

Sources, Fate, and Transport of NDMA, Pharmaceuticals and Personal Care Products (PPCPs) in Water

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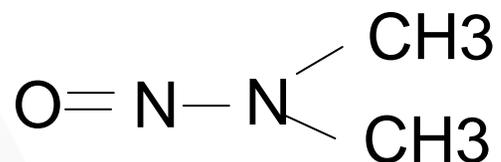
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Metropolitan Water District of Southern California

April 21, 2009 MWQI/Contractor face to face meeting

Background

What is NDMA?

- N-Nitroso Dimethyl Amine



- Part of a family of chemicals known as nitrosamines
- It is a semi-volatile organic chemical
- Soluble in water
- Is not likely to bioaccumulate, biodegrade, adsorb to particulates or volatilize
- May be reduced by sunlight
- It was originally found in various foods, primarily cured meats, as well as beer and tobacco smoke
- 1st showed up in drinking water wells as a contaminant in ground water near Aerojet in Rancho Cordova

Why study NDMA cont'd.

- NOM contains precursors for THMS and nitrosamines (organic carbon and organic nitrogen).
- NDMA may be formed as a DBP at a drinking water facility upon chlorination or chloramination of organic N precursors (wastewater derived, agriculturally derived-for example-diuron).
- In addition to NDMA formed in the distribution system, NDMA also formed during the chlorination of secondary effluent at wastewater treatment plants.
- Indirect potable reuse of wastewater likely to increase in the future, leading to potential increase in nitrosamines and their precursors at drinking water facilities. Some studies suggest that utilities that use effluent dominated surface waters are prone to NDMA formation during chloramination. (for exp. Charrois et al. 2004).

Why study NDMA cont'd.

- NDMA vs. THM disinfection byproducts

Highly Toxic!!!!

Why Study NDMA?

- Potent carcinogen—much more toxic than THMs

Compound	Abbreviation	10 ⁻⁶ Cancer Risk Level, ng/L
<i>N</i> -Nitrosodimethylamine	NDMA	0.7
<i>N</i> -Nitrosomethylethylamine	NMEA	2
<i>N</i> -Nitrosodiethylamine	NDEA	0.2
<i>N</i> -Nitrosodipropylamine	NDPA	5
<i>N</i> -Nitrosomorpholine	NMOR	Unknown
<i>N</i> -Nitrosopyrrolidine	NPYR	20
<i>N</i> -Nitrosopiperidine	NPIP	Unknown
<i>N</i> -Nitrosodibutylamine	NDBA	6
Trichloromethane (chloroform)		6000
Dibromochloromethane		600
Bromoform		4000
Dibromodichloromethane		

No current MCL. Action level of 10 ng/L set by CDHS in 2002. PHG set by OEHA in 2003 of 3 ng/L.

Why study NDMA cont'd.

- 2007 CA-NV AWWA, meeting, US EPA noted that it may be one of the next regulated DBPs.
- CDHS website—“Given the NDMA detections associated with drinking water sources and treatment, NDMA is a good candidate for future regulation (i.e., establishment of a drinking water standard, also know as a maximum contaminant level or MCL).”

WWTPs, NDMA and the Delta

Study Design

Study Design

- Starting 7/08, samples collected quarterly from 7 sites in the Delta.

- Upstream of WWTPs

 - W. Sac WTP intake

 - SJR @ Mossdale (but d/stream of Manteca WWTP)

 - SJR @ Vernalis-also ag input station

- Downstream of WWTPs

 - Sac R @ Hood

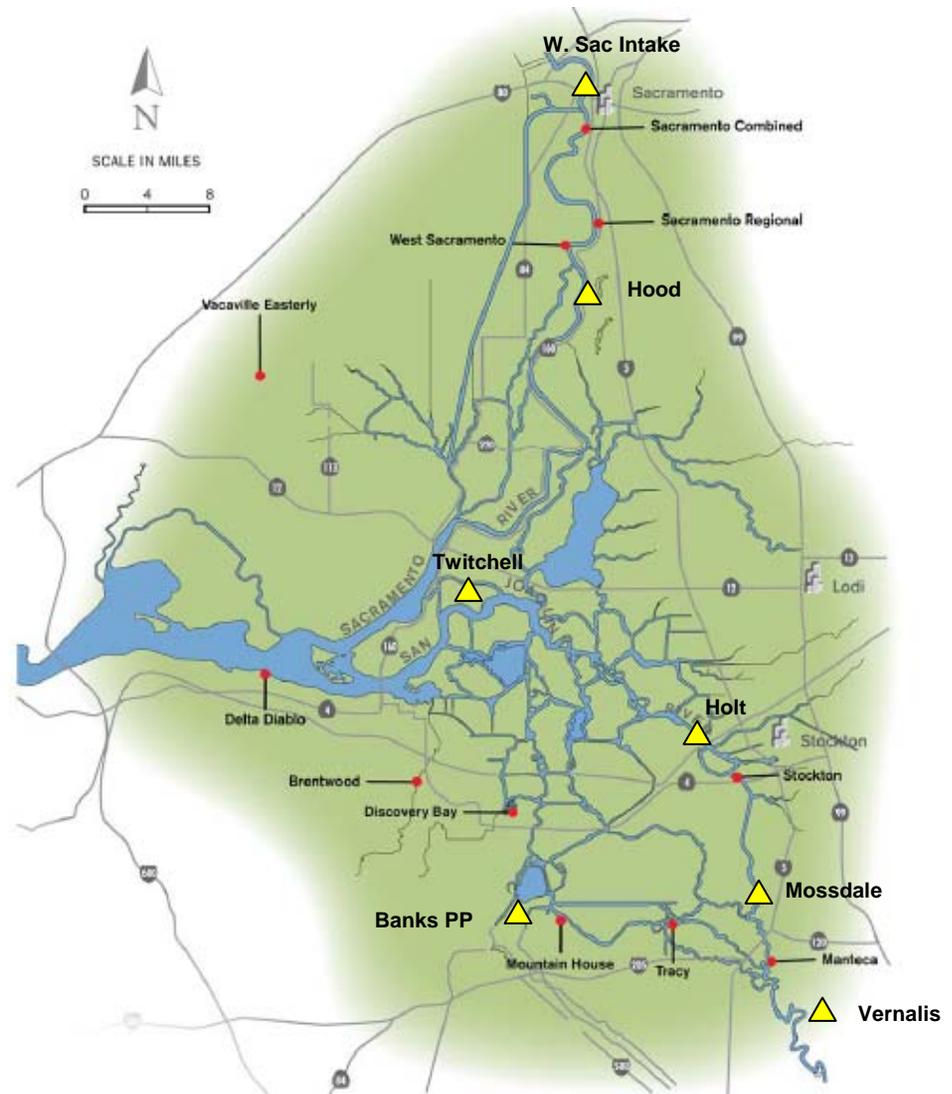
 - SJR at N. Holt Rd

- Agricultural Drain

 - Twitchell Island

- Other

 - Banks PP



▲ Sampling locations

Analytes

Instantaneous DBPs

Eight nitrosamines

DBP precursors

Formation potential (FP) tests
NDMAFP, THMFP, &
HAAFP. Note THMFP & HAAFP
for reference

Natural organic matter (NOM)

Dissolved organic carbon (DOC)

Ultraviolet absorbance (UVA)

Herbicide

Diuron

Analytes cont'd.--WWTP tracers

- 2 conservative tracers (anticonvulsants)
 - Carbamazepine
 - Primidone
- One biodegradable tracer (personal care product)
 - Caffeine

Selection of tracers based on EDC and PPCP work conducted by Carrie Guo of MWDSC

Results

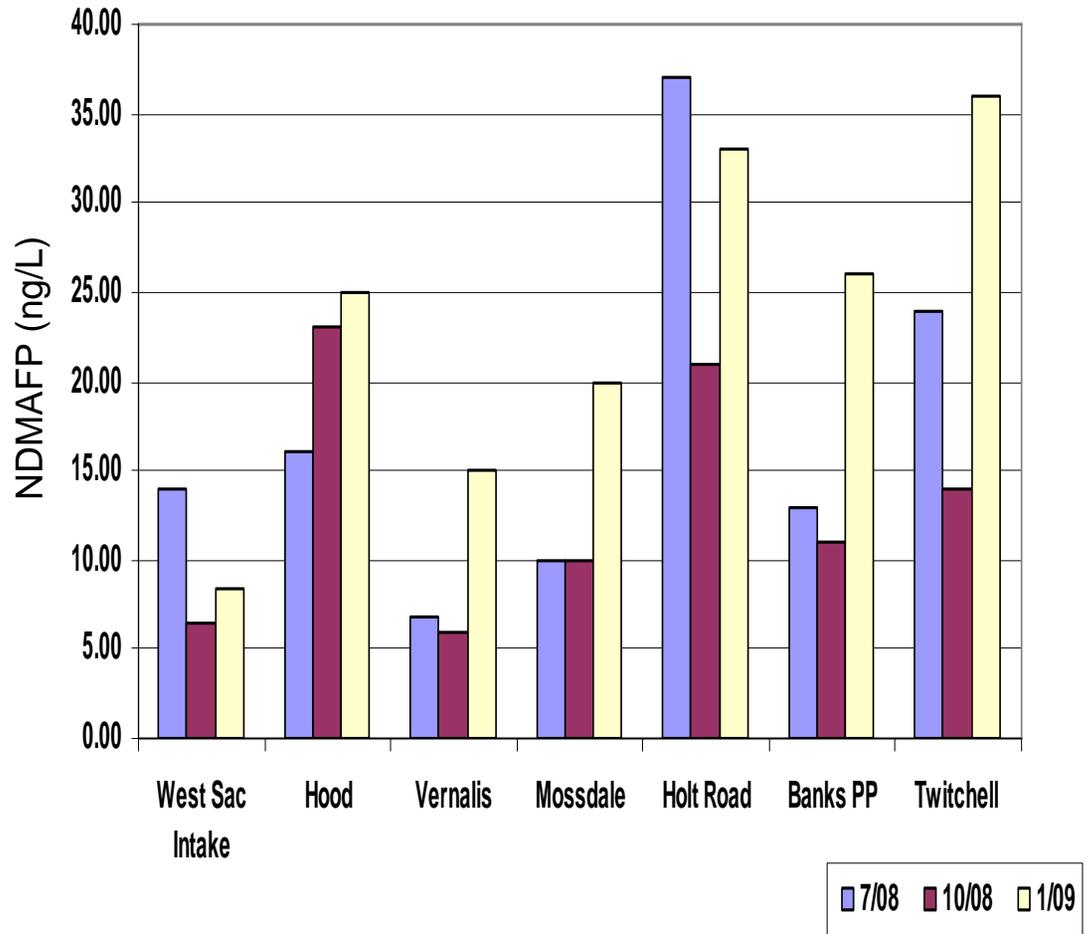
Concentrations

Highest NDMAFPs generally seen in January and d/stream of WWTPs

min= W. Sac intake = 6.5 ng/L
max = Holt Rd. = 37 ng/L

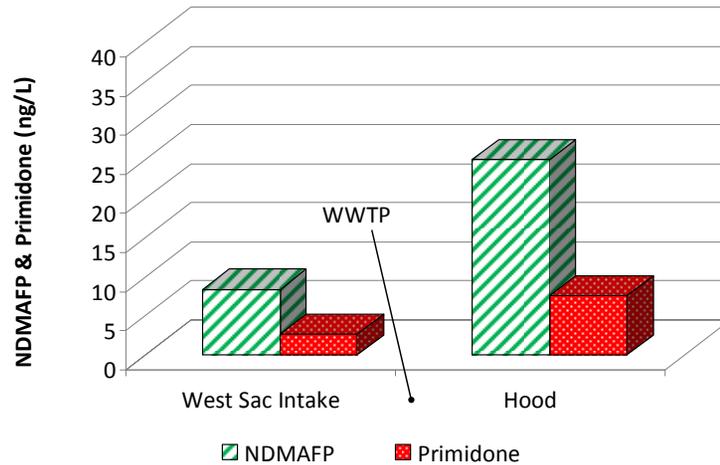
Little to no instantaneous nitrosamines found in river (data not shown).

Diuron observed in January sampling (range 0-145 ng/L)

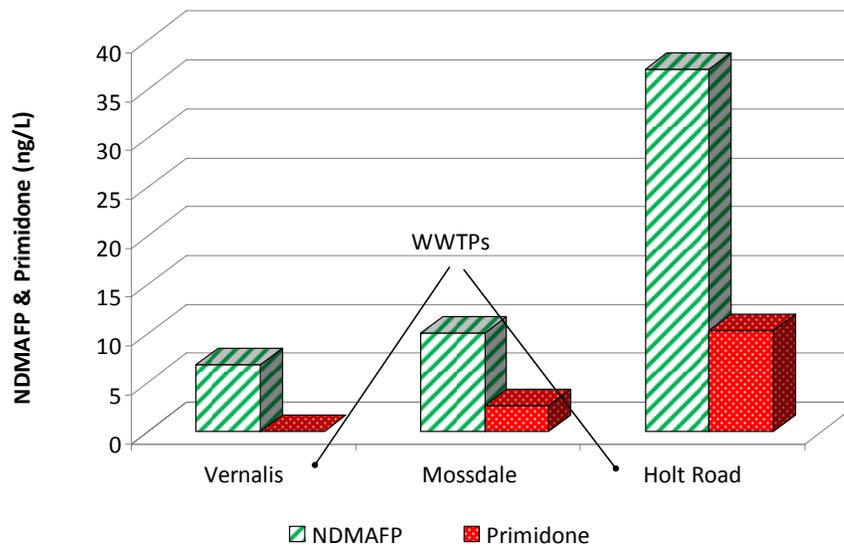


WWTP effects

Comparison of NDMAFP and Primidone Results
(Sac. R. - January 2009)

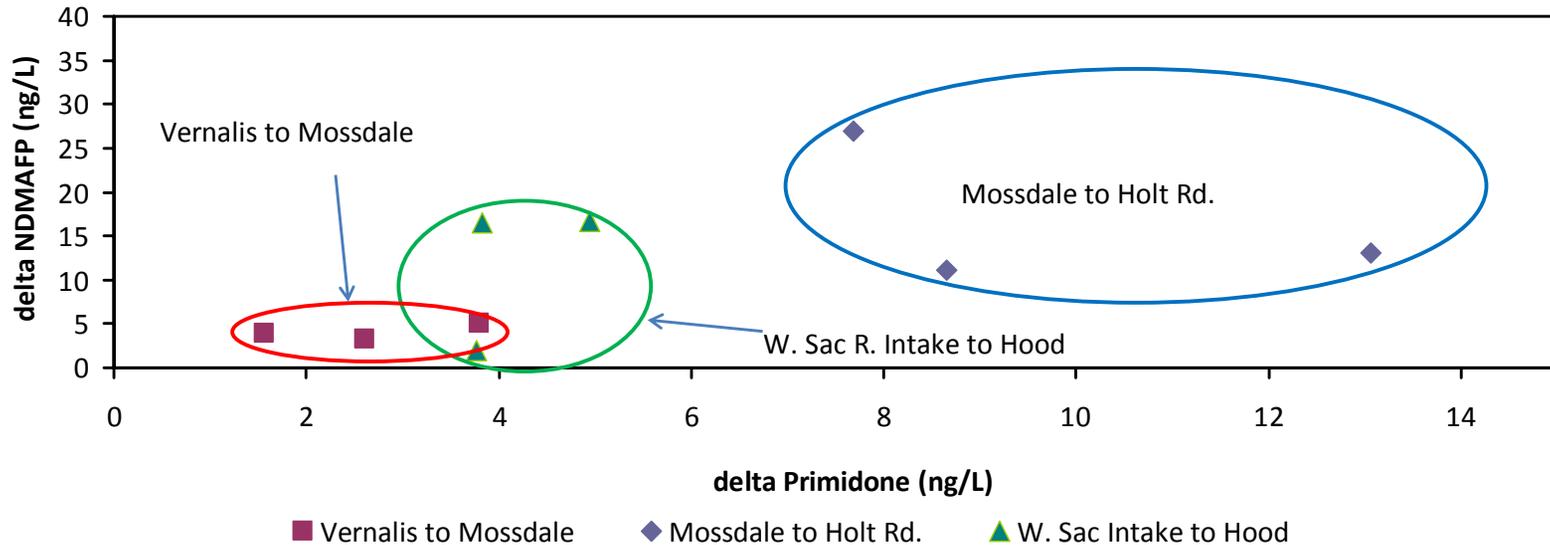


Comparison of NDMAFP and Primidone Results
(SJR - July 2008)

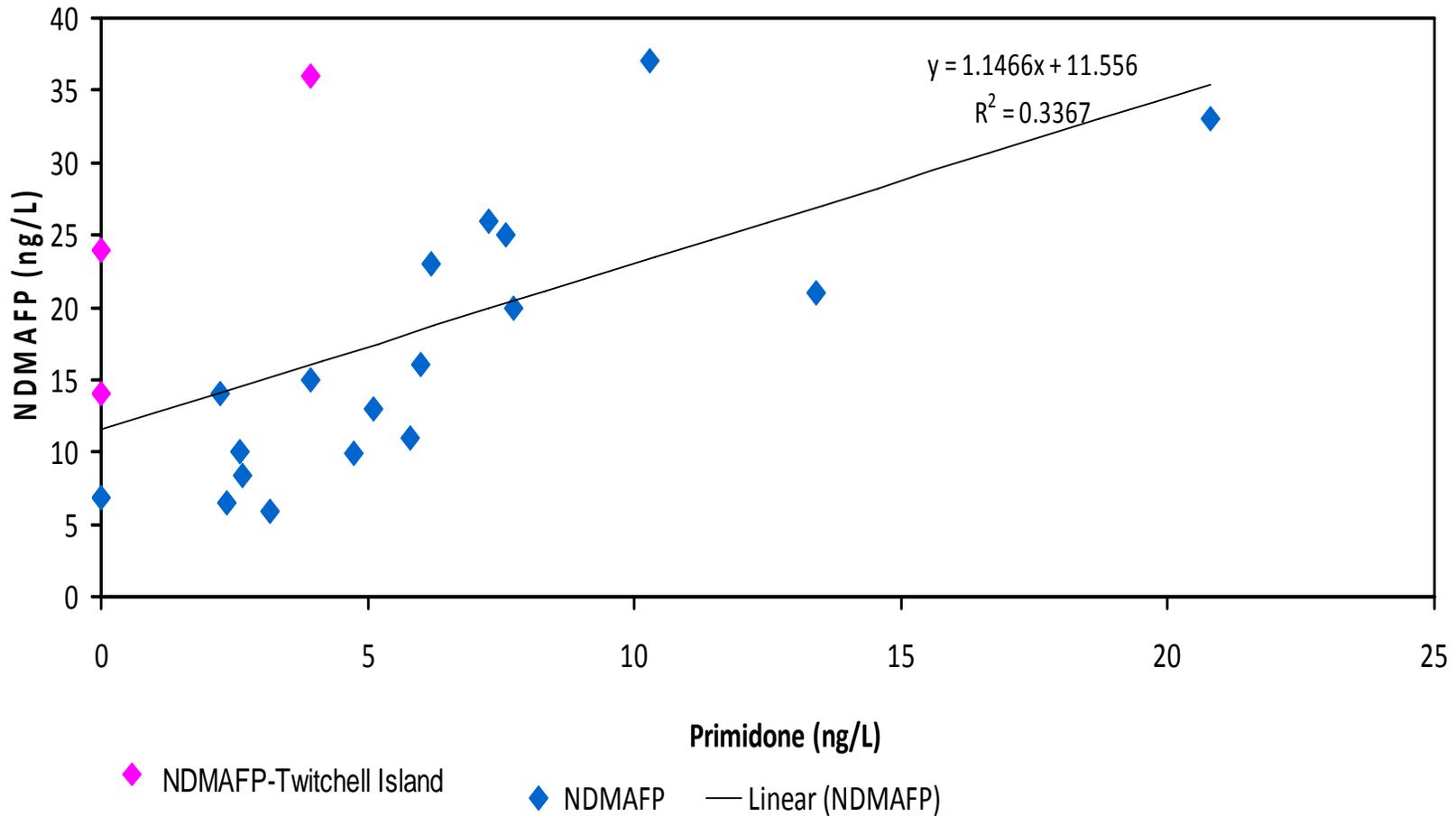


WWTP Effects by Location

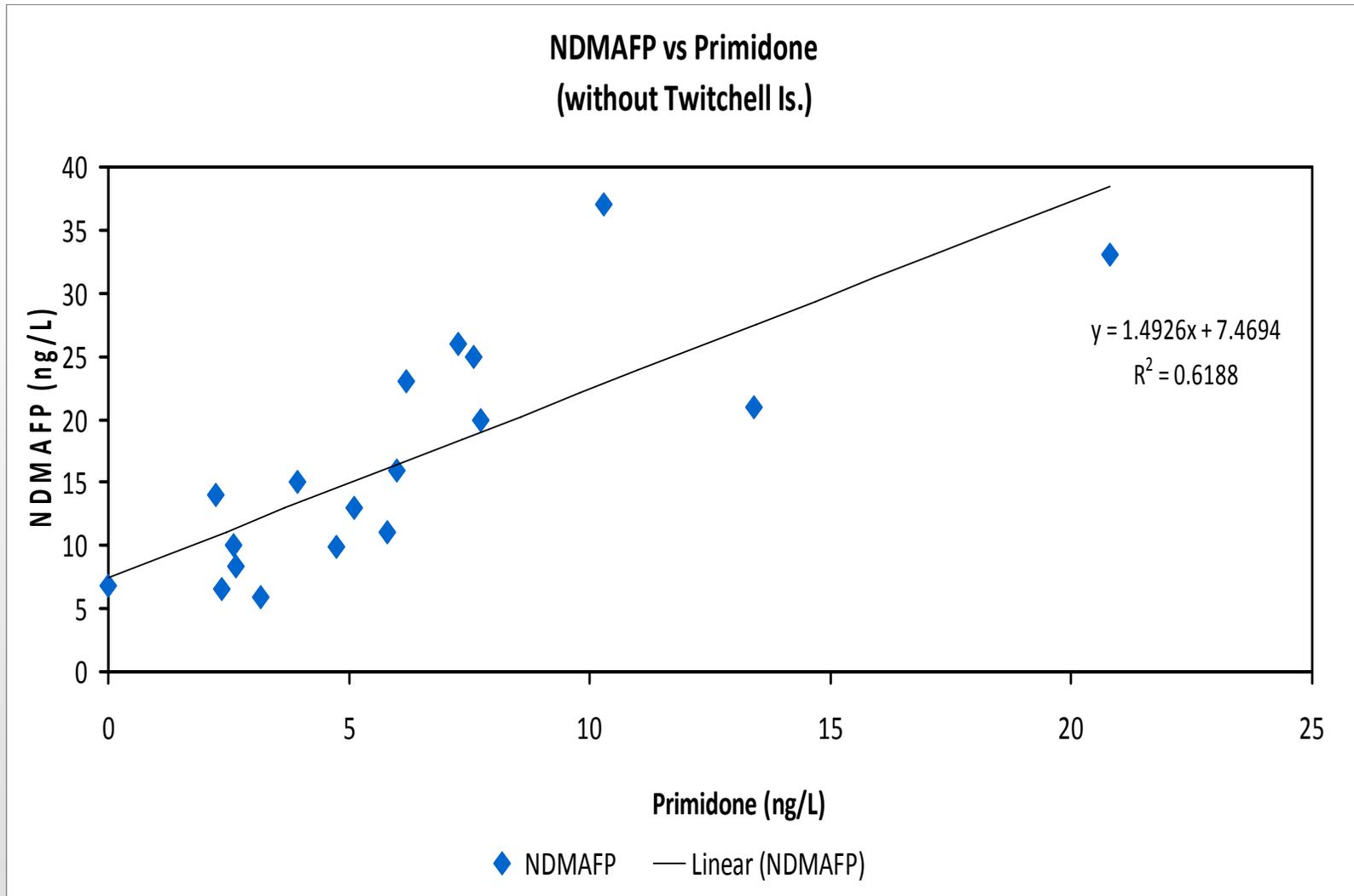
NDMAFP and Primidone



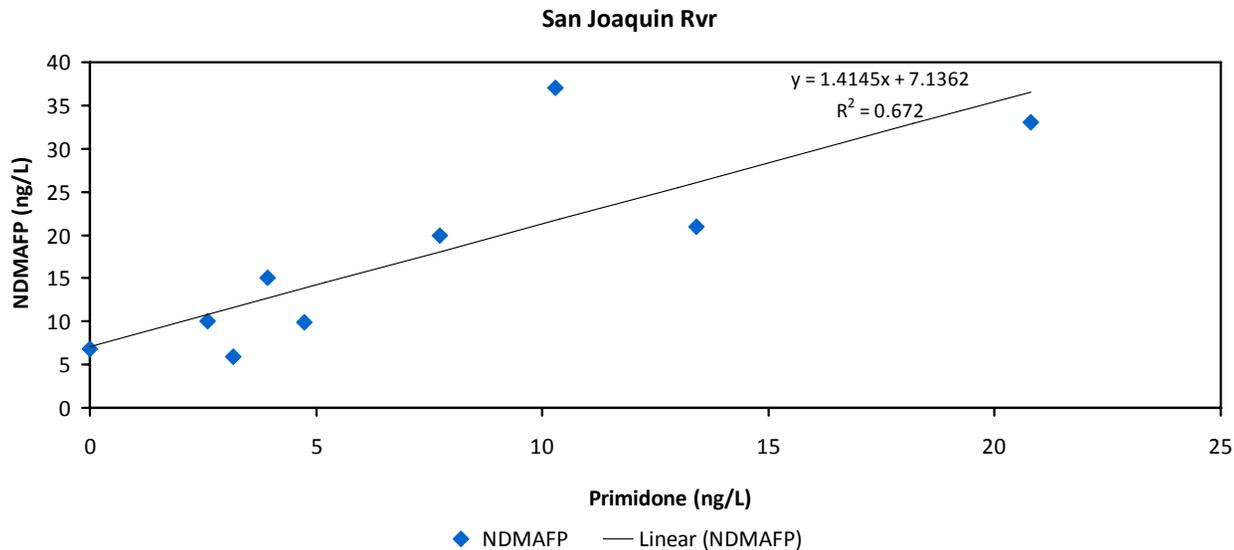
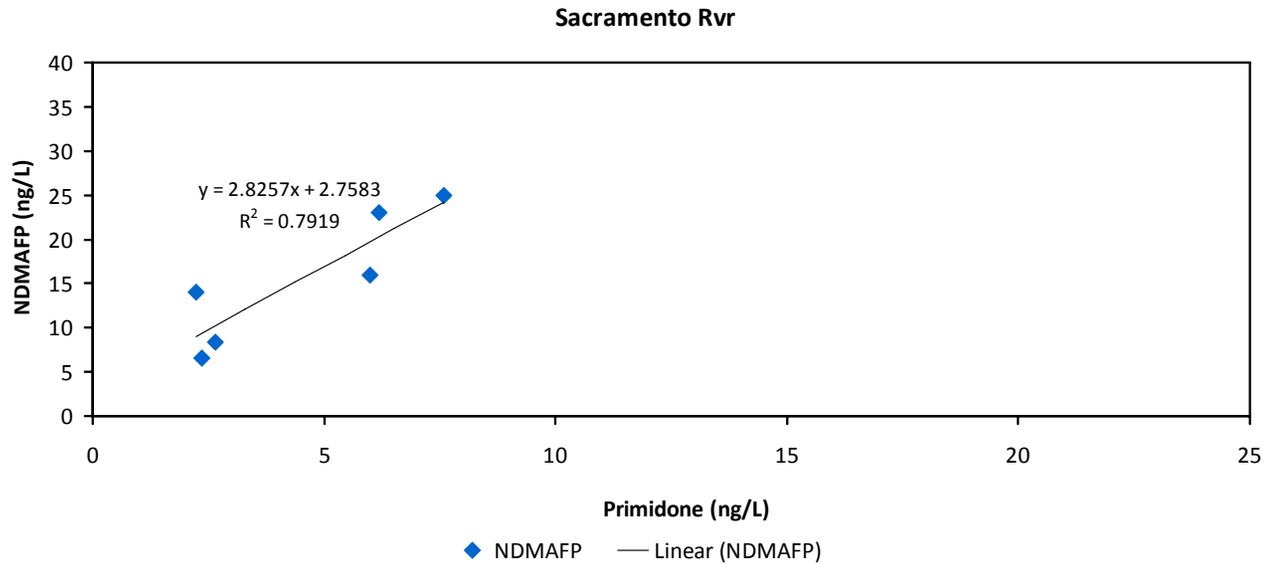
WWTP tracer vs. NDMA FP



WWTP tracer vs. NDMA FP

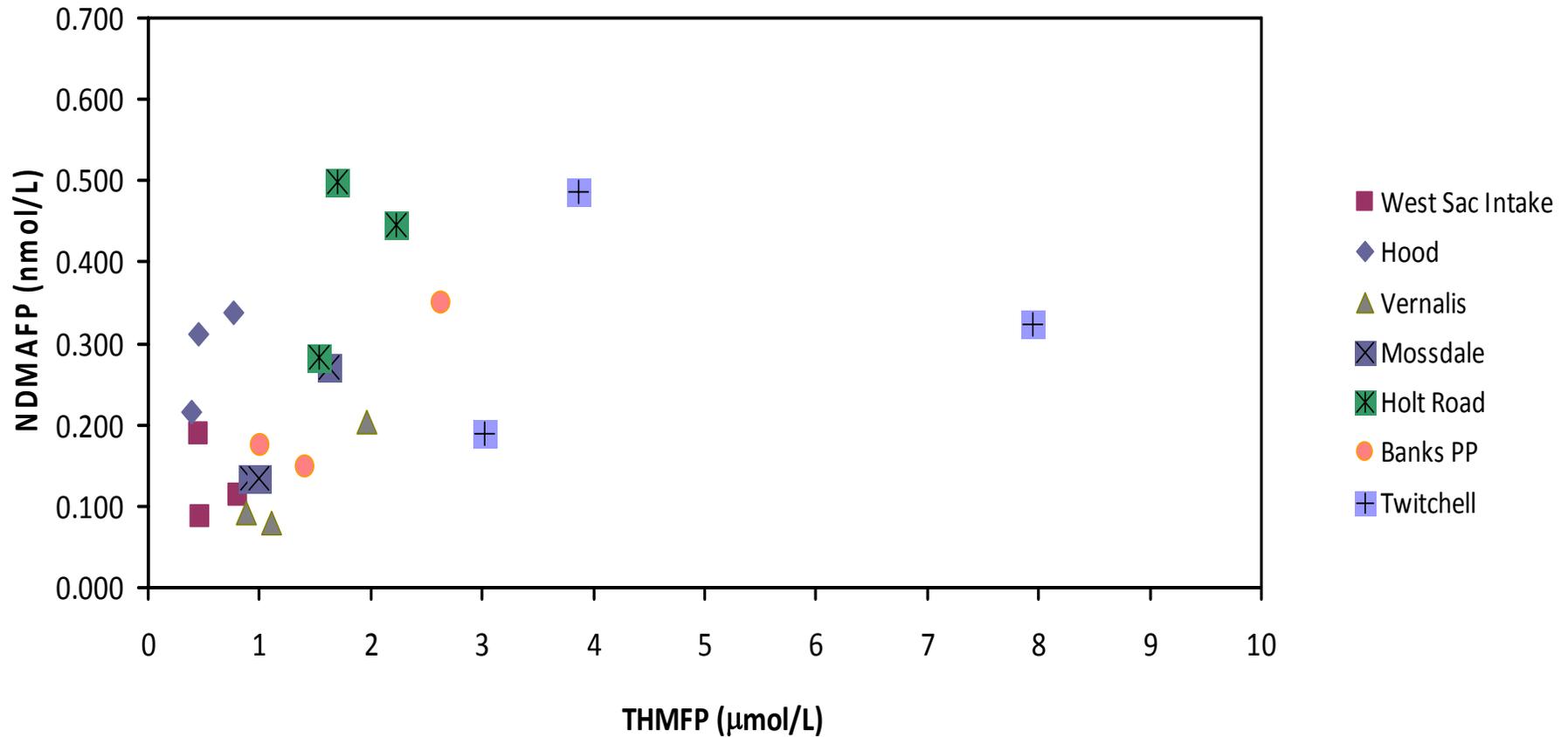


WWTP tracer vs. NDMAFP-by River



Relationship of NDMAFP to THMFP

(1st, 2nd & 3rd Qtrs)



Conclusions

- Locations downstream of WWTPs had highest levels of NDMA precursors. Actual nitrosamines in the rivers were low.
- Primidone fairly good tracer of WWTP effluent.
- THMs and HAAs formed from other sources than for NDMA. Highest levels of THMFPs not necessarily highest levels of NDMAFP
 - Humic substance in organic-rich soils from certain agricultural tracts of land.
- For these 3 sampling events, most NDMAFP being formed from WWTP effluent, not diuron.
- Control of each source (WWTP vs. ag) may require different solutions.

Acknowledgements

At MWQI:

Mark Bettencourt

Arin Conner

David Gonzalez

Sonia Miller

Steve San Julian

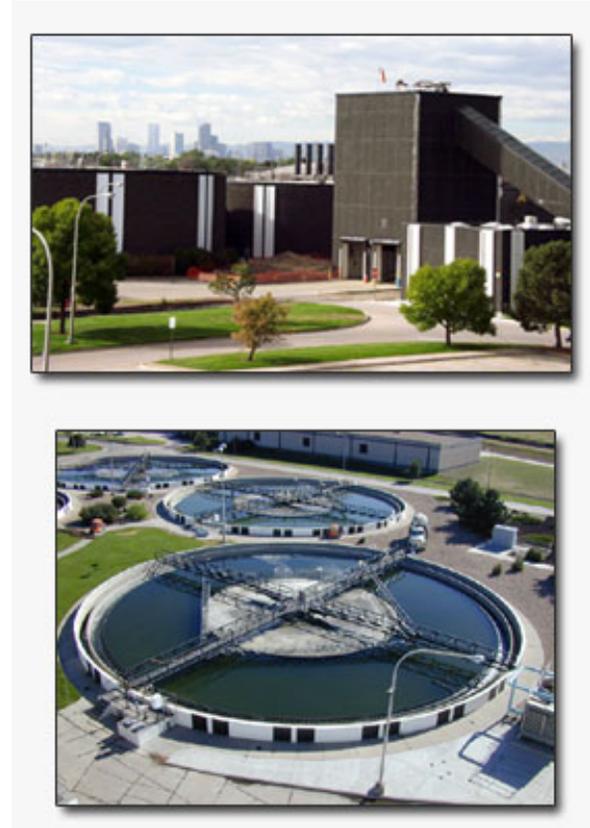
All the great staff at MWDSC and Stuart, Carrie, Melissa and Mike!

WWTPs in the Delta

Discharger	Average Flow (mgd)	Design Flow (mgd)	Level of Treatment
<i>Delta</i>			
Sacramento	157	207	Secondary
Stockton	34	55	Secondary / Tertiary
Vacaville	8	15	Secondary
Tracy	7.1	9	Secondary / Tertiary by 2008
Manteca/Lathrop	5.7	7.0	Secondary / Tertiary by 2007
West Sacramento	5.1	7.5	Secondary / To SRWTP by 2007
Brentwood	2.2	4.5	Tertiary
Discovery Bay	1.1	2.1	Tertiary
Mountain House	0.3	3.0	Tertiary
Total Delta	220	310	

Level of Nitrification is Key

- Depending on operational conditions WWTPs can achieve partial or complete nitrification.
- In terms of NDMA precursors, the higher the level of treatment the better---i.e., increased levels of nitrification decreases the concentrations of ammonia and organic nitrogen (amino compounds).



Relationship of Diuron to NDMAFP

