Jordan River TMDL:
2010 QUAL2Kw Model Calibration
Technical Memo
PUBLIC DRAFT

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The purpose of this technical memorandum is to summarize the calibration of the QUAL2Kw model of the Jordan River. This memo will document the methodology and results of the model calibration. The model validation was performed by Dave Wham of the Division of Water Quality (DWQ) and is summarized in a separate technical memorandum.

The model background, selection and initial calibration methodology and results, which were completed in 2006, are documented in the *DRAFT Lower Jordan River TMDL: Work Element 4 – Flow and Water Quality Modeling Report* (Stantec Consulting 2006). The 2006 model calibration and validation was determined to be insufficient due to a complete lack of or limited observed data, including reaeration, shading, nutrient speciation, free floating and fixed algae, and sediment oxygen demand. Subsequently, a three-year intensive data gathering effort was undertaken in order to better understand the causes of the DO impairment in the lower Jordan River and to collect additional data for the model calibration.

The original QUAL2K model was converted to the QUAL2Kw modeling platform for the calibration and validation activities. The QUAL2Kw modeling platform was developed and is maintained by the Washington State Department of Ecology [Pelletier and Chapra 2008(a) and 2008(b)]. QUAL2Kw is very similar to QUAL2K in most respects; however, QUAL2Kw has additional capabilities including an automatic calibration routine, simulation of hyporeic exchange, and input of observed solar radiation data. The DWQ has selected QUAL2Kw as the standard model for future UPDES permits. QUAL2Kw Version 5.1 was adopted for the model calibration and validation. The model is available for download from the Washington State Department of Ecology Models for TMDL Studies website (http://www.ecy.wa.gov/programs/eap/models.html).

Methodology

Four seasonal synoptic monitoring surveys were specifically scheduled and conducted by DWQ for use in the model development. Data from three of the events were utilized for the model calibration and one event was used for the model validation.

Sampling Methodology

Synoptic sampling was conducted along the Jordan River according to the attached sampling plan and the Division of Water Quality Monitoring Manual (2006). The following synoptic sampling events were conducted:

Date Range	Season
October 2-4, 2006	Early fall/late irrigation
February 27-March 1, 2007	Winter/non-irrigation
August 18-20, 2009	Summer/irrigation

Water quality samples were taken once daily at up to twelve locations along the Jordan River and at the major tributaries (Little Cottonwood Creek, Big Cottonwood Creek, Mill Creek, 1300 South Conduit and North Temple Conduit) and major point sources (South Valley Water Reclamation Facility, Central Valley Water Reclamation Facility, and South Davis South Water Reclamation Facility).

For October 2006, the samples along the Jordan River were equal-width integrated, while the tributaries and point sources were grab samples. For February 2007 and August 2009, grab samples were taken at most locations with selected equal-width integrated samples along the Jordan River.

The samples were analyzed at the Central Valley WRF environmental laboratory for the constituents listed below. Chlorophyll a was analyzed at the DWQ environmental laboratory:

1. Alkalinity (ALK)
2. Carbonaceous Biochemical Oxygen Demand 5-day (CBOD-5)
3. Soluble Carbonaceous Biochemical Oxygen Demand 5-day (SCBOD-5)
4. Ammonia (NH3-N)
5. Nitrite (NO2-N)
6. Nitrate (NO3-N)
7. Total Kjeldhal Nitrogen (TKN)
8. Orthophosphate (o-PO4)
9. Total Phosporus (TP)
10. Total Suspended Solids (TSS)
11. Volatile Suspended Solids (VSS)
12. Total Organic Carbon (TOC)
13. Chlorophyll a (CH-a)

In addition, Troll 9000 multi-parameter water quality probes were deployed at eight locations along the Jordan River to collect hourly diel data for the following constituents: temperature, pH, conductivity and dissolved oxygen.

A multi-parameter water quality probe was also used to measure temperature, pH, conductivity and dissolved oxygen while collecting samples from the major tributaries and wastewater treatment plants. The field probe malfunctioned during the February 2007 synoptic event; historical monthly or seasonal average was used for model input of temperature, pH, conductivity, and dissolved oxygen for the major tributaries.

DWQ staff collected periphyton data following Environmental Monitoring and Assessment (EMAP) protocols during early September 2009 at selected sites along the Jordan River.

Additional monitoring data was collected during the summer of 2009 by researchers at the University of Utah, Utah State University and the Farmington Bay/Jordan River Water Quality Council (FBJRWQC).

Research Topic	Institution	Principal Investigator	Reference
Sediment Oxygen Demand	University of Utah	Dr. Ramesh Goel	
Reaeration Rate	University of Utah	Dr. Ramesh Goel	
Phytoplankton Assessment	Rushforth Phycology	Dr. Sam Rushforth	2009(a)
Periphyton Assessment	Rushforth Phycology	Dr. Sam Rushforth	2009(b)
Light Extinction	FBJRWQC	Dr. Theron Miller	
Algal Growth Limitation	Utah State University	Dr. Michelle Baker	

Model Input Data

The source and reduction of data for model input is summarized below. Model input data for each synoptic event is included in Appendix A: Model Input.

Meteorological Data

Meteorological data was obtained from the National Weather Service's (NWS) weather station at the Salt Lake International Airport (Station ID 725720) through the National Oceanographic and Atmospheric Administration's National Climatic Data Center. Meteorological data entered into the QUAL2Kw model included hourly air temperature, dew point, wind speed and percent cloud cover. The input values were an average of each hour over the three day period, i.e. the values at 10:00am for each day were averaged to determine the input value for 10:00am.

Cloud cover percentage was based on the observed cloud cover code. The following relationship between cloud cover code and cloud cover percentage was used based on National Weather Service specifications.

Cloud Cover Code	Description	Cloud Cover (%)
CLR	clear	0
SCT	scattered	31.25
BKN	broken	75
OVC	overcast	100
OBS	obscured	100
POB	partial obscuration	100

Observed solar radiation data was obtained from the Salt Lake City station of the Integrated Surface Irradiance Study (ISIS) Network. The ISIS station is located at the NWS weather station at the Salt Lake International Airport. The downwelling global solar radiation in Watts per square meter was used as input to the model.

Shading Data

An analysis was performed to estimate shading along the Jordan River throughout the day. The near stream land cover (within 300 feet on either side of the river) was classified into seventeen riparian classes based on 2009 NAIP one-meter orthophotography. Field measurements of plant species composition, average height and average canopy density were made at 19 sites along the Jordan River by DWQ staff during July 2009. A height and density was associated with each riparian feature classification based on the field measurements and professional judgment.

Riparian Feature Classification		GIS Code	Height (m)	Density (%)	Assumption
1	Water	300	0	0	
2	Barren - Dirt	301	0	0	
3	Asphalt	400	0	0	
4	Rail	401	0	0	
5	Building	500	9	100	2 story building
6	Condominium	501	9	75	2 story building
7	Subdivision	502	6	50	1.5 story building
8	Trailer Park	503	4.5	75	1 story building
9	Rural	504	6	25	1.5 story building
10	Construction	505	0	0	
11	Trees	600	12	80	Average height trees
12	Trees Low	601	8	80	Low height trees
13	Trees Scattered	602	12	40	Low density of trees - average height
14	Shrubs	700	4	80	
15	Salt Marsh	701	1	50	
16	Field	702	0	0	Agricultural crop
17	Grass	703	1	80	Unmanaged grass
18	Lawn	704	0	0	Managed grass

The TTools ArcGIS extension, developed and distributed by the Oregon Department of Environmental Quality, was used along with geospatial data layers to calculate stream aspect, elevation and gradient; wetted width; near stream disturbance zone width; topographic shade angle; and riparian codes (for 9 zones on either bank) at every 0.5 kilometer along the Jordan River.

GIS Data Layer	Source	Description
River Alignment	Stantec Consulting	Created for Jordan River TMDL
Channel Width	Salt Lake County	Salt Lake and Davis County
	Stantec Consulting	Utah County
Orthophotography	Utah AGRC	2009 NAIP 1-meter
Near Stream Land Cover	Stantec Consulting	
Topography	USGS	National Elevation Dataset 10-meter DEM
Stream Aspect	Stantec Consulting	Derived from ODEQ TTools
Stream Elevation	Stantec Consulting	Derived from ODEQ TTools
Stream Gradient	Stantec Consulting	Derived from ODEQ TTools
Topographic Shade Angle	Stantec Consulting	Derived from ODEQ TTools
Land Cover by Riparian Zone	Stantec Consulting	Derived from ODEQ TTools

The geospatial attributes calculated by TTools were then input into the Shading Estimation Excel spreadsheet, developed and distributed by Washington State Department of Ecology, to calculate hourly shading for each of the synoptic sampling events. The estimated hourly shading for each 0.5 kilometer along the Jordan River was input into QUAL2Kw.

Flow Data

Flow data for the Jordan River, tributaries, point sources and diversions was obtained from stream gages and flow records maintained and operated by the USGS, Utah Division of Water Rights (DWR), Salt Lake County (SLCo), and each wastewater treatment plant. Mean daily flow from the three day period was averaged to obtain the model input values. A summary of flow data sources is presented below.

Instream, Tributaries and Point Sources

Location	River KM	Data Source	Station Number	Station Name
Utah Lake	82.70	DWR		Utah Lake Outflow
Jordan River Above Narrows	67.50	DWR	02	Jordan River Combined Flow
Jordan River Below Narrows	67.25	DWR	04.01.02	Jordan River Station No. 1
Rose Creek	58.90			No data
Corner Canyon Creek	56.10			No data
Midas Creek	50.70			No data
Willow Creek	49.50			No data
Dry Creek	46.05			No data
Jordan River at 9000 South	45.25	SLCo	120	Jordan River at 9000 South
South Valley WWTP	42.30			South Valley effluent monitoring
7800 S Drain Return Flow	42.29			10% of JVPS/Welby Canal & 20% of Utah Lake Distributing Canal
Little Cottonwood Creek	34.70	SLCo	290	LCC at 300 West
		USGS	10168000	LCC at Jordan River
Big Cottonwood Creek	33.20	SLCo	390	BCC at 300 West
Mill Creek	27.70	SLCo	490	Mill Creek at 460 West (above CVWRF)
Central Valley WWTP				Central Valley effluent monitoring
Kearns-Chesterfield Drain Return Flow	27.36			20% of South Jordan Canal & 20% of North Jordan Canal
Jordan River at Surplus Canal	25.80	USGS	10170490	Jordan River at Surplus Canal
Jordan River at 1700 South	24.26	USGS	10171000	Jordan River at 1700 South
1300 S Conduit	22.90			Summation of three creeks.
Parley's Canyon		SLCo	520	Parley's Creek at Suicide Rock
Emigration Canyon		SLCo	620	Emigration Creek at Canyon Mouth
Red Butte Canyon		SLCo	740	Red Butte Creek at 1600 East
800 South Drain	20.76			20% of Jordan & Salt Lake Canal
N Temple Conduit	18.35			
City Creek		SLCo	820	City Creek at Memory Grove Park
Jordan River at 500 North	11.15	SLCo	180	Jordan River at 5th North
South Davis South WWTP	8.20			South Davis South effluent monitoring
Jordan River at Cudahy Lane	7.20	DWR		Jordan River at Cudahy Lane

Diversions

Diversion	River KM	Data Source	Station Number	Station Name
Jordan Valley Pump Station	67.50	DWR	05.01.07	Jordan Valley Water Conservancy District
Utah Lake Distribution Canal	67.45	DWR	04.01.01	Utah Lake Distributing Canal
		DWR	06.01	Utah Lake Distributing Canal (59-13)
Utah and Salt Lake Canal	67.30	DWR	06.02	Utah and Salt Lake Canal (Total)
		DWR	06.02.01	Utah and Salt Lake Canal (59-3499)
East Jordan & Draper Canal	67.25	DWR	06.03	East Jordan Canal (Total)
		DWR	06.03.01	East Jordan Irrigation Company (57-7637)
		DWR	06.03.02	Salt Lake City (57-10186)
		DWR	06.04	Draper Irrigation Co. (57-23)
South Jordan Canal	64.30	DWR	07.02	South Jordan Canal
		DWR	05.01.03	South Jordan Canal Co. (59-5270 A15004)
Jordan & Salt Lake Canal	64.25	DWR	07.01	Jordan and Salt Lake Canal
North Jordan Canal	46.35	DWR		North Jordan Canal
		DWR	10.01.01	North Jordan Irrigation Co. (59-3496)
		DWR	10.01.02	Kennecott (59-23)
		DWR	10.01.02	Kennecott (59-3517 & A4907)
		DWR	10.01.02	Kennecott (59-5798)
		DWR	10.01.02	Kennecott (59-5610)
Brighton Canal	34.10	DWR		Brighton Canal
Surplus Canal	25.80	USGS	10170500	Surplus Canal
UP&L Diversion	19.65			No data
State Canal	2.70	DWR		State Canal

Groundwater flow, springs and ungaged smaller tributaries such as Rose Creek and Dry Creek were lumped together into diffuse sources for the purposes of the model. The diffuse sources were used to achieve a water balance at each of the stream gauges located along the Jordan River.

Mean monthly groundwater flow rates were obtained from the Jordan River water budget presented in *Jordan River TMDL: Work Element 2 – Pollutant Identification and Loading* (Cirrus Ecological Solutions and Stantec Consulting 2009). The groundwater flows in the report included irrigation return flows from farming practices as well as residential lawn and garden application.

The quantity and quality of surface irrigation return flow to the Jordan River is not well understood. The irrigation season runs approximately from April 15 to October 15. Some excess irrigation water and unused canal water returns to the Jordan River. Following is the return flow estimated for the QUAL2Kw model:

- 10% of the flow diverted to the Jacob Welby Canal and 20% of the flow diverted to the Utah Lake Distributing Canal discharged through the 7800 South Drain

- 20% of the flow diverted to the South Jordan Canal and 20% of the flow diverted to the North Jordan Canal discharged through the Kearns-Chesterfield Drain

- 20% of the flow diverted to the Jordan & Salt Lake Canal discharged through the 800 South Drain

Precipitation occurred during the February 2007 synoptic sampling event; therefore, stormwater was added as another diffuse source to this model. The amount of stormwater was estimated by balancing the flow at the gages along the Jordan River.

Travel Time

Travel time was estimated by routing the observed flow rates through the HEC-RAS model of the Jordan River. The HEC-RAS output includes stream velocity and cumulative travel time. The HEC-RAS model results were used as observed data for QUAL2Kw calibration. The HEC-RAS model did not have all of the instream weirs incorporated into the QUAL2Kw model, so the simulated travel time should be slightly greater than the observed.

Water Quality Constituents

Analytical sampling results from each of the three days were averaged to obtain the model input values for each of the constituents. Some input constituents in QUAL2Kw were not directly measured and were derived from the analytical results. A summary of model constituents and method of determination is presented below:

Model Constituent Input	Units	Method
Temperature (T)	deg C	Field Measurement/Probe
Specific Conductivity (SC)	umhos	Field Measurement/Probe
Inorganic Suspended Solids (ISS)	mg/L	Calculated [TSS – VSS]
Dissolved Oxygen (DO)	mg/L	Field Measurement/Probe
SCBOD Ultimate (SCBOD-u)	mg/L	Calculated [SCBOD-5/(1 – EXP(-4))]
Dissolved Organic Nitrogen (DON)	ug/L	Calculated [TKN - NH3 – (CH-a*7.2/1000)]
Ammonia (NH3-N)	ug/L	Analytical Results
Nitrate & Nitrite (NO2+NO3-N)	ug/L	Calculated [NO3 + NO2]
Dissolved Organic Phosphorus (DOP)	ug/L	Calculated [TP – PO4 – (CH-a*1/1000)]
Inorganic Phosphorus (o-PO4)	ug/L	Analytical Results
Phytoplankton (CH-a)	ug/L	Analytical Results
Detritus (DET)	mg/L	Calculated [VSS – (CH-a*100/1000)]
Alkalinity (ALK)	mg/L	Analytical Results
pH		Field Measurement/Probe

The hourly probe data from each of the Jordan River locations was used to determine the mean and daily range of the temperature, conductivity, pH, and dissolved oxygen. The minimum and maximum range input into the model was the average minimum and maximum from the three day period.

Due to a general lack of site specific data, groundwater quality was largely considered a calibration parameter; however, limited shallow groundwater well quality data from the USGS was referenced in estimating groundwater quality constituents (Thiros 2003).

Stormwater quality data for the February 2007 event is based on event mean concentration as monitored by Salt Lake County (Stantec 2008).

The irrigation return flow quality was assumed to be of the same quality as at the point of diversion, i.e. Jordan River at Turner Dam. Some transformation of water quality constituents is anticipated during conveyance through the canals and application to the fields; however, no recent irrigation water quality monitoring data was available for this study.

The meteorological, water quality, and flow model input data for each synoptic sampling event are included in Appendix A: Model Input. Any incomplete data or assumed data is highlighted in the tables for future reference.

Model Calibration

The model calibration consisted of adjusting model parameters in order to minimize error between simulated and observed constituent data for all three of the synoptic sampling events. The same rate coefficients were generally used for all three synoptic events. Rate parameters were maintained within published ranges (Bowie et al 1985).

A committee was formed in order to develop consensus on the model calibration and agree upon suitability for subsequent use in the Jordan River TMDL. The committee consisted of DWQ staff, consultant representatives, academic peer review, and selected stakeholder representatives. A preliminary model calibration was performed by Stantec and the model was distributed to the committee for review. A collaborative calibration workshop was held on 12/15/2009 in which model input, rate parameters and results were reviewed and potential revisions discussed and agreed upon. The list of participants and meeting minutes is included in the Appendix B: Collaborative Calibration.

Following the collaborative calibration meeting, revisions were made to the calibration based on direction from the meeting and follow-up investigations. The revised calibration model was distributed to the calibration committee for final review.

Once the calibration was completed, the model was validated by DWQ staff using a fourth synoptic sampling event conducted in early September 2007. The results of the validation effort are presented in a separate technical memorandum developed by DWQ.

Model Performance Criteria

A weight-of-evidence approach was used to evaluate the model calibration and validation performance and determine model acceptance for use in the TMDL. The weight-of-evidence approach is widely used and accepted for environmental modeling and consists of multiple graphical and statistical comparisons to assess model performance (Donigian 2002). The primary measures of model performance for this calibration included:

- Graphical comparison between simulated and observed mean, minimum and maximum daily concentrations for each water quality constituent. The objective was to achieve the best fit between simulated and observed concentrations.

- Statistical calculation of absolute error and relative error. The absolute error is the absolute value of the difference between the simulated and observed mean concentration. The relative error is the ratio of the absolute error to the observed mean concentration (reported in %).

No single statistic or error tolerance has been agreed upon in the model-related literature to determine acceptable model performance; however, it is agreed that error is inherent in both measuring and modeling of natural systems, and therefore some level of error is inherent. Donigian (2002) proposed the following error targets for HSPF applications:

	Relative Difference Between Simulated and Observed Mean Values (%)		
	Very Good	**Good**	**Fair**
Hydrology/Flow	< 10	10 – 15	15 - 25
Sediment	< 20	20 – 30	30 – 45
Water Temperature	< 7	8 – 12	13 – 18
Water Quality/Nutrients	< 15	15 - 25	25 – 35
Pesticides/Toxics	< 20	20 – 30	30 - 40

Several completed and EPA approved TMDL studies that utilized calibrated QUAL2Kw models to assess DO impairment were reviewed for acceptable error tolerances. As shown by the coefficient of variation (CV%) in the table below, the Wenatchee River calibrated QUAL2Kw model error ranged from 2.1 to 175.1% (Washington Department of Ecology 2006). In the Stillaguamish River calibrated QUAL2Kw model, the root mean square error (RMSE), or standard error, for maximum temperature ranged from 0.0 to 1.3 degrees Celsius [Washington Department of Ecology 2004(a)]. The absolute mean error for DO in the Umpqua Basin QUAL2Kw models ranged from 0.2 to 1.4 mg/L (Oregon Department of Environmental Quality 2006).

Table 19. Overall performance of Wenatchee River model calibrations using root mean square error (RMSE) and coefficient of variation (CV%) in comparison to overall observed field replicate relative standard deviations (RSD%).

Parameter	Units	Reporting limit	RSD% of replicates (<5X reporting limit)	RSD% of replicates (>5X reporting limit)	RMSE of model calibration	CV% of model calibration RMSE	Mean used to calculate RMSE CV	RMSE n
Temperature	C	-	-	-	0.47	3.0%	15.6	68
Conductivity	umhos/cm	-	-	3.4%	2.7	6.5%	41.1	22
Chloride	mg/L	0.1	5.6%	4.9%	0.06	10.0%	0.6	22
DO	mg/L	-	-	1.5%	0.20	2.1%	9.6	36
pH	s.u.	-	-	0.9%	0.20	2.5%	7.9	34
Organic-P	ug/L	-	-	-	0.6	147.4%	0.4	22
Inorganic-P	ug/L	3	15.9%	0.4%	0.96	21.8%	4.4	22
Organic-N	ug/L	-	-	-	15.5	114.5%	13.5	22
Ammonia-N	ug/L	10	11.9%	2.5%	3.5	175.1%	2.0	22
Nitrate-nitrite-N	ug/L	10	2.2%	4.5%	10.9	15.7%	69.9	22
Total N	ug/L	25	16.7%	5.2%	16.3	17.6%	92.7	22
Total P	ug/L	3	15.1%	5.7%	2.1	45.5%	4.7	22

n = number

Source: Washington State Department of Ecology 2006

Previous TMDLs completed in the State of Utah have not addressed acceptable error tolerances for model calibration, so no precedent has been established. The East Canyon Creek TMDL, which also used a quasi-steady state DO diel model, did not calculate nor address acceptable error tolerances in the model calibration (HydroQual 2008).

No single model fitness statistic was agreed upon by the calibration committee; however, the aforementioned model error tolerances are recommended as suitable for evaluating the QUAL2Kw model calibration performance.

Results and Discussion

This section presents the results of the model calibration along with a brief discussion of calibration considerations and performance. Charts of simulated versus observed results for each of the synoptic events are included in Appendix C: Model Output.

The relative error for each synoptic model is summarized in the table below. Both the average error of 10/2006 and 8/2009 and of all three events is shown. The 2/2007 synoptic sampling event was confounded by precipitation during the survey, and was therefore considered less important to the calibration.

Further discussion of the graphical and statistical comparisons for each constituent is provided below.

	Mean Observed			Relative Error of Mean (%)			Average	
Constituent	Oct-06	Feb-07	Aug-09	Oct-06	Feb-07	Aug-09	Oct & Aug	All
Temperature (deg C)	16.03	5.12	19.82	1.3%	10.2%	1.5%	1.4%	4.3%
Conductivity (mhos/cm^2)	1254.16	1280.15	1628.00	1.8%	4.2%	2.4%	2.1%	2.8%
Inorganic Suspended Solids (mg/L)	42.30	21.34	32.54	13.8%	35.4%	11.4%	12.6%	20.2%
DO (mg/L)	7.14	11.82	6.07	4.4%	6.2%	2.8%	3.6%	4.5%
SCBOD (mg/L)	1.46	0.91	1.00	20.3%	26.9%	49.4%	34.9%	32.2%
Organic Nitrogen (ug/L)	1040.88	1419.67	725.15	23.5%	36.2%	31.5%	27.5%	30.4%
NH4 (ug/L)	253.67	296.53	150.02	21.5%	40.8%	45.3%	33.4%	35.9%
NO3 (ug/L)	2685.56	1028.47	3589.44	8.8%	20.1%	12.5%	10.7%	13.8%
Organic Phosphorus (ug/L)	337.11	223.09	99.98	24.0%	31.9%	15.3%	19.6%	23.7%
Inorganic Phosphorus (ug/L)	251.89	70.28	588.63	10.4%	84.4%	13.2%	11.8%	36.0%
Phytoplankton (ug/L)	9.63	7.89	13.49	46.6%	25.7%	25.2%	35.9%	32.5%
Detritus (mg/L)	6.73	5.53	5.90	25.1%	21.3%	27.8%	26.4%	24.7%
Alkalinity (mg/L)	224.78	215.48	229.42	6.5%	6.4%	1.7%	4.1%	4.9%
pH	7.89	8.33	7.85	2.8%	2.9%	3.0%	2.9%	2.9%
TN (ug/L)	4489.25	2914.97	4561.46	8.0%	13.0%	9.9%	9.0%	10.3%
TP (ug/L)	655.00	292.59	696.67	14.7%	21.6%	11.7%	13.2%	16.0%
TSS (ug/L)	52.26	27.59	39.38	31.7%	28.4%	15.9%	23.8%	25.3%

Hydraulics
The simulated flow and travel time results matched well with the observed data. Groundwater was omitted from DWQ Segments 1 and 2 based on the streamflow gage data at 1700 South and 500 North. Additional stormwater was added as a diffuse source to the 2/2007 model due to precipitation occurring during the monitoring period.

Temperature
With a few exceptions, the mean temperature in the water column matched well with the observed data for 8/2009 and 10/2006 (average error of 1.4%). The diel range in temperature was overpredicted in the 8/2009 model at Bangerter Highway, 9000 South, 400 South and 500 North. The 2/2007 simulated temperature varied from the observed at various locations along the river.

In order to match the simulated to observed data, the diffuse source temperature was varied for each of the synoptic events. The diffuse flow is a combination of groundwater, irrigation return flow and ungaged tributaries; therefore, it was considered appropriate to vary the diffuse source temperature seasonally. The temperatures used for diffuse flow were 16 ºC for 8/2009, 17.5 ºC for 10/2006, and 14 ºC for 2/2007.

Conductivity

With a few exceptions, the mean conductivity in the water column matched well with the observed data for each of the synoptic events (overall average error of 2.7%). As for temperature, the diffuse source conductivity was varied for each of the synoptic events in order to improve the match between simulated and observed data.

Inorganic Suspended Solids

The average error for ISS for the 8/2009 and 10/2006 events was 12.6%. February 2007 had higher error (35.4%), as well as lower average observed concentration (21.3 mg/L). Both 8/2009 and 10/2006 had an observed increase in ISS downstream of Surplus Canal. Some of the increase in ISS was attributed to instream processes such as bank erosion and bed resuspension, which are beyond QUAL2Kw's capabilities to simulate. To account for these instream processes in the model, some ISS concentration was included in the diffuse sources.

Nutrients

A large drop in total nitrogen (TN) and total phosphorus (TP) was observed between the South Valley WRF outfall and the monitoring station at 3900 South. Several hypotheses were proposed to explain this rapid assimilation of nutrients within a relatively short stretch of river (approximately 10 kilometers). One possible explanation is that there is a groundwater exchange that occurs in this reach where river water with higher concentrations of nutrients is replaced with groundwater with lower nutrient concentration. Another possible explanation is physical and/or biochemical processes that assimilate the nutrients rapidly, i.e. inorganic phosphorus adsorption to sediment and settling. For the purposes of the model, it was assumed that a groundwater exchange is occurring; 2.5 cms for 8/2009 and 1.0 cms for 10/2006 and 2/2007. The groundwater exchange produced a much better fit of the nutrient data at 3900 South and 2100 South.

Nitrogen

The overall average error for TN was 9.9%. Organic nitrogen was underpredicted downstream of the Surplus Canal for 10/2006 and 8/2009 and ammonia was underpredicted downstream of the Surplus Canal for 8/2009, resulting in greater error for nitrogen speciation.

Phosphorus

The average error for TP was 13.2% for 10/2006 and 8/2009; average error for 2/2007 was 21.6%. Organic phosphorus was underpredicted downstream of the Surplus Canal for 10/2006. Larger error was observed in 2/2007 for both organic and inorganic phosphorus.

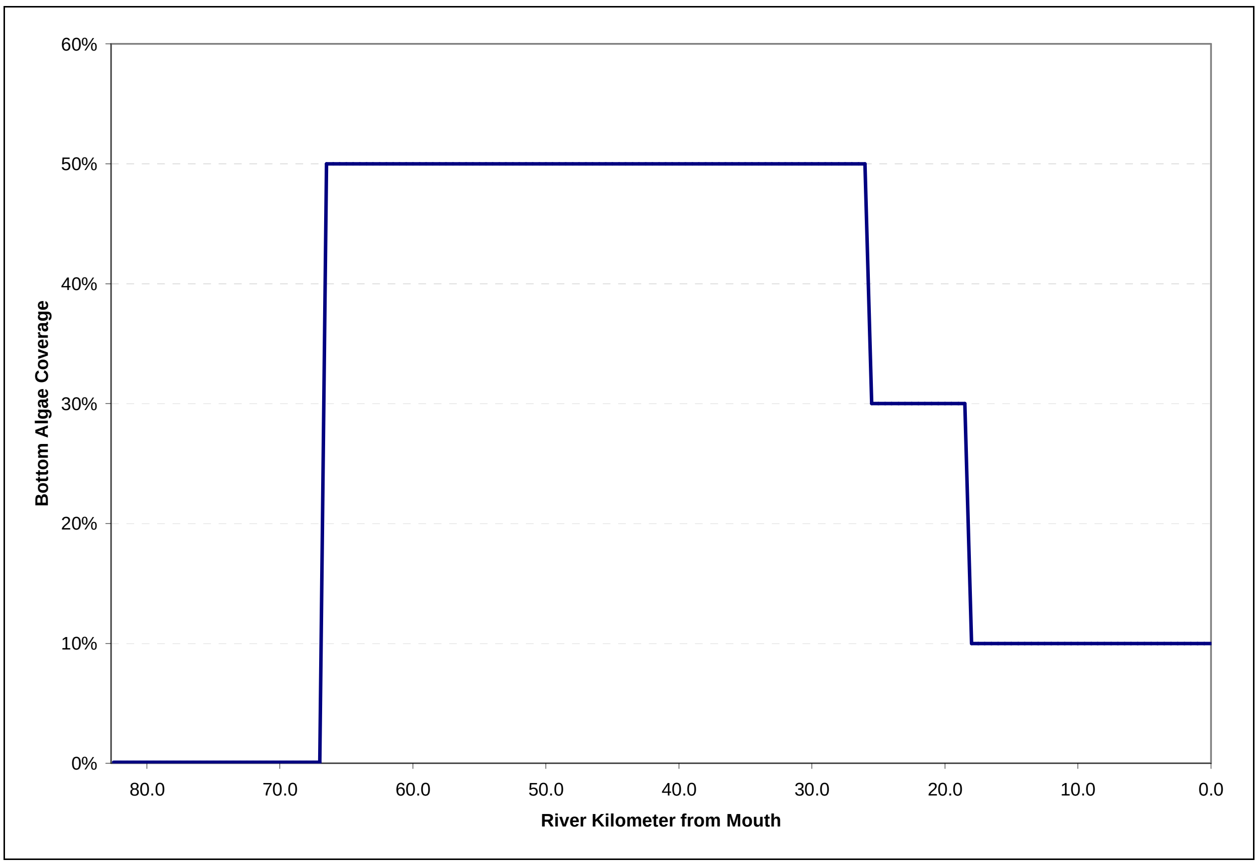
Detritus

The average error for detritus (particulate organic matter) was relatively uniform for each of the synoptic events (21.3% – 27.8%). Although relatively low in concentration (4 – 8 mg/L), detritus concentration remained constant or increased downstream of the Surplus Canal in each synoptic event. There are limited external sources of organic material in the lower Jordan River (two tributaries and one wastewater treatment plant). The death of algae is another source of detritus in QUAL2Kw. It was concluded that the primary productivity was accurately simulated in this reach (refer to algae and DO discussions below) and dead algae as a source of detritus was well characterized. Therefore, the source of detritus in the lower Jordan River was hypothesized to result from riparian vegetation and resuspension of organic material from the river bed, which is not represented in the model and resulted in calibration error.

Algae
The average error for phytoplankton ranged from 25.2% – 46.6%, while the average concentration was relatively low (7.9 – 13.5 µg/L). The 10/2006 model generally underpredicted phytoplankton, while the error varied in 2/2007 and 8/2009.

Some limited observed data was available for the biomass of bottom algae (or periphyton) collected in September 2009. The growth rate predicted by the model was compared to these observations. The bottom algae coverage percentage (or suitability of substrate to support algal growth) was adjusted based on the primary productivity indicated by the DO probe data. Following are the bottom algae coverage percentages specified:

Upstream Location	Downstream Location	Bottom Algae Coverage %
Utah Lake	Turner Dam	0%
Turner Dam	Surplus Canal	50%
Surplus Canal	UP&L Diversion	30%
UP&L Diversion	Burton Dam	10%



Dissolved Oxygen
Reaeration
The Internal Formula was used to estimate the reaeration rate in the QUAL2Kw model. The 8/2009 model results were compared to reaeration rates measured during a study conducted by

the University of Utah in the summer of 2009. There was a reasonably good match between predicted and measured reaeration rates. A reaeration rate of 0.75 /day was prescribed downstream of North Temple for 8/2009 due to an overprediction of reaeration based on hydraulics through this reach.

Soluble Carbonaceous Biochemical Oxygen Demand (SCBOD)
The average error for SCBOD was 30.7%. The 8/2009 model generally overpredicted SCBOD, while the other synoptic events had less error. For the model input, SCBOD from tributaries was given a slower decay rate and for wastewater treatment plants a higher decay rate.

Sediment Oxygen Demand
The diagenesis routine in QUAL2Kw was selected to simulate SOD. The 8/2009 model results were compared to SOD values measured during a study conducted by the University of Utah in the summer of 2009. There was a reasonably good match between predicted and measured SOD, with the exception of the Jordan River below the Surplus Canal. A SOD of 1.0 gO_2/m^2/day was prescribed from Surplus Canal to UP&L Diversion and 2.5 gO_2/m^2/day downstream of the UP&L Diversion for 8/2009, due to an underprediction through this reach. The SOD amount prescribed for SOD was 1.0 gO_2/m^2/day for 10/2006 and none for 2/2007. It is hypothesized that additional organic material is transported and deposited (resulting in SOD) into the lower Jordan River outside of the synoptic sampling period. It is anticipated that this SOD varies seasonally and potentially from year to year.

Dissolved Oxygen
The average error for mean DO was 4.9%, with 2/2007 the highest at 6.2%. For the 8/2009 event, mean DO was overpredicted and diel range underpredicted between 9000 South and 500 North. The mean DO for 10/2006 matched closely; however the diel range was generally underpredicted. The mean DO was underpredicted below 500 North in 2/2007; the observed diel range was small.

Conclusion and Recommendations

The model calibration is considered to have an acceptable amount of error in general and for the specific TMDL applications. Temperature mean and range are well simulated throughout the Jordan River and in particular for the impaired reach from Turner Dam to Little Cottonwood Creek. With regards to addressing the DO impairment in the lower Jordan River, the boundary conditions for the relevant water quality constituents are well represented by the model at the Surplus Canal. In addition, the nitrogen, phosphorus, algal growth, SOD, and DO mean and range are well simulated in the lower Jordan River.

The calibrated model is recommended for validation using the September 2007 synoptic sampling survey.

Further investigation is recommended for several of the observed and/or simulated phenomena that were not fully explained:

1. The rapid assimilation of nutrients downstream of the South Valley Water Reclamation Facility was handled in the model through a groundwater exchange. The presence or absence and quantity of this possible groundwater exchange should be verified. From a modeling standpoint, the groundwater exchange results in more accurate boundary conditions at the Surplus Canal for simulating DO in the lower Jordan River.

2. The prescribed SOD in the model accumulates outside of the synoptic sampling periods and is therefore beyond the capabilities of a steady-state water quality model. Further investigation of the source of this organic material is required.

3. The total growth of periphyton in the middle Jordan River (from 9000 South to Surplus Canal) is not well-documented. The primary productivity of bottom algae in the model was estimated through the diel DO range; however, the diel DO range was generally underpredicted and the DO mean overpredicted in this reach.

References

Bowie, G.L., W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopf, G.L. Rupp, K.M. Johnson, P.W.H. Chan, S.A. Gherini, and C.E. Chamberlin. 1985. *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition)*. United States Environmental Protection Agency, Athens, GA. EPA/600/3-85/040.

CH2M Hill. 2005. *Jordan River Return Flow Study.* Recycled Water Coalition.

Cirrus Ecological Solutions. 2007. *Jordan River TMDL: Work Element 1 – Evaluation of Existing Information*. Utah Division of Water Quality.

Cirrus Ecological Solutions and Stantec Consulting. 2009. *Jordan River TMDL: Work Element 2 – Pollutant Identification and Loading*. Utah Division of Water Quality.

Donigian, A.S. 2002. Watershed model calibration and validation: the HSPF experience. WEF National TMDL Science and Policy 2002, November 13-16, 2002. Phoenix, AZ. WEF Specialty Conference Proceedings on CD-ROM.

HydroQual. 2008. *East Canyon Creek Dissolved Oxygen Model Development: Water Quality Monitoring and Modeling Results*. Snyderville Basin Water Reclamation District, Park City, Utah.

Oregon Department of Environmental Quality. 2006. Umpqua Basin Total Maximum Daily Load and Water Quality Management Plan.

Oregon Department of Environmental Quality. 2009. TTools 7.56 ArcGIS 9.0 Extension. http://www.deq.state.or.us/wq/TMDLs/tools.htm

Pelletier, G. and S. Chapra. 2008(a). *QUAL2Kw User Manual (Version 5.1)*. Washington State Department of Ecology, Olympia, WA.

Pelletier, G. and S. Chapra. 2008(b). *QUAL2Kw Theory and Documentation (Version 5.1)*. Washington State Department of Ecology, Olympia, WA.

Rushforth, S.R. and S.J. Rushforth. 2009(a). *Assessment of the Phytoplankton Floras of the Jordan River*. Rushforth Phycology, LLC.

Rushforth, S.R. and S.J. Rushforth. 2009(b). *Assessment of the Periphyton Communities of the Jordan River*. Rushforth Phycology, LLC.

Stantec Consulting. 2006. *Draft Lower Jordan River TMDL: Work Element 4 – Flow and Water Quality Modeling Report*. Utah Division of Water Quality.

Stantec Consulting. 2008. *Stormwater Quality Data Technical Report*. Salt Lake County and Utah Department of Transportation.

Thiros, S.A. 2003. *Quality and Source of Shallow Ground Water in Areas of Recent Residential Development in Salt Lake Valley, Salt Lake County, Utah*. United States Geological Survey. Water Resources Investigations Report 03-4028.

Utah Division of Water Quality. 2006. *Monitoring Manual*.

Washington State Department of Ecology. 2004(a). *Stillaguamish River Watershed Temperature Total Maximum Daily Load Study*. Publication No. 04-03-010.

Washington State Department of Ecology. 2004(b). *Stillaguamish River Watershed Fecal Coliform, Dissolved Oxygen, pH, Mercury, and Arsenic Total Maximum Daily Load Study*. Publication No. 04-03-017.

Washington State Department of Ecology. 2006. *Wenatchee River Basin Dissolved Oxygen, pH, and Phosphorus Total Maximum Daily Load Study*. Publication No. 06-03-018.

Washington State Department of Ecology. 2009. Shade.xls Version 31b02. http://www.ecy.wa.gov/programs/eap/models.html

QUAL2Kw
Stream Water Quality Model
Jordan River (8/19/2009)
Global rate parameters

Fitness:

Parameter	Value	Units	Symbol	Auto-cal	Min value	Max value
				Auto-calibration inputs		
Stoichiometry:						
Carbon	40	gC	gC	No	30	50
Nitrogen	7.2	gN	gN	No	3	9
Phosphorus	1	gP	gP	No	0.4	2
Dry weight	100	gD	gD	No	100	100
Chlorophyll	1	gA	gA	No	0.4	2
Inorganic suspended solids:						
Settling velocity	0.001	m/d	v_i	Yes	0	2
Oxygen:						
Reaeration model	Internal			f(u h)		
Temp correction	1.024		θ_a			
Reaeration wind effect	None					
O2 for carbon oxidation	2.69	gO_2/gC	r_{oc}			
O2 for NH4 nitrification	4.57	gO_2/gN	r_{on}			
Oxygen inhib model CBOD oxidation	Exponential					
Oxygen inhib parameter CBOD oxidation	0.60	L/mgO2	K_{socf}	No	0.60	0.60
Oxygen inhib model nitrification	Exponential					
Oxygen inhib parameter nitrification	0.60	L/mgO2	K_{sona}	No	0.60	0.60
Oxygen enhance model denitrification	Exponential					
Oxygen enhance parameter denitrification	0.60	L/mgO2	K_{sodn}	No	0.60	0.60
Oxygen inhib model phyto resp	Exponential					
Oxygen inhib parameter phyto resp	0.60	L/mgO2	K_{sop}	No	0.60	0.60
Oxygen enhance model bot alg resp	Exponential					
Oxygen enhance parameter bot alg resp	0.60	L/mgO2	K_{sob}	No	0.60	0.60
Slow CBOD:						
Hydrolysis rate	1	/d	k_{hc}	Yes	0	5
Temp correction	1.047		θ_{hc}	No	1	1.07
Oxidation rate	1	/d	k_{dcs}	Yes	0	5
Temp correction	1.047		θ_{dcs}	No	1	1.07
Fast CBOD:						
Oxidation rate	4	/d	k_{dc}	Yes	0	5
Temp correction	1.047		θ_{dc}	No	1	1.07

EPA Rates, Constants and Kinetics		
Low	High	Table

QUAL2Kw

Stream Water Quality Model

Jordan River (8/19/2009)

Global rate parameters

Fitness:

Parameter	Value	Units	Symbol	Auto-cal	Min value	Max value	EPA Low	EPA High	EPA Table
				Auto-calibration inputs			EPA Rates, Constants and Kinetics		
Organic N:									
Hydrolysis	1	/d	k_{hn}	Yes	0	5	0.001	0.4	5-3
Temp correction	1.07		θ_{hn}	No	1	1.07	1.02	1.08	5-3
Settling velocity	0.05	m/d	v_{on}	Yes	0	2			
Ammonium:									
Nitrification	3	/d	k_{na}	Yes	0	10	0.04	3	5-3
Temp correction	1.07		θ_{na}	No	1	1.07	1.02	1.08	5-3
Nitrate:									
Denitrification	0.05	/d	k_{dn}	Yes	0	2	0.002	1	5-4
Temp correction	1.07		θ_{dn}	No	1	1.07	1.02	1.09	5-4
Sed denitrification transfer coeff	0.05	m/d	v_{di}	Yes	0	1			
Temp correction	1.07		θ_{di}	No	1	1.07			
Organic P:									
Hydrolysis	0.05	/d	k_{hp}	Yes	0	5	0.001	0.8	5-5
Temp correction	1.07		θ_{hp}	No	1	1.07	1.02	1.09	5-5
Settling velocity	0.05	m/d	v_{op}	Yes	0	2			
Inorganic P:									
Settling velocity	0.5	m/d	v_{ip}	Yes	0	2			
Sed P oxygen attenuation half sat constant	0.05	mgO_2/L	k_{spi}	Yes	0	2			
Phytoplankton:									
Max Growth rate	3	/d	k_{gp}	No	1.5	3	0.2	8	6-5
Temp correction	1.07		θ_{gp}	No	1	1.07			
Respiration rate	0.1	/d	k_{rp}	No	0	1	0.005	0.8	6-18
Temp correction	1.07		θ_{rp}	No	1	1.07			
Death rate	0.1	/d	k_{dp}	No	0	1	0.003	0.17	6-20
Temp correction	1		θ_{dp}	No	1	1.07			
Nitrogen half sat constant	15	ugN/L	k_{sPp}	No	0	150			
Phosphorus half sat constant	2	ugP/L	k_{sNp}	No	0	50			
Inorganic carbon half sat constant	1.30E-05	moles/L	k_{sCp}	No	1.30E-06	1.30E-04			
Phytoplankton use HCO3- as substrate	Yes								
Light model	Smith								
Light constant	57.6	langleys/d	K_{Lp}	No	28.8	115.2			
Ammonia preference	25	ugN/L	k_{hnxp}	No	25	25			
Settling velocity	0.05	m/d	v_a	No	0	5	0.01	4	6-19

QUAL2Kw

Stream Water Quality Model

Jordan River (8/19/2009)

Global rate parameters

Fitness:

Parameter	Value	Units	Symbol	Auto-calibration inputs			EPA Rates, Constants and Kinetics		
				Auto-cal	Min value	Max value	Low	High	Table
Bottom Plants:									
Growth model	Zero-order								
Max Growth rate	100	$gD/m^2/d$ or /d	C_{gb}	Yes	0	100	0.5	1.5	6-5
Temp correction	1.07		θ_{gb}	No	1	1.07			
First-order model carrying capacity	50	gD/m^2	$a_{b,max}$	No	50	200			
Basal respiration rate	0.042	/d	k_{r1b}	No	0	0.3	0.02	0..8	6-18
Photo-respiration rate parameter	0.39	unitless	k_{r2b}	No	0	0.6			
Temp correction	1.07		θ_{rb}	No	1	1.07			
Excretion rate	0.1	/d	k_{eb}	Yes	0	0.5			
Temp correction	1.05		θ_{db}	No	1	1.07			
Death rate	0.5	/d	k_{db}	Yes	0	0.5	0	0.8	6-20
Temp correction	1.07		θ_{db}	No	1	1.07			
External nitrogen half sat constant	163	ugN/L	k_{sPb}	Yes	0	300			
External phosphorus half sat constant	48	ugP/L	k_{sNb}	Yes	0	100			
Inorganic carbon half sat constant	1.30E-05	moles/L	k_{sCb}	Yes	1.30E-06	1.30E-04			
Bottom algae use HCO3- as substrate	Yes								
Light model	Half saturation								
Light constant	50	langleys/d	K_{Lb}	Yes	1	100			
Ammonia preference	1	ugN/L	k_{hnxb}	Yes	1	100			
Subsistence quota for nitrogen	30	mgN/gD	q_{0N}	Yes	0.072	72			
Subsistence quota for phosphorus	0.4	mgP/gD	q_{0P}	Yes	0.01	10			
Maximum uptake rate for nitrogen	447	mgN/gD/d	ρ_{mN}	Yes	350	1500			
Maximum uptake rate for phosphorus	114	mgP/gD/d	ρ_{mP}	Yes	50	200			
Internal nitrogen half sat ratio	2.9		$K_{qN,ratio}$	Yes	1.05	5			
Internal phosphorus half sat ratio	1.8		$K_{qP,ratio}$	Yes	1.05	5			
Nitrogen uptake water column fraction	1		$N_{UpWCfrac}$	No	0	1			
Phosphorus uptake water column fraction	1		$P_{UpWCfrac}$	No	0	1			
Detritus (POM):									
Dissolution rate	0.5	/d	k_{dt}	Yes	0	5			
Temp correction	1.07		θ_{dt}	No	1.07	1.07			
Settling velocity	0.5	m/d	v_{dt}	Yes	0	5			

QUAL2Kw

Stream Water Quality Model

Jordan River (8/19/2009)

Global rate parameters

Fitness:

Parameter	Value	Units	Symbol	Auto-calibration inputs Auto-cal	Min value	Max value
Pathogens:						
Decay rate	0.8	/d	k_{dx}	No	0.8	0.8
Temp correction	1.07		θ_{dx}	No	1.07	1.07
Settling velocity	1	m/d	v_x	No	1	1
alpha constant for light mortality	1	/d per ly/hr	*apath*	No	1	1
pH:						
Partial pressure of carbon dioxide	347	ppm	p_{CO2}			
Hyporheic metabolism						
Model for biofilm oxidation of fast CBOD	Zero-order		*level 1*			
Max biofilm growth rate	5	gO2/m^2/d or /d	"	No	0	20
Temp correction	1.047		"	No	1.047	1.047
Fast CBOD half-saturation	0.5	mgO2/L	"	No	0	2
Oxygen inhib model	Exponential		"			
Oxygen inhib parameter	0.60	L/mgO2	"	No	0.60	0.60
Respiration rate	0.2	/d	*level 2*	No	0.2	0.2
Temp correction	1.07		"	No	1.07	1.07
Death rate	0.05	/d	"	No	0.05	0.05
Temp correction	1.07		"	No	1.07	1.07
External nitrogen half sat constant	15	ugN/L	"	No	15	15
External phosphorus half sat constant	2	ugP/L	"	No	2	2
Ammonia preference	25	ugN/L	"	No	25	25
First-order model carrying capacity	100	gD/m^2	"	No	100	100

EPA Rates, Constants and Kinetics Low	High	Table

Jordan River QUAL2K Model Input
Flow Data
August 2009 Synoptic Sampling Event

Source	River KM	Flow Station	Station Name	Flow (cms)
Utah Lake	82.70	DWR	Utah Lake Outflow	14.573
Jordan River Above Narrows	67.50	DWR	02 JORDAN RIVER COMBINED FLOW	10.288
Jordan River Below Narrows	67.25	DWR	04.01.02 JORDAN RIVER STATION NO. 1	4.059
Rose Creek	58.90			
Corner Canyon Creek	56.10			
Midas Creek	50.70			
Willow Creek	49.50			
Dry Creek	46.05			
Jordan River at 9000 South	45.25	SLC 150	Jordan River @ 9000 South	2.231
South Valley WWTP	42.30			1.751
7800 S Drain Return Flow	42.29		10% of JVPS/Welby Canal & 20% of Utah Lake Distributing Canal	0.573
Little Cottonwood Creek	34.70	SLC 290	Little Cottonwood Creek at 300 West	0.290
		10168000	LITTLE COTTONWOOD CREEK @ JORDAN RIVER	0.305
Big Cottonwood Creek	33.20	SLC 390	Big Cottonwood Creek at 300 West	1.216
Mill Creek	27.70	SLC 490	Mill Creek at 460 West	1.607
			Mill Creek + Central Valley WRF	4.033
Central Valley WWTP				2.426
Kearns-Chesterfield Drain	27.36		20% of South Jordan Canal & 20% of North Jordan Canal	0.661
Jordan River at Surplus Canal	25.80	10170490	COM FLW JORDAN RIVER & SURPLUS CANAL	
Jordan River at 1700 South	24.26	10171000	JORDAN RIVER @ 1700 SOUTH	3.483
1300 S Conduit	22.90			0.245
Parley's Canyon		SLC 520	Parley's Creek at Suicide Rock	0.133
Emigration Canyon		SLC 620	Emigration Creek at Canyon Mouth	0.071
Red Butte Canyon		SLC 740	Red Butte Creek at 1600 East	0.041
800 S Drain	20.76		20% of Jordan & Salt Lake Canal	0.147
N Temple Conduit	18.35			
City Creek		SLC 820	City Creek at Memory Grove Park	0.056
Jordan River at 500 North	11.15	SLC 960	Jordan River at 500 North	7.057
South Davis South WWTP	8.20			0.106
Jordan River at Cudahy Lane	7.20	DWR	Jordan River at Cudahy Lane	4.225

Jordan River QUAL2K Model Input
Flow Data - Diversions
August 2009 Synoptic Sampling Event

Source	River KM	Flow Station	Station Name	Flow (cms)
Jordan Valley Pump Station	67.50	DWR	05.01.07 Jordan Valley Water Conservancy District	2.840
Utah Lake Distribution Canal	67.45	DWR	06.01 Utah Lake Distributing Canal (59-13) cfs	1.444
Utah and Salt Lake Canal	67.30	DWR	06.02 Utah and Salt Lake Canal (Total)	3.173
East Jordan & Draper Canal	67.25	DWR	06.03 East Jordan Canal (Total)	3.058
South Jordan Canal	64.30	DWR	07.02 South Jordan Canal	1.444
Jordan & Salt Lake Canal	64.25	DWR	07.01 Jordan and Salt Lake Canal	0.736
North Jordan Canal	46.35	DWR	North Jordan Canal	1.863
Brighton Canal	34.10	DWR	Estimated - Scott Baird, Salt Lake County	0.850
Surplus Canal	25.80	10170500	SURPLUS CANAL @ SALT LAKE CITY, UT	7.410
UP&L Diversion	19.65			
State Canal	2.70	DWR	State Canal	

Jordan River QUAL2K Model Input
Diffuse Sources Flow Data
August 2009 Synoptic Sampling Event

Number	Location Upstream km	Location Downstream km	Diffuse Inflow cms	Diffuse Inflow cfs
Segment 8	82.7	67.5	0.364	12.9
Segment 7	67.5	60.5	0.608	21.5
Segment 6	60.5	42.5	2.298	81.2
Segment 5	42.5	40	0.271	9.6
Segment 4	40	25.5	0.403	14.2
Segment 3	25.5	18.5	0.465	16.4
Segment 2	18.5	11.5	0.299	10.6
Segment 1	11.5	0	0.203	7.2
Total			4.910	173.4

Jordan River QUAL2K Model Input
Flow Data
February 2007 Synoptic Sampling Event

Source	River KM	Flow Station	Station Name	Flow (cms)
Utah Lake	82.70	DWR	Utah Lake Outflow	19.424
Jordan River Above Narrows	67.50	DWR	02 JORDAN RIVER COMBINED FLOW	19.595
Jordan River Below Narrows	67.25	DWR	04.01.02 JORDAN RIVER STATION NO. 1	19.595
Rose Creek	58.90			
Corner Canyon Creek	56.10			
Midas Creek	50.70			
Willow Creek	49.50			
Dry Creek	46.05			
Jordan River at 9000 South	45.25	SLC 120	Jordan River @ 90th South	21.238
South Valley WWTP	42.30			1.223
7800 S Drain Return Flow	42.29		10% of JVPS/Welby Canal & 20% of Utah Lake Distributing Canal	0.000
Little Cottonwood Creek	34.70	SLC 290	LCC at 300 W	
		10168000	LITTLE COTTONWOOD CREEK @ JORDAN RIVER	0.128
Big Cottonwood Creek	33.20	SLC 390	BCC at 300 W	0.653
Mill Creek	27.70	SLC 490	Mill Creek at 460 West	0.554
			Mill Creek + Central Valley WRF	2.755
Central Valley WWTP				2.201
Kearns-Chesterfield Drain	27.36		20% of South Jordan Canal & 20% of North Jordan Canal	0.258
Jordan River at Surplus Canal	25.80	10170490	COM FLW JORDAN RIVER & SURPLUS CANAL	29.619
Jordan River at 1700 South	24.26	1E+07	JORDAN RIVER @ 1700 SOUTH	1.067
1300 S Conduit	22.90			0.192
Parley's Canyon		SLC 520	Parley's Creek at Suicide Rock	0.123
Emigration Canyon		SLC 620	Emigration Creek at Canyon Mouth	0.046
Red Butte Canyon		SLC 740	Red Butte Creek at 1600 East	0.023
800 S Drain	20.76		20% of Jordan & Salt Lake Canal	0.000
N Temple Conduit	18.35			
City Creek		SLC 820	City Creek at Memory Grove Park	0.085
Jordan River at 500 North	11.15	SLC 180	Jordan River at 5th North	1.891
South Davis South WWTP	8.20			0.121
Jordan River at Cudahy Lane	7.20	DWR	Jordan River at Cudahy Lane	1.170

Estimated

Jordan River QUAL2K Model Input
Flow Data - Diversions
February 2007 Synoptic Sampling Event

Source	River KM	Flow Station	Station Name	Flow (cms)
Jordan Valley Pump Station	67.50	DWR	05.01.07 Jordan Valley Water Conservancy District	0.000
Utah Lake Distribution Canal	67.45	DWR	06.01 Utah Lake Distributing Canal (59-13)	0.000
Utah and Salt Lake Canal	67.30	DWR	06.02 Utah and Salt Lake Canal (Total)	0.000
East Jordan & Draper Canal	67.25	DWR	06.03 East Jordan Canal (Total)	0.000
South Jordan Canal	64.30	DWR	07.02 South Jordan Canal	0.000
Jordan & Salt Lake Canal	64.25	DWR	07.01 Jordan and Salt Lake Canal	0.000
North Jordan Canal	46.35	DWR	North Jordan Canal	1.288
		DWR	10.01.01 North Jordan Irrigation Co. (59-3496)	0.071
		DWR	10.01.02 Kennecott (59-23)	0.117
		DWR	10.01.02 Kennecott (59-30)	0.684
		DWR	10.01.02 Kennecott (59-3517 & A4907)	0.094
		DWR	10.01.02 Kennecott (59-5798)	0.076
		DWR	10.01.02 Kennecott (59-5610)	0.247
Brighton Canal	34.10	DWR	Brighton Canal	ND
Surplus Canal	25.80	10170500	Surplus Canal at Salt Lake City	28.553
UP&L Diversion	19.65		Gadsby Plant	ND
State Canal	2.70	DWR	State Canal	ND

ND: no data

Jordan River QUAL2K Model Input
Flow Data
October 2006 Synoptic Sampling Event

Source	River KM	Flow Station	Station Name	Flow (cms)
Utah Lake	82.70	DWR	Utah Lake Outflow	
Jordan River Above Narrows	67.50	DWR	02 JORDAN RIVER COMBINED FLOW	6.145
Jordan River Below Narrows	67.25	DWR	04.01.02 JORDAN RIVER STATION NO. 1	2.124
Rose Creek	58.90			
Corner Canyon Creek	56.10			
Midas Creek	50.70			
Willow Creek	49.50			
Dry Creek	46.05			
Jordan River at 9000 South	45.25	SLC 120	Jordan River @ 90th South	1.582
South Valley WWTP	42.30			1.223
7800 S Drain Return Flow	42.29		10% of JVPS/Welby Canal & 20% of Utah Lake Distributing Canal	0.140
Little Cottonwood Creek	34.70	SLC 290	LCC at 300 W	0.610
		10168000	LITTLE COTTONWOOD CREEK @ JORDAN RIVER	0.670
Big Cottonwood Creek	33.20	SLC 390	BCC at 300 W	1.466
Mill Creek	27.70	SLC 490	Mill Creek at 460 West	0.795
			Mill Creek + Central Valley WRF	2.995
Central Valley WWTP				2.201
Kearns-Chesterfield Drain	27.36		20% of South Jordan Canal & 20% of North Jordan Canal	0.444
Jordan River at Surplus Canal	25.80	10170490	COM FLW JORDAN RIVER & SURPLUS CANAL	11.213
Jordan River at 1700 South	24.26	1E+07	JORDAN RIVER @ 1700 SOUTH	4.115
1300 S Conduit	22.90			0.272
Parley's Canyon		SLC 520	Parley's Creek at Suicide Rock	0.120
Emigration Canyon		SLC 620	Emigration Creek at Canyon Mouth	0.061
Red Butte Canyon		SLC 740	Red Butte Creek at 1600 East	0.091
800 S Drain	20.76		20% of Jordan & Salt Lake Canal	0.000
N Temple Conduit	18.35			
City Creek		SLC 820	City Creek at Memory Grove Park	0.028
Jordan River at 500 North	11.15	SLC 180	Jordan River at 5th North	4.347
South Davis South WWTP	8.20			0.121
Jordan River at Cudahy Lane	7.20	DWR	Jordan River at Cudahy Lane	3.964

Jordan River QUAL2K Model Input
Flow Data - Diversions
October 2006 Synoptic Sampling Event

Source	River KM	Flow Station	Station Name	Flow (cms)
Jordan Valley Pump Station	67.50	DWR	05.01.07 Jordan Valley Water Conservancy District	
Utah Lake Distribution Canal	67.45	DWR	04.01.01 Utah Lake Distributing Canal	
		DWR	06.01 Utah Lake Distributing Canal (59-13)	0.698
Utah and Salt Lake Canal	67.30	DWR	06.02 Utah and Salt Lake Canal (Total)	
		DWR	06.02.01 Utah and Salt Lake Canal (59-3499)	0.982
East Jordan & Draper Canal	67.25	DWR	06.03 East Jordan Canal (Total)	1.595
		DWR	06.03.01 East Jordan Irrigation Company (57-	0.557
		DWR	06.03.02 Salt Lake City (57-10186)	0.755
		DWR	06.04 Draper Irrigation Co. (57-23)	0.283
South Jordan Canal	64.30	DWR	07.02 South Jordan Canal	
		DWR	05.01.03 South Jordan Canal Co. (59-5270	0.953
Jordan & Salt Lake Canal	64.25	DWR	07.01 Jordan and Salt Lake Canal	0.000
North Jordan Canal	46.35	DWR	North Jordan Canal	1.269
		DWR	10.01.01 North Jordan Irrigation Co. (59-3496)	0.425
		DWR	10.01.02 Kennecott (59-23)	0.283
		DWR	10.01.02 Kennecott (59-3517 & A4907)	0.193
		DWR	10.01.02 Kennecott (59-5798)	0.144
		DWR	10.01.02 Kennecott (59-5610)	0.224
Brighton Canal	34.10	DWR	Brighton Canal	
Surplus Canal	25.80	10170500	SURPLUS CANAL @ SALT LAKE CITY, UT	7.712
UP&L Diversion	19.65			
State Canal	2.70	DWR	State Canal	

Jordan River QUAL2K Model Input
Diffuse Sources Flow Data
February 2007 Synoptic Sampling Event

	Location		Diffuse Inflow	
	Upstream	Downstream		
Number	km	km	cms	cfs
Segment 8	82.7	67.5	0.1708	6.0
Segment 7	67.5	60.5	0.9123	32.2
Segment 6	60.5	42.5	2.0907	73.8
Segment 5	42.5	40	0.7842	27.7
Segment 4	40	25.5	2.6805	94.7
Segment 3	25.5	18.5	0.3625	12.8
Segment 2	18.5	11.5	0.2322	8.2
Segment 1	11.5	0	0.1586	5.6
Total				261.0

Jordan River QUAL2K Model Input
Diffuse Sources Flow Data
October 2006 Synoptic Sampling Event

	Location		Diffuse Inflow	
	Upstream	Downstream		
Number	km	km	cms	cfs
Segment 8	82.7	67.5	0.5500	19.4
Segment 7	67.5	60.5	0.7928	28.0
Segment 6	60.5	42.5	2.0386	72.0
Segment 5	42.5	40	0.2831	10.0
Segment 4	40	25.5	1.6422	58.0
Segment 3	25.5	18.5	0.3964	14.0
Segment 2	18.5	11.5	0.0000	0.0
Segment 1	11.5	0	0.0000	0.0
Total			5.7030	201.4

Jordan River QUAL2K Model Input
Meteorological Data
August 2009 Synoptic Sampling Event

Hour	Temp (deg C)	Dew Point (deg C)	Wind Speed (m/s)	Cloud Cover (%)	Solar Radiation (W/m^2)
0	19.6	5.0	3.1	10	0
1	17.4	3.5	3.1	21	0
2	16.3	4.1	2.1	21	0
3	15.9	4.3	2.7	21	0
4	15.7	3.7	3.3	21	0
5	15.0	4.4	2.8	21	0
6	15.0	5.4	3.0	21	72
7	17.0	5.7	2.2	21	259
8	19.7	4.7	3.0	35	419
9	22.4	4.3	0.9	35	597
10	24.4	4.3	1.8	25	770
11	26.3	4.4	1.6	25	842
12	28.3	3.1	2.5	21	881
13	29.1	2.0	3.0	35	878
14	29.5	1.3	1.2	21	796
15	29.8	3.5	3.4	35	645
16	30.4	2.0	4.0	35	478
17	30.0	2.0	3.6	35	288
18	29.3	2.8	2.8	25	71
19	27.0	2.6	2.7	35	0
20	24.7	5.3	2.2	35	0
21	23.3	6.1	1.8	21	0
22	20.9	5.2	2.1	21	0
23	20.6	5.3	1.9	10	0

Jordan River QUAL2K Model Input
Meteorological Data
February 2007 Synoptic Sampling Event

Hour	Temp (deg C)	Dew Point (deg C)	Wind Speed (m/s)	Cloud Cover (%)	Solar Radiation (W/m^2)
0	2.4	-6.9	3.0	75	0
1	1.7	-7.4	3.1	75	0
2	-0.7	-6.6	2.8	65	0
3	-0.7	-6.5	2.2	69	0
4	-1.6	-5.1	3.9	81	0
5	-1.0	-3.7	5.0	89	0
6	0.4	-1.3	4.8	100	0
7	-2.6	-5.4	3.4	69	18
8	-2.6	-6.5	4.7	68	99
9	-2.4	-6.1	5.4	75	224
10	-2.2	-6.3	3.3	60	316
11	-1.9	-7.4	5.4	57	417
12	-1.7	-7.6	6.0	54	566
13	-0.3	-6.7	6.9	52	514
14	-0.4	-4.6	5.3	81	399
15	-1.9	-4.6	4.3	90	307
16	-2.5	-5.8	4.7	88	200
17	-1.5	-5.7	4.2	85	55
18	-1.1	-6.2	3.8	80	0
19	-0.4	-7.6	3.6	75	0
20	0.7	-7.5	3.2	75	0
21	0.7	-7.2	3.0	75	0
22	0.7	-7.4	2.8	75	0
23	1.4	-8.5	2.6	88	0

Jordan River QUAL2K Model Input
Meteorological Data
October 2006 Synoptic Sampling Event

Hour	Temp (deg C)	Dew Point (deg C)	Wind Speed (m/s)	Cloud Cover (%)	Solar Radiation (W/m^2)
0	15.8	4.0	4.9	43	0
1	15.9	4.7	4.9	51	0
2	16.2	4.3	4.7	51	0
3	15.9	4.4	4.3	63	0
4	16.0	4.3	5.0	71	0
5	15.9	5.1	6.3	81	0
6	14.2	5.3	3.3	71	0
7	14.1	6.2	3.2	76	23
8	16.0	6.4	4.0	71	188
9	16.7	7.1	3.0	76	382
10	19.4	6.4	4.6	76	447
11	21.2	5.8	4.5	68	359
12	22.8	5.4	5.1	73	463
13	23.2	4.9	4.8	73	397
14	23.4	6.6	8.0	63	348
15	22.2	6.3	7.3	63	291
16	22.2	6.4	6.6	63	121
17	22.3	5.6	4.9	66	35
18	19.1	8.0	4.3	66	0
19	18.7	6.6	4.6	58	0
20	16.7	6.9	4.5	66	0
21	15.7	5.4	4.0	71	0
22	15.8	4.8	3.8	49	0
23	16.1	4.7	4.6	49	0

Jordan River QUAL2K Model Input
Water Quality Data
August 2009 Synoptic Sampling Event

		Analytical Results (mg/L)											
Location	Station	ALK	CBOD-5	SCBOD-5	NH3-N	NO2-N	NO3-N	TKN	o-PO4	TP	TSS	VSS	CH-a (ug/L)
Jordan River @ Utah Lake	4994790	197	2.85	0.85	0.003	0.010	0.020	1.008	0.018	0.121	44	6.9	27
Jordan River @ Bangerter	4994520	236	1.57	0.50	0.008	0.010	0.488	0.740	0.019	0.106	49	8.1	19
Jordan River @ 9000 S.	4994270	260	1.73	1.70	0.012	0.008	0.913	0.620	0.012	0.107	42	5.9	11
South Valley WWTP	4994160	168	1.93	1.44	0.026	0.012	16.759	1.041	3.704	3.892	3	3.2	2
Jordan River at Winchester	4994100	240	2.15	0.75	0.010	0.007	4.139	0.758	0.700	0.827	43	8.4	
Little Cottonwood Creek	4993580	209	1.62	2.20	0.031	0.011	0.541	0.843	0.064	0.098	32	7.5	26
Big Cottonwood Creek	4992970	210	1.99	0.75	0.015	0.011	0.334	0.868	0.025	0.088	35	7.5	22
Jordan River @ 3900 S.	4992890	236	1.04	0.45	0.015	0.009	2.722	0.732	0.403	0.514	39	6.5	16
Central Valley WWTP	4992500	167	1.86	1.65	1.554	0.524	14.667	2.487	3.158	3.466	5	5.1	3
Mill Creek above confluence	4992480	178	2.59	1.20	0.663	0.287	11.209	1.566	2.415	2.613	8	4.3	5
Jordan River @ 2100 S.	4992320	228	4.17	1.05	0.268	0.074	5.571	1.003	1.057	1.180	36	7.3	11
Jordan River @ 1700 S.	4992290	228	1.84	1.31	0.246	0.081	5.400	0.958	1.029	1.127	30	5.5	11
1300 S. Conduit	4992070	240	1.45	0.99	0.027	0.010	2.198	0.465	0.018	0.043	11	2.5	11
Jordan River at 400 S.	4991940	228	1.77	3.57	0.306	0.094	4.592	1.331	0.781	0.870	34	7.2	
N. Temple Conduit	4991920	275	1.01	2.21	0.012	0.027	3.838	0.191	0.016	0.032	1	1.1	1
Jordan River @ 500 N.	4991890	226	1.19	0.72	0.353	0.137	4.760	1.016	0.813	0.929	37	6.5	10
Jordan River @ 1800 N.	4991860	226	1.53	0.65	0.616	0.203	5.048	1.541	0.849	0.954	32	6.4	
Jordan River @ 2600 N.	4991830	226	1.33	0.81	0.263	0.080	4.357	0.906	0.712	0.860	50	7.7	10
Jordan River @ Cudahay Ln.	4991820	227	2.17	1.12	0.275	0.080	4.379	0.961	0.694	0.820	42	6.4	7
South Davis South WWTP	4991810	289	4.97	2.47	1.958	0.430	8.908	3.250	1.518	1.700	7	5.2	8
Jordan River @ Burnham Dam	4990890	228	1.45	1.71	0.180	0.061	4.333	1.044	0.683	0.811	48	7.7	10

Jordan River QUAL2K Model Input
Water Quality Data
August 2009 Synoptic Sampling Event

		Field Measurements				QUAL2K Calculated Constituents							
Location	Station	DO (mg/L)	T (deg C)	SC (umhos)	pH	ISS (mg/L)	Org. Nit. (ug/L)	NO2 + NO3 (ug/L)	TN (ug/L)	Org. Phos. (ug/L)	Detritus	CBOD Ultimate	SCBOD Ultimate
Jordan River @ Utah Lake	4994790					37	813	30	1038	77	4.28	2.90	0.87
Jordan River @ Bangerter	4994520					41	592	498	1238	67	6.19	1.59	0.51
Jordan River @ 9000 S.	4994270					36	528	921	1542	84	4.75	1.76	1.73
South Valley WWTP	4994160	8.4	22.1	1532.0	7.4	0	1004	16771	17812	187	3.05	1.96	1.47
Jordan River at Winchester	4994100					34	748	4146	4904	127	8.40	2.19	0.76
Little Cottonwood Creek	4993580	9.2	17.6	1403.0	8.2	24	628	552	1395	9	4.90	1.65	2.24
Big Cottonwood Creek	4992970	10.1	17.5	1298.7	8.3	28	695	344	1212	41	5.27	2.03	0.76
Jordan River @ 3900 S.	4992890					32	605	2731	3463	96	4.98	1.06	0.46
Central Valley WWTP	4992500	7.5	22.0	1364.0	7.1	0	914	15191	17679	305	4.80	1.89	1.68
Mill Creek above confluence	4992480	8.3	20.5	1286.7	7.3	4	868	11496	13062	193	3.77	2.63	1.22
Jordan River @ 2100 S.	4992320					29	657	5644	6647	111	6.26	4.25	1.07
Jordan River @ 1700 S.	4992290					24	633	5481	6440	87	4.38	1.87	1.33
1300 S. Conduit	4992070	8.6	16.8	1238.7	8.1	9	362	2209	2673	15	1.48	1.47	1.00
Jordan River at 400 S.	4991940					27	1025	4686	6017	89	7.20	1.80	3.63
N. Temple Conduit	4991920	8.4	19.2	1191.7	8.0	0	174	3866	4056	15	1.00	1.03	2.25
Jordan River @ 500 N.	4991890					31	592	4898	5914	107	5.55	1.21	0.73
Jordan River @ 1800 N.	4991860					25	925	5251	6792	106	6.40	1.56	0.66
Jordan River @ 2600 N.	4991830	7.2	20.8	1015.0	7.6	42	574	4437	5343	138	6.78	1.35	0.83
Jordan River @ Cudahay Ln.	4991820	7.2	21.0	1015.0	7.7	36	634	4459	5419	119	5.68	2.21	1.14
South Davis South WWTP	4991810	8.0	22.3	2626.7	7.5	1	1234	9339	12589	173	4.39	5.06	2.52
Jordan River @ Burnham Dam	4990890					41	791	4394	5438	118	6.72	1.47	1.74

University of Utah Reaeration Measurements
Summer 2009

Location along Jordan River	Length (ft)	River KM Start	River KM End	Reaeration Constant K (gm/m^3/hr)	Reaeration Rate K_2 (L/day)
Lehi	1183	73.6	74.75	0.87	2.36
12600 S to 10600 S	4900	49.2	54	4.33	12.73
9000 S to 7800 S	2970	42.3	45.3	6.65	19.77
5400 S to 4170 S	4206	32.9	37.1	3.36	9.67
3300 S to 2100 S	4008	24.45	29.5	1.54	5
1700 S to 900 S	3196	21.15	23.35	2.1	6.56
Redwood Rd to LNP	5965	6.85	12.8	0.2	0.644

University of Utah SOD Measurements
Summer 2009

Site Name	River KM	SOD_Rate (g/m^2 day)	Water Column Sample
Legacy Nature Preserve NE Site	7.4	2.54	X
Legacy Nature Preserve SW Site	7.7	3.17	X
Legacy Nature Preserve Upper Site	7.95	3.29	X
Division of Water Quality Site	17.25	1.95	X
900 South, N of RR Bridge Site	21.1	1.27	X
900 South, S of RR Bridge Site	21.3	1.84	X
1700 South, Raging Waters Site	24.3	0.77	X
2300 South Site	26.3	1.17	X
2780 S East Site	27.4	1.53	
2780 S West Site	27.4	2.88	
UTA Site	30.35	0.89	X
5400 South Site	37.1	2.53	
7800 South Site	42.3	1.29	
9000 South Site	45.4	2.21	
SR 154 Site	58.8	0.84	
14600 South Site	62.05	1.8	
US 73 Site	78.1	1.63	

DWQ Periphyton Measurements - EMAP
Summer 2009

Site Name	STORET	River KM	Date	Chlor-A (mg/m^2)
Bluffdale: EMAP; template	4994600	61.0	9/1/2009	
Bangerter: EMAP; template	4994520	54.5	9/2/2009	206.9
12300 S: EMAP	4994500	54.0	9/2/2009	289.6
9000 S: EMAP; template	4994270	45.3	9/1/2009	313.5
7200 S: EMAP		40.5	9/2/2009	336.0
5400 S: EMAP	4994090	39.0	9/2/2009	253.2
4100 S: EMAP; template	4992890	31.7	9/2/2009	335.6
2100 S: EMAP (brush with ring); Template (razor scrape)	4992320	25.7	9/1/2009	160.1
1700 S: no substrate for sampling	4992290	24.3	N/A	No data
500 N: too deep	4991890	16.6	N/A	No data
Legacy-below S Davis S: Core sampling	4991800		N/A	No data

Jordan River QUAL2K Model Input
Light Extinction Coefficient
Source: Farmington Bay/Jordan River Water Quality Council

Location Along Jordan River	River KM	7/14/09	7/15/09	7/16/09	7/22/09	7/23/09	7/28/09	7/29/09	8/10/09	8/11/09	8/12/09	8/18/09	8/19/09	8/28/09	8/31/09	9/11/09	Average	Standard Deviation	QUAL2Kw Aug-09
Utah Lake	82.5			4.037	3.652		4.191		4.403				3.464			3.19	3.82	0.46	3.464
Thanksgiving				3.52	4.357		4.534		5.515				4.741			4.55	4.54	0.64	4.741
Narrows	67								4.926				5.326			3.537	4.60	0.94	5.326
14600 S	61			2.322	2.348		4.958		3.452				4.793			4.131	3.67	1.16	4.793
9000 S	45.25								2.15				2.62			2.895	2.56	0.38	2.62
7800 S	42.5			2.03	1.253		2.67		2.32				2.623		1.971		2.14	0.52	2.623
7200 S	40.6			1.356	2.377		2.561		1.899				2.418		2.069		2.11	0.44	2.418
6400 S	39.8								2.268						1.947		2.11	0.23	
5400S	39			1.536	1.751		2.401		2.226				2.523		2.672		2.18	0.45	2.523
LCC	34.8		1.98												2.757		2.37	0.55	
3900 S	31.55									5.824			2.483		3.159		3.82	1.77	2.483
3300 S	29.5	2.139				1.515	2.186			3.314			2.791		2.557		2.42	0.62	2.791
Up Millcreek	27.8														2.178		2.18		
DS Millcreek	27.7														1.81		1.81		
2100 S	25.9	1.806				1.636	1.871			2.322		2.579		2.631			2.14	0.43	2.579
1700 S	24.3									2.655				2.714			2.68	0.04	
Cal. Ave	23		1.711			1.888	2.471			3.071		2.796					2.39	0.58	2.796
1300 S	22.6													2.625			2.63		
900 S	21.1	2.071				1.81		1.949		2.612		2.419		3.5			2.39	0.62	2.419
400 S	19.9													1.692			1.69		
North Temple	18.4													2.803			2.80		
300N	17.5											2.79		3.528			3.16	0.52	2.79
1800N	13.2										2.938			2.613			2.78	0.23	
Center St	8.1		2.779					3.024			3.884	4.026		3.586			3.46	0.54	4.026
SD SDSD	7.8										3.595			5.165			4.38	1.11	
Burnham Dam	2.7										3.859	6.101		3.754			4.57	1.33	6.101

Jordan River QUAL2K Model Input
Water Quality Data
February 2007 Synoptic Sampling Event

Location	Station	Analytical Results (mg/L)													
		ALK	CBOD-5	SCBOD-5	NH3-N	NO2-N	NO3-N	TKN	o-PO4	TP	TSS	VSS	TOC	CH-a (ug/L)	E COLI (mpn/ 100ml)
Jordan River @ Utah Lake (19)	4994790	205	2.43	0.79	0.092	0.000	0.245	1.574	0.002	0.121	31	6.8			
Jordan River @ Utah Lake (04)	4994790	203	2.22	0.70	0.088	0.000	0.254	1.416	0.000	0.084	22	5.7			
Jordan River @ Bangerter (19)	4994520	208	2.88	0.40	0.073	0.000	0.350	3.240	0.000	0.036	22	4.4			
Jordan River @ Bangerter (04)	4994520	208	1.20	0.53	0.090	0.000	0.275	1.232	0.001	0.076	28	4.8			
Jordan River @ 9000 S (19)	4994270	218	2.02	1.04	0.071	0.000	0.411	1.170	0.001	0.269	26	6.2			
Jordan River @ 3900/4100 S (19)	4992890	219	2.19	0.84	0.154	0.000	0.594	1.452	0.000	0.281	43	9.0			
Jordan River @ 2100 S (19)	4992320	216	2.25	0.81	0.391	0.000	1.509	2.034	0.134	0.755	99	17.9			
Jordan River @ 1700 S (19)	4992290	220	1.22	0.66	0.461	0.000	1.250	2.651	0.181	0.422	30	5.2			
Jordan River @ 1700 S (04)	4992290	219	1.08	1.19	0.437	0.000	1.215	2.132	0.179	0.406	22	4.0			
Jordan River @ 500 N (19)	4991890	216	1.91	1.78	0.214	0.000	1.546	1.725	0.061	0.325	23	6.2			
Jordan River @ 2600 N (19)	4991890	207	1.84	0.39	0.247	0.000	1.326	1.302	0.026	0.458	51	15.0			
Jordan River @ Cudahy LN (19)	4991820	213	2.22	0.82	0.228	0.000	1.333	1.346	0.064	0.313	27	7.1			
Jordan River @ Cudahy LN (04)	4991820	211	1.97	0.75	0.240	0.000	1.373	1.158	0.028	0.323	38	9.6			
Jordan River @ Burnham Dam (04)	4990890	225	2.97	3.29	0.985	0.000	2.019	2.462	0.190	0.575	19	5.1			
South Valley WWTP (04)	4994160	202	1.16	1.04	-0.029	0.000	2.147	2.162	2.347	3.579	18	4.8			
Little Cottonwood Creek (19)	4993580	189	2.49	1.34	0.166	0.000	0.987	1.715	0.001	0.136	52	14.8			
Big Cottonwood Creek 500 W (19)	4992970	204	1.14	0.45	0.054	0.000	0.603	1.348	0.000	0.071	15	3.6			
Big Cottonwood Creek (04)	4992970	207	0.84	1.02	0.040	0.000	0.603	1.148	0.000	0.040	14	3.7			
Central Valley WWTP (04)	4992500	190	1.60	1.07	3.447	0.430	9.512	5.161	2.410	2.751	6	4.6			
Mill Creek above Cnfl/JR (19)	4992480	207	2.95	2.08	2.403	0.579	8.296	4.297	2.061	2.546	24	7.5			
1300 S Conduit (04)	4992070	222	3.30	1.58	0.127	0.000	1.618	2.008	0.006	0.201	130	29.0			
N. Temple Conduit (04)	4991920	224	8.65	7.84	0.098	0.000	1.706	1.152	0.001	0.129	76	21.1			
South Davis South WWTP (04)	4991810	315	14.81	9.85	10.088	0.992	8.019	13.906	1.568	2.636	19	13.1			

Note: (04) is grab sampling technique and (19) is equal-width increments sampling technique.

Jordan River QUAL2K Model Input
Water Quality Data
February 2007 Synoptic Sampling Event

		Field Measurements			QUAL2K Calculated Constituents				
Location	Station	DO (mg/L)	T (deg C)	SC (umhos)	ISS	SCBOD-u	DON	DOP	DET
Jordan River @ Utah Lake (19)	4994790				25	0.81	1.482	0.118	6.8
Jordan River @ Utah Lake (04)	4994790				16	0.72	1.328	0.084	5.7
Jordan River @ Bangerter (19)	4994520				17	0.41	3.167	0.036	4.4
Jordan River @ Bangerter (04)	4994520				23	0.54	1.141	0.075	4.8
Jordan River @ 9000 S (19)	4994270				20	1.06	1.099	0.268	6.2
Jordan River @ 3900/4100 S (19)	4992890				34	0.86	1.298	0.281	9.0
Jordan River @ 2100 S (19)	4992320				81	0.83	1.643	0.621	17.9
Jordan River @ 1700 S (19)	4992290				25	0.68	2.190	0.241	5.2
Jordan River @ 1700 S (04)	4992290				18	1.21	1.695	0.226	4.0
Jordan River @ 500 N (19)	4991890				16	1.81	1.512	0.265	6.2
Jordan River @ 2600 N (19)	4991890				36	0.40	1.055	0.432	15.0
Jordan River @ Cudahy LN (19)	4991820				20	0.84	1.117	0.248	7.1
Jordan River @ Cudahy LN (04)	4991820				28	0.77	0.919	0.295	9.6
Jordan River @ Burnham Dam (04)	4990890				14	3.35	1.477	0.385	5.1
South Valley WWTP (04)	4994160				13	1.06	2.191	1.232	4.8
Little Cottonwood Creek (19)	4993580				38	1.37	1.549	0.136	14.8
Big Cottonwood Creek 500 W (19)	4992970				11	0.46	1.294	0.071	3.6
Big Cottonwood Creek (04)	4992970				10	1.04	1.108	0.040	3.7
Central Valley WWTP (04)	4992500				2	1.09	1.714	0.341	4.6
Mill Creek above Cnfl/JR (19)	4992480				16	2.12	1.894	0.485	7.5
1300 S Conduit (04)	4992070				101	1.61	1.881	0.195	29.0
N. Temple Conduit (04)	4991920				55	7.98	1.054	0.128	21.1
South Davis South WWTP (04)	4991810				6	10.04	3.818	1.068	13.1

Note: (04) is grab sampling technique and (19) is Note: No field measurements were collected as probe malfunctioned.

Jordan River QUAL2K Model Input
Water Quality Data
October 2006 Synoptic Sampling Event

Location	Station	Analytical Results (mg/L)													
		ALK	CBOD-5	SCBOD-5	NH3-N	NO2-N	NO3-N	TKN	o-PO4	TP	TSS	VSS	TOC	CH-a (ug/L)	E COLI (mpn/ 100ml)
Jordan River @ Utah Lake	4994790	211	0.93	1.09	0.396	0.000	0.113	1.420	0.042	0.159	97	10.9	5.5	11.3	69
Jordan River @ Bangerter	4994520	237	1.72	1.54	0.094	0.000	0.667	1.287	0.018	0.087	44	6.4	4.1	22.9	69
Jordan River @ 9000 S.	4994270	262	1.03	1.03	0.066	0.000	1.023	0.761	0.000	0.067	28	5.3	3.7	7.5	438
Jordan River @ 3900 S.	4992890	228	2.44	1.11	0.083	0.000	2.136	1.154	0.168	0.486	34	6.3	4.1	12.6	750
Jordan River @ 2100 S.	4992320	215	1.37	1.51	0.257	0.042	4.303	1.405	0.460	0.984	33	6.9	4.5	8.1	965
Jordan River @ 1700 S.	4992290	217	2.03	1.45	0.356	0.066	4.217	1.508	0.457	0.980	42	8.3	4.8	10.3	1222
Jordan River @ 500 N.	4991890	216	2.39	1.56	0.312	0.097	3.790	1.604	0.355	0.841	56	8.9	4.6	7.4	1039
Jordan River @ 2600 N.		219	1.16	0.77	0.528	0.140	4.326	2.076	0.352	0.956	126	17.1			1359
Jordan River @ Cudahay Ln.	4991820	219	1.17	1.79	0.461	0.139	4.318	2.066	0.355	0.987	114	18.1	4.7	10.8	1363
Jordan River @ Burnham Dam	4990890	218	1.77	2.09	0.258	0.076	3.603	1.652	0.412	0.808	67	9.9	4.8	9.0	1352
South Valley WWTP	4994160	182	1.12	0.52	0.068	0.000	13.029	1.014	1.405	3.711	4	3.5	5.5	0.9	12
Little Cottonwood Creek	4993580	173	1.14	1.15	0.087	0.000	0.511	0.808	0.000	0.075	23	4.9	4.5	10.8	1031
Big Cottonwood Creek	4992970	187	1.13	0.81	0.087	0.000	0.451	0.938	0.000	0.061	29	5.7	3.2	9.0	974
Central Valley WWTP	4992500	177	1.99	0.91	0.853	0.145	12.966	2.429	2.410	3.000	7	6.3	7.1	1.0	7
Mill Creek above confluence	4992480	184	2.05	1.02	0.865	0.180	10.307	2.497	1.574	2.259	19	7.4	5.9	2.9	237
1300 S. Conduit	4992070	208	1.75	1.69	0.086	0.000	1.318	1.041	0.097	0.067	23	4.6	3.5	5.8	1352
N. Temple Conduit	4991920	271	0.29	0.31	0.059	0.000	3.035	0.637	0.000	0.013	2	1.6	1.2	1.8	345
South Davis South WWTP	4991810	287	4.49	3.05	3.944	0.701	10.127	7.748	1.519	2.250	16	7.1	14.1	3.3	8

Jordan River QUAL2K Model Input
Water Quality Data
October 2006 Synoptic Sampling Event

		Field Measurements			QUAL2K Calculated Constituents				
Location	Station	DO (mg/L)	T (deg C)	SC (umhos)	ISS	SCBOD-u	DON	DOP	DET
Jordan River @ Utah Lake	4994790				86	1.11	0.943	0.106	9.7
Jordan River @ Bangerter	4994520				37	1.57	1.028	0.046	4.1
Jordan River @ 9000 S.	4994270				23	1.05	0.641	0.060	4.6
Jordan River @ 3900 S.	4992890				28	1.13	0.980	0.305	5.0
Jordan River @ 2100 S.	4992320				26	1.54	1.089	0.516	6.1
Jordan River @ 1700 S.	4992290				34	1.47	1.078	0.513	7.2
Jordan River @ 500 N.	4991890				47	1.59	1.239	0.479	8.1
Jordan River @ 2600 N.					109				
Jordan River @ Cudahay Ln.	4991820				96	1.82	1.527	0.622	17.1
Jordan River @ Burnham Dam	4990890				57	2.13	1.329	0.387	9.0
South Valley WWTP	4994160	7.7	21.3	1003	0	0.53	0.940	2.306	3.4
Little Cottonwood Creek	4993580	8.0	14.8	958	18	1.17	0.643	0.064	3.8
Big Cottonwood Creek	4992970	8.6	13.0	794	23	0.82	0.787	0.052	4.8
Central Valley WWTP	4992500	6.3	20.7	1240	0	0.93	1.570	0.589	6.2
Mill Creek above confluence	4992480	7.2	19.3	1216	11	1.04	1.611	0.682	7.1
1300 S. Conduit	4992070	7.4	14.8	821	18	1.72	0.913	-0.036	4.0
N. Temple Conduit	4991920	7.9	17.3	944	1	0.31	0.565	0.011	1.4
South Davis South WWTP	4991810	6.8	21.6	2610	9	3.11	3.780	0.727	6.7

QUAL2Kw

Stream Water Quality Model

Jordan River (2/28/2007)

Diffuse Source Data:

			Diffuse	*Diffuse*		*Spec*	*Inorg*	*Diss*	*CBOD*	*CBOD*	*Organic*	*Ammon*	*Nitrate*	*Organic*	*Inorganic*	*Phyto*			*Generic*		
			Abstraction	*Inflow*	*Temp*	*Cond*	*SS*	*Oxygen*	*slow*	*fast*	*N*	*N*	*N*	*P*	*P*	*plankton*	*Detritus*	*Pathogen*	*constituent*	*Alk*	*pH*
Name	*Up (km)*	*Down (km)*	*m3/s*	*m3/s*	*C*	*umhos*	*mgD/L*	*mg/L*	*mgO2/L*	*mgO2/L*	*ugN/L*	*ugN/L*	*ugN/L*	*ugP/L*	*ugP/L*	*ug/L*	*mgD/L*	cfu/100 mL	user defined	*mgCaCO3/L*	
Segment 8 - Groundwater	82.70	67.50	0.0000	0.2950	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 7 - Groundwater	67.50	60.50	0.0000	0.4930	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 6 - Groundwater	60.50	42.50	0.0000	1.8630	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 5 - Groundwater	42.50	40.00	0.0000	0.2200	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 4 - Groundwater	40.00	25.50	0.0000	0.3270	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 3 - Groundwater	25.50	18.50	0.0000	0.0000	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 2 - Groundwater	18.50	11.50	0.0000	0.0000	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
Segment 1 - Groundwater	11.50	0.00	0.0000	0.0000	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
GW Exchange	41.50	31.50	0.0000	1.0000	14.00	1400.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	0.0	0.0	0.0	300.0	6.9
GW Exchange	41.50	31.50	1.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Segment 8 - Stormwater	82.70	67.50	0.0000	0.0000	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 7 - Stormwater	67.50	60.50	0.0000	0.4200	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 6 - Stormwater	60.50	42.50	0.0000	0.2270	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 5 - Stormwater	42.50	40.00	0.0000	0.5640	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 4 - Stormwater	40.00	25.50	0.0000	2.3540	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 3 - Stormwater	25.50	18.50	0.0000	0.3770	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 2 - Stormwater	18.50	11.50	0.0000	0.2420	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0
Segment 1 - Stormwater	11.50	0.00	0.0000	0.1640	9.00	3000.00	20.00	12.00	0.00	1.00	100.0	500.0	2000.0	300.0	160.0	0.0	10.0	0.0	0.0	300.0	7.0

QUAL2Kw

Stream Water Quality Model

Jordan River (8/19/2009)

Diffuse Source Data:

Name	Up (km)	Down (km)	Diffuse Abstraction m3/s	Diffuse Inflow m3/s	Temp C	Spec Cond umhos	Inorg SS mgD/L	Diss Oxygen mg/L	CBOD slow mgO2/L	CBOD fast mgO2/L	Organic N ugN/L	Ammon N ugN/L	Nitrate N ugN/L	Organic P ugP/L	Inorganic P ugP/L	Phyto plankton ug/L	Detritus mgD/L	Pathogen cfu/100 mL	Generic constituent user defined	Alk mgCaCO3/L	pH
Segment 8	82.70	67.50	0.0000	0.3640	16.00	2000.00	40.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 7	67.50	60.50	0.0000	0.6080	16.00	2000.00	40.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 6	60.50	42.50	0.0000	2.2980	16.00	2000.00	40.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 5	42.50	40.00	0.0000	0.2710	16.00	2000.00	40.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 4	40.00	25.50	0.0000	0.4030	16.00	2000.00	40.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Segment 3	25.50	18.50	0.0000	0.4650	16.00	1400.00	100.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Segment 2	18.50	11.50	0.0000	0.0000	16.00	1400.00	100.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Segment 1	11.50	0.00	0.0000	0.0000	16.00	1400.00	100.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
GW Exchange	41.50	31.50	0.0000	2.5000	16.00	2000.00	40.00	0.00	0.00	2.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
GW Exchange	41.50	31.50	2.5000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00

QUAL2Kw

Stream Water Quality Model

Jordan River (10/3/2006)

Diffuse Source Data:

Name	Up (km)	Down (km)	Diffuse Abstraction m3/s	Diffuse Inflow m3/s	Temp C	Spec Cond umhos	Inorg SS mgD/L	Diss Oxygen mg/L	CBOD slow mgO2/L	CBOD fast mgO2/L	Organic N ugN/L	Ammon N ugN/L	Nitrate N ugN/L	Organic P ugP/L	Inorganic P ugP/L	Phyto plankton ug/L	Detritus mgD/L	Pathogen cfu/100 mL	Generic constituent user defined	Alk mgCaCO3/L	pH
Segment 8	82.70	67.50	0.0000	0.4120	17.50	1500.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 7	67.50	60.50	0.0000	0.6890	17.50	1500.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 6	60.50	42.50	0.0000	2.6040	17.50	1500.00	0.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 5	42.50	40.00	0.0000	0.3070	17.50	1500.00	40.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	6.0	0.0	0.0	300.0	6.9
Segment 4	40.00	25.50	0.0000	0.4570	17.50	1500.00	40.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Segment 3	25.50	18.50	0.0000	0.5270	17.50	1200.00	100.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Segment 2	18.50	11.50	0.0000	0.0000	17.50	1200.00	100.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Segment 1	11.50	0.00	0.0000	0.0000	17.50	1200.00	100.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
Additional Return Flow	42.50	25.50	0.0000	1.0000	17.50	1500.00	100.00	8.50	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
GW Exchange	41.50	31.50	0.0000	1.0000	17.50	1500.00	100.00	0.00	1.00	1.00	750.0	500.0	1000.0	50.0	10.0	0.0	10.0	0.0	0.0	300.0	6.9
GW Exchange	41.50	31.50	1.0000	0.0000	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Meeting Notes

QUAL2Kw Model Collaborative Calibration Meeting
12:30 – 5:00 pm
December 15, 2009
Room 336, Division of Water Quality

Attendees:

Hilary Arens, DWQ
Carl Adams, DWQ
Bill Moellmer, DWQ
Dave Wham, DWQ
Eric Duffin, Cirrus
Nicholas von Stackelberg, Stantec
Theron Miller, JR/FB Water Quality Council
Bethany Neilson, Utah State University
Jenni Oman, Salt Lake County

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- Feb 2007 Synoptic: field probe malfunction for tributaries, so we will look at October 06 (Oct) and August 09 (Aug) synoptics as focus for this meeting

Flow and Travel Time Calibration

- Irrigation return flow input
    - Aug: not using return flow, Oct: including return flow
    - For future scenarios, we need a number to use for return flows
- Travel Time
    - HECRAS model used
    - Weirs are causing some slow down, but not considered in HECRAS model
    - 10% error between travel time and plot point
    - UP&L plant: spike goes down un Aug, but spike goes up in Oct
        - Done on 12/17

Conductivity and Inorganic Suspended Solids Calibration

- Bill questioned some units being used for conductivity, but they were worked out
- Groundwater input
    - Based on USGS report
- ISS settling rate
    - TSS-VSS=ISS
    - Adjust settling velocity
    - Increasing ISS in lower Jordan: There are sources of detritus in the lower Jordan that we don't quite understand
        - Is it resuspending? Certain times and conditions lead to resuspension? Below 2100 S, we are beyond the model's capacity

Temperature Calibration

- Aug peaks are 2 degrees higher than they should be
    - Is too much radiation coming in?
- Shading input
    - Is shading not accounting for something?
- Light and heat formulas and parameters
    - Long wave radiation not as significant as short wave radiation
    - Nick: checked long wave

DO Calibration

Reaeration

- Reaeration formulas and parameters
    - Only in Aug data
    - Both Churchhill and Internal seem to be overestimates

        - Nick checked which one we should use
    - Do we believe the results from the study?
        - Not accounting for air and wind force, because it is a closed chamber
        - Does Goel have some quality assurance for reaeration rates? In lab work for validation?
            - Hilary sent Goel email 12/22

Nutrients – Nitrogen and Phosphorus

- Oct looks good on TP and TN
- Aug: too much total P and total N
    - ~ kilometer 31: What is happening in this stretch of river?
    - Is it a flow issue?
    - Is river assimulating P?
    - How much more groundwater or dilution to hit the mark? Is GW lost here?
    - Bill has flow in Brighton Canal as: 30 cfs in summer; 20 cfs in spring
    - Hypotheses to Investigate:

    1. Explore by adding flow:
        - Bethany changed diffuse sources between WWTP and kilometer 31 and took out river water and TP and TN looked good
            - 5 m^3/s
            - DO looks good too. This fixed a lot of problems and didn't change the Oct data
            - Does the geology support this?
            - Bethany and Hilary will contact Briant Kimball to see if it is possible to do a tracer study on the Jordan to account for this anomaly to see if there are significant gains and losses in this segment of the river. Email sent 12/22. Plans were in the works to do this spring 2010, but Utah Lake gates were opened unseasonably early. Possible plans have been delayed until fall 2010 (2/23)
    2. Settling out
        - May not be truthful
    3. Grow periphyton
- Ammonia good in Oct and Aug

SCBOD

- Dissolved fraction is actually SCBOD
- Water quality standards are in BOD5 and CBOD
- In Model:
    - Slow and fast are 2 different rates
    - Nick: re-tweak fast and low CBOD rates. Rate slow lower than fast.

Phytoplankton/Periphyton/Detritus (Particulate Organic Matter)

- Aug better than Oct. Oct under-stimulating phytoplankton.
    - Maybe radiation problem? Was it not cloudy, and it was assumed it was>
    - Possibly dealing with incorrect light limitation?
- Max Growth Rate: time limited, not light or nutrient limited. Seasonally adjusting light limitation.
    - Optimal substrate of bottom algae
    - No growth below Surplus Canal.
        - There was talk of changing 0% to 10%. Nick performed both of these
    - Is there growth upstream from Turner Dam?

DO

- GW as zero, not 4 for DO
- Oct in great shape, minus detritus and phytoplankton

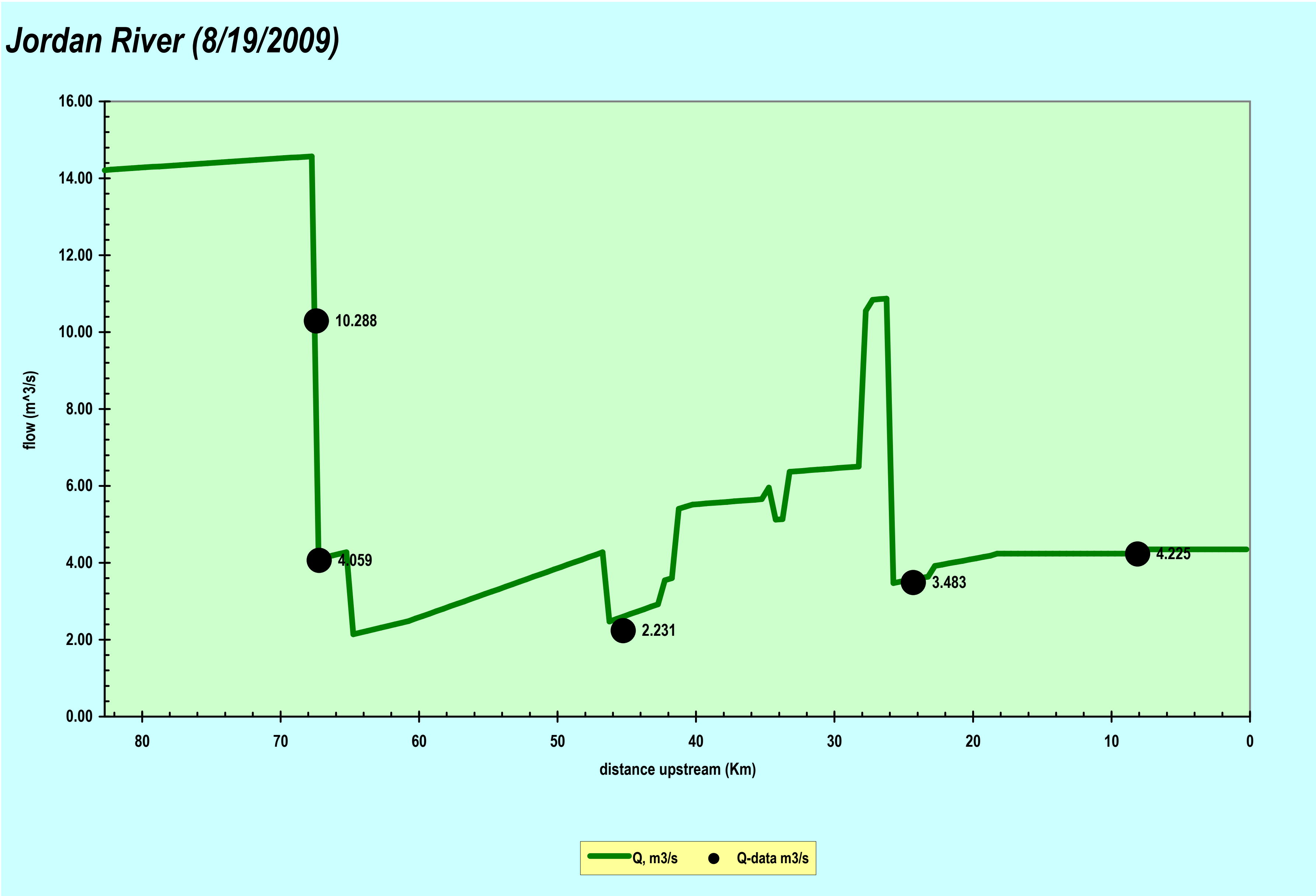
- Jordan with 5.5 mg/L site specific standard
- Burnham Dam point for Aug may be an outlier. Suggestion of throwing away that data point.
  - Theron has probe data at Burnham Dam from Sept 6, 2009 (close to synoptic) that he sent to Nick to validate this data point.

SOD

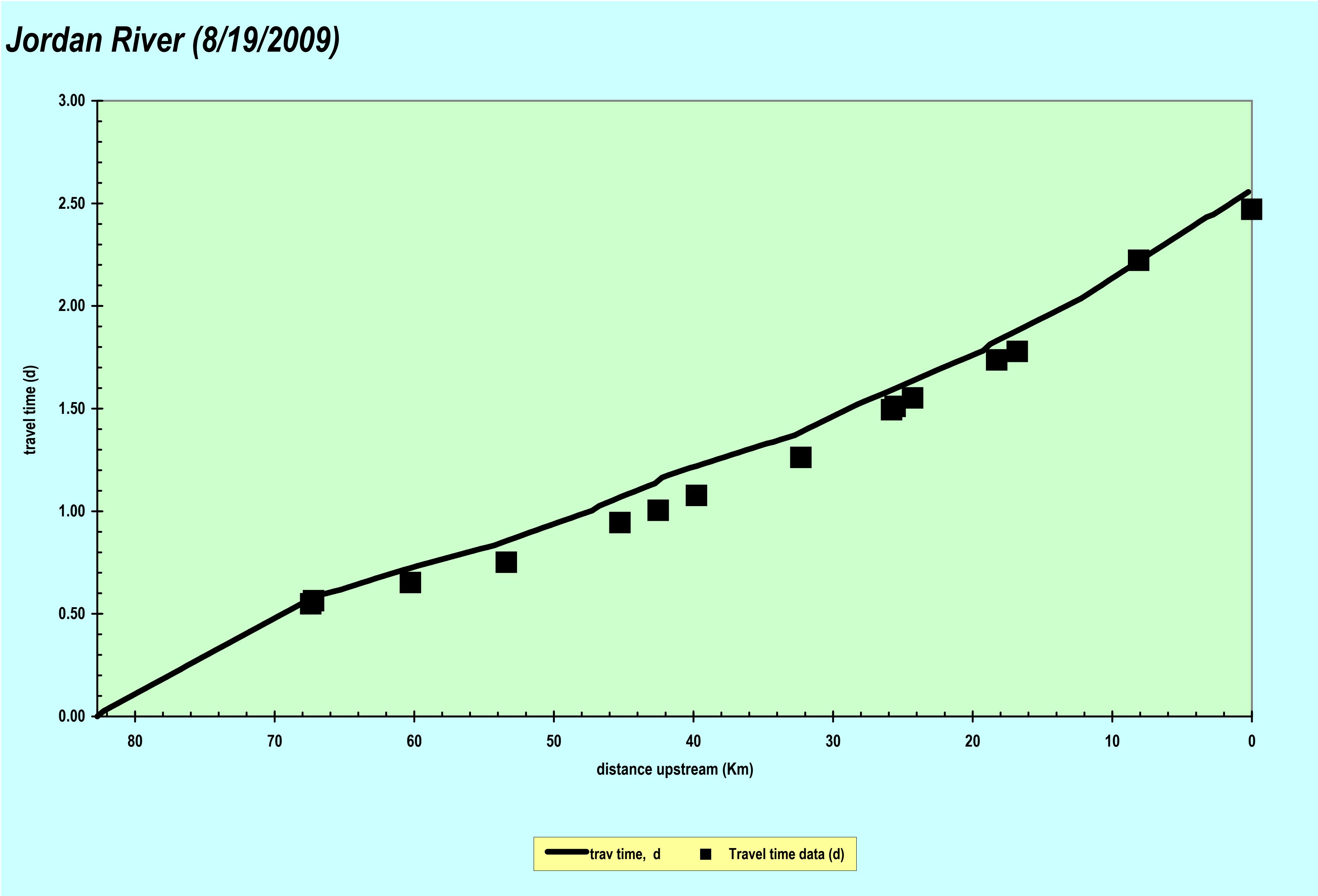
- Demand shown in graph
- Problems in same section as problems with TP and TN in Aug (kilometer 31)
- Prescribe SOD at lower reaches
  - 0 to Surplus Canal
  - 1 Surplus Canal to North Temple
  - 4 North Temple northward

BIG PICTURE/ CONCLUSIONS

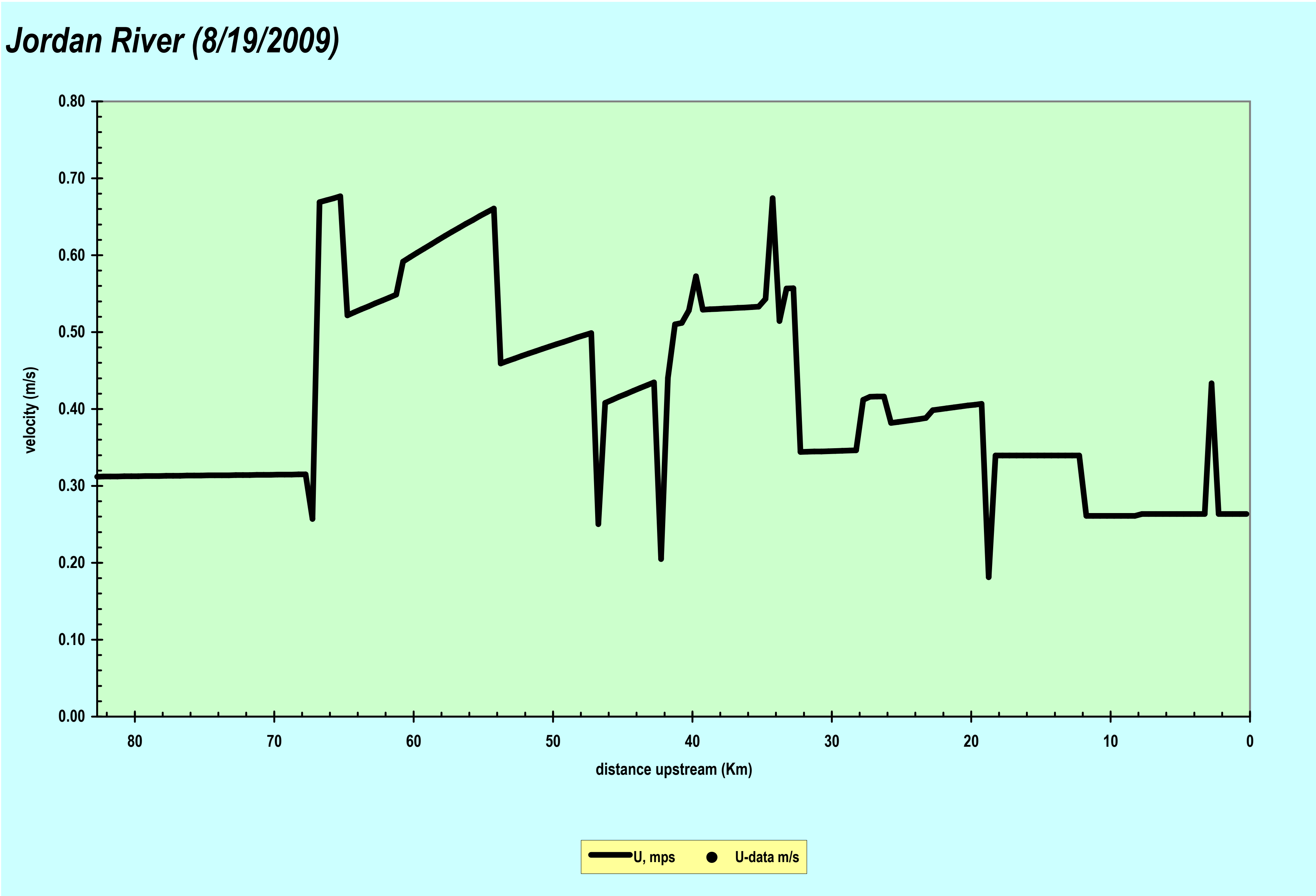
- Oct DO looks good
- Aug DO lower sections needs some conversation
  - Some upper readings are at or above saturation (which does in fact match up with what Goel's students were observing in the field).
  - Range looks ok
  - Theron says it is "remarkably close" and that (he) "has not real issues with the model."
  - Need a boundary condition for lower Jordan in Aug to be correct
- Nick believes the errors are acceptable and model is good
- Nick made sure all 3 synoptic events got the changes that were suggested.
- Dave says Aug has high DO, high productivity, and that we have got to get it right in the lower Jordan where the DO problems are
- Theron: recognizes absence of periphyton below 2100 S, SOD values prescribed or default are near Goel's data and DO is in alignment. He was happy and thought that the model was really close.
- Cirrus did a temp, collection time and flow review of data captured in Aug period.
- We need to define the critical condition
  - Consider using calibrated Aug model for TMDL. Need to back up critical condition with real data. Question of affect of sources rest of year, and how to we resolve that.



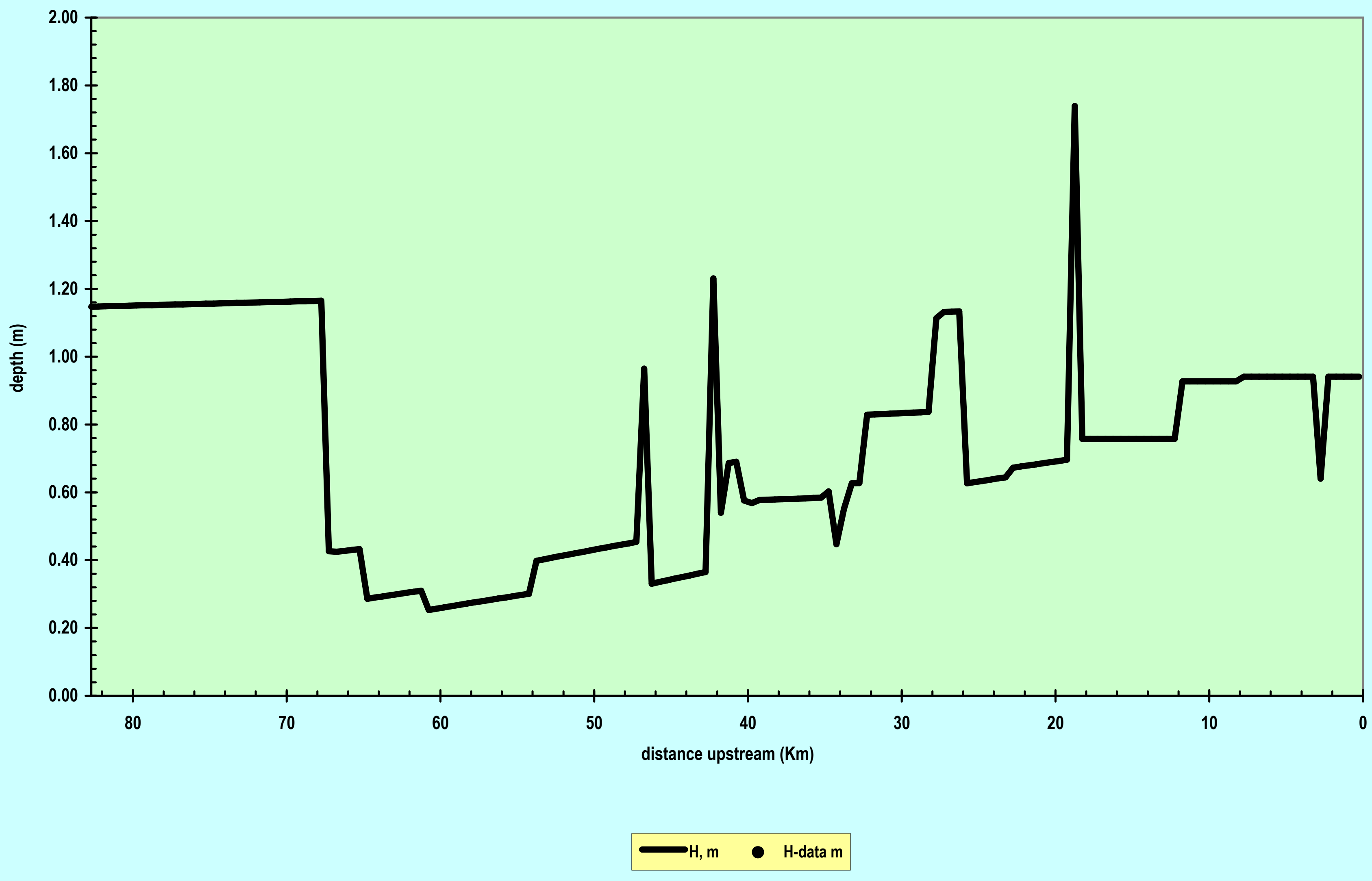
jordan_aug2009_q2kw_calwork.xls\Flow, 2/12/2010



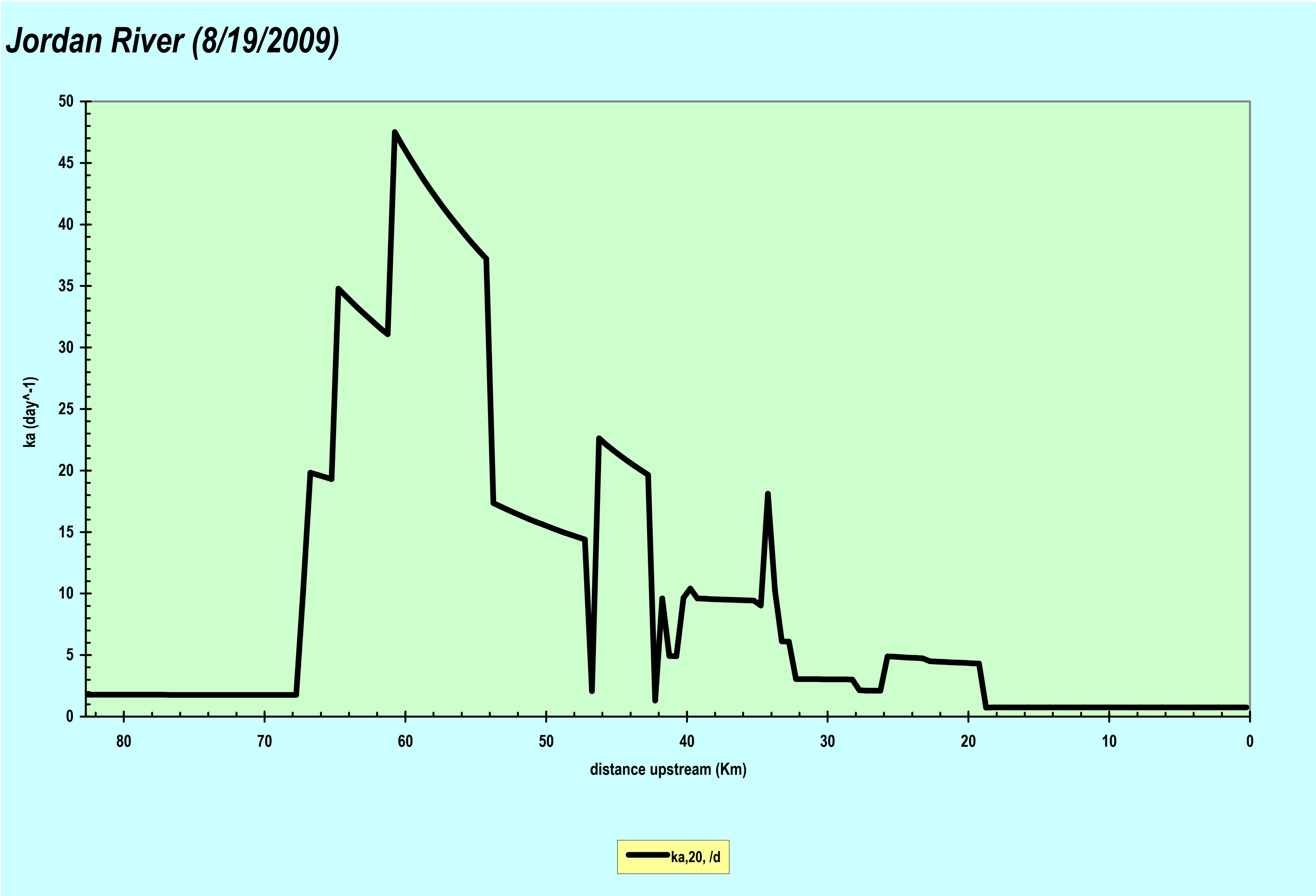
jordan_aug2009_q2kw_calwork.xls\Travel Time, 2/12/2010


Jordan River (8/19/2009)
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
velocity (m/s)
80
70
60
50
40
30
20
10
0
distance upstream (Km)
U, mps
U-data m/s

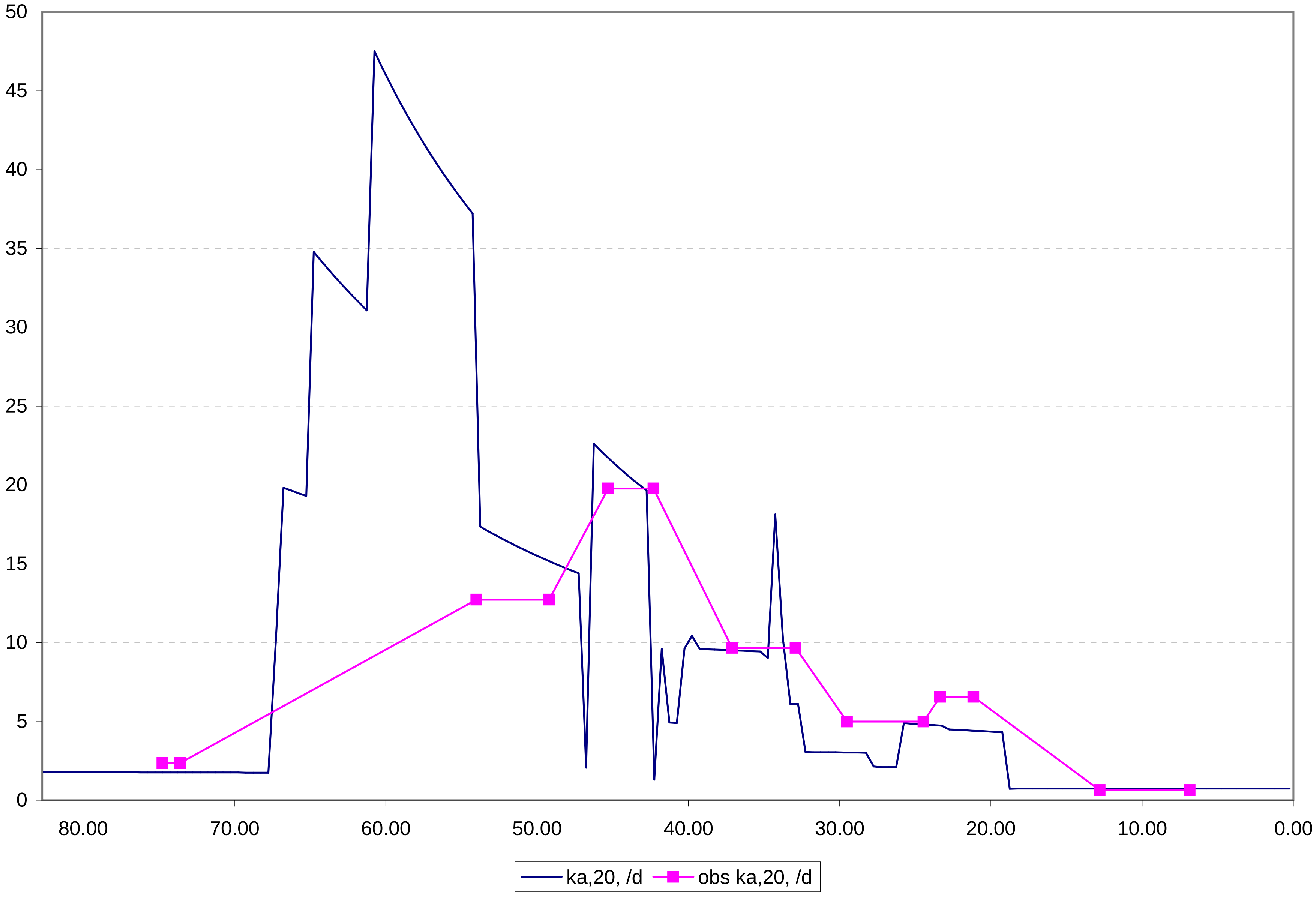
Jordan River (8/19/2009)

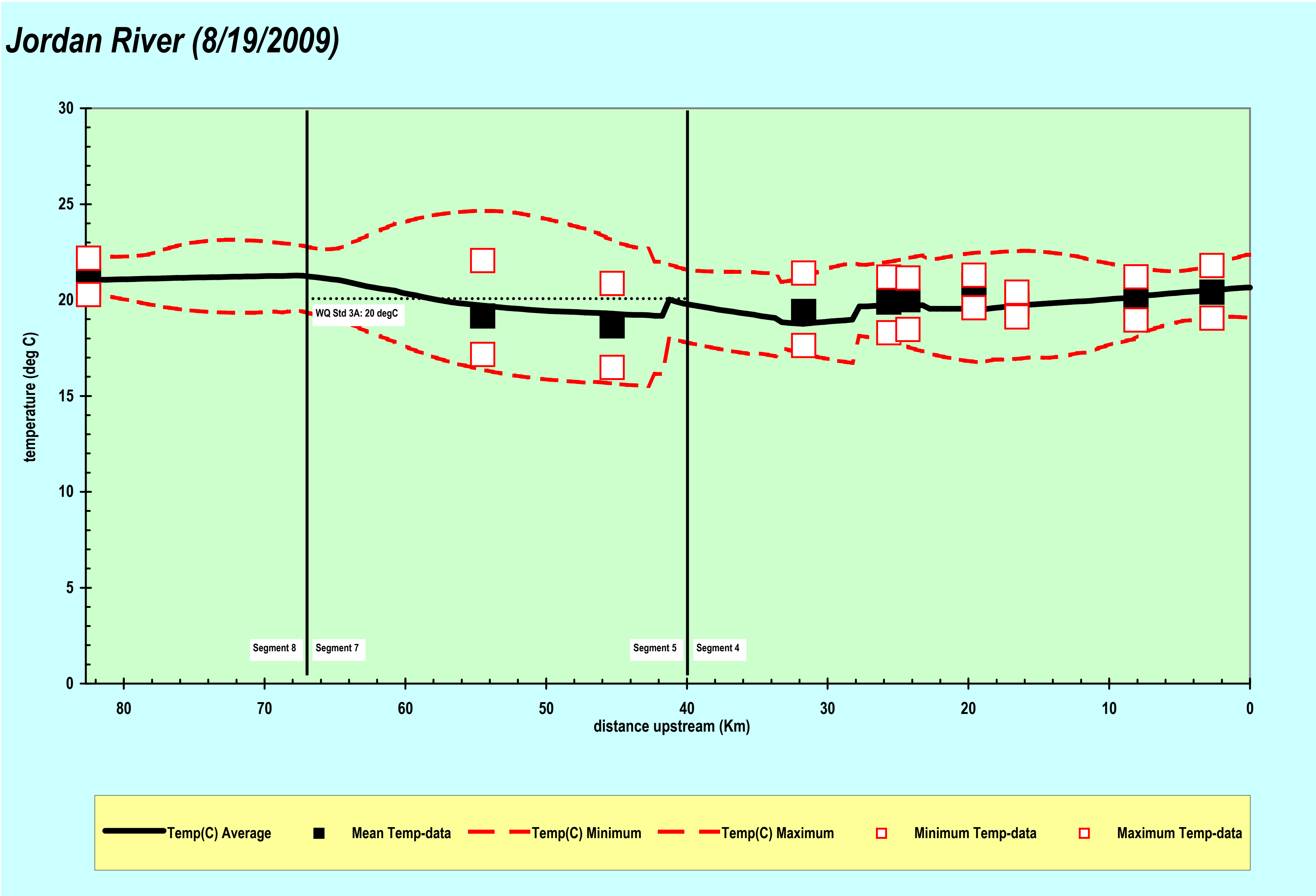


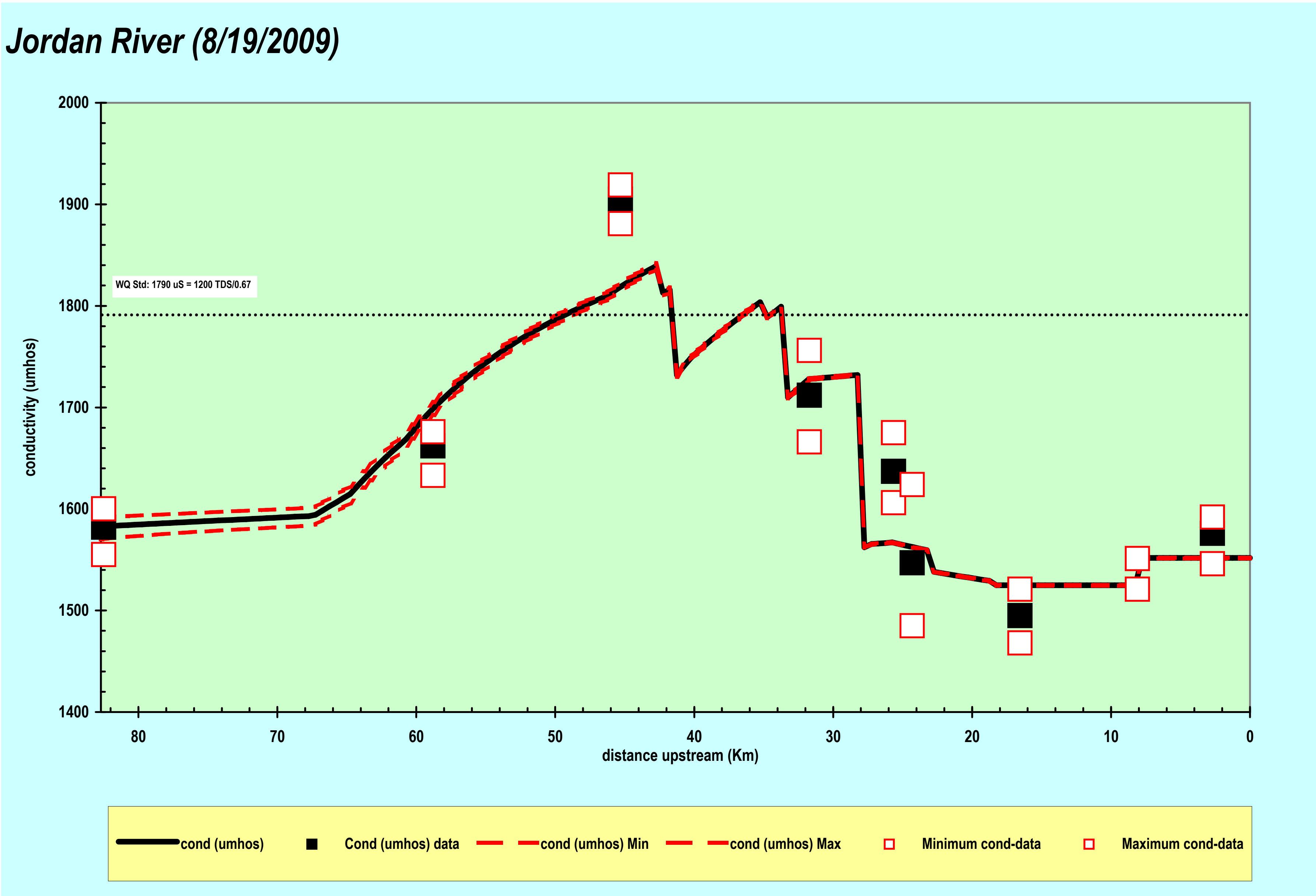
jordan_aug2009_q2kw_calwork.xls\Depth, 2/12/2010



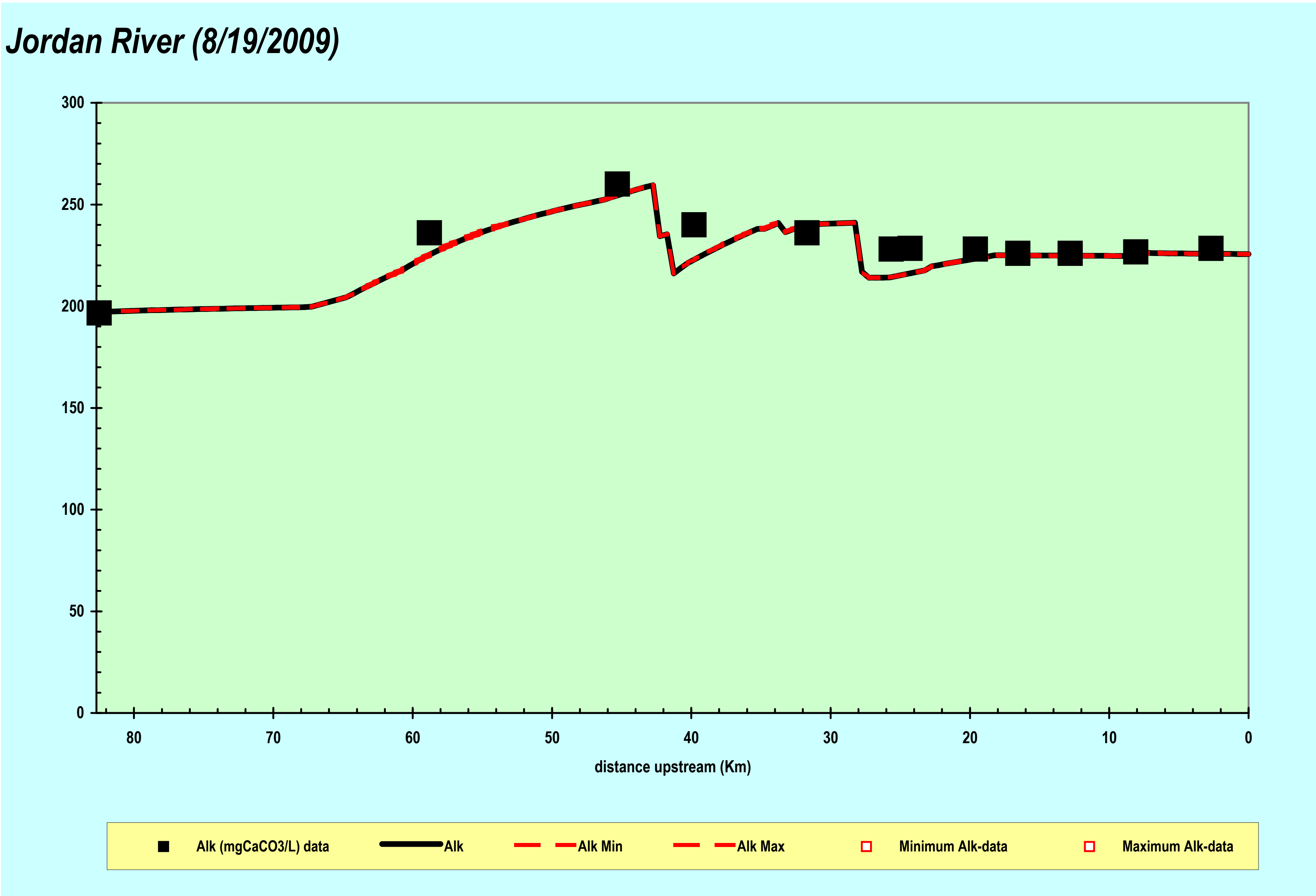
jordan_aug2009_q2kw_calwork.xls\Reaeration, 2/12/2010

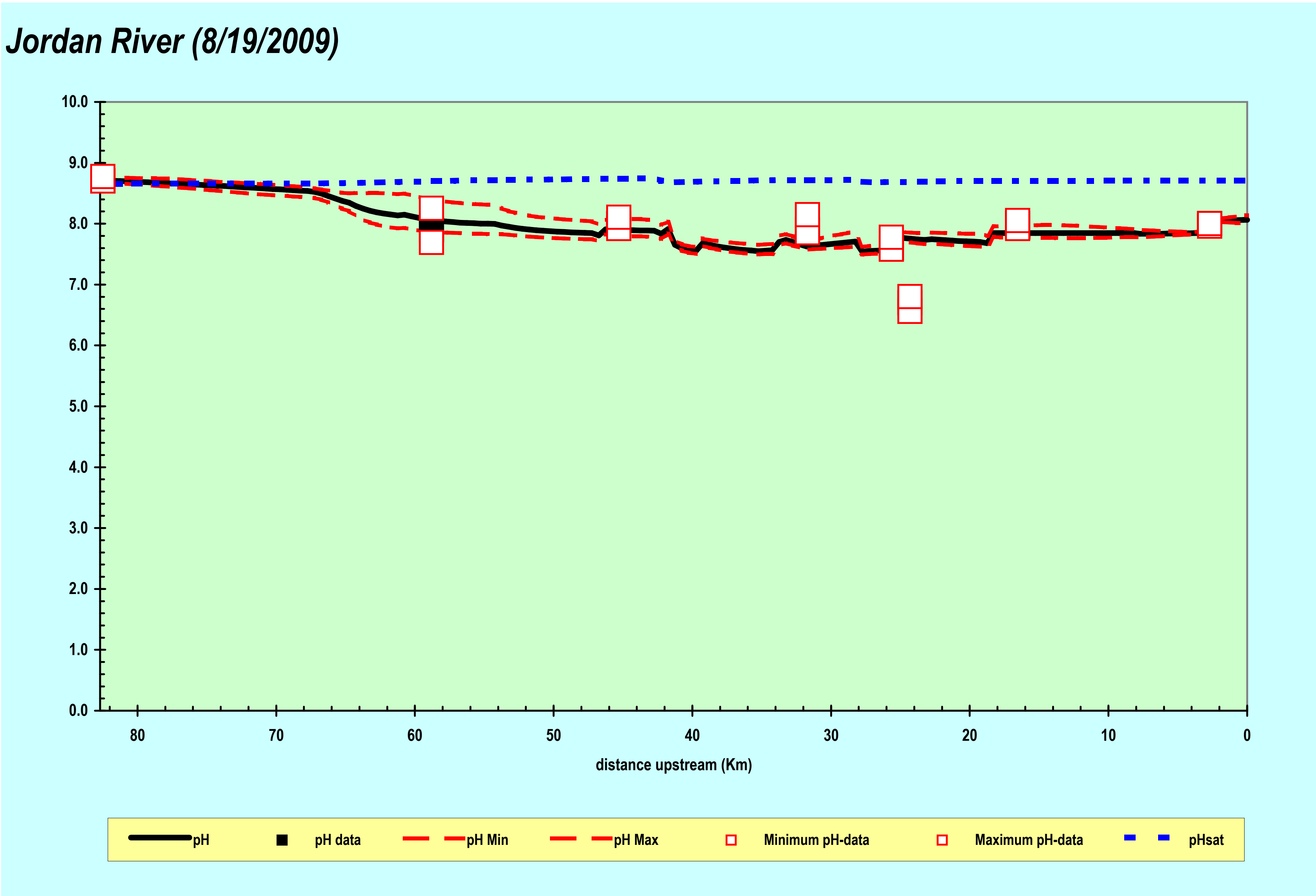

50
45
40
35
30
25
20
15
10
5
0
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
ka,20, /d
obs ka,20, /d

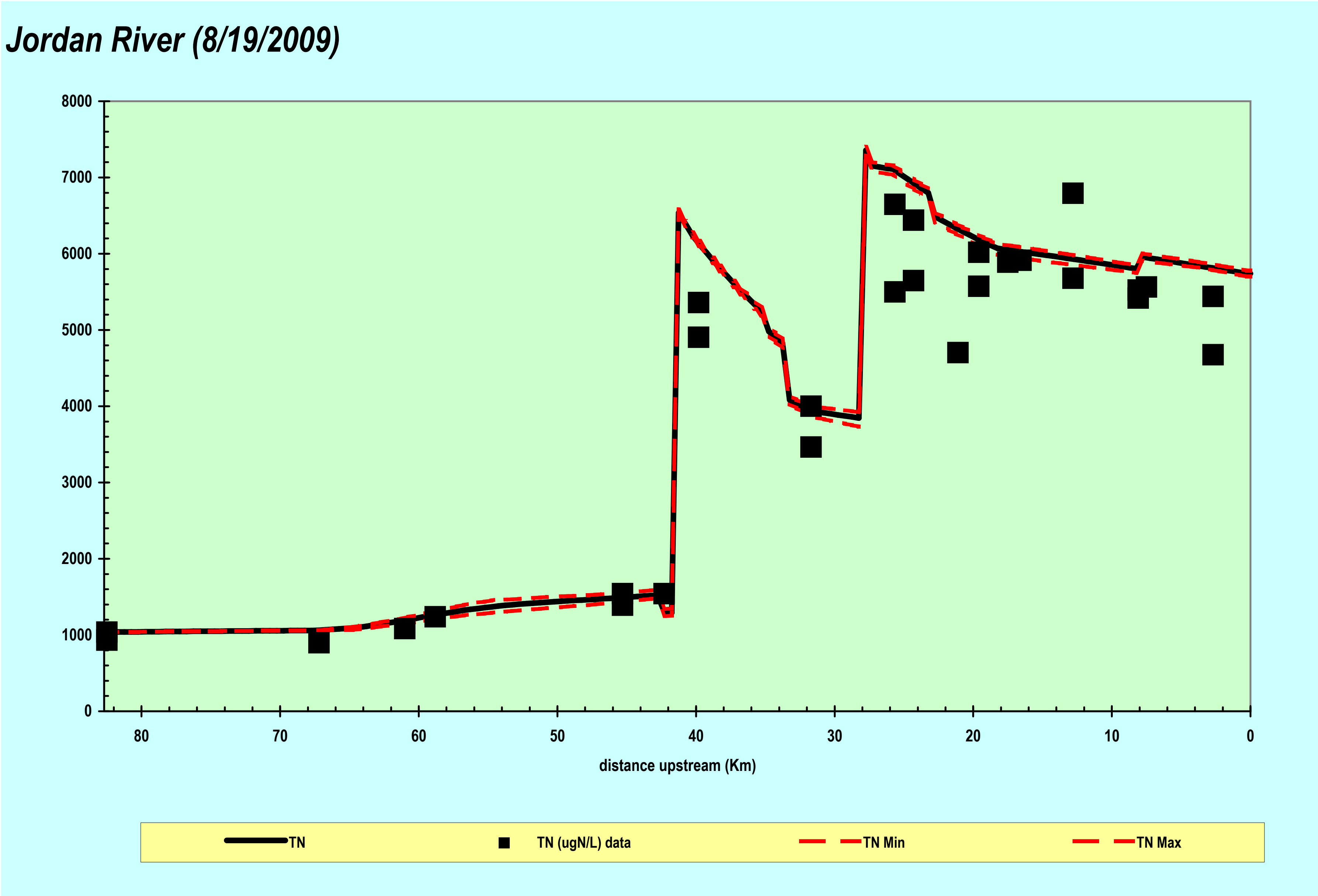

Jordan River (8/19/2009)
30
25
20
15
10
5
0
temperature (deg C)
WQ Std 3A: 20 degC
Segment 8
Segment 7
Segment 5
Segment 4
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Temp(C) Average
Mean Temp-data
Temp(C) Minimum
Temp(C) Maximum
Minimum Temp-data
Maximum Temp-data



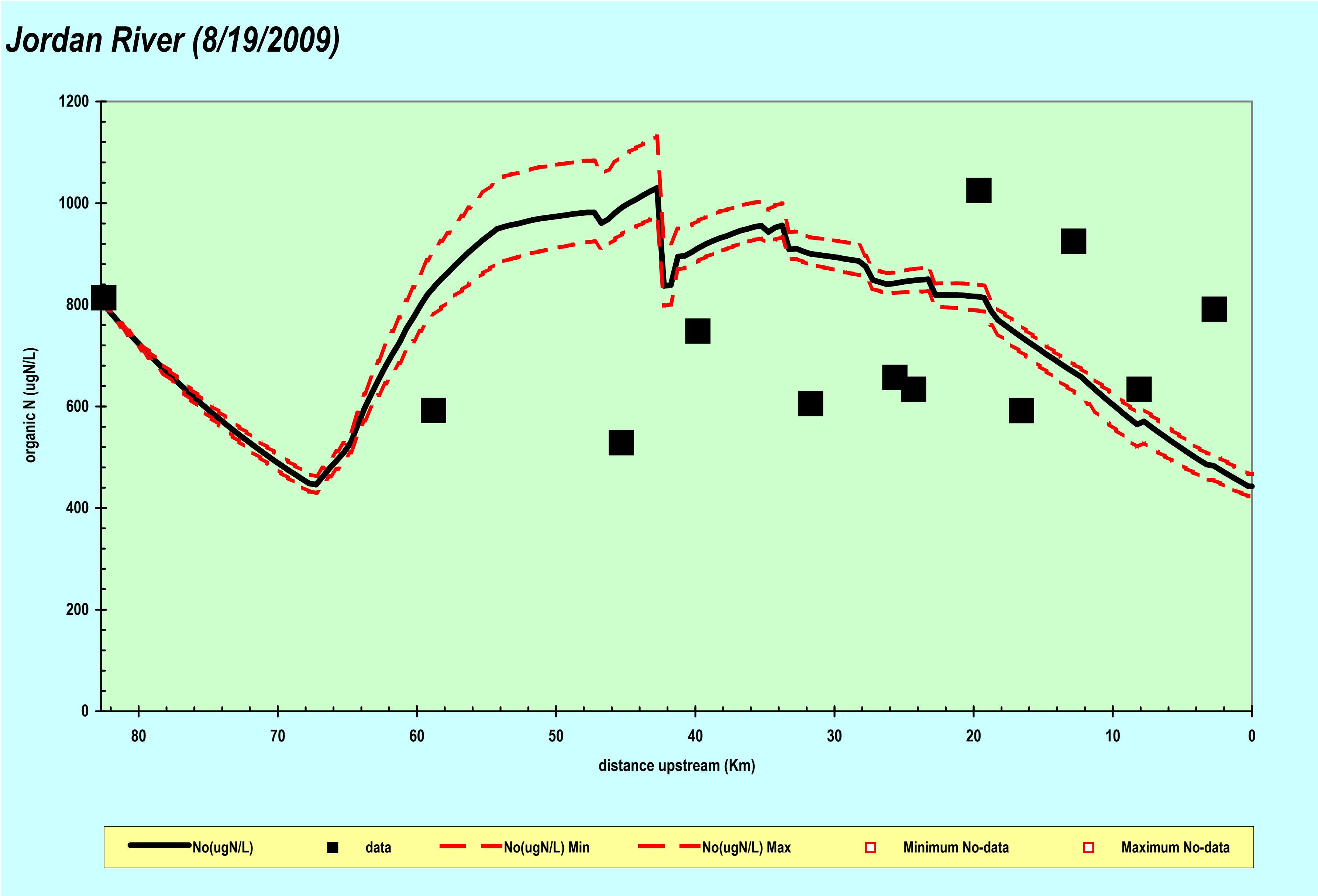
jordan_aug2009_q2kw_calwork.xls\Conductivity, 2/12/2010


Jordan River (8/19/2009)
300
250
200
150
100
50
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Alk (mgCaCO3/L) data
Alk
Alk Min
Alk Max
Minimum Alk-data
Maximum Alk-data

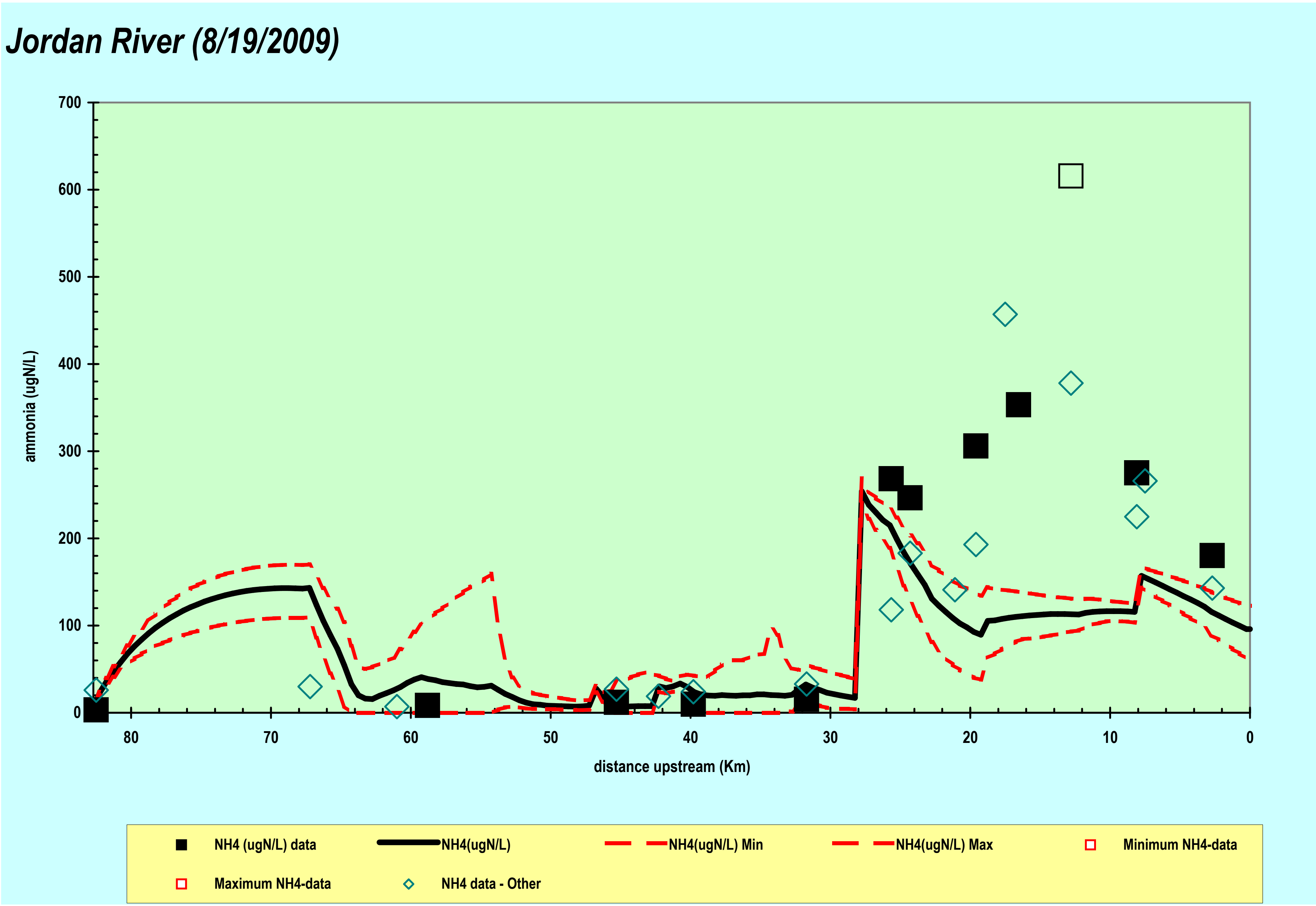

Jordan River (8/19/2009)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
pH
pH data
pH Min
pH Max
Minimum pH-data
Maximum pH-data
pHsat



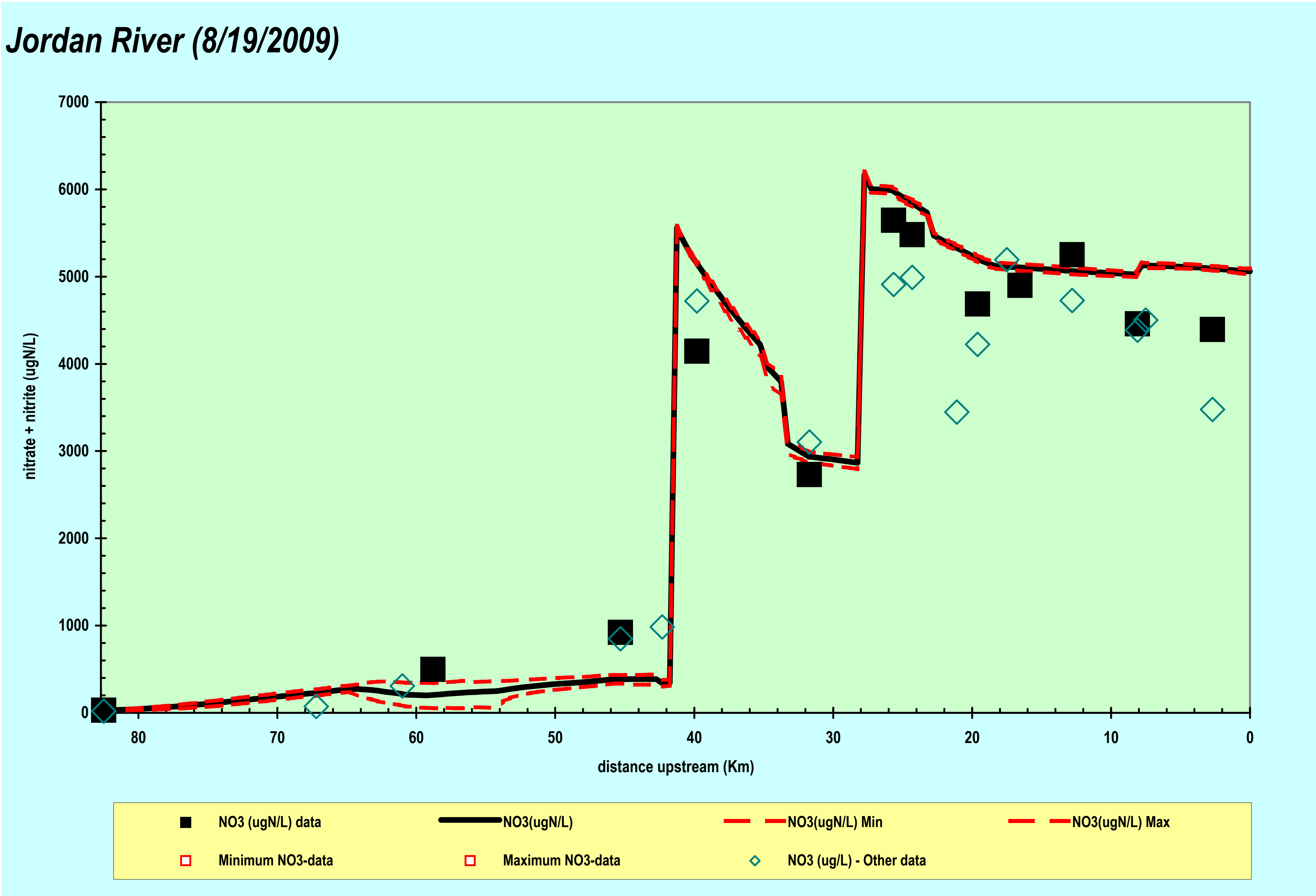
jordan_aug2009_q2kw_calwork.xls\Total N, 2/12/2010



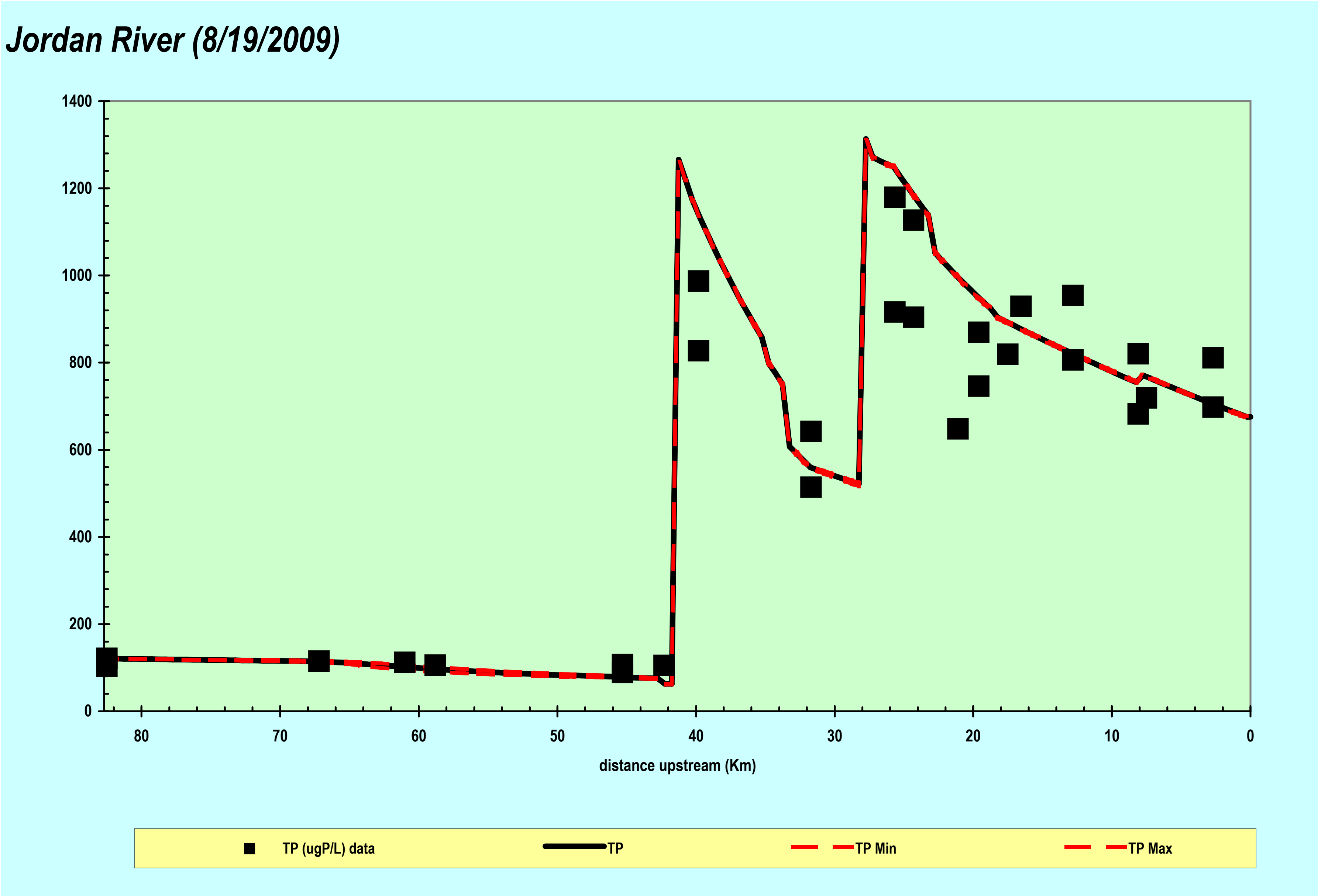
jordan_aug2009_q2kw_calwork.xls\Organic N, 2/12/2010



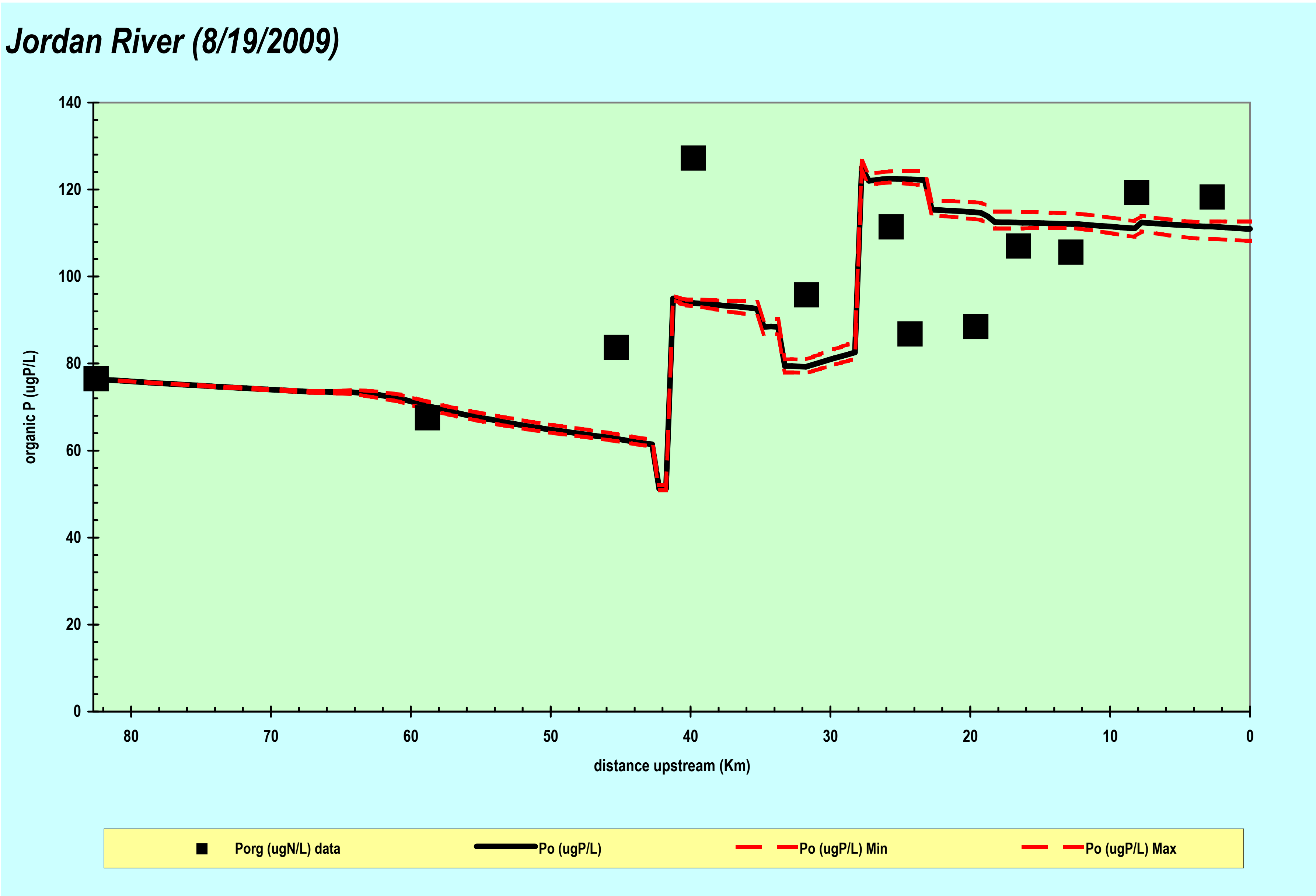
jordan_aug2009_q2kw_calwork.xls\NH4, 2/12/2010



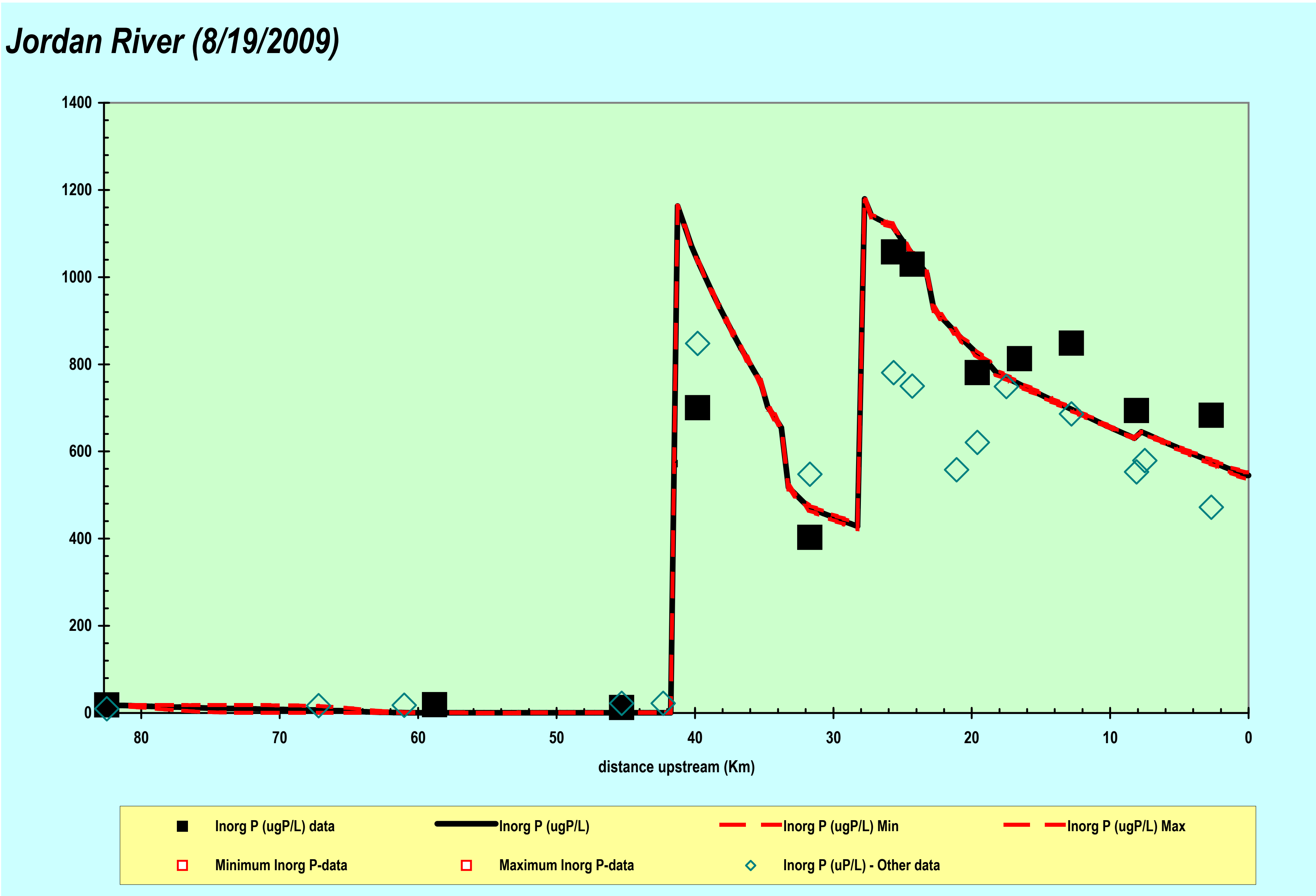
Jordan River (8/19/2009)
7000
6000
5000
4000
3000
2000
1000
0
nitrate + nitrite (ugN/L)
80
70
60
50
40
30
20
10
0
distance upstream (Km)
NO3 (ugN/L) data
NO3(ugN/L)
NO3(ugN/L) Min
NO3(ugN/L) Max
Minimum NO3-data
Maximum NO3-data
NO3 (ug/L) - Other data



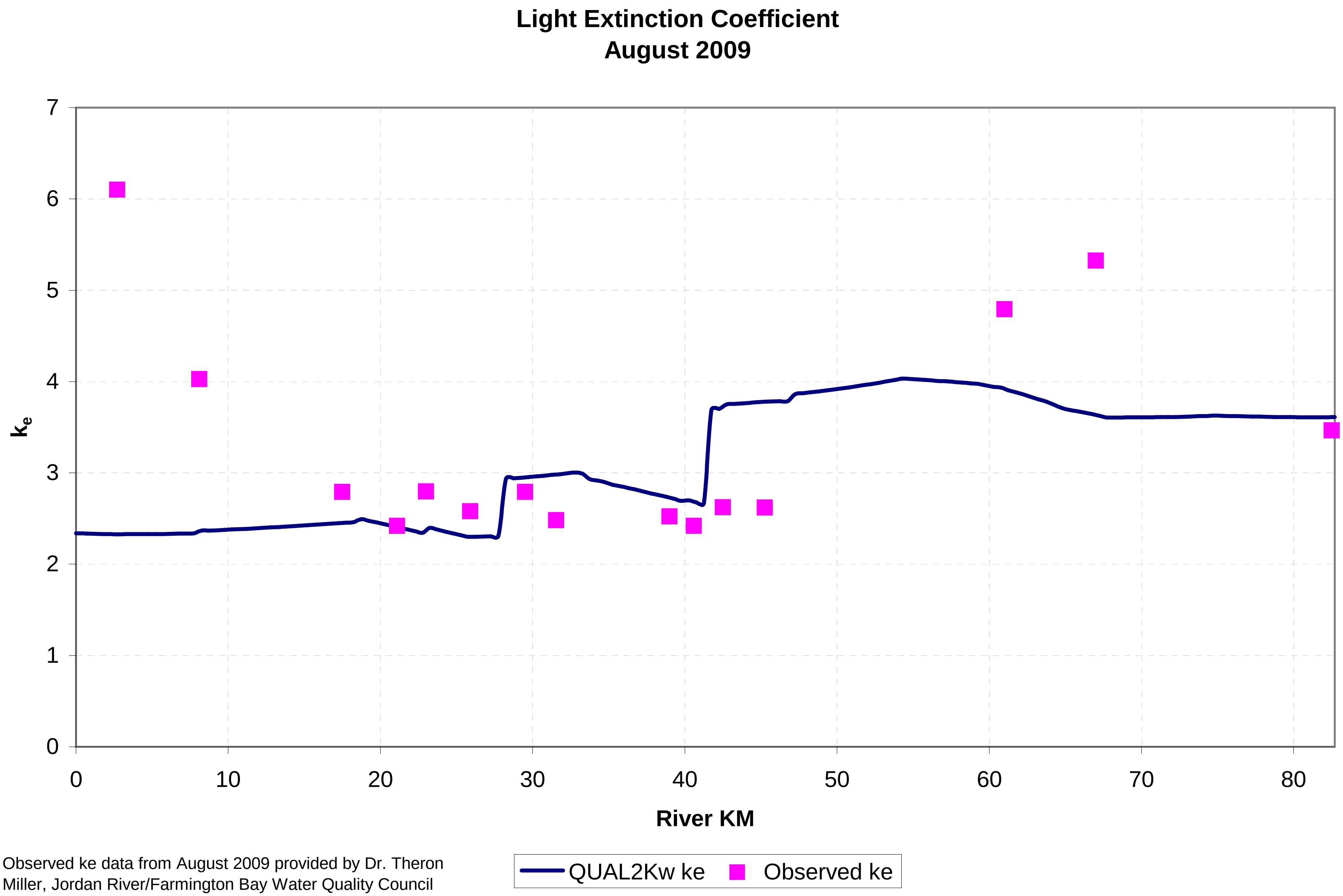
Jordan River (8/19/2009)
1400
1200
1000
800
600
400
200
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
TP (ugP/L) data
TP
TP Min
TP Max



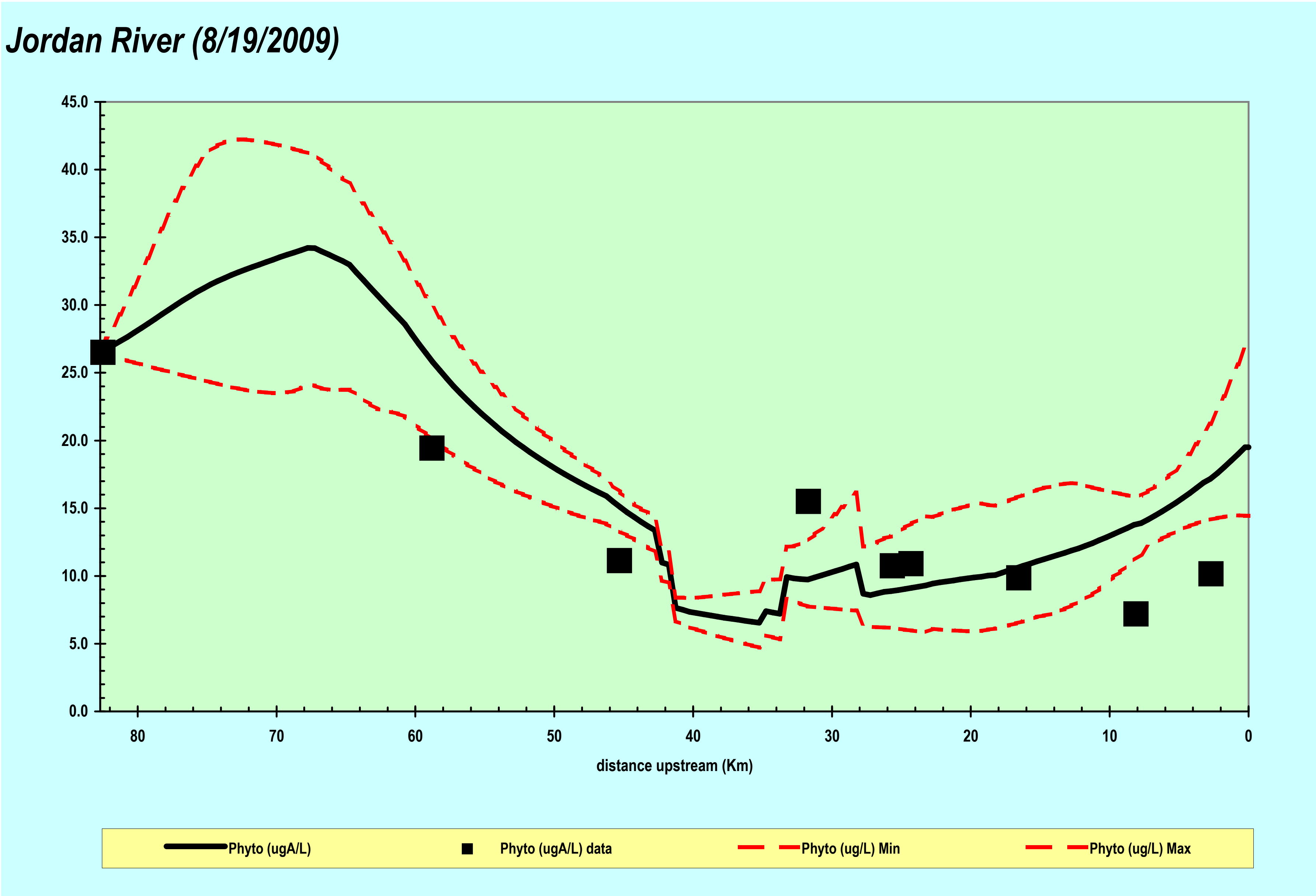
jordan_aug2009_q2kw_calwork.xls\Organic P, 2/12/2010



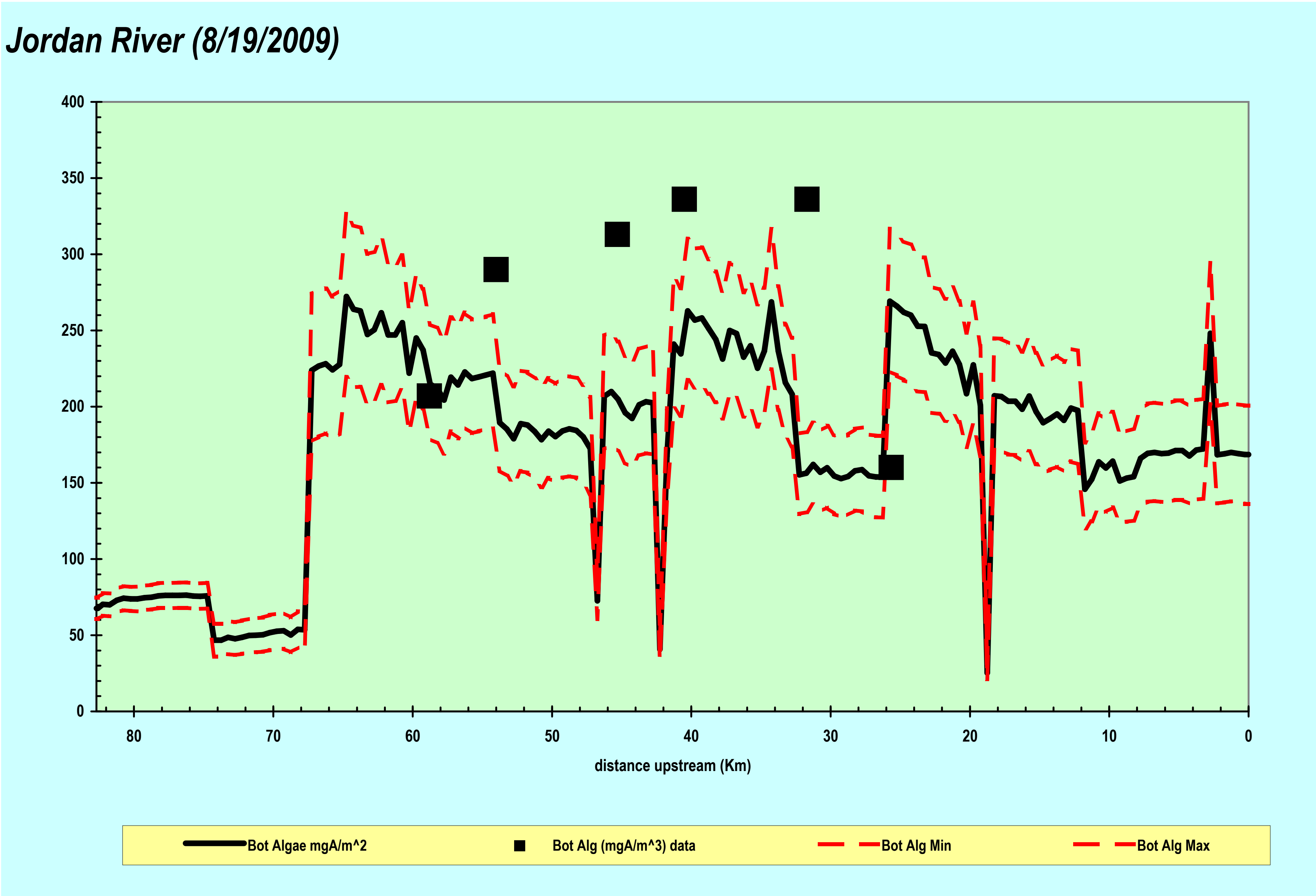
Jordan River (8/19/2009)
1400
1200
1000
800
600
400
200
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Inorg P (ugP/L) data
Inorg P (ugP/L)
Inorg P (ugP/L) Min
Inorg P (ugP/L) Max
Minimum Inorg P-data
Maximum Inorg P-data
Inorg P (uP/L) - Other data



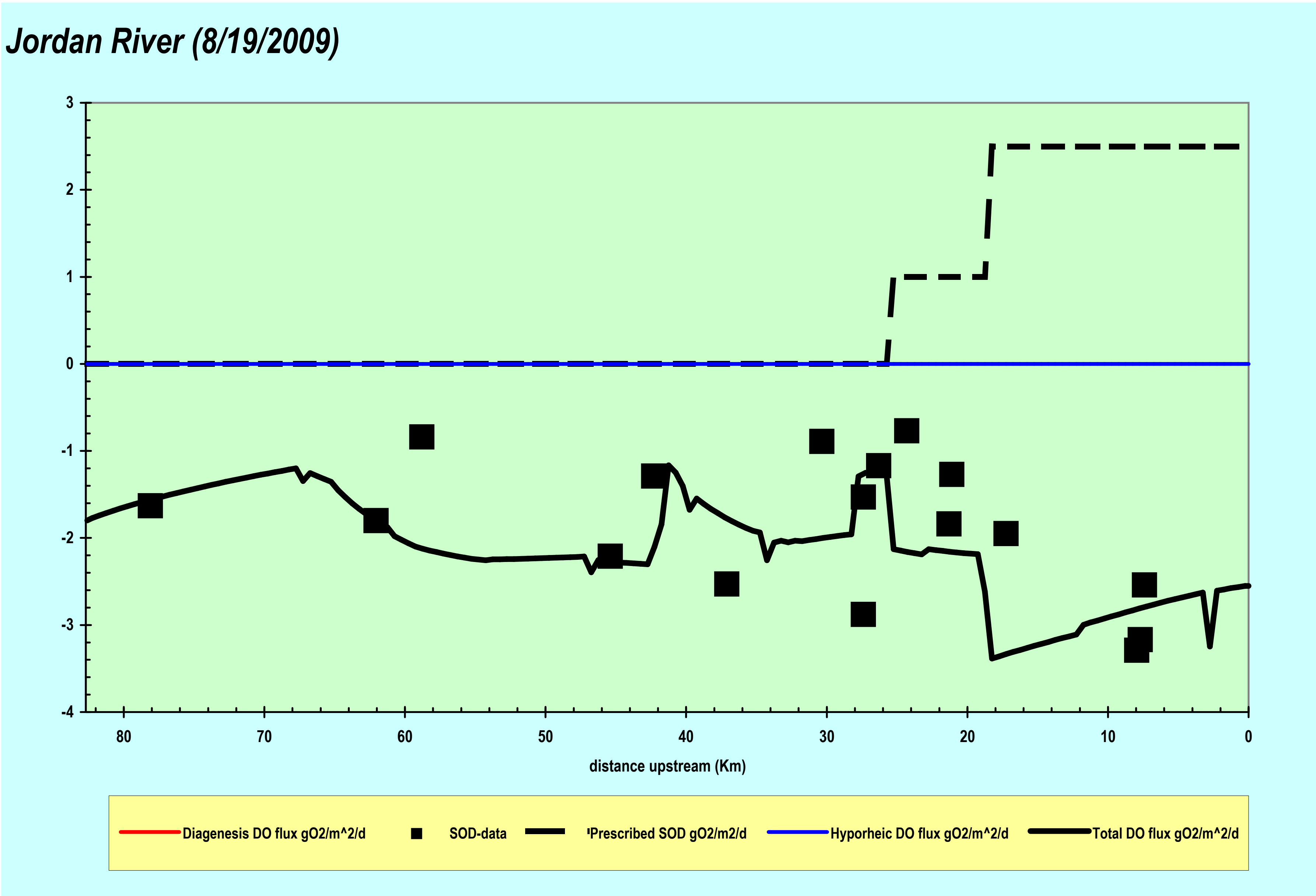
Observed ke data from August 2009 provided by Dr. Theron Miller, Jordan River/Farmington Bay Water Quality Council



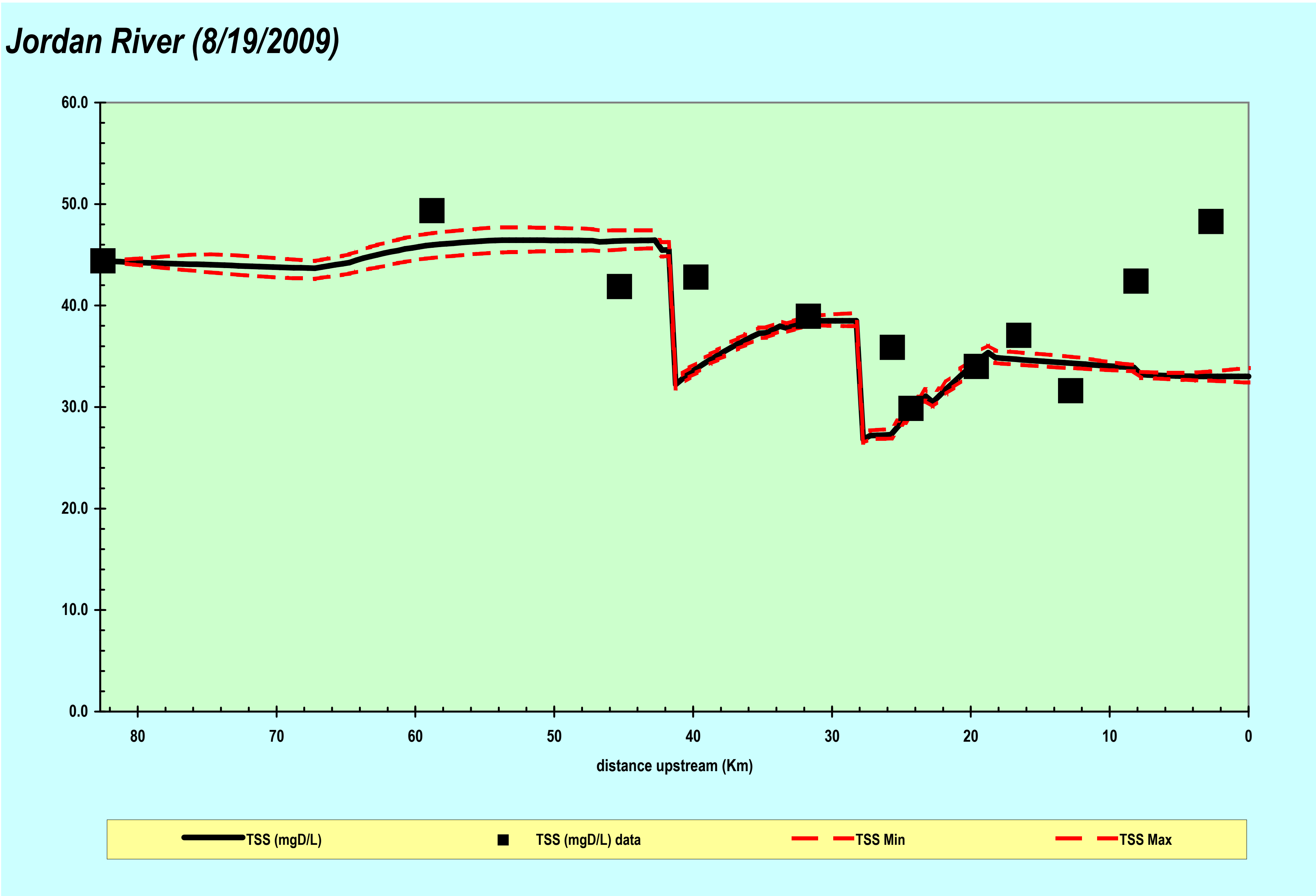
jordan_aug2009_q2kw_calwork.xls\Phytoplankton, 2/12/2010



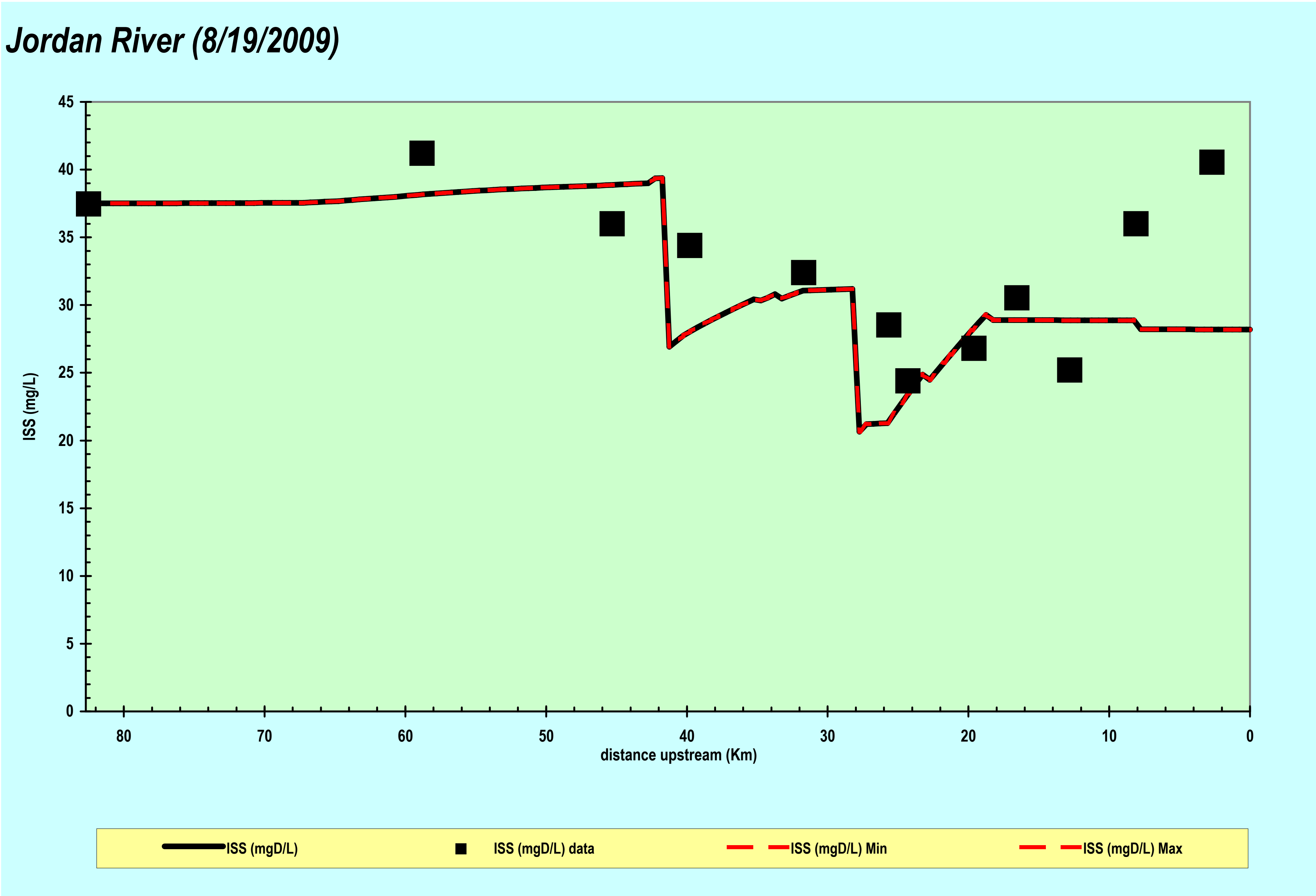
jordan_aug2009_q2kw_calwork.xls\Bot Algae mgA per m2, 2/12/2010



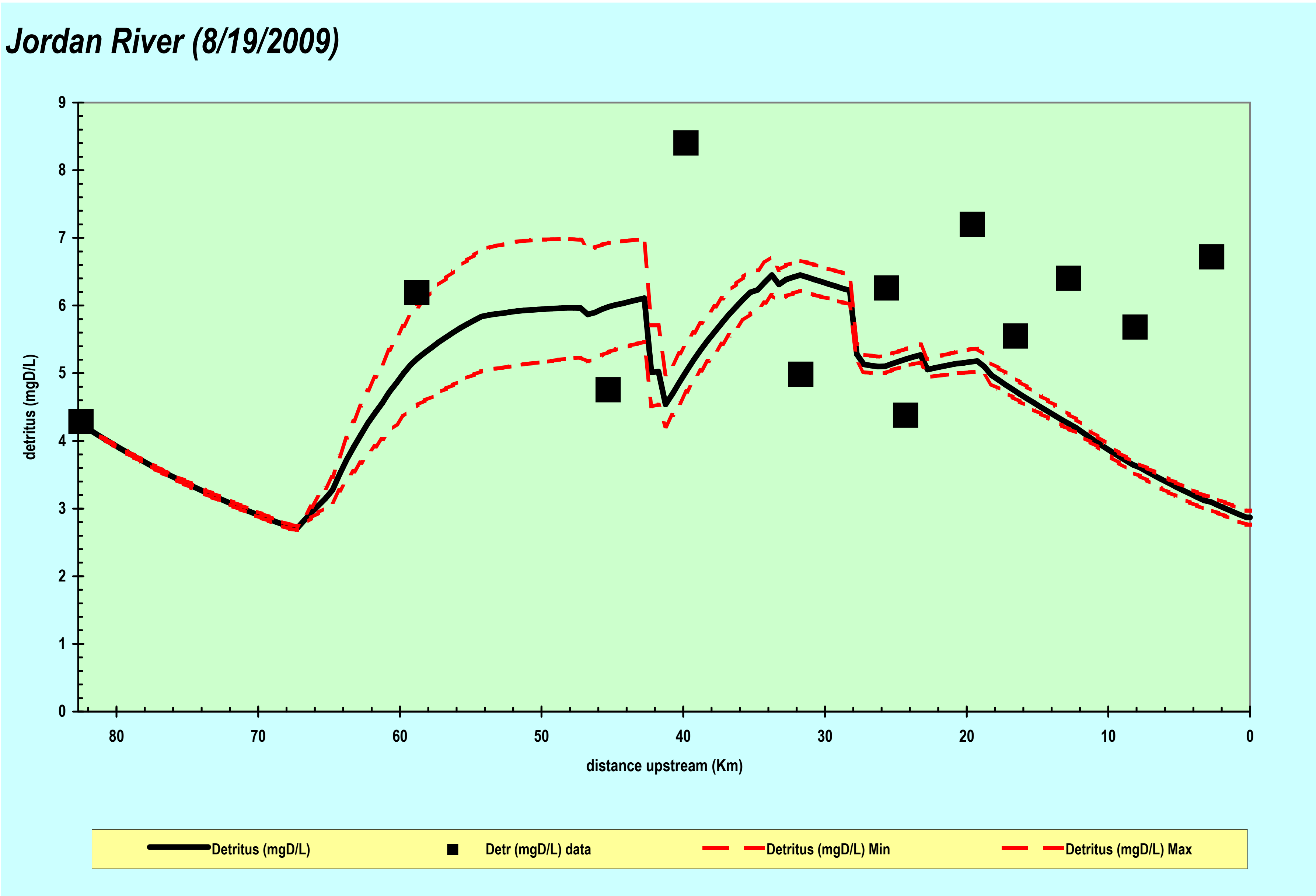
jordan_aug2009_q2kw_calwork.xls\SOD, 2/12/2010



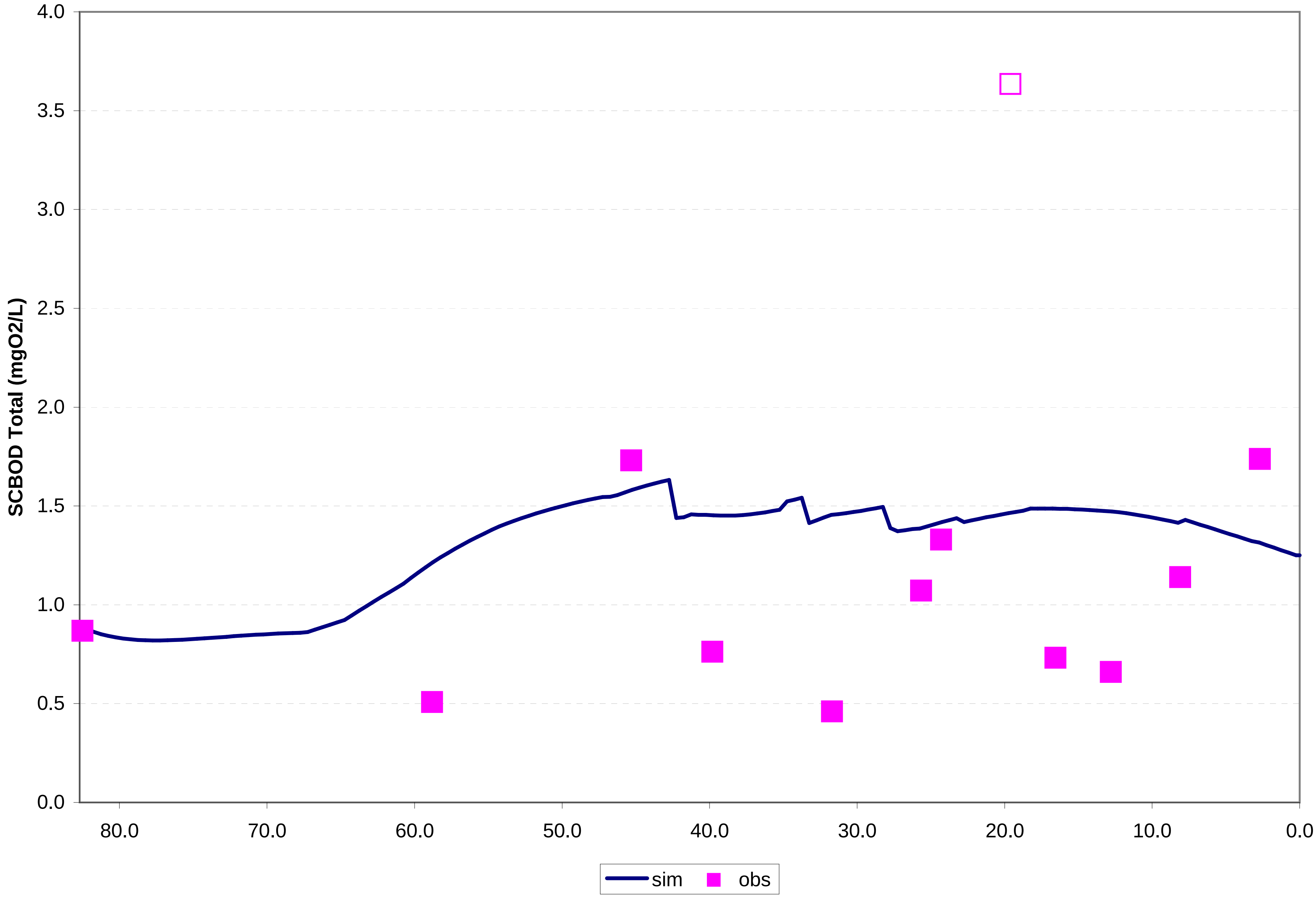
jordan_aug2009_q2kw_calwork.xls\TSS, 2/12/2010



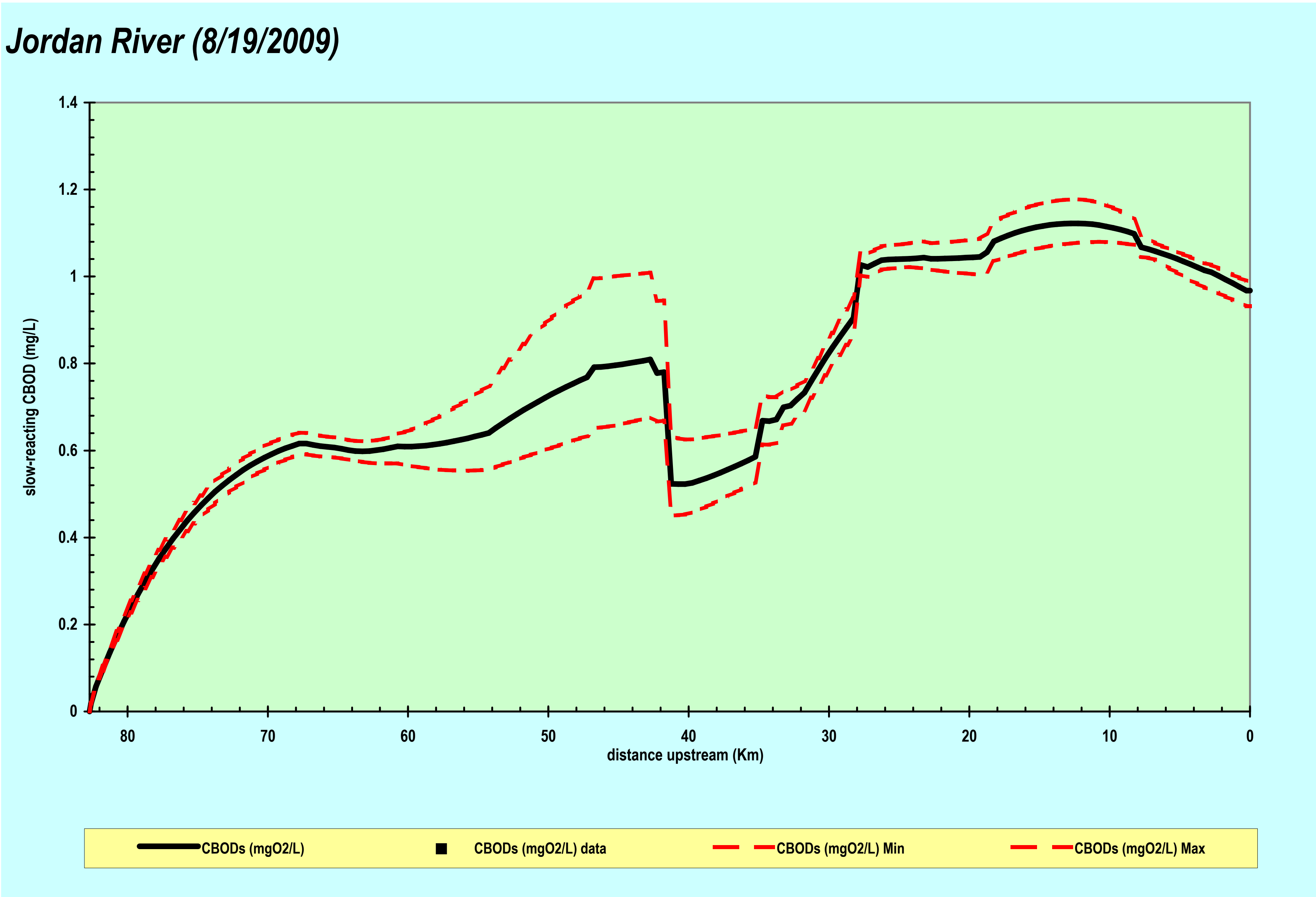
Jordan River (8/19/2009)
ISS (mg/L)
45
40
35
30
25
20
15
10
5
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
ISS (mgD/L)
ISS (mgD/L) data
ISS (mgD/L) Min
ISS (mgD/L) Max

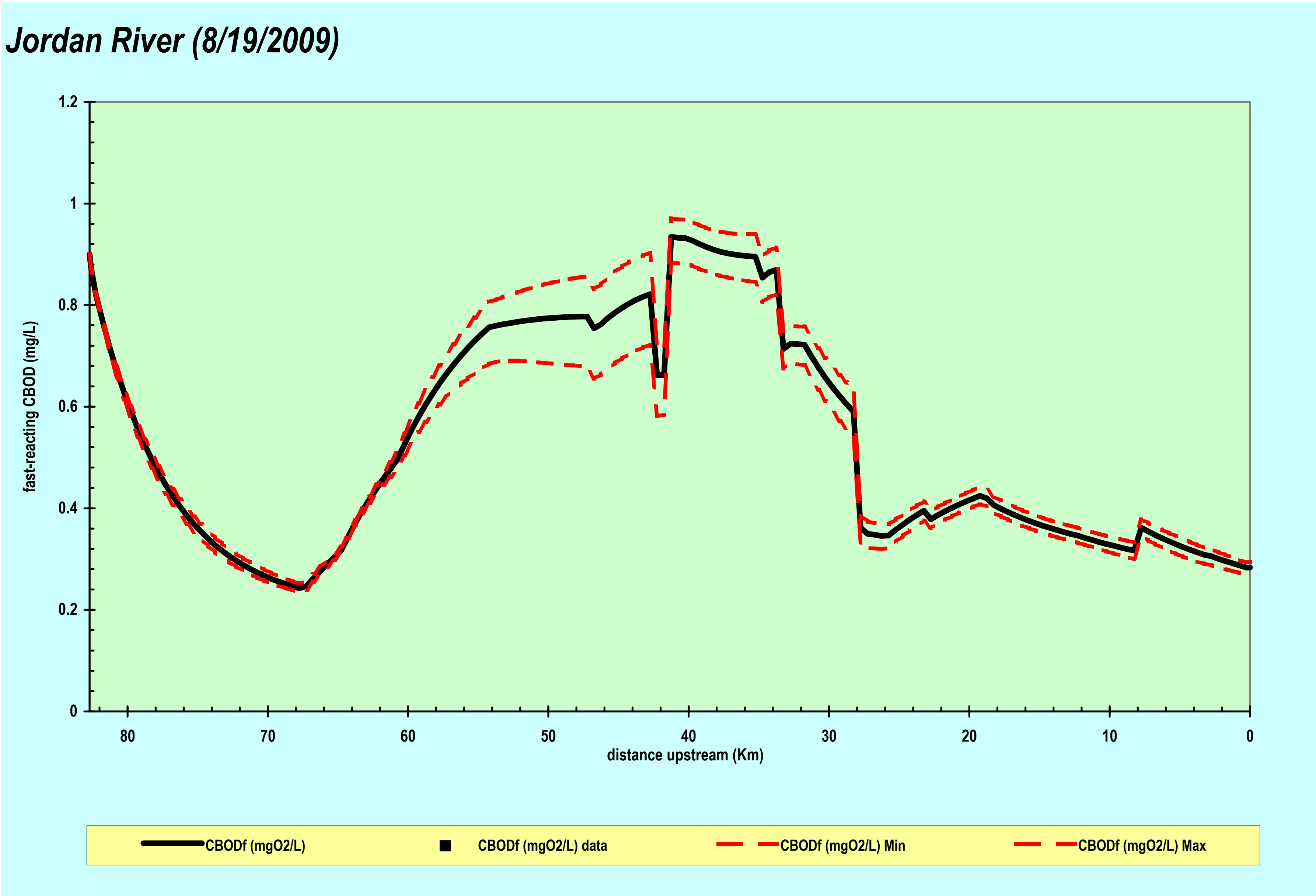


jordan_aug2009_q2kw_calwork.xls\Detritus, 2/12/2010

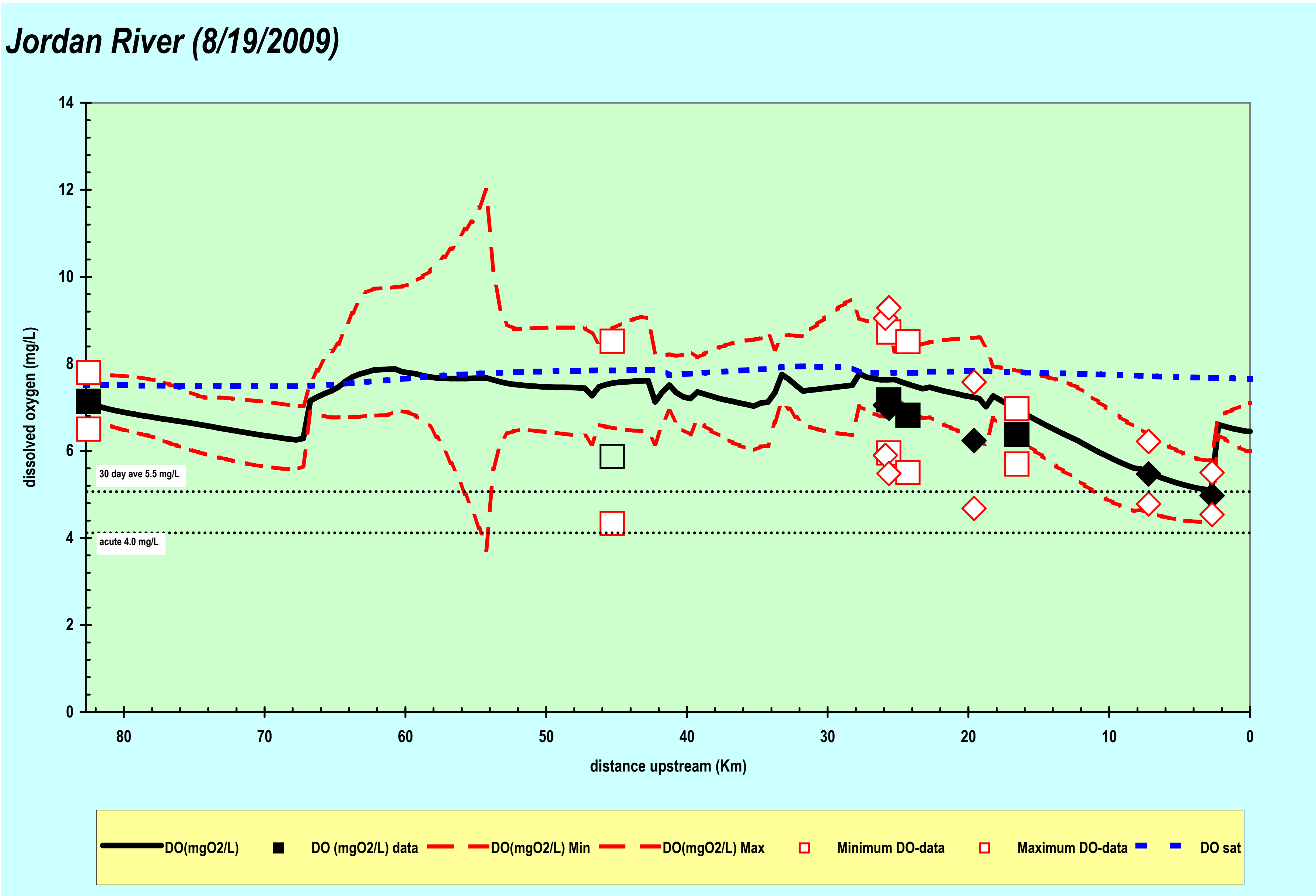


SCBOD Total (mgO2/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
sim
obs

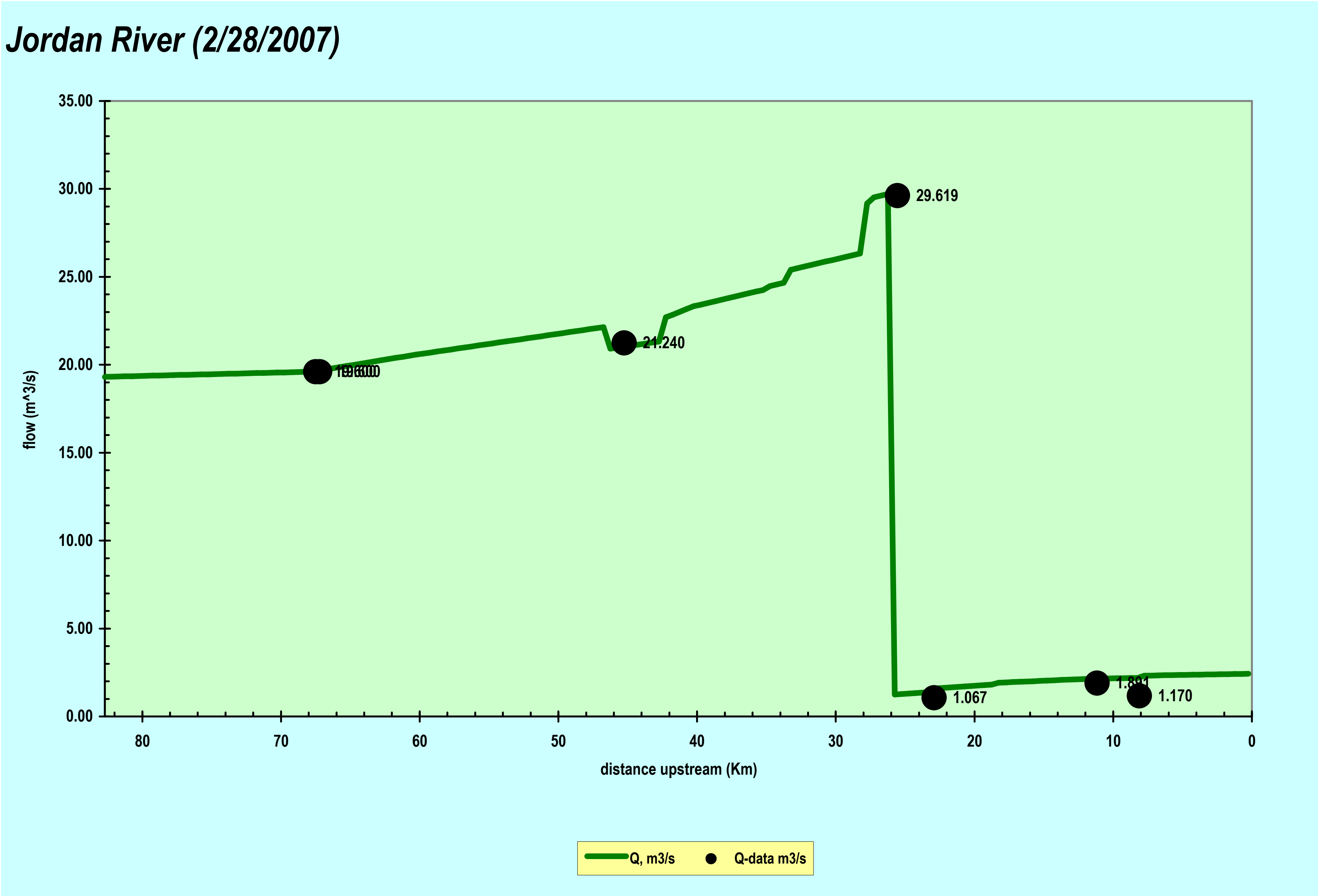

Jordan River (8/19/2009)
slow-reacting CBOD (mg/L)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
CBODs (mgO2/L)
CBODs (mgO2/L) data
CBODs (mgO2/L) Min
CBODs (mgO2/L) Max



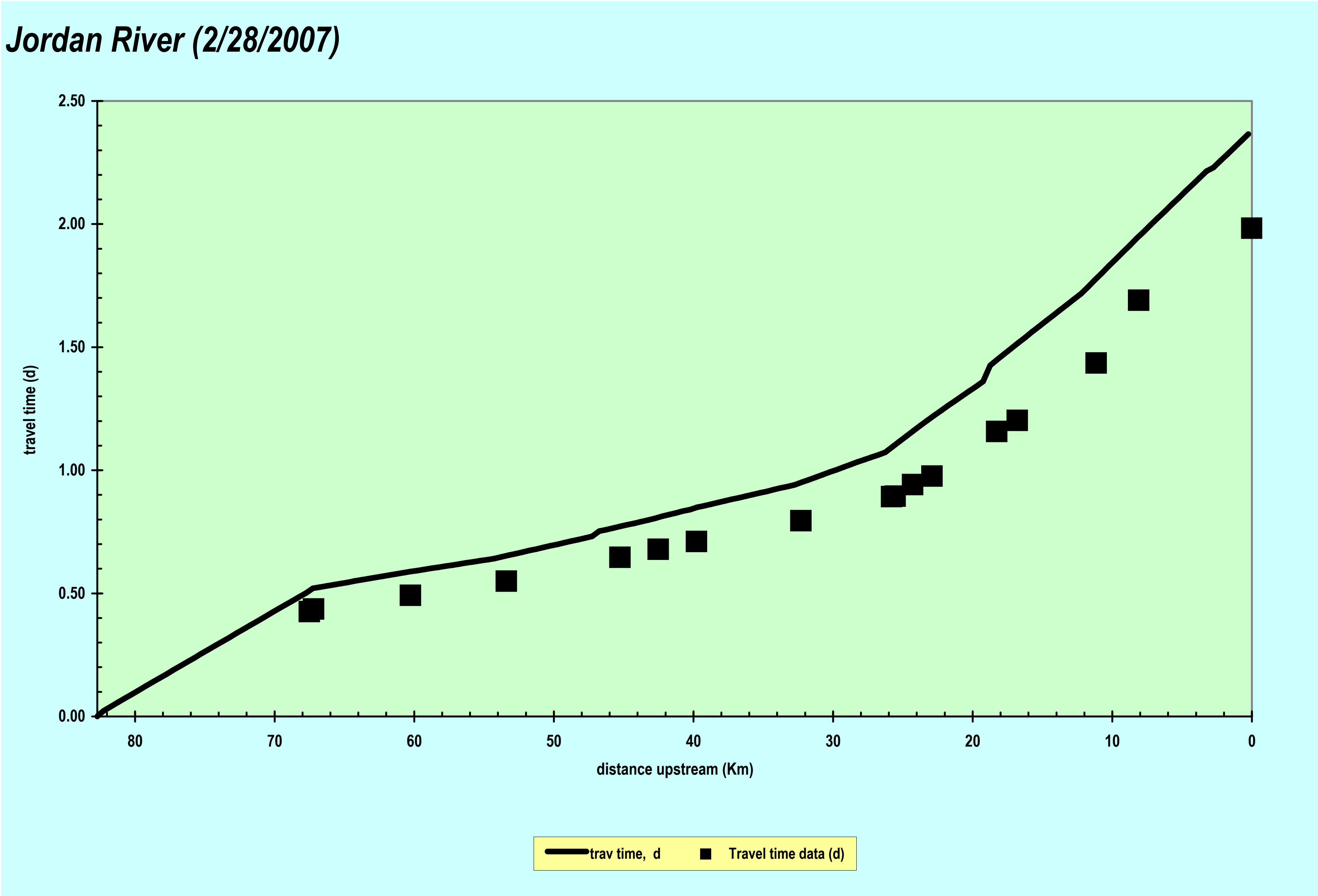
jordan_aug2009_q2kw_calwork.xls\CBOD fast, 2/12/2010



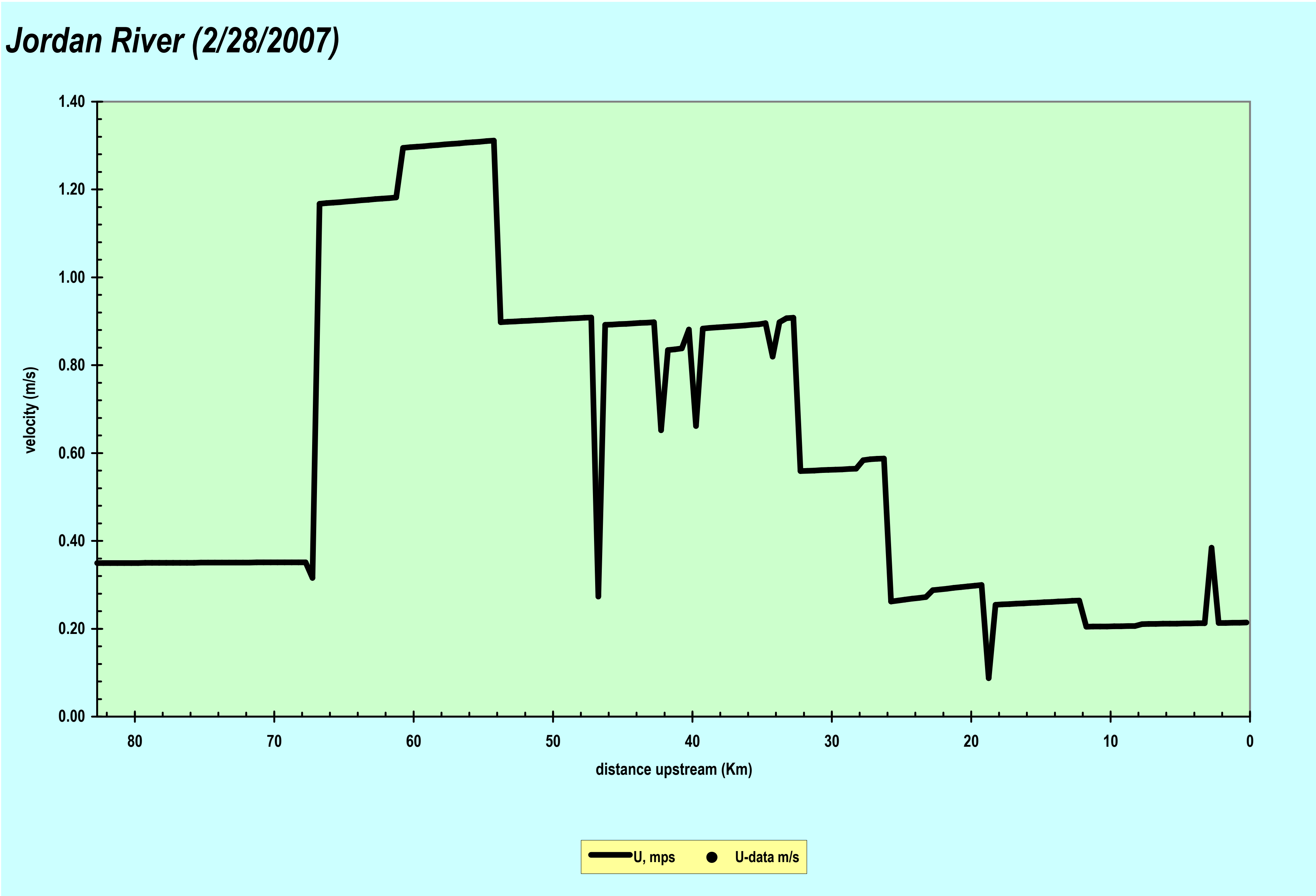
jordan_aug2009_q2kw_calwork.xls\Dissolved Oxygen, 2/12/2010



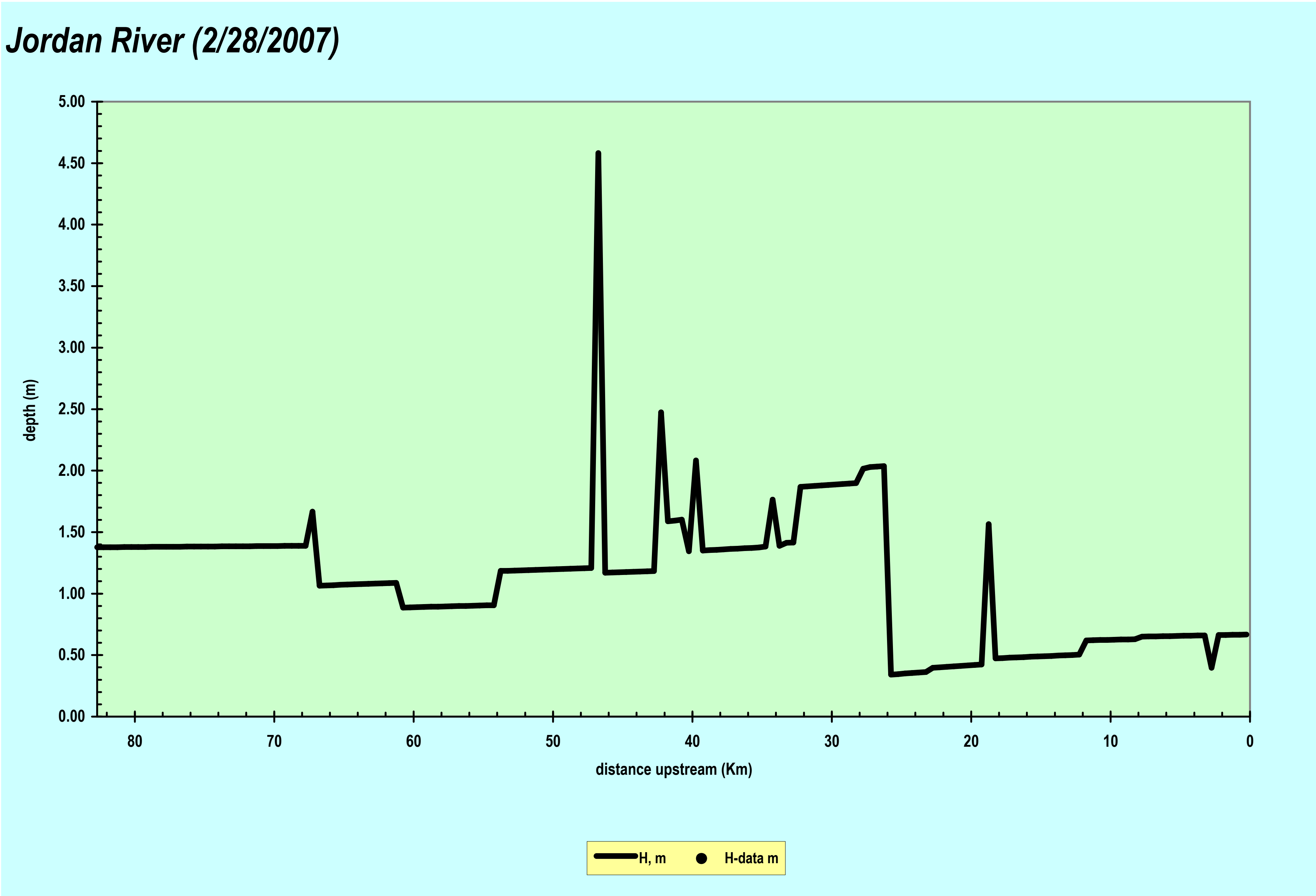
jordan_feb2007_q2kw_calwork.xls\Flow, 2/12/2010



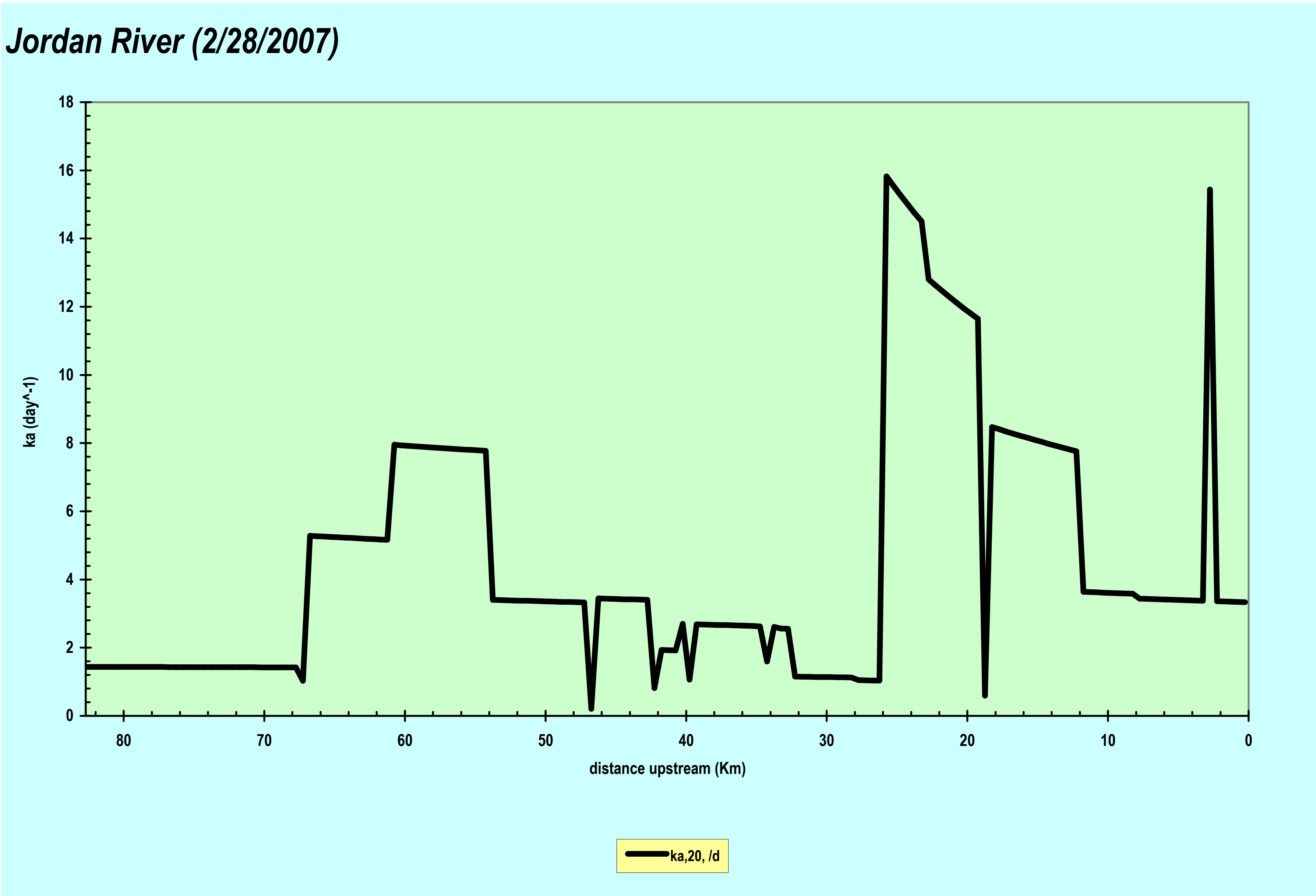
Jordan River (2/28/2007)
2.50
2.00
1.50
1.00
0.50
0.00
travel time (d)
80
70
60
50
40
30
20
10
0
distance upstream (Km)
trav time, d
Travel time data (d)



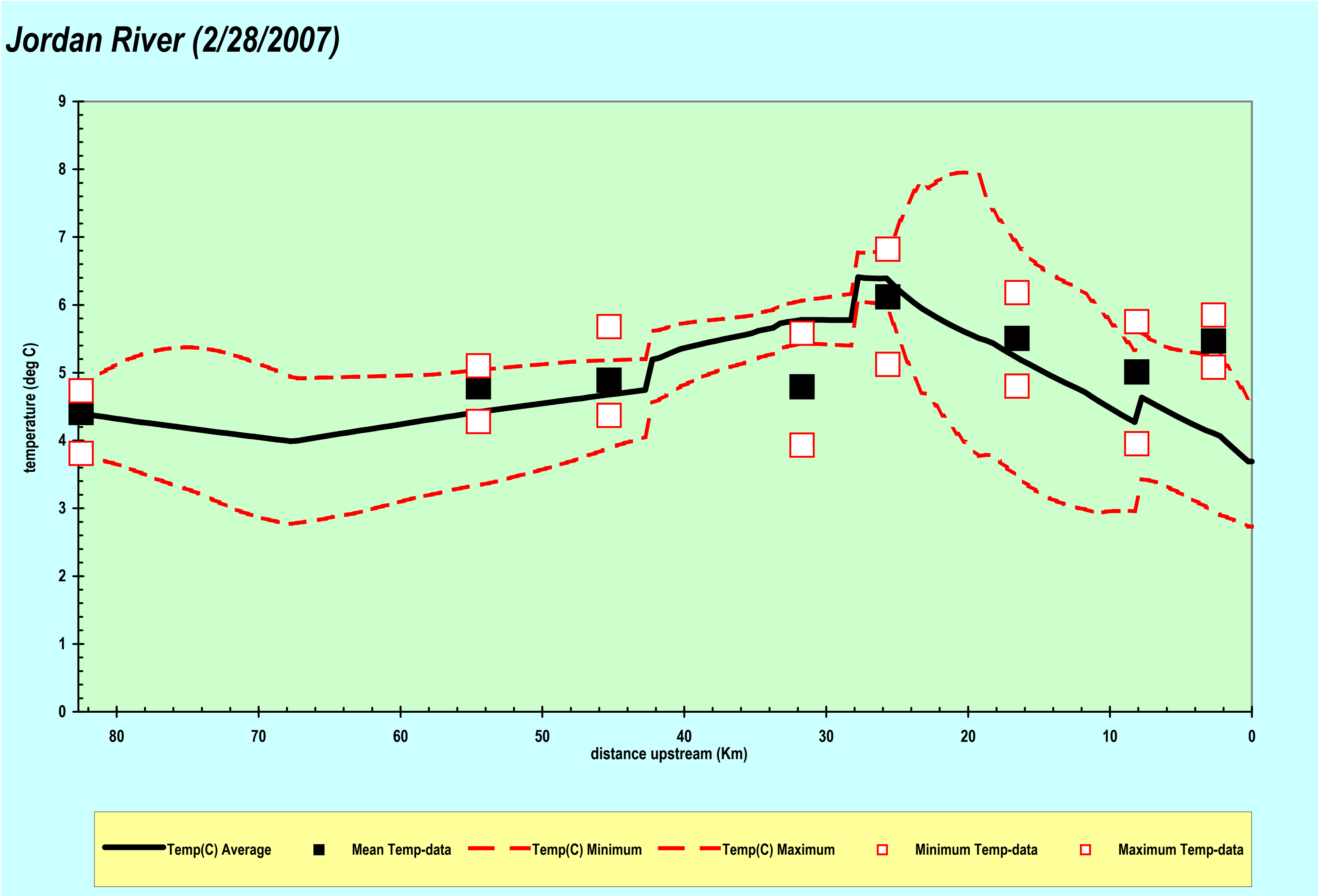
jordan_feb2007_q2kw_calwork.xls\Velocity, 2/12/2010



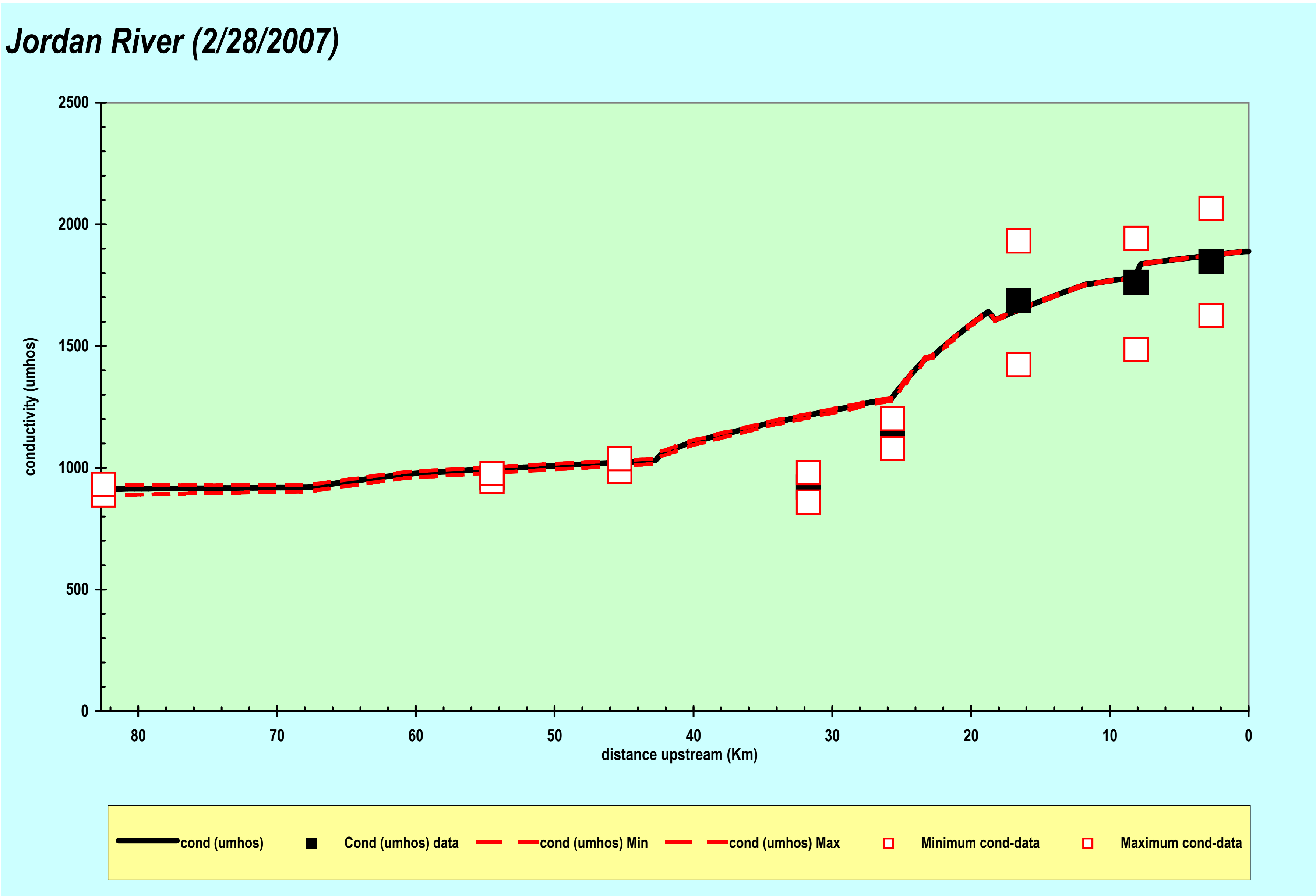
jordan_feb2007_q2kw_calwork.xls\Depth, 2/12/2010



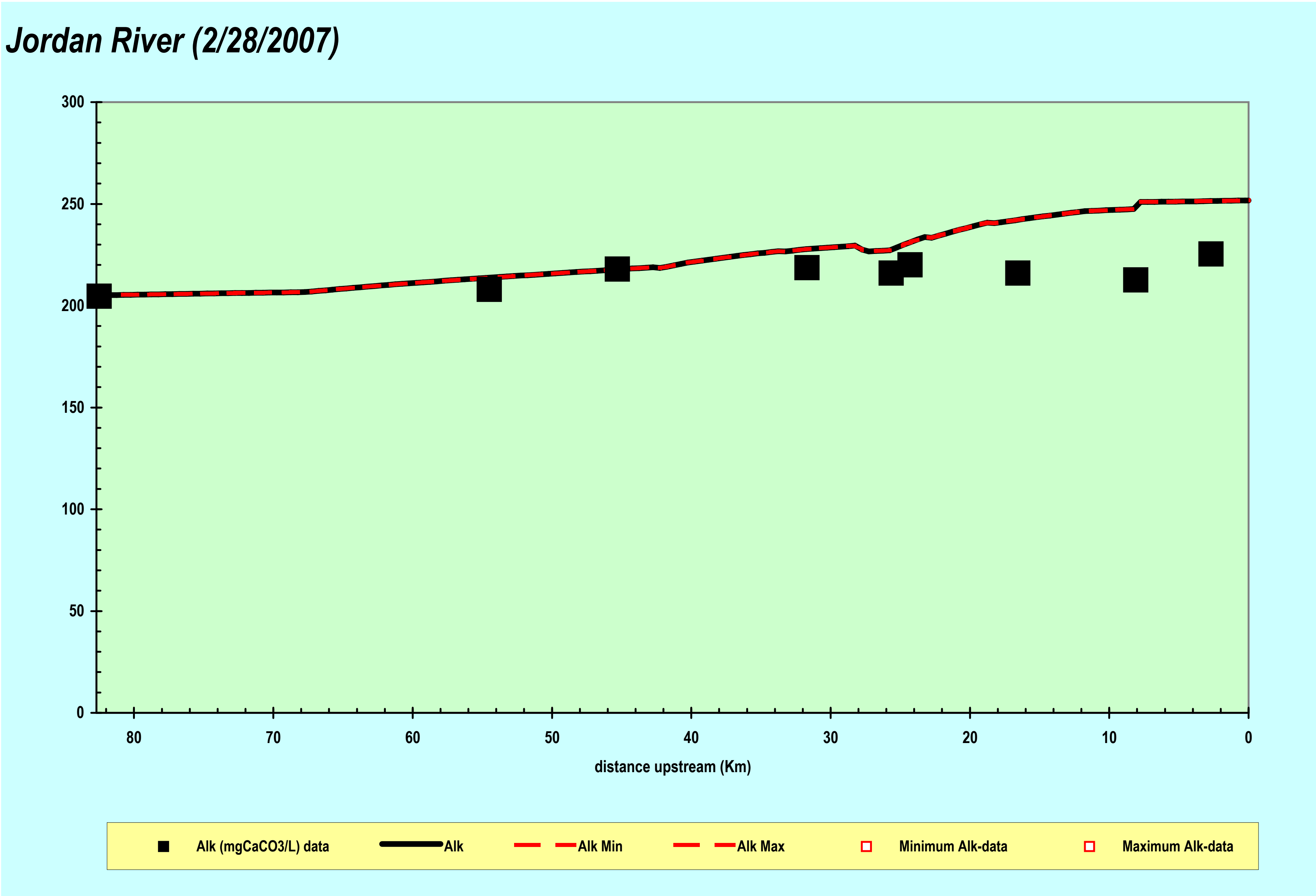
Jordan River (2/28/2007)
ka (day^-1)
18
16
14
12
10
8
6
4
2
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
ka,20, /d



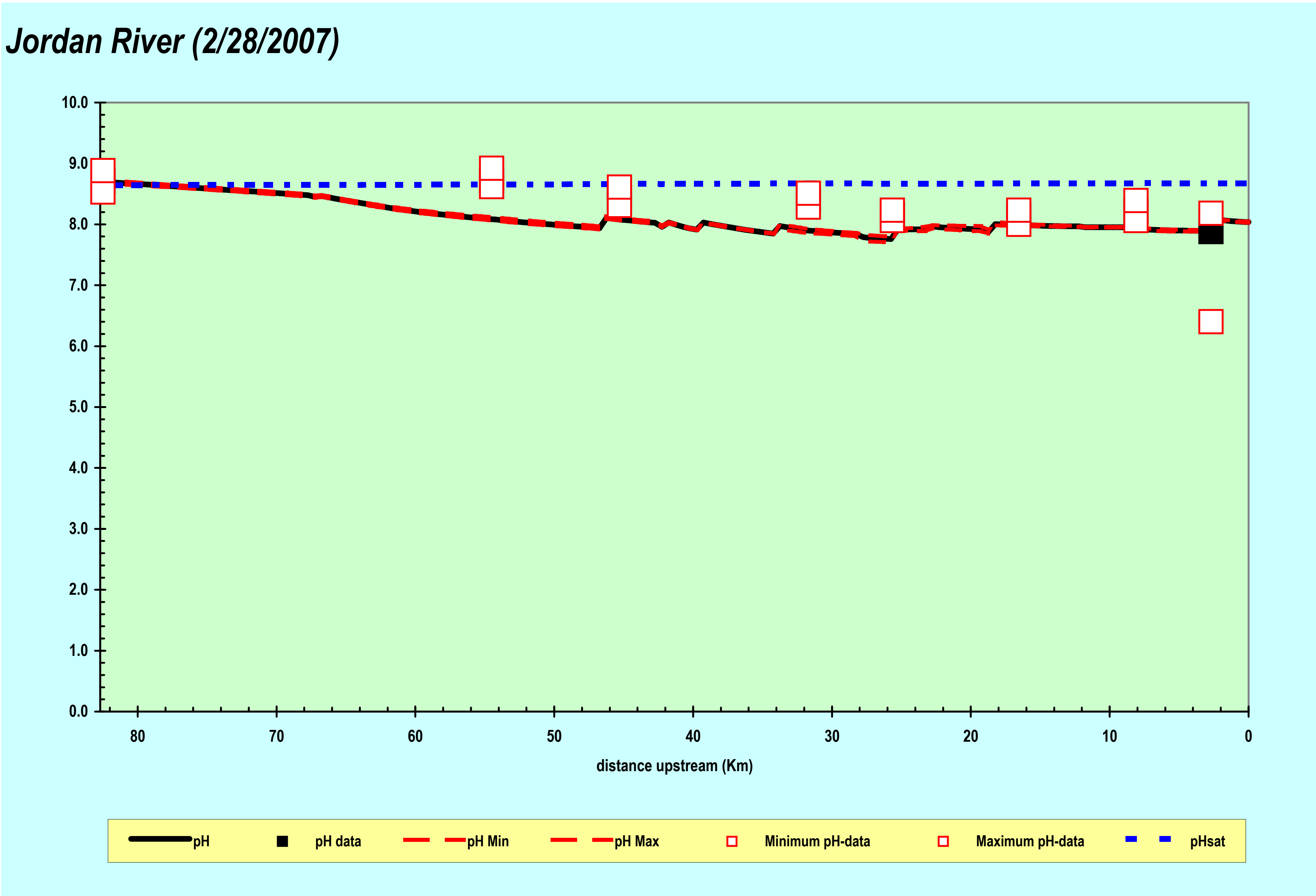
Jordan River (2/28/2007)
temperature (deg C)
distance upstream (Km)
0
1
2
3
4
5
6
7
8
9
80
70
60
50
40
30
20
10
0
Temp(C) Average
Mean Temp-data
Temp(C) Minimum
Temp(C) Maximum
Minimum Temp-data
Maximum Temp-data



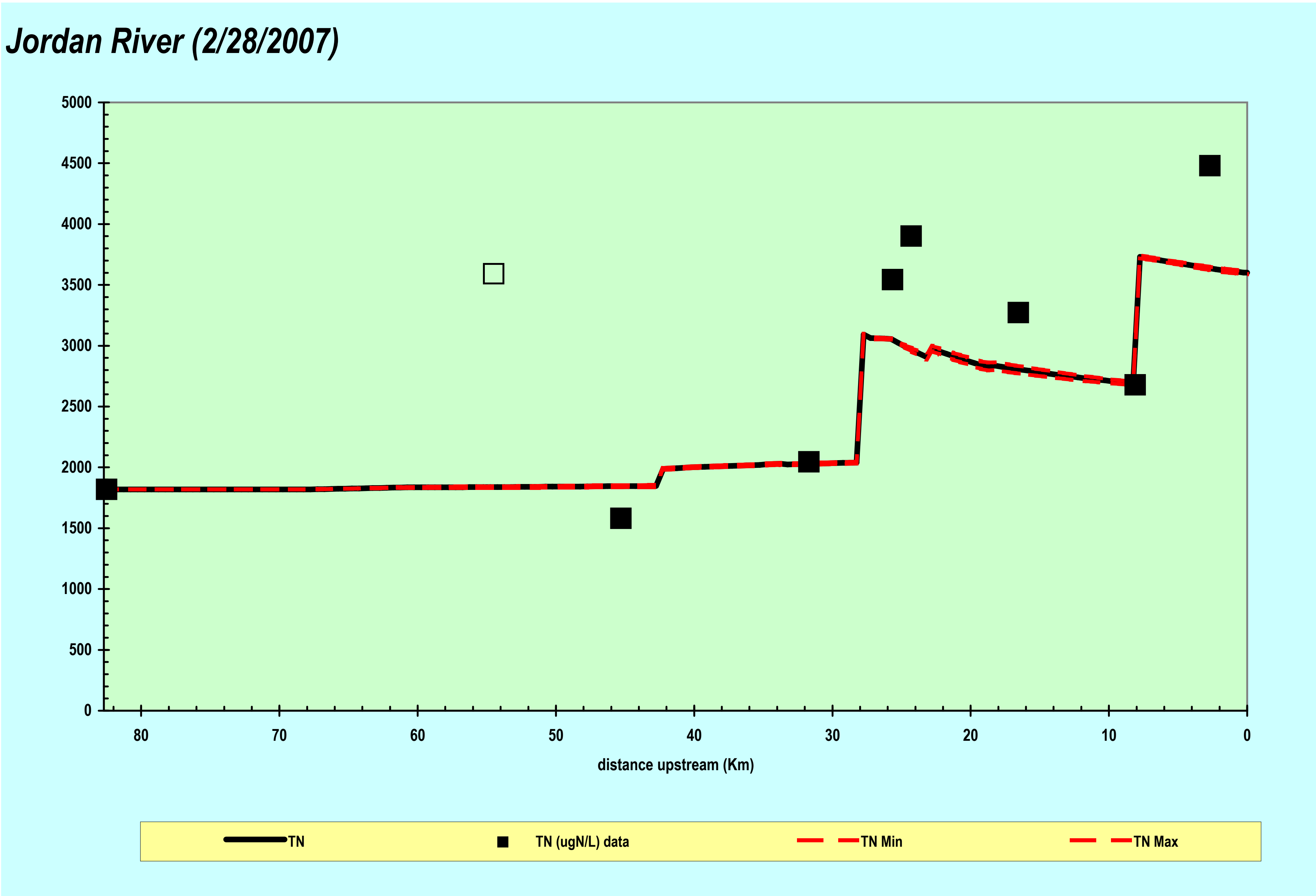
jordan_feb2007_q2kw_calwork.xls\Conductivity, 2/12/2010



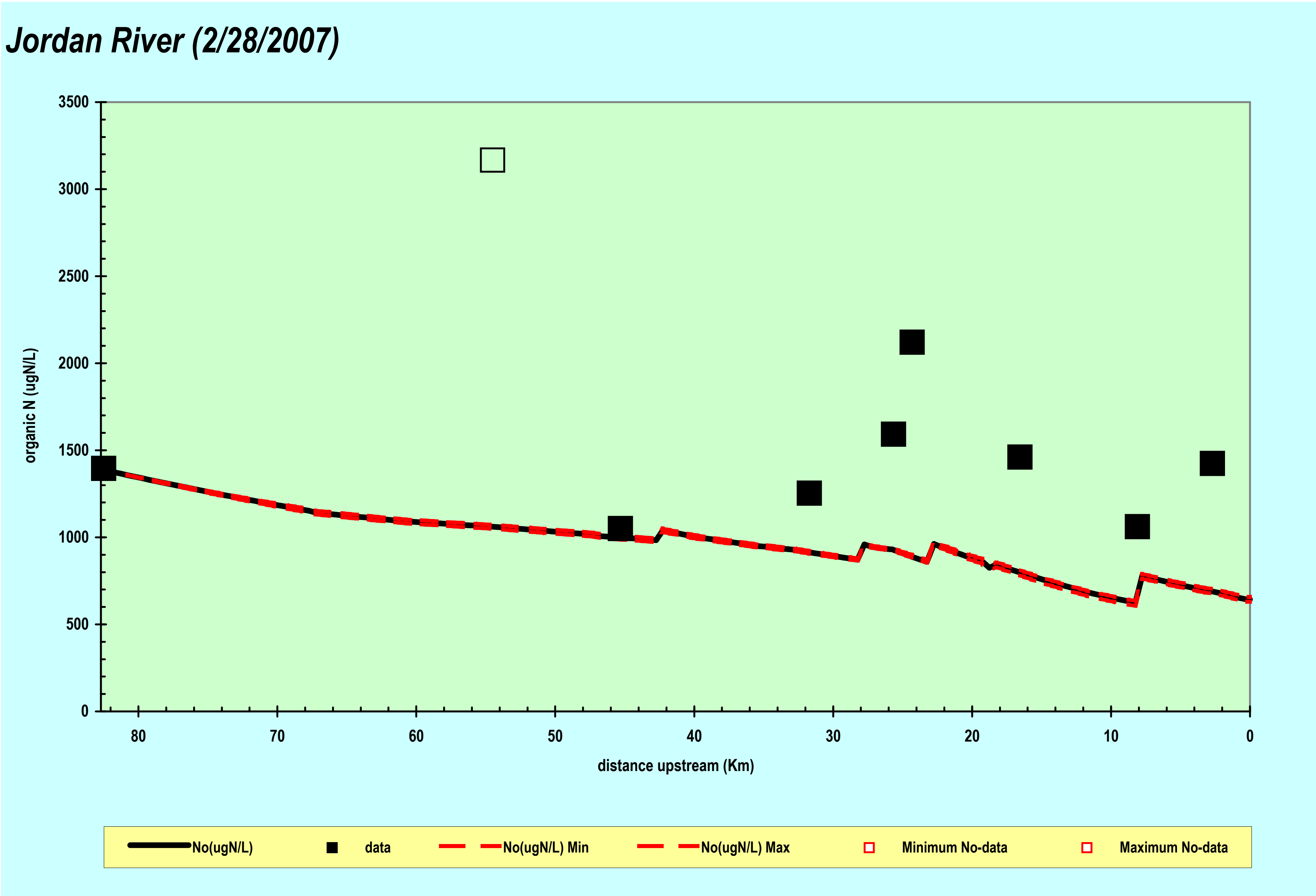
Jordan River (2/28/2007)
300
250
200
150
100
50
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Alk (mgCaCO3/L) data
Alk
Alk Min
Alk Max
Minimum Alk-data
Maximum Alk-data



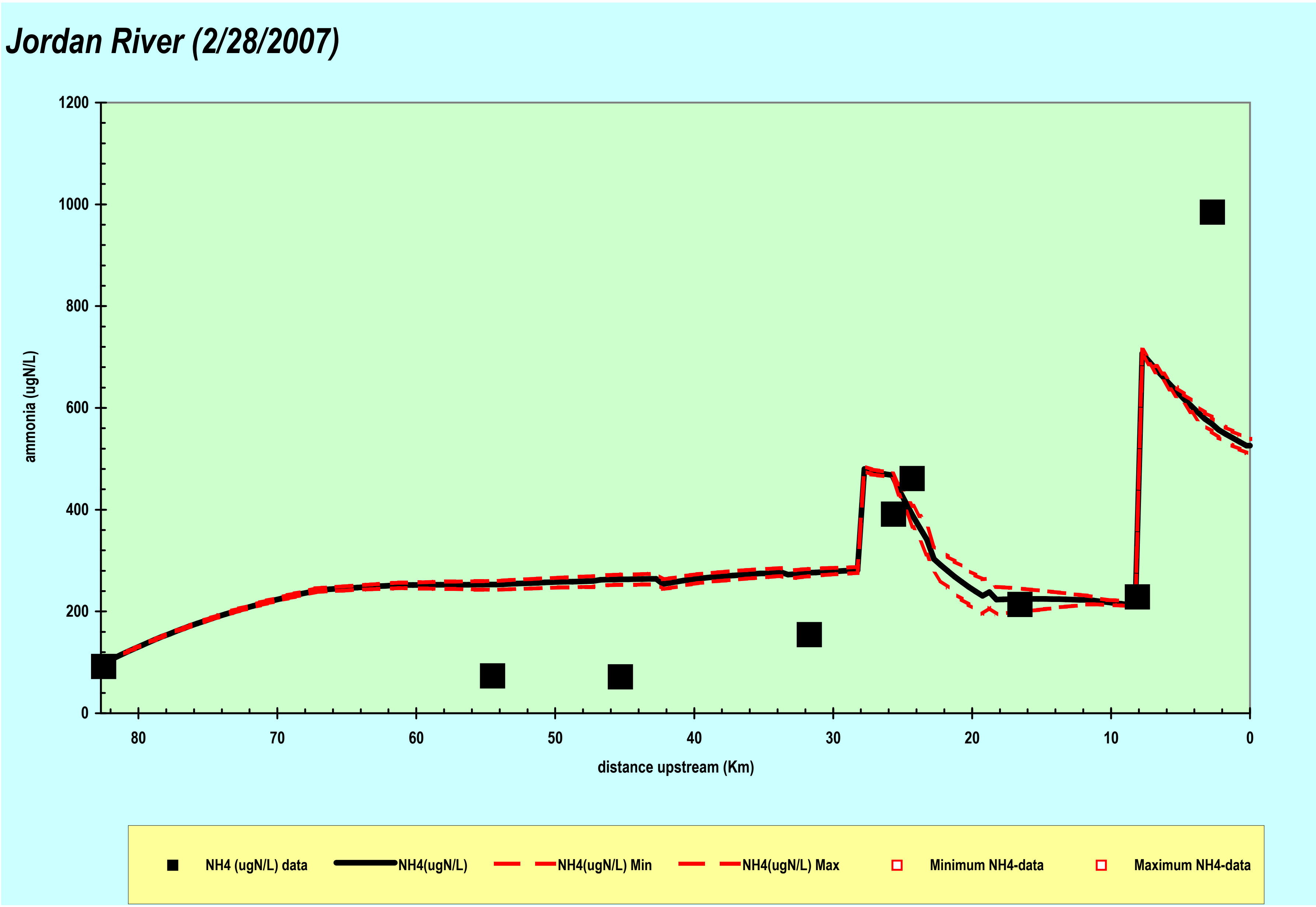
jordan_feb2007_q2kw_calwork.xls\pH, 2/12/2010

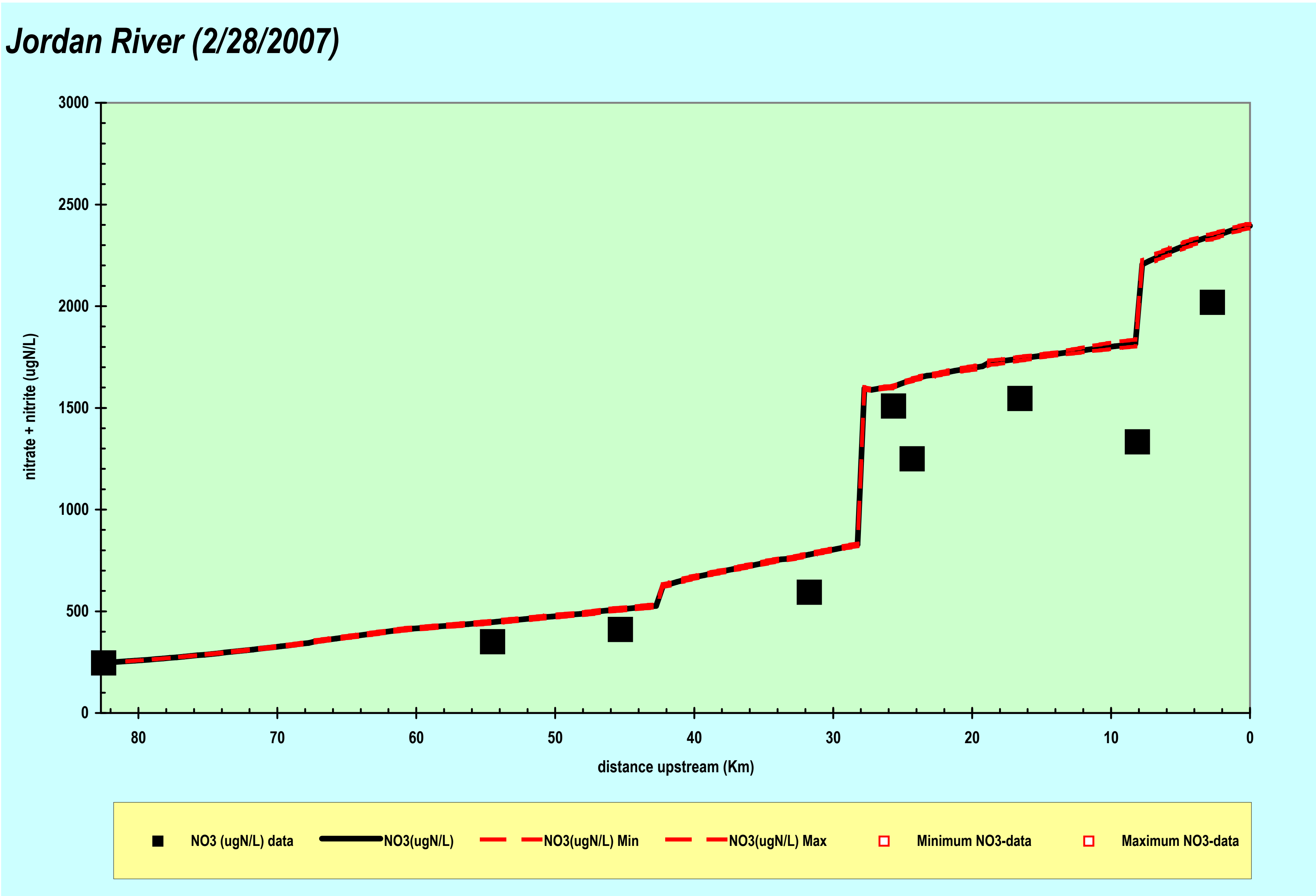


jordan_feb2007_q2kw_calwork.xls\Total N, 2/12/2010

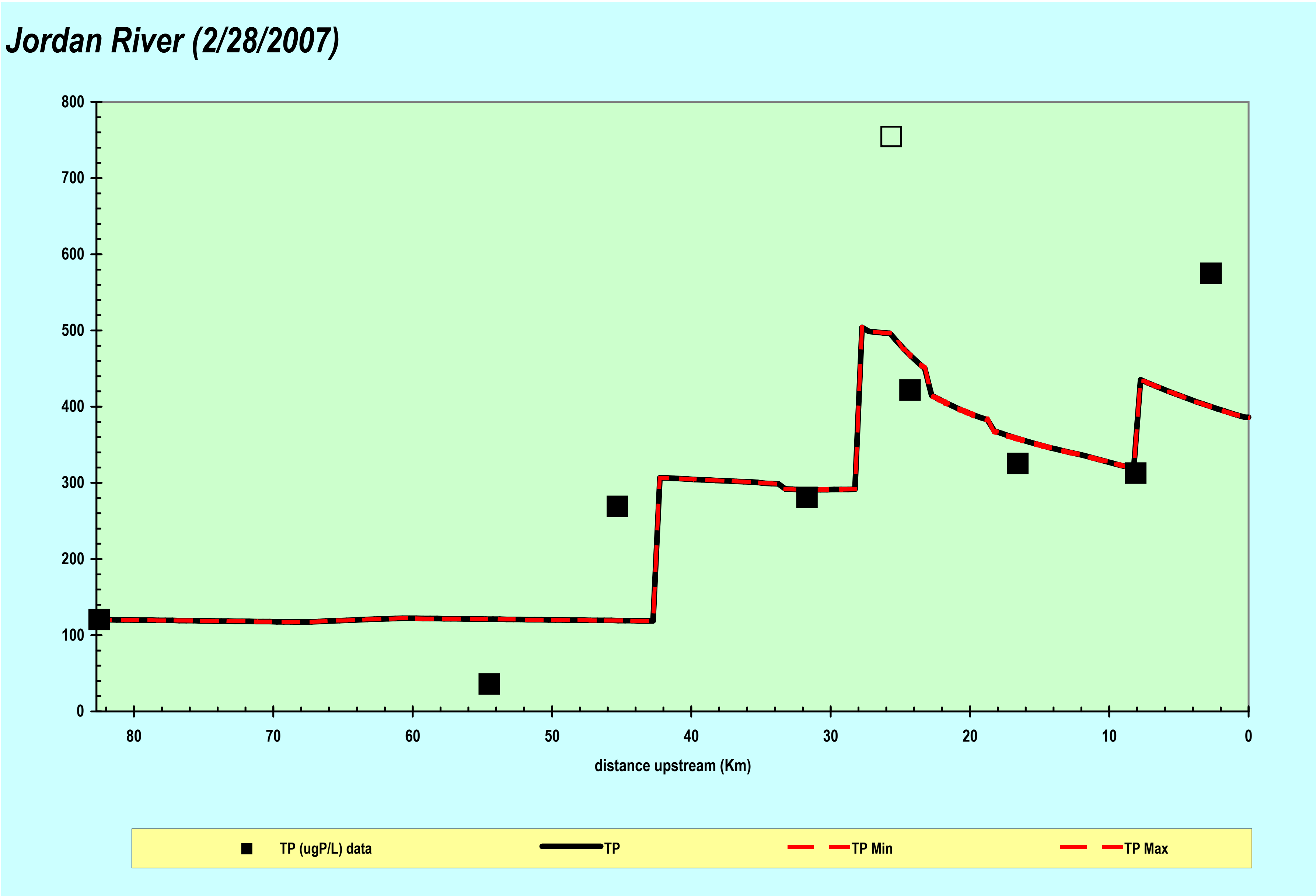


jordan_feb2007_q2kw_calwork.xls\Organic N, 2/12/2010

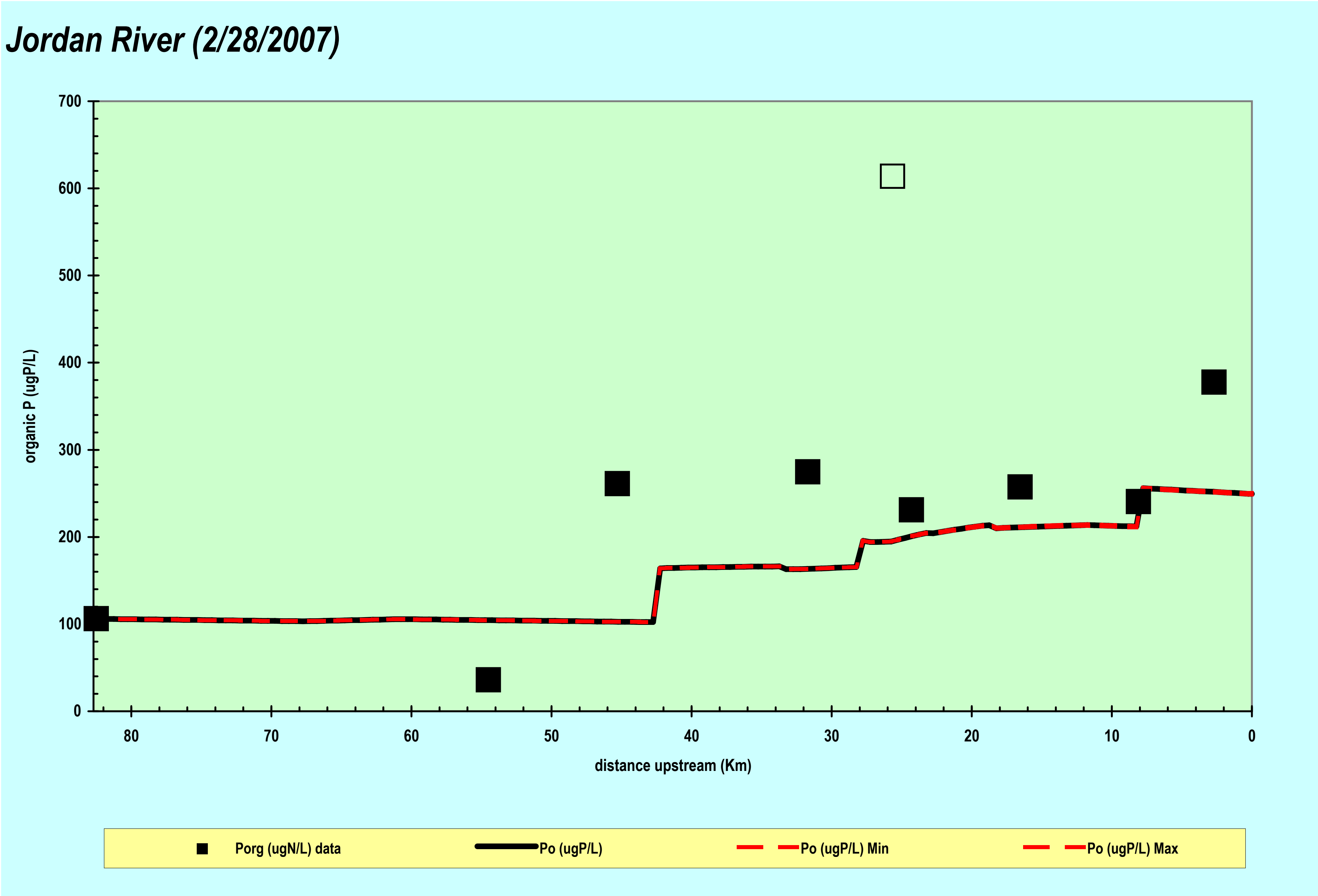

Jordan River (2/28/2007)
1200
1000
800
600
400
200
0
ammonia (ugN/L)
80
70
60
50
40
30
20
10
0
distance upstream (Km)
NH4 (ugN/L) data
NH4(ugN/L)
NH4(ugN/L) Min
NH4(ugN/L) Max
Minimum NH4-data
Maximum NH4-data



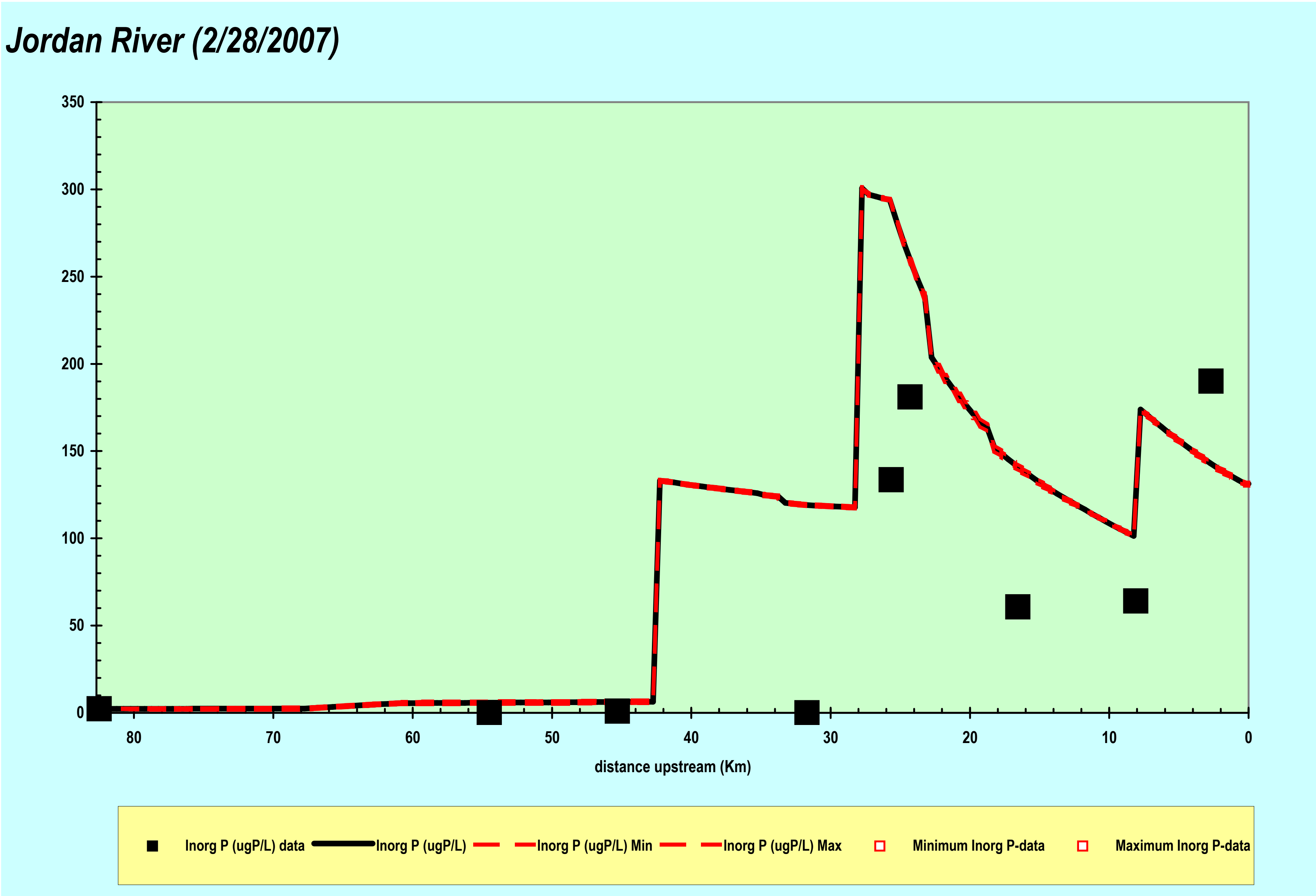
jordan_feb2007_q2kw_calwork.xls\NO3, 2/12/2010



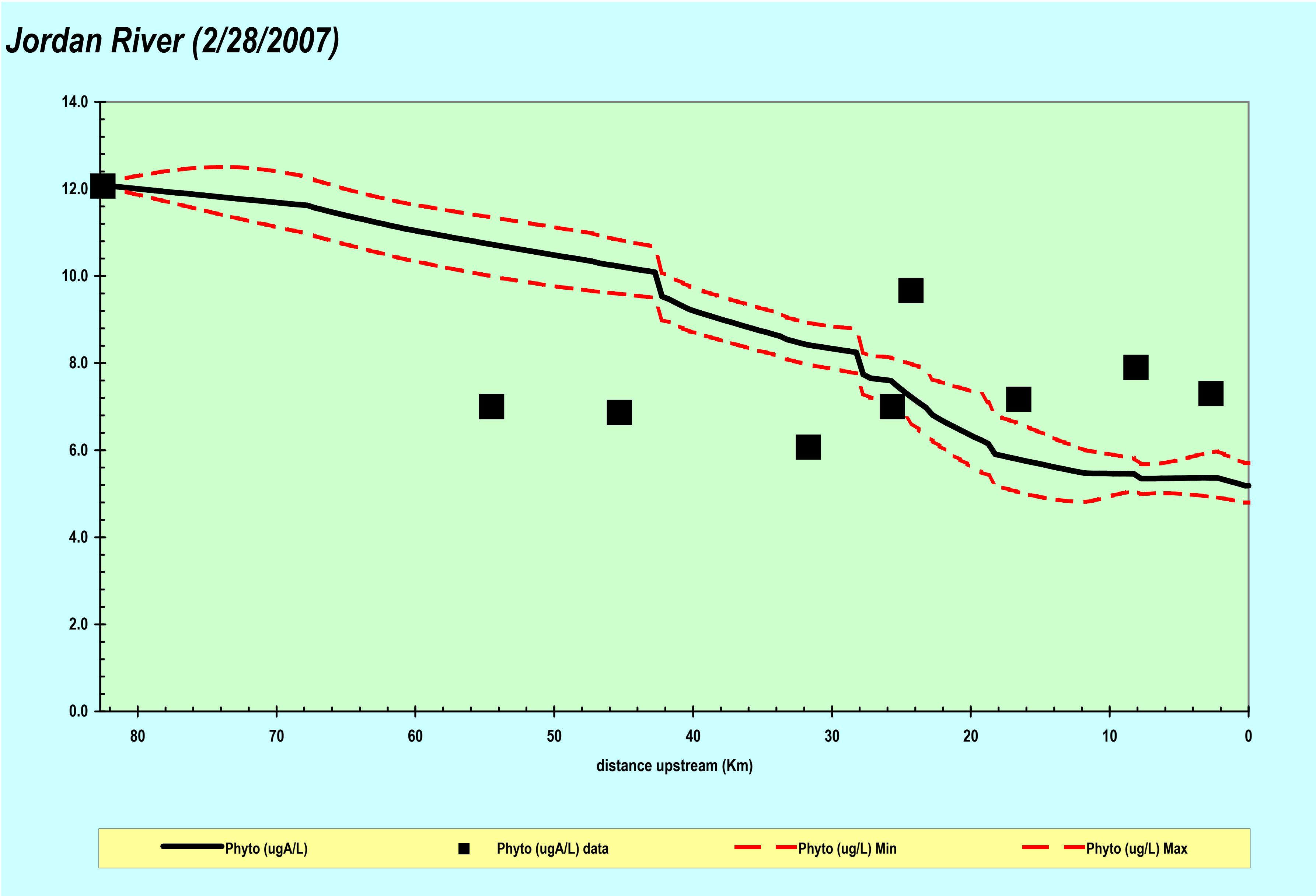
jordan_feb2007_q2kw_calwork.xls\Total P, 2/12/2010



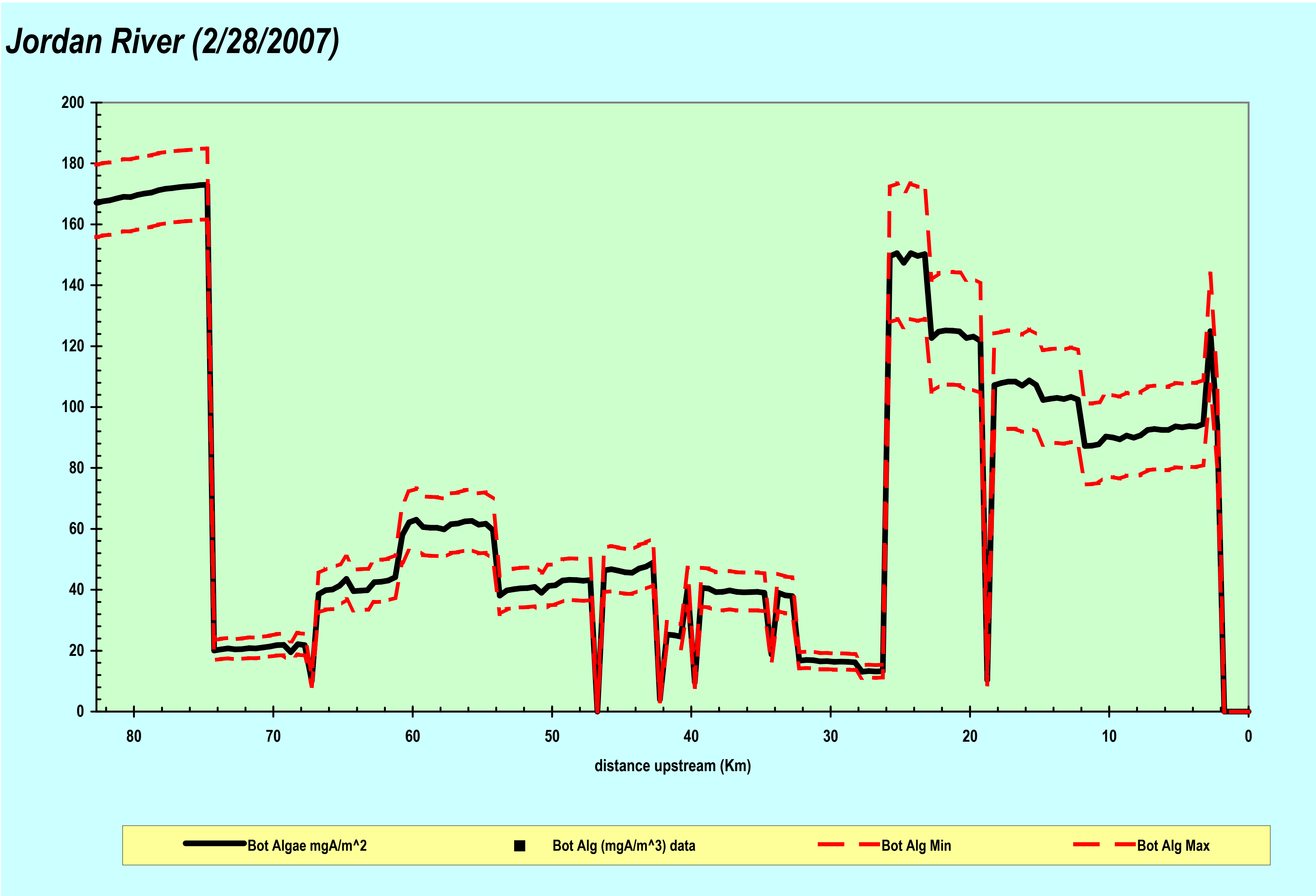
jordan_feb2007_q2kw_calwork.xls\Organic P, 2/12/2010



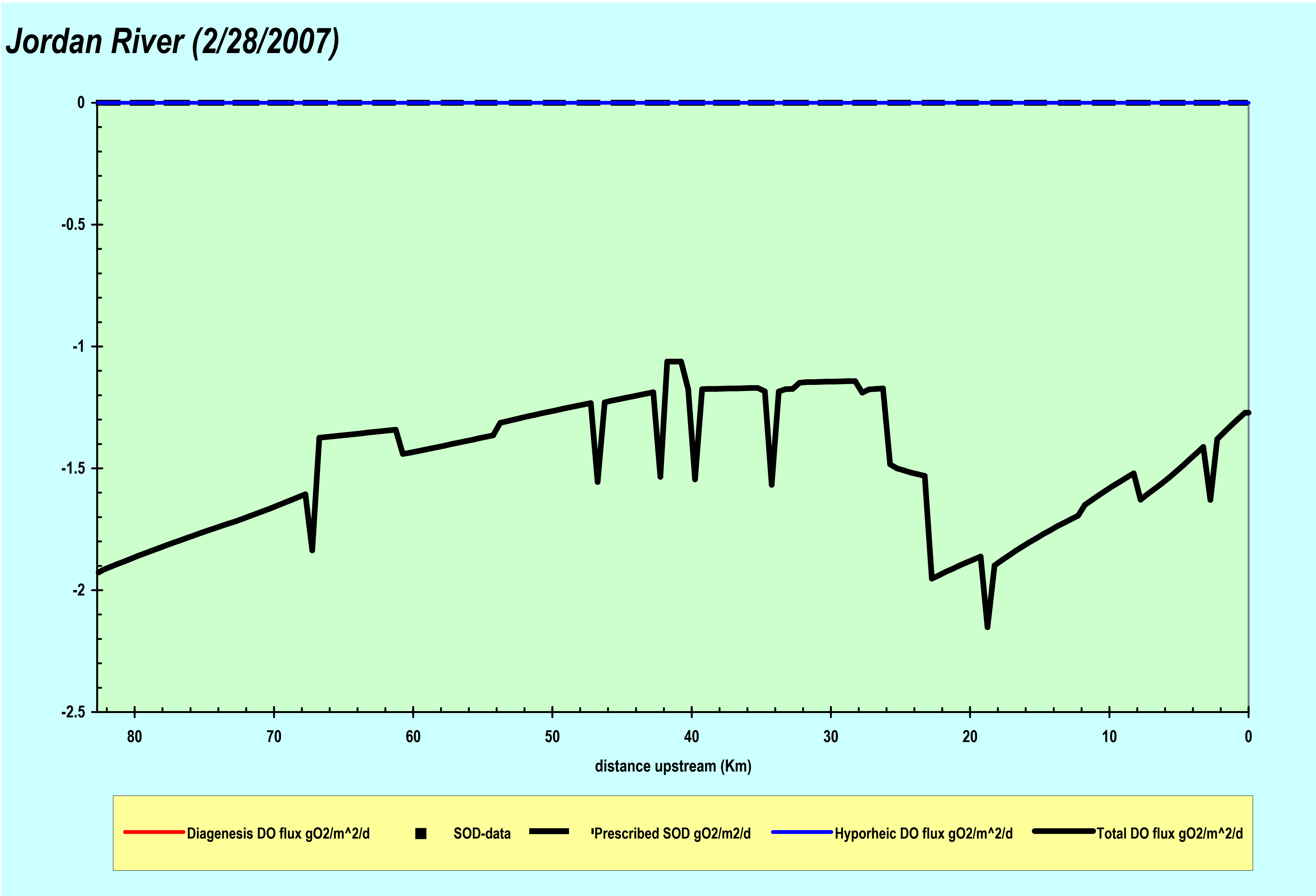
jordan_feb2007_q2kw_calwork.xls\Inorganic P, 2/12/2010



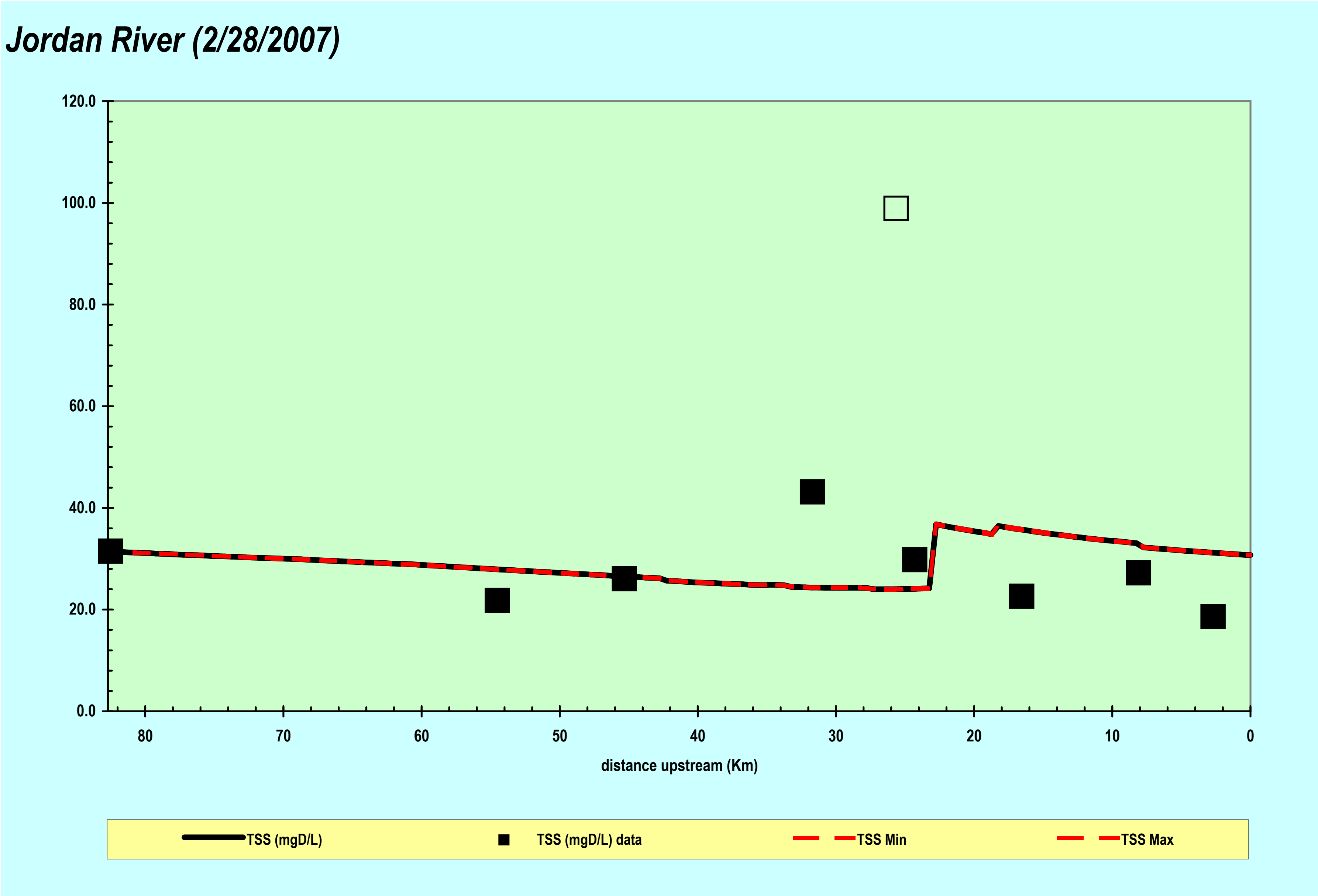
jordan_feb2007_q2kw_calwork.xls\Phytoplankton, 2/12/2010



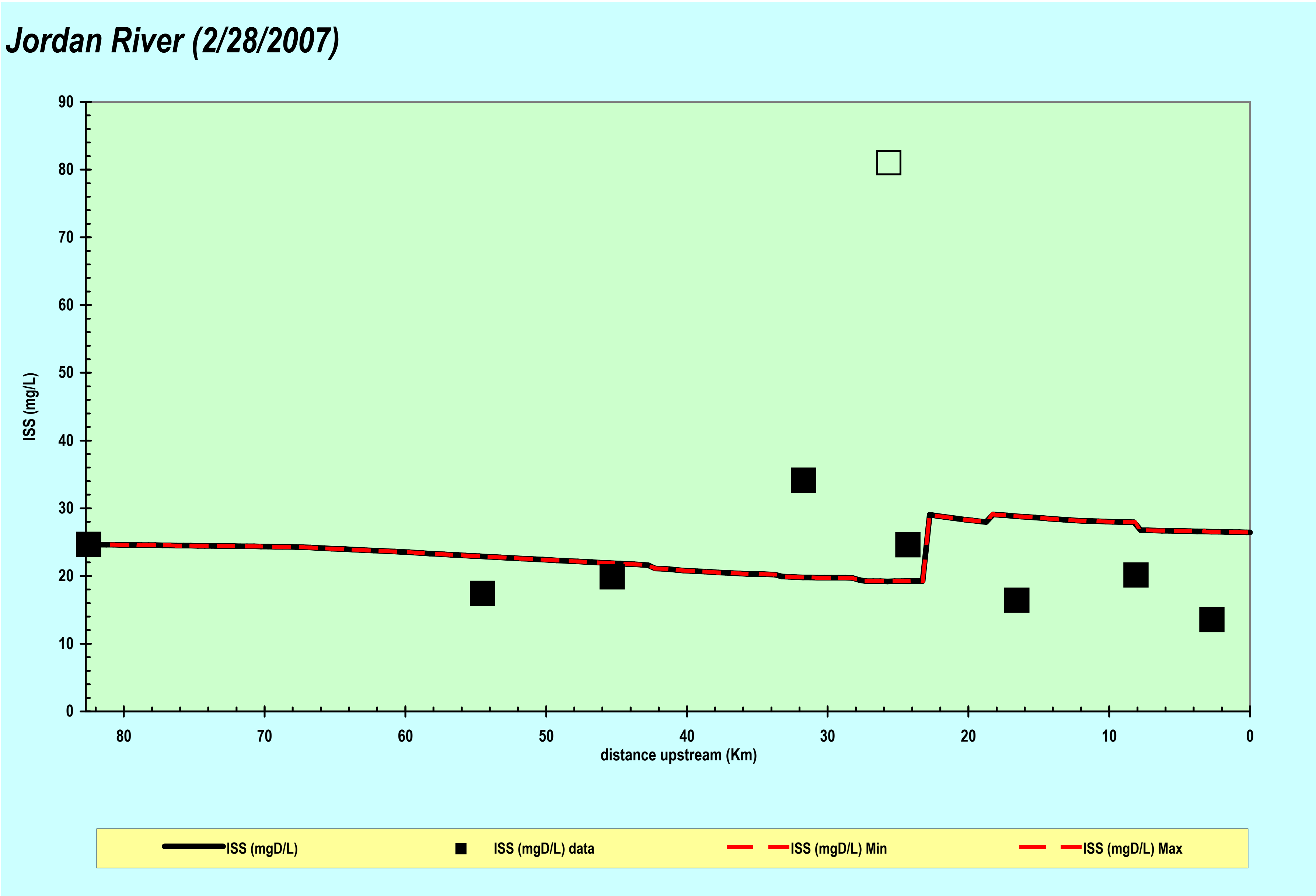
Jordan River (2/28/2007)
200
180
160
140
120
100
80
60
40
20
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Bot Algae mgA/m^2
Bot Alg (mgA/m^3) data
Bot Alg Min
Bot Alg Max



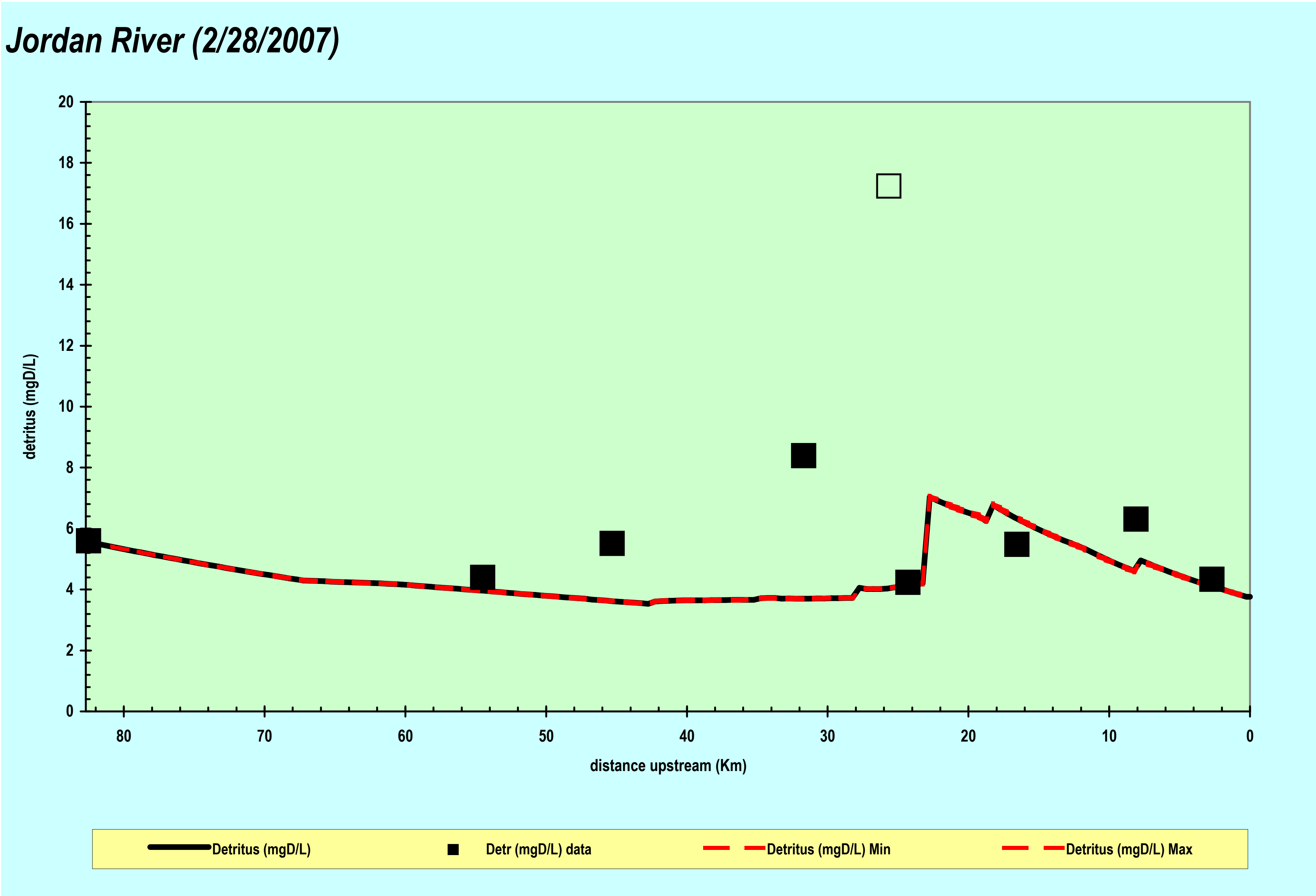
Jordan River (2/28/2007)
0
-0.5
-1
-1.5
-2
-2.5
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Diagenesis DO flux gO2/m^2/d
SOD-data
Prescribed SOD gO2/m2/d
Hyporheic DO flux gO2/m^2/d
Total DO flux gO2/m^2/d



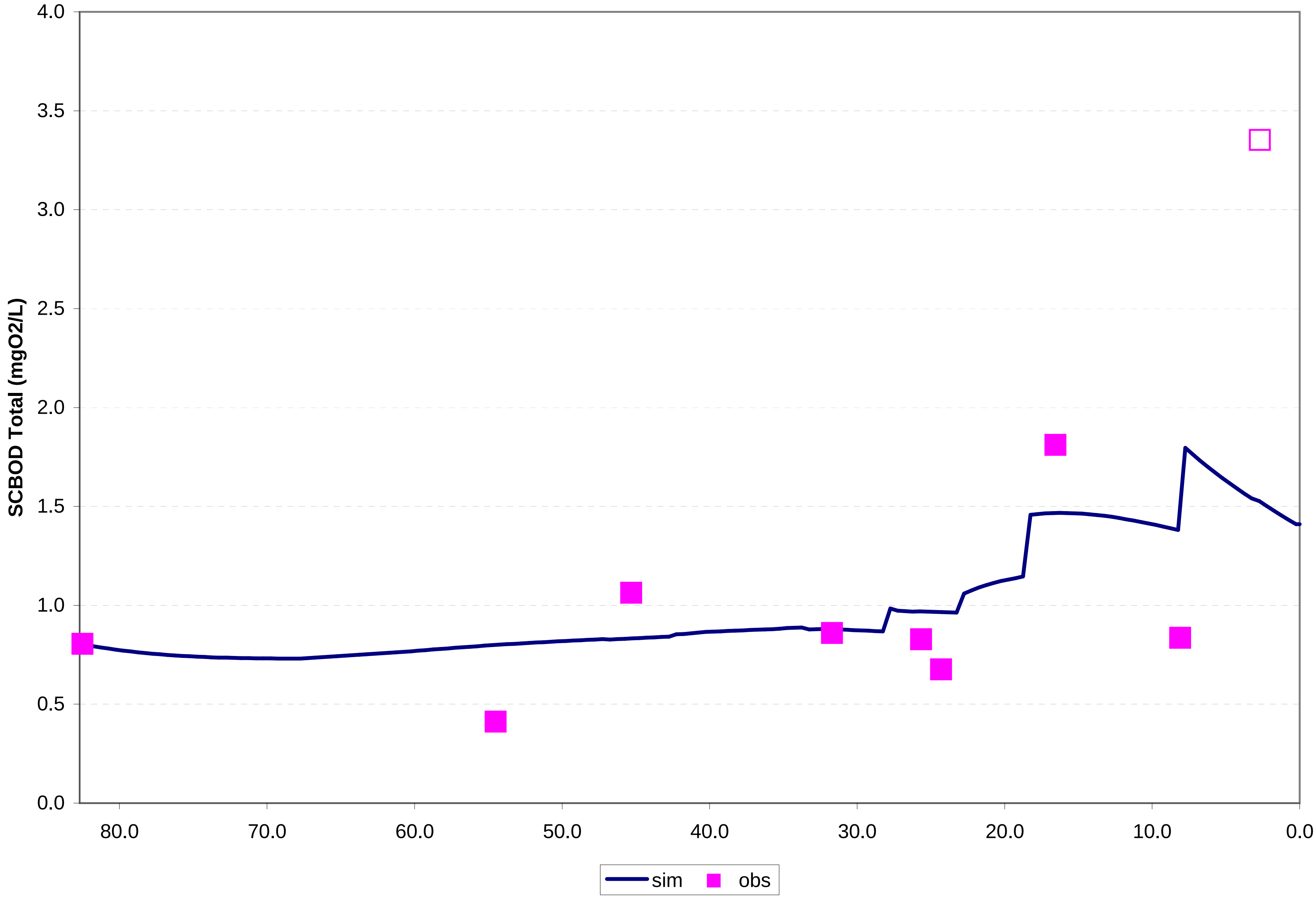
jordan_feb2007_q2kw_calwork.xls\TSS, 2/12/2010



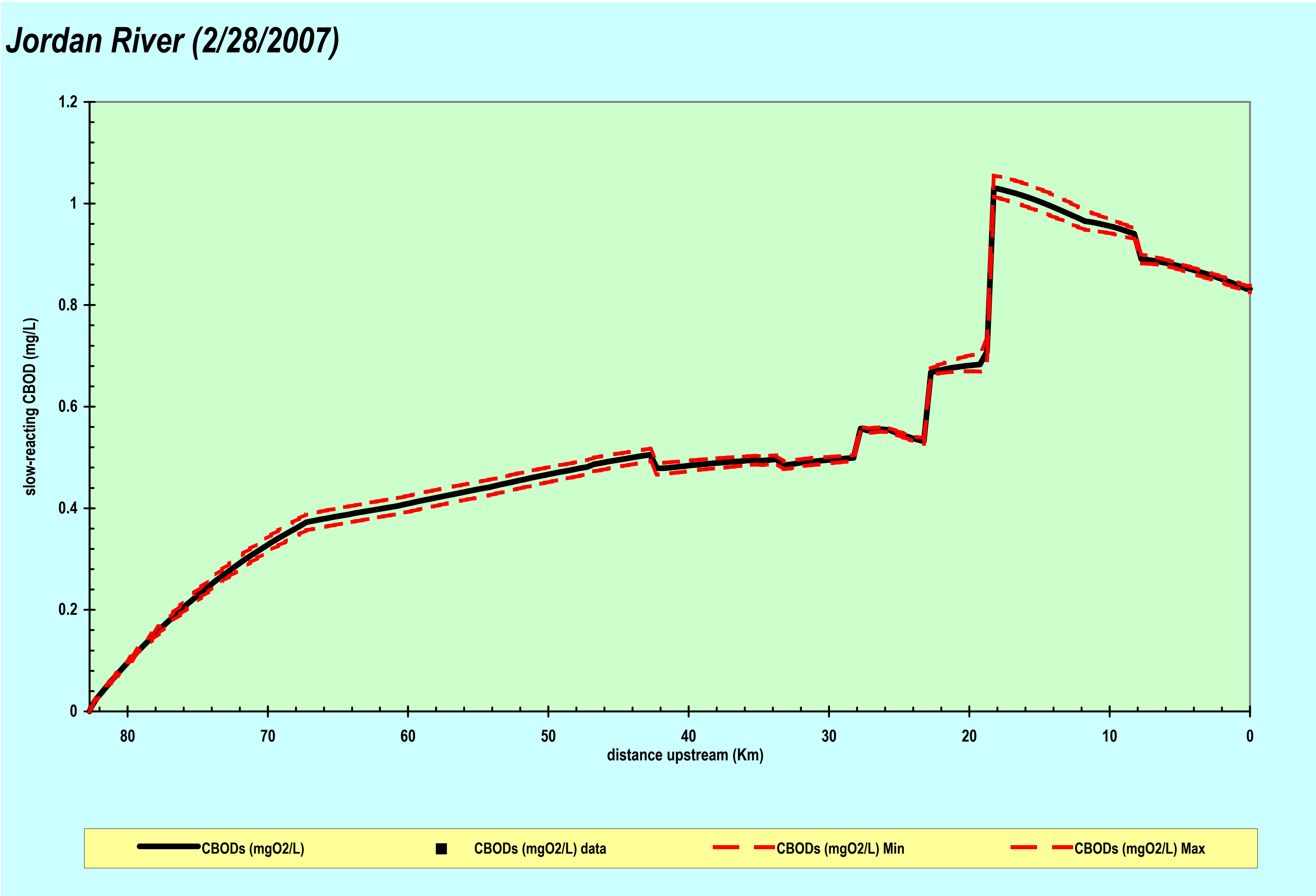
jordan_feb2007_q2kw_calwork.xls\ISS, 2/12/2010



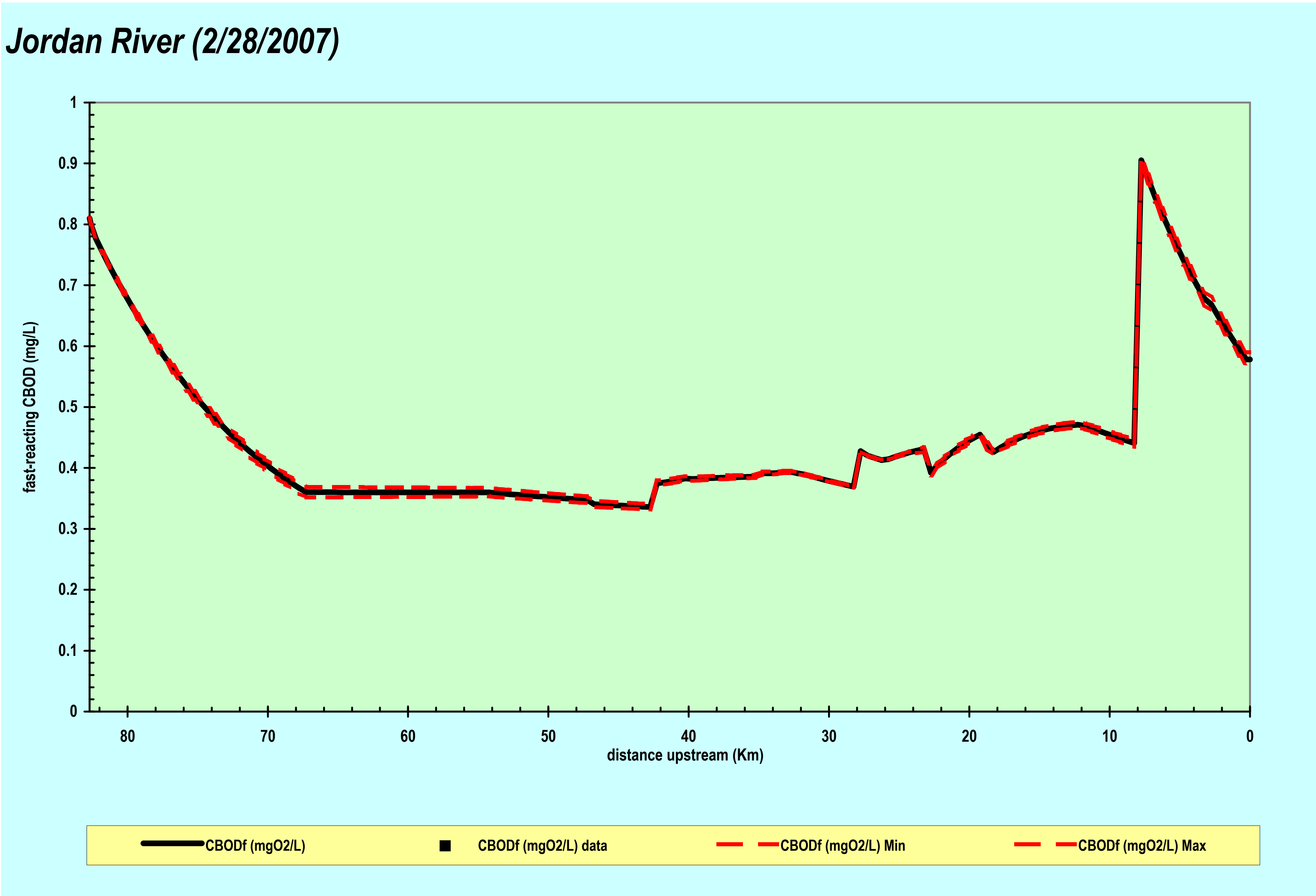
jordan_feb2007_q2kw_calwork.xls\Detritus, 2/12/2010



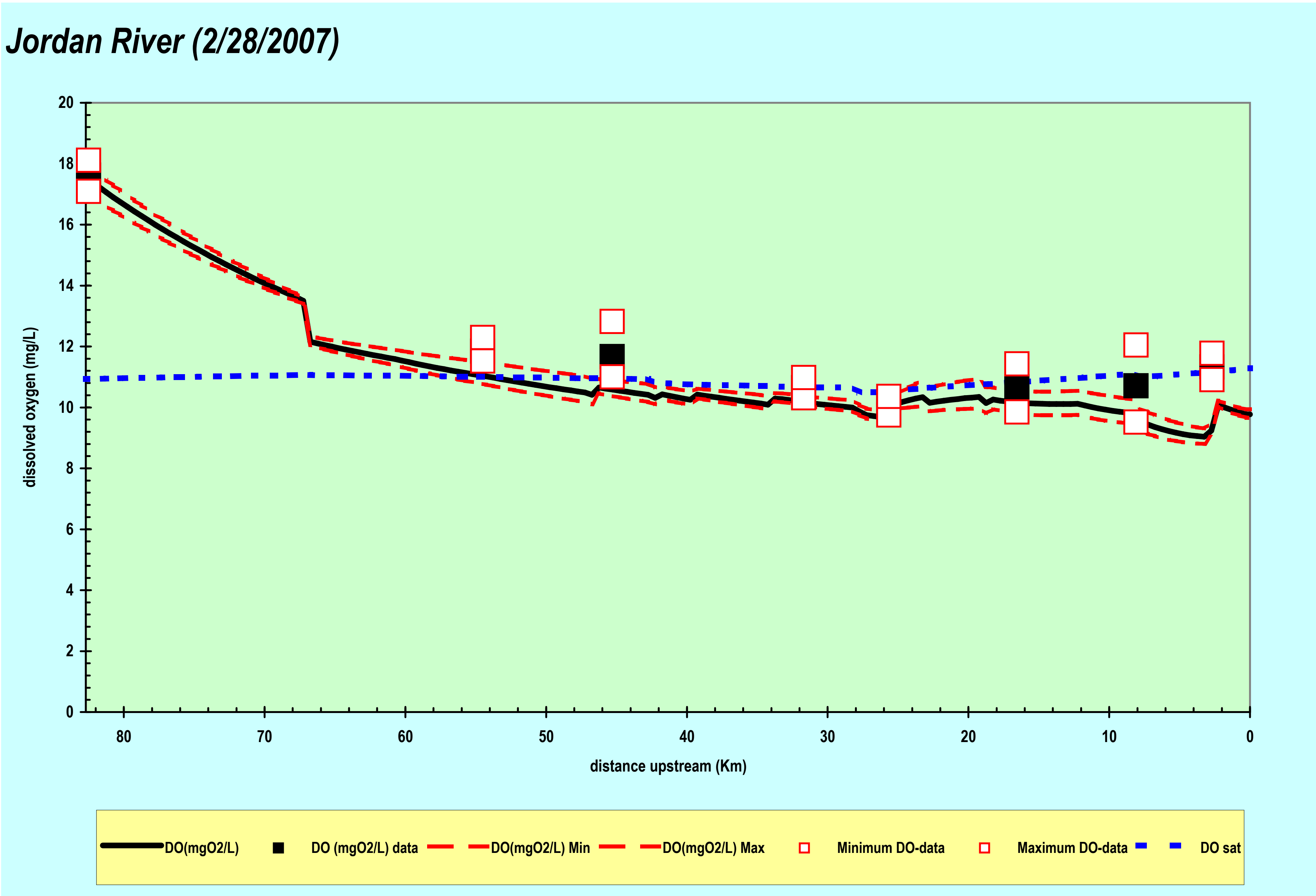
SCBOD Total (mgO2/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
sim
obs



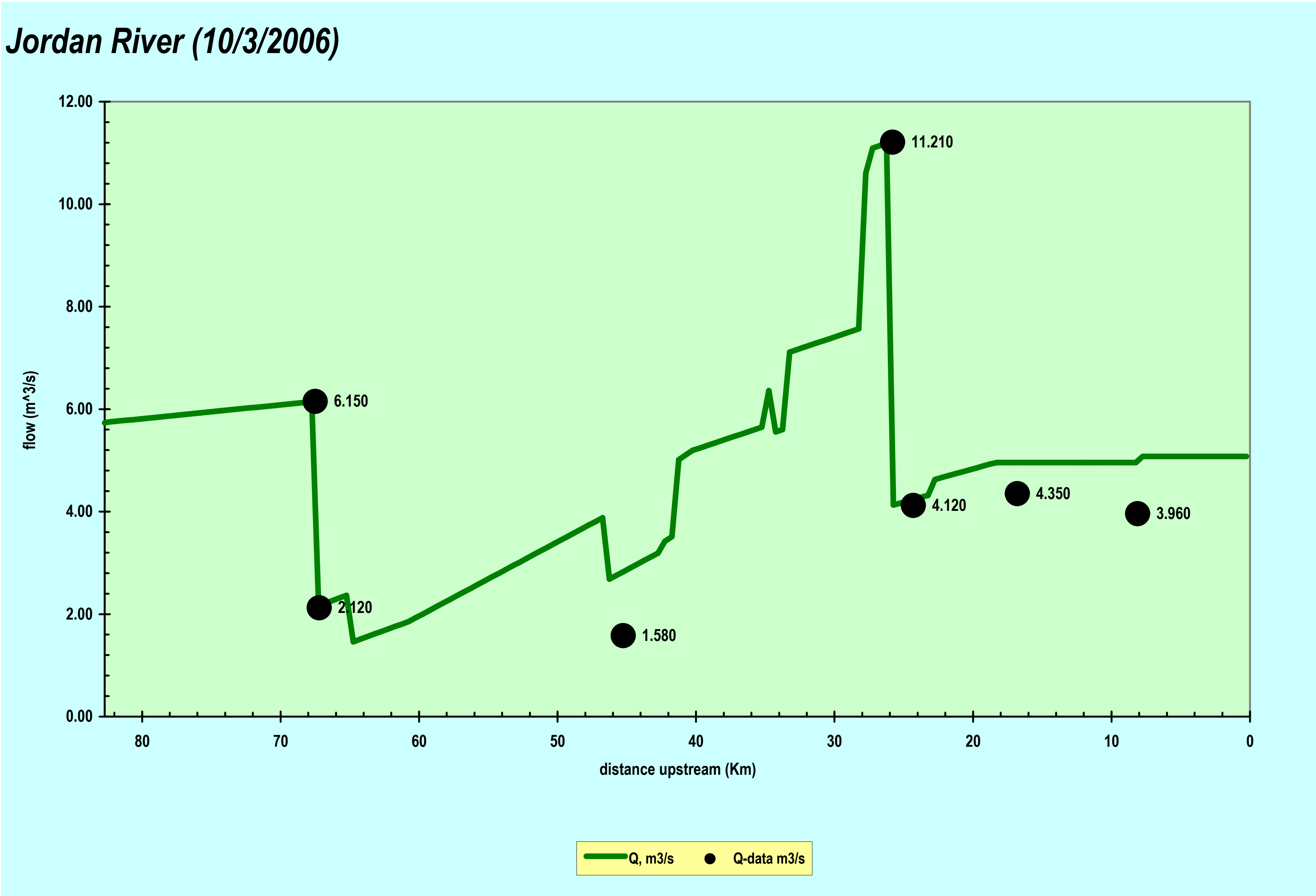
jordan_feb2007_q2kw_calwork.xls\CBOD slow, 2/12/2010



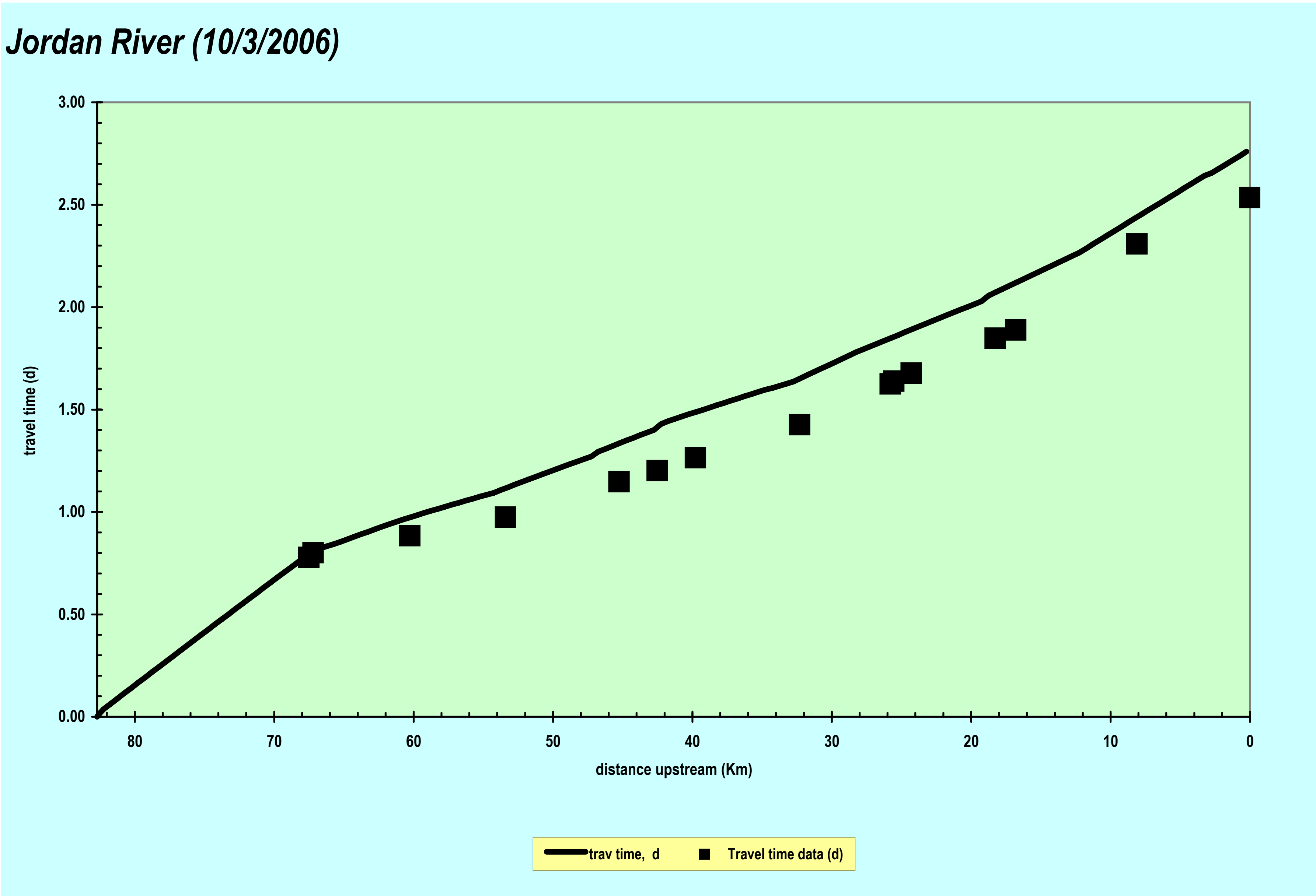
jordan_feb2007_q2kw_calwork.xls\CBOD fast, 2/12/2010



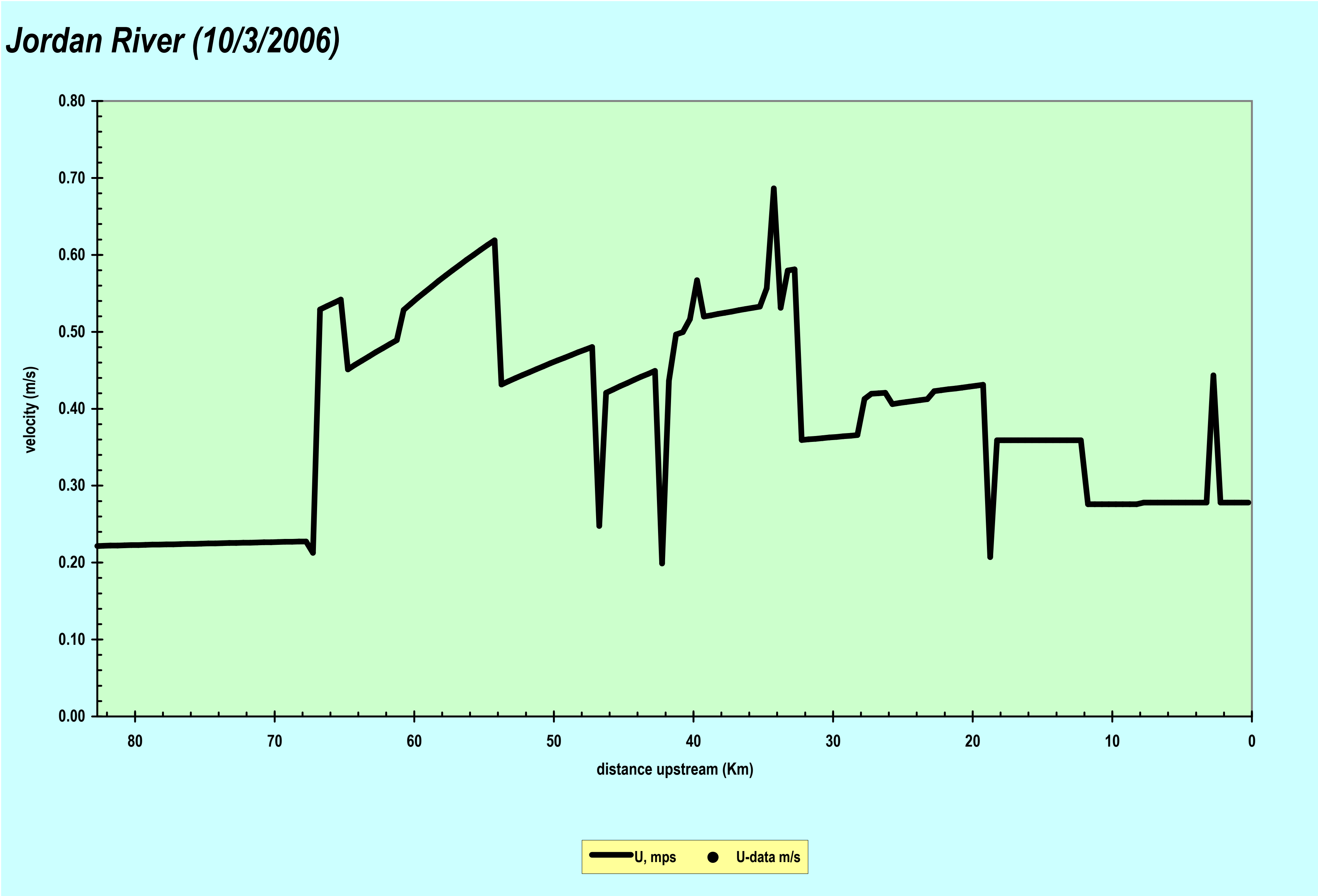
jordan_feb2007_q2kw_calwork.xls\Dissolved Oxygen, 2/12/2010



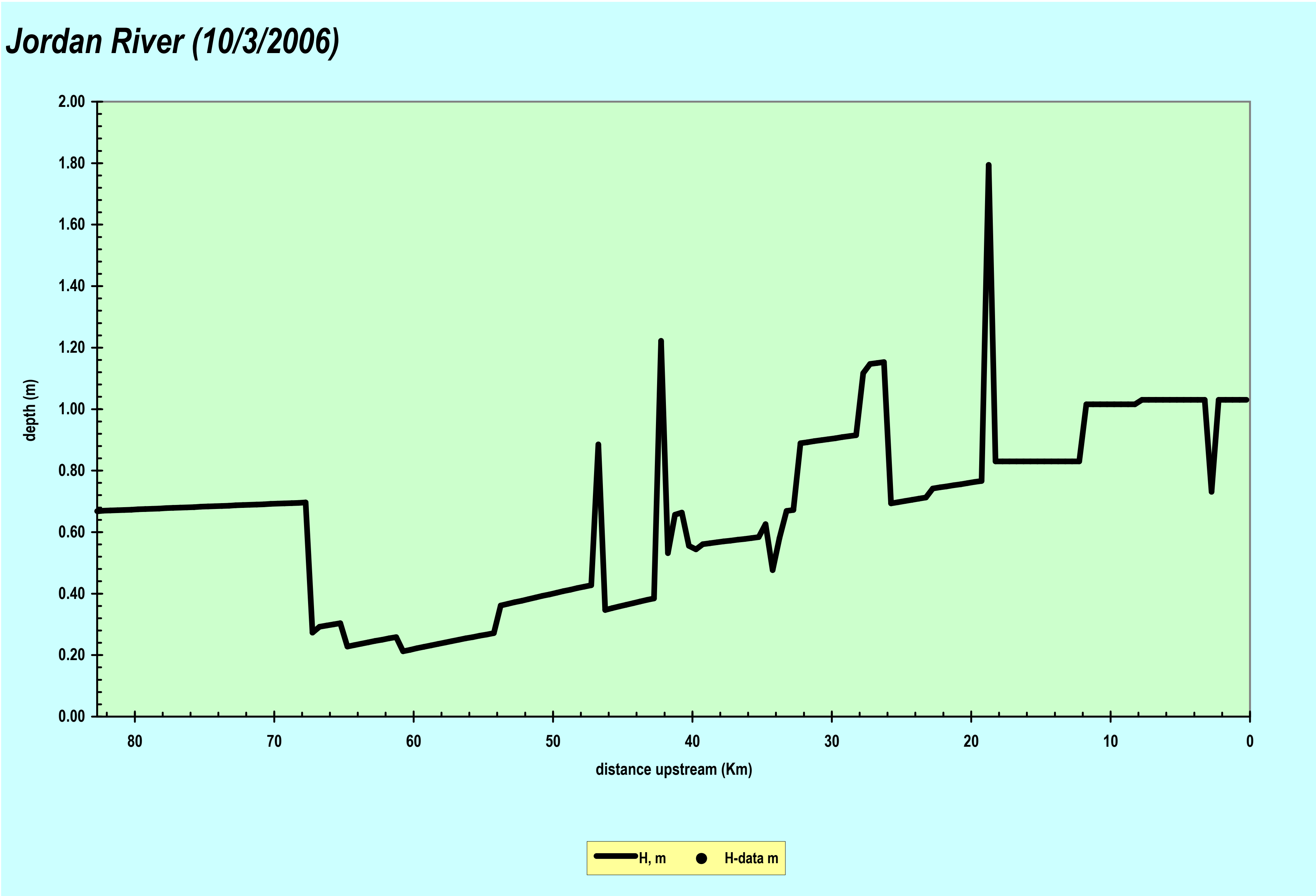
jordan_oct2006_q2kw_calwork.xls\Flow, 2/12/2010



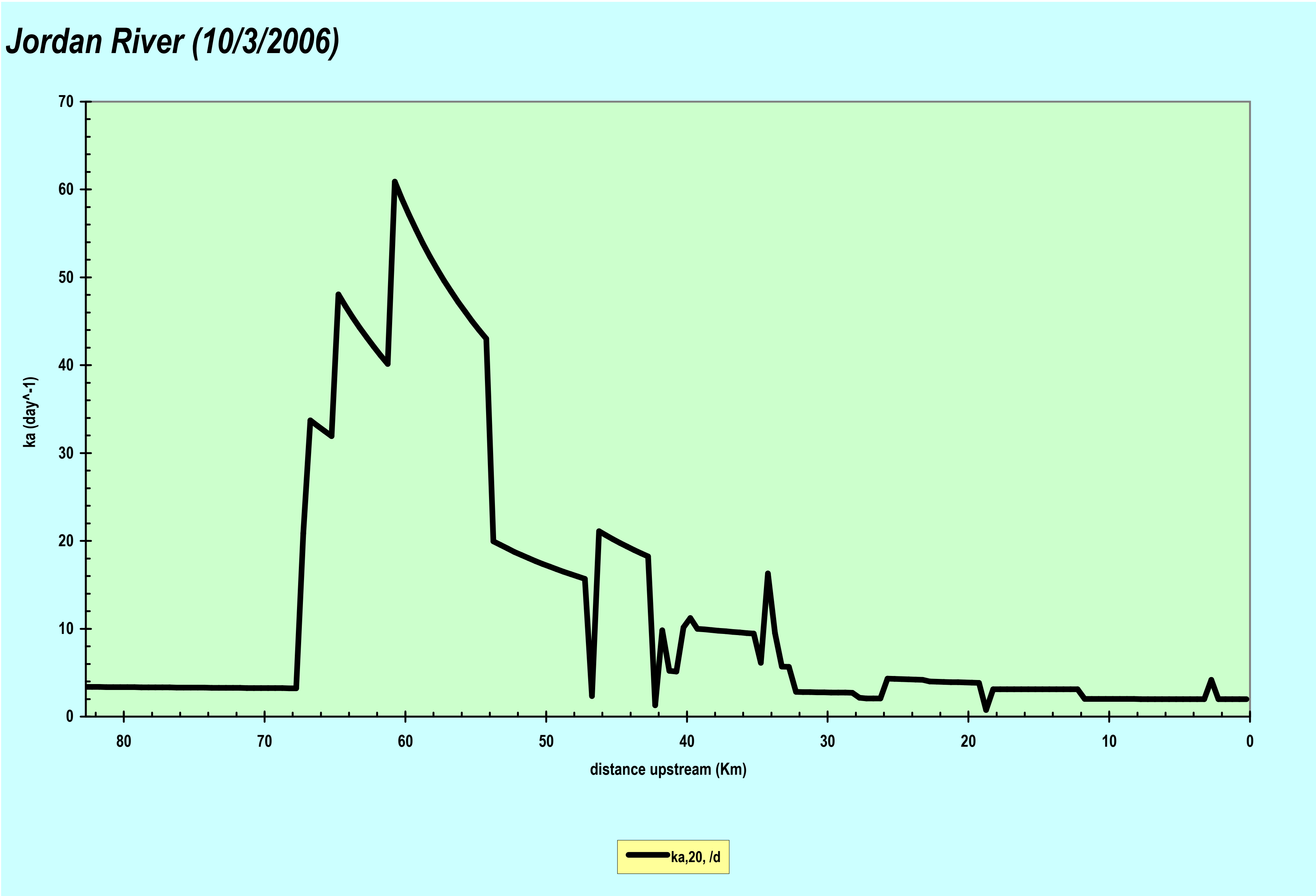
jordan_oct2006_q2kw_calwork.xls\Travel Time, 2/10/2010



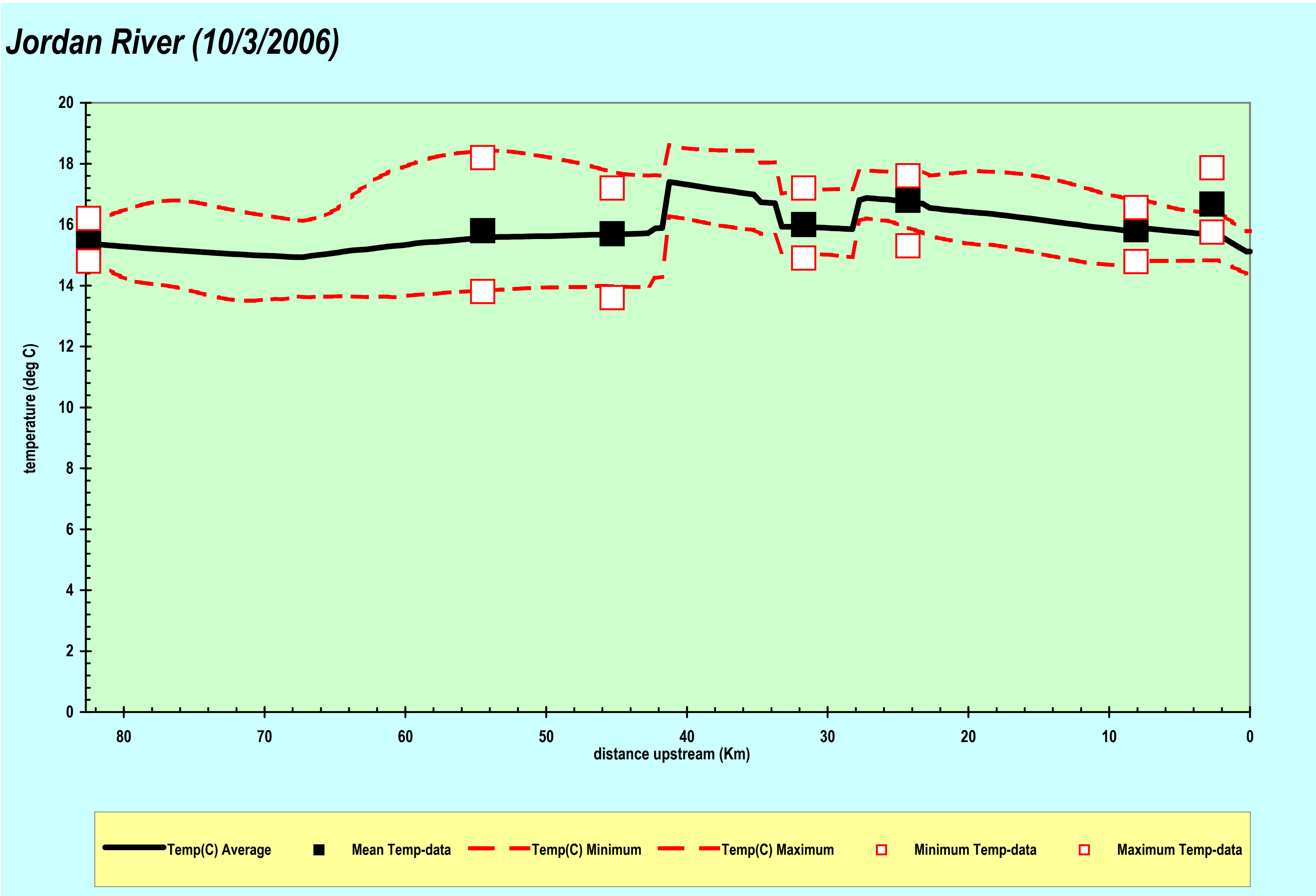
jordan_oct2006_q2kw_calwork.xls\Velocity, 2/12/2010



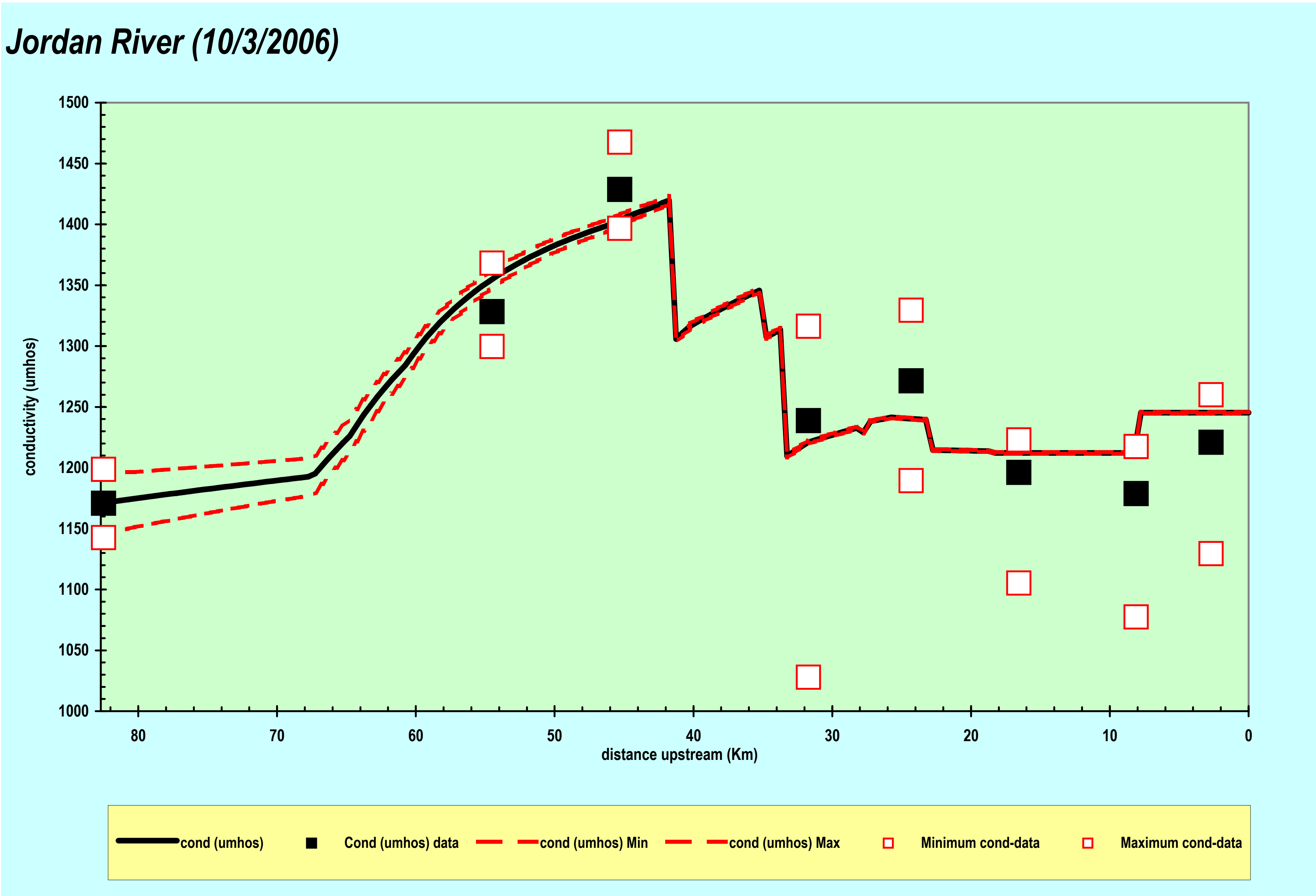
jordan_oct2006_q2kw_calwork.xls\Depth, 2/12/2010



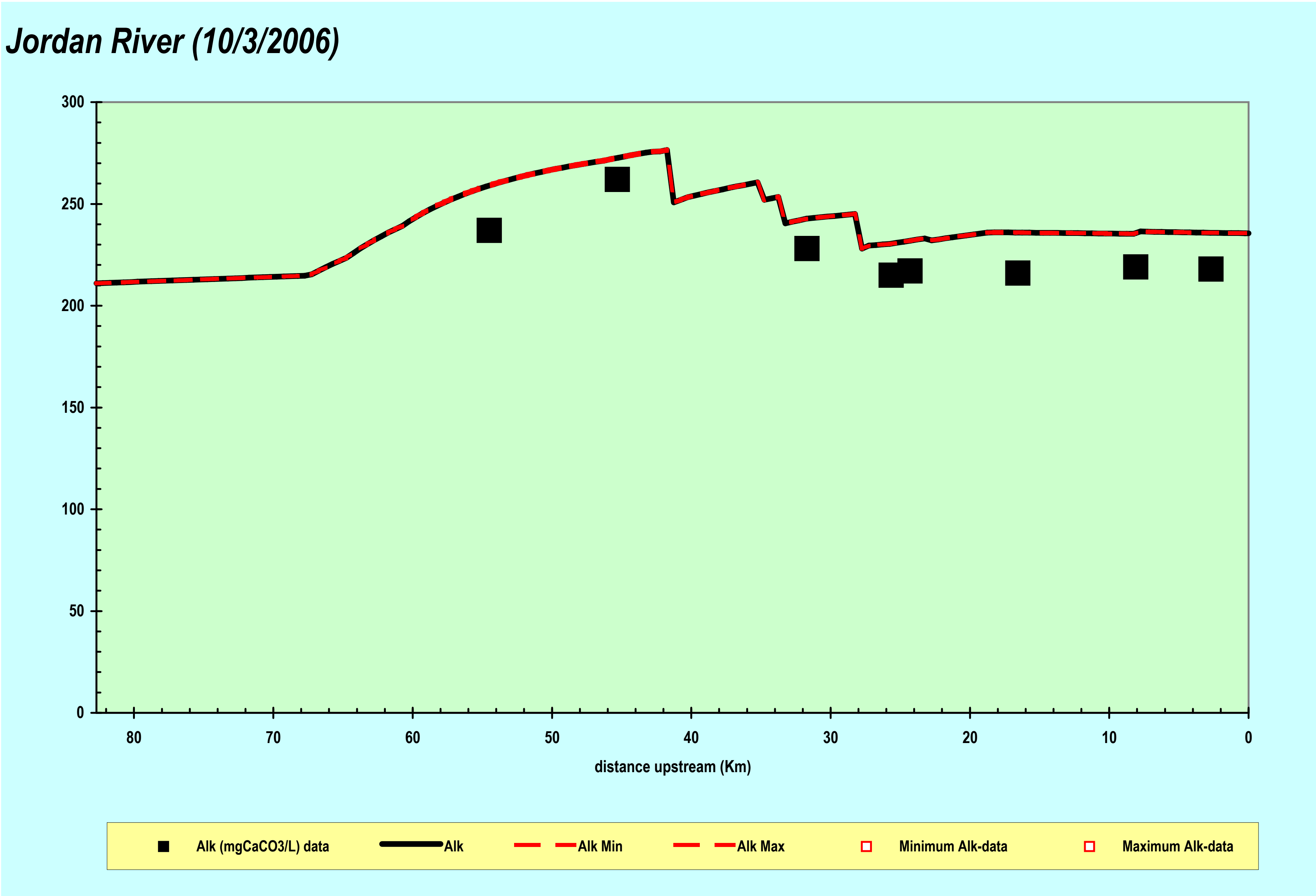
jordan_oct2006_q2kw_calwork.xls\Reaeration, 2/12/2010



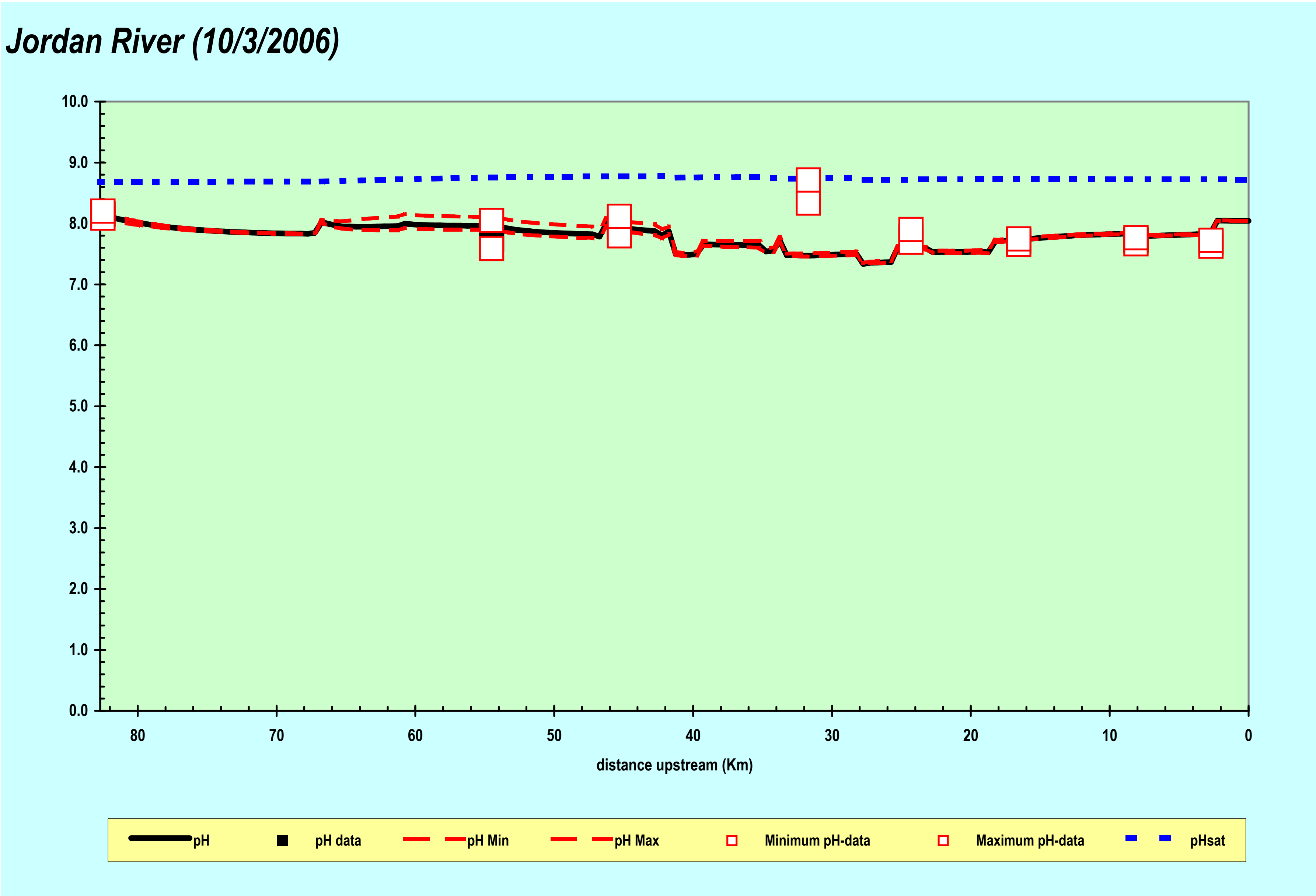
jordan_oct2006_q2kw_calwork.xls\Temperature, 2/12/2010



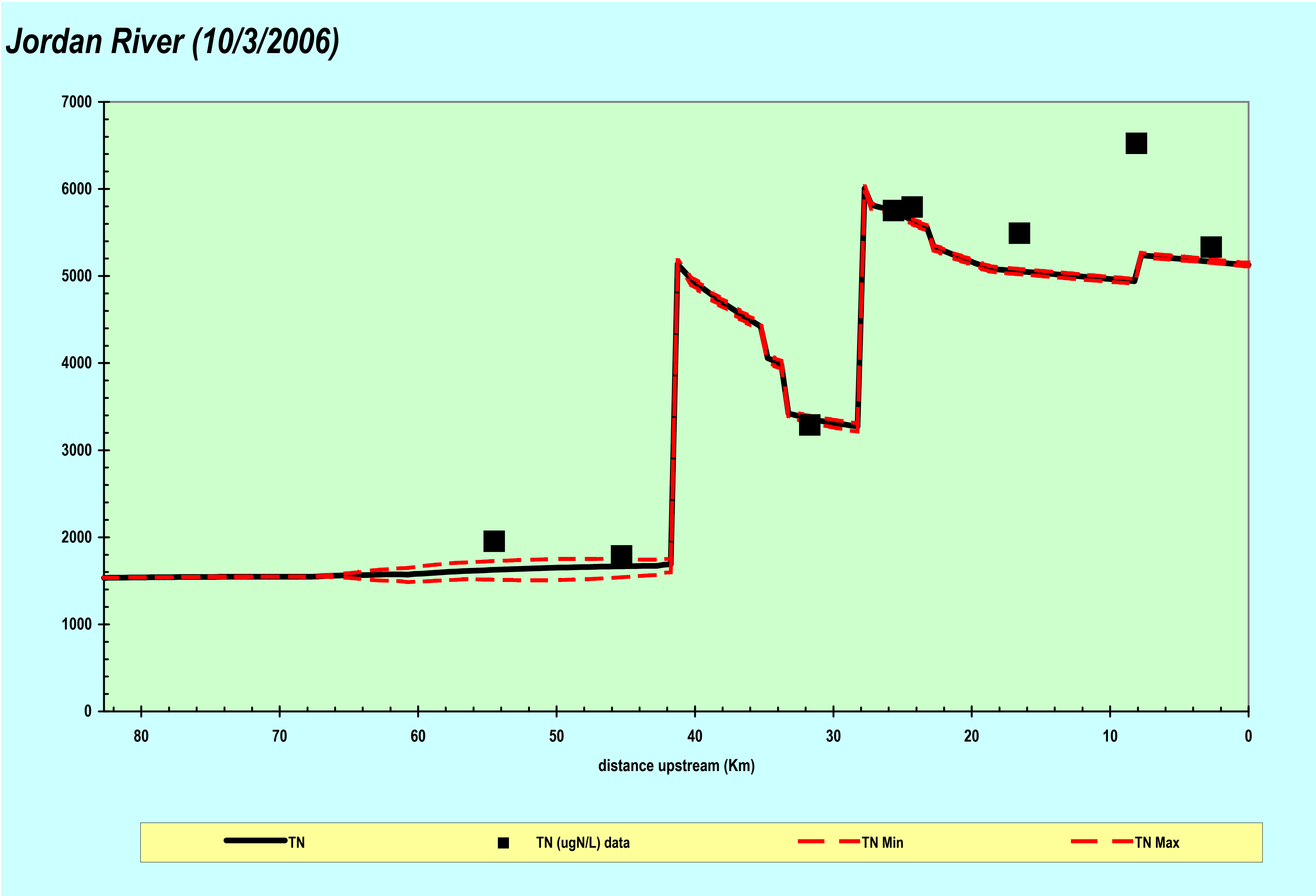
jordan_oct2006_q2kw_calwork.xls\Conductivity, 2/12/2010



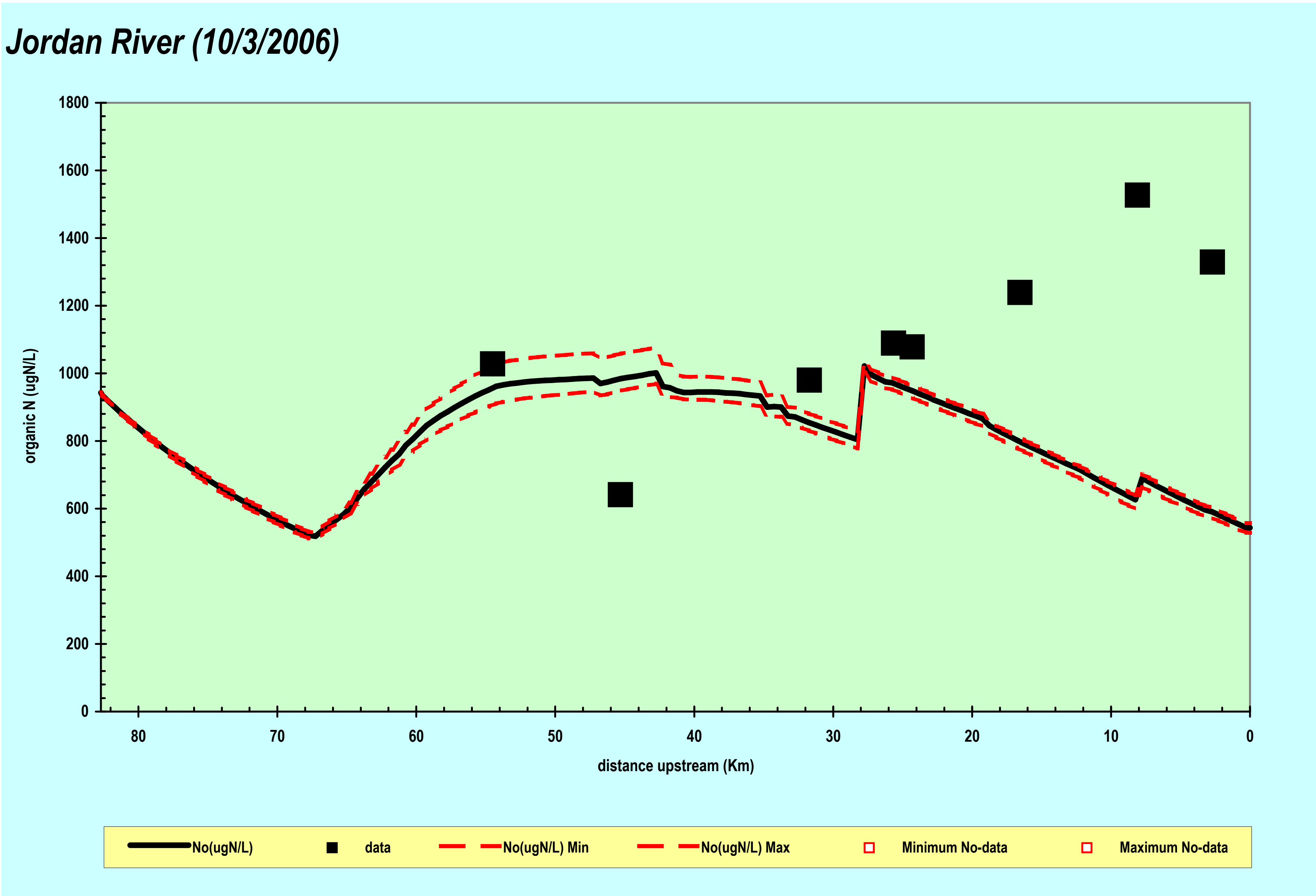
jordan_oct2006_q2kw_calwork.xls\Alkalinity, 2/12/2010

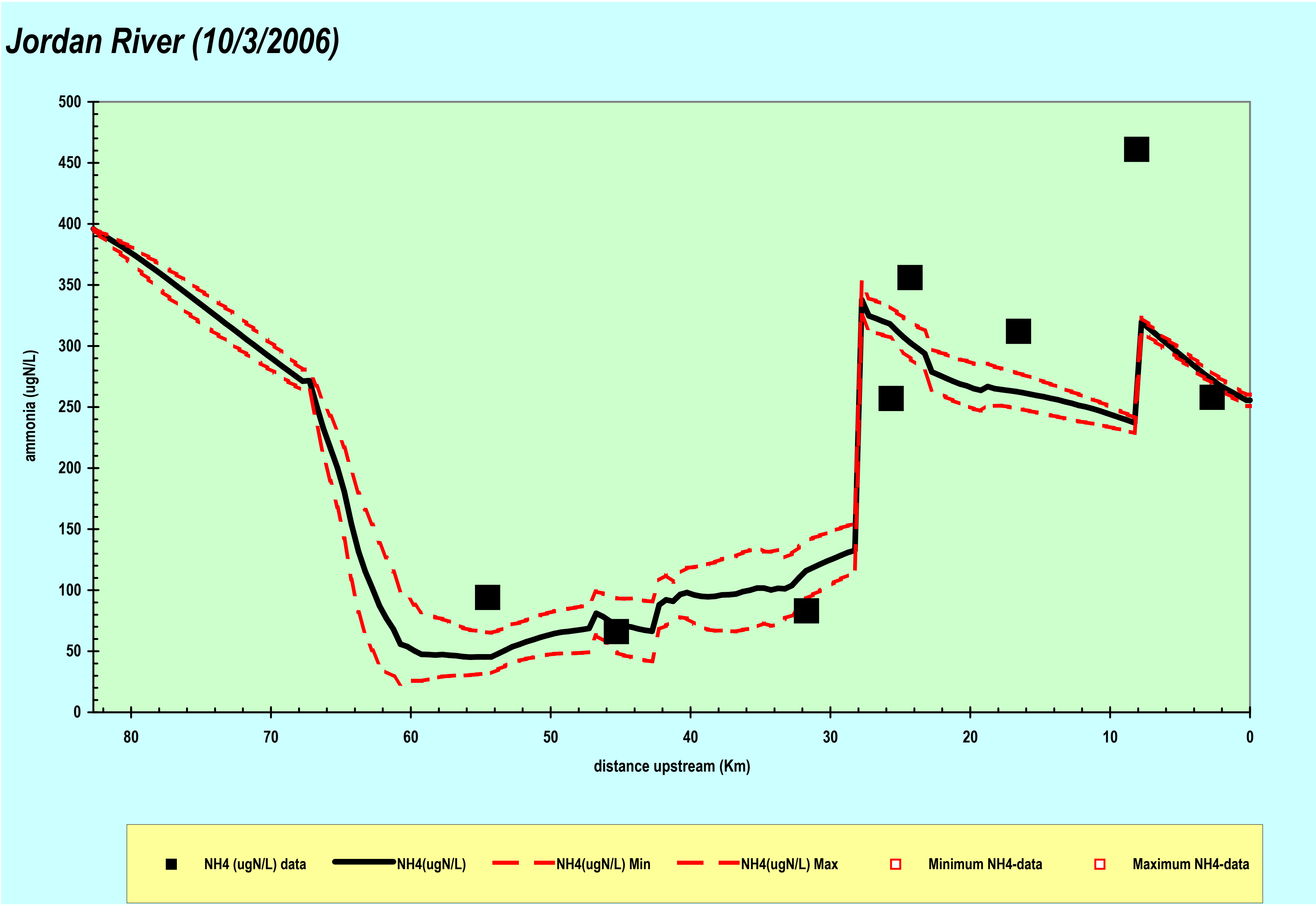


jordan_oct2006_q2kw_calwork.xls\pH, 2/12/2010

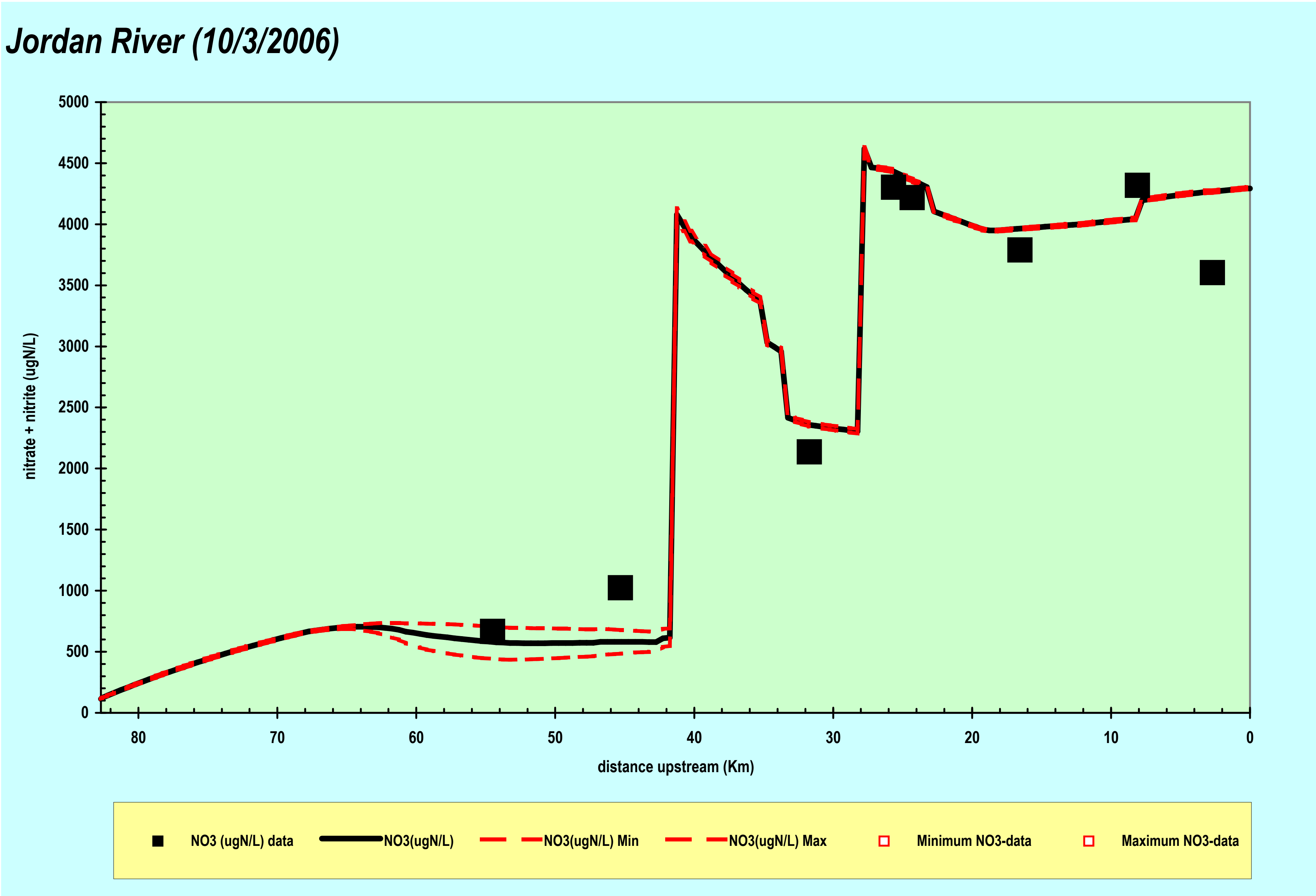


jordan_oct2006_q2kw_calwork.xls\Total N, 2/12/2010

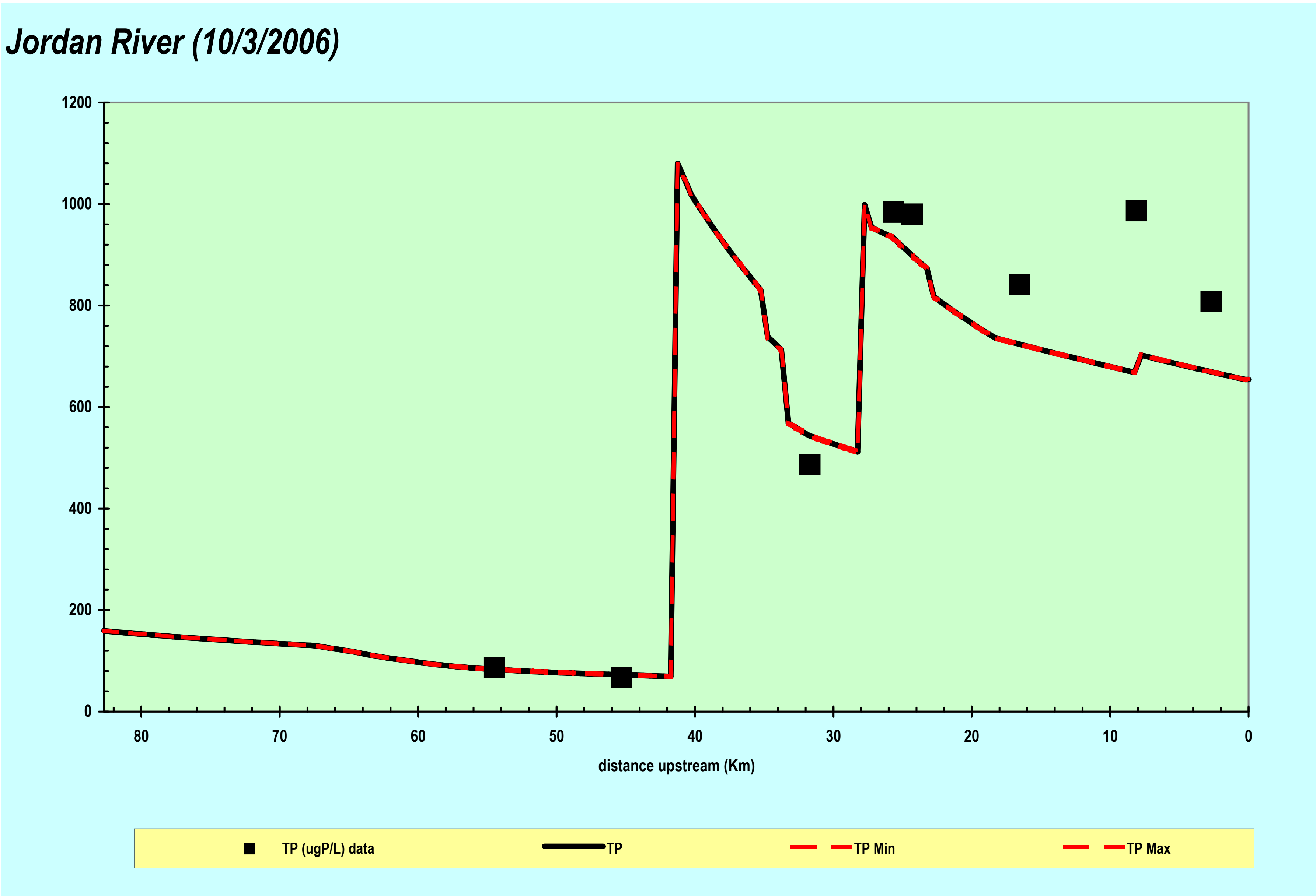

Jordan River (10/3/2006)
organic N (ugN/L)
1800
1600
1400
1200
1000
800
600
400
200
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
No(ugN/L)
data
No(ugN/L) Min
No(ugN/L) Max
Minimum No-data
Maximum No-data



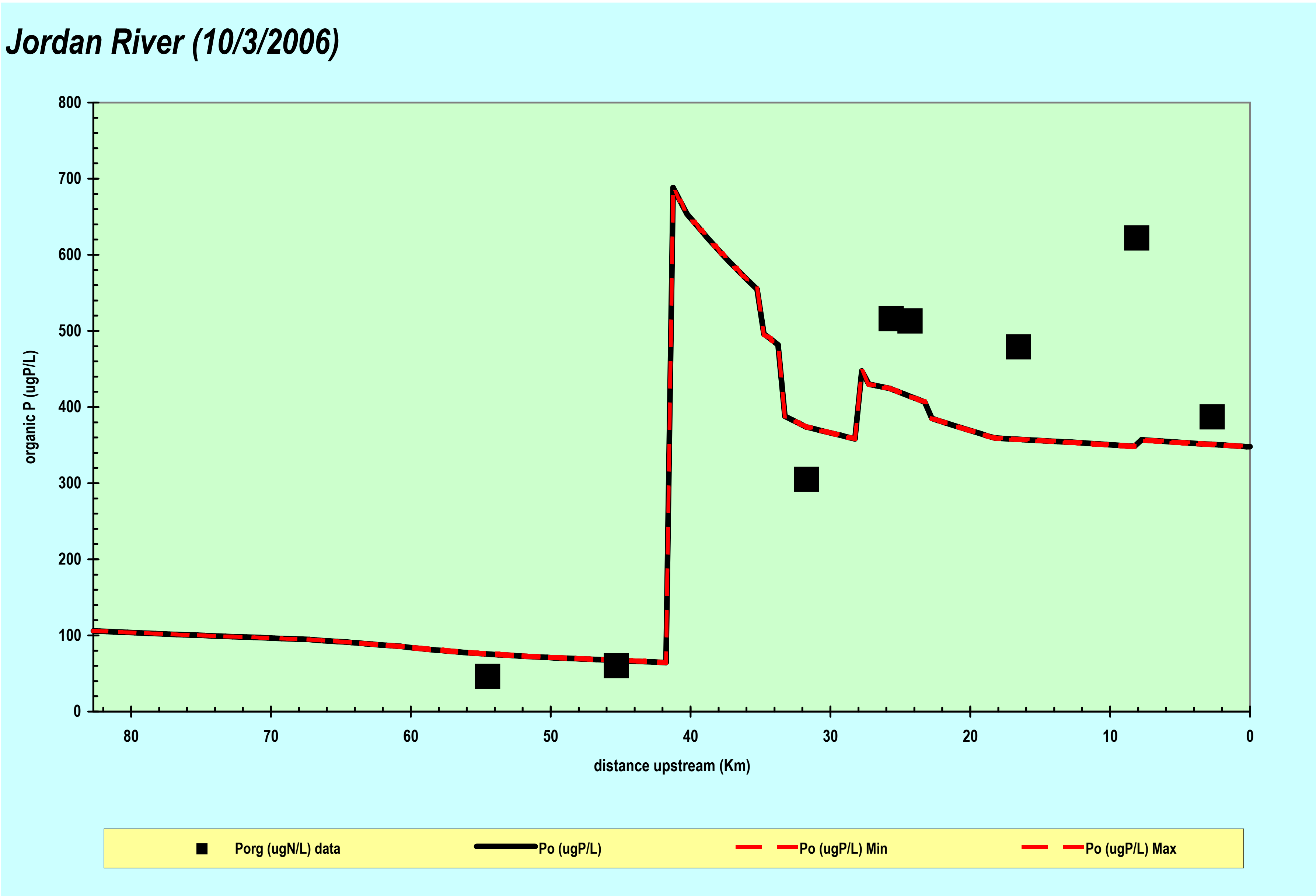
Jordan River (10/3/2006)
ammonia (ugN/L)
500
450
400
350
300
250
200
150
100
50
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
NH4 (ugN/L) data
NH4(ugN/L)
NH4(ugN/L) Min
NH4(ugN/L) Max
Minimum NH4-data
Maximum NH4-data

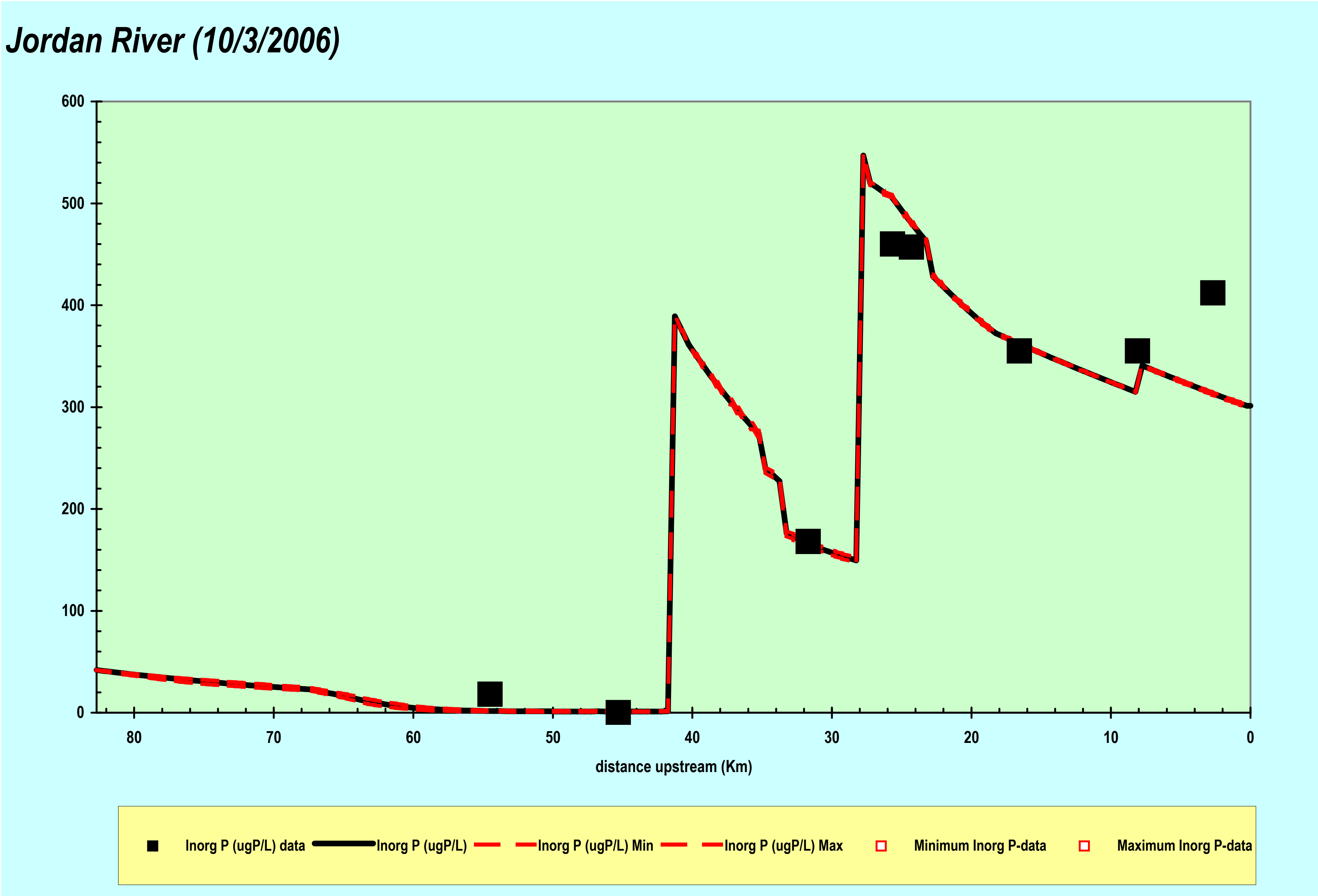


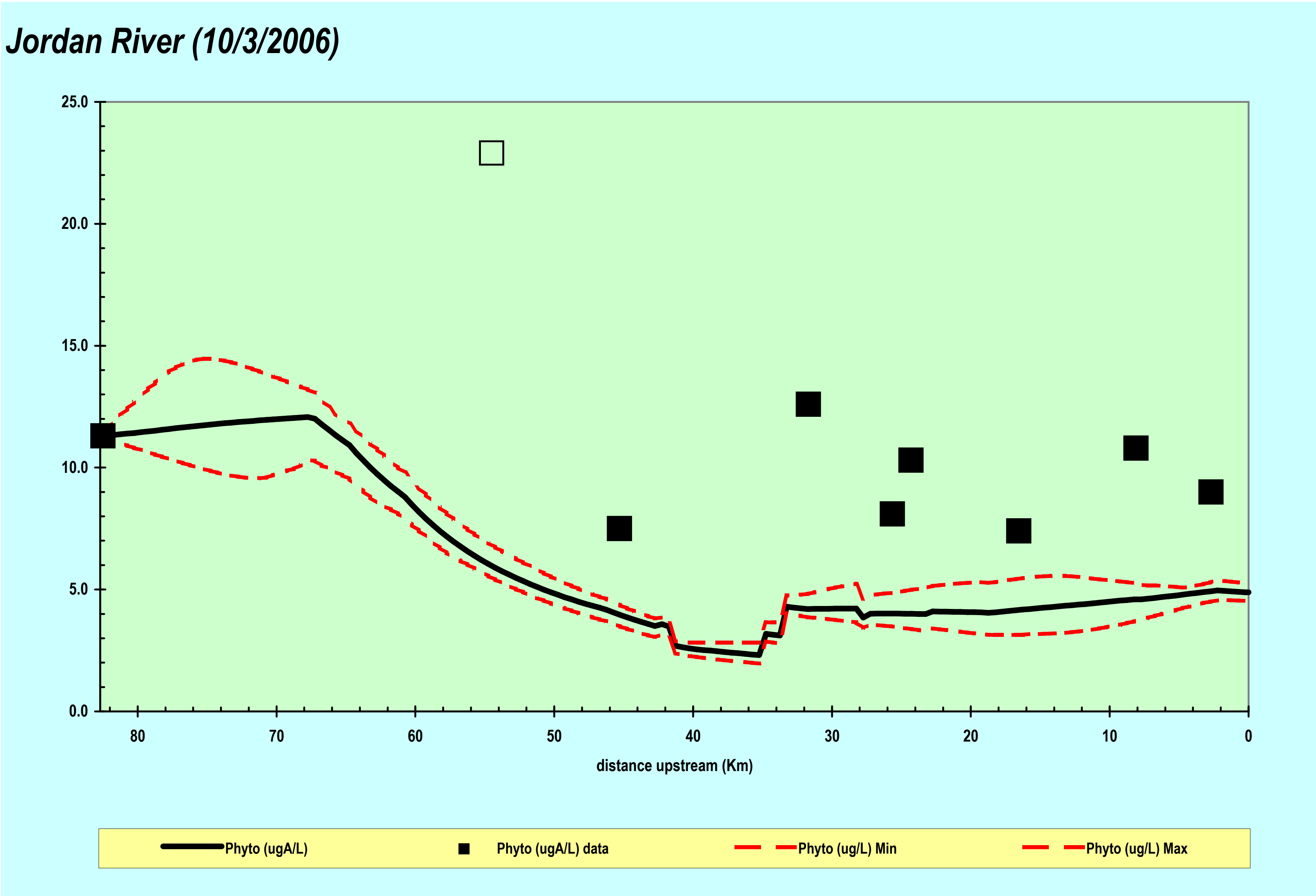
jordan_oct2006_q2kw_calwork.xls\NO3, 2/12/2010

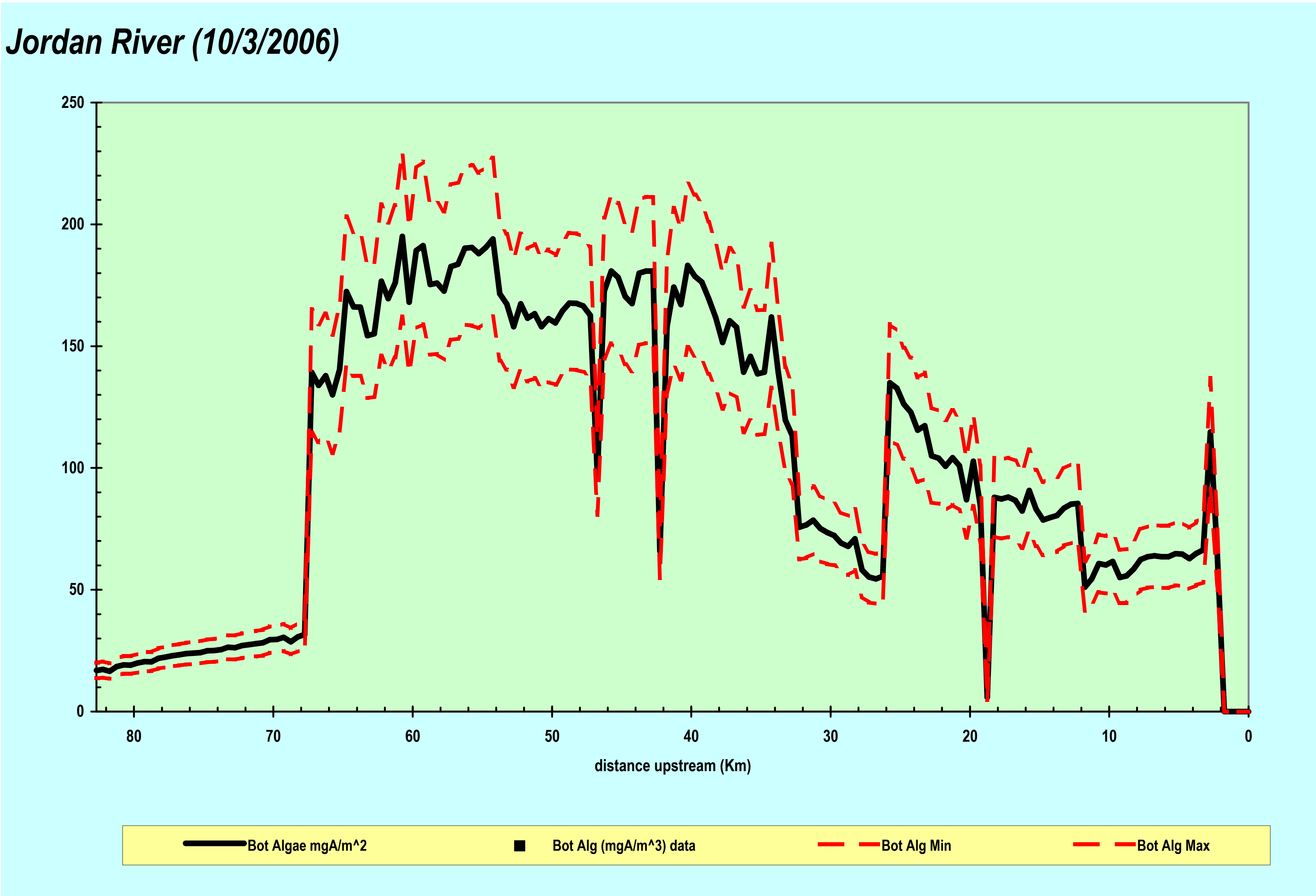


jordan_oct2006_q2kw_calwork.xls\Total P, 2/12/2010

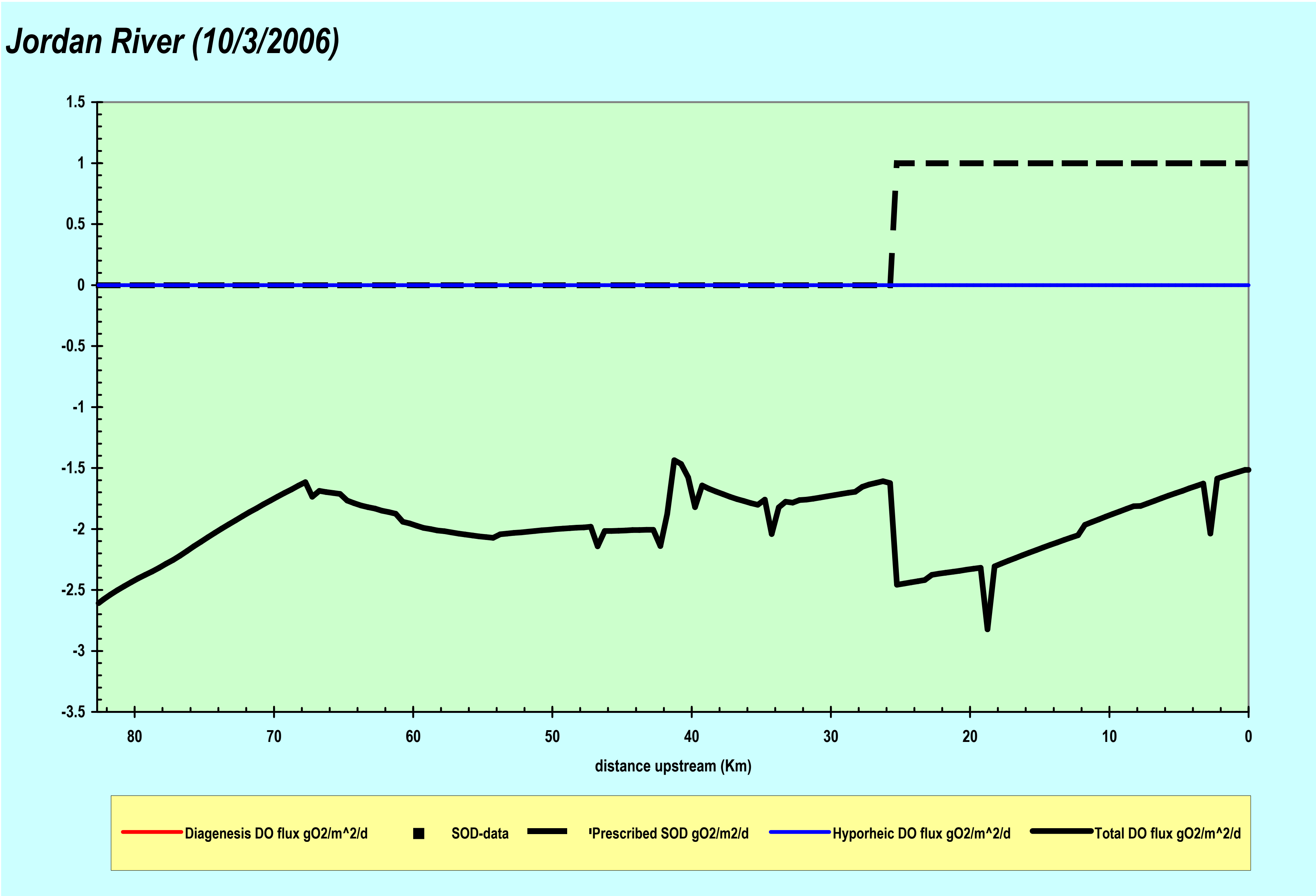

Jordan River (10/3/2006)
organic P (ugP/L)
800
700
600
500
400
300
200
100
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Porg (ugN/L) data
Po (ugP/L)
Po (ugP/L) Min
Po (ugP/L) Max


Jordan River (10/3/2006)
600
500
400
300
200
100
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Inorg P (ugP/L) data
Inorg P (ugP/L)
Inorg P (ugP/L) Min
Inorg P (ugP/L) Max
Minimum Inorg P-data
Maximum Inorg P-data

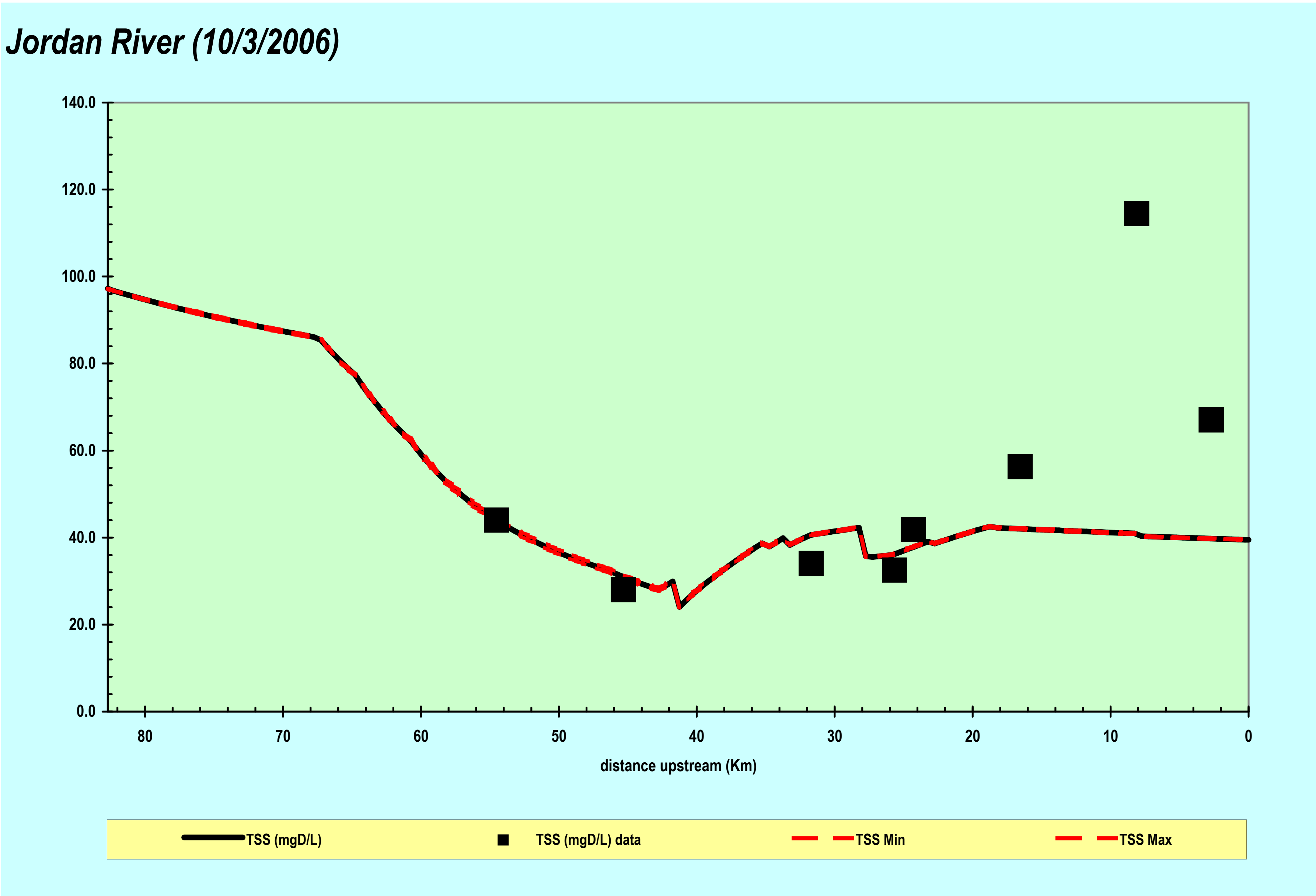

Jordan River (10/3/2006)
25.0
20.0
15.0
10.0
5.0
0.0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Phyto (ugA/L)
Phyto (ugA/L) data
Phyto (ug/L) Min
Phyto (ug/L) Max

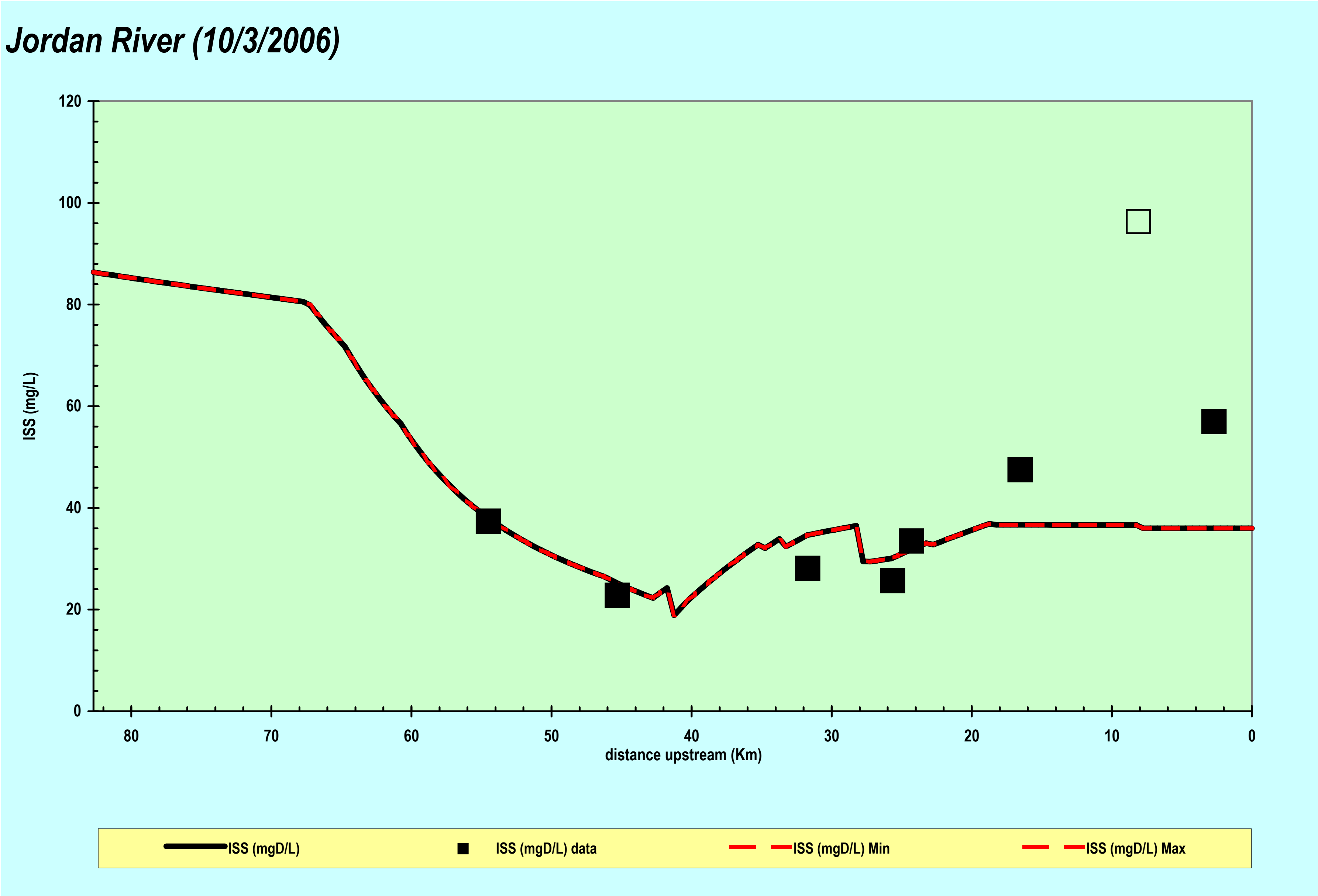


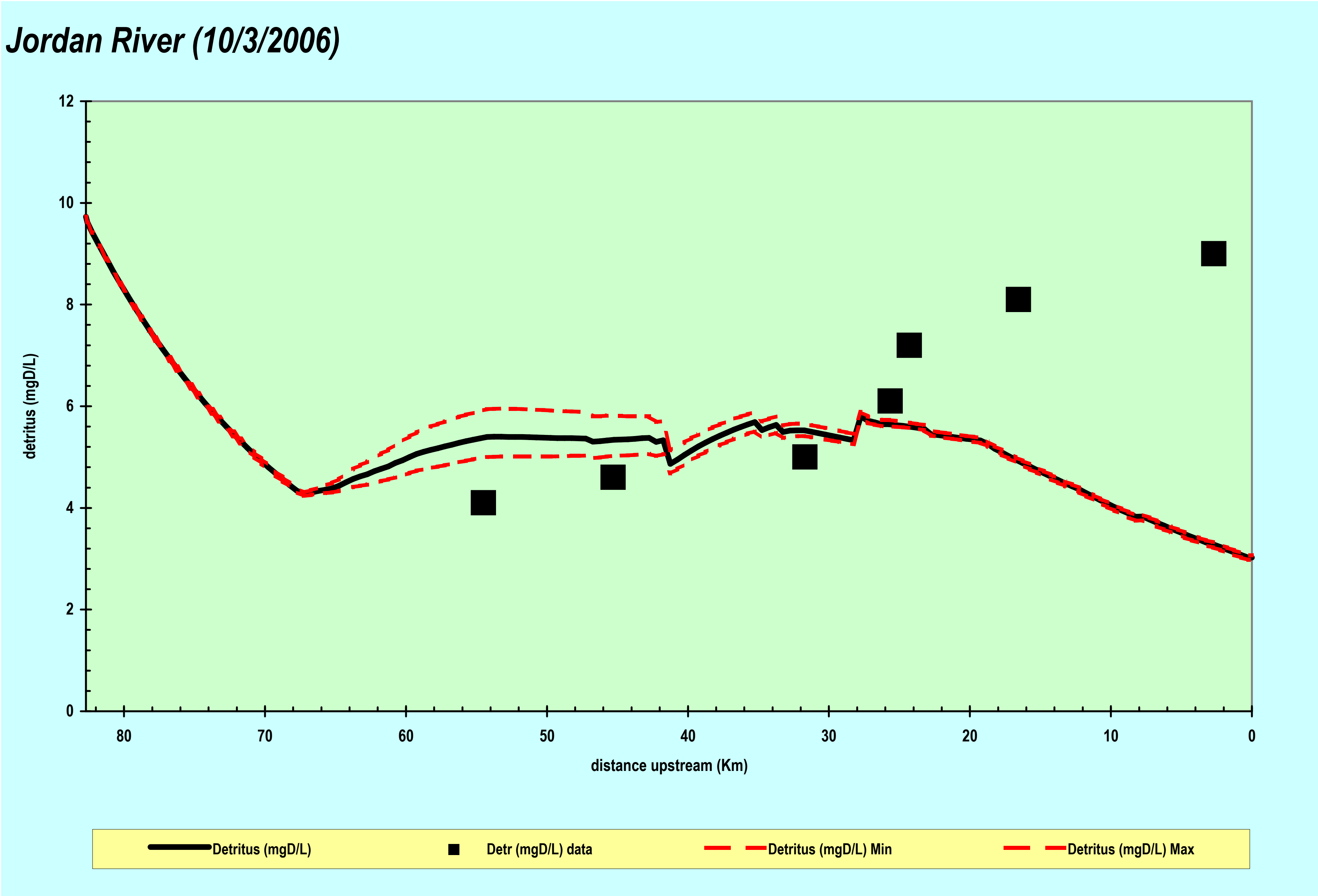
jordan_oct2006_q2kw_calwork.xls\Bot Algae mgA per m2, 2/12/2010

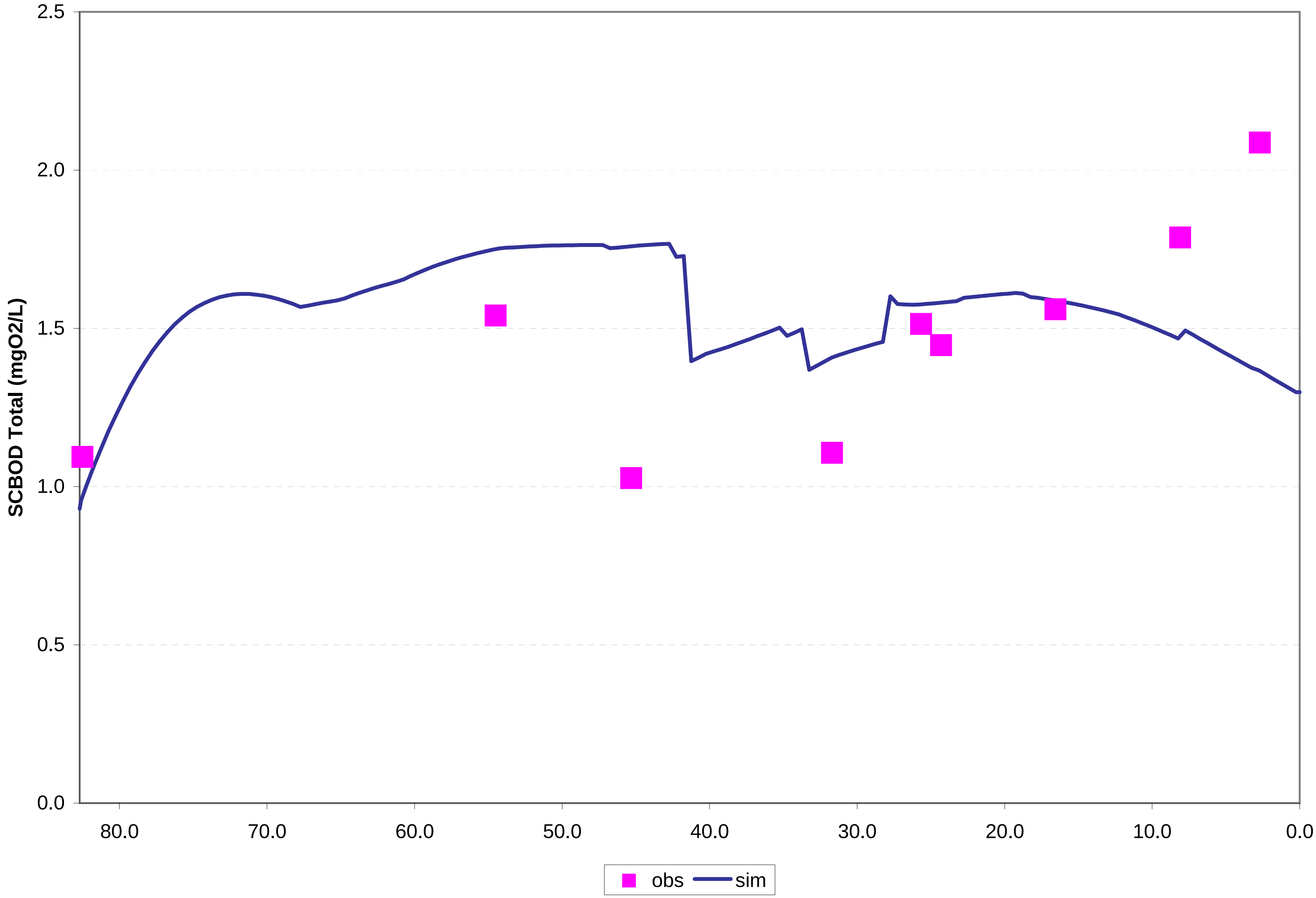


jordan_oct2006_q2kw_calwork.xls\SOD, 2/12/2010

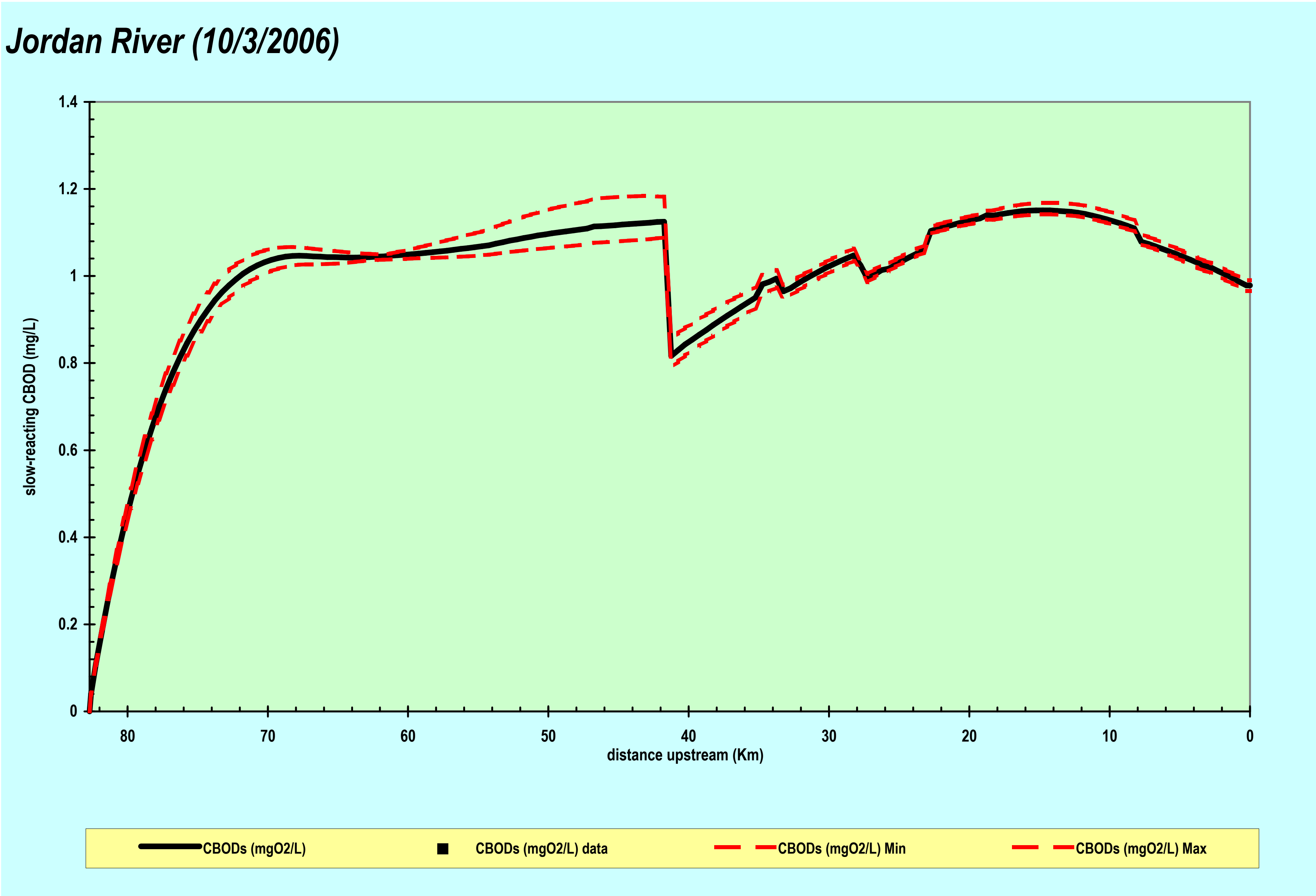

Jordan River (10/3/2006)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
TSS (mgD/L)
TSS (mgD/L) data
TSS Min
TSS Max

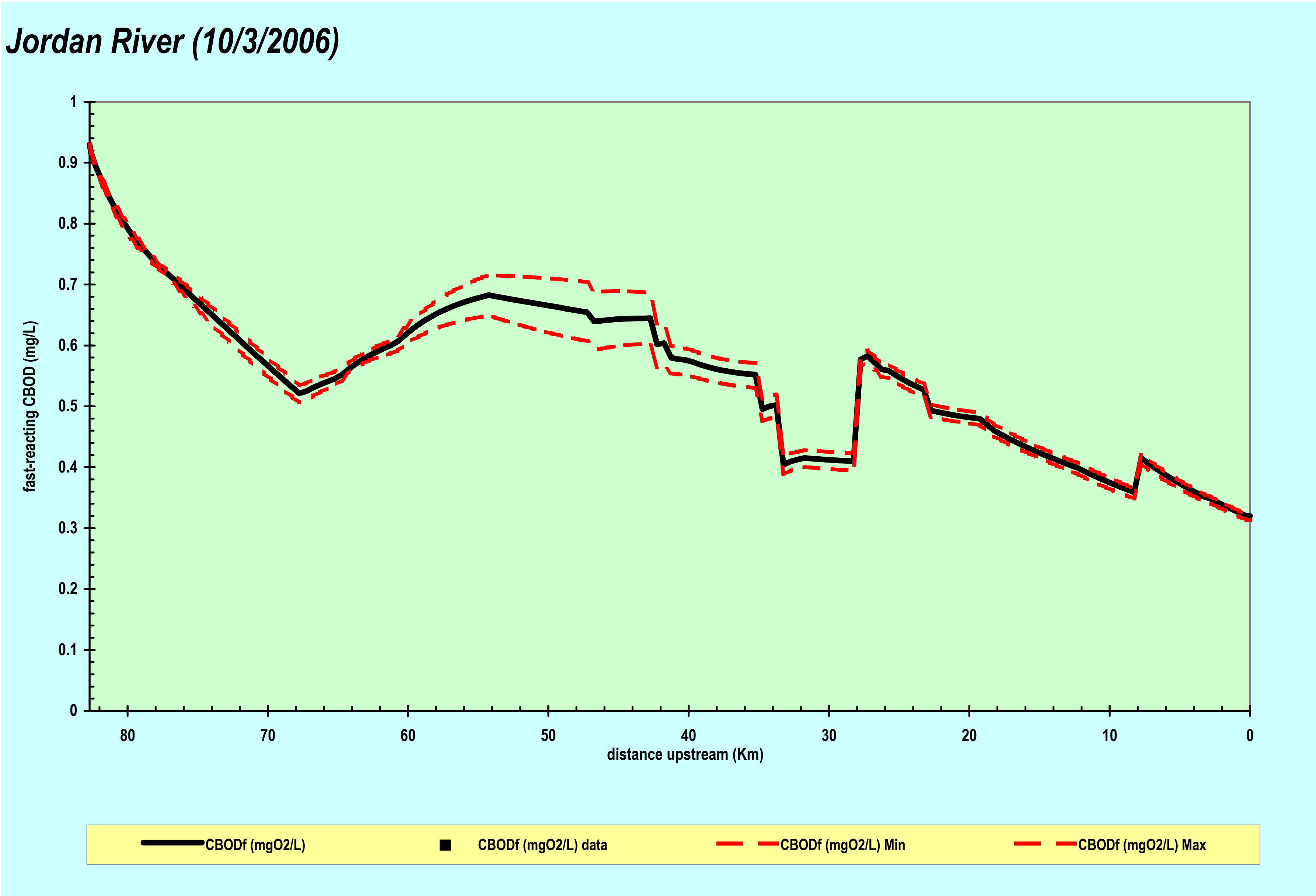

Jordan River (10/3/2006)
120
100
80
60
40
20
0
ISS (mg/L)
80
70
60
50
40
30
20
10
0
distance upstream (Km)
ISS (mgD/L)
ISS (mgD/L) data
ISS (mgD/L) Min
ISS (mgD/L) Max


Jordan River (10/3/2006)
detritus (mgD/L)
12
10
8
6
4
2
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
Detritus (mgD/L)
Detr (mgD/L) data
Detritus (mgD/L) Min
Detritus (mgD/L) Max

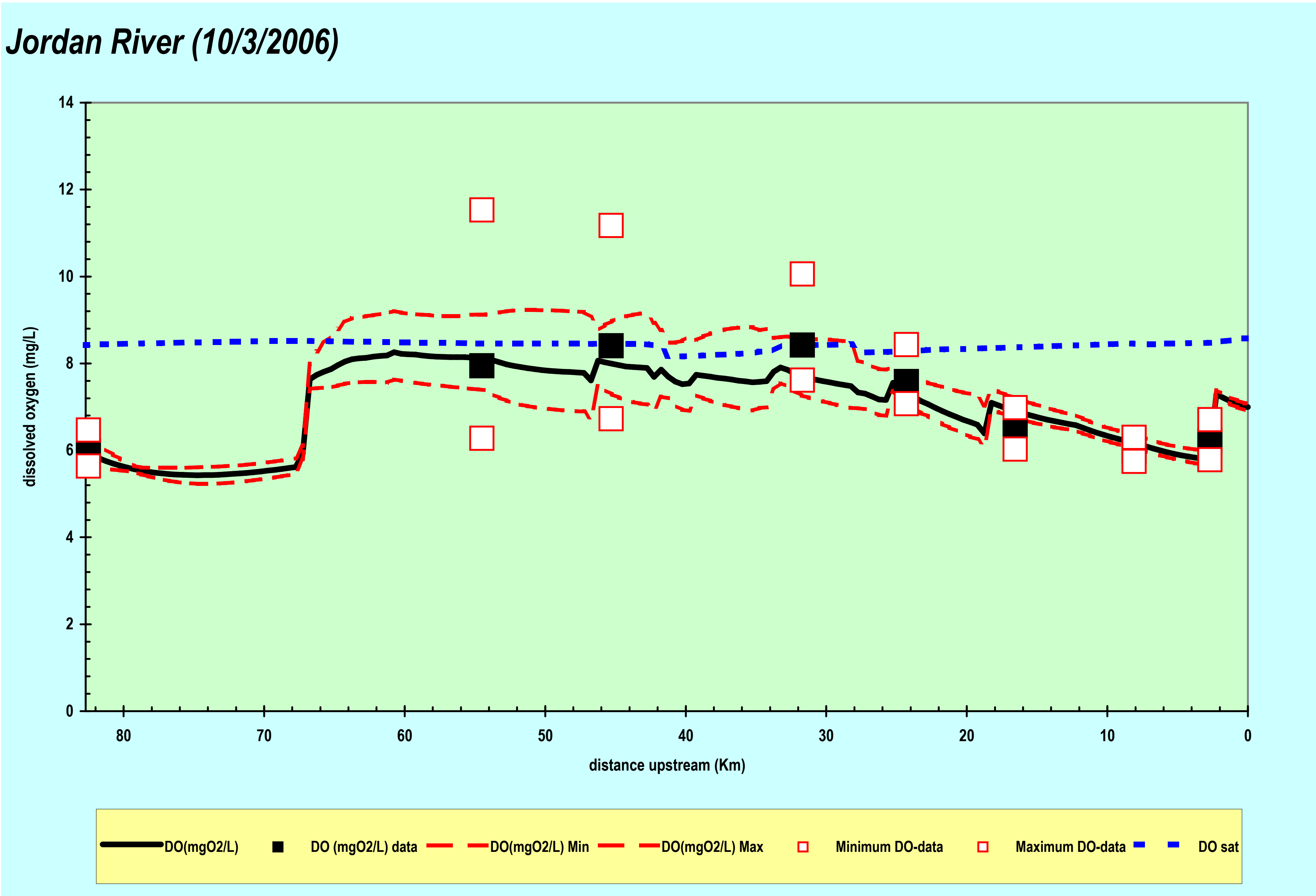


SCBOD Total (mgO2/L)
2.5
2.0
1.5
1.0
0.5
0.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
obs
sim


Jordan River (10/3/2006)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
slow-reacting CBOD (mg/L)
80
70
60
50
40
30
20
10
0
distance upstream (Km)
CBODs (mgO2/L)
CBODs (mgO2/L) data
CBODs (mgO2/L) Min
CBODs (mgO2/L) Max



jordan_oct2006_q2kw_calwork.xls\CBOD fast, 2/12/2010


Jordan River (10/3/2006)
dissolved oxygen (mg/L)
14
12
10
8
6
4
2
0
80
70
60
50
40
30
20
10
0
distance upstream (Km)
DO(mgO2/L)
DO (mgO2/L) data
DO(mgO2/L) Min
DO(mgO2/L) Max
Minimum DO-data
Maximum DO-data
DO sat