DEPARTMENT OF NATURAL RESOURCES

Memo

Date: 2/24/2022

To: Heron Lake Watershed District

From: MN DNR

RE: JD3 Model Review

The purpose of this memorandum is to summarize the review findings of the ISG Inc.'s XPSWMM model of the Jackson County Judicial Ditch No. 3 (JD3) system. A proposed project to modify JD3 system is under review by the Minnesota Department of Natural Resources (DNR) and the Heron Lake Watershed District Drainage Authority.

The following XPSWMM 1D models were downloaded from the "Heron Lake Modeling Memo", dated January 5, 2022 were reviewed:

- Existing model: '17285 (193) Existing – Heron Lake update.xp'
- Proposed model: '17285 (193) Proposed Heron Lake Outlet Updated.xp'

The following items were evaluated in the review:

- Confirming the model's consistency with the proposed design
- Evaluating the acceptability of modeling parameters and approach
- Verifying the model's calibration with historical lake level and precipitation data
- Evaluating the model's accuracy in evaluating the impacts to the calcareous fen adjacent to South Heron Lake

Recommendation

The updated model includes a larger drainage area and evaluates the dynamics between North Heron and South Heron Lake. It appears to be relatively well-calibrated to the historic rainfall events and lake water levels. However, both models appear to have high continuity error and associated instabilities, and both models are "losing" a significant amount of water. When the continuity and stability errors are corrected, that will likely impact the calibration and the model results. Therefore, we recommend that the continuity errors and instabilities be resolved to ensure accurate calibration and predictions, in addition to making any necessary changes to address the following comments.

Comments

Comment #1: The following files were not available at the time of review and are needed for a more complete and comprehensive review.

- Watershed GIS data (shapefiles) for each modeled subcatchment
- TR55 calculations
- Associated XPSWMM .tif files
- Associated landuse shapefiles

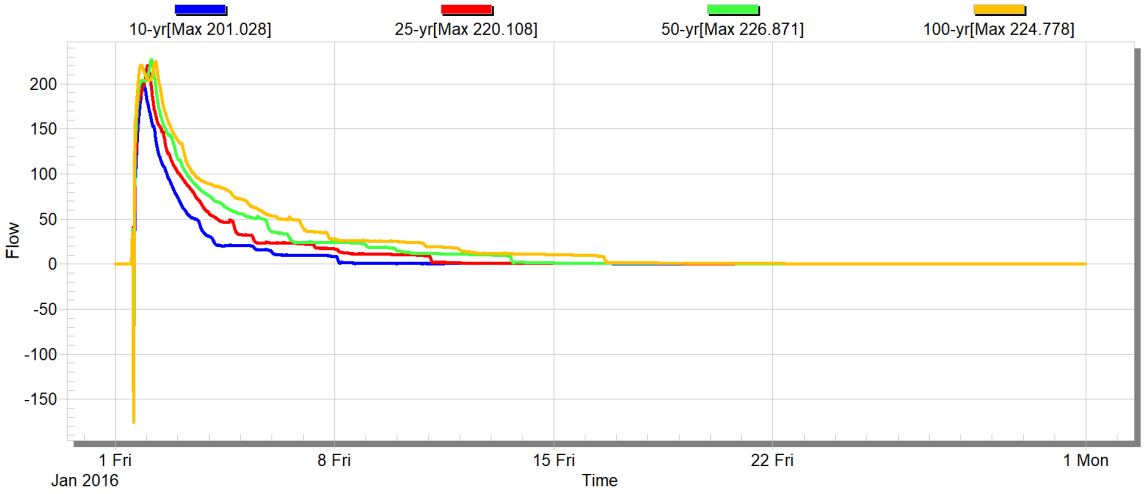
Comment #2: Table E21 in the output file, summarizes the continuity balance at the end of the simulation. This is a measure of the total system inflow minus the total system outflow. The total continuity error in the existing model "17285 (193) Existing – Heron Lake update_100-yr.out" file is 22.0% and in the proposed model "17285 (193) Proposed Heron Lake Outlet Updated_100-yr.out" file of 21.9%. This represents a loss of approximately 1.09E+09 ft^3 of water in both models due to continuity error and model instability. According to Table E18, this is considered "Poor" Continuity. Both models should be edited to be run with a "Good" total continuity error shown in Table E21 of less than 2%.

Comment #3: The link between South Heron Lake and North Heron Lake is modeled as a natural section with a custom shape. This conduit has a modeled length of 17,315 feet. In general, natural channel lengths that are too long will cause model instability. This is due to a disproportionality between the channel length, hydrograph being routed and computational time step (i.e., the channel length is much further than the flood wave can travel within the computational timestep being used). Additionally, assuming a constant natural channel shape throughout this entire 17,315-ft length does not account for changes in hydraulic properties throughout the channel between the two lakes. It is recommended to break longer links in the model up into smaller links to avoid numerical diffusion of the computations and lower the overall continuity error.

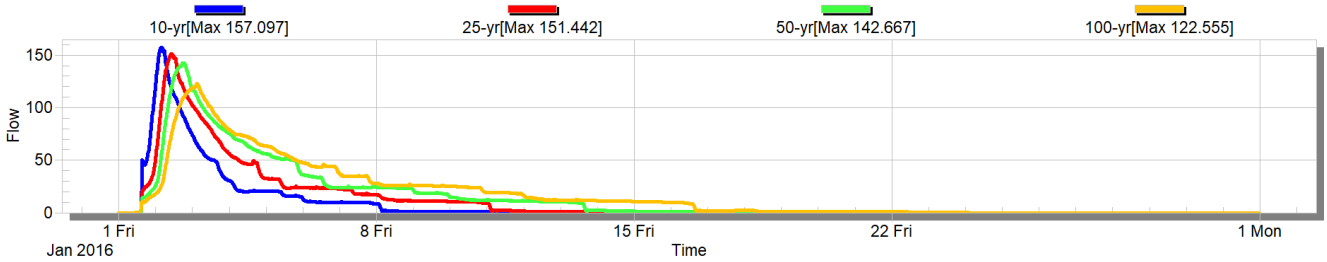
Comment #4: The "constructed wetlands" at Station 5+00 of Branch H and at Station 125+00 on the Mainline are modeled as a series of natural channel links with storage included within the custom natural section shape. XP-SWMM technical advisors at Innovyze advised that XP-SWMM is not able to accurately compute storage in the constructed wetland with it modeled this way. In addition, Innovyze advised that this storage approach overestimates storage and underestimates flow in the cross section. Instead, it should be modeled as a channel with an overflow to an adjacent storage node(s). The model should be revised to better model these storage areas.

Comment #5: The "constructed wetland" at Station 5+00 of Branch H adjacent to 400th Ave is modeled as a series of natural channel links with storage included within the custom natural section shape. The results for the peak flows through Link21 and Link 4934.1 show the peak flow through the "wetland" and at the 54-in RCP outlet decreasing with higher storm events (i.e., for Link21 100-yr peak is 224.778 cfs and 50-yr peak is 226.871 cfs). Please provide an explanation for this modeling result (see figures next page).

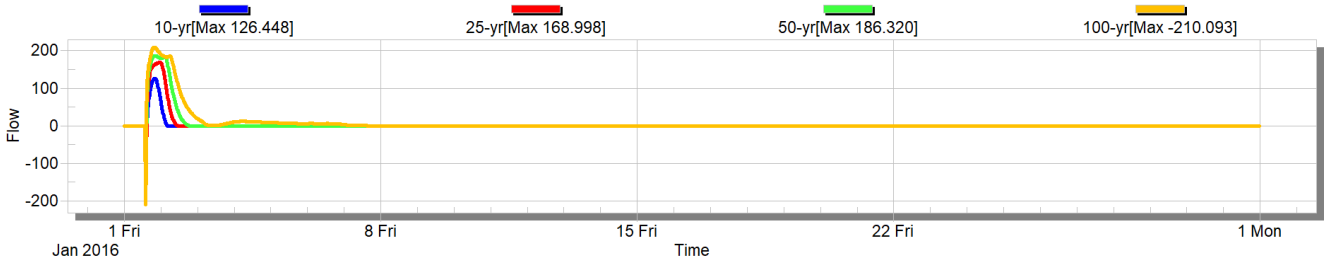
Conduit Link21 from Node21 to Node3109



Conduit 4934.1 from Node3109 to Node22



Conduit 4934.2 from Node3109 to Node22



Comment #6: The "constructed wetland" at Station 5+00 of Branch H adjacent to 400th Ave is at capacity for the 50-yr and 100-yr storm events, and the excess runoff is being stored with ponding in the nodes. This can be seen in the hydrograph for Node3109 at the downstream end of constructed wetland which has a peak water surface elevation of 1412.579 for the 50-yr and 1413.377 for the 100-yr event, both of which are higher than the highest closed contour in the grading plan of 1411. Furthermore, the output file indicates a total volume of ponded flow stored (See Table 1 below) of 474,000 ft^3. This ponded volume of water was most likely being routed on the 2D surface before the model was converted to a 1D model, which would more accurately depict any overland flow that took place during larger rain events. The proposed model should be modified to more accurately route the excess flow being "ponded" in the nodes during larger rain events. One example of how this could be accounted for is by modeling the area as a storage node that includes stage storage elevations above the modeled peak water surface elevation in the area for the 100-yr storm.

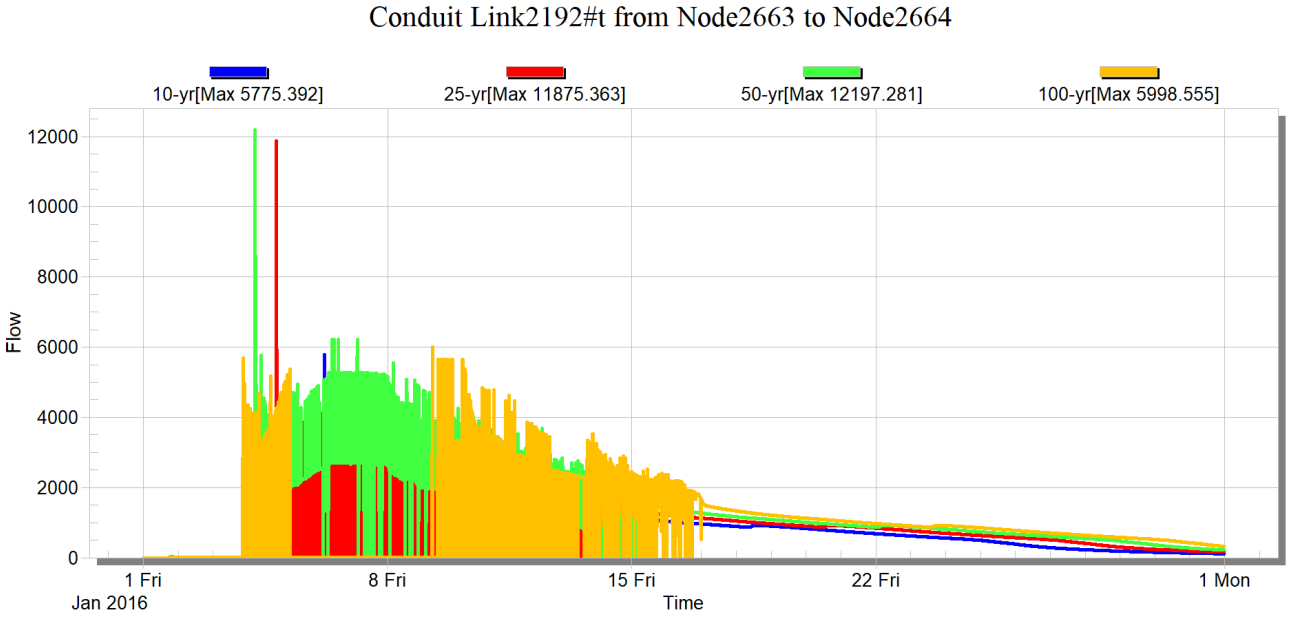
Table 1. Selected Proposed Model Node Results

Node ID	Ground Elevation (Spill Crest)	100-yr Max Water Elevation (ft)	Volume of Ponded Flow Stored (ft^3)	Duration of Surcharge (min)
Node19	1411.87	1413.378	71426.28	971.017
Node21	1412.6	1413.377	178462.13	989.917
Node20	1413	1413.377	127289.91	935.8
Node3107	1413.1	1413.377	50953.96	931.6
Node3109	1412.5	1413.377	45867.97	1068.517
			474,000.25	

Comment #7: According to the output files, the total modeled drainage area is not equal in the existing and proposed models. The total existing area is 283,003.86 ac and the total proposed area is 282,790.6 ac. This 213.26-acre difference could inaccurately underestimate the computed runoff volume in proposed conditions. The project proposer should modify the models to show an equal total drainage area in existing and proposed conditions.

Comment #8: The runoff node, 'NHL' representing North Heron Lake is modeled with a curve number of 80. Water bodies are impervious and should be modeled with curve numbers of 98 or greater. If this node represents area outside of the normal lake water surface area, the lake surface area should be split out in a second sub-catchment so that infiltration isn't accounted for in the lake surface area; as doing so could underestimate the computed runoff volume over the lake. This comment applies to South Heron Lake as well.

Comment #9: Link 2192 representing a bridge downstream of North Heron Lake appears to have an instable solution. The model should be modified to show a more stable solution in this link to ensure accurate model results.



Comment #10: The initial abstraction for the subwatersheds within the direct project area was set to be 0.5 fraction for all subwatersheds; however, it was set to 0.2 fraction for all other subwatersheds that drain to North and South Heron Lakes. Please explain why the different abstraction values were used.