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Memorandum

To: Randy Anhorn, Nine Mile Creek Watershed District
From: Michael McKinney and Janna Kieffer
Subject: Scope of Work for Watershed-wide Flood Risk Assessment (Atlas 14 Flood Risk and Resiliency- Phase 2)
Date: January 13, 2021

The Nine Mile Creek Watershed District (NMCWD) has a long history in flood planning and floodplain management going back to the 1960s and seeks to continue to be a leader in flood management. The NMCWD's Water Management Plan identifies several policies and actions related to reducing risk to public safety and permanent structures from flooding, including working with cities to address increased flood potential from Atlas 14 rainfall frequency estimates and understanding and addressing the potential for increased flood risk due to predicted changes in climate.

In February 2020, Barr provided a scope of work to update the NMCWD's watershed-wide hydrologic and hydraulic model to incorporate recent model updates completed by several cities within the watershed and refine other areas of the model (referred to as Phase 1 in the February memo). The memo also identified additional analyses for consideration to further assess flood risk, vulnerability, and mitigation options within the Nine Mile Creek watershed, including a flood risk/vulnerability assessment that includes evaluation of snowmelt and Atlas 14 and mid-21st century moderate rainfall estimates (referred to as Phase 2), and conducting a watershed-wide resiliency assessment to identify opportunities to optimize storage and floodplain use throughout the creek system and help alleviate flooding issues (referred to as Phase 3).

In May 2020, the NMCWD board approved Phase 1 of the February 2020 scope of work to update the NMCWD's Xp-SWMM model so as to continue to house the "best available" modeling information on a watershed basis.

At a December 16, 2020 board meeting, Barr presented a version of this scoping document which included scope items and related costs for Phase 2 (*Flood Risk/Vulnerability Assessment- Atlas 14 and Beyond*) and Phase 3 (*Nine Mile Creek Flood Risk Reduction Opportunity Analysis/Resiliency Analysis*). Upon discussion, the NMCWD board requested that a revised scope for Phase 2 be brought back to the board in January and scoping/approval of Phase 3 be delayed at this time and reconsidered once Phase 2 work is substantially completed. This scoping document provides a summary of Phase 2 tasks, deliverables, and planning-level cost estimates updated per comments received at the December 16, 2020 board meeting.

Scope of Work

Phase 2. Flood Risk Assessment- Atlas 14 and Beyond

Understanding flood risk includes identifying the likelihood of flooding and the consequences or impacts associated with the flooding.. A watershed-wide flood risk assessment would help the NMCWD and its communities and other partners gain a better understanding of flood risks throughout the watershed under current precipitation estimates and future climate change projections. A watershed-wide flood risk assessment could also help identify and characterize the risks of flooding from system failures, such as a failed culvert or clogged pipe along the creek system. Characterizing these risks is a first step in evaluating options to mitigate the risks, where appropriate, to minimize property damage and/or threats to public safety.

The following section summarizes tasks to be completed as part of a watershed-wide flood risk assessment. Several of the tasks are identified as optional. Although recommended, these tasks could be removed from the overall project or delayed without significant impacts on subsequent tasks presented here.

Task 1. Simulate runoff events (100-year snowmelt, Atlas 14 and mid-21st century rainfall estimates) and identify flood-prone structures and roadways- $65,000

A. Model range of runoff events, including mid-21st century event ($23,000)

The NMCWD's updated model will be used to simulate the following design rainfall events using precipitation estimates from Atlas 14 and from mid-century climate change predictions. The model would also be used to simulate a 100-year, 10-day snowmelt event.

- 1-, 2-, 5-, 10-, 50-, and 100-year, 24-hour events using Atlas 14 data (50th percentile)
- 100-year, 24-hour mid-21st century moderate estimate (10.2 inches)
- 10-year, 24-hour mid-21st century moderate estimate (6.6 inches)
- 100-year, 10 day snowmelt event

Updating the NMCWD's model to simulate larger rainfall events requires editing and updating the model to capture and store additional runoff volume (e.g., extending storage curves, adding new overflow pathways, etc.). All steps related to capturing additional runoff volume are included in this subtask.

B. Model review and QAQC - $10,000 *– added after December 16th board meeting*

Model review and quality assurance / quality control (QAQC) are critical to ensuring the validity of model input parameters and the accuracy and stability of model results. A complete model QAQC checklist will be performed on all hydrologic and hydraulic input parameters as well as results related to model stability and runoff and routing continuity. Additionally, flood inundation mapping will be reviewed to verify potential overland routing pathways have been correctly incorporated for the larger (mid-21st Century) rainfall event.

Finally, Barr will perform a detailed comparison of 100-year, 24-hour flood elevations and inundation areas from the previous model version (2015) to flood inundation from this modeling effort. Areas where results have changed significantly will be reviewed to (a) investigate the validity of model differences from 2015 to 2020 and (b) identify sources and causes of model differences.

C. Flood Mapping - $13,000

- Inundation mapping (level-pool mapping, not including portions of the creek or along roadways with sloped water surfaces) for all of the design events listed above.
- Flood mapping along creek corridor for 100-year Atlas 14 and mid-century predicted events (up to two events)

D. Identify Flood Prone Areas, Structures and Roadways (includes mapping) - $19,000 - *represents combination of two tasks from December 10, 2020 scope of work*

Flood risk areas, potentially flood prone structures, and overtopping roadways will be identified for the 100-year Atlas 14 event and 100-year, 24-hour mid-21st century moderate estimate event. Available GIS information on building footprints throughout the Nine Mile Creek watershed will be gathered from the cities. Where information is not available, the building footprint dataset from the 2011 MDNR LiDAR will be cleaned up and used. Upon intersection of buildings/roadways with the flood mapping, QA/QC will be conducted on the results to confirm results and remove buildings or roadways that are inadvertently selected due to intricacies of the elevation data. Potentially inundated structure counts and overtopping roadway segment lengths will be identified and quantified.

Mapping of flood risk areas, potentially flood prone structures, and overtopping roadways for the 100-year Atlas 14 event and 100-year, 24-hour mid-21st century moderate estimate event will be prepared in GIS. This scope of work assumes that mapping results will be presented/shared in electronic format and individual map PDFs will not be created. Barr will coordinate with NMCWD staff to determine the optimal format for delivery of flood mapping (e.g., ArcGIS Web Map, ArcMap with GIS feature classes, etc.).

Task 2. Update Model Calibration (optional) - $37,000 – *added per comments received at or following the December 16th board meeting*

Model calibration is the process of adjusting modeling hydrologic and hydraulic parameters to improve prediction of a monitored event (e.g., monitored stream flow during a monitored rainfall event). Performing model calibration improves the accuracy of model results and helps increase confidence that model parameters are representative of hydrologic and hydraulic conditions within the watershed.

The NMCWD model was calibrated upon original development in 2004 at four locations along Nine Mile Creek: South Fork at West 78th Street, North Fork at Metro Boulevard, and the main stem at West 98th Street and 160th Street. Given the development that has occurred throughout the watershed and the extent of changes to the Xp-SWMM model since original development, the model would not be

considered "calibrated" anymore, but rather the best available model. Recalibration of the NMCWD model using more recent flow monitoring and rainfall data should be considered to verify that model conditions reasonably reflect hydrologic and hydraulic conditions within the watershed.

Similar to the 2004 calibration effort, the NMCWD model will be calibrated to flow monitoring data collected at four Watershed Monitoring Outlet Program (WOMP) stations along Nine Mile Creek. Barr will perform a review of available WOMP and rainfall monitoring data and will calibrate the model to two (2) rainfall events at the four monitoring locations. Tasks included are outlined, below:

- Review of 2019 WOMP flow and rainfall monitoring data.
- Identify two (2) rainfall events to be used for model calibration.
- Update hydrologic modeling to reflect existing imperviousness conditions (i.e., estimate impervious area for each subwatershed based on most recent satellite data available versus using land use-based percent impervious assumptions that may represent a future condition).
- Calibrate the NMCWD model to two rainfall events at four (4) WOMP stations.
- Run one (1) validation event to evaluate calibration updates.
- Rerun design events (see Task 1.A) and compare results.
- Review calibration with the NMCWD board (one (1) review meeting).

Note: if this optional task is selected, model calibration would be conducted prior to flood mapping (Task 1.C) and subsequent tasks.

Task 3. Stakeholder Review of Model Results and Flood Inundation Mapping (optional) - $8,000 *– added per comments received at or following the December 16th board meeting*

Flood prone area mapping (Task 1.C., above) will be shared with members of the NMCWD Technical Advisory Committee (TAC), including cities, Hennepin County, Minnesota Department of Transportation (MnDOT), to solicit feedback and promote buy-in. Comments from TAC members will be compiled by NMCWD staff and provided to Barr. Barr will review and incorporate one round of comments, track how each comment was considered/addressed, and resubmit flood mapping.

Note: this optional task assumes Barr will spend no more than 40 hours reviewing and incorporating review comments. If this task is selected, stakeholder review would be conducted prior to identifying flood prone areas, structures, and roadways (Task 1.C) and subsequent tasks.

Task 4. Quantify potential flood damage costs - $20,000 *– presented as 'optional' in December 10, 2020 scope of work*

Flood impacts will be quantified in terms of potential damage to structures. The high-level flood damage costs will be approximated using estimated damage curves ($ as a function of water level per house) and flood probability curves (water level as a function of probability). Information needed for this analysis will include flood elevations for multiple storm recurrence periods (preferably including something greater

than a 100-year), building footprints, and topographic information. This task does not include survey of low entry elevations for potentially impacted structures.

Task 5. Risk analysis for potential pipe failures or clogging at creek crossings - $25,000 – *presented as 'optional' in December 10, 2020 scope of work*

The NMCWD's model and corresponding flood management elevations are based on an assumption that the existing infrastructure is in good working condition and flowing at full capacity during a simulated rainfall event. But what happens if a pipe becomes clogged with debris? Or fails entirely? A high-level review of the approximately 70 existing roadway and railroad crossings along the creek system will be completed to identify the creek crossings that pose the greatest risk if clogged or failed. A select number of crossings will be modeled to further evaluate risk of clogging or failure.

A. High-level review of risk for existing roadway and railroad crossings- $10,000

A high-level review of the approximately 70 existing roadway and railroad crossings along the creek system will be completed to identify the creek crossings that pose the greatest risk (i.e. those with the greatest potential for clogging, failure, and/or greatest consequences of failure).

B. Modeling of flood risk- $15,000

The NMCWD's model will be used to evaluate the risks of pipe failure for a select number of creek crossings during baseflow and large storm events to identify locations where reduced (or eliminated) capacity could lead to potential damage and/or safety concerns due to creek back-ups. The cost of this task will depend on the number of creek crossings selected for further analysis.

Task 6. Develop framework for evaluating potential flood mitigation and/or resilience projects along Nine Mile Creek corridor or in upland areas - $10,000 - *presented as a 'Phase 3' task in December 10, 2020 scope of work*

This task includes working with NMCWD staff, legal counsel, NMCWD board, and TAC to discuss premises and underlying assumptions for evaluating potential modifications to infrastructure and/or other capital improvements (e.g., creating additional floodplain storage). This task also includes discussion and consideration of trade-offs related to potential flood mitigation and/or resilience projects (e.g., potential wetland impacts, tree loss, transfer of flood risk, increasing conveyance to creek corridor).

Task 7. Meetings and presentations- $17,000 – *additional budget added per comments received at or following the December 16th board meeting*

Up to three working meetings will be held with NMCWD staff. Methodology and results will be summarized in a presentation and hand-out materials. The information will be presented at up to three NMCWD TAC meetings and two Board meetings.

Task 8. Documentation report- $15,000

A report will be prepared to describe the methodology and summarize the results. Cost will depend on whether all of Tasks 1 – 5 are completed.

Budget

Table 1 summarizes the estimated cost for each task described above. Several of the tasks are identified as optional. Although recommended, these tasks could be removed from the overall project or delayed. A more detailed table summarizing work subtasks, anticipated project team members, and estimated hours is included as an attachment.

Table 1. Summary of Estimated Costs, by Task.

Task ID	Task Description	Estimated Cost
Phase 2. Flood Risk Assessment- Atlas 14 and Beyond		
1.	Simulate runoff events and identify flood-prone structures and roadways	$65,000
2.	Update model calibration (*optional*) – *added per comments received at or following the December 16th board meeting*	$37,000
3.	Stakeholder review of model results and flood inundation mapping (*optional*) – *added per comments received at or following the December 16th board meeting*	$8,000
~~3.~~	~~Social vulnerability assessment (*optional*)~~ *presented as 'optional' in December 10, 2020 scope of work, removed from Phase 2 per Manager discussion*	~~$5,000~~
4.	Quantify potential flood damage costs – *presented as 'optional' in December 10, 2020 scope of work*	$20,000
5.	Risk analysis for potential pipe failures or clogging at creek crossings - *presented as 'optional' in December 10, 2020 scope of work*	$25,000
6.	Develop framework for evaluating potential flood mitigation and/or resilience projects along Nine Mile Creek corridor or in upland areas – *presented as 'Phase 3' task in December 10, 2020 scope of work*	$10,000
7.	Meetings and presentations	$17,000
8.	Documentation report (note- cost will depend on selected scope from Tasks 1-7)	$15,000
	Subtotal	$197,000

Schedule

Table 2 provides an approximate schedule for the tasks included in this work scope. If items noted as optional are not selected for completion, the schedule can be adjusted accordingly. The estimated schedule provided in Table 2 is based on an assumed project start date of January 21, 2020. The schedule can be further defined upon project initiation in consultation with NMCWD staff.

Table 2. Estimate schedule for individual tasks

Task ID	Task Description	Estimated Completion Schedule
--	Internal project kickoff	Late-January 2021
Task 1.A	Model range of runoff events, including mid-21st century event (includes capturing water)	April 2021
Task 2	Update model calibration (*optional*)	June 2021
Task 1.B	Model review and QAQC	June 2021
Task 1.C	Flood Mapping	July 2021
Task 3	Stakeholder review of model results and flood inundation mapping (*optional*)	August 2021
Task 1.D	Identify flood prone areas, structures and roadways (includes mapping)	September 2021
Task 4	Quantify potential flood damage costs	October 2021
Task 5	Risk analysis for potential pipe failures or clogging at creek crossings	December 2021*
Task 6	Develop framework for evaluating potential flood mitigation and/or resilience projects along Nine Mile Creek corridor or in upland areas	January 2022*
Task 7	Meetings and presentations	Included in schedule for tasks above
Task 8	Documentation report and project close	February 2022
* Completion of these tasks can be done concurrently with other tasks, if desired.		

Budgeting Tool: NMCWD Atlas 14 Flood Risk and Resiliency- Phase 2

	Estimated Hours by Key Project Team Members[1, 2]										
	Janna Kieffer, Principal ($175/hour)	Michael McKinney, Project Manager ($120/hour)	Lulu Fang, Water Resources Engineer ($110/hour)	Tyler Olson, Water Resources Engineer ($100/hour)	Brandon Barnes, Sr Water Resources Engineer ($155/hour)	Greg Fransen, Sr Water Resources Engineer ($135/hour)	Eddie Anderson, GIS Specialist ($95/hour)	Mike Strong, Senior GIS Specialist ($125/hour)	Total Estimated Hours	Project Total	Percentage of Total
Task 1.A Model range of runoff events, including mid-21st century event (includes capturing water)											
Model and run 100-year, 24-hour mid-21st century moderate estimate (10.2 inches). Includes capturing water for 10.2 inch event.									126	$ 13,910.00	
Run 100-year, 4-day rainfall event, results comparison									15	$ 1,675.00	
Run 100-year, 10 day snowmelt event, results comparison									34	$ 4,050.00	
Presentation of methodology and results									25	$ 3,400.00	
Subtotal	25	19	78	78	0	0	0	0	200	$ 23,035.00	**12%**
Task 1.B. Model review and QAQC											
Hydrologic QAQC (SWS parameters, hydrologic results)									10	$ 1,310.00	
Hydraulic QAQC (Inundation review, hydraulic results) + reruns and review to correct.									26	$ 3,230.00	
Review/investiage differences from 2015 to 2021 flood mapping.									46	$ 5,370.00	
Subtotal	10	40	16	16	0	0	0	0	82	$ 9,910.00	**5%**
Task 1.C Flood Mapping											
Preliminary flood mapping and related QAQC (during mid-21st century model development)									28	$ 3,200.00	
Inundation mapping (level-pool mapping, not including portions of the creek or along roadways with sloped water surfaces) for 100-yr, 24 hour mid-21st century moderate estimate									28	$ 3,200.00	
Flood mapping along creek corridor for 100-yr, 24 hour mid-21st century moderate estimate									54	$ 6,550.00	
Subtotal	16	16	20	20	0	0	24	14	110	$ 12,950.00	**7%**
Task 1.D Identify Flood Prone Areas, Structures, and Roadways and Prepare Mapping											
Identification of flood prone structures for mid-21 century event (GIS analysis)									38	$ 4,390.00	
Identification of flood prone roadways for mid-21 century event (GIS analysis)									38	$ 4,390.00	
Working meeting with NMCWD staff									12	$ 1,600.00	
Prepare figures / mapping (webmap, etc) of overtopped roadways and flood prone structures for NMWD review									44	$ 5,060.00	
Present results to TAC and NMCWD Board									28	$ 3,630.00	
Subtotal	24	22	25	25	0	0	34	30	160	$ 19,070.00	**10%**
Task 2. Update Model Calibration (optional)											
Review 2019 WOMP flow monitoring and rainfall data (historic review to ID presence of beaver dams, review against 2004 data, etc.).									16	$ 2,210.00	
Identify two (2) rainfall events for calibration and one (1) for validation.									16	$ 2,170.00	
Generate NEXRAD rainfall inputs for three (3) events.									29	$ 3,895.00	
Update hydrologic modeling from future condition to existing condition (prior to calibration)									12	$ 1,430.00	
Calibrate the model at four (4) WOMP locations for the two (2) rainfall events.									182	$ 19,950.00	
Run one (1) validation event									7	$ 835.00	
Rerun Atlas 14 design events and compare results									26	$ 3,140.00	
Present results to NMCWD board (review calibration)									28	$ 3,420.00	
Subtotal	20	62	92	92	10	24	0	16	316	$ 37,050.00	**19%**
Task 3. Stakeholder review (optional)											
Review and incorporate (+ track notes) institutional review comments.									42	$ 4,670.00	
Resubmit mapping after incorporating review.									30	$ 3,350.00	
Subtotal	4	12	22	22	0	0	8	4	72	$ 8,020.00	**4%**
Task 4. Quantify potential flood damage costs											
Evaluate methodology for quantifying flood damage cost: f(water depth per home), f(flood probability)									22	$ 2,850.00	
Working meeting with NMCWD staff									16	$ 2,190.00	
Run additional events for probability analyisis									44	$ 5,130.00	
Calculate flood damage costs per chosen methodology									86	$ 9,790.00	
Subtotal	26	28	46	46	0	0	12	10	168	$ 19,960.00	**10%**

Task 5. Risk analysis for potential pipe failures or clogging at creek crossings											
Initial summary of roadway/RR crossing information for 68 existing roadway crossings (plugging potential, 100-yr flood elevation, emergency overflow elevation)									44	$ 5,020.00	
Selection of roadways/RR crossings for further evaluation									18	$ 2,260.00	
Use model to simulate culvert failure for up to 20 highest priority crossings- baseflow conditions									50	$ 5,620.00	
Use model to simulate culvert failure for up to 20 highest priority crossings- 2-, 10-, 50-, and 100-year events									52	$ 5,970.00	
Summarize results									52	$ 6,060.00	
Subtotal	24	34	70	70	0	0	10	8	216	$ 24,930.00	**13%**
Task 6. Develop framework for evaluating potential flood mitigation and/or resilience projects along NMC corridor or in upland areas											
Investigate methodology for evaluating / prioritizing flood mitigation projects									22	$ 3,290.00	
Investigate 'trade offs' related to flood mitigation projects									16	$ 2,390.00	
Working meeting with NMCWD, legal counsel, board, and TAC to discuss assumptions and methodology									16	$ 2,360.00	
Incorporate framework discussion into project report									14	$ 2,010.00	
Subtotal	28	30	0	0	10	0	0	0	68	$ 10,050.00	**5%**
Task 7. Meetings and Presentations											
Prepare materials for up to three working meetings / presentation									90	$ 11,090.00	
Participate in up to three working meetings / presentations									40	$ 5,900.00	
Subtotal	40	40	16	16	0	0	14	4	130	$ 16,990.00	**9%**
Task 8. Documentation Report											
Draft report text									38	$ 4,570.00	
Draft XP-SWMM results (tables, figures, etc.)									48	$ 5,380.00	
Submit draft report for NMCWD review									3	$ 470.00	
Incorporate one (1) round of comments and finalize report deliverable									38	$ 4,670.00	
Subtotal	20	29	8	32	0	0	24	14	127	$ 15,090.00	**8%**
Project Total	237	332	393	417	20	24	126	100	1,649	$ 197,055.00	**100%**

[1] List of project team members includes anticipated key team members, other staff will likely be added to the team throughout the project, as needed.

[2] Hourly billing rates shown are for work completed in 2021 based on Exhibit A of the Agreement between Nine Mile Creek Watershed District and Barr Engineering Co. Work completed in 2022 will be based on billing rates for 2022 identified in Exhibit A.