Measurement of air Hg speciation and estimation of the potential for dry Hg deposition Antelope Island State Park

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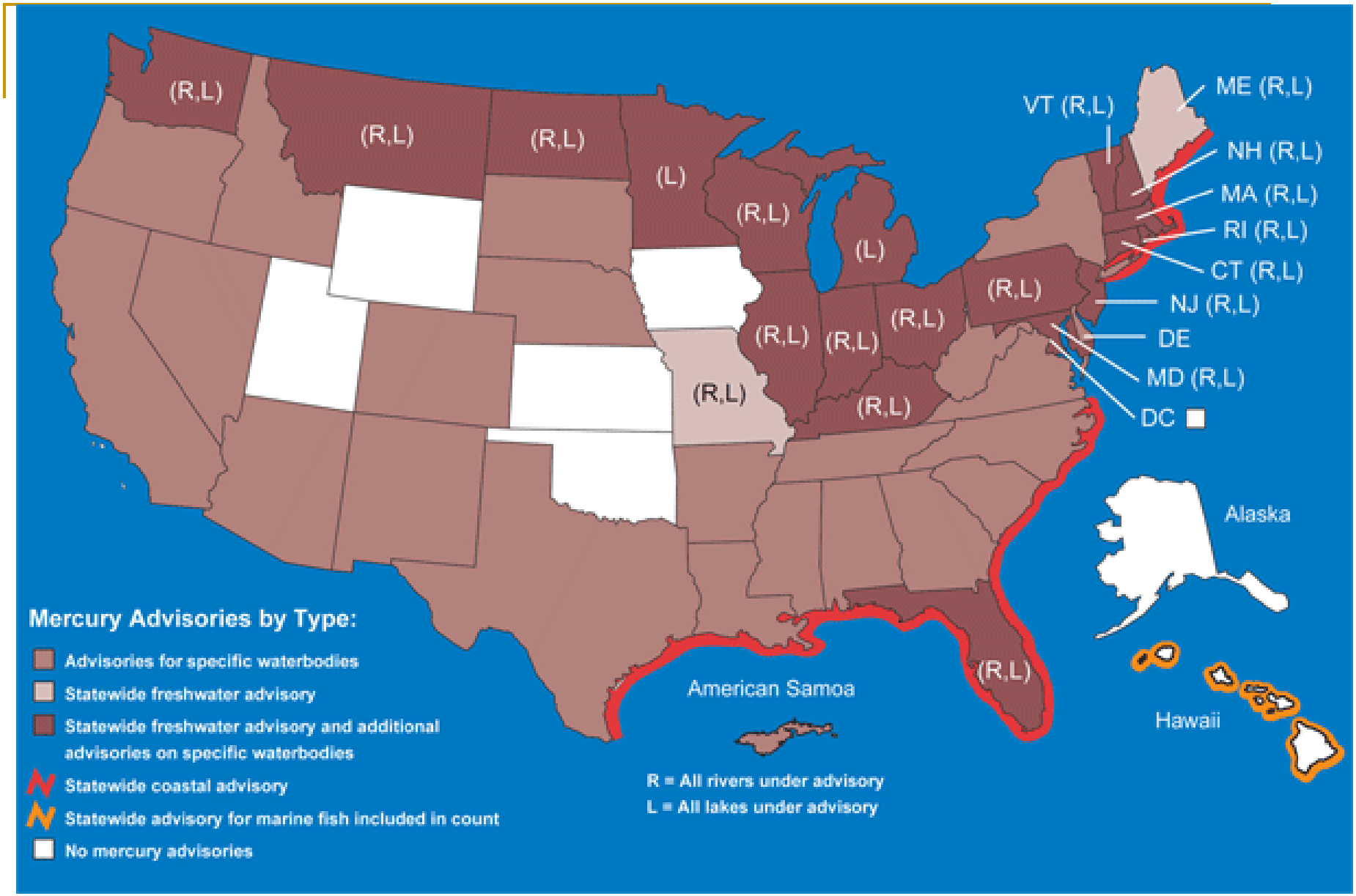
University of Nevada, Reno
Statewide • Worldwide

Acknowledgements

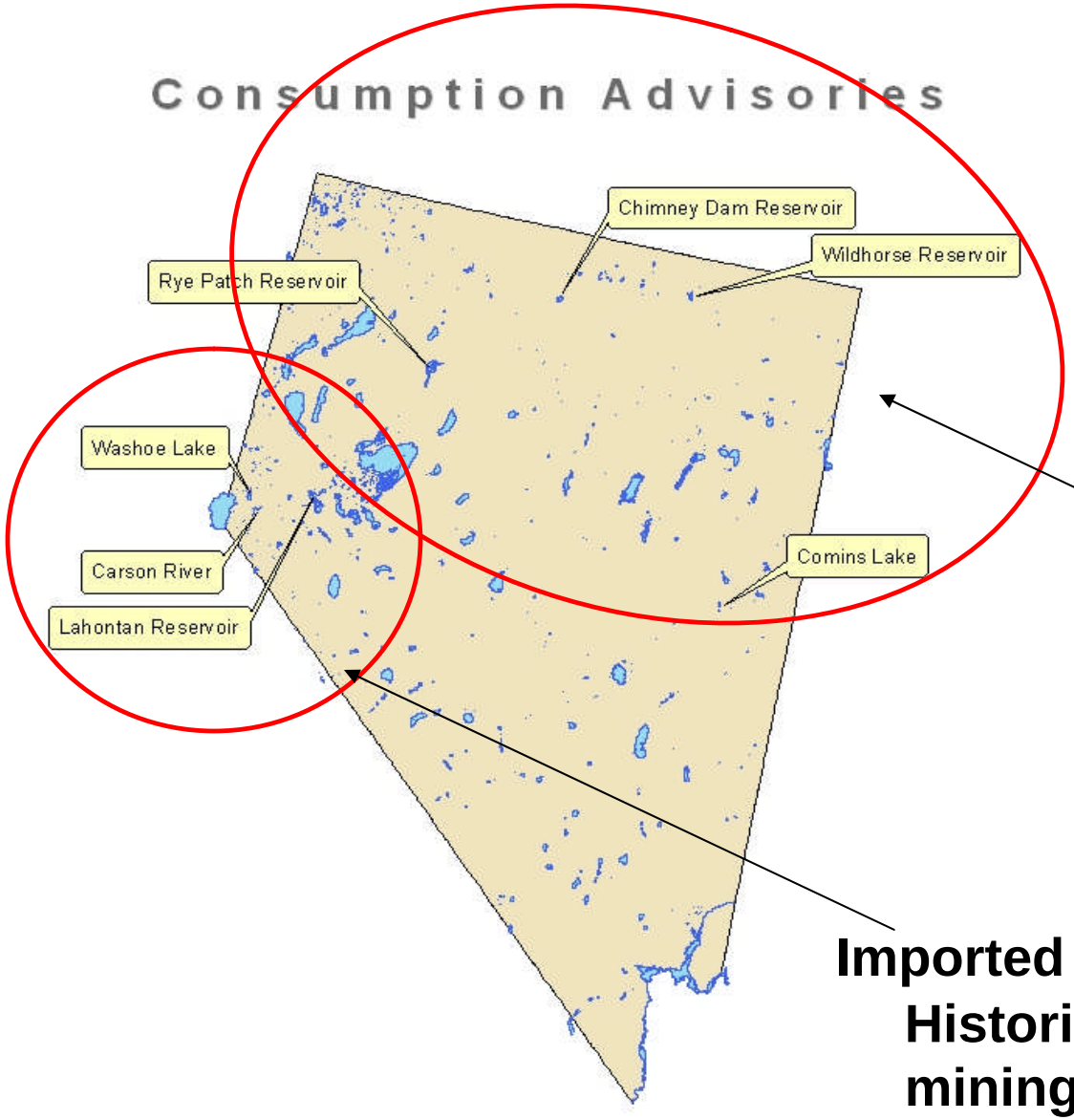
EPRI/EPA STAR

Antelope Island State Park *especially* Chris Haller, Ron Taylor Chris Haramoto



Source EPA webpage
2004

Fish consumption advisories NV



Terrestrial sources?

Atmospheric deposition?

Reservoir management?

Imported Hg
Historic mining

Bird consumption advisory

Terrestrial sources?

Atmospheric sources?

Evapoconcentration?

Research questions

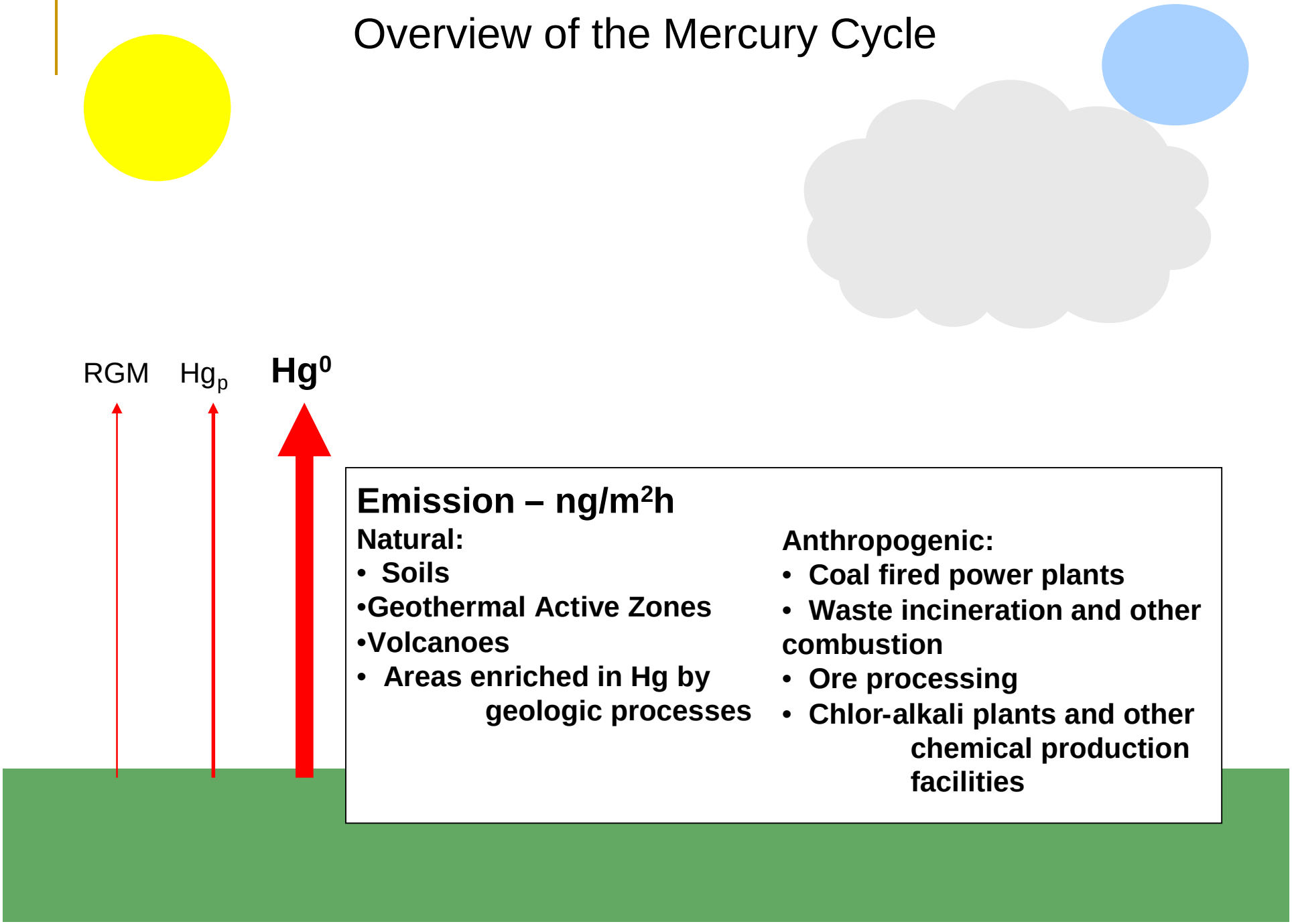
- What are the Hg concentrations in air at GSL?
  - Are there correlations with environmental parameters?
  - Are there high concentrations or specific sources?
- Are saline lakes a natural sink for atmospheric Hg?
  - Does atmospheric chemistry associated with saline systems facilitate their behavior as a sink?
  - Could dry deposition to the lake be the source of the bird contamination advisory?

Atmospheric Mercury

Relative amounts in air *:

- Elemental Hg- **Hg^0 – 90 to 99%**
- Reactive Hg- **RGM – 0 to 10%**
- Particulate Hg **Hg_p – 1 to 5%**

Overview of the Mercury Cycle



Emission – ng/m²h

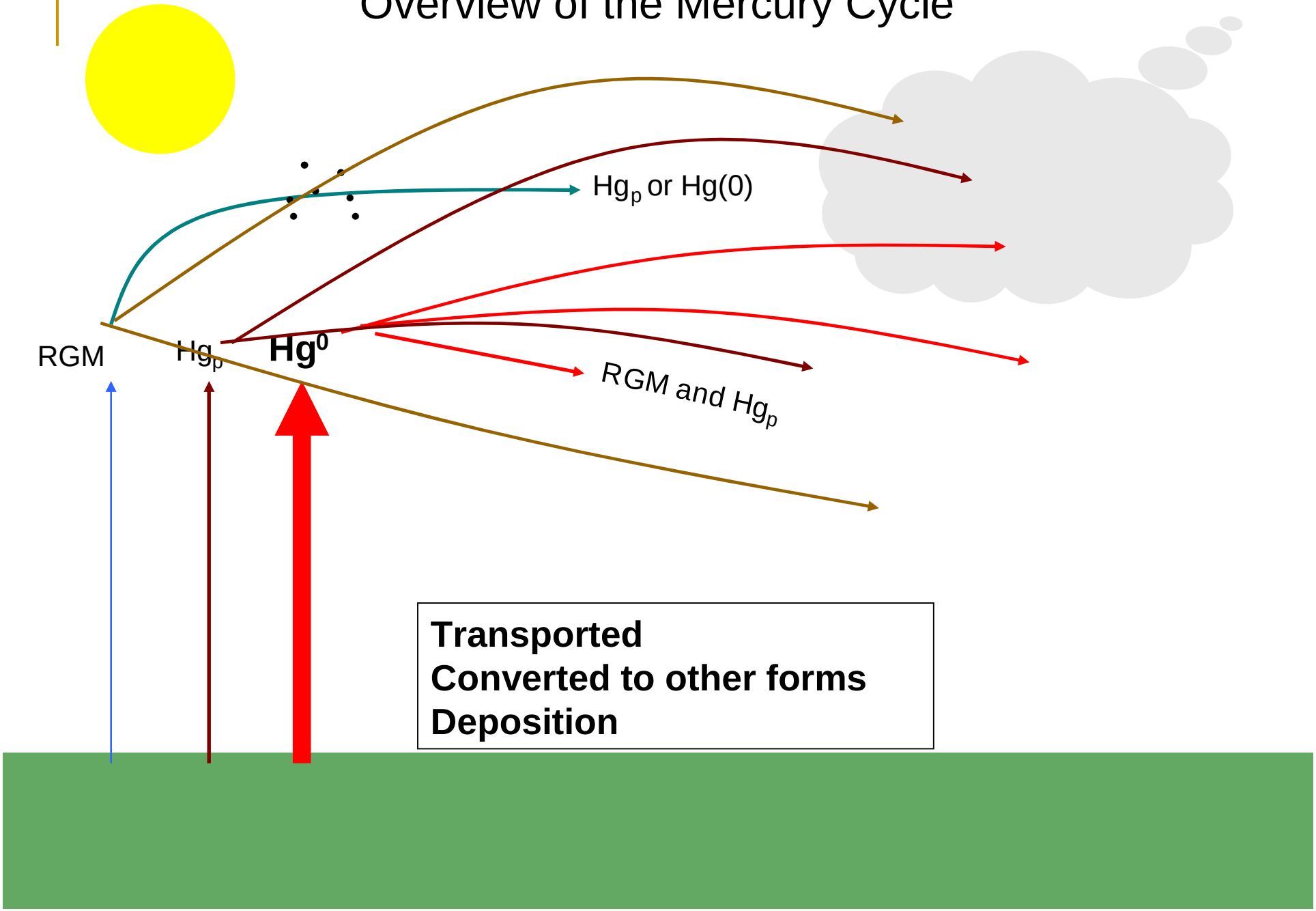
Natural:

- **Soils**
- **Geothermal Active Zones**
- **Volcanoes**
- **Areas enriched in Hg by geologic processes**

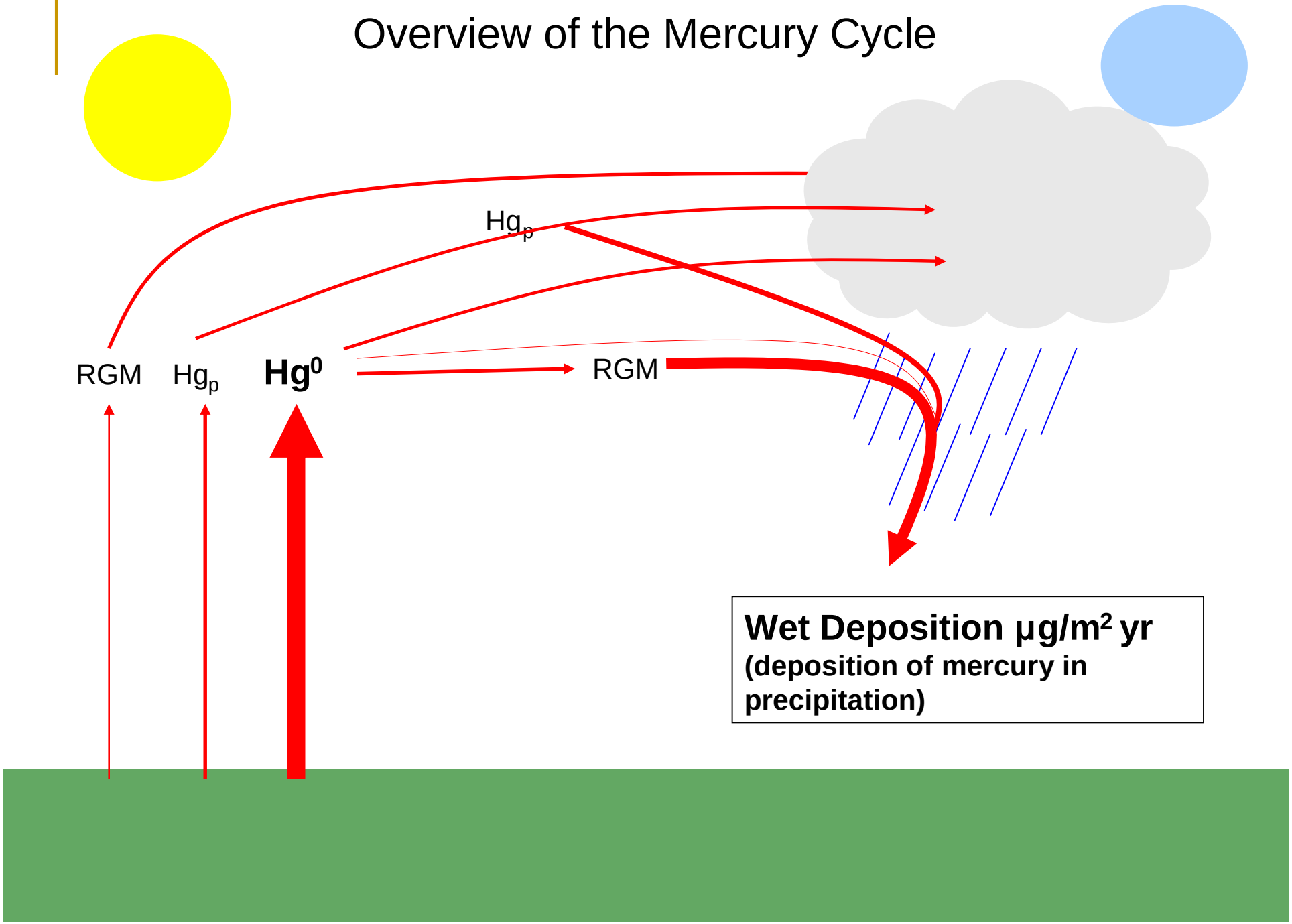
Anthropogenic:

- **Coal fired power plants**
- **Waste incineration and other combustion**
- **Ore processing**
- **Chlor-alkali plants and other chemical production facilities**

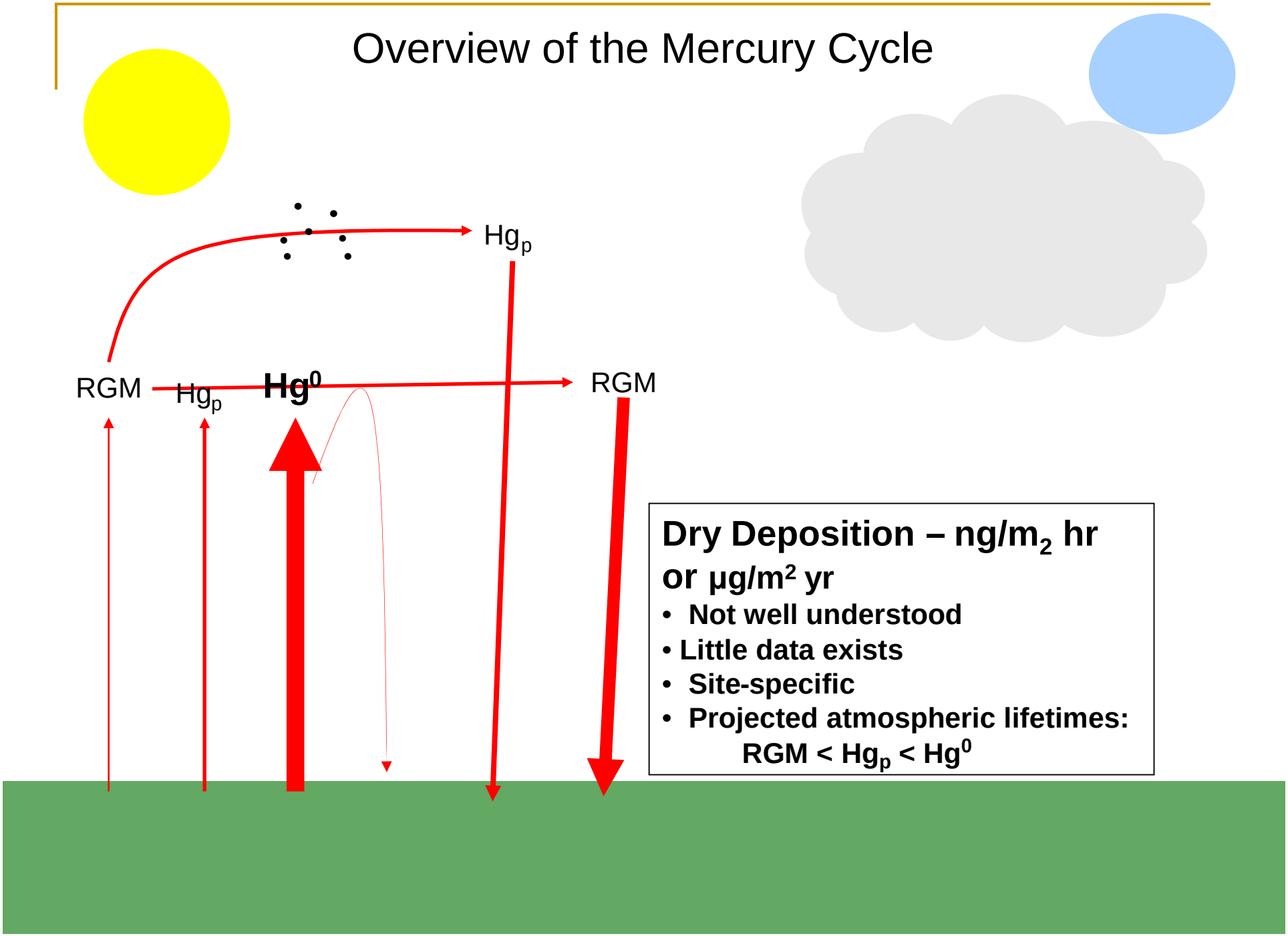
Overview of the Mercury Cycle



Overview of the Mercury Cycle



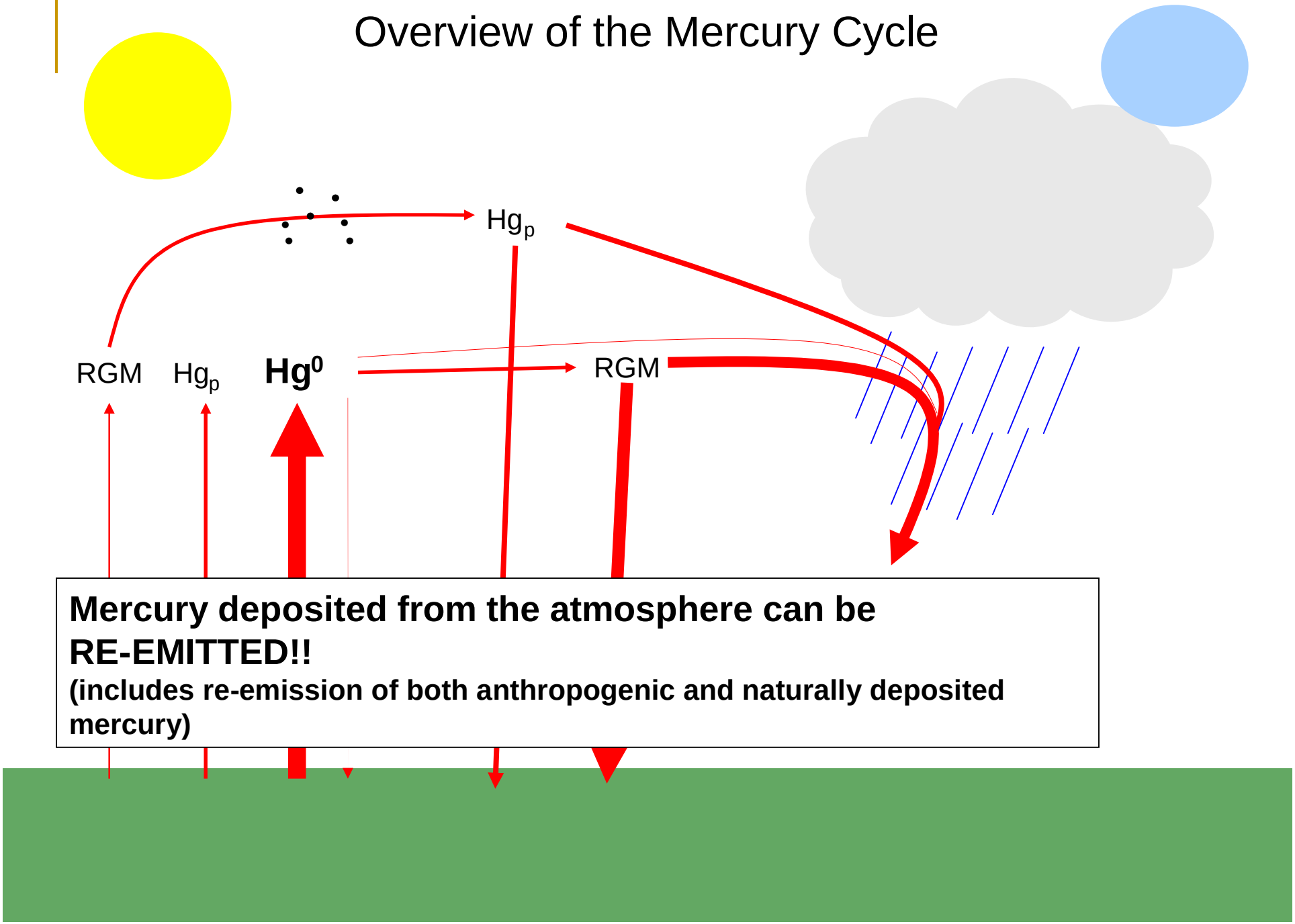
Overview of the Mercury Cycle



Dry Deposition – ng/m_2 hr or µg/m^2 yr

- **Not well understood**
- **Little data exists**
- **Site-specific**
- **Projected atmospheric lifetimes:**
  RGM < Hg_p < Hg^0

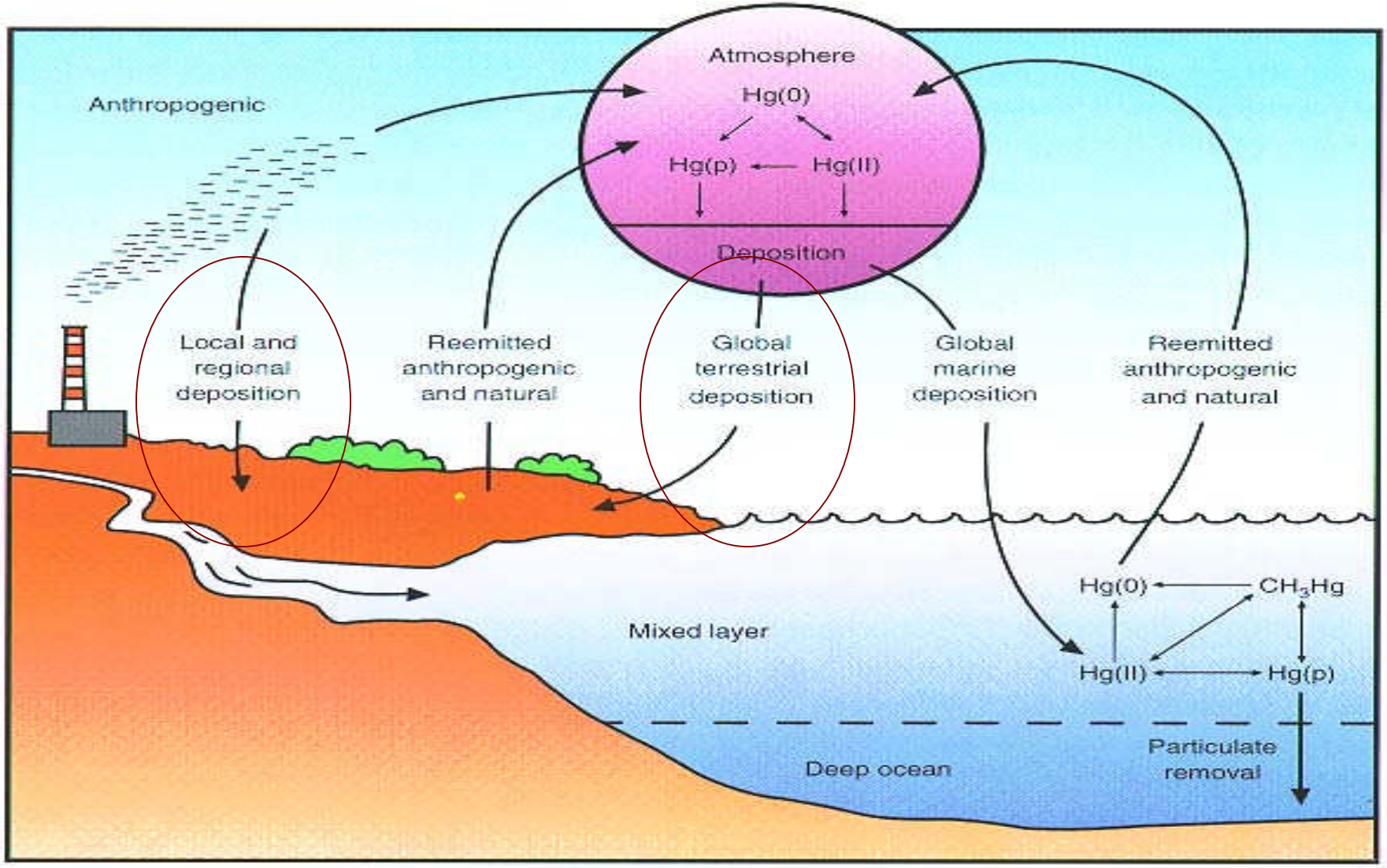
Overview of the Mercury Cycle



Mercury deposited from the atmosphere can be RE-EMITTED!!

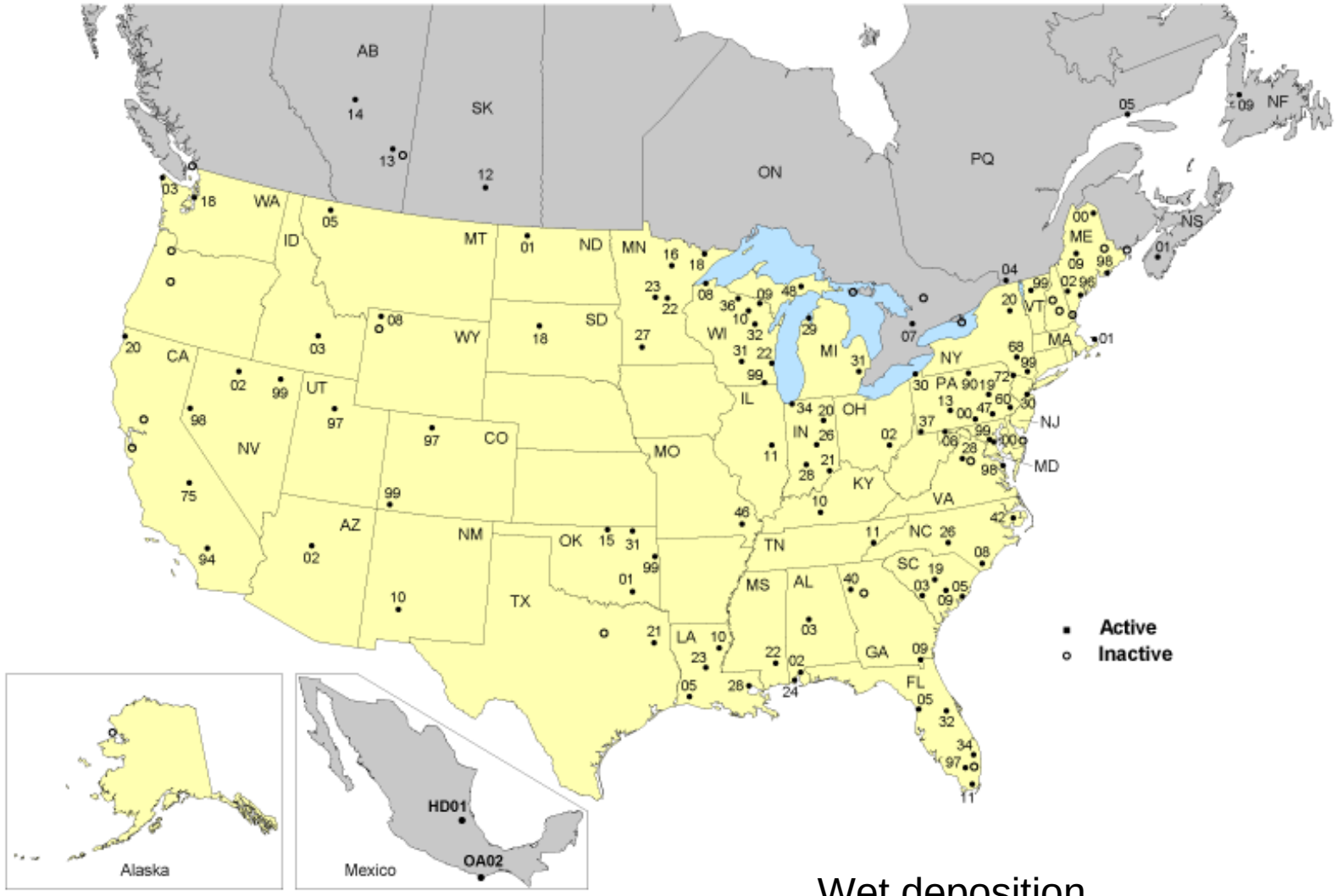
(includes re-emission of both anthropogenic and naturally deposited mercury)

Mercury Deposition is a Nationwide Issue

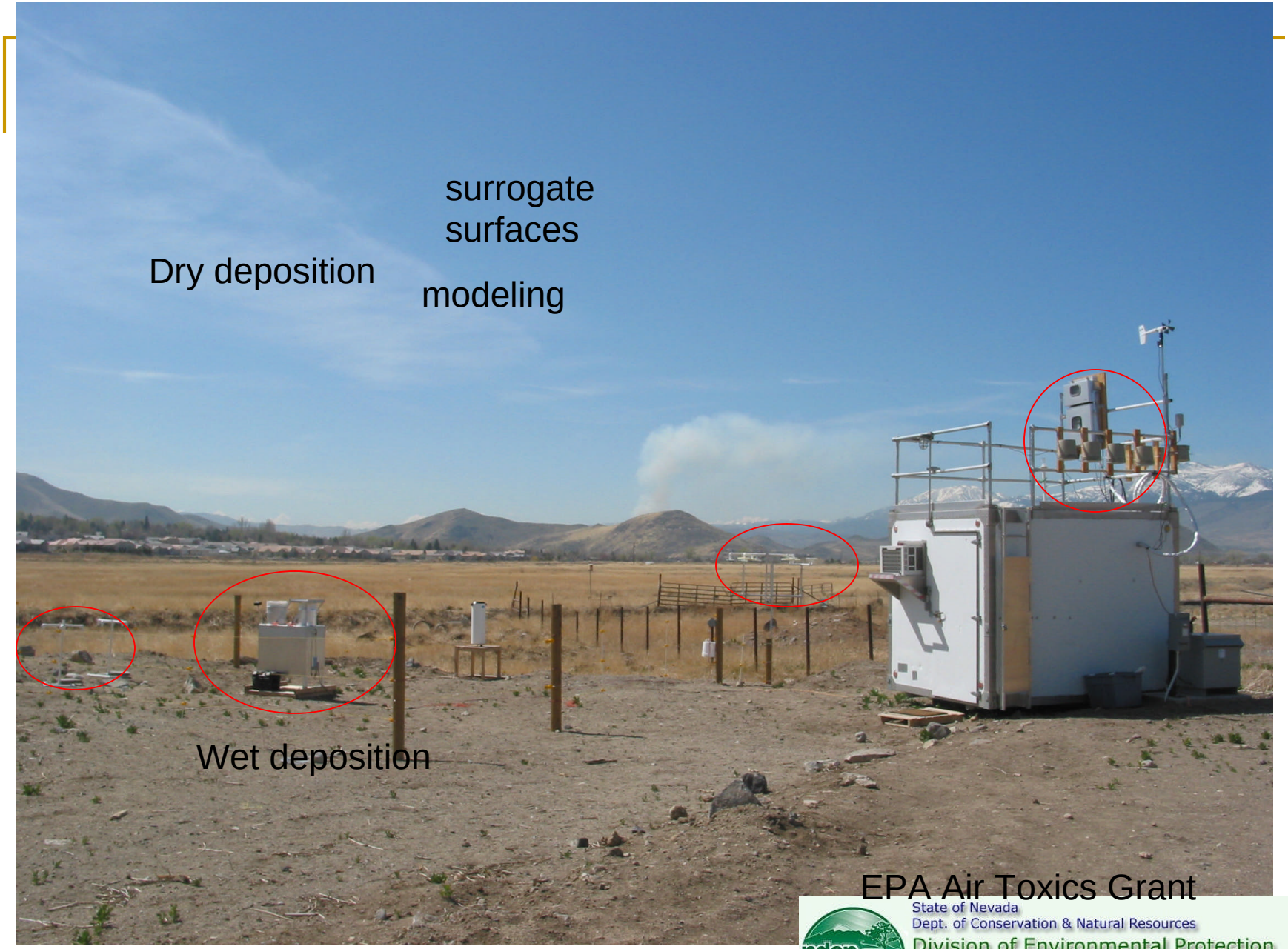


- Polar areas- Hg depletion events
- Oceans and seas?
  - Due to reactions with halogens in MBL
- What about saline water bodies?

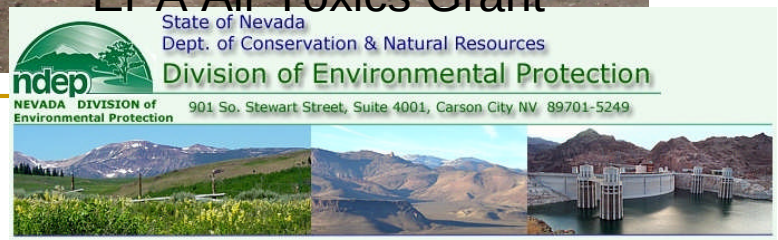
National Atmospheric Deposition Program
Mercury Deposition Network



Wet deposition



EPA Air Toxics Grant



MDN NV 98 –University Farms, Reno

Antelope Island State Park, Utah

Images courtesy of:

http://www.ugs.state.ut.us/surveynotes/geosights/spiraljetty.htm

Google Earth

Sampling sites

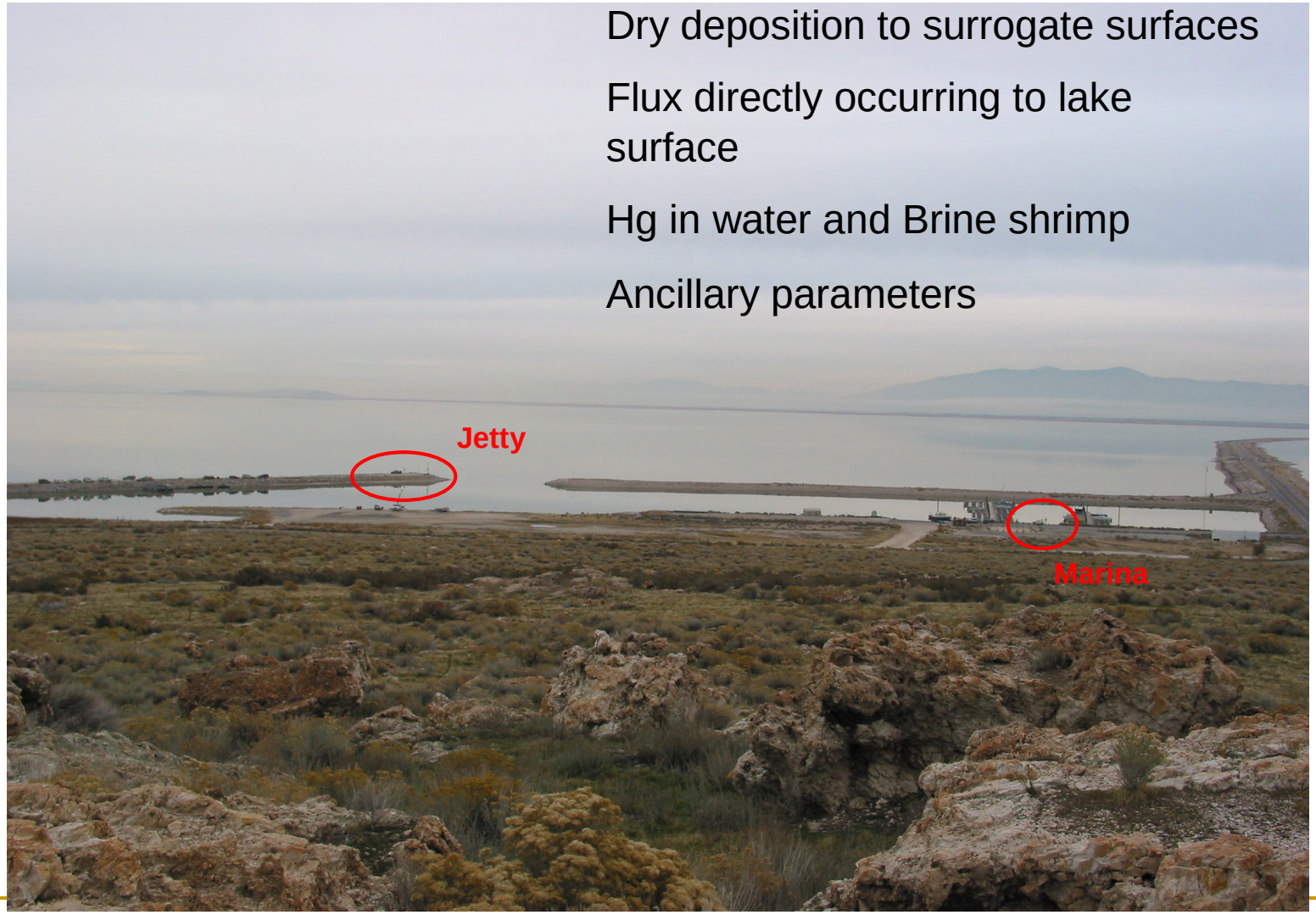
Air Hg speciation using two Tekran systems

Dry deposition to surrogate surfaces

Flux directly occurring to lake surface

Hg in water and Brine shrimp

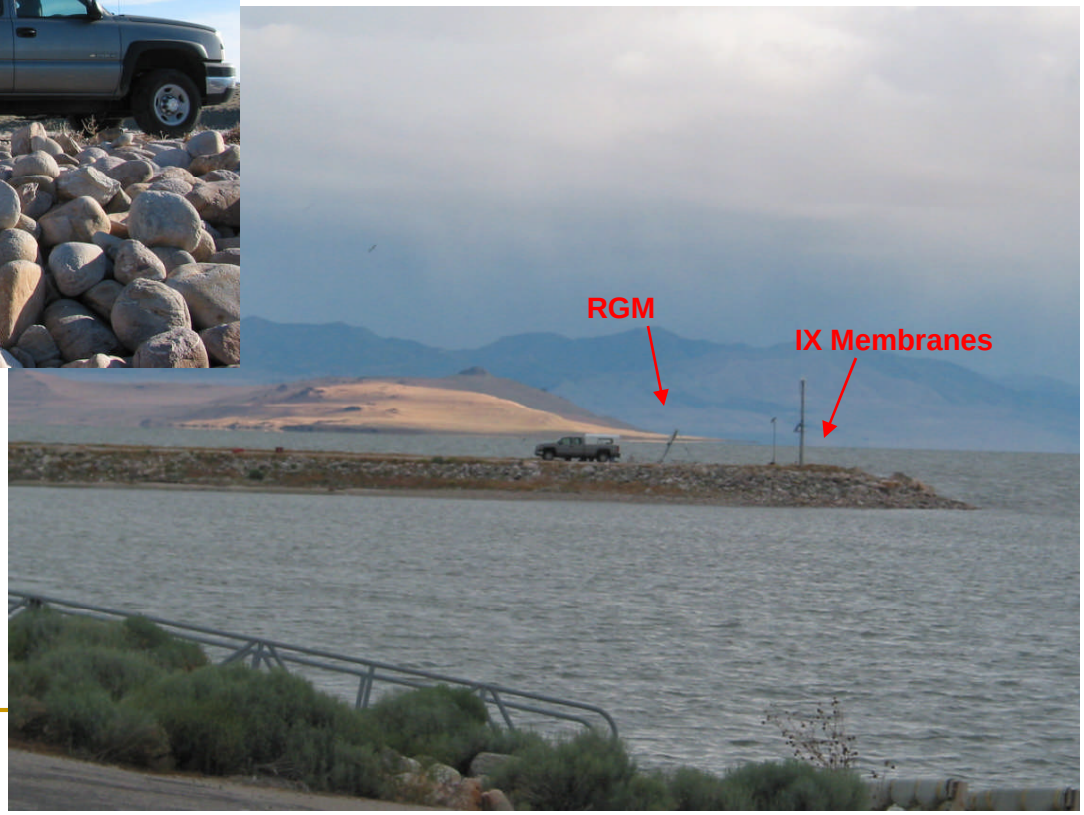
Ancillary parameters



Air sample Collection Summary

Month		Jetty (start)	Jetty (end)	Marina	Visitors Center
June 2006					
	RGM & Hg0	X	X		
	Met & O3	X	X (met only)		
	IX Membranes	X	X		
August 2006					
	RGM & Hg0		X	X	
	Met & O3			X	
	IX Membranes		X	X	
November 2006					
	RGM & Hg0		X	X	
	Met & O3			X	
	IX Membranes		X	X	X
January 2007					
	RGM & Hg0		X	X	
	Met & O3			X	
	IX Membranes		X	X	X
May 2007					
	RGM & Hg0		X	X	
	Met & O3			X	
	IX Membranes		X	X	X

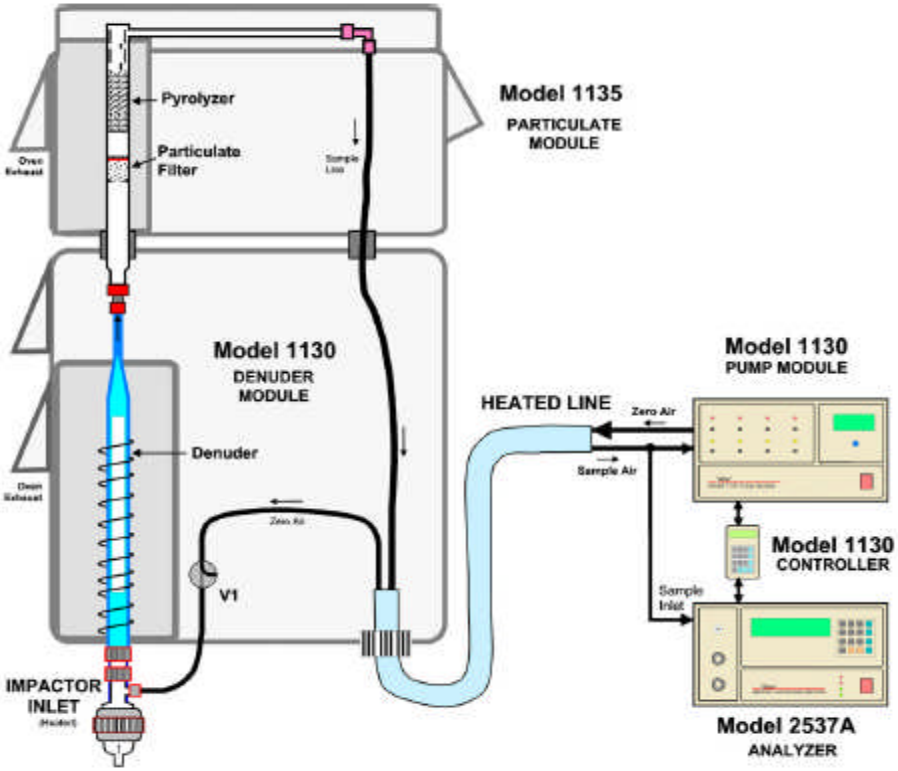
Jetty Sampling Site



Marina Sampling Site

RGM Sampling

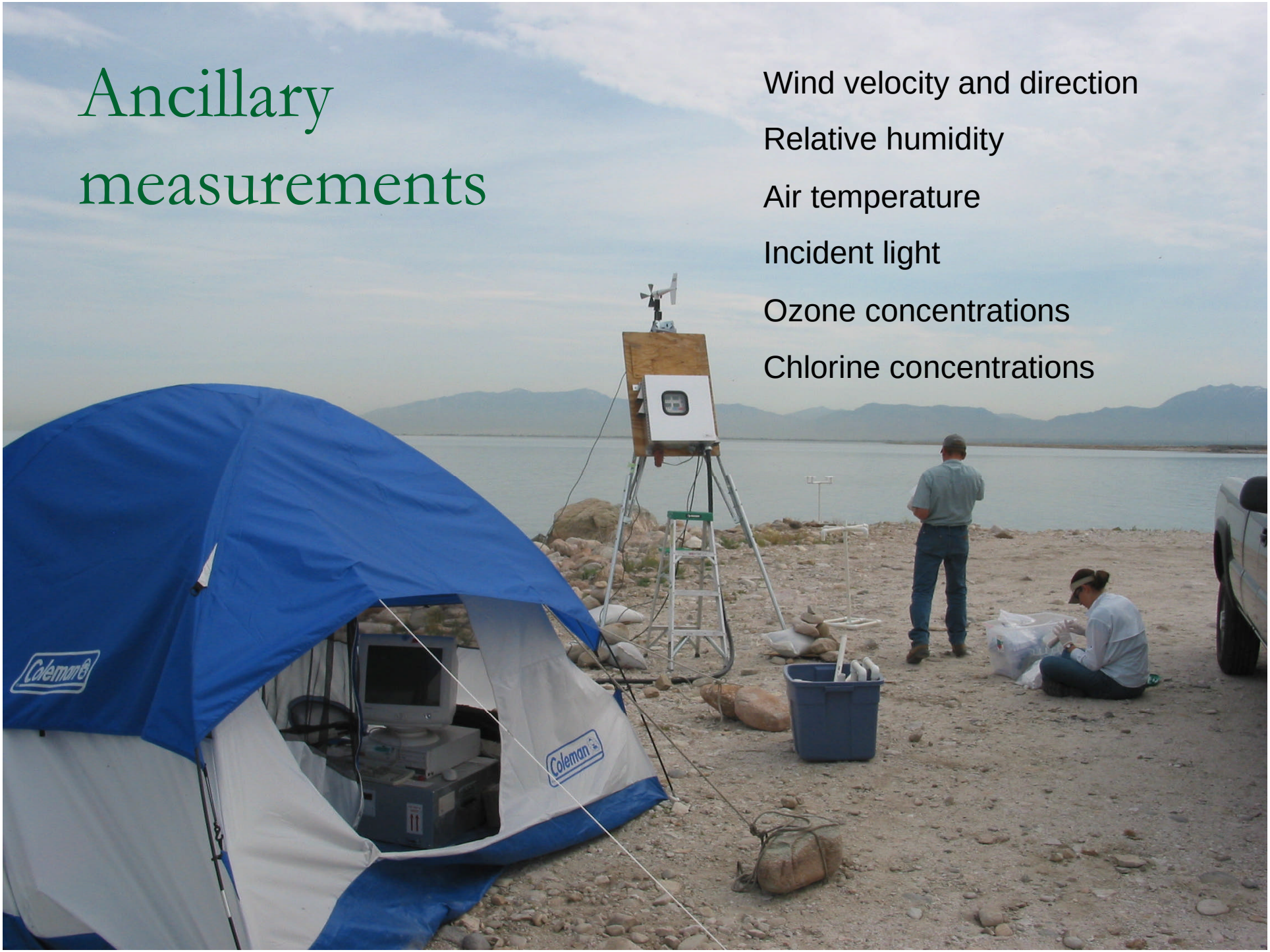
Measuring air concentrations



Tekran 2537A-1130-1135 system

Ancillary measurements

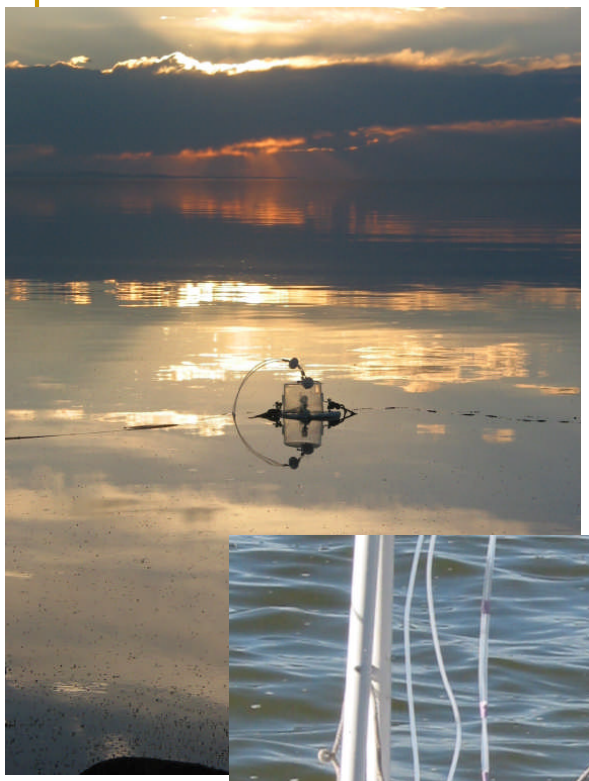
- Wind velocity and direction
- Relative humidity
- Air temperature
- Incident light
- Ozone concentrations
- Chlorine concentrations



Surrogate surfaces

Lyman et al. 2007

Water Flux



Water Flux (Total Gaseous Mercury).
Collected on calm days.
Flux collected on 20 minute cycle.

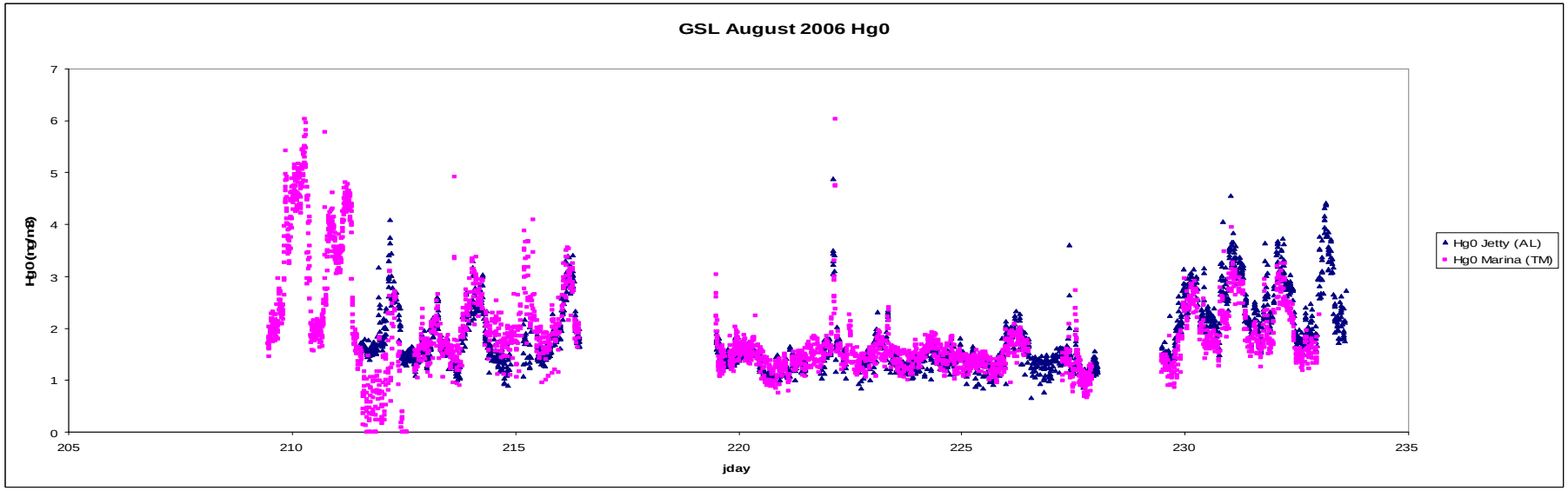
Water and Brine Shrimp Collection

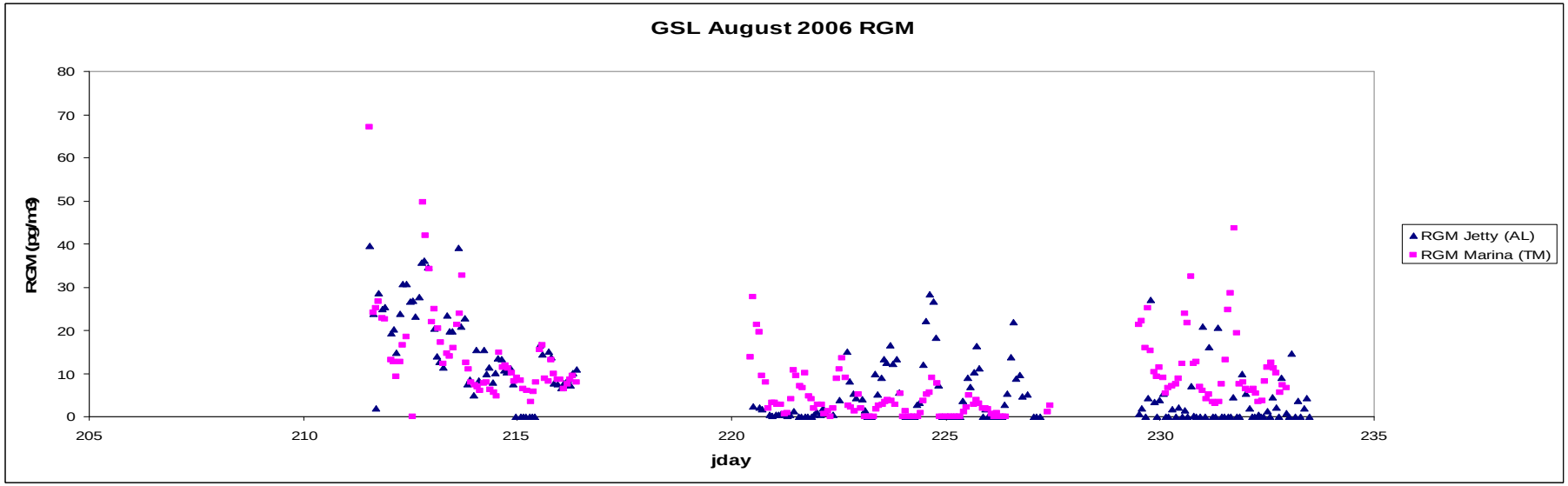
Water and Brine Shrimp Sampling Locations

Month		Jetty	Bridger Bay	Salt Lake
June 2006	Water	X	X	X
	Brine Shrimp		X	
August 2006	Water	X		X
	Brine Shrimp			X
November 2006	Water	X		X
	Brine Shrimp			X
January 2007	Water	X		X
	Brine Shrimp			X
May 2007	Water	X		X
	Brine Shrimp			X

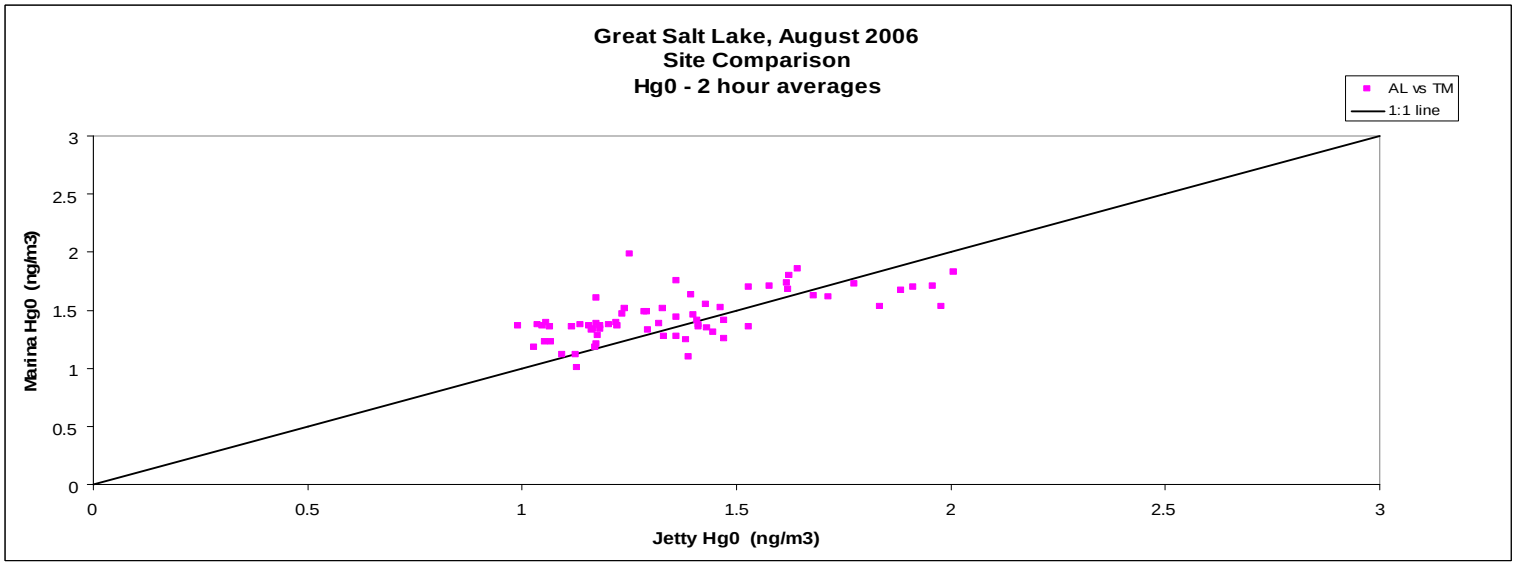
Salt Lake location: 41°07.382 N, 112°23.234W

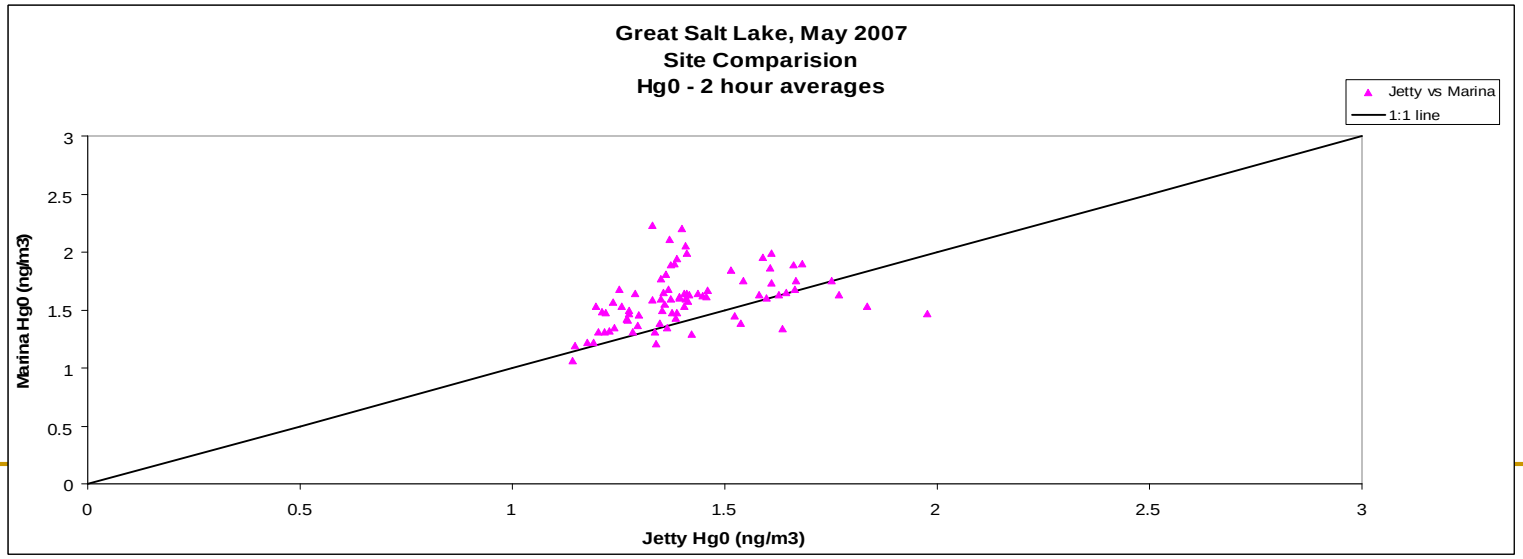
System comparability



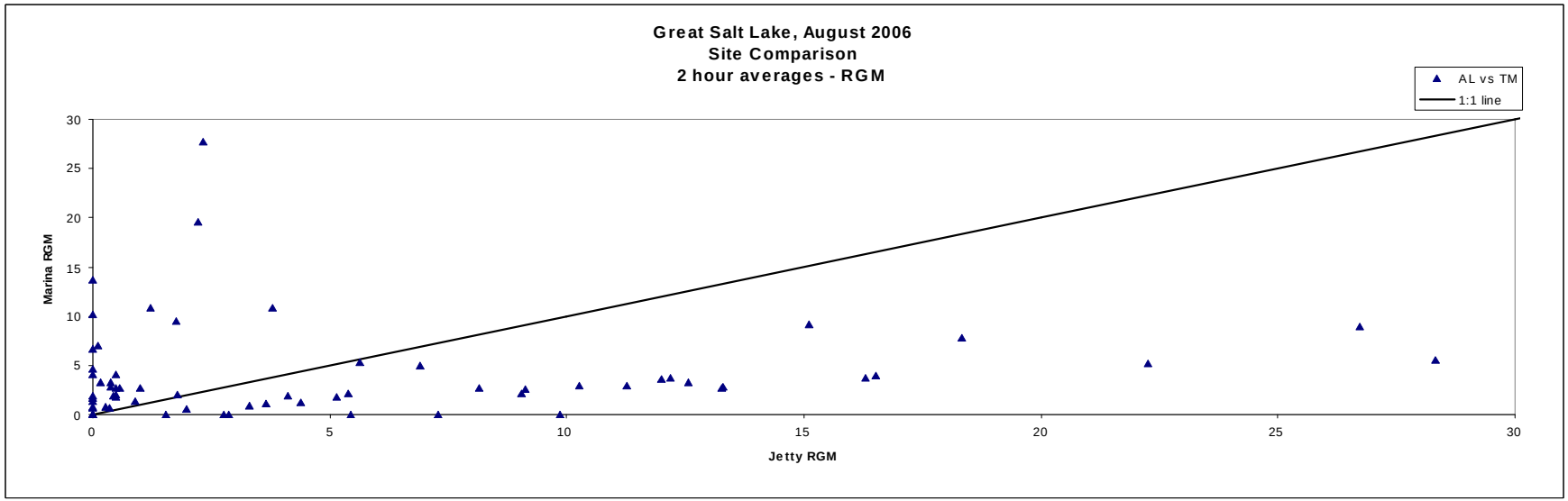


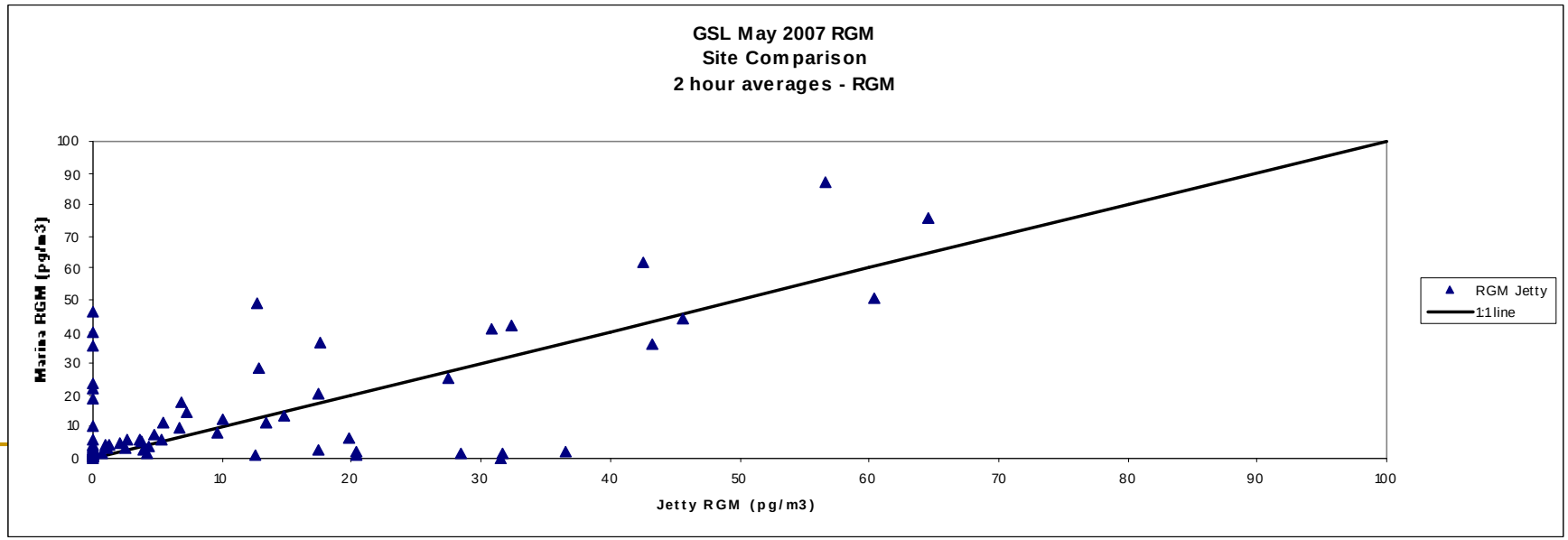
Site Variability cont



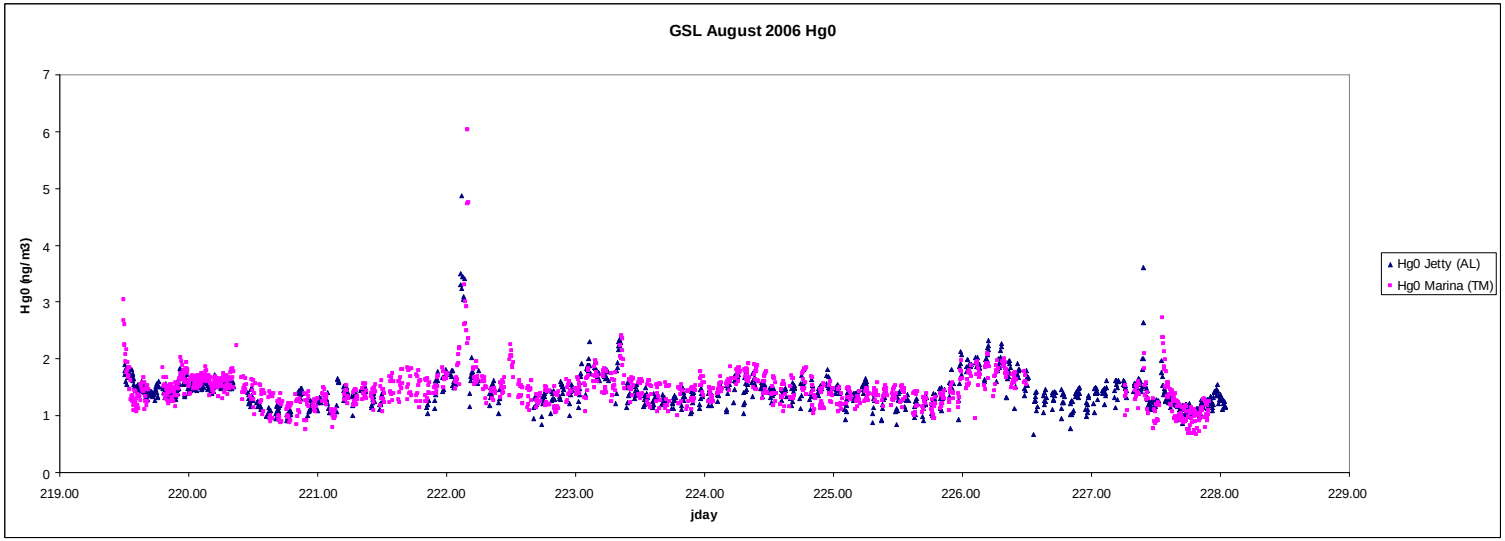


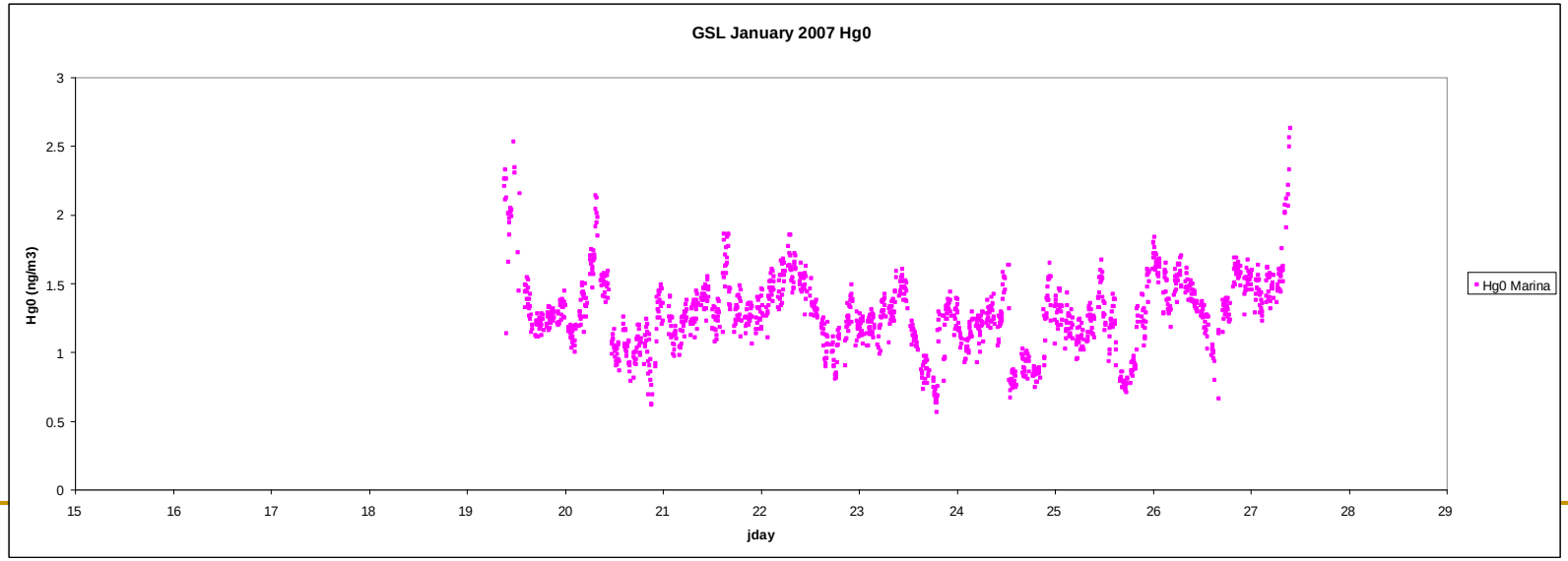
Site Variability (RGM)

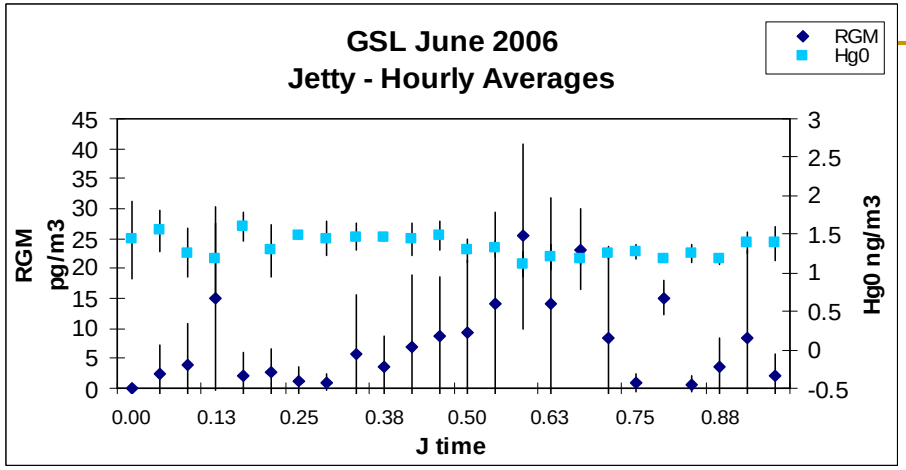


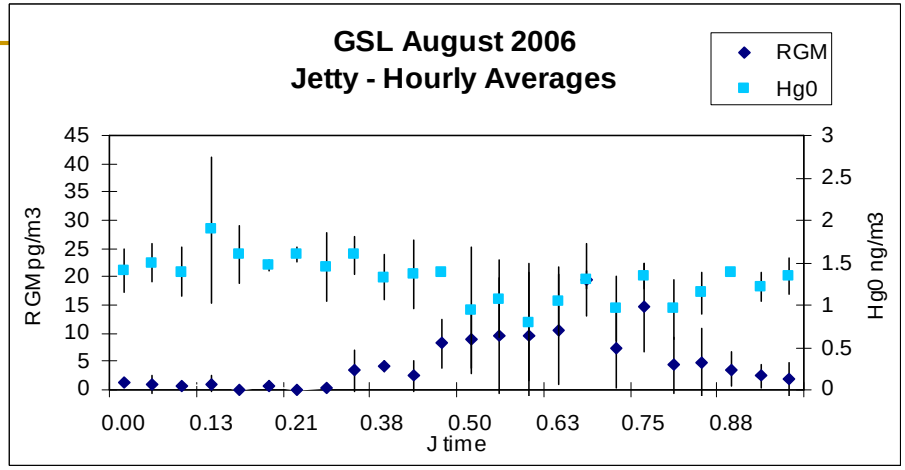


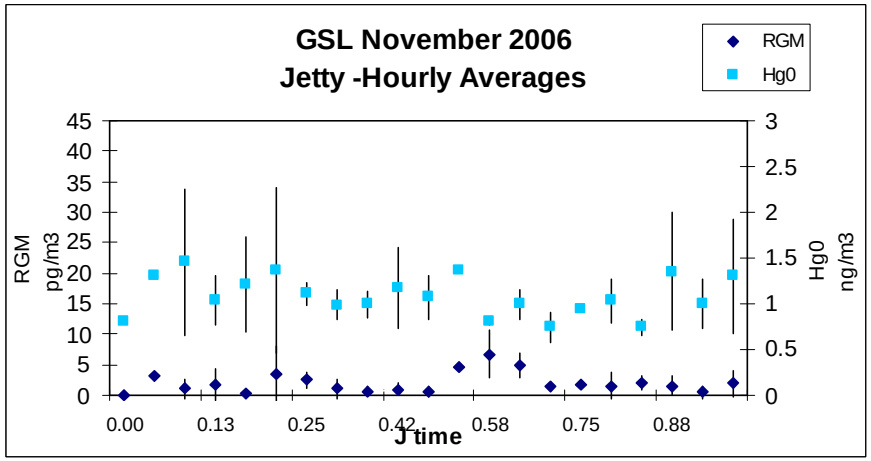
Trends over time



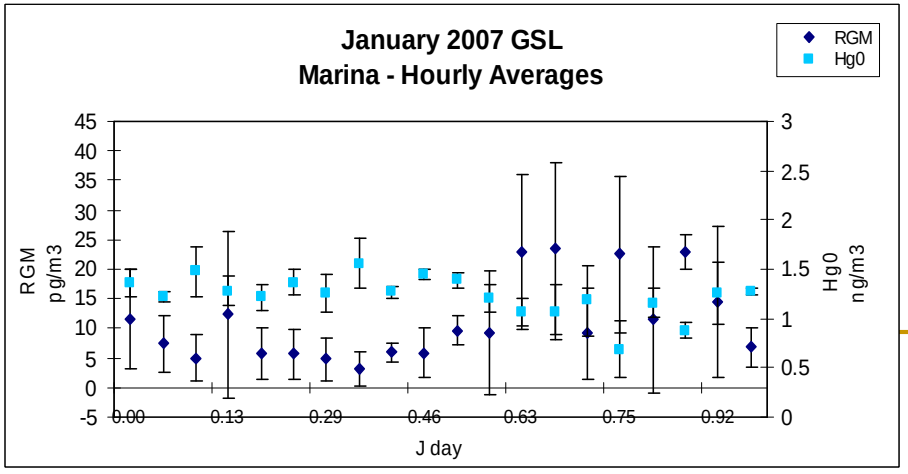


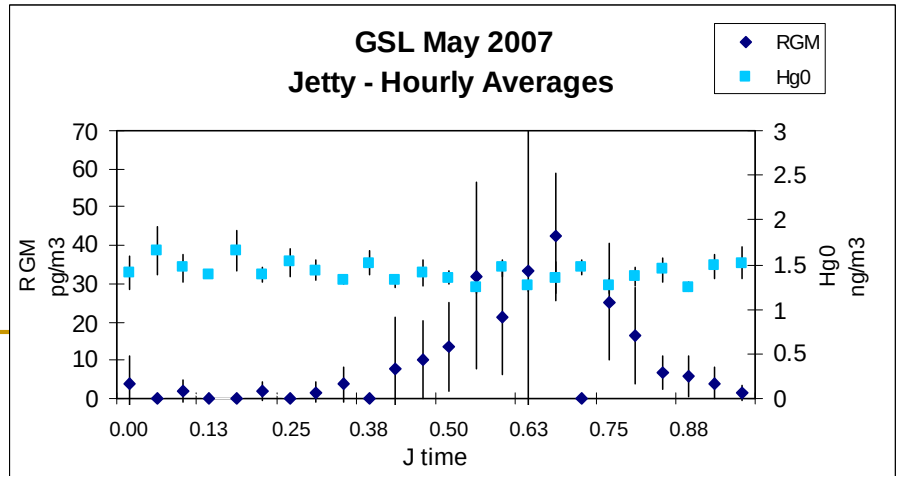






Trip Summaries				
		# Days	mean	std dev.
June 2006	RGM	9	7	7
	Hg0	9	1.3	0.2
August 2006	RGM	8	4	3
	Hg0	8	1.3	0.1
November 2006	RGM	7	2	1
	Hg0	7	1.3	0.9
January 2007	RGM	9	10	6
	Hg0	9	1.3	0.2
May 2007	RGM	11	14	11
	Hg0	11	1.6	0.2





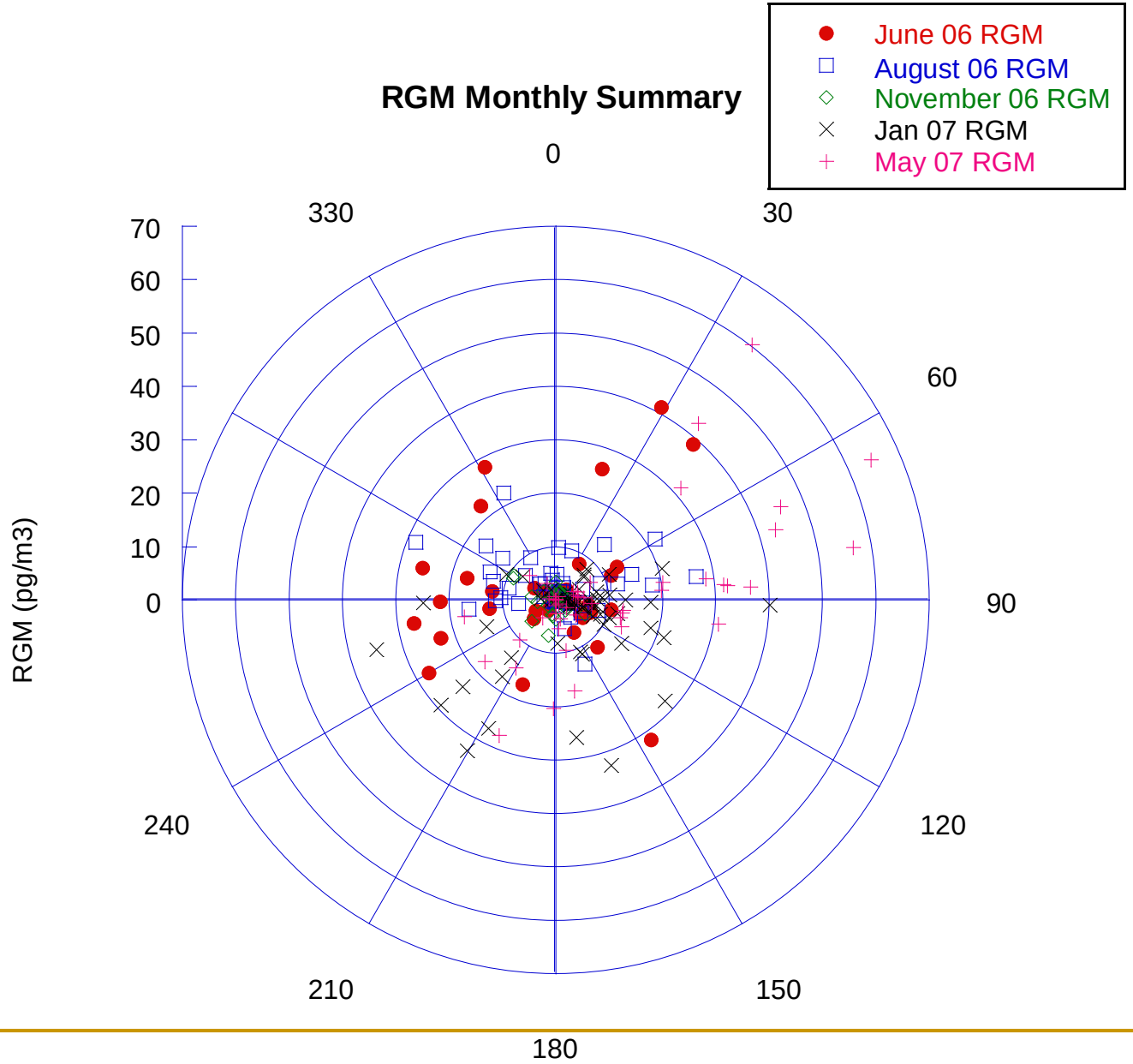
Correlations

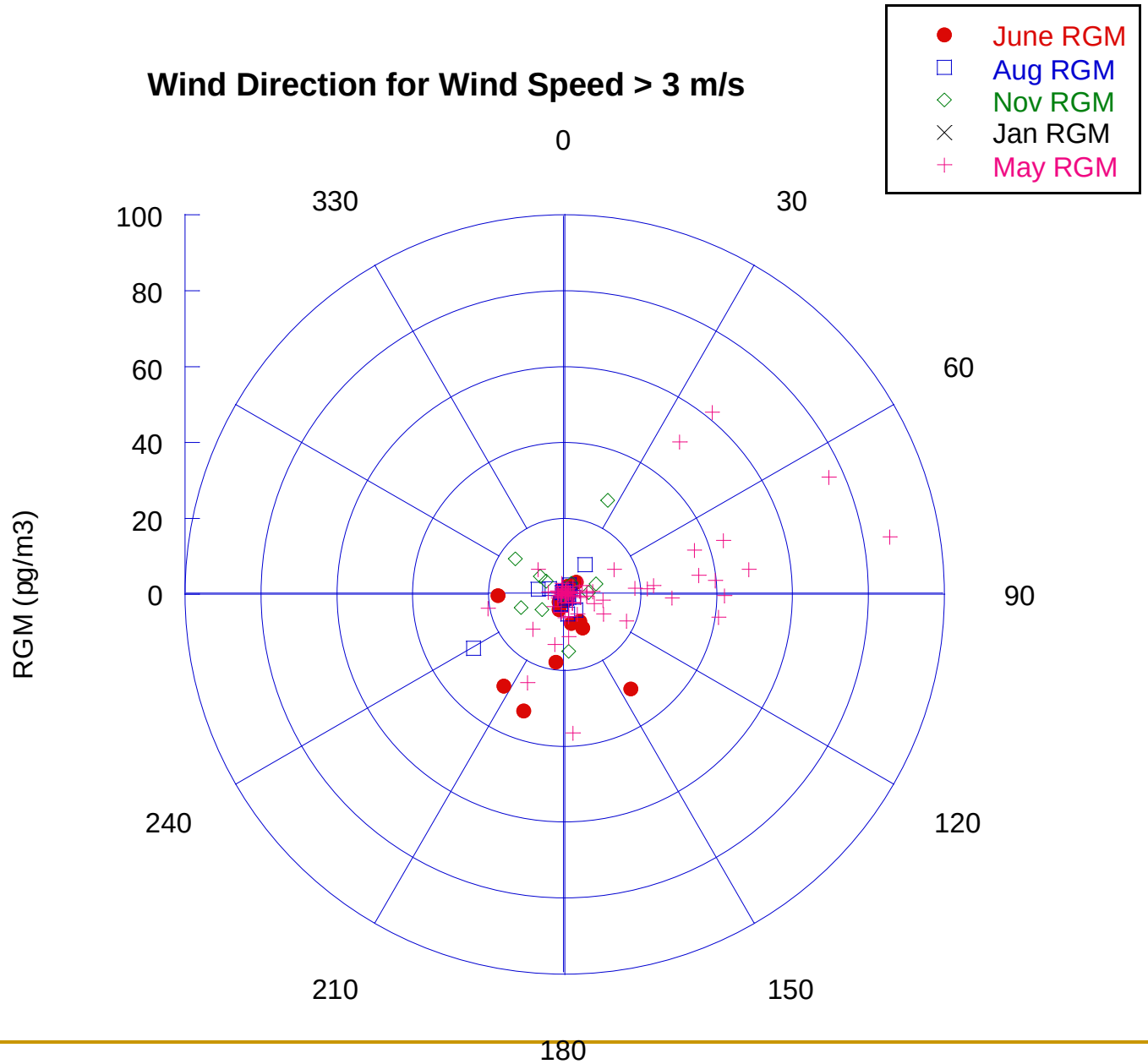
Great Salt Lake Statistics Summary

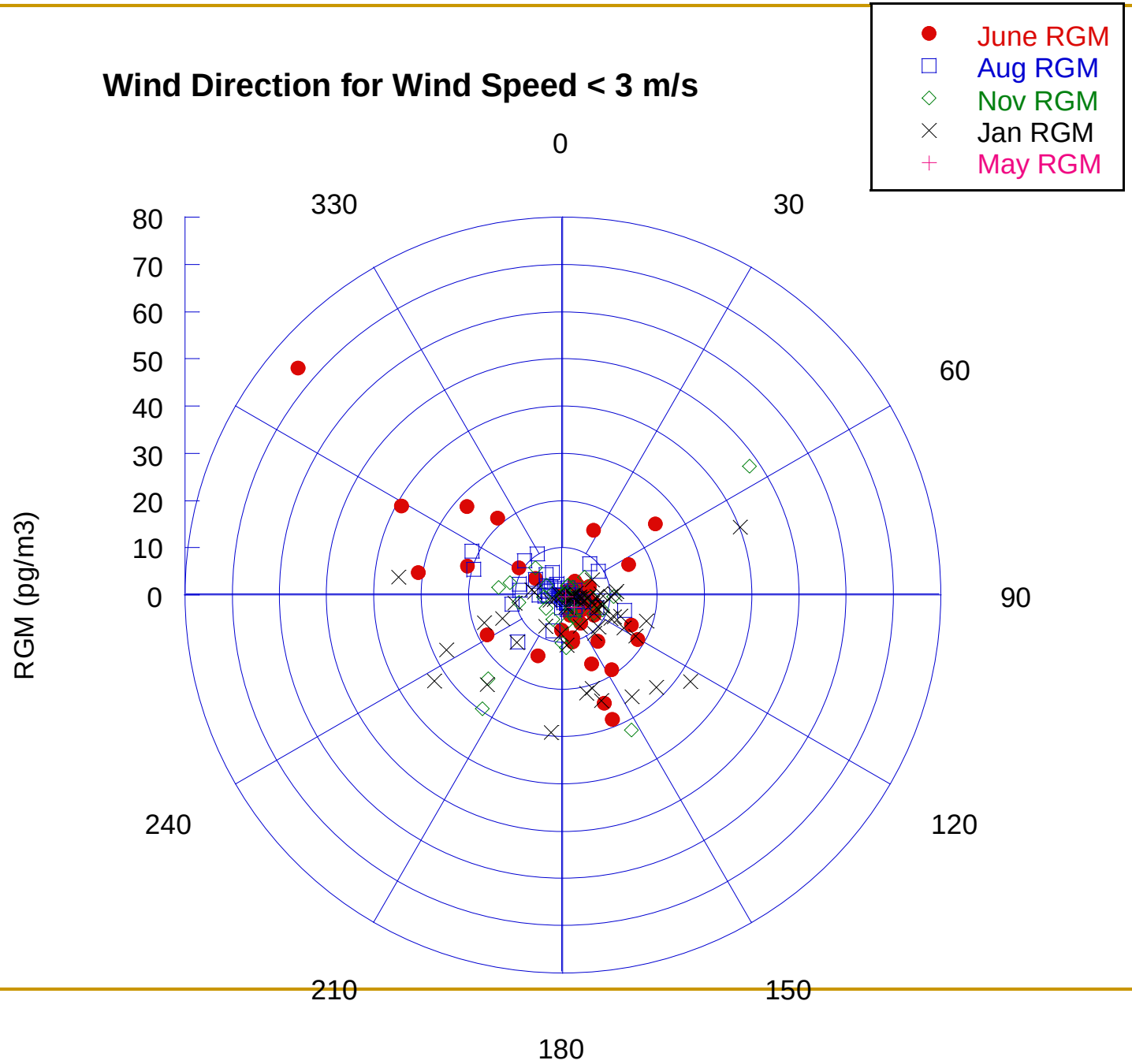
Correlation	Site	June 2006 r^2	Site	August 2006 r^2	November 2006 r^2	January 2007 r^2	May 2007 r^2
RGM-Hg0	Jetty 1	**0.17**	Jetty 2	**0.26**	*0.00*		**0.38**
	Jetty 2	**0.37**	Marina	*0.13*	*0.16*	**0.65**	**0.30**
RGM-O3	Jetty 1	**0.19**	Jetty 2	**0.67**	*0.04*		**0.63**
	Jetty 2	*0.12*	Marina	**0.65**	*0.19*	**0.38**	**0.80**
RGM-Temp	Jetty 1	**0.28**	Jetty 2	**0.70**	**0.19**		**0.58**
	Jetty 2	**0.67**	Marina	**0.64**	*0.03*	**0.40**	**0.51**
RGM-Rad	Jetty 1	**0.45**	Jetty 2	**0.47**	**0.32**		*0.56*
	Jetty 2	**0.43**	Marina	**0.52**	*0.05*	*0.05*	*0.34*
RGM-RH	Jetty 1	*0.15*	Jetty 2	**0.40**	*0.14*		**0.52**
	Jetty 2	**0.77**	Marina	**0.53**	**0.24**	**0.33**	**0.34**

NOTE:
Jetty 1 = start of Jetty
Jetty 2 = end of Jetty
Bold = p-value<0.05

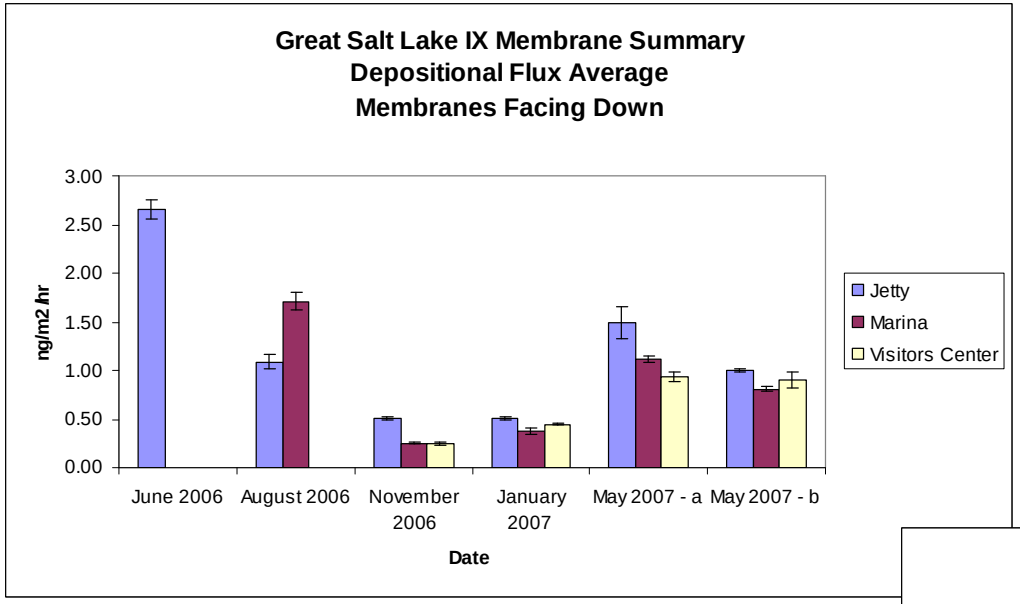
RGM and wind direction

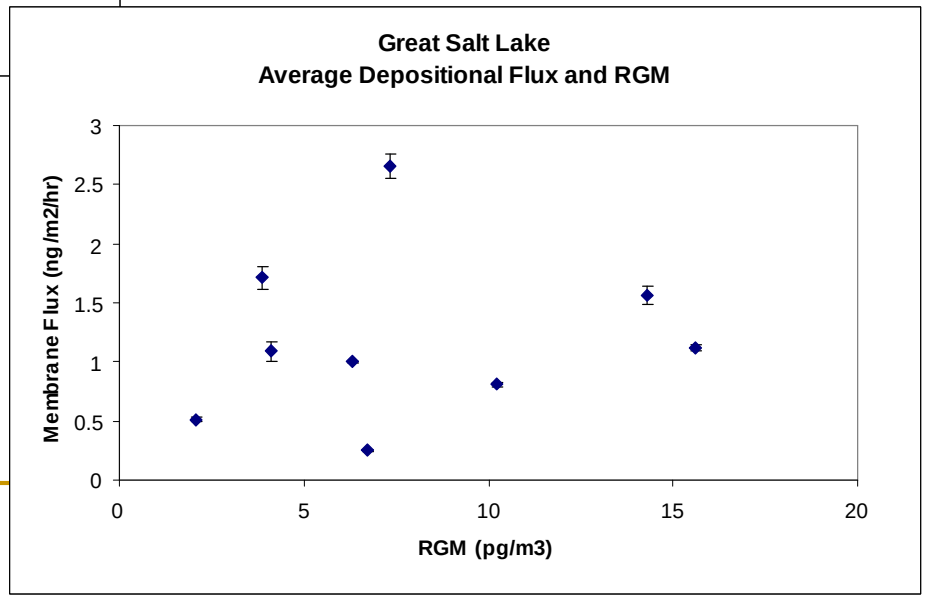



Wind Direction for Wind Speed > 3 m/s
June RGM
Aug RGM
Nov RGM
Jan RGM
May RGM
RGM (pg/m3)
0
30
60
90
120
150
180
210
240
330
100
80
60
40
20
0

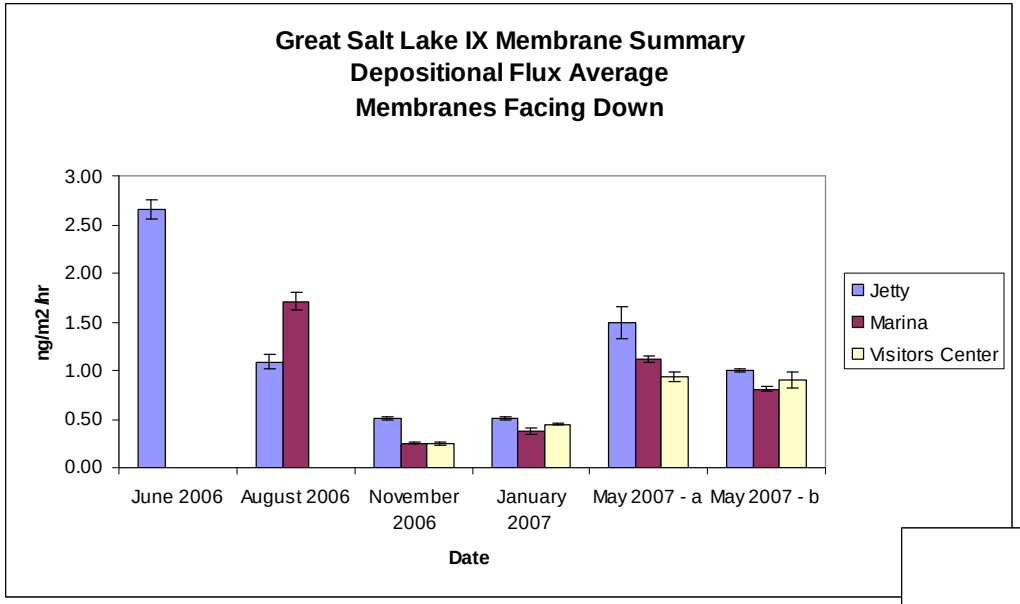

Wind Direction for Wind Speed < 3 m/s
June RGM
Aug RGM
Nov RGM
Jan RGM
May RGM
RGM (pg/m3)
80
70
60
50
40
30
20
10
0
0
30
60
90
120
150
180
210
240
330

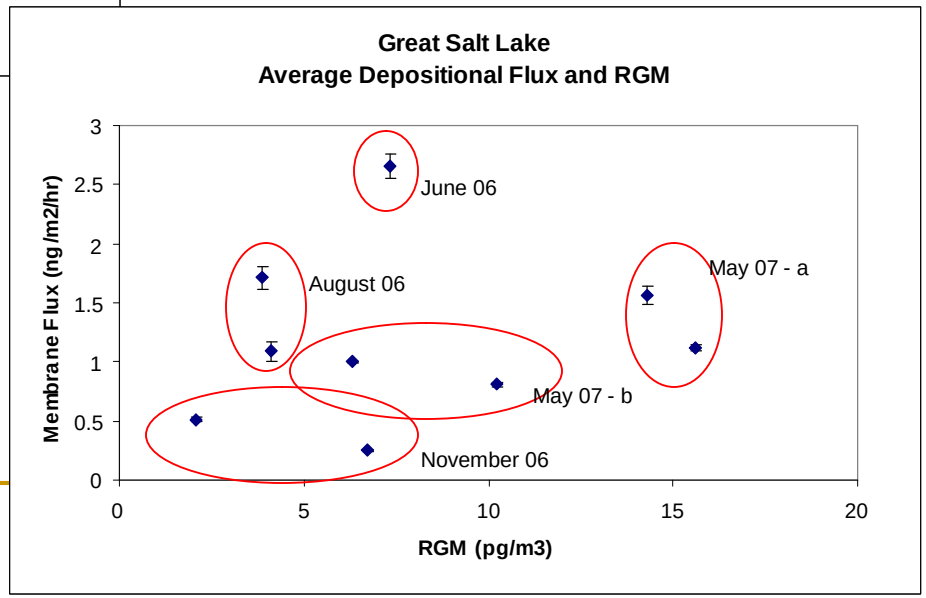
Membranes


Great Salt Lake IX Membrane Summary
Depositional Flux Average
Membranes Facing Down
ng/m2 /hr
3.00
2.50
2.00
1.50
1.00
0.50
0.00
June 2006
August 2006
November 2006
January 2007
May 2007 - a
May 2007 - b
Date
Jetty
Marina
Visitors Center

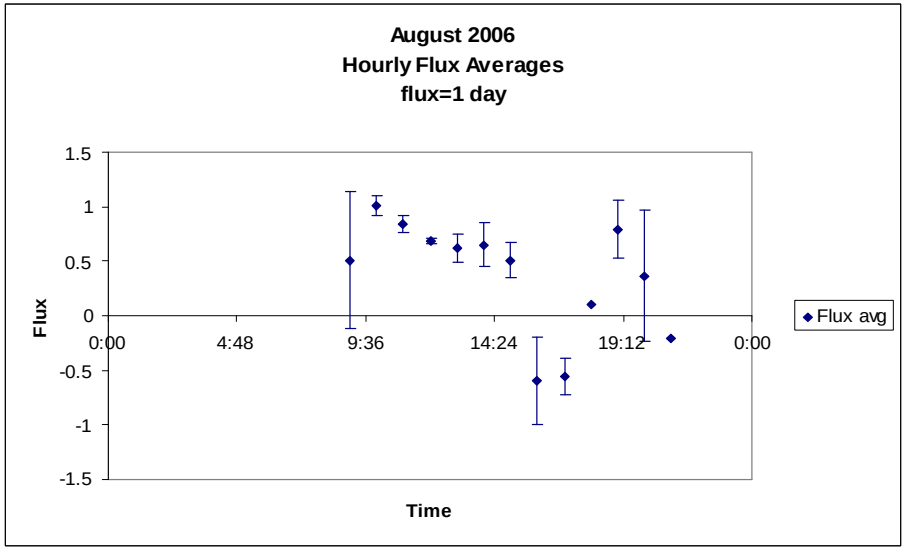

Great Salt Lake
Average Depositional Flux and RGM
Membrane Flux (ng/m2/hr)
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
RGM (pg/m3)

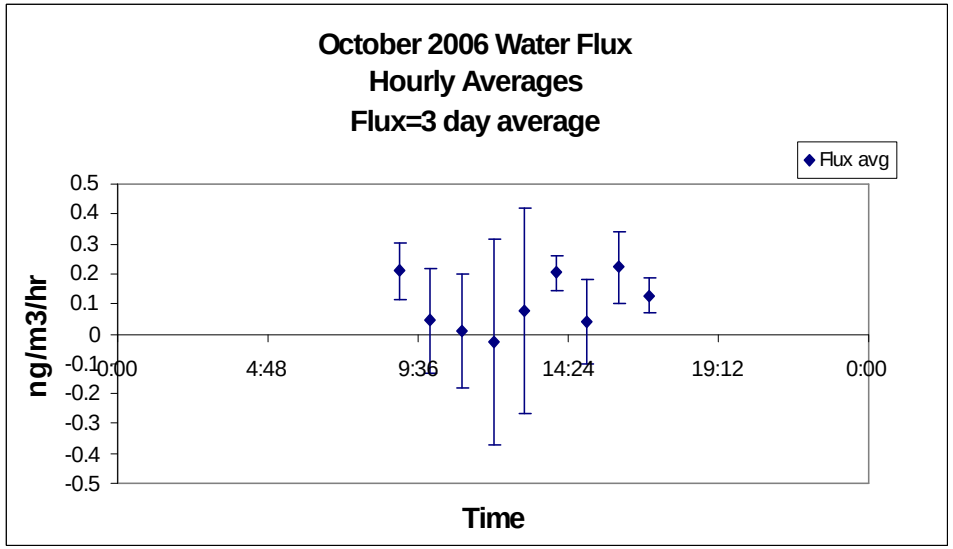
Membranes

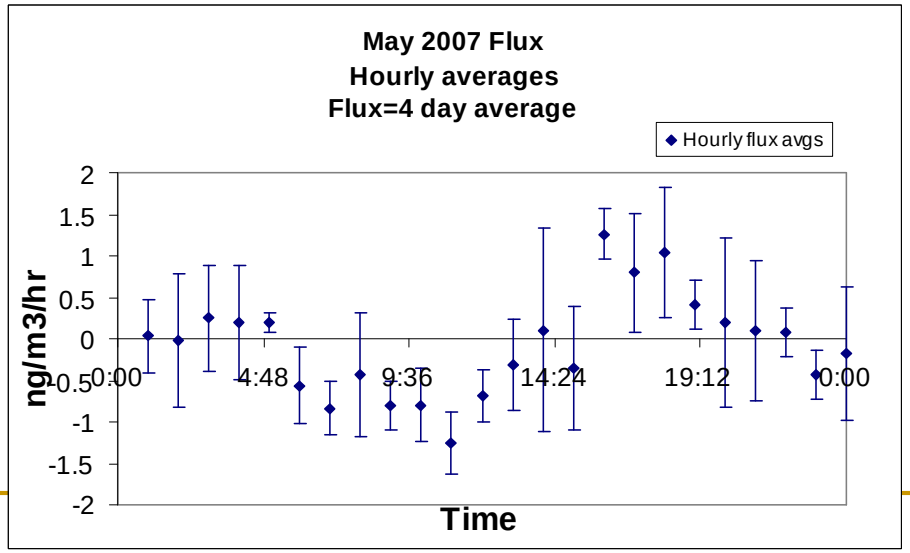

Great Salt Lake IX Membrane Summary
Depositional Flux Average
Membranes Facing Down
ng/m2 /hr
3.00
2.50
2.00
1.50
1.00
0.50
0.00
June 2006
August 2006
November 2006
January 2007
May 2007 - a
May 2007 - b
Date
Jetty
Marina
Visitors Center


Great Salt Lake
Average Depositional Flux and RGM
Membrane Flux (ng/m2/hr)
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
RGM (pg/m3)
June 06
August 06
May 07 - a
May 07 - b
November 06

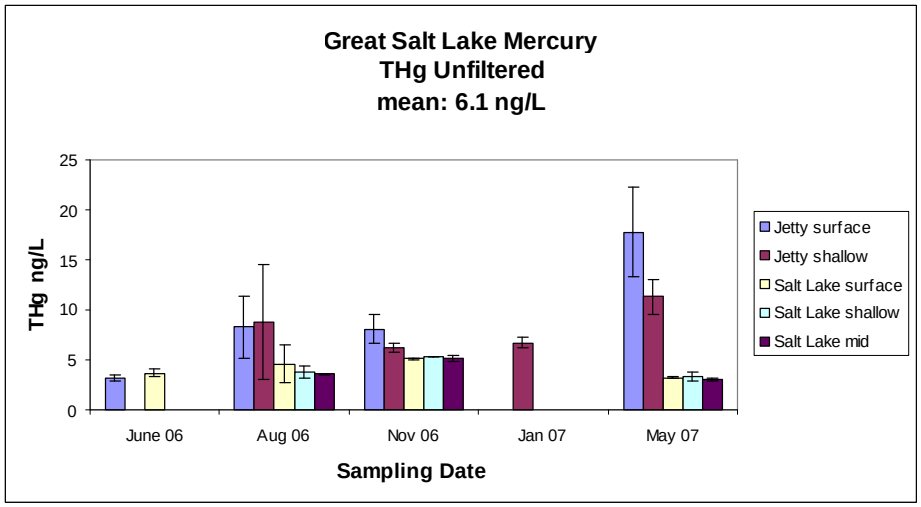
Water Flux

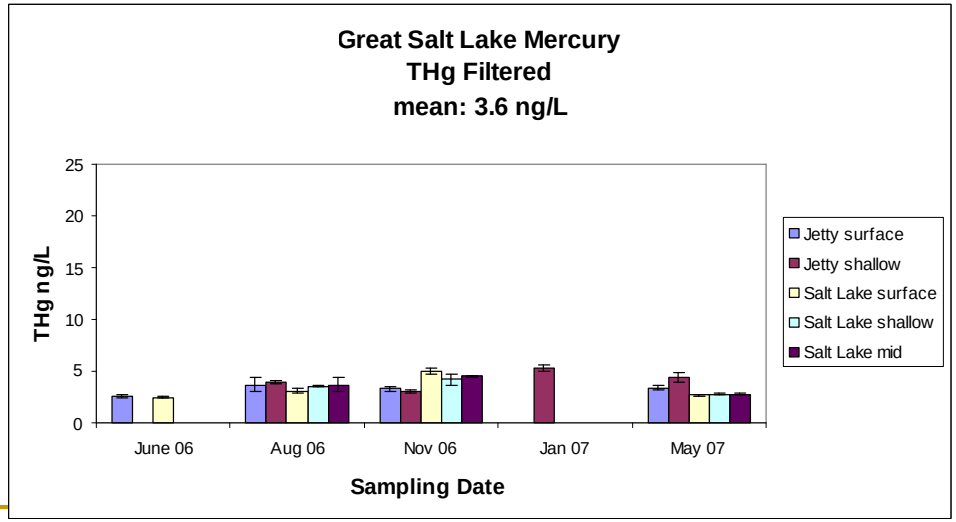

August 2006
Hourly Flux Averages
flux=1 day
Flux
Time
Flux avg
1.5
1
0.5
0
-0.5
-1
-1.5
0:00
4:48
9:36
14:24
19:12
0:00


October 2006 Water Flux
Hourly Averages
Flux=3 day average
ng/m3/hr
Time
Flux avg
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0:00
4:48
9:36
14:24
19:12
0:00

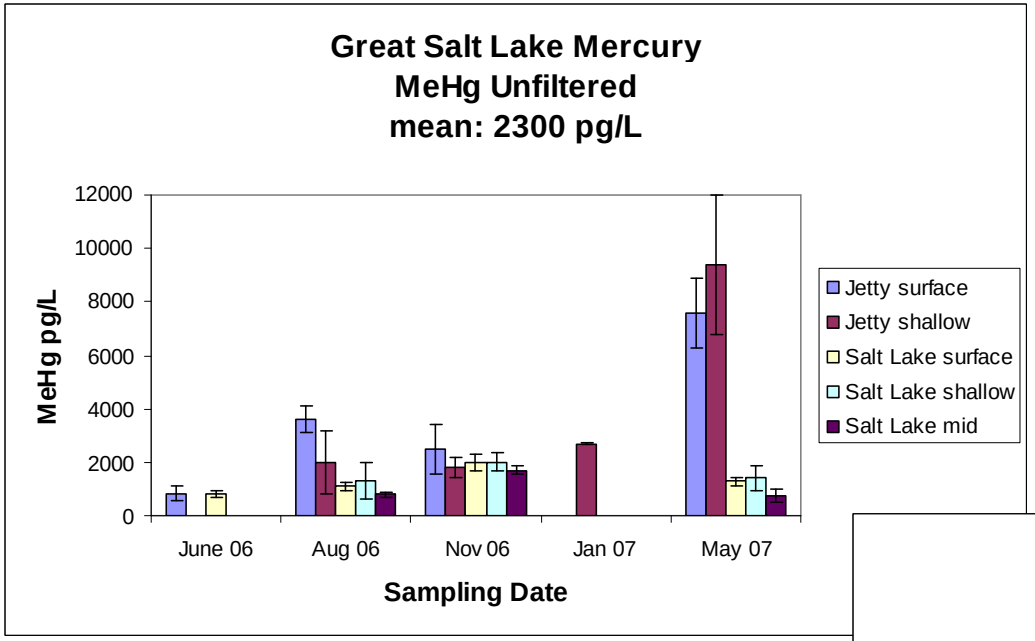

May 2007 Flux
Hourly averages
Flux=4 day average
ng/m3/hr
Time
Hourly flux avgs
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0:00
4:48
9:36
14:24
19:12
0:00

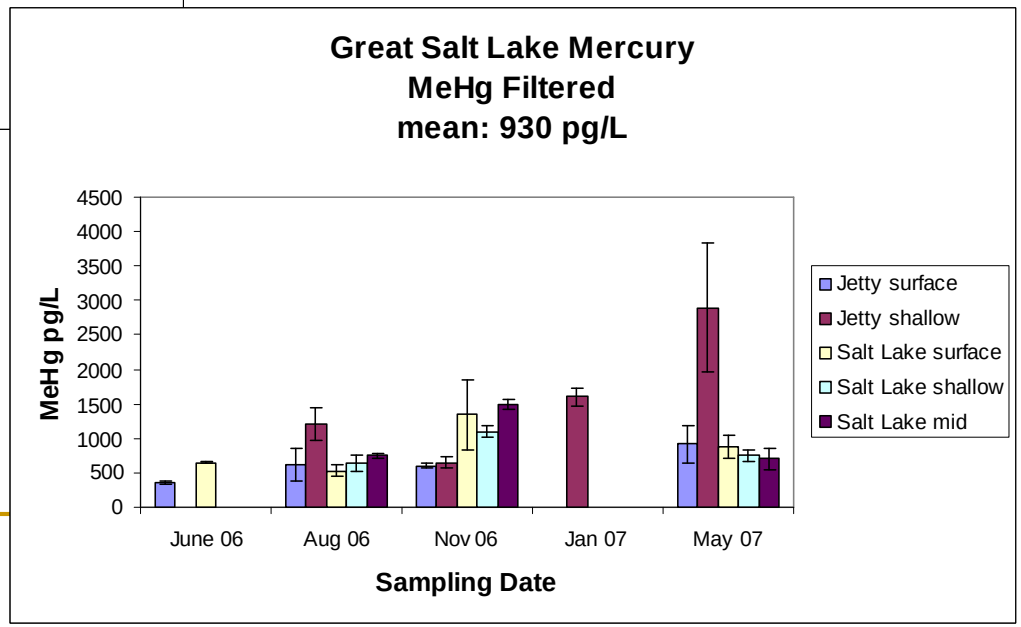
Water Analyses – Total Hg



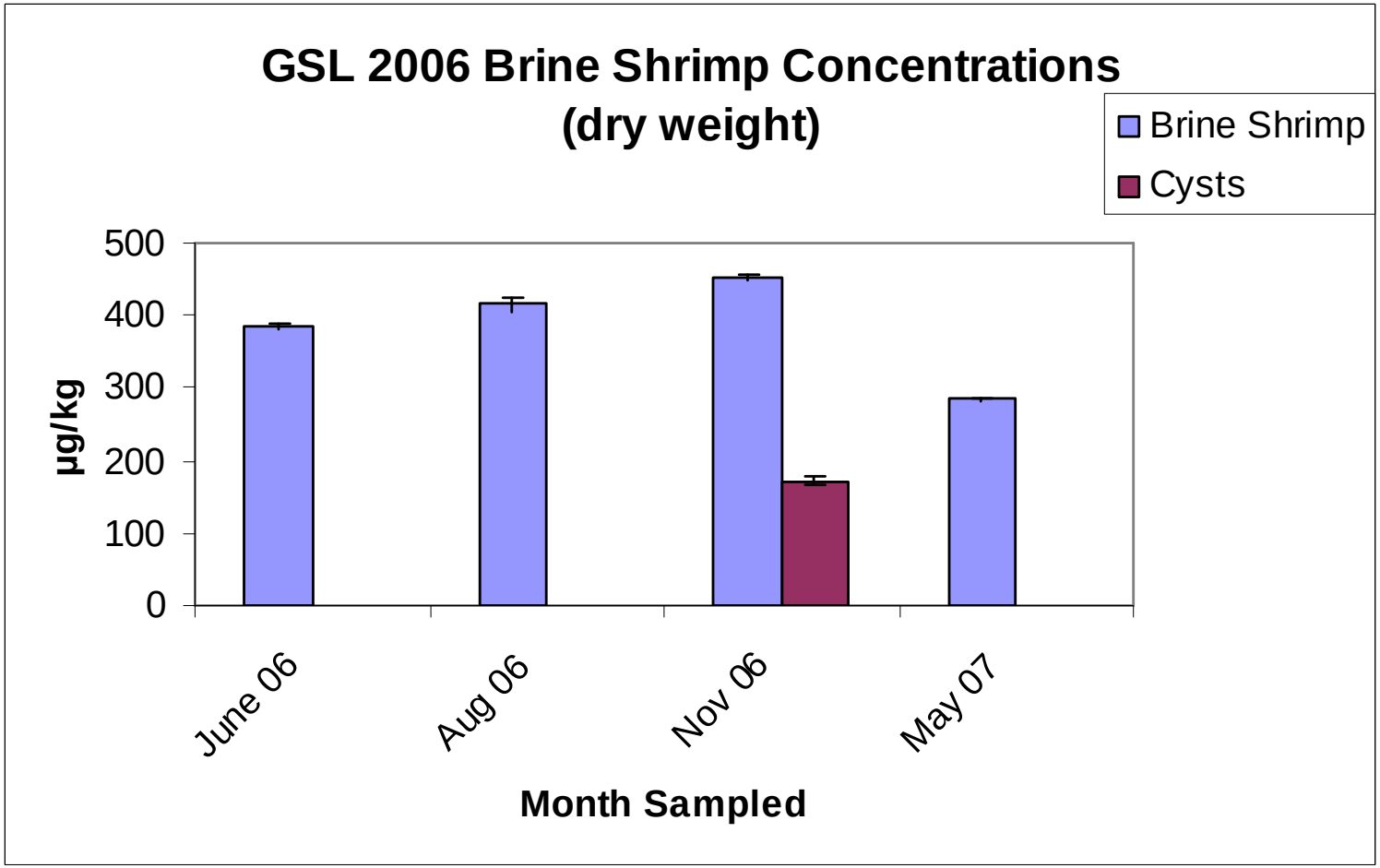


Water Analyses – Methyl Hg





Brine Shrimp Concentrations



Preliminary Mass Balance

Fig. 5: Great Salt Lake - Annual Hg Mass Balance

Analytical Method	Hg Deposition (12-24hr) (kg Hg/yr)	Shrimp Removed (kg Hg/yr)	Emission (24-12 hr) kg Hg/yr
IX scaled	35-70	2	0.35-0.97
IX & Met scale	30-60	2	0.35-0.97
Depositional Flux			
(V_d=0.2 cm/s)	0.8-1.9	2	0.35-0.97
(V_d=2.0 cm/s)	10-19	2	0.35-0.97

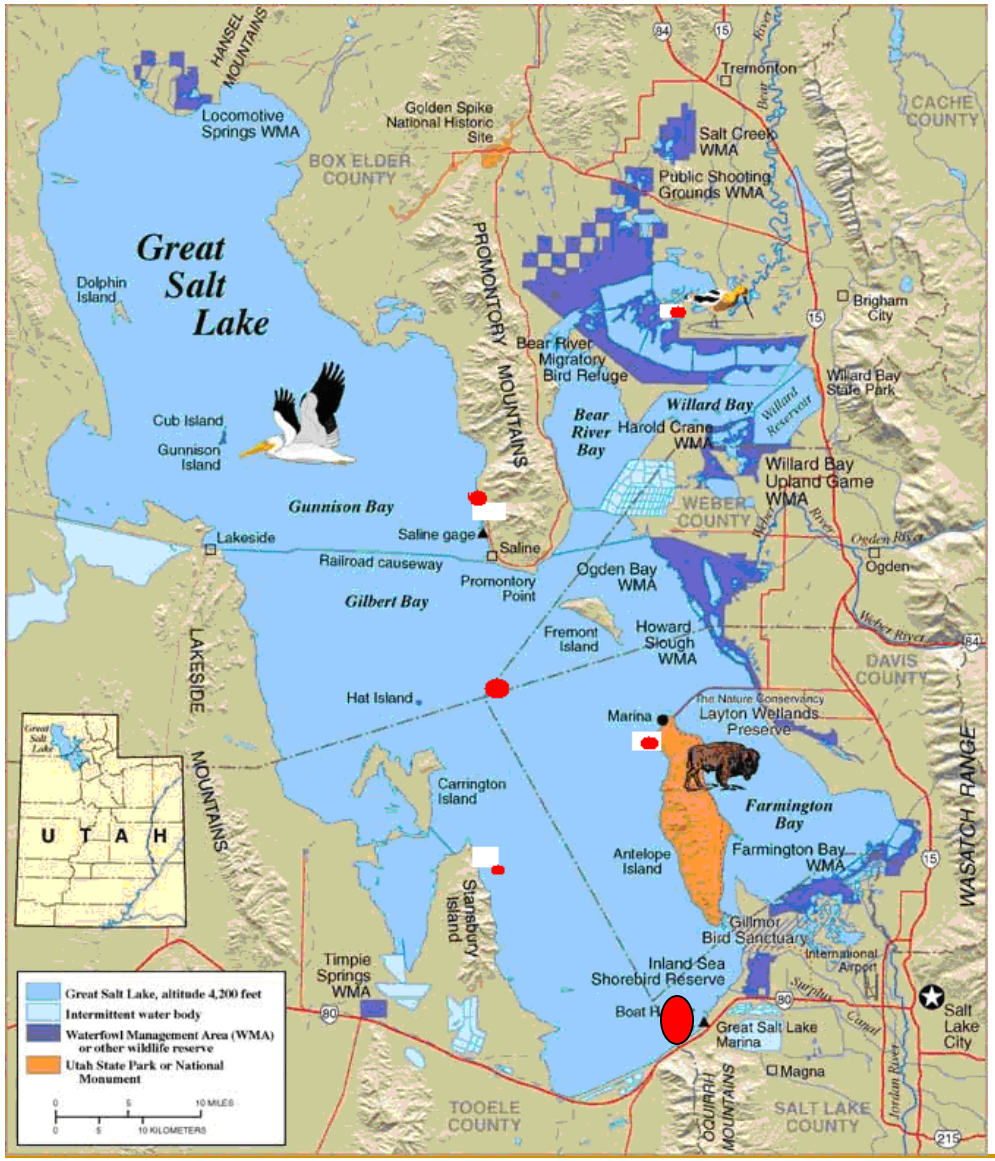
NOTE:

Lake surface area: 4.4*10^9 m^2

Hg Deposition values in range of 12-24 hour averages.

Future work

- What is the spatial and temporal variability of air Hg concentrations and speciation at GSL?
- Are Hg air concentrations and Hg speciation influenced by unique atmospheric chemistry associated with the lake and/or by anthropogenic air pollutants derived from within the GSL air shed?
  - Simultaneous measurement of air speciation at two to three locations
  - Air concentration changes across the lake
  - Measurement of aerosols
  - Air concentrations in urban –lake air transect
  - Detailed measurement of ancillary air chemistry
  - Use of surrogate surfaces across lake to urban transects
- How much “new” Hg input is input to the lake from the atmosphere?
  - Deposition with field chamber, gradient methods, and surrogate surfaces
- What is the potential for deposition of atmospheric Hg to the watershed area surrounding the lake?
  - Transects of surrogate surface



Air monitoring

Lake effect

Deposition to the Lake

Urban versus lake air

Surrogate surfaces-

Co-locate with air monitoring stations

Transects that look for urban versus lake produced RGM