CLEANAWAY

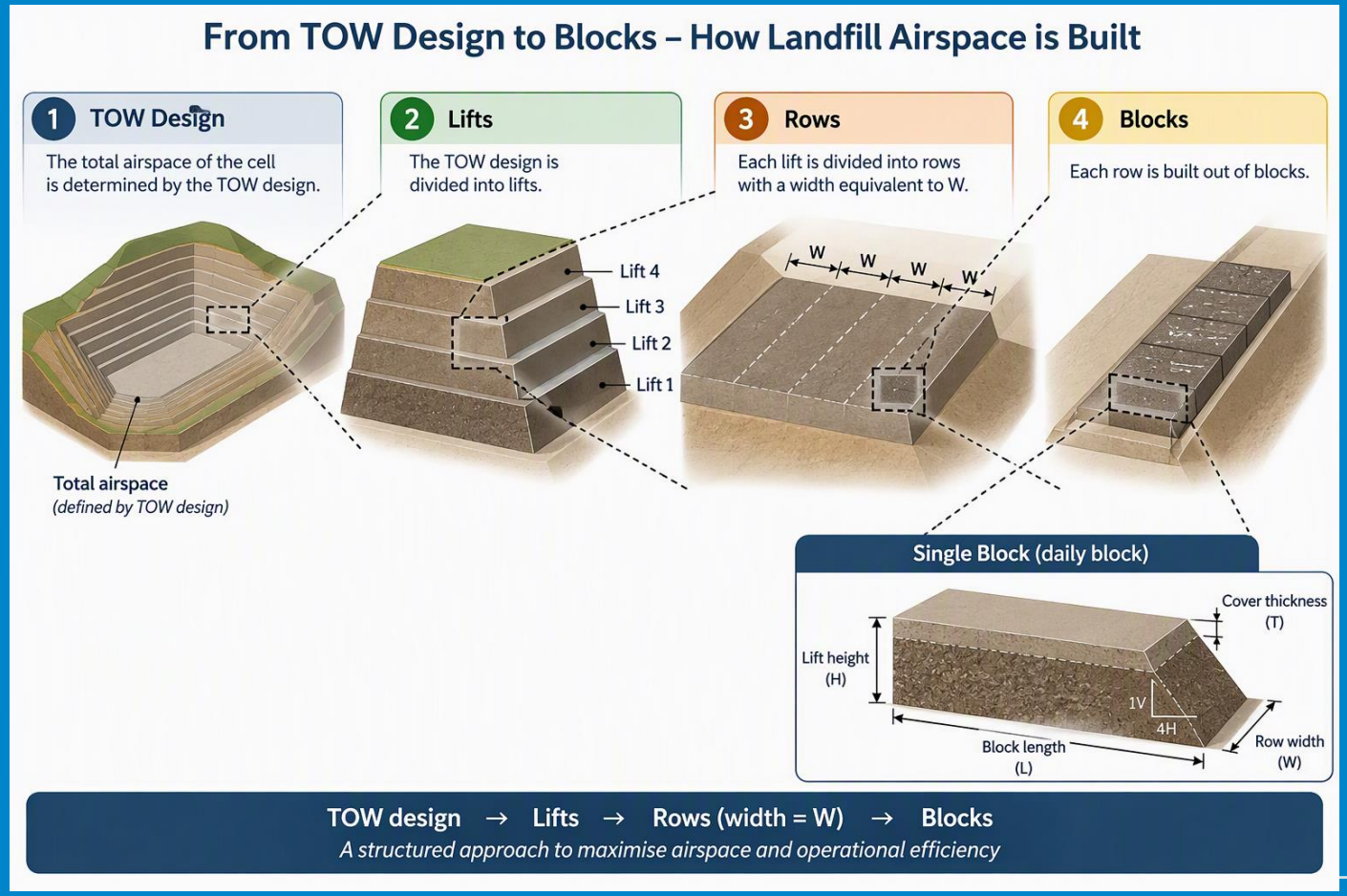
Making a sustainable future possible together

Optimising landfill daily block geometry

Improving Landfill Operational Efficiency Through Soil Reduction, Safe Working-Face Design, and Compactor Parameters

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Landfill Operation



- The total airspace of the cell is determined by the TOW design.
- The TOW design is divided into lifts
- Each lift is divided into rows with a width equivalent to W
- Each row is built out of blocks

Images were generated by Copilot AI

Why daily block geometry matters

Airspace

Cover soil occupies space that would otherwise be available for compacted waste.

Operations

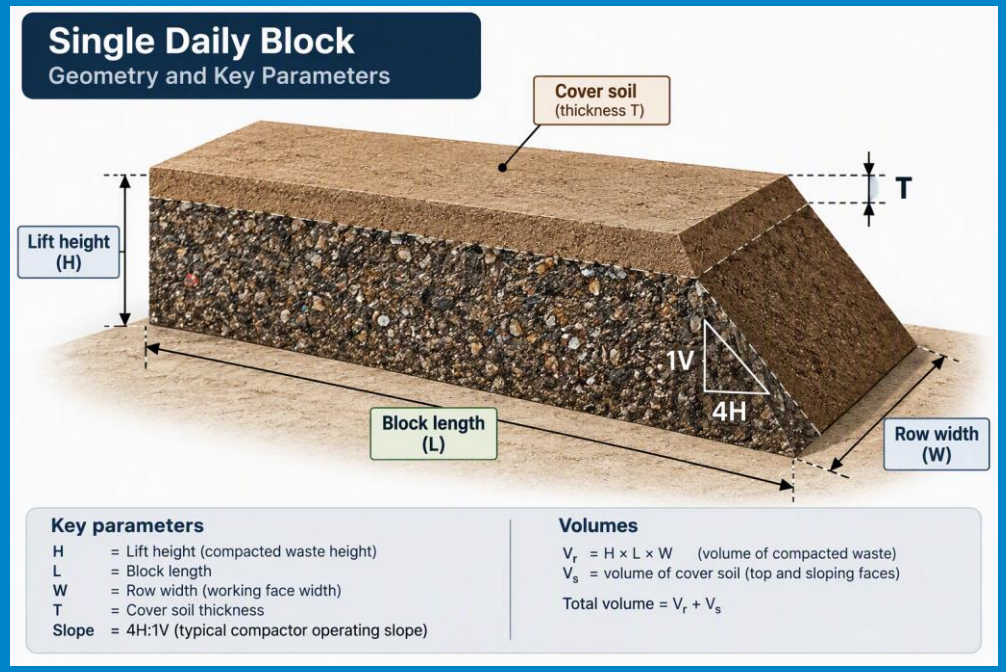
Block dimensions influence the working face, truck unloading arrangement and equipment movements.

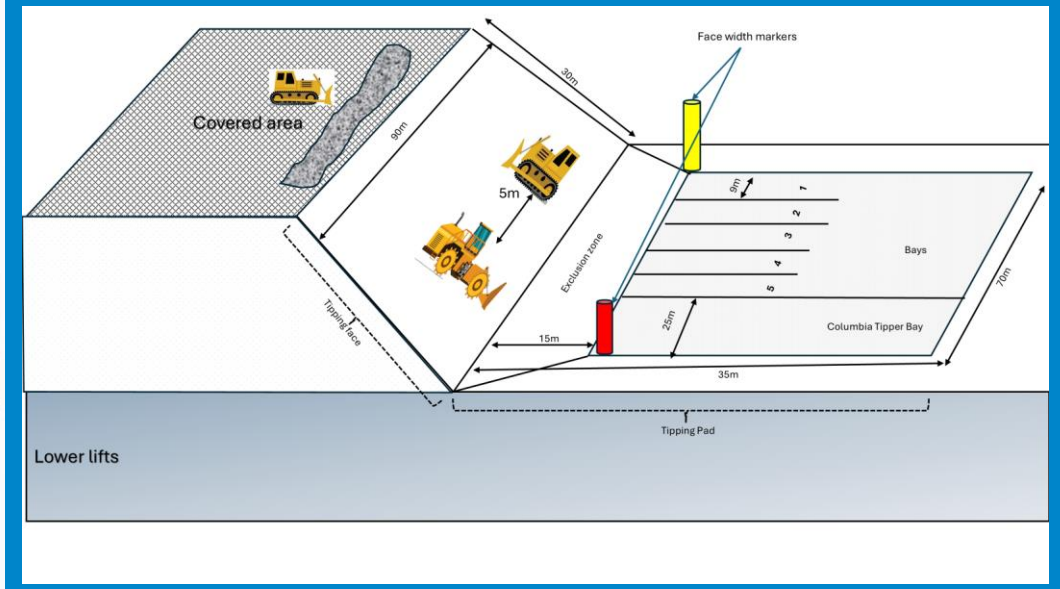
Safety & productivity

A practical design must accommodate vehicle circulation and the operating requirements of the compactor.

Design challenge: minimise soil use without compromising working-face functionality.

What is block geometry?





Research foundation: geometry and cover soil

Milke (1997)

Idealised parallelepiped; relates refuse volume, cover thickness, slope gradient and working-face length. For fixed inputs, optimum L/H = G (horizontal:vertical).

Panagiotakopoulos & Dokas (2001)

Constrained optimisation of block height, length, working-face length and slope to minimise the soil-to-refuse volume ratio.

Both studies provide theoretical benchmarks rather than complete traffic-and-equipment design procedures.

Research gap and study objective

Existing models

Geometric optimisation of soil-to-refuse ratio, under idealised block shape and operational constraints.

This study

Adds truck turnaround-time constraints, unloading-bay demand and compactor operating slope to daily block design.

Objective: identify a practical daily block geometry that balances cover soil, truck flow and compactor performance.

Study framework

01	**Daily waste & density**	Estimate compacted refuse volume
02	**Geometry & soil**	Assess block dimensions and cover demand
03	**Truck turnaround**	Determine required unloading bays
04	**Compactor checks**	Apply 4H:1V face and operating constraints
05	**Select block**	Compare feasible configurations

Method sequence based on the user abstract, p. 1

Truck turnaround-time constraint

Demand

Determine the peak truck arrival rate and unloading demand at the working face.

Service

Estimate unloading-bay occupancy and truck cycle time, including waiting and manoeuvring.

Constraint

Select sufficient simultaneous unloading bays to meet the target turnaround time.

Required bay count and resulting working-face width are calculated using site traffic inputs.

Integrated daily block selection

Geometry

L, h, working-face width

Cover soil

Minimum practical V_s / V_r

Truck traffic

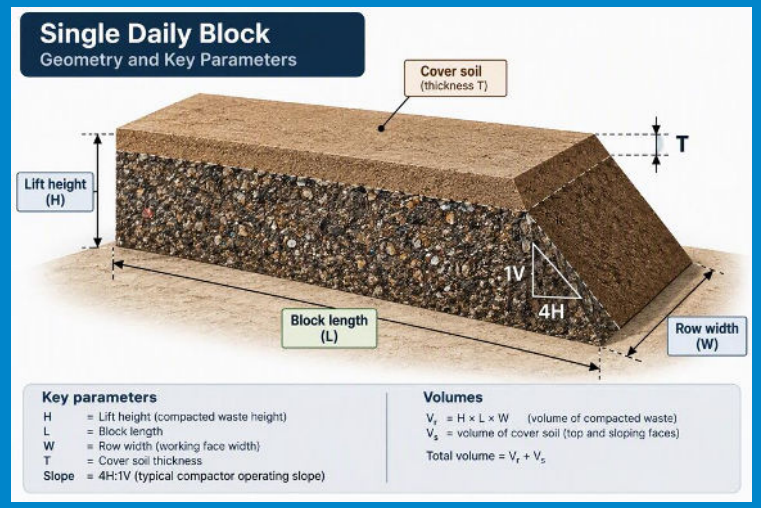
Target turnaround and bays

Compactor

- 4H:1V face and access
- Placement of waste in a 0.5 m layer on the face

Feasible block dimensions + minimum practical cover demand

Geometry of the idealised daily block



Notations

h	→ H	Compacted lift height (m)
M	→ W	Working-face width (m)
L	→ L	Block length (m)
ϕ_2, ϕ_3	→ ϕ	Side and front slope angles
w_1, w_2, w_3	→ cover	Top, side and front soil thickness
T / d	→ Q / d	Daily waste mass / density

Method sequence Waste inflow + density → Block geometry → Cover volume → Constrained minimisation → Sensitivity analysis

GEOMETRIC FORMULATION

Step 1 | Calculate waste and cover-soil volumes

Waste-only block volume

$$V_r = H \times L \times W = Q / d$$

Q = daily waste mass (t); d = compacted density (t/m^3)

Adding soil increases the idealised dimensions

$$H' = H + w_1$$

$$L' = L + w_3 / \sin(\varphi_3)$$

$$W' = W + w_2 / \sin(\varphi_2)$$

Exact geometric model

$$V_t = H' \times L' \times W'$$

$$V_s = V_t - V_r$$

$$V_s / V_r = (H'L'W' / HLW) - 1$$

The paper treats the soil-covered block as an expanded idealised volume. The method assumes consistent face angles and cover thicknesses.

Step 2 | Simplify the ratio and derive the optimum

Assumption in the paper: $\phi_2 = \phi_3 = \phi$. Approximate the cover volume by summing the top, side and front soil contributions.

$$R \approx V_s / V_r = w_1/H + w_2/(W \sin\varphi) + w_3/(L \sin\varphi)$$

For fixed W and ϕ, use $H = V_r / (LW)$

$$R(L) = w_1 LW/V_r + w_2/(W \sin\varphi) + w_3/(L \sin\varphi)$$

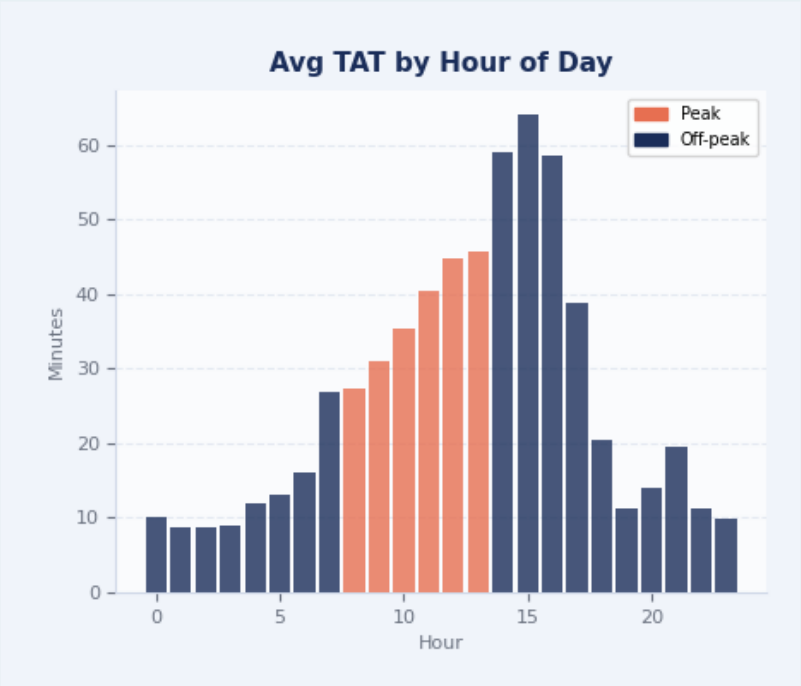
$$\partial R/\partial L = w_1 W/V_r - w_3/(L^2 \sin\varphi) = 0$$

This study incorporates TAT calculations to establish the minimum value for W, as well as the maximum face area and slope of the face to determine the maximum H value.

Step 3 | Determine min value for W

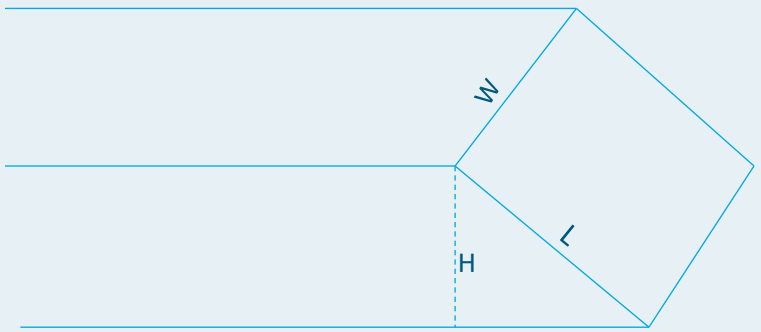
The face width is determined by the number of bays required to meet the site's TAT target. When the number of bays is determined, the Width of the face is the number of bays multiplied by the width of each bay (normally 9 meters)





Step 4 | Determine maximum value for H

The maximum height of the lift is determined by the face area (in m^2) and the slope of the face. For the Cat 836 compactor, an optimum slope of 4:1 is recommended.



Area of the face: W*L
$L = \sqrt{(1+G^2)} * H$
Area of the face= $W*\sqrt{(1+G^2)} * H$
W: width of face, H: height of lift and G is the slope 4 for a 1V:4H slope

The face area is determined by the operational license and the minimum safe size required for the compactor's operation. G represents the optimal slope for the face, while W is established through TAT modelling.

CONSTRAINED OPTIMISATION

Step 5 | Optimise within operating limits

Objective function

$$\text{MINIMISE} \quad R = w_1/H + w_2/(W \sin\varphi) + w_3/(L \sin\varphi)$$

Subject to

$$H \times L \times W = Q / d$$

$$H_{min} \leq H \leq H_{max}$$

$$W_{min} \leq W \leq W_{max}$$

$$0 < \varphi \leq \varphi_{max}$$

Illustrative ranges from Table 1

Block height H	**The maximum is determined using the optimum**
Working-face width W	The minimum determined by TAT modelling
Slope angle ϕ	**up to 30°**
Top cover w_1	**0.15–0.70 m**
Side/front cover w_2, w_3	**0.15–0.35 m**

Use site-specific limits, not these historical ranges, for real designs.

Solve constrained minimisation numerically (e.g., Excel Solver); compare objective values across feasible designs.



THANK YOU

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