Hydraulics and Conveyance Design and Evaluation Tools

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The Need For Hydraulic Modeling Tools

- Plan features may require substantial modifications to existing conveyance network
- The inclusion of large flow-ways in the configurations dictates the need for accurate estimates of hydraulic capabilities
- By using available hydrologic information and hydraulic modeling tools flow performance can be evaluated
- Associated costs for system modifications and new features can be estimated

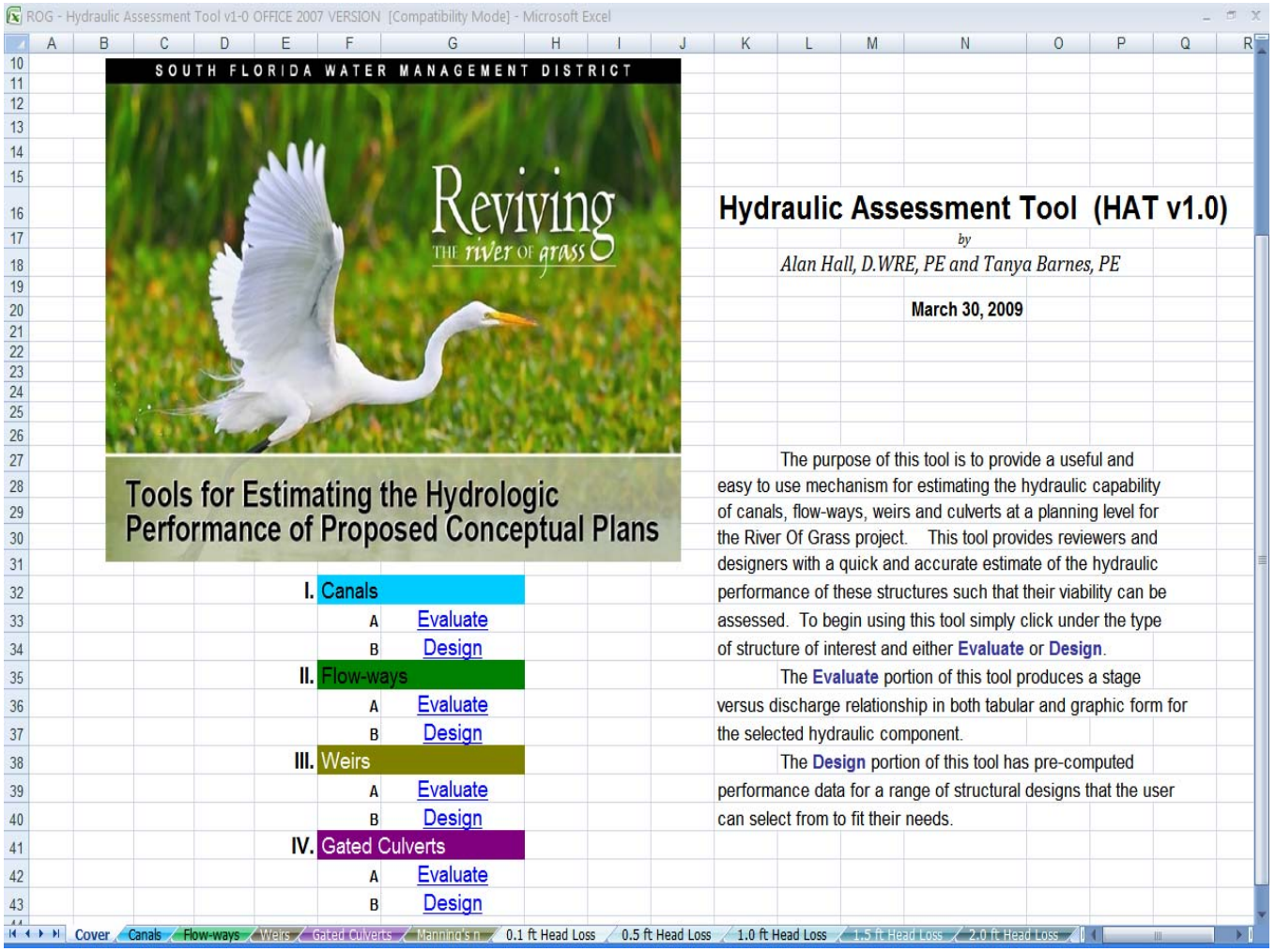
Hydraulic Modeling Tools

- HAT – Hydraulic Assessment Tool
  - Developed during Phase I as a design program
- MIKE 11
  - Developed by the Danish Hydraulic Institute for flood protection system design and analysis
- HEC-RAS – Hydrologic Engineering Center River Analysis System
  - Developed by the U.S. Army Corps of Engineers
    - Used nation-wide for design and analysis of conveyance systems

HAT – Hydraulic Assessment Tool

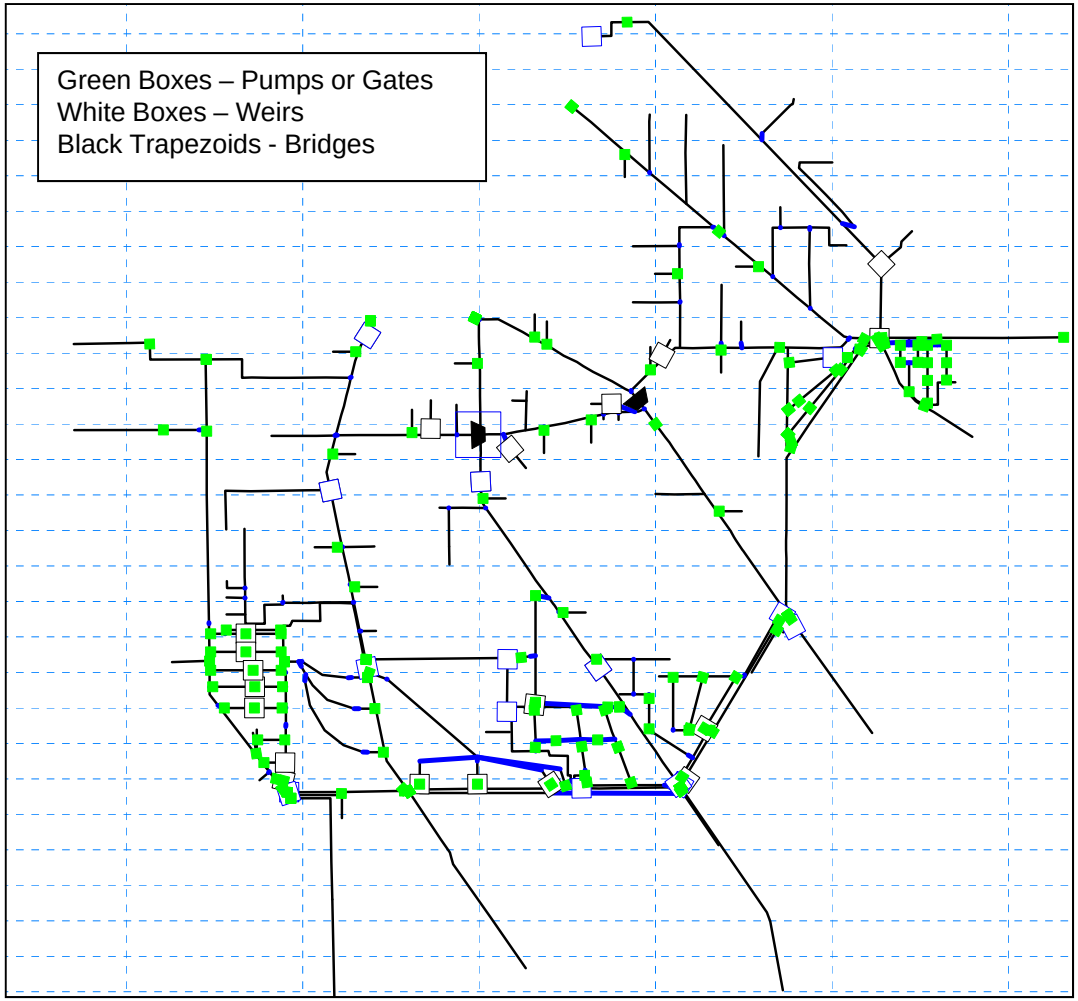
Engineer's
Design Tool for:

1. Canals
2. Flow-ways
3. STA cells
4. Weirs
5. Gate-controlled culverts

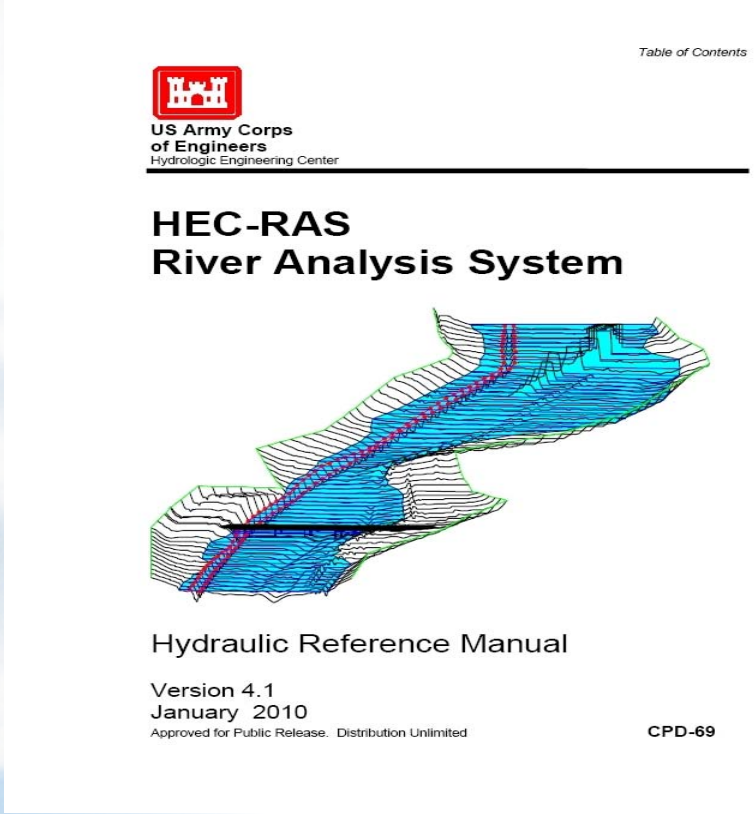


MIKE 11 – Canal System Simulations

- Model was used for the EAA Regional Feasibility Study
- Model includes all EAA canals, numerous private canals, and all STAs including interior structures
- Many private and public bridges that limit flows are also included in the model
- Model will be used to look at hydraulic conveyance limitations under design flow conditions
- Canals will be identified where conveyance limitations exist, areas with deficiencies will be resized and costs for necessary improvements quantified



HEC-RAS – HEC River Analysis System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US Army Corps
of Engineers
Hydrologic Engineering Center

HEC-RAS
River Analysis System

Hydraulic Reference Manual

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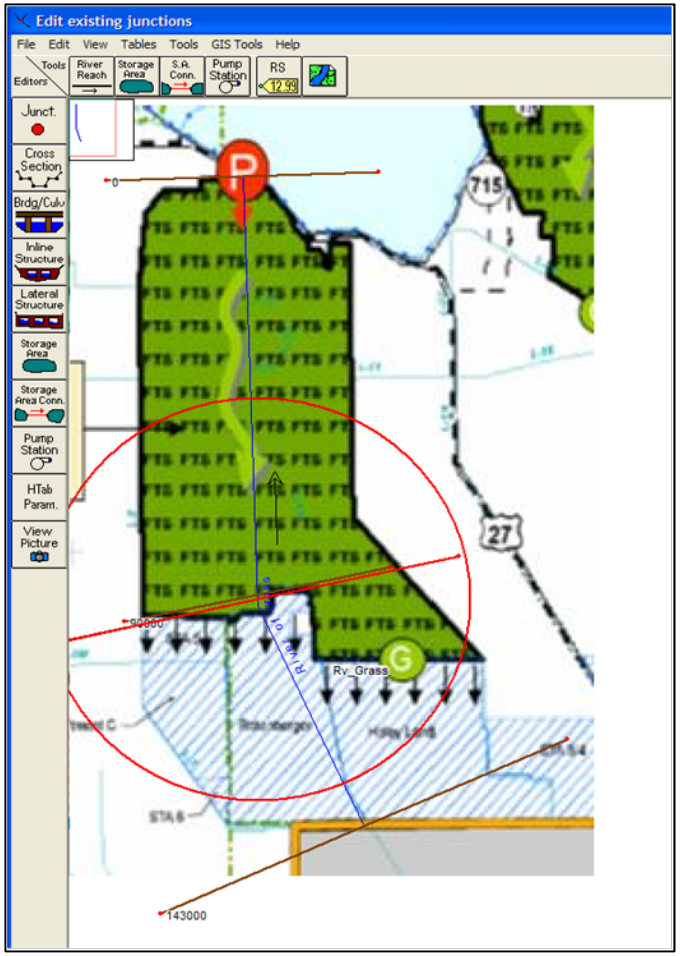


Useful tool for evaluating water depths when locating, sizing and designing flow-ways that deliver water through the EAA

Example Use of HEC-RAS Hydraulic Tool

HEC-RAS Application Example

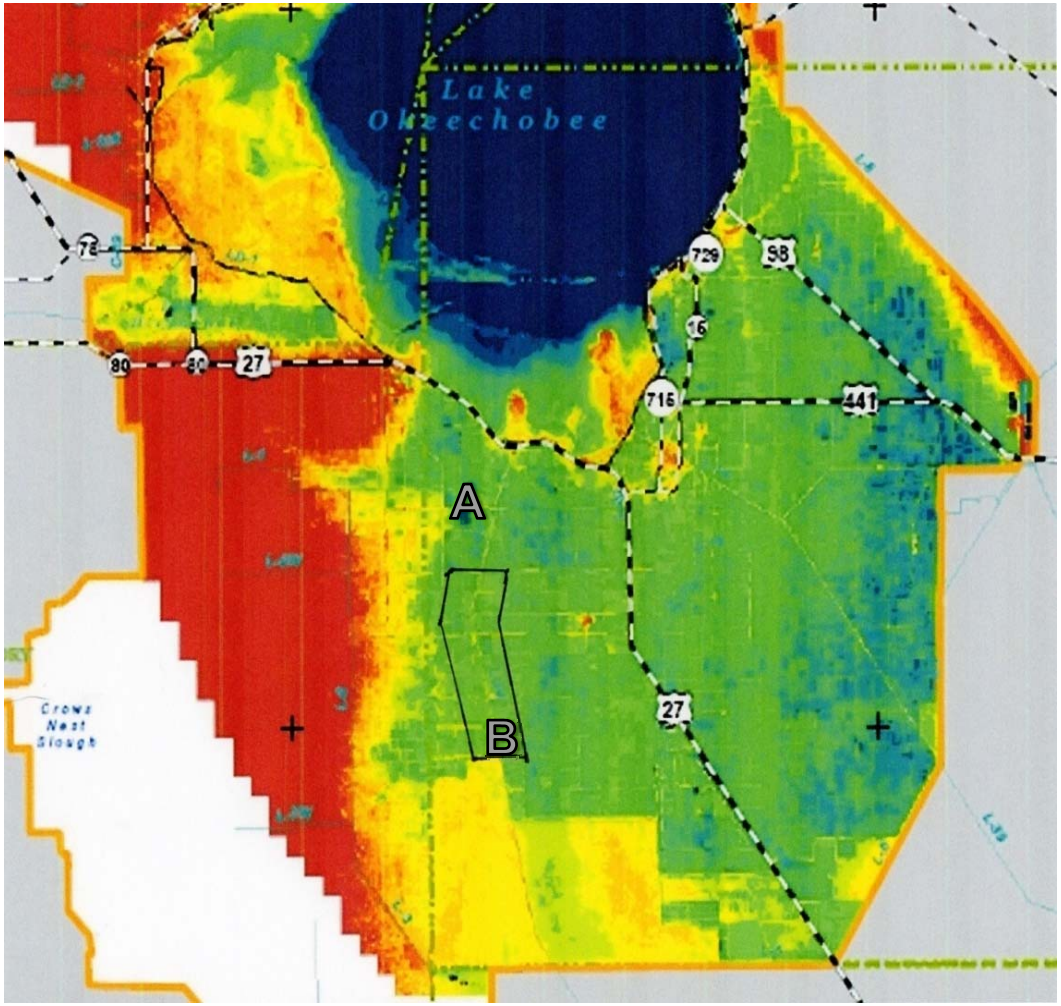
Hypothetical 2-mile wide by 10-mile long flow-way with alternative initial water depths

Actual topography of the area is used from the flow-way area for estimating cross-sectional dimensions

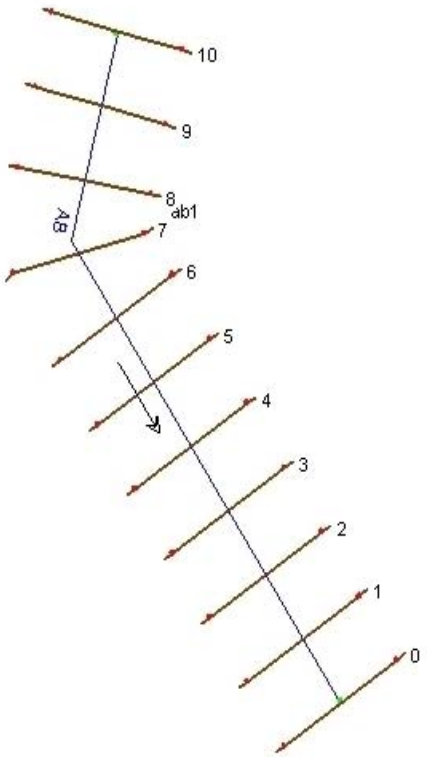
A= Upstream end of flow-way
B= Downstream end of flow-way

Evaluate stage profile with flow of 2,000 cfs

Evaluate stage profile with flow of 7,000 cfs



Example Use of HEC-RAS Hydraulic Tool
HEC-RAS Stage Profile



HEC-RAS Hydraulic Tool Look-Up Tables

With a 2-foot depth downstream at a flow of 7,000 cfs peak depths are over 12 feet at the north end of a 10-mile long flow-way

With a 3-foot depth downstream at a flow of 7,000 cfs the peak depth is less than 6 feet at the north end of a 10-mile long flow-way

Hydraulic characteristics directly effect peak water depths and required levee heights for containment

In some cases may require "Dam Safety Criteria" and seepage collection

Flow-way Depth at Upstream End for a 10-mile Long Flow-way

Starting Depth = 2 feet								
Width (miles)	1	2	3	4	5	6	7	10
W x L	1X10	2X10	3X10	4X10	5X10	6X10	7X10	10X10
Area (acres)	6,400	12,800	19,200	25,600	32,000	38,400	44,800	64,000
Flow = 0	2	2	2	2	2	2	2	2
500	2.21	2.05	2.02	2.01	2.01	2.01	2	2
1,000	2.85	2.21	2.09	2.05	2.03	2.02	2.02	2.01
2,000	5.38	2.85	2.38	2.21	2.14	2.09	2.07	2.03
3,000	9.61	3.9	2.85	2.48	2.3	2.21	2.16	2.08
4,000	15.53	5.38	3.5	2.85	2.54	2.38	2.28	2.14
5,000	23.15	7.29	4.35	3.32	2.85	2.59	2.43	2.21
6,000	32.45	9.62	5.38	3.9	3.22	2.85	2.62	2.3
7,000	43.45	12.36	6.61	4.59	3.66	3.15	2.85	2.41

Flow-way Depth at Upstream End for a 10-mile Long Flow-way

Starting Depth = 3 feet								
Width (miles)	1	2	3	4	5	6	7	10
W x L	1X10	2X10	3X10	4X10	5X10	6X10	7X10	10X10
Area (acres)	6,400	12,800	19,200	25,600	32,000	38,400	44,800	64,000
Flow = 0	3	3	3	3	3	3	3	3
500	3.05	3.01	3.01	3	3	3	3	3
1,000	3.22	3.06	3.02	3.01	3.01	3.01	3	3
2,000	3.88	3.22	3.1	3.05	3.04	3.02	3.02	3.01
3,000	4.97	3.49	3.22	3.12	3.08	3.05	3.04	3.02
4,000	6.5	3.88	3.39	3.22	3.14	3.1	3.07	3.04
5,000	8.47	4.37	3.61	3.34	3.22	3.15	3.11	3.05
6,000	10.88	4.97	3.88	3.49	3.32	3.22	3.16	3.08
7,000	13.72	5.68	4.19	3.67	3.43	3.3	3.22	3.11

HEC-RAS Hydraulic Tool Look-Up Tables

With a 2-foot depth downstream at a flow of 7,000 cfs depths are over 7 feet at the north end of a 5-mile long flow-way

With a 3-foot depth downstream at a flow of 7,000 cfs depths are just over 4 feet at the north end of a 5-mile long flow-way

Flow-ways in series achieve a much shallower top-end depth, an intermediate pump station would be required between the segments, but pump costs may be offset by lower embankment heights

In some cases may still require "Dam Safety Criteria" and seepage collection

Flow-way Depth at Upstream End for a 5-mile Long Flow-way

Starting Depth = 2 feet								
Width (miles)	1	2	3	4	5	6	7	10
W x L	1X5	2X5	3X5	4X5	5X5	6X5	7X5	10X5
Area (acres)	3,200	6,400	9,600	12,800	16,000	19,200	22,400	32,000
Flow = 0	2	2	2	2	2	2	2	2
500	2.11	2.03	2.01	2.01	2	2	2	2
1,000	2.42	2.11	2.05	2.03	2.02	2.01	2.01	2
2,000	3.69	2.42	2.19	2.11	2.07	2.05	2.03	2.02
3,000	5.81	2.95	2.42	2.24	2.15	2.11	2.08	2.04
4,000	8.77	3.69	2.75	2.42	2.27	2.19	2.14	2.07
5,000	12.57	4.64	3.18	2.66	2.42	2.29	2.22	2.11
6,000	17.23	5.81	3.69	2.95	2.61	2.42	2.31	2.15
7,000	22.72	7.18	4.3	3.3	2.83	2.58	2.42	2.21

Flow-way Depth at Upstream End for a 5-mile Long Flow-way

Starting Depth = 3 feet								
Width (miles)	1	2	3	4	5	6	7	10
W x L	1X5	2X5	3X5	4X5	5X5	6X5	7X5	10X5
Area (acres)	3,200	6,400	9,600	12,800	16,000	19,200	22,400	32,000
Flow = 0	3	3	3	3	3	3	3	3
500	3.03	3.01	3	3	3	3	3	3
1,000	3.11	3.03	3.01	3.01	3	3	3	3
2,000	3.44	3.11	3.05	3.03	3.02	3.01	3.01	3
3,000	3.98	3.25	3.11	3.06	3.04	3.03	3.02	3.01
4,000	4.75	3.44	3.19	3.11	3.07	3.05	3.04	3.02
5,000	5.74	3.68	3.3	3.17	3.11	3.08	3.06	3.03
6,000	6.94	3.99	3.44	3.25	3.16	3.11	3.08	3.04
7,000	8.36	4.34	3.6	3.34	3.21	3.15	3.11	3.05

Following are example simulations that will demonstrate some of the hydraulic principles just discussed …