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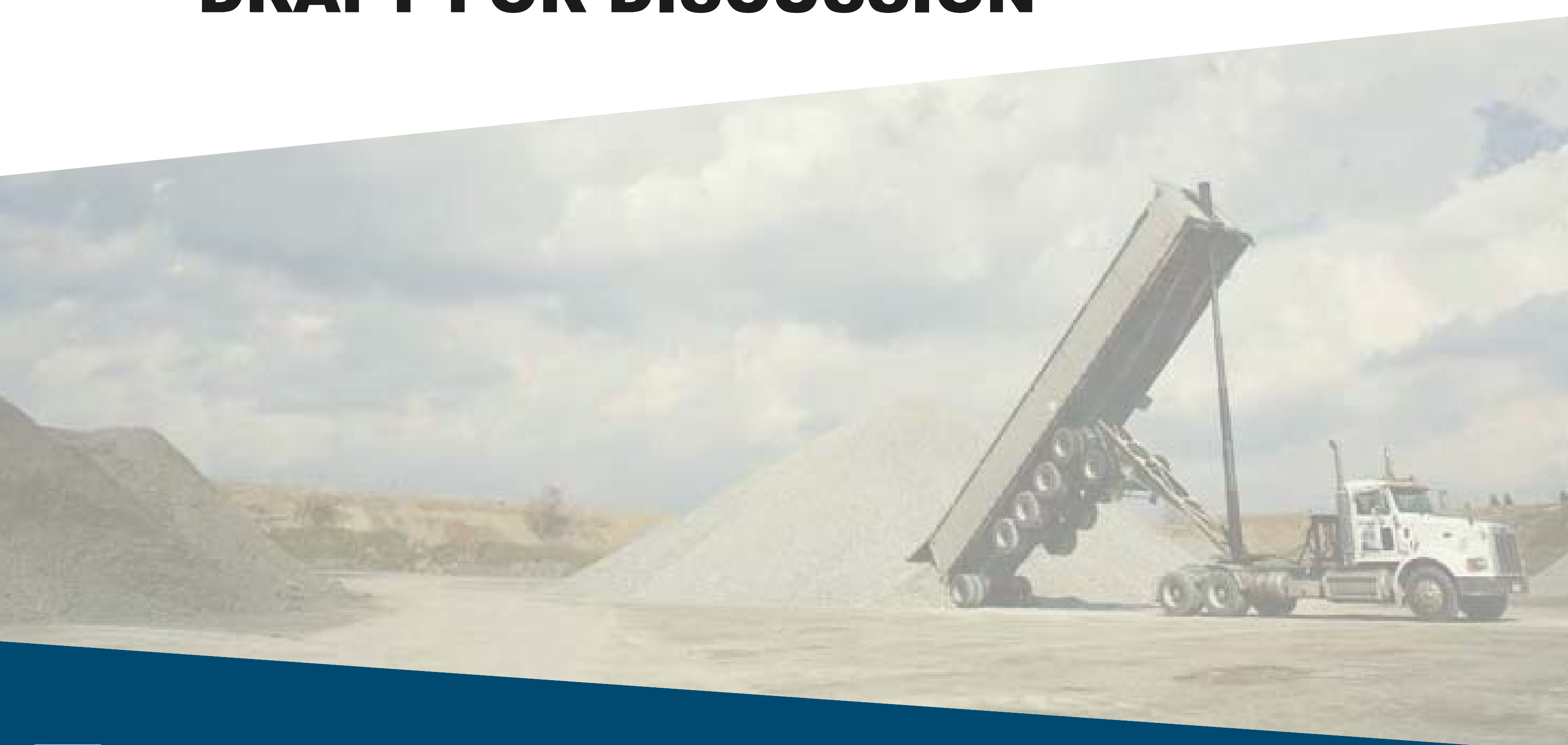
Stoney Creek Regional Facility Environmental Assessment

Design & Operations Detailed Impact Assessment Report DRAFT FOR DISCUSSION



GHD terrapure

65 Sunray Street, Whitby Ontario L1N 8Y3
Canada 11102771 | Report No 32 | June 19, 2018

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1. Introduction

This report documents the Design and Operations impact assessment of the Preferred Landfill Footprint for the Environmental Assessment (EA) for landfill expansion at the Stoney Creek Regional Facility (SCRF). In the preceding Alternative Methods phase of the EA, a net effects analysis as well as a comparative evaluation of the six alternative landfill expansion options was carried out in order to identify a Preferred Landfill Footprint. The Preferred Landfill Footprint was determined to be Option #5 – Reconfiguration and Height Increase. The potential environmental effects and 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 the Preferred Landfill Footprint.

1.1 Background and Purpose

In March of 2018, the recommended landfill expansion option (**Option #5**) was presented to the public, stakeholders and the Government Review Team (GRT) for comments and feedback. Following the stakeholder and agency engagement, the Recommended option was confirmed and **Option #5** became the 'Preferred' Landfill Footprint (also referred to as the Preferred Method). Following confirmation of the Preferred Landfill Footprint a detailed impact assessment was carried out.

The intent of the impact assessment is to allow for additional details to be developed on the Preferred Landfill Footprint from a design and operations perspective and to then review the impact management measures and resultant net effects described in the Alternative Methods stage within the context of the more detailed design for the Preferred Landfill Footprint. Specifically, the following can be accomplished:

- Potential environmental effects can be identified with more certainty.
- More site-specific impact assessment measures can be developed for application.
- 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.

At the completion of the impact assessment of the Preferred Landfill Footprint, the advantages and disadvantages to the environment of the Landfill Footprint were identified. Climate change mitigation and adaptation measures will also be reviewed as part of the detailed Site design established for the Preferred Landfill Footprint. In addition, during the impact assessment stage of the SCRF EA, Terrapure will complete an assessment of the cumulative effects of the proposed undertaking and other non-SCRF projects/activities that are existing, planned/approved or reasonably foreseeable within the Study Area.

A Facility Characteristics Report (FCR) for the SCRF has been prepared so that potential environmental effects and mitigation or compensation measures identified for the Preferred Landfill Footprint during the Alternative Methods phase of the EA could be more accurately defined, along with enhancement opportunities and approval requirements.

The discipline-specific work plans developed during the Terms of Reference (ToR) outlined how impacts associated with the Preferred Landfill Footprint would be assessed. The results of these assessments have been documented in the following nine standalone Draft Detailed Impact Assessment Reports:

- Atmospheric including; 1) Air Quality and Odour; and, 2) Noise
- Geology and Hydrogeology
- Surface Water
- Terrestrial and Aquatic
- Transportation
- Land Use and Economic
- Design and Operations
- Human Health

1.2 Description of the Preferred Landfill Footprint

The proposed expansion of the SCRF will increase the overall size of the landfill. Vertical limits will extend higher increasing the peak height by approximately 2.5 m. Horizontal limits will extend further toward the north, back to original approved footprint of the SCRF. The area currently approved to accept industrial fill will be replaced with a base liner system to accept residual material.

The proposed layout of the SCRF is presented in **Figure 1.1** below. The limits of the base liner system will be expanded back to the original approved footprint of 59.1 ha. The overall Site area of 75.1 ha. will not change. The figure shows the final extent of the landfill area after the final cover has been installed (the Post-Closure phase).

Minimum on-Site buffer distances of 30 m will be maintained around the perimeter of the residual material area throughout all phases. On-Site buffers currently extend to approximately 65 m in various areas along the east and south side of the Site, and up to approximately 130 m in the vicinity of the existing stormwater management facility in the northwest corner of the Site. These buffer distances will also be maintained.

The proposed expansion of the SCRF will increase the approved capacity by 3,680,000 m^3, resulting in a total Site capacity of 10,000,000[1] m^3 for post-diversion, solid, non-hazardous residual material. No changes are being proposed to the maximum approved fill rates of up to 750,000 tonnes of residual material in any consecutive twelve month period, or up to 8,000 tonnes per day.

The SCRF will continue to accept post-diversion, solid, non-hazardous industrial residual material. The SCRF will no longer be approved to accept industrial fill material. The SCRF will continue to accept residual material from sources within the Province of Ontario. The overall composition of the residual material is expected to remain relatively consistent as the main sources (i.e., steel making industry, soils from infrastructure development projects) will not change. Additional descriptive details on the design of the preferred alternative can be found in the detailed FCR.

1 The total Site capacity may increase to 10,180,000, pending the MOEEC approval of the current ECA Amendment Application noted in the Facility Characteristics Report.

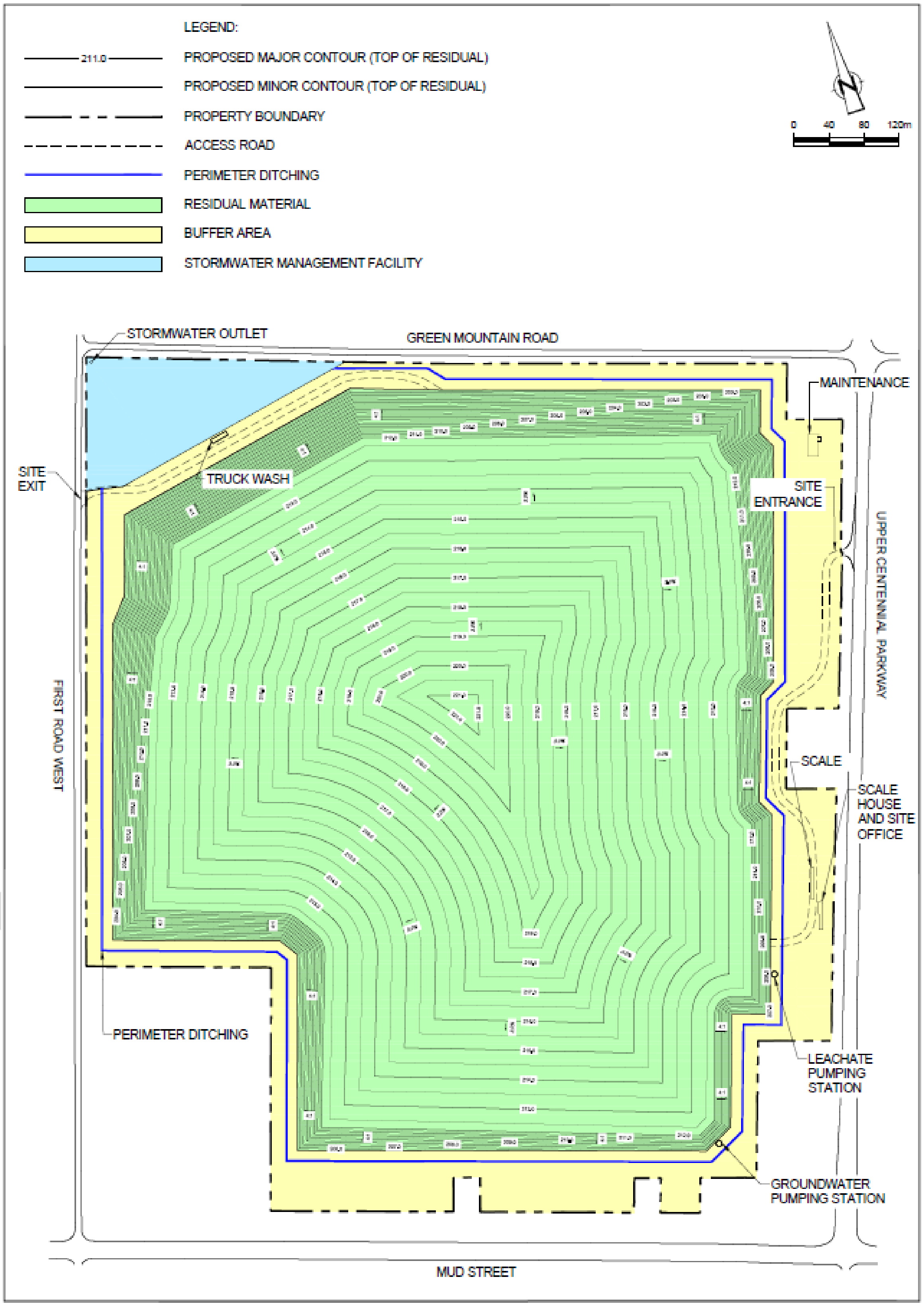


Figure 1.1 Preferred Landfill Footprint

1.3 Facility Characteristics Report

The Facility Characteristics Report (FCR) presents preliminary design and operations information for the Preferred Landfill Footprint (**Option #5**) 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.

1.4 Design and Operations Study Team

The Design and Operations study team consisted of GHD and Terrapure staff. The actual individuals and their specific roles are provided as follows:

- ***Brian Dermody – Discipline Lead***
- ***Kenneth Renner – CAD Design***
- ***Brad Mullin – Site Operations and Environmental Compliance***
- ***Andrew Wesolowski – Base Liner System Design***
- ***Neil Shannick – Leachate Modeling***
- ***Bryan Szalda – Landfill Gas Modeling***

2. Study Area

The study area for the Preferred Alternative Landfill Footprint at the SCRF related to the Design and Operations discipline is generally limited to the on-Site area. The on-Site area includes all the lands within the existing, approved boundaries of the SCRF, as defined by Environmental Compliance Approval (ECA) No. A181008, as amended. The on-Site area is defined by the Property Boundary, as shown in **Figure 1.1**.

3. Methodology

The assessment of impacts associated with the Preferred Landfill Footprint was undertaken through a series of steps that were based, in part, on a number of previously prepared reports (Design and Operations Existing Conditions Report, Design and Operations Comparative Evaluation Technical Memorandum, Facility Characteristics Report). The net effects associated with the Six Alternative Landfill Footprint Options identified during the Alternative Methods phase of the EA were based on Conceptual Designs. These effects were reviewed within the context of the detailed design plans developed for the Preferred Landfill Footprint, as identified in the FCR, to determine the type and extent of any additional investigations required to ensure a comprehensive assessment of net effects. Additional investigations were then carried out, where necessary, in order to augment the previous work undertaken.

With these additional investigations in mind, the potential impact on the Design and Operations environment of the Preferred Landfill Footprint was documented.

With a more detailed understanding of the Design and Operations environment developed, the previously identified potential effects and recommended impact management measures associated with the

Preferred Landfill Footprint (documented in the Design and Operations Comparative Evaluation Technical Memorandum, March 2018) were reviewed to ensure their accuracy in the context of the preliminary design. Based on this review, the potential effects, mitigation or compensation measures, and net effects associated with the Preferred Landfill Footprint were confirmed and documented. In addition to identifying mitigation or compensation measures, potential enhancement opportunities associated with the preliminary design for the Preferred Landfill Footprint were also identified, where possible.

Following this confirmatory exercise, the requirement for monitoring in relation to net effects was identified, where appropriate. Finally, any Design and Operations approvals required as part of the implementation of the Preferred Landfill Footprint were identified.

4. Additional Investigations

The current Design and Operations (D&O) Report for the Site was prepared by Gartner Lee Limited in 1995, as part of the original Environmental Assessment. This document forms part of the Environmental Compliance Approval (ECA) approved in 1996, and is still the basis for the overall design and operations of the Site.

Considerable knowledge and experience has also been gained through the operation of the Site over more than 20 years. In addition, the ongoing environmental monitoring activities documented in the Annual Monitoring Reports have lead to an in-depth understanding of actual field conditions encountered at the Site. These documents and direct experience allow for the establishment of realistic baseline conditions and the determination of potential effects on the design and operations of the Site as a result of the Preferred Alternative Landfill Footprint.

In addition to the above, the following investigations were undertaken to verify environmental characteristics within the Study Area related to the Design and Operations discipline:

- Review of the overall configuration of the Site, including the landfill footprint, contours, buffer areas, and infrastructure requirements
- Confirmation of the design of the Base Liner System and Final Cover System
- Hydrologic Evaluation of Landfill Performance (HELP) modeling to determine leachate management requirements
- Assessment of the Contaminating Lifespan
- Using the Scholl Canyon model to determine landfill gas management requirements

5. Detailed Description of the Environment Potentially Affected

As noted in **Section 1.2**, the Site currently covers a total area of 75.1 ha. The current approved footprint for residual material is 41.5 ha; the industrial fill material covers an area of approximately 17.6 ha; and the Site buffers and other infrastructure (e.g., stormwater management system, Site office) cover an area of approximately 16.0 ha. The current approved configuration of these components is shown in **Figure 5.1**, while the existing conditions are shown in **Figure 5.2**.

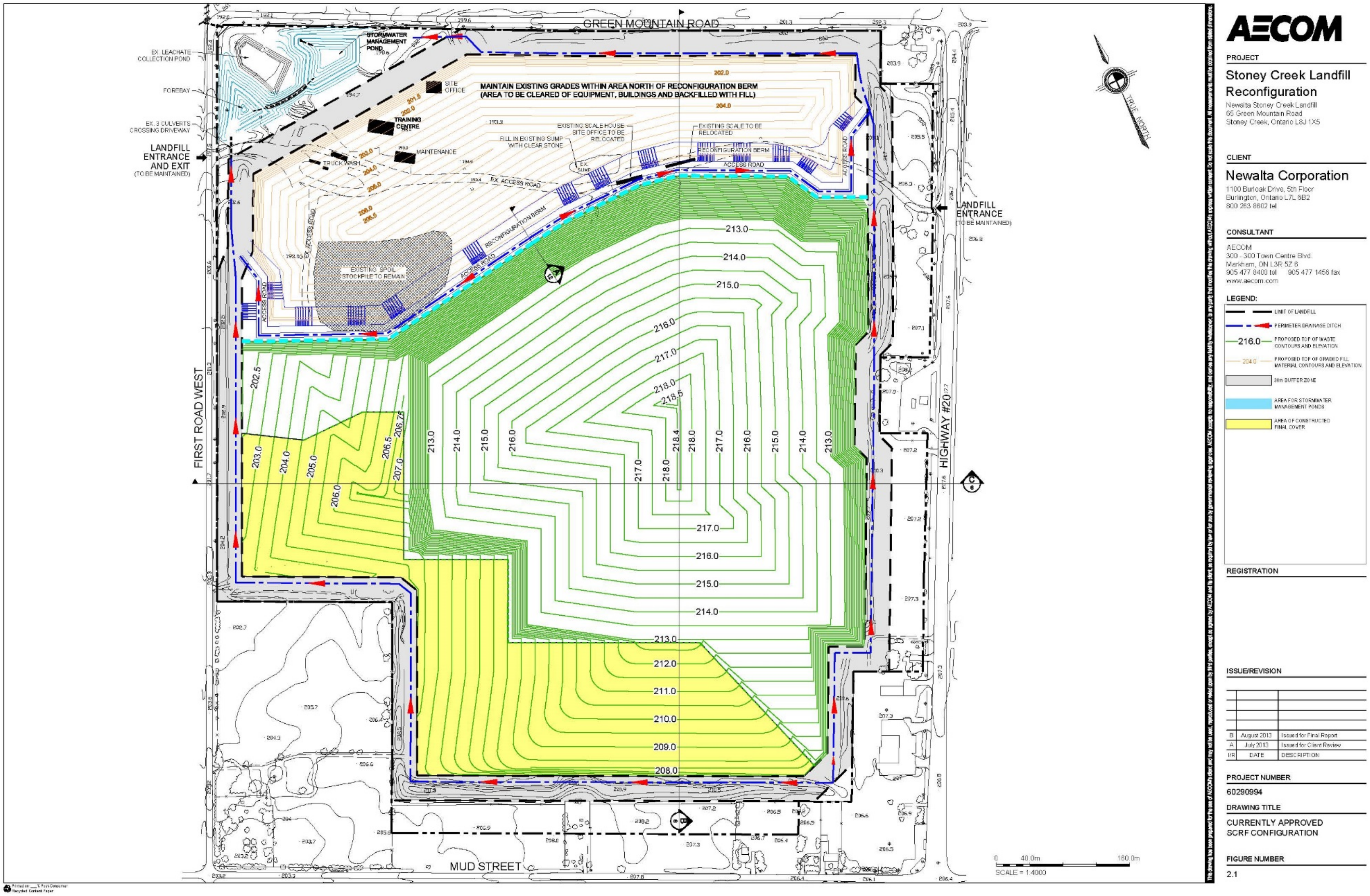
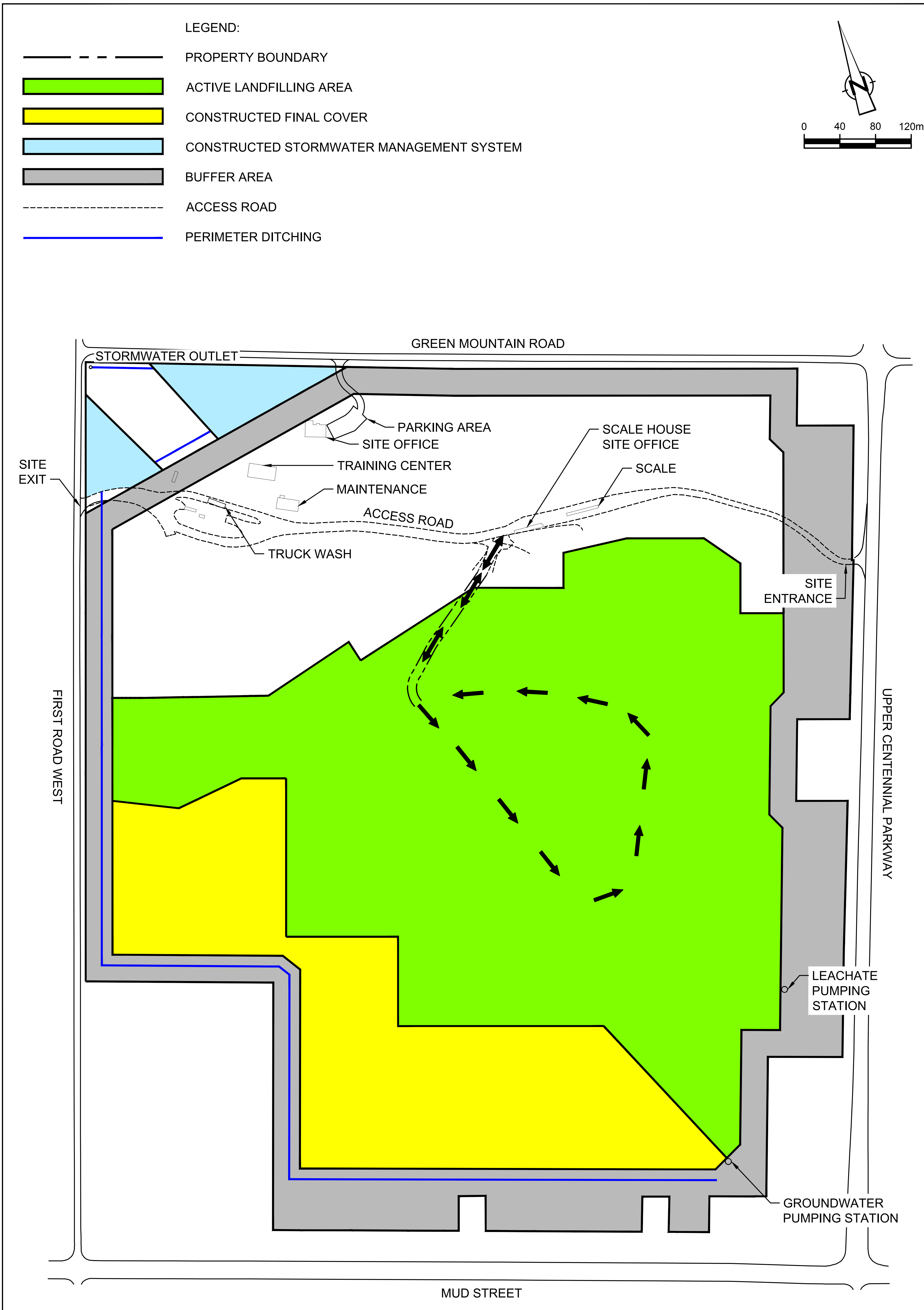


Figure 5.1 Stoney Creek Landfill Reconfiguration



TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
ENVIRONMENTAL ASSESSMENT - CAPACITY INCREASE

EXISTING CONDITIONS

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May 7, 2018

FIGURE 5.2

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The proposed expansion of the SCRF will increase the overall size of the landfill. The residual material area would be extended vertically, increasing the peak height by approximately 2.5 m. The residual material area would also be extended horizontally to the north, replacing the area currently approved for industrial fill material and extending back to the original approved footprint 59.1 ha. Industrial fill material would no longer be accepted at the Site. The overall Site area of 75.1 ha will not change.

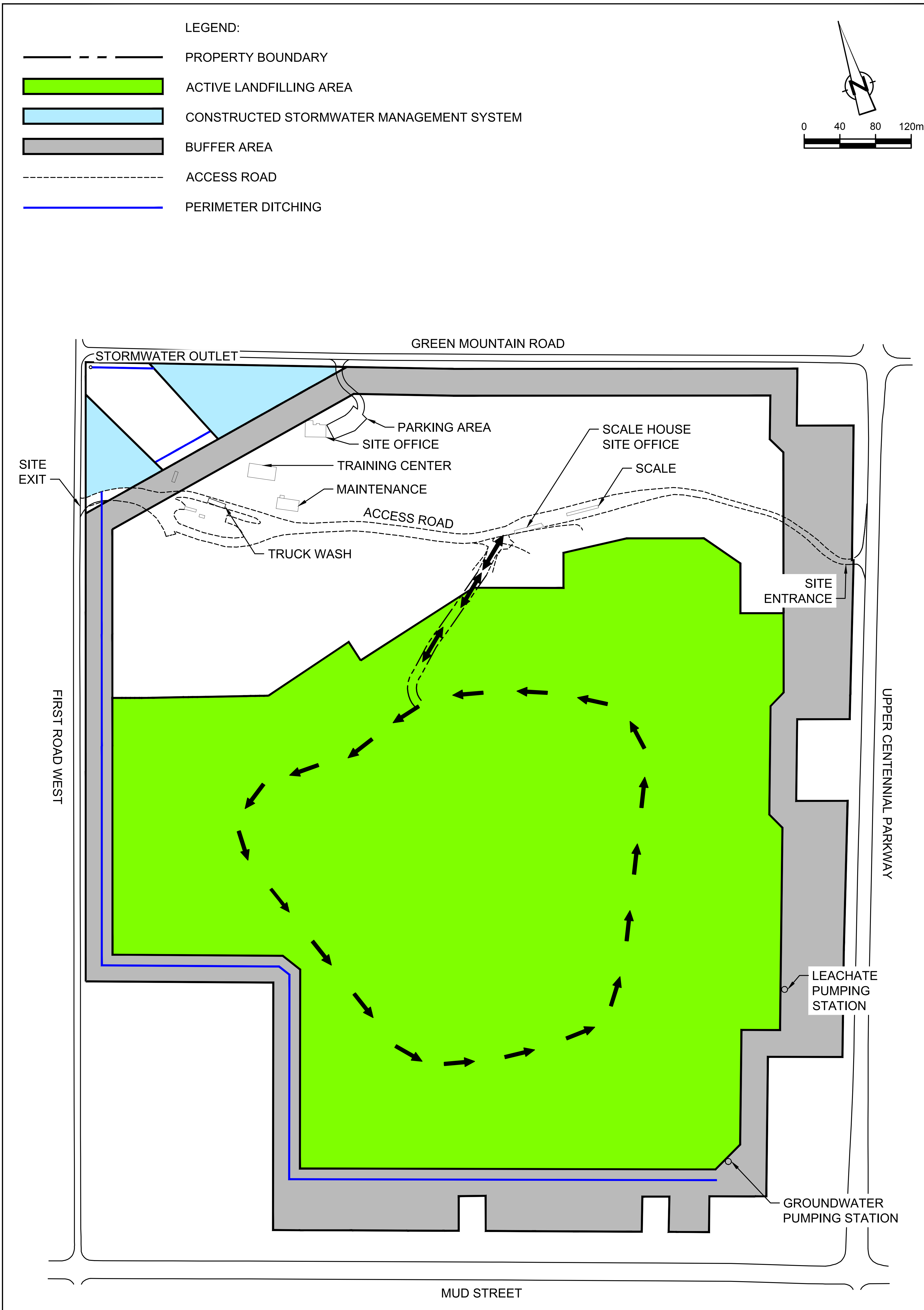
The potential effects of the Preferred Alternative Landfill Footprint related to the Design and Operations discipline will vary over the different development stages of the Site: existing conditions, operations, and post-closure. Furthermore, the operations stage is anticipated to occur over four (4) phases, with different sequencing for the following components:

- Active landfilling area
- Constructed final cover
- Constructed base liner system
- Constructed stormwater management system
- Buffer areas
- Access roads and Site infrastructure

The proposed staging of Phases 1 through 4 are presented in **Figures 5.3** through **5.6**, respectively. Post-closure conditions are presented in **Figure 5.7**. A summary of these components over each of the phases is provided in **Table 5.1**. The potential effects of the development of the Preferred Landfill Footprint over these phases under the Design and Operations discipline are discussed in **Section 6**.

Table 5.1 Estimated Areas of SCRF Components

Component	Area (ha)					
	Existing Conditions	Phase 1	Phase 2	Phase 3	Phase 4	Post-Closure
Size of Active Landfilling Area	28.9	40.2	21.8	16.8	18.8	0.0
Total Area with Final Cover	11.3	0.0	18.4	32.9	40.3	59.1
Amount of Base Liner System Constructed during Phase	0.0	0.0	9.4	9.4	0.0	0.0
Total Area of Constructed Stormwater Management System	1.5	1.5	1.5	2.5	2.5	2.5
Total Footprint of Buffer Areas	13.5	13.5	13.5	13.5	13.5	13.5
Total Footprint of Undeveloped Areas	19.9	19.9	10.5	0.0	0.0	0.0
TOTAL	75.1	75.1	75.1	75.1	75.1	75.1



TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
ENVIRONMENTAL ASSESSMENT - CAPACITY INCREASE
PHASE 1

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FIGURE 5.3

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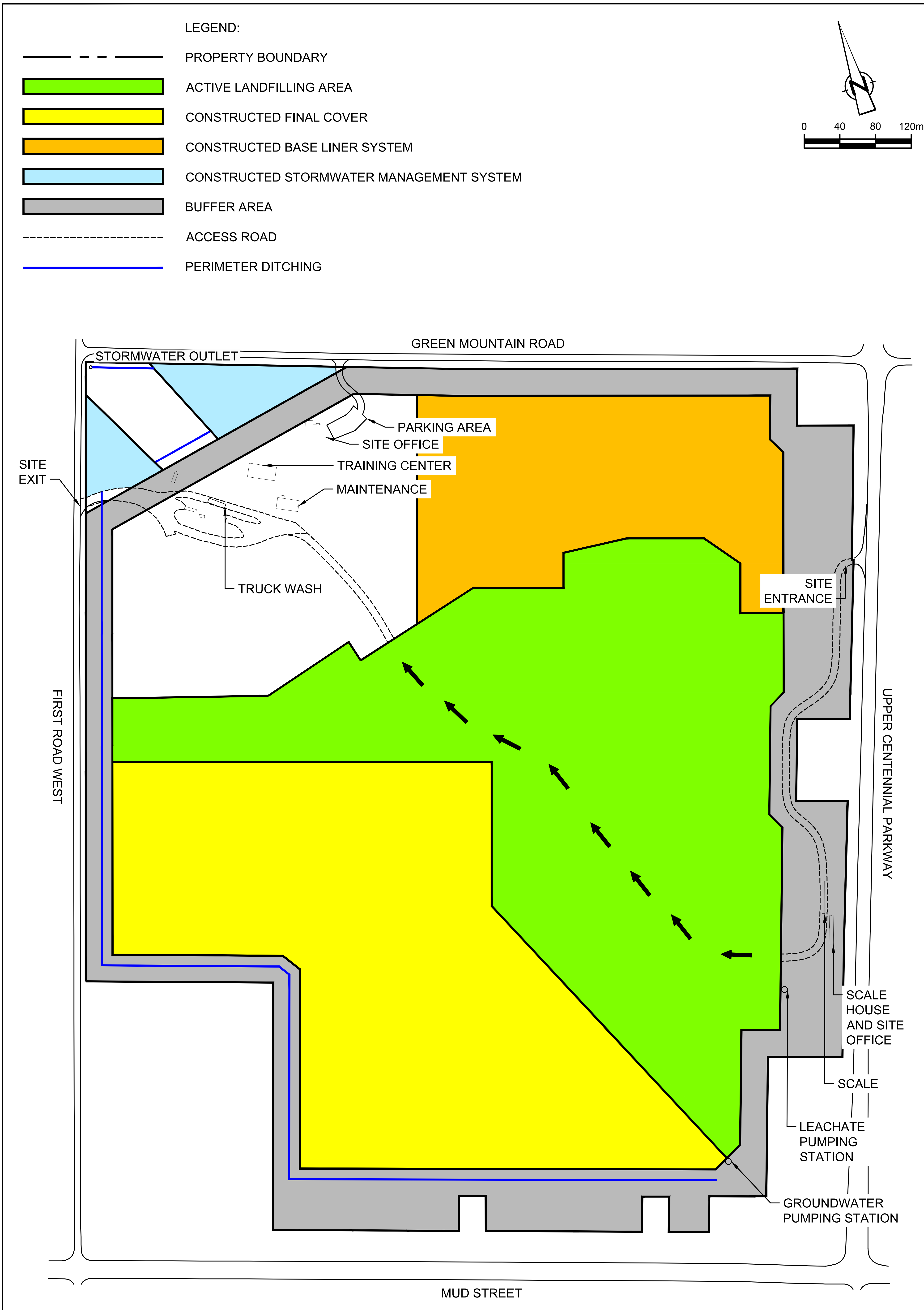

TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
ENVIRONMENTAL ASSESSMENT - CAPACITY INCREASE

PHASE 2

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FIGURE 5.4

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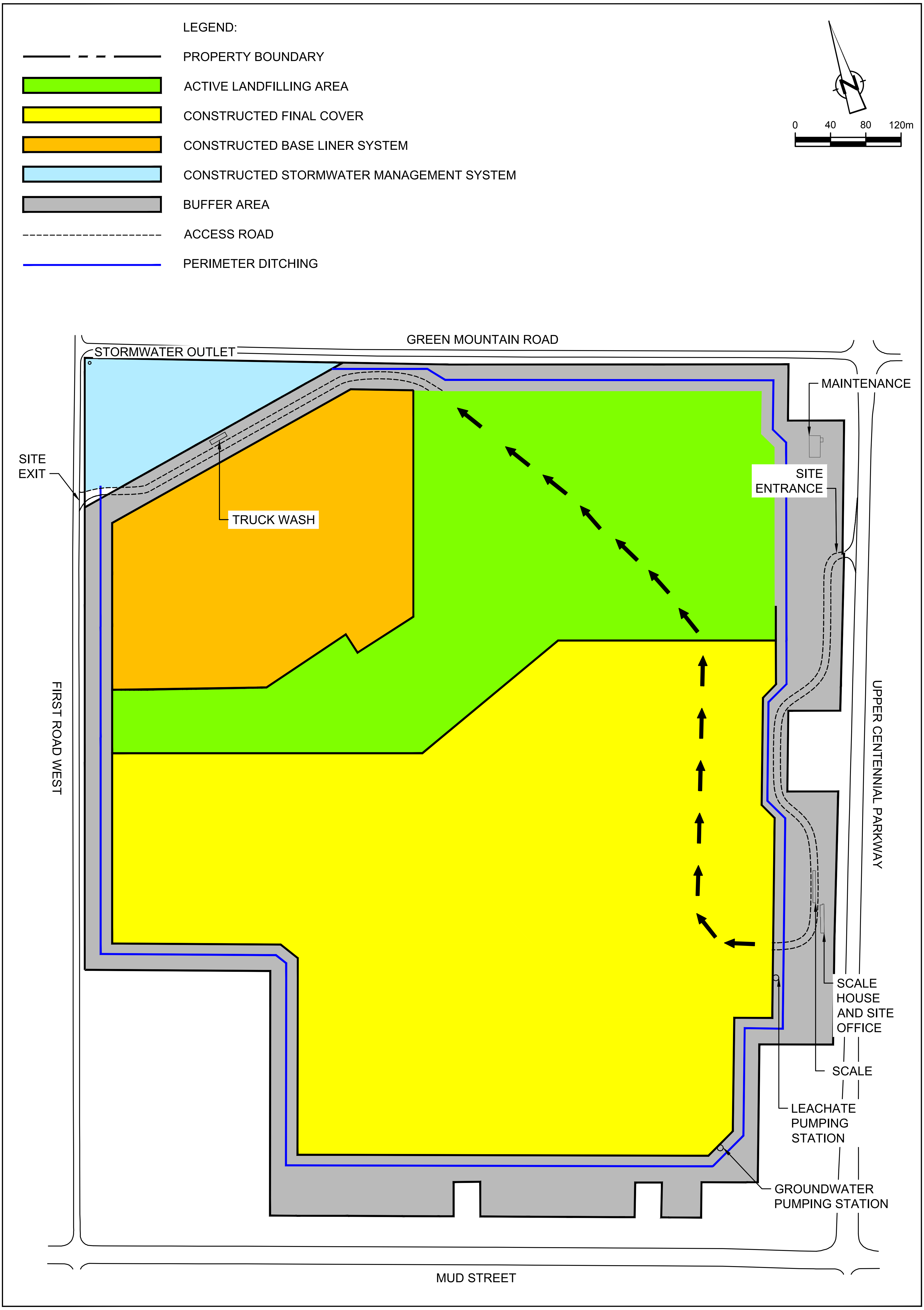

TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
ENVIRONMENTAL ASSESSMENT - CAPACITY INCREASE
PHASE 3

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FIGURE 5.5

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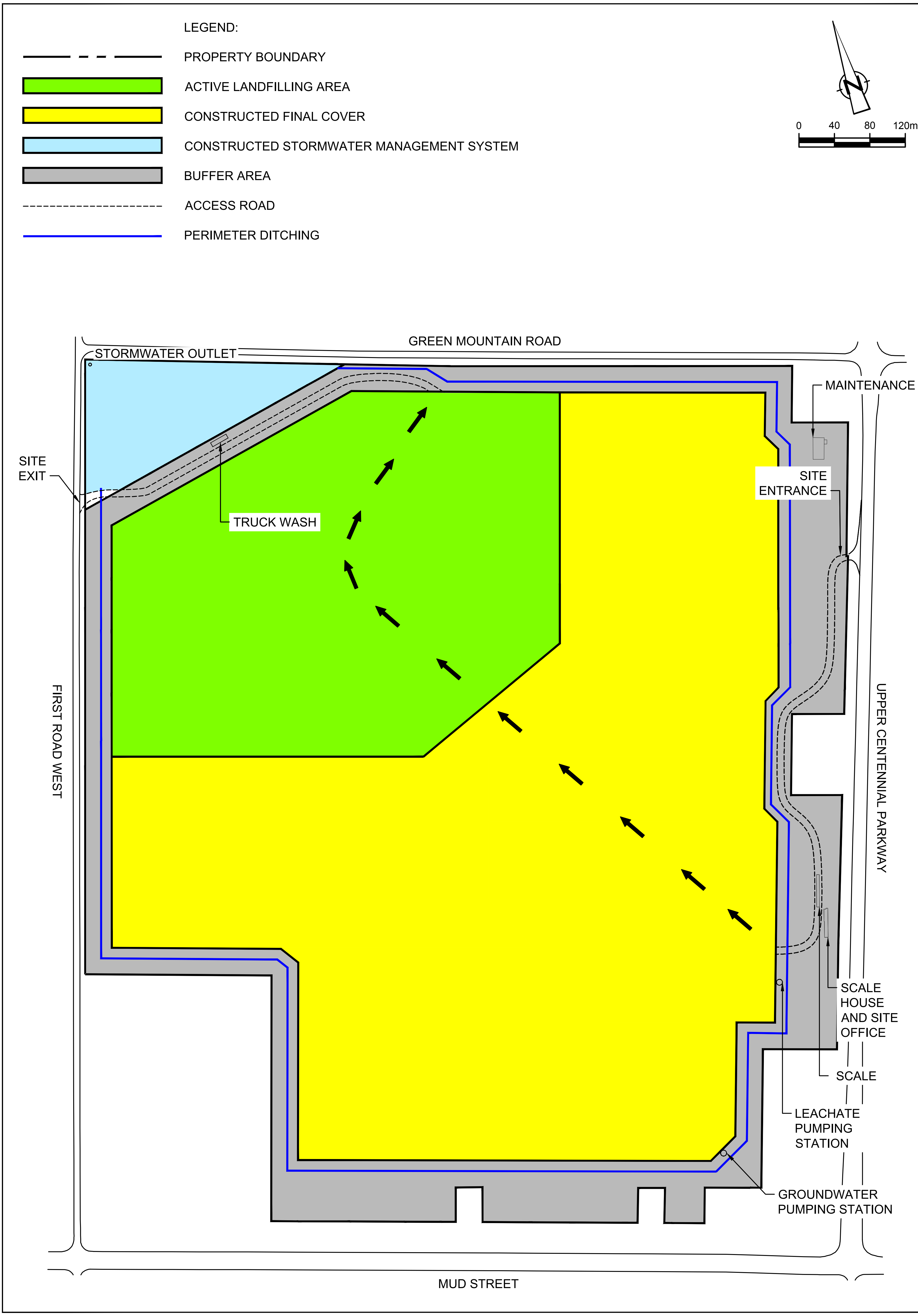

TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
ENVIRONMENTAL ASSESSMENT - CAPACITY INCREASE

PHASE 4

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FIGURE 5.6

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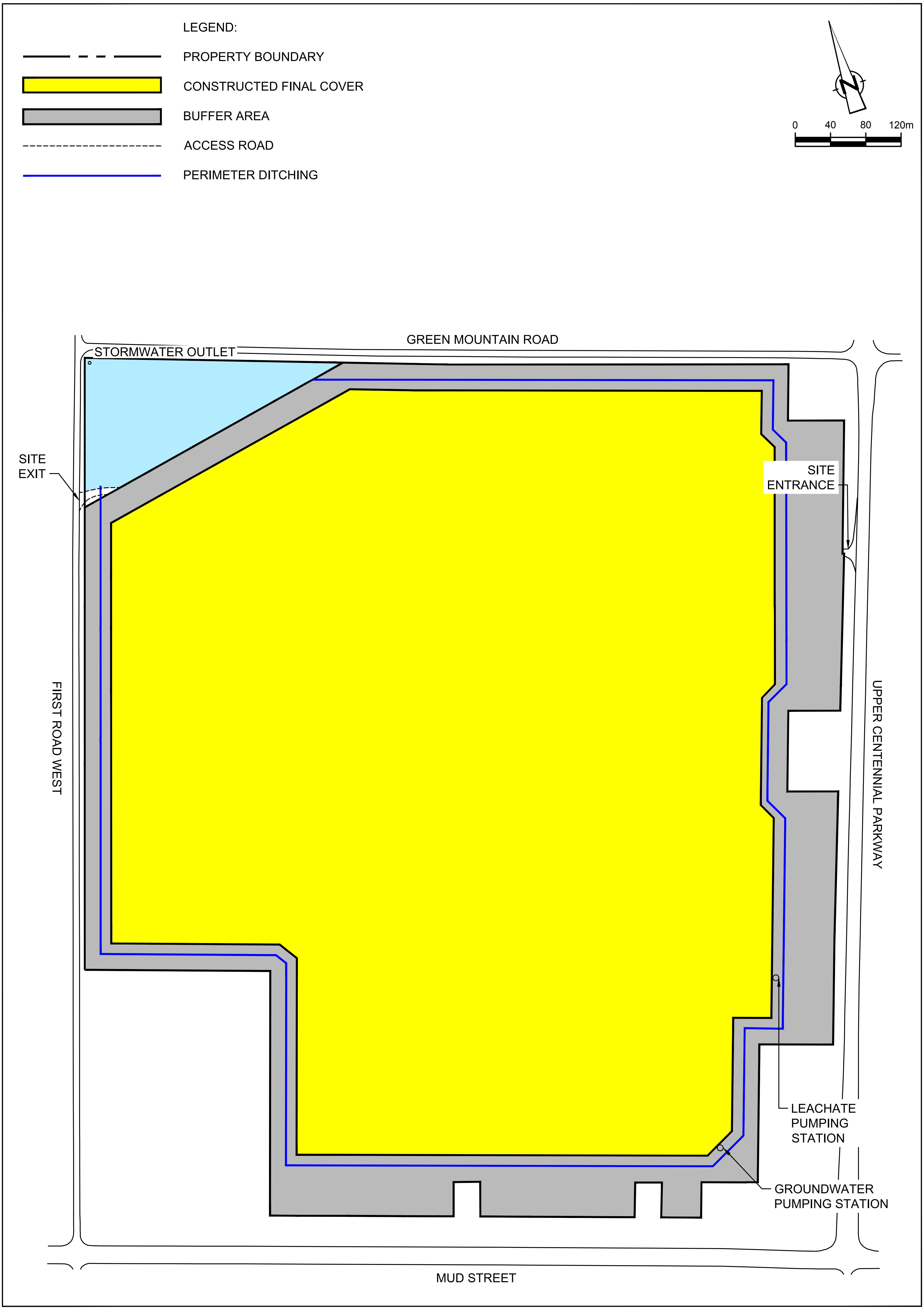

TERRAPURE ENVIRONMENTAL
STONEY CREEK REGIONAL FACILITY
ENVIRONMENTAL ASSESSMENT - CAPACITY INCREASE

POST-CLOSURE

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FIGURE 5.7

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6. Design and Operations Net Effects

As mentioned, the previously identified potential effects and recommended mitigation or compensation measures associated with the Preferred Landfill Footprint were reviewed to ensure their accuracy in the context of the preliminary design of the Preferred Landfill Footprint, based on the more detailed understanding of the Design and Operations environment developed through the additional investigations. With this in mind, the confirmed potential effects, mitigation or compensation measures, and net effects are summarized in **Table 6.3** and described in further detail in the sections below.

6.1 Potential Effects on Design and Operations

6.1.1 Accepted Materials

The SCRF will continue to accept post-diversion, solid, non-hazardous industrial residual material from sources from within the Province of Ontario. The SCRF will no longer be approved to accept industrial fill material.

Detailed records of the residual materials accepted at the Site each year are documented in the Annual Monitoring Report. **Table 6.1** provides a summary of the residual materials accepted at the Site and their approximate fraction of the overall total based on records from 1997 to 2017. The general composition of the residual material accepted at the Site in the future is not expected change significantly since the primary sources of material (i.e., steel making industry, soils from infrastructure development projects) are expected to remain the same.

Table 6.1 Summary of Accepted Materials (1997-2017)

Material	Approximate Fraction of Total
Non-Hazardous Industrial Waste	60.4%
Non-Hazardous Contaminated Soils	15.7%
Basic Oxygen Furnace Oxide	13.7%
Mixed Waste	8.5%
Construction & Demolition Waste, Asbestos, Slag Fines	1.7%
TOTAL	100.0%

6.1.2 Fill Rate

No changes are being proposed to the maximum approved fill rate for residual material of up to 750,000 tonnes in any consecutive twelve month period, or up to 8,000 tonnes per day.

6.1.3 Timing

The proposed expansion of the SCRF will increase the approved capacity by 3,680,000 m^3 for post-diversion, solid, non-hazardous residual material. Based on the total tonnage and volume of residual material received at the Site between 1997 and 2017, an in-situ, compacted density of approximately 1.9 tonnes/m^3 has been achieved for the residual material. Using a density conversion of 1.9 tonnes/m^3 would yield additional capacity for approximately 6,992,000 tonnes of residual material.

Assuming the maximum allowable fill rate of up to 750,000 tonnes per year, the Site could reach capacity in as little as 10 years. Using the actual average fill rate between 1997 and 2017 of approximately 562,000 tonnes per year, the Site would reach capacity in 13 years. Allowing for up to an additional 2 years to achieve Site closure, it is anticipated that the operating stage of the SCRF would be between approximately 10-15 years. However, it should be noted that these values represent estimates based on currently available information and may change depending on actual operating conditions encountered at the Site.

Construction activities associated with the SCRF (e.g., base liner system, stormwater management system, Site infrastructure) will be undertaken as required, but will occur concurrently with Site operations over the entire operating period of approximately 15 years. Post-Closure activities (e.g., maintenance and monitoring) are expected to last for a minimum of 25 years immediately following the closure of the Site.

6.1.4 Site Infrastructure

There are no additional requirements beyond the existing Site infrastructure as a result of the implementation of the Preferred Landfill Footprint. The existing Site infrastructure will generally be reconfigured as follows over the life of the Site:

- Trucks will continue to use the Site entrance from Upper Centennial Parkway and the Site exit onto First Road West throughout all phases.
- Site offices and parking areas will be relocated to the southeast buffer area during Phase 2.
- New, paved access roads will be established in the east buffer and north buffer areas during Phase 2.
- The weigh scale and scale house will be relocated to the southeast buffer area during Phase 2.
- The maintenance facility will be relocated to the northeast buffer area during Phase 3.
- The truck wash facility will be relocated to the northwest buffer area during Phase 3.
- The training center will be decommissioned during Phase 3.

All Site infrastructure (with the potential exception of the Site entrance and exit) will be decommissioned during the closure stage, as dictated by the proposed end use(s) for the Site.

6.1.5 Buffers

Minimum on-Site buffer distances of 30 m will be maintained around the perimeter of the residual material area throughout all phases. On-Site buffers currently extend to approximately 65 m in various areas along the east and south side of the Site, and up to approximately 130 m in the vicinity of the existing stormwater management facility in the northwest corner of the Site. These buffer distances will also be maintained. It should be noted that while the residual material area will expand toward the north of the Site, this area would have been occupied by industrial fill under the current configuration, which also would have maintained a minimum 30 m separation with the northern property boundary.

The buffer area will be used for the construction of on-Site infrastructure such as roads, buildings, monitoring systems, maintenance structures, stormwater drainage ditches, visual screening (e.g., fences, earth berms), and vegetation.

Off-Site separation distances are expected to remain similar to current conditions in areas to the north, south, and west of the Site over all phases. Current separation distances to the east of the Site may change if development of the adjacent properties occurs in the future.

6.1.6 Base Liner System

The design of the base liner system as presented in Section 2.11 of the FCR will remain unchanged as a result of the implementation of the Preferred Landfill Footprint. The base liner system will continue to be constructed in stages as required by landfilling operations and will be connected to the existing base liner system. The base liner system will be constructed in the northeast portion of the Site in Phase 2, and in the northwest portion of the Site in Phase 3.

In order to verify the suitability of the proposed height increase, it was also necessary to check that the installed geotextile would continue to provide sufficient protection of the HDPE liner from being punctured by the overlying granular material. Detailed calculation are provided in **Appendix A**.

It was determined that the existing 445 g/m^2 non-woven, needle-punched geotextile installed for the protection of the HDPE geomembrane meets the required factor of safety for protection against puncture. It was also determined that a geotextile with a minimum mass of 405 g/m^2 would be required to prevent damage to the HDPE geomembrane from construction, which is less than the proposed geotextile mass of 445 g/m^2, therefore the protection form construction procedures is fully satisfied.

6.1.7 Daily Operations

General Site operations are not expected to change from current practices (as presented in **Section 2.12** of the FCR) as a result of the implementation of the Preferred Landfill Footprint. This includes:

- Operating hours
- Staffing
- Equipment
- Waste receiving process
- Site administration
- Operations management
- Maintenance work
- Environmental monitoring

The key objective for the landfill design and operations will continue to be the minimizing of potential nuisance impacts including noise, litter, vectors, dust, and odour. Typical operating practices relating to these issues will continue to include:

- Vehicles transporting waste to and around the Site will be covered to prevent odour and dust;
- All materials received at the Site will be verified and recorded to ensure compliance with regulatory conditions;
- On-Site equipment will be operated in such a manner as to minimize noise and visual impacts wherever possible;
- All equipment required for the development, operation, or closure of the Site will comply with the noise levels outlined in applicable MOECC guidelines and technical standards;
- All vehicles leaving the Site will be required to drive through a wheel-wash to minimize track-out of mud/dirt; and,
- The Site design will include screening features, such as fences, berms and tree plantings, which mitigate visual impact and noise.

6.1.8 Traffic

No changes are being proposed to the current maximum allowable traffic limit of 250 vehicles/day. Traffic levels for the expanded SCRF are anticipated to remain similar to the current average of approximately 70-100 vehicles/day.

Trucks will continue to use the existing entrance and exit over the life of the Site. New, paved access roads will be constructed in the east and north buffers during Phase 2. The location of other internal access roads will vary over the life of the Site depending on construction staging and the location of the active landfilling area.

Truck traffic associated with the operation of the landfill will generally include transfer trailers, tri-axles, and roll-off trucks hauling waste to the Site. Construction activities will also require the importation of materials using tri-axles, flatbeds, and transfer trailer trucks. Traffic volumes will vary over the life of the Site depending on construction and landfilling activities.

6.1.9 Leachate Management

Leachate is formed when precipitation infiltrates into waste materials and dissolves various minerals, elements, and chemical compounds out of the waste. As the leachate infiltrates the landfill, it is collected through a network of perforated pipes on top of the base liner system which covers the entire landfill footprint. The leachate collection system is sloped at 0.5% towards the southeast where it drains by gravity to a leachate pumping station. The leachate is then pumped to the surface of the landfill where it is discharged to a gravity main that flows to the equalization pond in the adjacent closed west Site.

The SCRF currently produces leachate that exceeds various regulatory limits for surface and groundwater quality and thus cannot be released to the environment. Terrapure currently has a sewer use agreement with the City of Hamilton which allows for the controlled discharge of leachate from the Site to the sanitary sewer under Mistywood Drive.

The leachate generation rate will vary over the life of the Site depending on precipitation, waste characteristics, the size of the constructed base liner system, and the progress of final cover construction. The leachate generation rate in the post-closure condition (i.e., with final cover constructed) was estimated to be approximately 4.2 litres per second (L/s) in the Design and Operations Report. The amount of leachate generated and discharged from the Site is documented in the Annual Monitoring Report. In 2016, approximately 98,000,000 litres of leachate was discharged to the sanitary sewer, corresponding with a leachate generation rate of approximately 3.1 L/s.

In order to determine the potential future impacts related to leachate as a result of the implementation of the Preferred Landfill Footprint, GHD utilized the Hydrologic Evaluation of Landfill Performance (HELP) modeling to determine leachate management requirements. The anticipated leachate generation rates for each Site configuration are presented in **Table 6.2**. Detailed HELP modeling results are presented in **Appendix B**.

Table 6.2 Estimated Leachate Generation Rates

	Existing Conditions	Phase 1	Phase 2	Phase 3	Phase 4	Post-Closure
Leachate generation rate (L/s)	5.3	5.9	4.9	5.5	6.5	5.5

As can be seen, leachate generation rates are anticipated to increase as a result of the expanded SCRF when compared to current estimates. This is to be expected since the generation rate is largely tied to the overall footprint of the residual material area. However, it should also be noted that the values presented are assumed to be conservative, since the HELP model provides a much higher estimate for the leachate generation rate under existing conditions than the actual recorded values.

The existing sewer use agreement with the City of Hamilton to allow the controlled discharge of leachate would need to be amended. Leachate discharge from the Site is expected to increase slightly compared to current operations. The leachate quality (i.e., chemistry) is expected to be similar to current operations since the residual materials accepted at the Site are expected to remain relatively consistent.

It is anticipated that no changes would be required to the existing leachate collection system at the SCRF to accommodate the leachate from the expanded footprint. As per the current plans, the leachate pumping station will be reconfigured into its final location in the southeast corner of the Site. Terrapure are also looking into establishing a new discharge point to the existing sanitary sewer under Upper Centennial Parkway.

6.1.10 Final Cover

The final cover acts as a barrier between the waste and the environment. The cover also serves to intercept clean stormwater, reducing infiltration and leachate generation. The approved final cover design consists of 0.60 m of compacted clay overlain by 0.15 m of vegetated topsoil.

The regulatory requirements specify a maximum slope of four units horizontal to one unit vertical (4H to 1V, or 25%) and a minimum slope of 20H to 1V (5%), but allow variance where it can be shown to be appropriate with respect to slope stability, erosion potential, end uses, and infiltration requirements for groundwater protection. Slopes of a minimum 33.3H to 1V (3%) are currently approved at the SCRF.

The general design of the final cover system will remain unchanged as a result of the implementation of the Preferred Landfill Footprint. Final cover will be constructed as active landfilling areas are progressively filled to the approved final contours, eventually covering the entire landfill. The progression of final cover construction over the operating and closure stages of the Site will generally be as follows:

- Existing final cover over the south east portion of the Site will be removed in Phase 1
- Final cover will be constructed over the south east portion of the Site in Phase 2
- Final cover will be constructed over the east central portion of the Site in Phase 3
- Final cover will be constructed over the north east portion of the Site in Phase 4
- Prior to closure, final cover will be constructed over all remaining areas in the north west portion of the Site

6.1.11 Stormwater Management

Ontario Regulation 232/98 requires that landfill sites be designed to protect surface water to specified performance standards based on the following principles:

- Divert or control clean surface water flowing onto the Site.
- Control quality and quantity of run-off discharging from the Site to control erosion, sediment transport, and flooding.

Under the current design, clean surface run-off is shed from the final cover into perimeter drainage ditches, where it drains by gravity to a series of ponds (i.e., sediment forebay and detention pond) in the northwest corner of the Site before being discharged to the storm sewer under First Road West.

While the overall function of the stormwater management system will not change as a result of the implementation of the Preferred Landfill Footprint, the location and alignment of the existing ponds and ditches will be updated over the life of the Site to reflect current conditions.

The existing stormwater management system consists of perimeter ditching along the south and west sides of the capped landfill, as well as a forebay and detention pond in the northwest corner of the Site. This configuration would be maintained until Phase 3, when perimeter ditching will be constructed on the east and north sides of the capped landfill, and the existing ponds will be reconfigured to allow for two separate forebays and one large detention pond.

The existing stormwater outlet to the storm sewer under First Road West will remain. Significant changes to the approved configuration or capacity of the stormwater management system are not expected to be required since the overall catchment area of the Site will remain largely unchanged. Additional details are presented in the Detailed Impact Assessment for the Surface Water Discipline.

6.1.12 Landfill Gas Management

Ontario Regulation 232/98 requires that landfills greater than 1.5 million m^3 in capacity have a landfill gas control system in place. However, this applies primarily to sites that accept wastes that are capable of decomposing and generating gases. Since the SCRF does not accept these types of materials, a landfill gas emission study was prepared in 2011 demonstrating that very little gas is generated at the SCRF, and the Site was granted an exemption from the MOECC from the requirement to have a landfill gas collection system.

The relatively small amount of landfill gas generated at the SCRF is passively vented to the atmosphere through the final cover system. Confirmatory monitoring for landfill gas is documented in the Annual Monitoring Report.

In order to provide an estimate of the potential future impacts related to landfill gas as a result of the implementation of the Preferred Landfill Footprint, GHD utilized a form of the Scholl Canyon equation in order to model the maximum methane generation rate within the landfill. The methane generation within a landfill for a given year can be calculated based on historical waste records and future projections of the annual waste acceptance rate.

Results of the landfill gas modeling carried out using the Scholl Canyon model are presented in **Appendix C**. The Scholl Canyon model projects a maximum of 4,766 tonnes of methane to be generated in 2028, which equates to 119,154 tonnes of carbon dioxide equivalents (CO_2e) assuming a global warming potential of 25 for methane. Accounting for cover oxidation, the total portion of methane emitted in 2028 is anticipated to be approximately 3,575 tonnes (89,636 CO_2e).

For comparison purposes, a model run was also performed assuming that the SCRF is composed of 100% municipal solid waste (MSW). Under this scenario, the maximum methane generated was estimated to be approximately 50,422 tonnes (1,260,547 CO_2e). As such, it is estimated that the expanded SCRF would have methane and CO_2e emissions that are approximately 7.1% of emissions anticipated from a similar sized MSW landfill.

Based on these projections, it is anticipated that a gas collection system would not be warranted for the expanded SCRF, and that an exemption from the related requirements of Ontario Regulation 232/98 would again be granted by the MOECC. Notwithstanding this, an update to the landfill gas emission study will also be undertaken during the summer of 2018.

6.1.13 Groundwater Management

The dissolution of constituents from the residual material into leachate is an ongoing process, and, eventually, a sufficient amount of these constituents will be removed from the waste so that the leachate can no longer adversely impact the environment. The “contaminating lifespan” is thus defined as the length of time that the wastes can produce leachate that is unacceptable for direct release to the environment. The contaminating lifespan of the SCRF was estimated to be in the range of 200 to 300 years in the Design and Operations Report.

GHD is currently undertaking a detailed review of the contaminating lifespan calculations for the SCRF, and believes that the original estimate of 200 to 300 years is very conservative. This is based on the following preliminary observations:

- Previous modeling assumed a much higher amount of evapotranspiration than the value determined through current HELP modeling, reducing the amount of precipitation available for infiltration (i.e., precipitation surplus). Despite applying a higher percentage of this precipitation surplus as infiltration than current HELP modeling indicates, previous modeling returned a much lower infiltration rate, resulting in a more conservative estimate of the contaminating lifespan due to less water being available to dissolve contaminants from the waste mass.
- The target concentrations for the contaminants of concern should be evaluated against the reasonable use guideline (MOECC Guideline B-7) which requires compliance at the boundary of the adjacent property. Horizontal migration of leachate between the base of the landfill and the compliance boundary would further reduce contaminant concentrations, further lowering the contaminating lifespan.
- Original estimates assumed that the full amount of each parameter would be available for dissolution. In reality, numerous parameters will be in a low solubility form, meaning that the initial contaminant concentrations in the leachate would be lower, in turn leading to a lower contaminating lifespan.

For these reasons it is anticipated that the updated modeling will yield a much lower contaminating lifespan for the SCRF. Additional details of the potential effects of leachate on groundwater are presented in the Detailed Impact Assessment for the Geology and Hydrogeology Discipline.

6.1.14 Site Closure and End Use

Closure of the Site will be undertaken immediately following the completion of landfilling to the approved final contours. Closure activities will include the construction of final cover, removal of roads and other infrastructure (e.g., weigh scales, truck wash, maintenance facility) that is not required in the post-closure period, and the implementation of a long-term monitoring and maintenance program. The overall Site closure requirements will remain unchanged as a result of the implementation of the Preferred Landfill Footprint.

Site end use will be determined through consultation with the local community and other stakeholders as part of the EA approvals process. Potential end uses may include public open space (e.g., park) that could accommodate various passive or active recreational activities, or a restricted access open space.

Ongoing landfill monitoring and maintenance requirements will need to be incorporated into end use planning. Specific considerations will include but are not limited to:

- Access to leachate and gas control systems for ongoing operations, maintenance and monitoring;
- Access to environmental monitoring locations;
- Prevention of public access to operational or monitoring areas; and,
- Impact of potential end use activities on the Site's leachate, or surface water controls.

6.2 Proposed Mitigation and/or Compensation Measures

The potential effects associated with design and operational changes to the SCRF as a result of the implementation of the Preferred Landfill Footprint can only be mitigated through modifications to the Site's design and/or operations. There are also design and operating limitations that can affect the ability to mitigate these effects. Overall, the magnitude of the net effects from a Design and Operations standpoint is anticipated to be small since many aspects of the Site would have required modifications from their existing configuration in order to achieve their approved final configuration anyways.

6.3 Net Effects

The potential effects, mitigation or compensation measures, and net effects associated with the Preferred Landfill Footprint as they relate to the Design and Operations Discipline are summarized below in **Table 6.3**.

Table 6.3 Potential Effects, Proposed Mitigation and Compensation Measures, and Resulting Net Effects

	Potential Effect	Mitigation/Compensation	Net Effect
Leachate Management	Increased design and operating complexity of leachate management system	Design of new base liner system to integrate seamlessly with existing base liner system. Use of only one leachate pumping station. Establish new connection to sanitary sewer. Maintain uniform shape and contours of the residual material area.	Small increase in complexity relative to current leachate management system associated with: additional base liner and leachate collection system; increased leachate generation rate.
Stormwater Management	Increased design and operating complexity of stormwater management system	Design of new stormwater management system to integrate seamlessly with existing stormwater management system. Extend perimeter drainage ditches to accommodate new residual material area. Maintain current approved location and layout of stormwater pond. Maintain existing stormwater outlet to storm sewer.	No increase in complexity relative to current stormwater management system. The design and layout of the stormwater management system provides design and operational flexibility.
Groundwater Management	Increased design and operating complexity of groundwater management system	Design of new groundwater management system to integrate seamlessly with existing groundwater management system. Extend groundwater collection trenches to accommodate new residual material area. Maintain existing location of groundwater outlet. Establish new connection to sanitary sewer.	No increase in complexity relative to current groundwater management system. The design and layout of the groundwater management system provides design and operational flexibility.
Landfill Gas Management	Increased design and operating complexity of landfill gas management system	Continue acceptance of waste types that do not decompose and generate significant quantities of gas. Maintain MOECC exemption from the requirement to have a gas collection system.	No increase in complexity relative to current passive system for management of landfill gas. No requirement to implement gas collection system.

	Potential Effect	Mitigation/Compensation	Net Effect
Construction	Increased complexity and reduced constructability of facility components	Design of new base liner system to integrate seamlessly with existing base liner system. Design of new final cover system to integrate seamlessly with existing final cover system. Maintain open layout with simple configuration and dedicated areas for the various infrastructure components.	Small increase in complexity relative to current construction requirements associated with: additional base liner and leachate collection system, additional final cover.
Site Operations	Increased complexity and reduced operability of facility components	Maintain design and function of existing systems (leachate, stormwater, groundwater, gas) and infrastructure (access, roads, weigh scale, wheel wash). Maintain operational flexibility of existing systems and infrastructure.	No increase in complexity or reduction in operability relative to current site operations.
Closure and Post-Closure	Increased closure and post-closure requirements and reduced flexibility of potential end uses	Maintain open and uniform configuration that will simplify Site closure requirements. Maintain overall layout and contours that do not limit the flexibility of potential end uses.	Simplified closure requirements and increased flexibility of potential end uses relative to current design.

7. Climate Change Considerations

In support of the province of Ontario's Climate Change Action Plan the MOECC has developed a Guide entitled "Consideration of Climate Change in Environmental Assessment in Ontario" (the Guide). The guide provides direction on ways to incorporate climate change consideration into environmental assessments, including the consideration of:

- greenhouse gas (GHG) emissions;
- the effects of a project on climate change;
- the effects of climate change on a project; and,
- identifying and minimizing negative effects during project design.

The guide was consulted in preparation of this report, in particular the Guide was reviewed when considering the Alternative Methods as well as the Preferred Landfill Footprint from a Climate Change perspective and addressing potential climate risks to key infrastructure components at the landfill site.

7.1 Historical Climate and Meteorological Trends

In order to sufficiently determine the potential net effects from a climate change perspective, considering accepts such as potential power outages, physical damage, stormwater management and reduced access to the Site, and to develop potential climate change adaptation and mitigation measures, an in-depth understanding of the historical climate/meteorological trends, as well as the potential for extreme weather events must be established. The following sections provides a brief summary of the historical climate/ meteorological trends Hamilton, which is in the southern part of Ontario. Southern Ontario has a humid continental climate influenced by the Great Lakes with warm summers and no dry season. The Great Lakes moderate the effects of the weather of the surrounding areas. Hamilton wraps around the westernmost part of Lake Ontario and has an escarpment that divides upper and lower parts of the city, which creates noticeable differences in weather over short distances. Hamilton experiences warm summers, moderate temperatures in the spring and fall with higher precipitation rates and cold winters.

Temperature

Regional baseline climate data (climate normal data) were obtained from Environment Canada (EC). The closest EC climate station to the SCRF with 30-year climate normal data from 1981 to 2010 available is the Hamilton A Station (John C. Munro Hamilton International Airport) (climate ID 6153194) approximately 14 km south-west of the SCRF. The Hamilton A Station is located at latitude 43.10 N, longitude 79.56 W (Elevation: 237.7 m). The temperature data for the Hamilton A Station are provided in **Table 7.1**. The annual mean temperature is estimated as 7.9˚C. The mean summer high temperature is 20.9˚C for July, while the winter mean low temperature is -5.5˚C in January. The lowest extreme minimum temperature was in January of 2004 at -30.0˚C, and the highest extreme maximum was in July of 1988 at 37.4˚C (**Table 7.2**).

Table 7.1 Mean Temperature Profiles from 1981 to 2010 at Hamilton A Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Daily Average (˚C)	-5.5	-4.6	-0.1	6.7	12.8	18.3	20.9	20.0	15.3	9.3	3.7	-2.3	7.9
Daily Maximum (˚C)	-1.7	-0.5	4.3	11.8	18.5	23.9	26.5	25.3	21.2	14.1	7.5	1.2	13.7
Daily Minimum (˚C)	-9.3	-8.6	-4.5	1.5	7.1	12.6	15.2	14.5	10.4	4.5	-0.2	-5.8	3.1

Note:
1 Source: EC 1981 to 2010 Canadian Climate Normals (climate ID: 6153194)

Table 7.2 Minimum and Maximum Temperature Extremes

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Extreme Maximum (˚C)	16.7	15.8	25.0	29.7	33.1	35.0	**37.4**	36.4	34.4	30.3	24.4	20.7
Year	2005	1997	1998	1990	2006	1988	**1988**	2001	1973	2007	1961	1982
Extreme Minimum (˚C)	**-30.0**	-26.7	-24.6	-12.8	-3.9	1.1	5.6	1.1	-2.2	-7.8	-19.3	-26.8
Year	**2004**	1994	2003	1972	1966	1998	1961	1965	1974	1965	2000	1980

Note:
1 Source: EC 1981 to 2010 Canadian Climate Normals (climate ID: 6153194)

Precipitation

The mean climate normal monthly precipitation data are provided in **Table 7.3**. The mean annual average precipitation is 929.8 mm. Approximately 85 percent of the total precipitation was in the form of rain and 15 percent as snowfall. The extreme daily participation amounts are shown form 1981 to 2010 (**Table 7.4**). The highest rainfall experienced was 107.0 mm in 1989 and the highest snowfall experienced was 43.2 cm in 1966.

Table 7.3 Mean Monthly Precipitation Profiles from 1981 to 2010 at Hamilton A Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation (mm)	64.0	57.8	68.4	79.1	79.4	84.9	100.7	79.2	81.9	77.4	84.3	73.0	929.8
Rainfall (mm)	29.7	28.2	42.6	71.3	78.7	84.9	100.7	79.2	81.9	76.5	74.4	43.8	791.7
Snowfall (cm)	40.8	35.1	26.5	8.4	0.5	0.0	0.0	0.0	0.0	0.7	11.0	33.5	156.5

Note:
1 Source: EC 1981 to 2010 Canadian Climate Normals (climate ID: 6153194)

Table 7.4 Extreme Daily Precipitation at Hamilton A Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Extreme Daily Precipitation (mm)	44.6	54.1	42.8	45.2	39.9	66.6	**107.0**	90.8	59.4	91.0	58.8	56.8
Year	1982	1990	2010	1996	1969	1984	**1989**	1981	1996	1995	1999	1990
Extreme Daily Rainfall (mm)	39.3	54.1	41.0	45.2	39.9	66.6	**107.0**	90.8	59.4	91.0	58.8	56.8
Year	1995	1990	2010	1996	1969	1984	**1989**	1981	1996	1995	1999	1990
Extreme Daily Snowfall (cm)	**43.2**	30.4	28.0	29.2	11.0	0.0	0.0	0.0	0.0	23.6	21.5	35.6
Year	**1966**	2007	1999	1979	1989	1960	1960	1960	1960	1962	1997	1969

Note:
1 Source: EC 1981 to 2010 Canadian Climate Normals (climate ID: 6153194)

Rainfall Intensity Duration Frequency (IDF) data for 2010 were obtained from the Ontario Ministry of Transportation's (MTO) IDF Curve Look-up for the Site at latitude 43.19, longitude -79.77 (**Table 7.5**). The maximum estimated amount of rain is 127.8 mm for a 100-year 24 hour storm event. It should be noted that the information presented in **Table 7.5** is not a prediction of the future, but an estimation of the probability of a storm occurring within a certain time period (return period) for a certain duration and the intensity of that storm based on statistical analysis of past data.

Table 7.5 Extreme Daily Precipitation

Return Period (year)	Rainfall Depth (mm) by Storm Duration								
	5 min	10 min	15 min	30 min	1 hr	2 hr	6 hr	12 hr	24 hr
2	10.5	12.9	14.6	18.0	22.2	27.4	38.1	46.9	57.8
5	13.9	17.1	19.4	23.9	29.4	36.2	50.4	62.1	76.5
10	16.2	19.9	22.5	27.8	34.2	42.1	58.6	72.3	89.0
25	19.0	23.4	26.5	32.6	40.2	49.5	68.9	84.9	104.6
50	21.2	26.1	29.5	36.3	44.7	55.1	76.7	94.4	116.3
100	23.2	28.6	32.3	39.9	49.1	60.5	84.2	103.7	127.8
Source: MTO IDF Curve Look-up for the SCRF (latitude 43.19, longitude -79.77)									

Wind

The speed of the monthly maximum gust obtained from 2000 to 2010 data from Hamilton A Station (climate ID: 6153194) are representative of those that typically occur in much of Ontario and are presented in **Table 7.6** (EC 2016b). Predominate wind comes from the west (36 percent of the time), south west (13 percent of the time), and east (12 percent of the time)[2]. In winter, typically there are more high-speed winds coming mainly from the west. The average maximum gust speed was the highest in December, which was approximately 78 km/h. Winds are the lowest in the summer months; the lowest average maximum gust speed was in August, which was approximately 60 km/h. In the summer, the southwestern component is the strongest, with roughly 17 percent of the wind coming from the southwest.

Table 7.6 Average Observed Speed of the Max Gust from Hamilton A Station from 2000 to 2011

Month	Observed Average Speed of Max Gust (2000-2011) (km/h)
January	71.00
February	75.27
March	74.64
April	77.09
May	71.55
June	66.64
July	67.09
August	60.18
September	71.55
October	71.45
November	73.18
December	77.82
Source: EC Historical Data (climate ID: 6153194)	

The historical climate and climate trends described above were used to identify any possible climate change risks of concern for the construction, operation, closure, and post closure stages of the landfill.

2 Based on historical records from Hamilton RBG CS Station (climate ID: 6153301) from 2005 to 2012.

7.2 Potential Effects of the Undertaking on Climate Change

The SCRF receives primarily non-hazardous industrial fill with very little waste containing organics such as municipal solid waste (MSW). As a result, the potential to produce methane and other GHGs is significantly lower than a MSW landfill of the same size. Any gas produced at the Site migrates to the surface and dissipates into the atmosphere; there is currently no landfill gas collection system in place, nor is one required under O. Reg. 232/98 and the "Landfill Standards: A Guideline on the Regulatory and Approval Requirements for New or Expanding Landfill Sites" (MOECC, 2012). Terrapure is required (under current approval) to monitor for landfill gas and provide results in the Annual Monitoring Report (submitted to the MOECC every calendar year on June 30th). A landfill gas assessment was conducted in 2011, which confirmed that very little gas is generated at the SCRF.

Section **6.1.12** provides an overview of the landfill gas generation, as well as the estimated GHG emissions estimates.

Upon closure, the landfill will be sealed with a clay cap. This will significantly reduce the already low amount of GHGs released by the landfill. During post-closure the landfill will release less and less GHG emissions as each year passes.

7.2.1 Mitigation

In order to minimize or offset the effects of the Undertaking on climate change, in particular to reduce the GHG emissions associated with the construction, operation, closure and post-closure stages of the landfill, mitigation measures will be implemented. The MOECC Guide defines mitigation as "The use of measures or actions to avoid or reduce greenhouse gas emissions, to avoid or reduce effects on carbon sinks, or to protect, enhance, or create carbon sinks" (MOECC 2016, Page 40). Mitigation measures include actions such as utilizing different technologies and construction materials. Mitigation measures and BMPs to reduce the Undertaking's effect on the environment will be determined and implemented at the onset of each stage of the landfill. Possible BMP/mitigation measures for the four stages of the landfill include:

- Implement and enforce an anti-idling policy for all vehicles and machinery on Site during the construction stage and operation stage
- Try to use materials that have a lower carbon footprint and a long lifespan
- Reduce the size of the uncovered/working area
- Replace and plant additional vegetation to create a carbon sink

In addition to the above mitigation measures the Air Quality Monitoring Program will continue to ensure all emissions fall within accepted standards.

As the GHGs released by the landfill are already below required standards and with the implementation of BMP/mitigation measures the proposed Undertaking is not anticipated to have a potential effect on climate change.

7.3 Effect of Climate Change on the Undertaking

Key potential effects of climate change that may occur during the Undertaking may include:

- Increasing frequency of unusually high or low daily temperature extremes.
- Long-term increasing or decreasing mean annual temperatures and/or precipitation.
- Increasing or decreasing frequency of storm events (e.g., rainfall, snowfall, extreme wind).

Extreme and adverse weather could affect the Site operations. As an example, an increase in storm events could affect the facilities and systems that have been engineered for the Site as part of the Undertaking, such as the stormwater management system. Furthermore, extreme weather events could also cause potential power outages, physical damage and reduced access to the Site. The potential impacts for the Preferred Landfill Footprint are considered to be "low" or "nil". "Low" indicates that the effect may cause a minor impact on the Site, Site operations or the Site design/features. "Nil" indicates that no effect is projected due to the potential change. **Table 7.7**, below, summarizes the assessment of potential adverse effects of climate change on the SCRF.

Table 7.7 Estimated Sensitivity of the Undertaking to Potential Climate Change Effects[3]

Climate Parameters	Landfill Stage				Explanation
	Construction[4]	Operation[5]	Closure[6]	Post-Closure[7]	
Mean Temperature	NIL	NIL	NIL	NIL	A slight change in mean temperature will not impact landfill operations. Landfill operations are successfully conducted in areas with significantly higher/lower mean and extreme temperatures.
Frequency and/or Severity of Extreme Temperature	LOW	LOW	LOW	NIL	
Total Annual Rainfall	LOW	LOW	LOW	LOW	A slight change in annual precipitation will not impact landfill operations. Landfill operations are successfully conducted in areas with significantly higher/lower annual precipitation.
Total Annual Snowfall	LOW	LOW	LOW	LOW	
Frequency and/ or Severity of Precipitation and Weather Extremes	LOW	LOW	LOW	LOW	The landfill components have been designed to accommodate a Regional storm event. The Site has sufficient area to increase the stormwater works to accommodate larger storms. The system is designed to return to normal operating conditions within two days.
Soil Moisture & Groundwater	LOW	LOW	LOW	LOW	These items relate to potential weather changes Landfill operations are successfully conducted in areas with significantly different weather conditions.
Evaporation Rate	LOW	LOW	LOW	LOW	
Wind Velocity	LOW	LOW	LOW	NIL	

3 Table modified from: "Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners" (Federal-Provincial-territorial Committee on Climate Change, November 2003).

4 Excavation and grading of new waste cells; placement and grading of final cover on closed cells.

5 Placement, grading, and compaction of waste during life of each active cell.

6 Placement and grading of final cover on remaining active areas of waste area, decommissioning of ancillary Site facilities.

7 Monitoring of surface water and groundwater, observation, and repair (as necessary) of closed Site conditions (e.g., erosion, vegetation re-planting, etc.).

A slight change in annual precipitation and frequency and/ or severity of precipitation and weather extremes does not have the potential to impact specific stages (construction, operation, closure and post closure) of the undertaking, or cause any severe damage to any of the landfill components, except potentially the leachate management system and the stormwater system during closure and post-closure (**Table 7.8**). The leachate and stormwater management systems have been designed to accommodate a Regional storm, which is much greater than the historical daily maximum precipitation amount of 107 mm (**Table 7.4**), and the rainfall depth estimated for the 100-year storm event for the SCRF of 127.8 mm (**Table 7.5**). The leachate and stormwater management systems and are designed to return to normal operating conditions within approximately two days. There is also a slight potential for the berms to be impacted through erosion and impact to vegetation cover due to an increase in intensity and frequency of precipitation events. Changes to soil moisture and groundwater, evaporation rate and wind velocity as a result of changes to temperature and precipitation will have little to no impact to the landfill components during any stage of the landfill. There is a slight potential for an increase in wind velocity, changes to soil moisture and evaporation rates to lead to issues with erosion and vegetation establishment on the final cover during post-closure affecting the quality of surface water runoff.

Table 7.8 Potential Severity of Climate Impacts on Components of the Waste Management Infrastructure

Climate Parameters	Waste Management Infrastructure Components					Explanation
	Berms	Geotextile Liner	Leachate Management System	Stormwater System	Waste Piles	
Mean Temperature	NIL	NIL	NIL	NIL	NIL	A slight change in mean temperature will not impact landfill components. The landfill components listed function successfully in areas with significantly higher/lower mean and extreme temperatures.
Frequency and/or Severity of Extreme Temperature	NIL	NIL	LOW	LOW	NIL	
Total Annual Rainfall	LOW	NIL	LOW	LOW	NIL	A slight variation in annual precipitation will not impact the landfill components. The landfill components listed function successfully in areas with significantly higher/lower annual precipitation.
Total Annual Snowfall	NIL	NIL	LOW	LOW	NIL	
Frequency and/ or Severity of Precipitation and Weather Extremes	LOW	NIL	LOW	LOW	LOW	The landfill components have been designed to accommodate a Regional storm event. The Site has sufficient area to increase the stormwater works to accommodate larger storms. The system is designed to return to normal operating conditions within two days
Soil Moisture & Groundwater	LOW	NIL	NIL	NIL	NIL	These items relate to potential weather changes, the listed landfill components function successfully in areas with significantly different weather conditions.
Evaporation Rate	NIL	NIL	NIL	LOW	NIL	
Wind Velocity	LOW	NIL	NIL	NIL	LOW	

Monitoring of groundwater and surface water is currently carried out for the Site, and a report summarizing these results and other Site conditions is submitted to the MOECC annually. These measures mitigate the kinds of potential extreme adverse effects and events noted above; longer-term, more gradual changes are managed through regulatory changes and adaptive management by Terrapure.

As part of the Detailed Impact Assessment of the Preferred Landfill Footprint climate change was considered for each environmental component. Specific discussion on climate change and potential mitigation or adaptation from the perspective of various environmental components are discussed in detail within their respective reports.

7.3.1 Adaptation

Additional analysis was undertaken to determine what adaptation measures may be required for the Site. Adaptation will be focused on addressing effects of climate change on the Undertaking. The MOECC's Guide defines adaptation as "The process of adjustment in the built and natural environments in response to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (MOECC 2016, Page 38). Although it was determined climate change will have no appreciable adverse effects on the proposed Undertaking identification of possible adaptation measures was undertaken to increase both the project's and the local ecosystem's resilience to climate change.

To increase the project's and the local ecosystem's resilience to climate change, the project's and local ecosystem's vulnerability to climate change need to be reduced. The degree of vulnerability is associated with unpredictability of climate change. The unpredictability of climate change increases over time. Therefore the stage with the greatest vulnerability (e.g., most likely to be impacted by climate change) is the stage that occurs over a long period of time, which is post-closure. As such resources will be focused on employing adaption measures upon closure of the landfill to ensure the landfill is resilient to climate change during post-closure stage.

Adaptation measures will be aimed at strengthening and increasing the resilience of the landfill cover and leachate management system. Such measures could include:

- Choosing vegetation known, to withstand erosion and climatic stressors such as extreme heat, drought tolerance, and flood resistance;
- Planting additional vegetation every five to ten years; and
- Modification of existing stormwater management ponds, if necessary.

The above is by no means a comprehensive list of the additional adaption measures that will be considered upon closure of the Site. As required by Section 31 of the *O. Reg. 232/98 a Closure Report* is to be created two years before the anticipated closure date of a landfill or when 90 percent of the waste disposal volume is reached. In addition to detailing the activities for post-closure care the Closure Report will state the commitments to climate change adaptation and how they will be implemented. Emerging technologies and current climate projections will be reviewed during the development of the adaptation measures in the Closure Report. In addition, the development of BMP’s will be prepared such that they can flexible enough to adapt to a changing climate.

8. On-Site Diversion Assessment

8.1 Background

The SCRF is a unique facility in Ontario in that it only accepts post-diversion solid, non-hazardous industrial residual material, consisting mainly of material from the steel making industry (i.e., basic oxygen furnace oxide, slag) and excavated soils from infrastructure development projects. The majority of these waste materials have exhausted all recycling or recovery options and cannot otherwise be utilized.

Although there is minimal material received at the SCRF that has the potential to be reasonably diverted or recycled, Terrapure has reviewed and evaluated the potential for on-Site diversion of waste materials received at the Site. The Minister Approved ToR requested that on-Site diversion be considered as part of the environmental assessment. In addition, considering the possibility of on-Site diversion is in keeping with the goals for the Province's new Waste Free Ontario Act (WFOA) and its Strategy for a Waste-Free Ontario: Building the Circular Economy for managing residual material in attempt to move the Province to an aspirational goal of "zero waste".

As such, Terrapure committed in the ToR to examine and evaluate the feasibility and viability of implementing an on-Site diversion program as part of the environmental assessment process. This includes the consideration and assessment of a reasonable number of ways in which to divert the types of waste materials typically received at Site. Further, Terrapure has reviewed the potential for on-Site diversion in accordance with best management practices and in consideration of new and emerging technologies.

Currently the material accepted at the SCRF comes from a variety of customers and businesses that have implemented their own diversion and recovery systems, as per the WFOA and the Strategy for a Waste-Free Ontario, which places emphasis on requiring the industrial, commercial, and institutional (IC&I) sector to divert more of the waste they produce.

8.2 Terrapure's Current Diversion Initiatives

Terrapure has Standard Operating Procedures (SOP) that dictate that materials received at the SCRF are screened and verified to ensure they match the Generator's Waste Profile, and that the Generator of the material has made the determination that the material cannot reasonably be diverted or reintroduced into the circular economy from both an economical and technical feasibility perspective. Diversion at the source of the generated residual material from generators and customers considers both the economic viability of diversion, as well as ensuring that there is a viable end market for the diverted material.

Terrapure understands the importance of WFOA, its diversion goals and the need to establish a circular economy. To this end, Terrapure is constantly reviewing diversion technologies for existing waste generating customers. Terrapure's new Business Transformation Team (BTT) is leading initiatives to achieve higher performance and efficiency throughout the company. One of these initiatives is exploring the opportunity to recycle steel making waste through the BOF (basic oxygen furnace) steel making process with waste received from ArcelorMittal Dofasco (AMD). The production of wastes with high iron content, such as mill scale, dust and sludge are unavoidable during the steel making process. The re-use of these wastes is extremely important in preserving our non-renewable natural resources (Kumar, et al., 2017). An attractive option to recycle these wastes is through the BOF process, where BOF oxide waste is converted into briquettes using various binding agents and then is reintroduced back into the steel making process as a feedstock (Kumar, et al., 2017).

By converting the BOF oxide into a usable form, a substantial volume of material could be diverted from SCRF. This is an indication of the efforts that large companies such as AMD make in diverting materials from landfill and that landfill is typically only chosen when other viable options are not available. Additionally, Terrapure regularly explores opportunities to divert and recover materials within its own operations network to prevent unnecessary material ending up at the SCRF for disposal.

8.3 Assessment Methodology

Terrapure conducted an assessment of potential on-Site diversion programs, through a literature review to explore other jurisdictions' best management practices and possible new and emerging technologies for diverting industrial residual materials. A challenge encountered during the literature review was the majority of information discusses diversion of residual mixed solid waste, rather than the diversion of residual solid non-hazardous industrial waste. As previously mentioned, the SCRF is a unique facility in Ontario in that it only accepts post-diversion solid, non-hazardous industrial residual material, thus finding similar examples was difficult.

Mainly the literature discusses technologies involving thermal and combustion processes, as well as chemical and biological processes and fuel development alternatives. However, it should be noted that as per the Strategy for a Waste-Free Ontario: Building the Circular Economy, the conversion of waste to energy or alternative fuels (thermal and combustion processes), while permitted as waste management options, does not count towards diversion in Ontario[8].

The technologies (some still theoretical in nature) discussed for diversion of residual mixed solid waste in the literature include:

- Mechanical biological treatment (MBT)
- Refuse-derived fuel (RDF) with stoker firing
- RDF with fluidized bed combustion
- Catalytic depolymerization
- Hydrolysis
- Pyrolysis
- Gasification
- Plasma arc gasification

Although as listed above there are a number of technologies for dealing with residual mixed solid waste, landfills are still the most common method to address residual industrial waste. However, trends are emerging to attempt to reduce the amount of material that requires disposal to landfill.

In-Situ Stabilization of Contaminated Soils

One such trend is the use in-situ stabilization techniques in Ontario, which are being applied to various site remediation locations where brownfield legislation issued by the MOECC allows low levels of contaminants to remain at a site when there, will be limited after use of the site. An example of this is at a brownfield site in Sudbury, where heaps of slag, the by-product from iron and nickel ore mining operations, were regraded, 18 inches of silty-clay was added and wildflower seed mix was planted to remediate the site (Sudbury Star, 2014). This program resulted in a significant amount of material being diverted from landfills. Stabilized waste materials have also been used as landfill cover.

[8] Strategy for a Waste Free Ontario, p.10

Thermal & Combustion Technologies

Although, as stated above, thermal and combustion technologies are not considered as diversion in Ontario, these technologies were investigated for the purpose of completing a thorough review of how other jurisdictions are diverting industrial waste. In Australia, thermal waste to energy technologies have shown potential in treating a wide range of industrial wastes (WSP, 2013). However, it was noted that using thermal waste to energy technologies to treat industrial waste, is not yet financially viable and that fiscal measures/incentives would have to be provided for the technologies to be financially competitive with landfills (WSP, 2013).

8.4 Viability of Identified Diversion Options

In 2010, it was determined that the cost of disposing waste in a landfill is about 40% lower than the cost of recovering waste (MOECC, 2010). In addition to the large discrepancy in cost between recovering waste versus sending it to a landfill, the technology to recover waste, specifically waste heading to the SCRF, has not progressed enough to make it as affordable as processing raw materials. For example in 2017, the cost associated with BOF oxide process described above was more than double the price of iron ore (**Figure 8.1**). The high cost of drying the sludge and the binders required to provide strength for the recycling of steel wastes into feedstock is the main reason that makes BOF processing economically unattractive (Singh et al., 2011). This demonstrates the need for further development and improvement of the BOF processing technology before it can become a financially viable solution to divert waste from landfills.

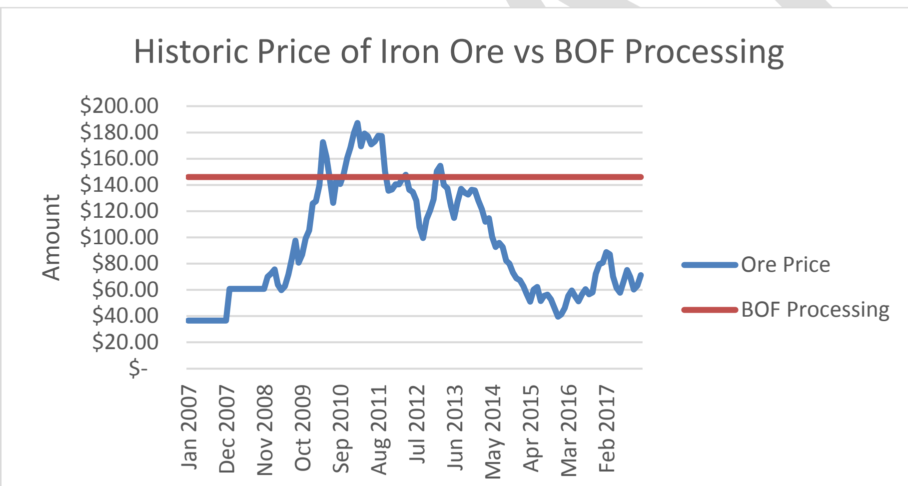

Figure 8.1 Cost of Raw Iron Ore Compared to Cost of Recovering Steel Wastes Through BOF Oxide Recovery/Processing Process

At this time, the solutions for diversion of residual industrial waste discussed above, including the recovery of steel making wastes through BOF recovery and processing, are still in their formative stages. Information on the generation and flow rates in Ontario is required to ensure the financial viability and strength of the end market.

In addition to the technologies investigated not being technically feasible and economically viable at this time, the infrastructure associated with the technologies would require greater space than currently available at the SCRF. The only potential location for an on-Site diversion program would be in the buffer areas surrounding the SITE's footprint; however, the size of the buffer areas will not be large enough to accommodate the required infrastructure footprint. Therefore, it is not appropriate or reasonable at this time for Terrapure to develop a diversion plan at the SCRF given that the volumes of material that could be potentially diverted are minimal, the lack of an established and financially viable end-market, as well as the limited space on Site for required infrastructure.

As Terrapure continues to develop its business, it will continue to investigate emerging technologies for potential diversion options, both on- and off-Site as more information on emerging technologies' financial viability becomes available. As per the commitment in the Environmental Compliance Approval (ECA) the SCRF operates under, Terrapure will also continue to review the 3R's technology with respect to landfill diversion every five years. Terrapure will also continue to work with its customers to ensure diversion at the source of the generated material takes place. Furthermore, Terrapure will monitor the introduction of regulations that may assist in creating more financially viable diversion tools, as well as the establishment of viable end-markets for the diverted material.

9. Cumulative Effects

During the ToR, Terrapure committed to including a discussion of the cumulative effects of the SCRF expansion on the environment. Terrapure committed to completing an assessment of the cumulative effects of the proposed undertaking and other non-SCRF projects/activities that are existing, planned/ approved or reasonably foreseeable[9] within the Study Area.

Although an assessment of cumulative environmental effects is not required as part of the provincial EA process, the Code of Practice for preparing an Environmental Assessment in Ontario encourages proponents to include information about potential cumulative effects of the project in combination with past, present and reasonably foreseeable future activities where possible[10]. Proponents are advised to consult with government agencies to identify projects that will be built in the future ad to consider their future cumulative effects. Terrapure consulted and reviewed examples of how to approach cumulative effects as part of the federal EA process, as described in the Canadian Environmental Agency's Operational Policy Statement and the Cumulative Effects Assessment Practitioners Guide[11].

Cumulative environmental effects are defined as effects that are likely to result from the proposed project in combination with other projects or activities that have been or will be carried out within the foreseeable future. The cumulative effects assessment completed for this project focused on the resultant net effects of the preferred undertaking combined with the other planned and approved or reasonably foreseeable projects in the Local Study Area.

9.1 Projects and Activities at the Site and Local Study Area

Stoney Creek Regional Facility (SCRF) Activities

In operation since 1996, the SCRF is an engineered landfill site that currently accepts industrial residual waste generated in Ontario. Prior to being an active landfill the SCRF study area was a former Quarry (Taro East Quarry). Typical operating activities at the site include; vehicles (trucks and construction vehicles) transporting waste to and around the site, as well as scale-house and wheel-wash activities. The

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[9] The term "reasonably foreseeable" is defined in the Cumulative Effects Assessment Practitioners Guide as projects that are, 'directly associated with the project under review, identified in an approved development plan or identified in an approved development plan in which approval is imminent",

[10] Code of Practice: Preparing and Reviewing Environmental Assessments in Ontario, January 2014.

[11] Cumulative Effects Practitioners Guide, 1999. https://www.ceaa-acee.gc.ca/default.asp?lang=En&n=43952694-1

site currently receives on average 70 to 80 trucks per day of waste material and is permitted to receive 750,000 tonnes of material annually.

Site and Local Study Area Land Uses and Activities

There are approximately 1,200 existing or registered residential dwellings within 500 m of the Site Study Area boundary, with the largest concentrations to the north along Green Mountain Road, and south and southwest along Mud Street. An additional subdivision is under construction to the north of the SCRF. These residential properties are primarily located within the Urban Area, as identified in the Urban Hamilton Official Plan. The majority of residential uses within the Local Study Area are located south of the SCRF. Lands to the south consist of existing and proposed phases of the Penny Lane Estates subdivision. In accordance with the City of Hamilton's filed registered and draft approved plans of subdivision, there are approximately 6,800 residential units both existing and proposed within the preliminary Study Area. Of the approximate 6,800 residential units within the Local Study Area, approximately 5,800 residential units currently exist (registered), and the remaining approximately 1,000 residential units are proposed (draft approved).

Located directly west of the SCRF are recreational uses consisting of the Heritage Green Sports Park and off-leash Dog Park. The Heritage Green Sports Park opened in 2005 and is a former closed landfill site. Institutional uses within 500 m of the Study Area boundary include St. James the Apostle Catholic Elementary School, which is approximately 270 m from the Terrapure SCRF property boundary, located within the Urban Area. There are currently four properties zoned for agricultural uses under City of Hamilton Zoning By-law 05-200 within 500 m of the Site. A cluster of commercial operations exists within the Local Study Area along major roads, including along Upper Centennial Parkway and Mud Street towards Red Hill. There are 11 commercial uses within 500 m of the Study Area boundary.

The SCRF is under the jurisdiction of the Urban Hamilton Official Plan and the City of Stoney Creek Zoning By-law No. 3692-92. The SCRF is also directly adjacent to areas designated under the Rural Hamilton Official Plan. The SCRF falls within the Nash Neighbourhood Secondary Plan Area designated under the Urban Hamilton Official Plan. The Urban Hamilton Official Plan identifies the Urban Structural Elements, Functional Road Classifications and Urban Land Use Designation comprising the Terrapure SCRF.

The SCRF currently conforms to the City of Stoney Creek Zoning By-law No. 3692-92 under Section 9.8.5 'Special Exemptions', as ME-1. In addition to permitted uses under the Extractive Industrial "ME" Zone, lands zoned ME-1 are permitted for operations associated with non-hazardous waste from industrial, commercial, and institutional sources. In accordance with the City of Hamilton's Urban and Rural Official Plans, Zoning By-law 05-200 and the City of Stoney Creek Zoning By-law No. 3692-92 land use designations within 1500m preliminary study area of the SCRF primarily include residential, commercial, recreational, institutional and agricultural uses as described above.

As mentioned above, there are over 1,000 residential developments proposed to be constructed within the Study area suggesting there will be continued construction works around and adjacent to the Site Area including improvements and additions to the transportation corridors to accommodate the increased residential and associated traffic and pedestrian growth. In addition to potential residential growth, an institutional land use designation is present at the northwest corner of Green Mountain Road West and First Road West (435 First Road West). This land is reserved for the future development of a school (zoned Neighbourhood Institutional (I1), as approved by council on November 11, 2015, By-law No. 15-260); however, at this time, the property is owned by a developer. Additional information regarding the current and planned land uses can be found in the ***Existing Land Use Conditions Report*** and the ***Detailed Land Use Impact Assessment Report.***

Existing and Planned Traffic Corridor and Networks

The study area includes major road corridors of Upper Centennial Parkway and Mud Street. Both of these roads carry the predominant traffic as they feed into the Red Hill Expressway and to the QEW highway. Major intersections around the SCRF also include:

- Upper Centennial Parkway at Green Mountain Road (signalized)
- Upper Centennial Parkway at Upper Centennial Parkway Access (entrance only)
- Upper Centennial Parkway at Mud Street (signalized)
- Mud Street at First Road West (signalized)
- First Road West at First Road West Access (entrance and exit)

Given the current development applications planned for the area including 1,000 residential homes and a school, it is likely that alterations or additions to the current road corridors will be made to accommodate increased vehicular and pedestrian traffic in the area. There is current roadway improvements being completed on Upper Centennial and improvements are planned for First Road West to accommodate increased growth in the area. Traffic Impact Studies completed for *Empire Communities* (2013) recommended infrastructure improvements for roads in the study area based on proposed residential development and within the horizon year of 2018.

Additional information about current and future Traffic Conditions and activities can be found in the ***Traffic Existing Conditions Report*** and the ***Detailed Traffic Impact Assessment Report.***

9.2 Valued Ecosystem Components (VECs)

In a typical cumulative effects analysis, Valued Ecosystem Components (VEC) are identified which represent specific features or attributes of the environment that are considered to be important for regulatory reasons, or because of their social, cultural, economic or ecological value. VEC's are the assessment endpoints and represent meaningful measures of the environmental effects that may be caused by a project. The VEC's for the analysis of the SCRF EA were taken from the list of Criteria and Indicators used in the Alternative Methods and Impact Assessment evaluation. Based on the net effects analysis completed during the Alternative Methods stage and the findings of the Detailed Impact Assessment the VEC's under consideration include the following:

Table 9.1 Rationale for Potential VEC's

VEC	Rationale	Effects Considerations
Air Quality Sensitive Receptors	• Assess compliance in terms of Provincial regulations • Changes in air quality have the potential to affect receptors and socio-economic conditions	• Potential for changes in air quality
Noise Sensitive Receptors	• Assess compliance in terms of Provincial regulations • Changes in noise levels have the potential to affect receptors and socio-economic conditions	• Potential for changes in sound levels during construction • Type and timing of construction activities

VEC	Rationale	Effects Considerations
		• Absolute sound exposure levels (55 dBA) at Noise Sensitive Areas • Change in sound exposure levels (55 dBA) at Noise Sensitive Areas
Natural Environment (Aquatic and Terrestrial Ecosystems)	• Specialized and sensitive wildlife habitat provide unique habitat functions and contribute to biodiversity • Species at Risk are indicators of specialized conditions in study areas. They contribute to biodiversity and need to be considered under the *Species At Risk Act*.	• Presence and effects on: o Breeding bird species richness and diversity o Habitat diversity o Vegetation o Species of Conservation Concern o Amphibian breeding habitat o Habitat block size o Habitat continuity • Presence and effects on habitats for Species At Risk
Use and Enjoyment of Private Property (Surrounding Land Uses)	• Nuisance effects from proximity to the SCRF have the potential to affect use and enjoyment of private property including Agricultural land uses.	• Projected levels of noise, dust and other air emissions
Landscape Composition	• Changes in landscape composition by way of views and viewsheds	• Change to current views and viewsheds

These VEC's are utilized to conduct the cumulative effects analysis, which looks at the combined effects of the proposed landfill and other WCEC facilities, both on a temporal and spatial basis. Cumulative effects are analyzed when one project effect acts in a cumulative fashion with the effects of other projects and their effects.

9.3 Cumulative Effects Analysis and Results

Table 9.2 provides a summary of the likely cumulative effects and mitigation measures of the Project in combination with other projects and activities.

Table 9.2 Cumulative Effects Table

Environmental Factors	Effects of the Project	Project Phase	Cumulative Effects	Mitigation/ Compensation	Residual Cumulative Effect
Air Quality	Infrequent occasions where exceedance of applicable threshold occurs. The largest effect on air quality is due to releases of TSP (i.e. fugitive dust).	Construction	• Exceedance of TSP may occur more frequently. This cumulative effect is most likely to occur when project construction activities are being undertaken simultaneously with other projects being undertaken in close proximity such as housing construction	• Effective mitigation of adverse cumulative effects can be achieved by controlling the timing and coordination of multiple projects and activities	Increased dust levels

Environmental Factors	Effects of the Project	Project Phase	Cumulative Effects	Mitigation/ Compensation	Residual Cumulative Effect
			in the immediate study area.		
Noise	Increased noise levels around the Site.	Construction & Operation	• Exceedance of noise may occur more frequently. This cumulative effect is most likely to occur when project construction activities are being undertaken simultaneously with other projects being undertaken in close proximity	• Effective mitigation of adverse cumulative effects can be achieved by controlling the timing and coordination of multiple construction projects • Noise levels are at acceptable levels with background traffic being the dominant source and maintaining existing noise barriers (berm)	Increased noise levels around the Site
Natural Environment	Disruption to Aquatic, Vegetative and Terrestrial Habitat	Construction	• 18 ha cumulative loss (temporary) of vegetation communities (marsh, meadow, and thicket habitat, threatened bird species (eastern meadowlark), and threatened bird species; barn swallow, where structures will be removed and relocated as part of Phase 2, 3, and closure. • Loss of on-Site aquatic habitat and disturbance of aquatic biota associated with open water habitats associated with the Site stormwater infrastructure is also anticipated as a result of regrading activities and changes in Site configuration throughout the project stages.	• Restore and enhance elsewhere or as appropriate.	Some loss of vegetation and vegetation communities
	Disruption to Species at Risk	Construction	• Highly unlikely that other projects will affect Species at Risk	• Protection as per appropriate legislation	Not anticipated to be affected

Environmental Factors	Effects of the Project	Project Phase	Cumulative Effects	Mitigation/ Compensation	Residual Cumulative Effect
Socio-Economic	Disruption to use and enjoyment of private property	Construction and Operation	• The project has the potential to affect up to approximately 7,000 properties (number of receptors within 500m of the Site) due to disruption of their use and enjoyment of property resulting from nuisance related effects	• Implement dust, air and noise mitigation measures • Effective mitigation of adverse effects on the socio-economic environment can be achieved by ensuring that all future development meets the broader planning objectives of the Provincial Policy Statement (2005) and policies set out in the City of Ottawa official plan	Disruption to use and enjoyment of private property
Socio-Economic	Change in landscape composition	Operation	• Change in visual appearance, topography, loss of agricultural land	• Implement appropriate screening measures	Changes in landscape composition

9.4 Significance Assessment

The following criteria were defined in relation to assessing the significance of the residual adverse effects from the SCRF EA:

Magnitude The size or degree of the effects compared against baseline conditions or reference levels, and other applicable measurement parameters (i.e., standards, guidelines, objectives).

Extent The geographic area over or throughout which the effects are likely to be measurable.

Duration The time period over which the effects are likely to last.

Frequency The rate of recurrence of the effects (or conditions causing the effect).

Permanence The degree to which the effects can or will be reversed (typically measured by the time it will take to restore the environmental attribute or feature).

Ecological Context The importance of the environmental attribute or feature to ecosystem health and function.

Table 9.3 provides the framework that was used to assess the degree of residual adverse effects. This framework includes the assessment criteria and definitions for three degrees of residual effects - low, medium and high. The determination of the degree of residual effects framed to generally reflect provincial regulatory and industry standards and guidelines to the extent possible. Specific documents were also consulted to determine the significance level of the effects in conjunction with reasonably foreseeable projects and activities within the Site and Local Study Area. Some of the documents used to identify potential activities and projects include:

- ***City of Hamilton Development Application Mapping Tool***[12] – Used to determine potential location and size of developments within the Local Study Area.
- ***City of Hamilton Transportation Master Plan Review and Update Future Travel Demands Background Report***[13] – Used to determine intersection and roadway improvements planned for Local Study Area
- **City of Hamilton Official Plan**[14] – Used to determine land uses and zoning around Site and Local Study Area.
- ***Land Use Existing Conditions*** and ***Alternative Methods Reports*** for the Terrapure SCRF EA
- ***Traffic Impact Study – Red Hill Residential Development – Phase 2 (2013) –*** Documents traffic impact for proposed residential development located in the North-West quadrant of the Green Mountain Road West/First Road West
- ***Traffic Impact Study – Nash Neighborhood Secondary Plan – City of Hamilton (2009) –*** Documents traffic impacts for proposed secondary plan at the northwest quadrant of Mud Street West and Centennial Parkway.

In cases where these points of reference were not available, the assessments were made based on best professional judgement concerning the type and nature of the environmental effects and the surrounding study area and land uses.

Table 9.3 Significance Assessment Framework

Significance Assessment Criteria	Significance Level		
	Low	Medium	High
Magnitude of Effect	Project-specific and/or cumulative effects may be noticeable and/or measureable, but are not likely to exceed a reference criterion or guideline value.	Project-specific and/or cumulative effects are likely to be noticeable and measureable, representing a small change relative to existing condition. Adverse effects may exceed a reference criterion or guideline value on occasion and/or at an individual location.	Project-specific and/or cumulative effects are likely to be noticeable and measureable, representing large measureable changes relative to existing conditions. Adverse effects caused by the Project are likely to result in the exceedance of a reference criterion or guideline on an ongoing basis across the Study Area.
Extent of Effect	Project-specific and/or cumulative effects are likely to be measureable within an area immediately surrounding the SCRF, generally within 500 m.	Project-specific and/or cumulative effects are likely to be noticeable and/or measureable within the Study Area	Project specific and/or cumulative effects are likely to be noticeable or measureable within the Study Area. Adverse effects will be experienced by VECs beyond the Study Area.
Duration/Timing (of effect)	Project-specific and/or cumulative effects result from short-term events, are considered to be short-term disturbances or losses limited to within the planning horizon (i.e., 10 years)	Project-specific and/or cumulative effects are ongoing effects related to the Construction and/or Operations phases of the SCRF	Project-specific and/or cumulative effects are ongoing effects that are likely to persist beyond the Construction and/or Operations phases of the SCRF and their effects are not readily reversible despite the implementation of mitigation and/or compensation measures (see Permanence criterion below).

[12] https://www.hamilton.ca/develop-property/planning-applications/development-applications-mapping

[13] https://d3fpllf1m7bbt3.cloudfront.net/sites/default/files/media/browser/2018-06-06/draft-tmp-backgroundreport-futuredemand-9.pdf

[14] https://www.hamilton.ca/city-planning/official-plan-zoning-by-law

Significance Assessment Criteria	Significance Level		
	Low	Medium	High
Frequency (or probability)	Conditions or phenomena causing a Project-specific effect occur infrequently or are effectively one-time events during the project phase in which they occur. A few other projects or activities causing cumulative effects are likely to occur with the SCRF. They will occur periodically over the planning horizon (i.e., 10 years)	Conditions or phenomena causing a Project-specific effect occur at regular but infrequent intervals during the project phase in which they occur. Several projects or activities causing cumulative effects are likely to occur along with the SCRF. They will occur periodically over the planning horizon (i.e., 10 years)	Conditions or phenomena causing a Project-specific effect occur at regular and frequent intervals, or are ongoing conditions during the project phase in which they occur. The majority of projects or activities causing cumulative effects are likely to occur along with the SCRF. They are likely to occur frequently or repeatedly over the planning horizon (i.e., 10 years).
Permanence (of effect)	Measureable or noticeable project-specific and/or cumulative effects are not likely to persist over the planning horizon (i.e., 10 years). Project-specific mitigation and/or compensation measures and potentially those of other projects and activities will ensure that long term cumulative effects attributable to the Project are not measureable.	Measureable or noticeable project-specific and/or cumulative effects are likely to persists for some time over the planning horizon. Adverse regional trends and cumulative effects attributable to the Project are potentially reversible.	Project-specific and/or cumulative effects are not readily reversible despite the implementation of mitigation and/or compensation measures. Adverse regional trends and cumulative effects attributable to the Project are likely to persist.
Ecological Importance (of a resource or VEC)	Not Applicable	The resource / VEC is common and abundant. The resource / VEC will continue to fulfill its ecological functions.	The resource / VEC is not common across the LSA. Abundance and quality is required for the resource / VEC to continue to fulfill its ecological functions.

Based on the application of this framework, an effect could be categorized as negligible, minor, moderate or significant, according to the following definitions:

a) **Negligible Effect (Not Significant)** are those environmental effects which, after taking into consideration applicable mitigation measures have been assessed to have a "low" level of significance for the majority of the significance criteria described above; or having a "low" or "medium" level of significance for the majority of the criteria with "low" permanence.

b) **Minor Adverse Effects (Not Significant)** are those environmental effects which, after taking into consideration mitigation measures, have been assessed to have a "low" or "medium" level of significance for the majority of the criteria described above.

c) **Moderate Adverse Effects (Not Significant)** are those environmental effects which, after taking into consideration mitigation measures, have been assessed to have a "medium" level of significance for the majority of the criteria described above or having a "low" or "medium" level of significance for the majority of the criteria with "high" permanence.

d) **Significant Adverse Effects** are those environmental effects which, after taking into consideration mitigation measures, have a magnitude that has a "high" magnitude, "high" extent and "high" duration.

Table 9.4 provides the significance assessment for the residual adverse effects, which includes the consideration of the residual adverse effects of the Project (i.e., Project-specific effects) and cumulative effects.

Table 9.4 Cumulative Effects Significance Assessment Summary

Significance of Residual Adverse Effects									
Residual Adverse Effects	Project Phase	VEC Affected	Significance Levels						Overall Significance of Residual Adverse Effects
			Magnitude	*Extent*	*Duration*	*Frequency*	*Permanence*	*Ecological Importance (of resource or VEC)*	
Increased dust levels	Construction	Air Quality Sensitive Receptors	**Low** Increased dust levels during construction of the SCRF and cumulative effects will be mitigated to the reference criterion or guideline value	**Low** Increased dust levels due to the Project and in combination with other projects and activities are likely to be measureable within 500 m of the SCRF	**Medium** Adverse effects are ongoing effects related to both the Construction and/or the Operations and Maintenance Phases of the SCRF	**Low** Project-specific effects will occur periodically, but infrequently during the construction phase. Cumulative effects may occur as a result of a few other projects/activities that are likely to occur in proximity to the SCRF	**Low** Project-specific and cumulative effects are not likely to persist once the activities causing the effects have ceased.	**High** Good air quality is required for the VEC to continue to function.	**Negligible Effect (Not Significant)**
Increased noise levels	Construction & Operation	Noise Sensitive Receptors	**Low** Noise levels during construction may exceed a reference criterion or guideline value on occasion or at an individual receptor location	**Low** Adverse effects are likely to be measureable within 500 m of the SCRF	**Medium** Adverse effects are ongoing effects related to both the Construction and/or the Operations and Maintenance Phases of the SCRF	**Low** Project-specific effects will occur periodically, but infrequently during the construction phase. Cumulative effects will occur periodically during the construction phase as a result of a few other projects/activities that are likely to occur within proximity to the SCRF	**Low** Adverse effects are not likely to persist once the activities causing the effects have ceased.	**N/A**	**Negligible Effect (Not Significant)**
Disruption to Natural Environment (Aquatic and Terrestrial Ecosystems	Construction	Specialized and Sensitive Wildlife, Aquatic and Vegetative Habitat	**Low** Disruption may be noticeable and/or measureable. Adverse effects may exceed a reference criterion or guideline value at an individual location	**Low** Adverse effects are likely to be measureable in close proximity to the SCRF and/or other projects and activities	**Medium** Adverse effects are ongoing effects related to the Construction and Operations Phases of the SCRF and/or	**Medium** Project-specific effects will occur periodically	**Low** Adverse effects are not likely to persist once the activities causing the effects have ceased and mitigation	**Low** VEC species are common and abundant. The resource / VEC will continue to fulfill its	**Negligible Effect (Not Significant)**

Significance of Residual Adverse Effects									
Residual Adverse Effects	**Project Phase**	**VEC Affected**	**Significance Levels**						**Overall Significance of Residual Adverse Effects**
			Magnitude	***Extent***	***Duration***	***Frequency***	***Permanence***	***Ecological Importance (of resource or VEC)***	
					those of other projects and activities		(compensation) has occurred.	ecological functions.	
Disruption to Species at Risk	Construction	Species at Risk	**Low** Adverse effects are likely to be measurable and/or noticeable within the known habitats of these species within proximity of the SCRF	**Low** Adverse effects are likely to be measureable in close proximity to the transportation corridor and/or other projects and activities	**Medium** Adverse effects are ongoing effects related to the Construction, and Operations Phases of the SCRF and/or those of other projects and activities	**Medium** Project-specific effects will occur periodically	**Low** Given the *Endangered Species Act* requirements for mitigation, measurable project-specific and cumulative effects attributable to the SCRF are not likely to persist over the planning horizon.	**Low** Some Species at Risk habitats are common in the Study Area.	**Negligible Effect (Not Significant)**
Disruption to use and enjoyment of private property	Construction and Operation	Use and Enjoyment of Private Property	**Low** Adverse effects represent small changes relative to baseline conditions	**Low** Adverse effects are likely to be measureable within 500 m of the SCRF	**Medium** Adverse effects are ongoing effects related to both the Construction and Operations Phases of the SCRF and those of other projects and activities	**Medium** Project-specific effects will occur periodically	**Medium** Adverse effects are likely to persist for some time over the planning horizon for existing residents.	**N/A**	**Minor Adverse Effect (Not Significant)**
Change in landscape composition	Operation	Landscape Composition	**Low** Adverse effects due to changes in landscape/viewshed composition are likely to represent a small change relative to baseline conditions in a Local Study Area context.	**Low** Adverse effects are likely to be noticeable in a limited portion of the built up areas within proximity to the SCRF.	**Medium** Adverse effects are ongoing effects related to both the Construction and Operations Phases of the SCRF and/or those of other projects and activities	**Medium** Conditions or phenomena causing Project-specific effects to occur are ongoing conditions.	**Medium** Adverse effects are likely to persist for some time over the planning horizon for existing residents.	**N/A**	**Moderate Adverse Effect (Not Significant)**

9.5 Summary and Conclusions

Based on the implementation of mitigation measures proposed for the SCRF, the determination of significance of effects and the context of this Project in conjunction with other Projects in the area, the SCRF expansion is not likely to cause significant adverse cumulative environmental effects.

10. Environmental Monitoring

The current environmental monitoring programs carried out at the SCRF as identified in Section 2.20 of the FCR (i.e., leachate, groundwater, surface water, landfill gas) will continue over the life of the Site. No changes to the current environmental monitoring programs are anticipated to be required from a Design and Operations standpoint as a result of the of the implementation of the Preferred Landfill Footprint. As before, existing methods and protocols may need to be amended periodically to accurately reflect conditions over the life of the Site. Confirmatory monitoring programs will continue to be documented in the Annual Monitoring Report. Any changes recommended by other disciplines in their respective Impact Assessment Reports will be incorporated into updated monitoring programs for the Site.

11. Commitments

The following commitments are included as part of this impact assessment:

- Preparation of an update to the original Design and Operations Report (Gartner Lee Limited, 1995).
- Development of detailed designs and specifications for all major components of the SCRF.
- Revisions to Site operating manuals and protocols.
- Updates to existing environmental monitoring programs.

12. Other Approvals

The implementation of the Preferred Landfill Footprint for the SCRF will be subject to MOECC approval of amendments to Waste ECA No. 181008, and Industrial Sewage Works ECA No. 5400-7DSSHU. The design and specifications for all Major Works (as defined in the ECA) will also be subject to MOECC approval prior to construction.

13. References

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Appendices

Appendix A

HDPE Liner Protection Evaluation

ENGINEERING DESIGN CALCULATION

PROJECT IDENTIFICATION

Client: Terrapure Environmental — 1110-2771

Project: Stoney Creek Regional Facility (SCRF) — Location: Stoney Creek , Ontario

CALCULATION IDENTIFICATION

Calculation Ref. No.: ______ No. Pages: ______ (Including calculation cover sheet)

Calculation Description:

BOTTOM HDPE LINER GEOTEXTILE CUSHION PROTECTION EVALUATION

Design: A.Wesolowski — Date: Mar 2/2018

Checked: H.Gilani — Date: Mar 2/2018

RECORD OF REVISION

Revision No.	Revision Date	Design	Checked	Supervised	Project Control	Detail of Revision
0	--	--	--	--	--	Original (per above)

HDPE LINER GEOTEXTILE CUSHION PROTECTION EVALUATION

1. Objective

The objective of this evaluation is to check if installed geotextile provides sufficient protection of the HDPE liner from being punctured by the granular material overlying the liner. The puncture of a geomembrane is the result of a stress concentration at the point of contact between the geomembrane and the culprit object.

2. Methods

The design method was developed at the Geosynthetic Institute (GSI), Drexel University, by Dr. Dhani Narejo, Dr. Robert Koerner and Dr. Ragui Wilson-Fahmy, as presented in Geomembrane Protection Design Manual , GSE Lining Technology, Inc 2002. Since the initial publication of the method in 1996, a limited amount of additional research and testing on various aspects of geomembrane protection has appeared in published literature. The manual includes most of the published information relevant to the design method. The manual can be regarded as state-of-the-art on geomembrane protection, see attached.

3 .Data Given, symbols and acronyms

- depth of material on top of geomembrane, max. **h = 35.5 m**, total including extra height as per Option 3, Draft Conceptual Design Report;

- unit weight of material on top of geomembrane 2 tonnes/m3, approx. **g =20 kN/m3**,

- existing geotextile for geomembrane protection, non-woven, needle-punched type, mass = 445 gr/m2;

- protrusion height approx 0.019 m , equal to maximum stone size 19 mm dia. of the Leachate Collection Granular Blanket, part of the Bottom Liner System;

- modification factor for packing density $\mathbf{MF_{PD} = 0.5}$, Part 3.2.1.4, Packed Stone category, page 3-10, GSE Geomembrane Protection Design Manual;

- factor of safety against puncture **FS = 3**, and **FS = 3.75**, (interpolated), against yield, for protrusion height of 9.5 mm, as recommended per Table 3.7 Geomembrane Protection Design Manual;

- modification factor for protrusion $\mathbf{MF_{PS} = 0.5}$, Table 3.5 for subangular and subrounded shape, GSE Geomembrane Protection Design Manual;

- reduction factor for long term creep $\mathbf{FS_{CR}}$ as per Table 3.3, to be determined, GSE Geomembrane Protection Design Manual;

- reduction factor for long term chemical/biological degradation , $\mathbf{FS_{CBD} = 1.5}$ for leachate as per part 3.2.1.5, GSE Geomembrane Protection Design Manual;

4. Design Analysis - Required Geotextile Mass for bottom HDPE liner protection

Determined effective protrusion height H', (as per Fig. 2.2):

$H' = MF_{PD} \times H = 0.5 \times 19$ mm = **9.5 mm**

Determine waste overburden pressure required Preq:

Preq = g x h = 20 KN/m3 x 35.5 m = **710 KN/m2**

Calculate allowable pressure Pallow , Equation 3.9 (Design Manual):

$P_{allow} = [450 \times M/(H')^2] \times [1/(MF_{PS} \times FS_{CR} \times FS_{CBD})] =$
$[450 \times M/(9.5)^2] \times [1/(0.5 \times FS_{CR} \times 1.5)] =$
$6.65 \times M/FS_{CR}$, where M is required mass of geotextile

Substituting the values of Pallow and Preq, Equation 3.10 (Design Manual):

$FS = (6.65 \times M)/(710 \times FS_{CR})$

Check installed geotextile of 445 gr/m2, as per Table 3.3.,
for this geotextile, $FS_{CR} = 1.35$ at a protrusion height of <12 mm

FS = (6.65 x 445)/(710 x 1.35) = **3.09**, which is more than required 3.0 against puncture and less than required 3.75 for yield

5. Conclusion

Existing 445 gr/m2 non-woven, needle-punched geotextile installed for the protection of the geomembrane, meets required FS for protection against puncture, and is less than required FS value for yield. However since the bottom liner structure was installed a few years ago, and the waste was placed, it is expected than the entire cell settled already and the additional waste load will not create any significant yield conditions

In addition, in order to prevent HDPE liner from construction damage a geotextile with a minimum mass of M = 405 gr/m2, for the stone size of 19 mm, is required based on Table 3.2 (Design Manual) , which is less than proposed geotextile at 445 gr/m2. Therefore, the protection from construction procedures is fully satisfied.

GSE

Geomembrane Protection
Design Manual

Co-Authors:

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GSE Lining Technology, Inc.
and
Greg Corcoran, P.E.
GeoSyntec Consultants, Inc.

First Edition

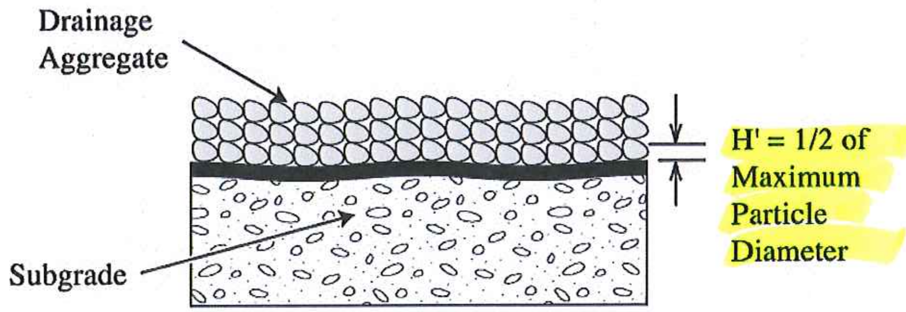

Figure 2.2 Effective Protrusion Height in the Case of Grouped Objects.

2.2 Protrusion Shape

For the purpose of geomembrane puncture protection, particle shape can be described by angularity. Angularity is a measure of sharpness of corners of a particle. Although a quantitative measurement of angularity is possible (Krumbein, 1941), for the design method presented here it is adequate to obtain a qualitative description as provided in Figure 2.3.

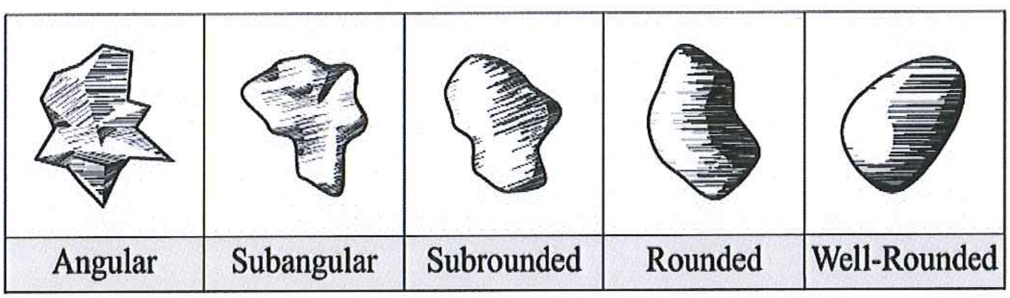

Figure 2.3 Angularity of Soil Particles (Sowers, 1979).

On the basis of the effect of shape on geomembrane protection requirements, soil particles can be placed into the following three categories:

Group I – Angular

Group II – Subangular and Subrounded

Group III – Rounded and Well Rounded

The design engineer should consider the angularity carefully as well rounded aggregate may become angular during installation, handling or excavation. When in doubt, it may be desirable to perform the calculations assuming angular stone.

Design recommendations provided in Table 3.2 are based on studies reported in the literature and authors own experience with protection requirements for HDPE geomembranes.

Table 3.2 Mass per Unit Area of Nonwoven Needlepunched Geotextile Recommended for Geomembrane Protection During Installation.

Maximum Stone Size		Mass per Unit Area	
(mm)	(inch)	(g/m^2)	(oz/sq. yard)
≤ 12	≤ 0.5	≥ 335	≥ 10
≤ 25	≤ 1.0	≥ 405	≥ 12
≤ 38	≤ 1.5	≥ 540	≥ 16
≤ 50	≤ 2.0	≥ 1080	≥ 32

3.2 Protecting Geomembrane from Puncture Due to Static Loads

The equations presented in this section were derived based on extensive quasi-performance and performance puncture testing. The final empirical relationship presented at the end of this chapter was obtained as follows:

a) An empirical equation relating truncated cone height and mass per unit area of a nonwoven needlepunched geotextile used as protection for a 1.5 mm (60 mil) HDPE geomembrane was obtained from Hydrostatic Truncated Cone Puncture Tests performed according to ASTM procedure D 5514.
b) The basic equation in (a) above was modified for the influence of geomembrane thickness.
c) The equation in step (b) above was modified for the influence of creep of the geomembrane and geotextiles.
d) The effect of type of overburden stress (hydrostatic vs. geostatic) on the equation in (c) above was evaluated.
e) The equation obtained from step (d) above was then adjusted for protrusion shape and arrangement.
f) Finally, the equation was modified for chemical and biological degradation of geomembranes and protection geotextiles.

All of the above work was performed by the author and other researchers at the Geosynthetic Institute, Drexel University, PA, using geotextiles from a number of different manufacturers. Thus the geotextile performance and the resulting design equations are representative of nonwoven needlepunched geotextiles manufactured and supplied in the US. The following sections provide details of each of the above steps.

3.2.1 Basic Equation

The failure pressure of a 1.5 mm (60 mil) thick HDPE geomembrane in Truncated Cone Puncture Test (ASTM D 5514) is related to the cone height H (mm) and the mass per unit area of

Table 3.3 Factors of Safety for Creep Obtained from Long Term Puncture Testing (Modified from Narejo et. al., 1996).

NW-NP Geotextile Mass		**Effective Protrusion Height (mm)**		
g/m^2	oz./sq. yard	**≤38 (1.5")**	**≤25 (1.0")**	**≤12 (0.5")**
None	None	N/R	N/R	N/R
270	8	N/R	N/R	>1.5
335	10	N/R	N/R	1.4
405	12	N/R	N/R	1.4
540	16	N/R	1.5	1.3
675	20	N/R	1.4	1.2
810	24	1.5	1.3	1.2
950	28	1.4	1.3	1.1
1100	32	1.3	1.2	1.1
2000	60	1.2	1.1	1.0

Note: Values in shaded rows are extrapolated; NW-NP = Nonwoven Needlepunched; N/R = Not Recommended

Table 3.4 Geostatic Failure Pressures for a 1.5 mm HDPE Geomembrane with Various Nonwoven Needlepunched Geotextiles (from Narejo, et. al., 1996).

Geotextile Mass		**Failure Pressure (kPa) at Various Protrusion Heights**			
(g/m^2)	**(oz./yard^2)**	**50 mm (2.0")**	**38 mm (1.5")**	**25 mm (1.0")**	**12 mm (0.5")**
None	None	240	310	450	700
270	8	380	510	>700	>700
540	16	580	>700	>700	>700
1080	32	>700	>700	>700	>700

A comparison of geostatic failure pressures (Table 3.4) with hydrostatic pressure in Figure 3.1 indicates an approximate advantage factor of 6 with the soil as the overburden medium. The higher failure pressures with soil are likely the result of soil arching. As the hydrostatic medium results in lower failure pressure, the design method based on hydrostatic testing is conservative. The authors recommend ignoring the influence of soil arching when making the design calculations for soil or waste overburden medium. Probably, in the future, after further research and testing, the influence of soil arching may be incorporated in Equation 3.7 through a modification factor. Presently, Equation 3.7 is recommended for use irrespective of type overburden medium.

3.2.1.4 Effect of Protrusion Shape and Arrangement

Equation (3.7) was derived on the basis of tests performed using truncated cones as indicated in Figure 1.2 (b). For the equation to be applicable to practical design cases, it must be modified to account for shape and arrangement of soil, aggregate or stones as discussed in Chapter 2. This was accomplished by performing tests on angular, sub-rounded and rounded stones of various sizes placed in the same manner as the truncated cones. The failure pressures thus obtained are provided in Figure 3.5. The geomembrane failure pressures are seen to decrease with an increase in angularity of the stones. On the basis of the test data in Figure 3.5, the modification factors to be incorporated in Equation 3.7 are provided in Table 3.5 (Narejo, et. al., 1996).

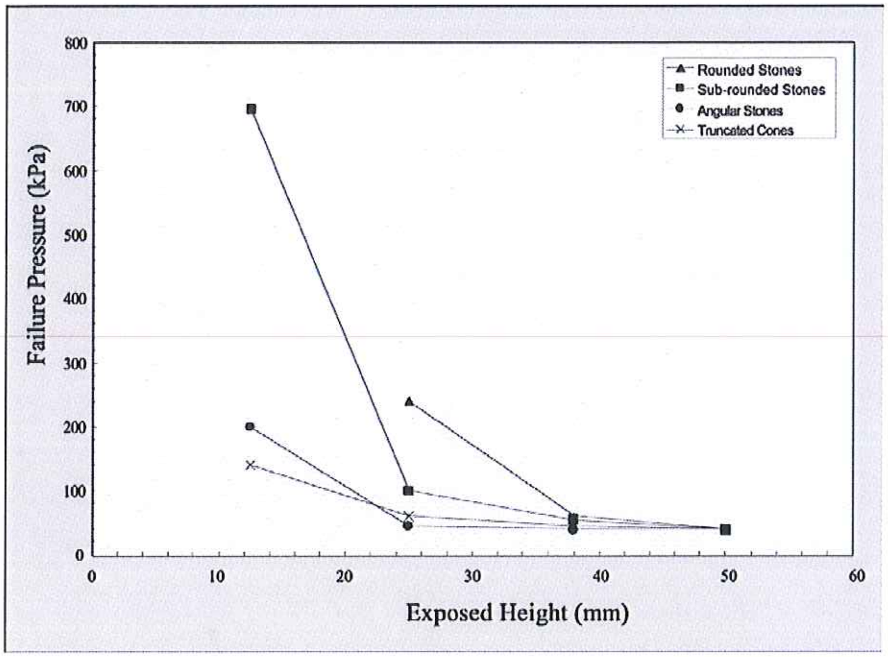

Figure 3.5 Influence of Stone Shape on Geomembrane Failure Pressures.

Table 3.5 Modification Factors for Shape of Stones.

Stone Shape	Modification Factor MF_{PS}
Angular	1.0
Subangular and subrounded	0.5
Rounded	0.25

To incorporate the effect of particle shape, Equation (3.7) can be modified as follows:

$$p_{allow} = \left[450\frac{M}{H^2}\right]\left[\frac{1}{MF_{PS} x FS_{CR}}\right] \tag{3.8}$$

Where, MF_{PS} = modification factor for particle shape.

Equation (3.8) represents the condition of isolated protrusions acting more or less independent of each other. This would be representative of an isolated stone protruding from a surface such as insitu soil or compacted clay liner. In some cases protrusions are placed so close together that their interaction can not be ignored. This is the case, for example, with a drainage layer placed on top of a geomembrane. To determine the influence of closely packed protrusions on geomembrane puncture, a number of tests were performed with AASHTO #3, 57 and 8 aggregate. For this purpose the truncated cones shown in Figure 1.2(b) were replaced by an aggregate layer. To the limit of the equipment, no failure of the geomembrane was noticed even without any protection geotextile. However, geomembrane yield was assumed to be the criteria for failure. Table 3.6 compares the truncated cone failure pressures from Figure 3.1 with yield pressures obtained in this case. It is seen that yield pressures with a layered soil are much higher than failure pressures with individualized stones in Figure 3.1.

The grouping advantage, as indicated in Table 3.6, is incorporated in Equation 3.8 by using a modification factor for packing density, MF_{PD}. Equation 3.8 can be written as:

$$p_{allow} = \left[450\frac{M}{H'^2}\right]\left[\frac{1}{MF_{PS} x FS_{CR}}\right] \qquad (3.8a)$$

Table 3.6 A Comparison of Geomembrane Failure Pressures with Truncated Cones and Assemblage of Stones.

HPTC Puncture Test		**Performance Puncture Test with Assemblage of Stones**			
Cone Height mm (in)	**Failure Pressure (kPa)**	**AASHTO Stone No**	**d_{50} (mm)**	**d_{max} (mm)**	**Yield Pressure (kPa)**
50 (2.0)	35	3	38	50	70
38 (1.5)	55	57	12	38	170
25 (1.0)	69	8	10	25	690

Where,

H' = Effective protrusion size = $H x MF_{PD}$

H= Maximum protrusion size

MF_{PD} = Modification factor for packing density

= 1.0 for isolated stones

= 0.5 for packed stones

3.2.1.5 Effect of Biological and Chemical Degradation

Biological degradation is generally not a concern for polypropylene and polyester geotextiles and HDPE geomembranes. Therefore, effectively a factor of safety of 1.0 can be used for biological degradation.

Chemical degradation is a function of type and concentration of chemicals. A factor of safety of 1.0 to 2.0 has been suggested in the literature with a value of 2.0 applicable to aggressive environments and a value of 1.0 to more inert usage conditions (Koerner, 1998). For example, for potable water ponds and canal liners a value of 1.0 may be used. For containment of brine or diluted acids, a value of 2.0 is generally proposed. For landfill leachate an intermediate value of 1.5 is generally proposed. The reader is recommended to use these values with adequate caution and engineering judgment. Equation 3.8 may be modified for chemical and biological degradation as follows:

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38 (1.5)	55	57	12	38	170
25 (1.0)	69	8	10	25	690

Where,

H' = Effective protrusion size = $HxMF_{PD}$
H= Maximum protrusion size
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$$p_{allow} = \left[450\frac{M}{H'^2}\right]\left[\frac{1}{MF_{PS}xFS_{CR}xFS_{CBD}}\right] \tag{3.9}$$

Where, FS_{CBD} = factor of safety for chemical and biological degradation.

Equation 3.9 is the final relationship for the calculation of allowable overburden pressure for an geomembrane protected by a nonwoven needlepunched geotextile of mass per unit area M grams/m^2. All terms in the equation and their values have been discussed in the forgoing sections.

3.3 Global Factor of Safety

A global factor of safety against the puncture of a geomembrane can be defined by Equation 3.10.

$$FS = \frac{p_{allow}}{p_{reqd}} \tag{3.10}$$

Where, p_{allow} = as defined in Equation 3.9, and p_{reqd} is the site-specific overburden pressure discussed in Section 2.3.

The objective of a successful design method for protection of geomembranes should be to prevent the geomembrane puncture over the design life of a geomembrane liner system. This requires the use of a suitable value for global factor of safety in Equation 3.10 to offset the effect of various uncertainties in design, testing and installation. The authors suggest using a value of 3 in Equation 3.10 as a reasonable value against an actual puncture, defined as a hole, in the geomembrane.

It is well known that HDPE geomembranes yield much earlier in the stress-strain curve than the actual rupture (see stress-strain curves for various geomembranes in Chapter 2). Thus, although a global factor of safety of 3 in Equation 3.10 will prevent an actual puncture, it is quite possible that the yield of the geomembrane would still take place. Thus, much higher values of global factors of safety need to be used to ensure that the yield of the geomembrane over the design life is prevented. Koerner, et. al. (1996) performed theoretical analysis of yield of geomembrane and compared it with failure pressures from truncated cone puncture test. On the basis of this analysis, they suggest using global factors of safety against yield provided in Table 3.7.

Table 3.7 Proposed Values of Global Factors of Safety (modified from Koerner, et. al., 1996).

Effective Protrusion Height (mm)	Minimum Global Factor of Safety Against Yield	Minimum Global Factor of Safety Against Puncture
6	3.0	3
12	4.5	3
25	7.0	3
38	10.0	3

Appendix B
Leachate Generation Rates

Phase	Existing Conditions	Phase 1	Phase 2	Phase 3	Phase 4	Post-Closure	Existing Approved (Post-Closure)
Area - Active Landfilling (ha)	28.9	40.2	21.8	16.8	18.8	0	0
Area - Final Cover (ha)	11.3	0	18.4	32.9	40.3	59.1	59.1
Cover Status	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)
Annual Leachate Generation (m^3)	131717	183219	99358	76569	85685	0	0
Annual Leachate Generation (m^3/day)	360.9	502.0	272.2	209.8	234.8	0.0	0.0
Cover Status	Final Cover	Final Cover	Final Cover	Final Cover	Final Cover	Final Cover	Final Cover
Annual Leachate Generation (m^3)	32995	0	53726	96065	117673	172567	172509
Annual Leachate Generation (m^3/day)	90.4	0.0	147.2	263.2	322.4	472.8	472.6
Total Leachate Generation (m^3)	***164712***	***183219***	***153084***	***172634***	***203357***	***172567***	***172509***
Total Leachate Generation (m^3/day)	***451***	***502***	***419***	***473***	***557***	***473***	***473***
Total Leachate Generation (L/s)	***5.2***	***5.8***	***4.9***	***5.5***	***6.4***	***5.5***	***5.5***

Notes:

Cover Status	Leachate Infiltration Rates (m/year)	Source	Option
Active (Daily Cover)	4558	From HELP model	5
Final Cover	2920	From HELP model	5
Final Cover	2919	From HELP model	Existing Approved

Phase	Existing Conditions	Phase 1	Phase 2	Phase 3	Phase 4	Post-Closure	Existing Approved (Post-Closure)
Area - Active Landfilling (ha)	28.9	40.2	21.8	16.8	18.8	0	0
Area - Final Cover (ha)	11.3	0	18.4	32.9	40.3	59.1	59.1
Cover Status	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)	Active (Daily Cover)
Annual Leachate Infiltration (m^3)	27.600	38.391	20.819	16.044	17.954	0.000	0.000
Annual Leachate Infiltration (m^3/day)	0.076	0.105	0.057	0.044	0.049	0.000	0.000
Cover Status	Final Cover	Final Cover	Final Cover	Final Cover	Final Cover	Final Cover	Final Cover
Annual Leachate Infiltration (m^3)	7.079	0.000	11.528	20.612	25.248	37.026	37.085
Annual Leachate Infiltration (m^3/day)	0.019	0.000	0.032	0.056	0.069	0.101	0.102
Total Leachate Infiltration (m^3)	***34.679***	***38.391***	***32.347***	***36.656***	***43.202***	***37.026***	***37.085***
Total Leachate Infiltration (m^3/day)	***0.095***	***0.105***	***0.089***	***0.100***	***0.118***	***0.101***	***0.102***
Total Leachate Infiltration (L/s)	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***	***0.001***

Notes:

Cover Status	Landfill Base Percolation Rates (m/year)	Source	Option
Active (Daily Cover)	0.955	From HELP model	5
Final Cover	0.627	From HELP model	5
Final Cover	0.6275	From HELP model	Existing Approved

Appendix C
Landfill **Gas** Modeling

In order to provide an estimate of future impacts to the Terrapure Stoney Creek Regional Facility (SCRF), GHD utilized a form of the Scholl Canyon equation in order to model the maximum methane generation rate within the landfill. The methane generation within a landfill for a given year can be calculated based on historical waste records and future projections of the annual waste acceptance rate (WAR). Equation 1 presents the formula used to calculate the methane generation from a landfill for a given year:

$$G_{CH4} = \sum \{W_x * L_{o,x} * (e^{-k\,(T - x - 1)} - e^{-k\,(T - x)})\} \quad \text{[for x = S through T-1]} \qquad (1)$$

where,

G_{CH4} = modeled methane generation rate in year T in tonnes per year

x = year in which waste was disposed

S = start year of calculation

T = reporting year for which emissions are calculated

W_x = quantity of waste disposed in year x (tonnes, wet weight)

L_o = CH_4 generation potential (tonnes CH_4 / tonnes waste)

k = rate constant (value of 0.045 yr^{-1} assumed)

The methane generation potential L_o is calculated using Equation 2:

$$L_o = \frac{MCF * DOC * DOC_F * F * 16}{12} \qquad (2)$$

where,

L_o = CH_4 generation potential (tonnes CH_4 / tonnes waste)

MCF = methane correction factor (default value is 1)

DOC = degradable organic carbon from Table 1 (tonnes C/tonne waste)

DOC_F = Fraction of DOC dissimilated (default value is 0.5)

F = Fraction by volume of CH_4 in landfill gas from measurement data, if available (value of 0.55 assumed)

The following methodology for determining the degradable organic carbon (DOC) and the methane generation potential for the SCRF waste types was taken from the Newalta Stoney Creek East Landfill Gas Emission Study (AECOM, January 24, 2011):

1. *Mixed Waste: It is our understanding that the mixed waste originates from Dofasco and is all inorganic. To be conservative, we have assumed that 5% of the waste is wood.*
2. *BOF Furnace Oxide: It is our understanding that the BOF furnace oxide waste is all inorganic with the exception of two (2) straw bales that are added to each 25 tonne truckload.*

3. *Asbestos: It is our understanding that the asbestos waste is all inorganic.*
4. *Non-Hazardous Industrial Waste: It is our understanding that the non-hazardous industrial waste is all inorganic. To be conservative, we have assumed that 5% of the waste is wood.*
5. *Non-Hazardous Contaminated Soils: To be conservative, we have assumed that the non-hazardous contaminated soil is black virgin soil with 10% organic matter (Government of Alberta Agriculture and Rural Development. 2001)*
6. *Construction and Demolition Waste: It is our understanding that the construction and demolition waste consists of approximately 15% to 20% wood and wood products. To be conservative, we have assumed that 20% of the waste is wood and wood products.*

Further, it has been assumed that the carbon content in wood and straw is 30% carbon per kg of wet waste (Environment Canada, 2010). The methane generation potential (L) was determined for each category of waste as described in Table C1 below:

Table C1. Determination of the methane generation potential (L_o)

Waste Category	Type of Organics	% Organics in Total Load	DOC (kg/tonne)	Methane Generation Potential (Lo) ($kg_{CH4}/tonne_{waste}$)
Mixed Waste	N/A	5.0%	15.0	5.5
BOF Furnace Oxide	Straw	0.2%	0.7	0.25
Asbestos	N/A	0.0%	0.0	0.0
Non-Haz. Industrial Waste	N/A	5.0%	15.0	5.5
Non-Haz. Contaminated Soils	Soil	10.0%	100.0	36.67
Construction and Demolition Waste	Wood	20.0%	60.0	22.0

The annual waste totals used in the model run were derived from the following:

- Annual waste totals for 1997 through 2008 were referenced from the Newalta Stoney Creek East Landfill Gas Emission Study (AECOM, January 24, 2011)
- Annual waste totals for 2009 through 2017 were provided by Terrapure
- Future waste totals for 2018 through 2028 were based on the maximum permitted waste acceptance rate of 750,000 tonnes per year until the design capacity of the landfill is reached. The estimated design capacity of 19.342 tonnes was calculated by multiplying the total airspace (10.180 million cubic meters) by a waste density of 1.9 tonnes per cubic meter. The breakdown of each type of waste was obtained by averaging the 1997 through 2017 quantities for each type of waste

Attachment 1 presents the results of the model run. The model projects a maximum of 4,766 tonnes of methane to be generated in 2028 (which equates to 119,154 tonnes of carbon dioxide equivalents (T CO_2e) assuming a global warming potential of 25 for methane).

A portion of the methane is oxidized to carbon dioxide as it passes through the soil cover. A cover oxidation value of 0.25 was referenced from 40 CFR 98, Subpart HH. Accounting for cover oxidation, the total portion of methane that is emitted in 2028 is approximately 3,575 tonnes (89,636 T CO_2e). A value of 89,636 metric tonnes CO_2e equates to a value of 98,508 U.S. tons CO_2e.

The United States Environmental Protection Agency defines a “major facility” of greenhouse gases as those facilities that emit greater than 100,000 US tons CO_2e in a given year. Based on our projections, the SCRF will not exceed this threshold throughout the life of the landfill.

For comparison purposes, a model run was performed assuming that the Newalta Landfill is composed of 100% municipal solid waste (MSW). According to 40 CFR 98, Subpart HH, MSW has a DOC value of 310 kilograms per tonne of waste. Assuming the same rate constant of 0.045 yr-1, the maximum methane generated within the SCRF is approximately 56,024 tonnes in 2028 (1,400,607 T CO_2e). Accounting for cover oxidation in the soil, the maximum of amount of methane emitted is approximately 50,422 tonnes (1,260,547 T CO_2e). A comparison of both scenarios is provided in Table C2 below:

Table C2. Maximum Annual Emissions

Model	**Maximum Annual CH4 Emissions (tonnes CH_4 / year)**	**Maximum Annual CO_2E Emissions (tonnes CO_2E / year)**
Terrapure SCRF	3,575	89,636
Comparable Size MSW Landfill	50,422	1,260,547
Terrapure SCRF as % of Comparable Size MSW Landfill	7.1	7.1

Based on these projections, a gas collection system is not warranted for the SCRF, since the facility is expected to produce landfill gas emission rates of less than 10% of what a comparable size MSW Landfill produces.

Table 1

Annual Waste Totals
Terrapure SCRF

	1997 (tonnes)	1998 (tonnes)	1999 (tonnes)	2000 (tonnes)	2001 (tonnes)	2002 (tonnes)	2003 (tonnes)	2004 (tonnes)	2005 (tonnes)	2006 (tonnes)	2007 (tonnes)
Mixed Waste	94,989	64,833	72,043	83,356	44,173	59,847	84,348	89,317	82,805	56,272	33,536
BOF Furnace Oxide	87,962	45,698	70,187	106,608	84,616	79,275	84,406	62,426	12,299	77,953	28,307
Asbestos	2,945	10,966	923	462	233	125	163	2	144	1,399	2,382
Non-Haz Industrial Waste	183,054	272,770	210,398	187,764	217,687	416,814	343,815	265,988	403,848	449,573	564,230
Non-Haz Cont Soils	298,908	68,643	56,379	34,804	37,990	2,032	39,382	63,215	33,856	51,565	55,684
C&D	0	0	0	17	418	66	1,116	299	5,691	3,758	3,960
Slag Fines	0	0	0	0	0	0	0	0	0	0	0
TOTALS	**667,858**	**462,910**	**409,930**	**413,011**	**385,117**	**558,159**	**553,230**	**481,247**	**538,643**	**640,520**	**688,099**

	2008 (tonnes)	2009 (tonnes)	2010 (tonnes)	2011 (tonnes)	2012 (tonnes)	2013 (tonnes)	2014 (tonnes)	2015 (tonnes)	2016 (tonnes)	2017 (tonnes)	Fraction of Total
Mixed Waste	53,436	16,363	6,441	10,556	24,659	20,836	29,144	40,699	20,289	15,827	0.0851
BOF Furnace Oxide	66,011	66,127	84,174	82,533	87,611	87,668	93,700	95,778	109,626	107,259	0.1374
Asbestos	3,704	3,021	3,583	4,275	3,876	5,097	7,229	3,658	4,719	5,646	0.0055
Non-Haz Industrial Waste	492,793	352,242	346,142	700,341	579,609	394,257	144,805	236,843	218,497	140,574	0.6039
Non-Haz Cont Soils	36,747	38,721	117,982	75,971	54,063	228,323	256,528	251,138	26,955	16,877	0.1565
C&D	1,230	536	1,818	481	180	2,105	467	578	472	403	0.0020
Slag Fines	0	0	0	0	0	0	0	358	98,097	15,612	0.0097
TOTALS	**653,921**	**477,011**	**560,141**	**874,157**	**749,998**	**738,285**	**531,874**	**629,052**	**478,655**	**302,199**	**1.0000**

TOTALS (1997-2017)	**11,794,017**	**tonnes**
DESIGN CAPACITY	**19,342,000**	**tonnes**
PERMITTED WAR	**750,000**	**tonnes / year**
REMAINING CAPACITY	**7,547,983**	**tonnes**

	2018 (tonnes)	2019 (tonnes)	2020 (tonnes)	2021 (tonnes)	2022 (tonnes)	2023 (tonnes)	2024 (tonnes)	2025 (tonnes)	2026 (tonnes)	2027 (tonnes)	2028 (tonnes)
Mixed Waste	63,831	63,831	63,831	63,831	63,831	63,831	63,831	63,831	63,831	63,831	4,084
BOF Furnace Oxide	103,033	103,033	103,033	103,033	103,033	103,033	103,033	103,033	103,033	103,033	6,592
Asbestos	4,105	4,105	4,105	4,105	4,105	4,105	4,105	4,105	4,105	4,105	263
Non-Haz Industrial Waste	452,902	452,902	452,902	452,902	452,902	452,902	452,902	452,902	452,902	452,902	28,975
Non-Haz Cont Soils	117,375	117,375	117,375	117,375	117,375	117,375	117,375	117,375	117,375	117,375	7,509
C&D	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	96
Slag Fines	7,254	7,254	7,254	7,254	7,254	7,254	7,254	7,254	7,254	7,254	464
TOTALS	**750,000**	**750,000**	**750,000**	**750,000**	**750,000**	**750,000**	**750,000**	**750,000**	**750,000**	**750,000**	**47,983**

TOTALS (2018-2028)	**7,547,983**	**tonnes**

Table 2

Methane Generation Model
Mixed Waste
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0.015	(mixed waste)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.0055	megagrams CH_4 / megagram waste

Year	Mixed Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	94,989	6
1998	64,833	4
1999	72,043	5
2000	83,356	6
2001	44,173	3
2002	59,847	5
2003	84,348	7
2004	89,317	8
2005	82,805	7
2006	56,272	5
2007	33,536	3
2008	53,436	5
2009	16,363	2
2010	6,441	1
2011	10,556	1
2012	24,659	3
2013	20,836	3
2014	29,144	4
2015	40,699	6
2016	20,289	3
2017	15,827	2
2018	63,831	10
2019	63,831	11
2020	63,831	11
2021	63,831	12
2022	63,831	12
2023	63,831	13
2024	63,831	13
2025	63,831	14
2026	63,831	15
2027	63,831	15
2028	4,084	

Total 2028 CH_4 Generated (metric tons):	**217**
Total 2028 CO_2 Equivalents Generated (metric tons):	**5,427**

Table 3

Methane Generation Model
BOF Oxide Waste
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0.00069	(BOF oxide waste)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.00025	megagrams CH_4 / megagram waste

Year	BOF Oxide Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	87,962	0
1998	45,698	0
1999	70,187	0
2000	106,608	0
2001	84,616	0
2002	79,275	0
2003	84,406	0
2004	62,426	0
2005	12,299	0
2006	77,953	0
2007	28,307	0
2008	66,011	0
2009	66,127	0
2010	84,174	0
2011	82,533	0
2012	87,611	0
2013	87,668	1
2014	93,700	1
2015	95,778	1
2016	109,626	1
2017	107,259	1
2018	103,033	1
2019	103,033	1
2020	103,033	1
2021	103,033	1
2022	103,033	1
2023	103,033	1
2024	103,033	1
2025	103,033	1
2026	103,033	1
2027	103,033	1
2028	6,592	

Total 2028 CH_4 Generated (metric tons): 17

Total 2028 CO_2 Equivalents Generated (metric tons): 433

Table 4

Methane Generation Model
Asbestos Waste
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0	(asbestos waste)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.00000	megagrams CH_4 / megagram waste

Year	Asbestos Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	2,945	0
1998	10,966	0
1999	923	0
2000	462	0
2001	233	0
2002	125	0
2003	163	0
2004	2	0
2005	144	0
2006	1,399	0
2007	2,382	0
2008	3,704	0
2009	3,021	0
2010	3,583	0
2011	4,275	0
2012	3,876	0
2013	5,097	0
2014	7,229	0
2015	3,658	0
2016	4,719	0
2017	5,646	0
2018	4,105	0
2019	4,105	0
2020	4,105	0
2021	4,105	0
2022	4,105	0
2023	4,105	0
2024	4,105	0
2025	4,105	0
2026	4,105	0
2027	4,105	0
2028	263	

Total 2028 CH_4 Generated (metric tons): **0**
Total 2028 CO_2 Equivalents Generated (metric tons): **0**

Table 5

Methane Generation Model
Non-Hazardous Industrial Waste
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0.015	(Non-hazardous Industrial Waste)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.00550	megagrams CH_4 / megagram waste

Year	Non-Haz. Industrial Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	183,054	11
1998	272,770	18
1999	210,398	14
2000	187,764	13
2001	217,687	16
2002	416,814	33
2003	343,815	28
2004	265,988	23
2005	403,848	36
2006	449,573	42
2007	564,230	56
2008	492,793	51
2009	352,242	38
2010	346,142	39
2011	700,341	83
2012	579,609	71
2013	394,257	51
2014	144,805	20
2015	236,843	33
2016	218,497	32
2017	140,574	22
2018	452,902	73
2019	452,902	76
2020	452,902	80
2021	452,902	84
2022	452,902	88
2023	452,902	92
2024	452,902	96
2025	452,902	100
2026	452,902	105
2027	452,902	110
2028	28,975	

Total 2028 CH_4 Generated (metric tons):	**1,634**
Total 2028 CO_2 Equivalents Generated (metric tons):	**40,838**

Table 6

Methane Generation Model
Non-Hazardous Contaminated Soil
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0.1	(Non-hazardous Contaminated Soil)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.03667	megagrams CH_4 / megagram waste

Year	Non-Haz. Cont. Soil Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	298,908	125
1998	68,643	30
1999	56,379	26
2000	34,804	17
2001	37,990	19
2002	2,032	1
2003	39,382	22
2004	63,215	36
2005	33,856	20
2006	51,565	32
2007	55,684	37
2008	36,747	25
2009	38,721	28
2010	117,982	89
2011	75,971	60
2012	54,063	44
2013	228,323	196
2014	256,528	231
2015	251,138	236
2016	26,955	27
2017	16,877	17
2018	117,375	126
2019	117,375	132
2020	117,375	138
2021	117,375	145
2022	117,375	151
2023	117,375	158
2024	117,375	165
2025	117,375	173
2026	117,375	181
2027	117,375	189
2028	7,509	

Total 2028 CH_4 Generated (metric tons):	**2,877**
Total 2028 CO_2 Equivalents Generated (metric tons):	**71,914**

Table 7

Methane Generation Model
Construction and Demolition Waste
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0.06	(Non-hazardous Contaminated Soil)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.02200	megagrams CH_4 / megagram waste

Year	Const. and Demo. Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	0	0
1998	0	0
1999	0	0
2000	17	0
2001	418	0
2002	66	0
2003	1,116	0
2004	299	0
2005	5,691	2
2006	3,758	1
2007	3,960	2
2008	1,230	1
2009	536	0
2010	1,818	1
2011	481	0
2012	180	0
2013	2,105	1
2014	467	0
2015	578	0
2016	472	0
2017	403	0
2018	1,500	1
2019	1,500	1
2020	1,500	1
2021	1,500	1
2022	1,500	1
2023	1,500	1
2024	1,500	1
2025	1,500	1
2026	1,500	1
2027	1,500	1
2028	96	

Total 2028 CH_4 Generated (metric tons): **22**

Total 2028 CO_2 Equivalents Generated (metric tons): **542**

Table 8

Methane Generation Model
Slag Fines Waste
Terrapure SCRF

Landfill Year Open:	1997	
Peak Year:	2028	
MCF:	1.0	(default value)
DOC:	0	(asbestos waste)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.00000	megagrams CH_4 / megagram waste

Year	Slag Fines Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	358	0
2016	98,097	0
2017	15,612	0
2018	7,254	0
2019	7,254	0
2020	7,254	0
2021	7,254	0
2022	7,254	0
2023	7,254	0
2024	7,254	0
2025	7,254	0
2026	7,254	0
2027	7,254	0
2028	464	

Total 2028 CH_4 Generated (metric tons):	**0**
Total 2028 CO_2 Equivalents Generated (metric tons):	**0**

Table 9

Methane Generation Model
Totals
Terrapure SCRF

Landfill Year Open:	1997
Reporting Year:	2028

Waste Type	2028 CH_4 Generation (metric tons)
Mixed Waste	217
BOF Oxide Waste	17
Asbestos Waste	0
Non-Haz. Industrial Waste	1,634
Non-Haz. Contaminated Soil	2,877
C&D Waste	22
Slag Fines Waste	0

Total 2028 CH_4 Generated (metric tons):	**4,766**
Total 2028 CO_2 Equivalents Generated (metric tons):	**119,154**

Table 10

Calculation of Methane Generation and Emissions
Terrapure SCRF

Calculation of methane generation, adjusted for oxidation, from the modeled CH_4, using Equation HH-5

$$MG = G_{CH4} * (1 - OX)$$

G_{CH4} =	Modeled methane generation rate =	4,766.2	metric tons CH_4 in 2028
SArea =	Surface Area of the landfill =	591,000	square meters
MF =	Methane Flux rate from the landfill =	22	$g/m^2/day$
OX =	Oxidation fraction =	0.25	(Landfill has 2 feet of clay cover; 6" of topsoil, option C6)

MG = 3,574.6 metric tons CH_4

MG = 89,365.9 metric tons CO_2 equivalents

Table HH-4 to Subpart HH of Part 98—Landfill Methane Oxidation Fractions

Under these conditions:	Use this landfill methane oxidation fraction:
I. For all reporting years prior to the 2013 reporting year	
C1: For all landfills regardless of cover type or methane flux	0.10
II. For the 2013 reporting year and all subsequent years	
C2: For landfills that have a geomembrane (synthetic) cover with less than 12 inches of cover soil for the majority of the landfill area containing waste	0.0
C3: For landfills that do not meet the conditions in C2 above, and for which you elect not to determine methane flux	0.10
C4: For landfills that do not meet the conditions in C2 above and that do not have a soil cover of at least 24 inches for a majority of the landfill area containing waste	0.10
C5: For landfills that have a soil cover of at least 24 inches for a majority of the landfill area containing waste and for which the methane flux rate is less than 10 grams per square meter per day ($g/m^2/d$)	0.35
C6: For landfills that have a soil cover of at least 24 inches for a majority of the landfill area containing waste and for which the methane flux rate is 10 to 70 $g/m^2/d$	0.25
C7: For landfills that have a soil cover of at least 24 inches for a majority of the landfill area containing waste and for which the methane flux rate is greater than 70 $g/m^2/d$	0.10

[a]Methane flux rate (in grams per square meter per day; $g/m^2/d$) is the mass flow rate of methane per unit area at the bottom of the surface soil prior to any oxidation and is calculated as follows:

Table 11

Methane Generation Model
Bulk MSW Waste Landfill

Landfill Year Open:	1997	
Reporting Year:	2028	
MCF:	1.0	(default value)
DOC:	0.31	(bulk waste)
DOC_F:	0.5	(default value)
F:	0.55	
k:	0.045	yr^{-1}
Calculated L_o	0.1137	megagrams CH_4 / megagram waste

Year	Bulk Waste Disposed (metric tons of waste disposed)	Contribution to 2028 Generation (metric tons of CH_4 Generated)
1997	667,858	866
1998	462,910	628
1999	409,930	582
2000	413,011	613
2001	385,117	598
2002	558,159	906
2003	553,230	940
2004	481,247	855
2005	538,643	1,001
2006	640,520	1,245
2007	688,099	1,399
2008	653,921	1,391
2009	477,011	1,061
2010	560,141	1,304
2011	874,157	2,128
2012	749,998	1,910
2013	738,285	1,967
2014	531,874	1,482
2015	629,052	1,833
2016	478,655	1,459
2017	302,199	964
2018	750,000	2,502
2019	750,000	2,617
2020	750,000	2,738
2021	750,000	2,864
2022	750,000	2,995
2023	750,000	3,133
2024	750,000	3,277
2025	750,000	3,428
2026	750,000	3,586
2027	750,000	3,751
2028	47,983	251

Total 2028 CH_4 Generated (metric tons):	**56,024**
Total 2028 CO_2 Equivalents Generated (metric tons):	**1,400,607**

Table 12

Calculation of Methane Generation and Emissions
Bulk MSW Waste Landfill

Calculation of methane generation, adjusted for oxidation, from the modeled CH_4, using Equation HH-5

$$MG = G_{CH4} * (1 - OX)$$

G_{CH4} =	Modeled methane generation rate =	56,024.3	metric tons CH_4 in 2028
SArea =	Surface Area of the landfill =	591,000	square meters
MF =	Methane Flux rate from the landfill =	260	$g/m^2/day$
OX =	Oxidation fraction =	0.1	(Landfill has 2 feet of clay cover; 6" of topsoil, option C7)

MG = 50,421.9 metric tons CH_4

MG = 1,260,546.7 metric tons CO_2 equivalents

Table HH-4 to Subpart HH of Part 98—Landfill Methane Oxidation Fractions

Under these conditions:	Use this landfill methane oxidation fraction:
I. For all reporting years prior to the 2013 reporting year	
C1: For all landfills regardless of cover type or methane flux	0.10
II. For the 2013 reporting year and all subsequent years	
C2: For landfills that have a geomembrane (synthetic) cover with less than 12 inches of cover soil for the majority of the landfill area containing waste	0.0
C3: For landfills that do not meet the conditions in C2 above, and for which you elect not to determine methane flux	0.10
C4: For landfills that do not meet the conditions in C2 above and that do not have a soil cover of at least 24 inches for a majority of the landfill area containing waste	0.10
C5: For landfills that have a soil cover of at least 24 inches for a majority of the landfill area containing waste and for which the methane flux rate is less than 10 grams per square meter per day ($g/m^2/d$)	0.35
C6: For landfills that have a soil cover of at least 24 inches for a majority of the landfill area containing waste and for which the methane flux rate is 10 to 70 $g/m^2/d$	0.25
C7: For landfills that have a soil cover of at least 24 inches for a majority of the landfill area containing waste and for which the methane flux rate is greater than 70 $g/m^2/d$	0.10

[a]Methane flux rate (in grams per square meter per day; $g/m^2/d$) is the mass flow rate of methane per unit area at the bottom of the surface soil prior to any oxidation and is calculated as follows: