Development of Water Quality Standards for Willard Spur

Overview of Hydrology & External Nutrient Loads

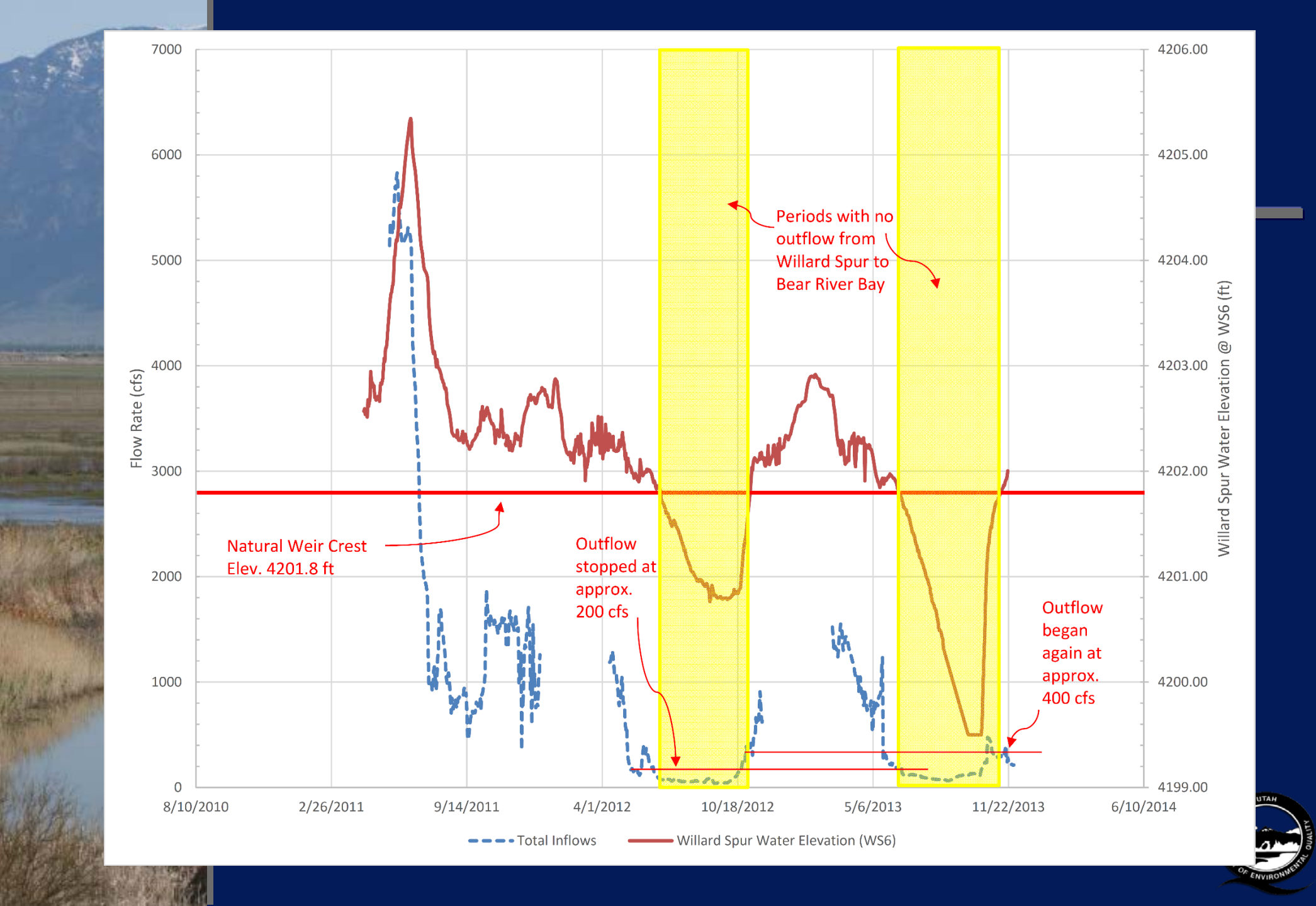
October 28, 2015

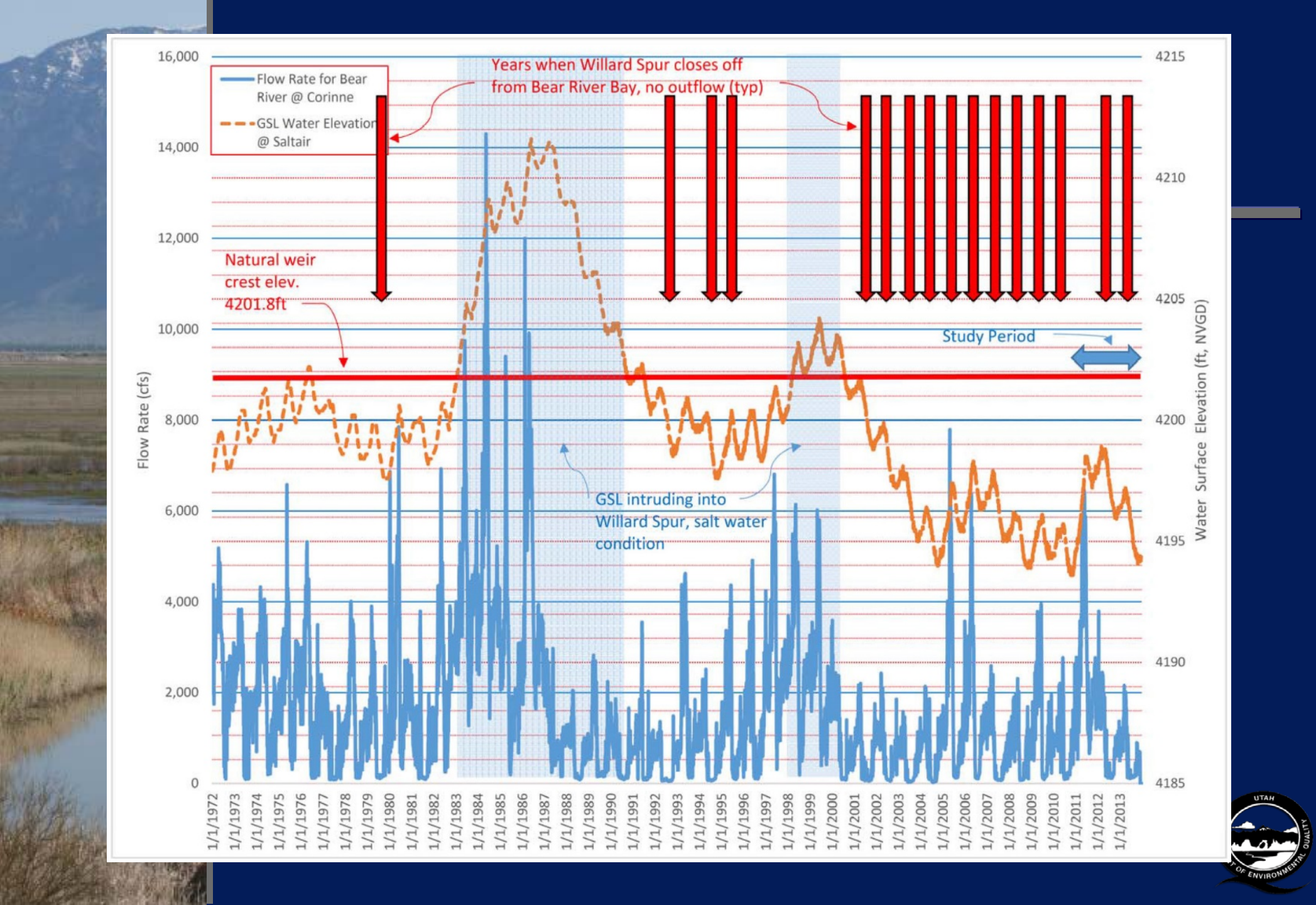
Key Observations - Hydrology

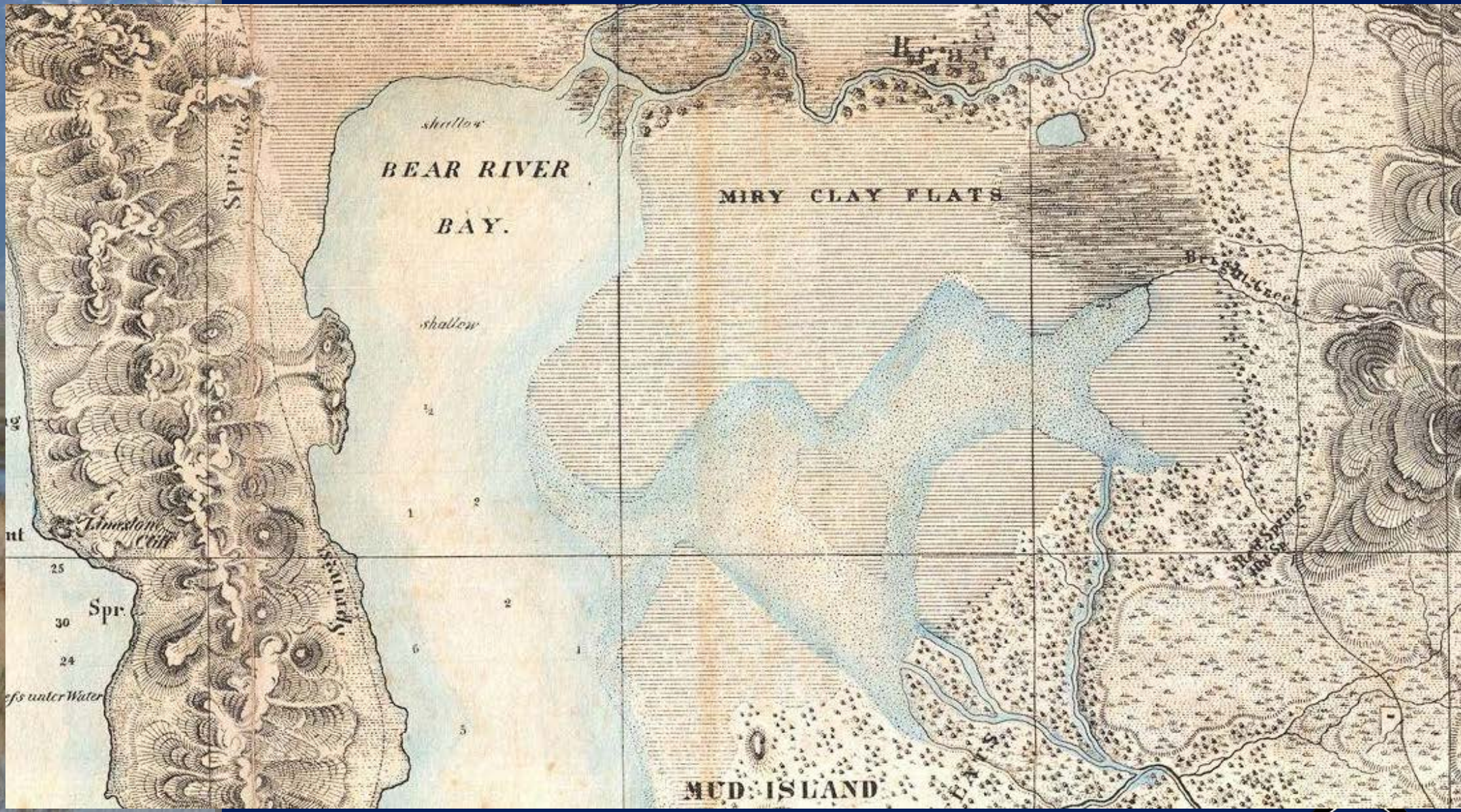
- **Three basins contributing surface water**
- **Very dependent upon dynamic inflows**
  - Dominated by Bear River flows, spring runoff
  - Water levels and conditions depend upon it

Key Observations - Hydrology

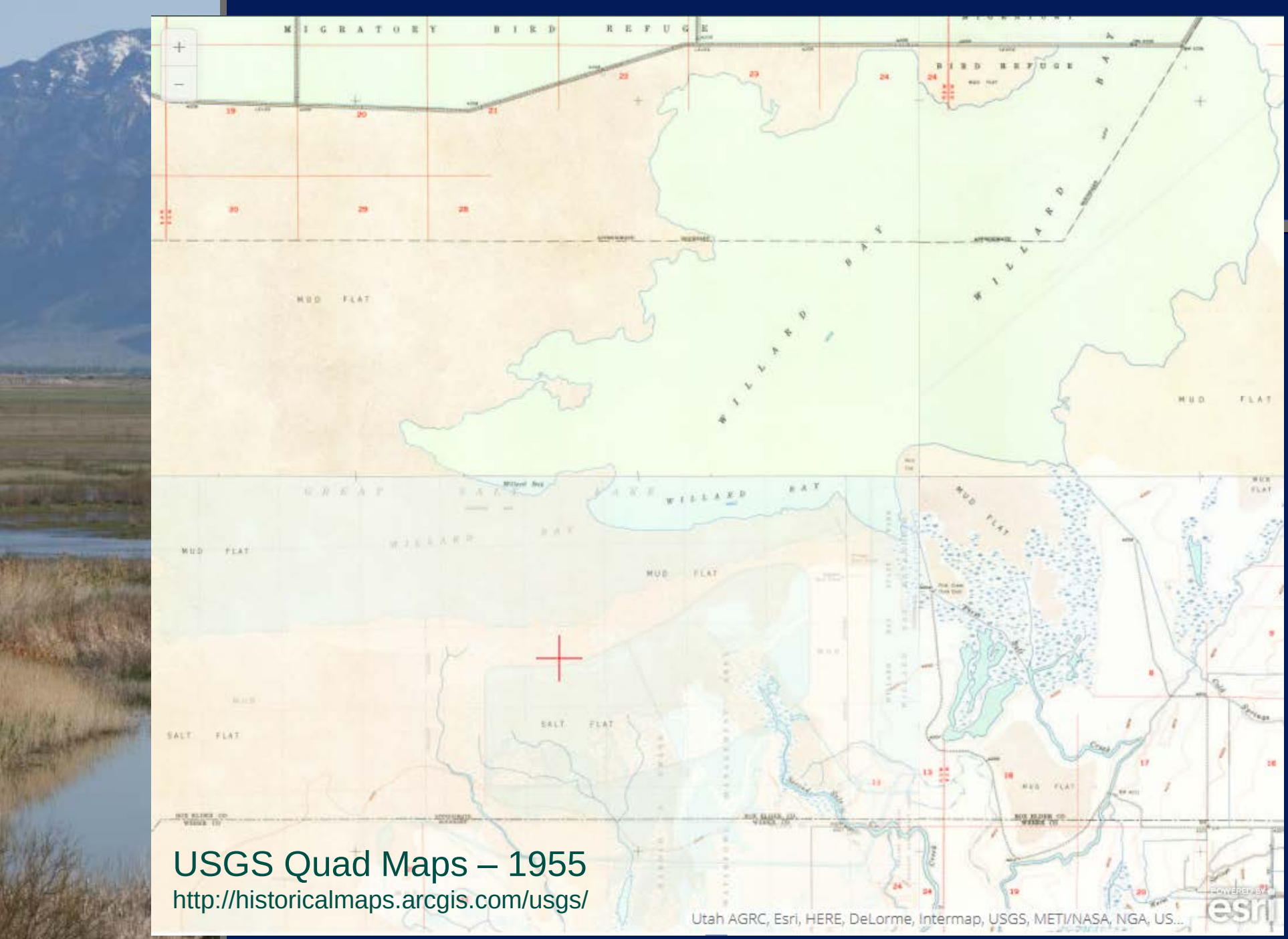
- **Typical Cycle is Key**
  - Small peak in February-March
  - Spring runoff peak in April – June
  - Sharp reduction in inflow in May – September
  - Increase in and sustained inflow in October - January
- **Typically two flow regimes per year**
  - Flowing and impounded, controlled by natural weir
  - “Flushing” flows from October-May seem to reset clock


7000
6000
5000
4000
3000
2000
1000
0
Flow Rate (cfs)
4206.00
4205.00
4204.00
4203.00
4202.00
4201.00
4200.00
4199.00
Willard Spur Water Elevation @ WS6 (ft)
8/10/2010
2/26/2011
9/14/2011
4/1/2012
10/18/2012
5/6/2013
11/22/2013
6/10/2014
Periods with no outflow from Willard Spur to Bear River Bay
Natural Weir Crest Elev. 4201.8 ft
Outflow stopped at approx. 200 cfs
Outflow began again at approx. 400 cfs
Total Inflows
Willard Spur Water Elevation (WS6)


Flow Rate for Bear River @ Corinne
GSL Water Elevation @ Saltair
Years when Willard Spur closes off from Bear River Bay, no outflow (typ)
Natural weir crest elev. 4201.8ft
Study Period
GSL intruding into Willard Spur, salt water condition
Flow Rate (cfs)
Water Surface Elevation (ft, NVGD)
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
4215
4210
4205
4200
4195
4190
4185
1/1/1972
1/1/1973
1/1/1974
1/1/1975
1/1/1976
1/1/1977
1/1/1978
1/1/1979
1/1/1980
1/1/1981
1/1/1982
1/1/1983
1/1/1984
1/1/1985
1/1/1986
1/1/1987
1/1/1988
1/1/1989
1/1/1990
1/1/1991
1/1/1992
1/1/1993
1/1/1994
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
1/1/2011
1/1/2012
1/1/2013



https://commons.wikimedia.org/wiki/File:1852_Stansbury_Map_of_Utah_and_the_Great_Salt_Lake_-_Geographicus_-_GreatSaltLake2-stansbury-1852.jpg

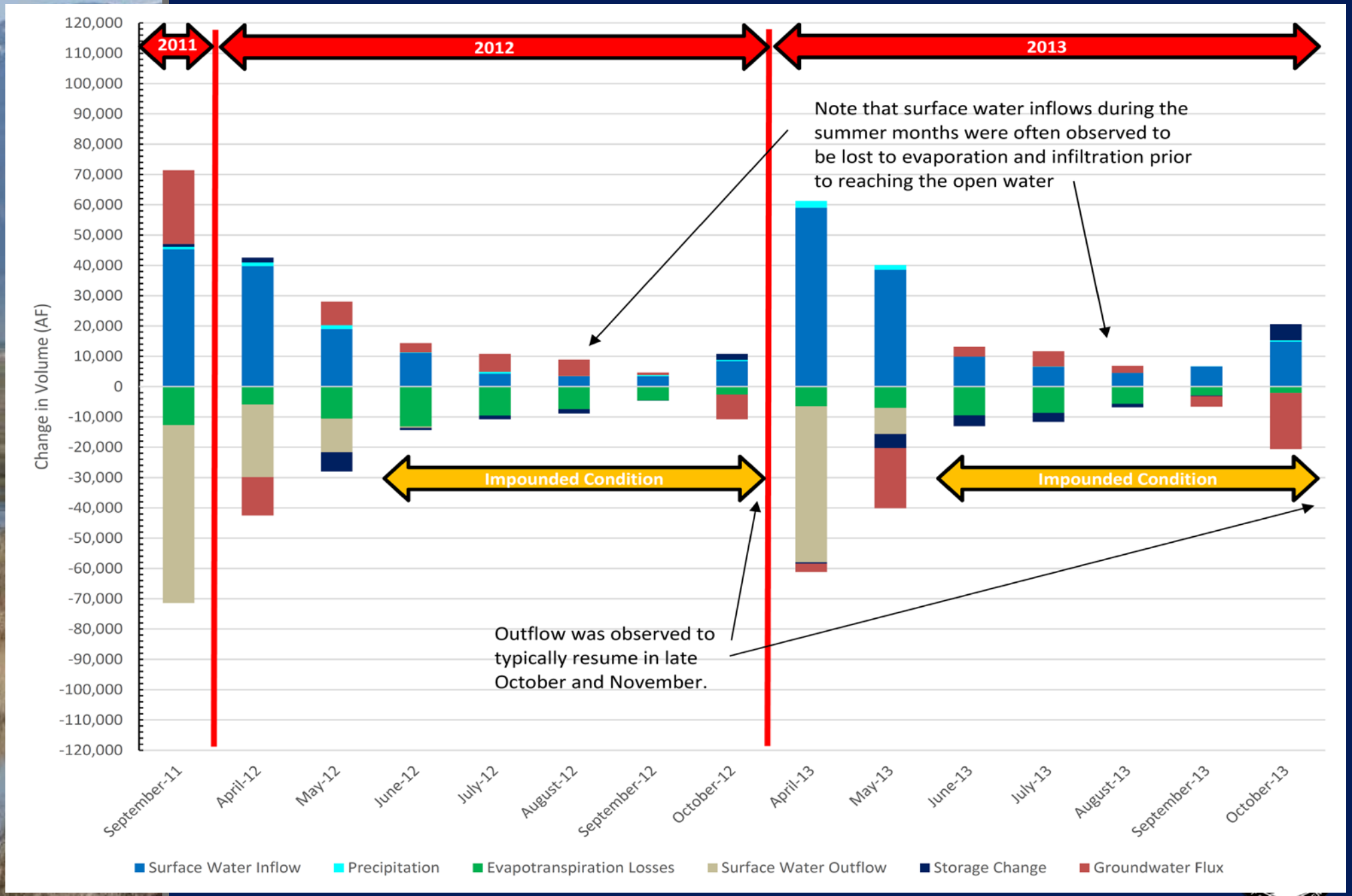


USGS Quad Maps – 1955

http://historicalmaps.arcgis.com/usgs/

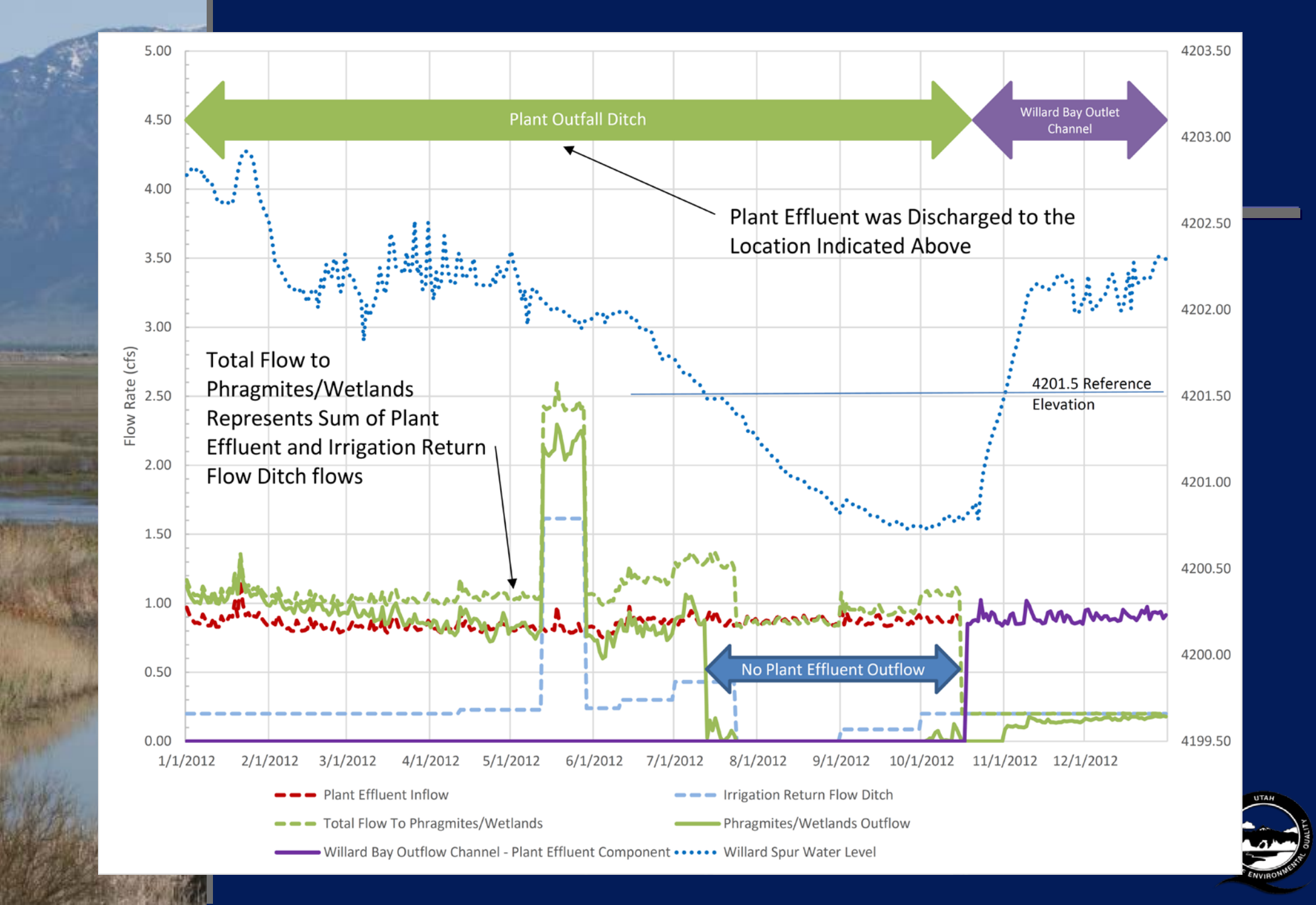
Key Observations - Hydrology

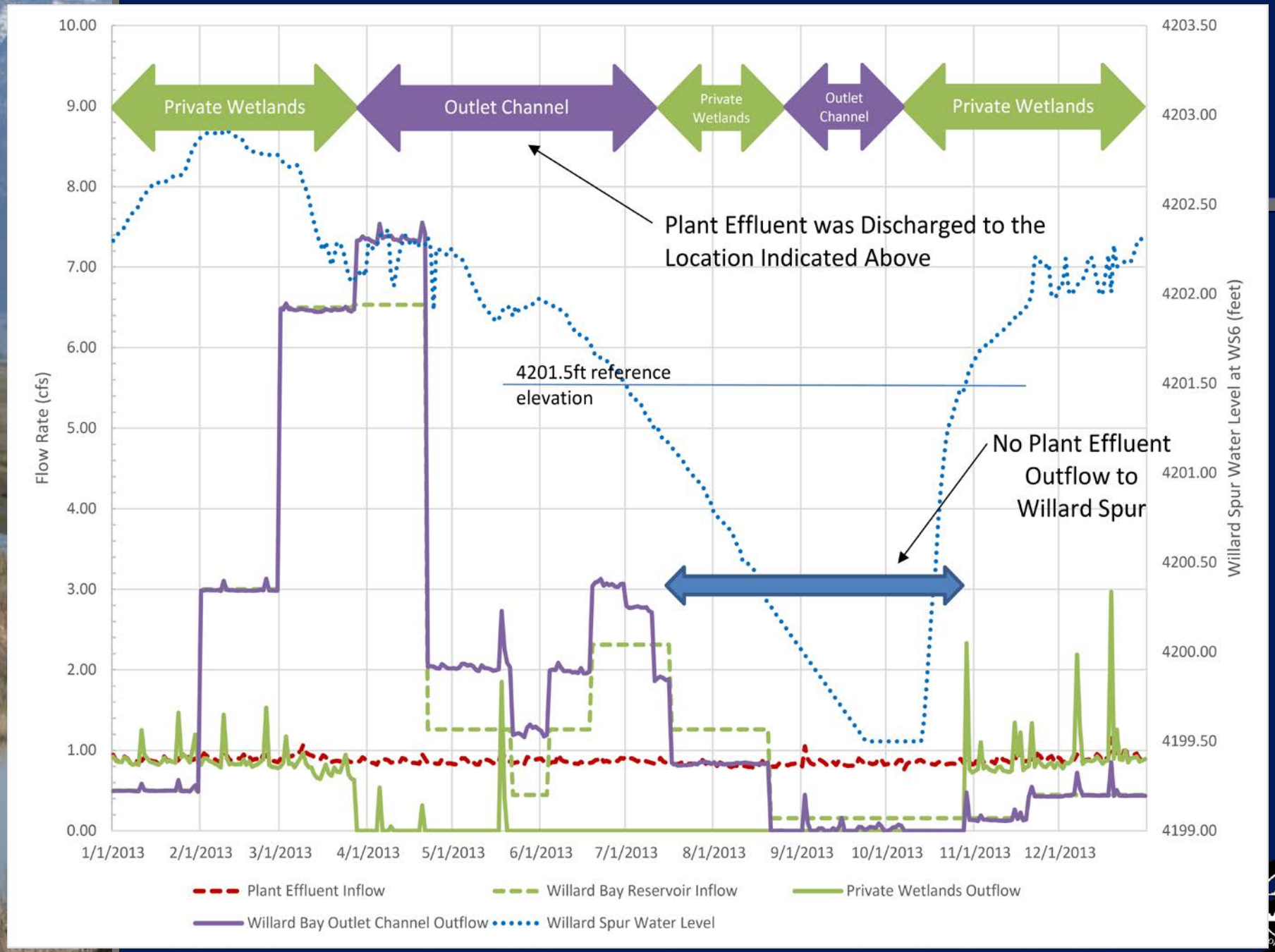
- **Water Balance indicated significant groundwater interaction**
  - Infiltrating inflows
  - Maintaining pool elevation
  - Recharging prior to outflow to Bear River Bay
  - Two unknowns; difficult to define


2011
2012
2013
Note that surface water inflows during the summer months were often observed to be lost to evaporation and infiltration prior to reaching the open water
Impounded Condition
Impounded Condition
Outflow was observed to typically resume in late October and November.
Change in Volume (AF)
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
-60,000
-70,000
-80,000
-90,000
-100,000
-110,000
-120,000
September-11
April-12
May-12
June-12
July-12
August-12
September-12
October-12
April-13
May-13
June-13
July-13
August-13
September-13
October-13
Surface Water Inflow
Precipitation
Evapotranspiration Losses
Surface Water Outflow
Storage Change
Groundwater Flux

Key Observations - Hydrology

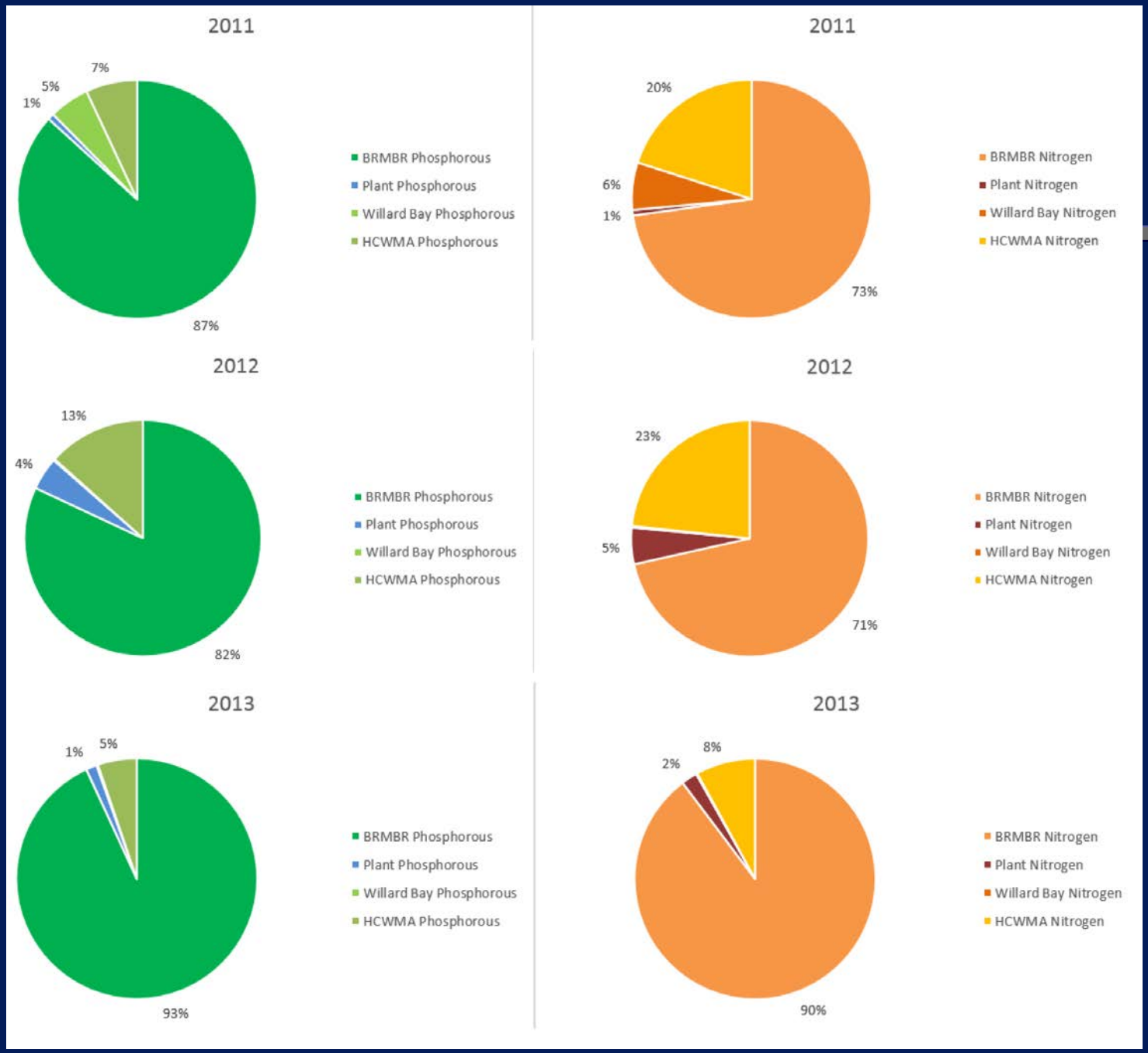
- **Plant's effluent did reach the open water; but, it depended upon:**
  - Location of discharge
  - Time of year
  - Water level in Willard Spur
  - Groundwater interaction


Plant Outfall Ditch
Willard Bay Outlet Channel
Plant Effluent was Discharged to the Location Indicated Above
Total Flow to Phragmites/Wetlands Represents Sum of Plant Effluent and Irrigation Return Flow Ditch flows
4201.5 Reference Elevation
No Plant Effluent Outflow
Flow Rate (cfs)
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
4203.50
4203.00
4202.50
4202.00
4201.50
4201.00
4200.50
4200.00
4199.50
1/1/2012
2/1/2012
3/1/2012
4/1/2012
5/1/2012
6/1/2012
7/1/2012
8/1/2012
9/1/2012
10/1/2012
11/1/2012
12/1/2012
Plant Effluent Inflow
Irrigation Return Flow Ditch
Total Flow To Phragmites/Wetlands
Phragmites/Wetlands Outflow
Willard Bay Outflow Channel - Plant Effluent Component
Willard Spur Water Level


Private Wetlands
Outlet Channel
Private Wetlands
Outlet Channel
Private Wetlands
Plant Effluent was Discharged to the Location Indicated Above
4201.5ft reference elevation
No Plant Effluent Outflow to Willard Spur
Flow Rate (cfs)
Willard Spur Water Level at WS6 (feet)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
4203.50
4203.00
4202.50
4202.00
4201.50
4201.00
4200.50
4200.00
4199.50
4199.00
1/1/2013
2/1/2013
3/1/2013
4/1/2013
5/1/2013
6/1/2013
7/1/2013
8/1/2013
9/1/2013
10/1/2013
11/1/2013
12/1/2013
Plant Effluent Inflow
Willard Bay Reservoir Inflow
Private Wetlands Outflow
Willard Bay Outlet Channel Outflow
Willard Spur Water Level

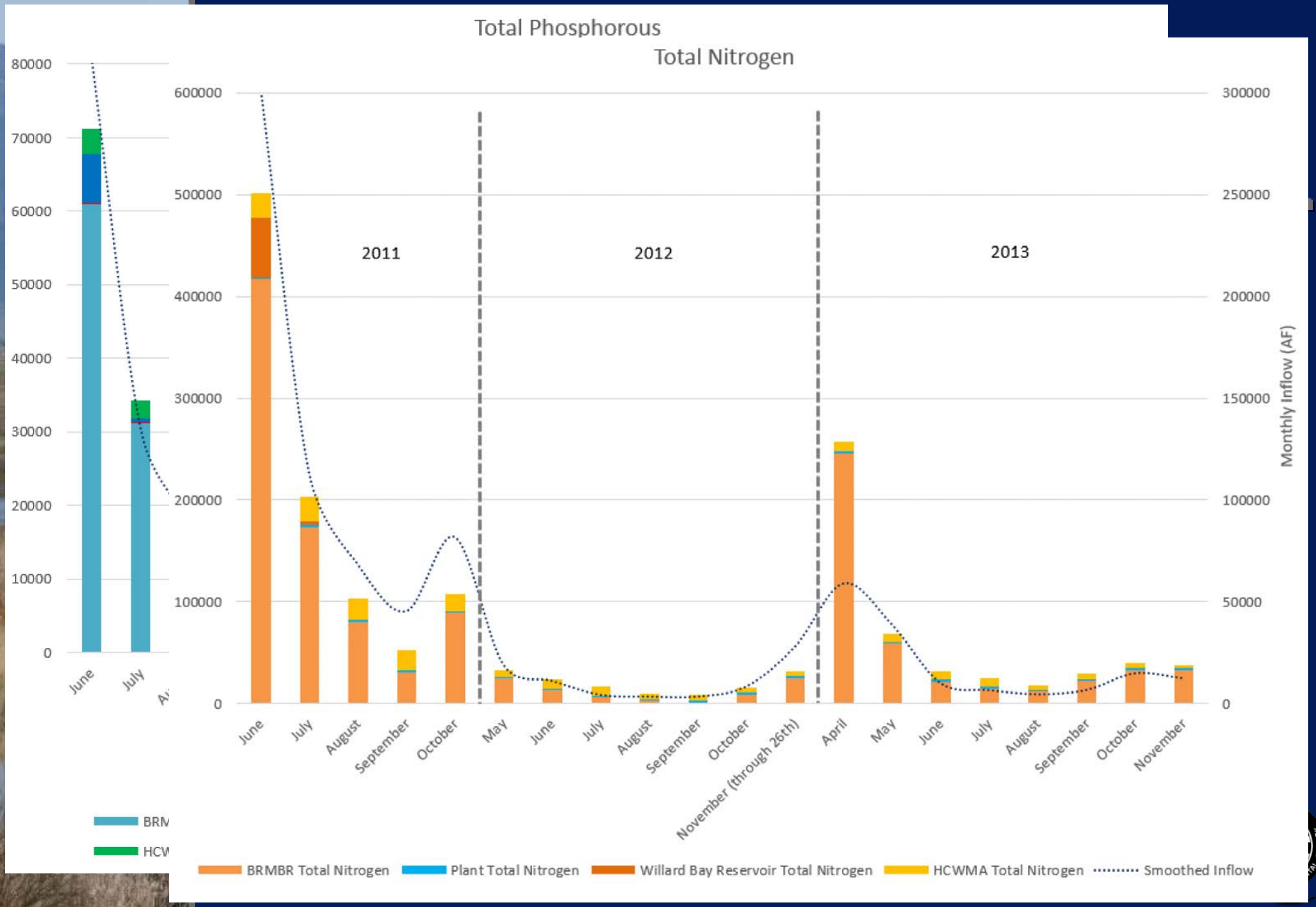
Key Observations – Nutrient Loads

- **BRMBR was primary source of nutrient inputs, followed by HCWMA**
  - Together represent 90-100% of nutrient input
- **Plant was typically <5% of the nutrient input**
  - Contribution to total budget increased as percentage during summer but actual load reaching open water during this period was negligible


2011
7%
5%
1%
87%
BRMBR Phosphorous
Plant Phosphorous
Willard Bay Phosphorous
HCWMA Phosphorous
2011
20%
6%
1%
73%
BRMBR Nitrogen
Plant Nitrogen
Willard Bay Nitrogen
HCWMA Nitrogen
2012
13%
4%
82%
BRMBR Phosphorous
Plant Phosphorous
Willard Bay Phosphorous
HCWMA Phosphorous
2012
23%
5%
71%
BRMBR Nitrogen
Plant Nitrogen
Willard Bay Nitrogen
HCWMA Nitrogen
2013
1%
5%
93%
BRMBR Phosphorous
Plant Phosphorous
Willard Bay Phosphorous
HCWMA Phosphorous
2013
8%
2%
90%
BRMBR Nitrogen
Plant Nitrogen
Willard Bay Nitrogen
HCWMA Nitrogen

Key Observations – Nutrient Loads

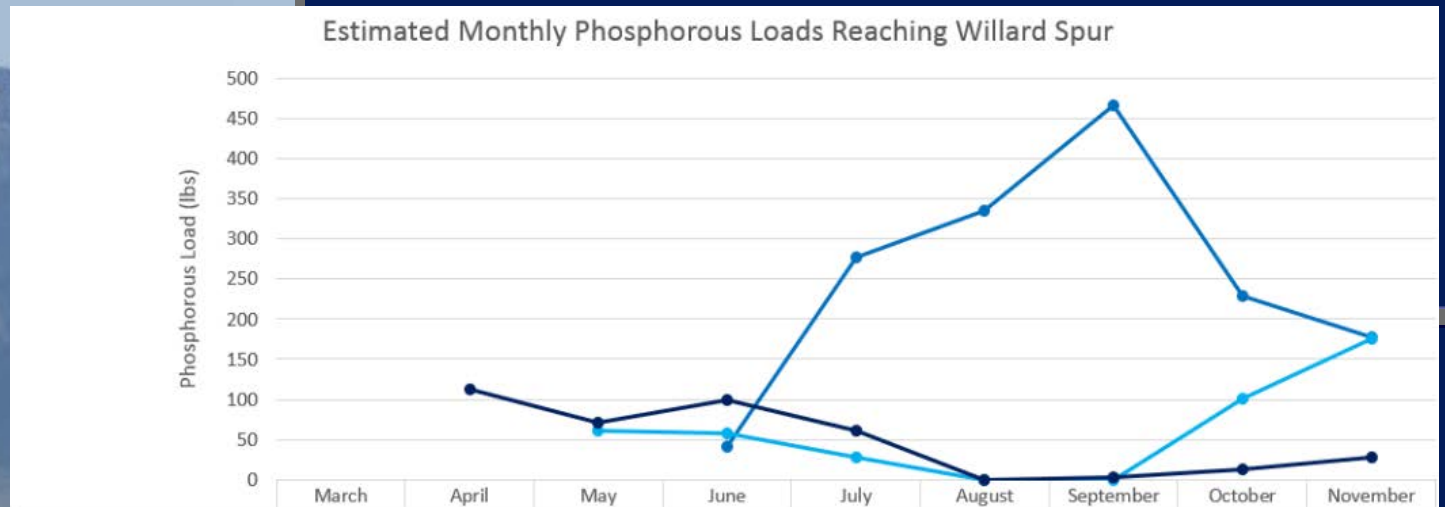
- **Seasonal loading tracked with inflow hydrographs**
  - Higher during spring runoff and winter flows
  - Low in summer, not certain how much of this load reached the open water
- **Majority of external load enters during spring runoff**
  - Perhaps also during winter?


Total Phosphorous
Total Nitrogen
2011
2012
2013
Monthly Inflow (AF)
June
July
August
September
October
May
June
July
August
September
October
November (through 26th)
April
May
June
July
August
September
October
November
BRMBR Total Nitrogen
Plant Total Nitrogen
Willard Bay Reservoir Total Nitrogen
HCWMA Total Nitrogen
Smoothed Inflow

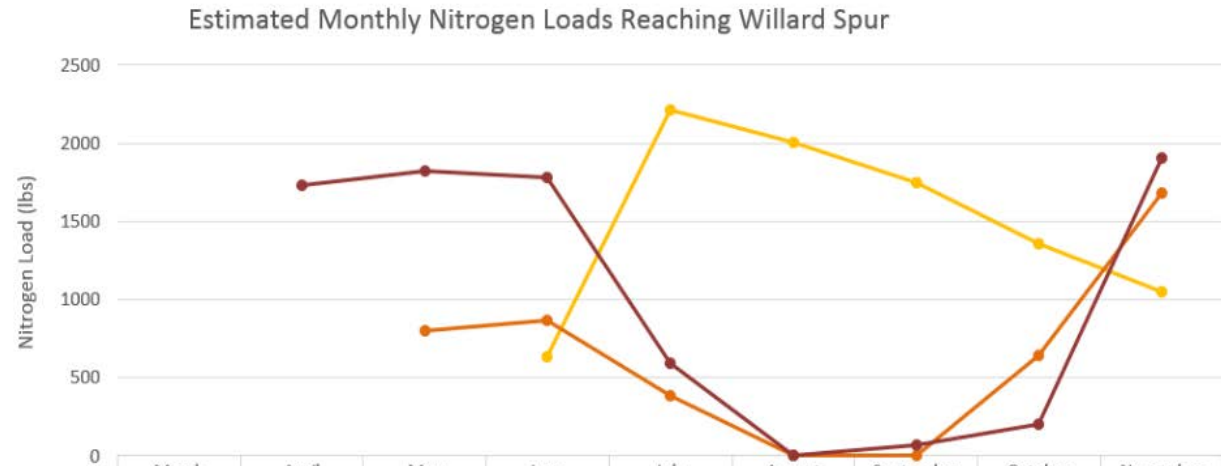
Key Observations – Nutrient Loads

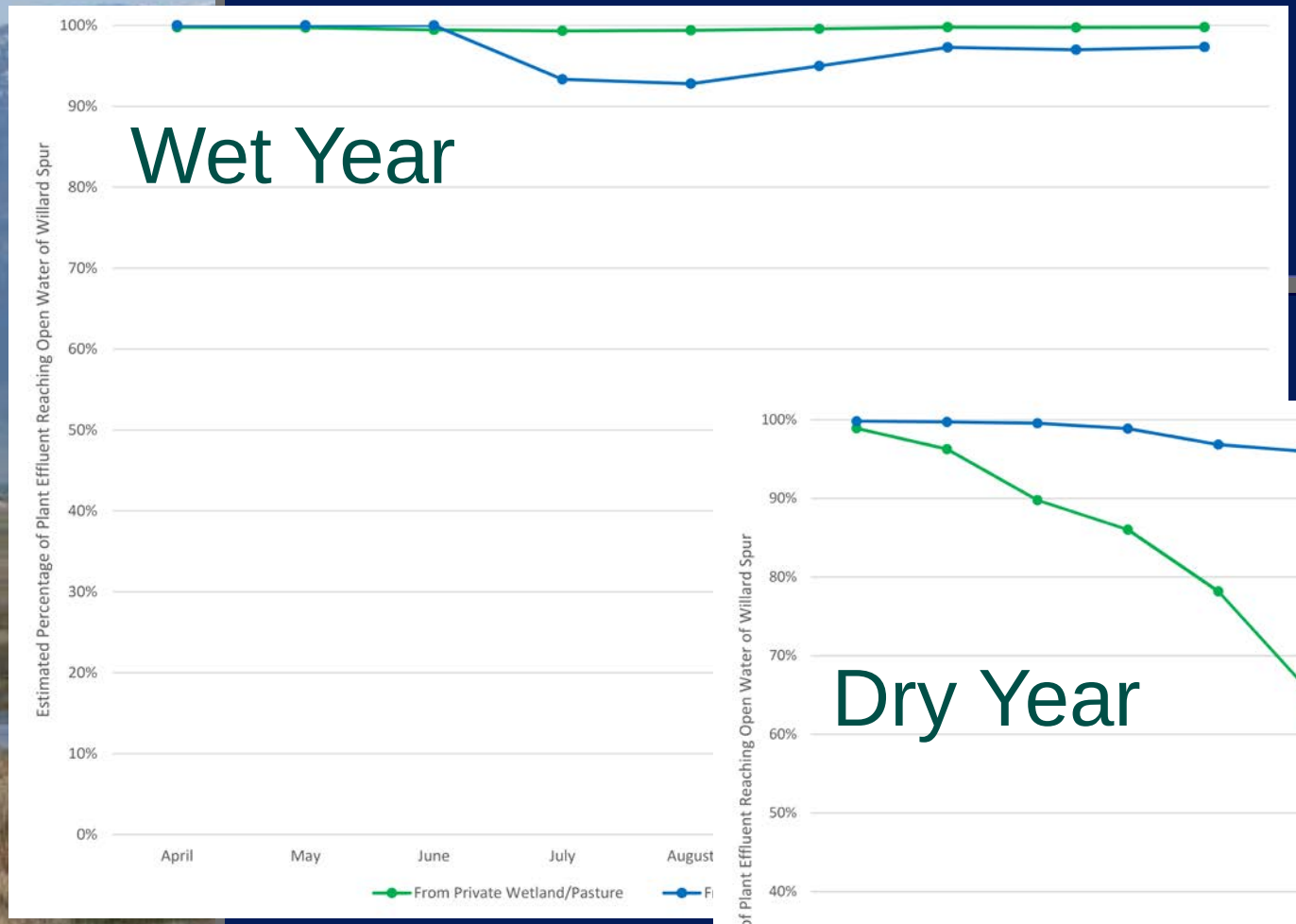
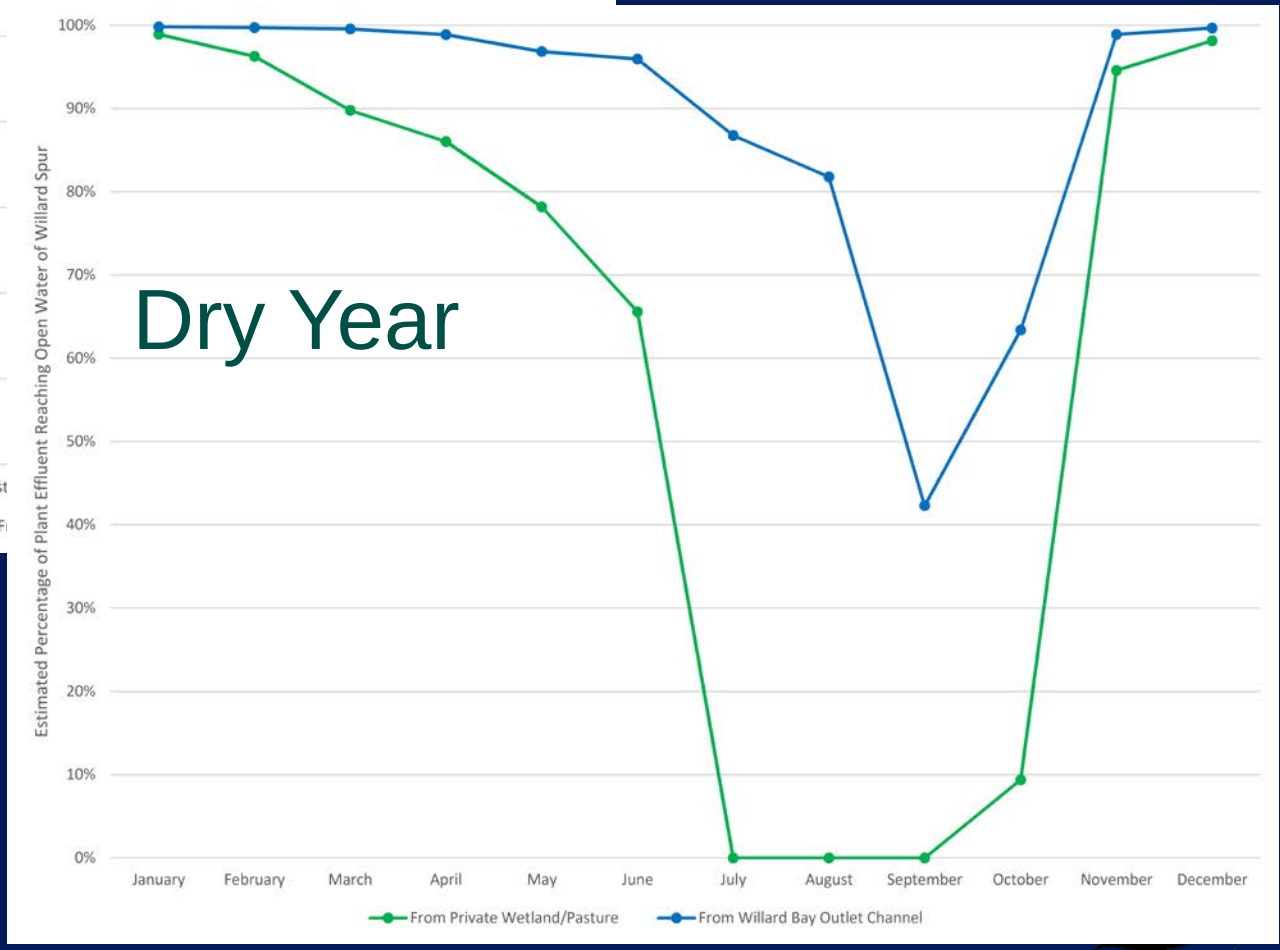
- **Plant's effluent did reach the open water; but, it depended upon:**
  - Location of discharge
  - Time of year
  - Water level in Willard Spur
  - Groundwater interaction

Estimated Monthly Plant Loads Reaching Willard Spur



	March	April	May	June	July	August	September	October	November
2011				41	277	335	467	230	178
2012			61	57	28	0	0	101	176
2013		112	71	99	62	0	3	13	27
2011 Average Daily Load			4	1	9	11	16	8	6
2012 Average Daily Load		2	2	2	1	0	0	3	7
2013 Average Daily Load	10	4	2						



	March	April	May	June	July	August	September	October	November
2011				637	2215	2008	1750	1355	1051
2012			798	865	387	0	0	642	1680
2013		1729	1823	1779	592	0	73	201	1906
2011 Average Daily Load			54	21	71	65	58	45	35
2012 Average Daily Load		20	26	29	12	0	0	21	65
2013 Average Daily Load	63	58	59	59	19	0	2	6	64

Simulated % of Effluent Reaching Willard Spur