First Year (2010) Of Continuous Dissolved Oxygen (DO) Measurements At The East End Of The Anchorage Canal

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April, 2011

Agenda

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Description of Environmental Monitoring Systems Available For The Continuous Dissolved Oxygen (DO) Study

- YSI 6920V2 Multiparameter Water Quality Sonde
  - YSI 6150 ROX Optical DO sensor w/ YSI 6155 membrane
  - YSI 6560 Conductivity/Temperature Probe
  - DO, Salinity, Water Temperature continuously monitored
  - Data recorded every 15 minutes.
  - Located close to the bottom in the Anchorage Canal at 105 Petherton Dr. South Bethany
- YSI Model 85 Handheld Oxygen, Conductivity, Salinity and Temperature System
  - DO, Salinity and Water Temperature Data recorded manually, approximately every two weeks
  - Measurements taken at the Continuous Monitoring Site
- ONSET #RG2 Data Logging Tipping-Bucket Rain Gage
  - Time at every bucket tip (0.01" of rainfall)
  - Located on the upper deck at 8 South 4th Street South Bethany
- USGA Tide Gage Unit 02060010
  - Data recorded every six minutes to 0.01 feet NGVD 1929
  - Located on bulkhead at the end of West 1st Street South Bethany
  - http://waterdata.usgs.gov/nwis/uv?01484696
- DEOS Bethany Beach Boardwalk Weather Station
  - Solar Radiation, Wind Direction and Wind Speed recorded every five minutes
  - http://www.deos.udel.edu/period_retrieval.html

Environmental Monitoring Systems

George Junkin with the Town of South Bethany deploys a continuously operating dissolved oxygen meter (YSI 6920V2) in the Anchorage Canal. Donated to the Anchorage Canal Study by the CIB.

YSI Model 85 Handheld Oxygen, Conductivity, Salinity and Temperature System

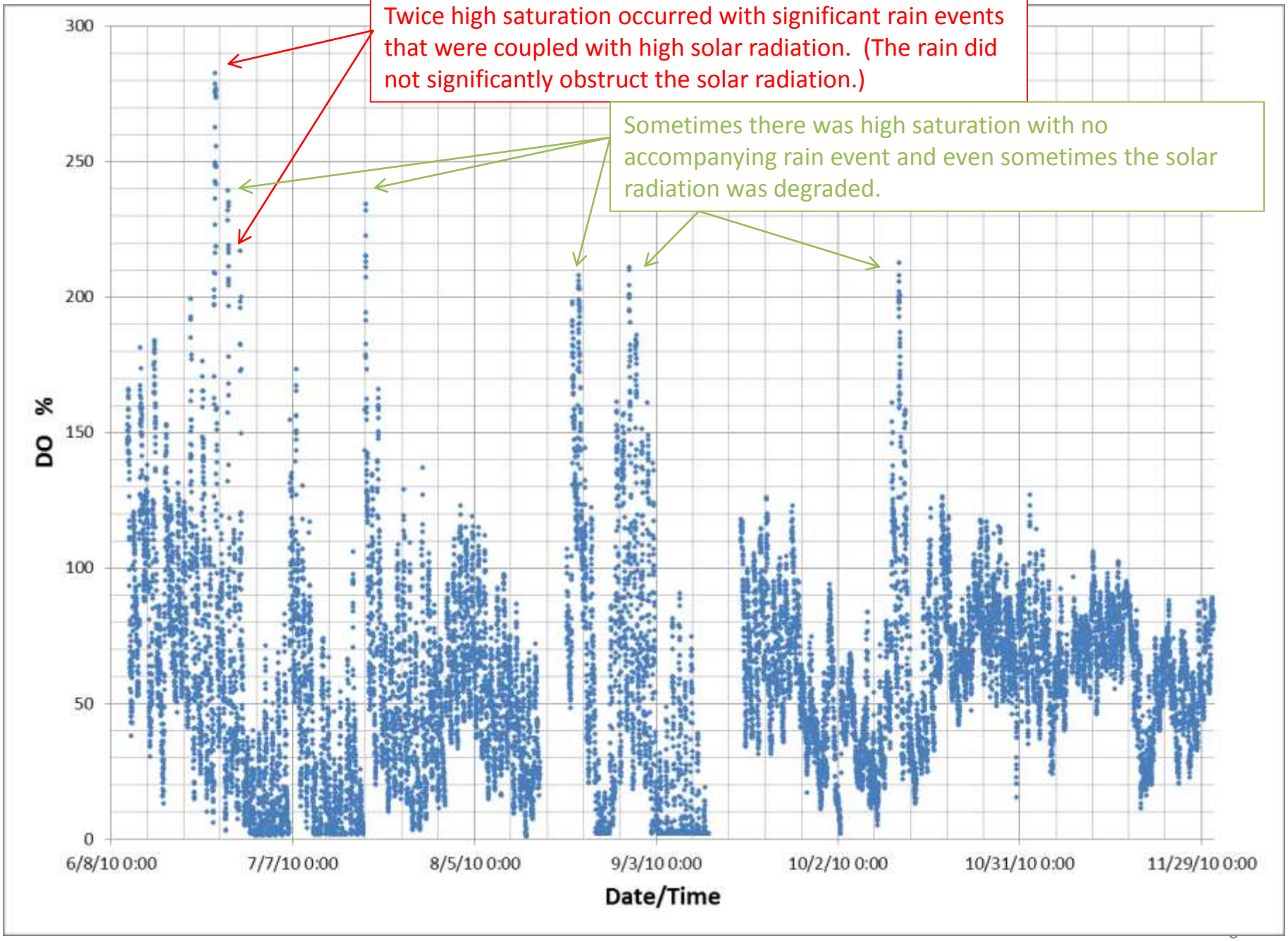
DEOS Bethany Beach Boardwalk Weather Station

ONSET #RG2 Data Logging Tipping-Bucket Rain Gage
Donated to South Bethany by DelDOT

USGA Tide Gage
Unit 02060010

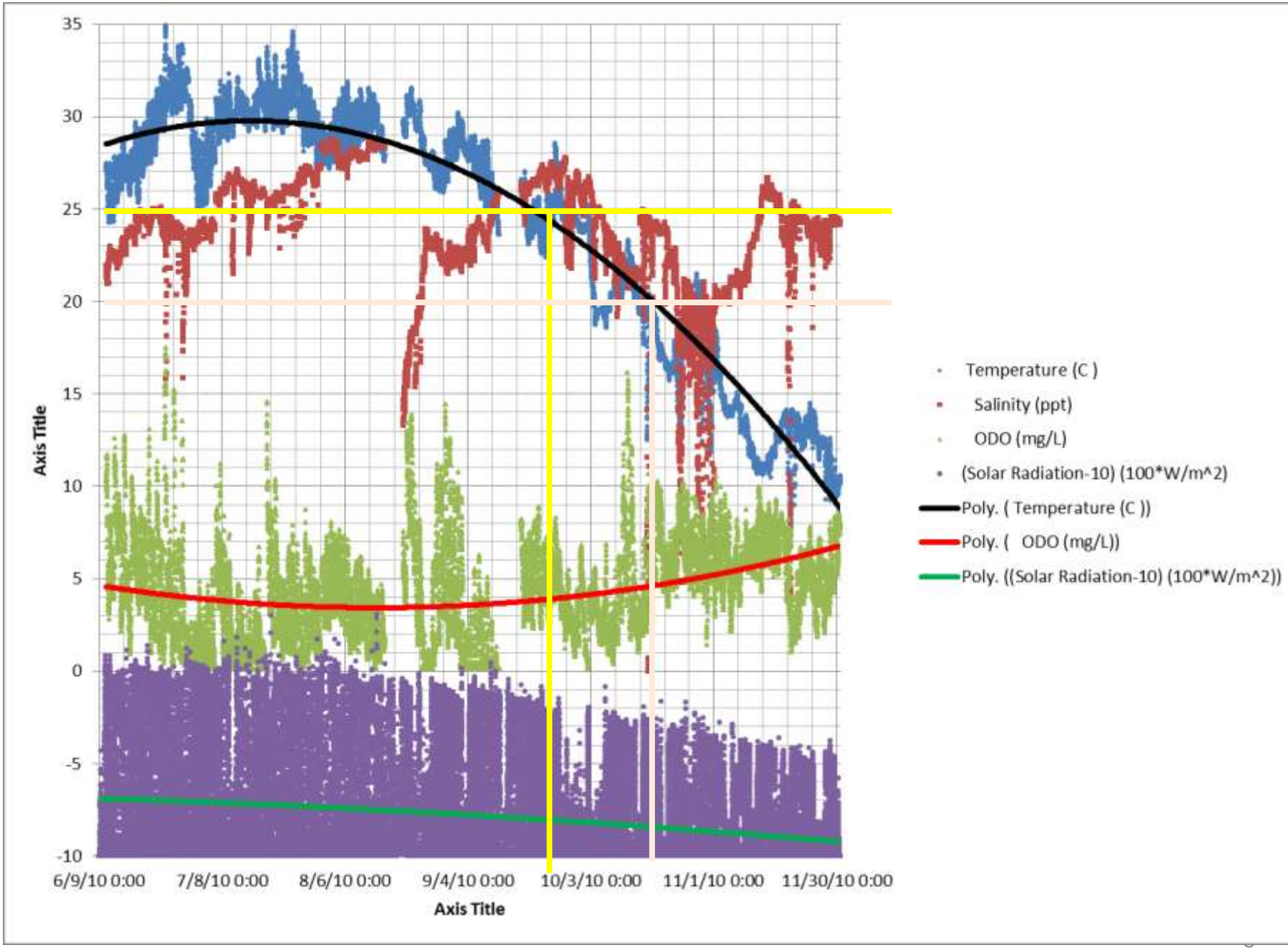
General Observations and Sample Data

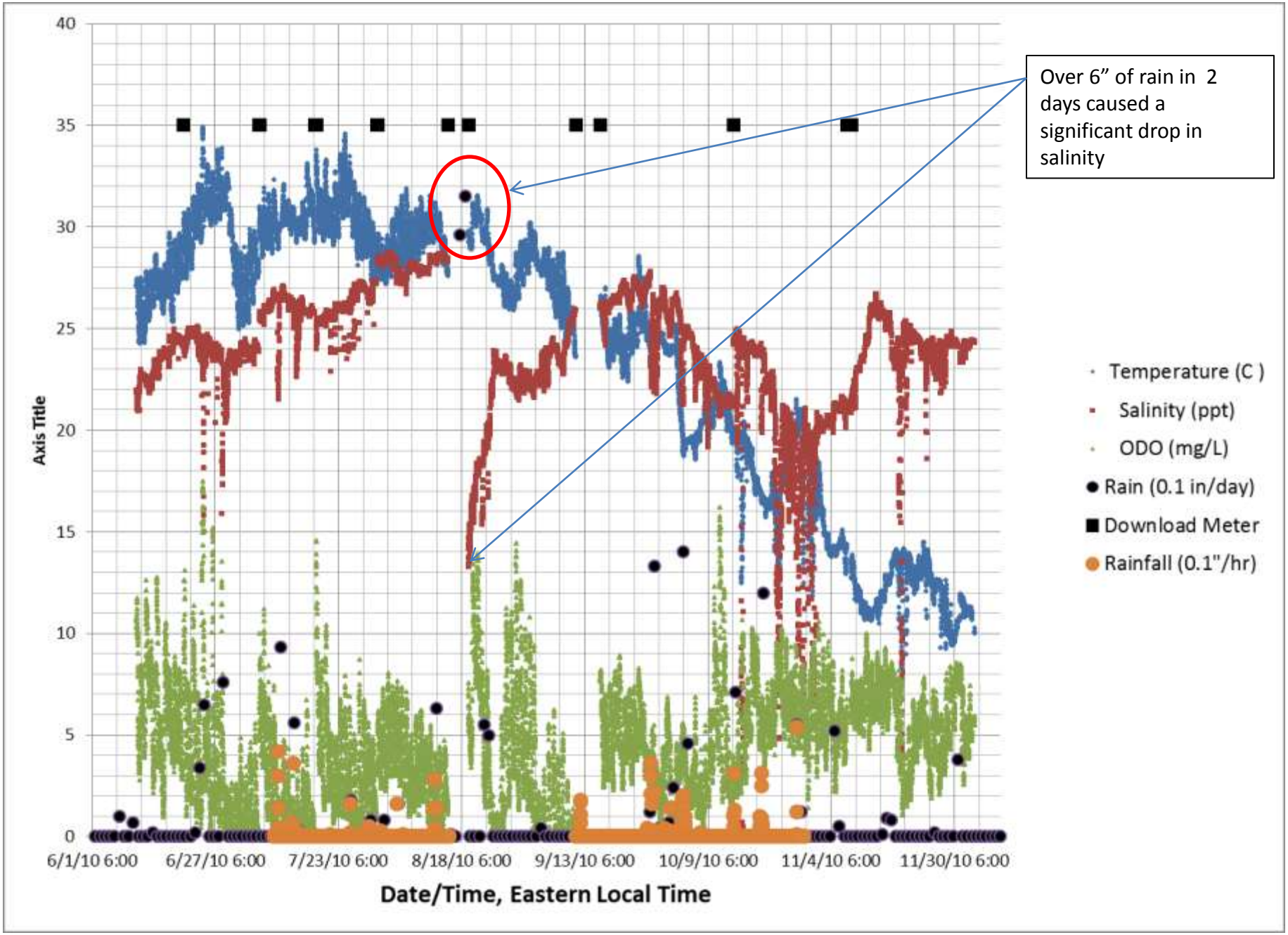
- **There are too many variables for my brain to handle**
  - Temperature
    - High temperatures cause algae to grow.
    - Low temperature H_2O holds more dissolved O_2 before saturation. See later slide.
  - Salinity – Low temperature H_2O holds more dissolved O_2 before saturation. **See later slide.**
  - Solar Radiation – Causes algae to produce O_2
  - Wind; speed and direction – Can cause turbulence which can increase O_2
  - The presence of algae causes depletion of O_2 when there is no solar radiation.
  - Rain Events - ?
- **Very often the dissolved O_2 in the water is highly saturated. See the next slide.**
- **Tidal Influence on dissolved O_2 See detail slides near the end of the presentation.**
  - 33 times the DO was above 10mg/L.
    - 22 times it corresponded with an out going tide.
    - 11 times it corresponded with an incoming tide.
  - During two rain events the DO was above 10mg/L
    - One time the tide was outgoing.
    - One time the tide was incoming.
  - **Five times the tide was below 0.0 feet NGVD and the Temperature/Conductivity Sensor probe was probably just out of the water.**

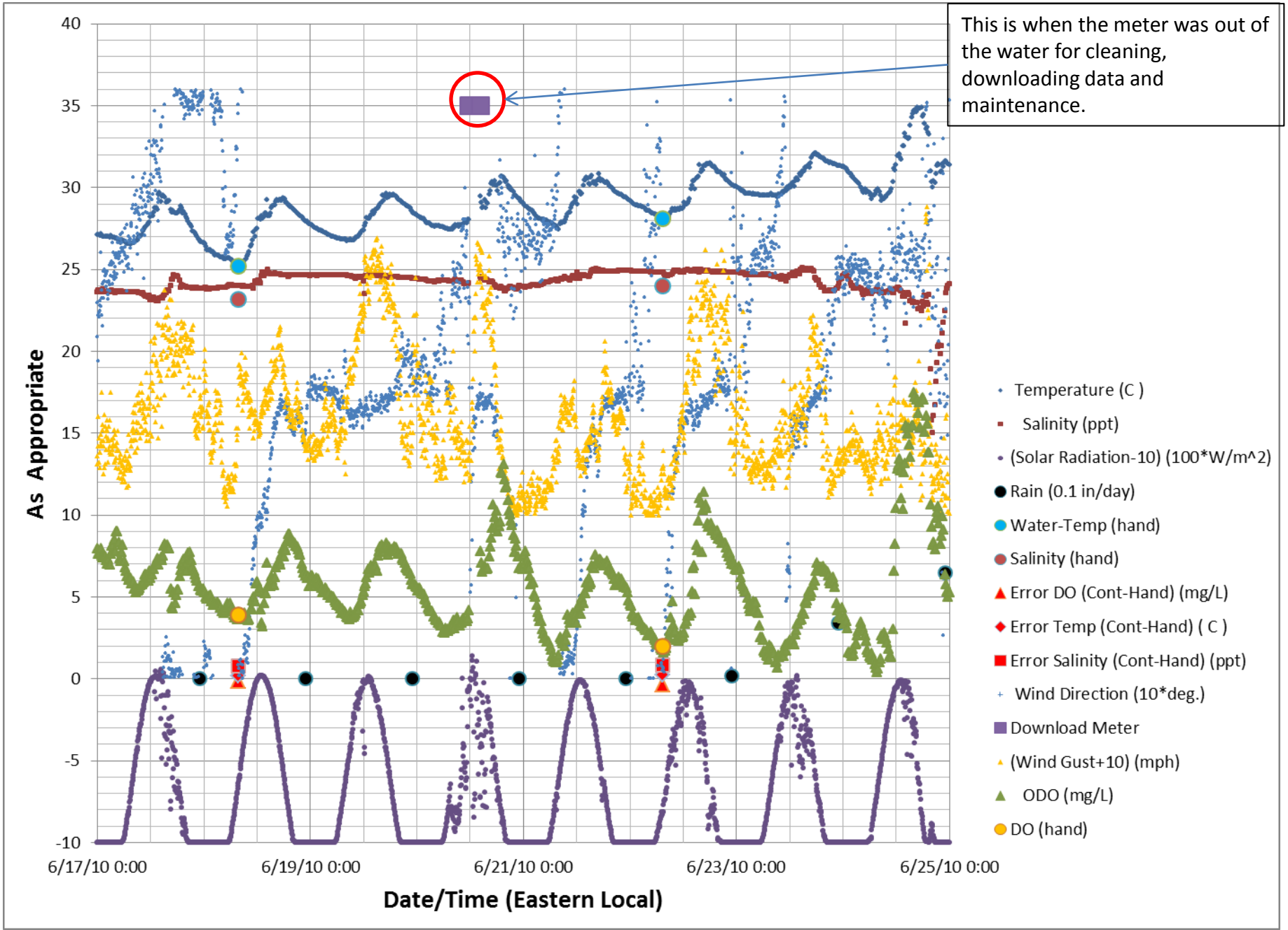

Twice high saturation occurred with significant rain events that were coupled with high solar radiation. (The rain did not significantly obstruct the solar radiation.)
Sometimes there was high saturation with no accompanying rain event and even sometimes the solar radiation was degraded.
DO %
300
250
200
150
100
50
0
6/8/10 0:00
7/7/10 0:00
8/5/10 0:00
9/3/10 0:00
10/2/10 0:00
10/31/10 0:00
11/29/10 0:00
Date/Time

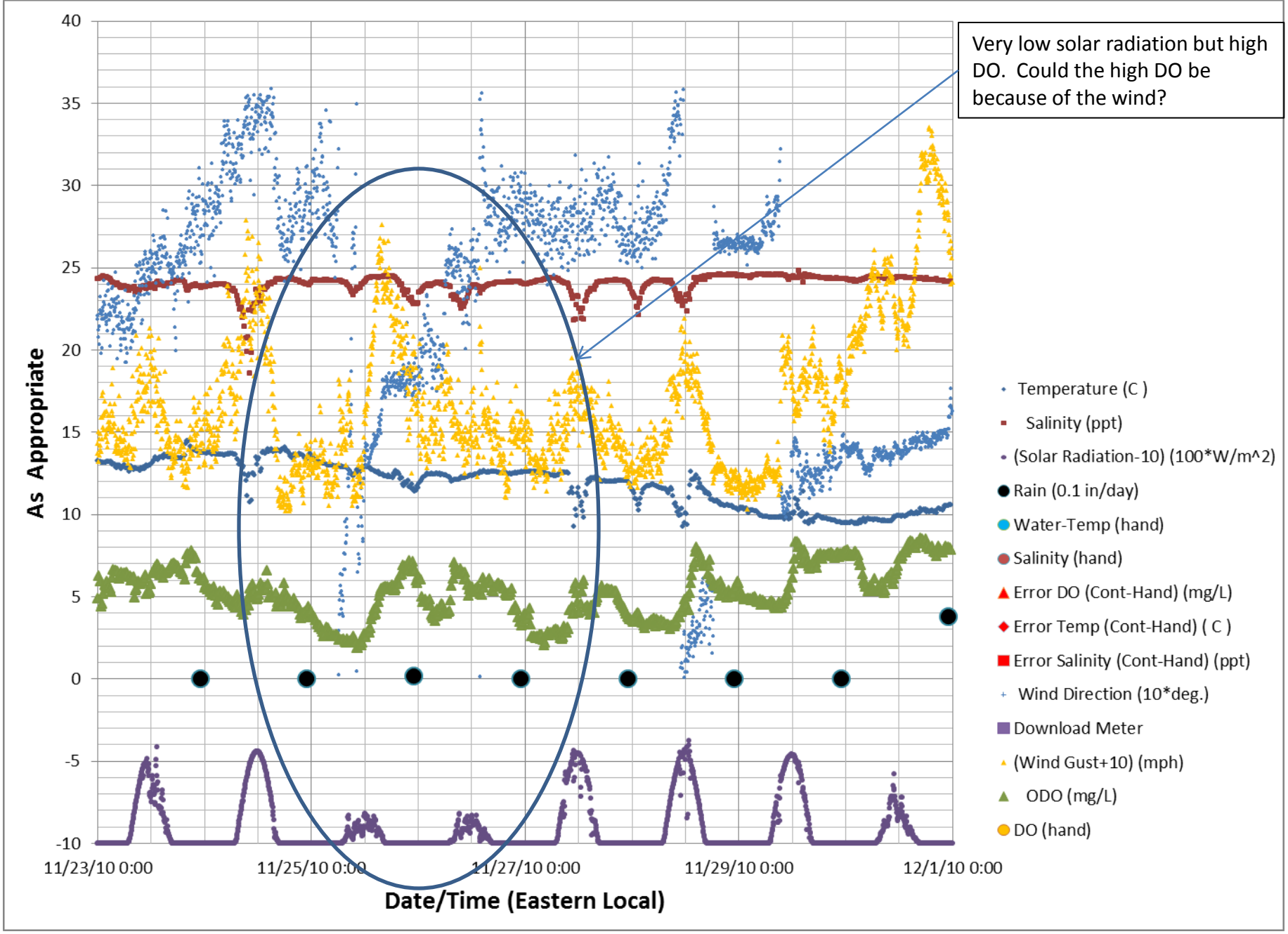
General Observations and Sample Data – (Continued)

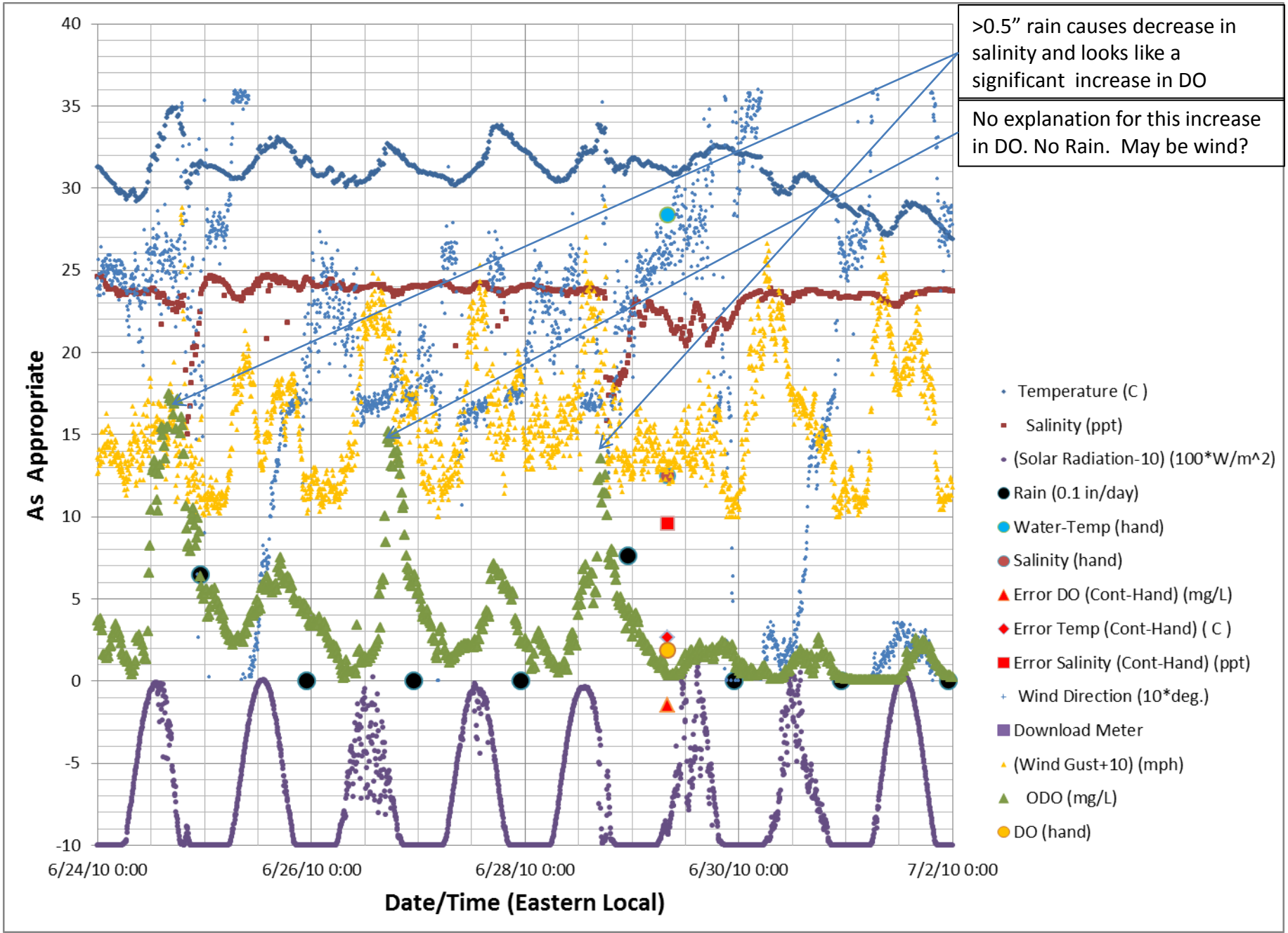
- **DO seems to be a lot more dependent on temperature than on solar radiation**
  - See the next slide.
  - Below may explain the above statement.
- **Dissolve DO is lower when it is warm (above 25^{O}C)**
  - See slide for 6/17/2010 to 6/25/2010.
  - Caused by Solar Radiation of about 1,000 W/m^2 during the day.
  - Algae grows causing large fluctuations of dissolved O_2 during a 24 hour period.
  - Dissolved O_2 drops to zero quite often at night.
- **Dissolved DO is Higher when it is cool (less than 20^{O}C)**
  - See slide for 11/23/2010 to 12/1/2010.
  - Caused by solar radiation less than ~700 W/m^2 during the day.
  - Significantly less fluctuations of dissolved O_2 during a 24 hour period.
  - Dissolved O_2 never drops to at night.
  - Wind appears to have influence on dissolved O_2.
  - The algae must die at less than 15^{O}C
- A significant rise in DO occurred two times after significant rain events along with significant solar radiation. After all other rain events there was no significant solar radiation and no significant change in DO.
  - See slide for 6/24/2010 to 7/2/2010


35
30
25
20
15
10
5
0
-5
-10
Axis Title
6/9/10 0:00
7/8/10 0:00
8/6/10 0:00
9/4/10 0:00
10/3/10 0:00
11/1/10 0:00
11/30/10 0:00
Axis Title
Temperature (C)
Salinity (ppt)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
Poly. (Temperature (C))
Poly. (ODO (mg/L))
Poly. ((Solar Radiation-10) (100*W/m^2))


Over 6” of rain in 2 days caused a significant drop in salinity
Temperature (C)
Salinity (ppt)
ODO (mg/L)
Rain (0.1 in/day)
Download Meter
Rainfall (0.1"/hr)
Axis Title
40
35
30
25
20
15
10
5
0
6/1/10 6:00
6/27/10 6:00
7/23/10 6:00
8/18/10 6:00
9/13/10 6:00
10/9/10 6:00
11/4/10 6:00
11/30/10 6:00
Date/Time, Eastern Local Time


This is when the meter was out of the water for cleaning, downloading data and maintenance.
40
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
6/17/10 0:00
6/19/10 0:00
6/21/10 0:00
6/23/10 0:00
6/25/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


Very low solar radiation but high DO. Could the high DO be because of the wind?
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
11/23/10 0:00
11/25/10 0:00
11/27/10 0:00
11/29/10 0:00
12/1/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

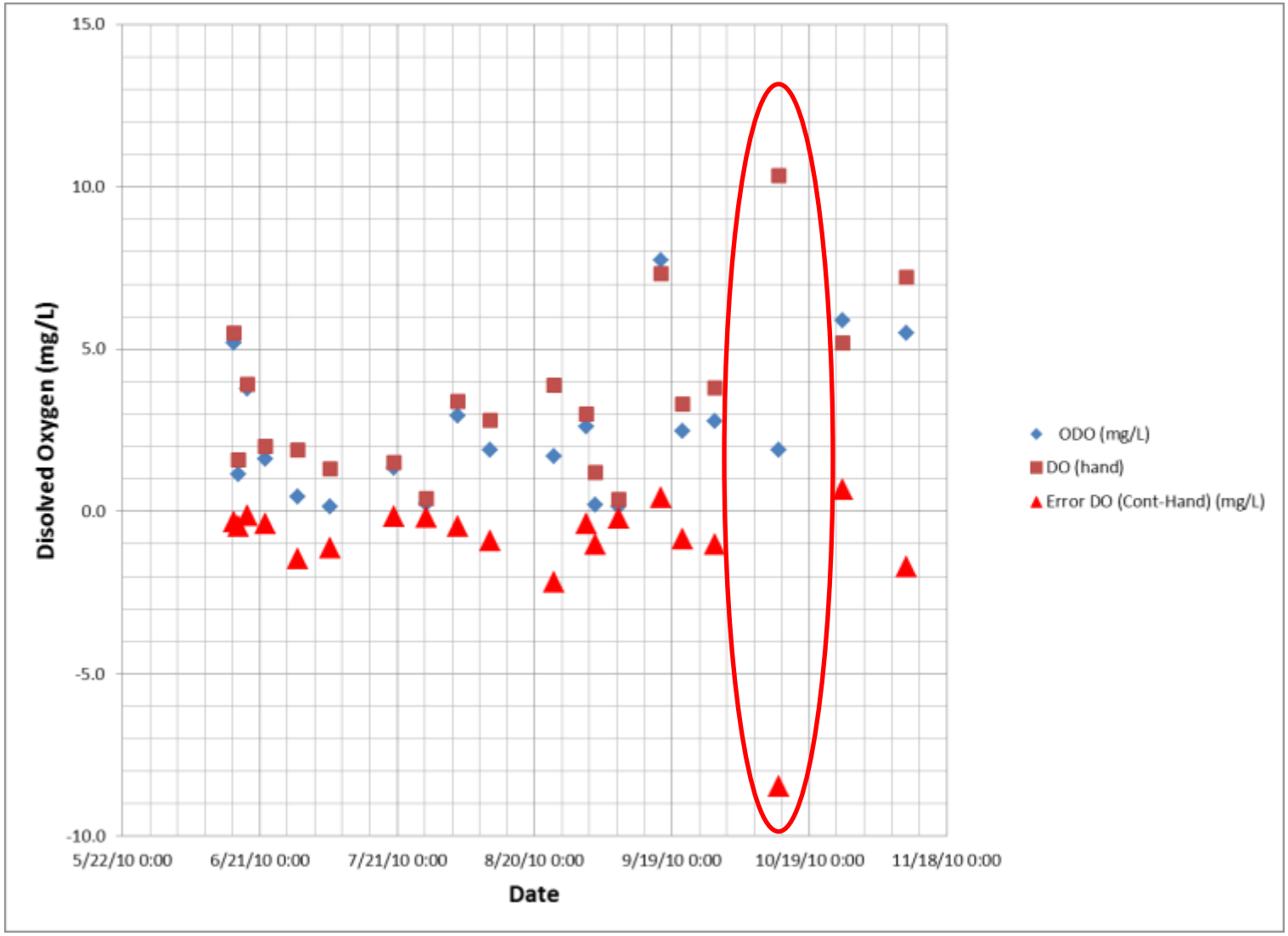

>0.5” rain causes decrease in salinity and looks like a significant increase in DO
No explanation for this increase in DO. No Rain. May be wind?
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
6/24/10 0:00
6/26/10 0:00
6/28/10 0:00
6/30/10 0:00
7/2/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

Comparison Of Continuously Recorded (Every 15 Minutes) Data With Point Data Obtained Using The Hand Held Meter

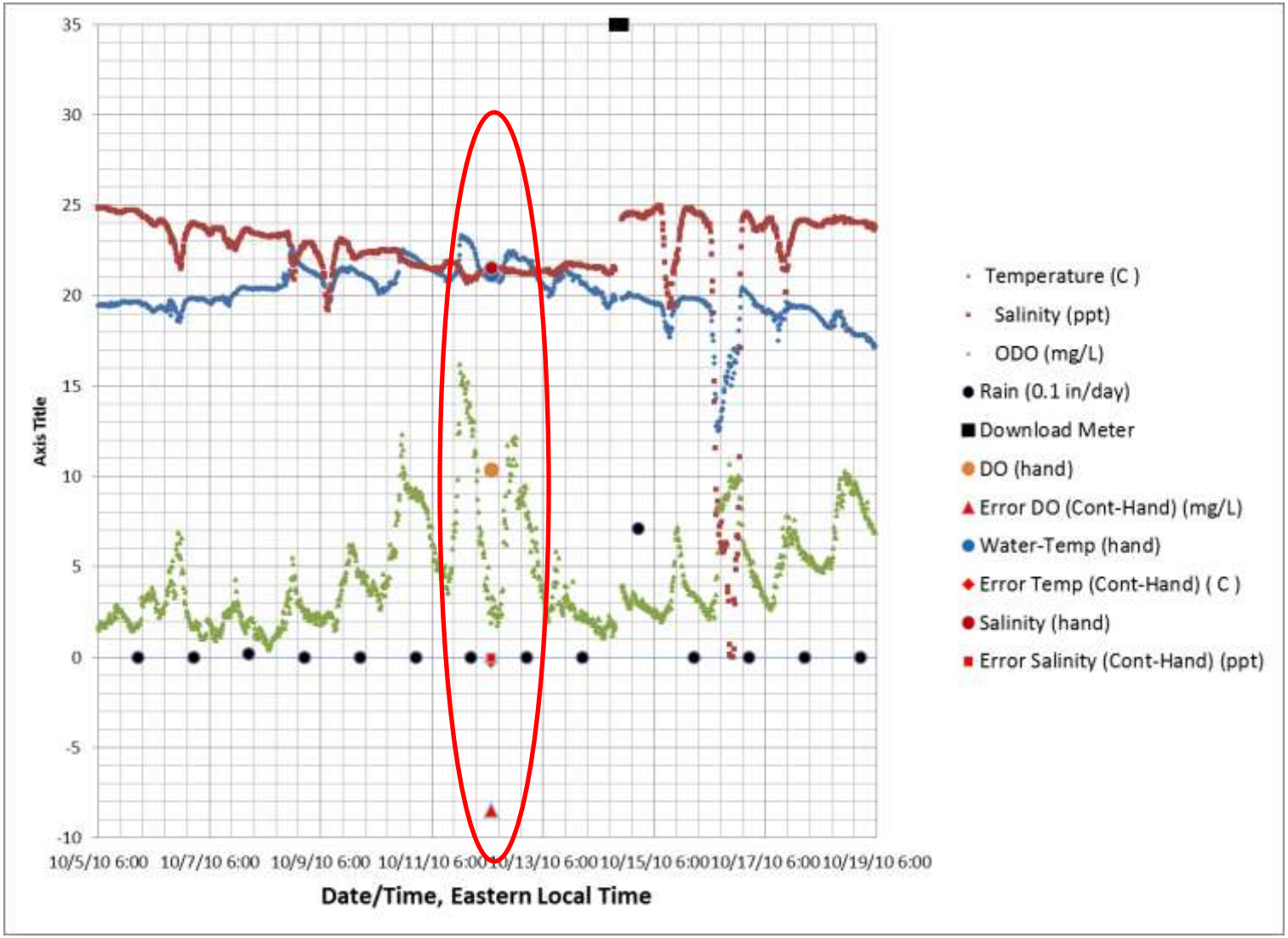
Summary

- There is relatively good correlation
  - Hand Held consistently had slightly higher DO
  - Hand held consistently l had lower salinity
- The hand held made readings near the surface
- The Sonde was near the bottom
- **In the future the hand held will be used near the surface and near the bottom to take readings at the Continuous Monitoring Site.**

Hand Held DO Is Almost Always Higher. Could It Be That The Hand Held Is Closer To The Surface? 10/12/2010 Has A Significant Difference, Hand Held Seems High, Continuous Seems Low.



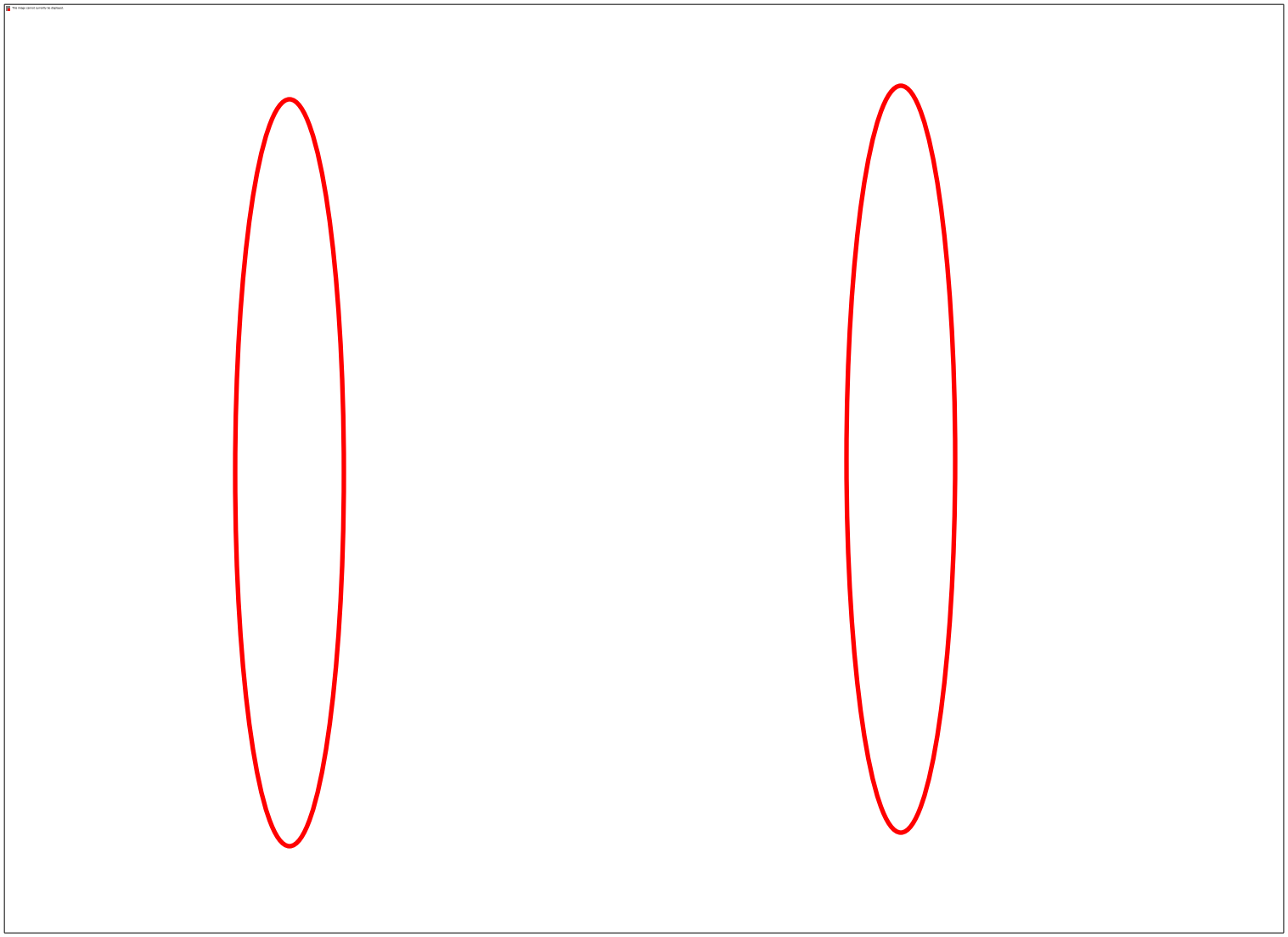
Data Comparison Showing 10/12/2010
Temperature And Salinity Were Right On. DO Was Way Off



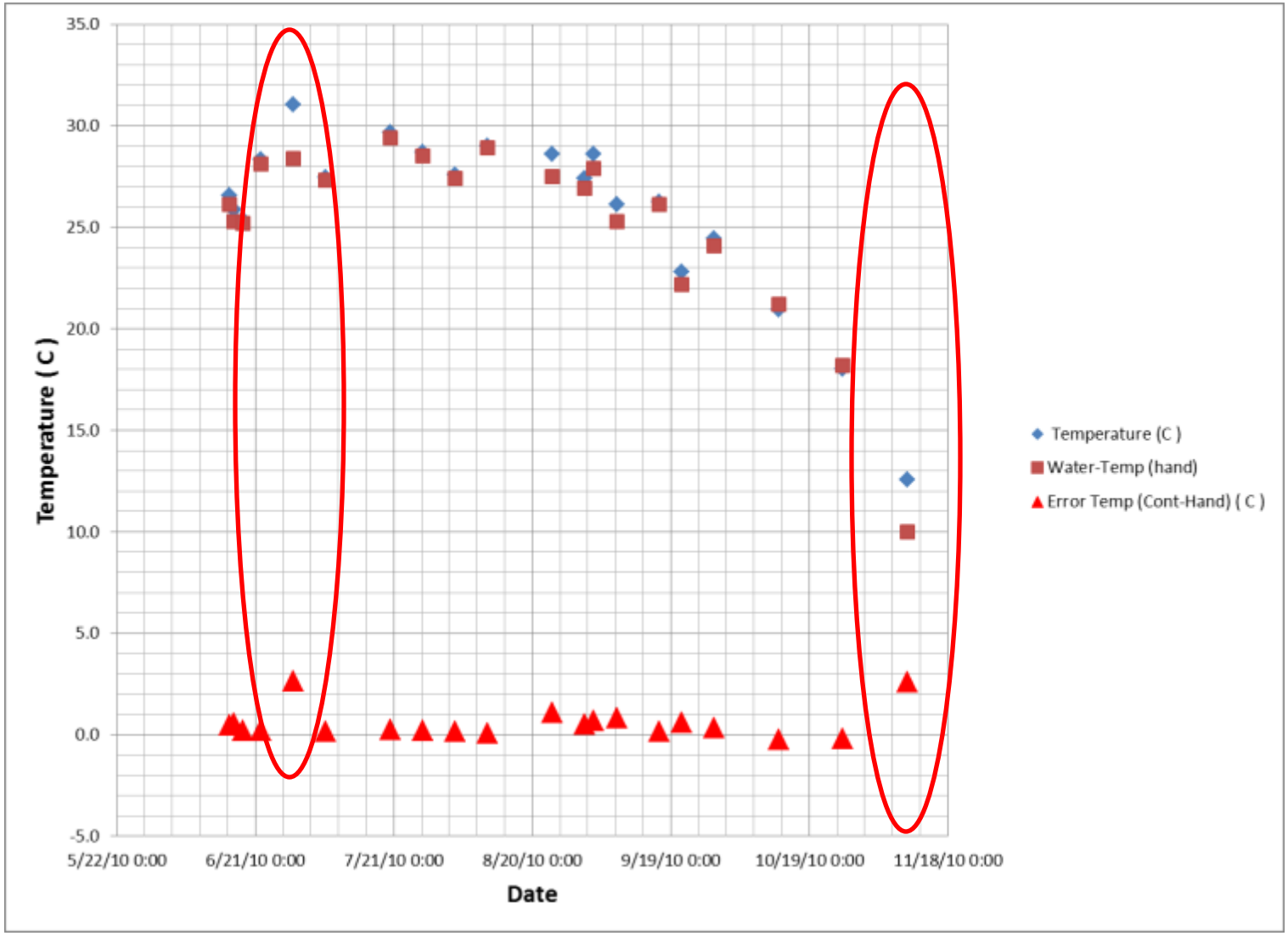
Hand Held Data From 10/12/2010

	Report Date:	10/12/10			Recorder:	D. Wilson				
Site	SB01	SB02	SB04	SB05	SB07	SB09	SB10W	SB10E	SB12	Cont. Mon
Data Date	10/12/10	10/12/10	10/12/10	10/12/10	10/12/10	10/12/10	10/12/10	10/12/10	10/12/10	10/12/10
Time	734	747	728	723	714	704	808	753	802	740
Monitor name(s)	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins	Hopkins
	Wilson	Wilson	Wilson	Wilson	Wilson	Wilson	Wilson	Wilson	Wilson	Wilson
Air Temperature, Deg C	18.6	18.8	18.7	18.5	18.7	19.8	19.1	18.7	19.7	18.6
Water Temperature, Deg C	21.2	20.6	20.8	20.5	20.2	19.6	20	19.8	19.9	21.2
%DO	104.4	150	95.1	123	100.2	97	79.5	78.6	88.2	131
DO,mg/l	8.25	11.85	7.45	9.78	7.93	7.85	6.26	6.28	7	10.35
Salinity XX.X % (PPT)	21.8	21.6	22.4	22.5	22.6	22.1	22.7	22.6	22.9	21.5
Water Depth (m)	0.8	0.9	0.5	0.9	1.4	1.4	1.1	1.1	0.7	
Secchi Depth (m)	0.7	0.9	0.5	0.9	1.4	1	1.1	1.1	0.7	

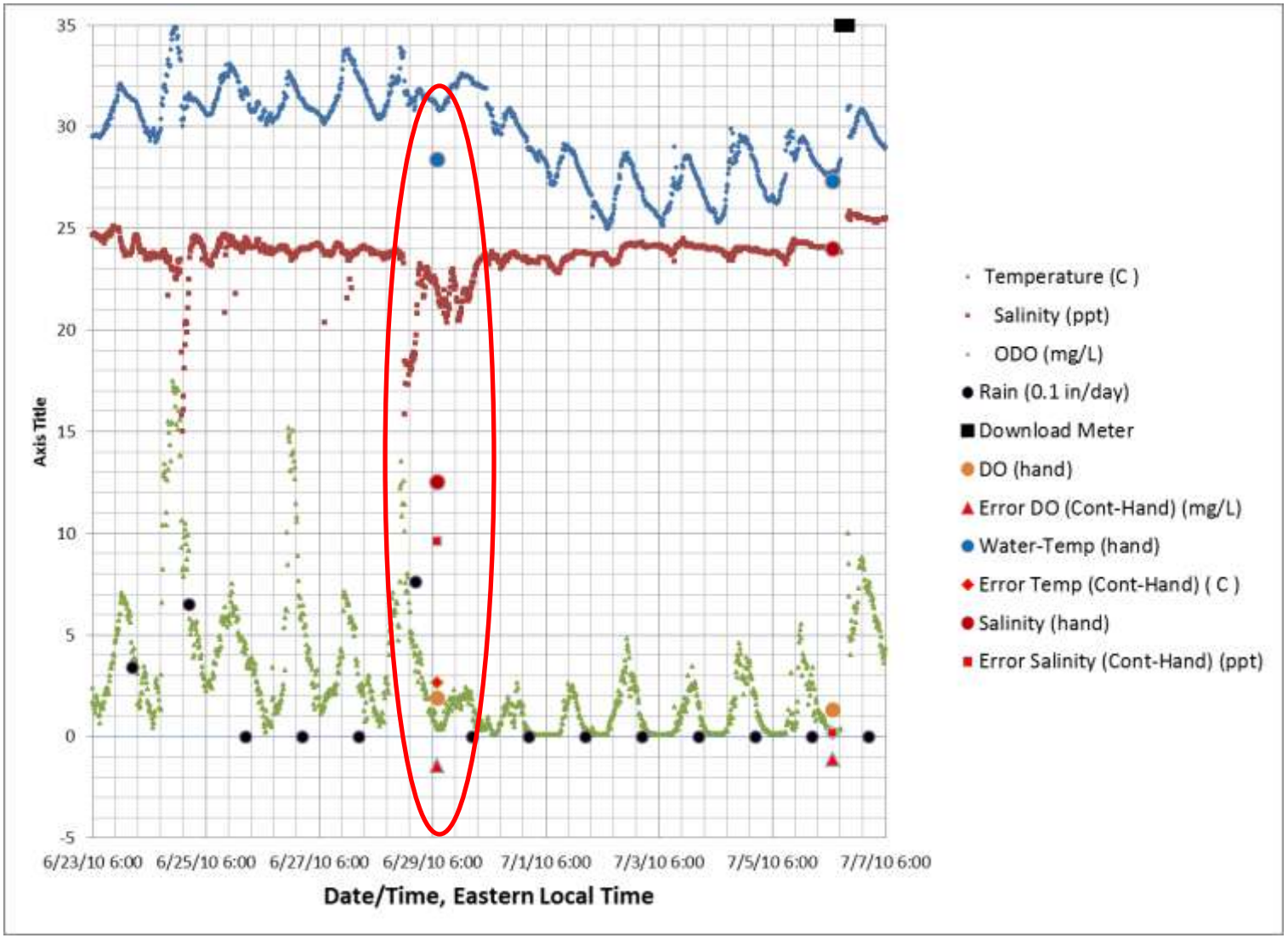
Hand Held Salinity Is Almost Always Lower. Could It Be Closer To The Surface? Large Difference on 6/29/2010 and 11/09/2010.



Temperatures Seem To Correlate Well Except On 6/29/2010 and 11/09/2010 The Same Dates That Had Significant Differences In Salinity.



Data Comparison Showing 06/29/2010



Hand Held Data For 6/29/2010

Citizens Monitoring Program

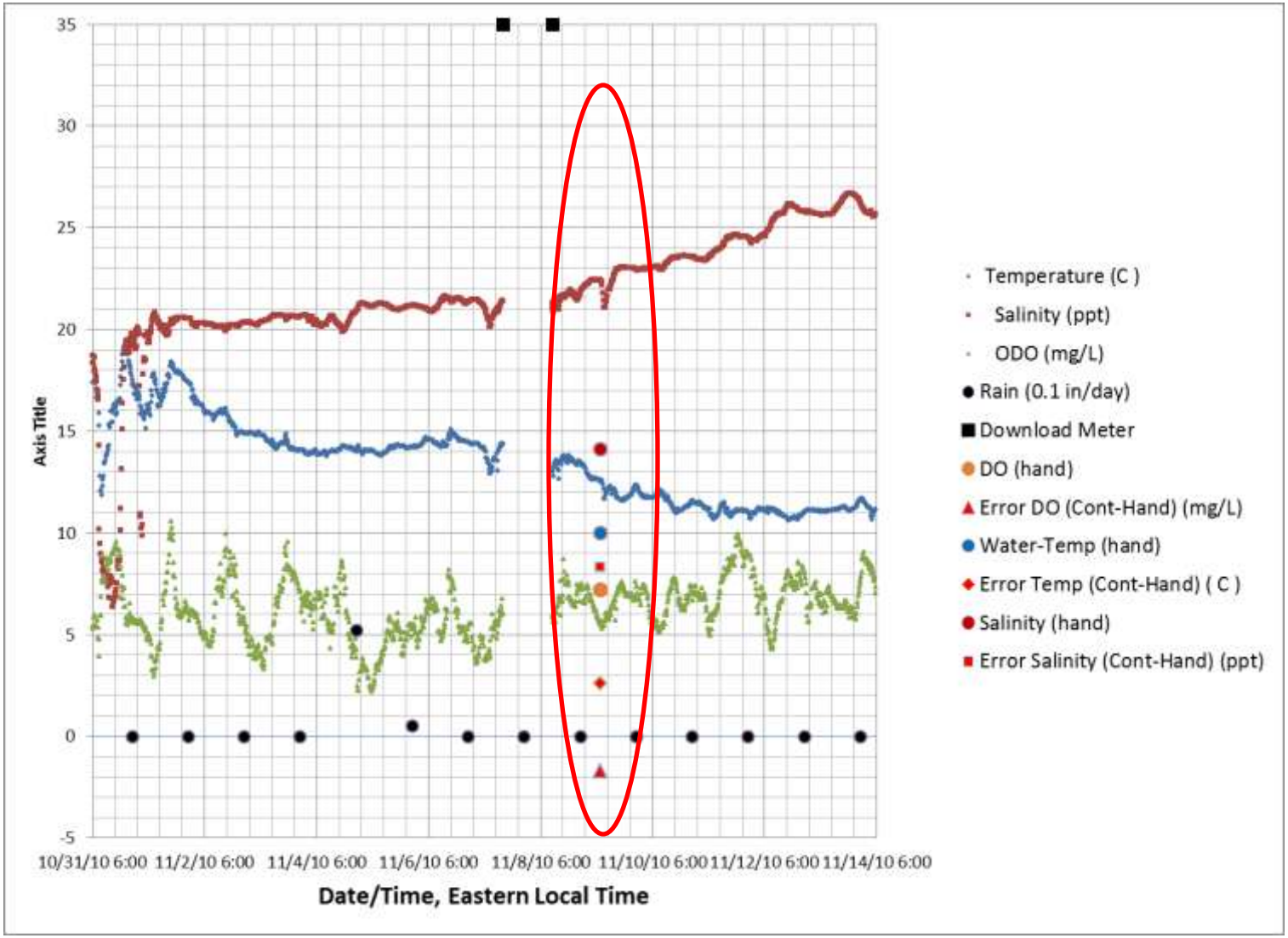
Data Collection Form

South Bethany, DE

Report Date: 06/29/10 Recorder: D. Wilson

Site	SB01	SB02	SB04	SB05	SB07	SB09	SB10W	SB10E	SB12	Cont. Mon
Data Date	06/29/10	06/29/10	06/29/10	06/29/10	06/29/10	06/29/10	06/29/10	06/29/10	06/29/10	06/29/10
Time	746	809	737	726	715	657	837	819	828	757
Monitor name(s)										
D. Wilson										
Air Temperature, Deg C	25.2	25.3	25.3	25.3	25.3	23.8	25.9	25.3	25.1	25.5
Water Temperature, Deg (	29	28.4	28.3	29.6	30.5	30.4	31	30.6	30	28.4
%DO	13	57	58	66	85	47.5	63.5	67	64	27
DO,mg/l	1	3.8	3.8	4.1	5.7	3.1	4.1	4.4	4.2	1.9
Salinity XX.X % (PPT)	12	19.3	19.2	20.5	23.2	23.1	23.5	23.5	23.5	12.5
Water Depth (m)	0.6	0.8	0.55	0.9	1.3	1.35	1.1	1.1	0.7	
Secchi Depth (m)	0.6	0.7	0.45	0.7	0.7	0.65	0.85	0.85	0.7	

Data Comparison Showing 11/09/2010



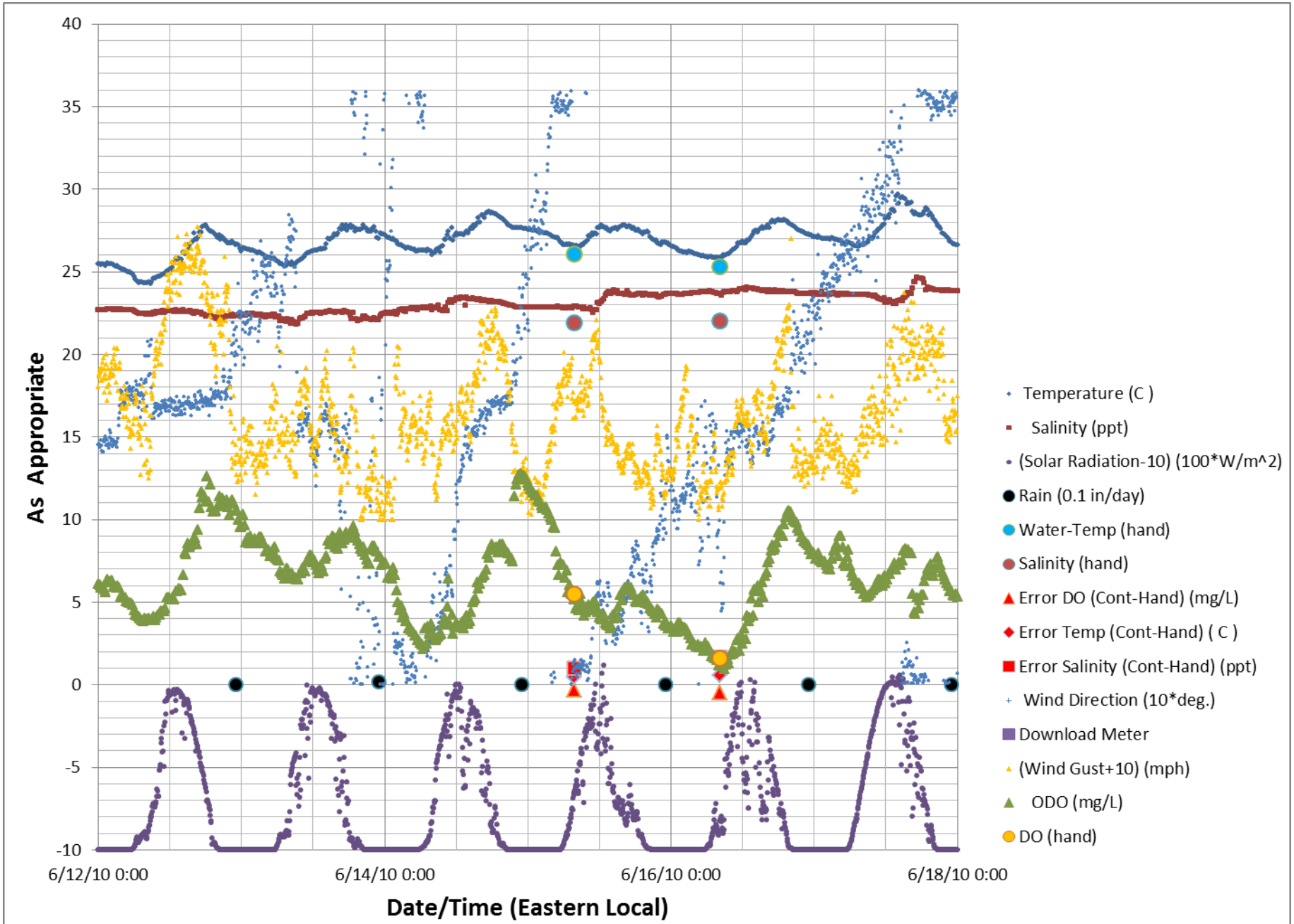
The Sonde's temperature probe was also checked against a Fisher Price Traceable © Lollipop Waterproof/Shockproof Thermometer, Cat No. 14-648-44, a few times during downloading and cleaning. The Sonde reading was always lower than the thermometer reading by less than 0.28^{O} C.

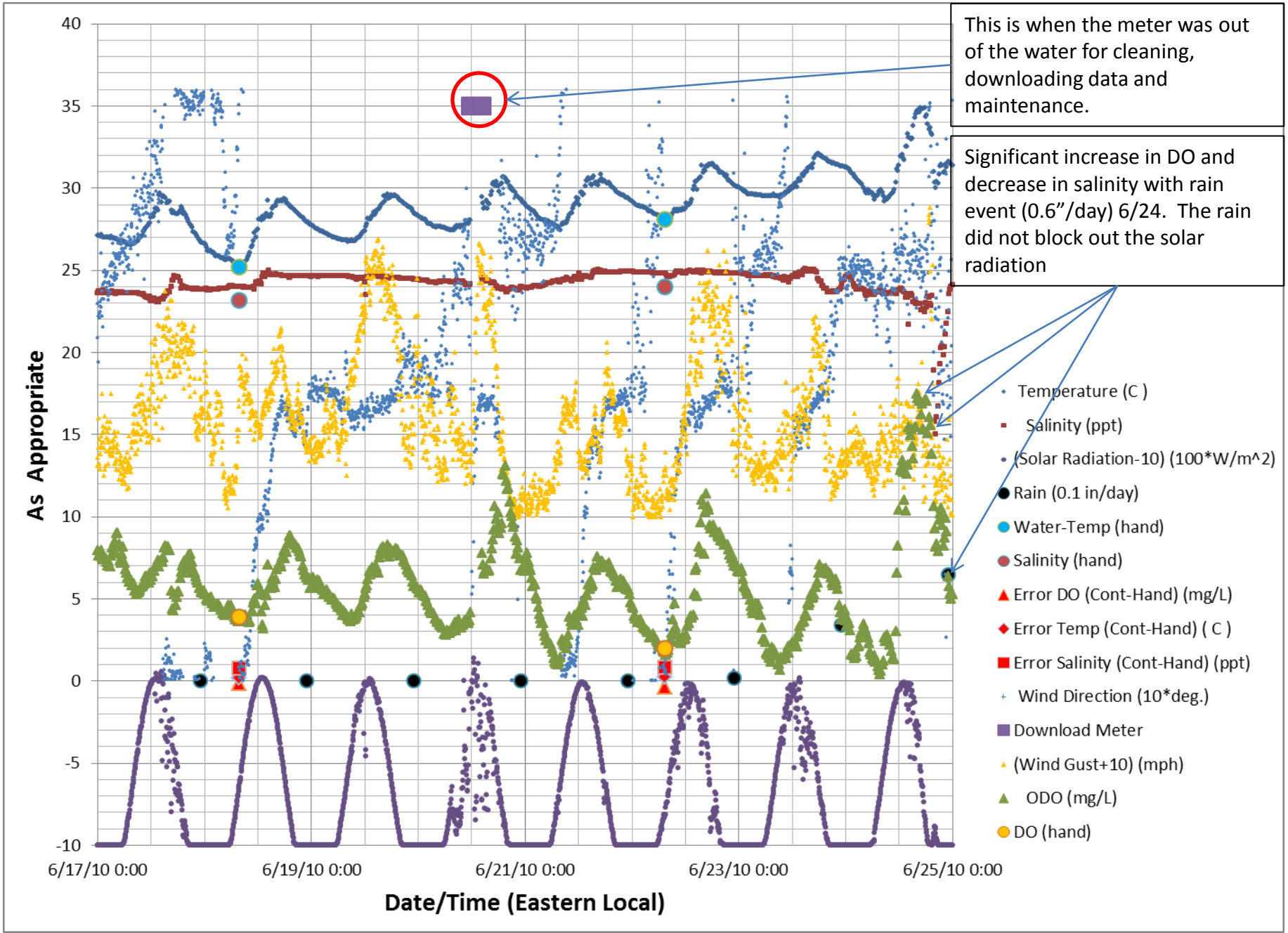
Date/Time	Temp. (^{o}C)	Ref Temp (^{o}C)	Delta Temp	Comments
7/6/10 12:15	27.03	27.3	-0.27	In a Bucket of Water
7/18/10 8:30	24.77	25.0	-0.23	In a Bucket of Water
7/18/10 11:00	23.55	23.8	-0.25	In a Bucket of Water
7/31/10 8:45	20.84	21.0	-0.16	In a Bucket of Water
7/31/10 9:00	20.83	21.0	-0.17	In a Bucket of Water
8/15/10 11:30	21.39	21.6	-0.21	In a Bucket of Water

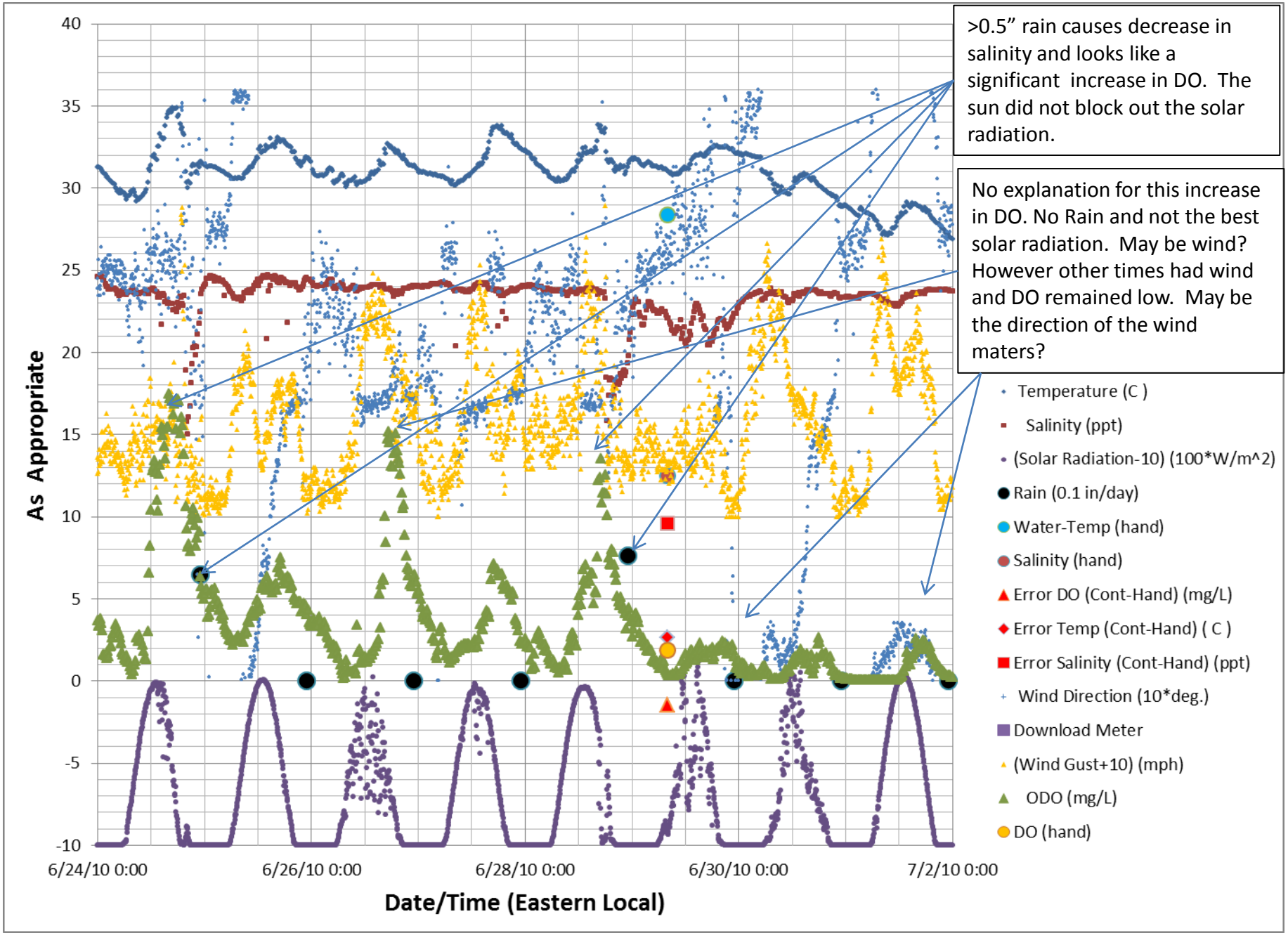
Detailed Collected Data

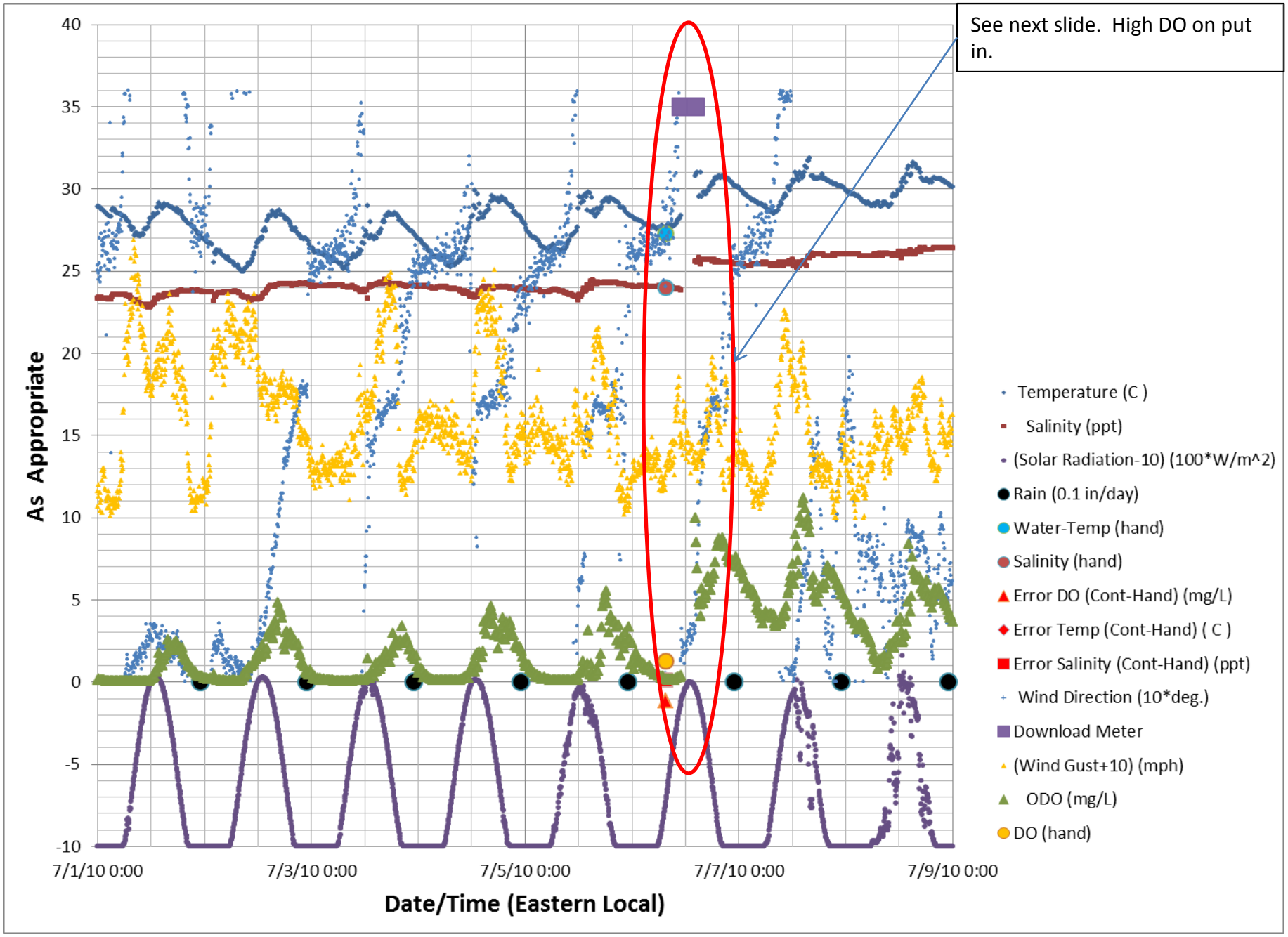
The Next Slides Show Data Collected During The Period 6/10/2010 to 12/8/2010 At The East End Of The Anchorage Canal

- Continuously collected data (every 15 minutes)
  - Dissolved Oxygen (DO) (mg/L), Salinity (ppt), Water Temperature (^{O}C)
- Hand held discrete data collected about every week
  - Dissolved Oxygen (DO) (mg/L), Salinity (ppt), Water Temperature (^{O}C)
- Rain Data
  - Plotted in 0.1 inches/day – Thus 1.0” is plotted with the value 10.0
- When hand held data is available the difference between the hand held data and the continuous data is plotted.
- When the Sonde is out of the water there are two points plotted at a value of 35.
- Solar Radiation is plotted in hecto-Watts per meter squared and displaced down by 10 heto-Watts per meter squared to separate the data. Thus 1,000 W/m^2 would be plotted as 0.0 W/m^2.
- Wind speed it displace up by 10 mph to separate the data. Thus 0.0 mph would be plotted as 10.0 mph.
- Wind direction is divided by 10 to fit it on the chart. Thus 180^{O} is plotted as 18^{O} .
- Comments are included where appropriate on the charts.

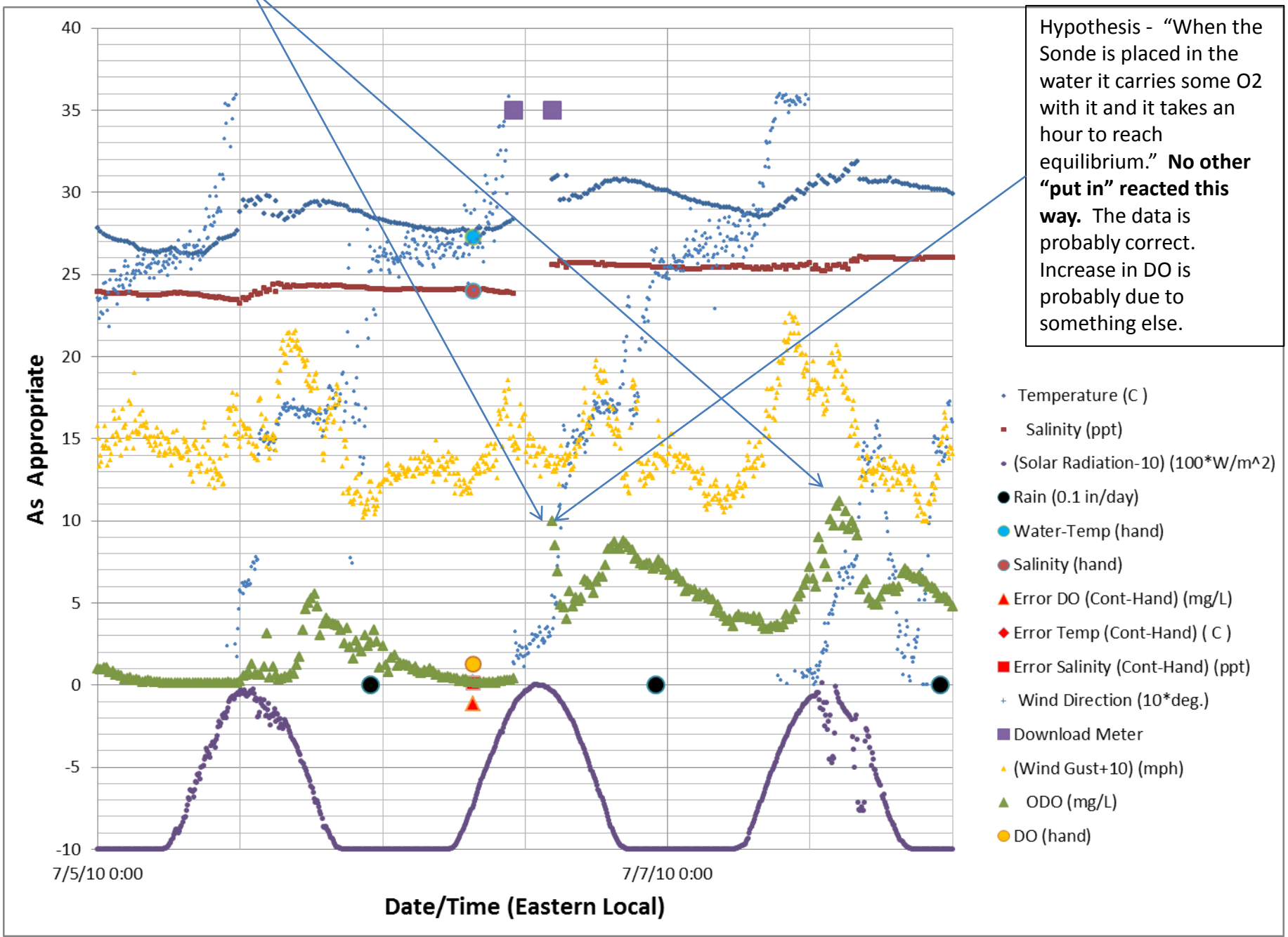

40
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
6/12/10 0:00
6/14/10 0:00
6/16/10 0:00
6/18/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


This is when the meter was out of the water for cleaning, downloading data and maintenance.
Significant increase in DO and decrease in salinity with rain event (0.6”/day) 6/24. The rain did not block out the solar radiation
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
6/17/10 0:00
6/19/10 0:00
6/21/10 0:00
6/23/10 0:00
6/25/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

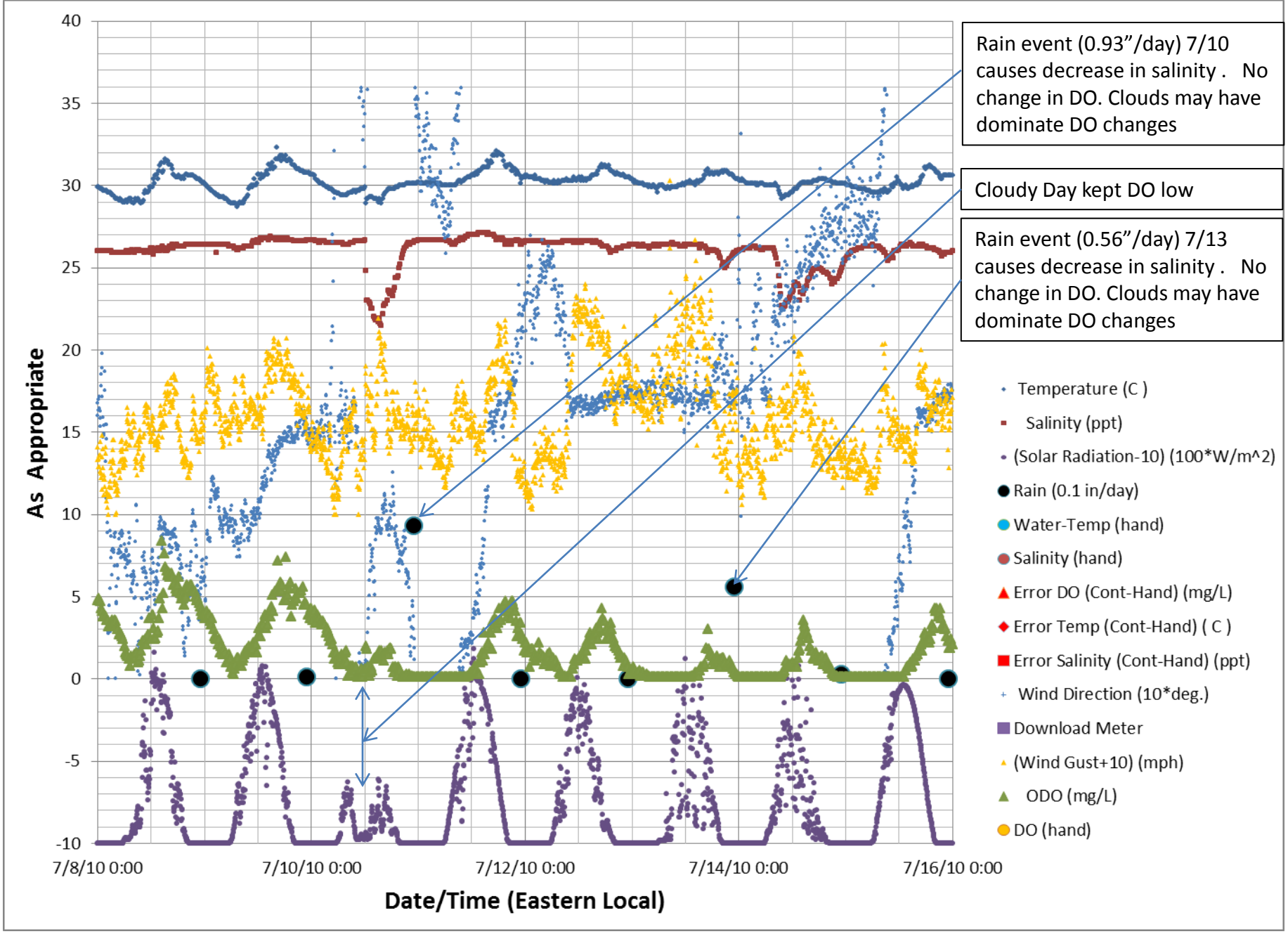

>0.5” rain causes decrease in salinity and looks like a significant increase in DO. The sun did not block out the solar radiation.
No explanation for this increase in DO. No Rain and not the best solar radiation. May be wind? However other times had wind and DO remained low. May be the direction of the wind maters?
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
6/24/10 0:00
6/26/10 0:00
6/28/10 0:00
6/30/10 0:00
7/2/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


See next slide. High DO on put in.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
7/1/10 0:00
7/3/10 0:00
7/5/10 0:00
7/7/10 0:00
7/9/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

Tide was going out at this time and could have influenced the DO. See the later tide charts.

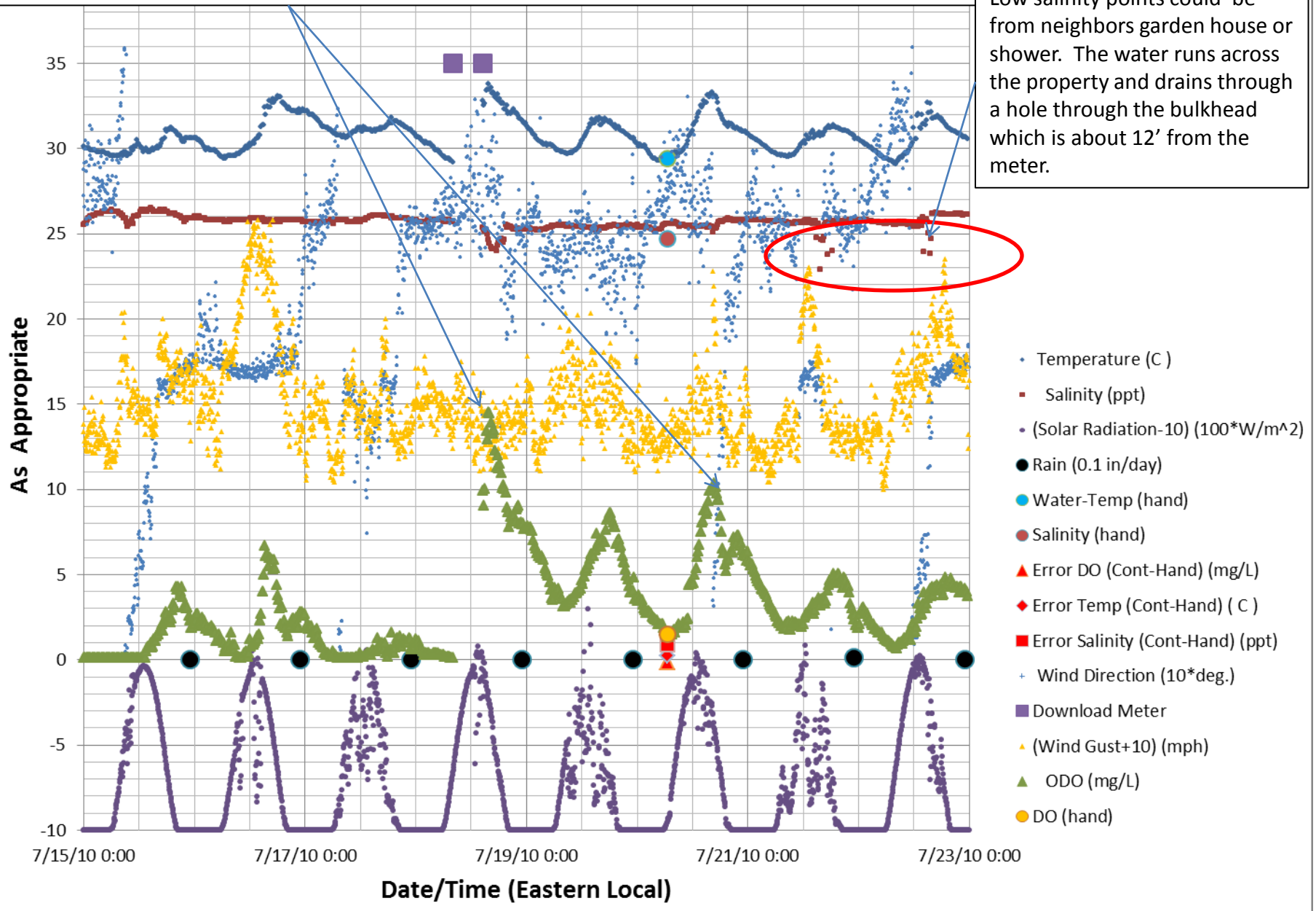


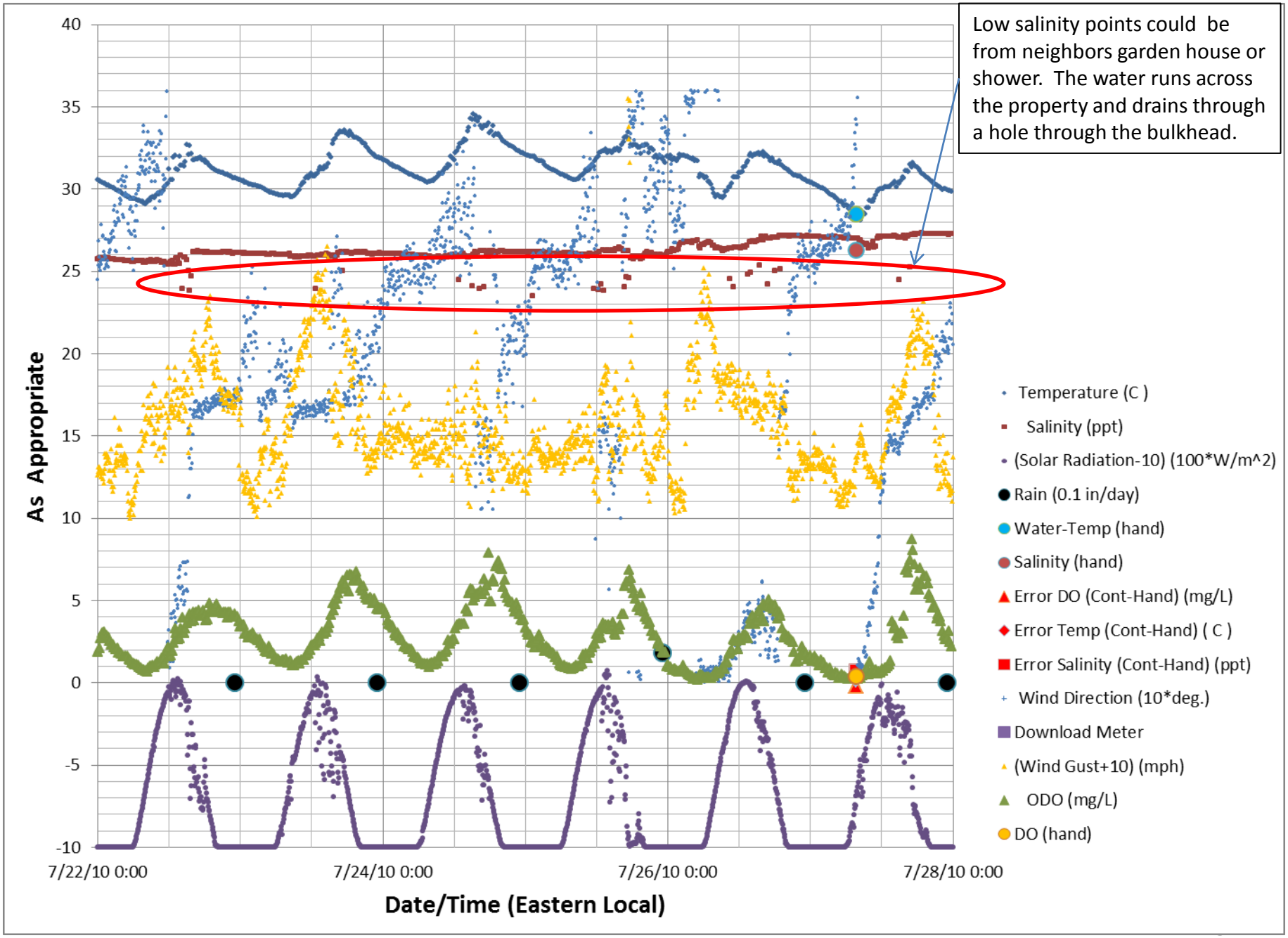
Hypothesis - "When the Sonde is placed in the water it carries some O2 with it and it takes an hour to reach equilibrium." **No other "put in" reacted this way.** The data is probably correct. Increase in DO is probably due to something else.

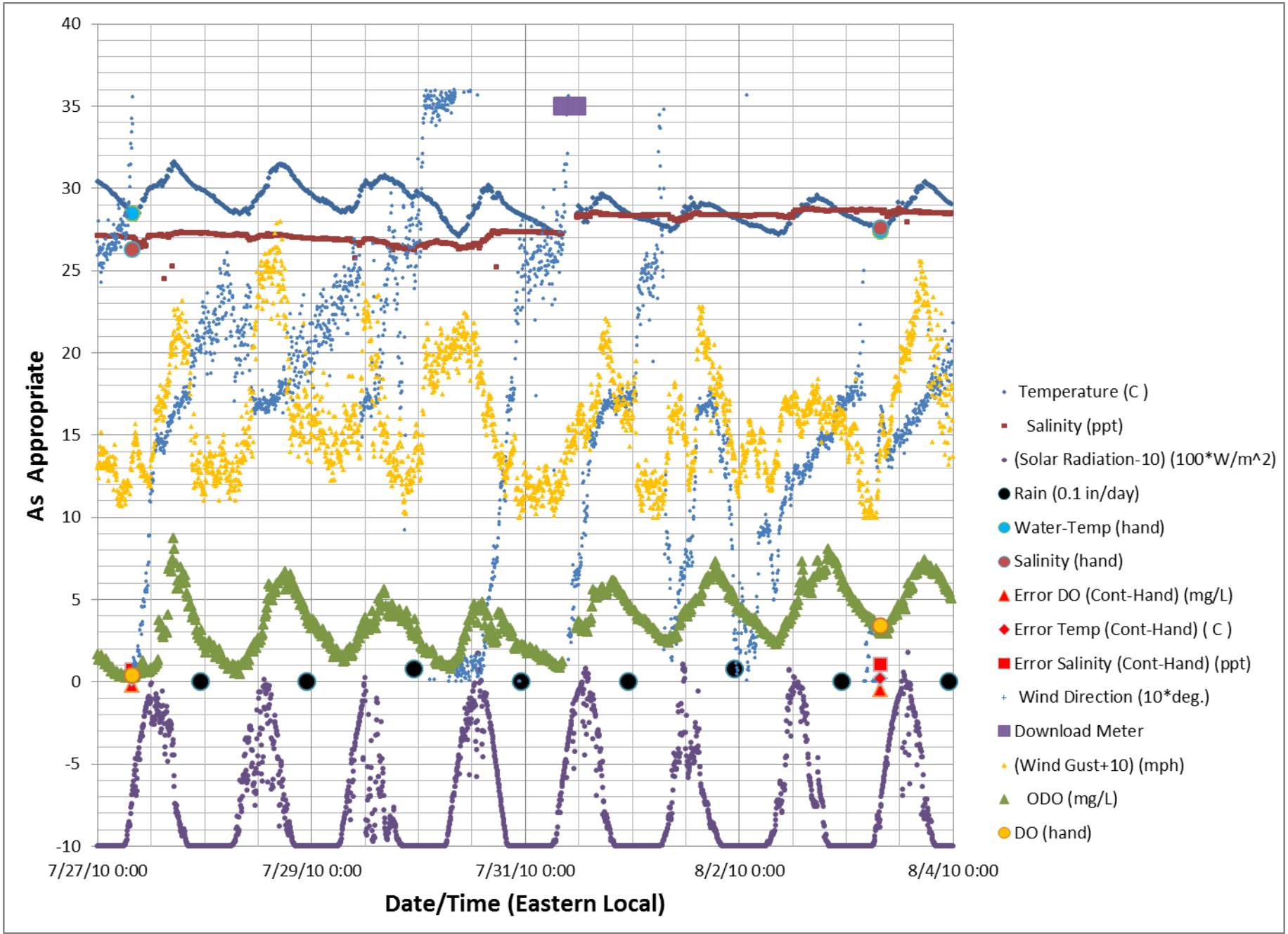

Rain event (0.93”/day) 7/10 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
Cloudy Day kept DO low
Rain event (0.56”/day) 7/13 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
7/8/10 0:00
7/10/10 0:00
7/12/10 0:00
7/14/10 0:00
7/16/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

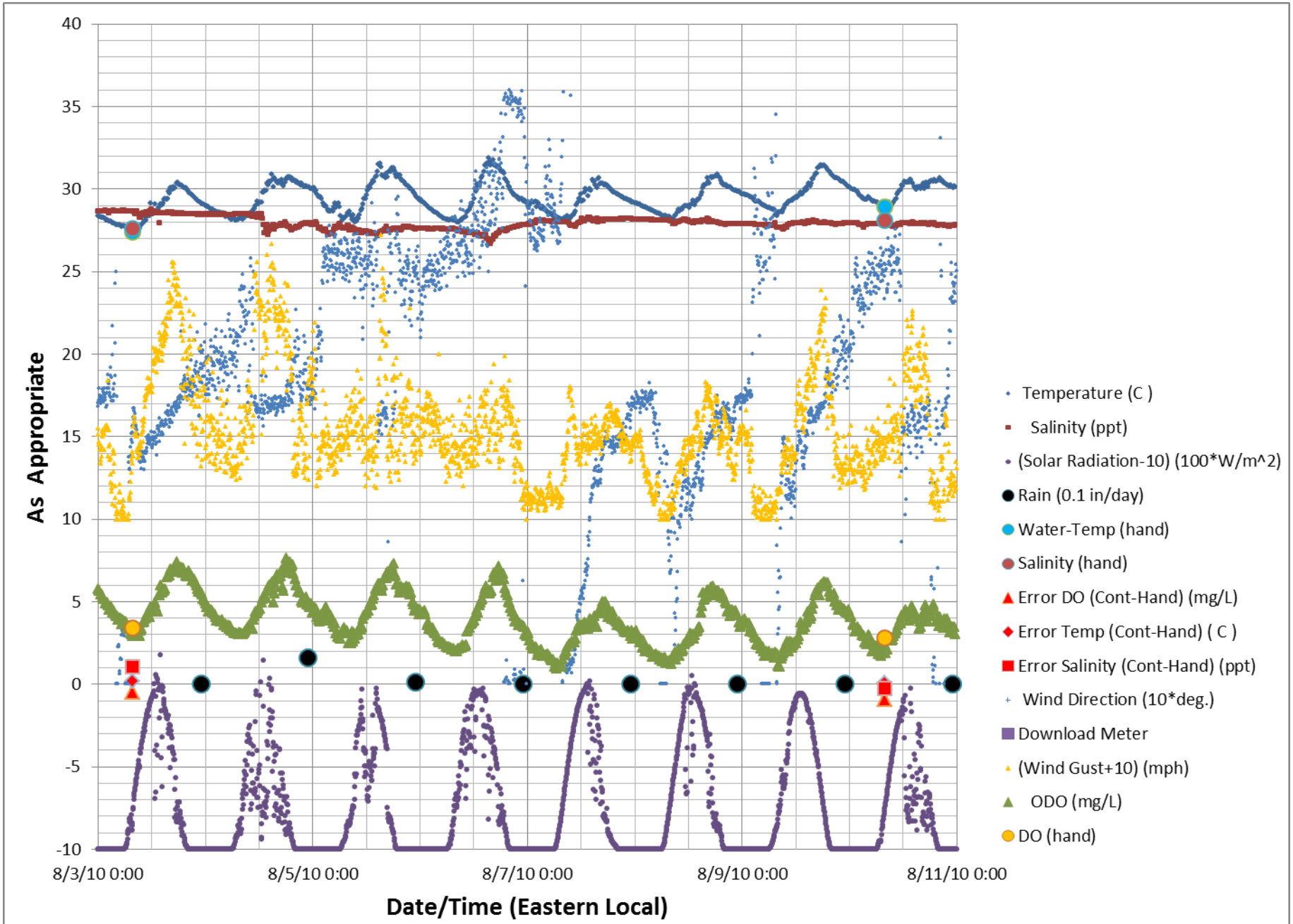
Tide was going out at this time and could have influenced the DO. See the later tide charts.

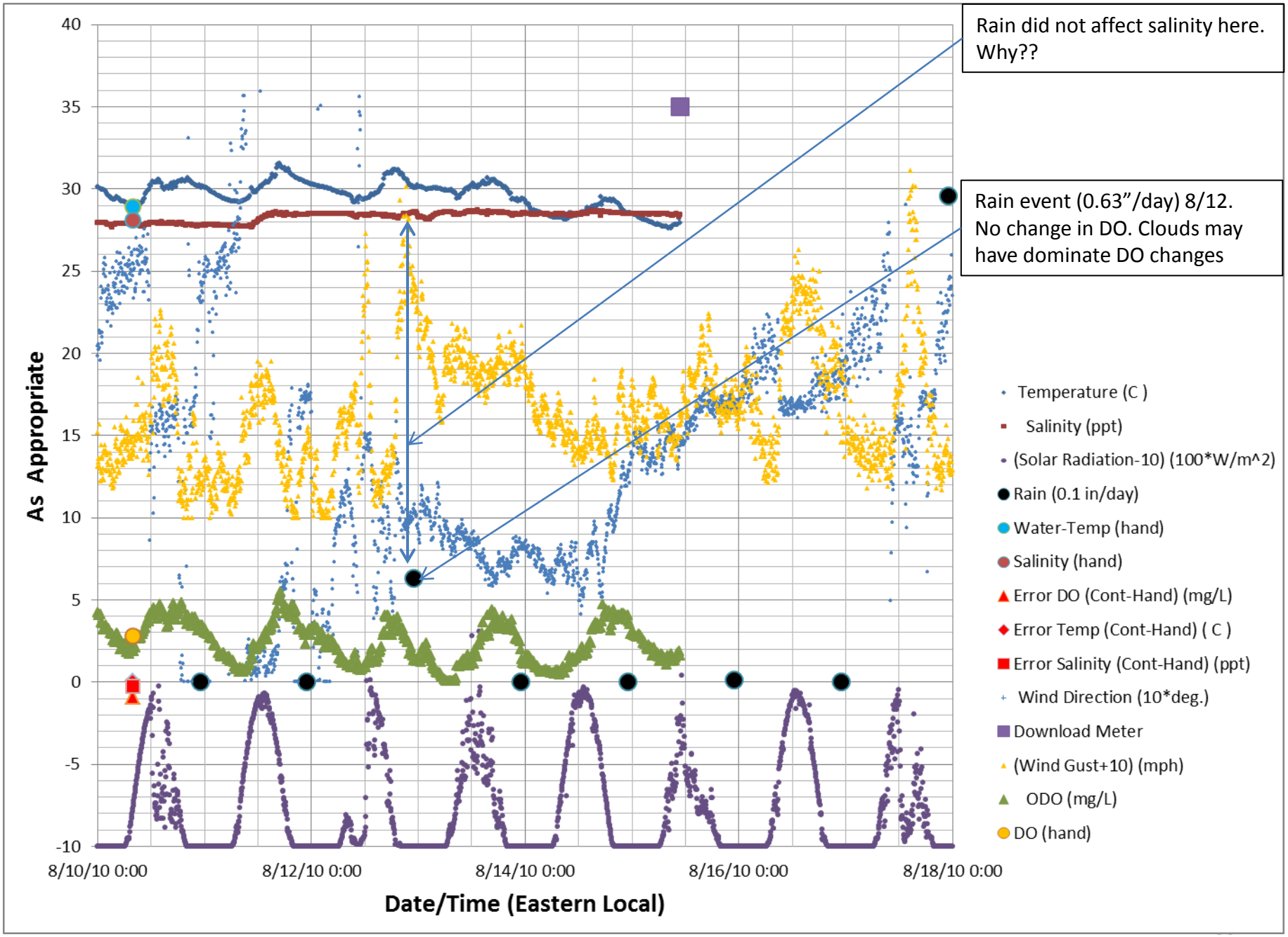
Low salinity points could be from neighbors garden house or shower. The water runs across the property and drains through a hole through the bulkhead which is about 12' from the meter.

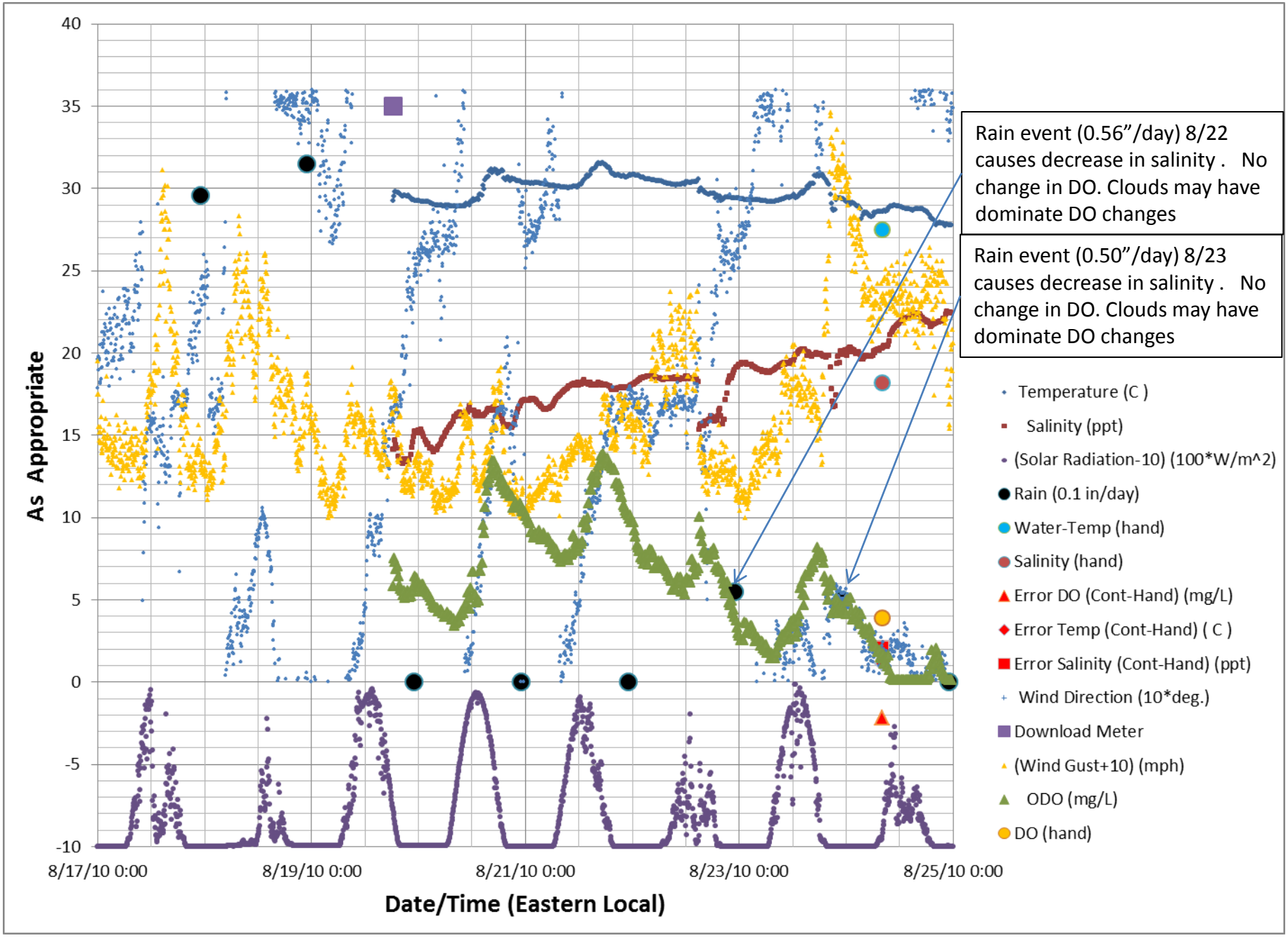


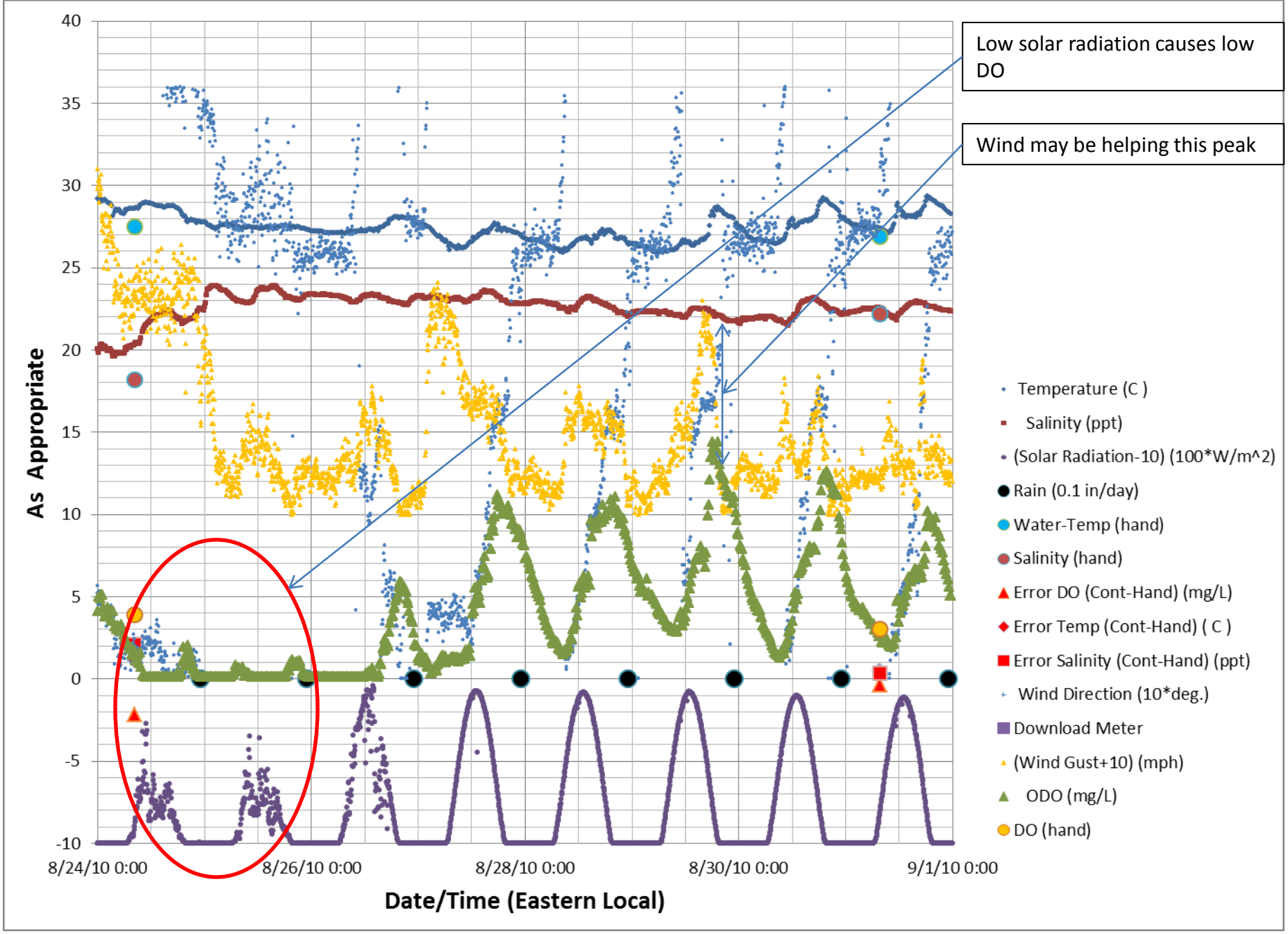

Low salinity points could be from neighbors garden house or shower. The water runs across the property and drains through a hole through the bulkhead.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
7/22/10 0:00
7/24/10 0:00
7/26/10 0:00
7/28/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

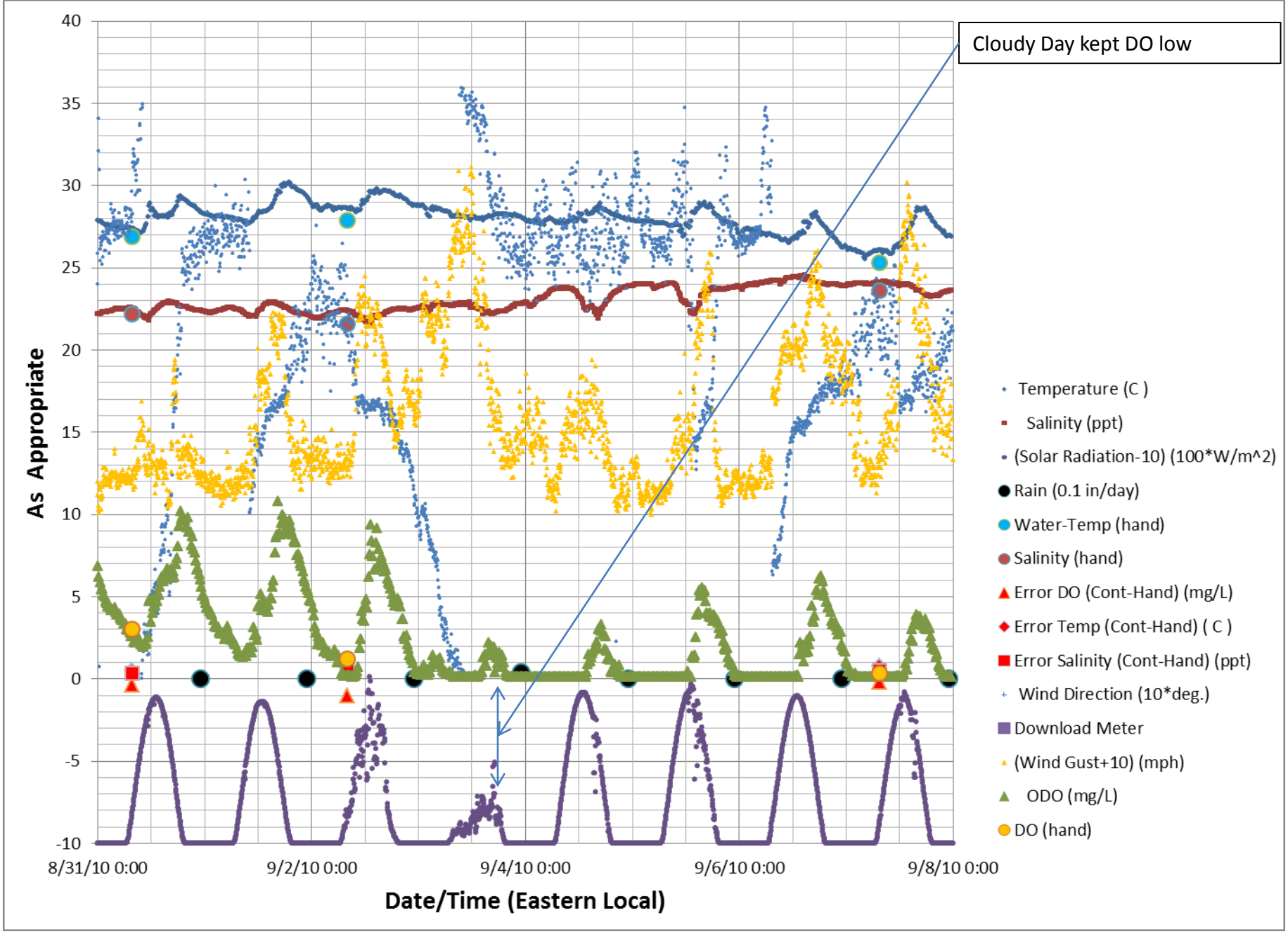

40
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
7/27/10 0:00
7/29/10 0:00
7/31/10 0:00
8/2/10 0:00
8/4/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

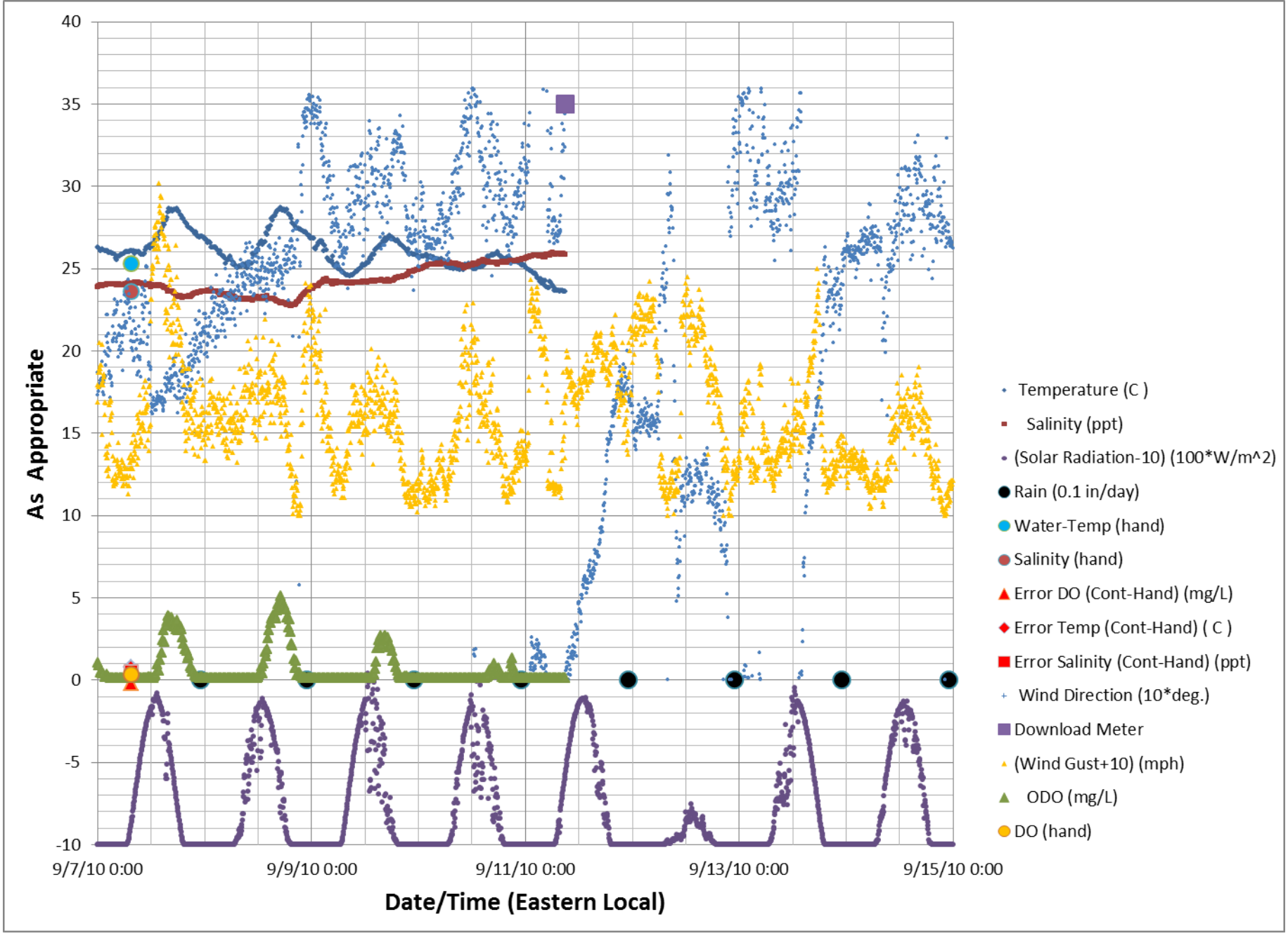

40
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
8/3/10 0:00
8/5/10 0:00
8/7/10 0:00
8/9/10 0:00
8/11/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

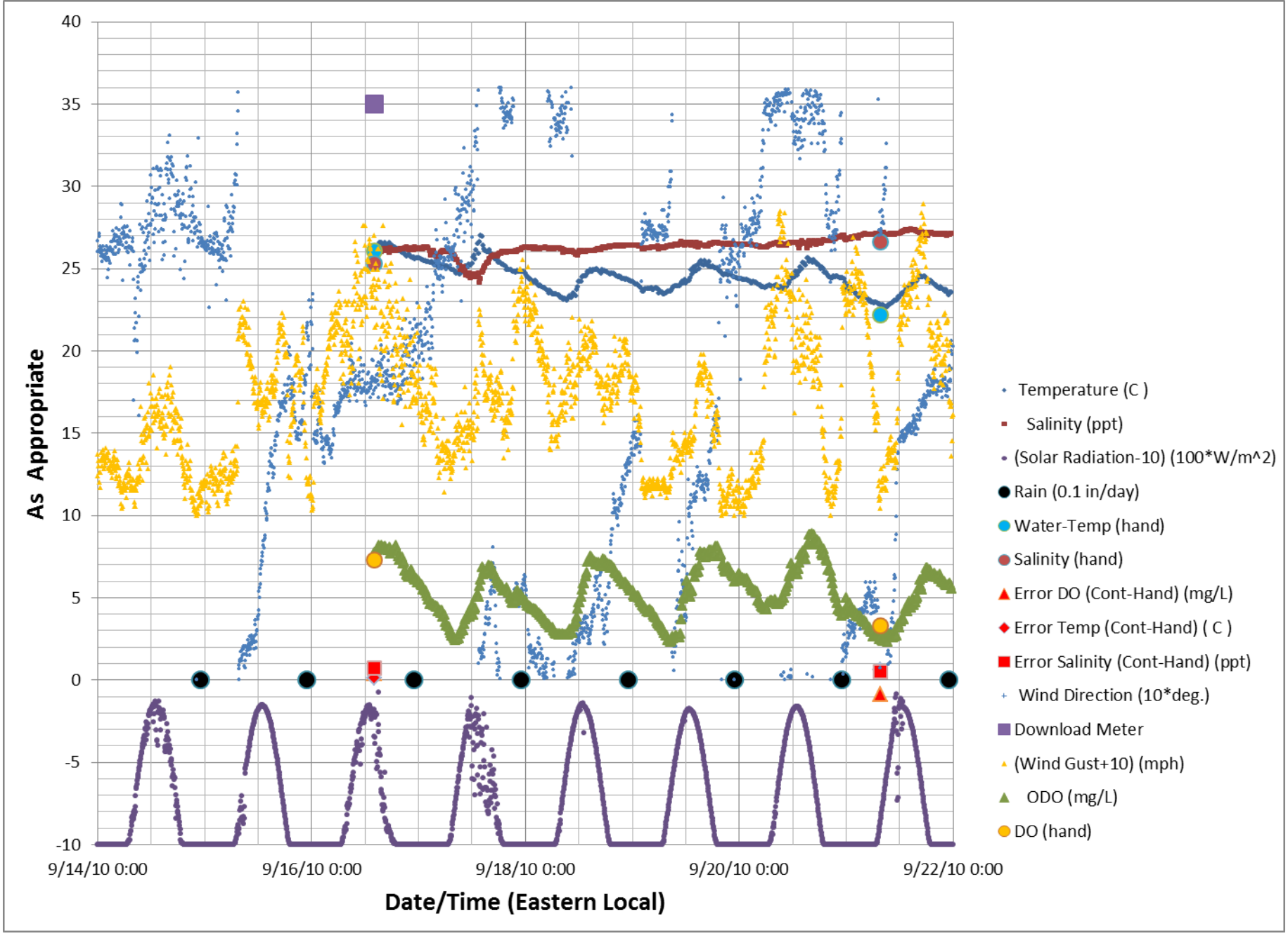

Rain did not affect salinity here. Why??
Rain event (0.63”/day) 8/12. No change in DO. Clouds may have dominate DO changes
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
8/10/10 0:00
8/12/10 0:00
8/14/10 0:00
8/16/10 0:00
8/18/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

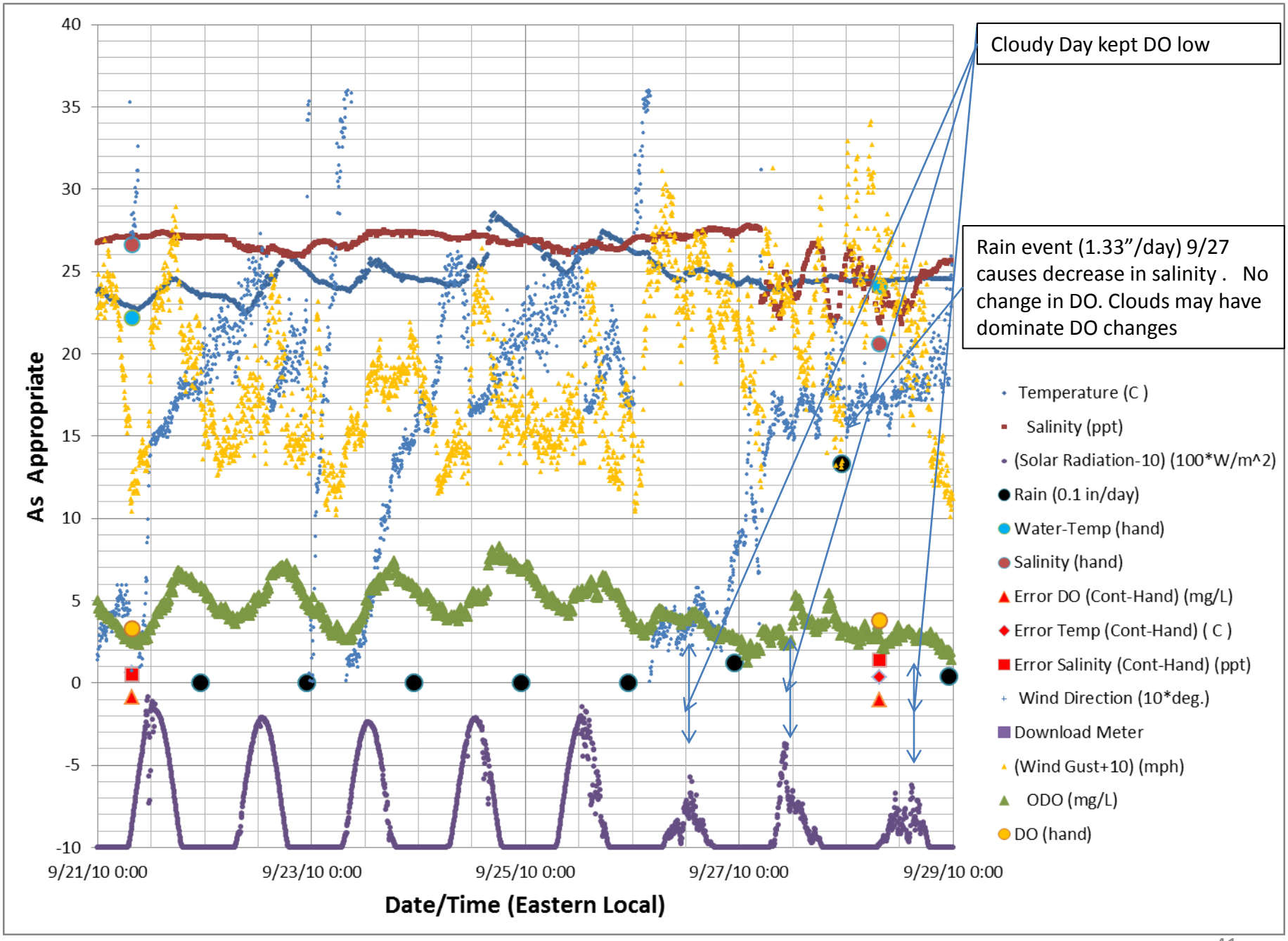

Rain event (0.56”/day) 8/22 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
Rain event (0.50”/day) 8/23 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
8/17/10 0:00
8/19/10 0:00
8/21/10 0:00
8/23/10 0:00
8/25/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

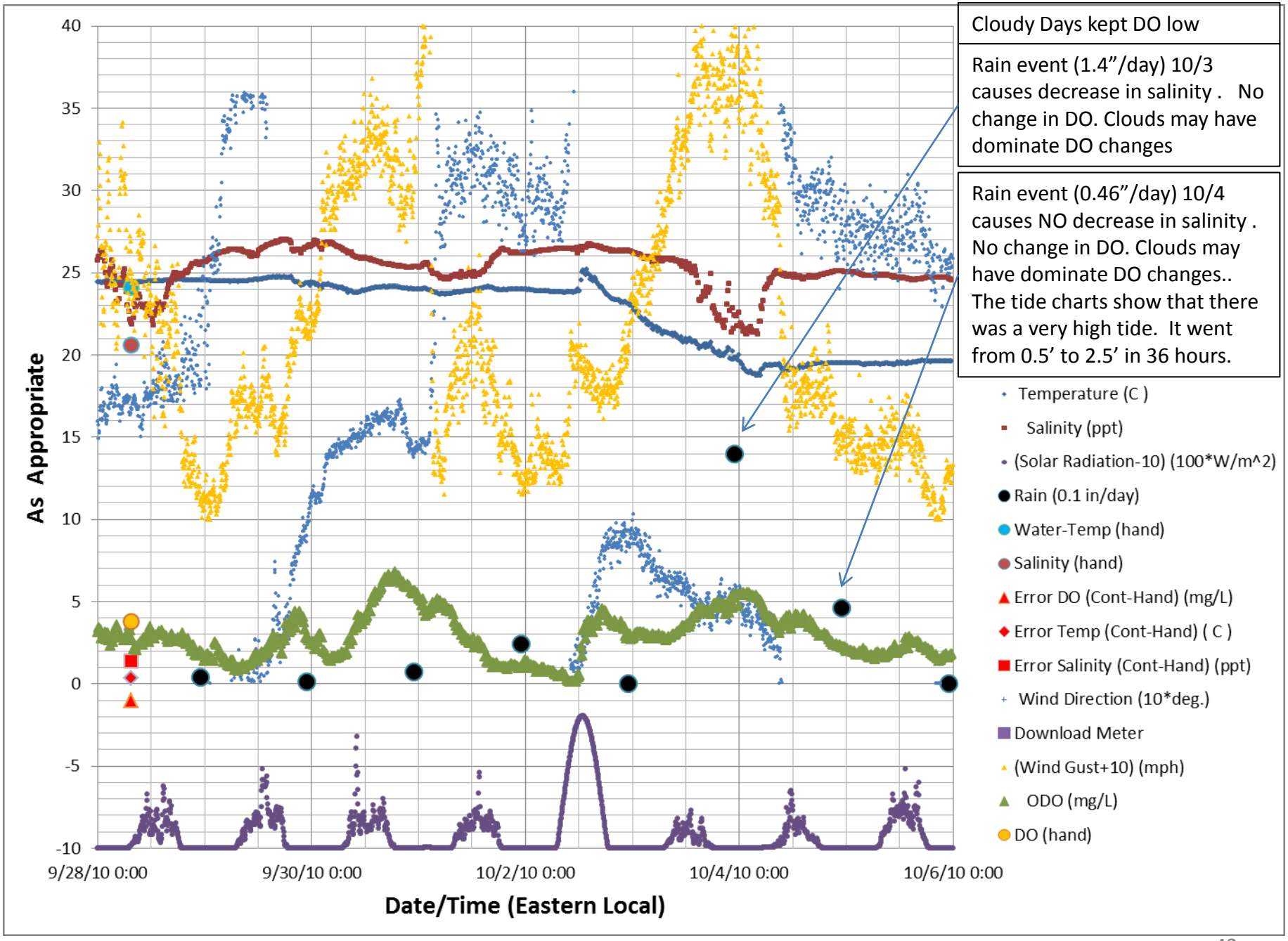

Low solar radiation causes low DO
Wind may be helping this peak
As Appropriate
Date/Time (Eastern Local)
40
35
30
25
20
15
10
5
0
-5
-10
8/24/10 0:00
8/26/10 0:00
8/28/10 0:00
8/30/10 0:00
9/1/10 0:00
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

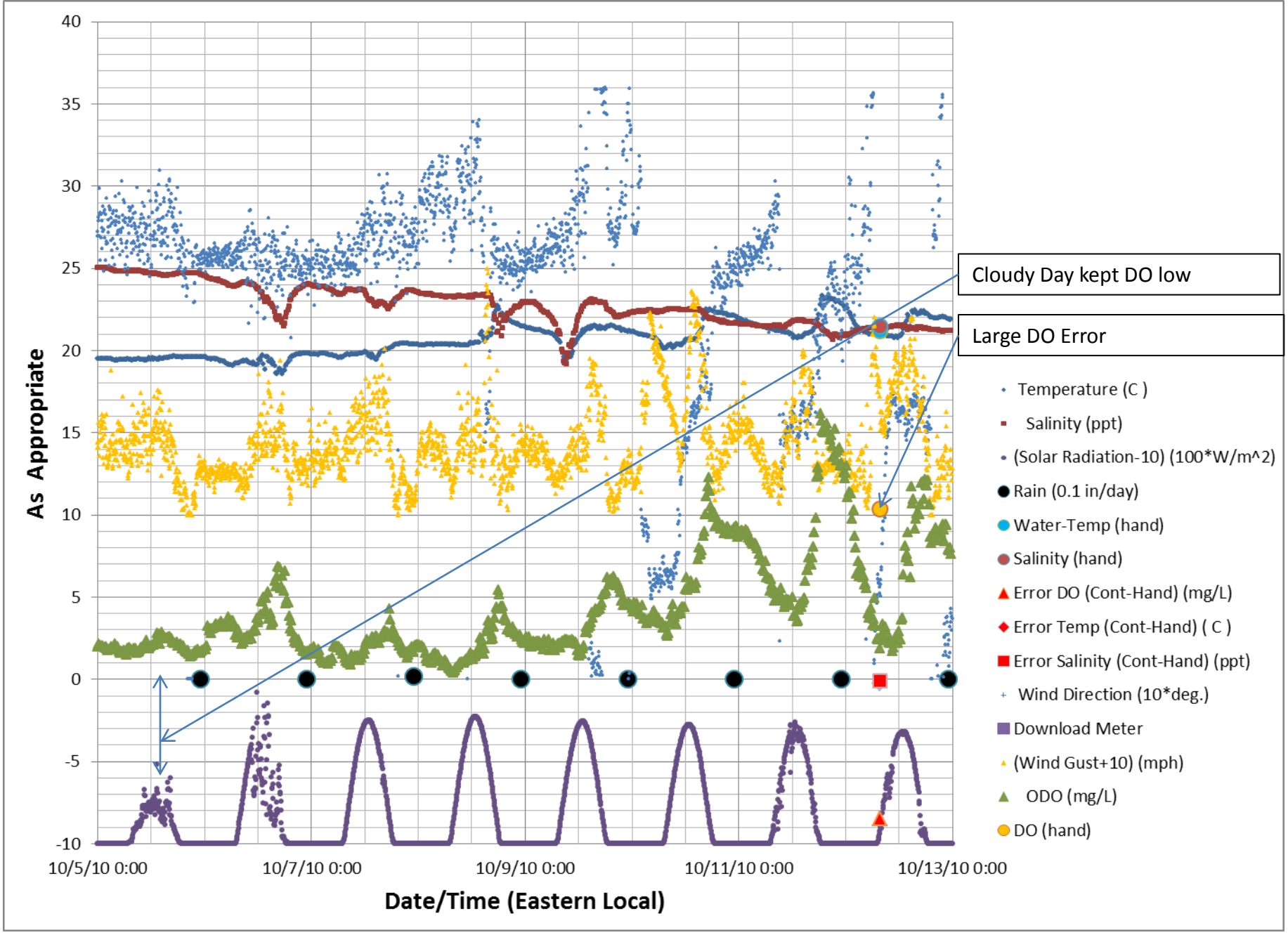

Cloudy Day kept DO low
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
8/31/10 0:00
9/2/10 0:00
9/4/10 0:00
9/6/10 0:00
9/8/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

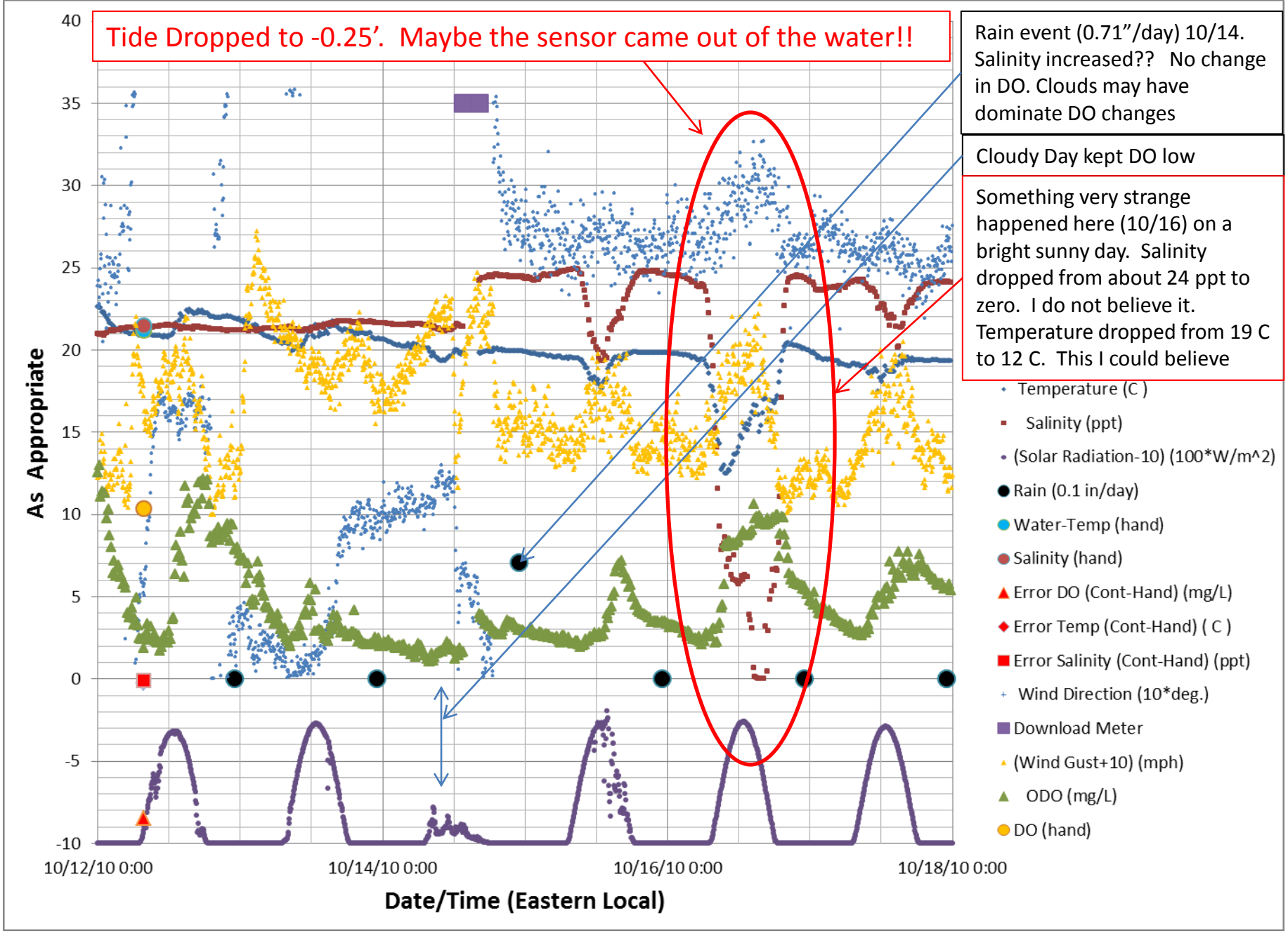

As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
9/7/10 0:00
9/9/10 0:00
9/11/10 0:00
9/13/10 0:00
9/15/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

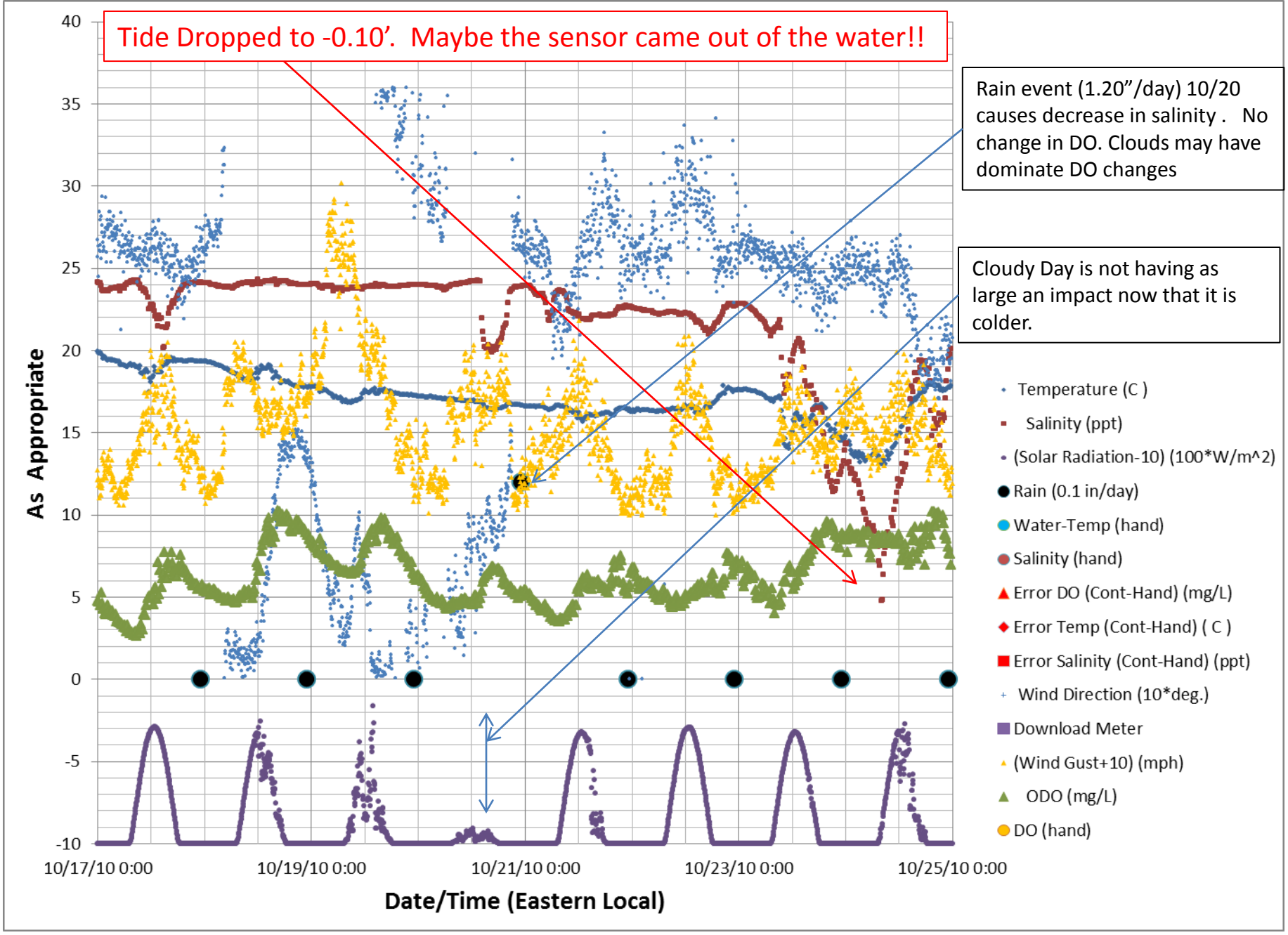

40
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
9/14/10 0:00
9/16/10 0:00
9/18/10 0:00
9/20/10 0:00
9/22/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

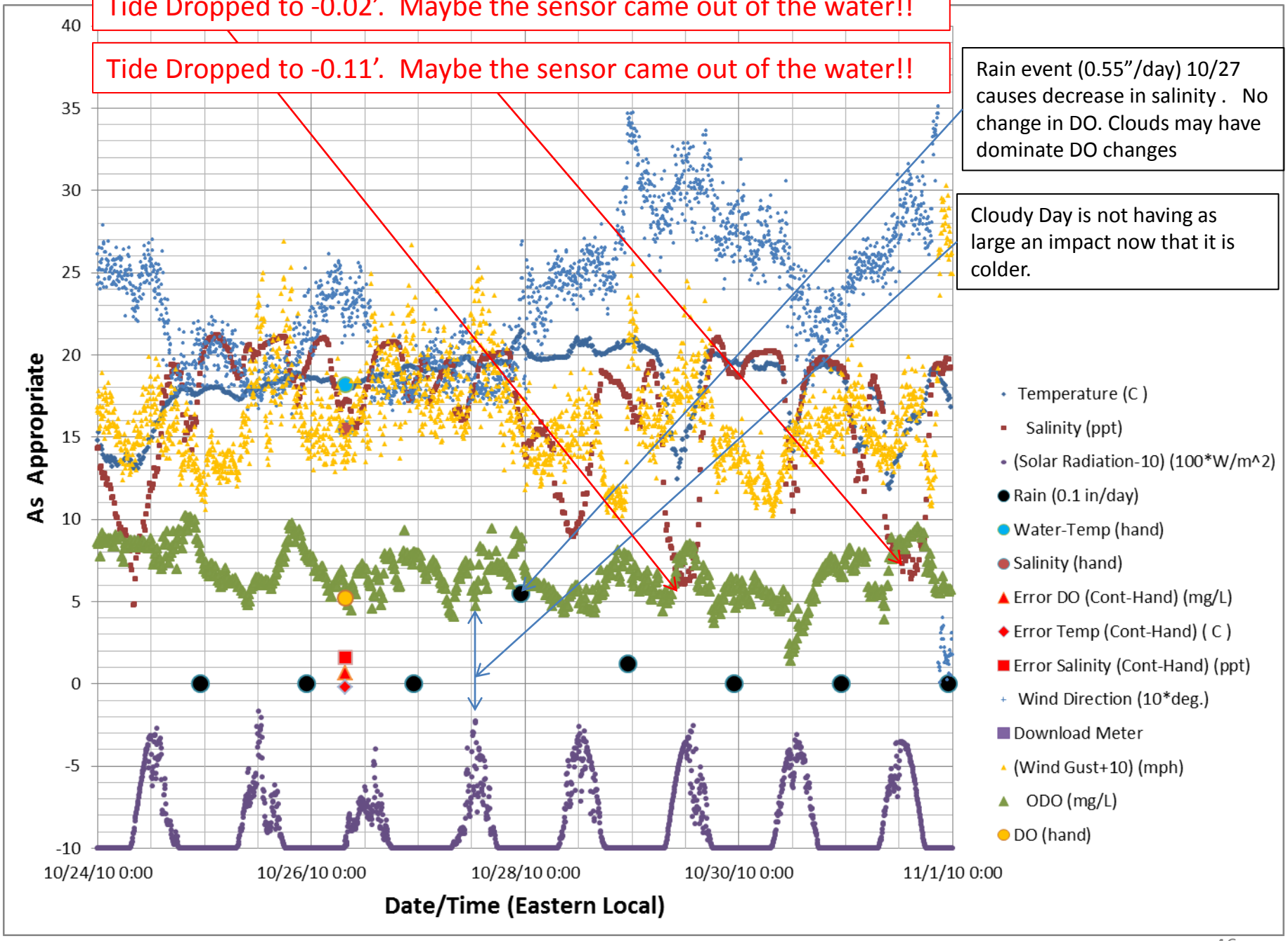

Cloudy Day kept DO low
Rain event (1.33”/day) 9/27 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
9/21/10 0:00
9/23/10 0:00
9/25/10 0:00
9/27/10 0:00
9/29/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

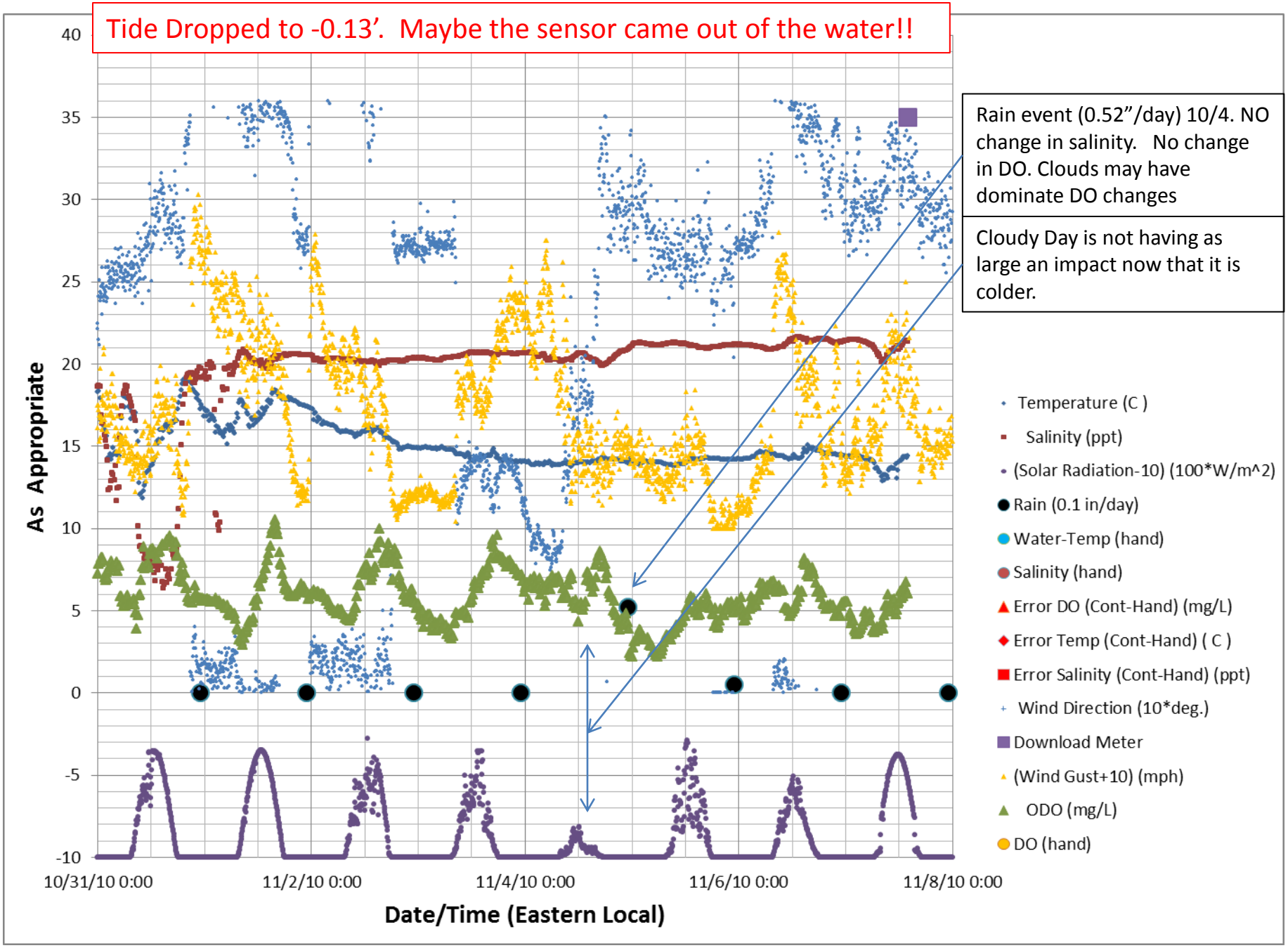

Cloudy Days kept DO low
Rain event (1.4”/day) 10/3 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
Rain event (0.46”/day) 10/4 causes NO decrease in salinity . No change in DO. Clouds may have dominate DO changes.. The tide charts show that there was a very high tide. It went from 0.5’ to 2.5’ in 36 hours.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
9/28/10 0:00
9/30/10 0:00
10/2/10 0:00
10/4/10 0:00
10/6/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

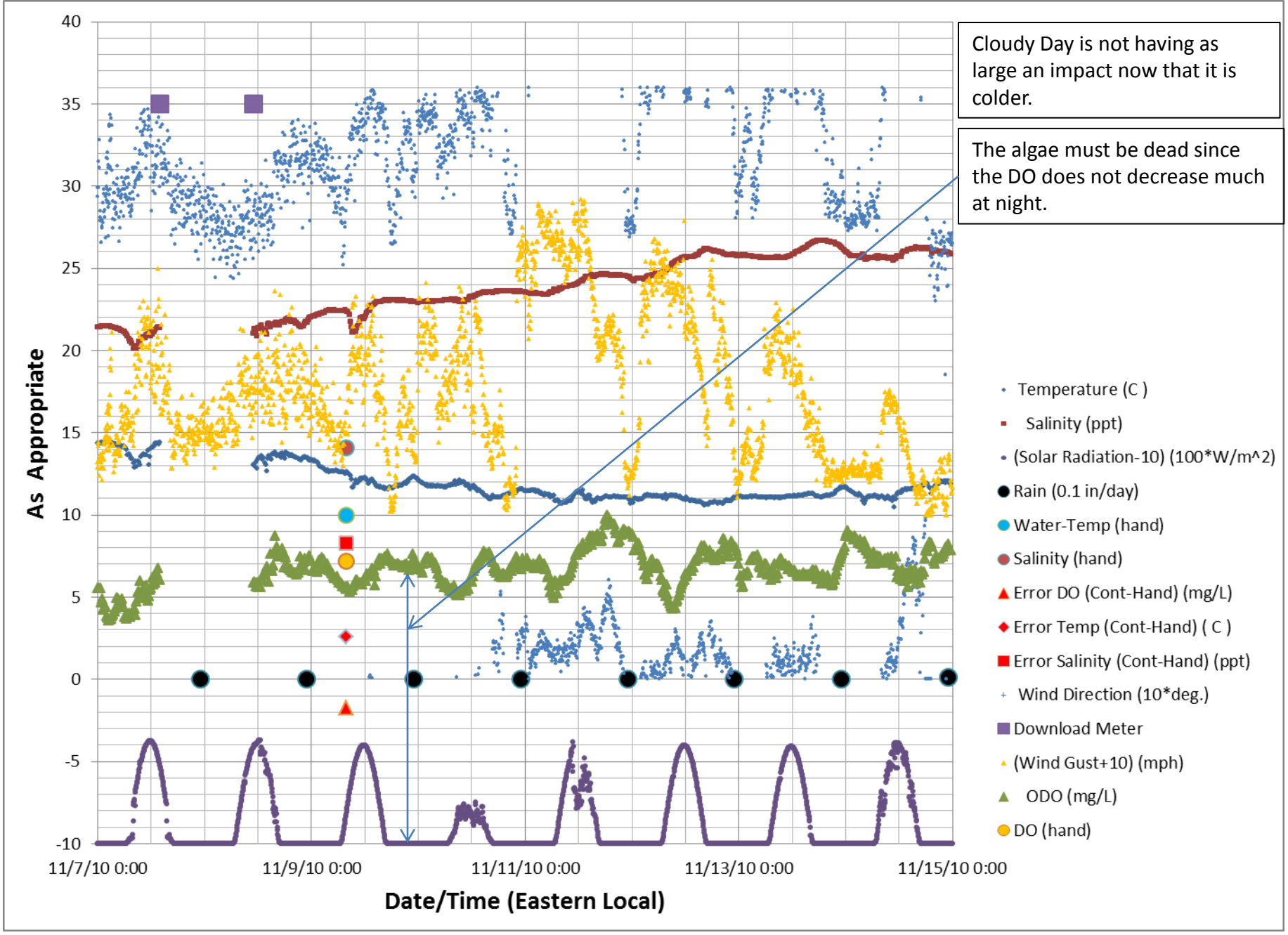

Cloudy Day kept DO low
Large DO Error
As Appropriate
Date/Time (Eastern Local)
40
35
30
25
20
15
10
5
0
-5
-10
10/5/10 0:00
10/7/10 0:00
10/9/10 0:00
10/11/10 0:00
10/13/10 0:00
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

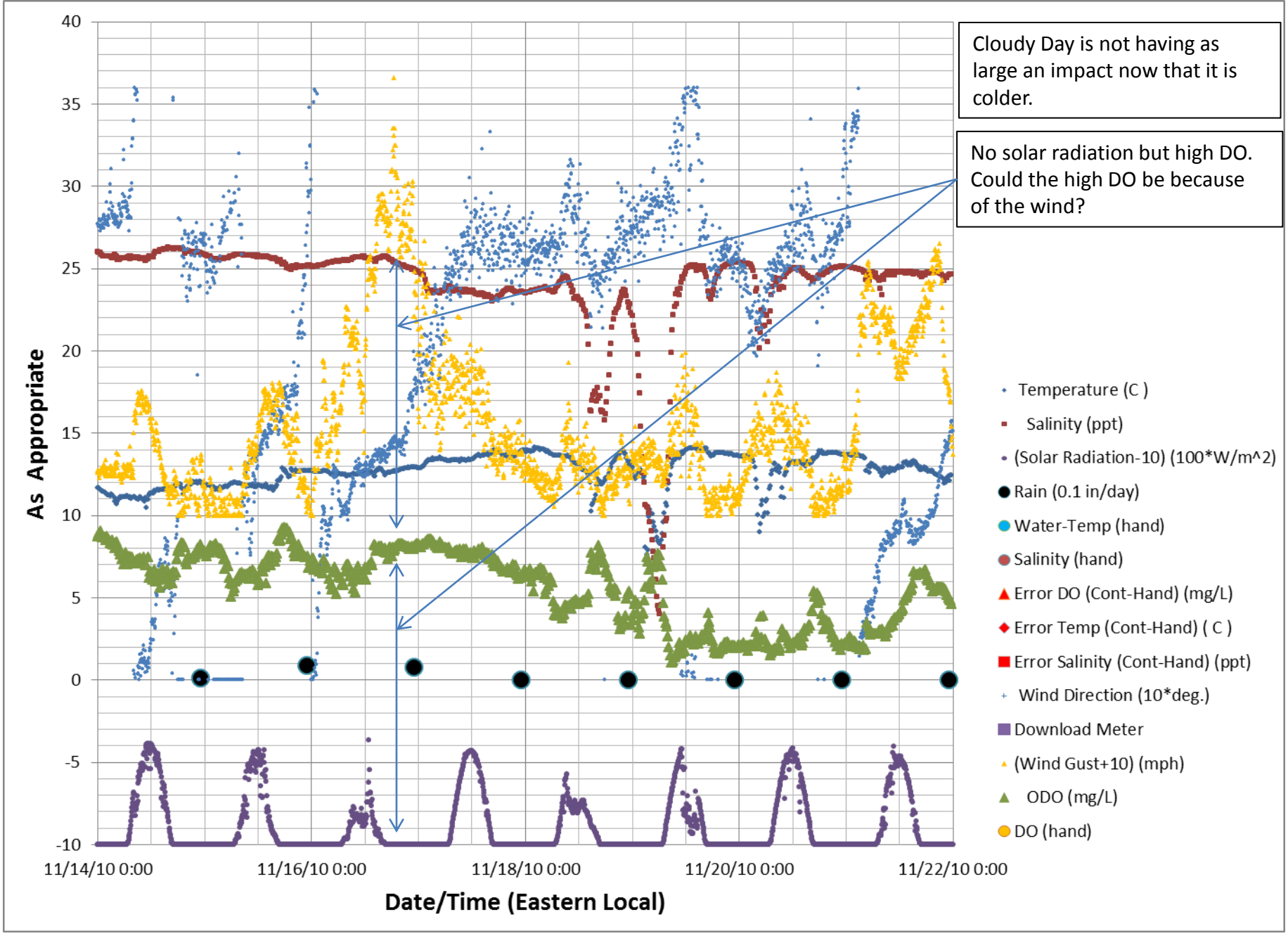

Tide Dropped to -0.25'. Maybe the sensor came out of the water!!
Rain event (0.71"/day) 10/14. Salinity increased?? No change in DO. Clouds may have dominate DO changes
Cloudy Day kept DO low
Something very strange happened here (10/16) on a bright sunny day. Salinity dropped from about 24 ppt to zero. I do not believe it. Temperature dropped from 19 C to 12 C. This I could believe
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
10/12/10 0:00
10/14/10 0:00
10/16/10 0:00
10/18/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

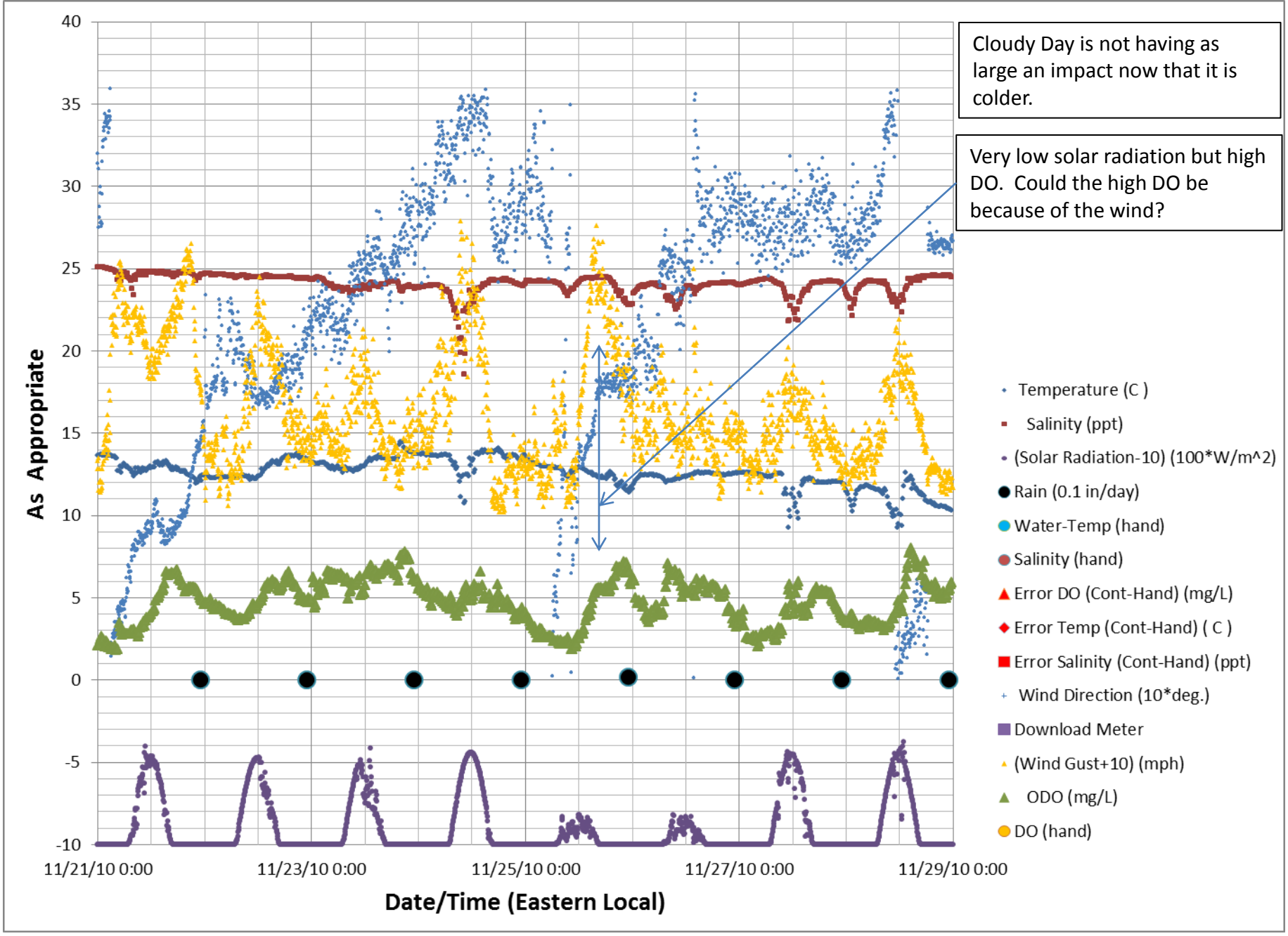

Tide Dropped to -0.10'. Maybe the sensor came out of the water!!
Rain event (1.20"/day) 10/20 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
Cloudy Day is not having as large an impact now that it is colder.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
10/17/10 0:00
10/19/10 0:00
10/21/10 0:00
10/23/10 0:00
10/25/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

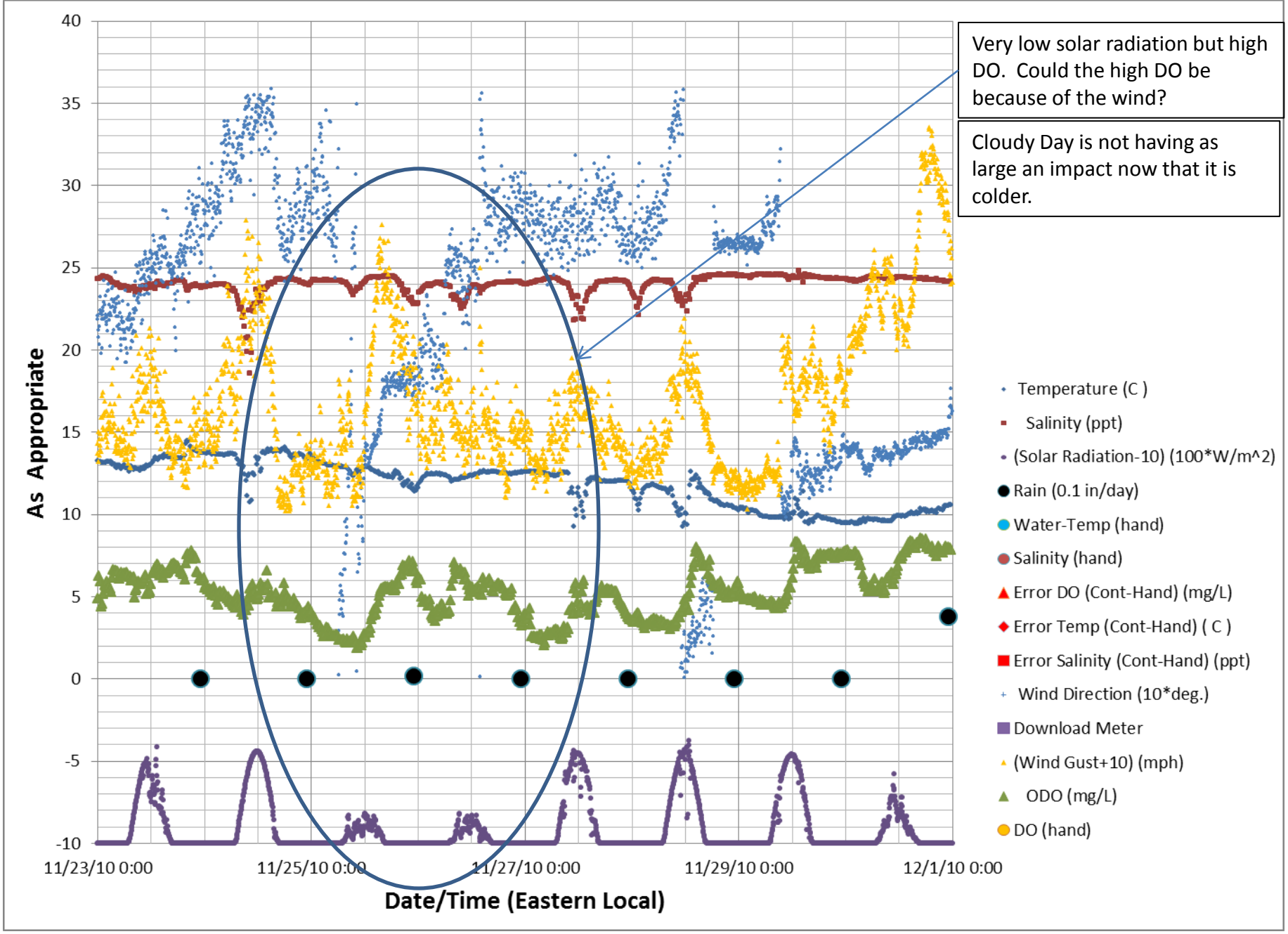

Tide Dropped to -0.02'. Maybe the sensor came out of the water!!
Tide Dropped to -0.11'. Maybe the sensor came out of the water!!
Rain event (0.55"/day) 10/27 causes decrease in salinity . No change in DO. Clouds may have dominate DO changes
Cloudy Day is not having as large an impact now that it is colder.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
10/24/10 0:00
10/26/10 0:00
10/28/10 0:00
10/30/10 0:00
11/1/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


Tide Dropped to -0.13'. Maybe the sensor came out of the water!!
Rain event (0.52"/day) 10/4. NO change in salinity. No change in DO. Clouds may have dominate DO changes
Cloudy Day is not having as large an impact now that it is colder.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
10/31/10 0:00
11/2/10 0:00
11/4/10 0:00
11/6/10 0:00
11/8/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


Cloudy Day is not having as large an impact now that it is colder.
The algae must be dead since the DO does not decrease much at night.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
11/7/10 0:00
11/9/10 0:00
11/11/10 0:00
11/13/10 0:00
11/15/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


Cloudy Day is not having as large an impact now that it is colder.
No solar radiation but high DO. Could the high DO be because of the wind?
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
11/14/10 0:00
11/16/10 0:00
11/18/10 0:00
11/20/10 0:00
11/22/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


Cloudy Day is not having as large an impact now that it is colder.
Very low solar radiation but high DO. Could the high DO be because of the wind?
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
11/21/10 0:00
11/23/10 0:00
11/25/10 0:00
11/27/10 0:00
11/29/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)


Very low solar radiation but high DO. Could the high DO be because of the wind?
Cloudy Day is not having as large an impact now that it is colder.
As Appropriate
40
35
30
25
20
15
10
5
0
-5
-10
11/23/10 0:00
11/25/10 0:00
11/27/10 0:00
11/29/10 0:00
12/1/10 0:00
Date/Time (Eastern Local)
Temperature (C)
Salinity (ppt)
(Solar Radiation-10) (100*W/m^2)
Rain (0.1 in/day)
Water-Temp (hand)
Salinity (hand)
Error DO (Cont-Hand) (mg/L)
Error Temp (Cont-Hand) (C)
Error Salinity (Cont-Hand) (ppt)
Wind Direction (10*deg.)
Download Meter
(Wind Gust+10) (mph)
ODO (mg/L)
DO (hand)

Tidal Influence On Dissolved Oxygen

- On the next two charts tide data is plotted as read in ft. NGVD
- On the charts that follow those two, tide data is multiplied by 10 and displaced 10 ft. up so that it fits better on the chart. Thus 1.0 ft. NGVD is plotted as 20 ft. And 0.0 ft. NGVD is plotted as 10 ft.

33 times the DO was above 10mg/L.

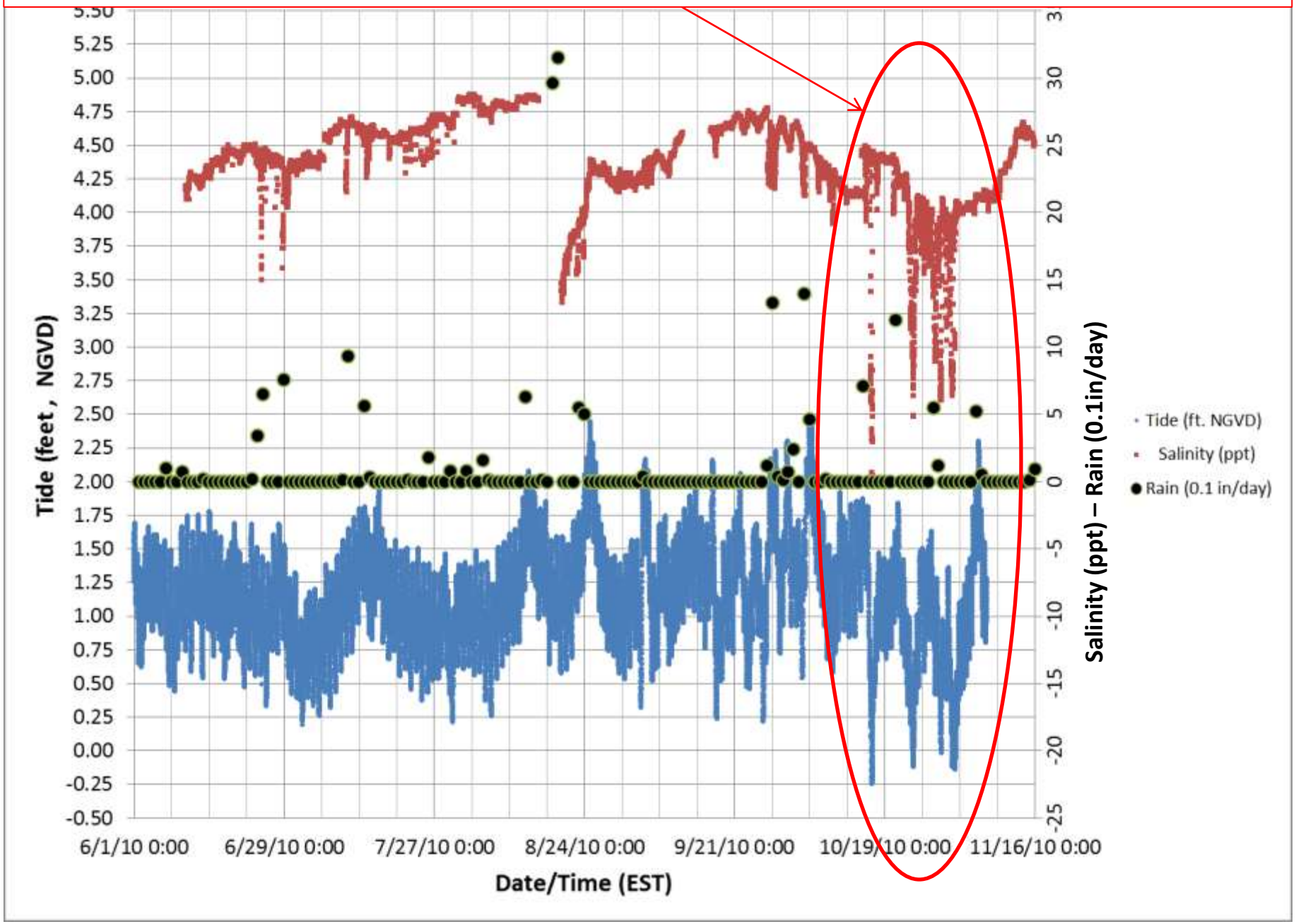
- 22 times it corresponded with an out going tide.
- 11 times it corresponded with an incoming tide.

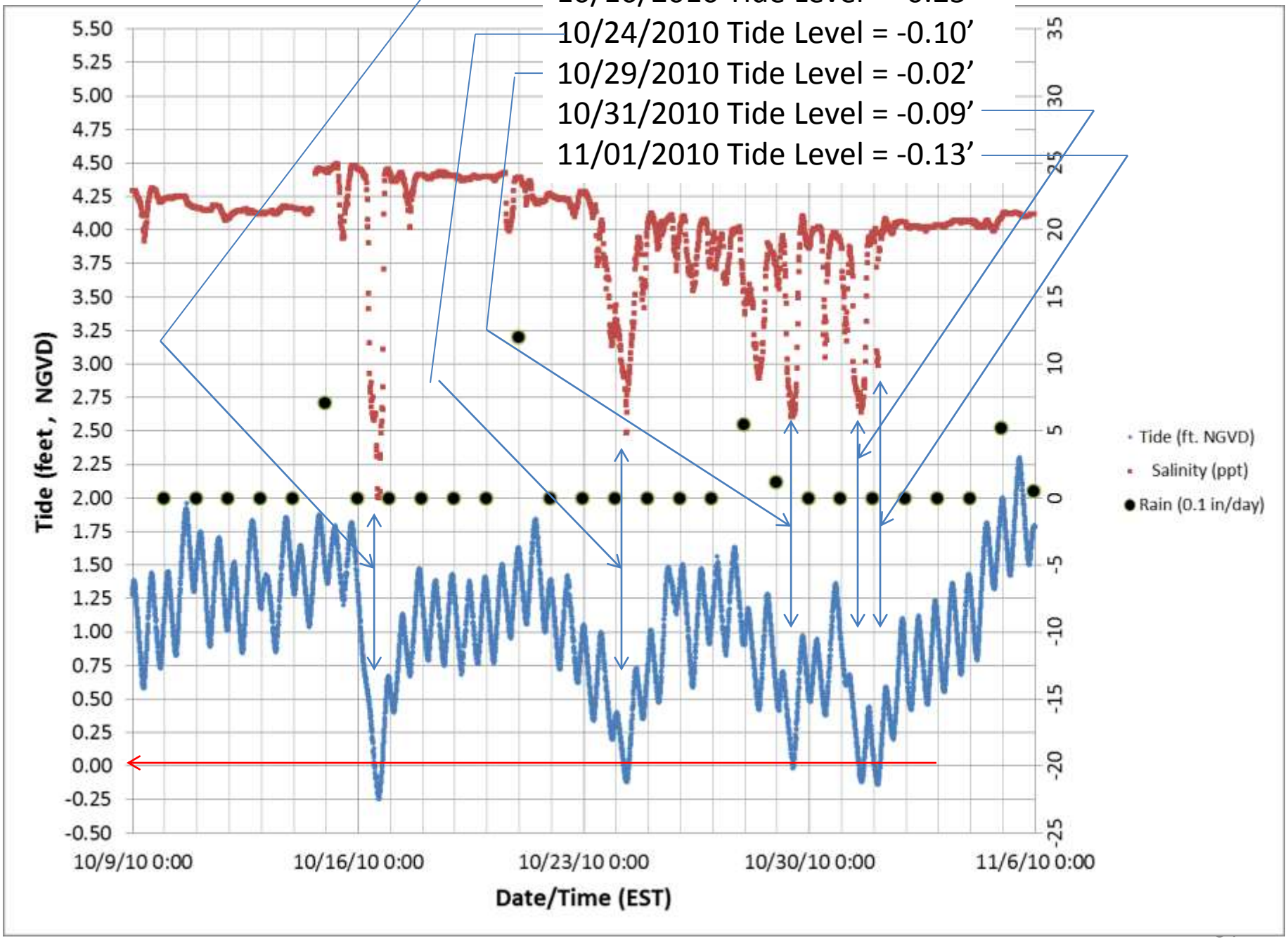
During two rain events the DO was above 10mg/L

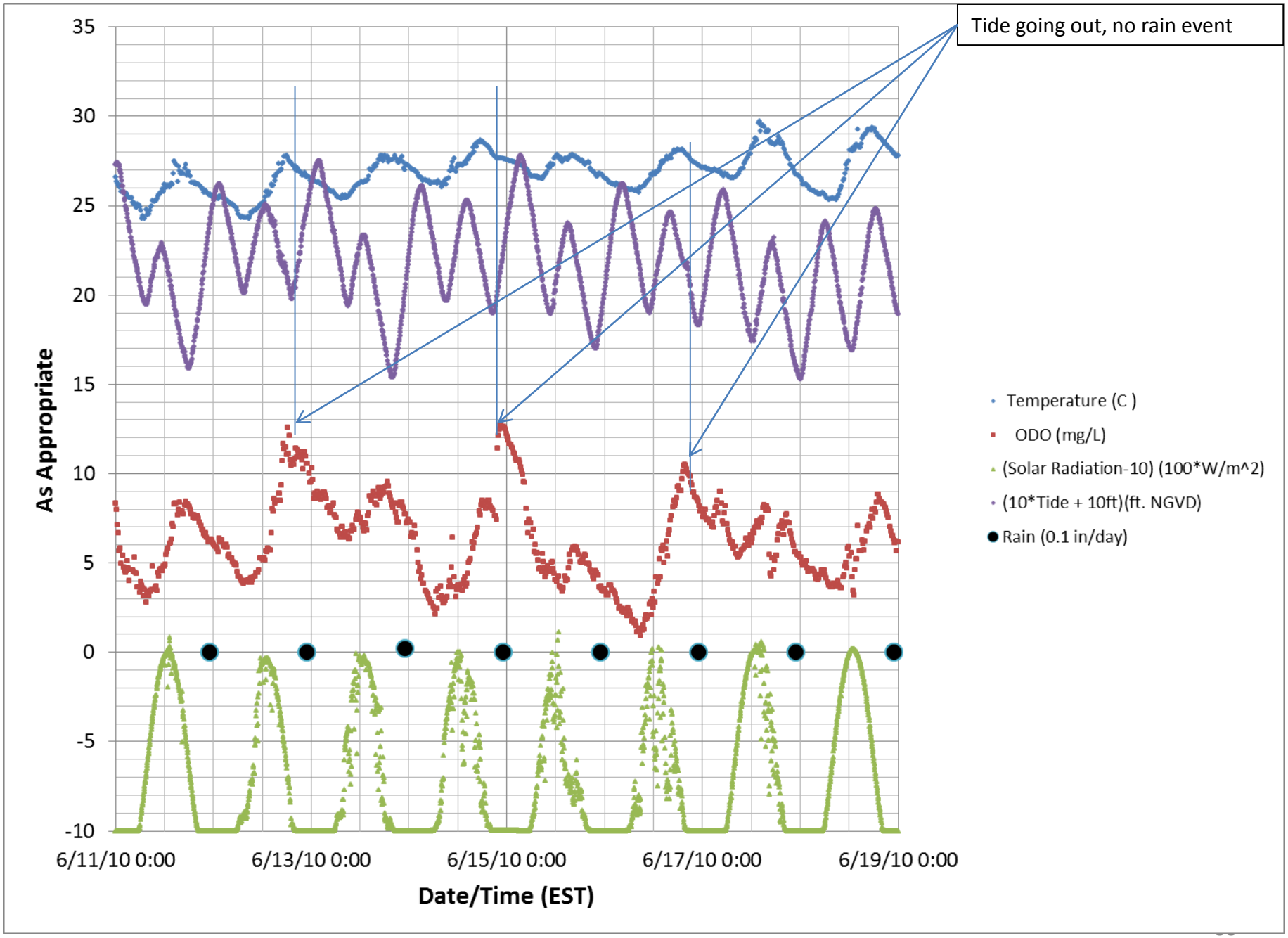
- One time the tide was outgoing
- One time the tide was incoming

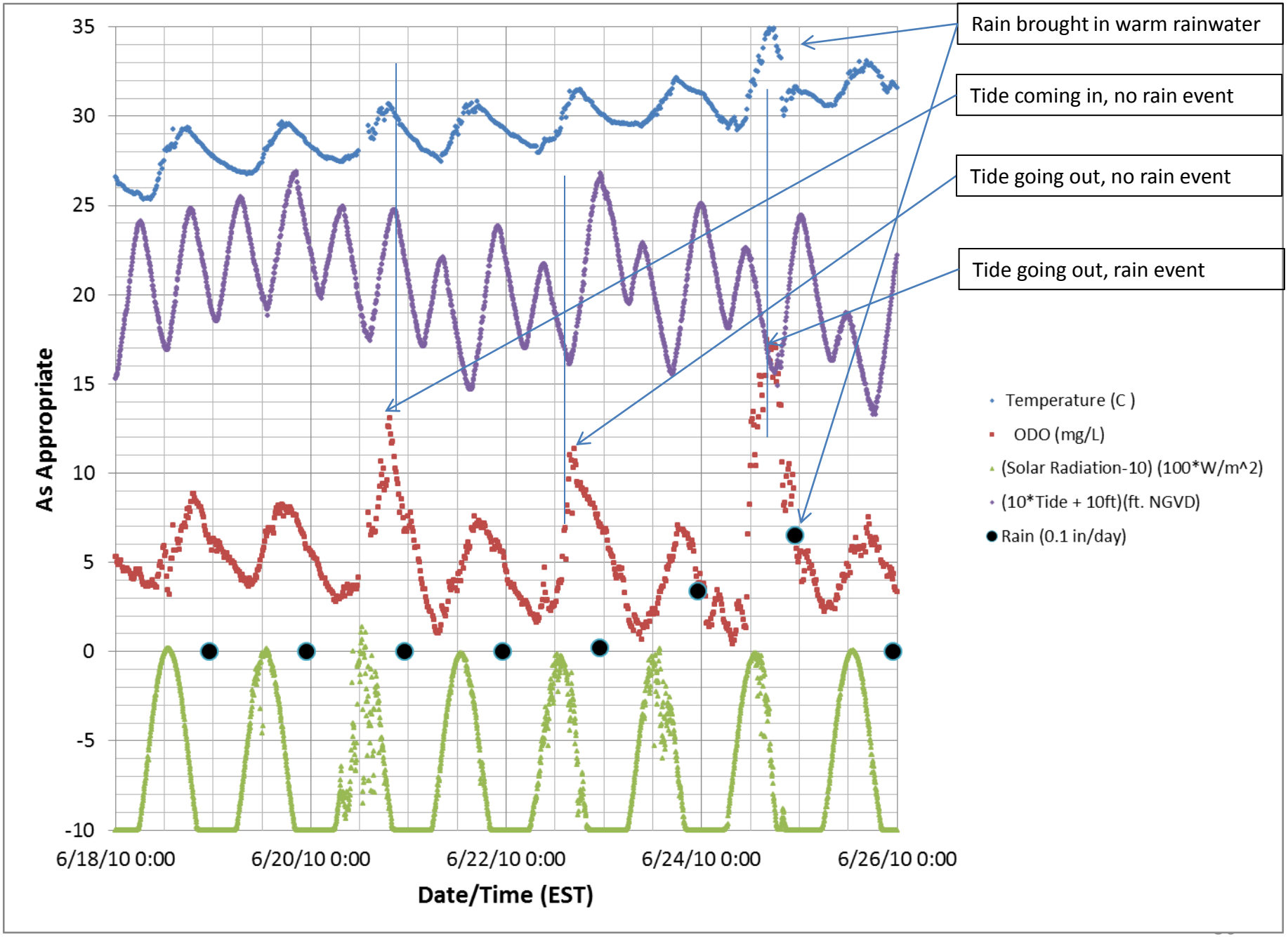
- Five times the tide was below 0.0 feet NGVD and the Temperature/Conductivity Sensor was probably just out of the water

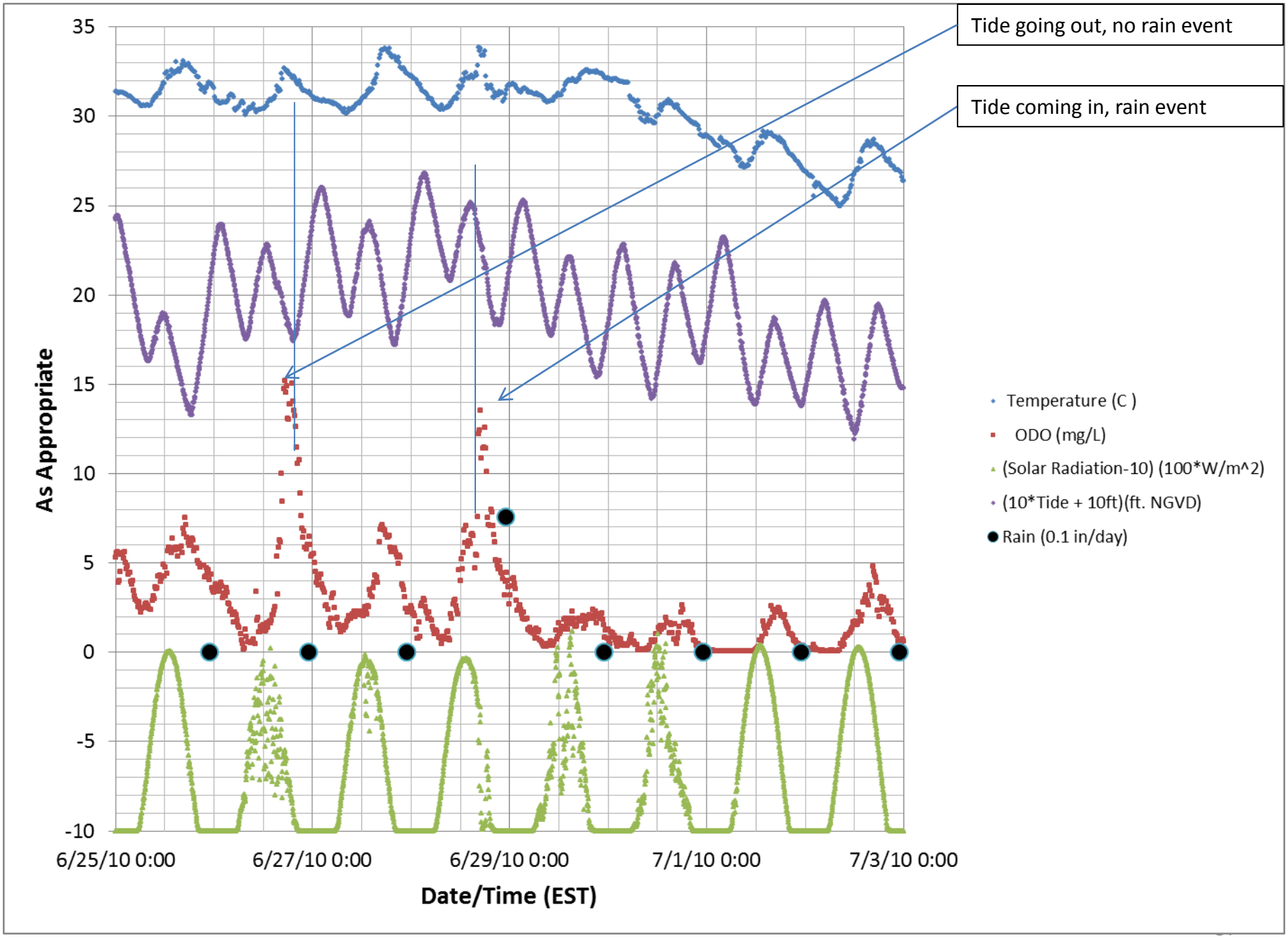
See details next chart. The tide was probable so low that the salinity sensor just came out of the water. The DO sensor is ~2.5" lower

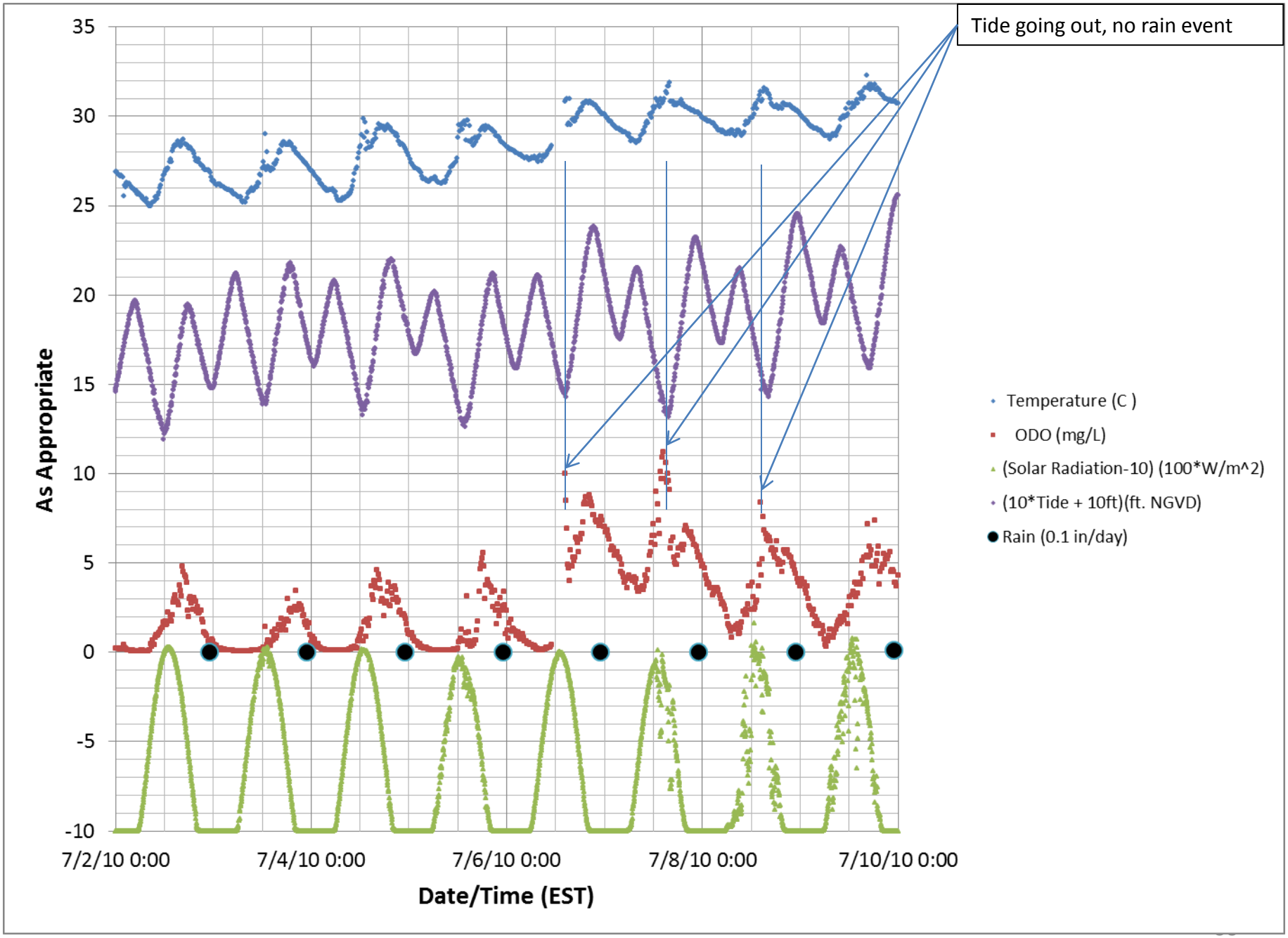


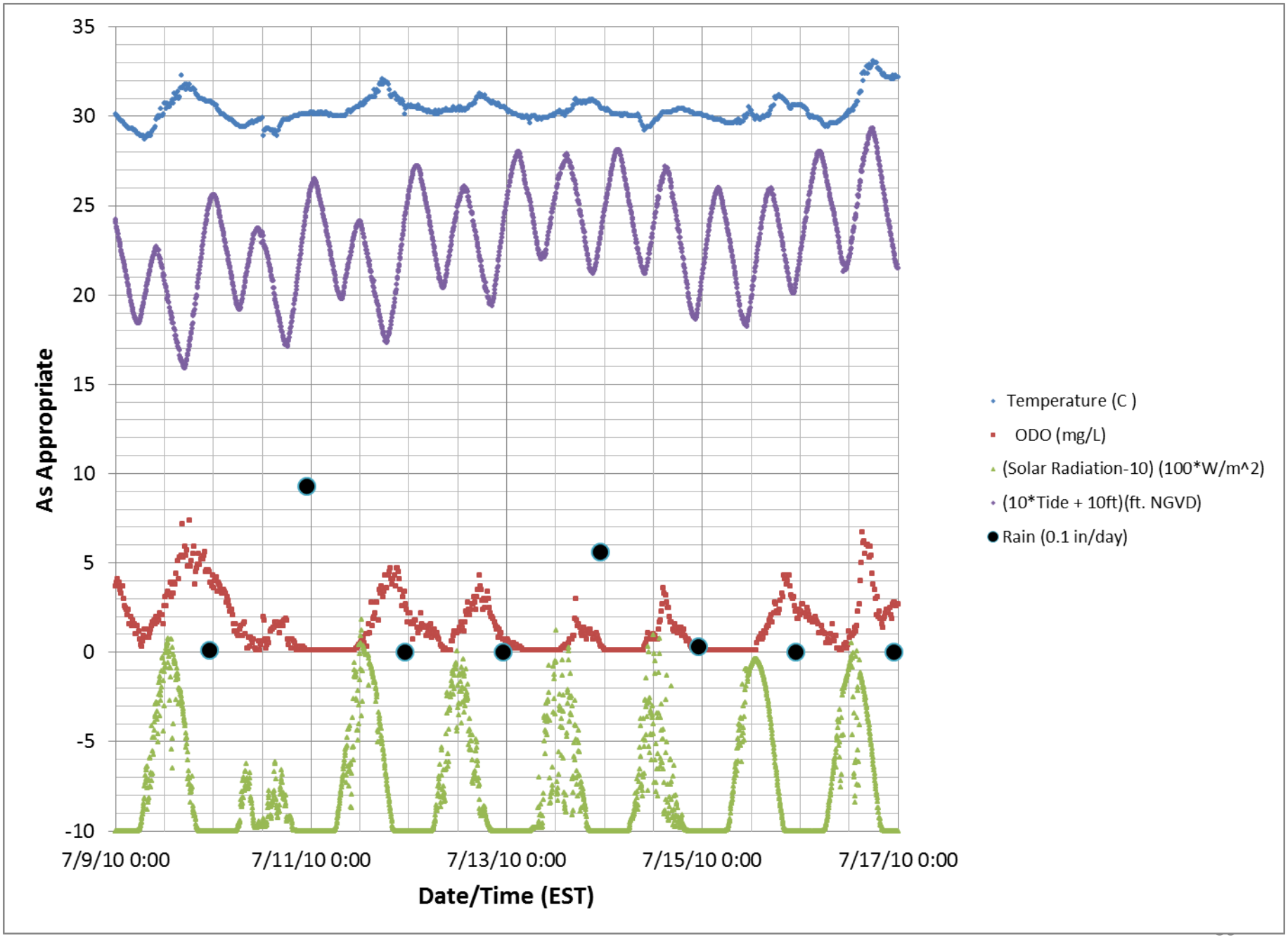

10/16/2010 Tide Level = -0.25'
10/24/2010 Tide Level = -0.10'
10/29/2010 Tide Level = -0.02'
10/31/2010 Tide Level = -0.09'
11/01/2010 Tide Level = -0.13'
Tide (feet , NGVD)
5.50
5.25
5.00
4.75
4.50
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
-0.25
-0.50
35
30
25
20
15
10
5
0
-5
-10
-15
-20
-25
10/9/10 0:00
10/16/10 0:00
10/23/10 0:00
10/30/10 0:00
11/6/10 0:00
Date/Time (EST)
Tide (ft. NGVD)
Salinity (ppt)
Rain (0.1 in/day)

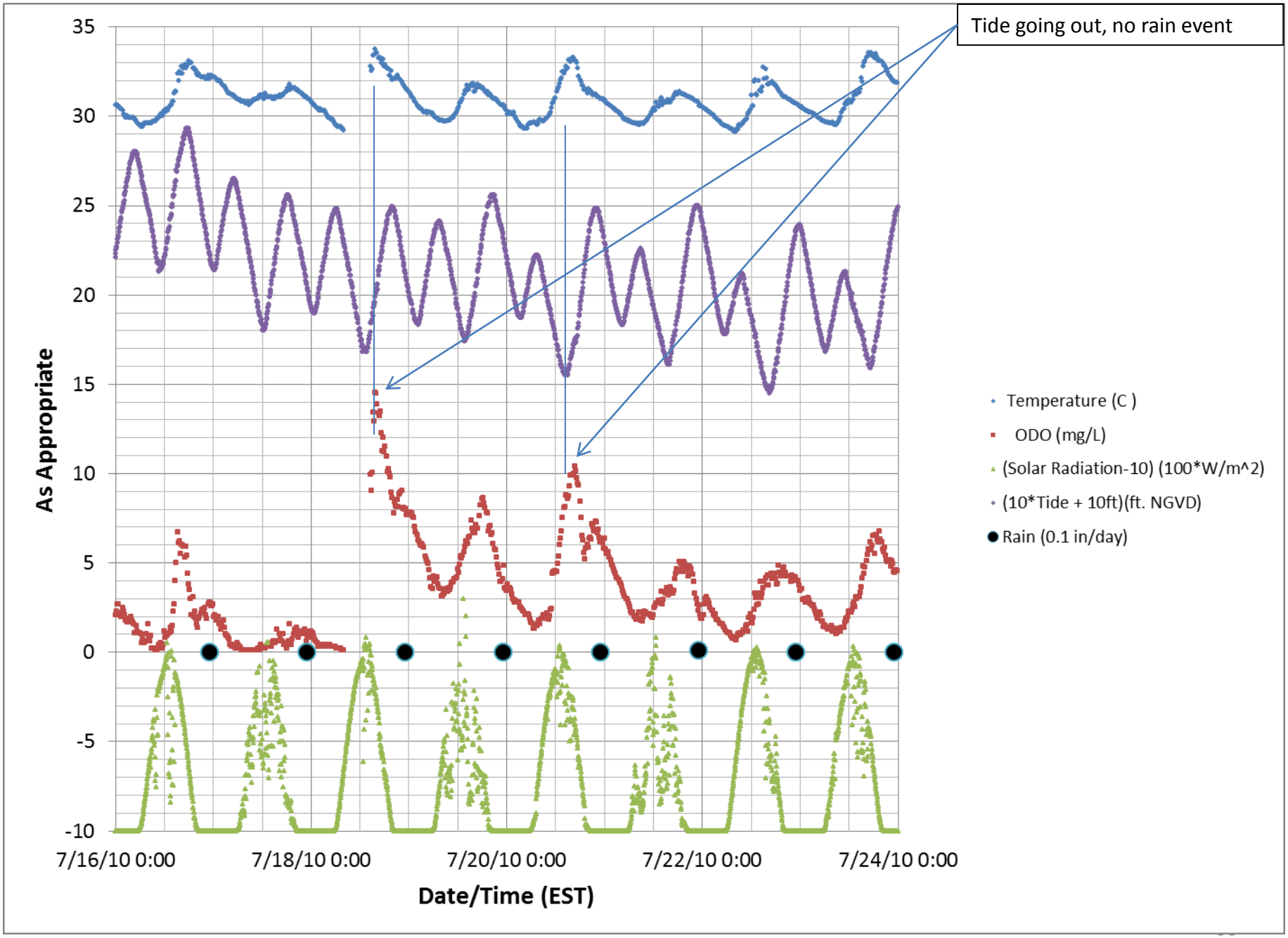

Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
6/11/10 0:00
6/13/10 0:00
6/15/10 0:00
6/17/10 0:00
6/19/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

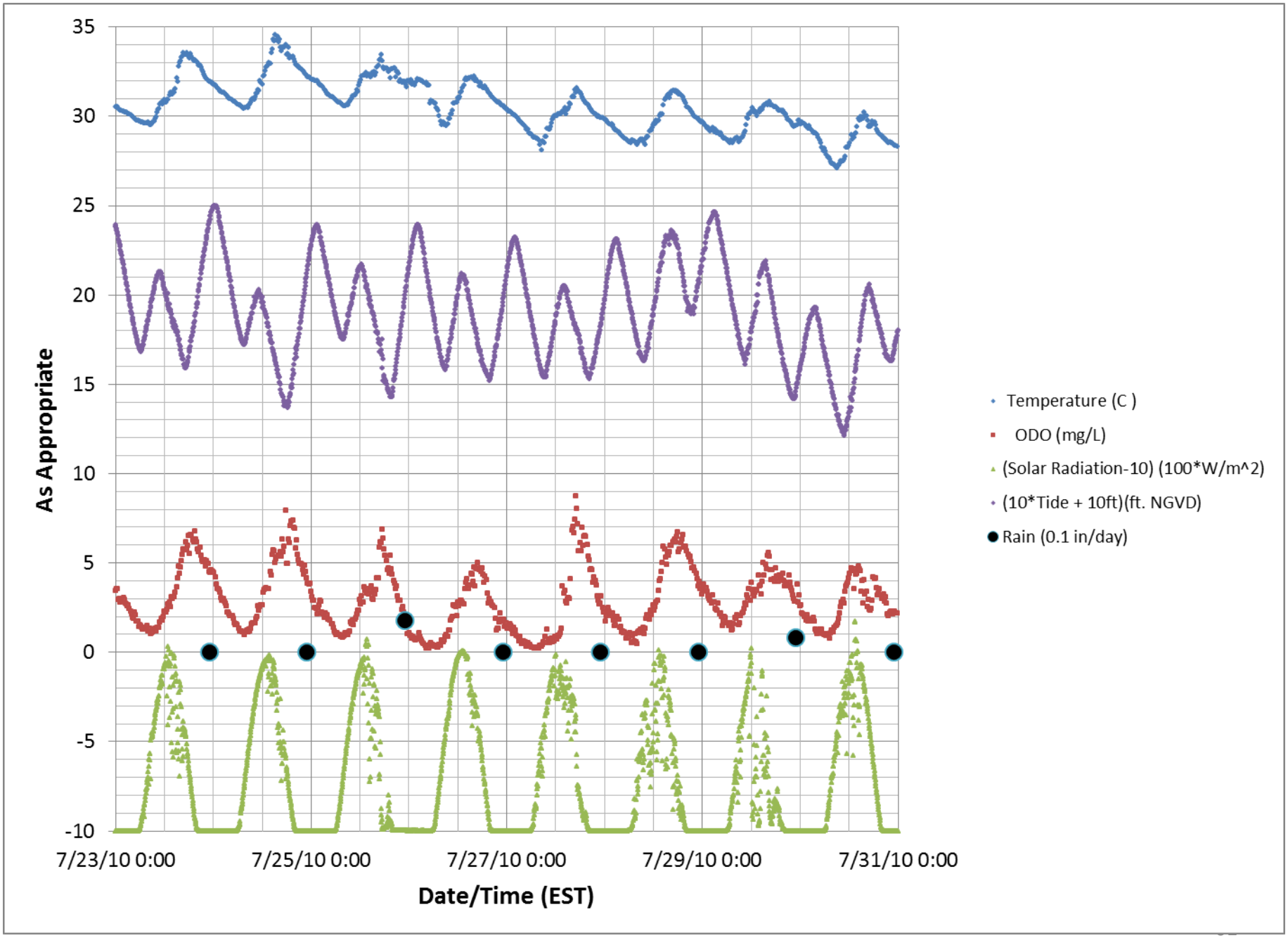

Rain brought in warm rainwater
Tide coming in, no rain event
Tide going out, no rain event
Tide going out, rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
6/18/10 0:00
6/20/10 0:00
6/22/10 0:00
6/24/10 0:00
6/26/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

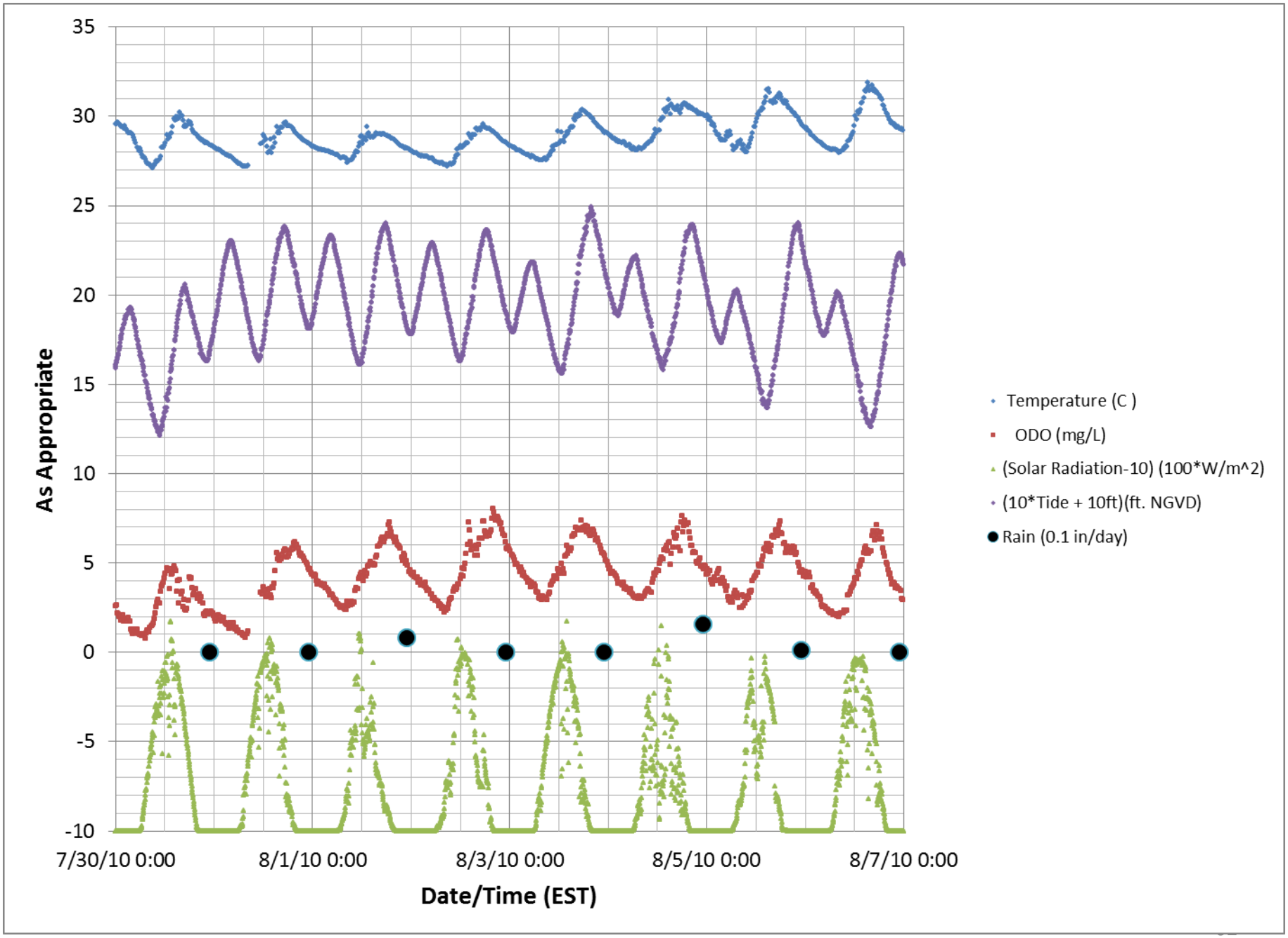

Tide going out, no rain event
Tide coming in, rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
6/25/10 0:00
6/27/10 0:00
6/29/10 0:00
7/1/10 0:00
7/3/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

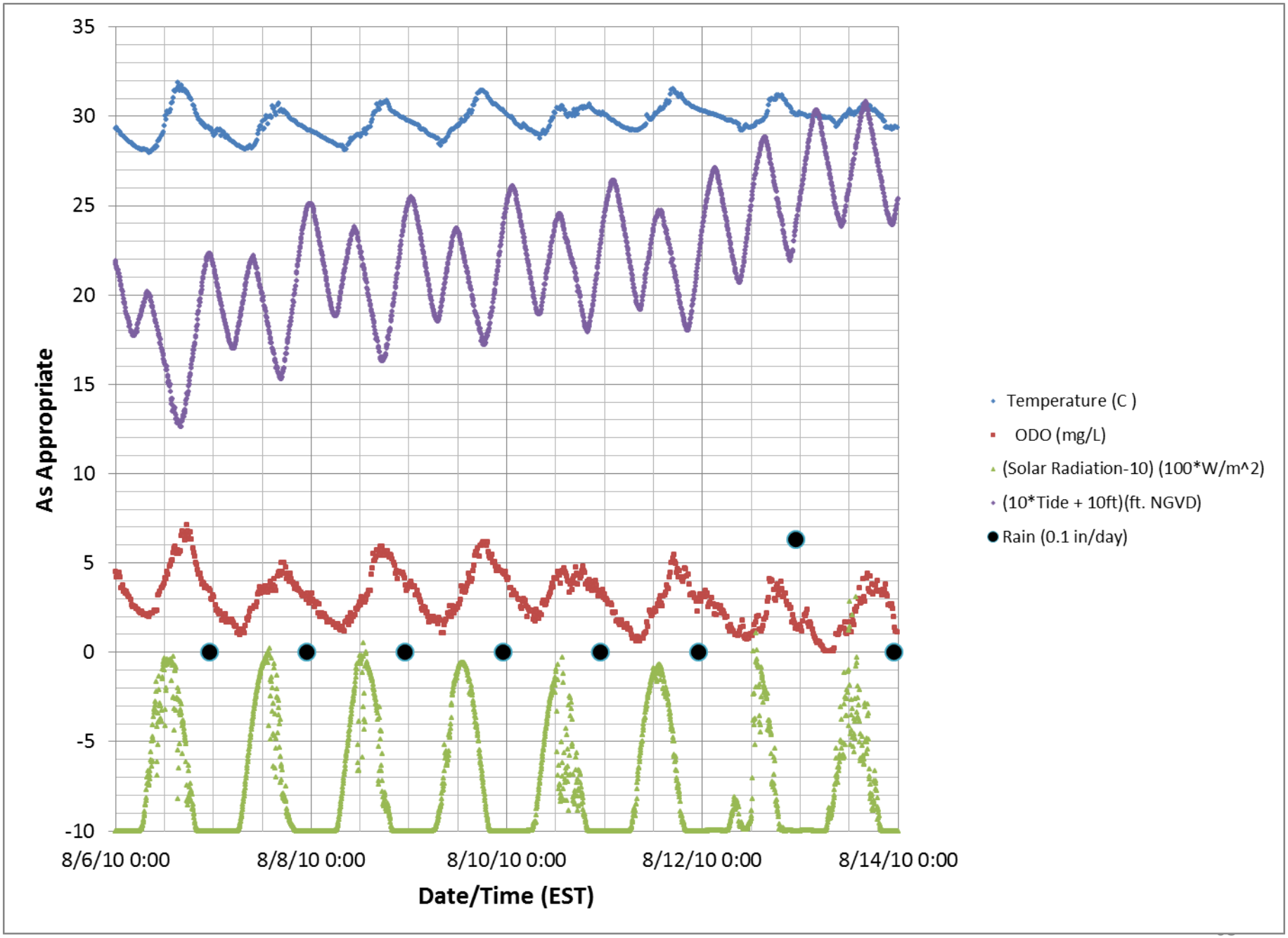

Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
7/2/10 0:00
7/4/10 0:00
7/6/10 0:00
7/8/10 0:00
7/10/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

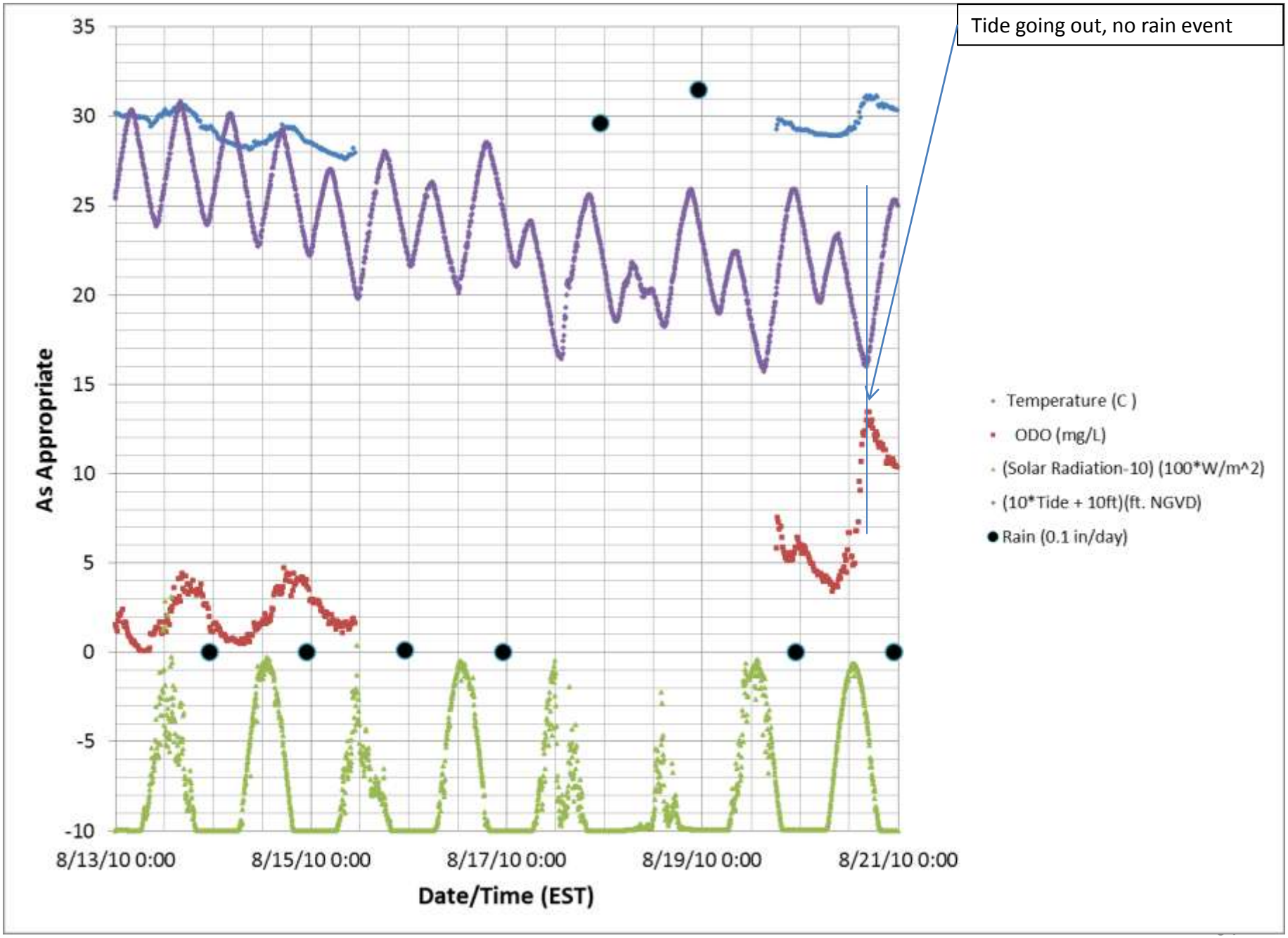

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
7/9/10 0:00
7/11/10 0:00
7/13/10 0:00
7/15/10 0:00
7/17/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

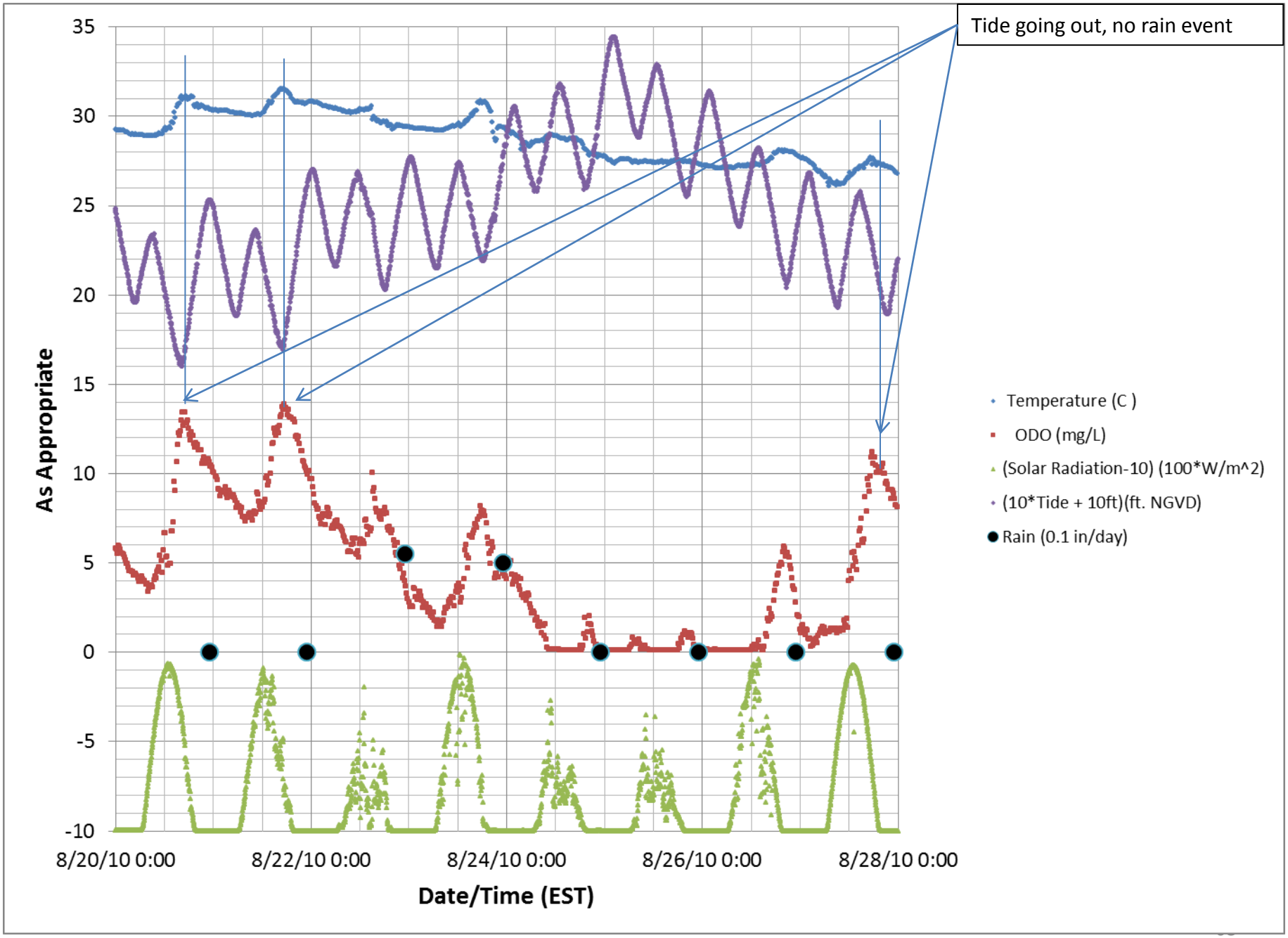

Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
7/16/10 0:00
7/18/10 0:00
7/20/10 0:00
7/22/10 0:00
7/24/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

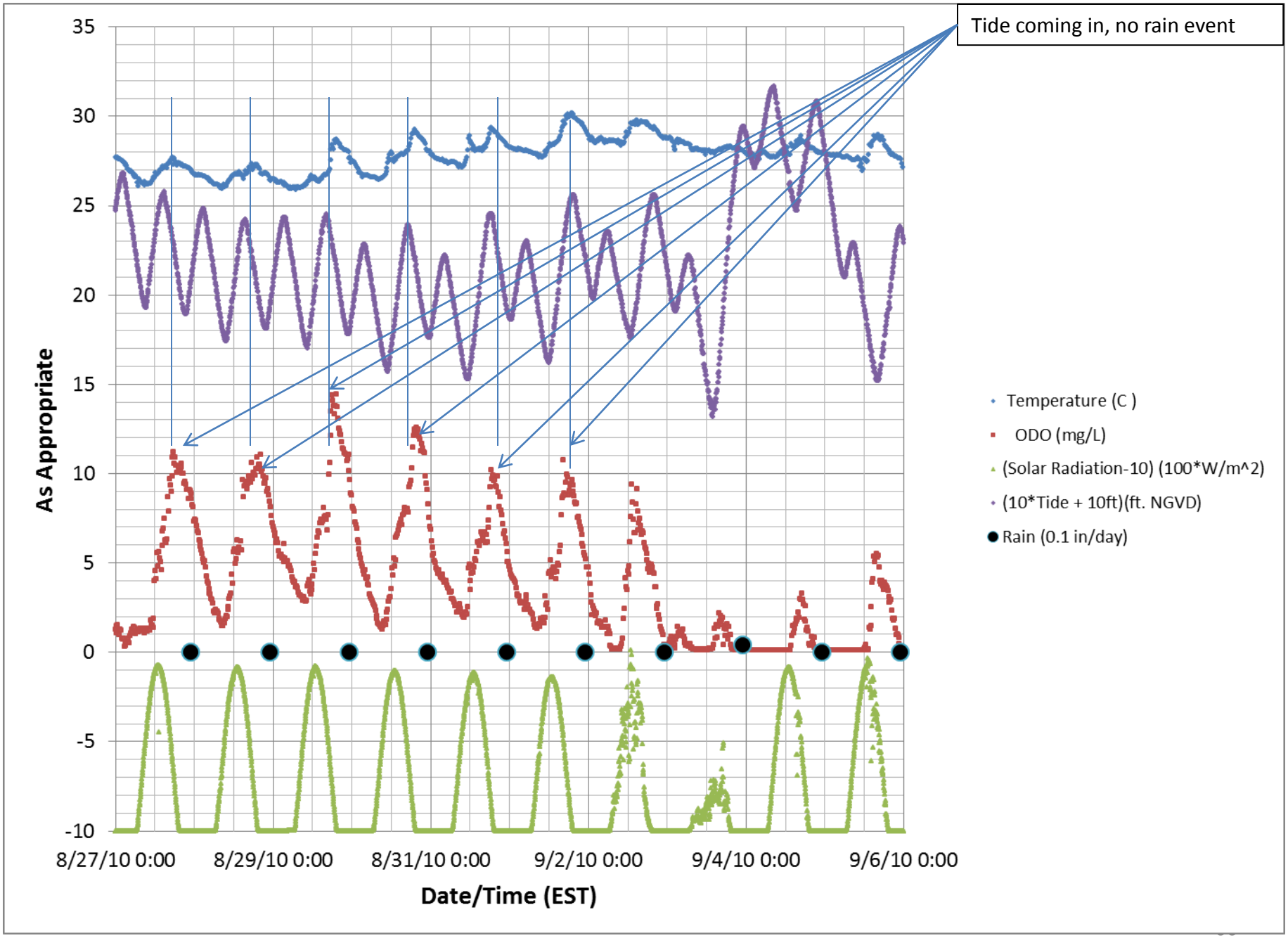

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
7/23/10 0:00
7/25/10 0:00
7/27/10 0:00
7/29/10 0:00
7/31/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

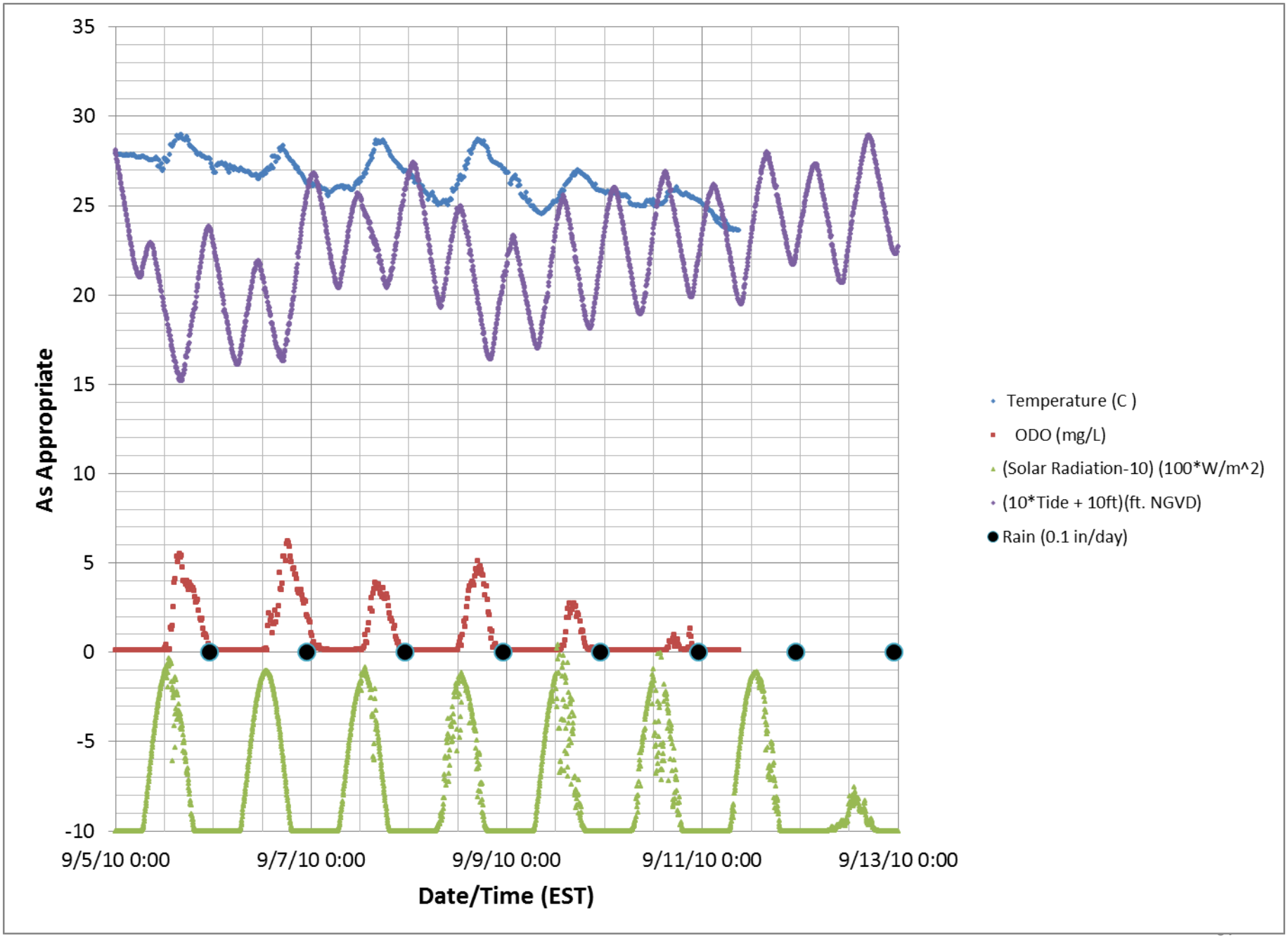

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
7/30/10 0:00
8/1/10 0:00
8/3/10 0:00
8/5/10 0:00
8/7/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

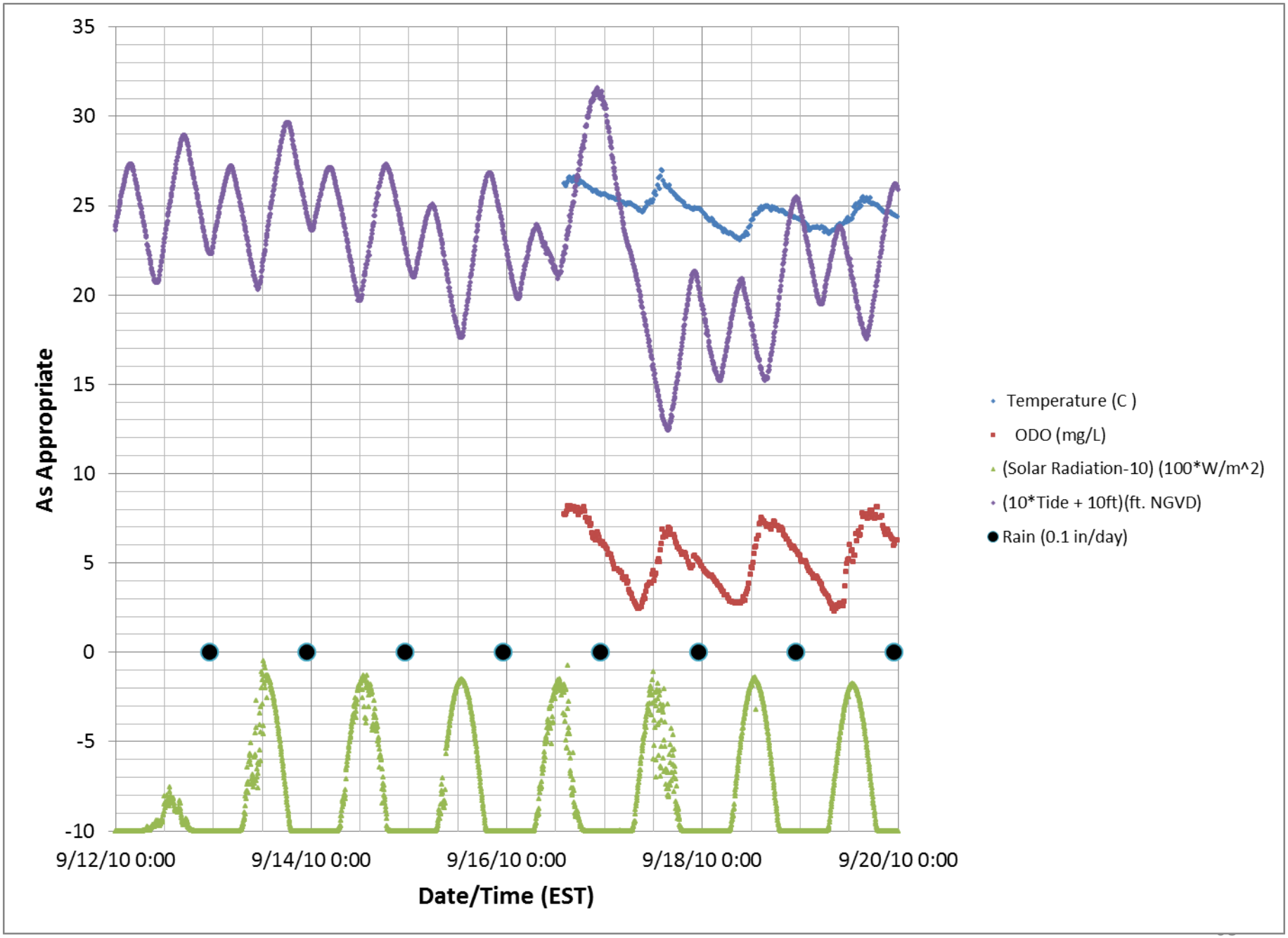

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
8/6/10 0:00
8/8/10 0:00
8/10/10 0:00
8/12/10 0:00
8/14/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

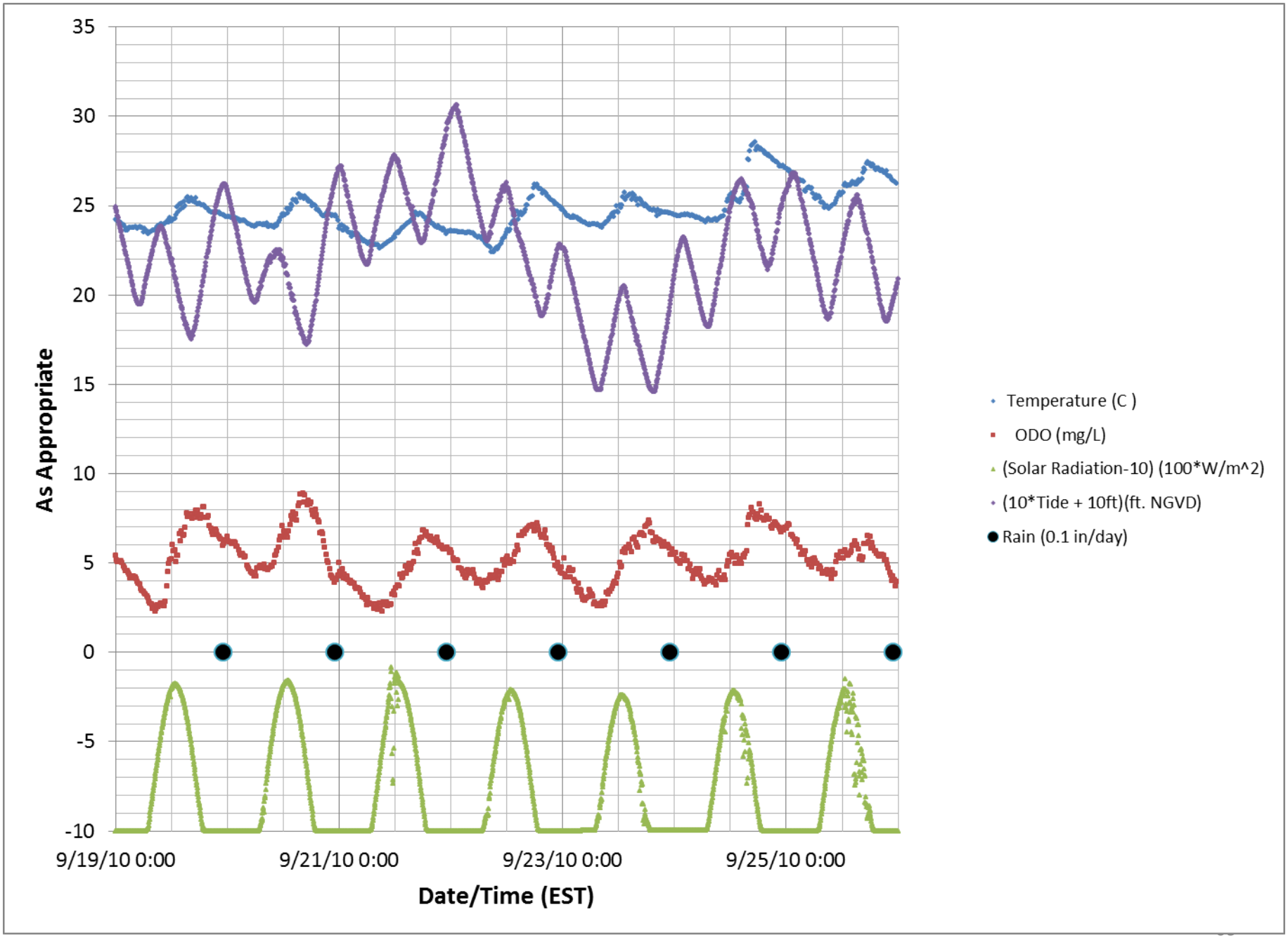

Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
8/13/10 0:00
8/15/10 0:00
8/17/10 0:00
8/19/10 0:00
8/21/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

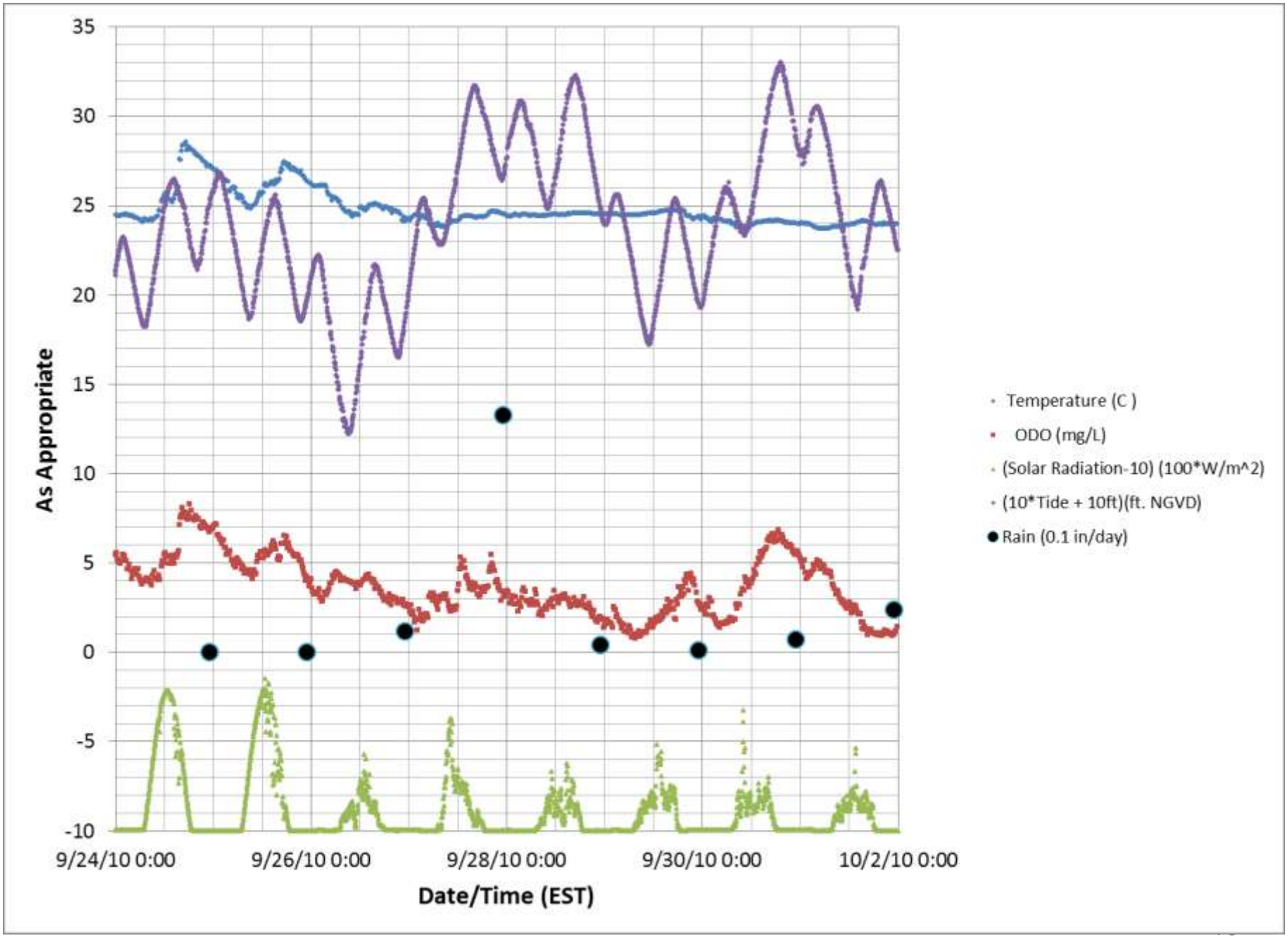

Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
8/20/10 0:00
8/22/10 0:00
8/24/10 0:00
8/26/10 0:00
8/28/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

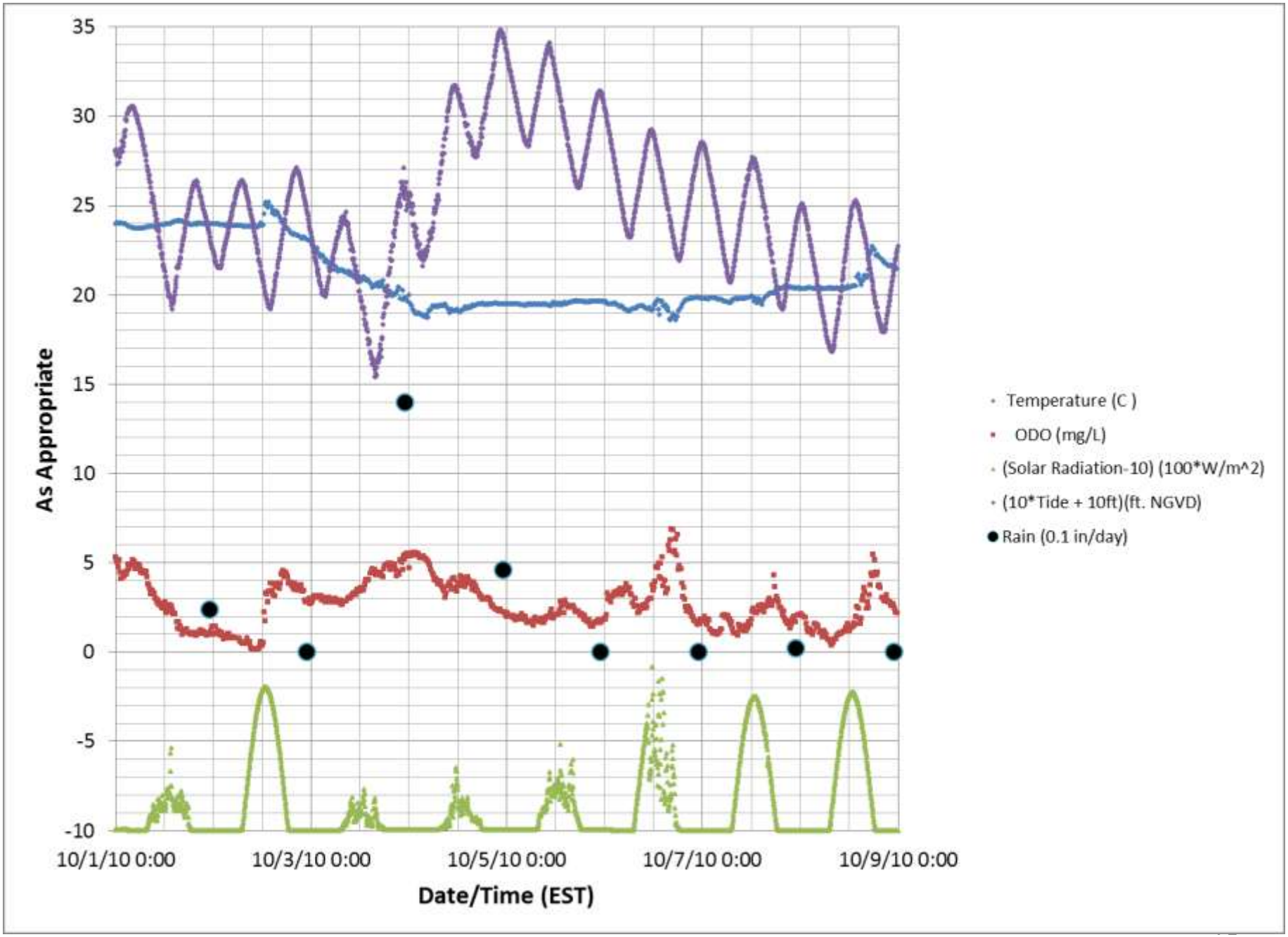

Tide coming in, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
8/27/10 0:00
8/29/10 0:00
8/31/10 0:00
9/2/10 0:00
9/4/10 0:00
9/6/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

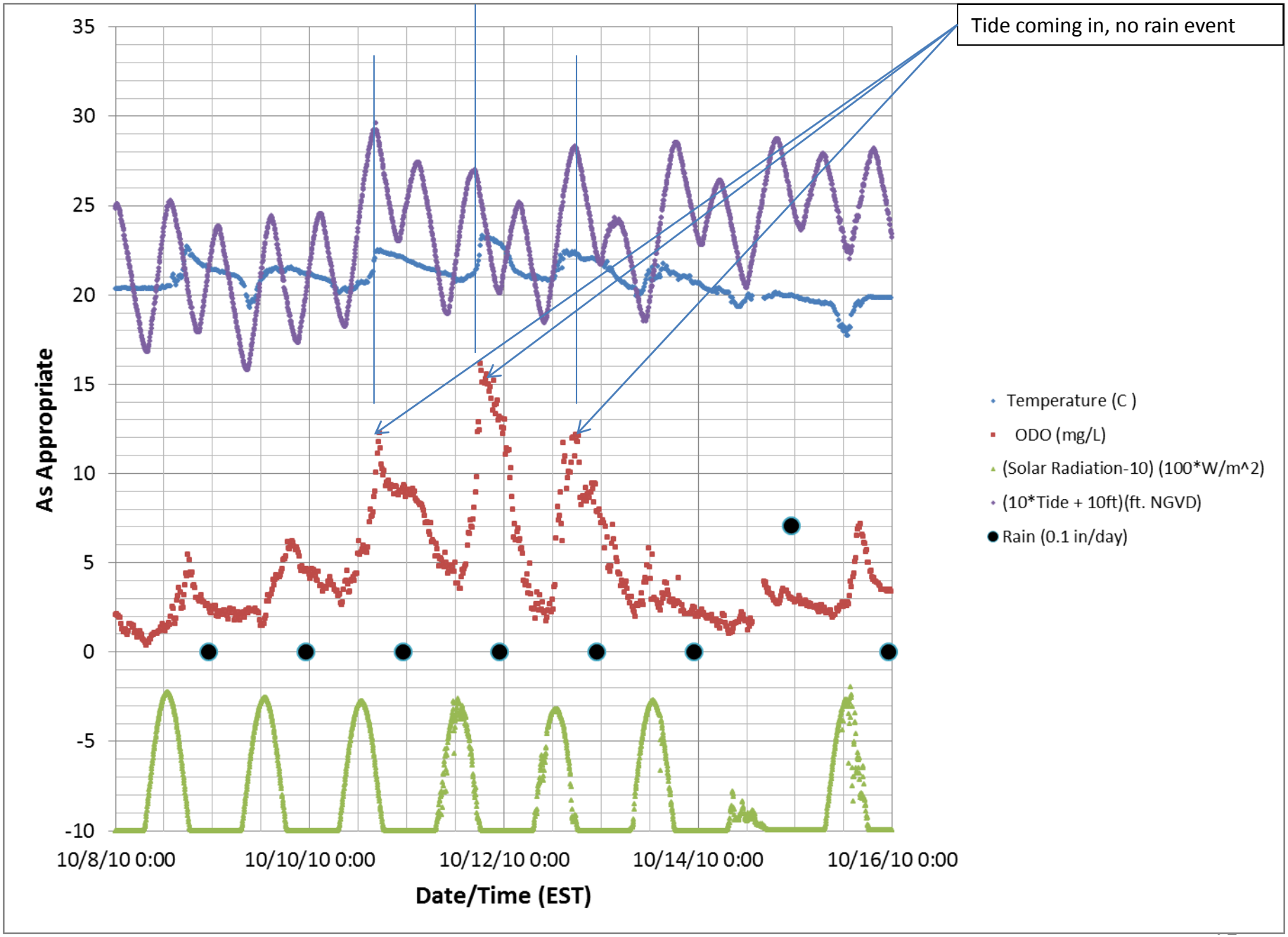

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
9/5/10 0:00
9/7/10 0:00
9/9/10 0:00
9/11/10 0:00
9/13/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

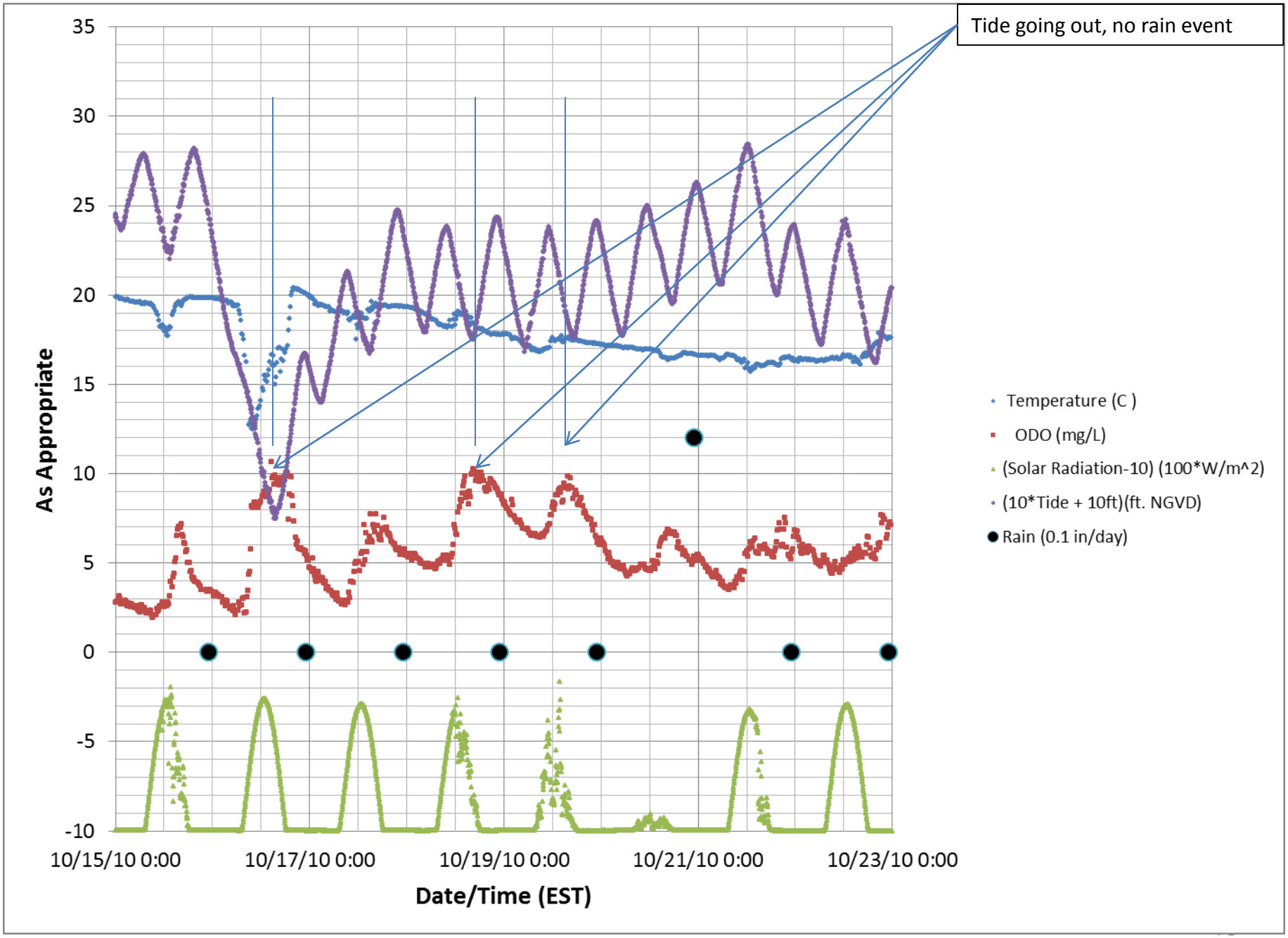

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
9/12/10 0:00
9/14/10 0:00
9/16/10 0:00
9/18/10 0:00
9/20/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

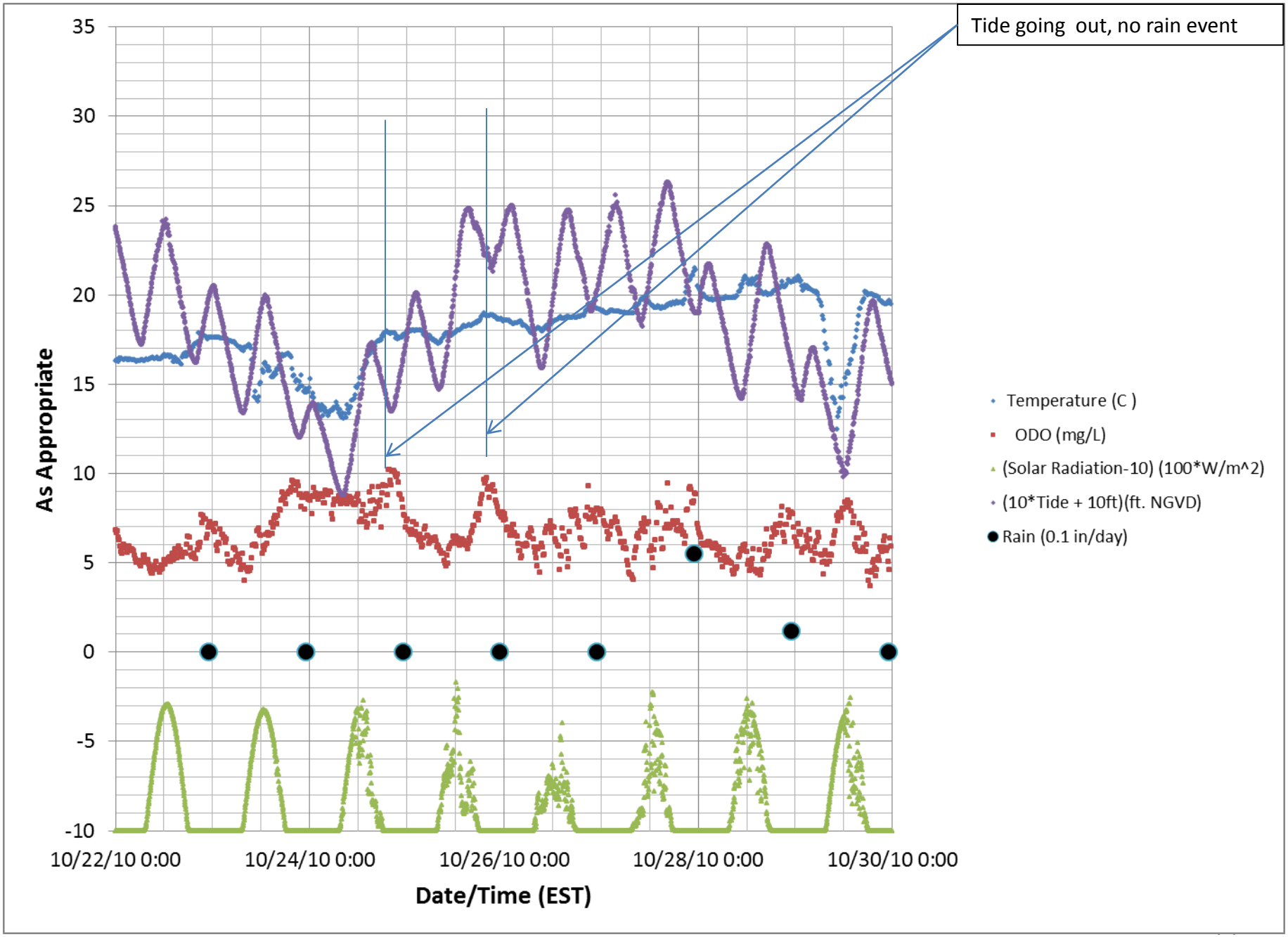

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
9/19/10 0:00
9/21/10 0:00
9/23/10 0:00
9/25/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

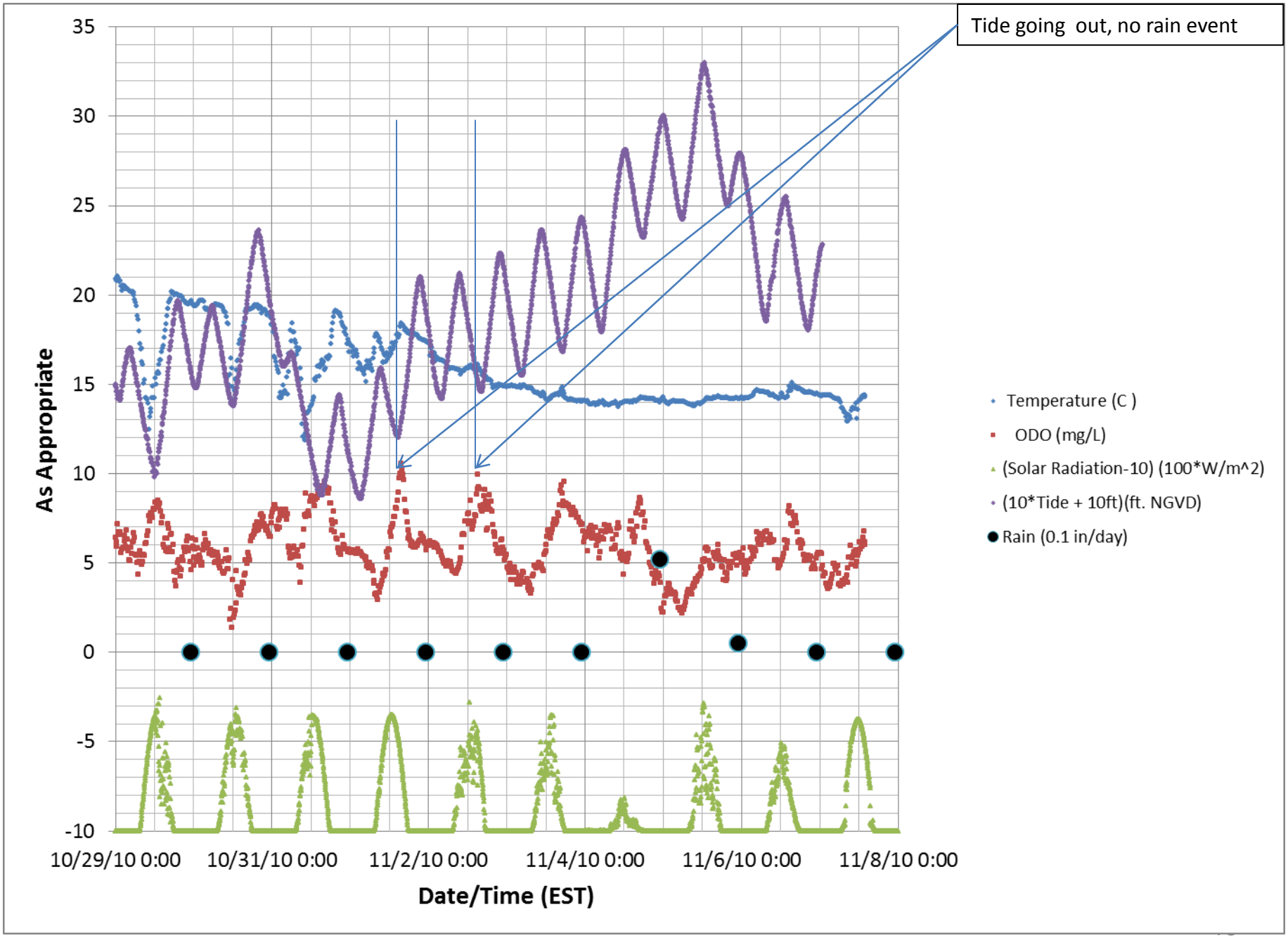

35
30
25
20
15
10
5
0
-5
-10
As Appropriate
9/24/10 0:00
9/26/10 0:00
9/28/10 0:00
9/30/10 0:00
10/2/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)


35
30
25
20
15
10
5
0
-5
-10
As Appropriate
10/1/10 0:00
10/3/10 0:00
10/5/10 0:00
10/7/10 0:00
10/9/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)


Tide coming in, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
10/8/10 0:00
10/10/10 0:00
10/12/10 0:00
10/14/10 0:00
10/16/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)


Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
10/15/10 0:00
10/17/10 0:00
10/19/10 0:00
10/21/10 0:00
10/23/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)


Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
10/22/10 0:00
10/24/10 0:00
10/26/10 0:00
10/28/10 0:00
10/30/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)


Tide going out, no rain event
35
30
25
20
15
10
5
0
-5
-10
As Appropriate
10/29/10 0:00
10/31/10 0:00
11/2/10 0:00
11/4/10 0:00
11/6/10 0:00
11/8/10 0:00
Date/Time (EST)
Temperature (C)
ODO (mg/L)
(Solar Radiation-10) (100*W/m^2)
(10*Tide + 10ft)(ft. NGVD)
Rain (0.1 in/day)

Continuous Dissolved Oxygen Procedure For 2011 (1 of 2)

1. Calibrate Sonde per manual. May need to type “Menu” to get started.
2. Start unattended recording.
3. Put Sonde in the 100% calibrator and obtain at least 2 readings.
4. Put Sonde and the hand held and the thermometer in a bucket of H_2O and record temperature on the thermometer and hand held readings at the times that the Sonde makes a recording every 15 minutes.
5. Check the housing pipe for obstructions.
6. Hang the Sonde in the housing pipe
7. After about 1 hour make hand held measurements at the depth of the Sonde for calibration.
8. Leave Sonde unattended for about two weeks.

Continuous Dissolved Oxygen Procedure For 2011 (2 of 2)

9. Before removing the Sonde make hand held measurements at the depth of the Sonde for calibration.
10. Remove the Sonde from the housing pipe. – DO NOT CLEAN IT YET.
11. Put Sonde in the 100% calibrator and obtain at least 2 readings.
12. Put Sonde and the hand held and the thermometer in a bucket of H_2O and record temperature on the thermometer and hand held readings at the times that the Sonde makes a recording every 15 minutes.
13. Stop the unattended recording.
14. Down load the data.
15. Clean the Sonde.
16. Proceed to Step 1. on the previous page.

Summary of Comments/Observations

- Many sources were used to collect data to help to understand DO variations.
- There are many variable that must be considered to understand the data.
- DO% was quite often above 150%. Maximum reading was 283%.
- The temperature/salinity probe was out of the water 5 times due to low tides.
- Twice rain events coupled with good solar radiation resulted in very high DO.
- Temperature is probably the most significant indicator for daily averaged DO.
- Solar Radiation has the most impact on the changes of DO during the day when the temperature is high which supports algae growth.
- When the temperature is low (<~15^{O} C) solar radiation is less and does not have nearly as much influence on DO. Sometimes it is hard to see a variation and DO does not decrease at night.
- Most rain events cause a significant decrease in salinity.
- Wind and wind direction probably has an impact on DO. More study is needed to assess this.
- The affect of tides probably has an impact on DO. More study is needed to assess this.
- In the future the hand held will be used near the surface and near the bottom to take readings at the Continuous Monitoring Site.
- Consistency between the hand held readings and the contiguous readings was generally very good.

Bottom Line – We are getting good readings from the SONDE and should Continue the efforts.