SITE DEVELOPMENT PLAN

Coffin Butte Landfill
Benton County, Oregon

Submitted to

Valley Landfills, Inc.
28972 Coffin Butte Road
Corvallis, Oregon 97330

Prepared by

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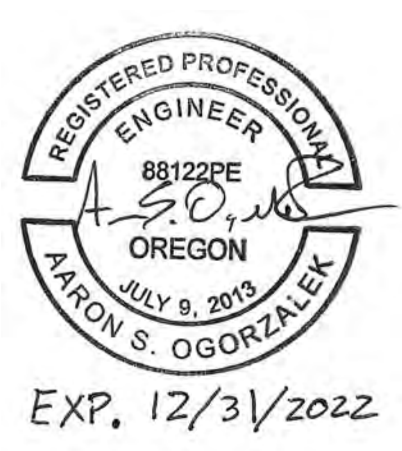
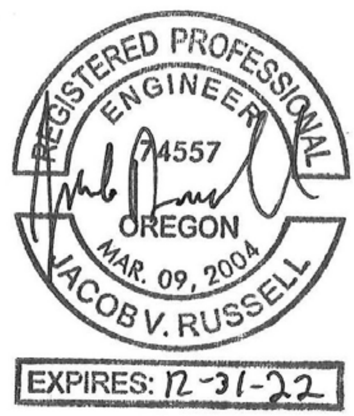
Certification

This Site Development Plan was prepared in accordance with generally accepted professional engineering principles and practices. This Site Development Plan makes no other warranties, either expressed or implied as to the professional advice or data included in it. This Site Development Plan has not been prepared for use by parties or projects other than those named or described herein. It may not contain sufficient information for other parties or purposes.

GEO-LOGIC ASSOCIATES





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1. Introduction

1.1 Purpose and Scope

This Site Development Plan (SDP) was prepared for the Coffin Butte Landfill (CBL) located in Corvallis, Oregon. This SDP was prepared as part of the CBL's Solid Waste Permit renewal issuance dated July 28, 2020 in accordance with Oregon Administrative Rules (OAR) Chapter 340, Division 094 (OAR 340-094) and 40 Code of Federal Regulations (CFR), Part 258, and is a submittal to the Oregon Department of Environmental Quality (ODEQ). This SDP is to be submitted within 360 days from the permit issuance date. ODEQ approved an extension with a due date of December 31, 2021.

1.2 Site Description

The CBL is located in Benton County, Oregon, approximately 10 miles north of the city of Corvallis. The CBL is owned and operated by Valley Landfills, Inc. (VLI), a subsidiary of Republic Services, Inc. (RSI). The CBL is an active municipal solid waste landfill (MSWLF) operating under ODEQ Solid Waste Permit No. 306. The site address is 28972 Coffin Butte Road, Corvallis, Oregon. The permitted landfill site encompasses approximately 178.1 acres inside the site's landfill zoning boundary. To date, the developed landfill footprint consists of approximately 123.5 acres. Of that 123.5 acres, approximately 41.7 acres have already received final closure. The permitted landfill footprint, existing and future cell boundaries, areas with final cover, and general site layout are shown in Drawing G02 in Appendix A.

1.3 Background

The most recent SDP was authored by Ausenco Vector (2011) and was amended by Thiel Engineering (2013). The 2011 SDP and 2013 Amendment divided the landfill into six major cells, as shown in Drawing G02 in Appendix A. The landfill footprint was slightly reduced in the 2013 Amendment due to slope stability considerations that were identified in the Cell 5 area of the 2011 SDP. To date, landfill development has consisted of Cells 1 through Cell 5D. Cell 5E and Cell 6 are future cells and are the focus of this SDP. Future Cell 6 will be in the area of the existing on-site quarry that is leased to and operated by Knife River Corporation (Knife River). Past SDPs depicted Cell 6 with a near-vertical quarry wall liner system and did not go into phasing details of Cell 6. This SDP update incorporates a phased design that reduces the lined landfill slopes to 1:1 (horizontal: vertical) in the existing quarry/Cell 6 area.

Organization of this SDP follows the latest version of ODEQ's *Solid Waste Landfill Guidance* document (https://www.oregon.gov/deq).

2. Facility Operations

2.1 Facility Operations

General facility operations have been previously described in the Operations Plan (GLA, 2020a) and the Operations and Maintenance Manual (GLA, 2020b). These documents were recently updated as part of the permit renewal associated with this SDP update. This section provides an overview of the information previously published, updated as appropriate.

The VLI land ownership around the CBL encompassing facility operations and waste placement areas can be seen in Drawing G02 in Appendix A. General facility operations consist of solid waste disposal operations, monitoring, maintenance, and management of leachate collection and removal systems, landfill gas collection systems, and stormwater management infrastructure, ancillary operations, and environmental monitoring operations.

2.2 Capacity and Projected Life

Site life calculations were performed for the CBL to estimate the overall life span of the landfill and the general schedule required for construction of the major individual phases. The site life calculations were based on (1) the volumetric capacities of the phases as shown on the SDP drawings in Appendix A, (2) an operational density of 1,600 lbs/cy, (3) a soil to waste ratio of 15% (for daily cover), and (4) an incoming tonnage of 2,959 tons per day (projected average daily tonnage). The capacity of each phase was volumetrically calculated from the top of waste design grades to the design liner grade using AutoCAD Civil 3D software. The volume of soil for the operations layer was subtracted from the gross air space. Supporting documentation for the site life calculations is presented in Appendix B.

The net available airspace volume available for disposal in Cell 5D/5E and Cells 6A – 6I, as of the March 30, 2021 topographical map, totals approximately 18,645,000 cy. For the purposes of this report, airspace is defined as the volume available for waste, daily cover, and interim cover. Soil for daily and intermediate cover is estimated to consume approximately 2,797,000 cy of this volume, with an assumed soil to waste ratio of 15% by volume. Using the above stated parameters, the current fill area was calculated to reach final grades during the middle of the year 2039. Table 1 summarizes the site life projections for the landfill.

Table 1

Site Life Projection

	Plan View Footprint (Acres)	Capacity (CY)	Cumulative Capacity (CY)	Total Life of Cell (Years)	Year Capacity is Reached
Cell 5D/5E	6.1[1]	4,834,330	4,834,330	4	2025
Cell 6A	19.8	1,482,260	6,316,590	1	2026
Cell 6B	11.3	1,029,430	7,346,020	1	2027
Cell 6C	4.3	1,742,130	9,088,150	2	2029
Cell 6D	11.0	1,859,820	10,947,970	2	2031
Cell 6E	3.9	1,078,420	12,026,390	1	2032
Cell 6F	5.1	1,686,070	13,712,460	2	2034
Cell 6G	2.4	2,015,260	15,727,720	2	2036
Cell 6H	1.1	1,295,450	17,023,170	1	2037
Cell 6I	1.2	1,622,130	18,645,300	2	2039

Notes: 1 – Cell 5 consists of Cells 5A through Cell 5E. Cell 5A through 5C are currently lined and accepting waste. Cell 5D (3.5 acres) was lined during 2021 and is awaiting approval for waste acceptance to begin in 2022. Cell 5E (2.6 acres) is planned to be lined in 2023. The plan view footprint presented in this table represents the areas of Cells 5D and 5E.

2.3 Population and Industry Served

At present, the landfill serves primarily the counties shown in Table 2. In addition, some amounts of overflow waste come to the landfill from Lane and Marion Counties. Future sources of waste are susceptible to change. The major industries served by the landfill consist of forest products, mobile home manufacturers, and the electronics industry.

Table 2

Principle Counties and Populations Served

Geographic Area Served	Estimated Population[1]
Benton County	92,100
Linn County	127,300
Polk County	85,200
Lincoln County	49,400
Tillamook County	26,800

[1] – Based on 2018 Census Data

2.4 Rate of Waste Disposal

The most recent estimate of the annual rate of disposal at the site based on the last two aerial topographic surveys (from April 7, 2020 to March 30, 2021) was approximately 869,343 tons. Historic waste flows have generally been lower because during the past 1-2 years the CBL has seen additional tonnage from outside its usual waste streams. Planned annual baseline tonnage is approximately 800,000 tons/year. Average daily rates of waste disposal are on the order of 3,200 tons per day, although peak daily flows can be double that amount.

2.5 Overall Description of Operation

The following bullets provide a broad-sweeping description of the site operation:

- Waste is delivered to the site by both commercial haulers and the general public. The landfill is open from 5 a.m. to 5 p.m. Monday through Friday, and 8 a.m. to 5 p.m. on Saturday. The landfill is closed to the public on Sundays and posted major holidays. Hour of operation may be adjusted based on the needs of customers.
- The waste haulers must stop at the gatehouse, and the loads are weighed for payment purposes. The cashier records the type and amount of waste, and origin.
- The waste is tipped by the hauler off of a prepared rock pad onto the tipping area. The landfill provides spotters to check for unacceptable waste and to assist with waste tipping as needed. The tipped waste is pushed away to the active working face by a D-9 dozer or a compactor. Two compactors currently work on the landfill to compact the waste.
- Waste haul vehicles return to the scales to obtain the net waste weight.

- Daily cover is applied in the form of soil or approved alternative daily cover (ADC).
- Interim soil cover, approximately 12 inches thick, is placed over waste areas that will not receive waste for more than about 3 months. A reinforced plastic cover is placed over these areas to minimize rainwater infiltration.

2.6 Site Economic Viability

The site's economic viability has been established by its long history and the growing demand for solid waste disposal in Benton County and in Oregon.

2.7 Site Screening

The active landfill area is screened from public view to the extent practicable by trees, stockpiled cover material, earthen berms, and strategic filling behind previously filled areas.

2.8 Planned Future Use

The planned end use of the facility is to convert the landfill to a grassy hillside with no further development.

2.9 Waste Stream Types

The estimated types and quantities of waste received in 2019 are presented in Table 3.

Table 3

Estimated Annual Quantities and Types of Waste Received

Waste Stream Type	Annual Quantity (Tons)[1]
Municipal Solid Waste	775,900
Commercial and Industrial Waste	204,200
C&D Waste	28,700
Petroleum Contaminated Soils	24,800
Asbestos	1,300
Total	1,034,900

[1] – Based on 2019 Site Data

Note that approximately 250,000 tons of MSW was diverted from the nearby Riverbend Landfill during 2019. This source of waste is no longer being received at the CBL; therefore, MSW tonnage and total tonnage are estimated to be approximately 250,000 tons lower than these reported values in the near term.

2.10 Acceptance of Industrial Wastes

The major types of industrial wastes accepted at the CBL are listed in Table 4 according to Standard Industrial Classification (SIC) code.

Table 4

Types of Industrial Waste Streams by SIC Code

Waste Stream Type
Manufactured Mobile Homes – SIC 2451
Hard Board – SIC 2493
Papermill – SIC 2621
Glass Fiber – SIC 3296
Metal Refining – SIC 3339
Manufactured Motor Homes – SIC 3617
Circuit Boards – SIC 3672

2.11 Regional Facility

The CBL is a regional facility. Some general facts related to the Solid Waste Guidance Document outline are:

- A local citizen's solid waste advisory committee has been active for several years.
- The only entities that bring more than 75,000 tons per year to the landfill are waste collection and hauling franchises. These commercial haulers have established waste recycling programs. There is no single waste generator that generates this amount of waste that would be the subject of a specific waste reduction program. During 2020, the Linn County, Benton County, Marion County, Lincoln County, and Washington County waste sheds generated more than 75,000 tons of waste annually that was sent to the landfill. This is discussed in Section 9.2.
- The county and state of waste origin is tracked at the gatehouse when the waste enters the site.

3. Phased Development of Landfill Facilities

This chapter describes the phased development of the landfill. The description begins with a discussion of the general criteria and constraints that govern the landfill development. This is followed by descriptions of the cell sequencing, filling, and closure stages that are currently envisioned for the site as the land is zoned today. The chapter closes with a discussion of the site soil balance, and future earthwork soils needs.

3.1 Design Criteria

This section presents the basis and assumptions used to establish the landfill's footprint boundary, overall configuration, capacity, and location.

3.1.1 Regulatory Standards for Location, Design, and Operation

The CBL is a municipal solid waste landfill. As such, the criteria for its location, design, and operation are prescribed by the United States Environmental Protection Agency in Title 40 CFR Part 258. The State of Oregon has become an "approved state" under these rules, and has codified its implementation of these rules under the Oregon Administrative Rules (OAR), and in particular OAR 340-094.

3.1.1.1 Location Restrictions

A brief description of the locational criteria contained in 40 CFR Part 258, Subpart B and OAR 340-094-0030 as they apply to the CBL is as follows:

- Airport Safety. The landfill is not located within 10,000 feet of any airports.
- Floodplains. The landfill is not located in a 100-year floodplain.
- Wetlands. Approval for filling limited areas of wetlands on the site has been applied for to the Oregon Division of State Lands and the US Army Corps of Engineers. Section 9.3 contains additional details on this subject.
- Fault Areas. No known Holocene faults exist within 200 feet of the landfill boundary.
- Seismic Impact Zones. Landfill cells have been, and will continue to be, designed for potential seismic events as described in the rules.

- Unstable Areas. No unusual unstable areas or foundation conditions are known to exist that adversely impact landfill development. Detailed geotechnical evaluations are routinely conducted as part of each new cell development.
- Endangered Species. No endangered species are known to be impacted by the landfill site location.
- Sensitive Hydrogeologic Environments. The landfill is not known to exist in a sensitive hydrogeologic environment.

3.1.1.2 Operating Criteria

Operating criteria for the CBL is outlined in 40 CFR Part 258, Subpart C and in OAR 340-094-0040. The operating procedures for the landfill are consistent with past permit applications and are most recently documented in the Operations Plan (GLA, 2020a) and the Operations and Maintenance Manual (GLA, 2020b).

3.1.1.3 Design Criteria

Design criteria for the CBL is outlined in 40 CFR Part 258, Subpart D and in OAR 340-094-0060. The general liner system design is consistent with that of past permit applications. Design criteria for future phased developments associated with this Plan are described in Sections 3, 4, 5, and 6.

3.1.2 Waste Stream Characteristics and Processing

The waste stream is municipal solid waste, of the quantities and origins described in Section 1. There is no special waste processing that occurs when the waste arrives at the site. This type of waste does not have an explicit impact on the phased development of the site, other than those already embodied in the regulations such as leachate and gas control.

3.1.3 Land Use, Zoning, and Buffer Zone Requirements

The landfill is entirely in Landfill Site (LS) Zone in Benton County. This zoning allows quarrying and landfilling. The boundaries of LS zoning are the primary constraint on the limit of the landfill, as discussed near the beginning of this section. There are no buffer or setback requirements. Landfill zoning boundaries are shown in Drawing G03 in Appendix A.

3.1.4 Site Physical Characteristics and Surface Drainage Patterns

The landfill is essentially a side-hill fill into and against a natural outcropping rock butte. Some amount of run-on onto the landfill comes from the butte area above the landfill. Most of the surface water management at the site is related to runoff from the landfill surface.

The run-on water above the landfill must be managed to flow around the landfill by gravity. This requirement introduces two constraints relative to the limit of landfill development to the north. First, adequate room must be maintained between the edge of the landfill and the property line to allow construction and maintenance of a stormwater run-on ditch. Second, the upper limit of Cell 5 was, in a previous SDP, restricted by an inside-corner boundary on the zoning line on the west side of Cell 5. The elevation of the land at the location of this inside corner controls how high up the butte Cell 5 can be developed to allow gravity-drainage of stormwater to the east. Since the Year 2000 SDP, the landfill has been permitted to allow for the use of two areas, referred to as the West and East Triangles (shown on Drawing G03 in Appendix A). The inclusion of these areas allows for the landfill to continue higher up the butte while maintaining positive surface water drainage. The northern landfill boundary (i.e., Cells 5 and 6) associated with this SDP update is consistent with that of the most recent SDP presented by Thiel Engineering (2013).

Runoff from the site flows down to the perimeter of the landfill. Cell 1, a portion of Cell 3, a portion of Cell 5, and areas west of Cell 1 drain to the west towards Soap Creek. Areas east of Cell 1 drain to the east, through Toketie Marsh, and eastward from there to an unnamed tributary of the Luckiamute River. Surface drainage patterns are further discussed in Section 5.

3.1.5 Slope Limitations

There are no explicit limitations on the bottom liner slopes. They may range from 1%, to 1:1 in the quarry areas. On a broader basis, the combination of bottom liner and cover slope geometry, and height, will affect the overall static and seismic stability of the landfill. These have been, and will continue to be, checked in detail for acceptable factors of safety for slope stability for each new cell construction. The maximum outer slope allowed by state regulation is 3(H):1(V).

Previous slope stability studies were performed for the overall landfill development as part of the design for Cell 2 (EMCON, 1995a), Cell 3A (Thiel Engineering, 1999), Cells 4 and 5 (Ausenco Vector, 2011), and the revised Cell 5 design (Thiel Engineering, 2013). Additional stability analyses were performed for the final build-out presented in this SDP to account for the addition of future Cell 6 (West Quarry Area), and upgraded standards for seismic design parameters. The results of these analyses are presented in Appendix C.

3.1.6 Support Facilities and Utilities

There are several support facilities and utilities crucial to landfill operations. None of these facilities constrains the future landfill development proposed in this Plan. A brief list and function of these facilities follows. Many of these features are shown on Drawing G02 in Appendix A.

- Gas-to-energy (GTE) plant. The gas plant is owned by a third party, Pacific Northwest Generating Cooperative (PNGC), and is the chief means by which the site's landfill gas is disposed. There are also two auxiliary flares next to the plant to burn surplus gas. The plant is located on the south side of Coffin Butte Road, outside the limits of future landfill expansion. The gas is brought to the plant from the landfill by a series of gas wells, lateral pipes, and header pipes. A blower at the gas plant provides the suction to draw the gas from the landfill to the plant. Currently the plant generates approximately 5.6 megawatts of electricity. PNGC may expand the plant as the landfill size increases.
- Leachate storage facility. This facility is located on the south side of Coffin Butte Road, directly across from Cell 3. This facility includes a 4-million-gallon leachate holding pond (West Leachate Pond), and a 5-million-gallon leachate holding pond (East Leachate Pond). This facility is located within the LS zone on the south side of the road, and does not constrain any of the development shown in this plan. Leachate is disposed of by hauling to off-site waste water treatment facilities.
- Site electric power and telephone service is currently drawn mostly from lines originating near Highway 99W, except for the office and the Cell 1 sump, which draw from the west.
- The landfill scale-house is located on the east side of the Cell 5 footprint on the main customer entrance road.
- The rock quarry operator has its own scale-house at the west end of the site next to Cell 1A.
- The landfill site administrative and operations office is located on the south side of Coffin Butte Road, across from the boundary between Cells 1 and 3.
- Potable water is provided by groundwater wells for the gatehouse and office.

- For sewage and septic wastewater, the office is served by its own leach field, and the gas plant, the gate-house, the leachate treatment plant, and the quarry scale-house are served by holding tanks.

3.1.7 Transportation and Access Patterns

All traffic for the landfill and rock quarry approach the site from the east on Coffin Butte Road. Turn lanes and drainage improvements were funded by the landfill, and constructed by the State of Oregon, at the turnoff from Highway 99W to improve traffic patterns at this intersection. There is almost no traffic from the west because the bridge over Soap Creek is closed.

For the landfill, there is one customer entrance, three construction gates (labelled A, B, and C), and access available through the quarry gate at the west end of the site. Customer traffic enters at the entrance from the east, checks in at the scale-house, and drives on to the tipping area. Signs and spotters direct customers exactly where to tip. The alignment of the current and future haul roads from the scale-house is shown on the phased development drawings discussed in Section 3.2.

3.1.8 Geotechnical and Hydrogeologic Constraints

The site is founded on a firm, competent geologic formation comprised of fresh basalt, weathered basalt, and some thin veneers of alluvium in the flatter areas away from the butte. The only geotechnical constraints provided by the site are global slope stability issues driven by the relative geometries of the bottom liner system, and the height and slope of the final landfill.

The site hydrogeology is discussed later in the report. There are no development constraints related to groundwater, although the presence of high groundwater has influenced the design such that continuous underdrains are included below the landfill cell liner systems.

3.1.9 End Use Alternatives

The proposed end use for the closed landfill is a grassy hill slope with no other development or activities, other than maintenance. This type of end use does not constrain its development.

3.2 Facility Development Drawings

The phased development, cross sections, and details of the landfill from the current Cell 5D through the future Cell 6 is presented in Appendix A. The content of these drawings is summarized as follows:

- Drawing G02 shows the existing site conditions, site ancillary facilities, utilities, and wells that are not repeated on other drawings. Specific features as they exist at the time of this plan preparation are shown on Drawing G02. They include:
  - Property line, zoning lines, current landfill footprint, status of existing landfill cell areas, and future landfill footprint
  - Groundwater, gas, and surface water monitoring probes
  - Landfill fencing, gates, and entrance road
  - Public drop-off locations for recyclable and bulky items
  - Leachate ponds
  - Asbestos disposal area
  - Landfill office
  - Rock quarry entrance road and scale-house
  - Major stormwater flow lines and sedimentation pond
- Drawing G03 shows landfill zoning designations and boundaries.
- Drawings C01-C11 present the cell-by-cell development and fill sequencing that is expected to occur through the life of the current proposed landfill build-out. The purpose of these drawings is to emphasize the fill-sequence patterns, and therefore many of the details for the rest of the site infrastructure shown on Drawing G02 are not called out. Some of the items that are directly affected by the future development, such as customer haul roads on the landfill surface and major stormwater control systems, are included.
- Drawing C12 shows the ideal final closed landfill grades and a preliminary closure-sequencing plan.
- Drawing C13 shows stormwater runoff patterns and the drainage plan.

- Drawing C14 presents an overview of the bottom liner grades for the entire proposed landfill development. This drawing emphasizes the leachate collection flow lines and sumps.
- Drawings C15-C16 presents cross-sections of the fully built-out landfill. These cross-sections are referenced on all of the plan-view drawings.
- Drawings C20-C24 present various details related to the bottom lining, leachate collection, final cover, and drainage systems.

3.3 Earthwork Materials for Construction and Development

Earthwork materials available onsite for landfill development include soil for use in operations layer, intermediate cover, and final cover construction; and quarry rock for use in drainage layers, roads, and ditch erosion protection. Earthwork materials that could be imported from offsite sources would include the same materials that are available onsite, and sand and rounded gravel for drainage layers. Since the site has been approved to use geosynthetic clay liners (GCLs) for the mineral portion of the bottom composite lining systems, no clay is required to be imported for landfill development.

Table 5 summarizes estimates earthwork materials required for future landfill development. The areas assumed for future cell and final cover development were taken from the phased development plans shown in Appendix A. The soil use assumptions are as follows:

- Typical bottom-liner construction: 1-foot thick operations layer on floor and 2-foot thick operations layer on side slopes over the remaining construction area.
- Landfill operations (includes daily and intermediate cover): 15% of waste volume, based on soil usage data provided by the site operator.
- Final Cover construction: 1.5 feet for infiltration barrier under geomembrane cover, plus 1.5 feet for vegetative soils above liner.

The estimates for drainage layer gravels are not included in the overall site soil balance and are for informational purposes only, as these materials are typically imported from offsite sources. The estimated site reserves in soil stockpiles is approximately 687,500 cy, and overburden soils that will be removed as part of quarry and landfill cell development is approximately 3,652,500 cy, totaling approximately 4,340,000 cubic yards (cy) of available materials. Based on the soil usage rates presented in Table 5, it is implied that the landfill is currently soil “rich.” However, these estimates are subject to change based on the quantities that are exported from the active quarry operations in the future Cell 6 footprint. Thus, the landfill may need to import certain earthwork material for future phase development.

Table 5

Summary of Earthwork Material Quantities (Cells 5E & Cell 6)

Item	Estimated Quantity (cy)
Underdrain Gravel [1]	49,000
Secondary Leachate Collection Gravel (Floor) [1]	40,000
Primary Leachate Collection Gravel [1]	66,000
Operations Layer	152,000
Engineered Fill	80,000
Quarry Wall Sliver Fill	370,000
Landfill Operations (est. 15% of waste volume)	2,797,000
Final Cover (est. 3-foot over future closures)	683,000
Estimated Total	**4,082,000**

Note: 1 – Typically imported from offsite source.

4. Leachate Management

4.1 Overview

Existing Cells 1-5 at the CBL have been constructed with liner systems and leachate collection systems that are designed to collect and convey leachate out of the landfill. Cell floors are graded to convey leachate by gravity to a low point, or collection sump. Each major cell (i.e., Cells 1-5) has its own sump. Leachate is then pumped from the sumps to on-site storage ponds where it is stored until being hauled to offsite treatment facilities.

This section describes leachate management strategies for existing cells and future cells as well as leachate generation analyses and design for future cells. The following general categories are presented below:

- General estimate of leachate volumes for future cells.
- Leachate containment and collection systems. This includes a description of the various bottom liner systems in the landfill and collection ponds.

- Leachate treatment.
- Leachate minimization. This includes operational strategies, as well as descriptions of the final cover system.

4.2 Leachate Generation Analysis

The leachate generation of future expansions at the CBL was estimated by modeling the water balance of the facility using the USEPA model Hydrologic Evaluation of Landfill Performance (HELP), version 3.07. The HELP model was used to calculate the maximum impingement rate for purposes of drainage layer transmissivity calculations, leachate collection pipe design, as well as the calculated maximum leachate head on the liner. Leachate generation potential for this analysis was evaluated for the critical active cell condition of the landfill operations, described below. The analysis herein pertains only to the design of the leachate collection and removal system (LCRS) for Cell 6. The LCRS design for Cell 5E, which is the final future subcell of Cell 5, drains into the existing Cell 5 sump and was designed in the previous SDP report. No changes are being proposed to the Cell 5E liner nor LCRS relative to the previous SDP report (Ausenco Vector, 2011 and Thiel Engineering, 2013).

4.2.1 HELP Model Description

The HELP model is a 'quasi 2-dimensional' deterministic water balance model that uses daily climate data, soil and refuse characteristics, and liner system design data to predict the movement of water into, within, and leakage out of the landfill boundaries. The US Army Corps of Engineers first generated the HELP model in 1983 under a contract with the United States Environmental Protection Agency (USEPA). Documentation of Version 3.07 of the HELP model can be found in Schroeder et al. (1994).

4.2.2 Landfill Profiles Simulated

Peak daily leachate generation potential is typically highest during the early stages of landfill operations when a relatively thin (i.e. 10 foot) layer of waste has been placed across the entire floor of the cell. As waste thickness increases, the storage capacity of the landfill tends to go up, which provides a buffer to large storm events and generally leads to attenuated peaks in leachate production. After closure construction, leachate production is expected to be greatly reduced. As such, the simulated profile for the design of Cell 6 consisted of a 10-foot waste thickness with a no daily cover to represent the critical stage of leachate production for the future CBL expansions. Landfill operations typically incorporate a 12-inch thick soil cover or alternative daily covers in the form of rain tarps or impermeable membrane barriers in attempt to minimize leachate production from the landfill. The 10-foot waste profile was also simulated with the following two cover conditions: 1) 12-inch thick soil cover, and 2) alternative "rain tarp" daily cover. The simulated liner system is consistent with the "standard liner system" described in Section 4.3, below.

Additional profiles representing thicker waste profiles and final closure conditions were presented in the 2011 SDP (Ausenco Vector, 2011) and the 2000 SDP (Thiel Engineering, 2000). Those profiles showed reduced leachate generation which are not critical to the LCRS design, and therefore are not repeated herein.

4.2.3 Climate Input

Climate data required as input into the HELP model consists of evapotranspiration (ET) parameters and daily values for precipitation, temperature, and solar radiation. Daily climate input was synthetically generated based on the HELP model's synthetic weather generator using the nearest default model coefficients of Salem, Oregon.

Precipitation input was specified based on historical climate data from the Oregon State University weather station (No. 351862) in Corvallis, Oregon (www.wrcc.dri.edu). The University weather station reports an average annual precipitation of 41.0 inches based on a period of record from 1893 through 2021. The maximum precipitation year consisted of 73.2 inches of rainfall during 1996.

The design precipitation scenario consisted of a thirty-year simulation period with average monthly totals from the Oregon State University weather station used as model input. The peak daily event resulting from that scenario was 2.8 inches, and the maximum annual precipitation from that scenario was 49.5 inches.

In addition to daily precipitation, temperature, and solar radiation, climate input pertinent to ET calculations within the HELP model include the evaporative zone depth, maximum leaf area index, growing season start and end dates, average annual wind speed, and the average relative humidity for each quarter in the year. HELP model defaults for Salem, Oregon were specified. An evaporative zone depth of 12 inches was used, which corresponds to a "bare" ground surface. Plants were conservatively not included in the analyses, as represented by a leaf area index of 0.0.

4.2.4 Material Properties

A summary of the soil and material properties used for HELP analyses are shown in Table 6. The HELP model defaults were used for characterizing the daily cover, waste, operations layer, drainage layer, geomembrane, and GCL layers. The daily cover layer was assumed to have properties of a clayey sand (SC) with a saturated permeability of 1.2×10^{-4} cm/s (default material texture No. 10). This assumption was based on the work presented by Thiel Engineering (2000). The operations layer was assumed to have properties of a poorly graded sand (SP) with a saturated permeability of 0.01 cm/s (default material texture No. 1). This assumption was based on the material that was imported for operations layer as part of the Cell 5D construction during 2021. Steady state initial moistures were specified for all layers. The percentage area susceptible to runoff was conservatively assumed to be 0 percent to represent the open cell condition and 100 percent to represent the rain tarp cover condition.

The slope and drainage length of the drainage layer was specified as the maximum drainage distance of Cell 6 with a 2% floor slope.

Table 6

Summary of HELP Model Material Properties

Layer Description	Thickness (in)	Hydraulic Conductivity (cm/s)	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)
Alt. Daily Cover (Rain Tarp)	0.01	2.0x10-11	NA	NA	NA
Daily Cover	12	1.2x10-4	0.398	0.244	0.136
Municipal Solid Waste	120	1.0x10-3	0.671	0.292	0.077
Operations Layer	12	0.01	0.417	0.045	0.018
Gravel Drainage Layer	12	10	0.397	0.032	0.013
HDPE Geomembrane	0.06	2.0x10-13	NA	NA	NA
GCL	0.2	3.0x10-9	0.75	0.747	0.40
Foundation/Subgrade	12	1.2x10-4	0.398	0.244	0.136

4.2.5 Results

Water balance predictions for the four landfill profiles are shown in Table 7, and HELP model output files are included in Appendix D.1. Peak daily drainage results were used as the 'impingement rates' for maximum head calculations, drainage layer permeability calculations, collection pipe sizing, and leachate storage estimations, which are described in the following sections. The maximum predicted head is less than the drainage layer thickness of 12 inches, thus confirming the condition of unconfined flow, which makes the maximum head equations valid (Giroud et al., 2000) and satisfies the criteria set forth in OAR 340-094-0060 and 40 CFR, Part 258.40(a)(2).

Table 7

Summary of HELP Model Results

Landfill Profile	Cover Condition	Average Annual Results				Peak Daily Results	
		Precip (in/yr)	Runoff (in/yr)	ET (in/yr)	LCRS Drainage (in/yr)	Maximum Head (in)	LCRS Drainage (in/yr)
Cell 6 (10-Foot Waste Thickness)	No Cover	41.6	0.0	9.7	31.3	0.75	0.87
	12-in. Soil Daily Cover	41.6	0.0	14.9	26.1	0.66	0.76
	Rain Tarp	41.6	38.9	0.5	1.6	0.02	0.03

4.2.6 Comparison to Historic Site Leachate Data

The CBL's leachate pumping records for the years 2011 through 2020 were provided by site staff and were compared to the leachate drainage predictions from the Cell 6 HELP modeling described above. A summary of the leachate generation records is shown in Table 8.

Table 8

Historic Leachate Generation at the CBL (2011-2020)

Year	Rainfall (in) [1]	Cell 1 (gal)	Cell 2 (gal)	Cell 3 (gal)	Cell 4 (gal)	Cell 5 (gal)	Site Total (gal)
2011	36.7	2,010,768	6,670,318	7,037,997	0	0	15,719,083
2012	58.8	2,010,336	11,685,697	6,871,550	4,540,012	0	25,107,595
2013	25.3	1,416,815	4,641,187	3,082,407	2,833,044	0	11,973,453
2014	46.0	1,370,095	5,764,414	3,223,487	4,348,274	2,307,342	17,013,611
2015	41.0	1,117,536	5,422,709	2,696,154	3,921,201	3,259,711	16,417,311
2016	51.4	1,342,476	6,522,676	2,897,070	3,219,805	5,900,089	19,882,116
2017	53.6	1,807,762	5,511,489	5,286,130	4,585,805	10,421,164	27,612,350
2018	33.1	1,689,051	4,983,697	4,666,869	2,623,233	6,038,184	20,003,589
2019	33.6	1,627,845	4,091,261	4,896,842	2,065,225	6,759,441	19,440,613
2020	41.1	1,608,412	4,006,831	4,977,486	2,276,442	9,438,701	22,307,872

Note: 1 – Rainfall totals from Oregon State University Weather Station in Corvallis, OR (Station No. 351862, Western U.S. Climate Historical Summaries (dri.edu)).

The leachate totals shown in Table 8 were divided by the contributing area of each cell for a relative comparison to the HELP model predictions. The resulting maximum annual leachate generation rate was 921,889 gallons/acre/year (Cell 5, 2016), the minimum annual leachate generation rate was 61,403 gallons/acre/year (Cell 1, 2015), and the average annual leachate generation rate was 191,102 gallons/acre/year. As a comparison, converting the average annual drainage predictions of 31.3, 26.1 and 1.6 inches per year from the HELP model results (Table 7), results in predicted average annual leachate generation rates of 849,929, 708,727 and 43,447 gallons/acre/year for the open cell condition with no cover, 12 inches of soil daily cover, and the rain tarp alternative daily cover condition, respectively. The maximum annual predicted drainage prediction was 39.6 inches or 1,075,310 gallons/acre/year with the no cover condition.

In summary, the maximum annual leachate prediction based on the HELP modeling of the open cell condition exceeds the maximum annual leachate generation rate from Cell 5 in 2016, and the average annual leachate predictions of the open cell condition (uncovered and with 12 inches of soil cover) are higher than the average annual volume generated at the site by a factor of 3.7 to 4.5. It can therefore be concluded that the HELP model predictions applied to the CBL Cell 6 LCRS design are conservative relative to the leachate volumes recorded from existing lined areas at the CBL, and that a pro-rated approach that incorporates both the open cell condition and the rain tarp cover condition is appropriate for estimating design volumes of leachate, discussed further in Section 4.4.

4.3 Leachate Containment and Collection Systems

There are several types of bottom liner systems that are existing or proposed for the CBL. They are generally described as follows:

- No lining system exists under the old burn dump that was closed in 1977 in the west quarry area, or under Cell 1A.
- A limited clay liner and leachate collection system exists under Cell 1, which was constructed in 1977. Very little documentation exists regarding the construction of this liner and collection system, but the collection system currently collects approximately 1.8 million gallons of leachate per year based on flow meter data reported by site personnel.
- A single composite clay/geomembrane liner and a primary leachate collection system exist under Cell 2A, which was constructed in 1987.
- A composite clay/geomembrane primary liner, a secondary geomembrane liner, secondary and primary leachate collection systems, and an underdrain exist under Cell 2B, which was constructed in 1993.
- A composite primary liner having a layer of bentonite sandwiched between two geomembranes, a secondary geomembrane liner, secondary and primary leachate collection systems, and an underdrain exist under Cells 2C (constructed 1995), 2D (constructed 1997), 3A (constructed 1999), 3B (constructed 2003), 3C constructed 2004), 3D PH I (constructed 2006), 3D PH II (constructed 2008), Cell 4 (constructed 2011), Cell 5A (constructed 2013), Cell 5B (constructed 2017), Cell 5C (constructed 2019), and Cell 5D (constructed 2021; approval pending). This same liner system is proposed for the future Cell 5E and Cell 6. The use of a geosynthetic clay liner (GCL, which is the liner element that contains the bentonite) was approved by the DEQ as part of an alternative liner design demonstration performed in 1994 and 1995 (EMCON, 1994a; EMCON, 1994b; EMCON, 1995b). This liner system is referred to as the “standard” bottom liner, and is described in more detail in the next part of this section.
- A single geomembrane liner “flap” was proposed by the DEQ as a requirement on top of the waste above that portion of Cell 2A that filled as a result of Cell 3 expansion. The reason for

this requirement is that Cell 2A was constructed before promulgation of Subtitle D, and the thickness of the clay component of the composite liner was only 18 inches instead of the prescriptive 24 inches required by Subtitle D. Lateral expansion of Cell 2, triggered by Cell 3, requires this flap over Cell 2A.

- A "piggyback" liner system was constructed over the east side of Cell 1 as part of the development of Cell 3D. This liner system consisted of the same elements as the "standard" liner system, plus the addition of a geosynthetic reinforcement layer below the liner system. The piggyback liner system is described in more detail in Section 4.3.2.
- Special precautions need to be taken for the liner system to be constructed against the steep quarry walls that will be encountered in future Cells 6. The quarry wall lining system is described in more detail in Section 4.3.3.
- In addition, there are currently two leachate ponds on the site that have double-liner systems with leak detection capability. These are described in more detail in Section 4.5.

For the remainder of this section, only those bottom liner systems that are proposed for future development are discussed in more detail. These include the "standard", "piggyback", and "quarry-wall" lining systems. Typical details of these liner systems are presented on Drawings C20 and C23 in Appendix A.

4.3.1 Standard Lining System

The standard lining system is so-called because it has been used for the last 10 sub-cells (2C, 2D, 3A, 3B, 3C, 4, 5A, 5B, 5C, and 5D) and is proposed for use in all future cells. Even the piggyback and quarry-wall lining systems are variations of the standard lining system. The standard lining system described herein is actually an approved alternative design incorporating a GCL as referenced above.

The layers, from bottom to top, and their design criteria are described in Table 9 for the standard bottom liner system proposed for future development in Cells 5E and 6.

4.3.2 Piggy Back Lining System

A piggyback lining system is so-called because it constructed over existing waste on the east side of Cell 1 rather than on an earthen subgrade. The reason for the piggyback liner requirement is that Cell 1 was constructed before promulgation of Subtitle D, and the underlying clay liner and leachate collection system do not meet the prescriptive standards of

Subtitle D. Construction of Cell 3D could be viewed as a lateral expansion of Cell 1, and therefore requires a liner system over any areas where new waste will be placed.

The piggyback lining system elements are generally the same as for the standard lining system, with the exception that a geosynthetic reinforcement layer is included beneath the lining system as a precaution against differential settlements in the underlying waste. Example calculations for the design of the reinforcement layer are presented in Ausenco Vector (2011).

Similar reinforcement layer design considerations might be required for portions of Cell 6 that will fill over parts of Cells 1 and 1A.

Table 9

Layers and Design Criteria for Standard Bottom Liner System (Bottom to Top)

Layer Description	General Design Criteria	Comments
Underdrain –typically 6-12 inches of sand or gravel.	Provide adequate capacity to allow any potential groundwater or springs to gravity flow under the lining system without exerting pressure on the lining system.	The pressure relief is only important during construction. Material could also be a geonet.
Secondary geomembrane – typically a textured 60-mil high-density polyethylene (HDPE).	Provide a barrier for secondary leachate containment.	Could also be other materials, such as 30-mil PVC if interface friction is adequate for slope stability
Secondary leachate collection layer –typically 12 inches of gravel with an embedded pipe network.	Provide secondary collection and removal capabilities for leachate that might leak through the primary liner system.	Material could also be a geonet with adequate flow capacity under high normal loads.
Lower primary geomembrane – typically a textured 40-mil HDPE material.	Provide redundant primary leachate containment.	In Cells 2C and 2D, the bentonite was glued to this geomembrane, with the composite material generically called a GCL, and marketed as Gunseal®. In Cells 3A and on this was a discreet welded HDPE liner.
Geosynthetic clay liner (GCL) – typically a layer of bentonite carried by two nonwoven-needlepunched (NWNP) geotextiles.	Provide the soil-portion of the primary composite liner, meeting specified low-permeability characteristics.	
Upper primary geomembrane – typically a textured 60-mil HDPE material.	Provide primary leachate containment.	
Leachate collection layer – typically 12 inches of gravel with an embedded pipe network.	Provide primary leachate collection so that maximum head buildup is less than 12 inches.	The permeability of the gravel has typically far exceeded the minimum standards. Coarse gravel has been provided around the pipes as a redundant feature to provide adequate flow capacity even in the event of total pipe failure. Supplemental pipes are included in this layer for enhanced gas collection.
Geotextile filter – typically 4 oz per square yard NWNP material.	Keep fine material from overlying waste and operations layer from getting into the leachate collection layer.	
Operations layer – typically 12-24 inches of soil, or 18 inches of shredded tires.	Provide protection to the liner system from waste placement operations.	Soil is used in selected areas to provide perimeter gas seals.

4.3.3 Quarry-Wall Liner System (Cell 6)

Rock quarry walls will exist in future Cells 6. The quarry walls will generally follow a geometric pattern of 40-foot near-vertical walls alternating with 20-foot wide benches. The quarry walls that have been mined to date have an average inclination of 1(H):4(V) (14° from vertical). Because of the marine-basalt geology, the mining produces an extremely rugged face containing protrusions, indentations, and overhangs.

The lining system proposed for the quarry walls contains the same elements of containment, primary leachate collection, and secondary leachate collection as for the standard liner. Challenges to providing a sound lining system on the rugged, steep faces of the quarry walls include:

- Providing a uniform surface that will not cause the overlying geomembranes to be stressed due to protrusions or concavities.
- Providing a durable surface that will not experience cave-outs and spalling between the time it is lined and the time it is buttressed with waste.
- Providing a substantial underdrain system to handle groundwater flows and springs, especially for areas that will be below the groundwater table.
- Providing a uniform crest along the outside edge of each bench so that the lining system will not experience stress concentrations along this edge and can be securely anchored.
- Addressing downdrag movements along the steep face caused by waste settlement to avoid stressing the primary lining system.
- Providing means to collect and convey underdrain water, and primary and secondary leachate off the benches.

Several options were evaluated as potential preparation of the rugged quarry walls to receive multiple geosynthetic lining elements. These options included stacked gabions, mechanically stabilized earth (MSE) wall veneers, shotcrete, spray-on polyurethane foam, spray-on lining systems, and the wire reinforced wall veneer design presented in the previous SDP (Ausenco Vector 2011 and Thiel Engineering 2013). Because of the difficulty of constructing and the estimated costs associated with the wire reinforced wall veneer design, an alternative quarry wall liner system has been developed and incorporated herein. The proposed quarry wall design is termed a "shingle-fill" style slope liner system. The concept is to place engineered fill along the quarry wall slopes, creating a smooth 1:1 (H:V) slope and a wedge of fill with a height equal to the approximate height of quarry wall between quarry benches. The shingle-fill slope will then receive the standard side slope liner system. In general, waste will be placed approximately up to the level of the next quarry bench, and when the next bench and shingle-fill are ready to be constructed, the same procedure would be followed. In areas where the toe of the shingle-fill extends onto the waste that was placed in the previous lift/phase, a “blanket” geomembrane will be placed below the engineered fill and above a prepared foundation layer on top of the previous lift of waste. The side slope liner from the above phase will extend out over the blanket geomembrane, directing leachate into the previous phase and ultimately towards the Cell 6 sump. Underdrain collection pipes will be placed on the inside toe of each shingle-fill/quarry bench, and horizontal landfill gas collection pipes will be placed in trenches beneath the blanket geomembrane. These pipes would follow the quarry benches and exit the landfill at the end of the quarry bench. Typical design details of this concept are presented on Drawing C23 of Appendix A. Design calculations for the shingle-fill liner system are included in Appendix E.

The quarry floor would receive the standard lining system, underdrain, primary leachate collection, and secondary leachate collection pipes running towards the Cell 6 sump. Header pipes for the underdrain water would connect to the ends of the pipes that exit from the landfill on the quarry benches. The header pipes would run down the slope along the landfill perimeter, to the toe of the slope. The underdrain water would be directed to discharge to the county roadside ditch. Primary and secondary leachate collection will be directed to the Cell 6 sump via a network of collection pipes, where it will then be pumped to the on-site leachate storage facility, as discussed in Section 4.5.

4.4 Leachate Collection and Removal Systems

The leachate collection and removal system (LCRS) is designed to control the maximum buildup of head on the lining system to less than 12 inches. This is accomplished by providing minimum 2% sloping bottom grades that drain to a sump, providing a 12-inch thick layer of granular drainage material, and an interbedded pipe network. On steeper slopes (e.g. the 2:1 side slopes of Cell 5 and the 1:1 shingle-fill slopes of the quarry-wall lining system), a geonet may be used in place of the granular drainage material. Pumps in the sumps run automatically to maintain the leachate head below a maximum established level in the sumps.

4.4.1 Drainage Layer Design

The permeability of the granular drainage material for the LCRS layer has been specified as a minimum of 0.5 cm/s for the last two sub-cells of Cell 2, and a minimum of 1.0 cm/s for Cell 3A, 3B, 3D, and Cell 4, and a minimum of 10.0 cm/s for Cells 5A, 5B, 5C, and 5D. These values are well in excess of the State and Federal recommendation of a minimum value of 0.01 cm/s. The permeability of the granular drainage material for the primary LCRS layer of Cells 5E and Cell 6 is also recommended to be a minimum of 10.0 cm/s. This value incorporates reduction factors for intrusion, creep deformation, chemical clogging, and biological clogging, resulting in an overall factor of safety between 16 and 67 for the range of impingement rates evaluated. Drainage layer design calculations are included in Appendix D.2.

The granular drainage layer permeability is primarily a function of the incoming leachate flux from the waste above (also called the impingement rate). The peak leachate impingement rate established as the design basis for Cell 6 was estimated based on a proration of the HELP model predicted drainage rates between the no cover condition and the rain tarp condition (see Table 7). The percent contribution of the average annual drainage predictions between the two conditions were iteratively prorated until the sum of the two approximately equaled the average annual leachate collection rate of 191,102 gallons/acre/year from the historic site collection data. The resulting rates of proration were 20% of the no cover condition and 80% of the rain tarp condition, and an average annual drainage of approximately 205,000 gallons/acre/year. The same rates of proration were then applied to the peak daily drainage predictions from the HELP modeling, and the resulting estimated peak daily drainage rate of 0.20 inch/day, or 5,377 gallons/acre/day was calculated.

4.4.2 Maximum Head

The maximum head that will build up on the liner system is a function of the impingement rate, the slope of the bottom liner, the permeability of the drain layer, and the spacing of the collection pipes. Calculations for the maximum head buildup on the liner system are presented in the HELP model results in Table 7 and Appendix D.1. In all cases of the modeling, the maximum predicted head was less than the maximum regulatory level of 12 inches.

The spacing of collection pipes will be approximately 300 feet with a maximum drainage distance of no more than 500 feet. Drawing C14 presents an overall picture of the existing and future bottom grades for the leachate collection system, pipe locations, and sump locations.

4.4.3 Leachate Collection Pipe Design

4.4.3.1 Pipe Size

The pipe size for primary leachate collection in Cell 6 is shown to be 8-inch diameter for the center collection swale, and 8-inch diameter for lateral pipes and toe-drain pipes. Pipes were sized to accommodate peak leachate generation from the maximum contributing area of lined cell. Pipe capacity calculations are included in Appendix D.3. Two pipes will be used for the center collection swale pipe for an added factor of safety and redundancy (see detail No 7 on Drawing C21 of Appendix A). Consistent with the designs of Cell 5, primary collection pipes will be embedded in the primary leachate collection gravel with a minimum permeability of 10.0 cm/s.

4.4.3.2 Pipe Perforations

Consistent with the designs of Cell 5, primary leachate collections pipes will be perforated with holes 9/16" in diameter, and secondary leachate collection pipes will be perforated with holes 3/8" in diameter. The size of the perforations in the leachate drainage pipes are designed for maximum leachate inflow per unit length of pipe as well as for compatibility with the grain size distribution of the filter material (i.e. gravel) in contact with the pipe. Perforation size calculations based on maximum estimated leachate inflow are included in Appendix D.3 and suggest that a minimum perforation size of 9/16-inch diameter results in a requirement of approximately 1 perforation per foot of pipe. The recommended perforation pattern provides 12 perforations per foot, resulting in a safety factor of 12 for pipe inflow with the recommended minimum perforation size of 9/16-inch diameter. Note that larger perforations are acceptable where pipe strength/overburden pressure and drainage gravel in contact with the pipe allows, and that the perforation size recommended herein represents the minimum size for design pipe inflow.

The grain size distribution of the drainage gravel that is in contact with the pipe is designed for compatibility with the recommended perforation size. The US Bureau of Reclamation (1973) suggests the following criteria for grain size of filter materials in relation to openings in pipes:

$$\frac{D_{85}\ of\ Filter\ Gravel}{Perforation\ Diameter} \geq 2$$

Thus, with a perforation diameter of 9/16 inch, the D_{85} of the drainage gravel in contact with the primary collection pipe should be $\geq$ 9/8, and with a perforation diameter of 3/8 inch, the D_{85} of the drainage gravel in contact with the secondary collection pipe should be $\geq$ 3/4 inch. Any changes or nonconformances related to the grain size distribution of the drainage gravel or the pipe perforation size or frequency should be verified by the design engineer at the time of construction.

4.4.3.3 Pipe Strength

The strength of the LCRS drainage pipes has been designed to accommodate the weight of the overlying waste. The calculations of pipe strength for Cell 6 were evaluated based on the maximum waste heights from the site's permitted final buildout grades. Under the final closure scenario, it is anticipated that up to approximately 335 feet of waste will overlay the leachate collection pipes in Cell 6.

Pipe strength calculations were based on the methodologies described in the Handbook of Polyethylene Pipe, Installation Category #3: Deep Fill Installation (PPI, 2012). These methods consist of discrete computations for 1) compressive ring thrust stress, 2) ring deflection, and 3) constrained pipe wall buckling. The calculations account for an increase in design overburden stress due to perforation size and frequency, elevated temperature of 100 °F for landfill leachate, load duration of 100 years, and the resulting reduction of the long-term modulus of elasticity of the pipe. Other assumptions that were made for the pipe, waste, and embedment material properties are shown in the calculation spreadsheets included in Appendix D.3. The recommended maximum standard dimension ratio (SDR) for LCRS collection pipes is SDR 11 for the main collection pipe, laterals, and toe drain pipes, and SDR 17 for sump and sump riser pipes, as shown in the pipe strength calculations (Appendix D.3). The floor collection pipes in Cell 6 will be installed with a minimum of 2 feet of gravel over the top of the pipe (see Detail Nos. 7 and 8 on Drawing C21 in Appendix A).

4.4.4 Sumps

There are currently five leachate sumps that pump leachate from the landfill Cells 1, 2, 3, 4, and 5 into on-site leachate ponds. The sump for Cell 1 was installed in 1998. Previous to that time, the leachate collection pipes from Cell 1 drained directly into the large leachate holding pond next to Cell 1. The new sump is a thick-walled, 4-foot diameter, 15-foot deep HDPE manhole located outside the limits of the current or future landfill footprint just inside gate C. Leachate collection pipes from Cell 1 drain by gravity into this sump. A 1-horsepower pump hung 6-

inches off the sump bottom is controlled by electronic controls to turn the pump on and off so that no leachate is allowed to back up into the landfill. A high-level alarm light turns on in the event leachate in the 15-foot deep manhole is greater than 6 feet deep. A flow meter is installed on the 3-inch diameter HDPE discharge line from the sump that records instantaneous flow rate, and totalizes the flow volume. The design and drawings for the sump were submitted to the DEQ by Thiel (1998b).

The sump for Cell 2 and Cell 3 were separately installed as part of the construction of Cell 2B and Cell 3C which located at the southeast corner of their cells. Cell 4 sump was installed south of Cell 4, and the Cell 5 sump was installed on the east side of Cell 5A. All sumps are used to collect both primary and secondary leachate from each cell. Generally speaking, the liquid levels in both the primary and secondary sumps are automatically controlled by LevelCom bubblers, which include high-level alarms. The liquid levels, flow rates, and totalized flow volumes are continually monitored and recorded by remote telemetry. More detailed descriptions of the existing sumps are provided in Appendix D of the 2011 SDP (Ausenco Vector, 2011). The discharge pipes from the sumps pass through a valve vault, where the valves can be manually changed to direct the leachate discharge to the either one of the two leachate storage ponds, discussed below.

Cell 6 will be constructed with a single sump located in the western perimeter of the cell. The Cell 6 sump is detailed in Detail 12 on Drawing C22 of Appendix A and will be used to collect both primary and secondary leachate. Leachate will be pumped from the Cell 6 sump into a dual containment perimeter header pipe that will feed into either of the two existing on-site leachate ponds.

4.5 Leachate Storage

There are currently two leachate storage ponds at the site:

- West Leachate pond - a 4-million-gallon leachate holding pond located on the south side of Coffin Butte Road, west of the leachate treatment facility.
- East Leachate Pond - a 5-million gallon holding pond located on the south side of Coffin Butte Road, southeast of the leachate treatment facility.

Both ponds are covered and are double-lined with leak detection systems. As-built drawings are maintained at the landfill operations office. Operation and maintenance of the leachate holding ponds includes the following activities:

- Monitoring liquid level in the pond is performed by visually comparing marks on the pond covers to a chart showing the pond volume at the corresponding depth.
- The pond leak-detection system is checked, sampled, and evacuated in accordance with protocols established in the Environmental Monitoring Plan (Tuppan 2014). A copy of the plan is maintained at the landfill operations office.
- Transferring leachate between the two ponds and to the leachate irrigation system. Appendix A includes drawings of the leachate piping and control valves.
- The East and West Leachate Ponds have a floating cover to keep rain out. A pump system on the floating covers is used to remove rain water falling on the cover. The floating covers shall be inspected for accumulation of water. Accumulation of water on the floating covers may be an indication that the cover pumps need repair. The covers can be removed to allow pond cleaning.

4.6 Leachate Treatment and Disposal

4.6.1 Background

Before 1996, all of the site leachate was stored in the large holding pond north of Coffin Butte Road over the winter, and irrigated at agronomic irrigation rates on hay fields in accordance with DEQ-approved plans. Extensive monitoring was performed, and subsequent reporting documentation was submitted to the DEQ. High nitrogen contents in the leachate had been a limiting factor in using the permitted irrigation fields, and the DEQ indicated that irrigation of raw leachate without pre-treatment would be phased out. Consequently, in 1995 VLI began evaluating methods to treat leachate as an alternative to irrigation.

The first of the leachate treatment alternatives evaluated was trucking to local publicly operated treatment works (POTWs), or industrial treatment works. It was discovered that although the cities of Corvallis and Albany were willing to provide emergency backup for leachate treatment, they were not willing to commit to being the long-term permanent solution. The only other local POTW at the city of Adair Village was determined to be technically impractical, even if the leachate was pre-treated. Furthermore, none of the local industries (e.g. Willamette Industries) that operated their own wastewater treatment systems were willing to commit to be a permanent solution. Therefore, the site was forced to look at onsite treatment options.

Landfill leachate contains four general categories of pollutants that pose different challenges to treatment: organics that usually create a biological oxygen demand (BOD), dissolved metals, nitrogen, and inorganic dissolved salts. Most conventional mechanical/biological treatment systems are able to treat organics, metals, and, to some extent, nitrogen. They have almost no treatment effect, however, on dissolved salts. Yet, dissolved salts are most easily detectable as impacts in ground and surface water monitoring. In addition, the DEQ guidelines for treated water discharges in the Willamette River basin are extremely stringent for dissolved salts. Consequently, VLI set a risk-management goal to significantly reduce the loading of dissolved salts to the environment for the onsite treatment options.

Requiring the treatment system to take out salts limited the available treatment technologies to two general categories: evaporation or osmotic membranes. After performing an evaluation of the costs and potential performance of several vendor-supplied options, and conducting a series of onsite pilot studies during the summers of 1996 and 1997, VLI ultimately selected a treatment system based on the principle of direct osmosis. A description of the system can be found in VLI (1998a), VLI (1998b), and Thiel (1997b). The selected system was installed during the 1997-98 winter, and began treating leachate by June 1998.

4.6.2 Current Leachate Management Strategy

At the present time the following methods are used to manage leachate:

- Spray irrigation of leachate onto the waste mass in accordance with an ODEQ-approved plan, Pilot Plan for Landfill Biodegradation Enhancement through Leachate Irrigation over Waste (Thiel 1997c) and subsequent plan revisions requested, and approved by DEQ in the annual leachate management reports. The results of leachate applications over waste are reported in the Annual Leachate Management Report for the CBL, submitted annually to ODEQ.
- Trucking leachate to wastewater treatment plants in the cities of Salem, Corvallis, and others facilities (i.e. Portland Power Vac, etc.).
- On-site treatment in the direct/reverse osmosis treatment plant. The site maintains the permit for the former leachate treatment plant; however, the plant is no longer in existence.

An example of how extensively each of the treatment methods has been used is presented in Table 10, taken from the most recent annual environmental monitoring report (Tuppan, 2020).

Table 10
Summary of 2019-2020 Leachate Management Volumes

Month	Corvallis WWTP/ other*	Leachate Irrigation on Landfill	Treatment Plant	Pond Volume at Start of Month	Rainfall (inches)	Cell 1 Flowmeter	Cell 2 Flowmeter	Cell 3 Flowmeter	Cell 4 Flowmeter	Cell 5 Flowmeter	Diaphragm Pumps (Hor. wells)	Downwell Pumps	Condensate Sump (Main)	Condensate Sump (Cell 4)	Horizontal Well Gravity Drains	Public Area	PRC Leachate Handled
Oct-19	2,321,815	0	0	3,139,712	2.35	109,070	350,317	427,822	141,968	452,713	36,804	320,561	39,850	29,078	23,884	1,740	35,000
Nov-19	2,309,502	0	0	2,665,166	1.02	97,625	265,558	364,748	89,189	349,930	32,625	260,852	39,415	22,624	49,695	630	21,000
Dec-19	2,970,358	0	0	2,020,526	4.30	128,537	344,481	371,966	199,884	924,356	52,678	321,262	39,765	24,277	42,413	17,933	28,000
Jan-20	3,591,657	0	0	1,505,581	8.41	272,890	435,198	454,176	474,340	1,339,887	72,834	397,275	42,173	39,991	40,768	46,989	40,500
Feb-20	2,732,210	0	0	1,469,605	1.65	177,493	314,918	379,831	129,562	591,549	20,938	360,050	42,928	28,956	37,701	2,358	13,000
Mar-20	2,001,139	0	0	767,260	2.92	128,615	289,790	402,540	148,119	655,563	27,219	370,839	47,915	42,339	39,256	2,400	21,000
Apr-20	1,434,283	0	0	882,152	1.52	127,300	270,267	396,227	103,329	515,827	20,785	383,301	59,224	50,080	47,096	1,720	39,000
May-20	2,020,850	0	0	1,446,475	2.62	127,790	288,538	471,412	121,977	607,061	15,731	372,695	72,671	42,032	49,484	3,230	83,000
Jun-20	1,979,368	0	0	1,589,934	1.59	112,340	280,556	507,846	93,595	714,072	55,620	246,251	70,086	42,244	47,001	1,210	42,000
Jul-20	1,315,895	0	0	1,790,512	0.00	101,591	281,798	523,721	36,743	665,586	122,273	347,300	62,250	30,988	37,970	7	32,500
Aug-20	498,885	0	0	2,529,224	0.05	89,739	283,313	417,172	42,049	515,288	35,286	304,425	64,127	33,019	35,601	3	28,000
Sep-20	1,624,071	0	0	3,875,125	1.68	80,010	295,071	347,203	96,453	477,668	22,383	249,628	60,798	30,118	32,560	0	33,500
Oct-20				3,920,670													
Totals	24,800,033	0	0	—	28.11	1,553,000	3,699,805	5,064,664	1,677,208	7,809,500	515,174	3,934,441	641,202	415,745	483,429	78,220	416,500

2019-20 Leachate Volume Treated:	**24,800,033**
Leachate Calculated by Volumetrics:	**25,580,991**
Leachate Recorded by Flowmeters:	**26,288,888**
Percent Difference: Meters vs. Volumetrics	**2.73%**

Notes: 1.) All values in gallons unless noted

2.) Leachate season: October 1, 2019 to September 30, 2020

* Also treated at Salem Wastewater treatment plant

4.6.3 Future Leachate Management Strategy

VLI intends on managing leachate in the same way in the future as the current strategy, which involves the three treatment options described in the preceding section, plus aggressive leachate minimization. On-site leachate treatment may be explored as a management strategy at some point in the future.

4.7 Leachate Minimization

With increasing leachate treatment costs, increased leachate-generating footprint area, and aggressive pumping of landfill gas wells, the needs and benefits of minimizing leachate generation are more apparent than ever. Landfill operations employs many practices in attempt to minimize water entering into the landfill, including the following:

- Smaller and more frequent moving of tipping area pads and working faces.
- Definitive slopes for runoff areas to avoid ponding within the landfill footprint.
- Perimeter ditches and berms used to eliminate stormwater run-on.
- Extensive use of temporary plastic/membrane cover, and replacement of old panels.

Leachate generation statistics per inch of rain indicate that the efforts made to minimize leachate have had positive results. The landfill operators will continue to make efforts to reduce leachate generation through improvements in landfill operations.

5. Surface Water Management

Surface water runoff from the landfill is permitted under a NPDES Storm Water Discharge Permit for the landfill. The NPDES permit and the Storm Water Pollution Control Plan (Tuppan 2021) describe the monitoring requirements, reporting requirements, site controls, inspections, and best management practices used at the landfill to manage storm water runoff.

The Year 2011 Site Development Plan (Ausenco Vector 2011) presented a master storm water control plan drawing, a summary of the major infrastructure requirements for storm water management, and the storm water controls that will be in place at final closure of the facility. (GLA 2015) presented a Stormwater Master Plan Revision for the site, which is included as Appendix F to this report. All storm water drainage structures were designed for a peak 25-year, 24-hour storm event. Most of the controls will be developed incrementally throughout the life of the landfill and include perimeter drainage ditches, sedimentation basins, and incremental construction of final cover ditches and downdrains.

General stormwater drainage patterns at final buildout of the landfill are shown on Drawing C13. A summary of the stormwater control design is as follows:

- Run-on from the north will be controlled by intercepting water in perimeter drainage channels and diverting to sedimentation basins, as shown on Drawing C13.
- Runoff will be collected by drainage benches constructed on the final cover surface at vertical intervals of 50 feet. In general, these benches will run in an east-west direction (except at the ends of the landfill footprint), with a longitudinal slope of 3%. The purpose of these benches is to interrupt sheet flow from the slopes to minimize erosion. Another benefit of the benches is that they will increase the time of concentration during a rain event, which will reduce the intensity of peak runoff rates from the site.
- Maintenance access roads on the final cover surface will also provide a drainage function similar to the drainage benches. These roads will have an inside ditch that will intercept runoff from the slopes and from some of the drainage benches.
- The ditches on the drainage benches, access roads, and at the landfill toe will have rock protection against erosion.
- In general, the drainage benches will flow to the landfill toe. Due to the length of some of the drainage benches, two sets of overside downdrains will be used to convey stormwater from the drainage benches down to the landfill toe. The size and locations of the overside drains are shown on Drawing C13 and in Appendix F. A detail of the downdrains and their inlets is shown on Drawing C24.
- The final cover slopes will be track-walked and hydroseeded to establish vegetation to resist erosion.
- Three sedimentation/detention basins and biofiltration strips have been established over the course of landfill development to trap sediment. One of these basins, located near the southeast corner of Cell 4, was constructed during the year 2011 Cell 4 construction. This basin collects runoff that flows east towards Toketie Marsh. A biofiltration strip, located east of the current scale house, was also constructed in the year 2011, and was designed to trap sediment run-off before it gets to Toketie Marsh. The second basin, located on the east of

the goose-neck entrance road, was constructed in 2012 with the ongoing Cell 4 construction. This basin collects runoff that flows from north section of the landfill. The third basin and biofiltration strip were constructed during 2016, and will collect all drainage that flows west towards Soap Creek (primarily the future Cell 6 drainage).

The success of the final cover vegetation and stormwater controls on the closed portions of Cells 1 and 1A is a testament to the soundness of the proposed final stormwater management approach. These covers, installed in two phases in 1990 and 1996, have displayed excellent durability, with no erosion problems and little maintenance needs.

6. Landfill Gas Management

This section describes the methods and technologies used to control landfill gas (LFG) at the site.

6.1 Overview

The CBL site utilizes an active gas collection and control system (GCCS) that delivers the gas to a gas-to-energy (GTE) plant that produces electricity and two landfill gas flares. The GTE plant is the primary control system, and the two flares combust collected LGF not utilized by the GTE plant. The current capacity of the GTE plant is approximately 5.66 megawatts of electricity, produced with five internal combustion engines. The GTE plant is operated by a third party under facility specific permits issued by DEQ.

6.2 Background

Active landfill gas control was initiated at the site in 1994 when a series of vertical gas wells were installed in the inactive Cell 1. The GTE plant was constructed at the same time by a third party (Pacific Northwest Generating Cooperative, or PNGC). The system originally consisted of 22 vertical wells, a header pipe, blower, condensate collection, the GTE, and a stand-by flare.

Since 1994, numerous additional vertical and horizontal gas extraction wells have been installed, and the GTE has been expanded. Additional gas collection is being designed with each new cell expansion, as part of annual GCCS expansion projects, and as part of final closure directly under the final covers.

6.3 Current Status

The current GCCS has been designed to be consistent with the Federal New Source Performance Standards (NSPS) requirements to achieve comprehensive control of both lateral migration and surface emissions of LFG. The existing and proposed future design consists of vertical and horizontal wells to extract LFG from the disposal area. The existing vertical extraction wells have a well spacing ranging from 150 to 200 feet throughout the fill area. Permanent lateral and header pipes are installed generally below ground surface and are typically constructed of high-density polyethylene (HDPE) pipe. Temporary piping may be installed either above or below ground surface to accommodate ongoing waste placement operations. LFG is conveyed through this pipe network to the electrical generation plant and backup utility flares, located southeast of the disposal area. Condensate that forms in the GCCS piping is discharged to the leachate collection system (LCS) via direct connections to LCS cleanout/access riser or to condensate pump stations located around the perimeter of the disposal area. Condensate drained by gravity to the condensate pump stations is discharged through a force main(s) to the LCS. Condensate collected in condensate drains is transported via gravity directly to the LCS via leachate system access risers. The condensate is disposed of coincidentally with landfill leachate in accordance with the requirements of the facility Solid Waste Permit. Energyneering Solutions Inc. (2020) shows the key elements of the LFG main system, valves, condensate traps, and GTE plant.

6.4 Future Plans

The CBL will continue to place waste in accordance with the solid waste permit. Installation of additional GCCS components is anticipated to be coordinated with cell expansions and fill development and as required by NSPS regulations. The GCCS Design Plan for the site was recently updated by Energyneering (2021). The GCCS design may be altered to maintain compliance with the provisions of the NSPS and to accommodate actual field conditions at the time of construction.

Future vertical well placement and spacing are described in the site's updated GCCS Design Plan (Energyneering, 2021). Permanent vertical wells will continue to be installed once the waste placement operations reach final grade elevations. Interim vertical extraction wells may be installed prior to the achievement of final grade conditions and will be extended or replaced as site operations warrant.

Additional capacity will be added to the LFG control system, as needed to handle the LFG flows, in accordance with the GCCS Design Plan. The CBL may require the installation of supplemental GCCS components to comply with State and Federal regulations at some point in the future. If that need is determined, an Alteration Request will be submitted to ODEQ for review and concurrence prior to the installation of those components.

7. Environmental Monitoring

7.1 Overview of Site Monitoring

Environmental monitoring has been conducted at the CBL since 1975 when the DEQ started collecting water quality data from the leachate lagoon and from surface water around the site. Groundwater monitoring began in 1977 when the first three well pairs were installed. Since 1977, the water quality monitoring network has evolved in response to different monitoring and site characterization needs required by the solid waste permit. There are currently active and abandoned groundwater monitoring wells or piezometers at the site shown on Drawing G02 in Appendix A.

The water quality monitoring network has five components:

- Groundwater monitoring wells, which include compliance and detection wells
- Observation wells and piezometers used for measuring water levels
- The secondary leachate collection system (formerly called the leak detection system, or LDS)
- Leachate sumps
- Surface water monitoring points

The rationale for the network design and the media monitored is presented in the environmental monitoring plan (EMP) (Tuppan 2014).

The solid waste permit also requires monitoring for gas that could potentially migrate from the landfill to surrounding native soil. A landfill gas monitoring plan, which describes gas monitoring probe locations and their construction, monitoring procedures, response to monitoring results, records, reporting, and monitoring of the interior of structures, was developed in 1995 (EMCON, 1995c) and is defined in the EMP (Tuppan 2014).

In addition to environmental monitoring specified by the solid waste permit, stormwater samples are collected four times a year and the results submitted to the DEQ quarterly under the National Pollutant Discharge Elimination System (NPDES) program in accordance with the site's Stormwater Pollution Control Plan (Tuppan 2021).

7.2 Site Hydrogeology

The geology and hydrogeology of the site have been described in a number of documents. The most recent of these was the site characterization report for Cell 3 (EMCON, 1999), which compiled a summary of the regional and site geology and hydrogeology from a number of earlier reports and the scientific literature. Discussions of water quality conditions at the site are summarized in annual reports (since 1992), the remedial investigation and its addendum (EMCON, 1994c, 1996b), a preliminary assessment for the area downgradient of the 1977-closed burn dump landfill (EMCON, 1996a), and the EMP (Tuppan, 2014).

7.2.1 Geologic Units

The landfill is situated along the south flank of Coffin Butte. The upper third (approximately) of the butte consists of steep grass-covered slopes, the middle third of exposed bedrock with little vegetation, and the lower third of gentle, soil-covered slopes. Generally, the steeper slopes are underlain by basalt bedrock and the lower, flatter slopes on the flanks of Coffin Butte are underlain by alluvium that generally consist of silty clay to clayey silt with variable amounts of thin, interbedded sands and silty to sandy gravels.

There are two principal water-bearing units: unconsolidated alluvium, and bedrock volcanics. Groundwater occurs in both units, although the alluvial deposits are absent or unsaturated over much of the site where landfill occurs. Where both units are present, they are not separated by a confining layer but are hydraulically interconnected. The two units are monitored separately by groundwater monitoring wells.

7.2.2 Groundwater Occurrence and Flow

Depth to groundwater depends on season and topography. In site wells, the groundwater depths range from over 80 feet below the ground surface midway up the slopes of Coffin Butte (in bedrock) to less than 1 foot in the flat lowland area southeast of the butte (in alluvium). East of Cell 2, potentiometric elevations measured during the wet winter and spring months are near or higher than the ground surface elevation, indicating that groundwater discharges in this area.

Groundwater levels at the site fluctuate in response to seasonal precipitation. The amount of fluctuation varies, depending on the hydrogeologic position of the monitoring point. The range of variation is a minimum of less than 0.1 foot, measured in flat lowland areas, to approximately 60 feet midway up the slopes of the butte. The average annual fluctuation measured for monitoring wells and piezometers at the site is from 4 to 10 feet, with the lowest groundwater elevations in late summer to fall and the highest in winter to spring.

The direction of groundwater flow is controlled by the topographic setting of Coffin Butte and Poison Oak Hill and the intervening low areas. Groundwater in the bedrock generally flows downslope from the hills until it reaches a groundwater divide near the southeast corner of Cell 1. At the divide, groundwater flows toward the east and west, generally following the long axes of the valleys. Groundwater flow direction in the saturated portion of the alluvium mimics the underlying bedrock.

Groundwater contours for the site are illustrated on Drawing GW-1 in Appendix A. The groundwater elevations are from wells that are screened either in the alluvium or the bedrock. With the relatively large topographic relief between wells, any vertical gradients (generally small) between hydrogeologic units at monitoring locations are not considered significant; therefore, they should not affect the site's groundwater flow pattern or horizontal gradients (hydrogeologic units were contoured separately in the Cell 3 characterization report [EMCON, 1999]). The estimated contours in this drawing are based on the groundwater elevations measured in site wells during April, 2020. The drawing can also be used to illustrate areas where there is the potential for groundwater to intersect the base of existing or planned landfill cells, as shown in the cross section on Drawing GW-2 in Appendix A.

7.2.3 Relationship of Hydrogeology to Landfill Development

The relationship of hydrogeologic units and the potentiometric surface at Coffin Butte is illustrated on Drawing GW-2 in Appendix A. Three hydrogeologic cross-sections are shown (there is no vertical exaggeration in the cross-sections [i.e. horizontal and vertical scales are the same]).

- Section A-A': Situated along the western end of Coffin Butte. This section shows the estimated thickness of waste in the closed landfill and the excavation for Cell 6.

- Section B-B': Aligned roughly north-south through the midpoint of Coffin Butte. This section shows the relationship of existing waste in Cell 1 to the excavation of Cell 6, which is north and upgradient of Cell 1.
- Section C-C': Follows a groundwater flowpath in the eastern part of the landfill. The section begins just over the crest of Coffin Butte and transverses the excavation of Cell 5, existing Cell 2, and planned Cell 4.

The cross-sections use information from the following sources:

- March 2021 topographic contours from aerial mapping for the existing grade.
- Base of excavations from the current site development plan drawings.
- Base of existing landfill for Cell 2 from engineering drawings, and for Cells 1 and the closed landfill from a 1975 site topographic map.

The geologic contacts are estimated from surface geologic mapping and from site boring logs.

Existing Cells

Groundwater is relatively shallow beneath older Cells 1 and 1A, as little as 10 feet below the base of waste in wet months, and in the case of the closed landfill, likely comes in contact with waste at least seasonally (EMCON, 1992, 1994c). With respect to each of these cells, excavation in Cell 6 should have a beneficial effect on groundwater quality.

As shown in Section B-B', the depth of excavation will effectively dewater the bedrock upgradient (north) of Cell 1, thus lowering the potential for seasonal high groundwater to percolate into the base of waste and generate leachate. In addition, lowering the groundwater table to this level will decrease the groundwater gradient immediately beneath the landfill, slow the groundwater flow, and further retard the migration of contaminants from this cell. Farther west, the Cell 6 excavation will remove the closed burn dump landfill waste (waste relocation will be completed in 2022) as well as part of the underlying rock (Section A-A'). This eliminates the primary source of contaminants in this part of the landfill and should promote rapid improvement in groundwater quality in this area.

Beneath most of Cell 2, groundwater is shallower than 10 feet below subgrade elevations, and in many areas comes in contact seasonally with the base of the liner system. Groundwater in the northern part of Cell 2 is controlled by an underdrain. It is not expected that the Cell 5 excavation will significantly affect groundwater levels beneath Cell 2 because the base elevation of the excavation is near the current elevation of groundwater upgradient of Cell 2 (see Section C-C'). Cell 4 was constructed over alluvium in an area of high groundwater. The groundwater elevation in this area is consistently measured near or above the ground surface. Groundwater beneath Cell 4 is controlled by an underdrain. Cell 5 is founded in bedrock volcanics with groundwater control by an underdrain.

Planned Cells

Cell 6 will be founded in the bedrock volcanics. Quarry excavations planned for Cell 6 cuts below the estimated potentiometric surface illustrated on the sections. This should depress the potentiometric surface in the upgradient direction, and shift the groundwater divide slightly to the north of its current position. Dewatering in the excavations should also decrease the groundwater gradient to the south. Groundwater in Cell 6 will also be controlled by an underdrain system.

7.3 Conceptual Monitoring Plan

Future environmental monitoring at the CBL will build on the existing framework of site knowledge as the landfill expands into adjacent areas. Overall, the goal of monitoring will remain essentially the same: to provide a means of detecting whether the landfill adversely affects environmental media. This section summarizes the objectives and strategies employed for the current program and then outlines aspects that will need to be addressed for monitoring in future phases of landfill development. The discussion focuses on water quality, which at the site includes groundwater, surface water, the secondary leachate collection system, and leachate. Landfill gas will continue to be monitored as is presently done, that is, at key points along the landfill perimeter and in site structures (landfill gas probe locations are shown on Drawing G02).

7.3.1 Current Program

The groundwater monitoring program was designed to address water quality conditions downgradient of:

- Older waste management units that have water quality impacts (Cells 1 and 1A, the closed burn dump landfill, and leachate lagoon).

- Newer lateral expansions (Cell 2, Cell 3, Cell 4, Cell 5, and future planned cells) that should have no water quality impacts, but whose groundwater could possibly be affected by past leachate irrigation or human activities.

The approach to monitoring in both areas is essentially the same: compare the monitoring results to numeric values (regulatory standards or site-specific limits), and assess longer-term geochemical trends.

The approach differs, however, in that for the older areas, some drinking water standards have been exceeded (e.g., for volatile organic compounds, chloride, and total dissolved solids) and the purpose of monitoring is thus to evaluate the stabilization and improvement of water quality. For the landfill cells on the east side (i.e., Cells 4 and 5), monitoring is more properly classified as detection monitoring-in essence, to identify whether the landfill adversely affects groundwater. The program for monitoring newer landfill sub-cells also integrates sampling the secondary leachate collection system and underdrains to provide a more immediate indication of potential releases to groundwater.

7.3.2 Conceptual Approach to Monitoring in Areas of Lateral Expansion

The basic elements of a monitoring strategy at the CBL need to consider the diverse groundwater quality between and within hydrogeologic units, and the progression of landfill development that ultimately results in one multiunit landfill with overlapping cells. Groundwater quality upgradient and downgradient of expansion areas is variable due to both natural water-rock interaction and to impacts from landfill operations (e.g., groundwater impacts associated with the closed burn dump landfill that are within and downgradient of planned Cell 6). The geometry of a multiunit landfill requires monitoring multiple cells with the same wells that may currently be used to monitor older, impacted areas of the landfill. This may create challenges in discerning whether newer landfill cells are adversely affecting previously impacted groundwater. Central to monitoring in this environment will be establishing a suitable baseline groundwater quality dataset at each of the compliance points. This data can then be used as part of intrawell comparisons at the compliance wells, which is the recommended approach to detection monitoring at the landfill.

For each of the major remaining cell development phases (Cells 5E and 6), the water quality monitoring program will involve sampling the groundwater, surface water, leachate, the secondary leachate collection system, and the underdrain. Specific details about the environmental monitoring plans and any changes to the network will be proposed closer to the time of cell development.

Cell 3

For the most part, Cell 3 is wedged between two existing landfill cells, and therefore monitoring was already in place. Before Cell 3A was constructed, a plan for monitoring was submitted to the DEQ (EMCON, 1998). The plan called for decommissioning six wells, installing two wells outside the Cell 3 footprint, and monitoring the Cell 3 secondary leachate collection system. Of these actions, two wells were decommissioned and two new wells were installed in 1999 (the wells remaining within the footprint were removed prior to construction of Cell 3C). In addition, baseline monitoring of the underdrain began before waste is placed in the cell.

Cell 4

Cell 4 extends east, and downgradient, of Cell 2. Monitoring for Cell 4 includes the following considerations:

- Relocated wells currently within the footprint to outside and downgradient of the cell (to the east).
- Begin baseline water quality monitoring at compliance well(s) to characterize natural groundwater variability. Use intrawell monitoring approach in this area because of the unique groundwater conditions at the compliance boundary. From historical monitoring results, groundwater east of this cell tends to be naturally elevated in inorganic compounds that contribute to total dissolved solids (e.g., sodium and chloride).
- Monitor the secondary leachate collection system and underdrain as part of detection monitoring.

Cell 5

Cell 5 is in an area where limited water quality monitoring data existed. In addition, the downgradient side of the cell abuts the upgradient (northern) sides of Cells 2D and 3, which limits compliance monitoring at its downgradient edge. Monitoring this area included the following:

- Relocate piezometers currently within the planned footprint upgradient to the north.

- Evaluate the need for a compliance well at the downgradient-southeast edge of the cell on the basis of groundwater flow direction.
- Begin baseline water level and water quality monitoring in piezometers.
- Monitor the secondary leachate collection system and underdrain as part of detection monitoring

Cell 6

Cell 6 is upgradient of existing Cells 1, 1A, and the closed landfill. As such, groundwater monitoring already takes place along most of the downgradient edge of this cell. Monitoring for this area will include the following:

- Decommission piezometers within the planned footprint of the cell. These are currently used to characterize baseline groundwater levels and water quality.
- Consider existing groundwater impacts associated with Cells 1, 1A, and the closed landfill, in developing the detection monitoring program.
- Establish monitoring along the northwest perimeter of the cell.
- Monitor the secondary leachate collection system and underdrain as part of detection monitoring.

8. Closure and End Use

Drawing C13 shows the final grading and drainage plan that would be achieved after final closure of the entire landfill. The contours are idealized 3 feet higher than the waste fill contours to represent the thickness of the final cover. In reality, the final contours will deviate from these idealized contours due to waste settlement.

The overall concept of the closure sequencing has not varied much from the Year 2011 Site Development Plan and the 2013 Amendment to the Site Development Plan. The outlines of the major closure sequencing zones are shown on Drawing C12 of Appendix A. Approximate areas of each of these zones are presented in Table 11. It is reasonable that the exact shape of these closure areas may differ somewhat from what is presented on this drawing, and that they may be phased in smaller or larger pieces based on areas that have reached final grades at the time of closure.

Table 11
Summary of Estimated Closure Areas

Closure Zone (see Drawing C12) (acres)	Plan-View Area (acres)
A	21.2
B	22.7
C	11.3
D	13.5
E	67.5
TOTAL	136.2

8.1 Closure

Existing final covers are installed over Cell 1A, the west half of Cell 1, the south slope of Cell 2, and the south slope of Cell 3 (see Drawing G02 in Appendix A). These covers incorporated a 60-mil geomembrane barrier layer overlain by either a 12-inch granular drainage layer or a geosynthetic drainage layer (Cell 3) with 18 inches of overlying planted vegetative soil. For Cell 1, which is an MSW cell, a gas-relief layer was also installed below the geomembrane. These covers, the oldest of which were installed in 1990 and 1996, have displayed excellent durability, with no erosion problems and little maintenance needs.

Closure activities are described in the site's Closure and Post-Closure Plan (GLA, 2020c). Final cover systems proposed for the future will be similar to the existing final covers, except that an 18-inch barrier soil having a maximum permeability of $1x10^{-5}$ cm/s will be placed just below the geomembrane to meet current Subtitle D requirements. A typical cross-sectional detail of the future proposed final cover system is shown in Detail 14 on Drawing C24 in Appendix A. The sequence for final cover installations is approximately indicated on Drawing C12.

8.2 Post-Closure

The final-closed surface of the completed landfill will appear to be a sloped grassy-savanna that blends with, and appears to be part of, the adjacent butte. A good example of this is the closure appearance of Cells 1 and 1A, parts of which have already been closed for more than three decades.

Post-closure maintenance activities are described in the site's Closure and Post-Closure Plan (GLA, 2020c), and include the following:

- LFG management
- Leachate collection and treatment
- Periodic monitoring of groundwater, surface water, and gas probes as required by the Closure Permit
- Inspection and maintenance of all stormwater drainage features
- Inspection and maintenance of final cover system items such as vegetation and settlement areas
- Up-keep of other miscellaneous site infrastructure such as active buildings, fences, and roads

9. Supporting Information

9.1 Local Government Endorsement – LUCS and Solid Waste Management Plan

Local government endorsement of the CBL is embodied in the county-issued Land Use Compatibility Statements (LUCS) and the local Solid Waste Management Plan. Copies of these documents are provided in Appendix G. Note that Benton County is in the process of updating its Solid Waste Management Plan.

9.2 Waste Reduction

Linn County, Benton County, Marion County, Lincoln County, and Washington County generate more than 75,000 tons of waste per year that is disposed at the CBL. The respective wasteshed material recovery rates and recovery rate goals for each of these counties are presented in the 2019 Oregon Material Recovery and Waste Generation Rates Report (ODEQ, 2021), included as Appendix H.

9.3 Other Permits

A list of all local, state, and federal permits required for the proposed development is as follows:

- State Solid Waste Permit #306
- NPDES Waste Discharge Permit #101545 (File #104176) (issued by state, pursuant to Federal Clean Water Act) – for discharges from the leachate treatment plant
- NPDES Stormwater Discharge Permit # 1200-Z (issued by state, pursuant to Federal Clean Water Act) – for surface water runoff from site
- Federal Fish and Wildlife Depredation Permit # MB005399-0, authorizing gull-control by shooting up to 50 gulls per year
- Oregon Title V Operating Permit for site air emissions

Copies of the permits, draft permits, or other relevant correspondence are included in Appendix I.

9.4 Statement of Need

The need for the continued development of the CBL is clearly demonstrated by its regional status, and historic service to Benton, Polk, Linn, Tillamook, Lincoln, Marion, and Lane counties. The landfill serves the region as a disposal resource for special wastes such as asbestos and petroleum-contaminated soils. In addition, the landfill occasionally serves as a valuable disposal resource for waste streams from other parts of the state, such as the cleanup of the Highway 99 fuel spill near the site entrance in 2017, waste diverted from the Riverbend landfill in 2019, and waste from fire debris cleanup in 2020.

10. Limitations

The data, analyses, results, and recommendations presented in this document pertain only to the CBL site in Corvallis, Oregon and assume that the conditions do not deviate substantially from those reported. If any variations or conditions are encountered that are materially inconsistent with those used in this document, or if the proposed development differs from that anticipated herein, GLA should be notified so that supplemental evaluations can be provided.

This document has not been prepared for use by parties or projects other than those named above. It may not contain sufficient information for other parties or other purposes. This document conforms to generally accepted civil, geotechnical, and environmental engineering practice and makes no other warranties, either expressed or implied, as to the professional advice or data included.

11. References

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