

CHAPTER 3

MATERIALS AND METHODS

HEC RAS 3.0

Two goals of the HEC-RAS simulations were: (1) to determine how much water the existing channel can convey to the target study area without spilling over its banks; and (2) to examine the maximum channel velocities and shear to ensure no scour would occur. Also, the minimum velocity was examined for a given flow rate to determine if the potential for deposition within the channel existed. Three surveys from an EPA gauge study form the base model geometry (Figures 13 to 15). From these cross sections, nineteen additional cross sections were interpolated using HEC-RAS 3.0's automatic interpolation scheme (Figure 16). Cross sections were interpolated approximately every 500 feet (152 m).

Roughness coefficients used were 0.1 for overbank flow and 0.03 for channel flow. These values fall into the range of typical published values for similar site conditions (Chow, 1959). Expansion and contraction coefficients were 0.3 and 0.1 respectively. Losses due to channel expansion and contraction were assumed to be negligible.

The downstream boundary condition for all runs was the Hope Canal stage data for January 1998. These data were obtained from the USGS gauge number 073802292 positioned at the I-10-Hope Canal Bridge (Figure 15). Note that these stage levels vary with time. Upstream boundary conditions used were steady flow rates ranging from 100 ft³/sec (2.9 m³/sec) to 400 ft³/sec (11.3 m³/sec) in 25 ft³/sec (0.7 m³/sec) increments. Initial conditions were 10 ft³/sec (0.3 m³/sec) for all runs.

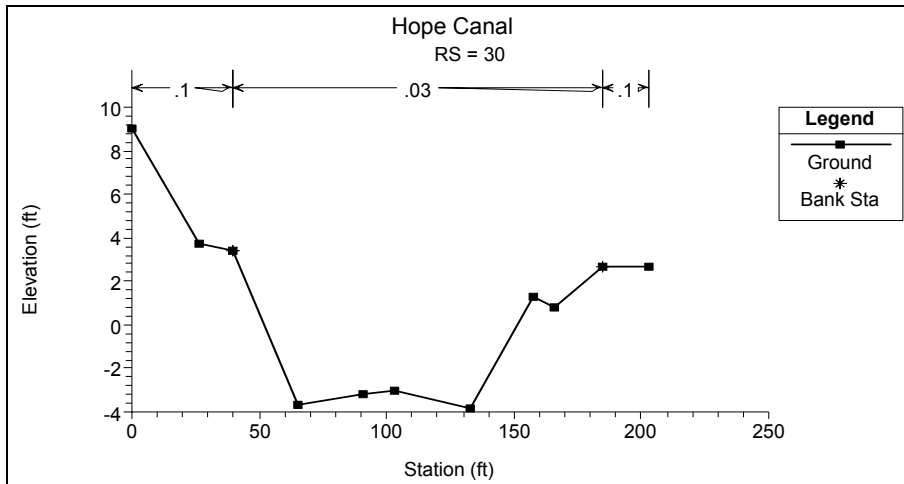


Figure 13: Hope Canal surveyed cross sections – upper section

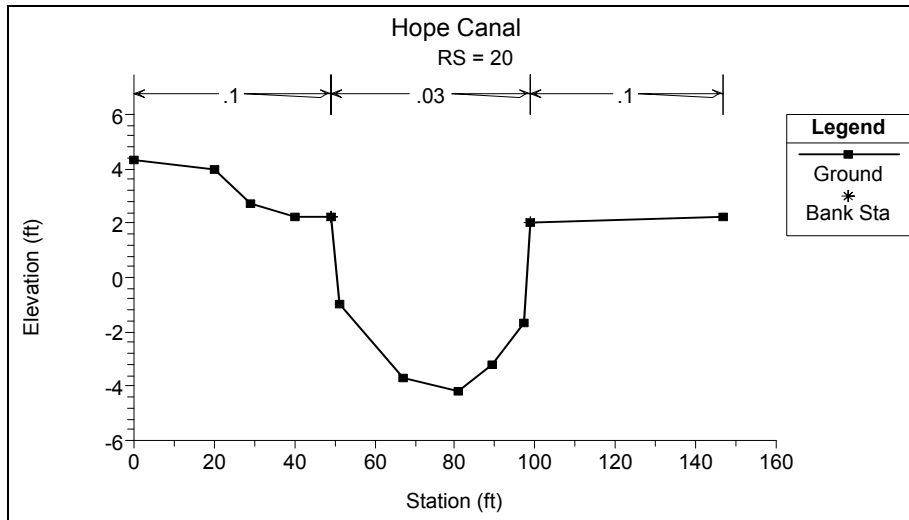


Figure 14: Hope Canal surveyed cross sections - middle section

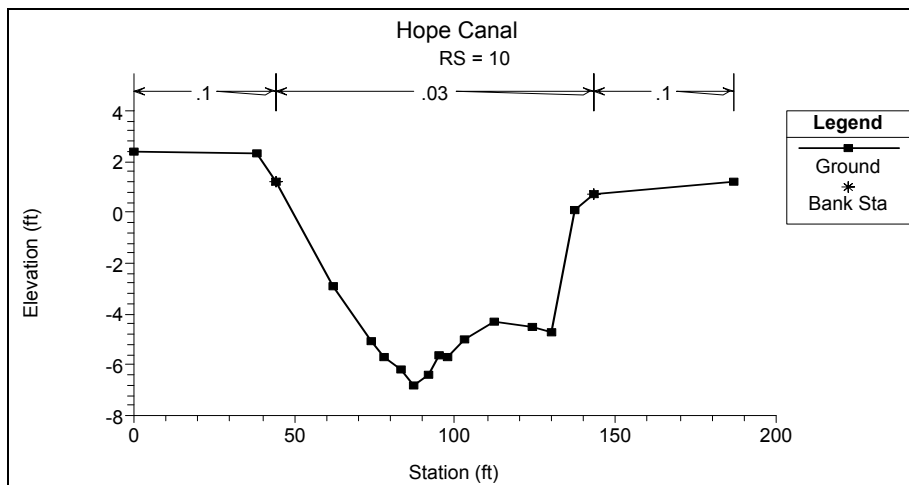


Figure 15: Hope Canal surveyed cross sections - lower section

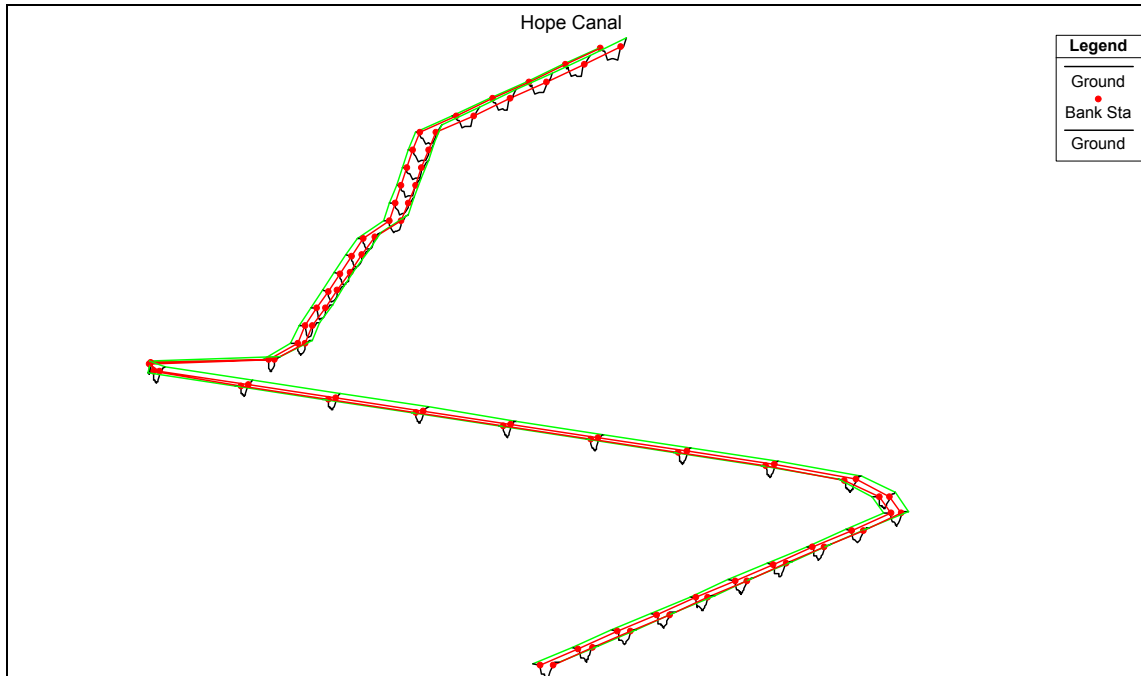


Figure 16: XYZ perspective plot of Hope Canal with interpolated cross sections. Aspect ratio is 10. Upstream is top of figure.

Once the “design” flow rate was determined (i.e., one that didn’t cause overbank flow and/or excessive scour), a sensitivity analysis was conducted on the in-channel roughness parameters. Values ranging from 0.02 to 0.04 were used; these are within the typical range of published roughness coefficients for this type of channel.

QUAL2E

The application of the QUAL2E model was to determine the nutrient, specifically nitrogen, transformation within the Hope Canal channel between Airline Highway and I-10. The results of this modeling run (i.e., the concentrations at the I-10 bridge) provide the nutrient input boundary condition for the RMA4 model. For hydraulic calculations, QUAL2E is only capable of working with uniform cross sections in a given reach (Figure 17). As a result, the surveyed and interpolated cross sections from the HEC RAS 3.0 model were converted to a trapezoidal cross section in order to be usable in QUAL2E (Figure 18).

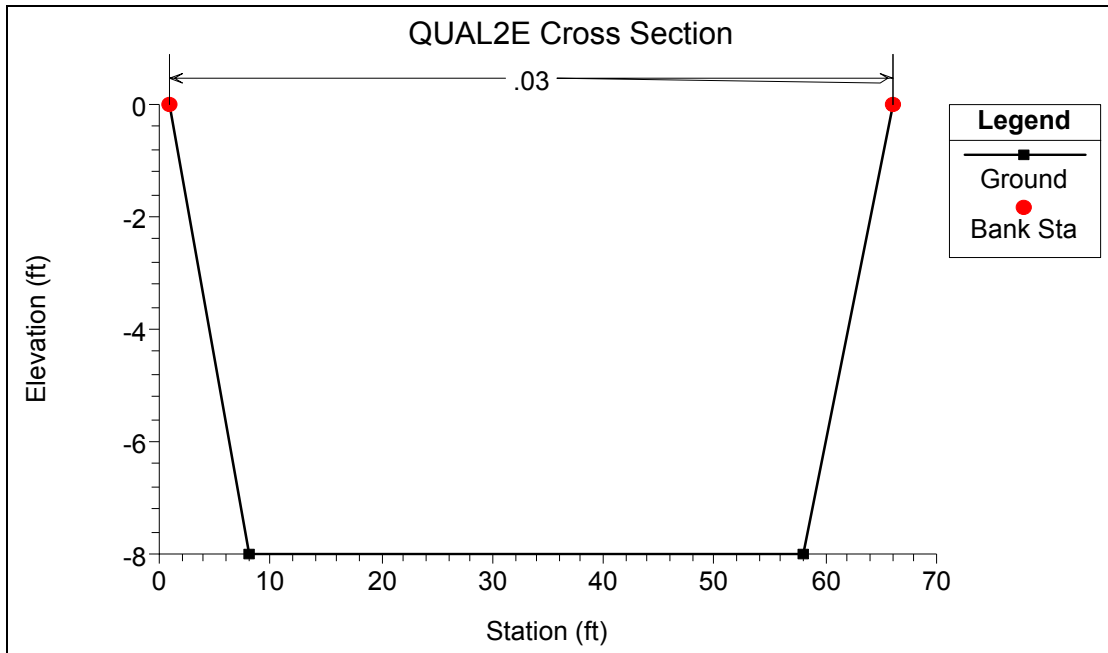


Figure 17: QUAL2E cross section.

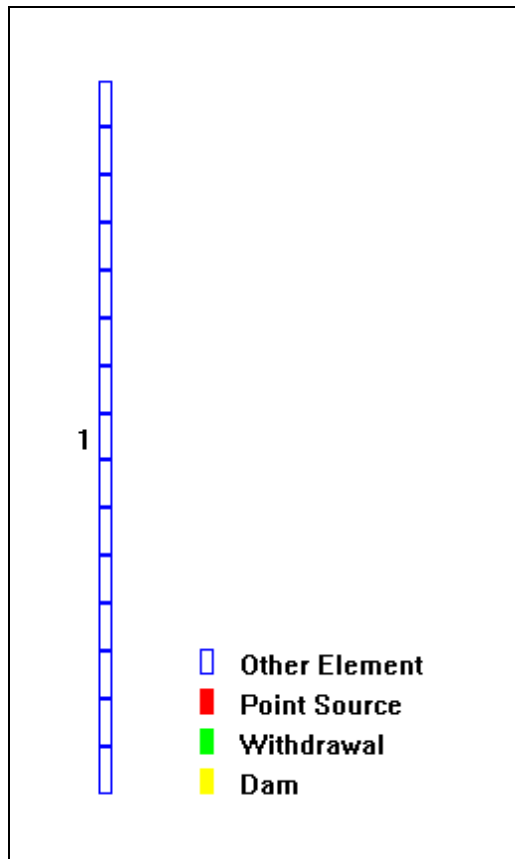


Figure 18: QUAL2E reach

Table 2: QUAL2E Parameters

			Range	Model
α_1	Fraction of algal biomass that is Nitrogen	mg N/mg A	.07-.09	.05
α_5	O ₂ uptake per unit of NH ₃ oxidation	mg O/mg N	3.0-4.0	3.43
α_6	O ₂ uptake per unit of NO ₂ oxidation	mg O/mg N	1.0-1.14	1.14
β_1	Rate constant for the biological oxidation of NH ₃ to NO ₂	day ⁻¹	0.10-1.0	.5
β_2	Rate constant for the biological oxidation of NO ₂ to NO ₃	day ⁻¹	0.20-2.0	1
β_3	Rate constant for the hydrolysis of organic N to ammonia	day ⁻¹	0.02-0.4	.3
σ_3	Benthos source rate for ammonia nitrogen	mg O/ft ² day	Variable	.5
σ_4	Organic nitrogen settling rate	day ⁻¹	0.001-0.1	.05

There are two major classes of parameters utilized in the QUAL2E model. The first are the hydraulic parameters that include flow rates (obtained from the HEC RAS 3.0 simulations) and reach geometry (Figures 17 and 18). The second are the concentrations and parameters driving the evolution of the materials of interest, which is nitrogen in this case (Table 2). For the hydraulic parameters, an input flow rate of 300 ft³/sec (8.5 m³/sec) was used while the stream geometry was interpolated from the surveyed cross sections shown in Figures 11 to 13. Concentrations of various forms of nitrogen as well as water temperature were obtained from the USGS 1999 water year data obtained at Luling, Louisiana (Table 3). This station, which is 20 miles (32.2 km) downstream from the study area, is the closest USGS station available with this type of data on record.

A sensitivity analysis was conducted on several of the parameters that influence the nitrogen evolution in the QUAL2E model. These parameters include

organic nitrogen, nitrate, nitrite, and ammonia decay rates in addition to organic nitrogen settling and ammonia benthic source rates.

Table 3: Mississippi River Water Quality at Luling LA in mg/L. (USGS, 1999)

Date	Nitrite Total	Nitrite Dissolved	Nitrogen NO ₂ + NO ₃ Total	Nitrogen NO ₂ + NO ₂ Dissolved	Nitrogen Ammonia Total	Nitrogen Ammonia Dissolved	Nitrogen Ammonia + Organic Total	Nitrogen Ammonia + Organic Dissolved
Mar 31	<0.01	0.02	1.4	1.4	0.02	<0.01	.65	E.26
Apr 29	<0.01	0.01	1.8	1.8	0.03	0.01	.68	E.28
May 27	<0.01	<0.01	2.2	2.2	<0.01	<0.01	.49	E.20
Aug 11	<0.01	<0.01	1.9	1.9	0.01	0.01	.50	0.34
Sep 15	<0.01	<0.01	1.1	1.1	0.03	<0.01	.51	0.42

E Estimated

RMA2

The purpose of running RMA2 was to determine the flow patterns and water depths in the Maurepas Swamp resulting from the “design” flow entering the swamp at the I-10-Hope Canal Bridge. As mentioned previously, the binary solution files (i.e., flow field) produced by these runs were also used to track nitrogen movement in the study area. The primary tools used to construct the finite element mesh were the USGS 1:24000 Quad map sheets and a digital DEM. A scanned and georegistered map sheet was imported into SMS and used as a template to draw the arc segments for the modeling area boundaries. Additional arcs were constructed to represent major streams, old railroad embankments, high voltage transmission lines, and manmade canals. The railroad embankments were assumed to be no flow areas due to their significant elevation difference relative to the rest of the wetland study area.

Once the arcs were complete, a triangular mesh was automatically generated with the SMS preprocessor. This mesh was edited to eliminate sharp triangles with an interior angle of less than 30 degrees as well as size differences of greater than fifty percent between adjacent elements. This edit was performed to eliminate any possibilities of

model instability due to the mesh geometry. Originally, the intent was to have the range of the study area be the Blind River on the west, Mississippi Bayou on the east, Lake Maurepas on the North, and I-10 on the south. However, the mesh generated for the proposed study area exceeded the RMA2 capabilities in terms of nodes, elements, and array front width. Thus, these factors had to be reduced to meet the limitations of the program. After editing for quality, elements were removed from the northern and eastern sectors of the grid until the mesh met the input requirements for the RMA suite. The final mesh characteristics are 2593 elements, 5801 nodes, and a frontal array width of 1000 (Figure 19). The GFGEN program, within SMS, was then used to create a binary file for the RMA2 program.

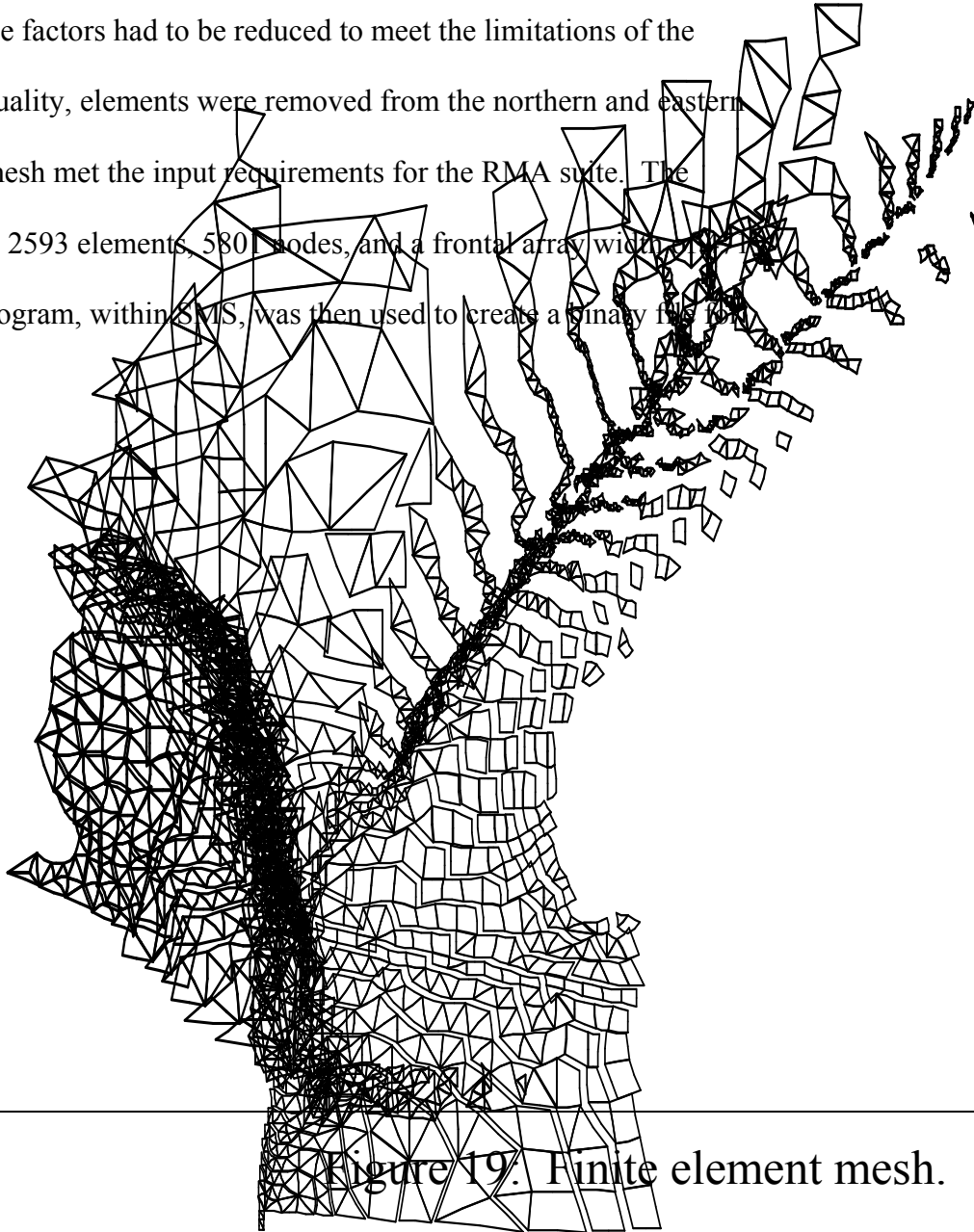


Figure 19. Finite element mesh.

The elements in the mesh were classified into four categories: swamp, natural channel, oil filed canals and Hope Canal (Figure 20). These categories were assigned roughness parameters as shown in Table 4. In addition, the swamp area and transmission line were assigned marsh porosity values.

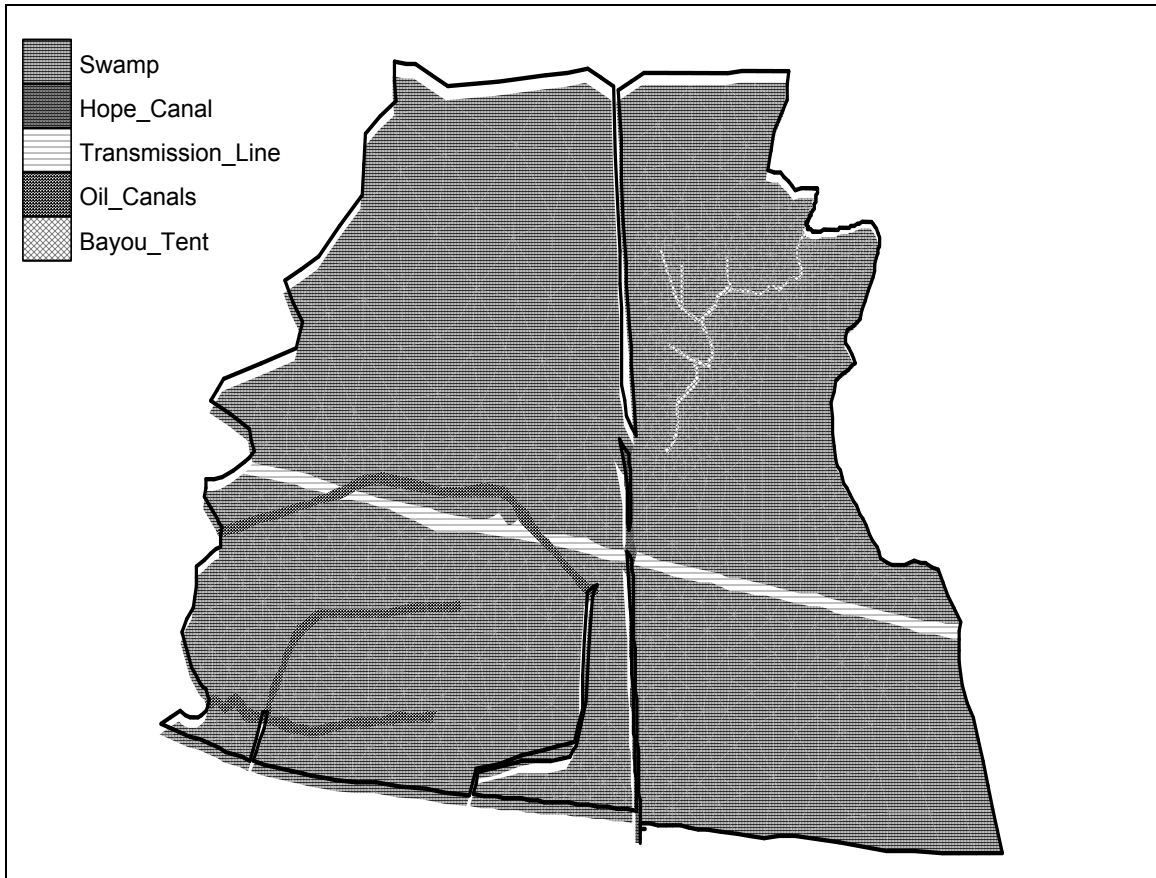


Figure 20: Element types.

Table 4: RMA2 Parameters

Area	Roughness			Marsh Porosity		
	w/veg.	w/o veg.	veg. depth	AC1	AC2	AC3
Swamp	.12	.08	2	2	1.3	.0001
Hope Canal	.033	.025	2	Not used		
Transmission Line	.08	.04	2	2	1.3	.0001
Oil Canals	.033	.025	2	Not used		
Bayou Tent	.05	.035	2	Not used		

Boundary conditions were based on the January hydrograph presented (Figure 6) and the “design” flow rate calculated during the HEC RAS 3.0 modeling phase. Initial conditions within the modeling domain were the start elevation at 1.5 feet (0.5 m). A hotstart file was generated to draw down the stage from 1.5 feet (0.5 m) to 0.4 feet (0.1m), which was used as the starting conditions for the dynamic simulation.

The RMA2 sensitivity analysis was conducted on the roughness, marsh porosity, and turbulent exchange coefficients to determine the robustness of the model with respect to these parameters. The impact of these parameters on water levels was investigated at both high and low lake levels.

RMA4

The objective of the RMA4 modeling was to evaluate the organic nitrogen transport through the modeled area. RMA4 uses the hydrodynamic solution files from RMA2 and simulates constituent transport and evolution with a first order decay rate. In addition to the flow data from RMA2, the primary input parameters for the RMA4 model are growth or decay parameters and diffusion coefficients. Initial conditions were a 0 mg/L nitrogen concentration within the swamp, and boundary conditions were 0 mg/L at the downstream end of the model and the results from the QUAL2E simulation introduced at the upstream (Hope Canal) end of the model. A sensitivity analysis was conducted on the diffusion coefficients and decay rates in order to determine their impact on simulation. This sensitivity analysis was conducted at both high and low steady state downstream boundary stages.