2016 Waste Management Facility Master Plan

Landfill Expansion and Site Development

Prepared for:
City of Lloydminster

Prepared by:
Stantec Consulting Ltd.

December 2016
110128003

Sign-off Sheet

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Executive Summary

The 2016 Waste Management Facility Master Plan for the City of Lloydminster has been prepared to outline the project objectives and rationale, concept design, construction alternatives, financial considerations and implementation plan.

Background

The Waste Management Facility (the "facility) for the City of Lloydminster is located within Section SW ¼ 13-50-28-W3M in the northeast corner of the City at the intersection of 40th Avenue and 67th Street. The facility covers an area of approximately 50 hectares. Waste landfilling at this site dates back to 1970 with waste generally been disposed in long trenches running north-south. It was estimated that the area occupied by the historical waste is approximately 15-20% of the total fenced area of the facility.

The first engineered cell Phase 1.1 was operational from 2007 to 2012 when the current active Phase 1.2 to its south was constructed. Leachate generated from the engineered phases or cells is currently conveyed by gravity to a leachate lift station from where it is pumped to an overflow pond and then overland to the septic manhole located south of the facility and discharges to the sewer running parallel to 67th Street. Currently, surface water is diverted to a stormwater management pond located in the northeast area of the facility and is discharged to the environment on an as-needed or as-required basis.

Objectives

The Master Plan has been developed to provide guidance for the development of this facility for a 20-year period (2017-2036).

Based on the trend in the population growth rate, the City's population is expected to increase by approximately 60% by the end of the Master Plan period and will require significant improvement to facility infrastructure so that waste can be managed efficiently and in an environmentally safe manner. The scope of this Master Plan and the objectives City intends to achieve are primarily focused around residual waste management infrastructure and broadly includes:

- Assess the existing site operation in consideration of future growth in waste generation
- Develop a plan for future lateral/vertical expansion of the existing landfill keeping in view the historical waste disposal area and other infrastructure currently in place
- Assess the current facility entrance and consider its re-location to facilitate commercial and residential traffic movement within the facility as well as minimize traffic safety concerns on 40th Avenue near the entrance
- Recommend improvements for the public drop-off area, snow disposal area and the management of construction and demolition (C&D) waste

- Recommend development plans and necessary upgrades required in the short- and long-term including estimates of CAPEX and OPEX for capital projects

Current Facility Assessment

An assessment of the existing facility was undertaken in term of current operation, current infrastructure and potential for future expansion keeping in view the historical waste disposal area and engineered Phases 1.1 and 1.2.

The facility currently receives municipal solid waste (MSW) mixed with C&D waste, concrete, wood waste, clean fill, treated petroleum hydrocarbon impacted soils and recyclables together with various other waste types regulated under provincial stewardship programs. In 2015, approximately 35,000 tonnes of solid waste was received at this facility which shows an annual growth rate of approximately 2% since 2006. The vehicle count at this facility also shows a growth rate of approximately 5% based on traffic data assessed for 2009 to 2015. Almost 80% of the vehicular traffic to this facility is contributed to city residents and commercial patrons with the remaining 19% contributed by City trucks, snow haulers, septic haulers and other. In terms of waste types disposed at this facility, 66% is MSW, 16% is clean fill and concrete and 1% other waste types.

The entrance to the facility is currently from 40th Avenue through a single lane weigh scale which serves both inbound and outbound traffic. Because of this, commercial vehicles have to make undue turns to get on to the weigh scale for their tare weight before they can exit the facility which causes traffic conflicts. Further, during peak hours it also causes vehicle stacking on 40th Avenue presenting additional safety concerns. Under its current operation, all vehicles, private residents and commercial haulers, have access to the active face of the landfill for the disposal of household waste and this further creates hindrance to general traffic movement at the facility, an increase in wait times for commercial vehicles and an overall safety concern for private residents.

There are 23 active groundwater monitoring wells at the facility and all these monitoring wells are examined annually as part of their Permit to Operate. The background groundwater quality at this site is generally poor, one of the downgradient monitoring wells does show elevated chlorides possibly an impact pursuant to current and past operation of this site including the operation of the snow disposal facility just north of the facility. The groundwater levels in the historical waste disposal area indicate an increasing trend based on available data from 2013-2015.

As part of this assessment, the existing snow disposal area, stockpiled materials, historical waste area and the impacted soil management area were also assessed.

Master Plan Recommendations

The facility is currently regulated by the Saskatchewan Ministry of Environment under the Environmental Management and Protection Act (2010). For the Master Plan period (2017-2036), it was estimated that approximately 1.0 million tonnes of waste including sludge solids will be disposed at this facility. This will require an airspace of approximately 2.3 million m3 inclusive of daily cover. With the anticipated growth in waste generation, the vehicular traffic at this facility will also increase proportionately. It has been estimated that by the end of 2036, the vehicular traffic at this facility will increase by 84% to 85,609 over its 2015 traffic count of 46,571.

This Master Plan has been developed considering the estimated increase in waste quantities and traffic volume. Based on these, recommendations are provided for future expansion of waste disposal areas within the existing property boundary including relocation of facility entrance with provision for separate inbound and outbound weigh scales, a separate public drop-off area away from the active face of the landfill to minimize interference with the commercial traffic, a leachate holding pond to eliminate the need for overland pumping of leachate to the septic manhole/wastewater treatment facility, an equipment/maintenance building, future material stockpile areas, snow disposal facility improvement and an interim and ultimate surface water management plan.

While providing recommendations for the future expansion of the landfill, the intent was to make efficient use of the area within the existing facility bounds and to limit the overall footprint of the landfill area. This includes the area currently occupied by the historical waste and the area between the east boundary of Phases 1.1 and 1.2 and the existing WWTF. For making effective use of available area for landfill expansion, two options are proposed for the reclamation of the historical waste disposal area. One option is to reclaim by piggybacking the existing historical waste disposal area. This will involve designing an overliner system above the existing waste. However, this method will require a thorough understanding of the geotechnical properties of the historically disposed waste. The other option is to reclaim this area by excavation (known as landfill mining) and re-disposing waste in a newly constructed and lined cell. This later method would enable efficient airspace utilization, organic fine recovery and reduce the overall long-term liability for the City.

A phased implementation plan for the Master Plan sub-periods 2017-2021, 2022-2026, 2027-2031 and 2032-2036 is provided to assist the City with making capital budget provisions for various capital projects and upgrades recommended as part of this Master Plan.

1.0 INTRODUCTION

The Waste Management Facility (the 'facility') for the City of Lloydminster (the 'City') is located within Section SW ¼ 13-50-28-W3M in the northeast corner of the City at the intersection of 40th Avenue and 67th Street. The current fenced area occupied by this facility is approximately 50 hectares. The City's wastewater treatment facility (WWTF) adjoins this facility towards its east perimeter fence. This facility is primarily used for disposal of waste generated within the City limits; however, individuals and businesses from the City's outskirt can dispose waste for a fee.

1.1 BACKGROUND

Historically, landfilling at this site dates back to 1970 and waste had generally been disposed in long trenches running north-south with no provision for seepage barrier or leachate collection system. The aerial extent and the precise depth of these trenches is largely unknown except for the information obtained from the borehole logs available from documents provided by the City. It is estimated that the area occupied by the historical waste is approximately 15-20% of the total fenced area of the facility.

Until 2007, landfilling of waste progressed from the southwest corner of the facility towards the east. The majority of waste during that time period was disposed in the south-southwest area which is currently used as a/the public drop off facility for cardboard, blue bag materials, e-waste, tires and HHW (paint, oil, glycol and battery). The area towards 67th street, which is currently used for stockpiling lumber/chipped wood, white goods and metals, is also expected to be underlain with historical waste.

The first engineered cell, Phase 1.1 was constructed in 2007 and was provided with a 1.1 m thick compacted clay liner (CCL) and a leachate collection and removal system (LCRS). This cell was in operation from 2007 to 2012 when the current active Phase 1.2 to the south was constructed. Phase 1.2 was designed in a similar manner to Phase 1.1 but with a geosynthetic clay liner (GCL) on the west side slope adjoining the historical waste disposal area. Leachate generated from Phase 1.1 and 1.2 is currently conveyed by gravity to a leachate lift station. Leachate collected in the lift station is pumped to the overflow pond from where it is periodically pumped overland using a 150 mm diameter hose to the septic manhole located south of the facility which discharges to a sewer running parallel to 67th Street.

The facility also has two wet cells constructed in 2010 in the south east portion adjacent to the east boundary of Phase 1.2. These wet cells were constructed for decanting sump waste from hydrovac trucks.

Surface water collected from the facility is diverted to a stormwater management pond located in the northeast area of the facility. This pond was constructed to provide a detention capacity of approximately 24,000 m^3. The storm water collected in this pond is discharged to the environment on an as-needed basis.

1.2 PURPOSE AND SCOPE

Between 1961 and 2011, the City's population increased by an average 3.2% annually[1]. The available municipal and federal census population data for the years 2001 to 2015 were plotted as shown in Figure 1. Over this period, the City's population shows a linear growth rate with a coefficient of correlation (R^2) of 0.97. In relation to Alberta, the City's population growth rate has consistently been higher; however, the overall trend in the growth rate appears to be tending downwards.

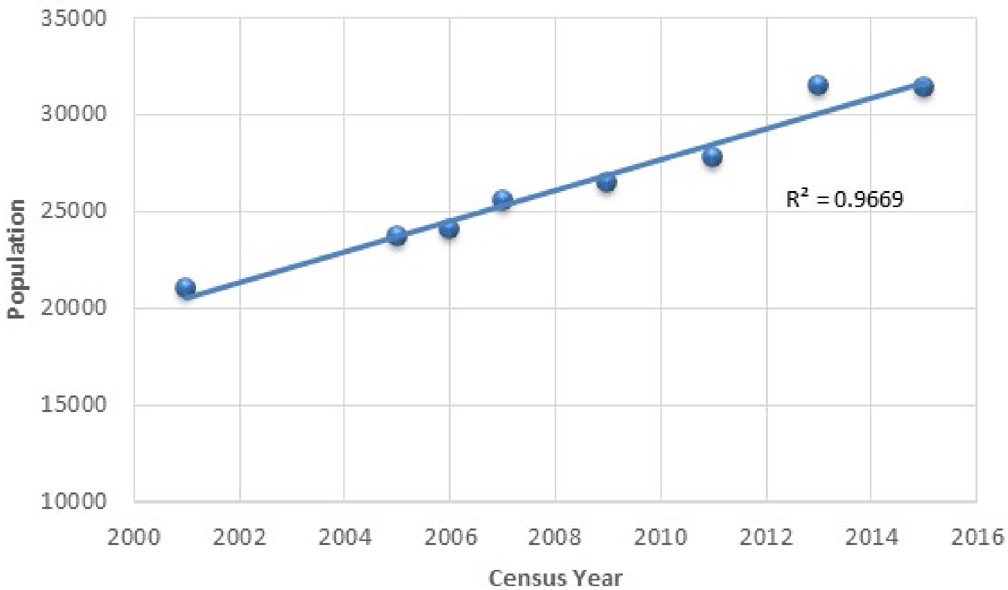

Figure 1 City's Population Trend based on Federal and Municipal Census

Given the projected population growth rate a significant enhancement to the existing municipal infrastructure will be necessary in the coming years including enhancement to solid waste management which primarily comprises three components:

- Waste collection infrastructure
- Waste recycling/material recovery infrastructure
- Residual waste management infrastructure i.e. Landfill

[1] Comprehensive Growth Strategy – Final Report prepared by ISL Engineering and Land Services (August 2013)

Stantec Consulting Ltd. (Stantec) was retained by the City to develop the 2016 Waste Management Facility Master Plan (the "Master Plan"). The scope of this Master Plan is primarily focused around residual waste management infrastructure which is one of the three components mentioned above. The scope of this report, therefore, broadly includes the following:

1. Assessment of current facility operation for determining necessary upgrades directed towards optimizing the land uses in consideration of future growth in waste generation
2. Development of a plan for future lateral and vertical expansion of the existing landfill keeping in view the historical waste disposal area, construction and demolition (C&D) waste disposal area towards north and the engineered cells (Phase 1.1 and 1.2)
3. Assessment of current facility entrance and its realignment or re-location to facilitate commercial and residential traffic movement within the facility as well as minimize traffic safety concerns on 40th Avenue at the facility entrance
4. Provide recommendations for improvement to the public drop-off area and management of construction and demolition (C&D) waste area
5. Prepare phased development plans and recommend necessary upgrades required in the short- and long-term including estimation of capital expenditure (CAPEX) associated with such upgrades.

1.3 STRUCTURE OF THIS REPORT

This report has been structured in the following manner to address the various requirements of the Master Plan:

Section 1 - Introduction	This section describes background information and site history, purpose/objectives and scope of this project.
Section 2 - Overview of Environmental Settings	This section describes topography, subsurface hydrogeology and hydrology of this site on a local and regional scale in relation to the existing facility and future site development.
Section 3 – Existing Facility Assessment	This section provides an assessment of facility operation and existing infrastructure at the facility
Section 4 – Waste Management Facility Master Plan	This section describes the proposed 2016 Waste Management Facility Master Plan based on information contained within the previous Sections. Major components addressed includes facility entrance relocation and traffic accommodation to enable smooth and efficient operation, alternate public drop-off, improvement to snow disposal area, facilitate commercial and residential traffic movement and phased development of the landfill during the Master Plan period of 20 years (The estimated facility life though is approximately 40 years within the current facility bounds)
Section 5 – Implementation Plan	This section outlines an implementation plan for the phased improvement/development of the facility including capital budget estimates for 5,10, 15 and 20-year milestones.

2.0 OVERVIEW OF ENVIRONMENTAL SETTINGS

2.1 TOPOGRAPHY

The topography of the Lloydminster area is generally flat to gently rolling with a gentle regional slope towards the northeast. The 620 masl (meter above sea level) ground elevation contour passes beneath the landfill across the north-northeast portion of the facility.

2.2 GEOLOGY AND HYDROGEOLOGY

The local and regional scale geology and hydrogeology of this site has been summarized in the Functional Landfill Study Report[2] as well as in various groundwater monitoring reports prepared by AMEC.

On a regional scale, the geology consists of glacial till and stratified sediments of the Saskatoon group underlain by glacial till and stratified sediments of the Sutherland Group in buried valleys and bedrock depressions. Beneath the landfill, the thickness of the till is greater than 40 m. The Empress Group, approximately 60 m thick infilling the base of the valley, is interpreted to occur just north of the landfill location 150 m below ground surface (bgs). On the local scale, the subsurface geology exhibits till with low to medium plasticity up to a depth of approximately 18 m bgs. Intertill sand and gravels were observed in a few boreholes drilled near the south boundary of the facility towards 67th Street (MW01-5 & MW03-12).

The regional scale intertill sand and gravel aquifer just north of the landfill site is interpreted to be approximately 85 m bgs and is approximately 10-20 m thick. However, its continuity or a hydraulic connection with the underlying regional intertill sand and gravel aquifer located just north of the landfill site doesn't appear to have been established based on the reports reviewed. The regional groundwater flow was interpreted by others to be northeast with a downward vertical component.

The well recovery tests performed in 2003 indicated an average hydraulic conductivity in the range of 10^{-8} to 10^{-9} m/s. The western portion of the facility exhibited lower hydraulic conductivity compared to its eastern portion currently occupied by Phase 1.1 and 1.2. The location of the wells where these hydraulic conductivity tests were conducted was not readily available from the reports reviewed.

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[2] City of Lloydminster Sanitary Landfill Functional Study prepared by UMA Engineering Ltd. (December 2006)

2.3 SURFACE WATER HYDROLOGY

The facility lies within the drainage basin of Gully Creek which is an east-southeast flowing tributary of the North Saskatchewan River. Further a small creek/stream located to the north of the current snow disposal area in the section NW-13-050-28-W3M flows eastward towards Neale Lake through a wetland area north of the landfill, and into a shallow water body to the east of the WWTF[3].

[3] 2011 Annual Groundwater monitoring report prepared by AMEC

3.0 OPERATIONAL ASSESSMENT AND ISSUES

The following components of the existing solid waste management system were reviewed to assist with the development of a Master Plan for this facility:

- Facility Entrance, in relation to:
  - landfill bound traffic on the 40th Avenue
  - internal traffic movement with regard to commercial and residential traffic
  - weigh scale and data logging at the scale house
- Waste Disposal Areas:
  - Historical waste disposal areas for municipal solid waste (MSW) and construction, renovation and demolition waste (C&D)
  - Current waste disposal areas i.e. engineered cells Phase 1.1 and 1.2
- Facility Infrastructure:
  - Public drop-off area
  - Snow disposal area
  - Wet cells – current usage and alternate use
  - Impacted soil management area
  - C&D waste management
  - Material stockpiles – clean fill, lumber, concrete, white metals, treated soils
  - Vehicle maintenance area
  - Landfill equipment
- Environmental Monitoring:
  - Groundwater
  - Leachate
  - Landfill gas
  - Surface water management

3.1 FACILITY ENTRANCE

The current entrance to the facility is from 40th Avenue through a single lane weigh scale which serves both inbound and outbound traffic. The 40th Avenue is an undivided single lane highway. Given its current geometric design in relation to the facility entrance, it does not offer clear line of sight for the vehicles entering and exiting the facility from the northbound and southbound traffic. Moreover, due to the single lane weigh scale at the facility, the commercial vehicles have to make undue turns to get on to the weigh scale for their tare weight before they can exit the facility. This traffic arrangement often creates undesirable traffic conflicts and operational challenges with traffic movement especially near the facility entrance and the public drop-off area (per communication with the City). Further, interactions of residential traffic those using the public-drop off area with the commercial traffic present safety issues as well as hindrance to the general traffic movement at the facility.

Waste received at this facility generally comprises:

- MSW – also called as trash or garbage, is defined as wastes consisting of everyday items such as product packaging, grass clippings, furniture, clothing, bottles and cans, food scraps, newspaper, appliances, consumer electronics and batteries. These wastes come from homes and institutions such as schools, hospitals and commercial sources such as restaurants and small businesses[4]
- C&D waste
- Treated soil from the impacted soil management area operated by Ridgeline Inc.
- Waste recyclables regulated under various provincial waste stewardship programs

At the scale house, the vehicles entering the facility are primarily logged for two categories. One is the category of customer i.e., residential, commercial, City and outside City. The second category is waste type being disposed i.e. garbage, mattresses, appliances, clean fill, etcetera. Garbage, per City's scale house record, is defined as a mixed load of MSW and C&D waste. Currently, C&D waste is not logged as an exclusive category. However, wood and concrete, the two major components of C&D waste, are logged individually. Actual weights are recorded at the weigh scale of commercial vehicles and City waste collection vehicles. Residents are allowed to drop off their MSW and recyclables for free. The waste quantities disposed by residents are logged in terms of 20, 30 or 50 kg based on visual examination of the waste loads. As a demonstration to their residency, the residents are required to show their Driver's license at the scale house.

3.1.1 Existing Traffic Volumes

The current facility is open 7-days a week during the summer months (May – Sep) and 6-days a week in the winter months (Oct – Apr) with the exception of statutory holidays. The scale house data provided by the City for 2009 to 2015 was analyzed for the current traffic volume and composition. **Table 1** shows the traffic volume at the facility contributed by city residents, commercial and others for the period between Jan 1, 2009 to Dec 31, 2015. The data for 2015 appears to be an anomaly which shows a sharp decline of approximately 20% in the traffic count from its 2014 count.

[4] USEPA Report on the Environment – Municipal Solid Waste (Accessed online Sep 22, 2016)

Table 1 Traffic Volume Assessment

Year	Annual Traffic Count			Total Annual Traffic Count	Annual Traffic Count (%)		
	City Residents	Commercial	Other vehicles		City Residents	Commercial	Other vehicles
2009	18078	16430	11416	45924	39%	36%	25%
2010	15381	16749	11220	43350	35%	39%	26%
2011	19241	20068	7134	46443	41%	43%	15%
2012	25456	18666	7927	52049	49%	36%	15%
2013	22820	22553	8142	53515	43%	42%	15%
2014	21750	28532	9528	59810	36%	48%	16%
2015	17698	19682	9191	46571	38%	42%	20%
7-Year Average Traffic Contribution					**40.3%**	**40.8%**	**18.9%**
Margin of Error in the Mean for a Confidence Level of 95%					**3.4%**	**3.2%**	**3.5%**

During this period the residential traffic volume appears to be at par with the commercial vehicles using this facility. Together these contribute approximately 81% of the total vehicular traffic and the remaining approximately 19% traffic being contributed by City vehicles, snow haulers, septic haulers, outside vehicles and the others as shown in **Figure 2**. Give the estimated margin of error in the average value shown in **Table 1**, it is expected that the contribution of residential vehicles, commercial vehicles and other vehicles in the future will be in the range of 37-44%, 38-44% and 15-22% respectively.

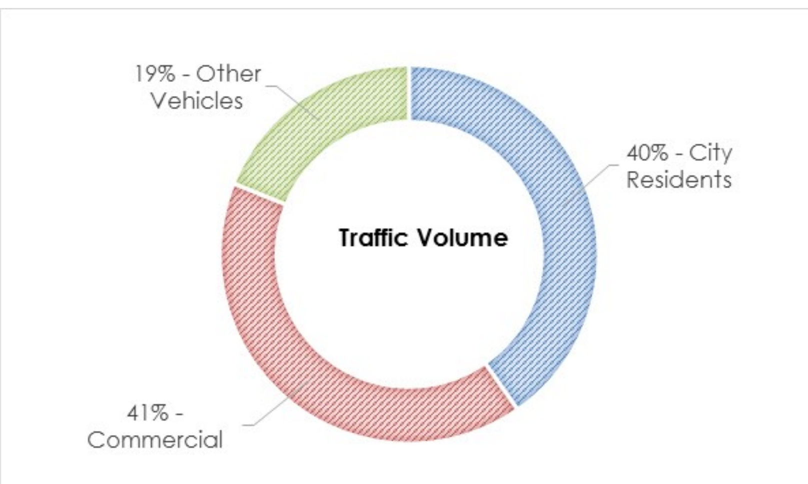


Figure 2 Traffic Volume Distribution for the Customer Types

Although, any conflicts between the two traffic streams were not evident from the documents, it does indicate that when determining facility upgrades and developing the Master Plan, both traffic streams would require equal emphasis. This would be crucial for achieving reduced wait times as well as increased safety of the patrons using this facility.

Shown in **Table 2** are the traffic count for the prominent waste types received at the facility. The count shown for garbage includes all customers– residents, commercial, City owned and outside City that disposed garbage at this facility.

Table 2 Traffic Volume Contribution for the Type of Waste Received

Year	Vehicle Count				Total	Vehicle Count (%)		
	Garbage	Clean Fill	Concrete	Others		Garbage	Clean Fill +Concrete	Others
2009	26867	4342	3195	11520	45924	59%	16%	25%
2010	25643	3721	1941	12045	43350	59%	13%	28%
2011	31387	4565	2731	7760	46443	68%	16%	17%
2012	39108	3748	2185	7008	52049	75%	11%	13%
2013	37780	5648	2993	7094	53515	71%	16%	13%
2014	37414	10331	3218	8847	59810	63%	23%	15%
2015	31465	4696	2210	8200	46571	68%	15%	18%
7-Year Average Traffic Contribution for the waste types received						**65.9%**	**15.7%**	**18.4%**
Margin of Error in the Mean for a Confidence Level of 95%						**4.5%**	**2.6%**	**4.3%**

On an average, approximately 66% of the total traffic to this facility is attributed to MSW with the remaining 16% waste contributed by clean fill and concrete and 18% by other miscellaneous waste types (**Figure 3**). For the estimated margin of error in the average value, it is expected that the future contribution of MSW, clean fill and concrete combined, and other waste types will be in the range of 61-70%, 13-18% and 14-23% respectively.

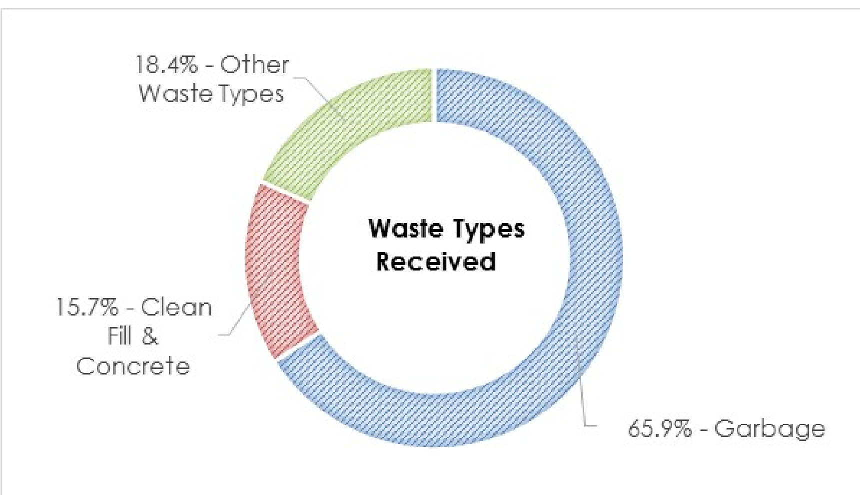


Figure 3 Distribution of Waste Types Received

3.2 WASTE DISPOSAL AREAS

3.2.1 Historical Waste Disposal: Pre-2006

Historically, waste disposal at this facility commenced during the 1970s. During this period, waste was disposed in unlined trenches and this practice continued until 2006 when the first engineered cell (Phase 1.1) was constructed. As evident from previous reports and per communication with the City, this historical waste disposal area is significant in size and comprises the area between the existing weigh scale and 67th street and between the west property boundary towards 40th Avenue and Phase 1.1 and 1.2. Although, the precise extent of the historical waste footprint is unknown, based on figures included in the Functional Landfill Study Report[2], this area measure approximately 8-10 hectares.

An assessment of waste quantities historically disposed at this site pre-2006 was made as shown in **Table 3**. The waste quantity was estimated based on historical populations census data obtained from Statistics Canada and interpolating data for the missing information. The lower estimate of waste quantity was made based on average residential waste generation rate of approximately 0.3 tonnes per capita per year[5]. The higher value was obtained considering both residential and non-residential waste.

[5] Waste Management Industry Survey: Business and Govt. Sectors (2010) published by Statistics Canada

Table 3 Assessment of In-Place Historical Waste Quantity (1971-2006)

Year	Population	National waste generation rate (Res. + Non-Res.)*	LOW ESTIMATE (Residential waste only)#	HIGH ESTIMATE (Res + Non-res.)	Notes
		Kg/Capita/Year	(tonnes)	(tonnes)	
1971	**8691**	472	2,607	4,101	*Rate extrapolated based on 1990 and 2006 data obtained from Conference Board of Canada
1972	9015	481	2,705	4,338	
1973	9339	491	2,802	4,582	
1974	9663	500	2,899	4,832	
1975	9987	509	2,996	5,087	
1976	**10311**	519	3,093	5,349	
1977	11255	528	3,377	5,944	
1978	12199	538	3,660	6,557	
1979	13143	547	3,943	7,188	
1980	14087	556	4,226	7,836	# Based on 0.3 tonnes/capita/year obtained from Statistics Canada
1981	**15031**	566	4,509	8,502	
1982	15496	575	4,649	8,910	
1983	15961	584	4,788	9,327	
1984	16426	594	4,928	9,753	
1985	16891	603	5,067	10,187	
1986	**17356**	613	5,207	10,631	Data in bold font represents values obtained from documented sources
1987	17341	622	5,202	10,784	
1988	17327	631	5,198	10,938	
1989	17312	641	5,194	11,091	
1990	17298	**650**	5,189	11,243	
1991	**17283**	659	5,185	11,396	
1992	17617	669	5,285	11,781	
1993	17951	678	5,385	12,173	
1994	18285	688	5,486	12,571	
1995	18619	697	5,586	12,975	
1996	**18953**	706	5,686	13,386	
1997	19360	716	5,808	13,855	
1998	19767	725	5,930	14,331	
1999	20174	734	6,052	14,815	
2000	20581	744	6,174	15,307	
2001	**20988**	753	6,296	15,807	
2002	21596	763	6,479	16,467	
2003	22204	772	6,661	17,139	
2004	22812	781	6,844	17,822	
2005	23420	791	7,026	18,516	
2006	**24028**	**800**	7,208	19,222	
Estimated Waste Quantity in Place (tonnes)			**179,330**	**394,742**	

The waste generation rate from 1970 to 2002 was obtained using linear extrapolation of waste generation rate in 1990 and 2006 obtained from Conference Board of Canada. For 2003 through 2006, the actual waste quantities disposed were obtained from the Functional Landfill Study Report[2]. Based on the data above, it was estimated that approximately 180,000 to 400,000 tonnes of waste may have been disposed at this site between 1971 and 2006 as per the estimate shown in **Table 3**.

Further, historical municipal landfills may contain up to 50-60 % (w/w) of soil type material (cover material and heavily degraded waste)[6]. In order to provide a conservative estimate of thickness of historical waste disposed at this facility, the cover soil was assumed to comprise 50% w/w which is approximately equivalent to 20% v/v based on an assumed cover soil density of 1300 kg/m3. This would mean another approximately 90,000 - 200,000 tonnes of soil may have been disposed with the historical waste as a daily/interim cover. Assuming an average in-place waste density of 500 kg/m3 and cover soil density of 1300 kg/m3, the average thickness of waste and soil disposed together in this area is estimated to vary from 4.0 m to 10.0 m.

Based on various historical site investigations and monitoring wells constructed by AMEC between 1997 and 2003, domestic waste was observed at a depth of 3.0 m to 7.0 m bgs. The thickness of such historical waste deposits varied from 1.0 m to 3.0 m as evidenced from the two boreholes (MW2 and MW 3) that have since been decommissioned. Further, four leachate monitoring wells were installed by AMEC in 2011 in the historical waste disposal area (MW11-1, MW11-2, MW11-3 and MW11-4)[7]. From the borehole logs as shown in **Table 4**, the thickness of historical waste disposed at these locations appears to vary from 3.0 m to 10.0 m which tends to support the thickness estimated based on historical waste quantity assessment shown in **Table 3**.

Table 4 Waste Thickness observed in Leachate Monitoring Wells

Leachate Monitoring Well ID	Ground Elevation (masl)	End of Borehole (masl)	Depth of Borehole (m)	Waste Elevation (masl)		Inferred Historical Waste Thickness (m)
				Start	End	
MW 11-1	635.82	627.59	8.23	635.07	628.81	6.26
MW 11-2	635.96	630.47	5.49	634.43	631.69	2.74
MW 11-3	637.19	627.74	9.45	636.27	628.35	7.92
MW 11-4	637.19	621.95	15.24	634.75	625.3	9.45

3.2.2 Current Waste Disposal: Post 2006

The first engineered cell Phase 1.1 came into operation in 2007. The base elevation of this cell varies from approximately 620 masl on the north end to 625 masl at the south end. Currently, Phase 1.2 is active which was constructed in 2012 adjoining Phase 1.1 on the south. It is

[6] Krook, J., Svensson, N and Eklund, M. (2012). Landfill Mining: A critical review of two decades of research. *Waste Management* 32, pp 513-520.
[7] Boreholes logs obtained from 2015 Groundwater Monitoring Report prepared by GHD Ltd.

understood that Phase1.2 is nearing its capacity for a proposed interim design elevation of approximately 640 masl which is higher than the current interim elevation of Phase 1.1. The data presented in **Table 5** for the waste quantities disposed between 2006 and 2015 was extracted from the weigh scale data and information provided in various reports provided by the City. The average growth rate in waste quantity received from 2006 to 2015 is approximately 2% with only a few years indicating a negative growth rate.

Table 5 Waste Quantities Disposed from 2006-2015

Year	Actual Quantities Received at the Weigh Scale (2006-2015)		
	MSW (tonnes)	Wood + Concrete (tonnes)	Total (tonnes)
2006	30,678	685	31,363
2007	31,263	567	31,830
2008	29,000	231	29,231
2009	26,430	270	26,700
2010	29,819	109	29,928
2011	33,337	1,519	34,856
2012	30,089	564	30,653
2013	35,343	576	35,919
2014	39,459	588	40,047
2015	34,347	600	34,947

3.3 FACILITY INFRASTRUCTURE

3.3.1 Public Drop-off Area

The facility currently accepts the following waste types:

- MSW mixed with C&D waste
- Household Hazardous Waste (HHW) - Paint, used oil, oil filters, E-waste, Propane, Batteries
- Discarded tires
- Metals and white goods
- Cardboard
- Concrete, lumber and clean fill

Currently, all vehicles including residential have access to the active face of the landfill for disposal of waste. There exist designated areas and bins located within the historical waste disposal area for the public to drop-off their recyclable waste. The area towards the west property boundary is currently used for storage of cardboard, paint, used oil, oil filters, e-waste, propane, batteries and tires. Metals and white goods; wood and concrete are stockpiled towards the south property boundary. Wood is chipped on site and used for daily cover along with stockpiled soil and treated soil received from the impacted soil management area.

3.3.2 Sump Waste and Septic Waste Disposal

Two wet cells located towards the south east portion of the facility were constructed in 2012 for decanting sump waste. The decant liquid from the wet cell is pumped directly to the WWTF through a 50 mm diameter hose. As per communication with the City, only wet cell No. 1 (north side) has been in use so far and that it has not required sludge/solids removal since its construction. Wet cell No. 2 has never been used as communicated by the City.

Septic waste received at the facility is disposed in the septic manhole located near the south boundary of the facility which discharges into the sewer on 67th street.

3.3.3 Impacted Soil Management Area

A portion of the facility towards its extreme north boundary beyond the current snow disposal area has been leased out to Ridgeline Inc. where they treat petroleum hydrocarbon impacted soils. It is understood that the majority of treated soil is stockpiled at the facility and re-used for daily cover. As per information provided by the City, approximately 255,000 m3 of treated soil including that contained in the soil treatment pad is currently stockpiled in this area and is periodically transferred to the facility on an as needed basis for daily cover. It is understood that this soil treatment facility will continue to remain in operation for a foreseeable period unless sufficient quantities of daily cover soil are available from other sources to meet prevailing demand.

3.3.4 Snow Disposal Area

The snow disposal area is located just north of the historical C&D waste disposal area and is approachable through the existing facility entrance on 40th Avenue. This snow disposal area even though seasonal, interferes with the general facility traffic. The snow disposal area is not engineered and does not provide detention of melt water and reduce sediment and contaminant loading on the receiving environment. The nearby creek which likely receives meltwater discharge from this snow disposal area ultimately merges into the Neale lake and local sub surficial aquifer. Therefore, it may be concerning to have an uncontrolled snow disposal at this location.

3.3.5 C&D Waste Management

Historically, C&D waste was disposed on the north periphery of the facility. Currently, the majority of C&D waste excluding wood and concrete are disposed in the landfill mixed with MSW. However, in the future, the City intends to divert C&D waste from the landfill from the viewpoint of saving landfill airspace as well as generate revenue from commercial haulers.

The actual composition of C&D waste depends on the type of construction, demolition and renovation projects in the community. Typically, the C&D waste would comprise wood, asphalt shingles, drywall, concrete, metals, bricks, glass, plastics, salvaged building materials e.g. doors, windows, and plumbing fixtures, and material from site cleanings such as trees, stumps, earth, and rock. Figure 4 shows an average break-down of various components of C&D waste stream. This data, although typical of Alberta, but adequately provides a general description of C&D waste across provinces.

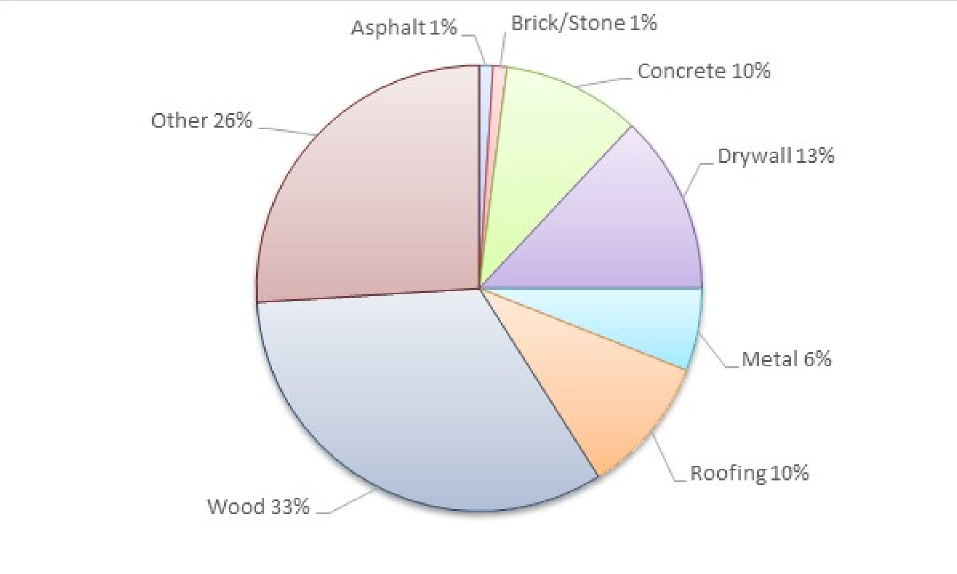


Figure 4 Alberta C&D waste composition (Source: Provincial Waste Characterization Framework – Redrawn for clarity)

3.3.5.1 Market Analysis of Recoverable Materials

The following paragraphs describe potential markets for various materials typical of C&D waste stream:

1. Wood/Lumber - Currently, lumber/scrap wood received at the facility is chipped and used as daily cover. Scrap lumber also finds utility with processed wood manufacturers where they are able to use it for manufacturing of engineered wood. Lumber recovered could be used as mulch and sold to retail markets at a competitive price or used by the City.
2. Drywall - Drywall constitutes significant portion of C&D waste besides lumber/wood. This recovered material has good application in the agriculture and cement industry. The cement industry uses approximately 5-10% gypsum for manufacturing cement.
3. Corrugated Cardboard - Corrugated cardboard does not comprise a significant portion of the C&D waste stream for its consideration for recovery. Although the market for corrugated cardboard is good given its small quantity in the C&D waste stream relative to other waste types such as lumber, drywall and asphalt shingles, it may not present lucrative opportunity for the City to recover this material for revenue generation.
4. Metals and Appliances – Metals/appliances account for 5-6% by weight of the C&D waste stream. The City currently has an adequate program for metal recycling at the existing

facility. The market for metal, typically mills and smelters, is quite robust. The City may further want to put some effort to analyze their waste stream from the viewpoint of recovering remaining metal from their MSW stream disposed in the landfill and assess whether such recovery could be made economically viable.

5. Asphalt Shingles - Asphalt shingles are found in significant quantities in the C&D waste stream and can be recovered. These can be crushed and sold to Asphalt plants or used as a fill material in road construction. The market value of crushed shingle may not be significant, however, it is still economical as recyclers of this material may be able to collect this material for free which would be cheaper than to transport it to a landfill for disposal.

3.3.6 Equipment

Landfill equipment generally fall under two categories: (a) waste compaction and (b)daily/intermediate cover transport and compaction. Below is a list of the equipment/machinery currently used at this facility:

- BOMAG Compactor
- 544K John Deere Loader
- 850K John Deer Dozer
- TopKick Gravel Truck

For the quantity of waste received at this site, the current fleet of equipment is adequate.

3.4 ENVIRONMENTAL MONITORING

The facility currently operates under 'The Permit to Operate' No. 00053728-01-00 issued by the Saskatchewan Ministry of Environment (the 'Ministry') and requires annual monitoring of groundwater and leachate for the parameters stated in the Permit. Monitoring of water quality of the stream located to the north of the facility is not required by the Permit.

3.4.1 Groundwater

Information about groundwater monitoring wells and groundwater characteristics was obtained from various reports prepared by AMEC and Conestoga-Rovers & Associates (now GHD Ltd.). Between 1997 and 2005 thirteen monitoring wells were constructed, some of them have since been decommissioned. During the later years more monitoring wells were added to the network of groundwater monitoring wells and some were decommissioned. Currently, as per 2015 Annual Groundwater Monitoring Report there are twenty-three [23] active groundwater monitoring wells in and around the facility including those located in the impacted soil management area.

As inferred by others in groundwater monitoring reports, the groundwater quality in the vicinity of this facility is generally poor with sodium and sulphate in the range of approximately 300-500 mg/l and 1400-2000 mg/l respectively. After reviewing the 2015 GW monitoring report[8], a few

[8] 2015 Annual Groundwater Monitoring Report prepared by GHD Limited (February 2016)

select monitoring wells as shown in **Table 6** were evaluated to assess any impact to the groundwater quality pursuant to past and current waste disposal activities at this facility (Please refer to **Appendix A** for location of these groundwater monitoring wells). The parameter assessed was chloride since it is considered to be a conservative tracer and does not attenuate naturally.

The background groundwater quality around the facility measured from the up gradient monitoring wells located south of 67th Street showed chlorides of the order of 66 -130 mg/l. Whereas, the groundwater quality measured in the downgradient monitoring wells MW07-9-12, has consistently showed high elevated chloride of the order of 1500 mg/L believed to be the influence of historical waste disposal activity. Further, it is worth noting that this monitoring well is shallowest of all the monitoring wells and installed at a depth of 3.7 m bgs. Due to its close proximity to the existing snow disposal area, the elevated chlorides could also be contributed by snow disposal activity but this does not preclude impact from uncontrolled disposal of waste in the past.

Table 6 List of Select Monitoring Wells for Analysis

Upgradient Monitoring Wells	Downgradient Monitoring wells
MW07-12-9	MW07-3-7
MW07-13-9	MW07-9-12
MW03-12	MW07-4-40
	MW02-9

There is some evidence of increasing elevation of groundwater table in several monitoring wells as illustrated in **Table 7**.

Groundwater elevation measured from 2009 through 2015 indicates an average increase of 0.52 m during this period. Increases of more than 1.0 m are observed at a number of monitoring wells but appear to be more regional in nature considering some of the greatest increases are observed north of the site across the groundwater flow divide (the creek north of the landfill). Further, the largest increase in groundwater elevation occurred between 2009 and 2010 (average 0.39 m). Otherwise, the groundwater levels have generally been relatively stable at most of the monitoring wells.

To support the hypothesis that the increase in ground water levels may be a regional phenomenon, the Palmer Drought Severity Index for Lloydminster area as shown in **Figure 5** was reviewed. Based on this index, the increasing levels could likely be a result of excess soil moisture which resulted in increased groundwater recharge in the years leading up to and including this period.

Table 7 Groundwater Elevations Change in the Monitoring Wells

Monitoring Well ID	Location	2009	2010	2011	2012	2013	2014	2015	Change (2009-2015)
MW03-12	Upgradient	629.36	629.71	629.41	629.93	629.77	630.05	629.45	**0.09**
MW07-12-9	Upgradient	628.42	628.58	628.49	629.12	628.77	628.69	626.82	**-1.60**
MW07-13-9	Upgradient	632.52	633.52	634.28	634.21	634.29	633.97	633.47	**0.95**
MW01-4	On-Site/Cross gradient	618.45	619.13	618.90	619.16	619.00	618.85	619.24	**0.79**
MW01-5	On-Site/Cross gradient	628.11	628.63	628.30	628.54	628.71	628.91	628.38	**0.27**
MW01-6	On-Site/Cross gradient	626.66	627.68	627.42	627.68	627.38	627.72	627.84	**1.18**
MW02-7	On-Site/Cross gradient	633.12	633.94	633.40	633.74	633.25	634.07	634.92	**1.80**
MW03-10	On-Site/Cross gradient	626.03	625.96	625.95	625.99	626.21	626.36	626.60	**0.57**
MW03-11A	On-Site/Cross gradient	633.31	633.59	633.30	633.29	633.43	633.42	633.54	**0.23**
MW03-11B	On-Site/Cross gradient	633.74	633.77	633.46	633.44	633.53	633.56	633.78	**0.04**
MW07-10-7	On-Site/Cross gradient	620.11	620.58	620.57	620.57	620.49	620.39	620.22	**0.11**
MW07-11-7	On-Site/Cross gradient	622.28	623.20	622.84	622.83	622.68	622.86	622.97	**0.69**
MW-1	On-Site/Cross gradient	627.30	627.32	627.39	627.90	628.15	628.23	627.26	**-0.04**
MW02-9	Downgradient	618.49	618.90	618.66	618.86	618.66	618.78	618.82	**0.33**
MW07-01-7	Downgradient	619.98	619.96	620.61	621.06	621.55	621.42	621.03	**1.05**
MW07-02-7	Downgradient	620.27	620.28	621.67	621.07	622.36	622.32	621.93	**1.66**
MW07-03-7	Downgradient	620.59	620.91	620.95	620.97	621.25	621.29	620.83	**0.24**
MW07-07-7	Downgradient	618.03				619.03	619.29	619.10	**1.07**
MW07-08-12	Downgradient	622.31	622.82	622.42	622.28	622.37	622.54	622.54	**0.23**
MW07-09-12	Downgradient	617.89	617.89	618.03	618.31	618.00	618.02	618.54	**0.65**
MW11-1	Leachate Well					628.73		629.98	
MW11-2	Leachate Well					633.59	634.18	633.96	
MW11-4	Leachate Well						626.12	630.76	

The Palmer Drought Severity index uses an algorithm to determine soil moisture deficit or surplus based on precipitation and temperature data from local weather stations. The index for Lloydminster shows drought conditions through most of the 1990's and early 2000, including extreme drought conditions in 2002. Prolonged drought will reduce recharge to groundwater and lower the water table/potentiometric surface. From 2004 to 2015, the drought index was rated as "near normal" to "very wet" with the exception of mid-2009 to mid-2010 and brief period of 2011 and 2012. This excess soil moisture could have led to increased groundwater recharge and an increase in the groundwater table elevation as observed at various monitoring wells at this facility. Further, it is also possible that the historical waste disposal at this site including waste liquid pit operation and WWTF may have modified the pre-existing hydrogeological settings.

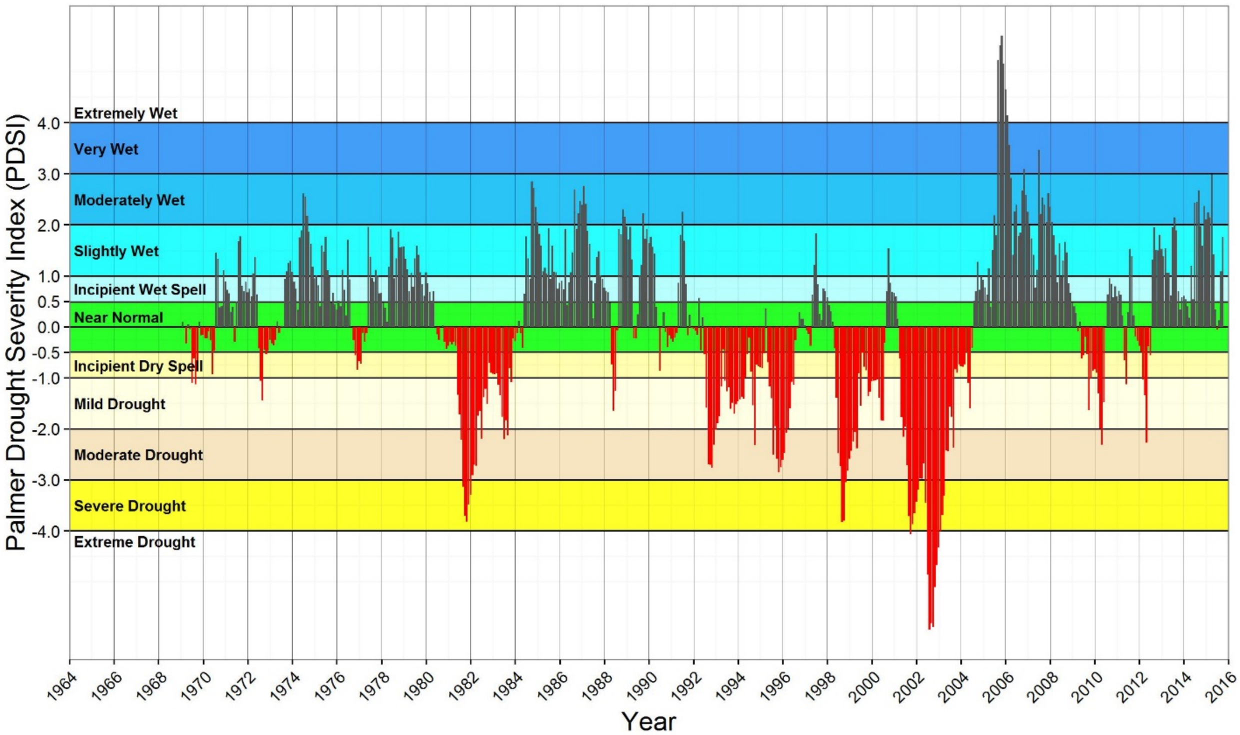


Figure 5 Palmer Drought Severity Index (PDSI) for Lloydminster Area

3.4.2 Leachate

Historically, pre 2006, waste at this site has been disposed using a dig and dump approach. Therefore, a system for the collection and removal of leachate is non-existent in the historical waste disposal area. Post 2006, Phase 1.1 and 1.2 were designed and constructed as engineered cells and equipped with LCRS. Phase 1.1 LCRS comprises three leachate collection pipes laid north-south at the base of the landfill and connected to a header which discharges under gravity into a lift station located on the north east corner of Phase 1.1. The lift station is a manhole 1.5 m in diameter and 4.20 m deep equipped with a submersible pump and is used for conveying leachate to the WWTF. The original design envisioned for leachate management was volume reduction through evaporation or recirculation. As per communication with the City, currently the leachate lift station has some operational challenges. Leachate is still collected in the lift station but is pumped to the overflow pond adjacent to lift station from where it is periodically pumped overland to septic manhole using 150 mm diameter hose for further management.

The Permit requires that the quality of the leachate collected in the lift station from the engineered cells be monitored. It also stipulated that the leachate from the historical waste disposal area be monitored (those monitoring wells listed in **Table 4**). One of the leachate monitoring wells (MW 11-3) has since been decommissioned in 2013. Therefore, leachate samples are currently obtained only from the remaining three leachate monitoring wells and leachate levels measured in the historical waste disposal area.

The Permit also requires recording annual volume of leachate produced. This information was not evident in the reports reviewed, however, the City did provide data for 2014 through 2016 for the volume of leachate removed from the sump (included in **Appendix B**). As per this data, approximately 8200 m3 of leachate was removed from the overflow pond in 2014, 2300 m3 in 2015 and 2800 m3 in 2016 (till end of July). These leachate volumes removed from the overflow pond does not necessarily correlate to the actual leachate volumes generated from Phase 1.1 and 1.2 during a particular period. The City should measure the leachate level in the lift station prior to and after pumping to the overflow pond to obtain information about leachate volumes generated from Phase 1.1/1.2 between any two monitoring events. This information will be more useful in assessing the integrity of the leachate collection system.

Knowledge of the leachate volumes removed from the base of the landfill provides crucial information about the effectiveness of the leachate collection system as it was designed. This further helps in determining if there could be leachate head mounding on the liner. It is not feasible to determine information about leachate head build-up at the base of Phase 1.1 and 1.2 from the way they were designed.

Based on a review of the groundwater monitoring reports for 2013, 2014 and 2015, the leachate levels below the historical waste disposal area appears to be continuously mounding as shown in **Table 8**. Data from previous years prior to 2013 are not available. These leachate levels appear to coincide with the groundwater levels based on the interpretation of the groundwater contours in the vicinity as presented in Figure 4.1 of the 2015 Groundwater Monitoring Report. However, the change in leachate level in MW 11-4 of approximately 5.0 m is much greater than would be expected in the groundwater and is likely due at least in part to leachate mounding or changes in the infiltration rate in this area. With only three water level measurements at each of these monitoring wells, this trend would need to be reviewed further during future groundwater monitoring events and analyzed. While it is possible that increasing trends are occurring, changes could also be due to short term seasonal or annual variability.

Table 8 Leachate levels Measured in the Historical Waste Disposal Area

Leachate MW ID	Depth of leachate in historical waste disposal area (m bgs)			Rise in leachate levels since 2013 (m)
	2013	2014	2015	
MW11-1	8.0	*	6.8	1.2
MW11-2	3.2	2.6	2.0	1.2
MW11-3	decommissioned			
MW11-4	moist	11.4	6.4	5.0

* data not available

Hydraulic conductivity had been reported by others in the range of 10^{-10} to 10^{-7} m/s with general higher hydraulic conductivity in the eastern portions and lower in the west portion of the facility[9]. The hydraulic conductivity contrast between the waste material and the clay till will result in water level variability in the waste cell compared to the surrounding water table. The fact that the groundwater still appears mounded around the former liquid waste pit four years after it was removed, supports the low hydraulic conductivity/ transmissivity and slow groundwater flow.

3.4.3 Landfill Gas Management

The facility does not have a landfill gas (LFG) management system, nor is there a system of gas monitoring probes to detect any subsurface migration of landfill gas. However, the subsurface geologic settings underlying this site warrant a mechanism to reduce subsurface migration of LFG subsequent to progressive closure of the landfill. This is to ensure that methane emissions in and around the facility does not exceed 5% of its lower explosive limit (LEL). Harnessing LFG for beneficial purpose is typically considered when the in-place waste quantity is greater than 1Mm^3.

The City may want to explore such opportunities in the long-term when there is enough quantity of waste in-place suitable for either co-generation or simply flaring to mitigate greenhouse gas contribution.

3.5 MATERIAL STOCKPILE

The current estimated volume of stockpiled clean fill material is approximately 75,000 m^3 as per the survey conducted by Select Engineering Consultant during September 2015. This material is currently stockpiled on the historical waste disposal area on the west side of Phase1.1. There is an additional approximately 150,000 m^3 of treated soil stockpiled in the impacted soil management area including the soil that was used for treatment pad construction. There is also approximately 25,000 m^3 of clean soil for final cover stockpiled in this area. The landfill phasing plan as discussed in the next section has been developed in a manner that will eliminate the need to relocate these stockpiles.

The majority of wood/lumber disposed at this site is chipped and used as an alternative daily cover. There are two large stockpiles of white goods/ metals occupying an area of approximately 200 m x 80 m (1.6 hectares). The white goods/metals are removed periodically for recycling when adequate quantities are accumulated. There also exists a raw concrete stockpile occupying an area approximately 90 m x 60 m and a crushed concrete stockpile spread over an area approximately 140 m x 40 m. As per communication with the City, majority of the crushed concrete is used for development projects including road works.

[9] 2015 Annual Groundwater Monitoring Report, prepared by GHD Ltd. dated Feb 2016

4.0 WASTE MANAGEMENT FACILITY MASTER PLAN

The following were considered when the 2016 Waste Management Facility Master Plan was developed:

1. Permits and Regulations
2. Waste Quantity Projections and Airspace Requirement
3. Overall Site Development Plan
4. Landfill Phasing Plan

4.1 PERMITS AND REGULATIONS

The following are the governing regulations for the operation and development of this facility:

- The Municipal Refuse Management Regulations (MRMR), 1986
- The Hazardous Substances and Waste Dangerous Goods Regulations
- The Environmental Management and Protection (General) Regulations, 2010

Section 8(2) of the MRMR specifies maintaining a setback distance of 100 m from a highway to the waste footprint. For this facility, 40th Avenue and 67th street are considered as highway within the definition specified in the MRMR.

The Master Plan has been developed to maintain a 100 m setback from the 40th Avenue and the 67st Street. Further, SaskPower requires a horizontal clearance of 15 m from the overhead powerline. An overhead power line exists towards the existing sewage treatment lagoon which runs N-S. Therefore, necessary horizontal clearance has been provided while staging the facility development to account for the existing overhead power line. The Master Plan assumes that no setback is required for the north property boundary which adjoins the current snow disposal area.

4.2 WASTE QUANTITY PROJECTIONS & AIRSPACE REQUIREMENT

As noted earlier, the estimated operational life of this facility, within the current property boundary is approximately 40 years. However, the Master Plan recommendations has been developed considering a period of 20 years as outlined by the RFP. Further, it is understood that besides the current waste types disposed at the landfill, dewatered sludge from WWTF will also require disposal at this site in the future.

4.2.1 Quantity of Dewatered Sludge Solids

It is believed that the City has plans to incorporate sludge management technologies when the proposed new mechanical wastewater treatment facility becomes operational. It is understood that these technologies may include, but not be limited to, sludge thickening (gravity, floatation) and mechanical dewatering (vacuum filtration, centrifugation, pressure filtration). The intent would be to make the sludge suitable for landfill disposal. However, alternatives exist for potential beneficial uses of sludge other than landfilling and the City may wish to explore those alternative usages as well. For the purpose of this Master Plan and to provide a conservative estimate of air space requirements, it was assumed that dewatered sludge solids generated from the WWTF will be disposed in the landfill.

Quantities of dewatered sludge solids generated was estimated based on population considering a typical sludge solids generation rate of 100 grams per capita per day as shown in **Table 9** and **Table 10**.

Table 9 Typical waste generation from the WWTP based on Treatment Process

Waste Type			Quantity - Dry Mass	Quality - Solids Content
			(g/capita.d)	(%)
Screenings			2 – 3	10 - 50
Grit			2 – 23	35 - 85
Sludge (post-dewatering)	Aerated Lagoon (current system)		8 – 13	30 - 40
	Mechanical Treatment (Future proposed)	Primary Sludge	25 - 28	25 – 45
		Secondary Sludge	35 - 50	20 – 40

Table 10 Estimate of Headworks waste quantities

Description	Unit	Headwork Wastes	
		Screening	Grit
Quantity Range	$m^3/10^3m^3$	0.006 - 0.009	0.004 - 0.037
Typical Quantity		0.008	0.015
S.G Range	kg/m^3	700 - 1,100	1,600
S.G Typical		900	
WWTP Flow (2013)	m^3/day	12,160	
Population (2013)	-	31,483	
Dry Mass Production per capita - Range	g/ capita/ day	2 - 3	2 - 23
Dry Mass Production per capita - Typical		3	9
Solids Content	%	10 - 50	35 - 85

4.2.2 Quantity of MSW, wood and concrete

Estimates of waste quantities that would require disposal during the Master Plan period were made considering a forecasted waste disposal growth rate under two scenarios: (a) growth rate derived from projected population growth rate, and (b) growth rate derived from actual quantities of waste disposed between 2006 and 2015.

The growth rate in population was projected in two ways by considering (i) available municipal and federal census data from 2001 to 2015, and (ii) medium growth rate scenario described in the Comprehensive Growth Strategy Report[10]. The population projected using the two approaches (i) and (ii) are shown in **Table 11**. Considering the population estimates based on municipal and federal census data (column A, **Table 11**), it is expected that in the next 20 years i.e. by 2037, the City's population will increase by approximately 58% over its 2015 population.

Table 11 Population Projections for the Master Plan Period

Year	Population	Data Source	Projection Year	Projected Population based on	
				Municipal and Federal Census Data	Comprehensive Growth Strategy Report
				(A)	(B)
2001	20988	Municipal Census	**2017**	33442	32527
2005	23643	Municipal Census	**2018**	34257	33333
2006	24028	Federal Census	**2019**	35071	34138
2007	25523	Municipal Census	**2020**	35885	34944
2009	26502	Municipal Census	**2025**	39956	38944
2011	27804	Federal Census	**2030**	44027	42863
2013	31483	Municipal Census	**2035**	48098	46710
2015	31377	Municipal Census	**2036**	48913	47477

The projected waste quantities (a) based on population growth rate derived from the municipal and federal census data and (b) based on actual historical waste quantities disposed between 2006 and 2015 is shown in **Table 12**, column 7 and 8 respectively. The values shown in column 7 were obtained using the estimated annual growth rate in population shown in column 3, which was obtained from municipal and federal census data. The base value of waste quantity used for making future projections was the 2015 actual waste quantity.

The projected waste quantities used in this report (column 9) for estimating airspace requirements were obtained by dividing the greater of the two values shown in columns 7 and 8 by an assumed waste compaction density of 0.5 tonnes per m3. Similarly, the sludge solids volume was obtained using the sludge generation rates shown in Table 9, Table 10 and a sludge solids density of 0.65 tonnes per m3. A 20% volume was added to the airspace requirement to account for daily cover soil (column 11). From the estimates shown in **Table 12**, it is anticipated that approximately 1.0 million tonnes of waste will be disposed at this facility in the next 20 years (2017-2036) which will require an airspace of approximately 2.3 million m3.

[10] Comprehensive Growth Strategy – Final Report prepared by ISL Engineering and Land Services for the City of Lloydminster (August 2013)

Table 12 Waste Quantity Projections

Year	Projected Population (Based on Census)	Estimated Annual Growth Rate	Actual Quantities Received at the Weigh Scale (historical)			Projected Total Waste Quantities based on:		Waste qunatities used in this report	Sewage Sludge solids	Cover soil (20%)	Annual airspace required	Cumulative airspace required
			Garbage	Wood+ concrete	Total	Population growth rate	Actual waste received					
			(tonnes)			(tonnes)	(tonnes)	(m3)	(m3)	(m3)	(m3)	(m3)
1	2	3	4	5	6	7	8	9	10	11	12	13
2006	24028		30678	685	31363							
2007	25523	6.22%	31263	567	31830							
2008	26013	1.92%	29000	231	29231							
2009	26502	1.88%	26430	270	26700							
2010	27153	2.46%	29819	109	29928							
2011	27804	2.40%	33337	1519	34856							
2012	29644	6.62%	30089	564	30653							
2013	31483	6.21%	35343	576	35919							
2014	31430	-0.17%	39459	588	40047							
2015	31377	-0.17%	34347	600	34947							
2016	32628	3.99%				36,341	37,214	74,428	1,832	15,252	91,513	91,513
2017	33442	2.50%				35,819	38,063	76,125	1,878	15,601	93,604	93,604
2018	34257	2.43%				36,691	38,911	77,822	1,924	15,949	95,695	189,299
2019	35071	2.38%				37,563	39,760	79,519	1,969	16,298	97,786	287,085
2020	35885	2.32%				38,435	40,608	81,216	2,015	16,646	99,878	386,963
2021	36699	2.27%				39,307	41,457	82,913	2,061	16,995	101,969	488,932
2022	37514	2.22%				40,180	42,305	84,610	2,107	17,343	104,060	592,992
2023	38328	2.17%				41,052	43,154	86,307	2,152	17,692	106,151	699,143
2024	39142	2.12%				41,924	44,002	88,004	2,198	18,040	108,243	807,386
2025	39956	2.08%				42,796	44,851	89,701	2,244	18,389	110,334	917,720
2026	40770	2.04%				43,668	45,699	91,398	2,289	18,738	112,425	1,030,145
2027	41585	2.00%				44,540	46,548	93,095	2,335	19,086	114,516	1,144,661
2028	42399	1.96%				45,412	47,396	94,792	2,381	19,435	116,608	1,261,269
2029	43213	1.92%				46,284	48,245	96,489	2,427	19,783	118,699	1,379,968
2030	44027	1.88%				47,156	49,093	98,186	2,472	20,132	120,790	1,500,758
2031	44842	1.85%				48,028	49,942	99,883	2,518	20,480	122,881	1,623,639
2032	45656	1.82%				48,900	50,790	101,580	2,564	20,829	124,973	1,748,612
2033	46470	1.78%				49,772	51,639	103,277	2,609	21,177	127,064	1,875,676
2034	47284	1.75%				50,645	52,487	104,974	2,655	21,526	129,155	2,004,831
2035	48098	1.72%				51,517	53,336	106,671	2,701	21,874	131,246	2,136,078
2036	48913	1.69%				52,389	54,184	108,368	2,747	22,223	133,338	2,269,416

4.3 TRAFFIC VOLUME PROJECTION

As shown in **Table 1**, the annual average growth rate in the traffic count between 2009 and 2014 was calculated as approximately 5%. With the inclusion of the 2015 traffic count, the annual average growth rate would be 0.23%. Since the traffic count for 2015 appears to be an anomaly, the projections for future traffic volume were made based on annual average growth rate of 5% by excluding the anomalous 2015 data.

An analysis of traffic data provided by the City for two select days (May 5, 2014 and Sep 22, 2015) is shown in **Table 13**. This data is for south bound and north bound traffic on 40th Avenue and 67th Street. During these periods, the landfill bound traffic was not very significant (13% and 22%). The City also provided Peak Hourly Traffic factor (PHF) for morning and afternoon peak traffic on these dates which ranged from 0.67 to 0.90.

Table 13 Vehicle Count Data for Two Select Periods

Date	Time	40 Avenue S 67 Street			Landfill Bound Traffic
		NB	SB	Total	
5-May-14	0:00	7	3	10	
	1:00	3	3	6	
	2:00	6	5	11	
	3:00	6	3	9	
	4:00	12	10	22	
	5:00	29	35	64	
	6:00	87	81	168	
	7:00	123	147	270	
	8:00	97	118	215	13
	9:00	78	60	138	25
	10:00	86	81	167	14
	11:00	77	93	170	20
	12:00	82	91	173	29
	13:00	83	76	159	27
	14:00	84	73	157	19
	15:00	104	72	176	20
	16:00	117	108	225	13
	17:00	137	141	278	8
	18:00	94	77	171	
	19:00	63	42	105	
	20:00	41	39	80	
	21:00	34	17	51	
	22:00	15	15	30	
	23:00	9	4	13	
Total				**2,868**	**188**
		Landfill Traffic Percentage		13%	

Date	Time	67 ST W OF 40 AV			Landfill Bound Traffic
		WB	EB	Total	
22-Sep-15					
	17:00	26	60	86	
	18:00	26	36	62	
	19:00	15	31	46	
	20:00	14	17	31	
	21:00	7	9	16	
	22:00	5	6	11	
	23:00	3	4	7	
23-Sep-15	0:00	3	1	4	
	1:00	0	1	1	
	2:00	1	0	1	
	3:00	3	2	5	
	4:00	2	6	8	
	5:00	10	13	23	
	6:00	41	25	66	
	7:00	44	79	123	
	8:00	61	61	122	11
	9:00	45	53	98	15
	10:00	47	54	101	10
	11:00	33	75	108	25
	12:00	57	65	122	9
	13:00	52	82	134	24
	14:00	58	55	113	38
	15:00	61	64	125	43
	16:00	61	63	124	36
	17:00				
Total				**1,537**	**211**
addition of landfill				**1,959**	
		Landfill Traffic Percentage		22%	

Not all the traffic included in **Table 13** is bound for the facility, however, in order to provide a conservative estimate of peak hourly traffic at the facility, a PHF of 0.67 was used. Shown in **Table 14** are the estimates of projected annual average traffic count, average daily traffic count and peak hourly traffic count expected during the Master Plan period.

Table 14 Traffic Volume Projection

Year	Projected Average Annual Traffic Count	Average Daily Traffic Count[1]			Estimated Peak Hourly Traffic Count[2] (20-Yr horizon)		
		City Residents	Commercial	Other vehicles	City Residents	Commercial	Other vehicles
2020	61647	78	79	36	14	14	6
2025	69135	87	88	41	15	15	7
2030	76623	97	98	45	17	17	8
2035	84111	106	107	50	19	19	9
2036	85609	108	109	51	19	19	9

1- Based on average number of days of operation in a year of = 320

2- Based on average 8.5 hours /day of operation and Peak Hour Factor of = 0.67

The peak hourly traffic estimates were later used for determining queuing space requirement at the weigh scale as well as number of parking bays required at the proposed public drop off area in order to maintain unhindered and smooth traffic flow as well as eliminate or reduce traffic stacking on the City roads (40th Avenue and 67th Street).

4.4 PROPOSED SITE DEVELOPMENT PLAN

The current layout of the facility including various infrastructure is shown in **Drawing 01 (Appendix C)**. The site development plan as proposed is based on following important considerations:

1. Relocation of the current facility entrance in a manner that will not require further relocation in the future pursuant to proposed site development.
2. Future facility development preferably be limited to north of 67th Street
3. Development of an office space and equipment maintenance area/workshop
4. Separate inbound and outbound weigh scales
5. Alternate public drop off area for recyclables and household waste so that access to the active face is limited to large loads/ garbage trucks and commercial vehicles.
6. Provide unidirectional traffic flow throughout the facility so as to reduce traffic conflicts and ensure the safety of the patrons using the facility
7. A properly designed snow disposal area at its current location that would reduce sediment and contaminant loading on the receiving groundwater and stream located north of the facility
8. Development of an exclusive future C&D waste management area

The locations and nature of development proposed herein are for planning purposes and should be considered conceptual. Further detail design and modelling will be necessary prior to implementation. All future design works should be based on updated site surveys.

4.4.1 Facility Entrance

An alternative entrance for the facility has been proposed from 67th Street in consideration of the challenges discussed above. Further, in accordance with the waste regulations, the edge of the waste footprint should be a minimum of100 m away from the highway. For this facility, 40th Avenue and 67th Street are considered as highways. Therefore, the 100 m wide strip on the south (67th street) and west (40th Avenue) is proposed to be utilized for development purposes other than landfilling.

The proposed alternative entrance is shown in **Drawing 02 (Appendix C).** As noted above, this new entrance has been planned to be located within the available 100 m setback so as not to interfere with the non-landfill bound traffic on the 67th Street destined for the race course, WWTF and other facilities. The current entrance to the facility from 40th Avenue can remain closed and should not be used except during contingent situations.

Based on the proposed development plan, it is believed that this new location will not require re-location during the operating life of the facility. As mentioned earlier, the estimated life of this facility is approximately 40 years within the existing perimeter fence. If the area further north between the current snow disposal area and the impacted soil management area is available, it will likely add another 50+ years to the operational life of this facility. However, this area is beyond the scope of this current project and therefore not included in the 2016 Master Plan.

The new facility entrance is proposed through a three-lane 12.0 m wide road off 67th Street. Two of these lanes will be dedicated for inbound traffic and one for outbound traffic. The purpose of providing two inbound lanes is to allow sufficient queuing area for vehicles within the facility premise and minimize traffic stacking on 67th street especially during peak hours. The two inbound lanes would, however, merge close to the weigh scale so that every vehicle gets weighed prior to entering the facility regardless of the waste type and the carrier. Similarly, every outbound vehicle will be weighed for tare. This will enhance record keeping and data management. Further, gated bypass lanes, one for the inbound scale and one for the outbound scale have been proposed. The intent is to allow unhindered traffic flow during contingent situation including firefighting or other such emergencies, as well as allow visitors, etc. access without having to pass over the weigh scales. During normal facility operation, these bypass lanes will remain closed. The concept plan allows for vehicle parking space for 6-8 vehicles north or south of the scale house. These parking spaces have not been shown on the drawings however, there exists ample space for the parking and should be detailed during the design stage.

4.4.1.1 Improvement to 67th Street

The 67th Street would require paving to provide all-weather access to the facility. Though not required at this time, some improvement to the intersection of 40th Avenue with 67th Street may be necessary in the future, e.g., addition of a left turning lane for the south bound traffic destined for the facility, race course and WWTF. This will free-up a lane for the south bound traffic going straight on 40th Avenue and those turning left at the intersection with 67th Street.

4.4.2 Weigh Scale, Scale House and Office

Two weigh scales, inbound and outbound including a scale house have been proposed within the 100 m setback as shown in **Drawing 02 (Appendix C)**. The new scale house is proposed to include some office space for the landfill supervisor, ticketing office, a staff room/lunch room and a washroom. These facilities will be housed in a pre-engineered building. The inbound and outbound lanes have been proposed with a full size weigh scale (90 feet long) to accommodate large trailers. The service life and the size of the existing weigh scale is unknown to Stantec and therefore its re-usability at this new location cannot be determined. Since the scale house has been located within the property boundary of the facility in the buffer area, the traffic bound for the race track and the WWTF will not be influenced.

4.4.3 Perimeter Access Road

A 9.0 m wide two-lane perimeter access road shown north-south along the East boundary of the property has been proposed as a continuation of the facility entrance road from the weigh scales. A 15.0 m horizontal clearance from the existing overhead power line running N-S has been proposed in the layout. This perimeter access road will be constructed to provide all-weather access to the current and future constructed cells as well as access to the proposed public drop-off area and sump waste/septic area. In the concept plan, this access road is proposed to terminate near the current location of the leachate pond. However, should a need arise, it can be extended further. The traffic movement on the perimeter access road is shown in **Drawing 02 (Appendix C).**

In the proposed concept plan, the 100 m setback area on the west side along 40th Avenue has been proposed for other purposes including stockpiling concrete, crushed concrete and cover soils. It is unlikely that residential traffic will require access to this area of the facility since disposal of concrete and soils is generally not delivered by the residents.

4.4.4 Public drop-off area – Recyclables and Household waste

Currently, residents have access to the active face of the landfill for disposal of their waste. Given the residential traffic volume in relation to the total traffic at this facility, it is recommended that residential traffic be confined to the proposed public drop-off area. The intent is to ensure safety of patrons by completely eliminating residential traffic access to the active face of the landfill except when necessary e.g. disposal of large items which may be difficult to dispose of into the bins placed in the proposed public drop-off area.

In the concept plan, the area to the south of the existing operational wet cells as shown in **Drawing 02 (Appendix C)** has been proposed for the public drop-off area for recyclables, bagged residential waste and small items that could be easily disposed into the bins. There are merits to this proposed location since it will not require relocation during the entire operation life of the facility and also it would allow residents to safely drop off their waste without interfering with larger and commercial vehicles. Further, the non-operational wet cell no. 2, which has not been required since its construction, is proposed for disposal/stockpiling of metals, appliances and tires. Since this wet cell was constructed with a CCL, it is recommended that prior to using this wet cell a minimum 300 mm thick soil protection layer be placed on the base and side slopes to minimize damage to the CCL. Further, the base should also be overlaid with 150 mm thick 20 mm minus granular aggregate layer to provide all weather access to this area. The intent of this protection is to allow future use of this wet cell should it become necessary. Due to the difference in grades between the wet cell bottom and the ground, access ramps will be needed for the wet cell. A suitable non-woven geotextile having a mass per unit area (MUA) of minimum 10 oz/yd2 should be used under the ramp access to provide cushioning/protection for the underlying CCL.

The entry to this proposed public drop-off area will be from the east side of the proposed perimeter access road and will exit from the west as shown in **Drawing 02 (Appendix C)**. This perimeter access road will loop around the proposed public drop-off area so as to provide all weather access to patrons disposing waste including septic haulers. The current space, as proposed, is adequate for turning of standard vehicles accessing the public drop off area and hydrovac trucks. However, some improvement to horizontal curves may be necessary to provide adequate space for turning of large trailers which are periodically required for bailing of stockpiled metal, appliances, tires and waste electronics. The traffic movement will be unidirectional counter clockwise in order to reduce traffic conflicts. Proper yield signs and traffic signage will be required to facilitate traffic movement. A detail design/layout of the proposed public drop-off area is not included in the scope of this project.

<u>Number of bins based on Peak Hour Traffic</u>

As discussed earlier in **Table 14**, the peak hour traffic to the proposed public drop-off area during the Master Plan period (2017-2036) will be approximately 19 vehicles. Assuming a typical average in and out time from the public drop-off area of 10 minutes, a minimum of 4 parking bays/ bins will be required for all waste types assuming disposed as comingled. However, since the intent is to allow for segregated disposal of recyclables and household hazardous waste (HHW), more bins are proposed.

<u>Number of bins based on daily tonnage disposed by residents</u>

The average daily traffic contribution from residential users at the end of the Master Plan Period would be approximately 108 vehicles **(Table 14).** Assuming a loose waste density of 300 kg/m3 and a waste disposal rate of 100 kg/vehicle, approximately 50 yd3 of waste storage will be required on a daily basis. Considering the peak hour traffic, it is recommended to provide 4- 20 yd3 bins dedicated for disposal of household waste. At the end of the day or as needed, these bins could be removed and weighed before being emptied at the active face or transported for further processing. This will facilitate an accurate accounting of waste quantities and destinations.

The proposed public drop-off area is approximately 80 m wide and 150 m long and is sufficient for development of a public drop-off or a waste transfer station facility for the waste types currently managed at this facility with the exception of metal and white goods. Further, the public drop-off area could be designed as an open facility similar to the current arrangement or an enclosed structure. Given the current usage, it may not be necessary to construct it as an enclosed structure. However, regardless of the open or enclosed structure, the concept design recommends at a minimum the following:

1. Designated area for HHW (used oil, filters, glycol etcetera) – The current infrastructure could be transferred to the proposed new area and re-used. A proper containment structure and operational plan will be required to deal with spills.
2. Bins for recyclables and waste regulated under various stewardship programs – The exiting bins currently in use for waste electronics and other recyclables are adequate for re-use at the new location
3. Bins for bagged household waste and yard waste – Currently, there are no bins for disposal of household waste since residents are allowed to dispose waste at the active face. It is recommended that 4- 20yd3 roll-off bins should be provided at the proposed new public drop-off area for the residents to drop-off their household waste.
4. For ease of accessibility to patrons disposing waste into the bins, elevated ramps could also be provided constructed with lock-blocks.

The bins and HHW disposal area will be arranged in a manner to provide access from both sides so that queuing could be minimized. Since, the residential small vehicle traffic will now be confined only to this area, it is expected that there will be minimal hindrance to garbage trucks and commercial vehicles accessing the active face of the landfill. Segregated and unidirectional traffic flow will further ensure the safety of the public drop-off area.

4.4.4.1 MATTRESSES

It is understood that the data for mattresses disposed at the landfill started being logged at the scale house in 2015. Between January 2015 and May 2016, approximately 2100 mattresses were received at this facility and it is likely that they were disposed in the landfill. Mattresses consume significant airspace in the landfill due to issues associated with their inflexible metal coil structure. It is recommended that a roofed area or an enclosed trailer unit within the proposed public drop-off area should be developed where patrons can dispose mattresses to keep them out of the landfill. Approximately 90% of the mattress material could be recycled and the City should contact authorized mattress recyclers in Alberta and Saskatchewan once appropriate quantities have been accumulated. Paying a third party for handling accumulated mattresses would still be cheaper than the cost of airspace consumed when disposed by landfilling.

It is recommended that a nominal flat fee must be charged from the patrons disposing mattresses at the landfill as a recycling and handling fee. A minimum fee of $15-20 per mattress or box spring should be charged to cover the cost of shipping and handling at a third party recycler based in Edmonton and Calgary. Soiled mattresses should be charged an extra fee due to extra handling cost by the third party recycler or for disposal in the landfill.

4.4.4.2 White Goods/Metals Stockpile

Currently, a significant area in the southern portion of the existing facility measuring approximately 80 m x 200 m is dedicated to the disposal of white goods and metals. The white goods/metal stockpiles are not recommended for placement within the proposed public drop-off area due to space limitation and safety of the public when they are processed. As per communication with the City, metals/white goods are processed 2-3 times in a year.

An alternate location for disposal of white goods/metals would be to consider the space currently occupied by the unused wet cell no. 2, since it is adjoining to the public drop-off area, yet facilitating a separate segregated area. All weather access ramps to this wet cell would be required for disposal of white goods/ metals. To protect the liner integrity underlining the wet cell, it is recommended that a 300 mm protective layer of soil/gravel should be placed at the base and side slopes of the wet cell prior to its use for stockpiling white goods/metals.

4.4.5 Vehicle Maintenance Area

A new equipment/vehicle maintenance area has been proposed at the south east corner of the facility within the setback area as shown in **Drawing 02 (Appendix C**). This area is approximately 4,300 m2 and adequate for providing a washroom, change room, lockers and small lunch area besides the area required for landfill equipment/vehicle maintenance. A pre-engineered building insulated and heated is suggested. It is assumed that the facility is currently serviced or will be serviced with a water line and natural gas line.

4.4.6 Surface Drainage

Run-off generated from within the site boundaries is currently diverted to a stormwater management pond located in the north east corner of the facility.

4.4.6.1 Interim Drainage Plan during Phase Development

The current site surface drainage is shown in **Drawing 01 (Appendix C)**. The proposed location of Phase 1.3 and 1.4 does not influence or change the existing surface water management system and the existing system will remain functional so long as development does not occur in the historical waste disposal area. Once the development begins in the historical waste disposal area as proposed, the existing surface water management infrastructure will automatically become dysfunctional and a surface drainage plan will need to be developed sequentially with the progression of phased development of the site.

The interim surface drainage required during the construction of Phases 1.3 and 1.4 has been proposed as part of this Master Plan and shown in **Drawing 01 (Appendix C).** Drainage ditches have been designed to handle run-off generated from a 1 in 100-year design storm. Drainage ditches and culverts would be constructed progressively with the construction of the landfill phases. All the surface drainage generated from the phased development of the facility will be diverted to the existing stormwater pond.

4.4.6.2 Ultimate Drainage Plan

As mentioned earlier, given the estimated operational life of this facility as 40 years, the Master Plan provides for an ultimate surface drainage plan at the end of 40 years when all the phases as proposed have been constructed and the facility will be closed and decommissioned. The layout of the proposed final surface management plan is shown in **Drawing 01 (Appendix C)**.

Based on the current grades available and concept design as proposed, surface drainage will not be an issue during the phased development of the site. The concept design provides for drainage swales constructed along the perimeter access road discharging into the low lying area to the north east of the facility and into the existing stormwater management pond. The capacity of the existing stormwater pond should be adequate. However, it is recommended that its capacity should be evaluated in the next 5-years. Any expansion of the existing Stormwater pond should not be undertaken towards south.

4.4.7 Leachate Holding Pond

The site development plan has proposed a centralized leachate holding pond/leachate evaporation pond at the current location of existing leachate overflow pond as shown in **Drawing 02 (Appendix C)**. The existing leachate lift station may need to be retrofitted with provision/retro-fit made to collect leachate from existing Phases 1.1/1.2 in the proposed leachate holding pond. The design of the existing leachate overflow pond is not known to Stantec.

The LCRS design conceptualized for Phase1.3 through Phase 1.7 suggest that leachate be collected in the sump provided at the base of each of these phases. The leachate collected in the sump will be removed by a sump pump assembly installed in the sump to drain into one of the service manholes located at the surface along the outer edge of the waste footprint numbered as MH-01 to MH-11 as shown in **Drawing 02 (Appendix C)**. These manholes will be connected with a 300 mm diameter HDPE drainage pipe to allow leachate to flow under gravity to the proposed leachate pond. These manholes will be developed in a phased manner with the phased construction of the landfill in Phase 1. The proposed location of the leachate pond will not be affected by the ultimate development of the facility as proposed. Proper cleanouts will be provided for maintenance purposes during their service life. Once the leachate pond is constructed, the transport of leachate overland to the septic manhole/WWTF will no longer be required. Leachate treatment will be accomplished by oxidation and evaporation in the pond. Although, a need to haul leachate from the pond is not anticipated at this time. However, in the event of extreme wet weather conditions, leachate can still be hauled by trucks to the WWTF on an as needed basis.

The entire leachate collection system will be designed to meet the leachate flow requirement expected during the operating life of the landfill and the post-closure care period. Based on the leachate generation estimates provided in **Appendix D**, the leachate pond would need to be designed for a holding capacity of approximately 13,000 m3 based on annual maximum leachate generation of approximately 34 m3/day. To enhance evaporation rates from the pond, inexpensive mechanical means e.g. Float evaporators, Turbo-Mister™ may be utilized during the summer months to reduce leachate volumes requiring management.

4.4.8 Material Stockpiles

With the proposed development, it may not be necessary to re-locate the current stockpiled materials. Based on desired geotechnical properties, the majority of the existing soil stockpile located directly west of Phase 1.1 can be utilized for construction of berms needed for Phases 1.3 and 1.4, construction/regrading of the perimeter access road and regrading wet cell no. 2 for disposal of metals etc. A detail design of the berm should be undertaken including slope stability modeling using the actual geotechnical properties of the stockpiled materials prior to using this material for construction. If necessary, reinforcement using geotextile/geogrids may be used to achieve structural properties as desired for the constructed berm/road when using these stockpiled materials. A soil balance including annual requirement of soil has been estimated and has been discussed further in Section 4.6.

4.4.9 Snow Disposal Facility

The current snow disposal area is not an engineered facility that could limit contaminants loading on the receiving water body or the environment. A concept design is included in **Appendix E** to minimize sediment and contaminant loading on the receiving stream. Though not shown on **Drawing 02 (Appendix C)**, the access to the snow disposal area is feasible from the new facility entrance as well as from the existing entrance on 40th Avenue. However, it is recommended that the existing access road from 40th Avenue be used for contingent situations only. The existing stormwater pond has a capacity of approximately 24,000 m3. Based on current data available, the meltwater volume from the snow melt detention pond is expected to be significantly higher for accommodation in the existing stormwater pond. It is therefore recommended that either a separate detention pond be designed or the existing stormwater pond be expanded to accommodate such additional meltwater volumes.

4.4.10 Relocation of Impacted Soil Management Area

Given the proposed development plan, the existing Impacted Soil Management Area can continue to operate for another 20 years at its current location.

4.5 PROPOSED LANDFILL DEVELOPMENT PLAN

Airspace is a crucial component for any landfill development. Therefore, finding ways to maximize airspace utilization within the available footprint should be the priority for the City.

4.5.1 Potential Landfill Expansion Area

Given the current layout of Phase 1.1 and 1.2, the area within the existing property boundary which could potentially be used for future cell construction includes:

1. The area currently occupied by the historical waste
2. The area between the east boundary of Phases 1.1 and 1.2 and the existing WWTF

The area towards the impacted soil management area further north of the current snow disposal area may also be used for future expansion. However, this area has not been included in the landfill phasing plan in this report. It is a best practice to limit lateral expansion of landfills unless all possibilities for vertical expansion have been exhausted. This is to limit the contaminated waste footprint and also to reduce closure costs which are directly related to the size of the waste footprint.

Currently, provincial regulations (MRMR, 1986) do not impose any height restrictions to landfill expansion.

4.5.2 Design Criteria

The conceptual design provided for landfill development/expansion was developed in accordance with the Ministry guidelines, applicable regulations and industry best practices. The following considerations were made:

- A Master Plan period of 20 years (2017-2036).
- Design to be equipped with a sub-liner drainage system (underdrain) or a hydraulic trap given the elevated groundwater table underlying this site. The hydraulic trap design enables inward groundwater flow and reduces contaminants migration from the landfill
- Proposed final design elevation of approximately 664 masl. This however doesn't restrict vertical expansion further beyond 664 as long as there is enough crest area available and stability of slopes has been ensured. The regulations currently do not impose restrictions on the maximum vertical height of landfills.
- Waste outer slopes not steeper than 3H:1V and not flatter than 5H:1V. The crest to be no flatter than 5%
- New landfill cell base to be graded at 2% and leachate collection pipes laid at minimum 1% grade
- Daily cover maximum 20% (6-part waste: 1-part daily cover) for estimation of airspace requirement
- Apparent waste density of 0.5 tonnes/m3 without accounting for daily cover
- Each cell to be equipped with its own leachate sump in one corner of the cell with an automated sump pump to pump the leachate into one of the manholes located at the periphery of the waste footprint. This is a preferred industry practice to have each cell equipped with its own leachate collection and removal system. Further, provision of these systems provides the ability to check leachate head build up above the liner in each cell. Being individual systems, it also ensures the leachate collection systems for other cells continues to function normally in the event of a malfunctioning.

- The leachate collected in these manholes will flow under gravity to the proposed leachate holding pond
- The manholes to be located in a manner to allow for unhindered maintenance and clean out during the entire operating life of the landfill
- The phasing of various cells should allow for progressive closure of the landfill so that leachate generation and closure costs could be reduced.

4.5.3 Limits of the Proposed Waste footprint

Lateral Limit - The lateral limits of the final waste footprint proposed in the Master Plan are shown in **Drawing 02 (Appendix C)**. This will provide approximately a waste footprint 30 hectares in size that includes approximately 8-10 hectares occupied by existing historical waste disposal area. This footprint excludes the regulated setback of 100 m from 40th Avenue and 67th Street.

Vertical Limit – The vertical expansion of the landfill has been proposed in four phases with each phase comprising several individual cells.

4.5.4 Proposed Landfill Phases

4.5.4.1 Phase 1

The Phase 1 expansion area is proposed to include the historical waste disposal area and the area between the east boundary of Phases 1.1 and 1.2 and the existing WWTF.

Reclamation of the historical waste disposal area presents both challenges and opportunities. Two options are proposed for Phase 1 expansion in the historical waste disposal area: (a) reclamation by constructing an overliner system, i.e., waste placement directly above the existing waste, and (b) reclamation by constructing an underliner system i.e. excavation and removing historical waste and constructing an underliner and re-disposing waste in the developed excavated area (typically known as landfill mining). Challenges, and pros and cons of each of the two options proposed are discussed further in Section 4.5.5.

Drawing 02 (Appendix C) shows the location of proposed Phases 1.3 through 1.7. Phases 1.3 and 1.4 are proposed on the east side adjoining existing Phases 1.1/1.2. Whereas, Phases 1.5, 1.6 and 1.7 are proposed in the historical waste disposal area when option (b) is used. However, should option (a) is preferred, the airspace contribution from Phases 1.5, 1.6 and 1.7 will not be available as shown in **Table 15**.

Table 15 Phase 1: Details of Potential Available Airspace

Phase 1	Plan Area (m2)	Available Airspace (m3) with Underliner System	Available Airspace (m3) with Overliner System
1.3	21,407	443,324	443,324
1.4	23,672	490,230	490,230
1.5	17,092	353,963	-
1.6	16,688	345,597	-
1.7	16,713	426,340	-
	95,572	2,059,454	933,554

4.5.4.2 Phase 2

Phase 2 is the above ground Phase proposed on top of Phase 1. The base layout plan for Phase 2 is shown in **Drawing 03 (Appendix C)** and comprises Phases 2.1 through 2.5. The access road to Phase 2 will be from east side of Phase 1.4. The potential airspace contribution from Phase 2 are shown in **Table 16**.

Table 16 Phase 2: Details of Potential Available Airspace

Phase 2	Plan Area (m2)	Available Airspace (m3)
2.1	27,033	298,540
2.2	23,984	302,887
2.3	26,429	308,500
2.4	26,559	298,050
2.5	26,667	306,462
	130,672	1,514,439

4.5.4.3 Phase 3

Phase 3 is proposed above Phase 2. The base layout plan for Phase 3 is shown in **Drawing 04 (Appendix C)** and comprises Phases 3.1 through 3.4. The access road to Phase 3 will be from west side of Phase 2.4. The potential airspace contribution from Phase 3 are shown in **Table 17**.

Table 17 Phase 3: Details of Potential Available Airspace

Phase No.	Area (m2)	Volume (m3)
3.1	22,715	278,569
3.2	23,462	241,029
3.3	24,399	265,410
3.4	29,411	251,326
	99,987	1,036,334

4.5.4.4 Phase 4

Phase 4 is proposed above Phase 3. The base layout plan for Phase 4 is shown in **Drawing 05 (Appendix C)** and comprises Phases 4.1 through 4.4. The access road to Phase 4 will be from west side of Phase 3.3. The potential airspace contribution from Phase 4 are shown in **Table 19**.

Table 18 Phase 4: Details of Potential Available Airspace

Phase No.	Area (m2)	Volume (m3)
4.1	24,759	160,528
4.2	15,457	158,059
4.3	20,290	165,321
4.4	34,232	166,151
	94,738	650,059

4.5.4.5 Airspace Utilization during the Master Plan (2017-2036)

During the proposed Master Plan period, of the four phases described above, only Phase I and part Phase 2 will need to be constructed as these would provide adequate airspace required to accommodate waste generation during the Master Plan period of 20 years. A cross-section A-A drawn through Drawing 02 is shown in **Drawing 08 (Appendix C)** which illustrates final shape of the landfill at the end of 40 years. The approximate design elevations proposed for various phases are tabulated in **Table 19**.

Table 19 Description of Proposed Phases of Landfill Development

Phase	Location	Option A (Underliner)			Option B (Overliner)			Proposed Average Elevation (masl)	
		Waste footprint (hactares)	No. of Cells	Estimated Life (years)	Waste footprint (hactares)	No. of Cells	Estimated Life (years)	Cell Base	Cell Top
Phase 1	Below grade	9.6	5	16	4.5	2	11	623.00	638.00
Phase 2	above Phase 1	13.1	5	13	13.1	5	13	638.00	646.00
Phase 3	above Phase 2	10.0	4	7	10.0	4	7	646.00	656.00
Phase 4	Final Cap	9.5	4	5	9.5	4	5	656.00	664.00
	Totals			41			36		

Details about air space requirements and phasing of various cells is included in **Appendix F** for reference.

4.5.5 Historical Waste Area Reclamation Options

As mentioned earlier, two options exist for reclaiming the historical waste disposal area:

4.5.5.1 Option A – Vertical expansion by constructing an Overliner System

One viable option is "piggybacking" the existing historical waste disposal area by constructing an overliner system on top of the area. The following are a few potential challenges with this approach:

- **Vertical and Horizontal Delineation of Waste Footprint and Waste Thickness** - As outlined earlier, the thickness of historical waste disposal is not well defined and it varies from 1.0 m to 9.5 m. With such a high variability in thickness and unknown biological state of degradation of waste, potential for significant differential settlement may exist should vertical expansion be proposed. However, such settlements could be reasonably estimated based on geotechnical investigation of the historical waste disposal area. Together with varying waste thickness, the density of waste is also expected to vary significantly leading to potential differential settlements in the overliner.
- **Groundwater Contamination** - Although the groundwater quality underneath this site is generally poor as observed from the background groundwater quality data described in various groundwater monitoring reports, it does not exhibit elevated chloride levels. However, leachate levels showed an increasing trend based on available limited data (**Table 8**). By designing an overliner system, moisture infiltration into the underlying historical waste will certainly reduce over time. However, the source of contamination will remain there forever and continue to provide long-term liability for the City.
- **Piggyback Landfill Design** - The concept of piggyback landfill expansion is not new and has been practiced at various historical landfill sites across North America. The prime design objective in this case would be to ensure that long-term settlement of the underlying waste does not lead to structural failure of the proposed vertical expansion. Geotechnical aspects such as slope stability and settlement issues will need to be assessed in detail considering the service life of the landfill up to the end of the post-closure care period. A thorough technical investigation will be necessary to evaluate geotechnical properties of the underlying historical waste and its current state of biological degradation. This would be a crucial step in providing a sound engineering design for the piggyback expansion as proposed.
- **Loss of Airspace** – Based on the review of borehole data from the historical waste disposal area, the thickness of fill material (clay) placed on top of the historical waste varies from 1.0 m to 6.0 m. Further, the waste thickness below this fill layer varies from 1.0 to 9.5 m. Therefore, by having to piggyback the historical waste disposal area, there could be significant loss of valuable airspace as illustrated further in Option B.

4.5.5.2 Option B – Vertical Expansion by Mining Existing Waste

This is another option for reclaiming the historical waste disposal area. Landfill mining is typically practiced for one or more of the following purposes (a) conservation of landfill space (b) elimination of potential contamination source (c) mitigation of an existing contamination source or (d) material/ energy recovery from excavated waste. Considering this, landfill mining of historical waste would offer following advantages:

- **Efficient Airspace utilization** – The net gain in volumetric space by way of landfill mining and re-structuring of the historical waste disposal area as an engineered facility would be approximately 500,000 m3 (**Table 20**) assuming that 65% of the excavated waste will still require re-disposal in the replacement engineered cell. This available airspace below ground can be expected to serve the waste disposal needs of the City for additional 5-6 years. The fines and cover soil recovered from this excavation could be used to replace the demand for additional cover soil.

Table 20 Net Gain in Airspace from Underliner Construction

S.No.	Description	Unit	Quantity
1	Estimated historical waste in-place	tonnes	394,742
2	Assume recyclables recovered (10%)	tonnes	39,474
3	Assume finely degraded waste and cover soil recovered (25%)	tonnes	98,686
4	Excavated waste requiring re-disposal	tonnes	256,583
5	Volume equivalent @0.5 tonnes/m3	m3	513,165
6	Add 20% for daily cover	m3	102,633
	Total airspace required for re-disposal	m3	615,798
	Airspace provided by Phases 1.5, 1.6, 1.7 (Underliner system)	m3	1,125,900
	Net gain in airspace	**m3**	**510,102**

- **Reduced Potential Liability** – Once the historical waste has been mined and the area redesigned to provide engineered containment, it will significantly reduce or even eliminate any potential liability for the City since the pathway, i.e. source of contamination would have been removed.
- **Resource Recovery** – Landfill mining provides an excellent opportunity to recover material that may not require landfilling. It would lead to various benefits besides airspace savings (a) there could be material such as lumber, metals which could be salvaged (b) it gives an opportunity to remove hazardous waste that may have been historically disposed and (c) re-use of cover material including interim cover including fines generated from biodegradation of organics to meet ongoing requirement of daily cover.

Landfill mining though has a few challenges as listed below; however, there are ways to mitigate those challenges.

- A Permit from the Ministry for such mining activity may be required since this is a non-traditional approach.
- Local risks such as pollutant emission during excavation (noxious odors, etcetera) may be a concern
- Cost of mining - This, however, should be evaluated in terms of:
  - cost of airspace gained,
  - reduced contaminated land footprint,
  - reduced liability for the City and
  - protection of groundwater resources.

Landfill mining of the historical waste would be phased to align with the phased development of the landfill. The cost associated with mining waste could then possibly be distributed over several years.

4.6 SOIL STORAGE & USAGE

Currently, large stockpiles of soils are located on the historical waste disposal area as well as in the impacted soil management area. The estimation of soil balance was made for two scenarios: (a) considering the historical waste disposal area will be reclaimed by piggybacking i.e. construction of an overliner system, and (b) considering reclamation of historical waste disposal area using landfill mining approach, i.e., by constructing an underliner system.

Table 21 shows the soil balance for the estimated soil sources, uses and surpluses for the proposed facility development for case (a) where historical waste is not excavated or mined. Based on estimates of waste projections, during the Master Plan period, there could be a total deficit of 335,000 m3 of daily cover. To meet this deficit an average approximately 16,750 m3 of fill material or treated soil will need to be stockpiled annually on site to meet the ongoing demand for daily/intermediate cover. A breakdown of annual soil requirement during the Master Plan period considering case (a) i.e. overliner system is shown in **Appendix G** for quick reference.

Table 21 Soil Balance for an Overliner System

Description of Items	Unit		Available soil volume	Required soil volume
Stockpiled Material			**(m3)**	**(m3)**
(a) located west of phase 1.1/1.2 (based on information provides by the City)	m3		75,000	
(b) Near Impacted soil management area 200850 tonnes (assume density of stockpiled soil = 1.3 tonnes/m3	m3		154,500	
(c)Soil treatment pad (33,860 tonnes)	m3		26,046	
(d) Average annual requirement of treated soil (2017-2036)	m3	16,750	335,000	
Berm Construction				
(a) Phase 1 (length = 2200 m)				(70,400)
(b) Phase 2 (length = 1200 m)				(31,200)
Daily, Intermediate, Final Cover				
Projected waste Disposal (2017-2036)	m3	1,954,999		
Daily cover @ 20%				(391,000)
Intermediate cover	m2	325,397		(97,619)
Final cover (Assumed no final cap required by 2036)	m2	404,864		-
			590,546	(590,219)

For case (b) i.e. underliner system or landfill mining, there will be a deficit of approximately 360,000 m3 of daily cover during the period 2017 through 2036 as shown in **Table 22**. To meet this deficit an average approximately 18,000 m3 of fill material/treated soil would need to be stockpiled annually on site to meet the ongoing demand for daily cover. This is a conservative estimate assuming that 65% of the excavated waste will be re-disposed in the lined cells.

Table 22 Soil Balance for Underliner System (i.e. Landfill Mining)

Description of Items	Unit		Available soil volume (m3)	Required soil volume (m3)
Stockpiled Material				
(a) located west of phase 1.1/1.2 (based on information provides by the City)	m3		75,000	
(b) Near Impacted soil management area 200850 tonnes (assume density of stockpiled soil = 1.3 tonnes/m3	m3		154,500	
(c)Soil treatment pad (33,860 tonnes)	m3		26,046	
(d) Annual required treated soil/soil (2017-2036)	m3	18,000	360,000	
Historical Waste Disposal				
(a) Quantity of historical waste requiring re-disposal	tonnes	256,583		
(d) Voulme of fines recovered and available for daily cover (@1.3 tonnes/m3)	tonnes	98,686	75,912	
Berm Construction				
(a) Phase 1 (length = 2200 m)				(70,400)
(b) Phase 2 (length = 1200 m)				(31,200)
Daily, Intermediate, Final Cover				
Projected waste Disposal (2017-2036)	m3	1,954,999		
Historical waste re-disposed	m3	513,165		
Total Waste disposed	m3	2,468,164		
Daily cover @ 20%				(493,633)
Intermediate cover	m2	325,397		(97,619)
Final cover (Assumed no final cap required by 2036)	m2	404,864		
			691,458	(692,852)

4.7 CONTAINMENT BERMS

The above grade waste placement will be contained by constructing permanent perimeter berms. The perimeter berm should be continuous all-round and constructed with a minimum height of 2.0 m and a top width of 5.0-10.0 m or as required by the site conditions and proposed development. The side slopes of the berms should be no steeper than 1V:3H. Prior to construction, the berm design should be checked for adequate structural stability against lateral pressures generated from waste mass disposal.

4.8 SNOW DISPOSAL

The existing snow disposal area is located north of the impacted soil management area. This area provides uncontrolled discharge of sediments and contaminants to the receiving waters during melt down stages. Water quality concerns for meltwater includes chlorides, petroleum hydrocarbons, salts, suspended sediment, turbidity and heavy metals. The Master Plan proposes to improve the existing snow disposal area.

4.8.1 Design basis

Based on data provided by the City for the volumes of snow disposed during 2014, 2015 and first three months of 2016, the highest volume of snow of approximately 60,000 m3 was disposed in the year 2014. The concept design basis used in this project provides a total snow storage capacity of approximately 90,000 m3 for a design factor of 1.5. The design should broadly consider the following:

1. Snow Storage Pads – for the designed storage capacity, an area of approximately 1.80 hectares will be required assuming an average height of snow disposal of 5 m. It is recommended that the storage pad is constructed with material that could reduce moisture infiltration into the native ground. A hydraulic conductivity of storage pad material of the order of 10^{-7} m/s of less is recommended. A series of "V" swale at suitable spacing should be constructed within the pad area to allow for movement of meltwater inside the snow pack free of sediments.
2. Pad Orientation – The orientation of the pad should be such that the downslope end of the V-swales axis is to the north in order to promote melting of the snow pack from the uphill side towards the downhill side and minimize exposure of loose sediments to the flowing meltwater.
3. Detention pond – should be designed based on hydrologic characteristics of meltwater from snow sites based on 40-hour duration snowmelt hyetograph and sediment removal rates.

A preliminary concept layout is provided in **Appendix E**. Prior to construction, it is recommended that a detailed design be conducted for sizing the V-swales and the detention pond.

5.0 RECOMMENDATIONS AND IMPLEMENTATION PLAN

The following paragraphs provide recommendations for the phased development of the facility and upgrades to the existing infrastructure within the parameters of the proposed Master Plan. These recommendations are also ranked according to the year in which such development activity is suggested for implementation. The Master Plan is divided into four sub-periods, each 5 years long in duration. The capital budget allocation is also provided to assist the City with their Capital Project Planning. The landfill phasing implementation plan is proposed considering option B for historical waste reclamation. However, the implementation plan could be easily modified should option A for historical waste reclamation is preferred.

5.1 CURRENT CONDITIONS: YEAR 2016

Drawing 01 (Appendix B) shows the existing conditions at the facility and the location of various current infrastructure as per the survey plan provided by the City. Phase 1.2 is the current active cell and is being used for the disposal of household waste. The remaining active life of the active Phase 1.2 is approximately 18-24 months as communicated by the City.

5.2 DEVELOPMENT PLAN: 2017-2021

The following infrastructure development activities are proposed for the first five years of the plan i.e. 2017 - 2021.

Year of Activity	Plan Period I: 2017-2021	Preliminary Capital Budget Estimate	
		2016	Activity Year
2017-18	**Phase 1.3 Construction** – Given the limited active life of Phase 1.2, the design and tender for Phase 1.3 construction should proceed in a manner so that it is ready for waste disposal by mid - 2018. Consider that during winter months (below 5^0C) installation of geosynthetics liner is not recommended.	$ 2,935,000	$ 2,995,000
2017-18	**New facility Entrance from 67th Street** - Construct new facility entrance from 67th Street including 67th street rehabilitation. Provide two weigh scales and construct new scale house with office space.	$ 1,495,000	$ 1,525,000
2017-18	**New Perimeter Access Road -**The perimeter access road in the expansion area to be constructed up to the leachate holding pond. Recommended all-	$ 1,650,000	$ 1,685,000

Year of Activity	Plan Period I: 2017-2021	Preliminary Capital Budget Estimate	
		2016	Activity Year
	weather access road (Approximate Total Area 16,000 m2)		
2018	**Interim Closure of Phase 1.2** - An interim cover should be provided to Phase 1.2 as soon as a design elevation of approximately 640 masl is reached (assuming that Phase 1.3 will be ready for waste disposal prior to reaching that elevation). Approximately 24,000 m2 of intermediate cover will be required which will require approximately 10,000 m3 of cover soil which should be available from the stockpiled material. The intermediate cover is assumed to be applied as part of normal facility operation	No Capital Budget provision required	
2017-18	**Public Drop-off Area** - Develop new public drop-off facility at the south east corner of the facility including wet cell development with protective material for metals/tires as per the concept shown in the Drawings. (Assumed existing bins will be used)	$ 425,000	$ 440,000
2018	**Relocate Septic Manhole –** Although as per the plan, this may not be necessary. However, a provision should be made in case it become necessary.	$ 85,000	$ 90,000
2018	**Construct Leachate holding pond -** The leachate holding pond is proposed to be constructed simultaneously with Phase 1.3 construction at the location of existing leachate overflow pond. It is anticipated that leachate holding pond will be operational at the same time Phase 1.3 becomes operational.	$ 555,000	$ 575,000
2018	**Manholes for leachate transport –** construct MH -10 and MH-11 including drainage pipe	$ 60,000	$ 60,000

Year of Activity	Plan Period I: 2017-2021	Preliminary Capital Budget Estimate	
		2016	Activity Year
2019	**White Goods/metal/ tire Pile -** Once the public drop off area becomes functional; it is recommended that the area currently occupied by wet cell No. 2 will be developed for storage/disposal of white goods/metals/tires. The existing pile should be cleaned up subsequently but prior to construction of Phase 1.5	No Capital Budget provision required	
2019	**Re-align outfall of Phase 1.1/1.2 Leachate collection system** - Once Phase 1.3 is constructed, it would be necessary to re-align/ retrofit the existing leachate outfall from Phase 1.1/1.2 to the new leachate holding pond	$ 75,000	$ 80,000
2020	**Design and construct Phase 1.4 -** By this time Phase 1.3 is expected to reach its designed interim elevation. The City should process the development of Phase 1.4 including construction of berms required to support side slopes of Phase 1.4	$ 3,215,000	$ 3,480,000
2020	**Manholes for leachate transport –** Construction of Phase 1.4 will require extend piping from MH-10 to MH-09 as well as construction of MH-09 to facilitate leachate transport to leachate holding pond	$ 85,000	$ 90,000
2017-21	**Daily Cover Stockpile -** Treated soils and other fill material for daily cover can continue to be stockpiled at the current location west of Phase 1.1 during this period (2017-2021). However, such stockpile volumes should be just sufficient to meet the demand until 2021.	No Capital Budget provision required	
2017-21	**Vehicle Maintenance Building -** the current location should remain functional in the interim during this sub-plan period	No Capital Budget provision required	
2017-21	**Concrete/Crushed Concrete Stockpile -** All the stockpiled concrete/ crushed concrete should be consumed from this location. Any future stockpiling of	No Capital Budget provision required	

Year of Activity	Plan Period I: 2017-2021	Preliminary Capital Budget Estimate	
		2016	Activity Year
	concrete should take place within the 100 m setback available towards 40th Avenue		
2017	**Demonstration project for Historical Waste Excavation (OPTIONAL)** - Develop and execute a program to demonstrate the feasibility of reclaiming historical waste disposal area by excavating and mining waste.	$ 250,000	$ 270,000
2017-21	**Snow Disposal Area -** The existing snow disposal area should continue to be used for next five years and record maintained of snow quantities disposed to assist with designing snow storage facility during the next sub-plan period (2022-2026)	No Capital Budget provision required in this Plan period	

5.3 DEVELOPMENT PLAN: 2022 – 2026

The following development activities are proposed for the 5-year short-term (2022 through 2026)

Year of Activity	Plan Period II: 2022-2026	Preliminary Capital Budget Estimate	
		2016	Activity Year
2022	**Existing white goods/metal Pile Clean-up -** This location will not be functional anymore. It is recommended that existing pile should be cleaned up/salvaged prior to construction of Phase 1.5	No Capital Budget provision required	
2022	**Historical Waste Excavation Underlying Proposed Phase 1.5 (OPTIONAL) -** Complete excavation of historical waste in the area proposed for Phase 1.5	To be estimated based on resources available with the City/Contract out	
2022	**Vehicle Maintenance Building -** Construct a new equipment/maintenance building on the south west corner of the facility as shown in Drawing 01 (Appendix C)	$ 555,000	$ 625,000

Year of Activity	Plan Period II: 2022-2026	Preliminary Capital Budget Estimate	
		2016	**Activity Year**
2022	**Design and develop existing snow disposal area -** Design and construct snow disposal area. By this time, it is believed that City would have gathered additional data from 2017-2021 regarding peak snow volumes to support the concept design proposed in this report.	$ 450,000	$ 505,000
2023	**Design and construction of Phase1.5 (Underliner) OPTIONAL OR Prepare for Phase 2.1 (Overliner System)-** It is expected that Phase 1.4 would be near completion. The City should proceed with the design and construction of Phase 1.5. This will require excavation and mining of historical waste disposal area, construction of supporting berms. The design should focus on management of high groundwater table/leachate level under the historical waste disposal area	$ 5,995,000	$ 6,885,000
2023	**Design and construction of interim stormwater drainage for phase 1.5 -** This stormwater system comprise drainage swales as shown in Drawing 02 with two culverts one near the weigh scale and another near existing wet cell no. 1	$ 68,040	$ 80,000
2023	**Manholes for leachate transport –** Construction of Phase 1.5 will require constructing piping from MH-1 to MH-08 as well as construction of manholes from MH-01 to MH-08 to facilitate leachate transport to leachate holding pond	$ 460,000	$ 530,000
2024	**Provide Interim Cover for completed Phase 1.4 -**Phase 1.4 is expected to have been filled to its designed elevation and should be provided with an interim cover. Waste filling continues to progress in Phase 1.5. Approximately 24,000 m2 of intermediate cover will be required which will require approximately 7000 m3 of cover soil which should be available at no cost to the City. The intermediate cover is assumed to be applied as part of normal facility operation	No Capital Budget provision required	

Year of Activity	Plan Period II: 2022-2026	Preliminary Capital Budget Estimate	
		2016	Activity Year
2025	**Historical Waste Excavation Underlying Proposed Phase 1.6 (OPTIONAL) OR Prepare for Phase 2.2 (Overliner System -** Complete excavation of historical waste in the area proposed for Phase 1.6	To be estimated based on resources available with the City/Contract out	
2026	**Design and construction of Phase1.6 (Underliner)** It is expected that Phase 1.5 would be near completion. The City should proceed with the design and construction of Phase 1.6. This will require excavation and mining of historical waste disposal area, construction of supporting berms. The design should focus on management of high groundwater table/leachate level under the historical waste disposal area	$ 5,865,000	$ 7,150,000
2022-26	**Clean Fill Stockpile -** It is believed that by 2021, stockpiled clean fill/treated soil would have either been consumed for berm construction and used for daily/intermediate cover to Phase 1.3. Henceforth, no stockpiling of daily cover material will take place at the existing location. Any future stockpiling until next sub-plan period (2027-2031) should be over the Phases 1.3 and 1.4 (beginning 2024) which had received interim cover.	No Capital Budget provision required	

5.4 DEVELOPMENT PLAN: 2027 – 2031

The following development activities are proposed for the 5-year short-term (2027 through 2031)

Year of Activity	Plan Period III: 2027-2031	Preliminary Capital Budget Estimate	
		2016	Activity Year
2027	**Provide Interim Cover for completed Phase 1.5 (Underliner) -** Phase 1.5 is expected to have been filled to its designed elevation and should be provided with an interim cover. Waste filling continues to progress in Phase 1.6	No Capital Budget provision required	

2028	**Historical Waste Excavation Underlying Proposed Phase 1.7 (OPTIONAL)** - Complete excavation of historical waste in the area proposed for Phase 1.6	To be estimated based on resources available with the City/Contract out	
2029	**Design and construction of Phase1.7 (Underliner)**	$ 6,775,000	$ 8,765,000
2030	**Provide Interim Cover for completed Phase 1.6 (Underliner)-**Phase 1.6 is expected to have been filled to its designed elevation and should be provided with an interim cover. Waste filling continues to progress in Phase 1.7	No Capital Budget provision required	

5.5 DEVELOPMENT PLAN: 2032- 2036

The following development activities are proposed for the 5-year short-term (2032 through 2036)

Year of Activity	Plan Period IV: 2032-2036	Preliminary Capital Budget Estimate	
		2016	**Activity Year**
2032	**Design and construction of Phase2.1**	$ 270,000	$ 370,000
2033	**Provide Interim Cover for completed Phase 1.7 (Underliner)-**Phase 1.7 is expected to have been filled to its designed elevation and should be provided with an interim cover. Waste filling continues to progress in Phase 2.1	No Capital Budget provision required	
2034	**Design and construction of Phase2.2 (Underliner)**	$ 270,000	$ 385,000
2035	**Provide Interim Cover for completed Phase 2.1 (Underliner)-** Phase 2.1 is expected to have been filled to its designed elevation and should be provided with an interim cover. Waste filling continues to progress in Phase 2.2	No Capital Budget provision required	

APPENDIX A
LOCATION OF MONITORING WELLS PER TABLE 6

NOTES:
1. MONITORING WELL COORDINATS DETERMINED BY SURVEY, PROVIDED BY THE CITY OF LLOYDMINSTER.
2. CONTOURS FROM TRANSIT TECHNICAL SERVICES, SURVEYED ON OCT 30, 2012; ADDITIONAL SURVEY COMPLETED BY CRA, MAY 13-16, 2013.
3. PROJECTION: NAD 83 UTM ZONE 12
4. AERIAL IMAGE PROVIDED BY THE CITY OF LLOYDMINSTER, DATED 2011
5. AERIAL IMAGE PROVIDED BY DIGITALGLOBE, DATED 2013

LEGEND

- MW03-12 EXISTING MONITORING WELL LOCATION
- MW02-8 MONITORING WELL (DESTROYED/DECOMMISSIONED)
- MW11-3-9 LEACHATE WELL LOCATION
- ESTIMATED LIMIT OF WASTE
- PROPERTY LINE
- CREEK
- FENCE

figure 1.2

MONITORING WELL LOCATIONS
2015 ANNUAL GROUNDWATER MONITORING REPORT
SOLID WASTE MANAGEMENT FACILITY
City of Lloydminster

78639-005(013)GN-WA001 NOV 25, 2015

APPENDIX B
LEACHATE VOLUME DATA FOR 2014 TO 2016

2016

Leachate Monitoring Form
6 inches Pump

Date	RPM	Hours	Volume	Purpose	
2016/05/21	1200	2	275 m³/hr	LEACHATE REMOVAL 550	550
2016/05/22	1200	2	275 m³/hr	LEACHATE REMOVAL 550	1100
2016/05/24	1200	1	275 m³/hr	LEACHATE REMOVAL 275	1375
2016/07/23	1400	4 1/2	325 m³/hr	LEACHATE REMOVAL 1463	2838 m³

Leachate Monitoring Form 2014

Date	RPM	Hours	Volume	Purpose	
June 20	1400	1 1/2	325 m3/hr	487.5	
June 22	1400	2 1/4	325 m3/hr	731.25	1218.75
May 31	1200	2	275 m3/hr	550	1768.75
June 23	1300	5	300 m3/hr	1,500	3268.75
June 25	1400	1	325	325	3593.75
July 24	1400	1	325	325	3918.75
July 30	1450	2 1/4 hrs	335	753.75	4672.5
AUG 02	1400	2 hrs	325	650	5322.5
AUG 09	1200	1 hr	275	275	5597.5
AUG 17	1400	2	325	650	6247.5
AUG 31	1400	2	325	650	6897.5
Sept 5	1400	2	325	650	7547.5
Sept 27	1400	2	325	650	8197.5

= 8200 m^3

APPENDIX C
PROPOSED CONCEPTUAL DEVELOPMENT PLAN

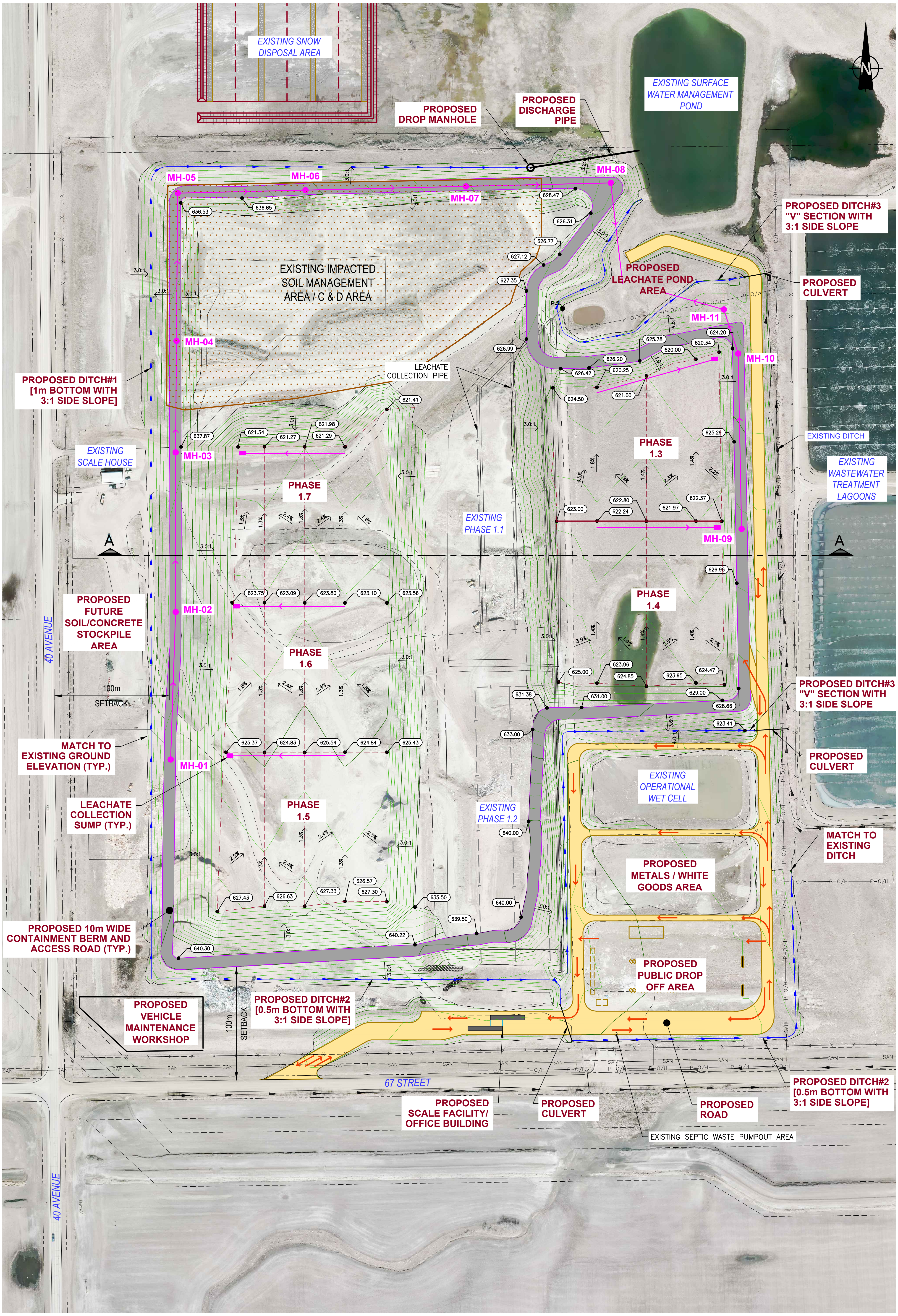
Drawing path: V:\1101\active\110128003\drafting\figures\current\figures.dwg Plotted: Wednesday, January 11, 2017 2:36:55 PM

Stantec
10160 - 112 Street
Edmonton AB
www.stantec.com

The City of Lloydminster
Alberta / Saskatchewan
Planning & Engineering

SCALE: 1:4000
DATE: 2017/01/11

2016 WMF MASTER PLAN
EXISTING SITE LAYOUT
DRAWING-01



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The City of Lloydminster
Alberta / Saskatchewan
Planning & Engineering

SCALE: 1:3000
DATE: 2017/01/11

2016 WMF MASTER PLAN
PHASE 1 - CELL □ASE LAYOUT PLAN
DRAWING-02

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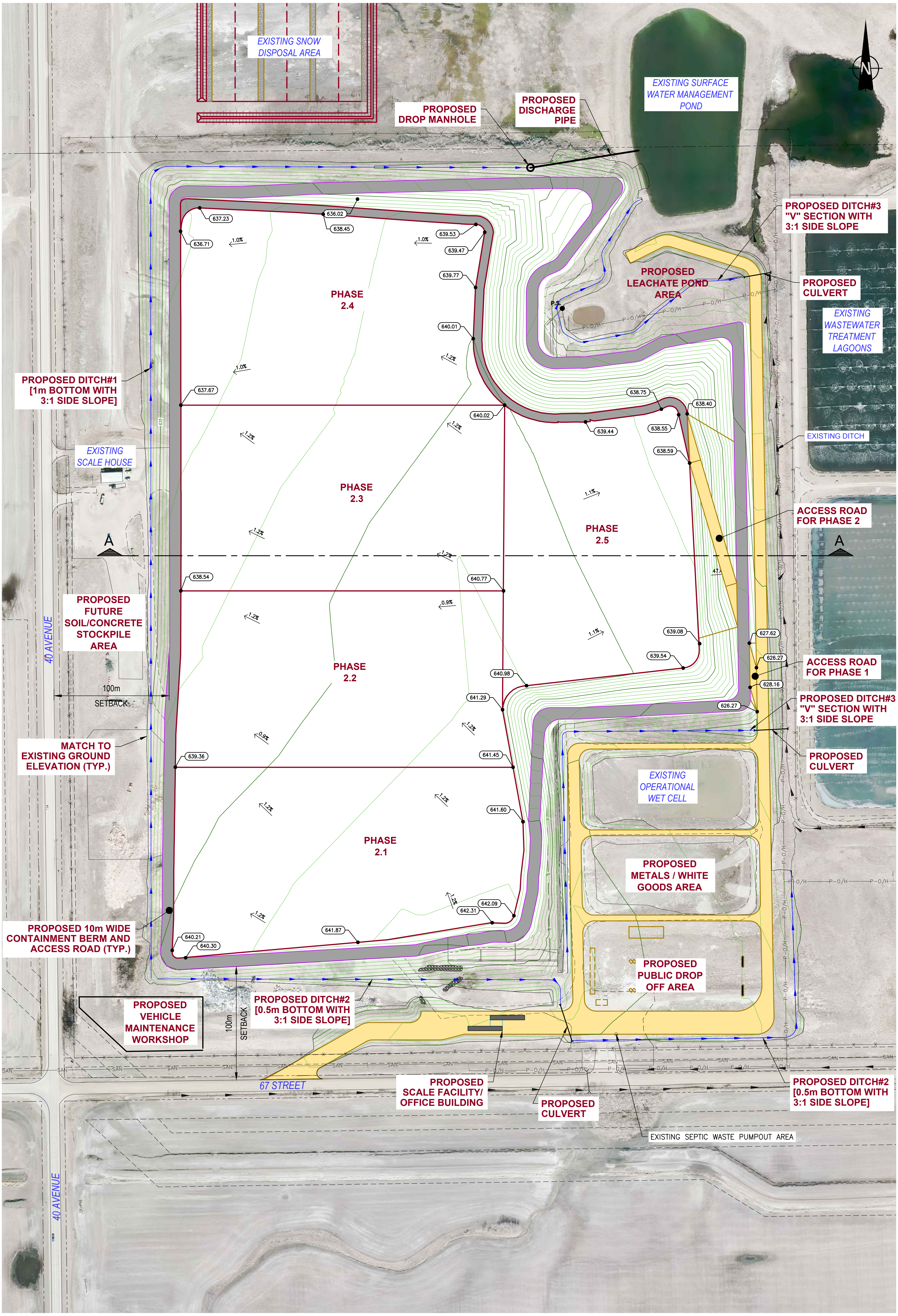

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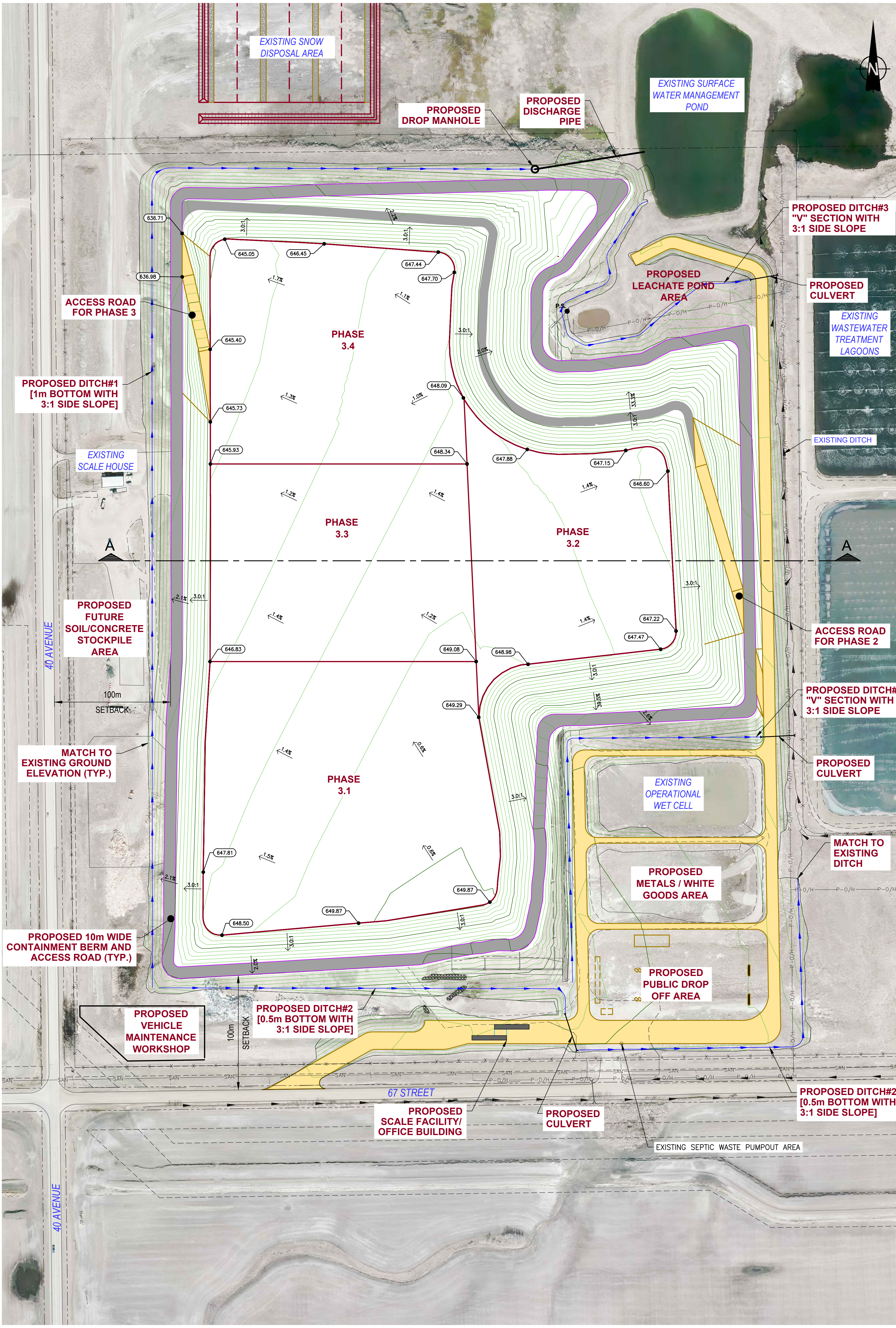
2016 WMF MASTER PLAN
PHASE 2 - CELL □ASE LAYOUT PLAN
DRAWING-03



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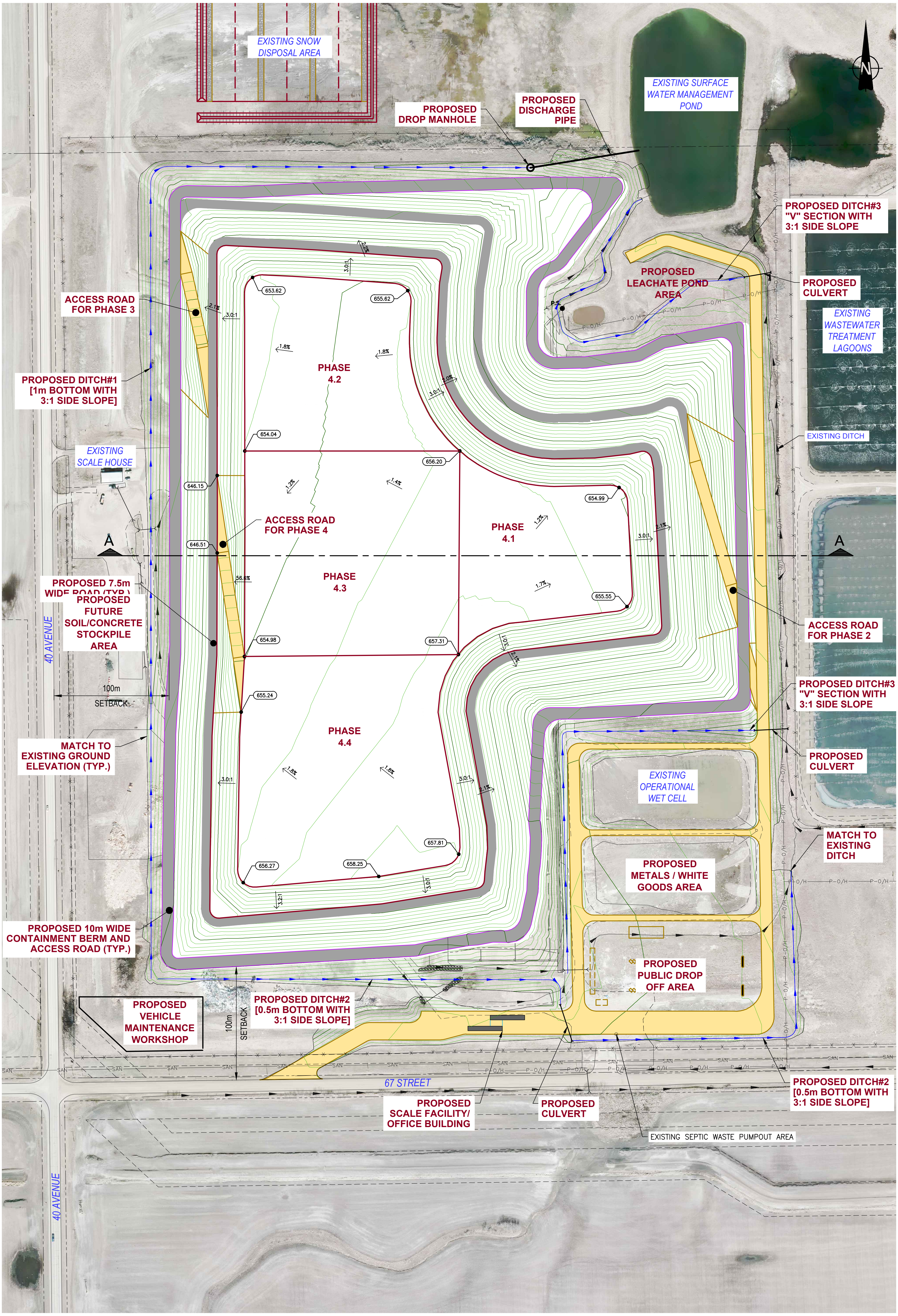
2016 WMF MASTER PLAN
PHASE 3 - CELL □ASE LAYOUT PLAN
DRAWING-04



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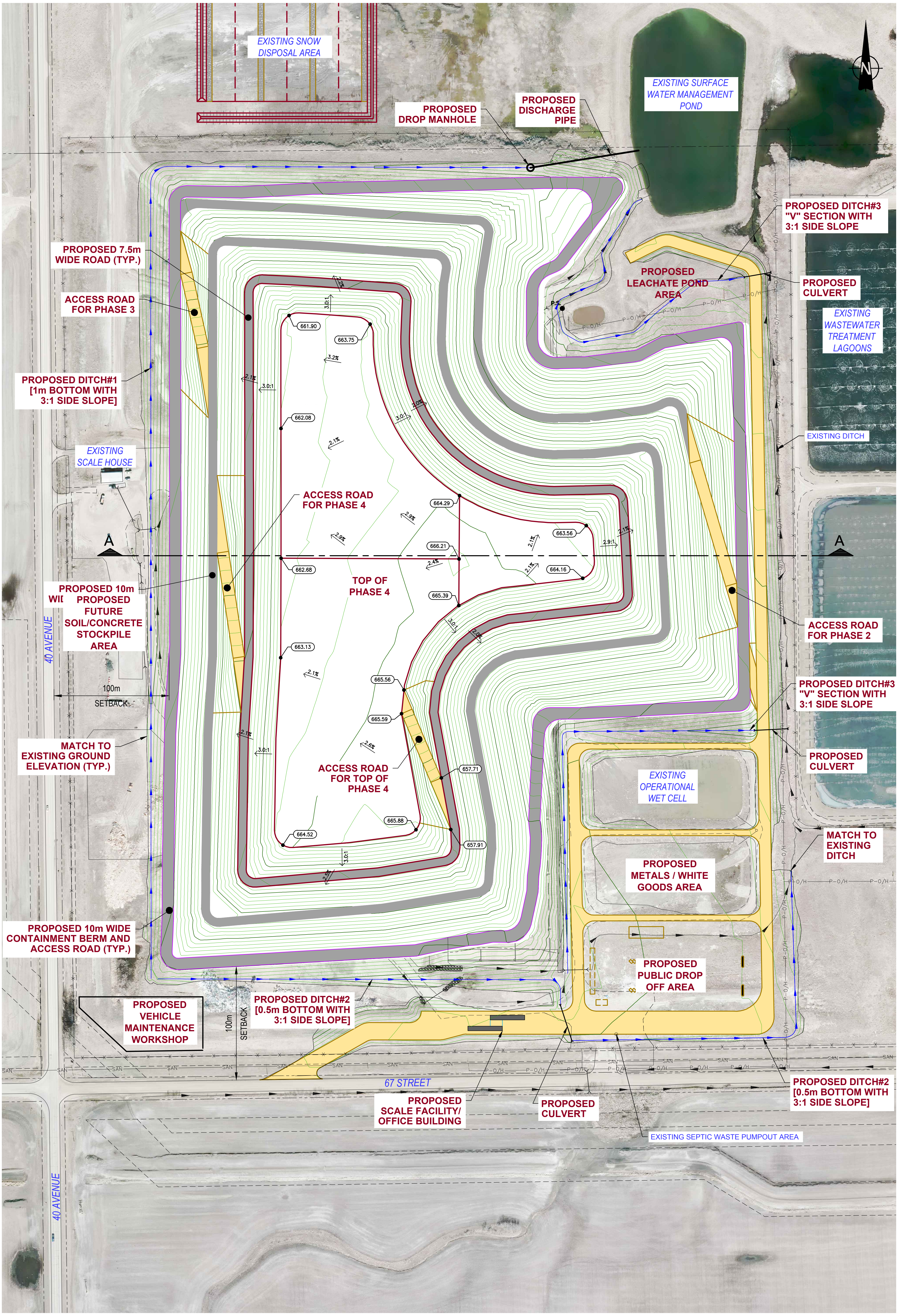
2016 WMF MASTER PLAN
PHASE 4 - CELL BASE LAYOUT PLAN
DRAWING-05



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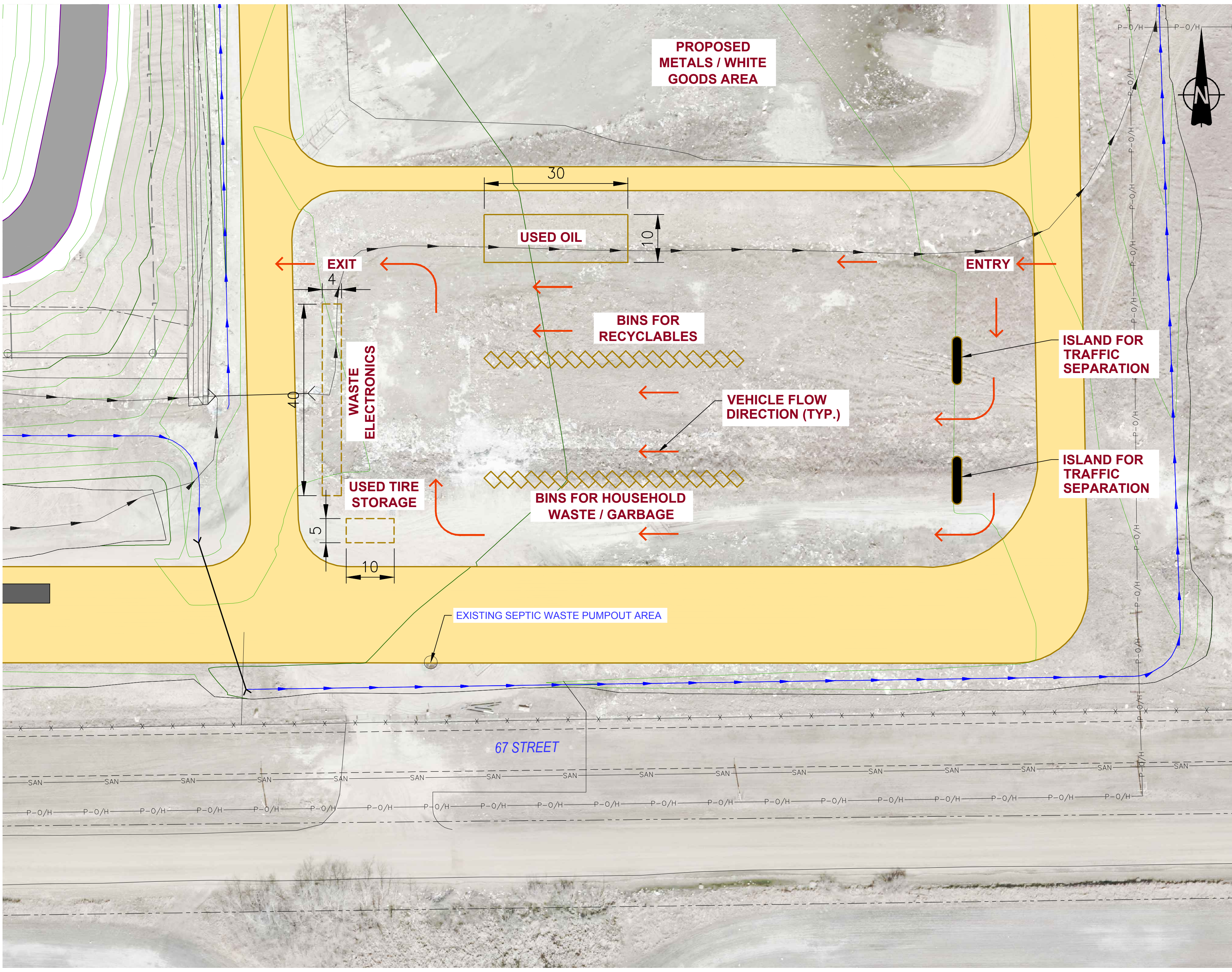
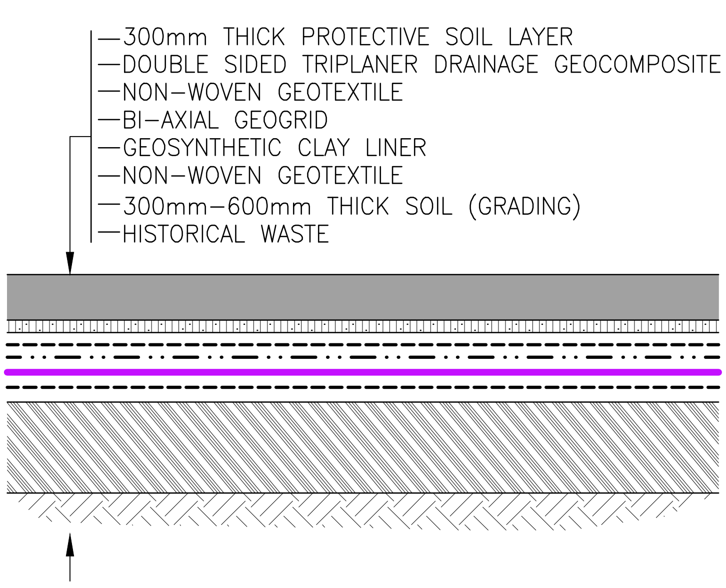
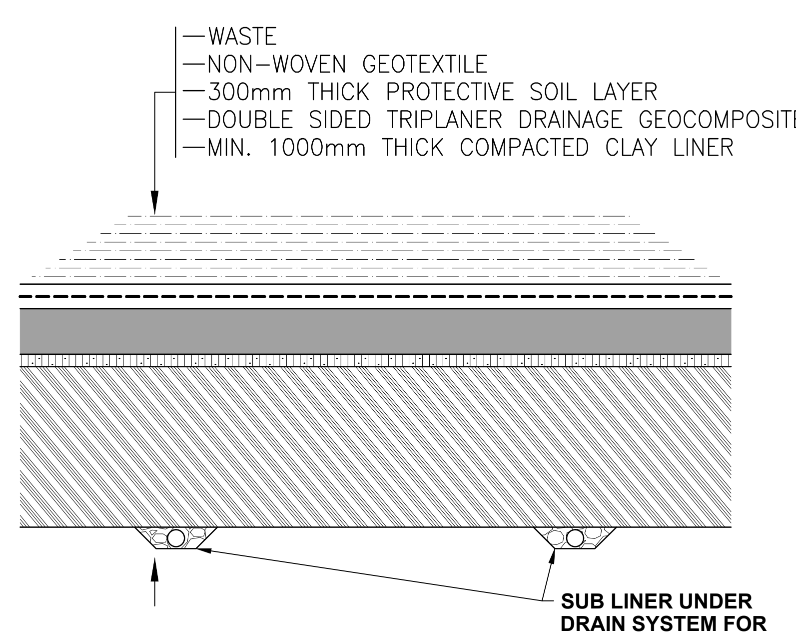
2016 WMF MASTER PLAN
PHASE 4 - CELL TOP LAYOUT PLAN
DRAWING-06



PROPOSED PUBLIC DROP OFF AREA
1:1000



TYPICAL OVER LINER DETAIL FOR
CELL CONSTRUCTION
ABOVE HISTORICAL WASTE
NTS



TYPICAL UNDER LINER
DETAIL FOR BELOW GRADE
CONSTRUCTION
NTS

Drawing path: V:\1101\active\110128003\drafting\figures\current\figures.dwg Plotted: Wednesday, January 11, 2017 2:38:56 PM

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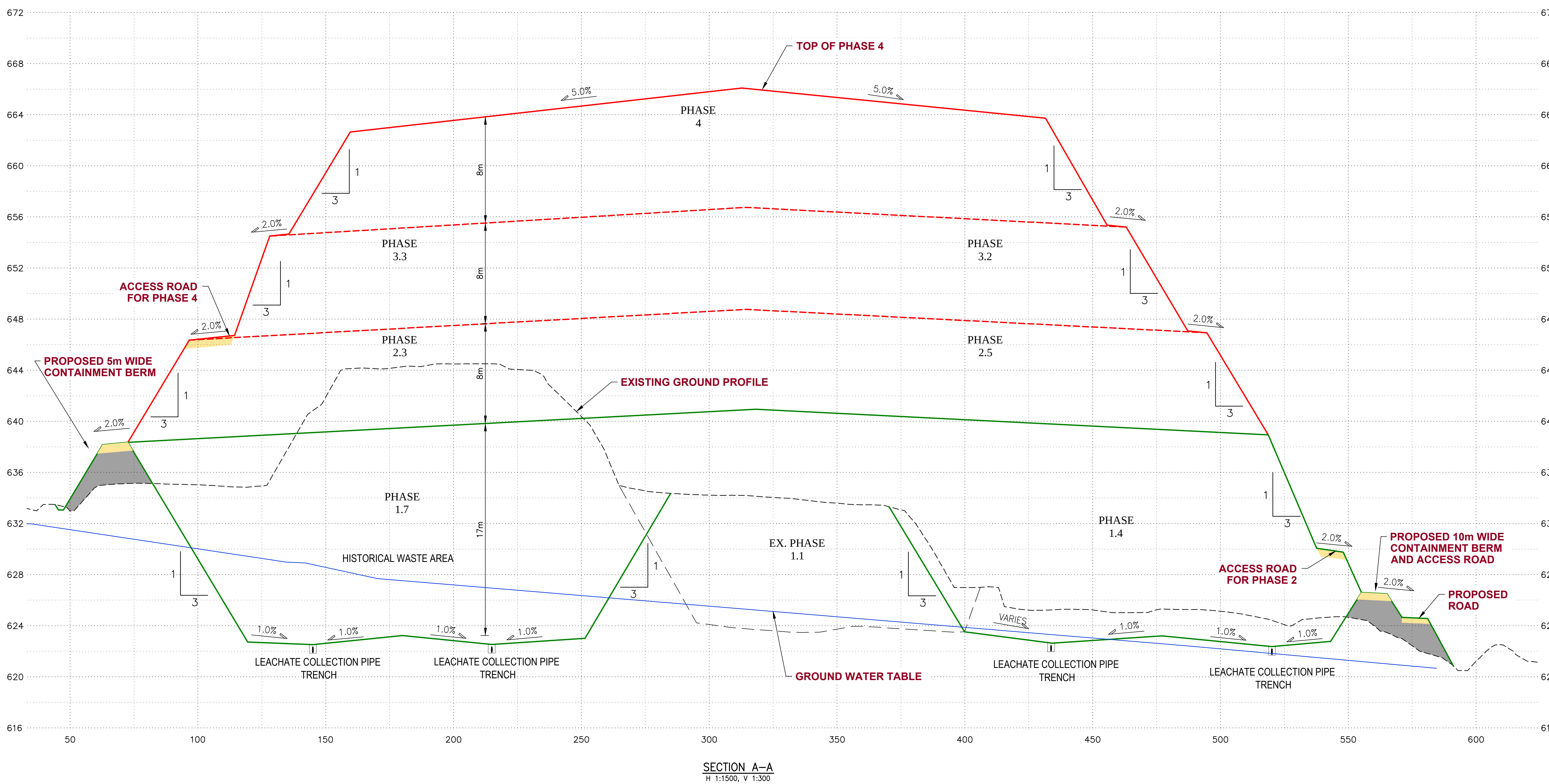
2016 WMF MASTER PLAN
STANDRAD DETAILS
DRAWING-07



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LANDFILL CONCEPTUAL PLAN
SECTION A-A

Drawn by:	Date:	Drawing #:
G	2017/01/11	FIG-08

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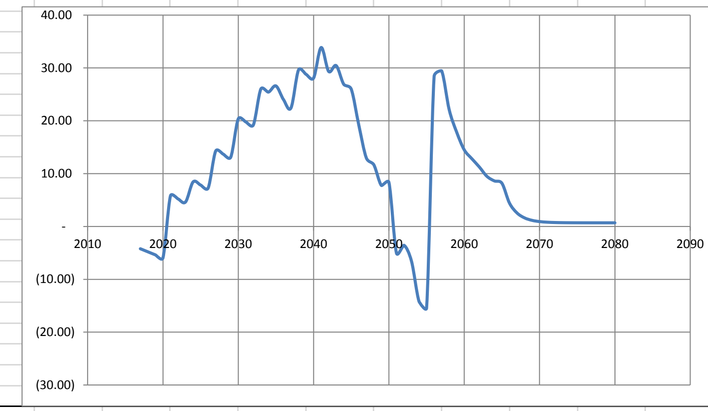
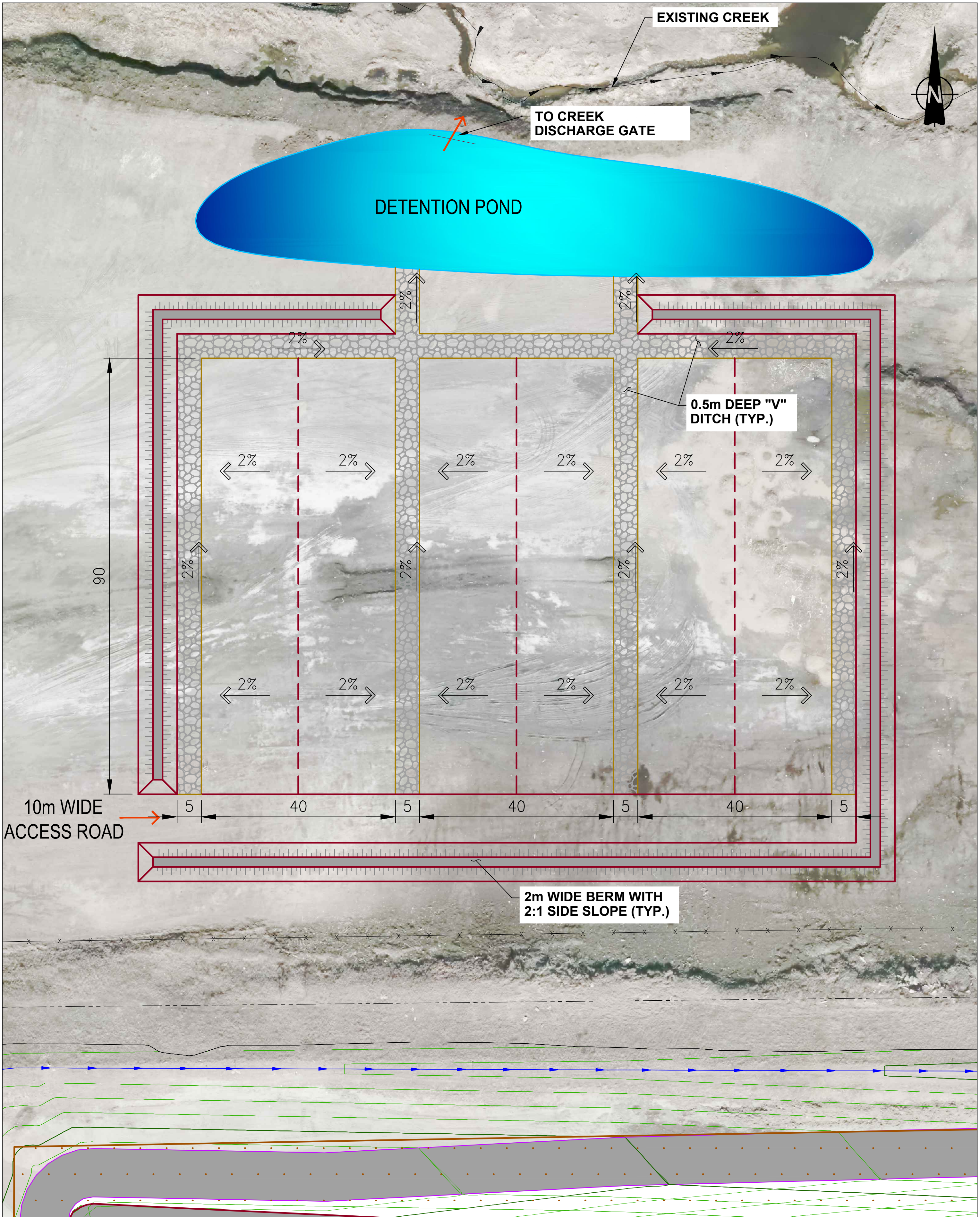
APPENDIX D
LEACHATE GENERATION ESTIMATE

Year	Waste disposed	Waste field capacity	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area
		Cell top Area (m2)	35,536		39,296		28,373		27,702		27,744		27,033		23,984		26,429	
		Phase	1.3		1.4		1.5		1.6		1.7		2.1		2.2		2.3	
	(tonnes)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)
2017	38063	9,516	1,756.45	6,220.78														
2018	38911	9,728	1,756.45	6,220.78														
2019	39760	9,940	1,756.45	6,220.78														
2020	40608	10,152	1,756.45	6,220.78														
2021	41457	10,364		3,659.28	1,942.30	6,878.98												
2022	42305	10,576		3,659.28	1,942.30	6,878.98												
2023	43154	10,788		3,659.28	1,942.30	6,878.98												
2024	44002	11,001		3,659.28		4,046.46	1,402.41	4,966.86										
2025	44851	11,213		3,659.28		4,046.46	1,402.41	4,966.86										
2026	45699	11,425		3,659.28		4,046.46	1,402.41	4,966.86										
2027	46548	11,637		3,659.28		4,046.46		2,921.68	1,369.26	4,849.46								
2028	47396	11,849		3,659.28		4,046.46		2,921.68	1,369.26	4,849.46								
2029	48245	12,061		3,659.28		4,046.46		2,921.68	1,369.26	4,849.46								
2030	49093	12,273		3,659.28		4,046.46		2,921.68		2,852.62	1,371.31	4,856.72						
2031	49942	12,485		3,659.28		4,046.46		2,921.68		2,852.62	1,371.31	4,856.72						
2032	50790	12,698		3,659.28		4,046.46		2,921.68		2,852.62	1,371.31	4,856.72						
2033	51639	12,910		3,659.28		4,046.46		2,921.68		2,852.62		2,856.90	1,336.19	4,732.33				
2034	52487	13,122		3,659.28		4,046.46		2,921.68		2,852.62		2,856.90	1,336.19	4,732.33				
2035	53336	13,334		3,659.28		4,046.46		1,460.84		2,852.62		2,856.90		2,783.72	1,185.48	4,198.58		
2036	54184	13,546		3,659.28		4,046.46		730.42		2,852.62		2,856.90		2,783.72	1,185.48	4,198.58		
2037	55033	13,758		3,659.28		4,046.46		365.21		2,852.62		2,856.90		2,783.72	1,185.48	4,198.58		
2038	55881	13,970		3,659.28		4,046.46		182.61		2,852.62		2,856.90		2,783.72		2,469.75	1,306.33	4,626.59
2039	56730	14,182		3,659.28		4,046.46		91.30		2,852.62		2,856.90		2,783.72		2,469.75	1,306.33	4,626.59
2040	57578	14,395		3,659.28		4,046.46		45.65		2,852.62		2,856.90		2,783.72		2,469.75	1,306.33	4,626.59
2041	58427	14,607		3,659.28		4,046.46		22.83		2,852.62		2,856.90		2,783.72		2,469.75		2,313.30
2042	59275	14,819		3,659.28		4,046.46		11.41		1,426.31		2,856.90		2,783.72		2,469.75		2,313.30
2043	60124	15,031		3,659.28		4,046.46		5.71		713.16		1,428.45		2,783.72		2,469.75		2,313.30
2044	60972	15,243		3,659.28		4,046.46		2.85		356.58		714.22		2,783.72		2,469.75		2,313.30
2045	61821	15,455		3,659.28		4,046.46		1.43		178.29		357.11		2,783.72		2,469.75		2,721.53
2046	62669	15,667		1,829.64		2,023.23		0.71		89.14		178.56		2,783.72		2,469.75		2,721.53
2047	63518	15,879		914.82		1,011.61		0.36		44.57		89.28		2,783.72		2,469.75		2,721.53
2048	64366	16,092		457.41		505.81		0.18		22.29		44.64		1,391.86		2,469.75		2,721.53
2049	65215	16,304		228.71		252.90		0.09		11.14		22.32		695.93		2,469.75		2,721.53
2050	66063	16,516		114.35		126.45		0.04		5.57		11.16		347.97		1,234.88		2,721.53
2051	66912	16,728		57.18		63.23		0.02		2.79		5.58		173.98		617.44		1,360.76
2052	67760	16,940		28.59		31.61		0.01		1.39		2.79		86.99		308.72		680.38
2053	68609	17,152		14.29		15.81		0.01		0.70		1.39		43.50		154.36		340.19
2054	69457	17,364		7.15		7.90		0.00		0.35		0.70		21.75		77.18		170.10
2055	70306	17,576		3.57		3.95		0.00		0.17		0.35		10.87		38.59		85.05
2056	PCC-1			1.79		1.98		0.00		0.09		0.17		5.44		19.29		42.52
2057	PCC-2			0.89		0.99		0.00		0.04		0.09		2.72		9.65		21.26
2058	PCC-3			0.45		0.49		0.00		0.02		0.04		1.36		4.82		10.63
2059	PCC-4			0.22		0.25		0.00		0.01		0.02		0.68		2.41		5.32
2060	PCC-5			0.11		0.12		0.00		0.01		0.01		0.34		1.21		2.66
2061	PCC-6			0.06		0.06		0.00		0.00		0.01		0.17		0.60		1.33
2062	PCC-7			0.03		0.03		0.00		0.00		0.00		0.08		0.30		0.66
2063	PCC-8			0.01		0.02		0.00		0.00		0.00		0.04		0.15		0.33
2064	PCC-9			0.01		0.01		0.00		0.00		0.00		0.02		0.08		0.17
2065	PCC-10			0.00		0.00		0.00		0.00		0.00		0.01		0.04		0.08
2066	PCC-11			0.00		0.00		0.00		0.00		0.00		0.01		0.02		0.04
2067	PCC-12			0.00		0.00		0.00		0.00		0.00		0.00		0.01		0.02
2068	PCC-13			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.01
2069	PCC-14			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.01
2070	PCC-15			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2071	PCC-16			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2072	PCC-17			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2073	PCC-18			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2074	PCC-19			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2075	PCC-20			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2076	PCC-21			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2077	PCC-22			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2078	PCC-23			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2079	PCC-24			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00
2080	PCC-25			0.00		0.00		0.00		0.00		0.00		0.00		0.00		0.00

Year	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Active area	Interim cover & open area	Surface infiltration	Quantity of Leachate generated	
Cell top Area (m2)	26,559		26,667		22,715		23,462		24,399		29,411		24,759		15,457		20,290		34,232		40,864		
Phase	2.4		2.5		3.1		3.2		3.3		3.4		4.1		4.2		4.3		4.4		Crest		
	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3)	(m3/year)	(m3/day)
2017																						(1,538.43)	(4.21)
2018																						(1,750.55)	(4.80)
2019																						(1,962.67)	(5.38)
2020																						(2,174.80)	(5.96)
2021																						2,116.40	5.80
2022																						1,904.28	5.22
2023																						1,692.15	4.64
2024																						3,074.47	8.42
2025																						2,862.35	7.84
2026																						2,650.23	7.26
2027																						5,209.23	14.27
2028																						4,997.11	13.69
2029																						4,784.98	13.11
2030																						7,434.80	20.37
2031																						7,222.67	19.79
2032																						7,010.55	19.21
2033																						9,495.81	26.02
2034																						9,283.68	25.43
2035																						9,709.98	26.60
2036																						8,767.44	24.02
2037																						8,190.10	22.44
2038																						10,813.99	29.63
2039																						10,510.57	28.80
2040																						10,252.79	28.09
2041	1,312.76	4,649.35																				12,360.32	33.86
2042	1,312.76	4,649.35																				10,710.48	29.34
2043		2,734.91	1,318.10	4,668.26																		11,110.20	30.44
2044		2,734.91	1,318.10	4,668.26																		9,824.42	26.92
2045		2,734.91	1,318.10	4,668.26																		9,483.70	25.98
2046		2,734.91		2,746.03	1,122.76	3,976.43																7,009.16	19.20
2047		2,734.91		2,746.03	1,122.76	3,976.43																4,736.39	12.98
2048		2,734.91		2,746.03		1,988.22	1,159.68	4,107.20														4,257.99	11.67
2049		2,734.91		2,746.03		1,988.22	1,159.68	4,107.20														2,834.78	7.77
2050		2,734.91		2,746.03		1,988.22		2,053.60	1,205.99	4,271.23												3,046.17	8.35
2051		1,367.46		1,373.02		2,339.08		2,053.60	1,205.99	4,271.23												(1,836.54)	(5.03)
2052		683.73		686.51		2,339.08		2,053.60		2,135.61	1,453.73	5,148.62										(1,298.65)	(3.56)
2053		341.86		343.25		2,339.08		2,416.00		2,135.61	1,453.73	5,148.62										(2,403.73)	(6.59)
2054		170.93		171.63		2,339.08		2,416.00		2,135.61		2,574.31	1,223.79	866.85								(5,180.94)	(14.19)
2055		85.47		85.81		2,339.08		2,416.00		2,135.61		2,574.31		866.85	764.01	541.17						(5,625.51)	(15.41)
2056		42.73		42.91		1,169.54		1,208.00		2,135.61		2,574.31	-	866.85		541.17	1,002.89	710.38				10,365.68	28.40
2057		21.37		21.45		584.77		604.00		2,135.61		2,574.31		866.85		541.17		710.38	1,692.02	710.38	252.48	10,750.44	29.45
2058		10.68		10.73		292.38		302.00		2,135.61		2,574.31		866.85		541.17		710.38		355.19	252.48	8,069.61	22.11
2059		5.34		5.36		146.19		151.00		1,067.81		2,574.31		866.85		541.17		710.38		177.60	252.48	6,507.40	17.83
2060		2.67		2.68		73.10		75.50		533.90		2,574.31		433.42		541.17		710.38		88.80	252.48	5,292.87	14.50
2061		1.34		1.34		36.55		37.75		266.95		2,574.31		216.71		541.17		710.38		44.40	252.48	4,685.61	12.84
2062		0.67		0.67		18.27		18.87		133.48		2,574.31		108.36		270.59		710.38		22.20	252.48	4,111.39	11.26
2063		0.33		0.34		9.14		9.44		66.74		2,574.31		54.18		135.29		355.19		11.10	252.48	3,469.09	9.50
2064		0.17		0.17		4.57		4.72		33.37		2,574.31		27.09		67.65		177.60		5.55	252.48	3,147.94	8.62
2065		0.08		0.08		2.28		2.36		16.68		2,574.31		13.54		33.82		88.80		2.77	252.48	2,987.36	8.18
2066		0.04		0.04		1.14		1.18		8.34		1,287.15		6.77		16.91		44.40		1.39	252.48	1,619.92	4.44
2067		0.02		0.02		0.57		0.59		4.17		643.58		3.39		8.46		22.20		0.69	252.48	936.20	2.56
2068		0.01		0.01		0.29		0.29		2.09		321.79		1.69		4.23		11.10		0.35	252.48	594.34	1.63
2069		0.01		0.01		0.14		0.15		1.04		160.89		0.85		2.11		5.55		0.17	252.48	423.41	1.16
2070		0.00		0.00		0.07		0.07		0.52		80.45		0.42		1.06		2.77		0.09	252.48	337.94	0.93
2071		0.00		0.00		0.04		0.04		0.26		40.22		0.21		0.53		1.39		0.04	252.48	295.21	0.81
2072		0.00		0.00		0.02		0.02		0.13		20.11		0.11		0.26		0.69		0.02	252.48	273.84	0.75
2073		0.00		0.00		0.01		0.01		0.07		10.06		0.05		0.13		0.35		0.01	252.48	263.16	0.72
2074		0.00		0.00		0.00		0.00		0.03		5.03		0.03		0.07		0.17		0.01	252.48	257.82	0.71
2075		0.00		0.00		0.00		0.00		0.02		2.51		0.01		0.03		0.09		0.00	252.48	255.15	0.70
2076		0.00		0.00		0.00		0.00		0.01		1.26		0.01		0.02		0.04		0.00	252.48	253.81	0.70
2077		0.00		0.00		0.00		0.00		0.00		0.63		0.00		0.01		0.02		0.00	252.48	253.15	0.69
2078		0.00		0.00		0.00		0.00		0.00		0.31		0.00		0.00		0.01		0.00	252.48	252.81	0.69
2079		0.00		0.00		0.00		0.00		0.00		0.16		0.00		0.00		0.01		0.00	252.48	252.65	0.69
2080		0.00		0.00		0.00		0.00		0.00		0.08		0.00		0.00		0.00		0.00	252.48	252.56	0.69



APPENDIX E
PRELIMINARY CONCEPT SNOW DISPOSAL AREA



PROPOSED PRELIMINARY CONCEPT PLAN FOR SNOW DISPOSAL AREA

NOTE: ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE NOTED.

APPENDIX F
DETAILS OF AIRSPACE CONSUMPTION

Vertical Expansion by landfill mining of historical waste i.e. underliner system

Year	Population (derived from Census data)	Waste quantity requiring landfilling	Assumed Qty. of historical waste re-disposed i/c daily cover	Annual airspace consumption for new waste i/c daily cover	PHASE 1					PHASE 2					PHASE 3	PHASE 4
					1.3	1.4	1.5	1.6	1.7	2.1	2.2	2.3	2.4	2.5	3	4
		(m3)	(m3)	(m3)	443,324	490,230	353,963	345,597	426,340	298,540	302,887	308,500	298,050	306,462	1,036,334	650,059
2017	33442	76125		76,125	367,199											
2018	34257	77822	41053	118,875	248,323											
2019	35071	79519	41053	120,572	127,751											
2020	35885	81216	41053	122,269	5,481											
2021	36699	82913	41053	123,966	-	371,745										
2022	37514	84610	41053	125,663	-	246,082										
2023	38328	86307	41053	127,360	-	118,721										
2024	39142	88004	41053	129,057	-	-	343,627									
2025	39956	89701	41053	130,754	-	-	212,872									
2026	40770	91398	41053	132,451	-	-	80,421									
2027	41585	93095	41053	134,148	-	-	-	291,869								
2028	42399	94792	41053	135,845	-	-	-	156,024								
2029	43213	96489	41053	137,542	-	-	-	18,482								
2030	44027	98186	41053	139,239	-	-	-	-	305,582							
2031	44842	99883	41053	140,936	-	-	-	-	164,646							
2032	45656	101580	41053	142,633	-	-	-	-	22,013							
2033	46470	103277	41053	144,330	-	-	-	-	-	176,222						
2034	47284	104974		104,974	-	-	-	-	-	71,248						
2035	48098	106671		106,671	-	-	-	-	-	-	267,464					
2036	48913	108368		108,368	-	-	-	-	-	-	159,096			MASTER PLAN PERIOD		
2037	49727	110065		110,065				-	-	-	49,031					
2038	50541	111762		111,762	-	-	-	-	-	-	-	245,768				
2039	51355	113459		113,459	-	-	-	-	-	-	-	132,309				
2040	52170	115156		115,156	-	-	-	-	-	-	-	17,153				
2041	52984	116853		116,853	-	-	-	-	-	-	-	-	198,350			
2042	53798	118550		118,550	-	-	-	-	-	-	-	-	79,800			
2043	54612	120247		120,247	-	-	-	-	-	-	-	-	-	266,015		
2044	55426	121944		121,944	-	-	-	-	-	-	-	-	-	144,071		
2045	56241	123641		123,641	-	-	-	-	-	-	-	-	-	20,430		
2046	57055	125338		125,338	-	-	-	-	-	-	-	-	-	-	931,426	
2047	57869	127035		127,035	-	-	-	-	-	-	-	-	-	-	804,391	
2048	58683	128732		128,732	-	-	-	-	-	-	-	-	-	-	675,658	
2049	59498	130429		130,429	-	-	-	-	-	-	-	-	-	-	545,229	
2050	60312	132126		132,126	-	-	-	-	-	-	-	-	-	-	413,103	
2051	61126	133823		133,823	-	-	-	-	-	-	-	-	-	-	279,280	
2052	61940	135520		135,520	-	-	-	-	-	-	-	-	-	-	143,760	
2053	62754	137217		137,217	-	-	-	-	-	-	-	-	-	-	-	656,602
2054	63569	138914		138,914	-	-	-	-	-	-	-	-	-	-	-	517,688
2055	64383	140611		140,611	-	-	-	-	-	-	-	-	-	-	-	377,077

Vertical Expansion above the existing historical waste i.e. Overliner System

Year	Population (derived from Census data)	Annual Waste quantity requiring landfilling	PHASE 1		PHASE 2					PHASE 3	PHASE 4
			1.3	1.4	2.1	2.2	2.3	2.4	2.5	3	4
		(m3)	443,324	490,230	298,540	302,887	308,500	298,050	306,462	1,036,334	650,059
2017	33442	76125	367,199								
2018	34257	77822	289,376								
2019	35071	79519	209,857								
2020	35885	81216	128,641								
2021	36699	82913	45,728								
2022	37514	84610		451,348							
2023	38328	86307	-	365,040							
2024	39142	88004	-	277,036							
2025	39956	89701	-	187,335							
2026	40770	91398	-	95,937							
2027	41585	93095	-	2,841							
2028	42399	94792	-		206,589						
2029	43213	96489	-		110,100						
2030	44027	98186	-	-	11,914						
2031	44842	99883	-	-		214,918					
2032	45656	101580	-	-		113,338					
2033	46470	103277	-	-		10,060					
2034	47284	104974	-	-			213,586				
2035	48098	106671	-	-			106,915				
2036	48913	108368	-	-				296,597	MASTER PLAN PERIOD		
2037	49727	110065						186,532			
2038	50541	111762	-	-				74,770			
2039	51355	113459	-	-					267,773		
2040	52170	115156	-	-					152,616		
2041	52984	116853	-	-					35,763		
2042	53798	118550	-	-						953,547	
2043	54612	120247	-	-						833,300	
2044	55426	121944	-	-						711,356	
2045	56241	123641	-	-						587,715	
2046	57055	125338	-	-						462,377	
2047	57869	127035	-	-						335,342	
2048	58683	128732	-	-						206,610	
2049	59498	130429	-	-						76,181	
2050	60312	132126	-	-							594,114
2051	61126	133823	-	-							460,290
2052	61940	135520	-	-							324,770
2053	62754	137217	-	-							187,553
2054	63569	138914	-	-							48,639
2055	64383	140611	-	-							(91,972)

APPENDIX G
BREAKDOWN OF ANNUAL SOIL REQUIREMENT FOR THE MASTER PLAN PERIOD

	Plan Year 2017-2021					Plan Year 2022-2026					Plan Year 2027-2031					Plan Year 2032-2036				
	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Soil Opening Balance (m3)	**229,500**	**144,275**	**103,710**	**72,807**	**56,563**	**39,981**	**(6,941)**	**(24,203)**	**(41,804)**	**(59,744)**	**(78,023)**	**(103,643)**	**(142,601)**	**(161,899)**	**(181,536)**	**(229,513)**	**(249,829)**	**(270,484)**	**(318,479)**	**(339,813)**
Annual Daily cover (m3)	(15,225)	(15,564)	(15,904)	(16,243)	(16,583)	(16,922)	(17,261)	(17,601)	(17,940)	(18,280)	(18,619)	(18,958)	(19,298)	(19,637)	(19,977)	(20,316)	(20,655)	(20,995)	(21,334)	(21,674)
Soil required for re-grading facility entrance	-20000																			
Soil required for perimeter access road construction	-20000	-15000	-15000																	
Cell Berm construction (1.3, 1.4, 2.1, 2.2, 2.3)	-20000					-20000						-20000			-20000			-20000		
Interim closure (Phases 1.2, 1.3, 1.4, 2.1, 2.2)		-10000				-10000					-7000				-8000			-7000		
Soil required for Wet cell 2 soil protection layer	-10000																			
Soil Closing Balance (m3)	144,275	103,710	72,807	56,563	39,981	(6,941)	(24,203)	(41,804)	(59,744)	(78,023)	(103,643)	(142,601)	(161,899)	(181,536)	(229,513)	(249,829)	(270,484)	(318,479)	(339,813)	(361,487)
Soil Deficit (m3)	0	0	0	0	0	6941.2945	24202.739	41,804	59,744	78,023	103,643	142,601	161,899	181,536	229,513	249,829	270,484	318,479	339,813	361,487
Annual Soil Requirement (m3)	**0**	**0**	**0**	**0**	**0**	**6941**	**17261**	**17,601**	**17,940**	**18,280**	**25,619**	**38,958**	**19,298**	**19,637**	**47,977**	**20,316**	**20,655**	**47,995**	**21,334**	**21,674**

NOTES: 1. Soil Opening balance in 2017 includes 75,000 m3 stockpiled west of Phase 1.1/1.2 & 154,500 m3 stockpiled near the Impacted soil management area

2. It is assumed that the stockpiled material is suitable for the intended use shown in the table or it can me made suitable through soil strengthening techniques

3. The quantities shown are approximate