

Grant Lake Hydroelectric Project (FERC No. 13212)
Natural Resource Study Results Meeting
March 18, 2014 – Anchorage, AK

Water Resources Studies
Water Quality
Hydrology



In Association with



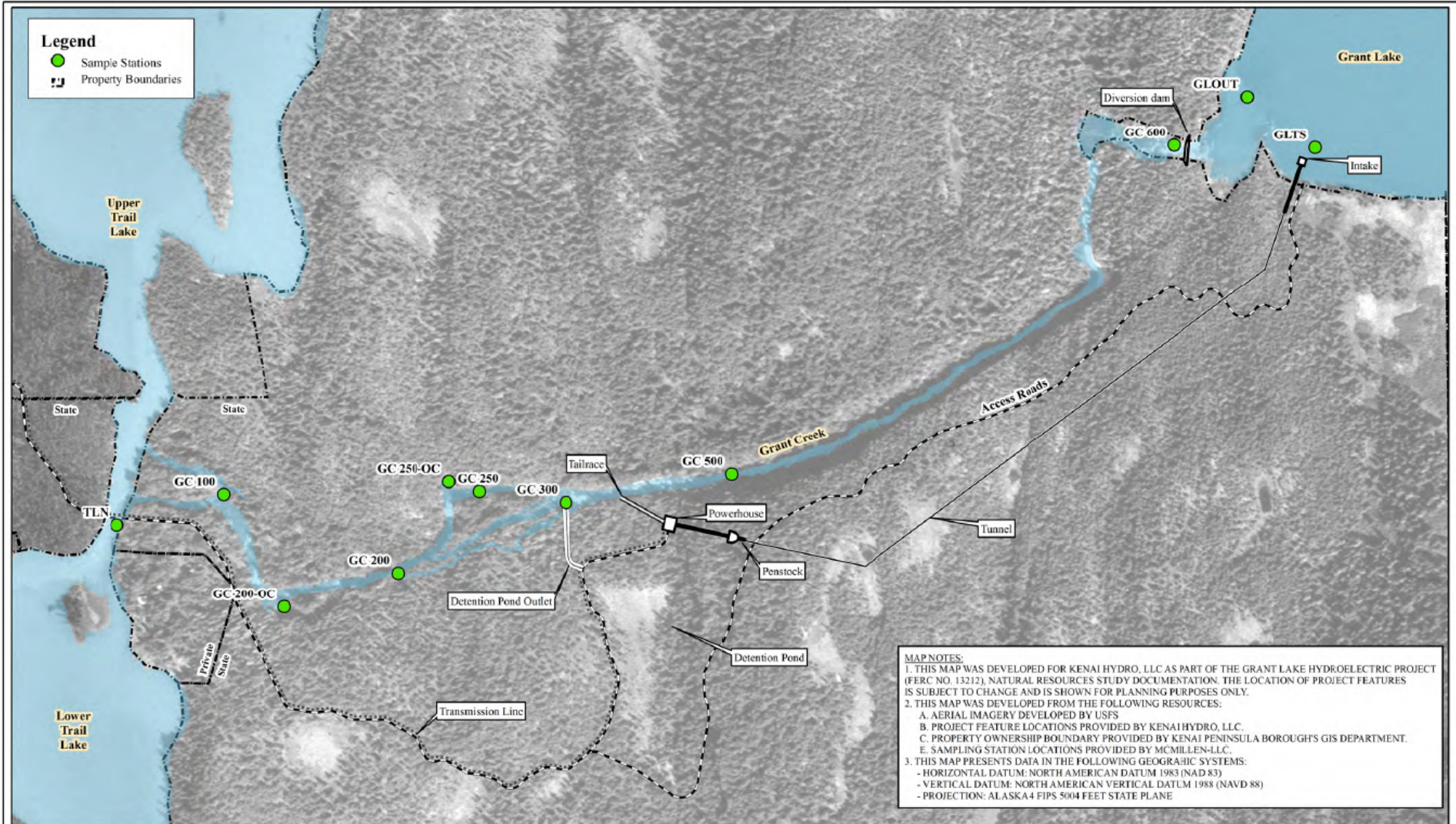
Resource Area Studies

- Water Quality and Temperature Studies
 - Grant Lake and Grant Creek Water Chemistry Sampling
 - Grant Lake and Grant Creek Water Temperature Data Collection
 - Trail Lakes Narrows Water Chemistry Sampling

Grant Lake and Grant Creek sampled once in late summer 2013

Trail Lakes Narrows sampled 3X, spring, summer, fall.

Water Quality and Hydrology Site Locations



						McMILLEN, LLC 1001 W. HUNTERS BLVD. OFFICE 208.542.4214 P.O. BOX 127023 FAX 208.542.4214		Designed For Homer Electric Association, Inc. A "Techsource Energy" Cooperative		GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO. 13212 GRANT LAKE NATURAL RESOURCES STUDY Figure 3.1-1 Water Quality, Temperature, and Hydrology Study Locations - 2013		DESIGNED: J. Woodbury DRAWN: J. Woodbury CHECKED: C. Samuelsen ISSUED DATE: 1/9/2014		DRAWING SCALE: 1:4,522	
--	--	--	--	--	--	---	--	--	--	---	--	---	--	---------------------------	--

Water Quality Study Parameters and ADEC Standards

Parameter	Units	ADEC Water Quality Standards*
Alkalinity (CaCO ₃)	mg/L	no criteria
Total dissolved solids (TDS)	mg/L	≤ 1000 mg/l
Total suspended sediment (TSS)	mg/L	no criteria
Kjeldahl Nitrogen	mg/L	no criteria
Nitrate/Nitrite	mg/L	10 mg/l
Orthophosphate	mg/L	no criteria
Total phosphorous	mg/L	no criteria
Lead	µg/L	16.4 µg/l (acute); 0.64 µg/l (chronic)
Hardness	mg/L	no criteria
Calcium	mg/L	no criteria
Magnesium	mg/L	no criteria
Sodium	mg/L	<2.55 mg/l
Potassium	mg/L	no criteria
Low level mercury	µg/L	1.4 µg/l (acute); 0.77 µg/l (chronic)
Fluoride	mg/L	no criteria
Chloride	mg/L	860 mg/l (acute); 230 mg/l (chronic)
Sulfate	mg/L	no criteria
pH	S.U.	≥6.5 to ≤8.5
Temperature	°C	May not exceed 20°C at any time; maximum temperatures may not exceed, where applicable: migration routes: ≤15°C; spawning areas: ≤13°C; rearing areas: ≤ 15°C; egg/fry incubation: ≤13°C.
Dissolved oxygen (DO)	mg/L	>7mg/l and <17 mg/l in waters used by anadromous fish; >5mg/l and <17 mg/l for waters not used by anadromous fish
Specific Conductivity	mS/cm	no criteria
Oxygen Reduction Potential (ORP)	mV	no criteria
Turbidity	NTU	Not to exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.
* Based on the following water use class/subclass: (1) fresh water/(C) growth and propagation of fish, shellfish, other aquatic life, and wildlife		

Water Quality Study Results – Trail Lakes Narrows

Hydrolab Readings		Hydrolab #1 June 2013	Hydrolab #2 June 2013	Hydrolab #1 August 2013	Hydrolab #2 August 2013	Hydrolab #1 Sept 2013	Hydrolab #2 Sept 2013
Temp	°C	9.05	9.08	11.81	11.94	8.39	8.51
Sp. Cond	mS/cm	0.08	0.08	0.07	0.04	0.07	0.07
Dissolved Oxygen	% Sat	102.5	102.5	102.9	102.1	87.4**	102.6
Dissolved Oxygen	mg/l	11.88	11.85	11.19	11.09	10.8**	11.82
ORP	mV	399	385	526	315	387	335
pH	S.U.	7.51	7.63	7.63	6.32	7.06	6.60
Turbidity	NTU	9.4	na	na	na	9.4	na
Depth	m	1.6	1.7	2.0	2.0	1.0	1.0
Analytical Lab Results		DUP				DUP	
pH	S.U.	7.60	7.60	6.90		7.20	7.10
Turbidity	NTU	8.5	8.8	13.0		11.0	11.0
T. Hardness	mg/l	38.9	41.2	33.0		36.8	33.8
T. Alkalinty	mg/l	25.1	25.5	18.7		22.0	21.8
TDS	mg/l	44	49	43		54	50
TSS	mg/l	3.1	5.7	11.3		4.1	3.8
T. Nitrate+Nitrite	mg/l	0.35	0.39	0.14		0.27	0.25
K. Nitrogen	mg/l	ND	ND	ND		ND	ND
T. Phosphorus	mg/l	ND	ND	0.03		ND	0.01
Orthophosphate	mg/l	ND	ND	0.02		0.02	0.02
Chloride	mg/l	0.32	0.32	0.21		0.21	0.21
Fluoride	mg/l	ND	ND	ND		ND	ND
Sodium	mg/l	1.17	1.15	0.91		0.99	1.05
Calcium	mg/l	13.6	14.4	11.3		12.5	11.4
Magnesium	mg/l	1.2	1.3	1.2		1.4	1.3
Potassium	mg/l	0.53	0.59	ND		0.62	0.56
Sulfate	mg/l	16.0	16.0	13.1		15.0	15.0
Lead	µg/l	0.2	ND	0.40		0.30	0.23
Low level Mercury	µg/l	0.0017	0.0016	0.0036		0.0022	0.0022
Gas Range Organics	mg/l	ND	ND	ND		ND	ND
Diesel Range Organics	mg/l	ND	ND	ND		ND	ND

na: not analyzed

ND: not detected

** faulty probe confirmed by manufacturer

Water Quality Study Results – Grant Creek (Site GC 200)

Hydrolab Readings		Jun-09	Aug-09	Jun-10	Aug-13
Temp	°C	7.4	11.26	8.51	12.46
Sp. Cond	mS/cm	na	0.07	0.09	0.06
Dissolved Oxygen	% Sat	60.9	75.1	92.3	101.5
Dissolved Oxygen	mg/l	7.31	8.22	10.79	10.89
ORP	mV	na	na	216	408
pH	S.U.	7.66	7.39	7.39	7.02
Turbidity	NTU	0.75	11.10	1.17	4.00
Depth	m	na	na	na	1.9
Lab Analyses					
pH	S.U.	na	na	na	7.00
Turbidity	NTU	na	na	na	4.0
T. Alkalinity	mg/l	25.0	23.5	25.5	20.6
T. Hardness	mg/l	na	na	na	34.4
TDS	mg/l	60	44	50	51
TSS	mg/l	0.8	3.4	0.7	2.9
T. Nitrate/Nitrite	mg/l	0.455	0.292	0.269	0.190
K. Nitrogen	mg/l	ND	ND	ND	ND
Orthophosphate	mg/l	ND	ND	ND	ND
T. Phosphorus	mg/l	ND	ND	ND	ND
Chloride	mg/l	na	na	0.284	0.225
Fluoride	mg/l	na	na	ND	ND
Sodium	mg/l	na	na	1.14	1.18
Calcium	mg/l	na	na	13.3	11.7
Magnesium	mg/l	na	na	1.26	1.25
Potassium	mg/l	na	na	0.52	0.54
Sulfate	mg/l	na	na	17.9	15.1
Lead	µg/l	3.09	ND	ND	ND
LL Mercury	µg/l	ND	0.0016	ND	0.0013

na: not analyzed

ND: not detected

Water Quality Study Results – Grant Lake (Site GLOUT)

Hydrolab Readings		Jun-09	Jun-09	Aug-09	Aug-09	Jun-10	Jun-10	Aug-13	Aug-13
Depth	m	0-Surf	4-Mid	0-Surf	6-Mid	0-Surf	6-Mid	0-Surf	3-Mid
Temp	°C	7.95	7.27	14.87	11.49	9.38	9.30	12.17	11.81
Sp. Cond	mS/cm	na	na	0.09	0.09	0.08	0.08	0.08	0.08
Dissolved Oxygen	% Sat	64.4	63.8	55.2	52.3	75.5	74.0	103.3	101.9
Dissolved Oxygen	mg/l	7.64	7.70	5.57	5.71	8.61	8.50	11.14	11.08
ORP	mV	na	na	na	na	73	29	334	332
pH	S.U.	7.27	7.37	7.24	7.24	6.98	7.06	6.28	6.59
Turbidity	NTU	0.82	na	4.18	na	1.46	1.14	4.50	5.10
Lab Analyses									
pH	S.U.	na	na	na	na	na	na	7.10	7.00
Turbidity	NTU	na	na	na	na	na	na	4.5	5.1
T. Alkalinity	mg/l	23.8	23.2	24.0	24.0	26.0	25.6	20.8	20.9
T. Hardness	mg/l	na	na	na	na	na	na	35.6	36.5
TDS	mg/l	51.3	40.0	32.5	47.5	57.0	64.0	46.0	52.0
TSS	mg/l	0.60	0.50	1.96	2.77	ND	0.75	2.08	2.75
T. Nitrate/Nitrite	mg/l	0.414	0.651	0.268	0.298	0.311	0.344	0.206	0.175
K. Nitrogen	mg/l	ND	ND	ND	ND	ND	ND	ND	ND
Orthophosphate	mg/l	ND	ND	ND	ND	ND	ND	ND	ND
T. Phosphorus	mg/l	ND	ND	ND	ND	ND	ND	ND	ND
Chloride	mg/l	na	na	na	na	0.298	0.291	0.221	0.220
Fluoride	mg/l	na	na	na	na	ND	ND	ND	ND
Sodium	µg/l	na	na	na	na	1.16	1.12	0.95	0.95
Calcium	µg/l	na	na	na	na	13.8	13.4	11.5	11.6
Magnesium	µg/l	na	na	na	na	1.32	1.27	1.18	1.2
Potassium	µg/l	na	na	na	na	0.53	0.53	0.51	0.51
Sulfate	mg/l	na	na	na	na	17.6	17.9	15.3	15.4
Lead	µg/l	ND	ND	ND	ND	ND	ND	0.24	ND
LL Mercury	µg/l	ND	ND	0.0014	0.0021	0.0011	0.0011	0.0011	0.0014

na: not analyzed

ND: not detected

Water Quality Study Results – Grant Lake (Site GLTS)

Hydrolab Readings		Jun-09	Jun-09	Jun-09	Aug-09	Aug-09	Aug-09	Jun-10	Jun-10	Jun-10	Aug-13	Aug-13	Aug-13
Depth	m	0-Surf	10-Mid	19-Bot	0-Surf	9-Mid	17-Bot	0-Surf	6-Mid	17-Bot	0-Surf	9-Mid	17 - Bot
Temp	°C	8.64	5.41	4.33	14.66	10.37	6.09	9.36	9.25	4.41	12.29	10.98	6.24
Sp. Cond	mS/cm	0.09	0.09	0.09	0.09	0.09	0.1	na	na	na	0.08	0.08	0.09
Dissolved Oxygen	% Sat	68.4	61.3	55.5	56.2	52.1	48.4	76.2	74.1	66.5	103.6	100.9	94.5
Dissolved Oxygen	mg/l	7.96	7.74	7.2	5.63	5.82	5.99	8.73	8.52	8.63	11.15	11.18	11.76
ORP	mV	na	na	na	na	na	na	91	26	65	319	320	327
pH	S.U.	7.43	7.49	7.06	7.56	7.2	7.06	6.68	6.82	6.43	7.26	7.42	7.42
Turbidity	NTU	0.6	na	na	3.87	na	4.8	0.81	1.14	1.17	3.9	7.8	4.8
Lab Analyses													
pH	S.U.	na	na	na	na	na	na	na	na	na	6.80	6.80	6.80
Turbidity	NTU	na	na	na	na	na	na	na	na	na	3.9	7.8	4.8
T. Alkalinity	mg/l	23.5	24.5	24	24.8	24.6	25.4	25.8	25.3	25.8	20.2	20.9	22.6
T. Hardness	mg/l	na	na	na	na	na	na	na	na	na	36.1	36.9	39.7
TDS	mg/l	75.0	68.8	61.3	46.3	48.8	45.0	67.0	64.0	63.0	43.0	45.0	49.0
TSS	mg/l	0.7	1.0	0.8	1.9	2.6	2.8	0.5	ND	0.7	2.7	2.6	4.2
T. Nitrate/Nitrite	mg/l	0.42	0.42	0.41	0.28	0.30	0.32	0.30	0.31	0.30	0.17	0.19	0.31
K. Nitrogen	mg/l	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Orthophosphate	mg/l	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND
T. Phosphorus	mg/l	ND	0.021	ND	ND	ND	ND	ND	ND	ND	ND	0.02	0.04
Chloride	mg/l	na	na	na	na	na	na	0.30	0.29	0.47	0.22	0.22	0.27
Fluoride	mg/l	na	na	na	na	na	na	ND	ND	ND	ND	ND	ND
Sodium	mg/l	na	na	na	na	na	na	1.16	1.15	1.16	0.95	0.96	1.08
Calcium	mg/l	na	na	na	na	na	na	13.5	13.3	13.4	11.6	11.6	13.0
Magnesium	mg/l	na	na	na	na	na	na	1.3	1.3	1.3	1.2	1.2	1.3
Potassium	mg/l	na	na	na	na	na	na	0.53	0.51	0.52	0.51	0.53	0.52
Sulfate	mg/l	na	na	na	na	na	na	18.0	17.9	17.9	15.1	15.4	16.9
Lead	µg/l	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LL Mercury	µg/l	ND	ND	ND	0.0015	0.0016	0.0017	ND	ND	ND	0.0011	0.0015	0.0015

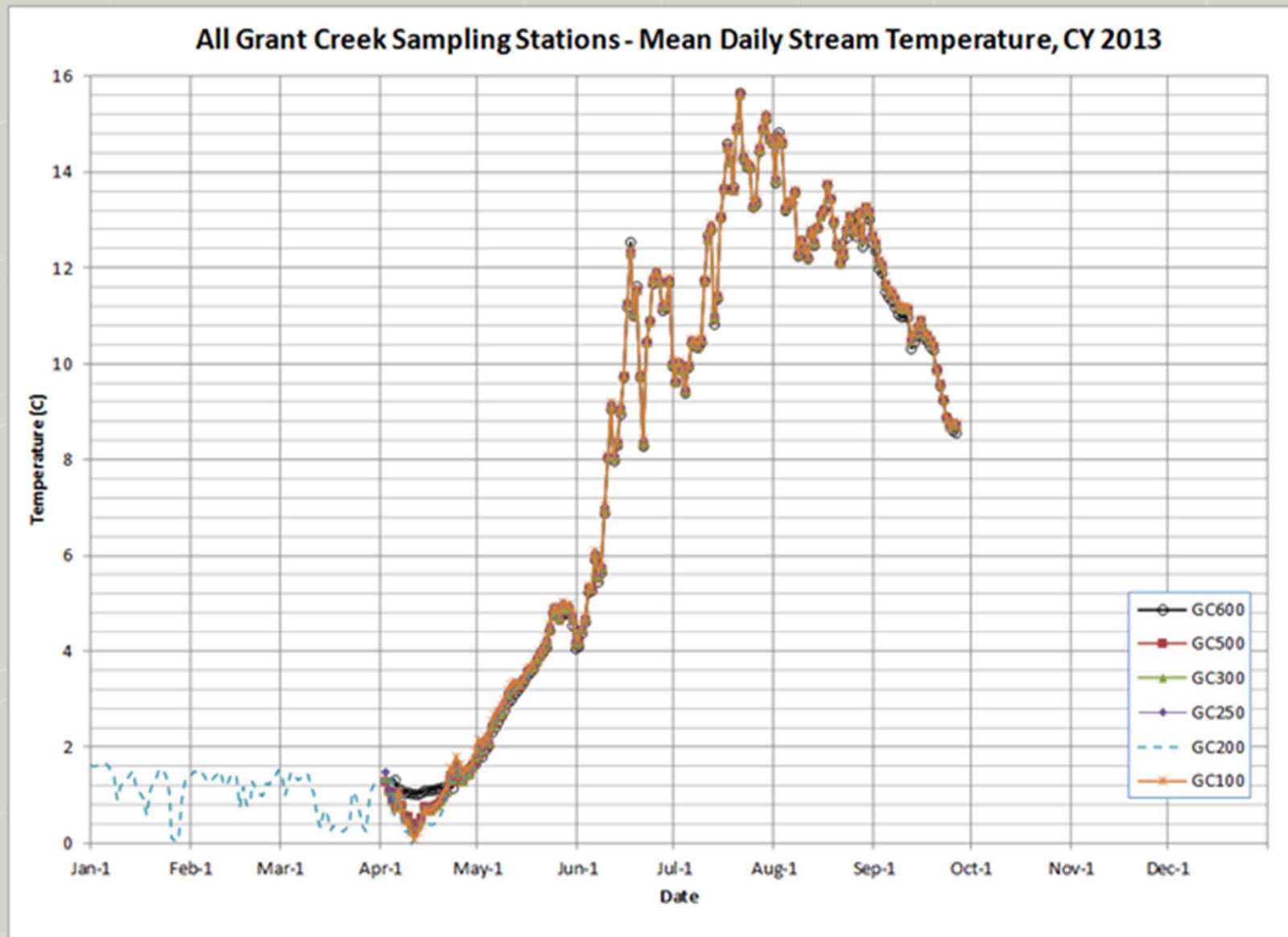
na: not analyzed

ND: not detected

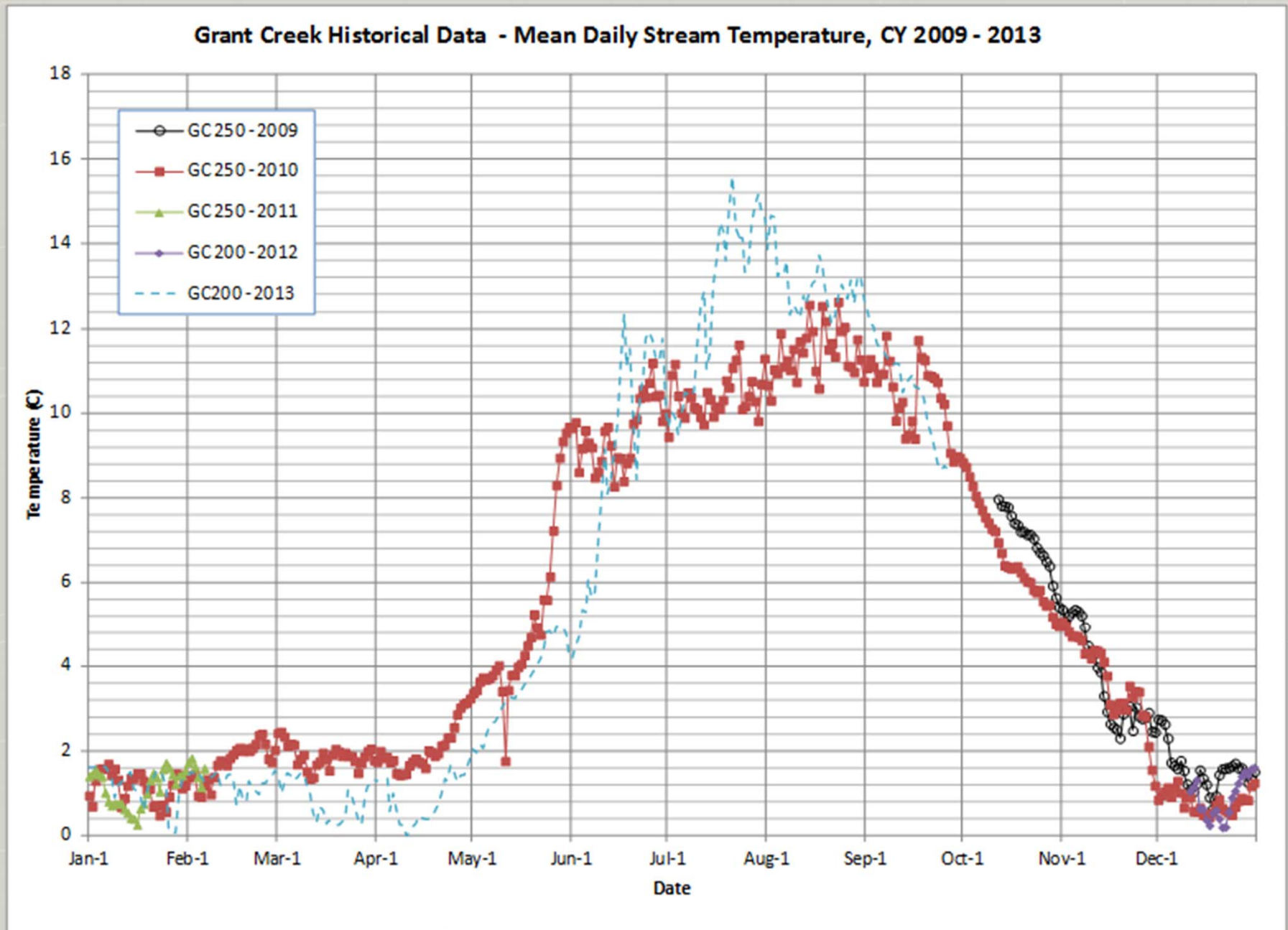
Water Quality Study – Conclusions

- Overall, Grant Lake, Grant Creek, and Trail Lakes have excellent water quality based on ADEC standards.
- Nearly all 2013 water quality parameters indicate stable and consistent values from the lower basin of Grant Lake (0.0 m to 18.0 m depth range), downstream to the Trail Lakes Narrows. **slightly higher turbidity values at Trail Lakes Narrows is the exception to this trend*
- Most water quality parameters have remained stable based on historical sampling efforts from the early 1980's and 2009-2010.
- 2013 dissolved oxygen results agree with ADF&G and AEIDC studies in the early 1980's. Low DO levels reported from 2009-2010 assumed to be a result of faulty monitoring equipment or calibration procedures. Some of the DO levels reported in the 2009-2010 sampling seasons would cause substantial impairment to resident or anadromous fish populations.

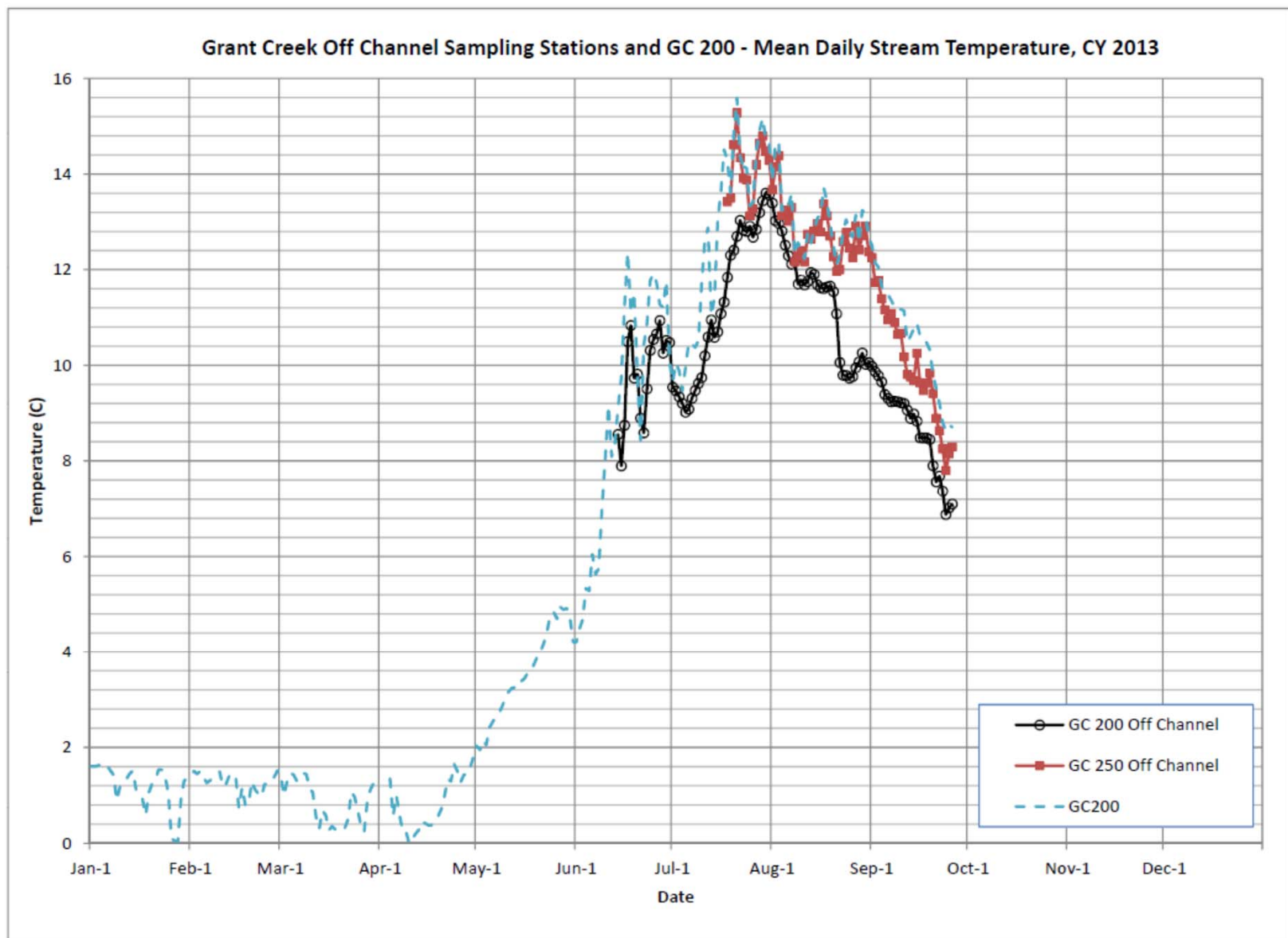
Water Temperature Results – Grant Creek 2013



Water Temperature Results – Grant Creek 2009-2013

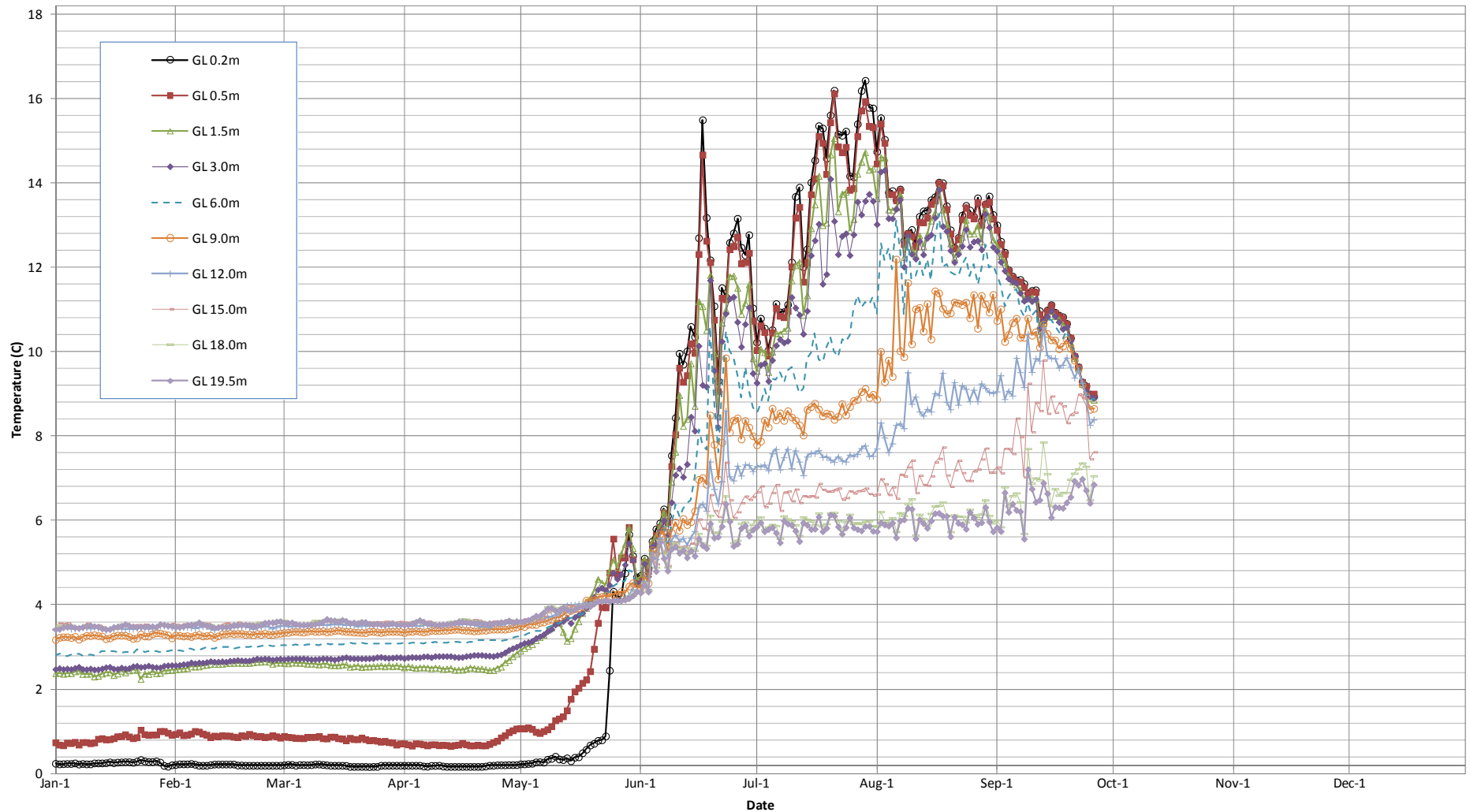


Water Temperature Results – Grant Creek Off Channel Areas

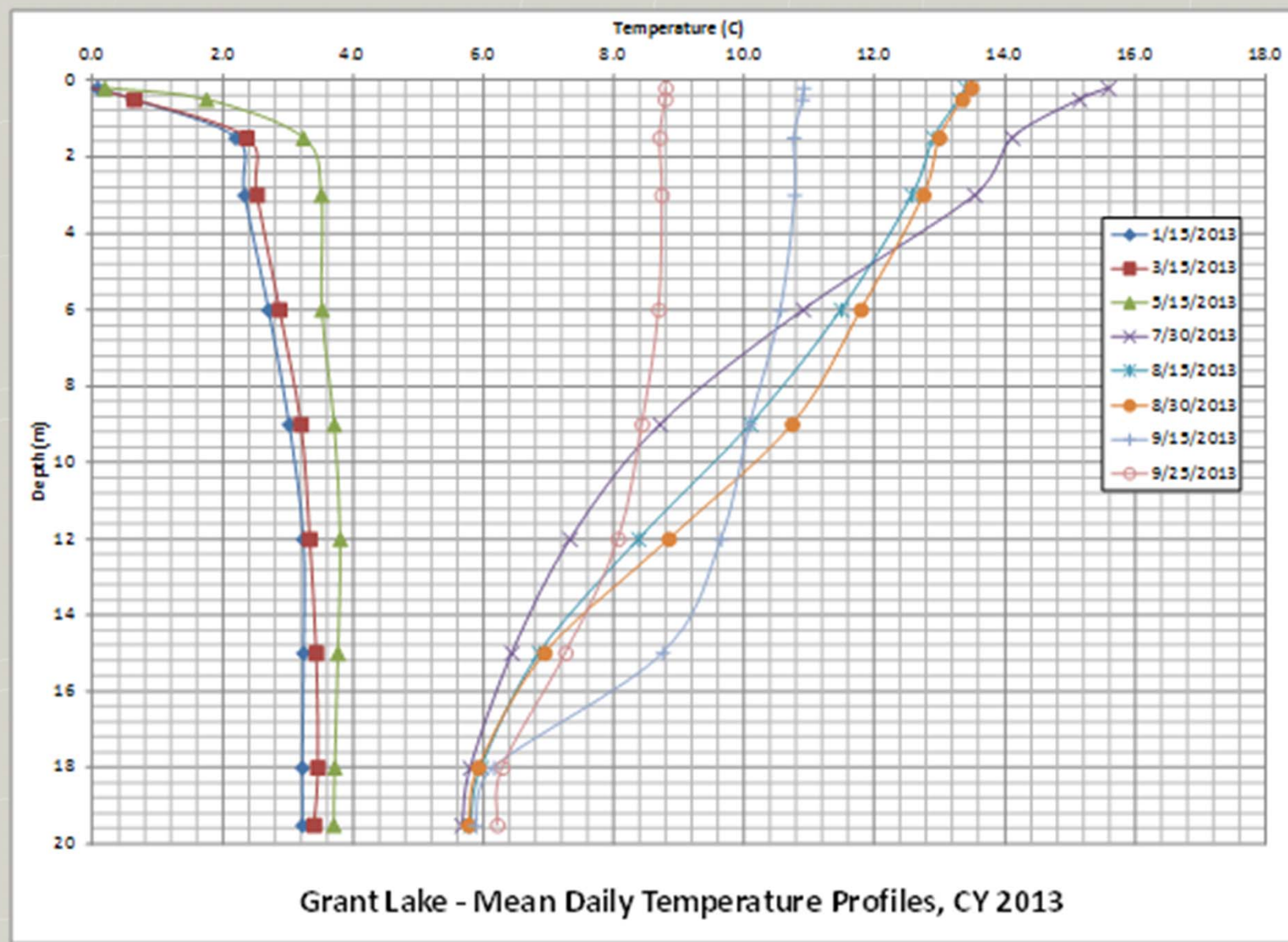


Water Temperature Results – Grant Lake Hydrograph

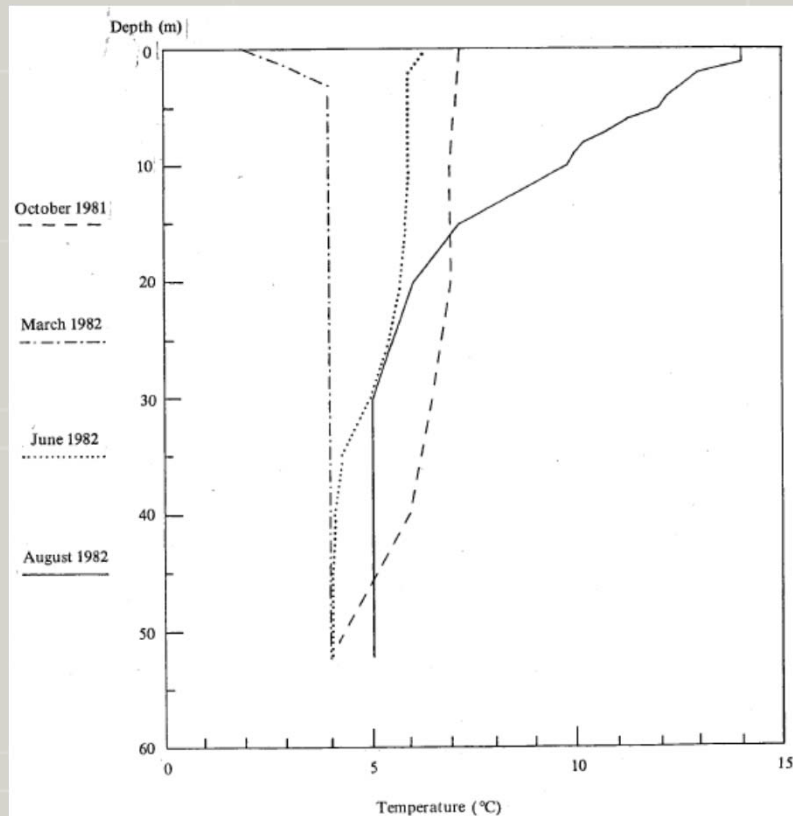
Grant Lake 0.2m - 19.0m - Mean Daily Lake Temperature, CY 2013



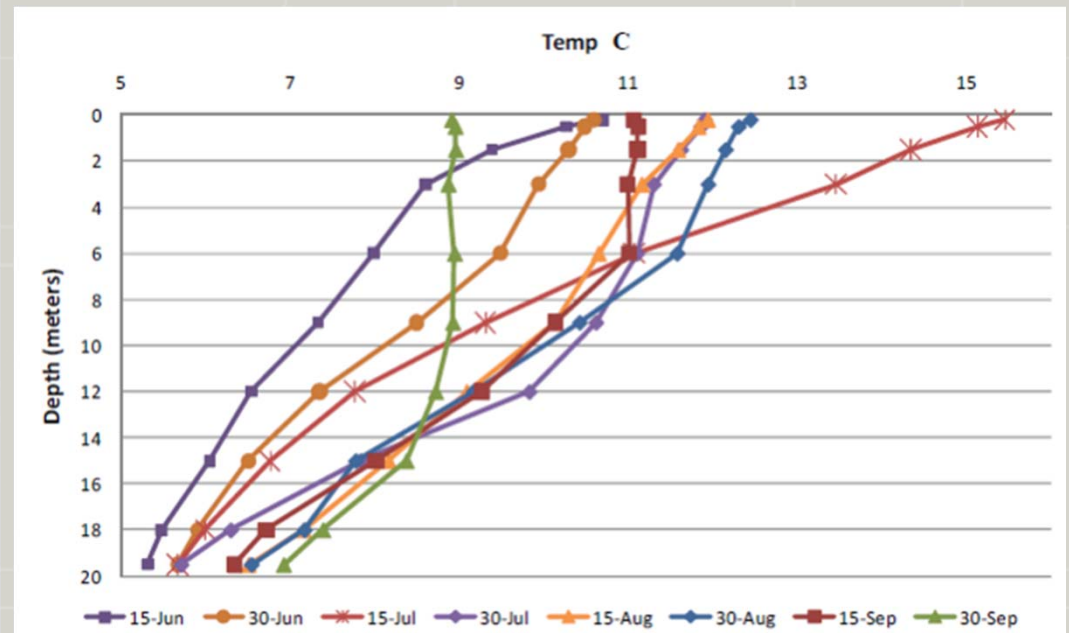
Water Temperature Results – Grant Lake Profiles



Water Temperature Results – Historical Grant Lake Profiles



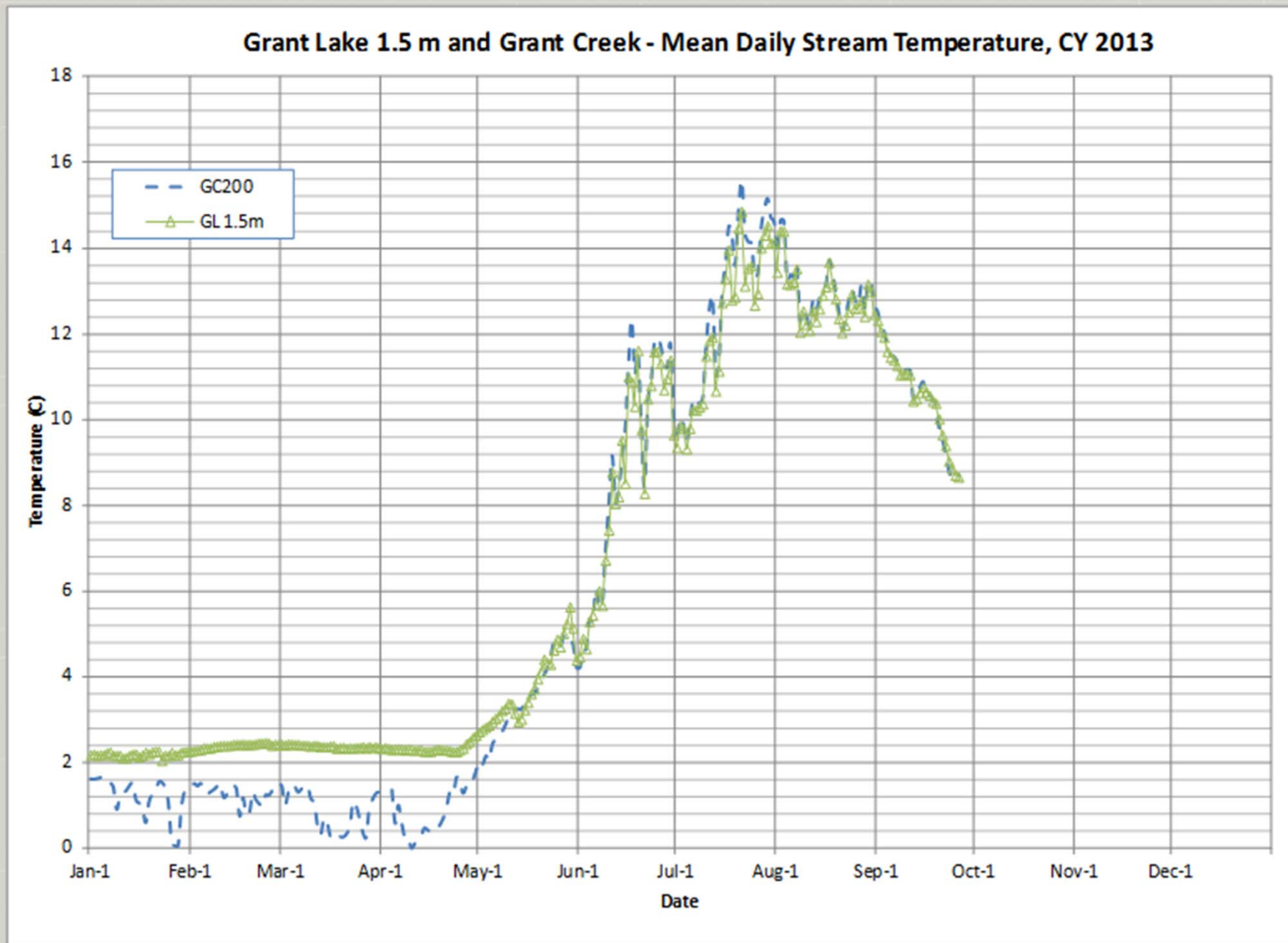
a)



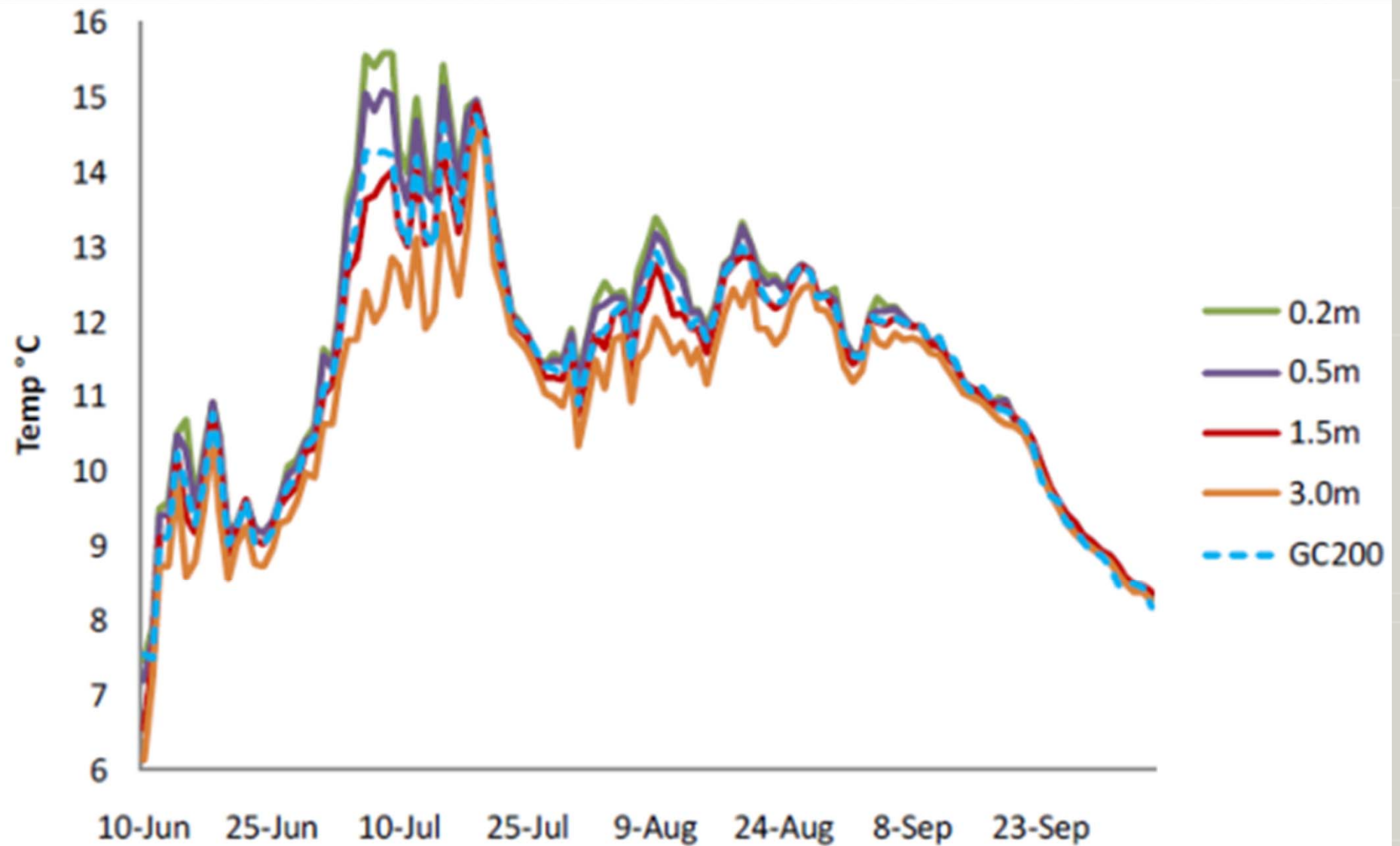
b)

Historical water temperature profiles in Grant Lake from a) AEIDC and b) HDR.

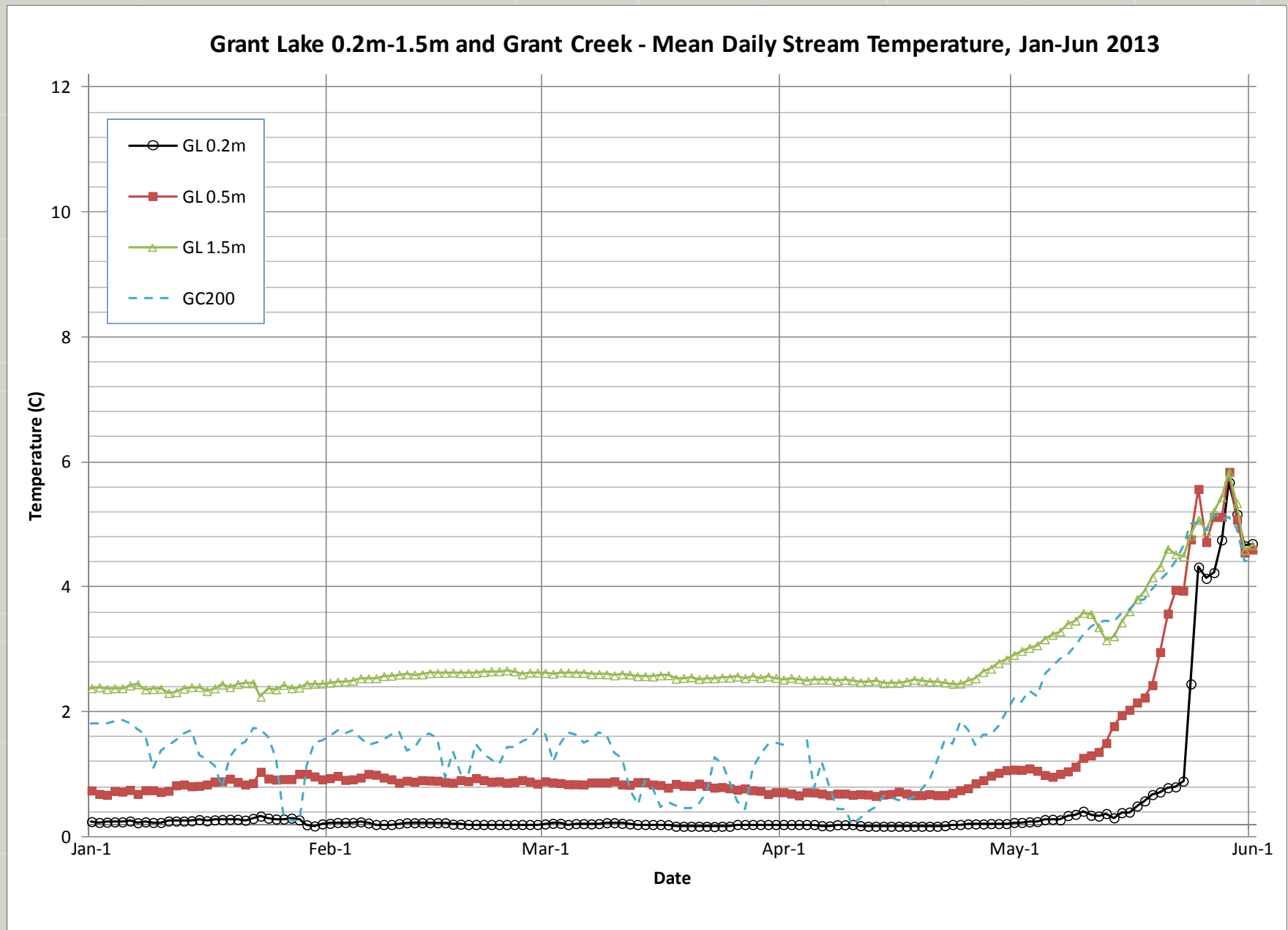
Water Temperature Results – Grant Lake and Grant Creek (2013)



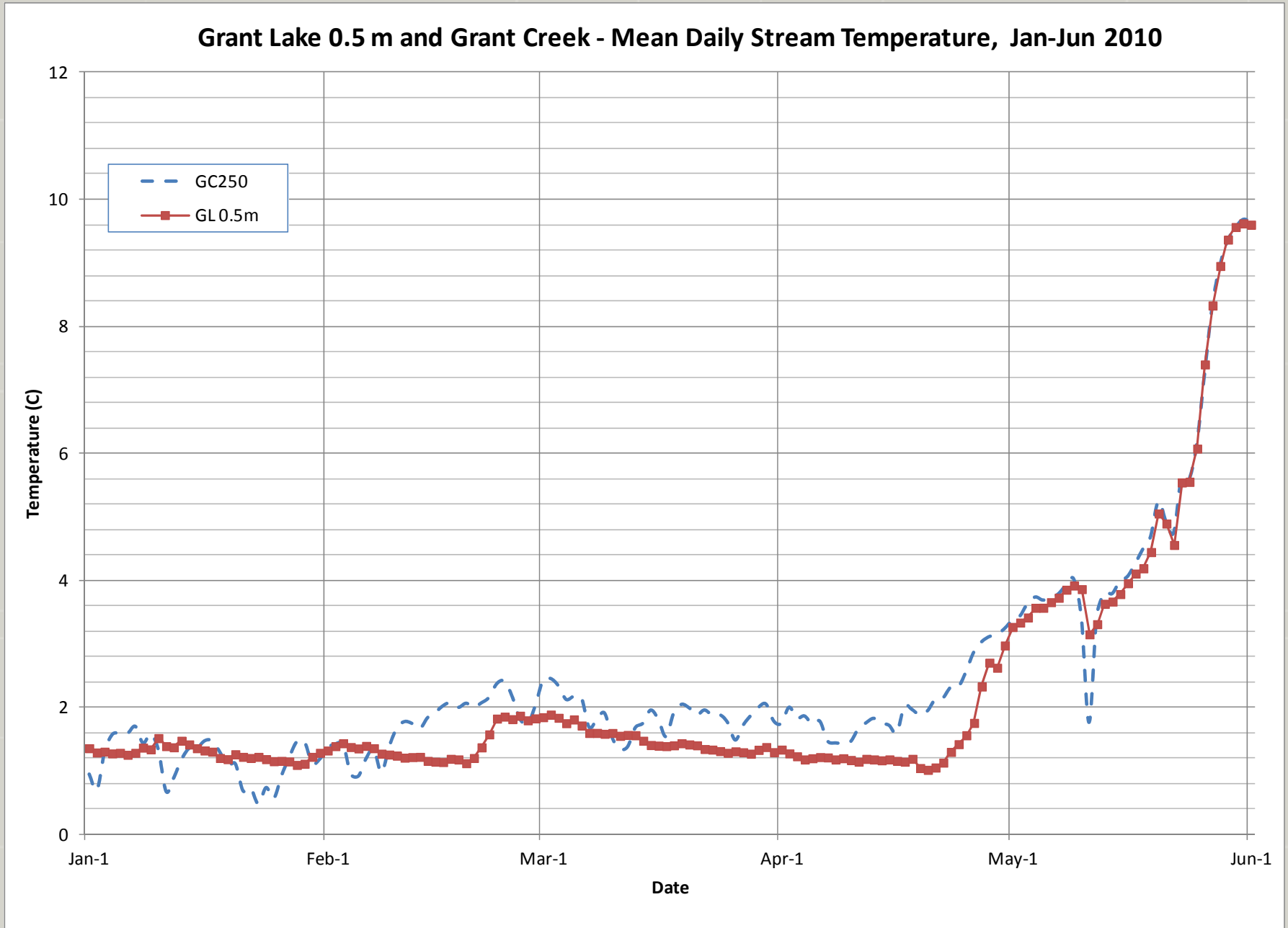
Water Temperature Results – Grant Lake and Grant Creek (2009)



Water Temperature Results – Grant Lake and Grant Creek (Jan-Jun 2013)



Water Temperature Results – Grant Lake and Grant Creek (Jan-Jun 2010)



Water Temperature Study – Conclusions

- General

- All lake and creek temperature trends are consistent with historical data.

- Ice Free Period

- Grant Creek water temperatures are identical from the upper Canyon Reach (GC 600) to the lower section of Reach 1 (GC 100) and are closely correlated with Grant Lake temperatures at a depth of 1.5 meters
- One off-channel site (GC200-OC) appears to have some groundwater influence as mean daily temperature values were slightly lower and did not exhibit the same inter-daily fluctuations as main channel sites.
- Grant Lake temperatures gradually decrease with depth, but the lower basin does not appear to stratify during the summer.

- Winter/Ice Period

- Grant Lake exhibits a typical winter temperature profile of cold surface water temperatures ($\sim 0.2 - 1.0^{\circ} \text{C}$) with warmer temperatures at depths greater than 1.5 meters ($\sim 2.4 - 3.6^{\circ} \text{C}$).
- Grant Lake temperatures at 1.5 meters are steadily at $\sim 2^{\circ} \text{C}$, while Grant Creek water temperatures fluctuate between $\sim 0.0 - 1.6^{\circ} \text{C}$.
- Upper Canyon Reach Site (GC 600) may follow the Grant Lake temperature hydrograph as opposed Grant Creek hydrographs in lower reaches (e.g. GC 200)

Resource Area Studies

- Hydrology Studies

- Re-establish historical USGS gaging station to continuously monitor stage.
- Take multiple discharge measurements throughout the season to develop a stage-discharge rating curve and extend the period of record.
- Conduct a low flow accretion study in Reach 5 and Reach 6 (i.e., Canyon Reach) of Grant Creek

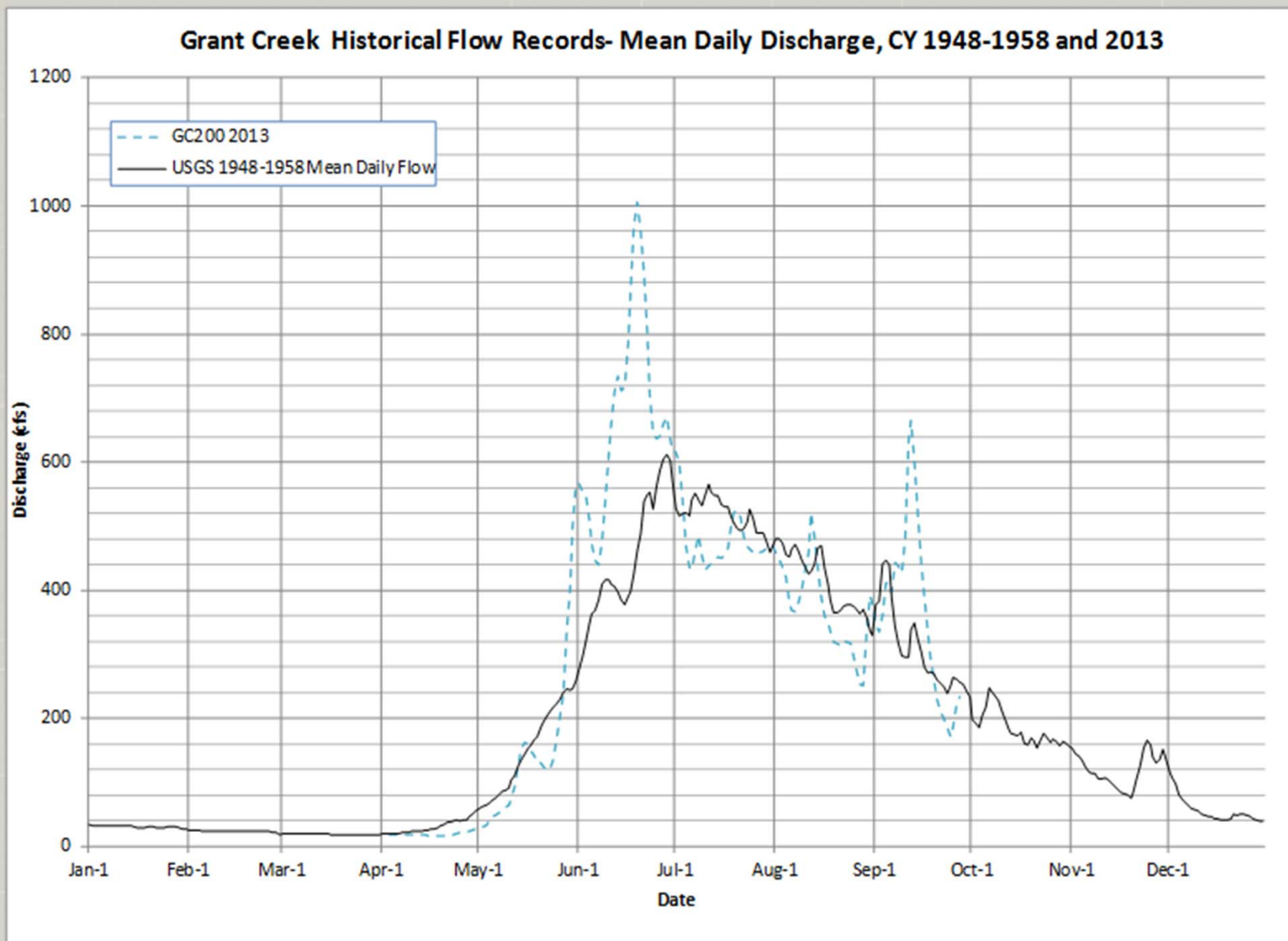
Hydrology Results – 2013 Gaging Equipment



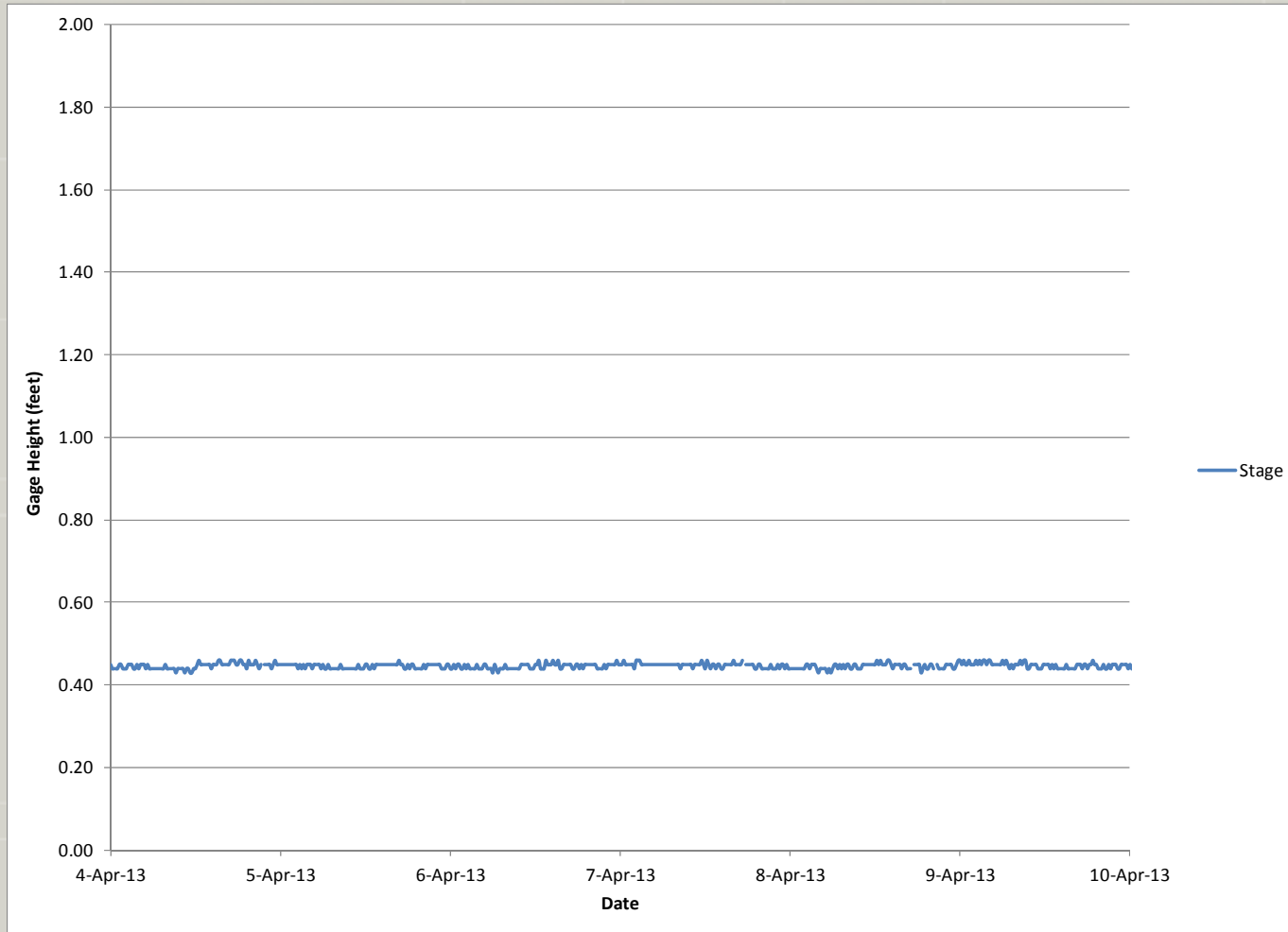
Hydrology Results – Discharge Summary

Q Meas #	Date	Stream Gage Water Level (ft)	Measured Discharge (ft ³ /s)	Calculated Discharge (ft ³ /s)	Percent Difference (meas/calc)
				Rating 1 LF	
1	4/4/2013	0.45	18.3	18.9	-3.3%
2	4/19/2013	0.41	16.6	16.1	2.8%
3	5/3/2013	0.64	34.3	34.3	0.0%
4	5/9/2013	0.88	59.6	58.4	2.0%
5	5/10/2013	0.93	63.1	64.0	-1.5%
				Rating 1 HF	
6_{HF}	5/14/2013	1.40	145.5	152.7	-4.7%
7_{HF}	6/12/2013	2.84	694.0	680.4	2.0%
8_{HF}	8/21/2013	2.00	312.2	324.6	-3.8%
9_{HF}	9/27/2013	1.78	257.6	253.7	1.5%
10_{HF}	10/11/2013	1.49	167.4	174.2	-3.9%

Hydrology Results – 2013 and Historical Mean Daily Flows



Hydrology Results - Accretion Study



- Reach 6 Discharge = 18.1 cfs April 5, 2013 (Q_{section} : 36 verticals; Max Q_{total} = 8.6%)
- Reach 5 Discharge = 18.3 cfs April 4, 2013 (Q_{section} : 42 verticals; Max Q_{total} = 8.1%)

Hydrology Study – Conclusions

- Discharge measurements ranging from 17 cfs to 694 cfs were completed and accurately defined the stage-discharge relationship in 2013.
- Stream flow period of record accurately extended starting on April 3, 2013 and directly comparable to USGS data based on gage location and regular calibration and maintenance.
- The 2013 discharge record (April 3- Sept 27, 2013) was similar to the historical USGS record with a few deviations from the general pattern in June and September .
 - The higher flows in June of 2013 most likely resulted from a sustained heat wave that that caused elevated rates of snow and glacial melt.
 - In September 2013, a pattern of frequent and long duration rain events is what caused flows to spike above the 11 year average.
- The accretion study results indicate that all of the water entering the Canyon Reach is conveyed downstream, with no net losses or gains for the 0.5 mile segment of Grant Creek.
- HEA has maintained the gage throughout the winter and will continue collecting and analyzing hydrology data to extend the long-term stream flow record.

Water Resources – Questions and Comments?