ADDRESSING UNIQUE STORAGE CHARACTERISTICS IN THE NORTH BRANCH CHICAGO RIVER WATERSHED USING HEC-RAS

> Adam Hacker, El HDR Engineering

Project Overview

- 1 of 6 DWPs in various stages of completion
- 4 main reaches modeled
- Existing conditions hydrologic and unsteady hydraulic modeling
- Flood control alternatives hydraulic modeling
- Damage Assessments
- Resulting design and final construction by others



Storage Related Challenges

- Balancing stage in split flow reaches along the Skokie River
- Modeling pump operations for the Northbrook Court Reservoir



Skokie River Geometry

- 19 river miles
 (Skokie River and Tribs)
- Complex reach
- I0 junctions
- 3 split flow reaches
- Several tributary to sub-reach overflow points



Skokie Lagoons Split Flow Reach







Skokie Lagoons Lateral Weirs





Skokie River & Lagoon Profiles

- Gaps in the lateral weirs come from either high points or weirs on the other reach
- 1 ground elevation is taken for each cross section
- WSEL for both reaches = 626.46 (NAVD88)





HEC-RAS Lateral Structure Output

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- Lateral Structure output table for both reaches
- Negative flow comes in from the other reach
- At max WSEL, 207cfs flows from Skokie reach to the Lagoon reach (accounting for 25% of the peak flow in the Lagoon)

🏛 Profile Output Table - Lateral Structures 📃 🗖 🔀							
File Options Std. Tables User Tables Locations Help							
	HEC-RAS Plan: 100 Year Profile: Max WS Reload Data						
Biv	ver	Reach	River Sta	QUS	Q Leaving Total	QDS	Q Weir
				(cfs)	(cfs)	(cfs)	(cfs)
Sk	okie.	Sko_004	23794	467.62	0.00	467.53	0.00
Sk	okie 🛛	Sko_004	23145	467.53	0.00	467.61	0.00
Sk	okie 🛛	Sko_004	21537	390.16	46.08	344.40	46.08
Sk	.okie	Sko_004	21163	344.40	0.23	343.99	0.23
La	g_Div	Lag_001	10468	460.96	5.77	452.67	5.77
La	g_Div	Lag_001	10347	452.67	0.00	453.95	0.00
La	g_Div	Lag_001	10098	453.95	0.00	454.19	0.00
La	g_Div	Lag_001	9958	454.19	0.00	450.83	0.00
La	g_Div	Lag_001	9814	450.83	0.00	451.04	0.00
La	g_Div	Lag_001	9620	451.04	0.00	448.44	0.00
La	g_Div	Lag_001	9404	448.44	0.00	443.12	0.00
La	g_Div	Lag_001	9079	443.12	0.00	446.97	0.00
La	g_Div	Lag_001	8877	446.97	0.00	440.95	0.00
La	g_Div	Lag_001	8110	447.20	0.00	447.89	0.00
La	g_Div	Lag_001	7613	447.89	0.00	442.66	0.00
La	g_Div	Lag_001	7461	442.66	0.00	445.73	0.00
La	g_Div	Lag_001	7273	445.73	-28.51	472.69	-28.51
La	g_Div	Lag_001	6976	472.69	-38.13	502.09	-38.13
La	g_Div	Lag_001	6733	502.09	-21.90	502.14	-21.90
La	g_Div	Lag_001	5916	502.93	0.00	502.59	0.00
La	g_Div	Lag_001	5489	502.59	0.00	502.43	0.00
La	g_Div	Lag_001	4812	502.43	0.00	501.63	0.00
La	g_Div	Lag_001	4654	501.63	0.00	501.80	0.00
La	g_Div	Lag_001	4110	499.76	-10.59	511.31	-10.59
La	g_Div	Lag_001	4015	511.31	-43.53	555.35	-43.53
La	g_Div	Lag_001	3554	555.35	-4.33	556.90	-4.33
La	g_Div	Lag_001	3418	556.90	-20.13	577.88	-20.13
La	g_Div	Lag_001	2999	622.42	0.00	622.84	0.00
La	g_Div	Lag_001	2677	622.84	0.00	622.66	0.00
La	g_Div	Lag_001	2465	622.66	0.00	622.51	0.00
La	g_Div	Lag_001	2318	622.51	4.00	618.14	4.00
La	g_Div	Lag_001	2004	618.14	0.64	617.53	0.64

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<u>Northbrook Court Reservoir</u> <u>Pumping Operations</u>

- 2 Dry Weather Pumps with one speed, operating over two stage ranges
- 3 Storm Pumps with high and low speed settings, operating over one stage range
- Pumps controlled by reservoir WSEL
- Pump override bubbler located 2.5 miles D/S of reservoir



Pump Connection Data

- Each pump setting is input as its own Pump Station
- Pump From
- Pump To
- Optional On-Off Reference not utilized

Pump Station I	Data Editor					
Pump Station Nam	e: SPL03	Rename Pump Station				
Pump Connection	Pump Connection Data Pump Group Data Advanced Control Rules					
Pump From: Sto	orage area: NB court Res.	Set RS Set SA Del				
Distance	e from upstream RS to the pump intake:					
Pump To: Mic	ddle Fork Middle Fork RS: 30056.76	Set RS Set SA Del				
Distance	e from the upstream RS to the pump outlet:					
Optional On-Off	Reference (If not set, then the From location is used)					
Reference:		Set RS Set SA				
Distance	e from the upstream RS to the reference:					
Highest elevatio	Plan Data Highest elevation in pump line (optional): Steady Flow Optimization					
Plot Pump Curv	/es					
Remove the contro	oller reference location					

Pump Group Data

- WSEL On
- WSEL Off
- Pump Efficiency
- Scope General performance

Pump Station Data Editor					
Pump Station Name: SP LO 3					
Pump Connection Data Pump Group Data Advanced C	Control Rules				
Group Name: Group #1 💽 Add Group [Delete Group	Rename Group			
Pump Groups					
Number of Pumps in Group: 1	Pump Effici	ency Curve			
Startup (min): 0 Shutdown (min): 0	Head(It)	Flow(cfs)			
Bias group operations to On	2 1	16.71			
Pump Operations	3 10	16.71			
Pump Name WS Elev On (ft) WS Elev Off (ft)	4 20	16.71			
1 Pump #1 647.25 637.75	5 50 6 100	16.71			
	7	10.71			
	8				
	9				
	10				
	12				
	13				
	14				
	15				
	16				
Plot Pump Curves	OK	Cancel			
,	_				

Advanced Control Rules

- New to HEC-RAS 4.0
- Rule Type
- Apply based on target WS

Pump Station Data Editor					
Pump Station Name: SP LO 3 💽 🖡 🕇 Rename Pump Station					
Pump Connectio	n Data Pump Group Data Advanced Control Rules				
	Add New Rule Delete Rule Copy Rule 🖡 🕇				
	Pump Rules				
WS based rule - flow max = 0 flow min = 0 trigger reference = Middle Fork_Middle Fork_RS: 163 WS based rule - flow max = 0 flow min = 0 trigger reference = Storage area: NB court Res. trigge ???? based					
	HEC-RAS				
	Rule Types				
	C Always apply this rule				
⊢ Edit Current S	C Apply based on target flow				
	C Apply based on target WS				
	C Apply based on day/hour and flow				
Trigger Node:	C Apply based on day/hour and WS S Set SA				
	Cancel				
	Ingger WS Max: 680 Ingger WS Min: 634.75				
Plot Pump Cur	ves OK Cancel				

Reservoir WSEL override

- Reservoir set as trigger node
- Rule operates pump while reservoir is falling, not rising
- Rule flow max at 0 shuts pump off
- Trigger WS min is the same as "pump on" elevation set in Pump Group Data

Pump Station Data Editor						
Pump Station Name: SP LO 3 💽 🚽 🕇 Rename Pump Station						
Pump Connection Data Pump Group Data Advanced Control Rules						
	Add New Rule	e Delete Rule	Copy Rule 🕴 🕇			
	Pump Rules					
WS based rule - fl	ow max = 0 flow min = 0 l	trigger reference = Middle	Fork Middle Fork RS: 1638			
WS Dased fulle - II	ow max = 0 now min = 01	nigger reference = storag	e alea. No coult nes, trigger			
Edit Current Sele	cted Rule					
	Rule Flow Maximum: 0	Rule Flo	w Minimum: 0			
	Transition (min):	Transitio	n (min): 0			
Trigger Node:	Storage area: NB court	Res.	Set RS Set SA			
	_					
	Trigger WS Max: 6	80 Trigger V	VS Min: 647.25			
Plot Pump Curves 0K Cancel						
J						

Downstream Bubbler Override

- Trigger node set at bubbler x-section location
- Rule flow max at 0 shuts pump off
- Trigger WS min is at an elevation independent of the reservoir

Pump Station Data Editor					
Pump Station Name:	SPL03	•] † F	Rename Pump Stati	on
Pump Connection Data Pump Group Data Advanced Control Rules					
	Add New F	lule Dele	te Rule	Copy Rule	I t
		Pump Rules			
WS based rule - flo	w max = 0 flow min =	0 trigger referen	ce = Middle For	k Middle Fork RS:	1638
WS based rule - fic	w max = U flow min =	: U trigger referen	ce = Storage ar	ea: NB court Hes, ti	rigger
Edit Current Selec	ted Bule				
	Rule Flow Maximum:	0	Rule Flow M	inimum: 0	
	Transition (min):	0	Transition (m	nin): O	_
Trigger Node:	Middle Fork Middle I	Fork RS: 16385.	80	Set RS Set	SA
inggoritodo.					
	Trigger WS Max:	680	Trigger WS I	Min: 634.75	_
Plot Pump Curves	:			OK Can	cel
			_		

Bubbler Performance Check

- Open Bubbler cross section stage and flow table
- Used excel to determine range of dates that the shutoff should be in effect
- Dates 01 July 1600 to 03 July 1700

🖴 Stage and Flow Hydrographs							
File	File Type Options Help						
River:	River: Middle Fork						
Reac	Reach: Middle Fork 💽 River Sta.: 16385.80 💌						
🔽 F	▼ Plot Stage ▼ Plot Flow □ Obs Stage □ Obs Flow ▼ Use Ref Stage						
Sta	ge Flow	ng Curve)					
		Stage	Flow				
	Date	INST-VAL	INST-VAL				
		FEET	CFS				
1	30Jun2009 2400	630.87	20.64				
2	01Jul2009 0100	630.93	23.02				
3	01Jul2009 0200	630.99	25.12				
4	01Jul2009 0300	630.91	22.02				
5	01Jul2009 0400	630.81	18.51				
6	01Jul2009 0500	630.74	16.50				
7	01Jul2009 0600	630.73	16.01				
8	01Jul2009 0700	630.82	19.01				
9	01Jul2009 0800	631.08	29.36				
10	01Jul2009 0900	631.61	55.52				
11	01Jul2009 1000	632.20	93.74				
12	01Jul2009 1100	632.77	138.63				
13	01Jul2009 1200	633.30	187.81				
14	01Jul2009 1300	633.74	234.41				

Bubbler Check - Continued



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Comparison Without Control Rules



<u>Summary</u>

- Usage of lateral weirs to balance split flow reaches
- Usage of the new advanced pump control rules to manipulate pump operation
- More on NBCR
 DWP tomorrow
 during session 3A

NORTH BRANCH CHICAGO RIVER WATERSHED





Adam Hacker, El HDR Engineering adam.hacker@hdrinc.com

