BURNSVILLE-SAVAGE AREA WATER STUDY

Task F – Quarry Lake Modeling

B&V PROJECT NO. 190289

PREPARED FOR

14 MARCH 2022

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Background

In 2007, the City of Burnsville (Burnsville), City of Savage (Savage), Kraemer Mining & Materials (KMM), and the State of Minnesota jointly funded improvements to the KMM limestone quarry located in Burnsville. The improvements were made so that water pumped from the Quarry could provide raw water to a new Burnsville surface water treatment plant (SWTP). An agreement between the parties was made to allow up to 6 million gallons per day (MGD) of raw water to be pumped from the South Reservoir within the Quarry to the SWTP while mining operations continue in other parts of the quarry away from the reservoir.

KMM will continue mining operations into the future for another estimated 20 to 40 years, dependent on material demand. At the end of mining operations, the quarry dewatering pumps will cease, and the quarry will fill to become a recreational lake. The plan also involves surrounding area to be redeveloped. In 2016, the City retained the team of Black & Veatch and Barr Engineering to investigate several questions related to the water supply and future conversion of the quarry to a lake. Specifically, groundwater in the region will rebound at this future time and the purpose of Task F of the study is to develop a hydrogeological model and estimate groundwater levels from this future lake level. The purpose of this technical memorandum is to document these results and solicit feedback from stakeholders on final elevation of the quarry lake.

Introduction

A groundwater flow model, based on Metro Model 3 (Metropolitan Council, 2014), that covers the vicinity of the Kraemer Mining & Materials (Kraemer) Quarry and surrounding areas was previously developed by Barr Engineering (Barr) for the City of Burnsville (Barr, 2015). The model was updated in 2016 and 2019 to include more detail regarding quarry operations and the South Reservoir, which the City of Burnsville operates as a water supply (Barr & Black and Veatch, 2015; Barr & Black and Veatch, 2020). This model was previously used to evaluate how the performance of the South Reservoir has changed since initial construction as quarry operations have expanded and the quarry floor has been lowered (Barr & Black and Veatch, 2016). Additionally, in 2019 the model was used to evaluate the potential expansion and deepening of the South Reservoir (Barr & Black and Veatch, 2020). The groundwater capture zone for the South Reservoir was also delineated for current and potential future configurations.

For this study the model was used to address questions regarding groundwater flow and water table elevations in the vicinity of the quarry pit at, and after the cessation of mining. Conditions evaluated included the end of mining with a dewatered pit (water elevation 600 feet) and a full pit (water elevation 690 feet). The model was also updated to allow simulation of the quarry pit filling to evaluate how conditions will change as the quarry pit fills with groundwater and how long it may take the water level in the pit to reach a final elevation of 690 feet.

A final quarry pit water level of elevation 690 feet has been used previously (Barr, 2015) as a presumed final elevation based on recommendation from the City of Burnsville that it is likely the lowest elevation that could be maintained without significant pumping. Additionally, the Minnesota Pollution Control Agency (MPCA) has indicated that designs of the remediation effort at the Freeway Landfills are also based on a future lake elevation of 690 feet. For these reasons, elevation

690 was used for this study as well. Ultimately multiple stakeholders in the area may consider an alternative final pit water elevation to meet their objectives.

The groundwater flow modeling code used for this study was MODFLOW (MODFLOW-NWT version 1.1.4, Niswonger et. al., 2011). MODFLOW was developed by the U.S. Geological Survey, is in the public domain, and is the most widely used groundwater model code in the United States. Details regarding the construction and calibration of the groundwater model are provided in the previous reports (Barr 2015; Barr & Black and Veatch, 2016 & 2020).

Model Updates

The following updates to the model were completed for this study:

- The future Kraemer quarry extent was updated based on information provided by Kraemer Mining (2021). This included both an expansion of the lateral extent and depth of the quarry. The final pit extent and depth used for the modeling are shown on Figure 1. Based on information provided by Kraemer, all material below elevation 600 feet will be mined below water, that is, the maximum dewatering depth will be elevation 600 feet.
- The boundary conditions representing the Kraemer quarry pit were updated to use the Lake Package of MODFLOW. The Lake Package allows for simulation of quarry filling after cessation of dewatering. It also allows for more accurate simulation of the groundwater conditions when the quarry pit bottom is at maximum depth (approximately elevation 578 but varying across the site) but the water surface in the pit is elevation 600 feet. During last phases of mining, a quarry lake will exist with mining occurring below the water surface.
- The model was updated to include aquifer storage and the ability to simulate transient conditions. This update was necessary to simulate the filling of the quarry pit after mining and to simulate flood conditions. Aquifer storage parameters from Metro Model 3 were used.
- The areas commonly referred to as McGowan Quarry and Marina Quarry (Figure 1) were updated to also be simulated with the MODFLOW Lake Package. Updating the boundary conditions in these areas allows them to fill or dewater as groundwater conditions in the area change. No active pumping is known to occur for these areas. The McGowan Quarry area is currently dewatered due to the depression of the water table from dewatering of the Kraemer Quarry. However, as the water table rises after cessation of mining at the Kraemer Quarry, these areas are expected to fill with water.

Summary of Simulated Conditions

Table 1 outlines the conditions that were simulated for this study. For the area surrounding Kraemer Quarry, the simulated water table contours and depth to groundwater are presented as part of this study. Particle tracking analysis using MODPATH (Pollock, 2012) was also conducted for each scenario to evaluate the groundwater flow paths from areas of interest. The areas of interest included Freeway Landfill, Freeway Dump, and Burnsville Landfill (Figure 1). It is important to note that the current plan for the Freeway Landfill and the Freeway Dump areas of interest is to have these areas remediated by the time mining ceases. Particles were introduced to the groundwater flow system at the water table in the center of each model cell that covers these areas of interest. Particles were advectively transported through the groundwater flow field to their ultimate discharge location. Particle tracking provides information on the groundwater flow paths but does not provide concentrations of groundwater constituents. To evaluate concentrations, contaminant fate and transport modeling would be necessary, and source concentrations would need to be well defined. The results of the particle tracking analysis were processed to estimate the percent of total groundwater flux into Kraemer Quarry or the future pit lake that originates from each area of interest.

Flood scenarios were simulated for both the end of mining (i.e., quarry pit dewatered to elevation 600 feet) and a full pit (i.e., pit lake elevation of 690 feet) condition. For hypothetical flood simulations the stage of the Minnesota River was allowed to rise to an elevation of 716 feet, which is the 100-year flood stage for the reach of the Minnesota River near the Freeway Landfill (FEMA, 2011). The total flood time was based on review of previous floods of similar magnitude and set at 120 days (60-day rise and 60-day fall).

Table 1.: Summary of Simulated Conditions

SCENARIO NUMBER	DESCRIPTION	SIMULATED WATER TABLE	DEPTH TO GROUNDWATER
1	Kraemer Quarry at maximum mining extent and depth. Quarry dewatered to elevation of 600 feet.	Figure 2	Figure 3
1-flood	Kraemer Quarry at maximum mining extent and depth. Quarry dewatered to elevation of 600 feet. Sixty-day 100-year flood scenario.	Figure 4	Figure 5
2	Kraemer Quarry at maximum extent and depth. Quarry lake stage at elevation 690 feet.	Figure 6	Figure 7
2-flood	Kraemer Quarry at maximum extent and depth. Quarry lake stage at elevation 690 feet. Sixty-day 100-year flood scenario.	Figure 8	Figure 9

Results

Groundwater contours and depth to groundwater for the modeled scenarios are presented on Figure 2 to Figure 9. Comparison of Figure 3 and Figure 7 shows the potential change in the depth to groundwater for the area surrounding Kraemer Quarry as it transitions from a dewatered condition to a full pit-lake. Areas surrounding the Quarry are simulated to transition from a depth to groundwater of greater than 30 feet to depth to groundwater of less than 20 feet. Many areas are simulated to have a depth to groundwater of less than 10 feet for the full pit-lake simulation (Figure

7). Note that the ground surface elevation used to calculate the depth to groundwater is LiDAR data collected in 2011. The current and future extent of the quarry do not match the surface elevations measured in 2011 and cause artifacts in the depth to groundwater figures within the quarry extent. The simulated future shallow groundwater is consistent with available historical land cover prior to development and quarry dewatering. The Minnesota Department of Transportation's Historical Hydrographic Model dataset (Minnesota DOT, 2019) indicates that much of this area was wetlands prior to development, consistent with a shallow water table. Therefore, stakeholders should recognize that the potential may exist for groundwater to appear at the surface in some areas when the pit-lake is full.

Comparison of groundwater contours (Figure 8) and depth to groundwater (Figure 9) for simulated flood conditions to non-flood conditions (Figures 6 and 7) indicates that most change in groundwater levels during a flood occurs near the Minnesota River, as expected. The rise in groundwater is minimal at peak flood conditions in areas away from the river.

Particle tracking for scenarios representing the end of mining (stage 600 feet) and a full pit-lake (stage 690 feet) are presented on Figure 10 and Figure 11 respectively. As shown on Figure 10, all particle traces from the areas of interest are simulated to discharge into the Kraemer Quarry at the end of mining when the quarry is at 600 feet. When the quarry is dewatered it acts as a groundwater sink and groundwater from a large area flows into the quarry rather than the Minnesota River due to groundwater levels being depressed. and pulling the water toward the quarry instead of toward the Minnesota River. Since the groundwater is depressed the groundwater is well below the areas of interest.

Figure 11 shows the particle traces for the simulated condition with a full Kraemer Quarry pit-lake at elevation 690 feet. For this simulation it was also assumed that the McGowan Quarry was held at a maximum stage of 690 feet. Particle traces on Figure 11 are color coded based on their ultimate discharge location. The simulations indicate the following:

- Approximately 80 percent of the simulated particles that originate within the footprint of Burnsville Landfill discharge to the Kraemer Quarry with the other 20 percent discharging to the Minnesota River and associated wetland areas.
- Approximately 80 percent of the particles that originate from within the current Freeway Landfill footprint discharge to the McGowan Quarry. Approximately 15 percent of particles originating from within the current footprint of the Freeway Landfill discharge to the Kraemer Quarry. The remainder of particles from Freeway Landfill (5 percent) discharge to the Minnesota River or other wetland areas. It is important to note that the current plan for the Freeway Landfill will have this landfill remediated by this time.
- Approximately 23 percent of the particle traces that originate within the current footprint of the Freeway Dump discharge to the Kraemer Quarry, Fifty-two percent of the particle traces discharge to the Minnesota River, eighteen percent of the particles discharge to wetlands, and 7 percent discharge to the McGowan Quarry. It is important to note that current plan for the Freeway Dump will have this landfill area remediated by this time.

For the simulated condition with the quarry pit-lakes at elevation 690 feet, a large percentage of particles from the areas of interest (82 percent) discharge to either the Kraemer Quarry or McGowan Quarry. This may at first appear counter intuitive, as one may expect that more particle traces would discharge to the Minnesota River. However, holding these areas at a stage of 690 feet is still below a static or natural stage for these areas and only slightly above the median Minnesota River Stage. So, groundwater originating from many areas of interest are simulated to discharge to the McGowan and Kraemer quarry lakes.

The particle tracking results were processed to estimate the percent of total groundwater flow into Kraemer Quarry originating from the areas of interest. Flow was modeled for each model cell where a particle trace discharges into the Kraemer Quarry. The groundwater flow into the quarry lake was then summarized and compared to the total flow into the quarry on a percentage basis for each area of interest. The results are presented in Table 2 below.

Table 2.: Summary of Groundwater Flow into Kraemer Quarry from Areas of Interest

AREA OF INTEREST	PERCENT OF TOTAL GROUNDWATER FLOW INTO KRAEMER QUARRY FOR A FULLY DEWATERED CONDITION (STAGE ELEVATION 600 FEET)	PERCENT OF TOTAL GROUNDWATER FLOW INTO KRAEMER QUARRY FOR A FULL PIT-LAKE (STAGE ELEVATION 690 FEET)
Burnsville Landfill	6%	1%
Freeway Landfill	8%	3%
Freeway Dump	2%	1%

Simulated conditions for the Kraemer Quarry filling are similar to the two end members of the quarry dewatered and the quarry full at stage 690 feet. As the quarry fills, groundwater flow paths from the areas of interest transition from those shown on Figure 10 to those shown on Figure 11. It is estimated that the quarry will fill to elevation 690 feet in 6 years.

This memo presents results from groundwater model simulations designed to address questions regarding groundwater flow and water table elevations in the vicinity of the quarry pit at, and after the cessation of mining. This analysis does not include analysis of water quality impacts from changes in groundwater flow directions or groundwater levels. Impacts that should be considered based on these results include existing public and private infrastructure, future development (public and private), landfill waste and liner elevations, sustainability of maintaining water levels (cost of pumping, infrastructure, etc.), and long-term water supply needs.

Future Steps & Feedback

This memorandum was issued in draft format on March 8th, 2022 to solicit stakeholder comments and collect feedback final lake elevation. The Project Team completed outreach to different stakeholders (Burnsville City Council, area property owners, public agencies) in different formats including meetings, mailing, and website information. Feedback regarding the final lake elevations is required as additional models runs will be required for any final lake elevation above or below modeled water surface elevation of 690 feet. Any revisions to modeling data at new lake elevations will be published in the final version of this Technical Memorandum. Impacts regarding the lake elevations will be addressed in future technical memorandums.

References

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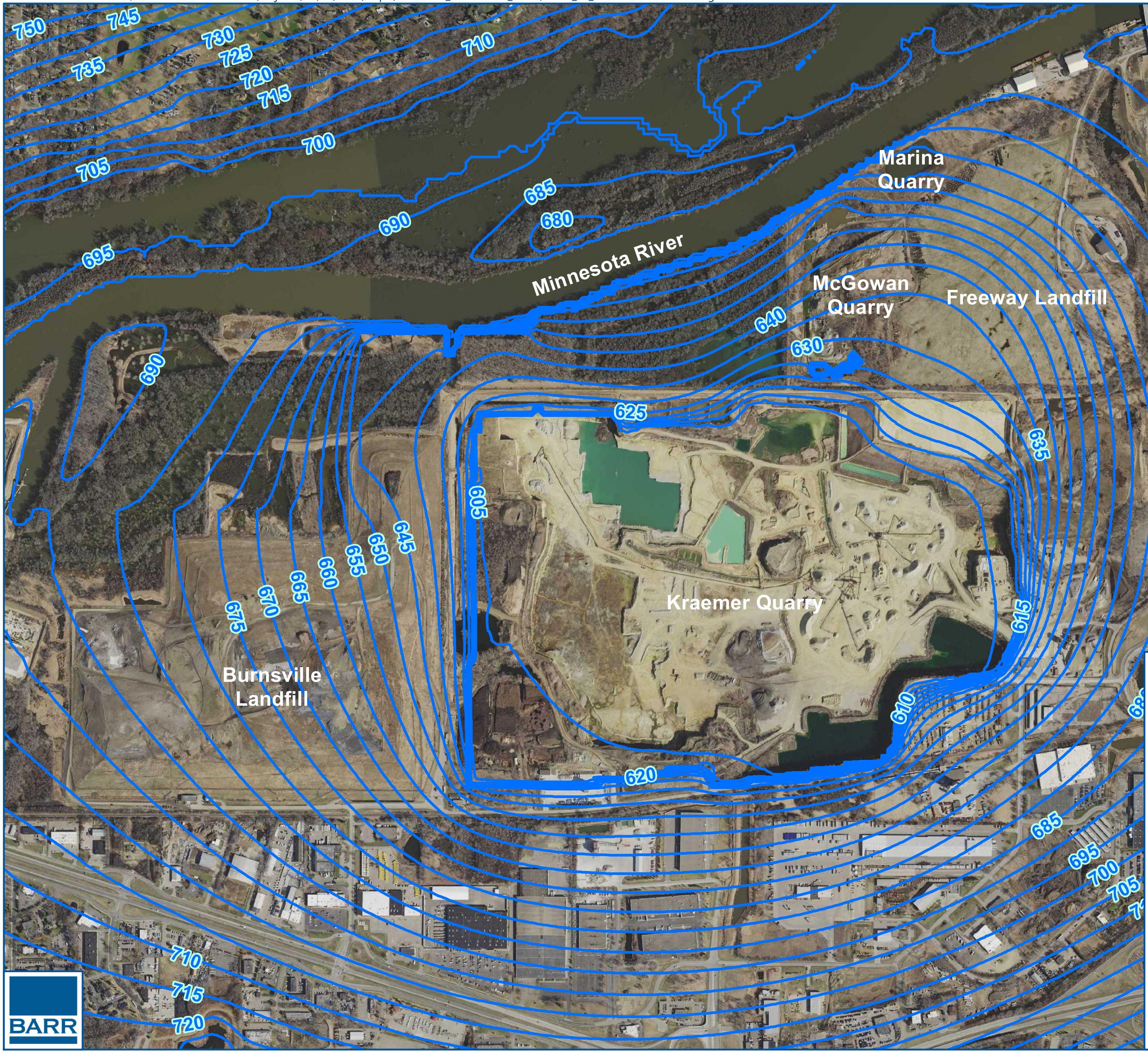

Simulated Watertable Kraemer Quarry at 600 feet (End of Mining)

FIGURE 2

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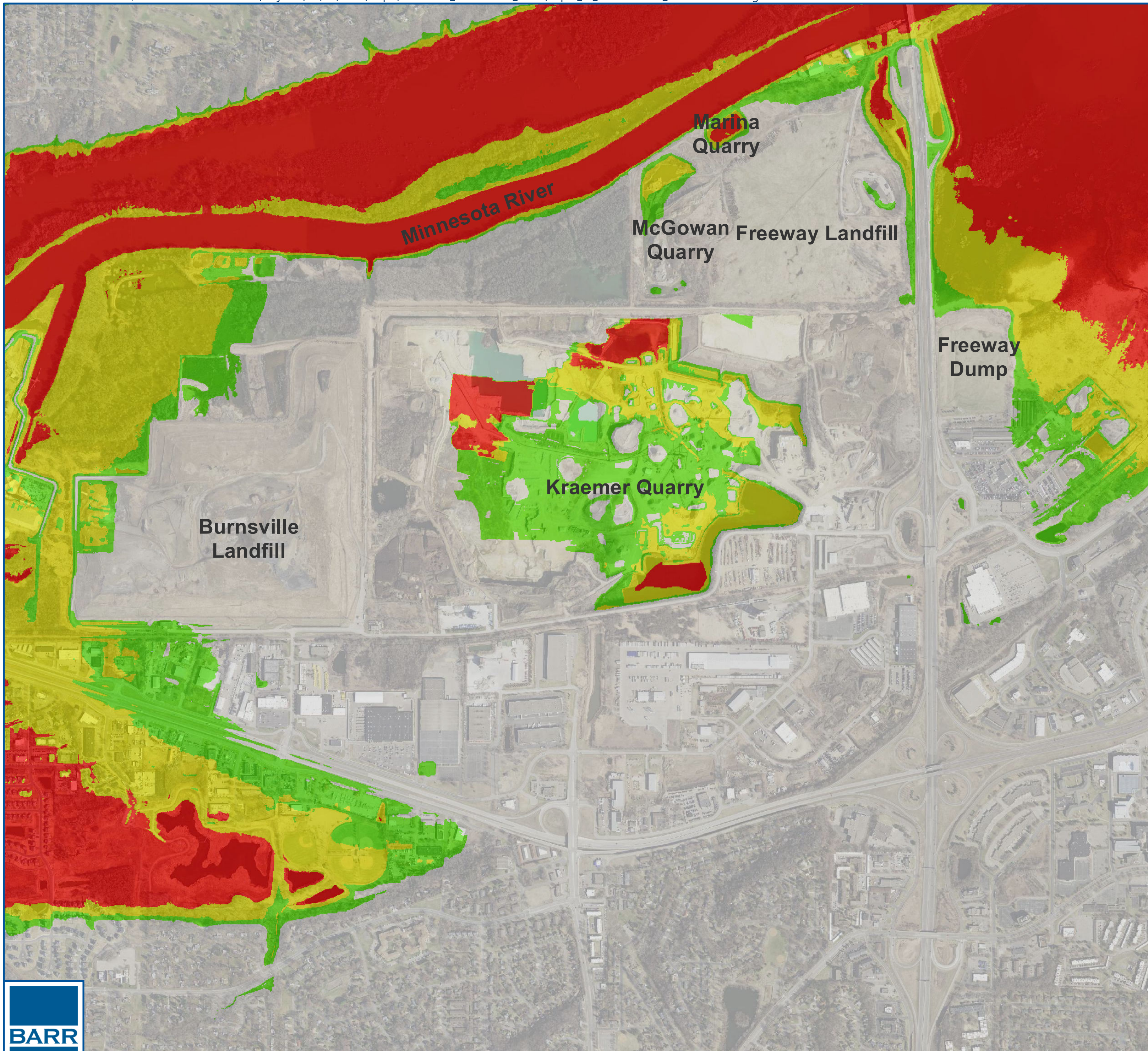


LiDAR used for ground surface elevation. Areas inside pit do not reflect current or future land surface.

Depth to Groundwater (feet)

- <=10
- 11 - 20
- 21 - 30
- >30

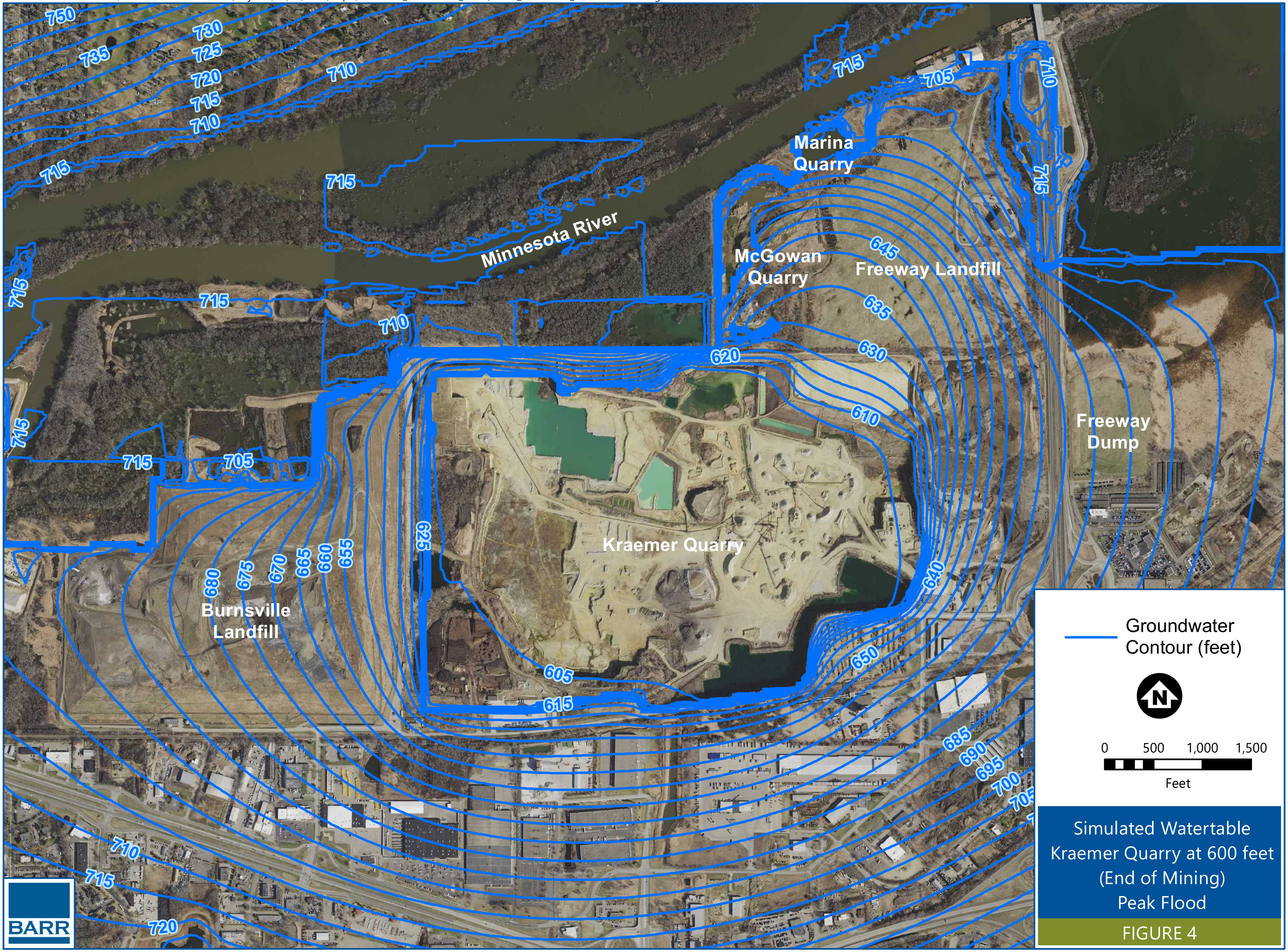
0 500 1,000 1,500

Feet

BARR

Simulated Depth to Groundwater
Kraemer Quarry at 600 feet
(End of Mining)

FIGURE 3



Simulated Watertable
Kraemer Quarry at 600 feet
(End of Mining)
Peak Flood

FIGURE 4

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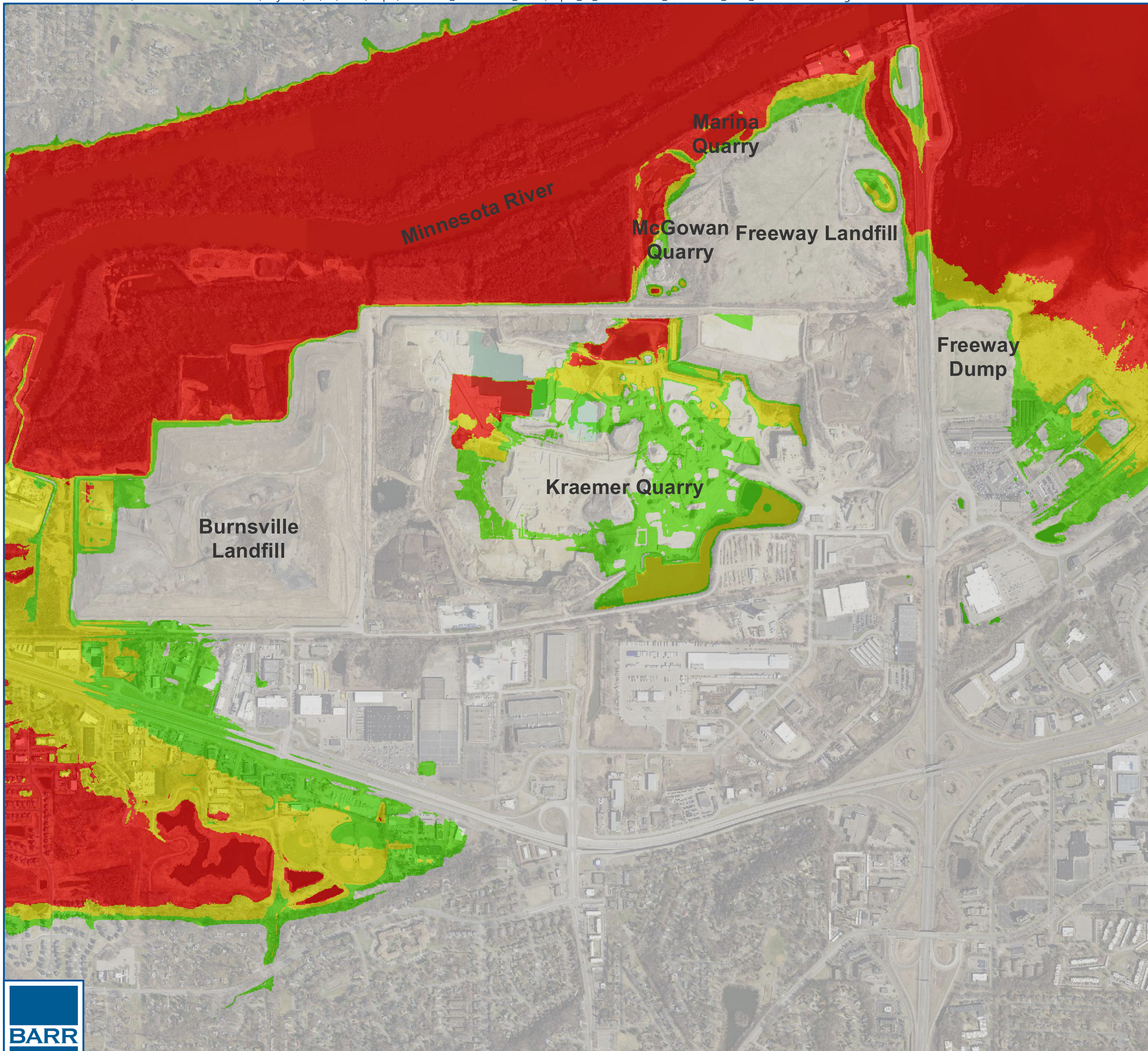

LiDAR used for ground surface elevation. Areas inside pit do not reflect current or future land surface.

Depth to Groundwater (feet)

- <=10
- 11 - 20
- 21 - 30
- >30

0 500 1,000 1,500
Feet

Simulated Depth to Groundwater
Kraemer Quarry at 600 feet
(End of Mining)
Peak Flood

FIGURE 5

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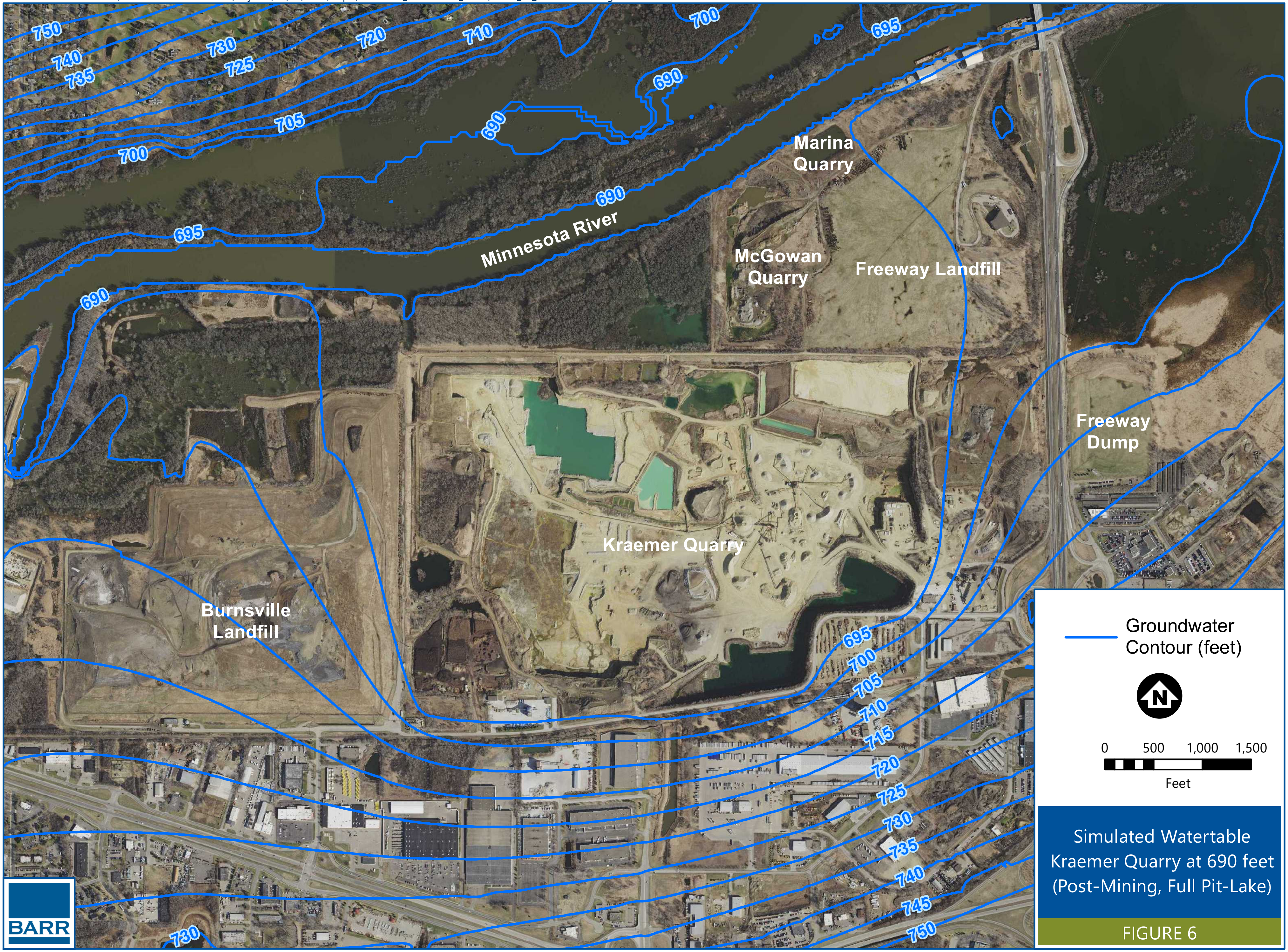
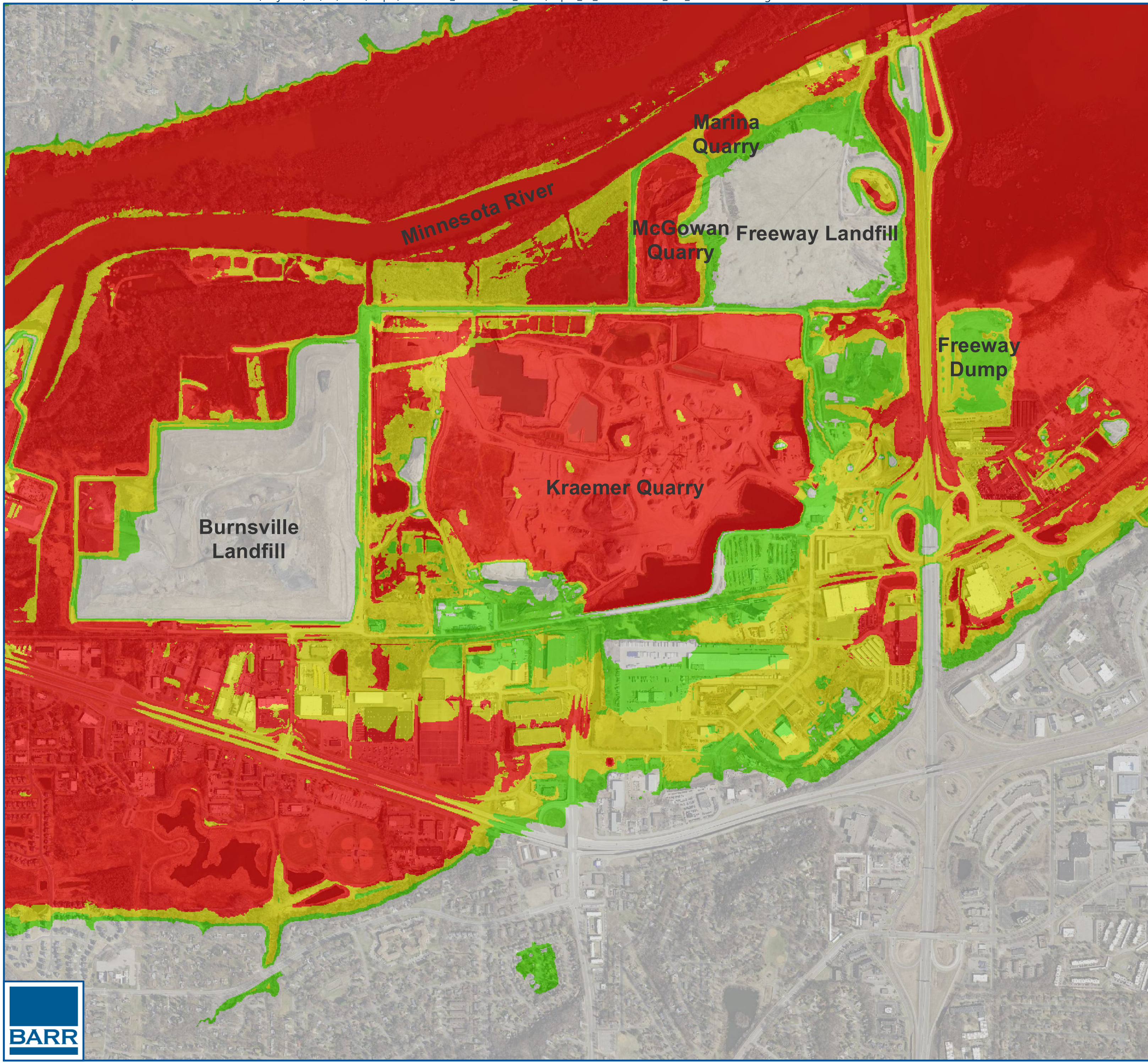


Simulated Watertable
Kraemer Quarry at 690 feet
(Post-Mining, Full Pit-Lake)

FIGURE 6



LiDAR used for ground surface elevation. Areas inside pit do not reflect current or future land surface.

Depth to Groundwater (feet)

- <=10
- 11 - 20
- 21 - 30
- >30

N

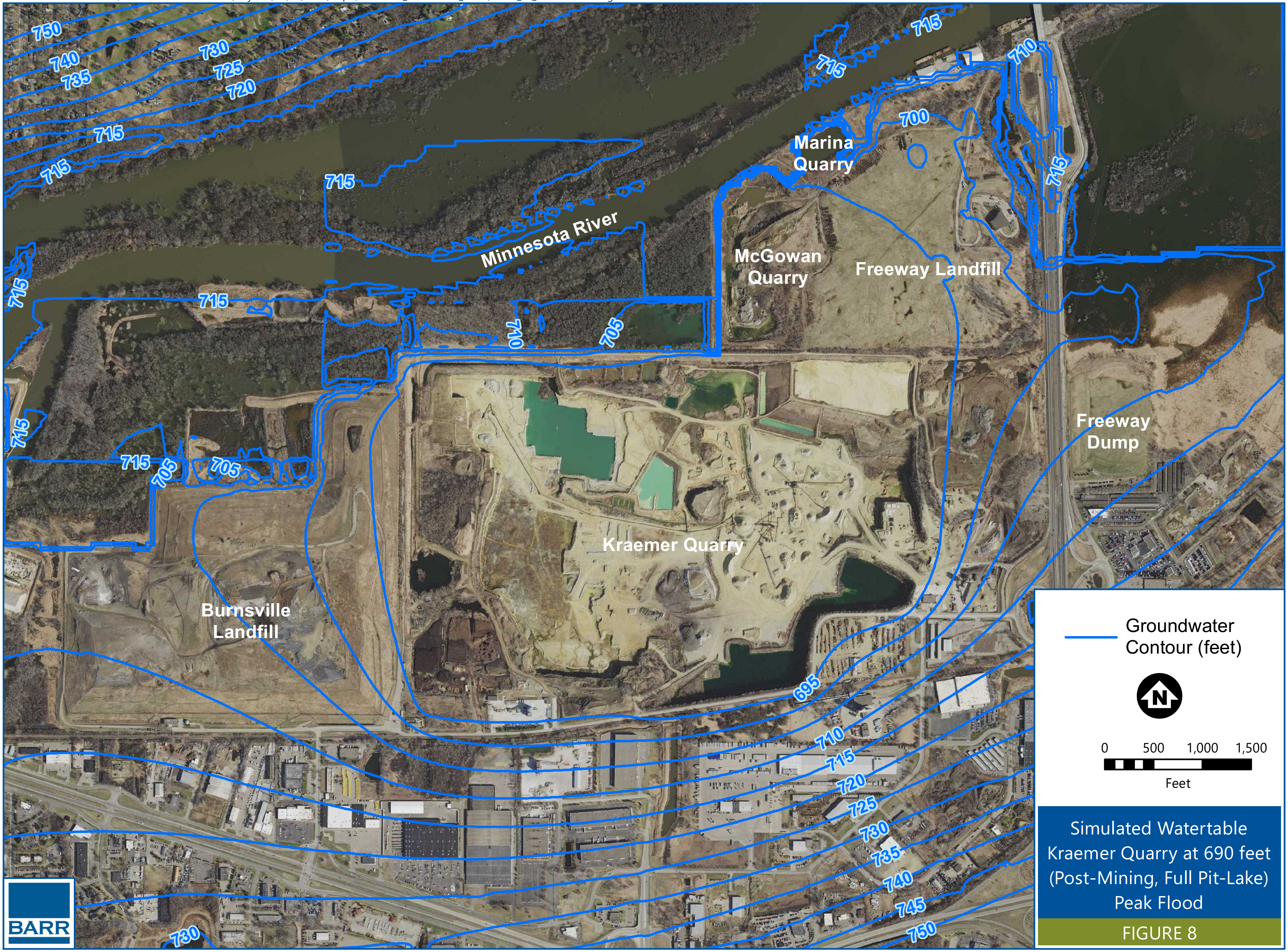
0 500 1,000 1,500

Feet

BARR

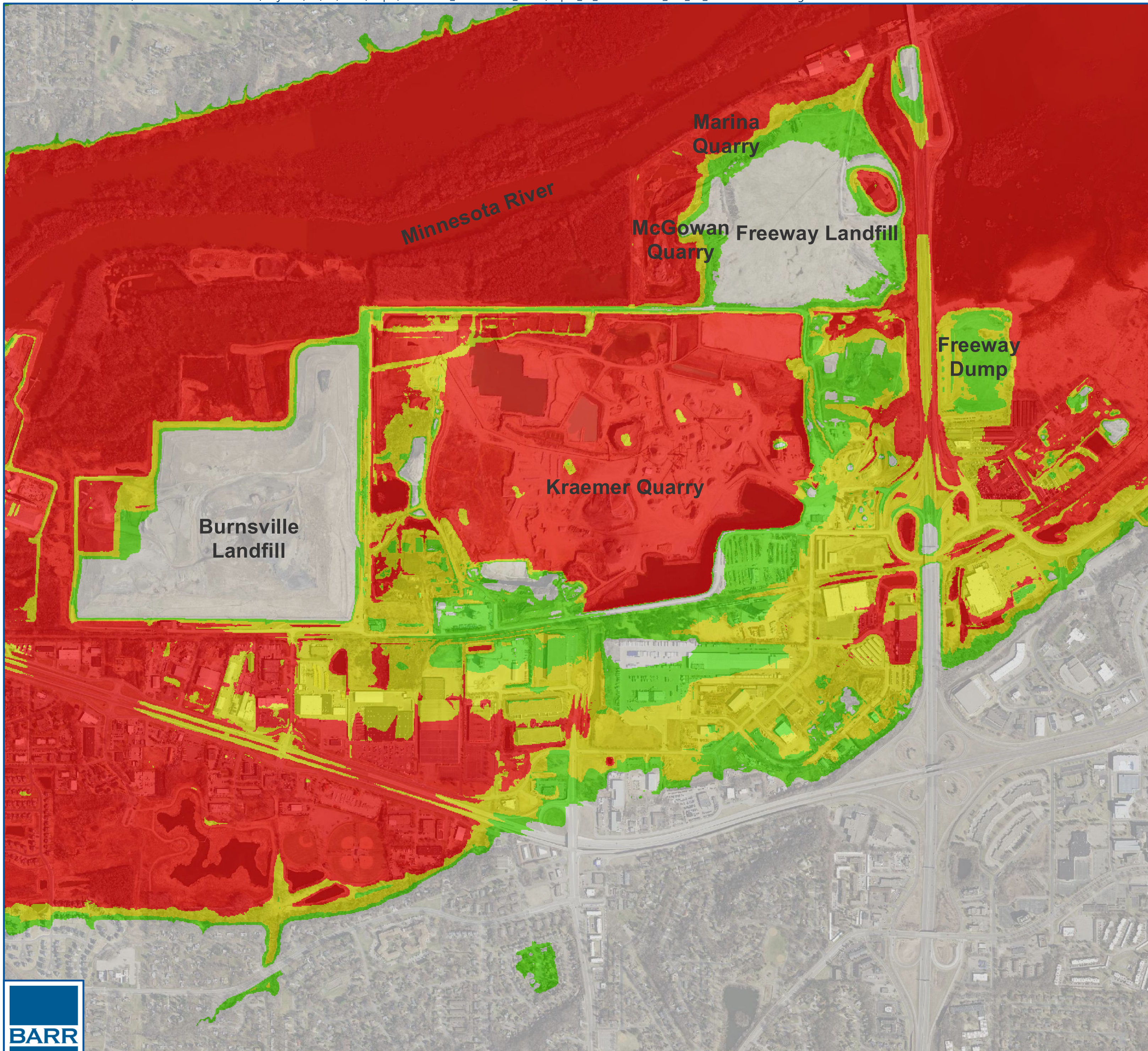
Simulated Depth to Groundwater
Kraemer Quarry at 690 feet
(Post Mining, Full Pit-Lake)

FIGURE 7



Simulated Watertable
Kraemer Quarry at 690 feet
(Post-Mining, Full Pit-Lake)
Peak Flood

FIGURE 8



LiDAR used for ground surface elevation. Areas inside pit do not reflect current or future land surface.

Depth to Groundwater (feet)

- <=10
- 11 - 20
- 21 - 30
- >30

N

0 500 1,000 1,500

Feet

Simulated Depth to Groundwater
Kraemer Quarry at 690 feet
(Post Mining, Full Pit-Lake)
Peak Flood

FIGURE 9

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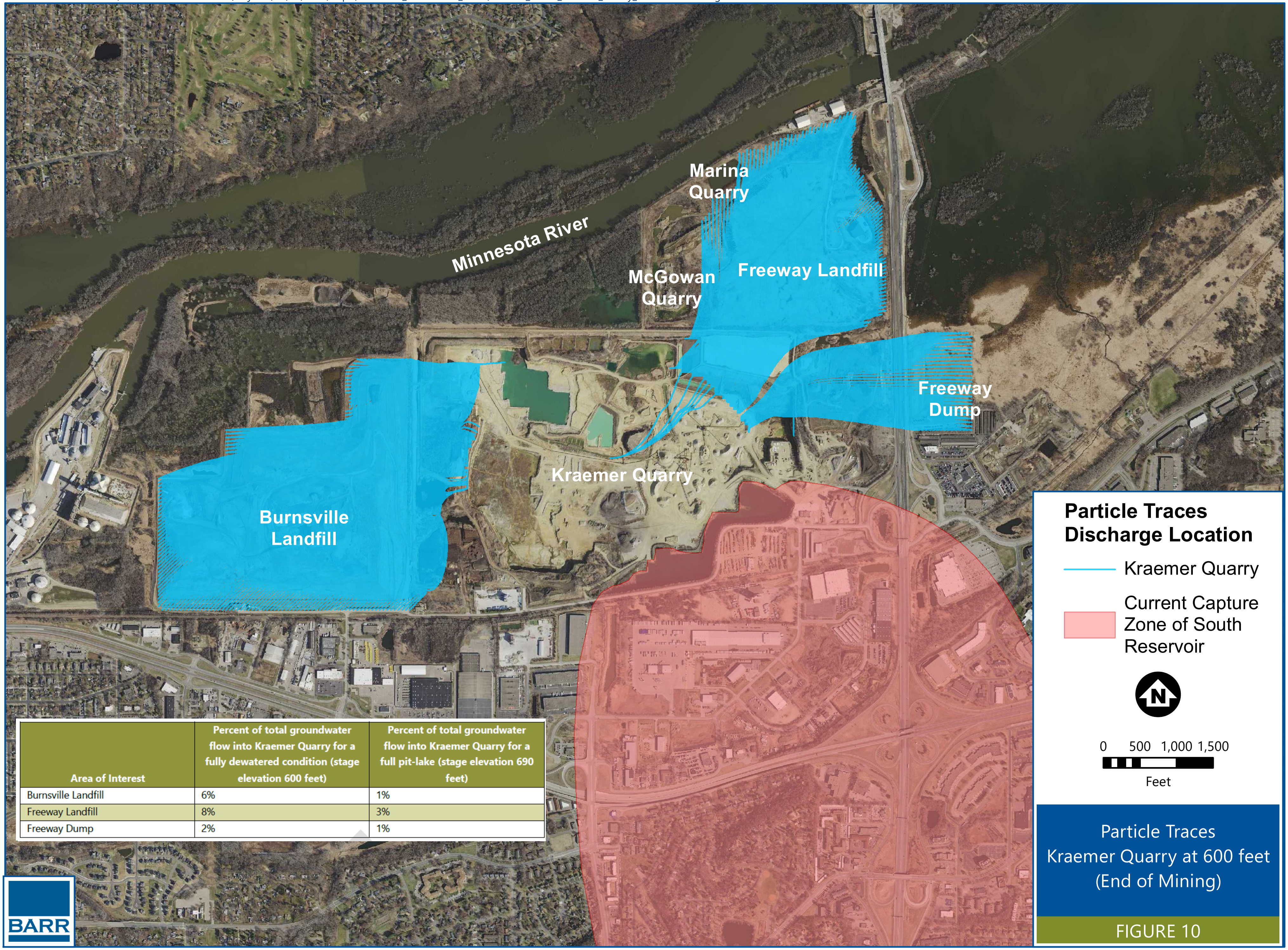
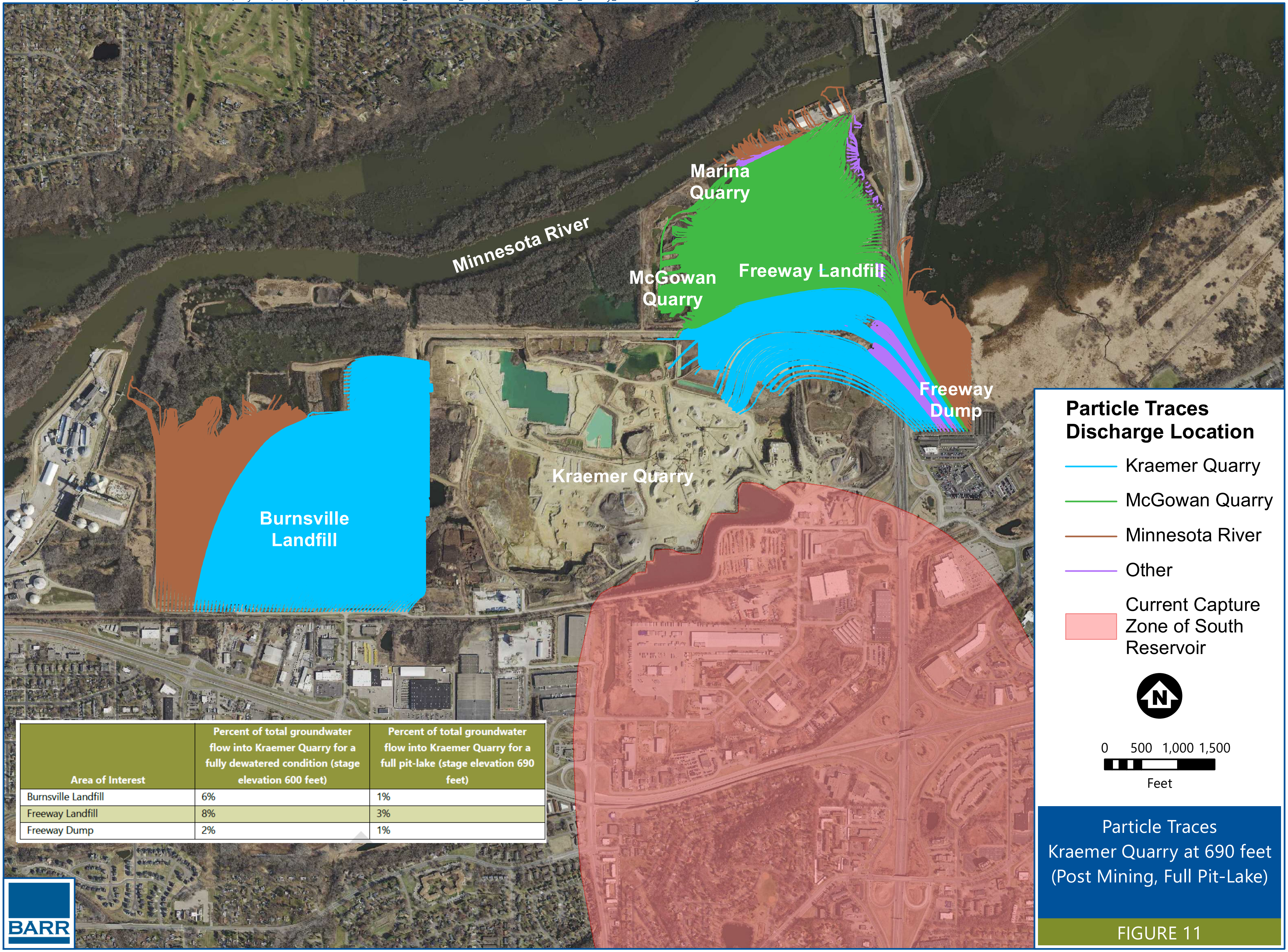


Area of Interest	Percent of total groundwater flow into Kraemer Quarry for a fully dewatered condition (stage elevation 600 feet)	Percent of total groundwater flow into Kraemer Quarry for a full pit-lake (stage elevation 690 feet)
Burnsville Landfill	6%	1%
Freeway Landfill	8%	3%
Freeway Dump	2%	1%

Particle Traces
Kraemer Quarry at 600 feet
(End of Mining)

FIGURE 10



Area of Interest	Percent of total groundwater flow into Kraemer Quarry for a fully dewatered condition (stage elevation 600 feet)	Percent of total groundwater flow into Kraemer Quarry for a full pit-lake (stage elevation 690 feet)
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Freeway Landfill	8%	3%
Freeway Dump	2%	1%

Particle Traces
Kraemer Quarry at 690 feet
(Post Mining, Full Pit-Lake)

FIGURE 11