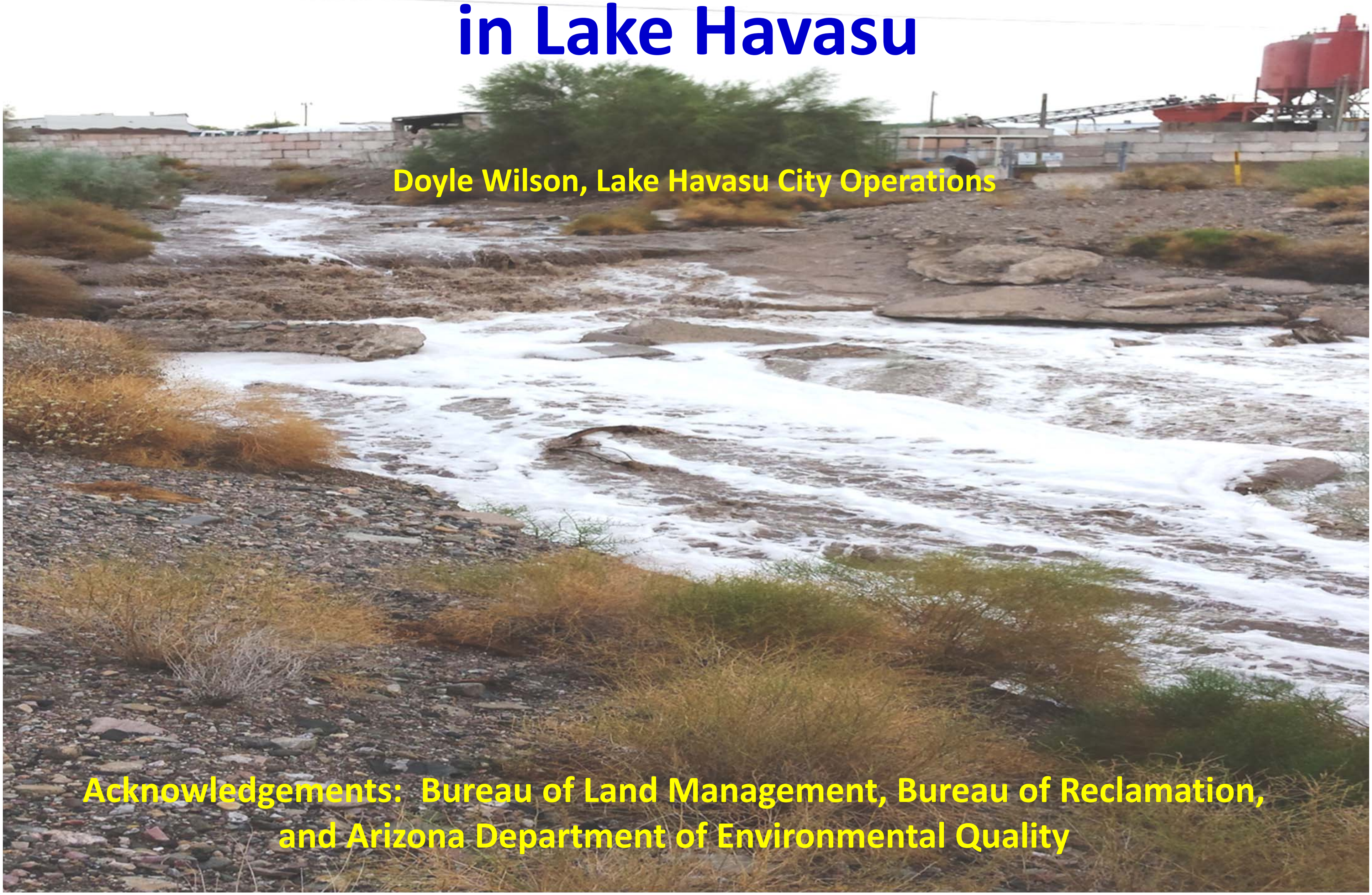
Nutrients in Runoff and Distribution in Lake Havasu

Doyle Wilson, Lake Havasu City Operations



Acknowledgements: Bureau of Land Management, Bureau of Reclamation, and Arizona Department of Environmental Quality

Study Objectives

- Collect baseline phosphorus and nitrogen chemistry runoff from Lake Havasu City into Lake Havasu.

- Relate runoff concentrations with same constituents in the reservoir system – i.e. shallow groundwater, wash mouth sediments, lake water column and bottom sediments.

Methods

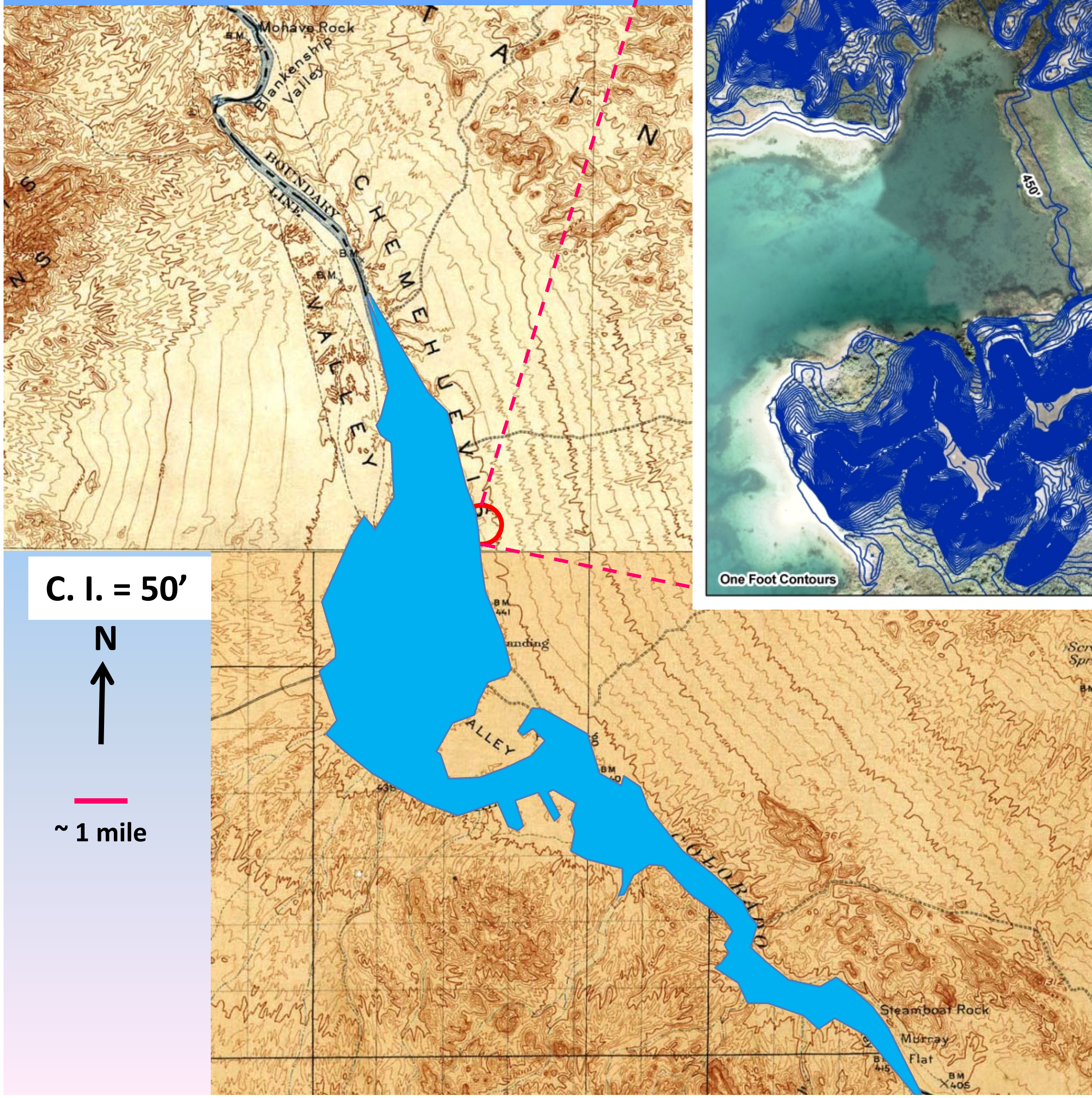
- Grab samples – water samples pumped through 0.45µm filter, wash mouth sediments collected from dug pits and composite cores, and lake sediments collected with ponar dredge.

- All chemical analyses performed at professional laboratories

Lower Colorado River Between Lake Mead and Lake Havasu

Lake Havasu is a retention reservoir for withdrawals specifically constructed for/by Metropolitan Water District of Southern California, but the Central Arizona Project withdraws the most water (1.5-1.6 MAF)

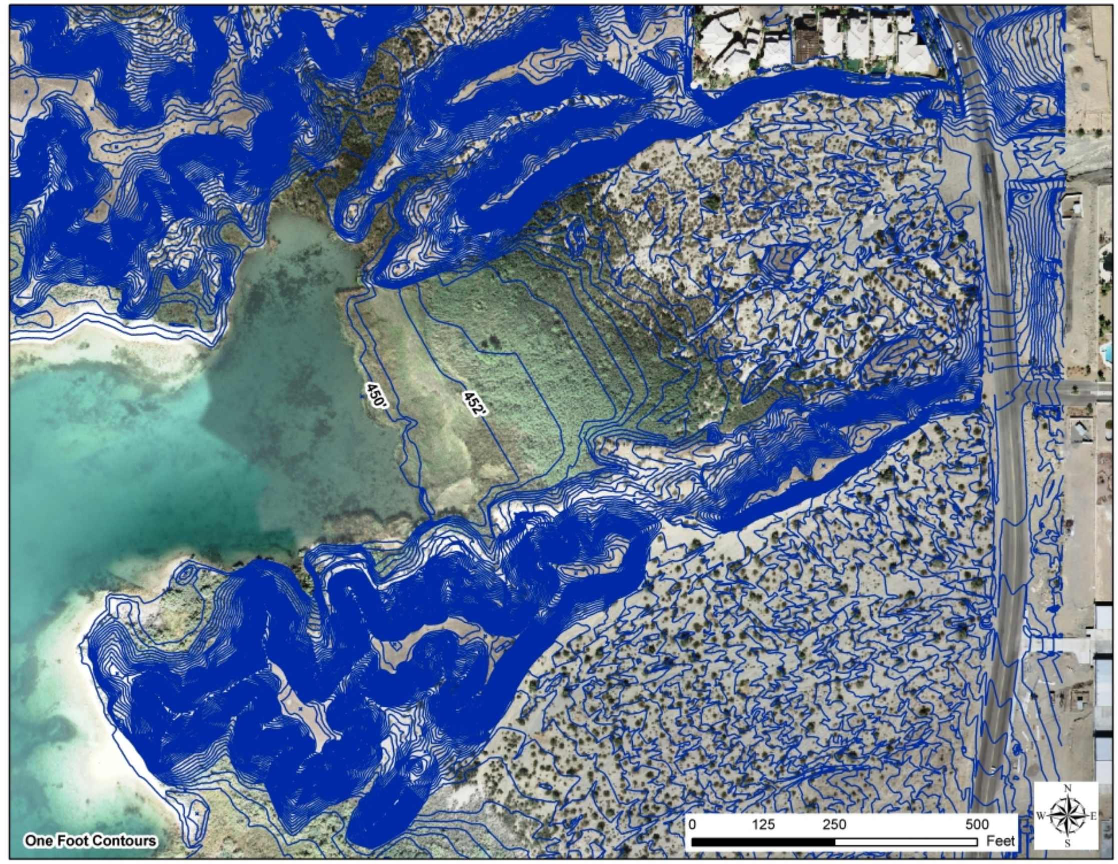
Pre-Lake Havasu Colorado River (Circa 1904-11)



C. I. = 50’

N

~ 1 mile



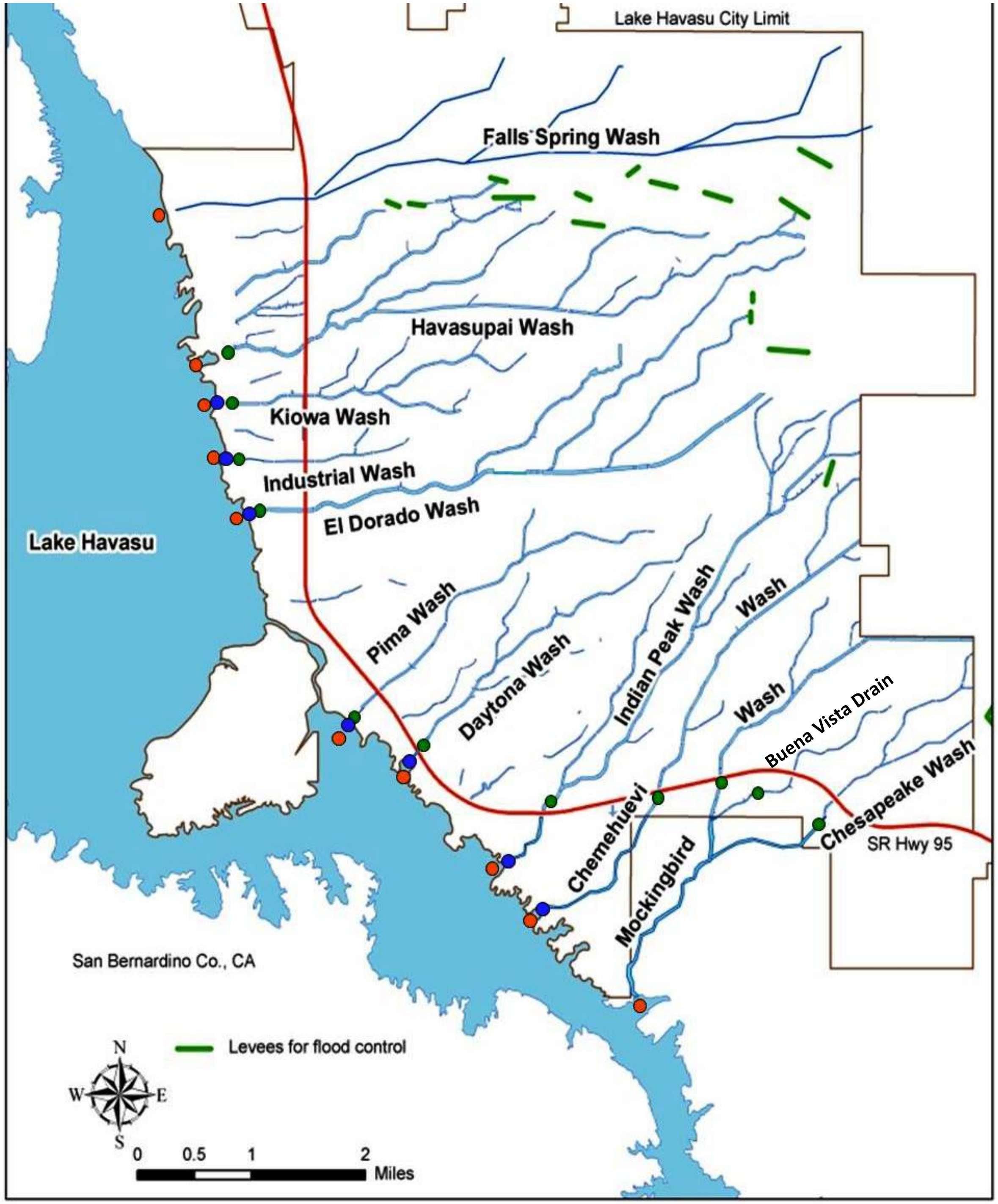
Havasupai Wash Mouth

Drainages in Lake Havasu City flow over a dissected, highly disturbed, coalescing alluvial fan system carrying runoff mostly from within the city. Drainage area = 112 km^2

Lake Havasu City Population: ~54,000, swelling to ~75,000 during the winter months.

Selected Sample Locations for Stormwater Runoff Study

- Stormwater Runoff Sample
- Groundwater and Sediment Samples
- Lake Sample



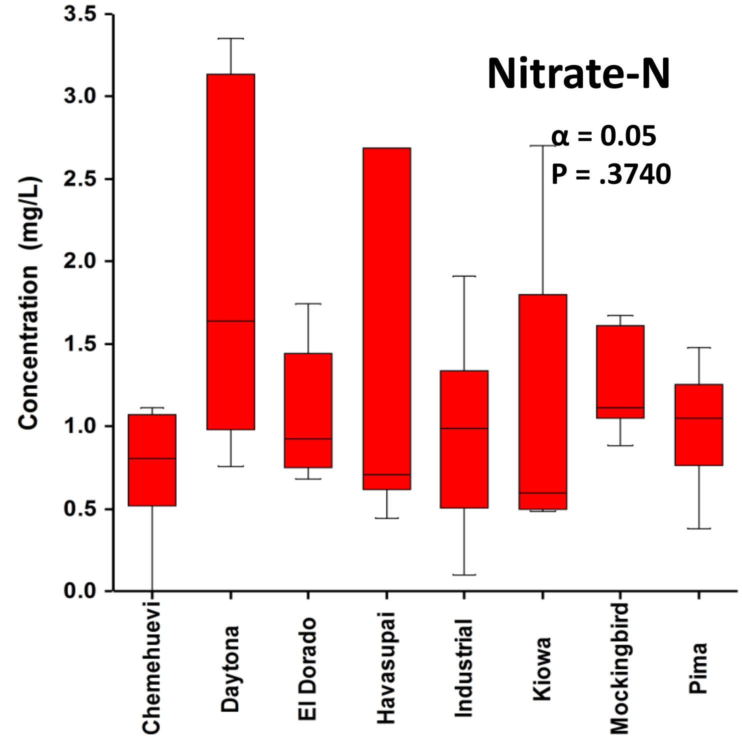
Runoff Events Large and Small

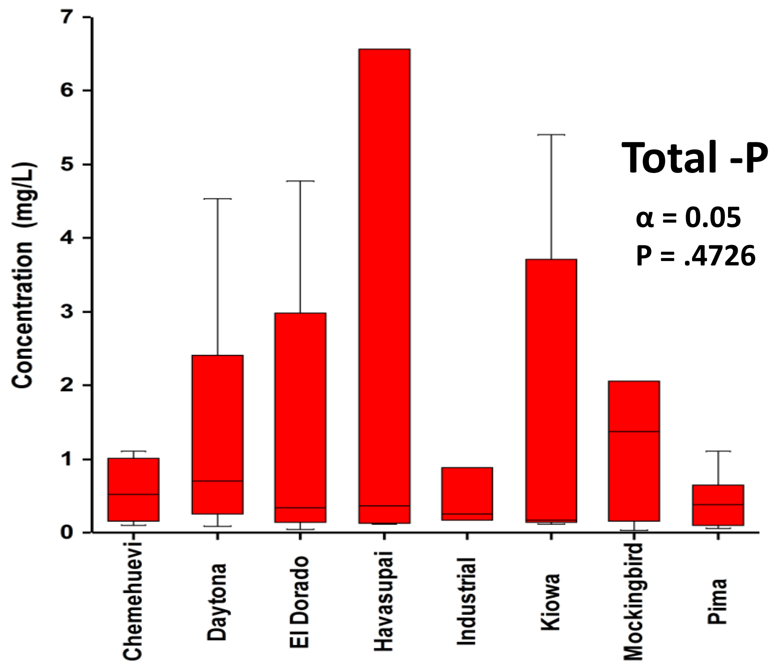
Runoff Concentrations

Wash Averages	Total Phosphate	Ortho-phosphate	Nitrate-N	# Samples
Havasupai	1.43	0.16	2.41	7
Kiowa	1.52	0.15	1.16	6
Industrial	0.91	0.28	1.12	7
El Dorado	1.35	0.27	1.63	6
Pima	0.43	0.18	0.95	8
Daytona	1.34	0.34	2.09	6
Chemehuevi	0.77	0.39	0.86	9
Mockingbird	1.67	0.32	1.32	7
Buena Vista	0.99	0.06	0.70	3
Chesapeake	0.26	0.13	3.48	4
Average of All Samples	1.05	0.25	1.35	63

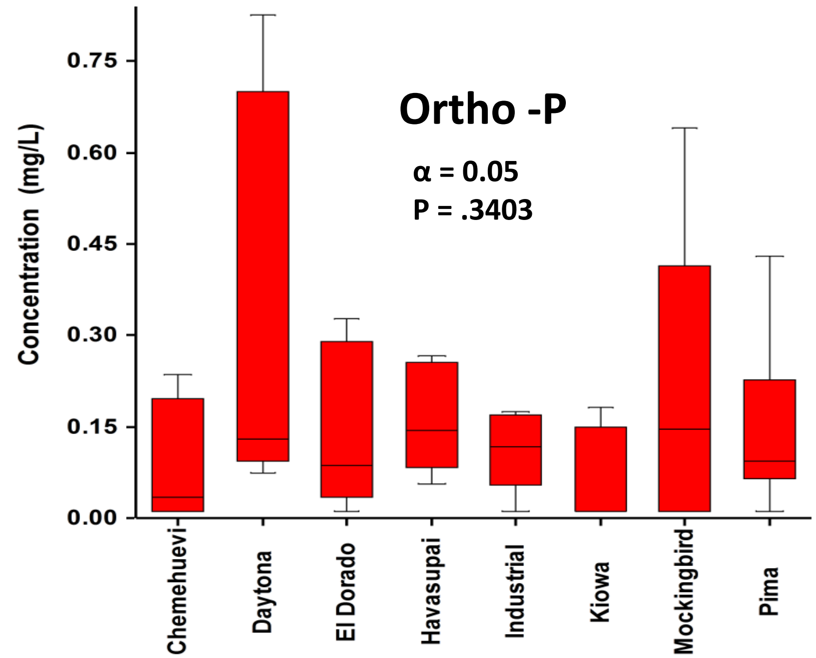
All Concentrations in mg/L

North ↕ South





Tukey-Kramer and Duncan's Multiple Comparison Tests Applied.



Estimates of Nutrient Loading into Lake Havasu

Basic Approach:

Channel cross-sectional area (m^2) = active channel width * water depth

Average Wash Discharge (L/sec) = channel area (m^2) * flow rate (m/sec) * correction coefficient (0.4) * 1000 L/m^3

Mass Flow Load (kg) = Discharge (L/sec) * Nutrient Concentration (mg/L) * Flow duration (sec) * 1 kg/1,000,000 mg

Range of Parameters During Flood Events for Lake Havasu Drainages

Channel Width	Water Depth	Flow Rate	Flow Duration	Events/Year
2 – 30 m	0.0508 to 1.0 m	1 to 4 m/sec	1800 to 5400 sec	4-8

EXAMPLE RANGE OF MASS LOADING: (10 drainages)

TP @ ave. 1.05 mg/L	OP @ ave. 0.25 mg/L	NO_3-N @ ave. 1.35 mg/L
3 - 30,000 kg/yr +	0.7 - 6,500 kg/yr +	4 - 35,000 kg/yr +

Note that these are water contributions only.

Wash Mouths / Deltas

Almost all washes have vegetated barriers at their mouths.

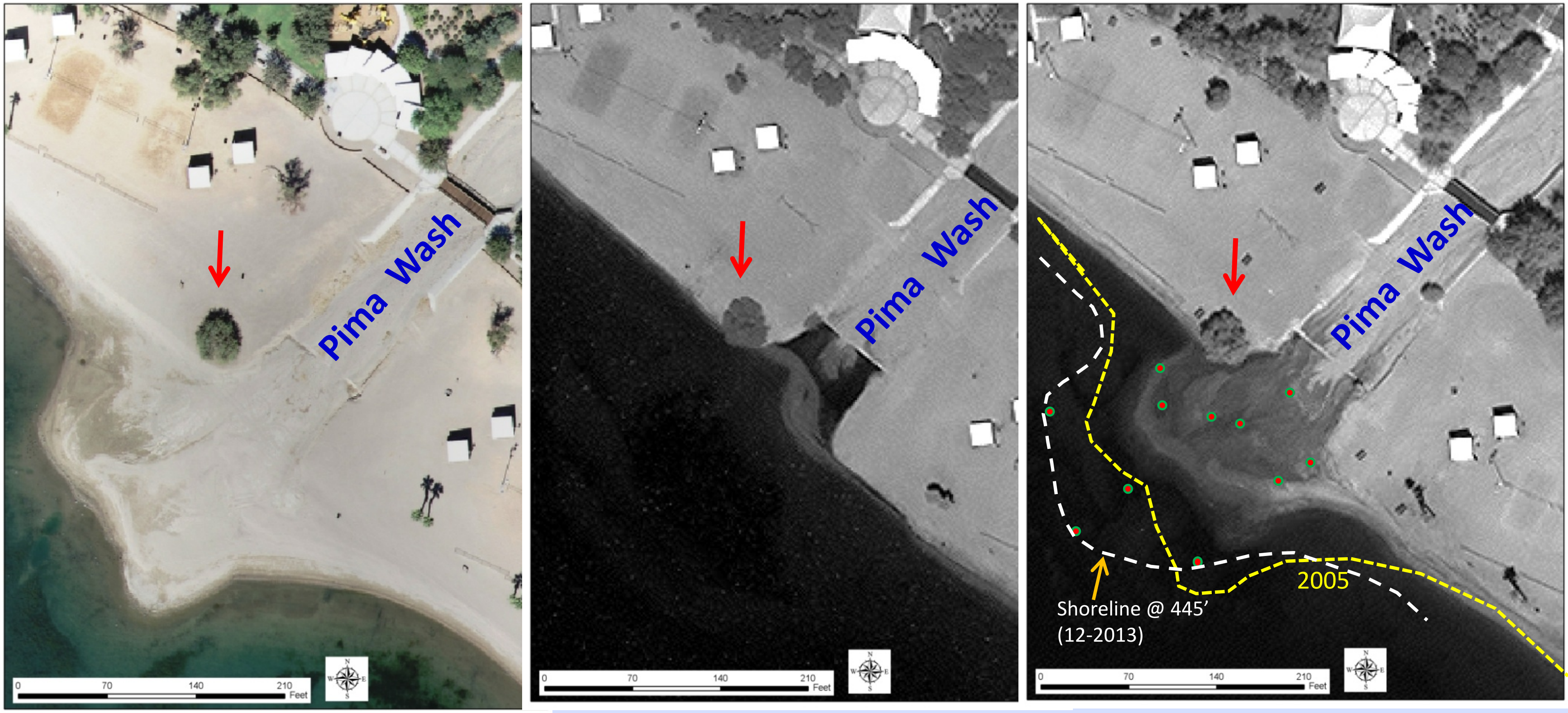
Mockingbird Wash Mouth

El Dorado Wash Delta

Two exceptions are Pima Wash and El Dorado Wash where deltas have formed.

AGE OF SURFACE SEDIMENTS AT WASH MOUTHS IS 76 YEARS OR LESS.

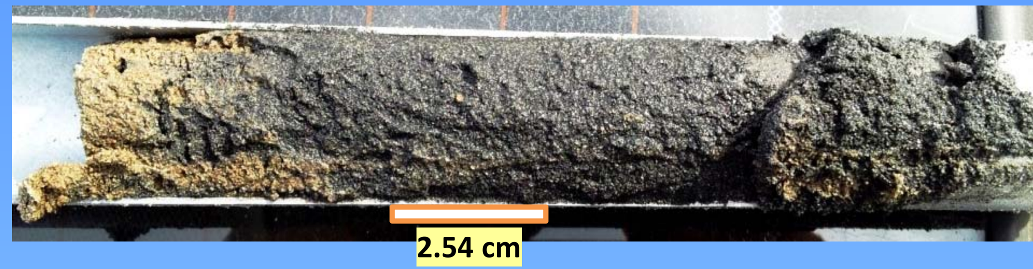
In the case of Pima Wash and parts of El Dorado Wash, the deltas are only 3 years old due largely to a flood event from a July 2012 storm that contributed significant sediment.



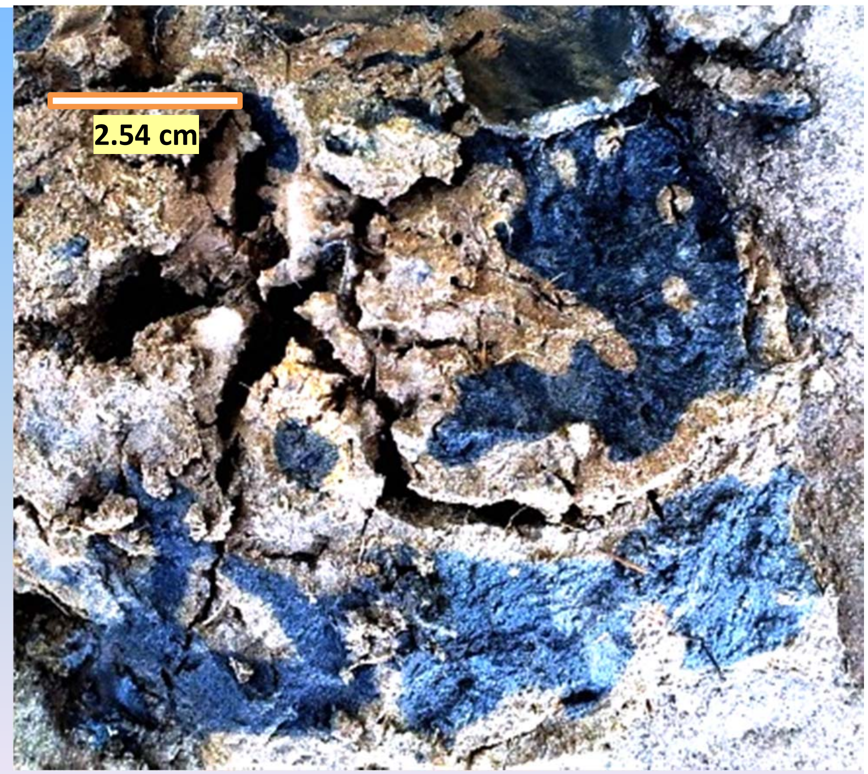
October 2005 | **May 2011** | **September 2012**

Lake Level: 447.7' amsl | **448.6'** | **448.1'**

Pima Wash Delta Pre-Dredging, Post Dredging and Post July 13, 2012 runoff event



Oxic to Anoxic Conditions in a Shallow Core Sample (Pima Wash) above and from a pit sample (Chemehuevi Wash) below.



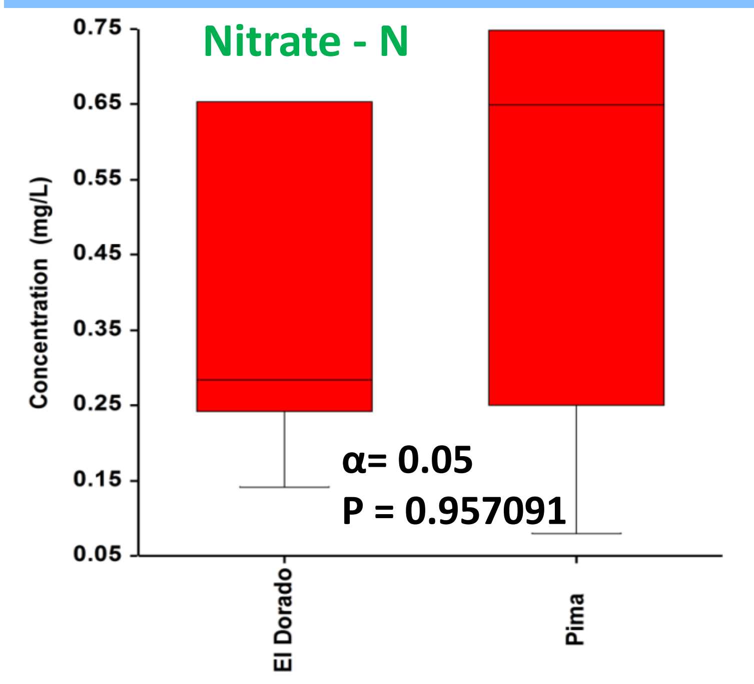
Measured groundwater redox values in cored borings ranged between -6mV to -60mV; pH between 7.6 – 8.4

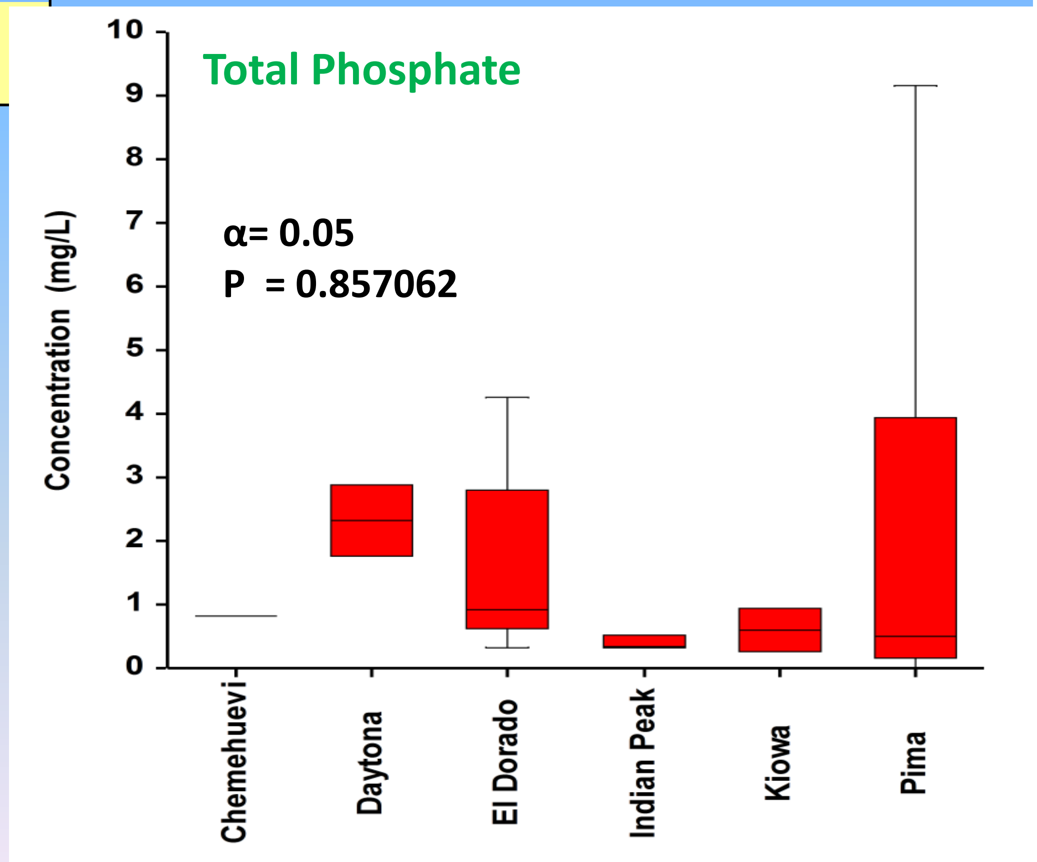
TOC conc. varied in sediment samples from mostly non-detect up to 2830 mg/kg in sediments. Most anoxic conditions probably bacterial derived.

Distribution of Nutrients in Shallow Groundwater

Wash Averages	Total Phosphate	Ortho-phosphate	Nitrate-N	# Samples
Kiowa	0.59	0.31	1.38	2
El Dorado	1.82	0.09	0.74	11
Pima	2.84	0.16	0.91	12
Daytona	2.32	0.19	0.47	2
Indian Peak	0.33	<0.02	2.52	3
Chemehuevi	0.83	<0.02	0.29	1
Average of All Samples	1.46	~0.13	1.05	31

All Concentrations in mg/L



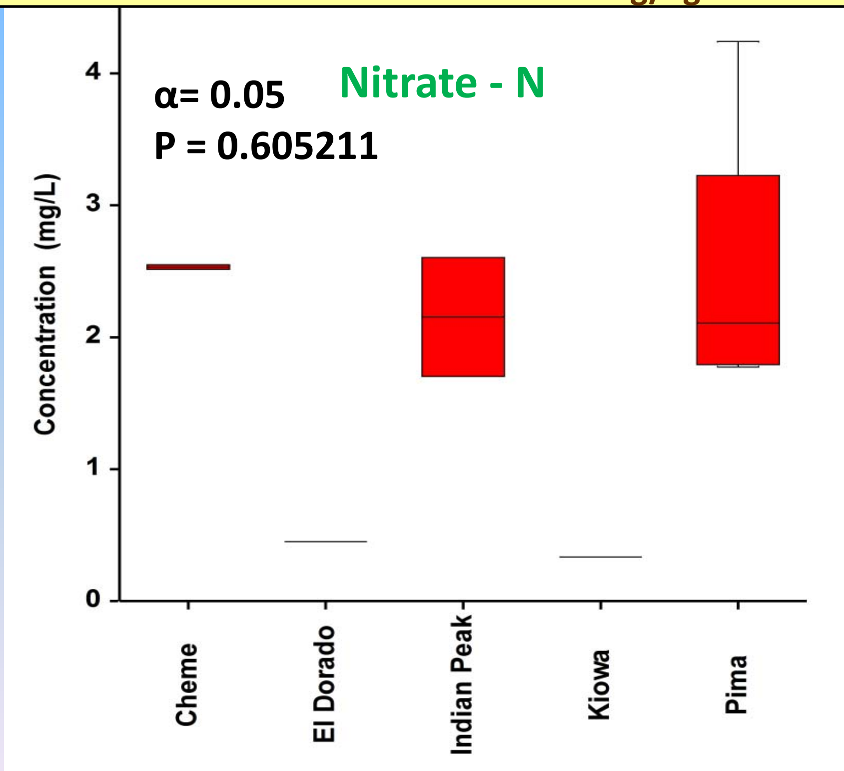


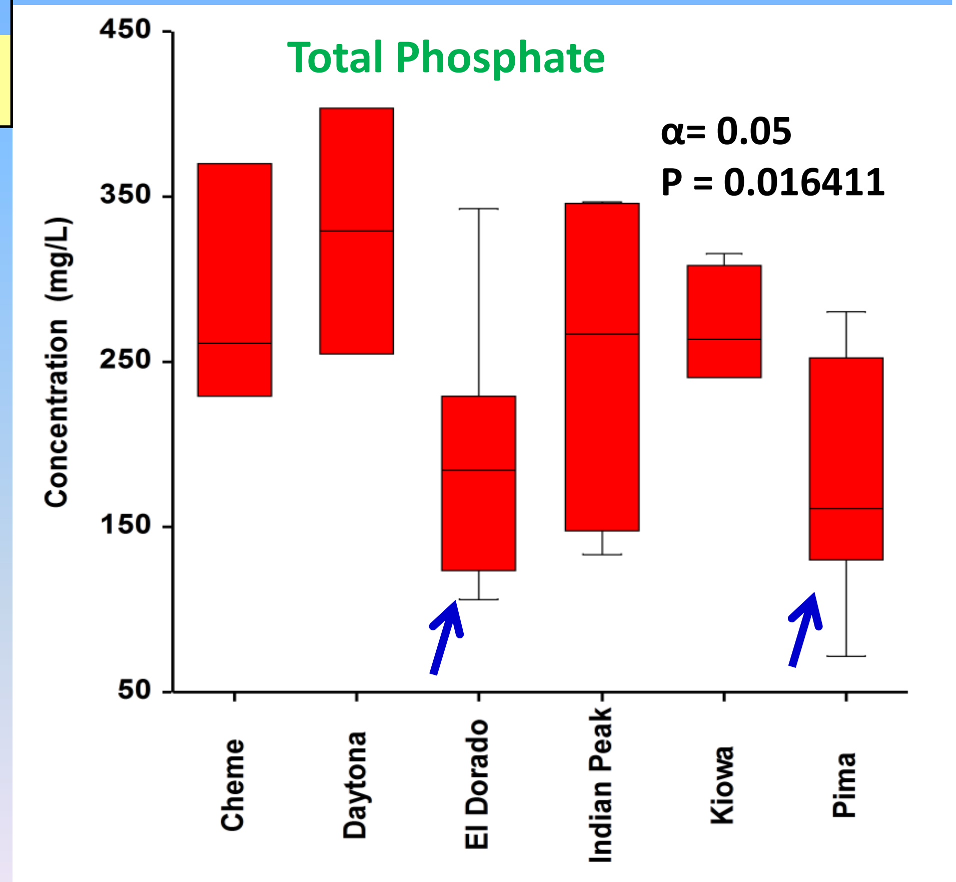
Tukey-Kramer and Duncan's Multiple Comparison Tests Confirm No Significant Difference between Locations.

Distribution of Nutrients in Wash Mouth Sediments

Wash Averages	Total Phosphate	Ortho-phosphate	Nitrate-N	# Samples
Kiowa	255	0.34	<0.40	4
El Dorado	191 ↔	<0.04	0.45	14
Pima	179 ↔	<0.04	2.73	21
Daytona	330	0.72	<0.40	2
Indian Peak	253	0.49	2.15	4
Chemehuevi	287	0.53	2.53	4
Average of All Samples	249	~0.36	~1.41	49

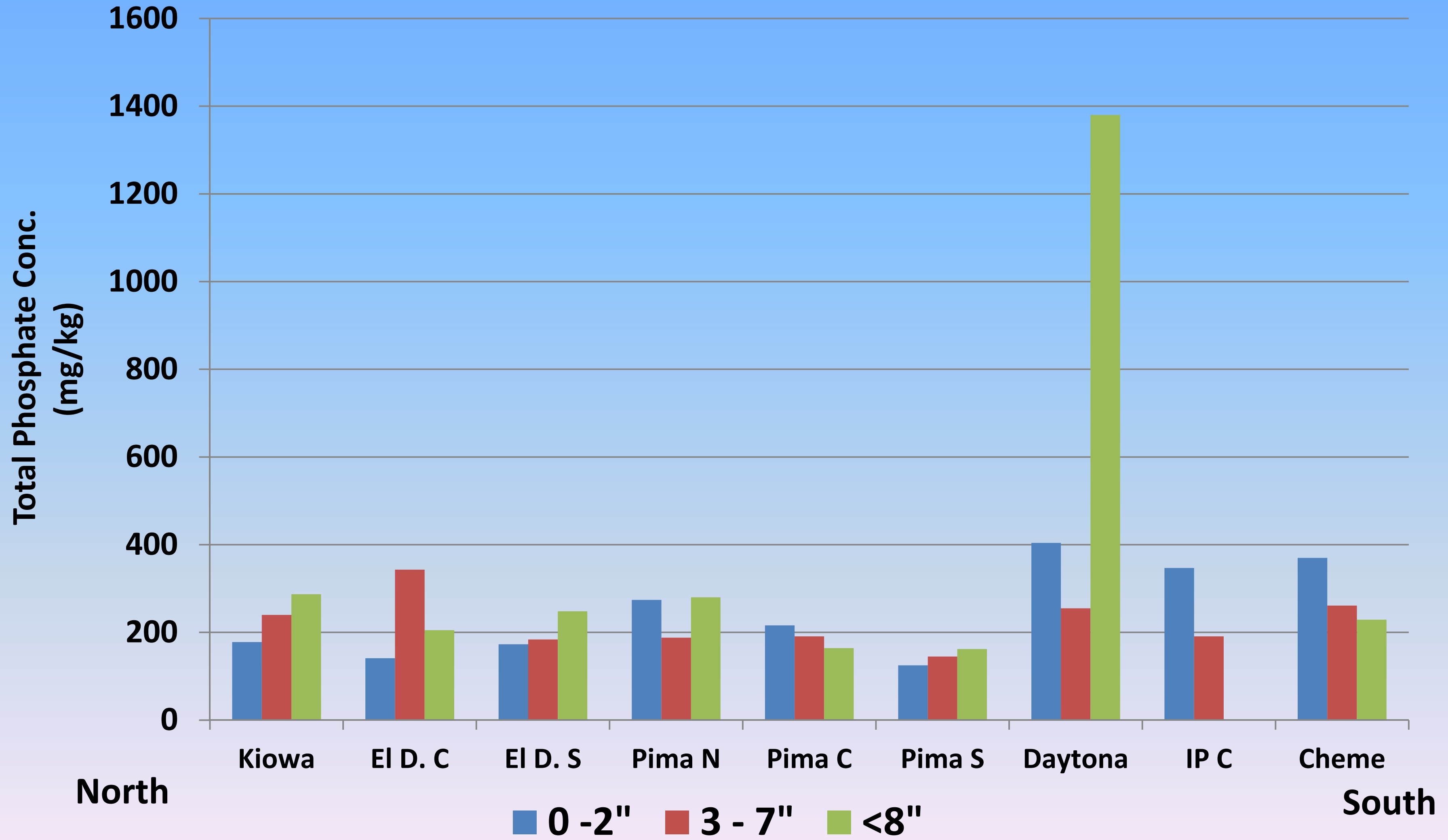
All Concentrations in mg/kg



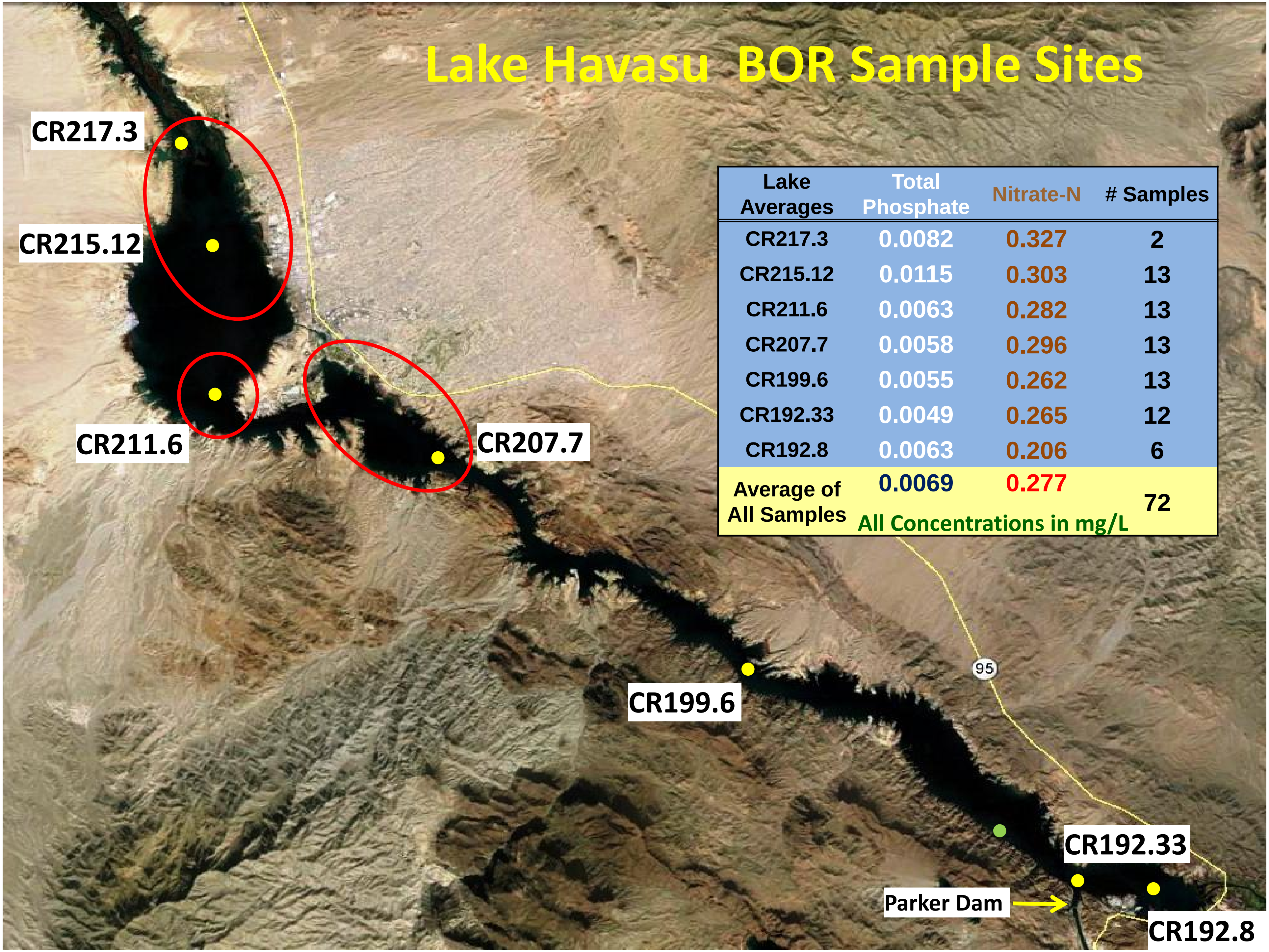


Tukey-Kramer and Duncan's Multiple Comparison Tests Confirm No Significant Difference between Locations for Nitrate, but do for Total Phosphate.

Observed Depth vs Total Phosphate Concentrations at Cored Sediment Sites



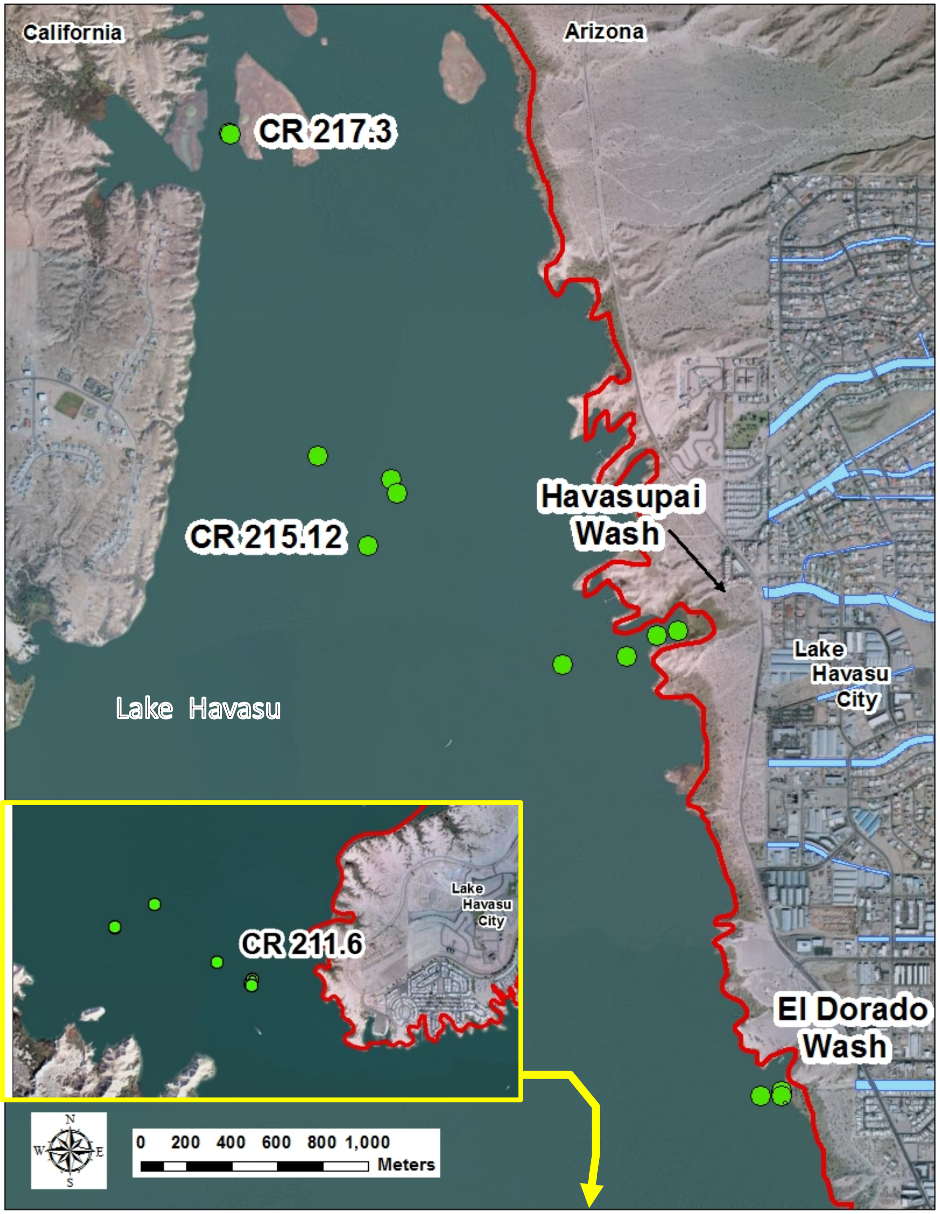
Lake Havasu BOR Sample Sites

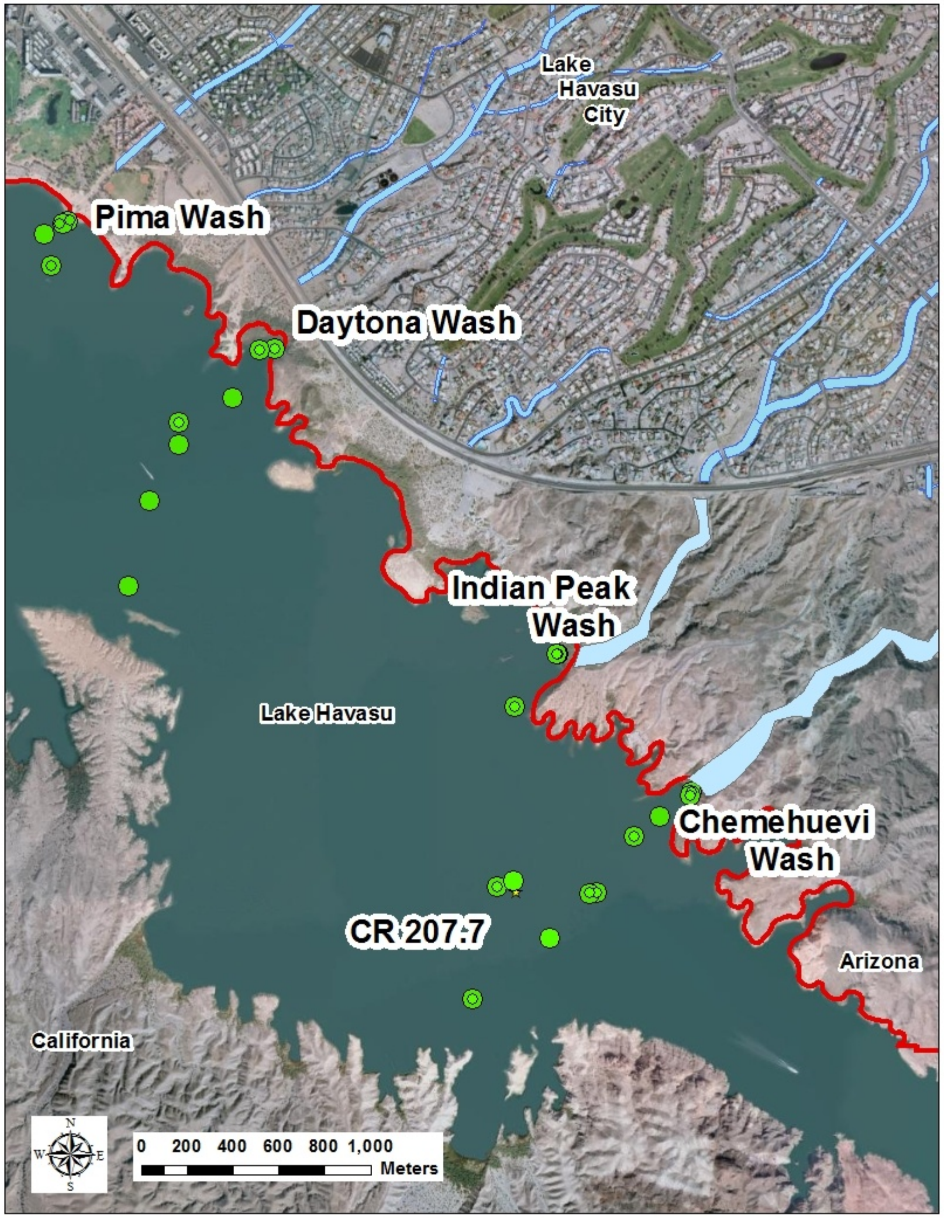


Lake Averages	Total Phosphate	Nitrate-N	# Samples
CR217.3	0.0082	0.327	2
CR215.12	0.0115	0.303	13
CR211.6	0.0063	0.282	13
CR207.7	0.0058	0.296	13
CR199.6	0.0055	0.262	13
CR192.33	0.0049	0.265	12
CR192.8	0.0063	0.206	6
Average of All Samples	0.0069	0.277	72

All Concentrations in mg/L

Lake Havasu Sediment Sample Sites





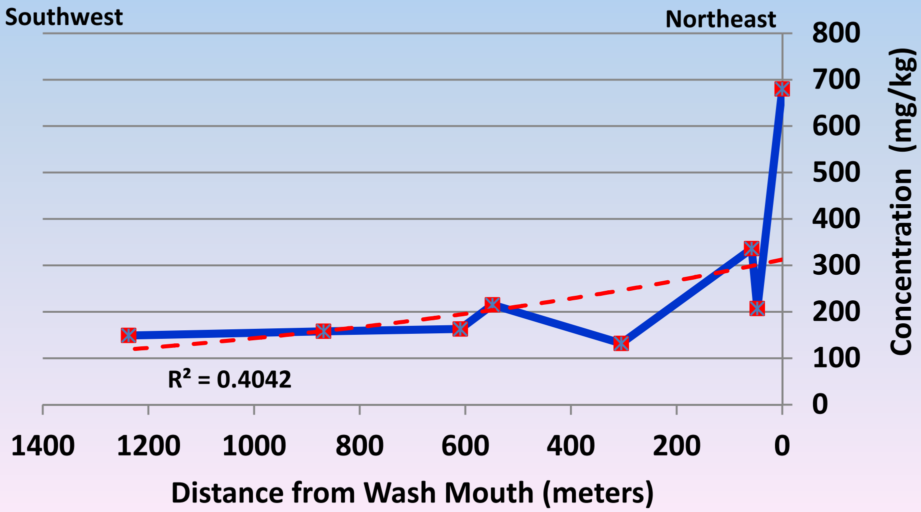
Lake Sediment Average Nutrient Concentrations

Lake Sediment Averages	Total Phosphate	Ortho-phosphate	Nitrate-N	# Samples	% SAND	%SILT/CLAY
Havasupai	237	0.42	4.20	4	27.6	72.4
El Dorado	223	0.38	<0.4	4	45.9	54.1
Pima	150	0.26	4.96	4		
Daytona	194	0.30	3.82	7	38.2	61.8
Indian Peak	252	0.33	4.47	3	71.5	28.5
Chemehuevi	246	0.60	1.88	10	38.8	61.2
CR217.3	187	0.4	2.03	3	89.9	10.1
CR215.12	275	0.81	1.57	4	30.7	69.3
CR211.6	197	0.53	2.53	4	57.5	42.5
Average of All Samples	207	0.45	3.18	43		

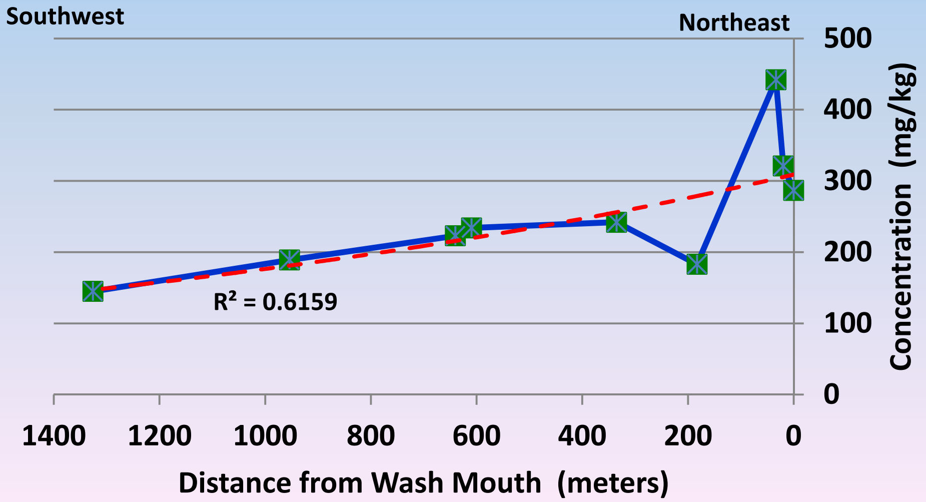
All Concentrations in mg/kg

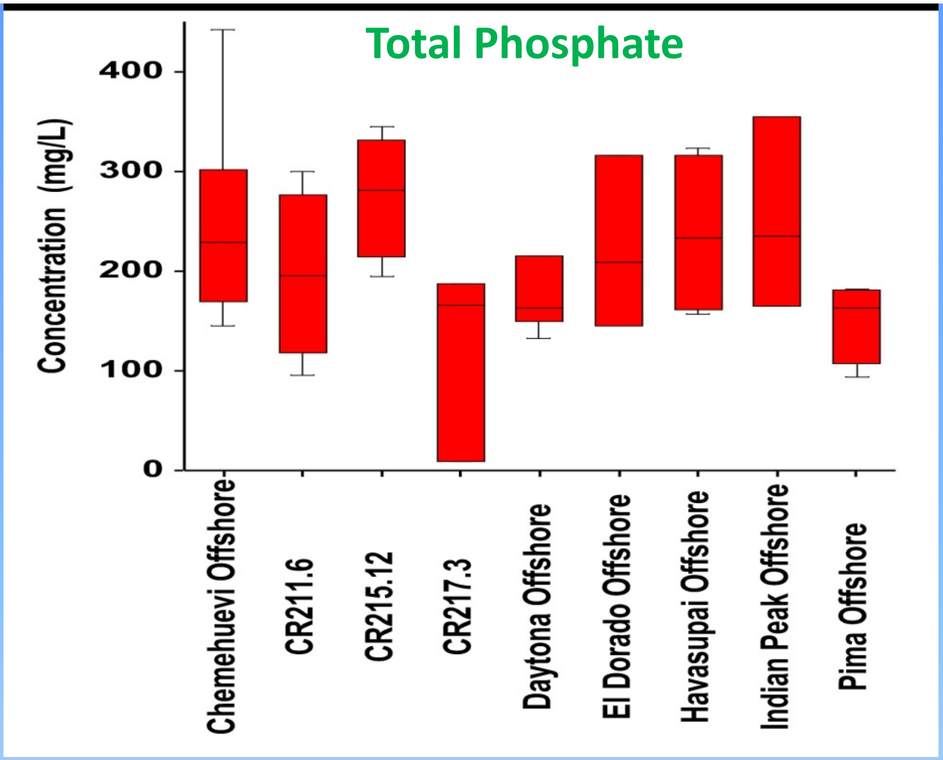
Nutrients:
No Correlation With Grain Size
All R^2 <0.22

Daytona Wash Transect - TP



Chemehuevi Wash Transect - TP





Statistical Differences Between Media Type?

Nutrient Type	Runoff-GDH2O	Runoff-Lake	Runoff - Wash Seds.	Runoff - Lake Seds.	GDH2O-Lake Seds.	GDH2O-Wash Seds.	GDH2O-Lake	Lake-Lake Seds.	Lake - Wash Seds.	Wash Seds. – Lake Seds.
TP	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
OP	No	Yes	No	No	No	Yes	Yes	Yes	Yes	No
NO3	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No

Summary Points
QUESTIONS??

Nutrient contributions into Lake Havasu from the City via runoff suspended load are calculable, yet impacts to the reservoir environment are yet to be determined.

With some exceptions, especially OP, nutrient concentrations tend to be orders of magnitude higher in sediments than in the three water types.

A correlation between nutrient loading into the reservoir with sediment nutrient accumulation at some wash mouths (i.e. Pima and El Dorado washes) is intuitively apparent, but not yet quantified.

No statistical differences between wash mouth and lake sediments for any nutrients are apparent with data collected to this point.

This implies sediment age or grain size characteristics are not significant controlling factors for observed concentrations.

Sediment TP levels from Daytona and Chemehuevi washes into the reservoir generally decrease, but reveal weak overall correlations with distance.