Polymathian
Industrial Mathematics

Simulation
Extraction Level Design

2023



Project Overview - Background

A high throughput extraction level design has been developed by Geoff Dunstan as a part of a PhD project. The extraction level layout is designed to achieve high loader rates by using truck loops through the extraction drives to minimise loader tramming distances.

A preliminary simulation of the extraction level design was developed. Simulation results are intended to support static calculations of the operational capability of the extraction level design to achieve high throughput levels including consideration for interactions between loaders and trucks.



Project Objectives

The objective of the proposed simulation model development & analysis is to

- demonstrate the feasibility of the extraction layout design, and
- provide a throughput estimate for a specific loader-drawpoint assignment pattern.

The model is suitable for short duration runs only (e.g. a shift) and does not include dynamic re-assignment of loaders to drawpoints, as would be required for longer duration runs.



Model Configuration

Model Description – Summary

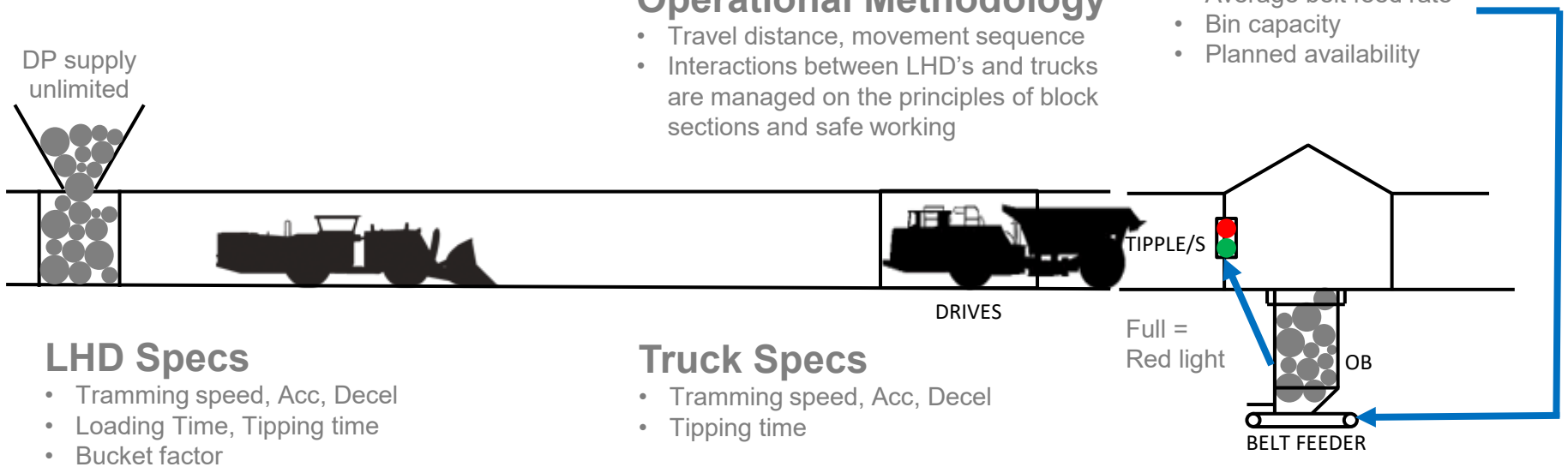
Key **Model Inputs** and **Logic**

Network Layout & Operational Methodology

- Travel distance, movement sequence
- Interactions between LHD's and trucks are managed on the principles of block sections and safe working

MHS

- Average belt feed rate
- Bin capacity
- Planned availability



LHD Specs

- Tramming speed, Acc, Decel
- Loading Time, Tipping time
- Bucket factor

Truck Specs

- Tramming speed, Acc, Decel
- Tipping time

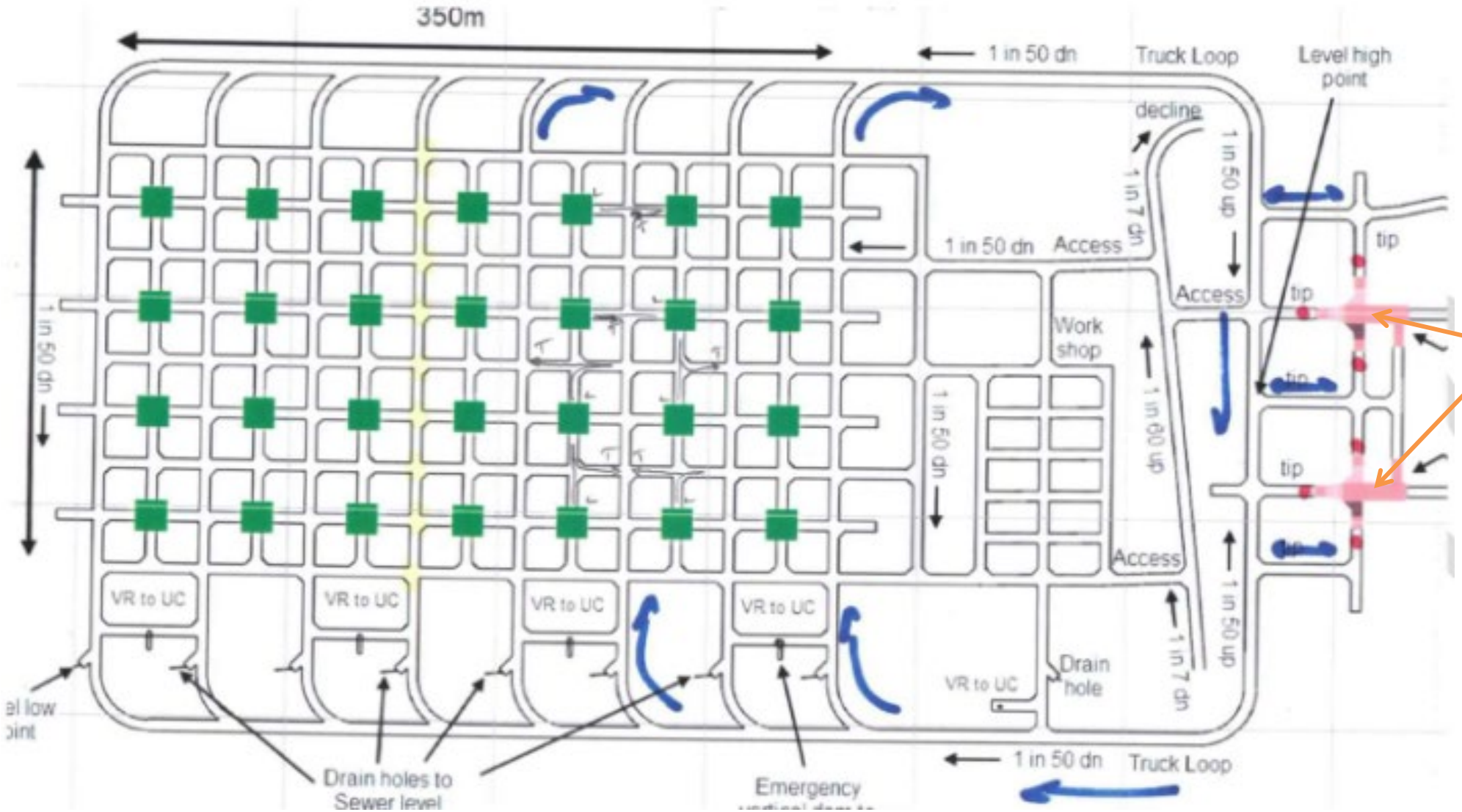
LHD Actions

- Perform cycles
- Pause due to interactions with trucks
- Request next order when complete

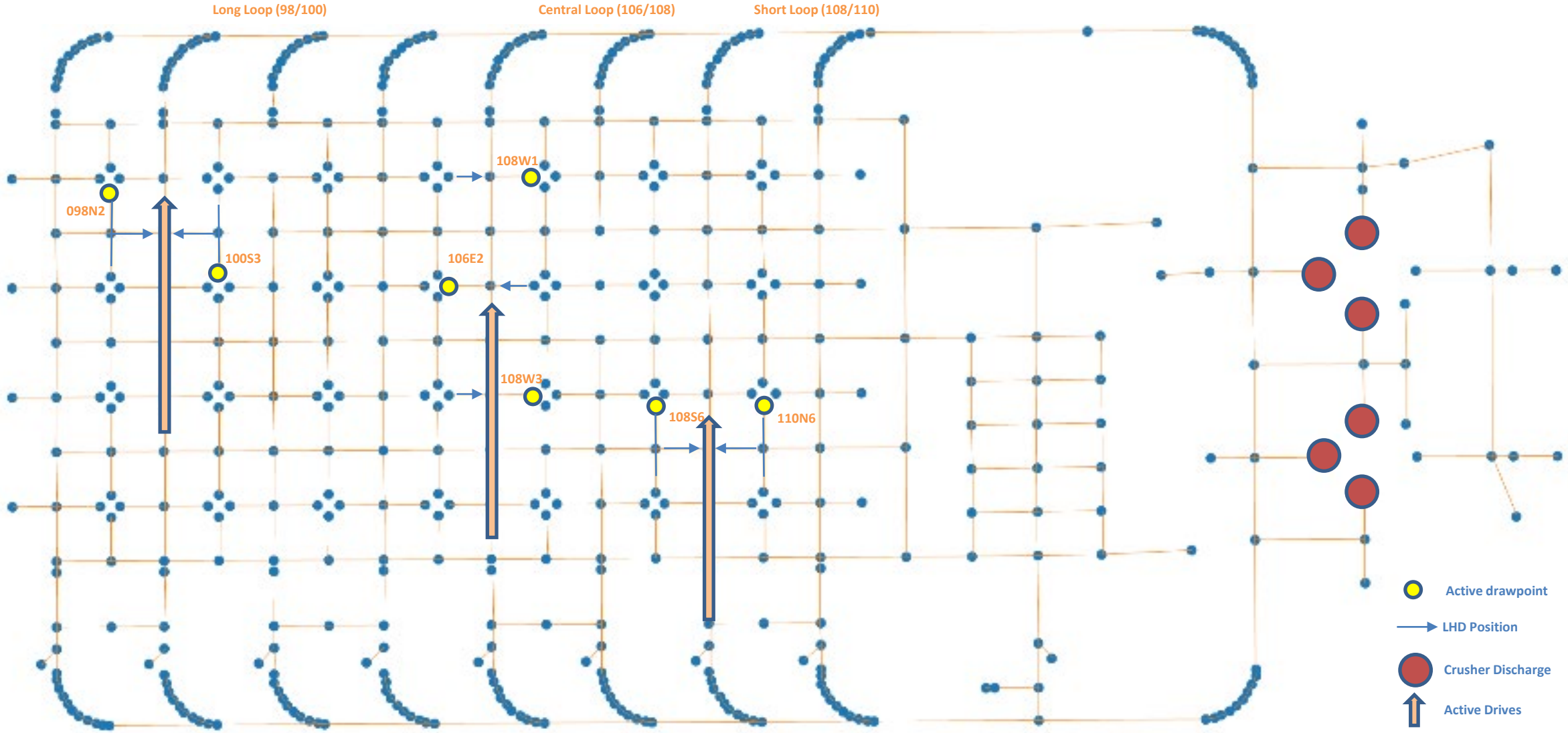
Truck Actions

- Perform cycles
- Pause due to interactions with LHDs
- Request next order when complete
- Allocation to tipples

Network Configuration (Layout)



Network Configuration (Layout)

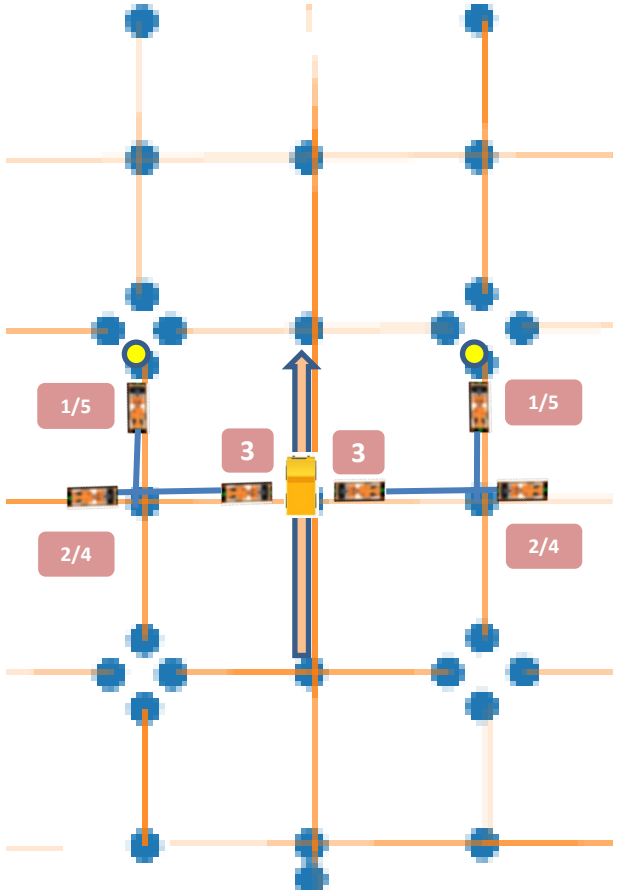


LHD Movements – Short/Long Loop

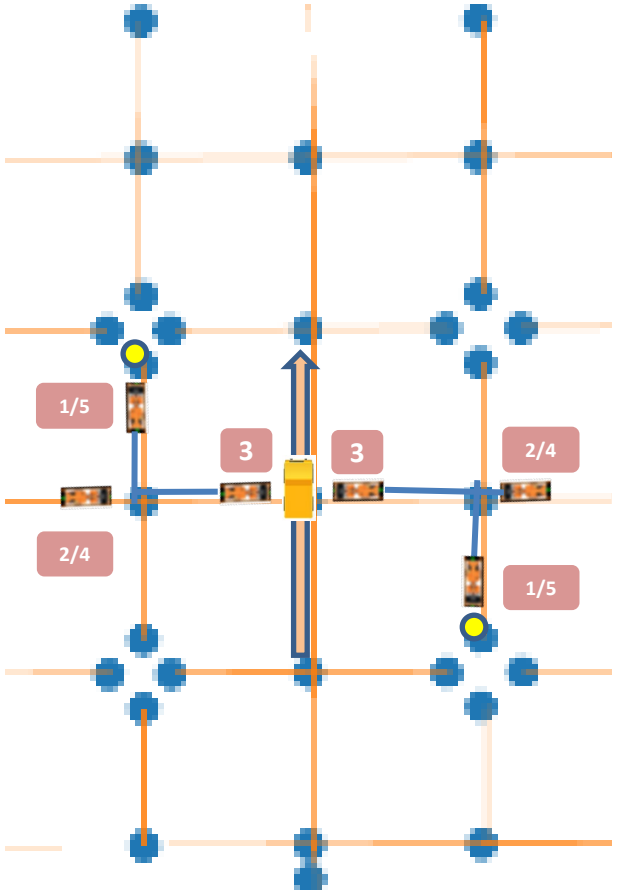
2 x LHDs draw from North/South drawpoints, on each side of the drive relative to the truck.



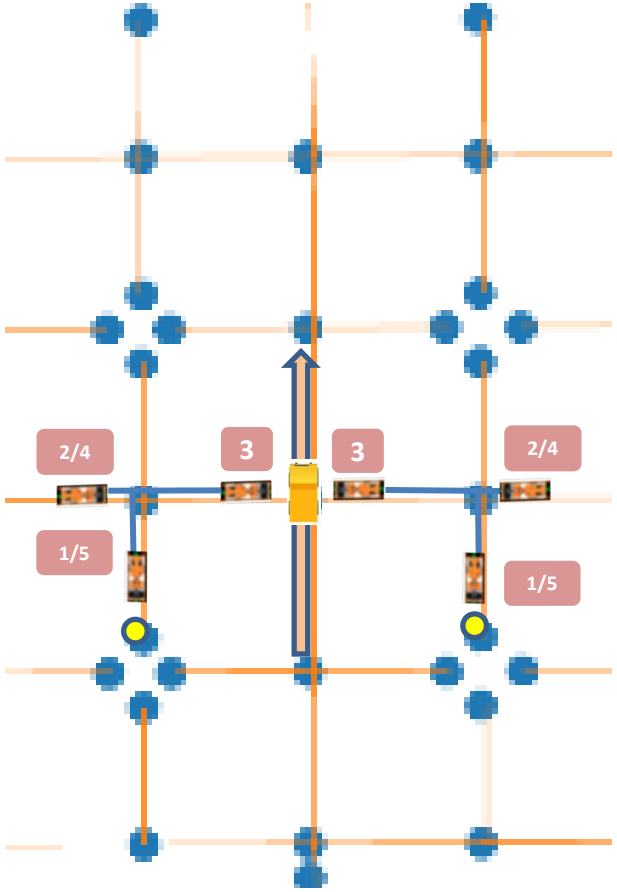
Option 1: 2 x South DPs



Option 2: 1 x South DP + 1 x North DP

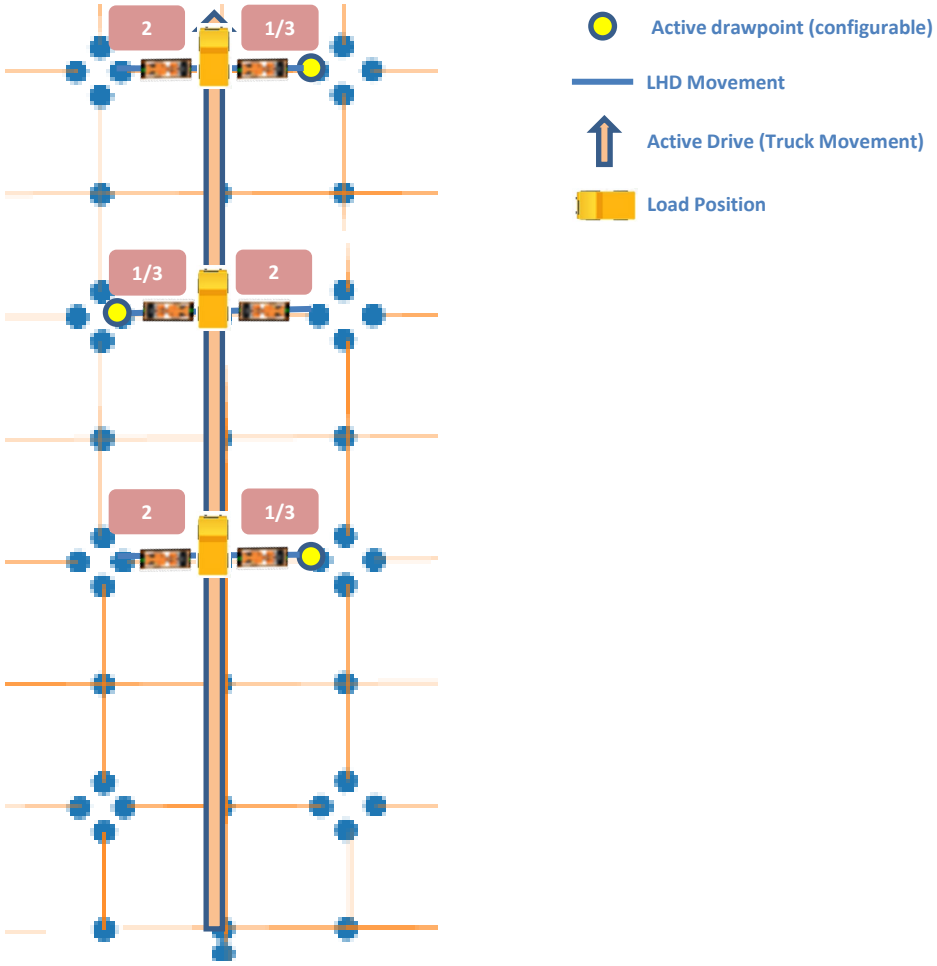


Option 3: 2 x North DPs



LHD Movements – East/West drawpoints

3 x LHDs draw from East/West drawpoints, on each side of the drive relative to the truck. The truck transits along the drive, accepting a load at each LHD position. If the LHD is not yet in position to dump, the truck waits *prior* to the LHD path.



LHD Model Inputs

Metrics	Value	Units
Type	Diesel	-
Number	7	#
Loader Bucket Size	21	t
Bucket Factor	95 +/- 10	%
Bucket Load Duration	45	sec
Bucket Discharge Duration	7.5	sec
LHD Length & Clearance	12.5 (20.0M INCL. CLEARANCE)	m
Avg. Max Speed (Loaded, Empty)	6.00	m/s
Acceleration	0.40	m/s^2
Deceleration	0.60	m/s^2
Operational Days	365	days
Operational Hours	22	hours

Truck Model Inputs

Metrics	Value	Units
Truck Capacity*	63	t
Discharge Duration	16	sec
Avg. Max Speed	6.00	m/s
Acceleration	0.40	m/s^2
Deceleration	0.60	m/s^2
Operational Days	365	days
Operational Hours	22	hours

* *Captured within the simulation model through LHD bucket size and ore factor*

MHS Model Inputs

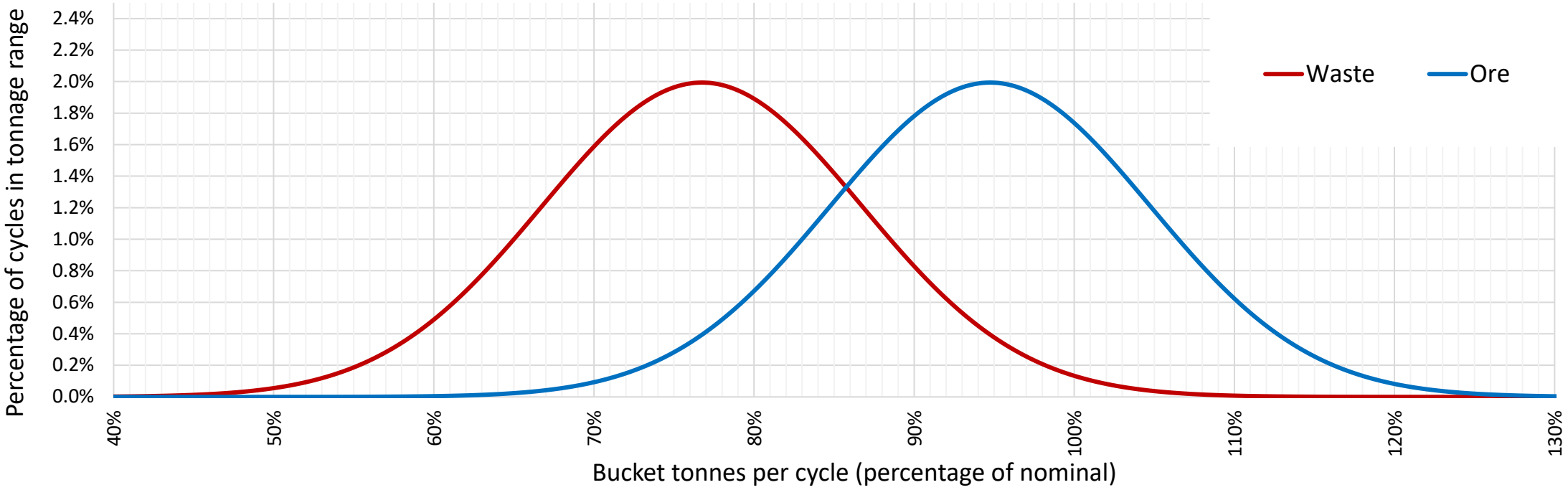
Metrics	Value	Units
Planned Availability	94	%
Time between Failure (TBF)	Weibull (98.78, 1.2)	mins
Time to Repair (TTR)	Weibull (6.3, 1.2)	mins
Crusher Instantaneous Rate	2,750	tph
Number of Crushers	2	#
Tipple ROM Bin Capacity	2,500	t

Overarching Model Logic

Logic Item	Description
Material Feed	The model operates under the assumption of an unlimited feed, ensuring that material supply from drawpoints is never a constraint
Truck Assignment	The model assigns trucks to LHDs based on minimising truck queuing

LHD Bucket Factor

- An ore bucket factor of 95% is currently used for all scenarios, with +/- 10% variation
- The bucket factor (along with cycle time delay) is one of the key stochastic model inputs that changes the rate of production
- Example variation for a nominal bucket size/ tonnage is provided below



Static Performance Assessment

Supporting Static Calculations (LHDs)

Static calculations are shown below for both the North/South and East/West configurations. These calculations do not allow for trucking interactions and therefore should be treated as indicative bounds for achievable throughput.

Metric	North/South	East/West	*Units*
Calendar Days	365		*days*
Hours in Day	22		*hours*
LHD Availability	94		*%*
Load Duration	45.0	45.0	*sec*
Tip Duration	7.5	7.5	*sec*
Transit Time (Total)	54.7	45.2	*sec*
Total Cycle Time	**1.79**	**1.63**	***min***
Tips per Day	739	810	***#***
Bucket Size	21	21	***t***
Bucket Factor	95%	95%	***%***
Tonnes per Day (1 x LHD)	**14,471**	**16,165**	***tpd***
Tonnes per Day (7 x LHDs)	**103,186**	**113,154**	***tpd***

** N/S Load Sequence – Load, Transit back and then forward to truck, tip, move back and forward to pass*
*** E/W Load Sequence – Load, Move back and forward to truck, clear path, tip, clear path, move back and forward to pass*

Supporting Static Calculations (Trucks)

Static calculations are shown below for both a short and long loop operation. These calculations do not allow for interactions and concurrent loop operations and therefore should be treated as indicative bounds for the number of trucks required.

Metric	Short Loop	Long Loop	*Units*
Calendar Days	365		*days*
Hours in Day	22		*hours*
MHS Availability	94		*%*
Distance Travelled (Circuit)	1,046	1,746	*m*
Transit Time **	6.3	10.5	*min*
Bucket Load Time *	81.89	22.5	*sec*
Bucket Discharge Time	16	16	*sec*
Total Cycle Time	**7.91**	**11.11**	***min***
Bucket Size	21	21	***t***
Bucket Factor	95%	95%	***%***
Buckets per Cycle	3	3	***#***
# Bucket Dumps / Day	**167**	**119**	***#***
Tonnes per Day per Truck	**9,991**	**7,108**	***Mtpa***
Trucks to meet 100kt target	**10.01**	**14.07**	***#***

** 3 buckets per cycle; accounts for LHD movements and 2 (short) or 3 (long) LHDS per drive and LHDs in position for some dumps*
*** Average speed of 2.8m/s*

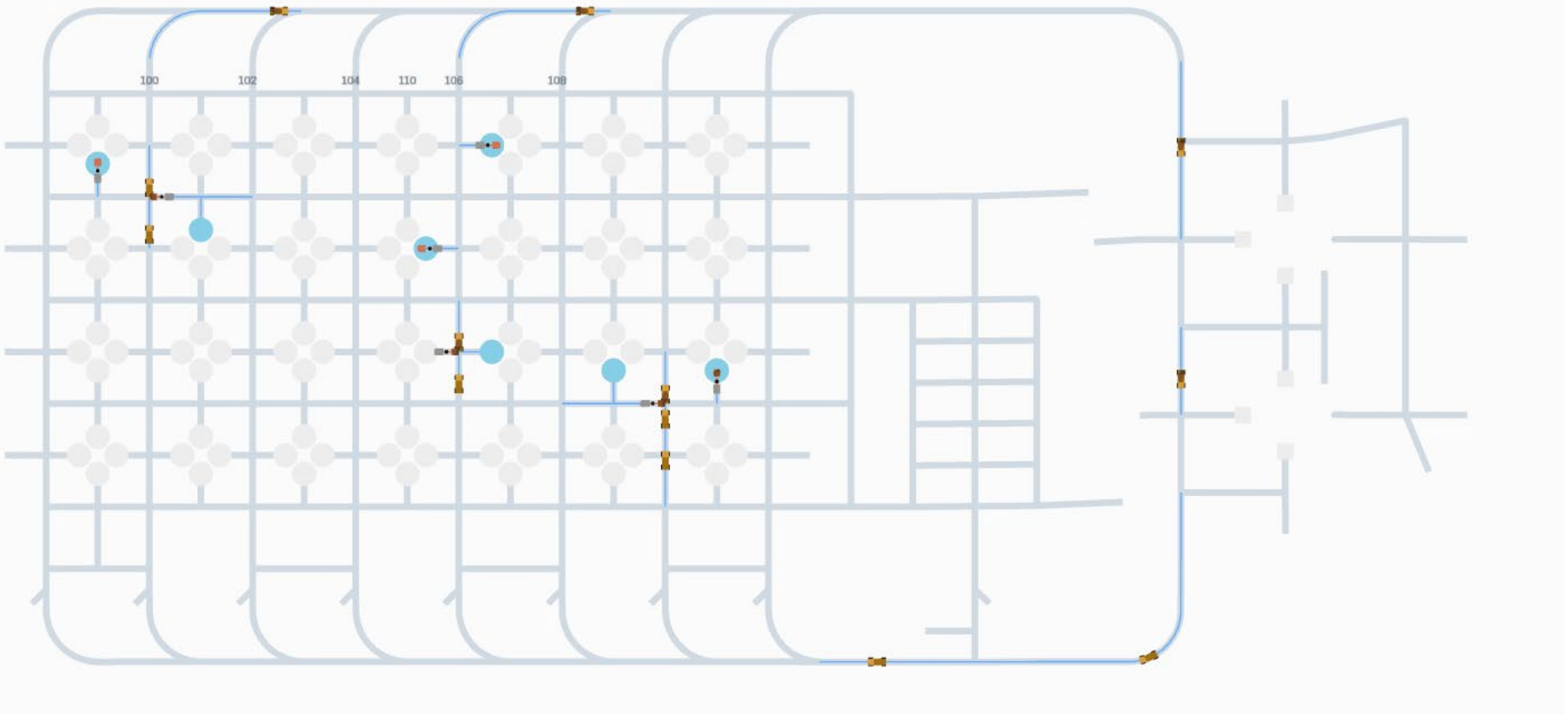
Supporting Static Calculations (MHS Capability)

The MHS is capable of processing 124kt per day, decreasing to 113kt per day with consideration for truck availability of 22hrs.

Metric	Value
Operational Rate of Crusher	2,750 tph
Number of Crushers	2.0
MHS Availability	94%
Operational Days per Year	365
Throughput, tpd	**124,080**
Throughput, tpd (with trucks available 22hrs/day)	**113,740**

Animation

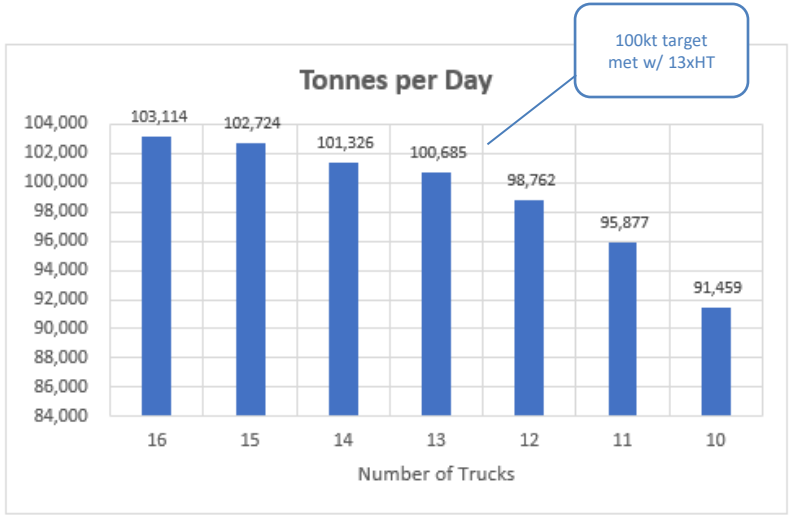
Animation

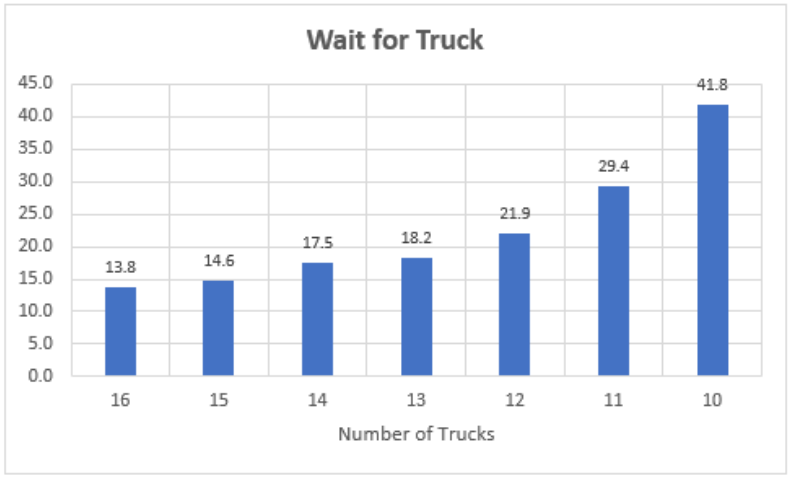


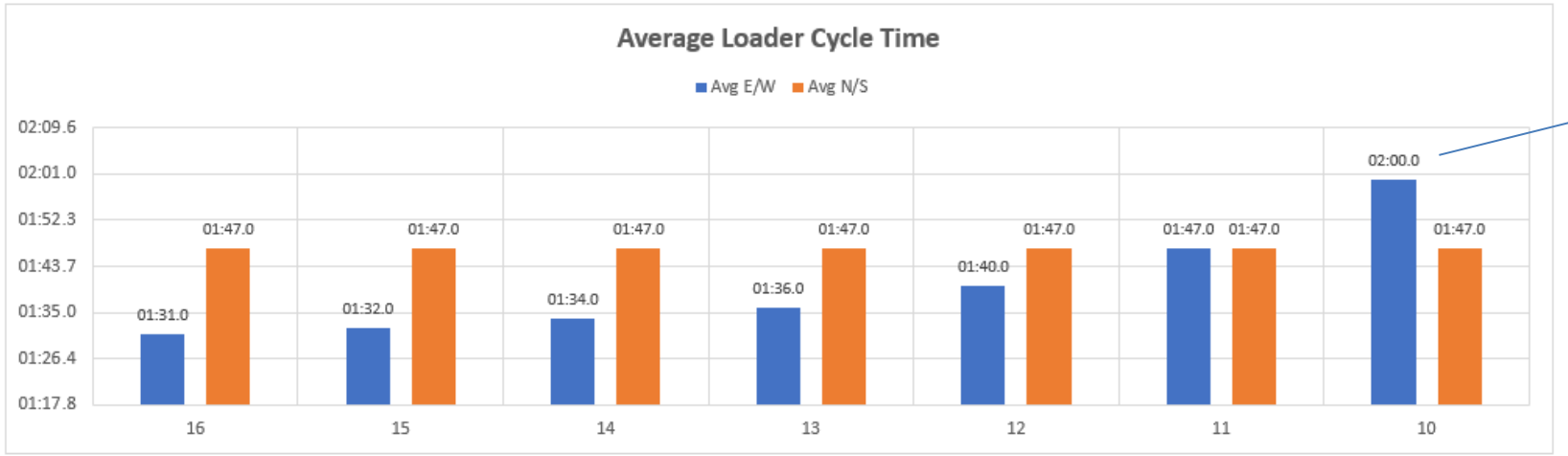
Scenario Analysis

Scenario Results – Daily Throughput

To meet target throughput of 100kt per day, 13 trucks are required under the existing configuration.







* *12 Hour Simulation, MHS at 94%, 22 Operational Hours per Day*

END