APPROACH OVERVIEW

San Diego's coastline and water resources are crucial to its attractiveness and economic vitality. Decisions to further enhance water quality and public health incur significant costs, but also may provide substantial benefits, and therefore warrant careful consideration. These decisions are informed by an analysis indicating the community's ability to pay for the current implementation schedule. This work plan describes these decisions, the structure of these analyses, anticipated analytic methods and expected results.

BACKGROUND

The California Regional Water Quality Control Board, San Diego Region (San Diego Regional Board) and a coalition of governmental and non-governmental entities (Steering Committee) are seeking an environmental Cost-Benefit Analysis (Environmental CBA or CBA) to evaluate the costs and benefits of meeting numeric fecal indicator bacteria targets established by the 2010 Bacteria Total Maximum Daily Load for Beaches and Creeks in the San Diego Region (Bacteria TMDL) (Map 1)[1,2]. Programs and actions to achieve TMDL compliance are costly both in terms of financial costs of capital investment and maintenance as well as opportunity costs associated with other investments foregone, but also provide multiple benefits to the community. CBA results will be used by the Steering Committee members to inform policy decisions.

ANALYSIS STRUCTURE: POLICY DECISIONS AND SCENARIOS

The Steering Committee has structured this economic analysis around a set of policy decisions which are informed by analytic scenarios. The primary policy decisions are

- Adjust bacteria regulatory endpoints;
- Adjust strategy for achieving bacteria load reductions;
- Change schedule of compliance.

Each policy decision has potentially significant ramifications related to the way water quality objectives are achieved and the costs to achieve them. In addition to the scenarios, additional economic analyses beyond the technical boundary of cost-benefit analyses are included in this effort. The structure of this analysis is presented in Figure 1, including policy decisions as green boxes, scenarios as dark blue boxes, additional analyses in light blue boxes and anticipated results in grey boxes. Each element of the analysis structure is further described after Figure 1.

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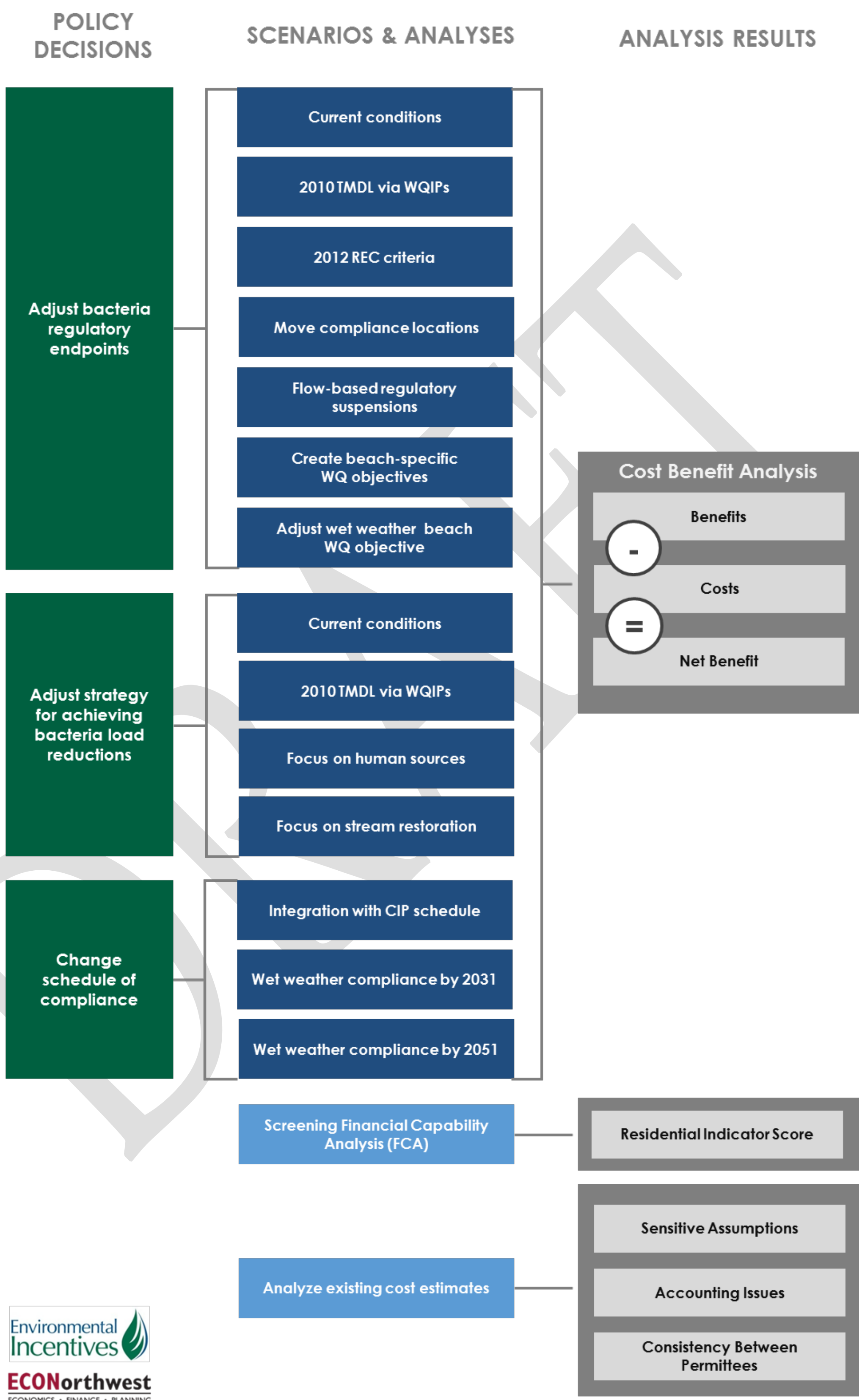
[1] Odermatt, John. *Revised Total Maximum Daily Loads for Indicator Bacteria Project I – Twenty Beaches and Creeks in the San Diego Region (Including Tecolote Creek)FINAL TECHNICAL REPORT February 10, 2010*. Tech. California Regional Water Quality Control Board San Diego Region, 10 Feb. 2010. Web. <http://www.waterboards.ca.gov/sandiego/water_issues/programs/tmdls/docs/bacteria/updates_022610/2010-0210_Final_Technical_Report.pdf>.

[2] Barker, David T. *Total Maximum Daily Loads for Indicator Bacteria Project I – Beaches and Creeks in the San Diego RegionFINAL TECHNICAL REPORT December 12, 2007*. Tech. California Regional Water Quality Control Board San Diego Region, 12 Dec. 2007. Web. <http://www.waterboards.ca.gov/sandiego/water_issues/programs/tmdls/docs/bacteria/update121207/finaltechrpt.pdf>.

Figure 1 – Policy Decisions, scenarios and anticipated results that form the structure of this economic analysis



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Map 1- Study Area showing Bacteria TMDL watersheds

POLICY DECISION: ADJUST BACTERIA REGULATORY ENDPOINTS

Bacteria regulatory endpoints are described in the Bacteria TMDL and each permittee's approach for achieving these endpoints is established in its WQIPs. The analysis will provide insight into the costs and benefits of current conditions and TMDL compliance. These regulatory endpoints can be adjusted in several ways, as represented by the associated scenarios. Each scenario associated with the policy decision will be described in terms of differences from the TMDL. For each scenario within the policy decision, except the current conditions scenario, compliance is achieved through implementation of best management practices (BMPs) identified in the WQIPs. BMPs represent all considered load reduction strategies. The current conditions scenario is based on current BMPs. Costs and benefits of BMP implementation will inform CBA analysis results. Based on analysis results, in combination with technical and field studies, the regulators can determine whether it is appropriate to adjust compliance endpoints.

FOR THE PURPOSE OF THIS REPORT **BEST MANAGEMENT PRACTICES (BMPS)** INCLUDE ANY STRUCTURE, ACTION OR PROGRAM UNDERTAKEN WITH THE INTENT OF REDUCING BACTERIA LOADS TO SURFACE WATERS

Current Conditions

Economic analysis requires a well-defined baseline for identification and measurement of the marginal or incremental effects of new policies and actions.[3] Because economic analyses must consider effects over the full lifespan of actions and investments, baseline definition must extend into the future as well. Analyzing changes resulting from scenarios, such as improvements in water quality, costs of compliance and noncompliance, requires information on baseline conditions for each area of benefit or cost. This analysis uses current conditions extended into the future, to measure change against. For example, the costs and benefits of reducing bacteria loading as required by the WQIP of the TMDL is compared to the costs and benefits associated with bacteria levels under current conditions. Current conditions are defined as the 2014-2015 period over which Surfer Health Study and other monitoring data was collected. This period was chosen based on the availability of data relating risk of illness and recreation from the Surfer Health Study.

While establishment of an understanding of current conditions to support scenario analysis will entail quantification of certain benefits and costs, this scenario does not include a definition of some specific set of actions and outcomes that were historically necessary to arrive at the current set of water quality conditions. This analysis will describe current conditions and the baseline in detail, but not fully value all benefits and costs that have arisen through regional water quality improvement investments to-date.

Current conditions analyses will include consideration of likely effects of climate change on regional storm timing, frequency and severity as well as temperature. Such changes will influence the timing and frequency of wet weather events with bacteria/pathogen levels above background, and the demand for activities at beaches that can result in exposure risk. Numerous studies exist to consider the regional effects of climate change, including the San Diego Foundation's 2050 Study[4]. The project team will also review any future scenario assumptions with respect to climate change with appropriate regional climate experts associated with the National Oceanic and Atmospheric Administration and the Center for Climate Change Impacts and Adaptation at the Scripps Institute of Oceanography at UC San Diego.

Scenario: 2010 TMDL via WQIPs

This scenario estimates the costs and benefits of complying with the water quality standards for bacteria outlined in the 2010TMDL via the WQIP approach. Bacteria levels have historically exceeded water quality standards. For San Diego the TMDL represents the maximum amount of bacteria (fecal coliform, total coliform, and enterococcus) that waterbodies (20 identified beaches and creeks, Dana Point, Baby Beach, and Shelter Island) in the San Diego region can receive and still attain water quality standards. To provide reasonable assurance that water quality objectives identified in the TMDL are achieved, WQIPs outlining numeric water quality goals, schedules for achieving these goals, and water quality improvement strategies have been developed and approved. Examples of compliance strategies include structural and nonstructural BMPs, such as engineered systems designed to remove pollutants or management programs to reduce pollutant loading. BMPs identified in the WQIPs focus exclusively on remediation of stormwater loading sources rather than on other human sources.

[3] See Chapter 5 for full discussion of baseline considerations in U.S. Environmental Protection Agency. 2014. Guidelines for Preparing Economic Analyses. May. http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html.
[4] San Diego Foundation. 2009. San Diego's Changing Climate: A Regional Wakeup Call.

Scenario: 2012 REC criteria

USEPA 2012 recreational water contact (REC-1) criteria recommendations are intended to protect people recreating at beaches and creeks from exposure to water that contains organisms that indicate the presence of fecal contamination (Enterococci and E. coli).[5] REC-1 standards apply to uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible, such as swimming or other water sports. EPA criteria recommend an acceptable health risk of 32 to 36 illnesses per 1,000 exposed individuals. The State of California is considering implementing the EPA's recommendations at the level of 32 illnesses. Therefore, for this analysis an acceptable health risk level of 32 illnesses was chosen. This is less than the 36 illnesses per 1,000 exposed individuals that was the basis for the FIB concentrations criteria used in the 2010 Bacteria TMDLs and, in turn, used to develop the proposed compliance strategies presented in the WQIPs. To meet the more stringent risk level of 32 illnesses additional load reductions are likely. Loading reductions will be achieved through implementation of stormwater BMPs identified in the WQIP. Reducing bacteria loading will likely increase costs and benefits.

Scenario: Move compliance locations

Final TMDL compliance is determined through sampling of bacteria concentrations at specific points along streams and along the ocean coastline. Maximum bacteria concentrations allowed in compliance sample results are currently established by AB 411. This scenario proposes moving the wet weather compliance points out of the creeks and the mouths of the river or from in front of the storm drain outfalls to downcoast to where winter recreation occurs on the ocean beaches. Therefore, the bacteria concentration in sample results will be more representative of recreation exposure. As a result, samples collected will be more likely to represent health risk. Further, this scenario will consider an ocean mixing zone at the creek mouths or at those storm drains that discharge to the ocean in cases where people recreate at these locations during wet weather. The requirement for bacteria loading is not changed, but concentrations at sampling points in the mixing zone will likely be lower than at current sampling points due to dilution. As a result, samples collected from the mixing zone are more likely to be in compliance. Therefore, fewer BMPs from the WQIPs will need to be implemented to meet the TMDL and costs will be lower.

Scenario: Flow-based regulatory suspensions

Under this scenario, during dry weather conditions when low or intermittent stream flow from the creek into the ocean would be minimal or non-existent a low flow suspension would apply. This analysis assumes regional creeks under dry weather conditions, except for Peñasquitos Creek, could not support recreational uses. Therefore, compliance with REC-1 requirements is suspended during low-flow periods because negligible load is delivered and risk of exposure is low. As a result, compliance costs may be lower due to periods of time where compliance requirements are suspended.

On days when rainfall is greater than or equal to a 0.5 inch as measured at the nearest local rain gauge high flow suspension applies for the day precipitation occurred and 24 hours following the rain event. Compliance with REC-1 requirements are suspended in during high-flow periods in engineered channels, defined as inland, flowing surface water bodies with a box, V-shaped or trapezoidal configuration that have been lined on the sides or bottom with concrete.[6] Bacteria loading

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[5] *Recreational Water Quality Criteria*. Tech. EPA OFFICE OF WATER 820-F-12-058, 26 Nov. 2012. Web. <https://www.epa.gov/sites/production/files/2015-10/documents/rwqc2012.pdf>.

[6] United States. Regional Water Quality Control Board. Los Angeles Region.*Non-Regulatory Amendments to the Water Quality Control Plan for the Los Angeles Region to Administratively Update Chapter 2 "Beneficial Uses" by Incorporating*

may increase, but the concentration of bacteria will decrease and the risk of exposure is low because recreation will be minimal. Recreation during large storm events would be hazardous due to dangerous flow conditions. High flow suspension exemptions reduce the calculated wet weather load reduction based on the number of wet weather days in the representative year that exceed a particular flow value. Therefore, fewer or less extensive BMPs from the WQIPs could be implemented to achieve compliance resulting in lower costs.

Scenario: Create beach-specific WQ objectives

Current water quality standards (WQS) are based on regional standards established in the Basin Plan. Using Surfer Health Study data, scientifically defensible site-specific load reduction goals and methods would be established for two beaches (Ocean Beach and Tourmaline). As a result, WQS are established at Ocean Beach and Tourmaline based on conditions specific to these beaches instead of regional trends. Permittees are then able to select BMPs from the WQIPs based on targeted water quality improvements in a specific sub watershed.

Scenario: Adjust wet weather beach WQ objective

Current WQS are based on regional standards established in the Basin Plan. Using Surfer Health Study data for two beaches (Ocean Beach and Tourmaline) scientifically defensible load reduction goals would be established. These WQS based on beach conditions would then be applied to all beaches north of the City of Imperial Beach in the San Diego region instead of using WQS based on older data.

POLICY DECISION: ADJUST STRATEGY FOR ACHIEVING BACTERIA LOAD REDUCTIONS

Strategies for achieving bacteria load reductions described in the WQIP emphasize the reduction of stormwater loading sources. Loading reduction strategies could focus on other sources of bacteria, not typically addressed by stormwater agencies activities which may be more effective or more readily fundable. Fecal indictor bacteria (indicator bacteria) such as enterococcus are commonly used for monitoring water quality at marine beaches. Indicator bacteria do not cause human illness, but are used as indicators or surrogates of human fecal contamination because they are found in sewage at high concentrations, are relatively easy and cheap to measure in the laboratory, and co-occur with the human pathogens found in sewage that do cause illness. Both human and nonhuman fecal sources contain indicator bacteria, but scientists agree that sources of human waste are the highest risk to human health.[7]

During rain events and the following three days water quality monitoring results from San Diego River and Tourmaline Creek, located within the footprint of the bacteria TMDLs, indicate that there is human waste in discharges to the ocean. The sources of human waste could be from transient encampments, failing septic systems, leaking wastewater collection systems and illegal discharges to the storm drain system such as recreational vehicle discharges. The WQIPs focus on activities and projects to manage

Previously Adopted Amendments, and Updated Surface and Groundwater Maps and Corresponding Beneficial Use Tables. N.p.: n.p., n.d. Print. Regional Board Resolution No. R03-010.

[7] Soller, Jeffrey A., Mary E. Schoen, Timothy Bartrand, John E. Ravenscroft, and Nicholas J. Ashbolt. "Estimated Human Health Risks from Exposure to Recreational Waters Impacted by Human and Non-human Sources of Faecal Contamination." *Water Research* 44.16 (2010): 4674-691. Science Direct, 25 June 2010. Web. <http://www.waterboards.ca.gov/centralcoast/water_issues/programs/enforcement/docs/carp_wwtp_acl_15_0011_docs/Exh_19_thru_22.pdf>.

pollutant sources and flows from land runoff conveyed by the stormwater system. Since scientists agree that sources of human waste are the highest risk to public health (USEPA, 2012; Soller, 2010), implementation could focus on addressing human sources first. Costly retrofits of the stormwater system proposed in the WQIPs may not improve public health. Focusing work directly at the source of the sewage may be more efficient. Based on analysis results the co-permittees and regulators can determine whether it is appropriate to implement a scenario other than the current WQIPs.

Scenario: 2010 TMDL via WQIPs

This scenario estimates the costs and benefits of complying with the water quality standards for bacteria outlined in the 2010 TMDL via the WQIP approach. Wet weather bacteria levels have historically exceeded water quality standards. For San Diego the TMDL represents the maximum amount of bacteria (fecal coliform, total coliform, and enterococcus) that waterbodies (20 identified beaches and creeks, Dana Point, Baby Beach, and Shelter Island) in the San Diego region can receive and still attain water quality standards. To provide reasonable assurance that water quality objectives identified in the TMDL are achieved, WQIPs outlining numeric water quality goals, schedules for achieving these goals, and water quality improvement strategies have been developed and approved. Examples of compliance strategies include structural and nonstructural BMPs, such as engineered systems designed to remove pollutants or management programs to reduce pollutant loading. BMPs identified in the WQIP focus exclusively on remediation of stormwater loading sources rather than on other human sources such as sewage, septic and transient encampments.

Scenario: Focus on human sources

This scenario estimates the costs and benefits of meeting bacteria water quality standards by addressing multiple human loading sources including leaking sewer lines and septic systems, and transient encampments instead of addressing traditional stormwater pollutant sources as is the case with the WQIPs.

Transient encampments are both a source of bacteria, and at risk of exposure to bacteria in creeks. Cleaning up transient encampments will reduce the loading of human fecal bacteria into waterways. Load reduction costs for transient encampment sources may be lower than the WQIP implementation scenario if these sources are easier to control than those examined in the WQIPs. There may be relatively large human health and non-water quality benefits in this scenario.

Leaking sewage and septic systems are sources of human pathogens that are prohibited from entering surface waters, but when they do, they represent a higher threat to public health than other sources of fecal indicator bacteria that are typically targeted by storm water managers. It is unlikely for stormwater BMPs to reduce loading from wastewater sources. Therefore, focusing on sewage and septic systems can potentially be more efficient than traditional storm water program efforts.

Scenario: Focus on stream restoration

Stream channel protection could be included with new development as a preventative measure to decrease the need for traditional treatment BMPs. Additionally restoration efforts could replace a portion of traditional BMP installation for remediating bacteria loading in creeks from stormwater runoff[8]. Co-benefits of stream restoration such as reduction of nutrients and improvements in recreation will be considered. Stream restoration costs for initial implementation in addition to continued maintenance efforts will be compared to traditional BMP costs. Load reduction potential of the scenarios will also be compared. Modeling of residence time, deposition, and resuspension of pathogens will be required to understand load reduction potential. Comprehensive stream restoration has been identified as an important, but not mandatory component of this CBA. Therefore, if schedule or budget constraints require elimination of analysis scenarios from the CBA, comprehensive stream restoration may be evaluated through literature studies, or may be removed.

POLICY DECISION: CHANGE SCHEDULE OF COMPLIANCE

The policy question considered by the Steering Committee is whether to adjust the timeline for implementation of wet weather bacteria load reduction efforts according to the TMDL. Scenarios for wet weather compliance schedules are compared in terms of both costs and benefits, and financial capability.

Dates for achieving compliance are established by the TMDL and implementation of compliance strategies are described in the WQIP. Thus this policy decision could be categorized with either of the previous policy decisions; however this potential decision is so important that it warrants clear focus in the analysis structure. Achieving TMDL compliance over an extended schedule will be analyzed in comparison to implementation according to the current schedule. Differences are compared on the basis of costs, benefits and residential indicator scores.

Scenario: Integration with CIP schedule

This scenario examines the costs and benefits of implementing BMPs in coordination with capital improvement projects (CIP). Implementation of BMPs at the same time as implementation of infrastructure projects according to the CIP schedule will reduce construction costs. For example, implementation of permeable pavement to reduce stormwater runoff could be installed in coordination with pavement repair according to the CIP schedule. As a result, pavement excavation and installation could be done for both projects simultaneously to eliminate the cost of multiple rounds of construction. Initial estimates for the timeframe necessary to glean a substantial savings are a 50 year extension of current compliance deadlines. This lengthened timeframe will also affect the distribution of costs and benefits over time and may adjust the net benefits calculated.

Scenario: Wet weather compliance by 2031

Wet weather conditions exist during storms with 0.2 inches of rainfall and for a 72 hour period after the storm. The TMDL has multipart wet weather numeric targets based on bacteria objectives in the REC-1 standard. Wet weather compliance is measured through load reduction achieved at flowing MS4 discharges to receiving waters as described in the WQIP. Bacteria compliance under wet weather conditions is required by 2031 according to the current TMDL schedule.

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[8] Myers, Monique and Ambrose, Richard F. (2015) "Salt Marsh Reduces Fecal Indicator Bacteria Input to Coastal Waters in Southern California," Bulletin of the Southern California Academy of Sciences: Vol. 114: Iss. 2. <http://scholar.oxy.edu/scas/vol114/iss2/2>.

Scenario: Wet weather compliance by 2051

The deadline to achieve wet weather compliance as described in the TMDL is extended to 2051. The extended compliance timeline may alter the costs and benefits of wet weather TMDL compliance. The timing or order that costs and/or benefits are realized may be altered under the extended timeframe. Additionally, discounting over the longer timeframe may alter calculations of costs and/or benefits. As a result, the total calculation of costs or benefits may be different over the longer timeframe.

Additional economic analysis: Screening Financial Capability Assessment (FCA)

The costs required to achieve bacteria compliance through implementation of BMPs can create an economic burden on the permittee complying. This scenario calculates Residential Indicators Scores (RIS) which are one portion of the analysis to determine the economic burden of compliance, financial capability assessment (FCA). FCA methodology is described by the EPA.

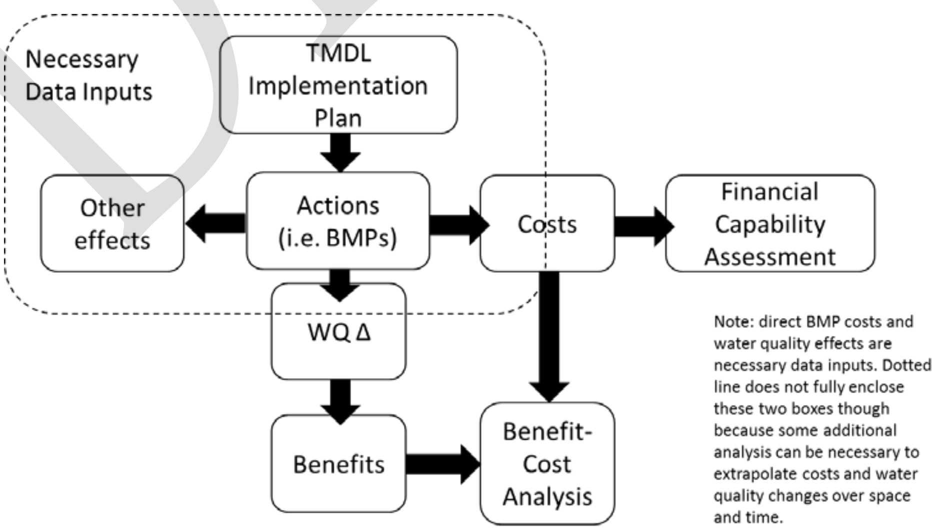
Additional economic analysis: Analyze existing cost estimates

Previous cost estimates like those incorporated in the WQIPs used techniques developed in Los Angles and accepted by the Los Angeles Water Quality Control Board, however there is interest in better understanding these crucial estimates that range in the billions of dollars. This analysis will provide a peer review that documents sensitive assumptions, compares methods used by each San Diego jurisdiction and checks for accounting issues.

CROSSCUTTING ANALYSES

Figure 2 provides an overall summary of the data and analysis interdependencies described in this Work Plan. All analyses stem from the identified BMPs and other efforts to reduce pollutant loads relevant to the scenarios under evaluation. These actions to improve water quality generate costs to implement, and provide water quality improvements, as well as other co-benefits. Evaluation of demand, scarcity, and value for the water quality improvements and co-benefits support calculation of benefit values for each scenario. These benefits are inputs to the CBA. The costs required to implement each scenario are also the primary inputs to the analysis of cost-per household for each scenario as part of the Residential Indicator Score calculation.

Figure 2 – Crosscutting analysis overview



MAJOR CONSTRAINTS, ASSUMPTIONS AND LIMITATIONS

Assumptions will be necessary across all categories of analyses and scenarios, and they will be documented appropriately. Specific analysis sections of this work plan include examples. To conduct these analyses overall, there are certain key constraints, assumptions, and limitations based on data availability and analytical feasibility. These key assumptions include:

- **Reliance on existing engineering and water quality data for BMPs –** while some extrapolations and refinements will be necessary, in general the analyses described in this work plan will not involve new modeling or analysis to identify the BMPs necessary under each scenario. This work will rely upon existing water quality information, and coordinate closely with appropriate engineering and water quality experts for application, extension, and refinement of those data. This is particularly relevant for quantitatively defining the scenarios and developing the necessary inputs to the CBA. See Appendix A: which describes the data plan for gathering additional detail about the inputs needed for each scenario.
- **Focus on wet weather water quality improvements –** the scenarios and associated benefits and costs are focused on improvements in water quality associated with wet weather events. This means that analyses are focused on effects likely to vary with changes in wet weather water quality. If scenarios reveal important secondary benefits for dry weather water quality, those benefits will be characterized and valued to the extent models and methods designed for wet weather effects allow. For example, beach recreation differs substantially between wet weather and dry weather conditions. Measurement of dry weather beach recreation and its value is relevant to this work plan only to the extent it can inform valuation of wet weather conditions. Baseline conditions of public health and recreation associated with water resources will provide some additional information regarding the current economic value of dry weather water quality. If some scenarios have specific measurable dry weather benefits, they will be included within the bounds of available information and modeling to-date.
- **Benefit and cost analyses are focused on incremental (marginal) effects of BMPs –** valuation of benefits and costs associated with each scenario to improve wet weather water quality is focused on the increment of change in comparison to the baseline (current conditions extended into the future). Therefore current conditions and the baseline are important to measure and describe for the purpose of analyzing scenarios, but a total value of water quality associated with current conditions would be difficult to isolate. Identifying the state of the world with no investments in water quality in the project area for comparison to measure the effects of current water quality investments, both public and private, would be a substantial and distinct effort, and require extensive valuation of dry weather water quality benefits.

EXPECTED ANALYSIS RESULTS

The analysis structure yields specific types of results. Benefit analysis results in a quantification of total benefits derived from a particular scenario. Cost analysis calculates the total costs associated with a particular scenario. The results of cost and benefit analyses are then compared to determine net benefits for a particular scenario. Net benefits for scenarios are compared to inform policy decisions (Table 1).

Implementation of programs to improve water quality and attain CWA objectives may cause economic challenges to a jurisdiction's limited financial resources. The screening FCA calculates residential indicator scores (RIS) to indicate financial burden of CWA compliance (Table 8). The results of a full FCA, including both calculation of RIS and financial capability scores (FCS), are used by the EPA to determine whether a longer compliance timeframe is appropriate for spreading costs over a longer time period. The screening FCA does not calculate FCS, but provides an indication of whether a full FCA is likely to result in a longer compliance timeframe.

An analysis of the strengths and weaknesses of the cost estimates performed is done by identifying sensitive assumptions, accounting issues, and consistency between permittees. The result is a quantified assessment of the defensibility of the analyses conducted through cost analyses, benefits analyses etc.

Table 1- Example of overall analytic results format for each of the three policy decisions.

ADJUST BACTERIA REGULATORY ENDPOINTS								
		Current conditions	2010 TMDL via WQIPs	2012 REC criteria	Move compliance locations	Flow-based regulatory suspension	Create beach-specific WQ objectives	Adjust wet weather beach WQ objective
Benefit Analyses	Benefit Type 1							
	Benefit Type 2							
	Benefits							
Cost Analyses	Cost Type 1							
	Cost Type 2							
	Costs							
	Net benefits							

ADJUST STRATEGY FOR ACHIEVING BACTERIA LOAD REDUCTIONS					
		Current conditions	2010 TMDL via WQIPs	Focus on human sources	Focus on stream restoration
Benefits Analyses	Benefit Type 1				
	Benefit Type 1				
	Benefits				
Costs Analyses	Cost Type 1				
	Cost Type 2				
	Costs				
	Net benefits				

CHANGE SCHEDULE OF COMPLIANCE				
		Integration with CIP schedule	Wet weather compliance by 2031	Wet weather compliance by 2051
Benefits Analyses	Benefit Type 1			
	Benefit Type 1			
	Benefits			
Costs Analyses	Cost Type 1			
	Cost Type 2			
	Costs			
	Net benefits			
Screening Financial Capability Assessment	Residential Indicator Score			

DELIVERABLE PRODUCT

The final product delivered to the SC will be a report describing the methods, data sources, and results for each crosscutting analysis performed and scenario analyzed. Although this report is referred to as the Final CBA Document; all analyses, including FCA and water quality input calculations, identified in the work plan will be included in the document. The document is structured around the different crosscutting analyses and each of these sections can be used independently. Summary results will be presented in the final document using Table 1 (Expected Analysis Results section above) and narrative descriptions of non-quantifiable costs and benefits. These results will be used by the SC to compare the net benefits of scenarios within a policy decision. A decision making process for comparison and selection of scenarios in addition to net benefits will not be identified in the document, but will be developed by the SC separately.

SCHEDULE

The schedule for delivery of the CBA document engages the SC on intermediate analyses as they are completed and then progresses through several rounds of official review once a complete draft document is available. This aggressive schedule relies on timely delivery from 3rd parties of substantial CBA-input information that quantitatively defines scenarios.

Intermediate analyses of scenario results will allow the SC to check progress and provide feedback about methods used, necessary assumptions and initial results. At these check points, it will be possible to substantially change the analyses. Later reviews of the CBA document will focus on the clarity of concepts communicated and results presented but are not expected to allow for major shifts in the scenarios or crosscutting analyses. The schedule further assumes that a second task order allows the team to begin the analyses in . General timing of key milestones includes:

- July 2016 - Begin analyses
- August-September 2016 – Receive CBA-input information from 3rd parties
- October-November 2016 – Review intermediate analyses with SC
- November 2016 – Complete all analyses & draft CBA document
- January 2016 – Deliver draft CBA document to SC
- January 2017 – Deliver draft CBA document to TAC
- March 2017 – Deliver draft CBA for public review
- April 2017 – Deliver final CBA document

CROSSCUTTING ANALYSIS: BENEFITS

Benefits analysis is often the most complex portion of environmental CBAs based on the challenge of demonstrating actual changes among scenarios, valuing the benefits and adequately communicating non-quantified benefits. Because benefits are of particular interest to the Steering Committee, this section provides relatively in-depth information that (1) introduces federal guidance, (2) overviews key analytic assumptions, (3) explains the types of benefits included, (4) details the steps in the analysis, (5) lists known data sources and gaps and (6) describes expected results.

FEDERAL GUIDANCE ON BENEFIT-COST ANALYSIS

These analyses will follow federal guidance for economic analysis, augmented by relevant economic theory, literature and research precedents, particularly from peer-reviewed sources. The Office of Management and Budget provides guidance to federal agencies on development of regulatory economic analyses via Circular A-4.[9] Circular A-4 recognizes that proposed regulations require economic analysis to understand tradeoffs. As initial overall guidance, it states,

> *"Cost-benefit analysis is a primary tool used for regulatory analysis. Where all benefits and costs can be quantified and expressed in monetary units, cost-benefit analysis provides decision makers with a clear indication of the most efficient alternative, that is, the alternative that generates the largest net benefits to society (ignoring distributional effects). This is useful information for decision makers and the public to receive, even when economic efficiency is not the only or the overriding public policy objective."*[10]

This overall guidance indicates that all benefits and costs should be considered, and it recognizes that for a balanced trade-off analysis dollars is the most appropriate metric.

> *"When important benefits and costs cannot be expressed in monetary units, BCA is less useful, and it can even be misleading, because the calculation of net benefits in such cases does not provide a full evaluation of all relevant benefits and costs."*[11]

Circular A-4 recognizes that cost-benefit analysis can lead to incorrect decisions if it does not include a complete valuation of all benefits and costs. OMB emphasizes that all benefits and costs of importance should be considered:

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[9] Office of Management and Budget. 2003. Circular A-4. http://www.whitehouse.gov/omb/circulars_a004_a-4.

[10] OMB Circular A-4.

[11] OMB Circular A-4.

> *"A good regulatory analysis should include [...] an evaluation of the benefits and costs— quantitative and qualitative—of the proposed action and the main alternatives identified by the analysis. [...] If you are not able to quantify the effects, you should present any relevant quantitative information along with a description of the unquantified effects, such as ecological gains, improvements in quality of life, and aesthetic beauty."*[12]

Circular A-4 goes on to provide guidance on how to measure and compare benefits and costs. The EPA echoes and references Circular A-4 guidance and these fundamental principles of cost-benefit analysis in its own *Guidelines for Preparing Economic Analyses.*[13] EPA states in its *Guidelines:*

> *"Estimating benefits in monetary terms allows the comparison of different types of benefits in the same units, and it allows the calculation of net benefits – the sum of all monetized benefits minus the sum of all monetized costs – so that proposed policy changes can be compared to each other and to the baseline scenario."*

BENEFIT APPROACH OVERVIEW AND RESUTLTS

Improvements in surface water quality (freshwater and saltwater) can provide a wide range of goods and services that people value. Natural resources often have the capacity to provide market-based benefits (goods and services bought and sold in normal markets) as well as non-market based benefits. Benefit analyses will assign values to goods and services based on their market prices and non-market information.

CATEGORIES OF ECONOMIC BENEFITS

Figure 3 summarizes the major categories of economic value for market and non-market goods and services. This concept of total economic value drives the overall benefit framework. The left side of the figure shows use value, which is perhaps the clearest type of economic value. Direct use value describes the value associated with the direct use of a good or service, such as using a stream to spend a day fishing. Indirect use value describes the goods and services that precede direct goods and services, such as the aquatic habitat that nurtures and provides refuge for the targeted fish. Actual valuation targets though must be final goods and services to avoid double-counting.

The right side of the figure shows passive-use value, which represents values that exist when there is no direct or indirect use of a resource. Passive-use values are less obvious than use values but (in some instances) can represent a greater total value because they incorporate demands from a larger population and less competition or congestion among users. The figure separates passive-use value into two categories. One, existence value, comes from people's desire for the continued existence of a species, landscape, or some other aspect of a resource—or of the ecosystem as a whole—without any contact or use of the good or service. The other, bequest value, arises because people want to ensure that the resource will be available for service and enjoyment by future generations. Typically, these passive-use values are described in terms of an individual's willingness to pay for an object's current or future existence. Passive use values might exist for people outside of the project area who still appreciate water quality improvements even without directly benefiting through use of the resource themselves.

The middle of the figure shows another component of the total economic value, known as option value. Option value refers to the benefit of maintaining an opportunity to derive services from a resource in the

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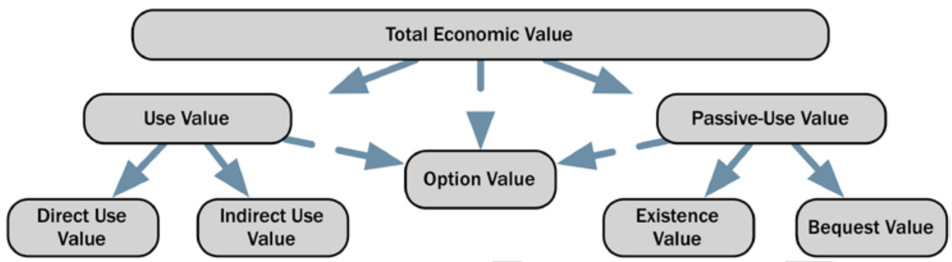
[12] OMB Circular A-4.

[13] U.S. Environmental Protection Agency. 2010. Guidelines for Preparing Economic Analyses. December. http://yosemite.epa.gov/ee/epa/eed.nsf/pages/guidelines.html.

future. It can originate from either side of the figure. Market prices sometimes exist that provide information useful for quantifying option values, but not always.

Quantitative analyses described in this work plan focus on use values, although option and passive-use values identified during the analytical process will be included in the qualitative and review sections of the cost-benefit analysis.

Figure 3 - The components of total economic value as defined by federal economic guidance



Approaches follow principles described in federal guidance documents discussed earlier as well as benefit-specific methods identified for each benefit below. Table 2 shows the goods and services anticipated to be included in the analysis, and whether the project team will value each using a market or non-market approach. In general, each benefit is experienced in its own way. Therefore the measurement of supply and demand and consequent value is specific to each benefit and must be analyzed individually. This approach includes benefits of water quality improvements as well as other co-benefits identifiable to the specific strategies and BMPs by scenario.

KEY ANALYSIS PRINCIPLES

Consistent analysis principles are applied to ensure consistent results and guide the consulting team. Analysis principles include marginal benefits, supply and demand, and geographic and temporal scale.

Marginal Benefits

Measuring benefits to society requires identifying and measuring the marginal (incremental) changes in valuable goods and services provided by a scenario. These changes are measured with respect to the baseline. The comparison of each scenario to the baseline scenario and other scenarios extends into the future to capture all important effects of the scenario. It also allows identification of differences among scenarios for measurement. If certain goods and services are consistent across all scenarios, it is not necessary to measure their value, and that value isn't attributed to any of the scenarios. For example, if dry weather water quality is the same across all scenarios, it is not appropriate to measure its value by scenario.

Supply and Demand

Supply is measured through water quality and co-benefit effects. Scenario analyses rely on information produced by the TMDL, historical data and modeling results to determine supply. In some cases it is necessary to quantify changes in the supply of final goods and services, such as illness, instead of water quality and co-benefits. Demand for goods and services indicates their value to society. Data and information requirements for determining supply and demand include:

- The number of people using the good/service
- The overall abundance of the good/service (e.g. scarce = demand exceeds supply)
- The availability, quality, and cost of substitutes (e.g. are there plenty of other beaches that are clean when one is dirty?)
- The availability, quality, and cost of complements (e.g. are travel and equipment very expensive to use the beach?)
- The importance of the final use or activity (e.g. is surfing important or are people just as happy doing something away from the beach?)

Geographic and Temporal Scale

The geographic focus of this analysis is the area of basins associated with watersheds included in the TMDL. According to federal guidelines the appropriate geographic scale is that area sufficient to capture all relevant benefits and costs, and of immediate jurisdictional interest for potential beneficiaries. Therefore, the appropriate region for analysis is the entirety of San Diego County and Orange County, but beaches and tributaries where water quality will improve are emphasized.

The appropriate timeframe for analysis captures all substantial benefits and costs of scenario investments and actions. It is important to include all appropriate costs for corresponding benefits including any capital replacement and operation and maintenance costs over time necessary to maintain the flow of benefits. The project team anticipates a focus on 50 years, with presentation of benefits and costs at 20 years and 100 years as well

Discounting is a necessary step in cost-benefit analysis to equalize the weighting of effects that occur in different years. OMB's *Circular A-4* recommends discount rates of 3 percent and 7 percent, generally based on market factors of growth in the economy and return on capital investments. For goods and services not necessarily substitutable for financial capital, at times it can be appropriate to use lower discount rates. Lower discount rates might be appropriate for sensitivity analyses.

SUMMARY DATA REQUIREMENTS BY BENEFIT TYPES

Table 2 shows the data inputs anticipated for each type of benefit. For each good or service providing an identifiable benefit, the general analytical approach requires data to describe:

1. Quantity (supply) by scenario; and
2. Value per quantity. This may be a price for goods traded in markets or other indicators of value, e.g., willingness-to-pay for goods and services not traded in markets.

The analysis will also describe the demand and value for each good or service analyzed. Table 2 illustrates the types of data and general analytical approach for each in the right column of the "Data Inputs" section (Demand and Value). For each type of data, to the extent available, the analysis will present historical records and future forecasts to show trends over time.

Table 2 does not identify all data sources for values at this time, which are described in more detail for each benefit section of this work plan, and in the Data Plan. As noted above, only a subset of goods and services will have identifiable and quantifiable variation appropriate for valuation.

Table 2 - Summary of Analytical Approach for Goods and Services Included in the Benefit Analysis

Good or Service	General Analytical Approach		Data Inputs	
	Market	Non-Market	Target Good/Service	Demand and Value
Surfing Recreation	Market expenditures and benefit transfer	Consumer surplus and benefit transfer	Surfing visitor-days	Number of surfers and surfing trips
Other Recreation	Market expenditures and benefit transfer	Consumer surplus and benefit transfer	Activity visitor-days	Recreation participants and trips
Public Health	Health expenditures	Willingness-to-Pay	Avoided illness	Recreation participants and exposure risk
Property value	Home prices		Home amenity price premium	Market prices housing demand
BMP Co-Benefits	Benefit transfer	Benefit transfer	Various	Benefit transfer and contextual scarcity

STEPS FOR BENEFIT ANALYSIS

Step 1: Identify and describe affected goods and services. In this case, "affected" refers to goods and services with changes in quality and/or quantity relative to existing conditions (the Affected Environment), and in particular relative to other scenarios.

Step 2: Analysis of the baseline scenario. This step will describe baseline conditions for each good/service including describing the past, current, and expected future conditions without the wet weather TMDL. This approach reflects that conditions today are not necessarily representative of future conditions because of outside forces and influences.

Step 3: Describe changes in supply of goods and services by scenario, using information from TMDL studies and secondary analysis, and compared to the baseline scenario. When the data will not allow quantification, the analysis will describe changes qualitatively, which may include describing the relative scarcity of the good or service at issue. The analysis will seek to isolate changes attributable to the management alternative (scenario), distinct from changes based on other forces such as changing demographic and market conditions.

Step 4: Estimate the changes in value of each good or service arising from changes in supply across scenarios. This will be based upon demand data, in terms of quantity and price or willingness-to-pay, specific to each good or service. When the data do not allow quantifying changes in values, the analysis will describe economic value qualitatively. This analysis will take into account economic forces and trends that affect demand, supply and economic values of goods and services. Where the analysis estimates a flow of values over time, it will report both per-year values and the present discounted value over the period using a discount rate consistent with federal guidance and the specific good or service in terms of time preference and opportunity costs.

Step 5: Identify beneficiaries of each good or service and describe the distribution of values across beneficiaries, geography, and time. This step will be coordinated with other analyses as appropriate, e.g., economic activity, economic stability, and capacity and resiliency of different types of communities. It will identify specific user groups and their geography where feasible and relevant. For example, surfing recreation benefits will describe the population of surfers receiving identified benefits.

Step 6: Describe risks and uncertainties that affect the analysis. These risks and uncertainties include factors that arise from biophysical sources of uncertainty (e.g., climate change effects on the supply of ecosystem goods and services) and socioeconomic sources of uncertainty (e.g., trends in market conditions that affect demand for goods and services, or supplies of substitute goods and services). Both have the potential to affect values, and should be recognized at a minimum qualitatively, and quantitatively through sensitivity analyses if data allow.

TYPES OF BENEFIT RESULTS

The analysis will describe the effect of each scenario on the value of each good or service. The description will include the *direction, general or specific magnitude, timing, and duration* of the effect. For the primary focus goods and services, the analysis will be able to provide a monetary value of the effect, either per year or as a present value discounted over a specific period of time. For some goods and services, it will describe the change in value qualitatively, providing as much information as possible to distinguish effects across scenarios.

Where possible the analysis will display changes in supply, demand, and values over time for each good or service using graphs and tables. The analysis will provide results describing the value of goods and services disaggregated to the extent possible by: (1) market price based values, (2) non-market monetary values, and (3) other measures and descriptions of the remainder of the total economic value for that particular good or service. Table 1 provides a possible results table structure. These benefits will be provided per-unit where relevant (e.g. per participant), in totals per year, and in discounted net present value over time within various timeframes.

For all goods and services shown in Table 3, the analysis will describe their supply, demand, and value using market data, non-market data, or both.

Table 3 - Example Summary of Value Results Table Structure

Good or Service	Metric	Market Price Value	Non-Market Value	Other Value Measure
Water Quality Benefits				
Surfing Recreation	Additional surfing participation by scenario	Revealed expenditures for participation	Consumer surplus, monetary value	Total trips, total participants, total participation time
Other Recreation	Additional participation by scenario	Revealed expenditures for participation	Consumer surplus, monetary value	Total trips, total participants, total participation time
Public Health	Avoided illness	Avoided healthcare costs	Willingness-to-Pay for avoided illness	Total illness occurrence, time of illness
Property value	Total market value in property	Home price share, and total	N/A	Possibly applied to other more distant beneficiaries as well
Co-Benefits (example, not the complete set)				
Potable Water	Avoided potable water consumption through rainwater harvest, use	Water rates for consumers	Instream flow benefits	Ecosystem services

BENEFITS INCLUDED IN THE ANALYSIS

The benefit types included in the analysis are expected to capture the significant changes in value for each scenario.

RECREATION (WATER QUALITY)

Outdoor recreation plays an important role in the health and quality of life for San Diego and Orange County residents and visitors. Many people decide to visit, live, stay, raise families, start and grow businesses, and make purchases in the region in part because of outdoor recreation opportunities. Well-educated and productive workers will choose to live in places with valuable outdoor recreation amenities, and possibly pass up higher-paying jobs in places where the quality of life would not be as great. Outdoor recreation opportunities not only influence where in the country people choose to live and work, but also where within a state, and even where within their community. Travel and tourism decisions are even more sensitive to the location, quality, and concentration of outdoor recreation opportunities.

Approach

The overall approach for valuing the recreation benefits provided by water quality improvements under each scenario is:

1. Identify recreation activities affected by the improvement in water quality
2. Quantify the change in water quality relative to the baseline in terms relevant to the activity (magnitude, timing, duration)
3. Identify number of trips and recreation duration associated with the change in water quality
4. Value the benefits of increases in trips and recreation associated with the change in water quality

The important information for the set of recreation benefits is how and where water quality improvements occur, and how recreation participation would likely occur with those improvements. With a focus on wet weather event bacteria and related pathogen events, it is necessary to look at how recreation participation varies historically with and without those events. Water quality data allow identification of the timing, magnitude, and frequency of wet weather events. Lifeguard beach counts, the Surfer Health study, and numerous state, federal, and regional studies provide information regarding outdoor recreation participation relevant to describing current levels and timing of activity-specific participation.

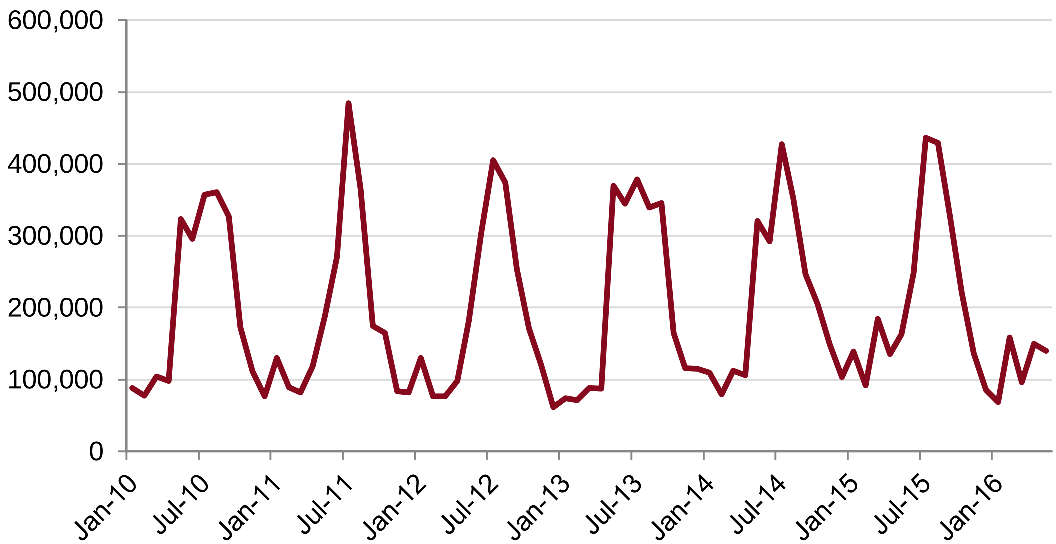
Activities that are affected differently by wet weather stormwater events and therefore provide different benefits, must be disaggregated. Beach recreation, for example, differs quite dramatically between winter and summer seasons, as well as between wet weather and dry weather conditions. See for example the charts of seasonal beach attendance for San Clemente and Newport Beach Beaches (Figures 4 and 5). These figures also show relatively stable attendance patterns over the timeframe. For this reason it is likely appropriate to group activities by their level of contact and dependence on water conditions, both in terms of water quality and otherwise. To some extent this process is data-driven in that measurement of outdoor recreation participation will determine how it is aggregated and disaggregated. It will be important to consider local vs. non-local participation for the value associated with each trip.

Surfer Health Study individual behavioral data provide the basis for changes in decisions to recreate based on changes in water quality, as well as overall levels of recreation activity. These data also then provide the basis for estimation of exposure rates for use in the public health benefit section below. Extensions using lifeguard daily count data and related sources including beach characteristics and participant populations within proximity will support extrapolations to the full set of affected beaches, and beach-related activities. An important distinction is the use of these data to identify behavior changes, but not necessarily trip values.

Based on the proximity of some of the most avid users of beaches, typical travel cost demand models are not likely the best source of approximating trip value, and are likely to severely underestimate trip value.[14] Therefore, while Surfer Health Study and related data provide a strong basis for behavior modeling, literature review and other existing relevant studies will provide the basis for per trip and user-day benefit estimates. The U.S. Forest Service, for example, provides extensive examples of guidance and values for application of activity-specific and region-specific trip and user-day values.[15] In addition, travel cost methods will inform determination of value estimates for non-local participants, following general principles from the literature.[16] Similar approaches are available for non-beach recreation, although they will rely on separate estimates for participation and behavioral responses from user groups and regional recreation participation rates based on available data (e.g. U.S. Census American Time Use Survey, Statewide Comprehensive Outdoor Recreation Plan Survey).

To calculate benefits over a scenario's lifespan, future demand must be estimated as well. This requires application of data concerning participation trends by activity type and demographic information regarding change in population size and composition. The Census Bureau, the U.S. Forest Service and various outdoor recreation organizations, as well as historical data support these projections.

Figure 4 - Monthly Beach Attendance at San Clemente Beaches, January 2010 - May 2016

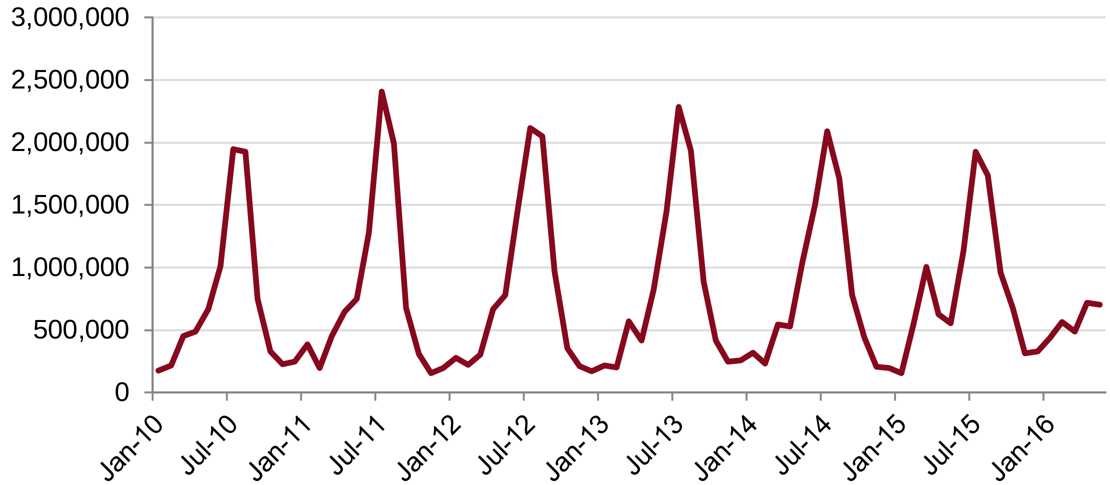


[14] For additional discussion see Scorse, Jason, F. Reynolds, & A. Sackett. 2015. "The Impact of Surf Breaks on Home Prices in Santa Cruz, CA." *Tourism Economics* 21(2).

[15] E.g. Loomis, J. 2005.Updated outdoor recreation use values on national forests and other public lands. General Technical Report. PNW-GTR-658. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. 34 pp. http://www.fs.fed.us/pnw/pubs/pnw_gtr658.pdf.

[16] See for reference recreation demand model explanations in Loomis, J.B. and Walsh, R.G., 1997. *Recreation Economic Decisions; Comparing Benefits and Costs* (No. Ed. 2). Venture Publishing Inc. and Parsons, G.R., 2003. The travel cost model. In *A Primer on Nonmarket Valuation* (pp. 269-329). Springer Netherlands.

Figure 5 - Monthly Beach Attendance at Newport Beach Beaches, January 2010 - May 2016



The appropriate measure of benefits are based on identifying the consumer surplus, or net benefit of participation costs (travel costs, equipment costs, etc.). The specific consumer surplus value will be based upon the best activity and context-specific literature values following EPA guidelines for benefit transfer.

Data Sources

Sources of data used to calculate each type of recreation benefits are identified below.

Recreation Supply Data

To understand how scenarios will affect supply of recreation opportunities, the project team will use data describing (Table 4):

- Current water quality conditions in terms of location, timing, and duration
- Other recreation characteristics of importance (e.g. surfing sites, historical surfing conditions, correlations between wet weather events and surfing conditions, similar characteristics for other activities)
- Expected changes in water quality conditions by scenario
- Relationships between water quality conditions and desirability

Table 4 - Summary of Key Beach Recreation Data Sources

County	Dataset	Data Source
Orange County	Beach Attendance / Recreation	City and County Lifeguard Stations
	Historic Rainfall	Orange County Public Works
	Water Quality	Orange County Public Works, Environmental Resources GIS Portal
San Diego County	Beach Attendance / Recreation	City and County Lifeguard Stations
	Historic Rainfall	Various sources (e.g. Weather Underground)
	Water Quality	County of San Diego Department of Environmental Health, Land and Water Quality Division
	Surf Recreation	Steele (2015), Surfer Health Study

There are multiple water quality databases that include the San Diego region and other southern California areas. Figure 6 below lists the datasets and the associated entity that provides the data. These datasets are high in quality. The California Environmental Data Exchange Network (CEDEN) is the State Water Resources Control Board's statewide data system for water quality. It coordinates with four regional CEDEN data centers across California and permits any person to access its data.[17]

San Diego County's Department of Environmental Health provides an interactive GIS mapping tool that allows users to check current water quality of San Diego County beaches. The water quality sampling data is funded from the Beach Safety Act (AB 411) and serves as an informative location for users to check the water quality of any San Diego beach. Many beaches are sampled weekly, with some only monitored during the summertime. Cities within San Diego County contribute to the data collection process at some beaches as well. Each beach receives its own color-coded marker: green for open, yellow for advised, and red for closed. The project team will need to coordinate with the Department of Environmental Health to receive the underlying data that determines a beach's water quality.[18]

The environmental nonprofit organization Heal the Bay has developed the Beach Report Card, an interactive GIS map providing dry and wet grades for beaches along the West Coast.[19] My WATERS Mapper is similar to the Beach Report Card and is developed by the U.S. Environmental Protection Agency. The tool provides water quality assessment data by STORET station. Stations are not exclusive to oceans; they also provide water quality data for estuaries, river/streams, and groundwater, among others.[20]

U.S. Geological Survey (USGS) water quality data is collected under their comprehensive application titled the National Water Information System (NWIS). Data provided include: current conditions (recent data collected by on-site automated recording equipment); historical observations (site data from October 1, 2007 to present); daily, monthly, and annual summary data; and field/lab samples, which are quality-assured data from laboratory analyses of water samples.[21]

The San Diego Coastkeeper is a nonprofit with a goal to protect and restore water in San Diego County. Trained volunteers frequently visit rivers and creeks to test water quality across nine of San Diego County's eleven watersheds. They assign a water quality rating (Excellent, Good, Fair, Marginal, or Poor) based upon water samples analyzed for nutrients, toxicity, and bacteria.[22]

[17] *California Environmental Data Exchange Network (CEDEN)*, California State Water Resources Control Board. Data available at: http://ceden.waterboards.ca.gov/AdvancedQueryTool.

[18] County of San Diego Beach Water Quality, Department of Environmental Health. Interactive map available at: http://sdbeachinfo.com/.

[19] Beach Report Card, Heal the Bay. Data and map available at: http://brc.healthebay.org/.

[20] My WATERS Mapper, The United States Environmental Protection Agency. Data and map available at: https://watersgeo.epa.gov/mwm/?layer=LEGACY_WBD&feature=18070304&extraLayers=null.

[21] Water-Quality Data for the Nation, U.S. Geological Survey. Data available at: http://waterdata.usgs.gov/nwis/qw.

[22] *San Diego Watersheds*, San Diego Coastkeeper. Data available at: http://www.sdcoastkeeper.org/learn/swimmable/san-diego-water-quality.html.

Figure 6 - Water quality datasets and sources

Dataset	Data Source
California Environmental Data Exchange Network (CEDEN)[1]	California State Water Board
County of San Diego Beach Water Quality[2]	Department of Environmental Health
Beach Report Card[3]	Heal the Bay
My WATERS Mapper[4]	U.S. Environmental Protection Agency
Water-Quality Data for the Nation[5]	U.S. Geological Survey
San Diego Watersheds[6]	San Diego Coastkeeper
Orange County/San Diego Water Quality[7]	GIS Cloud

Footnotes:
1. CEDEN data available at: http://ceden.waterboards.ca.gov/.
2. Beach Water Quality data available at: http://sdbeachinfo.com/.
3. Beach Report Card data available at: http://brc.healthebay.org/.
4. My WATERS Mapper data available at: https://watersgeo.epa.gov/.
5. Water-Quality Data available at: http://waterdata.usgs.gov/nwis/qw.
6. San Diego Watersheds data available at: http://www.sdcoastkeeper.org.
7. Orange County/San Diego Water Quality data available at: http://app102283.giscloud.com/.

Recreation Demand Data

Recreation demand data generally describes in detail current outdoor recreation activity associated with resources that would be affected by water quality improvement scenarios. It also supports calculation of how participation would vary under scenarios and over time into the future. Extensive data exist concerning ocean, beach, nearshore, and freshwater (stream) recreation for the project area from local, state, and national sources. Furthermore, numerous specific studies exist that have quantified general and activity-specific recreation for the project area (San Diego and Orange Counties). Overall demand is driven by population size and population preferences. San Diego County population projections are available from the San Diego Association of Governments[23] and for Orange County from the Center for Demographic Research at California State University, Fullerton.[24]

It is also relevant that the focus is on wet weather events when relevant recreation opportunities decrease in quality and quantity in terms of water quality, as opposed to dry weather improvements that would improve all conditions beyond those currently experienced. This distinction is relevant because of elasticity of demand, or responsiveness of demand to changes in supply. In general due to diminishing returns, an increase in recreation opportunities in terms of quality or quantity would not produce a proportional response in participation. For example, if a surfer has one beach to choose from and suddenly has two beaches to choose from it is unlikely he or she would double their total surfing trips. It is also difficult to predict how much more surfers would participate if current dry weather conditions were dramatically improved.

With the wet weather events though, it is a short-term and infrequent disruption in ongoing activity, so it represents a perturbation event, a short-term decrease from normal supply. Typical usage is a good indicator of usage with fewer or no such wet weather perturbations. It is important to assess the magnitude and frequency of wet weather events and changes in these conditions to identify whether

[23] SANDAG, 2050 Series 13 Regional Growth Forecast.

[24] Center for Demographic Research, CSUF, 2015 Orange County Progress Report.

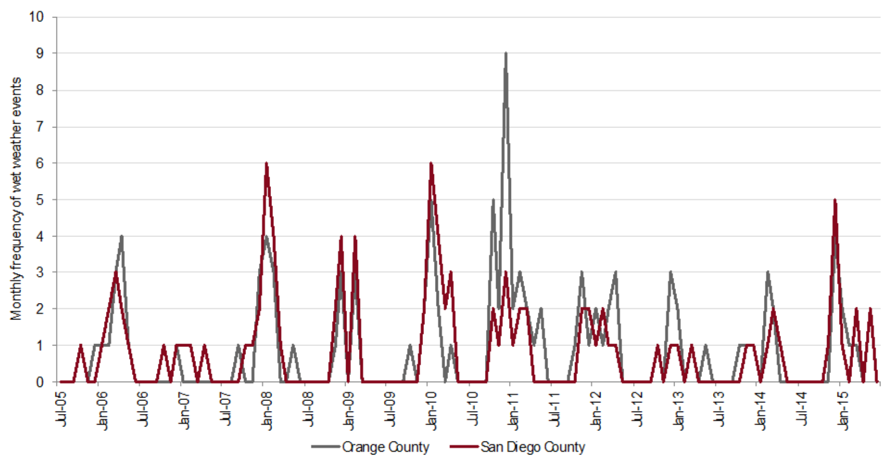
elasticity of demand calculations should be included in calculations of changes in recreation participation with water quality improvement scenarios. Studies show how beach recreation behavior relates to water quality, and they can be used to parameterize a model that characterizes demand responses when necessary.[25] It is likely that scenarios involving water quality improvements will involve fewer predicted beach warning rain advisories over the timeframe. Baseline conditions will be based upon projections of estimated current conditions involving historical advisories (Table 5) and long-term historical precipitation data (Figure 7).

Table 5 - San Diego County Rain Advisories, 2010 through May 2016.

Year	Rain Advisory Days*
2010	71
2011	63
2012	62
2013	25
2014	63
2015	44
2016	31

***Source*: County of San Diego Department of Environmental Health, Land and Water Quality Division.**
***For each rain event there are three rain advisory days.**

Figure 7 - San Diego County and Orange County Wet Weather Events, July 2005 through June 2016.



Note: A wet weather event is defined as at least 0.2 inches of rainfall on a given day.

Source: Orange County data are from OC Public Works, Newport Beach Harbor Master weather station; San Diego County data are from Weather Underground historic rainfall at San Diego International Airport, Lindbergh.

[25] e.g. Hilger, James R. (2006). The Impact of Water Quality on Southern California Beach Recreation: A Finite Mixture Model Approach. Retrieved from: http://escholarship.org/uc/item/07q7b0b9#page-4; Lew, Daniel K. & Larson, Douglas M. (2005). Valuing Recreation and Amenities at San Diego County Beaches. *Coastal Management* 33:71-86, 2005. Retrieved from: ftp://ftp.coast.noaa.gov/pub/socioeconomic/NSMS/California/Literature/Lew_Larson_2005.pdf.

Surfing Data

Based on the water quality objective and the Surfer Health study, surfing participation will be a primary focus of this analysis. Surfing demand is a function of local and non-local surfing participant population, wave quality, water quality, air and water temperature, access, travel costs, congestion, and other personal preferences. The Surfer Health Study demonstrated a relationship between precipitation and surfing activity (e.g. (Figures 8 and 9). Numerous studies exist describing and measuring these factors. Many of these factors are available from major public data sources. The actual number of surfing trips, trip lengths, number of surfers and their origin are less complete data sets, although several data sources support extrapolation and interpolation to approximate the measures necessary for this analysis.

The City of San Diego's Lifeguard department records daily beach attendance for several beaches, and going back several years. The data require formal request for particularly detailed data such as daily counts. Some similar lifeguard-based data sets exist for other beaches in San Diego and Orange Counties. Various state and federal data sources describe more general recreation participation and trip details that can support extrapolation of more granular data to elsewhere, in conjunction with expert review and support from surfing-specific studies.[26]

It is also important to compile historical detailed data on surfing conditions, including weather and wave conditions in order to develop statistical (econometric) models that show the relationships between surfing conditions and surfing participation. These data exist from a variety of local and non-local, public and private data sources.

Figure 8 - Total weekly surfers and weekly average precipitation, 1/20/14 - 3/3/14.

Note(s): Average weekly precipitation is calculated with data provided by Weather Underground. The data are recorded at San Diego International Airport (Lindbergh), Station ID KSAN. Each week begins on Monday and ends on the subsequent Sunday.

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[26] e.g. Wagner, G. S., Nelsen, C., & Walker, M. (July 2011). A Socioeconomic and Recreational Profile of Surfers in the United States. Retrieved June 1, 2016, from: http://surfridercdn.surfrider.org/images/uploads/publications/surfrider_report_v13(1).pdf. Nelsen, Chad Edward. (2012). Collecting and Using Economic Information to Guide the Management of Coastal Recreational Resources in California. Retrieved June 1, 2016 from: http://public.surfrider.org/files/nelsen/Nelsen_2012_CA_beachsurfecon_dissertation.pdf.

Figure 9 - Total weekly surfers and weekly average precipitation, 12/1/14 - 3/23/15

Note(s): Average weekly precipitation is calculated with data provided by Weather Underground. The data are recorded at San Diego International Airport (Lindbergh), Station ID KSAN. Each week begins on Monday and ends on the subsequent Sunday.

Other Recreation

Numerous other ocean, beach, and freshwater recreation activities utilize resources potentially improved under TMDL scenarios in this analysis. In general the methods described to identify changes in surfing participation by scenario will be applied to the other recreation types. The results therefore will be of similar format, by recreation type. The total visits, participants, trip value, expenditures, and response to improvements in bacteria levels for wet weather events will all be specific to each category. In general, modeling response to wet weather events will rely upon availability of daily participation data that can be compared to weather and bacteria data. It is likely that some activities might be discouraged more by the wet weather itself than the associated bacteria levels. In such cases, reducing bacteria levels might not lead to participation comparable to dry weather conditions.

Some of the activities with data and studies addressing participation relevant to the project area are fishing,[27] beachcombing and tidepool visitation,[28] wildlife viewing, kayaking and other paddlesports, hiking, and general beach visitation.[29] Additional data exist by activity type from the Statewide Comprehensive Outdoor Recreation Plan Survey, U.S. Forest Service, other state and local agencies, and activity-specific organizations.

[27] Wegge, T. C., Hanneman, W. M., and Strand, I. E. (1986). An Economic Assessment of Marine Recreational Fishing in Southern California. National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS). Retrieved from: https://swfsc.noaa.gov/publications/TM/SWR/NOAA-TM-NMFS-SWR-015.PDF.

[28] Hall, D., Hall, J., and Murray, S. (2002). Contingent valuation of marine protected areas: Southern California rocky intertidal ecosystems. Natural Resource Modeling, 15(3): 335-368. Retrieved from: http://www.marineecosystemservices.org/node/7824.

[29] Lew, Daniel K. & Larson, Douglas M. (2005). Valuing Recreation and Amenities at San Diego County Beaches. *Coastal Management* 33:71-86, 2005. Retrieved from: ftp://ftp.coast.noaa.gov/pub/socioeconomic/NSMS/California/Literature/Lew_Larson_2005.pdf.

Preliminary Modeling Approach

As the project progresses, the specific economic modeling approaches to assess changes in behavior that result in changes in recreation benefits will be refined based on available data, both in terms of recreation participation and water quality changes and both observed and predicted behavioral responses. As a preliminary assessment of likely modeling and data requirements, the project team assumes that the analysis of the recreational demand effects of water quality will take two forms. The first will be a linear regression, generally, of some measure of attendance or counts of a beach on a day on the attributes of the beach and weather on that day. The second will be a random utility model that models the utility provided by each of the various attributes of a surfing outing.

Attendance Model

Consider the following model,

$$A_{it} = \beta_0 + \beta_1 WQ_{it} + \beta_2 RainAdv_{it} + \beta_3 Weather_{it} + \beta_4 X_{it} + \epsilon_{it}$$

where A is a measure of attendance or surfing participation, *WQ* provides some measure(s) of water quality, *RainAdv* indicates a rain advisory in effect, *Weather* is a vector of weather control variables, X is a vector of other available control variables, and (i,t) index beach i and time t.

A coefficient of interest in this model would be β_1, which tells us the marginal effect of water quality (the policy objective) on the demand outcome. After estimating this coefficient, it can be used to evaluate the result of various policy scenarios on beach attendance or surfer participation. Similarly, $\beta_2$tells us the marginal effect of having a rain advisory. This would be policy relevant if the policy scenario can eliminate the need for rain advisories.

Surfer Random Utility Model

A random utility model is used to model the decisions of an individual over a discrete set of choices. Here, the utility of a particular surfing model is determined by the attributes of that location and a random (or unobservable) part of utility. We can specify the utility U of beach j for surfer i to be

$$U_{ij} = \alpha_0 + \alpha_{1,i} WQ_j + \alpha_{2,i} RainAdv_j + \alpha_{3,i} Weather_j + \alpha_{4,i} X_j + \eta_{ij}.$$

The parameter η_{ij} captures the random part of utility for person i at beach j. Using maximum likelihood estimation, we can estimate the marginal utility parameters to understand the relative importance of each beach attribute. Once we recover the utility parameters, we can predict changes in behavior if we change the attributes of a beach according to the hypothetical policy scenarios.

Recreation (water quality) results

The results of this analysis will be changes in total time spent for outdoor recreation by activity type or activity category, with breakdowns by demographics and area of origin to the extent data allow. Results will also provide benefits in terms of net benefit (consumer surplus) to the participant. Time projections will allow measurement of how these benefits accrue over time in real terms (inflation-adjusted). Finally, trip counts, local vs. non-local, will support recreation expenditure data for impact analysis in later subsequent analyses.

PUBLIC HEALTH (WATER QUALITY)

Water quality has a direct effect on the public's use and enjoyment of San Diego's beaches. Pathogen-contaminated beaches threaten the health of surfers and swimmers, with potentially cascading negative impacts on the region's recreation and tourism economy. The economic consequences of treating those who become ill from pathogen-contaminated water include healthcare costs and lost economic productivity. The County of San Diego's Department of Environmental Health (DEH) monitors beach water quality and notifies the public through advisories and closures when monitoring results indicate potential health hazards of water contact. Monitoring data indicates heightened contamination concerns from stormwater runoff during wet weather. To the extent that stormwater BMPs can reduce pathogen concentrations at area beaches they will also mitigate illness and related healthcare costs.

Approach

The overall approach for valuing the public health benefits provided by water quality improvements under each scenario is:

1. The recreation analysis (described above) will identify those at risk from contact with pathogen-contaminated beach water during wet-weather events.
2. Identify from existing epidemiology studies the relationships between water quality and the incidence of pathogen-caused illnesses during wet weather.
3. Describe the impacts of changing water quality on the incidence of pathogen-caused illnesses relative to baseline for the at-risk population.
4. Value the public-health benefits of improved water quality.

The public-health study will build on the recreation analysis. The public health study will focus on the extent to which improved water quality reduces pathogen-related illness among beach users, and will take into account recreation results showing changes in beach use with changing water quality.

DEH bases beach advisories and closures on levels of fecal indicator bacteria (FIB) (*Enterococci* and *E. Coli*) in water samples.[30] Important information for the public-health study are the data and results generated as part of recent epidemiology studies of the relationships between FIB levels and associated pathogen-caused illnesses. This information will be key to quantifying impacts of improved water quality on beach attendance and illness rates. A central component of this effort will be controlling for major differences between the population of beach users and populations included in the epidemiology studies.

The US EPA's *2012 Recreational Water Quality Criteria* for FIB concentrations inform the DEH's guidelines for beach advisories. Our analysis will focus on the public-health benefits of improved water quality, and not the extent to which TMDL scenarios affect the incidence of FIB concentrations registering below US EPA guidelines. That is, our analysis will describe the marginal public health benefits of improved water quality, and we assume that TMDLs that improve the quality of waters already registering below US EPA guidelines still generate public health benefits.

The appropriate measures of benefits in this analysis include the healthcare costs avoided because of reduced pathogen-related illnesses, and the avoided lost labor productivity from adults who do not miss days of work. Results from studies that report willingness-to-pay amounts to avoid water-borne illness for insights into the economic benefits at issue in our analysis are reviewed.

Data Sources

Several epidemiology studies provide the backbone of the public health analyses. These data sets and sources are summarized in Figure 10.

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[30] County of San Diego, Department of Environmental Health, Beach Water Quality. *Land and Water Quality Division. Beach and Bay Monitoring Program*. www.sdbeachinfo.com/#.

Figure 10 - Public health datasets and sources

Dataset	Data Source
Beach attendance and at-risk population.	Surfer Health Study and recreation participation calculations from this study
Concentrations of FIB and virus and bacteria pathogens.	Epidemiology studies of FIB and pathogen concentrations and incidence of illness.
Economic costs of waterborne illness and willingness-to-pay to avoid illness.	Literature review of economic studies.
Impacts of TMDLs on FIB or pathogen concentrations.	Engineering and stormwater BMP portions of WQIPs.

Beach attendance and at-risk population

Data for our analysis of beach attendance and the at-risk population will come from the recreation analysis. Important factors that affect this analysis include changing future demand over time, and impacts of water quality on recreation demand.

Concentrations of FIB and virus and bacteria pathogens

This portion of our analysis focuses on the data and results from three recently completed studies of the relationships among stormwater quality, FIB concentrations, pathogen concentrations, and resulting illnesses. All three studies were based on sampling stormwater runoff and water quality off two beaches in San Diego popular with surfers—Tourmaline Surfing Park and Ocean Beach. Each study explored a different aspect of water quality, FIB or pathogen concentrations, and human illness. They provide information that will allow us to trace the connection between changing water quality attributed to stormwater BMPs, and changes in illnesses incidence and the associated economic benefit of avoided illnesses.

Steele, et al., 2016[31] conducted a two-part analysis. The first part described FIB concentrations at varying distances from stormwater outfalls. In general, FIB concentrations are highest at stormwater outfalls and decrease with distance. These results provide insights into likely FIB concentrations in waters where surfers and swimmers spend most of their time. The second part describes the presence, and in some cases, the concentrations of Norovirus and *Campylobacter sp*. bacteria pathogens in stormwater discharges. These results are key because beach advisories are based on FIB concentrations, not pathogen concentrations. The assumption being that pathogens happen coincidently with FIB. This study confirms that relationship for stormwater discharges off beaches in San Diego. It also identifies concentrations of FIB, viruses and human pathogens in stormwater, which provides the basis for assessing the ability of stormwater BMBs to control these pathogens as a means of reducing illness in surfers and swimmers.

Soller, et al., 2016[32] estimated the risks of gastrointestinal (GI) illness from exposure to pathogen-contaminated ocean water during wet weather using a quantitative microbial risk assessment (QMRA) model. The model estimates the probability of GI illness based on the following variables.

[31]Steele, J., A.J. Griffith, R. Noble, and K. Schiff. 2016 (draft). *Quantification of pathogenic viruses and bacteria, host source markers, and fecal indicator bacteria in stormwater discharging to surfing beaches in San Diego, California*. April 20. *Submitted and being considered for publication*.

[32] Soller, J., M. Schoen, J. Steele, J. Griffith, and K. Schiff. 2016. *Wet weather recreational water gastrointestinal illness risks—quantitative microbial risk assessment harmonization with an epidemiological investigation*. *Submitted and being considered for publication*.

- A dose-response function for a given human pathogen including Norovirus, *Campylobacter jejuni*, and *Salmonella enterica*. The function describes the form of the parameter distribution, parameter values, units of measure and probability of morbidity.
- The volume of water ingested by type and age of water recreationist.
- The pathogen concentrations at stormwater discharge sites.
- The estimated dilution of pathogen concentrations in areas of exposure. Dilution estimates for pathogens were based on changing FIB concentrations at distances from stormwater outfalls.
- The morbidity for a given pathogen, generated from the dose-response function.

The average illness rates among surfers predicted by the QMRA model generally agreed with actual illness rates reported by Arnold et al., 2016.[33] A sensitivity analysis will be developed to test assumptions regarding volumes of water ingested by surfers.

By describing the impacts of stormwater BMPs on the pathogen concentrations at stormwater discharge sites, and applying the QMRA model and data for other variables as estimated by Soller, et al., we can estimate the impacts of stormwater BMPs on surfer and swimmer illnesses.

Arnold et al., 2016 surveyed surfers to compare illness rates following ocean exposure during wet and dry weather. They also estimated the relationship between FIB levels and incidence of illness during dry and wet weather. The study tracked a range of illnesses including GI and upper respiratory illness. Stormwater runoff was collected from Tourmaline Creek and the San Diego River immediately upstream from beaches and tested for FIB. With this data the researchers estimated the relationship between FIB concentrations at stormwater outfalls and the resulting incidence of surfer illness. The results include:

- Higher concentrations of FIB in stormwater during wet weather compared to dry.
- Surfers reported immersing their head in 96 percent and swallowing water in 38 percent of exposure days.
- Ocean exposure increased the risk of illness during dry and wet weather, compared to no ocean exposure. Risk of illness was higher for wet weather compared to dry.
- FIB concentrations were positively associated with increased incidence of almost all illnesses during wet weather. This association was absent during dry weather except for a single illness and infected wounds.

As noted above, these results confirm the strength of the QMRA model employed by Soller et al., 2016, at predicting illness during wet weather based on FIB concentrations at stormwater outfalls. Combining the data from the Soller et al, 2016 and Arnold et al., 2016 studies, with information on the impacts of stormwater BMPs at controlling FIB concentration, allows us to estimate the relationships between stormwater BMPs, improved water quality and avoided illnesses in surfers and swimmers.

The three studies and associated data summarized above provide the foundation for this analysis. Relevant information from other studies and reports will be added. Examples include:

- Arnold et al., 2016,[34] extends the body of knowledge on the relationships between FIB concentrations and illness to risk of illness among exposed children.

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[33] Arnold, B., K. Schiff, A. Ercuman, J. Benjamin-Chung, J Steele, J. Griffith, S. Steinberg, P. Smith, C. McGee, R. Wilson, C. Nelsen, S. Weisberg, and J. Colford, Jr. 2016. *Acute illness associated with ocean exposure and fecal indicator bacteria during dry and wet weather: a longitudinal cohort study of surfers in San Diego, California*. Report to the City and County of San Diego. May 19. *Submitted and being considered for publication*.

[34] Arnold, B., T. Wade, J. Benjamin-Chung, K. Schiff, A. Dufour, S. Weisberg, and J. Colford. 2016. "Acute gastroenteritis and health burden attributable to recreational water exposure in the United States." Forthcoming in *The New England Journal of Medicine.*

- Dufour et al., 2006,[35] reports estimates of average water ingestion by groups of swimmers.
- Given et al., 2006,[36] provides information on risks of GI illness at 28 beaches along the coastline in Los Angeles and Orange Counties.
- Atiyal et al., 2013,[37] describe the impacts of improved stormwater controls on beach attendance at 26 beaches in Southern California.

Economic costs of illness

This portion of the analysis estimates the value of public health via surfer and other recreationist illness reduction benefits. In general, estimates reported in the literature of the medical costs and lost work productivity caused by illness from water-borne pathogens in surfers or swimmers are used. Costs are multiplied by the reduction in illnesses attributed to improved stormwater controls and water quality. Results are interpreted as the benefit of avoided costs from improved water quality.

The relevant literature includes:

- Atiyal et al., 2013, described above, which includes information on the costs of treating GI illnesses in swimmers.
- Given et al, 2006, also described above, also includes information on the cost of treating GI illnesses in swimmers.
- Dwight et al., 2005,[38] describes the results of a case study conducted among swimmers in Orange County, California of the estimated economic costs and associated lost worker productivity in swimmers per incidence of illnesses by type of illness including GI, acute respiratory disease, ear aliment and eye ailment.
- Rabinovici, et al., 2006,[39] compares the health costs of treating GI illness in swimmers with the recreational value of swimming to determine the net economic benefit of measures that reduce GI illnesses.

In addition, see earlier discussions in this work plan describing methods for identifying changes in water quality, pathogen-specific, by scenario.

Impacts of stormwater BMPs on concentrations of FIB or pathogens

This portion of the analysis will rely on the results of the engineering and stormwater BMP portions of WQIPs. These data will describe the extent to which BMPs improve water quality by reducing concentrations of FIB or pathogens in stormwater that flows to area beaches. Key data will estimate changes in concentrations of FIB or bacteria and virus pathogens in stormwater runoff by BMP type, measured in units comparable with units used in dose-response models described above.

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[35] Dufour, A., O. Evans, T. Behymer, and R. Cantu. 2006. "Water ingestion during swimming activities in a pool: A pilot study," *Journal of Water and Health*. April: 425-430.

[36] Given, S., L. Pendleton, and A. Boehm. 2006. "Regional public health cost estimates of contaminated coastal waters: A case study of Gastroenteritis at Southern California Beaches," *Environmental Science & Technology*. Vol. 40, No. 16: 4851 – 4858.

[37] Atiyah, P., L. Pendleton, R. Vaughn, and N. Lessem. 2013. "Measuring the effects of stormwater mitigation on beach attendance," Marine Pollution Bulletin. Pages 1 – 7.

[38] Dwight, R., L. Fernandez, D. Baker, J. Semenza, and B. Olson. 2005. "Estimating the economic burden from illnesses associated with recreational coastal water pollution—a case study in Orange County, California," *Journal of Environmental Management*, 76: 95-103.

[39] Rabinovici, S., J. Warren, L. Pendleton, and A. Boehm. 2006. "Cost-benefit analysis of rapid microbial detection for improving marine swim advisories." *Environmental Science & Technology*. 48 pages.

Preliminary Modeling Approach

The SHS results describe current conditions for FIB and pathogen concentrations, morbidity probability, and illness incidence. These data and conditions describe the baseline against which to compare the impacts of stormwater BMPs on illness incidence and associated economic values and avoided costs. The BMP-effectiveness data describes the extent to which the BMPs reduce FIB concentrations. These results represent the marginal change in FIB concentrations attributed to improved water quality. These results will be input to the QMRA model that describes changes in morbidity per changes in FIB concentrations. The BMP-effectiveness results serve as inputs to the QMRA model.

The QMRA model is calculated as[40]:

$$Pill_{p,b} = DR_p\left(V * C_{p,b} * Dil_b\right) * M_p$$

Where
$Pill_{p,b}$ is the probability of illness
DR_p is the dose-response function for pathogen p
V is the volume of water ingested
$C_{p,b}$ is the pathogen concentration at beach b
Dil_b is the estimated dilution at beach b
M_p is morbidity for pathogen p

Changing the pathogen concentrations ($C_{p,b}$) in the QMRA model will generate changes in illness probability. The analysis will entail applying changes in illness probability to the at-risk population. The at-risk population is expressed as number of swimmers and surfers. This calculation yields the number of swimmers and surfers that avoid illness due to improved water quality. To estimate the economic value of improved water quality, the project team will apply the appropriate willingness-to-pay and cost value estimates per illness to the number of swimmers and surfers who avoid illness due to improved water quality.

Public Health Results

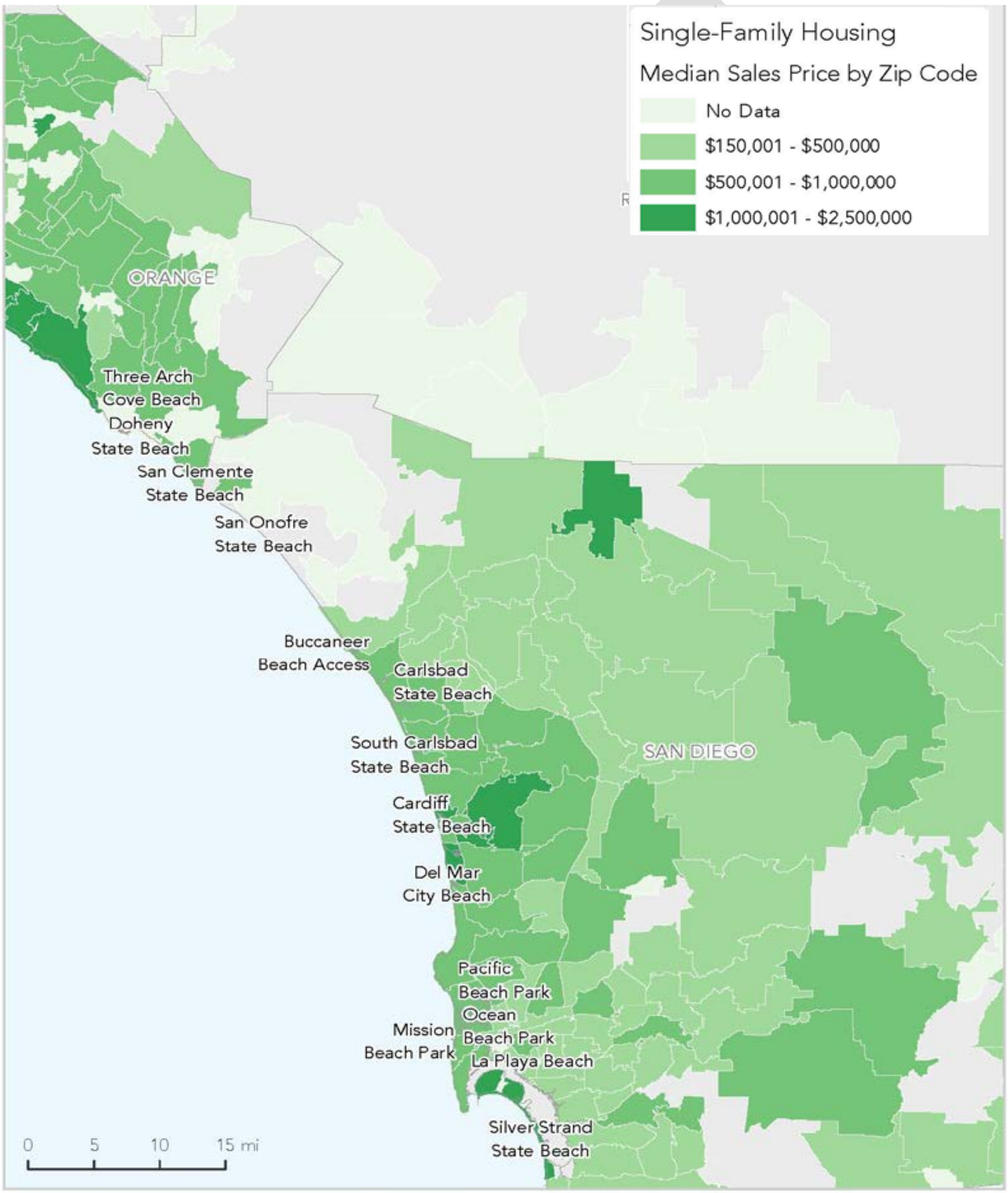
The results of this analysis are scenario-specific impacts of BMPs on stormwater runoff and quality which inform the estimates of changes in FIB and norovirus concentrations. The results of changes in FIB and norovirus concentrations will be combined with beach attendance by swimmers and surfers to inform the analysis of the impacts of BMPs on the incidence of water-borne illnesses. Combining information on changes in the incidence of water-borne illnesses with data on the economic costs per type of illness will inform the analysis of the economic benefits of GSIs as estimated based on avoided medical costs and possibly values of avoided discomfort and lost labor productivity.

[40] Soller, J., M. Schoen, J. Steele, J. Griffith, and K. Schiff. 2016. *Wet weather recreational water gastrointestinal illness risks—quantitative microbial risk assessment harmonization with an epidemiological investigation*. Submitted and being considered for publication.

PROPERTY VALUE (RESIDENTIAL WATER QUALITY AMENITY)

People pay more for homes that have desirable amenities. Analyses of variation in property values, when controlling for other factors that drive variation in home prices, can allow quantification of the premium paid in home purchases for specific amenities, including water quality. Beaches and waterbodies are particularly attractive amenities that elicit higher prices than otherwise. Generally homes in the project area have higher prices near beaches, although substantial variation does exist in prices along the coast (Map 2). Changes in water quality have discernable effects on public health and the ability to recreate in an area. Empirical research has shown that both coastal proximity and water quality improvement positively affects the implicit price of home values. [41]

Map 2 - Map of Median Residential Property Values, Study Area



[41] Artell, J. 2014. "Lots of value? A spatial hedonic approach to water quality valuation." *Journal of Environmental Planning and Management*. 57: 862-882.

Approach

Hedonic methods are the specific empirical tools for this type of analysis. They are useful for isolating the implicit value of small changes in nonmarket goods, such as environmental amenities using home prices as a proxy for value. Hedonic methods are needed because homes are not a single-characteristic good, but represent a bundle of different attributes valued by the homeowner. These attributes can include square footage, number of bedrooms, and age of the home. It is important to identify and measure all important drivers of home value, both in terms of characteristics of the homes themselves such as numbers of bedrooms and lot size as well as neighborhood effects and proximity to other desirable amenities such as golf courses, parks, and transportation. It is also important to review the literature to support specification of the most appropriate functional form of the hedonic model that best characterizes the specific types of water quality benefits associated with the scenarios.[42]

Accounting for all of these similarities across characteristics and space allows the researcher to isolate the differences in home values, which are attributable to the underlying characteristics of the property. By selecting a large enough sample size of homes to obtain sufficient variation in the model to construct a statistical model of the determinants of home sales price, represented generally as:

$$Price = f(Physical\ Attributes, Neighborhood, Environmental\ Amenities, etc)$$

In this representation, the variables identified in the parentheses represent characteristics that can have a marginal effect on the sales price of a home. For example, a small change in environmental amenities (e.g. water clarity) may result in a change in a home's sale price. The magnitude and significance of that change will need to be determined by identifying the appropriate model to accurately capture these relationships.

This analysis will entail a preliminary screening analysis of property value effects associated with changes in water quality conditions at nearby beaches. If data and model results allow and suggest, secondary analyses would entail greater investigation into specific effects of wet weather water quality events.

Data Sources

In order to perform this analysis, the project team will obtain explanatory data, including sales prices and characteristics to account for variation in property characteristics (Figure 11). The team will also seek to obtain GIS data which will be used to calculate spatial characteristics, such as nearby parks and distance to beaches. Additional data from the U.S. Census will be obtained to account for variation in education, income, and demographics. PropertyRadar and Redfin provide sales data and Multiple Listing Service (MLS) details on homes at the time of transaction.

Figure 11 – Property value datasets and sources

Dataset	Data source
Demographic data	U.S. Census Bureau - American Community Survey
Home attributes and sales transactions	PropertyRadar
GIS layers for parcel and zoning data	SANDAG Regional Database Warehouse
Macroeconomic indicators	Bureau of Economic Analysis

[42] E.g. Walsh, Patrick. 2009. "Hedonic property value modeling of water quality lake proximity, and spatial dependence in central Florida.: University of Central Florida.

The availability of water quality data will drive the decisions about specific method sfor identifying the most practical approach for teasing out implicit price premiums from improving environmental amenities. One consideration is to estimate the associated disamenity (reduced implicit price) with homes being co-located next to stormwater runoff sites that overflow during heavy rainfall. Research has identified that the aesthetic value of water, such as clarity, can have a statistically significant effect on implicit home values.[43] A potential issue with this approach, however, is understanding the time lag between severe runoff events and changes in property values.

An additional consideration will be to estimate the premium of being on or near beachfront property. Using previous research, the project team would seek to first identify the variation between beachfront properties, such as being near surf breaks, that can impact home prices. [44] The analysis will then include additional explanatory variables that capture the changes in water quality over time to explain any potential price variation from water quality improvements.

Property Value Results

The results of this analysis will be a model specifying the average contribution of the appropriate measure of water quality improvements to home prices as a percentage of total price. Initial analyses will investigate the potential for beach closures to affect property values. This model will allow identification of the effect on home prices of various water quality levels associated with specific scenarios. It cannot be certain that a statistically significant effect will be identified for changes limited to wet weather events, but given the total coastal region of the project area and density of homes, combined with the total value of these properties, it is highly likely that water quality will be a measurable contributor to home value in general. This calculation of water quality's contribution to property values will possibly then allow estimation of total changes in home values associated with each water quality improvement scenario.

It will be important to consider these results in conjunction with recreation benefit results, to avoid any double-counting. This might mean deducting identifiable recreation participants or a portion of their value that reside within the area found to experience price premiums from water quality.

CO-BENEFITS AND INDIRECT COSTS (OTHER BENEFITS AND COSTS)[45]

Some stormwater BMPs have effects that can provide economic benefits beyond managing water quality. This is especially true for a class of BMPs known as "green stormwater infrastructure," or GSI. [46] U.S. EPA describe green infrastructure as,

> "Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. While single-purpose gray stormwater infrastructure—conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment, green infrastructure

[43] Leggett, C. & N. Bocks. "Evidence on the Effects of Water Quality on Residential Land Prices." 2000. *Journal of Environmental Economics and Management*. 39: 121-144.

[44] Scorse, Jason, F. Reynolds, & A. Sackett. 2015. "The Impact of Surf Breaks on Home Prices in Santa Cruz, CA." *Tourism Economics* 21(2).

[45] This section describes positive and negative effects of BMPs (described as benefits and costs) as requested by the Technical Advisory Committee. Results are presented as a BMP effects table, formerly referred to as a "Conceptual Model."

[46] For a summary description of these benefits see, U.S. EPA. 2016. Benefits of Green Infrastructure. www.epa.gov/green-infrastructure/benefits-green-infrastructure.

reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.”[47]

To differentiate from other “green” types of infrastructure that might not directly address stormwater issues, this section uses the phrase “green stormwater infrastructure” (GSI). This subsection describes the analysis in which the project team will identify, describe, quantify, and value non-water quality effects of BMPs using currently available data and research results. In general the BMPs are selected for their benefits, and at this planning stage, it is assumed that any specific projects with substantial negative consequences would be avoided or delayed for implementation. Still though, this step of the process will also provide valuation, quantitatively or qualitatively, for any negative consequences for BMPs identified during the BMP literature and data review process. The term “cost” is used here for these negative effects, even though they might have market or only non-market values. Also, these costs do not include the actual BMP implementation costs (capital, operation and maintenance). Those costs are discussed and analyzed separately, and described in the next section of this work plan.

Approach

The overall approach for valuing indirect benefits and costs provided by water quality improvement under each scenario is:

1. Identify the stormwater BMPs included in each scenario.
2. Identify and describe the indirect (non-water quality) benefits (and potentially costs) that each BMP provides.
3. Quantify the identified effects for all BMPs in each scenario.
4. Value the indirect benefits and costs, based on appropriate benefit transfer techniques and scaling to the project area.

In general, this analysis will rely upon identifying the supply of and demand for each benefit, and then apply per-unit benefit values from the expanding literature on GSI benefits. Any identified costs would also be based on BMP-specific effects and identifying the appropriate literature, data, or BMP experts for review. If other important co-benefits beyond GSI are identified in the course of this analysis and it is feasible to include them, the project team will do so. For example, addressing transient encampments might provide social welfare and other social improvement benefits that might have supporting values in existing literature. This set of co-benefit analyses in general will rely upon opportunistic use of available data and literature describing the benefits identified.

Data Sources

We summarize the data that will inform the analysis of non-water quality benefits in Figure 12.

Figure 12 - Non-water quality datasets and sources

Dataset	Data Source
Stormwater BMPs in each scenario.	Engineering and stormwater BMP portions of WQIP analyses.
Non-water quality benefits.	Existing literature and research results.
Quantify non-water quality benefit.	Engineering and stormwater BMP portion WQIP analyses and existing literature and research results.
Value the non-water quality benefits.	Existing literature and research results.

[47] US. EPA. “What is Green Infrastructure?” https://www.epa.gov/green-infrastructure/what-green-infrastructure.

Stormwater BMPs in each scenario

Data for the project team's analysis of the stormwater BMPs included in each scenario will come from WQIPs for regulatory endpoint scenarios and wastewater engineering estimates for load reduction strategy scenarios. We anticipate that the scenarios will include a mix of grey and green stormwater infrastructure. Grey infrastructure typically provides little in the way of non-water quality benefits. These systems are designed to efficiently move and process stormwater, with little to no emphasis on other benefits. As described above, green infrastructure can provide a range of non-water quality benefits, which we describe in the next subsection.

Non-water quality benefits

Figure 13 lists some of the GSI BMP non-water quality benefits as reported by the project team from previous research supported by U.S. EPA.

Figure 13 - Non-water quality benefits of GSI BMPs

Benefit	Description
Household Energy Use	Trees planted near homes have the capacity to affect the amount of energy these households use for heating and cooling. Households realize the value of these benefits in the form of smaller energy bills.
Greenhouse Gas Emissions	GSI has the capacity to directly reduce energy-related greenhouse gas (GHG) emillions by decreasing household- and utility-related energy consumption. Furthermore, trees planted through GSI efforts sequester carbon from the atmosphere.
Air Quality	As with GHG reductions, GSI can improve air quality be reducing energy-related emissions and by removing pollutants from the atmosphere through natural processes.
Urban Habitats	Some GSI BMPs (e.g., rain gardens, green roofs, and trees) provide habitat-related benefits to different types of urban wildlife including mammals, birds, and insects. These small-scale habitat benefits are valuable in that they help improve the health and diversity of local wildlife populations. Individuals benefit from these habitat improvements insofar as they value the wildlife that habitat improvements and expansions support.
Hydrological Functions	GSI has the capacity to improve hydrologic function in the San Diego region, which would help support a wide range of benefits individuals derive from a functioning ecosystem.
Mental Health	Research shows that exposure to natural settings can help improve mental health in many ways, including improving community cohesion and reducing crime rates in specific neighborhoods. They can also provide a mental break for workers during their workday and during their daily commmutes to and from work.
Ecological Literacy and Stewardship Behavior	Evidence from several fields demonstrates the numerous ways people experience benefits from the environment and how these benefits and social signals motivate actions that promote environmental quality. GSI facilities contribute to these beneficial behaviors through education, reminders, and opportunities to contribute to water quality improvement and other areas of environmental protection.
Reduced O&M Costs	Managing more stormwater on site helps reduce the O&M costs of managing stormwater downstream.

Source: ECONorthwest. 2014. *Expanding the Benefits of Seattle's Green Stormwater Infrastructure*. Work supported by EPA Contract No. EP-C-11-009 as part of the 2012 EPA Green Infrastructure Technical Assistance Program.

A large and continuously expanding body of literature describes the non-water quality benefits of GSI and the mechanisms by which these stormwater BMPs create or provide these benefits. This literature will inform descriptions of the non-water quality benefits provided by type of GSI stormwater control. Because this analysis is focused on wet-weather conditions, the extent to which precipitation affects the provision of benefits is described and the analysis of benefits is adjusted accordingly.

Quantify and value non-water quality benefits

Our analysis will rely on currently available data on the quantities of non-water quality benefits provided by type of GSI, and the associated economic values of these benefits. A large body of literature exists on this information, as do a number of databases designed specifically to catalog the values of these benefits. Figure 14 below lists and describes some of the data sources that our analysis will rely on to estimate the quantity and value of non-water quality benefits that the GSI stormwater controls in each scenario provide.

Figure 14 - Data sources for non-water quality benefits

Data Source	Description	Source
Environmental Valuation Reference Inventory	A searchable database of over 4,000 empirical studies on the economic values of environmental benefits of ecosystem services. Supported by Environment Canada and U.S. EPA.	https://www.evri.ca/Global/Splash.aspx
Center for Neighborhood Technology's *Green Values Stormwater Calculator*	The *Calculator* is designed to help people evaluate sustainable design alternatives. It is based on extensive research into the long-term costs and performance of GSI. Developed in collaboration with U.S. EPA.	http://greenvalues.cnt.org/calculator/faq.php
The Marine Ecosystem Services Partnership Valuation Library	The valuation library includes a dynamic mapping tool that spacially displays values. Built on over 900 studies of economic values of marine-based ecosystem services. Initiated by the International Coral Reef Initiative, currently managed by Duke University's Nicholas Institute of Environmental Policy Solutions.	http://www.marineecosystemservices.org/
Research by U.S. EPA and others	Case studies, literature reviews and project assessments conducted on the performance and economic benefits provided by GSI.	U.S. EPA provides example studies at https://www.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources

The project team will employ the benefit transfer (BT) method of valuing BMP benefits, primarily those associated with GSI approaches. The BT method uses empirical estimates of values from previous studies and applies them in a similar context. This widely used method is an alternative to primary research in cases where budget, time or other factors prohibit original data collection. In this case the value of non-water quality benefits is estimated in the San Diego region using results of studies conducted in comparable locations or conditions. The project team anticipates providing a range of values for each benefit, rather than a point estimate. Whenever possible the project team will rely on results from studies in the San Diego region. U.S. EPA and others provide guidelines on conducting BT analyses and adjusting valuations in cases where differences exist between the sites or conditions at previous studies and the current study site or conditions.[48] The method is outlined in Table 6 below.

[48] U.S. EPA. Benefits Transfer Workshop Proceedings. https://yosemite.epa.gov/ee/epa/eerm.nsf/vwRepNumLookup/EE-0571?OpenDocumenthttps://yosemite.epa.gov/ee/epa/eerm.nsf/vwRepNumLookup/EE-0571?OpenDocument.

Table 6 - Benefit transfer (BT) analytical method

Step	Description
Step 1 Review information on BMPs	Identify the range of BMPs and describe their performance.
Step 2 Literature Review of BMP Values	Review databases and reports for information on values of non-water quality GSI benefits.
Step 3 Adjust Values for San Diego Conditions	Begin BT analysis. Report values from San Diego-specific studies and apply BT methods to adjust values from other locations.
Step 4 Estimate Range of Per Unit Values	Complete BT analysis. Estimate a range of values per benefit.
Step 5 Estimate Total Values per Scenario	Apply ranges from Step 4 to GSI BMPs in TMDL alternatives. Estimate total values of non-water quality benefits.

Other important co-benefits

Stormwater BMPs can include benefits in addition to those described above. An example specific to our study is minimizing concerns associated with transient encampments along streams in San Diego watersheds. These encampments can create public health, crime and water quality concerns. Our analysis will include a review of available reports, information, and data on stormwater BMPs that address these concerns. The project team will review information on programs in the San Diego region, California, and elsewhere. Examples of BMPs that have been tried and failed include placing trash and porta potties in designated locations. Other potential solutions, such as adding buffer zones along waterways to help filter runoff from encampments, are infeasible in our study area due to the fact that much of the affected stream banks are private property.

Non-Water Quality Results

The results of this analysis will include the types and quantities of non-water quality benefits and costs provided by BMPs. For each type of BMP, the project team will list the non-water quality benefits and costs and describe the corresponding economic values. When the data allows, the project team will describe economic values quantitatively. When the data do not support quantification, the project team will describe benefits and costs qualitatively. For each type of non-water quality benefit or cost, the project team will sum across the type and quantity of BMPs by scenario and estimate the total value of these effects. Results will provide per-unit, total annual, and total net present values of co-benefits identified and monetized in this analysis.

Results will also be presented in a table qualitatively describing positive and negative effects (costs and benefits by BMP type. The structure of these results is presented in Table 7.The information in this table will provide the SC with another metric for comparing scenarios, in addition to net benefits and RIS. Because these results are qualitative, their use is limited to indicating which types of BMPs may have more negative effects (costs) than others. For scenarios which have similar net benefits, the SC may use the BMP effects table to identify which scenario is likely to have fewer negative effects.

Table 7 – BMP Effects Table (Example)

BMP Type	BMP effects	
	Positive	Negative
BMP Type 1	Example: increased infiltration increases water supply	

OTHER BENEFIT ANALYSIS CONSIDERATIONS

Additional Benefits

In addition to these benefits identified for valuation above, our analysis will address any additional benefits identified during the process. This could include factors such as mental health, existence values for water quality, fish and wildlife population effects, or other ecosystem service effects (e.g. erosion control). In general, these analyses will involve description and documentation of the effect of a scenario on a resource known or believed to supply the identified benefit, compilation of evidence suggesting scarcity of the resource or service (supply does not exceed demand), and any information suggesting the magnitude of the benefit or its relative importance. For example, are there revealed expenditures demonstrating that individuals or institutions do value the service? Are there survey data identifying its relevance?

Changing Baseline Conditions

The baseline characterizing current conditions now and over the analytical timeframe serves as the counterfactual to other scenarios as described earlier. Depending on current conditions data identified during this project, there might be multiple potential future states to consider. Areas of potential data ambiguity likely to be evaluated via sensitivity analysis include: amenity and recreation preferences, population size and demographic composition, and climate patterns affecting precipitation severity and frequency. We intend to use the best data available to project baseline conditions and important future factors relevant to other scenarios as well, and consider multiple sets of these assumptions where relevant.

CROSSCUTTING ANALYSIS: COST

In general, the analysis will develop costs by category of cost type, sufficient to align costs to specific scenarios, and identify the timing of costs for appropriate time discounting. The primary cost categories of interest are:

Project Installation Costs - Constructing the project will involve labor and materials costs, expended during the period of installation. Costs should include these for installing the project and for any mitigation required for project installation. These costs will come from the project engineering and design information from the existing TMDL studies. These costs will be broken out annually over the period of installation, so they can be discounted appropriately.

Project Operation and Maintenance Costs - Managing the project over its lifespan will involve labor and materials costs. These costs will be broken out annually over the period of installation, so they can be discounted appropriately.

Project Planning and Administration Costs – In addition to cost categories described above, various permitting processes, public engagement processes, and internal program administration costs can be relevant to include. These costs should be limited to those beyond costs required by current operations and efforts. The project team will coordinate with the co-permittees to identify and estimate the appropriate costs, based on existing cost data.

Project Financing Costs – Based upon co-permittee implementation plans, the project team will estimate the costs of financing in terms of administration and costs of borrowing where necessary. The project team will coordinate with co-permittee agency staff where appropriate to estimate the appropriate cost of capital borrowing each faces, and cost categories and amounts that would require financing.

If other important categories of costs are identified during the analysis process, the project team will describe and quantify them to the extent possible given existing data. Depending on cost detail specifics, some costs to private parties (e.g. business owners) might be necessary to include as well, if not captured in the existing cost estimates and not fairly attributable to other existing actions or requirements such as existing stormwater code compliance. No such private cost categories have been identified to-date, but the project team will be mindful of such costs while reviewing available data and scenario details. Overall it is important to capture all costs necessary to achieve the intended outcomes associated with each scenario's objectives. This could include contingencies for repair, replacement, or improvement of BMPs that under-perform. If such failure rates exist and are not currently included in cost estimates, say for restoration projects, the project team will use existing data and evidence to estimate such cost contingencies for addressing failures and underperformance over time.

The project team will review the cost data and coordinate with the cost estimators to ensure all relevant costs are included in existing cost estimates, and address any gaps such as design, permitting, and contingencies in coordination with the appropriate engineers augmented by review of readily available actual costs for implementing similar projects in the project area, or if necessary, looking elsewhere. Federal guidance provides a basis for ensuring all relevant costs are included. It will be important to consider cost detail and format sufficient to input to the affordability analysis (Financial Capability Assessment) as well. Results will be annual costs and net present value (discounted) over each timeframe for each scenario.

Other Costs

Project cost estimates will include all major financial and non-financial costs. Currently, identified costs include only the direct costs of implementing the various BMPs by scenario, but if other substantial unintended negative consequences of a project scenario arise (in comparison to the baseline), such as increased traffic congestion, the project team will address it with existing data quantitatively or qualitatively. Similarly, the co-benefits section as described earlier includes addressing indirect negative consequences of BMPs if any are identified during the BMP effect review process under that task. No such cost categories have been identified at this point warranting extensive quantitative analysis. All costs will be quantified and distributed over time sufficient to develop total cost estimates for the full project timeframe, discounted based on appropriate discount rates.

The project team will rely primarily on existing cost estimates from engineering analyses associated with TMDL studies by the City of San Diego and the County of San Diego. If Orange County develops cost data in sufficient time to apply, the project team will use Orange County data as well. If not, the project team will coordinate with project engineers, Steering Committee and TAC members, and other relevant expertise to extrapolate available engineering cost data to the Orange County compliance costs. Similarly, human source scenarios primarily involving leaking septic systems and sewer pipes as well as transient camp sanitation issues do not have existing engineering cost data. The project team will coordinate closely with the appropriate experts to develop representative cost estimates for these scenarios based on existing data, with an understanding that these costs can potentially be updated in the future as more detailed scenario planning progresses.

Extrapolation of Existing Cost Estimates

It will likely be necessary to extrapolate some existing cost estimates to geographies not currently analyzed. The project team will coordinate with the steering committee and appropriate engineers for the appropriate permittee to develop the appropriate scaling factors. It is likely that scaling will be based upon population density and land use, and potentially include readily available stormwater volume or other measure of performance requirement if relevant. These extrapolations may require use of existing cost estimates.

ANALYSIS OF EXISTING COST ESTIMATES

The team will peer review existing cost estimates in current WQIPs. Data used in WQIP cost estimates is assumed to be accurate, relevant, and robust enough to conduct a cost analysis that yields defensible results. Cost analyses performed are assumed to be free of errors and correctly applying economic principles. This review is intended to identify sensitive assumptions, accounting issues and inconsistencies in cost analyses.
A sensitivity analysis examines how changes in the assumptions of a cost estimate affect the results. It is likely that there are many assumptions that could materially affect cost totals. The sensitivity analysis will document assumptions and the rationale for choices made. It is not anticipated that the team will test a comprehensive series of other values to provide a confidence interval or other statistical analyses.

Inconsistencies in cost analyses would result from the use of different analyses or data types to inform the same types of results. Types of data within and across scenarios must be comparable. For example, cost timeframes must be the same to combine net present values and discount rates should be compared and harmonized when costs are combined. It seems possible that there will be inconsistencies among the cost estimates prepared by different permittees unless detailed guidance was provided for the preparation of estimates – and the guidance was carefully followed.

Accounting issues analyzed include basic errors such as miscalculations in spreadsheets and data formatting issues such as propagated rounding errors. These errors are considered very unlikely but checksums and accounting checks will be included in the peer review.

SCREENING FINANCIAL CAPABILITY ASSESSMENT

A Financial Capability Assessment (FCA) determines the level of financial burden the study area will experience as a result of compliance with the 2010 TMDL according to the WQIP schedule, and inform consideration of an extended timeline. The SC has requested a screening FCA be performed to indicate whether high financial burden is likely. **Compared to the full FCA, a screening FCA only includes the residential indicator score calculation, not the financial capability score calculation.**

Information on the general data sources, methods, results, and applicability of FCA is extracted from EPA guidance documents.[49]

APPROACH: FEDERAL GUIDANCE

The EPA provides a series of guidance on considering the affordability of water quality standards and the investments necessary to achieve water quality improvements. EPA's initial and overarching affordability guidelines are in the 1995 document *The Interim Economic Guidance for Water Quality Standards*[50]. It describes the approach for assessing if meeting water quality requirements would lead to substantial and widespread negative economic and social burden for a particular business or community. Later in 1997,

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[49] U.S.A. Environmental Protection Agency (EPA). Office of Water, Office of Wastewater Management. Combined Sewer Overflows - Guidance for Financial Capability Assessment and Schedule Development. N.p.: n.p., 1997. Print.
[50] United States Environmental Protection Agency (U.S. EPA). 1995. Interim Economic Guidance for Water Quality Standards: Workbook. EPA-823-B-95-002. https://www.epa.gov/wqs-tech/economic-guidance-water-quality-standards.

EPA extended this area of guidance with *Guidance for Financial Capability Assessment and Schedule Development* which provides an approach to determining if a lengthened compliance schedule is justifiable because of the affordability of required expenditures[51].

In 2012, EPA issued the *Integrated Municipal Stormwater and Wastewater Planning Approach Framework*[52]. It addresses a number of issues for communities as they evaluate opportunities to plan for water quality improvements in a holistic fashion, including cost management and affordability considerations. More specific 2014 guidance builds from this 2012 framework to provide a specific approach for assessing a community's ability to afford water quality improvements and if not, the schedule whereby it could, in *Financial Capability Assessment Framework*[53].

Collectively, these guidance documents provide a roadmap for evaluating the affordability of costs under the various water quality improvement scenarios. Various data and assumptions about the community and future conditions are necessary to conduct these analyses, but they are crucial to identify the overall implementation schedule for TMDL actions if affordability and total cost is a question.

RESIDENTIAL INDICATOR SCORE

The RIS indicates a permittee's average cost per household (CPH) for water treatment as a percentage of the local median household income (MHI). RIS results are reported as a "low," "mid-range" or "high" financial impact on residential users.

DATA SOURCES

Cost Per Household

The scenario-level cost analyses described earlier provide the basis for project costs for the FCA. The project team will coordinate with the appropriate agency staff to compile data to calculate existing household water quality and supply costs, and other treatment costs not yet reflected. The U.S. Census has data on the number of households in the service area; 2014 is the most current data available. The Consumer Price Index (CPI) accounts for inflationary forces, and a representative average of recent years is appropriate. The CPI is available through the Bureau of Labor Statistics and always available up through the prior month, as of this writing May 2016.

MHI Estimate

Median household income is available for the project communities from the U.S. Census, 2014 being the most current data available.

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[51] United States Environmental Protection Agency (U.S. EPA). 1997. Combined Sewer Overflows – Guidance for Financial Capability Assessment and Schedule Development. EPA-832-B-97-004. https://www.epa.gov/sites/production/files/2015-10/documents/csofc.pdf.

[52] United States Environmental Protection Agency (U.S. EPA). 2012. Memorandum: Integrated Planning for Municipal Stormwater and Wastewater. https://www.epa.gov/npdes/integrated-planning-municipal-stormwater-and-wastewater.

[53] United States Environmental Protection Agency (U.S. EPA). 2014. Memorandum: Financial Capability Assessment Framework. https://www.epa.gov/sites/production/files/2015-10/documents/municipal_fca_framework.pdf.

METHODS

Development of the RIS starts with calculation of the current and proposed water quality control costs per household (CPH). Next, the service area's CPH estimate and the median household income (MHI) are used to calculate the Residential Indicator. Finally, the Residential Indicators are compared to national averages to establish financial impact ranges to determine whether CWA compliance will produce a possible high, mid-range or low financial impact on the permittee's residential users. The project team will calculate these measures for the overall project area households and costs in aggregate as well as for each permittee jurisdiction. If appropriate and cost distribution suggests, other geographical or jurisdictional scales for this calculation are possible as well.

CPH Estimate

To develop the CPH the permittee's total water quality control costs are calculated by adding together the current costs for existing water and stormwater treatment operations and calculating projected treatment costs. The final step is to calculate the CPH by dividing the residential share of total treatment costs by the number of households in the permittee's total service area.

Current treatment costs are defined as current annual operating and maintenance expenses plus current annual debt service. This fairly represents cash expenses for current treatment operations. Estimates of projected costs are made for any proposed treatment projects. Any concerns about including specific proposed projects in the projected costs, or the length of the planning period, should be discussed with the appropriate NPDES permitting and enforcement authorities. These costs are adjusted to current dollars. These include projected operation and maintenance expenses plus projected debt service costs for any proposed treatment controls.

MHI Estimate

After determining the CPH the adjusted median household income (MHI) for the permittee's entire service area is determined by averaging MHI census data.

RESULTS

The RIS indicates a permittee's average cost per household (CPH) for water and stormwater treatment as a percentage of the local median household income (MHI). RSI is the residential portion of current and planned treatment needed to meet CWA requirements. RIS results are reported as a "low," "mid-range" or "high" financial impact on residential users.

To assess the financial impact CWA compliance may have on the permittee's residential users, Residential Indicator is compared to the financial impact ranges as follows:

Table 8 – Residential Indicator Score Results

Financial Impact	Residential Indicator (CPH as % MHI)
Low	< 1.0% of MHI
Mid-Range	1.0 – 2.0 % of MHI
High	> 2.0% of MHI

Unless there are significant weaknesses in a permittee's financial and socioeconomic conditions, low residential indicator scores (less than 1.0) are unlikely to result in longer implementation schedules.

APPENDIX A: DATA PLAN - QUANTIFYING SCENARIO INPUTS

To determine the costs and benefits of each scenario, it is necessary to 1) identify the water quality objective, and then 2) specify the BMPs needed to meet the determined objective. A process for defining these necessary inputs to the CBA is defined generically in the steps below and Figure A1. The anticipated data sources for this information are provided for each scenario in Table A1.

The horizontal numbered list (1 – 5) at the top of each scenario indicates the general steps that will be applied to each scenario. These steps are described below.

1. **Identify basis for compliance** – Compliance may be based on fecal indicator bacteria concentration, human pathogen concentration or public health (number of illnesses).
    a. Example: The scenario "move compliance locations" is specified based on the level of bacteria concentration allowed according to the 2010 TMDL. Moving compliance locations will result in a dilution of the bacteria concentration at the sampling point. Because the sampled concentration is diluted but the compliance objective is the same, additional bacteria loading can occur.
2. **Determine bacteria loading (gather inputs and calculate loading)** – To calculate bacteria loading, appropriate inputs must first be gathered and recorded. These inputs may include a load reduction curve, dilution factor, or location of loading sources and attenuation factors. Using these inputs, calculate the total loading under current conditions and allowed under the scenario.
    a. Example: In the "move compliance locations" scenario, the expected difference in concentration between the two sampling points must be calculated. This requires first specifying compliance locations and then identifying a dilution factor. This data will allow for calculation of the total loading allowed such that the bacteria concentration standard is not exceeded at the new sampling locations.
3. **Identify information on BMPs** – Determine essential information, such as the cost and load reduction potential, of BMPs implemented or planned by each jurisdiction. If not supplied by the permittees, these will be determined based on estimations by consultants. Calculating the difference in load reduction potential between existing BMPs and the basis for compliance under a given scenario indicates whether fewer or additional BMPs are needed.
    a. Example: In the "move compliance locations" scenario, because the scenario is located within the regulatory end points policy decision, the most feasible and appropriate BMPs will be supplied by permittees. Comparing the total loading allowed under this scenario to the load reduction potential of the BMPs supplied by permittees will indicate whether additional or fewer BMPs are needed to achieve compliance.
4. **Develop BMP list** – This list of proposed BMPs will provide reasonable assurances of meeting the loading requirements of the scenario.
    a. Example: In the scenario "move compliance locations", the BMP list will be based on BMPs supplied by permittees, but scaled according to the loading requirements of the scenario.
5. **Complete CBA** - Once BMPs and WQ conditions are identified; the costs and benefits can be calculated using economic analysis.

Within each analysis step is a vertical numbered list (1. – X) that adds scenario-specific analysis steps required to determine water quality inputs. Bullet points (•) under the analysis step indicate sources of information, such as the name of a document. Underneath bullet points may be dashes (-) indicating specific types or locations of information that may be found within the source document identified. Analysis steps where the source of information is unknown are listed as a bullet points (•) followed by "DATA GAP". If sources cannot be identified to address data gaps, extrapolations of existing data will be made. Additional data needs and sources may be identified as the analysis is completed. It is likely sources in the data plan are not exhaustive. See an example of the analysis structure below.

		General Analysis Steps			
Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Policy name	**Scenario name**	**1. Scenario-specific analysis step** • Data source (example: document name) -Specific piece, type of data, or location of data within the document			

In some cases, characterizing the scenario inputs can be more easily accomplished through considering the change in the input from a reference scenario. For instance, it may be easier to determine load differences from current conditions or the 2010 TMDL scenario rather than making estimates without a well-analyzed starting point.

Information that is not already developed will need to be determined using engineering estimates, or relying on the expertise of other consultants. The effort necessary to quantify scenario inputs will have ramifications on the cost and duration of the CBA effort.

Figure A1 – A process to develop inputs to the CBA on the left and CBA on the right of the dotted line

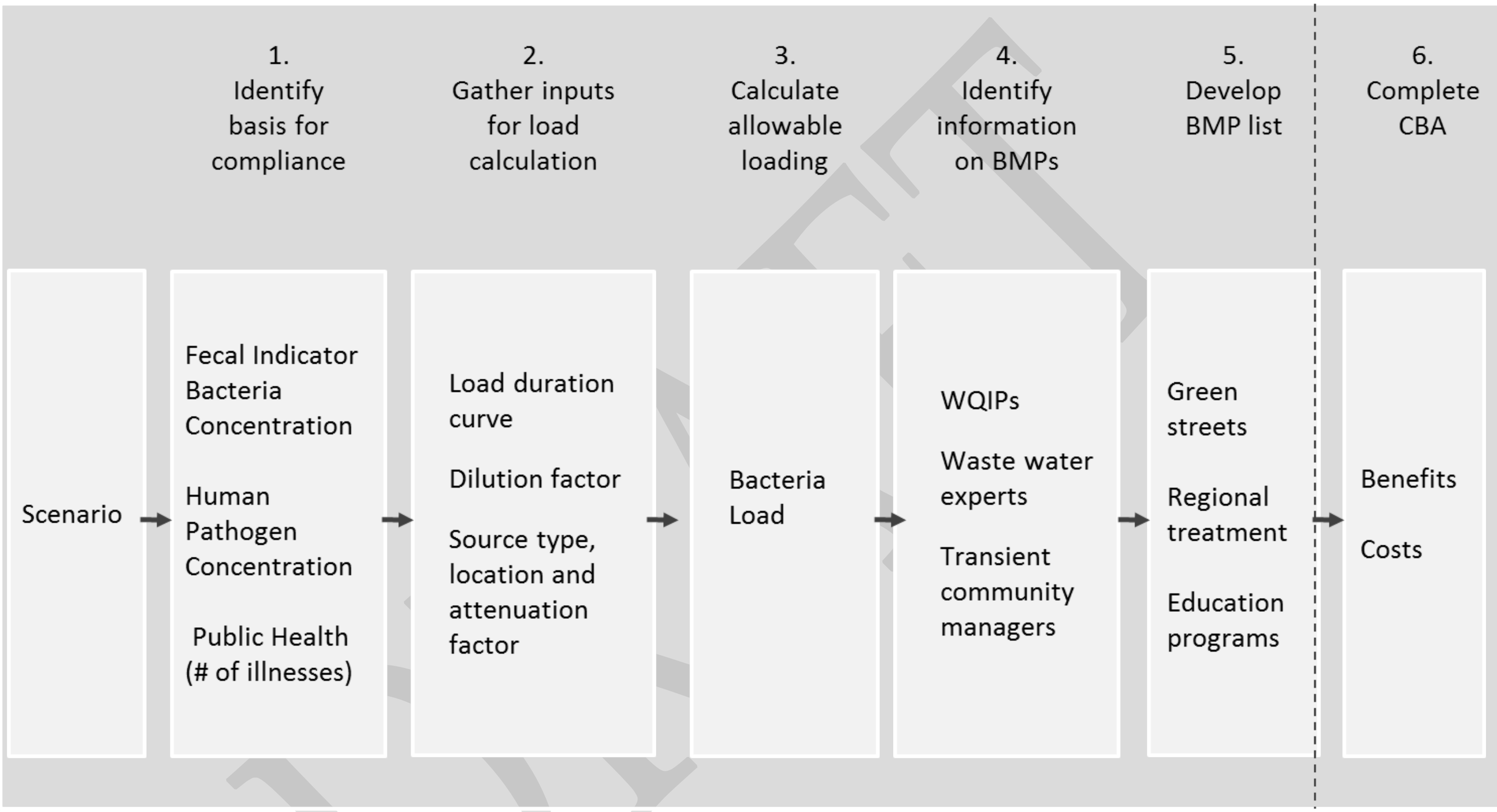

Table A1 – Data plan to calculate compliance requirements and identify BMPs for each scenario

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust bacteria regulatory endpoints	**Current conditions**	**1. Compliance standard is current bacteria concentration** **2. Data on current conditions concentration:** • Wet weather Epi: Surfer Health Study findings -Wet weather was defined as >0.25 cm of rain in 24 hours. - Summary of storm sample flow weighted concentrations -Summary of fecal indicator bacteria (cfu/100ml) and human marker data in stormwater discharges **3. Data on current conditions # of illnesses:** • Wet weather Epi: Surfer Health Study findings -12 GI illnesses / 1,000 surfers exposed	**1. Equation to convert between concentration and load** • Water Quality Control Plan Amendment -Bacteria Loading equation = flow rate (volume / time) X bacteria density (number of colonies / volume) **2. Determine loading allowed** • Water Quality Control Plan Amendment -Allowable concentration of indicator bacteria summary pg.8 -Allowable load table pg. 43 **3. Determine existing load** • Water Quality Control Plan Amendment -Existing bacteria load table pg. 43 • 2010 Bacteria TMDL -Load-duration curves to calculate wet weather mass-load Appendix I and for each modeled watershed Appendix O -Existing loads Section 8.1.5 Table 1-3 • Wet weather mass loading station data • Tetra Tech 2014-2015 model • LOADEST (USGS)	**1. Identify BMP type characteristics** • County of San Diego BMP Design Manual 2016 • Model BMP Design Manual San Diego Region 2016 **2. Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County) • SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **3. Determine load reduction Potential** • CLRP Table 3 • DATA GAP **4. Determine costs** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs Appendix H • DATA GAP **5. Determine strategy for BMP selection** • CLRP Section 3 – selection strategy	- Green Streets - Wet Pond - SSF Wetland - Infiltration Basin - GSRD - Rain Barrels - Downspout Disconnection - Home conversion - Commercial landscape conversion

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust bacteria regulatory endpoints	**2012 REC criteria**	**1. Compliance standard is 2012 REC bacteria concentration or # of illnesses** **2. Data on REC standard concentration:** • 2012 recreational water quality criteria document from USEPA - Criteria indicator is Enterococci (marine and fresh water) or E. Coli (fresh water) **3. Data on REC standard # of illnesses:** • 2012 recreational water quality criteria document from USEPA -Illness rate 32 / 1,000 exposures	**1. Determine loading allowed under REC standard: Convert between concentration and load** • Water Quality Control Plan Amendment -Bacteria Loading equation = flow rate (volume / time) X bacteria density (number of colonies / volume) • Tetra Tech modeled flow WY2003 • Wet weather Epi: Surfer Health Study findings: -Bacteria concentration vs illness curve • 2010 Bacteria TMDL -Load-duration curves to calculate wet weather mass-load Appendix I for each modeled watershed Appendix O	• **Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County)SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **2. Determine load reduction of existing BMP suite** • WQIP -Table 4-9 load reduction % • DATA GAP **3. Determine amount of additional BMPs needed to meet REC loading** (because REC concentration is lower than TMDL additional load reduction and BMPs are required) **4. Prioritize REC BMPs selected from existing suite based on cost and load reduction** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs -Appendix H - costs -Section 3 – selection strategy • DATA GAP	- Green Streets - Wet Pond - SSF Wetland - Infiltration Basin - GSRD - Rain Barrels - Downspout Disconnection - Home conversion - Commercial landscape conversion

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust bacteria regulatory endpoints	**Move compliance locations**	1. **Compliance standard is 2010 TMDL bacteria concentration** 2. **Data on TMDL bacteria concentration:** • 2010 Bacteria TMDL -Table 4-2 Wet Weather Numeric Targets (Indicator Bacteria, numeric target (MPN/100mL), allowable exceedance frequency)	**1. Identify existing compliance locations** • TMDL - monitoring location maps 5-1, 5-2, 5-3, 5-4 - section 11.3 MS4, HSC 115880, mouth of creek and upstream • WQIP - Monitoring Plan Figure 2-2 Outfalls and Monitoring Locations; Table 2-1 **2. Estimate dilution from existing to proposed sampling points** • Wet weather Epi: Surfer Health Study findings -CH 3. Figure 2: Dilution estimates • La Jolla ASBS dilution study (Jenkins, 2013) - surf zone dilution factors **3. Determine total loading allowed based on expected concentration at new sampling points** • Water Quality Control Plan Amendment -Bacteria Loading equation = flow rate (volume / time) X bacteria density (number of colonies / volume) • Tetra Tech modeled flow WY2003	**1. Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County) • SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **2. Determine load reduction of existing BMP suite** • WQIP -Table 4-9 load reduction % • DATA GAP 3. **Determine proportion of BMPs needed to meet lower load reduction requirement** (because sampled concentration is diluted, additional loading can occur) **4. Prioritize BMPs selected from existing suite based on cost and load reduction** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs -Appendix H - costs -Section 3 – selection strategy • DATA GAP	- Green Streets - Wet Pond - SSF Wetland - Infiltration Basin - GSRD - Rain Barrels - Downspout Disconnection - Home conversion - Commercial landscape conversion

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust bacteria regulatory endpoints	**Flow-based regulatory suspensions**	1. **HFS criteria** • EPA document: Suspension of Recreational Beneficial Uses in Engineered Channels during Unsafe Wet Weather Conditions - suspension of uses is applied when there is rainfall greater than or equal to 0.5 inch and remains in effect during the 24 hours following the rain event • Proposed Basin Plan Amendment: Water Quality Control Plan for the Los Angeles Region 2. **LFS criteria** • DATA GAP	**1. Determine loading during high flow and low flow periods** • 2010 Bacteria TMDL Load-duration curves - to calculate wet weather mass-load Appendix I for each modeled watershed Appendix O • City of San Diego special study • Los Angeles TMDLs	**1. Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County) • SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **2. Determine load reduction of existing BMP suite** • WQIP -Table 4-9 load reduction % • DATA GAP 3. **Determine proportion of BMPs needed to meet lower load reduction requirement** (loads generated during HF and LF do not have to be mitigated) **4. Prioritize BMPs selected from existing suite based on cost and load reduction** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs -Appendix H - costs -Section 3 – selection strategy • DATA GAP	- Green Streets - Wet Pond - SSF Wetland - Infiltration Basin - GSRD - Rain Barrels - Downspout Disconnection - Home conversion - Commercial landscape conversion

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust bacteria regulatory endpoints	**Create beach-specific WQ objectives**	1. **Compliance standard is bacteria concentration identified by SHS findings for Tourmaline Surfing Park and Ocean Beach** 2. **SHS bacteria concentration** • Wet weather Epi: Surfer Health Study findings - Section IV B: Enterococcus levels based on sampling results for Tourmaline Surfing Park and Ocean Beach	**1. Determine allowable load for two beaches based on SHS bacteria concentration** • Water Quality Control Plan Amendment -Bacteria Loading equation = flow rate (volume / time) X bacteria density (number of colonies / volume) • Tetra Tech modeled flow WY2003 **2. Determine allowable load for rest of TMDL area** • TMDL - Table 9-1, 9-2a, 9-2b loading by watershed **3. Determine difference between TMDL load and SHS/TMDL load**	**1. Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County) • SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **2. Determine BMPs for SHS beach area** • Scripps CLRP -Table 5-1, 5-3, 5-4, 5-5, 5-6, 5-7 -Table 4-2, 4-3, 4-6, 4-7, 4-9 -Table **3. Load reduction of BMPs** • WQIP Table 4-9 load reduction % • DATA GAP **4. Determine change in BMPs for Scripps watershed** **4. Prioritize BMPs selected from existing suite based on cost and load reduction** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs -Appendix H - costs -Section 3 – selection strategy -table 7-2 • DATA GAP	- Green Streets - Wet Pond - SSF Wetland - Infiltration Basin - GSRD - Rain Barrels - Downspout Disconnection - Home conversion - Commercial landscape conversion

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust bacteria regulatory endpoints	**Adjust wet weather beach WQ objectives**	3. **Compliance standard is bacteria concentration identified by SHS findings for Tourmaline Surfing Park and Ocean Beach** 4. **SHS bacteria concentration** • Wet weather Epi: Surfer Health Study findings - Section IV B: Enterococcus levels based on sampling results for Tourmaline Surfing Park and Ocean Beach	**1. Determine allowable load based on use of SHS bacteria concentration for all beaches** • Water Quality Control Plan Amendment -Bacteria Loading equation = flow rate (volume / time) X bacteria density (number of colonies / volume) • Tetra Tech modeled flow WY2003 **2. Determine difference between TMDL load and SHS load** • TMDL - Table 9-1, 9-2a, 9-2b	**1. Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County) • SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **2. Determine load reduction of existing BMP suite** • WQIP -Table 4-9 load reduction % DATA GAP 3. **Determine proportion of BMPs needed to meet SHS load reduction requirement** **4. Prioritize BMPs selected from existing suite based on cost and load reduction** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs -Appendix H - costs -Section 3 – selection strategy • DATA GAP	- Green Streets - Wet Pond - SSF Wetland - Infiltration Basin - GSRD - Rain Barrels - Downspout Disconnection - Home conversion - Commercial landscape conversion

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust strategy for achieving bacteria load	**Focus on stream restoration**	1. **Compliance standard is 2010 TMDL bacteria concentration** 2. **Data on TMDL bacteria concentration:** • 2010 Bacteria TMDL -Table 4-2 Wet Weather Numeric Targets -Indicator Bacteria, numeric target (MPN/100mL), allowable exceedance frequency	**1. Determine reduction in loading from restoration** • San Diego WQIP -Planned Alvarado Creek restoration project by the City of La Mesa Table 3-7 -Estimated load reduction from stream enhancement projects: Section 3.2.4.4, Table 3-27, Figure 3-27, Appendix 3E, Table 3E-3 -% of total load reduction Table 3-30 -location Table 3G-3	**1. Determine existing (since 2010 TMDL establishment) and planned BMPs** For each permittee's jurisdiction (SD City, SD County, Orange County) • SD County BMP spreadsheet • SD City BMP spreadsheet • DATA GAP: OC BMPs • City of San Diego pilot projects https://www.sandiego.gov/thinkblue/pilot-projects) • Stormwater Management Plan Instructions **2.Determine stream restoration BMP types, load reduction and cost** • San Diego WQIP -locations, linear feet -Section 3.2.4.4 -San Diego RWQCB & Restoration experts -Planned Alvarado Creek restoration project by the City of La Mesa Table 3-7 • DATA GAP **3. Prioritize BMPs selected from existing suite based on cost and load reduction** • WQIP cost-effectiveness curves • BMP O&M costs 2012 • CLRPs -Appendix H - costs -Section 3 – selection strategy • DATA GAP	Examples of BMPs: - Daylighting streams - Vegetation harvest - BMPs to enhance residence time - Water course rehabilitation

Policy	Scenario	1. Identify basis for compliance	2. Determine bacteria loading (Gather inputs and calculate loading)	3. Identify information on BMPs	4. Develop BMP list
Adjust strategy for achieving bacteria load	**Focus on human sources**	**1. Compliance standard is 2010 TMDL bacteria concentration or # of illnesses** 2. **Data on TMDL bacteria concentration:** • 2010 Bacteria TMDL -Table 4-2 Wet Weather Numeric Targets -Indicator Bacteria, numeric target (MPN/100mL), allowable exceedance frequency **3. Data on TMDL # of illnesses** • 2010 Bacteria TMDL -EPA REC-1 1986: 19 illnesses / 1,000 exposures	**1. Identify sewer pipe locations** • Subsurface discharge of sewage report -Table 1 -sewer repairs needed Table 1-1 • DATA GAP **2. Identify septic system locations** • DATA GAP **3. Identify transient community locations** -consult San Diego Police Department Homeless Outreach Team (HOT) & Psychiatric Emergency Response Team - consult City of San Diego Environmental Services Department -census data • DATA GAP **4. Determine loading from sewer sources** • Subsurface discharge of sewage report -Exfiltration from sewer defects Table 5-2, Table 6-1 • DATA GAP **5. Determine loading from septic sources** • County of SD Department of Env Heath -septic system design criteria • DATA GAP **6. Determine loading from transient encampment sources** • DATA GAP	**1. Determine Transient BMPs** • San Diego WQIP -Table 4-3, 5-2 -Table Pg. 3B-57, 3B-66 • DATA GAP **2. Determine Septic BMPs** • San Diego WQIP -Table 3-18, 3-22, 3-23, Pg. 3B-25 • DATA GAP **3. Determine Sewer BMPs** • San Diego WQIP -Table 3-18, 3-22, 3-23, Pg. 3B-25 • DATA GAP **4. Determine load reduction and cost of septic, sewer, and transient BMPs** • DATA GAP	Examples of BMPs: - WQIP BMPs - Cleanup transient encampments - Reduce leaking sewer lines - Upgrade septic systems

APPENDIX B: DATA PLAN – CROSSCUTTING ANALYSES

The format described here applies to both the tables for benefit analyses, and FCA analysis presented in Table B1 and B2, respectively.

To determine the costs and benefits of each scenario, it is necessary to first identify the sources of data for each benefit category. Additionally, to complete the financial capability analysis (FCA), it is necessary to identify the data sources necessary for completing the analysis. A process for defining the data sources for calculating the CBA and FCA is defined generically in the steps below and Tables B1 and B2.

The horizontal numbered list at the top of each scenario (1 – 4) indicates the general analysis steps that will be applied to calculate the benefits and residential indicator score of each scenario.

1. **Data requirement** – Each benefit category has specific data requirements. Calculation of RIS also has specific data requirements. The first step identifies the type of data required to calculate each category of benefits and FCA.
   a. Example: Data requirements for recreation benefits include recreation and recreation site characteristics, but data requirements for public health benefits include recreation exposure and illness occurrence.
2. **Data role** – The data role identifies the purpose of the data requirement and specifically how the data will be used in the benefit calculation and RIS calculation.
   a. Example: The recreation participation data requirement demands the measurement of the marginal effects of changes in conditions, including water quality, on recreation participation, when calculating recreation benefits.
3. **Data sources** – Identify the specific locations where data is located. These sources may include departments of government agencies, scientific literature, government regulations, and more.
   a. Example: Daily water quality reports are available from the San Diego County Department of Environmental Health or the County Public Works department.
4. **Result metric** – The type of result expected for each category of benefit calculation. For FCA the result will be a residential indicator score.
   a. Example: Calculation of recreation benefits results in changes in economic value to participants associated with changes in total recreation participation by activity-type

The general analysis steps (1-4) are vertical columns in the table. For each data requirement specific data roles and sources are identified moving horizontally from left to right across the table. Specific data roles and data sources are indicated with bullet points (•). See an example of the analysis structure below.

Analysis	Category	1. Data Requirement	2. Data Role	3. Data Sources	4. Result Metric
Benefits	Benefit Category	Type 1	• Data role 1 (for data requirement type 1) • Data role 2 (for data requirement type 1)	• Source of data for data type 1 • Source of data for data type 1	Result of benefit category calculation.
		Type 2	• Data role 1 (for data requirement type 2) • Data role 2 (for data requirement type 2)	• Source of data for data type 2 • Source of data for data type 2	

Table B1 – Data plan to calculate benefits (cost-benefit analysis)

Analysis	Category	1. Data Requirement	2. Data Role	3. Data Sources	4. Result Metric
Benefits	Recreation	Water quality conditions	• Calculate historical relationship between water quality and behavior. • Predict future water quality conditions under the baseline and each scenario.	• Scenario-specific BMP performance data (see earlier Data Plan tables) • Daily rain/water quality advisories (OR&SD Co.) • Daily water quality reports (SD Co. Dept. of Env. Health; OR Co. Pub Works) • Daily weather reports (NWS, WeatherUnderground) • Scientific literature on local effects of climate change (San Diego 2050, NOAA, Scripps, SCCWRP, etc.)	Changes in economic value to participants associated with changes in total recreation participation, by activity-type, by scenario
		Recreation participation	• Estimate total future recreation participation under baseline • Measure marginal effects of changes in conditions, including water quality, on recreation participation • Estimate future recreation participation under each scenarios	• Surfer Health Study • Lifeguard beach counts (OR & SD Co., SD city; other municipalities) • Statewide Comprehensive Outdoor Recreation Plan Survey • Activity-specific organizations • Watershed-specific organizations • Population and preference forecasts (SANDAG; Cal St. Fullerton)	
		Recreation site characteristics	• Calculate total recreation participation under the baseline • Calculate changes in total participation under scenarios • Estimate likely site-specific changes in participation	• Beach conditions (water quality data listed above, Heal the Bay report cards, etc.) • GIS data layers of recreation sites designated beaches, parks, and trails (OR & SD Co.; • Expert interviews (Surfrider, SDRPF, etc.) • Activity-specific site reports (Surfline, etc.)	
		Recreation trip values	• Calculate value to participants of changes in recreation participation trip counts	• Federal guidance on activity-specific trip values (EPA Econ Guidance, USFS Rec.) • Peer-reviewed literature on recreation trip consumer surplus (Loomis, Rosenberger, Hilger, Lew & Larson, etc.) • Technical reports on trip values (Loomis) • Validation with expert interviews (Surfrider, SDRPF)	

Analysis	Category	1. Data Requirement	2. Data Role	3. Data Sources	4. Result Metric
Benefits	Public Health	Water quality conditions	• Calculate historical relationship between water quality and behavior. • Predict future water quality conditions under the baseline as well as each scenario.	• Scenario-specific BMP performance data (see earlier Data Plan tables) • Daily rain/water quality advisories (OR&SD Co.) • Daily water quality reports (SD Co. Dept. of Env. Health; OR Co. Pub Works) • Other WQ data based on recreation behavior modeling (see Recreation table)	Changes in economic value to individuals experience exposure risk in terms of total willingness-to-pay to avoid illness, including medical costs and opportunity costs of time. Lost value of workforce productivity.
		Recreation Exposure	• Identify number of exposure events by scenario	• Recreation analyses under this work plan for trip decisions, relying primarily on SHS and lifeguard data (see Recreation table) • Demographic data (U.S. Census, SANDAG, Cal St. Fullerton)	
		Illness occurrence (dose-response)	• Calculate total number of illnesses by illness type based on exposure and water quality conditions	• SHS and related epidemiology studies including literature review of FIB and pathogens concentrations and incidence of illness, by population at risk. • Soller et al. 2016 QMRA model and associated parametric data. Including ingestion volumes, dilution factors, etc. Review application assumptions with study authors, TAC.	
		Cost of illness	• Calculate the benefits of avoided illness	• Literature regarding costs of illnesses to individuals (Given et al, 2006; Atiyal et al., 2013; Rabinovici, et al., 2006; updating cost estimates to present value) • Literature regarding lost workforce productivity (Dwight et al., 2005; overall regional industrial output estimates from labor, possibly via IMPLAN data.) • Median wages for the region (Bureau of Labor Statistics)	

Analysis	Category	1. Data Requirement	2. Data Role	3. Data Sources	4. Result Metric
Benefits	Co-Benefits	BMP effects	• Identify and potentially quantify outcomes of scenarios that have positive and negative effects on society.	• Scenario-specific BMP performance data (see earlier Data Plan tables) • BMP details in WQIPs, documented literature on BMPs with a priority for data of BMPs implemented within the region or similar contexts.	Increases and decreases in economic value based on effects of BMPs other than direct water quality objectives and direct costs of capital, operation and maintenance.
		Demand for effects and verification of scarcity	• Identify, verify, and measure scarcities that establish the relevance of values to society of effects, based on the regional context.	• Alignment of identified effects with regional expenditures that directly or indirectly attempt to provide the same services potentially provided by the BMP. • E.g. habitat restoration expenditures, marginal new water supply costs for Metropolitan Water District, landscaping expenditures for urban vegetation, etc. • Specific sources based on identification of marginal effects from BMPs	
		Per-unit values of effects	• Provide monetary values for effects, both positive and negative, that can be quantified in terms of effects of BMP and the value of those effects for society.	• Priority for local observed expenditures (e.g. potable water, irrigation water prices) • EPA-identified and funded studies for GSI effects • CNT Green Values Stormwater Calculator • Literature on GSI values (CNT, American Rivers, NRDC, ECONorthwest, Sustainable Sites Initiative, ASLA, LID Center, etc.	
		Value of total effect	• Sum effects of BMPs at the scenario level in order to consider total net benefits to society and make comparisons between scenarios and BMPs.	• Economic values by effect from above analyses • Total quantity of BMP effects based on scenario-specific total BMP inventories (identified in the scenario-specific sections of this Data Plan).	

Table B2 – Data plan to calculate residential indicator score (financial capability analysis)

Analysis	1. Data Requirement	2. Data Role	3. Data Sources	4. Result Metric
Financial Capability Assessment: Residential Indicator Score	Cost per household (CPH)	• Identify number of households in service area based on most recent data • Account for inflationary forces • Calculate current and projected costs for existing water and stormwater treatment operations	• 2014 U.S. Census data • Consumer Price Index (CPI) average of years (up to May 2016) from the Bureau of Labor Statistics • Permittee's current annual operating and maintenance expenses plus current annual debt service	• Average cost per household (CPH) for water and stormwater treatment as a percentage of the local median household income (MHI). • RSI is the residential portion of current and planned treatment needed to meet CWA requirements. RIS results are reported as a "low," "mid-range" or "high" financial impact on residential users.
	Median household income (MHI)	• Identify median household income is available for the permittee's service area	• 2014 U.S. Census data	