SBPAT:
MODELING OPTIONS IN SUPPORT OF REASONABLE ASSURANCE ANALYSES (RAA) COMPLIANT WITH R4-2012-0175 (LOS ANGELES MS4 PERMIT)

REVISED DRAFT

September 17, 2013

(Presented at the request of the City of Los Angeles)

Geosyntec consultants

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AGENDA

- Introduction to SBPAT for RAA
- Input types and inputting processes
- Target loading estimates/other implicit assumptions
- Format for information sharing, presentation, and use for decision support
- Quantified results
- Use of SBPAT results
- Target load reduction discussion
- Examples
- Potential Integration of multiple models

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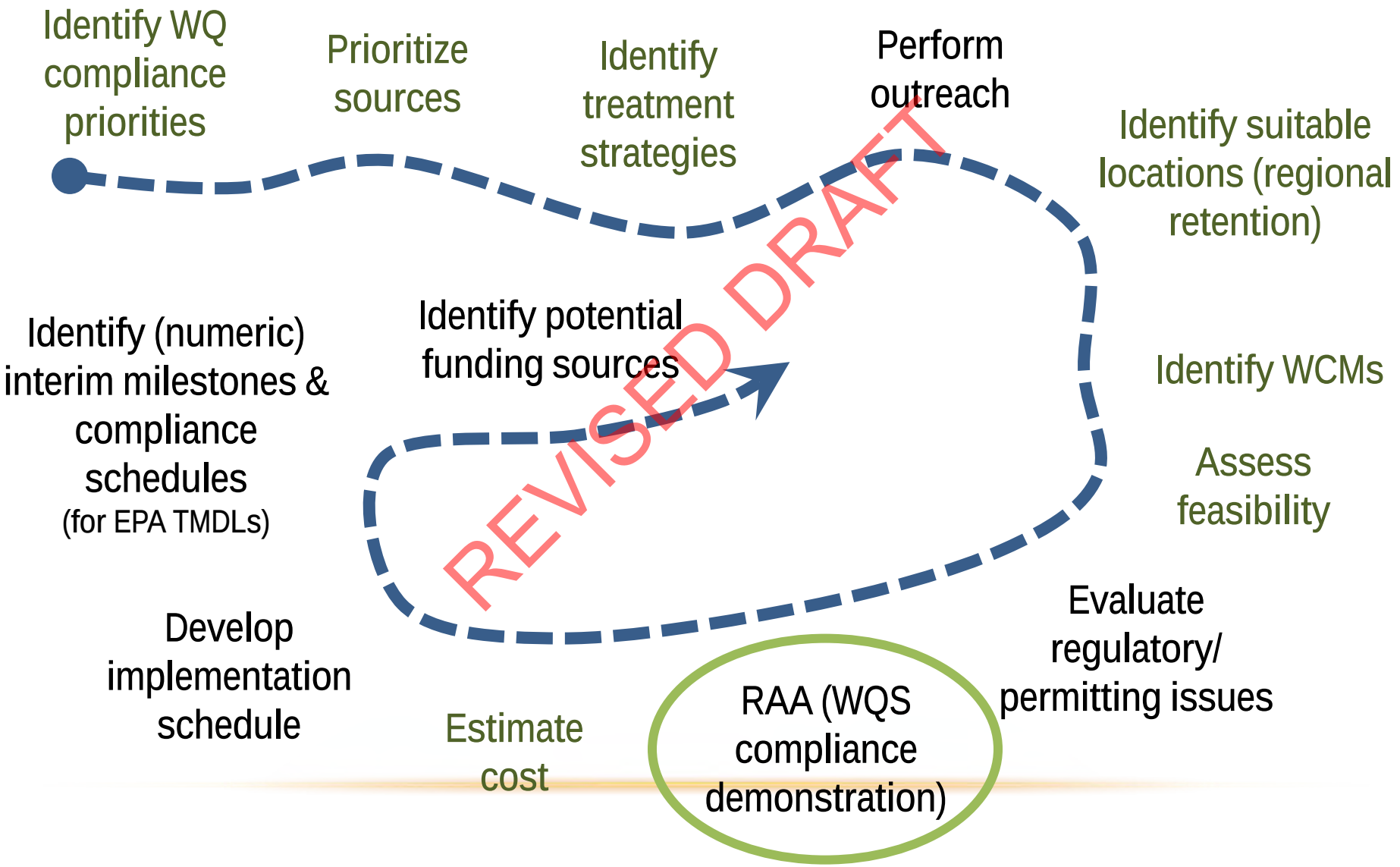
(Enhanced) Watershed Management Program



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PERMIT PROVISION C.5.B.IV(5)

(5) Permittees shall conduct a Reasonable Assurance Analysis for each water body-pollutant combination addressed by the WatershedManagement Program. A Reasonable Assurance Analysis (RAA) shall be quantitative and performed using a peer-reviewed model in the public domain. Models to be considered for the RAA, without exclusion, are the Watershed Management Modeling System (WMMS), Hydrologic Simulation Program-FORTRAN (HSPF), and the Structural BMP Prioritization and Analysis Tool (SBPAT). The RAA shall commence with assembly of all available, relevant subwatershed data collected within the last 10 years, including land use and pollutant loading data, establishment of quality assurance/quality control (QA/QC) criteria, QA/QC checks of the data, and identification of the data set meeting the criteria for use in the analysis. Data on performance of watershed control measures needed as model input shall be drawn only from peer-reviewed sources. These data shall be statistically analyzed to determine the best estimate of performance and the confidence limits on that estimate for the pollutants to be evaluated. The objective of the RAA shall be to demonstrate the ability of Watershed Management Programs and EWMPs to ensure that Permittees' MS4 discharges achieve applicable water quality based effluent limitations and do not cause or contribute to exceedances of receiving water limitations.

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STRUCTURAL BMP PRIORITIZATION AND ANALYSIS TOOL (SBPAT)

- SBPAT is:
  - Public domain, “open source” GIS-based water quality analysis tool
- Two major components:
  - Selection and Siting of BMPs
    - user-defined priorities
    - multiple pollutants
  - Quantification of pollutant reduction
    - Establishment of target load reductions (TLR)
    - Land use storm event pollutant concentrations
    - EPA-SWMM
    - USEPA/ASCE International BMP Database
    - Site and watershed-specific data
    - Monte Carlo approach

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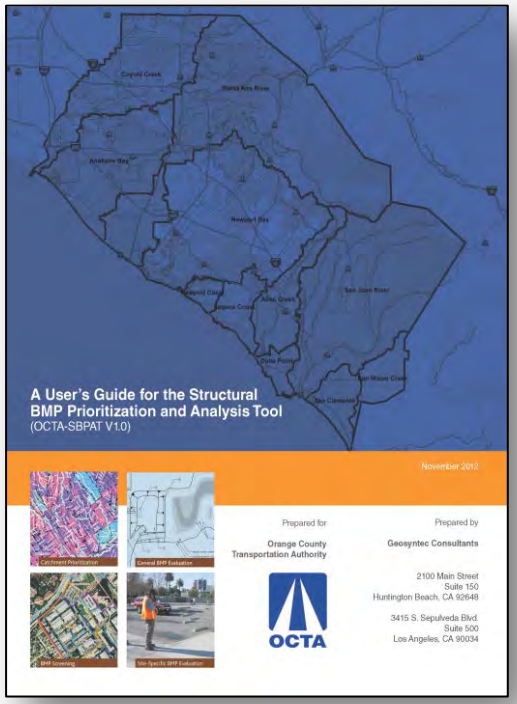

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BASIC STEPS

1. *Identify Priority Areas*
2. *Identify Opportunities*
3. *Assess Candidate BMPs*
4. Evaluate *BMP Effectiveness*

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www.sbpat.net

Original funding by agencies, SWRCB and RWQCB

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7

1. IDENTIFY PRIORITY AREAS FOR BMP IMPLEMENTATION

Permit Requirement

Based On

- Defined catchment areas
- Pollutant loading from catchments
- Pollutant priorities
  - severity and cause of impairments of receiving waters
  - TMDLs/303(d) listings
  - Stakeholder input

Result

- *Catchment Priority Index* (CPI) built from multiple pollutant loading model analyses

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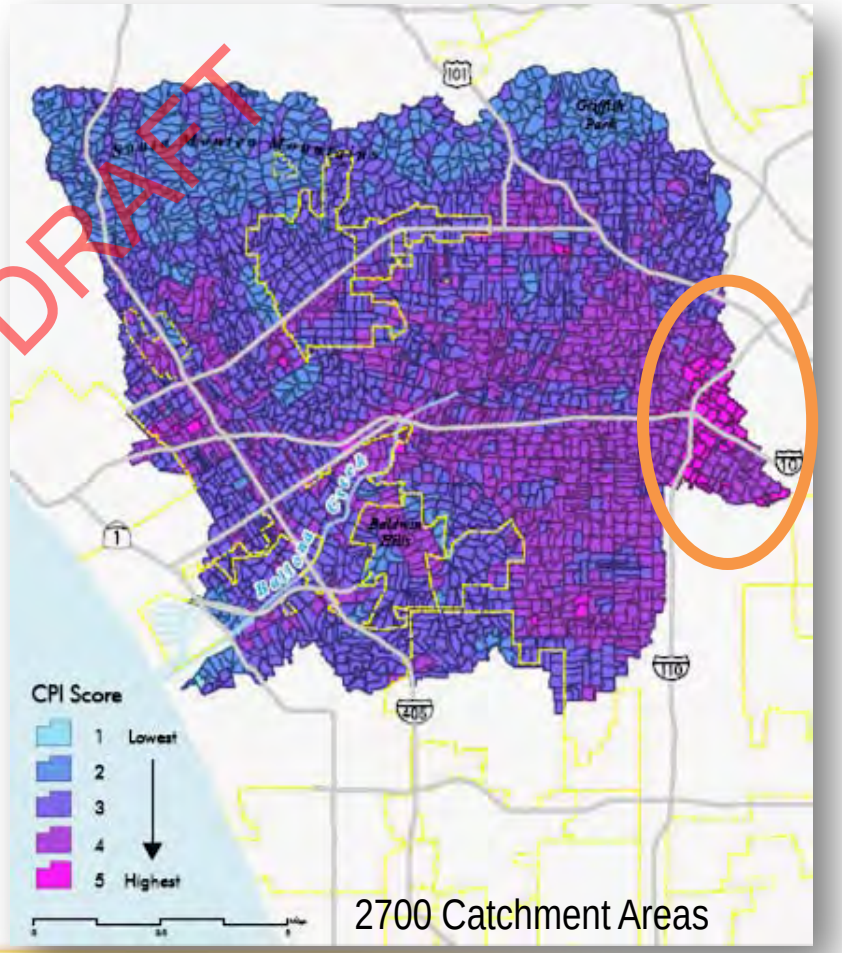

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PRIORITIZATION DATA

Regularly Updated with New Data* (built in)

Pollutant Loading Based on Land Use

Land Use	Trash[10], cf/ac	Nitrate, mg/L-N	Total Copper, ug/L	Total Lead, ug/L	Total Zinc, ug/L	Fecal Coliform, MPN/100ml	TSS, mg/L
Agriculture	0.0	34.4	100.1	30.2	274.8	6.03E+4	999
Commercial	1.0	0.55	31.4	12.4	237.1	7.99E+4	67.0
Educational	1.0	0.61	19.9	3.6	117.6	7.99E+4	99.6
Industrial	1.0	0.87	34.5	16.4	537.4	3.76E+3	219
Transportation	1.0	0.74	52.2	9.2	292.9	1.68E+3	77.8
Open	0.0	1.17	10.6	3.0	26.3	6.31E+3	216.6
HDSF Residential	1.0	0.78	18.7	11.3	71.9	3.11E+4	124.2
MF Res/ Mixed Res.	1.0	1.51	12.1	4.5	125.1	1.18E+4	39.9

Simple Calculation Methodologies

$$PCPI_x = \frac{\sum_y \left(EMC_{x,y} * RC_y * A_y * P\right)}{\sum_y A_y}$$

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Pollutant Priorities Reflected in Assigned Weights

Candidate Catchment Factors	Max Points
1. Rank catchment by pollutant load per unit area (5 bins each)	**50**
Trash	10
Nutrients (Nitrate)	10
Bacteria (Fecal Coliform)	10
Total Metals (Total Cu, Total Pb, Total Zn)	15
Sediment (TSS)	5
2. Multiply pollutant score by 2 if a d/s impairment, by 3 if a d/s TMDL	**x2 or x3**
3. Add 5 points for each "other" impairment (bioaccumulation, toxicity, legacy pesticides, and ecological impacts)	**20**
Theoretical maximum catchment pollutant load score	**170**

Stakeholder Driven Inputs to support prioritization**

*Updated through efforts in San Diego and Orange County

**TMDL = Category 1; 303(d) = Category 2; etc.

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2. IDENTIFY OPPORTUNITIES

- BMP Types (Regional, Distributed, Institutional)
- Opportunity Screening Process
  - Parcels, Roadways, Storm Drains
  - BMP Opportunity Maps
    - Available Space
    - Ownership
    - Slopes, Liquefaction Zones
    - Environmental Priority
  - Link Priority to Opportunity

Stakeholder Driven Inputs
(Supports Opportunity Development)

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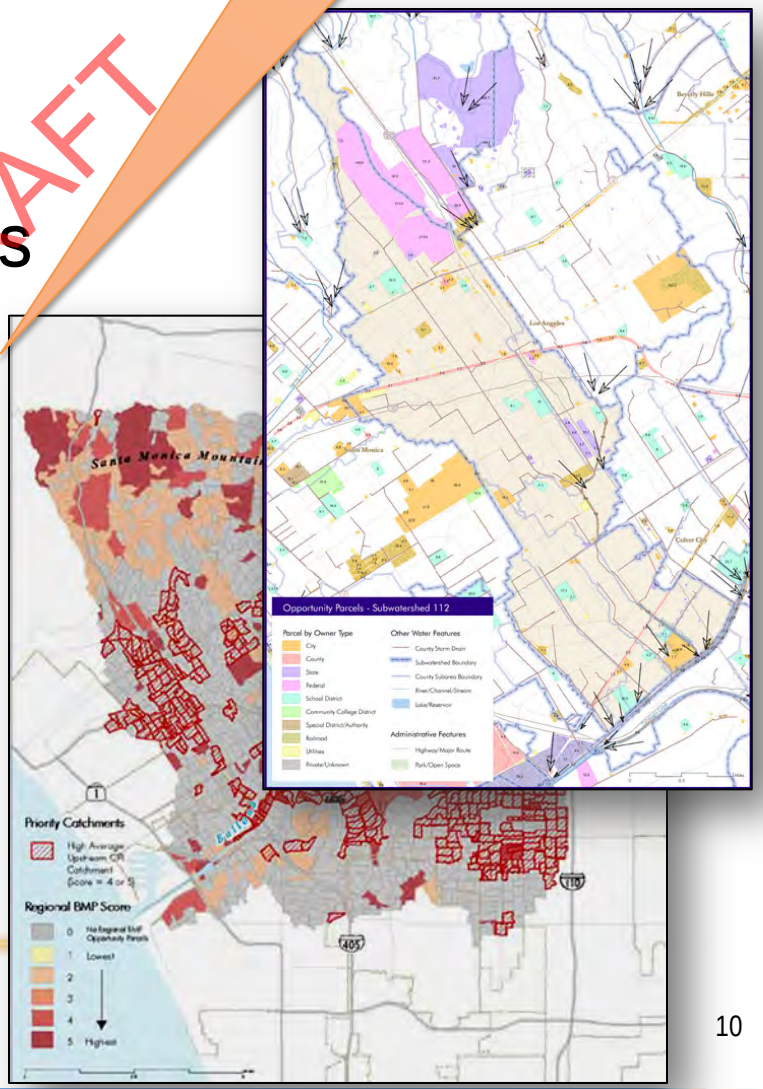

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REGIONAL BMPS

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Different Infrastructure/Retrofit Conditions than Distributed BMPs
Multiple Types of Regional BMPs (such as Wetlands) Analyzed

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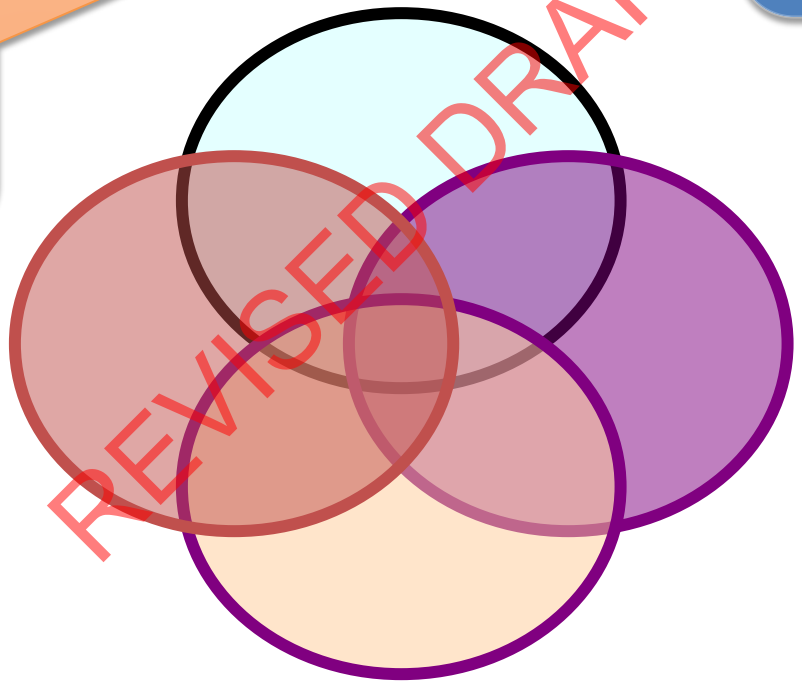
3. ASSESS CANDIDATE BMPS

Stakeholders inform implementation priorities (relative importance)

Links *Pollutant-specific* BMP Performance to Management Priorities



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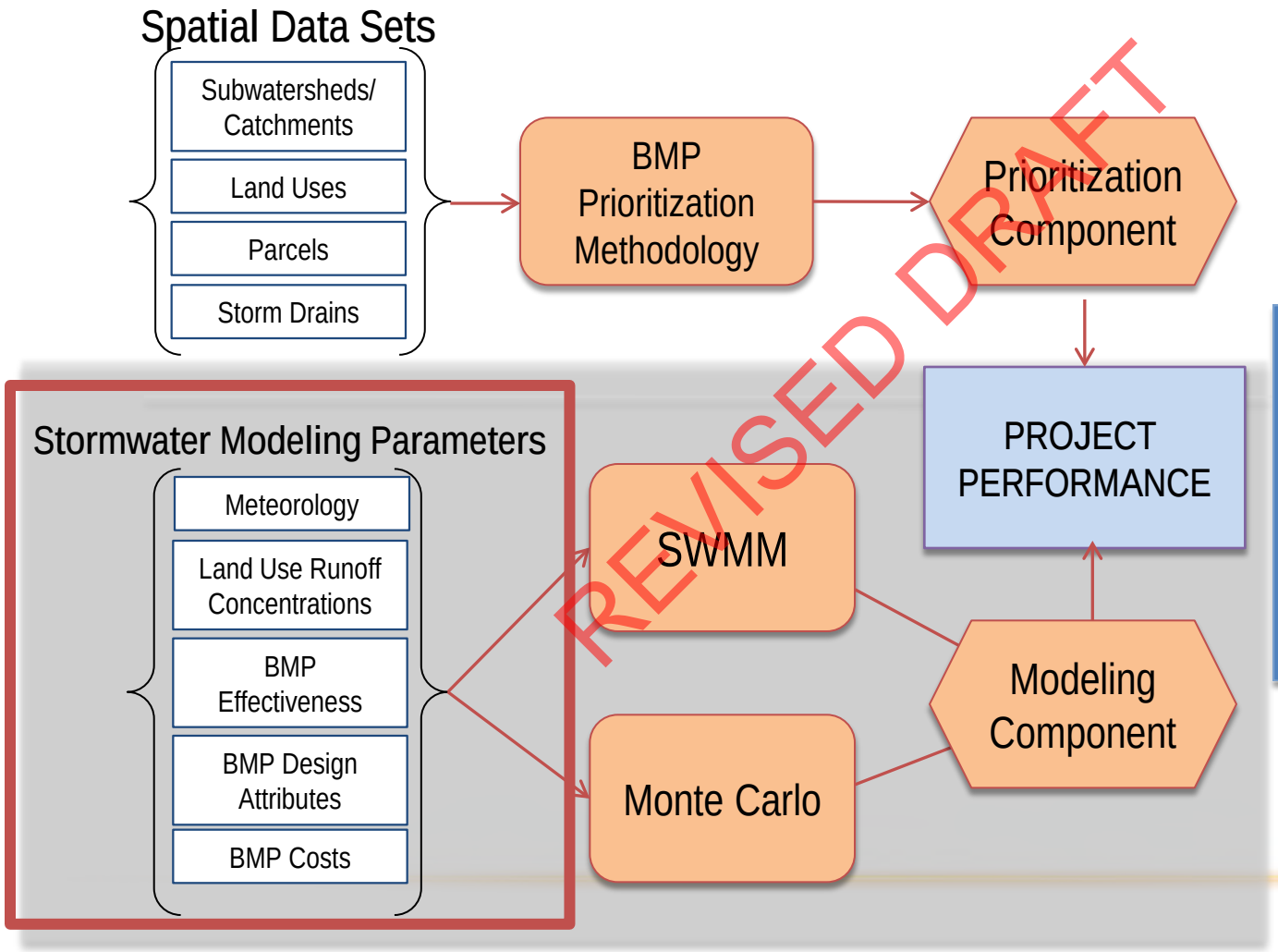
4. EVALUATE BMP EFFECTIVENESS FOR REASONABLE ASSURANCE ANALYSIS



Evaluate performance relative to:

- Load reduction
- Frequency reduction
- Costs
- Risk

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BMP DATABASE STATISTICS (2012 UPDATE)

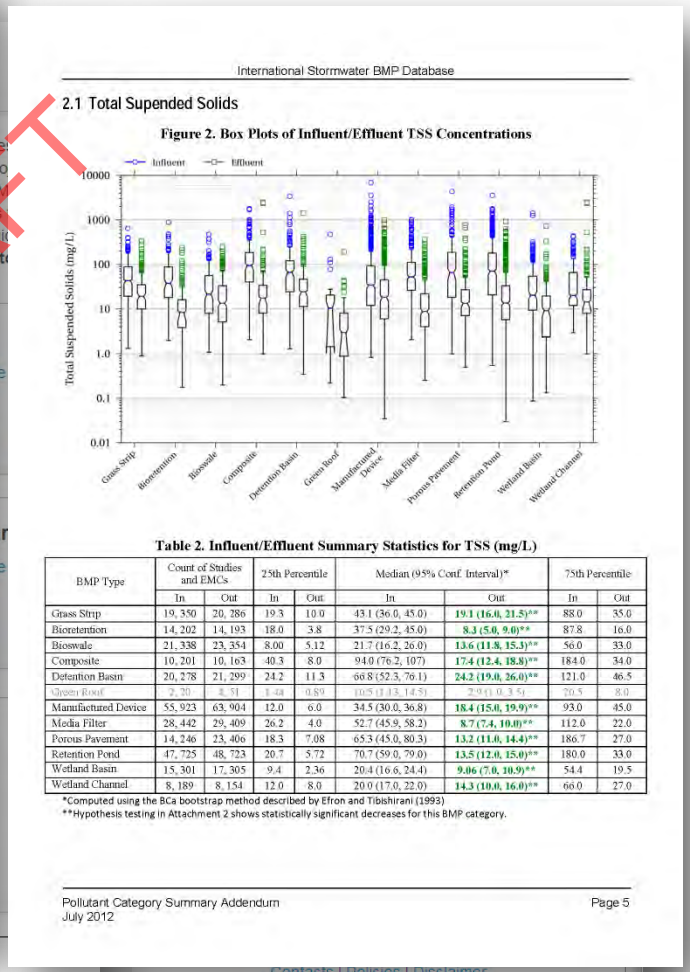

Table 2. Influent/Effluent Summary Statistics for TSS (mg/L)

BMP Type	Count of Studies and EMCs		25th Percentile		Median (95% Conf. Interval)*		75th Percentile	
	In	Out	In	Out	In	Out	In	Out
Grass Strip	19, 350	20, 286	19.3	10.0	43.1 (36.0, 45.0)	**19.1 (16.0, 21.5)****	88.0	35.0
Bioretention	14, 202	14, 193	18.0	3.8	37.5 (29.2, 45.0)	**8.3 (5.0, 9.0)****	87.8	16.0
Bioswale	21, 338	23, 354	8.00	5.12	21.7 (16.2, 26.0)	**13.6 (11.8, 15.3)****	56.0	33.0
Composite	10, 201	10, 163	40.3	8.0	94.0 (76.2, 107)	**17.4 (12.4, 18.8)****	184.0	34.0
Detention Basin	20, 278	21, 299	24.2	11.3	66.8 (52.3, 76.1)	**24.2 (19.0, 26.0)****	121.0	46.5
Green Roof	2, 20	8, 51	1.44	0.89	10.5 (1.43, 14.5)	2.9 (1.0, 3.5)	70.5	8.0
Manufactured Device	55, 923	63, 904	12.0	6.0	34.5 (30.0, 36.8)	**18.4 (15.0, 19.9)****	93.0	45.0
Media Filter	28, 442	29, 409	26.2	4.0	52.7 (45.9, 58.2)	**8.7 (7.4, 10.0)****	112.0	22.0
Porous Pavement	14, 246	23, 406	18.3	7.08	65.3 (45.0, 80.3)	**13.2 (11.0, 14.4)****	186.7	27.0
Retention Pond	47, 725	48, 723	20.7	5.72	70.7 (59.0, 79.0)	**13.5 (12.0, 15.0)****	180.0	33.0
Wetland Basin	15, 301	17, 305	9.4	2.36	20.4 (16.6, 24.4)	**9.06 (7.0, 10.9)****	54.4	19.5
Wetland Channel	8, 189	8, 154	12.0	8.0	20.0 (17.0, 22.0)	**14.3 (10.0, 16.0)****	66.0	27.0

*Computed using the BCa bootstrap method described by Efron and Tibshirani (1993)
**Hypothesis testing in Attachment 2 shows statistically significant decreases for this BMP category.

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STORMWATER MODELING ELEMENTS

- EPA SWMM4.4h (modified) accounts for:
  - Continuous hydrologic response and hydrologic performance of BMPs
  - Antecedent moisture conditions
  - Transient storage conditions
- Monte Carlo event simulation accounts for:
  - Tributary area properties
  - Interdependence of selected distributed/regional BMP types
  - Antecedent conditions
  - BMP volume, treatment rates, volume reduction processes and transient storage conditions
  - Observed variability in runoff quality
  - Observed variability in BMP effluent quality

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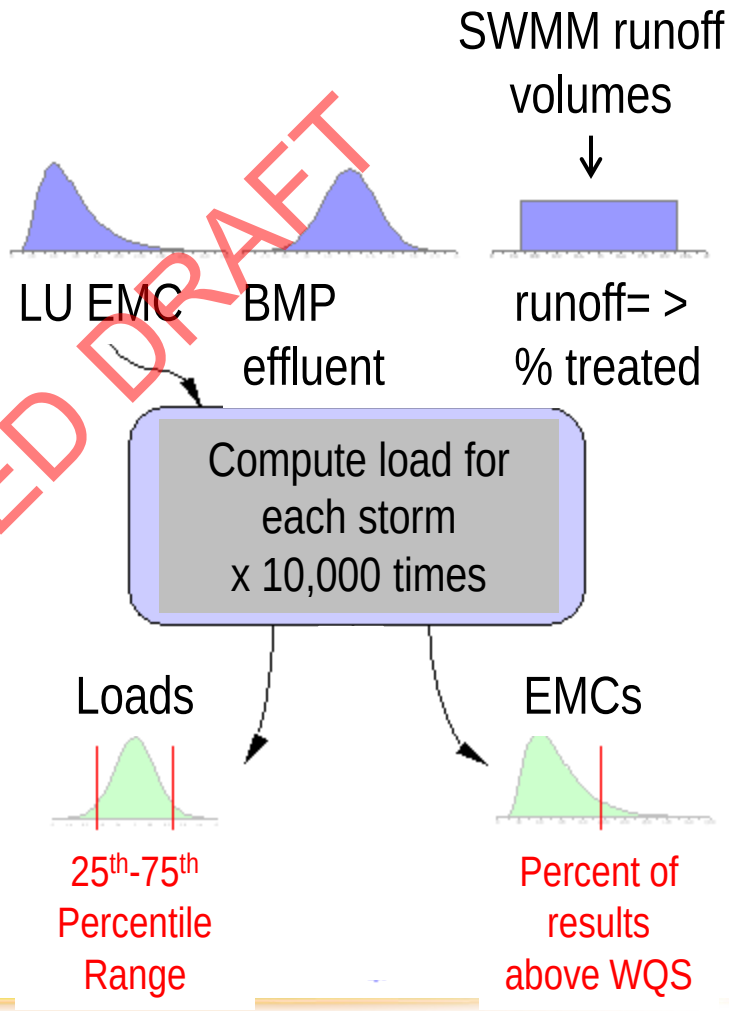
WHAT IS MONTE CARLO?



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HOW TO USE SBPAT OUTPUT

- Establish target load reductions
- Build menu of structural BMPs
  - Performance, costs, uncertainties quantified
  - Provide transparent understanding of "role" of each menu item in phased compliance strategy
- Demonstrate target load reductions have been met (event, annual, and long term basis)
  - Describe variability and associated uncertainty

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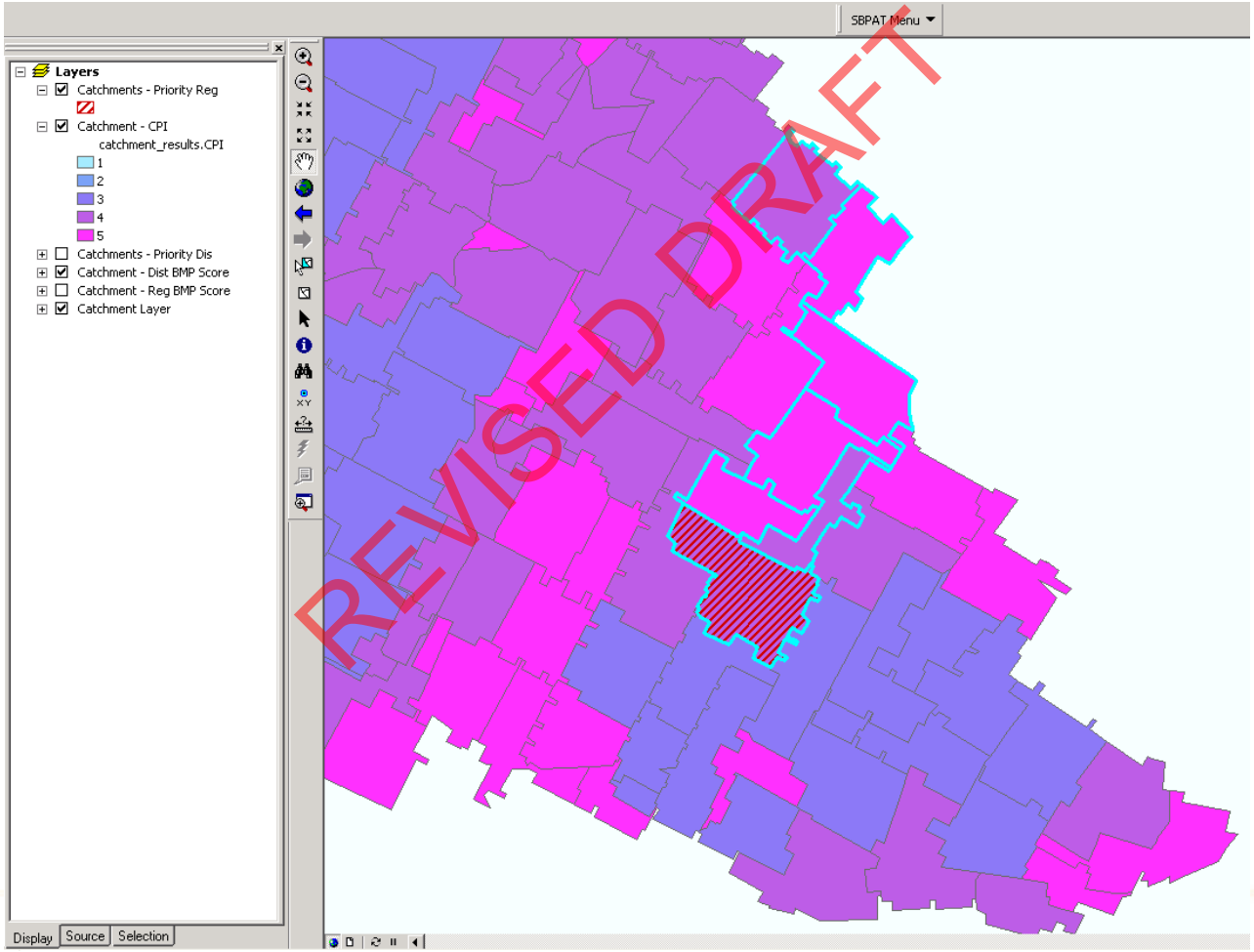
EXAMPLE SELECTED STUDY AREA



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EXAMPLE CATCHMENT LAND USES

Land Use Group	Acreage
Commercial	55.4
Education	20.9
Industrial	103.2
MF Residential	39.4
Transportation	16.1
Vacant/Open Space	2.7
Total	237.6

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EXAMPLE DISTRIBUTED BMP ASSIGNMENTS

Land Use Group	Cisterns	Bioretention	Perm. Pavement	Media Filters
Commercial	0%	0%	20%	20%
Education	20%	30%	0%	0%
Industrial	0%	0%	30%	50%
MF Residential	30%	20%	0%	0%
Transportation	0%	0%	0%	80%

Default, but can be modified for site-specific constraints

Distributed BMP	Acreage Treated	Default Design Size
Cisterns	10.8	0.75 in
Bioretention	10.0	0.75 in
Permeable Pavement	38.6	38.6 acres
Media Filters	69.1	0.2 in/hr
Total Impervious Area Treated By Distributed BMPs	118.1	
% of Total Impervious Area in Study Area	58%	

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EXAMPLE REGIONAL BMP* SIZING

- Infiltration basin
- Total study area properties:
  - 7 catchments,
  - 238 acres,
  - 85% impervious

- Example design storm sizing approach:
  - 0.75-inch storm runoff
  - 7.9 ac-ft
  - 4 ft storage depth @ 1.2 in/hr design infiltration rate = 40 hour drawdown

85th Percentile to meet regional proj. def'n.*

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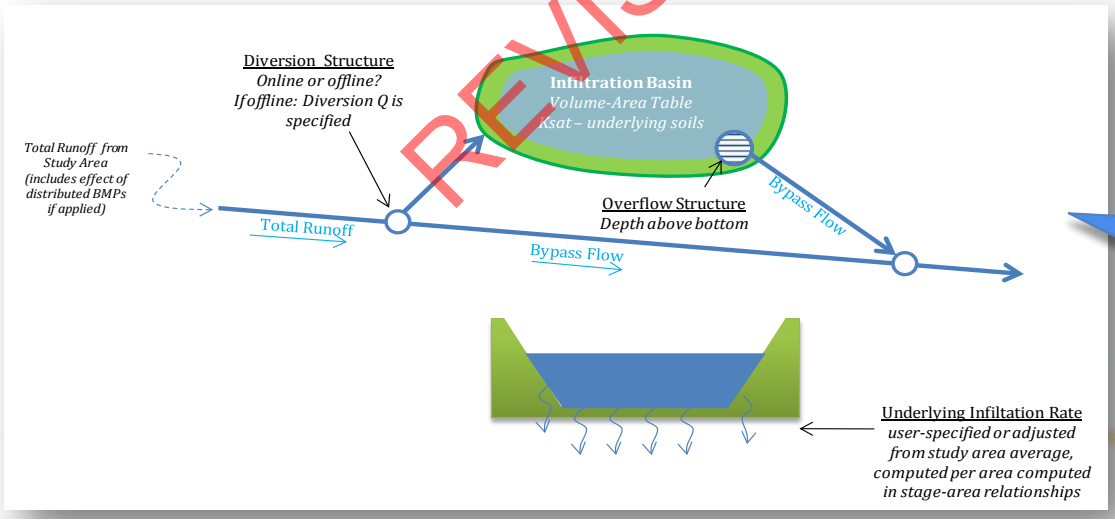
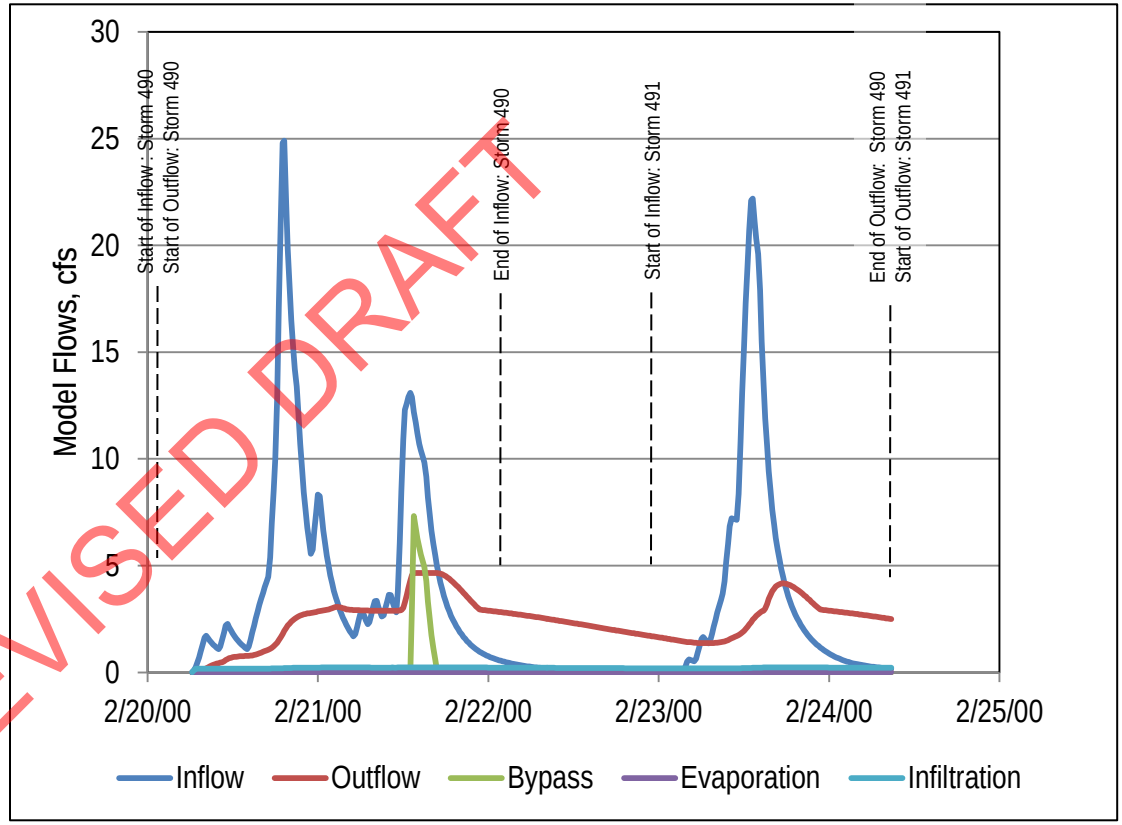


Flexible inputs to analyze surface or sub-surface infiltration system

* Could include functionally regional projects that do not meet regulatory definition at time of construction

EXAMPLE SWMM CONTINUOUS SIMULATION AND STORM EVENT TRACKING

- Tracks inflow, treated discharge, bypass, evaporation and infiltration at each 10 minute time step
- Discretizes runoff events by 6 hour minimum interevent time in rainfall record
- Tracks volume through BMP; summarizes by storm event
- Produces table of BMP hydrologic performance by storm event



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Input to Monte Carlo WQ Analysis

	Storm Event Volumes, cu-ft						
Event No.	Inflow	Infiltration	Evaporation	Bypass	Outflow	% Capture	% Lost
486	48,600	16,300	136	0	34,000	100	33.5
487	185,000	28,500	237	0	157,000	100	15.4
488	34,700	15,400	129	0	19,200	100	44.3
489	54,600	17,900	239	0	36,500	100	32.8
490	774,000	59,500	793	52,700	663,000	93.2	7.7
491	444,000	42,600	568	0	399,000	100	9.6

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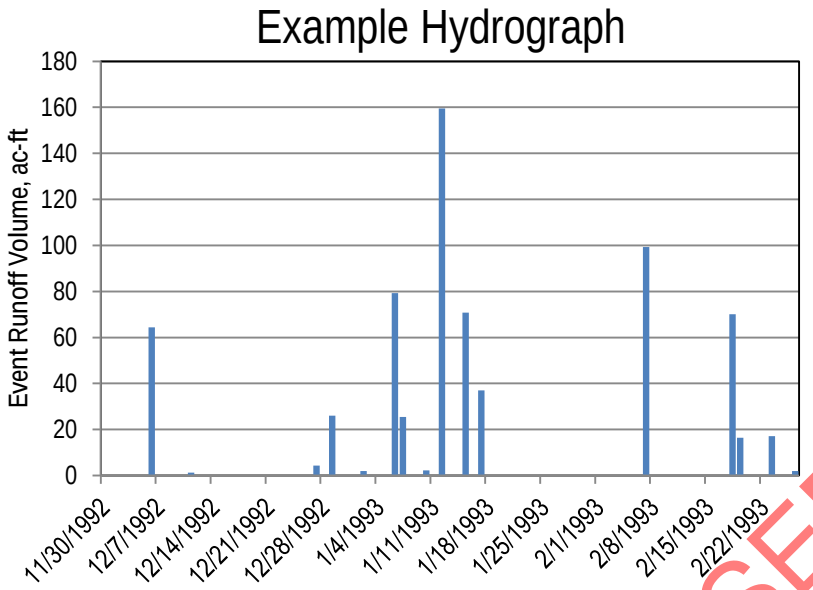
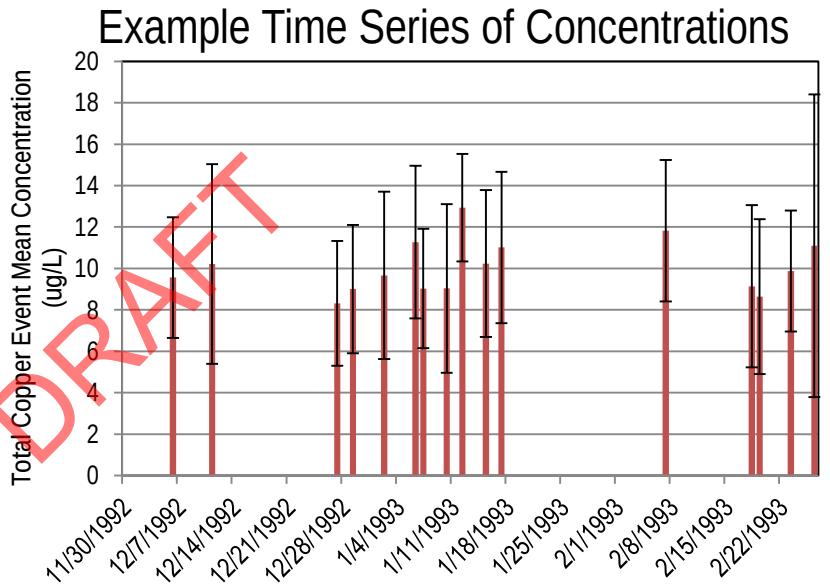
EXAMPLE DETAILED MONTE CARLO RESULTS (EVENT TIME STEP)





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Plots show a subset of the simulated period of record

Error bars represent one standard deviation

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EXAMPLE MODEL OUTPUT – ANNUAL AVERAGES

Average Annual Volume and Load Summary for Entire Study Area

		Average Annual Loads and Volumes			% Removed	
Pollutant	Units	Pre-BMP	w/ Dist. BMPs	w/ Dist. + Reg. BMPs	w/ Dist. BMPs	w/ Dist. + Reg. BMP
Total Runoff Volume	ac-ft	220	172	172	22%	
DCu	lbs	8.8	6.9	6.8	22%	23%
DP	lbs	170	125	118	27%	30%
DZn	lbs	163	73	63	55%	62%
FC	10^12MPN	52.8	35.4	24.3	33%	54%
NH3	lbs	435	276	190	37%	56%
NO3	lbs	500	384	378	23%	25%
TCu	lbs	18.9	10.7	8.1	43%	57%
TKN	lbs	1645	1257	1194	24%	27%
TPb	lbs	7.63	4.18	3.54	45%	54%
TP	lbs	235	140	98	41%	58%
TSS	Tons	42	19	12	54%	71%
TZn	lbs	218	101	66	54%	70%

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Compare to Target Load Reductions to Establish RAA

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EXAMPLE MODEL OUTPUT - PLANNING LEVEL COST ESTIMATES*

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BMP Capital, Maintenance and Land Costs

	Capital Costs ($)		Maintenance Costs ($/yr)		Land Cost ($)	
BMPs	Low	High	Low	High	Low	High
Dry Detention Basin	586,874	981,207	3,036	5,058	3,718,940	4,648,676
Perm. Pavement	3,150,968	5,251,617	5,253	9,454	0	0
Media Filters	781,309	1,296,637	108,053	181,196	0	0
Cisterns	100,317	167,556	1,154	1,898	0	0
Bioretention	125,741	208,466	2,480	4,136	1,699,490	2,124,363

*Includes Retrofit Factor

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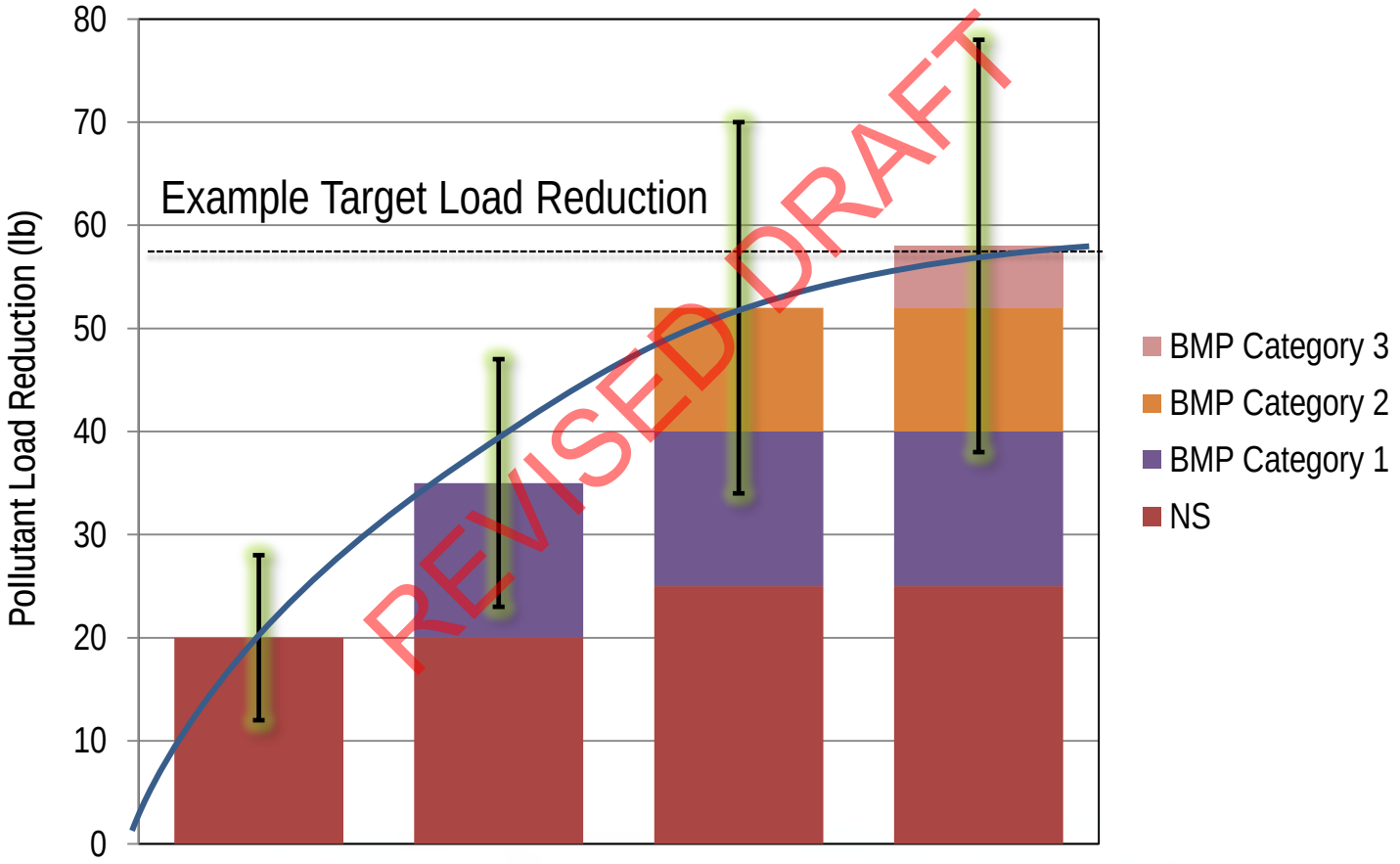
EXAMPLE PHASED IMPLEMENTATION APPROACH



Demonstration that selected control measures have reasonable assurance to meet interim and final WQBELs and RWL milestones.

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TARGET LOAD REDUCTION DISCUSSION (BACTERIA)

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Note: The following method assumes utilization of SBPAT to establish the target load reductions; other methods include utilizing monitoring data to establish ultimate objectives.

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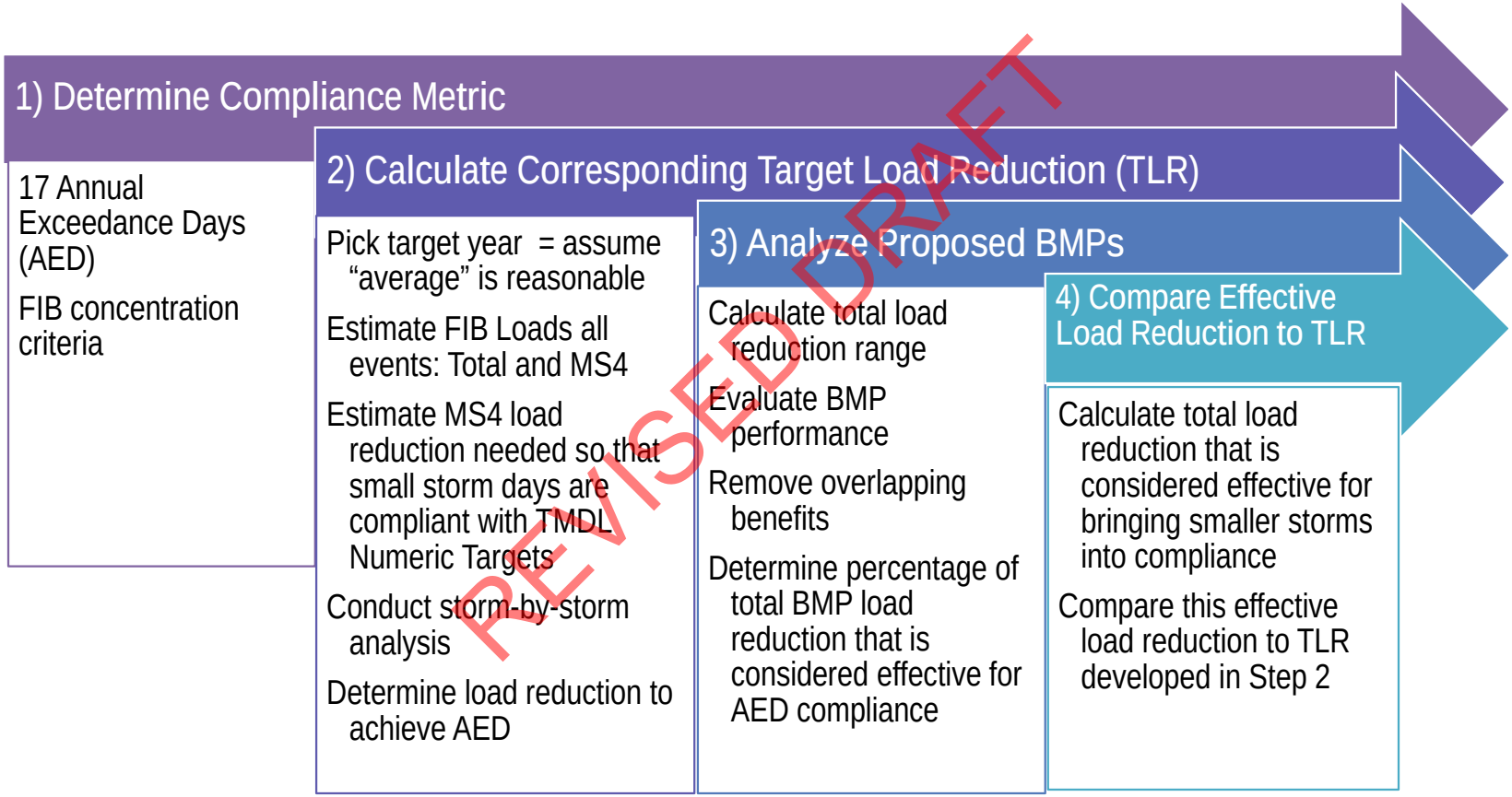
SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT (BACTERIA)



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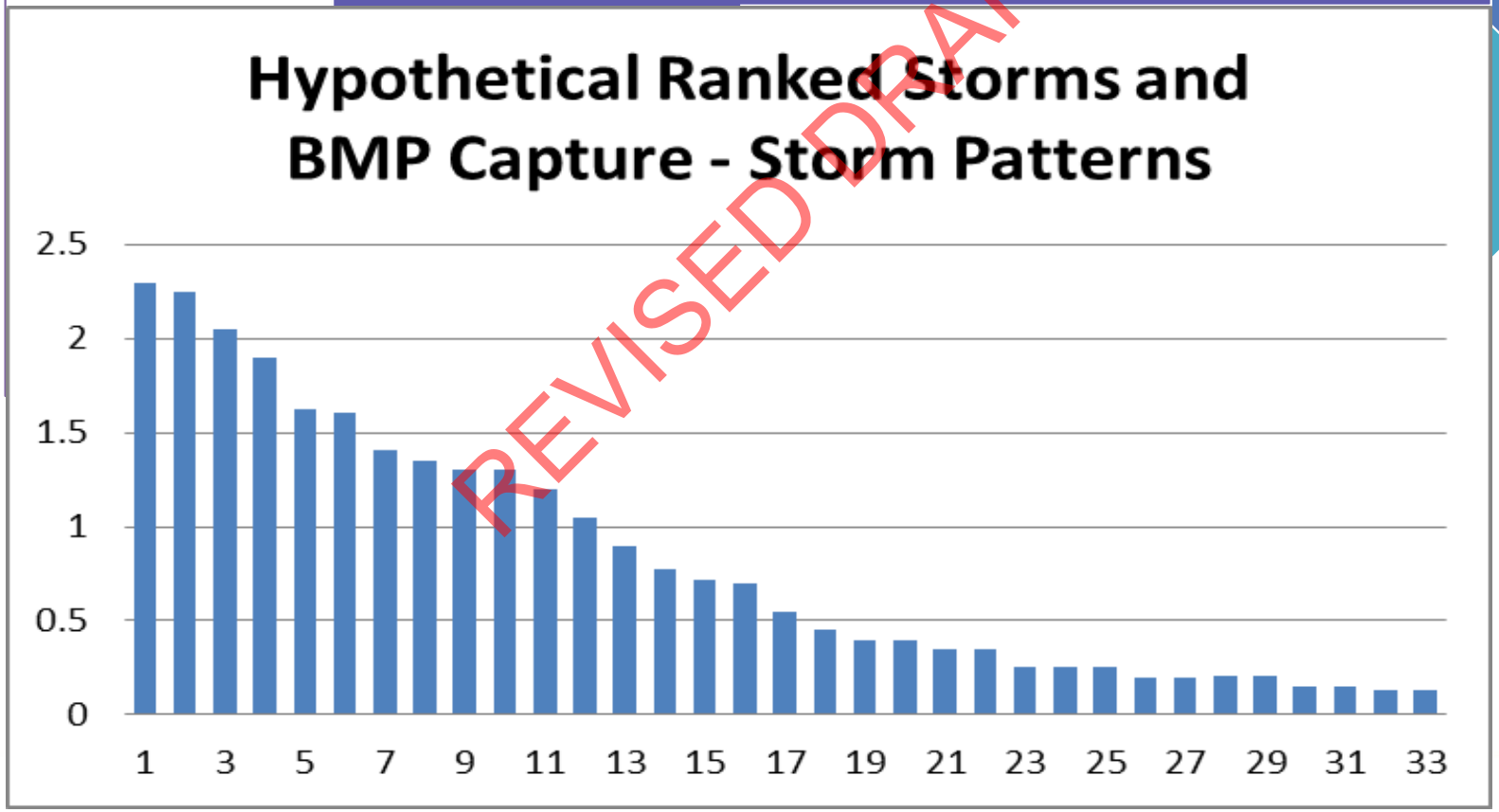
SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT

1) Determine Compliance Metric

2) Calculate Corresponding Target Load Reduction (TLR)



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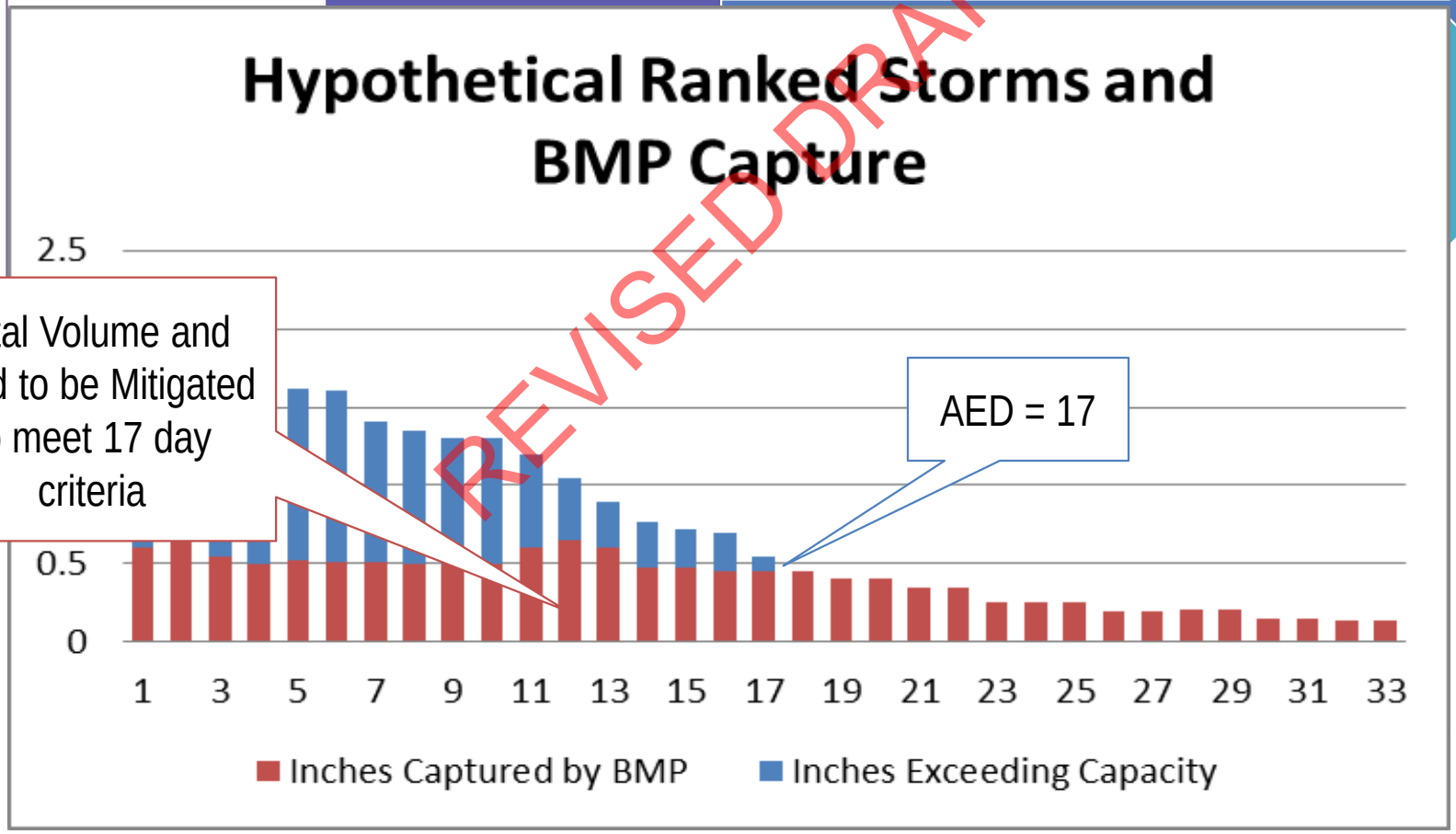
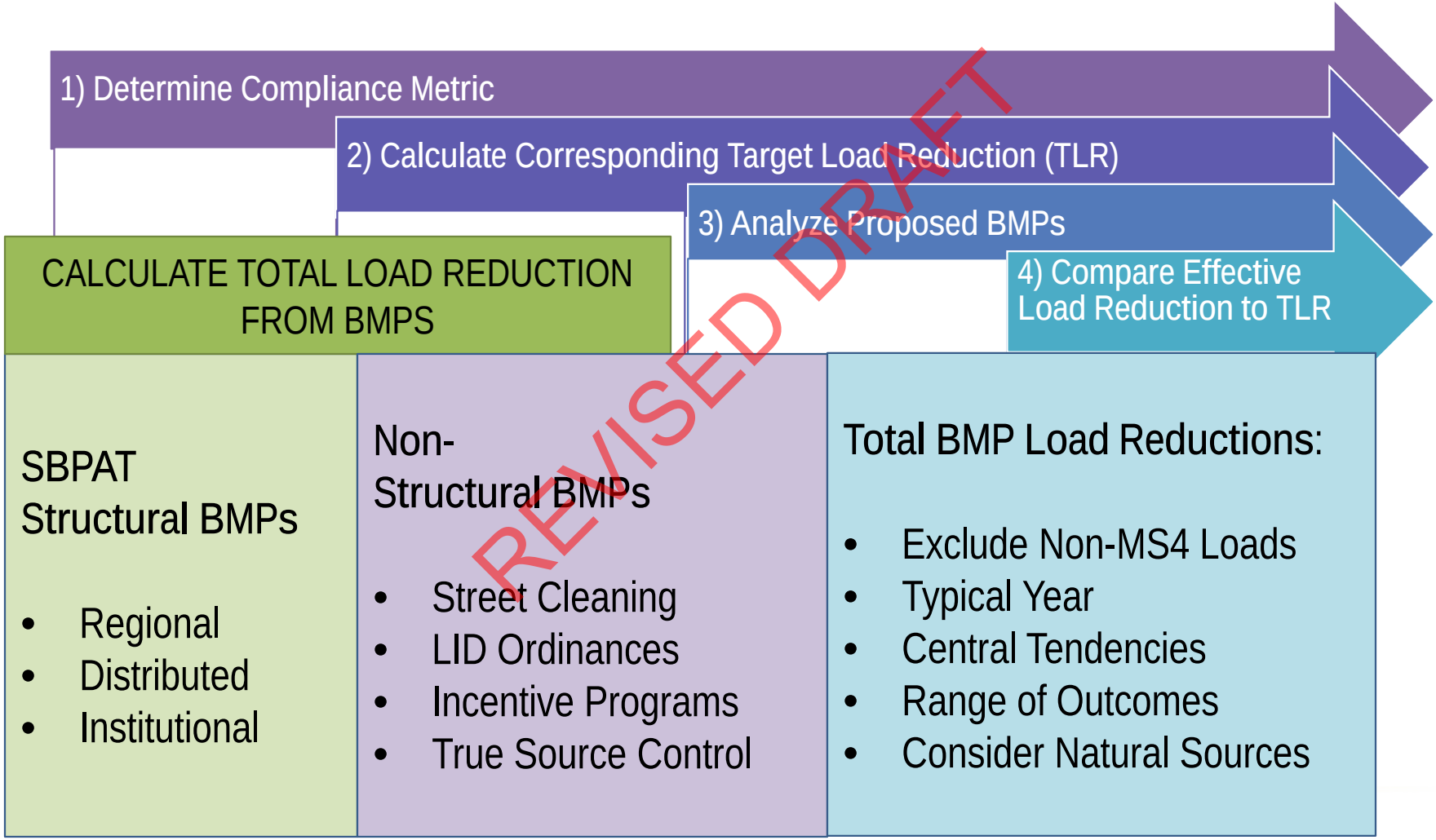


SBPAT-BASED METHOD FOR BMP QUANTITATIVE ASSESSMENT



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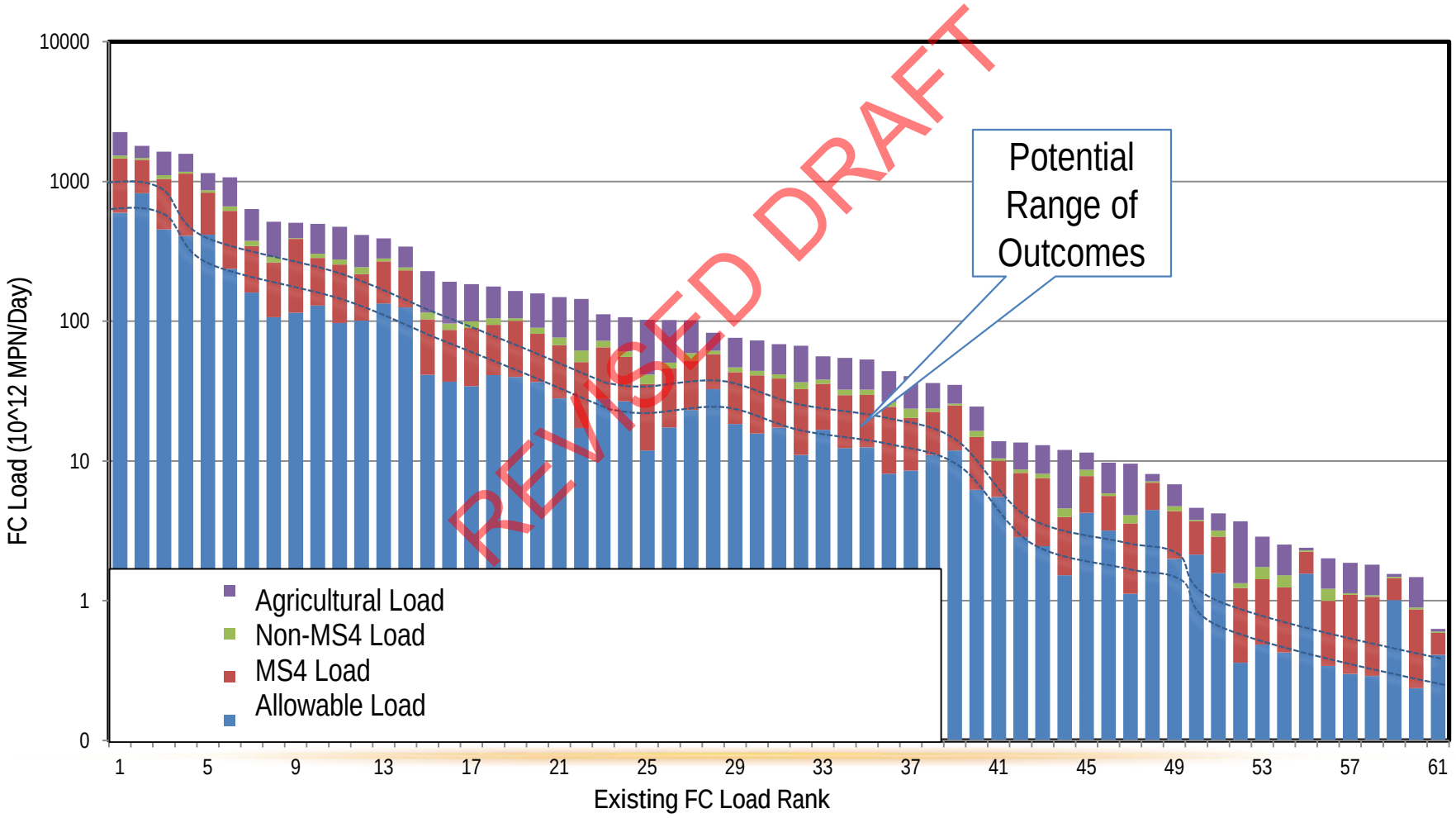
SAMPLE RESULTS DEMONSTRATING REASONABLE ASSURANCE



EXAMPLES OF USES

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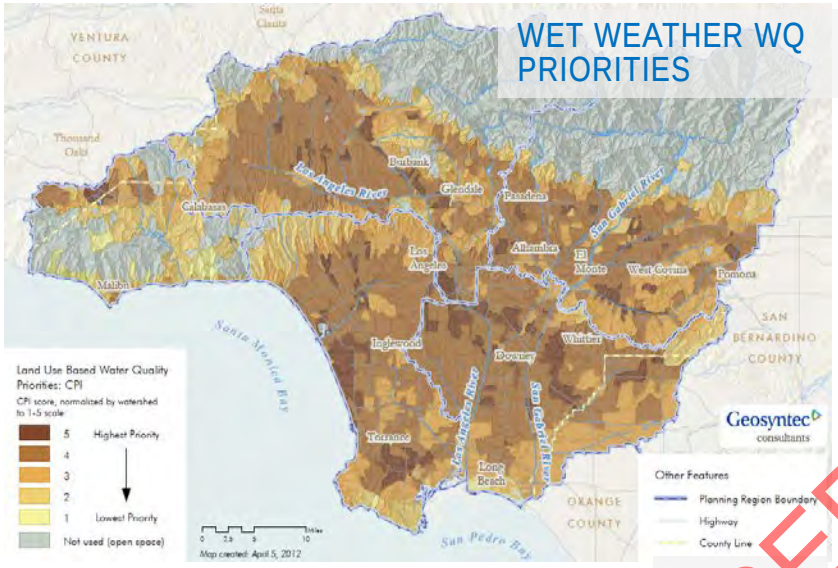
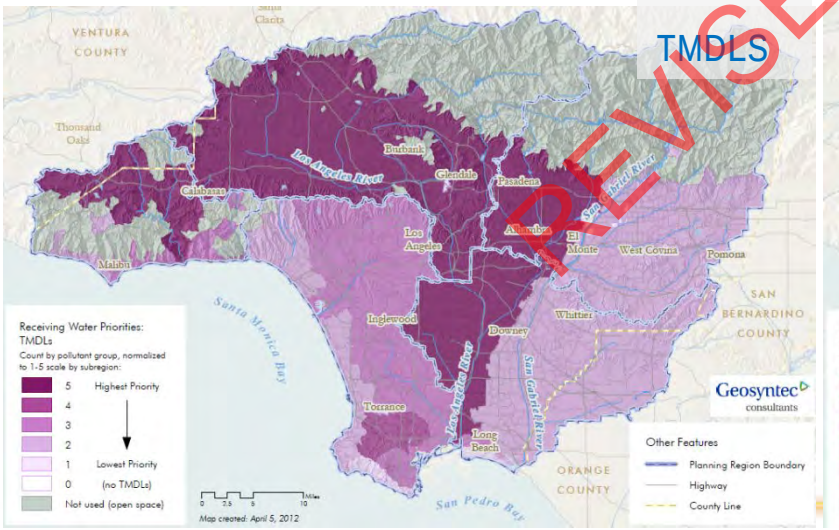
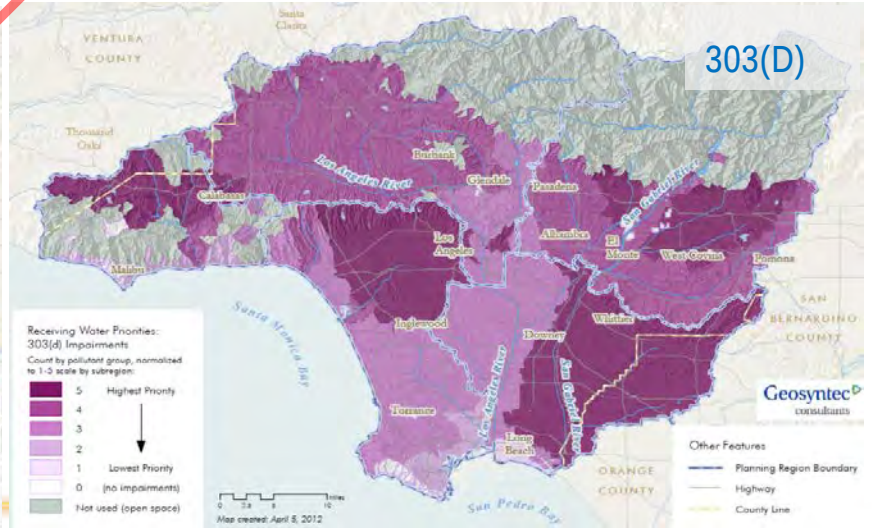
GLAC IRWMP DATA DEVELOPED COUNTY-WIDE







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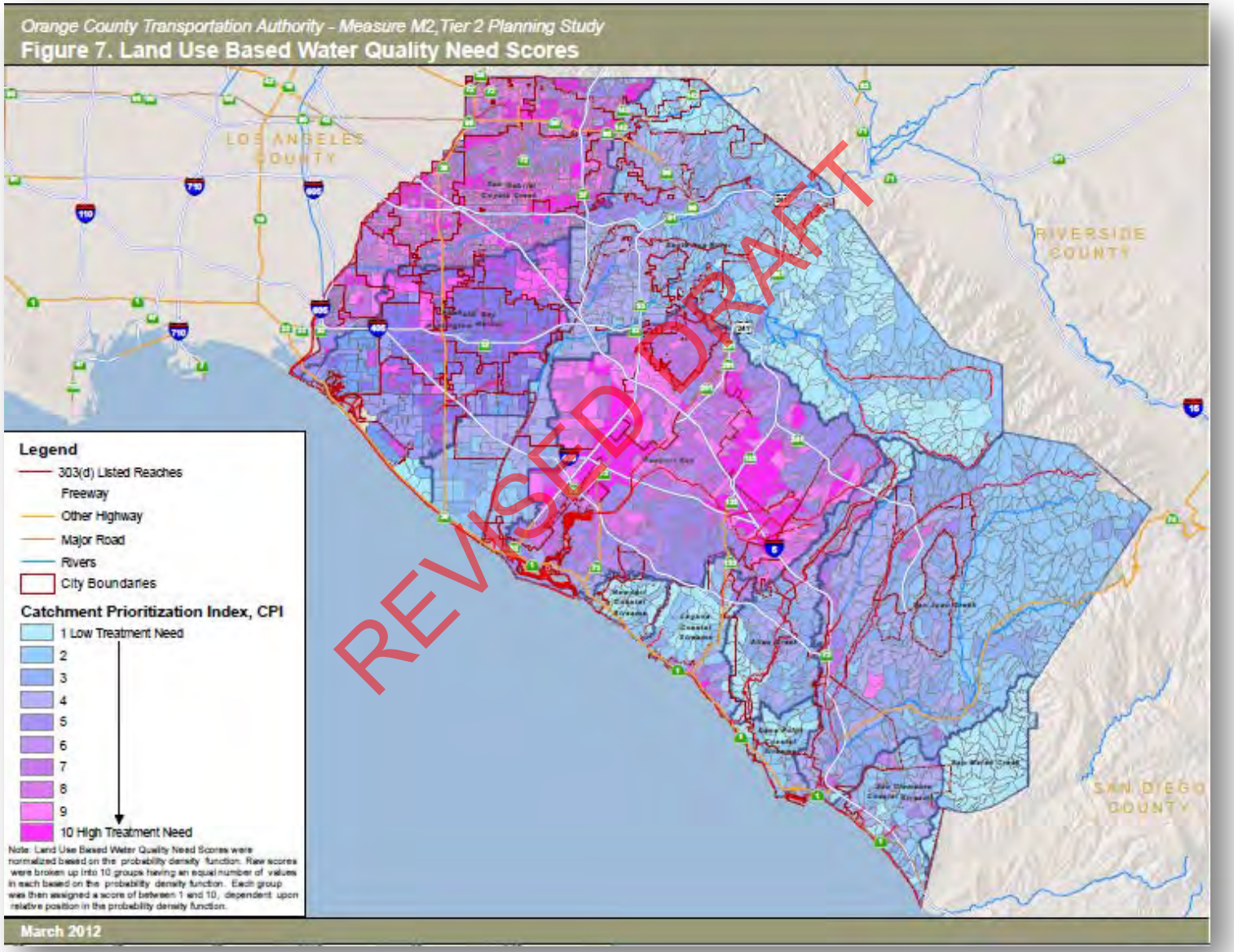
OCTA MEASURE M2



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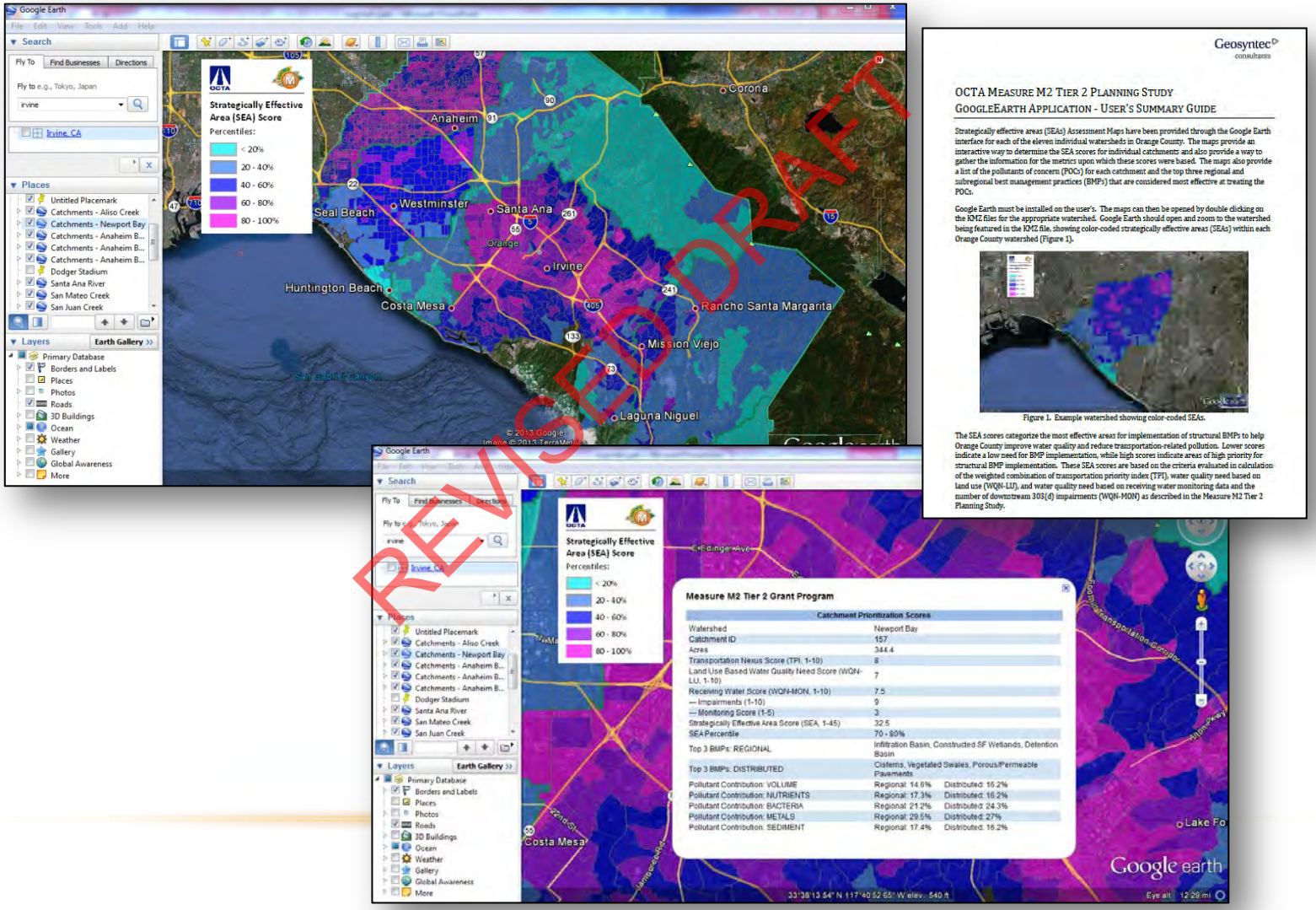
OCTA MEASURE M2

GOOGLE EARTH APPLICATIONS DEVELOPED



Geosyntec consultants

OCTA Measure M2 Tier 2 Planning Study
GoogleEarth Application - User's Summary Guide

Strategically effective areas (SEAs) Assessment Maps have been provided through the Google Earth interface for each of the eleven individual watersheds in Orange County. The maps provide an interactive way to determine the SEA scores for individual catchments and also provide a way to gather the information for the metrics upon which these scores were based. The maps also provide a list of the pollutants of concern (POCs) for each catchment and the top three regional and subregional best management practices (BMPs) that are considered most effective at treating the POCs.

Google Earth must be installed on the user's. The maps can then be opened by double clicking on the KMZ files for the appropriate watershed. Google Earth should open and zoom to the watershed being featured in the KMZ file, showing color-coded strategically effective areas (SEAs) within each Orange County watershed (Figure 1).

Figure 1. Example watershed showing color-coded SEAs.

The SEA scores categorize the most effective areas for implementation of structural BMPs to help Orange County improve water quality and reduce transportation-related pollution. Lower scores indicate a low need for BMP implementation, while high scores indicate areas of high priority for structural BMP implementation. These SEA scores are based on the criteria evaluated in calculation of the weighted combination of transportation priority index (TPI), water quality need based on land use (WQN-LU), and water quality need based on receiving water monitoring data and the number of downstream 303(d) impairments (WQN-MON) as described in the Measure M2 Tier 2 Planning Study.

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BALLONA CREEK (LOS ANGELES COUNTY)

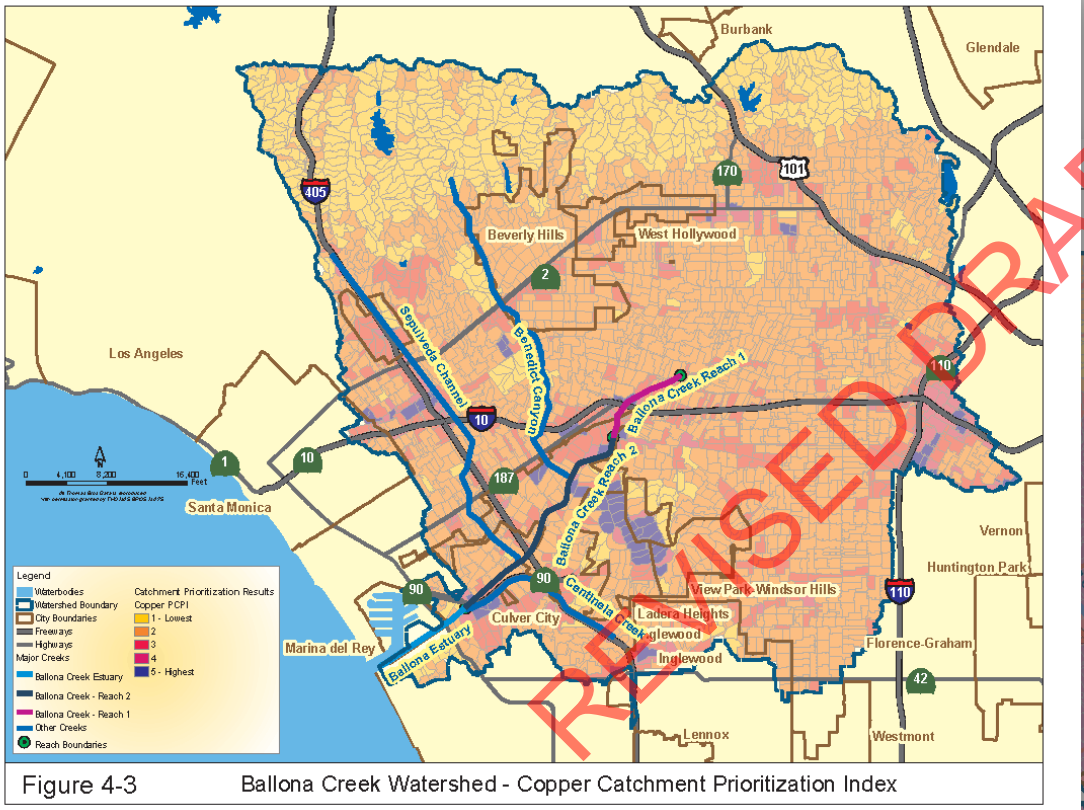

Figure 4-3 Ballona Creek Watershed - Copper Catchment Prioritization Index

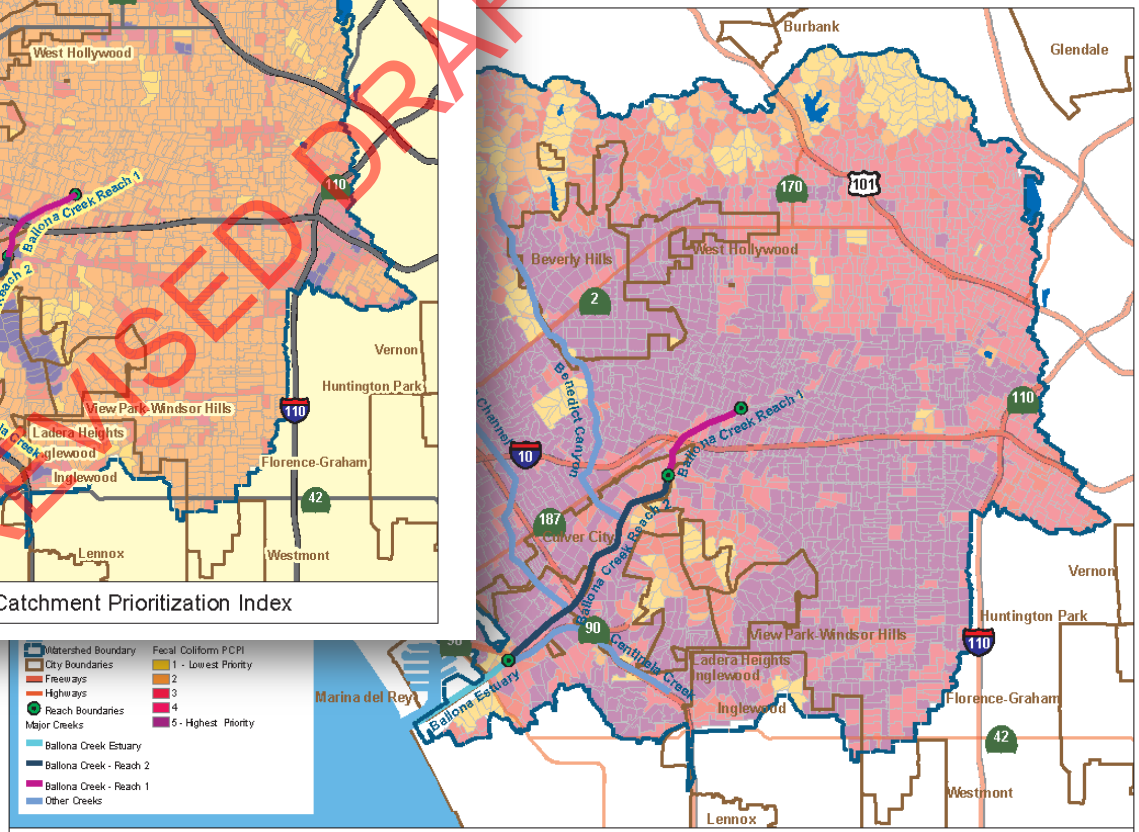

Figure 4-2 Ballona Creek Watershed - Fecal Coliform Catchment Prioritization Index

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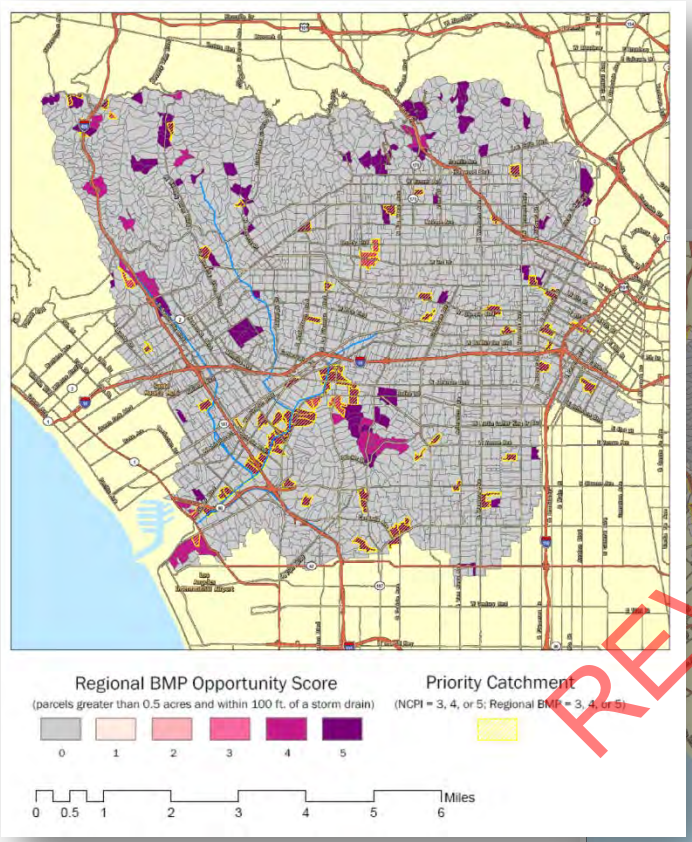
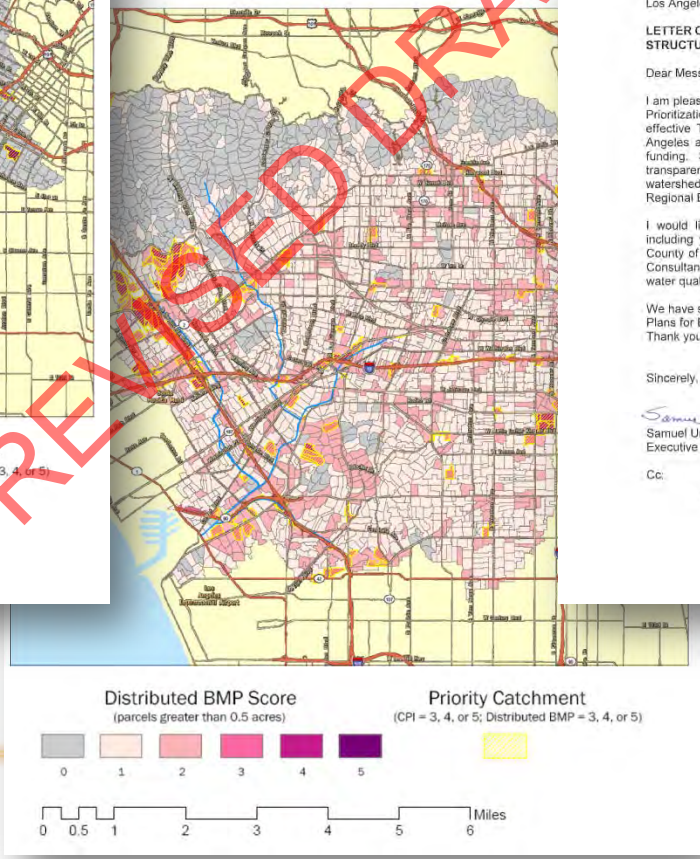
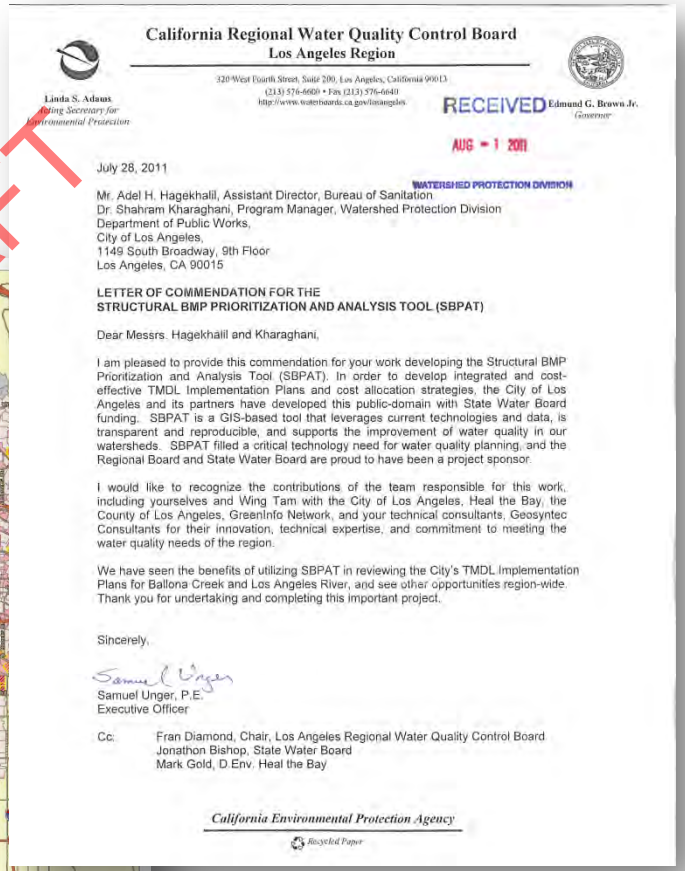
BALLONA CREEK (LOS ANGELES COUNTY)







California Regional Water Quality Control Board
Los Angeles Region

320 West Fourth Street, Suite 200, Los Angeles, California 90013
(213) 576-6600 • Fax (213) 576-6640
http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Acting Secretary for
Environmental Protection

Edmund G. Brown Jr.
Governor

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WATERSHED PROTECTION DIVISION

July 28, 2011

Mr. Adel H. Hagekhalil, Assistant Director, Bureau of Sanitation
Dr. Shahram Kharaghani, Program Manager, Watershed Protection Division
Department of Public Works,
City of Los Angeles,
1149 South Broadway, 9th Floor
Los Angeles, CA 90015

LETTER OF COMMENDATION FOR THE
STRUCTURAL BMP PRIORITIZATION AND ANALYSIS TOOL (SBPAT)

Dear Messrs. Hagekhalil and Kharaghani,

I am pleased to provide this commendation for your work developing the Structural BMP Prioritization and Analysis Tool (SBPAT). In order to develop integrated and cost-effective TMDL Implementation Plans and cost allocation strategies, the City of Los Angeles and its partners have developed this public-domain with State Water Board funding. SBPAT is a GIS-based tool that leverages current technologies and data, is transparent and reproducible, and supports the improvement of water quality in our watersheds. SBPAT filled a critical technology need for water quality planning, and the Regional Board and State Water Board are proud to have been a project sponsor.

I would like to recognize the contributions of the team responsible for this work, including yourselves and Wing Tam with the City of Los Angeles, Heal the Bay, the County of Los Angeles, GreenInfo Network, and your technical consultants, Geosyntec Consultants for their innovation, technical expertise, and commitment to meeting the water quality needs of the region.

We have seen the benefits of utilizing SBPAT in reviewing the City's TMDL Implementation Plans for Ballona Creek and Los Angeles River, and see other opportunities region-wide. Thank you for undertaking and completing this important project.

Sincerely,

Samuel Unger, P.E.
Executive Officer

Cc: Fran Diamond, Chair, Los Angeles Regional Water Quality Control Board
Jonathon Bishop, State Water Board
Mark Gold, D.Env. Heal the Bay

California Environmental Protection Agency

Recycled Paper

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EXAMPLE: SAN DIEGO COUNTY COMPREHENSIVE LOAD REDUCTION PLANS (CLRPS)

New land use and receiving water monitoring data considered in both models

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San Luis Rey River

- Area downstream of reservoir analyzed
- Larger Land Area Studied (~350 sq. miles study area)
- More Agriculture LU
- More Rural Residential LU
- More Septic Influence
- 3 Jurisdictions + Caltrans

San Diego River

- Area downstream of reservoirs analyzed (~180 sq. miles total study area)
- More Urban Area
- Larger Population
- Large Homeless Population
- 5 Jurisdictions + Caltrans
- More 303(d) Listings

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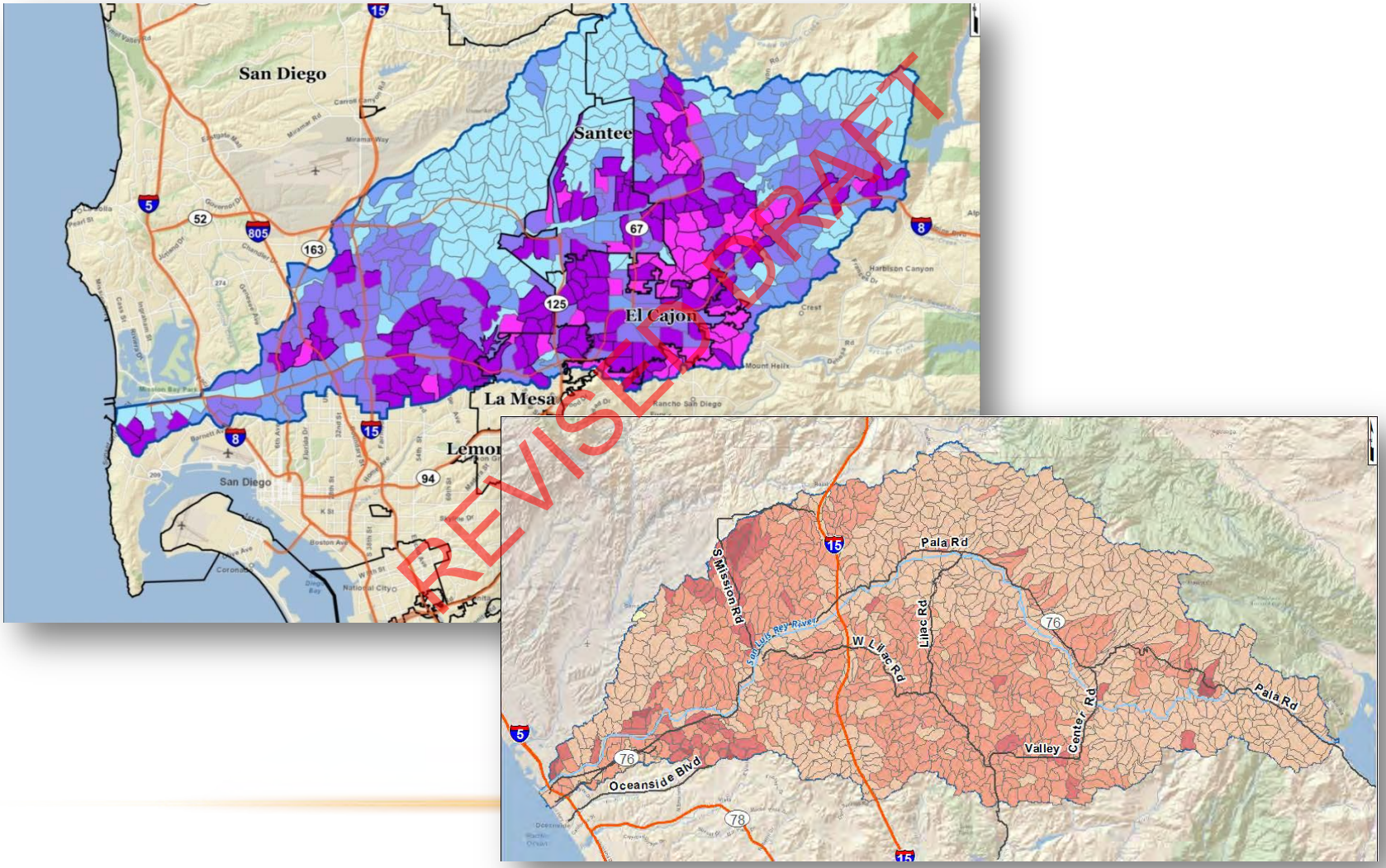
SAN DIEGO RIVER & SAN LUIS REY CATCHMENT PRIORITIZATION INDICES (CPI)



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SAN LUIS REY WATERSHED PRELIMINARY PLANNING LEVEL – RANGE OF EFFECTIVENESS

BMP CATEGORY	FC Load Reduction (10^{12} MPN/YEAR) 1993 WY Load[1] [Low-High Range]
Non-Structural BMPs	1,000 [260 – 1,700]
Regional Structural BMPs	700 [550 -790]
Wetland Mitigation Projects	100 [0 -240]
Distributed Structural BMPs	370 [200 – 430]
Subtotal	2,200 [1,[illegible]00 -3,200]
Load Reduction Adjustment	-210 [-63 - -3[illegible]
Load Reduction Effective Fraction	0.35
Load Reduction Sum	690 [330 - 990]
TARGET LOAD REDUCTION	670

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Elements Analyzed by SBPAT

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CONSIDERATION OF MODELS TOGETHER

(provided for information an discussion only)

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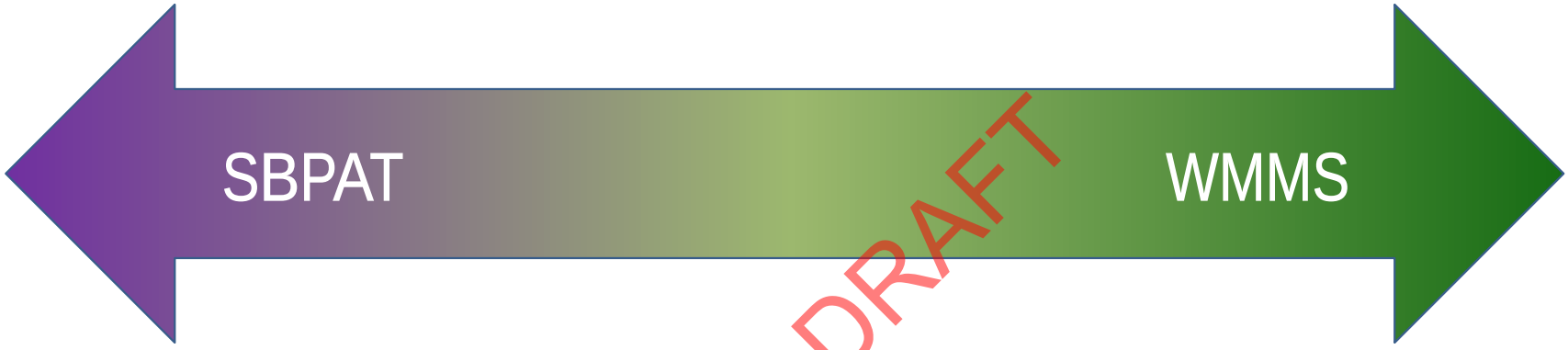
MODELING CONTINUUM



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Model Functionalities for RAA

- Establish Target Load Reductions
- Estimate reductions achieved by non-structural BMPs
- Evaluate existing BMPs
- Site and evaluate new BMPs
- Demonstrate TLRs are met
- Produce cost estimates

MANY POSSIBLE COMBINATIONS

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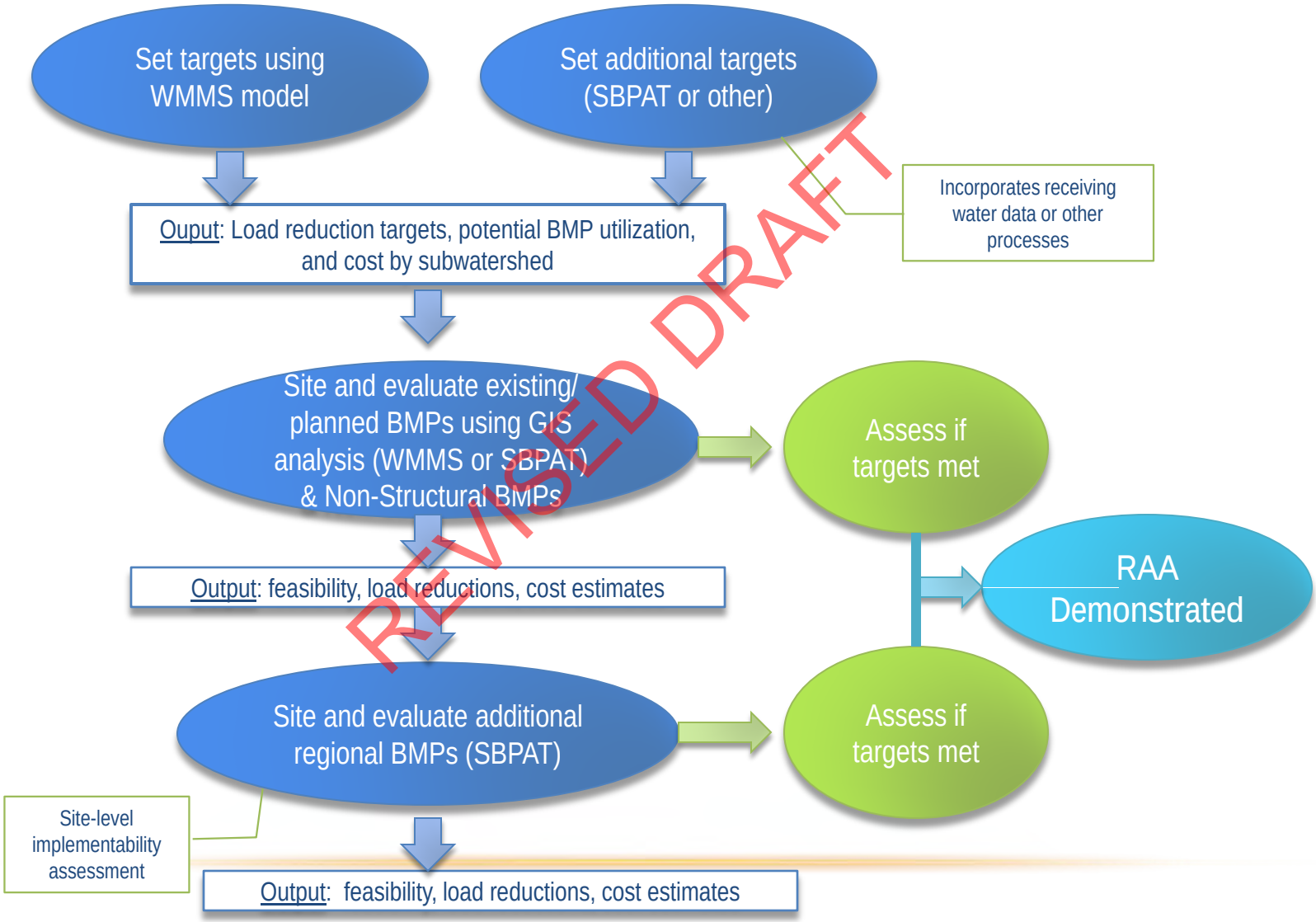
INFORMATION FLOW (DEPENDS ON CONDITIONS)



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SUMMARY

- Introduction to SBPAT for RAA
- Input types and inputting processes
- Target loading estimates/other implicit assumptions
- Format for information sharing, presentation, and use for decision support
- Final quantified and presented results
- Use of SBPAT results
- Target load reduction discussion
- Examples
- Potential Integration of multiple models

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QUESTIONS

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