

# **Site Development Plan**

**For Knott Landfill and Recycle Center**

**Deschutes County, Oregon**

*Prepared for:*

**Deschutes County**

Department of Solid Waste

61000 SE 27th Street

Bend, Oregon 97702

Prepared by:

**URS Corporation**

225 NW Franklin Avenue, Suite A

Bend, Oregon 97701 - (541) 389-4091

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Lake Oswego, Oregon 97035 -(503) 635-1233

July 31, 2003



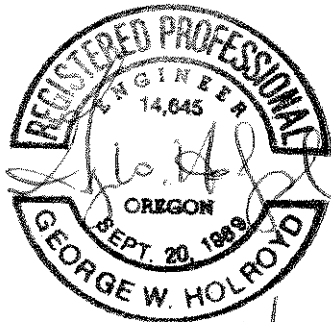
# Site Development Plan

## For Knott Landfill and Recycle Center

### Deschutes County, Oregon

July, 2003

The engineering material and data contained in this report was prepared under the supervision and direction of the undersigned, whose seal as an Oregon registered professional engineer is affixed below.



*renews 6/30/05*

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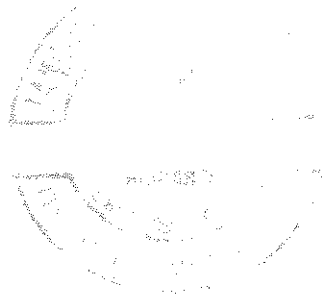
**URS Corporation**  
George Holroyd, P.E.  
Project Manager



*RENEWS 1/1/04*

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**G. Friesen Associates, Inc.**  
Gerald Friesen, P.E.  
Principal Engineer



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# References

David Evans and Associates, Inc. (DEA), 1994. Sample Protocol Report, Landfill Gas Survey. August.

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Spane, F.A. and Webber, W.D., 1995. Hydrochemistry and hydrogeologic conditions within the Hanford Site upper basalt confined aquifer system. Pacific Northwest Laboratory Report PNL-10817.

Su, G.W., Geller, J. T., Pruess, K., and Wen, F., 1999. Experimental studies of water seepage and intermittent flow in unsaturated, rough-walled fractures. *Water Resources Research*, V. 35, p. 1019-1037.

URS Corporation, 2002. 2002 Fall Monitoring Report, Knott Landfill, Deschutes County, Oregon. November.

URS Corporation, 2002. Environmental Monitoring Plan, Knott Landfill, Deschutes County, Oregon. June.

USEPA, 2000. Title 40—Protection of Environment. Chapter 1—Environmental Protection Agency. Part 264—Standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.





## **1.1 PURPOSE**

The purpose of this site development plan is to present the conceptual design for facilities that are planned for the Knott Landfill and Recycle Center and to document the design criteria and analyses that were utilized in its preparation. It is anticipated that this report will serve as the basis for the preparation of detailed design plans and specifications that are developed for new facilities in the future years.

## **1.2 BACKGROUND**

Deschutes County is currently permitted by the Oregon Department of Environmental Quality (DEQ) to dispose of solid waste on 69.2 acres at Knott Landfill in accordance with the provisions of Solid Waste Disposal Permit No. 6. If the landfill is developed in accordance with the currently approved plan, it is anticipated that the landfill will be filled to capacity on or before Year 2006.

In the fall of 2000, URS investigated the technical and financial feasibility of developing areas on the landfill site that are outside the current footprint and within the SM (surface mine) zone. The results of that study indicated it was economically feasible to develop the remaining SM zone as opposed to constructing a new regional disposal facility or shipping to another private facility.

The revised plan that is described in this site development plan proposes to laterally expand the footprint of the landfill to include all areas of the property within the SM zone. Currently, the County is planning to construct new support facilities to the north of the SM zone on a 70 acre parcel known as the North Area. Expansion of the landfill and the development of the North Area will provide an additional 26 years of disposal capacity for Deschutes County residents.

Development of the North Area and areas that are outside of the current footprint and within the SM zone has been approved by the Deschutes County Board of County Commissioners. Approval of the revised design for the landfill by DEQ is required. In order to review the proposed design, the DEQ is requiring a revised site development plan.

## **1.3 PROJECT TEAM**

In January of 2003, Deschutes County contracted with URS Corporation to assist in the preparation of a revised site development plan for the Knott Landfill and Recycle Center. For this project, URS teamed with G. Friesen and Associates (GFA) who serves as a subcontractor to URS.

## 1.4 PROJECT OBJECTIVES

The following objectives have been established by Deschutes County for the Knott Landfill and Recycle Center Site Development Plan Project:

- Amend the existing DEQ solid waste permit to reflect the full development of disposal capacity within the current surface mine (SM) zone;
- Amend the existing DEQ solid waste permit to reflect the movement and construction of new operational facilities north of the SM zone from locations currently within the SM zone;
- Construct and operate new facilities in a manner that complies with state and federal regulations and that will seek to meet recycling goals, prevent hazardous materials from entering the landfill and provide the public with a safe means for drop-off of refuse and recyclables;
- Have the next refuse cell (Cell 3) within the existing footprint area ready to accept refuse when needed, which is anticipated to be in the fall of 2004;
- Design a system that will enable the expansion and closure areas to be constructed incrementally as tipping fees are accumulated and additional landfill capacity is required;
- Develop a design and schedule for closure of Knott Landfill that will conform to DEQ regulations yet be flexible to accommodate a future end use that is yet to be determined;
- Manage and monitor environmental conditions at the landfill as it develops including landfill gas, groundwater, surface water and leachate; and
- Conform to state and federal rules regarding the operations, reporting and monitoring of a large landfill site.

## 1.5 REGULATORY REQUIREMENTS

### 1.5.1 State Regulations

Operations at the landfill are regulated by the Oregon DEQ, under Oregon Administrative Rule (OAR) Chapter 340, Divisions 93 through 97. The rule prescribes requirements, limitations, and procedures for storage, collection, transportation, and disposal of solid waste. For a site such as Knott Landfill and Recycle Center, the rule requires the person owning or controlling the site to

obtain a permit from the DEQ. A copy of the solid waste disposal permit for the landfill is included in Appendix 1a.

The permit limits municipal solid waste (MSW) disposal to the Phase I-B and II-B area (45.5 acres) and non-MSW disposal to the Phase III and non-MSW disposal area (23.7 acres). Prior to disposing of MSW outside of this footprint, the DEQ requires that a revised Site Development Plan for the landfill be approved.

### **1.5.2 Federal Regulations**

OAR Chapter 340, Division 94 incorporates by reference the criteria for municipal solid waste landfills (MSWLFs), prescribed by the United States Environmental Protection Agency (EPA) in Title 40, Code of Federal Regulations (CFR), Part 258 and any amendments or technical corrections thereto. These regulations, otherwise known as RCRA Subtitle D, will be adhered to at the Knott Landfill and Recycle Center site.

In the State of Oregon, DEQ has been approved by the EPA to administrate the RCRA Subtitle D rules. RCRA Subtitle D allows some flexibility within some of its provisions if alternatives that are proposed are approved by the Director of the DEQ.

## **1.6 SCOPE OF PLAN**

It is the intent of this site development plan to be in general accordance with the DEQ reporting guidelines as specified in Section 5 of the "Solid Waste Permit Guidance" document (dated September 1, 1996).

As requested in the guidance documents, this report is organized into the following sections:

- Facility Operation
- Site Development Plan
- Leachate Management Plan
- Surface Water Management Plan
- Landfill Gas Management Plan
- Environmental Monitoring
- Closure and End Use
- Other Permits
- Statement of Need



**Appendix 1a**  
**Solid Waste Disposal Permit**





# Oregon

John A. Kitzhaber, M.D., Governor

Department of Environmental Quality

400 E. Scenic Dr., Suite 307

The Dalles, OR 97058

(541) 298-7255

Eastern Region

Columbia Gorge Office

July 23, 2002

Timm Schimke, Director  
Deschutes County Department of Solid Waste  
61000 S.E. 27<sup>th</sup> Street  
Bend, OR 97702

Re: Knott Landfill  
SW Permit No. 6  
Deschutes County

Dear Mr. Schimke:

We did not receive any comments in response to the Department's proposed addendum to the Solid Waste Disposal Site Permit No. 6 for the Knott Landfill. Therefore, we have issued the enclosed permit addendum, which is a finalized version of the draft addendum transmitted to you by Department letter of May 17, 2002. You are urged to read the enclosed addendum carefully and comply with its conditions.

If you have any questions, please contact me in the Department's Columbia Gorge Office at 541/298-7255, ext. 22.

Sincerely,

Elizabeth Druback, Manager  
Solid Waste and Tanks  
Eastern Region

E:\WINWORD\IDESCHUTE\0216LTR07

Enclosure

Cc/enc: Larry Cwik, DEQ, Portland  
Don Bramhall, DEQ, Bend  
Joe Gingerich, DEQ, The Dalles







**SOLID WASTE DISPOSAL SITE PERMIT: Municipal Solid Waste Landfill**

Oregon Department of Environmental Quality  
400 E. Scenic Dr., Suite 307  
The Dalles, OR 97058  
Telephone: (541) 298-7255

Issued in accordance with the provisions of ORS Chapter 459

**ISSUED TO:**

Deschutes County Dept. of Solid Waste  
61000 S.E. 27th Street  
Bend, Oregon 97702

**FACILITY NAME AND LOCATION:**

Knott Landfill  
Section 14, T18S, R12E, W.M.  
Latitude: N44 Degrees, 00 Minutes, 43 Seconds  
Longitude: W121 Degrees, 15 Minutes, 10 Seconds

**OWNER:**

Deschutes County

**OPERATOR:**

Deschutes County Dept. of Solid Waste  
Telephone: (541) 317-3163  
Fax: (541) 317-3959  
E-Mail: timms@co.deschutes.or.us

**ISSUED IN RESPONSE TO:**

- a March 19, 2002 letter request from Deschutes County; and
- a Land Use Compatibility Statement from Deschutes County dated March 6, 2002.

**ISSUED BY THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY**

Elizabeth Druback  
Elizabeth Druback  
Manager, Solid Waste-Tanks Eastern Region

7/23/2002  
Date July 23, 2002

**ADDENDUM NO. 1**

In accordance with Oregon Administrative Rules 340-14-040, Solid Waste Disposal Site Permit No. 6 is hereby amended as follows:

- Subsection 5.2. (Authorized landfill area) is deleted and replaced with the following:

<b>Authorized landfill area</b>	This permit authorizes landfill development and operation within the "landfill footprint" identified in the: <ul style="list-style-type: none"> <li>• site development plan section of the April 11, 1996 <u>Engineering Report for Knott Landfill Upgrade and Closure Deschutes County, Oregon</u>; and</li> <li>• January 30, 2002 <u>Closure Plan for Knott Landfill – Area A</u>.</li> </ul>
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- Subsection 12.7 (Phase IB closure) is deleted and replaced with the following:

<b>Area A closure</b>	<p>Closure Area A includes the existing non-MSW footprint, Phase I-B, Cell 1 of Phase II-B and Phase III. These areas must be closed in accordance with this permit, and the January 30, 2002 <u>Closure Plan for Knott Landfill – Area A</u>, as approved by the Department.</p> <p>By November 1, 2003, the permittee must submit a work plan for conducting a demonstration project to show that that the conceptual alternative final cover system proposed for Area A closure will perform in accordance with applicable Federal and State closure criteria.</p>
-----------------------	---

This Addendum must be attached to and made part of Solid Waste Disposal Site Permit No. 6. The addendum is effective upon receipt.



**SOLID WASTE DISPOSAL SITE PERMIT: Municipal Solid Waste Landfill**

**Oregon Department of Environmental Quality  
400 E. Scenic Dr., Suite 307  
The Dalles, OR 97058  
Telephone: (541) 298-7255**

**Issued in accordance with the provisions of ORS Chapter 459 and  
subject to the land use compatibility statement referenced below.**

---

**ISSUED TO:**

Deschutes County Dept. of Solid Waste  
61000 S.E. 27th Street  
Bend, Oregon 97702

**FACILITY NAME AND LOCATION:**

Knott Landfill  
Section 14, T18S, R12E, W.M.  
Latitude: N44 Degrees, 00 Minutes, 43 Seconds  
Longitude: W121 Degrees, 15 Minutes, 10 Seconds

**OWNER:**

Deschutes County

**OPERATOR:**

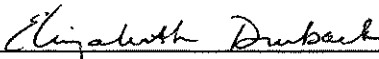
Deschutes County Dept. of Solid Waste  
Telephone: (541) 317-3163  
Fax: (541) 317-3959  
E-Mail: timms@co.deschutes.or.us

**ISSUED IN RESPONSE TO:**

- a solid waste permit renewal application received April 20, 2000; and
- a Land Use Compatibility Statement from Deschutes County dated June 6, 1995.

The determination to issue this permit is based on findings and technical information included in the permit record.

**ISSUED BY THE OREGON DEPARTMENT OF ENVIRONMENTAL QUALITY**

  
\_\_\_\_\_  
Elizabeth Druback  
Manager, Solid Waste-Tanks Eastern Region

8/10/01  
\_\_\_\_\_  
Date

---

**Permitted Activities**

Until such time as this permit expires or is modified or revoked, the permittee is authorized to operate, close, and maintain a solid waste land disposal site in conformance with the requirements, limitations, and conditions set forth in this document including all attachments.



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**Introduction** This document is a solid waste permit issued by the Oregon Department of Environmental Quality in accordance with Oregon Revised Statutes (ORS) 459 and Oregon Administrative Rules (OAR), Chapter 340.

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## PERMIT ADMINISTRATION

### 1.0 ISSUANCE

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1.1	<b>In this section</b>	This section describes the parameters surrounding permit issuance, including the following information: <ul style="list-style-type: none"><li>• Permittee</li><li>• Permit number</li><li>• Permit term</li><li>• Facility type</li><li>• Facility owner/operator</li><li>• Basis for issuance, and</li><li>• Definitions</li></ul>		
1.2	<b>Permittee</b>	This permit is issued to Deschutes County Dept. of Solid Waste.		
1.3	<b>Permit number</b>	This permit will be referred to as Solid Waste Permit Number 6.		
1.4	<b>Permit term</b>	The issue date of this permit is the date this document is signed. The expiration date of this permit is September 1, 2010.		
1.5	<b>Facility type</b>	The facility is permitted as a municipal solid waste landfill.		
1.6	<b>Facility owner/operator</b>	<table><tr><td>The owner of this facility is: Deschutes County</td><td>The operator of this facility is: Deschutes County Dept. of Solid Waste Telephone: (541) 317-3163 Fax: (541) 317-3959</td></tr></table>	The owner of this facility is: Deschutes County	The operator of this facility is: Deschutes County Dept. of Solid Waste Telephone: (541) 317-3163 Fax: (541) 317-3959
The owner of this facility is: Deschutes County	The operator of this facility is: Deschutes County Dept. of Solid Waste Telephone: (541) 317-3163 Fax: (541) 317-3959			
1.7	<b>Basis for issuance</b>	This permit is issued based upon the following documents submitted by the permittee: <ul style="list-style-type: none"><li>• a solid waste permit renewal application received April 20, 2000; and</li><li>• a Land Use Compatibility Statement from Deschutes County dated June 6, 1995.</li></ul>		
1.8	<b>Definitions</b>	Unless otherwise specified, all terms are as defined in OAR 340-093-0030.		

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## 2.0 DISCLAIMERS

2.1	<b>In this section</b>	This section describes disclaimer information for the Department, including: <ul style="list-style-type: none"><li>• Property rights, and</li><li>• Department liability.</li></ul>
2.2	<b>Property rights</b>	The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights.
2.3	<b>Department liability</b>	The Department, its officers, agents, or employees do not sustain any liability on account of the issuance of this permit or on account of the construction, maintenance, or operation of facilities pursuant to this permit.

## 3.0 AUTHORITY

3.1	<b>In this section</b>	This section describes the authority of the Oregon Department of Environmental Quality to issue this permit, including the following information: <ul style="list-style-type: none"><li>• 10 year permit</li><li>• Documents superseded</li><li>• Binding nature</li><li>• Other compliance, and</li><li>• Penalties</li></ul>
3.2	<b>Ten year permit</b>	This permit is issued for a maximum of 10 years as authorized by Oregon Revised Statutes 459.245 (2).
3.3	<b>Documents superseded</b>	This document is the primary solid waste permit for the facility, superseding all other solid waste permits issued for Knott Landfill by the Department.
3.4	<b>Binding nature</b>	Conditions of this permit are binding upon the permittee. The permittee is liable for all acts and omissions of the permittee's contractors and agents.
3.5	<b>Other compliance</b>	Issuance of this permit does not relieve the permittee from the responsibility to comply with all other applicable federal, state, or local laws or regulations. This includes the following solid waste requirements, as well as all updates or additions to these requirements: <ul style="list-style-type: none"><li>• solid waste permit application received April 20, 2000 ;</li><li>• Oregon Revised Statutes, Chapters 459 and 459A;</li><li>• Oregon Administrative Rules Chapter 340, and</li><li>• Any documents submitted by the permittee and approved by the Department.</li></ul>





**3.6 Penalties** Violation of permit conditions will subject the permittee to civil penalties of up to \$10,000 for each day of each violation.

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## **4.0 PERMIT MODIFICATION**

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**4.1 In this section** This section describes information about modification of this permit, including:

- 5 year review
- Modification
- Modification by Department
- Modification by permittee
- Public participation, and
- Changes in ownership

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**4.2 Five year review** Between the 4th and 6th year of the life of the permit, the Department may review the permit and determine whether or not the permit should be amended.

While not an exclusive list, the following factors will be used in making that determination:

- compliance history of the facility;
  - changes in volume, waste composition, or operations at the facility;
  - changes in state or federal rules which should be incorporated into the permit;
  - a significant release of leachate or landfill gas to the environment from the facility;
  - significant changes to a Department-approved site development plan, and/or conceptual design;
  - changes in environmental monitoring.
- 

**4.3 Modification** At any time in the life of the permit, the Department or the permittee may propose changes to the permit.

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**4.4 Modification and revocation by Department** The Director may, at any time before the expiration date, modify, suspend, or revoke this permit in whole or in part, in accordance with Oregon Revised Statutes 459.255, for reasons including but not limited to the following:

- violation of any terms or conditions of this permit or any applicable statute, rule, standard, or order of the Commission;
- obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or
- a significant change in the quantity or character of solid waste received or in the operation of the disposal site.

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**4.5 Modification by permittee** The permittee must apply for a modification to this permit if there is a significant change in facility operations or a deviation from activities described in this document.

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- 4.6 **Public participation** Significant changes in the permit will be made public by the issuance of a public notice as required by Department rules.
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- 4.7 **Changes in ownership** The permittee must report to the Department any changes in either ownership of the disposal site property or of the name and address of the permittee or operator within ten (10) days of the change.
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### ALLOWABLE ACTIVITIES

#### 5.0 AUTHORIZATIONS

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- 5.1 **In this section** This section describes the activities the permittee is authorized to conduct, including:
- Authorized landfill area
  - Wastes authorized for receipt
  - Authorization of other waste
  - Authorization of activities
  - Composting, and
  - Salvaging and recycling
- 
- 5.2 **Authorized landfill area** This permit authorizes landfill development and operation within the "landfill footprint" identified in the site development plan section of the Engineering Report for Knott Landfill Upgrade and Closure Deschutes County, Oregon, dated April 11, 1996.
- 
- 5.3 **Wastes authorized for receipt** This permit authorizes the facility to accept solid waste as defined in OAR 340-093-0030(81) except nondigested sewage sludges, septic tank pumpings and waste containing "free liquids" as defined by EPA Method 9095. The following specific solid waste are included in this authorization:
- Asbestos waste if managed in accordance with Subsection 9.7;
  - Household paint waste if managed in accordance with Subsection 9.8;
  - Cleanup materials contaminated by hazardous substances (e.g. such as petroleum contaminated soils) if managed in accordance with Subsection 9.9;
  - Waste tires if managed in accordance with Subsection 9.10;
  - Empty rigid pesticide containers if managed in accordance with Subsection 9.11; and
  - Infectious waste sharps if managed in accordance with Subsection 9.12.
- 
- 5.4 **Authorization of other wastes** Wastes excluded from the above authorization may be authorized for acceptance if:
- the permittee develops a special waste management plan and submits it to the Department for approval;
  - the Department approves the special waste management plan; and
  - the permittee can demonstrate that the materials do not constitute hazardous waste, as defined by state and federal regulations.
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5.5	<b>Authorization of activities</b>	All facility activities are to be conducted in accordance with the provisions of this permit. All plans required by this permit become part of the permit by reference once approved by the Department. Any conditions of the approval are also incorporated into this permit unless contested by the permittee within 30 days of the receipt of a conditional approval.
5.6	<b>Composting</b>	The permittee is authorized to compost green feedstocks and incidental amounts of amendments as provided for in the most current version of Solid Waste General Permit, Composting Facilities, Permit No. C2, initially issued on April 8, 1998.
5.7	<b>Salvaging and recycling</b>	Salvaging and recycling are authorized if conducted in a controlled and orderly manner.

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## 6.0 PROHIBITIONS

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6.1	<b>In this section</b>	This section describes specific activities the permittee is prohibited from conducting, including: <ul style="list-style-type: none"><li>• Hazardous waste disposal</li><li>• Liquid waste disposal</li><li>• Vehicle disposal</li><li>• Used oil disposal</li><li>• Battery disposal</li><li>• Tire disposal</li><li>• Recyclable material disposal</li><li>• Open burning, and</li><li>• Large appliance disposal</li></ul>
6.2	<b>Hazardous waste disposal</b>	The permittee must not accept hazardous wastes, including hazardous wastes from conditionally-exempt small quantity generators.  <u>Reference:</u> Hazardous wastes are defined in ORS 466.005 and OAR 340 Division 101.
6.3	<b>Liquid waste disposal</b>	The permittee must not accept liquid waste for disposal.  <u>Definition:</u> Liquid wastes are wastes that do not pass the paint filter test performed in accordance with EPA Method 9095 (Paint Filter Liquids Test), as described in <u>Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods</u> , EPA Pub. No. SW-846.
6.4	<b>Vehicle disposal</b>	The permittee must not accept discarded or abandoned vehicles for disposal.

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6.5	<b>Used oil disposal</b>	The permittee must not accept used oil for disposal.
6.6	<b>Battery disposal</b>	The permittee must not accept lead-acid batteries for disposal.
6.7	<b>Tire disposal</b>	The permittee must not dispose of whole tires unless the tires are exempt from OAR 340-064-0052(1) banning whole tire disposal.
6.8	<b>Recyclable material disposal</b>	<p>The permittee must not landfill or dispose of any source separated recyclable material brought to the disposal site.</p> <p><u>Exception:</u> If the source separated material is determined to be in a condition which makes the material unusable or not recyclable then it may be landfilled. This determination must be made after consultation with the Department.</p>
6.9	<b>Open burning</b>	The permittee must not conduct any open burning at the site.
6.10	<b>Large appliance disposal</b>	The permittee must not dispose of large metal jacketed residential, commercial, and industrial appliances such as refrigerators, washers, stoves, and water heaters.

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## OPERATIONS AND DESIGN

### 7.0 OPERATIONS PLAN

**7.1 In this section** This section describes the requirements associated with a facility Operations Plan, including:

- Operations Plan
- Plan content
- Operations and Maintenance Manual
- Plan and Manual maintenance
- Plan compliance, and
- Submittal address

**7.2 Operations Plan** Within 360 days of the permit issue date, the permittee must update and submit the site Operations Plan to the Department for approval. Upon approval, this plan is incorporated into this permit by reference.

**7.3 Plan content** The Operations Plan must describe the operation of the disposal site in accordance with relevant Department-approved plans, and all regulatory and permit requirements, including the following:

Content area	Describe plans for
General operations	<ul style="list-style-type: none"> <li>• handling and removal of unauthorized wastes discovered at the facility</li> <li>• management of landfill gas</li> <li>• management of landfill leachate</li> <li>• surface water and erosion control structure design</li> <li>• non-compliance response</li> </ul>
Disposal operations	<ul style="list-style-type: none"> <li>• placement of daily and interim cover</li> <li>• detecting and preventing the disposal of regulated hazardous wastes, polychlorinated biphenyl wastes, and any other unacceptable wastes as determined by the Department</li> <li>• disposal of putrescible wastes</li> <li>• disposal of cleanup materials contaminated with hazardous substances</li> <li>• fill progression and phasing</li> </ul>
Special waste management plan	<ul style="list-style-type: none"> <li>• identifying and characterizing wastes which require special management or waste streams not otherwise authorized by the permit</li> <li>• identifying the source of all special wastes</li> <li>• determining appropriate handling procedures</li> <li>• documenting plan implementation, including waste characterization</li> </ul>

References: OAR 340-093-0190, OAR 340-094-0040[11][b][J]





Ancillary operations	<ul style="list-style-type: none"> <li>• handling and removal of waste tires</li> <li>• management of transfer containers</li> </ul>
Inspection and maintenance	<ul style="list-style-type: none"> <li>• washing equipment</li> <li>• maintaining leachate and gas collection systems</li> <li>• maintaining surface water control structures</li> </ul>
Operating record	<ul style="list-style-type: none"> <li>• operating record location</li> </ul>
Contingency	<ul style="list-style-type: none"> <li>• providing fire protection equipment</li> <li>• notification of emergencies and fires to Department</li> </ul>

Reference: OAR 340-094-0040 describes requirements for preparation of an Operations Plan.

**7.4 Operations and Maintenance Manual** Within 90 days of approval of the Operations Plan, the permittee must prepare an updated Operations and Maintenance (O&M) Manual which describes specific procedures for conducting routine and emergency operations at the site. A copy of the O&M Manual must be maintained in the Operating Record location and be available for Department review.

Reference: The Department's *Solid Waste Guidance* document describes the Department's expectations for the O&M Manual.

**7.5 Plan and Manual maintenance** The permittee must revise both the Operations Plan and the O&M Manual as necessary to keep them current and reflective of current facility conditions and procedures.  
 The permittee must submit Operations Plan revisions to the Department for approval.

**7.6 Plan compliance** The permittee must conduct all operations at the facility in accordance the Department issued Solid Waste Disposal Site Permit and with the approved Operations Plan, including any amendments.

**7.7 Submittal address** All submittals to the Department under this section must be sent to:  
 Oregon Department of Environmental Quality  
 Manager, Solid Waste Program  
 400 E. Scenic Dr., Suite 307  
 The Dalles, OR 97058  
 Telephone: (541) 298-7255

**8.0 RECORDKEEPING AND REPORTING - OPERATIONS**





- 8.1 In this section** This section describes recordkeeping and reporting operational information for the facility, including:
- Non-compliance reporting
  - Permit display
  - Access to records
  - Procedure, and
  - Submittal address
- 8.2 Non-compliance reporting** In the event that any condition of this permit or of the Department's rules is violated, the permittee must immediately take action to correct the unauthorized condition and immediately notify the Department at:
- (541)388-6146
- Response:** In response to such a notification, the Department may conduct an investigation to evaluate the nature and extent of the problem, and to evaluate plans for additional corrective actions, as necessary.
- 8.3 Permit display** The permittee must display this permit or a photocopy thereof, where it can be readily referred to by operating personnel.
- 8.4 Access to records** Upon request, the permittee must make all records and reports related to the permitted facility available to the Department.
- 8.5 Procedure** The permittee must keep records and submit reports according to the following:

Step	Action
1	Establish a location for the Operating Record at the facility or another location mutually agreed with the Department.
2	Place information required by 40 CFR 258.29 in the Operating Record.
3	Collect information during facility operations on the amount of each type of solid waste received, recording "0" if the waste is not received. At a minimum, the following types of waste must be separately identified, and be categorized as being either in- or out-of-state wastes: <ul style="list-style-type: none"><li>• municipal solid waste</li><li>• industrial solid waste</li><li>• contaminated cleanup material, including petroleum-contaminated soil</li><li>• approved alternative daily cover</li></ul>
4	Collect information about the amount of each material recovered for recycling or other beneficial purpose each quarter





5	Submit the information collected in Step 3 above on the Solid Waste Disposal Report/Fee Calculation form provided by the Department. Pay solid waste fees as required by OAR 340-097. <u>Date due:</u> the last day of the month following the end of the calendar quarter
6	Submit the information collected in Step 4 above, on a form provided or approved by the Department, to the watershed representative. <u>Date due:</u> January 25 <sup>th</sup> of each year
7	Retain copies of all records and reports for five years from the date created.
8	Update all records such that they reflect current conditions at the facility.

**8.6 Submittal address**

All submittals to the Department under this section must be sent to:  
Oregon Department of Environmental Quality  
Waste Prevention and Management Division  
Solid Waste Program  
811 S.W. Sixth Ave.  
Portland, OR 97204  
(503)229-5913

**9.0 SPECIFIC OPERATING CONDITIONS**





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<b>9.1 In this section</b>	<p>This section describes specific conditions to which site operations must conform, including:</p> <ul style="list-style-type: none"><li>• Discovery of prohibited wastes</li><li>• Daily cover</li><li>• Interim cover</li><li>• Surface water structures</li><li>• Stormwater management</li><li>• Asbestos waste</li><li>• Household paint waste</li><li>• Cleanup material contaminated with hazardous substances</li><li>• Waste tires</li><li>• Empty rigid pesticide containers</li><li>• Infectious waste sharps</li><li>• Leachate management systems</li><li>• Litter control</li><li>• Vector control</li><li>• Air Emissions</li><li>• On-site roads</li><li>• Landfill gas management</li><li>• Access control, and</li><li>• Fire prevention, control, and notification</li></ul>
<b>9.2 Discovery of prohibited waste</b>	<p>Any solid wastes discovered at the facility which appear to be prohibited waste must be isolated or removed immediately. Non-hazardous prohibited waste must, within 48 hours, be transported to a disposal site authorized to accept such waste, unless otherwise approved by the Department.</p> <p>In the event discovered wastes are hazardous or suspected to be hazardous, the permittee must, within 7 days, notify the Department and initiate procedures to identify and remove the waste. Hazardous wastes must be removed within 90 days, unless otherwise approved by the Department. Temporary storage and transportation must be carried out in accordance with the rules of the Department.</p>
<b>9.3 Daily cover</b>	<p>At a minimum, all solid wastes must be covered with a layer of six inches of compacted soil or an approved alternative daily cover of equivalent performance at the end of each working day.</p>
<b>9.4 Interim cover</b>	<p>Interim cover must be constructed and maintained as specified in Department-approved design and Operations Plans. Interim cover must be constructed over fill areas which will not receive additional waste for an extended period of time (i.e., greater than 120 days), and interim cover that is to remain exposed for more than one year must be actively revegetated as approved by the Department.</p>

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9.5 Surface water structures	All stormwater drainage structures must be maintained in good functional condition. Any significant damage must be reported to the Department and repairs made as soon as possible.
9.6 Stormwater management	The permittee shall manage stormwater onsite by directing stormwater and surface water runoff to the constructed stormwater evaporation ponds.
9.7 Asbestos waste	Off loading and disposal of friable asbestos-containing solid waste must be conducted as specified in the Department-approved Operations Plan, and in accordance with OAR 340-248.
9.8 Household paint waste	<p>In accordance with the approved Operations Plan, household-generated latex and oil-based paint waste may be stored and accumulated for up to one year's time, or until sufficient volumes exist (approx. 51 cubic yards) to complete a full shipment for recycling and/or processing.</p> <p>The paint shall be stored in a covered storage facility with spill containment.</p> <p>Releases of paint shall be immediately cleaned up and properly disposed.</p> <p>The permittee shall report to the Department annually, in the Recycling Collectors Survey:</p> <ul style="list-style-type: none"><li>• the amount of paint shipped for recycling or processing;</li><li>• the name of the company(ies) to which the paint was shipped for recycling or processing; and</li><li>• year ending and beginning inventories if any.</li></ul>
9.9 Cleanup material contaminated with hazardous substances	Cleanup materials contaminated with hazardous substances (such as petroleum-contaminated soils) shall not be disposed of except in accordance with either the approved Operations Plan or a special waste management plan approved by the Department, and after payment of the applicable fee.

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**9.10 Waste Tires**

The facility may accept up to 100 whole tires for storage and removal.

The facility may accept up to 2,000 whole tires for storage and removal if the permittee maintains a continuous contract with a waste tire carrier to remove the tires from the site.

Tires may be disposed of in the landfill only in accordance with the approved Operations Plan, and if the tires are:

- chipped in accordance with standards established under OAR 340-064-0052(2).
- from vehicles not normally used on highways and the tires have been determined to be exempt from OAR 340-064-0052(1) banning whole tire disposal.

**9.11 Empty rigid pesticide containers**

Empty rigid pesticide containers may be accepted for disposal or recovery in accordance with the approved Operations Plan, if they have been properly decontaminated by jet or multiple rinsing or other methods in accordance with OAR 340-109-020, and altered. Alteration consists of puncturing or removing both ends and crushing the container, except that:

- 30-gallon or larger containers shall be punctured or have their ends removed but need not be crushed;
- Containers to be beneficially used or reused need not be altered if alteration would interfere with such use or reuse; and
- Gas cylinders shall be altered by removing the closure valve or valve stem to ensure venting.

**Note:** Extreme caution should be exercised in altering containers having held flammable pesticides or solvents.

**9.12 Infectious waste sharps**

"Sharps" are an infectious waste which may be received if they have been treated by being placed in a leak-proof, rigid, puncture-resistant, red container that is taped closed or tightly lidded to prevent loss of the contents. They may be disposed of only in a segregated, dedicated, clearly marked and documented location in accordance with the approved Operations Plan. Disposal at the asbestos disposal location is acceptable practice.

**9.13 Leachate management systems**

The permittee must operate the disposal site in a manner that deters unauthorized leachate production to the maximum extent practicable. The permittee must construct, operate and maintain in good functional condition all leachate containment, collection, detection, removal, storage and treatment systems approved by the Department. Leachate must be continuously removed from all landfill leachate collection systems, such that hydraulic head on the bottom liner is minimized and does not exceed one (1) foot.





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|-------------|-----------------------|---|
| <b>9.14</b> | <b>Litter control</b> | The permittee must implement procedures which minimize the scattering of windblown litter and provide for effective and timely collection of litter to ensure the appearance of a well-maintained facility and prevent nuisance conditions. |
|-------------|-----------------------|---|
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| <b>9.15</b> | <b>Vector control</b> | The permittee must implement procedures that minimize insects, rodents, and birds at the active disposal area. |
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| <b>9.16</b> | <b>Air emissions</b> | Air emissions (dust, malodors, air toxics, etc.) from construction, operation and all other activities at the disposal site must be controlled in compliance with Oregon air quality standards. |
|-------------|----------------------|---|
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|-------------|----------------------|---|
| <b>9.17</b> | <b>On-site roads</b> | Roads from the landfill property line to the active disposal area and environmental monitoring locations must be constructed and maintained to minimize traffic hazards, dust and mud, and to provide reasonable all-weather vehicle access to active disposal units. |
|-------------|----------------------|---|
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|-------------|--------------------------------|---|
| <b>9.18</b> | <b>Landfill gas management</b> | Landfill gas must be controlled in accordance with the requirements of 40 CFR Parts 51, 52 and 60. Landfill gas collection, containment, removal and treatment systems must be maintained in good functional condition. |
|-------------|--------------------------------|---|
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|-------------|-----------------------|--|
| <b>9.19</b> | <b>Access control</b> | Public access to the disposal site shall be controlled as necessary to prevent unauthorized entry and dumping. |
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|-------------|---|---|
| <b>9.20</b> | <b>Fire prevention, control, and notification</b> | The permittee must provide complete and sufficient fire protection equipment and facilities in accordance with the approved Operations Plan. Arrangements shall be made with the local fire control agency to facilitate immediate service when needed. Preventative measures to ensure adequate on-site fire control, as determined by the local fire control agency, shall be implemented. Any significant fire requiring notification to the fire department must be reported immediately to the Department's Bend office at 388-6146. All other fires must be reported to the Department within 8 hours of discovery. |
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## 10.0 SITE DEVELOPMENT AND DESIGN

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- 10.1 **In this section** This section describes site development and design requirements for continued use of the landfill, or any landfill expansion or new facility construction, including:
- Site development plan
  - Baseline design criteria
  - Design plans
  - Construction requirements
  - Construction documents
  - Construction inspection
  - Construction report submittal
  - Construction report content
  - Approval to use, and
  - Submittal address
- 
- 10.2 **Site Development Plan** Unless otherwise approved in writing by the Department, site development shall progress in accordance with the site development plan section of *Engineering Report for Knott Landfill Upgrade and Closure Deschutes County, Oregon*, April 11, 1996.
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**10.3 Baseline design criteria**

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Conceptual and detailed plans submitted for a new MSW landfill disposal unit pursuant to this permit must, at a minimum, provide for:

- A composite liner system which includes an approved geomembrane liner (not less than 60 mils in thickness when using high density polyethylene, and not less than 30 mils of thickness for other types of approved geomembranes) and at least two feet of compacted soil having an in-place permeability no greater than  $1 \times 10^{-7}$  cm/sec, or an alternative liner approved by the Department pursuant to 40 CFR Part 258.40(a)(1).
- A primary leachate collection and removal system (LCRS) which fully covers the liner system. As required by 40 CFR 258.40(a)(2), the primary LCRS must function to maintain less than a one (1) foot depth of leachate over the liner. All leachate collection pipes must be serviceable by clean out.
- A secondary leachate collection and removal system(s) designed to effectively monitor the performance of the overlying composite liner system. The secondary leachate collection and removal system(s) must, at a minimum, be: (1) capable of detecting and collecting leachate at locations of maximum leak probability; and (2) hydraulically separated from groundwater to prevent erroneous monitoring results caused by infiltrating groundwater.
- A leachate collection sump(s) having two composite bottom liners and a leak detection and removal system. Each composite liner must meet the minimum composite liner criteria described above in this subsection, or equivalent.
- Construction of an appropriate operations layer above the primary LCRS, to protect the LCRS and liner system from damage.
- If applicable, appurtenant leachate storage impoundments must be constructed with two liners and a leak detection and removal system. One liner must meet the minimum composite liner criteria described above in this subsection.

**10.4 Design plans**

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The permittee must submit engineering design plans for new disposal units, closure of existing units, or other ancillary facilities for Department review and approval at least six months prior to the anticipated construction date. The design plans must be prepared and stamped by a qualified professional engineer with current Oregon registration.

The engineering design plans must:

- specify applicable performance criteria, construction material properties and characteristics, dimensions, and slopes, and
- provide all relevant engineering analyses and calculations as a basis for the design.

**Reference:** Following the Department's current Solid Waste Guidance document will expedite Department review of the design plans.

**10.5 Construction requirements**

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The permittee must perform all construction in accordance with approved plans and specifications, including all conditions of approval, and any amendments to those plans and specifications approved in writing by the Department.

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- 10.6 **Construction documents** Prior to construction of the final landfill cover, a new landfill disposal unit, or other waste containment unit at the site, the permittee must submit and receive written Department approval of complete construction documents for the project to be constructed. The construction documents submitted must:
- define the construction project team;
  - include construction contract documents specifying material and workmanship requirements to guide how the Constructor is to furnish products and execute work, and
  - include a Construction Quality Assurance (CQA) plan, describing the measures taken to monitor that the quality of materials and the work performed by the Constructor complies with project specifications and contract requirements.
- Reference:** Following the Department's current Solid Waste Guidance document will expedite Department review of the construction documents.
- 
- 10.7 **Construction inspection** During construction of a new landfill disposal unit, liner system, intermediate cover system, final cover system, or a major appurtenant facility, the permittee must provide the Department with a summary and schedule of planned construction activities in order to facilitate Department inspection during periods of construction.
- 
- 10.8 **Construction report submittal** Within 90 days of completing construction of a waste containment unit (e.g., such as a landfill disposal unit or leachate storage impoundment), a final cover system over an existing or new unit, or a major appurtenant facility, the permittee must submit to the Department a Construction Certification Report prepared by a qualified independent party, to document and certify that all required components and structures have been constructed in compliance with the permit requirements and approved design specifications.
-



**10.9 Construction report content**

The construction report must include:

- an executive summary of the construction project and any major problems encountered;
- a list of the governing construction documents;
- a summary of all construction and CQA activities;
- manufacturers certifications for conformance of all geosynthetic materials with project specifications;
- test data documenting soil materials conformance with project specifications;
- a summary of all CQA observations, including daily inspection records and test data sheets documenting materials deployment and installation in conformance with project specifications;
- problem identification and corrective measures implemented;
- designer acceptance reports for errors and inconsistencies;
- a list of deviations from design and material specifications, including documentation justifying the deviations, copies of change orders and recorded field adjustments, and copies of written Department approvals for deviations and change orders;
- signed certificates for subgrade acceptance prior to placement of soil liner and for acceptance of soil liner prior to deployment of geomembrane liner, and
- photographs and as-constructed drawings, including record surveys of subgrade, soil liner, granular drainage layer and protective soil layer, and a certification statement(s) and signatures legally representing the CQA consultant, designer and facility owner, one of which is that of a professional engineer with current Oregon registration.

**10.10 Approval to use**

The permittee must not dispose of solid waste in newly constructed disposal units until the Department has accepted the Construction Certification. If the Department does not respond to the Construction Certification Report within 30 days of receiving the Construction Certification Report, the permittee may place waste in the unit.

**10.11 Submittal address**

All submittals to the Department under this section must be sent to:  
Oregon Department of Environmental Quality  
Manager, Solid Waste Program  
400 E. Scenic Dr., Suite 307  
The Dalles, OR 97058  
Telephone: (541) 298-7255



## 11.0 RECYCLING REQUIREMENTS

<b>11.1 In this section</b>	This section describes the requirements associated with recycling operations of source separated materials conducted at the facility: <ul style="list-style-type: none"><li>• Materials</li><li>• Receiving location</li><li>• Material use</li><li>• Recycling information</li><li>• Sign</li><li>• Storage</li></ul>
<b>11.2 Materials</b>	The permittee must provide a place for receiving the following recyclable materials: <ul style="list-style-type: none"><li><input checked="" type="checkbox"/> ferrous scrap metal</li><li><input checked="" type="checkbox"/> motor oil</li><li><input checked="" type="checkbox"/> newspaper</li><li><input checked="" type="checkbox"/> container glass</li><li><input checked="" type="checkbox"/> hi-grade office paper</li><li><input checked="" type="checkbox"/> non-ferrous scrap metal (including aluminum)</li><li><input checked="" type="checkbox"/> corrugated cardboard and kraft paper (brown paper bags)</li><li><input type="checkbox"/> tin cans</li></ul>
<b>11.3 Receiving location</b>	The place for receiving recyclable material must be located at the disposal site or at another location more convenient to the population served by the disposal site. The recycling center must be available to every person whose solid waste enters the disposal site.
<b>11.4 Material use</b>	All source separated recyclable materials must be reused or recycled.
<b>11.5 Recycling information</b>	The permittee must provide recycling information to disposal site users on printed handbills which includes the following: <ul style="list-style-type: none"><li>• the location of the recycling center at the disposal site or another location;</li><li>• the hours of operation of the recycling center;</li><li>• instructions for correct preparation of accepted source separated recyclable material;</li><li>• the material accepted for recycling, and</li><li>• reasons why people should recycle.</li></ul>
<b>11.6 Sign</b>	A sign must be prominently displayed which indicates: <ul style="list-style-type: none"><li>• the availability of recycling at the disposal site or another location;</li></ul> <p><u>Note:</u> the sign must indicate the recycling center location, if not at the disposal site</p> <ul style="list-style-type: none"><li>• the materials accepted at the recycling center, and</li><li>• the hours of operation of the recycling center (if different than disposal site hours).</li></ul>





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11.7 Storage All recyclable materials, except car bodies, white goods and other bulky items, must be stored in containers unless otherwise approved by the Department.

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## SITE CLOSURE

### 12.0 CLOSURE CONSTRUCTION AND MAINTENANCE

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12.1	In this section	This section describes requirements for closure construction and maintenance at the facility, including: <ul style="list-style-type: none"><li>• Worst-case plan development</li><li>• Notification</li><li>• Closure permit</li><li>• Closure plan approval</li><li>• Closure schedule</li><li>• Phase IB closure</li><li>• Final cover</li><li>• Vegetation</li><li>• Final cover maintenance</li><li>• Deed record. And</li><li>• Submittal address</li></ul>
12.2	Worst-case plan development	The permittee must maintain an up-to-date conceptual "worst-case" closure plan and a conceptual post-closure plan. The plans must be placed in the facility file. Reference: The plans must comply with 40 CFR, Part 258, Subpart F, and OAR 340-094-0110.
12.3	Notification	The permittee must notify the Department when the conceptual "worst-case" closure and conceptual post-closure care plans are updated and placed in the file.
12.4	Closure permit	At least five (5) years prior to the anticipated final closure of the landfill, the permittee must apply for a closure permit in accordance with OAR 340-094-0100.
12.5	Closure plan approval	At least 6 months prior to final closure of any portion of the landfill, the permittee must submit for approval detailed engineering plans, specifications, and a schedule for closure. Reference: The current <i>Solid Waste Guidance</i> provides information on applicable elements of a Closure Plan. Following the organizational format provided in the Guidance will expedite Department review of the plan.
12.6	Closure schedule	The permittee must initiate and complete closure of each landfill disposal unit in accordance with 40 CFR 258.60(f)&(g), or an alternate schedule approved by the Department.

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<b>12.7 Phase IB closure</b>	<p>Prior to September 30, 2001, the permittee shall submit to the Department a detailed report evaluating the interim cover on Phase IB, and proposing any improvements/rehabilitation to the interim cover, and a schedule for implementing such improvements.</p> <p>The permittee shall provide a final closure plan for Phase 1B and a schedule for that closure to the Department prior to January 31, 2002. The closure plan must be prepared to the level of informational detail required by Subsection 10.4 of this permit.</p>
<b>12.8 Final cover</b>	<p>Unless otherwise approved by the Department, the final landfill cover must be:</p> <ul style="list-style-type: none"><li>• at least three feet thick {OAR 340-094-0120(2)(a)};</li><li>• minimize infiltration of precipitation as required by 40 CFR Part 258.60, and</li><li>• graded to compensate for estimated differential settlement such that final (post-settlement) slopes will maintain positive drainage between two (2) percent and thirty (30) percent.</li></ul>
<b>12.9 Vegetation</b>	<p>The permittee must establish and maintain a dense, healthy growth of native vegetation over the closed areas of the landfill consistent with the approved end use.</p>
<b>12.10 Final cover maintenance</b>	<p>The permittee must maintain the final surface contours of the landfill cover such that erosion and ponding of water are deterred to the maximum extent practical; the integrity of the cover system is preserved in accordance with the approved plans; and the site is suitable for its approved end use.</p> <p>The permittee must reconstruct the cover system with approved materials and grade and seed all areas that have settled or where water ponds, and all areas where the cover soil has been damaged or thinned by cracking or erosion. Areas where vegetation has not been fully established shall be fertilized, re-seeded and maintained. Any damage repair or other reconstruction of a geomembrane barrier component in the final cover system shall be conducted in accordance with a construction quality assurance plan approved by the Department.</p>
<b>12.11 Deed record</b>	<p>Within 30 days after final closure of the disposal site, the Permittee must record a notation on the deed to the facility property as required by 40 CFR 258.60(l) and OAR 340-094-0130(1)(a), and submit a copy of the notation on the deed to the Department.</p>
<b>12.12 Submittal address</b>	<p>All submittals to the Department under this section must be sent to:</p> <p style="text-align: center;">Oregon Department of Environmental Quality Manager, Solid Waste Program 400 E. Scenic Dr., Suite 307 The Dalles, OR 97058 Telephone: (541) 298-7255</p>





### 13.0 FINANCIAL ASSURANCE

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<b>13.1 In this section</b>	This section describes requirements for financial assurance at the facility, including: <ul style="list-style-type: none"><li>• Financial assurance plan</li><li>• Financial assurance update</li><li>• Financial assurance plan submittal</li><li>• Use of financial assurance</li><li>• Continuous nature, and</li><li>• Submittal address</li></ul>
<b>13.2 Financial assurance plan</b>	The permittee must maintain and update a Financial Assurance Plan and provide financial assurance for the costs of site closure, post-closure care, and corrective action, if any, within ninety (90) days of permit issuance. The plan must be placed in the facility file.  <u>Reference:</u> The plan must be maintained and updated in accordance with OAR 340-094-0140. Acceptable mechanisms are described in OAR 340-094-0145.
<b>13.3 Financial assurance plan submittal</b>	Within 60 days after submitting the construction report for a new landfill disposal unit (as required by Subsection 10.8), the permittee must submit for Department review a copy of the facility's Financial Assurance Plan.
<b>13.4 Financial assurance update</b>	By March 1 <sup>st</sup> of each year, the permittee must submit to the Department evidence of adequate financial assurance consisting of: <ul style="list-style-type: none"><li>• a copy of the first financial assurance mechanism, and</li><li>• a written certification that the financial assurance meets all state requirements.</li></ul> <u>Note:</u> The permittee must annually review and update financial assurance in accordance with OAR 340-094-0140(6)(e).
<b>13.5 Use of financial assurance</b>	The permittee must not use the financial assurance for any purpose other than to finance the approved closure, post-closure, and corrective action activities or to guarantee that those activities will be completed.
<b>13.6 Continuous nature</b>	Continuous financial assurance must be maintained for the facility until the permittee or other person owning or controlling the site is no longer required to demonstrate financial responsibility for closure, post-closure care, or corrective action (if required).
<b>13.7 Submittal address</b>	All submittals to the Department under this section must be sent to: Oregon Department of Environmental Quality Manager, Solid Waste Program 400 E. Scenic Dr., Suite 307 The Dalles, OR 97058 Telephone: (541) 298-7255

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## ENVIRONMENTAL MONITORING

### 15.0 ENVIRONMENTAL MONITORING PLAN (EMP)

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- 15.1 In this section** This section describes requirements for an Environmental Monitoring Plan (EMP) for the facility, including:
- EMP submittal
  - EMP contents
  - EMP maintenance
  - Long term environmental monitoring
  - Additional environmental monitoring points and
  - Submittal address
- 
- 15.2 EMP submittal** Within 180 days of the permit issue date, the permittee must submit, for approval, three copies of an updated Environmental Monitoring Plan (EMP) to the Department. The plan must be prepared and stamped by either a Geologist or a Certified Engineering Geologist, with current Oregon registration. Upon approval, this plan is incorporated into this permit by reference.
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- 15.3 EMP contents** The updated EMP must include plans that implement an environmental monitoring program that will characterize potential facility impacts. The updated plan may consist of the previous approved EMP with any changes or additions since that time (i.e., approved permit-specific concentration limits, revised parameter lists, revised schedules, new wells...). At a minimum, the updated EMP should address the issues and topics found in Section 10 of DEQ's current *Solid Waste Guidance*.
- 
- 15.4 EMP maintenance** The permittee must revise the EMP as necessary to keep it reflective of current facility conditions, procedures, and sampling requirements or changes. The permittee must submit all EMP revisions to the Department for approval.
- 
- 15.5 Long-term monitoring plan** After approval of any Permit-Specific Concentration Limits (PSCLs), Concentration Limit Variances (CLVs), Action Limits (ALs), or Site-Specific Limits (SSLs) the permittee must update the EMP to reflect the long-term monitoring plan and submit the updated plan for department review and approval.
- Note: See also the requirements for establishing PSCLs, ALs, or SSLs in this permit, procedure for establishing CLVs can be found in OAR 340-40-030(4).
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- 15.6 Additional monitoring points** Any new or replacement monitoring point or device established during the time frame of this permit must be incorporated into the Environmental Monitoring Plan (EMP). The updated plan must be resubmitted to the Department for approval.
- 
- 15.7 Submittal address** All required copies of submittals to the Department under this section must be received by the due date and delivered to:
- Oregon Department of Environmental Quality  
Manager, Solid Waste Program  
400 E Scenic Drive, Suite 307  
The Dalles, OR 97058  
Telephone: (541) 298-7255  
Fax: (541) 298-7330
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**16.0 ENVIRONMENTAL SAMPLING REQUIREMENTS**

**16.1 In this section** This section describes general sampling requirements, including:

- Notification
- Split sampling
- Monitoring schedule
- Interim monitoring
- Monitoring after EMP approval and
- Changes in sampling or split sampling

**16.2 Notification** The Department must receive written notification of all upcoming sampling events at least ten (10) working days prior to the scheduled date of the sampling event at the following address:

Oregon Department of Environmental Quality  
 Manager, Solid Waste Program  
 400 E Scenic Drive, Suite 307  
 The Dalles, OR 97058  
 Telephone: (541) 298-7255  
 Fax: (541) 298-7330

**16.3 Split sampling** The permittee must split samples with the Department when requested, and must schedule all requested split-sampling events with the Department laboratory at least forty-five (45) days prior to the sampling event.

The following sampling events must be conducted as split sampling events with the department:

Fall 2002	Spring 2004
Fall 2006	Spring 2008
Fall 2010	

**16.4 Monitoring schedule** The permittee must perform environmental monitoring according to the approved EMP. Quarters are defined as the following:

If sampling in the...	Schedule the sampling event	
	On, or after...	But on, or before...
Winter	January 1	February 28
Spring	April 1	May 31
Summer	July 1	August 31
Fall	October 1	November 30



**16.5 Interim monitoring**

After the issue date of this permit and until a new EMP can be approved, the permittee must perform environmental monitoring in accordance with:

1. June 1995, Revised Environmental Monitoring Plan, Knot Landfill, Deschutes County, Oregon.
2. Attachment 2 of addendum 1 of the permit 6 dated November 17, 1997.

Semiannual sampling must be conducted in the Spring (April 1 to May 31) and in the Fall (October 1 to November 30) quarters.

Any new wells installed at the site will be sampled quarterly for parameter groups 1, 2, and 3 until a minimum of nine acceptable data points have been acquired for each well.

Leachate will be sampled annually for parameter groups 1a, 1b, 2a, 2b, 3, 4, and 5 (excluding TOX)

Reference: Parameter Groups are further defined in Attachment 1

**16.6 Monitoring after EMP approval**

Upon approval, the permittee must perform all environmental monitoring at the facility in accordance with the site-specific Environmental Monitoring Plan (EMP), including any conditions of the approval, and all approved amendments and updates.

**16.7 Changes in sampling or split sampling**

The Department must approve any changes to the sample program in writing prior to implementation. The permittee may make written requests to change: sample frequencies; parameters to be sampled for; or locations to be sampled. Once approved, this will become part of the EMP requirements by reference.

The Department reserves the right to add to or delete from the list of scheduled sampling events, sample locations, parameters to be sampled for, and to conduct unscheduled samplings or split sampling.

In the event of changes to the split-sampling schedule, the Department will make an effort to notify the permittee of any changes at least 30 days prior to the event.

**17.0 ESTABLISHING PERMIT-SPECIFIC CONCENTRATION LIMITS (PSCLs), ACTION LIMITS (ALs), CONCENTRATION LIMIT VARIANCES (CLVs) and SITE-SPECIFIC LIMITS (SSLs)**

**17.1 In this section**

This section describes requirements for establishing Permit-Specific Concentration Limits (PSCLs), Concentration Limit Variances (CLVs), Action Limits (ALs), and/or Site-Specific Limits (SSLs) for groundwater monitoring, including:

- Gathering data
- Proposing PSCLs, ALs or SSLs
- Changing PSCLs, ALs or SSLs, and
- Setting and changing CLVs



**17.2 Statistical analysis**

The permittee must perform statistical evaluations of monitoring results for each sampling event in accordance with 40 CFR 258.53 or other methods approved of in advance by the Department in order to establish compliance concentration limits (PSCLs, ALs, and SSLs).

References:

*Statistical Analysis of Groundwater Monitoring Data at RCRA facilities, Addendum to Interim Final Guidance*, USEPA, June 1992; and,

*Statistical Guidance for all RCRA Sites*, DEQ: SWPC, August 3, 1992.

**17.3 Proposing PSCLs, ALs, and/or SSLs**

The permittee must propose to the department, for all parameters the department deems necessary, for review and approval, a PSCL, AL, or SSL pursuant to the guidelines specified in OAR 340-40. A PSCL, AL, or SSL may be generated for each parameter that is to be included in the long-term monitoring of the site once there are at least nine acceptable data points from the appropriate background well(s) as established under this permit.

**17.4 Changing PSCLs, ALs, and/or SSLs**

If the permittee can demonstrate to the department's satisfaction that the background groundwater quality has significantly changed since the PSCL, AL, or SSL was established, and this change is not due to any influence from the permitted facility, then the permittee can propose for Department approval a revised level of the specific PSCL(s), AL(s), or SSL(s) that are affected.

**17.5 Setting and changing CLVs**

Regulations on how to set and change Concentration Limit Variances (CLVs) are found in the Oregon Groundwater Quality Protection Rules [OAR 340-40-030(4)].

**18.0 ENVIRONMENTAL MONITORING STANDARDS**

**18.1 In this section**

This section describes requirements for evaluating compliance with environmental monitoring standards, including:

- Rule
- Compliance points
- Review of monitoring results
- Resampling results
- Leak detection or secondary leachate collection system
- Methane limits
- Methane exceedance, and
- Certified environmental laboratory data

**18.2 Rule**

The permittee must not allow the release of any substance from the landfill into groundwater, surface water, or any other media which will result in a violation of any applicable federal or state air or water limit, drinking water rules, or regulations beyond the solid waste boundary of the disposal site or an alternative boundary specified by the Department.



**18.3 Compliance points** The following monitoring locations are designated as compliance points:  
 Groundwater Monitoring Wells (MWs) 1, 2, 3, 4, and 5.  
 Landfill Gas Probes (GPs) 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A.

**18.4 Review of results** The permittee must review the analytical results after each monitoring event according to the following table.

If data show results are...	Then...
above any one PSCL, CLV, or AL, or more than two SSLs (if established) or if results indicate a significant change in water quality at any monitoring point, <u>Note: Examples of significant changes</u> <ul style="list-style-type: none"> <li>• Detection of a VOC or other hazardous constituent not detected in background;</li> <li>• Exceedance of a Table 1 or 3 value listed in OAR 340-40 unless the background water quality is above these numerical limits;</li> <li>• Exceedance of a Safe Drinking Water Standard;</li> <li>• Detection of a compound in an order of magnitude higher than background.</li> </ul>	1. Notify the Department in writing within 10 days of receipt of laboratory results; and, 2. Perform resampling immediately and evaluate results as described below.  <u>Note:</u> If this is a known release, previously confirmed to the department in writing, resampling is not required
None of the above	Continue groundwater monitoring with next scheduled sampling event

Note: PSCLs, CLVs, ALs, and SSLs established to date are listed in Attachment 2 of this permit.

**18.5 Resampling results** Upon receipt of data from resampling, the permittee must review the results according to the following table.

If resampling data show results...	then: ...
that confirm the exceedance of at least one permit-specific concentration limit (PSCL) or concentration limit variance (CLV),  *See Attachment 1: Parameter Groups	1. notify the Department in writing within 10 days of receipt of laboratory data, or within 60 days of the sample date (whichever occurs first); and, 2. submit a Remedial Investigation workplan for department approval within 90 days of the date of resampling. Plan must specify how the objectives of OAR 340-40 will be met by the proposed investigation. This may include the monitoring of Groups 4 & 6* parameters, in addition to routine detection monitoring.
that confirm the significant change in water quality results noted in the routine sampling event or confirm that at least any one AL or more than two SSLs were exceeded,	1. Notify the department in writing within 10 days of receipt of laboratory data, or within 60 days of the sample date (whichever occurs first); and, 2. Submit a plan within 30 days (unless another time period is authorized) for developing an assessment program to the Department.



that do not confirm the results noted in the routine sampling event,	<ol style="list-style-type: none"> <li>1. continue with routine monitoring; and,</li> <li>2. discuss the data from the routine sampling event and the resampling results in the next annual environmental monitoring report.</li> </ol>
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**18.6 Leak detection system (LDS)** If the permittee observes the presence of liquids in the leak detection system (LDS), then the permittee must commence the sampling and analysis and reporting procedures defined in the Department approved Environmental Monitoring Plan (EMP). If landfill impacts are confirmed in this leak detection or SLC system, and the SLC system is compromised as a compliance point, then the Department may require the installation of more detection or compliance wells and further investigations.

Each new sub-unit(s) with an SLCS must be able to be sampled discretely; no mixing, no commingling and no composite samples from other leachate sources is allowed.

**18.7 Methane limits** The concentration of methane must not exceed:

- 25 percent of the Lower Explosive Limit for methane in onsite structures (excluding gas control structures or gas recovery system components); or,
- The Lower Explosive Limit for methane at the facility boundary.

Note: The Lower Explosive Limit for methane is 5 percent.

**18.8 Methane exceedance** If methane levels exceed the specified limits, then the permittee must:

1. Immediately take all necessary steps to ensure protection of human health;
2. Within 7 days of detection (unless the department approves an alternative schedule), enter the methane levels in the operating record and describe measures taken to protect human health and safety; and,

Within 60 days of detection, implement a remediation plan for the methane releases, incorporate the plan into the monitoring records, and notify the Department that the plan has been implemented.

**18.9 Certified environmental laboratory data** After December 31, 2000 the Department suggests the use of only environmental sampling data analyzed by an Oregon Laboratory Accredited Program (ORLAP) lab or a National Volunteer Laboratory Accreditation Program (NVLAP) lab. A copy of the certification should accompany the submitted data. Use of an ORLAP or NVLAP approved lab will aid you and the Department in Environmental Monitoring Plan and Annual Environmental Monitoring Report preparation and review.





## 19.0 RECORDKEEPING AND REPORTING – ENVIRONMENTAL MONITORING

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- |             |  |   |
|-------------|--|---|
| <b>19.1</b> | <b>In this section</b>                               | <p>This section describes recordkeeping and reporting requirements associated with environmental monitoring, including:</p> <ul style="list-style-type: none"><li>• Annual environmental monitoring report (AEMR)</li><li>• Statement of compliance</li><li>• Annual environmental monitoring report contents</li><li>• Annual leachate treatment report</li><li>• Annual leachate treatment report contents</li><li>• Submittal address</li><li>• Split sampling submittal</li><li>• Lab address, and</li><li>• Department response to split samples</li></ul> |
| <hr/>       |  |   |
| <b>19.2</b> | <b>Annual environmental monitoring report (AEMR)</b> | <p>Prior to March 1 of each year for the duration of this permit, the permittee must submit to the department three copies of an annual monitoring report covering the past year from January 1st to December 31st. The report must be prepared and stamped by either a Geologist or a Certified Engineering Geologist, with current Oregon registration. The report must follow the format approved in the Environmental Monitoring Plan.</p> <p><u>Note:</u> Whenever possible, the permittee must submit two-sided copies of all reports</p>                 |
| <hr/>       |  |   |
| <b>19.3</b> | <b>Statement of compliance</b>                       | <p>A short (approximately one-page) cover letter must be included in the AEMR that:</p> <ul style="list-style-type: none"><li>• Compares the analytical results with the relevant monitoring standards (PSCLs, CLVs, ALs, or SSLs);</li><li>• States whether or not federal or state standards were exceeded for the relevant media; and,</li><li>• States whether or not a significant change in water quality has occurred.</li></ul>   |
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**19.4 Annual environmental monitoring report (AEMR) contents**

Each AEMR must reflect actual conditions at the facility. Data presented in the reports must be error-free compared to the original field and lab data. The AEMR, at a minimum, must contain:

- Review of all significant events that occurred at the site during the last year;
- Review of the monitoring network performance and recommendations for changes;
- Summary of all the data collected in the past year media including, but not limited to: groundwater, surface water, leachate (lagoon, LDS and/or SLCS), and LFG (include any air sample data), and soil samples;
- A summary of any data problems (examples could include, but not limited to QA/QC failures, flagged data, switched samples, etc.);
- Piezometric maps for each sampling event for each monitored water bearing zone of concern;
- Time history plots for field specific conductivity, dissolved oxygen, and all group 1b and group 2a and 2b parameters;
- Box plots for field specific conductivity, dissolved oxygen, and all group 1b and group 2a and 2b parameters;
- For each location and sample event an anion-cation balance for each location that has adequate data. An additional explanation must be included for any balance outside of  $\pm 10\%$  error;
- Copy of the lab certification, if applicable (ORLAP or NVLAP)
- A copy of all field and lab data for the past year.

The Department may reduce the above reporting requirements for data produced by a laboratory with current ORLAP or NVLAP certification

**19.5 Annual leachate management summary**

As part of the Annual Environmental Monitoring Report required in Condition 19.2 above, the permittee must include an annual summary of the leachate management program to the department.

**19.6 Annual leachate management summary contents**

The annual leachate management summary must include at a minimum:

- Contents that satisfy the conditions of the Leachate Management System section of the Site Operations Plan;
- A review of all significant events that occurred at the site during the last year regarding leachate issues;
- A review of the leachate monitoring network performance and any recommendations for improvements;
- Evaluation of potential human health risk, relative to any reasonably foreseeable biological hazard exposure;
- The daily volume of leachate removed from each primary leachate sump;
- The daily volume of leachate managed by each implemented leachate management method; and,
- The daily volume of liquid removed from each secondary leachate collection sump, servicing any disposal unit(s).



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- 19.7 Submittal address** Except where otherwise noted, all required copies of submittals to the department under this section must be received by the due date and delivered to:
- Oregon Department of Environmental Quality  
Manager, Solid Waste Program  
400 E Scenic Drive, Suite 307  
The Dalles, OR 97058  
Telephone: (541) 298-7255  
Fax: (541) 298-7330
- 
- 19.8 Split sampling submittal** Within 90 days of any split sampling event, the permittee must submit the following information from the split sampling event to the department's laboratory:
- A copy of all information pertinent to the sample collection handling, transport and storage, including field notes;
  - Copies of all laboratory analytical reports;
  - Copies of all laboratory QA/QC reports;
  - Copy of the lab certification if applicable (ORLAP or NVLAP);
  - Site map showing flow directions and contours; and
  - Any other data or reports requested by the department.
- 
- 19.9 Lab address** All split sampling reporting must be sent to:
- Oregon Department of Environmental Quality  
Lab, Groundwater Monitoring Section  
1712 SW 11th Avenue  
Portland, OR 97201  
(503) 229-5983
- 
- 19.10 Department response to split samples** If requested by the permittee and after the permittee has submitted all split sampling data information, the Department lab may send the permittee a copy of:
- The Department's analysis of the split sample;
  - A copy of the QA/QC report;
  - A copy of the analytical report; and/or,
  - A copy of field data sheets.
-



## 20.0 ENVIRONMENTAL MONITORING NETWORK

20.1 In this section	<p>This section describes requirements for the environmental monitoring network, including:</p> <ul style="list-style-type: none"><li>• Well installation</li><li>• Monitoring devices</li><li>• Access to monitoring devices</li><li>• Damage reporting</li><li>• Device construction</li><li>• Construction reporting</li><li>• Recommendation to abandon</li><li>• Gas system maintenance</li><li>• Gas system repair, and</li><li>• Submittal address</li></ul>
20.2 Well installation	<p>For future units, the permittee must ensure that department-approved background and detection and/or compliance wells are in place for any future units, at least 12 months before refuse is accepted for disposal in the new cells. This requirement may be waived or modified in writing by the Department if adequate justification is made.</p>
20.3 Monitoring devices	<p>The permittee must protect, operate, and maintain gas, groundwater, leachate, and surface water monitoring devices in good functional condition so that samples representative of actual conditions can be collected.</p>
20.4 Access to monitoring devices	<p>The permittee must maintain reasonable all-weather access to all monitoring devices and/or locations in order to facilitate sample collection and/or inspection.</p>
20.5 Damage reporting	<p>Any damage to a monitoring device must be reported to the Department in writing within fourteen (14) days of the discovery, along with a description of proposed repair or replacement measures and a time schedule for completion of this work.</p> <p><u>Examples:</u> damage impairing well function or changing the physical location to any degree</p>
20.6 Device construction	<p>All monitoring well abandonment (decommissions), replacements, repairs, and installations must be conducted to comply with the Water Resources Department Rules OAR 690-240 and with the department's <u>Guidelines for Groundwater Monitoring Well drilling, Construction, and Decommissioning</u> dated August 1992.</p>
20.7 Construction reporting	<p>All monitoring well repairs, abandonments, replacements, and installations, including driller's logs, well location information, and construction information must be documented in a report prepared and stamped by either a Geologist or a Certified Engineering Geologist, with current Oregon registration. The report must be submitted to the department within thirty (30) days of the action and referenced in the next AEMR.</p>



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- 20.8 Recommendation to abandon** The permittee must submit a recommendation to the department to decommission or replace any well in the monitoring network that:
- Has been installed in a borehole that hydraulically intersects two saturated stratas;
  - Does not have the corresponding and necessary supporting documentation of appropriate installation or construction; or,
  - Is damaged beyond repair or destroyed during the time frame of this permit.
- 
- 20.9 Gas system maintenance** The permittee must operate and maintain in good working order the landfill gas containment, collection, removal, treatment, and monitoring system such that nuisance odors are deterred to the maximum extent practical and methane concentrations do not exceed compliance limits.
- 
- 20.10 Gas system damage repair** Within 60 days of discovery of the damage, the permittee must replace or repair the damage to any equipment in the gas system and submit a written inspection report to the department.
- 
- 20.11 Submittal address** All required copies of submittals to the Department under this section must be received by the due date and delivered to:
- Oregon Department of Environmental Quality  
Manager, Solid Waste Program  
400 E Scenic Drive, Suite 307  
The Dalles, OR 97058  
Telephone: (541) 298-7255  
Fax: (541) 298-7330
-



## COMPLIANCE SCHEDULE

### 21.0 SUMMARY OF DUE DATES

21.1 **Summary** The following is a summary of event-driven reporting required by this permit. This section does not include routine reporting and submittals required by this permit.

Due Date	Activity	See section
Within 360 days of permit issuance	Submit updated Operations Plan	7.2 Operations Plan
6 months before any construction	Submit design plans	10.4 Design plans
Prior to construction	Submit construction documents and receive Department approval.	10.6 Construction documents
90 days after completion of any major construction	Submit construction certification report	10.8 Construction report
5 years prior to closure	Submit closure permit application	12.4 Closure permit
6 months before conducting any final closure construction	Submit plans for final closure proposed to be constructed.	12.5 Closure plan approval
Prior to August 1, 2001	Submit Phase I Interim closure report	12.7 Phase 1B closure
Within 60 days after submitting the construction report for a new disposal unit	Submit a copy of the facility's Financial Assurance Plan	13.3 Financial assurance plan submittal
By March 1 for each year this permit is in effect	Submit annual financial assurance update	13.4 Financial assurance update
Within 180 days of permit issuance	Submit updated Environmental Monitoring Plan (EMP)	15.2 Environmental Monitoring Plan
By March 1 for each year this permit is in effect	Submit an Annual Environmental Monitoring Report (AEMR)	19.2 AEMR
By June 1 for each year this permit is in effect	Submit an Annual Leachate Treatment Report	19.5 Annual Leachate Treatment Report
Within 30 days of any well construction	Submit well construction report	20.7 Construction reporting



**ATTACHMENTS**

**22.0 ATTACHMENTS TO PERMIT**

**22.1 Attachment listing**

The following attachments to this document are:

Number	Description
1	Parameter Groups
2	Permit-specific concentration limits



## ATTACHMENT 1: PARAMETER GROUPS

### In this attachment

This attachment describes the parameter groups and any associated requirements for environmental monitoring.

Note: Method means EPA SW 846 Method [suggested methods are in square brackets].

### Group 1a: Field indicators

The following parameters comprise the field indicators parameter group:

Elevation of water level	Specific Conductance
pH	Dissolved Oxygen
Temperature	Eh

These parameters must be measured in the field at the time samples are collected, either down-hole in situ, in a flow-through well, or immediately following sample recovery, with instruments calibrated to relevant standards

### Group 1b: Leachate indicators

The following parameters comprise the laboratory indicators parameter group:

Hardness (as CaCO <sub>3</sub> )	Total Dissolved Solids (TDS)
Total Alkalinity (as CaCO <sub>3</sub> )	Total Suspended Solids (TSS)
Total Organic Carbon (TOC)	Chemical Oxygen Demand (COD)
pH (lab)	Tannin/Lignin
Specific Conductance (lab) [Method 9050]	

Sample handling, preservation, and analysis are determined by requirements for each individual analyte: EPA or AWWA Standard Methods techniques must be followed.

### Group 2a: Common anions and cations

The following parameters comprise the common anions and cations parameter group:

Calcium (Ca)	Manganese (Mn)
Sulfate (SO <sub>4</sub> ) [Method 9035]	Magnesium (Mg)
Ammonia (NH <sub>3</sub> )	Chloride (Cl) [Method 9250]
Sodium (Na)	Carbonate (CO <sub>3</sub> )
Nitrate (NO <sub>3</sub> ) [Method 9210]	Potassium (K)
Silica (SiO <sub>2</sub> )	Bicarbonate (HCO <sub>3</sub> )
Iron (Fe)	Ammonium (NH <sub>4</sub> )
Flouride (F)	

Dissolved concentrations must be measured. Samples must be field-filtered and field-preserved according to standard DEQ and/or EPA guidelines and analyzed by appropriate EPA or AWWA Standard Methods techniques. Results must be reported in mg/L and meq/L.





**Group 2b:  
Trace metals**

The following parameters comprise the trace metals parameter group:

Antimony (Sb)	Chromium (Cr)	Selenium (Se)
Arsenic (As)	Cobalt (Co)	Silver (Ag)
Barium (Ba)	Copper (Cu)	Thallium (Tl)
Beryllium (Be)	Lead (Pb)	Vanadium (V)
Cadmium (Cd)	Nickel (Ni)	Zinc (Zn)

If the Total Suspended Solids concentration is:	then analyze for:
less than or equal to 100.0 mg/L in the sample	total concentrations (unfiltered)
Greater than 100.0 mg/L in the sample	both total (unfiltered) and dissolved (field-filtered)

Samples must be field-preserved according to standard DEQ and/or EPA guidelines and analyzed by EPA Method 6010 or department-approved equivalent.

**Group 3:  
Volatile organic constituents**

Analysis for all compounds detectable by EPA Method 8260B (or current version) or EPA Method 524.2, including a library search to identify any unknown compounds present. EPA Method 8260 comprises the volatile organic constituents parameter group. Facilities that want to use EPA Methods 8021, or 8240B, as an alternative must obtain approval by the department prior to use.

**Group 4:  
Assessment monitoring**

The following analyses comprise the assessment monitoring parameter group:

- Semi-volatile Organic Constituents, including Phenols, EPA Method 8270
- Mercury, EPA Method 7470
- Cyanide, EPA Method 9010
- Nitrite

All Method 8270 analyses must include a library search to identify any unknown compounds present.

**Group 5:  
surface water and leachate**

The following parameters comprise the surface water parameter group:

- Total Kjeldahl Nitrogen (TKN)
- Total Phosphorus (P)
- Orthophosphate (PO<sub>4</sub>)
- Biological Oxygen Demand (BOD)
- Total Halogenated Organics (TOX) [EPA Method 9020B]
- Total Coliform Bacteria [EPA Method 9131]
- Fecal Coliform Bacteria [EPA Method 9131]
- E. Coli

**Group 6:  
Other Assessment parameters**

The following comprise additional assessment parameters:

- Dioxins and Furans [EPA Methods 8280 and/or 8290]
- Phenolics [EPA Methods 9065, 9066, and 9067]
- PCBs [EPA Methods 8080 and 8270]
- Pesticides, Herbicides and Fungicides [EPA Methods 8080, 8141, 8150, 8151, 8270]



**ATTACHMENT 2: PSCLs, ALs, and SSLs**

Permit-Specific Concentration Limits (PSCLs), Concentration Limit Variances (CLVs), Action Limits (ALs), and Site Specific Limits (SSLs) for [redacted] have not yet been established.





## **2.1 FACILITY DESCRIPTION**

The Knott Landfill and Recycle Center is located on a 205-acre parcel that is owned by Deschutes County and located at the intersection of SE 27th Street and Rickard Road, approximately 3 miles south of Highway 20 in Bend, Oregon (see Figure 2-1).

Landfilling operations at the site began in 1972. Figure 2-2 shows the existing site configuration. Access to the site is from SE 27th Street. The County's landfilling operations share the site with recycling facilities operated by Deschutes Recycling, LLC.

Prior to 1972, a quarry was operated at the site. Since that time, soil materials have been borrowed from the site and used for daily and intermediate cover at the landfill and for various other County projects. Excavation depths within the borrow area vary from 10 to 100 feet below the surrounding grades.

The County is currently permitted by the DEQ to dispose of MSW, in what is called the Phase I-B/II-B area. This 45.49-acre disposal area has served the County since 1972. Phase I-B (21.65-acres) is unlined and does not have a leachate collection system. The Phase II-B area is lined and is expected to be filled to capacity in year 2006.

When the site was originally planned, it was anticipated that eventually the 135-acres zoned for landfilling (SM zone) would be filled with refuse. Laterally expanding the landfill to encompass the entire 135-acres will require the approval of DEQ and is the subject of this report.

In September of 1996, the first lined refuse cell (Cell 1) in the Phase IIB footprint came on-line. As filling has progressed, the interface between Phase IB and Cell 1 was lined with a geosynthetic clay liner (GCL). It is anticipated that Cell 1 will be filled to capacity by in late-2003.

Cell 2 was constructed in Spring/Summer of 2001 and began accepting refuse in August of 2001. It is expected that it will be filled to capacity in late-2004 or early-2005. Prior to this date, Cell 3 will be constructed and landfilling operations within Cell 3 will begin.

It is anticipated the design for the new North Area facilities will begin in July, 2003 and that construction will be completed by the end of 2004.

## **2.2 CAPACITY AND PROJECTED LIFE**

If constructed in accordance with the revised excavation and final grading plans described in Section 3, the Knott Landfill and Recycle Center has 8.0 million cubic yards of remaining air

space available for solid waste disposal. If on average, refuse densities of 1250 lb per cubic yard are achieved, the landfill has a remaining disposal capacity of 5.0 million tons.

In the Year 2002, 137,000 tons of solid waste was disposed of at the landfill. If this rate of disposal continues to grow as projected (see Section 2.4), it is estimated that the landfill has a remaining useful service life of approximately 26 years.

### **2.3 POPULATION TO BE SERVED**

The landfill serves as the ultimate disposal site for the residential and commercial waste generated by the residents of Deschutes County, including the cities of Bend, Redmond, Sisters and surrounding areas.

URS has projected population growth within Deschutes County based on the Center for Population Research and Census projected population growth and other sources. The population projections for the study period are as follows:

2003 -	128,610 persons
2005 -	132,829 persons
2010 -	151,521 persons
2015 -	168,006 persons
2020 -	182,456 persons
2025 -	190,851 persons
2030 -	197,146 persons

### **2.4 INDUSTRY TO BE SERVED**

Knott Landfill and Recycle Center accepts solid waste from all types of major industries in Deschutes County. The solid waste that is accepted is as defined in ORS 459.005. Non-digested sewage sludges, septic tank pumpings, and free liquids other than those incidental free liquids associated with solid waste collection and transportation are excluded. In addition, abandoned vehicles and discarded home, industrial appliances and hazardous wastes are not accepted.

Under OAR 340-093-0030, "Solid waste" means all useless or discarded putrescible and nonputrescible materials, including but not limited to garbage, rubbish, refuse, ashes, paper, and

cardboard; sewage sludge, septic tank and cesspool pumpings or other sludge, useless or discarded commercial, industrial, demolition and construction materials; discarded or abandoned vehicles or parts thereof; discarded home and industrial appliances; manure, vegetable or animal solid and semi-solid materials, dead animals and infectious wastes. The term does not include:

- Hazardous waste as defined in ORS 466.005.
- Material used for fertilizer, soil conditioning, humus restoration or for other productive purposes or which are salvageable for these purposes."

Common types of wastes that are prohibited at the landfill include:

- Acids
- Adhesives
- Aerosols
- Batteries
- Catalysts
- Fungicides
- Herbicides
- Detergents
- Explosives
- Flammables
- Foaming Resins
- Fuels
- Rodenticides
- Solvents
- Industrial Oils
- Insecticides
- Material with over 50 ppm PCB's
- Radioactive materials
- Caustics
- Degreasing Agents

## 2.5 RATE OF WASTE DISPOSAL

Estimates of the solid waste volumes that will be disposed of by County residents through Year 2029 are shown in Table 2-1. If the landfill is to provide an additional 26 years of solid waste disposal capacity, it will need to accommodate 5.0 million tons of refuse.

The design flows for the period from 2003 through 2007 are as follows:

- 2003 Average Annual Rate = 139,000 tpy = 380 tpd
- 2007 Average Annual Rate = 150,000 tpy = 410 tpd
- Maximum Daily Rate = 800 tpd
- Maximum Monthly Rate = 600 tpd

It is anticipated that Knott Landfill and Recycle Center will provide the only disposal site in Deschutes County for three primary waste streams: municipal solid waste (MSW - including domestic or "residential" wastes and commercial/institutional or "non-residential" wastes), construction and demolition wastes (C&D), and industrial/special wastes.

All wastes received at the site for disposal will be as allowed for in ORS 459.005. On a weight basis, the contributions of the three waste streams to the overall Knott Landfill and Recycle

Center disposal tonnage are anticipated to be distributed as noted in Table 2-1. This is based upon landfill records of material deliveries over a recent 12 month period.

The Knott Recycle Center will continue to accept and handle a variety of source separated recyclable materials for diversion. These include: recyclable paper grades, scrap metals, glass, plastic bottles, clean construction wood, motor oil, cardboard, yard debris, tires, white goods, lead-acid batteries, used motor oil and cardboard.

## **2.6 OVERALL DESCRIPTION OF OPERATION**

The landfill now and in the future will be owned and operated by the Deschutes County Department of Solid Waste with the possible exception of some recycling facilities. Access to the landfill is from an entrance located off of SE 27<sup>th</sup> Street. The entrance has a locking steel gate that is secured whenever the landfill is closed.

Signs posted along the entrance road provide the following information:

- Name of facility
- Business address and telephone number
- Emergency telephone number
- Landfill operating hours
- Unauthorized or prohibited wastes

All incoming vehicles are weighed at the vehicle weigh station and surveyed for prohibited materials. Those vehicles carrying acceptable solid wastes are directed to the active working face where their loads are dumped or to the transfer station/MRF when its construction is completed. The vehicles are then directed to the exit. Those vehicles without tare weights are weighed as they leave the landfill.

The normal hours of access to the landfill are from 7:00 am to 4:30 p.m. on all days of the week throughout the year. The site is closed on the holidays of New Year's Day, Martin Luther King Day, Presidents Day, Memorial Day, Fourth of July, Labor Day, Veterans Day, Thanksgiving, and Christmas.

Delivery of solid waste to the landfill is by private vehicles, commercial vehicles, refuse collection trucks and County transfer trailers. It is anticipated that a receiving/transfer station will be constructed as part of the proposed North Area development in the near future. The transfer station will accommodate private and small commercial vehicles and will enable access to the active working face to be limited.



The general development of landfilling operations at the site is described in Section 3.

### **2.6.1 Personnel**

It is anticipated that under normal conditions the landfill will be operated with the following personnel working on a staggered schedule:

- Operations Manager
- Landfill Technician
- 4 Landfill Site Attendants
- 8 Equipment Operators
- 2 Maintenance Attendants
- 1 Senior Accounting Technician
- 1 Customer Service Clerk

Contract crews are available from local youth service groups and the County Juvenile Justice Department for assistance in litter control.

### **2.6.2 Equipment**

Equipment that is owned by the County's Solid Waste Department and which will be utilized by landfill operating personnel includes:

- 2 Large Dozers (Cat D7)
- 2 Compactors (Cat 816B)
- 2 Scrapers (Cat 623E)
- 2 Front End Loader (Cat 966F)
- 1 Water Truck
- 1 Integrated Toolcarrier Loader
- 5 Pickup Trucks
- 1 Dump Truck
- 1 Alternate Daily Cover Applicator
- 1 Road Sander
- 1 1-Ton Flatbed Truck

Additional equipment is available through the Deschutes County Public Works Department including, but not limited to bulldozers, loaders, excavators, backhoes, dump trucks and other infrastructure construction and maintenance vehicles and equipment.

## **2.7 SITE ECONOMIC VIABILITY**

The cost for disposal of MSW at the site is currently \$40 per ton. The County's Solid Waste Department is being operated as an independent cost center within the County. As an independent cost center, the entire cost for the solid waste department is paid for by the landfill's tipping fee.

## **2.8 SITE SCREENING**

The landfill is bounded on the south and west sides by SE 27th Street and Rickard Road. On the 27<sup>th</sup> Street side, a block retaining wall has been constructed to provide for final cover drainage and screening. Trees and shrubs have been planted on the street side of the retaining wall and will provide additional screening as the plants grow. In addition, a chain link fence has been constructed and is being utilized for security and to provide additional visual screening.

The majority of the landfilling operation will be below the grade of the adjacent roads. As is shown in the site development plan in Section 3, the final grade of the landfill will gently slope up at a 3 to 10 percent grade to promote drainage. With this approach, landfilling operations will generally be screened from public view.

## **2.9 PLANNED FUTURE USE**

The County is planning to have a study that analyzes the feasibility of potential end uses for the landfill performed in Fall, 2003/Spring, 2004. A description of the scope of the feasibility study and the end uses that are being considered by the County is included in Section 8.

## **2.10 WASTE STREAM CHARACTERIZATION**

It is anticipated that Knott Landfill will provide the only disposal site in Deschutes County for three primary waste streams: municipal solid waste (MSW - including domestic or "residential" wastes and commercial/institutional or "non-residential" wastes), construction and demolition wastes (C&D), and industrial/special wastes. All wastes received at the site for disposal will be as allowed for in ORS 459.005.

The Knott Recycle Center will continue to accept and handle a variety of source separated recyclable materials for diversion. These include: recyclable paper, scrap metals, glass, plastic

bottles, clean construction wood, motor oil, cardboard, yard debris, tires, white goods, and lead-acid batteries.

## **2.11 REGIONAL FACILITY**

The Knott Landfill and Recycle Center are intended for the use of Deschutes County residents. In the interest of being a good neighbor to adjacent counties, MSW may be accepted from these counties if they have no other cost effective alternative.

A waste reduction program has been developed by the County. In 2001, 35.1 percent of the material in the waste stream was recovered, prevented or diverted. The Year 2009 goal established by the DEQ for material recovery is 45 percent. Material recovery rates are being reported annually. If any waste is accepted from neighboring counties, it will be reported separately.

The County waste reduction program consists of curbside collection for mandated recyclables in Bend and Redmond. In addition, the opportunity to recycle is provided for at 4 transfer stations and 12 approved depots. All this material is delivered to the Knott Recycle Center for processing and marketing. A private company provides the processing and marketing under a license from the County.

Other materials included in the County's waste reduction program are as follows: 1) Yard debris delivered to the Knott facility and at 3 of the 4 transfer stations. This material is ground into mulch and compost is sold to consumers through the recycling licensee, 2) Clean wood material from construction projects is accepted at the Knott facility. This material is marketed as hog fuel or delivered to a processing plant in Redmond for reuse in the wood manufacturing industry.

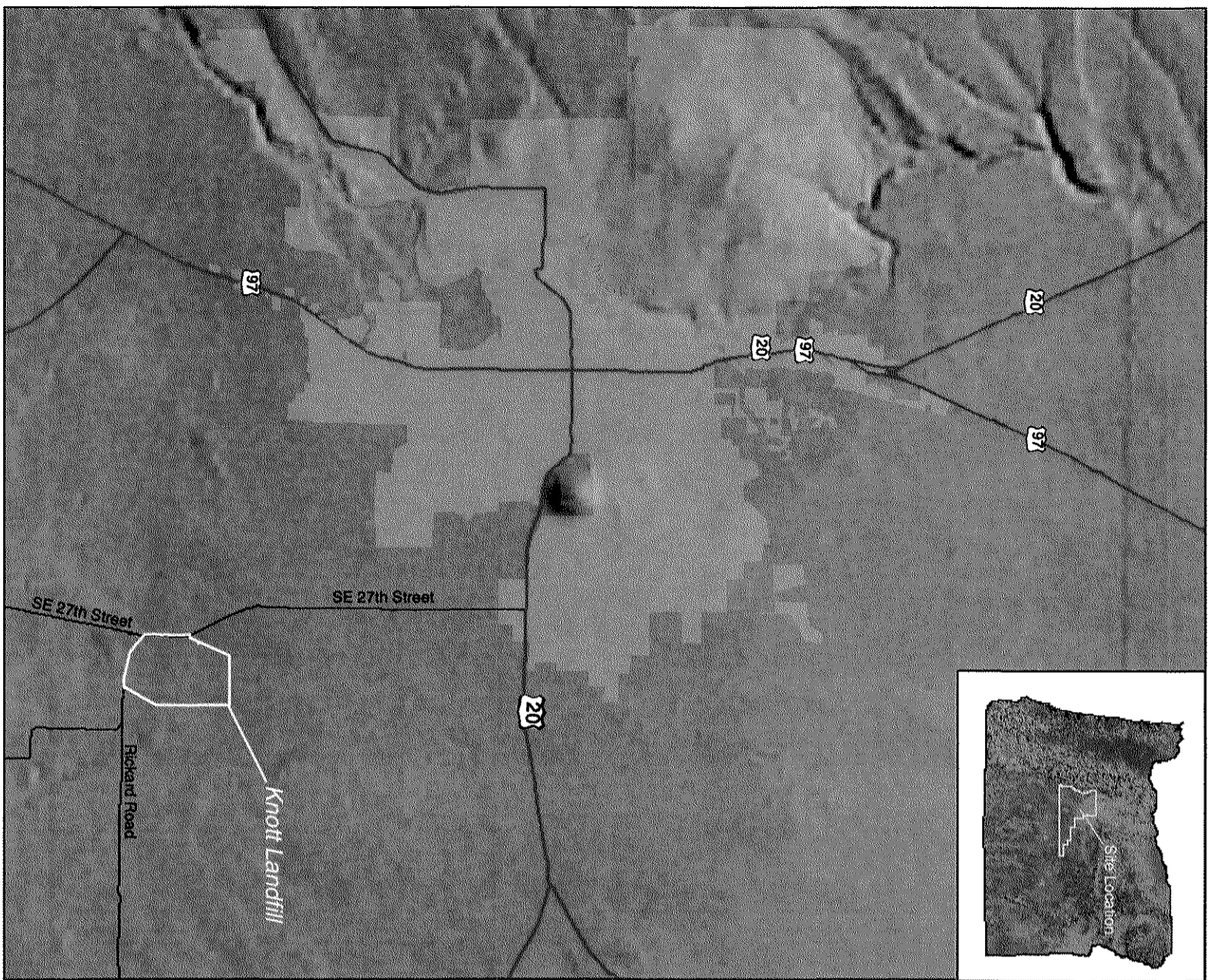
**Table 2-1: Deschutes County Waste Generation Forecast**

<b>Year</b>	<b>MSW Disposed</b>	<b>Non-MSW Disposed</b>	<b>Miscellaneous Waste</b>	<b>Total Waste Disposed</b>
	<b>tons per yr</b>	<b>tons per yr</b>	<b>tons per yr</b>	<b>tons per yr</b>
2003	83,066	50,592	5,714	139,372
2004	84,727	51,604	5,828	142,159
2005	86,421	52,636	6,470	145,527
2006	88,150	53,688	6,064	147,902
2007	89,913	54,762	6,185	150,860
2008	91,717	55,861	6,309	153,887
2009	93,545	56,974	6,435	156,954
2010	95,226	58,158	6,391	159,775
2011	96,027	58,648	6,445	161,120
2012	98,066	59,892	6,582	164,540
2013	100,104	61,138	6,718	167,960
2014	102,912	62,853	6,907	172,672
2015	104,951	64,097	7,044	176,092
2016	105,358	64,346	7,071	176,775
2017	107,146	65,438	7,191	179,775
2018	109,694	66,994	7,362	184,050
2019	111,526	68,114	7,485	187,125
2020	113,315	69,205	7,605	190,125
2021	115,147	70,325	7,728	193,200
2022	116,220	70,980	7,800	195,000
2023	117,248	71,608	7,869	196,725
2024	119,125	72,755	7,995	199,875
2025	120,198	73,410	8,067	201,675
2026	121,003	73,901	8,121	203,025
2027	121,763	74,365	8,172	204,300
2028	123,461	75,403	8,286	207,150
2029	124,266	75,894	8,340	208,500
<b>Total</b>	<b>2,840,295</b>	<b>1,733,641</b>	<b>192,184</b>	<b>4,766,120</b>

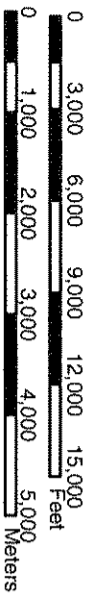
July 30, 2003

MSW: Compacted wastes; household/residential wastes/transfer trailer wastes

Non-MSW: Industrial wastes; demolition wastes



Source: Oregon Geospatial Data Clearinghouse



Approximate Scale: 1 inch equals 6,000 feet

**SITE LOCATION MAP**

SITE DEVELOPMENT PLAN  
KNOTT LANDFILL

DESCHUTES COUNTY, OREGON

August 2003

**FIGURE 2-1**



No.	DATE	BY	REVISION
A	5/22/03	PCF	REVISIONS PER DEQ/COUNTY COMMENTS FOR CLIENT REVIEW
B	7/19/03	GAS	REVISIONS PER DEQ/COUNTY COMMENTS

JOB No. 25895172	DESIGNED BY: G. FRIESEN	PROJ. ENGINEER: G. FRIESEN
SCALE: 1"=300'	DRAWN BY: P. FLURY	APPROVED BY: G. FRIESEN
	CHECKED BY: G. HOLROYD	DATE: JULY 2003

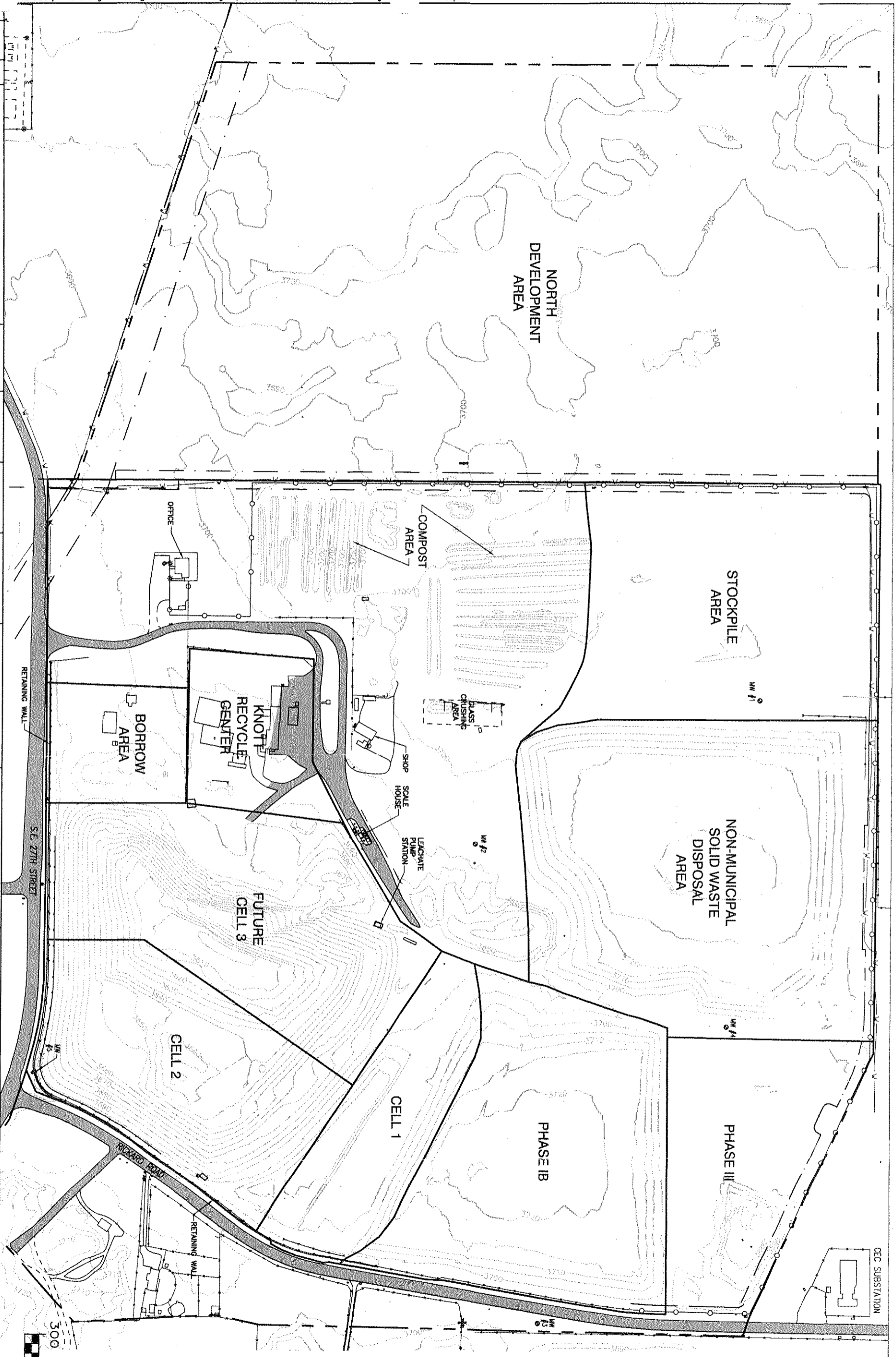
G. Friesen Associates, Inc.  
 4088 Orchard Drive  
 Portland, Oregon 97201  
 Tel: (503) 535-1447  
 Fax: (503) 535-1447

**URS**  
 111 S.W. Columbia, Suite 900  
 Portland, Oregon 97201  
 (tel) 503-222-7200  
 (fax) 503-222-4292

**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 EXISTING SITE PLAN

DRAWING NUMBER <b>Figure 2</b>	CAD FILE NUMBER <b>FIG 2 -</b>
SHEET OF	REV. REV.



**LEGEND**

- PROPERTY LIN
- EXIST. 10' CON
- EXIST. 5' CONT
- EASEMENT
- EXIST. WATER


**SCALE IN FEET**

0 300

**5' CONTOUR LEVEL**  
 FLIGHT AUGUST 9, 2002

No.	DATE	BY	REVISION
A	5/22/03	PCF	FOR CLIENT REVIEW
B	7/18/03	CAS	REVISIONS PER DESCHUTES COUNTY COMMENTS

JOB No.	25685172
DESIGNED BY:	G. FRIESEN
PROJ. ENGINEER:	G. FRIESEN
SCALE:	1" = 300'
DRAWN BY:	P. FLURY
APPROVED BY:	G. FRIESEN
CHECKED BY:	G. HOLROYD
DATE:	JULY 2003



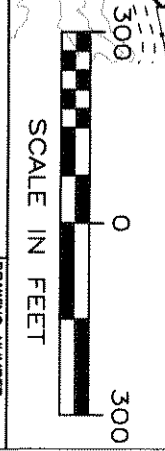
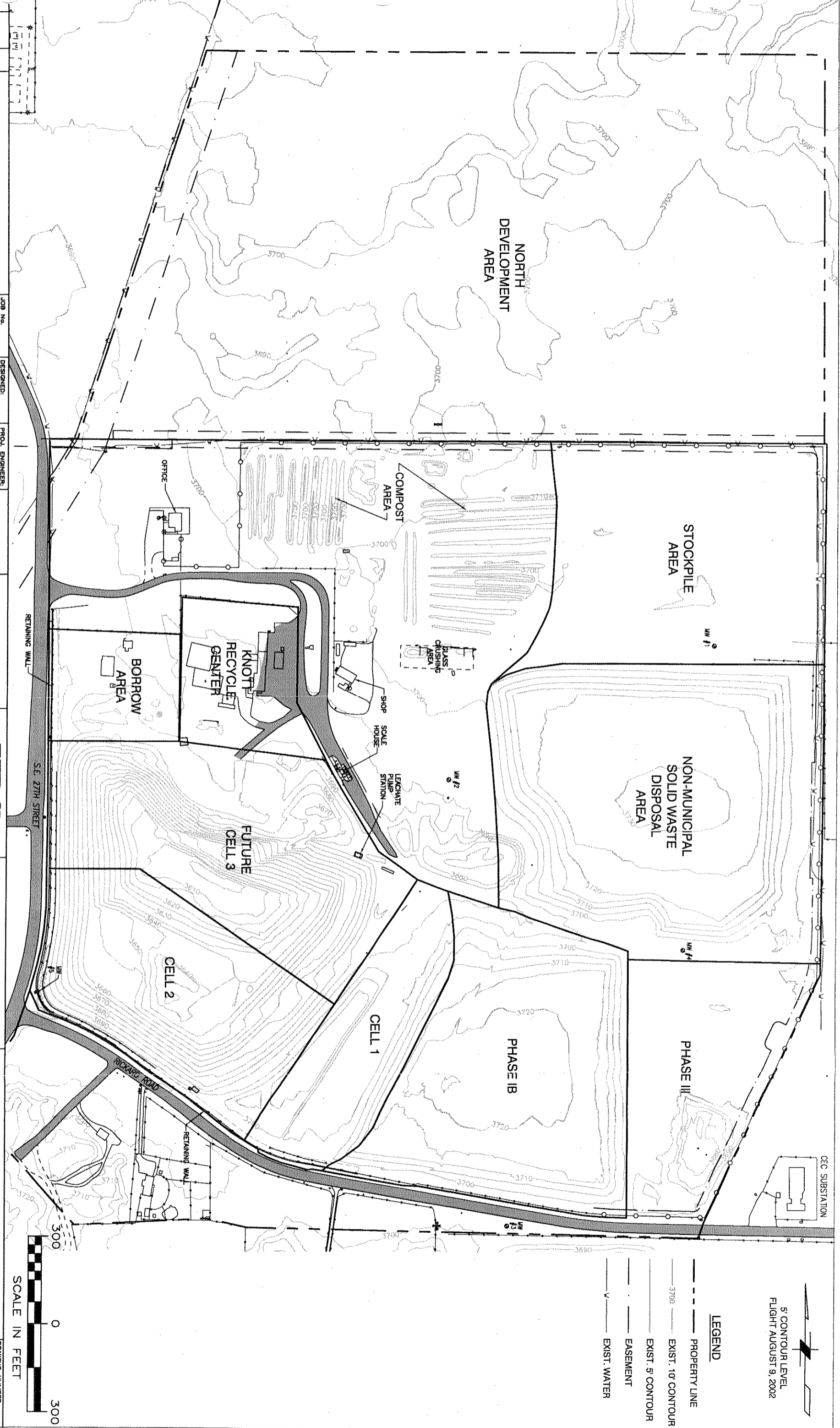
G. Friesen Associates, Inc.  
 4088 Columbia Blvd.  
 Lake Oswego, Oregon 97035  
 Tel: (503) 585-1233  
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 (fax) 503-222-4292

**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 EXISTING SITE PLAN

DRAWING NUMBER:	<b>Figure 2-2</b>
CAD FILE NUMBER:	FIG 2-2
SHEET:	B
OF	B



**LEGEND**

- PROPERTY LINE
- EXIST. 10' CONTOUR
- - - EXIST. 5' CONTOUR
- EASEMENT
- - - EXIST. WATER

5' CONTOUR LEVEL  
 FLIGHT AUGUST 9, 2002



No.	DATE	BY	REVISION
A	5/22/03	PCF	FOR CLIENT REVIEW
B	7/18/03	CAS	REVISIONS PER DESCHUTES COUNTY COMMENTS

JOB No.	25685172	DESIGNED BY:	G. FRIESEN	PROJ. ENGINEER:	G. FRIESEN
SCALE:	1" = 300'	DRAWN BY:	P. FLURY	APPROVED BY:	G. FRIESEN
CHECKED BY:	G. HOLROYD	DATE:	JULY 2003		



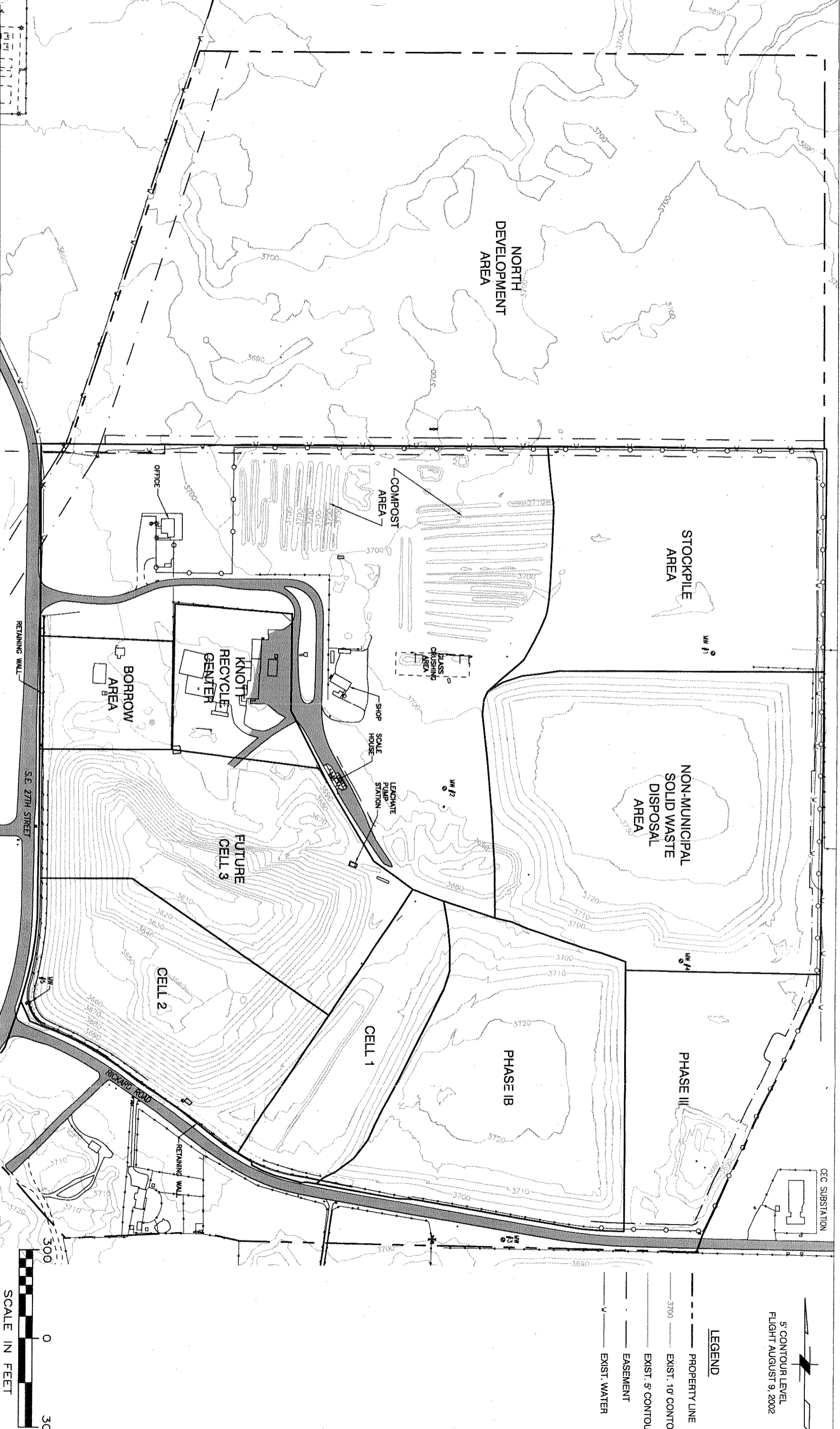
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 Portland, Oregon 97201  
 (Tel) 503-222-7200  
 (fax) 503-222-4292

**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 EXISTING SITE PLAN

DRAWING NUMBER:	Figure 2-2
CAD FILE NUMBER:	FIG 2-2
SHEET:	B
OF	8



**Section Three:  
Phased Development Plan**

### **3.1 INTRODUCTION**

The Knott Landfill and Recycle Center will be developed in phases. It is anticipated that the North Area facilities will be designed in 2003 and constructed by the end of 2004. Future refuse cells will be constructed as additional refuse disposal capacity is needed.

### **3.2 NORTH AREA FACILITIES DESCRIPTION**

In the fall of 2001, Deschutes County retained URS Corporation to conduct a number of studies relative to the future development of the Knott Landfill and Recycle Center. The URS team studied the technical and economic merits of several development options. As a result of the studies, the preferred option was to fully develop the area within the SM zone and maximize the capacity of the landfill. In order to enable this to occur, those facilities and operations located within the SM zone will have to be moved or relocated.

In the Summer of 2002, the County decided to look at the opportunity of developing a parcel of County owned land to the north of Knott Landfill as the location for new support facilities. A conceptual site plan (see Figure 3-1) was developed that showed the boundary of the proposed 70 acre parcel and the relative locations of an administrative building, a materials recovery facility, a public drop-off area, a household hazardous waste facility, a maintenance facility, scale and scale house and roads.

In the Fall of 2002, the County submitted an application for a Conditional Use Permit to develop the North Area to the County Community Development Department. The permit was reviewed, a public hearing held and the Conditional Use Permit approved in December of 2002.

The first phase of work will include the construction of roads, the scales, a material recovery facility (MRF) and a public drop-off center. The County is planning to construct these facilities as soon as possible in order to enable the public to be removed from the working face.

### **3.3 KNOTT LANDFILL DESIGN CRITERIA**

Design criteria have been established for the landfill's development based on regulatory agency requirements, standard design practices for a state-of-the-art landfill, typical operating procedures, and Deschutes County Solid Waste Department policies. It is the intent of this section to identify for future operators, designers, and regulators, the design criteria that were used in the development plan, and show how these criteria were used to determine the shape of the facility in its final configuration.

### 3.3.1 Landfill Footprint

The final footprint of the landfill is dictated by the following site constraints and design criteria:

- Landfilling is to occur only in those areas zoned for Surface Mining (SM) and where a conditional use permit has been issued.
- 25-foot buffer between the property line and refuse disposal area.

Based on these constraints, the final footprint of the landfill has been established and is shown on Figure 3-2. Of the total site area of 205-acres, 135 acres will be used for solid waste disposal (66 percent of the site).

### 3.3.2 Perimeter Access Road

Figure 3-2 shows the perimeter access road that will be constructed as landfilling progresses. This road will provide access for future maintenance activities and a location for the perimeter ditch system. A profile showing the vertical alignment of the roadway is shown on Figure 3-3 and 3-4.

Design criteria that have been established for the perimeter road are as follows:

- Minimum slope of 0.50 percent to enable the perimeter road ditch to drain.
- Minimum bench width of 25 feet to accommodate liner and final cover system anchor trenches, perimeter ditch and access road.
- Minimum roadway width of 12 feet.
- Minimum exterior sideslope of 2 horizontal to 1 vertical.
- Minimum interior sideslope of 3 horizontal to 1 vertical.

### 3.3.3 Excavation Plan

Bottom elevations for the landfill are established by the need to provide proper drainage slopes to the leachate collection system and minimize the quantity of rock excavation. Figure 3-5 shows the excavation plan for future areas. In this plan, leachate drains by gravity to 6 leachate collection sumps.

Design criteria used to develop the bottom plan are as follows:

- Minimize rock excavation.
- Minimum bottom slope toward the leachate transmission line of 5 percent to promote drainage.
- Minimum leachate transmission line slope of 2 percent.

- Maximum excavated sideslope of 3 horizontal to 1 vertical.
- Leachate transmission lines should be able to be accessed and cleaned.

It is planned to excavate for future refuse cells as they are required. Refuse cells, or portions thereof, will be constructed every 2-3 years depending upon incoming refuse volumes and cell configurations.

The following criteria will serve as the basis for selecting the next portion of a refuse cell to be constructed:

- In order to control capital expenditures and minimize leachate production, each development stage shall provide a minimum of 3 years of disposal capacity.
- Each cell shall have a minimum cell dimension of 250 feet in any direction to allow for truck turnaround.
- In order to minimize construction cost, excavation for future refuse cells shall be performed as part of daily and intermediate cover borrow operations, liner system construction, final cover system construction, or access road construction.
- To conserve space and minimize cost, onsite stockpiling shall be kept to a minimum.
- To minimize leachate production, each cell shall be filled to final closure elevation and closed with a final cover cap as quickly as possible.

### **3.3.4 Final Configuration**

The final grading plan for the landfill when fully developed is shown in Figure 3-6. Filling to these elevations will provide a total remaining air space capacity of 8.0 million cubic yards.

The grading that is shown is based on the following design criteria:

- Minimum top of landfill slope of 2 percent.
- Maximum final sideslope of 4 horizontal to 1 vertical.
- Match access road grade around the landfill perimeter.
- Maximum top elevation of 3739 feet msl.

The depth of refuse at completion will vary from zero at the landfill perimeter to 140 feet at the landfill center. Figures 3-7 and 3-8 show cross-section views of the landfill at completion.

### **3.4 FACILITY DEVELOPMENT DRAWINGS**

Drawings showing the phased development for the landfill have been prepared and are shown in Figures 3-9 and 3-10. Drawings for the phased development of the North Area have been prepared and are shown in Figures 3-11 through 3-15.

Soil quantities to be excavated from the landfill have been computed for the landfill and are shown in Table 3-2. A landfill construction sequencing plan has been developed and is shown in Table 3-3.

### **3.5 CELL CONSTRUCTION AND FILL SEQUENCE**

Filling in each landfill cell will occur as follows:

- An access road with a maximum grade of 8 percent will be constructed on the face of each refuse cell as filling progresses. The access road will serve as a haul road for daily cover material during filling. After the cell has been filled, it will serve as the access road to the active face during the filling of the next refuse cell.
- The minimum width of the access road will be 32 feet. A ditch will be provided for on the uphill side.
- A 175 foot by 175 foot tipping pad that is 10 feet in depth will be constructed on the landfill floor within each refuse cell. The tipping pad will be constructed of specially selected solid waste that may be compacted easily and does not threaten the integrity of the liner.
- The tipping pad will be advanced by back dumping using specially selected waste. A minimum of 6 feet of refuse will be in-place before a compactor is allowed to operate on top of the liner system.
- A single 10-foot lift will be placed across the entire landfill cell as quickly as possible during the dry summer months to minimize the production of leachate.
- Each succeeding lift of refuse will have an average depth of 15 to 20-feet. Where possible, filling will be up-slope to promote compaction. The top of each lift will be sloped at a 2 to 4 percent grade toward the preceding cell to minimize the potential for leachate short circuiting.
- Filling will continue until the final finish grade is achieved.

### **3.6 ONSITE SOILS USAGE PLAN**

Soils at the landfill have been characterized and an inventory has been developed. This information is included as Appendix 3a.

**3.7 SCHEDULE**

A schedule for the next 5-year period has been prepared and is shown in Table 3-1. It is anticipated that Refuse Cell 3 will be constructed and be ready to accept refuse by the end of 2004. After 2004, future refuse cells will be constructed as additional landfill disposal capacity is needed.

**Table 3-1: 5-Year Plan for Implementation**

<b>Fiscal Year</b>	<b>Major Project Description/Goals</b>
2003	<ol style="list-style-type: none"> <li>1. Remove Upper Layer of Rock in Cell 3 Borrow Area</li> <li>2. Prepare Site Development Plan</li> <li>3. Obtain DEQ Approval for Landfill Expansion</li> <li>4. Revise Site Operations Plan</li> <li>5. Design/Construct North Area Entrance</li> <li>6. Design MRF and Public Drop-off Center</li> <li>7. Design Refuse Cell 3</li> <li>8. Excavate Soil from Cell 3 and Utilize on County Projects</li> </ol>
2004	<ol style="list-style-type: none"> <li>1. Construct MRF and Public Drop-off Center</li> <li>2. Excavate Soil from Cell 3 and Utilize on County Projects</li> <li>3. Construct Cell 3</li> <li>4. Relocate Monitoring Well No. 4</li> <li>5. Prepare End Use Feasibility Study</li> </ol>
2005	<ol style="list-style-type: none"> <li>1. Relocate Recycle Center</li> <li>2. Remove Upper Layer of Rock in Cell 4 Borrow Area</li> <li>3. Design/Construct North Area Compost Facility</li> <li>4. Excavate Soil from Cell 4 and Utilize on County Projects</li> <li>5. Design Area A Closure and End Use</li> </ol>
2006	<ol style="list-style-type: none"> <li>1. Design/Construct Central Berm</li> <li>2. Relocate Monitoring Well No. 2</li> <li>3. Excavate Soil from Cell 4 and Utilize on County Projects</li> </ol>
2007	<ol style="list-style-type: none"> <li>1. Close Area A and Develop End Use</li> <li>2. Construct Cell 4</li> <li>3. Remove Upper Layer of Rock in Cell 5 Borrow Area</li> <li>4. Excavate Soil from Cell 5 and Utilize on County Projects</li> </ol>

**Table 3-2: Refuse Cell Volumetrics at the Knott Landfill**

Cell	Future Excavation		Gross Airspace (cy)	Refuse Bank Yards		Disposal Capacity (tons)	Future Soil Requirements	
	Surface Area (acres)	Required (cy)		Cell (cy)	Cumulative (cy)		Liner System (cy)	Daily/Interim Cover (cy)
2	11.1	0	550,000	420,000	420,000	260,000	0.0	80,000
3	11.2	300,000	700,000	570,000	990,000	360,000	36,000	146,000
4	5.5	370,000	750,000	690,000	1,680,000	430,000	18,000	158,000
5a	4.9	380,000	670,000	610,000	2,290,000	380,000	16,000	136,000
5b	4.1	320,000	560,000	510,000	2,800,000	320,000	13,000	113,000
5c	7.2	560,000	980,000	900,000	3,700,000	560,000	23,000	203,000
6a	5.3	410,000	720,000	660,000	4,360,000	410,000	17,000	147,000
6b	10.6	820,000	1,440,000	1,320,000	5,680,000	830,000	34,000	294,000
6c	5.2	410,000	710,000	650,000	6,330,000	410,000	17,000	147,000
6d	6.7	520,000	910,000	830,000	7,160,000	520,000	22,000	192,000
6e	7.6	590,000	1,040,000	950,000	8,110,000	590,000	25,000	215,000
<b>Total</b>	79.4	4,700,000	9,000,000	8,110,000		5,070,000	221,000	1,610,000
								1,831,000

**Notes:**

1. Excavation requirements and gross air space volumes are based on contours shown on Figure 3-5 through 3-10.
2. Refuse bank yards equals gross airspace minus liner and final cover system volume (7 vertical feet per square foot of disposal area) and is the airspace available for refuse disposal.
3. Disposal capacity assumes average refuse densities of 1,250 lb per refuse bank yard.
4. Liner system soil requirements assume that a 2-foot of drainage layer will be manufactured from on-site materials.
5. Daily/Interim cover assumes a soil/refuse bank yard volume ratio of 20 percent.



**Table 3-3: Landfill Construction Sequencing at the Knott Landfill**

Year	Projected Disposal Rate (tons/yr)	Refuse Bank Yards Required		Construction Activities		Future Soil Requirements				On-Site Soils Balance					
		Annual (cy)	Cumulative (cy)	New Cell No.	Phase	Closure Area (Acre)	Liner System (cy)	Daily/Interim Cover (cy)	Final Cover (cy)	Other Projects (cy)	Annual (cy)	Total Cumulative (cy)	Excavation Required (cy)	Cumulative Exc Req'd (cy)	Soils to Stockpile (cy)
2003	139,372	223,000	223,000	0.0	0.0	0	45,000	0	100,000	145,000	145,000	0	0	0	
2004	142,159	227,000	450,000	3	11.2	36,000	45,000	0	100,000	181,000	326,000	300,000	300,000	0	
2005	145,527	233,000	683,000	0.0	0.0	0	47,000	0	80,000	127,000	453,000	0	300,000	0	
2006	147,902	237,000	920,000	0.0	0.0	0	47,000	0	80,000	127,000	580,000	0	300,000	0	
2007	150,860	241,000	1,161,000	4	5.5	18,000	48,000	340,000	80,000	486,000	1,066,000	370,000	670,000	0	
2008	153,887	246,000	1,407,000	0.0	0.0	0	49,000	0	80,000	129,000	1,195,000	0	670,000	0	
2009	156,954	251,000	1,658,000	0.0	0.0	0	50,000	0	80,000	130,000	1,325,000	0	670,000	0	
2010	159,775	256,000	1,914,000	5a	4.9	16,000	51,000	0	80,000	147,000	1,472,000	430,000	1,100,000	0	
2011	161,120	258,000	2,172,000	0.0	0.0	0	52,000	0	80,000	132,000	1,604,000	0	1,100,000	0	
2012	164,540	263,000	2,435,000	5b	4.1	13,000	53,000	190,000	80,000	336,000	1,940,000	430,000	1,530,000	0	
2013	167,960	269,000	2,704,000	0.0	0.0	0	54,000	0	80,000	134,000	2,074,000	0	1,530,000	0	
2014	172,672	276,000	2,980,000	5c	7.2	23,000	55,000	0	80,000	158,000	2,232,000	430,000	1,960,000	0	
2015	176,092	282,000	3,262,000	0.0	0.0	0	56,000	0	80,000	136,000	2,368,000	0	1,960,000	0	
2016	176,775	283,000	3,545,000	6a	5.3	17,000	57,000	0	80,000	154,000	2,522,000	420,000	2,380,000	0	
2017	179,775	288,000	3,833,000	0.0	0.0	0	58,000	0	80,000	138,000	2,660,000	0	2,380,000	0	
2018	184,050	294,000	4,127,000	0.0	0.0	0	59,000	0	80,000	139,000	2,799,000	0	2,380,000	0	
2019	187,125	299,000	4,426,000	6b	10.6	34,000	60,000	180,000	80,000	354,000	3,153,000	830,000	3,210,000	0	
2020	190,125	304,000	4,730,000	0.0	0.0	0	61,000	0	80,000	141,000	3,294,000	0	3,210,000	0	
2021	193,200	309,000	5,039,000	0.0	0.0	0	62,000	0	80,000	142,000	3,436,000	0	3,210,000	0	
2022	195,000	312,000	5,351,000	0.0	0.0	0	62,000	0	80,000	142,000	3,578,000	0	3,210,000	0	
2023	196,725	315,000	5,666,000	6c	5.2	17,000	63,000	0	80,000	160,000	3,738,000	410,000	3,620,000	0	
2024	199,875	320,000	5,986,000	0.0	0.0	0	64,000	0	80,000	144,000	3,882,000	0	3,620,000	0	
2025	201,675	323,000	6,309,000	0.0	0.0	0	65,000	0	80,000	145,000	4,027,000	0	3,620,000	0	
2026	203,025	325,000	6,634,000	6d	5.2	17,000	65,000	0	80,000	162,000	4,189,000	530,000	4,150,000	0	
2027	204,300	327,000	6,961,000	0.0	0.0	0	65,000	0	80,000	145,000	4,334,000	0	4,150,000	0	
2028	207,150	331,000	7,292,000	6e	7.6	25,000	66,000	130,000	80,000	301,000	4,635,000	600,000	4,750,000	0	
2029	208,500	334,000	7,626,000	0.0	0.0	0	67,000	0	0	67,000	4,702,000	0	4,750,000	0	
2030	209,775	336,000	7,962,000	0.0	0.0	0	67,000	0	0	67,000	4,769,000	0	4,750,000	0	
2031	211,160	100,000	8,062,000	0.0	13.1	0	20,000	110,000	0	130,000	4,899,000	0	4,750,000	0	
Total	5,187,055	8,062,000		66.8	118.4	216,000	1,613,000	950,000	2,120,000	4,899,000		4,750,000		0	



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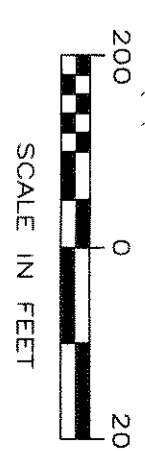
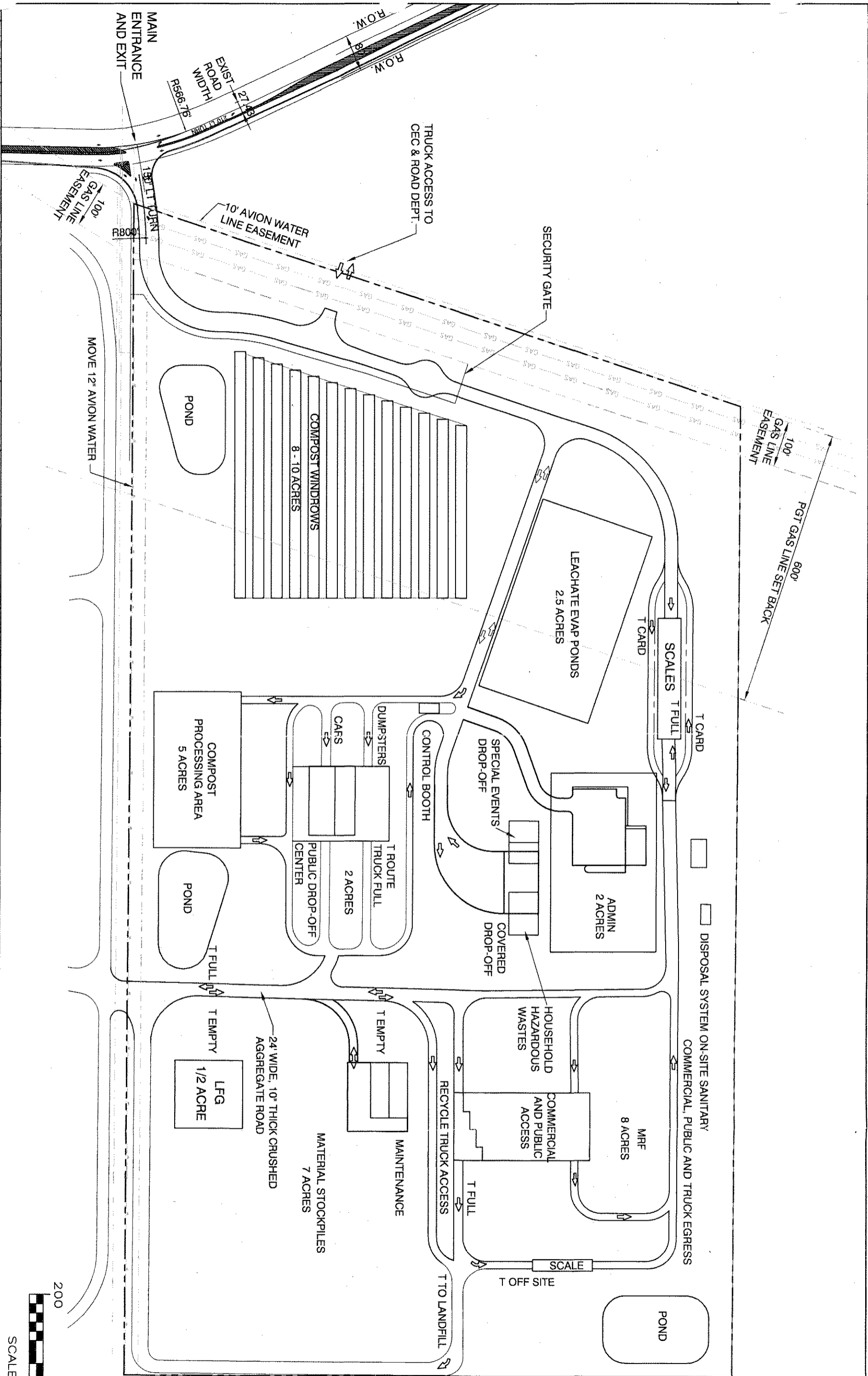
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Knott Landfill North Area  
NORTH AREA SITE PLAN

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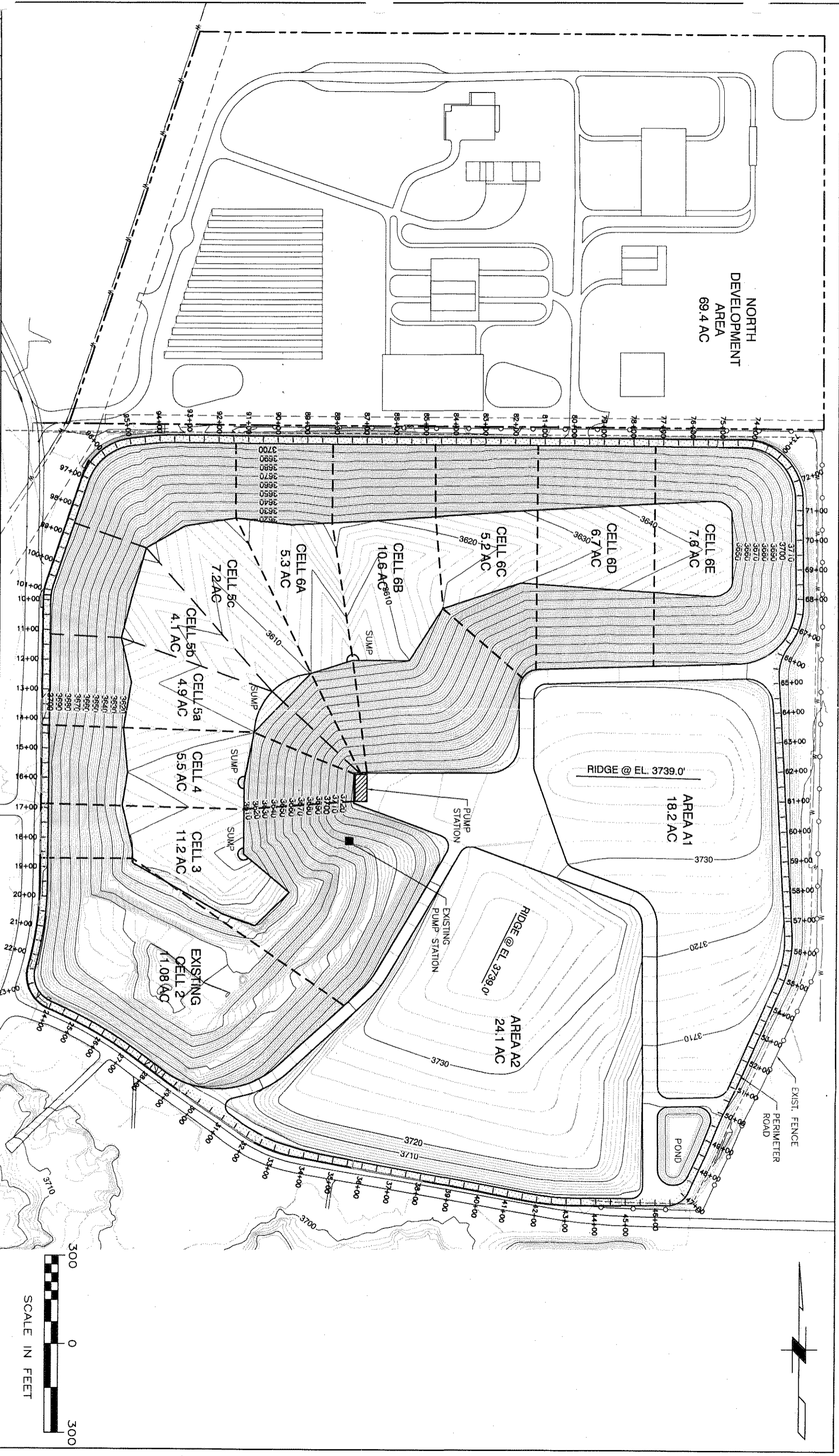
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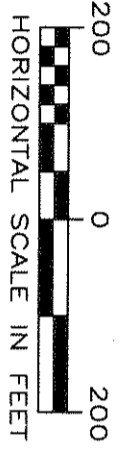
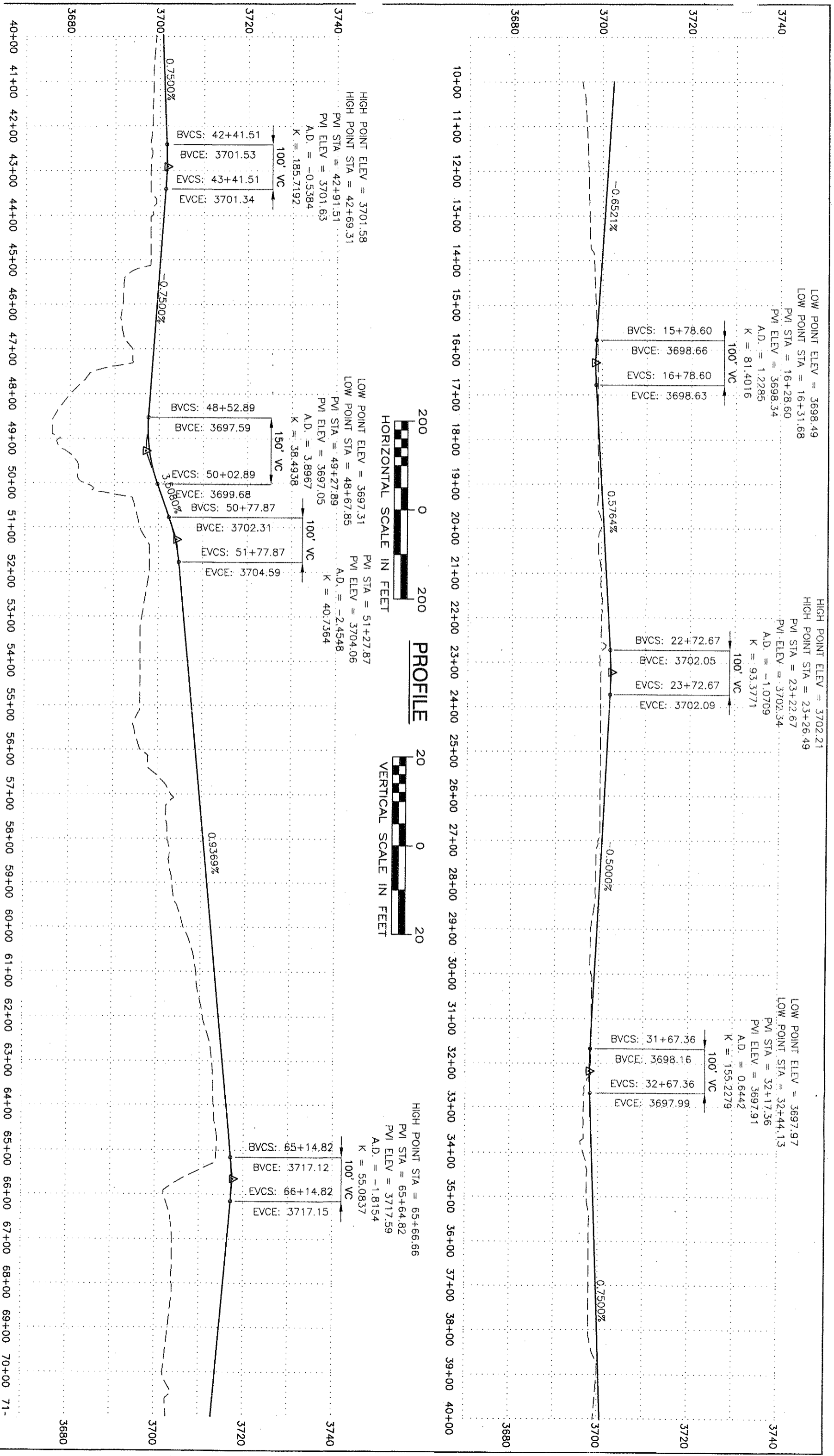
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**Knott Landfill Site Development Plan**  
 LANDFILL FOOTPRINT

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	FIG 3-2
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 G. Friesen Associates, Inc. 4088 Columbia Blvd. Lake Oswego, Oregon 97035 Tel: (503) 635-1233 Fax: (503) 635-1447											
 URS 111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (Tel) 503-222-7200 (Fax) 503-222-4292				DESCHUTES COUNTY DEPARTMENT OF PUBLIC WORKS BEND, OREGON				Knott Landfill Site Development Plan PERIMETER ROAD PROFILE STA 10+00 TO STA 71+00			
DRAWING NUMBER: <b>Figure 3-3</b>		CAD FILE NUMBER: FIG 3-3		SHEET: OF		REV: A					

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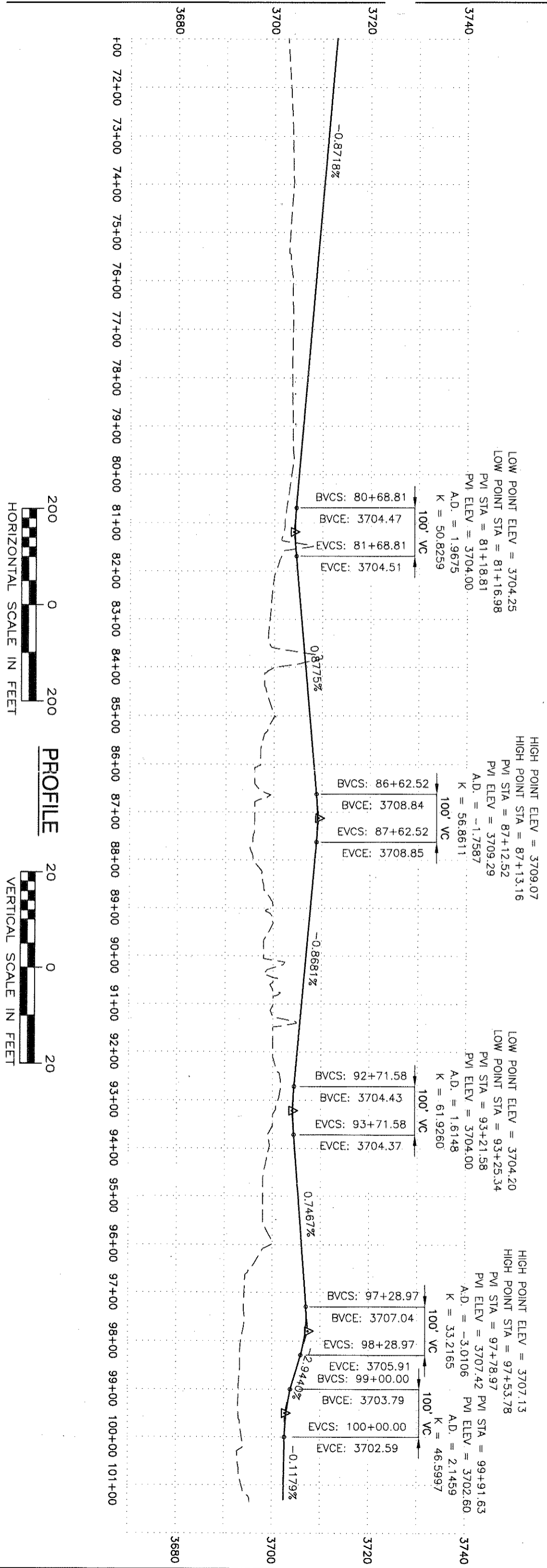
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Knott Landfill Site Development Plan  
PERIMETER ROAD PROFILE  
STA 71+00 TO STA 101+00

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**PROFILE**

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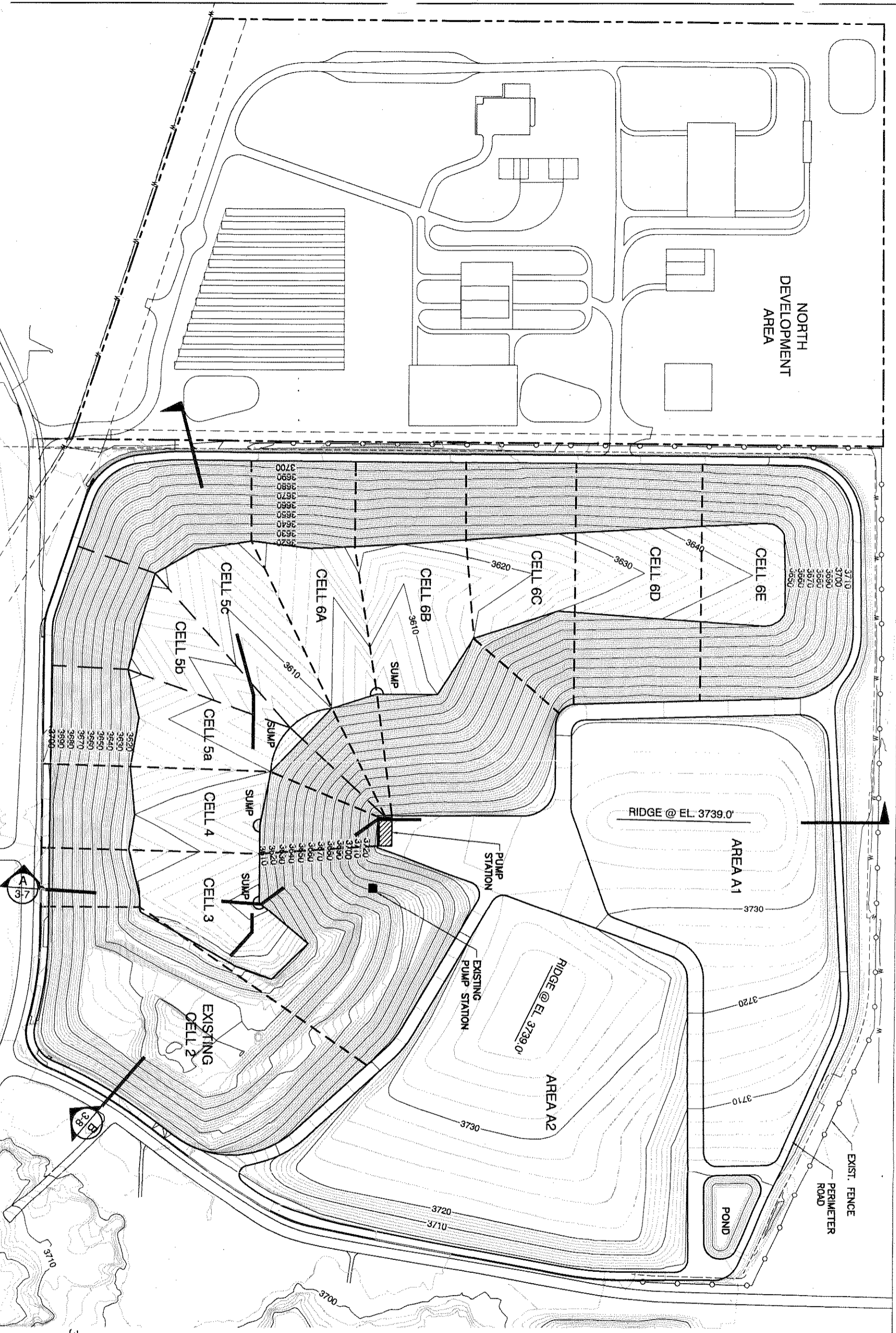
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**Knott Landfill Site Development Plan**  
 EXCAVATION PLAN

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DIRECTION OF VIEW

SECTION LETTER

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NORTH  
 DEVELOPMENT  
 AREA

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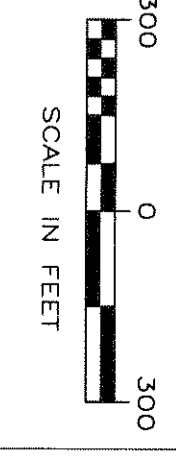
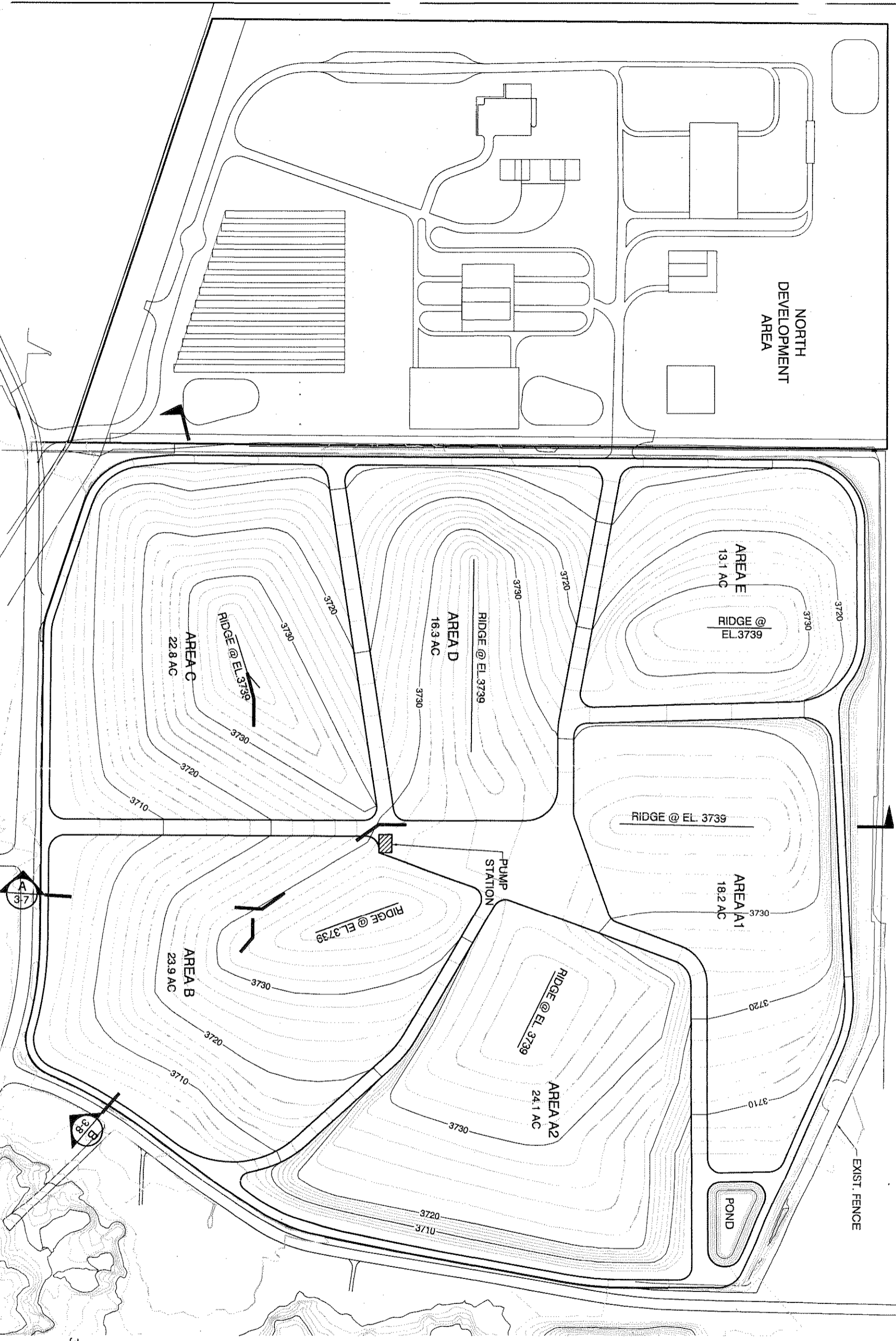
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Knott Landfill Site Development Plan  
 FINAL GRADING PLAN

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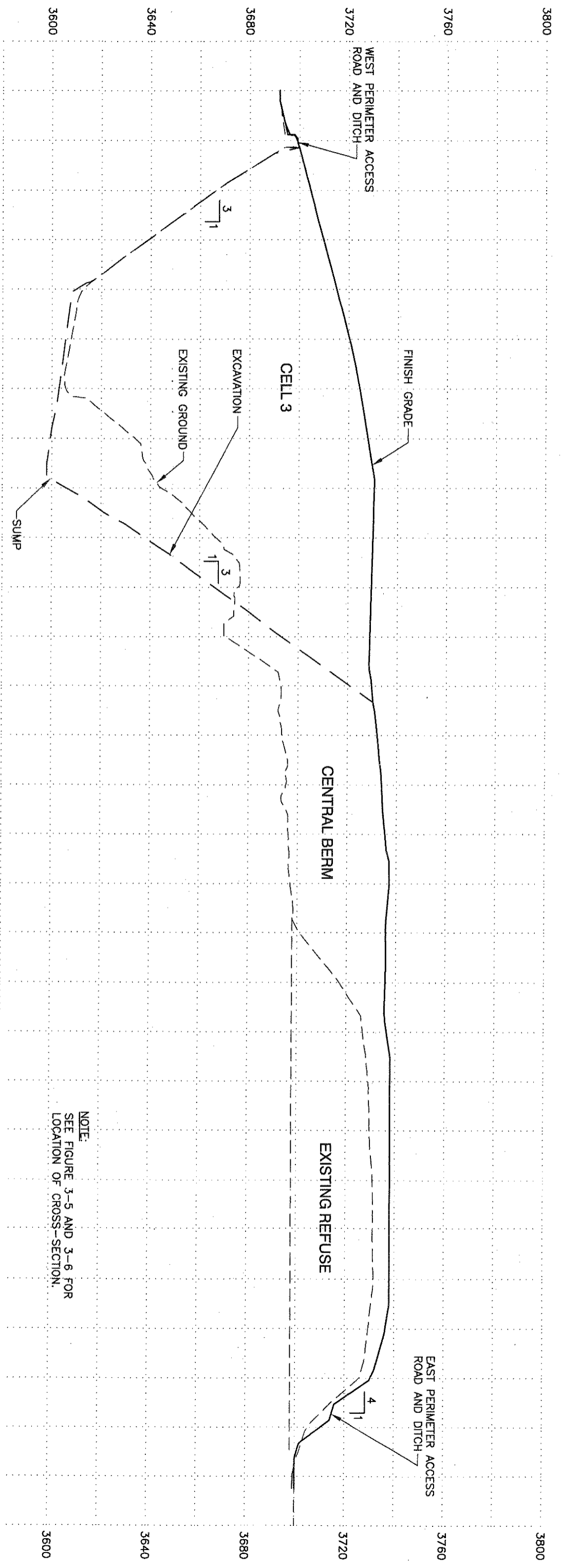
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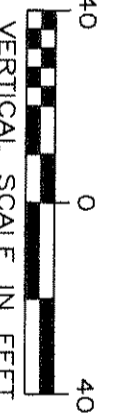
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NOTE:  
SEE FIGURE 3-5 AND 3-6 FOR  
LOCATION OF CROSS-SECTION.



**SECTION**

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3-5-3-6

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Knott Landfill Site Development Plan  
EAST/WEST CROSS SECTION

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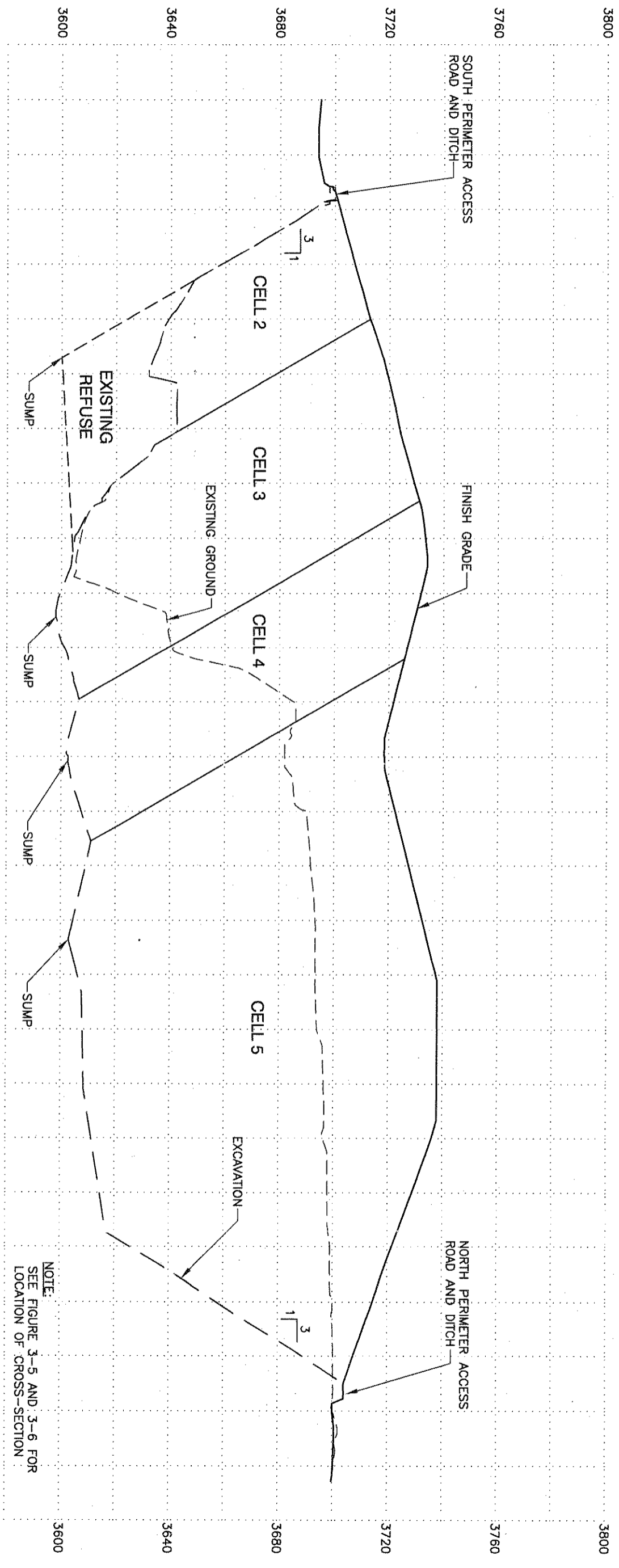
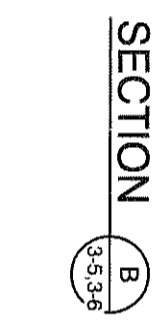
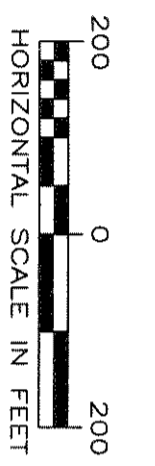
**G. Fritsen Associates, Inc.**  
 4088 Oakland Drive  
 Lake Oswego, Oregon 97035  
 Tel: (503) 635-1233  
 Fax: (503) 635-1447

**URS**  
 111 S.W. Columbia, Suite 900  
 Portland, Oregon 97201  
 (tel) 503-222-7200  
 (fax) 503-222-4292

**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 NORTH/SOUTH CROSS SECTION

**Figure 3-8**  
 CAD FILE NUMBER:  
 FIG 3-8  
 SHEET: OF  
 REV. A



No.	DATE	BY	REVISION
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8	5/22/03	PCF	FOR CLIENT REVIEW

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1"=300'	PCF	GF
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CH	JULY 2003	

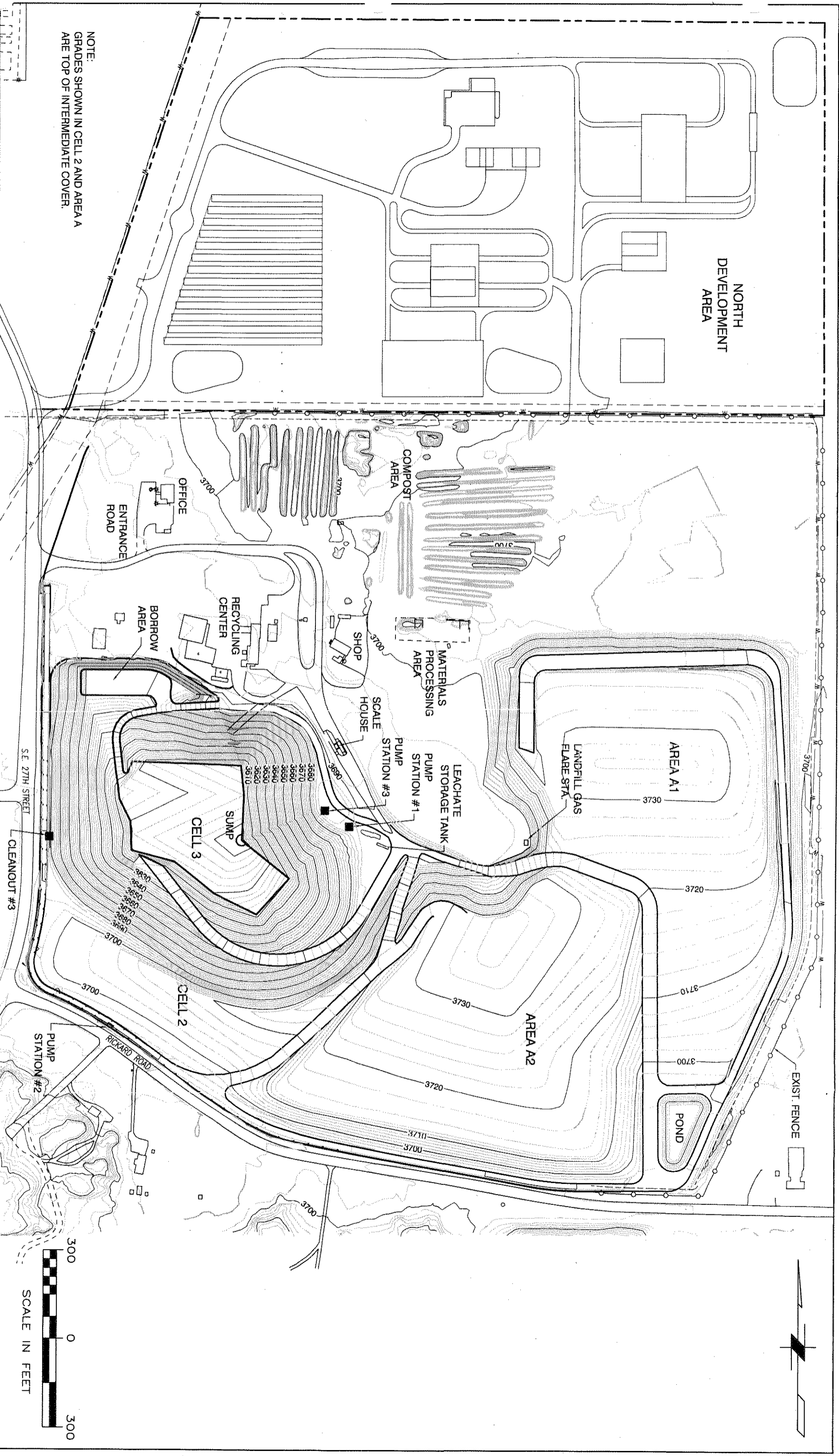
G. Friesen Associates, Inc.  
 Lake Oswego, Oregon 97039  
 Tel: (503) 635-1213  
 Fax: (503) 635-1447

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 111 S.W. Columbia, Suite 900  
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 (fax) 503-222-4292

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**Knott Landfill Site Development Plan**  
 CELL 3/AREA A SITE PLAN  
 (YEAR 2004-05)

DRAWING NUMBER:	Figure 3-9
CAD FILE NUMBER:	FIG 3-9
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No.	DATE	BY	REVISION
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B	7/18/03	CAS	REVISED PER DEQ/COUNTY REVIEW

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1" = 300'	PCF	GF
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GH	JULY 2003	

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 4088 Oregon Ave. N.E.  
 Lake Oswego, Oregon 97035  
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 Fax: (503) 635-1447

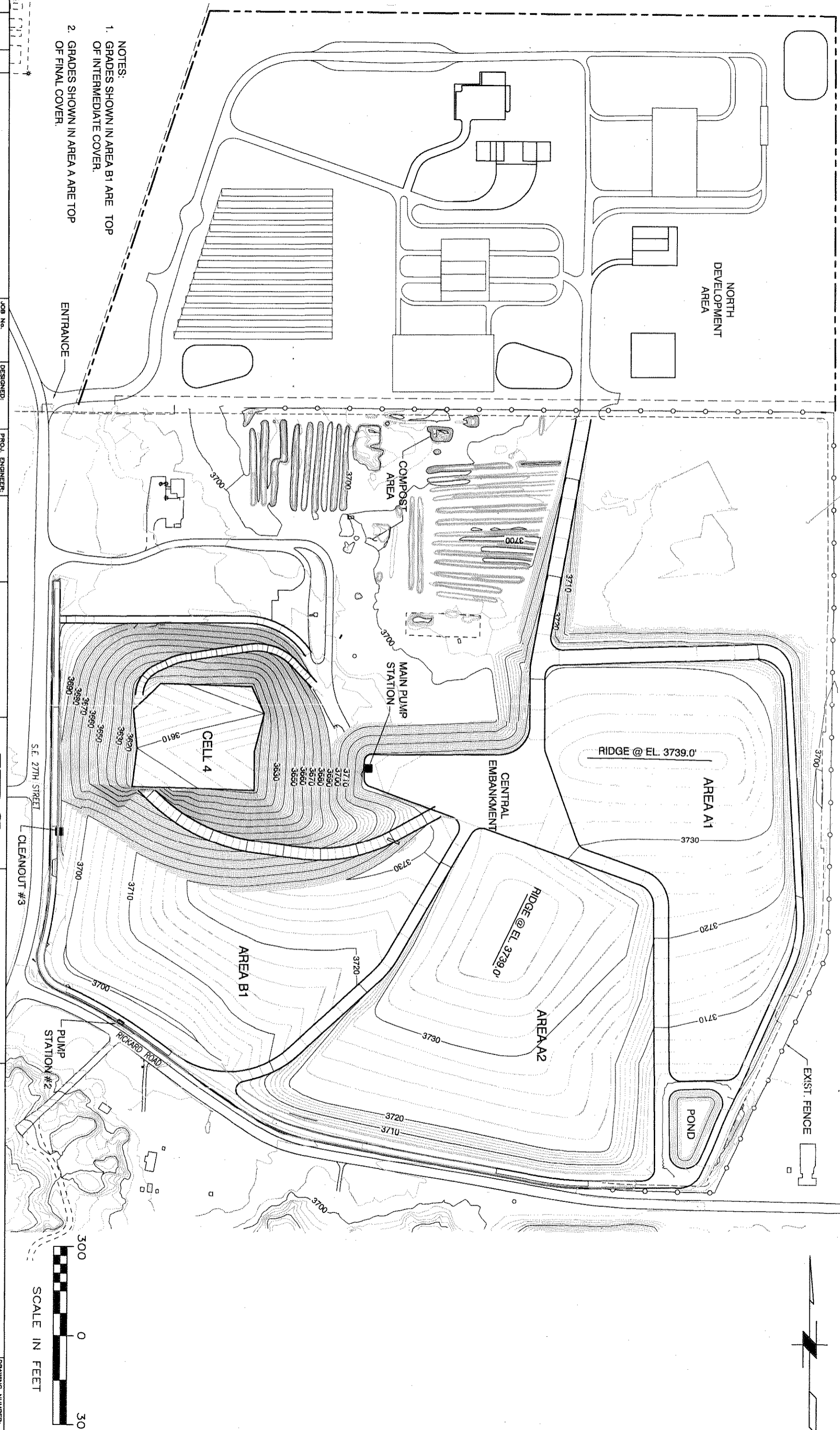
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 (fax) 503-222-4292

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**Knott Landfill Site Development Plan**  
 CELL 4 SITE PLAN  
 (YEAR 2007-2008)

DRAWING NUMBER:  
**Figure 3-10**  
 CAD FILE NUMBER:  
 FIG 3-10  
 SHEET:  
 OF  
 REV.  
 B

- NOTES:  
 1. GRADES SHOWN IN AREA B1 ARE TOP OF INTERMEDIATE COVER.  
 2. GRADES SHOWN IN AREA A ARE TOP OF FINAL COVER.



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DK	JULY 03	GH

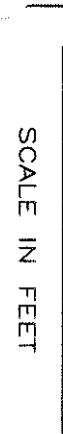
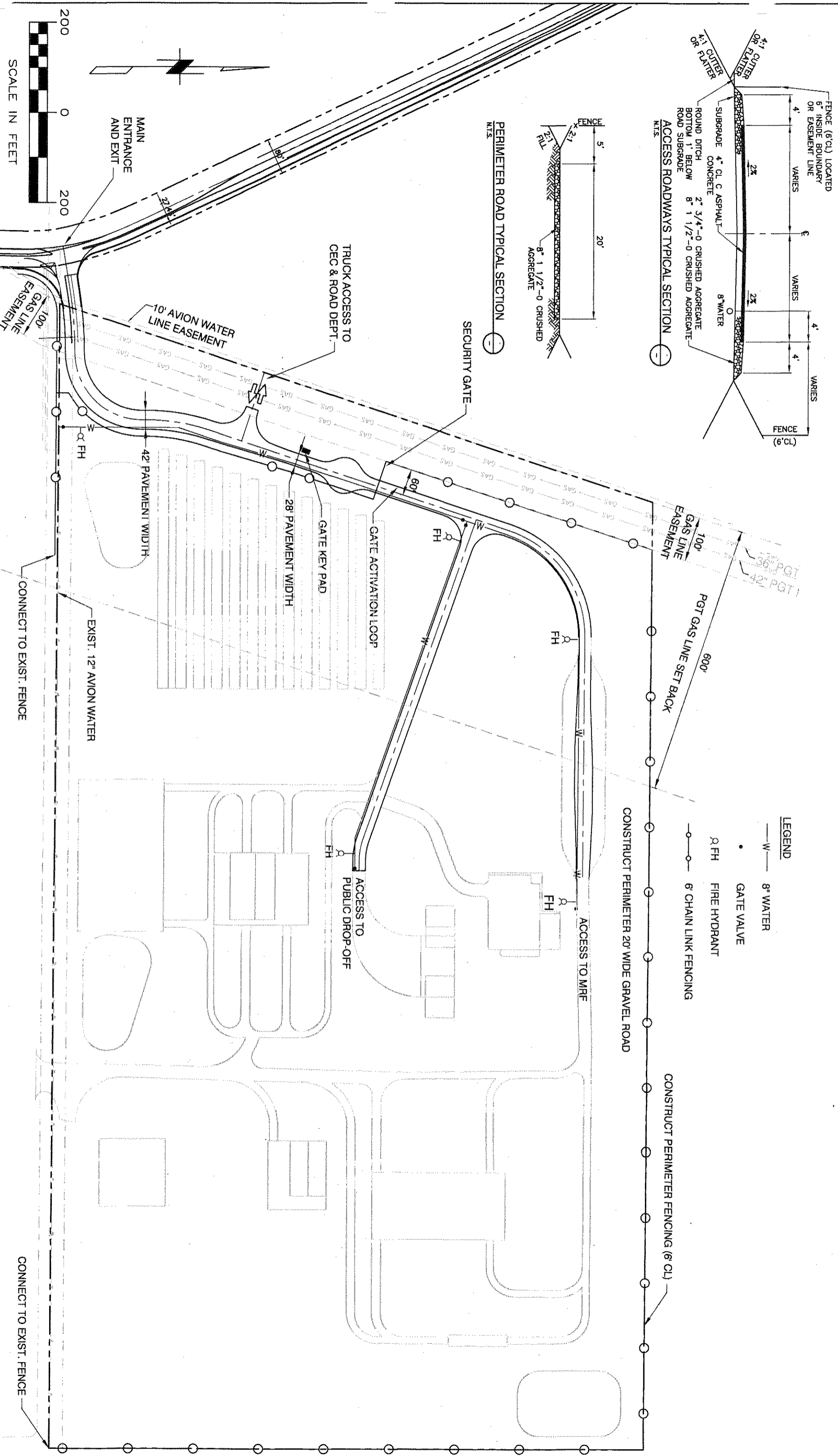
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(fax) 503-222-4292

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BEND, OREGON

Knott Landfill North Area  
CONCEPTUAL SITE LAYOUT  
PHASE 1

DRAWING NUMBER:	Figure 3-11
CAD FILE NUMBER:	FIG 3-11
SHEET:	OP
REV.	B



LEGEND	—W— 8" WATER
•	GATE VALVE
⊗ FH	FIRE HYDRANT
○—○	6' CHAIN LINK FENCING

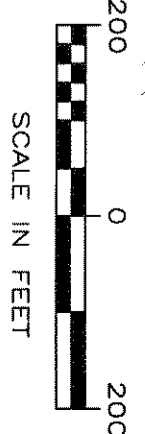
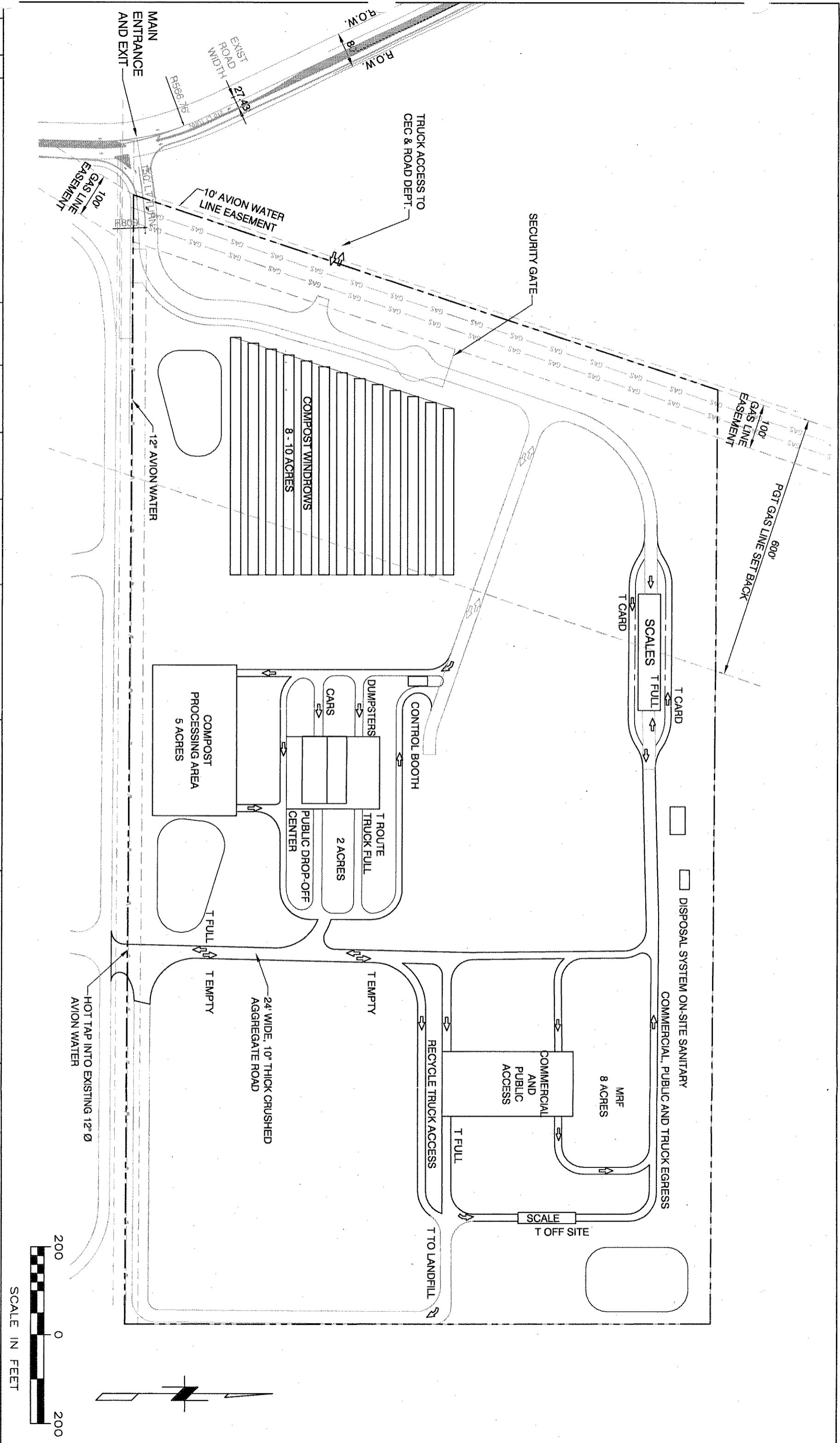
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	CAS	GH
	CHECKED BY:	DATE:
	DK	JULY 03

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Knott Landfill North Area  
CONCEPTUAL SITE LAYOUT  
PHASE 2



DRAWING NUMBER:  
**Figure 3-12**

FIG 3-12

SHEET: REV. B

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A	5/22/03	CAS	FOR CLIENT REVIEW

JOB No.	DESIGNED:	PROJ. ENGINEER:
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DRAWN BY:	CAS	APPROVED BY:
CHECKED BY:	DK	DATE:
		JULY 03

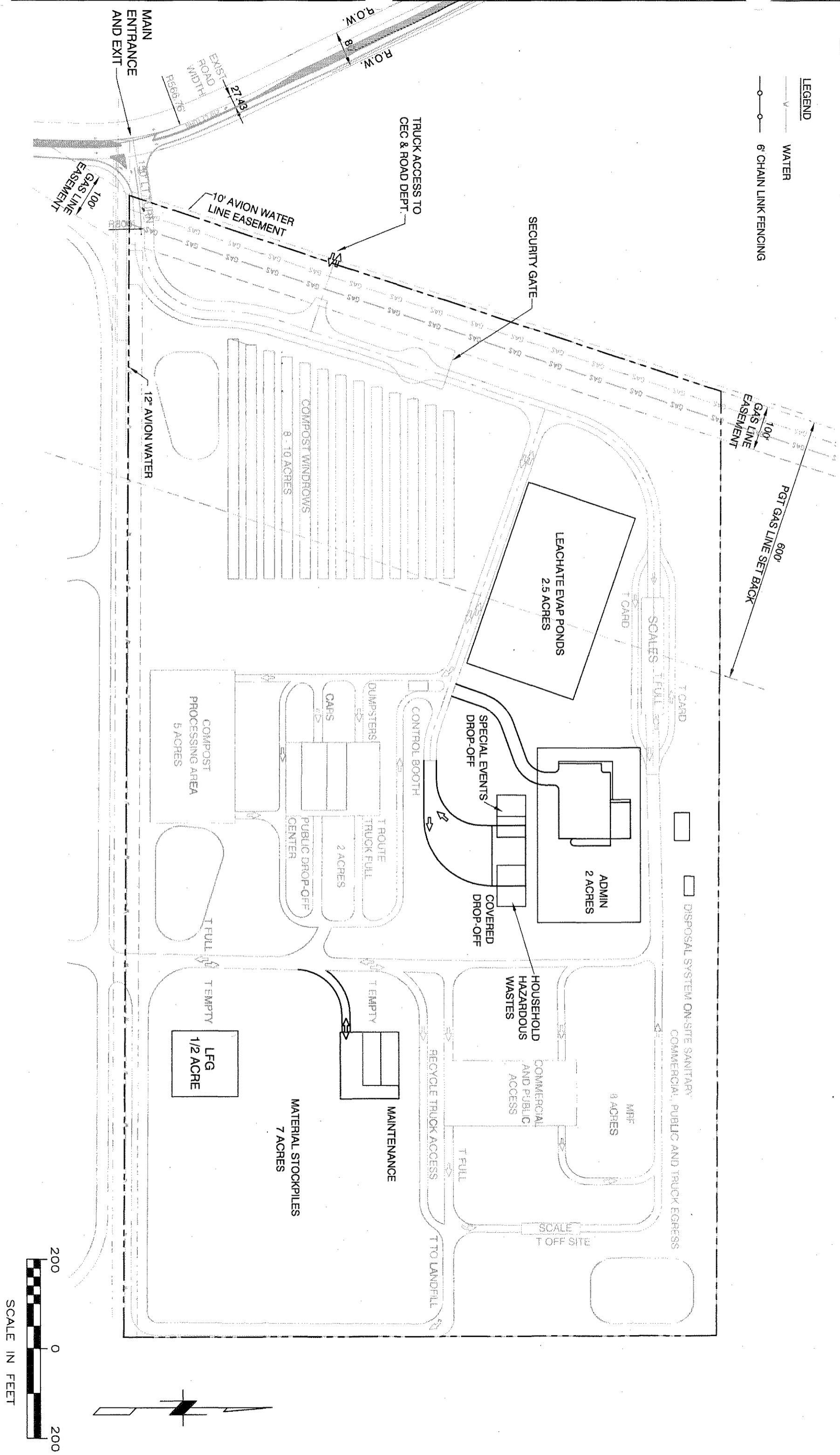
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 111 S.W. Columbia, Suite 900  
 Portland, Oregon 97201  
 (tel) 503-222-7200  
 (fax) 503-222-4292

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Knott Landfill North Area  
 CONCEPTUAL SITE LAYOUT  
 PHASE 3

DRAWING NUMBER:	Figure 3-13
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OF	



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A	5/22/03	CAS	FOR CLIENT REVIEW

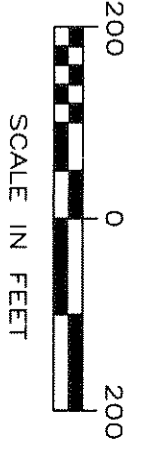
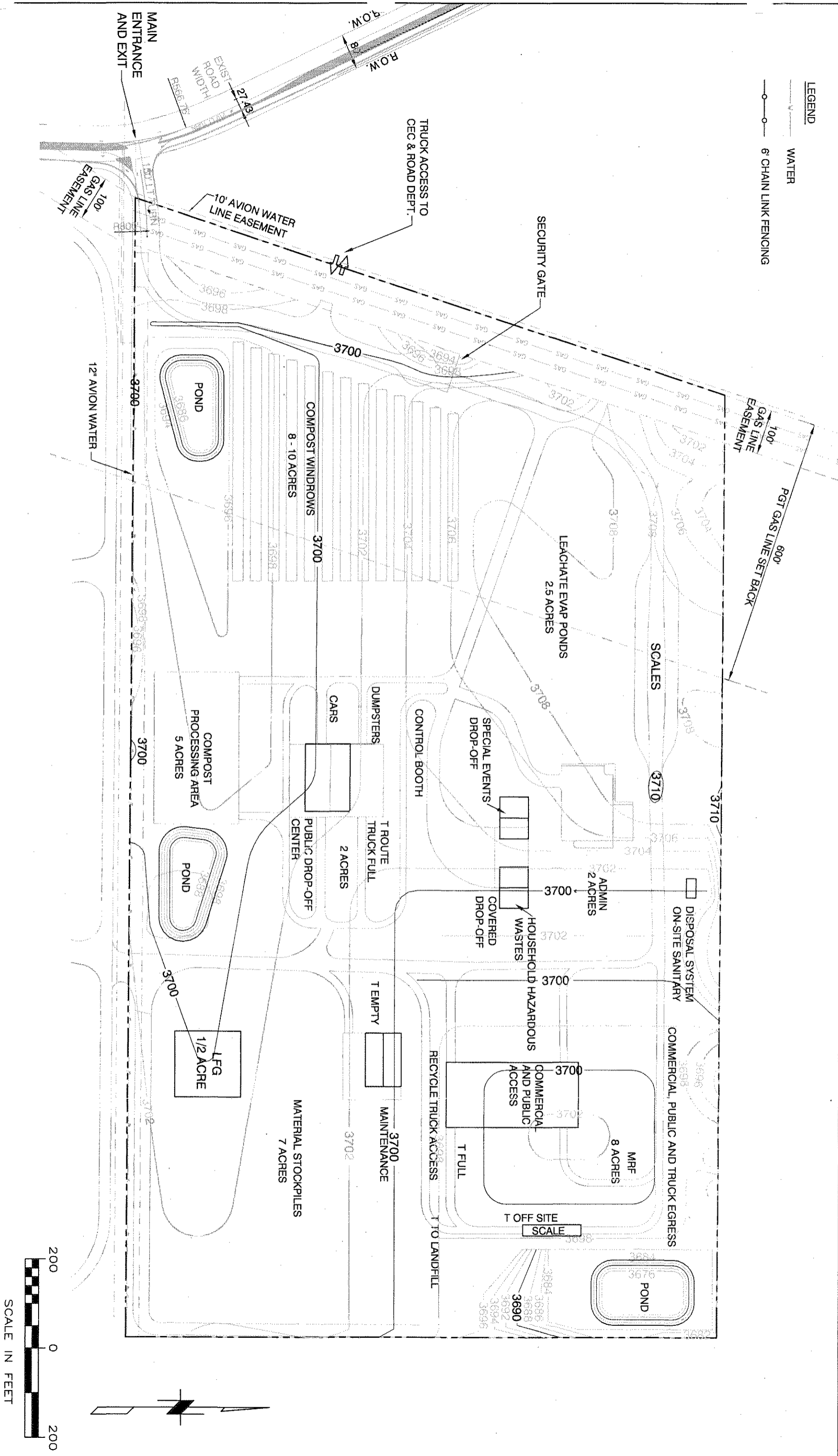
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AS SHOWN	GH	GH
SCALE:	DRAWN BY:	APPROVED BY:
	CAS	GH
	CHECKED BY:	DATE:
	DK	JULY 03

<b>URRS</b> 111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292	
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**DESCHUTES COUNTY**  
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**Knott Landfill North Area**  
 GRADING PLAN

DRAWING NUMBER:	Figure 3-14
CAD FILE NUMBER:	FIG 3-14
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OF:	8



**LEGEND**  
 WATER  
 6" CHAIN LINK FENCING



No.	DATE	BY	REVISION
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A	5/22/03	CAS	FOR CLIENT REVIEW

JOB No.	DESIGNED BY:	PROJ. ENGINEER:
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	CAS	GH
	CHECKED BY:	DATE:
	DK	JULY 03

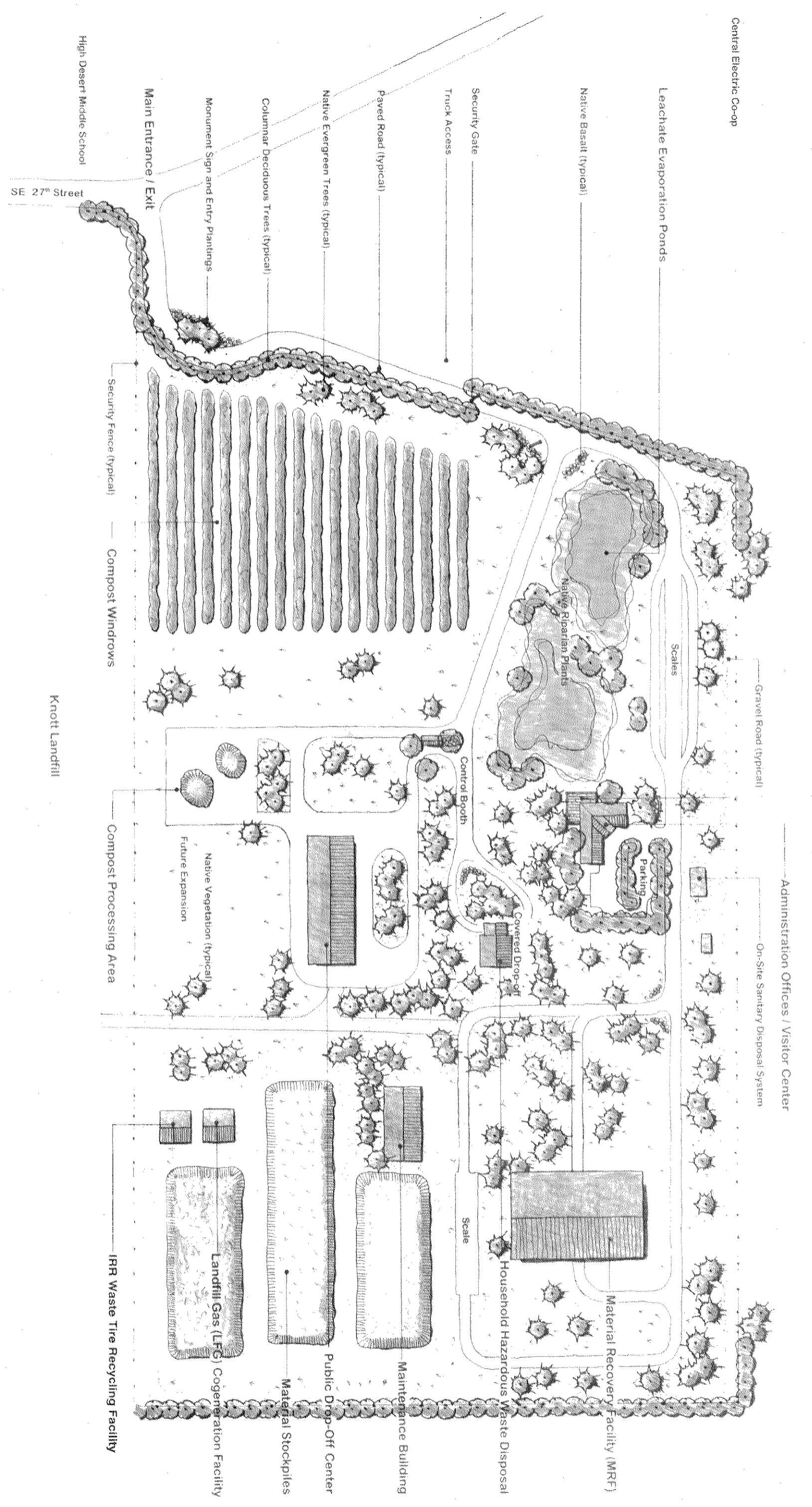
111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292
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**DESCHUTES COUNTY**  
**DEPARTMENT OF PUBLIC WORKS**  
**BEND, OREGON**

**Knott Landfill North Area**  
**SITE CONCEPTUAL PLAN**

DRAWING NUMBER:  
**Figure 3-15**  
 CAD FILE NUMBER:  
**FIG 3-15**  
 SHEET:  
 OF  
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**B**

October 2002



Central Electric Co-op

High Desert Middle School

SF 27th Street

Knott Landfill

Deck and Pond Overlook

Administration Offices / Visitor Center

On-Site Sanitary Disposal System

Leachate Evaporation Ponds

Native Basalt (typical)

Security Gate

Truck Access

Paved Road (typical)

Native Evergreen Trees (typical)

Columnar Deciduous Trees (typical)

Monument Sign and Entry Plantings

Main Entrance / Exit

Security Fence (typical)

Compost Windrows

Compost Processing Area

Gravel Road (typical)

Scales

Native Riparian Plants

Control Booth

Covered Drop-off

Parking

Native Vegetation (typical)  
Future Expansion

Scale

Household Hazardous Waste Disposal

Material Recovery Facility (MRF)

Maintenance Building

Public Drop-Off Center

Material Stockpiles

Landfill Gas (LFG) Cogeneration Facility

IRR Waste Tire Recycling Facility

**Appendix 3a**  
**On-Site Soils Usage Plan**



*Geotechnical Engineering and Laboratory Services*

URS Corporation  
225 NW Franklin Ave, Suite A  
Bend, Oregon 97701  
Attn: George Holroyd

March 5, 2001  
Project Number 1001063

**Project:** Knott Landfill Expansion Feasibility  
Bend, Oregon

**Subject:** Geotechnical Investigation of On-Site Soils and Rock

Dear George:

As requested, we have compiled a summary of the subsurface conditions throughout the area proposed for landfill expansion. The conditions encountered have been explored through a variety of methods with the data summarized in tabular and graphical (cross section) format providing a comprehensive yet readily decipherable review.

Encountered Conditions:

Geotechnical investigation was conducted to delineate subsurface conditions inside the existing Knott Landfill perimeter that have not been used for waste disposal and excludes zones currently delineated for planned expansion. Essentially, the study covers a total area of about 70 acres throughout the northern half of the property.

Most of this area hosts basalt at or near the ground surface as is commonly encountered in the Bend area. However, the surface basalt layer is fairly thin and conceals a vast quantity of underlying soils similar to those that were excavated as the existing solid waste footprint was developed. The average thickness of the upper basalt is calculated to be about 26 feet underlain by various types of soils with an average total thickness of about 58 feet that rest upon a lower basalt horizon that continues for many hundreds of feet interrupted only by minor soil and void inclusions.

The characteristics of the soils and rock encountered have been evaluated in an effort to assign future uses as landfill construction components such as daily cover, drainage layer material and final cover soil. These conclusions are summarized in the following Table A along with stratigraphic sequence and thickness.

**TABLE A: On-Site Soils and Rock Materials Summary**

Stratum	Material Type	Thickness Variation (Feet)	General Elevation Model: Ave. Surface = 3698'	Usage Remarks
2sm (Surficial)	Sand and Silt Topsoil, light brown	0 to 13 Ave. = 4	3698 to 3694	Good general purpose soil, moderate alternative final cover material, easy development
3a (Upper Unit Basalt)	Vesicular Basalt, Inflated, fractured and Jointed, gray	0 to 40 Ave. = 26	3694 to 3668	Excellent drainage properties when crushed and graded as aggregate, mod to poor durability as road building aggregate; LAR 30 to 45%
2sm	Sand and Silt, Cindery Character, Red	7 to 29 Ave. = 14	3668 to 3654	Good general purpose soil, moderate alternative final cover material, easy development, too many fines for drainage uses
2g	Sand w/ fine Gravel, Occ. thin, silty lens, gray	7 to 29 Ave. = 12	3654 to 3642	Good drainage characteristics, easy development, inter-bedded fine grained inclusions more predominant in northeast expansion area
2c	Cemented fine Sand and Silt, thin, clayey beds, gray	9 to 21 Ave. = 14	3642 to 3628	Mod to good general purpose soil, mod difficult to excavate (cemented), mod to poor alternative final cover soil characteristics (mostly fine sand)
2s & 2m (Undifferentiated)	Alternating thin layers of Medium to Fine Sand and Silty Sand and Silt, Occ. Clean Sand and Gravel layer, Brown	4 to 28 Ave. = 18	3628 to 3610	Good to excellent alternative final cover soil characteristics, easy to develop and large quantity available. Occasional clean sand zones occur with characteristics similar to Stratum 2g
3b (Lower Unit Basalt)	Vesicular Basalt, Fractured, Jointed and Possibly Inflated	Thickness not Explored	Top Elev. Ave. @ 3610	Limited quantity anticipated, usage similar to upper basalt

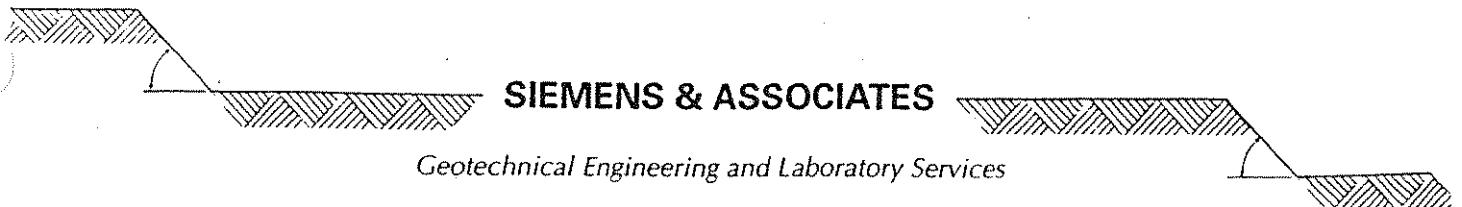
Conclusions:

As the planned Cells 2 and 3 develop soils shortages are anticipated to continue resulting in the expensive commitment to import material for construction and operation purposes. In addition, impending closure operations will demand large volumes of soil, particularly if alternative final cover solutions are adopted. As illustrated in Table A, tremendous quantities of soil (and rock) can be generated from the proposed expansion area with characteristics suitable for meeting the demands of modern landfill design thereby providing economy for future operation of Cells 2 and 3 in addition to providing space for continued operation many years into the future.

The challenge is in managing in the relative high cost associated with excavating the upper basalt to expose the valuable and easy to excavate soils below. To justify such cost, it is our opinion that the basalt should be viewed as a construction material differing from other materials only in that the rock must be processed to render it useful in landfill (and other) construction.

The upper basalt throughout the proposed expansion area offers characteristics similar to the shallow rock commonly encountered in other areas of Bend. Much of the basalt, when crushed will not meet durability requirements for ODOT road construction standards. However, this does not mean that the rock has no value. Similar basalt is crushed throughout the region and used as floor slab base, drainage material, high strength structural fill, residential driveways, private roads, etc. In addition, nearly half of the basalt (typically the upper 5 to 10 feet) can be crushed to meet ODOT durability standards.

The basalt is considered to be an excellent onsite source for high permeability drainage material that would otherwise need to be processed from some distant pit, probably from similar rock. Byproducts of a Knott pit crushing operation would offer high quality road building material for onsite purposes as well as a plethora of general purpose soil (reject) that could be exported or used as daily cover, etc. Shot rock basalt blocks can also be utilized to construct substantial



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rockery type screen walls or buttress steep perimeter MSW slopes allowing ease in establishing slope contours for thick final cover soil profiles. Experimental alternative final cover designs employ coarse rock (6 inch minus) layers acting as subsurface vents that assist in removing soil cover moisture. The possible uses of the rock are numerous.

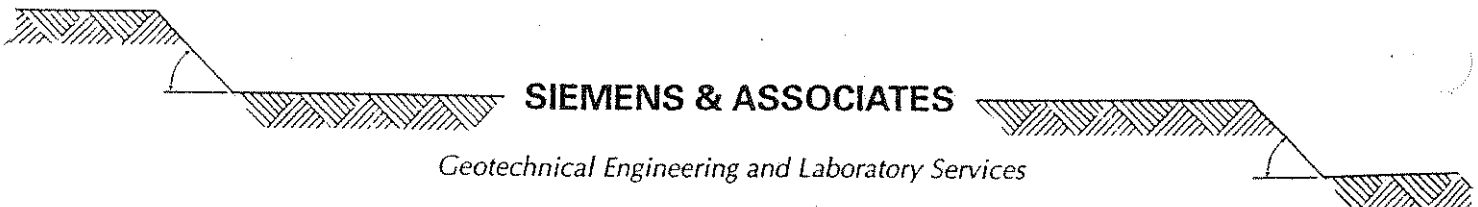
The abundance of deep, readily usable soils are one of the primary reasons that Knott Landfill was developed. The geologic similarity of the established footprint and the proposed expansion area differ primarily in the existence of the upper basalt cap, which, in our opinion need not be viewed as a restriction, but rather as an economic asset simply by considering the possibilities.

It has been a pleasure to conduct this investigation and present the results. If you have questions, or if we can be of further assistance, please call.

Respectfully Submitted:  
**SIEMENS & ASSOCIATES**

J. Andrew Siemens, P.E.

Addressee: 3  
Friesen Associates, Inc. 1,  
Encl: Field and Laboratory Appendix  
Site Plan  
Cross Sections A, B, C, D  
Table 1.0  
Boring Logs  
Earth Resistivity Soundings (R-1 through R-5)



## Appendix to Geotechnical Investigation:

### FIELD INVESTIGATION

The subsurface investigation was carried out using methods that amplify the volume of data for a reasonably low cost. Although more expensive procedures may be warranted in the future to gain more detail, it is our opinion that the results developed from the procedures used provide a robust description of the subsurface conditions to a level of detail appropriate for the intended use. These are described as follows:

#### Reconnaissance:

A thorough geotechnical reconnaissance was conducted of the property to define particular areas of interest and layout the exploration strategy. In addition, we conducted a review of past subsurface investigation conducted by us and others for inclusion with this work to support the findings.

#### Drilling:

Drilling was accomplished using both air-percussion methods and continuous flight auger. The strategy involved probing the thickness of the upper basalt with the air-percussion tools then entering select holes with small diameter flight auger equipment to extend the investigation to reach the lower basalt. This procedure was effective in most instances; however, the auger was refused in several borings prior to encountering the lower rock unit.

A disadvantage of solid stem auger drilling is the difficulty of retrieving soil samples. To overcome this problem we recorded an electrical resistivity log using the auger as a downhole electrode measuring resistance to grounding pins set at the surface. This procedure allowed interpretation of the depth to stratigraphic boundaries distinguished by differing electrical resistivity. The results of the three-pin resistivity survey are plotted along with lithostratigraphic interpretation of the subsurface conditions on the attached logs of select borings where this work was carried out.



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The results of the drilling program are summarized on the attached Cross Sections A through D, the locations and orientation of which are depicted on the Site Plan prepared by URS.

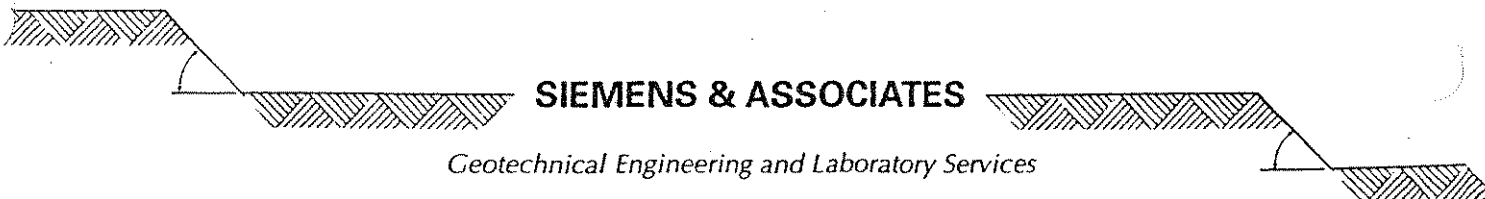
Geoprobe:

At select locations Geoprobe tools were advanced through the soils below the upper basalt unit providing samples for laboratory analysis and a means of correlating the three-pin electrical resistivity measurements to known lithology. Geoprobe exploration involves a pneumatic 'push' sample technology that can successfully provide nearly continuous subsurface sampling. The Geoprobe technique was carried out to refusal on the lower basalt in one instance but encountered difficulties (refusal) at two other locations prior to reaching the lower basalt. Since the procedure is relatively expensive, the Geoprobe approach to subsurface investigation was terminated following about 2 days of the activity.

Earth Resistivity Soundings:

Five earth resistivity soundings (R-1 through R-5) were conducted to provide a complementary means of evaluating subsurface characteristics. These data were gathered at select locations strategically placed where long, unobstructed (no fences, building, etc.) runs could be established in the area of interest. The results are presented graphically as plots of electrode spacing vs. apparent earth resistivity measured in ohm-feet. A simple Wenner electrode spacing array was utilized to collect the data.

The Wenner array is a series of four equally spaced electrodes inserted into the ground to a depth of about 18 inches. As the fieldwork progresses the electrodes are picked up and reinserted such that earth resistivity measurements are recorded at gradually increasing electrode spacing beginning with a relatively short spacing (two feet) and ending with a spacing of 300 feet. The electrode spacing influences the volume of earth that contributes to the apparent resistivity measurement (especially with respect to depth). When the electrodes are only two feet apart the distance between the outer electrodes is six feet and only the very shallow ground conditions influence the measurement. However, when the electrode spacing is great, say 300 feet, a great volume of earth influences the measurement since the distance between the outer electrodes is 900 feet.



The results of the earth resistivity soundings display three curves. The bold, solid line represents the standard Wenner array as described. The dashed and dotted lines represent the left and right "Lee" modifications to the Wenner array. The Lee modification is simply a fifth electrode that remains stationary at the center of the array and is utilized as a substitute for either the center left or center right Wenner electrode by means of a switching arrangement on the instrument. The effect is a method of distinguishing between horizontal and vertical variation of subsurface conditions left and right of the survey center by utilizing the center, fifth electrode that then shifts the survey center some distance either left or right of the traditional Wenner array.

The earth resistivity soundings are useful in verifying subsurface continuity both left and right of the survey center and survey area to area. A review of the curves verifies that the subsurface conditions are fairly uniform throughout the study area with the exception of the center, western area where the upper basalt tends to be thinner and, at least in some areas, the overlying soils thicker. The data has been incorporated in our interpretation of subsurface conditions presented on the cross sections.

#### LABORATORY INVESTIGATION

All laboratory testing was performed in our laboratory and representative samples of the materials tested have been stored for future use or review.

##### Soils

Limited laboratory analysis of soils and rock were performed to provide a general characterization of the conditions encountered. The analysis was performed from Geoprobe samples that are fairly small in volume and as a result may do not provide as accurate a description as large samples procured from say an open excavation or discrete drive sample from a large diameter drill hole.

In our opinion, the sampling limitations influence the characterization of Stratum 2g more profoundly than other soils encountered. That is, in order to provide a representative sample size for testing, thin, silty inclusions of this strata were incorporated with much cleaner material giving the impression of a finer gradation than



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could be managed if the strata were sampled or developed from a large excavation. With this exception, it is our opinion that the laboratory data provides a reasonably good description of the grain-size distribution, density and moisture content of the soils encountered.

Soils test data is presented on the attached Laboratory Summary.

Rock:


Several samples of loose rock were collected representative of the upper basalt. These were laboratory crushed to specified size and tested for durability in the Los Angeles Abrasion machine. The results from these tests indicate durability ranging from 30 to 33 percent loss. ODOT standards for road base aggregate specify results of 35% or less indicating the material sampled meets ODOT durability requirements. However, these results are similar to those that we have gathered through extensive testing of other, similar local basalt that, at depth will fail to meet ODOT standards.

Since samples of the deeper rock were not tested, we can only infer from experience and microscopic review of air-track cuttings (too small to test in the Los Angeles machine) that the basalt at Knott is similar to other rock of the same origin that we have analyzed.



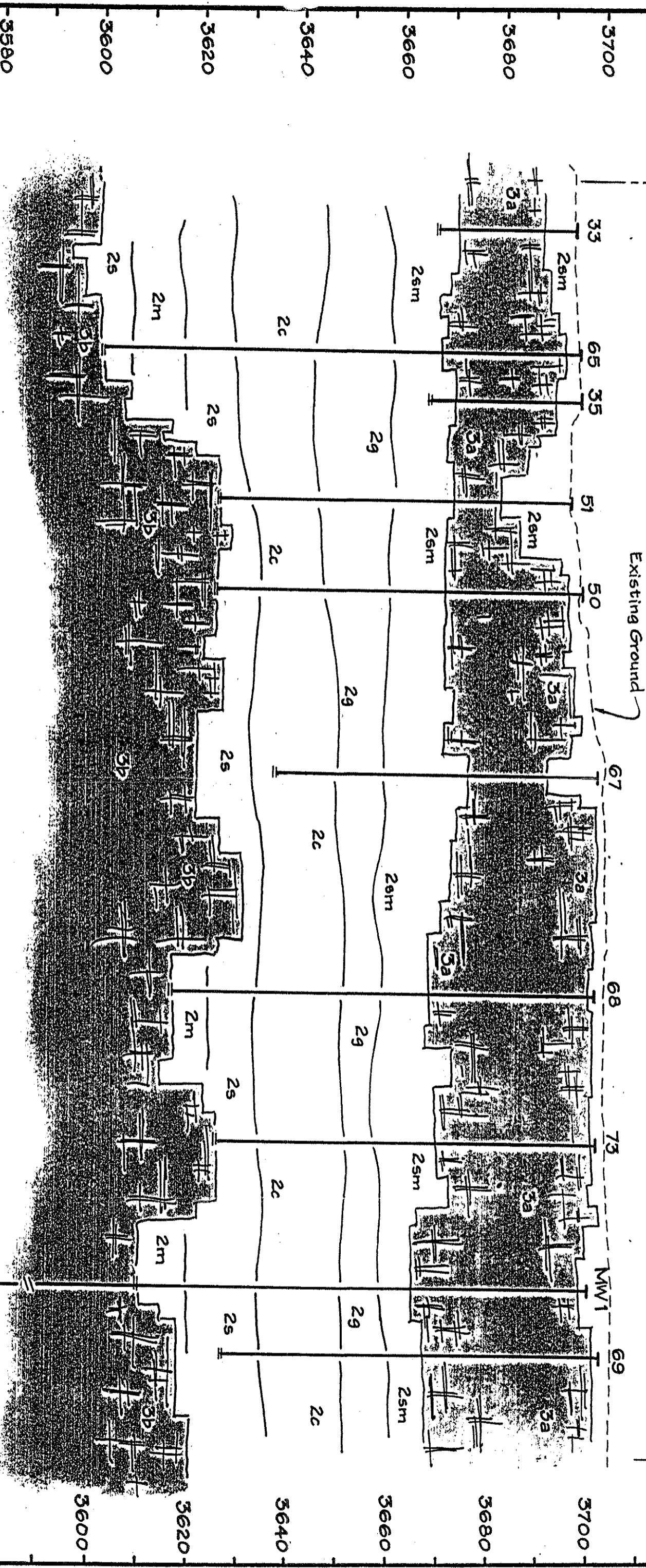
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 G. F. FISHER ASSOCIATES, INC. 4044 Oregon Drive Portland, Oregon 97201 TEL (503) 835-1333 FAX (503) 835-1447			
<b>URS</b> 111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292		KNOTT LANDFILL PHASE I-B EXPANSION DESCHUTES COUNTY, OREGON	
<b>SITE PLAN</b> <b>GEOTECHNICAL DATA</b>			
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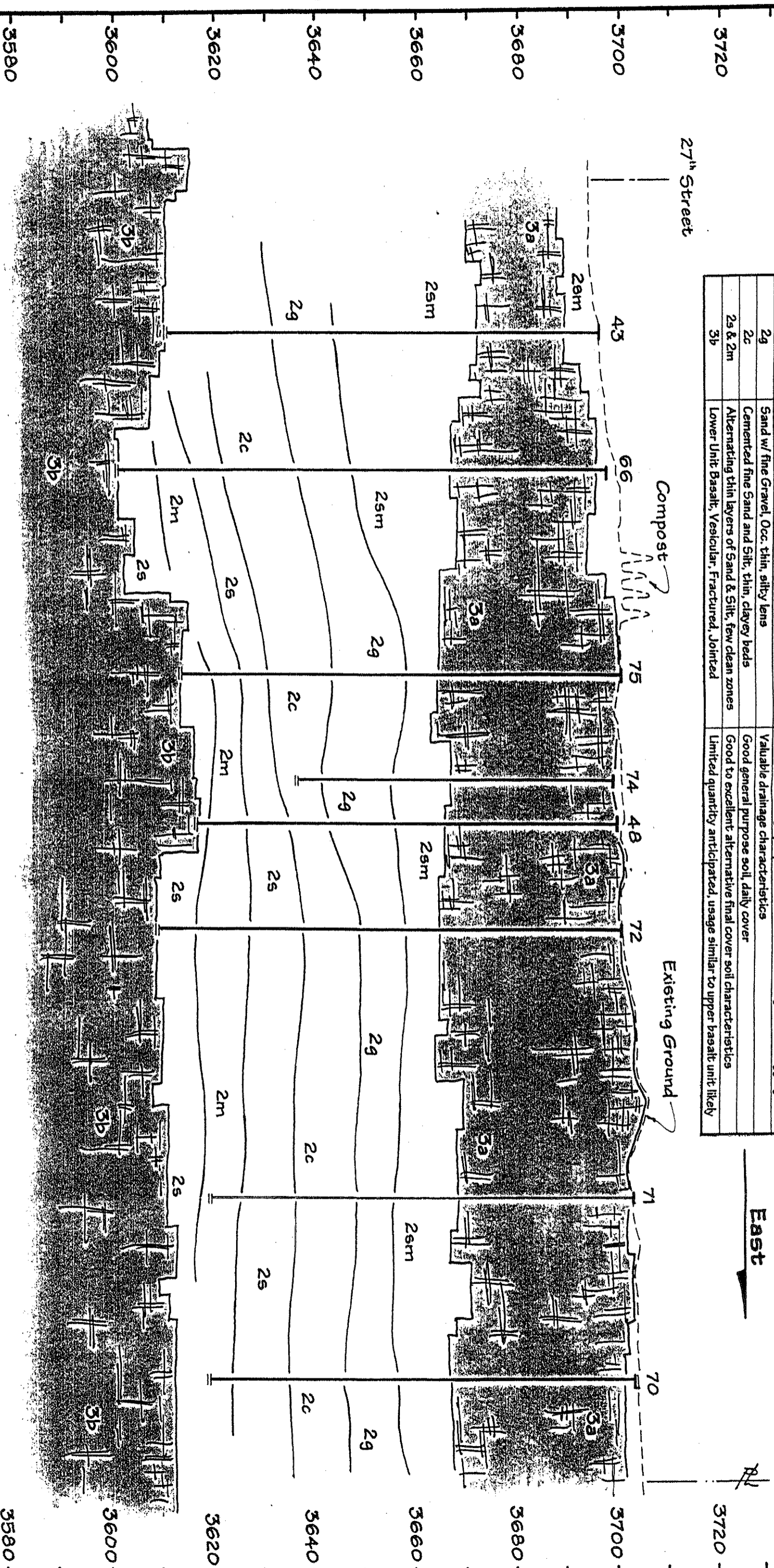
Stratum	Material Type	Usage Remarks
2a	Sand and Silt Topsoil, also underlies Upper Basalt Unit	Good alternative final cover material.
3a	Upper Unit Basalt, Vesicular, Fractured, Jointed	Excellent drainage properties when crushed and graded as aggregate
2g	Sand w/ fine Gravel, Occ. thin, silty lens	Valuable drainage characteristics
2c	Cemented fine Sand and Silt, thin, clayey beds	Good general purpose soil, daily cover
2s & 2m	Alternating thin layers of Sand & Silt, few clean zones	Good to excellent alternative final cover soil characteristics
3b	Lower Unit Basalt, Vesicular, Fractured, Jointed	Limited quantity anticipated, usage similar to upper basalt unit likely



Soil and rock classification should be considered accurate only at the boring locations. For engineering purposes, stratification is interpolated between test borings and may not necessarily reflect true subsurface conditions.

Cross Section A	
Knott Landfill: Expansion Feasibility	Horizontal Scale 1 inch = 200 feet
Bend, Oregon	Vertical Scale 1 inch = 20 feet
For: URS Corporation	Siemens Project No. 1001063
	February 2001
	Siemens & Associates

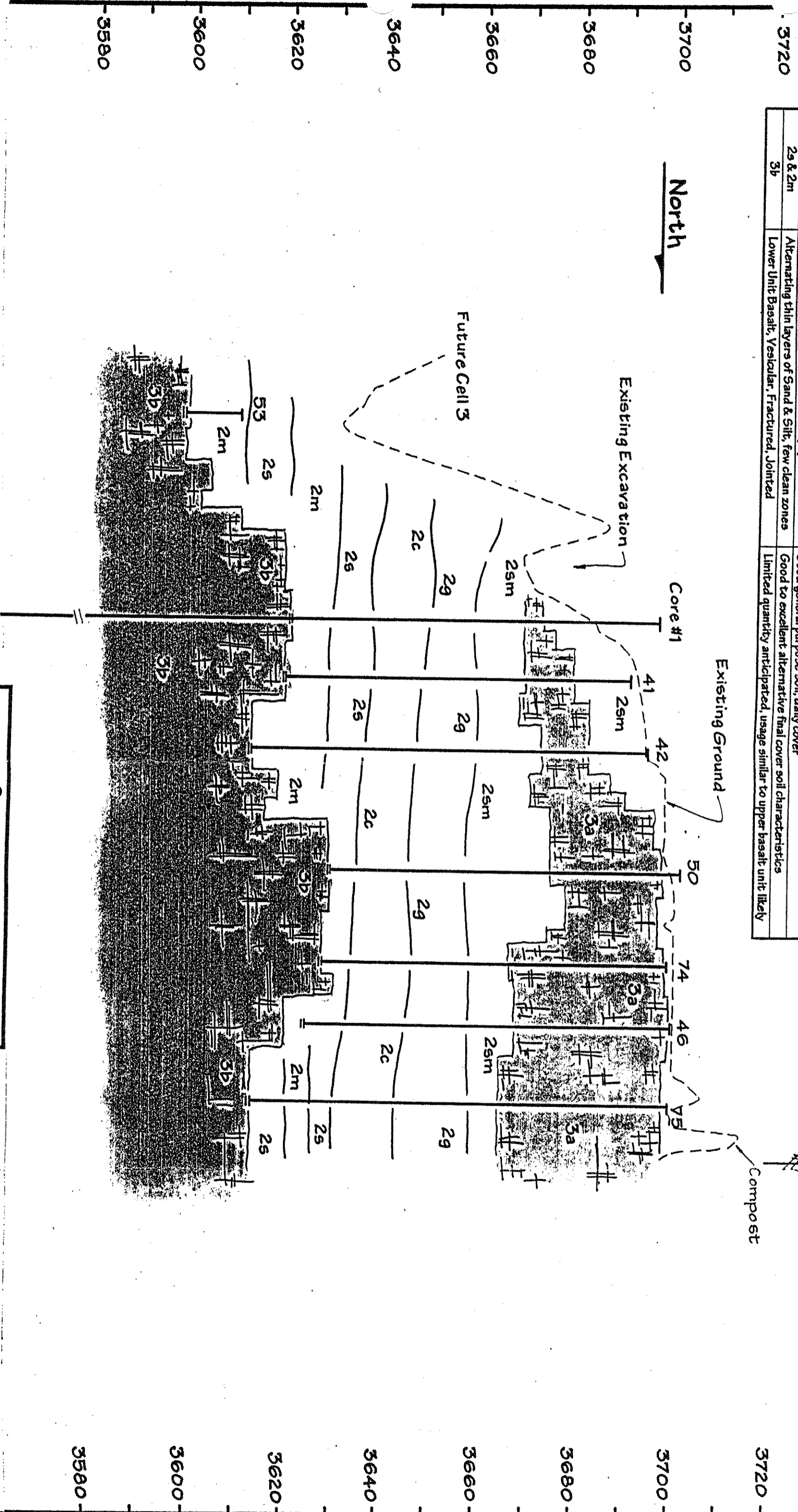
Stratum	Material Type	Usage Remarks
2sm	Sand and Silt Topsoil, also underlies Upper Basalt Unit	Good alternative final cover material.
3a	Upper Unit Basalt, Vesicular, Fractured, Jointed	Excellent drainage properties when crushed and graded as aggregate
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3b	Lower Unit Basalt, Vesicular, Fractured, Jointed	Limited quantity anticipated, usage similar to upper basalt unit likely



Soil and rock classification should be considered accurate only at the boring locations. For engineering purposes, stratification is interpolated between test borings and may not necessarily reflect true subsurface conditions.

<b>Cross Section B</b>	
Knott Landfill: Expansion Feasibility	
Bend, Oregon	
For: URS Corporation	
Horizontal Scale 1 inch = 200 feet	
Vertical Scale 1 inch = 20 feet	
Siemens Project No. 1001063	
	February 2001
	Siemens & Associates

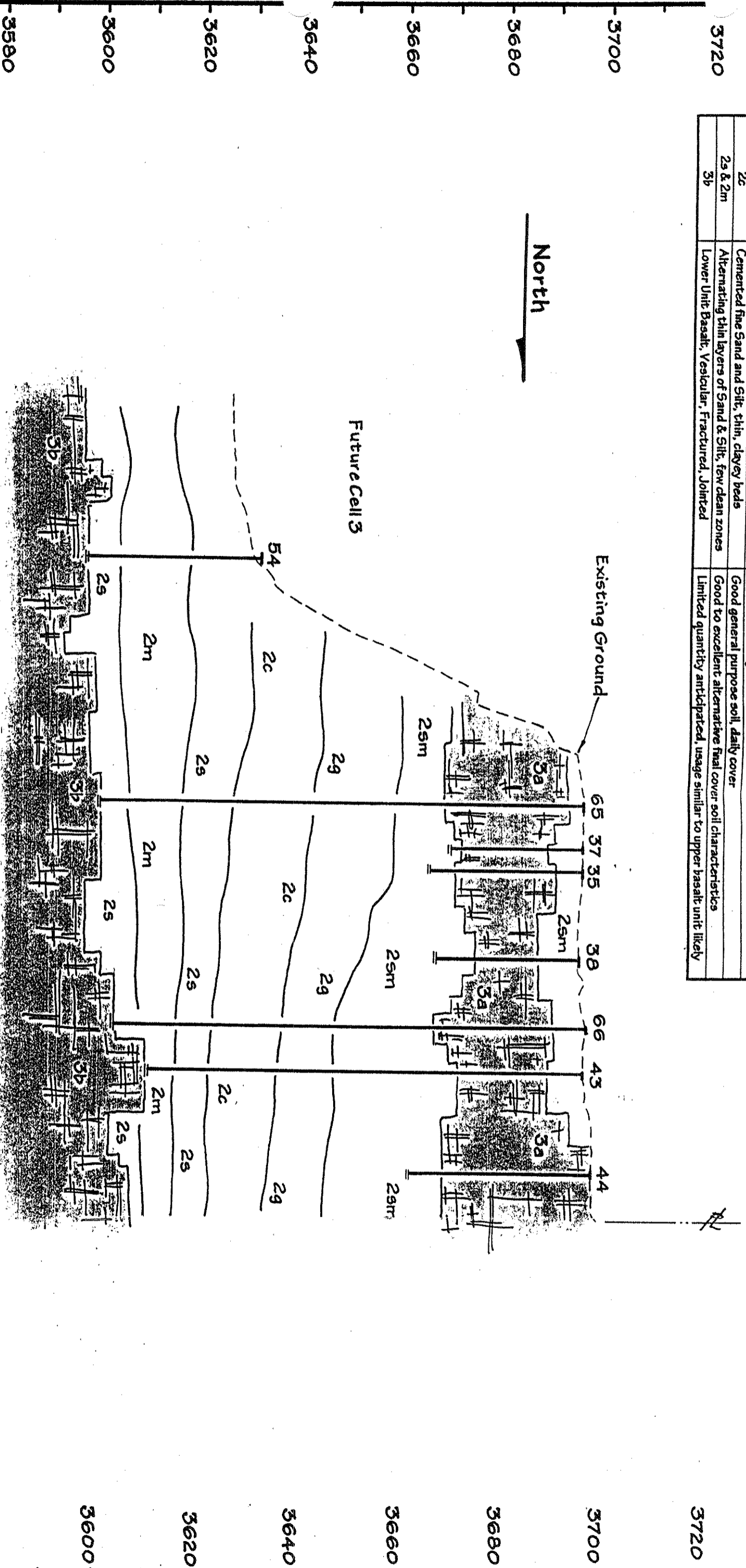
Stratum	Material Type	Usage Remarks
2sm	Sand and Silt; Topsoil, also underlies Upper Basalt Unit	Good alternative final cover material,
3a	Upper Unit Basalt; Vesicular, Fractured, Jointed	Excellent drainage properties when crushed and graded as aggregate
2g	Sand w/ fine Gravel, Occ. thin, silty lens	Valuable drainage characteristics
2c	Cemented fine Sand and Silt; thin, clayey lens	Good general purpose soil, daily cover
2s & 2m	Alternating thin layers of Sand & Silt; few clean zones	Good to excellent alternative final cover soil characteristics
3b	Lower Unit Basalt; Vesicular, Fractured, Jointed	Limited quantity anticipated, usage similar to upper basalt unit likely



Soil and rock classification should be considered accurate only at the boring locations. For engineering purposes, stratification is interpolated between test borings and may not necessarily reflect true subsurface conditions.

Cross Section D	
Knott Landfill: Expansion Feasibility	
Bend, Oregon	
For: URS Corporation	
Horizontal Scale 1 inch = 200 feet	Vertical Scale 1 inch = 20 feet
Siemens Project No. 1001063	February 2001
Siemens & Associates	

Stratum	Material Type	Usage Remarks
2sm	Sand and Silt; Topsoil, also underlies Upper Basalt Unit	Good alternative final cover material.
3a	Upper Unit Basalt; Vesicular, Fractured, Jointed	Excellent drainage properties when crushed and graded as aggregate
2g	Sand w/ fine Gravel, Occ. thin, silty lens	Valuable drainage characteristics
2c	Cemented fine Sand and Silt; thin, clayey beds	Good general purpose soil, daily cover
2s & 2m	Alternating thin layers of Sand & Silt; few clean zones	Good to excellent alternative final cover soil characteristics
3b	Lower Unit Basalt; Vesicular, Fractured, Jointed	Limited quantity anticipated, usage similar to upper basalt unit likely



Soil and rock classification should be considered accurate only at the boring locations. For engineering purposes, stratification is interpolated between test borings and may not necessarily reflect true subsurface conditions.

<b>Cross Section C</b>	
Knott Landfill: Expansion Feasibility	
Bend, Oregon	
For: URS Corporation	
Horizontal Scale 1 inch = 200 feet	
Vertical Scale 1 inch = 20 feet	
Siemens Project No. 1001063	
	February 2001
	Siemens & Associates



**TABLE 1.0 SUMMARY OF DRILLING RESULTS February 2 through February 15, 2000**

*Boring #	32	33	34	35	36	37	38	39	40	41	42	43
Ground Elevation	3696.7	3693.3	3695.4	3695.9	3694.5	3695.3	3695.9	3693.1	3691.5	3690.4	3694.4	3695.2
<u>Stratification:</u>												
Surficial Soils	0 to 12'	0 to 6	0 to 5	0 to 5	0 to 11	0 to 7	0 to 7	0 to 22	0 to 1	0 to 11	0 to 13	0 to 7
Upper Basalt (thickness, feet)	12 to 19 (7)	6 to 23 (17)	5 to 23 (18)	5 to 25 (20)	11 to 23 (12)	7 to 24 (17)	7 to 26 (19)	22 to 24 (27)	1 to 22 (21)	11 to 21 (10)	13 to 22 (9)	7 to 24 (17)
Sediments (soils)	19 to 31+	23 to 27+	23 to 32+	25 to 30+	23 to 28+	24 to 26+	26 to 28+	24 to 73	22 to 25+	21 to 71½	22 to 83	24 to 86
**Lower Basalt	ND	ND	ND	ND	ND	ND	ND	73	ND	71½	83	86
Total Depth:	31	27	32	30	28	26	28	73	25	7½	83	86
Refusal Elev.	ND	ND	ND	ND	ND	ND	ND	3620	ND	3619	3611	3609

**TABLE 1.0 continued SUMMARY OF DRILLING RESULTS February 2 through February 15, 2000**

Boring #	44	45	46	47	48	49	50	51	52	53	54
Ground Elevation	3698.9	3700.4	3700.0	3700	3698.9	3703.4	3697.1	3693.0	3610.4	3610.3	3631.8
<u>Stratification:</u>											
Surficial Soils	none	0 to 1	0 to 1	0 to 2	0 to 2	0 to 3	0 to 2	0 to 12	0 to 12½	0 to 13	0 to 35
Upper Basalt (thickness, feet)	0 to 30 (30)	1 to 35 (34)	1 to 33 (32)	2 to 34 (32)	2 to 34 (32)	3 to 38 (35)	2 to 27 (25)	12 to 22 (10)	Absent	Absent	Absent
Sediments (soils)	30 to 36+	34 to 41+	33 to 75+	34 to 39+	34 to 83½	38 to 40+	27 to 73	22 to 69	0 to 12½	0 to 13	0 to 35
**Lower Basalt	ND	ND	75+	ND	83½	ND	73	69	12½	13	35
Total Depth:	36	41	75	39	83½	40	73	69	12½	13	35
Refusal Elev.	ND	ND	ND	ND	ND	ND	3624	3624	3598	3597	3597

**TABLE 1.0 Cont. SUMMARY OF DRILLING RESULTS November, December 2000**

*Boring #	65	66	67	68	69	70	71	72	73	74	75	76
Ground Elevation	3695	3695	3700	3700	3700	3700	3700	3700	3700	3700	3700	3698
<u>Straatification:</u>												
Surficial Soils	0 to 4'	0 to 2'	0 to 10	0 to 2	0 to 3	0 to 1	0 to 1	0	0 to 3	0 to 2	0 to 3	0 to 2
Upper Basalt (thickness, feet)	4 to 26 (22)	2 to 28 (26)	10 to 26 (16)	2 to 33 (31)	3 to 34 (31)	1 to 36 (35)	1 to 34 (33)	0 to 36 (36)	3 to 34 (31)	2 to 34 (32)	3 to 34 (31)	2 to 31 (29)
Sediments (soils)	26 to 95	26 to 92	ND	33 to 75+	34 to 75+	35 to 84	ND	36 to 92	ND	34 to 64+	36 to 87	ND
**Lower Basalt	95	92	ND	ND	ND	84	ND	92	ND	ND	3613	ND
Total Depth:	95	92	26	75	75	84	34	92	34	64	87	31
Refusal Elev.	3600	3603	ND	ND	ND	3616	ND	3608	ND	ND	ND	ND

\* Borings are numbered consecutively with respect to previous work

\*\* Based on Auger Refusal Depth  
ND indicates "Not Determined"

SIEMENS & ASSOCIATES

**Siemens & Associates**

Bend, Oregon

Project Number 1001063

Ground Elevation: 3695 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M.

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 30' (3" dia.), Geoprobe, Auger 30 to 95'

**Knott Landfill Expansion Feasibility**

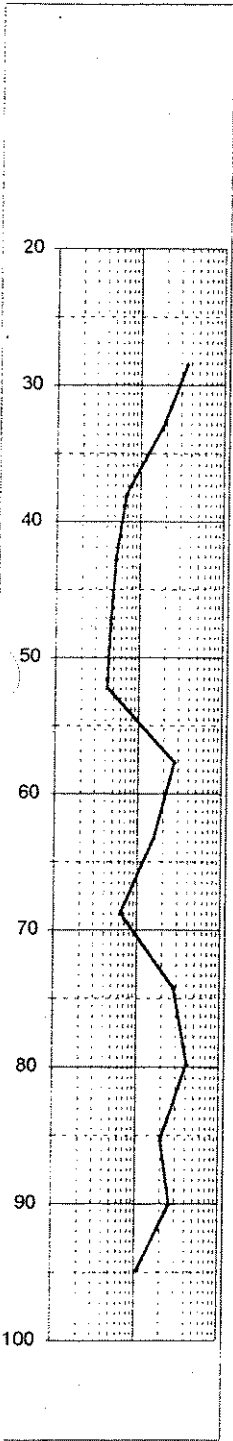
Bend, Oregon

**Log of Boring # 65**

West, Center Area (Existing Wood Yard)

Started November 17, 2000/ Completed November 21, 2000

3 - Pin Electrical Resistivity  
10,000 to 1,000,000 Ohm-Feet



Moisture	Condition	Color	Stratum	Deposit	Visual Description
Moist	Loose	Brown	2em	Aeolian	Surface Conditions: Graded Gravel & Wood Chips SAND: Small Amount SILT, Occ. Gravel Mod. Well Graded, Non-Plastic
Sl. Moist	Hard	Gray	3	Extrusive	BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)
Sl. Moist	Mod. Loose	Red	2em	Volcaniclastic	Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
Moist	Mod. Dense	Gray to Brown	2g	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Cinder-Like Character (Baked Soil Zone ??)
Moist	Mod. Dense	Gray	2c	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, Sl. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Occ. Silty Lens (less than 1 foot thick)
Moist	Mod. Loose	Brown	2e	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
Wet	(Silt Lens)	Brown	2m	Volcaniclastic	SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
Very Moist					SILTY SAND: Occ. Sandy Lens, Trace CLAY Trace Lapilli Pumice GRAVEL
Moist	Mod. Loose	Black to Brown	2e	Volcaniclastic	SAND: Trace SILT, Poorly Graded (Med- Fine) Few Lapilli Pumice Gravels, Non-Plastic
Sl. Moist	Hard	Gray	3	Extrusive	BASALT: Mod Vesicular Geoprobe/Auger Refused @ 95 feet

Visual Description

# Siemens & Associates

Bend, Oregon

Project Number 1001063

Ground Elevation: 3695 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M..

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 28' (3" dia.), Auger 28 to 95'

# Knott Landfill Expansion Feasibility

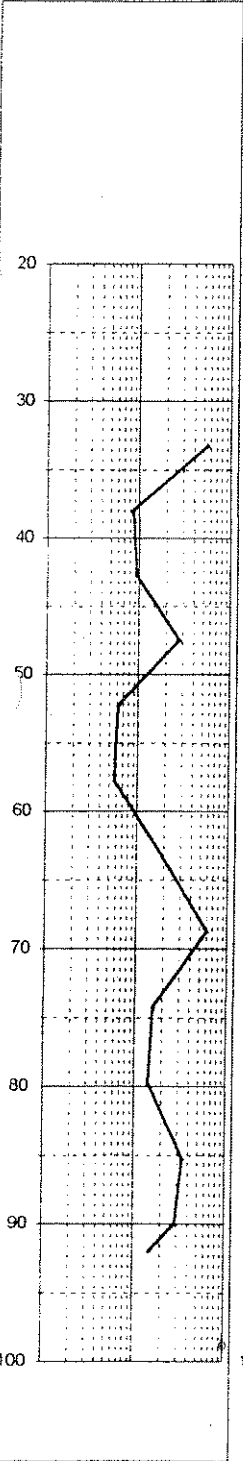
Bend, Oregon

## Log of Boring # 66

Northwest Area (East of Administration office)

Started November 17, 2000/ Completed December 2, 2000

3 - Pin Electrical Resistivity  
10,000 to 1,000,000 Ohm-Feet



Moisture	Condition	Color	Stratum	Deposit	Visual Description
Moist	Loose	Brown	Zem	Aeolian	Surface Conditions: Grass & Weeds SAND: Small Amount SILT, Occ. Gravel Mod. Well Graded, Non-Plastic
Sl. Moist	Hard	Gray	3	Extrusive	BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)
					Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
Sl. Moist	Mod. Loose	Red	Zem	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Cinder-Like Character (Baked Soil Zone ??)
Moist					
Moist	Mod. Dense	Gray to Brown	Zg	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, Sl. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Occ. Silty Lens (less than 1 foot thick)
Moist	Mod. Dense	Gray	Zc	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
					SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
Very Moist	Mod. Loose	Brown	Za	Volcaniclastic	
Very Moist	Stiff	Brown	Zm	Volcaniclastic	SILTY SAND: Occ. Sandy Lens, Trace CLAY Trace Lapilli Pumice GRAVEL
Very Moist	Mod. Loose	Black to Brown	Zs	Volcaniclastic	SAND: Trace SILT, Poorly Graded (Med- Fine) Few Lapilli Pumice Gravels, Non-Plastic
	Hard		3	Extrusive	BASALT: Mod Vesicular Auger Refused @ 95 feet

Visual Description

# Siemens & Associates

Bend, Oregon

Project Number 1001063

Ground Elevation: 3700 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M..

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 34' (3" dia.), Auger 34 to 75'

# Knott Landfill Expansion Feasibility

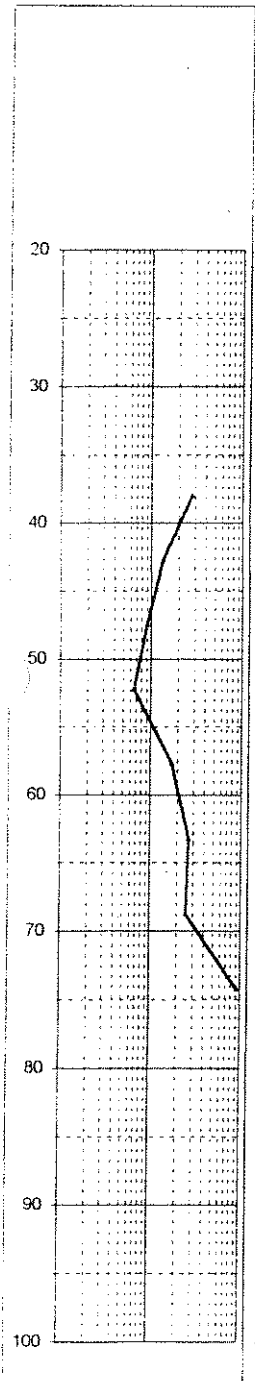
Bend, Oregon

## Log of Boring # 68

South, Center Expansion Area

Started November 17, 2000/ Completed December 28, 2000

3 - Pin Electrical Resistivity  
10,000 to 1,000,000 Ohm-Feet



Moisture	Condition	Color	Stratum	Deposit	Visual Description
Moist	Loose	Brown	2am	Aeolian	Surface Conditions: Grass & Weeds SAND: Small Amount SILT, Occ. Gravel Mod. Well Graded, Non-Plastic
Sl. Moist	Hard	Gray	3	Extrusive	BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)
	Mod. Hard				Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
Sl. Moist	Mod. Loose	Red	2om	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Clinker-Like Character (Baked Soil Zone ??)
Moist	Mod. Dense	Gray to Brown	2g	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, Sl. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Occ. Silty Lens (less than 1 foot thick)
Moist	Mod. Dense	Gray	2c	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
Moist	Mod. Loose	Brown	2a	Volcaniclastic	SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
	Stiff				Auger Refused @ 75 feet in Stiff Soils or Cobble ? Basalt Interpreted to be deeper than auger Refusal

Visual Description

**Siemens & Associates**

Bend, Oregon

Project Number 1001063

Ground Elevation: 3700 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M.

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 35' (3" dia.), Auger 35 to 75'

**Knott Landfill Expansion Feasibility**

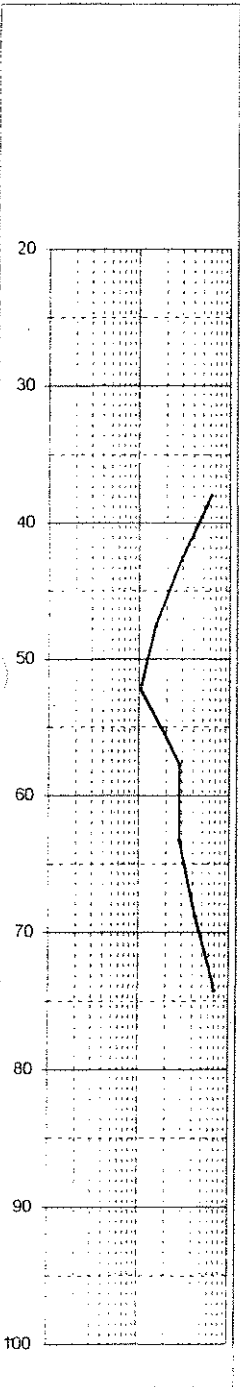
Bend, Oregon

**Log of Boring # 69**

South East Area of Expansion Area

Started November 17, 2000/ Completed January 3, 2001

**3 - Pin Electrical Resistivity**  
10,000 to 1,000,000 Ohm-Feet



Moisture	Condition	Color	Stratum	Deposit	Visual Description
Moist	Loose	Brown	2em	Aeolian	Surface Conditions: Grass & Weeds SAND: Small Amount SILT, Occ. Gravel Mod. Well Graded, Non-Plastic
St. Moist	Hard	Gray	3	Extrusive	BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)
	Mod. Hard				Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
St. Moist	Mod. Loose	Red	2em	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Cinder-Like Character (Baked Soil Zone ??)
Moist	Mod. Dense	Gray to Brown	2g	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, St. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Occ. Silty Lens (less than 1 foot thick)
Moist	Mod. Dense	Gray	2c	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
Moist	Mod. Loose	Brown	2e	Volcaniclastic	SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
	Stiff				Auger Refused @ 75 feet in Stiff Soils or Cobble ? Basalt interpreted to be deeper than auger Refusal

Visual Description

# Siemens & Associates

Bend, Oregon

Project Number 1001063

Ground Elevation: 3700 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M.

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 36' (3" dia.), Geoprobe 36 to 64, Auger 36 to 80'

# Knott Landfill Expansion Feasibility

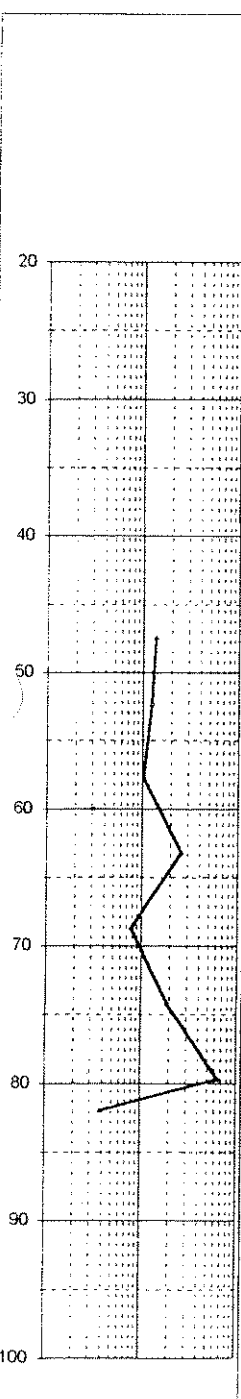
Bend, Oregon

## Log of Boring # 70

Northeast Expansion Area

Started November 18, 2000/ Completed November 30, 2000

3 - Pin Electrical Resistivity  
10,000 to 1,000,000 Ohm-Feet



Moisture	Condition	Color	Stratum	Deposit	Visual Description
Moist	Loose	Brown	2em	Aeolian	Surface Conditions: Grass, Weeds and Brush SAND: Small Amount SILT, Occ. Gravel Mod. Well Graded, Non-Plastic
Sl. Moist	Hard	Gray	3	Extrusive	BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)
	Mod. Hard				Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
Moist	Mod. Loose	Red to Orange	2em	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Cinder-Like Character (Baked Soil Zone ??)
Moist	Mod. Dense	Gray to Brown	2g	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, Sl. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Many Silty Lenses (up to 3 feet thick)
Moist	Mod. Dense	Gray	2c	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
Moist	Mod. Loose	Brown	2e	Volcaniclastic	SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
Wet	Stiff	Brown	2m	Volcaniclastic	SILTY SAND: Occ. Sandy Lens, Trace CLAY Trace Lapilli Pumice GRAVEL
					Geoprobe Terminated @ 64 feet Auger Refused in soils ?? @ 84 feet Basalt estimated to be deeper than 84 feet

Visual Description

**Siemens & Associates**

Bend, Oregon

Project Number 1001063

Ground Elevation: 3700 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M.

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 37' (3" dia.), Auger 36 to 92'

**Knott Landfill Expansion Feasibility**

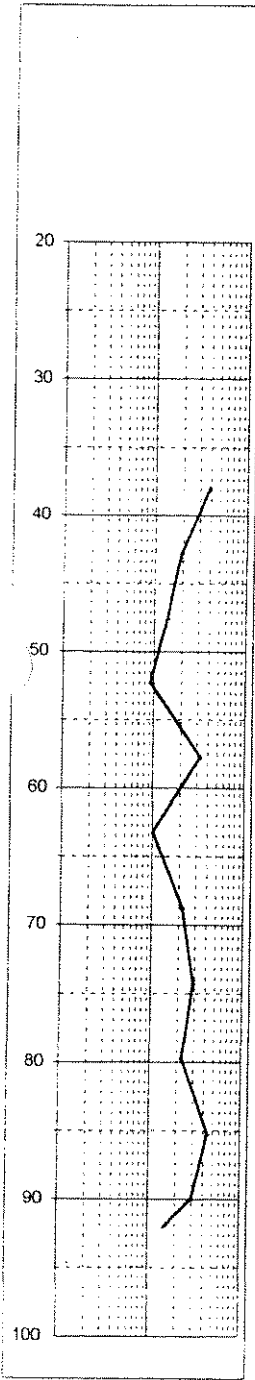
Bend, Oregon

**Log of Boring # 72**

Center of Expansion Area

Started November 17, 2000/ Completed December 1, 2000

3 - Pin Electrical Resistivity  
10,000 to 1,000,000 Ohm-Feet



Moisture	Condition	Color	Stratum	Deposit	Visual Description
Sl. Moist	Hard	Gray	3	Extrusive	Surface Conditions: Bare Rock (Basalt) BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)
	Mod. Hard				Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
Sl. Moist	Mod. Loose	Red	2em	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Cinder-Like Character (Baked Soil Zone ??)
Moist Moist	Mod. Dense	Gray to Brown	2g	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, Sl. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Occ. Silty Lens (less than 1 foot thick)
Moist	Mod. Dense	Gray	2c	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
Moist	Mod. Loose	Brown	2e	Volcaniclastic	SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
Wet	Stiff	Brown	2m	Volcaniclastic	SILTY SAND: Occ. Sandy Lens, Trace CLAY Trace Lapilli Pumice GRAVEL
Moist	Mod. Loose	Black to Brown	2a	Volcaniclastic	SAND: Trace SILT, Poorly Graded (Med- Fine) Few Lapilli Pumice Gravels, Non-Plastic
	Hard		3	Extrusive	BASALT: Mod Vesicular Auger Refused @ 92 feet (Basalt)

Visual Description



# Siemens & Associates

Bend, Oregon

Project Number 1001063

Ground Elevation: 3700 ft.

Location: Township 18 S, Range 12 E, South 1/2 of Sec. 14, W.M.

Groundwater Notes: No Groundwater Encountered

Drilling Methods: Air percussion 0 to 35' (3" dia.), Geoprobe, Auger 35 to 87'

# Knott Landfill Expansion Feasibility

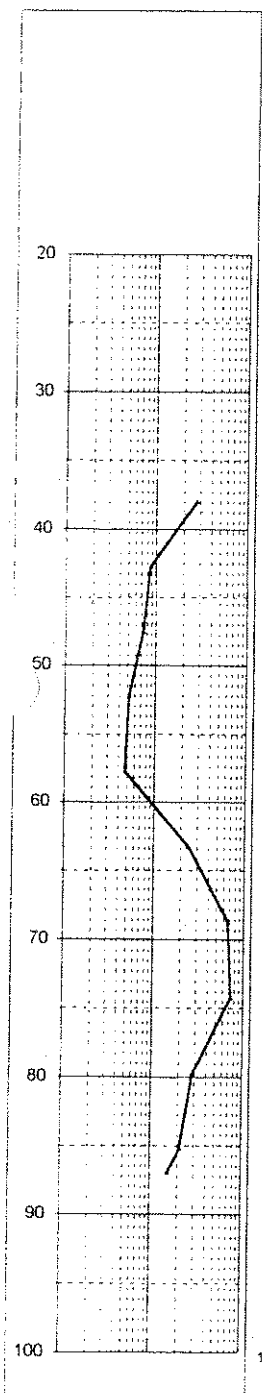
Bend, Oregon

## Log of Boring # 75

North Center Area of Expansion

Started November 18, 2000/ Completed December 27, 2000

3 - Pin Electrical Resistivity  
10,000 to 1,000,000 Ohm-Feet

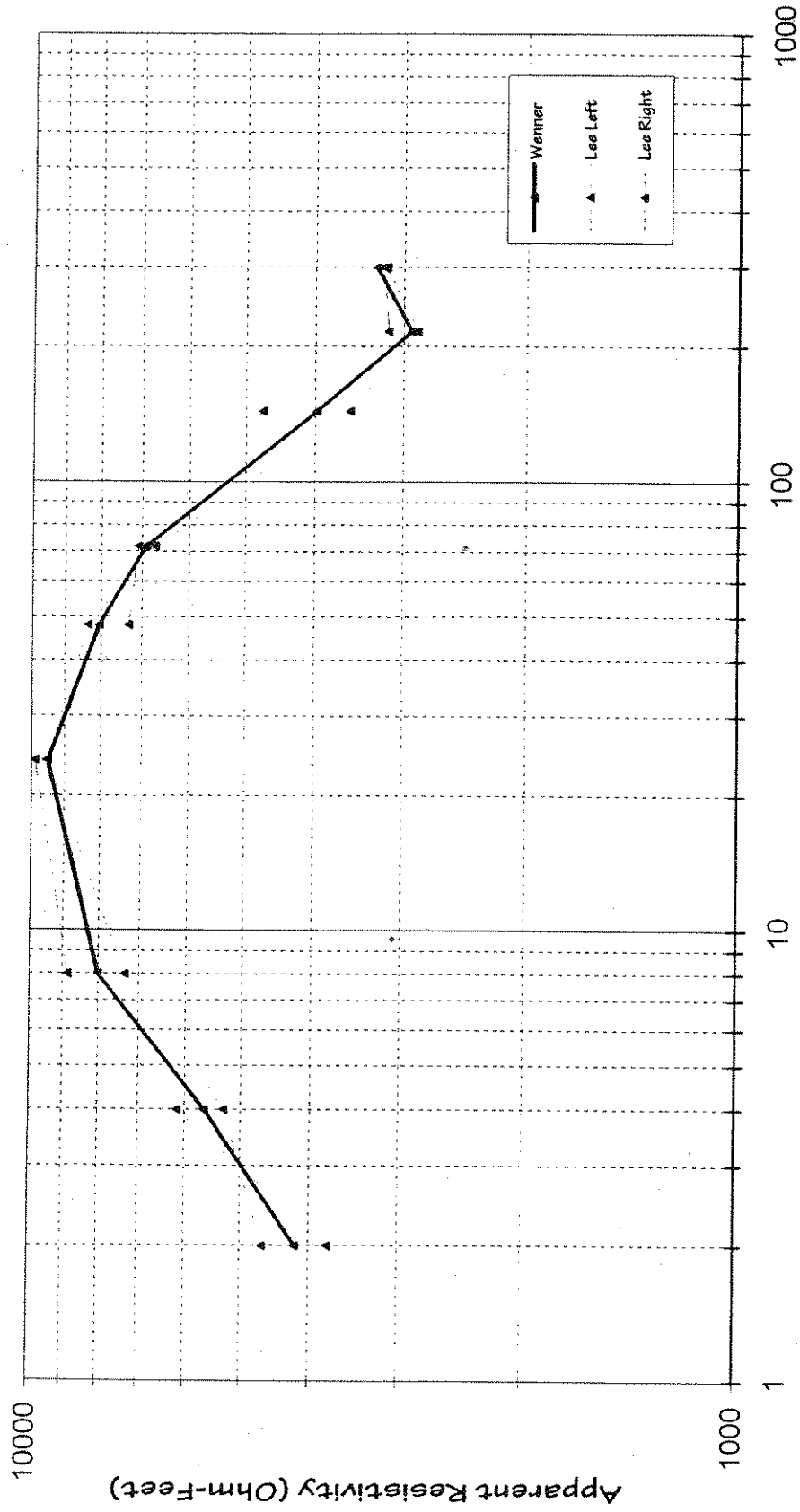


Moisture	Condition	Color	Stratum	Deposit	Visual Description
Moist	Loose	Brown	2em	Aeolian	Surface Conditions: Wood Chip Compost SAND: Small Amount SILT, Occ. Gravel Mod. Well Graded, Non-Plastic
Sl. Moist	Hard	Gray	3	Extrusive	BASALT: Mod. Vesicular, Mod. Fractured & Jointed Mod. Durability (Est. LAR = 30 to 35)  Fewer Macro-Vesicles, more Micro-Vesicles Massive Appearance, Probable Diminished Durability (Est. LAR = 40 to 45)
Sl. Moist	Mod. Loose	Red	2em	Volcaniclastic	SAND: Small Amount SILT, Few Gravels Expanded, Cinder-Like Character (Baked Soil Zone ??)
Moist	Mod. Dense	Gray to Brown	2g	Volcaniclastic	SAND: Trace GRAVEL (fine), Trace SILT, Sl. Cemented Mod. Well Graded, Sub rounded Gravel, Occ. Cobble Inferred Occ. Silty Lens (less than 1 foot thick)
Moist	Mod. Dense	Gray	2c	Volcaniclastic	Cemented SAND: Small amount to Some SILT Thin, Horizontally Bedded Layers, Non-Plastic
Moist	Mod. Loose	Brown	2a	Volcaniclastic	SAND: Small Amount to Some SILT, Occ. Pumiceous GRAVEL Non to Slightly Plastic w/ Occ. Very Silty Lens (less than 1 ft. thick) and Occ. Clean, Mod. Well Graded SAND Lens (up to 2 ft.) Occ. Thin Lens of fine Black Sand (~ 2 in. thick)
Wet	Stiff	Brown	2m	Volcaniclastic	SILTY SAND: Occ. Sandy Lens, Trace CLAY Trace Lapilli Pumice GRAVEL
Moist	Mod. Loose	Black to Brown	2a	Volcaniclastic	SAND: Trace SILT, Poorly Graded (Med- Fine) Few Lapilli Pumice Gravels, Non-Plastic
	Hard		3	Extrusive	BASALT
					Auger Refused @ 87 feet (Basalt)

Visual Description

# Earth Resistivity Sounding: R-1 Knott Landfill Expansion Feasibility

December, 2000



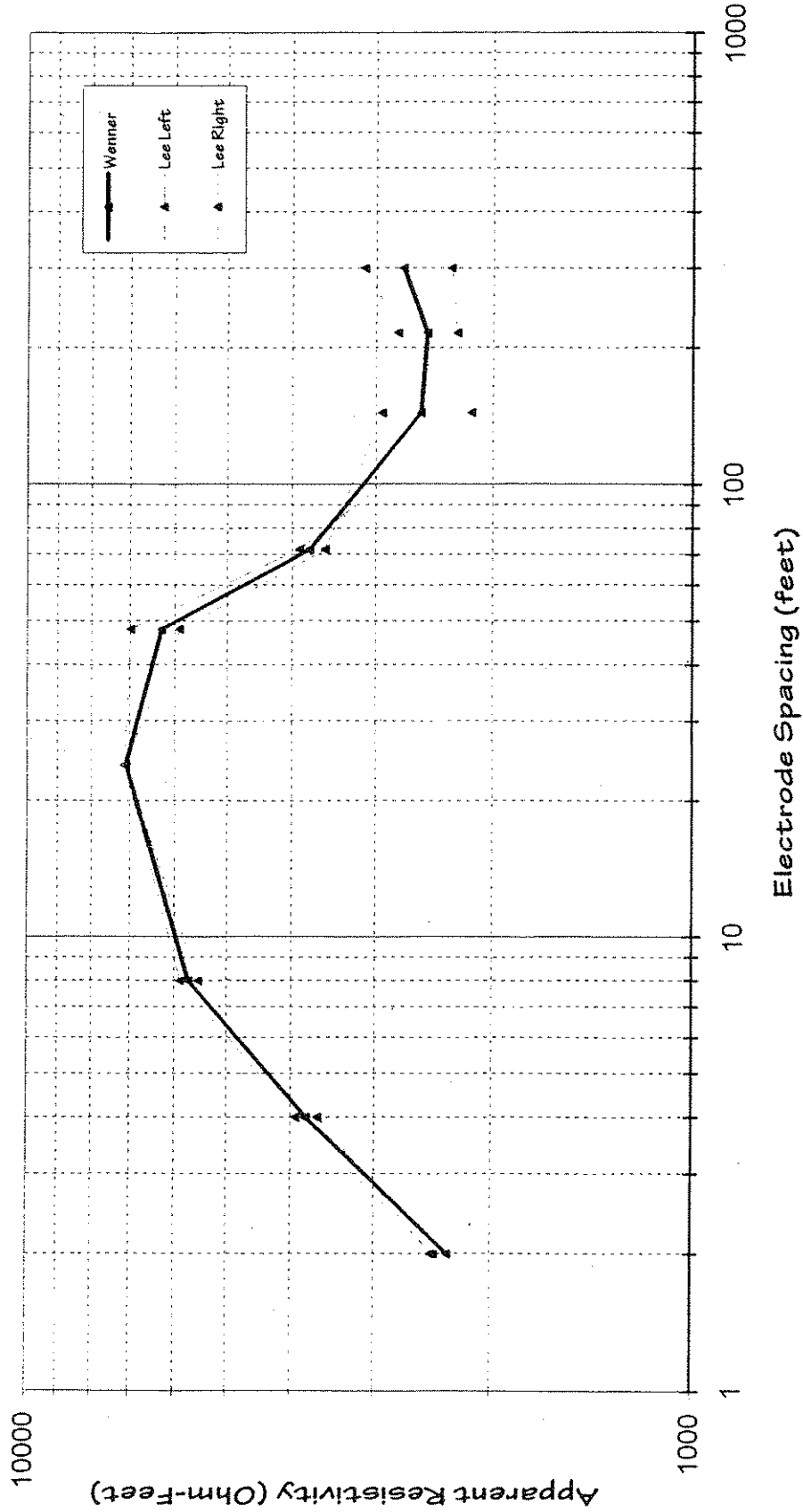
For: URS Corporation

Electrode Spacing (feet)

By: Siemens & Associates  
Bend, Oregon

# Earth Resistivity Sounding: R-2 Knott Landfill Expansion Feasibility

December, 2000

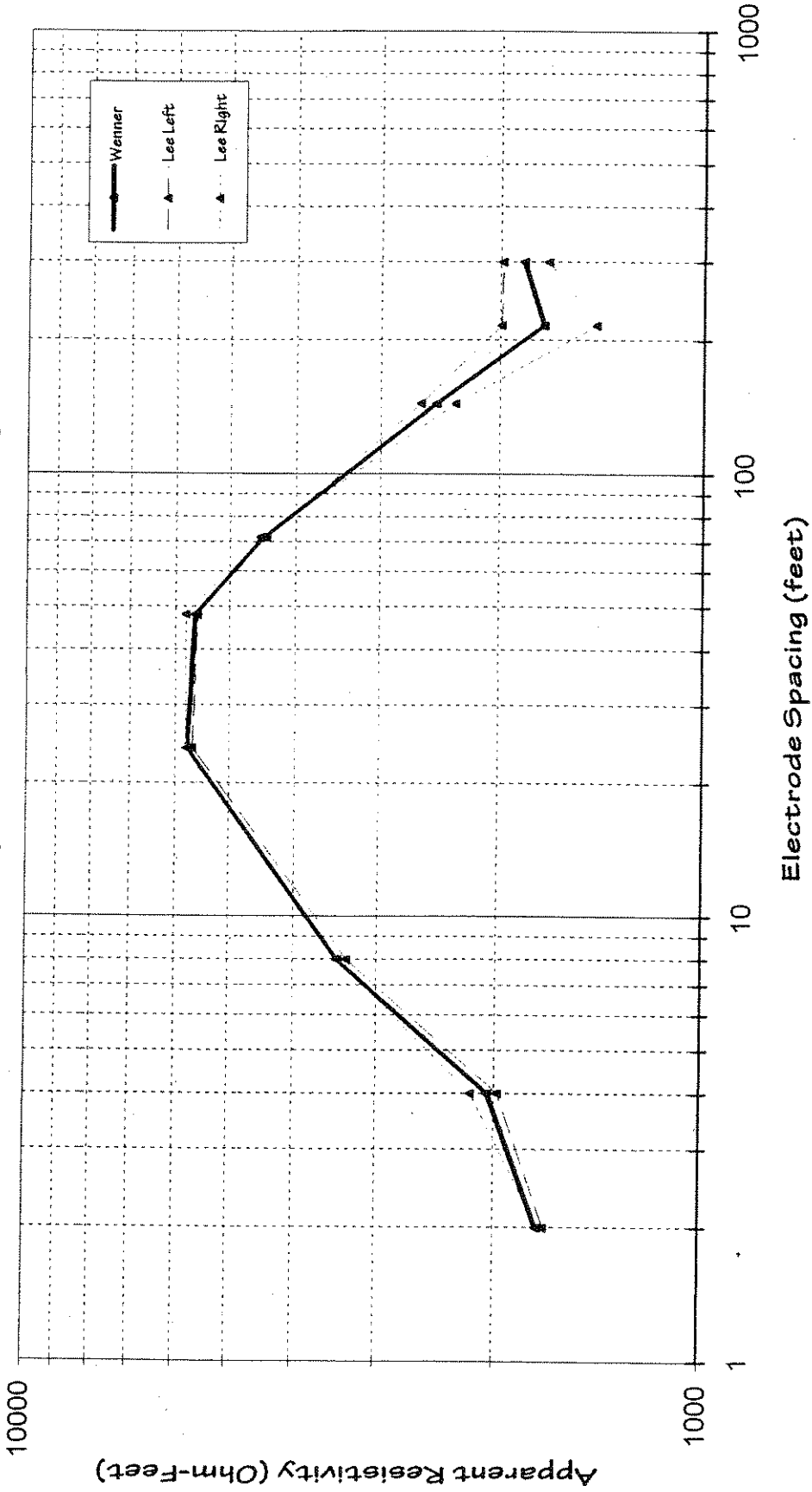


For: URS Corporation

By: Siemens & Associates  
Bend, Oregon

# Earth Resistivity Sounding: R-3 Knott Landfill Expansion Feasibility

December, 2000

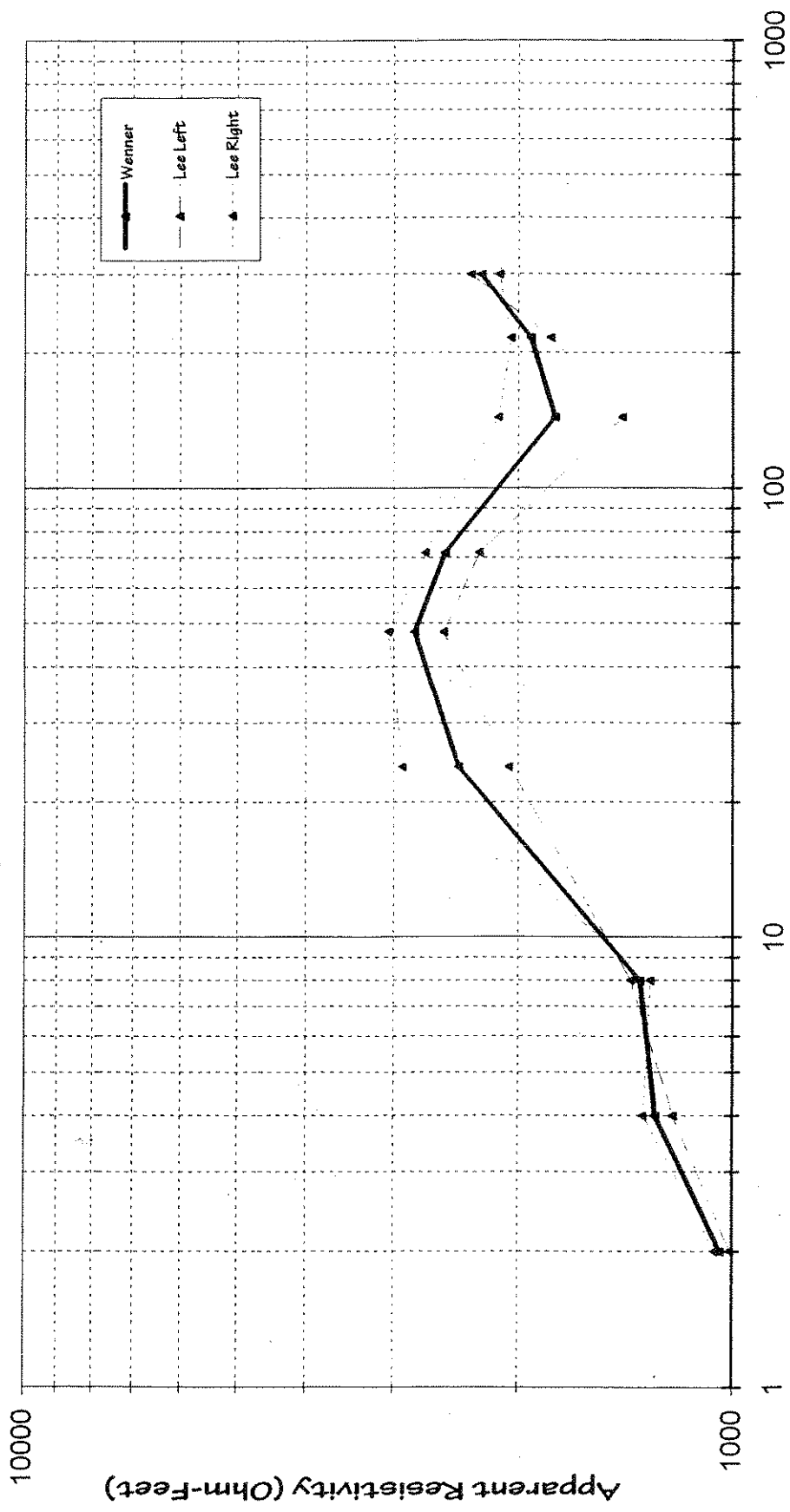


For: URS Corporation

By: Siemens & Associates  
Bend, Oregon

# Earth Resistivity Sounding: R-4 Knott Landfill Expansion Feasibility

December, 2000



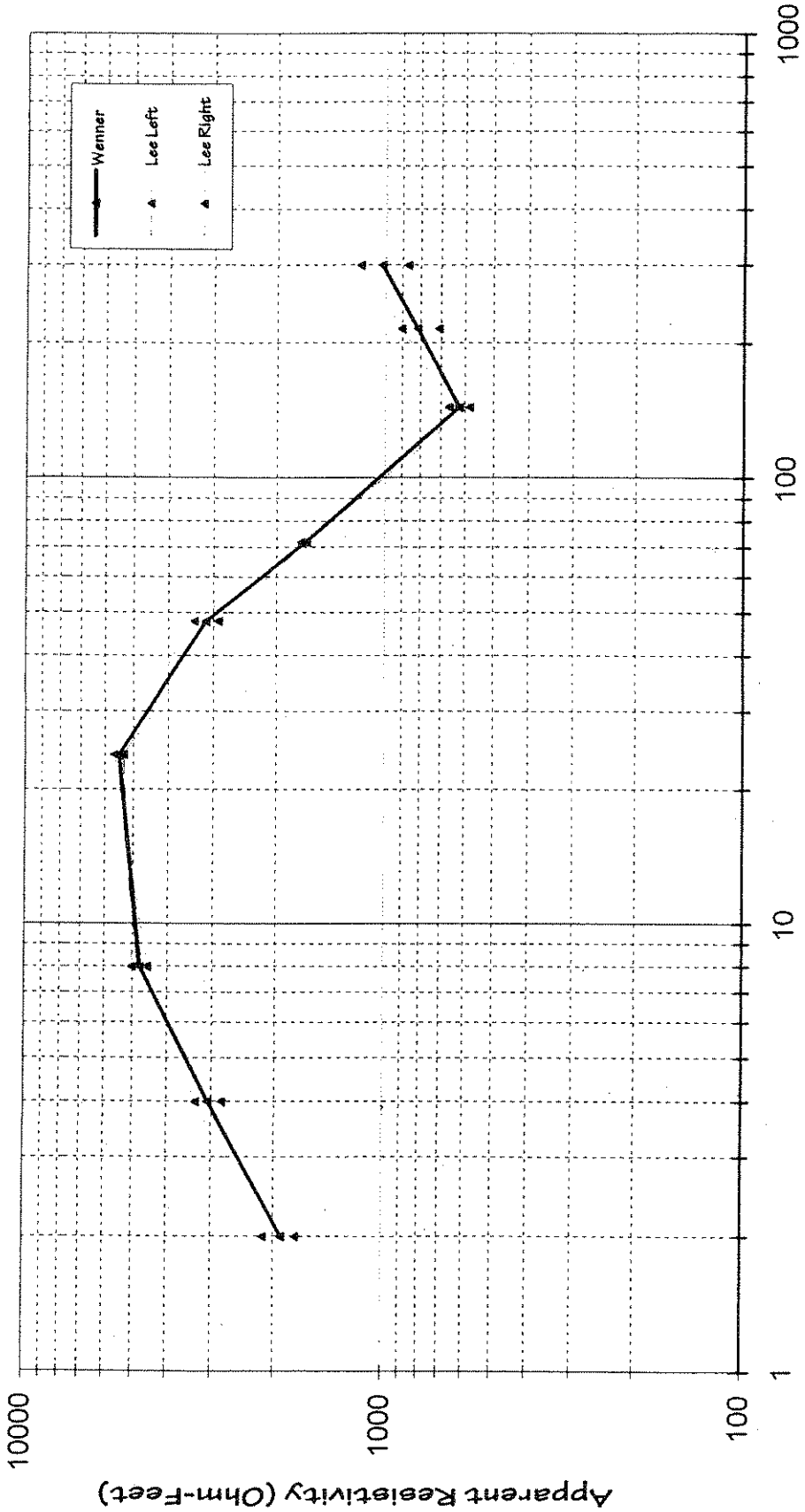
Electrode Spacing (feet)

For: URS Corporation

By: Siemens & Associates  
Bend, Oregon

# Earth Resistivity Sounding: R-5 Knott Landfill Expansion Feasibility

January, 2000



For: URS Corporation

Electrode Spacing (feet)

By: Siemens & Associates  
Bend, Oregon

# Knott Landfill Expansion Feasibility

## LABORATORY SUMMARY:

STRATUM	2am	2am	2a	2a	2a	2c	2c	2c	2c	2e	2e	2e	2e	2e	2s	2s	2s	2s	2s	2sm	2sm	2s	2s	2s	2sm	2a	2a	2c	2c	2sm	2a	2a	2a	2a	2a	2c																
Boring #	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65															
Depth (ft)	30-32	34-36	38-40	42-44	47-48	54-56	58-59	66-68	70-72	74-76	79-80	82-84	86-88	90-92	94-95	98-100	102-104	106-108	110-112	114-116	118-120	122-124	126-128	130-132	134-136	138-140	142-144	146-148	150-152	154-156	158-160	162-164	166-168	170-172	174-176	178-180	182-184															
Elevation (ft)																																																				
Sample Type	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD	UD																
In situ Moisture (%)	21.4	26.7	18.7	19.9	13.5	25.1	30.4	19.4	24.7	24.8	44.3	24.8	24.3	21	18.6	7.7	9.6	19.6	17.1	28	21.6	11.4	20.1	22.3	18.3	14.5	24.6																									
In situ Density (pcf)	93.6	89.3	94.8	90.9	109.7	81.4	90.6	98.5	77.7	76.9	69.6	79.3	95.8	97.6	96.8	97.2	105.2	81.4	82.8	86.6	85.4	86.7	81	83.5	80.9	78.6	84.2																									
Saturation (%)	74	83	67	64	71	64	98	76	58	57	85	61	89	80	70	29	44	50	45	82	61	33	51	60	46	35	68																									
Remarks:			SBV Lens			Clay Lens					Clay Lens	Clay Lens							SBV Lens		Clay Lens						SBV Lens																									
<b>GRAIN SIZE DISTRIBUTION:</b>																																																				
1" (25.0 mm)																																																				
3/4" (19.0 mm)			100%																																																	
1/2" (12.5 mm)			100%																																																	
3/8" (9.5 mm)			99	96	96	99	96	99	99	99	100%	99	98	100%	94	95	97	96	100%	99	95	93	92	100%	99	96	94	95	97	99	94	95	97	99	94	95																
1/4" (6.3 mm)			96	96	89	98	98	92	95	95		97	98	100%	98	90	91	89	97	98	90	84	84	99	86	77	88	83	85	91	87	91	100%																			
#4 (4.75 mm)			93	94	84	86	88	88	88	84	94	91	96	98	97	90	86	84	95	97	92	86	77	98	83	87	99																									
#10 (2.00 mm)			79	85	62	88	75	75	84	84	91	96	90	76	84	62	63	70	85	92	98	70	58	91	66	70	95																									
#16 (1.18 mm)			68	78	49	80	68	78	78	92	88	95	84	65	76	51	51	61	77	88	97	57	50	84	56	59	91																									
#30 (600 micro m)			55	68	37	68	55	70	66	89	85	94	76	57	63	33	40	51	67	80	96	39	41	74	46	44	88																									
#40 (425 micro m)			50	63	32	37	43	65	63	87	84	94	71	52	57	33	35	47	63	75	95	32	36	69	41	37	86																									
#100 (150 micro m)			51	43	16	40	16	38	46	66	73	89	48	32	33	18	17	29	39	53	93	16	22	49	21	14	65																									
#200 (75 micro m)			13	22	8	20	6	19	21	30	60	51	25	14	14	8	7	12	17	30	75	7	11	27	7	5	34																									

Section Four:  
Leachate Management Plan



## 4.1 PURPOSE

The purpose of this section of the report is to describe the leachate management system that is planned for the site. Included in this chapter are descriptions of the following items:

- Liner system.
- Primary leachate collection and removal system.
- Secondary leachate collection and removal system.
- Leachate recycling and disposal system.

## 4.2 LINER SYSTEM PROFILE

The design for the landfill's primary liner system that is planned for future refuse cells is shown in Figure 4-1. Components from top to bottom for the landfill floor area include:

- A 12-inch protective layer
- A separating geotextile used to prevent clogging of the drainage layer and provide additional protection to the liner system
- A 12-inch drainage layer used to transmit leachate to the leachate collection system and maintain less than 30 cm of hydraulic head on the liner.
- A cushioning geotextile used to provide protection to the underlying geomembrane.
- The flexible membrane liner that is required by RCRA Subtitle D. A 60-mil high-density polyethylene (HDPE) geomembrane will be utilized.
- A geosynthetic clay liner (GCL) used as the lower component within the liner system.
- A cushioning layer (3/4-inch minus material) used to provide a stable foundation for the liner system and protect the overlying GCL from the excavated subgrade.
- A prepared subgrade that is used to provide a uniform surface for construction of the liner system.

This liner profile meets the requirements for an alternative liner system under RCRA Subtitle D. The geosynthetic clay liner (GCL) replaces the design standard of two feet of compacted soil with a hydraulic conductivity of no more than  $1 \times 10^{-7}$  cm/sec.

### 4.2.1 Material Specifications

Geosynthetics are used in the liner system for a variety of reasons. The flexible membrane liner (FML) has very low permeability and diffusivity, the geosynthetic clay liner has low permeability and is self-healing, and the geotextile protects the geomembrane by cushioning. The primary characteristics of each of the liner system components are discussed below.

**Flexible Membrane Liner:** The FML selected for the site is a 60-mil high-density polyethylene (HDPE) geomembrane. HDPE was chosen because of its excellent chemical resistance, polymeric thermoplastic properties, and high-yield strength.

**Geosynthetic Clay Liner (GCL):** The GCL was selected as an alternative to the 2 feet of compacted soil due to the unavailability of low permeability soils in the Bend area. The GCL that is specified is a composite sandwich of geotextile and bentonite joined by needlepunching.

**Geotextiles:** Geotextiles are used in the liner system for two functions, cushioning and separating. The material specifications for the geotextiles will be based on the function they serve. For cushioning, a heavy non-woven 16-ounce geotextile will provide the best protection. For separation, a lighter weight geotextile will suffice and the apparent opening size will be the important criterion.

**Protective Soil and Drain Rock Layers:** The results of the onsite soils investigation can be found in Appendix 3a. Preliminary site investigations indicate that adequate quantities of soil and drain rock materials for the liner system can be found on site.

### 4.2.2 Settlement Analysis

Settlement within the landfill has been evaluated and a description of the analysis is included in Appendix 4a.

### 4.2.3 DEQ Alternative Liner System Design Policy

At Knott Landfill, it is planned to utilize a composite liner system comprised of a minimum 60-mil HDPE geomembrane that is underlain by a GCL with a minimum thickness of 0.6-cm and a hydraulic conductivity of no more  $3 \times 10^{-9}$  cm/sec. The average annual precipitation at the site is 11.73 inches per year. The depth to groundwater beneath the landfill's liner system is 575-feet and a secondary leak detection system is planned for installation beneath the leachate interceptors.

In a memorandum (dated July 13, 2000) DEQ issued a solid waste policy on alternative liner designs that approves an alternative liner system like that which is proposed at Knott Landfill without the need for an alternative liner design demonstration (see Appendix 4b).

#### **4.2.4 Point-of-Compliance Assessment**

An "Alternative Liner System Performance Analysis" was performed by Harding Lawson Associates in 1996 and included within the previous site development plan. The alternative liner system analysis evaluated the performance of the liner system shown in Figure 4-1. The analysis, which was reviewed and approved by the DEQ, demonstrates that the alternative liner system will:

- Meet the performance standard as established by RCRA Subtitle D (40 CFR 258.40(a)(a) at the relevant point of compliance.
- Comply with the performance requirements of Oregon's Groundwater Quality Protection Rules.

#### **4.2.5 EPA Comparison of GCL and CCL Composite Lined Landfills**

In 1999, a major study was performed for the EPA to determine if leakage rates from landfills lined with composite geosynthetic clay liners (GCL) and compacted clay liners (CCL) varied. A summary of this study is shown in Appendix 4c. Leakage rates in the leak detection systems at 91 landfill's that were double-lined were compared. The studies showed that leakage from the geomembrane/GCL lined landfill's into their leak detection system was significantly less than that which was measured at the landfill's lined with a geomembrane/CCL combination.

### **4.3 PRIMARY LEACHATE COLLECTION AND REMOVAL SYSTEM**

Leachate produced in the landfill is collected by a primary leachate collection and removal system (LCRS) located above the liner system. The leachate flows by gravity to collection sumps located near the center of the landfill cells as shown on Figure 4-2. The LCRS has been designed to operate by gravity and maintain less than 1-foot of leachate head over the liner as required by RCRA Subtitle D.

#### **4.3.1 System Description**

The leachate collection system consists of a 12-inch gravel drainage layer and collection pipes constructed above the composite liner. In future refuse cells, the bottom of the landfill will be sloped at a 5 percent grade so leachate will flow through the gravel layer to the collection pipes. The collection pipes flow to header pipes which drain to a low point where leachate is collected for discharge to the leachate recycling and disposal system.

The base grades of the landfill will contain a series of trenches, with the collection pipes located within these trenches (see Figure 4-3). The leachate collection lines will be extended up the sidewalls on both ends as solid pipe to allow for clean-out access.

The entire base of the landfill slopes toward collection sumps which will be located at the center of the landfill (see Figure 4-4). These are depressed, lined areas within the landfill where leachate will be temporarily stored. A HDPE riser will be utilized to allow a pump to be used for the removal of leachate from the sump. The sidewall riser will be accessible from the perimeter of the landfill during all phases of the landfill development.

Liquid level sensors will be used within the sumps to detect the head on the liner system. If significant quantities of leachate are detected it will be pumped into an above-ground leachate storage tank and recirculated or disposed of at the City of Bend wastewater treatment plant.

### **4.3.2 Design Criteria**

The following design criteria will be utilized:

- Granular drainage layer in-place hydraulic conductivity greater than or equal to 1 cm/sec.
- Less than 5 percent of the granular drainage layer fines passing No. 200 sieve.
- Collection pipe slopes will be greater than or equal to 2 percent.
- Drainage layer slopes toward the leachate collection trench will generally be equal to 5 percent.
- Where pipe bends are required, pipe shall be bent with a minimum radius of 25-feet to facilitate access by cleanout/inspection equipment. Pipe bend fittings shall not be utilized.

### **4.3.3 Leachate Quantity and Quality**

The leachate quantity and quality that have been generated by the landfill during 1998 through 2002 is shown in Table 4-1 and 4-2. Precipitation during this period has averaged 10.04 inches annually at the Bend weather reporting station. During the 5 year period of record that was analyzed, the leachate generated by Cell 1 (8.0 acres) averaged 340,000 gallons per year or approximately 15.7 percent of the incident precipitation.

Generation rates over this time period averaged 116 gpd per acre of contributing landfill disposal area. As the refuse fill depth has increased, the per acre leachate generation rates have significantly decreased.

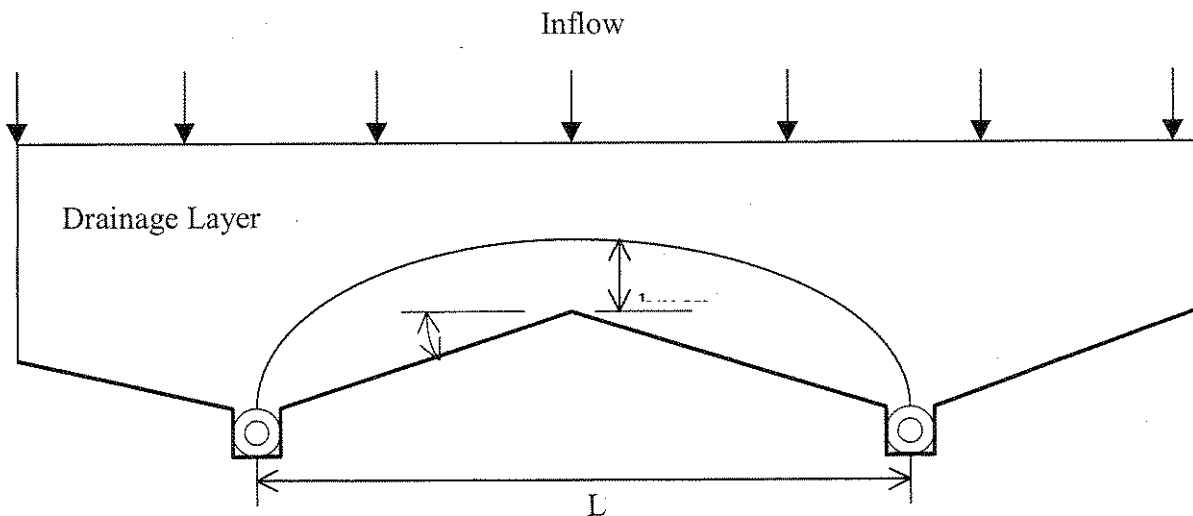
**4.3.4 Pipe Spacing**

RCRA Subtitle D stipulates that the maximum allowable head,  $h_{max}$ , on an MSW landfill liner system be 30 centimeters (12-inches) or less. DEQ indicates in their 1996 guidance document for MSW landfill's that the impingement rate that should be assumed is the wettest month's average rainfall. Monthly precipitation records for Bend are shown in Appendix 4d. At Knott Landfill, the maximum monthly average precipitation is 1.78 inches ( $1.69 \times 10^{-6}$  cm/sec) and occurs in December.

In the future, it is anticipated that leachate will be recirculated. In order to allow this to occur the LCRS system has been designed to recirculate an entire year of precipitation monthly. Over the period from 1971 through 2000, the Bend weather reporting station received an average annual precipitation of 11.73 inches. To recirculate the entire average annual flow monthly, the impingement rate on the liner system will be  $1.15 \times 10^{-5}$  cm/sec. This will allow landfill operators to take advantage of favorable evapotranspiration rates during the summer months.

In order to maintain less than 12-inches of leachate head on the liner system, leachate collection pipes will be spaced at regular intervals. Pipe spacing is dependent upon drainage slope, drainage layer permeability and cell geometry. The slope toward the drainage piping that is planned is 5.0 percent (which is  $\tan \alpha = 0.05$ ) and the minimum drainage layer permeability is 1 cm/sec.

Based on these design values, the pipe spacing can then be computed using the Mound equation.



**Figure 4-1: Definition of Terms for Mound Model**

In the Mound Model, the maximum height of fluid ( $h_{max}$ ) between two parallel perforated drainage pipes is equal to the following:

$$h_{max} = \frac{S * (c)^{0.5}}{2} * \left( \frac{\tan^2 \alpha}{c} + 1 - \frac{\tan \alpha}{c} * (\tan^2 \alpha + c)^{0.5} \right)$$

where:

$h_{max}$  = Height of leachate mound (maximum allowable = 1-foot) (ft)

S = Maximum distance between drainage pipes (ft)

$\alpha$  = Bottom slope angle (degrees) = 2.86°

c = q/k = 1.15 x 10<sup>-5</sup> cm/sec.

q = Impingement rate (cm/sec) = 1.15 x 10<sup>-5</sup> cm/sec

k = Drainage layer permeability (cm/sec) = 1 cm/sec

Substituting into the general equation yields the following:

$$h_{max} = \frac{S * (1.15 \times 10^{-5})^{0.5}}{2} * \left( \frac{\tan^2 2.86^\circ}{1.15 \times 10^{-5}} + 1 - \frac{\tan 2.86^\circ}{1.15 \times 10^{-5}} * (\tan^2 2.86^\circ + 1.15 \times 10^{-5})^{0.5} \right)$$

$$h_{max} = S (.00170) * (217.85 + 1 - 4,348 * 0.05015)$$

$$1.0 \text{ feet} = S (0.00170) * (0.7978)$$

$$S = 737 \text{ feet}$$

**Conclusion:** If less than 1-foot of head on the liner is to be maintained, the maximum distance between leachate interceptors is required to be 737-feet. The maximum distance between leachate interceptors that is planned is 350 feet.

**4.3.5 Pipe Structural Stability**

Leachate collection piping installed beneath the landfill must be designed to withstand the anticipated height and weight of refuse to be placed over it. At the Knott Landfill the maximum height of fill over the piping is anticipated to be 140 feet. If it is assumed that refuse densities over the pipe average 75 lb per cubic foot, the maximum vertical soil pressure on the pipe is 73 pounds per square inch (psi).

The performance of HDPE pipe at Knott Landfill is governed by the following principles:

- The pipe that will be installed is flexible. Because flexible pipes can deform, the pipe will over time conform to the surrounding soil and relieve the pipe of pressure concentrations.
- Arching action of the soil around the pipe will support the vertical load. The soil will perform similarly to a masonry arch. No cement will be needed to hold the arch together because the pipe will retain the soil arch.
- The flexible pipe ring will be held in shape by the surrounding granular backfill.
- Stresses in the HDPE pipe will relax. If the soil holds the pipe in a fixed shape, the pipe will relax over a period of time and relieve itself of a portion of the stresses in it.
- Performance limits within the pipe are ring crushing and excessive deflection. Ring deflection is approximately equal to, but not greater than, the vertical strain on the side fill soil due to the weight of the landfill.
- Collapse of the pipe will occur if ring deflection is excessive and the strength of the adjacent side fill is inadequate.

Eight-inch HDPE pipe will be utilized for leachate collection. Based on the calculated design pressure that the pipe must withstand, a standard dimension ratio (SDR) of 9.0 has been selected. This SDR will meet wall crushing, wall buckling and ring deflection criteria. Because the pipe will be placed on well-compacted subgrade material, stresses associated with the differential settlement of refuse are not expected to impact the pipe. The amount of long-term differential consolidation of the landfill foundation is minimal (see Appendix 4a), and it is anticipated that the flexible nature of HDPE will allow the pipe to accommodate any settlement that does occur.

#### **4.4 SECONDARY LEACHATE COLLECTION AND REMOVAL SYSTEM**

The solid waste permit requires a leak detection and removal system “capable of detecting and collecting leachate at locations of maximum leak probability.” The secondary LCRS will be constructed beneath the leachate collection trenches and sumps, as shown in Figures 4-3 and 4-4. Components of the secondary system from top to bottom include:

- A separating geotextile to prevent intrusion of bentonite from the GCL into the geonet.
- A geonet which transmits leachate that may have leaked through the primary liner system to the collection sump.
- A 60-mil HDPE geomembrane.

- A geosynthetic clay liner (GCL) used as the lower component within the secondary liner system.
- A cushioning layer (3/4-inch minus material) used to provide a stable foundation for the liner system and protect the overlying GCL from the excavated subgrade.
- A prepared subgrade that is used to provide a uniform surface for construction of the liner system.

Any moisture which may accumulate as a result of condensation following liner construction or leachate leaking through the liner system will flow to collection sumps for detection and removal. In order to enable the secondary system pumps to be tested and operate, their pump impellers will always need to be submerged and liquid will always be present within the secondary sumps. If liquid in excess of that which has been introduced for testing and pump operation occurs in the leak detection system, it will be analyzed to determine if its origin is condensation from construction or leachate leaking through the liner system. An approved sampling procedure for leachate in the secondary sump is described in the *2002 Knott Landfill Environmental Monitoring Plan*.

#### **4.5 LEACHATE RECIRCULATION AND DISPOSAL SYSTEM**

Leachate generated by the landfill will either be recirculated or disposed of at the City of Bend wastewater treatment plant. The following is a discussion of the system that is planned.

##### **4.5.1 Leachate Recirculation**

The primary means for disposal of leachate will be recirculation. Leachate that is generated in each lined area will be pumped to an above ground storage tank and temporarily stored. Periodically, leachate will be recirculated into lined disposal areas that have a minimum of 20-feet of refuse in-place. Initially, a 3,500-gallon tanker truck will be utilized for hauling and spreading leachate near the working face of the landfill.

In the future, an automatic leachate recirculation system that includes a pumping system and infiltration galleries may be developed. Prior to its construction, an engineering design report will be submitted to the DEQ for review.

##### **4.5.2 City of Bend Wastewater Treatment Plant**

If leachate cannot be recirculated it will be transported to the City of Bend wastewater collection system for treatment in their wastewater treatment plant. Deschutes County has obtained an industrial discharge permit and a copy of this is included in Appendix 4e.



**Table 4-1: Leachate Generation Rates at Knott Landfill**

Year	Month	Monthly Precip inches	CELL 1		CELL 2	
			Primary Gallons	Secondary Gallons	Primary Gallons	Secondary Gallons
1998	January	2.39	16,584	0		
	February	1.12	14,098	0		
	March	0.58	21,490	0		
	April	0.88	25,793	0		
	May	4.11	22,023	0		
	June	0.35	18,520	0		
	July	0.63	10,566	0		
	August	0.80	9,532	0		
	September	0.35	11,361	0		
	October	0.12	8,097	0		
	November	4.23	15,679	0		
	December	2.34	56,602	0		
	TOTALS	17.90	230,345	0	0	0
1999	January	2.16	114,838	0		
	February	3.08	90,837	0		
	March	0.52	107,135	0		
	April	0.00	82,121	0		
	May	0.04	55,868	0		
	June	0.12	40,812	0		
	July	0.14	39,303	0		
	August	2.76	32,544	0		
	September	0.00	30,804	0		
	October	1.17	26,980	0		
	November	0.39	35,506	0		
	December	0.27	59,694	0		
	TOTALS	10.65	716,442	0	0	0
2000	January	2.67	25,381	0		
	February	1.75	33,283	0		
	March	0.20	46,766	0		
	April	0.54	36,334	0		
	May	0.45	38,656	0		
	June	0.00	32,841	0		
	July	0.15	20,163	0		
	August	0.00	18,450	0		
	September	0.42	13,781	0		
	October	0.76	14,386	0		
	November	0.28	10,737	0		
	December	0.96	12,943	0		
	TOTALS	8.18	303,721	0	0	0

**Table 4-1: Leachate Generation Rates at Knott Landfill**

Year	Month	Monthly Precip inches	CELL 1		CELL 2	
			Primary Gallons	Secondary Gallons	Primary Gallons	Secondary Gallons
2001	January	0.17	24,980	0		
	February	1.47	32,061	0		
	March	0.56	38,960	0		
	April	0.67	35,500	0		
	May	0.04	34,620	0		
	June	0.38	32,980	0		
	July	1.07	22,012	0		
	August	0.00	18,450	0		
	September	0.45	12,780	0	3,720	0
	October	0.29	7,366	0	127	0
	November	2.22	7,714	0	44,194	0
	December	2.34	13,262	0	289,883	0
	TOTALS	9.66	280,685	0	337,924	0
2002	January	1.20	33,216	0	248,845	0
	February	0.33	26,571	0	52,307	0
	March	0.64	18,858	0	13,655	0
	April	0.12	21,763	0	9,305	0
	May	0.10	15,227	5	7,998	0
	June	0.12	12,329	0	6,350	0
	July	0.00	14,802	0	10,310	0
	August	0.57	9,039	0	0	0
	September	0.11	6,608	0	2,868	0
	October	0.29	8,783	21	4,560	40
	November	0.31	7,683	0	0	0
	December	N/A	8,935	0	34,751	0
	TOTALS	3.79	183,814	26	390,949	40
Average Annual		10.04	343,001			

**Table 4-2: Summary of Leachate Analytical Data  
Knott Landfill - Cell 1 Primary Sump**

	Reporting Limits	MCL <sup>1</sup>	Fall, 2000	Spring, 2001	Fall, 2002	Average
<b>LABORATORY INDICATORS</b>						
Hardness, mg/L	0.660	NR	1820	1810	1590	1740
Total Alkalinity, mg/L	100	NR	1640	1680	1460	1593
Specific conductance $\mu$ S/cm	1000	NR	4440	4790	4670	4633
pH	-	6.5-8.5	6.46	6.59	6.82	6.62
Total Dissolved Solids, mg/L	40.0	NR	2280	2270	2280	2277
Total Suspended Solids, mg/L	10.0	NR	60.0	112	88	87
Chemical Oxygen Demand, mg/L	50.0	NR	226	225	230	227
Total Organic Carbon, mg/L	1.00	NR	210	ND	63.8	137
<b>ANIONS AND CATIONS (mg/L)</b>						
Calcium (Ca)	1.00	NR	282	258	226	255
Magnesium (Mg)	1.00	NR	256	282	250	263
Sodium (Na)	10.0	NR	221	242	246	236
Potassium (K)	1.00	NR	49.8	51.1	50.3	50.4
Iron (Fe)	0.100	NR	0.835	37.7	40.9	26.5
Manganese (Mn)	0.0100	NR	2.90	1.40	1.45	1.92
Ammonia (NH <sub>4</sub> )	0.0500	NR	5.74	1.49	4.24	3.82
Carbonate (CO <sub>3</sub> )	100	NR	ND	ND	ND	ND
Bicarbonate (HCO <sub>3</sub> )	100	NR	1640	1680	1480	1600
Sulfate (SO <sub>4</sub> )	1.00	NR	0.420	3.02	ND	1.72
Chloride (Cl)	25.0	NR	348	443	456	416
Nitrate - Nitrogen (NO <sub>3</sub> )	0.100	10	ND	ND	ND	ND
Silica (SiO <sub>2</sub> )	0.500	NR	24.2	59.8	64.8	49.6
<b>TOTAL TRACE METALS (mg/L)</b>						
Antimony (Sb)	0.00100	0.006	ND	ND	ND	ND
Arsenic (As)	0.00200	0.05	0.00434	0.00226	0.00321	0.00327
Barium (Ba)	0.00400	2	0.424	0.339	0.401	0.388
Beryllium (Be)	0.00100	0.004	ND	ND	ND	ND
Cadmium (Cd)	0.00200	0.005	ND	ND	ND	ND
Chromium (Cr)	0.00200	0.1	0.00223	0.00330	0.00212	0.00255
Cobalt (Co)	0.00400	NR	0.00508	0.00408	0.00468	0.00461
Copper (Cu)	0.00400	1.3	0.00565	0.0169	0.0131	0.0119
Lead (pb)	0.00200	0.015	ND	ND	ND	ND
Nickel (Ni)	0.00400	NR	0.0353	0.0441	0.0352	0.0382
Selenium (Se)	0.00200	0.05	0.00282	0.00478	ND	0.0038
Silver (Ag)	0.00200	NR	ND	ND	ND	ND
Thallium (Tl)	0.00100	0.002	ND	ND	ND	ND
Vanadium (V)	0.0100	NR	0.00546	ND	0.00651	0.0060
Zinc (Zn)	0.0100	NR	0.0143	0.0349	0.00588	0.0184

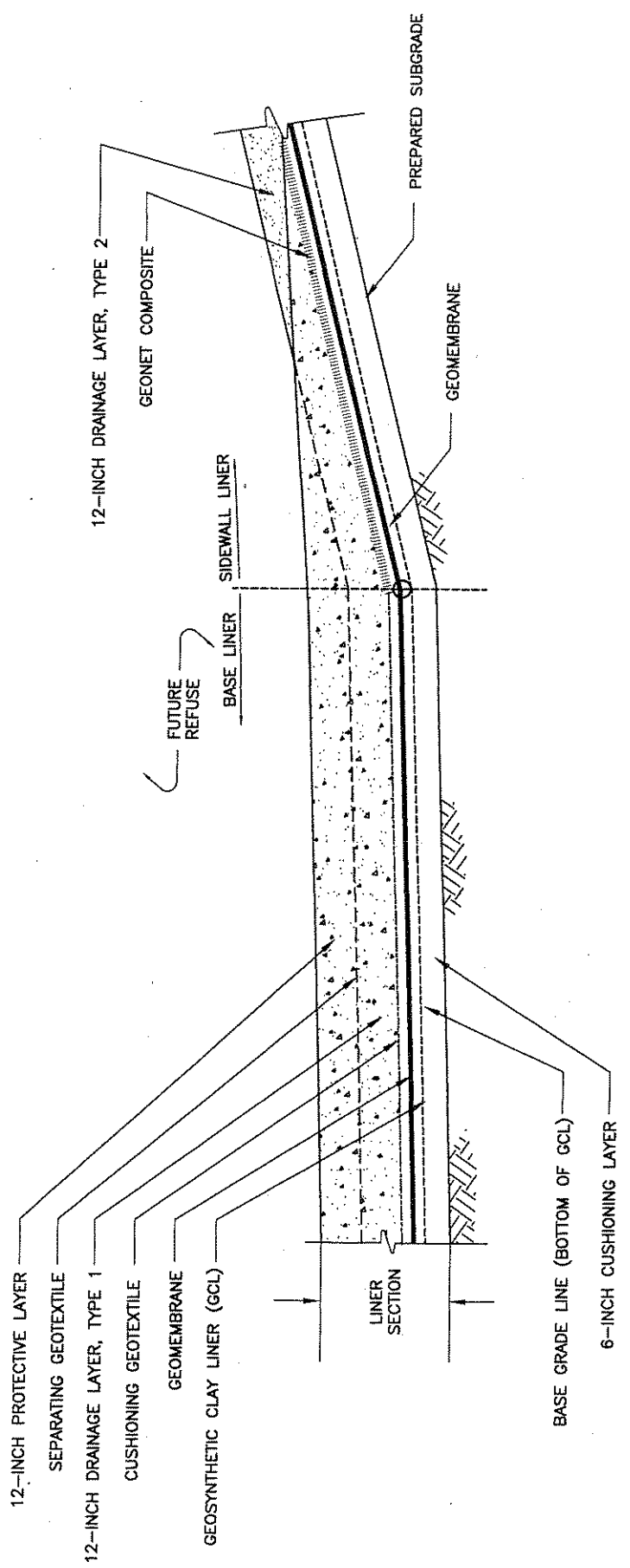
**Table 4-2: Summary of Leachate Analytical Data  
Knott Landfill - Cell 1 Primary Sump**

	Reporting Limits	MCL <sup>1</sup>	Fall, 2000	Spring, 2001	Fall, 2002	Average
<b>DISSOLVED TRACE METALS (mg/L)</b>						
Antimony (Sb)	0.000500	0.006	NA	ND	NA	ND
Arsenic (As)	0.00100	0.05	NA	0.00645	NA	0.00645
Barium (Ba)	0.00200	2	NA	0.431	NA	0.431
Beryllium (Be)	0.000500	0.004	NA	ND	NA	ND
Cadmium (Cd)	0.00100	0.005	NA	ND	NA	ND
Chromium (Cr)	0.00100	0.1	NA	0.00296	NA	0.00296
Cobalt (Co)	0.00200	NR	NA	0.00572	NA	0.00572
Copper (Cu)	0.00200	1.3	NA	0.00605	NA	0.00605
Lead (pb)	0.00100	0.015	NA	ND	NA	ND
Nickel (Ni)	0.00200	NR	NA	0.0341	NA	0.0341
Selenium (Se)	0.00100	0.05	NA	0.00489	NA	0.00489
Silver (Ag)	0.00100	NR	NA	ND	NA	ND
Thallium (Tl)	0.000500	0.002	NA	ND	NA	ND
Vanadium (V)	0.00500	NR	NA	0.00736	NA	0.00736
Zinc (Zn)	0.00500	NR	NA	0.0347	NA	0.0347
<b>VOCS - EPA METHOD 8260 (µg/L)</b>						
Acetone	10	5.00	36.5	NA	NA	36.5
Benzene	0.500	5.00	17.5	15.5	14.7	15.9
Chloroethane	1.00	NR	51.7	40.3	25.4	39.1
1,4-Dichlorobenzene	0.500	75.00	1.32	1.20	NA	1.26
1,1-Dichloroethane	0.500	NR	4.39	4.85	7.5	5.58
1,2-Dichloroethane	0.500	5.00	NA	0.580	2.06	1.32
cis-1,2-Dichloroethene	0.500	70.00	115	133	NA	124
Ethylbenzene	0.500	700.00	38.1	23.5	32.8	31.5
Isopropylbenzene	2.00	NR	3.86	3.07	NA	3.47
n-Propylbenzene	0.500	NR	1.05	0.750	NA	0.900
Tetrachloroethene	0.500	5.00	NA	0.610	NA	0.610
Toluene	0.500	1000.00	15.6	12.9	9.8	12.8
Trichloroethene	0.500	5.00	NA	0.540	NA	0.540
1,2,4-Trimethylbenzene	1.00	NR	6.52	3.94	5.15	5.20
1,3,5-Trimethylbenzene	0.500	NR	2.19	1.46	NA	1.83
Vinyl chloride	0.500	2.00	1.22	3.67	NA	2.45
o-Xylene	0.500	10000.00	22.1	15.2	16.2	17.8
m,p-Xylene	1.00	10000.00	66.10	32.4	42.4	47.0

**Table 4-2: Summary of Leachate Analytical Data  
Knott Landfill - Cell 1 Primary Sump**

	Reporting Limits	MCL <sup>1</sup>	Fall, 2000	Spring, 2001	Fall, 2002	Average
<b>TENTATIVELY IDENTIFIED COMPOUNDS - GC/MS (µg/L)</b>						
1,1-difluoroethane	2.0	NR	NA	4.90	NA	4.90
Benzene, 1-ethyl-2-methyl-	2.0	NR	2.6	3.20	NA	2.9
Benzene, 1-ethyl-3-methyl-	2.0	NR	NA	2.60	NA	2.60
Bicyclo[2.2.1]heptan-2-one, 1,3,3-t	2.0	NR	3.3	3.40	NA	3.4
Cyclohexane	2.0	NR	2.5	3.80	NA	3.2
Ethane, 1-chloro-1-fluoro-	2.0	NR	62.0	58.8	NA	60.4
Ethyl ether	2.0	NR	161	191	NA	176
Furn, tetrahydro-	2.0	NR	97.4	105	NA	101
Methane, chlorodifluoro-	2.0	NR	12.9	12.5	NA	12.7
Methane, chlorofluoro-	2.0	NR	13.9	13.1	NA	13.5
<b>MICROBIOLOGICAL PARAMETERS - APHA STANDARD METHODS (MPN/100 mL)</b>						
Fecal Coliforms	2.0	5 <sup>2</sup>		ND	ND	
Total Coliforms	2.0	5 <sup>2</sup>		ND	2	
<p>ND=Not Detected            NR=Not Regulated            NA=Not Available            MCL=Maximum Contaminant Level            mg/L=milligrams per liter            µg/L=micrograms per liter            MPN/ 100 milliliter=Most probable number per 100 milliliter of water</p> <p><sup>1</sup> Groundwater MCLs; listed for comparative purposes only; not a permit requirement.  <sup>2</sup> Units in mg/L.</p>						





**PRIMARY LINER SYSTEM**  
 SITE DEVELOPMENT PLAN  
 KNOTT LANDFILL  
 DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 4-1**







No.	DATE	BY	REVISION
B	7/16/03	CAS	REVISED PER DEO/COUNTY REVIEW
A	5/22/03	PCF	FOR CLIENT REVIEW

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	GF	GF
1"=300'	PCF	GF
CHECKED BY:	DATE:	
GH	JULY 2003	



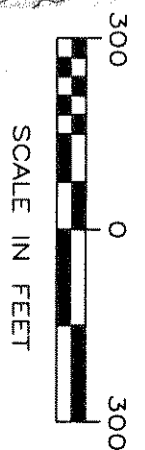
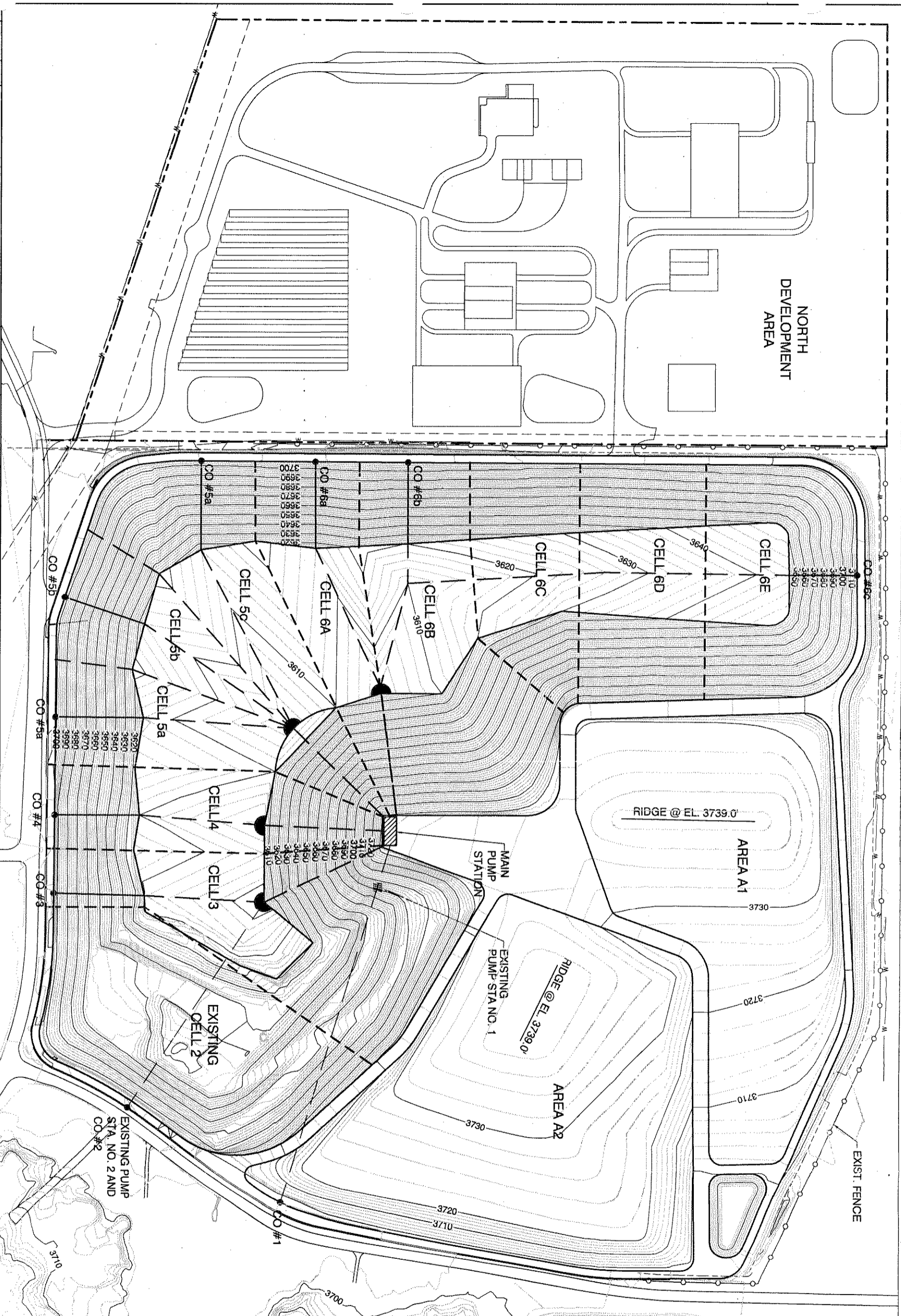
G. Fritsen Associates, Inc.  
4088 Orchard Drive  
Lake Oswego, Oregon 97075  
Tel: (503) 635-1235  
Fax: (503) 635-1447

**URS**  
111 S.W. Columbia, Suite 900  
Portland, Oregon 97201  
(tel) 503-222-7200  
(fax) 503-222-4292

**DESCHUTES COUNTY**  
DEPARTMENT OF PUBLIC WORKS  
BEND, OREGON

**Knott Landfill Site Development Plan**  
LEACHATE COLLECTION AND REMOVAL SYSTEM

DRAWING NUMBER:	Figure 4-2
CAO FILE NUMBER:	FIG 4-2
SHEET:	OF
REV.	B



**LEGEND**

- PUMP RISER
- LEACHATE COLLECTION TRENCH (SEE FIG 4-3)
- LEACHATE CLEANOUT
- LEACHATE COLLECTION SUMP

NORTH  
DEVELOPMENT  
AREA

RIDGE @ EL. 3739.0'

AREA A1

RIDGE @ EL. 3739.0'

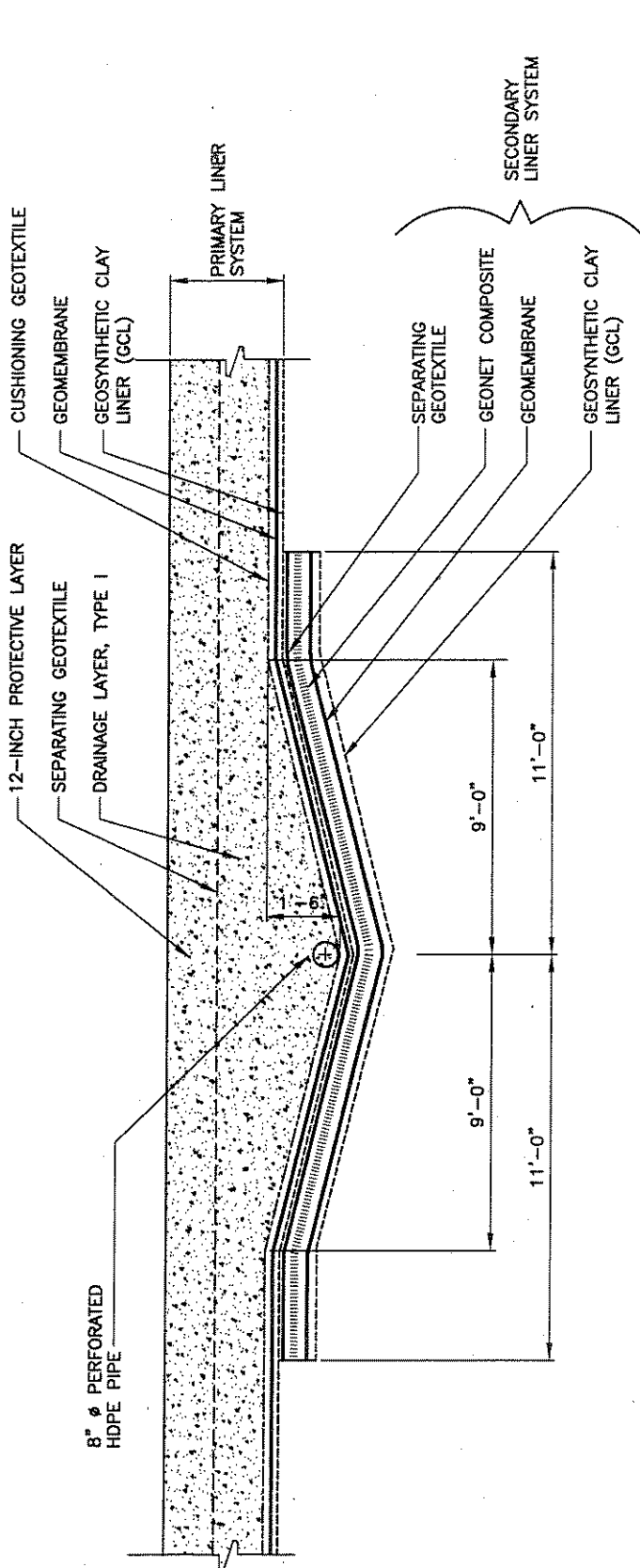
AREA A2

MAIN  
PUMP  
STATION

EXISTING  
PUMP STA NO. 1

EXISTING PUMP  
STA. NO. 2 AND  
CO #2

EXIST. FENCE



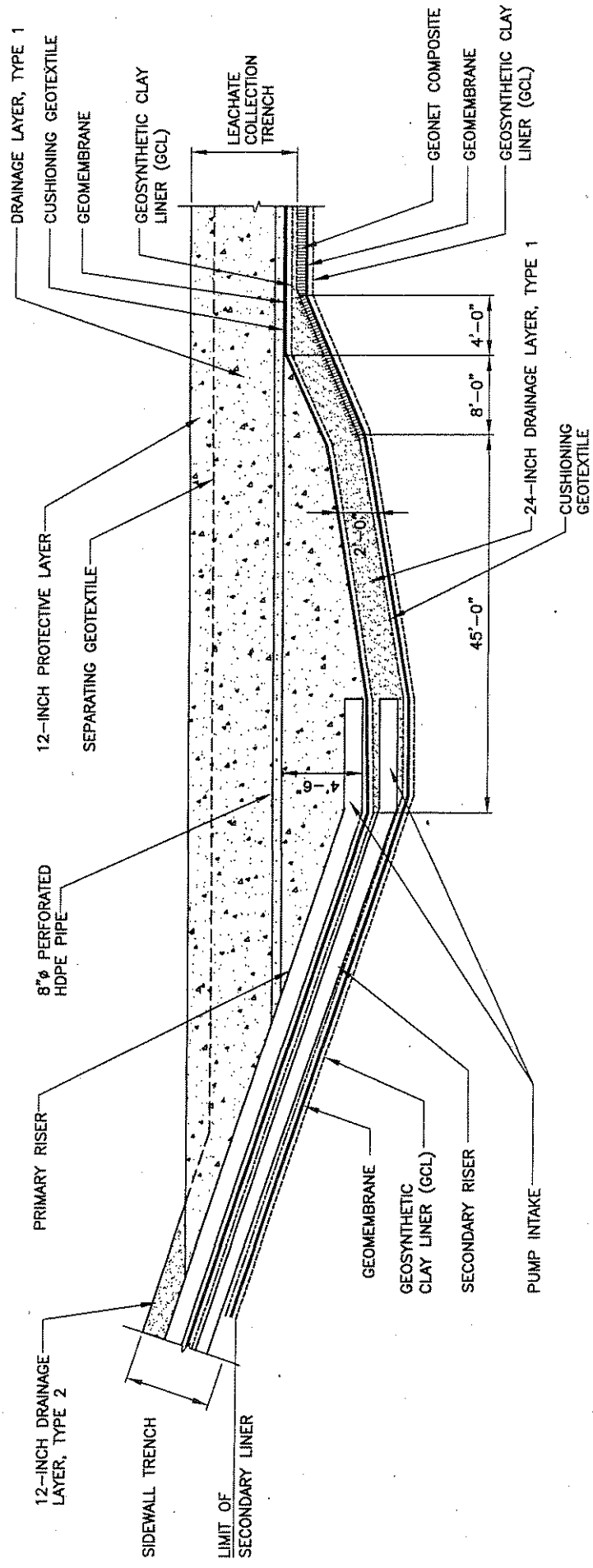
**LEACHATE COLLECTION TRENCH**  
 SITE DEVELOPMENT PLAN  
 KNOTT LANDFILL  
 DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 4-3**







**LEACHATE SUMP CROSS-SECTION**

SITE DEVELOPMENT PLAN  
 KNOTT LANDFILL  
 DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 4-4**





**Appendix 4a**  
**Landfill Settlement Analysis**



**URS Corporation**

225 N.W. Franklin Ave. Suite A  
Bend, Oregon 97701  
Attention: George Holroyd

May 21, 2003  
Project Number 1031018

**Project:** Knott Landfill & Recycling Center Site Development Plan  
Bend, Oregon

**Subject:** Landfill Settlement Analysis

Dear George:

As requested, we have reviewed available data in context with expansion plans to estimate the potential for consolidation of soils supporting existing and future solid waste and liner system components. Consolidation of the supporting soils (or rock) would translate as settlement of the solid waste and induce some degree of strain to the liner system.

This evaluation is based on limited available subsurface information and future design criteria. The important assumptions are as follows:

Approximate final height of refuse = Elev. 3739 feet.

Approximate bottom of refuse = Elev. 3600 feet.

Original ground elevation = 3700 feet.

Approximate top elevation of lower basalt =  $3600 \pm 25$  feet.

Unit weight of solid waste = 1250 pounds/cubic yard.

20% soil used as intermediate and final cover, moist unit weight = 98 pcf.

Coefficient of consolidation soils between liner and lower at effective stress = .03.

Coefficient of consolidation of basalt at effective stress = negligible (i.e. incompressible).

GWT is Greater than 600 foot depth and inconsequential.

The various assumptions as listed lead to a simplified model composed of a solid waste column approximately 140 feet in height inducing a consolidating stress to a 25 foot thick compressible soil sandwiched between the landfill floor and the underlying incompressible rock (basalt). Pre-consolidation pressure is estimated to be equivalent to a soil and rock column approximately 100 feet high or roughly 9800 psf. Pressure induced by solid waste is estimated to be 8000 psf

Siemens & Associates  
office: 541-385-6500

siemens@bendcable.com  
19134 River Woods Dr. 97702

Bend, Oregon  
fax: 503-296-2271



(combined soil and solid waste unit weight = 57 pcf). This leads to an over consolidation ratio (OCR) of about 1.2.

As a result, there is a net loss in effective stress within the compressible soil layer below the solid waste and liner system and the load can be considered to be fully compensated. The soils are not expected to rebound or swell when unloaded and as such, we estimate negligible settlement induced stress to the landfill liner system due to consolidation of supporting soils. Consequently, design floor slope is anticipated to remain about the same as constructed and no strain induced compromise to the liner or drainage system is expected.

### **Limitations**

We present the analysis to be applicable for this project and representative of the standard of care practiced by area geoprofessionals conducting similar explorations for similar local projects at this time. We offer no other warranty express or implied.

We appreciate the opportunity to be of service on this project and look forward to continuing the study. If you have any questions, please call.

Respectfully submitted,  
**Siemens & Associates**

J. Andrew Siemens, P.E.  
Renews 6/30/04

Addressee: 3

**Appendix 4b**

**DEQ Policy on Alternative Liner System Design Approval**



Date: July 13, 2000

To: All DEQ Solid Waste Staff

Through: DEQ Solid Waste Managers

From: DEQ Solid Waste Engineers and Hydrogeologists

Subject: Solid Waste Policy on Alternative Liner Design (ALD) Approval Without Conducting an ALD Demonstration.

## Background

Federal "Subtitle D" rules, 40 CFR 258.40, define the minimum design criteria for constructing new municipal solid waste (MSW) landfill units. More specifically, the permittee has the option of constructing a landfill containment system, which either conforms to the standard design defined in 40 CFR 258.40(a)(2), or a performance-based, alternative liner design (ALD) approved by the Department.

To obtain Department approval for an ALD, the permittee must demonstrate that the ALD will satisfy the following criteria:

- the performance standard in 40 CFR 258.40(a)(1) which requires the design to "... ensure that the concentration values listed in Table 1 ... will not be exceeded in the uppermost aquifer at the relevant point of compliance. ..."; and
- the policies and specific requirements of Oregon's Groundwater Quality Protection Rules (i.e., prevent a leachate release exceeding the statistical background concentrations at the relevant point of compliance).

Currently, to facilitate Department review and approval of an ALD demonstration, the permittee must submit a workplan describing how to:

- Characterize leachate quality;
- Estimate leachate leakage to the subsurface using a hydrologic model such as USEPA's HELP model; and
- Evaluate the impact of estimated leakage on groundwater quality using an appropriate groundwater flow and solute transport model.

In practice, the Department requires reasonably conservative assumptions to be used in the workplan for conducting an ALD demonstration, as follows:

- Characterize leachate quality by comparing site-specific data to the USEPA study of landfill leachates (Gibbons, et al., 1992). Average constituent concentrations from the study are then compared with site-specific values derived from the results of leachate monitoring. The higher of the two numbers are used in the ALD demonstration modeling. This approach generates a theoretical leachate tending to have concentrations higher than actual facility leachate;
- Estimate landfill leakage using HELP model simulations that are run in accordance with the attached Department guidance. This approach tends to conservatively estimate leachate generation, and landfill liner leakage; and
- Evaluate groundwater quality impacts using the MULTIMED model. The Department is reviewing the model to determine the most appropriate way of using it for ALD demonstrations.

An ALD demonstration gets approved by the Department, when the results from implementing the approved workplan demonstrate that an ALD adequately protects groundwater quality, throughout the operating and post-closure period.

Based on experience with past ALD demonstrations, the Department is issuing this policy to streamline the review process for ALD and siting combinations that are inherently protective of the environment.

### **ALD Approval Without ALD Demonstration**

The Subtitle D standard design for a composite liner consists of an upper geomembrane liner and a lower compacted clay liner (CCL). Past ALD demonstrations show that lower leakage rates occur if a geosynthetic clay liner (GCL) is substituted for the CCL component of the standard composite liner. The Department believes that the ALD demonstration process should be simplified for such ALDs when proposed in combination with a favorable site location and secondary leak detection/leachate collection system.

#### **Policy Statement:**

*The Department exempts the following liner design from the conventional ALD demonstration: an alternative composite liner comprised of a minimum 60-mil-thick HDPE geomembrane, underlain by a minimum 0.6-cm-thick GCL with a hydraulic conductivity of no more than  $3 \times 10^{-9}$  cm/sec. This exemption applies only at facilities where it is technically feasible to make this liner substitution, and where site characteristics and facility design meet one of the following conditions:*

- *Site precipitation is less than or equal to 15 inches per year, depth to groundwater is 100 feet or more, and the ALD is underlain by at least a partial secondary leak detection/leachate collection system; or*
- *The ALD is underlain by a continuous secondary leak detection/leachate collection system.*

### **Other ALD Demonstrations**

The current ALD demonstration process is HELP and MULTIMED-model based. The Department is considering whether to accept other approaches, such as a comparison of alternative-liner and standard-liner leakage rates. Accordingly, this policy may be modified in the future to accommodate other ALD demonstration methods.



**Appendix 4c**

**Liner System Performance Comparison**







COLLOID ENVIRONMENTAL TECHNOLOGIES COMPANY

1350 West Shore Drive • Arlington Heights, IL 60004-1440 • USA

(847) 392-5800 • Fax (847) 306-6150

<http://www.cetco.com>

FAX MEMO

**TO:** Gerry Friessen  
Friessen & Associates  
fax (503) 635-1447

**DATE:** February 11, 2000

**CC:**

**FROM:** Jim Olsta

**SUBJECT:** USEPA Study of Leak Detection Systems at Double-lined Landfills

Dear Mr. Friessen :

Per your request, please find attached information regarding GCL equivalency to CCLs. Attached is a two-page Technical Reference summarizing the US EPA report titled Assessment and Recommendations for Optimal Performance of Waste Containment Systems that studied leak detection systems at double-lined landfills. The data clearly shows that leakage through composite liner systems using GCLs outperformed composite liner systems using CCLs.

Sincerely,

Jim Olsta  
Technical Manager  
Lining Technologies Group



COMPARISON OF GCL AND CCL COMPOSITE LINED LANDFILLS

Since their inception in 1986, GCLs have been used in the upper liner system of double liners with leak detection in a number of landfills. [There are 12 states requiring double liner systems for MSWLFs, Koerner, et al., 1998]. Having the underlying leak detection system as a witness drain allows for an assessment of the upper liner's performance. Fortunately, a major study has just been completed for the U. S. EPA which includes 91 landfills containing 287 single or multiple cells, Bonaparte, et al., 1999. Three different types of primary liners were involved (GM alone, GM/CCL and GM/GCL) and two types of leak detection materials (sand and geonet). Thus six combinations are available, see Table 1. Even further, data is available for three different stages during the life of the respective landfill cells (initial, active and post closure).

Table 1 - Leakage Rates from Leak Detection Systems of Double-Lined Landfills from EPA Study CR-821448, by Bonaparte, et al., 1999

[All Flow Rates in Gal/Acre-day (gpad)]

Liner/LDS Type	Type I (GM-Sand)			Type II (GM-GN)			Type III (GM/CCL-Sand)		
	1	2	3	1	2	3	1	2	3
Life of Cycle Stage									
Average Flow	41	18	6.8	10	11	ND	12	15	6.8
Minimum Flow	0.81	0.0	0.02	0.51	0.15	ND	0.13	2.4	0.0
Maximum Flow	229	158	26	40	38	ND	126	71	29
No. of "points"	30	32	8	7	11	ND	31	41	15
No. of landfills	11	11	4	4	6	ND	11	11	4

Liner/LDS Type	Type IV (GM/CCL-GN)			Type V (GM/GCL-Sand)			Type VI (GM/GCL-GN)		
	1	2	3	1	2	3	1	2	3
Life of Cycle Stage									
Average Flow	18	8.9	7.0	14	2.38	0.03	0.70	0.28	ND
Minimum Flow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	ND
Maximum Flow	74	54	14	104	30	0.10	3.6	1.0	ND
No. of "points"	21	27	12	19	19	4	6	4	ND
No. of landfills	6	9	3	3	3	1	2	2	ND

Life Cycle Stage: "points" = Number of measuring points (i.e., outlets of single or multiple cells)  
 Stage 1 - Initial Life  
 Stage 2 - Active Life  
 Stage 3 - Post Closure ND = No Data

The above data set has been plotted in Figure 1 (for the average flow rates) so as to give a graphic representation as to the effectiveness of the GM/GCL alternate barrier system. Readily seen is that the alternate GM/GCL outperforms the standard GM/CCL in all cases and at every life cycle stage. Clearly, the strong absorptive capability of the bentonite in the GCLs is having a significant influence in attenuating the leakage through the covering geomembrane.

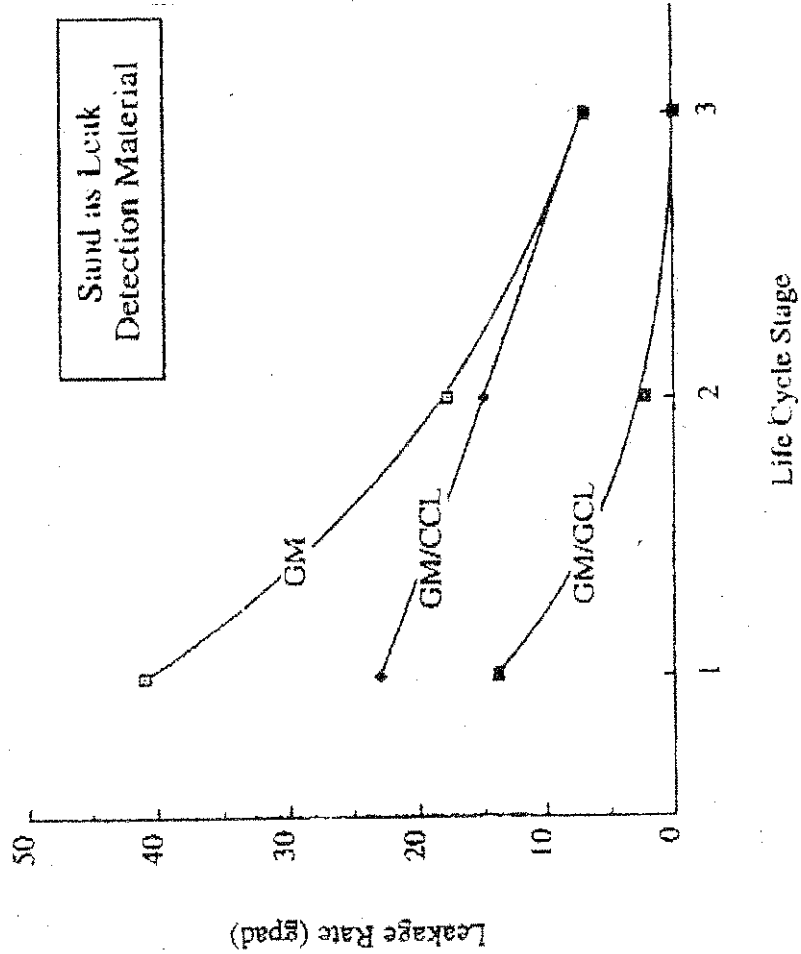
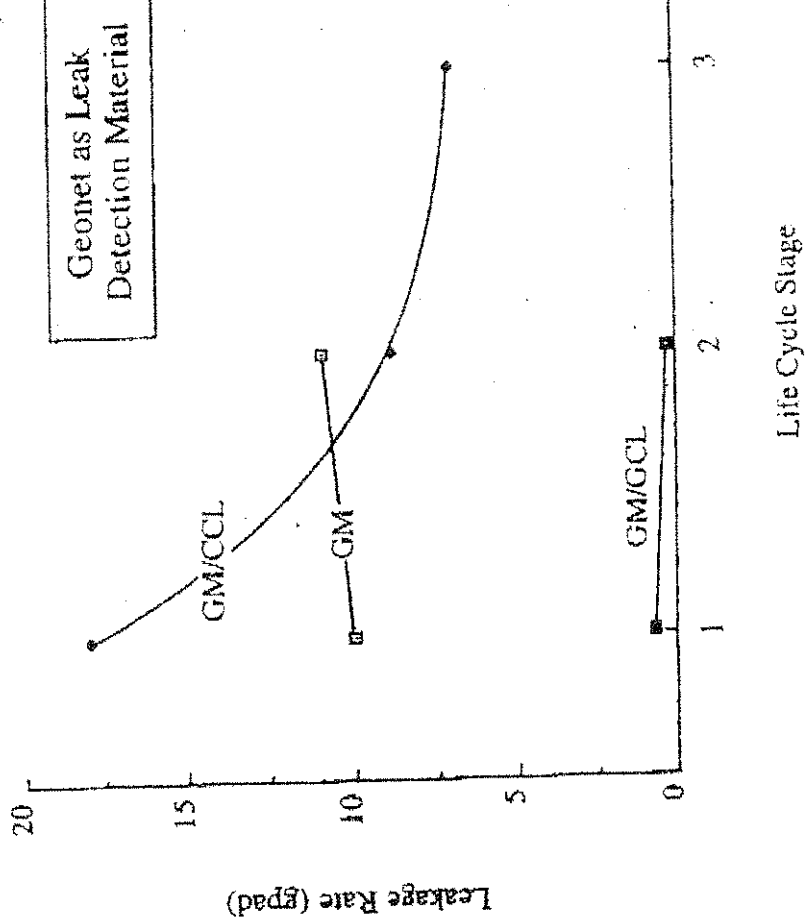


Figure 1 Leakage Rates for 287 Landfills Cells from CR-821448-01-0  
 Final Report to U. S. EPA, Bonaparte, et al. 1999



**Appendix 4d**

**Weather Data**



# BEND, OREGON

## Monthly Total Precipitation (inches)

(350694)

File last updated on Jan 8, 2002

\*\*\* Note \*\*\* Provisional Data \*\*\* After Year/Month 200110

a = 1 day missing, b = 2 days missing, c = 3 days, ..etc.,

z = 26 or more days missing, A = Accumulations present

Long-term means based on columns; thus, the monthly row may not sum (or average) to the long-term annual value.

MAXIMUM ALLOWABLE NUMBER OF MISSING DAYS : 5

Individual Months not used for annual or monthly statistics if more than 5 days are missing.

Individual Years not used for annual statistics if any month in that year has more than 5 days missing.

YEAR (S)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1928	1.71	0.47	1.89	0.06	0.85	0.81	0.05	0.07	0.15	0.82	0.48	1.34	8.70
1929	1.09	0.31	0.52	1.80	0.93	2.33	0.41	0.00	0.22	0.11	0.04	5.72	13.48
1930	1.72	1.00	0.72	0.48	1.09	0.35	0.00	0.36	1.25	0.29	1.79	0.14	9.19
1931	0.58b	0.45	1.34	0.27	0.26	2.31	0.00	0.11	0.46	1.01	0.58	1.37	8.74
1932	1.86a	0.27	0.96	1.84	1.74	0.00	0.01	0.15	0.00	0.24	2.06	1.21	10.34
1933	1.74	1.01	0.68	0.32	1.02	1.69	1.18a	0.00	0.08	0.41	0.06	2.49	10.68
1934	0.95a	0.36	0.87	1.09	0.39	2.37	0.34	0.63	0.24	1.18a	2.10	1.41	11.93
1935	1.12	0.64	0.53	1.53	0.57	0.60	0.86	0.00	0.09	0.92	0.65	1.16	8.67
1936	4.37	1.13	0.55	1.14	0.70	1.20	0.58	0.02	0.64	0.05	0.28	0.86	11.52
1937	1.61	1.18	1.53	1.90	0.77	2.74	0.43	0.04	0.48	0.52	1.63	2.50	15.33
1938	1.00	2.35	1.77	1.14	0.38	0.24	0.48	0.00	0.57	0.49	0.82	0.96	10.20
1939	0.78	1.09f	0.96	0.41	1.22	0.40	0.15	0.02a	0.66	0.46	0.02a	2.12	7.20
1940	2.01	1.51	1.31	1.37	0.55	0.24	1.63	0.00	1.82	1.66	0.56	1.03	13.69
1941	0.80g	1.16	0.20	0.44	1.59	1.26	1.74	1.68	0.54	1.04	2.57	2.53	14.75
1942	2.02	1.32	0.07	0.28	0.84	0.77	0.06	0.00	0.15	0.43	4.51	4.40	14.85
1943	3.07	0.17	0.66	0.89	0.44	0.94	0.58	0.64	0.00	1.70	0.87	0.41	10.37
1944	0.75	1.03	0.20	0.70	0.53	2.06a	0.61	0.29b	0.50	0.69	0.86	0.72	8.94
1945	0.69	1.36	0.18	0.34	3.76	0.08	1.04	0.97	0.28	0.47	3.20	4.26	16.63
1946	2.03	0.98	1.51	0.04	0.67	1.44	0.05	0.77	0.63	0.56	2.01	0.10	10.79
1947	0.68	0.80	1.14	0.32	1.00	1.01	1.34	0.21	0.14	2.84	0.64	0.41	10.53
1948	3.49	2.07	0.53	0.72	3.20	2.98	0.79	1.61	1.59	0.27	1.89	2.75	21.89
1949	0.35	1.20	1.11	0.07	0.60	0.21	0.00	0.07	0.26	0.15	1.60	0.42	6.04
1950	3.36	0.29	0.60	0.15	0.21	2.81	0.00	1.62	0.04	5.87a	1.42	1.72	18.09
1951	2.61	0.73a	0.56	0.33	1.98	0.00	0.35	0.57	0.00	0.92a	2.60	2.90	13.55
1952	0.65	1.87	0.10	0.09a	0.65	2.02	0.00	0.42	0.73	0.00	0.25	2.61	9.39
1953	4.16	1.86	0.66	0.27	1.99	1.69	0.00	1.23	0.03	0.47	2.65a	1.89	16.90
1954	4.21a	0.74	0.52	0.18	0.35	1.94	0.10	1.70	0.75	0.38	0.13	0.59	11.59
1955	0.61	0.07	0.36	1.12	0.18	0.30	0.30	0.00	0.31	0.50	2.13a	4.98	10.86



1956	2.80	2.50	0.17	0.66	3.63	0.79	0.26	0.21	0.05	2.24	0.31	0.79	14.41
1957	0.77	1.68	1.68	0.24	1.30	0.01	0.14	0.24	1.02	0.59	0.22	3.28	11.17
1958	2.31	1.30	0.22	0.63	1.96	2.47	0.24	0.01	0.13	0.32	0.70	0.65	10.94
1959	1.26	1.44	0.73	0.07	0.63	0.30	0.12	0.01	0.21	0.44	0.26	0.28	5.75
1960	1.27	1.43	2.28	0.90	0.58	0.01	0.15	0.23	0.05	0.10	4.19	1.04	12.23
1961	0.22	2.23	0.95	0.13	1.04	0.47	0.04	0.17	0.00	0.91	3.56	2.17	11.89
1962	1.09	0.49	0.99	0.50	2.31	0.26	0.17	1.03	0.45	2.18	1.39	1.56	12.42
1963	1.29	1.78	0.63	0.82 a	1.44	0.79	0.25	0.15	0.65	0.10	1.84	1.01	10.75
1964	1.95	0.12	0.75	0.05	0.00	0.80	0.29	0.06	0.00	0.27	1.59	8.74	14.62
1965	1.99	0.26	0.01	0.44	0.30	1.69	0.80	1.39	0.07	0.25	1.42	0.76	9.38
1966	3.45	0.15	0.57	0.05	0.00	0.51	0.70	0.00	0.39	0.42	2.16	1.80	10.20
1967	2.95	0.08	0.56	2.03	0.00	1.17	0.00	0.00	0.03	0.98	0.59	0.66	9.05
1968	0.69	1.18	0.30	0.06	1.07	0.07	0.00	1.66	0.11	0.48	1.08	1.71	8.41
1969	2.62	0.71	0.68	0.21	1.14	3.20	0.23	0.00	0.49	0.88	0.35	2.50	13.01
1970	4.37	0.41	1.30	0.10	0.17	1.05	0.32	0.00	0.15	0.97	2.87	1.21	12.92
1971	3.15	0.26	1.12	0.14	0.79	1.29	0.07	0.20	0.40	0.71	1.26	1.42	10.81
1972	2.17	0.48	1.46	0.31	1.50	0.56	0.22	0.43	0.11	0.94	0.08	2.13	10.39
1973	1.31	0.53	0.10	0.41	0.68	0.01	0.42	0.03	0.88	0.83	4.58	1.64	11.42
1974	3.47	0.93	2.76	0.72	0.39	0.07	0.75	0.00	0.00	0.56	0.67	1.26	11.58
1975	1.86	1.70	2.29	0.48	0.03	1.07	1.34	0.89	0.01	1.17	1.26	1.48	13.58
1976	1.28	1.59	0.73	0.57	0.19	0.58	0.09	2.18	0.49	0.35	0.32	0.00	8.37
1977	0.20	0.28	0.23	0.00	1.84	0.63	0.11	0.83	1.19	0.24	2.43	3.37	11.35
1978	1.33	0.60	0.89	2.18	0.62	1.73	1.12	1.18	0.89	0.01	0.95	1.21	12.71
1979	2.10	1.05	0.87	0.70	0.39	0.19	0.01	1.49	0.32	1.45	0.79	0.48	9.84
1980	3.01	0.53	0.46	1.27	1.71	2.83	0.28	0.00	0.62	0.46	1.54	3.16	15.87
1981	0.94	1.15	0.50	0.46	1.63	0.67	0.25	0.00	1.23	0.44	3.34	6.32	16.93
1982	1.84	1.71	0.75	1.12	0.19	1.65	1.03	0.44	1.74	0.88	1.04	2.55	14.94
1983	0.99	2.30	2.39	0.63	1.03	0.58	1.32	1.46	0.57	0.95	2.00	4.95	19.17
1984	0.20	1.24	1.33	1.16	0.20	0.99	0.34	0.70	0.44	0.88	4.53	0.76	12.77
1985	0.12	0.85	0.58	0.26	0.21	0.46	0.10	0.58	1.10	0.75	1.05	1.58	7.64
1986	2.27	3.65	0.59	0.11	0.42	0.16	0.42	0.05	0.90	0.32	0.97	0.40	10.26
1987	1.81	1.59	1.19	0.22	1.60	0.31	3.73	0.02	0.02	0.00	0.40	3.38 b	14.27
1988	1.42	0.23	0.33	1.01	0.14	1.81	0.00	0.17	0.23	0.00	2.70	0.83 a	8.87
1989	1.93	0.42	1.83	1.69	0.49	0.05	0.02	0.93	0.10	0.78	0.20	0.29	8.73
1990	3.01	0.51	0.50	0.29	1.44	0.04	0.38	1.36	0.49	0.23	0.27	0.44	8.96
1991	1.26	0.10	1.86	0.65	1.68	1.25	1.09	0.34	0.00	0.44	1.67	0.46	10.80
1992	0.90	0.43	0.25	1.15	0.26	0.40	1.72	0.00	0.48	1.40	0.60	2.82 a	10.41
1993	3.00	1.10	1.22	0.25 a	1.91	1.59	0.74	0.56	0.00	0.49	0.17 a	1.06 a	12.09
1994	0.27	0.74	0.14	0.64	0.43	0.25	0.00	0.00	0.79	0.76	1.07	0.33	5.42
1995	1.98	1.38	0.58	1.26	0.62	1.18	1.28	0.05	0.14	0.09	0.90	2.72	12.18
1996	1.96 b	1.85	0.87	1.06	1.36	0.20	0.04	0.24	0.17	0.31	3.63	4.39	16.08
1997	1.83 a	0.78	0.56	0.78	0.77	1.53	0.94	0.39	0.51	1.17	0.37	0.31	9.94
1998	2.39	1.12	0.58	0.88	4.11	0.35	0.63	0.80	0.35	0.12	4.23	2.34 a	17.90
1999	2.16	3.08	0.52	0.00 z	0.04	0.12	0.14	2.76	0.00	1.17	0.39	0.27	10.65
2000	2.67 a	1.75	0.20	0.54	0.45	0.00	0.15	0.00	0.42	0.76	0.28	0.96 a	8.18
2001	0.17 b	1.47 a	0.56	0.67	0.04	0.38	1.07	0.00	0.45	0.29	1.96 a	2.09 a	9.15

2002 0.33x 0.00z 0.00z 0.00z 0.00z 0.00z 0.00z 0.00z 0.00z 0.00z 0.00z 0.20z 0.00

Period of Record Statistics

MEAN	1.80	1.06	0.84	0.65	0.96	0.96	0.49	0.49	0.42	0.74	1.44	1.85	11.70
S.D.	1.09	0.74	0.60	0.54	0.88	0.86	0.61	0.62	0.43	0.81	1.22	1.61	3.18
SKEW	0.53	0.97	1.12	0.99	1.63	0.86	2.48	1.43	1.36	3.85	1.02	1.73	0.74
MAX	4.37	3.65	2.76	2.18	4.11	3.20	3.73	2.76	1.82	5.87	4.58	8.74	21.89
MIN	0.12	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	5.42
NO YRS	73	73	74	73	74	74	74	74	74	74	74	74	71

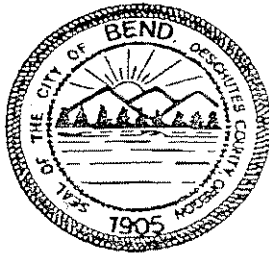


**Appendix 4e**  
**Wastewater Discharge Permit**



CITY OF BEND, OREGON

Public Works Department  
1375 N.E. Forbes Road, Bend, OR 97701  
503-388-5540 Fax 503-389-2245



Larry Patterson, City Manager  
Tom Gellner, Public Works Director

December 29, 1995

Mr. George Holroyd, P.E.  
Environmental Engineer  
David Evans & Associates, Inc.  
709 NW Wall Street, Suite 102  
Bend, OR 97701

RE: Deschutes County Knott Landfill  
Leachate Disposal Option  
Septage Receiving Facility

Dear Mr. Holroyd:

As I discussed with Mr. Jon Sprecher of your firm on Wednesday, November 29, 1995, the City of Bend Public Works Department operates an Oregon Department of Environmental Quality (DEQ) permitted septage disposal facility. It is feasible that the septage disposal facility can be used for the disposal of Knott Landfill leachate if the leachate parameters including general chemistry, organic and mental concentrations, are within the permit limits specified in our DEQ permit.

Data on the composition of leachate from new and mature landfills from the reference source, "Integrated Solid Waste Management", McGraw-Hill, 1993, indicates that the Knott Landfill leachate concentrations may be within our permit guidelines. Before the material can be treated at the septage disposal facility, an agreement would need to be formalized concerning the chemical parameters to be tested, test schedule, and reporting requirements.

If you have any questions, please call me at (541) 388-5585.

Sincerely,

Michael J. Luther  
Wastewater Operations Supervisor

/bl



Section Five:  
Surface Water Management Plan



## 5.1 INTRODUCTION

The Knott Landfill and Recycle Center is a topographic upland that is not subject to flooding. No perennial or intermittent streams are located onsite, and there is no known flow of surface water onto the site. What surface runoff that does occur is generally the result of snowmelt or infrequent rainstorms and is restricted on-site.

The surface water management plan presented in this engineering report describes the facilities necessary for the collection, control, and conveyance of surface water generated from both the North Area and the landfill. Surface water control facilities have been designed based on the site's final grading plan. In addition, measures for control of surface water in active landfill areas have also been considered. The surface water management system and facilities were designed to:

- Collect, control, convey, and discharge surface water run-off from non-landfill areas,
- Control surface water run-on and run-off in active landfill areas, and
- Collect, control, convey, and discharge surface water from closed landfill areas.
- Minimize site erosion,
- Maintain the integrity of the final landfill cover system, and
- Minimize long term maintenance requirements.

The surface water control facilities that are planned are shown in Figure 5-1.

## 5.2 CLIMATE

The site is located in a semi-arid region where precipitation averages 12 inches per year. Much of the precipitation occurs during the winter as snow and in the spring as rain, although brief episodes of high intensity rainfall occur during summer thunderstorms. Infiltration of rainfall into the substrate is generally limited to the upper several feet. Given temperature and sunlight conditions in the area, a portion of snowfall is returned directly to the atmosphere by sublimation. This reduces snowmelt and associated infiltration of water into the ground.

The climate in the area is characterized by high radiation intensities, high maximum summertime temperatures, and prolonged dry spells. The latitude of the site is significant because long summer days enhance evapotranspiration and inhibit water infiltration into the ground.

### **5.3 FLOW MODELING**

The hydrological design criteria for surface water facilities at the site is based on management of the 25-year, 24-hour design storm. This storm event produces 2.5 inches of precipitation for the Bend area of Deschutes County, Oregon (NOAA Atlas 2, 1973). The rainfall distribution is assumed to be represented by the Type IA 24-hour dimensionless distribution developed by the Soil Conservation Service (SCS).

Peak runoff flows have been estimated using the Santa Barbara unit hydrograph method. Conveyance system flow velocities are estimated using the Manning equation.

#### **5.3.1 Drainage Areas**

Surface water drainage for the North Area has been broken down into four drainage areas. Knott Landfill has been broken into nine drainage areas. The drainage areas for the landfill and the retention ponds are shown on Figure 5-1.

#### **5.3.2 Curve Numbers and Times of Concentration**

Site surface conditions for each subbasin are represented by Curve Numbers (CNs) that describe the area's hydrologic soil group and land use. In general, site soils fall into the SCS Group A classification; the soils are sandy with high infiltration capacity. Little to no runoff occurs from pervious areas at the site during average precipitation events.

Development of the North area may increase the volumes of surface water runoff because of increased impervious surfaces in the North Area and decreased soil permeability after the final landfill cover system is constructed.

A Curve Number of 68 was used for calculating the runoff from the finished surface of the landfill and for the existing conditions in the North Area. To ensure adequate pond and pipe sizing, a CN of 80 was used in anticipation of less permeability in the landfill end-use condition and in the development of the North Area.

#### **5.3.3 Predicted Runoff Volumes and Peak Flows**

Total runoff volumes are predicted using the following equations developed from empirical analyses by the SCS:

$$Q = (P - 0.2S)^2 \div (P + 0.8S)$$

where, Q = runoff depth (inches)

P = precipitation (inches)

S = retention determined by:  $(S = 1000/CN - 10)$

## **5.4 RUNOFF PREDICTIONS**

The modeling parameters and results of analysis for the 25-year, 24-hour storm event are summarized in Table 5-1. Copies of the computer model generated data are included in Appendix 5a of this report.

An analysis of the runoff volumes generated using average monthly precipitation and average evapotranspiration is summarized in Table 5-2. This analysis was conducted using the CNs discussed previously for each subbasin and the SCS equation for runoff volumes. Precipitation is normally spread out over an entire month. It does not tend to occur as one storm event and, therefore, the soils recover their retention capacities between rainfall events via evapotranspiration. The analysis has considered the effects of this recovery by using net precipitation values (total monthly precipitation less average evapotranspiration).

When the value of 0.2S is more than the net precipitation for a month, no runoff is generated. Net precipitation is zero for months where average evapotranspiration exceeds average precipitation resulting in the data blanks shown in Table 5-2.

## **5.5 SURFACE WATER CONTROL SYSTEM**

The components of the final surface water control system shown in Figure 5-1 are discussed below. Each facility has been designed based on runoff volumes calculated using the site's final grading plan when surface water runoff will be greatest. Since the North Area is still in the process of being designed, the grading plan and the surface runoff is still conceptual.

### **5.5.1 Perimeter Ditch**

Surface water from the North Area will be collected and conveyed by a series of swales and culverts directed to one of three ponds.

Surface water runoff from the landfill will be collected and conveyed in a lined drainage ditch constructed around the landfill's perimeter. This collection ditch will also function as a perimeter access road for the landfill (see Figure 5-2).

The ditch will have a minimum slope of 0.50 percent and be 1 foot in depth at the centerline. To limit the potential for surface water infiltration and migration into the landfill and to provide a firm road surface, the ditch will be lined with a watertight membrane that is underlain by 6 inches of aggregate base course. An asphaltic surface will be placed over the membrane and will provide an all-weather surface for the access road.

Based on the Manning equation, a ditch with a roughness coefficient of 0.013 (smooth asphalt surface), a 0.80% slope, and the designed configuration shown in Figure 5-1 will have a maximum capacity of 38 cfs, and a maximum velocity of 6.4 fps. This capacity is well above the 25-year event predicted peak flow of less than 1 cfs, given a velocity of 2.6 fps and a depth of 0.25 feet.

### **5.5.2 Catch Basin and Storm Sewer**

Stormwater from Drainage Areas A, B and C1 will runoff and be collected in 2 catch basins. A 18-inch diameter PVC pipe will transport the stormwater beneath the perimeter road to the retention ponds. Maintenance manholes will be installed at 400 foot intervals between the catch basins and the retention pond.

### **5.5.3 Stormwater Storage Ponds**

Pond No. 1 will be a geomembrane-lined and will be used for storage of surface water runoff from the southern portion of the landfill. The stored water will be utilized for dust control. For surface water runoff from the north half of the landfill and the runoff from the North Area, Ponds No. 2, Pond No. 3 and Pond 4 will be constructed. Since the ponds will be located adjacent to the lined landfill, it is anticipated that it will not be necessary to line these ponds.

The size of the retention ponds is based on consideration of the volume of runoff collected from the design storm. The 25-year design storm and a CN of 80 will require ponds with the following capacities:

- Pond No. 1 – 264,000 cubic feet
- Pond No. 2 – 351,200 cubic feet
- Pond No. 3 144,600 cubic feet
- Pond No. 4 – 102,300 cubic feet

These pond volumes will contain the 25-year storm event on-site.

**5.6 MANAGEMENT DURING ACTIVE LANDFILL FILLING**

Surface water run-on/run-off from active areas will be controlled. Precipitation directly into the landfill cells and onto active areas cannot be avoided. The County will limit the potential that surface water runoff generated in other areas will enter the active landfill area with the use of the following practices and facilities:

- Areas adjacent to the landfill will be graded away from the landfill when possible to physically direct runoff away from the active area.
- Surface water diversion channels will be constructed in closed areas to channel flow away from the active area and into the perimeter ditch system.

Surface water runoff generated in the active area will be contained within the active area by use of containment berms, grading, and the landfill’s liner system. Runoff generated in the active area will be collected in the leachate collection system and treated as leachate.

**Table 5-1: Summary of 24 hr, 25 yr Stormwater Flows**

North Area	Subarea	Area (acres)	CN	TOC (hours)	25-year Runoff (cf)	25-year Peak Flow (cfs)
NA-1	Pond 3	10.86	68	0.98	15,275	0.29
NA-2	Pond 2	14.90	68	1.21	20,959	0.38
NA-3	Pond 2	12.25	68	0.71	17,239	0.33
NA-4	Pond 4	24.70	68	0.81	34,766	0.66
Knott Landfill						
A1	Pond 1	24.01	68	1.17	33,790	0.65
A2	Pond 1	25.87	68	0.69	36,409	0.70
B1	Pond 1	13.86	68	1.00	19,500	0.37
B2	Pond 2	13.16	68	0.71	18,520	0.35
C1	Pond 2	16.50	68	0.51	23,222	0.46
C2	Pond 2	7.98	68	0.50	11,229	0.22
D1	Pond 2	8.90	68	0.69	12,522	0.24
D2	Pond 3	9.13	68	0.52	12,848	0.25
E	Pond 3	14.93	68	0.60	21,014	0.41


**Table 5-2: Runoff Volumes Generated from Average Monthly Precipitation**

Month	Ave. P (inch)	Ave. ET (inches)	Net P (inch)	Runoff Volumes Generated (cubic feet)												
				Area A1	Area A2	Area B1	Area B2	Area C1	Area C2	Area D1	Area D2	Area E	Area NA1	Area NA2	Area NA3	
Jan	1.80	0.0	1.80	138,626	149,365	80,023	75,982	95,266	16.50	07,98	8.90	9.13	14.93	10.86	14.90	12.25
Feb	1.06	0.2	0.86													
Mar	0.84	0.6	0.24													
Apr	0.65	1.7	0.00													
May	0.96	2.7	0.00													
Jun	0.96	3.5	0.00													
Jul	0.49	4.7	0.00													
Aug	0.49	4.0	0.00													
Sep	0.42	2.8	0.00													
Oct	0.74	1.7	0.00													
Nov	1.44	0.5	0.94													
Dec	1.85	0.0	1.85	153,855	165,774	88,814	84,329	105,731	51,136	57,031	58,505	95,671	69,590	95,479	78,498	
Totals	11.70	0.0	5.69	292,482	315,139	168,838	160,311	200,997	97,210	108,417	111,218	18,1872	132,293	181,507	149,225	



No.	DATE	BY	REVISION
A	5/22/03	CAS	REVISED PER DEQ/COUNTY REVIEW
B	7/16/03	CAS	FOR CLIENT REVIEW

JOB No.	DESIGNED:	PROJ. ENGINEER:
SCALE:	GF	GH
1"=300'	DRAWN BY:	APPROVED BY:
	PCF	DK
	CHECKED BY:	DATE:
	GH	JULY 2003



G. Fritson Associates, Inc.  
 Lake Oswego, Oregon 97035  
 4088 Orchard Drive  
 Fax: (503) 635-1447

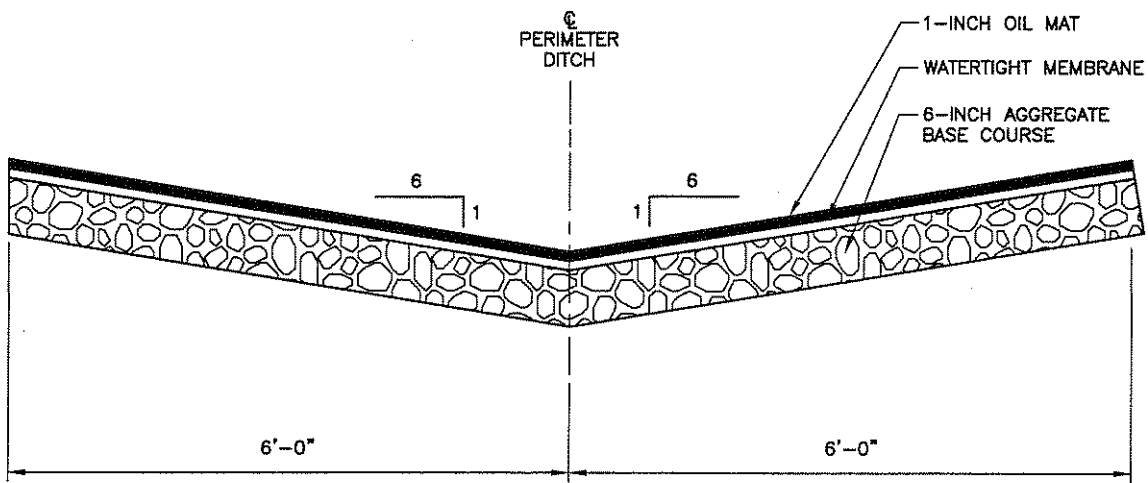
**URS**  
 111 S.W. Columbia, Suite 900  
 Portland, Oregon 97201  
 (Tel) 503-222-7200  
 (Fax) 503-222-4292

**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 SURFACE WATER MANAGEMENT FACILITIES

DRAWING NUMBER:	Figure 5-1
CAD FILE NUMBER:	FIG 5-1
SHEET:	OF
REV.	B





**PERIMETER ACCESS ROAD AND DITCH**

SITE DEVELOPMENT PLAN  
KNOTT LANDFILL  
DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 5-2**







**Appendix 5a**  
**Surface Water Flow Analysis**



Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt A1,A2, B1End Use

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	277.0	2.0'	0.72%	48.6'
2	intermittent channel	earth.channel	K=20	1256.0	34.0'	2.71%	6.4'
3	pipe	plastic.pipe	n=0.010	1440.0	7.2'	0.50%	4.8'

total Time of Concentration = 59.8'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 38.24 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 25.50 A CN = 98 *40% imp coverage*  
total site area = 63.74 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a1,a2,blenduse.hyd

peak flow = 8.49cfs @ 8.17 hr.  
runoff volume = 264,017 cu.ft.

*25-yr volume w/ 40% imp coverage @ End Use*

Project 25695172.47000  
 Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
 Knott Landfill - Pt A2, BlEnd Use

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	277.0	2.0'	0.72%	48.6'
2	intermittent channel	earth.channel	K=20	1256.0	34.0'	2.71%	6.4'
3	pipe	plastic.pipe	n=0.010	1440.0	7.2'	0.50%	4.8'

total Time of Concentration = 59.8'

storm hyetograph: SCS TypeIA  
 return period = 25 years  
 storm duration = 24 hr.  
 total rainfall = 2.50 in.

pervious area = 18.23 A CN = 68 GpA:Open.space,pr.cnd  
 impervious area = 12.15 A CN = 98 *Assume 40% coverage of imp. mtl*  
 total site area = 30.38 A

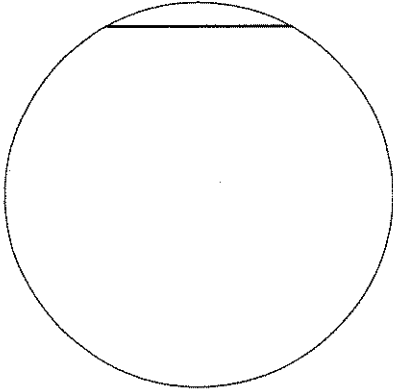
hydrograph file: c:\program files\quick3\knottlandfill\pt a2,blenduse.hyd

peak flow = 4.04cfs @ 8.17 hr.  
 runoff volume = 125,817 cu.ft.

*Peak Flow still flows thru 15"Ø PVC Pipe*

Project 25695172.47000  
Knott Landfill Storm Water Runoff

GRAVITY PIPE FLOW (Chezy-Manning)  
Area A2 Pipe to Pond



diameter = 15.0"  
slope = 0.50%  
material: ABS, PVC  
Manning's n = 0.011  
depth of flow = 93.82% of diameter (max)

wetted perimeter = 3.30'  
area = 1.20 s.f.  
hydraulic radius = 0.36'  
velocity = 4.87 fps  
flow = 5.82 cfs

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt A1, A2, B1

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	277.0	2.0'	0.72%	48.6'
2	intermittent channel	earth.channel	K=20	1256.0	34.0'	2.71%	6.4'
3	pipe	plastic.pipe	n=0.010	1440.0	7.2'	0.50%	4.8'

total Time of Concentration = 59.8'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 55.89 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 55.89 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a1,a2,b1.hyd

peak flow = 1.47cfs @ 12.67 hr.  
runoff volume = 78,678 cu.ft.

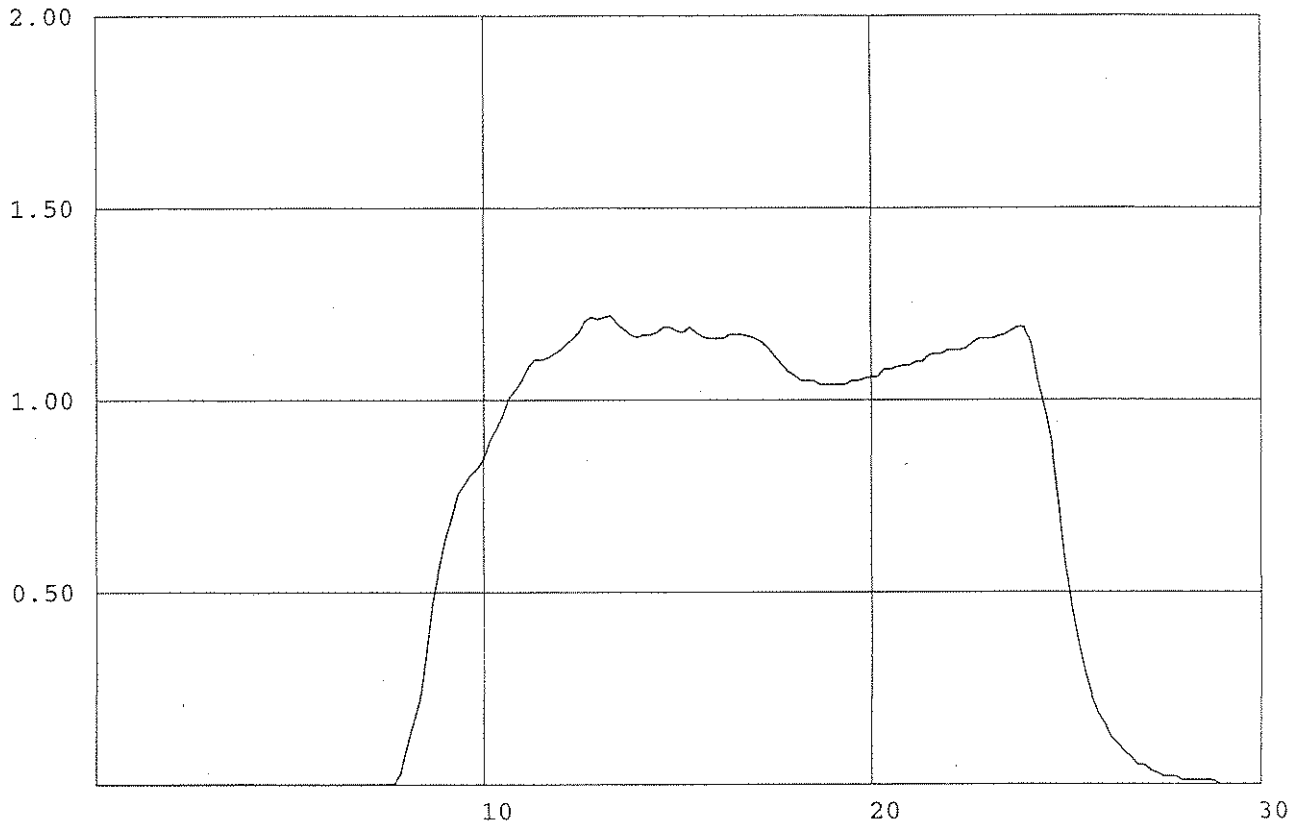
25-yr Pmd Volume - Open-space surface

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

Knott Landfill Pt A1 & A2 & B1 to Pond

load C:\Program Files\QUICK3\KnottLandfill\pt A2 & B1 to Pond.HYD  
add C:\Program Files\QUICK3\KnottLandfill\pt a1-1.hyd  
save as C:\Program Files\QUICK3\KnottLandfill\pt A1 & A2 & B1 to Pond.HYD



peak flow = 1.22 cfs @ 13.33 hours  
volume = 65,491 cu.ft.

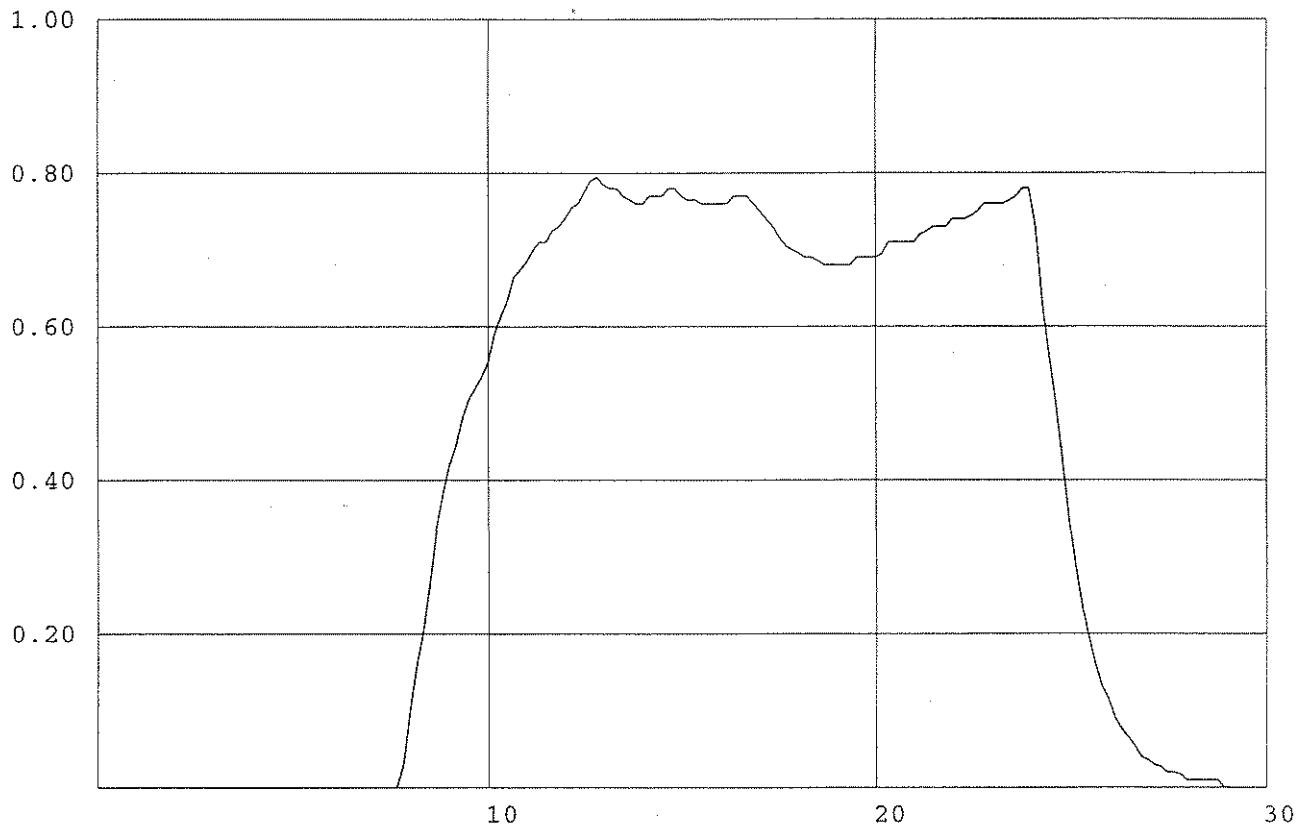


Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

Knott Landfill Pt A2 & B1 to Pond

load C:\Program Files\QUICK3\KnottLandfill\pt a2-2,pond.hyd  
add C:\Program Files\QUICK3\KnottLandfill\pt b1,pond.hyd



peak flow = 0.79 cfs @ 12.83 hours  
volume = 42,780 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt A2 & B1 to Pond

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	277.0	2.0'	0.72%	48.6'
2	intermittent channel	earth.channel	K=20	1256.0	34.0'	2.71%	6.4'
3	pipe	plastic.pipe	n=0.010	1440.0	7.2'	0.50%	4.8'

total Time of Concentration = 59.8'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 30.38 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 30.38 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a2\_b1 to pond.hyd

peak flow = 0.80cfs @ 12.67 hr.

runoff volume = 42,759 cu.ft.

Don Kliewer

DJK 14:05 02-May-03

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt B1-1

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass,lawns	n=0.15	277.0	2.0'	0.72%	48.6'
2	intermittent channel	earth.channel	K=20	1256.0	34.0'	2.71%	6.4'
3	pipe	plastic.pipe	n=0.010	1440.0	7.2'	0.50%	4.8'

total Time of Concentration = 59.8'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 13.86 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 13.86 A

hydrograph file: c:\program files\quick3\knottlandfill\pt b1,pond.hyd

peak flow = 0.36cfs @ 12.67 hr.

runoff volume = 19,498 cu.ft.

Don Kliever

DJK 14:08 02-May-03

Project 25695172.47000

Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH

Knott Landfill - Pt B1-1

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	277.0	2.0'	0.72%	48.6'
2	intermittent channel	earth.channel	K=20	1256.0	34.0'	2.71%	6.4'

total Time of Concentration = 55.0'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 13.86 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 13.86 A

hydrograph file: c:\program files\quick3\knottlandfill\pt b1.hyd

peak flow = 0.37cfs @ 12.67 hr.

runoff volume = 19,500 cu.ft.

Don Kliever

DJK 13:29 02-May-03

Project 25695172.47000

Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH

Knott Landfill - Pt A2-2

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	264.0	9.0'	3.41%	25.1'
2	intermittent channel	earth.channel	K=20	1116.0	32.0'	2.87%	5.5'
3	pipe	plastic.pipe	n=0.010	1440.0	7.2'	0.50%	4.8'

total Time of Concentration = 35.4'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 16.52 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 16.52 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a2-2,pond.hyd

peak flow = 0.45cfs @ 12.67 hr.

runoff volume = 23,253 cu.ft.

Don Kliever

DJK 13:26 02-May-03

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt A2-2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	264.0	9.0'	3.41%	25.1'
2	intermittent channel	earth.channel	K=20	1116.0	32.0'	2.87%	5.5'

total Time of Concentration = 30.6'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 16.52 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 16.52 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a2-2.hyd

peak flow = 0.45cfs @ 12.67 hr.

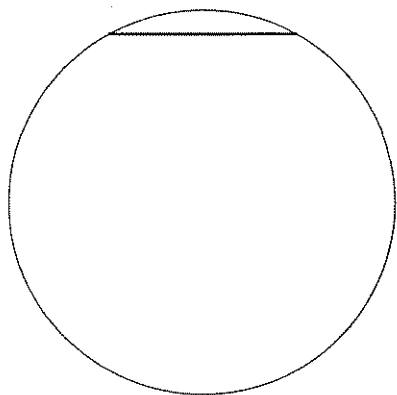
runoff volume = 23,254 cu.ft.

Don Kliewer

DJK 13:29 02-May-03

Project 25695172.47000  
Knott Landfill Storm Water Runoff

GRAVITY PIPE FLOW (Chezy-Manning)  
Area A2 Pipe to Pond



□ 2"

diameter = 12.0"  
slope = 0.50%  
material: ABS, PVC  
Manning's n = 0.011  
depth of flow = 93.82% of diameter (max)

wetted perimeter = 2.64'  
area = 0.77 s.f.  
hydraulic radius = 0.29'  
velocity = 4.19 fps  
flow = 3.21 cfs

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt A2-1,3

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	5.0'	1.67%	33.1'
2	shallow concentrated	bare.ground	K=13	332.0	5.0'	1.51%	3.5'
3	intermittent channel	earth.channel	K=20	934.0	24.0'	2.57%	4.9'

total Time of Concentration = 41.4'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 9.35 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 9.35 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a2-1,3.hyd

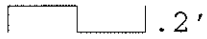
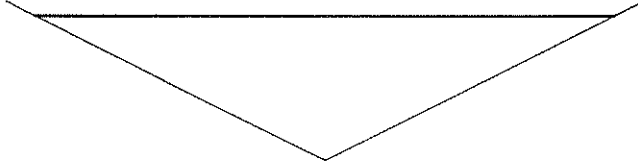
peak flow = 0.25cfs @ 12.67 hr.

runoff volume = 13,155 cu.ft.



Project 25695172.47000  
Knott Landfill Storm Water Runoff

**TRAPEZOIDAL CHANNEL FLOW**  
To Pt a2-1



left slope = 50.00%  
bottom width = 0.00'  
right slope = 50.00%  
channel slope = 2.57%  
flow = 0.25 cfs  
channel type: Clean, new      Manning's n = 0.018

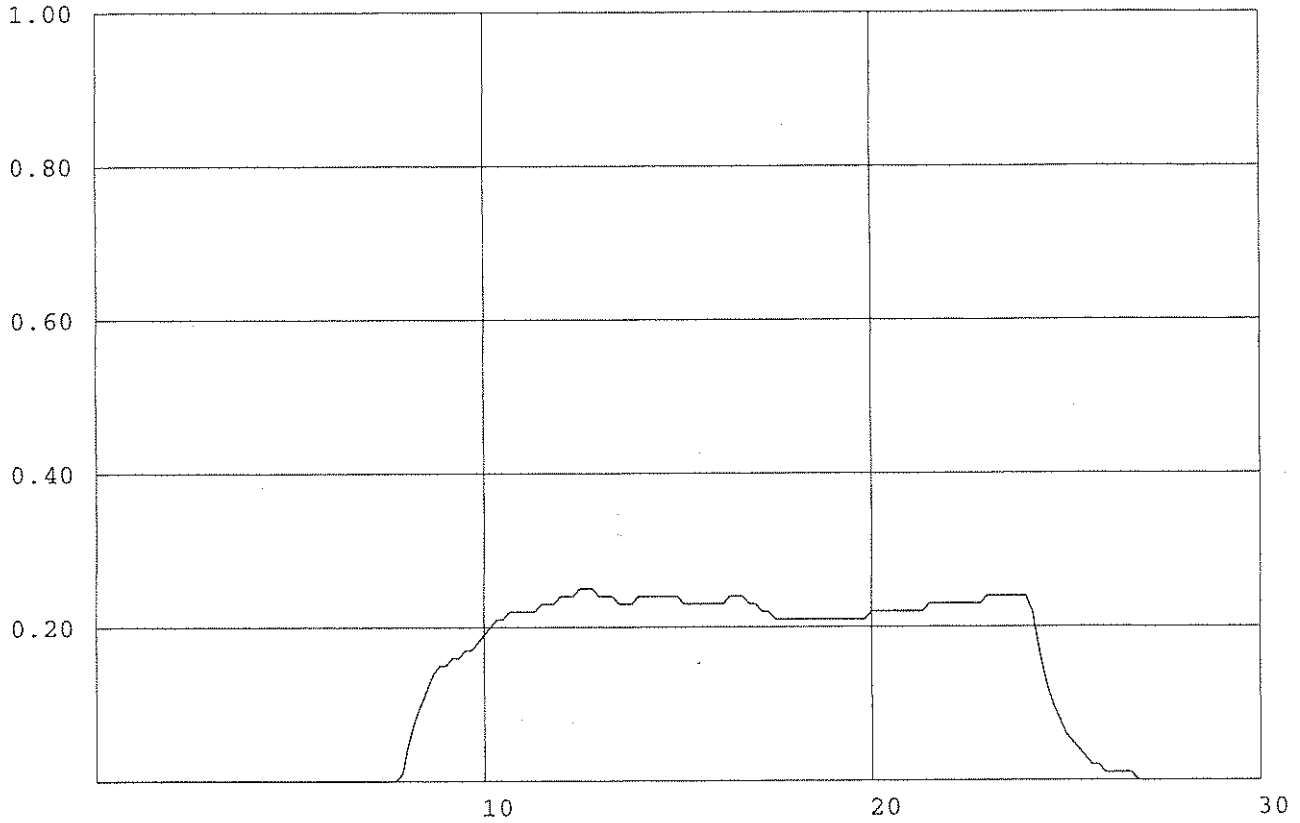
depth = 0.21'  
velocity = 2.76 feet/sec  
flow area = 0.09 sq.ft.  
surface width = 0.85'

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

Knott Landfill Pt A2- 1,3

load C:\Program Files\QUICK3\KnottLandfill\pt a2-1,3.hyd



peak flow = 0.25 cfs @ 12.50 hours  
volume = 13,128 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt A2-1

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	natural.range	n=0.13	300.0	5.0'	1.67%	33.1'
2	shallow concentrated	bare.ground	K=13	332.0	5.0'	1.51%	3.5'

total Time of Concentration = 36.5'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 1.88 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 1.88 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a2-3.hyd

peak flow = 0.05cfs @ 12.67 hr.

runoff volume = 2,638 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
Knott Landfill - Pt A2-1,3

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	300.0	5.0'	1.67%	37.1'
2	intermittent channel	earth.channel	K=20	332.0	5.0'	1.51%	2.3'
3	intermittent channel	earth.channel	K=20	934.0	24.0'	2.57%	4.9'
total Time of Concentration =							44.2'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 5.35 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 4.00 A CN = 98  
total site area = 9.35 A

*Assume higher imp. area  
for end use*

hydrograph file: c:\program files\quick3\knottlandfill\pt a2-1,3enduse.hyd

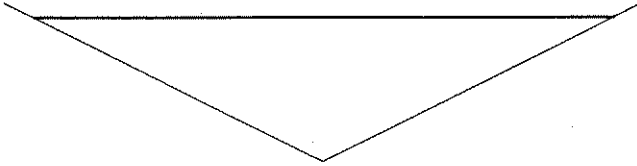
peak flow = 1.50cfs @ 8.00 hr.  
runoff volume = 40,493 cu.ft.

Don Kliewer

DJK 13:13 02-May-03

Project 25695172.47000  
Knott Landfill Storm Water Runoff

TRAPEZOIDAL CHANNEL FLOW  
To Pt a2-1



□.2'

left slope = 50.00%  
bottom width = 0.00'  
right slope = 50.00%  
channel slope = 2.57%  
flow = 1.50 cfs  
channel type: Clean, new      Manning's n = 0.018

depth = 0.42'  
velocity = 4.32 feet/sec  
flow area = 0.35 sq.ft.  
surface width = 1.67'

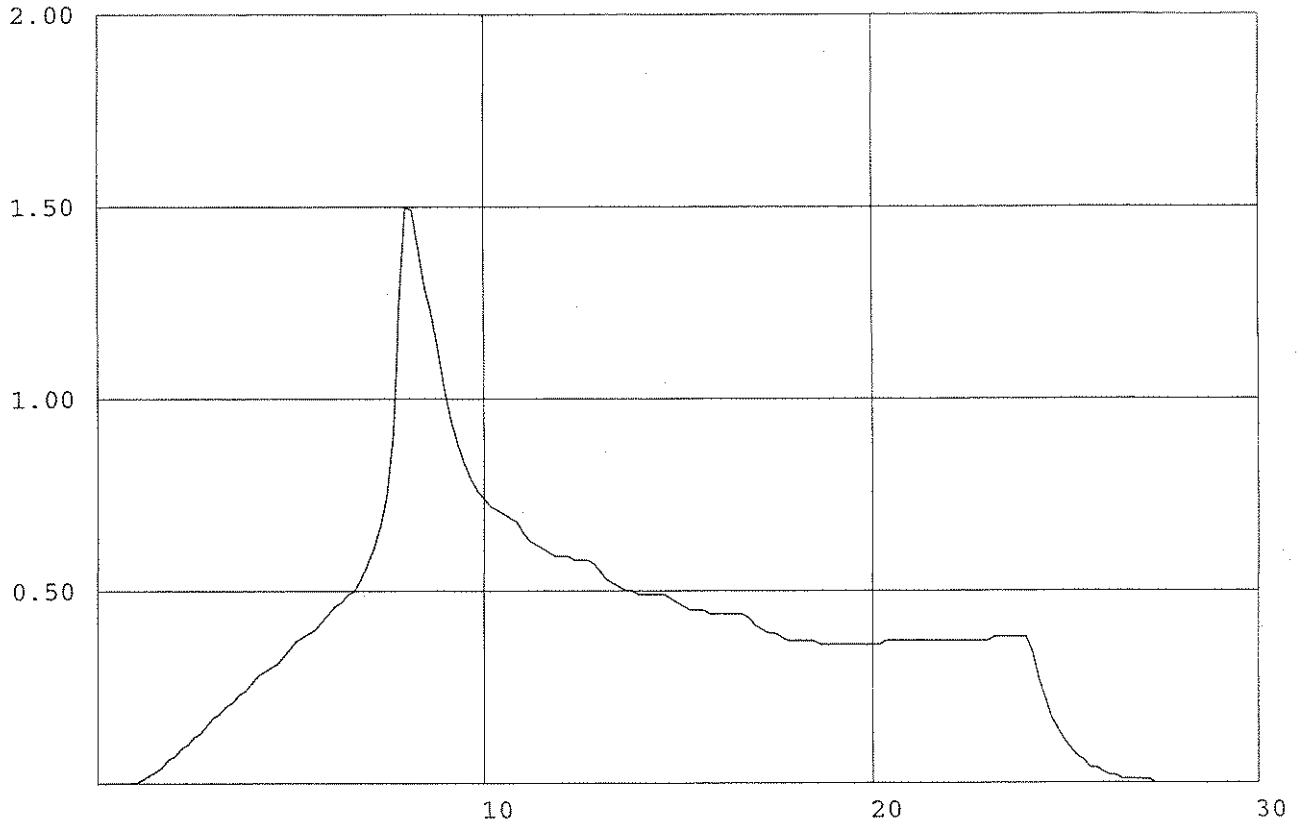
Project 25695172.47000

Knott Landfill Storm Water Runoff

**HYDROGRAPH**

Knott Landfill Pt A2- 1,3 End Use

load C:\Program Files\QUICK3\KnottLandfill\pt a2-1,3enduse.hyd



peak flow = 1.50 cfs @ 8.00 hours  
volume = 40,488 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
Knott Landfill - Pt A1-2

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	300.0	9.0'	3.00%	29.3'
2	intermittent channel	earth.channel	K=20	1019.0	32.0'	3.14%	4.8'

total Time of Concentration = 34.1'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 16.16 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 16.16 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a1-1.hyd

peak flow = 0.44cfs @ 12.67 hr.  
runoff volume = 22,746 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
Knott Landfill - Pt A1-1

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	300.0	9.0'	3.00%	29.3'
2	intermittent channel	earth.channel	K=20	967.0	13.0'	1.34%	7.0'
total Time of Concentration =							36.3'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 7.85 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 7.85 A

hydrograph file: c:\program files\quick3\knottlandfill\pt a1-1.hyd

peak flow = 0.21cfs @ 12.67 hr.  
runoff volume = 11,044 cu.ft.



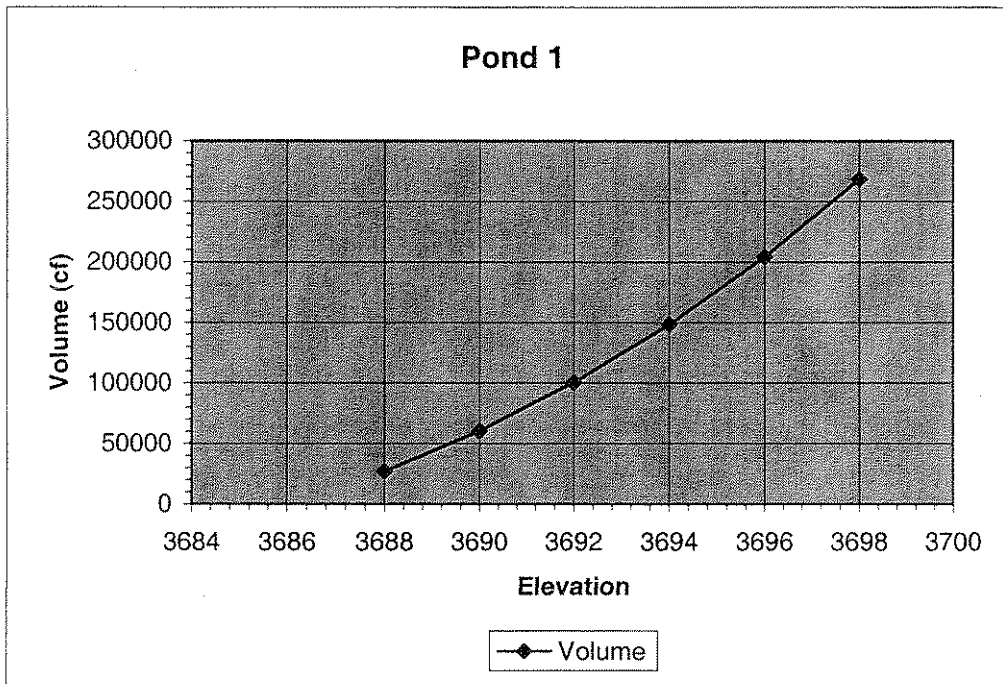


# Pond 1

## Stage -Volume Quantities

Elev	Area sf	Depth ft	Volume cf	Accum Volume cf	Elev
3686	11952				3686
3688	14939	2	26891	26891	3688
3690	18433	2	33372	60263	3690
3692	21898	2	40331	100594	3692
3694	25908	2	47806	148400	3694
3696	29835	2	55743	204143	3696
3698	34375	2	64210	268353	3698

Required Volume for 25-yr Storm      264,017 cf      Developed





5)



11,952 sf  
 14,939 sf  
 18,433 sf  
 21,898 sf  
 25,908 sf  
 29,835 sf  
 34,375 sf

3686

3698

POND

LOW

3697

48 + 6  
00

48 + 6  
00

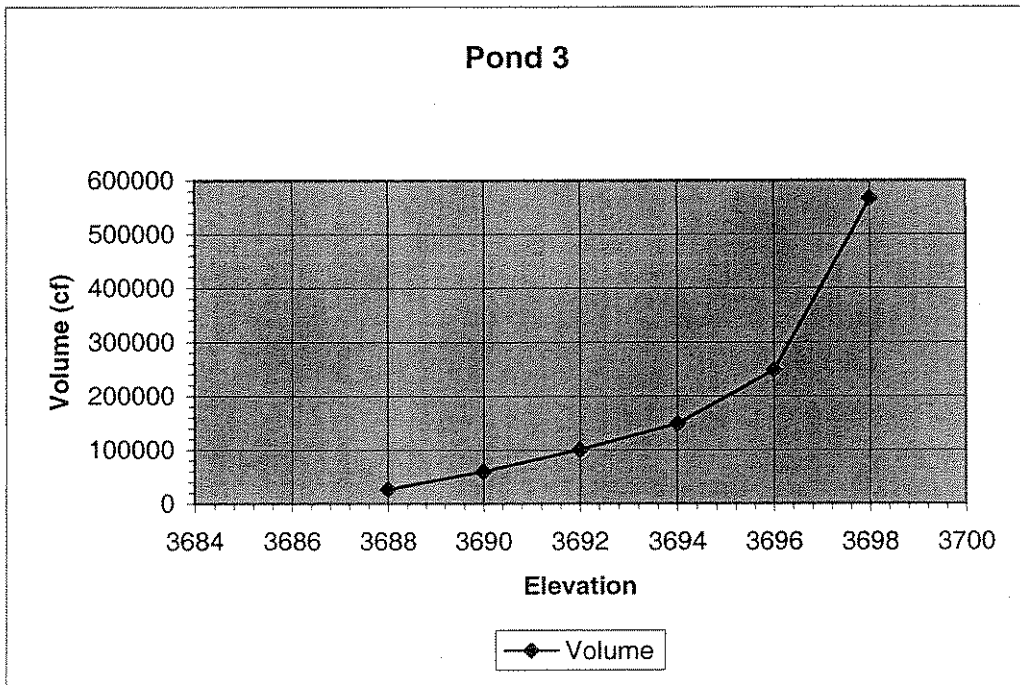
4

78,678 CF

**Pond 2**  
**Stage -Volume Quantities**

Elev	Area sf	Depth ft	Volume cf	Accum Volume cf	Elev
3686	11952				3686
3688	14939	2	26891	26891	3688
3690	18433	2	33372	60263	3690
3692	21898	2	40331	100594	3692
3694	25908	2	47806	148400	3694
3696	73742	2	99650	248050	3696
3698	245203	2	318945	566995	3698

Required Volume for 25-yr Storm      351,176 cf      Developed



Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 4 & 5 & 6 & 3 & Knott Landfill Areas Improved (100-yr) To Pond 2

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	1.0'	0.33%	62.9'
2	intermittent channel	paved.channel	K=30	513.0	3.7'	0.72%	3.4'
3	intermittent channel	paved.channel	K=30	771.0	10.0'	1.30%	3.8'

total Time of Concentration = 70.1'

storm hyetograph: SCS TypeIA

\*return period = 100 years\*

storm duration = 24 hr.

total rainfall = 3.00 in.

pervious area = 37.27 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 36.24 A CN = 98

total site area = 73.51 A

*49.3% impervious area*

hydrograph file: c:\program files\quick3\northarea\pt 4 & 5, 6 & 3, b2,c1,c2, d1 improved

peak flow = 14.22cfs @ 8.17 hr.

runoff volume = 448,925 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 4 & 5 & 6 & 3 & Knott Landfill Areas Improved To Pond 2

2-year, 24-hour rainfall = 1.50"

flow type	description	coeff.	distance	fall	slope	T/C
1 overland sheet	natural.range	n=0.13	300.0	1.0'	0.33%	62.9'
2 intermittent channel	paved.channel	K=30	513.0	3.7'	0.72%	3.4'
3 intermittent channel	paved.channel	K=30	771.0	10.0'	1.30%	3.8'

total Time of Concentration = 70.1'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 37.27 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 36.24 A CN = 98

total site area = 73.51 A

hydrograph file: c:\program files\quick3\northarea\pt 4 & 5, 6 & 3, b2,c1,c2, d1 improved

peak flow = 11.18cfs @ 8.17 hr.

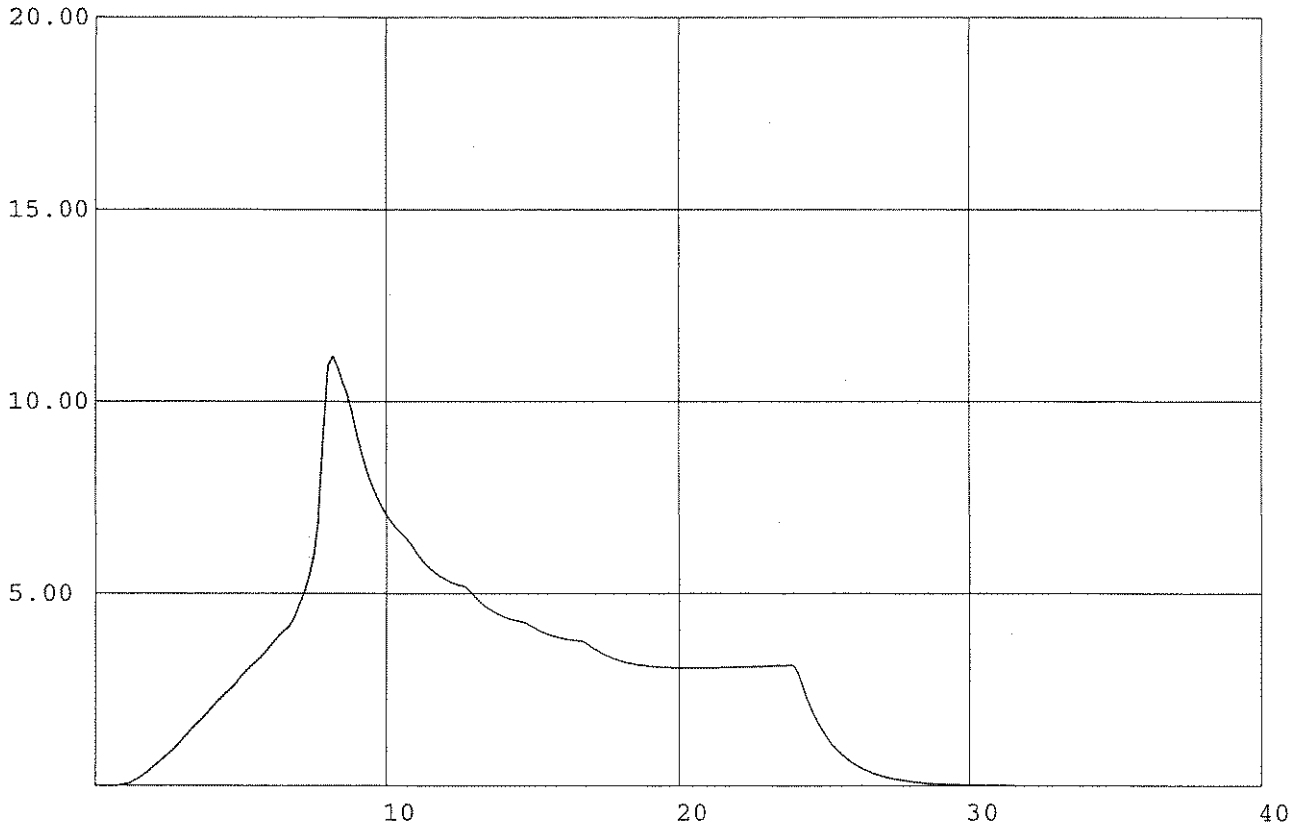
runoff volume = 351,176 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pond 2

load C:\Program Files\QUICK3\NorthArea\pt 4 & 5, 6 & 3, b2,c1,c2, d1 improved to pond 2.hy  
save as C:\Program Files\QUICK3\NorthArea\pt 6.HYD



peak flow = 11.18 cfs @ 8.17 hours  
volume = 351,150 cu.ft.



Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 4 & 5 Improved To Pond 2 (ALT 2)

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	1.0'	0.33%	62.9'
2	intermittent channel	paved.channel	K=30	513.0	3.7'	0.72%	3.4'
3	intermittent channel	paved.channel	K=30	771.0	10.0'	1.30%	3.8'

total Time of Concentration = 70.1'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 2.00 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 12.72 A CN = 98

total site area = 14.72 A

*Assumes most of area is impervious  
say paved compost area*

hydrograph file: c:\program files\quick3\northarea\pt 4 & 5 improved(alt 2) to pond 2.hyd

peak flow = 3.86cfs @ 8.17 hr.

runoff volume = 107,647 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

## RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH

North Area Pt 4 &amp; 5 IMPROVED

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	1.0'	0.33%	62.9'
2	intermittent channel	paved.channel	K=30	513.0	3.0'	0.58%	3.7'
3	intermittent channel	earth.channel	K=20	771.0	10.0'	1.30%	5.6'
total Time of Concentration =							72.3'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 8.94 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 5.96 A CN = 98 *Assumes 40% impervious area*

total site area = 14.90 A

hydrograph file: c:\program files\quick3\northarea\pt 4 &amp; 5 improved.hyd

peak flow = 1.83cfs @ 8.17 hr.

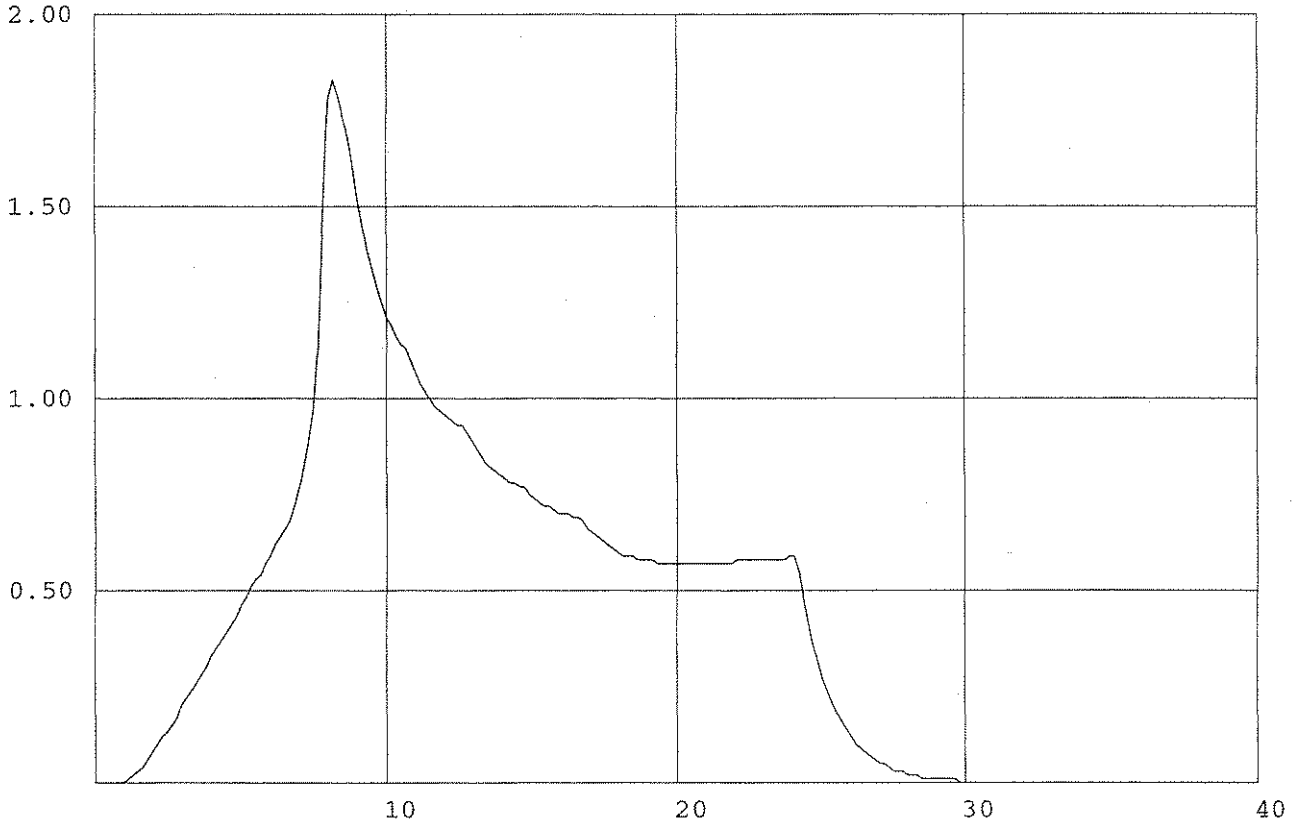
runoff volume = 61,694 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 4 & 5 Improved

load C:\Program Files\QUICK3\NorthArea\pt 4 & 5 improved.hyd  
save as C:\Program Files\QUICK3\NorthArea\pt 4 & 5.HYD



peak flow = 1.83 cfs @ 8.17 hours  
volume = 61,680 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 4 & 5

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	300.0	1.0'	0.33%	62.9'
2	intermittent channel	paved.channel	K=30	513.0	3.0'	0.58%	3.7'
3	intermittent channel	earth.channel	K=20	771.0	10.0'	1.30%	5.6'

total Time of Concentration = 72.3'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 14.90 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 14.90 A

hydrograph file: c:\program files\quick3\northarea\pt 4 & 5.hyd

peak flow = 0.38cfs @ 12.83 hr.

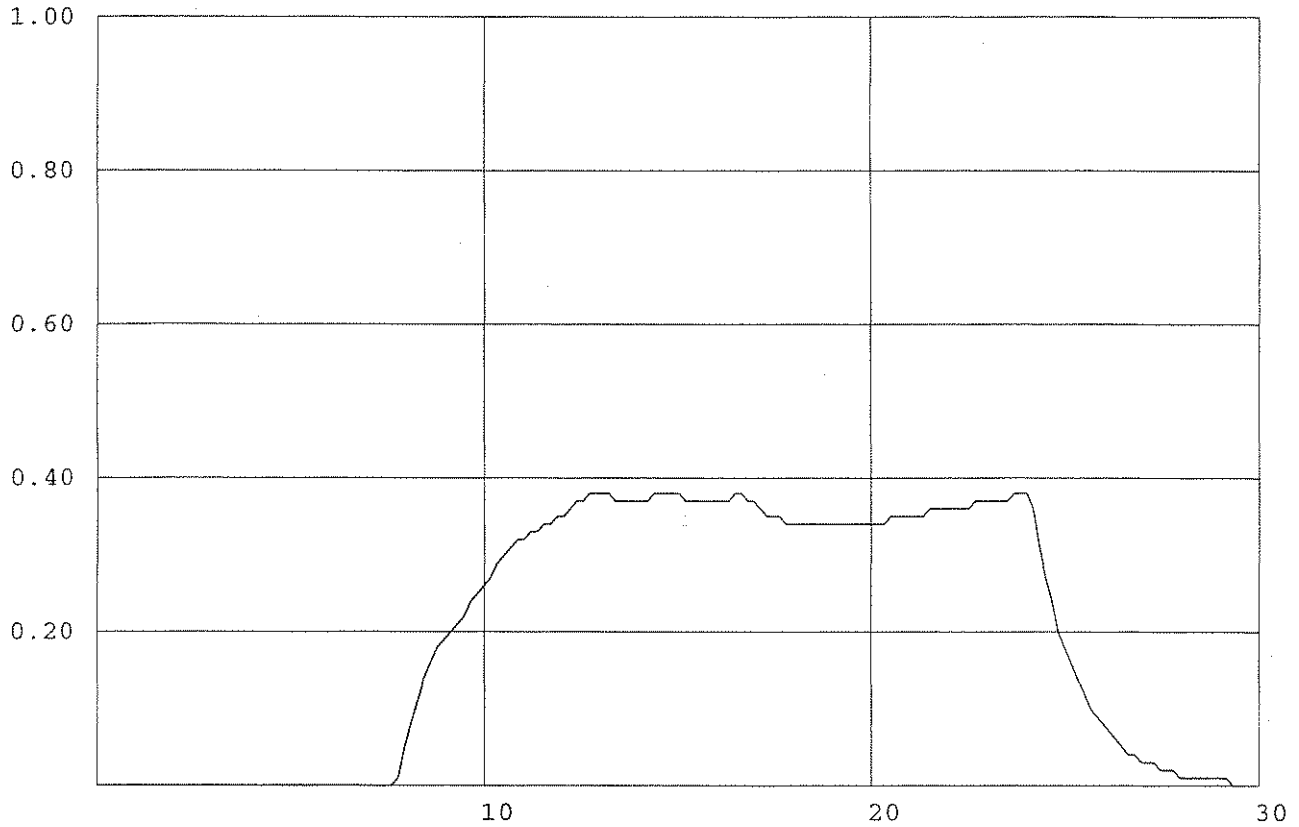
runoff volume = 20,959 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 4 & 5

load C:\Program Files\QUICK3\NorthArea\pt 4 & 5.hyd  
save as C:\Program Files\QUICK3\NorthArea\pt 4 & 5.HYD



peak flow = 0.38 cfs @ 12.67 hours  
volume = 20,952 cu.ft.

**Project** 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 5

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	natural.range	n=0.13	300.0	1.0'	0.33%	62.9'
2	intermittent channel	paved.channel	K=30	513.0	3.0'	0.58%	3.7'

total Time of Concentration = 66.7'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 4.04 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 4.04 A

hydrograph file: c:\program files\quick3\northarea\pt 5.hyd

peak flow = 0.10cfs @ 12.83 hr.

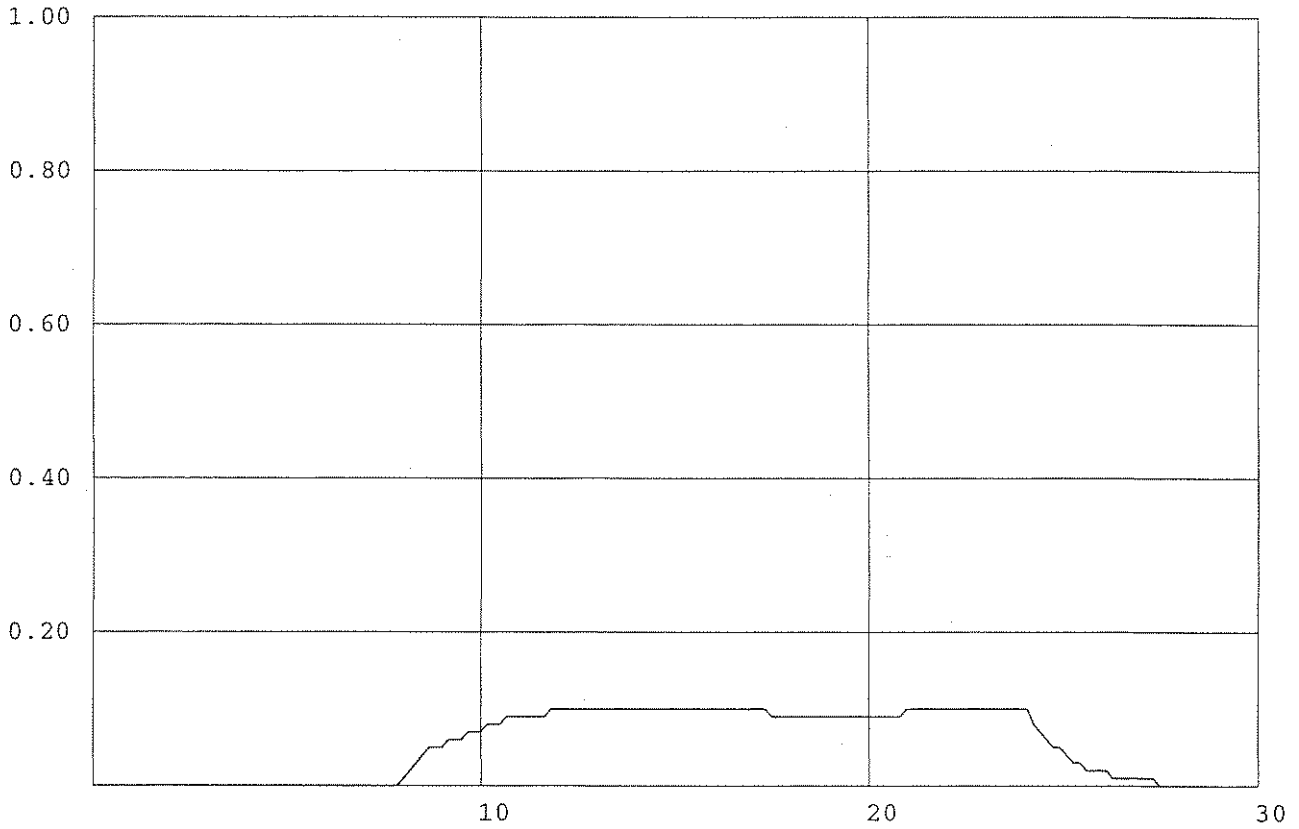
runoff volume = 5,671 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 5

load C:\Program Files\QUICK3\NorthArea\pt 5.hyd  
save as C:\Program Files\QUICK3\NorthArea\pt 1 & 2 & e1-1 & d2 improved.HYD



peak flow = 0.10 cfs @ 11.83 hours  
volume = 5,616 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**North Area Pt 6 & 3 Improved To Pond 2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	natural range	n=0.13	300.0	4.0'	1.33%	36.1'
2	intermittent channel	paved channel	K=30	248.0	11.0'	4.44%	0.7'
3	intermittent channel	paved channel	K=30	703.0	3.0'	0.43%	6.0'
4	intermittent channel	paved channel	K=30	329.0	2.0'	0.61%	2.3'

total Time of Concentration = 45.1'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 7.35 A CN = 68 GpA: Open space, pr. cnd

impervious area = 4.90 A CN = 98 *40% impervious area assumed*

total site area = 12.25 A

hydrograph file: c:\program files\quick3\northarea\pt 3 &amp; 6 improved to pond 2.hyd

peak flow = 1.82cfs @ 8.00 hr.

runoff volume = 50,729 cu.ft.



Project 25695172.47000  
 Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
 North Area Pt 6 & 3

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	300.0	4.0'	1.33%	36.1'
2	intermittent channel	paved.channel	K=30	248.0	11.0'	4.44%	0.7'
3	intermittent channel	paved.channel	K=30	703.0	3.0'	0.43%	6.0'

total Time of Concentration = 42.8'

storm hyetograph: SCS TypeIA  
 return period = 25 years  
 storm duration = 24 hr.  
 total rainfall = 2.50 in.

pervious area = 12.25 A CN = 68 GpA:Open.space,pr.cnd  
 impervious area = 0.00 A CN = 98  
 total site area = 12.25 A

hydrograph file: c:\program files\quick3\northarea\pt 3 & 6.hyd

peak flow = 0.33cfs @ 12.67 hr.  
 runoff volume = 17,239 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 6 & 3 To Pond 2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	natural.range	n=0.13	300.0	4.0'	1.33%	36.1'
2	intermittent channel	paved.channel	K=30	248.0	11.0'	4.44%	0.7'
3	intermittent channel	paved.channel	K=30	703.0	3.0'	0.43%	6.0'
4	intermittent channel	paved.channel	K=30	329.0	2.0'	0.61%	2.3'

total Time of Concentration = 45.1'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 12.25 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 12.25 A

hydrograph file: c:\program files\quick3\northarea\pt 3 & 6 to pond 2.hyd

peak flow = 0.33cfs @ 12.67 hr.

runoff volume = 17,238 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

## RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH

North Area Pt 6

2-year, 24-hour rainfall = 1.50"

flow type	description	coeff.	distance	fall	slope	T/C
1 overland sheet	natural.range	n=0.13	300.0	4.0'	1.33%	36.1'
2 intermittent channel	paved.channel	K=30	248.0	11.0'	4.44%	0.7'

total Time of Concentration = 36.8'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 4.25 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 4.25 A

hydrograph file: c:\program files\quick3\northarea\pt 6.hyd

peak flow = 0.12cfs @ 12.67 hr.

runoff volume = 5,975 cu.ft.

- Area 6 presents a grading problem and therefore a drain problem
- Area 6 could be self-contained to a pond
- Area 6 could be uniformly graded to flow towards PT 3
- Area 6 could be piped to Pond 2 (expensive) and likely force Pond 2 deeper.

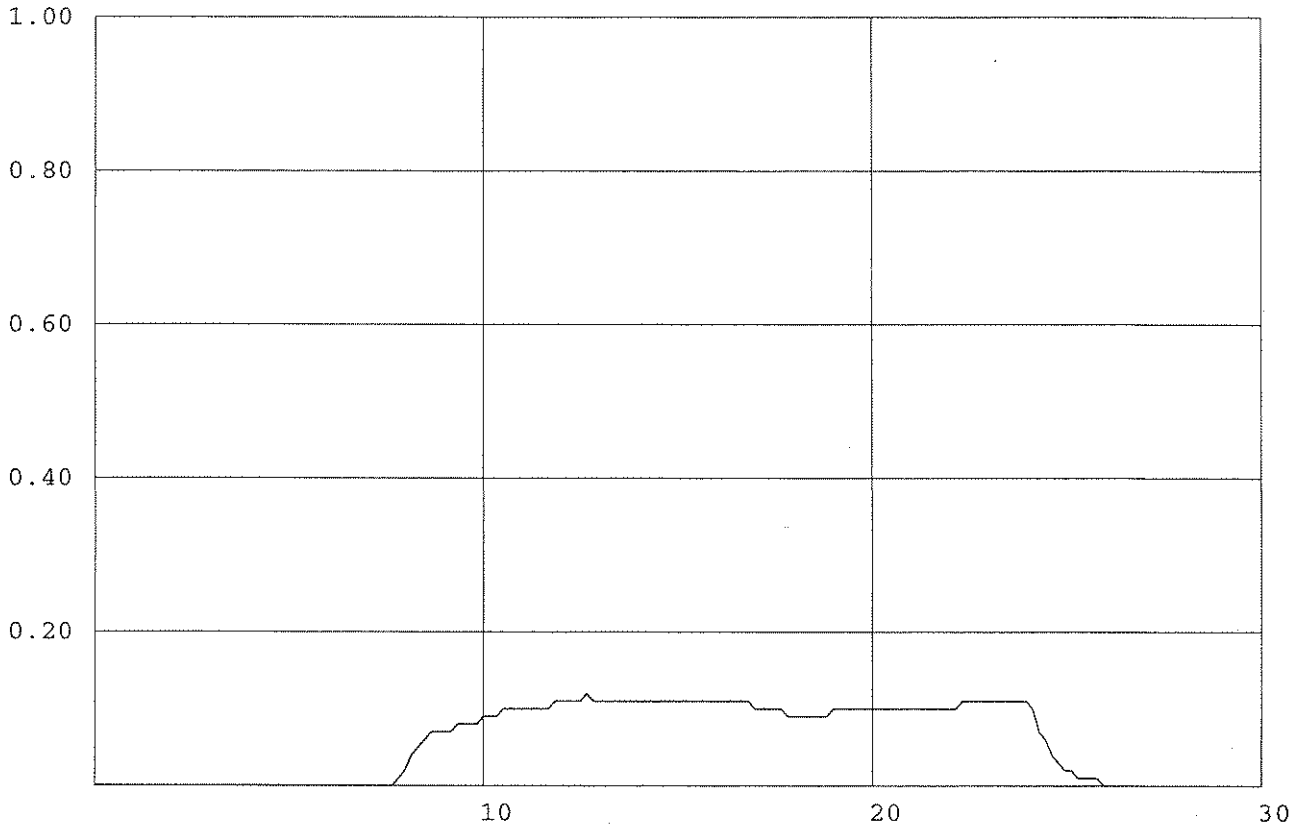
For this analysis, assume Area 6 flows on the surface towards PT 3 @ Pond 2

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 6

load C:\Program Files\QUICK3\NorthArea\pt 6.hyd  
save as C:\Program Files\QUICK3\NorthArea\pt 6.HYD



peak flow = 0.12 cfs @ 12.67 hours  
volume = 5,994 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt B2, C1, C2 & D1 to Pond 2 End Use

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass,lawns	n=0.15	300.0	6.0'	2.00%	34.5'
2	intermittent channel	earth.channel	K=20	1120.0	22.0'	1.96%	6.7'
3	intermittent channel	earth.channel	K=20	414.0	4.0'	0.97%	3.5'

total Time of Concentration = 44.6'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 27.92 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 18.62 A CN = 98

total site area = 46.54 A

*40% imp. cover @ End Use*

hydrograph file: c:\program files\quick3\knottlandfill\pt b2,c1,c2,d1 to pond 2 end use.hy

peak flow = 6.95cfs @ 8.00 hr.

runoff volume = 192,753 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
Knott Landfill - Pt B2-1, C1-1 to Pond 2 End Use

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	300.0	15.0'	5.00%	23.9'
2	intermittent channel	earth.channel	K=20	1172.0	23.5'	2.01%	6.9'
3	pipe	plastic.pipe	n=0.010	1425.0	7.1'	0.50%	4.8'

total Time of Concentration = 35.6'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

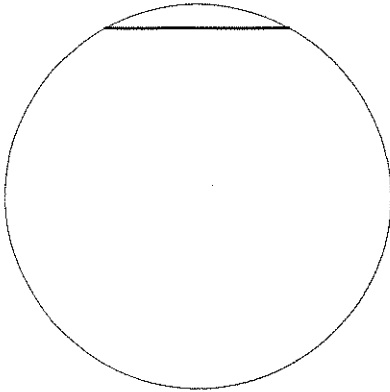
pervious area = 19.34 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 12.89 A CN = 98  
total site area = 32.23 A *40% imp cover*

hydrograph file: c:\program files\quick3\knottlandfill\pt c1-1,b2 to pond2 end use.hyd

peak flow = 5.30cfs @ 8.00 hr.  
runoff volume = 133,487 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

GRAVITY PIPE FLOW (Chezy-Manning)  
Area B2\_C1 Pipe to Pond 2



□ 2"

diameter = 18.0"  
slope = 0.50%  
material: ABS, PVC  
Manning's n = 0.011  
depth of flow = 93.82% of diameter (max)

wetted perimeter = 3.96'  
area = 1.72 s.f.  
hydraulic radius = 0.43'  
velocity = 5.50 fps  
flow = 9.47 cfs

*Handles 40% imp cover @ End Use*

**Project** 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt B2, C1, C2 & D1 to Pond 2

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass,lawns	n=0.15	300.0	6.0'	2.00%	34.5'
2	intermittent channel	earth.channel	K=20	1120.0	22.0'	1.96%	6.7'
3	intermittent channel	earth.channel	K=20	414.0	4.0'	0.97%	3.5'

total Time of Concentration = 44.6'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 46.54 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 46.54 A

hydrograph file: c:\program files\quick3\knottlandfill\pt b2,c1,c2,d1 to pond 2.hyd

peak flow = 1.25cfs @ 12.67 hr.  
runoff volume = 65,516 cu.ft.



Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt D1

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass.lawns	n=0.15	300.0	6.0'	2.00%	34.5'
2	intermittent channel	earth.channel	K=20	1120.0	22.0'	1.96%	6.7'
3	intermittent channel	earth.channel	K=20	414.0	4.0'	0.97%	3.5'

total Time of Concentration = 44.6'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 8.90 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 8.90 A

hydrograph file: c:\program files\quick3\knottlandfill\pt d1 to cb.hyd

peak flow = 0.24cfs @ 12.67 hr.

runoff volume = 12,520 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt D1

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	300.0	6.0'	2.00%	34.5'
2	intermittent channel	earth.channel	K=20	1120.0	22.0'	1.96%	6.7'
total Time of Concentration =							41.1'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 8.90 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 8.90 A

hydrograph file: c:\program files\quick3\knottlandfill\pt d1.hyd

peak flow = 0.24cfs @ 12.67 hr.

runoff volume = 12,522 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt C2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	300.0	19.0'	6.33%	21.7'
2	intermittent channel	earth.channel	K=20	1172.0	15.8'	1.35%	8.4'

total Time of Concentration = 30.1'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 7.98 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 7.98 A

hydrograph file: c:\program files\quick3\knottlandfill\pt c2.hyd

peak flow = 0.22cfs @ 12.67 hr.

runoff volume = 11,229 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt C1-2

2-year, 24-hour rainfall = 1.50"

flow type	description	coeff.	distance	fall	slope	T/C
1 overland sheet	short.grass,lawns	n=0.15	300.0	20.0'	6.67%	21.3'
2 intermittent channel	earth.channel	K=20	222.0	16.0'	7.21%	0.7'
total Time of Concentration =						22.0'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 2.43 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 2.43 A

hydrograph file: c:\program files\quick3\knottlandfill\pt.c1-2.hyd

peak flow = 0.07cfs @ 12.67 hr.  
runoff volume = 3,418 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt B2-1, C1-1 to Pond 2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	300.0	15.0'	5.00%	23.9'
2	intermittent channel	earth.channel	K=20	1172.0	23.5'	2.01%	6.9'
3	pipe	plastic.pipe	n=0.010	1425.0	7.1'	0.50%	4.8'

total Time of Concentration = 35.6'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 32.23 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 32.23 A

hydrograph file: c:\program files\quick3\knottlandfill\pt c1-1,b2 to pond2.hyd

peak flow = 0.88cfs @ 12.67 hr.

runoff volume = 45,371 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt C1-1

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass,lawns	n=0.15	300.0	15.0'	5.00%	23.9'
2	intermittent channel	earth.channel	K=20	1172.0	23.5'	2.01%	6.9'
total Time of Concentration =							30.8'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 14.07 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 14.07 A

hydrograph file: c:\program files\quick3\knottlandfill\pt c1-1.hyd

peak flow = 0.39cfs @ 12.67 hr.

runoff volume = 19,804 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt B2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	300.0	5.0'	1.67%	37.1'
2	intermittent channel	earth.channel	K=20	1117.0	33.5'	3.00%	5.4'

total Time of Concentration = 42.4'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 13.16 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 13.16 A

hydrograph file: c:\program files\quick3\knottlandfill\pt b2.hyd

peak flow = 0.35cfs @ 12.67 hr.  
runoff volume = 18,520 cu.ft.



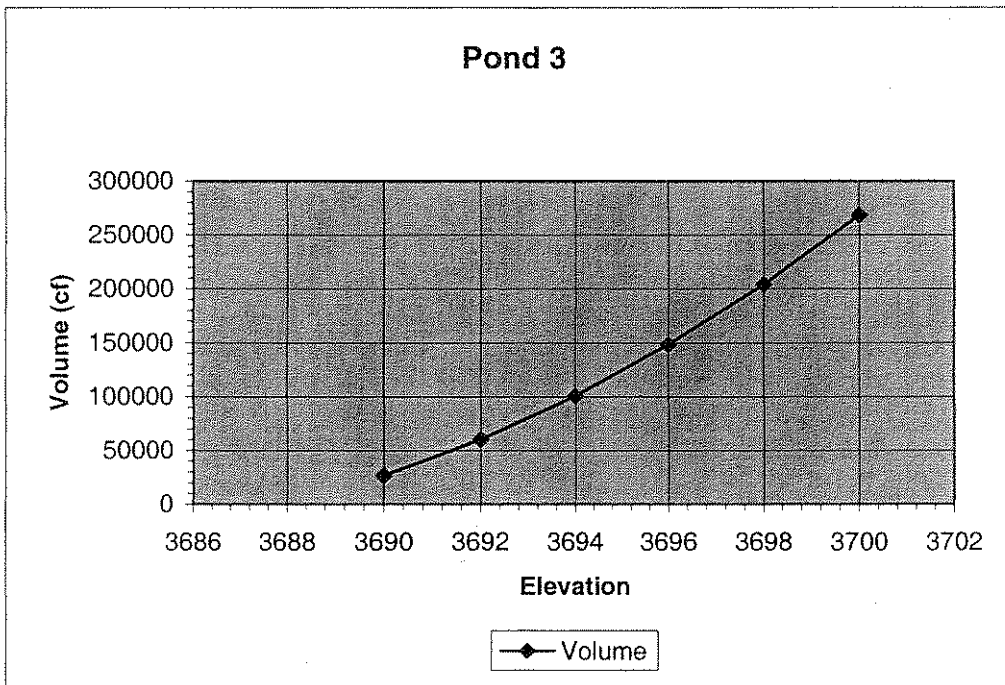


# Pond 3

## Stage -Volume Quantities

Elev	Area sf	Depth ft	Volume cf	Accum Volume cf	Elev
3688	11952				3688
3690	14939	2	26891	26891	3690
3692	18433	2	33372	60263	3692
3694	21898	2	40331	100594	3694
3696	25908	2	47806	148400	3696
3698	29835	2	55743	204143	3698
3700	34375	2	64210	268353	3700

Required Volume for 25-yr Storm      144,567 cf      Developed



Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 1 & 2; E1-1 & D2 Improved to Pond 3

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	1.5'	0.50%	53.5'
2	intermittent channel	paved.channel	K=30	620.0	3.0'	0.48%	5.0'

total Time of Concentration = 58.5'

storm hyetograph: SCS TypeIA

\* return period = 100 years \*

storm duration = 24 hr.

total rainfall = 3.00 in.

pervious area = 20.96 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 13.96 A CN = 98

total site area = 34.92 A

hydrograph file: c:\program files\quick3\northarea\pt 1 & 2 & e1-1 & d2 improved-100 yr.hy

peak flow = 6.10cfs @ 8.17 hr.

runoff volume = 187,941 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 1 &amp; 2; E1-1 &amp; D2 Improved to Pond 3

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	300.0	1.5'	0.50%	53.5'
2	intermittent channel	paved.channel	K=30	620.0	3.0'	0.48%	5.0'

total Time of Concentration = 58.5'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 20.96 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 13.96 A CN = 98 *Assumes 40% Developed Imp. Area*

total site area = 34.92 A

hydrograph file: c:\program files\quick3\northarea\pt 1 &amp; 2 &amp; e1-1 &amp; d2 improved.hyd

peak flow = 4.69cfs @ 8.17 hr.

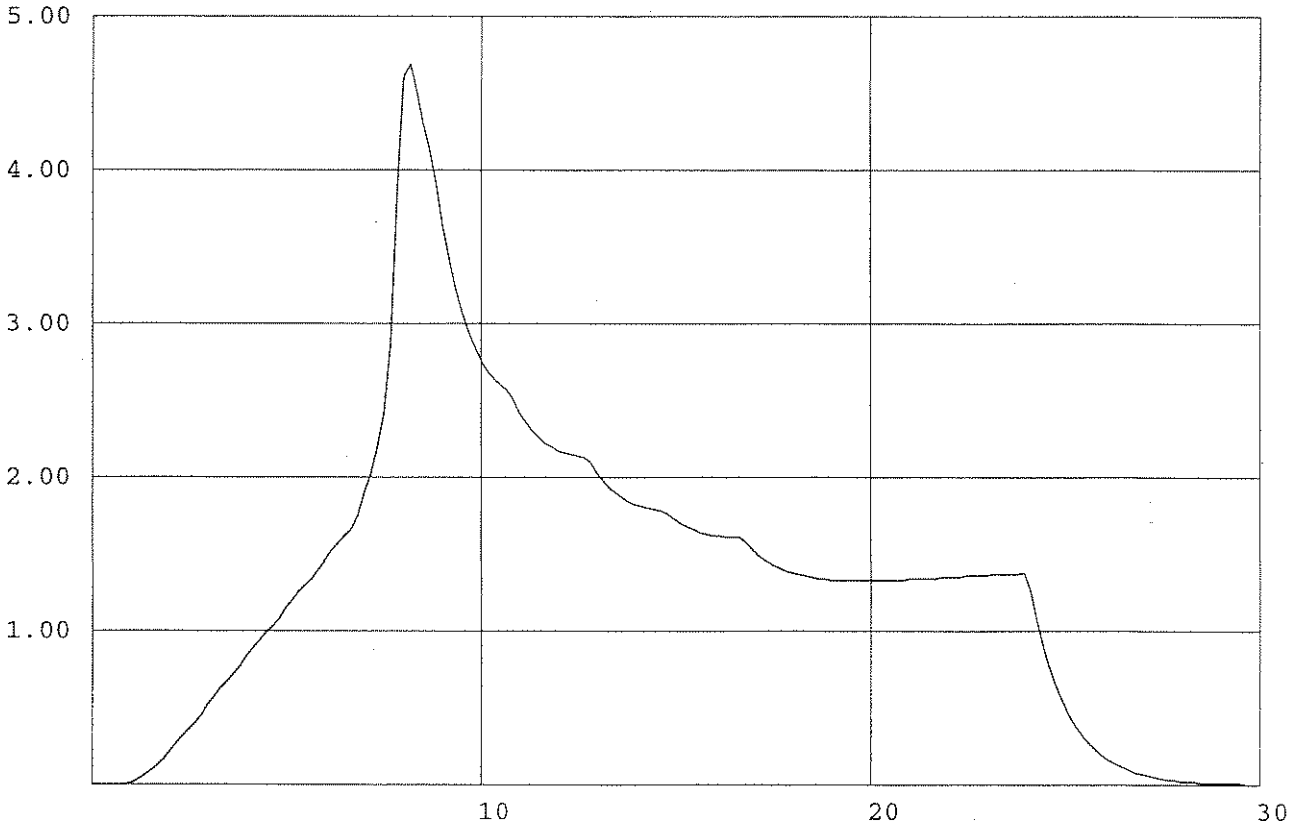
runoff volume = 144,567 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 1 & 2 & E1 & D2 Improved to Pond 3

load C:\Program Files\QUICK3\NorthArea\pt 1 & 2 & e1-1 & d2 improved.hyd  
save as C:\Program Files\QUICK3\NorthArea\pt 1 & 2 & e1-1 & d2 improved.HYD



peak flow = 4.69 cfs @ 8.17 hours  
volume = 144,576 cu.ft.

Project 25695172.47000  
 Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
 North Area Pt 1 & 2 Improved to Pond 3

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	300.0	1.5'	0.50%	53.5'
2	intermittent channel	paved.channel	K=30	620.0	3.0'	0.48%	5.0'

total Time of Concentration = 58.5'

storm hyetograph: SCS TypeIA  
 return period = 25 years  
 storm duration = 24 hr.  
 total rainfall = 2.50 in.

pervious area = 6.52 A CN = 68 GpA:Open.space,pr.cnd  
 impervious area = 4.34 A CN = 98 *Assume 40% impervious area*  
 total site area = 10.86 A

hydrograph file: c:\program files\quick3\northarea\pt 1 & 2 improved.hyd

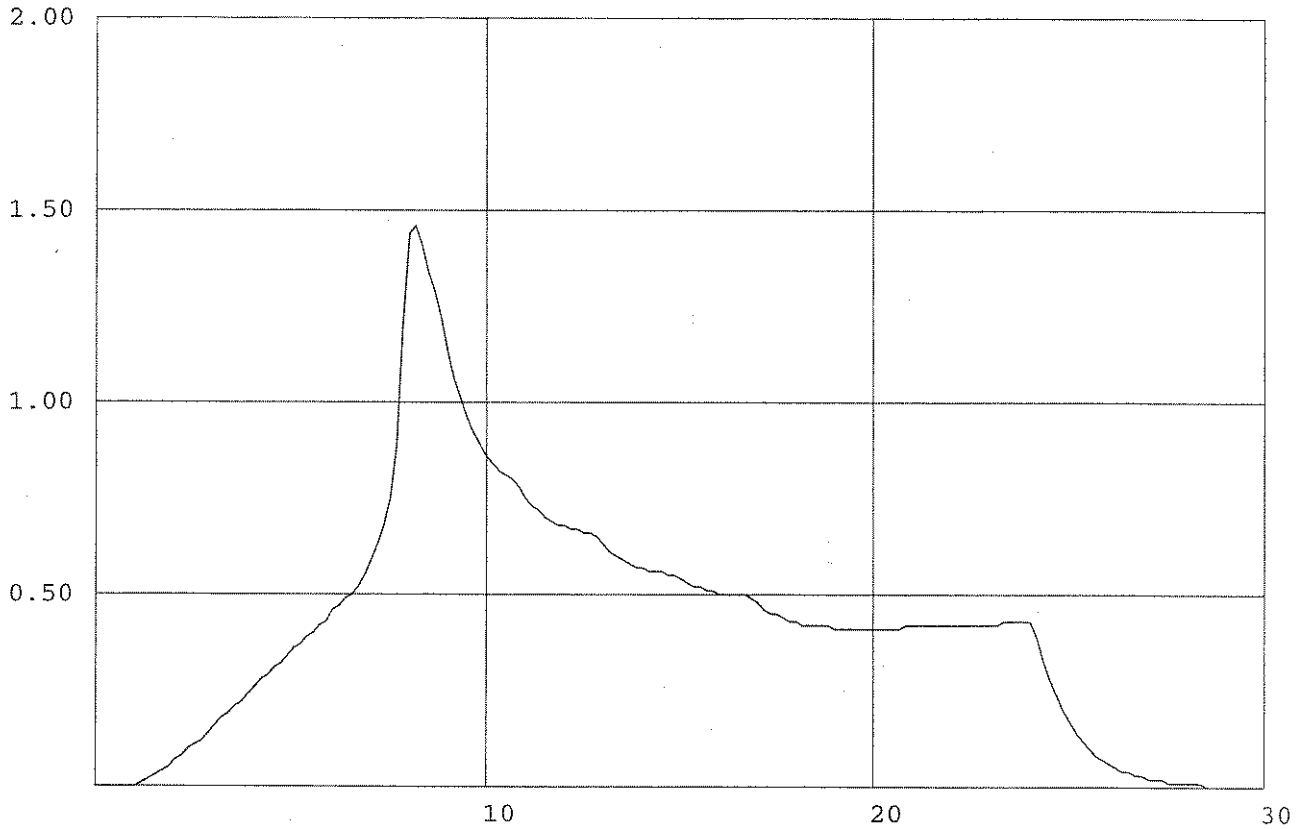
peak flow = 1.46cfs @ 8.17 hr.  
 runoff volume = 44,966 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 1 & 2 Improved to Pond 3

load C:\Program Files\QUICK3\NorthArea\pt 1 & 2 improved.hyd



peak flow = 1.46 cfs @ 8.17 hours  
volume = 44,946 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 1 & 2 to Pond 3

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	300.0	1.5'	0.50%	53.5'
2	intermittent channel	paved.channel	K=30	620.0	3.0'	0.48%	5.0'

total Time of Concentration = 58.5'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 10.86 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 10.86 A

hydrograph file: c:\program files\quick3\northarea\pt 1 & 2.hyd

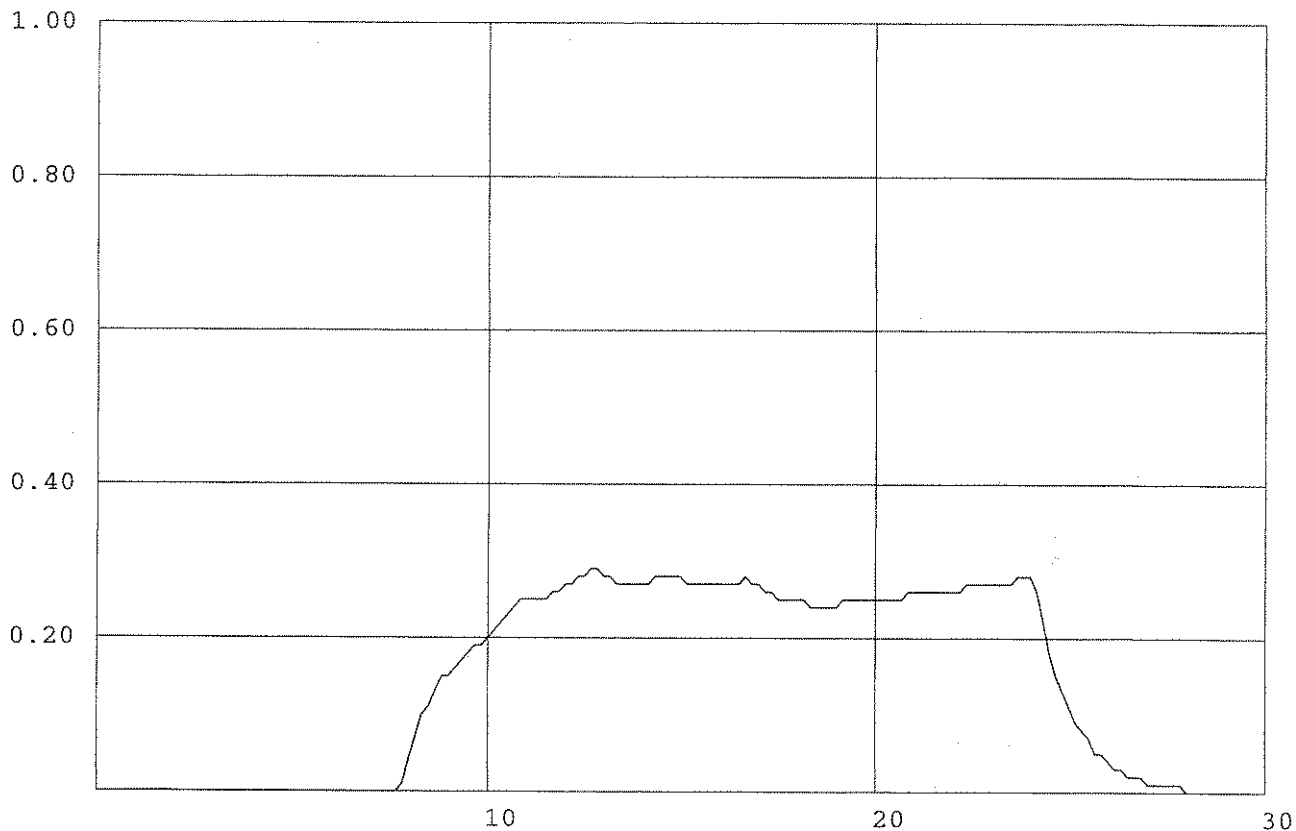
peak flow = 0.29cfs @ 12.67 hr.  
runoff volume = 15,275 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**HYDROGRAPH**

North Area Pt 1 & 2

load C:\Program Files\QUICK3\NorthArea\pt 1 & 2.hyd



peak flow = 0.29 cfs @ 12.67 hours  
volume = 15,270 cu.ft.



Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
North Area Pt 1

2-year, 24-hour rainfall = 1.50"

<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1 overland sheet	natural.range	n=0.13	300.0	1.5'	0.50%	53.5'
total Time of Concentration =						53.5'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 2.36 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 2.36 A

hydrograph file: c:\program files\quick3\northarea\pt 1.hyd

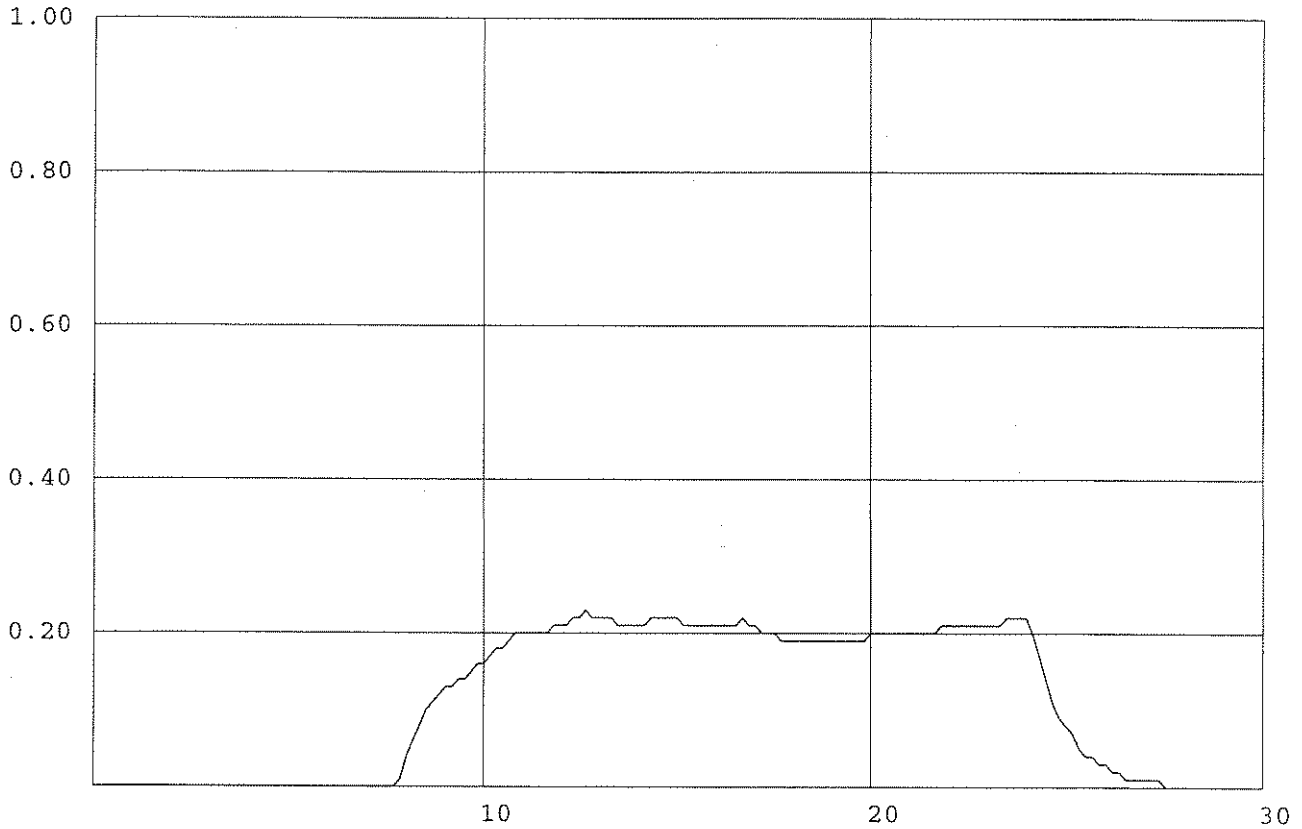
peak flow = 0.06cfs @ 12.67 hr.  
runoff volume = 3,309 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

HYDROGRAPH

North Area Pt 1

load C:\Program Files\QUICK3\NorthArea\pt 1.hyd



peak flow = 0.23 cfs @ 12.67 hours  
volume = 11,940 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt E1-1 & D2 to Pond 3 End Use

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	short.grass,lawns	n=0.15	243.0	11.0'	4.53%	21.0'
2	intermittent channel	earth.channel	K=20	1908.0	20.8'	1.09%	15.2'

total Time of Concentration = 36.2'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 14.44 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 9.62 A CN = 98

total site area = 24.06 A

*Assumes 40% imp cover @ End Use*

hydrograph file: c:\program files\quick3\knottlandfill\pt d2 & e1-1 end use.hyd

peak flow = 3.93cfs @ 8.00 hr.

runoff volume = 99,646 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt E1-1 & D2 to Pond 3

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass,lawns	n=0.15	243.0	11.0'	4.53%	21.0'
2	intermittent channel	earth.channel	K=20	1908.0	20.8'	1.09%	15.2'
total Time of Concentration =							36.2'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 24.06 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 24.06 A

hydrograph file: c:\program files\quick3\knottlandfill\pt d2 & e1-1.hyd

peak flow = 0.66cfs @ 12.67 hr.  
runoff volume = 33,867 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

Knott Landfill - Pt E1-1 & D2

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	243.0	11.0'	4.53%	21.0'
2	intermittent channel	earth.channel	K=20	1908.0	20.8'	1.09%	15.2'

total Time of Concentration = 36.2'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 24.06 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 24.06 A

hydrograph file: c:\program files\quick3\knottlandfill\pt d2 & e1-1.hyd

peak flow = 0.66cfs @ 12.67 hr.

runoff volume = 33,867 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt E1-1

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	short.grass,lawns	n=0.15	243.0	11.0'	4.53%	21.0'
2	intermittent channel	earth.channel	K=20	1908.0	20.8'	1.09%	15.2'
total Time of Concentration =							36.2'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 14.93 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 14.93 A

hydrograph file: c:\program files\quick3\knottlandfill\pt e1-1.hyd

peak flow = 0.41cfs @ 12.67 hr.  
runoff volume = 21,014 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
Knott Landfill - Pt D2

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	short.grass,lawns	n=0.15	300.0	11.0'	3.67%	27.0'
2	intermittent channel	earth.channel	K=20	832.0	24.0'	2.88%	4.1'
total Time of Concentration =							31.1'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 9.13 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 9.13 A

hydrograph file: c:\program files\quick3\knottlandfill\pt d2.hyd

peak flow = 0.25cfs @ 12.67 hr.  
runoff volume = 12,848 cu.ft.



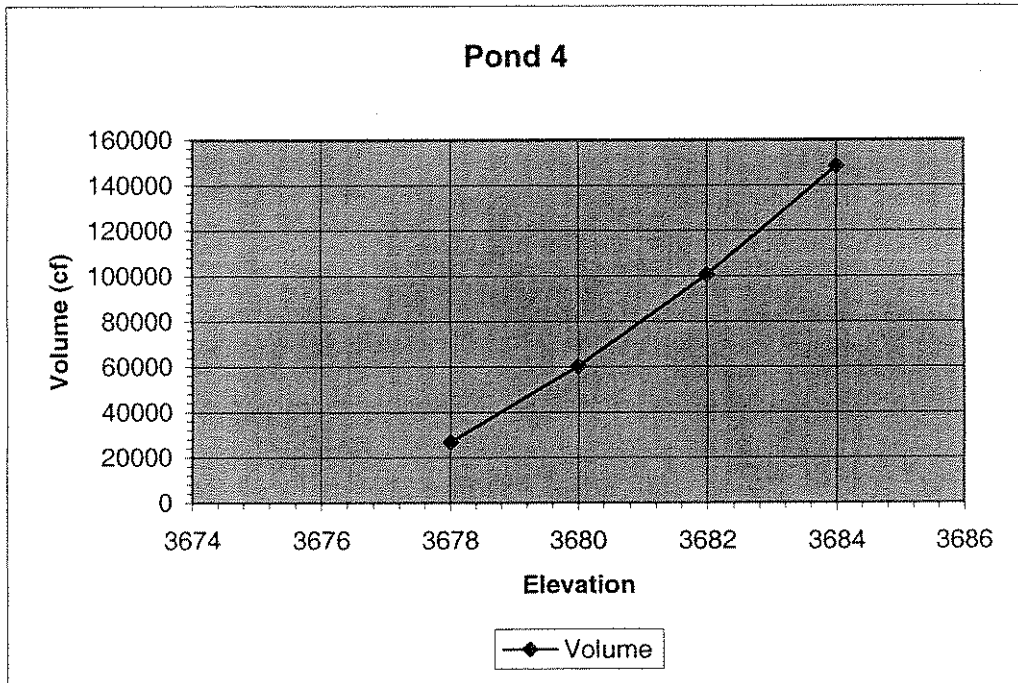


# Pond 4

## Stage -Volume Quantities

Elev	Area sf	Depth ft	Volume cf	Accum Volume cf	Elev
3676	11952				3676
3678	14939	2	26891	26891	3678
3680	18433	2	33372	60263	3680
3682	21898	2	40331	100594	3682
3684	25908	2	47806	148400	3684

Required Volume for 25-yr Storm      102,300 cf      Developed



Project 25695172.47000  
 Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
 North Area Pt 7, 8, Remainder to Pond (Improved)

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	200.0	4.0'	2.00%	22.2'
2	intermittent channel	paved.channel	K=30	387.0	3.7'	0.96%	2.2'
3	pipe	plastic.pipe	n=0.010	570.0	3.0'	0.53%	1.9'
total Time of Concentration =							26.3'

storm hyetograph: SCS TypeIA  
 return period = 25 years  
 storm duration = 24 hr.  
 total rainfall = 2.50 in.

pervious area = 14.82 A CN = 68 GpA:Open.space,pr.cnd  
 impervious area = 9.88 A CN = 98  
 total site area = 24.70 A

hydrograph file: c:\program files\quick3\northarea\pt7,8, remainder to pond.hyd

peak flow = 4.57cfs @ 8.00 hr.  
 runoff volume = 102,300 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 7, 8, Remainder to Pond (100yr)

2-year, 24-hour rainfall = 1.50"

flow type	description	coeff.	distance	fall	slope	T/C
1 overland sheet	natural.range	n=0.13	200.0	4.0'	2.00%	22.2'
2 intermittent channel	paved.channel	K=30	387.0	3.7'	0.96%	2.2'
3 pipe	plastic.pipe	n=0.010	570.0	3.0'	0.53%	1.9'

total Time of Concentration = 26.3'

storm hyetograph: SCS TypeIA

~~\*~~ return period = 100 years ~~\*~~

storm duration = 24 hr.

total rainfall = 3.00 in.

pervious area = 14.82 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 9.88 A CN = 98

total site area = 24.70 A

hydrograph file: c:\program files\quick3\northarea\pt7,8, remainde (100-yr) to pond.hyd

peak flow = 6.00cfs @ 8.00 hr.

runoff volume = 132,985 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH

North Area Pt ~~Remainder~~, 7, 18  
9

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	2.0'	0.67%	47.7'
2	intermittent channel	paved.channel	K=30	400.0	12.0'	3.00%	1.3'

total Time of Concentration = 49.0'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 24.70 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 24.70 A

hydrograph file: c:\program files\quick3\northarea\pt remainder.hyd

peak flow = 0.66cfs @ 12.67 hr.  
runoff volume = 34,766 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
North Area Pt 8 to Pond

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	200.0	4.0'	2.00%	22.2'
2	intermittent channel	paved.channel	K=30	387.0	3.7'	0.96%	2.2'
3	pipe	plastic.pipe	n=0.010	570.0	3.0'	0.53%	1.9'

total Time of Concentration = 26.3'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 3.99 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 2.66 A CN = 98 *40% impervious*  
total site area = 6.65 A

hydrograph file: c:\program files\quick3\northarea\pt8 to pond.hyd

peak flow = 1.23cfs @ 8.00 hr.  
runoff volume = 27,538 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
North Area Pt 8 *Improved*

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	natural.range	n=0.13	200.0	4.0'	2.00%	22.2'
2	intermittent channel	paved.channel	K=30	387.0	3.7'	0.96%	2.2'

total Time of Concentration = 24.4'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 3.99 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 2.66 A CN = 98 *40% impervious*  
total site area = 6.65 A

hydrograph file: c:\program files\quick3\northarea\pt8.hyd

peak flow = 1.26cfs @ 8.00 hr.  
runoff volume = 27,540 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 8

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	200.0	4.0'	2.00%	22.2'
2	intermittent channel	paved.channel	K=30	387.0	3.7'	0.96%	2.2'

total Time of Concentration = 24.4'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 6.65 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 6.65 A

hydrograph file: c:\program files\quick3\northarea\pt8.hyd

peak flow = 0.18cfs @ 12.67 hr.

runoff volume = 9,359 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 8

2-year, 24-hour rainfall = 1.50"

	<i>flow type</i>	<i>description</i>	<i>coeff.</i>	<i>distance</i>	<i>fall</i>	<i>slope</i>	<i>T/C</i>
1	overland sheet	natural.range	n=0.13	200.0	4.0'	2.00%	22.2'
2	intermittent channel	paved.channel	K=30	387.0	3.7'	0.96%	2.2'

total Time of Concentration = 24.4'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 0.00 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 6.65 A CN = 98

total site area = 6.65 A

hydrograph file: c:\program files\quick3\northarea\pt8.hyd

peak flow = 3.08cfs @ 8.00 hr.

runoff volume = 54,811 cu.ft.



Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 7 Improved to Pond

2-year, 24-hour rainfall = 1.50"

flow type	description	coeff.	distance	fall	slope	T/C
1 overland sheet	natural.range	n=0.13	175.0	5.0'	2.86%	17.3'
2 intermittent channel	paved.channel	K=30	318.0	3.0'	0.94%	1.8'
3 pipe	plastic.pipe	n=0.010	500.0	2.5'	0.50%	1.7'

total Time of Concentration = 20.8'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 3.00 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 2.00 A CN = 98 *40% impervious*

total site area = 5.00 A

hydrograph file: c:\program files\quick3\northarea\pt7 improved to pond.hyd

peak flow = 1.00cfs @ 8.00 hr.

runoff volume = 20,707 cu.ft.

Project 25695172.47000

Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**

North Area Pt 7 to Pond

2-year, 24-hour rainfall = 1.50"

	<b>flow type</b>	<b>description</b>	<b>coeff.</b>	<b>distance</b>	<b>fall</b>	<b>slope</b>	<b>T/C</b>
1	overland sheet	natural.range	n=0.13	175.0	5.0'	2.86%	17.3'
2	intermittent channel	paved.channel	K=30	318.0	3.0'	0.94%	1.8'
3	pipe	plastic.pipe	n=0.010	500.0	2.5'	0.50%	1.7'

total Time of Concentration = 20.8'

storm hyetograph: SCS TypeIA

return period = 25 years

storm duration = 24 hr.

total rainfall = 2.50 in.

pervious area = 5.00 A CN = 68 GpA:Open.space,pr.cnd

impervious area = 0.00 A CN = 98

total site area = 5.00 A

hydrograph file: c:\program files\quick3\northarea\pt7 to pond.hyd

peak flow = 0.14cfs @ 12.67 hr.

runoff volume = 7,037 cu.ft.

Project 25695172.47000  
Knott Landfill Storm Water Runoff

**RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH**  
North Area Pt 7

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	175.0	5.0'	2.86%	17.3'
2	intermittent channel	paved.channel	K=30	318.0	3.0'	0.94%	1.8'

total Time of Concentration = 19.1'

storm hyetograph: SCS TypeIA  
return period = 25 years  
storm duration = 24 hr.  
total rainfall = 2.50 in.

pervious area = 5.00 A CN = 68 GpA:Open.space,pr.cnd  
impervious area = 0.00 A CN = 98  
total site area = 5.00 A

hydrograph file: c:\program files\quick3\northarea\pt7.hyd

peak flow = 0.14cfs @ 12.67 hr.  
runoff volume = 7,036 cu.ft.

Project 25695172.47000  
 Knott Landfill Storm Water Runoff

RUNOFF by the SANTA BARBARA URBAN HYDROGRAPH  
 North Area Pt Remainder(9)

2-year, 24-hour rainfall = 1.50"

	flow type	description	coeff.	distance	fall	slope	T/C
1	overland sheet	natural.range	n=0.13	300.0	2.0'	0.67%	47.7'
2	intermittent channel	paved.channel	K=30	400.0	12.0'	3.00%	1.3'

total Time of Concentration = 49.0'

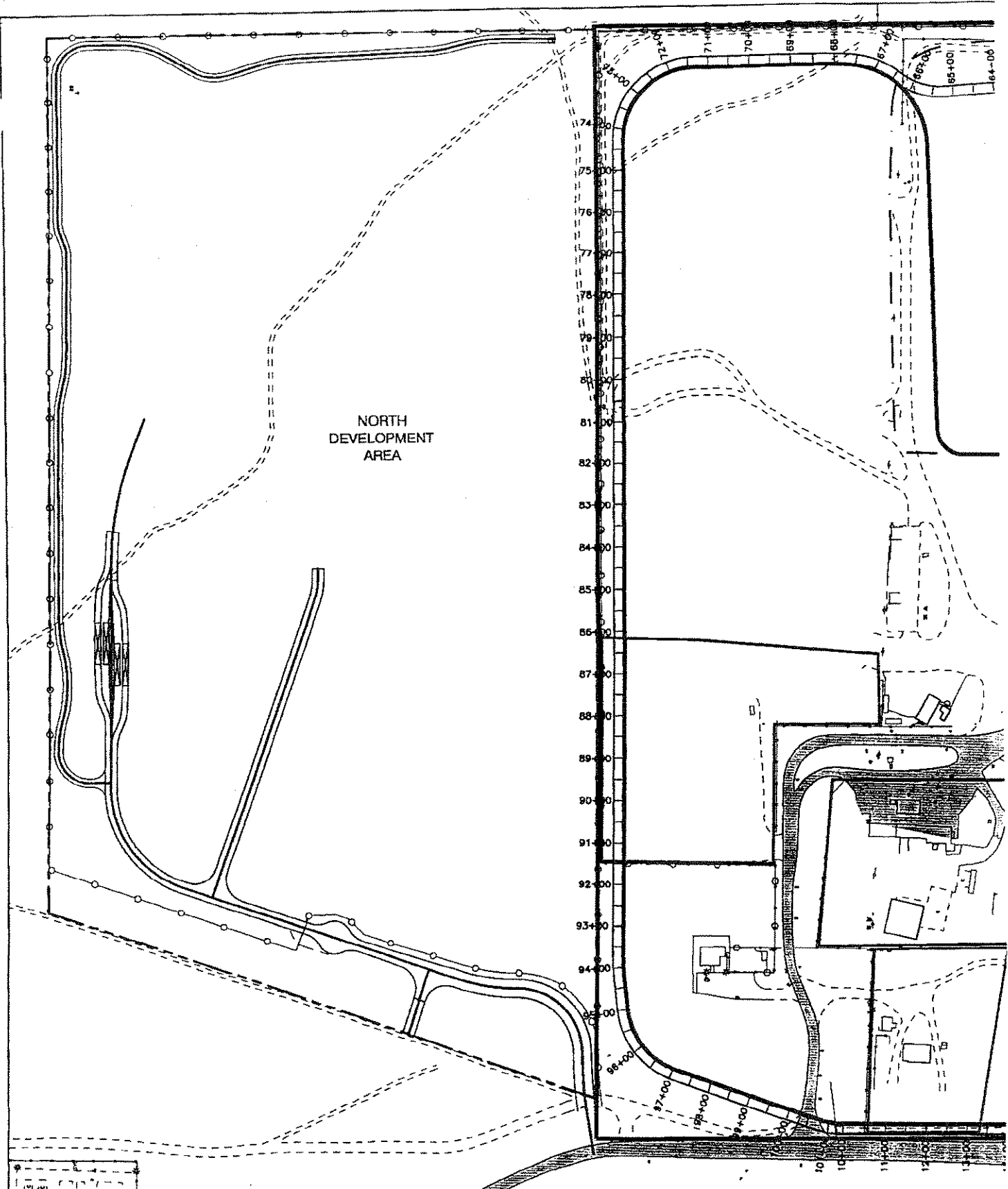
storm hyetograph: SCS TypeIA  
 return period = 25 years  
 storm duration = 24 hr.  
 total rainfall = 2.50 in.

pervious area = 13.05 A CN = 68 GpA:Open.space,pr.cnd  
 impervious area = 0.00 A CN = 98  
 total site area = 13.05 A

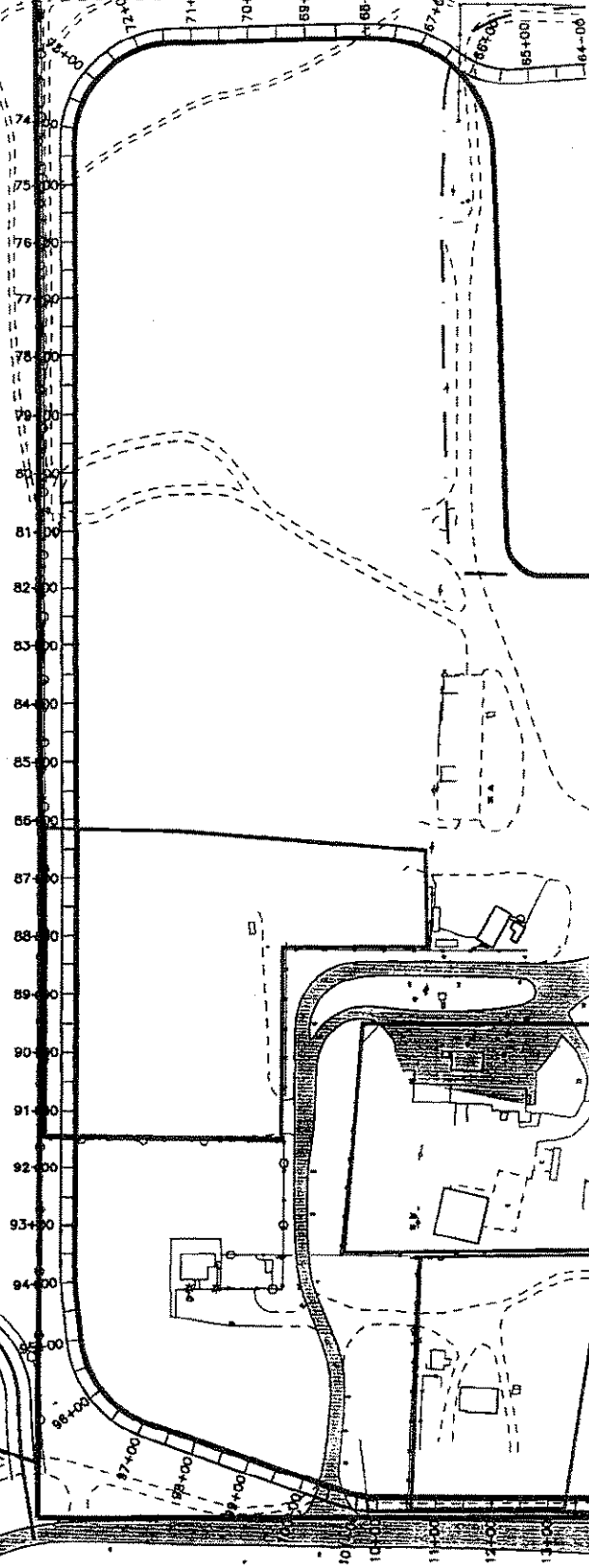
hydrograph file: c:\program files\quick3\northarea\pt remainder.hyd

peak flow = 0.35cfs @ 12.67 hr.  
 runoff volume = 18,363 cu.ft.

I:\Deschut\...ntycad SITE DEV\FIG 3-1.dwg Apr 29, 2003 - 3:53pm



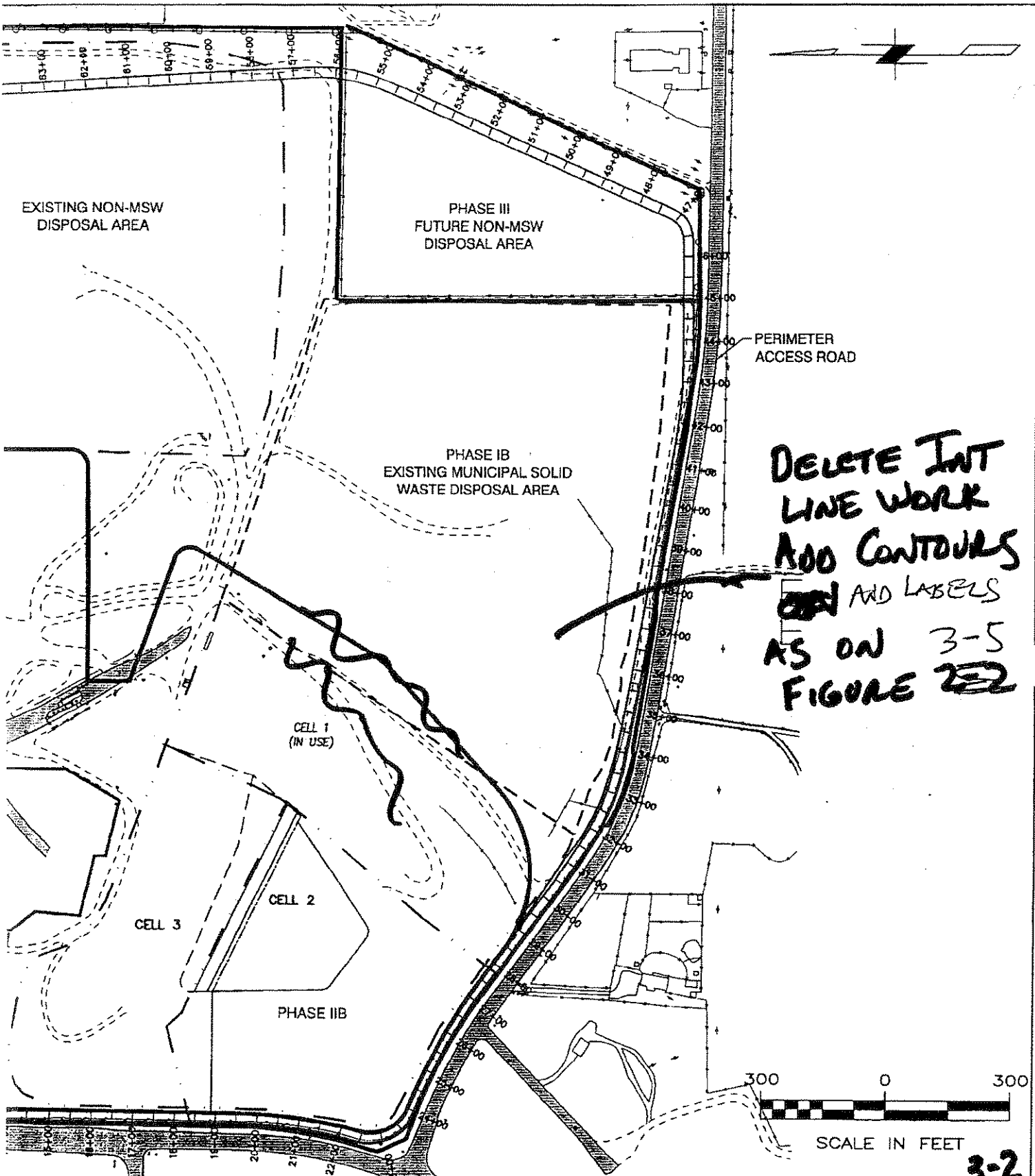
NORTH  
DEVELOPMENT  
AREA



			JOB No.	DESIGNED: GF	PROJ. ENGINEER:
			SCALE: 1"=300'	DRAWN BY: CAS	APPROVED BY:
				CHECKED BY: GH	DATE: APR. 2003
A	5/01/03	CAS	FOR CLIENT REVIEW		
No.	DATE	BY	REVISION		



G. Friesen Associates, Inc.  
4088 Orchard Drive  
Lake Oswego, Oregon 97075  
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(fax) 503-222-4292

**DESCHUTES COUNTY**  
**DEPARTMENT OF PUBLIC WORKS**  
BEND, OREGON

**Knott Landfill Site Development Plan**  
**LANDFILL FOOTPRINT**

DRAWING NUMBER:  
**Figure 3-1**

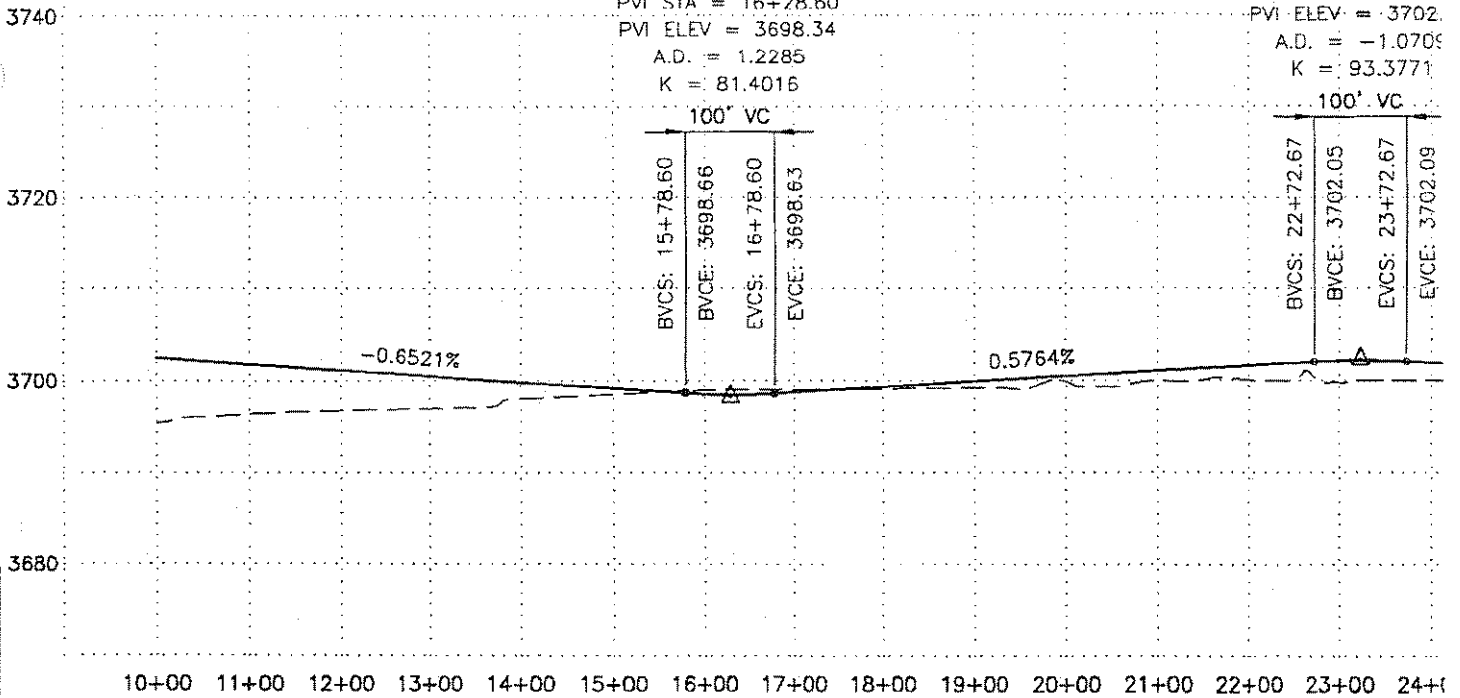
CAD FILE NUMBER:  
FIG 3-1

SHEET: OF REV. A

**3-2**

LOW POINT ELEV = 3698.49  
 LOW POINT STA = 16+31.68  
 PVI STA = 16+28.60  
 PVI ELEV = 3698.34  
 A.D. = 1.2285  
 K = 81.4016

HIGH POINT ELEV = 3702.05  
 HIGH POINT STA = 23+05.00  
 PVI STA = 23+22  
 PVI ELEV = 3702.05  
 A.D. = -1.0705  
 K = 93.3771

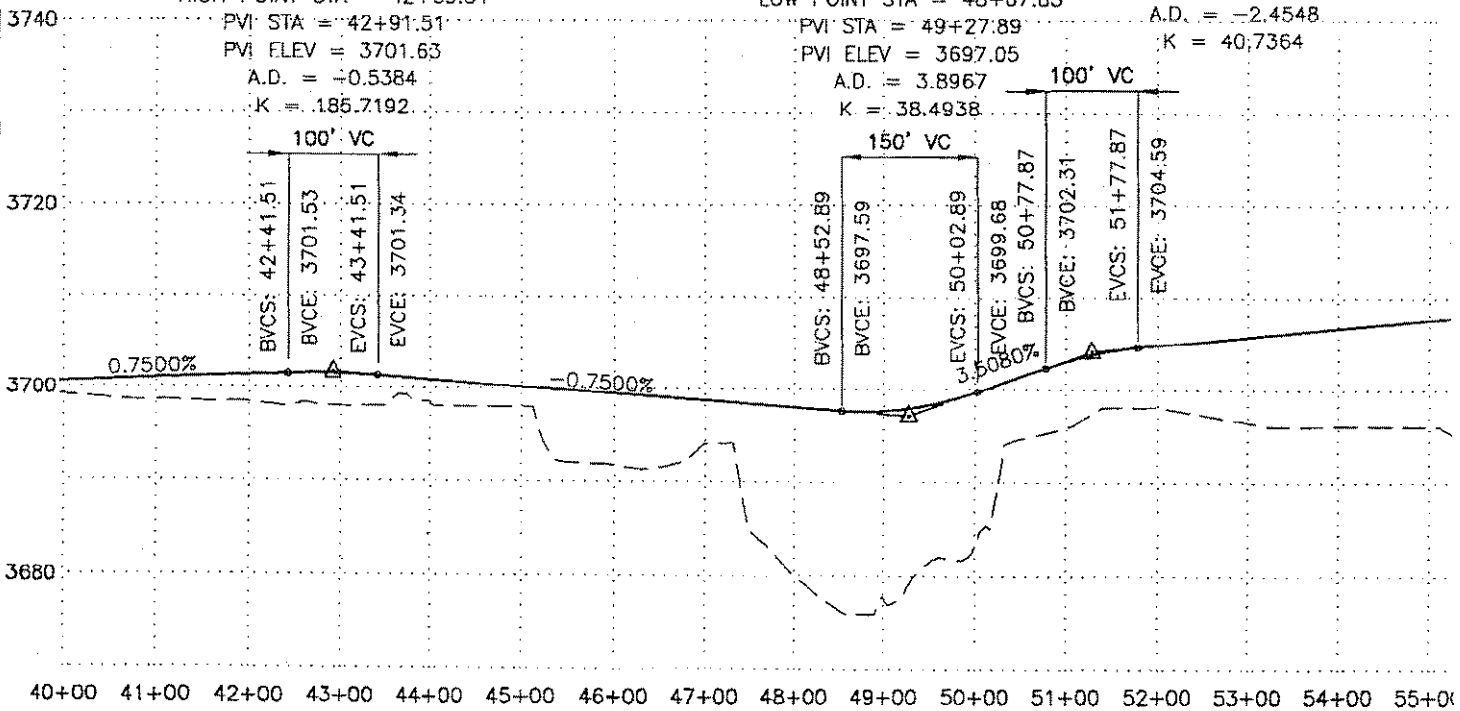


**PROFILES**

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I:\Deschute\I\CAD SITE DEV\FIG 3-2.dwg Apr 29, 2003 - 3:24pm

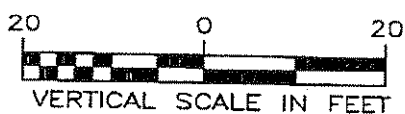
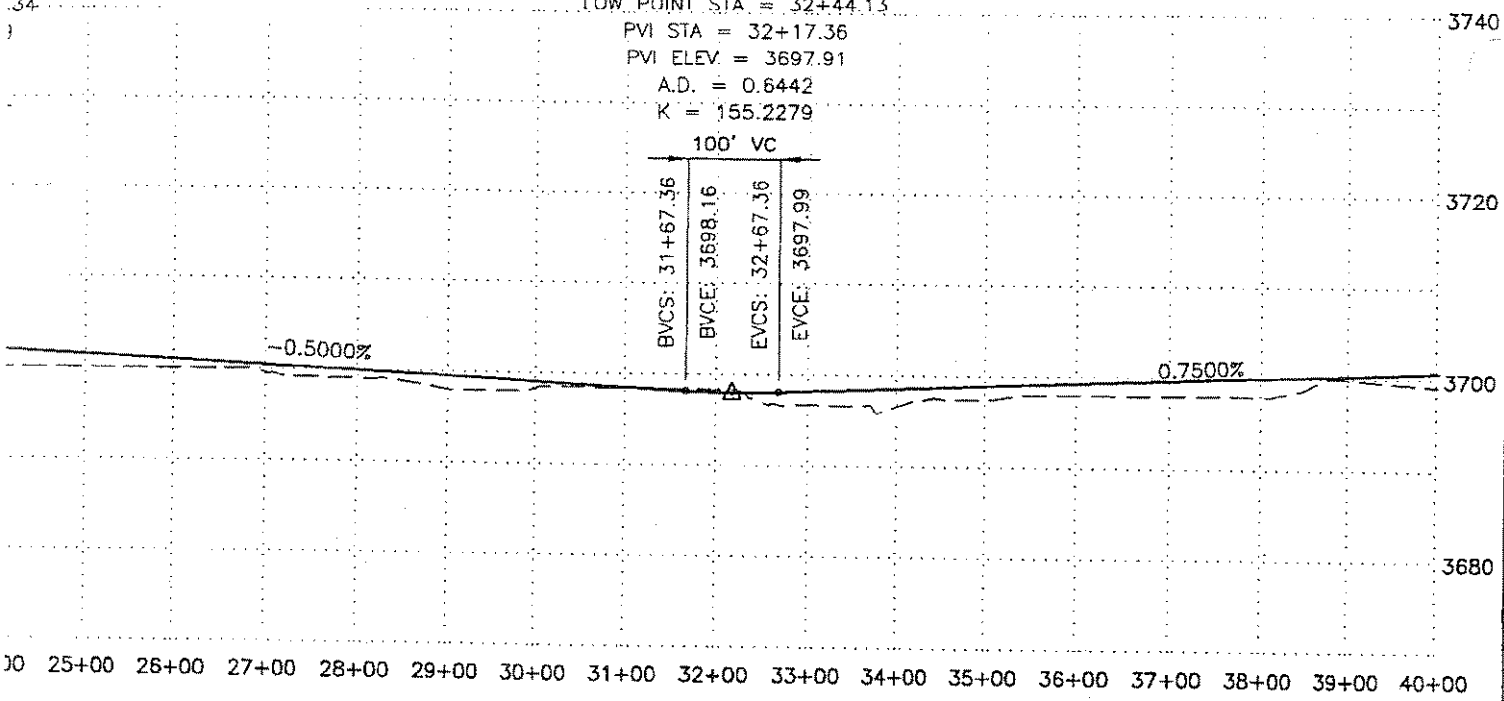
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					CHECKED BY: GH	DATE: APR. 2003
A	5/01/03	CAS	FOR CLIENT REVIEW			
No.	DATE	BY	REVISION			



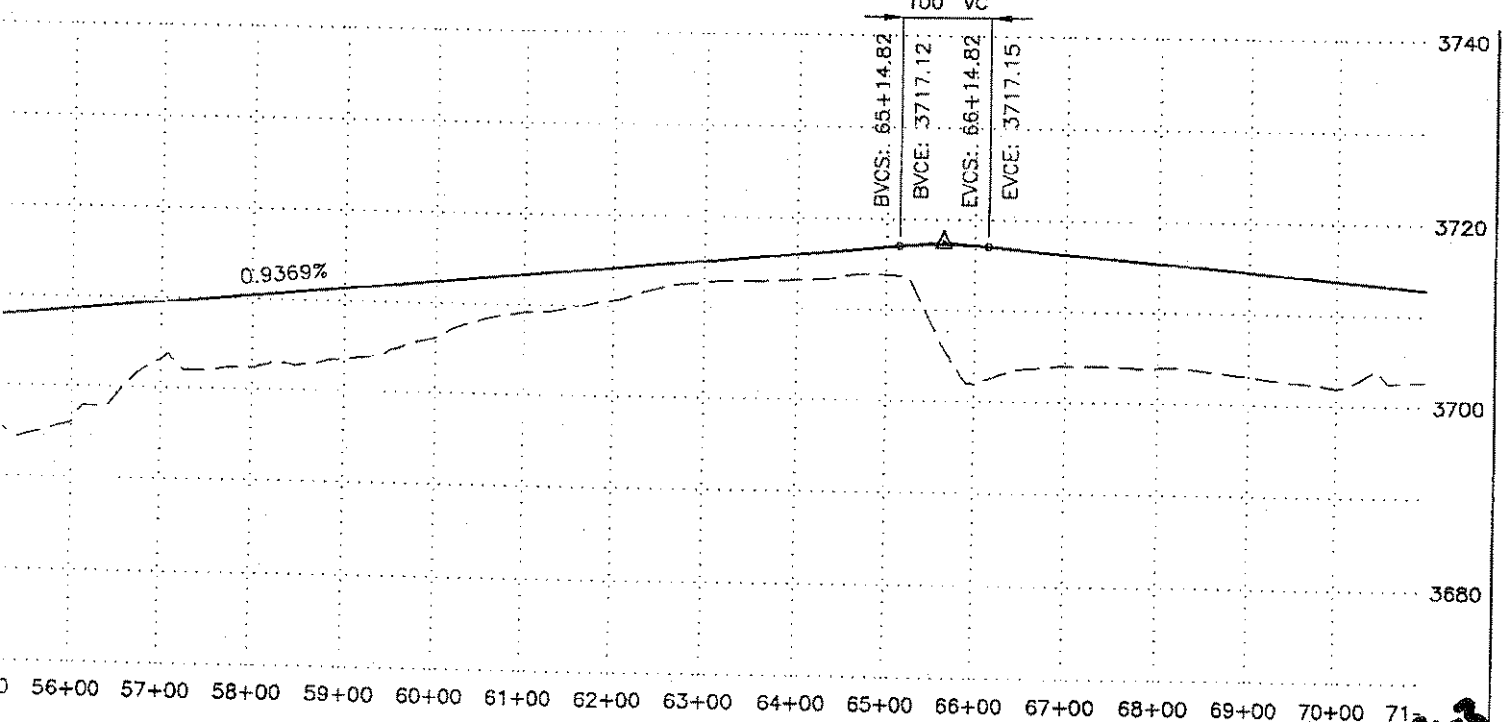
G. Friesen Associates, Inc.  
 4988 Orchard Drive  
 Lake Oswego, Oregon 97075  
 Tel: (503) 635-1233  
 Fax: (503) 635-1447

1702.21  
 +26.49  
 .67  
 .34

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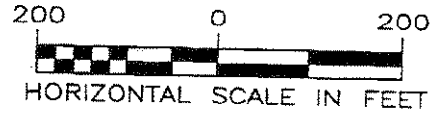
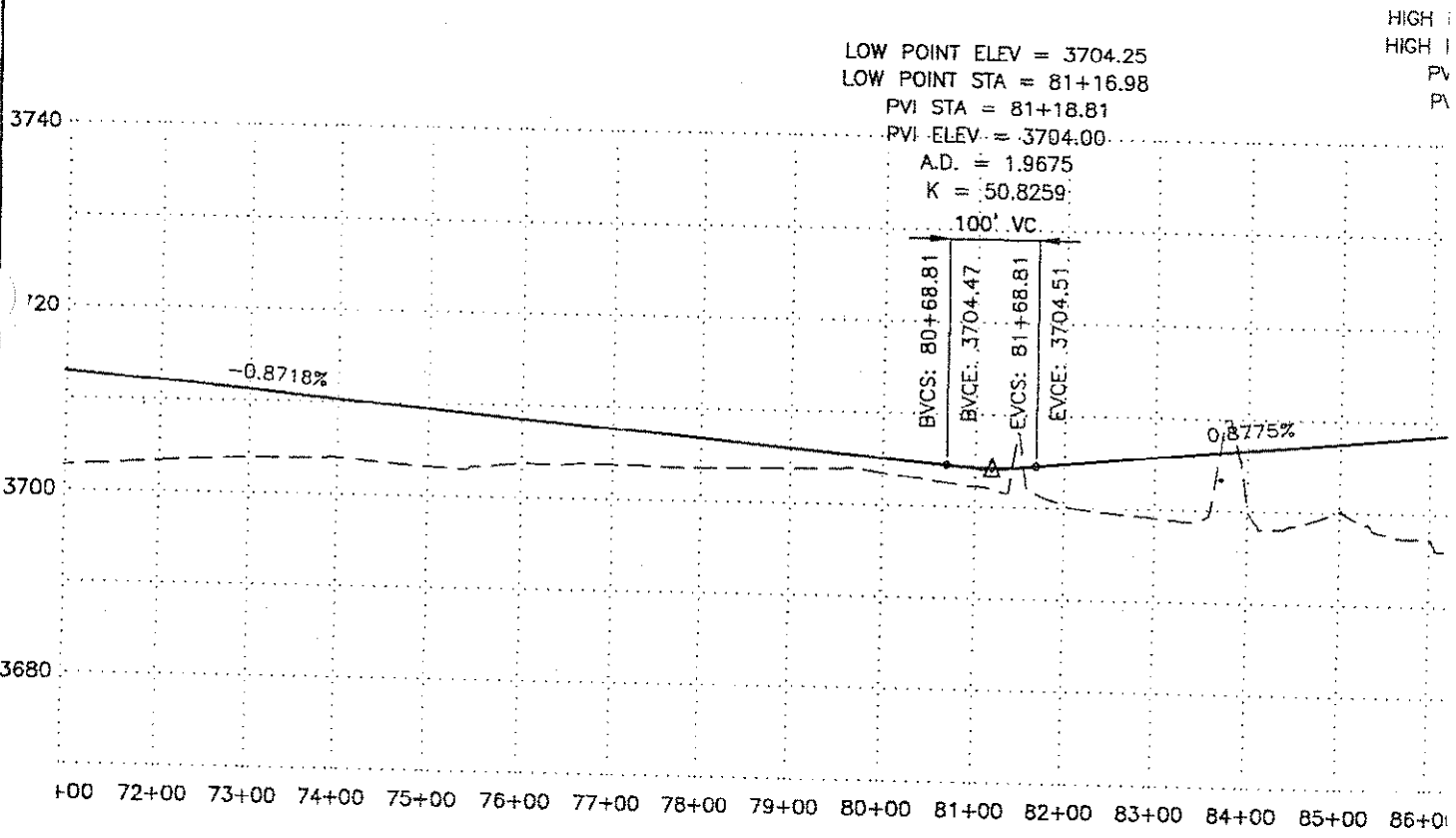
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 K = 55.0837



<p>111 S.W. Columbia, Suite 900          Portland, Oregon 97201          (tel) 503-222-7200          (fax) 503-222-4292</p>	<p><b>DESCHUTES COUNTY</b></p>	<p><b>Knott Landfill Site Development Plan</b></p>	<p>DRAWING NUMBER:  <b>Figure 22</b></p>
	<p><b>DEPARTMENT OF PUBLIC WORKS</b>          BEND, OREGON</p>		<p>PERIMETER ROAD PROFILE          STA 10+00 TO STA 71+00</p>
			<p>CAD FILE NUMBER:          FIG 3-2</p>
			<p>SHEET: OF      REV. A</p>



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HIGH I  
HIGH I  
PV  
PV

				JOB No.	DESIGNED: GF	PROJ. ENGINEER:	
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A	5/01/03	CAS	FOR CLIENT REVIEW				
No.	DATE	BY	REVISION				



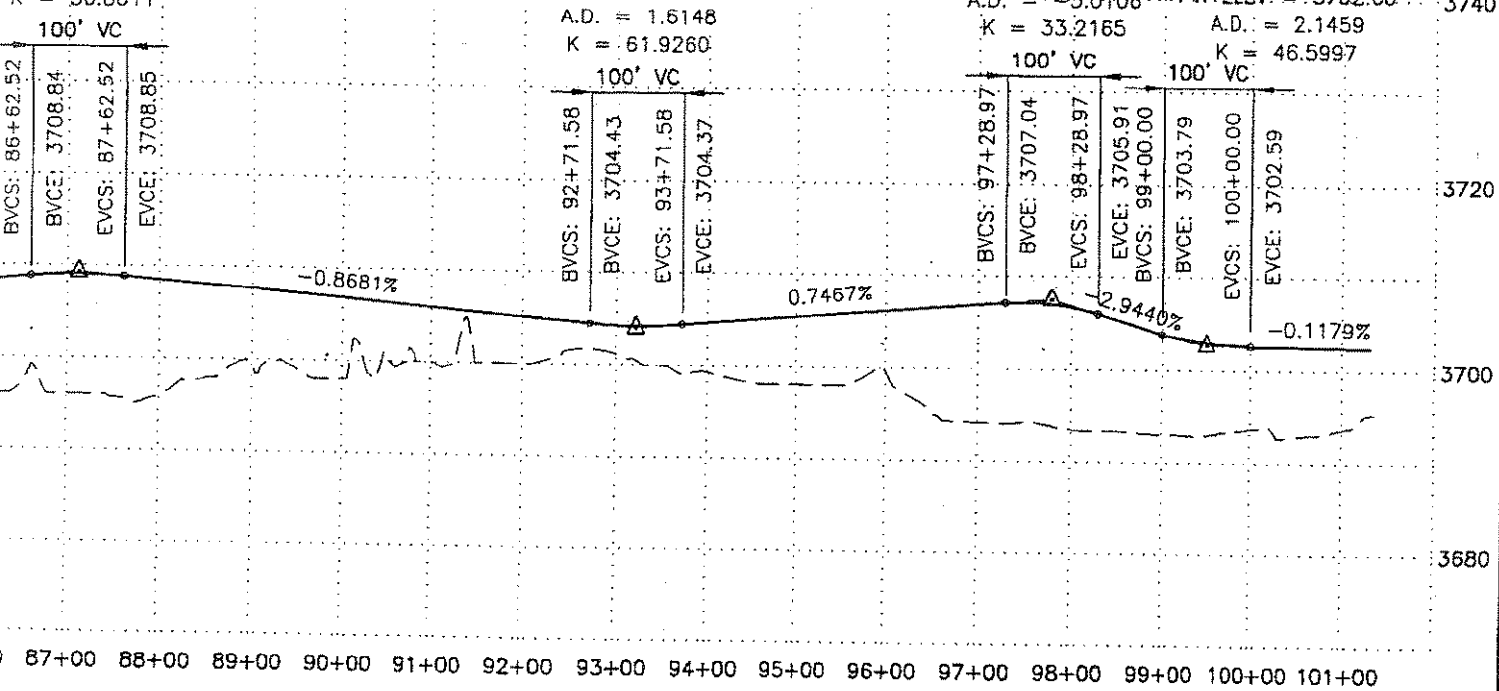
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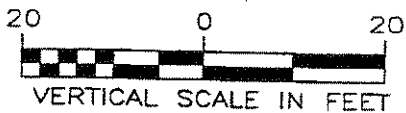
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 PVI ELEV = 3707.42  
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 PVI ELEV = 3702.60



PROFILE



3-4

<b>URS</b> 111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292	<b>DESCHUTES COUNTY</b>	Knott Landfill Site Development Plan  PERIMETER ROAD PROFILE STA 71+00 TO STA 101+00	DRAWING NUMBER: <b>Figure 3-3</b>
	DEPARTMENT OF PUBLIC WORKS BEND, OREGON		CAD FILE NUMBER: FIG 3-3
			SHEET: OF REV. A

**Section Six:  
Landfill Gas Management**

## 6.1 INTRODUCTION

The decomposition of solid waste generates landfill gases that must be managed and monitored. The composition and volume of the gas generated is dependent on many factors, which include landfill oxygen levels, moisture content, temperature, the age of the waste, and the organic make-up of the solid waste undergoing decomposition. The primary gases produced by anaerobic waste decomposition are methane and carbon dioxide. Other gases include hydrogen, mercaptans, and volatile organics. Landfill gas (LFG) control systems are generally designed to control the emission and migration of methane. Methane is a colorless, odorless gas that can migrate through surrounding soils and accumulate to explosive levels in enclosed areas.

In 2001, Deschutes County installed an active LFG control system at the Knott Landfill to minimize the potential for lateral migration of LFG from the Phase IB landfill area. The Phase IB area is an unlined MSW fill area in which the County installed a series of perimeter gas wells to extract landfill gas along the southern boundary. The current landfill phase, Phase IIB, is a lined MSW fill area that is compliant with Subtitle D requirements. As the landfill continues to develop, LFG control systems will be put in place to limit LFG emissions and migration.

A system for monitoring the areas surrounding the landfill is planned to ensure that the control systems are functioning to limit the potential for lateral LFG migration. The monitoring system is discussed in Section 7.

Development of the LFG control system design was based on consideration of the following factors:

- site conditions that affect the potential for, and risk associated with, gas migration,
- estimates of the rates and volumes of LFG that are likely to be generated, and
- a monitoring program that will enable the County to monitor lateral gas migration.

## 6.2 SITE LOCATION AND HISTORY

Knott Landfill is located at the intersection of SE 27th Street and Rickard Road in Bend, Oregon (Figure 6-1). The landfill is currently operated by the Deschutes County Department of Solid Waste. Prior to 1972 the area was utilized as a quarry. From 1972 to 1996 the County disposed of municipal solid waste (MSW) in a 21.65-acre disposal area, referred to as the Phase IB area. Since that time, MSW has been disposed of in the 23.84-acre Phase IIB area, located in the south-central portion of the site. The County also disposes of non-MSW in a separate area at the site that is located north and east of Phase IB.

To date, approximately 1.4 million cubic yards (through 2001) of solid waste has been disposed of at the landfill.

Phase IB served as the primary disposal site for municipal solid waste in Deschutes County from 1972 to 1996. This unlined portion of the landfill is located within a former rock quarry, and contains refuse extending to a depth of 90 feet or more below the top of the landfill cell, approximately 60-70 feet below the natural grade. An interim soil cover of between 18 and 36 inches has been placed on top of Phase IB.

In 1996, the County started Phase IIB (Cell 1) by developing a new landfill cell adjacent to (west) Phase IB. The bottom of this Phase IIB was lined using a RCRA Subtitle D compliant liner system. Phase IIB is approximately 80-100 feet below the natural grade.

Future phases of the landfill will extend the overall landfill life to 2026. These phases are expected to range in depth from 80 to 120 feet below existing grade, and will bring the total remaining capacity of the landfill to 8 million cubic yards.

Knott Landfill site features are depicted in Figure 6-1.

### **6.3 LANDFILL GAS MONITORING RESULTS**

In the fall of 2000, the County conducted LFG monitoring using barhole sampling techniques over the surface of Phase IB. No odor problems were detected, and barhole results did not detect appreciable quantities of methane gas.

In January 2001, URS installed a series of nine LFG monitoring probes, around the landfill perimeter, to determine if LFG was migrating beyond the Knott Landfill property boundary. Monitoring data, obtained from these probes, indicated the presence of LFG beyond the landfill's southern property boundary. In particular, elevated LFG concentrations were detected south of the unlined Phase IB footprint in both the upper and lower screened areas of monitoring probes GP-2 and GP-3. The presence of LFG detected in these probes was not compliant with the County's solid waste disposal permit issued by the DEQ. It also represented a potential safety concern to nearby off-site residences.

LFG generated within the unlined portion of Phase IB is the likely source of the LFG migrating off-site from the southern property line. The geologic formation at the southern edge of the landfill is comprised of unconsolidated materials and fractures in the surrounding bedrock. Bedrock in the vicinity of Knott Landfill consists of multiple basalt flows interbedded with sand or gravel/cinder layers. The sand and gravel/cinder layers provide a likely conduit for the lateral migration of landfill gas.

Operations at Knott Landfill are regulated by DEQ through the facility's solid waste disposal permit (Permit Number 6). The permit directly addresses LFG migration, stating, "Landfill decomposition gasses shall be controlled such that nuisance odors are minimized and the methane concentration does not exceed 1.25 percent within on-site structures or exceed 5 percent of the soil atmosphere beyond the landfill property boundary". If such conditions exist, the permit language indicates that the landfill operator must take corrective measures to protect human health and comply with the concentration limits listed above.

In response to this requirement, the County installed an active gas control system in September and October of 2001. The installed system is discussed in more detail in Section 6.4.1. Operation of the system has resulted in the reduction of LFG in the gas monitoring probes along the landfill boundary to be within permit requirements.

## **6.4 TYPES OF LANDFILL GAS CONTROL SYSTEMS**

Landfill gas control systems can be used to control LFG migration through soils adjacent to the landfill. Constructed systems are classified as either active or passive as described below.

### **6.4.1 Passive Gas Systems**

Passive gas collection systems rely on pressure and/or concentration gradients within the landfill to drive the movement of gas to and through vents and/or low-permeability materials in trenches. Passive systems are generally suitable for small landfills (less than 40,000 cubic meters), when gas generation is low, or when the potential for off-site migration is low. Passive gas collection systems are also well suited for landfills with geomembrane liners, which provide a barrier to lateral LFG migration. When a geomembrane liner is used, LFG migrates vertically and vents through the landfill cover. A system for venting the LFG must be designed if a geomembrane is also used in the cover to prevent the build-up of excessive gas pressure beneath the geomembrane that could compromise the integrity of the cover system.

### **6.4.2 Active Gas Systems**

Active landfill gas collection systems rely on external energy to draw LFG out of the landfill to a collection system. Active systems consist of deep extraction wells and/or horizontal collection trenches. The system is connected to a blower by a header pipe and the extracted gas is released to the atmosphere, delivered for energy reuse purposes, or delivered to an on-site burner. Ultimate discharge of the gas depends on its chemical constituents, landfill proximity to communities, and regulatory requirements.

Based on the conditions at the site and on estimates of landfill gas generation rates, an active LFG collection system is planned for Knott Landfill, and is already installed within the Phase IB

area. As cells within the landfill phase are closed, the County will install an active gas collection system. A passive LFG control system may be installed on a temporary basis if it becomes necessary. A conceptual design for the system that is planned is discussed in Section 6.6.

## **6.5 ESTIMATES OF LANDFILL GAS GENERATION**

The generation of landfill gases occurs in four phases. The initial phase occurs as soon as the waste is placed into the cell and involves the aerobic decomposition of organic waste. The second phase begins as the oxygen levels in the waste are depleted and alternative electron acceptors, such as nitrate and sulfate, are used in biological reactions. During the third phase methane generation exceeds carbon dioxide generation as fermentation by methanogenic bacteria becomes dominant. The final phase of landfill gas production begins as overall gas generation declines due to depletion of readily degradable organics and the loss of available nutrients.

Landfill gas collection systems are designed based on the expected volumes and rates of methane and carbon dioxide production because they represent the vast majority of the gases that will be produced.

### **6.5.1 LFG Rate Modeling**

The total volume of LFG that theoretically can be generated at a landfill based on stoichiometric and biodegradability relationships is about five to eight cubic feet per pound (5 to 8 ft<sup>3</sup>/lb) of typical municipal refuse. The volume of LFG actually generated will generally be less than theoretical estimates because not all the waste will be degraded. In addition, some organics will be lost to cell synthesis and some refuse will decompose to end products other than methane and carbon dioxide. Estimates of actual gas generation levels range from one-third to two-thirds of the total theoretical volume predicted (McBean et al., 1995).

Moisture plays an important role in the degradation process and can be a limiting factor in the generation of LFG. For complete waste degradation, optimum moisture conditions would be required. Optimum moisture condition estimates for degradation of landfill waste range from 50 percent to 100 percent of the waste's dry weight. The Knott Landfill is located in an arid or desert climate and optimum moisture conditions are not expected. It is therefore assumed that the total volume of LFG generated at the Knott Landfill facility will be significantly lower than theoretical volumes.

Two solid waste industry standard gas generation models were used to estimate LFG generation rates. Both models can be modified based on the known characteristics of disposed waste (nature, volume, age, and relative moisture content). One of the models used to calculate LFG production is the Landfill Gas Emissions Model (LFGEM) Version 2.0 authored by Radian International and prepared for the United States Environmental Protection Agency (EPA). This

model can be run using site specific data for the parameters needed to estimate emissions or, if no site-specific data are available, default values are used. There are two sets of default values. One set of default values is for estimating emissions to determine the applicability of the Clean Air Act (CAA) regulations for MSW landfill emissions (the CAA defaults). This model was developed as part of the New Source Performance Standards (NSPS) for new and existing MSW landfills to generate conservatively high estimates of LFG and non-methane organic compounds production rates. The other set of default values is based on emissions factors in the US EPA's Compilation of Air Pollutant Emission Factors, AP-42. Both sets of default values can be used to produce air emission estimates in the absence of site-specific test data. The users manual for LFGEM also includes additional default values that can be used to generate estimates for landfills in arid climates (receiving less than 25 inches of precipitation each year).

The second model used for this evaluation was the Energy Project Landfill Gas Utilization Software (E-PLUS) Version 1.0. ICF Consulting Associates, Inc., (January 1997) prepared this model for the Atmospheric Pollution Prevention Division of the U.S. EPA. The purpose of this model is to assist developers in evaluating the cost effectiveness of converting LFG to energy. Therefore, it uses default values that will predict more realistic, if not conservatively low, LFG generation rates.

Both methane generation models are based on first order decay equations. They estimate methane quantities based on two parameters:  $L_0$ , the potential methane generation capacity of the refuse, and  $k$ , the methane generation rate constant, which accounts for how quickly the methane generation rate decreases once it reaches its peak rate. The methane generation rate is assumed to be at its peak upon closure of the landfill. The  $L_0$  and  $k$  can be obtained from site specific data or using additional program default values. The methane generation rate,  $k$ , determines the rate of methane generation for each annual mass of refuse (or packet of refuse) in the landfill. The higher the value of  $k$ , the faster the methane generation rate increases and then decays over time. The value of  $k$  is a function of numerous site-specific factors.

The arid climate default  $k$  and  $L_0$  values for each of these models were used to estimate an upper and lower range of LFG quantities expected to be generated through the life of the currently permitted landfill. The models also both assume carbon dioxide emissions and methane are the same and the total landfill gas emissions equals the combination of both.

### 6.5.2 LFG Rate Estimate

The estimated rate of methane produced is highest at closure (2026) and decreases asymptotically with time. The projected maximum rate of methane produced  $506 \times 10^6$  ft<sup>3</sup>/yr using the CAA arid climate default values (conservatively high). Use of the E-Plus arid climate default values results in a smaller maximum rate of estimated methane production  $376 \times 10^6$  ft<sup>3</sup>/yr (approximately 74% of the gas generation estimate using the CAA arid climate default



value). Assuming that methane comprises 50% (by volume) of the LFG produced the amount of landfill gas generated at its peak is estimated to be 1924 standard cubic feet per minute (cfm) using CAA default values. At the lower generation rate the amount of landfill gas is estimated to be 1430 cfm.

As shown by these two models, LFG production is significant. Since Knott Landfill is located in an area that average annually receives 12-inches per year, decomposition rates will tend to be slower. Recirculation of leachate within the lined cells will enhance gas production.

The County will utilize gas flow data from the existing LFG extraction system in designing the future LFG control/recovery systems. The landfill gas estimates will be updated from time to time as the landfill continues to develop.

## **6.6 LFG CONTROL SYSTEM DESIGN**

The following sections present alternatives and considerations relative to the selection, design, and construction of various components of the active LFG control system for the Knott Landfill facility. At this stage in the design process it is not feasible to select final alternatives for some components of the system. Therefore, a general presentation of many design details is warranted. Sizing for specific system components will be conducted during the final design process, after selection of the complete system has been made. Where practical, specific criteria for the final design are presented.

Since the landfill occupies approximately 135 acres and is expected to operate until 2029, it may not be feasible to have a single LFG control system. Instead, several cells may have an individual control system or several adjacent cells may share a common LFG control system. The LFG control system for each cell will be designed as the cell is designed, using the current technologies and practices available at the time. During design, the County will review the quality of landfill gas that is expected to be produced to determine the appropriate end-use of the gas, i.e. burn in flare or energy recovery. Additionally, during operation, the County will periodically review the quality of landfill gas being produced and reassess the end-use of the landfill gas.

The following general criteria will be considered when the final collection system is designed:

- Capable of handling the maximum gas generation rate predicted over the life of the landfill cell.
- Monitorable and adjustable to accommodate variations in gas generation and other parameters.
- Expandable as needed to collect gas from future MSW disposal areas.

- Components of the systems should be relocatable as older cells stabilize and methane production reduces to be within acceptable levels for handling by other means.

### 6.6.1 Existing Control System

In October 2001, Deschutes County installed an active LFG extraction system along the southern boundary of Phase IB. The purpose of this system is to control the off-site migration of LFG, which was identified in monitoring probes south of Phase IB. The extraction system consists of a total of nine dual completion extraction wells connected to a temporary flare/blower unit via a header piping system.

Six wells are located along the southern boundary of Phase IB and serve to capture LFG before migrating offsite to the south. The remaining three wells were installed in the interior portion of the landfill parallel to and approximately 150 feet north of the six perimeter wells. These wells compliment the six perimeter wells, and will be used to supplement LFG, as methane gas concentrations decrease along the southern property boundary.

LFG extracted from the landfill is pulled under vacuum to a skid mounted flare unit, where it is burned. The temporary flare unit is located to the west of the existing non-MSW Disposal Area. A by-product of the extraction/collection system operation is the generation of condensate. Condensate is generated as a result of warm landfill gas (typically 80° to 90° F) coming in contact with cooler surface temperatures, which causes water vapor to condense and drop out of the LFG. Condensate in the existing control system collects in the header system and is drained by gravity to either a sump or “knockout” tank. Once a sufficient volume of condensate has accumulated in the tanks, it is pumped to the leachate sump in Cell 1 of Phase IIB, which is a lined area. Pending an initial observation period, condensate may be re-circulated within the lined portion of Cell 1 rather than mixed with the landfill leachate, or pumped directly into trucks for treatment.

### 6.6.2 Landfill Conditions

An active LFG control system is proposed for the future phases within the Knott Landfill. An active landfill gas collection system is appropriate due to the large gas generation potential of the landfill to comply with Title V emission regulations, and to reduce odors from the landfill. The design of the control system will be based on the following issues and considerations:

- **Geomembrane Liner.** The geomembrane bottom liner in Phase IIB will serve as a physical barrier to lateral gas migration and will promote the vertical movement of LFG within the landfill.

- **Porous Daily Cover.** The material to be used for daily cover within the landfill cells will be taken from the site's natural soils, which are relatively porous. Such porous media will provide routes for movement of LFG within the landfill to the collection trenches and wells.
- **Site Geology.** Bedrock in the vicinity of Knott Landfill consists of multiple basalt flows interbedded with sand or gravel/cinder layers. Prior to use as a solid waste disposal facility, the Knott Landfill site was used as a gravel pit. The gravel/cinder layers can act as a conduit for the lateral migration of LFG, if present.
- **Hydrogeology.** Groundwater can be found approximately 700 ft. below ground surface, and flows to the north and slightly northeast. Due to the depth of the water and the landfill liner, it is very unlikely that landfill gas from the Phase IIB cells could contaminate the groundwater.
- **Environmental Conditions.** The Bend area is located in an area of high desert prairie, which typically received less than 15 inches of precipitation per year, with maximum precipitation occurring during the winter months. It is expected that the low amount of moisture entering the landfill from the atmosphere will limit the ultimate generation of LFG. Due to the arid climate in Bend, soil moisture is typically very low. Additionally, there is not sufficient moisture within the landfill to interfere with the migration of LFG to the collection trenches or wells within the landfill.
- **Land Use.** The area immediately surrounding Knott Landfill is primarily rural, with single family residences and a sand and gravel quarry located to the south and southeast of the facility. A middle school is located approximately ½ mile northwest of the site. Central Electric Co-op and Deschutes Department of Public Works facilities are located to the north. East of the landfill is an electric company substation, with undeveloped land beyond.
- **On-Site Structures.** Currently, the recycling area, composting operation, and the solid waste administrative offices occupy the northwest corner of the landfill property, which is intended to become part of the landfill in future phases. These operations and associated structures will be relocated to an area north of the landfill property in 2004-05.
- **LFG Monitoring Plan.** The facility will implement the LFG monitoring plan proposed in Section 6 of this design report. The plan will facilitate early detection of the lateral migration of LFG from the landfill.
- **Landfill Depth.** The Knott Landfill will be filled to a total depth of 80 to 120 feet. As landfill depth increases, the effectiveness of a passive collection system decreases since gas produced within the landfill would have to permeate through nearly the entire vertical

depth of the compacted waste in the landfill. With a landfill this deep, collection trenches can be installed at several lifts within the landfill, allowing collection at multiple elevations within the landfill.

Due to the absence of field test data to determine actual extraction capabilities for the wells, typical criteria for municipal solid waste are utilized in the conceptual design.

### **6.6.3 LFG Control System Components**

The active LFG control system will be made up of several components, including horizontal and/or vertical extraction wells, header pipe, condensate driplegs, blowers, and a flare or energy recovery component. LFG would be collected mainly through a series of horizontal extraction wells, which could be augmented with vertical extraction wells as needed. The gas would be pulled through the header pipe by a blower(s) and delivered to a flare or energy recovery unit (electricity or fuel production). Below is a discussion of the control system components and their design factors as they apply at Knott Landfill.

### **6.6.4 Horizontal Extraction Wells**

The system would consist of deep horizontal extraction wells as a method for active landfill gas extraction. For the Knott Landfill design, well trenches would be constructed after completion of the second cell lift. Each trench would be about 4 feet deep and 2 feet wide. A perforated polyethylene pipe would be placed in the middle of the trench, which would be back filled with aggregate. Some landfills have substituted crushed glass for aggregate to facilitate recycling of glass material, which has limited markets as a recycled material. Crushed glass acts as a porous media similar to gravel, allowing gas to travel within the trench to the openings in the polyethylene pipe. Each end of the horizontal pipe is connected to a non-perforated riser pipe, which extends out of the landfill cell and connects to the header pipe.

A significant advantage of horizontal collection systems is that they can be constructed as the landfill is filled and the installation can be conducted by landfill personnel. Figure 6-2 shows the configuration of the trench and placement of perforated pipe. To allow for refuse settlement, the pipe lengths are constructed from alternating 40-foot lengths of varying diameters such as 6-inch and 8-inch diameter HDPE pipe.

It is difficult, in the absence of field test data, to determine appropriate spacing for horizontal collection trenches. In addition, a problem associated with horizontal collection trenches is the significant loss of vacuum along the length of the perforated pipe. Horizontal collection trenches are most efficient when placed deep in the landfill and spaced closely together. When LFG is extracted for energy reuse, system designs weigh system efficiencies against construction costs

to determine appropriate spacing. For systems where efficiencies are less critical, cost considerations weigh more heavily.

### **6.6.5 Vertical Extraction Wells**

The vertical extraction wells would extend through 80 to 90% of the landfill thickness. The well boreholes would be at least 24 inches in diameter. The well casings would be constructed of 6-inch to 8-inch diameter PVC or HDPE pipe.

Alternatively, the extraction wells may be constructed as dual completion wells. Dual completion wells consist of two wells screened at different intervals within the same borehole. At locations where soil was not encountered, the deeper well was screened within the bottom portion of the refuse (typically 90 to 70 feet bgs), and the shallow well was screened higher up in the refuse (typically 50 to 20 feet bgs). The use of dual completion wells allows for more control over gas extraction locations. By adjusting the flow at individual wells at various elevations, LFG can be removed from specific zones within the refuse. The existing vertical extraction wells are dual completion wells. Figure 6-4 shows a typical detail for a dual completion vertical extraction well.

With the absence of field test data to determine an appropriate radius of influence, a typical radius of influence for layout of vertical extraction wells is 150 ft. The wells should be spaced so that the radii of influence for adjacent wells overlap.

The vertical extraction wells will be installed to augment the horizontal extraction wells. Site-specific radius of influence values will be obtained from the existing vertical extraction wells, in multiple areas, as available at the time of the design for each control system. This methodology provides the County with the opportunity to tailor the design specifically to the cell in question, allowing for a more efficient and economical design.

### **6.6.6 Header Pipe**

A header pipe will be used to connect the active LFG extraction system (horizontal and vertical wells) to a blower. The header pipe will be a non-perforated HDPE pipe embedded in a sand-filled trench. The top of the trench will be about six inches below the final cover layers and will be covered with a geotextile fabric. The trench dimension will vary depending on the distance to transport landfill gas to flare systems or energy recovery facilities and vary depending on header location/direction. The header pipe will be located in the center of the trench and will have a 4% slope between driplegs to promote condensate drainage. A tracing wire will be located in the trench above the pipe. Figure 6-5 shows the detail for a typical header pipe and trench.

### 6.6.7 Condensate Dripleg

Moisture in LFG forms a liquid called condensate that must be removed from the header pipe system. The condensate can be released back into the landfill refuse or removed for treatment with the landfill leachate. Release of the condensate back into the landfill refuse is planned since it is expected that the landfill refuse will be relatively dry (by landfill standards) and will easily absorb the condensate volumes generated. Additionally, the added moisture from the condensate will help promote decomposition of waste within the landfill. Figure 6-5 shows the detail for a typical condensate dripleg. The driplegs will be spaced no more than 600 feet apart along the header pipe length. A condensate trap should be installed in the header pipe system prior to its connection to the blower.

### 6.6.8 Blowers

Selection and design details for a blower will be determined based on the configuration of the final system. The blower size will be based on calculations of total negative head required and the volume of gas to be extracted. The selected extraction system must be fully designed before these calculations can be made. Some conceptual considerations are summarized below.

- The blower should be located at an elevation slightly higher than the end of the header pipe to facilitate condensate removal.
- A three-phase electrical connection is generally required for blowers needing larger than a 5-horsepower motor.
- The blower system should have 100% standby (backup) capability.

### 6.6.9 Gas Flare

Due to the size of the landfill, LFG reuse (energy recovery) may be economical. It is likely that methane concentrations will not be low enough to allow venting to the atmosphere. Therefore a gas burner, or flare, would be needed as the primary destruction system or as backup to an energy recovery facility. Flares are generally required when LFG contains hazardous air contaminants that must be completely destroyed, when the generated volumes of LFG cannot simply be released to the atmosphere, or when enough LFG is generated such that energy recovery is a practical option. The flares installed at the landfill should be constructed so that they can be relocated after LFG production within a closed cell decreases to low enough levels to allow venting to the atmosphere. The flare can then be taken out of service and moved into a new location for use at another cell.

**6.7 LFG ENVIRONMENTAL MONITORING**

Lateral migration of landfill gas can be a concern because of the potentially explosive nature of methane. The dangers associated with gas migration increase substantially with development around the landfill and as buildings are constructed on adjacent properties. Since this landfill is to be fully lined with a geomembrane system, lateral migration of LFG is not expected to be a problem. To verify that migration is not occurring, the County will have an organized LFG monitoring program. A detailed discussion of the LFG monitoring program is included in Section 7.

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B	5/22/03	PCF	FOR CLIENT REVIEW

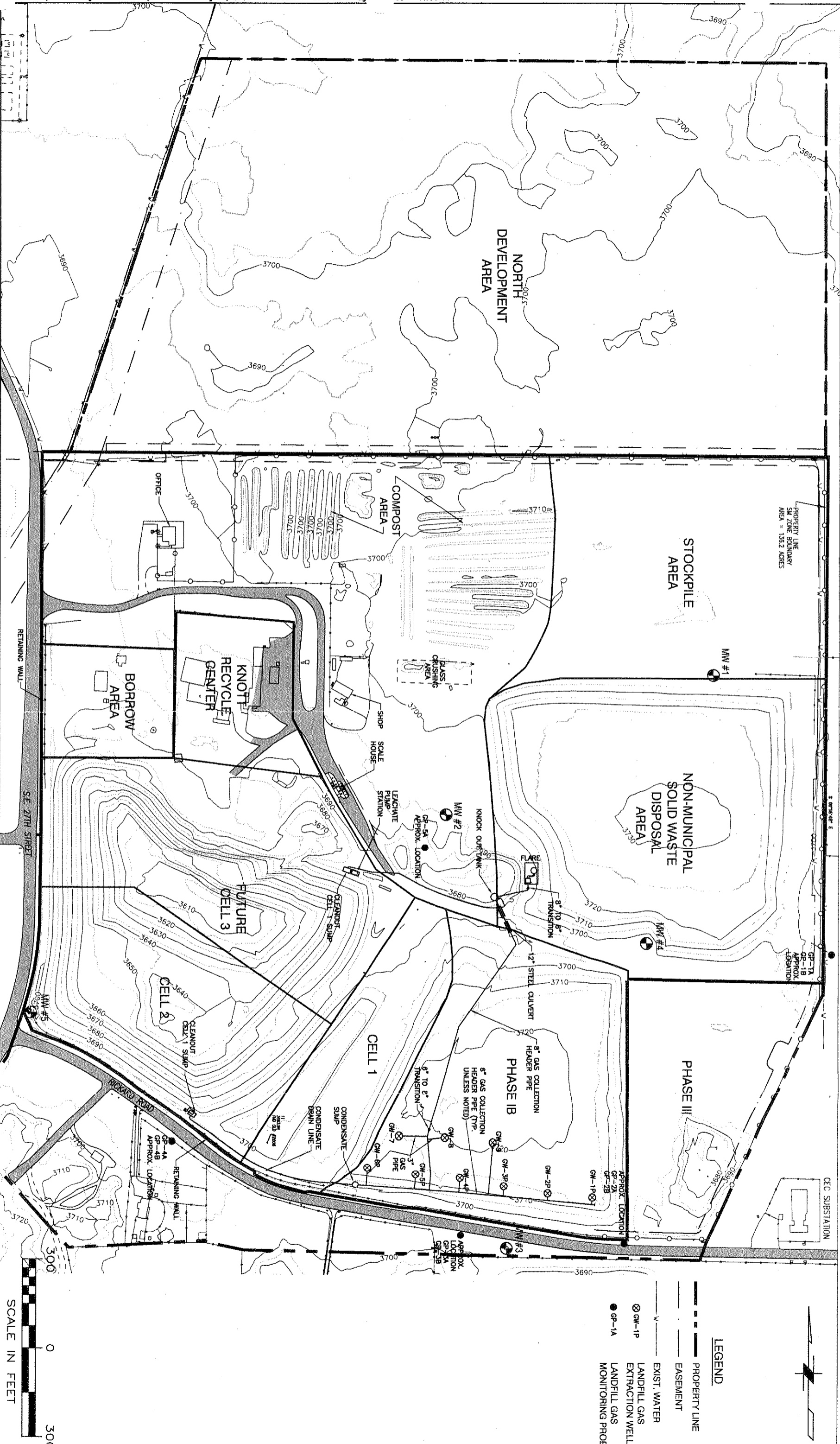
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111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292
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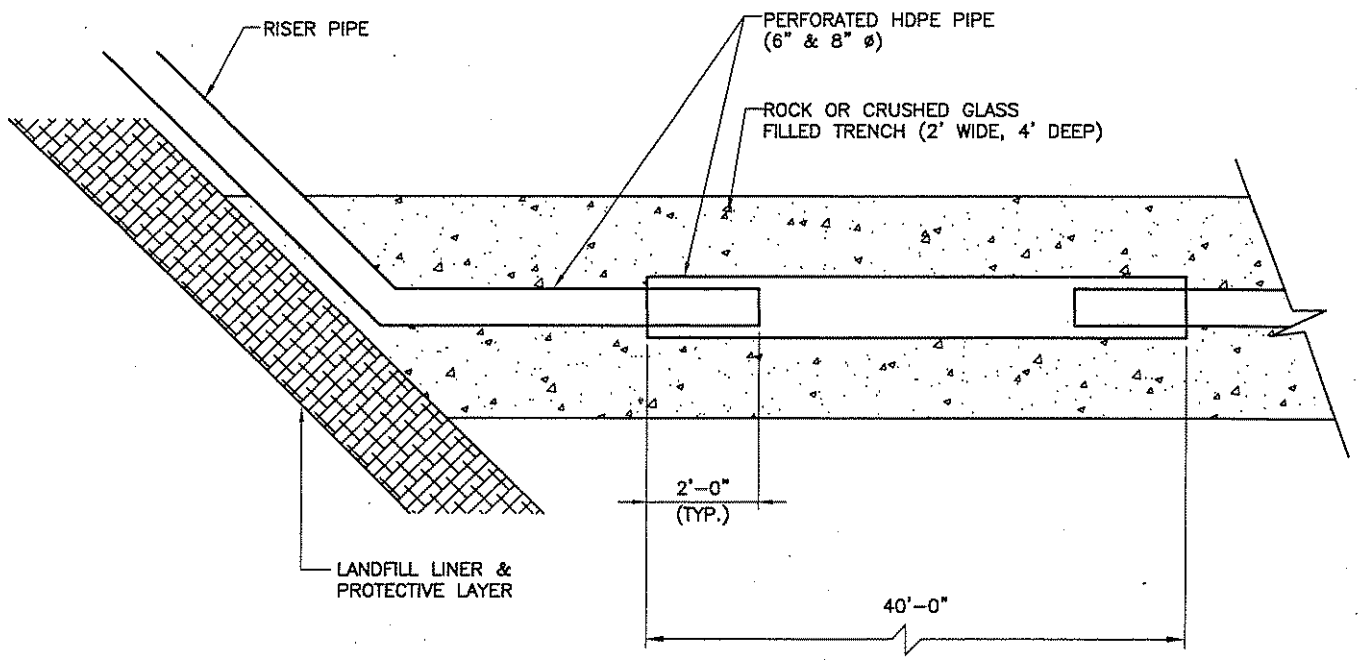
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Knott Landfill Site Development Plan  
EXISTING LANDFILL GAS  
MANAGEMENT FACILITIES

DRAWING NUMBER:	Figure 6-1
CAD FILE NUMBER:	FIG 6-1
SHEET:	B
OF	B







**TYPICAL HORIZONTAL GAS EXTRACTION WELLS**

SITE DEVELOPMENT PLAN  
 KNOTT LANDFILL  
 DESCHUTES COUNTY, OREGON

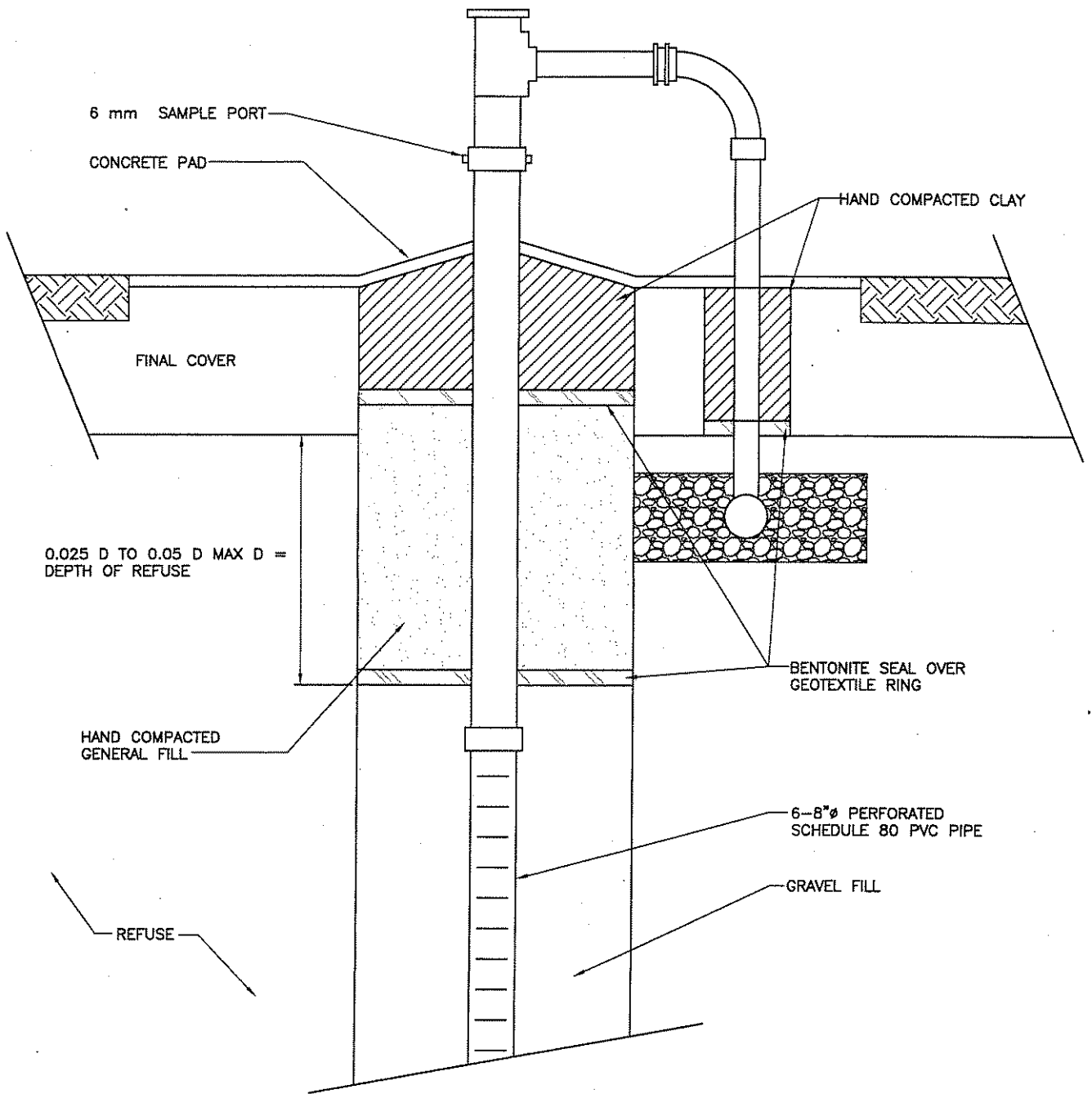
JULY 2003

**FIGURE 6-2**

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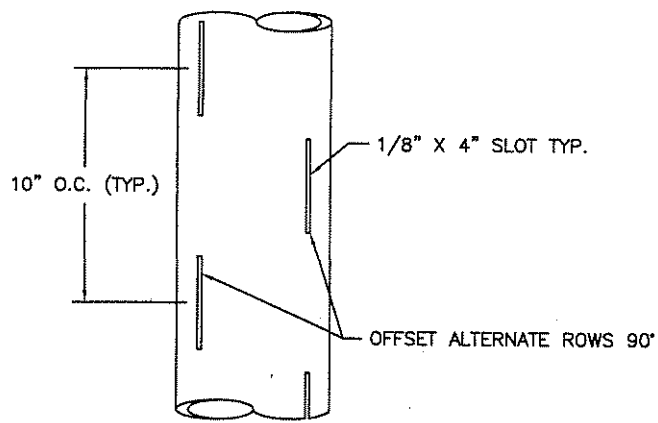
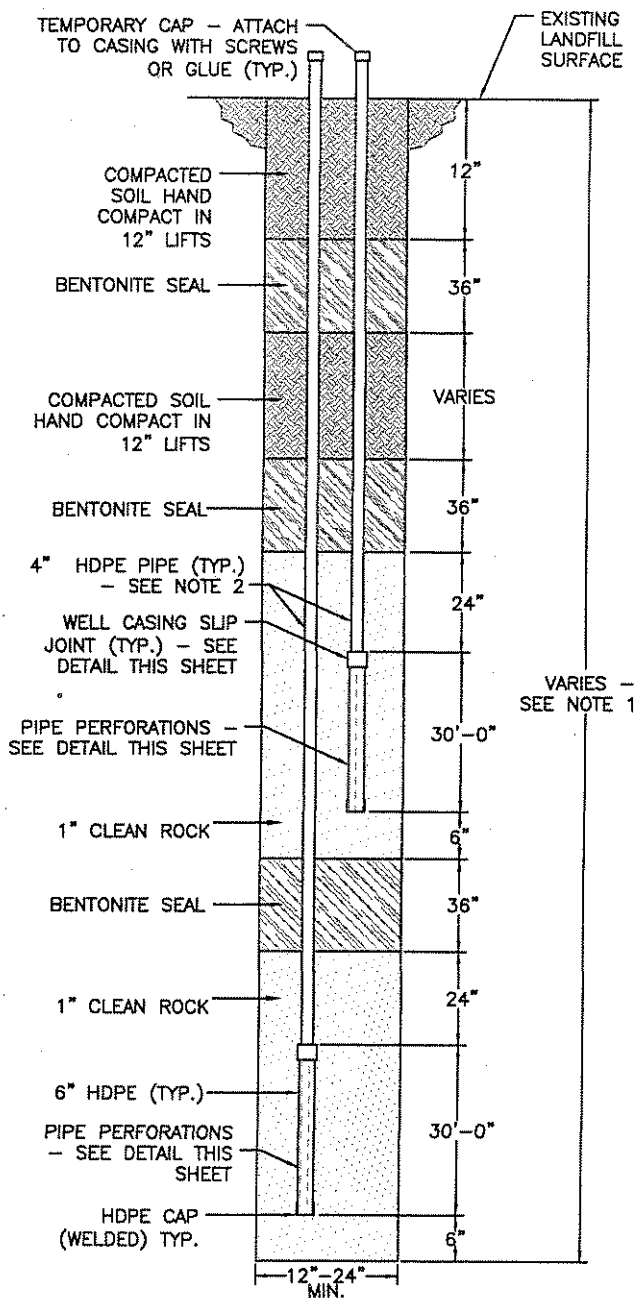


**TYPICAL VERTICAL GAS EXTRACTION WELL**

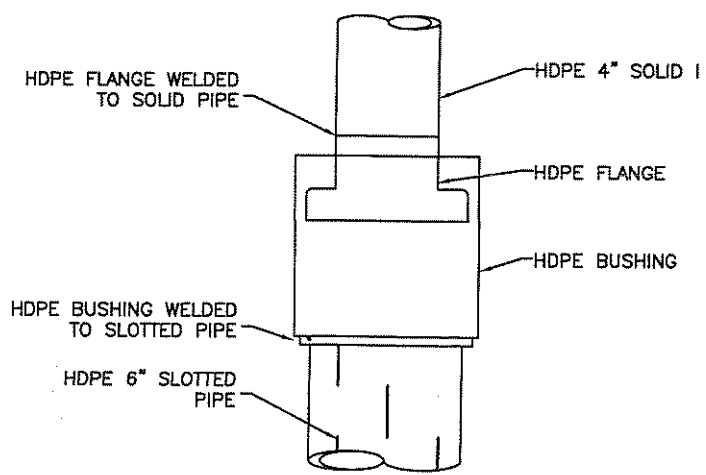
SITE DEVELOPMENT PLAN  
 KNOTT LANDFILL  
 DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 6-3**



**PIPE PERFORATIONS**  
N.T.S.



**WELL CASING SLIP JOINT**  
N.T.S.

**LFG DUAL COMPLETION  
VERTICAL EXTRACTION WELL**  
N.T.S.

**NOTES:**

1. SCREEN AND CASING LENGTHS VARY DEPENDING ON DEPTH OF WELL. SEE BORING LOGS FOR PRECISE INTERVALS.
2. NO WELD SEAM OR OTHER OBSTRUCTION SHALL BE PRESENT ON THE 4" PIPE THAT MIGHT HINDER ITS MOVEMENT IN THE TELESCOPING JOINT FOR A DISTANCE OF 20' ABOVE THE JOINT. HOLD 4" PIPE VERTICAL DURING BACKFILL.

**DUAL COMPLETION EXTRACTION WELL DETAILS**

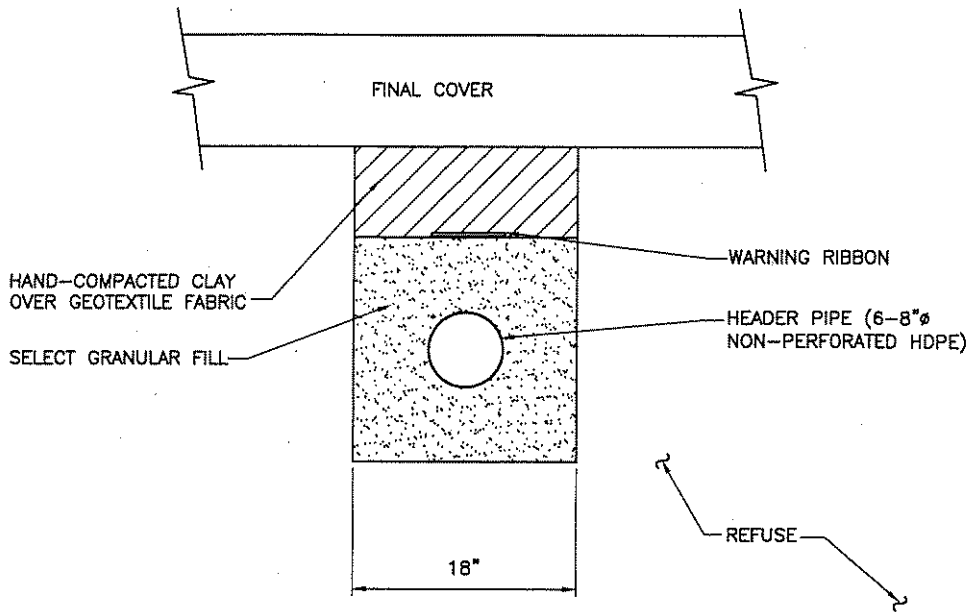
SITE DEVELOPMENT PLAN  
KNOTT LANDFILL  
DESCHUTES COUNTY, OREGON

JULY 2003

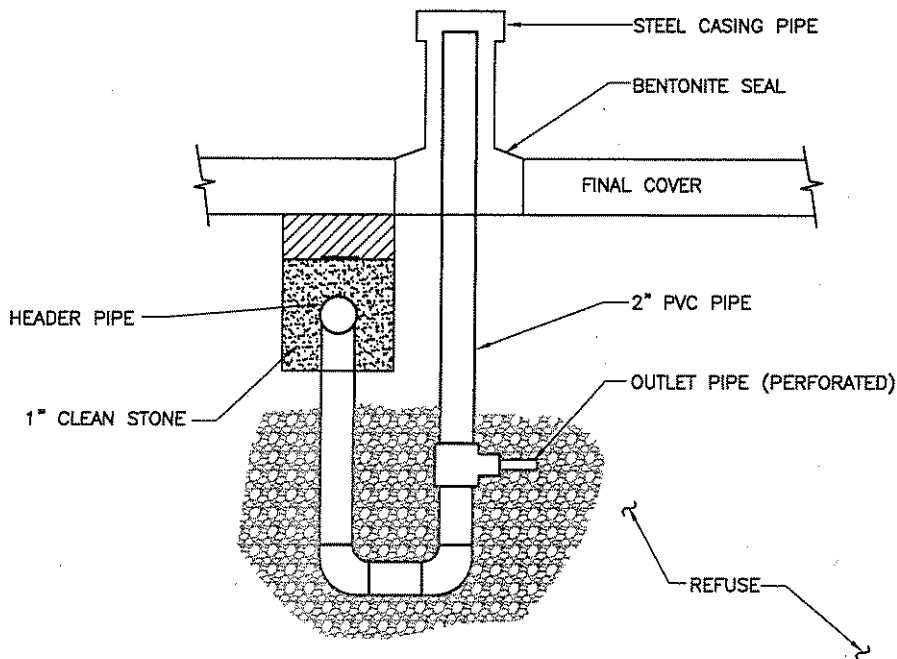
**FIGURE 6-4**



\V\FG 6-4.dwg Aug 01, 2003 -- 1:25pm  
 Deschutes County



**TYPICAL DETAIL OF LFG EXTRACTION HEADER PIPE & TRENCH**  
N.T.S.



**TYPICAL DRIPLEG DETAIL**  
N.T.S.

**LFG EXTRACTION HEADER DETAILS**

SITE DEVELOPMENT PLAN  
KNOTT LANDFILL  
DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 6-5**

**Section Seven:  
Environmental Monitoring**

As Knott Landfill is expanded, the existing environmental monitoring program will be expanded to assess the potential for impacts to the environment from site operations. This section describes the main components of the monitoring program and discusses the overall monitoring strategy and objectives. Furthermore, it provides a summary of the anticipated supplemental monitoring activities that will be utilized as Knott Landfill is expanded.

It is recognized that some of the details of the future monitoring activities may be revised from that described herein, as new information and data become available. These will be assessed relative to site conditions and expansion activities at the time of construction. For example, with the installation of each new groundwater monitoring well, additional water level data will increase the understanding and characterization of the groundwater flow patterns. Sequential well locations will be based on the best information available at the time each new well is constructed.

The following monitoring elements are addressed in this site development plan:

- Groundwater
- Surface Water
- Leachate
- Landfill Gas
- Air

In compliance with state and federal regulations (OAR 340-40, OAR 340-94, and 40 CFR Part 258), the Solid Waste Landfill Guidance Document, and the Permit (Knott Landfill Disposal Permit No. 6), an environmental monitoring plan (EMP) for the County has been developed for the landfill (URS, 2002). Included in this EMP is a description of the current environmental monitoring network and the methods and procedures for conducting environmental monitoring. Changes to the current environmental monitoring program necessary to accommodate future landfill expansion will be reflected in future versions of the EMP.

## **7.1 GROUNDWATER**

The existing groundwater monitoring network at Knott Landfill is comprised of five groundwater monitoring wells. Two of the wells are located hydraulically upgradient, south of all landfill disposal areas, and three are located downgradient of disposal areas. The wells were installed in two phases; monitoring wells MW-1 through MW-3 were installed in 1994, and wells MW-4 and MW-5 were installed in 1997.

As the landfill is expanded, additional wells will be installed to maintain compliance with the requirements of CFR 40 264.97, as discussed in Chapter 3.1.3 of the EMP. Point of compliance monitoring wells will be maintained downgradient from existing disposal cells and new wells will be installed downgradient of future cells. New well locations will be selected so that they intercept potential pathways for contaminant migration, based on the conceptual understanding of groundwater flow and the calculated groundwater flow direction. It is anticipated that at least two of the existing wells may need to be abandoned and replaced at alternative locations to be compatible with landfill operational requirements. Replacement wells will be located to serve the existing compliance monitoring function, but will also aim to address the monitoring needs of landfill expansion, to the extent practical.

Existing background wells will be maintained upgradient of the disposal cells to provide a representative measure of groundwater quality that is unaffected by landfill operations. If necessary, additional background wells will be installed.

The placement of all supplemental monitoring wells is based on the groundwater flow conceptual model described in the next section; however, the actual locations will consider operational needs such as the need to replace or relocate wells, and the phasing of landfill cell development.

### **7.1.1 Hydrogeologic Setting**

Below the thin soil cover at Knott Landfill is a sequence of young basalt flows, interflow rubble and cinders, and volcanic sediments that extends beyond the total depth explored by well drilling activities (Figure 7-1) (DEA, 1995). Groundwater is approximately 700 feet below ground surface, and flows to the north and slightly northeast (Figures 7-2 and 7-3). The horizontal hydraulic groundwater gradient is relatively subdued, as expressed by the 2002 Annual Monitoring Report estimate of 0.003 ft/ft (same for both Spring and Fall events). Fluctuations in groundwater levels over the past three monitoring events have been less than four feet in MW-1 through MW-5. Although pumping tests have not been performed at the site to characterize hydraulic conductivity, a test at a nearby well was estimated to be  $2 \times 10^{-3}$  ft/s (USGS, 2001). Using this hydraulic conductivity, a gradient of 0.003 ft/ft, and a porosity of 0.3, the horizontal flow velocity is estimated to be 600 feet/year.

### **7.1.2 Groundwater Flow Conceptual Model**

There are two important flow regimes to consider in siting compliance monitoring wells. The first is flow in the unsaturated zone, which determines where potential contaminants from the landfill will first encounter the groundwater table. The second is flow in the saturated zone, which determines which wells are upgradient (and used as background) and which are downgradient (and used for compliance).

*Flow in the Unsaturated Zone*

Unsaturated fluid flow and chemical transport in basalt flows, such as those underlying Knott Landfill, have been shown to depend on the location and hydraulic conductivity of faults, fractures, and interflow zones (Faybeshenko et al. 2000). A typical structural and lithologic section for the region includes multiple volcanic flows, each of which exhibits, from top to bottom, a highly fractured interflow zone of enhanced permeability, a densely-welded zone with low intrinsic permeability, and a second fractured layer. Field and numerical experiments demonstrate that infiltration in fractured rock proceeds from the preferential wetting of fractures to the slower absorption into the matrix (Su et al. 1999). Although permeable interflow zones can direct groundwater parallel to bedding, columnar joints and open fractures predominantly direct infiltrating groundwater downward in relatively flat-lying volcanics (Doughty, 2000).

Several arguments have been presented for a large vertical component to groundwater infiltration at Knott Landfill. First of all, well logs indicate the presence of vertical fractures within a relatively flat-lying sequence of basalt, cinder, pumice, silt, and sand underlying the site (Figure 7-1) (DEA, 1995). Secondly, groundwater levels in similar volcanic flows in the vicinity of Bend were found to respond within days to recharges from diversion canals, suggesting rapid vertical transport to the deep groundwater table (Gannett et al., 2000). Finally, evidence exists that confining layers potentially inhibiting vertical infiltration are absent at the site. Pumping tests from Bend indicate that underlying aquifers are likely unconfined, with high associated transmissivities (Gannett et al., 2000). Also, perched groundwater was not encountered during drilling above the saturated zone at the site (DEA, 1995).

In contrast to this evidence, data also exists for horizontal transport being more important than previously believed. For example, densely welded basalt flows potentially inhibiting vertical infiltration were recovered during monitoring well development (DEA, 1995). Also, some seeps have been observed in existing Knott Landfill cell excavations, indicating the presence of perched water over low permeability confining layers.

The most important parameter in selecting locations for monitoring wells is the relative vertical to horizontal transport component in the vadose zone. Although vertical fractures at the site will direct water downward, flow will follow the dip of interflow zones between these joints. Given the uncertainty in the number, orientation, and permeability of fractures at the site, the previous assertion that flow is predominantly vertical (DEA, 1995) is refutable.

*Flow in the Saturated Zone*

Groundwater flow within the saturated zone occurs in the direction of decreasing hydraulic head, which can either be vertical or horizontal. As demonstrated by hydrologic and hydrochemical characterization of the confined basalt aquifer at the Hanford Site, Washington, hydraulic



gradients result from topographic differences, zones of recharge/depletion, and structural/stratigraphic impediments such as fracture-filled faults (Spane and Webber, 1995). Lateral flow within favorable geologic units such as interlayer zones is expected to predominate in flat-lying basalt aquifers. A vertical flow component is possible where recharge is prevalent or confining layers are absent. In the Deschutes Basin, downward flow occurs in the vicinity of leaking irrigation canals (Gannett et al., 2000).

There are two normal faults that bound the landfill to the southwest and northeast (Peterson et al. 1976). Although fracture-filled coatings or fault gouge could potentially isolate the landfill hydrologically (Sholz and Anders, 1993), potentiometric measurements of groundwater at Knott Landfill (URS, 2002) indicates the hydraulic gradient at the site generally mirrors the regional gradient (i.e. southwest from MW-5 to northeast MW-1) (Figures 7-2 and 7-3). Based on the high transmissivities of fractured lava, interflow zones, and coarse-grained volcanoclastic sediments (Gannett et al., 2000), it is hypothesized that groundwater flows laterally in the saturated zone, along a path that is generally unimpeded along the southwest to northeast direction.

### **7.1.3 Proposed Stormwater Management System Influence on the Groundwater**

This section addresses the possible impacts of stormwater infiltration on groundwater, and the best management practice (BMP) which will be considered to protect water quality. Currently, infiltration of rainfall into the substrate tends to be evenly distributed across the existing Knott Landfill and the proposed future development areas. The model results discussed in Section 5.2 indicate that infiltration is limited to the upper several feet of soil, and that moisture is returned to the atmosphere by evapotranspiration (see Section 5). The groundwater elevation, as reported above, is generally at 700 feet below ground surface (3,000 feet MSL). During and after the proposed landfill expansion, infiltration will be reduced where the landfill is capped. Stormwater runoff will be directed to an impermeable perimeter channel and then to storage ponds (Surface Water Control System, Section 5.5). Three unlined storage ponds north of the lined landfill, shown in Figure 5-1, will receive the majority of the site's runoff.

URS evaluated surface water infiltration from the ponds using the runoff volume of the 25-year, 24-hour storm, which totals 598,000 cubic feet (i.e., the sum of pond volumes 1 through 3, Section 5.5.3). This analysis makes the conservative assumption that all of the runoff volume would enter the soil (vadose zone) at the location of a single pond. The topsoil is comprised of two layers approximately 10-50 feet of sand and silt. These are found on the surface and also underlying the Upper Basalt Unit, but within the uppermost 100 feet of the ground surface (see Table 1 and Geotechnical Figures, Section 4). This analysis estimates that infiltrating water will pass through at least 10 feet of the Sand and Silt Topsoil. The actual path of the water at each pond is unknown at this time due to the irregular topsoil and basalt patterns.

To evaluate water quality, the Green-Ampt equation (Tindall, Kunkel, 1999) was used to estimate the infiltration rate and time of contact of the stormwater within the estimated ten feet of Sand and Silt Topsoil. The contact time for the infiltrating water in the sand layer will be approximately 2 hours. Sand filters are common Best Management Practices to control stormwater pollution in suspended sediment. A typical recommended substrate depth is three feet. In this case, the runoff will pass through a depth of Sandy and Silt Topsoil material much greater than three feet judging by the records of the borings nearest the pond locations (Section 4).

The northeast flow of the groundwater follows a regional pattern (Section 5, and GANNETT, ET. AL, 2001). The existing and planned expansion to the monitoring plan is based upon the groundwater flow direction. To evaluate whether infiltrated runoff from the storage ponds may divert the flow of the local groundwater we compared the estimated maximum infiltration volume (598,000 cubic feet) to the irrigation water losses known to affect groundwater elevation (GANNETT, ET. AL, 2001). USGS estimated that irrigation water loss recharges the aquifer and raises the groundwater elevation in the vicinity. However, regionally, the flow of the groundwater remained unchanged, flowing to the northeast during the affected period. USGS also studied the local-scale water table fluctuations. Water elevation changes of approximately three feet per season (roughly six inches per three weeks) were correlated to canal flows. The study well location was within a half-mile of a canal. The well response to canal operation was noted to be a matter of days. USGS mapped canal leakage ranging 1-3 per mile in this system (Figure 9, GANNETT, ET. AL, 2001).

We compared the infiltration volumes of the two cases, our estimated maximum infiltration, and the canal loss that effects a significant change in water elevation. We considered six inches to be a significant change in groundwater elevation at our site where the groundwater slope is 1 foot per 300 feet (Section 7.1.1). At the USGS study site six inches of water elevation gain under steady state conditions appears to correspond to three weeks of irrigation (Figure 35, GANNETT, ET. AL, 2001). Three weeks of canal loss at a leakage rate of 1 cubic foot per second per mile, the low end of the range, above, amounts to 907,000 cubic feet for a half mile of canal. This is greater than the total runoff volume of the 25 year, 24 hour storm, 598,000 cubic feet (Section 5.5.3).

Partly due to the irregular nature of vertical and horizontal groundwater flows in basalt (noted above in Section 7.1.2), we based our evaluations, above, on a mass balance comparison and a Best Management Practice. In the case of water quality, the existing sand and silt layers, projected to occur at the location of the new ponds, provide sufficient depth to meet Best Management Practice objectives to attenuate pollutants in stored runoff. In the case of groundwater elevation impacts, we compared a very conservative infiltration slug volume to the steady state infiltration of canal leakage that occurs continuously for five months and found no significant increase in groundwater elevation to be anticipated. Though difficult to predict due to

the uncertainty in the basalt layers, it is likely that most of the stored runoff will disperse in the basalt and sand layers. As the landfill is expanded, and new monitoring wells are installed and monitored it may be appropriate to further evaluate these conclusions.

**7.1.4 Future Well Placement and Sequencing**

The Code of Federal Rules (40 CFR 264.97) requires that the groundwater monitoring system consist of a sufficient number of wells, installed at appropriate locations and depths to monitor both upgradient (ambient) and downgradient conditions. In some cases, it is practical to place the point of compliance well at the hydraulically downgradient limit of the waste management unit; however, in fractured rock, a location farther downgradient of the known saturated flow direction may improve the detection system. It is up to the discretion of the Regional Administrator to specify in the facility permit the point of compliance at which the groundwater protection standards apply, and at which monitoring must be conducted.

The preceding conceptual model of groundwater infiltration and transport is generally consistent with the placement of the previous background and compliance wells. Knott Landfill currently has two upgradient (background) wells (MW-3 and MW-5) and three downgradient (compliance) wells (MW-1, MW-2, and MW-4). These compliance wells monitor groundwater downgradient of the cells in Phase IB and IIB.

Two categories of new monitoring wells are anticipated to be needed to support expansion at Knott Landfill, including:

- Replacement wells
- Additional compliance wells

A tentative Groundwater Monitoring Well Construction Schedule is provided in Table 7-1.

**Table 7-1: Tentative Groundwater Monitoring Well Schedule**

<b>Well ID</b>	<b>Installation Date</b>	<b>Rationale</b>
MW-4R	2004	Monitor downgradient of Phase 1B; replace MW-4
MW-2R	2006	Monitor downgradient of Cell 2 and Cell 3; replace MW-2
MW-6	TBD	Monitor downgradient of Cell 5
MW-7	TBD	Monitor downgradient of Cell 6
MW-1R	TBD	Monitor downgradient of Cell 6; replace MW-1

The County presently anticipates that MSW will be placed at the locations of existing wells MW-2 and MW-4 during calendar year 2004. MW-1 will need to be abandoned to accommodate Cell 6e, the last waste disposal cell planned at Knott Landfill. Cell 6e will not be constructed until at least 2015. Prior to the disposal of waste in these areas, these wells will be abandoned in accordance with WRD regulations. Replacement wells will be installed to provide the monitoring functions of MW-2 and MW-4, and will be installed generally along the same inferred groundwater flow path from the existing well, but further downgradient from the current well locations. The replacement for MW-2, MW-2R ("replacement"), will be installed along the north edge of the site as shown in Figure 7-4. The replacement for MW-4, MW-4R, will be installed along the east property boundary adjacent to the non-MSW cell (Figure 7-4).

Section 20.2 of the Permit indicates that DEQ must approve the installation of wells used to monitor new cells, and that the wells must be in place at least 12 months before MSW is accepted in the new cell. The Permit does not explicitly address the installation of replacement wells. Nonetheless, the County believes it will be beneficial to schedule the installation of replacement wells such that, for a period of at least one year (two semi-annual groundwater monitoring events), both the existing well and the replace well are included in the sampling events. This will allow a baseline data set developed for comparison between two wells serving the same compliance monitoring objective, prior to the abandonment of the original well. It will also provide some allowance for potential sampling or pumping trouble-shooting to be accomplished. Based on these objectives, replacement wells will be installed a minimum of one calendar year prior to prior to the operational need for well abandonment.

The rationale for installation of a replacement well for MW-1 will be evaluated closer to the time that Cell 6e is constructed. It is anticipated that the function MW-1 currently provides will be provided by the same well or wells installed downgradient of Cell 6e.

Additional compliance wells will be needed to monitor downgradient of new waste disposal cells. As described in Section 3 of this plan, the next cell the County intends to develop is Cell 3, immediately north of Cell 2. Cell 3 is currently under construction. Groundwater flow direction at the landfill, based on water level measurements from the existing five wells, suggests that existing monitoring wells MW-2 is downgradient from Cell 3. MW-1 is also downgradient of Cell 3. As noted above, the County plans to abandon MW-2 prior to 2006. Replacement well MW-2R will be installed along the north edge of the site as shown in Figure 7-4. This location will serve to monitor both existing Cell 2 and Cell 3. Cell 4 and Cell 5 will be located north of Cell 3, along the west property boundary. Based on the groundwater flow direction as currently known, it is expected that MW-2R will meet the compliance monitoring requirements for Cell 4. This will be reevaluated, at least one year prior to the placement of waste in Cell 4. Data from MW-2R will facilitate this interpretation. It is anticipated that a new compliance well may be needed west of MW-2R to monitor Cell 5. Again, the need for a well at this location will be

determined based on groundwater flow directions as from available wells, at least one year prior to the placement of waste in the new cell. At least one more compliance well is expected to be needed along the north boundary of the refuse disposal area to monitor new Cells 6a through 6e. The number and location of wells needed will be determined at a future time, closer to the time they are needed.

A third category of new monitoring well may also be needed at Knott Landfill. While the facility currently has two wells, MW-3 and MW-5, upgradient of all areas where MSW has been placed, both are very close to the disposal cells. Due to the proximity of these upgradient wells to the landfill, there is some uncertainty as to the suitability of groundwater from the wells to accurately reflect background conditions, truly unaffected by the landfill. Even in hydrogeologic settings where vertical fractures control unsaturated zone flow, there is some horizontal flow component (Doughty, 2000). Consequently, the close proximity of wells MW-3 and MW-5 to Phase IB and Phase IIB cells, respectively, cannot preclude the possibility that measured groundwater chemical concentrations at these well locations are affected by landfill operations. The County is currently working on a plan to address this issue. It is possible that establishment of a new background well, further downgradient of the landfill may be needed.

All new wells installed at Knott Landfill will be constructed in a manner generally consistent with the existing wells and described in the EMP.

The EMP will be updated to reflect any changes made to the groundwater monitoring activities.

## **7.2 SURFACE WATER**

No surface water monitoring is currently conducted at Knott Landfill and none is anticipated.

### **7.2.1 Leachate**

There are three MSW disposal cells currently at Knott Landfill. The original disposal cell, known as Phase IB, is an unlined cell and therefore leachate is not collected. The other two cells are part of Phase IIB and referred to as Cell 1 and Cell 2. Both Cell 1 and Cell 2 are lined and equipped with leachate collection systems. The County captures, monitors, and disposes of leachate from the existing cells.

Future disposal cells will also be equipped with primary and secondary liners and leachate collection systems as described in Section 4 of this SDP. Monitoring of the leachate generated in future disposal cells will be in accordance with the procedures described in the existing EMP, and will include liquid level monitoring, using pressure transducers and data loggers, and sample collection and analysis.

### 7.2.2 Landfill Gas

Landfill gas (LFG) monitoring probes are used to determine the degree of subsurface LFG migration from the disposal cells into the surrounding native soils. Spaced along the perimeter of the landfill property boundary, LFG probes are installed in boreholes that provide conduits to the surface, enabling measurement of LFG composition and pressure. Probe monitoring is necessary to determine compliance with the state and federal rules, the following criteria apply:

- Methane concentrations at the property boundary must not exceed 5 percent by volume, the lower explosive limit (LEL) for methane.
- Methane concentrations inside buildings and structures on landfills must not exceed 25 percent of the LEL or 1.25 percent by volume.

Additional monitoring probes will be installed and monitored to assess landfill LFG control compliance. The purpose of landfill compliance monitoring is to verify current federal regulations and OAR 340-94-060[4][a] that require methane concentrations be below 25 percent of the lower explosive limit (LEL) in facility structures and to be below the LEL at the property boundaries.

Monitoring currently consists of LFG sample collection and field testing at nine compliance monitoring probes (GP-1A, GP-1B, GP-2A, GP-2B, GP-3A, GP-3B, GP-4A, GP-4B, and GP-5A), as well as on-site and off-site structures. Existing monitoring probes serve as the compliance points for LFG monitoring, as required by Section 18.3 of the Permit. Six of the probes are located south of the landfill along Rickard Road (Figure 7-5). The remaining three probes are located to the north and east of the landfill.

As described in the current EMP, one additional probe will be installed on the west and one on the north perimeter of the landfill. The new probe locations are approximated on Figure 7-5. Each new probe will be constructed at the time the cell adjacent to the probe is built. The construction of new probes will be determined at a later date. The new probe depth will be determined based on geologic materials penetrated at the new locations so as to maximize the potential for gas collection.

Structures on-site and off-site that are to be tested for gas migration are monitored as identified in the *Sample Protocol Report, Landfill Gas Survey*, (DEA, 1994). As new structures are constructed, the sampling plan will be updated to include the monitoring of these facilities, and the procedures will be incorporated into the EMP. Gas probe monitoring procedures are described in the EMP.

**7.2.3 Air**

The facility operates under an Air Contaminant Discharge Permit (ACDP), issued through DEQ's Eastern Region (Permit 09-0040). Current requirements of this permit include monitoring of the operation and maintenance of the LFG extraction system, including monitoring of: operating parameters (flow rates, temperature, gas composition), operation of flame arrestor, operating hours, and general condition of the flare.

As the landfill increases its design capacity to certain operation levels, new regulatory requirements are triggered, including New Source Performance Standards (NSPS) Subpart WWW and Title V permitting. Design estimates show the facility reaching the NSPS trigger level of 2.5 million megagrams (Mg) by 2010. Pursuant to 40 CFR 60.756, monitoring requirements under Subpart WWW follow closely with the existing ACDP requirements, although measurement methods and schedules are specific to NSPS. As the landfill and LFG system expands, the NSPS monitoring requirements will need to be implemented for all additional applicable equipment. There should be no additional monitoring requirements under Title V permitting procedures.

Surface water runoff used for dust suppression will likely not require any monitoring. There are no regulatory requirements to monitor particulate matter, a regulated pollutant, from the landfill. However, dust suppression activities should be recorded and maintained.

No.	DATE	BY	REVISION
B	7/16/03	CAS	REVISED PER DEPT/COUNTY REVIEW
A	5/22/03	PCF	FOR CLIENT REVIEW

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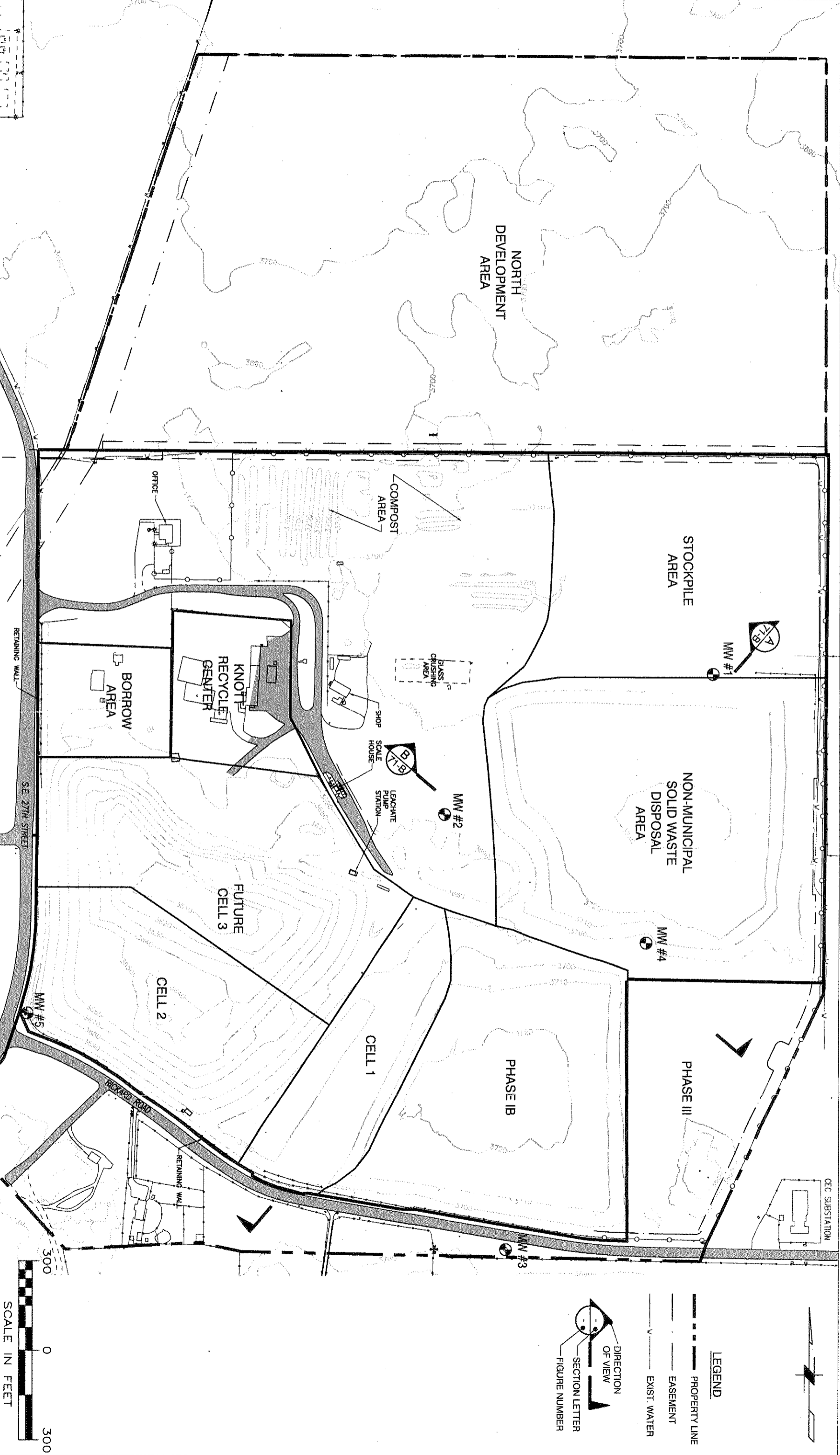
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BEND, OREGON

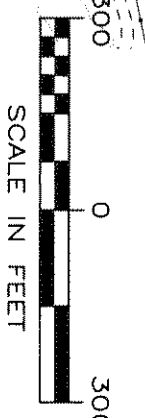
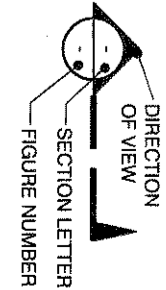
Knott Landfill Site Development Plan  
PLAN VIEW OF  
GEOLOGIC CROSS SECTIONS

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**LEGEND**

- — — — — PROPERTY LINE
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No.	DATE	BY	REVISION
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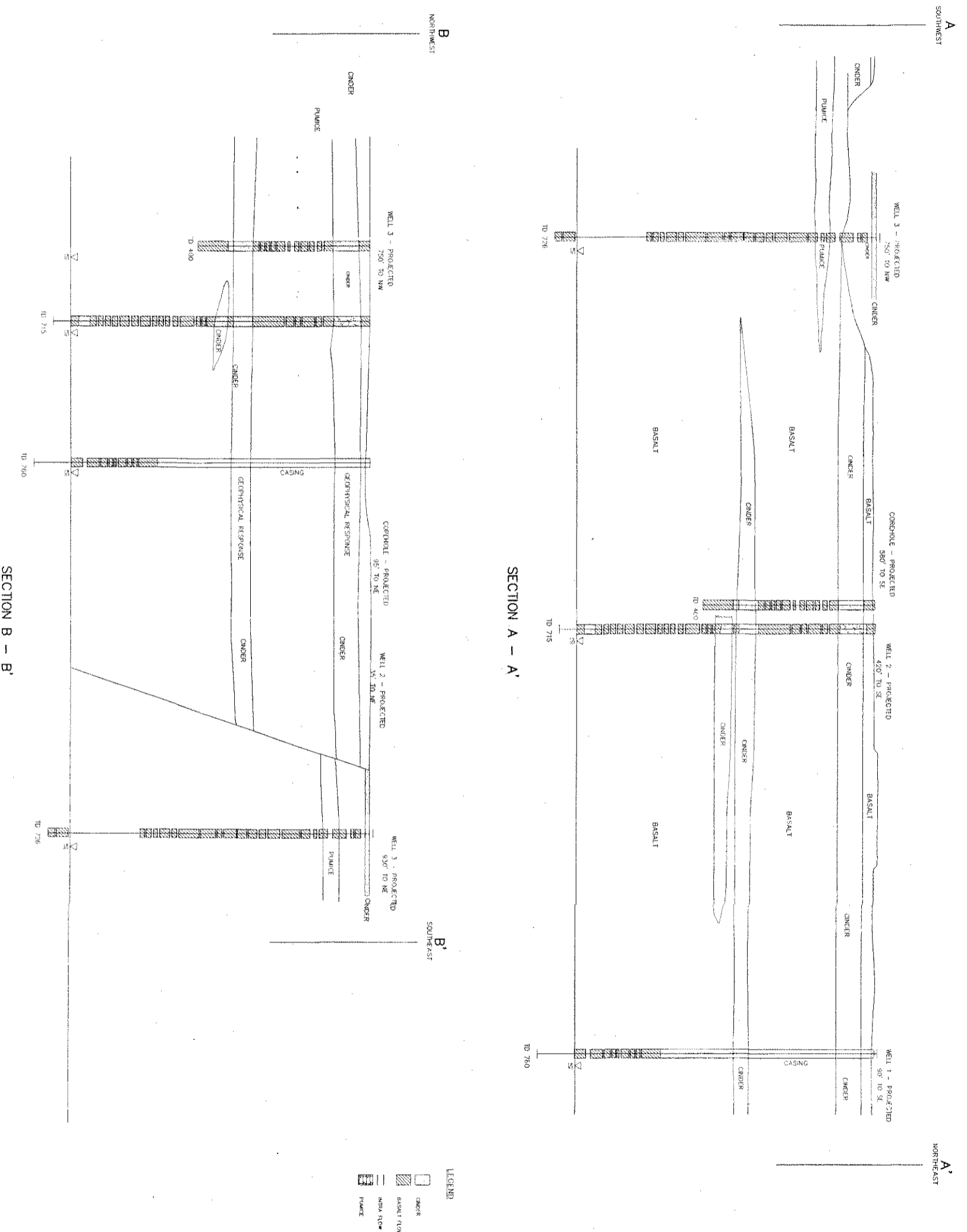
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25695172	BB	BB
SCALE:	DRAWN BY:	APPROVED BY:
	CAS	BB
	CHECKED BY:	DATE:
	JW	JULY 03

**URS**  
 111 S.W. Columbia, Suite 900  
 Portland, Oregon 97201  
 (tel) 503-222-7200  
 (fax) 503-222-4292

**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill North Area**  
 GEOLOGIC CROSS SECTIONS

DRAWING NUMBER:  
**Figure 7-1B**  
 CAD FILE NUMBER:  
 FIG 7-1B  
 SHEET: REV.  
 OF A



LEGEND

[Symbol]	CINDER
[Symbol]	BASALT
[Symbol]	GRAVEL
[Symbol]	WATER TABLE
[Symbol]	PUMPE

No.	DATE	BY	REVISION
A	5/22/03	CAS	FOR CLIENT REVIEW
B	7/16/03	CAS	REVISED PER DEQ/COUNTY REVIEW

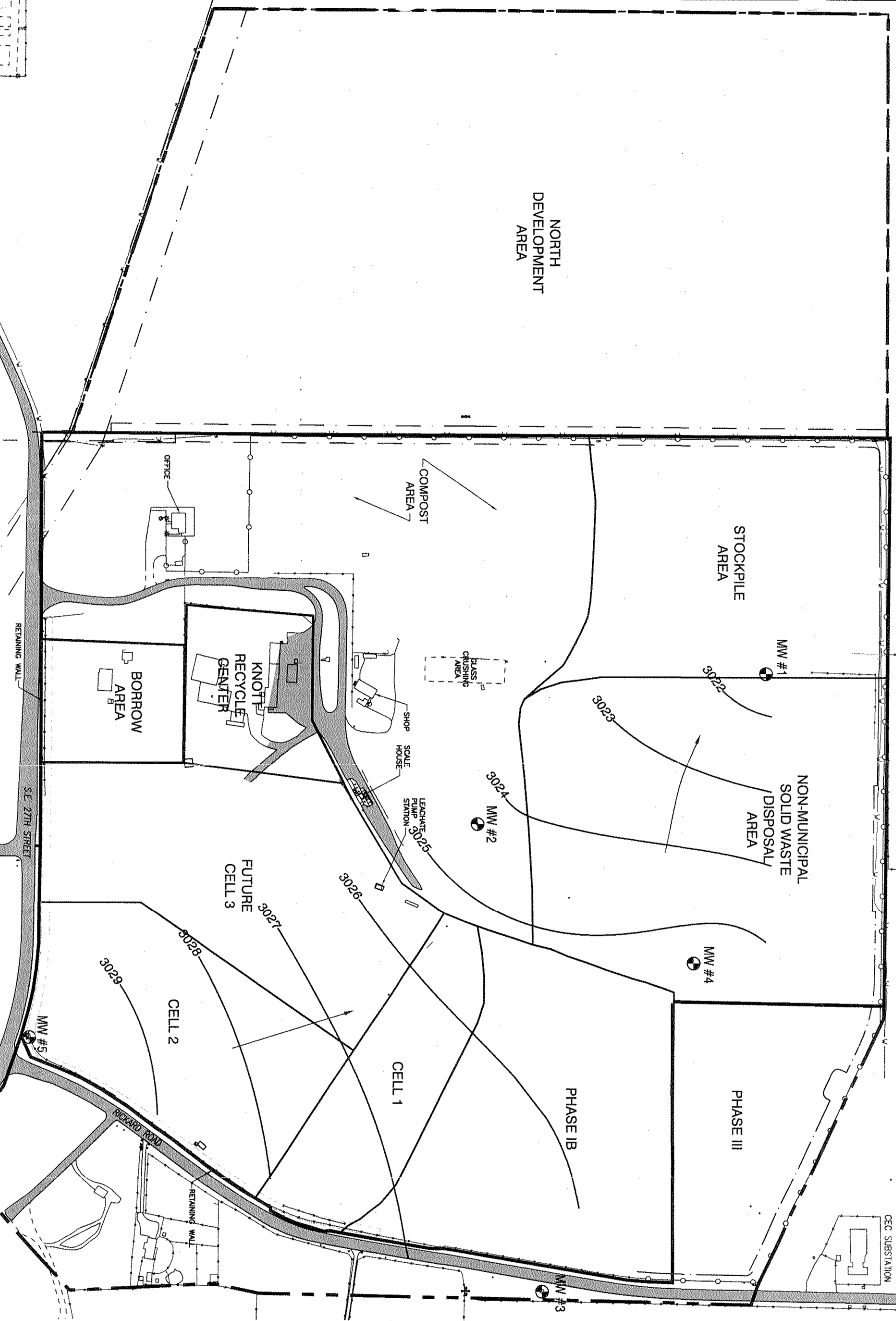
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25695172	BB	BB
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AS SHOWN	CAS	BB
CHECKED BY:	DATE:	
JW	JULY 2003	

111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292
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**URS**  
DESCHUTES COUNTY  
DEPARTMENT OF PUBLIC WORKS  
BEND, OREGON

Knott Landfill Site Development Plan  
SPRING 2002 GROUNDWATER CONTOUR MAP

DRAWING NUMBER:	Figure 7-2
CAD FILE NUMBER:	FIG 7-2
SHEET:	B
REV:	B



**LEGEND**

- PROPERTY LINE
- - - EASEMENT
- - - EXIST. WATER
- 3022 WATER ELEVATION CONTOUR (IN FEET ABOVE MEAN SEA LEVEL)
- APPROXIMATE GROUNDWATER FLOW DIRECTION

SCALE IN FEET

No.	DATE	BY	REVISION
1	5/22/03	CAS	FOR CLIENT REVIEW
2	7/18/03	CAS	REVISED PER DEQ/COUNTY REVIEW

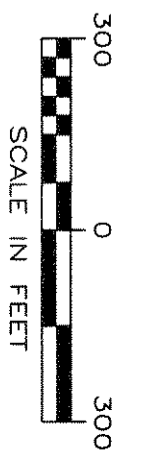
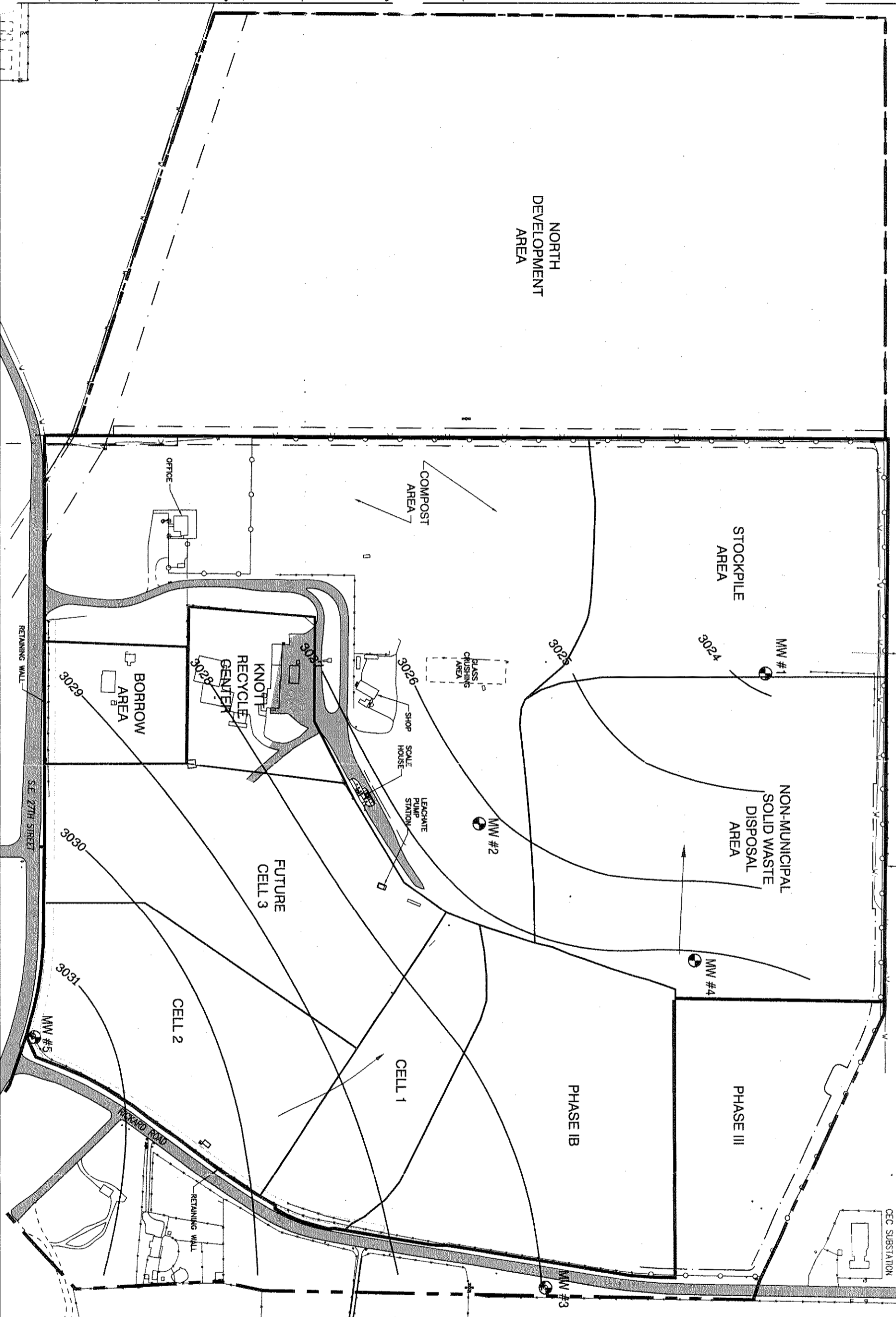
JOB NO.	25695172	DESIGNED BY:	BB	PROJ. ENGINEER:	BB
SCALE:	AS SHOWN	DRAWN BY:	CAS	APPROVED BY:	BB
CHECKED BY:	JW	DATE:	JULY 2003		

111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292	<b>URS</b>
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DEPARTMENT OF PUBLIC WORKS  
BEND, OREGON

Knott Landfill Site Development Plan  
FALL 2002 GROUNDWATER CONTOUR MAP

DRAWING NUMBER: <b>Figure 7-3</b>	CAD FILE NUMBER: FIG 7-3
SHEET: OF	REV. B



- LEGEND**
- PROPERTY LINE
  - - - EASEMENT
  - - - EXIST. WATER
  - 3022 — WATER ELEVATION CONTOUR (IN FEET ABOVE MEAN SEA LEVEL)
  - APPROXIMATE GROUNDWATER FLOW DIRECTION



No.	DATE	BY	REVISION
B	7/18/03	CAS	REVISED PER DEQ/COUNTY REVIEW
A	5/22/03	CAS	FOR CLIENT REVIEW

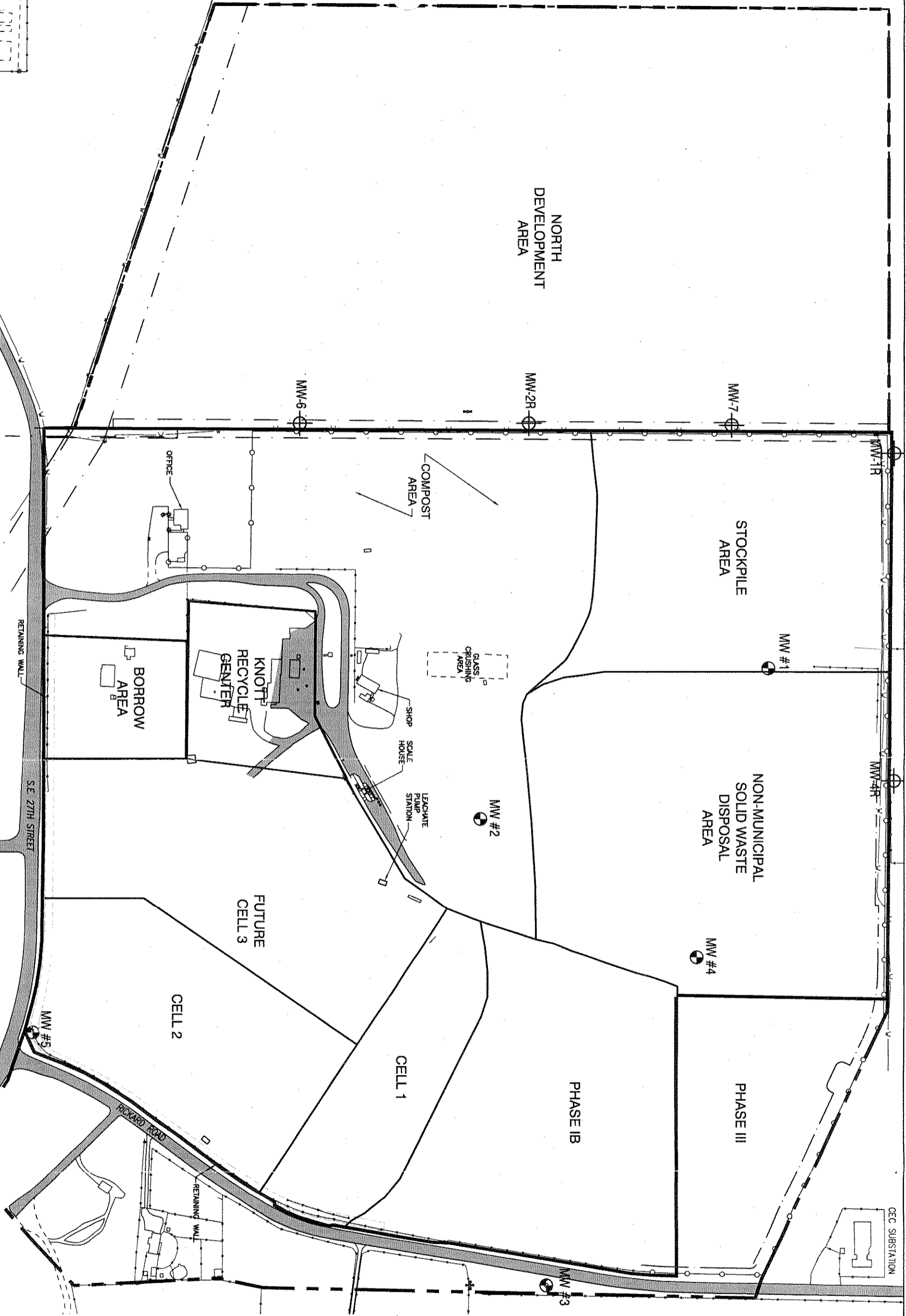
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CHECKED BY:	JW	DATE:	JULY 2003		

<b>URS</b> 111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (tel) 503-222-7200 (fax) 503-222-4292	
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**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 LOCATION OF  
 EXISTING AND PROPOSED  
 GROUNDWATER MONITORING WELLS

DRAWING NUMBER:	<b>Figure 7-4</b>
CAD FILE NUMBER:	FIG 7-4
SHEET:	B
REV:	B



**LEGEND**

- PROPERTY LINE
- EXIST. 10' CONTOUR
- EXIST. 5' CONTOUR
- EASEMENT
- EXIST. WATER
- ⊕ MW-1R PROPOSED MONITORING WELL
- ⊕ MW #1 EXIST. MONITORING WELL

SCALE IN FEET

300 0 300

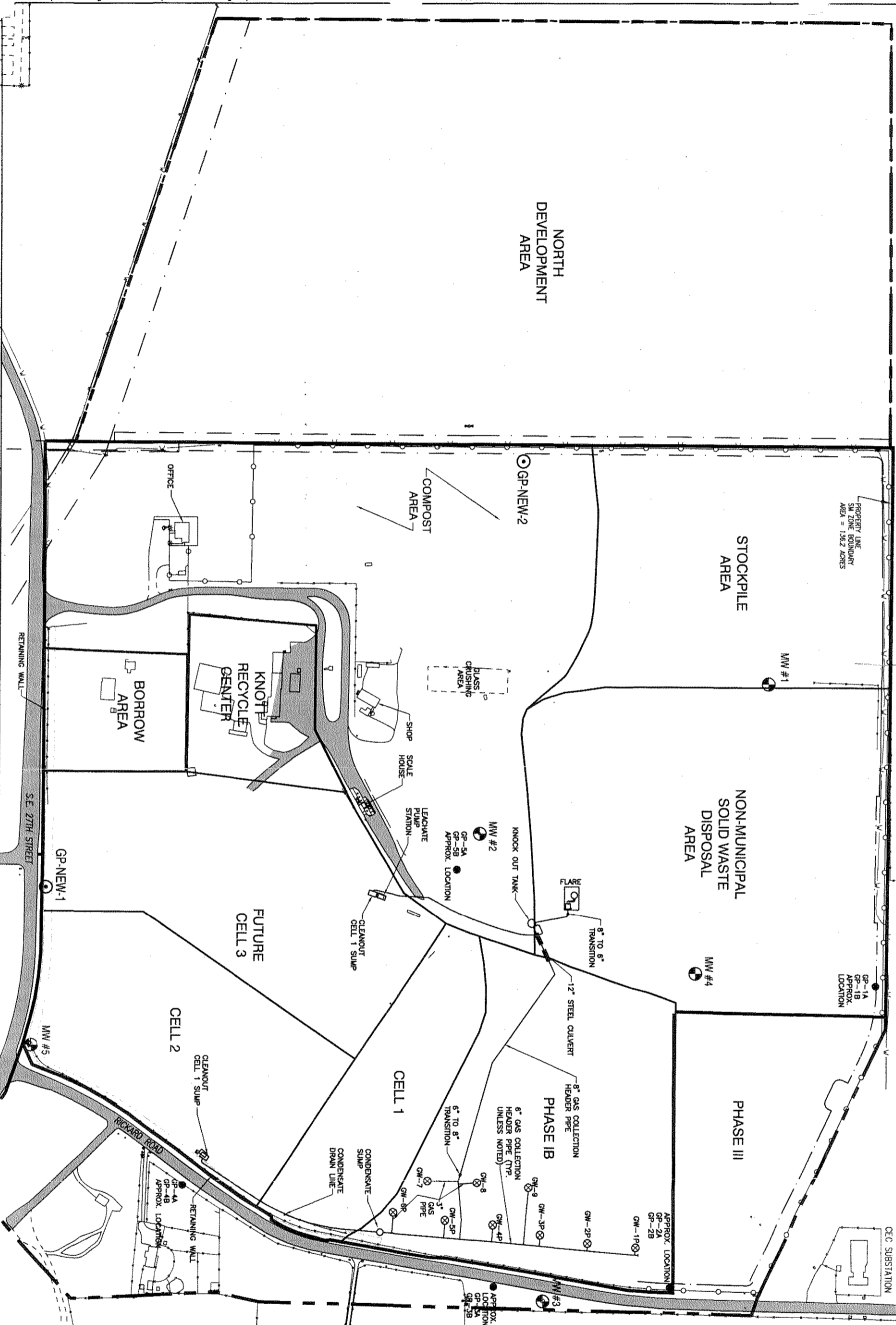
No.	DATE	BY	REVISION
1	7/18/03	CAS	REVISED PER DEQ/COUNTY REVIEW
2	9/22/03	PCF	FOR CLIENT REVIEW

JOB No.	DESIGNED:	PROJ. ENGINEER:
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1"=300'	P. FLURY	GF
	CHECKED BY:	DATE:
	GH	JULY 2003

111 S.W. Columbia, Suite 900 Portland, Oregon 97201 (Tel) 503-222-7200 (Fax) 503-222-4292	<b>URS</b>
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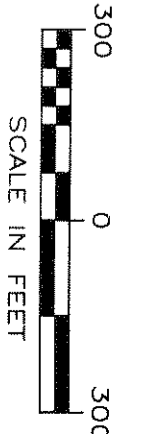
**DEPARTMENT OF PUBLIC WORKS**  
**BEND, OREGON**

**Knott Landfill Site Development Plan**  
**EXISTING AND PROPOSED LANDFILL GAS PERIMETER SYSTEM LAYOUT**



**LEGEND**

	PROPERTY LINE
	EASEMENT
	EXIST. WATER
	LANDFILL GAS EXTRACTION WELL
	LANDFILL GAS MONITORING PROBE
	GP-NEW-1 PROPOSED LANDFILL GAS MONITORING PROBE
	MW #4 EXIST. MONITORING WELL



DRAWING NUMBER:	FIGURE NUMBER:
Figure 7-5	FIG 7-5
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Section Eight:  
Closure and End Use

The objective in closing the landfill will be to minimize potential threats to human health and the environment. RCRA Subtitle D (40 CFR 258.60) requires a minimum of 30 years of post-closure monitoring and maintenance activities. In addition it specifies that a final cover system be installed that:

- Minimizes infiltration and erosion.
- Minimizes the escape of waste or waste constituents to the groundwater, surface water or the atmosphere.
- Minimizes the maintenance activities that will be required.

Final end use for Knott Landfill after closure is limited due to 1) potential settlement within the landfilled area; 2) the generation of landfill gas as refuse decomposes; and 3) the presence of landfill gas, leachate and surface water control facilities.

## 8.1 FINAL COVER

The Knott Landfill facility is located in a semi-arid climate. Average precipitation at the site is about 12 inches per year. Design of the final cover system is dependent upon the type of final end use that is selected.

If a passive, non-irrigated landfill end use is selected it is anticipated that an alternative earthen final cover (AEC) system will be utilized. In this type of final cover system, precipitation will be stored in the upper soil layers until soil evaporation and plant transpiration return it to the atmosphere.

Components from top to bottom of the monolithic AEC that is planned are as follows:

- Vegetation - a mixture of crested wheat grasses, alfalfa and clover that are adapted to the semi-arid climate.
- A monolithic soil layer consisting of a fine sandy/silt loam used to store incident precipitation and provide nutrients to the vegetation.

Design criteria that have been utilized in the development of the design for the final cover system and which will be incorporated into the final closure designs for the Knott Landfill are as follows:

- **Minimum and maximum slopes.** The top of the landfill will generally have a slope of 5 percent and not be less than 2 percent. The completed landfill will have sideslopes that generally are 4 horizontal:1 vertical and which will not exceed 30 percent.

- **Erosion loss.** An estimate of annual soil loss is contained in Section 8.3. The established growth of the select species will provide a dense vegetative cover that will offer excellent long-term protection against erosion from wind and rain.

Species selected for the design seed mix are specifically identified as range grasses suitable for environments receiving less than 12 inches of rainfall per year. The selected seed mix was recommended by the Oregon State University Extension Office and the Soil Conservation Service as ideal for application to the unamended topsoil that is available on site and is likely to propagate readily with no irrigation.

Fall planting of the seed blend is recommended. The seed supplier should guarantee sterilized (weed free) blends and germination within 1 month of planting. The seed should show no sign of water damage and have a good appearance at the time of application. The application rates specified are for seeding using shallow bury and cover planting methods. Broadcast and drilled seeding are not recommended.

**Table 8-1: Recommended Seed Blend Application Rate**

Seed Type	Application Rate
Idaho Fescue	4 lb/acre
Indian Rice grass	2 lb/acre
Siberian Wheat grass	3 lb/acre
Covar Fescue	3 lb/acre
Secar Blue Bunchgrass	3 lb/acre

### 8.1.2 Monolithic Water Storage Layer

A 48 to 60-inch thick erosion/water storage layer will be utilized to support the overlying vegetation and provide water storage capacity. The layer will utilize on-site soils that have been classified as 2sm (see Appendix 3a). The 2sm soil is a sand with silt and typically has the following properties:

- Porosity (based on volume): 43%
- Permeability:  $1 \times 10^{-5}$  cm/sec



### 8.2.2 Computation of Cover Thickness Required

The upper soil layer at the Knott Landfill will be composed of the 2sm soils as described in the Results of Onsite Soils Investigation (Appendix 3a). The water balance for the cover system is described by the following equation:

$$\text{Precipitation} = \text{Evapotranspiration} + \text{Runoff}$$

The cover system will be designed so that the precipitation under average conditions will be stored in the upper soil layers. Runoff will occur under severe storm events, such as the 25-year storm used for design of the surface water management system. Runoff may also occur during average precipitation events when the ground surface is frozen. For final cover system design purposes, it is assumed that all the precipitation infiltrates into the upper soil layers, where it is stored until it is removed by evaporation to the atmosphere and by vegetation transpiration.

### 8.2.3 Demonstration Project

The water balance cover cap system that is proposed is based on theoretical assumptions about the behavior of a AEC and estimated evapotranspiration rates. Although the use of this type of final cover system has been demonstrated successfully at the Finley Buttes Landfill and by the Department of Energy (DOE) at Pacific Northwest Laboratory (Vaugh et al., 1983 1991) and at Los Alamos National Laboratory (Nyban, 1989 and Nyban et al., 1990), there currently is limited data available to support the effectiveness of a AEC as a barrier to surface water infiltration at MSW landfills.

If a AEC is selected for use as a final cover, it is proposed to demonstrate the effectiveness of the proposed final cover system design through the construction of test sections and installation of lysimeters prior to its construction.

## 8.3 EROSION LOSS ESTIMATES

Soil loss from erosion was estimated for the proposed final cover system. Typically, on central Oregon projects, no more than two tons of average annual soil loss per acre is allowed.

An estimate of the anticipated soil loss was prepared utilizing the Universal Soil Loss Equation:

$$A = R \times K \times LS \times C \times P$$

where,

A = Annual sediment yield in tons per acre

R = Rainfall Erosion Index equal to 10.0 for the study area

## 8.6 END USE

Identification of an end use that meets the needs of the Bend community, while maintaining the integrity of the landfill's final cover system, is an important part of the proposed design. Much of the design and construction of the cover system is dependent on the final end use that is selected for the site.

It is critical that systems and facilities required to monitor the landfill be accommodated in the final design plans so that they remain accessible but are also adequately buffered from on and off-site views and public access. Also, if extensive berming or planting is desired, additional earthwork in addition to the minimum soil depth required to meet closure regulations will be necessary.

### 8.6.1 End Use Alternatives

During 2003-2004, the County plans to conduct an end use feasibility study for Knott Landfill. The end use feasibility study will look at the planned future development described in this Site Development Plan and evaluate the economic and technical feasibility of a number of end use options. It is expected that due to the condition, size, nature of the landfill site, and its proximity to low density residential and rural land uses, the potential options for development fall into the following alternatives:

**Alternative I: Minimal Use Open Space.** Under this alternative, the closed landfill would become open space. A fence around the perimeter would prevent public access. A native grass cover would provide erosion control from wind, rain or heavy snow melt. This alternative requires little or no additional earthwork, minimal surface preparation, and minimal maintenance.

This is the least expensive alternative for both the short term and the long term.

**Alternative II: Passive Use Open Space.** While similar to Alternative I, this alternative also includes the design and construction of recreational facilities which promote passive uses such as dog walking, hiking or jogging and which minimize the site's use by large numbers of people for long periods of time. Public facilities such as restrooms, hard surfaces or enclosed buildings located adjacent to the landfill may be included.

**Alternative III: Passive/Active Use Open Space.** This alternative combines the major components of Alternatives I and II and expands the potential use of the site to include specific user groups and activities which may be needed in the community but which will not lessen the integrity of the cover system.

**Sewer Treatment, Water, and Utilities.** Existing utility systems at the landfill will be relocated as part of the North Area development. Existing utilities at the site include:

- Sewer: Onsite septic and drainfield system
- Water: Avion Water District
- Electric: Central Electric Cooperative
- Telephone: Qwest
- Drainage: Onsite disposal

No connection or additional user fees above those currently assessed are anticipated.

**Off-Site Roadway Improvements.** Based on the final end-use decided upon, it may be necessary to improve off-site roadways and/or intersections to meet user requirements for access to the site. The intersection at S.E. 27th and Rickard Road currently operates at a high level of efficiency and is not identified for any improvement. A second site access may be possible from Rickard Road if required by the final end-use.

**Onsite Roadway Improvements.** The final end-use and its intensity of development will also determine the extent of onsite improvements required. Most uses will be accommodated by the existing access located on S.E. 27th. Onsite parking can be accommodated in the area north of the capped landfill in the location currently used by the existing recycling center. This will not be capped as part of the landfill operation and may, therefore, be developed for construction of paved areas, buildings, or other improvements.

**Planting and Vegetation.** Existing vegetation at Knott Landfill is limited to central Oregon high desert plant material in areas which have not been impacted by the landfill operation. Species include native grasses, sage, rabbit brush at perimeters, and a sparse number of juniper trees. At closure and during the phased capping of the landfill cells, the cover system will include a final erosion layer which will be seeded with native grasses compatible with high desert vegetative patterns. These grasses will ensure that erosion from wind, rain, and snow melt is minimized and that the cover system is maintained in an effective condition.

Additional planting will require earthwork over the cover system to allow for additional root system space, and, depending on intensity of planting, irrigation. Due to the overall size of the landfill area and the surrounding land use and vegetative patterns, introduction of extensive planting may be very expensive and may not "blend" into the surrounding landscape. Great care must be taken to ensure that off-site views are not impacted by the planned end-use improvements and that additional plantings do not compromise the cover system.

Each inspection form will be forwarded to DEQ for review, and appropriate corrective actions will be taken, if necessary, by the County. Any corrective actions that are taken will be documented.

The Soil Conservation Service recommends a regular maintenance program for the vegetative cover in a proactive effort to maximize plant density and minimize erosion and infiltration. Periodic mowing is recommended to promote a balance of high plant density in the species identified for the vegetative cover.

In accordance with Subpart F of RCRA Subtitle D, the County intends to hire an independent registered engineer to verify that the post-closure activities at the Knott Landfill have been conducted in accordance with the DEQ approved closure and post-closure plan.

No.	DATE	BY	REVISION
B	7/16/03	CAS	REVISED PER DEQ/COUNTY REVIEW
A	5/22/03	PCF	FOR CLIENT REVIEW

JOB No.	DESIGNED BY:	PROJ. ENGINEER:
SCALE:	GF	GF
1" = 300'	PCF	GF
CHECKED BY:	DATE:	
GH	JULY 2003	



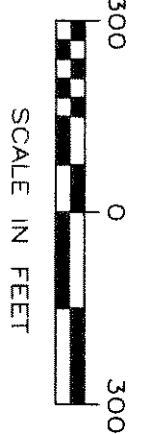
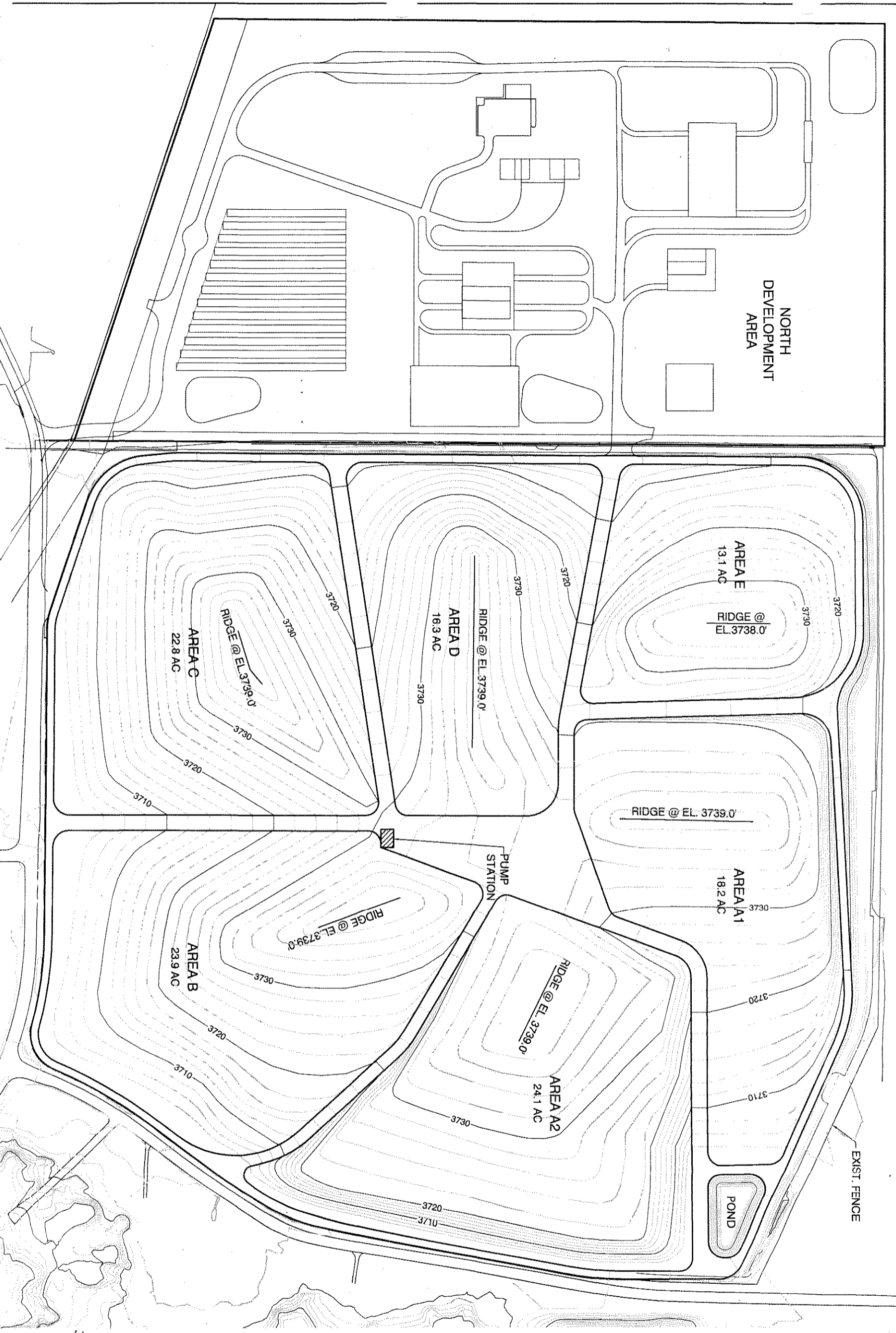
G. Friesen Associates, Inc.  
 4088 Columbia Drive  
 Lake Oswego, Oregon 97035  
 Tel: (503) 635-1233  
 Fax: (503) 635-1447

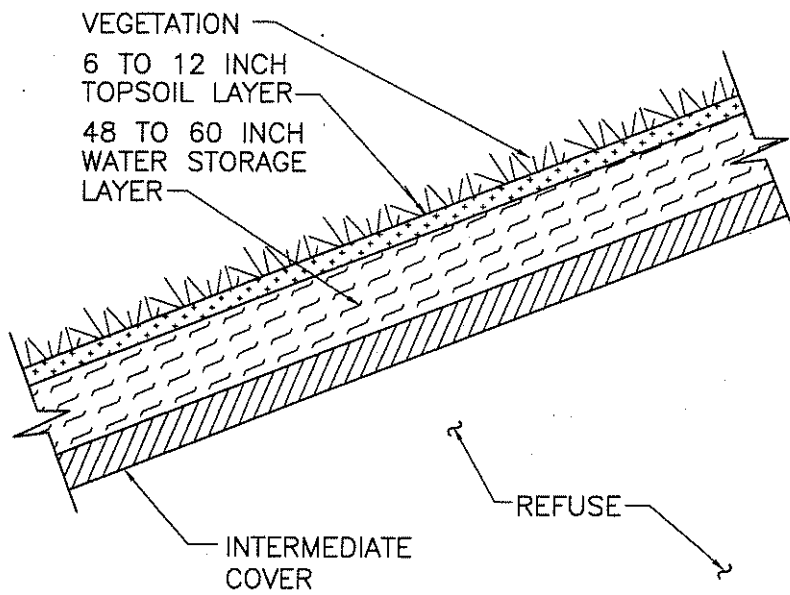
**URS**  
 111 S.W. Columbia, Suite 900  
 Portland, Oregon 97201  
 (tel) 503-222-7200  
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**DESCHUTES COUNTY**  
 DEPARTMENT OF PUBLIC WORKS  
 BEND, OREGON

**Knott Landfill Site Development Plan**  
 CLOSURE AREAS

DRAWING NUMBER:	Figure 8-1
CAD FILE NUMBER:	FIG 8-1
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OF	B





**FINAL COVER SYSTEM**

SITE DEVELOPMENT PLAN  
 KNOTT LANDFILL  
 DESCHUTES COUNTY, OREGON

JULY 2003

**FIGURE 8-2**



Section Nine:  
Other Permits

State regulations require that the following information be submitted as part of the document proposing an expansion to an existing landfill.

### **9.1 STATE MINING PERMIT**

Deschutes County has obtained a mining permit from the Oregon Department of Geology. A copy of the 2002 Mining Permit that was submitted to the Oregon Department of Geology is included in Appendix 9a.

### **9.2 ENDORSEMENT BY LOCAL GOVERNMENT**

Deschutes County has endorsed the expansion of Knott Landfill. Resolution 2002-008 and a statement of compatibility is attached as Appendix 9b. Also, a copy of the approved Conditional Use Permit for the County's North Area Development is in Appendix 9b.

### **9.3 COMPATIBILITY WITH COUNTY AND STATE SOLID WASTE MANAGEMENT PLAN**

The Knott Landfill currently serves Deschutes County residents as their only remaining MSW landfill. According to the state integrated solid waste management plan, the County is primarily responsible for providing options for refuse disposal. Expansion of Knott Landfill is needed to meet the landfill disposal needs of County residents.

### **9.4 WASTE REDUCTION PROGRAM**

Chapter 13.20 of the Deschutes County Code establishes the waste reduction program for the County.

Section 13.20.010 defines the opportunity to recycle within the watershed pursuant to ORS Chapter 459A and OAR Chapter 340, Division 90. Knott Landfill and the 4 rural transfer stations provide facilities for persons within the watershed to deposit source-separated recyclables (Figure 2-3). In addition, there are 12 recycling depots in the more densely populated areas of the County available for deposit of source separated recyclables.

Franchised collection companies provide weekly curbside collection of source separated recyclables from their customers within the City of Bend urban growth boundary. The City of Redmond and customers within its urban growth boundary currently receive weekly curbside recycling service from a franchised hauler. The City of Sisters provides their own collection service and utilizes one of the recycling depots mentioned above. Several of the franchised



collection companies are implementing pilot programs to provide curbside recycling services in areas outside the urban growth boundaries.

Deschutes County recycles the following items as required by OAR 340-90-070(1) and (7): ferrous metal, cardboard, nonferrous metal, used motor oil, newspaper, magazines, glass, aluminum, and high-grade paper. In addition, the County mandates the recycling of tin cans and plastic bottles. Additional recyclables may be mandated for on-route collection pursuant to Board approval.

**Appendix 9a**

**Mining Permit**



Oregon Dept. of Geology & Mineral Industries  
Mineral Land Regulation & Reclamation Program  
229 Broadalbin St. SW  
Albany OR 97321-2246  
(541) 967-2039

OPERATING PERMIT -- Renewal  
ISSUED SUBJECT TO ANY LISTED CONDITIONS



Deschutes County Dept. of Solid Waste  
61000 SE 27th Street  
Bend OR 97702

ID No.: 09-0128  
County: Deschutes  
Site: Knott Pit  
Section: 14  
Twp: 18S  
Range: 12E

This permit shall be in effect, unless revoked or suspended for cause, from the date of issuance and shall remain in effect so long thereafter as the Permittee pays the annual fee to renew the permit, complies with the provisions of ORS 517.750 through 517.955 as applicable, the Rules as promulgated to administer the Oregon Mined Land Reclamation Act, the approved reclamation plan, and any conditions attached to this permit, and maintains a performance bond as required by the Act.

Issuance of this permit is not a finding of compliance with state-wide planning goals or the acknowledged comprehensive plan. The applicant must receive land-use approval from local government before using this permit.

NOTE: Reclamation plans may be modified per ORS 517.830(4) and OAR 632-(30) and (35)-035.

*CONDITIONS: (Conditions may be appealed per OAR 632-30-030. If an appeal is made, this permit is invalid until the condition(s) appealed is/are resolved and the permit reissued.)*

NONE

Issued 12/11, 2002

  
Gary W. Lynch  
Assistant Director

**RENEWAL IS REQUIRED BY OCTOBER 31, 2003**

c: Deschutes County Planning Department  
DEQ Bend

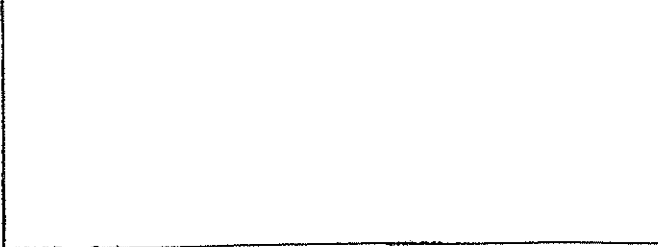


**Appendix 9b**

**Endorsement by Local Government**



REVIEWED  
*J*  
LEGAL COUNSEL



For Recording Stamp Only

BEFORE THE BOARD OF COUNTY COMMISSIONERS OF DESCHUTES COUNTY, OREGON

A Resolution adopting the Knott Landfill  
Development Analysis report and directing the  
implementation of the development option which  
maximizes the life of Knott Landfill

\*  
\* RESOLUTION NO. 2002-008  
\*  
\*

WHEREAS, the Board of County Commissioners of Deschutes County, Oregon have adopted a Solid Waste Management Planning Timeline and directed the Department of Solid Waste to implement said Timeline, and

WHEREAS, implementation of said Timeline involves assessment of the lifespan of Knott Landfill, and

WHEREAS, an engineering study and economic analysis indicate that maximizing the life of Knott Landfill (kown as option 3) will provide significant economic and other benefits to the citizens of Deschutes County, and

WHEREAS, the Director of Solid Waste and consulting engineers who performed the study and analysis recommend maximizing the life of Knott Landfill, and

WHEREAS, a public involvement campaign on the development and end use of Knott Landfill was conducted by the Department of Solid Waste, and

WHEREAS, the results of the public involvement campaign show that the citizens of Deschutes County support maximizing the life of Knott Landfill and developing end uses for the site, now, therefore,

BE IT RESOLVED BY THE BOARD OF COUNTY COMMISSIONERS OF DESCHUTES COUNTY, OREGON, as follows:

Section 1. The Knott Landfill Development Analysis report dated January 2002 is hereby adopted.

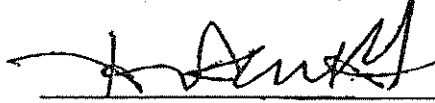
Section 2. The Solid Waste Department is hereby directed to implement the development option that will maximize the life of Knott Landfill and develop end uses for the site that will benefit the community.

Section 3. The Knott Landfill Development Analysis report is hereby incorporated into and made part of the Solid Waste Management Planning timeline.

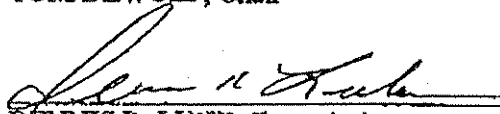


DATED this 28<sup>th</sup> day of January, 2002.

BOARD OF COUNTY COMMISSIONERS FOR  
DESCHUTES COUNTY, OREGON



TOM DEWOLF, Chair



DENNIS R. LUKE, Commissioner



MICHAEL M. DALY, Commissioner

ATTEST:

Bonnie Baker  
Recording Secretary

**Appendix 9c**

**Deschutes County Wasteshed Recovery Plan**



**DESCHUTES COUNTY**  
**Wasteshed Recovery Plan**  
**December 31, 2001**

As required by HB 3744, this document outlines the Wasteshed Recovery Plan for Deschutes County. HB 3744 establishes a 2005 recovery rate goal of 32% for Deschutes County. We have exceeded that goal in 2000 when we recorded a 37% recovery rate. HB 3744 also sets a 2009 recovery rate goal of 45% for Deschutes County. The following narrative describes the measures and timeline for reaching that goal.

**Description of Existing Waste Recovery Programs and Policies**

County Programs – Deschutes County provides for the deposit of source separated recyclables at all active disposal sites (Knott Landfill and Rural Transfer Stations). Materials accepted include: scrap metal, used motor oil, newspaper, glass, aluminum, cardboard, tin cans, magazines, lead acid batteries, plastic bottles, tires, and yard debris. It should be noted that this list includes several commodities that are not required by state law to be included.

Deschutes County also maintains 12 unmanned rural depots throughout the County where residents can deposit source separated recyclables. These depots handle the same list of materials with the exception of scrap metal, used motor oil, batteries, tires, and yard debris. One of these depots is located in the City of Sisters. It should be noted that the City Public Works Department offers curbside collection of recyclables to residents and businesses in Sisters which are then deposited at this depot.

Deschutes County currently holds several annual collection events including household hazardous waste, electronics, BOPA (Batteries, Oil, Paint & Anti-freeze) and Fire Free Yard Debris Collection.

City of Bend Programs – The City of Bend offers curbside collection of source separated recyclables once each week for residential, multifamily units and commercial collection customers. Items collected include: used motor oil, newspaper, glass, aluminum, cardboard, tin cans, magazines, and plastic bottles. The commercial customers also include High grade office paper and mixed waste paper on their list.

1 unmanned depot where residents can deposit source separated recyclables is located within the city limits. This depot handles the same list of materials as residential curbside collection with the exception of used motor oil.

City of Redmond Programs - The City of Redmond offers curbside collection of source separated recyclables once each month for residential, multifamily units and commercial collection customers. Items collected include: used motor oil, newspaper, glass, aluminum, cardboard, tin cans, magazines, and plastic bottles. The commercial customers also include High grade office paper on their list.

1 unmanned depot where residents can deposit source separated recyclables is located within the city limits. This depot handles the same list of materials as residential curbside collection with the exception of used motor oil. A second depot for deposit of recyclables is located at the yard of the local collection company.

### **Expansion of Existing Waste Recovery Programs**

Addition of Materials Collected Curbside – We are proposing the addition of mixed waste paper to the curbside collection list for both Bend and Redmond. This is expected to increase the County's diversion rate by 2%. We expect to implement this change in 2002.

We are proposing the addition of yard debris to the curbside collection list for Bend and Redmond during the summer months. This is expected to increase the County's diversion rate by 1%. We expect to implement this change in 2004.

Redmond Collection Frequency - We hope to have the City of Redmond move from monthly curbside collection to weekly curbside collection. This is expected to increase the County's diversion rate by 1%. We expect to implement this change in 2002.

Curbside Collection in Rural Areas - We are proposing to implement curbside collection in certain rural areas of the County outside of the Bend and Redmond City limits. The County designated Rural and Distant Rural collection Zones in 2001. Rural zones have higher density and are closer to urban areas making implementation of curbside collection of recyclables possible. We expect to implement this program after any additions to the materials list are implemented, in the year 2004. This change is expected to increase the County's diversion rate by 2%.

### **Implementation of New Waste Diversion Programs**

Material Recovery – Deschutes County is proposing to construct a Materials Recovery Facility as part of the long term development of Knott Landfill. The County is proposing to expand the excavation of the landfill and will displace the existing recyclables processing facilities. As a result of this, it is anticipated that a new, state of the art materials recovery facility will be constructed by 2007. This facility will have the capability to recover recyclables that have not been source separated from certain portions of the waste stream. At a minimum, a "dump and pick" effort will be employed, with possible sort lines installed at a later date.

In addition, possibly as early as 2002, the construction of a public receiving station is being considered at Knott Landfill. This will allow us to resolve a safety issue by bringing the public off the working face of the landfill and onto a facility designed for their use. The facility will also be designed to take advantage of some "dump and pick" activity

## Summary of Proposed Waste Recovery Plan for Deschutes County

### Addition of mixed waste paper to recycling list County-wide

Proposed Date of Implementation: 2002  
Expected Impact to Recovery Rate: 2%

### Move from Monthly Collection to Weekly Collection in Redmond

Proposed Date of Implementation: 2002  
Expected Impact to Recovery Rate: 1%

### Addition of Yard Debris Collection in Bend (and Redmond??)

Proposed Date of Implementation: 2004  
Expected Impact to Recovery Rate: 1%

### Institute Curbside Collection in Rural Collection Areas

Proposed Date of Implementation: 2004  
Expected Impact to Recovery Rate: 2%

### Construction of Materials Recovery Facilities (MRF)

Proposed Date for Full MRF: 2007  
Expected Impact to Recovery Rate: 2% to 3%

Proposed Date for limited Facility: 2002  
Expected Impact to Recovery Rate: 1% to 2%

**Current Recovery Rate:** 37%  
**Rate Gain by Proposed Plan:** 8% to 9%  
**Recovery Rate Goal for 2009** 45%



**Section Ten:  
Statement of Need**



Deschutes County has operated Knott Landfill as a municipal solid waste facility since 1972. The operation is permitted under DEQ Permit No. 6. In 1985, the County retained Fetrow Engineering to prepare an operations plan for the site and, with some exceptions, has operated the site according to that plan. With the adoption of RCRA Subtitle D requirements, municipal solid waste disposal was restricted to the Phase IB/IIB area. That restriction limited the capacity and shortened the time that the County was anticipating using the site. The County is proposing an upgrade to the site to provide additional waste disposal capacity and to meet its short- and long-term goals for waste disposal.

The landfill is needed for the following reasons:

- Knott Landfill is the only site in Deschutes County permitted to receive municipal solid waste generated within the County. The current approved disposal area will likely be filled to capacity by the end of 2006.
- The upgrade will provide the County with time to generate funds for development, closure and other system needs consistent with the goals of the County.
- The Knott Landfill site is operated by Deschutes County personnel and is under the control and direction of the County. All municipal solid waste materials generated within the County are disposed of at this site. The upgrade area will also be under the control and direction of the County, with all disposal work being performed by Deschutes County personnel. Development contracts will be awarded to qualified bidders as the upgrade area is expanded.