Development of Water Quality Standards for Willard Spur

What are the Impacts from the Plant?

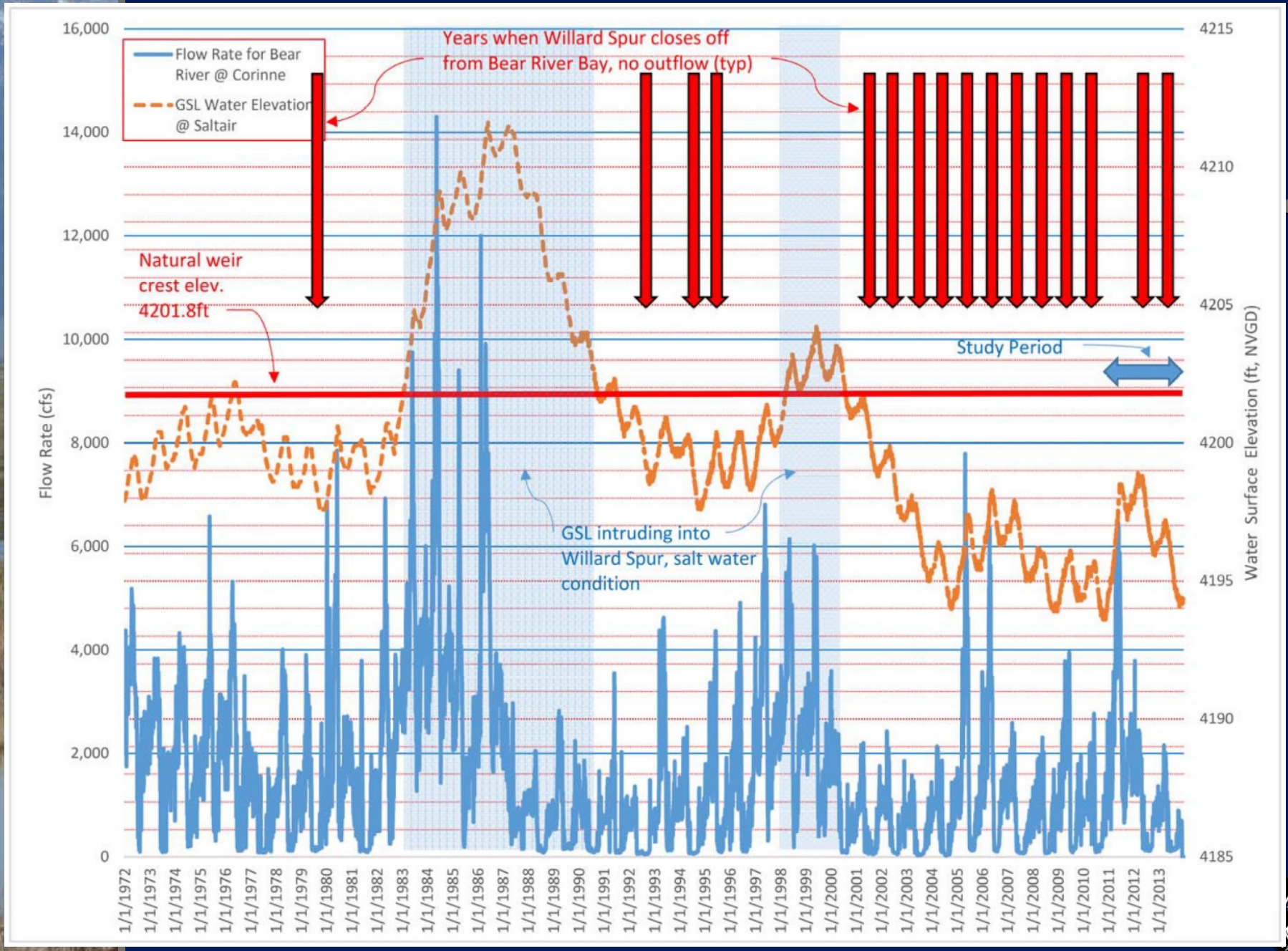
July 9, 2014

Key Observations - Uses

- **What are the key beneficial uses we observed in Willard Spur?**
  - Primary and secondary recreation
  - Waterfowl & Shorebirds
  - Other water-oriented wildlife including their necessary food chain
  - Warm-water fishery
  - Fresh water invertebrates
  - Emergent and submerged vegetation

Key Observations - Hydrology

- **Very dependent upon dynamic inflows**
  - Dominated by Bear River flows, spring runoff
  - Water levels and conditions depend upon it
- **Typically two flow regimes per year**
  - Flowing and impounded, controlled by natural weir
  - "Flushing" flows from October-May seem to reset clock


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
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1/1/2004
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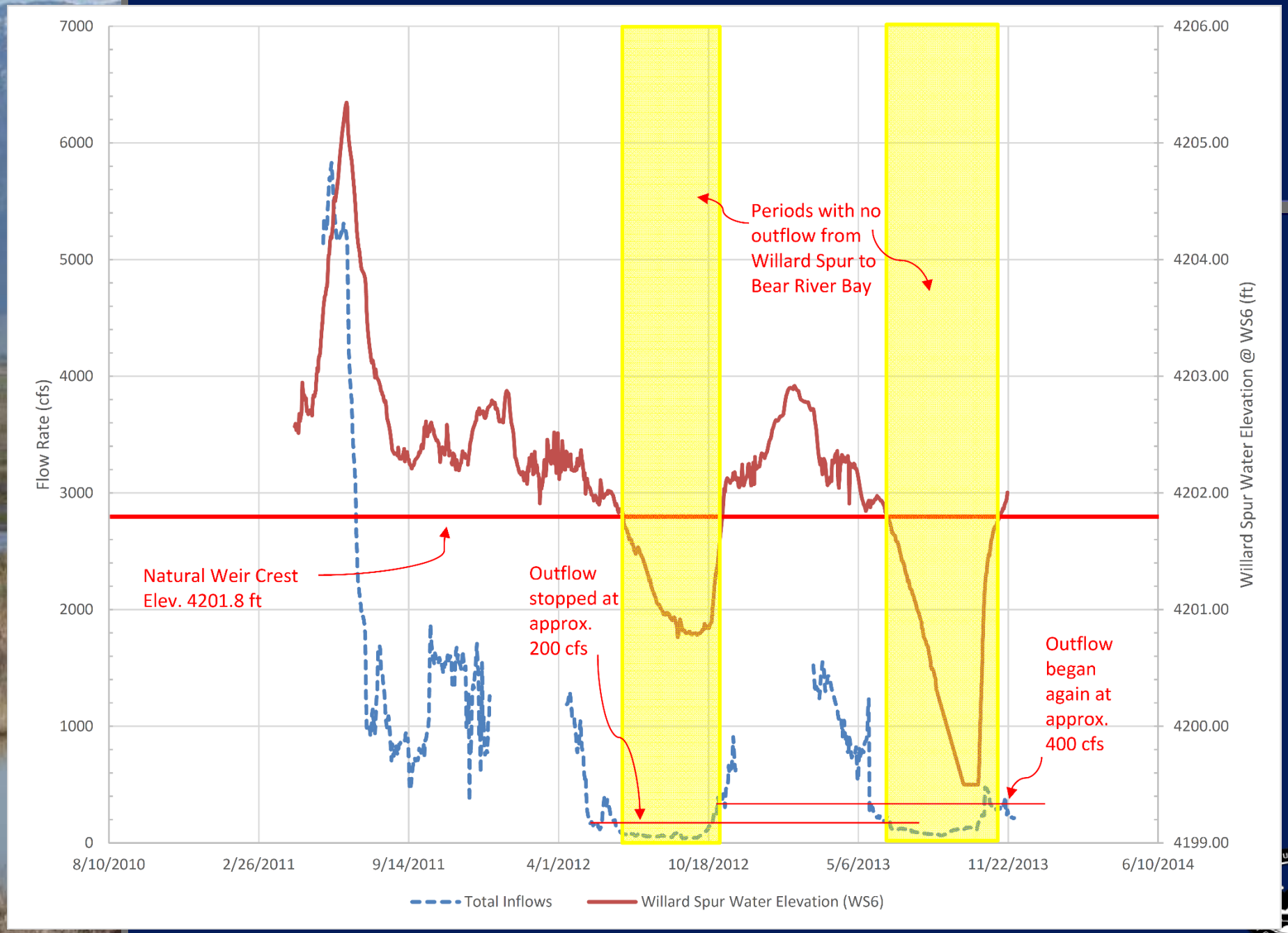
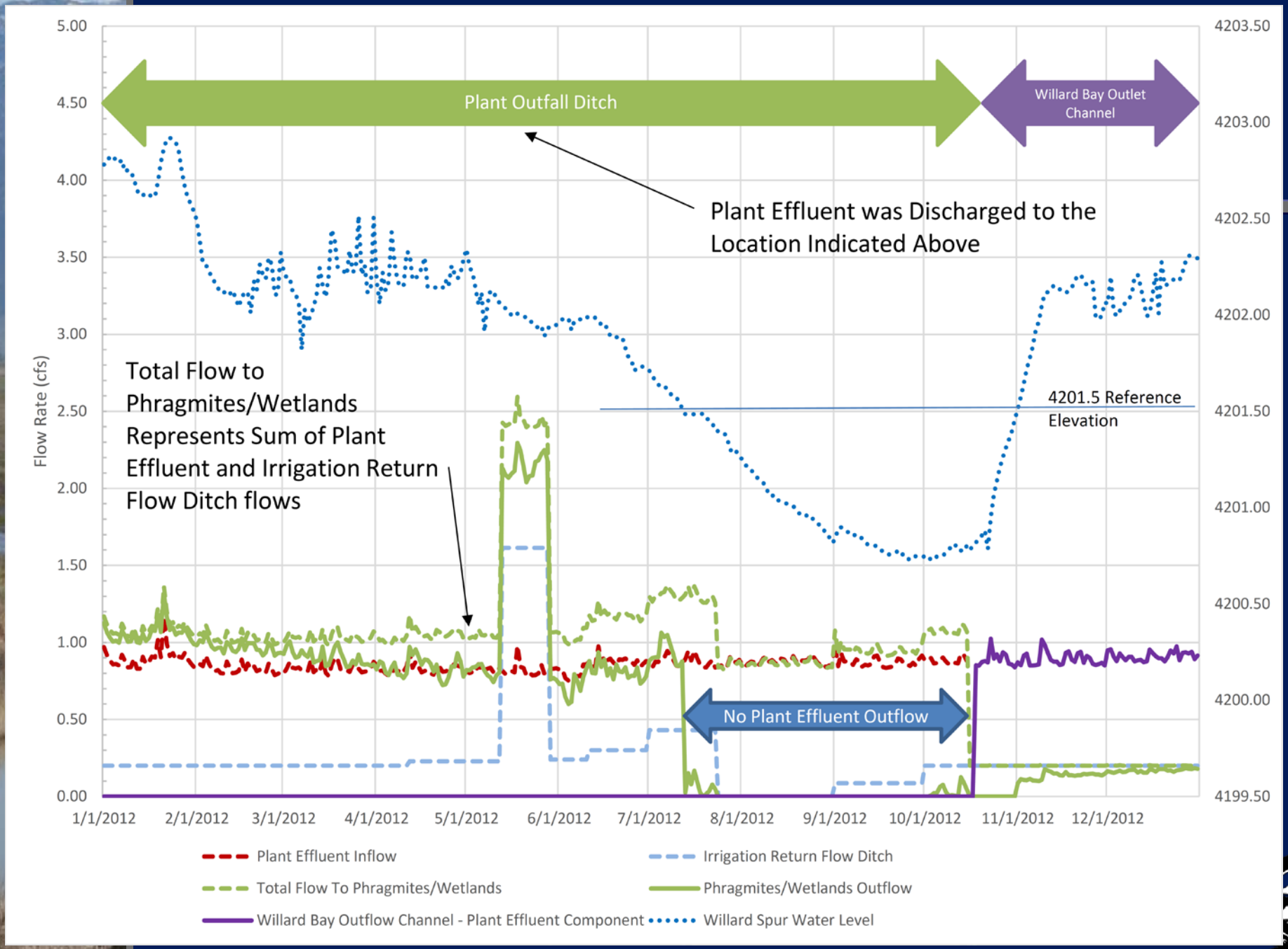
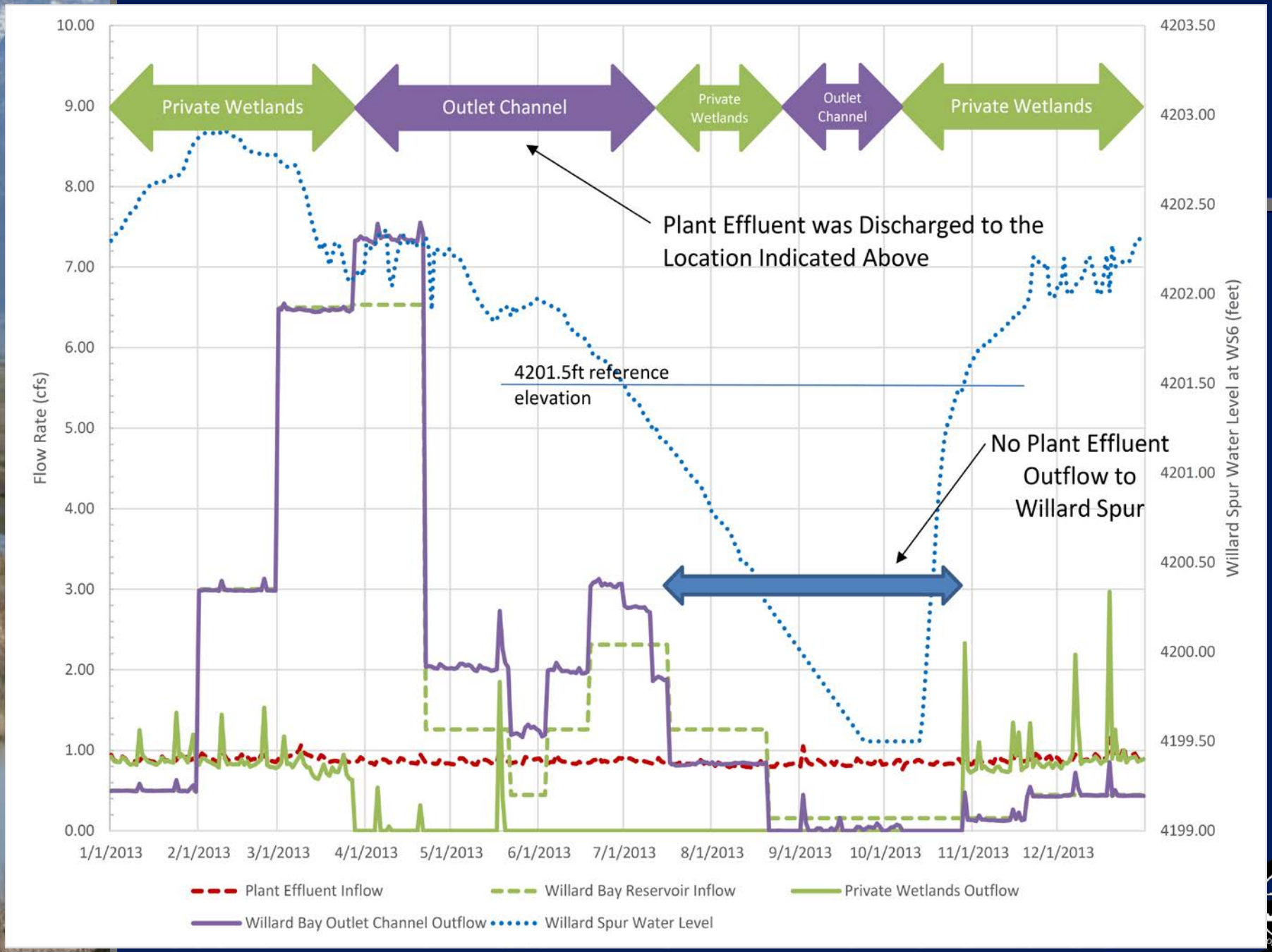
1/1/2011
1/1/2012
1/1/2013


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)


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

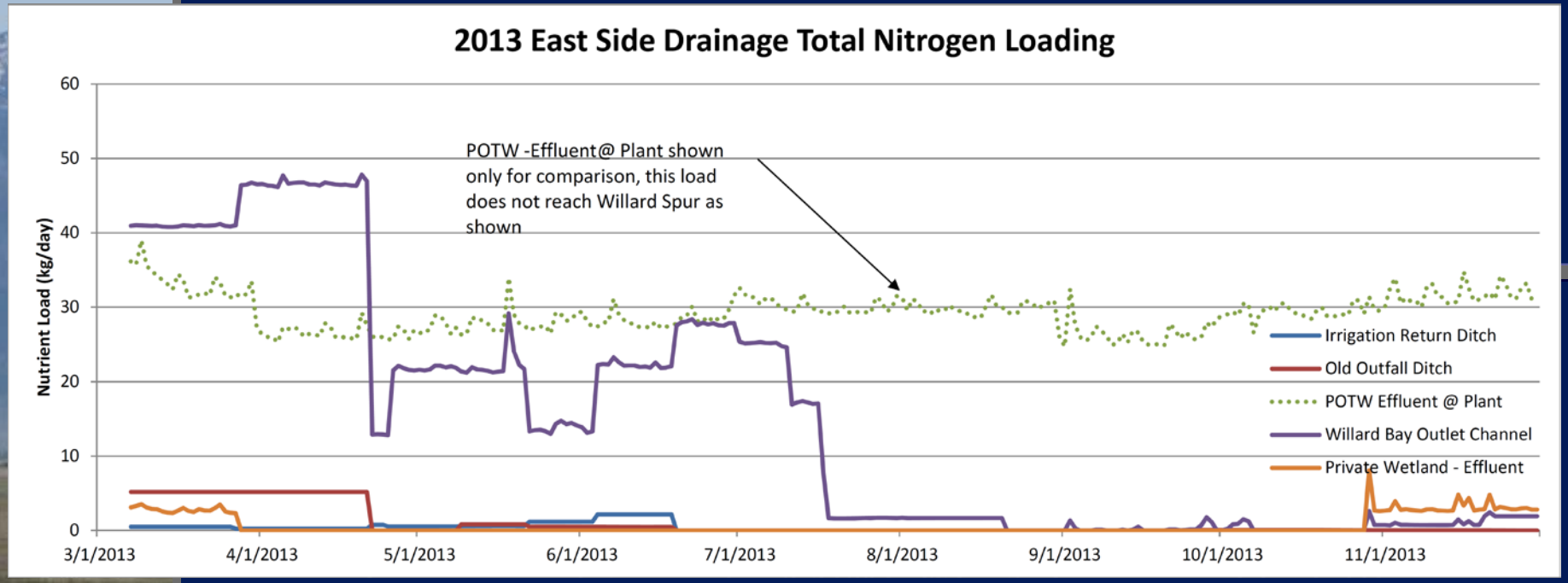

Private Wetlands
Outlet Channel
Private Wetlands
Outlet Channel
Private Wetlands
Plant Effluent was Discharged to the Location Indicated Above
4201.5ft reference elevation
No Plant Effluent Outflow to Willard Spur
Flow Rate (cfs)
Willard Spur Water Level at WS6 (feet)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
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

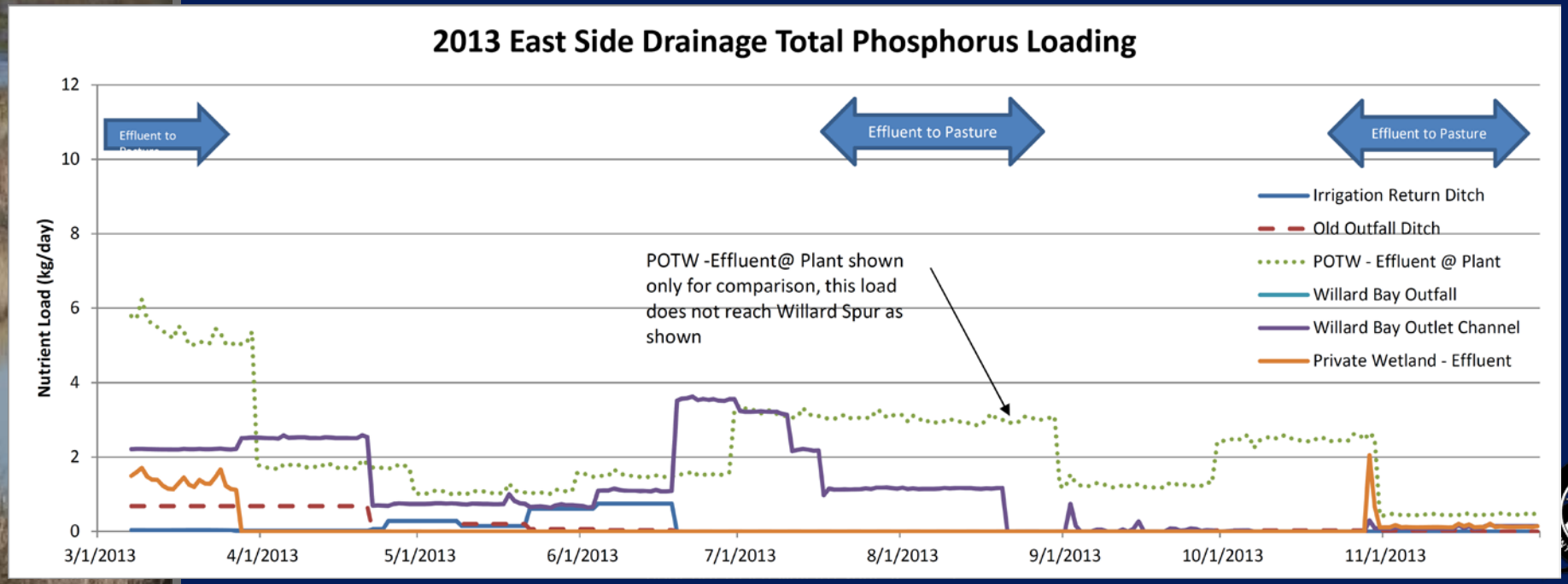
Key Observations - Hydrology

- **Will not be able to “close” the water balance**
  - Outflow rating curve only good up to about 1500 cfs
  - Infiltration losses

Key Observations – Nutrient Loads

- **BRMBR was primary source of nutrient inputs, followed by HCWMA**
  - Together represent 90-100% of nutrient input
- **Plant was typically <3% of the nutrient input**
  - Pasture exhibited significant assimilation/loss of water and nutrients


2013 East Side Drainage Total Nitrogen Loading
Nutrient Load (kg/day)
60
50
40
30
20
10
0
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
POTW -Effluent@ Plant shown only for comparison, this load does not reach Willard Spur as shown
Irrigation Return Ditch
Old Outfall Ditch
POTW Effluent @ Plant
Willard Bay Outlet Channel
Private Wetland - Effluent


2013 East Side Drainage Total Phosphorus Loading
Nutrient Load (kg/day)
12
10
8
6
4
2
0
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
Effluent to Pasture
Effluent to Pasture
POTW -Effluent@ Plant shown only for comparison, this load does not reach Willard Spur as shown
Irrigation Return Ditch
Old Outfall Ditch
POTW - Effluent @ Plant
Willard Bay Outfall
Willard Bay Outlet Channel
Private Wetland - Effluent

2011	Monthly % Contribution of TP				Monthly % Contribution of TN			
	BRMBR	POTW Effluent	WB Outfall	HCWMA	BRMBR	POTW Effluent	WB Outfall	HCWMA
May	89%	0%	8%	2%	84%	0%	13%	2%
June	86%	0%	10%	5%	83%	0%	12%	5%
July	91%	1%	1%	7%	85%	1%	1%	12%
August	84%	3%	0%	14%	78%	2%	0%	20%
September	78%	4%	0%	18%	59%	3%	0%	38%
October	89%	2%	0%	10%	83%	1%	0%	16%

2013	Monthly % Contribution of TP						Monthly % Contribution of TN					
	BRMBR	Irr Ret Ditch	Old Outfall Ditch	Private Wetland	WB Outfall	HCWMA	BRMBR	Irr Ret Ditch	Old Outfall Ditch	Private Wetland	WB Outfall	HCWMA
March	95%	0%	0%	0%	0%	4%	95%	0%	0%	0%	1%	4%
April	95%	0%	0%	0%	1%	4%	95%	0%	1%	0%	1%	4%
May	94%	0%	0%	0%	0%	5%	86%	0%	3%	0%	2%	12%
June	83%	1%	0%	0%	4%	13%	69%	0%	7%	0%	5%	25%
July	78%	0%	0%	0%	6%	16%	63%	0%	0%	0%	4%	34%
August	82%	0%	0%	0%	3%	15%	72%	0%	0%	0%	0%	28%
September	86%	0%	0%	0%	0%	14%	81%	0%	0%	0%	0%	19%
October	96%	0%	0%	0%	0%	4%	87%	0%	0%	0%	0%	13%
November	97%	0%	0%	0%	0%	3%	92%	0%	0%	1%	0%	8%

Key Observations – Nutrient Response

- SAV begin to grow in April, water is usually cold and turbid, significant inflows to Willard Spur
- As water warms up in May, SAV grow vigorously in deeper water and assimilate/store nutrients, algal mats are observed in shallow shoreline areas, water begins to clear, algae/BDS begins to flourish on the SAV and assimilate/store nutrients, inflows begin to decline to the point where Willard Spur becomes an impoundment, water chemistry begins to change
- Water continues to warm in June, water chemistry evolves, macroinvertebrates begin to increase, algae/BDS continue to increase on the SAV and outcompete the SAV for nutrients, SAV begin to senesce and release nutrients back into the water

Key Observations – Nutrient Response

- SAV crash in July, begin to decompose, algae/BDS decline (due to lack of substrate?), macroinvertebrate/zooplankton species change to decomposers, nutrients from plants released back into the water column. See ammonioa, TP and TN increase in water, phytoplankton take over to consume nutrients, sediment becomes more significant uptake mechanism
- Some SAV seem to return in late August/September
- Inflows ramp up again in October, flushing any water in Willard Spur into Bear River Bay, perhaps also flushing any organic material and nutrients that remain out to Bear River Bay. Flushing flows continue through April-May of the following year. Reset the clock.

Key Observations – Nutrient Response

- **Are nutrients a primary factor in the conditions we observe?**
- **What can we say about Willard Spur's condition? Is it supporting its uses?**
- **Are the conditions observed during the impounded condition satisfactory?**
  - Did the Plant have a role in what we observed in the impoundment?

Impacts from the Plant

- **How much of the load reaches Willard Spur and when?**
  - Most of the load reaches the open water when Willard Spur levels are high
    - *Correlated to high inflows, high nutrient input from other sources, thriving SAV*
    - *High level of dilution, export and nutrient assimilation*
    - *Low risk of impact?*

Impacts from the Plant

- **How much of the load reaches Willard Spur and when?**
  - Significant evaporation/infiltration when Willard Spur levels are low, very little if any effluent reaches open water
    - *Correlated to low/no inflows to Willard Spur, impounded condition*
    - *Significant internal cycling in the impoundment, perhaps more sensitive to new inputs*
    - *But effluent currently doesn't reach it*

Impacts from the Plant

- **What happens if Plant flows increase and loads reach impoundment?**
  - Impoundment currently receives flows from BRMBR and HCWMA
  - Annual “flushing” flows become important

Impacts from the Plant

- **Localized impacts**
  - Reduced soil salinity – *phragmites*?
  - If discharged to channel, enough flow to push load to open water?
  - Algae/chl-a in outlet channel?

- **Any other impacts?**

Impacts from the Plant

- **Risks from the Plant appear to currently be low**
- **Risk could be further reduced if:**
  - Effluent is discharged to location where assimilation, evaporation, infiltration can be maximized
  - Flows reaching Willard Spur minimized
  - Flows released in pulses rather than continuous
  - Nutrient removal at Plant continued
  - *Phragmites* control
- **Assumes nutrient concentrations/loads don't increase**