MSC THESIS SUPPLAMENTARY DOCUMENT

Hydro-Archeological Modeling of Neo-Assyrian Watercourses: ANNEX

Student: Alexis Stampoultzidis
Student Number: 4799933

Table of Contents

List of Figures and Tables

Figures

Tables

Thesis ANNEX

Methodology

Irrigation schedules

The tables 1 and 2 present the Irrigation schedules used for Wet and Dry year in Spring and Autumn growing seasons. For the Dry year days are counted from the beginning of the simulation at 15th of August of the previous year, while for the Wet year from the sowing dates 7th of March and November, in Spring and Autumn, respectively.

Table 1 Irrigation schedule in Dry year, Spring and Autumn with day zero 15th of August.

Irrigation schedule Dry year 1999	**Nineveh**			**Navkur**			**Faida**		
	20mm Events	30mm Events	40mm Events	20mm Events	30mm Events	40mm Events	20mm Events	30mm Events	40mm Events
	205	205	205	205	205	205	205	205	205
	206	206	206	206	206	211	206	206	206
	207	214	218	211	217	242	207	214	223
	214	239	242	217	244	250	214	247	247
	221	247	251	242	250	257	223	251	254
	240	253	257	246	256	264	242	256	259
	246	257	265	250	261	270	247	260	265
	250	261	270	256	265	275	253	264	270
Spring	254	266	276	260	270	283	258	268	276
	257	271	282	262	274	290	261	272	283
	261	276	289	266	278	299	264	277	290
	264	281	296	269	284		266	282	298
	267	286		271	290		269	287	
	270	290		282	296		271	292	
	274	296		285			275	298	
	276			288			277		
	279			292			281		

	283			296			284		
	286			300			291		
	289						295		
	292						299		
	296								
	300								
Autumn	83	83	83	83	83	83	85	85	85
	84	84	84	84	84	84	86	86	86
	85	94	94	85	92	95	87	93	96
	93	111	138	92	97	106	93	97	106
	100	135	193	95	104	121	96	104	120
	120	190	216	99	118	233	99	115	220
	141	210	229	103	228	247	103	133	234
	189	220	236	112	235	262	110	226	246
	203	230	245	120	246		129	233	257
	215	236		142	257		217	243	
	225	244		233	264		227	248	
	230			237			231	257	
	234			246			235		
	238			258			243		
	245			264			246		
							253		
							257		

Table 2 Irrigation schedule in Wet year, Spring and Autumn with day zero on 7th March, November.

Irrigation schedule Wet year 1980	**Nineveh**			**Navkur**			**Faida**		
	20mm Events	30mm Events	40mm Events	20mm Events	30mm Events	40mm Events	20mm Events	30mm Events	40mm Events
	52	53	52	59	59	59	52	52	52
	59	59	61	64	68	73	59	62	64
	63	64	67	74	76	79	64	69	75
	68	69	74	76	82	88	69	76	82
	71	75	79	79	87	99	75	82	90
	75	78	87	84	92		78	87	
	77	84		87	101		82	92	
	82	89		91			85		
Spring	84	96		96			88		
	87			101			92		
	91						99		
	97								

Autumn	1	1	1	1	1	1	1	1	1
	2	2	5	4	12	17	9	16	15
	6	10	21	17	169	170	20	165	169
	16	24	167	169	180	182	165	174	
	101	167		175	187	192	172		
	133			182					
	163			187					
	170								

Table 3 Wet year Spring and Autumn, maximum number of days to complete an irrigation cycle, calculated as the duration in days between 3 consecutive events dived by the 2 event that should be completed by then.

Spring	**Nineveh**				**Navkur**				**Faida**	
20mm Events	30mm Events	40mm Events		20mm Events	30mm Events	40mm Events		20mm Events	30mm Events	40mm Events
5.5	5.5	7.5		7.5	8.5	10		6	8.5	11.5
4.5	5	6.5		6	7	7.5		5	7	9
4	5.5	6		2.5	5.5	10		5.5	6.5	7.5
3.5	4.5	6.5		4	5			4.5	5.5	
3	4.5			4	7			3.5	5	
3.5	5.5			3.5				3.5		
3.5	6			4.5				3		
2.5				5				3.5		
3.5								5.5		
5										
Autumn										
2.5	4.5	10		8	84	84.5		9.5	82	84
7	11	81		82.5	84	82.5		78	79	
47.5	78.5			79	9	11		76		
58.5				6.5						
31				6						
18.5										

Tables 3 and 4 are created by calculating the days between 3 consecutive irrigation events (Tables 1 and 2) and dividing them by 2, the number of events that should be completed in that time span.

Table 4 Dry year Spring and Autumn, maximum number of days to complete an irrigation cycle, calculated as the duration in days between 3 consecutive events dived by the 2 event that should be completed by then.

Spring	**Nineveh**				**Navkur**				**Faida**	
20mm Events	30mm Events	40mm Events		20mm Events	30mm Events	40mm Events		20mm Events	30mm Events	40mm Events
1	4.5	6.5		3	6	18.5		1	4.5	9
4	16.5	18		5.5	19	19.5		4	20.5	20.5
7	16.5	16.5		15.5	16.5	7.5		8	18.5	15.5
13	7	7.5		14.5	6	7		14	4.5	6
12.5	5	7		4	5.5	6.5		12	4.5	5.5
5	4	6.5		5	4.5	5.5		5.5	4	5.5
4	4.5	5.5		5	4.5	6.5		5.5	4	5.5
3.5	5	6		3	4.5	7.5		4	4	6.5
3.5	5	6.5		3	4	8		3	4.5	7
3.5	5	7		3.5	5			2.5	5	7.5
3	5			2.5	6			2.5	5	
3	4.5			6.5	6			2.5	5	
3.5	5			7				3	5.5	
3				3				3		
2.5				3.5				3		
3.5				4				3.5		
3.5				4				5		
3								5.5		
3								4		
3.5										
4										
Autumn										
1	5.5	5.5		1	4.5	6		1	4	5.5
4.5	13.5	27		4	6.5	11		3.5	5.5	10
7.5	20.5	49.5		5	6	13		4.5	5.5	12
13.5	39.5	39		3.5	10.5	63.5		3	9	57
20.5	37.5	18		4	62	63		3.5	14.5	57
34.5	15	10		6.5	58.5	14.5		5.5	55.5	13
31	10	8		8.5	9			13	50	11.5
13	8			15	11			53.5	8.5	
11	7			56.5	9			49	7.5	
7.5				47.5				7	7	
4.5				6.5				4		
4				10.5				6		
5.5				9				5.5		
								5		
								5.5		

Flow Water Level Boundaries

Figure 1 show how a typical setting of a Flow water level boundary, by creating a rating curve for the specific cross-section (1 or 2 m width). These were created with the Open Channel Flow Calculator program (Dr. Xing Fang, Department of Civil Engineering, 2000). Tables 5 through 7 present the 1 and 2 m offtake water depth – discharge inputs along with the Kissiri canal's 4,8 m width and 1,6 m water depth.

Table 5 1m offtake Water Depth versus Discharge.

Water Depth (m)	Discharge (m^3/s)
0	0
0.1	-0.0318
0.2	-0.0911
0.3	-0.1638
0.4	-0.2446
0.5	-0.3307
0.75	-0.5602
1	-0.8012

Table 6 2m offtake Water Depth versus Discharge.

Water Depth (m)	Discharge (m^3/s)
0	0
0.1	-0.0674
0.2	-0.2019
0.3	-0.3762
0.4	-0.5784
0.5	-0.8012
0.7	-1.2914
0.9	-1.823
1	-2

.

Table 7 4 m width and 1,6 m water depth Kissiri canal endings, Water Depth versus Discharge

Water Depth (m)	Discharge (m^3/s)
0	0
0.1	-0.151
0.3	-0.8949
0.5	-1.9991
0.7	-3.3501
1	-5.708
1.2	-7.4457
1.4	-9.286
1.5	-11.211
1.6	-12.7

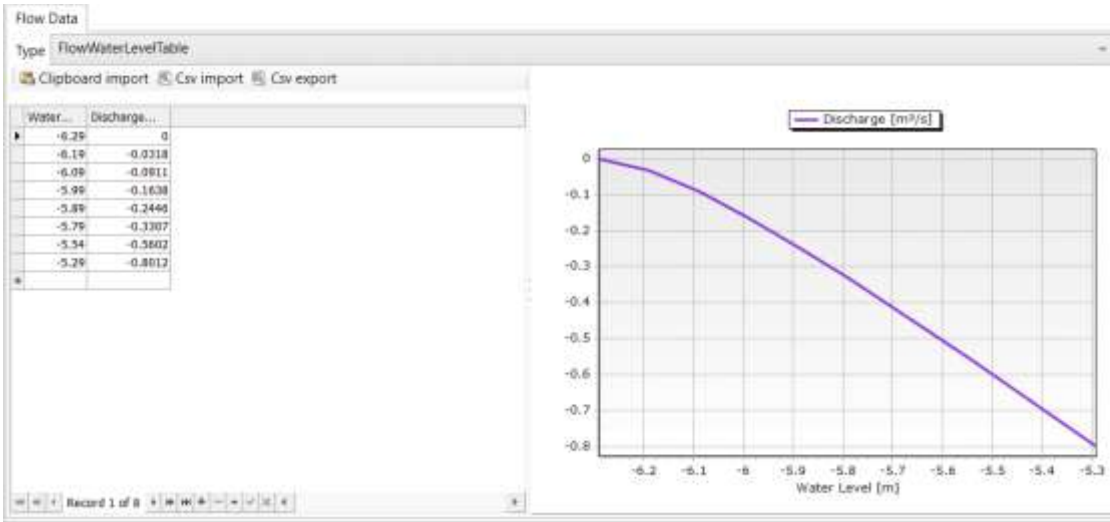

Figure 1 Flow Water Level boundary condition Sobek input screen.

Results

Coverage

The percentage of irrigation (water) needs met or otherwise referred to as "**coverage**" for Local system and Khosr-Kissiri canals presented in Figures 2-5.

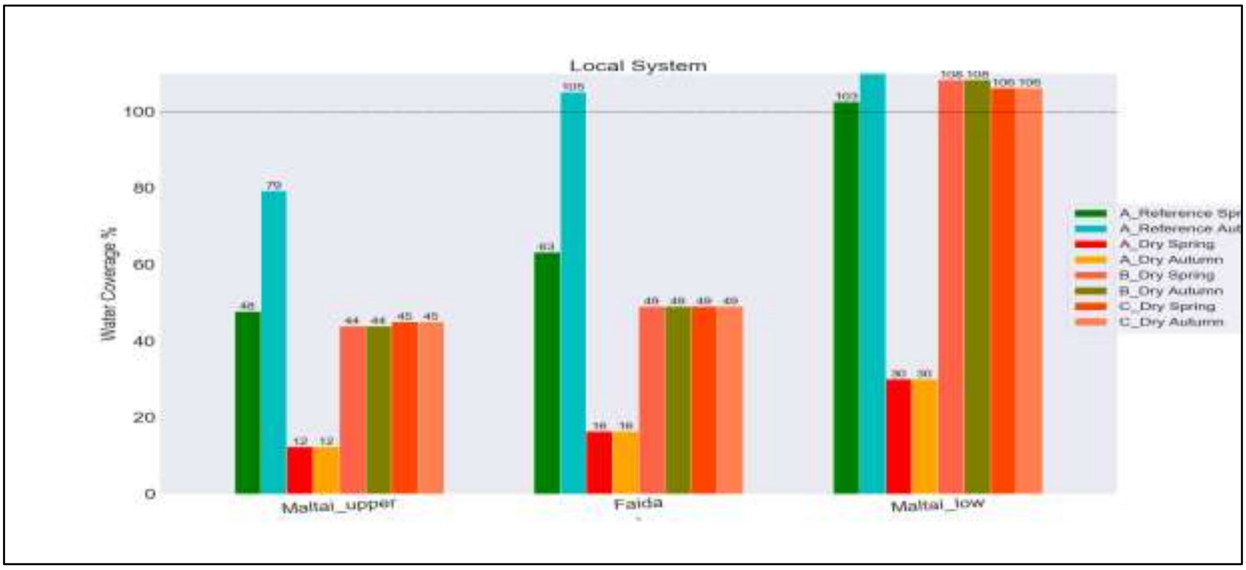

Figure 2 Sobek 1m offtake width water coverage % results per canal reach and, Control scenarios A (Reference-Dry, Spring-Autumn), B (Dry, Spring-Autumn) and C (Dry, Spring-Autumn) indicated on the x axis, while numbers on top of the bars indicate the exact value.

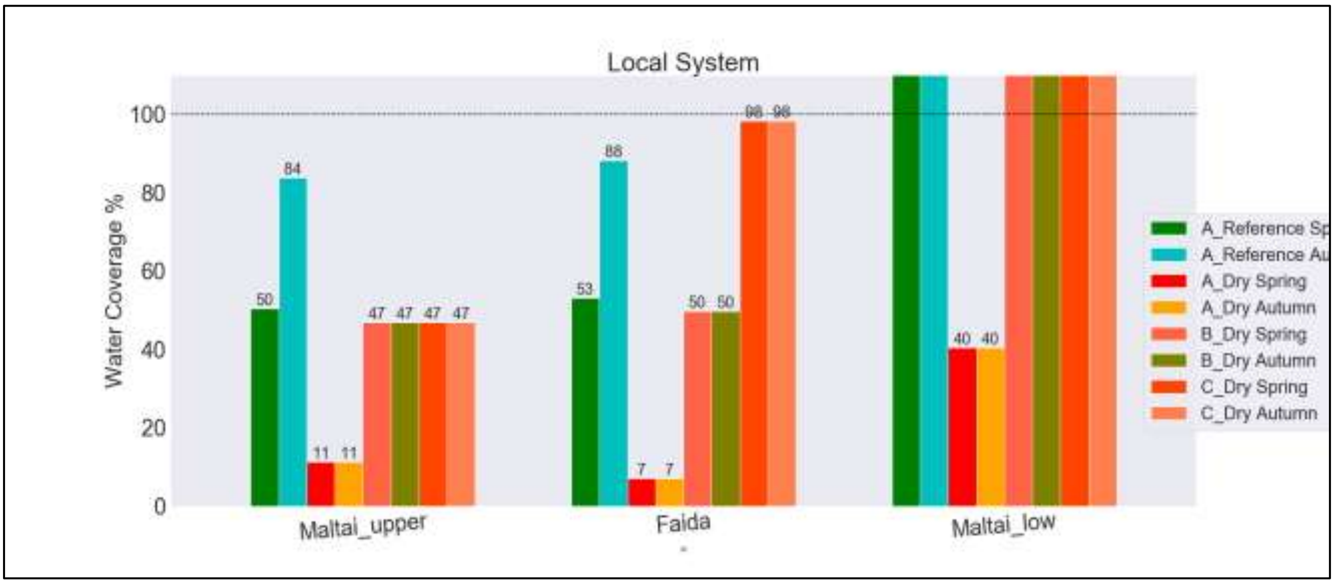

Figure 3 2m Sobek water coverage % results per canal reach and, Control scenarios A (Reference-Dry, Spring-Autumn), B (Dry, Spring-Autumn) and C(Dry, Spring-Autumn) indicated on the x axis, while numbers on top of the bars indicate the exact values.

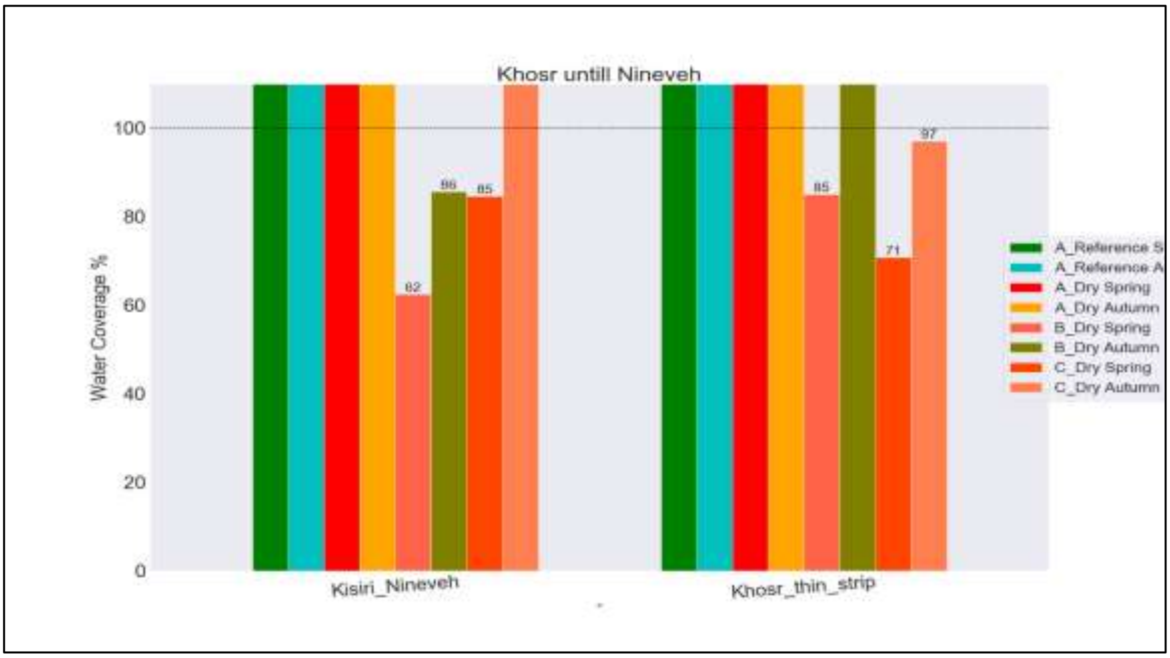

Figure 4 2m Sobek water coverage % results per canal reach and, Control scenarios A (Reference-Dry, Spring-Autumn), B (Dry, Spring-Autumn) and C(Dry, Spring-Autumn) indicated on the x axis, while numbers on top of the bars indicate the exact values.

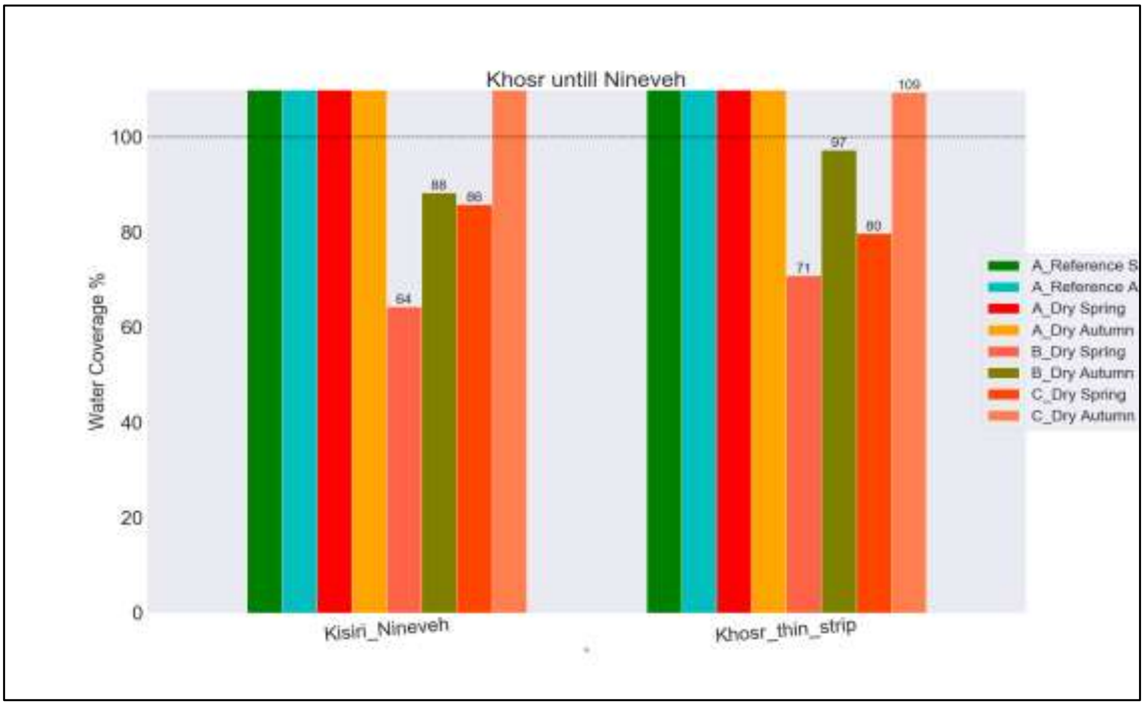

Figure 5 Sobek 1m offtake width water coverage % results per canal reach and, Control scenarios A (Reference-Dry, Spring-Autumn), B (Dry, Spring-Autumn) and C (Dry, Spring-Autumn) indicated on the x axis, while numbers on top of the bars indicate the exact values.

Harvests

Kilograms per hectare of land cultivated for Khosr-Kissiri canals presented through Figures 6 and 7.

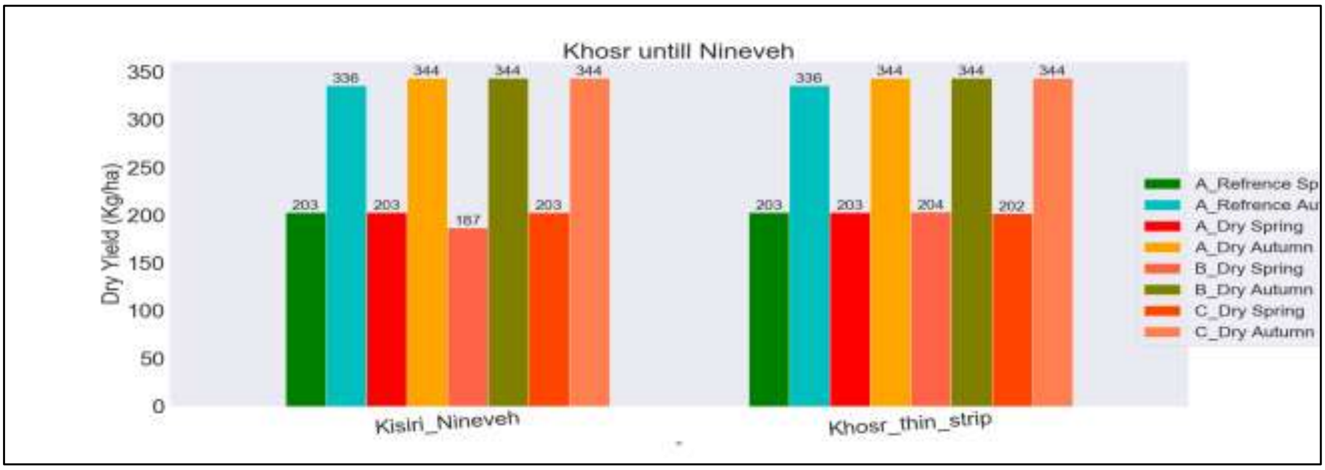

Figure 6 2m AquaCrop dry harvest yield results per canal reach and, Control scenarios A (Reference-Dry, Spring-Autumn), B (Dry, Spring-Autumn) and C (Dry, Spring-Autumn) indicated on the x axis, while numbers on top of the bars indicate the exact values.

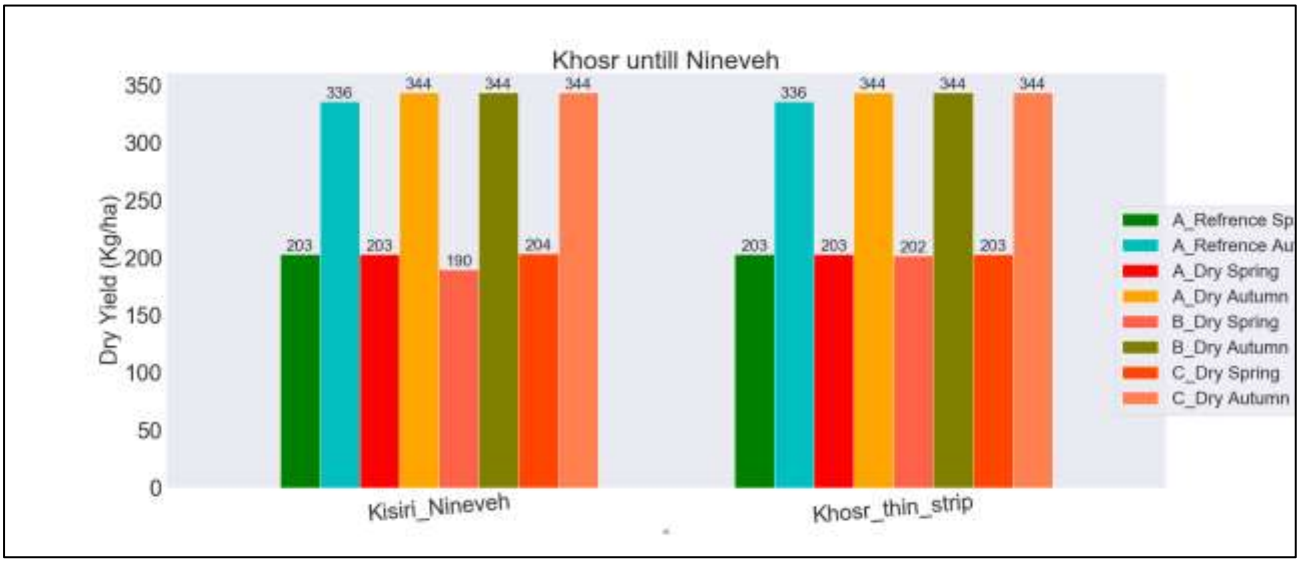

Figure 7 AquaCrop 1m offtake width dry harvest yield results per canal reach and, Control scenarios: A (Reference-Dry, Spring-Autumn), B (Dry, Spring-Autumn) and C (Dry, Spring-Autumn) indicated on the x axis, while numbers on top of the bars indicate their exact values.

List of Modeling Files

Table 8 List of modeling files used in Sobek, AquaCrop and their results visual editing.

File Type	***Number***	***Role Description***
NetCDF	2	Climate files Precipitation, Temperature 1979-2010
QGIS	1	Estimation of stream location and settlements near canals
Python scripts	6	Converting NetCDF to AquaCrop acceptable files
AquaCrop	200	Yield simulations, irrigation schedule files
Sobek	6	Flow simulation
Python notebooks	12	Editing Sobek results, figures-tables
Excel	1	Simple table calculations on harvest and potential inflows

NetCDF files acquired from NOAA with precipitation and temperature daily values over the region from 1979-2010. QGIS file is used in assessing where natural streams-rivers could intersect with canals and archaeologically identified settlements proximity to canals. A few python scripts were used to download separate via location (into three sets Nineveh, Navkur, Faida) and per to make them acceptable format for AquaCrop. Yield simulations and irrigation schedule files are evenly distributed, with the former showing harvest amount in tons and irrigation used in mm. While irrigation schedules are produced to integrate flow modeling results (Coverage) in AquaCrop. Sobek file represent the different control and offtake width scenarios that were run for Ref, Dry and Wet inflow (where applicable). Python notebooks are used in making Sobek's and AquaCrop's results in visible format (figures, tables). The Excel file used in simple calculation for potential inflows, irrigation schedule timing and amounts and the more general tables features last in the Results section of the main text.

The modeling files can be received upon request from Dr. Maurits Ertsen (M.W.Ertsen@tudelft.nl) or the repository (http://repository.tudelft.nl).