Landfill Measurement – Why & How do we measure and monitor landfills?

SWANA 2019 – Back to School

By Steve Johnson

AECOM

Review References

- SWANA Landfill Operator Basics Course and Manager of Landfill Operations Course
- CAT Handbook
- The Handbook of Landfill Operations by Neil Bolton
- Pancake Filling Method, Neal Bolton
  - Pancake filling method (https://www.youtube.com/watch?v=rxrfixX8Yq0
- Magazine references:
  - MSW Magazine Hidden Benefits of Compaction & ADC
  - https://www.wastetodaymagazine.com/article/correct-compaction/
- Carlson Landfill brochure and presentation
  - http://www.carlsonsw.com/wordpress/wp-content/uploads/2010/12/Carlson-Landfill-Brochure-2017.pdf
- Redcliff Landfill (Corey Popick)
- City of Saskatoon (Scott Theede)
- Thinkolio (Paul Raj) - GPS

Introduction

- Compaction and Cover
  - Why
  - Equipment
  - Method
  - Monitoring
- Active Face
  - Fill Plan
  - SWANA method and Pancake method
- Landfill Culture
- Data Management and Financials

Compaction and Cover – Why?

Compaction

- Extends the life of the site
- Reduces litter and vectors
- Reduces amount of soil cover
- Reduces settlement
- Potential to reduce depth of landfill fire
- Provides subgrade for construction of roads and tipping pads
- Potential to improve landfill financials

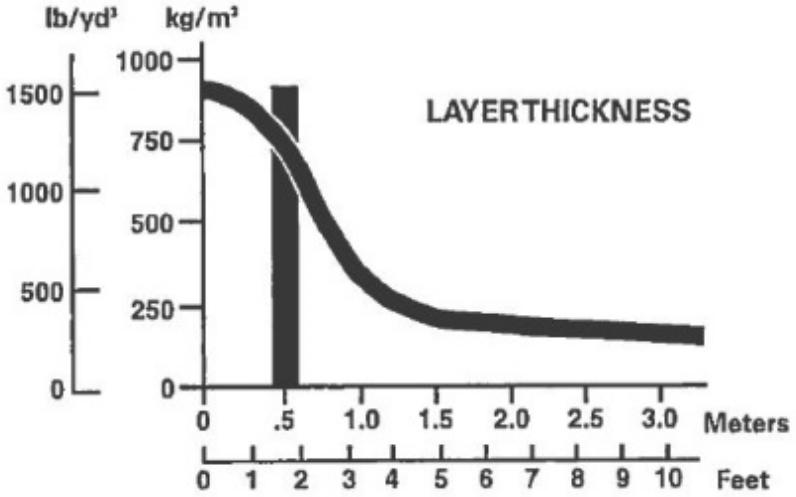
Cover

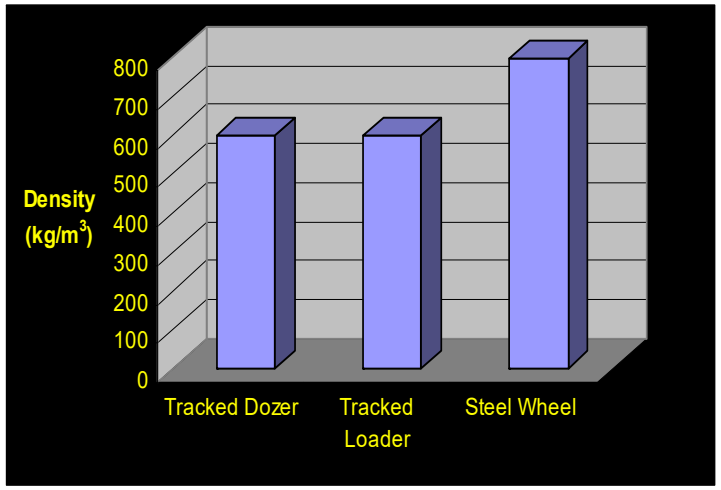
- Regulatory requirement!
- Reduce risk of fires
- Reduce odours and litter
- Control access to some vectors
- Reduce leachate generation
- Site aesthetics

So What To Monitor? (WTM)

Compaction - Equipment

- Tracked loader
- Tracked dozer
- Steel wheeled landfill compactors
  - With compactor should obtain between 700 kg/m^3 to 1100 kg/m^3 depending on type of compactor, waste characteristics and operations





WTM - yellow iron asset and compaction operation

Compaction - Equipment

- Asset Monitoring
  - Is one of the larger waste expenses so monitor to maintain the asset
  - Equipment inspection form (manufacturer or make own)
  - Manufacturer warrantee
    - Excel tracking systems
    - Inhouse monitoring systems
    - Fleet services
  - Fuel
  - Maintenance costs
  - Landfill Manager discretionary monitoring
  - Manufacturer remote monitoring

Compaction – Equipment Monitoring

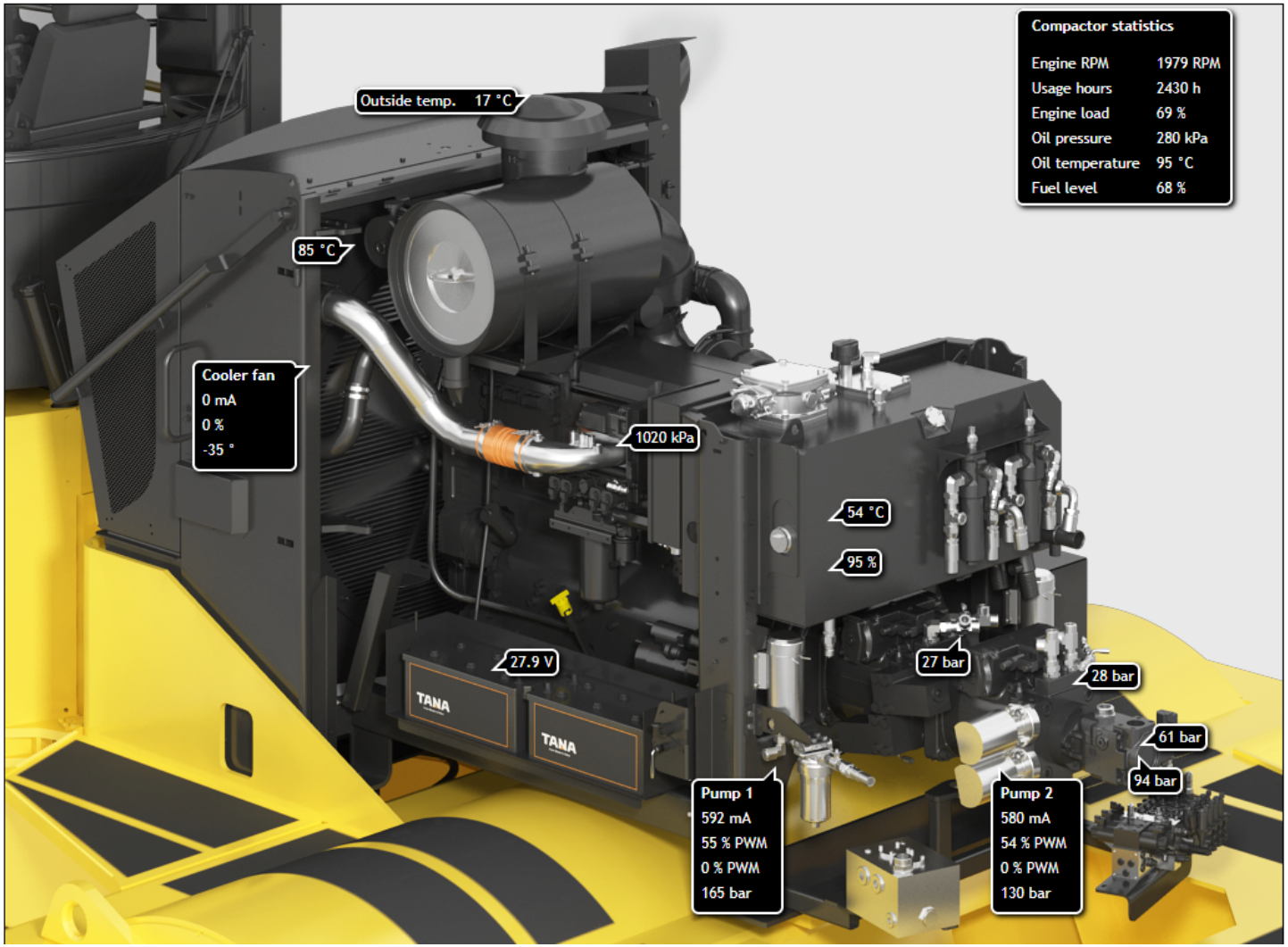
Tana Protrack

Realtime view

Realtime view

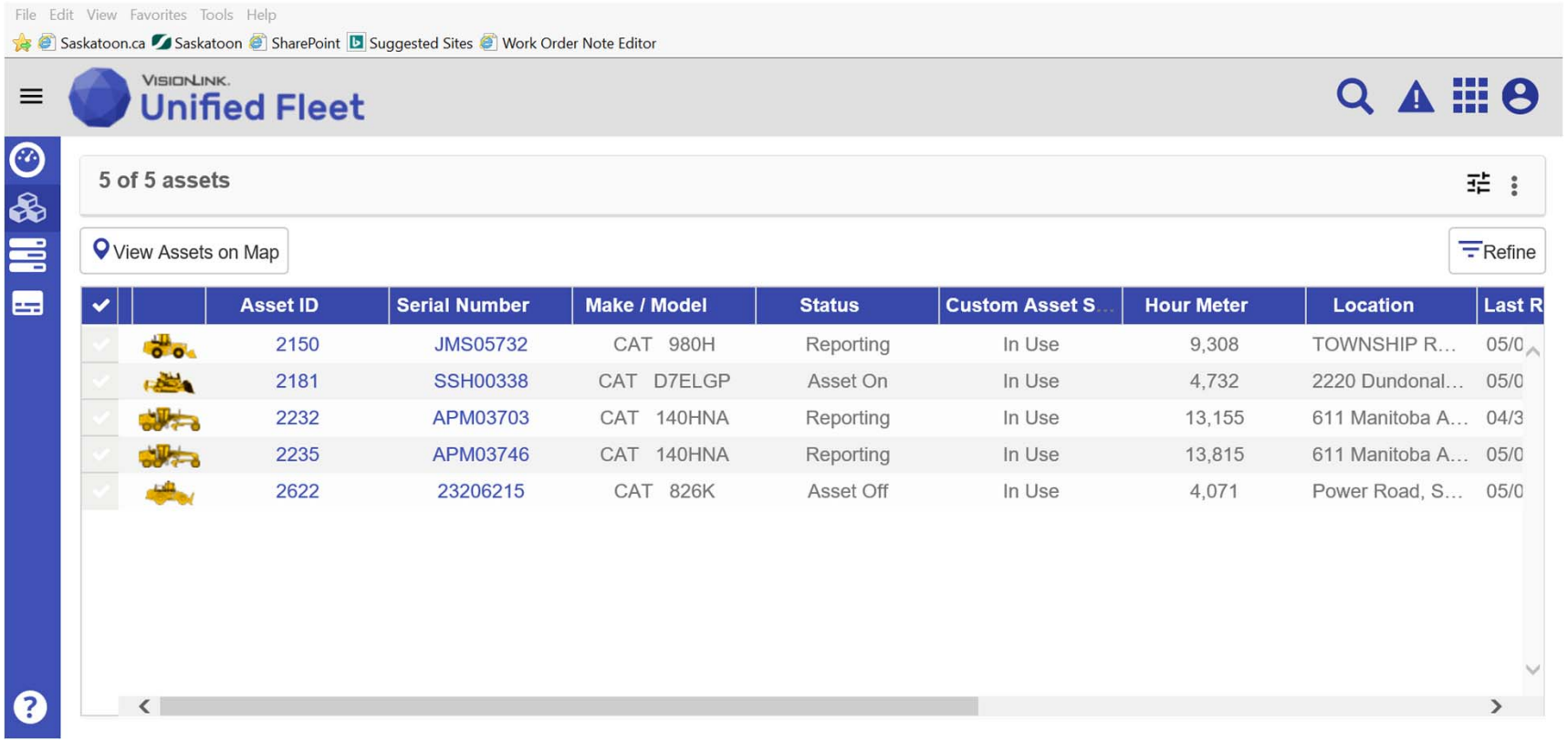
Compaction – Equipment Monitoring

Realtime view

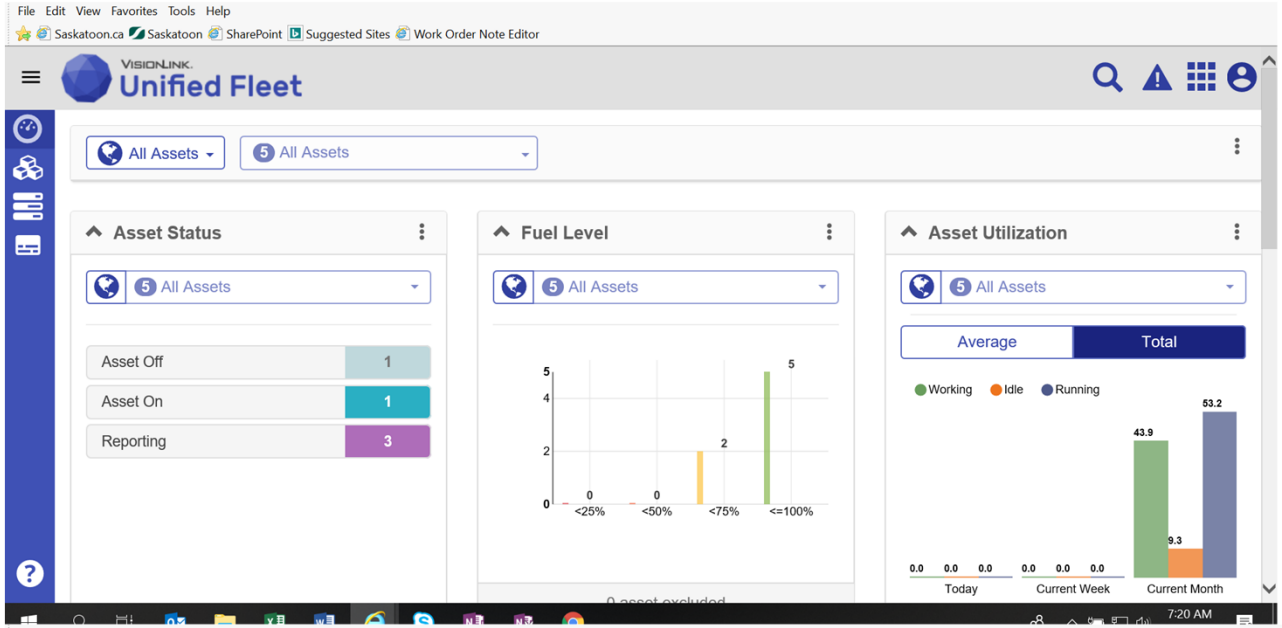


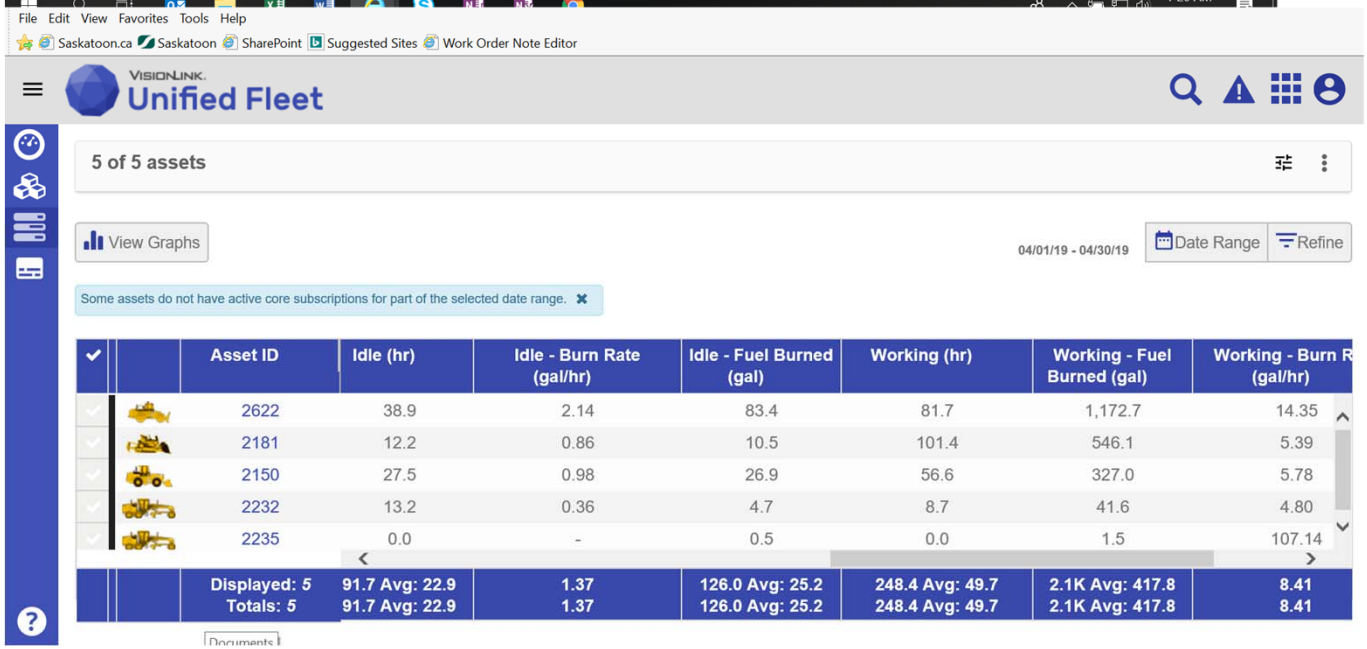
Compaction – Equipment Monitoring

United Fleet



Compaction – Equipment Monitoring

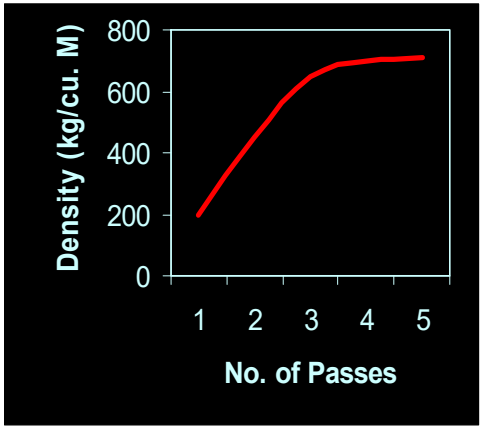




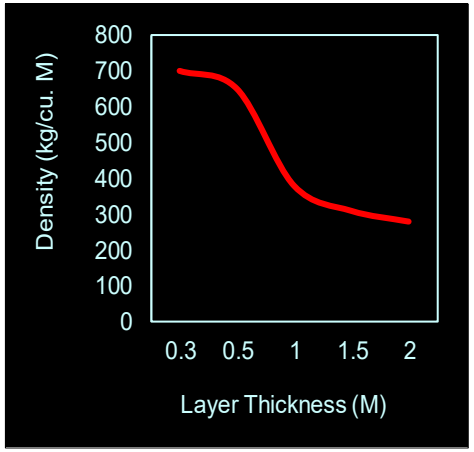
Asset ID	Idle (hr)	Idle - Burn Rate (gal/hr)	Idle - Fuel Burned (gal)	Working (hr)	Working - Fuel Burned (gal)	Working - Burn R (gal/hr)
2622	38.9	2.14	83.4	81.7	1,172.7	14.35
2181	12.2	0.86	10.5	101.4	546.1	5.39
2150	27.5	0.98	26.9	56.6	327.0	5.78
2232	13.2	0.36	4.7	8.7	41.6	4.80
2235	0.0	-	0.5	0.0	1.5	107.14
Displayed: 5 Totals: 5	91.7 Avg: 22.9 91.7 Avg: 22.9	1.37 1.37	126.0 Avg: 25.2 126.0 Avg: 25.2	248.4 Avg: 49.7 248.4 Avg: 49.7	2.1K Avg: 417.8 2.1K Avg: 417.8	8.41 8.41

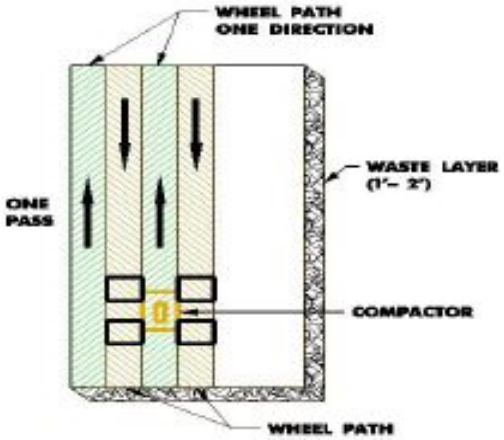
Compaction - Method

- Spread waste in thin layers
  - Assess blade height. Operators should know approximately the top of blade in relation to cab and the corresponding depth of waste.
  - Check lift thickness
  - GPS on equipment will provide feed back on waste depth



- Compact each layer before placing next one
  - Compact waste in 3–5 passes up and down slope
  - First crushing pass is forward for visibility (watch for problem waste)
  - Alternate wheel paths as per figure
  - Cross knit waste – run at angle or perpendicular to, for additional 1-2 passes
  - Wheels should be UP, not DOWN on the waste when compacted
  - NOTE:Tana's full width wheel so different compaction technique



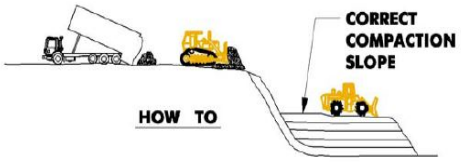


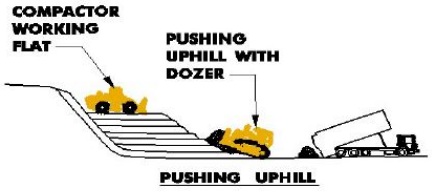
Wheels up

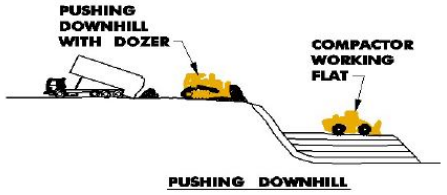
Wheels down

Compaction - Method

- Keep working face as flat as possible
  - No steeper than a 5:1 slope
- Compactors do best at compacting. Use tracked equipment to push and grade waste for compactor operators to compact; this is based on daily tonnage. See pancake filling method online which demonstrates tracked and compactor equipment https://www.youtube.com/watch?v=rxrfixX8Yq0
- Maintain cleats. Must have a wear monitoring and replacement program to change out cleats.
- Finish off active face with dozer at end of day when doing soil daily cover operations
  - Fill in cleat voids with fine shredded material
  - Reduces soil required for cover, and for better soil recovery
- Moisture Conditioning with Leachate/Biosolids/Wetwaste application
  - Moisture conditioning waste will improve waste compaction (see biosolids mixing picture)
  - There are advantages and disadvantages to leachate application if this is to be implemented
  - Must be approved by Regulator and methodology provided in the Operations Plan
  - NOTE – NWRA/SWANA Advances in Liquid Management https://cdn.ymaws.com/wasterecycling.org/resource/resmgr/letters/NWRA_SWANA_Liquids_addition_.pdf







Compaction - Monitoring

- Active face size/grade (as per Operations Plan/Fill Plan based on waste tonnage and traffic numbers) – on daily inspection sheet by GPS or visual

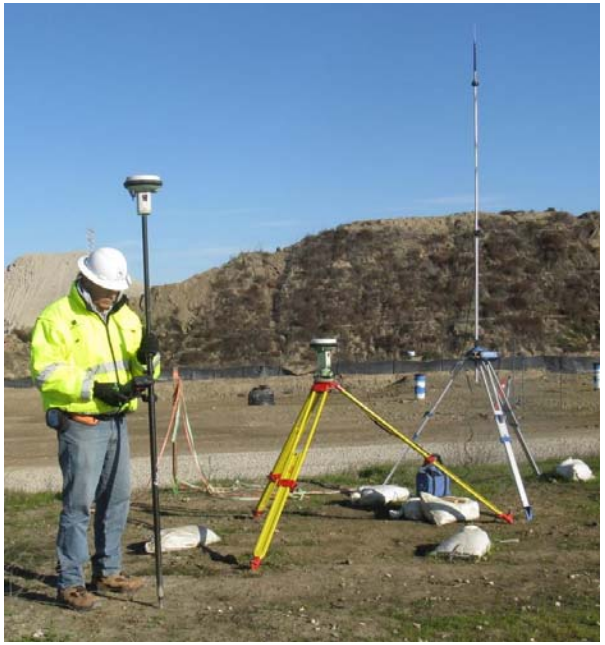
- Annual airspace assessment
  - Drone or GPS survey of site to determine volume utilized on an annual cycle
  - Calculate airspace utilized as per methods provided in the SWANA Manager of Landfill Operations manual
  - Trend data overtime

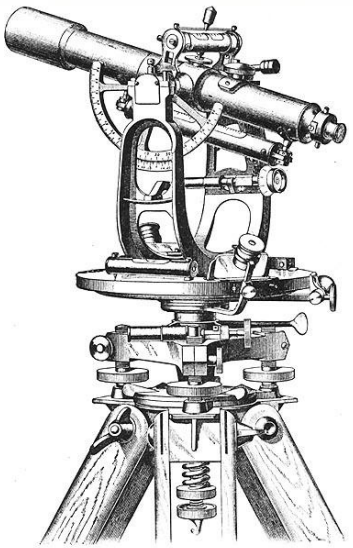
- Operations Airspace assessment methods
  - Excavate several cubic meters of a finished active area. Weigh the waste and survey the excavation or measure the excavation dimensions to determine the volume. Calculate the density (tonnage/volume)
  - Drone or GPS survey of the active area of a basis set by the Landfill Manager. The surveyor will provide the volume. With scale records on tonnage disposed, and the amount of soil cover applied through tracking records, the waste density can be calculated as per methods provided in the SWANA Manager of Landfill Operations manual
  - With GPS on equipment, the waste compaction density can be determined daily (and matched to operator and possibly waste types)

- Observations
  - Video monitoring of the active face with operator reviews as needed
  - Manager/Lead operator visual observation of compactor operations

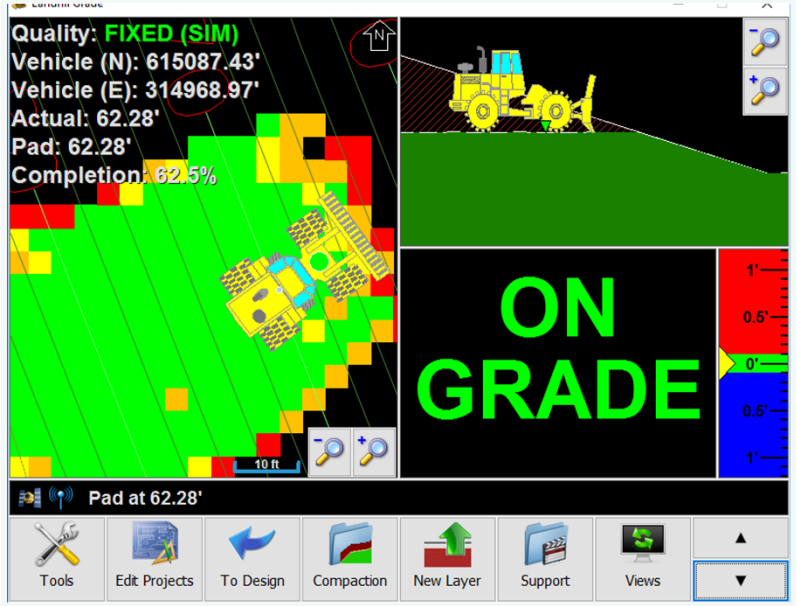
- Moisture Conditioning
  - Track volume or tonnage by moisture balance forms/excel sheet
  - Leachate balance tracking (weather station, head level and removal records, disposal/recir records)

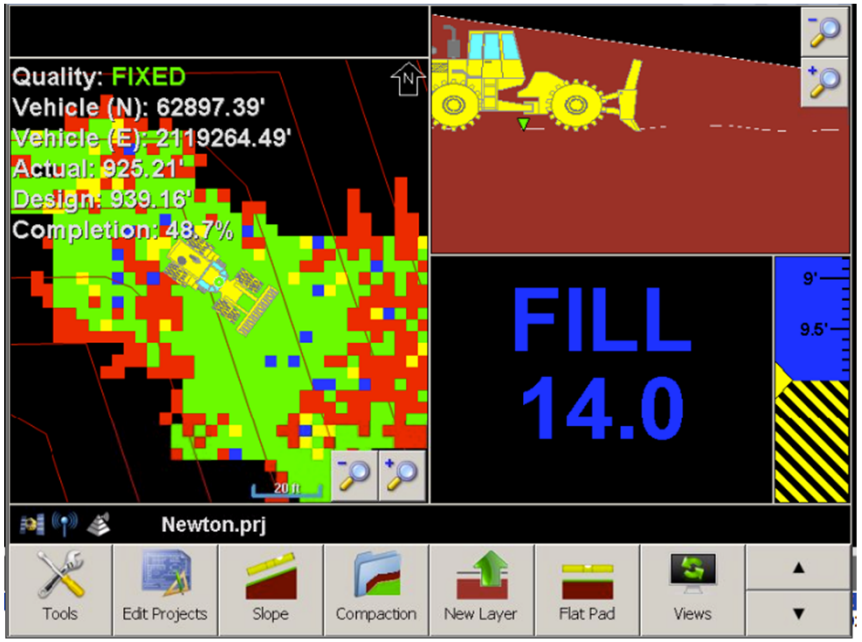
Compaction - Monitoring

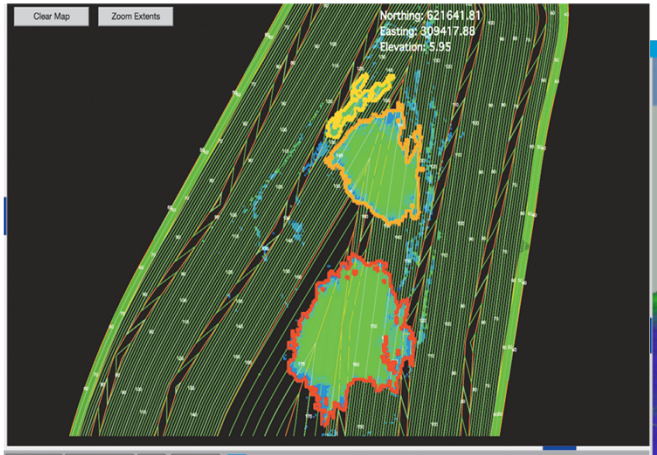




Compaction - Monitoring

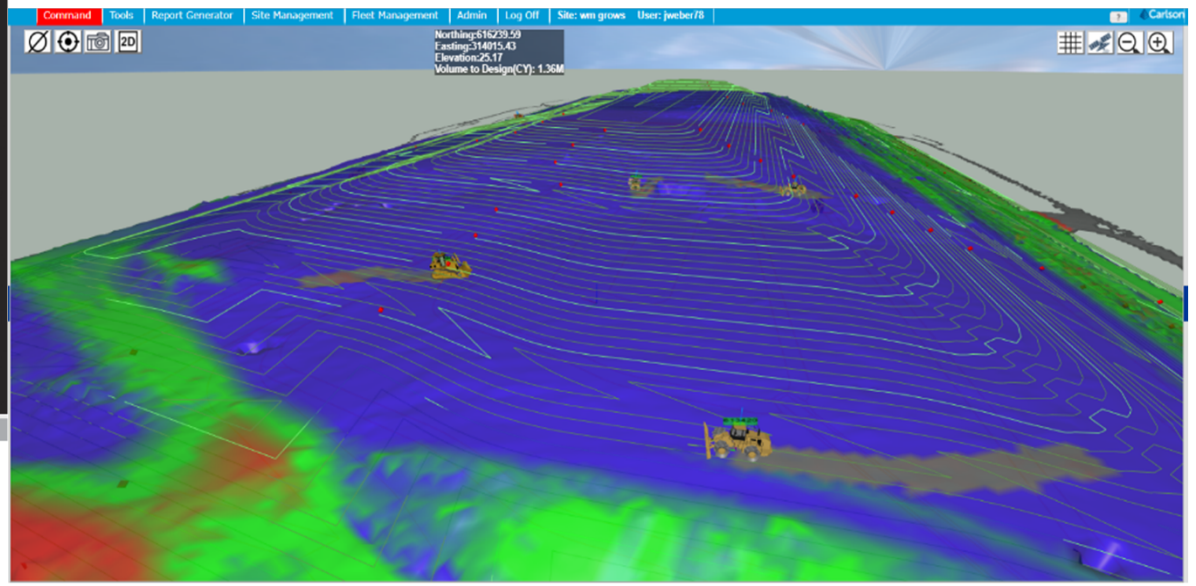






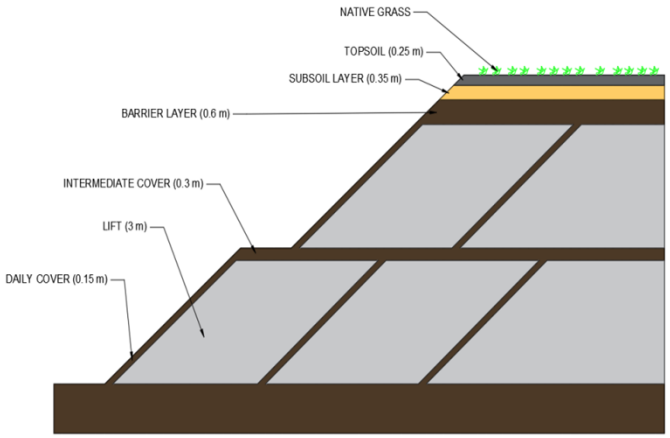
General Info | Transfer Queue | Alerts | AUF Zones | PDF

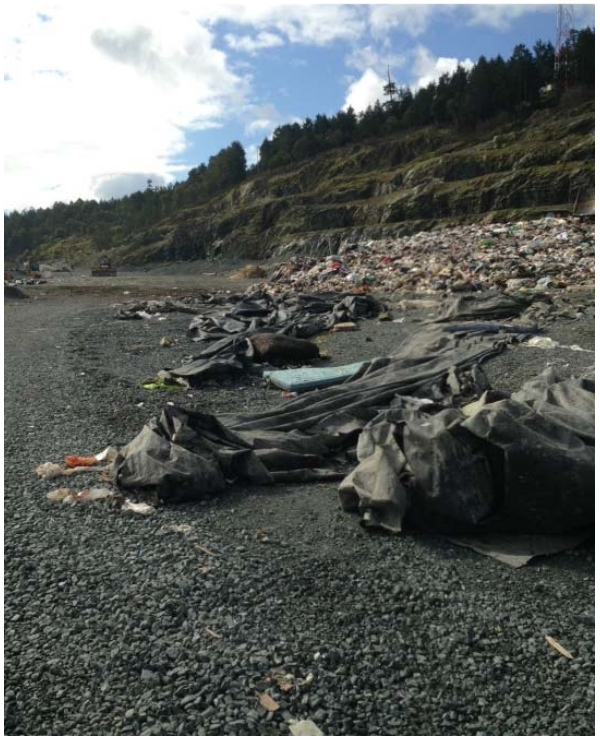
Work Zones	Work Zone 1	Work Zone 2	Work Zone 3	Work Zone Total
Total Volume(CY)	23770.96	9617.19	741.35	34129.50
Total Area(SqFt)	58016.00	31792.00	4480.00	94288.00
Avg Fill Depth(Ft)	11.06	8.17	4.47	9.77
Max Fill Depth(Ft)	26.79	20.60	9.07	9.07
AUF(Tons/CY)				1.03
Density(lb/CY)				2051.01



Cover - Method

- Soil cover
  - Cover all wastes with minimum 6 inches (15cm) of soil at end of day (figure- working face cover)
  - Remove daily and intermediate soil cover, and temporary road base, for future cover
- Alternative Daily Cover (ADC) may be used in lieu of soil as per operations plan
  - Processed waste material (i.e., wood/green waste)
  - Tarps/conveyor belts/metal plates/film/contaminated soil/snow
- Film cover Saskatoon Landfill, Polyethylene tarp Hartland landfill





Cover - Monitoring

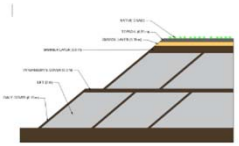
- Soil volume
  - calculation based on daily tonnage on how many buckets of soil to use
  - survey
- Soil placement/breaching/stripping
  - daily inspection form and observation
- ADC use
  - daily inspection form and observation

Active Face - Method

- For large landfills a formal Landfill Fill Plan is recommended to provide direction for Operations on the fill sequencing, roads, and for Managers for budgeting. A Landfill Annual Fill Plan will outline:
  - Waste tonnage projections
  - A designed top of waste with road network
  - Landfill grid system for waste placement tracking
  - Waste lift sequencing with road access
  - Soil balance for daily, intermediate, and final cover
  - Winter and summer active face sizing
  - Active Face control methods
  - Grade control methods
  - Methodology on how staff to update and implement a Monthly Fill Plan
  - Matching equipment & productivity needed based on incoming waste types and tonnage
- Landfill should have one active face to limit equipment and staffing requirements. Exceptions to having one active face which are discussed in a Fill Plan include:
  - Separating commercial and public traffic
  - Wet weather disposal area
  - High wind disposal area
  - Special waste disposal area (e.g. asbestos)
  - Separate C&D landfill cell

Active Face - Method

- A Fill Plan will provide for the filling progression technique, which the active area can be sized based on SWANA method, or pancake fill method
- Each method based on an overall fill lift, set by the Landfill Manager, but typically 3 m as shown in the figure (depth between intermediate cover application)
- SWANA active face method is prefaced on reducing soil cover
  - Narrow working face minimizes cover soil requirements
  - Allows for spreading, compacting and covering in the shortest time
  - Equipment run distance is short (many start stops)
  - Must be large enough for safe operation
    - Minimum of 3 m between customers
    - Landfill Manager and Lead Hand to size active face for customer service (reduce waiting time) based on seasonal tonnage records and special waste requests



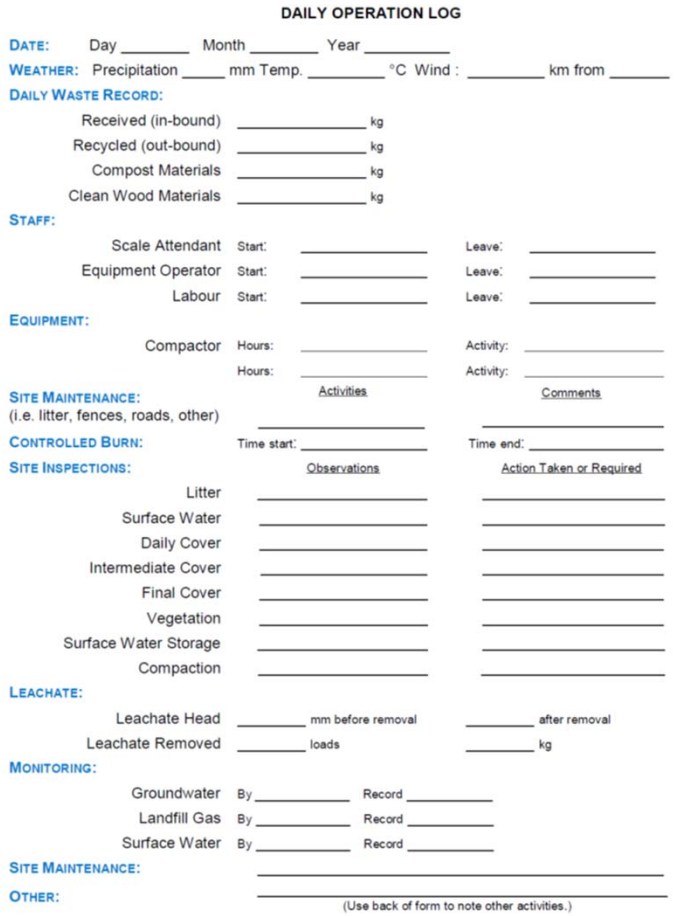
- Pancake fill method is prefaced on compaction and equipment efficiency
  - Active area based on a weekly fill area
  - Longer time to place and remove soil cover
  - Requires better cover soil management or ADC program
  - Should obtain better waste compaction
- Survey as required to control cell height and slope as directed by Landfill Manager/Fill Plan

Active Face – Method

- Delineating the active face to control the public and commercial haulers is important
- Delineating active face methods include
  - Use of portable litter fences, survey stakes, jersey barricades, or other hardscape items
  - Perimeter soil berm
    - Outside slope soil perimeter berm for lift height (3 m high, match outside slope design grade, 1:1 inside slope)
    - Active face mounded berm for 3 m active face height where material is used for soil cover
  - GPS on equipment as area can be programmed into equipment
  - Spotter or operator directs customers to safe unloading area at the active face
    - Potential for onsite radio communication with commercial haulers

Active Face – Monitoring

- Daily inspection form
  - Size of active face
  - Cover soil stockpile tracking
  - Perimeter berm construction/size
  - Leachate levels/movement
  - Survey (outside slope, lift thickness)
  - pictures
- Equipment/GPS records
- Recording of onsite communication



DAILY OPERATION LOG

DATE: Day _____ Month _____ Year _____

WEATHER: Precipitation _____ mm Temp. _____ °C Wind : _____ km from _____

DAILY WASTE RECORD:

Received (in-bound) _____ kg
Recycled (out-bound) _____ kg
Compost Materials _____ kg
Clean Wood Materials _____ kg

STAFF:

Scale Attendant Start: _____ Leave: _____
Equipment Operator Start: _____ Leave: _____
Labour Start: _____ Leave: _____

EQUIPMENT:

Compactor Hours: _____ Activity: _____
Hours: _____ Activity: _____

SITE MAINTENANCE: (i.e. litter, fences, roads, other)

Activities _____ Comments _____

CONTROLLED BURN: Time start: _____ Time end: _____

SITE INSPECTIONS:

	Observations	Action Taken or Required
Litter		
Surface Water		
Daily Cover		
Intermediate Cover		
Final Cover		
Vegetation		
Surface Water Storage		
Compaction		

LEACHATE:

Leachate Head _____ mm before removal _____ after removal
Leachate Removed _____ loads _____ kg

MONITORING:

Groundwater By _____ Record _____
Landfill Gas By _____ Record _____
Surface Water By _____ Record _____

SITE MAINTENANCE: _____

OTHER: _____

(Use back of form to note other activities.)

Month/Year: _____

Date	Removal Location (Leachate Pond/Cell 5 Sump 1 or 2/Leachate Pond Secondary Sump)	Volume Estimate (m^3) or Scale (Tonnes)	Usage (Active Face, Evaporation, Infiltration)	Disposal (Offsite WWTP or Deepwell)	Staff Initials

Landfill Culture - Method

- Build a culture of optimizing waste compaction
  - Regular airspace analysis for feedback
    - Survey
    - GPS on equipment
  - Operator weekly team meetings to
    - Overview compaction methods with new operators
    - Discuss active face operations including projected weekly tonnage, fill sequencing, weather considerations, active face sizing, special wastes being received, cover operations
    - Rotate staff responsible for waste compaction and active face training
  - Lead Operator/Manager observation assessments
    - Watch compactor operations and provide feedback
      - Weekly to biweekly for new operators
      - Quarterly or less frequent for experienced operators
    - Look for Wheels Up

WTM – ???

Data Management and Financials

- What to do with the compaction, cover, equipment, leachate, and inspection forms data?
  - ANNUAL BUDGETS
  - Optimization for cost savings
  - Different tracking systems that don't talk to each other (yet), so manager to review/compile/assess
  - GPS/Survey – can track by equipment, operator, and match to type of waste, season, and check density program changes such as moisture conditioning, changing to flatter slopes, etc.
  - Matching tonnage to equipment productivity to reduce equipment O&M costs
  - Reduce clean soil cover use
  - Minimize rework (leachate outbreaks, over/under fills)
  - MANY other things depending on what is the focus on a continuous improvement cycle

THE END

Questions?