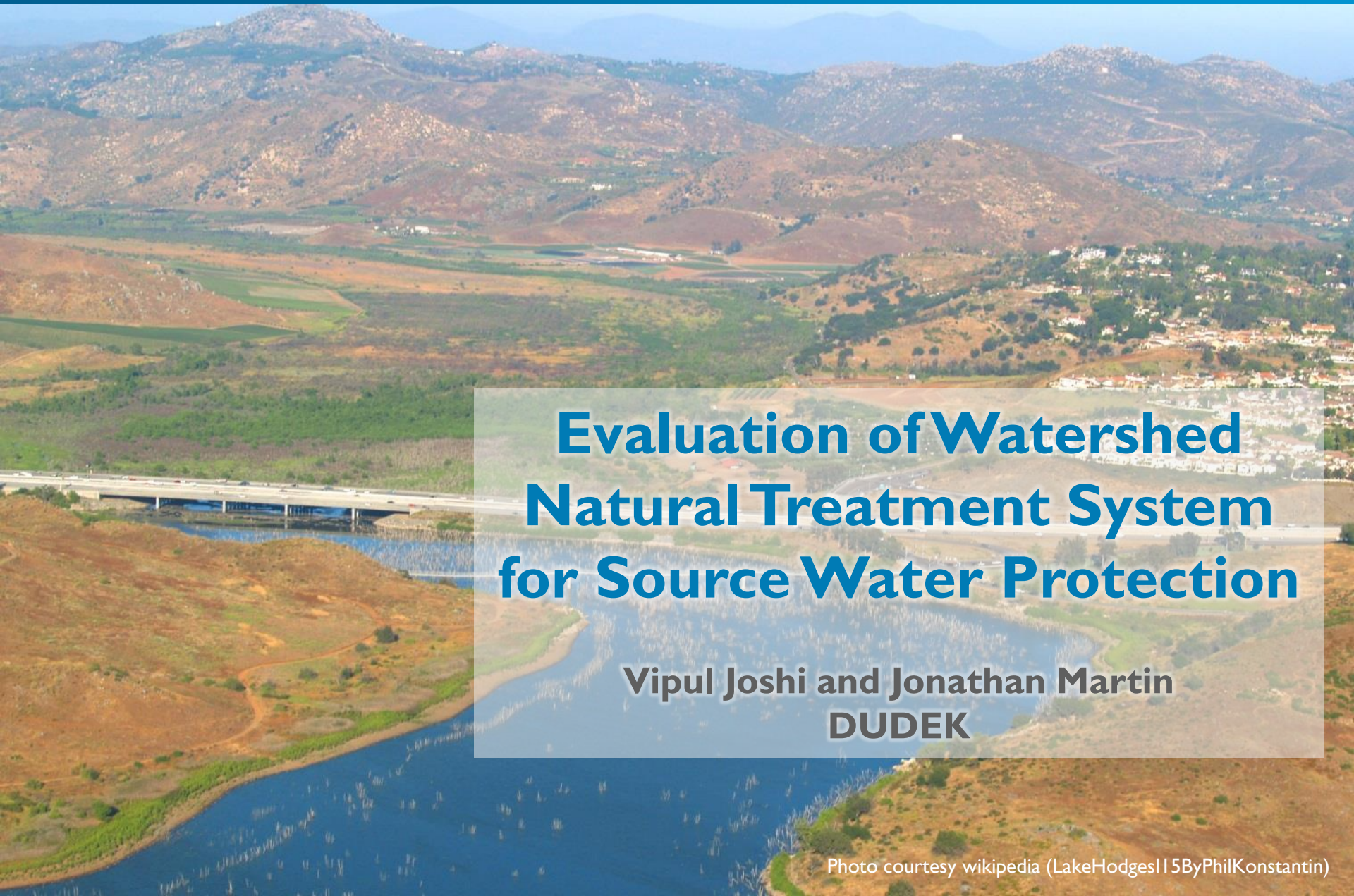
HODGES RESERVOIR
NATURAL TREATMENT SYSTEM PROJECT



Evaluation of Watershed Natural Treatment System for Source Water Protection

Vipul Joshi and Jonathan Martin
DUDEK

Photo courtesy wikipedia (LakeHodges115ByPhilKonstantin)

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- Issues
  - Nutrient Loading
    - Algal Blooms
    - Taste & Odor
    - Treatment Costs
- City of San Diego
  - Land Ownership
  - Drinking Water Reservoir – multiple users/partners
- Treatment Options
  - In Reservoir
  - NTS Alternatives
    - Distributed
    - Centralized

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Distributed NTS Examples

Photo courtesy: ocean friendly gardens San Diego

Photo courtesy: semcog.org

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Centralized NTS Examples

Project Brays Bayou
Stormwater Basin

South Los Angeles Wetland Park

Image courtesy: inhabitat

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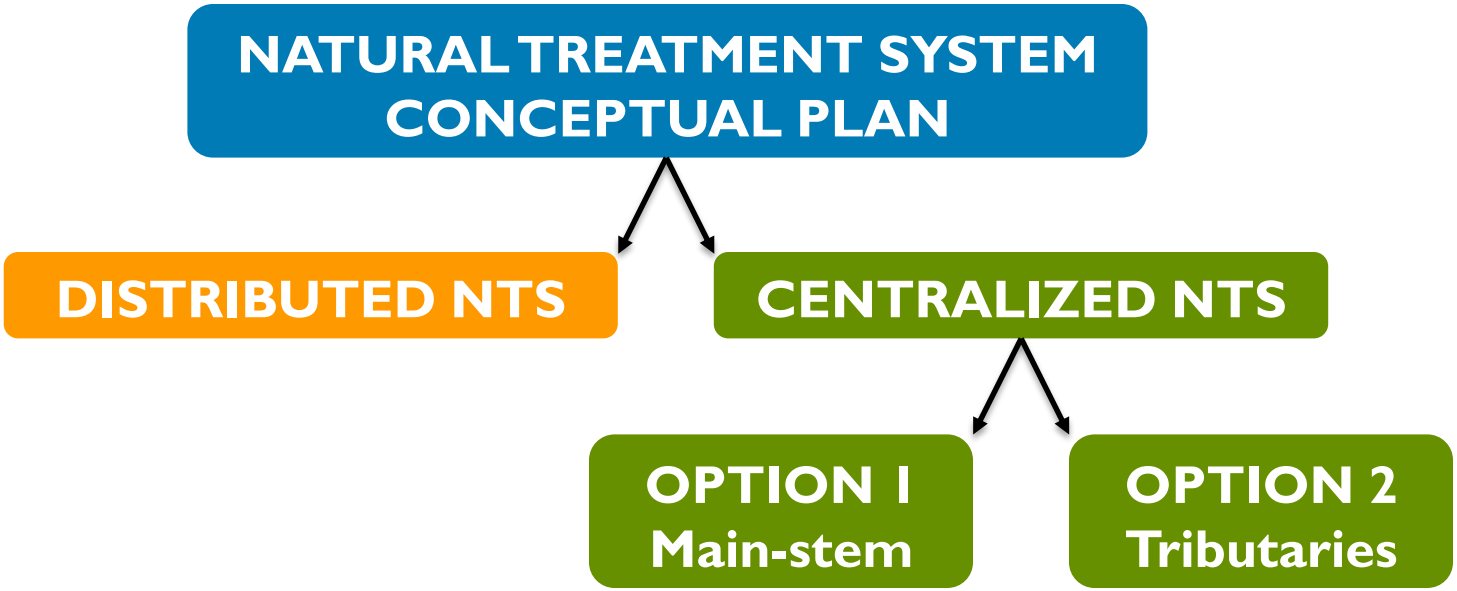
Natural Treatment System Alternatives



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	Effectiveness	Area	Capital Costs	Maintenance Costs*
Basins	37%	2-3%	$0.93/cf	<1-6%
Wetlands	49%	3-5%	$1.14/cf	<2%
Swales	52%	10-20%	$0.62/cf	<5-7%

* Maintenance costs as a percentage of construction costs

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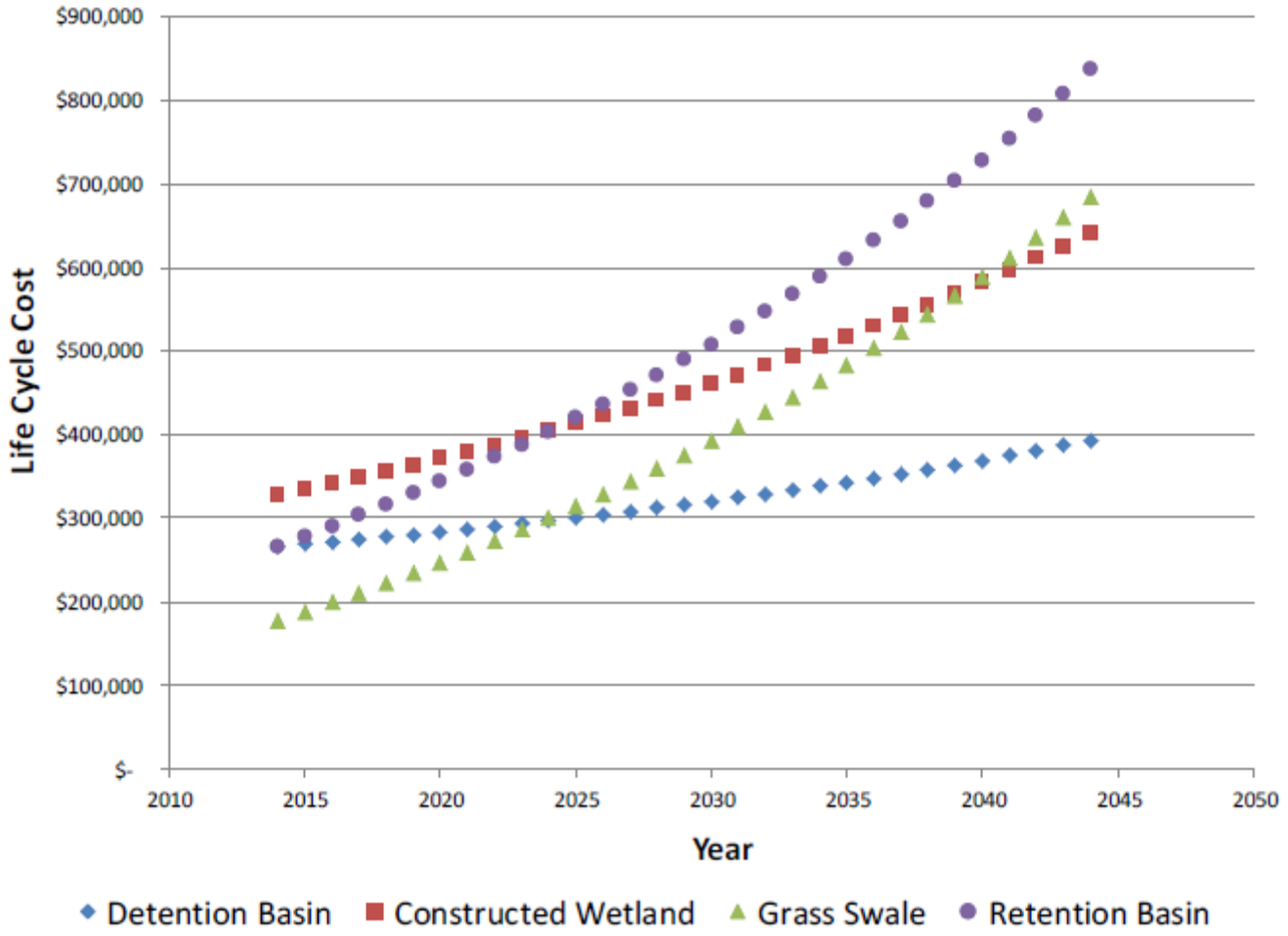
Exhibit 1. Life Cycle Costs for Stormwater BMPs in the Kit Carson Sub-Catchment



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- Model Development
  - Watershed
  - Land Use
  - Nutrients
  - SWMM

- Hydrologic and Water Quality Analysis
  - 2.5-Year Strom Event (2010-2011 Wet Year)
  - Base Flow and Smaller Storm Events (2012-2013 Dry Year)

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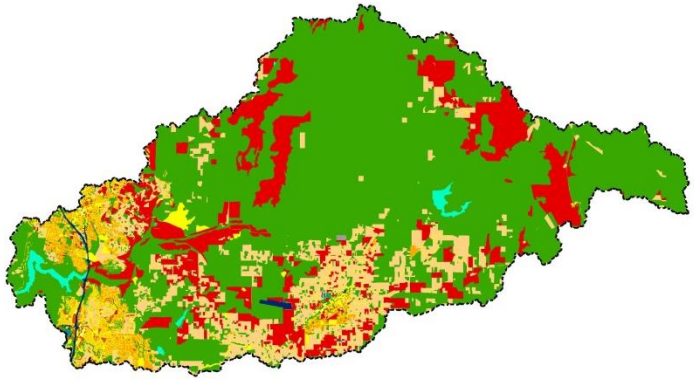
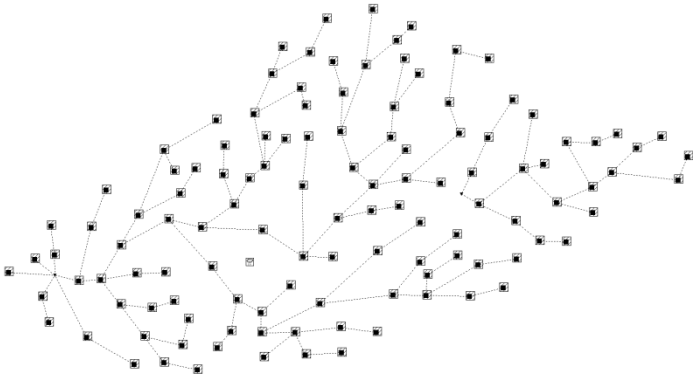
Storm Water Management Model (SWMM)

Topography + Hydrology



Land Use + Nutrients



SWMM

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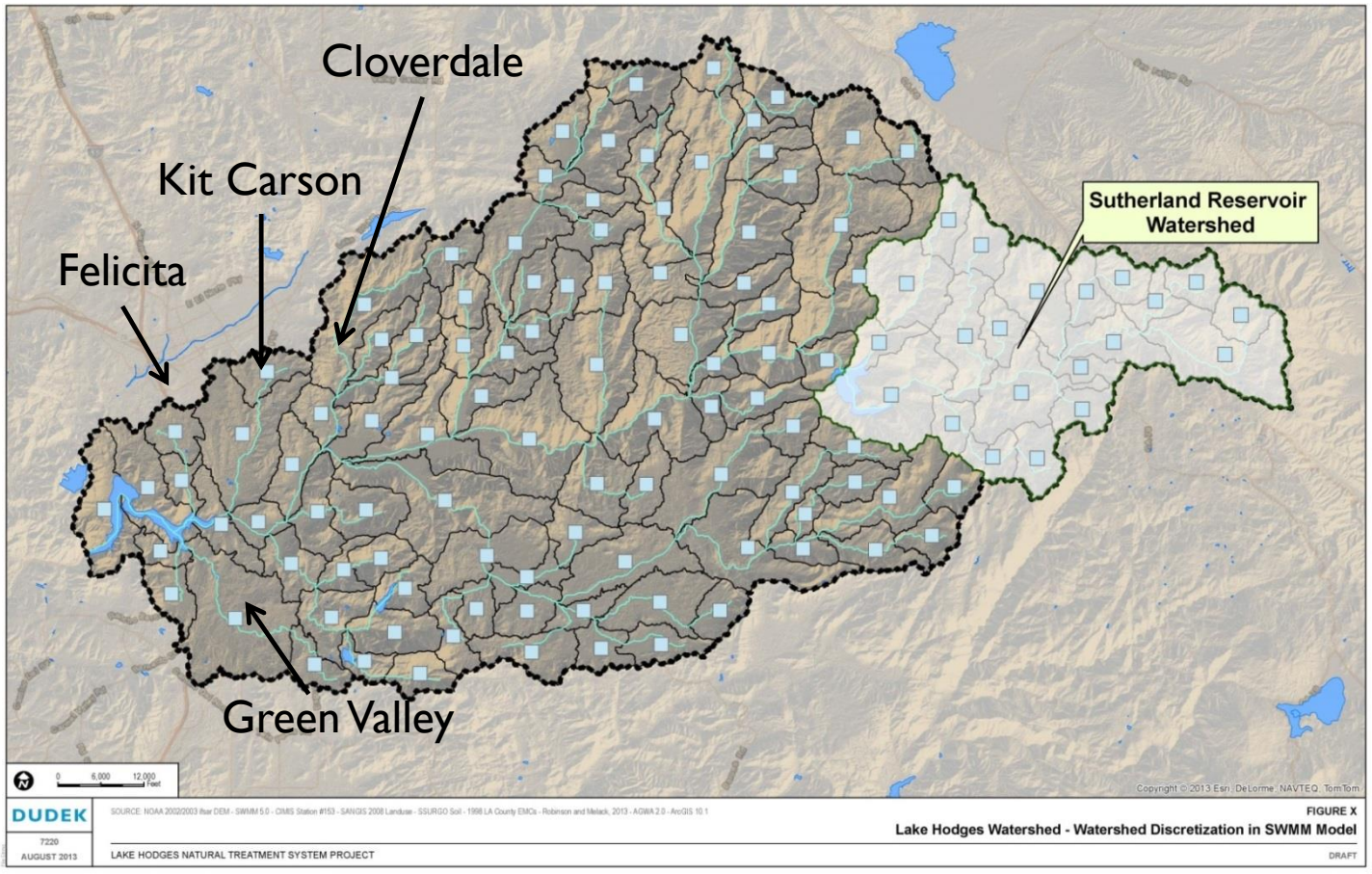
Hodges Watershed (300 mi^2)



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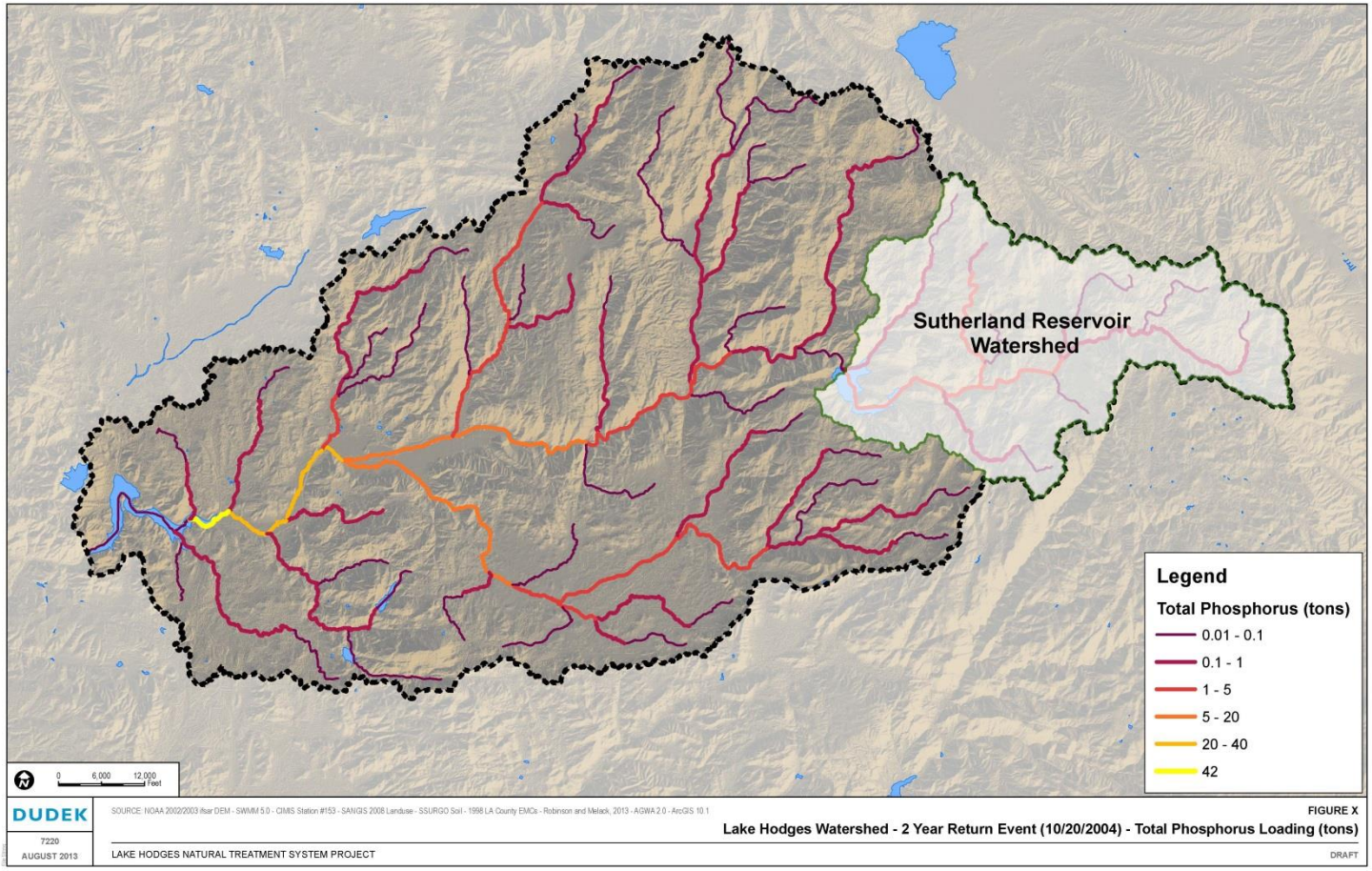
Nutrient component based on land use coefficients developed throughout Southern California



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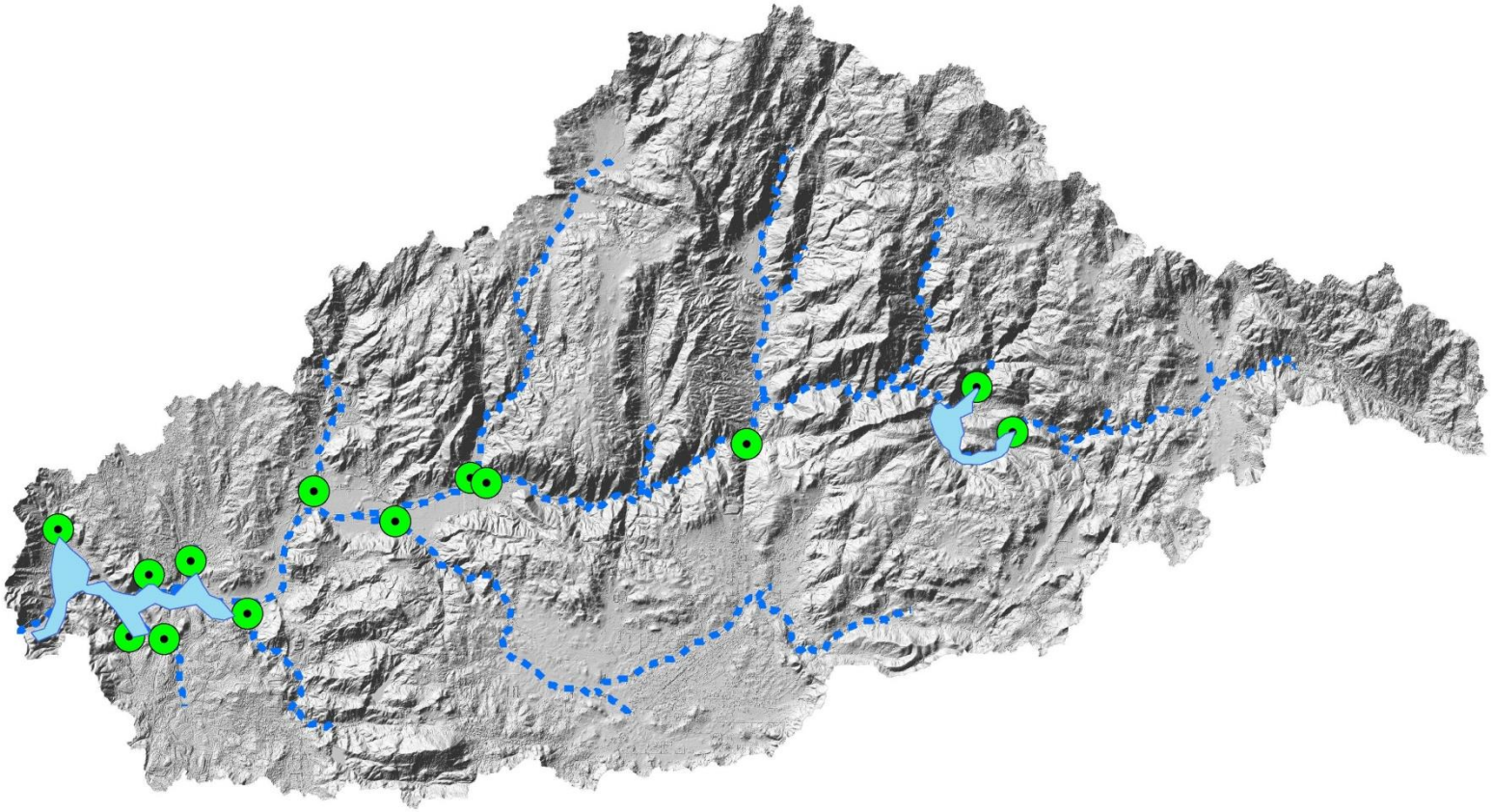
Watershed Specific Data



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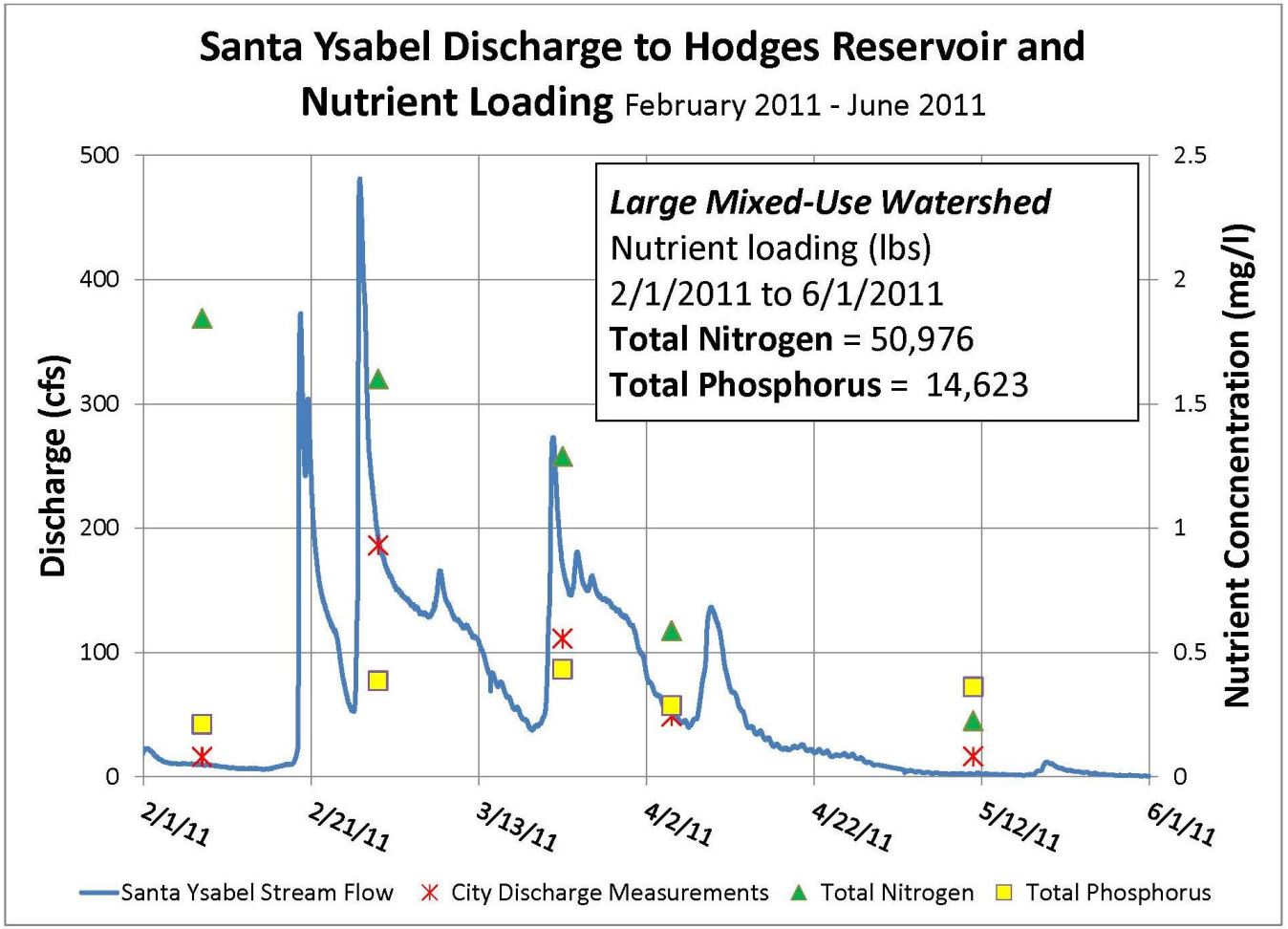
Nutrient Loading based on Watershed Specific Data



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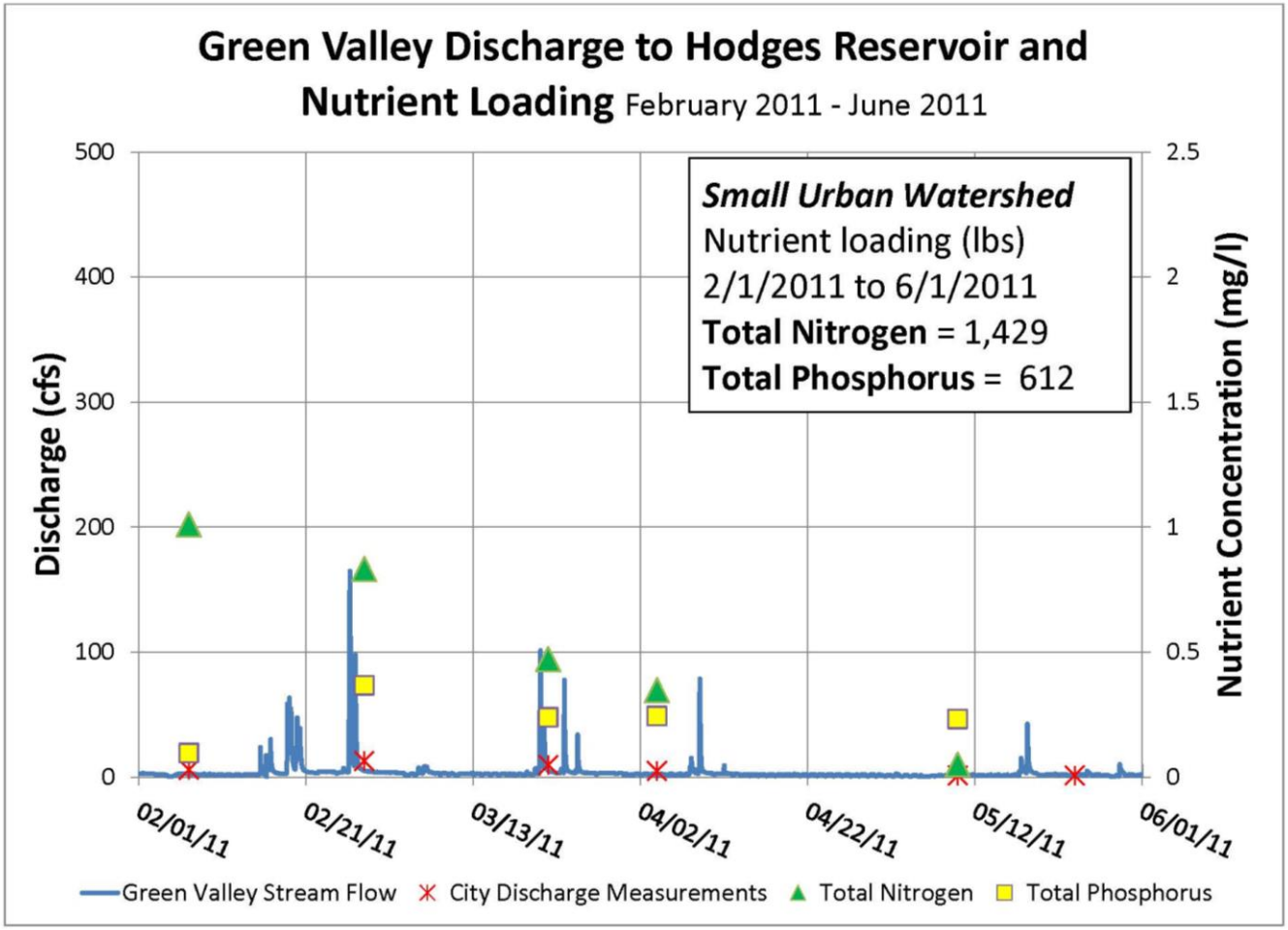
Nutrient Loading based on Watershed Specific Data



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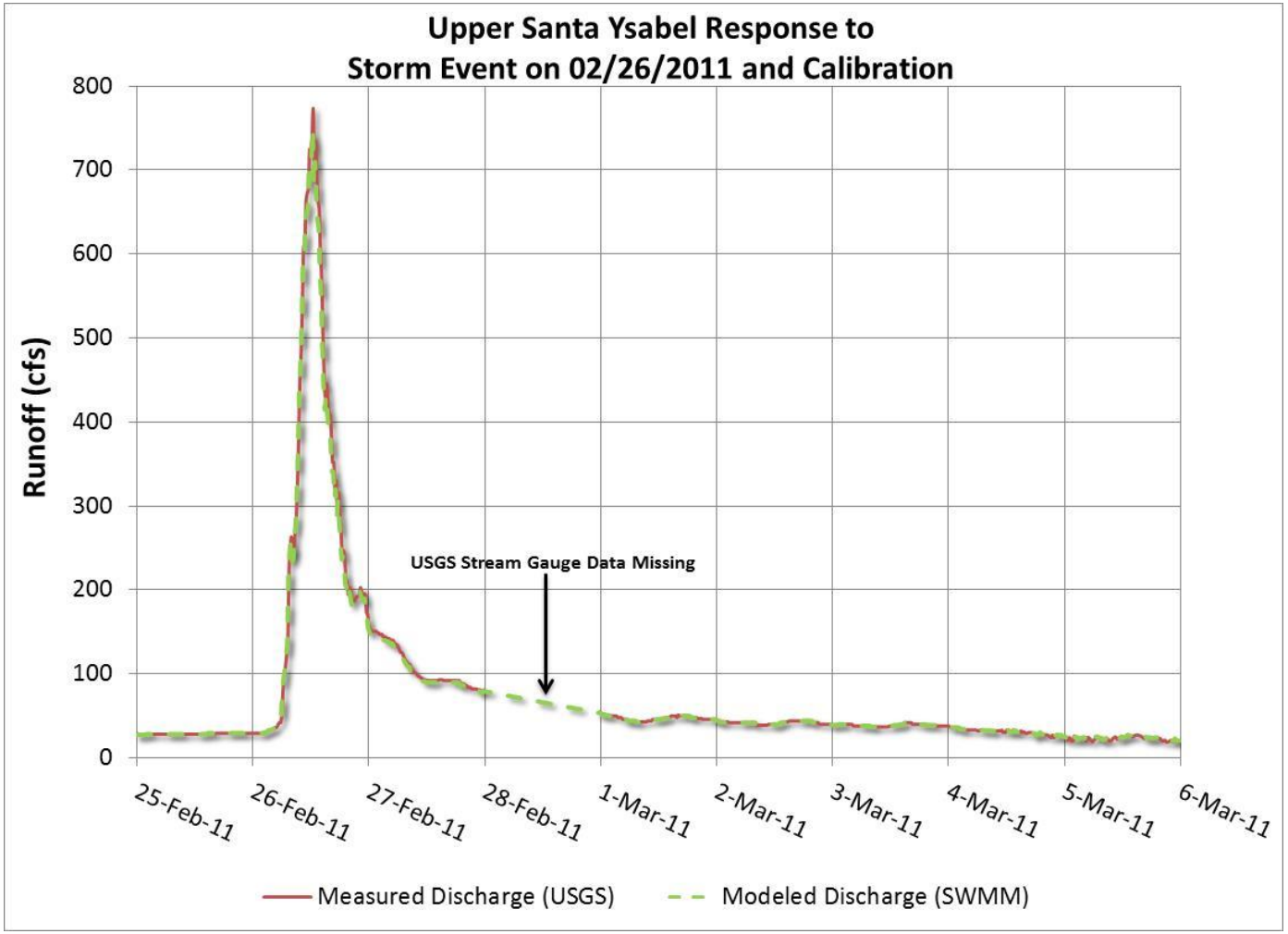
Calibration for 2.5-year Storm Event



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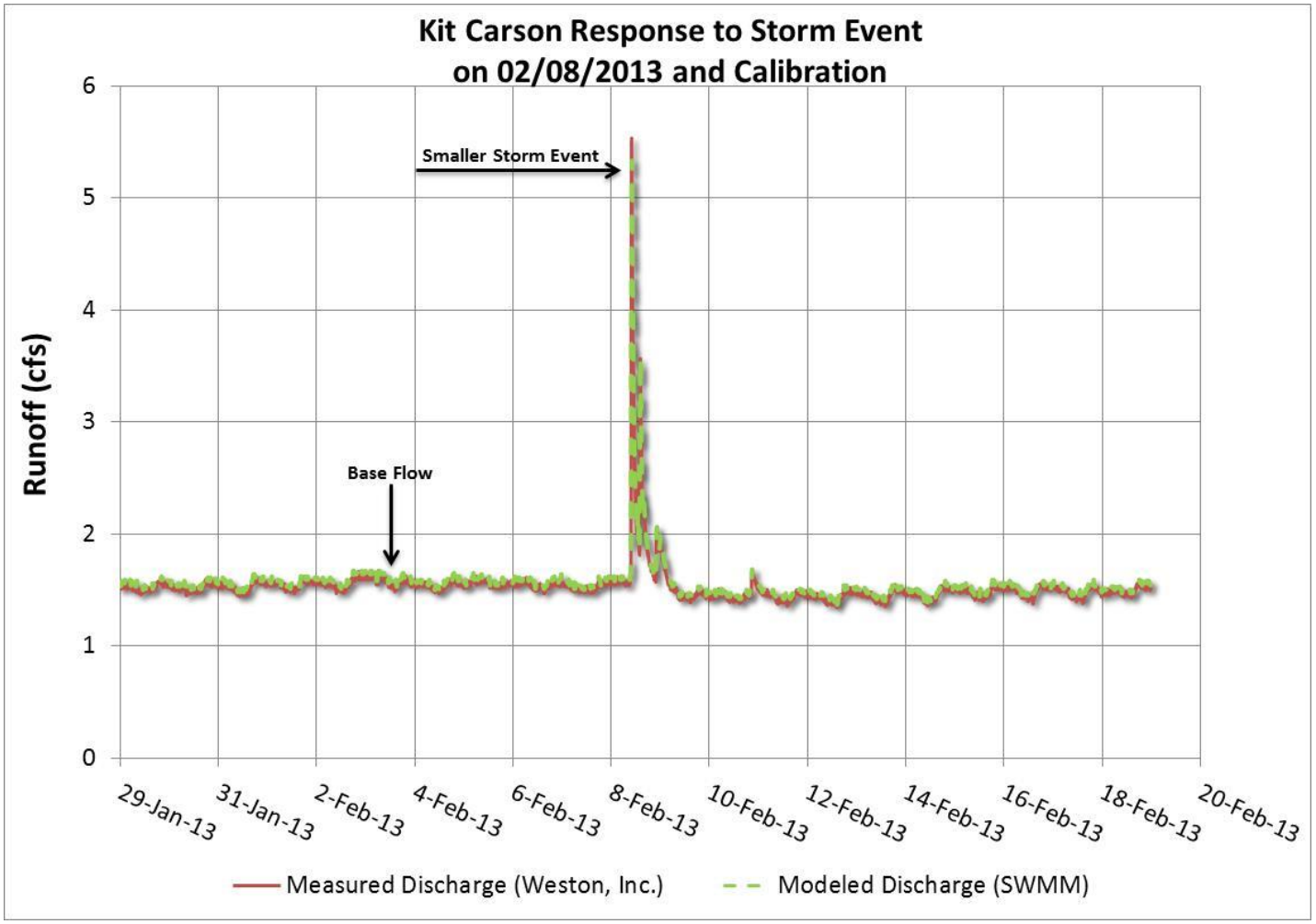
Calibration for Base Flow and Smaller Storm Events



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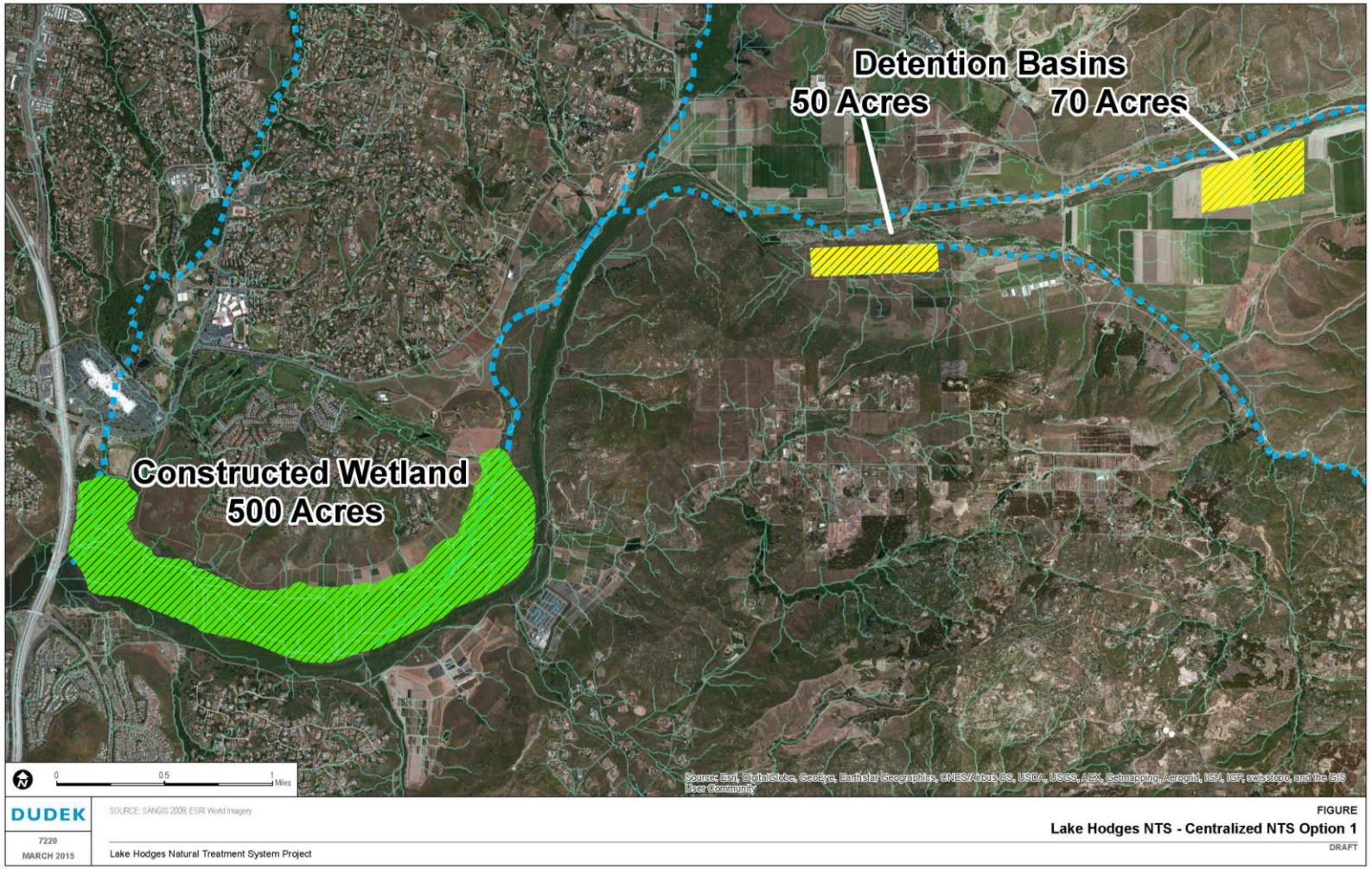
Centralized NTS: Option 1



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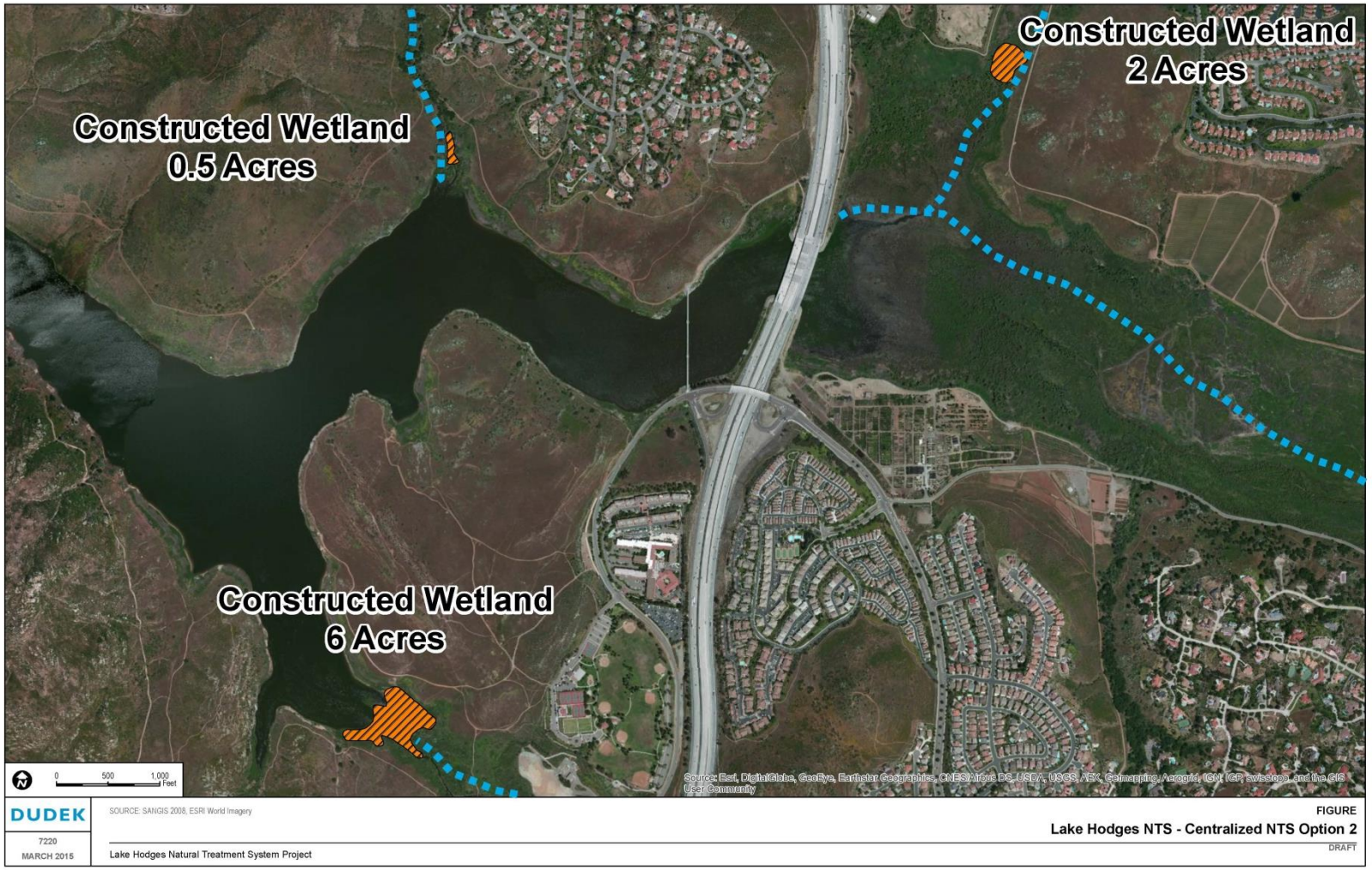
Centralized NTS: Option 2



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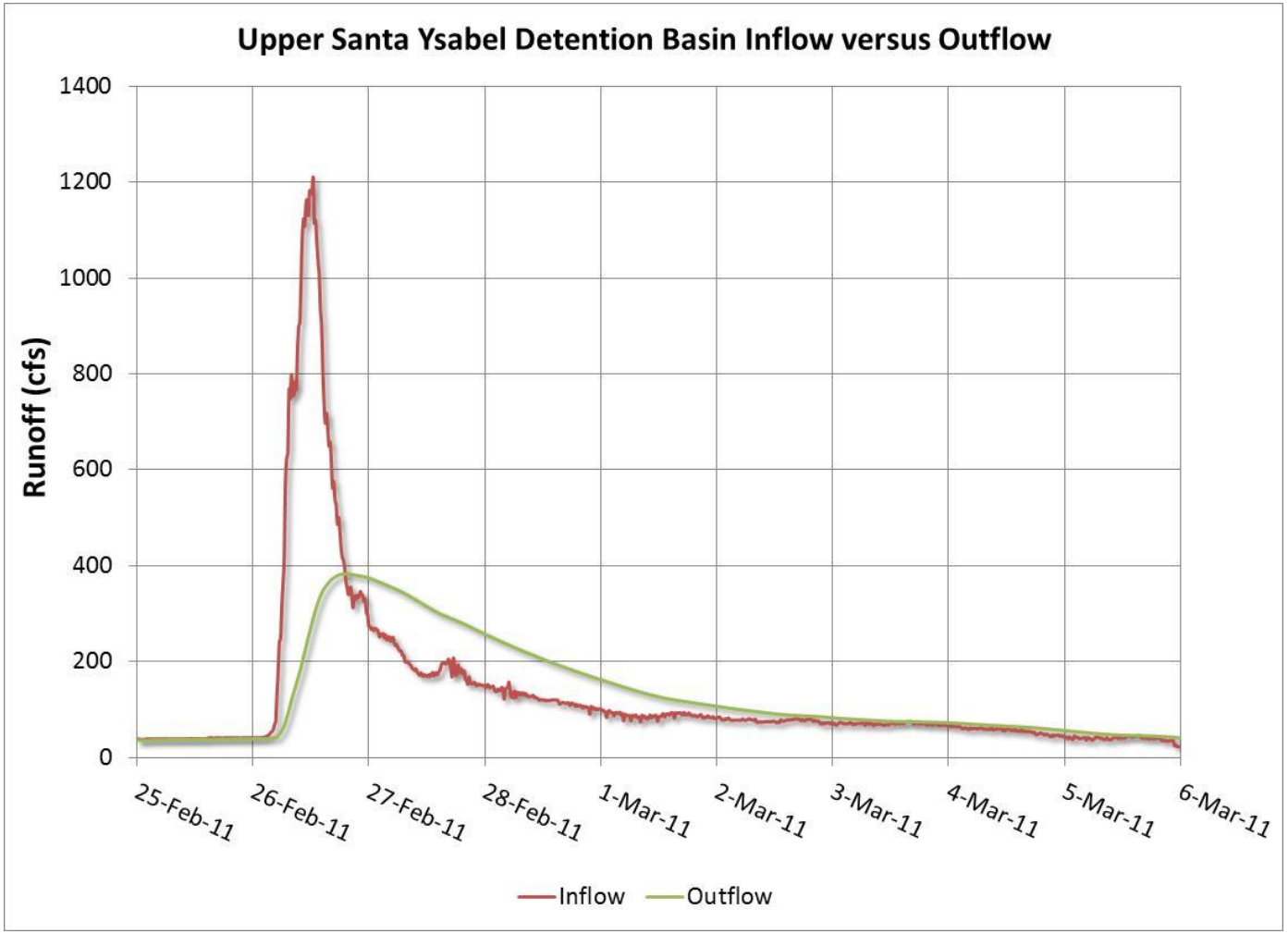
Centralized NTS: Option 1 Performance



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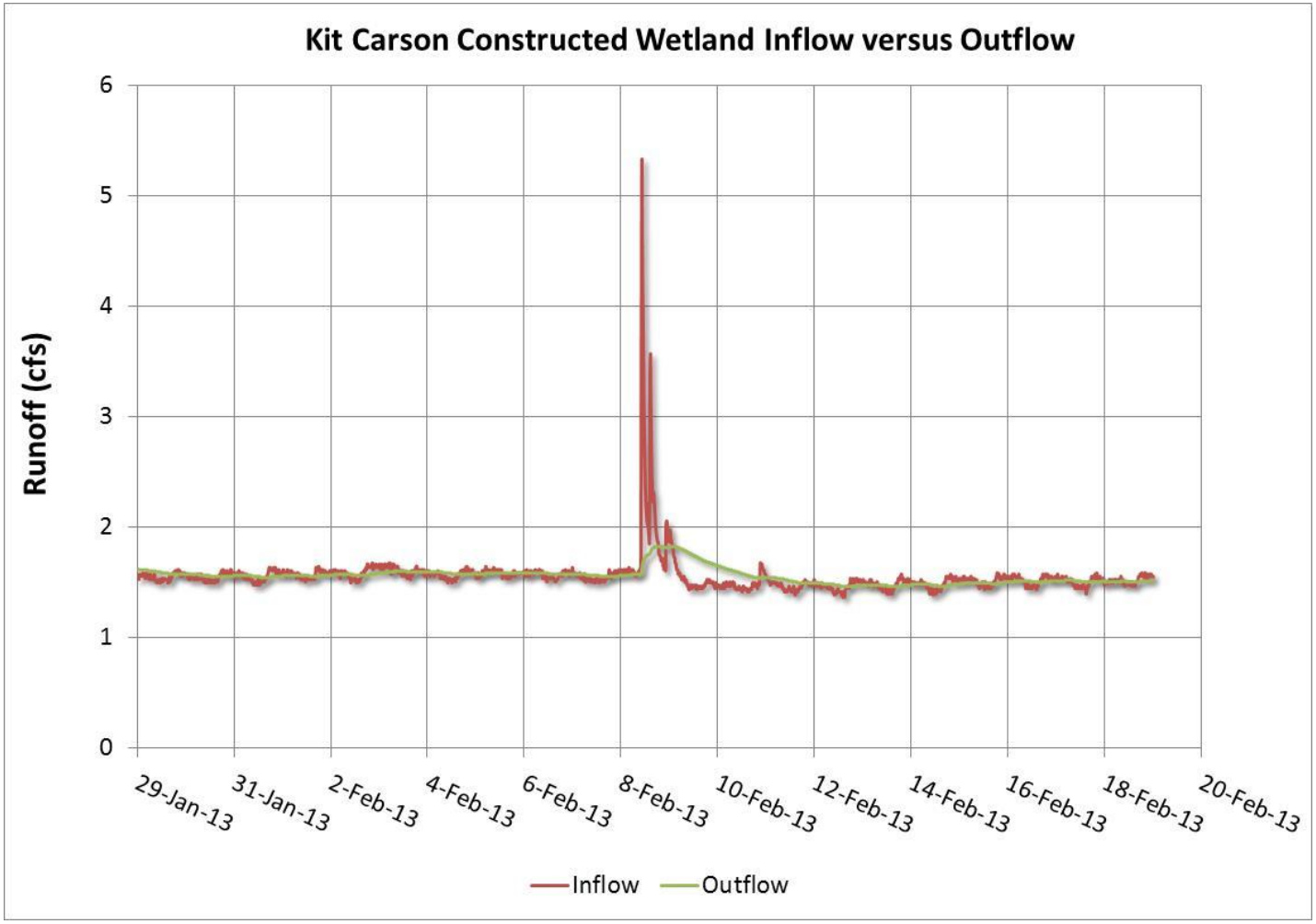
Centralized NTS: Option 2 Performance



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Option 1 – Nutrient Removal (Single 2.5-year Storm Event)

NTS	NTS Type	Nitrogen (lbs)			Phosphorus (lbs)		
		N_{in}	N_{out}	$N_{removed}$	P_{in}	P_{out}	$P_{removed}$
Upper Santa Ysabel	Detention Basin	1,056	727	329	1,056	658	398
Santa Maria	Detention Basin	6,578	4,525	2,053	1,549	965	584
Santa Ysabel	Constructed Wetland	5,293	3,597	1,696	1,739	838	901
Total Nutrient Removal				**4,078**			**1,883**

Option 2 – Nutrient Removal (Annual Base Flow)

NTS	NTS Type	Nitrogen (lbs)			Phosphorus (lbs)		
		N_{in}	N_{out}	$N_{removed}$	P_{in}	P_{out}	$P_{removed}$
Kit Carson	Constructed Wetland	9,853	6,619	3,234	596	284	312
Green Valley	Constructed Wetland	2,643	1,770	873	673	320	353
Felicita	Constructed Wetland	3,967	2,654	1,313	182	86	96
Total Nutrient Removal				**5,420**			**761**

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Evaluation Factors	Option 1 – NTS A	Option 2 – NTS B	Distributed NTS
Modeled Nutrient Load Reduction	High load reduction, but dependent on wet years.	High load reduction, but dependent on baseflow.	N/A
Land Availability	City of SD, PUD-owned	City of SD, PUD-owned	Dependent on private land & ROWs
Feasibility	Complex hydraulic engineering	Relatively simple – few sites, focused on low flows	High number of sites, difficult to coordinate and implement
Wetlands Regulations/ Habitat & Species Benefits	Largest impact, moderate benefit	Moderate impact, largest benefit	Minimal impact and minimal benefit
Agriculture	Largest impact	No impact	No impact

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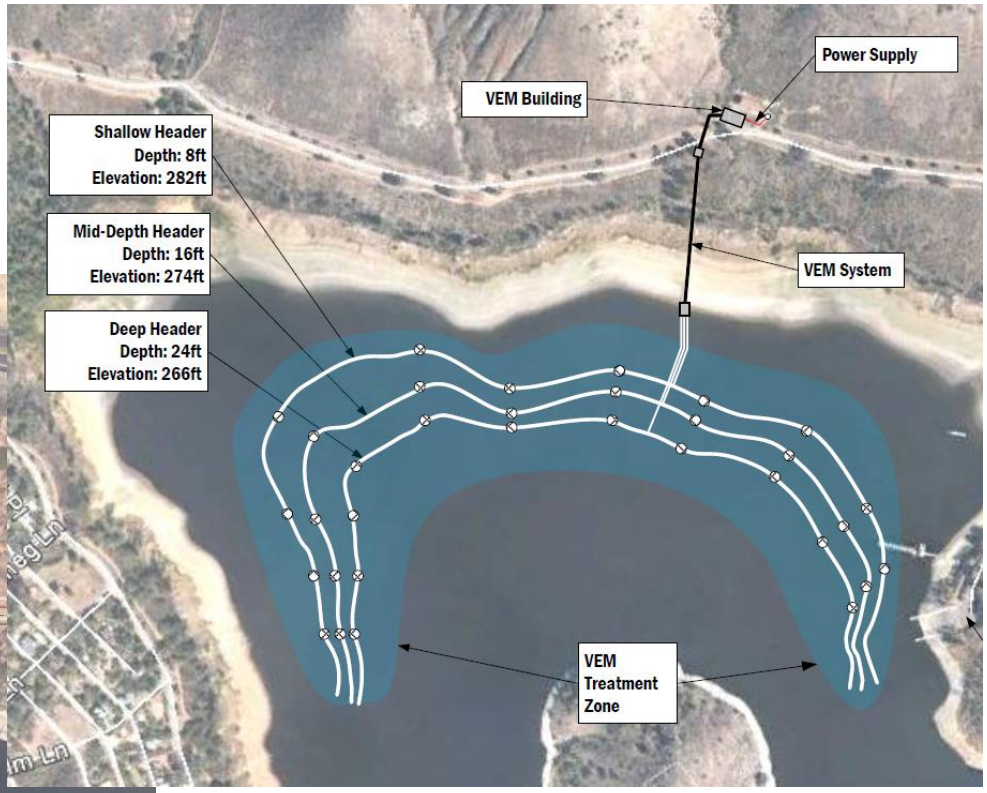
In-Reservoir Treatment Options

Vigorous Epilimnetic Mixing System



Hypolimnetic Oxygenation System

Prepared by Brown and Caldwell

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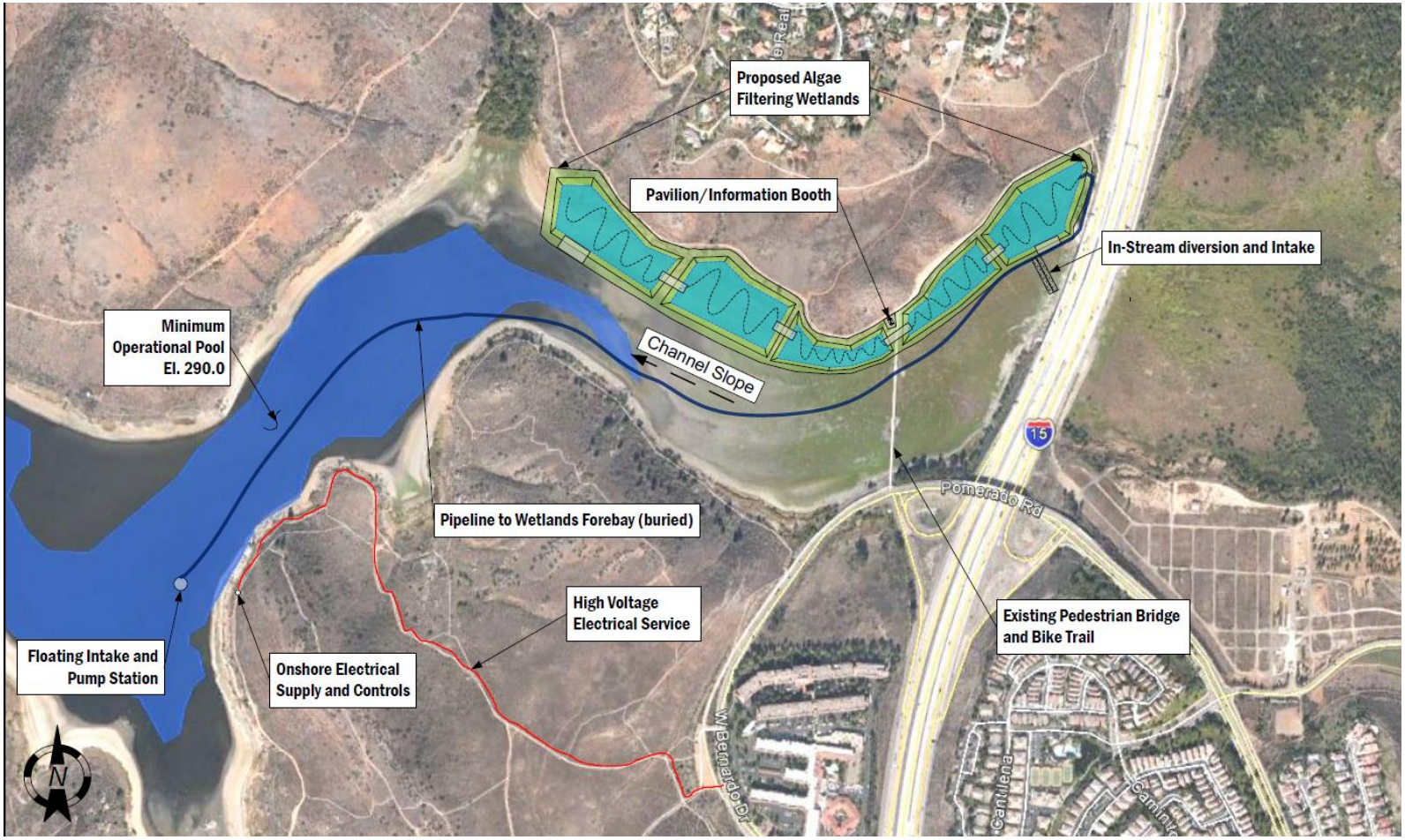
In-Reservoir Treatment Options



Prepared by Brown and Caldwell

QUESTIONS?