

Technical Memorandum

Project ID:	GISC9312-D2: Raster Based Analysis of Terrain Surfaces – Gumby Landfill		
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1. INTRODUCTION

The Town of Gumby has hired Equilibrium Consulting to assist in an analysis pertaining to the capacity of a landfill under investigation to determine the lifespan of the site until the remaining landfill volume is expended. An elevation profile, dictated by the Ontario Ministry of the Environment (MOE), is used as the source to calculate the extents. Previous analysis has determined that the landfill has reached its capacity. Equilibrium Consulting will re-assess the landfill, providing an accurate investigation of the landfill and provide future predictions for the landfill's use. The goal of this will be to provide the Town of Gumby's landfill with a volume measurement of the capacity, and number of years remaining for waste disposal.

With a calculated production of **13,175 tonnes/capita/annum** of waste, the capacity remaining in the landfill was an estimated **125,486 m³**. With no external factors or any variance in the rate of which the landfill is used, it is estimated by Equilibrium Consulting that in **9.5** years the maximum allowed volume, as governed by the Ontario Ministry of the Environment, will be consumed.

2. METHODOLOGY AND FINDINGS

The Ontario Ministry of the Environment (MOE) has provided Equilibrium Consulting with a shapefile expressing the allowable elevation profile for the Town of Grumby landfill site. A landfill footprint, provided by the town of Grumby, is also used to show the current boundary that is used in the analysis of the landfill capacity. In addition, 8,525 traversed survey points were collected over a two day period by Dewey, Rippem & Howe Consultants using a DGPS unit (Trimble 5700). The elevation ('Z' value) to the co-ordinates of the landfill is measured in meters above sea-level, contained in the corrected elevation (CORR_ELEV). **Table 1** shows the summary of used data-sources.

Table 1 Data used in Landfill Capacity Analysis

<i>DATASET</i>	<i>DATA DESCRIPTION</i>	<i>SOURCE</i>
Landfill_Footprint.Shp	Landfill's current boundary	Town of Grumby
Data_Points.Shp	Data collected by DGPS Unit	Equilibrium Consulting (2015)
Moe_Contour.Shp	Allowable landfill elevation outlined by the Ontario Ministry of Environment	Ontario Ministry of Environment

2.2 TIN SURFACE CREATION

Two different Triangulated Irregular Network (TIN) surfaces were created. The first was created using the GPS points collected by the surveyors contracted by Equilibrium Consulting. The second using the allowable volume defined by the Ministry of the Environment, 'MOEContours.shp'.

After which, the two created Triangulated irregular Network TIN images were used to calculate the remaining volume of the landfill and the volume both allocated and unallocated. **Figure 1** shows the created TIN raster and the traverse routes of the GPS data collection. **Figure 2** displays the acceptable area as outlined by the Ministry of the Environment.

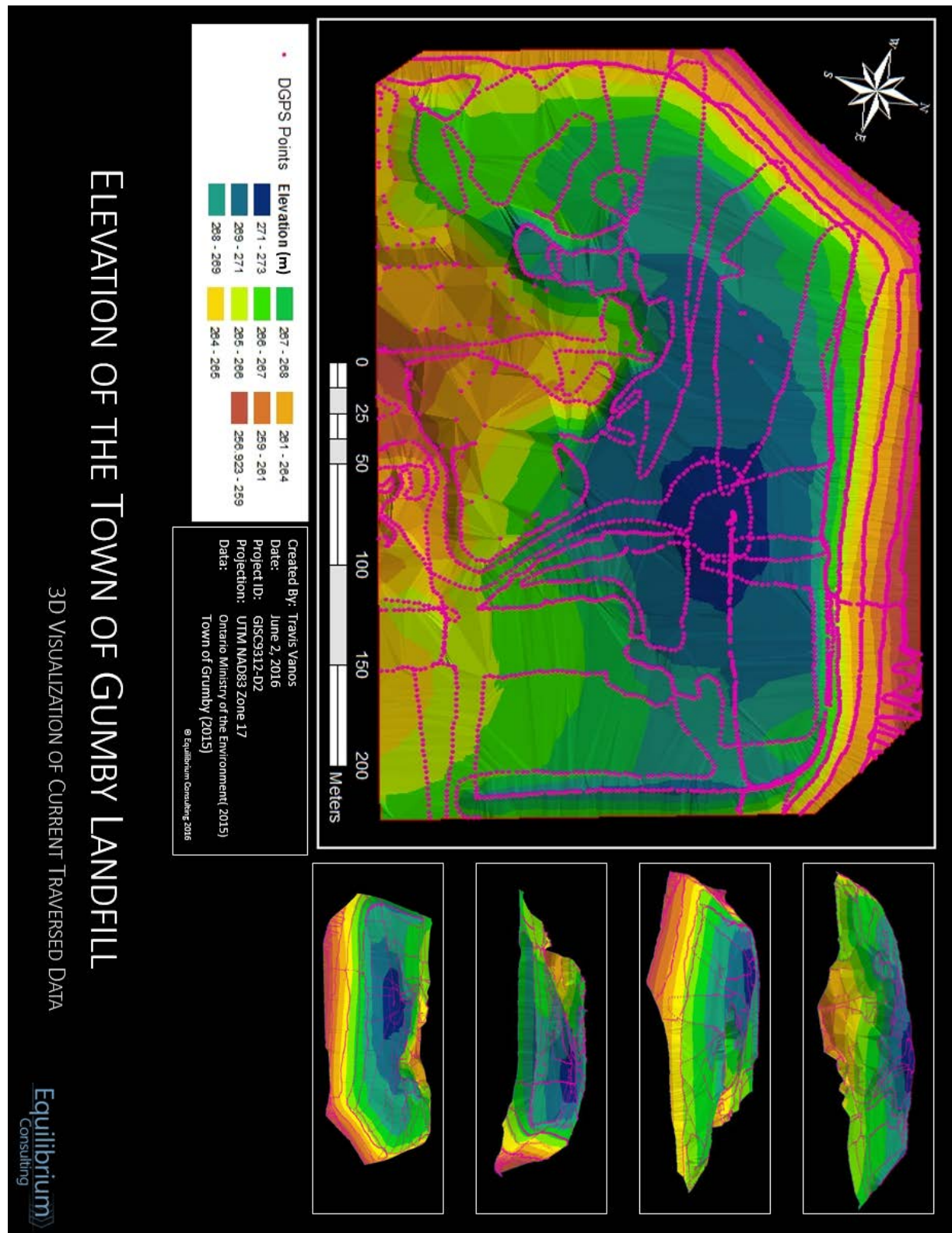


Figure 1 3D Visualization of Traversed Data Points Captured with DGPS (Trimble 5700)

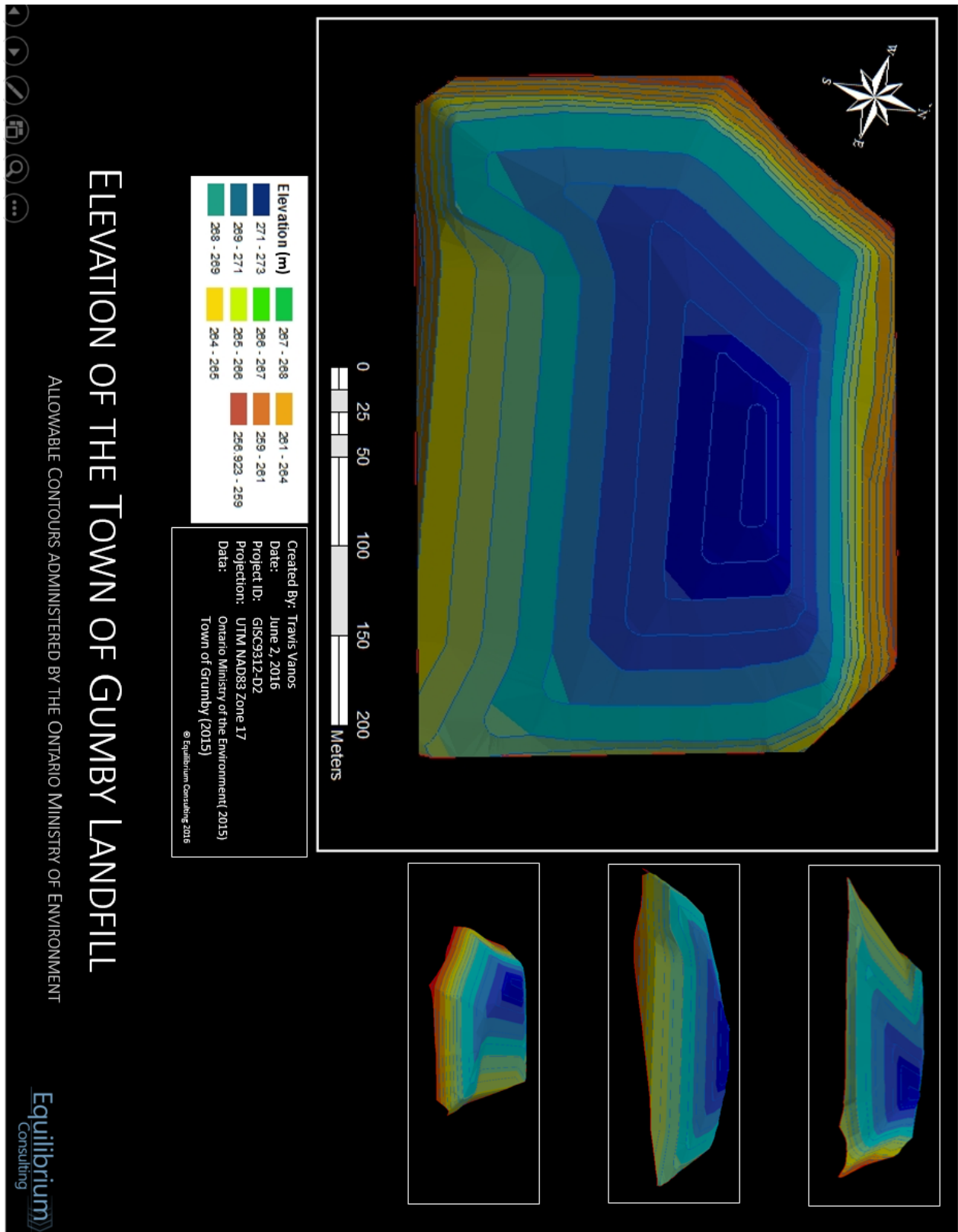


Figure 2 3D Visualization of MOE Allowable Contour Lines of the Gumby Landfill

2.3 RASTER CALCULATIONS

The created TIN datasets that were created needed to be converted to raster datasets, which allowed for an assessment of the surfaces with tools available for raster calculation. After the raster calculation, the tools, **Raster Calculator** and the **Cut/Fill** methods were used to measure the remaining volume of the landfill site. Both of these methods provide information in regards to the remaining capacity of the landfill by calculating the differences between the raster datasets.

2.4 CALCULATING LANDFILL CAPACITY

The purpose of the cut/fill and Raster Calculation toolsets is to clearly define areas that were under capacity, and areas that were above the allowed elevation. The calculated layers were reclassified so the elevation ('z'-values) were separated in **1 meter** intervals. The cut/fill toolset highlights areas that are over and under the allowable capacity. The red areas are over-allocated space, and those in blue are areas with available capacity for waste as seen in **Figure 3**.

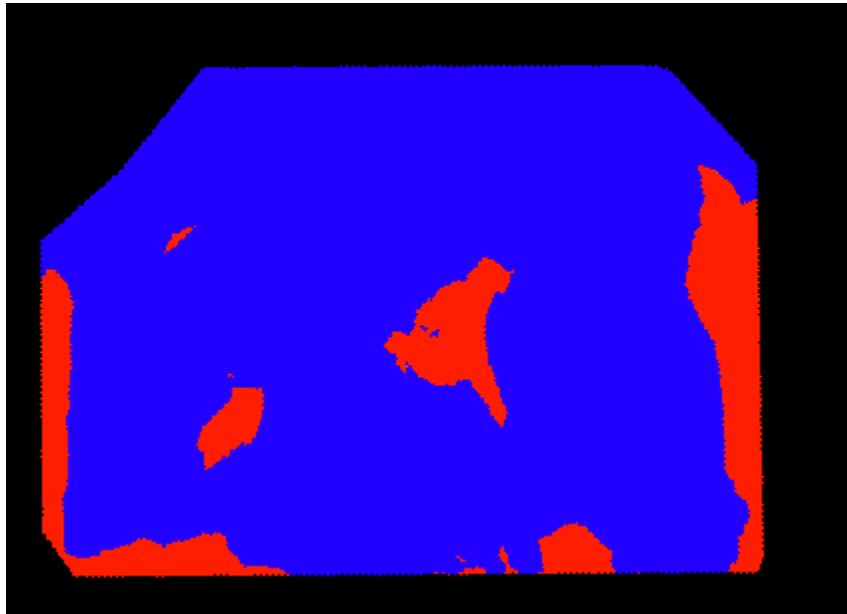


Figure 3 Cut/Fill Analysis of Gumby Landfill Remaining Space

After the raster calculation was performed, it has been determined that there is **134,066.63m³** in the area that can be occupied with waste. However, **8,480.70m³** of the landfill is currently above the allowable height and must be displaced. Observing the calculated volume in the attribute table for the calculated raster and subtracting the needed displacement, the capacity remaining in the landfill was an estimated **125,486 m³**. There is significantly more available space than previously determined in the landfill and thus the landfill is not at capacity. Therefore, the Ministry of the Environment was incorrect stating that the landfill had already reached the limit. This can be seen below in **Figure 4**.

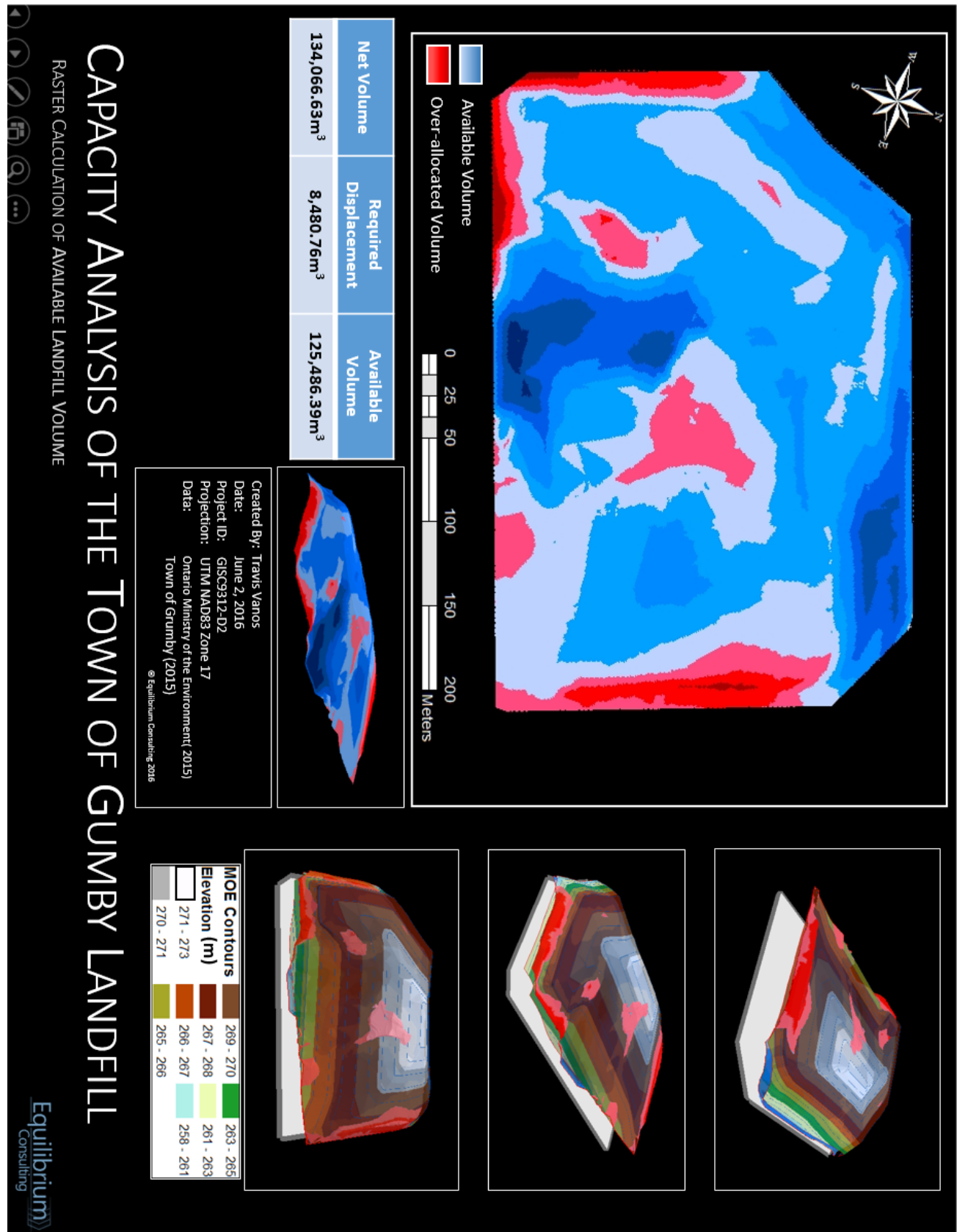


Figure 4 Allocated and Un-allocated Landfill Area of the Town of Gumby Landfill

3. PROJECTING LANDFILL LIFESPAN

There is a total of **10,200** households serviced by the landfill is and has remained at that level for twelve years. In addition there is a mean occupancy rate of 2.5 persons per household equating to **~25,500 persons**.

Through a rigorous and successful recycling and compostable waste diversion program, a marked effect can be noted upon the amount of waste that is actually sent to the Gumby Landfill by the residents of the Town of Gumby in the past fourteen years.

Table 2 Results of Annual Waste Generation of the Town of Gumby

Year	Waste Generation Rate (To Landfill) Tonnes/Capita/Year
2001	0.65
2002	0.60
2003	0.49
2004	0.44
2005	0.40
2006	0.35
2007	0.33
2008	0.31
2009	0.31
2010	0.30
2011	0.31
2012	0.30
2013	0.30
2014	0.31

Observing the waste generation data, the yearly capacity flat lines at approximately **0.31 tonnes/capita/per annum**. In estimating the further allocation of the landfill, it provides the most accuracy to continue to use the landfill only to service 10,200 households. However, this assumes no population increase or other means to decrease the annual waste disposed at this location. Accounting for planning contingencies, future trends in population increase and additional waste per household, a 2nd order polynomial may better accurately describe the future requirements for landfills that service the Town of Gumby, **Figure 5**.

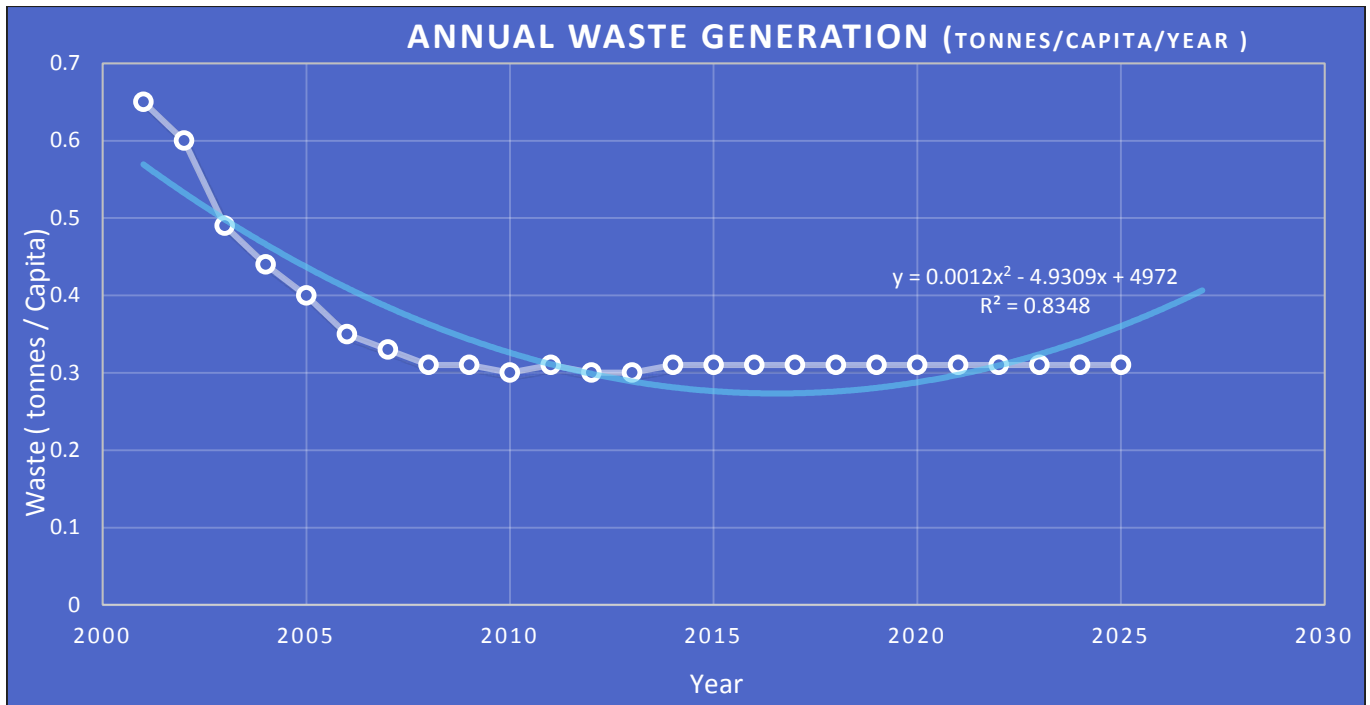


Figure 5 Annual Waste Generation per Capita

The cut/fill method shows areas that are over and under the allowable capacity reveals that a total of **125,486 m³** can be allocated. As seen in **Table 3**, the total allowable space allowed would be occupied mid-2023. The landfill continually filled with a yearly waste rate of **13,175 tonnes/annum**, compacted at **0.6/m³**, is estimated to fill the site capacity with is **~9.5 years on June 22, 2023**.

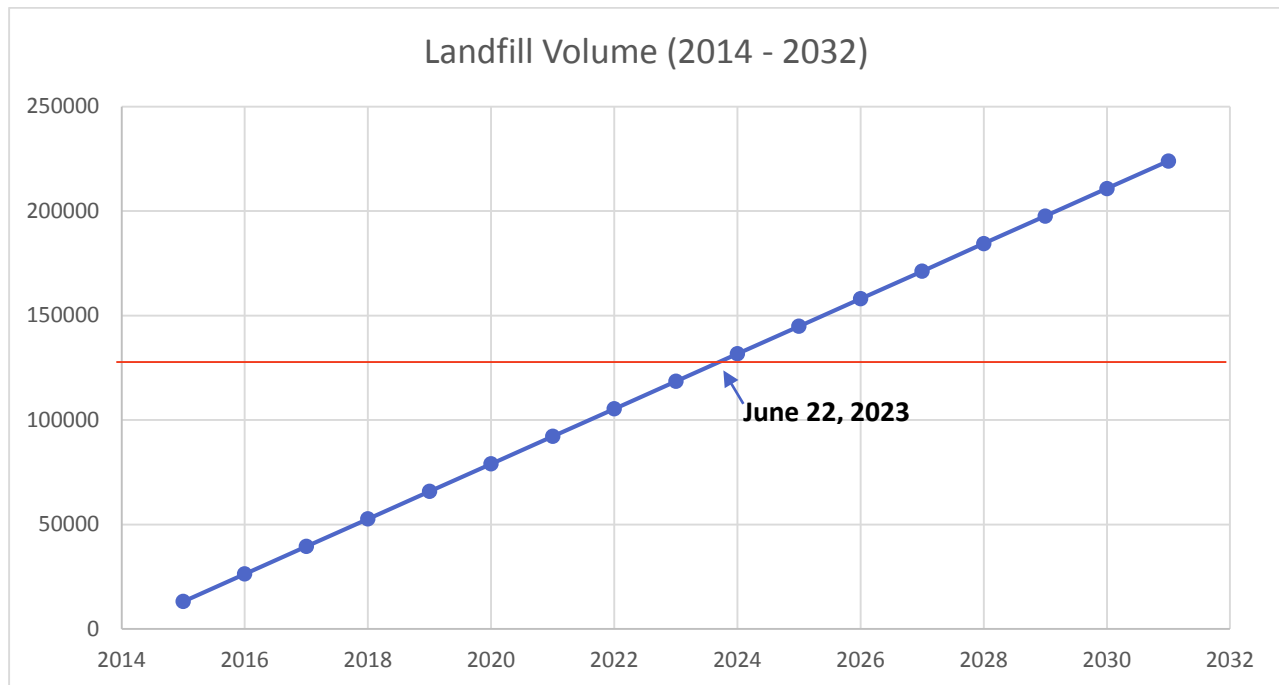


Figure 6 Predicted Lanfill Volume (2014 - 2032)

Table 3 Analysis of Landfill Lifespan

Year	Waste Generation Rate (To Landfill) <i>Tonnes/Capita/Year</i>	Total Household Waste Generation (To Landfill) <i>Tonnes/Houshold/Year</i>	Total Waste Generated <i>Tonnes</i>	Total yearly Volume of Landfill Waste (m ³) <i>(Compacted at 0.6/m³)</i>	Total Landfill Volume (m ³) <i>(Cumulative Volume Compacted at 0.6/m³)</i>
2001	0.65	1.625	16,575.00	27,625	27,625
2002	0.6	1.5	15,300.00	25,500	53,125
2003	0.49	1.225	12,495.00	20,825	73,950
2004	0.44	1.1	11,220.00	18,700	92,650
2005	0.4	1	10,200.00	17,000	109,650
2006	0.35	0.875	8,925.00	14,875	124,525
2007	0.33	0.825	8,415.00	14,025	138,550
2008	0.31	0.775	7,905.00	13,175	151,725
2009	0.31	0.775	7,905.00	13,175	164,900
2010	0.3	0.75	7,650.00	12,750	177,650
2011	0.31	0.775	7,905.00	13,175	190,825
2012	0.3	0.75	7,650.00	12,750	203,575
2013	0.3	0.75	7,650.00	12,750	216,325
2014	0.31	0.775	7,905.00	13,175	229,500
2015	0.31	0.775	7,905.00	13,175	13,175
2016	0.31	0.775	7,905.00	13,175	26,350
2017	0.31	0.775	7,905.00	13,175	39,525
2018	0.31	0.775	7,905.00	13,175	52,700
2019	0.31	0.775	7,905.00	13,175	65,875
2020	0.31	0.775	7,905.00	13,175	79,050
2021	0.31	0.775	7,905.00	13,175	92,225
2022	0.31	0.775	7,905.00	13,175	105,400
2023	0.31	0.775	7,905.00	13,175	118,575
2024	0.31	0.775	7,905.00	13,175	131,750
2025	0.31	0.775	7,905.00	13,175	144,925
2026	0.31	0.775	7,905.00	13,175	158,100
2027	0.31	0.775	7,905.00	13,175	171,275
2028	0.31	0.775	7,905.00	13,175	184,450
2029	0.31	0.775	7,905.00	13,175	197,625
2030	0.31	0.775	7,905.00	13,175	210,800

4. CONCLUSION

In closing, the first addressable matter is a total of **8,480.70m³** that needs to be displaced to adhere to proper elevation requirements. Many factors affecting the landfill's use must be considered when accurately assessing the continued use of the site. With no external factors or any variance in the rate of which the landfill is used, it is estimated by ***Equilibrium Consulting*** that in 9.5 years the maximum allowed volume, as governed by the Ontario Ministry of the Environment, will be consumed.

For continued use of the site for a period longer than 10 years, Equilibrium Consulting recommends:

- 1. New technologies to achieve higher compact rate/ m³**
- 2. Increasing awareness and promoting recycling more by limiting waste production per household**
- 3. Reducing the garbage collection and container sizes to prolong the accumulation of waste in the unallocated landfill space.**

To reduce the error in findings and accurately monitor further landfill allocation, the Town of Gumby should consider these recommendations as soon as possible. For a higher return on investment for the location, the town can either implement a technology rollout or begin planning for new, restrictive waste protocols for the citizens.