Great Salt Lake - Farmington Bay
Evaluation of Phosphorus Loading

Introduction

There has been concern expressed that Farmington Bay is highly eutrophic and impaired due to this condition. The concern over eutrophication focuses on the abundant supply of phosphorus that reaches the Bay which allows the growth of cyanobacteria. There has been a desire to control such bacteria growth through the control of phosphorus discharges to the lake. The primary method of implementing phosphorus control would be to implement stringent restrictions on point source discharges. However, it has not been determined that such action would sufficiently reduce the phosphorus loading to make it effective at controlling cyanobacteria blooms. This study was conducted to determine the contribution of point sources in relationship to total phosphorus entering the Bay.

Evaluation Methodology

Previous studies attempting to quantify the sources of phosphorus entering the Bay have focused on water quality sampling available through the STORET database. This data base contains State and other sampling sources evaluating waters which ultimately enter Farmington Bay. While this is one methodology which is sometimes effective at evaluating phosphorus sources there are various short comings to it. First, routine sampling often fails to quantify the amount of phosphorus which arrives at the Bay from slug loading. An example would be agricultural and other sources of phosphorus runoff associated with storm water discharges. Such discharges could carry significant runoff of phosphorus as a result of possible buildup of phosphorus in surface soils. It has long been known that agricultural buildup of phosphorus occurs in the surface when over fertilization takes place. In addition, sampling from all inflow sources to the Bay is not always done and is not always representative of all water sources. Either a comprehensive sampling program needs to be developed to quantify

all sources, including storm water surges, or a different method needs to be developed.

Previous attempts at quantifying phosphorus to Farmington Bay only included point source discharges which have a direct discharge to the Bay. There are also two major wastewater discharges to the Jordan River which also significantly affect the loading arriving at the Bay. While there may be some losses from these discharges as the flow passes through the river, these discharges need to be individually identified too, as significant point sources.

This attempt at producing a phosphorus mass balance to Farmington Bay takes a new approach. We have, in recent years, been able to accurately measure flows leaving the Bay through the Antelope Island causeway. The U.S. Geological Survey (USGS) has installed a bi-directional flow meter which accurately quantifies the flow through the causeway breach. Since during the past several years, water leaving the Bay has been discharged through this measured opening, it is possible to quantify the amount of phosphorus leaving the Bay. During the October, 2003 to the September, 2004 the flow from the Bay averaged 412 cfs. There are several STORET sampling locations in Farmington which allow the approximation of the outflow sampling concentration. Over the past several years (see appendix) the average discharge concentration is 0.56 mg/L phosphorus as P. Using the flow and concentration the annual mass discharge can be calculated.

Point source discharges with measurable impact on Farmington Bay are the following publically owned wastewater treatment plants (POTW's):

South Valley WRF
Central Valley WRF
Salt Lake City WRF
South Davis South Plant
South Davis North Plant
Central Davis Sewer District
North Davis Sewer District.

In order to determine the phosphorus being discharged from each POTW, the flows and average concentrations are required. STORET values for each discharge

were retrieved for the period 2000-2005. Phosphorus as P values were averaged for each POTW. In addition, POTW's are required to submit discharge monitoring reports to the Utah Division of Water Quality monthly. The monthly values for the sixty-two months previous to this report being prepared were averaged for each facility. The total monthly average for all facilities being discharged to the Bay is about 144 MGD. Again, there are probably some losses for discharges which indirectly reach the Bay through either canals or rivers, but for this exercise the assumption is made that all discharge flows reach the Bay. In addition the decision was also made to assume that no phosphorus losses occur in these same channels either to the sediment or to bank vegetation. These two assumptions may create an over statement of phosphorus coming from POTW's.

Since the difficulty encountered in quantifying phosphorus inflow exists, the alternative approach is to determine what either stays in Farmington Bay or leaves the system. The amount leaving has been discussed previously; the amount staying in the Bay needs to be determined. To quantify the amount remaining, results of a previous sediment study was used. The amount of phosphorus over time deposited in the sediment would represent the amount staying in the Bay. Some phosphorus remains in the water, but this amount was assumed to be insignificant in relation to the sediment sink. Sediment samples were collected during 2004 and 2005. The average surface concentration for the samples of 792 ppm of phosphorus as P on a dry weight basis was determined and used as representative value for the entire Bay. The Bay surface area is about 94 square miles. The USGS has performed an analysis at two locations in Farmington Bay to time date sediment cores. These two evaluations indicated a sediment deposition rate of about 0.4 cm per year. Using the annual deposition rate, the surface area and sediment concentration, the annual deposition of sediment phosphorus could be calculated.

Results

The results of the evaluation indicate that the average annual phosphorus as P loading to Farmington Bay are as follows:

Annual Sediment Phosphorus	2,724,000 lbs/year

Annual Bay Discharge Phosphorus 454,000 lbs/year

Total Annual Loading 3,178,000 lbs/year

Loading from POTW point source discharges are as follows:

Central Davis Sewer Dist.	49,000	lbs/year
So. Davis North & South	63,000	lbs/year
North Davis Sewer Dist.	224,000	lbs/year
So. Valley WRF	259,000	lbs/year
Salt Lake City WRF	292,000	lbs/year
Central Valley WRF	489,000	lbs/year

As can be determined, the total annual phosphorus as P loading from POTW's is about 1,376,000 lbs/year.

Finally, given the above information, the total phosphorus as P received from POTW's is 43%. This amount is the amount which could be removed if all phosphorus were eliminated from point sources.

Conclusion

A previous study conducted by students at USU reported an approximate point source loading to Farmington Bay of about 50%. While this report failed to account for all POTW sources, it probably also failed to account for all phosphorus reaching the Bay. This current study, using a different approach to assessing the Bay loading, concluded that phosphorus from POTW's amounts to about 43% of the total phosphorus load. There are two options to further refine Farmington Bay phosphorus loading. The first is to increase the data base used in this study. Differing values for sediment deposition or long term outflows may significantly alter the percentage from POTW's. The second approach is to identify and measure all flow sources to the bay, including all flow surges, and measure each source concentration. Without further data, the conclusion is that POTW's contribute about 50% of all phosphorus reaching Farmington Bay.

Phosphorus Analysis
Great Salt Lake Farmington Bay
Loading Analysis

WWTP Loading

CDSD	48,855	lbs/yr		GSL Farmington Bay P Discharge at Dike	
SDN	47,032	lbs/yr			
SDS	15,668	lbs/yr		0.56	mg/L
NDS	224,264	lbs/yr		(Storet Average 3 Sites)	
CVSRF	489,497	lbs/yr			
SLC	291,874	lbs/yr	USGS Acoustic Gage Average 10/3 to 9/4		
SVWRF	259,029	lbs/yr		412	CFS
Annual Loading	1,376,220	lbs/year	P In Farminton Bay Discharge at Causeway		
				Flow	412 CFS
Sediment Loading				Concentration	0.56 mg/L
Sediment Area	2,620,569,600	Sq. Ft.	94 Sq Mi.	Mass P Annual	453,899 lbs/year
Depth of Deposition	0.4	cm/yr.	Inches/cm 0.3937		
Assumed density	100	lbs/cf			
Average Conc. P	792	ppm			
			P Accumulated in Sediment	2,723,736	lbs/year
			P Released to GSL Thru Causeway	453,899	lbs/year
Sediment P	2,723,736	lbs/year			
			Total P into Farmington Bay	3,177,635	lbs/year

Percent of P from Wastewater Treatment Plants 43%

Phosphorus - GSL Storet Site 1

1/5/2000	0.249	FARMINGTON BAY AT ANTELOPE IS-SYRACUSE CAUSEWAY
2/17/2000	0.081	BRIDGE 41.0663611 -112.2306111 NAD27
2/17/2000	0.219	All Values Phosphorus as P mg/L
5/2/2000	0.275	
5/2/2000	0.147	
6/20/2000	0.292	
6/27/2000	0.222	
8/3/2000	0.265	
8/22/2000	0.2	
9/13/2000	0.145	
10/3/2000	0.152	
1/23/2001	0.304	
5/3/2001	0.469	
5/24/2001	0.242	
6/6/2001	0.294	
6/21/2001	0.374	
7/11/2001	0.604	
7/18/2001	0.298	
8/20/2001	0.871	
9/19/2001	0.704	
10/2/2001	0.504	
11/5/2001	0.411	
11/6/2001	0.411	
1/22/2002	0.397	
2/19/2002	1.54	
5/14/2002	0.492	
6/6/2002	0.341	
6/25/2002	0.415	
7/11/2002	0.391	
7/31/2002	1.06	
8/15/2002	0.682	
8/15/2002	0.508	
10/16/2002	0.426	
10/31/2002	0.35776	
12/10/2002	0.527	
2/4/2003	0.533	
3/11/2003	0.234	
3/11/2003	0.349	
5/20/2003	0.324	
5/29/2003	0.342	
6/26/2003	0.352	
8/28/2003	0.528	
8/28/2003	0.83	
8/28/2003	0.198	
8/28/2003	0.419	
8/28/2003	0.522	
8/28/2003	0.449	
8/28/2003	0.76	
8/28/2003	0.563	
Average	0.43	mg/L

Phosphorus - GSL Storet Site 2

2/17/2000	0.077	GSL FARMINGTON BAY AT ANTELOPE ISLAND CAUSEWAY
2/17/2000	0.201	CULVERT EAST 41.0892222 -112.1631111 NAD27
5/2/2000	0.126	All Values Phosphorus as P mg/L
5/2/2000	0.664	
6/20/2000	0.205	
6/27/2000	0.153	
8/3/2000	0.42	
8/22/2000	0.2	
9/13/2000	0.13	
10/3/2000	0.338	
1/23/2001	0.325	
5/3/2001	0.486	
5/24/2001	0.315	
6/6/2001	0.456	
6/21/2001	0.328	
7/11/2001	0.571	
7/18/2001	0.44	
8/20/2001	1.05	
9/19/2001	0.613	
10/2/2001	0.816	
11/5/2001	0.5	
11/6/2001	0.5	
1/22/2002	0.552	
2/19/2002	0.677	
5/14/2002	0.401	
6/6/2002	0.393	
6/25/2002	0.429	
7/11/2002	0.478	
7/31/2002	0.265	
8/15/2002	0.973	
8/15/2002	0.821	
10/16/2002	0.713	
10/31/2002	0.22604	
12/10/2002	1.09	
2/4/2003	0.587	
3/11/2003	0.169	
3/11/2003	0.795	
5/29/2003	1.05	
6/26/2003	2.28	
Average	0.53	mg/L

Phosphorus - GSL Storet Site 3

6/1/2000	2.21
6/15/2000	0.227
6/29/2000	0.169
8/3/2000	0.205
9/13/2000	0.145
5/24/2001	0.219
6/6/2001	0.342
6/21/2001	0.366
7/11/2001	0.342
7/31/2001	0.371
8/20/2001	0.154
9/19/2001	0.39
6/6/2002	0.311
7/11/2002	0.049
7/11/2002	0.04
7/31/2002	0.493
7/31/2002	0.429
8/15/2002	0.426
8/15/2002	1.07
8/29/2002	0.84
8/29/2002	0.463
9/16/2002	0.478
9/16/2002	0.807
10/16/2002	0.567
10/16/2002	0.824
3/11/2003	0.258
3/11/2003	0.936
6/26/2003	0.546
6/26/2003	0.14
6/26/2003	0.137
6/26/2003	0.202
6/26/2003	0.172
6/26/2003	0.208
6/26/2003	0.613
6/26/2003	0.341
6/26/2003	0.556
6/26/2003	0.196
7/16/2003	0.482
7/16/2003	0.48806
7/16/2003	0.329
7/16/2003	0.33279
7/16/2003	0.368
7/16/2003	0.384
7/16/2003	0.54288
7/16/2003	0.33434
8/28/2003	0.465
8/28/2003	1.88
8/28/2003	0.313

FARMINGTON BAY 1 MILE SOUTH OF CAUSEWAY
BRIDGE 41.0497499 -112.1886833 NAD27
All Values Phosphorus as P mg/L

Phosphorus - GSL Storet Site 3

8/28/2003	0.609	
8/28/2003	0.489	
8/28/2003	0.32	
8/28/2003	0.442	
8/28/2003	0.495	
11/5/2003	0.508	
11/5/2003	0.923	
11/5/2003	0.346	
11/5/2003	0.561	
11/5/2003	0.363	
11/5/2003	0.618	
6/17/2004	0.109	
6/17/2004	0.456	
6/17/2004	0.463	
6/17/2004	0.108	
6/17/2004	0.089	
6/17/2004	0.335	
6/17/2004	0.103	
6/17/2004	0.521	
7/7/2004	0.142	
7/7/2004	0.464	
7/7/04	0.133	
7/7/2004	0.521	
7/7/2004	0.124	
7/7/2004	0.978	
7/7/2004	8.05	
7/7/2004	14.7	
7/7/2004	0.395	
7/7/2004	0.099	
8/31/2004	0.177	
8/31/2004	0.384	
8/31/2004	0.172	
8/31/2004	0.313	
7/22/2005	2.47	
8/18/2005	0.872	
8/18/2005	0.512	
Average	0.72	mg/L

Phosphorus - SVWRF Storet

1/12/2000	1.21		South Valley WRF		
1/12/2000	1.3				
2/29/2000	2.38				
2/29/2000	3.72				
3/27/2000	3.36				22.1
3/27/2000	3.23				29.37
4/20/2000	3.51				19.5
4/20/2000	3.59				28.28
6/7/2000	4.19				25.4
6/7/2000	4.15				33.3
7/8/2004	3.09				30.5
9/15/2004	3.11				28
11/2/2004	2.58				16.67
12/8/2004	3.5				28.6
1/27/2005	4.36				23
4/14/2005	2.82				23.1
6/30/2005	4.46				26.4
8/24/2005	1.34				31.3
					30.6
Average	3.11	mg/L			25
					28.5
					28
					27.2
					29.1
					25.8
					29.2
					3.16
					32.1
					32.4
Mass Discharge		259,029	lbs/Yr		32.5
					24.3
					22.5
					30.9
62 Mo. Average Annual Discharge - DMR				27.4	31.6
				MGD	31.96
					59.1
					12.6
					25.4
					25.8
					27
					27.7
					28.82
					31.7
				Average	27.4 MGD Storet

Phosphorus - CVWRF Storet

2/29/2000	2.56		Central Valley WRF				
2/29/2000	3.74						
12/8/2004	2.07						
1/13/2000	3.48						
1/13/2000	3.41				61.9		
5/5/2000	3.33				70.6		
5/5/2000	3.17				41		
8/24/2005	2.14				63.2		
3/27/2000	3.33				59.25		
3/27/2000	3.28				57		
6/7/2000	2.63				49.3		
6/7/2000	2.84				54.3		
6/30/2005	3.16				59.3		
4/14/2005	2.75				50		
1/27/2005	3.55				52.2		
5/24/2000	4.49				25.8		
5/24/2000	3.14				66.8		
9/14/2004	3.41				67.7		
7/8/2004	2.73				53.8		
					51.4		
Average	3.12	mg/L			52		
					59.8		
					53.3		
					67.5		
					69.2		
					59.5		
					63.1		
					51		
					58		
					55		
					52.3		
Mass Discharge		489,497	lbs/Yr		49.7		
					90		
					51.4		
					66.4		
					56		
62 Mo. Average Annual Discharge - DMR				51.6	56.7		
				MGD	55.1		
					54.1		
					70.3		
					45.45		
					57.1		
					61.6		
					63.5		
			Average		57.5	MGD	Storet

Phosphorus - SLC Storet

4/13/2005	2.48		Salt Lake City WRF				
11/4/2004	2.44						
9/14/2004	3.87						
2/29/2000	2.49				38.7		
2/29/2000	3.58				35.3		
8/17/2004	2.54				30.5		
3/28/2000	3				35		
3/28/2000	3.53				31.64		
6/30/2005	3.15				29.4		
12/8/2004	2.72				32		
1/26/2005	3.54				33		
4/18/2000	0.259				31.3		
4/18/2000	2.9				37.8		
6/6/2000	3.42				39.7		
6/6/2000	2.8				35.1		
5/23/2000	4.08				30.2		
5/23/2000	2.92				13.9		
1/12/2000	2.97				35.86		
1/12/2000	2.89				22.3		
7/7/2004	3.92				33.3		
5/4/2000	3.28				43.6		
5/4/2000	4.44				2.95		
8/23/2005	2.79				38		
					26.1		
Average	3.04	mg/L			37.2		
					29.9		
					33.5		
					33.8		
					41		
					32.3		
					35		
Mass Discharge		291,874	lbs/Yr		40		
					41		
					43		
62 Mo. Average Annual Discharge - DMR				31.5	14.8		
				MGD	63		
					28.6		
					34.3		
					32		
					40.4		
					41		
					25.4		
					41.5		
					32.59		
				Average	33.6	MGD	Storet

Phosphorus - So Davis So. Storet

1/11/2000	1.63		S DAVIS S WWTP Facility	40.8425	-111.9416667		
1/11/2000	1.62						
2/29/2000	1.31						
2/29/2000	2.3						
3/28/2000	2						
3/28/2000	2.06				3.2		
4/18/2000	0.142				2.327		
4/18/2000	2.06				2.6		
5/4/2000	3.68				2.7		
5/4/2000	2.08				2.7		
5/23/2000	2.47				3.1		
5/23/2000	1.61				3.7		
6/6/2000	1.89				3.1		
6/6/2000	2.03				3.5		
7/6/2004	2.9				2.6		
8/17/2004	2.08				2.3		
9/14/2004	1.69				3.024		
11/4/2004	2.19				2.9		
1/26/2005	2.4				3.4		
4/13/2005	2.21				2.8		
6/30/2005	1.88				3		
8/23/2005	1.32				9.9		
					5.4		
Average	1.98	mg/L			4.5		
					3.28		
					9.3		
					3.5		
					2.57		
					2		
					2.85		
					2.4		
					2		
					2.47		
					2.8		
Mass Discharge		15,668 lbs/Yr			2.3		
					2.8		
62 Mo. Average Annual Discharge - DMR				2.6	3.8		
				MGD	2.1		
					4.8		
					2.5		
					1.7		
			Average		3.3	MGD	Storet

Phosphorus - So. Davis No. Storet

1/11/2000	2.64		S DAVIS N WWTP Facility	40.9047222	-111.9344444		
1/11/2000	2.07						
2/29/2000	1.68						
2/29/2000	2.89						
3/28/2000	2.94						
3/28/2000	3						
4/18/2000	0.212				7.34		
4/18/2000	2.66				7.1		
5/3/2000	3.59				8		
5/3/2000	4.58				9		
5/23/2000	4.34				7.9		
5/23/2000	2.87				11.6		
6/6/2000	3.18				7.9		
6/6/2000	2.57				10.6		
7/6/2004	3.06				8.3		
8/17/2004	2.35				7.08		
9/13/2004	2.08				7.7		
11/4/2004	1.96				6.8		
1/26/2005	3.39				10.4		
4/13/2005	2.33				8.2		
8/23/2005	2.53				8.2		
					7.5		
Average	2.71	mg/L			7.6		
					6.86		
					7.4		
					7.4		
					8.5		
					8.2		
					7.6		
					9		
					8		
					8.7		
					7.9		
					7.48		
					9.2		
Mass Discharge		47,032 lbs/Yr			10.7		
					7.4		
					8.03		
					6.44		
62 Mo. Average Annual Discharge - DMR				5.7	2.8		
				MGD	7.5		
					8.4		
					7.2		
					6.96		
					10.1		
					7.1		
				Average	8.0	MGD	Storet

Phosphorus - CDSD Storet

1/11/2000	3.55	CENTRAL DAVIS WWTP Facility	40.9972222	-111.9444444		
1/11/2000	3.38					
3/1/2000	1.71					
3/1/2000	3.44					
3/28/2000	0.226				0.5	
3/28/2000	4.33				6	
4/18/2000	0.198				6.8	
4/18/2000	2.39				4.1	
5/3/2000	2.09				4.8	
5/3/2000	2.44				3.6	
5/23/2000	4.49				8	
5/23/2000	6.74				6.1	
6/6/2000	4.32				7.7	
6/6/2000	4.32				4.8	
7/6/2004	4.87				5.6	
8/17/2004	3.84				7.6	
9/13/2004	3.28				7.7	
11/4/2004	1.91				5.6	
1/26/2005	2.66				4.5	
4/13/2005	1.63				5.9	
8/23/2005	3				5.8	
					5.1	
Average	3.086381 mg/L				4.4	
					6.4	
					5.9	
					4	
					5.3	
					7.7	
					9.4	
					6.2	
					4.8	
					7	
					4.5	
Mass Discharge	48,855 lbs/Yr				6.7	
					5.2	
					6.7	
					6	
					6.5	
					5.6	
62 Mo. Average Annual Discharge - DMR			5.2		7.3	
			MGD		6.1	
					7.9	
			Average		5.9 MGD	Storet

Phosphorus - No. Davis Storet

1/11/2000	3.35		N DAVIS WWTP Facility 41.0847222 -112.1116667				
1/11/2000	3.79						
3/1/2000	3.44						
3/1/2000	2.78						
3/28/2000	4.81						
3/28/2000	8.52				17		
4/18/2000	0.27				15.7		
4/18/2000	3.55				22.3		
5/3/2000	3.24				16.7		
5/3/2000	4.63				22.37		
5/23/2000	6.04				21.3		
5/23/2000	4.19				29.16		
6/6/2000	3.18				17.4		
6/6/2000	3.62				16		
7/6/2004	2.93				17.23		
8/17/2004	3.38				23.3		
11/4/2004	2.11				22		
4/13/2005	2.71				17		
8/23/2005	3.1				19.6		
					21.4		
Average	3.67	mg/L			19.7		
					21.5		
					19.9		
					26.95		
					19.2		
					21.8		
					18.4		
					18		
					22.5		
					17.8		
					22.64		
Mass Discharge		224,264	lbs/Yr		17.7		
					18.1		
					19		
					17.2		
62 Mo. Average Annual Discharge - DMR				20.1	21.14		
				MGD	24.4		
					18.9		
					17.8		
					23		
					14.3		
					18		
					32		
				Average	20.2	MGD	Storet