MEMORANDUM

To: Nelson Review Team

From: Earthfx Incorporated

Date: May 29, 2022

Subject: Documentation of Deep Pond Simulation Results presented at May 20, 2022 NDMNRF Meeting

1 Introduction

This technical memorandum provides information on the simulation of a new infiltration pond design as discussed at the project meeting on May 20, 2022.

2 Simulation Objectives

The objectives of the new simulation were to determine the effects of modifying the proposed infiltration ponds, as presented in Earthfx, 2020, Scenario P3456, to increase infiltration to the bedrock.

3 P3456 Scenario Summary

Earthfx (2020, Section 8.7) reporting on the likely impact of extracting aggregate from Phases 3 through Phase 6 in the proposed West Extension of the Burlington Quarry. For the purposes of those analysis, referred to as Scenario P3456, it was assumed that extraction was at its maximum depth and dewatering was ongoing in all four extraction areas. The final elevation of the quarry floor is 252.5 masl in the P3456 footprint. Quarry discharge was directed to the existing quarry lakes and eventually discharged from the Northwest sump. Figure 1 shows the topography and drainage in the quarry vicinity in the P3456 scenario.

Results of the analysis were compared against baseline (current) conditions and showed the likely change in groundwater levels, stream flows, and discharge of groundwater to land surface within the

Medad Valley west of the quarry site. These were discussed in detail in Earthfx (2020) and several key figures are reproduced here. Figure 2 shows the average simulated drawdown (decrease in groundwater levels compared to Baseline) in Model Layer 6. The drawdowns decrease rapidly with distance from the excavation, and exhibit less than 2.0 m of drawdown at a distance of 500 m from the active face. Figure 2 also shows the average simulated change in streamflow. Increases in simulated flow occur within the P3456 area, at the Northwest sump, and in the conduits carrying flow to the infiltration pond. Slight decreases in average simulated flow occur in the Medad Valley compared to Baseline Conditions.

Figure 3 shows a hydrograph comparing simulated daily streamflow under Scenario P3456 to Baseline Conditions for SW07 in the Medad Valley. Changes in streamflow are shown (inverted) on the secondary y-axis. Results show very small decreases in baseflow and small losses in peak flows during storm or snowmelt events.

A feature of the P3456 Scenario was the addition of an infiltration pond in the West Extension area between Cedar Springs Road and the extraction area (see Figure 1) for the purpose of replicating existing golf course ponds. Under current conditions, water is routinely diverted from the north quarry discharge pond and conveyed through ditches to the golf course ponds. This water is used for irrigation (a portion of which likely recharges the groundwater system), and in addition the standing water in the ponds also directly leak to the groundwater system. The pond leakage was investigated during a pumping test reported in Earthfx (2020). Figure A12 on page 439 of that report, shows the increase in temperature in borehole BS-06 due to leakage from warmer pond water.

The P3456 infiltration pond was designed intended to function in a similar manner to the irrigation ditches and golf course ponds, and help maintain the existing surface and groundwater system. Water from quarry discharge at the northwest sump will be continuously diverted to the infiltration pond. The proposed infiltration pond was assumed to be shallow, occupying model Layer 1, and underlain by unweathered Halton Till. The proposed P3456 infiltration ponds were not optimized to maximize infiltration, but simply to replicate the existing system. The lake average seepage under this scenario is shown in Figure 4.

Simulations of the P3456 scenario were run with and without the infiltration pond to determine the incremental benefit of the shallow layer 1 pond. Results showed that the infiltration pond raised the groundwater levels in Layer 6 (middle of the Amabel aquifer) by 5.5 m at the pond location1.5 to 3.5 m along Cedar Springs Road, and 0.5 m along the edge of the Medad Valley, when compared to a scenario without the infiltration pond (Figure 5).

The effects on the water levels and gradients in the Medad Valley under P3456 were evaluated by identifying areas where there was a change in water level gradient. Water levels decline modestly in the valley during P3456. One measure of that decline are areas where, on average, water levels in the Layer 4 bedrock will no longer be above ground surface. (Seasonally, water levels may still be above ground surface, however). These areas, shown as purple squares in Figure 6, are generally located along the easter wall of the Medad Valley.

In summary, the original P3456 pond design is effective at generally replicating the effects of the golf course ponds. The effects of the design P3456, including the proposed shallow infiltration ponds, result in minimal impact on water levels in the Medad Valley.

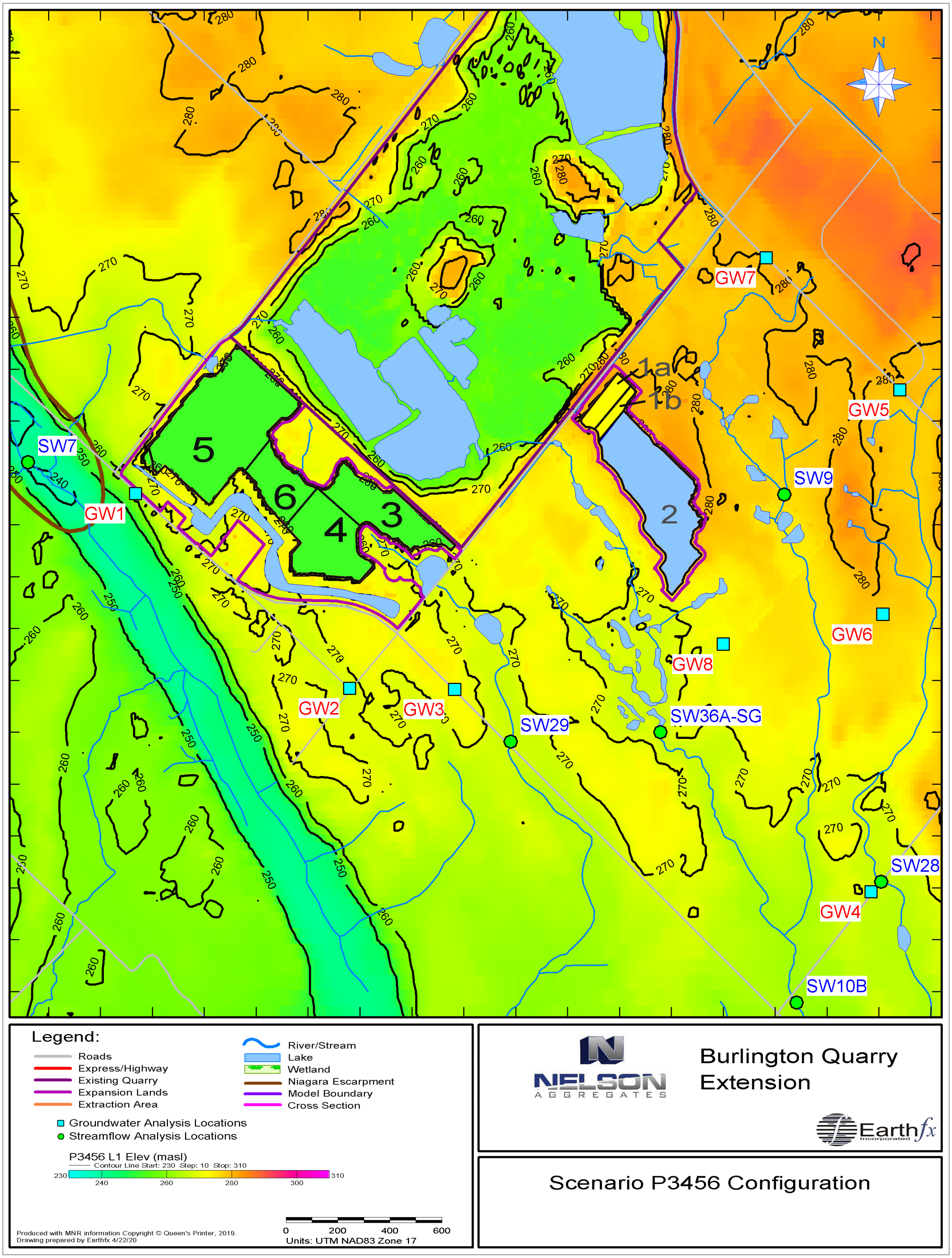

Figure 1: Scenario P3456 and Deep Pond Scenario configurations.

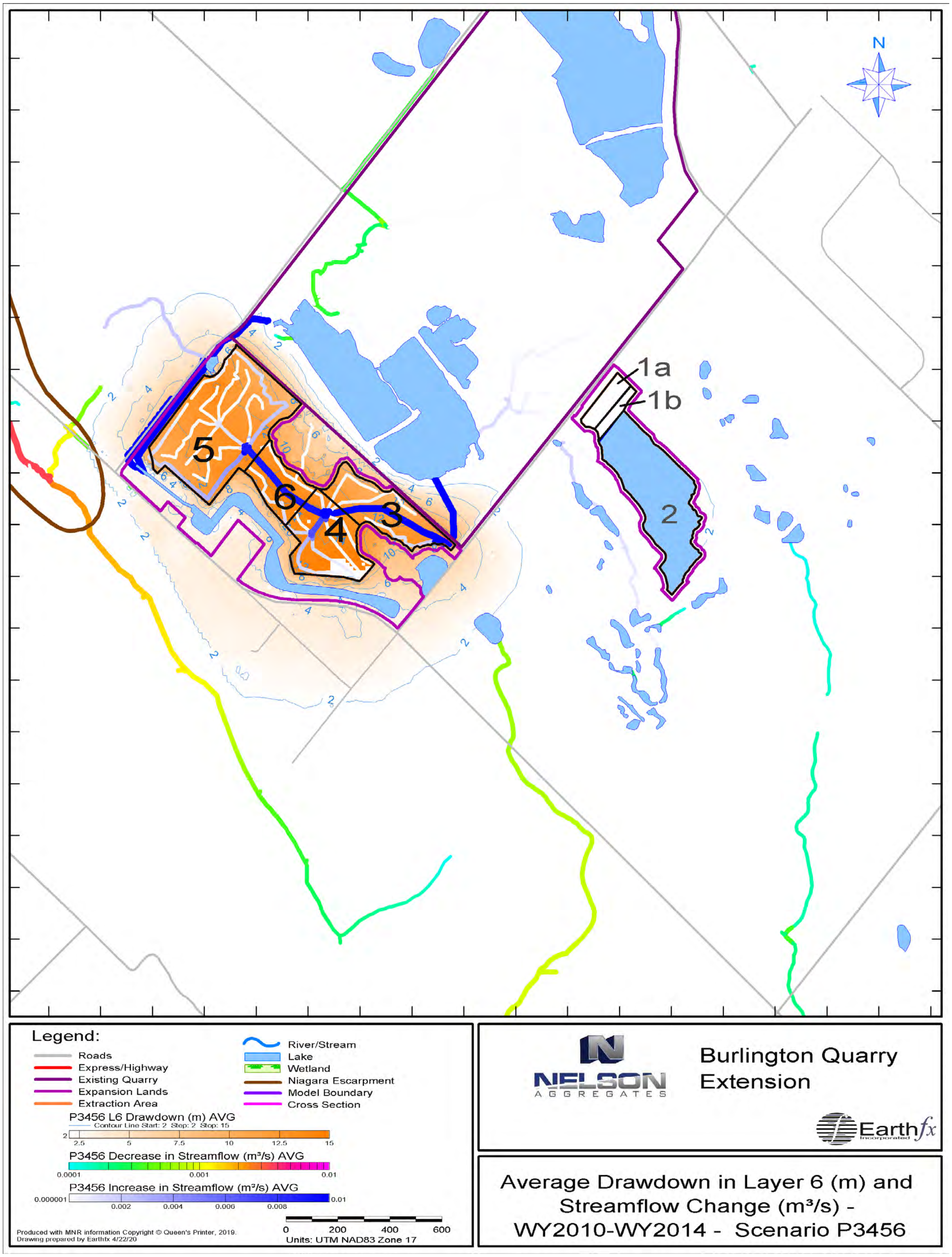

Figure 2: Average simulated drawdown in Model Layer 6 (m) and increase/decrease in streamflow (m3/s) for WY2010 to WY2014 under Scenario P3456.

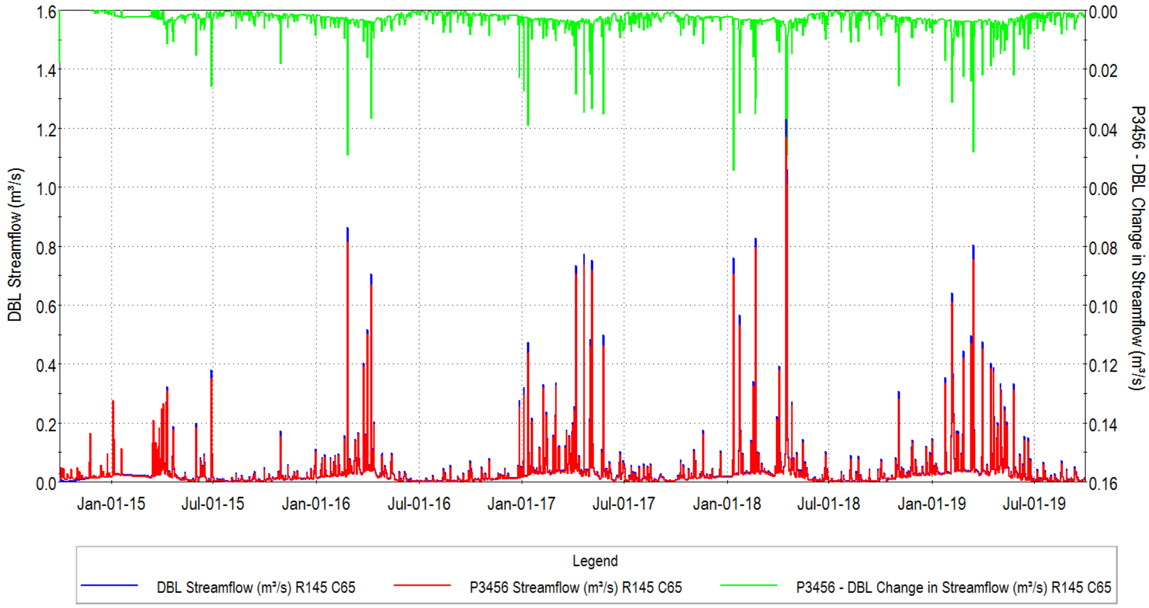

Figure 3: Simulated streamflow at SW07 for WY 2014-2019 – P3456 and Baseline Conditions.

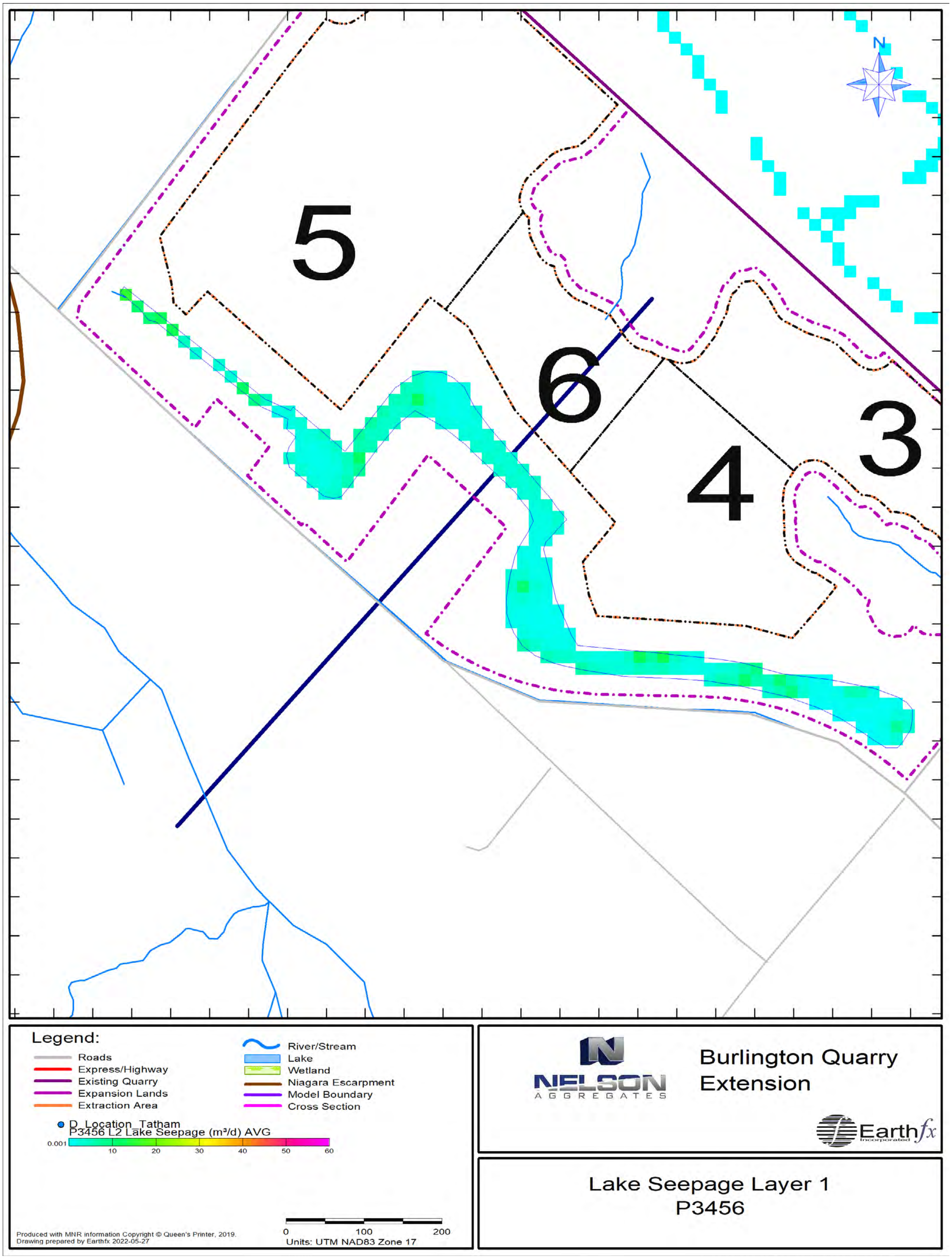

Figure 4: Lake seepage in Layer 1 P3456 Scenario

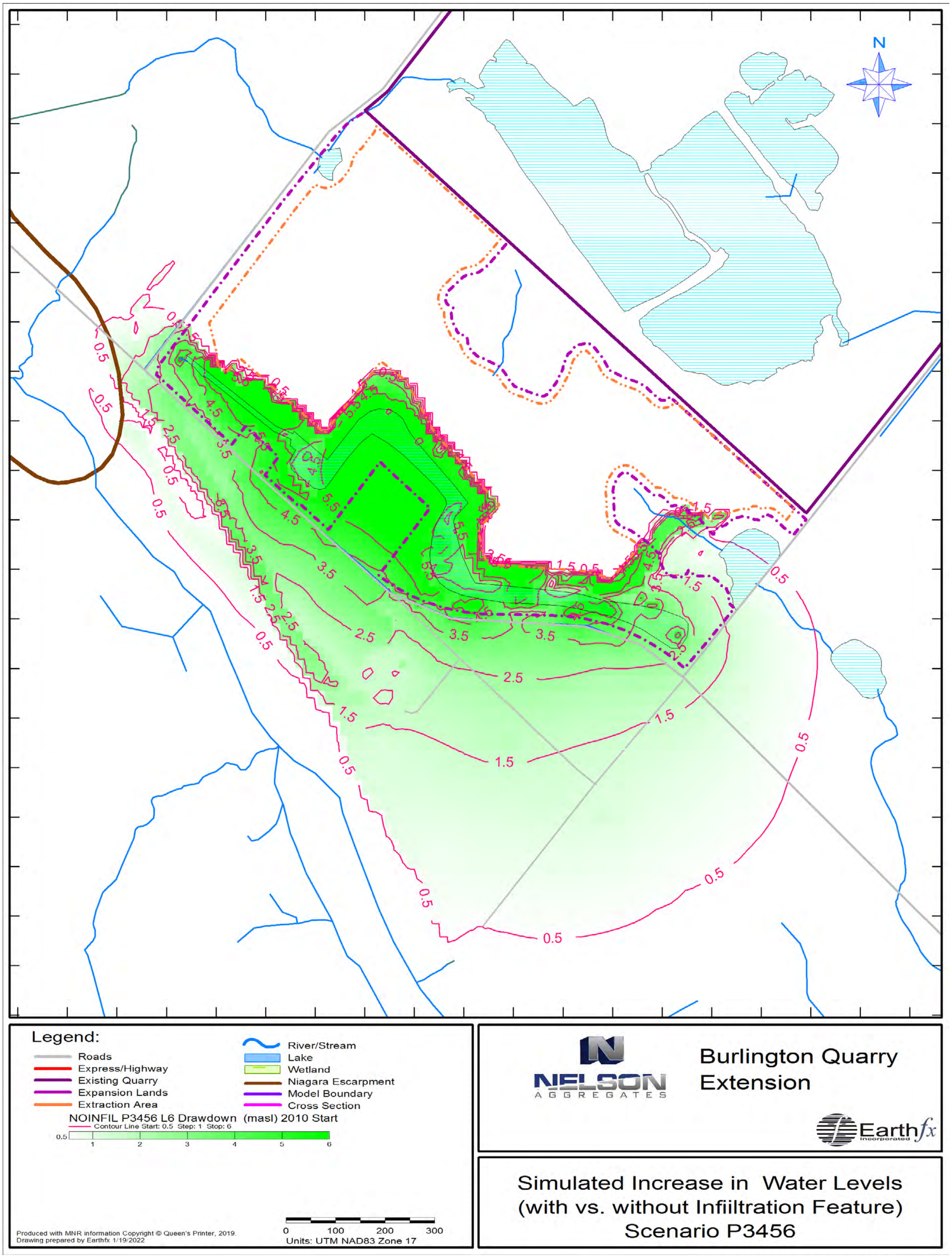

Figure 5: Simulated increase in water levels due to P3456 shallow infiltration ponds

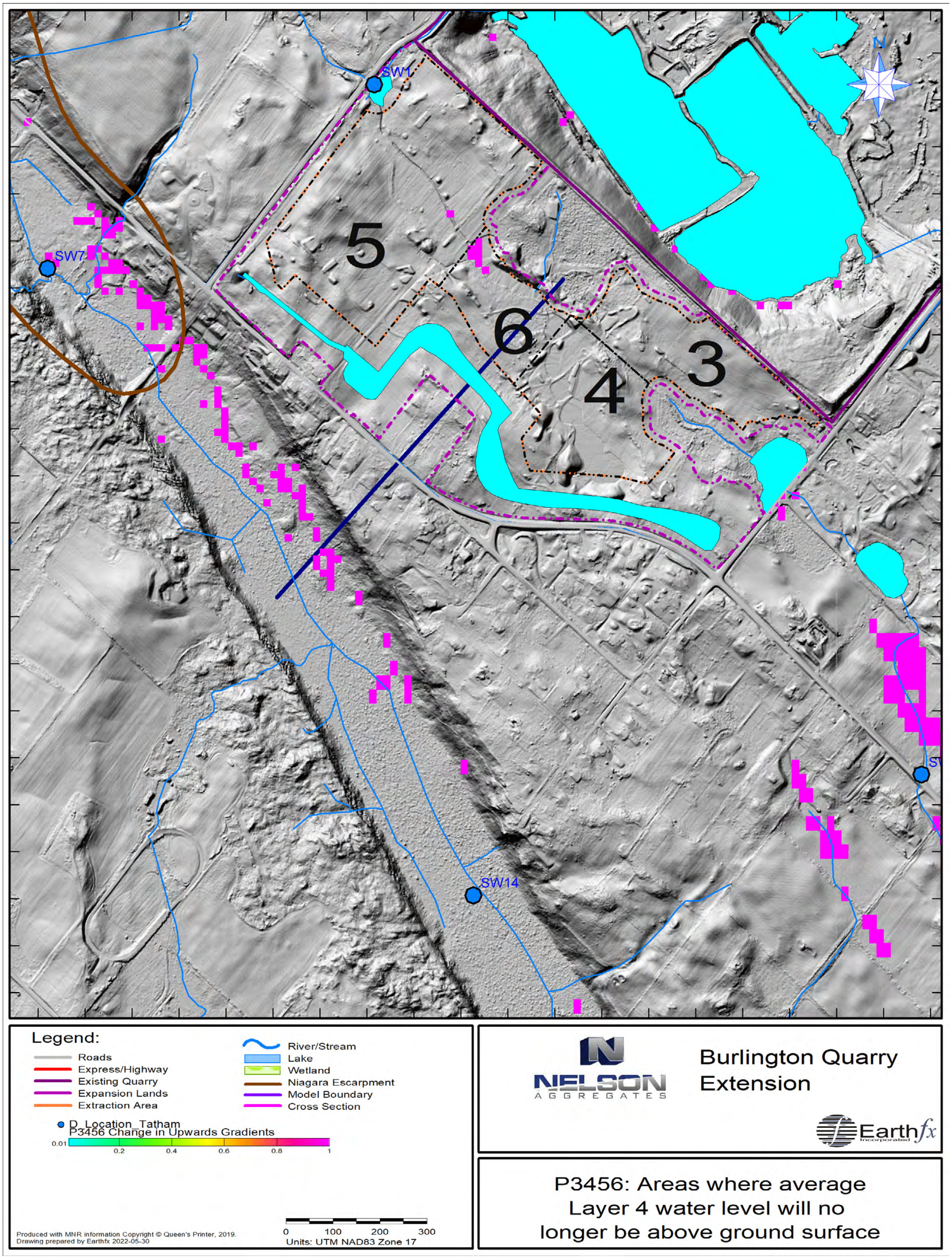

Figure 6: P3456 Areas where average Layer 4 water levels will no longer be above ground surface

4 Modified Scenario P3456: Deep Pond Scenario

The P3456 infiltration pond was not specifically designed to maximize infiltration. During discussions in April, 2022, MNDMNRF reviewers requested that additional simulations be undertaken to determine whether simple changes could be made to the operation and configuration of the infiltration pond to further reduce the impacts of the quarry on the Medad Valley.

A modified Scenario P3456 was run to assess the effects of changes to the infiltration pond. For this scenario the infiltration pond is fully excavated through the Halton till to the bedrock (base of Layer 3). This will provide more opportunity for infiltration compared to the previous P3456 scenario where the ponds were constructed only to the top of the unweathered till (base on Layer 1). To further enhance leakage, the proposed operating water level in the pond was raised from 269.05 masl to 270.05 masl to provide a higher driving head for infiltration.

While a direct excavated connection to the bedrock is proposed, there remains the possibility that some fine-grained sediments may remain (or accumulate) over time on the bedrock surface. This may limit leakage. As a conservative assumption, the hydraulic conductance of the lake bottom sediments was assigned a hydraulic conductivity one-half an order of magnitude lower than that of the Layer 4 weathered bedrock.

As in the previous P3456 simulation, extraction is assumed to be at its maximum depth and dewatering is ongoing in all four extraction areas. The final elevation of the quarry floor is 252.5 masl in the P3456 footprint. Quarry discharge is directed to the existing quarry lakes and eventually discharged from the Northwest sump.

The GSFLOW model was run with the updated inputs. This scenario is referred to as the “Deep Pond Scenario” and model results were post-processed and compared to the original P3456 Design Conditions.

Figure 7 shows the increase in average water levels between the P3456 and new Deep Pond scenario. The increased leakage causes water levels rise locally up to 4 m, and as much as 0.5 m in the eastern portion of the Medad Valley.

Figure 8 shows the average leakage to bedrock under the Deep Pond Scenario. Compared to P3456 (Figure 4), the leakage to bedrock doubles from an average of 778 m^3/d to 1405 m^3/d. As noted above, this is under a conservative assumption of lake bed conductance. Leakage would be still higher if no fine-grained sediments remain or accumulate. Strict settlement and discharge water quality monitoring will be implemented to prevent fine grained sediments from entering the ponds.

As in the previous scenario, the effects on the water levels and gradients in the Medad Valley were evaluated by identifying areas where there was a change in water level gradient. Areas where, on average, water levels in the Layer 4 bedrock will no longer be above ground surface are shown in Figure 9. These areas, shown as purple squares in Figure 9, are generally located along the easter wall of the Medad Valley. Compared to the P3456 conditions shown in Figure 6, the affected area is reduced by over 50% and is now sporadically distributed along the eastern portion of the Medad valley (in areas of slightly higher local relief). Figure 10 compares the P3456 results to those of the Deep Pond scenario, showing the difference as green cells.

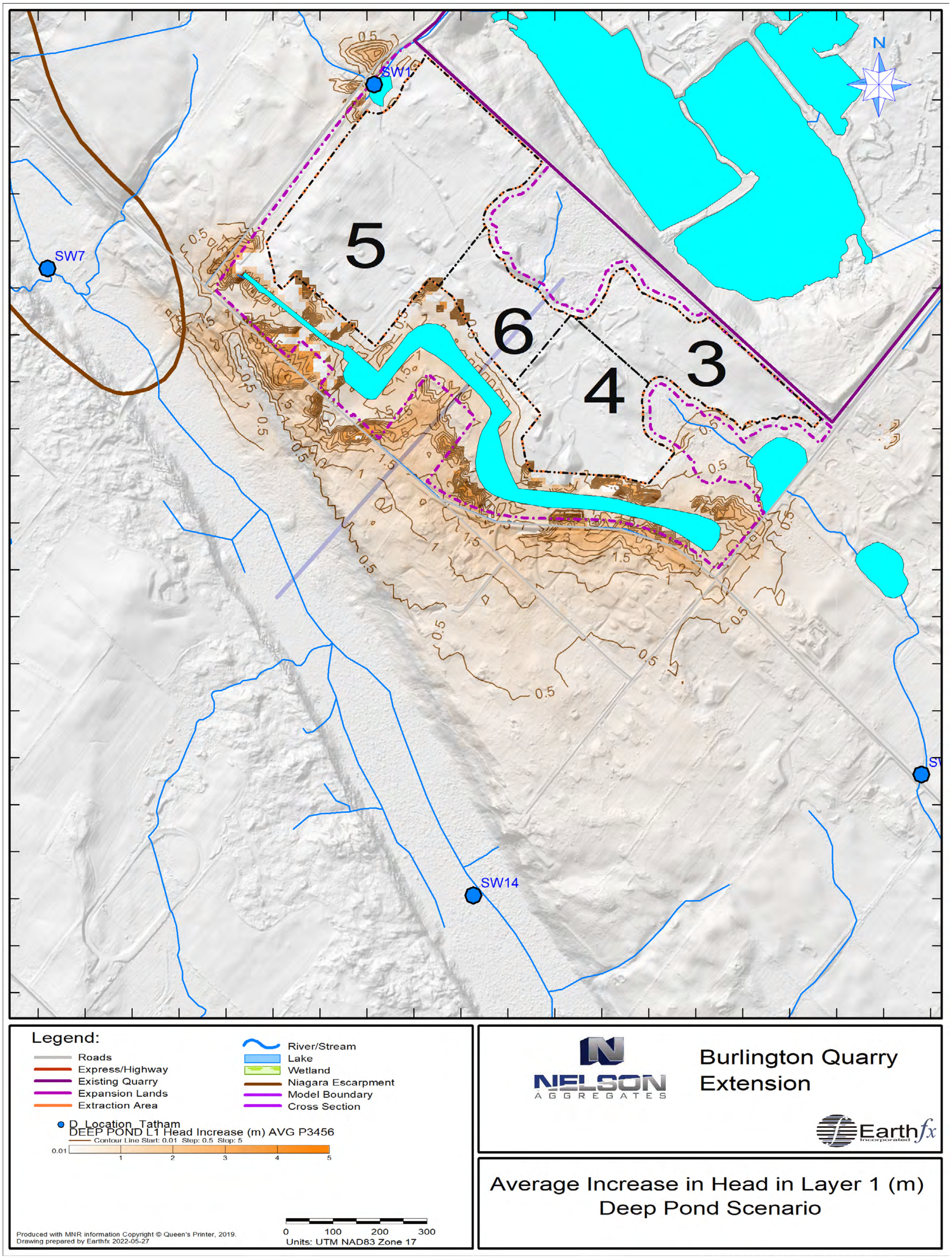

Figure 7: Average increase in Layer 1 water levels between P3456 and Deep Pond Scenario

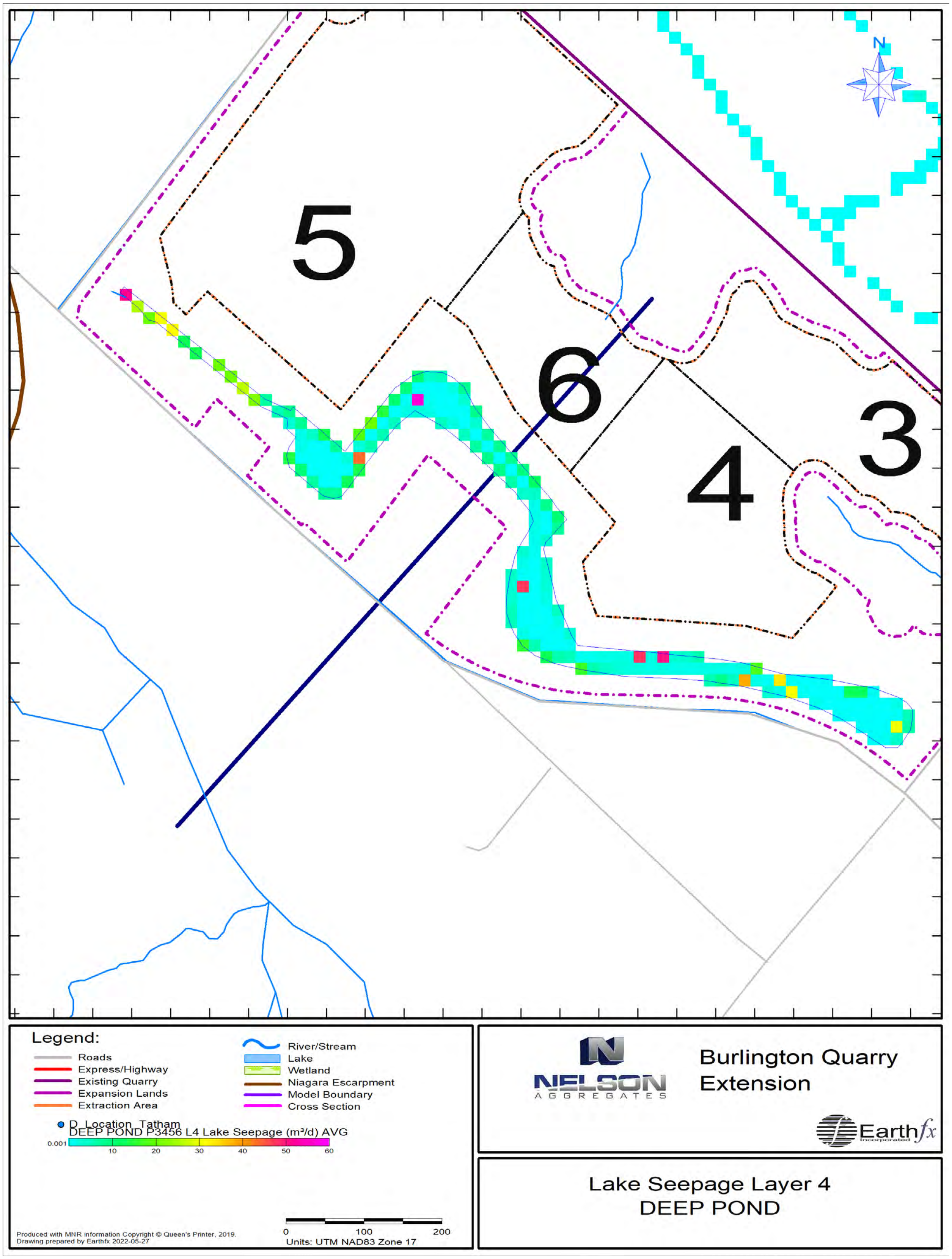

Figure 8: Lake seepage under the Deep Pond Scenario

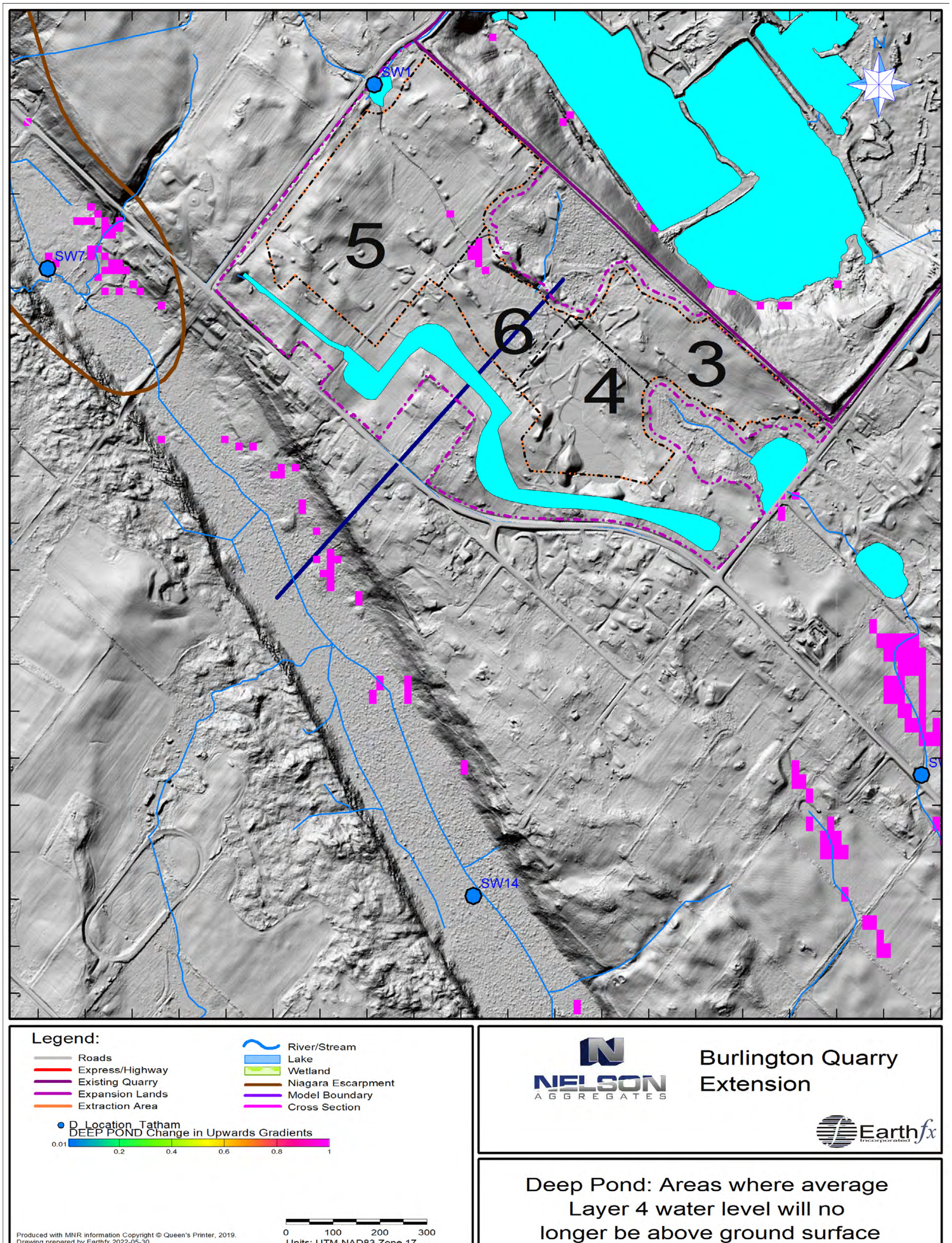

Figure 9: Deep Pond Scenario areas where average Layer 4 water levels will no longer be above ground surface

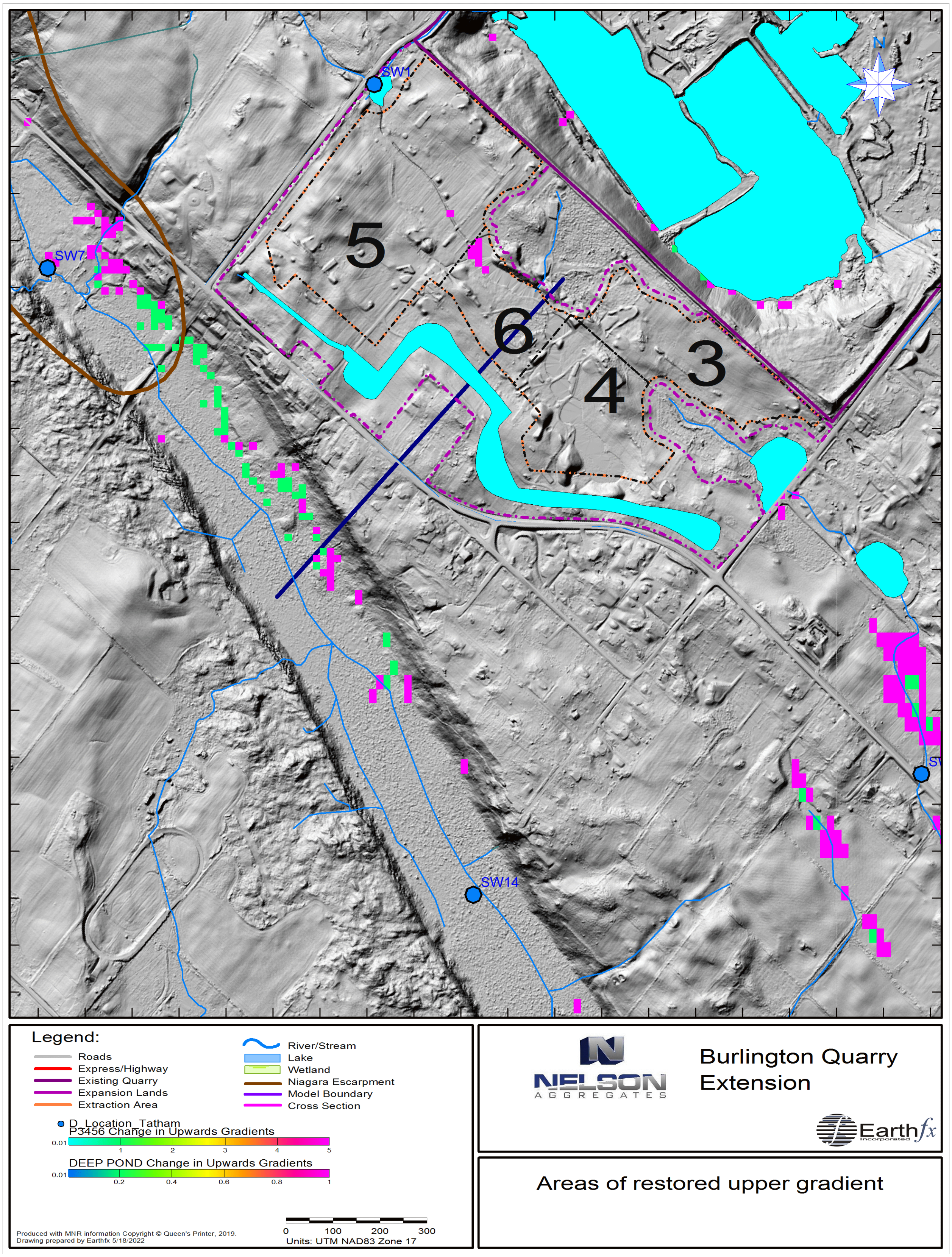

Figure 10: Areas where average water levels will be restored (green cells) between P3456 and Deep Pond scenario. Remaining affected cells are shown in purple.

To conclude, the new Deep Pond scenario demonstrates that modest improvements in the pond design can significantly improve water levels both locally and in the Medad Valley. Conservative assumptions were used to represent the deeper infiltration pond. Under the new design, the effects on the Medad Valley will be very limited and highly dispersed across the extensive wetland feature that occupies the valley.

Yours truly
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