Appendix I

Detailed Impact Assessment Reports

Appendix I-1

Geology & Hydrogeology Detailed Impact Assessment Report

REPORT

Draft Geology and Hydrogeology Detailed Impact Assessment

Walker South Landfill Phase 2 Environmental Assessment

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1 INTRODUCTION

This report documents the Geology and Hydrogeology impact assessment of the Preferred Method for the Environmental Assessment (EA) to develop the next phase of the existing South Landfill (i.e., South Landfill Phase 2) located at the Walker Resource Management Campus (Campus). The proposed South Landfill Phase 2 will add approximately 19.8 million cubic metres (m^3) of landfill capacity over a 20-year period.

In the preceding Alternative Methods phase of the EA, net effects analyses as well as a comparative evaluation of three Alternative Landfill Configuration Options and two Leachate Management Options were carried out in order to identify a Preferred Landfill Footprint and a Preferred Leachate Management Option. The three Alternative Landfill Configuration Options and two Leachate Management Options presented in the Alternative Methods phase were developed to a conceptual level of design and documented in a Conceptual Design Report (CDR). The potential environmental effects, preliminary impact management measures to address the potential adverse environmental effects, and the remaining net effects following the application of the impact management measures were identified for all three Alternative Landfill Configuration Options and both Leachate Management Options. The Preferred Landfill Configuration Option was determined to be Option A (*Same Height and Slopes as Current South Landfill Phase 1*[1]) and the Preferred Leachate Management Option was determined to be Option A (*Continued and Expanded Use of the Municipal Wastewater Treatment System*), hereafter collectively referred to as the Preferred Method.

At the detailed impact assessment phase, additional details are developed for the Preferred Method from a design and operations perspective, as documented in a Facilities Characteristics Report (FCR), so that potential environmental effects, preliminary impact management and compensation measures, and resultant net effects described at the Alternative Methods stage can be reviewed and more accurately defined, as required, along with enhancement opportunities and approval requirements. Specifically, the following can be accomplished:

- Potential environmental effects can be identified with more certainty.
- More site-specific impact management measures can be developed for application.
- Additional mitigation and impact management measures can be identified, as required.
- Net environmental effects can be identified with more certainty.
- Appropriate monitoring requirements can be clearly defined.
- Specific approval/permitting requirements for the proposed undertaking can be identified.

Climate change mitigation and adaptation measures are also reviewed as part of the detailed site design established for the Preferred Method. In addition, during the impact assessment stage of the South Landfill Phase 2 EA, Walker has committed to completing an assessment of the cumulative effects of the proposed undertaking and other non-Walker projects and activities that are existing, planned/approved or reasonably foreseeable within the Study Area.

[1] Following consultation on the comparative evaluation of the alternative methods, the Preferred Landfill Configuration Option was refined based on public, stakeholder and Government Review Team (GRT) comments and feedback received. Specifically, the proposed maximum height was decreased to reduce visual impact, the proposed Limit of Fill was adjusted in several areas to avoid sensitive natural features and to accommodate necessary infrastructure within the buffer, and slopes were adjusted to maximize compatibility with an agricultural end use, all of which resulted in a slightly reduced waste capacity.

The discipline-specific work plans developed during the Terms of Reference (ToR) outlined how impacts associated with the Preferred Method would be assessed. The results of these assessments are documented in 13 stand-alone Detailed Impact Assessment Reports:

- Geology and Hydrogeology
- Surface Water Resources
- Noise and Vibration
- Air Quality
- Terrestrial and Aquatic Environment
- Land Use
- Agriculture
- Transportation
- Social Environment
- Economic Environment
- Built Heritage and Cultural Heritage Landscapes
- Archaeology
- Visual

1.1 Description of the Preferred Landfill Configuration Option

Landfill Configuration Option A was originally selected as preferred due to its long-term benefits, including the largest waste capacity, longest operational lifespan, and associated economic and employment advantages. Following its selection, the design of Landfill Configuration Option A was refined in response to feedback received during consultation to reduce its visual impact and improve compatibility with a future agricultural end use. Furthermore, the Limit of Fill boundaries were adjusted to avoid natural features and to accommodate necessary infrastructure within the buffer. These refinements included a reduction in peak elevation to 211 metres above sea level (masl) at the top of waste (TOW; 211.75 masl at the top of cap), and adjustments to slope gradients, now designed to a maximum steepness of 3:1 (horizontal:vertical) for below-ground slopes and between 16:1 and 3.5:1 for above-ground slopes, improving the area compatibility with an agricultural end use. These changes bring Option A closer in form to the Options B and C while preserving its advantage of a higher overall waste capacity. The refined Option A design would provide approximately 19.8 million m^3 of expanded landfill capacity and include 40 hectares (ha) of land compatible with an agricultural end use. From the Geology and Hydrogeology perspective, these adjustments have no significance as the depth, footprint, liner design and setting within the former quarry excavation do not change. The adjustments do not have an influence on the geology and groundwater conditions.

1.2 Description of the Preferred Leachate Management Option

Leachate Management Option A builds upon the pre-existing leachate management system and approach while including the necessary expansion of the system capacity as South Landfill Phase 2 is expected to generate approximately 131,000 m^3 of additional leachate per year at the time of closure (2050) and approximately 147,000 m^3 of additional leachate per year in 2070 when considering climate change. The expansion of the leachate management system would include a leachate pump station equipped with the needed metering equipment and controls for monitoring and contingency purposes, a forcemain to transport the leachate from the pump station to the lagoon area, and lagoon upgrades consisting of 2 additional lagoons, if required (located adjacent the existing two lagoons), for pretreatment and eventual discharge.

Once pretreated at the on-site lagoons, leachate will be conveyed via an existing force/gravity main to the Niagara-on-the-Lake sanitary sewer system for final treatment at the Region of Niagara's Port Weller Wastewater Treatment Plant. The need to upgrade the private sewer that connects to the Niagara-on-the-Lake sanitary sewer system has been identified and will be considered in the assessment.

1.3 Facility Characteristic Report for the Preferred Method

The FCR presents preliminary design and operations information for the Preferred Method and provides information on all main aspects of landfill design and operations including:

- Site layout design, including existing and proposed Site characteristics;
- stormwater management;
- leachate management;
- landfill gas management; and,
- landfill development sequence and daily operations.

The FCR also provides estimates of parameters relevant to the detailed impact assessment, including estimates of leachate generation, landfill liner performance, landfill gas generation, and traffic levels associated with waste and construction materials haulage.

2 STUDY AREA

From a Geology and Hydrogeology perspective, the characterization of impacts within the following study areas are appropriate to this EA:

- Site Study Area (SSA): The SSA is consistent across all technical disciplines and encompasses a total of 81.30 ha of land owned and operated by Walker. The SSA includes the current quarry extraction limit, and encompasses the proposed limit of fill, the buffer area, and aligns with the proposed Waste Disposal Site Limit Boundary. While the SSA captures the core area of the proposed landfill development, certain ancillary features related to the landfill are proposed to be located outside the SSA. These features will be addressed within the broader Local Study Area.
- Local Study Area (LSA): The LSA includes all lands within a one (1) km radius to the east, south, and southwest of the Walker Campus, which includes the SSA, and bounded by the Welland Canal and the Niagara Escarpment to the north and northwest of the Campus.
- Regional Study Area (RSA): The RSA includes all lands bounded by the Welland River to the south, the Welland Canal to the west, the Niagara Escarpment and specifically the Lockport and Rochester Formation bedrock subcrops to the north, and the Queenston-Chippewa Hydro Canal to the east.

The Geology and Hydrogeology study areas are illustrated in **Figure 1**.

3 METHODOLOGY

3.1 Assessment Approach and Confirmation of Effects

The assessment of impacts associated with the Preferred Method was undertaken through a series of steps that were based, in part, on a number of previously prepared reports (**Geology and Hydrogeology Existing Conditions Report**, **Geology and Hydrogeology Comparative Evaluation Technical Memorandum**).

In order to characterize the existing Geology and Hydrogeology conditions within the study areas, available secondary sources of information were collected and reviewed. The existing secondary information was supplemented through a detailed field investigation to address data gaps. The field investigation included a drilling and hydraulic testing program, a baseline groundwater monitoring program, and a residential water well use inventory. The approach and methodologies are detailed in the **Geology and Hydrogeology Existing Conditions Report**.

Evaluation Criteria and Indicators were established during the development of the ToR based on feedback from Indigenous communities, government agencies, and the public. Prior to undertaking the Comparative Evaluation of Alternative Methods process, a Public Event, accompanied by a virtual event, was held to present the Criteria and Indicators to the public and invite additional feedback.

In order to fully characterize these indicators and to adopt measures by which potential effects could be identified, several considerations were developed for each indicator, as shown below in **Table 1**.

Table 1: Considerations for Criteria and Indicators

Criteria	Indicators	Considerations
Effect on groundwater flow	– Predicted effects to groundwater flow at property boundaries and off-site.	– Changes to water levels in the bedrock – Changes to flow regimes and current inward groundwater gradient conditions – Number of off-site groundwater users affected
Effect on groundwater quality	– Predicted effects to groundwater quality at property boundaries and off-site.	– Potential for leakage from base of landfill – Groundwater movement (flux and direction) in the shallow Rochester shale bedrock below the landfill footprint – Maintenance of inward groundwater gradients – Number of off-site groundwater receptors affected

The net effects associated with the three Alternative Landfill Configuration Options and two Alternative Leachate Management Options identified during the Alternative Methods phase of the EA were based on conceptual designs and the following assumptions.

- Effect on groundwater flow:
  - The existing groundwater underdrain system beneath the East Landfill (i.e., groundwater collection system or GWCS) and/or a future sub-drain system beneath the South Landfill Phase 2 will continue to be operated
- Effect on groundwater quality:
  - The proposed landfill will have an engineered leachate collector system (LCS) and liner design that meets or exceeds O.Reg. 232/98 requirements

- Future on-site leachate lagoons will be constructed with an engineered liner to ensure containment.

As set out in the original ToR work plan, numerical groundwater modelling was completed to simulate existing, future existing, proposed landfill operations and post-closure conditions. The groundwater modelling methodology is described further in **Section 3.2**. The groundwater flow modelling, along with the contaminant transport modelling completed for the proposed site-specific liner design, verified the above-noted assumptions and were used to identify the potential net effects of each alternative on the Geology and Hydrogeology environment.

The net effects were reviewed within the context of the preliminary design plans developed for the Preferred Method, as identified in the FCR, to determine the type and extent of any additional investigations required to ensure a comprehensive assessment of net effects. Feedback previously received from the EA consultation process was incorporated into the assessment approach, as outlined below.

Consultation with the Ministry of the Environment, Conservation and Parks (MECP) was held in March 2025 to discuss the proposed site-specific liner design for the South Landfill Phase 2, and again in early January 2026 to discuss the proposed hydrogeology work program for characterization of existing conditions and detailed impact assessment. During consultation events, the MECP hydrogeologist identified the importance of understanding groundwater conditions northeast of the SSA, contaminant loadings entering the flow system below the proposed liner, and modelling supported by good quality data and sensitivity / uncertainty analysis. Based on feedback from the consultation, and initial comments from draft reports, the following modifications were made to the field investigation and assessment contributing to the Geology and Hydrogeology Existing Conditions Report, and to the groundwater modelling completed for the detailed impact assessment.

- Shifted location of 1 monitoring well nest (BH80) to provide additional groundwater level and quality information toward the northeast of the SSA.
- Added additional data loggers to residential wells northeast of the SSA (residential wells 13-2 and 14) to provide additional groundwater level information.
- Confirmed inclusion of sensitivity and uncertainty analysis as part of the groundwater modelling.

With a more detailed understanding of the potential impacts from the preliminary landfill and leachate treatment designs on the Geology and Hydrogeology environment, the previously identified potential effects and recommended mitigation or compensation measures associated with the Preferred Method (documented in the **Geology and Hydrogeology Comparative Evaluation Technical Memorandum**) were reviewed to ensure their accuracy. Based on this review, the potential effects, mitigation or compensation measures, and net effects associated with the Preferred Method were confirmed and documented. In addition to identifying mitigation or compensation measures, potential enhancement opportunities associated with the preliminary design for the Preferred Method were also considered.

Following this confirmatory exercise, the requirement for a future monitoring program was identified. Finally, any Geology and Hydrogeology approvals required as part of the implementation of the Preferred Method were identified.

3.2 Groundwater Modelling

A three-dimensional numerical groundwater flow model (MODFLOW) was developed to simulate Existing Conditions within the RSA, the details of which are provided in **Appendix A**. In summary, the model was constructed and calibrated using data obtained during the baseline monitoring period as well as an extensive historical data set within the LSA and RSA. Calibration metrics included groundwater elevation data, Southeast Quarry daily pumping records and water level / discharge data from the GWCS. The calibrated baseline model was then adapted to simulate two scenarios: (i) the future existing conditions (i.e., "do-nothing" option) with the Southeast Quarry rehabilitated to an agricultural use, and (ii) the proposed landfill operation conditions. An additional scenario for the proposed landfill post-closure conditions was considered; however, it was determined that the model parameters would be the same as those of the operation conditions scenario and that model could be used to assess impacts for both conditions. The model hydraulic head distribution output was used to assess impacts on local residential well users and inward groundwater gradients. An uncertainty analysis was completed to evaluate potential uncertainty in the calibrated values for the most sensitive model parameters to the predicted impacts. Climate change effects were simulated for both scenarios to evaluate the effect of long-term changes to precipitation on the model predictions.

As per the **Geology and Hydrogeology Existing Conditions Report**, the base of the Rochester Formation shale was simulated as a lower no-flow boundary given its function as a regional aquitard. Groundwater within the lower Irondequoit limestone bedrock is hydraulically separated from the existing and proposed landfills by the Rochester shale. As such, groundwater flow and quality within the Irondequoit limestone will not be affected. This interpretation has been confirmed through extensive monitoring completed as part of the South Landfill annual monitoring program. An additional inherent assumption was made that the operation of the GWCS will continue to function under all future scenarios, thus maintaining the inward hydraulic gradients that are observed under Existing Conditions.

Numerical groundwater contaminant transport modelling was completed as part of the Leachate Containment System Design Description Report (provided in the FCR); further discussion is provided below.

3.3 Additional Investigations

Upon completion of the preliminary design for the Preferred Method as documented in the FCR, the environmental characteristics of the Study Areas were reviewed to verify the accuracy of the assessment of net effects from the Preferred Method. From this review, it was determined that no additional investigations were required.

4 DESCRIPTION OF THE ENVIRONMENT POTENTIALLY AFFECTED

A summary of the Geology and Hydrogeology environment under existing condition is presented below. A more detailed description and list of references can be found in the **Geology and Hydrogeology Existing Conditions Report**.

4.1 Existing Conditions

The SSA and LSA are situated just south of the Niagara Escarpment in an area characterized by low topographic relief and poorly drained soils. A relatively thin layer of lacustrine clayey silt covers the area and is underlain by a glacial silt till. The overburden thickness generally increases to the south within the LSA and RSA, away from the Escarpment. Beneath the overburden are various bedrock units.

The Lockport Formation dolostone is the uppermost bedrock unit in the Study Areas and has been quarried historically at the Campus. The unit thickness ranges from about 2 m to 15 m and is relatively porous due to the presence of natural fractures, vugs, larger cavities, and occasional fossiliferous zones. The underlying DeCew dolostone is an argillaceous (shaley) dolostone that is up to 5 m thick and tends to become increasingly shaley with depth. The Rochester Formation underlies the DeCew dolostone and consists of thin to medium bedded shale and thin beds of dolomitic shale with occasional isolated thin beds of dolostone. The Rochester shale bedrock ranges from 14 m to 18 m thick. These bedrock units extend regionally to the south but are limited to the north of the Site by the Niagara Escarpment.

The bedrock units below the Rochester Formation, including the Irondequoit Formation limestone, and the deeper bedrock formations of the Clinton and Cataract Groups are not exposed through the historic or current quarry operations at the Campus.

The groundwater setting within the LSA consists of the upper overburden aquitard, the Lockport Formation dolostone bedrock aquifer, the lower aquitard associated with the DeCew and Rochester Formations, and the underlying Irondequoit Formation semi-pervious aquifer. The Rochester shale is considered a natural barrier separating groundwater movement between the upper Lockport dolostone unit and the underlying Irondequoit limestone and Reynales dolostone units.

The design of the South and East Landfills and presence of the GWCS maintains groundwater flow patterns similar to the conditions at the former quarries prior to landfilling, which is a natural sink or drawdown effect in the dolostone bedrock aquifer and shale bedrock aquitard. This creates a continuous inward groundwater gradient (i.e., hydraulic trap) surrounding the South and East Landfills and the Southeast Quarry, whereby groundwater within the dolostone aquifer and shale aquitard below the Campus does not flow off-site.

Within the RSA and LSA, the glaciolacustrine clay and silt overburden deposits act as an aquitard and are not a significant source of potable water owing to its low permeability and poor yields.

Within the LSA, groundwater in the Lockport dolostone aquifer and lower aquitard associated with the DeCew and Rochester shale flows inward toward the SSA (current Southeast Quarry), South Landfill and East Landfill due to the drawdown effect of the GWCS and quarry. At the SSA, groundwater discharges slowly into the quarry through the north, east and south rock faces toward the quarry sump. Around the perimeter of the South Landfill and East Landfill, which are sealed by clay sidewalls, groundwater moves downward along the buried vertical quarry faces and into the weathered shale floor. The groundwater then moves beneath the South Landfill and East Landfill clay liners and mixes with the shallow shale groundwater before draining to the GWCS. The water level response within the shallow Rochester shale suggests a strong hydraulic influence from the GWCS that maintains a continuous inward groundwater gradient whereby groundwater within the dolostone aquifer and shale aquitard below the Campus does not flow off-site.

Groundwater in the Irondequoit aquifer in the LSA typically flows west to southwest or west to northwest; but the flow direction is seasonally influenced by the draining and filling of the Welland Canal. The groundwater potentiometric head in the Irondequoit aquifer is lower than the overlying lower aquitard piezometric surface; as such, a downward hydraulic gradient exists between these two units.

A significant number of parcels within the LSA are connected to the municipal water supply, and a large proportion of the un-serviced lands are either (i) owned by Walker, (ii) vacant with no associated street address, or (iii) within the hydro corridor right-of-way to the southeast of the SSA or the Niagara Escarpment Parks and Open Spaces System to the west of the SSA. A total of 97 MECP water well records plot within the LSA, of which 36 are reported as domestic supply, while the remainder are for use as livestock / irrigation, industrial / commercial, or monitoring wells / test holes. Based on the residential water well survey, there are four (4) residents within the LSA that use their well as the sole water source for domestic purposes. Each of these residences are included in Walker's current residential well monitoring program for the Southeast Quarry, and the closest wells are approximately 500 m south and northeast of the SSA, respectively.

Groundwater interactions with natural surface water features within the LSA are limited. There is no hydraulic connection between 10 Mile Creek and the groundwater system, and the potential for surface water percolation to the underlying aquifer is independent of the piezometric head in the aquifer. The Old Welland Canal is situated below the Escarpment face and is not influenced by groundwater conditions at the Walker Campus operations. The water seepage areas and spring fed ponds present north of the SSA and LSA, are fed intermittently by the groundwater, typically during the wet spring season.

Groundwater quality within the Lockport dolostone is influenced by the infiltration of precipitation through the overlying overburden, which results in less saline and less mineralized groundwater than in the deeper, more isolated bedrock units. The natural groundwater quality in the Lockport dolostone ranges from potable to non-potable, with increasing mineralization and, therefore, decreasing potability, with increasing depth.

The Rochester shale was formed in a saline marine depositional environment, which resulted in naturally saline and highly mineralized groundwater within this formation. The Rochester shale groundwater is considered a brine, which is more mineralized than modern seawater, to dilute brine. The salinity generally increases with both depth within the formation and distance from the Niagara Escarpment. Natural fractures in the shale near the Niagara Escarpment cause mixing with groundwater from overlying units, which decreases the salinity. Trace concentrations of BTEX parameters (benzene, toluene, ethylbenzene and xylenes) have historically been detected in the Rochester shale groundwater at the site, as the Rochester shale is naturally petroliferous.

Groundwater in the Irondequoit Formation limestone is not suitable as a drinking water source due to the poor quality of the groundwater. The natural groundwater quality in the Irondequoit aquifer is less mineralized than the quality in the overlying Rochester shale; but is typically considered non-potable owing to its high mineralization. Groundwater in this unit is also considered to be naturally petroliferous.

Water quality in the GWCS and sub-liner monitors below the East Landfill do not exhibit any leachate influences. Water quality within the GWCS is typical of a mixture of Lockport, DeCew and Rochester shale groundwater with minor mixing of meteoric or surface water infiltrating through the open quarry floor. Groundwater quality in the East Landfill sub-liner monitors is consistent with that of the Rochester shale, as expected.

4.2 "Future" Existing Conditions (Do Nothing Option)

The Existing Conditions described in **Section 4.1** reflect the current active quarry operations. The Future Existing Conditions described below reflect the currently approved post-extraction land use if the proposed landfill were not developed (i.e., the "Do Nothing Option"). Therefore, the purpose of the Future Existing Conditions scenario is to establish future baseline conditions upon which the impacts of the Preferred Method (i.e., proposed landfill operations) may be assessed.

The SSA encompasses the existing Southeast Quarry. Once extraction ceases, the Southeast Quarry is required to be rehabilitated to agricultural use under its Aggregate Resources Act (ARA) Licence No. 11175 approved Rehabilitation Plan. The ARA licence stipulates that the quarry lands are to be rehabilitated to approximately 48.2 ha of agricultural land with the creation of a 2.4 ha pond in the southern portion of the SSA.

A detailed description of the model adaptations made for the Future Existing Conditions scenario is provided in **Section A.7.1**, **Appendix A**. In summary, the remaining northeastern portion of the approved Limit of Extraction for the Southeast Quarry will be removed. Overburden from the site will be placed on the quarry floor and sidewalls “to prevent groundwater discharge into the quarry” and graded such that excess runoff would flow to the future pond. The thickness of the placed soils would range between 1 m and 3 m (excluding the sloped portions at the sidewalls); therefore, it is expected that the SSA would continue to be considered as a Highly Vulnerable Aquifer (HVA) under Future Existing Conditions.

The future pond contents would be discharged by gravity flow via pipe under Taylor Road (i.e., the 1,200 mm solid pipe), of which the invert would be the controlling elevation. It is noted that the as-built culvert invert elevation of 159.6 masl is marginally above the average autumn sump elevation of approximately 158 masl; as such, a marginal rebound of localized groundwater elevations in the Lockport and Rochester Formations is predicted under Future Existing Conditions.

The simulated Lockport and Rochester Formation groundwater contours for the Future Existing Conditions scenario are shown in **Figures A-9 and A-10**, **Appendix A**. Although the inferred radius of influence from the quarry excavation extends somewhat further northeast in the Future Existing Conditions scenario in both the Lockport and Rochester Formations, the overall inward groundwater gradients toward the site remain similar to the Existing Conditions. Groundwater flow patterns elsewhere within the LSA do not change substantially from Existing Conditions, which is not unexpected.

There are inferred to be no negative impacts to the operation of the four identified residential wells for domestic use. Marginally increased drawdown at these wells is predicted under the Future Existing Conditions scenario; however, the impacts are well within the available drawdown at each location.

Historically, it has been interpreted from the annual monitoring data that runoff within tributaries of 6 Mile Creek with headwaters north of the SSA originate as overland flow from precipitation, with minimal groundwater contribution, particularly during the autumn period. The Existing Conditions model results are consistent with this interpretation, and the Future Existing Conditions model shows no negative impact to the marginal groundwater discharge amounts to these tributaries.

Significant changes to groundwater quality are not anticipated for the Future Existing Conditions relative to Existing Conditions in much of the LSA outside of the Limit of Extraction. The exceptions may be at selected well nests in close proximity to the northeast portion of the SSA (i.e., nests 48, 49 and 77), where marginally increased drawdown and a potential increase in hydraulic conductivity (due to blasting activities) may lead to increased mixing of the groundwater between the Lockport Formation and underlying DeCew and Rochester Formations. Future agricultural activities within the Limit of Extraction may result in elevated concentrations of parameters such as nitrate in the shallow groundwater, attributed to potential fertilizer use. Runoff collecting within the future pond has the potential to dilute groundwater quality within the GWCS; however, minimal change in water quality in the GWCS is anticipated since runoff from within the SSA would continue to be directed to the 1,200 mm solid pipe, rather than infiltrate to the groundwater system.

5 GEOLOGY AND HYDROGEOLOGY NET EFFECTS

As described in **Section 1**, following the confirmation of the Preferred Landfill Configuration Option and the Preferred Leachate Management Option, these components, together with all other project elements that were consistent across the previously assessed alternative methods, collectively formed the “Preferred Method.” The potential effects and associated mitigation or compensation measures identified following the preliminary design were re-evaluated to confirm their validity for the Preferred Method. This review incorporated the refined engineering design details described in the FCR.

Of particular importance from a Geology and Hydrogeology perspective, the following items were incorporated into the engineering design for the Preferred Method:

- The proposed liner and leachate collection system is a site-specific design that closely resembles the O. Reg. 232/98 Generic Double Composite Liner Design Option II, with the exception of a geosynthetic clay liner (GCL) rather than a compacted clay liner will be used in the primary composite liner. The proposed design is expected to perform equal to or better than the O.Reg. 232/98 Generic Double Composite Liner Design as per the findings of the Leachate Containment System Design Description Report (provided in the FCR).

  The primary and secondary leachate collection systems will include 200 mm diameter perforated HDPE pipes, clear stone drainage layers, granular filter/bedding layers, geotextile separator layers and clean-out access pipes. The design will comply with the O.Reg 232/98 requirements for a service life of 100 years and 1,000 years, respectively. The LCS piping will drain to a leachate sump at the southwest corner of the landfill floor from which the collected leachate will be pumped via a forcemain to the onsite leachate lagoons for pre-treatment prior to discharge to the municipal sanitary sewer system for further treatment.

  The results of the Leachate Containment System Design Description Report indicate that the predicted peak concentration of all key contaminants were less than the MECP Reasonable Use Guidelines (RUG) over the 1,000-year modelling timeframe. As such, the contaminant transport modelling predicts no negative impacts to the groundwater quality at the base of the proposed liner.

- Liner subgrade engineered fill and a sub-drain system will be placed below the liner system. Compacted engineered fill will be placed between the quarry floor and the bottom of the basal and perimeter sideslope lining systems. To minimize build-up of groundwater pressures beneath the engineered fill along the eastern, southern and northern perimeter sideslopes, the engineered fill will include a continuous rockfill sub-drain layer in direct contact with the quarry floor and vertical sidewall. The sub-drain layer will direct any groundwater seepage from the quarry sidewall down to the quarry floor. A series of finger drains (i.e., slots) cut into the quarry floor and backfilled with rockfill will provide hydraulic connection between the perimeter sub-drain layer and the 1,200 mm non-contact groundwater/surface water discharge pipe at MH7S. MH7S will be equipped with valving to allow control of drainage to the 1,200 mm solid conveyance pipe.

  Once the landfill floor has been fully developed with the liner and waste cells, the valve at the inlet of the 1,200 mm solid drainage pipe at MH7S will remain open. Groundwater seepage collected by the sub-drain system will drain to the 1,200 mm pipe via MH7S. If required, the sub-drain system could be used to contain groundwater below the landfill liner as a contingency measure in the event of unacceptable impacts from the landfill on groundwater quality. The sub-drain system could be isolated by closing the valve at MH7S and drained by pumping from MH7S to the leachate management system.

- During the construction of the landfill, precipitation and groundwater seepage on the undeveloped portions of the existing quarry floor (i.e., where no liner construction or waste placement activities have yet occurred) will be segregated from the active landfill areas using berms, ditches and sumps. This non-contact water will be managed through the existing approved quarry water management system.

  Any precipitation or water that comes into contact with the active working area, portions of the landfill that do not have final cover or new cells once constructed will be considered as potentially contaminated (i.e., contact water). Berming, ditches, grading and other works will be used to contain contact water within the uncapped area of the landfill where it will be directed to the LCS for treatment as landfill leachate.

Precipitation on areas where final cover has been applied (i.e., non-contact runoff) will be directed via perimeter ditching to the stormwater management ponds for sediment removal and monitoring prior to discharge off-site. Controlled discharge will be to the 10 Mile Creek and/or to the Old Welland Canal via the solid 1,200 mm surface water conveyance pipe. Stormwater from other areas of the site such as buffer areas, parking lots and roadways will be treated similarly.

The refined engineering design details described in the FCR were incorporated into the groundwater modelling summarized in **Section 3** and detailed in **Appendix A**.

The updated assessment of predicted potential effects, recommended impact management measures, and resulting net effects are provided in **Table 2** as described below.

5.1 Potential Effects on Geology and Hydrogeology

The potential effects analysis for the Geology and Hydrogeology environment is focused on the effect of the Preferred Method (i.e., the proposed landfill operation conditions scenario) on groundwater flow and groundwater quality at the property boundaries and off-site.

The potential effects on groundwater flow consider changes to bedrock groundwater levels, groundwater flow regimes and the inward groundwater gradient observed under Existing Conditions and impacts on available groundwater supply for the identified residential well users.

The potential effects on groundwater quality considers potential leachate-impacted seepage from the base of the landfill liner; groundwater movement (flux and direction) in the shallow Rochester shale bedrock below the landfill footprint and the Lockport dolostone adjacent to the landfill and maintenance of inward groundwater gradients.

As per **Section 1.3**, the FCR indicates that observable quantities of landfill (i.e., combustible methane) gas will be produced under the Preferred Method. The proposed landfill liner design is intended to contain both the leachate and landfill gas generated within the waste cells. However, there remains a potential for migration of landfill gas laterally within the subsurface unsaturated zone as a result of an unforeseen liner breach or defect. The potential subsurface migration of landfill gas will not affect groundwater flow or quality, but rather it is considered a health and safety hazard for workers and nearby structures on-site. Since any potential landfill gas migration would occur within the subsurface, the appropriate hazard mitigation is to monitor landfill gas concentrations within the headspace of selected groundwater monitoring wells included in the Environmental Management Plan (EMP). Therefore, a recommendation to include such monitoring has been provided in **Section 8**.

5.1.1 Effect on Groundwater Flow

The existing Geology and Hydrogeology conditions within the SSA and LSA are well understood (i.e., groundwater flow directions and seasonal gradients are consistent and predictable) through decades of studies and monitoring at the East Landfill, South Landfill Phase 1 (and their historical quarry operations), as well as the Southeast Quarry.

The proposed landfill will be constructed within the exhausted Southeast Quarry, with no changes to the approved Limit of Extraction. As noted above, the fully exhausted Quarry rehabilitated for agricultural use is considered in the Future Existing Conditions scenario and is used as the basis for the evaluation of potential effects of the Preferred Method.

The potential effects on groundwater flow under the Preferred Method were evaluated as part of the numerical groundwater flow modelling studies (**Appendix A**) and summarized in the following section.

5.1.1.1 Groundwater Model Predictive Analysis and Results

A detailed description of the model adaptations made for the Preferred Method scenario is provided in **Section A.7.2**, **Appendix A**. In summary, under the proposed landfill operation conditions, the extent of bedrock extraction remains the same as the Future Existing Conditions scenario. It was assumed for the operation conditions scenario that the proposed landfill liner was fully constructed such that it covers the entire waste footprint. As noted above, the proposed liner design consists of a sub-drain placed on the former quarry floor and along the vertical faces to facilitate drainage of potential groundwater accumulation below the liner, with a hydraulic connection to manhole MH7S that facilitates gravity drainage to the WEG Drainage System (WDS). The as-built invert elevation of 159.6 masl is the controlling elevation, identical to the Future Existing Conditions scenario. Since the MH7S valve will be operated in the “open” position under normal conditions, the model boundary conditions for the Preferred Method are the same as those of the Future Existing Conditions scenario.

The only difference between models used to simulate the Preferred Method and Future Existing Conditions is the change in recharge over the waste footprint for the South Landfill Phase 2. The recharge boundary was adapted to match that of the existing South Landfill, where negligible seepage from the base of the liner is inferred due to the double-layer design. In practical terms, this model adaptation means that marginally less groundwater recharge will infiltrate to the underlying groundwater system within the SSA due to the capture of both contact and non-contact water and either release as stormwater discharge or treatment as leachate.

As per **Section 3.2**, an additional scenario for the proposed landfill post-closure conditions was considered; however, it was determined that the model parameters would be the same as those of the operation conditions scenario and therefore the model could be used to assess impacts for both operation and post-closure conditions under the Preferred Method.

5.1.1.2 Potential Effects

The simulated Lockport and Rochester Formation groundwater contours for the Preferred Method are shown in **Figures A-11 and A-12**, **Appendix A**. From a qualitative perspective, the groundwater contours and flow directions with the Lockport and Rochester Formations within the LSA do not significantly differ between the Future Existing Conditions and Preferred Method scenarios and the overall inward groundwater gradients toward the site are maintained.

There are inferred to be no negative impacts to the operation of the four identified residential wells for domestic use. Additional marginal increases in drawdown at these wells are predicted under the Preferred Method scenario, attributed to the marginal decrease in groundwater recharge noted above. However, as is the case for the Future Existing Conditions scenario, the predicted drawdown under the Preferred Method is well within the available drawdown at each location.

Finally, no negative impacts are predicted to the marginal groundwater discharge amounts to the tributaries of 6 Mile Creek originating north of the SSA. Groundwater discharge to these features under the Preferred Method remains consistent with the Future Existing Conditions scenario, at about 0.3 m^3/day.

5.1.1.3 Potential for Cumulative Impacts

It is acknowledged that there is a potential for cumulative impacts to groundwater flow due to other known and/or proposed developments within the RSA. Additional model scenarios were completed to incorporate cumulative impacts within the simulations; further discussion is provided below in **Section 6**.

5.1.2 Effect on Groundwater Quality

As stated previously, the existing Geology and Hydrogeology conditions at the SSA and LSA are well understood (i.e., seasonal groundwater quality is consistent and predictable) through decades of studies and monitoring.

The potential effect on groundwater quality under the Preferred Method was evaluated as part of the contaminant transport modelling studies outlined in the Leachate Containment System Design Description Report (provided in the FCR) and summarized in the following section.

5.1.2.1 Potential Effects

As noted at the outset of **Section 5**, the proposed landfill will utilize a site-specific liner and LCS design that will perform equal to or better than the O.Reg. 232/98 Generic Double Composite Liner Design and comply with the 100- and 1,000-year service life requirements.

Results of the contaminant transport modelling indicate that the predicted peak concentrations of all key contaminants were less than the RUG criteria over the 1,000-year modelling time frame. As such, the modelling predicted no negative impacts to the groundwater quality at the base of the proposed liner under the Preferred Method.

As noted in Section 4.4.1 of the **Geology and Hydrogeology Existing Conditions Report**, the SSA is situated within a Highly Vulnerable Aquifer (HVA) with an assigned vulnerability score of 6. As per the MECP’s Table of Drinking Water Threats, a waste disposal site is considered a low drinking water quality threat, with the exception of leachate containing vinyl chloride or other dense non-aqueous phase liquids (DNAPLs) that could degrade to vinyl chloride which is considered a moderate drinking water quality threat. As noted above, the predicted peak concentrations of all key contaminants, including vinyl chloride, will remain below the RUG criteria at the base of the landfill liner and therefore, the Preferred Method is considered a low drinking water quality threat.

As per **Section 1.2**, the preferred Leachate Management Option A will require the continued use of the existing on-site leachate lagoons, along with construction of two additional lagoons, to support the proposed landfill. The existing leachate lagoons were constructed with engineered liners for leachate containment, and the proposed lagoons will be constructed using a similar engineered design. While these systems are designed to limit releases, there remains a potential for leakage. As predicted by the numerical groundwater flow modelling, an inward groundwater gradient toward the site will be maintained through the continued operation of the GWCS. As such, any unforeseen leakage of leachate through the lagoon liners will not impact off-site groundwater users or receptors. Nevertheless, additional monitoring requirements are proposed in **Section 8** to monitor the lagoon liner performance and confirm no negative impacts to groundwater quality.

As shown by the numerical groundwater flow model results summarized in **Section 5.1.1.1**, no changes to the inward groundwater gradient groundwater flow regime in the Lockport dolostone and Rochester shale bedrock aquifers are expected under the Preferred Method. The continued operation of the GWCS and sub-liner during operating and post-closure conditions will continue to have hydraulic influence over the entire SSA footprint. In addition, the sub-liner will provide a contingency for potential impacts to groundwater quality in the SSA, although no impacts are predicted as a result of the proposed landfill liner design.

As noted previously, the valve at the inlet of the 1,200 mm conveyance pipe at MH7S will remain open during the landfill operation and post-closure conditions, and groundwater seepage collected by the sub-drain system will drain to the 1,200 mm solid drainage pipe via MH7S. Under existing conditions, water draining into the 1,200 mm pipe from the Southeast Quarry consists mainly of precipitation and surface water runoff, with some groundwater seepage. Once the landfill liner has been fully developed, only groundwater seepage will drain to the 1,200 mm pipe. The 1,200 mm solid drainage pipe directs the flow west under Taylor Road, across the Campus, and discharges north of the escarpment to the Old Welland Canal. The only other contribution to the 1,200 mm pipe under both existing and operation / post closure conditions is the existing South Landfill stormwater management pond batch discharge.

The groundwater draining into the 1,200 mm pipe during the landfill operation and post-closure conditions may be influenced by highly mineralized water with elevated parameter concentrations typical of the Rochester shale water quality, as observed in the GWCS water quality under existing conditions. Therefore, there is a potential that the Rochester shale influenced discharge may negatively impact the surface water quality in the Old Welland Canal when the MH7S valve is open during landfill operation or post-closure conditions. The existing South Landfill stormwater management pond, which also discharges to the 1,200 mm pipe, captures all surface water runoff from the areas of the South Landfill completed with final cap and may offset effects from the mineralized groundwater in the 1,200 mm pipe. Nonetheless, water quality in the 1,200 mm pipe will be monitored through the EMP. If monitoring results confirm the potential for negative impacts to the Old Welland Canal, the valve at MH7S could be closed as a mitigation measure. In this scenario, the groundwater flow model results demonstrate that inward groundwater gradients would be maintained if the valve at MH7S was closed.

In summary, no effect to groundwater quality is predicted at the property boundaries and off-site. Nevertheless, the landfill liner performance will be monitored through the EMP which will include groundwater level and quality monitoring, as outlined in **Section 8**. Use of the sub-liner as a contingency measure can be implemented, if required, in the event of unanticipated issues with landfill liner performance to maintain no negative off-site impacts to groundwater quality.

Groundwater entering the 1,200 mm pipe during the landfill operation and post-closure conditions has the potential to negatively impact surface water quality in the Old Welland Canal. However, water quality in the 1,200 mm pipe will be monitored through the EMP and the valve at MH7S could be closed if required.

5.1.2.2 Potential for Cumulative Impacts

As noted above, the contaminant transport modelling demonstrated that the RUG criteria will be met under the Preferred Method. As such, there is no potential for cumulative effects on off-site groundwater quality.

5.2 Proposed Mitigation and Compensation Measures

As described above, there are no negative impacts to groundwater flow and quality within the LSA, and the continued operation of the GWCS and sub-liner during operating and post-closure conditions will continue to have hydraulic influence (inward groundwater gradient) over the entire SSA footprint. As such, there is no need for mitigation or compensation measures in the design or operations of the proposed landfill related to the Geology and Hydrogeology environment.

The exception is related to groundwater quality entering the 1,200 mm pipe during the landfill operation and post-closure conditions, which may potentially effect surface water quality in the Old Welland Canal. Water quality in the 1,200 mm pipe will be monitored through the EMP, and the valve at MH7S could be closed as a mitigation measure if required.

The proposed landfill design and Campus setting provide contingency measures in the event of unforeseen issues with the landfill liner performance as demonstrated above. Should groundwater quality impacts be observed, the valve at MH7S can be closed, allowing containment of impacted water and diversion to the LCS for treatment as leachate, if necessary.

5.3 Net Effects

Based on the rationale presented above, there is no potential for net effects on groundwater flow and quality at the property boundaries or off-site. A summary of the rationale is provided in **Table 2**.

Table 2: Geology and Hydrogeology Potential Environmental Effects, Proposed Impact Management Measures, and Net Effects

Criteria	Indicator	Potential Effects	Impact Management Measures	Net Effects
Effect on groundwater flow	Predicted effects to groundwater flow at property boundaries and off-site	Continued operation of the existing groundwater underdrain system beneath the East Landfill (GWCS) and sub-liner will continue to have a hydraulic influence over the entire SSA footprint. Therefore: No substantial changes to the water levels in the various bedrock units are expected under both operation and post-closure conditions for the Preferred Method in comparison to Future Existing Conditions. Additionally, the current hydrogeologic conditions at the Campus will remain unchanged, with groundwater flow in the Lockport dolostone and Rochester shale drawn inward toward the GWCS. The Future Existing Conditions flow regimes and inward groundwater gradients toward the site within these key bedrock units will be maintained under both operation and post-closure conditions for the Preferred Method. Under Future Existing Conditions, removal of the bedrock resource up to the northeastern extent of the Southeast Quarry approved Limit of Extraction will result in marginally increased drawdown at four identified residential well users in the LSA. Marginal additional drawdown is predicted under the operating and post-closure conditions of the Preferred Method. However, the predicted drawdowns are well within the available drawdown at each residential well and therefore no negative impacts to the operation of the identified residential wells for domestic use are predicted. No negative impacts are predicted to the groundwater discharge to the tributaries of 6 Mile Creek originating north of the SSA under the Preferred Method. Groundwater in the lower Irondequoit limestone bedrock is hydraulically separated from groundwater below the landfill by the Rochester shale, which acts as a regional aquitard. As	No mitigation measures are required	No effect to groundwater flow at property boundaries and off-site NO NET EFFECTS

Criteria	Indicator	Potential Effects	Impact Management Measures	Net Effects
		such, groundwater flow in the Irondequoit limestone will not be affected under the Preferred Method.		
Effect on groundwater quality	Predicted effects to groundwater quality at property boundaries and off-site	Results from the contaminant transport modelling completed as part of the landfill liner design indicate that the predicted peak concentrations of all key contaminants will remain below the Reasonable Use Guideline (RUG) criteria over the 1,000-year modelling time frame (which includes both operation and post-closure conditions under the Preferred Method). The SSA is situated within a Highly Vulnerable Aquifer (HVA) with an assigned vulnerability score of 6. As per the MECP's Table of Drinking Water Threats, a waste disposal site is considered a low drinking water quality threat, with the exception of leachate containing vinyl chloride or other dense non-aqueous phase liquids (DNAPLs) that could degrade to vinyl chloride which is considered a moderate drinking water threat. As noted above, the predicted peak concentrations of all key contaminants, including vinyl chloride, will remain below the RUG criteria at the base of the landfill liner and therefore, the Preferred Method is considered a low drinking water quality threat. The leachate lagoons were (or will be) constructed with an engineered liner for containment of the leachate; however, there is the potential for leakage. As predicted by the numerical groundwater flow modelling, an inward groundwater gradient toward the site will be maintained through the continued operation of the GWCS. As such, any unforeseen leakage of leachate through the lagoon liners will not impact off-site groundwater users or receptors. As shown by the numerical groundwater flow modelling results, no changes to the inward groundwater gradient flow regime are expected under the Preferred Method. The continued operation of the GWCS will continue to have hydraulic influence over the entire SSA footprint. This will provide a contingency for potential impacts to groundwater quality in the SSA, although no impacts are predicted as a result of the proposed landfill liner design.	The EMP will include water quality monitoring in the 1,200 mm pipe. If the potential for negative impacts to the surface water quality in the Old Welland Canal are confirmed, the valve at MH7S could be closed as a mitigation measure. No other mitigation measures are required	No effect to groundwater quality at property boundaries and off-site NO NET EFFECTS

Criteria	Indicator	Potential Effects	Impact Management Measures	Net Effects
		The valve at the inlet of the 1,200 mm solid drainage pipe at MH7S will remain open during the landfill operation and post-closure conditions. Groundwater draining into the 1,200 mm pipe during these future conditions may be influenced by highly mineralized Rochester shale water quality and may potentially negatively impact surface water quality in the Old Welland Canal. The existing South Landfill stormwater management pond, which also discharges into the 1,200 mm pipe, captures all surface water runoff from the areas of the South Landfill completed with final cap and may offset effects from the mineralized groundwater influence on water quality in the 1,200 mm pipe. Groundwater in the lower Irondequoit limestone bedrock is hydraulically separated from groundwater below the landfill by the Rochester shale, which acts as a regional aquitard. As such, groundwater quality in the Irondequoit limestone will not be affected under the Preferred Method.		

6 CUMULATIVE IMPACT ANALYSIS

As part of the approved ToR, Walker committed to undertaking an assessment of the cumulative effects of the Preferred Method and other Campus components/facilities and other non-Walker projects that are existing, planned, approved or reasonably foreseeable. The following were considered in the assessment of cumulative impacts:

- Walker Activities/Projects on Campus
  - Ongoing Southeast Quarry operations
  - New residential drop off area for the existing Campus landfills
  - RNG 2 – expansion of existing renewable natural gas facilities
- Walker Projects off Campus
  - Uppers Quarry
- Non-Walker Projects
  - Garden City Bridge Twinning
  - Glendale Secondary Plan Area development
  - Development at Niagara College's Niagara-on-the-Lake Campus
  - Northwest Secondary Plan Area development
  - Golf course/agro-tourism development to east of the Walker Campus
  - Garner West Secondary Plan Area development
  - Welland Thorold Power Line Project

6.1 Cumulative Impacts on Groundwater Flow

Additional scenario models were adapted from the Future Existing Conditions and Preferred Method models to simulate cumulative impacts to groundwater flow within the RSA, as outlined in **Section A.8**, **Appendix A**. From the list of activities and projects above, only the proposed Uppers Quarry (in the southern portion of the RSA) and golf course/agro-tourism development to the east of the LSA are inferred to have a potential cumulative effect on groundwater flow. Separate model scenarios were developed for each of these projects to quantify the effects from each undertaking.

Uppers Quarry is a proposed below-water quarry which will require dewatering to maintain dry working conditions, similar to the Southeast Quarry. The cumulative model scenario incorporates dewatering of the proposed quarry at its maximum operational footprint and floor depth, as this represents the period of greatest potential for cumulative effects. The simulated groundwater contours and flow directions in the Lockport and Rochester Formations are shown on **Figures A-17 and A-18, Appendix A**. For both the Future Existing Conditions and Preferred Method scenarios, the incorporation of the proposed Uppers Quarry does not affect the general groundwater flow patterns or the inward groundwater gradient towards the site. Additional drawdown is predicted at the residential wells as a result of the future quarry dewatering; however, there is sufficient available drawdown such that negative impacts to the operation of the residential wells for domestic use are not predicted.

The proposed golf course/agro-tourism development will require the use of irrigation wells to top up a planned future irrigation pond, which would influence local groundwater elevations and flow directions within the bedrock around the wells. The simulated groundwater contours and flow directions in the Lockport and Rochester Formations are shown on **Figures A-19 and A-20, Appendix A**. For both the Future Existing Conditions and Preferred Method, operation of the irrigation wells is predicted to somewhat “flatten” the bedrock water table within the future golf course property. However, overall inward groundwater gradients persist around the SSA, similar to Existing Conditions. More substantial drawdown is predicted for residential well 14; however, the predicted drawdown only represents about 33% of the available drawdown. Therefore, negative impacts due to cumulative effects of the operation of the future irrigation wells are not predicted.

6.2 Cumulative Impacts on Groundwater Quality

As noted in **Section 5.1.2.2**, no cumulative effects to groundwater quality are anticipated under the Preferred Method as there are no predicted negative groundwater quality impacts from the proposed undertaking.

The new residential drop off area for the existing Campus landfills would be designed, constructed and operated in such a manner as to reduce/mitigate the risk of groundwater quality impacts. In addition, the proposed drop of area remains within the area of inward groundwater gradients and any potential unforeseen impacts would be monitored as part of the recommended EMP in **Section 8**.

There is the potential for the golf course/agro-tourism development east of the Campus to contribute some additional nitrogen loading to the shallow groundwater as a result of fertilizer use. However, the low permeability of the shallow overburden soils limits infiltration to the bedrock aquifer.

7 CLIMATE CHANGE CONSIDERATIONS

In accordance with the Minister-approved ToR, the detailed impact assessment is to include consideration of climate change. In support of the province of Ontario’s Climate Change Action Plan, the MECP developed a Guide entitled “Consideration of Climate Change in Environmental Assessment in Ontario” (the Guide) to aid proponents in considering climate change as part of EAs for infrastructure and facilities (MECP 2016).

The Guide outlines the Ministry’s expectations for considering climate change throughout the EA process. As stated in Section 3 of the Guide, consideration is to include:

- Greenhouse gas (GHG) emissions
- Effects of a project on climate change
- Effects of climate change on a project
- How the project will minimize identified negative effects on climate change.

The preceding was considered as part of the South Landfill Phase 2 EA in addressing the potential climate risks to the Alternative Methods. During the impact assessment, the climate change adaptation and mitigation analysis undertaken for the Alternative Methods stage was used and augmented, as needed, to develop climate change mitigation and adaptation measures for the Preferred Method. Climate change considerations relevant to the Geology and Hydrogeology environment are documented in the following subsections.

7.1 Potential effects of the Undertaking on Climate Change

The Preferred Method is not expected to have an impact on climate change from a Geology and Hydrogeology perspective.

7.2 Potential effects of Climate Change on the Undertaking

Additional model scenarios were developed to assess potential effects of climate change on the Preferred Method, as outlined in **Section A.9, Appendix A**. Impacts to groundwater infrastructure are not identified as a current or future climate risk within the literature provided by the province. Future drought conditions represent a potential impact to private well users within the LSA due to possible lowering of the local groundwater elevation within the bedrock aquifers. However, climate change projections for the RSA suggest that long-term annual precipitation amounts would increase by up to 10% relative to baseline conditions under the “high-emission” (i.e., RCP 8.5) scenario.

Although the increased precipitation amounts will also increase the available water surplus (i.e., precipitation less evapotranspiration), actual infiltration to the groundwater system is subject to an upper limit based on the hydraulic properties of the surficial soils (which are not impacted by climate change). During high-intensity rainfall events or when ground conditions are already saturated, excess water surplus will flow overland as runoff to local watercourses rather than manifest as increased groundwater recharge. Nevertheless, the climate change scenario models assume a 10% increase in infiltration to the groundwater system. It is noted that the climate change scenario flow models were adapted from the Preferred Method cumulative effects scenario as it represents the worst-case potential effect on groundwater flow.

The simulated groundwater contours and flow directions within the Lockport and Rochester Formations are shown on **Figures A-47 and A-48, Appendix A**. The overall groundwater flow pattern and inward groundwater gradients under the climate change scenario are consistent with the cumulative effects scenario; therefore, predicted climate change effects within the RSA do not substantially alter the impact assessment presented above. The predicted increase in recharge to the groundwater system from future climate change impacts somewhat mitigates the predicted drawdown at the residential wells under the cumulative effects scenario, which is not unexpected.

8 ENVIRONMENTAL MONITORING

Key components of the EMP were developed for monitoring environmental effects to be carried out as part of the construction, operation, and maintenance of the landfill.

8.1 Environmental Effects Monitoring

As detailed in **Table 2**, no net negative effects were predicted for the Preferred Method based on the Geology and Hydrogeology impact assessment. Therefore, the proposed monitoring strategy and schedule was developed to 1) confirm that no negative impacts to groundwater flow and quality occur, consistent with the above predictions, and 2) ensure that potential unforeseen negative impacts are identified and addressed. **Table 3** lists the proposed monitoring requirements for each potential effect identified in the Geology and Hydrogeology impact assessment.

It is noted that there are extensive on-going monitoring programs in place for the existing East and South Landfills and Southeast Quarry. Selected locations from these existing monitoring programs should be incorporated into the future landfill annual monitoring program, along with the proposed additional requirements listed below, to monitor for potential unexpected negative effects from the Preferred Method.

Table 3: Geology and Hydrogeology Proposed Monitoring Requirements

Potential Effect	Proposed Monitoring Requirement	Associated Licences, Permits or Authorizations
Continued operation of the GWCS to maintain inward groundwater gradients toward the site within key bedrock units during operation and post-closure of the Preferred Method. Off-site residential groundwater supplies will not be negatively impacted by the predicted effects under the Preferred Method.	Seasonal (i.e., quarterly) water level measurements at the newly installed EA monitoring wells and selected monitoring wells and residential wells from the existing annual monitoring programs for the East and South Landfills and the Southeast Quarry, screened within the Lockport dolostone aquifer, Rochester shale aquitard and the lower Irondequoit limestone aquifer.	Environmental Compliance Approval (ECA) under Part II.1 of the Environmental Protection Act for the establishment, operation and monitoring of a waste disposal site Permit-to-Take-Water (PTTW) under Section 34 of the Ontario Water Resources Act for continued operation of the GWCS
No Reasonable Use Guideline (RUG) criteria exceedances in groundwater quality at the base of the landfill due to the proposed landfill liner design. Unforeseen leakage from the on-site leachate treatment lagoons could impact local groundwater quality but would be subject to inward groundwater gradients induced by the GWCS.	Semi-annual leachate forcemain sampling to characterize the leachate and identify indicator parameters for compliance assessment. Annual groundwater quality monitoring at selected locations from the water level monitoring program outlined above for compliance assessment. Additional shallow groundwater monitoring well(s) to be installed in the vicinity of the leachate lagoons to monitor lagoon liner performance.	Environmental Compliance Approval (ECA) under Part II.1 of the Environmental Protection Act for the establishment, operation and monitoring of a waste disposal site
Mineralized groundwater influence on water quality in the 1,200 mm pipe during the landfill operation and post-closure conditions has the potential to negatively impact surface water quality in the Old Welland Canal.	Quarterly water quality monitoring at MH7S and other selected manhole locations along the 1,200 mm pipe, and at the discharge point.	Environmental Compliance Approval (ECA) under Part II.1 of the Environmental Protection Act for the establishment, operation and monitoring of a waste disposal site
Potential for subsurface landfill gas migration.	Annual combustible gas monitoring during frozen conditions within the headspace of selected monitoring wells to ensure to subsurface landfill gas migration is not occurring.	Environmental Compliance Approval (ECA) under Part II.1 of the Environmental Protection Act for the establishment, operation and monitoring of a waste disposal site

It is noted that the frequency of groundwater quality sampling at slow recovering monitoring wells may fall under a reduced 2- or 4-year sampling frequency, consistent with the current East and South Landfill monitoring programs.

8.2 Development of an Environmental Management Plan

An EMP will be prepared following approval of the undertaking by the MECP and prior to construction. The EMP will include a description of the proposed mitigation measures, commitments, and monitoring.

9 COMMITMENTS

The following commitments have been proposed for ensuring that the identified mitigation or compensation measures and monitoring requirements are carried out as part of the construction, operation, and maintenance of the undertaking:

- Access to / protection of all monitoring locations will be maintained to ensure that the operation and post-closure EMP requirements are met.
- Additional shallow groundwater monitoring well(s) will be installed in the vicinity of the on-site leachate lagoons.

10 GEOLOGY AND HYDROGEOLOGY APPROVALS REQUIRED FOR THE UNDERTAKING

An Environmental Compliance Approval (ECA) under Part II.1 of the Environmental Protection Act will be required for the establishment, operation and monitoring of a waste disposal site, which will include the details of the Environmental Monitoring Program.

Continued operation of the GWCS, which will maintain the inward hydraulic gradient toward the site, will require a Permit-to-Take-Water (PTTW) under Section 34 of the Ontario Water Resources Act. Pumping of the GWCS is currently approved under existing Southeast Quarry PTTW No. 3612-CMTM5V. Upon completion of extraction activities at the Southeast Quarry, the Aggregate Resource Act License will be surrendered and the PTTW will be transferred to the appropriate Walker division such that the permit can be maintained. The PTTW is subject to an expiration date and must be periodically renewed, typically after a 10-year period, over the course of the landfill operation and post-closure time periods. The PTTW monitoring requirements should be aligned with those of the ECA monitoring program.

Signature Page

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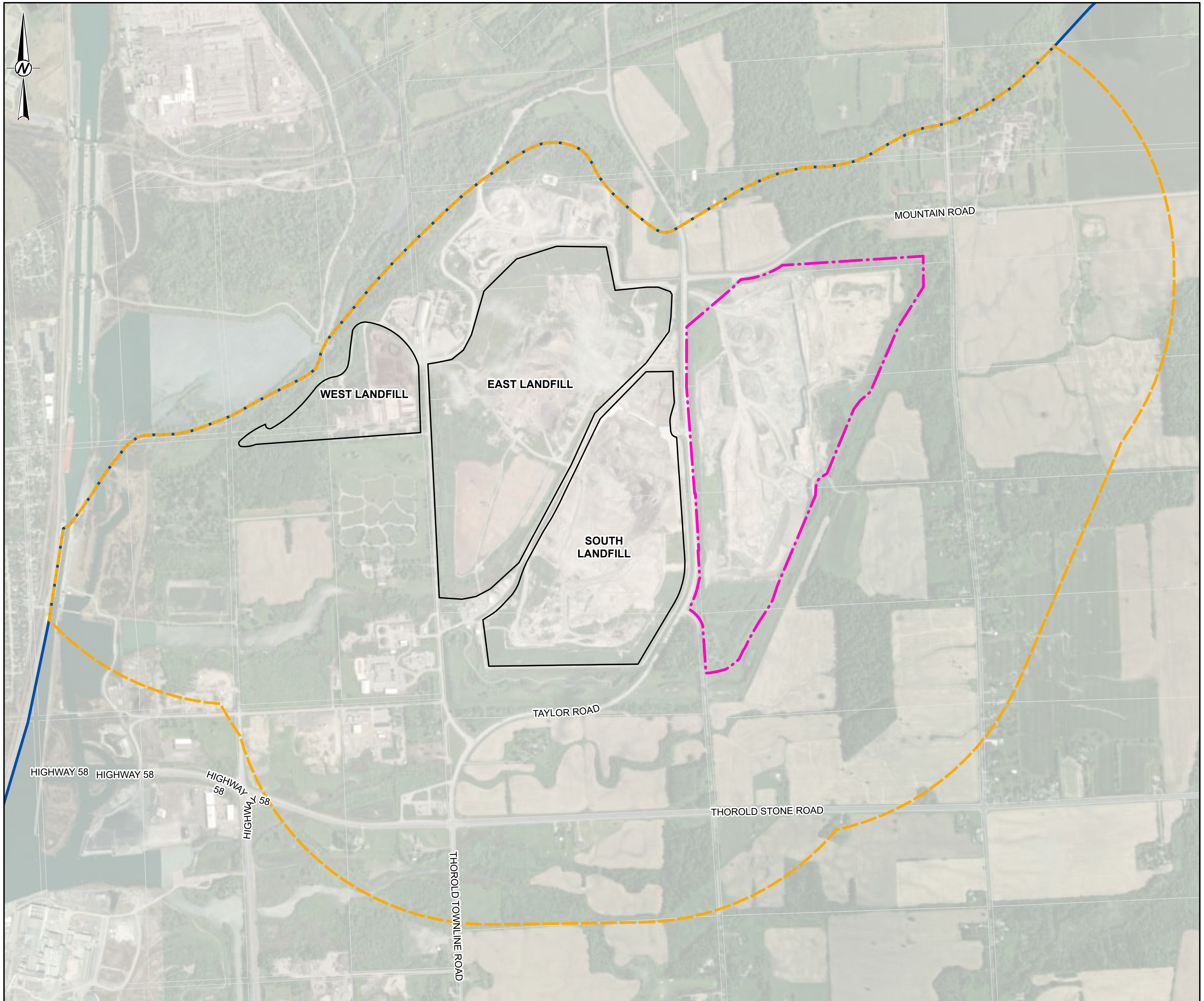
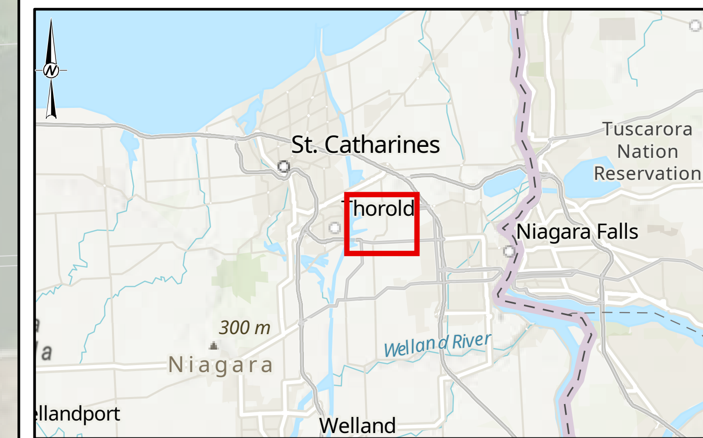
https://wsponlinecan.sharepoint.com/sites/ca-ca00372481905/shared documents/05. technical/100 groundwater & surface water consulting/ground water/2. detailed impact assessment - gw/ca0065457.5367-slf2 detailed impact assessment_gw-draft 2_jun 2026.docx

Figures



KEY MAP



SCALE: 1:500,000

LEGEND

- PROPOSED LOCAL STUDY AREA (LSA) (1KM CAMPUS BUFFER)
- PROPOSED REGIONAL STUDY AREA (RSA)
- SITE STUDY AREA (SSA)
- WALKER RESOURCE MANAGEMENT CAMPUS (EAST, SOUTH AND WEST LANDFILLS)

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0 150 300 600

1:15,000 METRES

NOTE(S)
1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)
1. CONTAINS INFORMATION LICENSED UNDER THE OPEN GOVERNMENT LICENCE - ONTARIO
2. BASE MAP: ESRI, CGIAR, USGS, SOURCES: ESRI, TOMTOM, GARMIN, FAO, NOAA, USGS, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY, NEW YORK STATE, VANTOR
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N

CLIENT
WALKER ENVIRONMENTAL GROUP

PROJECT
GEOLOGY AND HYDROGEOLOGY DETAILED IMPACT ASSESSMENT

TITLE
GEOLOGY AND HYDROGEOLOGY STUDY AREA

CONSULTANT
wsp

YYYY-MM-DD	2026-05-14
DESIGNED	----
PREPARED	JM
REVIEWED	----
APPROVED	----

PROJECT NO.	CONTROL	REV.	FIGURE
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APPENDIX A

Numerical Groundwater Flow Model Report

REPORT

Appendix A - Numerical Groundwater Flow Model Report - Draft

Walker South Landfill Phase 2 Environmental Assessment

Submitted to:

Walker Environmental Group

Submitted by:

WSP Canada Inc.

55 King St., Suite 700 St. Catharines, ON L2R 3H5

905-687-1771

CA0037248.1905

June 10, 2026

Study Limitations

MODFLOW-USG was used to simulate steady-state groundwater flow conditions under various development conditions. The steady-state model provides a reasonable representation of groundwater conditions and allows for the simulation of changes to these groundwater conditions as a result of the proposed landfill.

Services performed by WSP Canada Inc. were conducted in a manner consistent with a level of care and skill ordinarily exercised by members of the environmental engineering and consulting profession. This report presents the results of data compilation and computer simulations of a geologic setting. Subsurface investigations explore a relatively large volume of material with a fixed number of boreholes. Computer models represent a deliberate simplification of the actual geologic conditions. Models constructed from these data reflect the quality and completeness of the information available at the time the work was performed.

Environmental conditions and the amount of data available can change over time. Results and discussions relating to the baseline conditions are based upon information that existed at the time the model was constructed.

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A.1 INTRODUCTION

This report summarizes the numerical groundwater modeling activities undertaken as part of the Geology and Hydrogeology Detailed Impact Assessment report prepared to meet the study requirements for the Walker South Landfill Phase 2 Environmental Assessment. The purpose of the groundwater modeling is to predict the potential effects of the proposed landfill on the local groundwater users and receptors.

The calibrated baseline model incorporates an extensive data set for the Local Study Area (LSA), consisting of borehole stratigraphy, hydraulic testing results and groundwater elevation data that has been collected both historically as part of the on-going compliance monitoring programs for the East, South and Closed West Landfills, as well as during the existing conditions baseline monitoring period (June 2025 to March 2026), as summarized in the *Geology and Hydrogeology Existing Conditions Report* (WSP Canada Inc., June 2026a) (**Existing Conditions Report**). Climatic data from local Environment and Climate Change Canada (ECCC) stations were used to estimate recharge to the groundwater system from infiltration of water surplus (precipitation less evapotranspiration).

A steady-state model was constructed for this study, calibrated to average autumn conditions within the Regional Study Area (RSA). Calibration targets include groundwater elevation data from the Campus, as well as additional groundwater elevation data from other known sites within the RSA where groundwater monitoring data are available. Water level data from the Ministry of the Environment, Conservation and Parks (MECP) water well records were also included. Finally, flow rate (flux) targets were used to calibrate the model to the Southeast quarry dewatering sump and the Closed West Landfill leachate purge well system discharge rates.

A.1.1 Model Objectives

The primary objectives of the numerical groundwater modeling are as follows.

- Formulate the conceptual hydrogeologic setting of the RSA and construct a steady-state numerical groundwater flow model representing the conceptualization. Calibrate the model to existing (i.e., baseline) conditions.
- Modify the baseline model to simulate two alternative scenarios:
  - The future baseline (i.e., “do nothing”) scenario by simulating quarry extraction to the full approved extraction limit and rehabilitated conditions.
  - The proposed South Phase 2 landfill extension scenario.
- Incorporate the cumulative effects of the proposed Uppers Quarry to the south of the LSA and potential golf course development in the eastern portion of the LSA within both alternative scenario models.
- Complete a sensitivity analysis of the calibrated baseline model parameters and perform an uncertainty analysis on the most sensitive parameters to assess the reliability of the predictive alternative scenario models.

A.1.2 Previous Investigations

S.S. Papadopulos & Associates Inc. (SSPA) previously completed modeling of the current study area (S.S. Papadopulos & Associates, Inc., February 2006). The purpose of the previous work was to evaluate potential impacts from changes in the water management operations at the East Landfill as part of the *South Landfill Phase*

1 Environmental Assessment (Gartner Lee Limited, 2006) (**Phase 1 EA**). The previous model domain covers a large portion of the RSA. The SSPA report and conclusions were considered when determining appropriate boundary conditions and hydraulic properties for the current study.

The RSA was also modeled as part of the *Level 1 and 2 Water Study Report* for the proposed Uppers Quarry (WSP Canada Inc., October 2021) (**Uppers Quarry Water Study**), situated to the south of the LSA. A substantial portion of the hydrogeology conceptualization as well as calibration targets were utilized for the present study. Details of the proposed quarry operating conditions were used to simulate cumulative effects for the predictive scenarios included below.

A.2 CONCEPTUAL MODEL

Prior to constructing a numerical groundwater model, a “conceptual” model must be developed to characterize the hydrogeologic conditions and water budget of the natural system to be simulated (Anderson & Woessner, 1992) and other physical elements of the undertaking to be considered. Some components of the conceptual model include:

- A decision on the areal extent and scale to be studied both in the horizontal and vertical dimensions;
- Identification of the geologic framework and hydrogeologic properties of the subsurface;
- Definition of hydrostratigraphic units (i.e., aquifers and aquitards) in the subsurface;
- An understanding of the regional movement of groundwater, including groundwater elevations and trends as well as hydraulic gradients;
- Identification of hydrologic features, such as watershed divides, groundwater seeps and springs and watercourses; and
- Analysis of water budget components that include recharge and discharge conditions and controls.

The conceptual model is used to make decisions regarding the construction of the numerical model to provide adequately representative simulations. The conceptual model for the present study is fully outlined in the Existing Conditions Report; further discussion is provided where warranted below.

Conceptual model development and the subsequent construction of the numerical model typically involve some degree of deliberate simplification and categorization of the data to represent the groundwater system in sufficient detail to provide reasonably representative results. Ultimately, model accuracy depends on the ability of the conceptual model to approximate observed conditions. Calibration statistics show how well the numerical model simulates these observed conditions.

A.3 SIMULATION CODE SELECTION

The numerical simulation code selected for this study was MODFLOW-USG (**U**n-**S**tructured **G**rid) developed in part by the United States Geological Survey (USGS) (Panday, Langevin, Niswonger, Ibaraki, & Hughes, 2013; Panday, March 2025). Like previous versions of MODFLOW (USGS 1988-2005), MODFLOW-USG is a modular numerical groundwater flow simulator capable of representing the complex three-dimensional multi-layer systems for steady-state conditions in the confined and unconfined aquifers within the RSA using the finite-difference method. However, MODFLOW-USG allows for more robust grid refinement in areas of increased interest. The MODFLOW family of software is the most widely used groundwater modeling code in the world and has been extensively tested and applied in the research and consulting communities. The MODFLOW-USG code is public domain and freely distributed. For this study, version 2.5.0 of the MODFLOW-USG code (released in March 2025) was used.

Model input datasets include the physical geometry of the system, boundary conditions (no-flow, recharge or discharge) and aquifer properties (hydraulic conductivity). Groundwater flow can be modeled for many different types of sources or sinks, including lakes, rivers, drains, recharge from infiltration of precipitation, and pumping wells, among others. The code is flexible when modeling aquifer properties, allowing heterogeneity and anisotropy in three dimensions.

The flow system being modeled is split up into layers comprised of many smaller blocks referred to as nodes (or cells for previous versions of MODFLOW) based on the conceptual hydrogeological understanding of the model domain. The MODFLOW-USG code solves the groundwater flow mass balance equation for each node using the model input parameters. The general mass balance equation can be expressed as:

Sum of Boundary Inflows	+	Sum of Internal Sources of Water	=	Sum of Boundary Outflows	+	Sum of Internal Sinks of Water

The mass balance equation for an unconfined aquifer with recharge, discharge and leakage (Bear, 1979) can be written as:

$$\frac{\partial}{\partial x}\left[(h-b)\left(K_{xx}\frac{\partial}{\partial x}\right)\right]+\frac{\partial}{\partial y}\left[(h-b)\left(K_{yy}\frac{\partial}{\partial y}\right)\right]+\frac{K'}{B'}(H_0-h)+N-W=0$$

Where:
- K_{xx} = hydraulic conductivity in the x direction;
- K_{yy} = hydraulic conductivity in the y direction;
- h = hydraulic head;
- b = elevation of the unit bottom;
- K' = vertical hydraulic conductivity of an underlying confining unit;
- B' = thickness of the confining unit;
- H_0 = head in the aquifer underlying the confining unit;
- N = a general source term representing groundwater recharge; and
- W = a general sink term representing groundwater discharge.

Similar equations can be written for each aquifer in a layered sequence of aquifers / aquitards. When an aquifer is confined, the saturated thickness (h-b) is replaced with the total aquifer thickness.

MODFLOW-USG computes a mass balance for each time step specified by the model input, as well as cumulative flow volumes for each type of source / sink included in the model.

The solution to the mass balance equation is obtained by iteratively solving the system of equations for each model node. Initial conditions for the hydraulic head in each node are specified in the model input. A calculation procedure is used to adjust the initial head estimates and produce a new estimate of the heads which are closer to the solution of the system of equations. The procedure is repeated until the maximum head change in a model node between successive iterations falls below a closure criterion which is user specified. MODFLOW-USG Sparse Matrix Solver (SMS) package provides two linear solution methods to obtain the model solution; for this study, the χMD method was used with a head closure criterion of 0.001 m.

MODFLOW-USG is accompanied by a utility program called ZONBUDUSG, a water budget calculator which sums the flow volumes from the various groundwater sources / sinks over a zone of interest. The program was modified from the earlier ZoneBudget version 3.01 (Harbaugh, 1990) to work with un-structured grid models. ZONBUDUSG was used in this study to calculate the water balance components of the study area.

The model construction and calibration process was completed using Groundwater Vistas version 9.19 (Environmental Simulations Inc., 2024). Groundwater Vistas is a pre- and post-processor that is capable of creating MODFLOW-USG input files as well as reading output files in a user-friendly graphical user interface. Groundwater Vistas is also capable of importing model input datasets created by third-party software, including ArcGIS (Environmental Systems Research Institute, 2021). Both of these software programs were used to interactively prepare, edit and manage the information needed for model development.

To calibrate the baseline model, PEST (**P**arameter **EST**imation) version 17.3 (Doherty, May 2020) software was used. PEST facilitates computer-assisted calibration of MODFLOW-USG models by back-calculating model parameters to match observation data such as groundwater elevation data, surface watercourse baseflow rates and horizontal and vertical hydraulic gradients. This procedure is referred to as “inverse modeling”. Additional utilities included in the Groundwater Data Utilities suite (Doherty, 2015b) were also used in tandem with PEST during the calibration process.

Particle tracking analysis was completed using mod-PATH3DU (Muffels, et al., November 2024), a particle-tracking model that uses MODFLOW-USG groundwater flow velocity vector output to delineate the travel path and time-of-travel for unstructured model grids.

A.3.1 Equivalent Porous Media Approach

Numerical modeling of groundwater flow through saturated porous media typically simulates water movement through a continuous fully-saturated medium such as sand and gravel with assigned distributions of porosity and hydraulic conductivity. Within fractured bedrock, the groundwater movement is typically greater within the fractures than within the surrounding matrix. Assuming sufficient fracture density and hydraulic connectivity among fractures, the fractured rock can be simulated as an “equivalent porous media” using a model constructed to simulate flow through porous media with appropriate hydraulic properties. On a small scale, actual groundwater movement and simulated groundwater movement can be different. With simulations at a larger scale, the equivalent porous media approach provides a reasonable representation of groundwater flow patterns that is accepted by industry.

A.4 MODEL CONSTRUCTION

The groundwater model construction consisted of the following four tasks:

- Spatial domain and grid discretization;
- Input of model layers;
- Boundary condition implementation; and
- Selection and input of hydraulic properties.

The following sub-sections describe each stage of the groundwater model construction.

A.4.1 Spatial Domain and Grid Discretization

The model domain (i.e., RSA) was set to encompass approximately 17,908 hectares (ha), with the LSA located in the northern portion of the domain, as shown in **Figure A-1**. The dimensions of the model are 12,100 metres on the north and south sides, and 14,800 metres on the east and west sides. The lower left corner of the model is located at UTM coordinates 644,800 E and 4,765,100 N (NAD83 Zone 17N).

The size of the domain was set to incorporate regional "boundaries", including the Niagara Escarpment to the north, the Queenston-Chippewa Power Canal to the east, the Welland River to the south and the Welland Canal to the west. These features generally represent natural groundwater boundary conditions for the model domain and are sufficiently distant from the LSA such that edge effects of the model boundaries do not have a direct influence on the groundwater flow patterns near the Site. The exception is the Niagara Escarpment, which is expected to influence the model results within the LSA. Outside of these boundaries, the model cells were set as no-flow (inactive). Groundwater Vistas was set to remove inactive model cells from the MODFLOW-USG input files to reduce the model numerical burden.

Quadtree grid refinement was used at the Site and for other features of interest, as shown in **Figure A-1**. Quadtree grid refinement is compatible with MODFLOW-USG and is implemented in Groundwater Vistas. For a quadtree-refined grid, parent grid cells are divided into smaller cells by powers of 2 (i.e., 2^x where x is the order of the desired refinement). The grid is then "smoothed" around the refined cells, such that no cell is refined by more than a factor of 2 compared to any adjacent cell. The quadtree approach provides numerical stability and reduces the number of unnecessary grid cells that are typically present in more traditional grid refinement methods.

Initially, a uniform grid of 148 rows by 121 columns was set up, resulting in grid spacing of 100 m in the x- and y-directions. Third order refinement (i.e., 8x8 sub-divided cells) was used for the model cells of interest within the LSA, resulting in a local grid spacing of 12.5 m square as shown in **Figure A-1A**. Second order refinement was used for cells coincident with watercourses, wetland features and the brow of the Niagara Escarpment.

A.4.2 Model Layers

Prior to construction of the numerical groundwater model, a three-dimensional geological model of the study area was developed using Leapfrog Works (Seequent, 2025) based on the available borehole logs, stratigraphic interpretations, and supporting geoscientific data included in the **Existing Conditions Report** and the **Uppers Quarry Water Study**. Lithological units were coded and interpolated using implicit modelling techniques to generate continuous stratigraphic surfaces representing the major hydrostratigraphic units. The resulting model provided a three-dimensional representation of subsurface conditions, facilitating visualization and interpretation of unit geometry and thickness variability. Selected 3-dimensional oblique views of the geological model showing the interpolated stratigraphy through the LSA are provided in **Figure A-2**.

Surfaces derived from the Leapfrog model were then exported and used to define the layer elevations and hydrostratigraphic framework of the numerical groundwater flow model. This approach ensured consistency between the conceptual geological model and the numerical representation, allowing key stratigraphic controls on groundwater flow to be preserved within the discretized model domain.

Following a similar model layer scheme adopted by Yager (1996), seventeen (17) hydrostratigraphic layers were established in the model, representing the overburden, contact aquifer and bedrock stratigraphy outlined in the **Existing Conditions Report**, as summarized in **Table A.4.1**.

Table A.4.1: Model Layer Scheme

<table>
<tr><th>Model Layer</th><th>Description</th><th>Layer Thickness (m)</th><th>Layer Type</th></tr>
<tr><td>1</td><td>Surficial Soils</td><td>Up to 3.0</td><td rowspan="17">Upstream Water Table (Type 4)</td></tr>
<tr><td>2</td><td>Unweathered Silt and Clay</td><td>Variable</td></tr>
<tr><td>3</td><td>Contact Aquifer</td><td>Variable</td></tr>
<tr><td>4</td><td>Weathered Bedrock</td><td>5.0</td></tr>
<tr><td>5</td><td rowspan="2">Guelph Formation</td><td rowspan="2">Variable</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td rowspan="3">Lockport Formation Eramosa Member</td><td rowspan="3">Variable</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td><td rowspan="2">Lockport Formation Goat Island Member</td><td rowspan="2">Variable</td></tr>
<tr><td>11</td></tr>
<tr><td>12</td><td rowspan="2">Lockport Formation Gasport Member</td><td rowspan="2">Variable</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td><td>DeCew Formation</td><td>Variable</td></tr>
<tr><td>15</td><td rowspan="3">Rochester Formation</td><td rowspan="3">Variable</td></tr>
<tr><td>16</td></tr>
<tr><td>17</td></tr>
</table>

Multiple layers were used to simulate the Guelph Formation, the Eramosa, Goat Island and Gasport Members of the Lockport Formation and the Rochester Formation. Layer 17 of the model represents the lower Rochester Formation shale, a lower no-flow boundary. Conductivity of the model cells in all model layers was computed using the upstream weighting method included in MODFLOW-USG (i.e., layer type 4).

The ground surface elevation (top of layer 1) is based on the 1 m Digital Elevation Model (DEM) released in 2020 by the Niagara Peninsula Conservation Authority (NPCA).

The top of bedrock (top of layer 4) was interpolated using Site data, high-quality data from other Sites within the model domain, and the MECP water well database. The interpolated top of bedrock was constrained to below the ground surface elevation within the geology model.

It is interpreted that the surficial soils mapping applies to the upper 3 m of overburden and, as such, the conductivity zones corresponding to surficial soil types is only present in layer 1. The contact aquifer is discontinuous in the LSA. The top of the contact aquifer (top of layer 3) was calculated by adding one third of the total overburden thickness to the interpolated top of bedrock. This simplification was used due to the lack of data to ensure that in areas of thin overburden thickness the contact-zone till thickness is minimal.

The top of bedrock is variable owing to the irregular upper erosional surface. For the underlying bedrock units, the stratigraphic contact surfaces are not perfectly planar over the RSA and were interpolated to the data in the geology model.

Layer 4 in the model represents the upper weathered bedrock. A thickness of 5 m was selected to represent this layer. Layer 4 is continuous across the entire model domain. The underlying bedrock unit layer thicknesses and dip angle were interpolated in the geological model. Where an underlying bedrock layer intersected the bottom of layer 4, the layer thickness was set at a nominal value of 0.1 m. Groundwater Vistas was set to pinch-out model cells less than a thickness of 0.15 m and set them as inactive. As such, layers 5 through 17 model cells north of their respective sub-crops were inactive. **Figure A-2** illustrates how the lower bedrock layers 5 through 17 pinch out where they intersect the weathered bedrock layer 4.

A.4.3 Boundary Conditions

The boundary conditions assigned to the model are shown in **Figure A-3**. The boundary conditions in the vicinity of the Site are shown in **Figure A-3A**. In Groundwater Vistas, boundary types may be grouped together into “reaches” to represent different features of interest and to make it easier to calibrate the model.

As noted above, all model cells outside of the model domain are set as no-flow boundaries (inactive). Additional no-flow boundary cells were simulated within the East Quarry Operations Area overburden, the East and South Landfill (from ground surface to top of Rochester Formation), and existing (2025) Southeast Quarry extraction footprint (shown in **Figure A-3A**). Since the East and South Landfills are completed with low-conductivity clay liners, the internal flow processes within the waste itself were not simulated in this model. The reader is directed to the *Leachate Containment System (LCS) Design Description Report* (WSP Canada Inc., June 2026b) (**LCS Design Report**). Recharge which falls within these no-flow areas was used to simulate steady-state seepage emanating from the base of the landfill liners and was applied to highest active layer of the model below the inactive nodes. Further discussion is provided below.

A.4.3.1 Constant Head Boundaries

Constant head boundaries are used for model cells for which the head is specified in advance of the simulation and held at the specified value through all model time steps. Flow to or from constant head boundaries is a function of the hydraulic conductivity of the model cells and the gradient between the simulated groundwater elevation and the defined elevation of the constant head boundary.

Constant head boundaries were used to represent the Welland Canal and turn basins and the Queenston-Chippewa Power Canal. The 2,201 constant head boundaries used in the model are summarized in **Table A.4.2**.

Table A.4.2: Constant Head Boundary Parameter Values

Reach	Description	No. of Cells	Layer	Stage Elevation (masl)
0	Welland Canal – above Lock 6	616	1 – 17	159
1	Welland Canal – above Lock 7	416	1 – 4	173.4
2	Welland Canal – Central Turn Basin	303		
3	Welland Canal – South Turn Basin	702		
4	Queenston-Chippewa Power Canal	164	14	165.5

Between Lake Erie and the Niagara Escarpment, the stage elevation in the Welland Canal is governed by Lock 8 (in Port Colborne south of the RSA) and Lock 7 (northwest of the LSA near the escarpment face). As noted in the **Existing Conditions Report**, north of (i.e., below) Lock 7, the canal stage is maintained at approximately 159 masl upstream of Lock 6 (situated northwest of the RSA) during autumn conditions. South of (i.e., above) Lock 7, the canal stage is approximately 1 m to 2 m below the average Lake Erie water level elevation of 175 masl. The published total depth of the Welland Canal is approximately 8.2 m. Based on information provided by the Niagara Peninsula Conservation Authority (NPCA), the canal is completed into bedrock from approximately Hurricane Road in Thorold to Glendale Avenue in St. Catharines (i.e., essentially along the entire route within the study area). In the vicinity of the Site, the canal is inferred to be completed approximately 1 m to 2 m into the shallow bedrock (i.e., model layer 4). The bedrock faces along the canal turn basin are visible from the western end of Old Thorold Stone Road, in the western portion of the LSA.

As noted in the **Uppers Quarry Water Study**, the Queenston-Chippewa Power Canal is reportedly concrete lined north of Oldfield Road (i.e., along the entire length of the canal within the study area). The reported maximum depth (including soil and rock cut) of the canal is approximately 43.5 mbgs. It is inferred that this maximum depth occurs at the point of highest ground surface elevation along the canal route. Based on the 2010 DEM released by NPCA, this point is located just south of Lundys Lane. An assumed depth of 43.5 m puts the base of the canal at approximately the top of the DeCew Formation (i.e., model layer 14). There is reportedly very minimal bottom depth vertical declination along the canal route from the inlet at the Welland River to the outlet at Sir Adam Beck generating station. Hourly canal water level data from 2008 to 2012 suggest a relatively narrow range of fluctuation between 164 masl and 170 masl, with an assumed mean value of 165.5 masl.

A.4.3.2 Rivers

River boundaries are head-dependent boundary conditions capable of simulating both discharge from and recharge to the groundwater system (i.e., groundwater sinks or sources) depending on the specified stage elevation of the boundary. Each river boundary requires three parameters which must be specified in the MODFLOW-USG input file: stage elevation, bottom elevation and conductance. The stage elevation determines the gradient between the boundary condition and the adjacent model cell. The bottom elevation dictates which model layer the boundary condition is placed in. Finally, the conductance of the river boundary governs the rate of flux to or from the groundwater system. River conductance is an aggregate of several parameters including stream width, bed thickness and bed vertical hydraulic conductivity of the streambed the river boundary represents.

River boundary cells were used to represent small undifferentiated waterbodies and the Welland River. The 184 river boundaries used in the model are summarized in **Table A.4.3**.

Table A.4.3: River Boundary Parameter Values

Reach	Description	No. of Cells	Layer	Stage Elevation (masl)	Bottom Elevation (masl)	Conductance (m^2/day)
0	Waterbodies	102	1	GS – 0.5 m	GS – 1.0 m	0.1
1	Welland River	82	1	171.3	166	0.1

Note: GS – denotes ground surface elevation

The small waterbodies scattered sparsely throughout the domain were simulated as Reach 0. These boundaries were assigned a stage elevation equivalent to the interpolated ground surface minus 0.5 m, with a bottom elevation equal to 1.0 m below the interpolated ground surface.

As noted in the **Uppers Quarry Water Study**, the Welland River is a significant low-gradient watercourse flowing from west to east and draining much of the Niagara Peninsula above the escarpment brow to the Niagara River in the east. Much of the river reach within the model domain has undergone considerable anthropogenic changes in the past. The river by-passes underneath the modern Welland Canal south of the community of Port Robinson via syphon in the southwestern portion of the RSA. When first constructed, the entire reach of the Welland River from Port Robinson to the mouth at the Niagara River was used as the upper part of the Welland Canal. Finally, during the construction of the Queenston-Chippewa Power Canal, which diverts water from the Niagara River upstream of Niagara Falls to the Sir Adam Beck hydroelectric station, the reach of the Welland River from the canal to the Niagara River was channelized, and the flow direction was reversed. Currently, the Welland River no longer drains to the Niagara River, but rather to the Queenston-Chippewa Power Canal. Based on river cross sections provided by NPCA, the Welland River is inferred to be underlain by a considerable thickness of clayey silt overburden. Within the study area, the river stage and bottom elevation were estimated to be approximately 171.3 masl and 166 masl, respectively.

A.4.3.3 Drains

Drain boundaries are head-dependent boundary conditions only capable of simulating discharge from the groundwater system (i.e., groundwater sinks). Each drain boundary requires two parameters which must be specified in the MODFLOW-USG input file: stage elevation and conductance. As noted above, the stage elevation determines the gradient between the boundary condition and the adjacent model cell. Finally, the conductance of the drain boundary serves the same purpose as that of river boundaries.

Drain boundary cells were used to represent groundwater seepage along the escarpment face and Queenston-Chippewa Power Canal, groundwater discharge to creeks and wetlands and groundwater discharge to other anthropogenic features including the East Landfill Groundwater Collection System (GWCS), Closed West Landfill leachate pumping wells, East and South Landfill liners and the Southeast Quarry sump. The 6,823 drain boundaries used in the model are summarized in **Table A.4.4**.

Table A.4.4: Drain Boundary Parameter Values

Reach	Description	No. of Cells	Layer	Stage Elevation (masl)	Conductance (m^2/day)
0	Escarpment Face	188	4	TOP	10
1	10 Mile Creek – Upstream of Garner Road	66	1	GS – 0.5 m	0.004
2	10 Mile Creek – Upstream of SW9	73			
3	10 Mile Creek – Upstream of SW8	35			
4	10 Mile Creek – Upstream of SW4	32			
5	10 Mile Creek – Downstream of SW4	68			
6	8 Mile Creek	3			
7	6 Mile Creek	46			
8	11 Mile Creek	235			
9	Shriners Creek	326			
10	Beaverdams Creek	283			
11	Thompson Creek	195			
12	Unnamed Watercourses	232			
13	Queenston-Chippewa Power Canal Seeps	317	1 – 3	BOT + 0.1 m	10
15	East Landfill Wall Drains	617	2 – 14		0.02
16	East Quarry Operations Area Floor Drain	314	4	TOP	625
17	East Quarry Operations Area Wall Drains	45	1 – 3	BOT + 0.1 m	625
19	South Landfill Wall Drains	944	1 – 14		0.02
20	Southeast Quarry Sump	1,630	15	BOT + 1.0 m	100
	Southeast Quarry Wall Seeps		1 – 14	BOT + 0.1 m	100
22	Closed West Landfill – Leachate Pumping Well 1	1	14	167.0	100
23	Closed West Landfill – Leachate Pumping Well 2	1	4	168.1	100
24	Groundwater Collection System (GWCS)	83	15 – 16	158.6	1,000
25	Wetlands	1,089	1	GS – 0.5 m	0.1

Note: GS – denotes ground surface elevation; BOT – denotes layer bottom; TOP – denotes layer top

There are seven named creeks within the model domain: 6 Mile Creek, 8 Mile Creek, 10 Mile Creek, 11 Mile Creek, Shriners Creek, Beaverdams Creek and Thompson Creek. There are also several unnamed watercourses and mapped wetland features. The stage elevations of these creeks and wetlands were estimated as 0.5 m below ground surface. The elevations of watercourses along the escarpment face (reach 0) were assumed equivalent to the ground surface elevation. Queenston-Chippewa Power Canal seeps (reach 13) were assumed equivalent to the bottom of layers 1 through 3 plus a nominal head of 0.1 m to maintain numerical stability. Seeps along the escarpment face provide baseflow to streams flowing north to Lake Ontario (and out of the model domain). Similarly, seeps along the power canal walls drain to the canal and out of the model domain.

As outlined in the **Existing Conditions Report**, the groundwater collection system (GWCS) was constructed as a dewatering trench during the development of the former East Quarry to divert excess groundwater discharge and surface water runoff collecting within the quarry floor north through the escarpment face to the Old Welland Canal. Prior to the construction of the East Landfill liner, a perforated pipe was installed within the excavation, and the trench was backfilled with granular material to relieve the hydrostatic pressure within the Rochester Formation shale below the liner and maintain inward hydraulic gradients toward the East Landfill. Drains are used to represent the GWCS within the model (reach 24), with the average autumn elevation in the WEG Collection Chamber during the baseline monitoring period specified as the stage elevation.

The Closed West Landfill was constructed without an engineered liner; as such, infiltration occurs within the waste fill footprint and generates leachate as it flows through the waste. A series of leachate pumping wells were installed through the waste fill to collect the leachate and divert to the leachate lagoons for aeration, ultimately discharging to the municipal sanitary sewer for treatment. Drains are used to represent leachate pumping wells 1 and 2 (reaches 22 and 23, respectively), with elevation values based on the current float switch elevations and conductance values similar to those of previous studies (S.S. Papadopulos & Associates, Inc., February 2006).

For the East and South Landfills, the wall drains (reaches 15 and 19, respectively) allow for the possibility of lateral groundwater infiltration through the landfill liner (i.e., out of the model domain). The conductance values were set at a relatively low value to simulate the low-permeability compacted clay liner.

Finally, floor and wall drains are used to represent groundwater discharge and surface water runoff that collects within the East Quarry Operations Area (reaches 16 and 17) and the Southeast Quarry (reach 20). The combined flow to the Southeast Quarry drains is used to simulate discharge from the quarry sump. The East Quarry Operations Area floor drains were assumed equivalent to the top of the weathered bedrock, while the Southeast Quarry floor drain elevations were set at a nominal thickness of 1 m above the bottom of the model layer or 158 masl, whichever is greater. A minimum of 158 masl was specified to ensure the minimum drain elevation is consistent with average autumn conditions during the baseline monitoring period within the Southeast Quarry sump. Wall drain elevations were assumed equivalent to the layer bottom elevation plus a nominal head of 0.1 m to maintain numerical stability. The conductance values were set at relatively high values to represent the estimated bulk conductivity of the fractured bedrock multiplied by the model cell area (i.e., 12.5 m square within these areas of interest as noted above).

A.4.3.4 Recharge

Recharge boundaries were used in the uppermost active model cell to represent infiltration to the groundwater system. It is noted that for this study, infiltration to the groundwater system is defined as total precipitation less evapotranspiration and runoff to surface water features. In the model, the recharge boundaries were applied to the uppermost active cell in the vertical column (i.e., NRCHOP = 3).

Eight (8) zones were used to define areas of similar surficial soil types based on the surficial geology mapping (Ontario Geological Survey, 2003). The recharge zones are shown in **Figure A-4**, and the calibrated baseline model parameter values are summarized in **Table A.4.5**.

Table A.4.5: Recharge Zone Parameter Values

Zone	Description	Autumn Recharge Rates	
		mm	m/day
1	Weathered Silt and Clay (8a)	1	$1.4x10^{-5}$
2	Glaciolacustrine Sand and Gravel (9)	41	$4.5x10^{-4}$
3	Modern Fill (21)	41	$4.5x10^{-4}$
4	Paleozoic Bedrock Outcrops (3)	0	0
5	South Landfill	0	0
6	Closed West Landfill	41	$4.5x10^{-4}$
7	East Landfill	7	$8.2x10^{-5}$
8	Southeast Quarry / East Quarry Operations Area	41	$4.5x10^{-4}$

Note: Numbers in brackets in the zone description correspond to legend nomenclature in Ontario Geological Survey (OGS) surficial geology mapping.

As noted in the **Existing Conditions Report**, the estimated average annual water surplus is 330 mm based on the most recent 30-year climate normal (i.e., 1991-2020). This represents the upper limit of recharge to the groundwater system in any given year, equivalent to a rate of $9.0x10^{-4}$ m/d. This upper limit is subject to additional losses as runoff to local watercourses, dependent on such factors as topography and surficial soils. An area of steep, low conductivity soil or rock would be expected to divert more water surplus to surface runoff in comparison to an area of flatter, higher conductivity soil. For recharge zones 1 through 4, baseline climate data were used to estimate representative autumn recharge rates over the September to November period (i.e., 91 days). For higher conductivity surficial soils including glaciolacustrine sand and gravel and modern fill, runoff was assumed to be negligible. Conversely, for the lower conductivity weathered silt and clay, infiltration was assumed to be negligible. Infiltration was also assumed to be negligible along the paleozoic bedrock outcrops as they are situated along the escarpment in areas of high topographic relief.

Different conceptual approaches were used to simulate recharge within the East, South and Closed West Landfill footprints. The South Landfill liner consists of a generic double layer design as per O.Reg. 232/98; as such, negligible seepage is inferred to emanate from the base of the South Landfill. Any infiltration into the landfill cells would be removed through the leachate collection system. The East Landfill liner consists of an older single clay layer design, which results in an estimated seepage rate of 30 mm/year (i.e., 7 mm during the autumn period) based on an average thickness of 2 m and an average leachate head of 1.5 m above the liner during the baseline monitoring period. Finally, the full available water surplus was assumed for the Southeast Quarry, East Operations Area and Closed West Landfill as no runoff originates from these footprint areas.

In general, numerical groundwater models are much less sensitive to changes in recharge values in comparison to the hydraulic properties. Furthermore, recharge values and hydraulic properties are often correlated, in that different combinations may produce similar model results (i.e., non-unique solutions). To avoid this, the representative autumn recharge rates noted above were fixed during the calibration process.

A.4.4 Hydraulic Properties

Zones were used to represent hydraulic conductivity and vertical anisotropy for the various hydrostratigraphic units present within the RSA. During the calibration process, additional localized zones were used to improve model calibration to average autumn water level data; further discussion is provided below. The zone extents for model layers 1 and 4 are shown on **Figures A-5 and A-6**. The calibrated model values for each of the twenty-five (25) zones used in the model are summarized below in **Table A.4.6**.

Table A.4.6: Hydraulic Conductivity Zone Parameter Values

Layer	Description	Zone	Horizontal Hydraulic Conductivity (K_H) (m/s) (m/day)	Vertical Anisotropy (K_H / K_V) (Unitless)
1	Weathered Rochester Formation Bedrock (3)	14	*(refer to Layer 4 values below)*	
	Weathered DeCew Formation Bedrock (3)	15		
	Weathered Gasport Member Bedrock (3)	16		
	Weathered Silt and Clay (8a)	23	2.6×10^{-5} (2.3)	1.0
	Modern Fill (21)	24	1.2×10^{-6} (0.10)	1.0
1 – 3	Glaciolacustrine Sand and Gravel (9)	21	7.0×10^{-7} (0.061)	5.0
1 – 14	Closed West Landfill Waste Fill	25	5.8×10^{-5} (5.0)	5.0
2	Unweathered Silt and Clay	22	5.8×10^{-6} (0.50)	500
3	Contact Aquifer	20	2.6×10^{-7} (0.022)	2.0
4	Weathered Rochester Formation Bedrock	14	9.4×10^{-6} (0.81)	3,200
	Weathered DeCew Formation Bedrock	15	7.2×10^{-9} (0.00063)	100
	Weathered Gasport Member Bedrock	16	1.4×10^{-8} (0.0012)	100
	Weathered Goat Island Member Bedrock	17	1.7×10^{-4} (14.3)	100
	Weathered Eramosa Member Bedrock	18	7.5×10^{-8} (0.0065)	200
	Weathered Guelph Formation Bedrock	19	1.4×10^{-6} (0.12)	200
5	Guelph Formation Bedrock	13	1.4×10^{-3} (121)	200

Layer	Description	Zone	Horizontal Hydraulic Conductivity (K_H) (m/s) (m/day)	Vertical Anisotropy (K_H / K_V) (Unitless)
6		12		
7	Lockport Formation - Eramosa Member Bedrock	11	7.0×10^{-7} (0.061)	200
8		10		
9		9		
10	Lockport Formation - Goat Island Member Bedrock	8	3.0×10^{-5} (2.6)	100
11		7		
12	Lockport Formation - Gasport Member Bedrock	6	1.4×10^{-8} (0.0012)	100
13		5		
14	DeCew Formation Bedrock	4	7.2×10^{-9} (0.00063)	100
15	Upper Rochester Formation Bedrock	3	9.4×10^{-6} (0.81)	3,200
16	Middle Rochester Formation Bedrock	2	5.6×10^{-7} (0.049)	300
17	Lower Rochester Formation Bedrock	1	2.2×10^{-9} (0.00019)	1,000

Note: Numbers in brackets in the zone description correspond to legend nomenclature in Ontario Geological Survey (OGS) surficial geology mapping.

Three zones (zones 21, 23 and 24) were used to represent hydraulic conductivity and vertical anisotropy of similar surficial soil types in model layer 1 based on surficial geology mapping (Ontario Geological Survey, 2003). Based on MECP water well record information, the glaciolacustrine sand and gravel (zone 21) was included in layers 1 through 3 in the calibrated model. The weathered bedrock (model layer 4) was broken up into six (6) zones (zones 14 to 19), based on their inferred subcrops as shown in **Figure A-6**. Initially, separate conductivity zones were included for each layer in the Guelph Formation and Lockport Formation Members; however, early sensitivity analyses indicated a high degree of correlation between these zones, which was not unexpected. As such, these zones were “tied” for the remainder of the calibration process. The “weathered” bedrock zones were also tied to their unweathered counterparts for the same reason.

Zone 25 was added to model layers 1 through 14 to represent the waste fill in the Closed West Landfill. Zones were not used to represent the East and South Landfills and Southeast Quarry, as the model cells within these footprints were set as no-flow boundaries (i.e., inactive) in the model simulation. In addition, due to the dip angle of the bedrock, the model cells in the northern portion of model layers 5 through 14 are “pinched out” and are inactive in the model simulation.

Horizontal hydraulic conductivity and vertical anisotropy can also be correlated in numerical groundwater models and may lead to non-unique solutions. To avoid this, vertical anisotropy values for the majority of the conductivity zones noted above were fixed during the calibration process, based on values from previous studies and published data available in the literature (Freeze & Cherry, 1979; Domenico & Schwartz, 1990; Shepley, 2024). The exceptions are the vertical anisotropy values for the Upper and Middle Rochester Formation bedrock zones which showed a relatively high degree of sensitivity and were therefore refined as part of the calibration process.

Initial (i.e., pre-calibration) horizontal hydraulic conductivity values were based on results from previous studies and published ranges available in the literature. The calibrated values presented above are consistent with the hydraulic conductivity ranges for the various hydrostratigraphic units established in the **Existing Conditions Report**.

As noted above, localized zones in addition to the zones presented in **Table A.4.6** were used to improve model calibration to average autumn water level data. For example, through the course of calibration it was determined that localized zones around the western portion of the East Landfill and the southern portion of the South Landfill with a marginally higher horizontal hydraulic conductivity (i.e., within one to two orders-of-magnitude greater than the surrounding bedrock) and a lower anisotropy ratio resulted in a better fit between nearby observed and simulated groundwater elevations in multiple hydrostratigraphic units. These localized zones are consistent with the findings presented in the **Existing Conditions Report** that localized hydraulic conductivity within the bedrock surrounding the former East and South Quarries marginally increased, inferred to be the result of historical quarrying activities. Similarly, other localized zones with higher or lower anisotropy ratios were also utilized where the degree of vertical hydraulic connectivity between bedding planes appears to influence local groundwater elevations. Based on recent publications in the literature, anisotropy ratios ranging from 1.0 up to 10,000 were used to represent conditions within the localized zones.

A.5 MODEL CALIBRATION

A.5.1 Objectives and Methodology

The objective of the groundwater flow model calibration is to achieve an approximation of the observed baseline groundwater elevation and flow patterns within the study area. The quantification of the model fit to calibration targets is evaluated using “residuals”. Residuals are calculated as the difference between the calibration target values and the simulated model output (i.e., observed minus simulated). Positive residual values are indicative of model “under-prediction”, while negative residual values are indicative of “over-prediction”.

Model calibration statistics typically include max / min residual values, residual mean, absolute residual mean, sum of squared error (SSE), root mean square error (RMSE), and normalized root mean sum of squares (NRMS). The residual mean is an average of the residuals; a value approaching zero is desired (i.e., there is a balance of under-prediction and over-prediction occurring in the model). The spatial distribution of residuals is also considered; randomly distributed positive and negative residuals are desired. The mean of the absolute value of residuals provides an estimate of the total error of the model output. The SSE is calculated by summing the squares of the residuals. RMSE is calculated by taking the square root of the SSE divided by the total number of calibration targets. Another indicator of a successful model calibration is if the RMSE is comparable to the variance of the calibration target values. Finally, NRMS is calculated by dividing the RMSE by the total range in the calibration target values. An industry accepted target for the NRMS is less than or equal to 10% (Spitz & Moreno, 1996).

The model calibration was also evaluated using the volumetric water budget output summarized by MODFLOW-USG at the end of each simulation. The volumetric water budget provides the simulated water balance (groundwater flow into and out of the model domain) broken down by boundary condition type. An acceptable water balance error is less than 0.1%.

As noted above, PEST was used to assist in the model calibration, along with various utility programs developed by Watermark Numerical Computing. Groundwater Vistas was used to import calibration targets into the model in order to provide PEST with the observation data required to perform the inverse modeling. Sensitivity analyses of the model parameters were completed throughout the calibration process to determine which parameters were most sensitive to the model output and guide the process.

The following sections describe the calibration target data and model parameters used in the PEST calibration.

A.5.2 Calibration Targets

For this study, a total of 374 targets were used to calibrate the model to baseline conditions, described in the sections below. A summary of the calibration statistics is provided in **Section A.5.3** below.

A.5.2.1 LSA Observation Data

As noted in the **Existing Conditions Report**, natural fluctuations in groundwater elevations occur as a result of seasonal climatic conditions. However, the potential impacts to groundwater users and receptors are inferred to be worst during the drier period of the year (i.e., September to November). Therefore, the average autumn groundwater elevations were used as the calibration targets for the LSA wells.

A total of ninety-six (96) bedrock groundwater monitoring wells / residential wells were imported to Groundwater Vistas as head targets, designated as Group 1. Groundwater elevation data from interpreted slow-recovery wells, particularly those screened within the DeCew and Rochester Formations, were excluded from the calibration. In addition, it was determined through the calibration process that the average autumn water level at monitoring well 79-1 appears to be an outlier and was also excluded from the calibration process.

An additional nineteen (19) overburden monitoring wells were imported as head targets, designated as Group 2. The overburden targets were handled separately as the calibration of the bedrock hydrostratigraphic units was the primary focus of the calibration process.

Three (3) flux targets were also used to complete the calibration, designated as Group 6 and estimated as follows.

The flux target for the Southeast Quarry sump discharge is based on the autumn daily pumping records for the baseline monitoring period (UEM & WSP Canada Inc., March 2026). The reported autumn water takings from the Southeast Quarry sump were 70,890 m^3 over a period of 91 days, equivalent to a rate of approximately 780 m^3/day. It is noted that this rate includes both excess runoff from precipitation and groundwater influx to the quarry, both of which are simulated in the baseline model.

The flux targets for the Closed West Landfill leachate pumping wells 1 and 2 were based on the autumn monthly pumping volumes from the baseline monitoring period (UEM & WSP Canada Inc., in press). The reported autumn leachate volumes at wells 1 and 2 were 2,675 m^3 and 846 m^3, respectively, over a period of 91 days. These volumes are equivalent to a rate of approximately 29 m^3/day and 9 m^3/day for well 1 and 2, respectively.

A.5.2.2 Other High-Quality Observation Data

High-quality autumn water level data from the **Uppers Quarry Water Study** from monitoring wells at other sites within the RSA were imported to Groundwater Vistas as head targets, designated as Group 3. Data from a total of fifty-nine (59) monitoring wells from outside of the LSA are included in Group 3.

A.5.2.3 Water Well Records

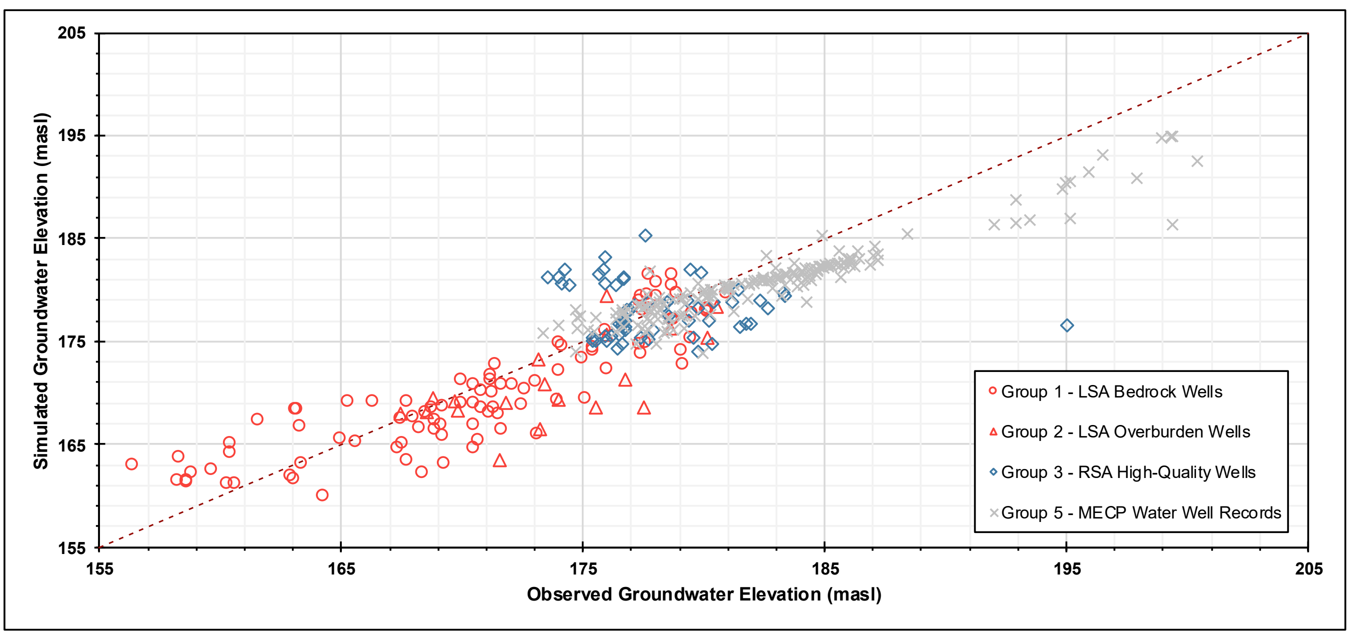
Lower-quality water level data from MECP water well records within the RSA were imported to Groundwater Vistas as head targets, designated as Group 5. The water well record data were parsed to remove data of low reliability and for wells with well screens / static water levels below the base of the model domain. A total of 197 water levels were included in Group 5.

It is noted that the MECP water well record target data represent a single "snapshot" in time. Calculated residuals of up to ± 5 m between the model simulated head and water level reported on the record are therefore not unexpected. The reasons for such a relatively large discrepancy include, among others, (1) seasonal variance at the well during the period in which the level was measured, (2) incomplete recovery after the well was installed, (3) poor (or no) elevation control on the data and (4) inaccuracy in the reported well location. As such, the Group 5 targets were assigned a weighting of 0.5 (i.e., half the weight of the high-quality data in the other target groups) to reflect the larger inherent degree of uncertainty in the observation data.

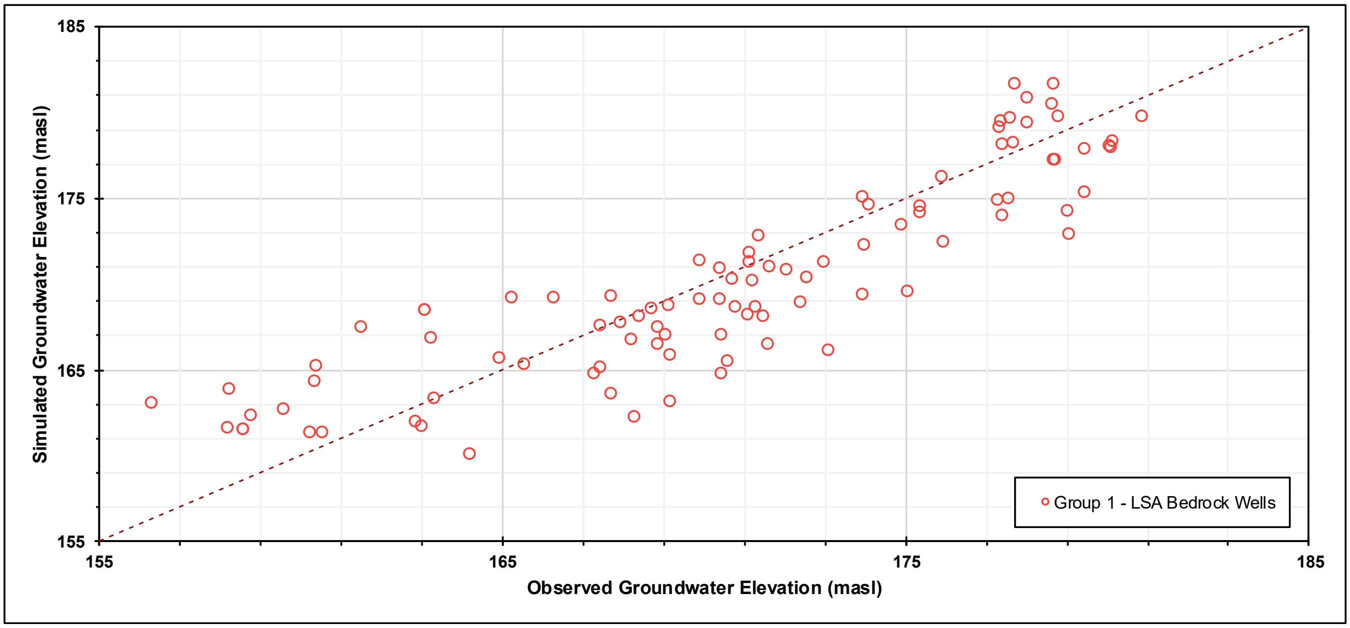
A.5.3 Calibration Results

A.5.3.1 Diagnostic Residual Plots

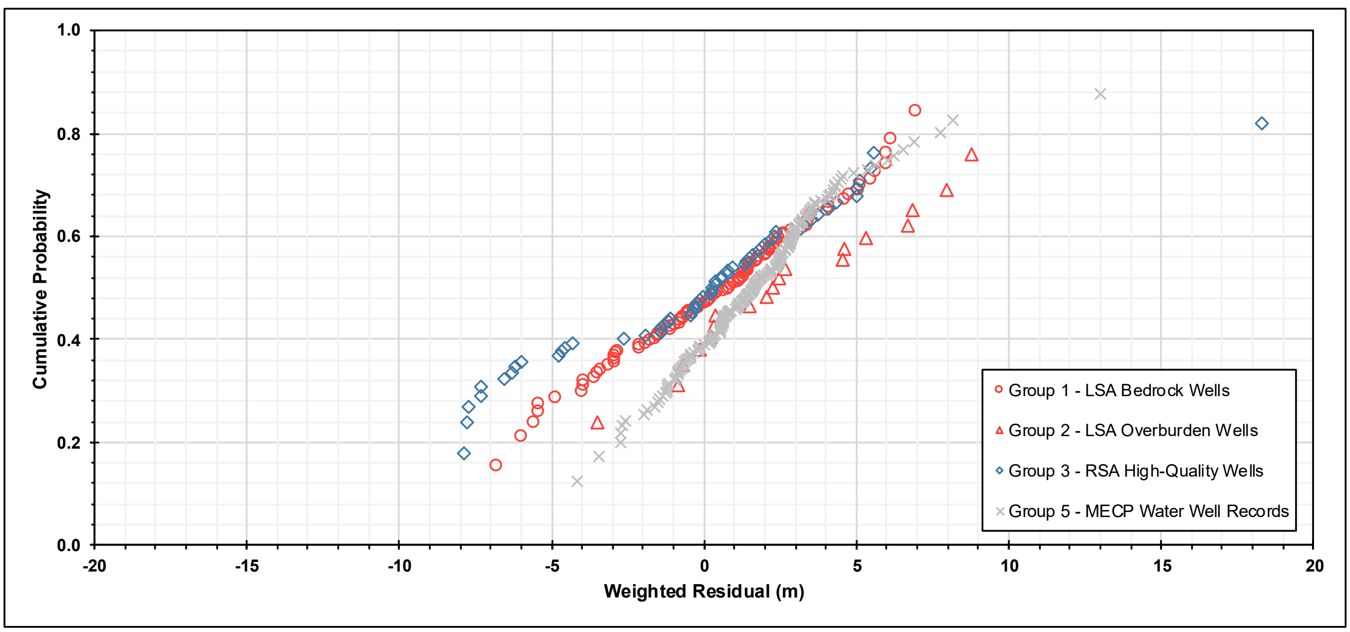
A scatterplot of the weighted residuals for the calibrated baseline model is shown below, with different symbols representing the different head target groups discussed above.



A scatterplot of the calculated residuals for the calibrated baseline model for the LSA bedrock well data only is shown below.



Cumulative probability plots for Group 1, Group 2, Group 3 and Group 5 head targets for the calibrated baseline model are provided below.



The spatial distribution of weighted residuals within the LSA for the Lockport Formation (model layers 4 and 10 through 13) and the Rochester Formation (model layers 15 through 17) from the calibrated baseline model are shown in **Figures A-7 and A-8**.

A.5.3.2 Group 6 Flux Targets

The Group 6 flux targets for the calibrated baseline model are summarized in **Table A.5.1**.

Table A.5.1: Flux Targets

No.	Description	Drain Boundary Reach No.	Flux Target (m^3/day)	
			Observed	Simulated
1	Southeast Quarry Sump	20	780	724
2	Closed West Landfill – Leachate Pumping Well 1	22	29	16
3	Closed West Landfill – Leachate Pumping Well 2	23	9	4

A.5.3.3 Calibration Statistics

The calibration statistics for the various target groups in the calibrated baseline model are summarized in **Table A.5.2**.

Table A.5.2: Calibration Statistics

Statistical Measurement	Unit	Overall	Head Targets			
			Group 1	Group 2	Group 3	Group 5
Number of Observations	--	371	96	19	59	197
Min Residual	m	-7.9	-6.8	-3.5	-7.9	-4.2
Max Residual	m	+18.3	+7.0	+8.8	+18.3	+13.0
Residual Mean	m	1.1	0.5	2.7	-0.1	1.6
Absolute Residual Mean	m	2.4	2.5	3.3	3.1	2.1
SSE	m^2	3,821	899	341	1,146	1,436
RMSE	m	3.2	3.1	4.2	4.4	2.7
Range of Observations	m	44.1	24.6	13.1	21.5	27.1
NRMS	**%**	**7.3**	**12.4**	**32.2**	**20.5**	**10.0**

A.5.3.4 Mass Balance Error

The mass balance for the calibrated baseline model is shown in **Table A.5.3**.

Table A.5.3: Baseline Calibrated Model Mass Balance

Boundary Type	Mass Balance (m^3/day)		
	Inflows	Outflows	Outflow – Inflow
Recharge (RCH)	8,794.7	0	-8,794.7
Constant Head (CHD)	973.8	3,007.0	2,033.2
River (RIV)	2.8	94.3	91.5

Drain (DRN)	0	6,670.1	6,670.1
TOTAL	**9,771.3**	**9,771.4**	**0.1**
Discrepancy (%)			**<0.1**

A.5.4 Calibrated Baseline Model Sensitivity Analysis

PEST was used to complete a sensitivity analysis to estimate the calibrated baseline model parameter correlation and sensitivity (i.e., NOPTMAX set to -1).

Composite Scaled Sensitivity

Composite scaled sensitivity (CSS) values are used to evaluate the overall sensitivity of a parameter and are calculated as the sum of the square roots of the dimensionless scaled sensitivity (DSS) divided by the number of observations. The DSS is the partial derivative of the simulated observation with respect to the parameter, multiplied by the square root of the weight assigned to the observation. DSS is used to evaluate the importance of an observation relative to the estimation of a single parameter.

The CSS typically is a good measure of the information that observations contribute to the estimation of parameters. The relative size of CSS values can be used to assess whether additional parameters can be estimated. A relatively large CSS value indicates that observations contain enough information to represent that aspect of the system. A relatively small CSS value (about two orders of magnitude less than the largest CSS value) indicates that the observations provide insufficient information with which to estimate the parameter. CSS values are useful in identifying those parameters which may be degrading, or are likely to degrade, the performance of the parameter estimation process through lack of sensitivity to model outcomes.

It is noted that some hydrogeological model parameters, such as hydraulic conductivity, are log transformed in PEST for easier processing. Therefore, sensitivity is expressed with respect to the log of the parameter. The relative composite sensitivity of a log-transformed parameter is determined by multiplying the composite sensitivity of that parameter by the absolute log of the value of that parameter. The CSS values for model parameters included in the calibration process are shown in **Tables A.5.4, A.5.5 and A.5.6**. The yellow shaded targets indicate the most sensitive model parameters, while grey shaded rows indicate parameters which are relatively insensitive to calibration of the LSA bedrock wells.

Table A.5.4: Composite Scaled Sensitivities for Horizontal Hydraulic Conductivity Zones

		All Targets	Group 1 Targets Only
1	Lower Rochester Formation Bedrock	0.00018	0.00017
2	Middle Rochester Formation Bedrock	0.035	0.040
3	Upper Rochester Formation Bedrock	0.31	0.26
4	DeCew Formation Bedrock	0.025	0.081
6	Gasport Member Bedrock	0.21	0.58
8	Goat Island Member Bedrock	0.020	0.027
11	Eramosa Member Bedrock	0.0054	0.0014
13	Guelph Formation Bedrock	0.030	0.0075
14	Weathered Rochester Formation Bedrock	0.051	0.054
15	Weathered DeCew Formation Bedrock	0.0014	0.0018

		All Targets	Group 1 Targets Only
17	Weathered Goat Island Member Bedrock	1.79	0.47
18	Weathered Eramosa Member Bedrock	0.083	0.022
19	Weathered Guelph Formation Bedrock	0.29	0.062
20	Contact Aquifer	0.028	0.019
21	Glaciolacustrine Sand and Gravel	0.011	0.0055
22	Unweathered Silt and Clay	0.13	0.051
23	Weathered Silt and Clay	0.042	0.022
24	Modern Fill	0.0087	0.0018
25	Closed West Landfill Waste Fill	0.067	0.019
26	Localized Zone for Calibration	0.21	0.045
27	Localized Zone for Calibration	0.51	0.17
28	Localized Zone for Calibration	0.013	0.040
30	Localized Zone for Calibration	0.00039	0.0015
31	Localized Zone for Calibration	0.077	0.051
33	Localized Zone for Calibration	0.000040	0.00012
36	Localized Zone for Calibration	0.092	0.036
37	Localized Zone for Calibration	0.38	0.077
38	Localized Zone for Calibration	0.00064	0.0025
39	Localized Zone for Calibration	0.0035	0.010

Table A.5.5: Composite Scaled Sensitivities for Vertical Anisotropy Zones

		All Targets	Group 1 Targets Only
1	Lower Rochester Formation Bedrock	0.0074	0.029
2	Middle Rochester Formation Bedrock	0.0063	0.013
3	Upper Rochester Formation Bedrock	0.15	0.058
4	DeCew Formation Bedrock	0.024	0.080
6	Gasport Member Bedrock	0.088	0.24
8	Goat Island Member Bedrock	0.0031	0.0012
11	Eramosa Member Bedrock	0.0039	0.00071
13	Guelph Formation Bedrock	0.000078	0.000051
14	Weathered Rochester Formation Bedrock	0.040	0.043
15	Weathered DeCew Formation Bedrock	0.00031	0.00090
17	Weathered Goat Island Member Bedrock	0.020	0.0074
18	Weathered Eramosa Member Bedrock	0.014	0.0043
19	Weathered Guelph Formation Bedrock	0.27	0.056
20	Contact Aquifer	0.012	0.0043
21	Glaciolacustrine Sand and Gravel	0.0012	0.00040
22	Unweathered Silt and Clay	0.033	0.010
23	Weathered Silt and Clay	0.0000085	0
24	Modern Fill	0.0031	0.0011

		All Targets	Group 1 Targets Only
25	Closed West Landfill Waste Fill	0.00051	0.000062
26	Localized Zone for Calibration	0.000090	0.000070
27	Localized Zone for Calibration	0.000088	0.000075
28	Localized Zone for Calibration	0.0015	0.0035
30	Localized Zone for Calibration	0.010	0.040
31	Localized Zone for Calibration	0.013	0.024
33	Localized Zone for Calibration	0	0
36	Localized Zone for Calibration	0.093	0.032
37	Localized Zone for Calibration	0.38	0.074
38	Localized Zone for Calibration	0.00063	0.0024
39	Localized Zone for Calibration	0.0030	0.0090

Table A.5.6: Composite Scaled Sensitivities for Recharge Zones

		All Targets	Group 1 Targets Only
1	Weathered Silt and Clay	0.58	0.31
2	Glaciolacustrine Sand and Gravel	1.7	0.58
3	Modern Fill	0.72	0.30
4	Paleozoic Bedrock Outcrops	0	0
5	South Landfill	0	0
6	Closed West Landfill	0.24	0.069
7	East Landfill	0.050	0.043
8	Southeast Quarry / East Quarry Ops Area	1.2	0.020

A.5.5 Calibration Summary

A number of calibration targets and statistics related to different aspects of the conceptual understanding of the RSA have been provided above. The objective of the calibration process for this study was to achieve a reasonable balance of these various targets.

The overall statistics for the head targets show that the model NRMS of 7.3% is within the industry accepted value of 10%. The residual mean error of 1.1 m indicates that there is a reasonable balance of over- and under-prediction of groundwater elevation within the model. The NRMS values for the individual groups of targets are higher than the overall model NRMS, which demonstrates the difficultly with fitting a deliberately simplified regional model to different collections of local target data.

Target residuals were plotted on scatterplots as shown in **Section A.5.3.1**. If a model were perfectly calibrated to fit the observation data, all of the points on the scatterplot would fall along the 45º line (i.e., the dotted red line on the plots). The scatterplot of all of the head targets (Groups 1 through 5) indicates that there is a reasonable balance between over- and underprediction in the calibrated baseline model. The scatterplot for the LSA bedrock wells (Group 1) only indicates that the residuals generally follow the trend of the 45º line.

Cumulative probability plots for the head target groups are provided in **Section A.5.3.1**. In practice, error is inherent in all numerical models due to various factors. However, it is desirable that the model error is not biased to one extreme. Cumulative probability plots are an indication of whether the error in the model simulated groundwater elevation is randomly distributed. If this is the case, all of the calibration targets tend to plot along a straight line. The scatterplot indicates that the majority of head target residuals in the cumulative probability plots, particularly for the LSA bedrock wells, plot along a straight line, which suggests that the model error is generally randomly distributed.

There are two datapoints (Uppers Quarry monitoring well MW11-2A and MECP water well record 7258351) plot off the straight lines for the Group 3 and 5 targets. These targets have the largest residual values in the calibrated baseline model. However, these wells are located sufficiently distant from the LSA that the model under-prediction is not expected to have a significant influence on the predictive scenarios below.

The spatial distributions of head target residuals are shown in **Figures A-7 and A-8**. The simulated groundwater elevation contours are also shown. Model over- and under-predictions generally appear to be randomly dispersed throughout the LSA and do not appear to be spatially correlated.

Flux targets (Group 6) were also considered in the model calibration, as summarized in **Table A.5.1**. The simulated flux values for the Southeast Quarry sump from the calibrated baseline model are a reasonable match to the observed flux target. The calibrated baseline model marginally underpredicts the Closed West Landfill leachate pumping well discharge, but this is not expected to have a significant impact on the model predictions below.

The mass balance error for the calibrated baseline model is less than 0.1% as shown in **Table A.5.3**, which indicates that there are no mass-balance issues in the calibrated model.

A sensitivity analysis was completed on the calibrated baseline model and included the horizontal hydraulic conductivity zones, vertical anisotropy zones and recharge zones. The purpose of the sensitivity analysis was to quantify the sensitivity of the different parameters to the model calibration and to identify parameters which are highly correlated (i.e., different combinations of the correlated parameters may result in similar model predictions).

Parameter sensitivities for the overall model calibration and the model calibration to monitoring well data only (Group 1 head targets) are shown in **Tables A.5.4, A.5.5 and A.5.6**. Three of the top five most sensitive model parameters included the recharge zones representing the glaciolacustrine sand and gravel east of the LSA, the weathered silt and clay and modern fill. The second and third most sensitive model parameters were the horizontal hydraulic conductivity zones representing the Gasport Member bedrock and the weathered Goat Island Member bedrock, respectively. Other sensitive horizontal hydraulic conductivity zones included those representing the upper Rochester Formation bedrock and a localized zone representing a higher conductivity / lower anisotropy ratio at the southern end of the South Landfill within the upper Rochester Formation bedrock. The majority of the zones representing the vertical anisotropy ratios were marginally to completely insensitive, with the exception being the vertical anisotropy of the Gasport Member bedrock.

Like many fractured-bedrock settings in southern Ontario, the hydrogeological setting of the RSA is complex. The numerical model is a deliberate simplification of a complex natural system and has been calibrated to achieve a best-fit with the available data at the time this report was published. The objective of the calibration process is not to capture every detail of the hydrogeological setting and match every observation; instead, the goal is to achieve a reasonable balance between over- and under-prediction of the simulated groundwater elevations. In practice, all models have some degree of error; however, ensuring that model error is randomly distributed helps to reduce the possibility of bias in the model predictions.

In summary, the calibrated baseline model represents the best-fit to the available data, with a reasonable balance between over- and under-prediction of the simulated groundwater elevations and a random distribution of error. The parameters that are most sensitive to the model calibration have physically realistic values based on the available data. Parameters which are relatively insensitive and cannot be inferred through the model calibration process have been assigned values which are physically realistic and within the ranges of published data. As such, results from the alternative future scenario models outlined below can be interpreted with a high degree of confidence.

A.6 CALIBRATED EXISTING CONDITIONS MODEL

The simulated Lockport Formation and Rochester Formation groundwater contours for the existing conditions model are shown in **Figures A-7 and A-8**. The simulated groundwater flow directions in the calibrated baseline model are similar to those included in the **Existing Conditions Report** and are consistent with the observed inward gradients.

Four (4) property owners within the LSA indicated that their well is either their sole water source or used for domestic purposes, as summarized in the **Existing Conditions Report**. All of these wells are included in the on-going residential well monitoring program for the Southeast Quarry. Details for each residential well are provided in **Table A.6.1**.

Table A.6.1: Estimated Available Drawdown for Residential Well Users

	Residential Well 3 (9332 Thorold Stone Road)	Residential Well 7-2 (10056 Thorold Stone Road)	Residential Well 8-1 (3933 Thorold Townline Road)	Residential Well 14 (8865 Mountain Road)
MECP Water Well Record No.	n/a	6604319	n/a	6602700
Stickup (m)	0.40	0.78	0.71	0.94
Total Depth (m)	15 (estimated)	18.55	13.11	17.78
Measuring Point Elevation (masl)	181.50	178.53	176.94	179.95
Autumn Average Water Level (masl)	175.4	171.1	171.4	175.4
Estimated Available Drawdown (m)	8.9	11.1	7.6	13.2
Simulated Water Level in Existing Conditions Model (masl)	174.6	171.3	172.8	174.2

As shown in the table, the simulated water levels in the calibrated baseline model are a reasonable match to the average water level elevation observed in autumn. Estimated available drawdown for each well is calculated using the available bottom depth information. Available drawdown is used to assess impacts to the well operation in the subsequent scenario models presented below.

Groundwater seepage to the Lockport portion of the escarpment (i.e., the Lockport scarp) is simulated by drain reach 7 in the existing conditions model. Historically, it has been interpreted from the annual monitoring data that runoff within tributaries of 6 Mile Creek which originate north of the SSA originate as overland flow from precipitation based on the water quality relative ion signatures (UEM & WSP Canada Inc., March 2026). Minimal groundwater contribution to these tributaries is inferred, particularly during the autumn period. The existing conditions model results are consistent with this interpretation, suggesting that only 0.3 m^3/day of groundwater discharges to these features. Drain reach 0, which simulates tributaries further down the escarpment face for both 8 Mile and 6 Mile Creeks, indicates higher rates of groundwater discharge, estimated to be 194.9 m^3/day.

A.7 PREDICTIVE SCENARIO MODELS

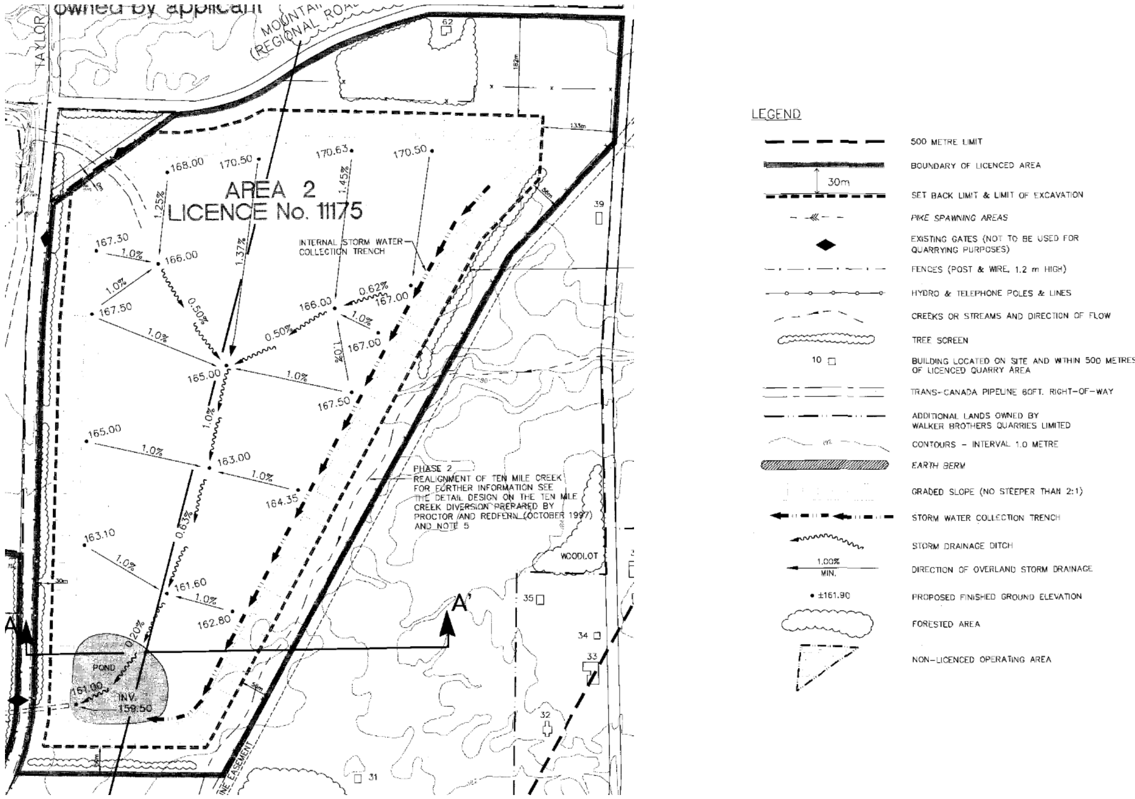
Three predictive scenario models were considered for this study:

- Future existing conditions (i.e., the “do-nothing” option);
- Proposed landfill operation conditions; and
- Landfill post-closure conditions.

For each scenario, the calibrated existing conditions model was adapted to simulate key hydrogeological changes within the LSA for each scenario. The scenarios, model adaptations and predicted effects relative to baseline existing conditions are summarized below.

A.7.1 Future Existing Conditions Scenario

In the future, the quarry excavation within the SSA would proceed to the remaining portions in the northeast area of the approved extraction limit. Upon resource depletion, the approved future use of the SSA is shown in the Aggregate Resource Act (ARA) Rehabilitation Plan for the Southeast Quarry (Plan no. 3 of 4, MHBC, March 2005), a portion of which is reproduced in the image below.



In summary, the Rehabilitation Plan for the Southeast Quarry is reversion to agricultural use, with overburden from the site placed "to prevent groundwater discharge into the quarry" and graded within the limit of excavation. Grading would be completed such that excess runoff would flow to a pond within the southern portion of the former quarry floor. An outlet pipe running under Taylor Road would convey excess runoff to the solid drainage pipe of the WEG Drainage System (WDS) for discharge to the Old Welland Canal, as described in the **Existing Conditions Report**. The invert elevation of the pipe is indicated as 159.5 masl on the Rehabilitation Plan; however, as-built survey data for manhole MHS7 confirm that the outlet elevation is 159.6 masl.

To simulate the effects of the future agricultural use, the following modifications were made to the calibrated baseline model:

- Recharge zone 8 (representing recharge within the Southeast Quarry extraction area) was extended across the entire limit of extraction;
- The no-flow boundary condition was also extended across the limit of extraction; and
- Drain boundary reaches 30 and 31 were incorporated to simulate drainage along the former quarry floor and seepage from the quarry faces within the currently unexcavated portion of the Southeast Quarry. Properties for these reaches were consistent with reach 20 used to simulate existing conditions; however, the minimum floor drain elevation was reset to 159.6 masl to represent the outlet invert. It is noted that the invert elevation is marginally higher than the existing conditions sump elevation of 158.0 masl.

A.7.1.1 Predicted Effects

The simulated Lockport Formation and Rochester Formation groundwater contours for the future existing conditions scenario model are shown in **Figures A-9 and A-10**. The simulated groundwater flow directions in the future existing conditions model are similar to those included in the **Existing Conditions Report** and the baseline existing conditions model and confirm that inward gradients are predicted under future existing conditions.

The predicted impacts on the four residential well users are summarized in **Table A.7.1**.

Table A.7.1: Predicted Drawdown at Residential Wells Under Future Existing Conditions

	Residential Well 3 (9332 Thorold Stone Road)	Residential Well 7-2 (10056 Thorold Stone Road)	Residential Well 8-1 (3933 Thorold Townline Road)	Residential Well 14 (8865 Mountain Road)
Simulated Water Level in Existing Conditions Model (masl)	174.6	171.3	172.8	174.2
Simulated Water Level in Future Existing Conditions Model (masl)	174.5	171.3	172.8	173.9
Predicted Drawdown (m)	0.1	<0.1	<0.1	0.3
Estimated Available Drawdown (m)	8.9	11.1	7.6	13.2

In summary, marginal drawdowns are predicted under future existing conditions. The range of impacts vary from less than 0.1 m of drawdown at wells 7-2 and 8-1, up to 0.3 m at well 14. The slightly higher predicted drawdown at well 14 is not unexpected given that this is the closest residential well to the unexcavated portion of the Southeast Quarry. Nonetheless, the predicted drawdown is well within the available drawdown for the well, and therefore negative impacts to the operation of this well are not predicted.

Under future existing conditions, no negative impacts are predicted for the tributaries of 6 Mile Creek north of the SSA. Minimal groundwater flows discharge to these features under existing conditions, and flow volumes under future existing conditions remain the same at 0.3 m^3/day.

A.7.2 Proposed Landfill Operation Conditions Scenario

Under the proposed landfill operation conditions, the currently unexcavated portion of the Southeast Quarry limit of extraction would also be excavated to the same extent as the future existing conditions scenario. It is assumed for the purposes of this scenario that the proposed landfill liner has been fully constructed such that it covers the entire waste footprint.

As indicated in the **LCS Design Report**, the proposed liner design will consist of a sub-drain (i.e., relatively high hydraulic conductivity) layer placed on the former quarry floor and along the quarry faces at the outer edges of structural fill. The purpose of the sub-drain system is to facilitate drainage of potential groundwater accumulation below the liner, with a hydraulic connection to manhole MH7S and the WDS. The outlet discharge location will differ from the future existing conditions scenario; however, the outlet invert elevation of 159.6 masl remains the same. Manhole MH7S will be completed with a valve to control discharge to the WDS, which is to be operated in the “open” position under normal operation. Therefore, the no-flow and drain boundary conditions for the proposed landfill operation conditions scenario are identical to the future existing conditions scenario.

Likewise, the recharge zone was also extended across the entire limit of extraction; however, the zone number was changed to zone 5 to match conditions within the existing South Landfill, where negligible seepage from the liner is inferred due to the proposed double-layer liner design.

It is noted that the MH7S valve may be "closed" as a contingency for containment of potential landfill-influenced groundwater; an additional model scenario was prepared to evaluate the effects of the sub-drain valve closure and is summarized in **Section A.8.1** below.

A.7.2.1 Predicted Effects

The simulated Lockport Formation and Rochester Formation groundwater contours for the proposed landfill operation conditions scenario model are shown in **Figures A-11 and A-12**. The simulated groundwater flow directions in the proposed landfill operation conditions model are similar to those included in the **Existing Conditions Report** and the baseline existing conditions model and confirm that inward gradients are predicted under proposed landfill operation conditions.

The predicted impacts on the four residential well users are summarized in **Table A.7.2**.

Table A.7.2: Predicted Drawdown at Residential Wells Under Proposed Landfill Operation Conditions

	Residential Well 3 (9332 Thorold Stone Road)	Residential Well 7-2 (10056 Thorold Stone Road)	Residential Well 8-1 (3933 Thorold Townline Road)	Residential Well 14 (8865 Mountain Road)
Simulated Water Level in Existing Conditions Model (masl)	174.6	171.3	172.8	174.2
Simulated Water Level in Proposed Landfill Operation Conditions Model (masl)	174.5	171.3	172.8	173.8
Predicted Drawdown (m)	0.1	<0.1	<0.1	0.4
Estimated Available Drawdown (m)	8.9	11.1	7.6	13.2

In summary, the predicted marginal drawdowns are the same as the future existing conditions model, with the exception of a slightly larger drawdown of 0.4 m as well 14. The completion of the liner within the SSA will marginally reduce infiltration to the underlying bedrock, leading to slightly more drawdown at well 14 relative to the future existing conditions model. Nonetheless, the predicted drawdown is well within the available drawdown for the well, and therefore negative impacts to the operation of this well are not predicted.

Under the proposed landfill operation conditions, no negative impacts are predicted for the tributaries of 6 Mile Creek north of the SSA. Minimal groundwater flows discharge to these features under existing conditions and future existing conditions, and flow volumes under the proposed landfill operation conditions remain the same at 0.3 m^3/day.

A.7.3 Landfill Post-Closure Conditions Scenario

The main difference between the proposed landfill operation and post-closure conditions is the completion of waste filling and placement of the final cap. Estimated seepage from the landfill will remain negligible due to the operation of the double-layer liner. From a hydrogeological perspective, none of the boundary or recharge conditions used in the proposed landfill operation conditions model require adjustment to simulate post-closure conditions. Therefore, predicted impacts for post-closure conditions are identical to the proposed landfill operation conditions model impacts, and a separate landfill post-closure conditions model is not required.

A.8 CUMULATIVE IMPACT ANALYSIS

Additional scenario models were adapted from the future existing conditions and proposed landfill operation conditions models described above. A complete list of activities / projects both on- and off-Campus that were considered in the cumulative impact analysis is provided in **Section 6** of the **Geology and Hydrogeology Detailed Impact Assessment Report**. From this list, only the proposed Uppers Quarry in the southern portion of the RSA and golf course development to the east of the LSA are inferred to have a potential cumulative hydrogeological effect and require additional scenario models to quantify cumulative impacts. For conciseness, the scenario nomenclature presented in **Table A.8.1** was adopted.

Table A.8.1: Cumulative Impact Analysis Scenario Nomenclature

Nomenclature	Description
FB	Future existing conditions scenario model with no cumulative impacts
FBc1	Future existing conditions scenario model with Uppers Quarry
FBc2	Future existing conditions scenario model with Uppers Quarry and golf course development
FL	Proposed landfill operation conditions scenario with no cumulative impacts
FLc1	Proposed landfill operation conditions scenario with Uppers Quarry
FLc2	Proposed landfill operation conditions scenario with Uppers Quarry and golf course development

Simulation of the proposed Uppers Quarry was achieved using the same approach as was used to simulate the Southeast Quarry:

- No-flow boundary condition and recharge zone 8 simulated within the maximum proposed extraction limit to simulate worst-case effects; and
- Additional drain boundary reaches 40 and 41 were used to simulate the quarry sump in model layer 14 (i.e., base of quarry above the DeCew Formation) and quarry face seepage in model layers 1 through 13, with similar properties as reach 20 used to simulate the Southeast Quarry.

The proposed golf course development east of the LSA will require the use of irrigation wells to top up a future irrigation pond. Combined takings of up to 258 m^3/day are proposed during the irrigation season from three wells completed as open holes through the Lockport Formation bedrock and into the upper Rochester Formation shale. Drain boundary conditions were placed within each bedrock model layer at the three well locations with elevations set at 0.1 m above the layer bottom to maintain numerical stability and simulate the maximum cumulative effect. The exception was for the lowest drain boundary where the elevation was set at the reported bottom depths of the open holes. It is noted that the proposed combined daily takings from the three irrigation wells was not achieved in the model.

The cumulative impact scenario model results are summarized in **Table A.8.2**.

Table A.8.2: Summary of Cumulative Impact Analysis Results

	Scenario	Lockport / Rochester Contour Figure No.	Residential Well 3	Residential Well 7-2	Residential Well 8-1	Residential Well 14
Predicted Drawdown (m)	FB	**A-9 / A-10**	0.1	<0.1	<0.1	0.3
	FBc1	**A-13 / A-14**	2.3	0.9	<0.1	0.9
	FBc2	**A-15 / A-16**	2.4	0.9	<0.1	4.3
	FL	**A-11 / A-12**	0.1	<0.1	<0.1	0.4
	FLc1	**A-17 / A-18**	2.3	0.9	<0.1	1.2
	FLc2	**A-19 / A-20**	2.4	1.0	<0.1	4.7
Estimated Available Drawdown (m)			8.9	11.1	7.6	13.2

For both the future existing conditions and proposed landfill operation conditions models, the incorporation of the proposed Uppers Quarry (i.e., scenarios FBc1 and FLc1) does not affect the general groundwater flow patterns observed in the models where Uppers Quarry is not included in the simulation (i.e., scenarios FB and FL). For the scenarios which consider Uppers Quarry and the golf course development (i.e., scenarios FBc2 and FLc2), the groundwater contours are influenced by the proposed irrigation well pumping to the east of the LSA. In general, the water table is somewhat “flattened” within the future golf course property. However, inward gradients persist around the SSA, similar to existing conditions.

Both the future existing conditions and proposed landfill operation conditions generally result in similar drawdown impacts to the residential well users. More substantial impacts are observed for residential well 14 under the cumulative scenarios where the golf course development is included (i.e., scenarios FBc2 and FLc2). However, the maximum predicted drawdown at a single well in any of the cumulative scenarios (i.e., 4.7 m of drawdown at residential well 14 for scenario FLc2) only represents about 33% of the available drawdown. Therefore, negative impacts due to cumulative effects to the operation of these wells for domestic purposes are not predicted.

A.8.1 Landfill Sub-Drain Valve Closure Scenario

As noted previously, the MH7S valve may be closed to provide containment of potential landfill-influenced groundwater as a contingency. An additional model scenario was created to simulate this contingency, based on the proposed landfill operation conditions with cumulative effects scenario model “FLc2” described above.

To simulate this scenario, the drain boundaries (reaches 20 and 30) within the South Landfill Phase 2 footprint were removed from the model. In addition, the conductance for the wall drains (reaches 20 and 31) was reduced to 0.02 m^2/day to match the boundaries for the East and South Landfills, which simulate potential lateral inflows to the landfill through the clay liner sidewalls as noted in **Section A.4.3.3**.

The simulated Lockport Formation and Rochester Formation groundwater contours for the sub-drain valve closure scenario model are shown in **Figures A-19A and A-20A**. Similar to the cumulative impact analysis scenarios presented above, the groundwater contours are flattened within the future golf course property; however, inward gradients persist around the SSA. Therefore, the presence of the inward groundwater gradients is not predicted to be impacted in the event of closure of the sub-drain valve for contingency purposes.

This model scenario also provides an uncertainty analysis to assess the effects of failure of the 1,200 mm solid drainage pipe to provide drainage to the Old Welland Canal. As noted above, in the event that the 1,200 mm drainage pipe is no longer functional, groundwater within and below the sub-drain would continue to be drawn to the GWCS and the inward groundwater gradients would be maintained.

A.8.2 Uncertainty Analysis

An uncertainty analysis was completed in an attempt to quantify the effects of model parameter uncertainty on the predictive scenario outcomes. The methodology for the uncertainty analysis involved systematically altering selected hydraulic conductivity zone values by an order of magnitude both greater than and less than the calibrated values, while remaining within the previously established ranges in the **Existing Conditions Report** (Anderson & Woessner, 1992). For this analysis, only the three most sensitive hydraulic conductivity / vertical anisotropy zones identified in the sensitivity analysis presented above were included. It is noted that uncertainty in the recharge zone values is addressed as part of the climate change scenario models below.

Since the scenario modeling completed for the cumulative impact analysis for both Uppers Quarry and the golf course development represents the “worst-case” conditions for off-site groundwater users and receptors (i.e., scenarios FBc2 and FLc2), the uncertainty analysis was only completed on these models.

The uncertainty analysis scenario nomenclature and parameter values are summarized in **Table A.8.3**.

Table A.8.3: Cumulative Impact Analysis Scenario Nomenclature

Nomenclature	Description	Parameter Zones	K_H (m/d)	K_V (m/d)
FBc2a / FLc2a	Gasport Member bedrock horizontal hydraulic conductivity	5 / 6 / 16	1.2×10^{-4}	1.2×10^{-6}
FBc2b / FLc2b			1.2×10^{-2}	1.2×10^{-4}
FBc2c / FLc2c	Weathered Goat Island Member bedrock horizontal hydraulic conductivity	17	1.43	0.014
FBc2d / FLc2d			143	1.4
FBc2e / FLc2e	Gasport Member bedrock vertical anisotropy	5 / 6 / 16	1.2×10^{-3}	1.2×10^{-6}
FBc2f / FLc2f			1.2×10^{-3}	1.2×10^{-4}

The uncertainty analysis scenario model results are summarized in **Table A.8.4**.

Table A.8.4: Summary of Uncertainty Analysis Results

	Scenario	Lockport / Rochester Contour Figure No.	Residential Well 3	Residential Well 7-2	Residential Well 8-1	Residential Well 14
Predicted Drawdown (m)	FBc2	**A-15 / A-16**	2.4	0.9	<0.1	4.3
	FBc2a	**A-21 / A-22**	2.7	1.9	<0.1	5.3
	FBc2b	**A-23 / A-24**	2.4	0.7	<0.1	5.3
	FBc2c	**A-25 / A-26**	-0.9	1.4	0.1	1.7
	FBc2d	**A-27 / A-28**	3.2	-0.4	-0.4	4.9
	FBc2e	**A-29 / A-30**	2.8	1.9	<0.1	5.7
	FBc2f	**A-31 / A-32**	2.4	0.7	<0.1	4.6
	FLc2	**A-19 / A-20**	2.4	1.0	<0.1	4.7
	FLc2a	**A-33 / A-34**	2.7	1.9	<0.1	5.8
	FLc2b	**A-35 / A-36**	2.4	0.7	<0.1	5.5
	FLc2c	**A-37 / A-38**	-0.9	1.4	0.1	2.0
	FLc2d	**A-39 / A-40**	3.2	-0.4	-0.4	5.2
	FLc2e	**A-41 / A-42**	2.8	1.9	<0.1	6.2
	FLc2f	**A-43 / A-44**	2.4	0.7	<0.1	4.8
Estimated Available Drawdown (m)			8.9	11.1	7.6	13.2

Similar to the results for the cumulative impacts analysis above, the water table is “flattened” within the future golf course property, but inward gradients persist around the SSA as shown in the simulated groundwater contour figures noted in **Table A.8.4**.

The hydraulic conductivity values used for the uncertainty analysis result in a somewhat wider range of potential drawdown in the residential wells. As was the case above, more substantial impacts are observed for residential well 14. However, the maximum predicted drawdown at a single well in any of the uncertainty analysis scenarios (i.e., 6.2 m of drawdown at residential well 14 for scenario FLc2e) represents less than 50% of the available drawdown. Therefore, the results of the uncertainty analysis suggest that unforeseen negative impacts related to the uncertainty of the model parameters are not predicted.

A.9 CLIMATE CHANGE CONSIDERATIONS

Impacts to groundwater infrastructure are not identified as a current or future climate risk within the *Ontario Provincial Climate Change Impact Assessment Technical Report* (Climate Risk Institute and Dillon Consulting Ltd., January 2023). The report does contain multiple references that drought represents a potential impact to private well users within the LSA due to possible lowering of the local groundwater elevation within the aquifers. However, in the report on *Climate Projections for Niagara Region* (Toronto and Region Conservation Authority, February 2022), it is predicted that the average long-term annual precipitation amounts will increase from 1,081 mm/year under baseline (1971-2000) conditions to 1,192 mm/year under the "high-emission" scenario (i.e., Representative Concentration Pathway (RCP) 8.5) as defined by the Intergovernmental Panel on Climate Change (IPCC) (the nomenclature 8.5 refers to the 8.5 Watts/m^2 of additional energy predicted to be trapped by the atmosphere by the year 2,100 without mitigation). This represents a 10% increase in annual precipitation within the RSA.

Although the increased precipitation amounts will also increase the available water surplus (i.e., precipitation less evapotranspiration), actual infiltration to the groundwater system is subject to an upper limit based on properties of the surficial soils which are not impacted by climate change. During high-intensity rainfall events or when ground conditions are already saturated, excess water surplus will flow overland as runoff to local watercourses. Nevertheless, the climate change scenario modelled for this study assumes a 10% increase in infiltration to the groundwater system during the autumn period. As noted above, the climate change scenario was also used to assess model uncertainty with respect to the sensitive recharge parameters identified in **Section A.5.4**.

As noted previously, the scenario modeling completed for the cumulative impact analysis for both Uppers Quarry and the golf course development represents the "worst-case" conditions for off-site groundwater users and receptors (i.e., scenarios FBc2 and FLc2), and therefore the climate change scenario was only completed on these models. The recharge zone values were adjusted as shown in **Table A.9.1**.

Table A.9.1: Climate Change Scenario Recharge Zone Parameter Values

Zone	Description	Autumn Recharge Rates	
		mm	m/day
1	Weathered Silt and Clay (8a)	1.5	$1.6x10^{-5}$
2	Glaciolacustrine Sand and Gravel (9)	45	$4.9x10^{-4}$
3	Modern Fill (21)	45	$4.9x10^{-4}$
4	Paleozoic Bedrock Outcrops (3)	0	0
5	South Landfill	0	0
6	Closed West Landfill	45	$4.9x10^{-4}$
7	East Landfill	7	$8.2x10^{-5}$
8	Southeast Quarry / East Quarry Operations Area	45	$4.9x10^{-4}$

Note: Numbers in brackets in the zone description correspond to legend nomenclature in Ontario Geological Survey (OGS) surficial geology mapping.

It is noted that the recharge zone values for zones 4, 5 and 7 were not altered as they are not climate-dependant. The climate change scenario model results are summarized in **Table A.9.2**.

Table A.9.2: Summary of Climate Change Scenario Results

	Scenario	Lockport / Rochester Contour Figure No.	Residential Well 3	Residential Well 7-2	Residential Well 8-1	Residential Well 14
Predicted Drawdown (m)	FBc2	**A-15 / A-16**	2.4	0.9	<0.1	4.3
	FBc2g	**A-45 / A-46**	-0.4	<-0.1	<-0.1	-0.4
	FLc2	**A-19 / A-20**	2.4	1.0	<0.1	4.7
	FLc2g	**A-47 / A-48**	-0.4	-0.1	<-0.1	-0.3
Estimated Available Drawdown (m)			8.9	11.1	7.6	13.2

Similar to the results for the cumulative impacts and uncertainty analyses above, the water table remains “flattened” within the future golf course property when considering the increased recharge from climate change, but inward gradients persist around the SSA as shown in the simulated groundwater contour figures noted in **Table A.9.2**.

The predicted increase in recharge to the groundwater system from future climate change impacts somewhat mitigates the predicted drawdown at the residential wells, which is not unexpected. Therefore, the predicted effects of climate change will not have a negative impact on the operation of the residential wells.

Signature Page

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https://wsponlinecan.sharepoint.com/sites/ca-ca00372481905/shared documents/05. technical/100 groundwater & surface water consulting/ground water/2. detailed impact assessment - gw/appendix a/slf2 - gw model report_d2.docx

REFERENCES

Anderson, M. P., & Woessner, W. W. (1992). *Applied Groundwater Modeling: Simulation of Flow and Advective Transport.* Sandiego: Academic Press.

Bear, J. (1979). *Hydraulics of Groundwater.* Toronto: McGraw-Hill Book Company.

Climate Risk Institute and Dillon Consulting Ltd. (January 2023). *Ontario Provincial Climate Change Impact Assessment Technical Report.*

Doherty, J. (2015a). *Calibration and Uncertainty Analysis for Complex Environmental Models.* Brisbane, Australia: Watermark Numerical Computing.

Doherty, J. (2015b). *Groundwater Data Utilities.* Queensland, Australia: Watermark Numerical Computing.

Doherty, J. (May 2020). *PEST - Model-Independent Parameter Estimation and Uncertainty Analysis, User Manual: 7th Edition.* Queensland, Australia: Watermark Numerical Computing.

Domenico, P. A., & Schwartz, F. W. (1990). *Physical and Chemical Hydrogeology.* New York: John Wiley & Sons.

Environmental Simulations Inc. (2024). *Guide to Using Groundwater Vistas Version 9.* Reinholds, PA: Environmental Simulations Inc.

Environmental Systems Research Institute. (2021). *ArcGIS Desktop version 10.8.2.*

Freeze, R. A., & Cherry, J. A. (1979). *Groundwater.* Englewood Cliffs, N.J.: Prentice-Hall Inc.

Gartner Lee Limited. (2006). *Walker Environmental Assessment, Groundwater / Surface Water Impact Assessment.*

Harbaugh, A. W. (1990). *A computer program for calculating subregional water budgets using results from the U.S. Geological Survey modular three-dimensional groundwater flow model.* U.S. Geological Survey Open-File Report 90-392, 46 pp.

Muffels, C., Scantlebury, L., Wang, X., Tonkin, M., Neville, C. J., Ramadhan, M., & Craig, J. R. (November 2024). *User's Guide for mod-PATH3DU, A groundwater path and travel-time simulator.* Bethesda, Maryland: S.S. Papadopulos & Associates, Inc.

Ontario Geological Survey. (2003). Surficial Geology of Southern Ontario.

Panday, S. (March 2025). *USG-Transport Version 2.5.0: Transport and Other Enhancements to MODFLOW-USG.* GSI Environmental.

Panday, S., Langevin, C. D., Niswonger, R. G., Ibaraki, M., & Hughes, J. D. (2013). *MODFLOW-USG version 1: An unstructured grid version of MODFLOW for simulating groundwater flow and tightly coupled processes using a control volume finite-difference formulation.* U.S. Geological Survey Techniques and Methods, book 6, chap. A45, 66p.

S.S. Papadopulos & Associates, Inc. (February 2006). *Analysis of Groundwater Flow for the Walker Environmental Assessment.* Perpared for Walker Industries Holdings Limited.

Seequent. (2025). *Leapfrog Works, version 2025.1.* Seequent, The Bentley Subsurface Company.

Shepley, M. G. (2024). Vertical hydraulic conductivity and layered heterogeneity: from measurements to models. *Hydrogeology Journal, 32*, 1017-1042.

Spitz, K., & Moreno, J. (1996). *A Practical Guide to Groundwater and Solute Transport Modeling.* New York: John Wiley & Sons, Inc.

Toronto and Region Conservation Authority. (February 2022). *Climate Projections for Niagara Region.*

UEM & WSP Canada Inc. (in press). *April 2023 to March 2026 Monitoring Report, Closed West Landfill Site.* Prepared for Walker Environmental Group. WSP Project No CA0065322.8113.

UEM & WSP Canada Inc. (March 2026). *2025 Walker Brothers Quarry Aggregate License, Environmental Compliance Approval for Industrial Sewage Works and Permit to Take Water Annual Monitoring Report.* Prepared for Walker Aggregates Inc. WSP Project No. CA0065321.5057.

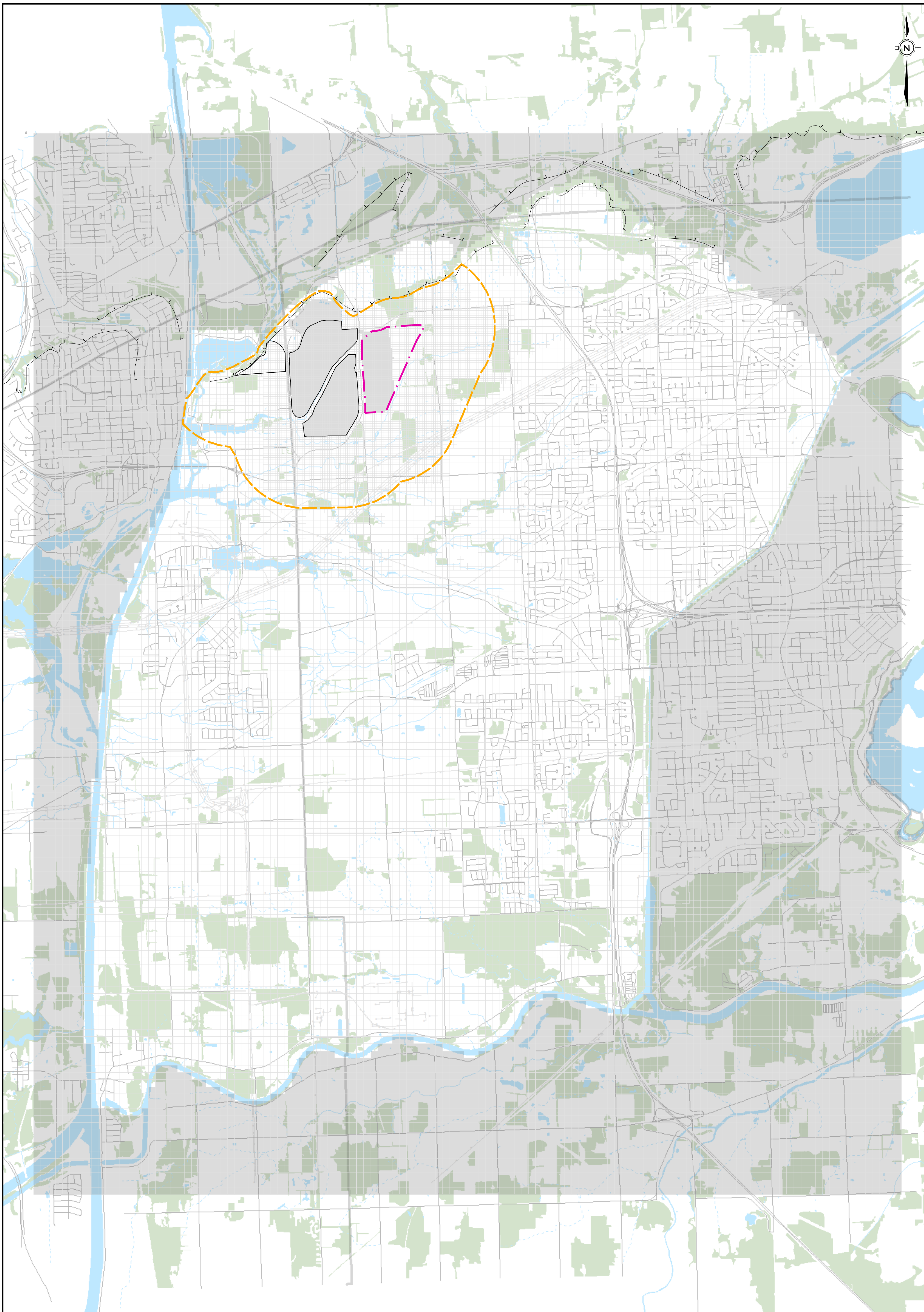
WSP Canada Inc. (June 2026a). *Geology and Hydrogeology Existing Conditions Report, Walker South Landfill Phase 2 Environmental Assessment.* Prepared for Walker Environment Group.

WSP Canada Inc. (June 2026b). *Leachate Containment System Design Description Report, South Landfill Phase 2 - Environmental Assessment.* Prepared for Walker Environment Group.

WSP Canada Inc. (October 2021). *Proposed Uppers Quarry, Level 1 and 2 Water Study Report.* Prepared for Walker Aggregates Inc.

Yager, R. M. (1996). *Simulated Three-Dimensional Groundwater Flow in the Lockport Group, a Fractured-Dolomite Aquifer near Niagara Falls, New York.* U.S. Geological Survey Water Supply Paper 2487.

Figures



LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

MODEL GRID

NO-FLOW BOUNDARY

0 1,000 2,000 m

NAD 1983 UTM Zone 17N

MODEL DOMAIN GRID

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 50,000
DRAWN BY:	JLD
FIGURE No:	A-1

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55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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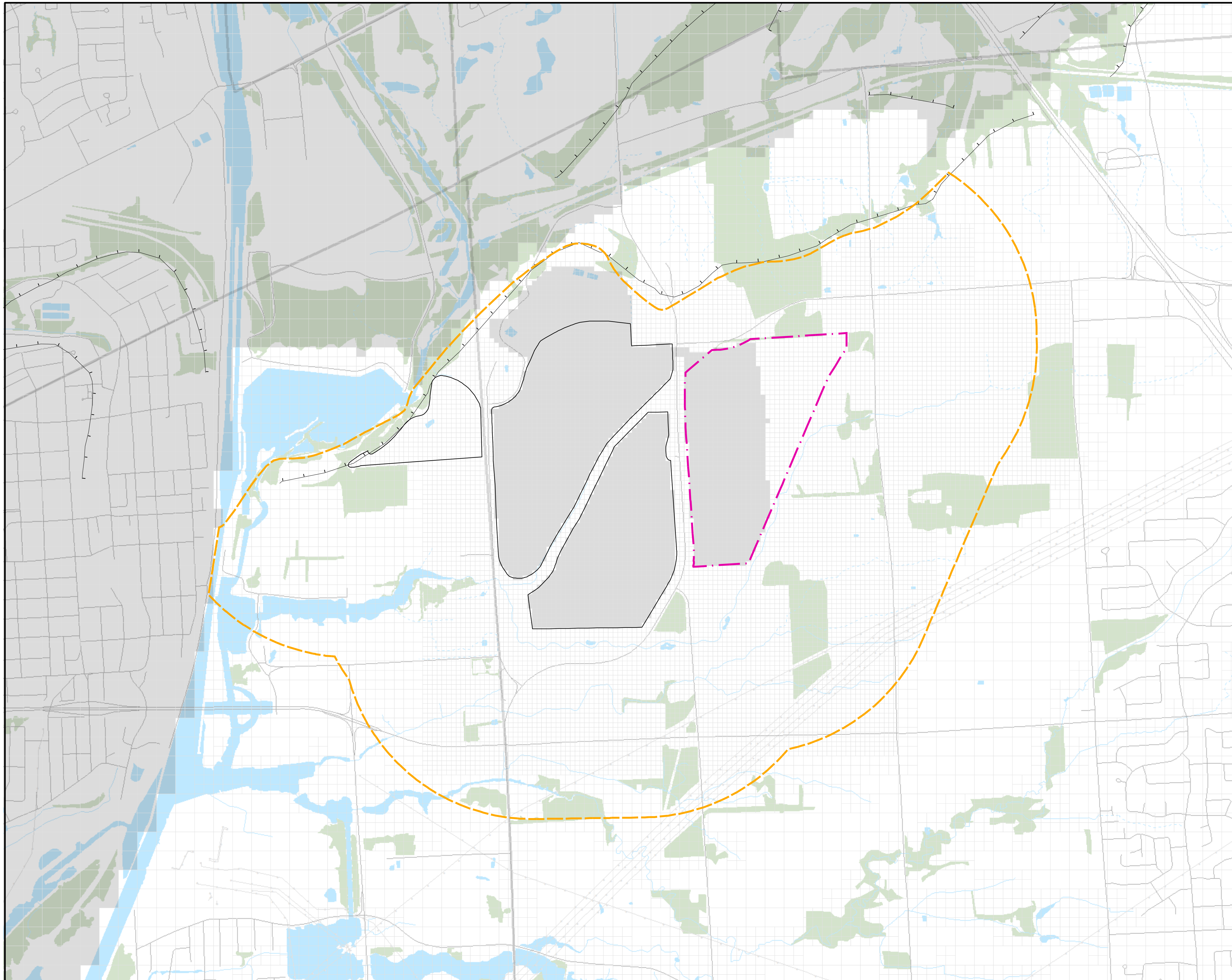

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- MODEL GRID
- NO-FLOW BOUNDARY

N

0 400 800 m

NAD 1983 UTM Zone 17N

LSA MODEL GRID

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
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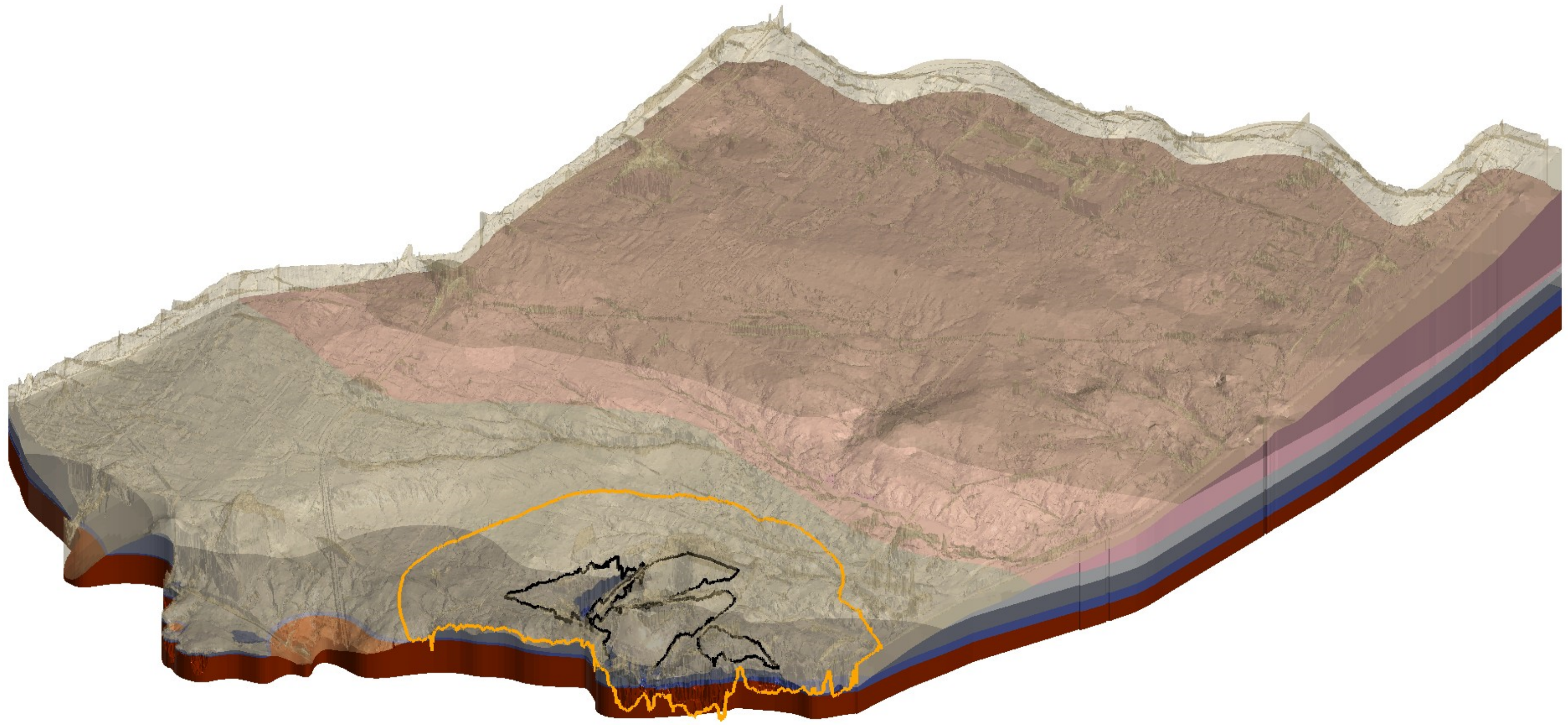
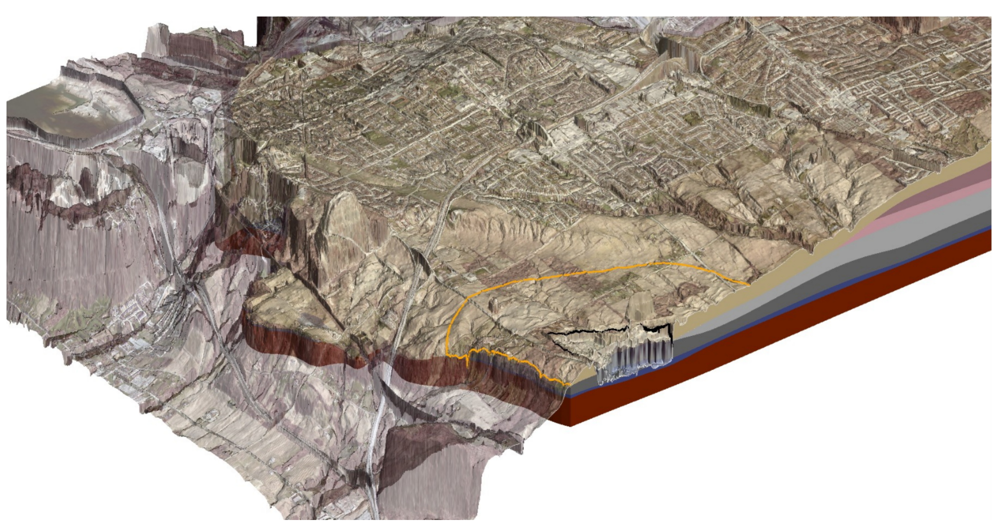
LEGEND

- Overburden
- Guelph
- Eramosa
- Lockport - Goat Island
- Lockport - Gasport
- DeCew
- Rochester



OBLIQUE VIEW OF MODEL DOMAIN
(LOOKING DOWN TO THE SOUTHEAST)
NOTE: OVERBURDEN IS TRANSPARENT SO UNDERLYING BEDROCK SUBCROPS ARE VISIBLE.



NORTH-SOUTH SECTION THROUGH LOCAL STUDY AREA (LSA)

EAST-WEST SECTION THROUGH LOCAL STUDY AREA (LSA)

3-DIMENSIONAL VIEWS OF GEOLOGICAL MODEL

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	NOT TO SCALE
DRAWN BY:	JLD
FIGURE No:	A-2

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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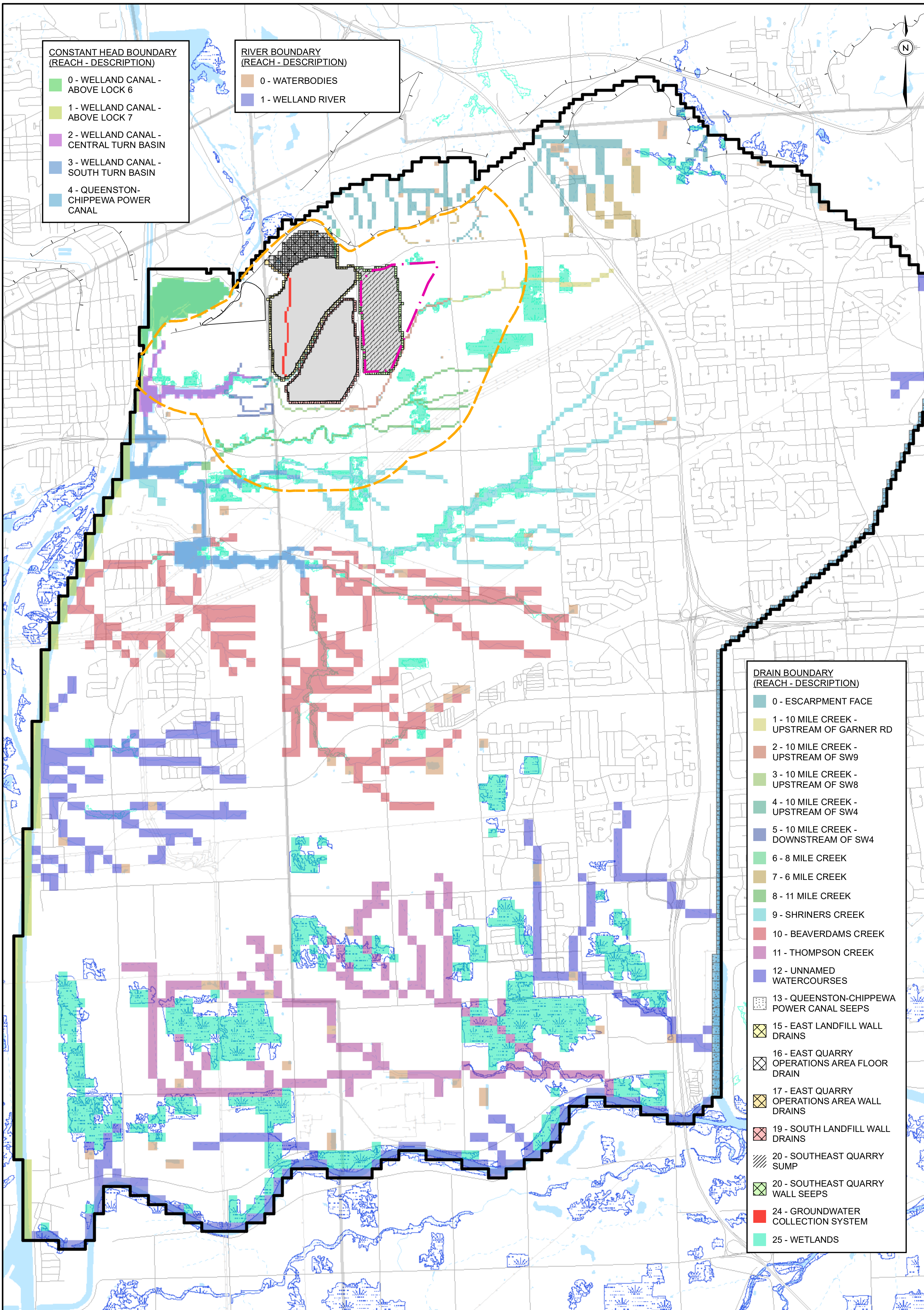

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS
SITE STUDY AREA (SSA)
LOCAL STUDY AREA (LSA)
ACTIVE MODEL DOMAIN
NO-FLOW BOUNDARY

0 800 1,600 m

NAD 1983 UTM Zone 17N

BOUNDARY CONDITIONS

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 40,000
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55 KING STREET, SUITE 600
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FIGURE No: **A-3**

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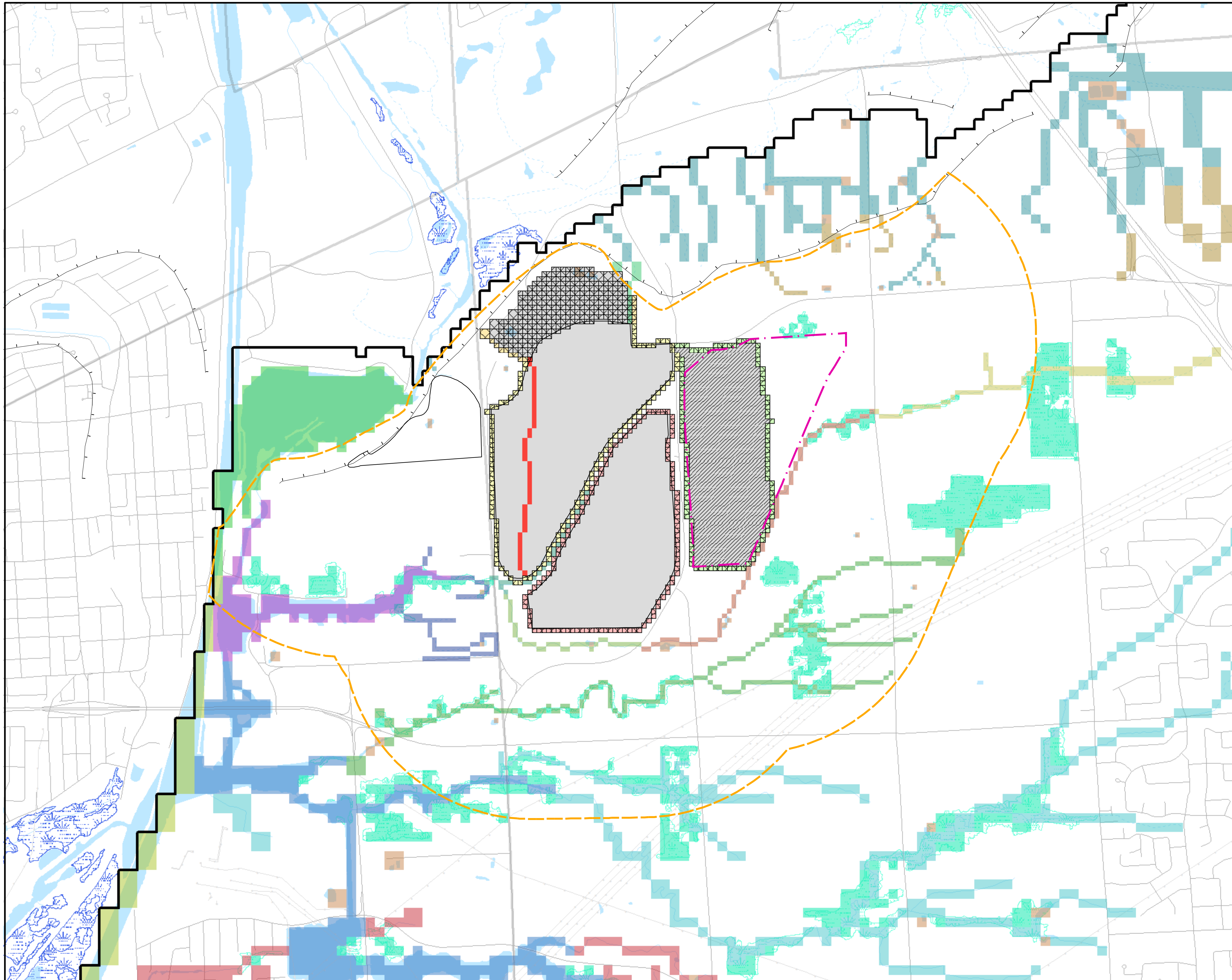

LSA BOUNDARY CONDITIONS

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
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FIGURE No:	A-3A

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ST. CATHARINES, ON L7R 3H5
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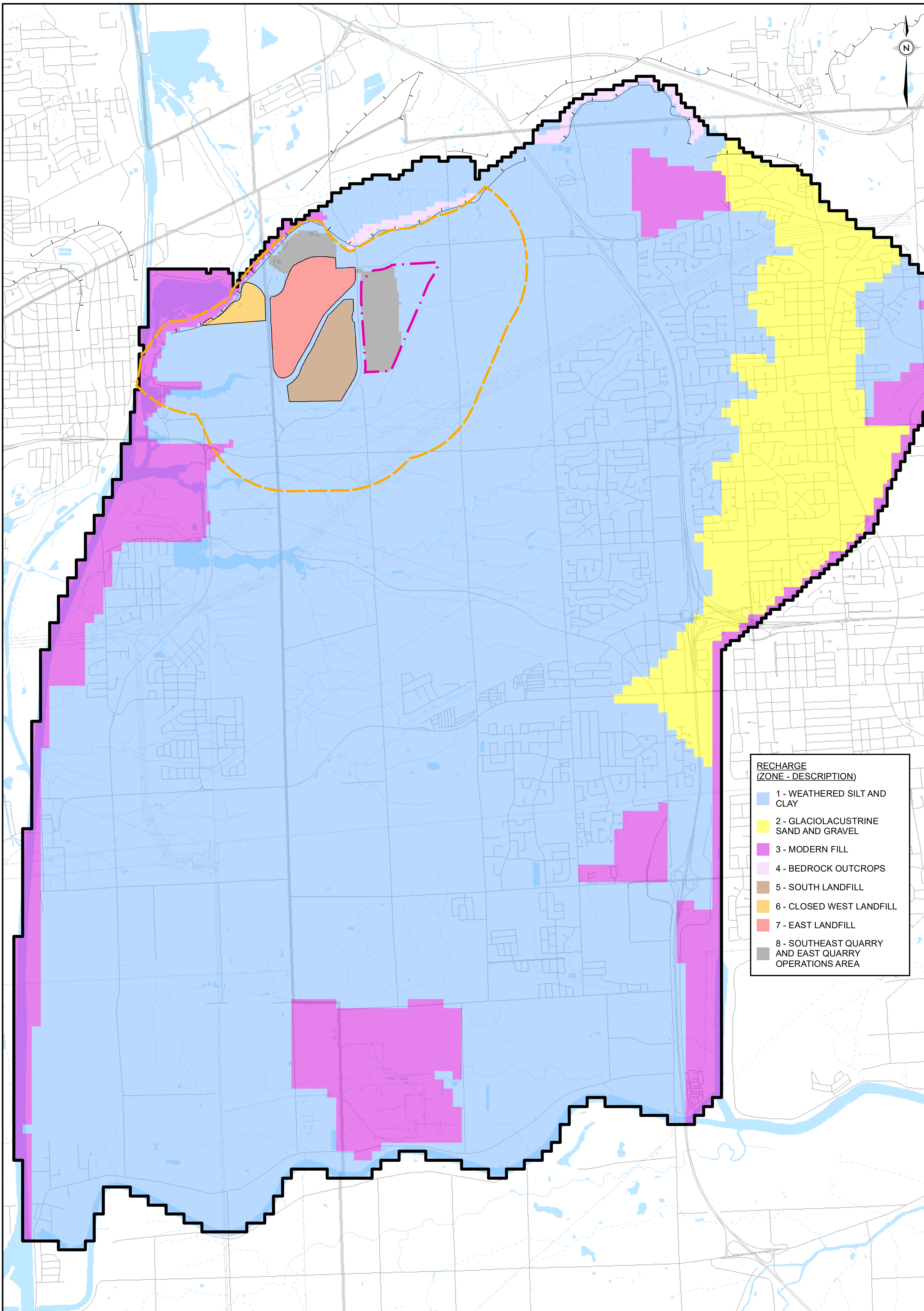

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

0 800 1,600 m

NAD 1983 UTM Zone 17N

RECHARGE ZONES

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 40,000
DRAWN BY:	JLD
FIGURE No:	A-4

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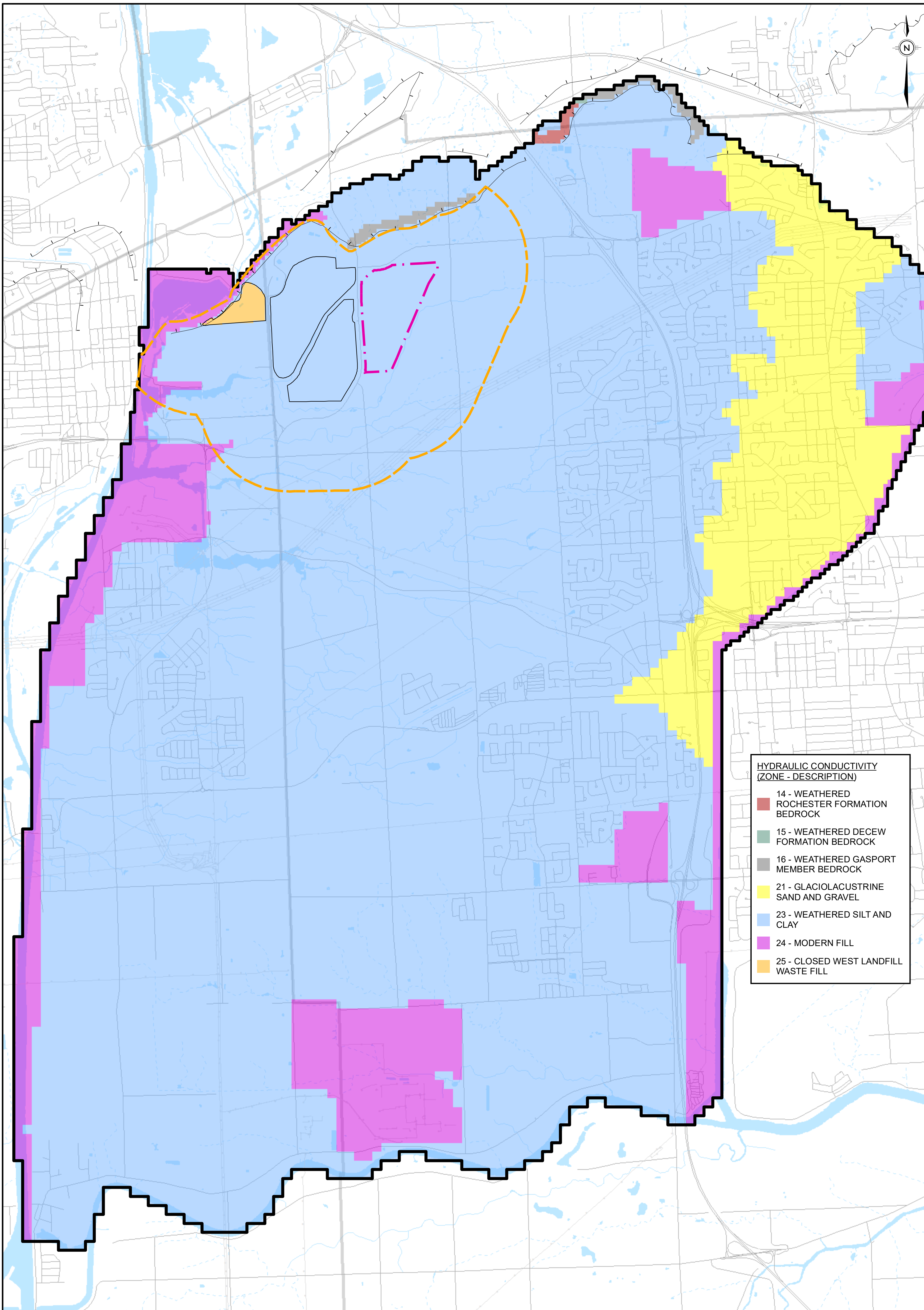

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

0 800 1,600 m

NAD 1983 UTM Zone 17N

LAYER 1 HYDRAULIC CONDUCTIVITY ZONES

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
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55 KING STREET, SUITE 600
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FIGURE No: A-5

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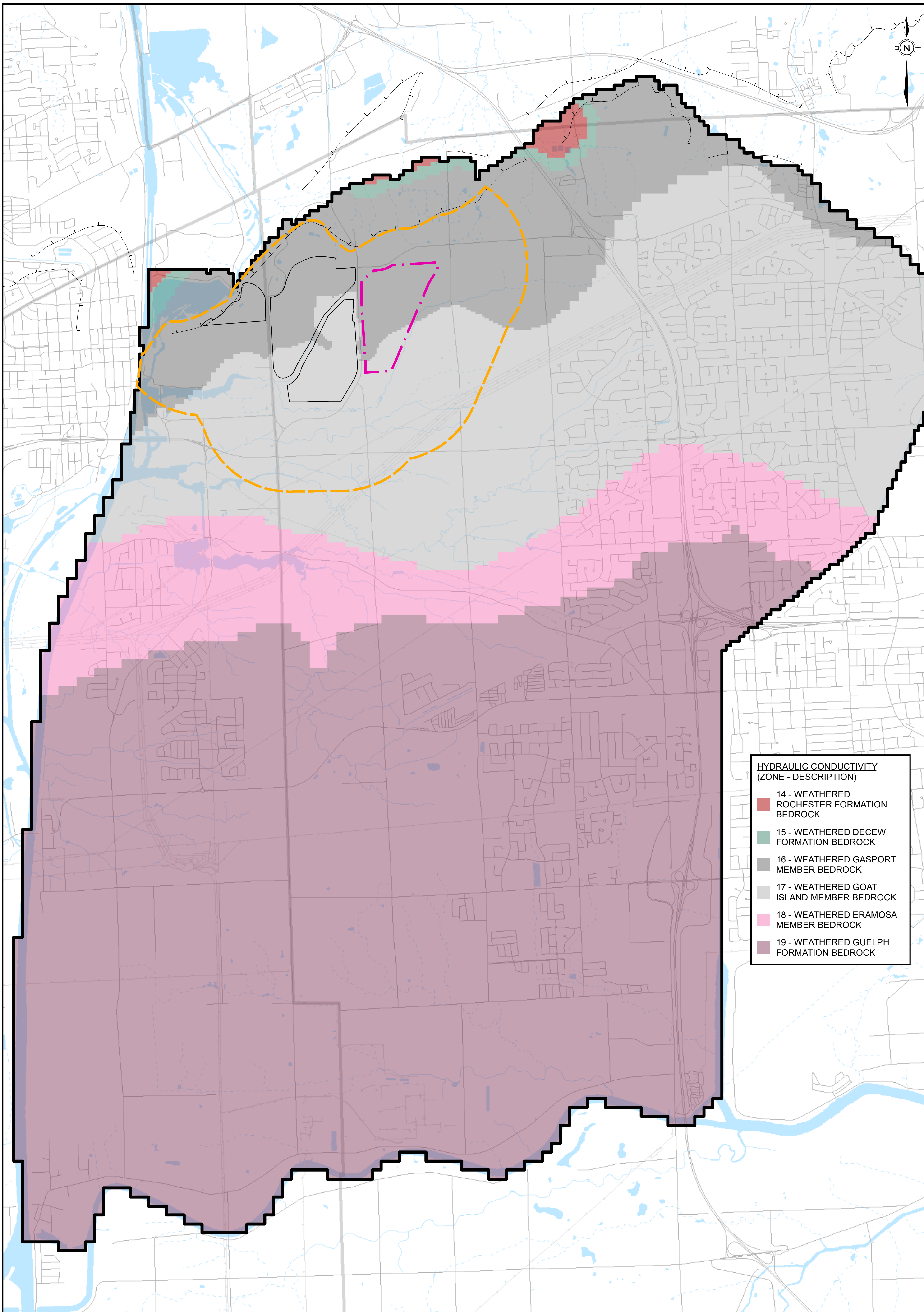

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

0 800 1,600 m

NAD 1983 UTM Zone 17N

LAYER 4 HYDRAULIC CONDUCTIVITY ZONES

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 40,000
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55 KING STREET, SUITE 600
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FIGURE No: A-6

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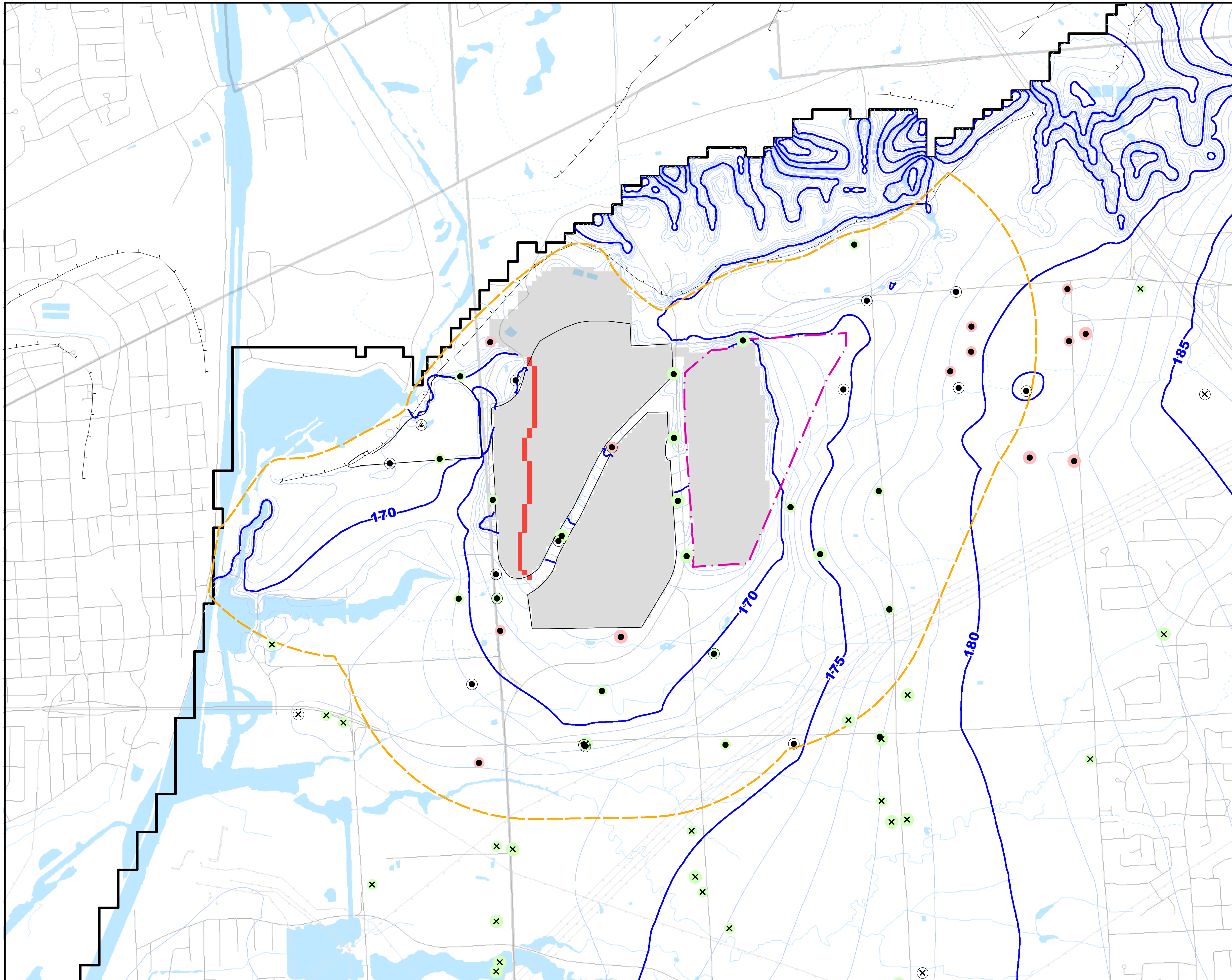

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

NO-FLOW BOUNDARY

LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

5 m INTERVALS

1 m INTERVALS

TARGET TYPE
(GROUP - DESCRIPTION)

1 - LSA BEDROCK WELLS

2 - LSA OVERBURDEN WELLS

5 - MECP WATER WELL RECORDS

RESIDUALS

OVER-PREDICTION > 2.5 m

OVER-PREDICTION 1 m - 2.5 m

± 1 m

UNDER-PREDICTION 1 m - 2.5 m

UNDER-PREDICTION > 2.5 m

N

0 400 800 m

NAD 1983 UTM Zone 17N

SPATIAL DISTRIBUTION OF CALIBRATED RESIDUALS - LOCKPORT FORMATION

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-7**

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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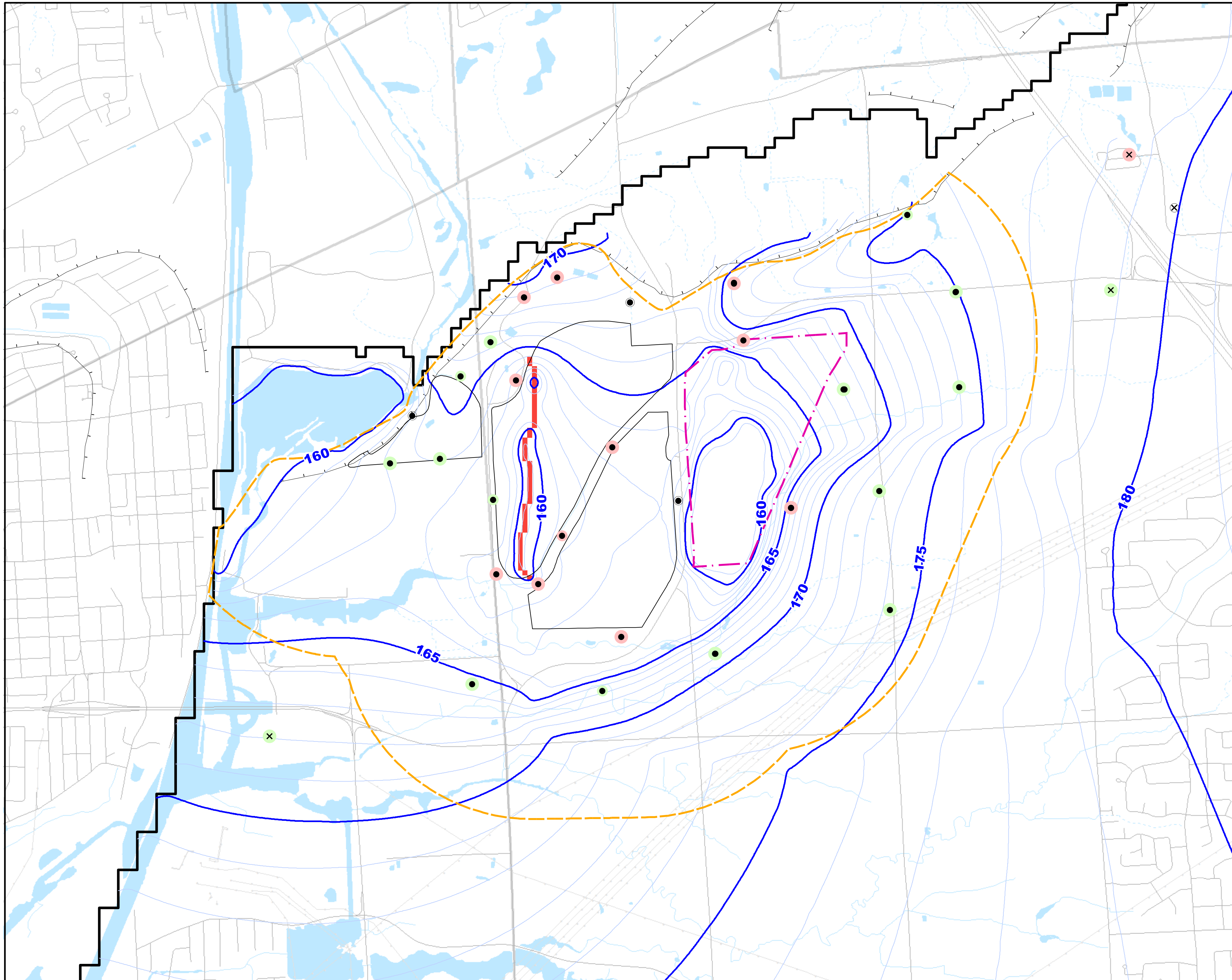

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

5 m INTERVALS

1 m INTERVALS

TARGET TYPE
(GROUP - DESCRIPTION)

1 - LSA BEDROCK WELLS

5 - MECP WATER WELL RECORDS

RESIDUALS

OVER-PREDICTION > 2.5 m

OVER-PREDICTION 1 m - 2.5 m

± 1 m

UNDER-PREDICTION 1 m - 2.5 m

UNDER-PREDICTION > 2.5 m

N

0 400 800 m

NAD 1983 UTM Zone 17N

SPATIAL DISTRIBUTION OF CALIBRATED RESIDUALS - ROCHESTER FORMATION

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: A-8

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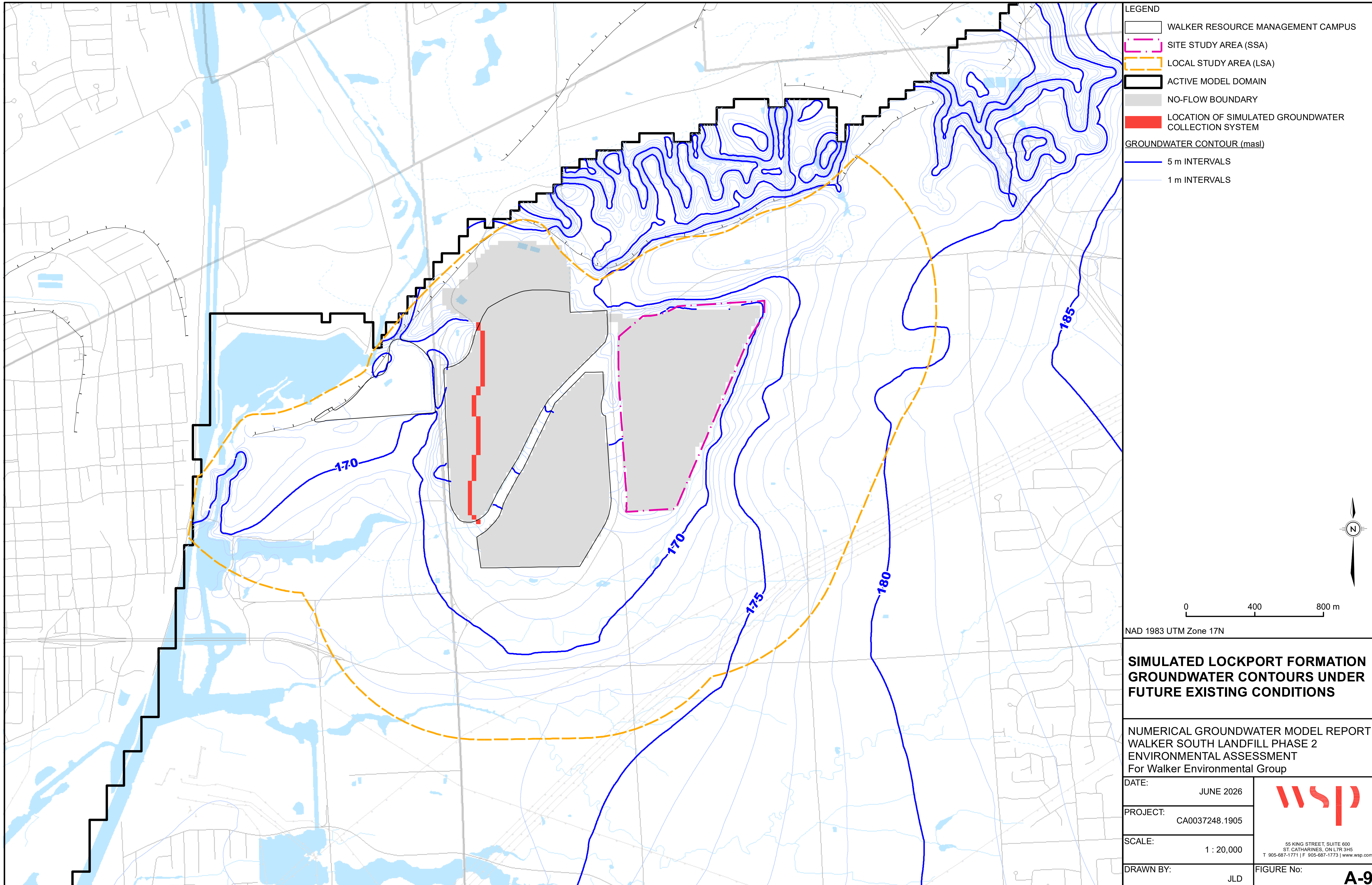

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP 55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-9

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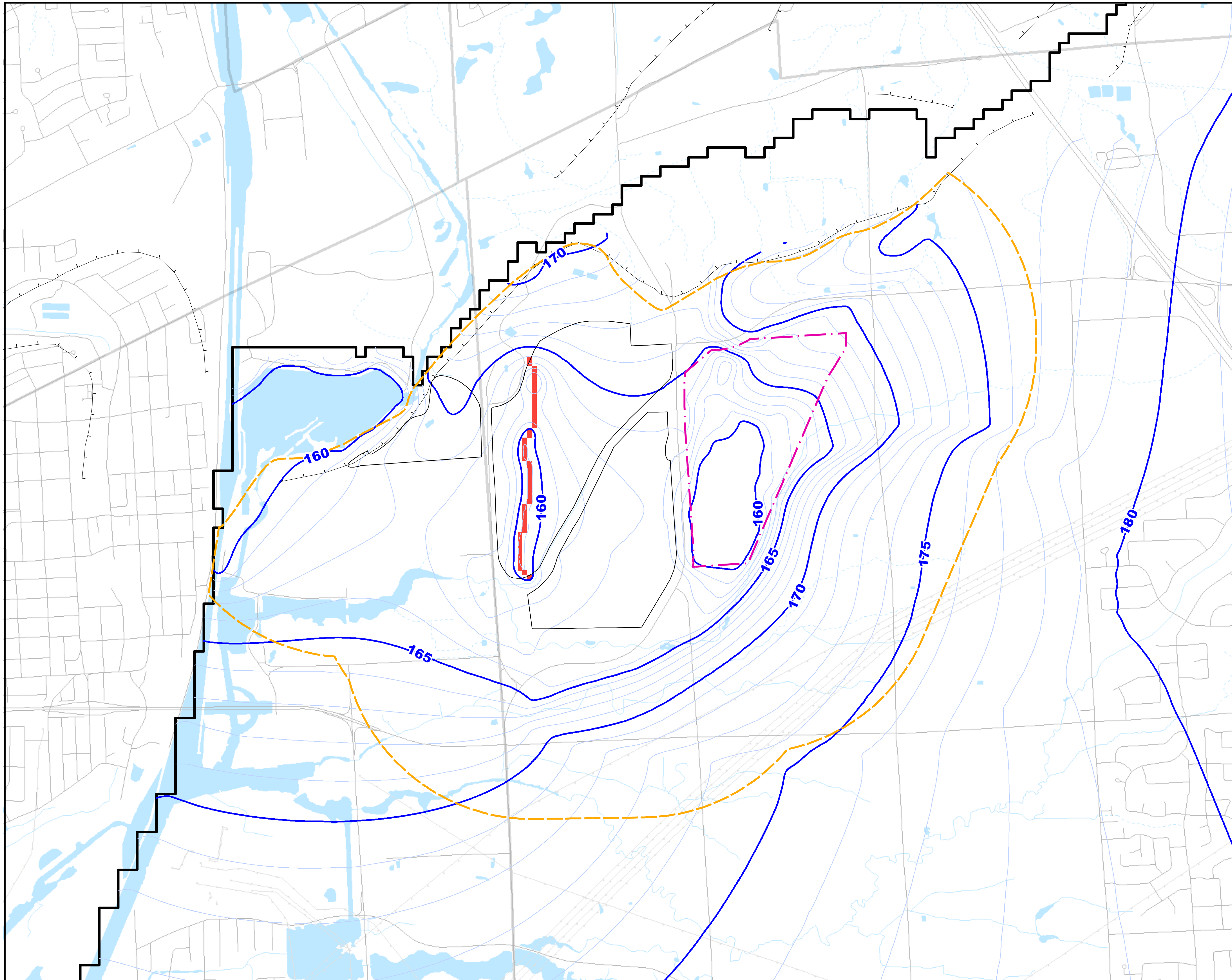

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-10

wsp
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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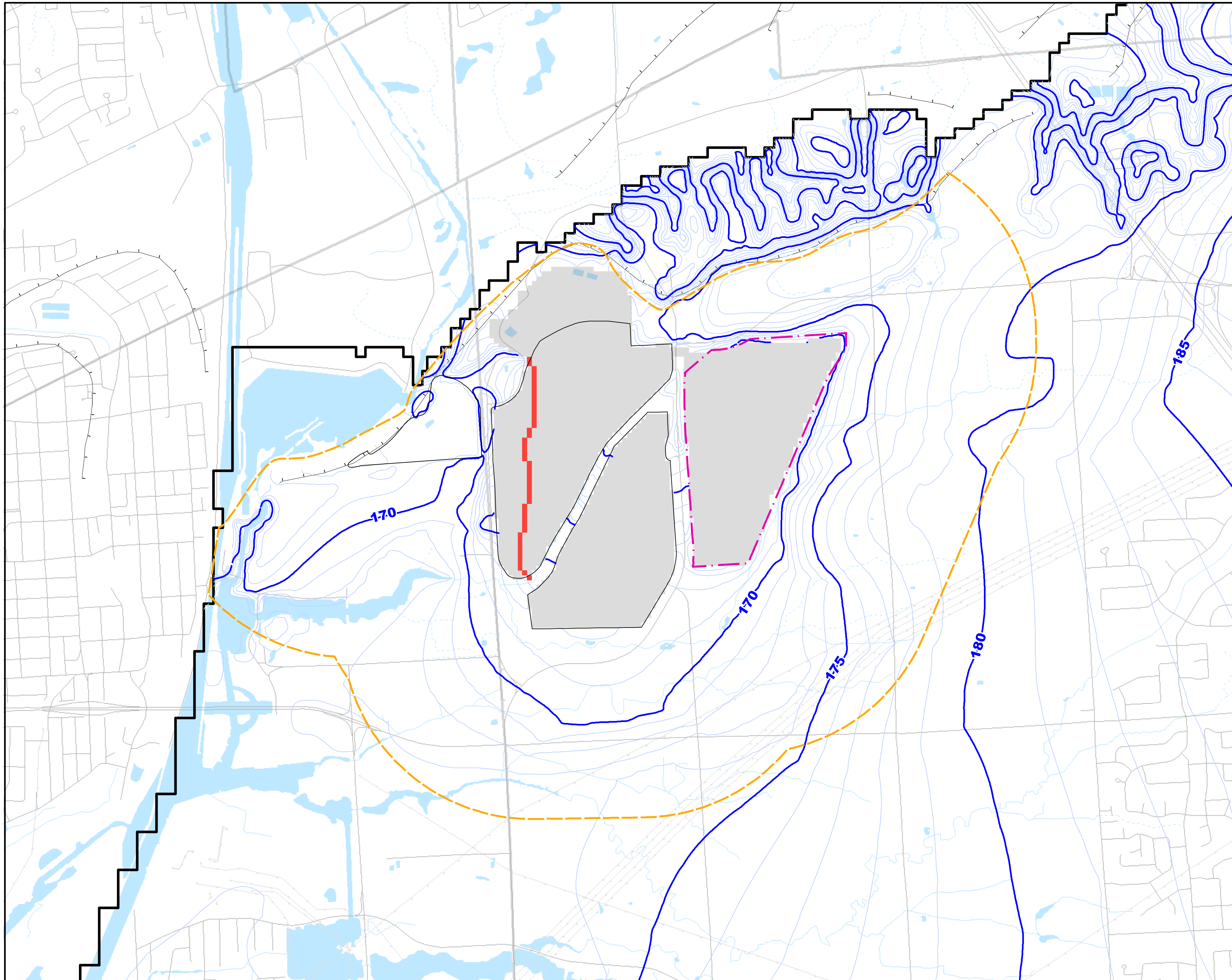


LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

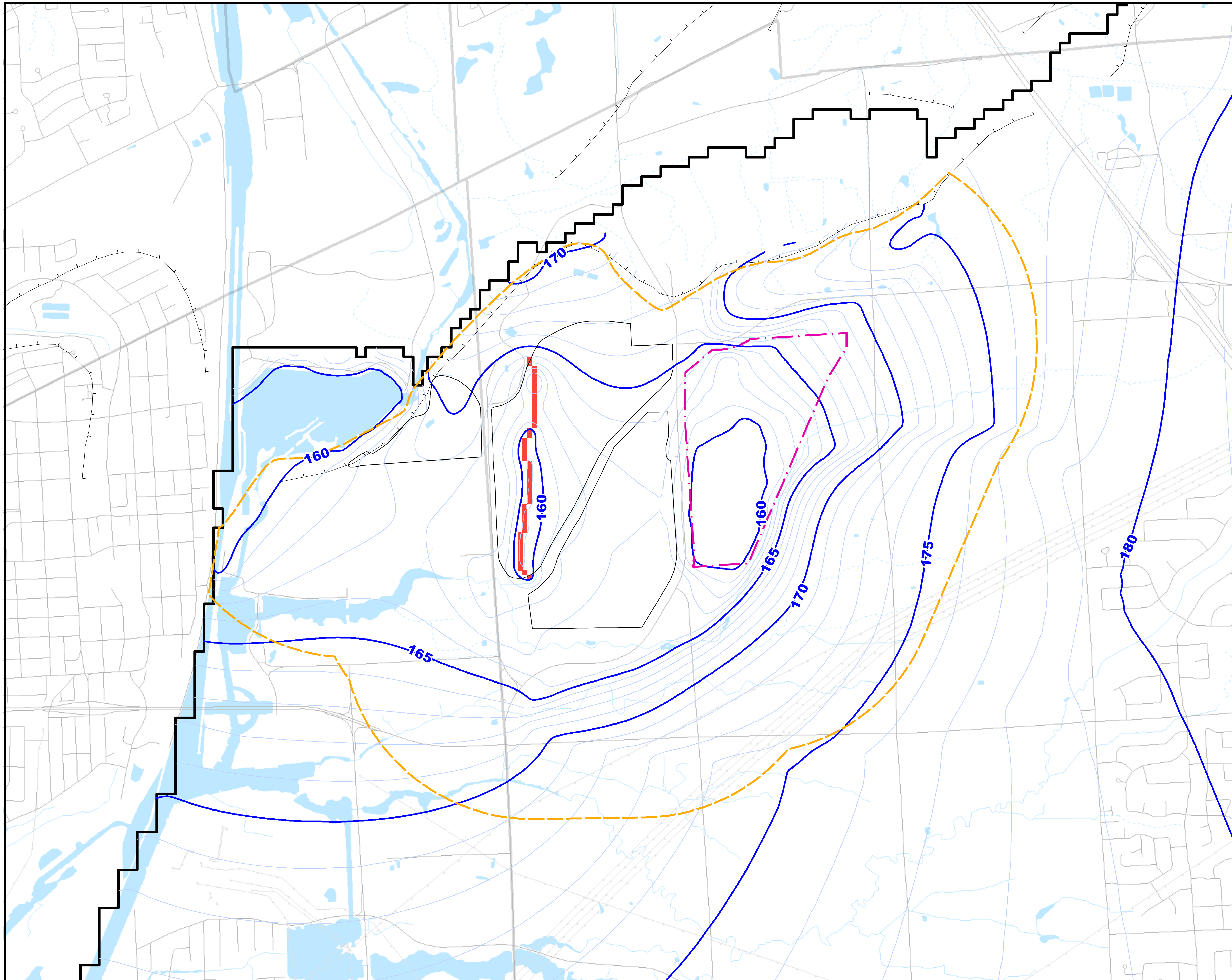
SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

FIGURE No: **A-11**



LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: **A-12**

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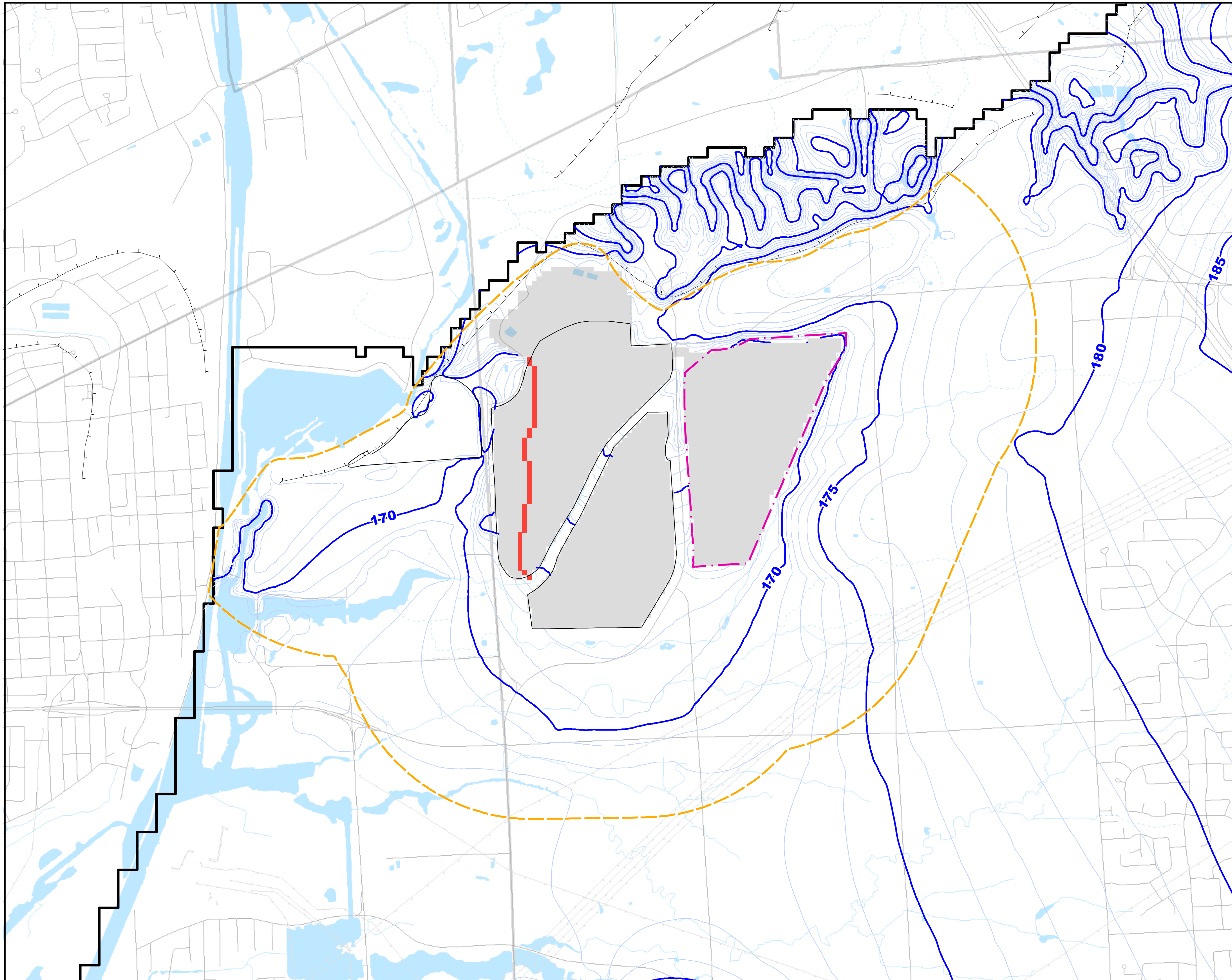

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS CUMULATIVE IMPACT SCENARIO FBc1

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-13

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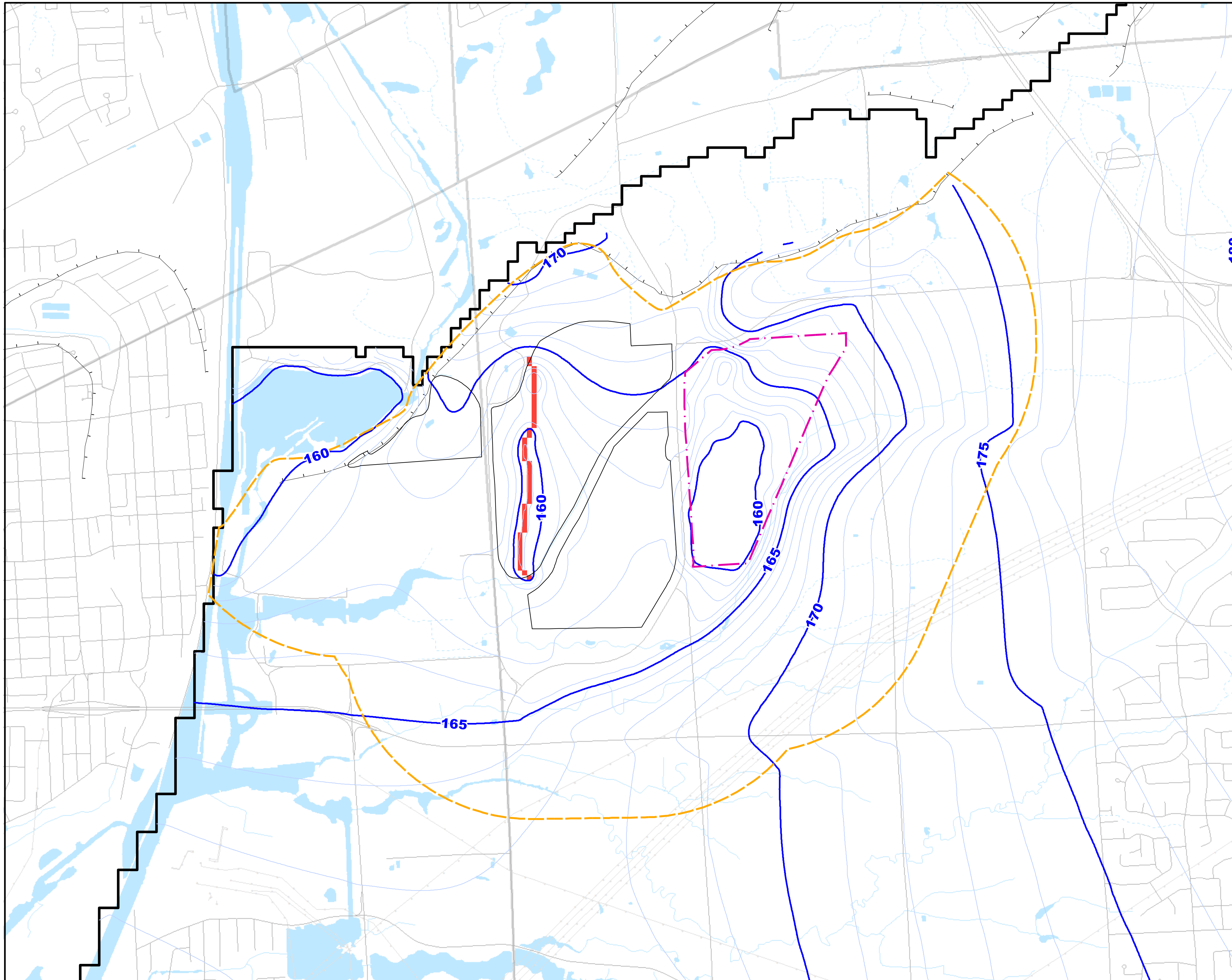

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS CUMULATIVE IMPACT SCENARIO FBc1

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2 ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-14

WSP
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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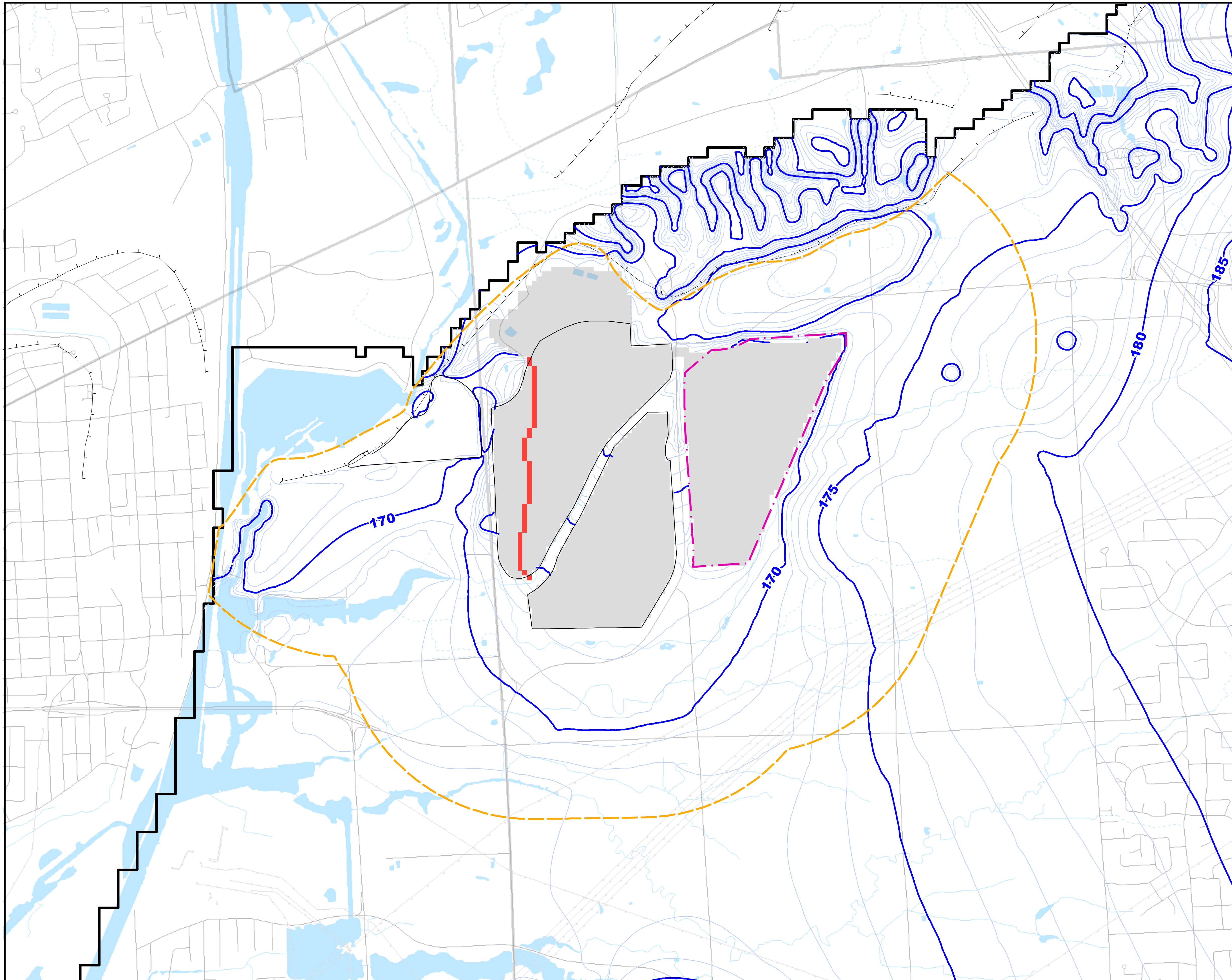

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS CUMULATIVE IMPACT SCENARIO FBc2

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-15

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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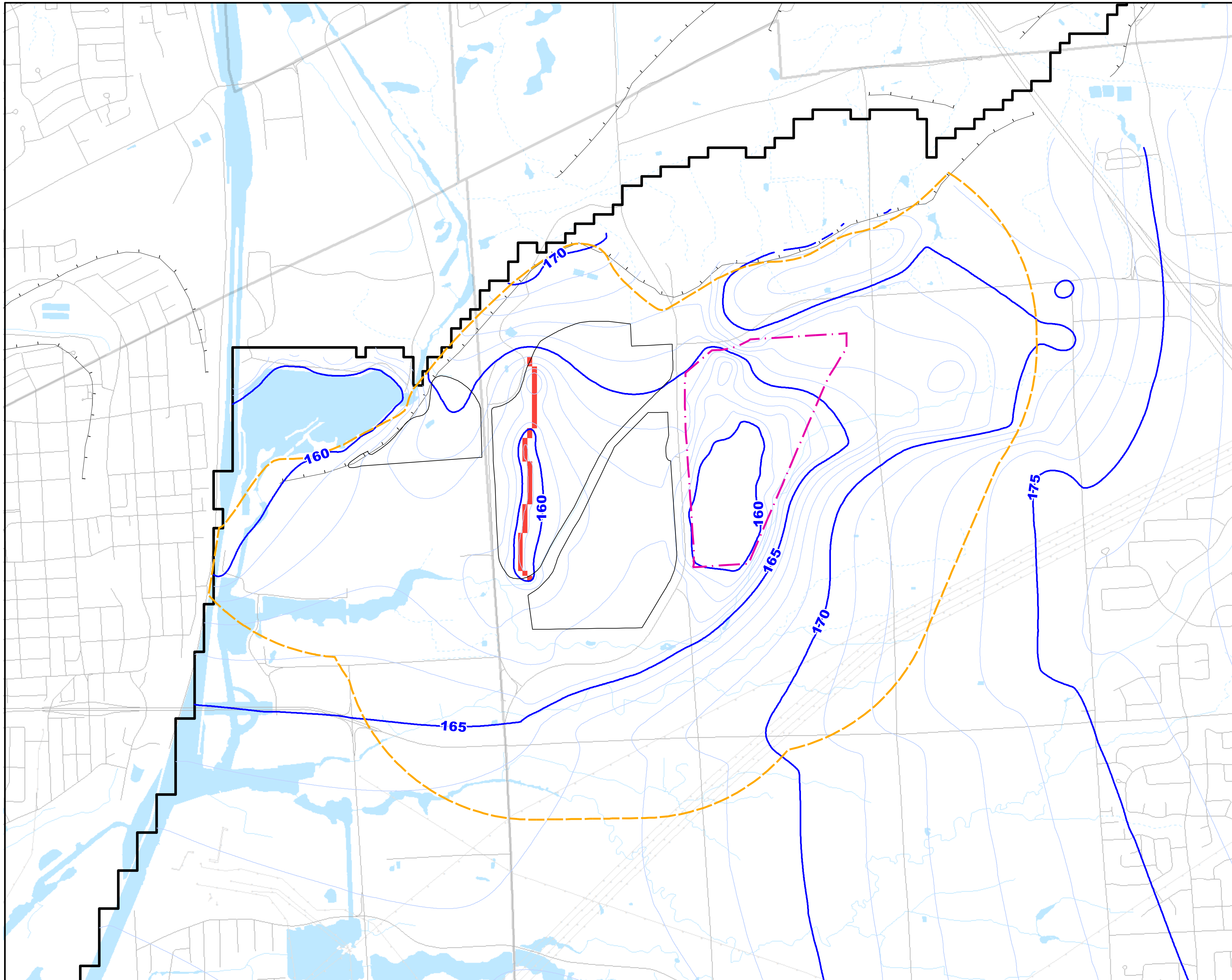

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS CUMULATIVE IMPACT SCENARIO FBc2

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-16

WSP
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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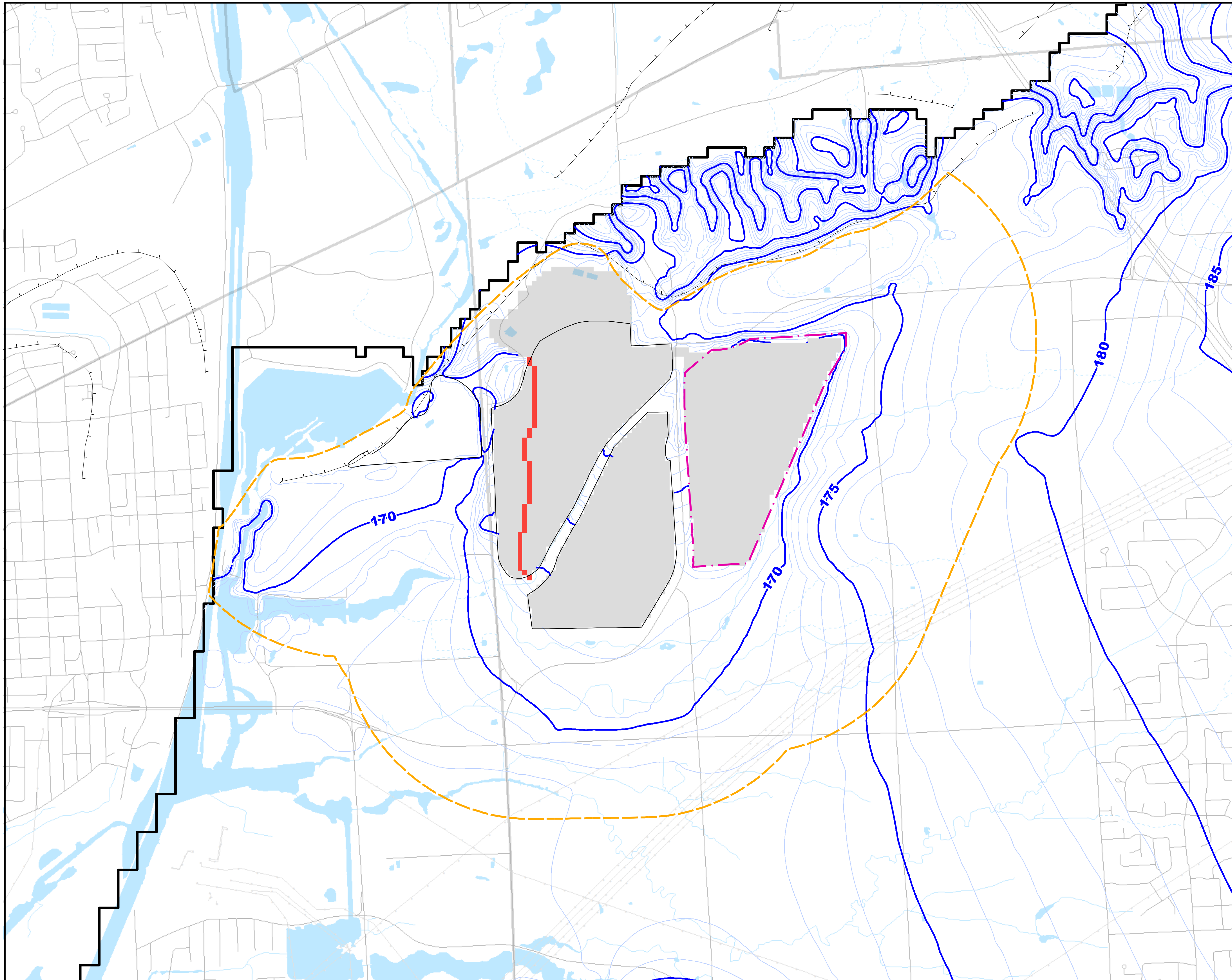

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS CUMULATIVE IMPACT SCENARIO FLc1

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	wsp
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: **A-17**

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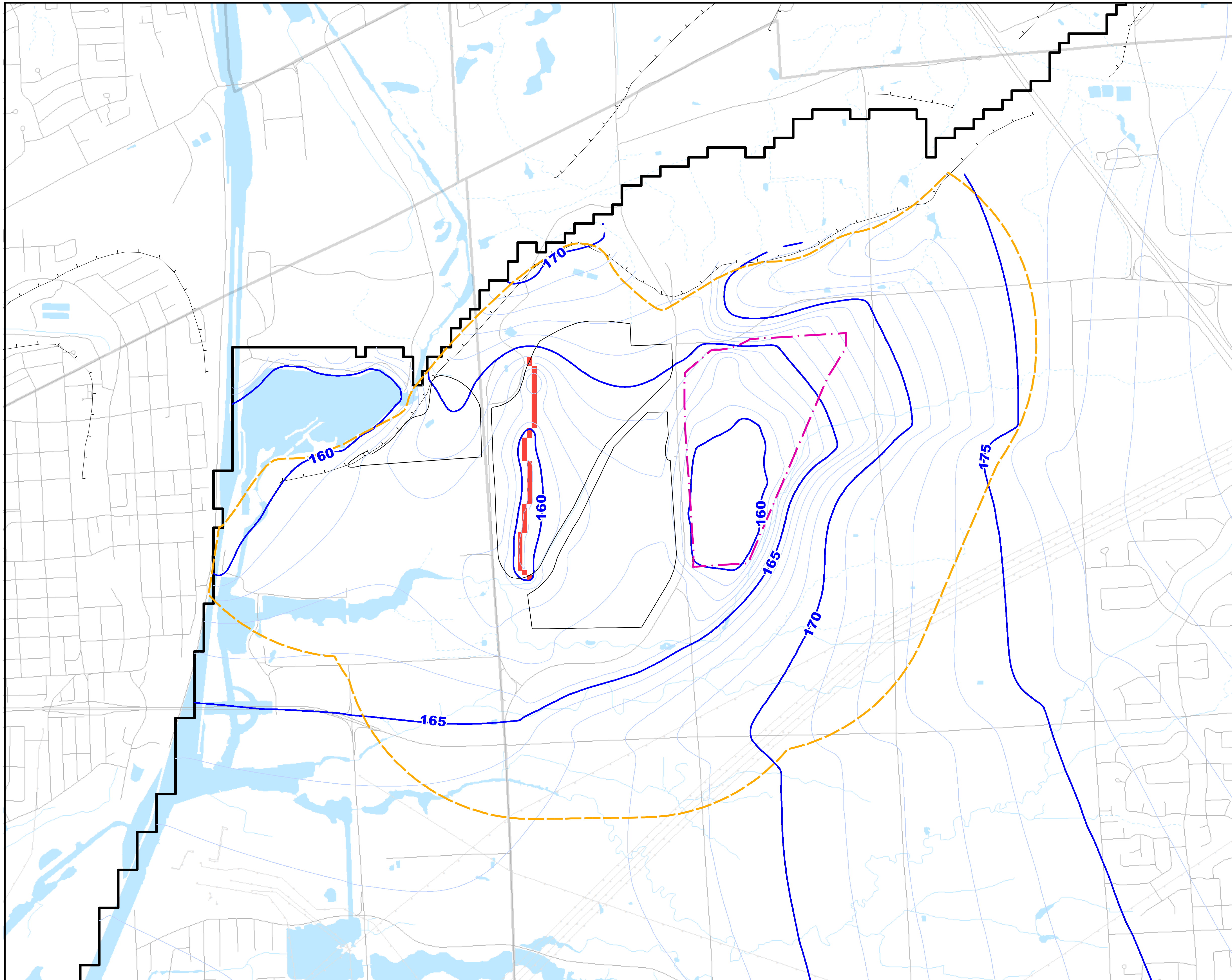

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS CUMULATIVE IMPACT SCENARIO FLc1

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: A-18

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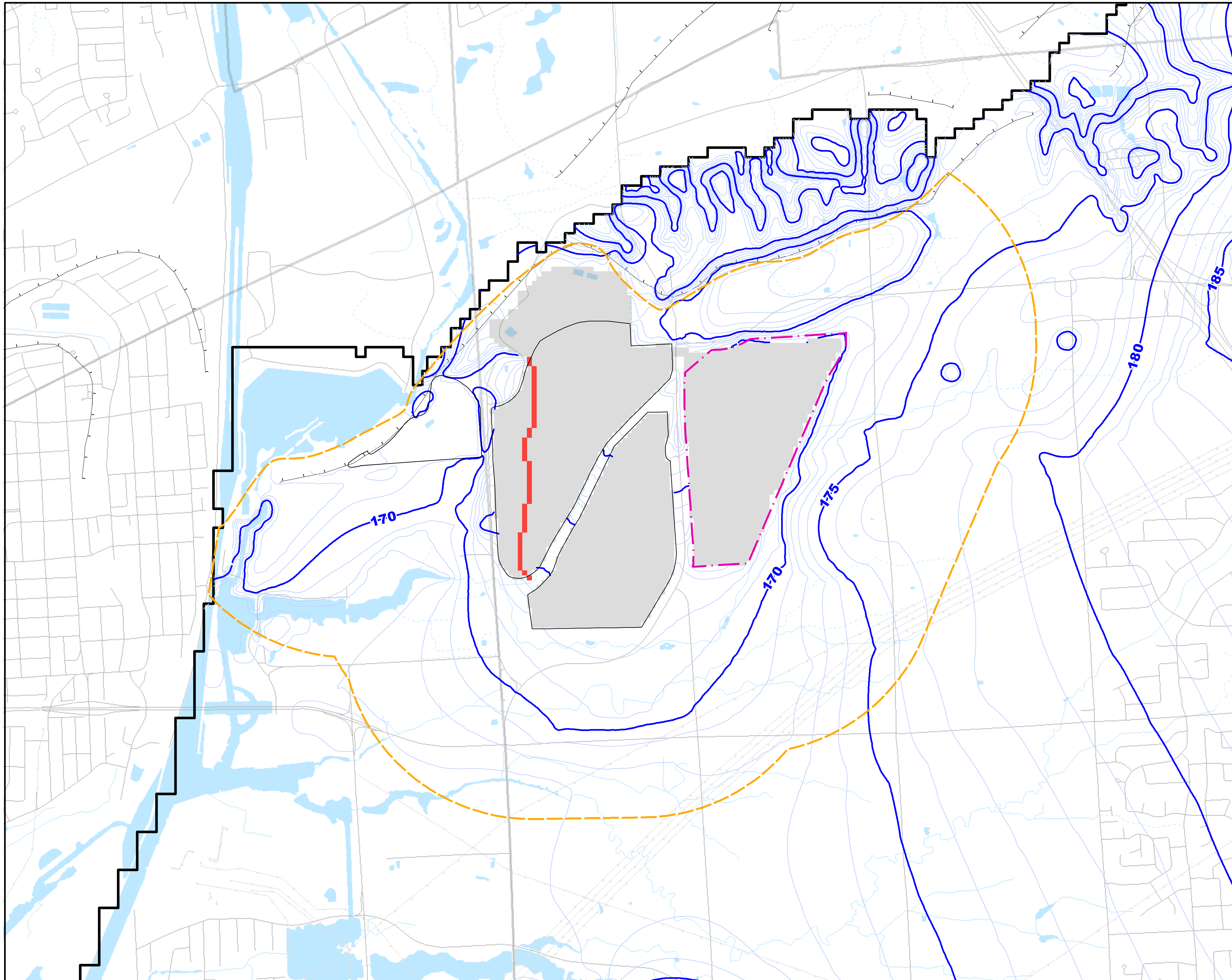

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS CUMULATIVE IMPACT SCENARIO FLc2

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: A-19

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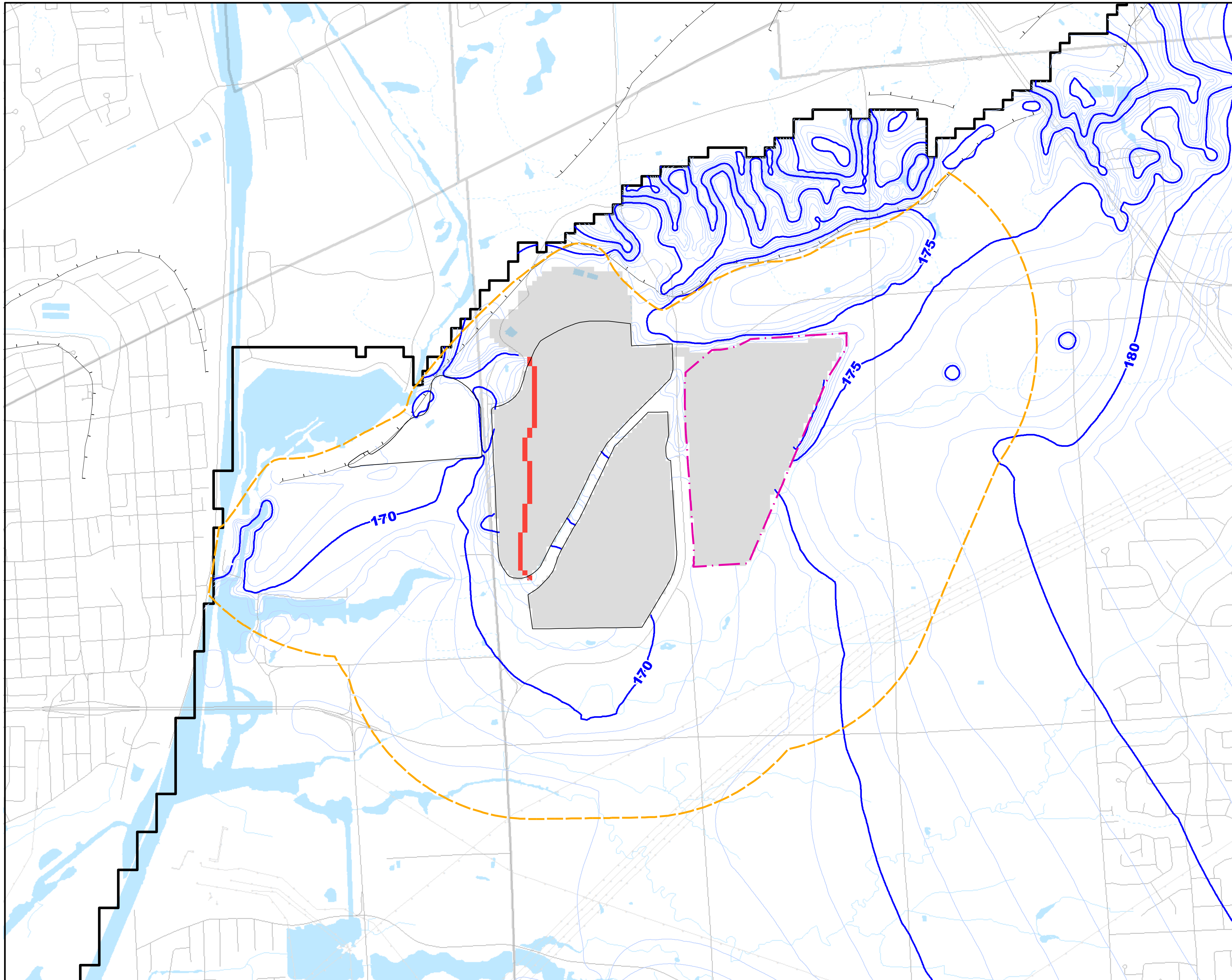

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS WITH SUB-DRAIN VALVE CLOSURE

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-19A

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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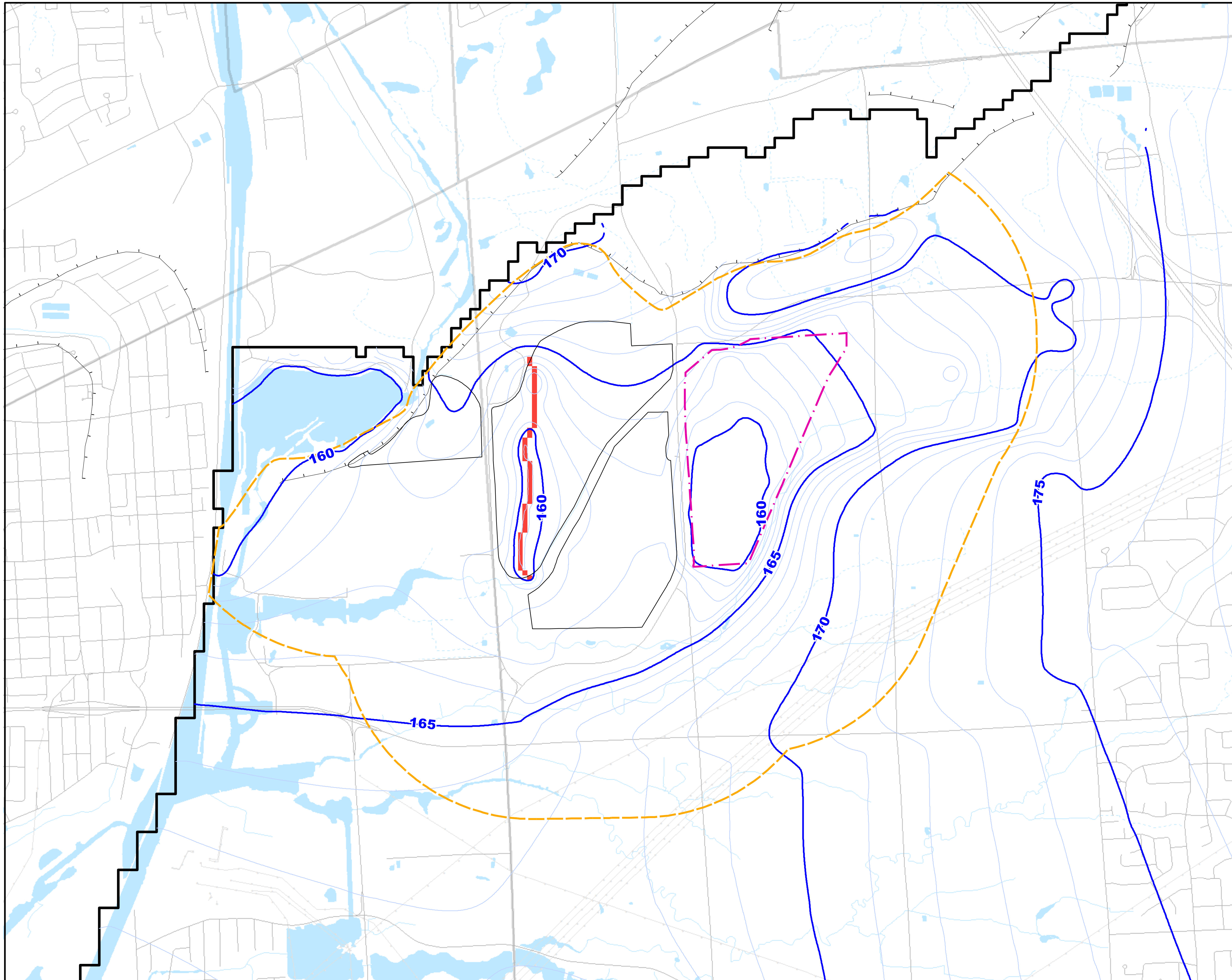

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS CUMULATIVE IMPACT SCENARIO FLc2

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: **A-20**

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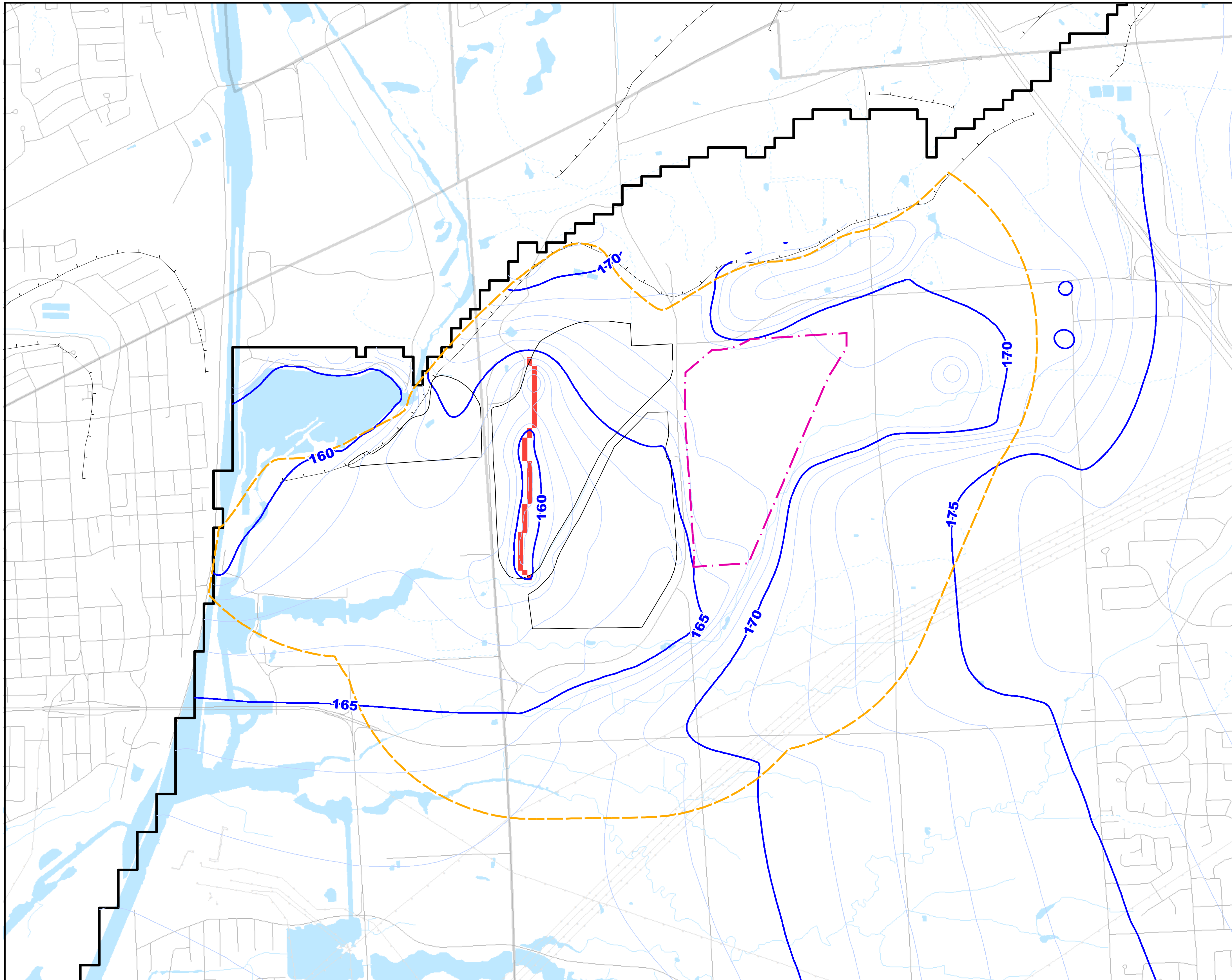

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS WITH SUB-DRAIN VALVE CLOSURE

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-20A

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55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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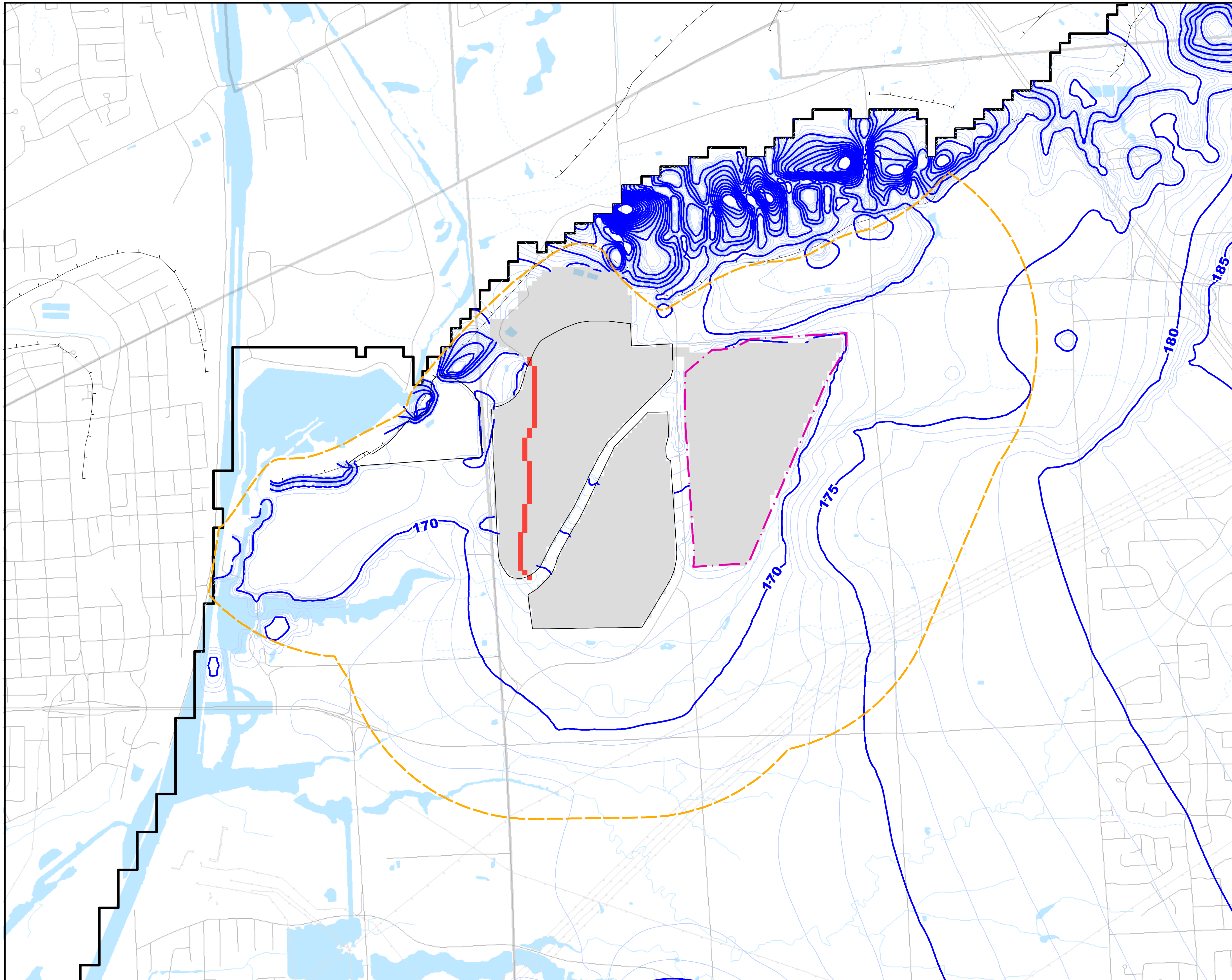

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2a

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	wsp
PROJECT: CA0037248.1905	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-21**

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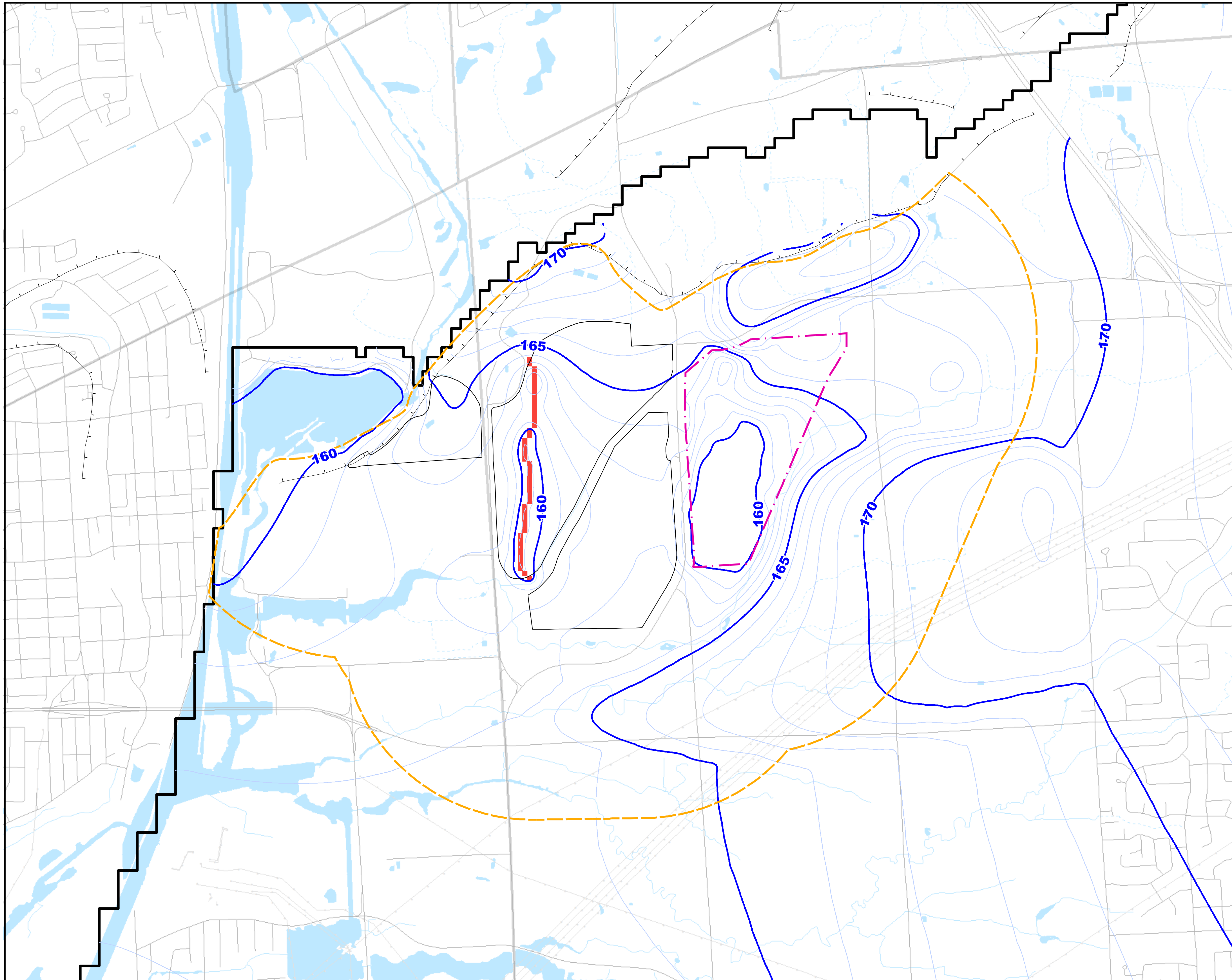

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2a

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-22

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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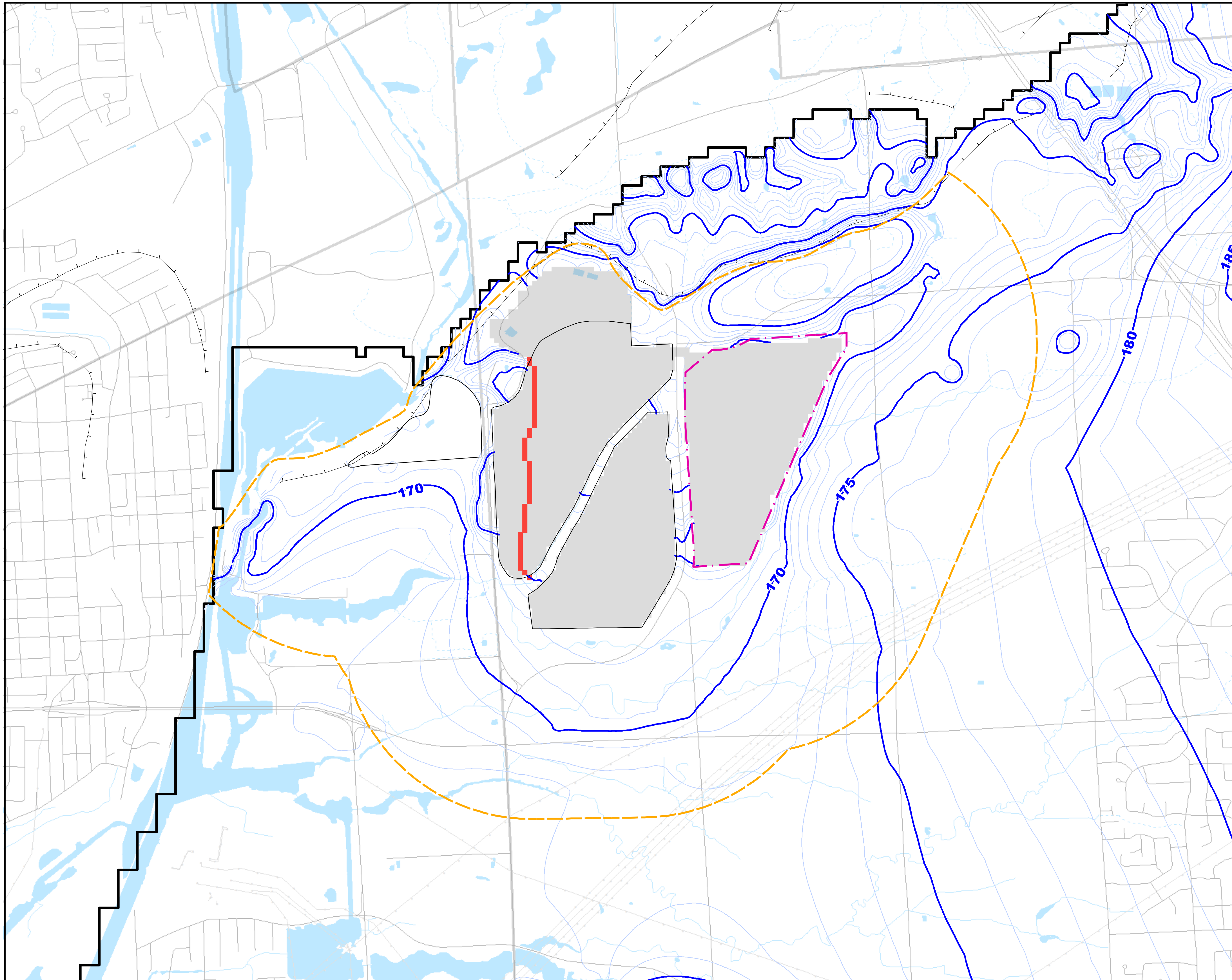


LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

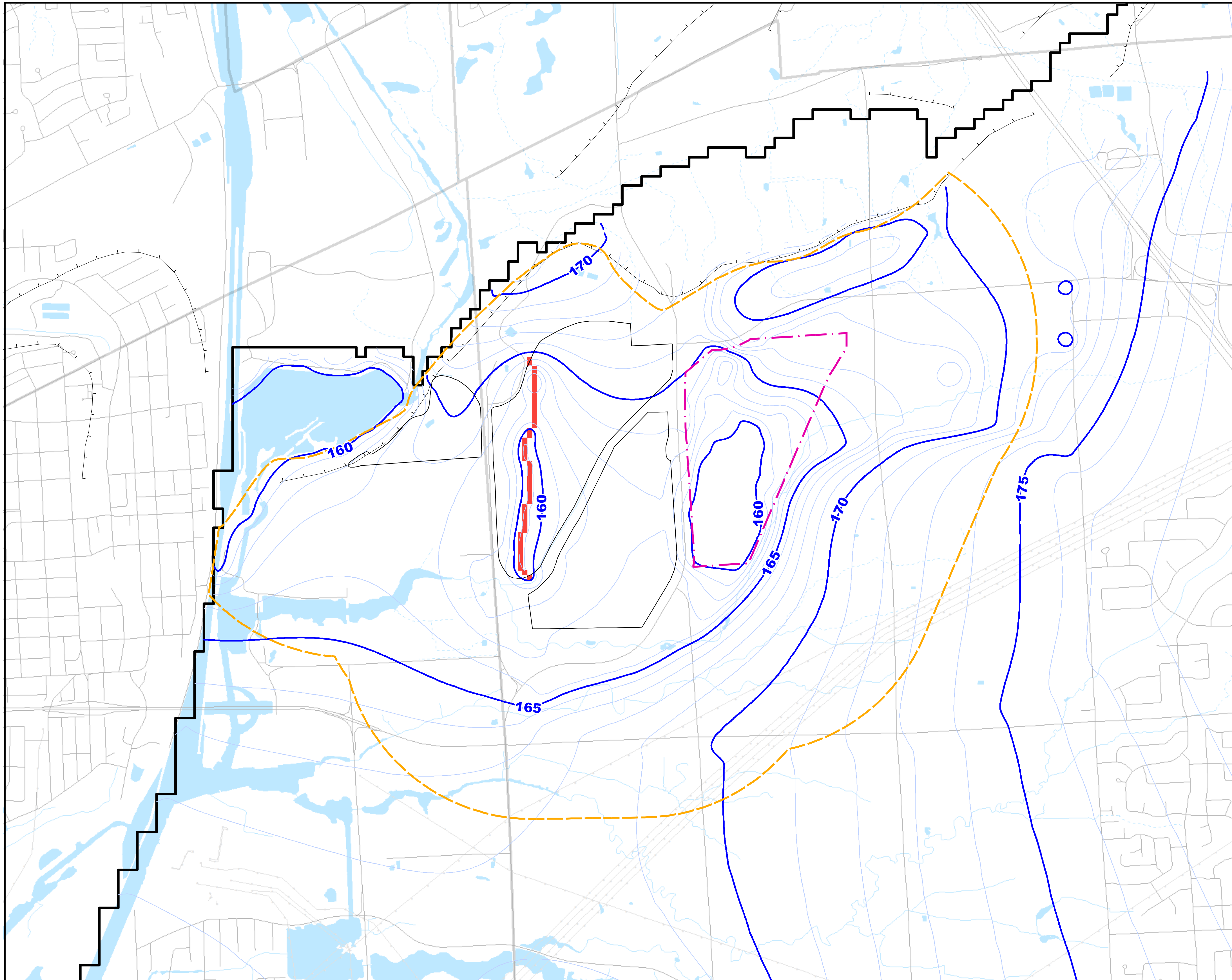
NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2b

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-23**

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com



LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2b

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-24**

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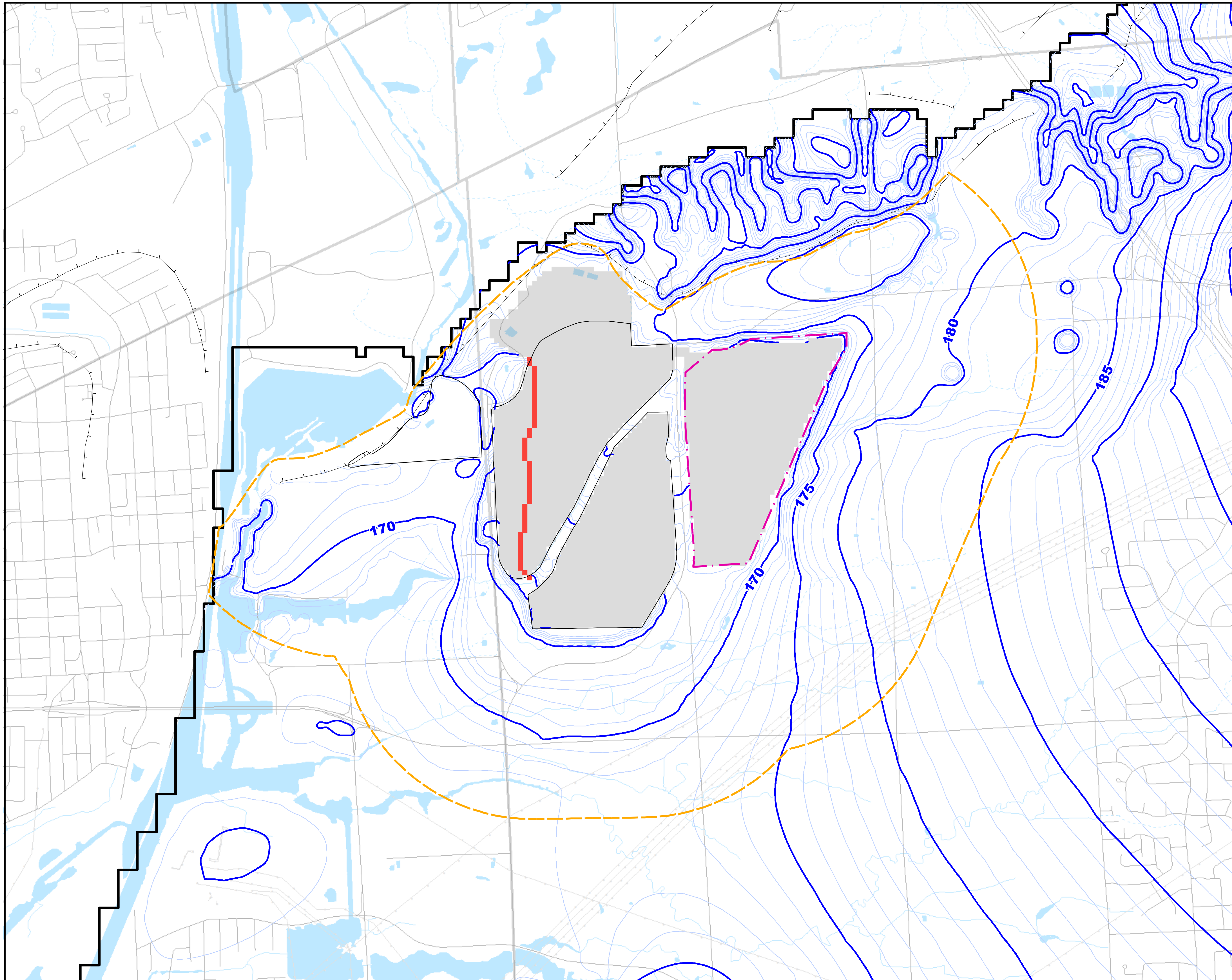


LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

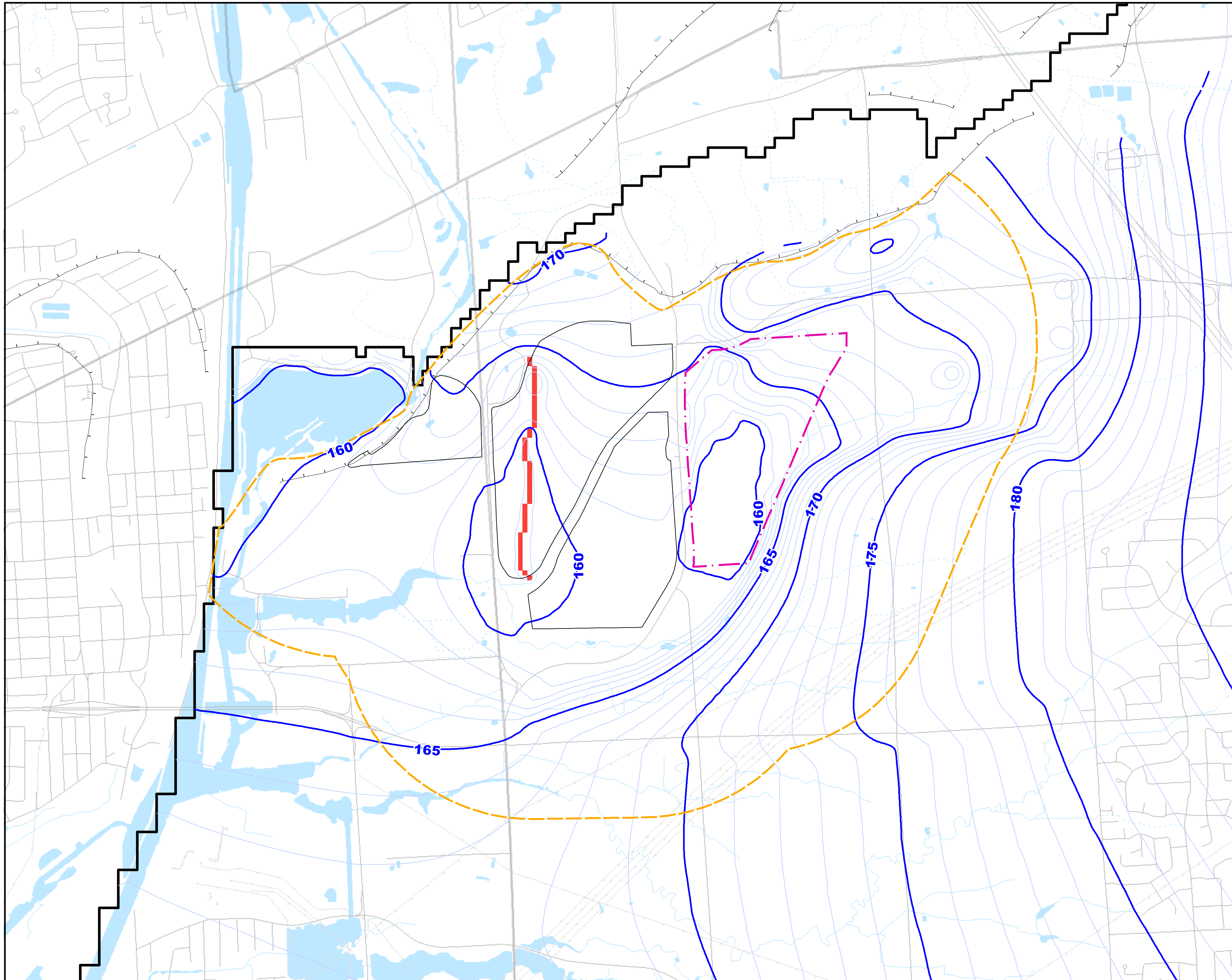
NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2c

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-25

wsp
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com



LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2c

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-26

WSP
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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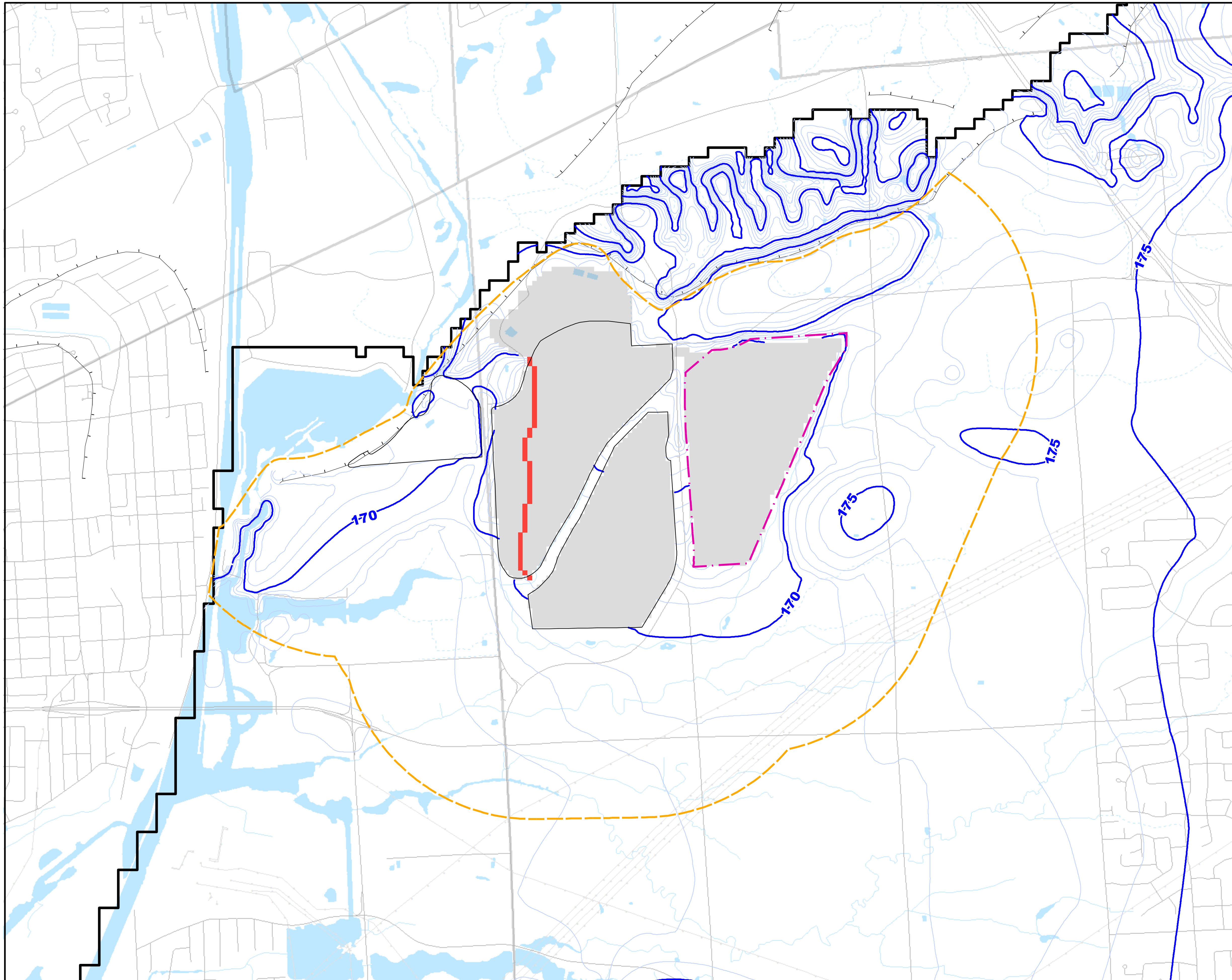

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2d

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-27

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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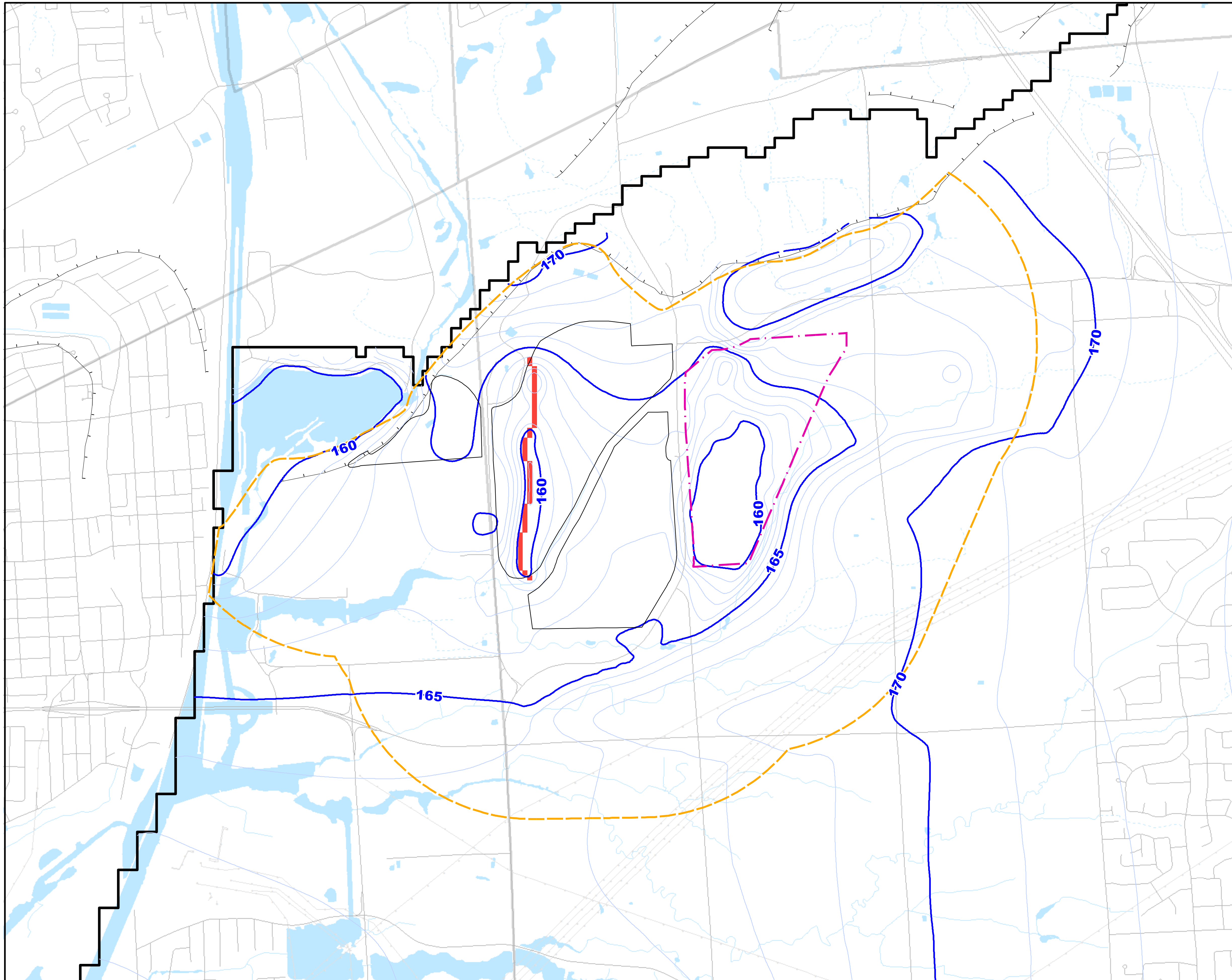

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2d

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-28

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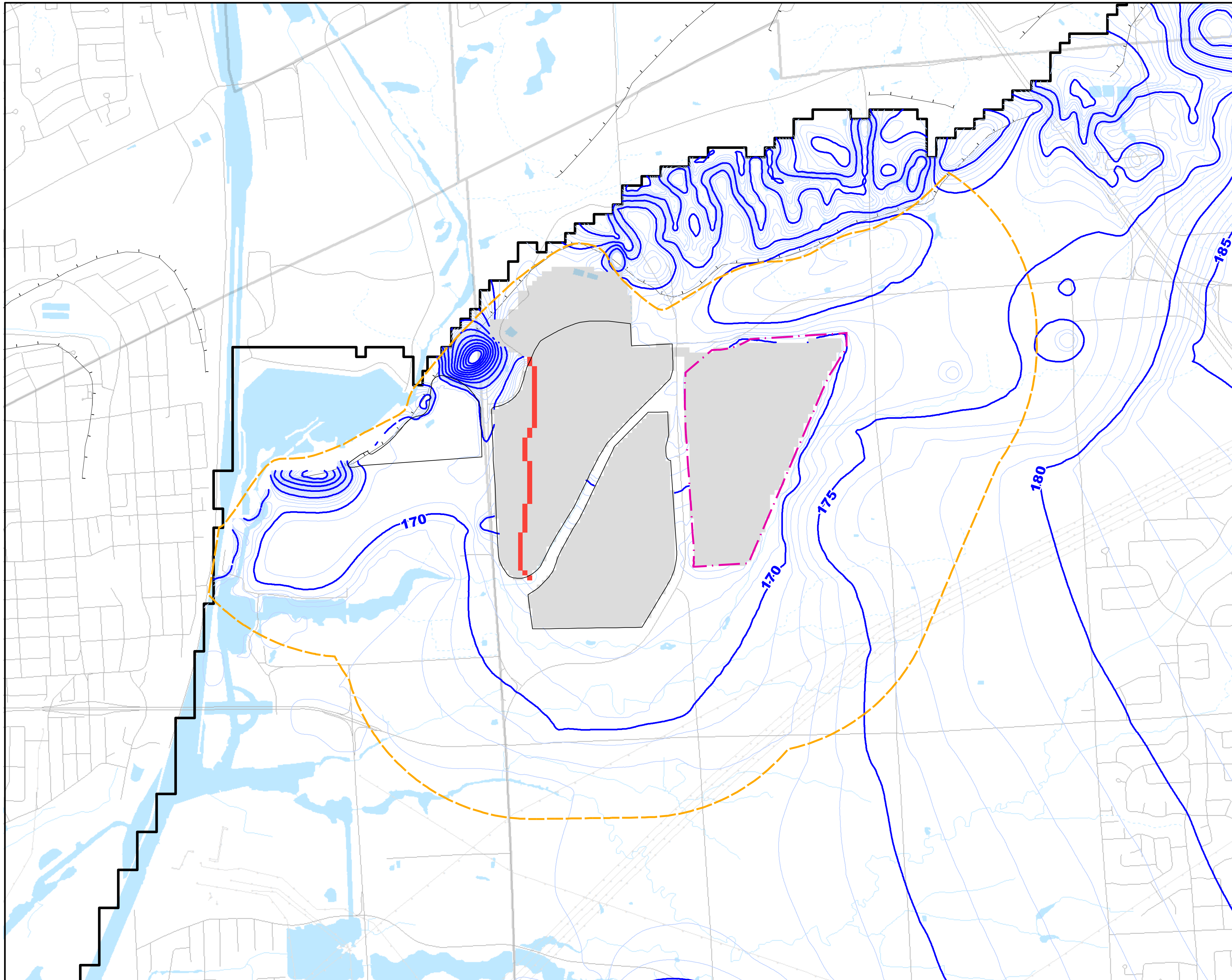

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2e

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-29**

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55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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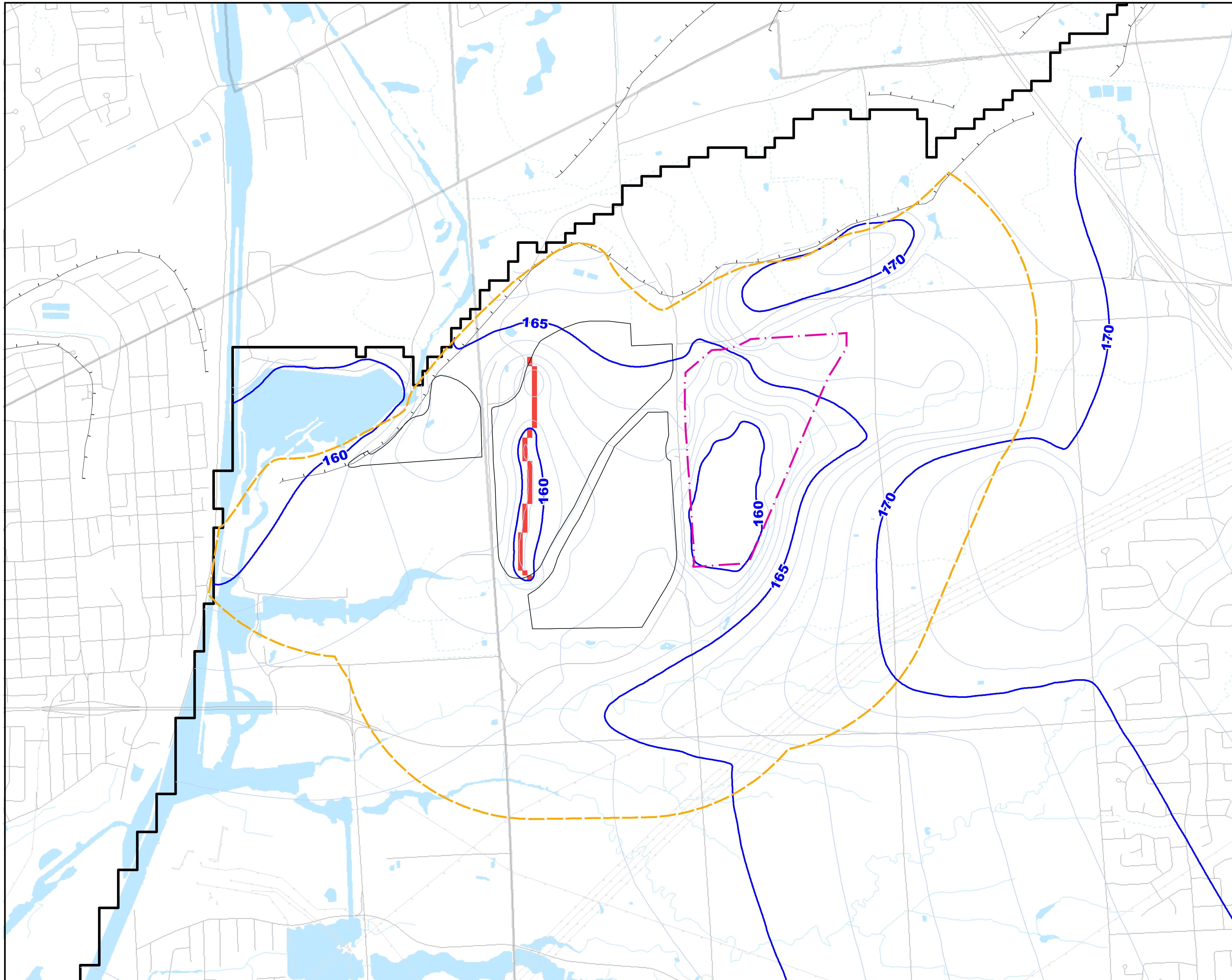

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2e

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: A-30

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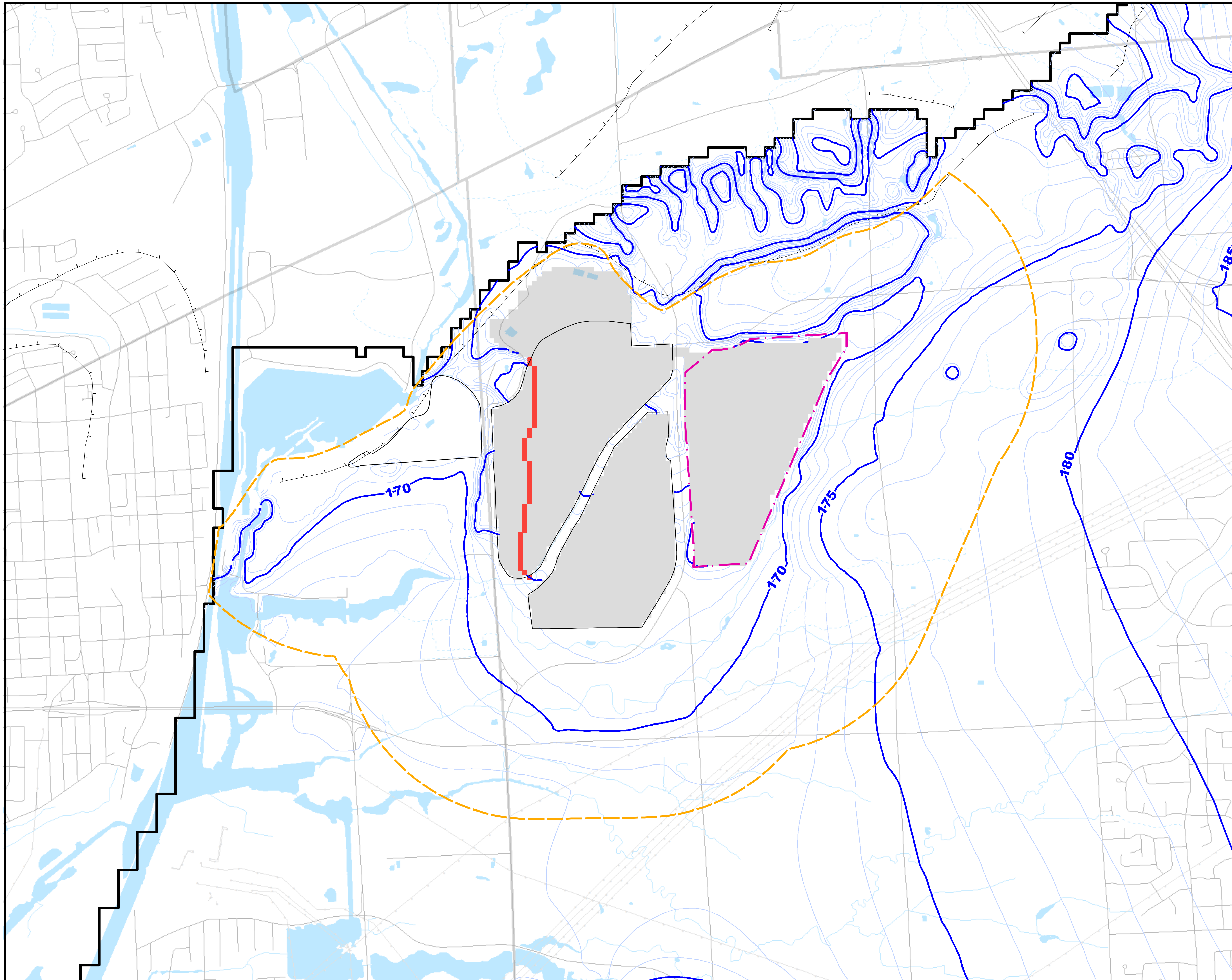


LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

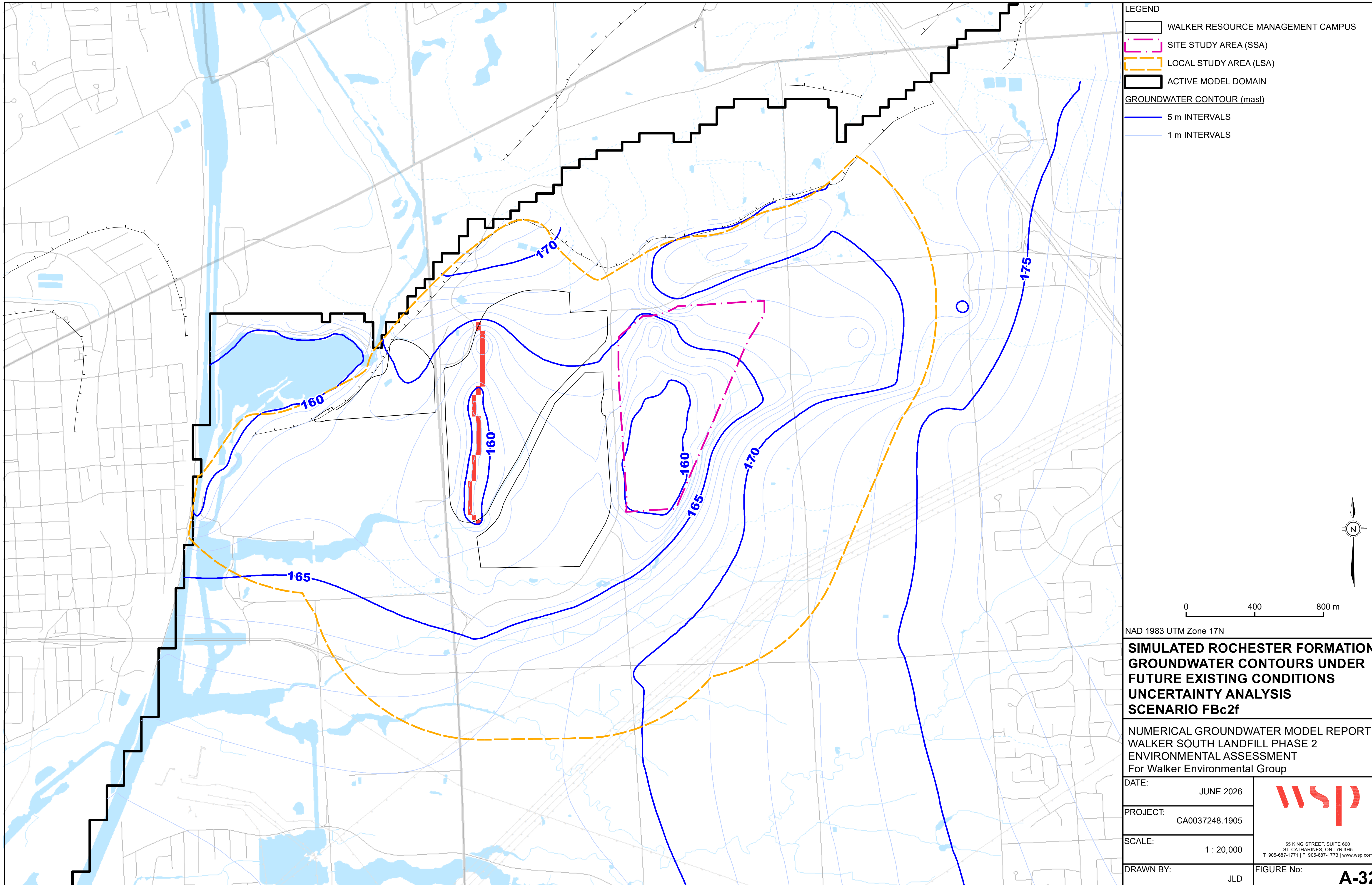
0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2f

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: **A-31**



NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FBc2f

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
DRAWN BY: JLD	FIGURE No: A-32

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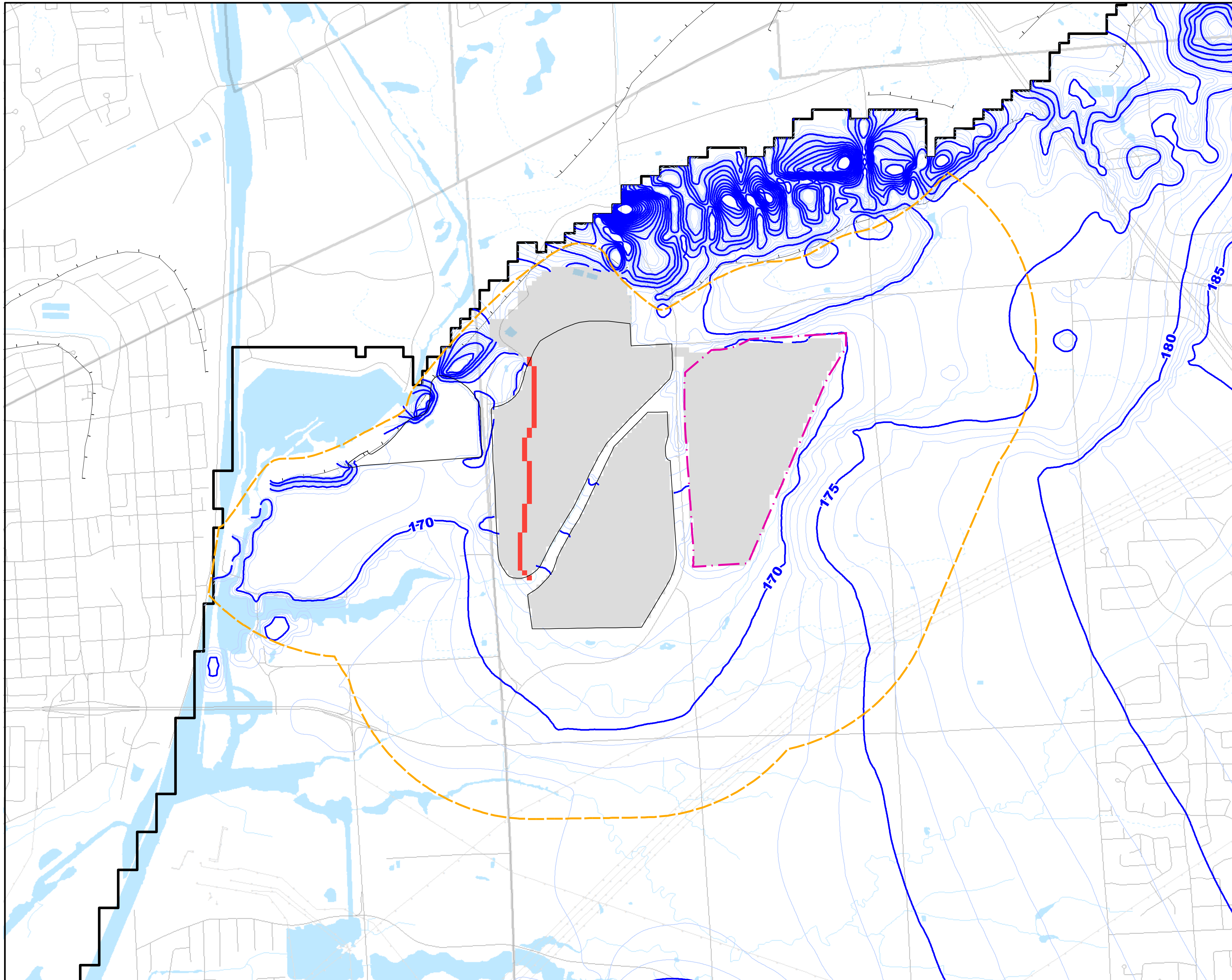

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2a

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026

PROJECT: CA0037248.1905

SCALE: 1 : 20,000

DRAWN BY: JLD

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

FIGURE No: A-33

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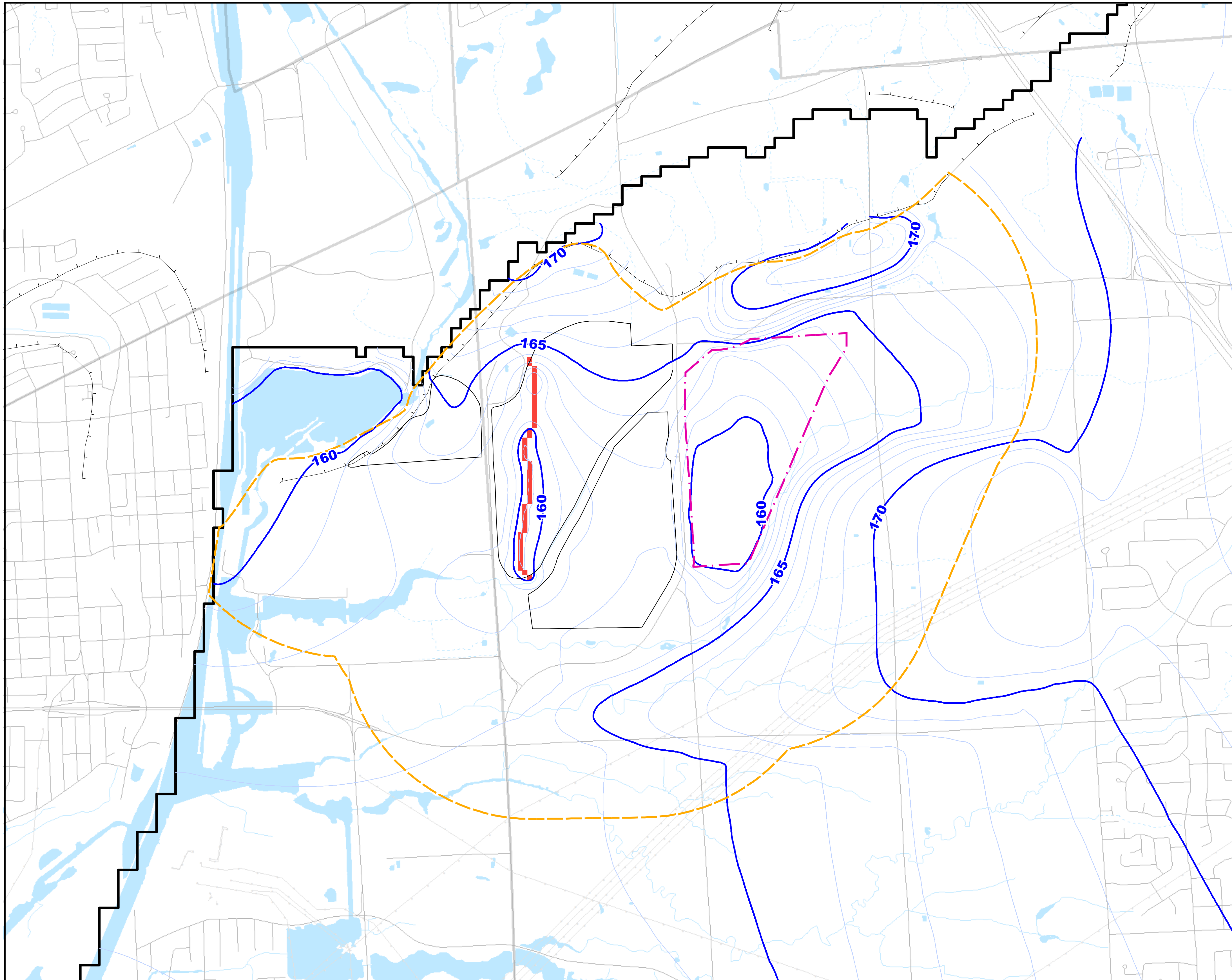

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2a

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-34

WSP
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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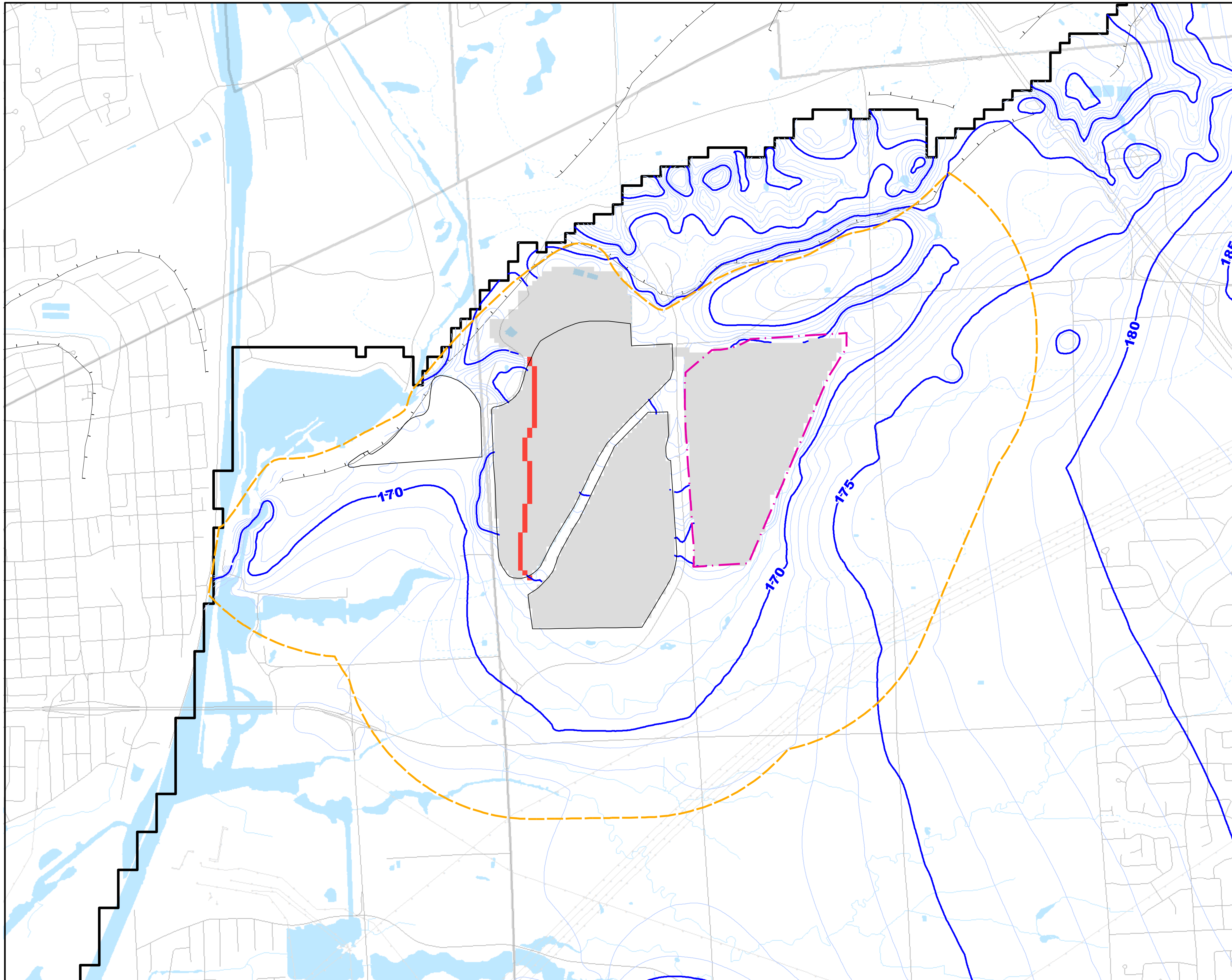

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2b

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	wsp
PROJECT: CA0037248.1905	55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-35**

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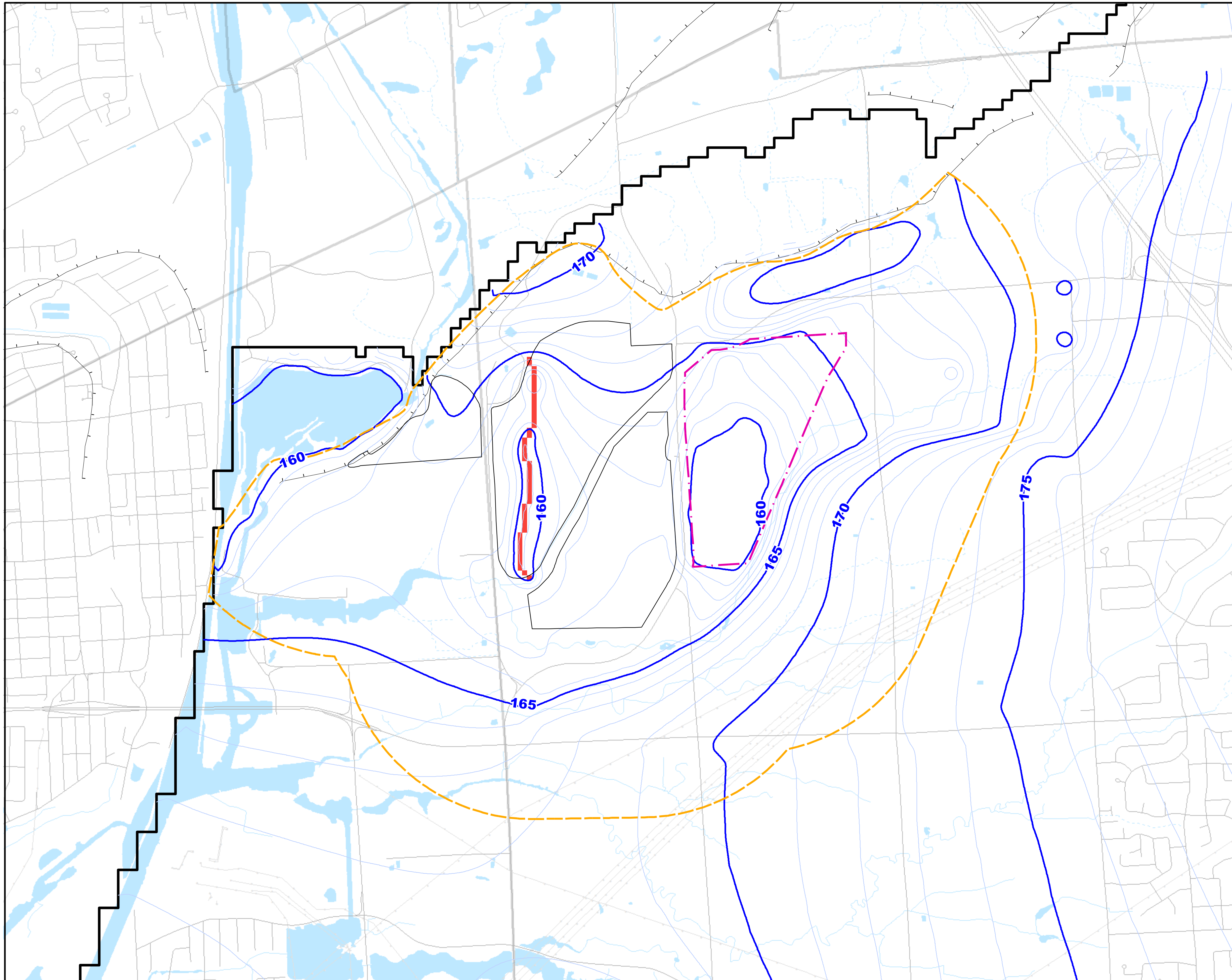
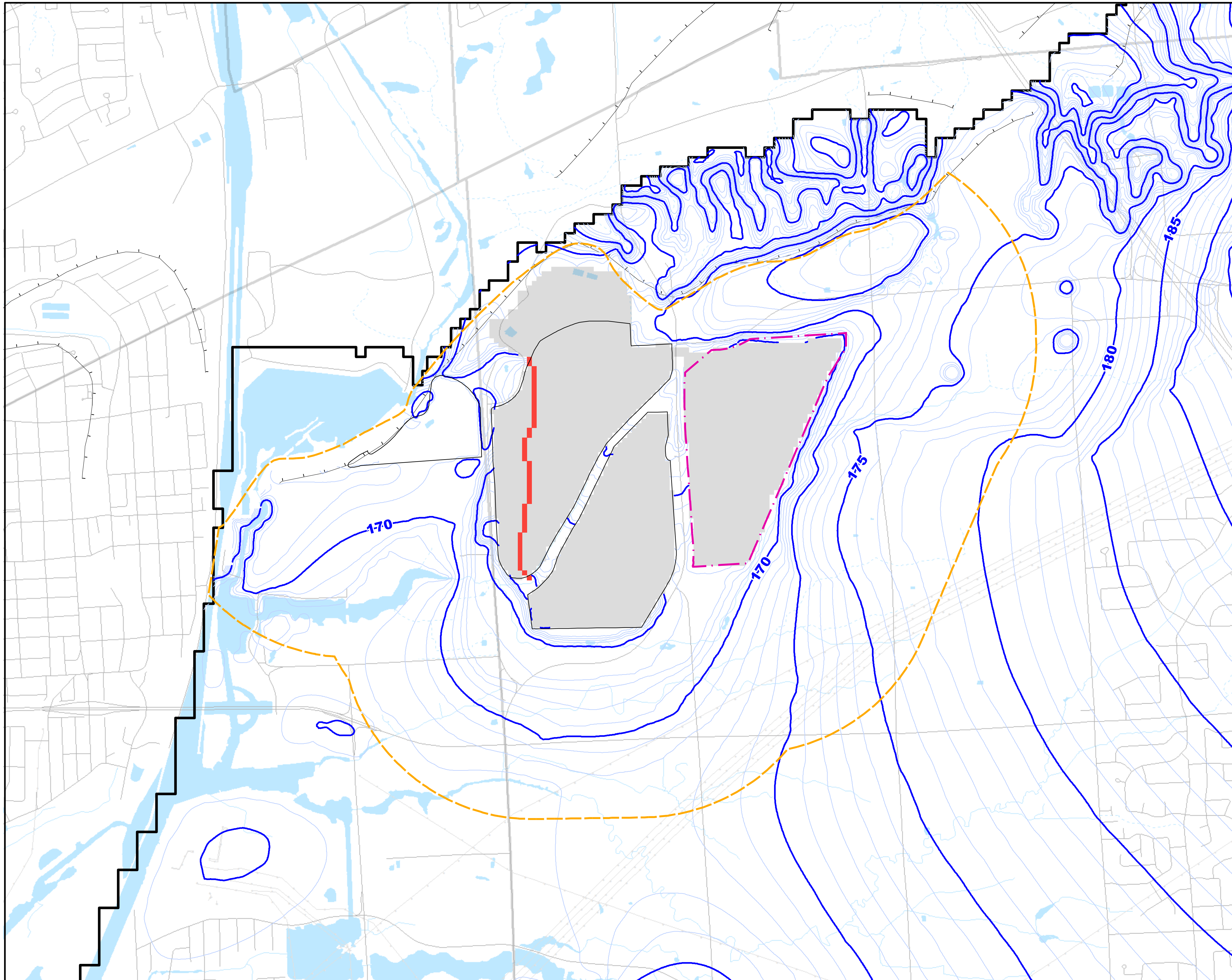


SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2b

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-36

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com



SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2c

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-37

WSP
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

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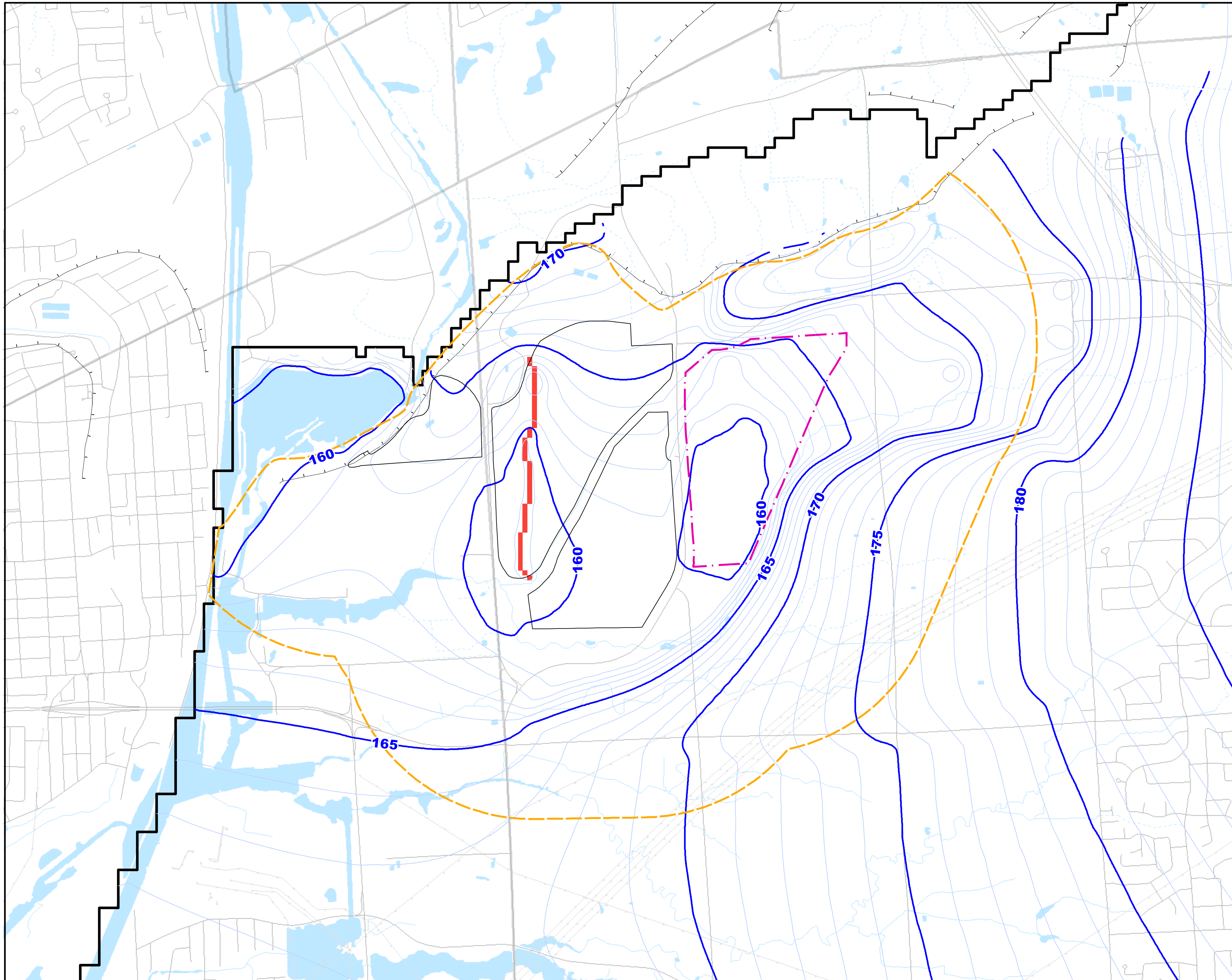


LEGEND
- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)
- 5 m INTERVALS
- 1 m INTERVALS

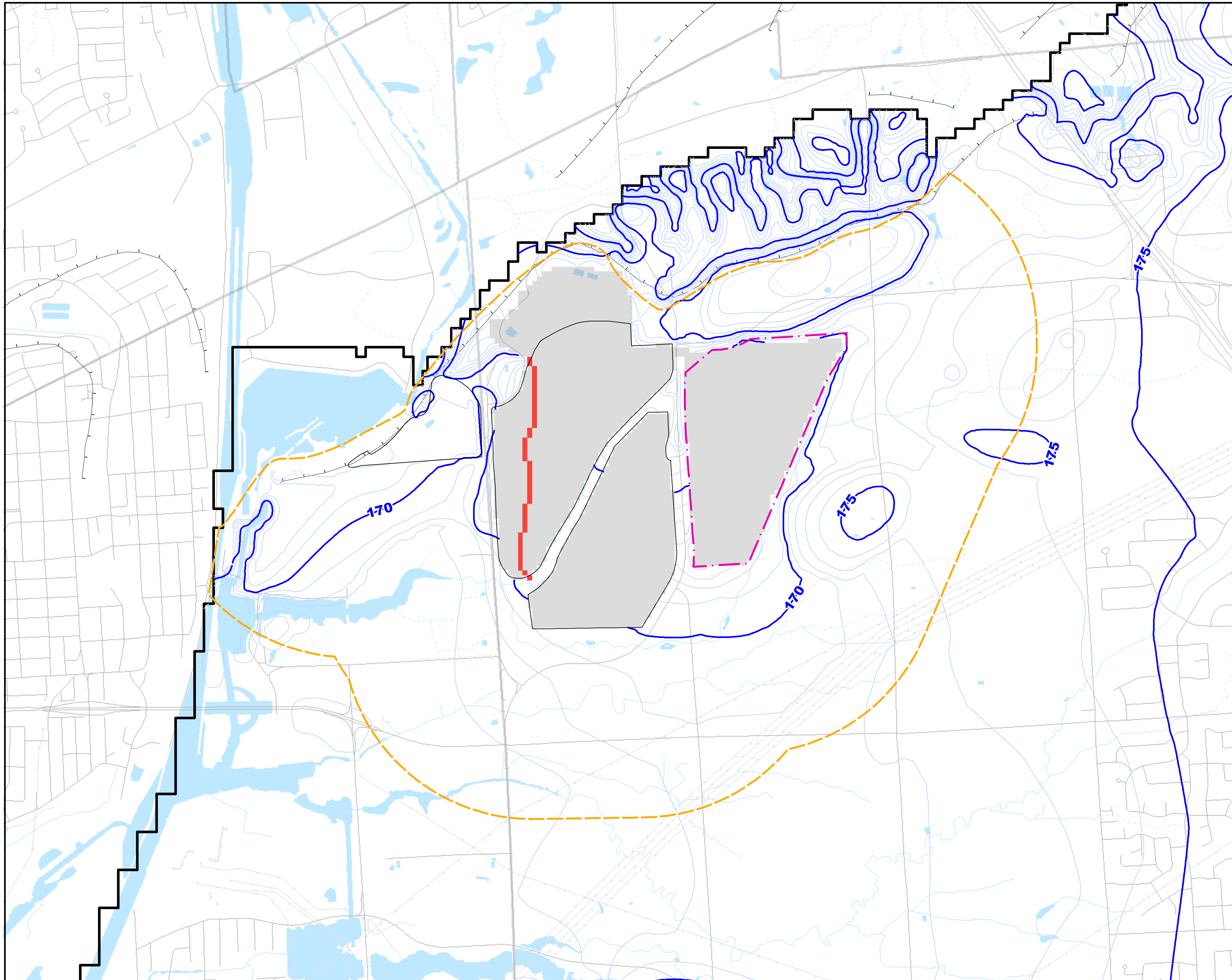
NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2c

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-38

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com



LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2d

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-39

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55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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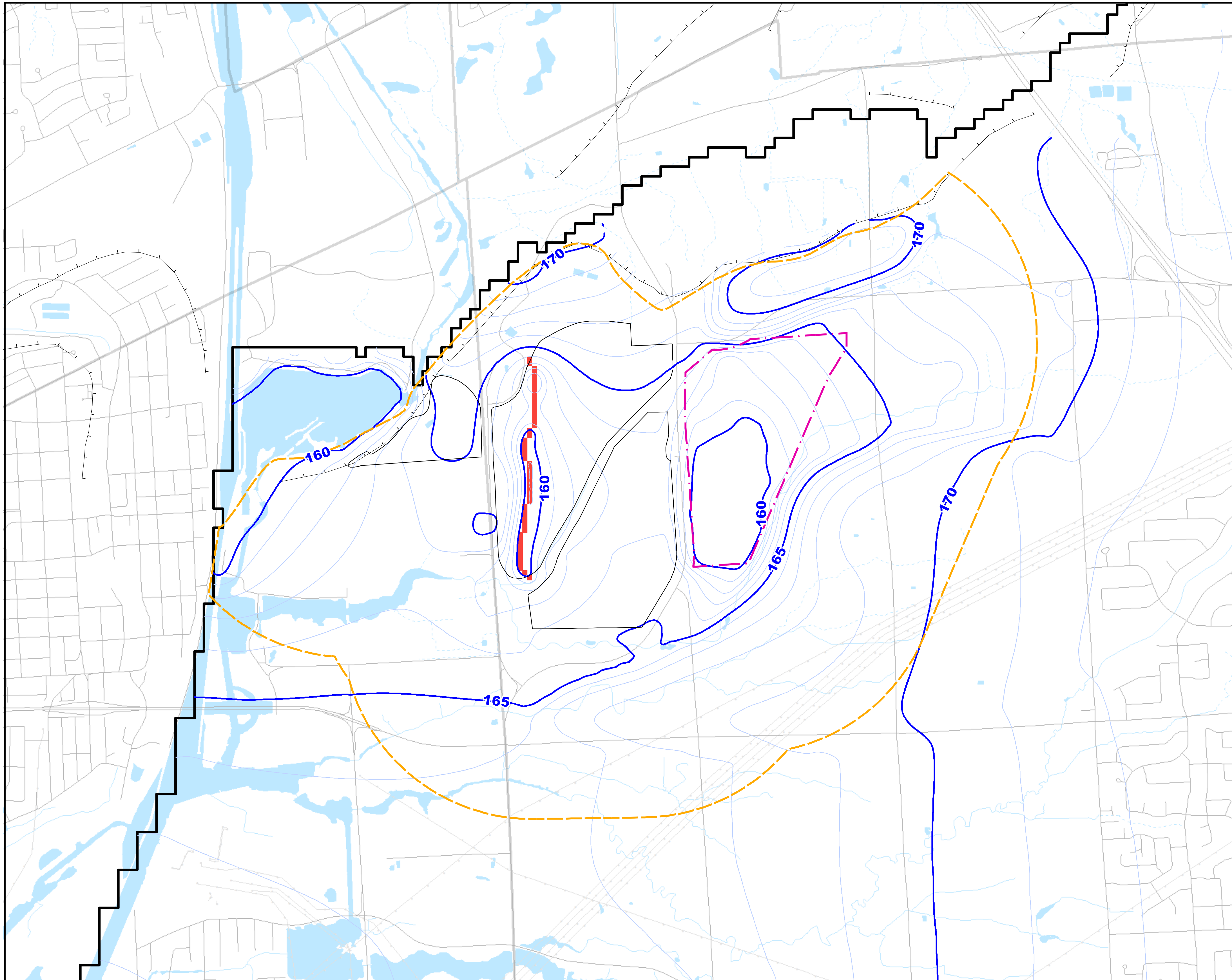

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2d

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-40

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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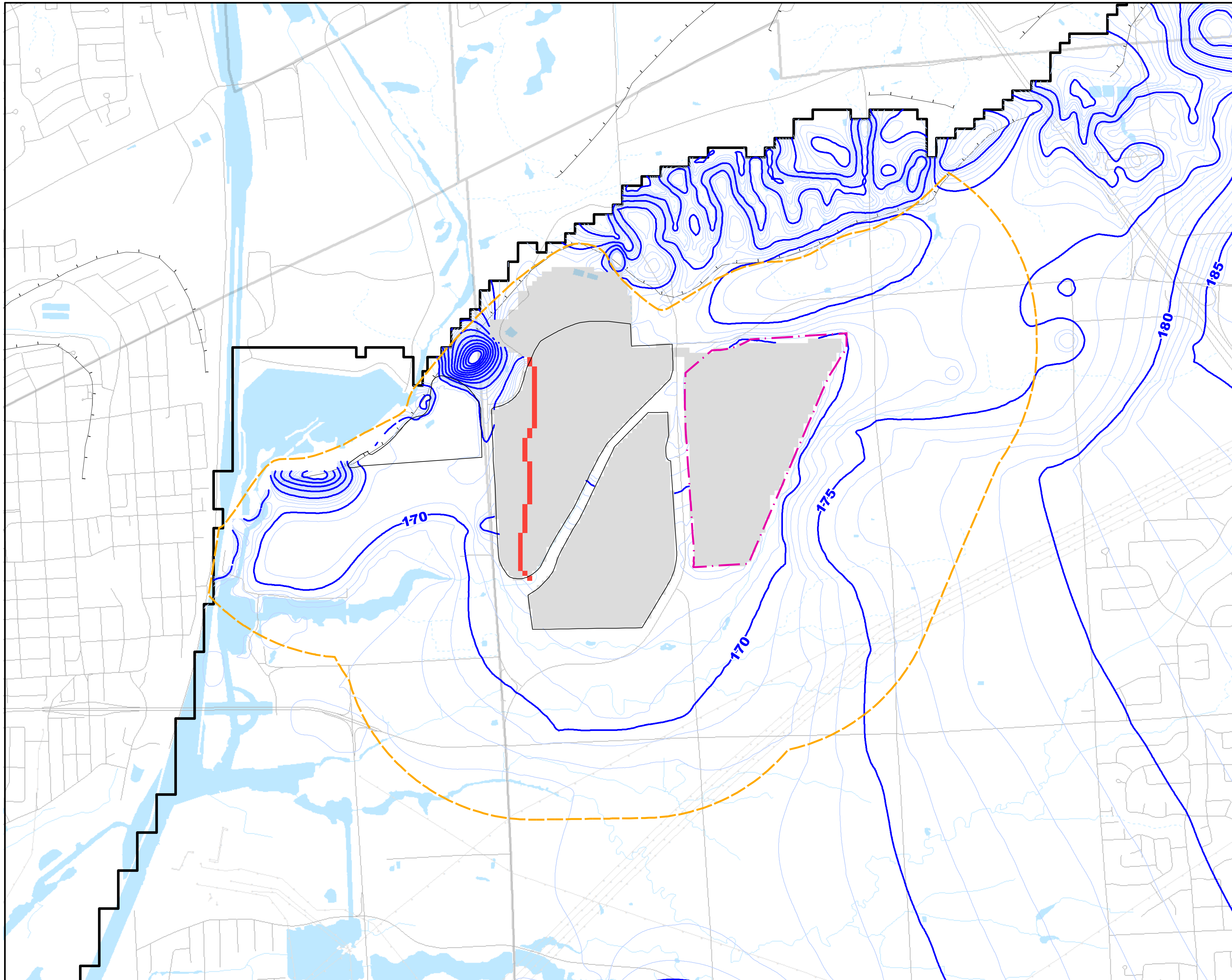

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2e

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	WSP 55 KING STREET, SUITE 600 ST. CATHARINES, ON L7R 3H5 T 905-687-1771 | F 905-687-1773 | www.wsp.com
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-41

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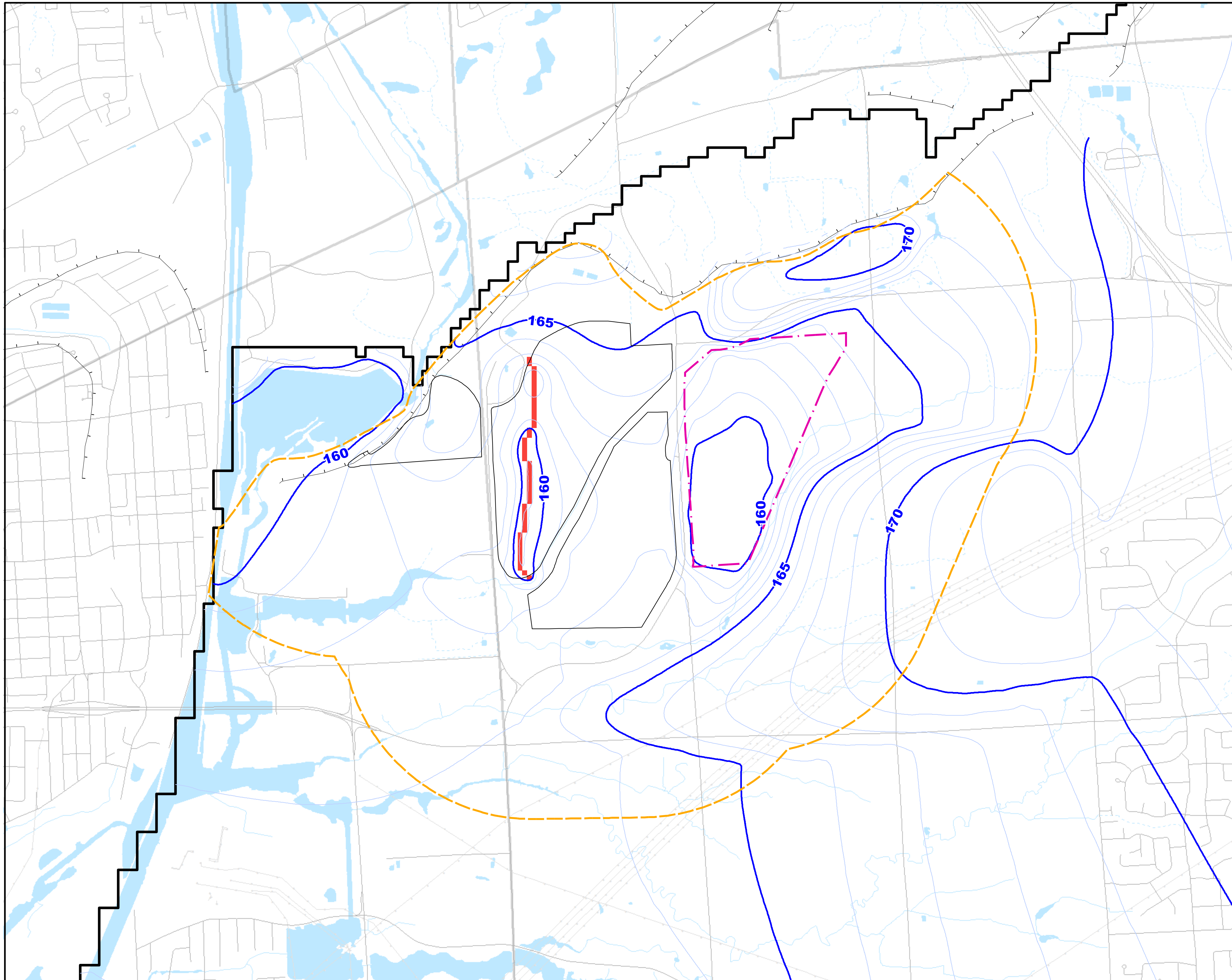


LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

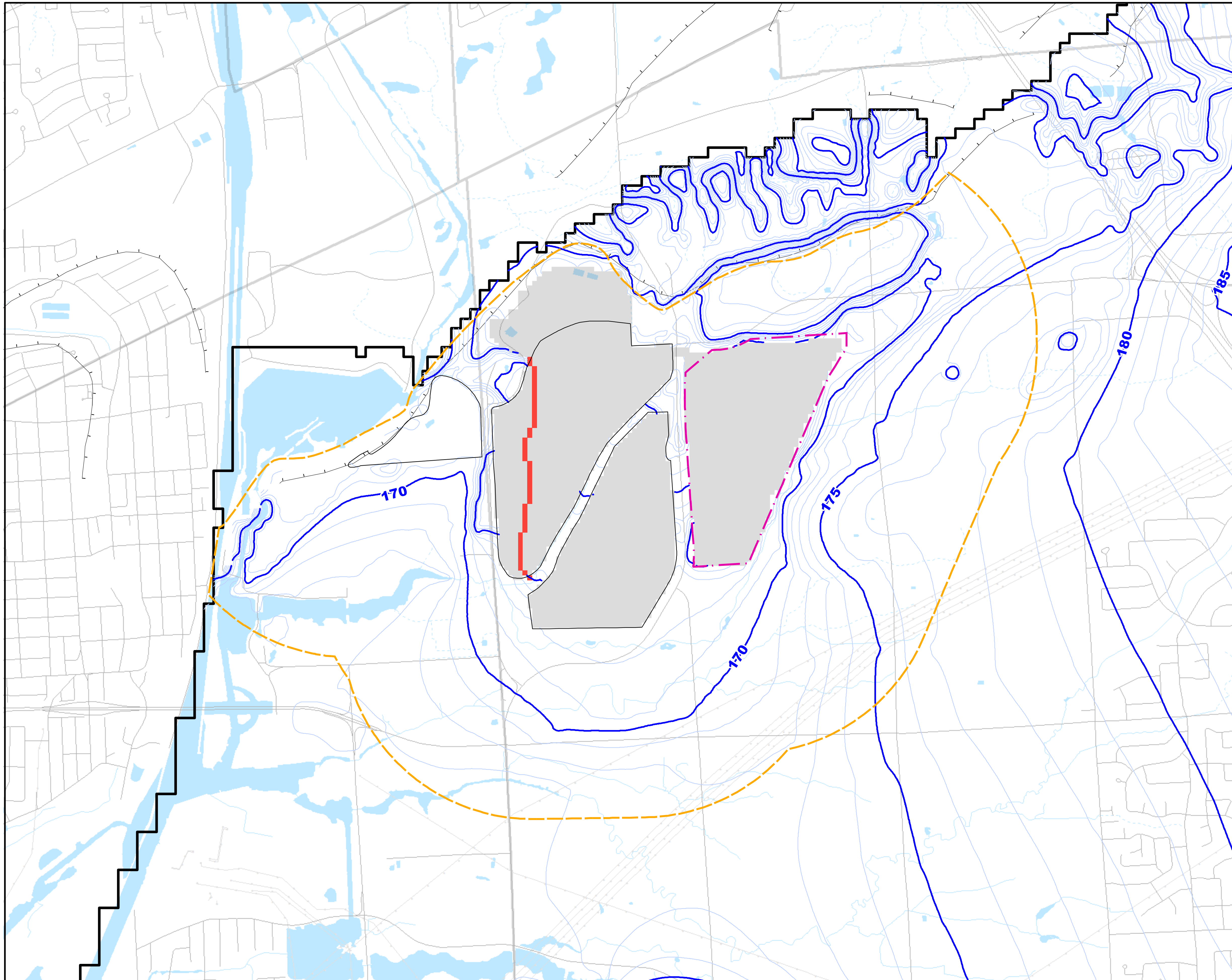
NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2e

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-42

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com



LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

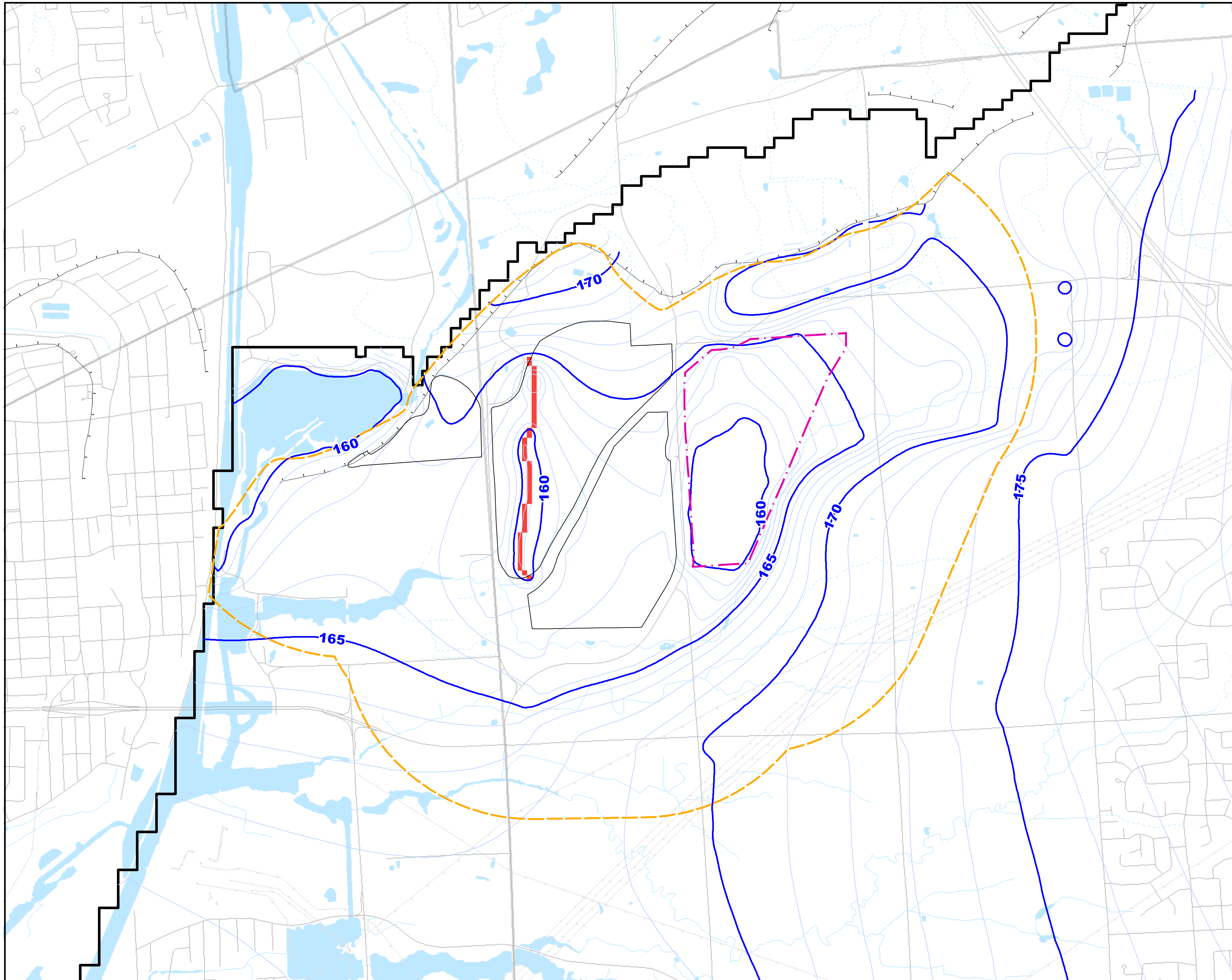
SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2f

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
T 905-687-1771 | F 905-687-1773 | www.wsp.com

FIGURE No: **A-43**



LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2f

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-44

wsp
55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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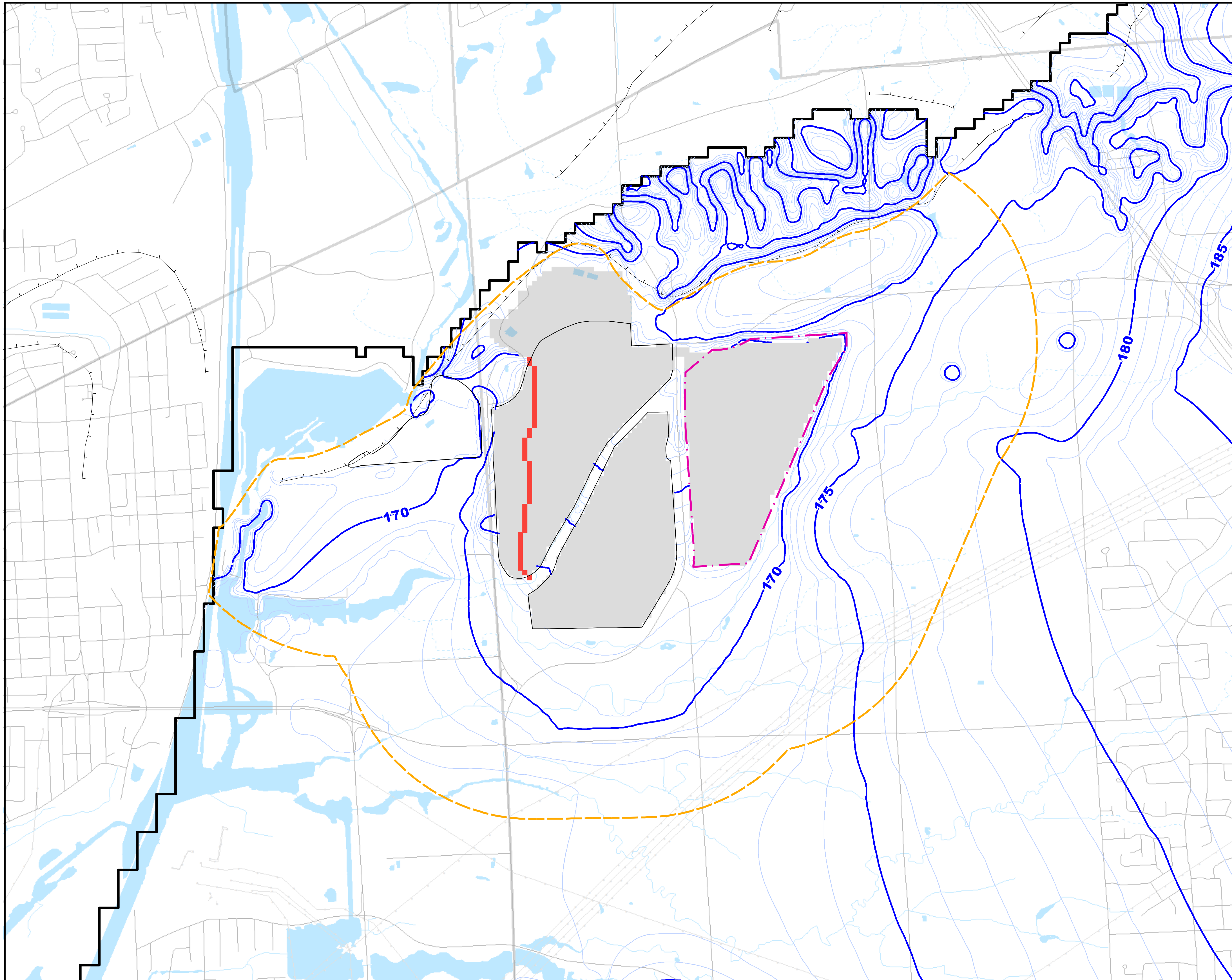

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

N

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS CLIMATE CHANGE SCENARIO FBc2g

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-45

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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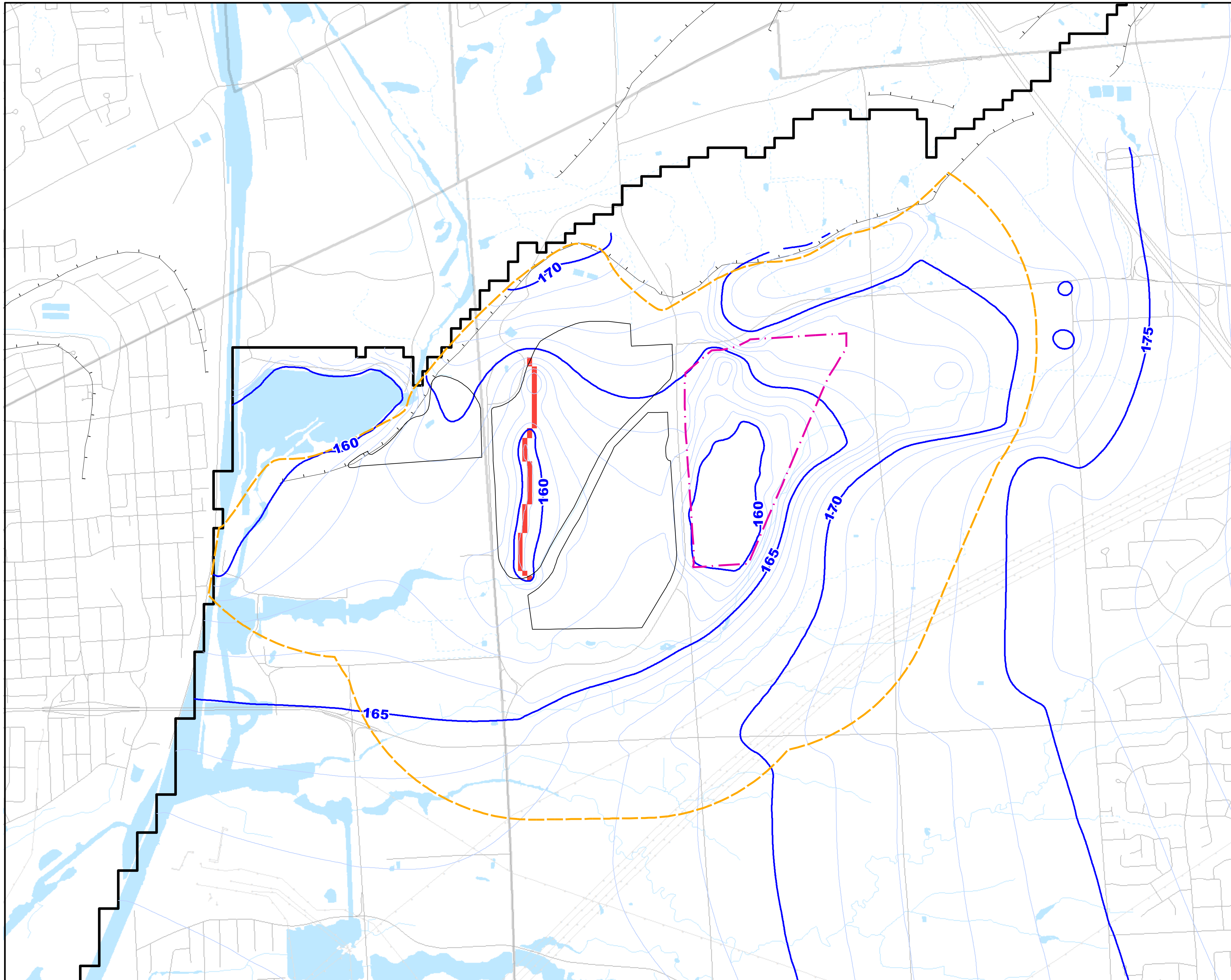

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

5 m INTERVALS

1 m INTERVALS

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER FUTURE EXISTING CONDITIONS CLIMATE CHANGE SCENARIO FBc2g

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: **A-46**

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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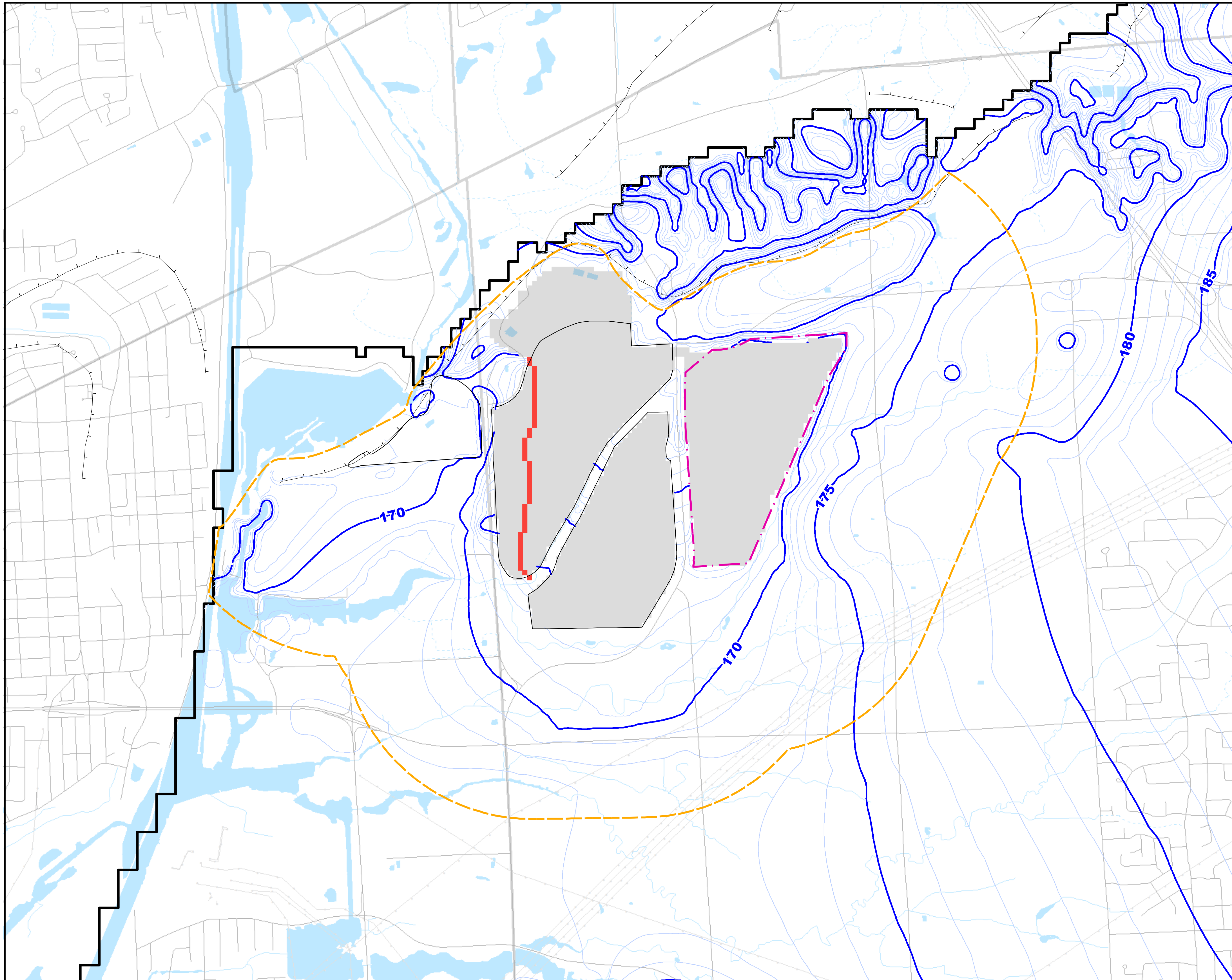

LEGEND

- WALKER RESOURCE MANAGEMENT CAMPUS
- SITE STUDY AREA (SSA)
- LOCAL STUDY AREA (LSA)
- ACTIVE MODEL DOMAIN
- NO-FLOW BOUNDARY
- LOCATION OF SIMULATED GROUNDWATER COLLECTION SYSTEM

GROUNDWATER CONTOUR (masl)

- 5 m INTERVALS
- 1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED LOCKPORT FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS UNCERTAINTY ANALYSIS SCENARIO FLc2f

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE: JUNE 2026	
PROJECT: CA0037248.1905	
SCALE: 1 : 20,000	
DRAWN BY: JLD	FIGURE No: A-47

55 KING STREET, SUITE 600
ST. CATHARINES, ON L7R 3H5
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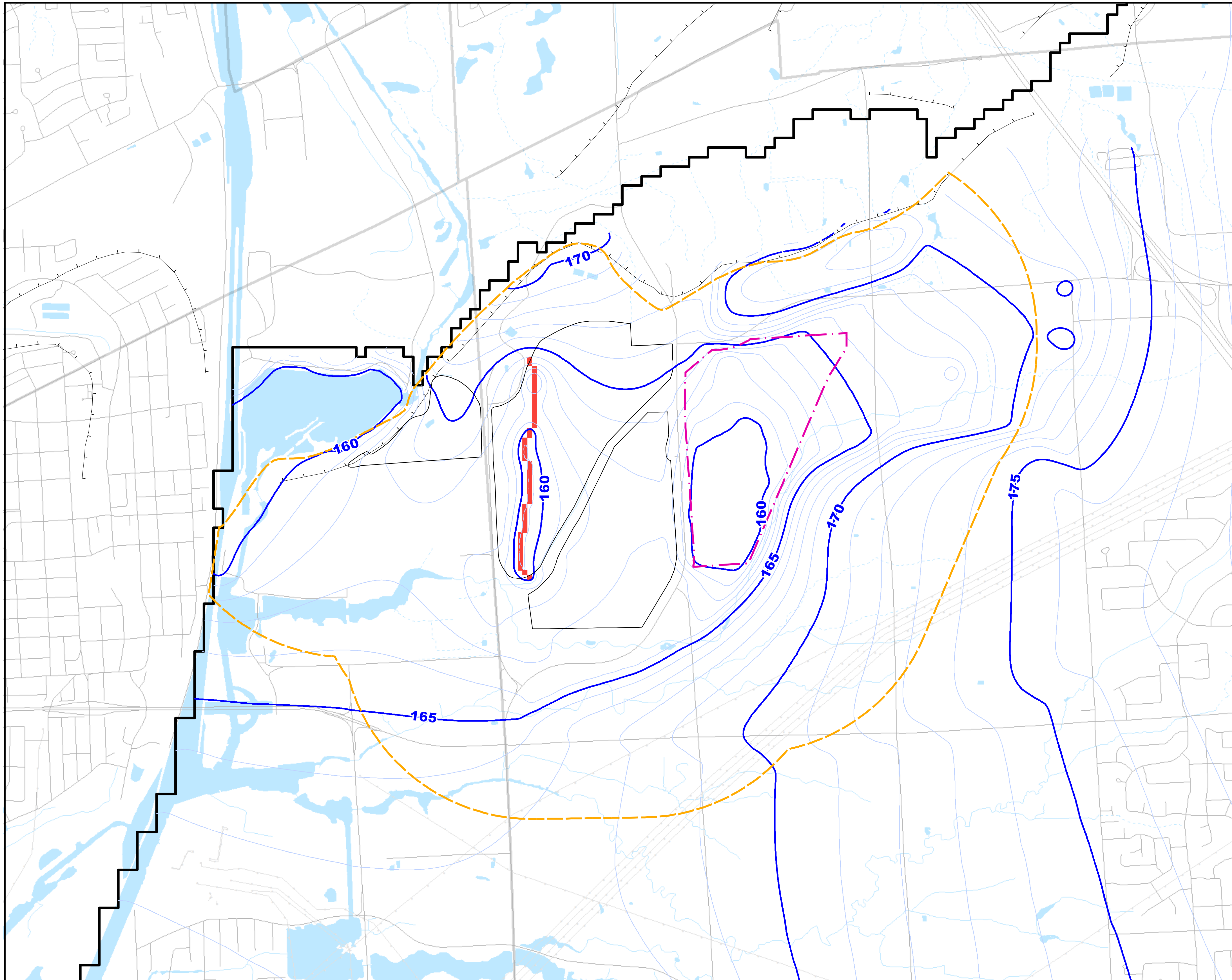

LEGEND

WALKER RESOURCE MANAGEMENT CAMPUS

SITE STUDY AREA (SSA)

LOCAL STUDY AREA (LSA)

ACTIVE MODEL DOMAIN

GROUNDWATER CONTOUR (masl)

5 m INTERVALS

1 m INTERVALS

0 400 800 m

NAD 1983 UTM Zone 17N

SIMULATED ROCHESTER FORMATION GROUNDWATER CONTOURS UNDER PROPOSED LANDFILL OPERATION CONDITIONS CLIMATE CHANGE SCENARIO FLc2g

NUMERICAL GROUNDWATER MODEL REPORT
WALKER SOUTH LANDFILL PHASE 2
ENVIRONMENTAL ASSESSMENT
For Walker Environmental Group

DATE:	JUNE 2026
PROJECT:	CA0037248.1905
SCALE:	1 : 20,000
DRAWN BY:	JLD
FIGURE No:	A-48

55 KING STREET, SUITE 600
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