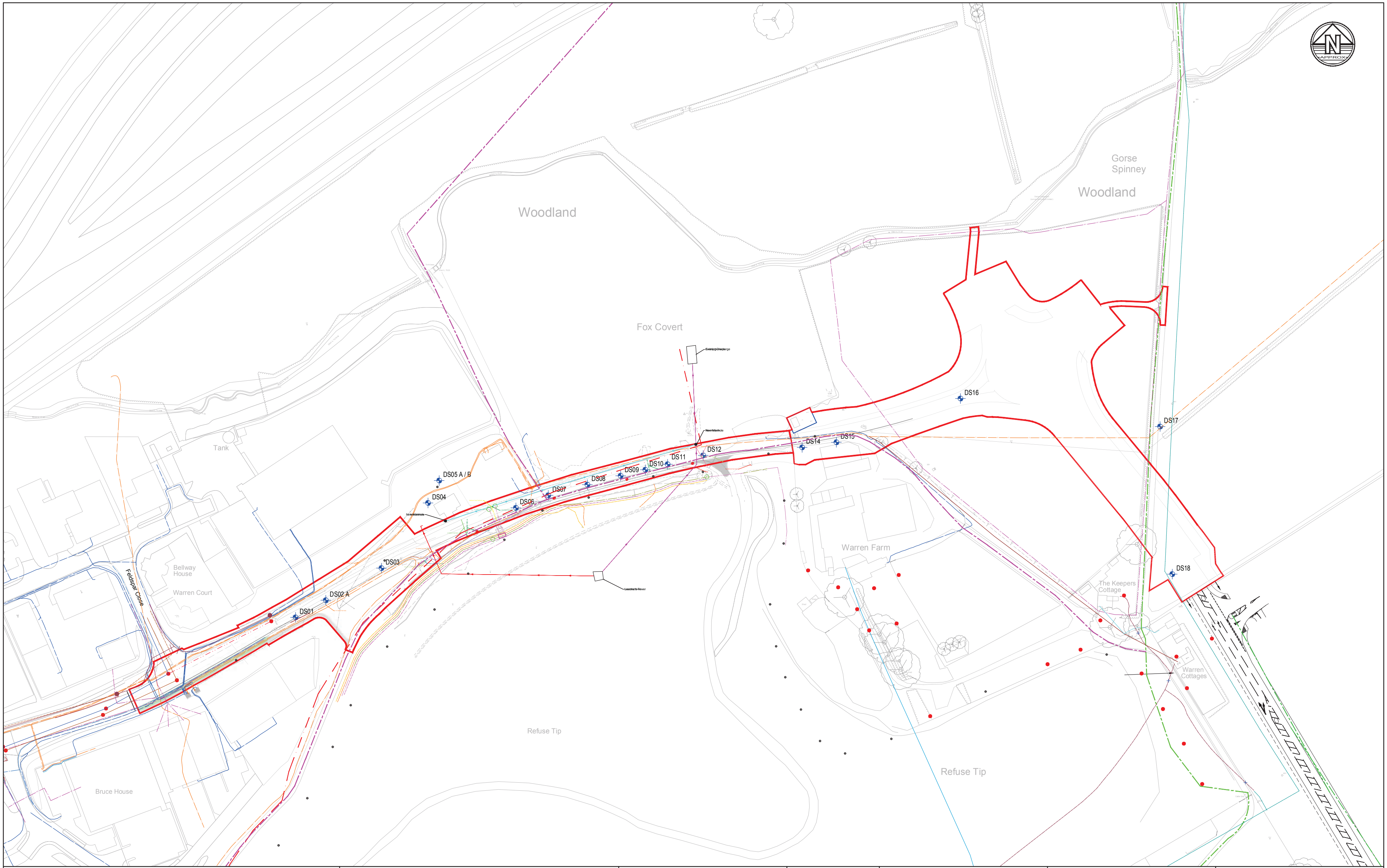

## Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. It is considered to have one step relaxation for horizontal alignment.
6. 1.5m clearance considered at the back of footway for proposed earthwork.

## Key

## ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P6 | 16/07/19 | Updated following the completion of the GI | LC | TJH |

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■ Nottingham | 0115 924 1100
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Client
**MATHER JAMIE**

Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

Drawing Title
**ENVIRONMENTAL HOLE LOCATION PLAN**

| | | | |
|---|---|---|---|
| Drawn: | L. Cross | Reviewed: | T. Hull |
| BWB Ref: | NTH2304 | Date: | 16.07.2019 |
| Scale@A1: | 1:1000 | | |

Drawing Status
**FINAL**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-HGN-05-DR-D-100 | S8 | P6 |

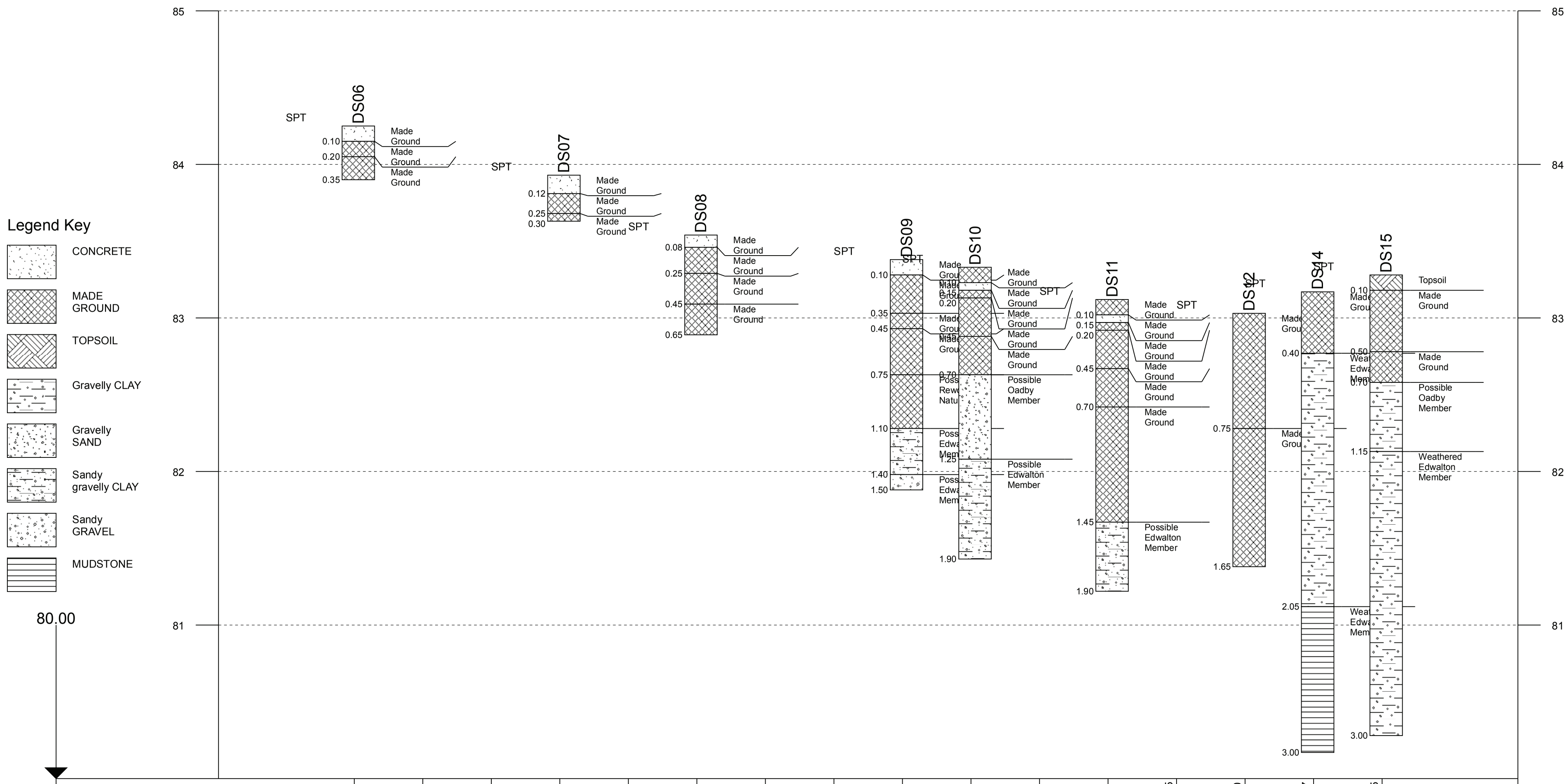
## Drawing 3: Geological Cross Sections

Project No: NTH2304
Location: Enderby
Client: The Trustees for ER Brook Drummend Deceased

Title: Enderby Relief Road

Engineer: PT

Scale
Vertical: 1:38
Horizontal: Not to scale



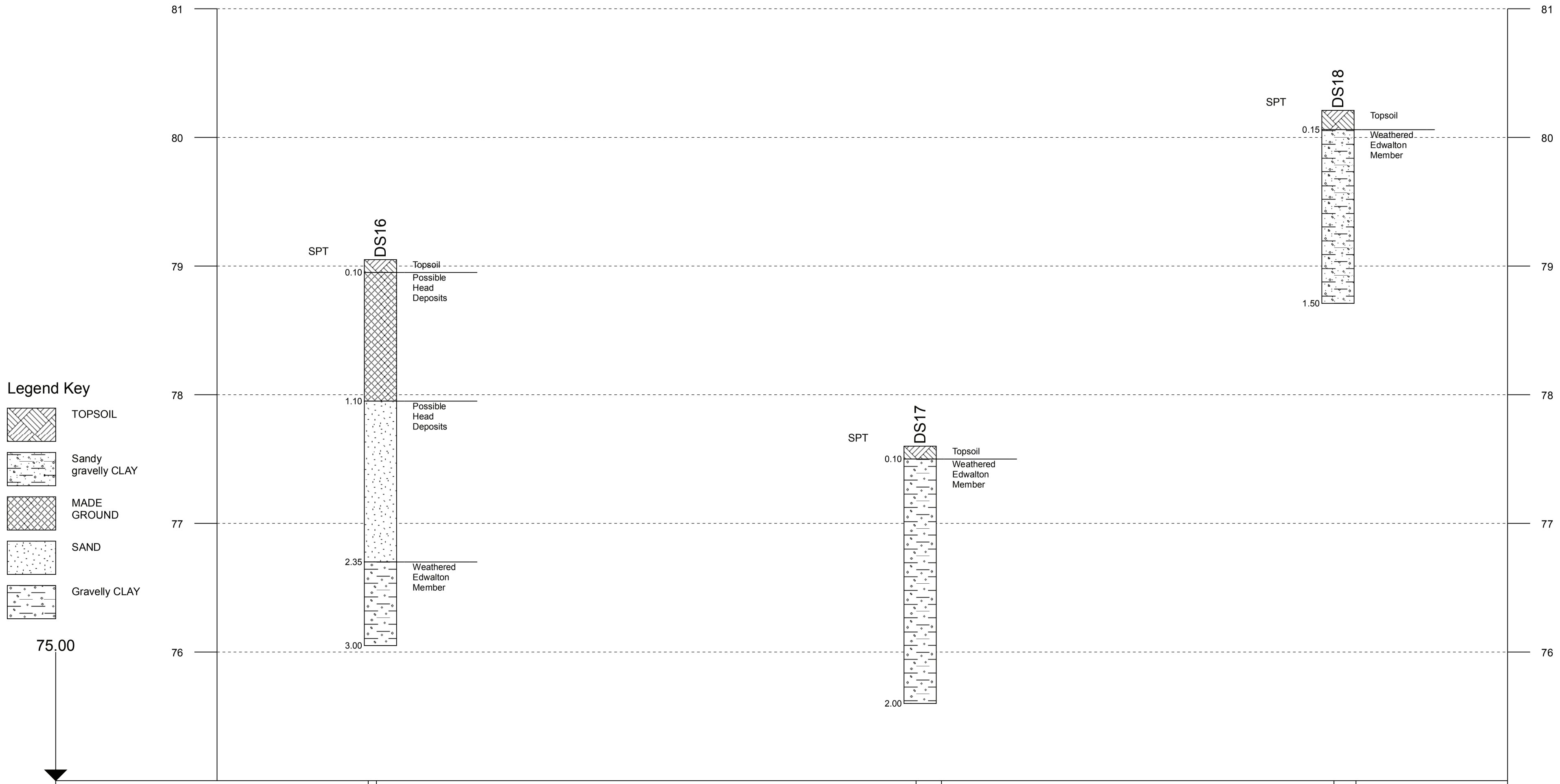
| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chainage (m) | 1.53 | 5.86 | 20.92 | 22.02 | 42.11 | 46.17 | 52.22 | 65.46 | 66.63 | 81.76 | 88.10 | 95.40 | 109.35 | 117.20 | 176.37 | 196.95 |
| Offset (m) | 1.10 | 1.71 | 0.40 | 0.97 | 0.13 | 0.92 | 0.35 | 0.39 | 0.73 | 0.30 | 0.30 | 0.05 | 1.72 | 0.60 | 1.79 | 0.71 |
| Elevation (mAOD) | 84.25 | 84.14 | 83.94 | 83.93 | 83.64 | 83.54 | 83.49 | 83.40 | 83.38 | 83.33 | 83.18 | 83.12 | 82.94 | 83.03 | 83.17 | 83.28 |

Project No: NTH2304
Location: Enderby
Client: The Trustees for ER Brook Drummend Deceased

Title: Enderby Relief Road

Engineer: PT

Scale
Vertical: 1:45
Horizontal: 1:1287



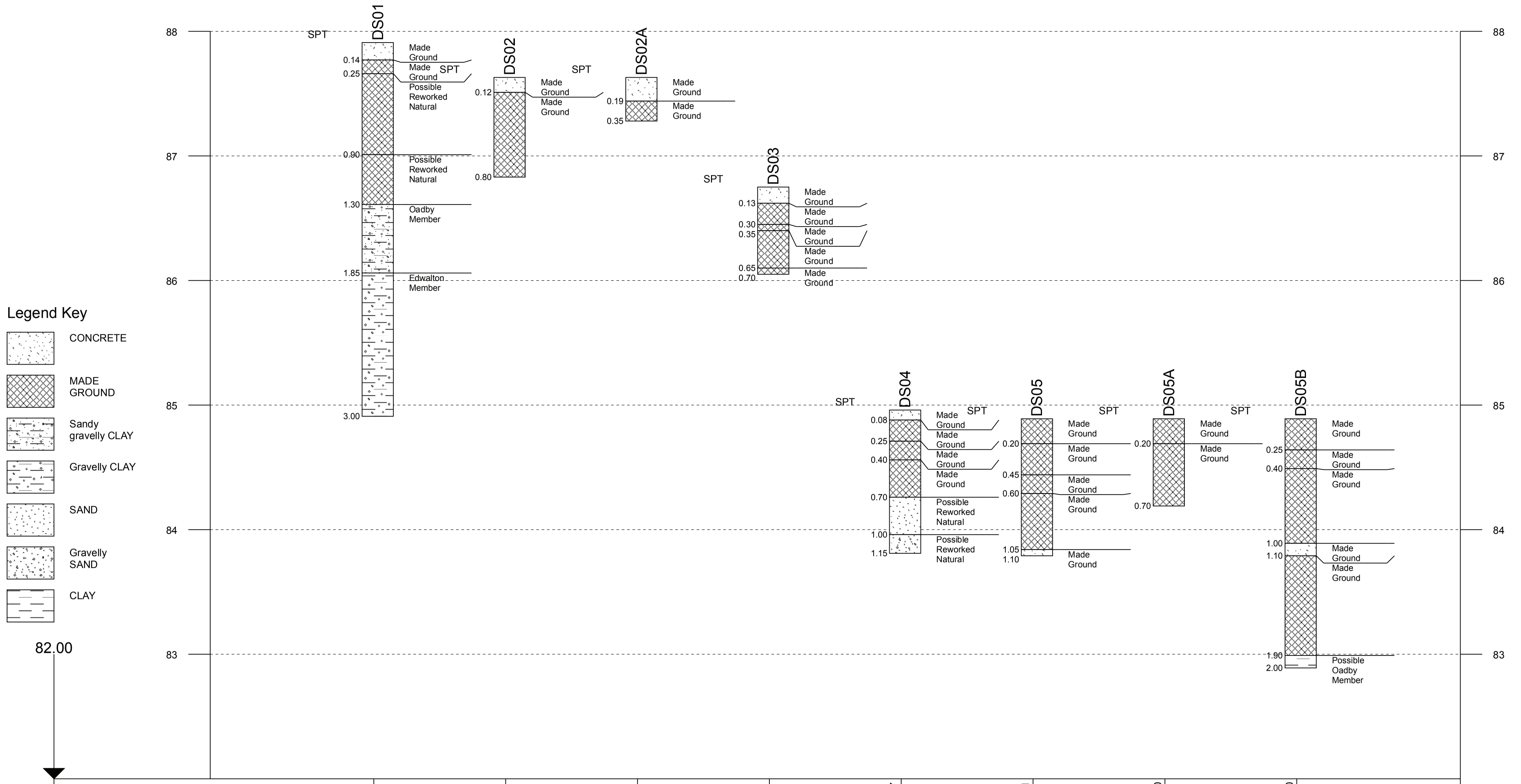
| | | | |
|---|---|---|---|
| Chainage (m) | 0.00<br>1.82 | 121.71<br>127.35 | 214.55<br>219.45 |
| Offset (m) | 1.37 | 0.21 | 1.41 |
| Elevation (mAOD) | 79.05 | 77.60 | 80.21 |

Project No: NTH2304
Location: Enderby
Client: The Trustees for ER Brook Drummend Deceased

Title: Enderby Relief Road

Engineer: PT

Scale
Vertical: 1:45
Horizontal: Not to scale



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Chainage (m) | 11.15 | 31.82 | 32.68 | 70.01 | 119.07 | 134.01 | 134.90 | 135.80 |
| Offset (m) | 1.60 | 1.14 | 0.62 | 0.60 | 1.21 | 1.23 | 0.79 | 0.34 |
| Elevation (mAOD) | 87.91 | 87.63 | 87.63 | 86.75 | 84.96 | 84.89 | 84.89 | 84.89 |

# *APPENDICES*

# Appendix 1: Exploratory Hole Records

# BOREHOLE LOG

Scale 1:25 Sheet 1 of 1

| | | | | | | |
|---|---|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | | **Ground Level (m AOD):** | 87.91 | |
| **DS01** | **Project Number:** | NTH2304 | | **Eastings:** | 453695.76 | |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | | **Northings:** | 300172.35 | |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** | 08/07/2019 | **Engineer:** LC | **Checker:** | TJH |

| Level (m AOD) & [Thickness (m)] | Description | Depth (m bgl) |
|---|---|---|
| [0.14] | Asphalt.<br>(Made Ground) | 0.14 |
| 87.77<br>[0.11] | Compacted grey occasionally brown slightly sandy GRAVEL of angular to sub-angular fine to coarse granite and quartzite. Sand is fine.<br>(Made Ground) | 0.25 |
| 87.66<br>[0.65] | Brown occasionally orangish brown slightly sandy GRAVEL of angular to sub-angular fine to coarse quartzite and granite with occasional sandstone.<br>(Possible Reworked Natural) | 0.90 |
| 87.01<br>[0.40] | Soft dark greyish brown slightly clayey slightly gravelly silty fine SAND. Gravel is angular to sub-angular fine and medium quartzite and granite with rare sandstone. Occasional organic matter and tree roots. Slight organic odour.<br>(Possible Reworked Natural)<br>*0.9m - 1.3m: Slight organic odour noted.* | 1.30 |
| 86.61<br>[0.55] | Soft grey mottled green slightly gravelly very sandy CLAY. Gravel is sub-angular fine and medium granite.<br>(Oadby Member)<br>*1.7m - 1.85m: Green mottling no longer noted.* | 1.85 |
| 86.06<br>[1.15] | Firm brownish red slightly gravelly CLAY with fine and medium sand lenses. Gravel is sub-angular fine and medium quartzite and granite with occasional weak sandstone.<br>(Edwalton Member)<br>*2.6m - 2.85m: Becomes very gravelly.*<br>*2.75m - 3.0m: Becomes stiff.*<br>*2.85m - 3.0m: Becomes more brown.* | 3.00 |
| 84.91 | Hole Terminated at 3.00m bgl. | |

Groundwater: Strike | Strike Details | Well

Samples: Type (Ublows) | From (m) | To (m)

In-Situ Tests: Type | Depth (m) | Result | Casing Depth & (Water Level)

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |

## Remarks

**Reason for Termination:**

Sufficient depth reached

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**
- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**
- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**
- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25

Sheet 1 of 1

| | | | |
|---|---|---|---|
| **LOCATION ID**<br>**DS02** | **Project Name:** Enderby Relief Road | **Ground Level (m AOD):** | 87.63 |
| | **Project Number:** NTH2304 | **Eastings:** | 453713.75 |
| | **Client:** The Trustees for ER Brook Drummend Deceased | **Northings:** | 300182.54 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR **Start & End Date:** 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.12] | Asphalt.<br>(Made Ground) | ░ | | | | | | | | |
| | | | 87.51<br>[0.68] | Compacted grey occasionally brown slightly sandy GRAVEL of angular to sub-angular fine to coarse granite. Sand is fine.<br>(Made Ground) | ▩ | 0.12 | | | | | | | |
| | | | 86.83 | Hole Terminated at 0.80m bgl. | | 0.80 | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Obstruction causing the drillings rods to skew off centre.

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25 Sheet 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | | **Ground Level (m AOD):** | 87.63 |
| **DS02A** | **Project Number:** | NTH2304 | | **Eastings:** | 453714.75 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | | **Northings:** | 300182.54 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** | 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| **Groundwater** | | | **Strata** | | | | **Samples** | | | **In-Situ Tests** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.19]<br>87.44 | Asphalt.<br>(Made Ground) | | 0.19 | | | | | | | |
| | | | [0.16]<br>87.28 | Compacted grey occasionally brown slightly sandy GRAVEL of angular to sub-angular fine to coarse granite. Sand is fine.<br>(Made Ground) | | 0.35 | | | | | | | |

Hole Terminated at 0.35m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |

## Remarks

**Reason for Termination:**

Rock obstruction encountered at 0.35m, unable to core through due to loose debris above it

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**
- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**
- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**
- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25 Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 86.75 |
| **DS03** | **Project Number:** | NTH2304 | **Eastings:** | 453746.82 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300201.65 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| **Groundwater** | | | **Strata** | | | | **Samples** | | | **In-Situ Tests** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | ░ | [0.13]<br>86.62 | Asphalt.<br>(Made Ground) | ░ | 0.13 | | | | | | | |
| | | ▨ | [0.17]<br>86.45 | Compacted grey occasionally brown slightly sandy GRAVEL of angular to sub-angular fine to coarse granite. Sand is fine.<br>(Made Ground) | ▨ | 0.30 | | | | | | | |
| | | ■ | [0.05]<br>86.40 | Compacted pinkish grey slightly sandy GRAVEL of angular to sub-angular fine to coarse granite with occasional quartzite.<br>(Made Ground) | ▨ | 0.35 | | | | | | | |
| | | ▨ | [0.30]<br>86.10 | Pinkish reddish grey BOULDER of granite.<br>(Made Ground)<br>*0.35 - 0.65m: Diamond cored through boulder.* | ▨ | 0.65 | | | | | | | |
| | | ■ | [0.05]<br>86.05 | Pinkish reddish grey interlocking COBBLES of angular to sub-angular granite.<br>(Made Ground) | ▨ | 0.70 | | | | | | | |
| | | | | Hole Terminated at 0.70m bgl. | | | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unable to penetrate through granite cobbles

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID**<br>**DS04** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 84.96 |
| | **Project Number:** | NTH2304 | **Eastings:** | 453774.51 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300240.41 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| **Groundwater** | | | **Strata** | | | | **Samples** | | | **In-Situ Tests** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.08]<br>84.88 | Asphalt.<br>(Made Ground) | | 0.08 | | | | | | | |
| | | | [0.17]<br>84.71 | Compacted grey occasionally brown slightly sandy GRAVEL of angular to sub-angular fine to coarse granite. Sand is fine.<br>(Made Ground) | | 0.25 | | | | | | | |
| | | | [0.15]<br>84.56 | Black occasionally brown and grey slightly clayey sandy GRAVEL of angular fine to coarse crushed concrete, ash and occasional clinker.<br>(Made Ground) | | 0.40 | | | | | | | |
| | | | [0.30]<br>84.26 | Grey slightly sandy GRAVEL of angular fine and medium granite.<br>(Made Ground) | | 0.70 | | | | | | | |
| | | | [0.30]<br>83.96 | Greyish brown fine to coarse SAND.<br>(Possible Reworked Natural) | | 1.00 | | | | | | | |
| | | | [0.15]<br>83.81 | Greyish brown slightly gravelly fine to coarse SAND. Gravel is sub-angular fine to coarse quartzite and granite.<br>(Possible Reworked Natural) | | 1.15 | | | | | | | |

Hole Terminated at 1.15m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction at 1.15m - possibly rock

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25

Sheet 1 of 1

| | | | |
|---|---|---|---|
| **LOCATION ID** | **Project Name:** Enderby Relief Road | **Ground Level (m AOD):** | 84.89 |
| **DS05** | **Project Number:** NTH2304 | **Eastings:** | 453781.19 |
| | **Client:** The Trustees for ER Brook Drummend Deceased | **Northings:** | 300253.77 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR **Start & End Date:** 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | ▨ | [0.20] | Compacted grey occasionally pinkish grey slightly sandy GRAVEL of angular to subangular fine to coarse granite. (Made Ground) | ▨ | | | | | | | | |
| | | ■ | 84.69<br>[0.25] | Compacted grey to dark grey slightly sandy GRAVEL of angular to sub-angular fine to coarse crushed concrete. (Made Ground) | ▨ | 0.20 | | | | | | | |
| | | ■ | 84.44<br>[0.15] | Black slightly sandy GRAVEL of angular to sub-angular fine to coarse crushed concrete, brick, ash, clinker and occasional granite. (Made Ground) | ▨ | 0.45 | | | | | | | |
| | | ■ | 84.29<br>[0.45] | Firm orangish brown mottled greenish brown slightly sandy gravelly CLAY. Gravel is angular to sub-rounded fine to coarse brick, quartzite and flint with occasional inclusions of ash, clinker and glass. (Made Ground) | ▨ | 0.60 | | | | | | | |
| | | | 83.84<br>[0.05]<br>83.79 | Concrete. (Made Ground) | | 1.05<br>1.10 | | | | | | | |

Hole Terminated at 1.00m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Concrete obstruction encountered at base

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**

- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**

- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25 Sheet 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | | **Ground Level (m AOD):** | 84.89 |
| **DS05A** | **Project Number:** | NTH2304 | | **Eastings:** | 453781.19 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | | **Northings:** | 300254.77 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** | 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | ▨ | [0.20]<br>84.69 | Compacted grey occasionally pinkish grey slightly sandy GRAVEL of angular to subangular fine to coarse granite. (Made Ground) | ▨ | 0.20 | | | | | | | |
| | | ■ | [0.50]<br>84.19 | Compacted grey to dark grey slightly sandy GRAVEL of angular to sub-angular fine to coarse crushed concrete, brick and granite with rare inclusions of glass, clinker and timber. (Made Ground)<br>*0.6m - 0.65m: Large piece of timber noted.* | ▨ | 0.70 | | | | | | | |
| | | | | Hole Terminated at 0.70m bgl. | | | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction encountered at 0.7m

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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Scale 1:25 Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 84.89 |
| **DS05B** | **Project Number:** | NTH2304 | **Eastings:** | 453781.19 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300255.77 |

| | | | | | |
|---|---|---|---|---|---|
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** | 08/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.25]<br>84.64 | Compacted grey occasionally pinkish grey slightly sandy GRAVEL of angular to subangular fine to coarse granite. (Made Ground) | | 0.25 | | | | | | | |
| | | | [0.15]<br>84.49 | Reddish brown occasionally grey slightly sandy GRAVEL of angular fine to coarse weak mudstone and occasional quartzite with inclusions of concrete and limestone. (Made Ground) | | 0.40 | | | | | | | |
| | | | [0.60]<br>83.89 | Firm with stiff bands grey to dark grey with occasional greenish brown mottled grey slightly sandy gravelly CLAY with low cobble content. Gravel is angular to sub-rounded fine to coarse brick, crushed concrete, quartzite and limestone. Occasional pockets of ash and clinker. (Made Ground) | | 1.00 | | | | | | | |
| | | | [0.10]<br>83.79 | Concrete arising as a slightly sandy gravel. (Made Ground) | | 1.10 | | | | | | | |
| | | | [0.80]<br>82.99 | Soft brown to greyish brown slightly sandy gravelly CLAY. Gravel is angular to subangular fine to coarse quartzite and flint with occasional brick and rare glass. (Made Ground)<br>*1.72m - 1.8m: Quartzite cobble.* | | 1.90 | | | | | | | |
| | | | [0.10]<br>82.89 | Soft greenish grey CLAY. (Possible Oadby Member) | | 2.00 | | | | | | | |

Hole Terminated at 2.00m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction encountered at 2.0 - possibly rock

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitoring completed at 1.0m intervals.

## Legend

| Sample Type: | Groundwater: | In-Situ Tests |
|---|---|---|
| B - Bulk<br>C - Core<br>D - Disturbed<br>ES - Environmental Sample<br>U - Undisturbed | ▽ Groundwater Strike<br>▼ Resting Groundwater<br>NR = Not Recorded | C - Cone Penetration Test<br>HSV - Hand Shear Vane Test<br>PID - Photo Ionisation Detection Screen<br>S - Standard Penetration Test |

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# BOREHOLE LOG

Scale 1:25

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| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 84.25 |
| **DS06** | **Project Number:** | NTH2304 | **Eastings:** | 453826.79 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300237.53 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Hole Type:** WLS | **Rig:** | Premier 110 PR | **Start & End Date:** | 09/07/2019 | **Engineer:** | LC | **Checker:** | TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | ░ | [0.10]<br>84.15 | Asphalt.<br>(Made Ground) | ░ | 0.10 | | | | | | | |
| | | ▧ | [0.10]<br>84.05 | Compacted grey occasionally pinkish grey slightly sandy GRAVEL of angular to subangular fine to coarse granite.<br>(Made Ground) | ▩ | 0.20 | | | | | | | |
| | | ■ | [0.15]<br>83.90 | Pinkish grey BOULDER of granite.<br>(Made Ground) | ▩ | 0.35 | | | | | | | |
| | | | | Hole Terminated at 0.40m bgl. | | | | | | | | | |

**Chiseling**

| From (m bgl) | To (m bgl) | Time (hh:mm) |
|---|---|---|
| | | |

**Water Added**

| From (m bgl) | To (m bgl) | Volume (l) |
|---|---|---|
| | | |

## Remarks

**Reason for Termination:**

Rock obstruction encountered at 0.35m, unable to core through due to loose debris above it

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

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| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 83.93 |
| **DS07** | **Project Number:** | NTH2304 | **Eastings:** | 453846.00 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300244.97 |

**Hole Type:** WLS **Rig:** Premier 110 PR **Start & End Date:** 09/07/2019 **Engineer:** LC **Checker:** TJH

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.12]<br>83.81 | Asphalt.<br>(Made Ground) | | 0.12 | | | | | | | |
| | | | [0.13]<br>83.68 | Compacted grey to dark grey slightly sandy GRAVEL of angular to sub-angular fine to coarse granite and occasional asphalt chipping.<br>(Made Ground) | | 0.25 | | | | | | | |
| | | | [0.05]<br>83.63 | Grey speckled red and pink BOULDERS of granite arising as a slightly sandy gravel.<br>(Made Ground) | | 0.30 | | | | | | | |
| | | | | Hole Terminated at 0.30m bgl. | | | | | | | | | |

**Chiseling**

| From (m bgl) | To (m bgl) | Time (hh:mm) |
|---|---|---|
| | | |

**Water Added**

| From (m bgl) | To (m bgl) | Volume (l) |
|---|---|---|
| | | |

## Remarks

**Reason for Termination:**

Rock obstruction encountered at 0.3m, unable to core through due to loose debris above it

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

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| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 83.54 |
| **DS08** | **Project Number:** | NTH2304 | **Eastings:** | 453869.30 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300251.33 |

| | | | | |
|---|---|---|---|---|
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 09/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.08]<br>83.46 | Asphalt.<br>(Made Ground) | | 0.08 | | | | | | | |
| | | | [0.17]<br>83.29 | Compacted grey speckled pink slightly sandy GRAVEL with low cobble content. Gravel is angular to sub-angular fine to coarse granite. Cobbles of angular granite.<br>(Made Ground) | | 0.25 | | | | | | | |
| | | | [0.20]<br>83.09 | Grey speckled red and pink interlocking COBBLES and BOULDERS of granite.<br>(Made Ground) | | 0.45 | | | | | | | |
| | | | [0.20]<br>82.89 | Compacted brown slightly sandy GRAVEL with low cobble content. Gravel is angular to sub-angular fine to coarse granite and quartzite with occasional inclusions of ceramic and brick.<br>(Made Ground) | | 0.65 | | | | | | | |
| | | | | Hole Terminated at 0.65m bgl. | | | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Granite cobbles and boulders stopping progress of hand pit

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

| **Sample Type:** | **Groundwater:** | **In-Situ Tests** |
|---|---|---|
| B - Bulk<br>C - Core<br>D - Disturbed<br>ES - Environmental Sample<br>U - Undisturbed | ▽ Groundwater Strike<br>▼ Resting Groundwater<br>NR = Not Recorded | C - Cone Penetration Test<br>HSV - Hand Shear Vane Test<br>PID - Photo Ionisation Detection Screen<br>S - Standard Penetration Test |

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# BOREHOLE LOG

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| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 83.38 |
| **DS09** | **Project Number:** | NTH2304 | **Eastings:** | 453889.07 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300256.58 |

**Hole Type:** WLS **Rig:** Premier 110 PR **Start & End Date:** 09/07/2019 **Engineer:** LC **Checker:** TJH

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.10]<br>83.28 | Asphalt.<br>(Made Ground) | | 0.10 | | | | | | | |
| | | | [0.25]<br>83.03 | Compacted grey occasionally pinkish grey slightly sandy GRAVEL of angular to subangular fine to coarse granite.<br>(Made Ground) | | 0.35 | | | | | | | |
| | | | [0.10]<br>82.93 | Grey interlocking COBBLES and BOULDERS of angular granite with fine and medium sand and angular gravel of granite between joints.<br>(Made Ground) | | 0.45 | | | | | | | |
| | | | [0.30]<br>82.63 | Brown occasionally orangish brown and grey slightly sandy GRAVEL with low cobble content. Gravel is angular fine to coarse granite and occasional inclusion of brick. Sand is fine and medium. Cobbles of angular granite.<br>(Made Ground)<br>*0.6m - 0.75m: Becomes more sandy.* | | 0.75 | | | | | | | |
| | | | [0.35]<br>82.28 | Brown to orangish brown gravelly fine and medium SAND. Gravel is angular fine to coarse granite.<br>(Possible Reworked Natural) | | 1.10 | | | | | | | |
| | | | [0.30]<br>81.98 | Stiff reddish brown slightly gravelly sandy highly desiccated CLAY arising as a slightly gravelly sand when handled. Gravel is angular to sub-angular fine and medium granite and occasional quartzite. frequent roots throughout.<br>(Possible Edwalton Member) | | 1.40 | | | | | | | |
| | | | [0.10]<br>81.88 | Reddish brown slightly sandy GRAVEL of angular fine and medium mudstone, granite and occasional quartzite. Frequent roots throughout.<br>(Possible Edwalton Member) | | 1.50 | | | | | | | |

Hole Terminated at 1.50m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction encountered at 1.5 - possibly rock

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitored upon refusal.

## Legend

**Sample Type:**

- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**

- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**

- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

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| | | | | | |
|---|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | | **Ground Level (m AOD):** | 83.33 |
| **DS10** | **Project Number:** | NTH2304 | | **Eastings:** | 453903.77 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | | **Northings:** | 300260.18 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** | 10/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.10]<br>83.23 | Compacted grey and brown slightly sandy GRAVEL of angular fine to coarse granite, quartzite, asphalt and brick. (Made Ground) | | 0.10 | | | | | | | |
| | | | [0.05]<br>83.18 | Asphalt. (Made Ground) | | 0.15 | | | | | | | |
| | | | [0.05]<br>83.13 | Compact greyish brown slightly sandy GRAVEL with low cobble content. Gravel is frequent angular fine to coarse granite. Cobbles of angular granite. (Made Ground) | | 0.20 | | | | | | | |
| | | | [0.25]<br>82.88 | Grey interlocking COBBLES and BOULDERS of angular granite with fine and medium sand and angular gravel of granite between joints. (Made Ground) | | 0.45 | | | | | | | |
| | | | [0.25]<br>82.63 | Grey occasionally brown slightly sandy GRAVEL with low cobble content. Gravel is angular fine to coarse granite. Cobbles of angular granite. (Made Ground) | | 0.70 | | | | | | | |
| | | | [0.55]<br>82.08 | Orangish brown gravelly fine and medium SAND with low cobble content. Gravel is angular fine to coarse granite and occasional quartzite. Cobbles of angular granite. (Possible Oadby Member) | | 1.25 | | | | | | | |
| | | | [0.65]<br>81.43 | Stiff reddish brown occasionally speckled dark grey slightly sandy slightly gravelly CLAY with frequent roots throughout. Sand is fine and medium. Gravel is angular to sub-rounded fine and medium quartzite and granite. (Possible Edwalton Member)<br>*1.75m - 1.8m: Granite cobble.*<br>*1.8m - 1.9m: Becomes friable.* | | 1.90 | | | | | | | |

Hole Terminated at 1.90m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction encountered at 1.5 - possibly rock

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**

- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**

- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**

- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

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| | | | |
|---|---|---|---|
| **LOCATION ID** | **Project Name:** Enderby Relief Road | **Ground Level (m AOD):** | 83.12 |
| **DS11** | **Project Number:** NTH2304 | **Eastings:** | 453917.02 |
| | **Client:** The Trustees for ER Brook Drummend Deceased | **Northings:** | 300263.46 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR **Start & End Date:** 10/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.10]<br>83.02 | Compacted grey slightly sandy GRAVEL of angular fine to coarse concrete, brick, granite and quartzite. (Made Ground) | | 0.10 | | | | | | | |
| | | | [0.05]<br>82.97 | Asphalt. (Made Ground) | | 0.15 | | | | | | | |
| | | | [0.05]<br>82.92 | Compact greyish brown slightly sandy GRAVEL of angular fine to coarse granite. (Made Ground) | | 0.20 | | | | | | | |
| | | | [0.25]<br>82.67 | Grey interlocking COBBLES and BOULDERS of angular granite with fine and medium sand and angular gravel of granite between joints. (Made Ground) | | 0.45 | | | | | | | |
| | | | [0.25]<br>82.42 | Grey sandy GRAVEL of angular granite with rare inclusions of brick and quartz. (Made Ground) | | 0.70 | | | | | | | |
| | | | [0.75]<br>81.67 | Orangish brown gravelly fine and medium SAND with low cobble content. Gravel is angular to sub-angular fine to coarse quartzite and granite with rare brick. Cobbles of angular granite. (Made Ground) | | 1.45 | | | | | | | |
| | | | [0.45]<br>81.22 | Stiff reddish brown mottled greenish grey and occasionally black slightly sandy slightly gravelly CLAY with rare roots. Gravel is angular fine and medium granite and occasional quartzite. (Possible Edwalton Member) | | 1.90 | | | | | | | |

Hole Terminated at 1.90m bgl.

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction encountered at 1.5 - possibly rock

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**
- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**
- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**
- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

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| LOCATION ID | | | | |
|---|---|---|---|---|
| **DS12** | **Project Name:** Enderby Relief Road | | **Ground Level (m AOD):** | 83.03 |
| | **Project Number:** NTH2304 | | **Eastings:** | 453938.18 |
| | **Client:** The Trustees for ER Brook Drummend Deceased | | **Northings:** | 300268.72 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 10/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.75] | Compacted grey occasionally reddish brown slightly sandy GRAVEL with low to moderate cobble content. Gravel is angular to sub-angular brick, concrete, granite and quartzite. Rare inclusions of metal, plastic and plaster (gypsum). Cobbles of angular brick and concrete.<br>(Made Ground) | ▨ | | | | | | | | |
| | | | 82.28<br>[0.90] | Brown occasional reddish brown gravelly SAND with low cobble content. Gravel is angular to sub-angular fine to coarse granite with occasional brick. Cobbles of angular granite.<br>(Made Ground)<br>*0.95m - 1.10m: Band of stiff reddish brown sandy gravelly clay.*<br>*1.15m - 1.65m: Brick fragments become rare.* | ▨ | 0.75 | | | | | | | |
| | | | 81.38 | Hole Terminated at 1.65m bgl. | | 1.65 | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Obstruction causing the drillings rods to skew off centre.

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's and asphalt. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**
- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**
- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**
- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 83.17 |
| **DS14** | **Project Number:** | NTH2304 | **Eastings:** | 453997.03 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300273.50 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 11/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.40] | Compacted grey becoming greyish brown at 0.15m slightly sandy GRAVEL with low to moderate cobble content. Gravel is angular to sub-rounded fine to coarse brick, crushed concrete, granite and quartzite. Cobbles of angular granite.<br>(Made Ground) | | 0.40 | | | | | | | |
| | | | 82.77<br>[1.65] | Stiff reddish brown with occasional bands of grey (2mm-15mm) gravelly CLAY. Gravels of sub-angular fine and medium weak mudstone and occasional siltstone.<br>(Weathered Edwalton Member)<br>*0.77 - 0.79m: Band of grey gravelly clay.*<br>*0.85 - 0.86m: Band of grey gravelly clay.*<br>*0.93 - 0.94m: Band of grey gravelly clay.*<br>*1.15 - 1.18m: Band of grey gravelly clay.*<br>*1.5 - 1.58m: Band of grey occasionally mottled reddish brown slightly silty gravelly clay.*<br>*1.9 - 2.05m: Becomes friable.*<br>*2.0 - 2.03m: Band of grey gravelly clay.* | | 2.05 | | | | | | | |
| | | | 81.12<br>[0.95] | Weathered reddish brown with occasional grey bands (2mm-15mm) MUDSTONE arising as a slightly clayey silty gravel.<br>(Weathered Edwalton Member)<br>*2.13 - 2.18m: Very clayey.*<br>*2.63 - 2.66m: Very clayey.*<br>*2.8 - 2.85m: Very clayey.* | | 3.00 | | | | | | | |
| | | | 80.17 | Hole Terminated at 3.00m bgl. | | | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Sufficient depth reached

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25 Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID**<br>**DS15** | **Project Name:** Enderby Relief Road | | **Ground Level (m AOD):** | 83.28 |
| | **Project Number:** NTH2304 | | **Eastings:** | 454017.41 |
| | **Client:** The Trustees for ER Brook Drummend Deceased | | **Northings:** | 300276.53 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 11/07/2019 | **Engineer:** LC | **Checker:** TJH |

## Strata

| Level (m AOD) & [Thickness (m)] | Description | Depth (m bgl) |
|---|---|---|
| [0.10]<br>83.18 | Grass over greyish brown fine SAND with frequent roots throughout.<br>(Topsoil) | 0.10 |
| [0.40]<br>82.78 | Compacted grey sandy GRAVEL of angular to sub-rounded fine to coarse granite, quartzite and occasional brick.<br>(Made Ground) | 0.50 |
| [0.20]<br>82.58 | Reddish brown gravelly SAND with low cobble content. Gravel is angular to sub-angular fine to coarse granite and brick. Cobbles of angular brick.<br>(Made Ground) | 0.70 |
| [0.45]<br>82.13 | Firm greyish brown occasionally reddish brown slightly gravelly CLAY. Gravel is angular to sub-angular fine to coarse granite. Occasional pockets of fine and medium sand.<br>(Possible Oadby Member) | 1.15 |
| [1.85]<br>80.28 | Stiff reddish brown with occasional bands of grey (2mm-15mm) gravelly CLAY. Gravels of sub-angular fine and medium weak mudstone and occasional siltstone.<br>(Weathered Edwalton Member)<br>*1.68 - 1.74m: Band of grey slightly silty gravelly clay.*<br>*1.77 - 1.81m: Band of grey slightly silty gravelly clay.*<br>*2.10 - 2.25m: Band of grey slightly silty gravelly clay.*<br>*2.40 - 2.65m: Band of grey slightly silty gravelly clay.*<br>*2.65 - 3.00m: Becomes very friable, arising more as a sandy gravel.* | 3.00 |

Hole Terminated at 3.00m bgl.

| Groundwater: Strike | Strike Details | Well | Samples: Type (Ublows) | From (m) | To (m) | In-Situ Tests: Type | Depth (m) | Result | Casing Depth & (Water Level) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |

| Chiseling: From (m bgl) | To (m bgl) | Time (hh:mm) |
|---|---|---|
| | | |

| Water Added: From (m bgl) | To (m bgl) | Volume (l) |
|---|---|---|
| | | |

## Remarks

**Reason for Termination:**

Sufficient depth reached

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**
- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**
- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**
- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25 Sheet 1 of 1

| | | | |
|---|---|---|---|
| **LOCATION ID** | **Project Name:** Enderby Relief Road | **Ground Level (m AOD):** | 79.05 |
| **DS16** | **Project Number:** NTH2304 | **Eastings:** | 454091.17 |
| | **Client:** The Trustees for ER Brook Drummend Deceased | **Northings:** | 300302.55 |
| **Hole Type:** WLS | **Rig:** Premier 110 PR **Start & End Date:** 12/07/2019 | **Engineer:** LC | **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.10]<br>78.95 | Grass over brown fine SAND with frequent rootlets throughout.<br>(Topsoil) | | 0.10 | | | | | | | |
| | | | [1.00] | Brown gravelly fine and medium SAND with occasional rootlets to 0.2m. Gravel is angular to sub-rounded fine to coarse granite and quartzite.<br>(Possible Head Deposits)<br>*0.95 - 1.1m: Becomes slightly clayey.*<br>*1.00 - 1.1m: Becomes reddish brown.* | | | | | | | | | |
| | | | 77.95<br>[1.25] | Reddish brown occasionally orangish brown with occasional grey bands (10mm - 50mm) fine to coarse SAND with rare gravel of sub-angular fine and medium granite and weak sandstone.<br>(Possible Head Deposits) | | 1.10 | | | | | | | |
| | | | 76.70<br>[0.65] | Stiff reddish brown with occasional bands of grey (2mm-15mm) gravelly CLAY. Gravels of sub-angular fine and medium weak mudstone and occasional siltstone.<br>(Weathered Edwalton Member)<br>*2.60 - 3.0m: Becomes friable, arising more as a slightly clayey gravel.* | | 2.35 | | | | | | | |
| | | | 76.05 | Hole Terminated at 3.00m bgl. | | 3.00 | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Sufficient depth reached

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

C - Cone Penetration Test
HSV - Hand Shear Vane Test
PID - Photo Ionisation Detection Screen
S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25 | Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID**<br>**DS17** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 77.60 |
| | **Project Number:** | NTH2304 | **Eastings:** | 454209.91 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300285.90 |

| | | | |
|---|---|---|---|
| **Hole Type:** WLS | **Rig:** Premier 110 PR | **Start & End Date:** 12/07/2019 | **Engineer:** LC **Checker:** TJH |

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.10]<br>77.50 | Grass over Firm brown slightly sandy slightly gravelly CLAY with frequent rootlets throughout. Gravel is sub-angular to sub-rounded fine to coarse quartzite.<br>(Topsoil) | | 0.10 | | | | | | | |
| | | | [1.90]<br>75.60 | Stiff brown becoming reddish brown from 0.45m slightly gravelly CLAY with occasional small pockets of fine sand. Gravel is angular to sub-rounded fine and medium mudstone and siltstone with rare quartzite.<br>(Weathered Edwalton Member)<br>*1.1 - 2.0m: Occasional grey mottling noted.* | | 2.00 | | | | | | | |
| | | | | Hole Terminated at 2.00m bgl. | | | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |

## Remarks

**Reason for Termination:**

Sufficient depth reached

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**
- B - Bulk
- C - Core
- D - Disturbed
- ES - Environmental Sample
- U - Undisturbed

**Groundwater:**
- ▽ Groundwater Strike
- ▼ Resting Groundwater
- NR = Not Recorded

**In-Situ Tests**
- C - Cone Penetration Test
- HSV - Hand Shear Vane Test
- PID - Photo Ionisation Detection Screen
- S - Standard Penetration Test

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# BOREHOLE LOG

Scale 1:25

Sheet 1 of 1

| | | | | |
|---|---|---|---|---|
| **LOCATION ID** | **Project Name:** | Enderby Relief Road | **Ground Level (m AOD):** | 80.21 |
| **DS18** | **Project Number:** | NTH2304 | **Eastings:** | 454217.14 |
| | **Client:** | The Trustees for ER Brook Drummend Deceased | **Northings:** | 300198.08 |

**Hole Type:** WLS **Rig:** Premier 110 PR **Start & End Date:** 12/07/2019 **Engineer:** LC **Checker:** TJH

| Groundwater | | | Strata | | | | Samples | | | In-Situ Tests | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strike | Strike Details | Well | Level (m AOD) & [Thickness (m)] | Description | Legend | Depth (m bgl) | Type (Ublows) | From (m) | To (m) | Type | Depth (m) | Result | Casing Depth & (Water Level) |
| | | | [0.15]<br>80.06 | Grass over Firm brown slightly sandy slightly gravelly CLAY with frequent rootlets throughout. Gravel is sub-angular to sub-rounded fine to coarse quartzite. (Topsoil) | | 0.15 | | | | | | | |
| | | | [1.35]<br>78.71 | Firm becoming Stiff from 0.3m yellowish brown becoming reddish brown from 0.45m slightly sandy slightly gravelly CLAY. Gravel is angular to sub-rounded fine and medium mudstone, siltstone and occasional quartzite. (Weathered Edwalton Member) | | 1.50 | | | | | | | |
| | | | | Hole Terminated at 1.50m bgl. | | | | | | | | | |

| Chiseling | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Time (hh:mm) |
| | | |

| Water Added | | |
|---|---|---|
| From (m bgl) | To (m bgl) | Volume (l) |
| | | |

## Remarks

**Reason for Termination:**

Unknown obstruction encountered - possible cobble

**Groundwater Remarks:**

No groundwater encountered.

**Other Remarks:**

1. No olfactory or visual evidence of contamination noted. 2. Backfilled with bentonite and capped with arising's. 3. Gas monitoring completed at 1.0m intervals.

## Legend

**Sample Type:**

B - Bulk
C - Core
D - Disturbed
ES - Environmental Sample
U - Undisturbed

**Groundwater:**

▽ Groundwater Strike
▼ Resting Groundwater
NR = Not Recorded

**In-Situ Tests**

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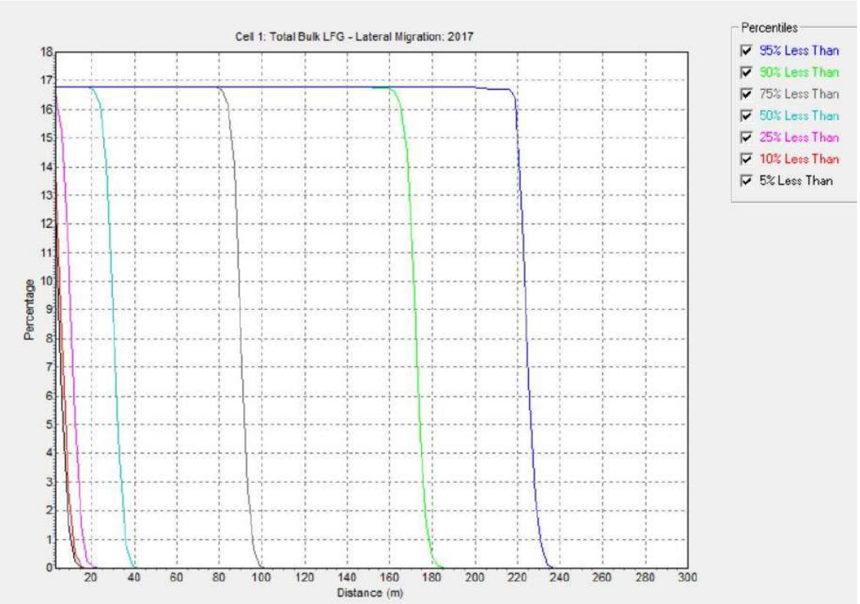
# Appendix 2: Gas Monitoring Results

| Location Reference | Date Monitored | Depth of Borehole (m bgl) | Barometric Pressure (mB) | Flow (l/hr) | Methane (%v/v) | | Carbon Dioxide (%v/v) | Oxygen (%v/v) | Hydrogen Sulphide (ppm) | Carbon Monoxide (ppm) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Steady | Peak | Steady | Steady | Steady | | | |
| DS01 | 08/07/19 | 1.00 | 1018 | <0.1 | - | <0.1 | 0.19 | 21.2 | <1 | 3 | |
| | | 2.00 | 1018 | <0.1 | - | <0.1 | 0.12 | 21.1 | <1 | 3 | |
| | | 3.00 | 1018 | <0.1 | - | <0.1 | 0.04 | 21.3 | <1 | 5 | |
| DS02 | 08/07/19 | 0.80 | 1017 | <0.1 | - | <0.1 | 10.52 | 16.8 | <1 | 10 | |
| DS03 | 09/07/19 | 0.70 | 1013 | <0.1 | - | <0.1 | 6.1 | 14.2 | <1 | <1 | |
| DS04 | 08/07/19 | 1.00 | 1018 | <0.1 | - | <0.1 | 0.11 | 21 | <1 | 1 | Callapsed prior to monitoring. |
| DS05 | 08/07/19 | 1.00 | 1018 | <0.1 | - | <0.1 | 0.4 | 20.1 | <1 | 3 | |
| DS05A | 08/07/19 | 0.40 | 1018 | <0.1 | - | <0.1 | <0.1 | 20.1 | <1 | 1 | |
| DS05B | 08/07/19 | 2.00 | 1018 | <0.1 | - | <0.1 | 0.32 | 20.4 | <1 | 2 | |
| DS06 | 09/07/19 | 0.40 | 1012 | <0.1 | - | <0.1 | <0.1 | 20.9 | <1 | <1 | |
| DS07 | 09/07/19 | 0.30 | 1012 | <0.1 | - | <0.1 | <0.1 | 20.9 | <1 | <1 | |
| DS08 | 09/07/19 | 0.65 | 1012 | <0.1 | - | <0.1 | 1.4 | 19.2 | <1 | <1 | |
| DS09 | 10/07/19 | 1.50 | 1011 | <0.1 | - | <0.1 | 3.0 | 16.9 | <1 | 1 | |
| DS10 | 10/07/19 | 0.95 | 1010 | <0.1 | - | <0.1 | 0.2 | 20.9 | <1 | 1 | |
| DS11 | 10/07/19 | 1.90 | 1010 | <0.1 | 0.3 | <0.1 | 0.9 | 19.8 | <1 | <1 | |
| DS12 | 11/07/19 | 1.65 | 1012 | <0.1 | - | <0.1 | 0.3 | 21.3 | <1 | <1 | |
| DS14 | 11/07/19 | 1.00 | 1012 | <0.1 | - | <0.1 | 0.1 | 21.2 | <1 | <1 | |
| | | 2.00 | 1012 | <0.1 | - | <0.1 | <0.1 | 21.2 | <1 | <1 | |
| | | 3.00 | 1012 | <0.1 | - | <0.1 | <0.1 | 21.2 | <1 | <1 | |
| DS15 | 11/07/19 | 1.00 | 1012 | <0.1 | - | <0.1 | 0.5 | 20.6 | <1 | <1 | |
| | | 2.00 | 1012 | <0.1 | - | <0.1 | 0.3 | 20.8 | <1 | <1 | |
| | | 3.00 | 1012 | <0.1 | - | <0.1 | 0.2 | 20.1 | <1 | <1 | |
| DS16 | 12/07/19 | 1.00 | 1012 | <0.1 | - | <0.1 | 0.7 | 20.1 | <1 | <1 | |
| | | 2.00 | 1012 | <0.1 | - | <0.1 | 0.6 | 20.1 | <1 | <1 | |
| | | 3.00 | 1012 | <0.1 | - | <0.1 | 0.5 | 20.3 | <1 | <1 | |
| DS17 | 12/07/19 | 1.00 | 1012 | <0.1 | - | <0.1 | 0.5 | 20.4 | <1 | <1 | |
| | | 2.00 | 1012 | <0.1 | - | <0.1 | 0.1 | 20.1 | <1 | <1 | |
| DS18 | 12/07/19 | 1.00 | 1012 | <0.1 | - | <0.1 | 0.6 | 20.4 | <1 | <1 | |
| | | 1.50 | 1012 | <0.1 | - | <0.1 | 0.5 | 20.1 | <1 | <1 | |

# APPENDIX E LANDFILL GAS RISK ASSESSMENT ENDERBY WARREN, GREGORY ENVIRONMENTAL CONSULTING, FEBRUARY 2017

Gregory
Environmental Consulting



# Landfill Gas Risk Assessment Enderby Warren

Submitted to:
SUEZ Recycling and Recovery UK Ltd
Narborough Lodge,
Huncote Road,
Leicester,
LE19 3RQ

Report 160121.501
Final Report

February 2017

## Executive Summary

Gregory Environmental Consulting Ltd (GECL) was approached by Suez Recycling and Recovery UK Ltd (SUEZ) to prepare a risk assessment report explaining in clear and concise terms the potential risk to any development proximal to the Enderby Warren landfill site.

The aim of the report, summarised in this Executive Summary, is to provide a clear risk assessment to benefit the developers of the New Lubbesthorpe strategic employment park, and Blaby District Council.

### Introduction

The Enderby Warren landfill is located at National Grid Reference (NGR) SK 536 000, approximately 7km south-west of Leicester. The landfill is situated in the void of a former granodiorite quarry, excavated to a maximum depth of 80m. The site has a total area of approximately 8.3Ha. There are 3 unregulated landfill sites, constructed in the same granodiorite intrusion, which were filled with biodegradable wastes between 1951 – 1981, before Enderby Warren became a landfill site, and these all lie within 500m of the Site.

Waste deposition commenced at Enderby Warren under Leicestershire County Council (LCC) in 1981. SUEZ acquired the Site in 1991, continuing operations until December 2001. The Site was capped and completed in December 2007. There are currently three Environmental Permits associated with the Site, demonstrating the depth and complexity of environmental regulation which applies to this site.

- The landfill site originally operated under a waste management licence (WML43366) and is now regulated under an Environmental Permit (EPR/AP3993CV/V002).
- The Enderby Leachate Treatment Plant is also operated by SUEZ Recycling and Recovery Ltd and is separately permitted under Environmental Permit EPR/RP3738ZK.
- Enderby Generation Plant, the facility for landfill gas recovery and renewable energy generation, is operated by Novera Energy Generation No.2 Ltd. This is a subsidiary company of Infinis Ltd, the largest independent landfill gas to energy company in the UK, which manages 40% of the UK's landfill gas resource. This is managed under Environmental Permit EPR/MP3734LU.

### Landfill Gas Risk Assessment

Landfill gas generation at the Enderby Warren Landfill peaked in 2001 at the same time as the site closed to waste, as has been declining ever since.  Landfill gas management is achieved at the site by a combination of active and passive systems. Landfill gas abstraction for utilisation and flaring is the active technology employed at the site for landfill gas control. The site is unlined and this means there is no passive barrier to assist in lateral migration management. SUEZ installed an engineered cap in 2007 to help manage the landfill gas collection at the site.

Despite this engineered capping, Enderby Warren does not exhibit the higher landfill gas recovery rates, as might be seen on fully lined and capped closed landfills, reflected in the Environment Agency's target of 85% collection efficiency, because there is no barrier engineering on the buried flanks of the site. This was common practice at the time the site was designed and first operated, and retrospective landfill lining cannot be installed.

Modelling suggests that potentially, only 60% (rather than 85%) of the landfill gas is captured by the active gas control system, and up to 27% is potentially lost through the sidewalls of the landfill. While this figure of 27% appears high, it is to be realised that this is derived from modelling, and the number of lateral migration events annually has actually declined significantly with time, and with the engineered capping of the Site.

Lateral migration modelling also demonstrates that the flux of gas on the sidewalls of the quarry is reducing year on year. Nevertheless, there remain four potential pathways for lateral gas migration:

- Unconfined diffusion of landfill gas.
- Confined diffusion of landfill gas.
- Unconfined advective migration of landfill gas.
- Confined advective migration of landfill gas.

Inspection of monitoring data from 1999 to the present day shows that:

- the frequency of lateral migration events seemed to be highest in the early years of the data set;
- there is evidence of diffusive gas migration to the present day; and
- there is evidence of advective gas migration to the present day.

Currently there is monitoring evidence for both diffusion and advection of landfill gas from the site. Diffusion is a low risk mechanism which is modelled to have an impact no further than 10m from the waste boundary. Diffusion allows methane oxidation to remove most of the methane risk and convert methane to carbon dioxide.

Advection is a high-risk mechanism which is modelled to have an impact to at least 240m from the waste boundary.

Suez manages the current risks by alarms in high risk residential properties identified in their monitoring reports, in addition to routine monitoring around the perimeter of entire landfill body. Any diffusion driven or advection driven anomalies will be detected in perimeter monitoring boreholes around the site, but the distance of migration depends on the driving force. 50% of modelled migration is to a distance of up to 35m from the waste boundary. One in 20 migration events can reach 240m, and 5% of all migration events will have the potential to migrate further than this, depending on the driving force.

At Enderby Warren, there are two meteorological factors which dominate the potential for lateral landfill gas migration:

- Change in atmospheric pressure. It is not the absolute value of pressure that is significant, but the rate of change of atmospheric pressure that regulates the migration potential.
- Rainfall (soil moisture content). Rainfall increases the soil moisture content and seals the surface, reducing atmospheric exchange.

Gas migration through the granodiorite is through secondary fissure pathways of high permeability and porosity, above the groundwater level. Gas migration through the Mercia mudstone formation and superficial deposits will be preferentially through sandstone lenses with a high matrix permeability, also above the groundwater level. Such sandstone lenses have been identified above the groundwater level in boreholes BH03, BH05 and BH06 recently drilled by ERM. There is also evidence for a man-made migration pathway in the form of a backfilled conveyor tunnel leading from the landfill offsite, approximately from between perimeter gas monitoring points 35 and 36, toward the off-site perimeter gas monitoring point 43, near Quartz Close, to the north of the landfill.

### Risk to Adjacent Properties and the Impact of New Construction

SUEZ's current risk assessment of the high-risk properties which they monitor continuously are that while the potential risks to these properties are high, the actual risks to these properties, based on the results of their ongoing monitoring, and their management systems, are actually low.

However, two new significant developments proposed adjacent to the Enderby Warren landfill will change the subsurface gas regime in ways which cannot be accurately predicted, and which may increase the risks to existing high-risk properties and may bring risks to existing neighbouring properties for which no risk has yet been identified:

- The strategic employment park will bring new warehouses to the northeast of Enderby Warren landfill, which will increase the lateral migration risk to the northeast and east of the landfill, toward the existing buildings on this side of the landfill, which are already on Suez's list of receptors at high risk from lateral migration, and also the new warehouses themselves.
- The new arterial road to the north of the landfill will increase the lateral migration risk to the north and north-west of the landfill. There is a newly built waste transfer station on Quartz Close, immediately to the north west of the landfill, and there are many other proximal developments on this Industrial Estate. None of these have gas protection measures as part of their design. All these properties may be put at higher risk, because of the magnitude of the new development proposed.

For the new build proposals, on the strategic employment park, gas protection measures should as a minimum consider a metallised methane gas barrier across the entire footprint of all buildings, and all service entry points should break ground outside the concrete raft foundations, and enter the buildings through the sides of the constructions, thereby breaking the source-pathway-receptor pollutant linkage. Such an approach would mean the risk would be significantly reduced to these proposed developments, and in-building alarms may potentially not be needed. This requires some additional consideration by the developers.

For the new arterial road proposed immediately to the north of the landfill, the initial risk will be during the construction phase, when the gas transmission pipework between the landfill and the landfill gas management compound may be disrupted. Any break in the continuous collection of landfill gas could significantly increase the lateral migration risk around the entire landfill. To minimise this risk, GECL considers that the Option 2 road route, which preserves more of the monitoring and gas collection systems on the landfill itself, is the better of the two options presented to date, but neither option addresses the challenge of disconnecting the gas field from the gas compound and reconnecting it following completion of the road. This also requires some additional consideration by the developers.

For the existing high risk properties surrounding the landfill, and those existing properties in the Industrial Estate which are currently not on SUEZ's high risk register, it is not yet known whether the significant changes in the lateral migration pathways to the north and north east of the landfill will have an equally significant impact, raising the future risks to these properties, which do not have any in ground protection, because of the sealing of the ground due to the new development proposals. This also requires some additional consideration by the developers.

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# 1.0 Introduction

Gregory Environmental Consulting Ltd (GECL) was approached by Suez Recycling and Recovery UK Ltd (SUEZ) to prepare a risk assessment report explaining in clear and concise terms the potential risk to any development proximal to the Enderby Warren landfill site.

The aim of the report is to provide a clear risk assessment to benefit the developers of the New Lubbesthorpe strategic employment park, and Blaby District Council.

There are a number of existing receptors in the proximity of Enderby Warren landfill. The new receptors to be considered in this risk assessment are the newly constructed waste transfer building on Quartz Close, a proposed upgraded link road and the new strategic employment park. The risk assessment will also consider pre-existing receptors.

The document structure is as follows:

- Section 2 describes the Site and its environs, including the presence of older landfills to the south and west.
- Section 3 gives details of the landfill design and landfill gas management at the site, in the context of the geological and hydrogeological setting.
- Section 4 analyses the bulk gas production rates forecast by GasSim, and the recovery of landfill gas at the site. The modelling then uses GasSim to demonstrate the differential risks from diffusive gas migration, and changes in barometric pressure causing advective gas migration, and how landfill gas management manages the risks.
- Section 5 sets out a conceptual site model using the lateral migration risks to prioritise high and medium risk receptors as the site has developed from an operational site through temporary capping and permanent engineered capping, validating the modelled risk assessment. Section 5 then presents a conceptual site model of gas generation and emission under current and proposed conditions.
- Section 6 is a list of references used in the preparation of this report.
- Figures are included throughout the report. Two A3 Drawings are appended, and three Appendices supporting the main body of the text are also attached.

# 2.0 The Site and its Environs

## 2.1 Site Location

The site is located at National Grid Reference (NGR) SK 536 000, approximately 7km south-west of Leicester.

The landfill is situated in the void of a former granodiorite quarry, excavated to a maximum depth of 80m. The site has a total area of approximately 8.3Ha.

There are 3 unregulated landfill sites, constructed in the same granodiorite intrusion, which were also filled with biodegradable wastes and lie within 500m of the Site.

| | |
|---|---|
| Mill Hill Quarry | Approximately 200m to the south-west. Environment Agency web based records suggest the site was infilled by Leicestershire County Council between 1977 and 1980. |
| Off Mill Hill Quarry | Approximately 400m south-west of the site. A smaller landfill with no details of infilling recorded by the Environment Agency. |
| Enderby Hill Quarry | Approximately 500m to the south-west. Infilled by Leicester County Council. The date when filling commenced is recorded by the Environment Agency as 1951, and operations ceased in 1981 with the opening of Enderby Warren. |

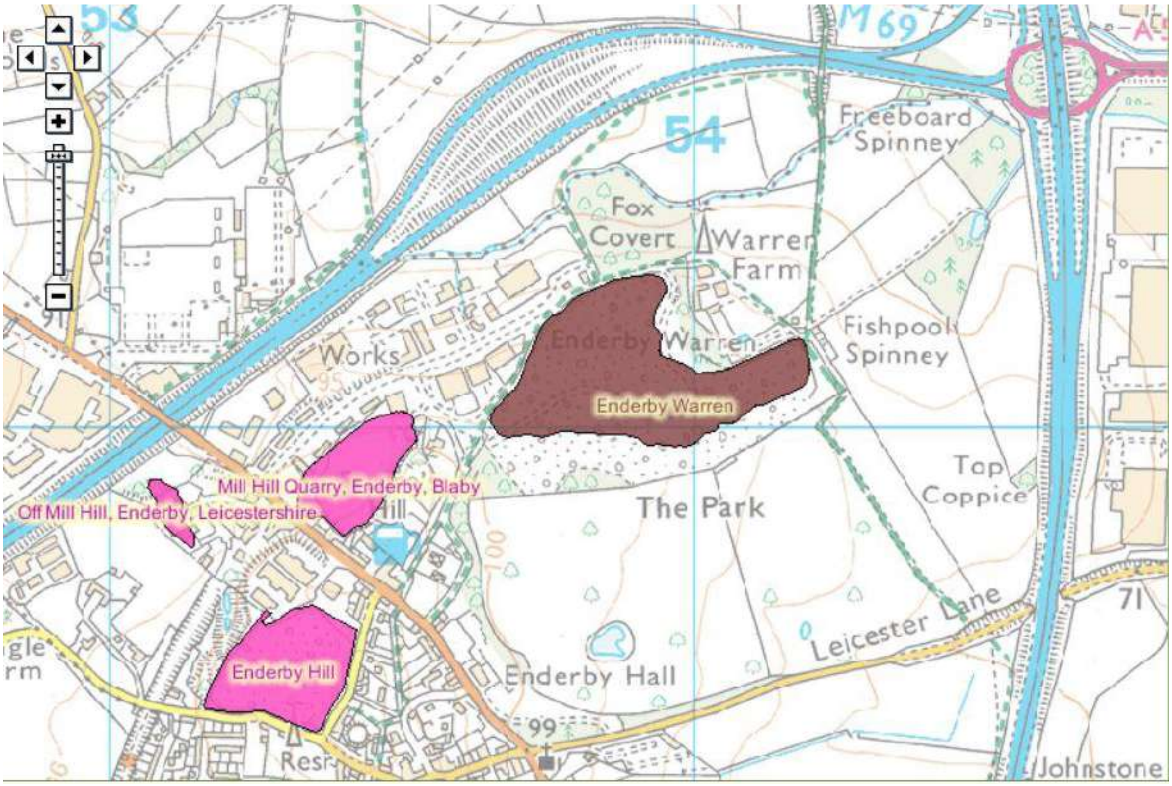


Figure 1. Licensed and unlicensed landfills in Enderby

Grid squares 1km spacing.

Source http://maps.environment-agency.gov.uk/wiyby/

Waste deposition commenced at Enderby Warren under Leicestershire County Council (LCC) in 1981. SUEZ acquired the Site in 1991, continuing operations until December 2001. The Site was capped and completed in December 2007.

There are currently three Environmental Permits associated with the Site, demonstrating the depth and complexity of environmental regulation which applies to this site:

- The landfill site originally operated under a waste management licence (WML43366) and is now regulated under an Environmental Permit (EPR/AP3993CV/V002). The site is operated by Midland Land Reclamation Ltd, a SUEZ Company.
- The Enderby Leachate Treatment Plant is operated by SUEZ Recycling and Recovery Ltd and is separately permitted under Environmental Permit EPR/RP3738ZK.
- Enderby Generation Plant, the facility to the immediate north of the landfill, for landfill gas recovery and renewable energy generation, is operated by Novera Energy Generation No.2 Ltd. This is a subsidiary company of Infinis Ltd, the largest independent landfill gas to energy company in the UK, which manages 40% of the UK's landfill gas resource. This is managed under Environmental Permit EPR/MP3734LU.

All waste disposal operations were performed in an unlined quarry with almost sheer walls. The leachate produced by rainfall into the site was managed by the dilute and attenuate principle, considered acceptable practice at the time of licensing, with contaminants slowly leached into the surrounding groundwater (which is not used as a potable water supply).

Residential, industrial and agricultural buildings are located to the north and north-west, east and south-west, with agricultural land immediately to the south. A Site of Special Scientific Interest (SSSI) for Earth Heritage lies within the south-eastern part of the Site, where the mineral palygorskite was identified (see Figure 2). The SSSI has been buried with inert material as part of a planning agreement and will be re-exposed once the Site receives a landfill completion certificate.

## 2.2 Site Geology

Drift deposits, comprising river deposits, river terrace gravels and glaciofluvial deposits overlie Triassic Mercia Mudstone bedrock, characterised by layers of mudstone, siltstone and sandstone. The Mercia Mudstone is underlain by an Ordovician granodiorite pluton which extends to the south west. Figure 2 shows the geology in detail.

The superficial deposits and Mercia Mudstone strata are between 1.5m and greater than 23m thick, with the greatest thickness increasing towards the north from the Site boundary.

A weathered granodiorite horizon, which would be the surface of the Ordovician-Triassic unconformity has been recorded in all monitoring points drilled into the granodiorite, indicating the Mercia Mudstones are not particularly thick in the area surrounding the quarry.

The granodiorite pluton is likely to have a low rock matrix permeability, but the rock is known to be fractured, and this high fracture permeability will no doubt have been exacerbated by blasting in the quarry.

The granodiorite is expected to extend to a wider area beneath the surface outcrop, and the Mercia Mudstone formation lies unconformably on the granodiorite, and is of a younger age than the granodiorite.

Enderby Warren Quarry SSSI (the green hatched area adjacent to the surface outcrop of the intrusion in Figure 2) is the only British locality where palygorskite is found (Tien, 1973).

## 2.3 Site Hydrology and Hydrogeology

The Site is located in the surface water catchment of the River Soar. Freeboard Brook, a tributary of the River Soar flows roughly west to east, approximately 150m north of the Site, joining the River Soar approximately 2.5km to the east (Figure 2).

The superficial deposits and the Mercia Mudstone bedrock are classified by the Environment Agency as 'Unproductive Strata' and a 'Secondary B' aquifer respectively. The underlying granodiorite is designated as a Secondary (undifferentiated) aquifer.

The low permeability mudstones within the Mercia Mudstone are interspersed with occasional thin sandstone units of moderate permeability. The granodiorite has a low primary permeability but a high secondary permeability due to the presence of fissures and fractures. This is likely to be enhanced in the immediate vicinity of the quarry as a result of blasting.

It is believed that the groundwater in the Mercia Mudstone is not in hydraulic continuity with the granodiorite (MJCA, 1992). Groundwater flows in a north-east direction.

The groundwater in the granodiorite flows in the same direction, although locally it is influenced by leachate extraction within the landfill, resulting in an overall in-flow to the Site from all directions. Specific groundwater levels have not been examined for this risk assessment report, as these levels will vary with time, but it is expected that there will nearly always be unsaturated ground between the landfill and any receptors nearby, and that condition is what is assumed in the conceptual model for lateral migration at the Site described in Section 5 below.

There are no groundwater Source Protection Zone's (SPZ's) within 1km of the Site and there are no groundwater abstractions within the granodiorite.

## 2.4 Geological Gas Migration Pathways

The Mercia Mudstone Group is believed to be sub-horizontal in dip, with a series of moderately permeable thin sandstone units between low permeability mudstones. In places, there is a basal breccia evident on the surface of the Ordovician granodiorite pluton. These sandstone units and the unconformity itself, could act as lateral migration pathways for landfill gas which may migrate offsite.

Furthermore, the high secondary permeability of the fissured and fractured granodiorite pluton which underlies the entire region, can also act as landfill gas migration pathways.

These migration pathways are only likely to be significant if they are present above the groundwater table, where they can be activated by a drop in atmospheric pressure or failure of the landfill gas management system installed in the site.

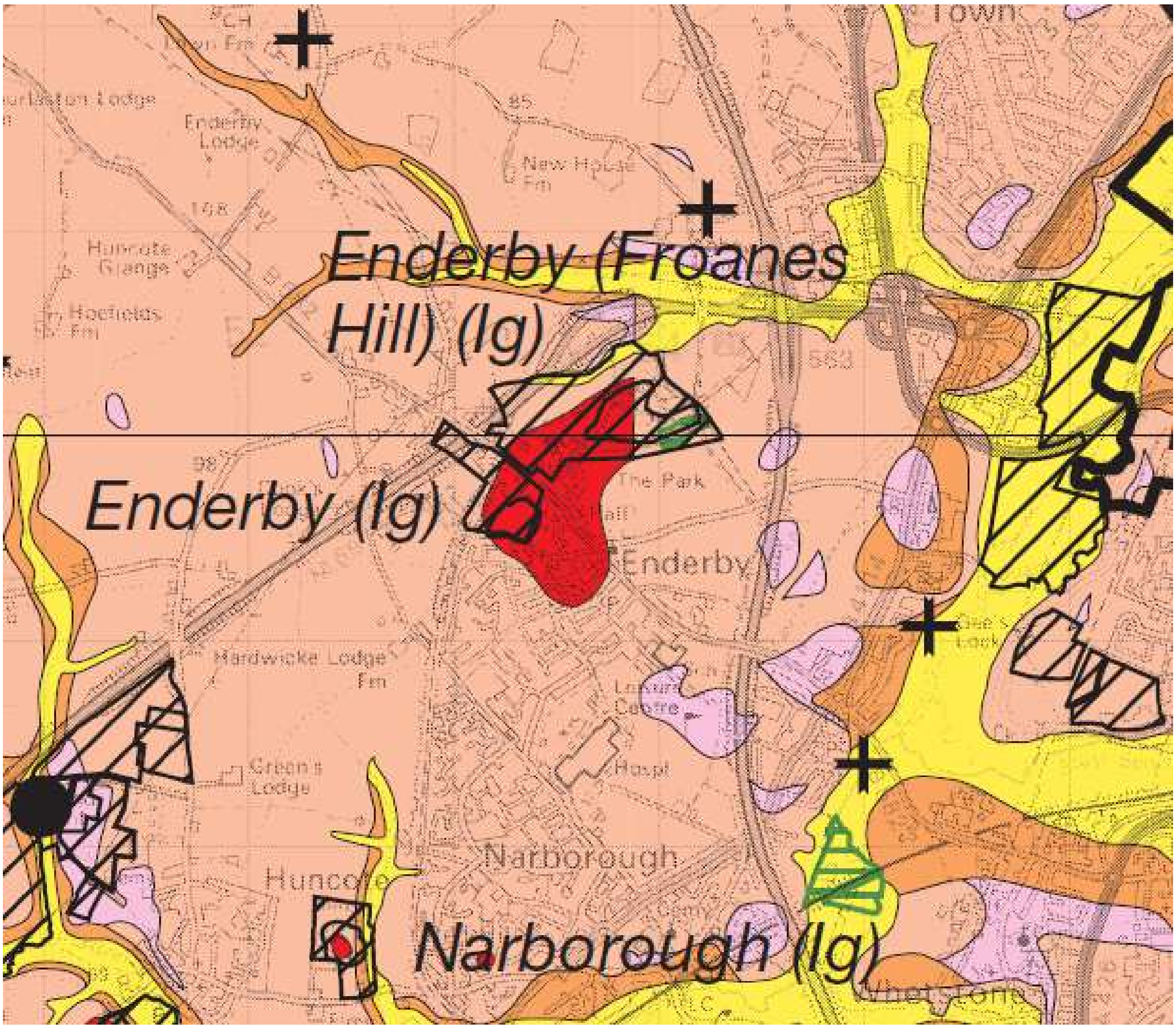


Figure 2. Extract from Mineral Resources Map of Leicestershire and Rutland

Drift Deposits:

| | |
|---|---|
| Yellow | sub-alluvial river deposits |
| Orange | river terrace deposits |
| Lilac | glaciofluvial deposits |

Solid Geology:

| | |
|---|---|
| Sand | Mercia Mudstone Group (Triassic period) |
| Red | Granodiorite (Ordovician period) |

| | |
|---|---|
| Black hatched areas | Inactive, worked out, and/or restored mineral workings |
| Green hatched areas | SSSI |

Grid squares at 1km spacing

Map produced by British Geological Survey to accompany report by Harrison DJ et al (2002). Mineral Resource Information for National, Regional and Local Planning: Leicestershire and Rutland (comprising City of Leicestershire, Leicestershire and Rutland). British Geological Survey Commissioned Report CR/02/24N. Crown Copyright.

Source http://www.bgs.ac.uk/mineralsuk/planning/resource.html

# 3.0 Landfill Gas Management and the Landfill Design

## 3.1 Landfill Gas Generation and Composition

Landfill gas composition varies with time, and rates of landfill gas generation also vary with time. Landfill gas typically follows the Farquhar and Rovers (1973) conceptual model of gas generation and compositional changes. This conceptual model has been developed over the years, and the most commonly accepted model of gas generation and gas compositional variation is shown in Figure 3.

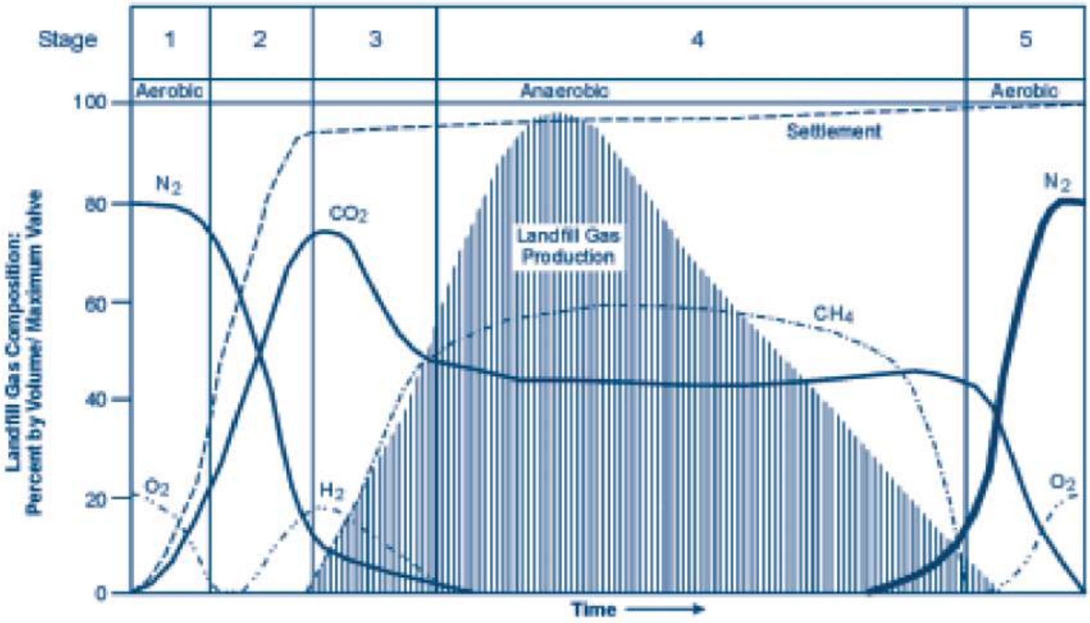


Figure 3. Landfill Gas Composition and Production Rate v Time

In Stage 1 of landfill gas generation, waste degrades aerobically, like compost, consuming the air which surrounds it. Only when this air has been consumed does Stage 2 commence, which is the start of acidogenic waste degradation.

Waste is first hydrolysed (where complex carbohydrates like cellulose are broken down to simple sugars like glucose) and subsequently degrade to produce long chain organic acids. This phase is characterised by carbon dioxide and hydrogen generation, and no methane is produced at this stage. Stage 3 is known as the acetogenic phase, when acetic acid is a primary product of degradation, and when carbon dioxide and hydrogen production peaks. Methane is starting to be generated at this time.

Landfill gas generation reaches its peak in Stage 4, the final phase of anaerobic waste degradation when methane is formed by microbes known as methanogens. The time from emplacement of waste until measurable and recoverable methane gas generation (stages 1-3 complete) is typically six months.

In the era of landfilling when Enderby Warren was filled, there were no EU waste diversion targets for moving biodegradable waste away from landfill to above ground waste treatment methods, and all municipal and similar commercial wastes were landfilled. Peak landfill gas production would have occurred almost contemporaneously with the cessation of landfilling.

Landfill gas control systems are therefore required in all gassing landfills shortly after waste is first deposited. Enderby Warren has been through the peak of landfill gas production in Stage 4, but has not moved to stage 5. In fact, the site is probably about half way through stage 4 at the current time.

### 3.2 Landfill Gas Collection and Utilisation

The landfill gas control system currently comprises a large number of in-waste gas extraction wells connected to a single 1MW engine and a 1,000m$^3$/hr flare (see Drawing 1). There have been more landfill gas engines and additional flares historically, when gas generation was greater than current gas production rates.

### 3.3 Interaction of Landfill Engineering Design with Landfill Gas Collection systems

The way LFG risk assessments are undertaken by GECL has been developed over the past decade and a half since the start of development of the GasSim regulatory assessment tool began in 2001. The modelling approach used was first developed by Dr Gregory of GECL in a spreadsheet proof of concept model called HELGA (Health and Environmental effects from Landfill Gas) while employed at Atkins in 1997-1999, and was further developed while at Land Quality Management (1999-2003) as a scientific advisor to Golder Associates, when the GasSim model was first commissioned by the Environment Agency in 2001.

This was at a period in time when there was considerable regulatory and third party interest in the health and environmental impacts arising from living close to operational landfills. During the evolution of GasSim v1.0, the regulatory regime also changed with the introduction of the EU Landfill Directive (Council Directive 1999/31/EC) in 1999, and the consequent implementation of permitting of landfills under the Integrated Pollution Prevention and Control (IPPC) Regulations (as amended). GasSim became the regulatory tool for all landfill gas risk assessments, and it was this link to the regulatory regime that enabled GasSim to develop and become the most flexible risk assessment tool for landfill gas environmental impact assessment available today. It is used regularly in the UK, Ireland, and South Africa by landfill developers, and it was internationally peer-reviewed prior to its introduction. This validated model status enables modellers to trust the empirical algorithms and probabilistic modelling approach adopted in GasSim to be robust, and enables modellers to focus on the data used to drive the model rather than the model itself.

In risk assessment, the 95th percentile output from GasSim is used. This is an output from a probabilistic model that is unlikely to be exceeded more than 1 in 20 times, and this is the usual degree of conservatism employed in a risk assessment. When undertaking calibration with historic performance of the gas abstraction system, the 50th percentile (the most likely value) is used.

In a typical engineered landfill, with a basal and lateral liner, and different capping materials, the following gas collection efficiencies may be forecast to apply (Golder Associates and the Environment Agency, 2005). This table of gas collection efficiencies is from the GasSim User Manual (Table 1). What the table demonstrates is that when a landfill gas collection system is in operation, only 60% of landfill gas generated by the landfill is likely to be collected in the collection system if no capping or only daily cover is present on the landfill. When temporary capping is emplaced, this rises to 85% and then when permanent capping in used, up to 95% of the landfill gas can be collected.

### Table 1 Gas Collection Efficiency Matrix

| Cap Type | Collection Efficiency (%) | | |
|---|---|---|---|
| | Daily Cover | Temporary Capping | Permanent Capping |
| **No gas field** | 0 | 0 | 0 |
| **Temporary/sacrificial gas field** | 30 | 50 | 65 |
| **Permanent/engineered gas field** | 60 | 85 | 95 |

Obviously, these are maxima for gas collection efficiency, as there are often situations where landfill gas wells are non-operational across a landfill, or other operational factors occur which are not considered in GasSim, which can reduce the collection efficiency. Work undertaken by Gregory et al (2014) for Defra showed that a subset of 43 of the most modern landfills which achieve what the industry believes to be very high gas collection efficiencies, in the region of 68% in the operational phase of landfilling, compared to 52% for all landfills in the UK. Enderby Warren is not in this category of landfill, and because it is unlined, is unlikely to achieve these high instantaneous gas collection efficiencies.

When Enderby Warren was first licenced, in 1981, the risks of lateral migration from landfill gas were not well known. It was the acute explosion risk first documented at the Loscoe landfill in Derbyshire, England, in 1985 (Aitkinhead and Williams, 1986) that brought the risks of landfill gas migration to the attention of the regulator, and the first guidance on landfill gas management was published in 1989 (Department of the Environment, 1989), three years after the first guidance was published on landfill engineering (Department of the Environment, 1986).

Enderby Warren and the other landfills in the granodiorite intrusion was developed without any basal or sidewall lining system, and no passive engineering system was employed throughout the operation of the Site. Normally, lateral migration risk in engineered landfills is managed by a combination of passive engineering and active gas collection, but at Enderby Warren, the landfill gas control system was and remains the only active technology available to provide control on the lateral migration risk.

In 2006, SUEZ applied for a permit variation to install a permanent cap on the Site. This was intended to help SUEZ manage the landfill gas by moving the site into the permanent capping and permanent engineered gas field region of Table 1 above, increasing the potential collection efficiency of the landfill gas collection system and thereby reducing the lateral migration risk. In section 4 below, GECL will demonstrate that this has only been partially successful.

# 4.0 The Source Term and Lateral Migration Models

## 4.1 The Source Term GasSim Model

GECL built a GasSim model of the site to assess the degree of gas control achieved by the gas plant on site, and the potential for lateral migration.

The waste tonnages and compositions for the model were provided by SUEZ. GECL built a single cell model, as the Site would have been filled from the bottom of the quarry, and a multi cell model would not have been appropriate. The site accepted approximately 5.4 million tonnes of mixed domestic, civic amenity, commercial, industrial and inert waste from 1981 to 2001, with a steadily increasing fill rate throughout the site's operational life. A GasSim waste composition of 1980s to 2000s waste composition was used to simulate the mix of waste components found within the waste at the time of filling.

The landfill engineering is simulated thus. A temporary cap of 0.2 – 0.4m clay with a permeability of 1 x $10^{-8}$ – 1 x $10^{-7}$ $ms^{-1}$ is modelled from 1995. A permanent engineered composite cap comprising 0.4 – 0.6m of reworked clay from the temporary cap, plus a 1mm LLDPE welded cap with a permeability of 1 x $10^{-14}$ – 1 x $10^{-12}$ $ms^{-1}$ was modelled from 2007, which was the year of installation of the LLDPE cap (Egniol Consulting Ltd, 2008). The sides of the landfill are actually unlined, but are modelled in GasSim as if they were lined with 1 m of permeable clay liner of 1 x $10^{-7}$ – 1 x $10^{-5}$ $ms^{-1}$ permeability, to simulate for modelling purposes the condition of the host lithology, as this allows modelling of the impact of lateral migration by diffusive and/or advective flow.

The waste moisture content is modelled as wet, and a further simulation was performed with the waste moisture content modelled as average, to demonstrate that the use of the wet waste degradation rate was appropriate. Figure 3 below from Gregory et al (2014) supports GECL's view that the most likely waste degradation rate for Enderby Warren should be wet.

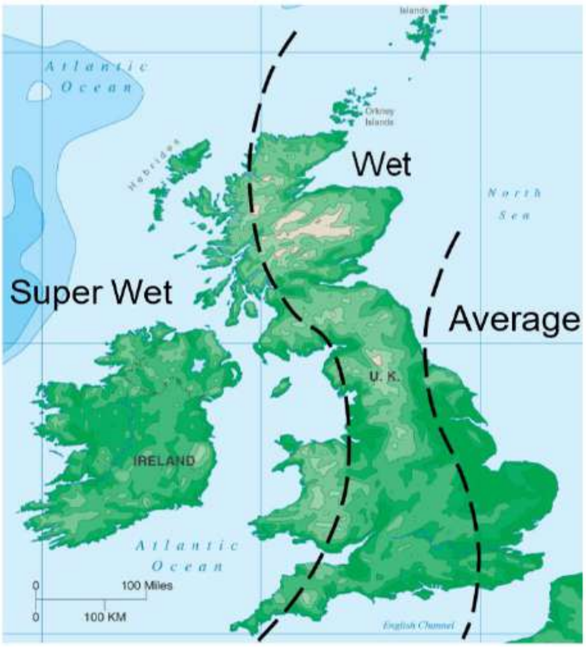


**Figure 3. Approximation of the Effect of a Maritime Climate with a south-westerly prevailing storm track on typical UK waste degradation rates (Gregory et al 2014)**

The gas plant is modelled with five nominal 1MW gas engines from 2001, reducing to two gas engines in 2004 and one gas engine in 2013. The gas engine currently installed is a Jenbacher J320 of nominal 1MW capacity. Two flares are also modelled, although only one is currently operational.

Figure 4 below shows the GasSim simulation outputs on a single graph. Outputs from GasSim are modelled at the 50th percentile (the most likely value) for validation against historic landfill gas recovery to the gas engines.

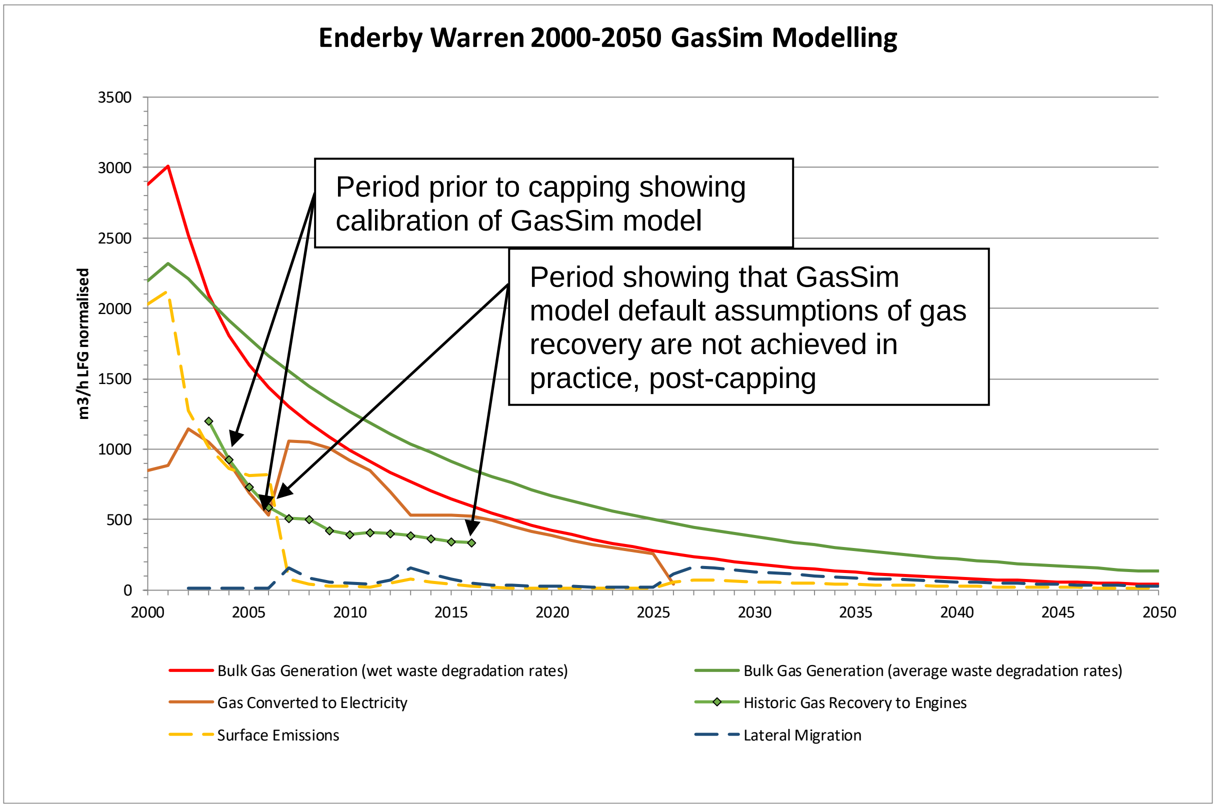


Figure 4. GasSim Modelling of Enderby Warren 2000 - 2050

The red curve shows the bulk gas generation rate for the site, using wet waste degradation rates, while the green curve shows the gas generation rate using an average waste degradation rate. The calibration of the modelled gas converted to electricity, with the historic value of gas recovery to the engines, particularly between 2004 – 2006, and prior to capping in 2007, indicates that using the GasSim defaults for collection efficiency from Table 1 above, and the wet waste degradation rate curve, rather than the average waste degradation rate, is appropriate. The values produced by GasSim and used in Figure 4 are given in Appendix A.

What is significant about this Figure and this site is that conventional wisdom indicates that gas collection efficiency, and consequent power generation, should improve with final capping in place, although probably not as significantly as the GasSim model suggests, post 2007. However, gas recovery does not significantly improve, as suggested by the modelled gas converted to electricity, and gas recovery continues to be challenging post 2007. This is an important observation (see Figure 4).

Another important observation from Figure 4 is that now the site has been capped, as long as there is abstraction of landfill gas for utilisation or flaring, the residual flux to both the landfill surface and to the lateral flanks of the waste mass, is quite small. In 2025, when the currently installed gas engine and flare does not have the turndown capacity to be able to utilise or flare the gas, the lateral migration flux increases to almost the rate of gas generation. This is because the cap is effectively less permeable to landfill gas than the liner. The calculation performed by GasSim to evaluate this difference is described in detail in the GasSim User Manual (Golder Associates and the Environment Agency, 2006), but the relative difference between surface emissions and lateral emissions is determined as a function of (1) the areal extent of the unsaturated liner or the cap; (2) the thickness of the lowest permeability engineering barrier in each of the liners; and (3) the permeability of that part of the engineering barrier. Before the permanent cap is installed, nearly all the gas which is not collected from the gas control scheme is potentially lost through the surface, but when the engineered cap is installed, the ration of gas lost through the surface compared to that lost through the sidewalls of the landfill is approximately 31% through the cap and 69% through the unlined landfill sidewalls.

GECL has also used a technique which is normally used by GECL for portfolio assessment purposes for power generation to simulate a more detailed risk assessment approach, using the GasSim bulk gas curve as the starting point, and attributing, as GasSim does, various collection efficiencies for different conditions on the site. The spreadsheet approach is more flexible than the GasSim approach, particularly because of the unlined nature of the site. The forecast using the spreadsheet approach, the details of which are also provided in Appendix A, is shown in Figure 5.

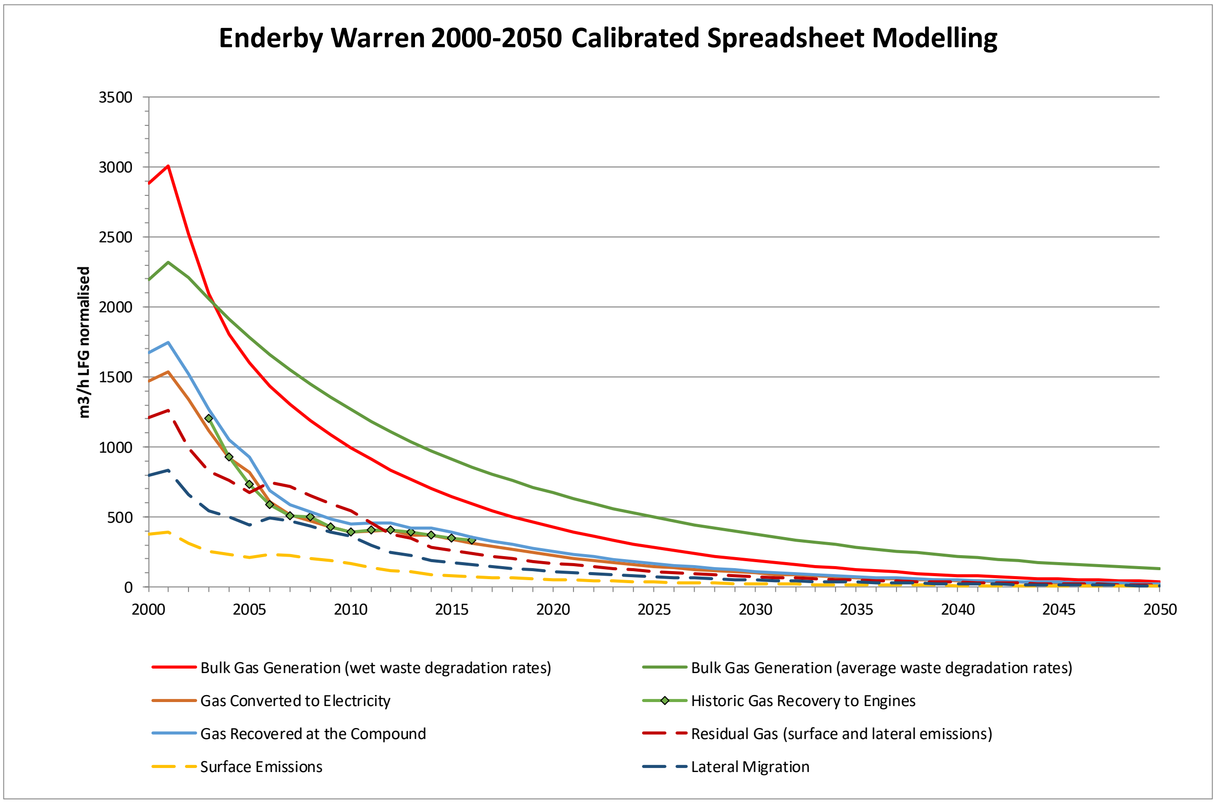


Figure 5. Spreadsheet Modelling of Enderby Warren 2000 - 2050

In Figure 5, GECL has been able to continue the calibration of the historic gas recovery to engines against the modelled gas converted to electricity for the entire period 2004 – 2016. GECL has used the ration of 31% to 69% determined by GasSim to calculate the flux on the landfill sidewalls from this spreadsheet approach, which better distributes the proportion of landfill gas which has been converted to electricity, and the proportion lost through the cap and through the sidewalls. The detail of the period 2000-2025 is shown in Figure 6 below. Table A6 in Appendix 1 indicates that the calculated estimated flux through the sidewalls is approximately 150 m$^3$/h landfill gas, and in this spreadsheet model, it is assumed that low calorific value landfill gas flaring will continue past 2025 to keep the flux on the lateral flanks low.

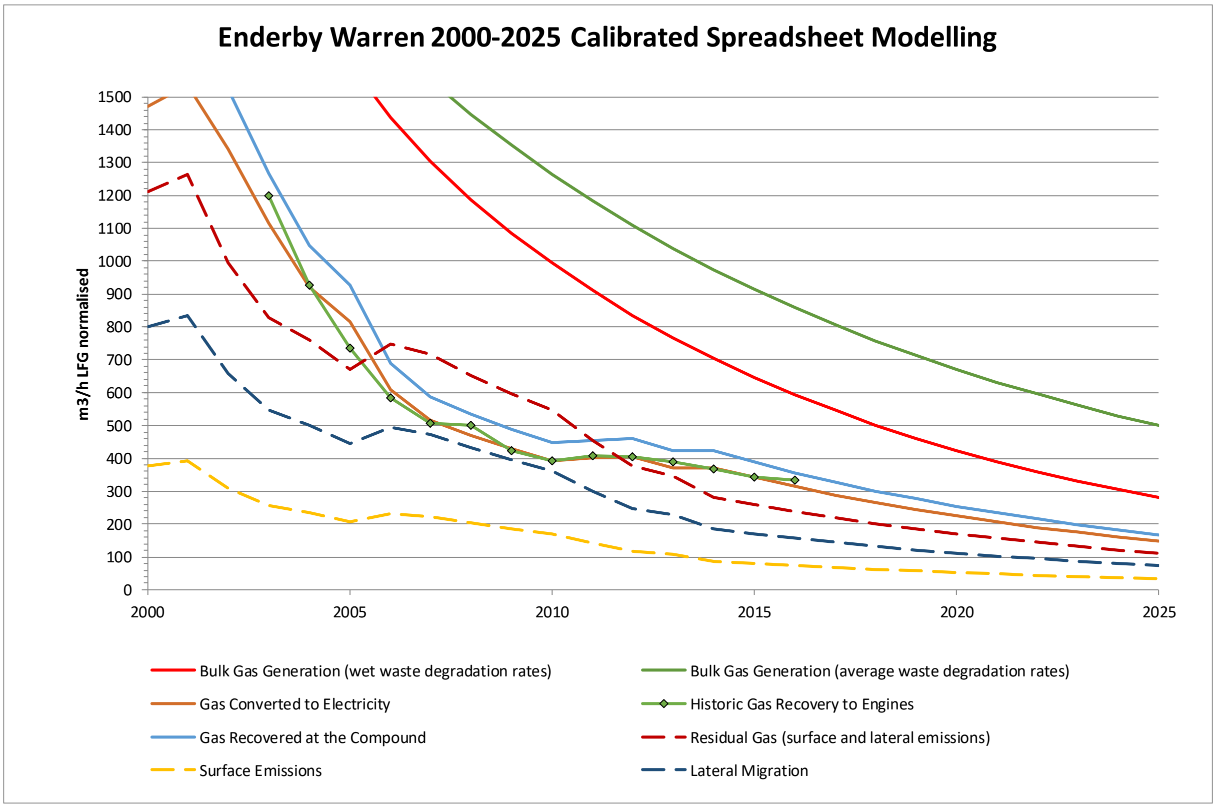


Figure 6. Spreadsheet Modelling of Enderby Warren 2000 - 2025 (detail)

## 4.2 The Lateral Migration GasSim Model

GasSim is very good at assessing the proportion of gas which potentially can be lost through surface emissions or through the unlined sidewalls of the site. When there is only a temporary cap on the site, the flux on the site sidewalls is considered to be very low, but once the engineered cap in in place, the proportion of flux through the sidewall increases significantly to approximately 69% of the gas not collected by the gas control system. However, the unlined nature of the site makes the modelling somewhat more difficult than if there had been an engineered barrier in place, and so this forecast value is only a potential flux. Whether this flux happens, and more particularly the frequency at which it happens, cannot be modelled in GasSim, as the annual or monthly timeframes used by GasSim for modelling purposes are significantly greater than the frequency of landfill gas migration events, which can happen on a timeframe of hours rather than months.

GasSim models can, however, be built which demonstrate the effect of this potential flux and the concentrations of landfill gas which might be detected offsite, and how far lateral migration may take place.

To do this, the various mechanisms of lateral migration in the local host geology need to be understood. A combination of ground conditions, gas control, and atmospheric pressure changes can mean one or more of four different migration pathways may exist at the Site at any one time. These combinations can result in gas migration mechanisms described as:

- Unconfined diffusion of landfill gas.
- Confined diffusion of landfill gas.
- Unconfined advective migration of landfill gas.
- Confined advective migration of landfill gas.

The risks arising from each of these mechanisms increases down this list, with confined advective migration the highest risk. It is therefore important to understand the nature of the host geology, the ability of the gas control system on managing the relative pressure within the landfill, and the effect of atmospheric pressure changes on the migration pathways existing around the landfill.

### 4.2.1 Geological Factors

The granodiorite pluton has a low rock matrix permeability, so gas migration will not take place through the intact granodiorite. However, the rock is known to be naturally well fractured, and the high fracture permeability has been exacerbated by blasting in the quarry, a phenomenon also observed in SUEZ’s nearby Narborough landfill.

Lateral migration pathways in the granodiorite will be difficult to predict, but the leachate level within the site has been artificially reduced by pumping, and so groundwater levels will most likely drain both into the quarry and away from it to the northwest (MJCA, 1992). Specific groundwater levels have not been examined for this risk assessment report, as these levels will vary with time, but it is expected that there will nearly always be unsaturated ground between the landfill and any receptors nearby, and such a ground condition is what has been in the conceptual model for lateral migration at the Site described in Section 5 below.

The granodiorite is expected to extend to a wider area beneath the surface outcrop, and the Mercia Mudstone formation lies unconformably on the granodiorite, and is of a younger age than the granodiorite.

There is a basal breccia at the junction of the granodiorite and the Mercia Mudstone, and if this was above the water table, would be a relatively permeable pathway for landfill gas to migrate along.

The Mercia Mudstone is described as comprising interlayered sandstones, siltstones and mudstones. This is consistent with the boreholes BH01 – BH06 drilled by ERM for the developer of the strategic employment park (see Appendix B). The sandstone lenses are most likely to be the matrix in which landfill gas will migrate most easily. The sandstone lenses encountered in BH01, BH02, BH04, were below the water table, but in BH03, BH05 and BH06, the sandstone lens was above the water table, suggesting that this could be associated with a gas migration pathway to the east of the landfill.

The sandstone lenses, also known as Skerrie bands, are one of the most important factors at Enderby in facilitating lateral gas migration, and SUEZ and other landfill operators have had similar experience of sandstone lenses facilitating lateral gas migration in other sites. Add to this variability in the sandstone lenses the high fracture permeability of the granodiorite pluton, exacerbated by blasting. The highly variable nature of the relationship between the fracture permeability of the granodiorite, and the matrix connectivity of the Skerrie bands makes management of lateral gas migration challenging at this site.

### 4.2.2 Flow Mechanisms

There are also two mechanisms of gas migration which need to be considered: diffusive flow and advective flow. Inspection of monitoring data from 1999 to the present day shows that:

(1) the frequency of lateral migration events seemed to be highest in the early years of the data set;

(2) there is evidence of diffusive gas migration to the present day; and

(3) there is evidence of advective gas migration to the present day.

Diffusive flow takes place around all landfills, through discrete migration pathways, where flow is not driven by pressure but by a concentration gradient. In diffusive flow regimes, the methane in the landfill gas will frequently oxidise to carbon dioxide, and the ratio of methane to carbon dioxide will not be the typical 57% methane:43% carbon dioxide ratio seen in most gassing landfills (Gregory et al, 2014). Perimeter monitoring boreholes which record evidence of diffusive flow will often contain no methane or very much reduced levels of methane compared to the concentrations of carbon dioxide present.

Advective gas migration is driven by a pressure gradient, and is substantially faster than diffusive gas migration. An advective flow event would usually be triggered by a rapid drop in atmospheric pressure, relative to the pressure within the landfill itself. Such a mechanism was described by the British Geological Survey as the driving force for the lateral migration which took place at Loscoe and destroyed the bungalow in Clarke Avenue in Loscoe (Aitkinhead N and Williams GM, 1986). Advective flow is demonstrated in perimeter borehole measurements by methane:carbon dioxide ratios in the migrated landfill gas very similar to those encountered within the landfill itself. Flow is so fast, there is little or no opportunity for oxidation of methane within the surrounding rock matrix.

Another factor which affects the risk of gas migration is whether the migration pathway is confined or unconfined. A confined gas migration pathway is one which has no opportunity of atmospheric pumping and air exchange to dilute the migrating landfill gas. This is likely to take place in sandstone lenses confined by clay rock above and below the more porous sandstone. An unconfined gas migration pathway is, for example, where the sandstone which is the medium for the migrating gas plume is in direct connectivity with the atmosphere, i.e. there is only a soil layer between the sandstone and the atmosphere. Diurnal changes in temperature are sufficient to cause atmospheric pumping between the gas in the ground and the atmosphere, diluting the methane concentration in the ground and replacing the landfill gas with some oxygen and nitrogen from the air. This can also then lead, in some situations, to further methane oxidation in the sandstone matrix.

### 4.2.3 An Example: The Loscoe Scenario

At Loscoe, there was positive pressure within the old landfill because there was no gas abstraction on the site. An atmospheric depression passed over the site, and the atmospheric pressure dropped by approximately 30mbar in just a few hours. The Loscoe landfill was already at a slight positive pressure compared to atmospheric pressure because landfill gas was being generated within the body of the waste, and over a few hours, this slight positive pressure became 30mbar greater, causing the landfill gas in the site to migrate along pre-existing confined migration pathways from the landfill to beneath the property (Aitkinhead and Williams, 1986), which subsequently blew up when a source of ignition (a gas stove) was lit in the house, and the methane concentration within the house was within the explosive range (5% to 15% methane in air). The magnitude of the pressure drop which was observed has been evaluated subsequently to be in the order of a 30-year atmospheric event.

### 4.2.4 Enderby Warren

At Enderby Warren, landfill gas abstraction keeps the net partial pressure within the landfill negative, compared to most atmospheric conditions. If, for example, the landfill gas abstracted was at a suction of -15mbar, and the atmospheric pressure was 1005 mbar, the absolute pressure of the gas within the landfill would be at 990mbar. It is likely that any landfill gas flux at the site boundary would be characterised by matrix diffusion under these conditions.

If there was a sudden drop in atmospheric pressure, from the passing of a low-pressure depression across the site, it is unlikely that the landfill gas system would react to the difference in relative pressure within the site as quickly as the atmospheric pressure could change. Abstraction of landfill gas by a gas utilisation company is typically characterised by a constant flow rate short term, which also tracks the long-term trend of gas production. So, applying the same 30mbar pressure drop seen at Loscoe to Enderby Warren, the landfill would remain at 990mbar as the atmospheric pressure would have dropped from 1005mbar (with the landfill 15mbar below this pressure) to 975mbar, which would mean there would now be a 15mbar driving force on the gas within the landfill, across the waste: host rock boundary, above the groundwater level, even with gas collection taking place across the entire landfill.

The risk then depends upon the ability of atmospheric exchange to dilute the landfill gas plume or not. Currently, lateral migration might be by either confined or unconfined pathways. However, one of the most significant risks arising from the proposed development around the landfill is the increase in the likelihood of confined pathways being created. Both the building of the strategic employment park, with its large warehouse buildings with concrete slab foundations (see Appendix B), and the construction of a substantially wider arterial road planned to pass adjacent to the northern boundary of the landfill (see Appendix C), automatically changes any unconfined migration pathway into a confined one, which brings substantially higher risks from lateral gas migration, as there is no atmospheric exchange to dilute the gas in a confined migration pathway.

### 4.2.5 Modelling the potential for Lateral Migration by all four Migration Mechanisms

The difference between unconfined diffusive flow, confined diffusive flow, unconfined advective flow and confined advective flow is demonstrated in Figures 7 – 10 below. The important percentile to examine in these graphs from GasSim is the 95th percentile, as that is the percentile most commonly used in risk assessment. It represents a condition where there is only a 1 in 20 chance of exceeding this risk. By contract, the worst-case scenario is the 100th percentile, which could be significantly worse than the 95th percentile value.

Modelling of diffusive flow at Enderby Warren gives the following potential for gas migration, shown in Figures 7 – 8 below. This is landfill gas which has been modelled, with a methane content of approximately 50% methane, so the lower explosive limit of methane would be at approximately 9 – 10% landfill gas, which is encountered in Figure 7 (unconfined pathway) at 2.5m from the landfill, and in Figure 8 (the confined pathway) at approximately 7m from the landfill. The dashed line at 7.5% represents the concentration at which displacement of oxygen in the root zone is likely to be seen as vegetation dieback. Diffusive flow is therefore a much lower risk overall to proximal developments than advective flow, which has much further migration potential.

Modelling of advective flow at Enderby Warren gives the following potential for gas migration, shown in Figures 9 – 10 below.

The lower explosive limit of methane in landfill gas would be again at 9 – 10 % landfill gas, which is found some 225m from the landfill in the unconfined migration pathway and some 230m from the landfill in the confined pathway, at the 95th percentile. However, at these distances, methane oxidation as well as atmospheric exchange could also have an effect on the lateral migration methane concentration. Lateral migration at the 50th percentile, the most likely distance for gas migration to take place, is only approximately 35m from the landfill, but this is sufficient to be picked up in perimeter monitoring boreholes, and such anomalies are present in the monitoring dataset from 1999 to the present day.

There are four meteorological factors which affect lateral landfill gas migration (Hartless, 2000):

- Rainfall (soil moisture content).
- Change in atmospheric pressure.
- Temperature.
- Wind speed (Coriolis effect).

The driving force for lateral migration is predominantly a sudden drop in atmospheric pressure, although Hartless (2000) has demonstrated that rainfall is the most important factor in lateral gas migration, as it increases the soil moisture content and seals the surface, reducing atmospheric exchange. The fatal landfill gas explosion at Skellingsted in Denmark followed a period of heavy rain (Kjeldsen and Fischer, 1995).

Changes in atmospheric pressure are considered by Hartless as the second most important effect, as during warm dry weather, atmospheric air exchange will dilute the migrating gas plume, and it is predominantly in wet weather, when the soil surface is sealed, that lateral migration is a greater risk. The Loscoe explosion was due to atmospheric pressure changes.

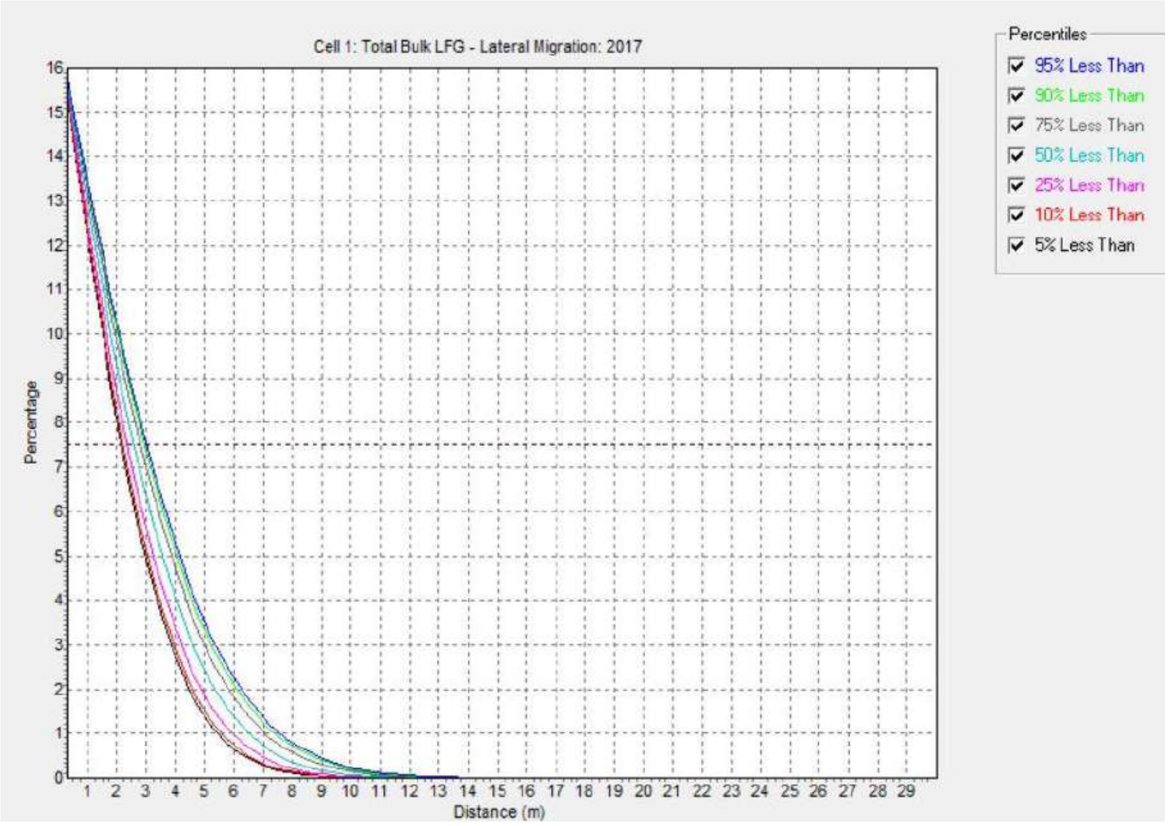


Figure 7. GasSim Model of Unconfined Diffusive Flow Potential at Enderby Warren

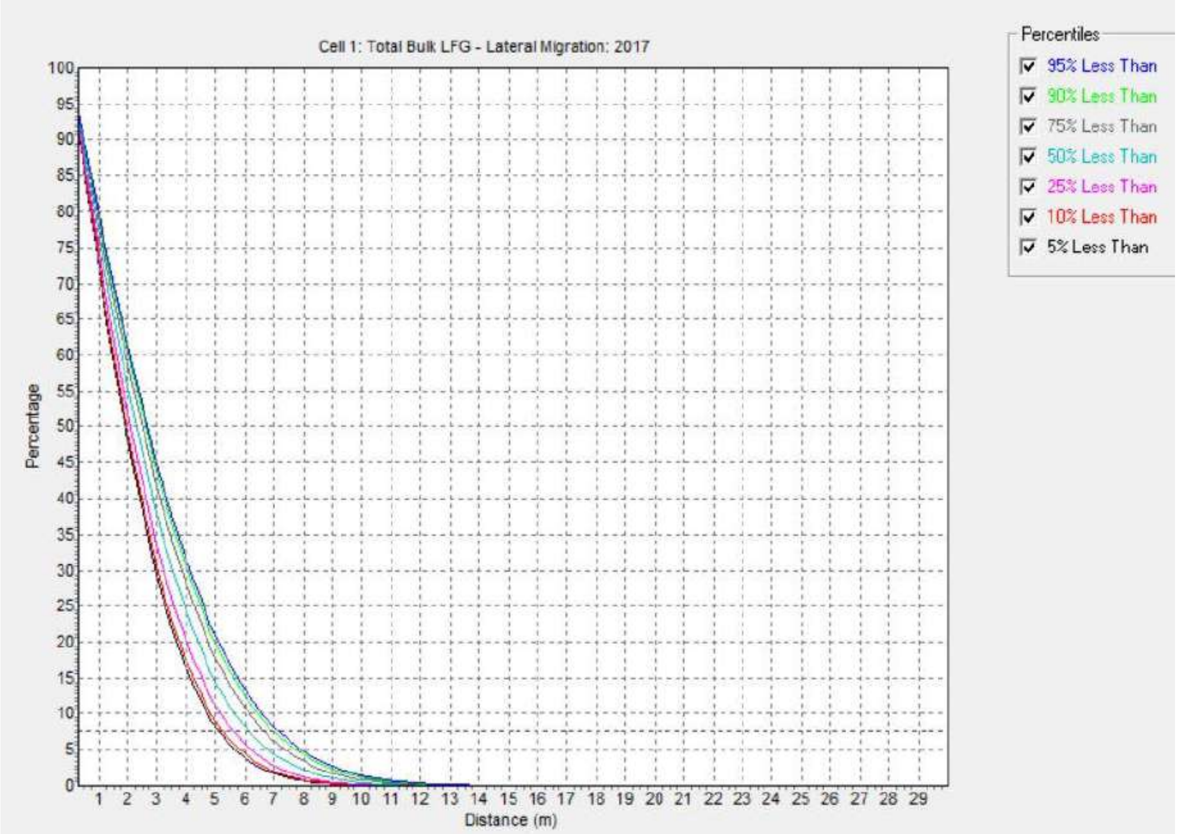


Figure 8. GasSim Model of Confined Diffusive Flow Potential at Enderby Warren

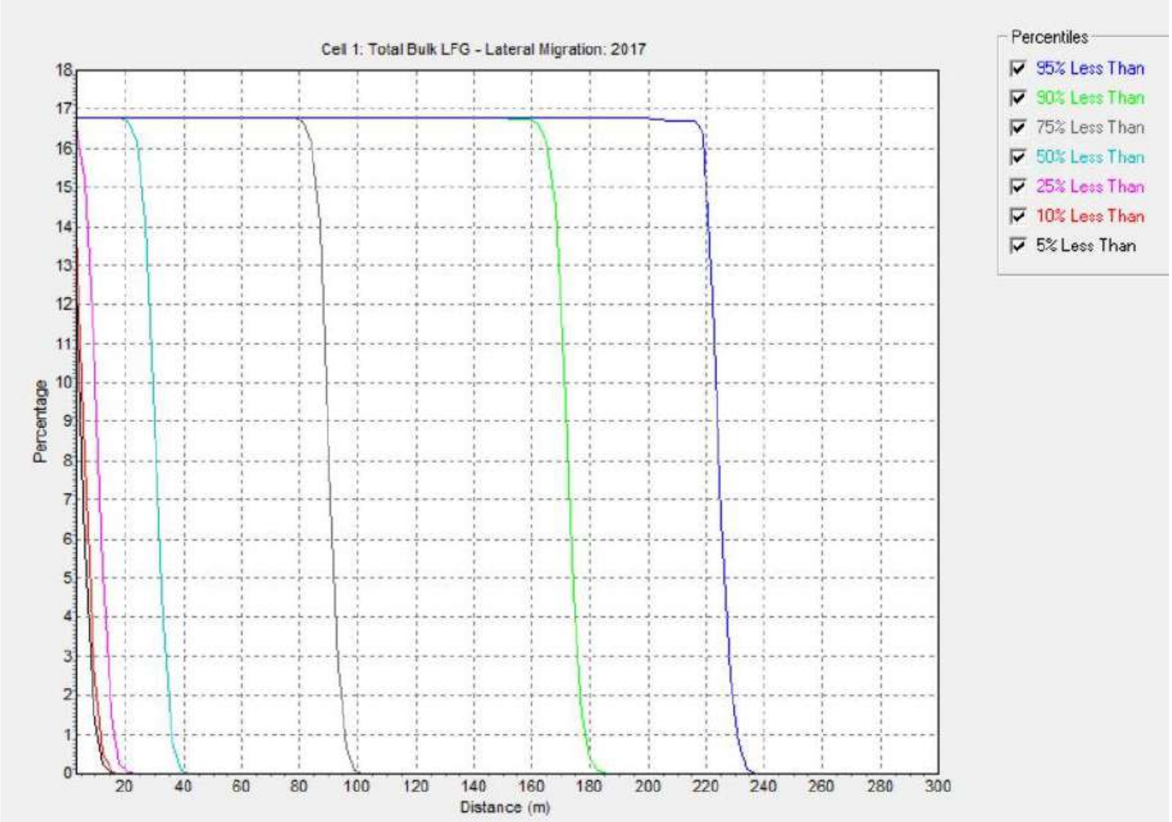


Figure 9. GasSim Model of Unconfined Advective Flow Potential at Enderby Warren

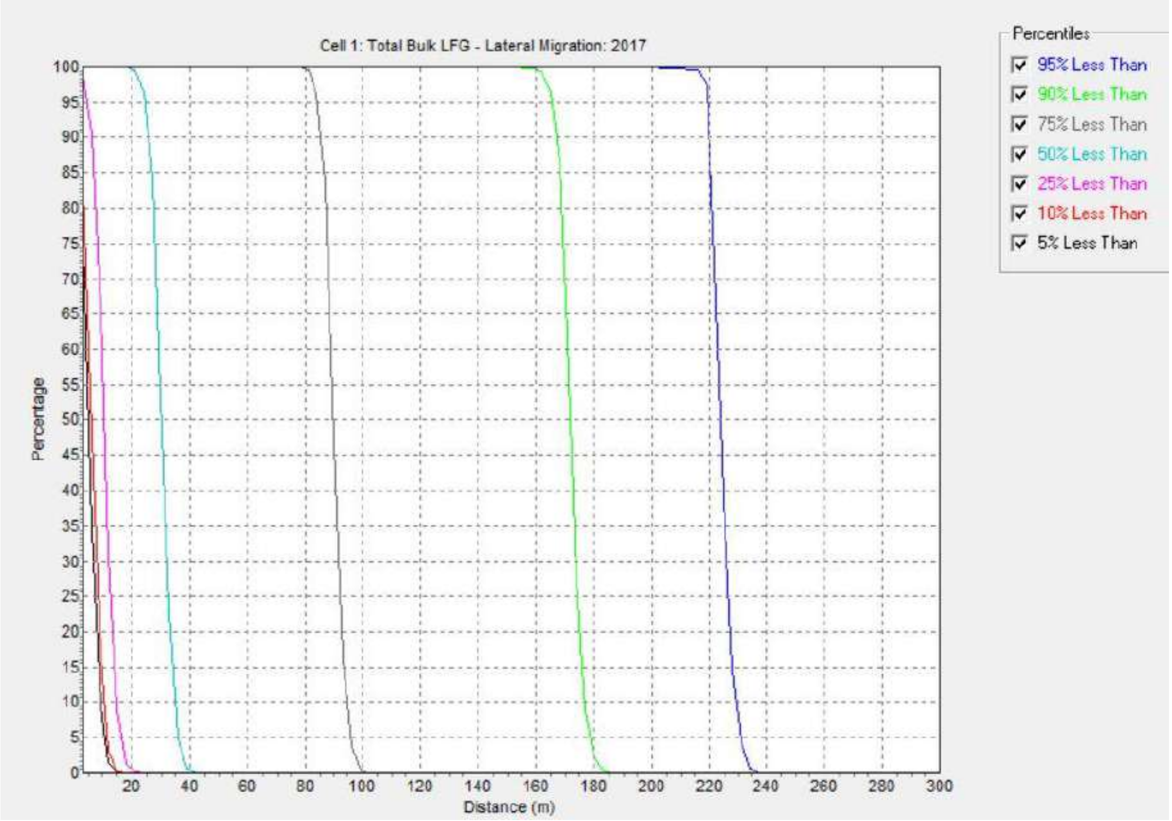


Figure 10. GasSim Model of Confined Advective Flow Potential at Enderby Warren

Temperature is the third most important factor, but its influence is relatively small, except where the ground surface is frozen.

Wind speed over the surface of the ground is the fourth and least important factor, but this can reduce the risk of lateral migration in dry weather. Its effect is negated in wet soil conditions.

At Enderby Warren, rainfall and atmospheric pressure changes will be the dominant factors, with some effect from temperature if the ground surface is frozen, and wind speed if the ground surface is dry.

It is clear that whatever the likelihood of gas migration, the advective flow regime has the most significant risk for developments proximal to the landfill. The high-risk developments identified in the current environmental report (SUEZ, 2016), and reproduced as Table 4 below, all lie within the 240m zone of potential lateral migration.

### 4.2.6 SUEZ's Lateral Migration Assessment Procedure

Suez is required to produce an annual report each year to satisfy two conditions in the two permits relating to the site. These are condition A7 of Environmental Permit EPR/AP3993CV/V002 (also referred to as WML43366) for the landfill site, and condition 4.2.2 of Environmental Permit EPR/RP3738ZK for Enderby Leachate Treatment Plant:

Condition A7

*'The licence holder shall submit an annual report from the date of issue of the reviewed licence, prepared by a suitably qualified person, detailing all of the monitoring that has taken place during the preceding twelve months.*

*The report shall include a summary of the waste input for the year, an accurate end of year survey of the waste levels within the Site, a summary of the leachate, groundwater, surface water and gas monitoring data, an interpretation of any developing trends suggested by the data and a review of the adequacy of the current monitoring regime based on the conclusions of the report.*

Condition 4.2.2

*The report shall include a summary on the performance of the activities over the previous year shall be submitted to the Environment Agency by 31 January (or other date agreed in writing by the Environment Agency) each year. The report(s) shall include as a minimum:*

*a) a review of the results of the monitoring and assessment carried out in accordance with the permit including an interpretive review of that data;*

*b) the annual production /treatment data set out in schedule 4 table S4.2, and;*

*c) the performance parameters set out in schedule 4 table S4.3 using the forms specified in table S4.4 of that schedule.*

The period for the most recent Environmental Monitoring Review report is 1 May 2015 to 30 April 2016. The information used by SUEZ in these reports are clearly part of any conceptual site model (CSM) developed for the Site and its environs.

Table 2 below sets out the Landfill Gas Monitoring Points established around the perimeter of the Site, and at key high risk receptors (Suez, 2016, Table 1).

Point-specific compliance limits for methane and/or carbon dioxide apply and are listed in the report for 2015 (SITA, 2015). Concentrations in all points have also been assessed in this report. The assigned risk banding is shown in Table 3 (from SUEZ 2016, Table 2).

**Table 2. Landfill Gas Monitoring Points (from SUEZ, 2016)**

| Monitoring Point | Category |
|---|---|
| EN/01 to EN/40 | Perimeter monitoring points (adjacent to the extent of the landfilling area), used to assess the effectiveness and aid the balancing of the landfill gas extraction system |
| EN41 (T and B) to EN43 (T and B),<br>EN/COTT (S and D)<br>EN/Farm<br>EN/PC (S and D) | Deep and shallow monitoring points, located between the perimeter monitoring points and the surrounding receptors to monitor potential gas migration |
| EN/COTT (P) | Single shallow piezometer located adjacent to Colston Cottage to monitor potential gas migration |
| EN/KCOT (T, M and B)<br>EN/WCOT (T, M and B)<br>EN/PC1 (T, M and B)<br>EN/PC2 (T, M and B)<br>EN/PC3 (T and B)<br>EN/WF1 (T and B)<br>EN/WF1A (T, M and B)<br>EN/WF2 (T, M and B)<br>EN/WF3 (T, M and B) | Discrete piezometers located in close proximity to residential receptors to supplement the assessment of potential gas migration |
| EN/KCHM<br>EN/WCHM (1 and 2)<br>EN/PCHM (1 to 3)<br>EN/WFHM (1 to 4) | House monitoring points |

**Table 3. Landfill Gas Risk Band Monitoring Points (from SUEZ, 2016)**

| Risk Banding | Monitoring Point |
|---|---|
| High Risk Boreholes | EN41 (T and B) to EN43 (T and B), EN/COTT (S, D and P), EN/Farm, EN/PC (S and D), EN/23, EN/KCOT (T, M and B), EN/WCOT (T, M and B), EN/PC1 (T, M and B), EN/PC2 (T, M and B), EN/PC3 (T and B), EN/WF1 (T and B), EN/WF1A (T, M and B), EN/WF2 (T, M and B) and EN/WF3 (T, M and B) |
| Medium Risk Boreholes | EN/06 to EN/11, EN/12A, EN/12B, EN/13 to EN/22 and EN/30 to EN/39 |
| Low Risk Boreholes | EN/01 to EN/05, EN/24, EN/25, EN/26R, EN/27 to EN/29 and EN/40 |

A total of 7 potential receptors to subsurface landfill gas migration are identified within 500m of the Site. The potential risk was determined as part of the SITA (2011) Environmental Monitoring Review and Risk Assessment, based on the magnitude of the potential impact to identified receptors and the probability of that impact occurring, taking into account the underlying geology, landfill design and the distance between the Site and the receptors as summarised in Table 4 (from SUEZ 2016, Table 3) and shown on Drawing 2.

### Table 4. Receptors at Potential Risk from Subsurface Landfill Gas Migration (from SUEZ, 2016)

| **Receptor** | **Location** | **Potential Risk** |
|---|---|---|
| Penn Crag | 100m West | High |
| Colston Cottage | 75m West | High |
| Warren Farm | 70m East | High |
| Keepers Cottage and Warren Cottage | 35m – 40m East | High |
| Industrial Estate | 30m – 250m North West | High |
| Gas Utilisation Compound | 25m – 30m North | High |
| Surrounding Agricultural and Woodland | Immediately Surrounding | Medium |

Locations are as measured from the edge of the waste mass. See Drawing 2.

Additional receptors up to 500m from the Site were considered as part of the SITA (2012) Environmental Monitoring Review and Risk Assessment but found to lie within the same pathway of those within 250m of the Site. The risk was considered to be similar in nature, but was likely to be much lower in magnitude and was not assessed further.

Currently, lateral migration might be by either confined or unconfined pathways.

SUEZ current assessments (SUEZ, 2016) are that while the potential risks to these properties are high, the actual risks to these properties, due to their monitoring and management systems, are actually low.

However, with the proposed hard developments around the landfill, there is an increase in the likelihood of confined pathways being created. Both the strategic employment park, with its large warehouse buildings with concrete slab foundations (see Appendix B), and the arterial road planned to pass adjacent to the northern boundary of the landfill (see Appendix C), automatically change any unconfined migration pathway into a confined one, which brings substantially higher risks from lateral gas migration, as there is no atmospheric exchange to dilute the gas in a confined migration pathway.

## 5.0 A Conceptual Site Model (CSM) for Enderby Warren

Modelling has demonstrated that landfill gas generation at Enderby Warren Landfill peaked in 2001, at the same time as the site closed to waste, and has been declining ever since.

Landfill gas management at the Site is achieved, as at all gassing landfills, by a combination of active and passive systems. Landfill gas abstraction for utilisation and flaring is the active technology employed at the site for landfill gas control. The site is unlined and this means there is no passive barrier to assist in lateral migration management. SUEZ has installed a passive barrier in the form of an engineered cap in 2007, to help reduce leachate production and help manage the landfill gas collection at the site, and while this has evidently made balancing the gas field less challenging, the unlined nature of the site, and the significant depth of the landfill means control of lateral migration of landfill gas remains challenging.

Despite the engineered capping, Enderby Warren does not exhibit the higher landfill gas recovery rates, as might be seen on fully lined and capped closed landfills, reflected in the Environment Agency’s target of 85% collection efficiency, because there is no barrier engineering on the buried flanks of the site. This was common practice at the time the site was designed and first operated, and retrospective landfill lining cannot be installed by SUEZ.

Modelling suggests that potentially, only 60% (rather than 85%) of the landfill gas is captured by the active gas control system, and up to 27% (69% of the remaining 40%) is potentially lost through the sidewalls of the landfill. While this figure of 27% appears high, it is to be realised that this is derived from modelling, and the number of lateral migration events annually has declined significantly with time, and with the engineered capping of the Site.

Lateral migration modelling also demonstrates that the flux of gas on the sidewalls of the quarry should be reducing year on year. However, there remain four potential pathways for lateral gas migration:

- Unconfined diffusion of landfill gas.
- Confined diffusion of landfill gas.
- Unconfined advective migration of landfill gas.
- Confined advective migration of landfill gas.

Inspection of monitoring data from 1999 to the present day shows that:

- the frequency of lateral migration events seemed to be highest in the early years of the data set;
- there is evidence of diffusive gas migration to the present day; and
- there is evidence of advective gas migration to the present day.

Currently there is monitoring evidence for both diffusion and advection of landfill gas from the site. Diffusion is a low risk mechanism which is modelled to have an impact no further than 10m from the waste boundary. Diffusion allows methane oxidation to remove most of the methane risk and convert methane to carbon dioxide. Such anomalies are detected in perimeter monitoring boreholes around the site.

Advection is a high-risk mechanism which is modelled to have an impact to at least 240m from the waste boundary. Suez manages the current risks by alarms in high risk residential properties identified in their monitoring reports, in addition to routine monitoring around the perimeter of entire landfill body. Any diffusion driven or advection driven anomalies will be detected in perimeter monitoring boreholes around the site, but the distance of migration depends on the driving force. 50% of modelled migration is to a distance of up to 35m from the waste boundary. One in 20 migration events can reach 240m, and 5% of all migration events will have the potential to migrate further than this, depending on the driving force.

At Enderby Warren, there are two meteorological factors which dominate the potential for lateral landfill gas migration:

- Change in atmospheric pressure. During warm dry weather, atmospheric air exchange will help dilute the migrating gas plume, and it is predominantly in wet weather, when the soil surface is sealed, that lateral migration is a greater risk. The Loscoe explosion was due to atmospheric pressure changes (Aitkinhead and Williams, 1986). It is not the absolute value of pressure that is significant, but the rate of change of atmospheric pressure that regulates the migration potential.
- Rainfall (soil moisture content). Rainfall increases the soil moisture content and seals the surface, reducing atmospheric exchange. The fatal landfill gas explosion at Skellingsted in Denmark followed a period of heavy rain (Kjeldsen and Fischer, 1995).

There are two less important factors which may have some influence:

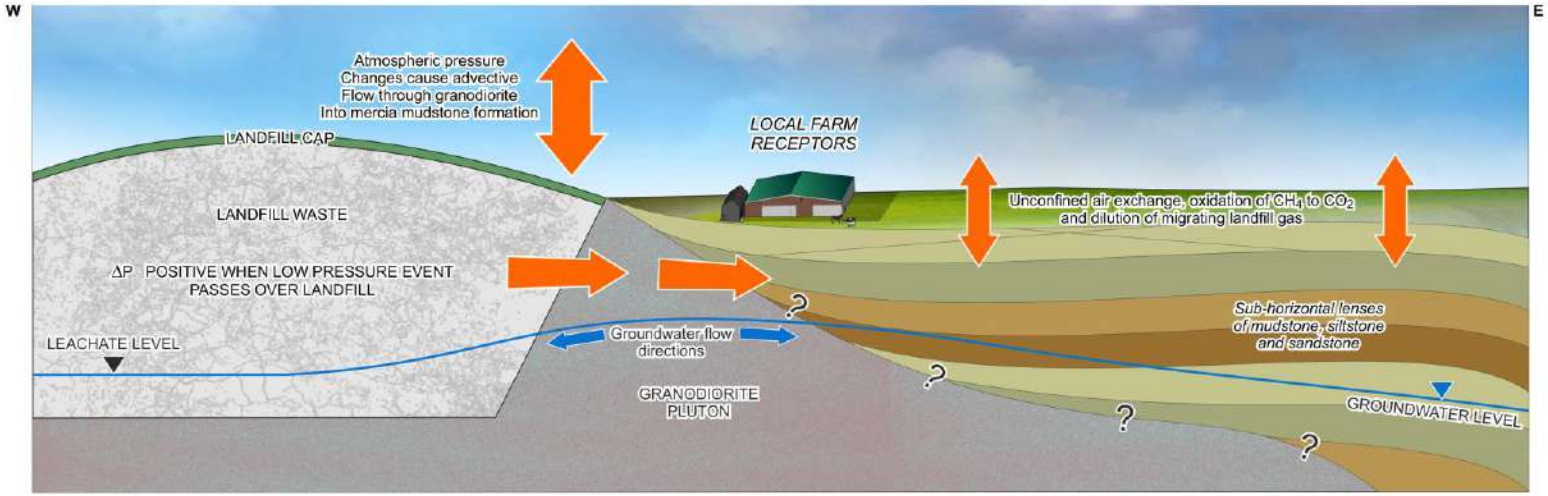
- Temperature. When the ground surface is frozen, this will enhance the lateral migration potential.
- Wind speed (Coriolis effect). This can reduce the risk of lateral migration in dry weather. Its effect is negated in wet soil conditions.

Gas migration through the granodiorite intrusion is through secondary fissure pathways of high permeability and porosity, above the groundwater level. Gas migration through the Mercia mudstone formation and superficial deposits will be preferentially through sandstone lenses with a high matrix permeability, also above the groundwater level. Such sandstone lenses have been identified above the groundwater level in boreholes BH03, BH05 and BH06 recently drilled by ERM (see Appendix B).

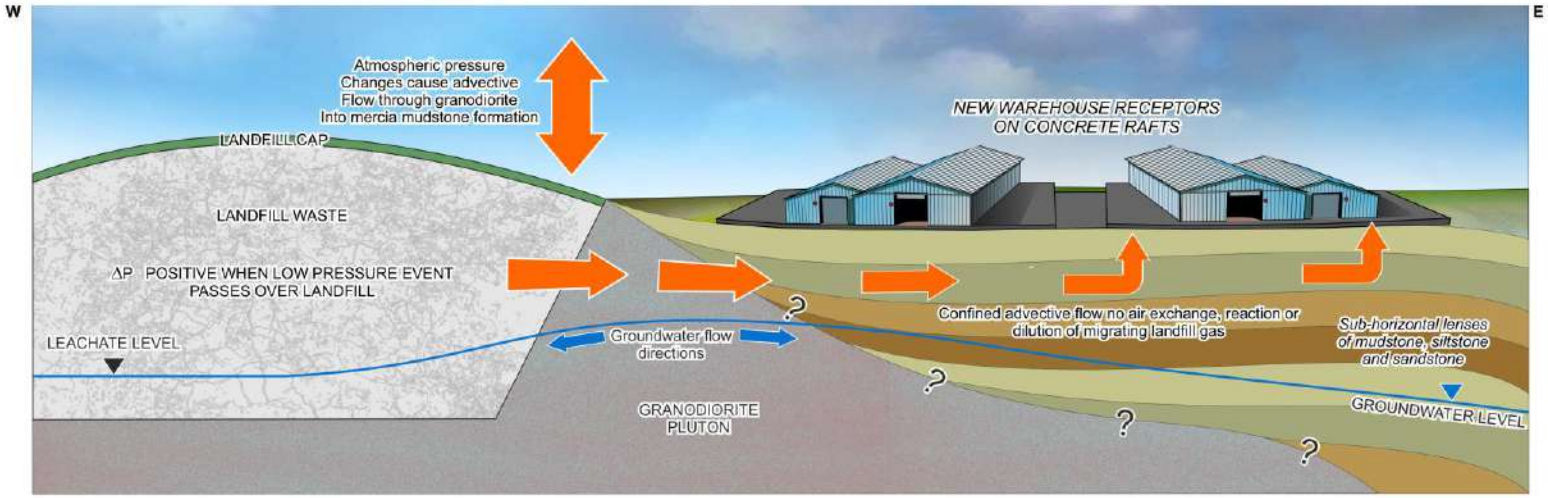
There is also evidence for a man-made migration pathway in the form of a backfilled conveyor tunnel leading from the landfill offsite, approximately from between perimeter gas monitoring points 35 and 36, toward the off-site perimeter gas monitoring point 43, near Quartz Close.

Figure 11 illustrates the CSM for Enderby Warren. The significant difference between the current conditions and the conditions following the development of the proposed warehousing, or the construction of the new arterial road, will be the increase in the sealing of the land surface, leading to a predominantly confined advective flow regime.

Current risk assessment techniques which assess the risk using measured gas flux and concentration are not ideal for acute, advective landfill gas risks, because they only capture a moment in time. Continuous measurement of atmospheric pressure and borehole flow would be a much more appropriate approach for identifying when and where lateral migration may occur. However, in-borehole continuous monitoring technologies are not currently able to measure flow rate (they can measure pressure), but the large number of boreholes around Enderby Warren mean that such an approach is not cost-effective, and Suez approach which monitors boreholes at a frequency proportional to the identified risk, and which uses continuous monitoring devices at identified receptors is an appropriate approach.



**(1) EXISTING LATERAL MIGRATION RISK - UNCONFINED SEDIMENTARY STRATA**



**(2) POTENTIAL LATERAL MIGRATION RISK - CONFINED SEDIMENTARY STRATA**

***Not to Scale***

Figure 11. Schematic Conceptual Site Model of Lateral Migration at Enderby Warren

# 6.0 Requirements for Gas Protection Measures

SUEZ's current risk assessment of the high-risk properties which they monitor continuously are that while the potential risks to these properties are high, the actual risks to these properties, based on the results of their ongoing monitoring, and their management systems, are actually low.

However, two new significant developments proposed adjacent to the Enderby Warren landfill will change the subsurface gas regime in ways which cannot be accurately predicted, and which may increase the risks to existing high-risk properties and may bring risks to existing neighbouring properties for which no risk has yet been identified:

- The strategic employment park will bring new warehouses to the northeast of Enderby Warren landfill, which will increase the lateral migration risk to the northeast and east of the landfill, toward the existing buildings on this side of the landfill, which are already on Suez's list of receptors at high risk from lateral migration, and also the new warehouses themselves.
- The new arterial road to the north of the landfill will increase the lateral migration risk to the north and north-west of the landfill. There is a newly built waste transfer station on Quartz Close, immediately to the north west of the landfill, and there are many other proximal developments on this Industrial Estate. None of these have gas protection measures as part of their design. All these properties may be put at higher risk, because of the magnitude of the new development proposed.

For the new build proposals, on the strategic employment park, gas protection measures should as a minimum consider a metallised methane gas barrier across the entire footprint of all buildings, and all service entry points should break ground outside the concrete raft foundations, and enter the buildings through the sides of the constructions, thereby breaking the source-pathway-receptor pollutant linkage. Such an approach would mean the risk would be significantly reduced to these proposed developments, and in-building alarms may potentially not be needed. This requires some additional consideration by the developers.

For the new arterial road proposed immediately to the north of the landfill, the initial risk will be during the construction phase, when the gas transmission pipework between the landfill and the landfill gas management compound may be disrupted. Any break in the continuous collection of landfill gas could significantly increase the lateral migration risk around the entire landfill. To minimise this risk, GECL considers that the Option 2 road route, which preserves more of the monitoring and gas collection systems on the landfill itself, is the better of the two options presented to date, but neither option addresses the challenge of disconnecting the gas field from the gas compound and reconnecting it following completion of the road. This also requires some additional consideration by the developers.

For the existing high risk properties surrounding the landfill, and those existing properties in the Industrial Estate which are currently not on SUEZ's high risk register, it is not yet known whether the significant changes in the lateral migration pathways to the north and north east of the landfill will have an equally significant impact, raising the future risks to these properties, which do not have any in ground protection, because of the sealing of the ground due to the new development proposals. This also requires some additional consideration by the developers.

# 7.0 Conclusions

Landfill gas generation at the Enderby Warren Landfill peaked in 2001 at the same time as the site closed to waste, and has been declining ever since.

Landfill gas management is achieved by a combination of active and passive systems. Landfill gas abstraction for utilisation and flaring is the active technology employed at the site for landfill gas control. The site is unlined and this means there is no passive barrier to assist in lateral migration management.

Enderby Warren does not exhibit high gas recovery rates because the site has only an engineered cap installed, and there is no engineering on the buried flanks of the site. Modelling suggests that potentially, only 60% of the landfill gas is captured by the active gas control system, and up to 27% (69% of the remaining 40%) is potentially lost through the sidewalls of the landfill. While this figure of 27% appears high, it is to be realised that this is derived from modelling, and the number of lateral migration events annually has declined significantly with time, and with the engineered capping of the Site. However, there remain four potential pathways for lateral gas migration:

- Unconfined diffusion of landfill gas.
- Confined diffusion of landfill gas.
- Unconfined advective migration of landfill gas.
- Confined advective migration of landfill gas.

Currently there is monitoring evidence for both diffusion and advection of landfill gas from the site.

- Diffusion is a low risk mechanism which is modelled to have an impact no further than 10m from the waste boundary. Diffusion allows methane oxidation to remove most of the methane risk and convert methane to carbon dioxide.
- Advection is a high-risk mechanism which is modelled to have an impact to at least 240m from the waste boundary.

At Enderby Warren, there are two meteorological factors which dominate the potential for lateral landfill gas migration:

- Change in atmospheric pressure. It is not the absolute value of pressure that is significant, but the rate of change of atmospheric pressure that regulates the migration potential.
- Rainfall (soil moisture content). Rainfall increases the soil moisture content and seals the surface, reducing atmospheric exchange.

Gas migration through the granodiorite is through secondary fissure pathways of high permeability and porosity, above the groundwater level. Gas migration through the Mercia mudstone formation and superficial deposits will be preferentially through sandstone lenses or Skerries with a high matrix permeability, also above the groundwater level. Such sandstone lenses have been identified above the groundwater level in boreholes BH03, BH05 and BH06 recently drilled by ERM (Appendix B). There is also evidence for a man-made migration pathway in the form of a backfilled conveyor tunnel leading from the landfill offsite, approximately from between perimeter gas monitoring points 35 and 36, toward the off-site perimeter gas monitoring point 43, near Quartz Close.

The risk then depends upon the ability of atmospheric exchange to dilute the landfill gas plume or not. Currently, lateral migration might be by either confined or unconfined pathways. SUEZ's current risk assessment of the high-risk properties which they monitor continuously are that while the potential risks to these properties are high, the actual risks to these properties, based on the results of their ongoing monitoring, and their management systems, are actually low.

However, there are two new significant developments proposed adjacent to the Enderby Warren landfill, which will change the subsurface gas regime in ways which cannot be accurately predicted, and which may increase the risks to existing high-risk properties and existing neighbouring properties for which no risk has yet been identified:

- The strategic employment park will bring new warehouses to the northeast of Enderby Warren landfill, which will increase the lateral migration risk to the northeast and east of the landfill.
- The new arterial road to the north of the landfill will increase the lateral migration risk to the north and north-west of the landfill.

One of the most significant risks arising from the proposed development around the landfill is the increase in the likelihood of confined pathways being created. Both the building of the strategic employment park, with its large warehouse buildings with concrete slab foundations, and the construction of a substantially wider arterial road planned to pass adjacent to the northern boundary of the landfill, automatically changes any unconfined migration pathway into a confined one, which brings substantially higher risks from lateral gas migration, as there is no atmospheric exchange to dilute the gas.

For the new build proposals, on the strategic employment park, gas protection measures should as a minimum consider a metallised methane gas barrier across the entire footprint of all buildings, and all service entry points should break ground outside the concrete raft foundations, and enter the buildings through the sides of the constructions, thereby breaking the source-pathway-receptor pollutant linkage. Such an approach would mean the risk would be significantly reduced to these proposed developments, and in-building alarms may potentially not be needed. This requires some additional consideration by the developers.

For the new arterial road proposed immediately to the north of the landfill, the initial risk will be during the construction phase, when the gas transmission pipework between the landfill and the landfill gas management compound may be disrupted. Any break in the continuous collection of landfill gas could significantly increase the lateral migration risk around the entire landfill. To minimise this risk, GECL considers that the Option 2 road route, which preserves more of the monitoring and gas collection systems on the landfill itself, is the better of the two options presented to date, but neither option addresses the challenge of disconnecting the gas field from the gas compound and reconnecting it following completion of the road. This also requires some additional consideration by the developers.

For the existing high risk properties surrounding the landfill, and those existing properties in the Industrial Estate which are currently not on SUEZ's high risk register, it is not yet known whether the significant changes in the lateral migration pathways to the north and north east of the landfill will have an equally significant impact, raising the future risks to these properties, which do not have any in ground protection, because of the sealing of the ground due to the new development proposals. This also requires some additional consideration by the developers.

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## Report Signature Page

GECL appreciates the opportunity to submit this report to Suez. If you require further information or clarification, please do not hesitate to contact the undersigned.

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Director

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Date 2 February 2017
Author Robert G Gregory

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Registered in England and Wales, Company No 9946140

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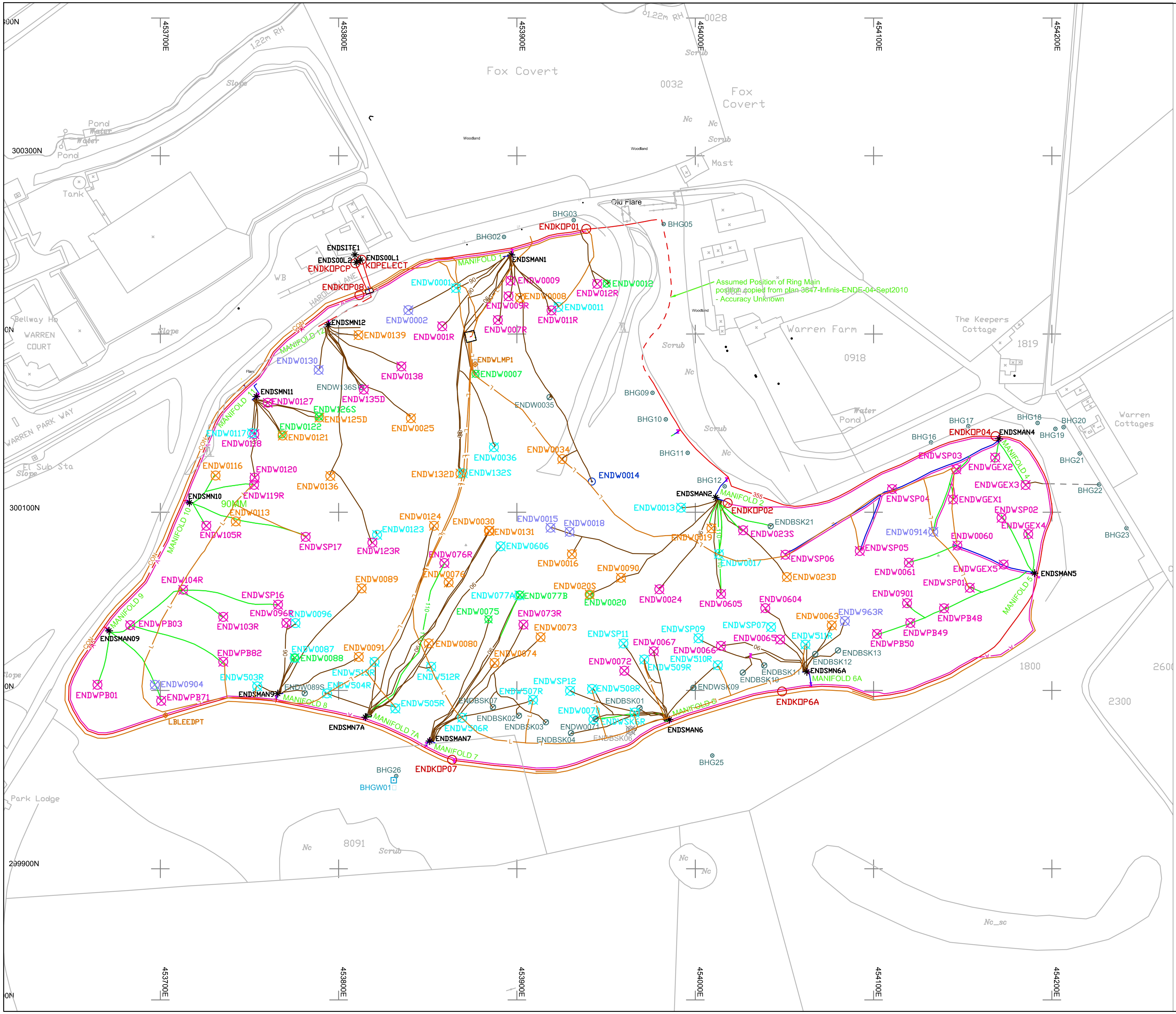
# Drawings



## LEGEND

### Monitoring Points

- ⊙ Landfill Gas Monitoring Borehole
- ◎ Landfill Gas Surface Monitoring Point
- ⊡ Combined Gas/ Groundwater Monitoring Point
- ⊛ Gas Flare Stack
- ◈ Landfill Gas Extraction/ Leachate Monitoring Point
- ⊕ Condensate Unit (Knock-out Pot)
- ⊡ Groundwater Monitoring Borehole
- ◈ Groundwater Pumping Point
- ⊠ Surface Water Monitoring Point
- ⊕ Leachate Collection Point
- ◈ Leachate Monitoring Point
- ⊕ Leachate Recirculation Point
- ⧗ Valve
- ○ KOP
- ▫ PEG
- ▬ Manifold
- ⊠ Finn Drains
- ⊘ Pinwell

### Gas Wells

- ⊙ Gas Well 63Ø
- ⊙ Gas Well 90Ø
- ⊠ Gas Well 110Ø
- ⊠ Gas Well 120Ø
- ⊠ Gas Well 160Ø
- ⊠ Gas Well 180Ø
- ⊠ Gas Well 225Ø
- ⊠ Gas Well 250Ø >
- ⊠ Proposed Gas Well
- ⊠ Underground Gas Well (dimension unknown)
- ⊠ Assumed Underground Gas Well Location

Gregory
Environmental Consulting

Site Name
**Enderby Warren**

Drawing Title
**Gas Collection Infrastructure**

| | | | | |
|---|---|---|---|---|
| SCALE: | 1:2000 | Size: | A3 | DRAWING No. |
| DATE: | January 2017 | | | 1 |
| By: | CB | Dwg: | GEC160121-01 | |

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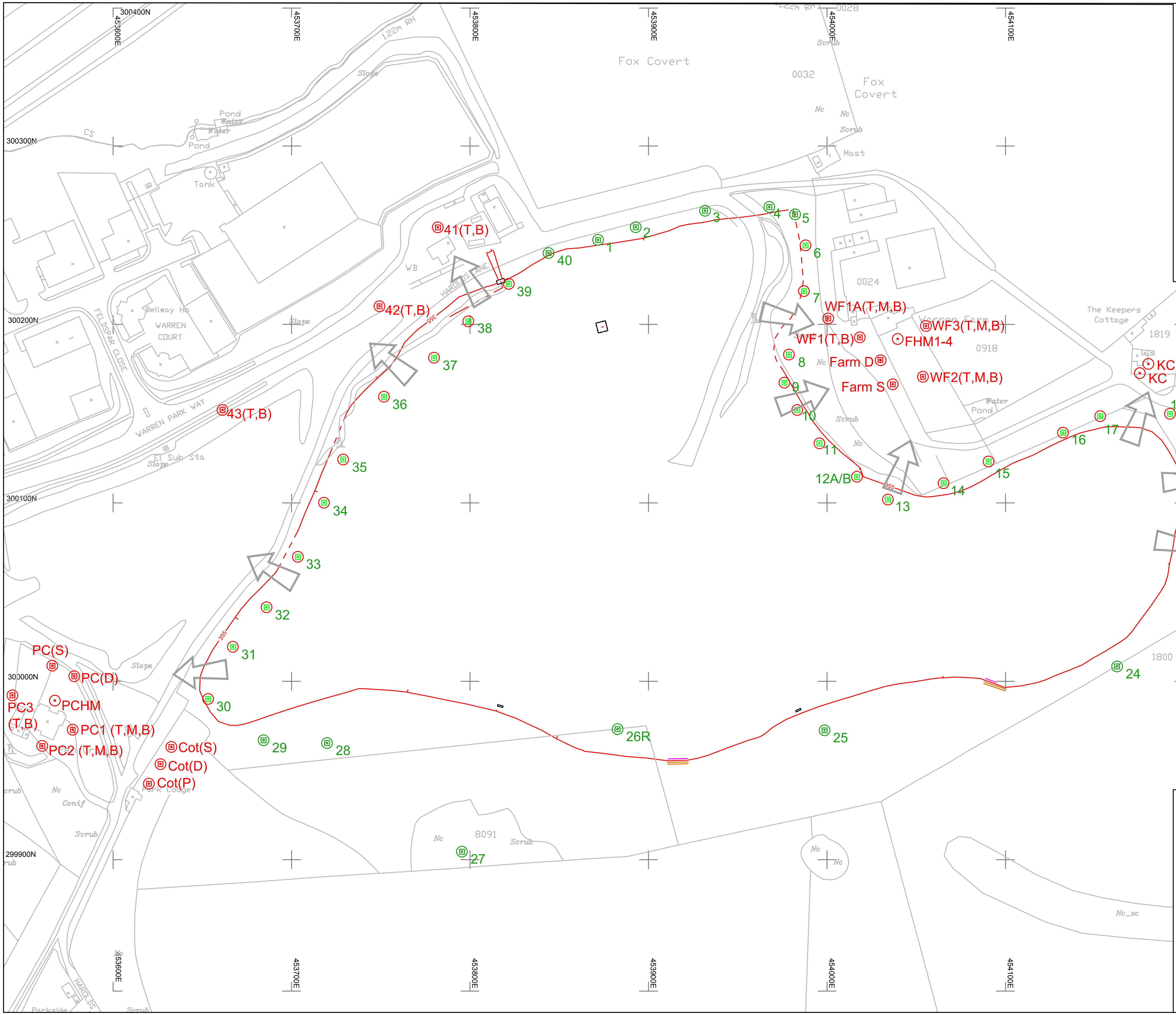

**LEGEND**

**Monitoring Points**

| | |
|---|---|
| — | Perimeter Ring Main (dashed where not surveyed) |
| ⊙ | In House Gas Monitoring Point - High Risk |
| 🟩 | Perimeter Gas Monitoring Point - Low Risk |
| ▣ | Perimeter Gas Monitoring Point - Medium Risk |
| 🟥 | Perimeter Gas Monitoring Point - High Risk |

**KEY**

| | |
|---|---|
| T,M,B | Top, Middle and Bottom |
| S,D | Shallow, Deep |
| P | Single Pie ometer |

Gregory Environmental Consulting

Site Name
**Enderby Warren**

Drawing Title
**Perimeter Gas Monitoring Points**

SCALE: 1:2000
Si e: A3
DATE: January 2017
By: CB
Dwg: GEC160121-02
DRAWING No. 2

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# Appendices

# Appendix A

## Results of GasSim Modelling and Spreadsheet Modelling

**Table A1. REF Public Domain Database Data (correct as of November 2016)**

| Suez Operated Power Station Site | ID | Generator Name | Country | IC (kW) | Subsidy | Accreditation | Running Load Factor % | Annual Load Factor % | Latest Data | Latest MWh per annum | Latest ROCs per annum |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Enderby Warren** | R00013RJEN | Enderby Warren Phase 1 | England | 1,978 | RO | 01/04/2002 | 66.60% | 70.20% | Sep-16 | 6,188 | 5,692 |
| | R00011RJEN | Enderby Warren Phase 2 | England | 3,000 | RO | 01/04/2002 | 27.50% | 10.40% | Mar-05 | 2,728 | 2,728 |

**Table A2. MWh per RO Financial Year (April - March). FY16 and FY17 data (highlighted) extrapolated to full year for trend analysis.**

| Suez Operated Power Station Site | ID | FY03 | FY04 | FY05 | FY06 | FY07 | FY08 | FY09 | FY10 | FY11 | FY12 | FY13 | FY14 | FY15 | FY16 | FY17F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh |
| **Enderby Warren** | R00013RJEN | 15,944 | 13,938 | 13,886 | 13,067 | 10,454 | 9,334 | 9,572 | 7,544 | 7,410 | 7,877 | 7,575 | 7,331 | 6,827 | 6,436 | 6,270 |
| | R00011RJEN | 13,876 | 6,479 | 2,728 | | | | | | | | | | | | |
| **Total** | | 29,820 | 20,417 | 16,614 | 13,067 | 10,454 | 9,334 | 9,572 | 7,544 | 7,410 | 7,877 | 7,575 | 7,331 | 6,827 | 6,436 | 6,270 |

**Table A3. MWh per SUEZ Financial Year (Jan - Dec)**

| Suez Operated Power Station Site | ID | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh | MWh |
| **Enderby Warren** | R00013RJEN | 14,440 | 13,899 | 13,272 | 11,107 | 9,614 | 9,513 | 8,051 | 7,444 | 7,760 | 7,651 | 7,392 | 6,953 | 6,534 | 6,312 |
| | R00011RJEN | 8,328 | 3,666 | 682 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | 22,768 | 17,565 | 13,954 | 11,107 | 9,614 | 9,513 | 8,051 | 7,444 | 7,760 | 7,651 | 7,392 | 6,953 | 6,534 | 6,312 |

**Table A4. kWh/h per SUEZ Financial Year (Jan - Dec)**

| Suez Operated Power Station Site | ID | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h | kWh/h |
| **Enderby Warren** | R00013RJEN | 1,648 | 1,587 | 1,515 | 1,268 | 1,097 | 1,086 | 919 | 850 | 886 | 873 | 844 | 794 | 746 | 720 |
| | R00011RJEN | 951 | 418 | 78 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total** | | 2,599 | 2,005 | 1,593 | 1,268 | 1,097 | 1,086 | 919 | 850 | 886 | 873 | 844 | 794 | 746 | 720 |
| **m3/h LFG @ 57% CH4** | | 1,200 | 926 | 735 | 585 | 507 | 501 | 424 | 392 | 409 | 403 | 390 | 366 | 344 | 333 |

| Conversion Factors Used Throughout Spreadsheet | | |
|---|---|---|
| **Electrical Efficiency** | 38% | |
| **CH4 net calorific value** | 36 | MJ/m3 |
| **MJ to kWh** | 3.6 | MJ/kWh |

### Table A5. GasSim Model Outputs

**Bulk Gas Generation m3/h (Wet waste degradation rates)**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | 87 | 373 | 593 | 759 | 888 | 998 | 1093 | 1202 | 1308 | 1439 | 1603 | 1780 | 1918 | 2032 | 2139 | 2237 | 2351 | 2465 | 2560 | 2729 | 2835 | 2386 | 1984 | 1714 | 1518 | 1365 | 1237 | 1127 | 1030 | 943 | 865 | 793 | 728 | 668 | 613 | 564 | 518 | 476 | 437 | 402 | 370 | 341 | 313 | 288 | 266 |
| 10% Less Than | 91 | 386 | 611 | 779 | 912 | 1019 | 1121 | 1226 | 1333 | 1458 | 1631 | 1804 | 1949 | 2061 | 2167 | 2266 | 2380 | 2492 | 2589 | 2760 | 2883 | 2421 | 2010 | 1732 | 1532 | 1377 | 1249 | 1137 | 1039 | 952 | 872 | 799 | 734 | 674 | 619 | 568 | 522 | 480 | 441 | 406 | 373 | 344 | 316 | 291 | 268 |
| 25% Less Than | 99 | 412 | 644 | 811 | 947 | 1054 | 1159 | 1265 | 1375 | 1499 | 1673 | 1857 | 1993 | 2113 | 2216 | 2316 | 2434 | 2549 | 2645 | 2819 | 2939 | 2465 | 2049 | 1768 | 1564 | 1405 | 1274 | 1160 | 1060 | 971 | 890 | 816 | 749 | 688 | 632 | 580 | 533 | 490 | 451 | 414 | 381 | 351 | 323 | 297 | 274 |
| 50% Less Than | 109 | 444 | 680 | 851 | 986 | 1100 | 1199 | 1308 | 1423 | 1550 | 1727 | 1909 | 2051 | 2166 | 2268 | 2371 | 2494 | 2606 | 2706 | 2883 | 3007 | 2520 | 2093 | 1807 | 1600 | 1438 | 1304 | 1188 | 1086 | 994 | 911 | 836 | 767 | 704 | 647 | 594 | 546 | 502 | 461 | 424 | 390 | 359 | 331 | 304 | 280 |
| 75% Less Than | 118 | 474 | 718 | 890 | 1031 | 1141 | 1243 | 1352 | 1469 | 1602 | 1780 | 1959 | 2105 | 2227 | 2326 | 2426 | 2548 | 2668 | 2765 | 2945 | 3079 | 2577 | 2140 | 1846 | 1635 | 1470 | 1333 | 1215 | 1110 | 1016 | 931 | 854 | 784 | 720 | 661 | 607 | 558 | 513 | 472 | 434 | 399 | 367 | 338 | 311 | 287 |
| 90% Less Than | 127 | 503 | 751 | 928 | 1069 | 1177 | 1283 | 1394 | 1511 | 1645 | 1820 | 2008 | 2149 | 2272 | 2381 | 2475 | 2604 | 2716 | 2820 | 2999 | 3142 | 2627 | 2184 | 1886 | 1672 | 1503 | 1363 | 1242 | 1135 | 1039 | 953 | 874 | 802 | 736 | 676 | 621 | 571 | 525 | 483 | 444 | 408 | 376 | 346 | 318 | 293 |
| 95% Less Than | 131 | 517 | 773 | 953 | 1091 | 1199 | 1309 | 1429 | 1534 | 1671 | 1848 | 2031 | 2176 | 2307 | 2409 | 2507 | 2634 | 2745 | 2844 | 3030 | 3175 | 2655 | 2212 | 1907 | 1690 | 1518 | 1376 | 1254 | 1147 | 1050 | 962 | 882 | 810 | 744 | 683 | 627 | 576 | 530 | 487 | 448 | 412 | 379 | 349 | 321 | 296 |

**Bulk Gas Generation m3/h (Average waste degradation rates)**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | 30 | 144 | 265 | 380 | 485 | 584 | 676 | 771 | 870 | 972 | 1092 | 1221 | 1343 | 1458 | 1560 | 1670 | 1776 | 1878 | 1975 | 2096 | 2218 | 2113 | 1967 | 1830 | 1705 | 1589 | 1481 | 1383 | 1292 | 1208 | 1130 | 1058 | 991 | 929 | 871 | 818 | 768 | 722 | 679 | 639 | 602 | 567 | 534 | 504 | 475 |
| 10% Less Than | 31 | 150 | 272 | 388 | 494 | 596 | 693 | 788 | 884 | 986 | 1110 | 1240 | 1364 | 1476 | 1584 | 1685 | 1797 | 1901 | 1998 | 2119 | 2240 | 2133 | 1985 | 1847 | 1720 | 1603 | 1495 | 1395 | 1303 | 1218 | 1140 | 1067 | 1000 | 937 | 879 | 825 | 775 | 729 | 686 | 645 | 607 | 572 | 539 | 508 | 480 |
| 25% Less Than | 33 | 159 | 286 | 405 | 517 | 619 | 716 | 814 | 913 | 1018 | 1138 | 1271 | 1391 | 1505 | 1616 | 1717 | 1827 | 1935 | 2035 | 2156 | 2276 | 2168 | 2018 | 1878 | 1749 | 1630 | 1520 | 1419 | 1326 | 1240 | 1160 | 1086 | 1017 | 953 | 895 | 840 | 789 | 742 | 698 | 656 | 618 | 582 | 549 | 517 | 488 |
| 50% Less Than | 37 | 172 | 304 | 426 | 538 | 642 | 742 | 840 | 940 | 1046 | 1171 | 1304 | 1427 | 1542 | 1647 | 1751 | 1864 | 1973 | 2071 | 2198 | 2322 | 2211 | 2058 | 1916 | 1784 | 1663 | 1551 | 1448 | 1353 | 1265 | 1184 | 1109 | 1039 | 974 | 914 | 858 | 806 | 758 | 713 | 671 | 632 | 595 | 561 | 529 | 499 |
| 75% Less Than | 40 | 186 | 321 | 446 | 560 | 668 | 769 | 869 | 966 | 1075 | 1202 | 1334 | 1461 | 1579 | 1688 | 1792 | 1903 | 2010 | 2115 | 2236 | 2361 | 2249 | 2094 | 1949 | 1815 | 1692 | 1578 | 1473 | 1376 | 1287 | 1204 | 1128 | 1057 | 991 | 930 | 873 | 820 | 771 | 725 | 683 | 643 | 606 | 571 | 539 | 508 |
| 90% Less Than | 43 | 198 | 337 | 464 | 580 | 689 | 793 | 892 | 993 | 1102 | 1228 | 1366 | 1492 | 1608 | 1721 | 1828 | 1938 | 2046 | 2149 | 2276 | 2395 | 2281 | 2123 | 1976 | 1840 | 1715 | 1600 | 1494 | 1396 | 1305 | 1221 | 1144 | 1072 | 1005 | 943 | 885 | 832 | 782 | 736 | 692 | 652 | 614 | 579 | 546 | 516 |
| 95% Less Than | 46 | 204 | 345 | 473 | 592 | 706 | 805 | 911 | 1016 | 1117 | 1243 | 1385 | 1512 | 1632 | 1741 | 1847 | 1961 | 2071 | 2168 | 2292 | 2418 | 2301 | 2141 | 1992 | 1855 | 1729 | 1613 | 1506 | 1407 | 1316 | 1232 | 1154 | 1081 | 1014 | 951 | 893 | 839 | 789 | 742 | 699 | 658 | 620 | 584 | 551 | 520 |

**Residual Gas m3/h**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | 87 | 373 | 593 | 759 | 888 | 998 | 1093 | 1202 | 1308 | 1439 | 1603 | 1780 | 1918 | 2032 | 1302 | 1363 | 1432 | 1493 | 1561 | 1657 | 1724 | 1127 | 949 | 769 | 684 | 650 | 179 | 89 | 59 | 50 | 45 | 46 | 199 | 139 | 85 | 50 | 39 | 35 | 32 | 30 | 27 | 25 | 23 | 21 | 20 |
| 10% Less Than | 91 | 386 | 611 | 779 | 912 | 1019 | 1121 | 1226 | 1333 | 1458 | 1631 | 1804 | 1949 | 2061 | 1362 | 1420 | 1486 | 1558 | 1614 | 1722 | 1800 | 1171 | 969 | 794 | 705 | 693 | 192 | 97 | 64 | 55 | 49 | 52 | 206 | 146 | 91 | 55 | 42 | 38 | 35 | 32 | 29 | 27 | 25 | 23 | 22 |
| 25% Less Than | 99 | 412 | 644 | 811 | 947 | 1054 | 1159 | 1265 | 1375 | 1499 | 1673 | 1857 | 1993 | 2113 | 1472 | 1535 | 1615 | 1690 | 1750 | 1867 | 1947 | 1259 | 1010 | 842 | 768 | 810 | 218 | 113 | 73 | 63 | 56 | 79 | 221 | 160 | 104 | 61 | 47 | 42 | 39 | 36 | 33 | 30 | 28 | 26 | 24 |
| 50% Less Than | 109 | 444 | 680 | 851 | 986 | 1100 | 1199 | 1308 | 1423 | 1550 | 1727 | 1909 | 2051 | 2166 | 1596 | 1666 | 1751 | 1835 | 1902 | 2031 | 2120 | 1353 | 1061 | 907 | 906 | 873 | 247 | 135 | 84 | 72 | 65 | 142 | 238 | 176 | 118 | 70 | 52 | 47 | 43 | 40 | 37 | 34 | 31 | 29 | 29 |
| 75% Less Than | 118 | 474 | 718 | 890 | 1031 | 1141 | 1243 | 1352 | 1469 | 1602 | 1780 | 1959 | 2105 | 2227 | 1733 | 1805 | 1897 | 1983 | 2056 | 2189 | 2288 | 1417 | 1119 | 984 | 1005 | 914 | 276 | 158 | 98 | 85 | 79 | 205 | 257 | 192 | 134 | 81 | 59 | 53 | 49 | 45 | 42 | 38 | 35 | 32 | 63 |
| 90% Less Than | 127 | 503 | 751 | 928 | 1069 | 1177 | 1283 | 1394 | 1511 | 1645 | 1820 | 2008 | 2149 | 2272 | 1852 | 1948 | 2040 | 2124 | 2214 | 2359 | 2453 | 1477 | 1177 | 1112 | 1055 | 947 | 306 | 185 | 108 | 96 | 90 | 255 | 274 | 208 | 148 | 93 | 65 | 59 | 55 | 50 | 46 | 42 | 39 | 36 | 130 |
| 95% Less Than | 131 | 517 | 773 | 953 | 1091 | 1199 | 1309 | 1429 | 1534 | 1671 | 1848 | 2031 | 2176 | 2307 | 1934 | 2024 | 2124 | 2204 | 2290 | 2439 | 2547 | 1504 | 1207 | 1176 | 1078 | 969 | 321 | 198 | 115 | 100 | 100 | 268 | 282 | 216 | 155 | 100 | 68 | 62 | 57 | 53 | 48 | 45 | 41 | 38 | 169 |

**Surface Emissions m3/h**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | 87 | 373 | 593 | 759 | 888 | 998 | 1093 | 1202 | 1308 | 1439 | 1603 | 1780 | 1918 | 2032 | 1302 | 1363 | 1432 | 1493 | 1561 | 1657 | 1724 | 848 | 679 | 579 | 536 | 511 | 42 | 21 | 14 | 12 | 11 | 12 | 44 | 32 | 20 | 12 | 9 | 8 | 8 | 7 | 6 | 6 | 5 | 5 | 5 |
| 10% Less Than | 91 | 386 | 611 | 779 | 912 | 1019 | 1121 | 1226 | 1333 | 1458 | 1631 | 1804 | 1949 | 2061 | 1362 | 1420 | 1486 | 1558 | 1614 | 1722 | 1800 | 973 | 778 | 661 | 614 | 591 | 46 | 24 | 16 | 13 | 12 | 16 | 47 | 34 | 22 | 13 | 10 | 9 | 8 | 8 | 7 | 6 | 6 | 5 | 5 |
| 25% Less Than | 99 | 412 | 644 | 811 | 947 | 1054 | 1159 | 1265 | 1375 | 1499 | 1673 | 1857 | 1993 | 2113 | 1472 | 1535 | 1615 | 1690 | 1750 | 1867 | 1947 | 1132 | 926 | 769 | 705 | 699 | 55 | 30 | 19 | 16 | 15 | 27 | 53 | 39 | 26 | 16 | 12 | 11 | 10 | 9 | 8 | 8 | 7 | 6 | 7 |
| 50% Less Than | 109 | 444 | 680 | 851 | 986 | 1100 | 1199 | 1308 | 1423 | 1550 | 1727 | 1909 | 2051 | 2166 | 1596 | 1666 | 1751 | 1835 | 1902 | 2031 | 2120 | 1273 | 1012 | 860 | 815 | 822 | 77 | 44 | 26 | 23 | 21 | 47 | 73 | 55 | 37 | 23 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 14 |
| 75% Less Than | 118 | 474 | 718 | 890 | 1031 | 1141 | 1243 | 1352 | 1469 | 1602 | 1780 | 1959 | 2105 | 2227 | 1733 | 1805 | 1897 | 1983 | 2056 | 2189 | 2288 | 1374 | 1082 | 940 | 965 | 889 | 152 | 84 | 53 | 45 | 41 | 79 | 153 | 111 | 74 | 44 | 33 | 30 | 28 | 26 | 24 | 22 | 20 | 18 | 26 |
| 90% Less Than | 127 | 503 | 751 | 928 | 1069 | 1177 | 1283 | 1394 | 1511 | 1645 | 1820 | 2008 | 2149 | 2272 | 1852 | 1948 | 2040 | 2124 | 2214 | 2359 | 2453 | 1451 | 1149 | 1063 | 1034 | 928 | 220 | 125 | 76 | 65 | 59 | 141 | 209 | 156 | 107 | 64 | 47 | 42 | 39 | 35 | 33 | 30 | 28 | 25 | 48 |
| 95% Less Than | 131 | 517 | 773 | 953 | 1091 | 1199 | 1309 | 1429 | 1534 | 1671 | 1848 | 2031 | 2176 | 2307 | 1934 | 2024 | 2124 | 2204 | 2290 | 2439 | 2547 | 1482 | 1189 | 1148 | 1061 | 953 | 247 | 144 | 87 | 75 | 70 | 179 | 229 | 170 | 119 | 73 | 52 | 48 | 44 | 40 | 37 | 34 | 31 | 29 | 83 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface emissions as a percentage of Residual | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 94% | 95% | 95% | 90% | 94% | 31% | 32% | 31% | 32% | 33% | 33% | 31% | 31% | 32% | 32% | 31% | 31% | 31% | 31% | 31% | 31% | 31% | 31% | 49% |

**Lateral Emissions m3/h**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 13 | 7 | 4 | 4 | 4 | 6 | 12 | 9 | 6 | 4 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| 10% Less Than | | | | | | | | | | | | | | | | | | | | | | 0 | 0 | 0 | 0 | 0 | 25 | 13 | 9 | 7 | 7 | 12 | 24 | 18 | 12 | 7 | 5 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 4 |
| 25% Less Than | | | | | | | | | | | | | | | | | | | | | | 2 | 1 | 1 | 1 | 1 | 84 | 47 | 28 | 25 | 22 | 34 | 83 | 61 | 40 | 24 | 18 | 16 | 15 | 14 | 13 | 12 | 11 | 10 | 11 |
| 50% Less Than | | | | | | | | | | | | | | | | | | | | | | 14 | 11 | 9 | 9 | 9 | 157 | 83 | 52 | 45 | 41 | 67 | 159 | 114 | 74 | 44 | 33 | 30 | 28 | 26 | 24 | 22 | 20 | 18 | 19 |
| 75% Less Than | | | | | | | | | | | | | | | | | | | | | | 139 | 109 | 94 | 93 | 86 | 193 | 107 | 67 | 57 | 53 | 129 | 185 | 136 | 93 | 55 | 41 | 37 | 34 | 32 | 29 | 27 | 25 | 23 | 28 |
| 90% Less Than | | | | | | | | | | | | | | | | | | | | | | 362 | 286 | 245 | 241 | 229 | 220 | 128 | 79 | 70 | 65 | 179 | 202 | 152 | 106 | 65 | 47 | 43 | 40 | 37 | 34 | 31 | 29 | 26 | 84 |
| 95% Less Than | | | | | | | | | | | | | | | | | | | | | | 510 | 392 | 356 | 342 | 325 | 234 | 141 | 85 | 75 | 71 | 201 | 210 | 159 | 113 | 71 | 51 | 46 | 43 | 39 | 36 | 33 | 30 | 28 | 114 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lateral emissions as a percentage of residual | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 1% | 63% | 61% | 62% | 63% | 63% | 47% | 67% | 65% | 63% | 63% | 64% | 64% | 64% | 64% | 64% | 64% | 64% | 64% | 66% |

**Gas to Engines and Flares m3/h**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | | | | | | | | | | | | | | | 368 | 382 | 399 | 423 | 438 | 469 | 487 | 1062 | 899 | 617 | 550 | 524 | 1049 | 1028 | 944 | 866 | 776 | 529 | 523 | 523 | 523 | 504 | 463 | 426 | 392 | 360 | 331 | 305 | 281 | 258 | 101 |
| 10% Less Than | | | | | | | | | | | | | | | 434 | 451 | 472 | 494 | 518 | 550 | 569 | 1078 | 926 | 688 | 550 | 525 | 1050 | 1037 | 956 | 877 | 805 | 545 | 523 | 523 | 523 | 511 | 470 | 432 | 397 | 365 | 336 | 309 | 284 | 262 | 142 |
| 25% Less Than | | | | | | | | | | | | | | | 542 | 565 | 597 | 621 | 641 | 685 | 717 | 1097 | 980 | 825 | 550 | 527 | 1053 | 1048 | 980 | 899 | 825 | 613 | 525 | 525 | 525 | 520 | 482 | 443 | 407 | 374 | 344 | 317 | 291 | 268 | 208 |
| 50% Less Than | | | | | | | | | | | | | | | 669 | 700 | 736 | 767 | 797 | 849 | 883 | 1145 | 1047 | 907 | 688 | 532 | 1056 | 1053 | 1004 | 921 | 846 | 696 | 528 | 528 | 528 | 524 | 494 | 454 | 417 | 384 | 353 | 325 | 299 | 275 | 253 |
| 75% Less Than | | | | | | | | | | | | | | | 797 | 832 | 873 | 915 | 948 | 1008 | 1050 | 1259 | 1087 | 969 | 858 | 631 | 1059 | 1057 | 1026 | 943 | 866 | 778 | 531 | 531 | 531 | 528 | 506 | 465 | 427 | 393 | 362 | 333 | 306 | 282 | 260 |
| 90% Less Than | | | | | | | | | | | | | | | 901 | 943 | 984 | 1043 | 1074 | 1142 | 1190 | 1338 | 1099 | 1011 | 895 | 755 | 1062 | 1061 | 1042 | 963 | 885 | 813 | 532 | 532 | 532 | 531 | 517 | 476 | 438 | 403 | 371 | 341 | 314 | 289 | 266 |
| 95% Less Than | | | | | | | | | | | | | | | 956 | 996 | 1048 | 1100 | 1139 | 1212 | 1268 | 1416 | 1100 | 1042 | 923 | 817 | 1064 | 1063 | 1049 | 978 | 898 | 825 | 533 | 533 | 533 | 532 | 521 | 483 | 444 | 409 | 376 | 346 | 318 | 293 | 270 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Actual gas to Engines | | | | | | | | | | | | | | | | | | | | | | | 1200 | 926 | 735 | 585 | 507 | 501 | 424 | 392 | 409 | 403 | 390 | 366 | 344 | 333 | | | | | | | | | |

**Gas to Flares m3/h**

| X Co-ordinates | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5% Less Than | | | | | | | | | | | | | | | 368 | 382 | 399 | 423 | 438 | 469 | 487 | | | | | | | | | | | | | | | | | | | | | | | | |
| 10% Less Than | | | | | | | | | | | | | | | 434 | 451 | 472 | 494 | 518 | 550 | 569 | | | | | | | | | | | | | | | | | | | | | | | | |
| 25% Less Than | | | | | | | | | | | | | | | 542 | 565 | 597 | 621 | 641 | 685 | 717 | | | | | | | | | | | | | | | | | | | | | | | | |
| 50% Less Than | | | | | | | | | | | | | | | 669 | 700 | 736 | 767 | 797 | 849 | 883 | | | | | | | | | | | | | | | | | | | | | | | | |
| 75% Less Than | | | | | | | | | | | | | | | 797 | 832 | 873 | 915 | 948 | 1008 | 1050 | | | | | | | | | | | | | | | | | | | | | | | | |
| 90% Less Than | | | | | | | | | | | | | | | 901 | 943 | 984 | 1043 | 1074 | 1142 | 1190 | | | | | | | | | | | | | | | | | | | | | | | | |
| 95% Less Than | | | | | | | | | | | | | | | 956 | 996 | 1048 | 1100 | 1139 | 1212 | 1268 | | | | | | | | | | | | | | | | | | | | | | | | |

**Table A6. Yearly Recoverable Gas Resource Calculations 2000-2050**

| Enderby Warren | | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gas Field Coverage** | **% of gas lost** | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % | % |
| **Operational area with no gas system installed (%)** | 100 | 10 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Operational area with sacrificial gas system installed (%)** | 50 | 0 | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Temporary capped without gas control (%)** | 100 | 10 | 10 | 15 | 15 | 20 | 20 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Temporary capped with gas control (%)** | 15 | 80 | 80 | 80 | 80 | 80 | 80 | 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Permanently capped without gas control (%)** | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Permanently capped with gas control (%)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Cell flanks with no gas control (%)** | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Overtipped areas with buried or damaged gas field (%)** | 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Area check (%), need to be 100%** | | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| **Other Gas Field Losses** | **% of gas lost** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Stockpiled areas without gas collection (%)** | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Areas subject to landfill hotspots/fires (%)** | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Areas subject to high/perched leachate (%)** | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Other potential gas recovery loss factors (%)** | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 45 | 45 | 45 | 45 | 40 | 35 | 35 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| **Area affected by failed/decommissioned wells (%)** | 100 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| **Area check (%), need to be <100%** | | 10 | 10 | 10 | 10 | 10 | 10 | 20 | 55 | 55 | 55 | 55 | 50 | 45 | 45 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| **Engine and Grid Losses** | **Power lost %** | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Scheduled maintenance downtime (%)** | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% |
| **Unscheduled maintenance downtime (%)** | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% | 3.5% |
| **Parasitic losses (%)** | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% | 5.0% |
| **Potential excess gas flared (kWh/h)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Recoverable Gas Resource** | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| **Gas collection efficiency based on coverage only (%)** | | 68% | 68% | 71% | 71% | 68% | 68% | 68% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| **Other gas field losses as a percentage of the recoverable gas (%)** | | 10% | 10% | 10% | 10% | 10% | 10% | 20% | 55% | 55% | 55% | 55% | 50% | 45% | 45% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% | 40% |
| **Overall gas collection efficiency (%)** | | 58% | 58% | 61% | 61% | 58% | 58% | 48% | 45% | 45% | 45% | 45% | 50% | 55% | 55% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% | 60% |
| **Engine and Grid Losses (%)** | | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% | 12% |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** | **m3/h** |
| **Bulk gas generation before any losses (m3/h)** | | 2883 | 3007 | 2520 | 2093 | 1807 | 1600 | 1438 | 1304 | 1188 | 1086 | 994 | 911 | 836 | 767 | 704 | 647 | 594 | 546 | 502 | 461 | 424 | 390 | 359 | 331 | 304 | 280 |
| **Recoverable gas at the compound (m3/h)** | | 1672 | 1744 | 1524 | 1266 | 1048 | 928 | 690 | 587 | 535 | 489 | 447 | 456 | 460 | 422 | 422 | 388 | 356 | 328 | 301 | 277 | 255 | 234 | 216 | 198 | 183 | 168 |
| **Forecast energy exported (m3/h)** | | 1471 | 1535 | 1341 | 1114 | 922 | 817 | 607 | 516 | 471 | 430 | 394 | 401 | 405 | 371 | 372 | 341 | 314 | 288 | 265 | 244 | 224 | 206 | 190 | 175 | 161 | 148 |
| **Actual Energy Exported (m3/h equivalent)** | | 0 | 0 | 0 | 1200 | 926 | 735 | 585 | 507 | 501 | 424 | 392 | 409 | 403 | 390 | 366 | 344 | 333 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Residual Gas (Surface Emissions and Lateral Migration)** | | 1211 | 1263 | 995 | 827 | 759 | 672 | 748 | 717 | 654 | 597 | 547 | 456 | 376 | 345 | 282 | 259 | 238 | 218 | 201 | 185 | 170 | 156 | 144 | 132 | 122 | 112 |
| **Surface Emissions** | 31% | 375 | 392 | 309 | 256 | 235 | 208 | 232 | 222 | 203 | 185 | 170 | 141 | 117 | 107 | 87 | 80 | 74 | 68 | 62 | 57 | 53 | 48 | 45 | 41 | 38 | 35 |
| **Lateral Migration** | 69% | 835 | 872 | 687 | 571 | 524 | 464 | 516 | 495 | 451 | 412 | 377 | 314 | 260 | 238 | 194 | 178 | 164 | 151 | 139 | 127 | 117 | 108 | 99 | 91 | 84 | 77 |

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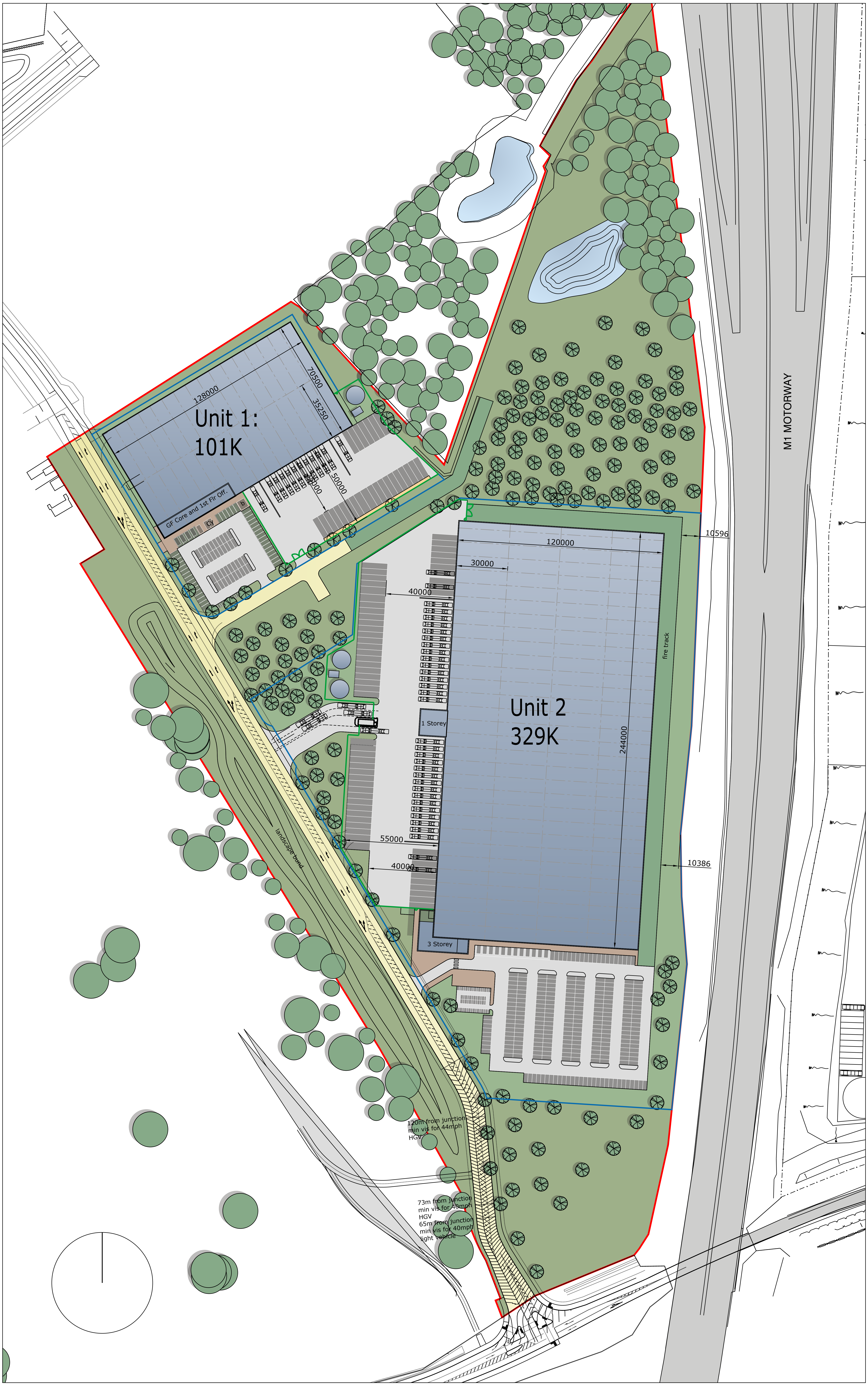
# Appendix B

## Supplied Information on Location of Warehouse Units and Investigation Boreholes

REVISIONS
A: kbl 12/08/16 Area adjusment to Unit 2.
B: kbl 15/08/16 Client comments incorporated.



**Site area:** 151,236sq.m. / 37.37 acres / 15.12 hectares

**Unit 1:**
Warehouse = 9,024 sq.m. [97,125 sq.ft.]
Office [1st flr] = 384 sq.m. [4,100 sq.ft.]
Total GIA = 9,408 sq.m. [101,225 sq.ft]
Nett Site area = 18,969 sq.m. [204,182 sq ft] 4.69 Acres/1.90 Hectares
Density = 49.6%
No. Docks Doors = 10
No Level Access Doors = 2
No Trailers = 39
No Cars [inc wheelchair] =82 [4 whchr]
No of Cycles =24
No of Motorcycles = 9
Haunch = 12m

**Unit 2:**
Warehouse = 29,275 sq.m. [315,117 sq.ft.]
Office [3 Storey] = 1,068 sq.m. [11,500 sq.ft.]
Hub Office [1 storey] = 234 sq.m. [2,525 sq.ft.]
Gatehouse = 26.9 sq.m. [289 sq.ft]
Total GIA [excluding gatehouse] = 30,577 sq.m. [329,142 sq.ft]
Nett Site area = 66,280 sq.m. [713,430 sq.ft.] 16.38 Acres/6.63 Hectares
Density = 46.1%
No. Docks Doors = 30
No Level Access Doors = 4
No Trailers = 90
No Cars [inc wheelchair] = 270 [12 whlchr]
No of Cycles = 80
No of Motorcycles = 28
Haunch = 15m

Architects | Masterplanners
**STEPHEN GEORGE**
& PARTNERS LLP

170 London Road
Leicester LE2 1ND

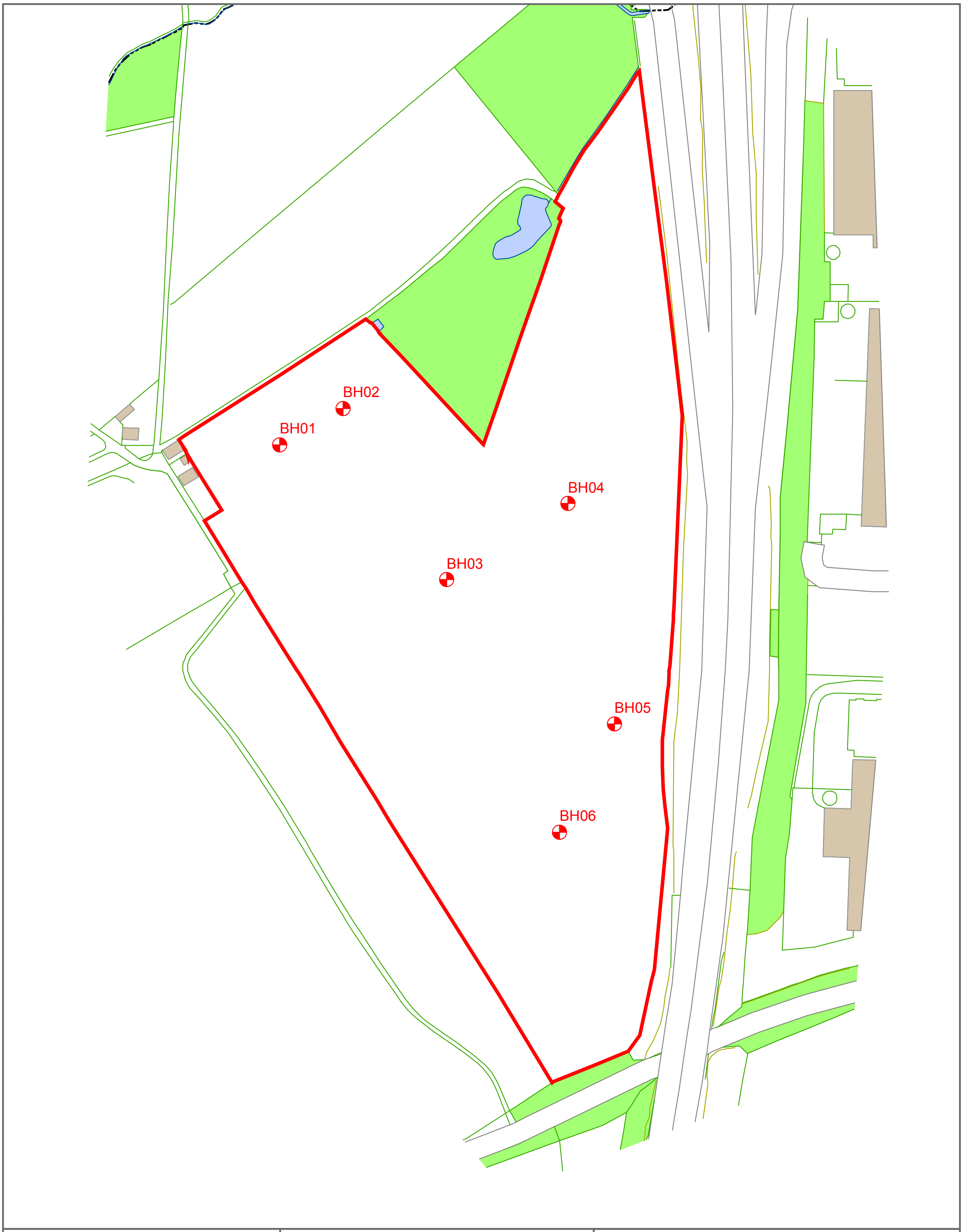
**t:** 0116 247 0557 **f:** 0116 254 1095
www.stephengeorge.co.uk

Lubbesthorpe - Leicester

Masterplan

| | |
|---|---|
| Drawing status: | Preliminary |
| Cad reference: | 10-101 MP11 |
| Drawn: | CDW |
| Team: | CDW |
| Date: | Aug 2016 |
| Scale: | 1:1500 @ A2 |

| Project no: | Dwg no: | Rev: |
|---|---|---|
| 10-101 | MP11-001 | B |



🟥 Site Boundary

⊕ Borehole Location

0 20 40 60 80 100
Metres

N

## Figure 2
## Borehole Location Plan
## Lubbesthorpe, LE19 4SA

SCALE: See Scale Bar
SIZE: A4
PROJECT: 0383453
DATE: 20/12/2016

VERSION: A
DRAWN: MTC
CHECKED: PB
APPROVED: ADS

ERM

Goodman

PROJECTION: British National Grid

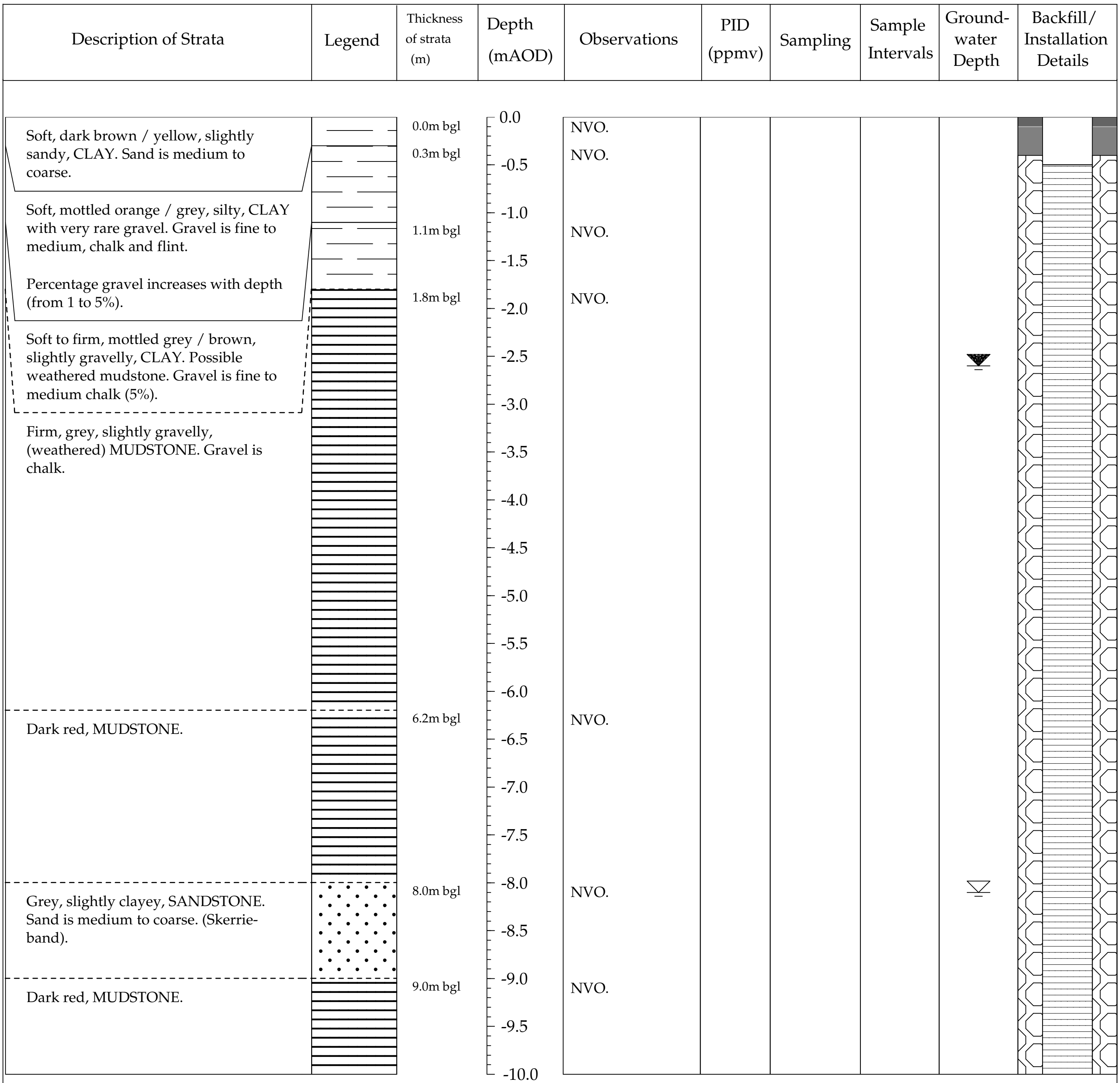
SOURCE: Reproduced from Ordnance Survey digital map data. © Crown copyright, All rights reserved. 2016 License number 0100031673.

Path: P:\Projects\0383453 Goodman Lubbesthorpe.CIY\GIS\MAPS\00383453_BoreholeLocationPlan_A01.mxd

# Environmental Resources Management
## Borehole Log

Borehole No.
**BH01**
Page 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| Client: | **Goodman** | Drilling Method: | **Solid Stem - 'Rock Roller'** | Coordinates: | **454293.130** |
| Location: | **Lubbesthorpe, Leicester** | Drill Rig Type: | **MI3** | | **300172.428** |
| Project No: | **0383453** | Borehole Diameter: | **100mm** | Ground Level: | **77.618m ASL** |
| Completed by: | **PB** | Logged by: | **Peter Bray** | Total Depth: | **10m** |
| Checked by: | **CIY** | Dates Drilled: | **12/12/2016** | | |



| Description of Strata | Thickness of strata (m) | Observations |
|---|---|---|
| Soft, dark brown / yellow, slightly sandy, CLAY. Sand is medium to coarse. | 0.0m bgl | NVO. |
| Soft, mottled orange / grey, silty, CLAY with very rare gravel. Gravel is fine to medium, chalk and flint.<br>Percentage gravel increases with depth (from 1 to 5%). | 0.3m bgl | NVO. |
| Soft to firm, mottled grey / brown, slightly gravelly, CLAY. Possible weathered mudstone. Gravel is fine to medium chalk (5%). | 1.1m bgl | NVO. |
| Firm, grey, slightly gravelly, (weathered) MUDSTONE. Gravel is chalk. | 1.8m bgl | NVO. |
| Dark red, MUDSTONE. | 6.2m bgl | NVO. |
| Grey, slightly clayey, SANDSTONE. Sand is medium to coarse. (Skerrie-band). | 8.0m bgl | NVO. |
| Dark red, MUDSTONE. | 9.0m bgl | NVO. |

**Remarks:**

m bgl: metres below ground level.
NVO: no visual or olfactory evidence of impact.
Hand excavated to 1.5m bgl prior to drilling work.
Borehole installed with raised headworks to 0.5m above ground level.

**Groundwater:**

▽ Strike: 8.1m bgl

▼ Depth:2.6m bgl

mASL = Metres Above Sea Level
mAOD = Metres Above Ordnance Datum

**Backfill/Installation Details:**

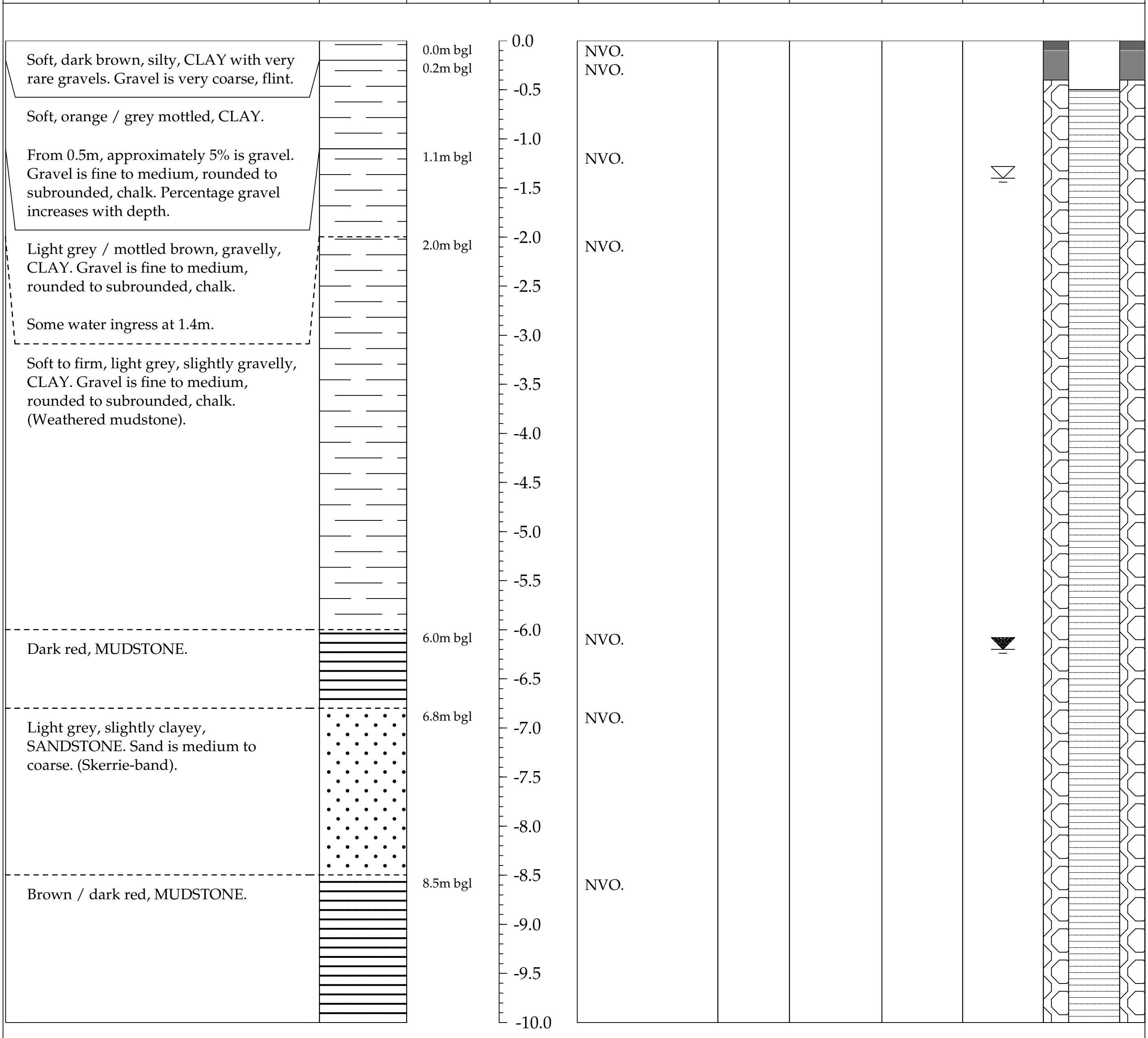
| | |
|---|---|
| Concrete: | 0.0 - 0.1m |
| Bentonite: | 0.1 - 0.4m |
| Gravel: | 0.4 - 10m |
| Plain pipe: | 0.0 - 0.5m |
| Slotted screen: | 0.5 - 10m |
| Well diameter: | 100mm |
| Slot size: | 1mm |
| Well material: | HDPE |
| Backfill: | - |

# Environmental Resources Management

## Borehole Log

Borehole No.
**BH02**
Page 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| Client: | **Goodman** | Drilling Method: | **Solid Stem - 'Rock Roller'** | Coordinates: | **454341.375** |
| Location: | **Lubbesthorpe, Leicester** | Drill Rig Type: | **MI3** | | **300200.198** |
| Project No: | **0383453** | Borehole Diameter: | **100mm** | Ground Level: | **75.211m ASL** |
| Completed by: | **PB** | Logged by: | **Peter Bray** | Total Depth: | **10m** |
| Checked by: | **CIY** | Dates Drilled: | **13/12/2016** | | |



| Description of Strata | Legend | Thickness of strata (m) | Depth (mAOD) | Observations | PID (ppmv) | Sampling | Sample Intervals | Ground-water Depth | Backfill/ Installation Details |
|---|---|---|---|---|---|---|---|---|---|
| Soft, dark brown, silty, CLAY with very rare gravels. Gravel is very coarse, flint. | | 0.0m bgl | 0.0 | NVO. | | | | | |
| Soft, orange / grey mottled, CLAY.<br>From 0.5m, approximately 5% is gravel. Gravel is fine to medium, rounded to subrounded, chalk. Percentage gravel increases with depth. | | 0.2m bgl | | NVO. | | | | | |
| Light grey / mottled brown, gravelly, CLAY. Gravel is fine to medium, rounded to subrounded, chalk.<br>Some water ingress at 1.4m. | | 1.1m bgl | | NVO. | | | | | |
| Soft to firm, light grey, slightly gravelly, CLAY. Gravel is fine to medium, rounded to subrounded, chalk. (Weathered mudstone). | | 2.0m bgl | | NVO. | | | | | |
| Dark red, MUDSTONE. | | 6.0m bgl | | NVO. | | | | | |
| Light grey, slightly clayey, SANDSTONE. Sand is medium to coarse. (Skerrie-band). | | 6.8m bgl | | NVO. | | | | | |
| Brown / dark red, MUDSTONE. | | 8.5m bgl | | NVO. | | | | | |

**Remarks:**

m bgl: metres below ground level.
NVO: no visual or olfactory evidence of impact.
Hand excavated to 1.5m bgl prior to drilling work.
Borehole installed with raised headworks to 0.5m above ground level.

**Groundwater:**

▽ Strike: 1.4m bgl
▼ Depth:6.2m bgl

mASL = Metres Above Sea Level
mAOD = Metres Above Ordnance Datum

**Backfill/Installation Details:**

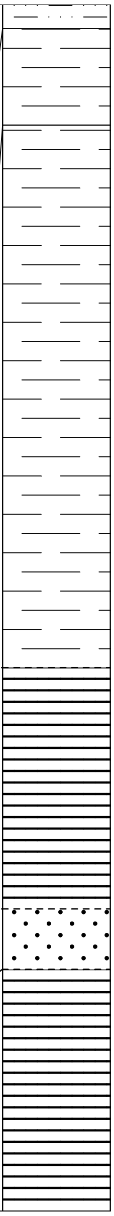
| | |
|---|---|
| Concrete: | 0.0 - 0.1m |
| Bentonite: | 0.1 - 0.4m |
| Gravel: | 0.4 - 10m |
| Plain pipe: | 0.0 - 0.5m |
| Slotted screen: | 0.5 - 10m |
| Well diameter: | 100mm |
| Slot size: | 1mm |
| Well material: | HDPE |
| Backfill: | - |

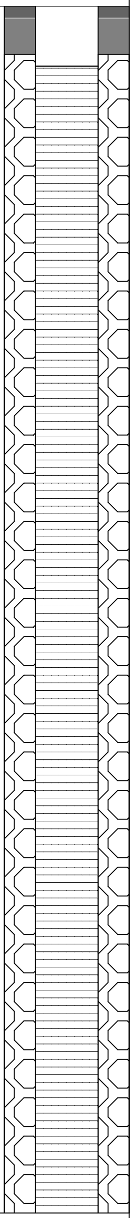
# Environmental Resources Management
## Borehole Log

Borehole No.
**BH03**
Page 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| Client: | **Goodman** | Drilling Method: | **Solid Stem - 'Rock Roller'** | Coordinates: | **454420.809** |
| Location: | **Lubbesthorpe, Leicester** | Drill Rig Type: | **MI3** | | **300069.345** |
| Project No: | **0383453** | Borehole Diameter: | **100mm** | Ground Level: | **76.470m ASL** |
| Completed by: | **PB** | Logged by: | **Peter Bray** | Total Depth: | **10m** |
| Checked by: | **CIY** | Dates Drilled: | **13/12/2016** | | |

| Description of Strata | Legend | Thickness of strata (m) | Depth (mAOD) | Observations | PID (ppmv) | Sampling | Sample Intervals | Groundwater Depth | Backfill/ Installation Details |
|---|---|---|---|---|---|---|---|---|---|
| Soft, light brown, slightly clayey, slightly gravelly, SAND. Sand is fine to medium. Gravel is fine to coarse, flint and chalk (<5%). | | 0.0m bgl<br>0.2m bgl | 0.0<br>-0.5 | NVO.<br>NVO. | | | | | |
| Soft to firm, light grey / brown mottled, slightly gravelly, CLAY. Gravel is fine to medium, chalk.<br>Clay becomes red and slightly silty with depth. | | 1.0m bgl | -1.0<br>-1.5<br>-2.0 | NVO. | | | | ▽ | |
| Soft, red / brown, silty, slightly sandy, slightly gravelly, CLAY. Gravel is chalk. (Weathered mudstone). | | | -2.5<br>-3.0<br>-3.5<br>-4.0<br>-4.5<br>-5.0 | | | | | | |
| Dark red, MUDSTONE. | | 5.5m bgl | -5.5<br>-6.0<br>-6.5<br>-7.0 | NVO. | | | | | |
| Hard, grey / white, slightly clayey, SANDSTONE. | | 7.5m bgl | -7.5 | NVO. | | | | | |
| Dark red, MUDSTONE. | | 8.0m bgl | -8.0<br>-8.5<br>-9.0<br>-9.5<br>-10.0 | NVO. | | | | ▼ | |





**Remarks:**

m bgl: metres below ground level.
NVO: no visual or olfactory evidence of impact.
Hand excavated to 1.5m bgl prior to drilling work.
Borehole installed with raised headworks to 0.5m above ground level.

**Groundwater:**

▽ Strike: 1.5m bgl
▼ Depth:8.0m bgl

mASL = Metres Above Sea Level
mAOD = Metres Above Ordnance Datum

**Backfill/Installation Details:**

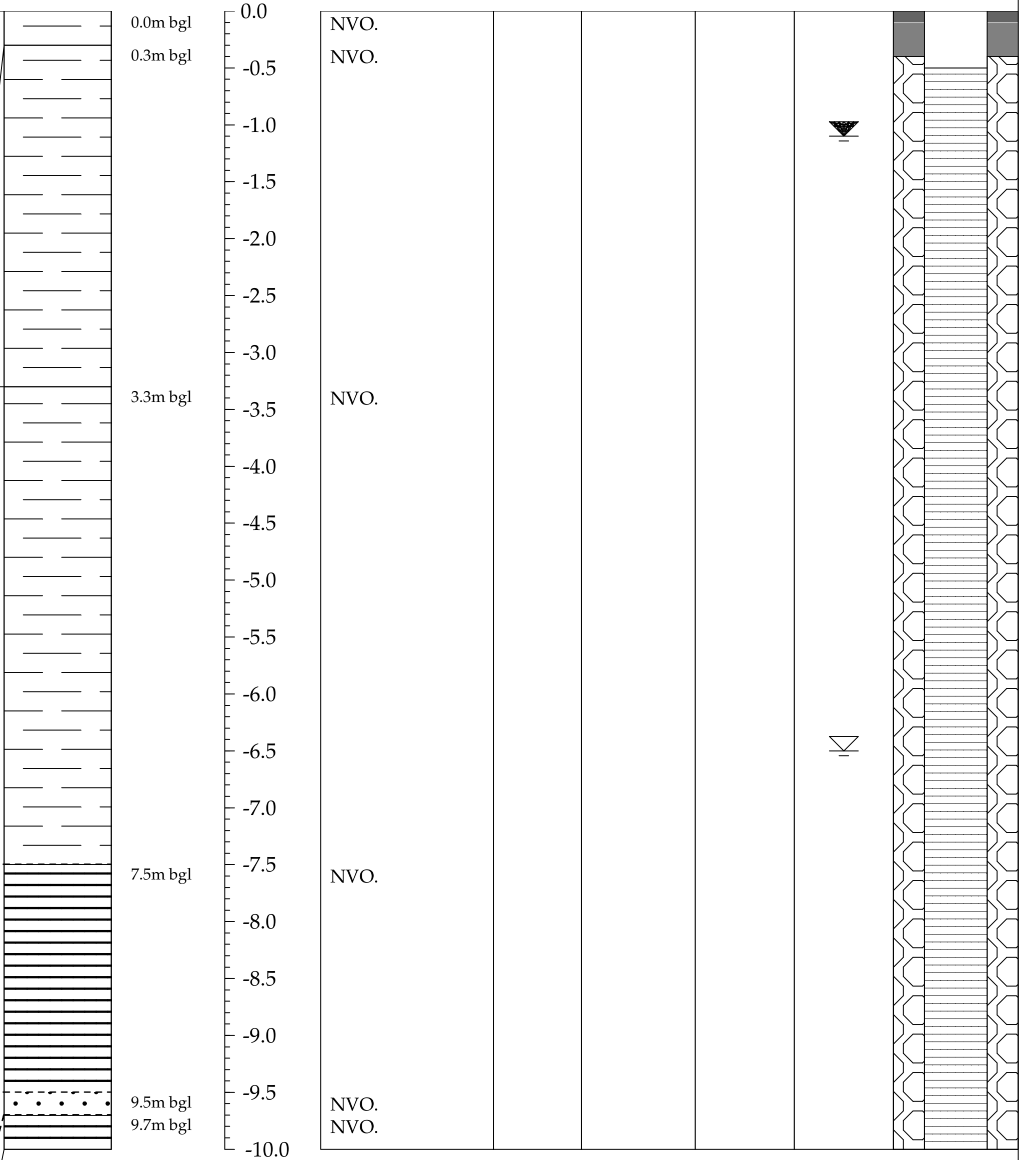
| | |
|---|---|
| Concrete: | 0.0 - 0.1m |
| Bentonite: | 0.1 - 0.4m |
| Gravel: | 0.4 - 10m |
| Plain pipe: | 0.0 - 0.5m |
| Slotted screen: | 0.5 - 10m |
| Well diameter: | 100mm |
| Slot size: | 1mm |
| Well material: | HDPE |
| Backfill: | - |

# Environmental Resources Management
## Borehole Log

Borehole No.
**BH04**
Page 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| Client: | **Goodman** | Drilling Method: | **Solid Stem - 'Rock Roller'** | Coordinates: | **454513.541** |
| Location: | **Lubbesthorpe, Leicester** | Drill Rig Type: | **MI3** | | **300127.476** |
| Project No: | **0383453** | Borehole Diameter: | **100mm** | Ground Level: | **75.854m ASL** |
| Completed by: | **PB** | Logged by: | **Peter Bray** | Total Depth: | **10m** |
| Checked by: | **CIY** | Dates Drilled: | **14/12/2016** | | |

| Description of Strata | Legend | Thickness of strata (m) | Depth (mAOD) | Observations | PID (ppmv) | Sampling | Sample Intervals | Ground-water Depth | Backfill/ Installation Details |
|---|---|---|---|---|---|---|---|---|---|
| Soft, dark brown, very silty, CLAY. | | 0.0m bgl | 0.0 | NVO. | | | | | |
| Some black, organic / 'coal-like' material at base of layer (fines upwards). | | 0.3m bgl | | NVO. | | | | ▼ | |
| Slightly firm, red / brown, silty, sandy, CLAY with occasional cobbles of flint and gravel of fine to medium, rounded to subrounded chalk.<br>From 1.5m, approximately 1m containing pockets (5cm x 5cm) of light brown / yellow, siltly, SAND. | | | | | | | | | |
| Firm, grey, gravelly, CLAY. Gravel is medium to coarse, flint. (Weathered mudstone).<br>Water encountered at 5.5m, approximately 0.2m thick. | | 3.3m bgl | | NVO. | | | | ▽ | |
| Red, slightly silty, MUDSTONE. | | 7.5m bgl | | NVO. | | | | | |
| Grey / white, slightly clayey, SANDSTONE. (Skerrie-band). | | 9.5m bgl | | NVO. | | | | | |
| Red, slightly silty, MUDSTONE. | | 9.7m bgl | -10.0 | NVO. | | | | | |



**Remarks:**

m bgl: metres below ground level.

NVO: no visual or olfactory evidence of impact.

Hand excavated to 1.5m bgl prior to drilling work.

Borehole installed with raised headworks to 0.5m above ground level.

**Groundwater:**

▽ Strike: 6.5m bgl

▼ Depth:1.1m bgl

mASL = Metres Above Sea Level
mAOD = Metres Above Ordnance Datum

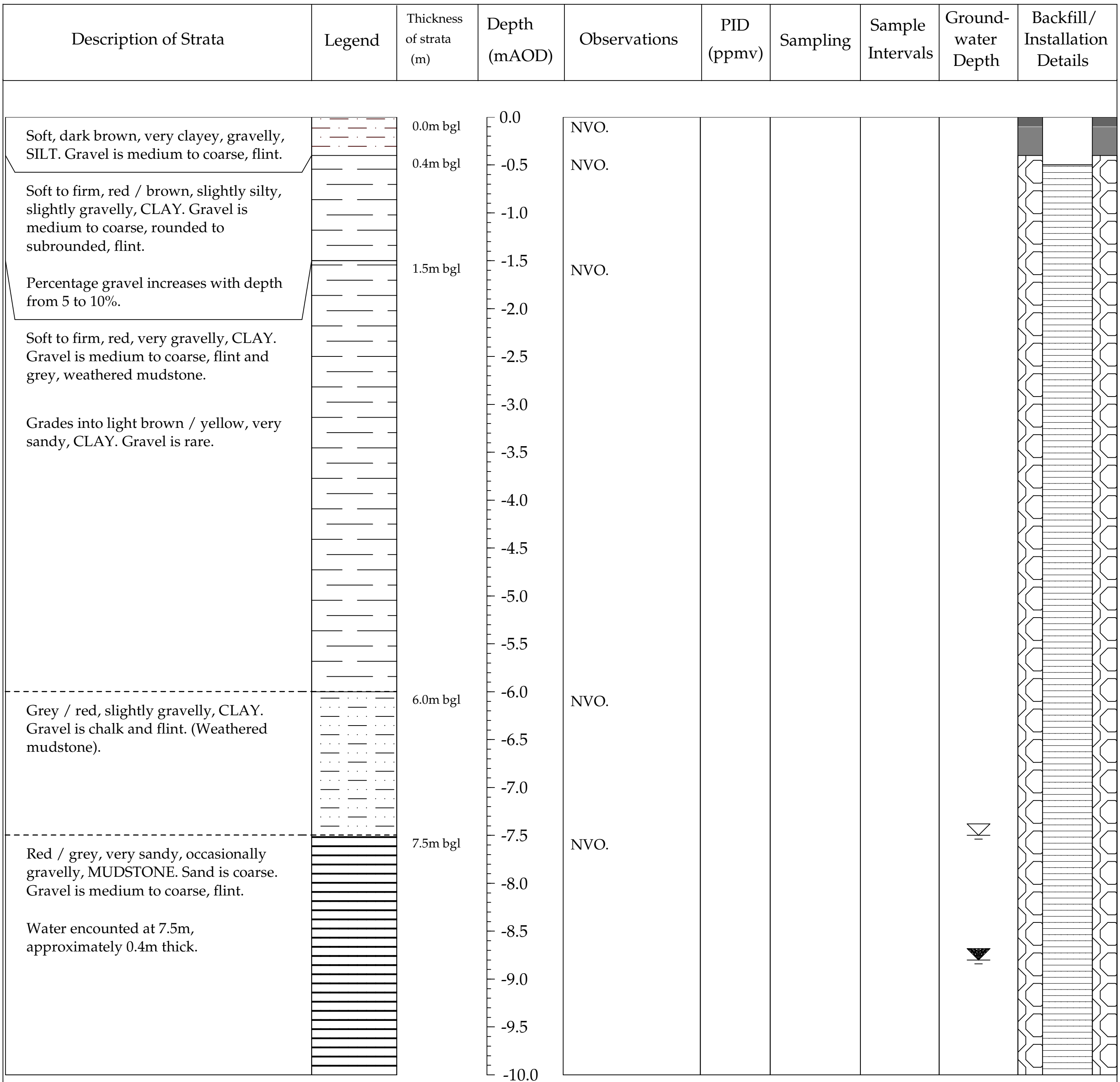
**Backfill/Installation Details:**

| | |
|---|---|
| Concrete: | 0.0 - 0.1m |
| Bentonite: | 0.1 - 0.4m |
| Gravel: | 0.4 - 10m |
| Plain pipe: | 0.0 - 0.5m |
| Slotted screen: | 0.5 - 10m |
| Well diameter: | 100mm |
| Slot size: | 1mm |
| Well material: | HDPE |
| Backfill: | - |

# Environmental Resources Management
## Borehole Log

Borehole No.
**BH05**
Page 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| Client: | **Goodman** | Drilling Method: | **Solid Stem - 'Rock Roller'** | Coordinates: | **454549.109** |
| Location: | **Lubbesthorpe, Leicester** | Drill Rig Type: | **MI3** | | **299959.245** |
| Project No: | **0383453** | Borehole Diameter: | **100mm** | Ground Level: | **81.676m ASL** |
| Completed by: | **PB** | Logged by: | **Peter Bray** | Total Depth: | **10m** |
| Checked by: | **CIY** | Dates Drilled: | **14/12/2016** | | |



| Description of Strata | Thickness of strata (m) | Observations | PID (ppmv) | Sampling | Sample Intervals | Groundwater Depth |
|---|---|---|---|---|---|---|
| Soft, dark brown, very clayey, gravelly, SILT. Gravel is medium to coarse, flint. | 0.0m bgl | NVO. | | | | |
| Soft to firm, red / brown, slightly silty, slightly gravelly, CLAY. Gravel is medium to coarse, rounded to subrounded, flint.<br>Percentage gravel increases with depth from 5 to 10%. | 0.4m bgl | NVO. | | | | |
| Soft to firm, red, very gravelly, CLAY. Gravel is medium to coarse, flint and grey, weathered mudstone.<br>Grades into light brown / yellow, very sandy, CLAY. Gravel is rare. | 1.5m bgl | NVO. | | | | |
| Grey / red, slightly gravelly, CLAY. Gravel is chalk and flint. (Weathered mudstone). | 6.0m bgl | NVO. | | | | |
| Red / grey, very sandy, occasionally gravelly, MUDSTONE. Sand is coarse. Gravel is medium to coarse, flint.<br>Water encounted at 7.5m, approximately 0.4m thick. | 7.5m bgl | NVO. | | | | ▽<br>▼ |

**Remarks:**

m bgl: metres below ground level.
NVO: no visual or olfactory evidence of impact.
Hand excavated to 1.5m bgl prior to drilling work.
Borehole installed with raised headworks to 0.5m above ground level.

**Groundwater:**

▽ Strike: 7.5m bgl
▼ Depth:8.8m bgl

mASL = Metres Above Sea Level
mAOD = Metres Above Ordnance Datum

**Backfill/Installation Details:**

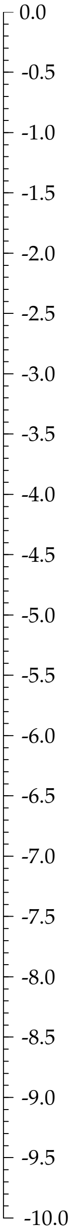
| | |
|---|---|
| Concrete: | 0.0 - 0.1m |
| Bentonite: | 0.1 - 0.4m |
| Gravel: | 0.4 - 10m |
| Plain pipe: | 0.0 - 0.5m |
| Slotted screen: | 0.5 - 10m |
| Well diameter: | 100mm |
| Slot size: | 1mm |
| Well material: | HDPE |
| Backfill: | - |

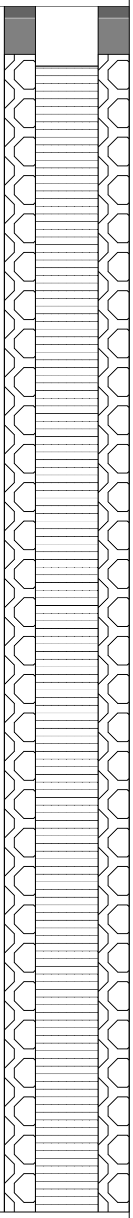
# Environmental Resources Management
## Borehole Log

Borehole No.
**BH06**
Page 1 of 1

| | | | | | |
|---|---|---|---|---|---|
| Client: | **Goodman** | Drilling Method: | **Solid Stem - 'Rock Roller'** | Coordinates: | **454507.120** |
| Location: | **Lubbesthorpe, Leicester** | Drill Rig Type: | **MI3** | | **299876.378** |
| Project No: | **0383453** | Borehole Diameter: | **100mm** | Ground Level: | **80.757m ASL** |
| Completed by: | **PB** | Logged by: | **Peter Bray** | Total Depth: | **10m** |
| Checked by: | **CIY** | Dates Drilled: | **15/12/2016** | | |

| Description of Strata | Legend | Thickness of strata (m) | Depth (mAOD) | Observations | PID (ppmv) | Sampling | Sample Intervals | Ground-water Depth | Backfill/ Installation Details |
|---|---|---|---|---|---|---|---|---|---|
| Very soft, red / brown, silty, slightly gravelly, CLAY. Gravel is medium to coarse, subangular to rounded, flint and lithics.<br>Becomes firmer (to soft) with depth. | | 0.0m bgl | | NVO. | | | | | |
| Soft, light brown, rare gravelly, CLAY. Gravel is medium to coarse, subangular to rounded, flint and lithics. | | 2.5m bgl | | NVO. | | | | | |
| Red, sandy, MUDSTONE. | | 4.0m bgl | | NVO. | | | | | |
| Grey / white, slightly clayey, SANDSTONE. (Skerrie-band).<br>Some small interbeds with the red mudstone ~0.1m thick. | | 5.0m bgl | | NVO. | | | | | |
| Red, very sandy, MUDSTONE. Sand is medium to coarse. | | 5.8m bgl | | NVO. | | | | | |
| Hard, white, SANDSTONE. (Skerrie-band). | | 6.5m bgl | | NVO. | | | | | |
| Red, very sandy, MUDSTONE. Sand is medium to coarse. | | 7.0m bgl | | NVO. | | | | | |
| Dark grey, very sandy, gravelly, MUDSTONE. Gravel is flint. | | 8.2m bgl | | NVO. | | | | | |





**Remarks:**

m bgl: metres below ground level.
NVO: no visual or olfactory evidence of impact.
Hand excavated to 1.5m bgl prior to drilling work.
Borehole installed with raised headworks to 0.5m above ground level.

**Groundwater:**

▽ Strike: Dry
▼ Depth:Dry

mASL = Metres Above Sea Level
mAOD = Metres Above Ordnance Datum

**Backfill/Installation Details:**

| | |
|---|---|
| Concrete: | 0.0 - 0.1m |
| Bentonite: | 0.1 - 0.4m |
| Gravel: | 0.4 - 10m |
| Plain pipe: | 0.0 - 0.5m |
| Slotted screen: | 0.5 - 10m |
| Well diameter: | 100mm |
| Slot size: | 1mm |
| Well material: | HDPE |
| Backfill: | - |

# Appendix C

## Supplied Information on Route of New Arterial Road

## Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key Plan

### ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 13.10.16 | PRELIMINARY ISSUE FOR REVIEW | FT | KJ |

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Client
**THE TRUSTEES OF DRUMMOND ESTATE**

Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

Drawing Title
**ROAD ALIGNMENT EFFECT ON SITA - OPTION 1**

Drawn: F.Taleb
Reviewed: K.James
BWB Ref: NTH2304
Date: 13.10.16
Scale@A1: 1:250

Drawing Status
**DRAFT**

Project - Originator - Zone - Level - Type - Role - Number
**ERR-BWB-HGN-XX-DR-D-SK02**
Status
**S1**
Rev
**P1**

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## Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key Plan

ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 13.10.16 | PRELIMINARY ISSUE FOR REVIEW | FT | KJ |

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Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

Drawing Title
**ROAD ALIGNMENT EFFECT ON SITA - OPTION 2**

| | | | | | |
|---|---|---|---|---|---|
| Drawn: | F.Taleb | | Reviewed: | K.James | |
| BWB Ref: | NTH2304 | Date: | 13.10.16 | Scale@A1: | 1:250 |

Drawing Status
**DRAFT**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-HGN-XX-DR-D-SK03 | S1 | P1 |

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# APPENDIX F BWB DRAWINGS

For Junction Improvement Works Refer to RPS Drawing

REFER TO DRAWING ERR-BWB-HSN-8B-DR-D-1204

## Road Markings Schedule

Refer to Traffic Signs Regulations and General Directions 2016

| DIAG No. | SYMBOL | LINE | GAP | WIDTH | DIAGONAL | SIZE | COLOUR | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 1018.1 | 🟨 | - - | 100mm | 100mm | - - | - - | YELLOW | WAITING OF VEHICLES ON A LENGTH OF ROAD PROHIBITED AT ANY TIME |

## Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key

| | |
|---|---|
| ═ | Existing Road Markings |
| 🟨 | Proposed 'Double Yellow' Restriction Road Markings |
| 🟥 | Planning Redline Boundary |

ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 24.11.20 | Issued for Planning | DH | DH |
| P2 | 08.12.20 | Planning boundary amended | DH | DH |

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Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

Drawing Title
**ENDERBY RELIEF ROAD TRAFFIC REGULATION ORDER PLAN SHEET 1**

| | | | |
|---|---|---|---|
| Drawn: | D. Hodgson | Reviewed: | D. Hodgson |
| BWB Ref: | NTH 2304 | Date: | 24.11.20 |
| Scale@A1: | 1:1000 | | |

Drawing Status
**PLANNING**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-HSN-8B-DR-D-1203 | S8 | P2 |

Proposed road markings to tie in with those being implemented as part of separate S38 works

For details refer to drawing LUB-BWB-HML-S38-DR-S-0101 S38 General Arrangement

REFER TO DRAWING ERR-BWB-HSN-8B-DR-D-1203

## Road Markings Schedule

Refer to Traffic Signs Regulations and General Directions 2016

| DIAG No. | SYMBOL | LINE | GAP | WIDTH | DIAGONAL | SIZE | COLOUR | DESCRIPTION |
|---|---|---|---|---|---|---|---|---|
| 1018.1 | 🟨 | - - | 100mm | 100mm | - - | - - | YELLOW | WAITING OF VEHICLES ON A LENGTH OF ROAD PROHIBITED AT ANY TIME |

## Notes

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2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key

| | |
|---|---|
| ═ | Existing Road Markings |
| 🟨 | Proposed 'Double Yellow' Restriction Road Markings |
| 🟥 | Planning Redline Boundary |

## ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 20.11.20 | Issued for Planning | AR | DH |
| P2 | 08.12.20 | Planning boundary amended | DH | DH |

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Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

Drawing Title
**ENDERBY RELIEF ROAD TRAFFIC REGULATION ORDER PLAN SHEET 2**

| | | | | | |
|---|---|---|---|---|---|
| Drawn: | M. Ross | | Reviewed: | D. Hodgson | |
| BWB Ref: | NTH2304 | Date: | NOV '20 | Scale@A1: | 1:1000 |

Drawing Status
**PLANNING**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-HSN-8B-DR-D-1204 | S8 | P2 |

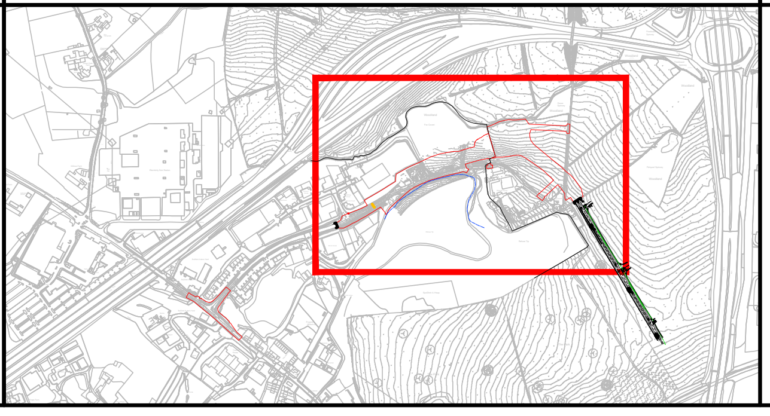
Important Notes:

- Layout Subject to review and approval from LCC
- Layout subject to a street lighting design

## Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key Plan



## Legend

| | |
|---|---|
| ━━ | Proposed Planning Boundary |
| ━ ━ ━ | Proposed Retained Earth Slope |
| — — — | Existing Public Right of Way |
| /\/\/\ | Existing Public Right of Way to be Removed/Diverted |
| —— —— | Junction Visibility Splay (2.4m x 120m) |
| — · — · | Extent of Existing Landfill |
| ━━ | Pedestrian route |

ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 30.10.20 | Preliminary Issue | MR | DH |
| P2 | 06.11.20 | Earthworks batters added | MR | DH |
| P3 | 20.11.20 | Issued for Planning. | MR | DH |
| P4 | 06.12.20 | Planning boundary amended | DH | DH |

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Client
**The Trustees of Drummond Estate**

Project Title
**Enderby Relief Road, Leicestershire**

Drawing Title
**Option 8B**

**Highway General Arrangement**

| | | | |
|---|---|---|---|
| Drawn: | M. Ross | Reviewed: | D. Hodgson |
| BWB Ref: | NTH 2304 | Date: | Sep' 20 |
| | | Scale@A1: | 1:1000 |

Drawing Status
**PLANNING**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-DGN-8B-DR-C-100 | S8 | P4 |

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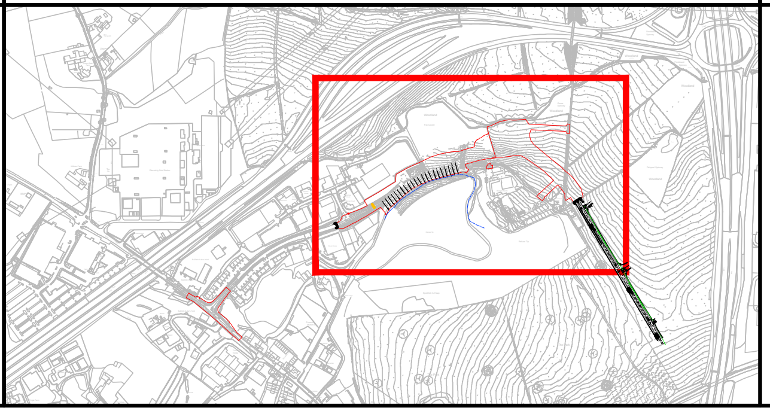
Important Notes:

- Layout Subject to review and approval from LCC
- Layout subject to a street lighting design

## Notes

1. Do not scale this drawing. All dimensions must be checked/ verified on site. If in doubt ask.
2. This drawing is to be read in conjunction with all relevant architects, engineers and specialists drawings and specifications.
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key Plan



## Legend

| | |
|---|---|
| 🟥 | Proposed Planning Boundary |
| 🟩 | Proposed Retained Earth Slope |
| — — | Existing Public Right of Way |
| /\/\/\ | Existing Public Right of Way to be Removed/Diverted |
| — — | Junction Visibility Splay (2.4m x 120m) |
| — · — | Extent of Existing Landfill |
| — | Pedestrian route |

## ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 30.10.20 | Preliminary Issue | MR | DH |
| P2 | 06.11.20 | Earthworks batters added | MR | DH |
| P3 | 20.11.20 | Issued for Planning. | MR | DH |
| P4 | 06.12.20 | Planning boundary amended | DH | DH |

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Project Title
**Enderby Relief Road, Leicestershire**

Drawing Title
**Option 8B**
**Highway General Arrangement - Quarry Wall Distance**

| | | | |
|---|---|---|---|
| Drawn: | M. Ross | Reviewed: | D. Hodgson |
| BWB Ref: | NTH 2304 | Date: | Sep' 20 |
| Scale@A1: | 1:1000 | | |

Drawing Status
**PLANNING**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-DGN-8B-DR-C-100 | S8 | P4 |

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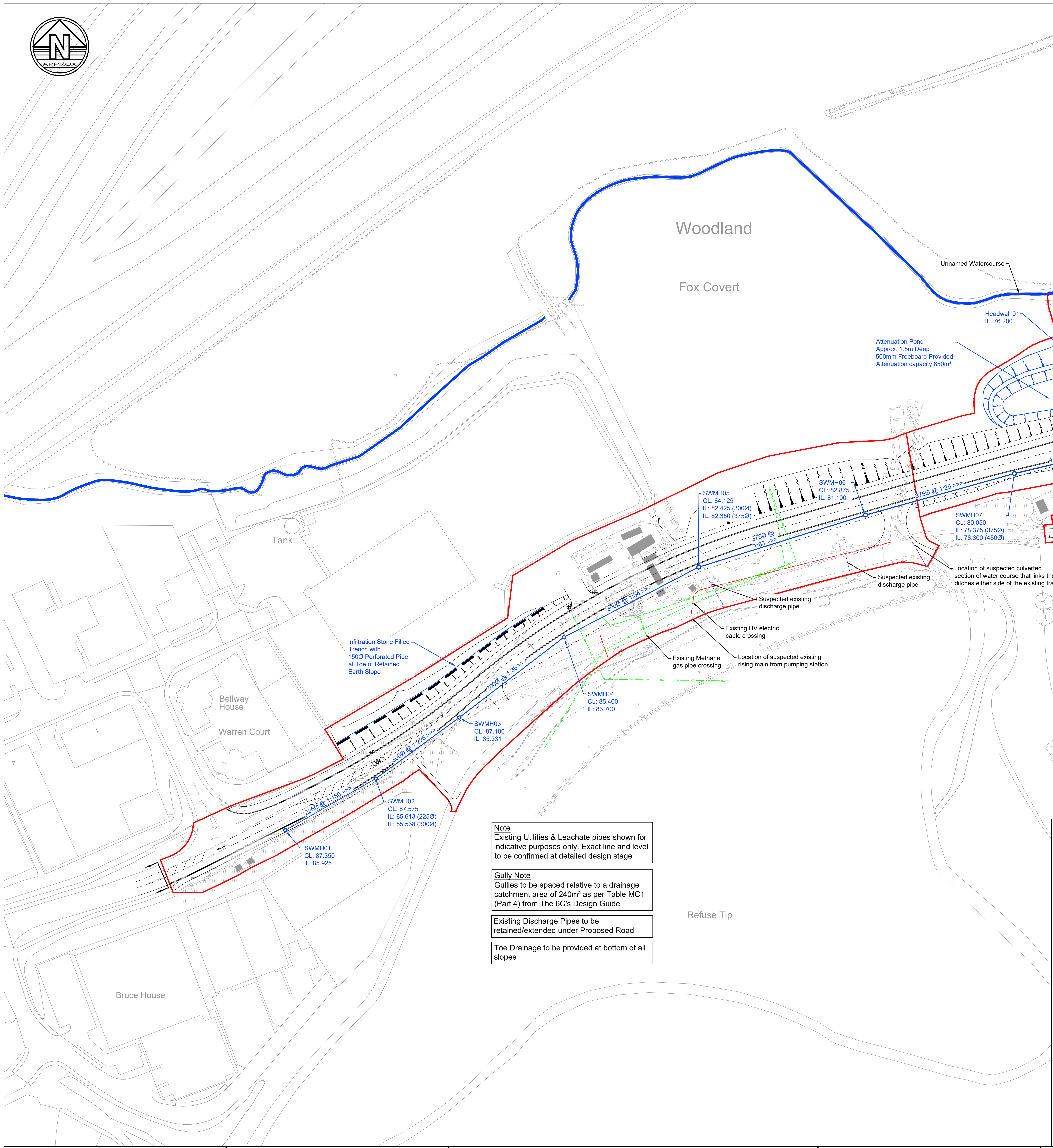

**Note**
Existing Utilities & Leachate pipes shown for indicative purposes only. Exact line and level to be confirmed at detailed design stage

**Gully Note**
Gullies to be spaced relative to a drainage catchment area of 240m² as per Table MC1 (Part 4) from The 6C's Design Guide

Existing Discharge Pipes to be retained/extended under Proposed Road

Toe Drainage to be provided at bottom of all slopes

## CLASS Z BED AND SURROUND
(SCALE 1:20)
FOR EXCAVATIONS AND TRENCHES IN HIGHER PERMEABLE SOILS

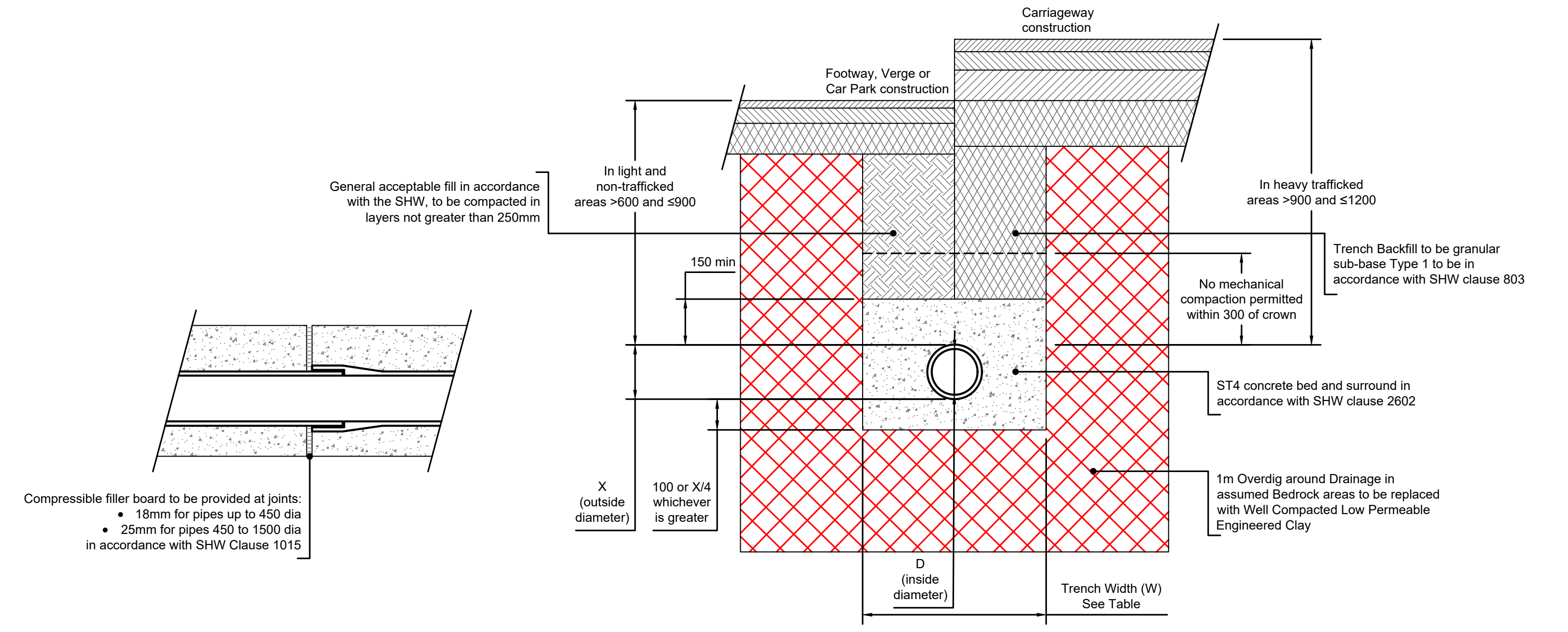

Table: Trench Widths: Classes B, S and Z

| Pipe Diameter (D) (mm) | Min Trench Width (Wmin) (mm) | Max Trench Width (Wmax) (mm) |
|---|---|---|
| 100 | 420 | 720 |
| 150 | 480 | 780 |
| 225 | 560 | 860 |
| 300 | 710 | 1010 |
| 375 | 790 | 1090 |
| 450 | 880 | 1180 |
| 525 | 970 | 1270 |
| 600 | 1070 | 1370 |
| 675 | 1130 | 1430 |
| 750 | 1210 | 1510 |
| 800 | 1280 | 1580 |
| 900 | 1380 | 1680 |
| 1050 | 1560 | 1860 |
| 1200 | 1740 | 2040 |
| >1200 | X+300 | X+600 |

BED & SURROUND NOTES

1. Minimum trench width is X+300, maximum trench width is X+600, where X is the outside diameter of the pipe. These values are set in order for the trench to comply with BS EN 1295. Min and max values are provided in order to give flexibility to the Contractor to select appropriate bucket sizes.
2. No mechanical compaction permitted within 300mm of top of pipe.

## Notes

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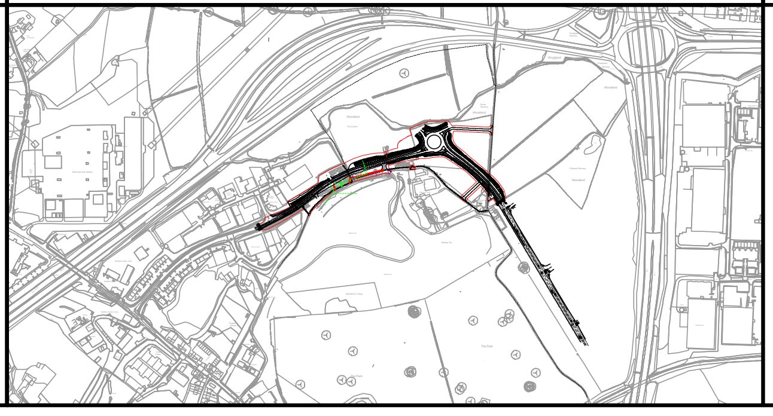
3. All dimensions in millimetres unless noted otherwise. All levels in metres unless noted otherwise.
4. Any discrepancies noted on site are to be reported to the engineer immediately.

## Key Plan



## Legend

| | |
|---|---|
| 🟥 | Redline Planning Boundary |
| — | Highway Surface Water Drainage |
| ▬ | Existing Unnamed Watercourse |
| - - HW - - | Existing Leachate collection pipe |
| ○ | Highway Surface Water Manhole |
| ⏢ | Highway Surface Water Headwall |

## ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 20.11.20 | Issued for Planning | MR | DH |

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Client
**The Trustees of Drummond Estate**

Project Title
**Enderby Relief Road, Leicestershire**

Drawing Title
**Highway Drainage Strategy**

| | | | |
|---|---|---|---|
| Drawn: | M. Ross | Reviewed: | D. Hodgson |
| BWB Ref: | NTH 2304 | Date: | Nov' 20 |
| Scale@A1: | 1:1000 | | |

Drawing Status
**Planning**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-HDG-8B-DR-C-500 | S8 | P1 |

Y:\NTH\NTH2304_Enderby Relief Road\02. Project Delivery\01. WIP\Drawings\ERR-BWB-HGN-8B-DR-D-500_Highway Drainage Strategy.dwg

For details refer to drawing
LUB-BWB-HML-S38-DR-S-0101
S38 General Arrangement

Refer to drawing ERR-BWB-HGT-8B-DR-D-650
for Illustrative Longsections and Typical Sections

## Notes

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4. Any discrepancies noted on site are to be reported to the engineer immediately.
5. It is considered to have one step relaxation for horizontal alignment.

🟥 Planning Redline Boundary

ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 20.11.20 | Issued for Planning | MR | DH |

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Client
**THE TRUSTEES OF DRUMMOND ESTATE**

Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

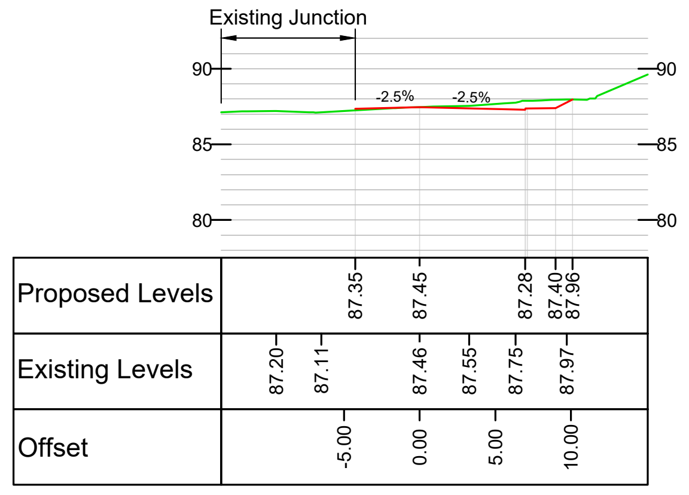
Drawing Title
**ILLUSTRATIVE HORIZONTAL DESIGN STRINGS**

Drawn: M. Ross
Reviewed: D. Hodgson
BWB Ref: NTH2304
Date: NOV '20
Scale@A1: 1:1000

Drawing Status
**PLANNING**

Project - Originator - Zone - Level - Type - Role - Number: **ERR-BWB-HGN-8B-DR-D-200**
Status: **S8**
Rev: **P1**

## ERR - EASTWEST CROSS-SECTIONS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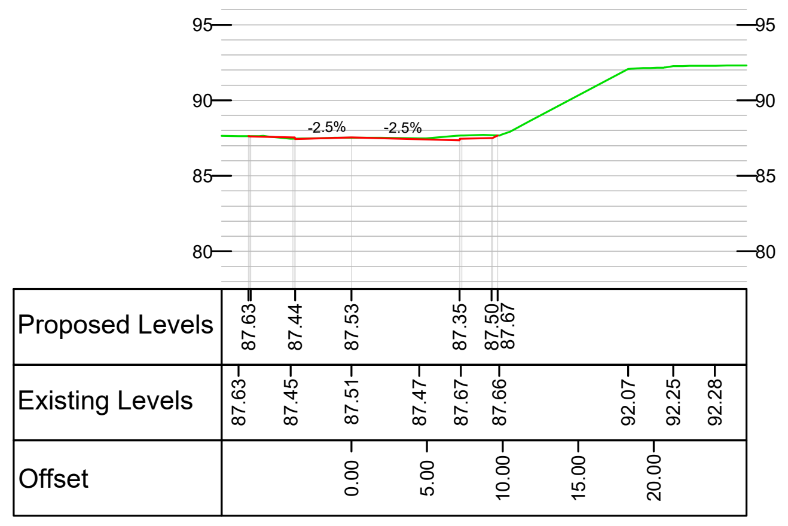
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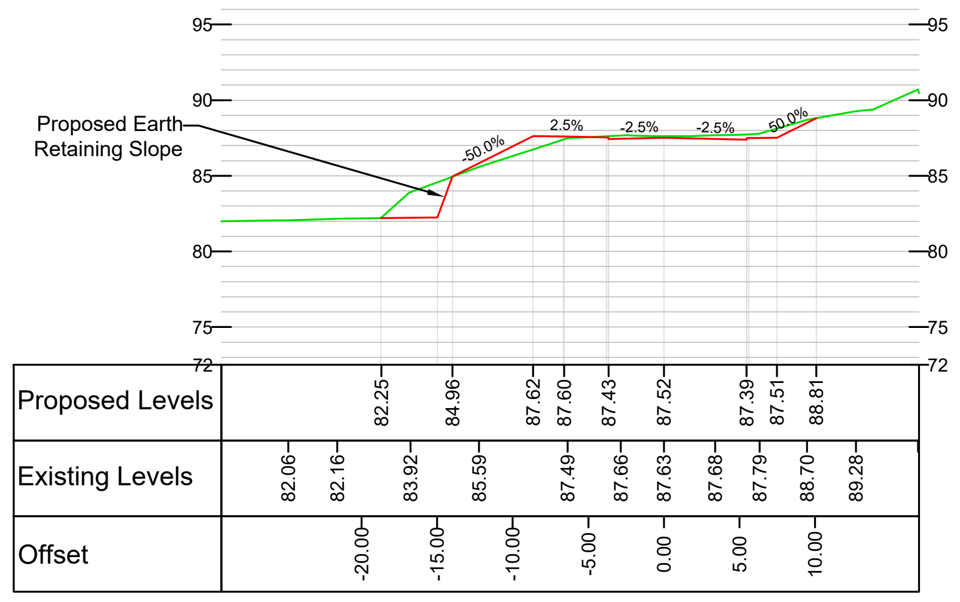
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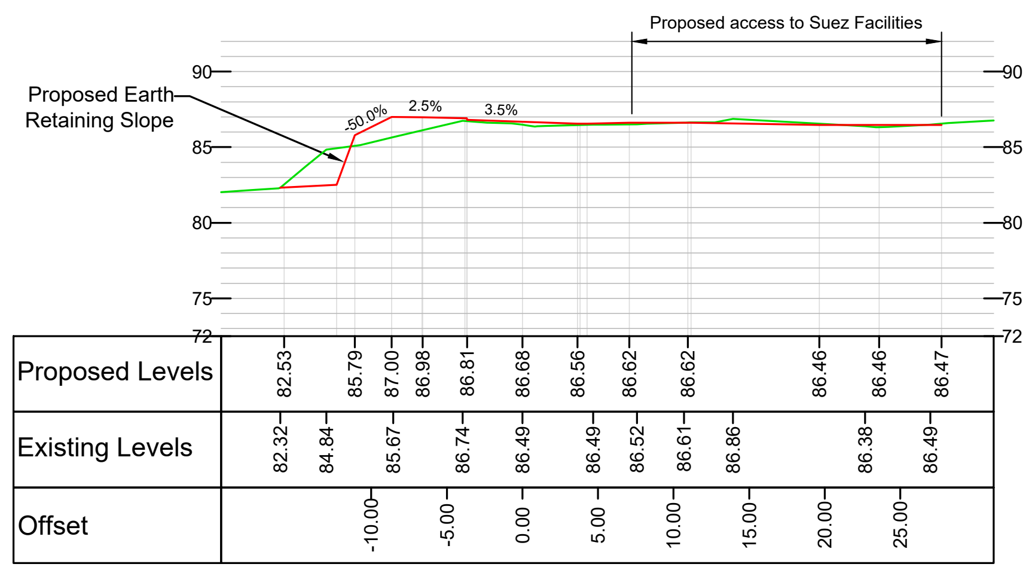
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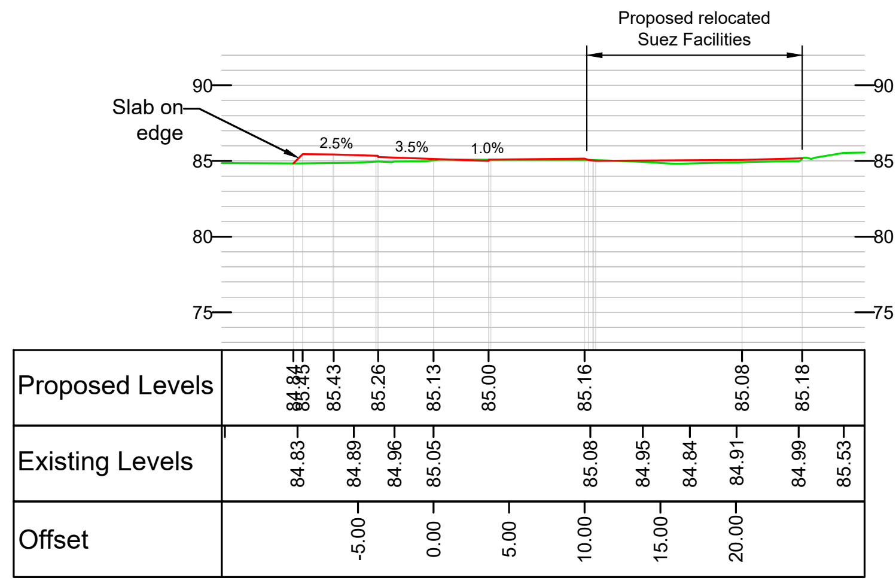
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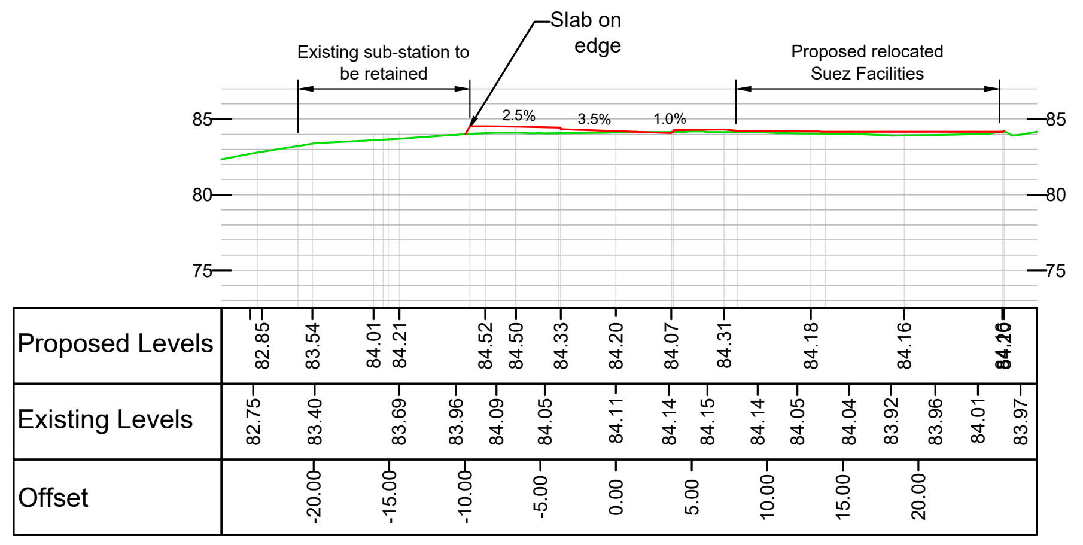
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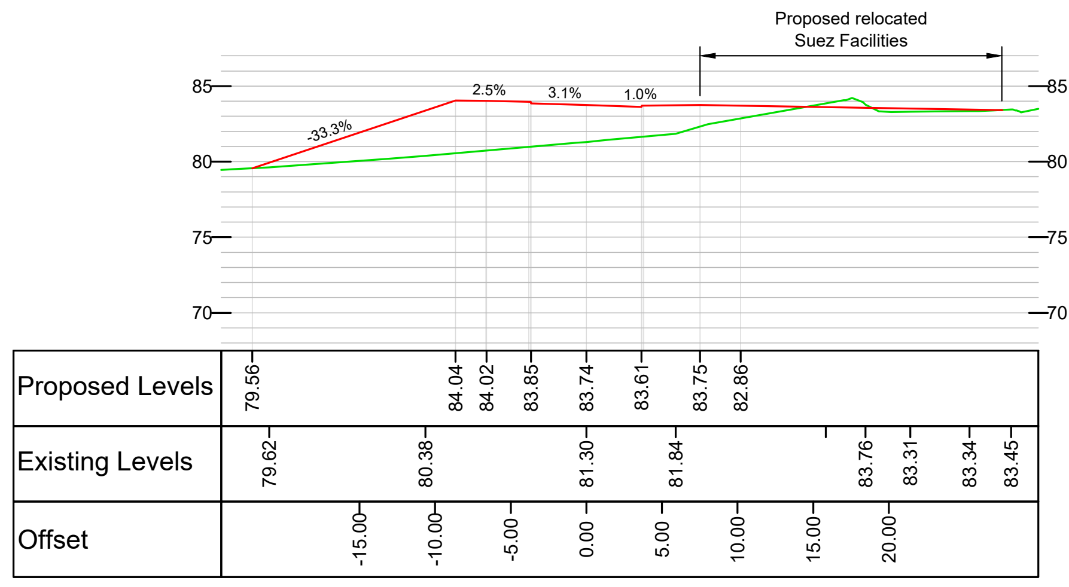
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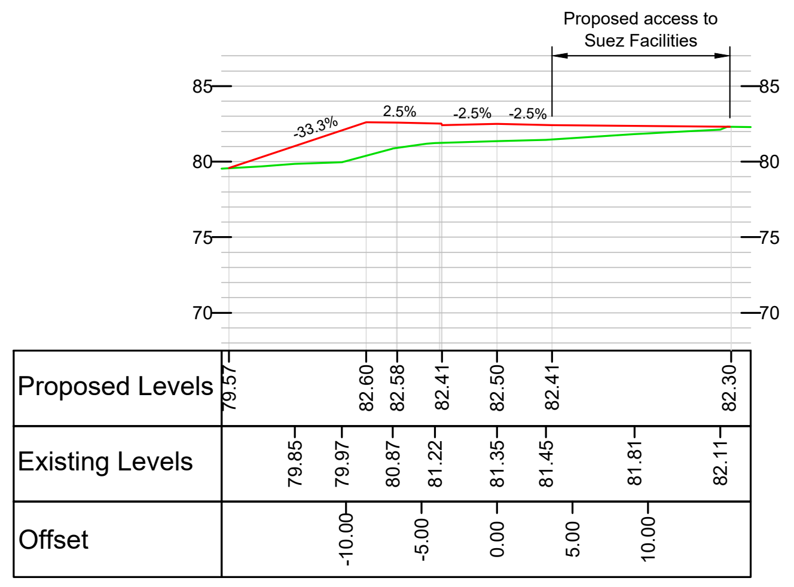
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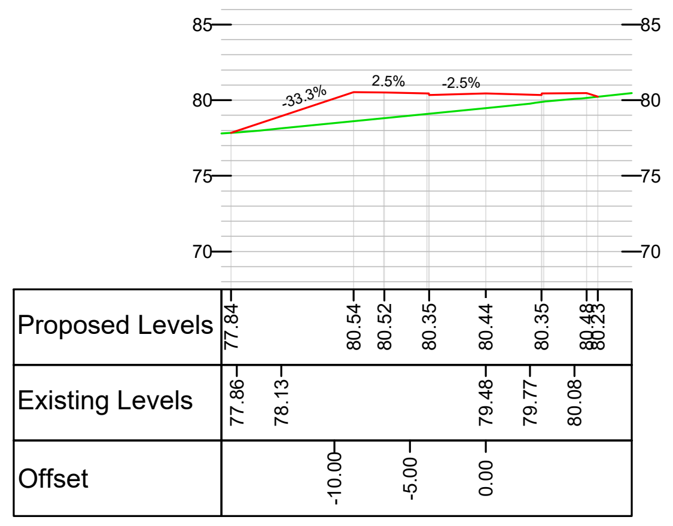
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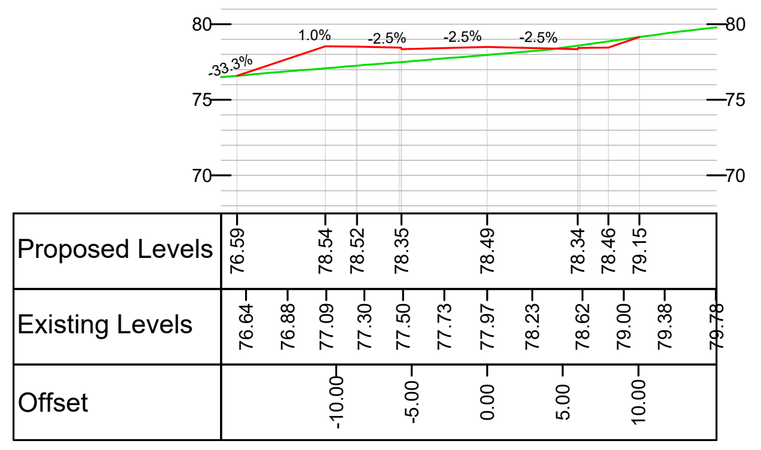
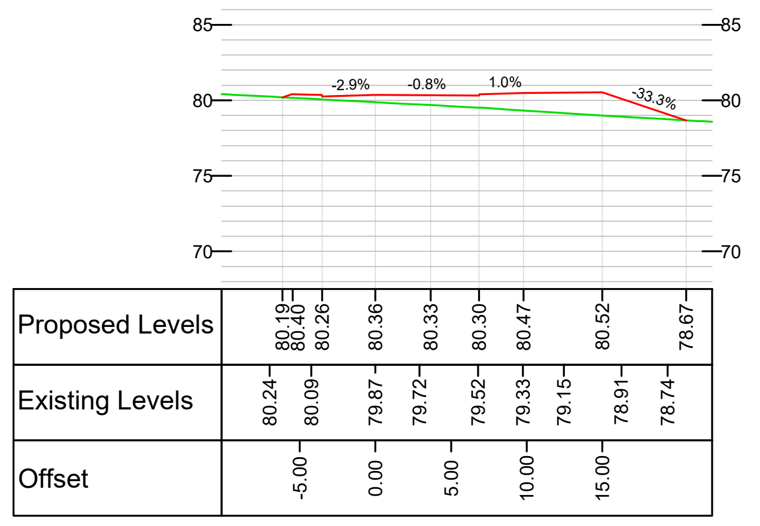

Chainage 500.000

Refer to drawing
ERR-BWB-HGN-8B-DR-D-0200_Illustrative
Horizontal Design Strings for
chainage locations

## ERR - SOUTHNORTH CROSS-SECTIONS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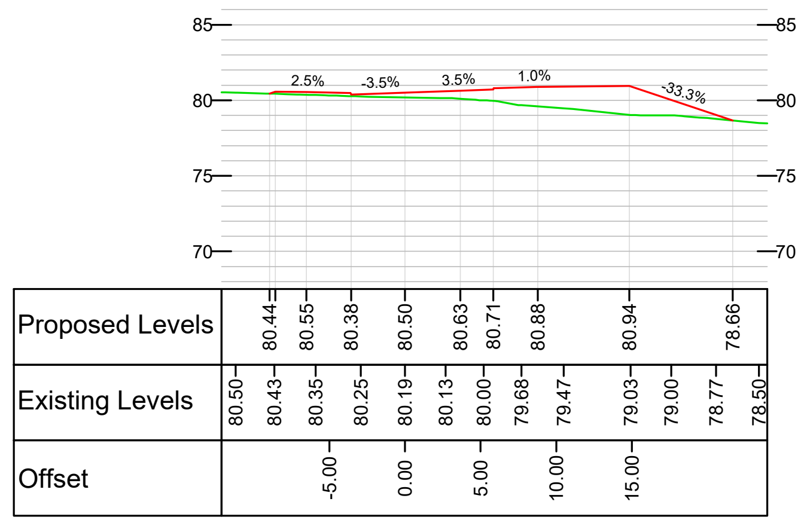
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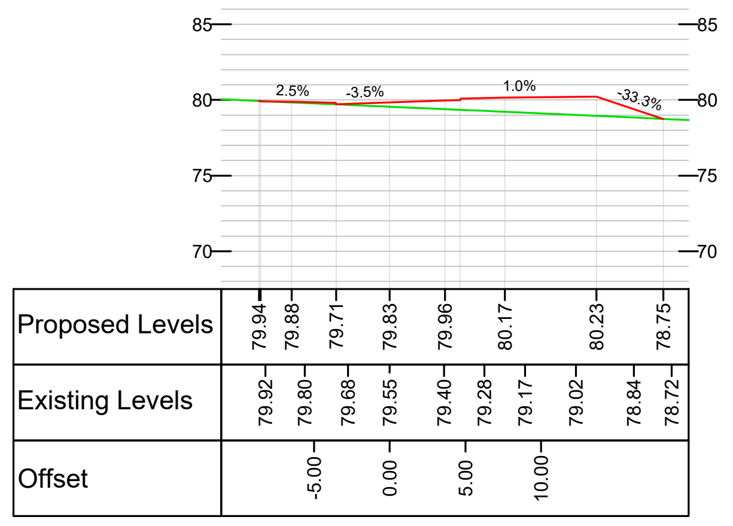
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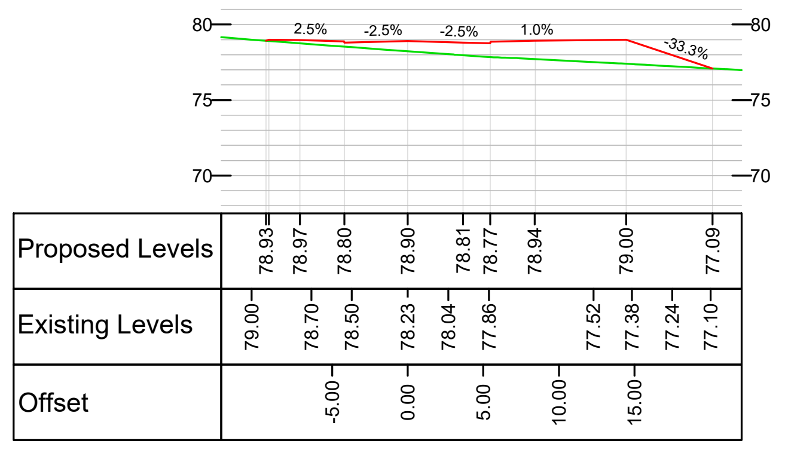
Chainage 200.000

**Notes**

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**Key**

Existing Ground Profile
Proposed Ground Profile

ISSUES & REVISIONS

| Rev | Date | Details of issue / revision | Drw | Rev |
|---|---|---|---|---|
| P1 | 20.11.20 | Issued for Planning | MR | DH |

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Client
**THE TRUSTEES OF DRUMMOND ESTATE**

Project Title
**ENDERBY RELIEF ROAD, LEICESTERSHIRE**

Drawing Title
**ILLUSTRATIVE CROSS-SECTIONS: ERR - EASTWEST & ERR - SOUTHNORTH**

| Drawn: | M. Ross | Reviewed: | D. Hodgson |
|---|---|---|---|
| BWB Ref: | NTH2304 | Date: | NOV '20 |
| Scale@A1: | 1:500 | | |

Drawing Status
**PLANNING**

| Project - Originator - Zone - Level - Type - Role - Number | Status | Rev |
|---|---|---|
| ERR-BWB-HGN-8B-DR-D-130 | S8 | P1 |

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