Wilson, Donna

From: David Garrett [david@davidgarrettpe.com]
Sent: Thursday, September 02, 2010 2:27 PM
To: Wilson, Donna
Cc: lfnick@msn.com; 'Vernon Smith'; 'Nick Marotta'; 'Dennis Gehle'
Subject: RE: WCA Material Recovery LF
Attachments: Brownfield Engineering Report.pdf

Per our telephone conversation this week, I have revised Section 3.3.1 to include Franklin County population data – and took the opportunity to update all the population data with the latest census data – and I have combed the report to correct several faulty references in the text. This submittal is called Revision 1.1, dated 9/2/2010. I have the plat in hand (from Wake County) and will bring you that shortly. Please contact me on my cell phone if you have any questions. The WCA staff and I are anxious to wrap up this permit to construct. We appreciate your diligent work. Thank you. David

---

From: Wilson, Donna [mailto:donna.wilson@ncdenr.gov]
Sent: Wednesday, August 04, 2010 1:45 PM
To: David Garrett
Subject: WCA Material Recovery LF

David, I'm working on the WCA Material Recovery Landfill application. Can you confirm for me that the table below (and the notes below) are correct? The capacity numbers should represent gross capacity, including daily, intermediate, and final cover.
It is OK that the numbers are approximate, but they still need to be as accurate as possible. And the numbers should add up to the totals (Phase 1 acreage is off a little).
Thanks, Donna

Phase	Acres	Gross Capacity	Status
1	20	1,636,000	Partially filled
2A	16.7	1,400,000	To be approved for construction
2B	8.2	1,400,000	future
2C	*	1,400,000	future
Total northern area	45	5,836,000	
Southern area 3-5	24.2	2,300,000	future
Total northern and southern areas	**69.2**	**8,136,000**	

* Vertical expansion over Phases 1, 2A,and 2B.
Gross Capacity is defined as the volume from the bottom of the waste to the top of final cover.
Estimated life of the landfill, both north and south areas, is 21.9 years from 2010.

Donna J. Wilson
Environmental Engineer
Solid Waste Section/Division of Waste Management/NC DENR
1646 Mail Service Center
Raleigh NC 27699-1646
Phone 919-508-8510
Section webpage - http://wastenotnc.org/swhome

New email address - donna.wilson@ncdenr.gov

E-mail correspondence to and from this address may be subject to the
North Carolina Public Records Law and may be disclosed to third parties.

David Garrett & Associates
Engineering and Geology

September 2, 2010

Ms. Donna Wilson
NC DENR Division of Waste Management
Solid Waste Section
401 Oberlin Road
Raleigh, North Carolina, 27611

RE: **Addendum to Response Submittal**
Permit to Construct Application
WCA Material Recovery CDLF Phase 2A
Raleigh (Wake County), North Carolina
Solid Waste Permit No. 92-31

Dear Ms. Wilson:

On behalf of WCA, I am pleased to present the following additional responses to your verbal comments, conveyed to me in a telephone conversation on August 31, 2010. You indicated three outstanding issues from your May 7, 2010 letter, to which I had responded on May 30, 2010. These issues have been addressed (see below) and I am hereby submitting the requested information. Thank you for your comments, and please contact me if I can be of further help.

Sincerely,

G. David Garrett, PG, PE
Project Consultant

cc: Mr. Dennis Gehle – WCA Facility Manager
Mr. Nick Marotta – WCA Regional Engineer
Mr. Vernon Smith – WCA Regional Manager

5105 Harbour Towne Drive • Raleigh • North Carolina • 27604
919-418-4375 (Mobile) • 919-231-1818 (Office/fax) • E-mail: david@davidgarrettpe.com

The following responses are attached, or included in the electronic submittal forwarded via e-mail on September 2, 2010 to Ms. Wilson.

1. Section 3.3.1 describing the population served did not include Franklin County.

   Section 3.3.1 has been amended to include Franklin County and all relevant population data has been updated per the current census data available on the State Demographic Office web site.

2. Several references to specific sections of text and drawings were incorrect.

   The report has been thoroughly reviewed (again) to identify and correct typos in the references – a few more typos were, indeed, found after the May 30, 2010 revision.

3. The plat has not been furnished.

   I visited the Wake County register of deeds in June 2010 and obtained the current plat and General Warranty Deed on file for the subject property. Please find these documents attached. At present, they say "Material Recovery, LLC" which, in fact, should be correct in that Material Recovery as a business entity was purchased in 2005 by WCA but the property still belongs to the business entity, best as I can determine.

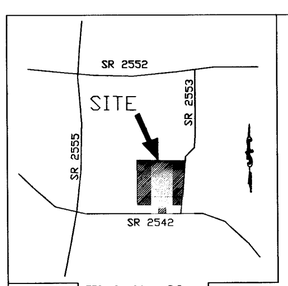
I might suggest, in the interest of facilitating the permit to construct – which is badly needed to take advantage of the remaining construction season this year – that if the Section requires any further plat or title work, this be made a contingency to the future permit to operate, rather than a permit to construct issue. The property is duly owned by WCA Material Recovery and has no contests regarding the ownership of which I am aware.

Thank you.

Cert. of Registration By Register Of Deeds
North Carolina, Wake County

Filed For Registration on the _____day of _____ , ____
and duly recorded in Map Book _____ on Page _____.

Register Of Deeds



Vicinity Map
NTS

NC GRID NORTH NAD 83

City Of Raleigh
DB 2064, PG 43d3
Current Zoning R-30

Horace Benton Heirs
PIN NO. 1741.03 44 6022
Current Zoning R-30

SURVEY NOTE:
Partial Boundary Information Taken From Map Entitled "Ashley Turner Building Co., Inc. Dated June 23, 1995, Prepared by Williams-Pearce & Assoc., PA, And Recorded In BOM 1995, PG 1025.

Tract 1-B
98.41 Ac. Incl. R/W
97.52 Ac. Excl. R/W
PIN: 1741.04-73-2924
Current Zoning R-30
DB 8806, PG 849

S82°50'24"E 3107.70'
N00°48'14"E 1534.73'
S87°55'15"E 2879.54'
OLD DIVISION LINE
CP&L 90' R/W
S82°50'24"E 32.03'
S04°28'47"W 811.79'
S04°39'47"W 102.91'
S05°41'37"W 113.61'
S06°52'39"W 76.00'
S10°22'09"W 52.22'
S14°27'54"W 55.00'
S19°07'50"W 70.27'
S24°14'24"W 56.47'
S28°21'09"W 55.62'
S33°47'21"W 92.11'
S34°51'54"W 62.67'
35.68'
Conc. Mon. Cont. Cor.
S35°35'00"W 801.74'
S35°25'33"W 122.54'
S34°46'39"W 103.54'
S34°25'54"W 115.25'
S33°42'51"W 122.91'
S33°34'14"W 109.37'
S32°51'31"W 104.44'
S31°20'44"W 105.20'
SR 2553 (60' R/W) BROWN-FIELD ROAD
S30°38'26"W 874.08'
S28°24'19"W 53.84'
S21°50'36"W 51.28'
S10°10'37"W 58.49'
S03°54'58"W 70.65'
S54°26'32"W 707.37' (Tie Line)
SR 2542 (60' R/W) OLD BAUCOM ROAD
N89°34'18"W 578.19'
S00°14'58"W 492.33'
N00°56'07"W 546.05'
S89°54'28"W 888.40'
N00°48'02"E 959.50'
N01°28'17"E 314.90'
N01°28'05"E 959.90'
43.82'
43.15'
S53°15'50"W 17.28'
ISS
ISF

Daryl J. Garrett
BOM 1983, PG 368
PIN: 1741.04-53-4141
Current Zoning R-30

Total Acres, Tr. 1-A & Tr. 1-B
211.96 Ac. Incl. R/W
209.19 Ac. Excl. R/W

Material Recovery, LLC
Lots 6 & 6A,
BM 1985, P 2157,
Lot 7B
BM 1983, P 368
Current Zoning R-30
PIN: 1741.04-52-4456

SURVEY NOTE:
PARTIAL BOUNDARY INFORMATION TAKEN FROM MAP ENTITLED "ASHLEY TURNER BUILDING CO., INC. DATED JUNE 23, 1995, PREPARED BY WILLIAMS-PEARCE & ASSOCIATES, AND RECORDED IN BOM 1995, PG 1025, AND MAP ENTITLED "ASHLEY TURNER ENTERPRISES PREPARED BY WILLIAMS - PEARCE & ASSOC." DATED APRIL 27, 1999.

Tract 1-A
113.55 Ac. Incl. R/W
111.67 Ac. Excl. R/W
Current Zoning R-30
PIN: 1741.04-62-7630
DB 8806, PG 845, Tract 1

Map For Record
Recombination Of Tracts 1A & 1B
Material Recovery, LLC
St. Marys Twsp. Wake Co., N.C.

Current Owner: Material Recovery, LLC
421 Raleigh View Road
Raleigh, NC 27610

Wake County,NC 312
Laura M Riddick, Register Of Deeds

Presented & Recorded 05/14/2002 14:00:51

Book : BM2002 Page : 00791

Polly S. Quinn
DB 2050, PG 567
Current Zoning R-30
PIN: 1741.03-41-6454

Margaret Talton
DB 4631, PG 872
BM 1989, P 422
PIN: 1741.04-60-8848
Current Zoning R-30

John Baucom
DB 6282, PG 177
PIN: 1741.02-78-3586
Current Zoning R-30

LEGEND

E.P.K.	-	Existing P.K. Nail
P.K.S.	-	P.K. Nail Set
E.C.M.	-	Existing Concrete Monument
I.S.F.	-	Iron Stake Found
I.S.S.	-	Iron Stake Set
R/W	-	Right of Way
P.P.	-	Power/Utility Pole
TEL	-	Telephone Pedestal
	-	Property Line
	-	Existing Right of Way
	-	Adjoining Property Owners
	-	Center Line

Notes:

1. No NCGS Monument Within 2000'
2. This Survey Is In A County That Is Regulated As To The Division Of Land.
3. This Survey Creates A Recombination Of Land Out Of Two Existing Parcels.

WAKE COUNTY, NORTH CAROLINA

I certify that I am (we are) the owner (s) of the property shown and described hereon, which is in the subdivision jurisdiction of the County of Wake and that I (we) hereby adopt this plat with my (our) free consent.

Owner; Material Recovery, LLC, By:
[signature] - Managing Member

Date: 5-10-02

Certificate of Survey and Accuracy

I, Walter M. Reynolds III, certify that this plat was drawn under my supervision from an actual survey made under my supervision (deed description recorded in Deed Book 8806, page 845); that the boundaries not surveyed are clearly indicated as drawn from information found in Deed Book 8806, page 845 ; that the ratio of precision as calculation is 1: 15,000; that this plat was prepared in accordance with G. S. 47-30 as amended. Witness my original signature, registration number and seal this 15th day of April A. D., 2002

[signature]
Walter M. Reynolds, III P.L.S. 1320

NORTH CAROLINA PROFESSIONAL SEAL L-1320 LAND SURVEYOR WALTER M. REYNOLDS III

TRC Triangle
500 GLENWOOD AVE.
RALEIGH, N.C. 27603
(919)828-3150

DATE: 04/15/2002	DRAWN BY: wmrIII		
SCALE: 1"= 300'	FILE: 35256	PAGE: 1 of 1	Revised: 05/09/2002

GRAPHIC SCALE
300 150 0 300 600 900
(IN FEET)
1 inch = 300 ft.

Wake County Certification

I, Adam C. Bledsoe, Subdivision Administrator and Review Officer of Wake County, certify that this plat does not create a subdivision subject to and in accord with the Wake County Subdivision Ordinance, and that it meets all statutory requirements for recording.

5/13/02
Date

Adam C. Bledsoe
Subdivision Administrator/Review Officer

Approval expires if not recorded on or before 5/28/02

Book 2002 PAGE 791

S 250-02

WAKE COUNTY
NORTH CAROLINA

Wake County Register of Deeds
Post Office Box 1897
Raleigh, North Carolina 27602-1897

Laura M. Riddick
Register Of Deeds

STATE OF NORTH CAROLINA
COUNTY OF WAKE

I, LAURA M. RIDDICK, REGISTER OF DEEDS IN AND FOR THE ABOVE NAMED STATE AND COUNTY, DO HEREBY CERTIFY THAT THE ATTACHED IS A TRUE AND EXACT COPY OF AN INSTRUMENT RECORDED IN THE WAKE COUNTY REGISTRY ON FEBRUARY 12, 2001, IN BOOK 8806 PAGE 845.

IN TESTIMONY WHEREOF, I HAVE HEREUNTO SET MY HAND AND CAUSED THE OFFICIAL SEAL OF MY SAID OFFICE TO BE AFFIXED HERETO THIS, THE 9TH DAY OF JUNE, 2010.

Laura M. Riddick
REGISTER OF DEEDS

Glenda G. Smith
DEPUTY / ~~ASSISTANT~~

(SEAL)

BK008806PG00845

Wake County,NC 444
Laura M Riddick, Register Of Deeds

Presented & Recorded 02/12/2001 13:55:10
State Of NC Real Estate Excise Tax : $3923
Book : 008806 Page : 00845 - 00848

Stamps $3,923.00 Excise Tax

Recording Time, Book and Page

Tax Lot No.

Parcel Identifier No. ID # 0211684 and ID # 0004648

Verified by

County on the day of , 19

by

Mail after recording to L. James Blackwood, II, 108 Commerce Pl., Greensboro, NC 27401

This instrument was prepared by L. James Blackwood, II, 108 Commerce Pl., Greensboro, NC 27401

Brief description for the Index 2 Tracts 163.43 gross acres Brunswick Road

NORTH CAROLINA GENERAL WARRANTY DEED

THIS DEED made this 12 day of February, 2001 , 19 , by and between

GRANTOR	GRANTEE
William A. Turner and wife, Debra C. Turner	Material Recovery, LLC 421 Raleighview Road Raleigh, NC 27610

Enter in appropriate block for each party: name, address, and, if appropriate, character of entity, e.g. corporation or partnership.

The designation Grantor and Grantee as used herein shall include said parties, their heirs, successors, and assigns, and shall include singular, plural, masculine, feminine or neuter as required by context.

WITNESSETH, that the Grantor, for a valuable consideration paid by the Grantee, the receipt of which is hereby acknowledged, has and by these presents does grant, bargain, sell and convey unto the Grantee in fee simple, all that certain lot or parcel of land situated in the City of , Township, Wake County, North Carolina and more particularly described as follows:

See Exhibit A attached hereto and incorporated herein by reference as if fully set forth.

The property described in Exhibit A consisting of 2 Tracts was heretofore conveyed to Grantor by Deed recorded in Book 6555, Page 646, Wake County Public Registry and Grantor by this Deed intends to convey to Grantee all of the property therein described

BK008806PG00846

The property hereinabove described was acquired by Grantor by instrument recorded in .....

A map showing the above described property is recorded in Plat Book ..... page .....

TO HAVE AND TO HOLD the aforesaid lot or parcel of land and all privileges and appurtenances thereto belonging to the Grantee in fee simple.

And the Grantor covenants with the Grantee, that Grantor is seized of the premises in fee simple, has the right to convey the same in fee simple, that title is marketable and free and clear of all encumbrances, and that Grantor will warrant and defend the title against the lawful claims of all persons whomsoever except for the exceptions hereinafter stated. Title to the property hereinabove described is subject to the following exceptions:

This conveyance is made subject to rights-of-way, restrictions and easements of record, if any, and ad valorem taxes for the year 2001.

IN WITNESS WHEREOF, the Grantor has hereunto set his hand and seal, or if corporate, has caused this instrument to be signed in its corporate name by its duly authorized officers and its seal to be hereunto affixed by authority of its Board of Directors, the day and year first above written.

USE BLACK INK ONLY

..... (Corporate Name)

By: .....

..... President

ATTEST:

.....

..... Secretary (Corporate Seal)

William A. Turner (SEAL)
William A. Turner

Debra C. Turner (SEAL)
Debra C. Turner

..... (SEAL)

..... (SEAL)

SEAL-STAMP PHILIP A. SCHMITT NOTARY PUBLIC WAKE COUNTY, NC

Use Black Ink

NORTH CAROLINA, Wake County.

I, a Notary Public of the County and State aforesaid, certify that William A. Turner and wife, Debra C. Turner Grantor, personally appeared before me this day and acknowledged the execution of the foregoing instrument. Witness my hand and official stamp or seal, this 12 day of February, 2001 /11

My commission expires: 2/5/2003 Philip A. Schmitt Notary Public

SEAL-STAMP

Use Black Ink

NORTH CAROLINA, ... County.

I, a Notary Public of the County and State aforesaid, certify that .....,

personally came before me this day and acknowledged that ..... he is ..... Secretary of

..... a North Carolina corporation, and that by authority duly

given and as the act of the corporation, the foregoing instrument was signed in its name by its .....

President, sealed with its corporate seal and attested by ..... as its ..... Secretary.

Witness my hand and official stamp or seal, this ..... day of ....., 19.....

My commission expires: ..... Notary Public

The foregoing Certificate(s) of .....

.....

.....

is/are certified to be correct This instrument and this certificate are duly registered at the date and time and in the Book and Page shown on the first page hereof.

..... REGISTER OF DEEDS FOR ..... COUNTY

By ..... Deputy/Assistant - Register of Deeds

N.C. Bar Assoc Form No. 3 © 1976, Revised 1977.

EXHIBIT A
to
DEED FROM WILLIAM A. TURNER and wife, DEBRA C. TURNER
to
MATERIAL RECOVERY, LLC

TRACT 1

BEGINNING at a point 70.65 feet North of the intersection of NCSR 2542 and NCSR 2553, having a line from NCSR 2542 to the point of Beginning of South 03° 54' 58" 70.65 feet, thence from said point North 89° 34' 18" West 578.19 feet to an existing iron pipe, thence from the existing iron pipe South 00° 15' 03" West 449.24 feet to an existing iron pipe, thence from the existing iron pipe South 00° 15' 03" West 36.92 feet to the center of NCSR 2542, thence from the center of NCSR 2542 South 53° 15' 50" West 172.61 feet along NCSR 2542, thence from this center point of NCSR 2542 North 00° 59' 07" West 36.56 feet to an existing iron pipe, thence from the existing iron pipe North 00° 59' 07" West 552.64 feet to an existing iron pipe, thence from the existing iron pipe South 89° 54' 28" West 888.40 feet to an existing iron pipe, thence from the existing iron pipe North 01° 28' 05" East 959.90 feet to an existing iron pipe, thence from the existing iron pipe North 01° 28' 17" East 314.90 feet to an existing iron pipe, thence from the existing iron pipe North 00° 46' 02" East 959.50 feet to an existing iron pipe, thence from the existing iron pipe South 87° 55' 55" East 2879.54 feet to a new iron pipe, thence from the new iron pipe South 87° 55' 55" East 35.68 feet to the center of NCSR 2553, thence from the center of NCSR 2553, traversing along the same road at the following coordinates: North 34° 51' 54" East 62.67 feet, North 35° 35' 00" East 601.74 feet, North 35° 25' 33" East 122.54, North 34° 46' 39" East 103.54 feet, North 34° 25' 54" 115.25 feet, North 33° 42' 51" East 122.91 feet, North 33° 34' 14" East 109.37 feet, North 32° 51' 31" East 104.44 feet, North 31° 20' 44" East 105.20 feet, North 30° 38' 28" East 914.06 feet, North 28° 24' 19" East 53.84 feet, North 21° 50' 36" East 51.26 feet and North 10° 10' 37" East 58.49 feet, which includes the 60 feet right-of-way reserved by DOT on NCSR 2553, to the point and place of BEGINNING, containing 113.55 gross acres, according to the plat of same prepared by William-Pearce & Associates, P.A., Registered Land Surveyors, dated March 21, 1995 and recorded in Book of Maps 1995, Page 456, of the Wake County Registry (and re-recorded in Book of Maps 1995, Page 1025, Wake County Registry).

TRACT 2

BEGINNING at the same point as did Tract 1 above and traversing along NCSR 2553 with those same coordinates as set forth above in Tract 1, those being as follows: North 10° 10' 37" East 58.49 feet, North 21° 50' 36" East 51.26 feet, North 28° 24' 19" East 53.84 feet, North 30° 38' 28" East 914.06 feet, North 31° 20' 44" East 105.20 feet, North 32° 51' 31" East 104.44 feet, North 33° 34' 14" East 109.37 feet, North 33° 42' 51" 122.91 feet; North 34° 25' 54" East 115.25 feet, North 34° 46' 39" East 103.54 feet, North 35° 25' 33" East 122.54 feet, North 35° 35' 00" East 601.74 feet, North 34° 51' 54" East 62.67 feet, North 33° 47' 21" East 92.11 feet, North 28° 21' 05" East 55.62 feet, North 24° 14' 24" East 56.47 feet, North 19° 07' 50" East 70.27 feet, North 14° 27' 54" East 55.00 feet, North 10° 22' 09" East 52.22 feet, North 06° 52' 39" East 76.00 feet, North 05° 41' 37" East 113.61 feet and North 04° 39' 47" 102.92 feet to a new PK nail in the center of NCSR 2553, thence from said new PK nail North 89° 23' 26" East 30.13 feet to a new iron pipe, thence from a new iron pipe 89° 23' 26" East 229.08 feet to an existing iron pipe, thence from said existing iron pipe South 52° 46' 34" East 600.84 feet to an existing iron pipe, thence from said existing iron pipe South 00° 02' 37" 311.54 feet to an existing iron pipe, thence from said existing iron pipe South 00° 12' 23" West 580.92 feet to an existing iron pipe, thence from said existing iron pipe South 89° 25' 55" West 731.89 feet to an existing iron pipe, thence from said existing iron pipe South 28° 23' 31" West 1687.75 feet to an existing iron pipe, thence from said existing iron pipe South 28° 23' 31" West 33.90 feet to the center of NCSR 2542, thence from this center point North 89° 34' 18" West 703.21 feet, which includes the 60 feet right-of-way reserved by DOT on NCSR 2542, to the point and place of BEGINNING, containing 49.88 gross acres, according to the plat of same prepared by William-Pearce and Associates, P.A., Registered Land Surveyor, dated March 21, 1995 and recorded in Book of Maps 1995, Page 456, of the Wake County Registry (and re-recorded in Book of Maps 1995, Page 1025, Wake County Registry, to correct right-of-way acreage in the above Tract 2).

WAT
DCT

BK008806PG00848

Laura M Riddick
Register of Deeds
Wake County, NC

Book : 008806 Page : 00845 - 00848

Yellow probate sheet is a vital part of your recorded document.
Please retain with original document and submit for rerecording.

WAKE COUNTY
NORTH CAROLINA

Wake County Register of Deeds
Laura M. Riddick
Register of Deeds

North Carolina - Wake County

The foregoing certificate___ of Philip A. Schmitt

_____ Notary(ies) Public is (are) certified to be correct. This instrument and this certificate are duly registered at the date and time and in the book and page shown on the first page hereof.

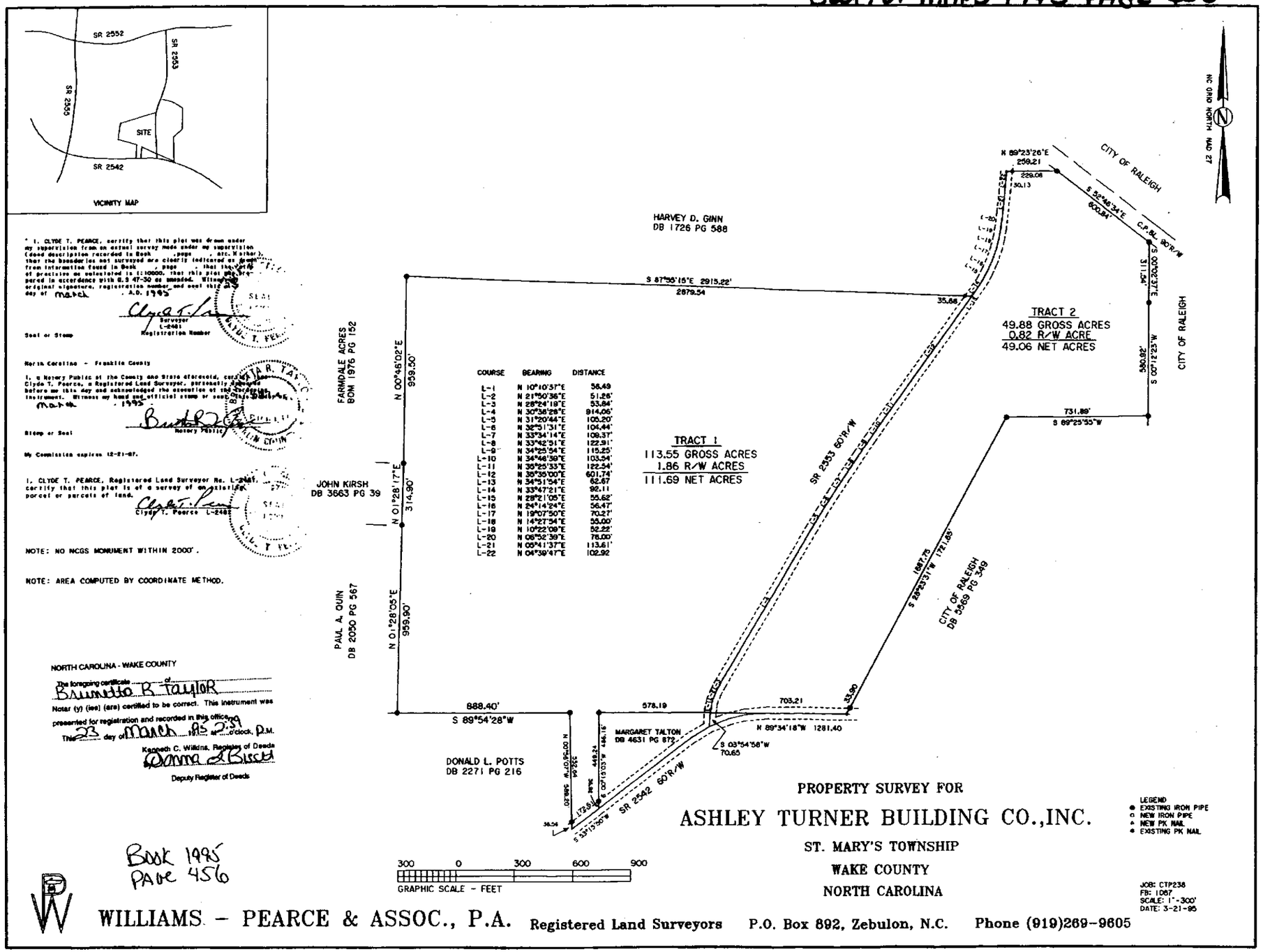
Laura M. Riddick, Register of Deeds

By: P. Anne Redd
Assistant/~~Deputy~~ Register of Deeds

This Customer Group
2 # of Time Stamps Needed

This Document
_____ New Time Stamp
4 # of Pages

BOOK OF MAPS 1995 PAGE 456



COURSE	BEARING	DISTANCE
L-1	N 10°10'37"E	56.49
L-2	N 21°50'36"E	51.26'
L-3	N 28°24'18"E	53.84'
L-4	N 30°38'28"E	914.06'
L-5	N 31°20'44"E	105.20'
L-6	N 32°51'31"E	104.44'
L-7	N 33°34'14"E	109.37'
L-8	N 33°42'51"E	122.91'
L-9	N 34°23'54"E	115.25'
L-10	N 34°46'39"E	103.54'
L-11	N 35°25'33"E	122.54'
L-12	N 35°35'00"E	601.74'
L-13	N 34°51'54"E	62.67
L-14	N 33°47'21"E	92.11
L-15	N 29°21'05"E	55.62'
L-16	N 24°14'24"E	56.47'
L-17	N 19°07'50"E	70.27'
L-18	N 14°27'54"E	55.00'
L-19	N 10°22'09"E	52.22'
L-20	N 06°52'39"E	76.00'
L-21	N 05°41'37"E	113.61'
L-22	N 04°39'47"E	102.92

* I, CLYDE T. PEARCE, certify that this plat was drawn under my supervision from an actual survey made under my supervision (deed description recorded in Book , page , etc. Neither) that the boundaries not surveyed are clearly indicated as drawn from information found in Book , page , that the ratio of precision as calculated is 1:10000, that this plat was prepared in accordance with G.S 47-30 as amended. Witness my original signature, registration number and seal this 23 day of March, A.D. 1995

Clyde T. Pearce
Surveyor
L-2481
Registration Number

Seal or Stamp

North Carolina - Franklin County

I, a Notary Public of the County and State aforesaid, certify that Clyde T. Pearce, a Registered Land Surveyor, personally appeared before me this day and acknowledged the execution of the foregoing instrument. Witness my hand and official stamp or seal, this 23 day of March, 1995.

Brunetta R. Taylor
Notary Public

Stamp or Seal

My Commission expires 12-21-97.

I, CLYDE T. PEARCE, Registered Land Surveyor No. L-2481, certify that this plat is of a survey of an exterior parcel or parcels of land.

Clyde T. Pearce L-2481

NOTE: NO NCGS MONUMENT WITHIN 2000'.

NOTE: AREA COMPUTED BY COORDINATE METHOD.

NORTH CAROLINA - WAKE COUNTY

The foregoing certificate of Brunetta R. Taylor Notar (y) (ies) (are) certified to be correct. This instrument was presented for registration and recorded in this office in Book 95 This 23 day of March, 1995 at 2:39 o'clock P.M.

Kenneth C. Wilkins, Register of Deeds
Donna L. Bissett
Deputy Register of Deeds

Book 1995
Page 456

PROPERTY SURVEY FOR

ASHLEY TURNER BUILDING CO.,INC.

ST. MARY'S TOWNSHIP
WAKE COUNTY
NORTH CAROLINA

LEGEND
● EXISTING IRON PIPE
○ NEW IRON PIPE
▲ NEW PK NAIL
◆ EXISTING PK NAIL

JOB: CTP238
FB: 1087
SCALE: 1"=300'
DATE: 3-21-95

WILLIAMS - PEARCE & ASSOC., P.A. Registered Land Surveyors P.O. Box 892, Zebulon, N.C. Phone (919)269-9605

PERMIT TO CONSTRUCT APPLICATION
VOLUME 1 OF 2

Engineering and Design Report

WCA Material Recovery, LLC,
C&D Landfill (Phases 1 and 2A)
Wake County, North Carolina
NCDENR Solid Waste Permit #92-31

Prepared for

Original June 2008
Revised June 2010

David Garrett and Associates

Engineering and Geology

5105 Harbour Towne Drive, Raleigh, NC 27604 *Telephone/Fax (919) 231-1818*

ENGINEERING AND DESIGN REPORT

WCA Material Recovery, LLC
(Brownfield Road) C&D Landfill Phase 2A

Wake County, North Carolina
NC DENR Solid Waste Permit #92-31
Permit to Construct Application

Prepared for:

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Raleigh, North Carolina 27610

To the Attention of:

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Regional Engineer

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6-18-2010

Original June 2008
Revised June 2010

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E2	Incremental Fill Grades by Cells
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EC1	Final Closure S&EC Plan
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APPENDICES – VOLUME 1

1 Airspace, Earthwork, Stability, and Settlement Calculations

2 Sedimentation and Erosion Control Calculations

3 Operation Plan Information

- 3A Waste Screening Form
- 3B Emergency and Other Useful Contacts
- 3C Fire Notification Form

4 Financial Assurance Documents

INTRODUCTION

WCA Waste Corporation and subsidiary WCA Material Recovery, LLC, hereby makes application to build Phase 2A of the Construction and Demolition debris landfill (CDLF), located at 2600 Brownfield Road (S.R. 2553) in Wake County, North Carolina. The planned Phase 2A is contiguous with existing Phase 1 and is located in the "North" disposal area shown in the original site suitability documents (prepared by others). This expansion and future operations at this facility will be conducted in accordance with **Solid Waste Rules 15A NCAC 13B .0531** *et seq.*, effective January 1, 2007 – known as the "**2006 C&D Rules**." This CDLF is an "existing facility" as of August 31, 2007, with respect to the **2007 Solid Waste Act (S1492)**, and the facility meets the vertical separation requirements of the 2006 C&D Rules.

As such, Phase 2A and subsequent expansions of this facility do not require a synthetic liner, but the soil-type requirements prescribed by the 2006 C&D Rules for the upper two (2) feet beneath the base grade do apply for Phase 2A and beyond – these soil types are present in abundance on the premises. The facility is regulated by the North Carolina DENR Division of Waste Management, Solid Waste Section, a.k.a. the "Division" or "SWS."

The permitted facility boundary encompasses approximately 210 acres. Original plans submitted to Division of Waste Management ca. 2001-02 included two disposal areas, the currently active "North" area (45 acres, 20 acres of which are developed as Phase 1) and the "South" area (24 acres, future development). Phase 2 includes the remaining 25 acres of the "North" area, matching the originally planned footprint and final grades. Earlier site investigations include the December 2001 Site Suitability Application, i.e., the Hydrogeologic Characterization Report) and the December 2001 Construction Plan Application, prepared by Joyce Engineering, Inc. Supplemental permitting documents include the Sedimentation and Erosion Control (S&EC) Plan submitted to Wake County Environmental Services, who has jurisdiction under authority from NC DENR Division of Land Resources, Land Quality Section.

This report augments earlier site studies relative to the planned Phase 2 CDLF construction, including the footprint and down gradient monitoring zones, along with engineering and design work performed in accordance with the 2006 C&D rules. This report was originally prepared and submitted in June 2008; regulatory agency review comments were received May 7, 2010, hence this updated and amended report has been prepared. The following presents **Volume 1** of two volumes – i.e., the Facility Plan Report, Closure and Post-Closure Plans, and Financial Assurance Calculations, while **Volume 2** presents Design Hydrogeologic Report and the Facility Monitoring Plan. A Sedimentation and Erosion Control (S&EC) Plan 2 has been submitted to Wake County as a separate document, which is currently under review.

Phase 2 has been divided into two subphases: Phase 2A and Phase 2B reflect the permitted airspace that will approximate 5-years of capacity; Phase 2A has been further divided into two stages for construction, Stage 1 and Stage 2, to reflect a construction sequence based on drainage patterns. This application requests a Permit to Construct from the Division for the southern half of the Phase 2 footprint (Phase 2A), which, along with the airspace remains available in Phase 1, will provide the facility approximately 5 years of airspace. The reasoning behind making this request to initiate Phase 2A now, rather than filling Phase 1 to its maximum capacity and then commencing with Phase 2A, is to allow the Operator more physical space for truck and equipment access for more efficient operations and better compaction.

OWNER/OPERATOR INFORMATION

WCA Material Recovery, LLC
Mr. Dennis Gehle, General Manager
2600 Brownfield Road (S.R. 2553)
Raleigh, North Carolina 27610

Tel 919-838-6973 (administrative office)
Fax 919-779-3339 (scale house)

Please refer to the applicant signature page.

SITE LOCATION DATA

Latitude N 35.7094
Longitude E -78.5042

Wake County Tax Department provides the following information on the parcel: PIN identification is 1741639103; deed book is 08806 and page number 0845; date of deed is 2/12/2001; acreage is 210.19. Refer to the Wake County GIS Parcel Map (see **Figure A**); also see http://imaps.co.wake.nc.us/imaps.

REVISIONS

Rev 0	Permit to Construct Application Engineering and Design Report WCA Material Recovery CDLF (Vol. 1 of 2)	June 2008
Rev 1	Update of Volume 1 of 2 in response to regulatory rule changes and comments	May-June 2010
Rev 1.1	Revision of Volume 1 of 2 in response to regulatory review	September 2010

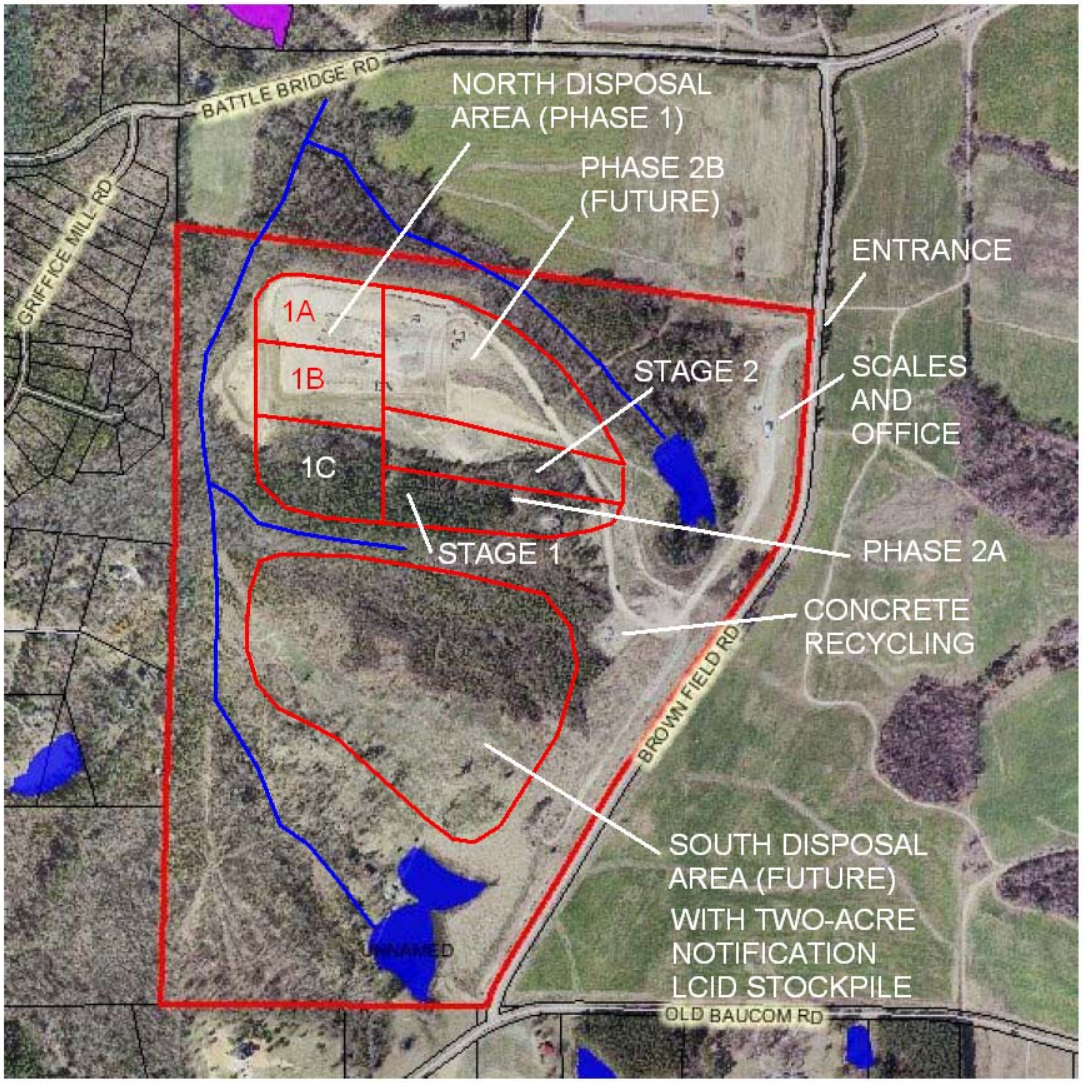


FIGURE A - Facility Layout
(Waste Boundaries are Approximate)

Wake County GIS aerial photography, 2005

0 866 ft

CERTIFICATION

This engineering plan for the WCA Material Recovery C&D Landfill, Phase 2A disposal unit has been prepared by, or under the responsible charge of, one or more North Carolina Licensed Professional Engineers to meet the requirements of 15A NCAC 13B .0539. The individual signature and seal below attests to compliance with this rule requirement.

Signed _____

Printed G. David Garrett

Date June 18, 2010

Not valid unless this document bears the seal of the above-named licensed professional.

1.0 BACKGROUND INFORMATION

1.1 Existing Facilities and Development History

WCA Material Recovery, LLC, operates a C&D landfill that is permitted to accept construction and demolition (C&D) debris, including asbestos-containing material (ACM) subject to special operational and documentation requirements, land clearing inert debris (LCID) – which is handled within a two-acre notification stockpile – concrete debris – which is handled in a separate storage and processing area – and pallets, which are proposed to be ground into boiler fuel or mulch within the LCID area. Phases 1 and 2 encompass a 45-acre contiguous footprint within the "North" disposal area, contained within a 210-acre permitted facility boundary.

Phase 2 is located to the east (uphill) of Phase 1 within the "North" disposal area and will share the storm water management facilities. Phase 2A consists of the southern half of Phase 2. The facility has scales and office/scale house building, an inert debris stockpile (concrete debris only) used for making beneficial fill. An LCID stockpile is operated under a two-acre notification within the future "South" disposal area (**Figure A**). WCA seeks to amend the permit for the LCID stockpile to include pallets – please note that no "in-ground" LCID disposal activities occur on the premises. On-site fuel storage is permitted under Wake County ordinances; routine equipment maintenance (fueling and lubrication) takes place on-site, but there is currently no equipment maintenance depot. The Facility Plan is shown on **Drawing S4**.

Opened October 2003 and operated by Material Recovery and Recycling, LLC (MRR), the facility was acquired in 2005 by Waste Corporation of America (WCA) and is now operated by WCA Waste Corporation and subsidiary WCA Material Recovery, LLC. Phase 1 includes 20 acres and was permitted in three subphases (1A, 1B, and 1C), now operating in Phases 1B, and 1C. Portions of Phases 1A and 1 B have reached final grades along the outer slopes (north and west sides). Phase 1C grading was completed in 2007. In early 2008 the facility received a 5-year permit to operate renewal for Phase 1.

The current franchise with Wake County was approved January 20, 2004. The approved Service Area includes all or parts of Wake, Johnston, Durham, Orange, Chatham, and Franklin Counties. A majority of the C&D waste stream is derived from two material-transfer/recycling facilities operated by WCA, located on Durant Road and Raleighview Road in Wake County. The permitted daily tonnage is **1,100 tons per day** in accordance with the Wake County Franchise and the current NC DENR permit. Wake County is currently reviewing the S&EC plan for the new construction; the S&EC permit will be forwarded to the Section when acquired.

1.2 Environmental Setting

The CDLF is located in eastern Wake County near the intersection of Brownfield Road (SR 2553) and Battle Bridge Road (SR 2552). The City of Raleigh owns and operates facilities adjacent to the subject site, including a municipal waste water treatment plant and associated former sludge disposal fields to the east and a police training ground to the north. Private residential development exists across a large wooded creek bottom to the west of the site, and mixed farmland and residential development exists to the south, several thousand feet from the disposal unit. The site is relatively isolated from the public by hilly topography and numerous streams (see **Drawings S1** and **S2**). The site is located within the Neuse River Basin and is subject to riparian buffer rules. Three perennial streams have been identified – the one between the North and South disposal areas is under evaluation for proposed future impacts and possible mitigation.

1.3 Future Facility Expansion

Based on the 2001 Joyce Engineering report, **Phase 1 will contain approximately 1.6 M cubic yards of total airspace, or 1,429,000 cubic yards (964,000 tons)** of C&D when completely full – according to the original PTC for Phase 1 (prepared by others – excluding a projected 11% soil use and a 2-foot thick final cover; thus the estimated initial airspace in Phase 1 is approximately 1,636,433 cubic yards. Based on volume calculations prepared for the Phase 2 PTC in 2008, there were approximately **762,000 cubic yards (514,000 tons) remaining** to reach the permitted grades in Phase 1. By this calculation, approximately 874,433 cubic yards of airspace had been consumed (including periodic cover soil).

Phase 2 will encompass a 25-acre footprint – contiguous with Phase 1 – with a planned vertical expansion over Phase 1 (included in the Operations Plan for Phase 2A) that will bring the final elevations to approximately El. 404 (MSL) – consistent with the original permitted final grades. Phase 2 will be constructed and operated as three subphases, beginning in the south (Phase 2A) and working toward the north (Phase 2B), culminating in a vertical expansion over both Phases 1 and 2 (Phase 2C). Phase 2A may be constructed in two stages due to drainage.

Based on projected volume calculations, the entire Phase 2 and the vertical expansion will add an estimated **4.2M cubic yards (2.8M tons)** of net disposal volume, relative to elevations established in a February 2008 aerial survey, allowing for 0.7M cubic yards remaining in Phase 1. The total waste volume in the North disposal area will be approximately 1.6M + 4.2M = **5.8M cubic yards (3.8M tons)**, assuming an in-place density of **0.67 tons/cubic yard**. The estimated remaining life of Phases 1 and 2 will be

16 years (from 2008), or 14 years from now, representing three 5-year permitting cycles (14 years from May 2010). The following is a summary of the waste volumes by phase:

EXISTING CONDITIONS	**WCA Material Recovery CDLF (Permit #92-31)**		
Solid Waste Units Present	C&D Landfill, Concrete Recycling, Wood Waste Processing		
Other Activities/Infrastructure	Scales/Office, Alternative Cover Demonstration		
CDLF Unit Footprint Acreage			20 acres
CDLF Phases/Sub-Phases [1]	**1A**	**1B**	**1C**
New Ground Footprint Acreage [1]	7 ac	5.5 ac	7 ac
Final Elevations (Phase 1) [1]			EL. 308
Maximum Waste Thickness [2]			88 feet
Permitted Side Slope Ratios			3H:1V
Acreage of Closed Slopes			0
Facility Boundary Acreage			210.19 acres
Permitted Capacity (Phase 1) [2]			1,636,000 c.y.
Existing Permitted Capacity [3]			83,166 c.y.
Remaining Operational Life [3]			3.3 months

PROPOSED PERMITTING	**Phase 2 is contiguous to Phase 1**		
Solid Waste Units Present [4]			Unchanged
Other Activities/Infrastructure [4]			Unchanged
New CDLF Unit Footprint Acreage [4]			45 acres
New CDLF Phases/Sub-Phases [1]	**2A**	**2B**	**2C**
New Ground Footprint Acreage [1]	16.7 ac	8.2 ac	0 [5]
Interim Capacities (Sub-Phases) [2]	1,400,000 c.y.	1,400,000 c.y.	1,400,000 c.y.
Interim Operational Life [3]	55.7 mos.	55.7 mos.	55.7 mos.
Interim Elevations (Sub-Phases)	EL. 310	EL. 310	EL. 404
Final Elevations (Entire Unit) [2]			EL. 404
New Phase 2 CDLF Unit Capacity [2]			4,200,000 c.y.
Maximum Waste Thickness [2]			184 feet
Permitted Side Slope Ratios [4]			3H:1V
Acreage of Closed Slopes			0
Facility Boundary Acreage [4]			210.19 acres
CDLF Footprint (Phases 1 and 2) [4]			45 acres
Proposed Capacity (Phases 1 and 2A) [6]			3,036,000 c.y.
Operational Life (Phases 1 and 2A) [6]			4.9 years
Total Capacity (Phases 1 and 2) [4]			5,836,000 c.y.
Remaining Capacity (Phases 1 and 2) [4]			4,283,166 c.y.
Remaining Operational Life (Phases 1 and 2) [4]			14.3 years

PROJECTED CONDITIONS	**South Disposal Area**		
Solid Waste Units Present [4]			Unchanged
Other Activities/Infrastructure [4]			Unchanged
New CDLF Unit Footprint Acreage [4]			24.2 acres
New CDLF Phases/Sub-Phases [1]	3	**4**	**5**
New Ground Footprint Acreage [1]	12.2 ac	12.2 ac	0 [5]
Interim Capacities (Sub-Phases) [2]	780,000 c.y.	780,000 c.y.	740,000 c.y.
Interim Elevations (Sub-Phases)	EL. 272	EL. 272	EL. 362
Projected South Area CDLF Capacity [2]			2,300,000 c.y.
Projected Operational Life (South area) [2]			7.6 years
Facility Boundary Acreage [4]			210.19 acres
Future CDLF Acreage (North and South areas) [4]			69.2 acres
Future CDLF Capacity (North and South areas) [4]			8,136,000 c.y.
Projected Operational Life (North and South areas) [6]			21.9 years

Notes:

1 Based on Drawing No. 5, 12/28/01, by Joyce Engineering

2 Includes Final Cap System and Operational Cover – Allocate one-third the airspace for Phase 2 to Phase 2A

3 Based on an analysis performed based on the February 2008 survey (see **Section 3.3.2**), the average total airspace consumption is approximately **25,142 c.y. per month**; considering that 2 years have passed since the Phase 2 permit application document was prepared, the airspace consumed between Feb 2008 and May 2010 will be approximately 25,142 * 27 months = 678,834 cy (assuming a consistent average); thus the current airspace consumed since the opening of Phase 1 is approximately 874,433 + 678,834 = 1,553,267 cy (subtract this from permitted capacity); remaining capacity in Phase 1 is 1,636,433 – 1,553,267 = 83,166 cy, which provides approximately 3 months of disposal volume, based on average airspace consumption; compaction may be reduced in the higher elevations of the waste pile – these calculations do not account for settlement and density variations

4 Subject to Approval of this Application – includes all of Phase 1 and Phase 2 in the North disposal area

5 Vertical Expansion – not actual ground disturbance

6 Add the remaining capacity of Phase 1 to the interim capacity associated with the area of interest

1.4 Regulatory Requirements

Solid Waste Rules 15A NCAC 13B .0531 *et seq.* became effective January 1, 2007 – known as the "**2006 C&D Rules**." Rule .0547 requires that existing CDLF units, i.e., facilities that accepted waste prior to January 1, 2007 and wish to continue operating under the "**2006 C&D Rules**," submit an application to depict the proposed long-term development of the site and demonstrate compliance with the new rule requirements. This document constitutes said application and is organized in general accordance with the sequence of presentation of topics under **Rules .0531** through **.0547** (with references). This document includes provisions of the "2006 C&D Rules" that must be met:

(1) Existing C&D units that did not and will not receive solid waste after June 30, 2008 must be closed under the requirements of Rule .0510 (the previous rules).

Final exterior slopes in Phase 1 were not reached by June 30, 2008

(2) Financial Assurance must be demonstrated prior to July 1, 2008 to cover the estimated costs of closure and post-closure for C&D units (typically, a local government test for political subunits of the State, i.e., counties).

WCA Material Recovery, LLC and WCA Waste Systems, Inc., has in place an appropriate fiduciary instrument within the specified time frame, based on costs estimates developed elsewhere in this document for Phase 2 and the remaining portions of Phase 1 at the time of closure.

(3) A Permit to Construct application for a new phase must contain a comprehensive facility plan for long-range development, including the layout, aerial limits and capacity of various proposed waste management units, along with identification of the anticipated waste stream and criteria for waste acceptance and segregation; an Engineering Plan for the initial phase of development; a Construction Quality Assurance (CQA) plan; an Operation Plan prepared under the "**2006 C&D Rules**" that includes amended monitoring programs (both environmental and waste acceptance monitoring); a Closure and Post-Closure Plan (with cost estimates to facilitate the financial assurance demonstration).

WCA Material Recovery, LLC and WCA Waste Corporation will have met the application requirements within this document (pending Division approval). The Facility Plan depicts the Phase 2 expansion; further development of the facility (the "southern" disposal area) remains in the long-range facility plan but no formal plans have been derived at this time, nor has a site specific design hydrogeologic investigation been performed.

2.0 PHASE 1 CDLF CLOSURE (15A NCAC 13B .0510)

Portions of Phase 1 have reached final grades, i.e., exterior slopes on the north and west sides, near the northwest corner, up to a planned erosion control bench. These slopes have been covered with 24 inches of soil and stabilized with vegetation, but the slopes are not considered "closed" in the current C&D rules. As such, none of the final closure requirements of Rule .0510 apply. All slopes will be closed in due time under the current C&D rules – closure plan is described elsewhere in this report. A sedimentation and erosion control (S&EC) plan has been in place for Phase 1 throughout its operation; anticipated work associated with the closure of Phase 1 will include cleaning out and refurbishing the sediment basin, as needed, and maintaining miscellaneous ditches, traps, and check dams, as needed.

3.0 PHASE 2 CDLF FACILITY PLAN (15A NCAC 13B .0537)

3.1 Regulatory Summary

The Rules require that the facility plan define the comprehensive development of the property, consistent with the approved site suitability. This updated PTC application includes preliminary design information regarding the entire Phase 2 footprint within the "North" disposal area and future phases (tentatively identified as Phases 3, 4, and 5) within the "South" disposal area, which was included in the original site suitability but not reported for design volume (see **Section 1.3** and **Drawing S4**). The "2006 C&D Rules" emphasize vertical separation and minimum subgrade soil type requirements. The proposed C&D expansion meets or exceeds the 4-foot minimum vertical separation requirement to groundwater and bedrock, thus no liner or leachate collection system is required under these rules. Subgrade soil types that will be exposed via excavation and used in the compacted fill sections are anticipated to exhibit a mix of finer soil types, e.g., ML, MH, CL, CH, SM and mixed SM-ML classifications, based on site data, thus subgrade permeability is expected to be low, providing the soils are reworked and compacted (see **Section 4.2**).

3.2 Facility Drawings

3.2.1 Facility Layout

Drawings E1 and **E3** are the base grades and final grades for Phase 2, respectively, while incremental grades are shown on **Drawing E2**. The aerial limits are set to provide a minimum 200-foot buffer to the facility boundary, a 50-foot buffer to jurisdictional water bodies, per the rules that were in effect when the project initiated – this is an "existing" facility relative to the 2007 Solid Waste legislation, hence the original setback requirement applies for jurisdictional waters. The Facility Plan (**Drawing S4**) shows the locations of current and future soil borrow areas and the inert debris stockpile area. The Phase 2 footprint contains no identified floodplains or wetlands (adjacent areas with these features will be avoided), unstable areas or cultural resource areas that affect project development.

3.2.2 Operational Sequence

The Phase 2 footprint will be developed as two "subphases," split east-to-west along a dividing ridge – Cell 2A along the south side of the ridge will be developed first. The operational sequence will mirror the development sequence for Phase 2 – Phase 2A (south side) will be filled first, during which time Phase 2B (north) side will be built then filled. Finally, Phase 2C (vertical expansion over Phases 1 and 2) will be built. The

sequence is expected to provide capacity for two 5-years permit cycles beyond the current operational permit. Stages or cells within the Phase 2 footprint may be constructed incrementally, as needed to manage surface runoff. Interior and exterior slopes will be maintained at a 3H:1V ratio, demonstrated to be adequate in **Section 4.5** and **Appendix 1**; upper surfaces shall be graded to promote positive drainage, ideally at a 5% slope.

Upon reaching final grades (**Drawings E2** and **E3**), exterior slopes will be covered with an interim cover soil with vegetation or mulch and allowed to settle for up to 6 months; the final cover will be placed incrementally. Soil excavated from the adjacent grading activities and/or existing stockpiles will be used for interim cover. Soils suitable for meeting the 2006 final cover permeability requirements will be segregated and stockpiled until needed (**Section 8.0**). Please refer to **Section 1.3** for a table-facilitated discussion of the operational sequence and approximate volumes of each phase and subphase.

3.3 Facility Report

3.3.1 Waste Stream

The CDLF is permitted for 1,100 tons per day. The facility operates 6 days per week (300 days per year) – this equates to approximately 330,000 tons per year. Scale-house records indicate the average daily intake is consistent with the original permit. Per the Wake County Franchise and the Solid Waste Permit, the following populations (by county) are potentially served by the facility:

SELECTED COUNTY	2000 Census[1]	2009 Census	% Growth[2]	2019 Pop Est[3]	% Growth	2029 Pop Est[3]	% Growth
CHATHAM	49,329	62,492	26.7%	72,612	47.2%	84,861	72.0%
DURHAM	223,013	266,189	19.4%	291,390	30.7%	328,327	47.2%
FRANKLIN	47,260	59,199	25.3%	71,930	52.2%	85,249	80.4%
JOHNSTON	121,964	168,253	38%	214,626	75.9%	268,223	120%
ORANGE	118,200	132,306	11.9%	145,051	22.7%	159,816	35.2%
WAKE	627,816	892,607	42.2%	1,111,606	77.1%	1,382,214	120%
MULTI-COUNTY SERVICE AREA	1,187,582	1,581,046	33.1%	1,910,215	60.8%	2,308,690	94.4%
STATE OF NORTH CAROLINA	8,047,764	9,382,610	16.6%	10,744,214	33.5%	12,167,409	51.2%

[1]Source data: 2009 Provisional County Population Estimates, North Carolina State Data Center, May 2010, http://demog.state.nc.us/

[2]All growth is relative to 2000 Census Data

[3]Source data: Projected Annual County Population Totals (for years given), North Carolina State Demographics, North Carolina State Data Center, http://demog.state.nc.us/

According to the NC DENR Solid Waste Section annual reports, found on-line at http://www.wastenotnc.org/swhome/, the actual annual disposal at the subject facility during FY 2008-09 was 121,393 tons, and for FY 2007-08 the annual disposal was 176,344 tons. Based on the population projections, there is expected to be an adequate supply of waste to keep the facility operational for the foreseeable future. It is understood that an increase in the waste intake will require modification of the Wake County Franchise Agreement and, if the increase is 10% or more, a permit modification (necessitating a public hearing) will be required.

3.3.2 Landfill Capacity

The volumetric analysis for Phase 2 (**Appendix 1)** compared a surface model for the February 2008 aerial survey and the final waste grades at full build-out. This analysis indicated an estimated 4,980,657 cubic yards of airspace, (average of three calculations methods facilitated by Land Desktop software interacting with AutoCAD), which includes interim cover soils but excludes final cover. A similar analysis for the projected interim grades within Phase 1 (relative to the February 2008 survey) indicated 762,442 cubic yards remaining in Phase 1 (at the time) – this subtracted from the total airspace yields approximately 4,218,215 cubic yards contributed by Phases 2A, 2B, and 2C.

A volume analysis comparing the February 2008 surface model, i.e., waste contours in Cells 1A and 1B (at the completion of Cell 1B grading), to the waste contours in Cell 1A in March 2005 determined that approximately 880,000 cubic yards of airspace had been consumed, mostly during the prior 35-month period. This equates to an average monthly airspace consumption of 25,142 cubic yards per month. Scale house records for a 25-month period spanning February 2006 through March 2008 indicate 357,412 tons were disposed, for an average of 14,300 tons per month. Assuming 15% soil use, 748,000 cubic yards of the consumed airspace was actual waste, or 21,370 cubic yards per month. This yields an in-place waste density of 0.66 tons per cubic yard – this agrees with earlier calculations by Joyce Engineering based on 0.68 tons per cubic yard.

Projecting the monthly airspace consumption (25,142 cubic yards) to the total airspace for the "North" disposal area (4,218,215 cubic yards for Phase 1 and Phase 2), the operational life relative to the February 2008 survey is 168 months, or approximately 14 years, which represents approximately three 5-year permitting cycles. These projections assume even waste intake (regional growth factors are not factored in). Using a projected 15% periodic soil use and assuming a 3-foot thick final cover (i.e., consistent with the 2006 C&D rules) the net disposal capacity in Phase 2 is as follows: 4,218,215 * 85% - 121,000 = 3,464,483 cubic yards * 0.66 = 2,286,558 tons. The estimated capacities in the each subphase (2A, 2B, and 2C) are one-third of the total.

3.3.3 Special Engineering Features

No seeps, springs, soft ground, or unstable conditions were identified in the characterization studies. As such, no special engineering design features are required. The subsurface investigations revealed differential weathering along the upper reaches of the bedrock – evidenced by variable depths to "auger refusal" within the central and eastern portions of Phase 2. This pattern suggests the presence of boulders embedded in a saprolite matrix, which does not constitute continuous "bedrock." A preliminary blasting plan has been prepared to allow the Owner the option of removing boulders to predetermined elevations via ripping and carefully controlled blasting, and backfilling to design grades that will maintain the regulatory minimum 4 feet of separation to continuous bedrock. The preliminary blasting plan (submitted under separate cover) has been prepared for regulatory review based on successful blasting performed at other landfill facilities in North Carolina (under the author's supervision) – once a contract has been let and the specifics of the weathered rock surface have been identified during construction of Phase 2, a detailed blasting plan will be prepared and made part of the CQA documentation for the Phase 2A construction.

3.3.4 Equipment Requirements

The minimum required equipment to operate the subject facility is as follows:

- One D-6 or equivalent dozer with single-tooth ripper
- One CAT 235 or equivalent track-mounted excavator
- One CAT 963D or equivalent track-mounted loader
- One CAT 826 or equivalent steel-wheel landfill compactor
- One 725 articulated off-road dump truck
- One water truck (make and model not specified)

Other equipment shall be contracted, rented, or purchased as needed to facilitate operation of the facility.

3.3.5 Other Solid Waste Activities

The facility operates an inert debris stockpile (concrete debris only) used for making beneficial fill and a LCID stockpile operated under a two-acre notification within the future "South" disposal area (see **Drawing S4** and **Figure A**). Upon approval of this plan, WCA will store and process pallets within the LCID area – subject to the 6,000 cubic yard material stockpile criteria for two-acre stockpiles – with no "in-ground" LCID disposal activities on the premises.

4.0 ENGINEERING PLAN (15A NCAC 13B .0539)

4.1 Engineering Report

This section of the report describes the physical aspects of the facility design, with emphasis on waste containment and environmental control systems, based on the hydrogeologic data discussed in **Section 10.0**. The design was prepared by a qualified Professional Engineer, who is licensed to practice in North Carolina and is familiar with the requirements of the North Carolina Division of Waste Management (Division) rules. The design of the first operational cells of Phase 2 is set to provide approximately 5 years of capacity, in keeping with rules – normally 5 years of airspace are permitted at a time. Also, in keeping with the intent of the **2006 C&D Rules**, there is no liner or leachate collection system proposed for this facility since the site meets the rule requirements for soil types present within two feet below planned base grades, and there is at least 4 feet of vertical separation between the waste and seasonal high ground water and/or bedrock, (see **Rule .0540 (2)**). The planned base grades and outer slopes will have maximum slope ratios of 3H:1V, which have been demonstrated to be stable.

4.1.1 Analytical Methods

The facility design incorporates elements that are consistent with Division rules and guidelines, as well as sound engineering practice. Various analyses used in the design of the facility include evaluations of soil conditions, i.e., the consistency of subgrade soils and the availability of suitable soils for constructing stable embankments and other earthen structures (discussed below), and ground water characteristics, i.e., flow directions and seasonal water depth fluctuations, discussed in **Section 10.0** (see **Design Hydrogeologic Report**). Soil properties testing used to facilitate these evaluations included grain size analysis, shear strength, consolidation, and compaction characteristics. Stability and settlement of foundation soils were considered in setting base grades, as was outer slope stability for the final cover system (see **Appendix 1**). Other analyses included a detailed evaluation of S&EC and storm water management systems (see **Appendix 2**).

4.1.2 Critical Conditions

Based on the nature of the soils within the Phase 2 footprint and across the site, no inherent foundation stability or long-term settlement problems are anticipated. There are no wetlands identified within the Phase 2 footprint – either Phase 2A or 2B, based on the original site suitability report.

4.1.3 Technical References

Calculations found in **Appendix 1** are referenced within the various analyses.

4.1.4 Location Restriction Demonstrations

The site was granted a Site Suitability determination that meets the requirements of **15A NCAC 13B .0531** *et seq.***,** based on work completed in 2001-02. Relative to **Rule .0536** pertaining to C&D landfills, the site has no disqualifying conditions with respect to zoning, setbacks from residences or potable wells, historic or cultural sites, state or nature preserves, 100-year floodplains, wetlands, water supply watersheds, or endangered species. Documentation pertaining to these site selection criteria is found in the **December 2001 Site Suitability Application**.

4.2 Construction Materials and Practices

Based on the Design Hydrogeologic investigation (**Section 10.0**), on-site soils available for embankment and subgrade construction consist chiefly of variably silty sand (i.e., Unified Soil Classification System classifications of SM and SM-ML) with clayey sand (SC) and clayey silt (ML and MH). These soils meet the requirements for the upper two feet beneath the landfill subgrade referenced in **15A NCAC 13B .0540 (2)** (**Section 6.0**). The soils exhibit adequate compaction characteristics and shear strength (when properly compacted) to build stable embankments and subgrades that will not undergo excessive settlement. Some selective use of soils and/or field evaluation will be required to place the correct soil types within the upper two (2) beneath the subgrade elevations. During construction and operations, select soils capable of being compacted to meet final cover permeability requirements will be segregated and reserved for final cover construction.

Good construction practices for embankments and subgrades include compaction using steel-wheel rollers, sheep foot rollers, and/or smooth-drum rollers of sufficient weight – not bulldozers – making a minimum numbers of passes (typically three to five passes) in two perpendicular directions in order to achieve the desired strength properties for stability. Past experience at the site indicates that material selection (i.e., avoiding soils that are excessively wet or exhibit excess organic debris content) and/or blending soils to negate the effects of wet or slick soils will produce satisfactory results. The targeted compaction criterion is 95% of standard Proctor maximum dry density (**ASTM D-698**). Critical embankment and subgrade areas will be tested to ensure proper compaction in accordance with the CQA Plan (**Section 6.0**). General earthwork calculations for subgrade preparation, operational soil, and final cover are presented in **Appendix 1.**

4.3 Design Hydrogeologic Report

Refer to **Section 10.0** (**Volume 2**) of this report.

4.4 Engineering Drawings

Refer to the rolled plan set that accompanies this report. All relevant criteria required by the rules (except as noted) are depicted on the plans.

4.4.1 Existing Conditions

See **Drawings S1 – S5**.

4.4.2 Grading Plan

See **Drawing E1**.

4.4.3 Stormwater Segregation

See **Drawings E1** and **E2** – stormwater runoff will be diverted away from active disposal areas via ditches and berms, maintaining slopes with positive drainage (always directed toward approved stormwater control measures), and following an orderly waste placement.

4.4.4 Final Cap System

A general description of the final cover materials, including barriers, soil layers, drainage components, and gas extraction systems, is provided below (also see **Section 8.2** of the **Closure Plan**, later in this document). Detail drawings of the various components are provided on **Drawing E3** for final contours and **Drawing EC2** for the final cover cross-section and details.

Final Cover Section – Two alternative final cover sections are proposed: (1) the regulatory minimum cover, which consists of 18 inches of compacted soil barrier (minimum permeability of 1 x 10^{-5} cm/sec) installed above an interim soil cover, overlain by 18 inches of vegetation support soil (see **Detail H** on **Drawing EC2**), and (2) a synthetic barrier (tentatively welded HDPE flexible membrane) with a synthetic polymer drainage net, overlain by 24 inches of vegetation support soil

(see **Detail J** on **Drawing EC2**); a compaction and soil type are specified for neither the interim soil cover nor the vegetative support layer;

Erosion Control Breaks – The use of "tack-on" compacted soil berms and swales integrated into the final cover is preferred by the Owner for final cover erosion control (see **Details A** and **D** on **Drawing EC2**); these features have a gentle slope (approximately 2%) and will be spaced on 30-foot vertical intervals; The resulting swales will be lined with a permanent erosion control mat and vegetated, as shown on **Drawing EC4**; the various swales were designed for peak flows associated with a 25-year, 5-minute storm (for volume and velocity), with each channel specific to the drainage area; a channel design schedule is provided on **Drawing EC5**;

Drainage Components – Runoff control will be accomplished via several strategically located "down pipes" that convey water from the erosion control breaks; the piping consists of corrugated HDPE and can either be buried within the final cover soil (shown on **Details B, C,** and **E** on **Drawing EC2**) or staked to the exterior of the slope (see **Detail F** on **Drawing EC2**); either way, the down pipes pass beneath the soil berm on the erosion control breaks (see **Detail A** on **Drawing EC2**), where the inlet protection consists of a stone filter berm that will curtail erosion and prevent soil and debris intrusion (see **Detail I** on **Drawing EC3**), and the pipes will be self-cleaning at the design side slopes; the pipes will discharge to the perimeter swales (which lead to the main sediment basin) and outlet protection will consist of rip-rap aprons underlain by geotextile scour protection (see **Detail J** on **Drawing EC3**); pipe sizes are provided in a schedule on **Drawing EC5**;

Landfill Gas Vents – Passive gas vents have been provided to prevent gas pressure build-up beneath the final cover components, to be installed at regularly spaced intervals of three vents per acre; the gas vents consists of perforated PVC or HDPE pipes – with a 2% slope up to a central riser pipe – in a shallow trench within the waste that is filled with filter stone (see **Detail K** on **Drawing EC2**); the trenches are installed beneath the barrier layer during the final cover construction; a supplemental pipe boot (not shown in the drawings) may be added to ensure a water tight seal at the riser pipe penetration;

Vegetation – A seeding schedule for vegetation that is appropriate to the local climate is provided on **Drawing EC5**.

4.4.5 Temporary and Permanent S&EC

See **Drawing EC1A** for temporary sedimentation and erosion control (S&EC) measures (for construction) and **Drawing EC1B** for final measures. A separate S&EC plan submittal to Wake County Environmental Services has been made. Minor design revisions to the S&EC plan, if any, resulting from the Wake County review will be incorporated during construction and shown on "as-built" drawings for the Permit to Operate application.

4.4.6 Vertical Separation

See **Drawings E4** and **E5** for base grades relative to ground water and bedrock, respectively; also see cross section **Drawings X1 – X2**.

4.4.7 Other Features

This rule pertains to liners and leachate collection systems, if proposed (none are).

4.5 Specific Engineering Calculations and Results

Calculations for settlement and slope stability were performed using site specific data. The calculations can be found in **Appendix 1**, the geotechnical lab data are found in **Appendix 8** of the approved **Phase 2 Design Hydrogeologic Report**. The following is brief description of the analyses and results.

4.5.1 Settlement

Settlement is a concern at unlined landfills for maintaining vertical separation between the bottom of the waste (or base liner) and the maximum long-term seasonal high water table. Settlements of the foundation soils result from time-dependent strain, i.e., a change in thickness within the various soil layers due to the vertical stress (weight of the landfill) applied at the surface, accompanied by drainage of the various soil layers. Vertical stresses beneath landfills gradually increase as the waste becomes thicker over long periods of time; strain-induced settlements within sands and/or well drained silts and clays are relatively short-term, thus long-term settlements are not typically a concern unless thick uniform clay deposits are present (which tend to drain slowly) – such is not the case at the subject landfill. The critical section for settlement, considering the maximum fill height and the deepest identified weathering profile (deepest soils) occurs at boring G-4. Relative to soil types that could be sampled with a Shelby tub and

subjected to laboratory consolidation tests, the soils at G-13 were selected to be representative of the softer materials (lower SPT values).

Settlements were calculated using elastic methods adapted from the US Federal Highway Administration (FHWA) for highway embankments. Ostensibly, a landfill is a large flexible embankment with the highest stresses impinging on the foundation soils near the center. The FHWA settlement calculation is based on the work of Hough (1959) and others, which considers both the material type and overburden depth for determining a "correction factor" for standard penetration test (SPT) values, from which the compressibility and load-induced strain of each soil layer can be evaluated. For sandy soils conventional sampling via Shelby tubes and laboratory consolidation testing is infeasible. For clayey soils, representative Shelby tube samples were acquired and laboratory consolidation tests were performed (see **Design Hydrogeologic Report**), and the consolidation data were substituted into the calculations for appropriate soil layers.

A spreadsheet facilitates the settlement calculation (see **Appendix 1**). Initially, the vertical stress increase resulting from varying embankment heights was calculated using an average unit weight of 1000 pounds per cubic yard (37 pcf) and by applying a depth-related "influence factor" based on elastic stress distribution theory. Next a subsurface stress distribution was developed for original and post-construction (final height) conditions, based on the depth and average unit weight of the soil layers, plus the added vertical stresses. The SPT correction factor was applied to determine the compressibility factor and strain within each sand layer. For the clays, consolidation theory was applied to determine the strain in those layers – using site-specific laboratory consolidation data – which was added to the strain in the sand layers to estimate total settlement under a given load. Time-dependent settlement was not considered due to the well drained conditions indicated by the subsurface data.

For this project, the maximum estimated settlement at the center of the landfill near G-4 is 1.3 feet. The base grade design provides nearly 10 feet of vertical separation at this location, (more than the minimum required 4 feet), which is sufficient to accommodate the anticipated settlement while maintaining the required minimum vertical separation. Differential settlement within the footprint is not a concern. Anticipated settlement over most of the site are expected to be negligible, since the "worst case" scenario represented at G-4 is an unusual circumstance, i.e., the deep soils encountered at this boring are not typical of a majority of the site, rather the presence of shallow rock and/or partially weathered rock is more typical across the site. The deeper soils at G-4 have been characterized as a "slot" of deeply weathered material extending vertically along a joint surface – these conditions are expected to be isolated to the Phase 2B area, not Phase 2A.

4.5.2 Slope Stability

Two primary concerns exist for landfills with respect to slope stability:

(1) Deep-seated or global stability involving a deep layer in the foundation or along the base of the landfill, which could potentially result in catastrophic (occurring relatively sudden) and costly slope failure, and

(2) Veneer stability (sliding of the cover), which can be catastrophic such as to expose the waste but is typically more of a maintenance issue relative to repairs in the event of a failure.

Subsurface conditions identified at this site are relatively sandy (high strength soils) with interspersed this clay layers with sand seams that are expected to drain readily under the applied embankment loads – only "effective" stresses (i.e., drained conditions) were considered. The site is not earthquake prone, with a design horizontal loading of 0.03g (USGS data). The water table is relatively deep and the soils are saprolite – with locked in stresses that typically exceed existing overburden pressures – so liquefaction is not a concern. No extremely soft layers that would pose stability concerns were identified by the SPT testing, and the foundation soils are expected to undergo a strain-hardening strength increase as settlement occurs, i.e., the foundation soils will become even more stable with time.

4.5.2.1 Deep-seated stability – Limit-equilibrium methods, i.e., the STABL-5M model used for this project, evaluate the balance of forces driving a slide (weight of the porous material and contained water) against the forces resisting a slide (shear strength, expressed as cohesion and friction) along a theoretical failure surface, which can be either a circular surface or a series of intersecting planar surfaces. A "static" analysis considers just the weight of the materials and the shear strength (tie-back loads may be considered for reinforced embankments); a "dynamic" analysis might consider external loads, such as linear loads at the top of the embankment (i.e., traffic forces) or additional horizontal loads to represent earthquakes (expressed as a fraction of the normal gravity field, specific to the region of interest). In more advanced routines, the mass above the failure surface is divided into many slices, the driving and resisting forces for each of which are calculated and summed up. This "method of slices" expresses the balance of resisting forces and driving forces as a ratio, e.g., 1.5:1, or simply 1.5, which is the "safety factor." Ratios less than unity (safety factor <1) indicate unstable conditions. Typical minimum safety factors for maintaining stable embankment conditions throughout the life of a project are 1.5 for static conditions, 1.2 for seismic conditions.

Shear strength inputs to the STABL-5M model were developed from the drilling and laboratory data (see **Design Hydrogeologic Report**). A circular failure surface was used with a Janbu method of slices analysis, which typically gives the most conservative results; then an irregular surface and a sliding block failure mechanism were analyzed. A representative soil profile was developed from the drilling data. A slope ratio of 3H:1V was modeled for both an interim slope height (Phase 2A) and a final slope height (Phases 2A – 2C). The following table shows a summary of the soil strength input values for the representative cross section at the project site (see **Appendix 1**):

Soil Layer	Layer Thickness (feet)	Soil Layer Description	Saturated Unit Weight (pcf)	Drained Cohesion (psf)*	Drained Friction Angle (deg)
1	80, 190	Waste	60	20	45
2	Varies	Silty sand N = 7 to 50	125	400	34
3	Varies	Silty sand (PWR) N = 100	130	800	35
4	Undefined	Bedrock	150	1000	45

*Apparent cohesion for waste is based on retrogression analysis from other projects; site specific laboratory data (see the **Design Hydrogeologic Report**) was used for the sands. The water table was modeled with a slope based on seasonal high conditions (as shown on the hydrogeologic profiles), assuming no pore pressure build-up in the waste.

The following slope stability safety factors were determined:

Slope Condition	Analysis	Safety Factor
Phase 2 Interim	Janbu circular surfaces (auto-search), seismic	1.8
	Janbu irregular surface (auto-search), seismic	2.3
	Sliding block targeting weakest layer, seismic	2.7
Phase 2 Final	Janbu circular surfaces (auto-search), seismic	1.5 OK

4.5.2.2 Veneer Stability – Sliding of the final cover (or veneer failure) is dependent on slope angle, material strength, i.e., the interface friction angle and cohesion within the soils and between the soils and synthetic components (if any), and the degree of saturation. Veneer failure occurs when the pore pressures build up along a critical interface in excess of available shear strength. The severity of failure can range from minor sloughing of small areas (maintenance nuisances) to large-scale slides requiring complete replacement of large sections – this type of failure is expensive to repair, especially when synthetic components are involved. The analysis is typically performed for preliminary design conditions to anticipate (and try to avoid) the large-scale failures.

A worse-case scenario involves little (or no) cohesion, as in a geotextile-geomembrane interface, and complete saturation of the soils overlying that interface. Good engineering practice requires a drainage layer (typically a synthetic geonet) on slopes steeper than 10% when a flexible membrane barrier is used, e.g., an alternative final cover that might be considered. The regulatory minimum cover includes 18 inches of vegetative support soil overlying a compacted soil barrier. North Carolina Solid Waste regulations allow alternative final covers, subject to approval by the Solid Waste Section, but specific interface testing will be required to verify future designs.

Even when all natural soil covers are used, drainage is still important relative to veneer stability, so a final cover section will include higher permeability sand layer next to the barrier to prevent the soils above the barrier from becoming saturated. Assuming a regulatory minimum cover soil profile is used, the critical interface for veneer stability exists within a low-cohesion sand layer overlying the compacted soil barrier at full saturation on a 3H:1V slope. While a minimum cohesion could be assumed along the sand layer and the compacted soil barrier, the stresses near the base of the sand layer would control stability.

A veneer stability analysis (**Appendix 1**) adapted from Matasovic (1991) was performed to evaluate four conditions: static unsaturated and saturated conditions (with a required safety factor of 1.5) and seismic unsaturated and saturated conditions (with a safety factor of 1.1). For this site, the static (non-seismic) saturated case is the critical condition for design because of the higher required safety factor. The calculations start with the given slope geometry and saturation state, then for a given safety factor the required friction (with or without cohesion) is back-calculated to provide the desired safety factor.

The analysis assumed full saturation of the vegetation support layer (upper cover soil is at field capacity) with a 1-year, 60-minute design storm impinging, resulting in a head of

just over 12 inches acting on the base of the upper soil layer. Assuming the deeper compacted soil layer is stronger (due to cohesion) ***a minimum friction angle of 31 degrees is required within the upper soil layer***. Select soils available in the region (including the borrow sites on the premises) are capable of providing this minimum friction angle, combined with the required high permeability for drainage. The CQA program for the final closure will verify the available friction angles for the actual cover components (including alternative cover designs, if these are to be used).

5.0 CONSTRUCTION PLAN REQUIREMENTS (15A NCAC 13B .0540)

This section demonstrates compliance of the facility design for CDLF Phase 1A with the requirements of the **2006 C&D Rules, 15A NCAC 13B .0531 *et seq.*** Reference is made to the construction plan set and various appendices, in which the calculations are presented.

5.1 Horizontal Separation

The following regulatory criteria are addressed in project drawings specified below. Refer to the rolled plan set that accompanies this report.

5.1.1 Property Lines

The minimum setback to property lines is 200 feet (**Drawings S4** and **S5**).

5.1.2 Residences and Wells

The minimum setback to residences and wells is 500 feet (**Drawings S1 – S3**).

5.1.3 Surface Waters

The minimum setback to surface waters is 50 feet (**Drawings S4** and **S5**).

5.1.4 Existing Landfill Units

None are present.

5.2 Vertical Separation

5.2.1 Settlement

Maximum waste thicknesses are approximately 163 feet (middle of Phases 1 and 2); the waste density is approximately 0.66 tons/cubic yard. Foundation soils typically consist of very dense, normally consolidated silty sand, sandy silt and/or clayey sand (all saprolite), but there appears to the be a deeply weathered pocket near G-4 with SPT values varying from 8 to 15 that is anticipated to produce local settlement. A settlement calculation performed for this worst-case scenario (**Appendix 1**) indicates localized post-construction foundation settlements on the order of 1.4 feet, or less. Elsewhere the soils are stiffer, so settlements are expected to be less. Based on **Drawing E4**, the vertical separation to ground water on the order of 10 feet near G-4, i.e., near the maximum waste thickness. The settlements will not decrease the vertical separation to less than 4 feet.

5.2.2 Soil Consistency

Based on the laboratory data (**Section 10.1.4**), a majority of the on-site soils generally classify as silty sands (SM), silt (ML) or dual classify as sand-silt (SM-ML). A relatively small fraction of the near surface soils consist of low plasticity silty clay (CL), and there are minor high plasticity silty clay (MH-CH) soil types present. These soil types will be present either in-situ or within compacted subgrades, meeting the requirements of **Rule .0540 (2) (b)** for the upper two feet beneath the subgrade. No modification of the soils, i.e., admixtures, will be required to meet this rule requirement, but reworking to blend the soils to a more uniform consistency and proper compaction may be required to mitigate isolated pockets of granular soils. Soil types present within the upper two feet beneath subgrade shall be documented in the CQA program.

5.3 Survey Control Benchmarks

A permanent benchmark has been established by ASD Land Surveying, P.A., of Apex, NC. The permanent bench mark is located next to three steel pipes that convey storm water from the perimeter swale to the main sediment basin, just west (and across the perimeter road) from Phase 1, Cell A (northwest corner). The benchmark is tied into the North Carolina State Plan (NCSP) coordinate system with the following coordinates:

BM-1	N 714227.5410	E 2146136.6030	EL 212.14 (NAD 83)

5.4 Site Location Coordinates

The latitude and longitude coordinates of the center of the site (determined from topographic mapping) are approximately:

LATITUDE	LONGITUDE
DD MM SS.sssss	DDD MM SS.sssss
35 42 33.62411	78 30 13.02853
35.70934	78.50361

5.5 Landfill Subgrade

5.5.1 Subgrade Inspection Requirement

The Owner/Operator shall have the Phase 2A subgrade inspected by a qualified engineer or geologist upon completion of the excavation (as part of the CQA) in accordance with **Rule .0540 (5) (a)**, to verify that subgrade conditions are consistent with expected conditions based on the Design Hydrogeologic Report.

5.5.2 Division Notification

The Owner/Operator shall notify the Division at least 24 hours in advance of the subgrade inspection.

5.5.3 Vertical Separation Compliance

The subgrade inspection shall verify to the Division that the minimum vertical separation requirements are met and that required subgrade soil types are present.

5.6 Special Engineering Features

This section of the rules generally pertains to liners and leachate collection systems, if any are present (none will be).

5.7 Sedimentation and Erosion Control

The sedimentation and erosion control structures described elsewhere (**Appendix 2**) are designed to accommodate the 25-year, 24-hour storm event, per the North Carolina Sedimentation Pollution Control Law (**15A NCAC 04**). An S&EC plan has been submitted to the Wake County Department of Environmental Services, and is depicted in the construction plan set (see **Drawings EC1A** and **EC1B**). Existing sediment basins and sediment traps remaining from the Phase 1 construction shall be cleaned out and upgraded as needed; new measures to be constructed for Phase 2will include staged grading practices to minimize soil exposure, silt fence, ditches/berms and sediment traps ("custom basins" meeting Wake County requirements.) The plan is under review and notification will be made available to the SWS upon issuance of the Wake County S&EC permit.

6.0 CONTRUCTION QUALITY ASSURANCE (15A NCAC 13B .0541)

6.1 General Provisions

This Construction Quality Assurance (CQA) Plan has been prepared to provide the Owner, Engineer, and CQA Testing Firm – operating as a coordinated team – the means to govern the construction quality and to satisfy landfill certification requirements under current solid waste management regulations. The CQA program includes both a quantitative testing program (by a third-party) and qualitative evaluation of construction materials to assure that the construction meets the desired performance criteria, i.e., sufficient strength and permeability. Variations in material properties and working conditions may require minor modification of handling and placement techniques throughout the project. Close communication between the various parties is paramount. It is anticipated that the early stages of the construction activities will require more attention by the CQA team, i.e., the Contractor, Engineer, Owner, and CQA Testing Firm.

It should be noted that this CQA plan pertains to both the base grading construction (all stages) and the final cover construction (all stages). Whereas both the base grades and final cover will be built in increments, the CQA program must also be implemented in corresponding stages. Separate CQA documentation must be prepared for each stage of construction.

6.1.1 Definitions

6.1.1.1 Construction Quality Assurance (CQA) – In the context of this CQA Plan, Construction Quality Assurance is defined as a planned and systematic program employed by the Owner to assure conformity of the final cover system installation with the project drawings and the project specifications. CQA is provided by the CQA Testing Firm as a representative of the Owner and is independent from the Contractor and all manufacturers. The CQA program is designed to provide confidence that the items or services brought to the job meet contractual and regulatory requirements and that the final cover will perform satisfactorily in service.

6.1.1.2 Construction Quality Control (CQC) – Construction Quality Control refers to actions taken by manufacturers, fabricators, installers, and/or the Contractor to ensure that the materials and the workmanship meet the requirements of the project drawings and the project specifications. The manufacturer's specifications and quality control (QC) requirements are included in this CQA Manual by reference only. A complete updated version of each manufacturer's QC Plan for any Contractor-supplied components shall be incorporated as part of the Contractor's CQC submittal. The Owner and/or the Engineer shall approve the Contractor’s QC submittal prior to initial construction.

Contractor submittals may be (but us not required to be) incorporated into the final CQA certification document at the Owner's discretion.

6.1.1.3 CQA Certification Document – The Owner and/or the Engineer will prepare a certification document upon completion of construction, or phases of construction. The Owner will submit these documents to the NC DENR Solid Waste Section. The CQA certification report will include relevant testing performed by the CQA Testing Firm, including field testing used to verify preliminary test results and/or design assumptions, records of field observations, and documentation of any modifications to the design and/or testing program. An "as-built" drawing (prepared by/for the Owner), showing competed contours, shall be included. The Certification Document may be completed in increments, i.e., as several documents, as respective portions of the final cover are completed. Section 2 discusses the documentation requirements.

6.1.1.4 Discrepancies Between Documents – The Contractor is instructed to bring discrepancies to the attention of the CQA Testing Firm who shall then notify the Owner for resolution. The Owner has the sole authority to determine resolution of discrepancies existing within the Contract Documents (this may also require the approval of State Solid Waste Regulators). Unless otherwise determined by the Owner, the more stringent requirement shall be the controlling resolution.

6.1.2 Responsibilities and Authorities

The parties to Construction Quality Assurance and Quality Control include the Owner, Engineer, Contractor, CQA Testing Firm (i.e., a qualified Soils Laboratory).

6.1.2.1 Owner – The Owner is WCA, who operates and is responsible for the facility. The Owner or his designee is responsible for the project and will serve as liaison between the various parties.

6.1.2.2 Engineer – The Engineer (a.k.a. the "Design Engineer") is responsible for the engineering design, drawings, and project specifications, regulatory affairs, and communications coordinator for the project for the final cover system. The Engineer represents the Owner and coordinates communications and meetings as outlined in **Section 7.3**. The Engineer shall also be responsible for proper resolution of all quality issues that arise during construction. The Engineer shall prepare the CQA certification documents, with input from the Owner, the CQA Testing Firm, and the Owner's Surveyor. The Engineer shall be registered in the State of North Carolina.

6.1.2.3 Contractor – The Contractor is responsible for the construction of the subgrade, earthwork, and final cover system. The Contractor is responsible for the overall CQC on the project and coordination of submittals to the Engineer. Additional responsibilities of the Contractor include compliance with North Carolina Sedimentation and Erosion Control rules.

Qualifications – The Contractor qualifications are specific to the construction contract documents and are independent of this CQA Manual.

6.1.2.4 CQA Testing Firm – The CQA Testing Firm (a.k.a. Soils Laboratory) is a representative of the Owner, independent from the Contractor, and is responsible for conducting geotechnical tests on conformance samples of soils, and aggregates used in structural fills and the final cover system. The Owner will pay for the services of the Soils Laboratory. Periodic site visits shall be coordinated with the Contractor.

Qualifications – The CQA Testing Firm (Soils Laboratory) will have experience in the CQA aspects of the construction and testing of landfill final cover systems, and be familiar with ASTM and other related industry standards. The Soils CQA Laboratory will be capable of providing test results within 24 hours or a reasonable time after receipt of samples, depending on the test(s) to be conducted, as agreed to at the outset of the project by affected parties, and will maintain that standard throughout the construction.

6.1.3 Control vs. Records Testing

6.1.3.1 Control Testing – In the context of this CQA plan, Control Tests are those tests performed on a material prior to its actual use in construction to demonstrate that it can meet the requirements of the project plans and specifications. Control Test data may be used by the Engineer as the basis for approving alternative material sources.

6.1.3.2 Record Testing – Record Tests are those tests performed during or after the actual placement of a material to demonstrate that its in-place properties meet or exceed the requirements of the project drawings and specifications.

6.1.4 Modifications and Amendment

This document was prepared by the Engineer to communicate the basic intentions and expectations regarding the quality of materials and workmanship. Certain articles in this document may be revised, if so warranted based on project specific conditions. No modifications will be made without the Engineer's approval. Modifications to the CQA Plan will also be approved by the Solid Waste Section, as appropriate to meet Solid Waste Rules and Statutes, and for input regarding quality of construction.

6.1.5 Miscellaneous

6.1.5.1 Units – In this CQA Plan, and through the plans and specifications for this project, all properties and dimensions are expressed in U.S. units.

6.1.5.2 References – This CQA Plan includes references to the most recent version of the test procedures of the American Society of Testing and Materials (ASTM) and/or the Geosynthetic Research Institute (GRI), as applicable. **Table 6D** (following this section) contains a list of these procedures.

6.2 Inspection, Sampling and Testing

The requirements of the General Earthwork (perimeter embankments and subgrade) and Final Cover Systems (soil barrier, vegetative cover, storm water management devices) differ with respect to continuous or intermittent testing and oversight. The following two sections are devoted to the specific requirements of each work task.

6.2.1 General Earthwork

This section outlines the CQA program for structural fill associated with perimeter embankments, including sedimentation basins, and general grading of the subgrade. Issues to be addressed include material approval, disposal cell subgrade approval, field control and record tests, if any, and resolution of problems.

6.2.1.1 Compaction Criteria – All material to be used as compacted embankment shall be compacted to a minimum of **95% of the Standard Proctor Maximum Dry Density (ASTM D-698)**, or as approved by the Engineer or designated QC/QA personnel. Approval is based on visual evaluation for consistency with project specification and objectives. Such material evaluations may be performed either during material handling, i.e., delivery to or upon receipt at the landfill, or from existing stockpiles and/or the soil borrow site. Borrow soils shall be evaluated by the Engineer and QC/QA personnel prior to placement on the work site.

6.2.1.2 Testing Criteria – Periodic compaction (moisture-density) testing requirements are imposed on the structural fill, although compaction and testing requirements may not be as stringent as that required for the final cover construction. Initial compaction testing shall be in accordance with the project specifications. The Engineer may recommend alternative compaction testing requirements based on field performance. Additional qualitative evaluations shall be made by the Contractor Superintendent and the Engineer to satisfy the performance criteria for placement of these materials.

CQA monitoring and testing will not be “full-time” on this project. Rather, the CQA

Testing Firm will test completed portions of the work at the Contractor's or Owner's request. The CQA Testing Firm may be called upon to test final cover and/or compacted structural fill at any time, ideally scheduling site visits to optimize his efforts. The Engineer will make an inspection at least monthly, more often as needed (anticipated more often in the initial stages of new construction).

6.2.1.3 Material Evaluation – Each load of soil will be examined either at the source, at the stockpile area, or on the working face prior to placement and compaction. Any unsuitable material, i.e., that which contains excess moisture, insufficient moisture, debris or other deleterious material, will be rejected from the working face and routed to another disposal area consistent with its end use. Materials of a marginal natural, i.e., too dry or too wet, may be stockpiled temporarily near the working face for further evaluation by designated QC/QA personnel. The Contractor may blend such materials with other materials (in the event of dryness) or dry the materials (in the event of excess moisture).

6.2.1.4 Subgrade Approval – Designated QC/QA personnel shall verify that the compacted embankment and/or subgrade are constructed in accordance with the project specifications prior to placing subsequent or overlying materials.

6.2.2 General Earthwork Construction

6.2.2.1 Construction Monitoring – The following criteria apply:

A. Earthwork shall be performed as described in the project specifications. The Construction Superintendent has the responsibility of assuring that only select materials are used in the construction, discussed above.

B. Only materials previously approved by the Engineer or his designee shall be used in construction of the compacted embankment. Unsuitable material will be removed and replaced followed by re-evaluation to the satisfaction of the Engineer and retesting, as may be required.

C. All required field density and moisture content tests shall be completed before the overlying lift of soil is placed – as applicable. The surface preparation (e.g. wetting, drying, scarification, compaction etc.) shall be completed before the Engineer (or his designate) will allow placement of subsequent lifts.

D. The CQA Testing Firm and/or the Engineer shall monitor protection of the earthwork, i.e., from erosion or desiccation during and after construction.

6.2.2.2 Control Tests – The control tests, as shown on **Table 6A**, will be performed by the CQA Testing Firm prior to placement of additional compacted embankment.

6.2.2.3 Record Tests – The record tests, as shown on **Table 6A**, will be performed by the CQA Testing Firm during placement of compacted embankment. The CQA Testing Firm may propose and the Engineer may approve an alternative testing frequency. Alternatively, the Engineer may amend the testing frequency, without further approval from the regulatory agency, based on consistent and satisfactory field performance of the materials and the construction techniques.

6.2.2.4 Record Test Failure – Failed tests shall be noted in the construction report, followed by documentation of mitigation. Soils with failing tests shall be evaluated by the Engineer (or his designee), and the soils shall either be recompacted or replaced, based on the Engineer's judgment. Recompaction of the failed area shall be performed and retested until the area meets or exceeds requirements outlined in the specifications.

6.2.2.5 Judgment Testing – During construction, the frequency of control and/or record testing may be increased at the discretion of the CQA Testing Firm when visual observations of construction performance indicate a potential problem. Additional testing for suspected areas will be considered when:

- Rollers slip during rolling operation;
- Lift thickness is greater than specified;
- Fill material is at an improper moisture content;
- Fewer than the specified number of roller passes is made;
- Dirt-clogged rollers are used to compact the material;
- Rollers may not have used optimum ballast;
- Fill materials differ substantially from those specified; or
- Degree of compaction is doubtful.

6.2.2.6 Deficiencies – The CQA Testing Firm will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner and Engineer. The CQA Testing Firm shall properly document all defects and deficiencies – this shall be more critical on the final cover construction, although this applies to structural fill, as well. The Contractor will correct defects and deficiencies to the satisfaction of the Owner and Engineer. The CQA Testing Firm shall perform retests on repaired defects.

6.2.3 Final Cover Systems

This section outlines the CQA program for piping, drainage aggregate, geotextiles, compacted soil barrier layer, and the vegetative soil layer of the final cover system, as well as the related erosion and sedimentation control activities. Issues to be addressed include material approval, subgrade approval, field control and record tests, if any, and resolution of problems.

6.2.3.1 Material Approval – The Engineer and/or the CQA Testing Firm shall verify that the following materials (as applicable) are provided and installed in accordance with the project drawings, specifications, and this CQA Manual. In general, the Contractor shall furnished material specification sheets to the Engineer for review and approval. In certain cases, materials furnished by the Contractor may need to meet the Owner's requirements, in which case the Owner shall approve of the materials with the Engineer's concurrence. The materials approval process may involve the submittals furnished by the Owner, (for documentation purposes) in the event that the Owner decides to furnish certain materials.

A. <u>High Density Polyethylene (HDPE) Pipe</u>

(1) Receipt of Contractor's submittals on HDPE pipe.

(2) Review of submittals for HDPE pipe for conformity to the project specifications.

B. <u>Corrugated Polyethylene (CPE) Pipe</u>

(1) Receipt of Contractor's submittals on CPE pipe.

(2) Review of submittals for CPE pipe for conformity to the project specifications.

C. <u>Aggregates</u> (Verify for each type of aggregate)

(1) Receipt of Contractor's submittals on aggregates.

(2) Review of submittals for aggregates for conformity to the project specifications.

(3) Verify that aggregates in stockpiles or at borrow sources conform to the project specifications. A quarry testing certification will be sufficient.

(4) Perform material evaluations in accordance with **Table 6B**.

D. Vegetative Soil Layer

(1) Review the proposed source of vegetative soil layer for conformance with the project specifications.

(2) Perform material evaluations in accordance with **Table 6C**.

E. Compacted Barrier Layer

(1) Review the proposed source material for compacted barrier layer for conformance with the project specifications.

(2) Conduct material control tests in accordance with **Table 6C**.

F. Erosion and Sedimentation Control

(1) Receipt of Contractor's submittals on erosion and sedimentation control items (including rolled erosion control products and revegetation).

(2) Review of submittals for erosion and sedimentation control items for conformity to the project specifications.

6.2.3.2 Final Cover Systems Installation – The CQA Testing Firm, in conjunction with the Engineer, will monitor and document the construction of all final cover system components for compliance with the project specifications. Monitoring for the components of the final cover system includes the following:

- Verify location of all piping;
- Monitoring for minimum vertical buffer between field equipment and piping;
- Monitoring thickness and moisture-density of the final cover layers and verification that equipment does not damage the compacted barrier layer or other components; and
- Monitoring that erosion and sedimentation control items are properly installed.

6.2.3.3 Deficiencies – The CQA Testing Firm and/or the Engineer will immediately determine the extent and nature of all defects and deficiencies and report them to the Owner. The CQA Testing Firm and/or the Engineer shall properly document all defects and deficiencies. The Contractor will correct defects and deficiencies to the satisfaction of the Engineer. The CQA Testing Firm and/or the Engineer shall observe all retests on repaired defects.

6.3 CQA Meetings

Effective communication is critical toward all parties' understanding of the objectives of the CQA program and in resolving problems that may arise that could compromise the ability to meet those objectives. To that end, meetings are essential to establish clear, open channels of communication. The frequency of meetings will be dictated by site conditions and the effectiveness of communication between the parties.

6.3.1 Project Initiation CQA Meeting

A CQA Meeting will be held at the site prior to placement of the compacted barrier layer. At a minimum, the Engineer, the Contractor, the CQA Testing Firm and a representative of the Owner will attend the meeting. The purpose of this meeting is to begin planning for coordination of tasks, anticipate any problems that might cause difficulties and delays, and, above all, review the CQA Manual with all of the parties involved.

During this meeting, the results of a prior compaction test pad will be reviewed, and the project specific moisture-density relationships and it is very important that the rules regarding testing, repair, etc., be known and accepted by all. This meeting will include all of the activities referenced in the project specifications. The Engineer shall document the meeting and minutes will be transmitted to all parties.

6.3.2 CQA Progress Meetings

Progress meetings will be held between the Engineer, the Contractor, a representative of the CQA Testing Firm, and representatives from any other involved parties. Meeting frequency will be, at a minimum, once per month during active construction or more often if necessary during critical stages of construction (i.e., initial stages of final cover). These meetings will discuss current progress, planned activities for the next week, and any new business or revisions to the work. The Engineer will log any problems, decisions, or questions arising at this meeting in his periodic reports. Any matter requiring action, which is raised in this meeting, will be reported to the appropriate parties. The Engineer will document these meetings and minutes will be transmitted to affected parties.

6.3.3 Problem or Work Deficiency Meetings

A special meeting will be held when and if a problem or deficiency is present or likely to occur. At a minimum, the Engineer, the Contractor, the CQA Testing Firm, and representatives will attend the meeting from any other involved parties. The purpose of the meeting is to define and resolve the problem or work deficiency as follows:

- Define and discuss the problem or deficiency;
- Review alternative solutions; and
- Implement an action plan to resolve the problem or deficiency.

The Engineer will document the meeting; minutes will be transmitted to all parties.

6.4 Documentation and Reporting

An effective CQA plan depends largely on recognition of which construction activities will be monitored and on assigning responsibilities for the monitoring of each required activity. This is most effectively accomplished and verified by the documentation of quality assurance activities. The CQA Testing Firm will provide documentation to address quality assurance requirements. Monitoring will not be continuous and full-time, although the CQA Testing Firm representative (typically this is a Soil Technician) and the Engineer will make frequent and periodic visits to inspect and/or test the work. Both parties shall keep records of their visits and observations.

The Soils Technician will visit the site periodically (e.g., once per week) to document activities during placement of the structural fill and during final cover construction. Site visits by the CQA Testing Firm shall be coordinated between the Contractor and the CQA Testing Firm. The Engineer will make monthly site visits during these critical stages to review the work.

The Construction Superintendent or his representative shall be present on-site daily and shall keep a record of the general construction progress, noting specifically any problems or inconsistencies that need to be brought to the Owner's attention. The specifics of the Contractor's records will not be spelled out, but at a minimum, daily or weekly progress records shall be kept and made available to the Owner upon request.

The CQA Testing Firm will provide the Owner (or his designee) with periodic progress reports including signed descriptive remarks, data sheets, and logs to verify that required CQA activities have been carried out. These reports shall also identify potential quality assurance problems. The CQA Testing Firm will also maintain at the job site a complete

file of project drawings, reports, project specifications, the CQA Plan, periodic reports, test results, and other pertinent documents. The Owner shall furnish a location to keep this record file. Occasional documentation by the Contractor and the Engineer will be kept in the record file.

6.4.1 Periodic CQA Reports

The CQA Testing Firm representative's reporting procedures will include preparation of a periodic report that will include the following information, where applicable:

- A unique sheet number for cross referencing and document control;
- Date, project name, location, and other identification;
- Data on weather conditions;
- A Site Plan showing all proposed work areas and test locations;
- Descriptions and locations of ongoing construction;
- Descriptions and specific locations of areas, or units, of work being tested and/or observed and documented;
- Locations where tests and samples were taken;
- A summary of test results (as they become available, in the case of laboratory tests);
- Calibration or recalibration of test equipment, and actions taken as a result of recalibration;
- Off-site materials received, including quality verification documentation;
- Decisions made regarding acceptance of units of work, and/or corrective actions to be taken in instances of substandard quality;
- Summaries of pertinent discussions with the Contractor and/or Engineer;
- The Technician's signature.

The periodic report must be completed by the end of each Technician's visit, prior to leaving the site. This information will keep at the Contractor’s office and reviewed periodically by the Owner and Engineer. The CQA Testing Firm on a weekly basis will forward copies of the Periodic CQA Reports electronically to the Engineer. Periodic

CQA Reports shall be due to the Engineer no later than Noon on the next working day (typically Monday) following the end of a work week (typically Friday). If a periodic visit is postponed or cancelled, that fact will be documented by the CQA Testing Firm and noted in the next periodic report.

6.4.2 CQA Progress Reports

The Engineer will prepare a summary progress report each month, or at time intervals established at the pre-construction meeting. As a minimum, this report will include the following information, where applicable:

- Date, project name, location, and other information;
- A summary of work activities during the progress reporting period;
- A summary of construction situations, deficiencies, and/or defects occurring during the progress reporting period;
- A summary of all test results, failures and retests, and
- The signature of the Engineer.

The Engineer's progress reports must summarize the major events that occurred during that week. This report shall include input from the Contractor and the CQA Testing Firm. Critical problems that occur shall be communicated verbally to the Engineer immediately (or as appropriate, depending on the nature of the concern) as well as being included in the Periodic CQA Reports.

6.4.3 CQA Photographic Reporting

Photographs shall be taken by the CQA Testing Firm at regular intervals during the construction process and in all areas deemed critical by the CQA Testing Firm. These photographs will serve as a pictorial record of work progress, problems, and mitigation activities. These records will be presented to the Engineer upon completion of the project. Electronic photographs are preferred, in which case the electronic photos will be forwarded to the Engineer (the CQA Testing Firm shall keep copies, as well). In lieu of photographic documentation, videotaping may be used to record work progress, problems, and mitigation activities. The Engineer may require that a portion of the documentation be recorded by photographic means in conjunction with videotaping.

6.4.4 Documentation of Deficiencies

The Owner and Engineer will be made aware of any significant recurring nonconformance with the project specifications. The Engineer will then determine the cause of the non-conformance and recommend appropriate changes in procedures or specification. When this type of evaluation is made, the results will be documented, and the Owner and Engineer will approve any revision to procedures or specifications.

6.4.5 Design and/or Technical Specification Changes

Design and/or project specification changes may be required during construction. In such cases, the Contractor will notify the Engineer and/or the Owner. The Owner will then notify the appropriate agency, if necessary. Design and/or project specification changes will be made only with the written agreement of the Engineer and the Owner, and will take the form of an addendum to the project specifications. All design changes shall include a detail (if necessary) and state which detail it replaces in the plans.

6.5 Final CQA Report

A certified CQA report shall will be prepared and submitted to the SWS upon completion of each major construction activity at the landfill unit, i.e., the completion of a CDLF cell or phase base grading and/or the installation of a portion of a final cap, in accordance with **Rule .0541 (d) (1) and (2)**, whereas both activities are expected to be incremental. The Engineer will provide one or more final reports, pertinent to each portion of completed work, which will certify that the work has been performed in compliance with the plans and project technical specifications, and that the supporting documents provide the necessary information.

The Engineer will provide Record Drawings, prepared with input from the Owner's Surveyor, which will include scale drawings depicting the location of the construction and details pertaining to the extent of construction (e.g., depths, plan dimensions, elevations, soil component thicknesses, etc.). All final surveying required for the Record Drawings will be performed by the Owner's Surveyor. At a minimum, the items shown below shall be included in the Final CQA Report(s). Note that some items may not be applicable to all stages of the project.

FINAL CQA REPORT GENERAL OUTLINE

1.0 Introduction
2.0 Project Description
3.0 CQA Program
3.1 Scope of Services
3.2 Personnel

4.0 Earthwork CQA
5.0 Final Cover System CQA
6.0 Summary and Conclusions
7.0 Project Certification

Appendices
A Design Clarifications/Modifications
B Photographic Documentation
C CQA Reporting
C1. CQA Reports
C2. CQA Meeting Minutes
D Earthwork CQA Data
D1. CQA Test Results - Control Tests
D2. CQA Test Results - Record Tests
E Final Cover System CQA Data
E1. Manufacturer's Product Data and QC Certificates
E2. CQA Test Results - Drainage Aggregate
E3. CQA Test Results - Vegetative Soil Layer
E4. CQC Test Results - Pressure Testing of HDPE Piping
F Record Drawings
F1. Subgrade As Built
F2. Vegetative Soil Layer As Built

6.6 Storage of Records

All handwritten data sheet originals, especially those containing signatures, will be stored in a secure location on site. Other reports may be stored by any standard method, which will allow for easy access. All written documents will become property of the Owner.

6.7 Protection of Finished Surfaces

The only relevant systems exposed after construction will be the finished slopes, including both interior and exterior slopes, various drainage systems, and the subgrade,. Ground cover shall be established on all finished surfaces shall to prevent erosion, i.e., seeding of the finished surfaces within 20 days, per NC DENR Division of Land Quality rules, or other measures for preventing erosion (e.g., mulch, rain sheets). Maintenance of finished slopes and subgrade until waste is placed is required. Exterior slopes shall be vegetated in accordance with application sediment and erosion control regulations. The Engineer shall document that the finished surfaces are adequately protected upon completion, and said documentation shall be recorded in the CQA report.

The Owner/Operator shall be responsible for maintaining the finished surfaces, including exterior slope vegetation and drainage conveyances, along with the interior slopes and subgrades. If finished surfaces within the waste disposal area will be required to sit

completed for more than 30 days following completion, the Engineer shall examine the finished surfaces prior to waste disposal and the Owner shall be responsible for any necessary repairs, e.g., erosion that might affect embankment integrity or vertical separation with a subgrade. The Engineer shall document any required maintenance or repairs prior to commencing disposal activities, placing said documentation into the Operating Record.

TABLE 6A
CQA TESTING SCHEDULE FOR GENERAL EARTHWORK

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
CONTROL TESTS:		
Consistency Evaluation	ASTM D 2488 (visual)[1]	Each Material
RECORD TESTS:		
Lift Thickness[5]	Direct Measure	Each compacted lift
In-Place Density	ASTM D 2922[2]	20,000 ft^2 per lift
Moisture Content	ASTM D 3017[3]	20,000 ft^2 per lift
Subgrade Consistency within the upper 24 inches[4]	Visual	4 tests per acre
Subgrade Consistency within the upper 24 inches[4]	ASTM D 422 ASTM D 4138	1 test per acre

Notes:

1. To be performed by Contractor Superintendent, Engineer, or CQA Testing Firm. Direct measure shall be facilitated with hand auger borings.
2. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear testing device. ***Minimum required soil density is 95 percent of the standard proctor maximum dry density, which is dependent on the moisture-density characteristic developed for the specific soil during initial construction; lower density or incorrect moisture results in a failed test and the lift must reworked and retested.***

2a. If "beneficial fill" materials are used to construct embankments or structural fill, the Contractor shall spread large particles evenly and fill all voids with finer soil – this is referred to as "choking off" the voids; density testing shall be suspended at the discretion of the Engineer, but judgment testing shall be applied and the use of these materials and evaluation thereof shall be documented as would any other soil placement activity

3. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every 10 nuclear density-moisture tests, perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.
4. Subgrade evaluation shall be conducted via continuous inspection with the indicated testing frequency, in order to evaluate the full 24 inch depth, of an intrusive investigation (e.g., hand auger borings) may be performed after portions of the subgrade are completed with the indicated testing frequency – all testing locations, testing types and test results shall be recorded on a site map and made part of the construction record
5. The maximum allowable uncompacted lift thickness is 9 inches, targeting a maximum compacted lift thickness of 6 inches, depending on soil characteristics.

TABLE 6B
CQA TESTING SCHEDULE FOR DRAINAGE AND FINAL COVER SOIL

COMPONENT	PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
RECORD TESTS:			
Coarse Aggregate:	Confirm Gradation	Visual	5,000 CY[1]
Vegetative Soil Layer: (In-Situ Verification)	Visual Classification	ASTM D 2488	1 per acre
	Layer Thickness	Direct measure	Survey[4]

Notes:

1. A quarry certification is acceptable for aggregate from a commercial quarry. If a byproduct is used, i.e., crushed concrete aggregate, the gradation test frequency may be adjusted based on project specific conditions. The Engineer shall approve all materials and alternative test frequencies. ***Materials that do not meet relevant ASTM or ASHTO standard gradation specifications (either may be used at the discretion of the Engineer) shall be rejected.***

TABLE 6C
CQA TESTING SCHEDULE FOR FINAL COVER COMPACTED SOIL BARRIER

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
RECORD TESTS:		
Lift Thickness	Direct measure	Survey[4]
Permeability	ASTM D5084[1]	1 per acre per lift
In-Place Density	ASTM D 2922[2]	4 per acre per lift
Moisture Content	ASTM D 3017[3]	4 per acre per lift

Notes:

1. Optionally use ASTM D6391. ***Maximum allowable soil permeability is 1 x 10^{-5} cm/sec; higher permeability results in a failed test and the lift must reworked and retested.***
2. Optionally use ASTM D 1556, ASTM D 2167, or ASTM D 2937. For every 10 nuclear density tests perform at least 1 density test by ASTM D 1556, ASTM D 2167, or ASTM D 2937 as a verification of the accuracy of the nuclear device. ***Minimum required density is dependent on the moisture-density-permeability characteristic developed for the specific soil during initial construction; lower density or incorrect moisture may result in higher permeability. Permeability criteria shall govern the determination of a passing test.***
3. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For every ten nuclear-moisture tests, perform at least 1 moisture test by ASTM D 2216, ASTM D 4643, or ASTM D 4959 as a verification of the accuracy of the nuclear testing device.
4. Topographic graphic survey by licensed surveyor
5. The maximum allowable uncompacted lift thickness is 9 inches, targeting a maximum compacted lift thickness of 6 inches, depending on soil characteristics.

TABLE 6D
REFERENCE LIST OF TEST METHODS

American Society American Society of Testing and Materials (ASTM):

ASTM C 136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
ASTM D 422	Standard Test Method for Particle Size Analysis of Soils.
ASTM D 698	Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3).
ASTM D 1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
ASTM D 2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
ASTM D 2216	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
ASTM D 2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).
ASTM D 2922	Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
ASTM D 2937	Standard Test Method for Density of Soil in Place by the Drive Cylinder Method.
ASTM D 3017	Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
ASTM D 4318	Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
ASTM D 4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method.
ASTM D 4959	Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating Method.
ASTM D5084	Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter
ASTM D 5993	Standard Test Method for Measuring Mass per Unit of Geosynthetic Clay Liners.
ASTM D6391	Standard Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole
ASTM D 6768	Standard Test Method for Tensile Strength of Geosynthetic Clay Liners.

7.0 OPERATION PLAN (15A NCAC 13B .0542)

7.1 General Conditions

This Operations Plan was prepared for WCA Material Recovery, LLC, to provide landfill personnel with an understanding of relevant rules and how the facility will be operated. While deviations from the operation plan outlined here may be acceptable, significant changes will be reviewed and approved by the Design Engineer and/or regulatory personnel.

7.1.1 Facility Description

The landfill entrance is located at 2600 Brownfield Road (S.R. 2553). The scales and office are located near the front gate, which is the only means of accessing the site by the public. After crossing the scales, incoming loads are directed either to one of the stockpile areas (LCID or inert concrete debris) or to the working face of the C&D disposal unit. Tires are not accepted at the facility. Refer to the Facility Plan Map (**Drawing S4**).

7.1.2 Geographic Service Area

The current service area authorized by the Wake County Commissioners includes a multi-county area (see **Section 3.3**). The facility receives C&D from commercial haulers, contractors, and private individuals, most of which is processed off-site at either a material recovery center or a C&D transfer station, both operated by WCA subsidiaries. The operator will be responsible for knowing his customer base and waste stream characteristics, such that the approved service area is observed.

7.1.3 Hours of Operation

The landfill is open to the public from 7 AM to 4 PM on Monday – Friday and 7 AM to 12 PM on Saturday. All current operations for the C&D landfill are within those hours.

7.1.4 Personnel Training and Certification

NC DENR Division of Waste Management rules require that a certified Operator be present on-site at all times during operations. As many of the facility staff as practical will receive Operations Specialist training from a credible organization, e.g., SWANA. Certificates will be posted prominently in the scale house and kept up-to-date.

7.1.5 Utilities

Electrical power, water, telephone, and restrooms are provided at the scale house.

7.1.6 Equipment Requirements

The Facility will maintain on-site equipment required to perform the necessary landfill activities. Periodic maintenance of landfill equipment and minor and major repair work will be performed at designated maintenance zones outside of the landfill footprint.

7.1.7 Safety

All aspects of the facility operation were developed with the health and safety of the landfill's operating staff, customers, and neighbors in mind. The Owner or General Manager of the facility is the designated Site Safety Officer and is responsible for the safe operation of the facility in keeping with Occupational Safety and Health Administration (OSHA) requirements. Regular safety meetings with staff (minimum one per month) shall be conducted.

Safety equipment to be provided includes (at a minimum) equipment rollover protective cabs, seat belts, audible reverse warning devices, hard hats, safety shoes, and first aid kits. Landfill personnel will be encouraged to complete the American Red Cross Basic First Aid Course with CPR. Safety for customers will be promoted by the Operator and his staff knowing where the equipment and customer vehicles are moving at all times. Radio communications between the scale house and the field staff will help keep track of the location and movement of customers.

7.2 CONTACT INFORMATION

7.2.1 Emergencies

For fire, police, or medical/accident emergencies dial 911.

A partial listing Emergency and other Useful Contacts, published on the NC DENR Division of Waste Management web site, is provided in **Appendix 3B**.

All correspondence and questions concerning the operation of the C&D Landfill will be directed to the appropriate County staff and/or State personnel listed below.

7.2.2 WCA Material Recovery, LLC

Mr. Dennis Gehl, General Manager
421 Raleighview Road
Raleigh, North Carolina 27601
Tel 919-422-1519 (cell)

7.2.3 North Carolina Department of Environment and Natural Resources

Division of Waste Management

Raleigh Regional Office	Central Office
1628 Mail Service Center	1646 Mail Service Center
Raleigh, NC 27699-1628	Raleigh, NC 27699-1646
Location:	Location:
3800 Barrett Drive	401 Oberlin Road
Raleigh, NC 27609	Raleigh, NC 27605
Tel. 919/791-4200	Tel. (919)508-8400

Division of Waste Management - Solid Waste Section Staff

Eastern Regional Supervisor: Dennis Shackelford Tel. (910) 433-3349
Fayetteville Regional Office dennis.shackelford@ncdenr.gov

Environmental Engineer: Donna Wilson Tel. (919) 508-8510
DWM Central Office donna.wilson@ncdenr.gov

`Waste Management Specialist: Brad Baily Tel. (919) 508-8565
DWM Central Office Bradley.bailey@ncdenr.gov

Groundwater Hydrogeologist: Jaclynne Drummond Tel. (919) 508-8500
DWM Central Office jaclynne.drummond@ncdenr.gov

Division of Land Resources - Land Quality Section

Regional Engineer: John Holley, P.E Tel. (919) 791-4200
Raleigh Regional Office john.holley@ncmail.net

7.2.4 Wake County Department of Environmental Services

Water Quality Division

Sedimentation and Erosion Control
336 Fayetteville Street
Raleigh, NC 27602
Tel. 919-856-6195

Jennifer Sjaardema Jennifer.Sjaardema@co.wake.nc.us
Environmental Engineer

7.3 Facility Operation Drawings

A copy of the approved Facility Plan and construction drawings must be kept on-site at all times. Periodically, the Owner/Operator shall note the location of the active working area on a copy of the drawing, noting areas that have come to final grade and are ready to be closed. The drawings show special waste areas (asbestos, animal carcasses) and the locations of soil borrow and stockpile areas.

7.4 Waste Acceptance Criteria

7.4.1 Permitted Wastes

The facility shall only accept (for disposal) the following wastes generated within approved areas of service:

- Construction and Demolition Debris Waste: (Waste or debris from construction, remodeling, repair, or demolition operations on pavement or other structures);
- Land Clearing and Inert Debris Waste: (yard waste, stumps, trees, limbs, brush, grass, concrete, brick, concrete block, uncontaminated soils and rock, untreated and unpainted wood, etc.);
- Other Wastes as approved by the NC DENR Solid Waste Section.

In addition, the special wastes, i.e., asbestos (see **Section 7.6.3.3**) may also be accepted at this facility. Municipal solid waste (MSW) shall be rejected of placed in roll-off boxes and removed from the site. Animal carcasses may not be disposed on the working face – a special designated area within the premises may be permitted, subject to requirements by the State Veterinary's office (e.g., ground water separation and immediate covering).

7.4.2 Asbestos

The facility may dispose of asbestos within a designated area within the normal footprint, only if the asbestos has been processed, packaged and transported in accordance with State and Federal (40 CFR 61 Subpart M) regulations. Handling asbestos requires advance arrangements between the hauler and the landfill with 24 hours notice and special placement techniques (see (**Section 7.6.3.3**). No friable asbestos will be accepted by the facility.

7.4.3 Wastewater Treatment Sludge

WWTP sludge may **not** be disposed in the C&D Landfill, per Division rules. WWTP sludge may be used as a soil conditioner to enhance the final cover, upon receipt of permission from the Division, to be applied at agronomic rates.

7.5 Waste Exclusions

No municipal solid waste (MSW), hazardous waste as defined by 15A NCAC 13A .0101, or hazardous waste from conditionally exempt small quantity generators (CESQG waste), or liquid waste will be accepted. No drums or industrial wastes shall be accepted. No tires, batteries, polychlorinated biphenyl (PCB), electronic devices (computer monitors), medical wastes, radioactive wastes, septage, white goods, yard trash, fluorescent lamps, mercury switches, lead roofing materials, transformers, of CCA treated wood shall be disposed. No pulverized or shredded C&D wastes may be accepted.

The Facility will implement a waste-screening program, described in **Section 7.6** below, to control these types of waste. The reader is directed to **Solid Waste Rule .0542 (e)** for further exclusions.

7.6 Waste Handling Procedures

In order to assure that prohibited wastes are not entering the landfill facility, screening programs have been implemented at the landfill. Waste received at both the scale house entrance and waste taken to the working face is inspected by trained personnel. These individuals have been trained to spot indications of suspicious wastes, including: hazardous placards or markings, liquids, powders or dusts, sludges, bright or unusual colors, drums or commercial size containers, and "chemical" odors. Screening programs for visual and olfactory characteristics are an ongoing part of the landfill operation.

7.6.1 Waste Receiving and Inspection

All incoming vehicles must stop at the scale house located near the entrance of the facility, and visitors are required to sign-in. All waste transportation vehicles shall be uncovered prior to entering the scales to facilitate inspection; all incoming loads shall be weighed and the content of the load assessed. The scale attendant shall request from the driver of the vehicle a description of the waste it is carrying to ensure that unacceptable waste is not allowed into the landfill.

Signs informing users of the acceptable and unacceptable types of waste shall be posted at the entrance near the scale house. The attendant shall visually check the vehicle as it crosses the scale. Any suspicious loads will be pulled aside for a more detailed inspection prior to leaving the scale house area. Loads with unacceptable materials will be required to be recovered (with a tarp) and turned away from the facility. Wastes generated from outside of the service area will be turned away.

Once passing the scales, the vehicles containing C&D wastes are routed to the working face. **Vehicles shall be selected for random screening a minimum of three times per week.** The selection of vehicles for screening might be based on unfamiliarity with the vehicle/driver or based on the driver's responses to interrogation about the load content.

Selected vehicles shall be directed to an area of intermediate cover adjacent to the working face where the vehicle will be unloaded and the waste shall be spread using suitable equipment. An attendant trained to identify wastes that are unacceptable at the landfill shall inspect the waste discharged at the screening site. The Operator shall use the **Waste Screening Form** (see **Appendix 9A**) to document the waste screening activities. If no unacceptable waste is found, the load will be pushed to the working face and incorporated into the daily waste cell.

- If unacceptable waste is found, the load will be isolated and secured via soil berms, barricades, or cordons. Unacceptable wastes that are non-hazardous will be isolated and removed from the facility.

- For unacceptable wastes that are hazardous, the Hazardous Waste Contingency Plan outlined in **Section 7.7.3** will be followed.

The hauler is responsible for removing unacceptable waste from the landfill property. The rejection of the load shall be noted on the **Waste Screening Form**, along with the identification of the driver and vehicle. A responsible party to the load generator or hauler shall be notified that the load was rejected. The generator or hauler may be targeted for more frequent waste screening and/or banished from delivering to the facility, depending on the nature of the violation of the waste acceptance policy. If the violation is repetitive or severe enough, State and/or County authorities may be notified.

7.6.2 Disposal of Rejected Wastes

Attempts will be made to inspect waste as soon as it arrives in order to identify the waste hauler; ideally, the hauler can be stopped from leaving the site and the rejected materials reloaded onto the delivery vehicle. Non-allowed materials that are found in the waste

during sorting or placement, i.e., after the delivery vehicle has left the site, shall be placed in a roll-off box and sent to a facility that may accept these wastes.

Small quantities of garbage (chiefly food containers) are not acceptable at the C&D landfill and will be source separated or removed from the waste stream. A separate container will be provided for non-acceptable wastes that may be detected at the working face. If large quantities of garbage, "black bags," or any prohibited wastes are detected, the Operator shall be responsible for removing these materials.

7.6.3 Waste Disposal Procedures

7.6.3.1 Access – The location of access roads during waste placement will be determined by operations personnel in order to reflect waste placement strategy.

7.6.3.2 General Procedures – Waste transportation vehicles will arrive at the working face at random intervals. There may be a number of vehicles unloading waste at the same time, while other vehicles are waiting. In order to maintain control over the unloading of waste, only a certain number of vehicles will be allowed on the working face at a time. The working face superintendent and/or equipment operator(s), who will serve as 'spotters', will determine the actual number. This procedure will be used in order to minimize the potential for disposal of unacceptable waste.

Operations at the working face will be conducted in a manner that will encourage the efficient movement of transportation vehicles to and from the working face, and to expedite the unloading of waste. At no time during normal business hours will the working face be left unattended. Scale house and field staff shall be in constant communication regarding incoming loads and the movement of vehicles on the site, irrespective of facility vehicles or private vehicles. It is the responsibility of the working face superintendent to know the location of each vehicle in the facility.

The use of portable signs with directional arrows and portable traffic barricades will be used to direct traffic to the disposal area. These signs and barricades will be placed along the access route to the working face of the landfill or other designated disposal areas that may be established. The approaches to the working face will be maintained such that two or more vehicles may safely unload side by side – a tipper may also be used. A vehicle turn-around area large enough to enable vehicles to arrive and turn around safely with reasonable speed will be provided adjacent to the unloading area. The vehicles will back to a vacant area near the working face to unload. Upon completion of the unloading operation, the transportation vehicles will immediately leave the working face. Personnel will direct traffic as necessary to expedite safe movement of vehicles.

Waste unloading at the landfill will be controlled to prevent disposal in locations other than those specified by site management. Such control will also be used to confine the working face to a minimum width, yet allow safe and efficient operations. The width and length of the working face will be maintained as small as practical in order to maintain the appearance of the site, control windblown waste, and minimize the amount of required periodic cover.

Normally, only one working face will be active on any given day, with all waste in other areas covered, as appropriate. The procedures for placement and compaction of solid waste include: unloading of vehicles, spreading of waste into 2 foot lifts, and compaction on relatively flat slopes (i.e., 5H: IV max.) using a minimum number of three full passes. Depending on the nature of the wastes and long-term volume analysis of in-situ density, the waste placement geometry and compaction procedures may require adjustment to optimize airspace.

7.6.3.3 Special Wastes: Asbestos Management – Asbestos will arrive at the site in vehicles that contain only the asbestos waste and only after advance notification by the generator and if accompanied by a proper NC DMV transport manifest. Once the hauler brings the asbestos to the landfill, operations personnel will direct the hauler to the designated asbestos disposal area. Operations personnel will prepare the designated disposal area by leveling a small area using a dozer or loader. Prior to disposal, the landfill operators will stockpile cover soil near the designated asbestos disposal area. The volume of soil stockpiled will be sufficient to cover the waste and to provide any berms, etc. to maintain temporary separation from other landfill traffic.

Once placed in the prepared area, the asbestos waste will be covered with a minimum of 18 inches of daily cover soil placed in a single lift. The surface of the cover soil will be compacted and graded using a tracked bulldozer or loader. The landfill compactor will be prohibited from operating over asbestos disposal areas until at least 18 inches of cover are in-place. The landfill staff will, with record the approximate location and elevation of the asbestos waste once cover is in-place.

The Owner/Operator will review pertinent disposal and location information to assure compliance with regulatory requirements and enter the information into the Operating Record. Once disposal and recording for asbestos waste is completed, the disposal area may be covered with waste. No excavation into designated asbestos disposal areas will be permitted.

7.7 Cover Material

7.7.1 Periodic Cover

Wastes shall be covered with a minimum 6 inch thick layer of earthen material at least weekly, or whenever the exposed waste area exceeds one-half acre in size. This periodic cover is intended to control vectors, fire, odors, and blowing debris. Alternative periodic cover may be considered, including ground LCID, WWTP sludge and/or other non-C&D waste materials, but any alternative cover must be approved by the Division. Areas which will not have additional wastes placed on them for three months or more, but where final termination of disposal operations has not occurred, must be covered and stabilized with vegetative ground cover or other stabilizing material.

7.7.2 Final Cover

Exterior slopes shall be closed upon reaching final grades in increments throughout the operation of the facility. The regulatory minimum final cover shall consist of at least 18 inches of compacted soil (with a minimum 10^{-5} cm/sec permeability requirement), overlain by 18 inches of vegetation support soil. An interim soil cover (at least 12 inches in thickness) may be placed on exterior slopes that have attained final grade and left for no more than 20 days without temporary vegetation, until an area of approximately 2 to 3 acres is ready to be closed simultaneously. An alternative final cover under consideration shall consist of a flexible membrane (40-mil LDPE or HDPE) overlain by a single-sided geocomposite drainage layer and 24 inches of vegetative support soil (see **Section 8.1.3**). Alternative final cover designs are allowed by the 2006 C&D rules.

All final soil cover shall be spread in at least two uniform lifts (maximum of 9 inches before compaction, 6 inches after compaction), and all soils shall be compacted by "tracking" with dozers or other equipment. All disturbed soils shall be vegetated with a seed mix that is suitable to climatic conditions (see construction plans) within 20 days following completion of the grading. All seeded areas will be provided with lime, fertilizer, and straw mulch. An emulsified tack may be required to prevent wind damage. Other stabilization treatments, e.g., curled wood matting of synthetic slope stabilization blankets may be employed.

At the operator's discretion, wood mulch may be spread evenly over the final surfaces to provide nutrient (without immediate vegetation); this treatment can be allowed to remain until the wood mulch undergoes partial decomposition, as long as the slopes are stable (not eroding). This allows the operator some flexibility is establishing vegetation at optimum times of the year. The maximum allowable depth of mulch is 3 inches. The

operator shall ensure that all protective measures are functioning prior to placing soil cover on exterior slopes.

If settlement occurs after the cover is placed, the cover shall be fortified with additional soil. In the case of extreme settlement (unlikely), the old cover can be stripped and the affected area built up with waste prior to replacing the cover. Long-term post-closure maintenance is phased in incrementally, as such, final cover maintenance (erosion repair, reseeding as needed). The sedimentation and erosion control criteria that govern the final closure (final reclamation) of this facility are performance-based; some trial and error may be required, but the goal is to protect the adjacent water bodies and buffers throughout the operational and post-closure periods.

7.7.3 Unacceptable Waste Contingency

The owner or operator shall notify the Section within 24 hours of attempted disposal of a waste that is not permitted to receive, in accordance with Rule .0542 (c) (1).

7.7.3.1 Hot Loads Contingency Plan – In the event of a "hot" load detected entering the landfill, the vehicle will be isolated from structures and other traffic, and the fire department will be called. The vehicle will be unloaded and, if safe to do so, the vehicle will be moved from the unloaded material. If a hot load is detected on the working face, the load will be treated as a fire condition (see **Section 7.10.2**), whereas the load will be covered with soil immediately (a water truck may be used to help extinguish the fire). Other traffic will be redirected to another tipping area (away from the fire), or other waste deliveries may be suspended until the fire is out. The fire will be monitored to ensure it does not spread. If the fire cannot be controlled, the fire department will be notified and the area cleared of non-essential personnel.

7.7.3.2 Hazardous Waste Contingency Plan – In the event that identifiable hazardous waste or waste of questionable character is detected at the scales or in the landfill, appropriate protective equipment, personnel, and materials will be employed as necessary to protect the staff and public. Hazardous waste identification may be based on (but not limited to) strong odors, fumes or vapors, unusual colors or appearance (e.g., liquids), smoke, flame, or excess dust. The fire department and/or emergency response personnel will be called immediately in the event a hazardous material is detected – typically, fire departments have haz-mat response capabilities or can coordinate the necessary responders. An attempt will be made to isolate the wastes in a designated area where runoff is controlled, preferably prior to unloading, and the vicinity will be cleared of personnel until trained emergency personnel (fire or haz-mat) take control of the scene.

Staff will act prudently to protect personnel but no attempt will be made to remove the material until trained personnel arrive. A partial listing of Emergency and Other Useful Contacts is found in **Appendix 3B**. The Owner/Operator is encouraged to compile a list of regional **Hazardous Waste Responders** and disposal firms – these are available on the **NC Division of Waste Management** Hazardous Waste Section web site – and keep it handy in the event of an incident. These firms have the training and equipment to deal with hazardous materials, as needed.

The Operator will notify the Division (see **Section 7.2.3**) that an attempt was made to dispose of hazardous waste at the landfill. If the vehicle attempting disposal of such waste is known, attempts will be made to prevent that vehicle from leaving the site until it is identified (license tag, truck number driver and/or company information) or, if the vehicle leaves the site, immediate notice will be served on the owner of the vehicle that hazardous waste, for which they have responsibility, has been disposed of at the landfill.

The landfill staff will assist the Division as necessary and appropriate in the removal and disposition of the hazardous waste (acting under qualified supervision) and in the prosecution of responsible parties. If needed, the hazardous waste will be covered with on-site soils, tarps, or other covering until such time when an appropriate method can be implemented to properly handle the waste. The cost of the removal and disposing of the hazardous waste will be charged to the owner of the vehicle involved. Any vehicle owner or operator who knowingly dumps hazardous waste in the landfill may be barred from using the landfill or reported to law enforcement authorities. Any hazardous waste found at the scales or in the landfill that requires mitigation under this plan shall be documented by staff using the **Waste Screening Form** provided in **Appendix 3A**. Records of information gathered as part of the waste screening programs will be maintained throughout the operational life of the facility.

7.7.4 Severe Weather Contingency

Unusual weather conditions can directly affect the operation of the landfill. Some of these weather conditions and recommended operational responses are as follows.

7.7.4.1 Ice Storms – An ice storm can hinder access to the landfill, prevent movement or placement of periodic cover, and, thus, may require closure of the landfill until the ice is removed or has melted and the access roads are passable without risk to personnel of the side slopes cover.

7.7.4.2 Heavy Rains – Exposed soil surfaces can create a muddy situation in some portions of the landfill during rainy periods. The control of drainage and use of crushed stone (or recycled aggregates) on unpaved roads will provide all-weather access for the

site and promote drainage away from critical areas. In areas where the aggregate surface is washed away or otherwise damaged, aggregate will be replaced. Intense rains can affect newly constructed drainage structures such as swales, diversions, cover soils, and vegetation. After such a rain event, inspection by landfill personnel will be initiated and corrective measures taken to repair any damage found before the next rainfall.

7.7.4.3 Electrical Storms – Landfill activities will be temporarily suspended during an electrical storm. To promote the safety of field personnel, refuge will be taken in buildings or in rubber-tire vehicles.

7.7.4.4 Windy Conditions – High winds can create windblown wastes, typically paper and plastic, but larger objects have been known to blow in extreme circumstances. Operations will be suspended if blowing debris becomes a danger to staff, after the working face is secured. The proposed operational sequence minimizes the occurrence of unsheltered operations relative to prevailing winds. If this is not adequate during a particularly windy period, work will be temporarily shifted to a more sheltered area.

When this is done, the previously exposed face will be immediately covered with daily cover. Soil cover shall be applied whenever windblown wastes become a problem. Staff shall patrol the perimeter of the landfill periodically, especially on windy days, to remove windblown litter from tress and adjacent areas. Windscreens of various sorts have been used with mixed success at other facilities in the region. Good planning is essential on the operator's part to be prepared for windy conditions.

7.7.4.5 Violent Storms – In the event of a hurricane, tornado, or severe winter storm warning issued by the National Weather Service, landfill operations will be temporarily suspended until the warning is lifted. Daily cover will be placed on exposed waste; equipment will be properly secured. In the event of eminent danger to staff, personal safety shall take precedence over concerns regarding the waste or equipment.

7.8 Spreading and Compaction of Waste

The working face shall be restricted to the smallest possible area; ideally, the maximum working face area with exposed waste shall be one-quarter to one-half acre. Wastes shall be compacted as densely as practical. Appropriate methods shall be employed to reduced wind-blown debris including (but not limited to) the use of wind fences, screens, temporary soil berms, and periodic cover. Any wind-blown debris shall be recovered and placed back in the landfill and covered at the end of each working day.

7.9 Vector Control

Steps shall be employed to minimize the risk of disease carrying vectors associated with the landfill (e.g., birds, rodents, dogs, mosquitoes). The C&D wastes will be mostly inert and not attractive to animals, but care will be taken to bury animal carcasses or other putrescible wastes that are admitted to the landfill (subject to the waste screening procedures). Operations will be conducted to avoid pools of standing water in and around the disposal area.

7.10 Air Quality Criteria and Fire Control

7.10.1 Air Quality Criteria

Appropriate measures will be taken to control fugitive emissions (dust) that might be generated during dry seasons. Water shall be sprinkled on roads and other exposed soil surfaces as needed to control dust. No open burning of any waste shall be allowed. Prior to any burning of land clearing debris generated onsite or from emergency clean-up operations, a request must be submitted to the Section for approval.

7.10.2 Fire Control

The possibility of fire within the landfill or a piece of equipment must be anticipated in the daily operation of the landfill. A combination of factory installed fire suppression systems and/or portable fire extinguishers shall be operational on all heavy pieces of equipment at all times. Brush fires of within the waste may be smothered with soil, if combating the fire poses no danger to the staff. The use of water to combat the fire is allowable, but soil is preferable. For larger or more serious fire outbreaks, the local fire department will respond. In the event of any size fire at the facility, the Owner shall contact NC DENR Division Waste Management personnel immediately and complete a **Fire Notification Form** (**Appendix 3C**), which will be placed in the Operating Record.

7.11 Access and Safety

7.11.1 Access Control

Access control to the C&D Landfill is required for the following reasons:

1. Prevention of unauthorized and illegal dumping of waste materials,
2. Trespassing, and possible injury resulting from such, is discouraged,
3. The risk of equipment theft or vandalism is greatly reduced.

Access to active areas of the landfill will be controlled by a combination offences and natural barriers, such as the creeks, and strictly enforced operating hours. A landfill attendant will be on duty at all times when the facility is open for public use to enforce access restrictions.

7.11.1.1 Physical Restraints – The site will be accessed by the existing entrance along Brownfield Road. Scales and a scale house are provided near the entrance. All waste will be weighed prior to being placed in the landfill. The entrance gates will be securely locked during non-operating hours.

7.11.1.2 Security – Frequent inspections of gates and fences will be performed by landfill personnel. Evidence of trespassing, vandalism, or illegal operation will be reported to the Owner.

7.11.1.3 All-Weather Access – The on-site roads will be paved or otherwise hardened and maintained for all-weather access.

7.11.1.4 Traffic – The Operator shall direct traffic to a waiting area, if needed, and onto the working face with safe access to an unloading site is available. Once a load is emptied, the delivery vehicle will leave the working face immediately.

7.11.1.5 Anti-Scavenging Policy – The removal of previously deposited waste by members of the public (or the landfill staff) is strictly prohibited by the Division for safety reasons. The Operator shall enforce this mandate and discourage loitering after a vehicle is unloaded. No persons that are not affiliated with the landfill or having business at the facility (i.e., customers) shall be allowed onto or near the working face.

7.11.2 Signage

A prominent sign containing the information required by the Division shall be placed just inside the main gate. This sign will provide information on operating hours, operating procedures, and acceptable wastes. Additional signage will be provided within the landfill complex to distinctly distinguish access routes. Restricted access areas will be clearly marked and barriers (e.g., traffic cones, barrels, etc.) will be used.

7.11.3 Communications

Visual and radio communications will be maintained between the C&D landfill and the landfill scale house and field operators. The scale house has telephones in case of emergency and for the conduct of day-to-day business. Emergency telephone numbers are displayed in the scale house.

7.12 Sedimentation and Erosion Control

Measures depicted in the approved S&EC plan (see construction plans) shall be installed and maintained throughout the operational life of the facility and into the post-closure period (see **Section 8.0**). Measures to curtail erosion include vegetative cover and woody mulch as ground cover. Measures to control sedimentation include stone check dams in surface ditches, sediment traps, and basins. The key to compliance with Sedimentation and Erosion Control rules is vegetative cover. A rule of thumb is that all exposed soils, regardless of whether they are inside or outside the disposal area, will be covered as soon as possible, not to exceed 20 days after any given area is brought to final grade.

7.13 Drainage Control and Water Protection

Coupled with the measures and practices intended to comply with the S&EC rules, steps to protect water quality include diverting surface water ("run-on") away from the disposal area, allowing no impounded water inside the disposal area, and avoiding the placement of solid waste into standing water. The facility is obligated by law not to discharge pollutants into the waters of the United States (i.e. surface streams and wetlands). Any conditions the Operator suspects might constitute a discharge will be brought to the immediate attention of the Engineer, who in turn, may prescribe mitigation and/or may need to contact proper regulatory authorities.

7.14 Survey for Compliance

7.14.1 Height Monitoring

The landfill staff will monitor landfill top and side slope elevations on a weekly basis or as needed to ensure proper slope ratios and to ensure the facility is not over-filled. This shall be accomplished by use of a surveyor's level and a grade rod. When such elevations approach the grades shown on the Final Cover Grading Plan, the final top-of-waste grades will be staked by a licensed surveyor to limit over-placement of waste.

7.14.2 Annual Survey

The working face shall be surveyed on an annual basis to verify slope grades and to track the fill progression. In the event of problems (slope stability, suspected over-filling), more frequent surveys may be required at the request of the Division.

7.15 Operating Record and Recordkeeping

The following related to the C&D landfill shall be maintained in an operating record:

A Waste inspection records (on designated forms); fire notification forms, as needed;

B Daily tonnage records - including source of generation;

C Quantity, location of disposal, generator, and special handling procedures employed for all special wastes disposed of at the site;

D List of generators and haulers that have attempted to dispose of restricted wastes;

E Employee training procedures and records of training completed;

F All ground water quality monitoring and surface water quality information including:

1. Monitoring well construction records;
2. Sampling dates and results;
3. Statistical analyses; and
4. Results of inspections, repairs, etc.

G All closure and post-closure information, where applicable, including:

1. Testing;
2. Certification; and
3. Completion records;

H Cost estimates for financial assurance documentation;

I Annual topographic survey of the active disposal phase intended to determine volume consumption;

J Records of operational problems or repairs needed at the facility, e.g., slope maintenance, upkeep of SE&C measures, other structures (excluding equipment);

K Methane monitoring data and documentation;

L Financial assurance documentation;

M Notation of date and time of placement of cover material;

N A copy of the approved engineering plan;

O A copy of the current Permit to Construct and Operate, and

P The water quality and landfill gas monitoring plan.

The Owner or his designee will keep the operating record up to date. Daily logbooks may be used for some items. Records shall be presented upon request to DWM for inspection. A copy of this Operations Manual shall be kept at the landfill and will be available for use at all times.

7.16 Annual Reporting

Reporting requirements for the C&D Landfill include a summary of waste intake by type and tonnage, and disposal practice. The Division requires an **Annual Report** be submitted, detailing the waste intake in tonnage. New rules for C&D landfills require an annual survey to determine slope, height, and volume (see **Section 7.14**). The reporting requirements include a map prepared by a licensed surveyor.

7.17 Permanent Edge of Waste Markers

The edge of waste boundary shall be permanent marked in all permitted sections, whether active or not, with a pole or other durable marker that is visible from a distance. The spacing of said markers shall not exceed 200 feet on-center. The height of said markers shall be at least 4 feet. Two methods commonly used to mark the waste boundary are steel posts set in concrete – painted a bright, visible color – or metal "T-posts" (fence posts) with white PVC pipe sleeves. The initial staking of the waste limits will be performed by a licensed surveyor, using the original permit drawings, followed by setting the permanent markers.

8.0 CLOSURE AND POST-CLOSURE (15A NCAC 13B .0543)

8.1 Summary of Regulatory Requirements

8.1.1 Final Cap

The final cap design for Phases 1 and 2A shall conform to the minimum requirements of the Solid Waste Rules, i.e., the compacted soil barrier layer shall exhibit a thickness of 18 inches and a field permeability of not more than 1.0 x 10^{-5} cm/sec. The overlying vegetative support layer shall exhibit a thickness of 18 inches. See **Drawing E3** for final contours and **Drawing EC2** for final cover cross-section and details.

8.1.2 Construction Requirements

Final cap installation shall conform to the approved plans (see accompanying plan set), inclusive of the approved Sedimentation and Erosion Control Plan (see **Section 7.12** and **Appendix 2**). The CQA plan must be followed (see **Section 6.0**) and all CQA documentation must be submitted to the Division. Post-settlement surface slopes must not be flatter than 5% (on the upper cap) and not steeper than 3H:1V (on the side slopes). Per the **2006 C&D Rules**, a gas venting system is required for the cap. A passive venting system will be specified, which will consist of a perforated pipe in crushed stone-filled trench – installed just below the final cap soil barrier layer – with a tentative minimum vent spacing of three vents per acre. **Drawing EC2** shows the gas vent system details.

8.1.3 Alternative Cap Design

The **2006 C&D Rules** make a provision for an alternative cap design, to be used in the event that the permeability requirements for the compacted soil barrier layer cannot be met. Laboratory testing indicates that on-site soils are available that will meet the required field permeability of not more than 1.0 x 10^{-5} cm/sec (**Volume 2**, **Section 10.0**). Tentative final closure plans have assumed that on-site soils will be used for the compacted barrier layer – an alternative cap designs consisting of a 40-mil LDPE or HDPE barrier, overlain by a single-bonded geonet drainage layer and 24 inches of vegetative support soil is under consideration. Both final cap profiles are shown on **Drawing EC2**.

8.1.4 Division Notifications

The Operator shall notify the Division prior to beginning closure of any final closure activities. The Operator shall place documentation in the Operating Record pertaining to the closure, including the CQA requirements and location and date of cover placement.

8.1.5 Required Closure Schedule

The Operator shall close the landfill in increments as various areas are brought to final grade. The final cap shall be placed on such areas subject to the following:

- No later than 30 days following last receipt of waste;
- No late that 30 days following the date that an area of 10 acres or greater is within 15 feet of final grades;
- No later than one year following the most recent receipt of waste if there is remaining capacity.

Final closure activities **shall be completed within 180 days** following commencement of the closure, unless the Division grants extensions. Upon completion of closure activities for each area (or unit) the Owner shall notify the Division in writing with a **certification by the Engineer** that the closure has been completed in accordance with the approved closure plan and that said documentation has been placed in the operating record.

8.1.6 Recordation

The Owner shall record on the title deed to the subject property that a CDLF has been operated on the property and file said documentation with the Register of Deeds. Said recordation shall include a notation that the future use of the property is restricted under the provision of the approved closure plan.

8.2 Closure Plan

The following is a tentative closure plan for CDLF Phase 2, based on the prescribed operational sequence and anticipated conditions at the time of closure.

8.2.1 Final Cap Installation

8.2.1.1 Final Elevations – Final elevation of the landfill shall not exceed those depicted on Drawing E2 when it is closed, subject to approval of this closure plan. The elevations shown include the final cover. A periodic topographic survey shall be performed to verify elevations.

8.2.1.2 Final Slope Ratios – All upper surfaces shall have at least a 5 percent slope, but not greater than a 10 percent slope. The cover shall be graded to promote positive drainage. Side slope ratios shall not exceed 3H:1V. A periodic topographic survey shall be performed to verify slope ratios.

8.2.1.3 Final Cover Section – The terms "final cap" and "final cover" are used interchangeably. The final cover may subscribe to the following minimum regulatory requirement for C&D landfills (an alternative cover describes in **Section 8.1.3** is also under consideration):

- An 18-inch thick compacted soil barrier layer (CSB) with a hydraulic conductivity not exceeding 1 x 10^{-5} cm/sec, overlain by
- An 18-inch thick "topsoil" or vegetated surface layer (VSL).

8.2.1.4 Final Cover Installation – All soils shall be graded to provide positive drainage away from the landfill area and compacted to meet applicable permeability requirements. Suitable materials for final cover soil shall meet the requirements defined above. Care shall be taken to exclude rocks and debris that would hinder compaction efforts. The surface will then be seeded in order to establish a good stand of vegetation.

Test Pad – Whereas the lab data indicate that the required permeability is attainable, the ability to compact the materials in the field to achieve the required strength and permeability values shall be verified with a field trial involving a test pad, to be sampled with drive tubes and laboratory density and/or permeability testing, prior to full-scale construction. The materials, equipment, and testing procedures will be representative of the anticipated actual final cover construction. The test pad may be strategically located such that the test pad may be incorporated into the final cover.

Compacted Soil Barrier – Also known as the "infiltration layer." Materials shall be blended to a uniform consistency and placed in two loose lifts no thicker than 9 inches uncompacted (6 inches compacted), with the soils compacted by tamping, rolling, or other suitable method – the targeted final thickness is 18 inches minimum. A thicker compacted barrier is acceptable. The cover shall be constructed in sufficiently small areas that can be completed in a single day (to avoid desiccation, erosion, or other damage), but large enough to allow ample time for testing without hindering production. The Contractor shall take care not to over-roll the cover such that the underlying waste materials would pump or rut, causing the overlying soil layers to crack – adequate subgrade compaction within the upper 36 inches of waste materials and/or the intermediate cover soil underlying the final cover is critical. All final cover soils shall be thoroughly compacted through the full depth to achieve the required maximum permeability required by Division regulations of 1.0 x 10^{-5} cm/sec, based on site-specific test

criteria (see below). Compaction moisture control is essential for achieving adequate strength and permeability.

Vegetated Surface Layer – Also known as the "erosion layer." Materials shall be blended and placed in loose lifts no thicker than 9 inches and compacted by tamping, rolling, or other suitable method – the targeted final layer thickness is 18 inches minimum per the design criteria. A thicker soil layer is acceptable. A relatively high organic content is also desirable. The incorporation of decayed wood mulch or other organic admixtures (WWTP sludge, with advance permission from the Division) is encouraged to provide nutrient and enhanced field capacity. The target value for organic admixtures to the topsoil layer is 20%. Mulch may be added to the surface, not to exceed a thickness of 2 to 3 inches. These surface materials are not subject to a permeability requirement, thus no testing will be specified. Care will be taken to compact the materials sufficiently to promote stability and minimize erosion susceptibility, but not to over-compact the materials such that vegetation would be hindered. Following placement and inspection of the surface layer, seed bed preparation, seeding and mulching will follow immediately. The work will be scheduled to optimize weather conditions.

Inspection and Testing – Soils for the barrier layer are subject to the testing schedule outlined in the Construction Quality Assurance plan (see **Section 6.0**). The proposed testing program includes a minimum of one permeability test per lift per acre and four nuclear density gauge tests per lift per acre, to verify compaction of the compacted barrier layer. The moisture-density-permeability relationship of the materials has been established by the laboratory testing (discussed elsewhere in this report). The Contractor shall proof roll final cover subgrade materials (i.e., intermediate cover), which consist of essentially the same materials as the compacted barrier layer (without the permeability requirements), to assure that these materials will support the final cover.

8.2.1.5 Final Cover Vegetation – Seedbed preparation, seeding, and mulching shall be performed in accordance with the specifications provided in the Construction Plans (see **Drawing EC5**), unless approved otherwise (in advance) by the Engineer). In areas to be seeded, fertilizer and lime typically will be distributed uniformly at a rate of 1,000 pounds per acre for fertilizer and 2,000 pounds per acre for lime, and incorporated into the soil to a depth of at least 3 inches by disking and harrowing. The incorporation of the fertilizer and lime may be a part of the cover placement operation specified above. Distribution by means of an approved seed drill or hydro seeder equipped to sow seed and distribute lime and fertilizer at the same time will be acceptable. Please note that the seeding schedule varies by season.

All vegetated surfaces shall be mulched with wheat straw and a bituminous tack. Areas identified as prone to erosion mat be secured with curled-wood excelsior, installed and pinned in accordance with the manufacturer's recommendations. Certain perimeter channels may require excelsior or turf-reinforcement mat (TRM), as specified in the Channel Schedule (see **Drawing EC5**). Alternative erosion control products may be substituted with the project engineer's prior consent. All rolled erosion control materials will be installed according to the generalized layout and staking plan found in the Construction Plans or the manufacturer's recommendations.

Irrigation for landfill covers is not a typical procedure, but consideration to temporary irrigation may be considered if dry weather conditions prevail during or after the planting. Care will be taken not to over-irrigate in order to prevent erosion. Collected storm water will be suitable for irrigation water. Maintenance of the final cover vegetation, described in the **Post-Closure Plan** (see below), is critical to the overall performance of the landfill cover system.

8.2.1.6 Documentation – The Owner shall complete an "as-built" survey to depict final elevations and to document any problems, amendments, or deviations from the Construction Plan drawings. Records of all testing, including maps with test locations, shall be prepared by the third-party CQA testing firm. All materials pertaining to the closure shall be placed in the Operational Record for the facility. Whereas the closure will be incremental, special attention shall be given to keeping the closure records separate from the normal operational records.

8.2.2 Maximum Area/Volume Subject to Closure

The largest anticipated area that will require final closure at any one time, that is, the maximum area subject to financial assurance requirements under the 2006 C&D rules, is **20 acres (Phase 1) plus 16.7 acres (Phase 2A), for a total of 36.7 acres (Section 1.3)**. Intermediate cover shall be used on areas that have achieved final elevations until the final cover is installed – typically this will occur in 2 to 3 acre increments – but it will be more cost effective to close the landfill in larger sections. Based on the volumetric analysis (**Appendix 1**), the volume of waste within the anticipated maximum open area is 1.6 M c.y. (Phase 1) plus 1.4 M c.y. (Phase 2A), for a total of 3M c.y.

8.2.3 Closure Schedule

Refer to the requirements outlined in **Section 8.1.5** (above).

8.2.4 Closure Cost Estimate

The following cost estimate is considered suitable for the **Financial Assurance** requirements (see **Section 9.0)**. The cost analysis includes the alternative final cover profile discussed on **Table 8A**.

TABLE 8A
ESTIMATED FINAL CLOSURE COSTS FOR PHASES 1 and 2A (2010 dollars) [1]

1) Regulatory Minimum Cover with Compacted Soil Barrier

VSL (topsoil)[2] – 36.7 acres	88,814 c.y.	@	$3.25 / cubic yard [6]	$288,645
CSB (barrier)[2] – 36.7 acres	102,136 c.y.	@	$8 / cubic yard [6]	$817,088
Establish Vegetation	36.7 acres	@	$1,300 per acre	$ 47,710
Storm Water Piping [3]	2500 LF	@	$35.00 / LF	$ 87,500
Erosion Control Stone [3]	100 tons	@	$40.00 / ton	$ 4,000
Gas Vents – 15 ac * 3/ac [4]	45 each	@	$100 each	$ 4,500
			Subtotal Construction Costs	$1,249,443
Testing and Surveying [5]	Estimated 20 percent of subtotal			$249,889
Contingency	Estimated 15 percent of subtotal			$187,416
			Total Construction Cost (if contracted out)	**$1,686,748**
			Cost per acre (if contracted out)	**$45,960**

1 Intended to represent likely third-party construction costs (hired contractor, not the Owner/Operator), based on knowledge of local construction costs for similar projects – these estimates provided to meet NC DENR Division of Waste Management financial assurance requirements; actual costs may be lower for construction by the Owner/Operator; final closure work will be performed incrementally, spreading out the costs over the life of the project.

2 Includes soil work for regulatory requirements of 15A NCAC 13B .0543 (c), i.e., a minimum of 18 inches of compacted soil barrier (CSB) with maximum permeability of 1 x 10^{-5} cm/sec and 18 inches of vegetation support layer (VSL), or topsoil, with a total soil thickness of 36 inches. For the compacted soil barrier, use a shrinkage factor of 15%; costs include surface preparation, soil procurement and transport costs, soil placement and compaction, machine/equipment costs, fuel

3 Estimate based on similar project history; includes materials and installation

4 Three trench-style vents per acre on the 5% slopes

5 Includes Construction document and bidding, construction administrative fee, CQA field monitoring and lab testing, CQA reporting and certification, final survey for as-built drawings, recordation/notation fee

6 Suitable soil has been identified on the site in sufficient quantities to close the landfill, which would be available for third-party closure

TABLE 8A (continued)
ESTIMATED FINAL CLOSURE COSTS FOR PHASES 1 and 2A (2010 dollars) [1]

2) Alternative Final Cover with Flexible Membrane Barrier

VSL (topsoil)[2] – 36.7 ac	118,418 c.y.	@	$3.25 / cubic yard [6]	$288,645
Single-bond Geocomposite Drainage Layer – 36.7 ac	1,598,652 s.f.	@	$0.45 / s.f.	$719,393
40-mil HDPE flexible Membrane– 36.7 ac	1,598,652 s.f.	@	$0.35 / s.f.	$559,528
Establish Vegetation	36.7 acres	@	$1,300 per acre	$ 47,710
Storm Water Piping [3]	2500 LF	@	$35.00 / LF	$ 87,500
Erosion Control Stone [3]	100 tons	@	$40.00 / ton	$ 4,000
Gas Vents – 15 ac * 3/ac [4]	45 each	@	$100 each	$ 4,500
			Subtotal Construction Costs	$1,711,276
Testing and Surveying [5]	Estimated 20 percent of subtotal			$342,255
Contingency	Estimated 15 percent of subtotal			$256,691
			Total Construction Cost (if contracted out)	**$2,310,222**
			Cost per acre (if contracted out)	**$62,948**

1 Intended to represent likely third-party construction costs (hired contractor, not the Owner/Operator), based on knowledge of local construction costs for similar projects – these estimates provided to meet NC DENR Division of Waste Management financial assurance requirements; actual costs may be lower for construction by the Owner/Operator; final closure work will be performed incrementally, spreading out the costs over the life of the project

2 Includes soil work for regulatory requirements of 15A NCAC 13B .0543 (c), with a minimum of 24 inches of vegetation support layer (VSL), or topsoil ; costs include surface preparation, soil procurement and transport costs, soil placement and compaction, machine/equipment costs, fuel

3 Estimate based on similar project history; includes materials and installation

4 Three trench-style vents per acre on the 5% slopes

5 Includes Construction document and bidding, construction administrative fee, CQA field monitoring and lab testing, CQA reporting and certification, final survey for as-built drawings, recordation/notation fee

6 Suitable soil has been identified on the site in sufficient quantities to close the landfill, which would be available for third-party closure

WCA Material Recovery, LLC, plans to complete the closure work using in-house forces. The costs shown above are for a third-party contractor to complete the work. Please note that the final closure work will be performed incrementally, thus spreading out the costs over the life of the project.

8.3 Post-Closure Plan

8.3.1 Monitoring and Maintenance

8.3.1.1 Term of Post-Closure Care – The facility shall conduct post-closure care for a minimum of 30 years after final closure of the landfill, unless justification is provided for a reduced post-closure care period. The post-closure care period may be extended by the Division if necessary to protect human health and the environment.

8.3.1.2 Maintenance of Closure Systems – Inspections of the final cover systems and sediment and erosion control (S&EC) measures shall be conducted quarterly. Maintenance will be provided during post-closure care as needed to protect the integrity and effectiveness of the final cover. The cover will be repaired as necessary to correct the effects of settlement, subsidence, erosion, or other events. Refer to the **Post Closure Monitoring and Maintenance Schedule** (see **Table 8B**).

8.3.1.3 Landfill Gas Monitoring – The presence of gas is not anticipated during the post-closure period, due to the inert nature of the wastes. Gas monitoring will be conducted for the first five years following the closure of Phase 1A via sampling the head-space in monitoring wells and bar-hole punch tests with an Organic Vapor Analyzer (OVA), or similar equipment, during routine sampling events and continual monitoring in on-site buildings via a gas detection meter. After five years, if no explosive gas is detected, the landfill gas monitoring will be discontinued. If gas is detected at the sampling points at any time, the Division will be notified and an evaluation of protective measures will be performed. Gas wells and cap vents shall be inspected annually and any needed repairs made.

8.3.1.4 Ground Water Monitoring – Groundwater monitoring will be conducted under the current version of the approved Sampling and Analysis Plan (see **Section 11.0**). This plan will be reviewed periodically and may change in the future. Approximately one year prior to the landfill reaching permitted capacity, the facility will submit post-closure monitoring and maintenance schedules, specific to the ground water monitoring. Procedures, methods, and frequencies will be included in this plan. This future plan, and all subsequent amendments, will be incorporated by reference to this document. Monitoring wells shall be inspected annually and any needed repairs made.

8.3.1.5 Record Keeping – During the post closure period, maintenance and inspection records, i.e., a **Post Closure Record**, shall be kept as a continuation of the **Operating Record** that was kept during the operational period. The Post Closure Record shall include future inspection and engineering reports, as well as documentation of all routine and non-routine maintenance and/or amendments. The Post Closure Record shall include the ground water and gas monitoring records collected for the facility.

8.3.1.6 Certification of Completion – At the end of the post-closure care period the facility manager shall contact the Division to schedule an inspection. The facility manager shall make the Post Closure Record available for inspection. A certification that the post-closure plan has been completed, signed by a North Carolina registered professional engineer, shall be placed in the operating/post closure record. The Owner/Operator shall maintain these records indefinitely.

TABLE 8B
POST-CLOSURE MONITORING AND MAINTENANCE SCHEDULE

Activity	Frequency Yrs. 1 - 5	Frequency Yrs. 6-15	Frequency Yrs. 16-30
General - Inspect access gates, locks, fences, signs, site security	Monthly	Monthly	Monthly
Maintain access roads, monitoring well access	As needed	As needed	As needed
Final Cover Systems/Stability - Inspect cap and slope cover for erosion, sloughing, bare spots in vegetation, make corrections as needed (1)	Monthly	Monthly	Monthly
Storm Water/Erosion Control Systems - Inspect drainage swales and sediment basin for erosion, excess sedimentation (1)	Monthly	Monthly	Monthly
Mow cover vegetation and remove thatch	Semi-Annually	Annually	None (2)
Inspect vegetation cover and remove trees	Annually	Annually	Annually
Landfill Gas Monitoring	Quarterly	Quarterly (3)	Quarterly (3)
Ground Water Monitoring System - Check well head security, visibility (4)	Semi-Annually	Semi-Annually	Annually
Inspect and maintain ground water monitoring wells, landfill gas monitoring wells, landfill gas vents	Annually	Annually	Annually

Notes:

1. Inspect after every major storm event, i.e., 25-year 24-hour design storm

2. Dependent on vegetation type, periodic mowing may be required

3. The Division may be petitioned to discontinue gas monitoring if no detections occur in monitoring wells or on-site buildings

4. See current Ground Water Sampling and Analysis Plan

8.3.2 Responsible Party Contact

Vernon Smith
Regional Vice President
40 Estes Plant Rd
Piedmont, SC 29673
Office (864) 845-8354

8.3.3 Planned Uses of Property

Currently, there is no planned use for the landfill area following closure. The closed facility will be seeded with grass to prevent erosion. Any post-closure use of the property considered in the future will not disturb the integrity of the final cover or the function of the monitoring systems unless necessary (and to be accompanied by repairs or upgrades). Future uses shall not increase the potential threat to human health and the environment. Any proposed use of the landfill property after closure requires approval of the Solid Waste Section.

8.3.4 Post-Closure Cost Estimate

The following cost estimate (see **Table 8C**) is considered suitable for the **Financial Assurance** requirements. Refer to the 30-year cost projection (see **Section 9.0**).

TABLE 8C
ESTIMATED POST-CLOSURE COSTS FOR PHASE 1 and 2A (in 2010 dollars)

Annual Events	Units		Unit Cost	Cost/ Event	Annual Costs
Reseeding/mulching and erosion repair (Assume 10% cap, once per year) [1]	5	ac.	$1500	$7500.00	$3,000.00
Mow final cap (twice per year)	37	ac.	$25	$925.00	$1,850.00
Ground Water Monitoring and Reporting [2]	2	ea.	$7,500	$7,500.00	$15,000.00
Methane Monitoring and Reporting [3]	1	ea.	$2,500	$2,500.00	$5,000.00
Maintain storm water conveyances, groundwater and gas monitoring wells, fence, gate, signs, roads, and final cover gas vents [4]	1	ea.	$4,000	$4,000.00	$4,000.00
Annual inspection	1	ea.	$1,500	$1,500.00	$1,500.00
Annual report	1	ea.	$1,200	$1,200.00	$1,200.00
Monthly inspections	12	ea.	$200	$1,200.00	$1,200.00
Contingency (10% of above)					**$3,155**
Total Cost for One Year					**$34,705.00**
Annual Cost per acre (if contracted out)					**945.00**

Notes:

1. 10% of 36.7 acres, rounded up

2. Fifteen sampling locations (wells and surface water) with Appendix I analytical; allow $250 per location for sampling and testing, $250 per location for reporting

3. Four bar-hole punch locations and six landfill gas wells; sampling consist of gas survey with gas detection meter, allow 1,500 for field work and $1,000 for reporting

4. As needed

9.0 FINANCIAL ASSURANCE

The **2006 C&D Rules** require that Owners/Operators demonstrate financial assurance for closure and post-closure activities. Typically, for local government-owned facilities, said demonstration is based on a local government test. For private facilities, the posting of a performance bond or insurance policy is typically acceptable to the Division.

Cost estimates for closure of CDLF Phase 1 and 2A and post-closure activities for the entire C&D landfill are presented in **Sections 8.2.4** and **8.3.4**, respectively. The following is a summary of the closure costs (in 2008 dollars) and post closure costs (in 2010 dollars) projected over 30 years of post-closure care.

The bond will be reduced by the amount of the projected closure costs after final closure is completed. Maximum post-closure cost liabilities exist at the time of closure – these liabilities decrease with time and, thus, the amount of the post-closure instrument will be reduced over time. Once into the post-closure period, the financial assurance instrument will be recalculated periodically, ideally on an annual basis, and the posted amount (bond, insurance, etc.) will be adjusted accordingly on a periodic basis.

SUMMARY OF CLOSURE AND POST-CLOSURE COST

1.	Final Closure Construction (see **Table 8A, Part 1**)	$1,686,748
2.	Projected Post-Closure Costs (see **Table 8C * 30 years)**	$1,041,150
	TOTAL CLOSURE/POST-CLOSURE COST	**$2,727,898**

NCDENR Division of Waste Management will review these calculations and concur or negotiate a mutually agreeable bond amount. Owners/Operators must complete the demonstration (e.g., irrevocable performance bond, letter of credit, insurance policy, other fiduciary instrument) within 30 days following NCDENR Division of Waste Management concurrence with the calculations. The documentation will be included as a future amendment to this report (see **Appendix 4**).

Earthwork Balance for Phase 2A

1. Base Grading (performed with average-end area method, vertical composition by elevation contours):

Stage 1:

a) Stage 1 CUT = 254,534 c.y. (maximum available cut)*

b) Stage 1 FILL (embankment) = 1,565 c.y. (includes 15% shrinkage)

c) net surplus (to stockpile) = 252,969 c.y.**

Stage 2:

d) Stage 2 CUT = 301,249 c.y. (maximum available cut)*

e) Stage 2 FILL (embankment) = 54,093 c.y. (includes 15% shrinkage)

f) net surplus (to stockpile) = 247,156 c.y.**

TOTAL NET SURPLUS 500,125 c.y.

*expect ripping and blasting (bouldery soils with rock ledges) required within higher elevations

**beyond that needed for base grading, assume all will not be usuable for structural embgankment due to rock - the excavation is unclassified

2. Final COver (Regulatory Minimum Cover, includes 16.7 acres above Phase 2A) - EXCLUDES PHASE 1:

a) Vegetative support soil over the compacted soil barrier (1.5 feet thick)

1.5 * 1600 c.y./acre * 16.7 acres * 1.10 shrinkage = 44,088 c.y.

b) Compacted Soil Barrier (1.5 feet thick, structural fill with max. 10-5 cm/sec permeability)

1.5 * 1600 c.y./acre * 16.7 acres * 1.20 shrinkage = 48,096 c.y.

c) Interim cover (typically 1 foot thick on exterior slopes, minimal compaction, no permeability requirement)

1.0 * 1600 c.y./acre * 16.7 acres * 1.10 shrinkage = 29,392 c.y.

TOTAL SOIL USED FOR CONVENTIONAL COVER = 121,576 c.y.

3. Final COver (Alt. Flexible Membrane, includes 12.5 acres above Phase 2 and vertical expansion over Phase 1):

a) Vegetative support soil over the compacted soil barrier (2.0 feet thick)

2.0 * 1600 c.y./acre * 16.7 acres * 1.10 shrinkage = 58,784 c.y.

b) Compacted Subbase (1.0 feet thick, structural fill in place of interim cover, no permeability requirement)

1.0 * 1600 c.y./acre * 16.7 acres * 1.20 shrinkage = 32,064 c.y.

TOTAL SOIL USED FOR ALTERNATIVE COVER = 90,848 c.y.

4. Operational Cover Soil (assume 15% of total volumetric capacity minus covers calculated in #3 above):

a) Total airspace = 1,400,000 c.y. total - 121,576 c.y. = 1,278,424 c.y.

b) 15% * 1,278,424 c.y. = 121,764 c.y. for conventional cover

C) similarly 15% of total volume = 196,373 c.y. for alternative cover
(more airspace can go to waste disposal)

SUMMARY	Regulatory Minimum Cover (Compacted Soil)	Alt. Flexible Membrane Cover
Available base grade cut		
Stage 1	254,534 c.y.	254,534 c.y.
Stage 2	301,249 c.y.	301,249 c.y.
TOTAL Phase 2A	555,783 c.y.	555,783 c.y.
Required base grade fill		
Stage 1	1,565 c.y.	1,565 c.y.
Stage 2	54,093 c.y.	54,093 c.y.
TOTAL Phase 2A	55,658 c.y.	55,658 c.y.
Required final cover soil	121,576 c.y.	90,848 c.y.
Required operational soil	121,764 c.y.	196,373 c.y.
TOTAL REQUIRED FILL	298,998 c.y.	342,879 c.y.
NET SURPLUS SOIL	256,785 c.y.	212,904 c.y.

RECOMMENDATION

Keep in mind the earthwork balance for the entire Phase 2 expansion (subphases 2A, 2B and 2C) resulted in a net deficit on the order of 300,000 to 390,000 c.y. (see Earthwork Balance for Phase 2)

Stockpile surplus soils using appropriate S&EC measures within the South Disposal Area until needed

CUT & FILL VOLUMES BY AVERAGE AREA METHOD
BASED ON DEPTH CONTOURS (ISOPACHS)

Isopach Volume Function: S = Ks * Z^b

Contour interval (feet) = 2

Phase 2A - Stage 1 Base Grades - CUT

Cut Depth	Contour Area, sf	Contour Area, ac.	Increment Vol., cf	Accum. Vol., cf	Accum. Vol., cy
0	392,745.0	9.0	759,225.0	759,225.0	28,119.4
-2	366,480.0	8.4	710,362.0	1,469,587.0	54,429.1
-4	343,882.0	7.9	665,665.0	2,135,252.0	79,083.4
-6	321,783.0	7.4	613,585.0	2,748,837.0	101,808.8
-8	291,802.0	6.7	561,877.0	3,310,714.0	122,619.0
-10	270,075.0	6.2	517,761.0	3,828,475.0	141,795.4
-12	247,686.0	5.7	476,721.0	4,305,196.0	159,451.7
-14	229,035.0	5.3	438,825.0	4,744,021.0	175,704.5
-16	209,790.0	4.8	398,633.0	5,142,654.0	190,468.7
-18	188,843.0	4.3	358,439.0	5,501,093.0	203,744.2
-20	169,596.0	3.9	319,622.0	5,820,715.0	215,582.0
-22	150,026.0	3.4	280,471.0	6,101,186.0	225,969.9
-24	130,445.0	3.0	241,978.0	6,343,164.0	234,932.0
-26	111,533.0	2.6	196,878.0	6,540,042.0	242,223.8
-28	85,345.0	2.0	144,744.0	6,684,786.0	247,584.7
-30	59,399.0	1.4	98,187.0	6,782,973.0	251,221.2
-32	38,788.0	0.9	60,103.0	6,843,076.0	253,447.3
-34	21,315.0	0.5	25,339.0	6,868,415.0	254,385.7
-36	4,024.0	0.1	4,024.0	6,872,439.0	254,534.8

Phase 2A - Stage 1 Base Grades - FILL

Cut Depth	Contour Area, sf	Contour Area, ac.	Increment Vol., cf	Accum. Vol., cf	Accum. Vol., cy
0	12,148.0	0.3	19,419.0	19,419.0	719.2
2	7,271.0	0.2	11,375.0	30,794.0	1,140.5
4	4,104.0	0.1	5,033.0	35,827.0	1,326.9
6	929.0	0.0	929.0	36,756.0	1,361.3

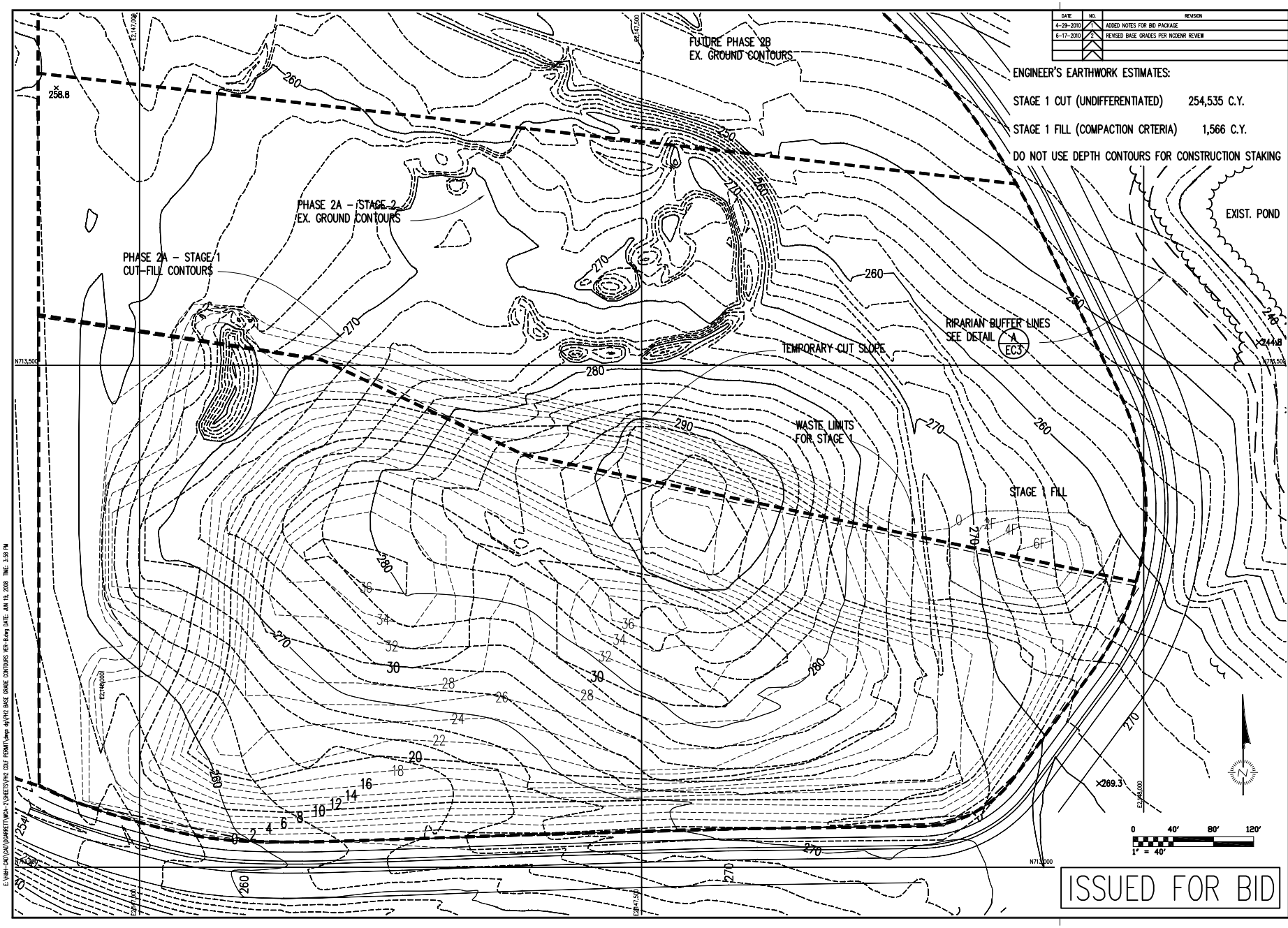
Required Borrow (15% Shrinkage) = 1,565.5

Phase 2A - Stage 2 Base Grades - CUT

Cut Depth	Contour Area, sf	Contour Area, ac.	Increment Vol., cf	Accum. Vol., cf	Accum. Vol., cy
0	378,494.0	8.7	741,202.0	741,202.0	27,451.9
-2	362,708.0	8.3	710,554.0	1,451,756.0	53,768.7
-4	347,846.0	8.0	682,741.0	2,134,497.0	79,055.4
-6	334,895.0	7.7	656,661.0	2,791,158.0	103,376.2
-8	321,766.0	7.4	629,207.0	3,420,365.0	126,680.2
-10	307,441.0	7.1	595,400.0	4,015,765.0	148,732.0
-12	287,959.0	6.6	557,190.0	4,572,955.0	169,368.7
-14	269,231.0	6.2	520,227.0	5,093,182.0	188,636.4
-16	250,996.0	5.8	481,737.0	5,574,919.0	206,478.5
-18	230,741.0	5.3	443,249.0	6,018,168.0	222,895.1
-20	212,508.0	4.9	404,679.0	6,422,847.0	237,883.2
-22	192,171.0	4.4	360,752.0	6,783,599.0	251,244.4
-24	168,581.0	3.9	320,635.0	7,104,234.0	263,119.8
-26	152,054.0	3.5	287,665.0	7,391,899.0	273,774.0
-28	135,611.0	3.1	250,595.0	7,642,494.0	283,055.3
-30	114,984.0	2.6	212,187.0	7,854,681.0	290,914.1
-32	97,203.0	2.2	169,223.0	8,023,904.0	297,181.6
-34	72,020.0	1.7	88,810.0	8,112,714.0	300,470.9
-36	16,790.0	0.4	18,901.0	8,131,615.0	301,170.9
-38	2,111.0	0.0	2,111.0	8,133,726.0	301,249.1

Phase 2A - Stage 2 Base Grades - FILL

Cut Depth	Contour Area, sf	Contour Area, ac.	Increment Vol., cf	Accum. Vol., cf	Accum. Vol., cy
0	174,482.0	4.0	321,151.0	321,151.0	11,894.5
2	146,669.0	3.4	265,773.0	586,924.0	21,737.9
4	119,104.0	2.7	220,295.0	807,219.0	29,897.0
6	101,191.0	2.3	185,069.0	992,288.0	36,751.4
8	83,878.0	1.9	138,081.0	1,130,369.0	41,865.5
10	54,203.0	1.2	83,037.0	1,213,406.0	44,941.0
12	28,834.0	0.7	38,454.0	1,251,860.0	46,365.2
14	9,620.0	0.2	13,104.0	1,264,964.0	46,850.5
16	3,484.0	0.1	4,272.0	1,269,236.0	47,008.7
18	788.0	0.0	788.0	1,270,024.0	47,037.9
		Required Borrow (15% Shrinkage) =			54,093.6



ENGINEER'S EARTHWORK ESTIMATES:

STAGE 1 CUT (UNDIFFERENTIATED) 254,535 C.Y.

STAGE 1 FILL (COMPACTION CRTERIA) 1,566 C.Y.

DO NOT USE DEPTH CONTOURS FOR CONSTRUCTION STAKING

DATE	NO.	REVISION
4-29-2010	1	ADDED NOTES FOR BID PACKAGE
6-17-2010	2	REVISED BASE GRADES PER NCDENR REVIEW

ISSUED FOR BID

David Garrett & Associates
Engineering and Geology
3005 Harbour Towne Drive, Raleigh, North Carolina 27604
Email: david_garrett_pe@mindspring.com 919-231-1898 (Office and Fax) 919-418-0375 (mobile)

SEAL

PROJECT TITLE:
WCA WASTE CORPORATION, INC.
BROWNFIELD RD. C&D LANDFILL
PH2 PERMIT MODIFICATIONS (#92-31)
WAKE COUNTY, NORTH CAROLINA

DRAWING TITLE:
CDLF PHASE 2A - STAGE 1
CUT-FILL DEPTH CONTOURS
CONSTRUCTION BID PACKAGE

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.D.G.	PROJECT NO.: WCA-2
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: PH2 BASE GRADE CONTOURS VER-B	
SHEET NO. 6	DRAWING NO. E3

E:\WAH-CAD\CAD\DGARRETT\WCA-2\SHEETS\PH2 CDLF PERMIT\temp dg\PH2 BASE GRADE CONTOURS VER-B.dwg DATE: JUN 19, 2008 TIME: 3:58 PM

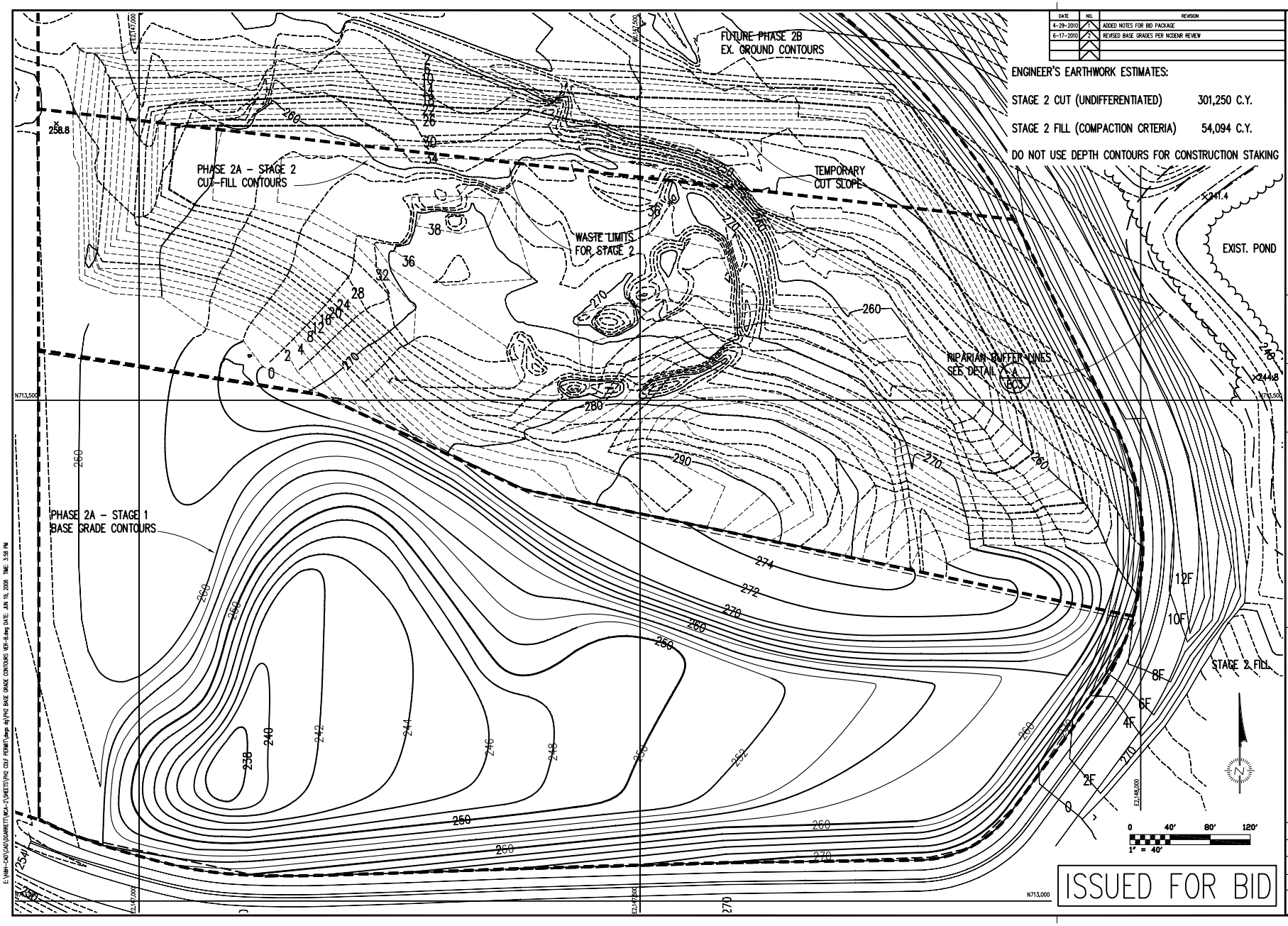
DATE	NO.	REVISION
4-29-2010	1	ADDED NOTES FOR BID PACKAGE
6-17-2010	2	REVISED BASE GRADES PER NCDENR REVIEW

ENGINEER'S EARTHWORK ESTIMATES:

STAGE 2 CUT (UNDIFFERENTIATED) 301,250 C.Y.

STAGE 2 FILL (COMPACTION CRTERIA) 54,094 C.Y.

DO NOT USE DEPTH CONTOURS FOR CONSTRUCTION STAKING



ISSUED FOR BID

David Garrett & Associates
Engineering and Geology
3905 Vinson Drive, Raleigh, North Carolina 27604
Email: david_garrett_geologist@yahoo.com 919-231-1035 (Office and Fax) 919-815-4375 (mobile)

SEAL:

PROJECT TITLE:
WCA WASTE CORPORATION, INC.
BROWNFIELD RD. C&D LANDFILL
PH2 PERMIT MODIFICATIONS (#92-31)
WAKE COUNTY, NORTH CAROLINA

DRAWING TITLE:
CDLF PHASE 2A - STAGE 2
CUT-FILL DEPTH CONTOURS
CONSTRUCTION BID PACKAGE

DESIGNED BY: G.D.G.	DRAWN BY: A.W.H.
CHECKED BY: G.D.G.	PROJECT NO.: WCA-2
SCALE: AS SHOWN	DATE: JUNE 2008
FILE NAME: PH2 BASE GRADE CONTOURS VER-B	
SHEET NO. 7	DRAWING NO. E4

E:\WAH-CAD\CAD\GARRETT\WCA-2\SHEETS\PH2 CDLF PERMIT(Large sq)\PH2 BASE GRADE CONTOURS VER-B.dwg DATE: JUN 19, 2008 TIME: 1:58 PM

Earthwork Balance for Phase 2

1. Base Grading (see backup calculations performed with AutoCAD Land Desktop):

a) required cut (whole phase) = 722,266 c.y. (maximum available cut, Volume Calc #1, average of three methods)*

b) required fill (embankment) = 50,339 c.y. * 1.20 shrinkage = 60,406 c.y.

c) net surplus (to stockpile) = 661,859 c.y.**

*Of the quantity above, approximately 3715 c.y. (average cut, Volume Calc #2) will be rock-like and can be processed into aggregate (exclude this quantity from remaining calculations), and this quantity includes stockpiled soils previously excavated from Phase 1

**if excavated in two stages (beginning with Cell 2A on the south side of ridge) the estimated cut volume is 20% of the total cut, thus approximately 132,372 c.y. will require stockpiling - assume stockpile will be located within Cell 2B the north side of the Phase 2 footprint or within the controlled drainage area served by existing sediment basin SB-1

2. Final COver (Regulatory Minimum Cover, includes 41 acres above Phase 2 and vertical expansion over Phase 1):

a) Vegetative support soil over the compacted soil barrier (1.5 feet thick)

1.5 * 1600 c.y./acre * 41 acres * 1.10 shrinkage = 108,240 c.y.

b) Compacted Soil Barrier (1.5 feet thick, structural fill with max. 10-5 cm/sec permeability)

1.5 * 1600 c.y./acre * 41 acres * 1.20 shrinkage = 118,080 c.y.

c) Interim cover (typically 1 foot thick on exterior slopes, minimal compaction, no permeability requirement)

1.0 * 1600 c.y./acre * 41 acres * 1.10 shrinkage = 72,160 c.y.

3. Final COver (Alt. Flexible Membrane, includes 41 acres above Phase 2 and vertical expansion over Phase 1):

a) Vegetative support soil over the compacted soil barrier (2.0 feet thick)

2.0 * 1600 c.y./acre * 41 acres * 1.10 shrinkage = 144,320 c.y.

b) Compacted Subbase (1.0 feet thick, structural fill in place of interim cover, no permeability requirement)

1.0 * 1600 c.y./acre * 41 acres * 1.20 shrinkage = 78,720 c.y.

4. Operational Cover Soil (assume 15% of total volumetric capacity, see Volume Calc #3):

a) Total airspace = 4,980,657 c.y.***

b) 15% * 4,980,657 c.y. = 747,098 c.y.

SUMMARY	Regulatory Min. Cover	Alt. Flexible Membrane Cover
Available base grade cut	722,266 c.y.	722,266 c.y.
Required base grade fill	60,406	60,406
Required final cover soil	298,480	223,040
Required operational soil	747,098	747,098
TOTAL AVAILABLE CUT	722,266 c.y.	722,266 c.y.
TOTAL REQUIRED FILL	1,105,984 c.y.	1,030,544 c.y.
NET REQUIRED FILL	383,718 c.y.	308,278 c.y.

RECOMMENDATION

Use alternative periodic cover or develop supplemental borrow area (plenty of room within facility boundary)

PH2 BASE GRADES VER B VOLS

Volume Calc #1 - base grades between topo flown 2-29-08 and proposed grading plan (Version B)

Site Volume Table: Unadjusted

Cut cu.yds	Fill cu.yds	Net cu.yds	Method

Site: WCA-2 PH2

Stratum: bottom grades version b vols ex topo 2-20-08 ph2 bottom grades and pberm version b

720922	49563	671359	(C) Grid
722050	50650	671400	(C) Composite
723826	50804	673021	(C) End area

VOLUMNS DIFFERENCE FROM BLASTING & NO BLASTING

Volume Calc #2 - difference between grading plans with minimal rock excavation (Version A) and maximum rock excavation (Version B)

Site Volume Table: Unadjusted

Cut cu.yds	Fill cu.yds	Net cu.yds	Method

Site: WCA-2

Stratum: vol diff between blasting & no blast ph2 bottom grades no blast version a ph2 bottom grades and pberm version b

1683	3588	1906	(F) Grid
1777	3673	1896	(F) Composite
1795	3884	2089	(F) End area

Stratum: vols diff between no blast & blasting ph2 bottom grades and pberm version b ph2 bottom grades no blast version a

3588	1683	1906	(C) Grid
3673	1777	1896	(C) Composite
3884	1795	2089	(C) End area

AIRSPACE VOLUMNS

Volume Calc #3 - total airspace between 2-20-08 aerial topo and final cover grades

Site Volume Table: Unadjusted

Cut cu.yds	Fill cu.yds	Net cu.yds	Method

Site: WCA-2 PH2

Stratum: airspace volumns ex topo and bottom grades ph2 top of waste grades no benches

15	4978901	4978887	(F) Grid
81	4981542	4981461	(F) Composite
69	4981528	4981459	(F) End area

Calculations based on Hough's method for sand (corrected SPT values) and consolidation theory for clays (using lab data)
These preliminary calculations assume no soil surcharge (preloading) to establish baseline settlement for planning purposes

Assume soil surcharge height =	0	feet	x	soil unit weight =	100	pcf =	0	psf		
				Soil surcharge pressure increase =			0	psf	* Soils data for G-13 (24-25 ft.) represent worst conditions in Phase 2 footprint	
Max. final waste height =	123	feet	x	unit weight =	50	pcf =	6150	psf	** Past consolidation pressure (Pc) in psf -- see laboratory consolidation curves	
Est'd base soil thickness =	0	feet	x	soil unit weight =	100	pcf =	0	psf		
				Final vertical pressure increase =			6150	psf	ALL STRESSES USED IN THE CALCULATIONS ARE EFFECTIVE STRESS	

Soil Profile for Boring G-4 (worst case) **Grd. Elev.** **259.09** **Water table depth (ft) * =** **46**

Water Table Elevation = 213.09

initial vertical stress condition	surcharge preload, if any	final vertical stress

The ground surface will be excavated here **Grade El.** **226**

Cut Depth **33**

Layer	Original Depth (ft)	Depth After Cut (ft)	Base Elev.	Unit Wt. (pcf) - wet	Po (psf)	u (psf)	Po' (psf)	After Cut Thickness (ft)	Soil Type	N (bpf)	Zave (ft)	I	Average Po'	Past Pc**	Pi	Surcharge Ps	Pp=Pi+Ps	del-P	Pf
					0		0				0								
1	12		247.09	92	1104.00	-2121.60	3225.60	0	SM-ML	8	0	1	1613		1613	0	1613	6150	7763
2	48	15	211.09	96	4560.00	124.80	4435.20	15	SM	12	7.455	0.97	3830	4560	4560	0	4560	5966	9796
3	59	26	200.09	120	5880.00	811.20	5068.80	11	SM	25	20.41	0.9	4752	5880	5880	0	5880	5535	10287
4	92	59	167.09	120	9840.00	2870.40	6969.60	33	SM	100	42.41	0.78	6019	9840	9840	0	9840	4797	10816
5	100	67	159.09	135	10920.00	3369.60	7550.40	8	Rock	100	62.91	0.63	7260	10920	10920	0	10920	3875	11135

Reference: Cheney, R.S., and R.G. Hassie, Soils and Foundations Workshop Manual, US Federal Highway Administration, November 1982

RR = Recompression ratio (staged loading/unloading)

CR = Consolidation ratio (virgin compression curve)

Use consolidation data, considering maximum past pressure for peat & clay layers:

for log Pc/Po < Pc: **del-H = Ho * RR * log(Pc/Po)**

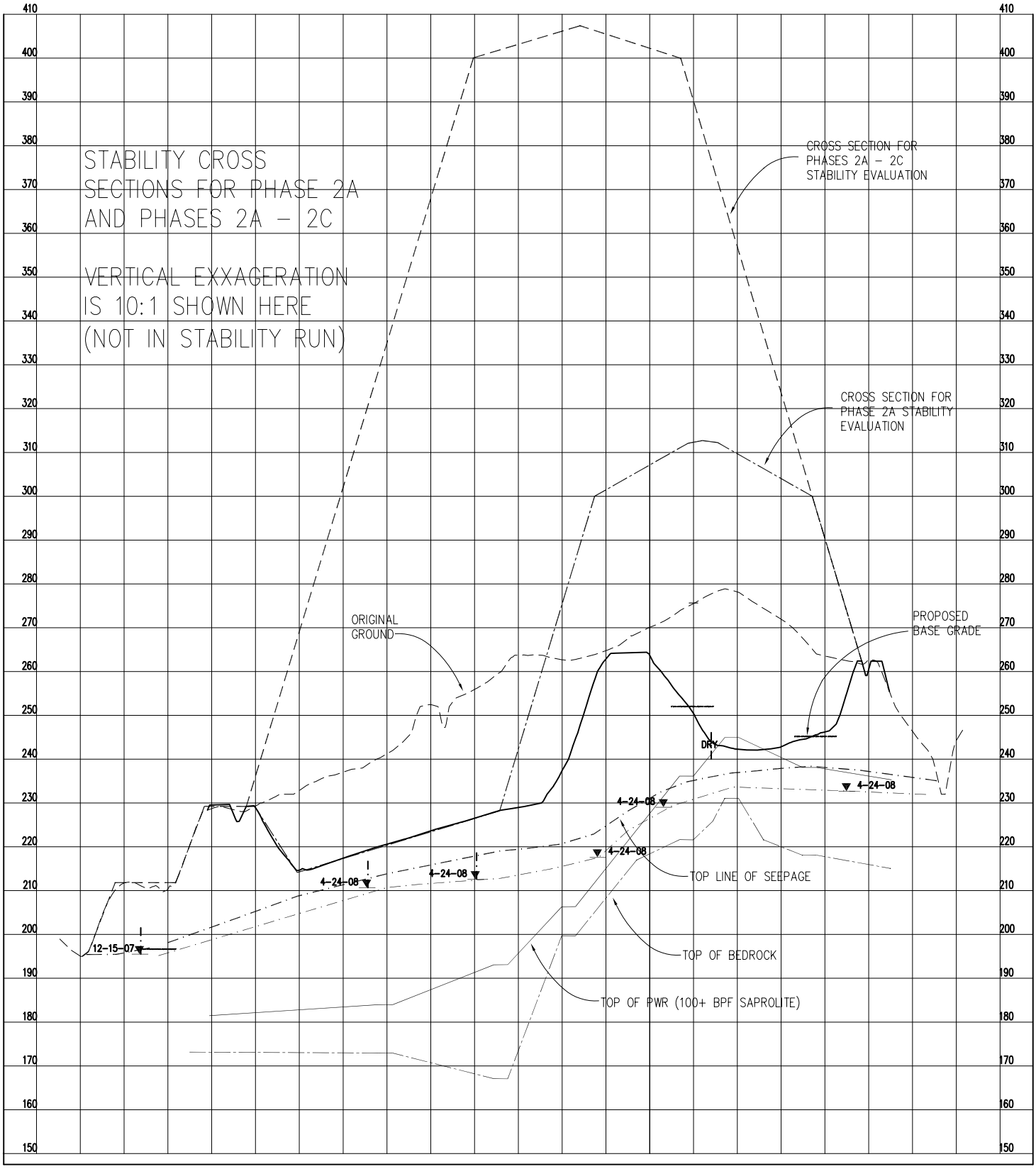
for log Pf/Pc > Pc: **del-H = Ho * CR * log(Pf/Pc)**

add the two:

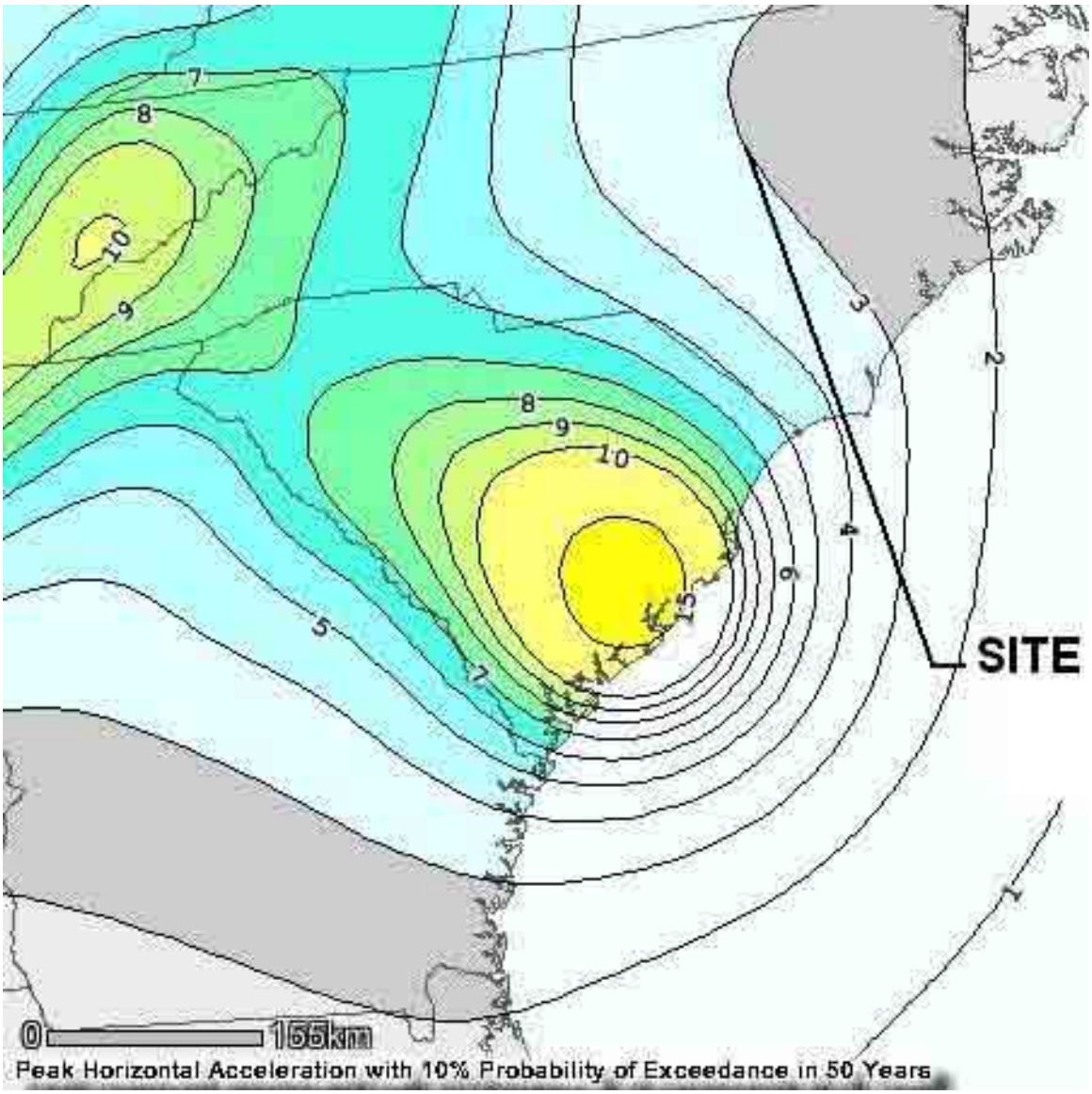
Use corrected spf, without past pressure, for sands:

del-H = Ho * 1/C' * log(pf/Po)

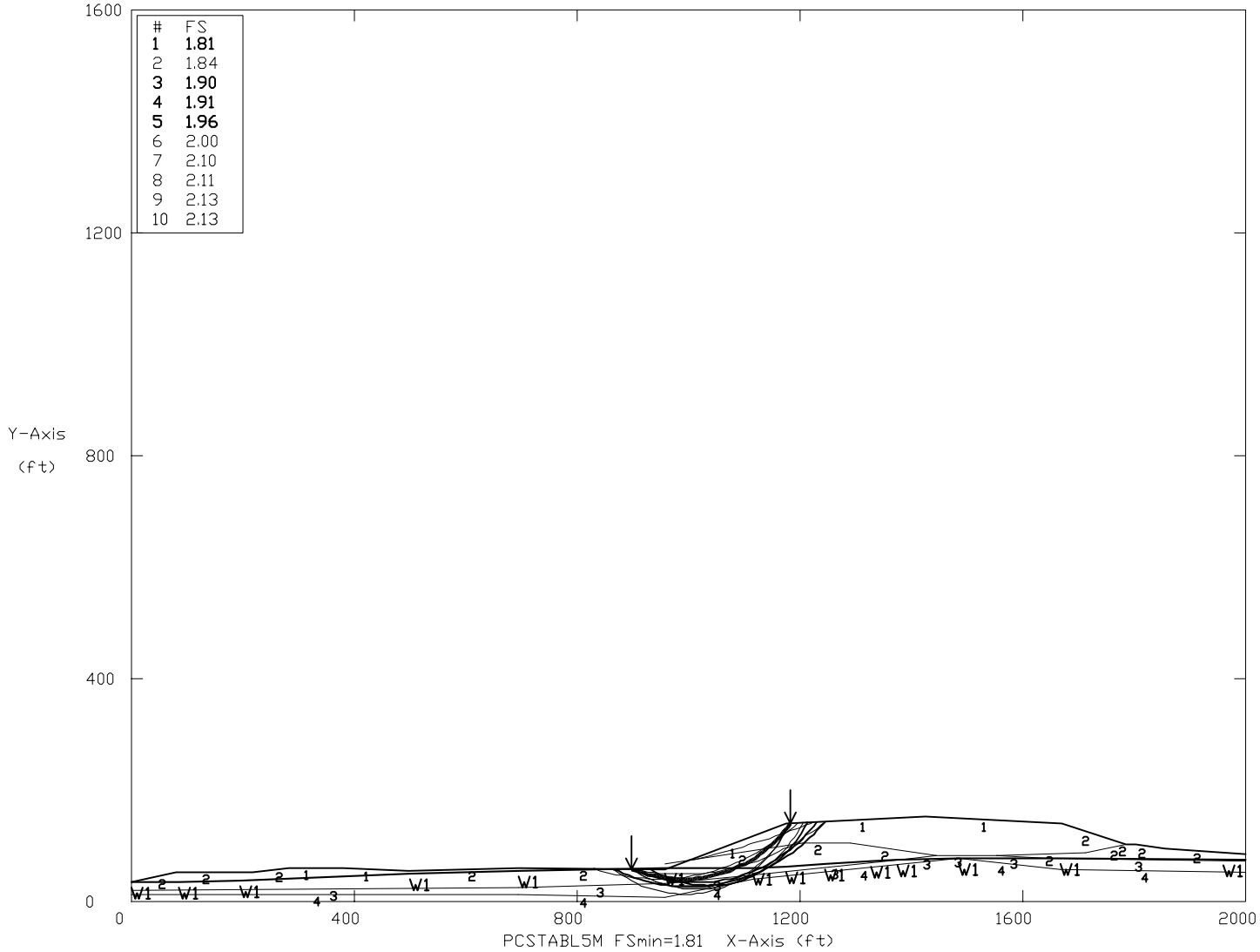
Layer	Ref. Consol Data	RR Cr/1+eo	CR Cc/1+eo	log Pp/Po	del-H (ft)	log Pf/Pp	del-H (ft)	del-H clay (ft)	N'/N	N'	C'	log Po/Pf	del-H sand (ft)	TOTAL SETTLEMENT
1														
2	G-13, 24 - 25 ft	0.018	0.180	0.08	0.02	0.33	0.89	0.91						0.91
3									1.7	43	85	0.34	0.04	0.04
4									1.4	140	25	0.25	0.34	0.34
5									1.3	130	55	0.19	0.03	0.03
					Consolidation Settlement - Clay Layers			**0.91**	**Elastic Settlement - Sand Layers**				**0.41**	**1.32**


STABILITY CROSS SECTIONS FOR PHASE 2A AND PHASES 2A – 2C
VERTICAL EXXAGERATION IS 10:1 SHOWN HERE (NOT IN STABILITY RUN)
CROSS SECTION FOR PHASES 2A – 2C STABILITY EVALUATION
CROSS SECTION FOR PHASE 2A STABILITY EVALUATION
ORIGINAL GROUND
PROPOSED BASE GRADE
DRY
4-24-08
12-15-07
TOP LINE OF SEEPAGE
TOP OF BEDROCK
TOP OF PWR (100+ BPF SAPROLITE)
410
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150

Data from US Geological Survey, on line at www.eqmaps.cr.usgs.gov/serv1



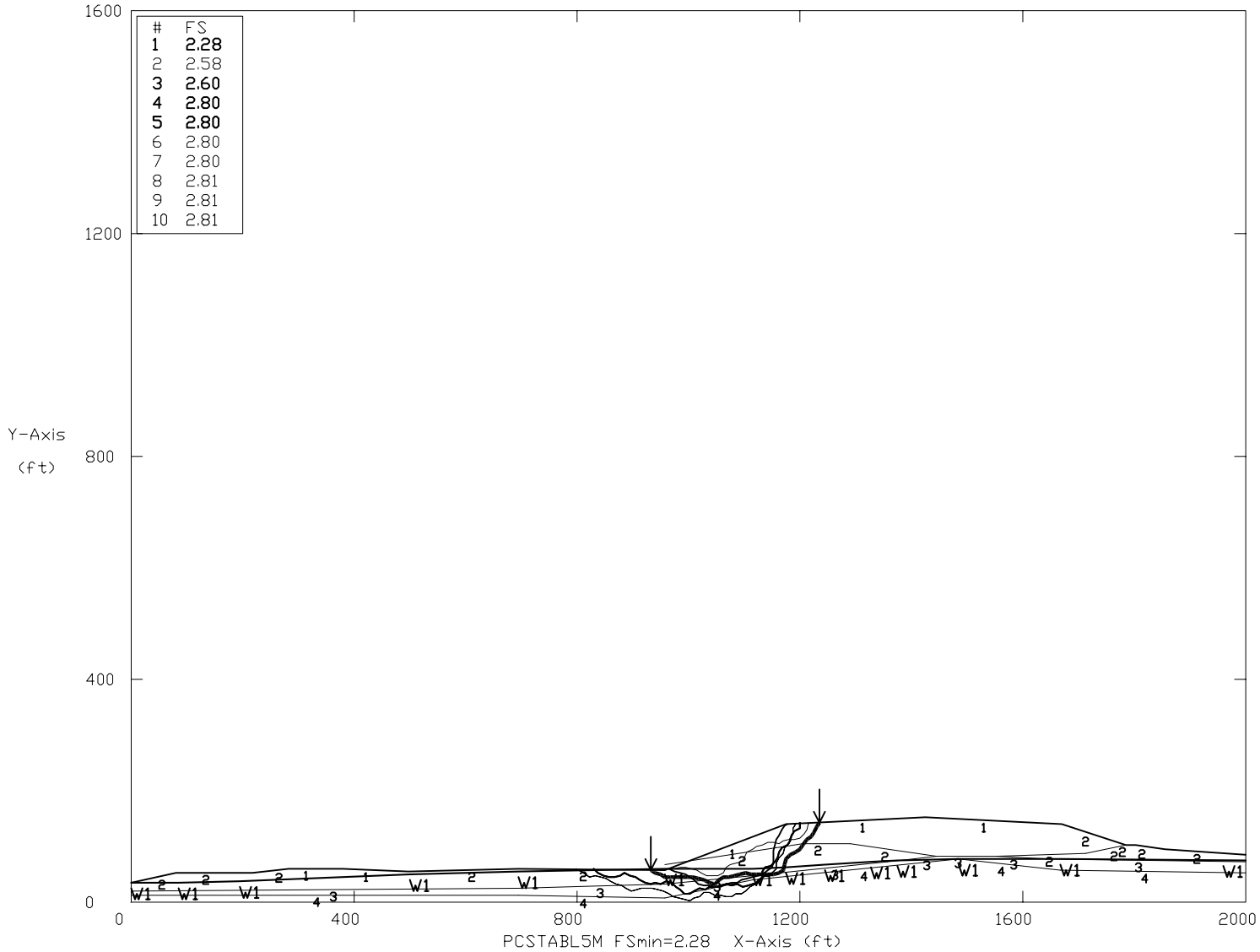
WCA BROWNFIELD PHASE 2A INTERIM 3H:1V JANBU CIRCULAR W/ SEISMIC 0.03g
Ten Most Critical. C:WCA2A1_2.PLT By: DAVID GARRETT 06-01-10 2:35pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	45	60	20	45	.3	0	1
2	115	125	400	34	.3	0	1
3	125	135	800	35	.3	0	1
4	145	150	1000	45	.3	0	1

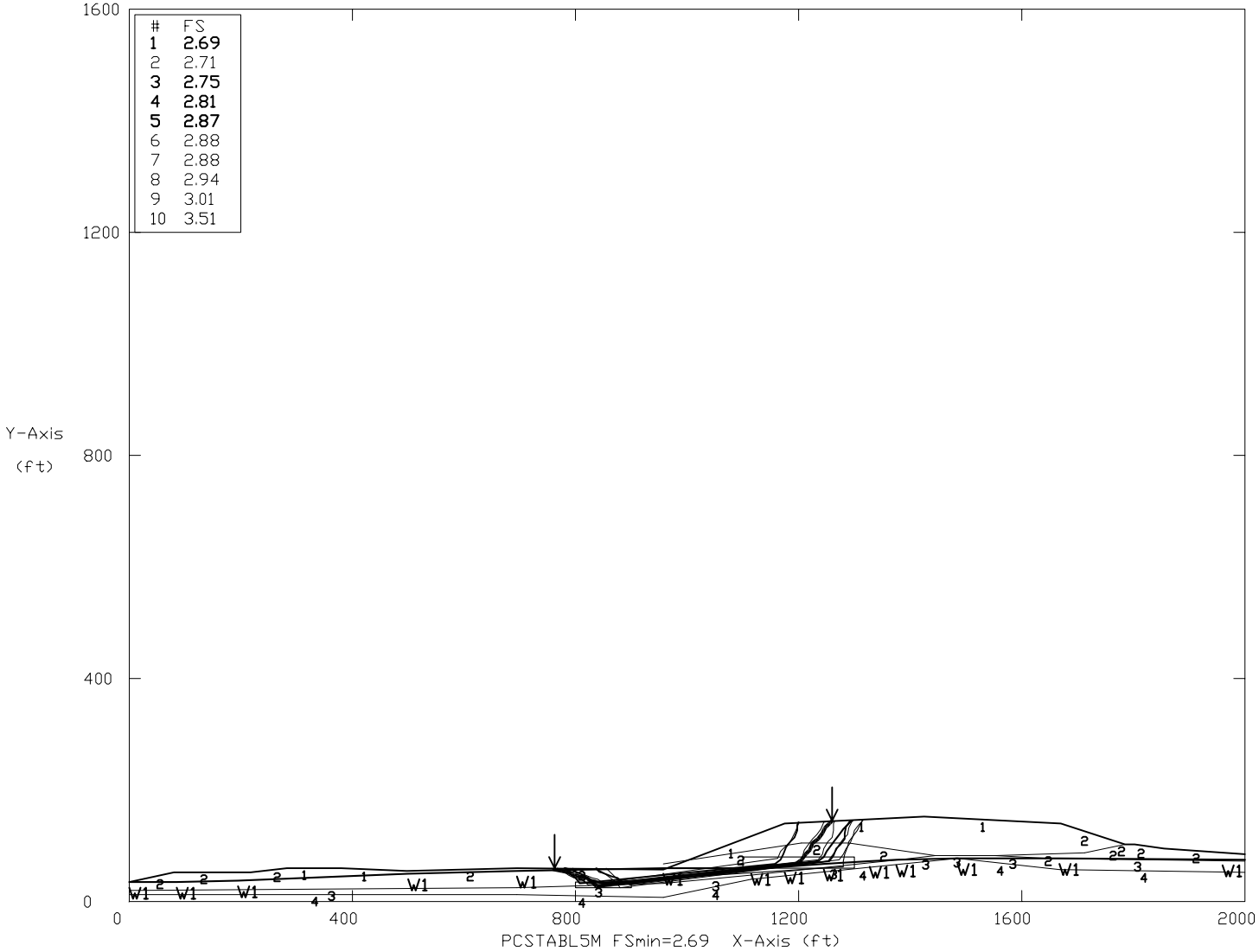
WCA BROWNFIELD PHASE 2A INTERIM 3H:1V JANBU IRREGULAR W/ SEISMIC 0.03g

Ten Most Critical. C:WCA2A1_3.PLT By: DAVID GARRETT 06-01-10 5:16pm



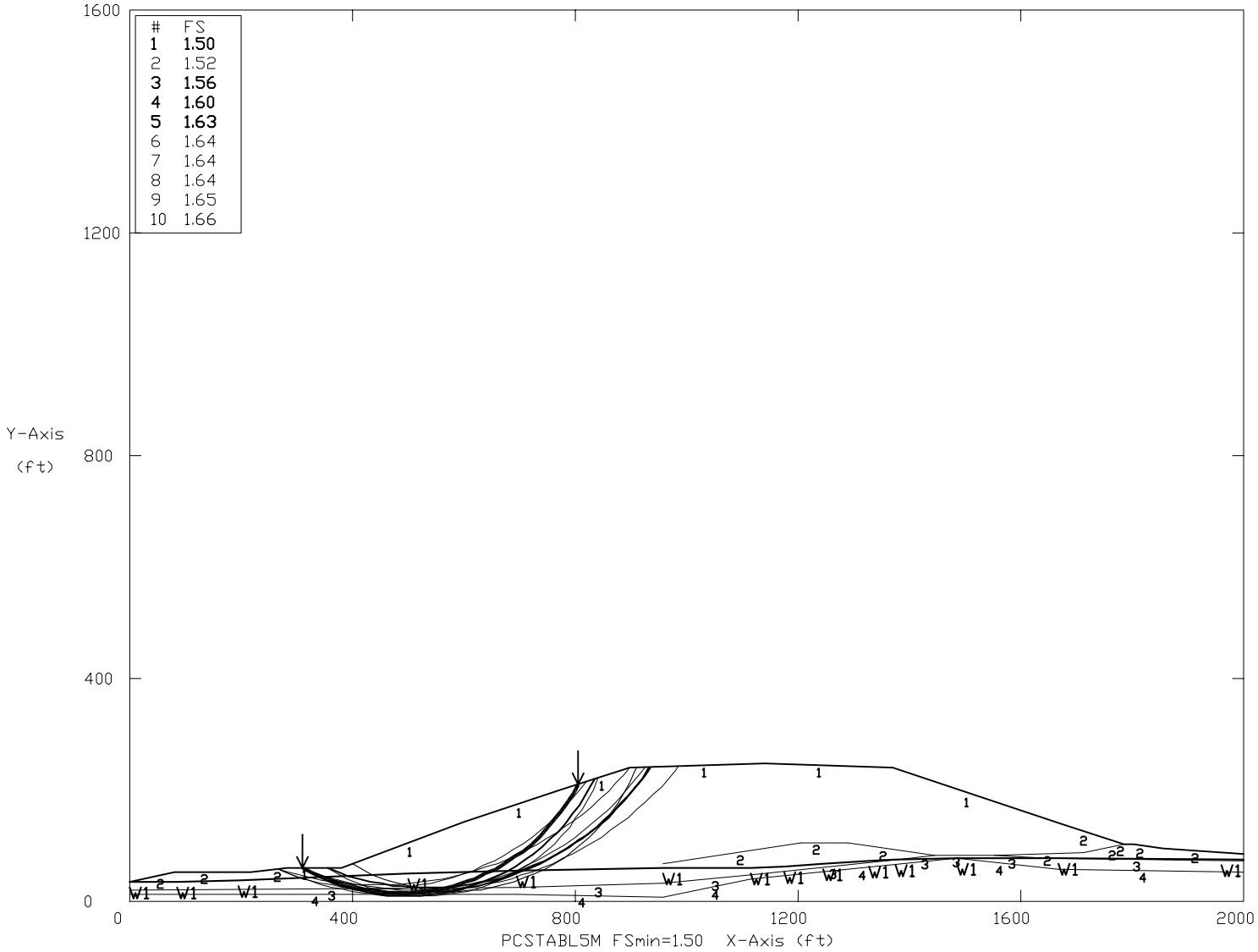
Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	45	60	20	45	.3	0	1
2	115	125	400	34	.3	0	1
3	125	135	800	35	.3	0	1
4	145	150	1000	45	.3	0	1

WCA BROWNFIELD PHASE 2A INTERIM 3H:1V JANBU SLIDING BLK SEISMIC 0.03g
Ten Most Critical. C:WCA2A1_7.PLT By: DAVID GARRETT 06-01-10 5:51pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	45	60	20	45	.3	0	1
2	115	125	400	34	.3	0	1
3	125	135	800	35	.3	0	1
4	145	150	1000	45	.3	0	1

WCA BROWNFIELD PHASE 2 FINAL 3H:1V JANBU CIRCULAR W/ SEISMIC 0.03g
Ten Most Critical. C:WCA2_6.PLT By: DAVID GARRETT 06-01-10 5:23pm



Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	45	60	20	45	.3	0	1
2	115	125	400	34	.3	0	1
3	125	135	800	35	.3	0	1
4	145	150	1000	45	.3	0	1

** PCSTABL5M **

by
Purdue University

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date: 06-01-10
Time of Run: 2:35pm
Run By: DAVID GARRETT
Input Data Filename: C:WCA2A1_2
Output Filename: C:WCA2A1_2.OUT
Plotted Output Filename: C:WCA2A1_2.PLT

PROBLEM DESCRIPTION WCA BROWNFIELD PHASE 2A INTERIM 3H:1V
JANBU CIRCULAR W/ SEISMIC 0.03g

BOUNDARY COORDINATES

14 Top Boundaries
33 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	35.00	79.00	52.00	2
2	79.00	52.00	217.00	52.00	2
3	217.00	52.00	283.00	59.00	2
4	283.00	59.00	379.00	59.00	1
5	379.00	59.00	497.00	54.00	1
6	497.00	54.00	696.00	60.00	2
7	696.00	60.00	958.00	58.00	2
8	958.00	58.00	1174.00	140.00	1
9	1174.00	140.00	1424.00	152.00	1
10	1424.00	152.00	1671.00	140.00	1
11	1671.00	140.00	1784.00	102.00	2
12	1784.00	102.00	1803.00	102.00	2
13	1803.00	102.00	1854.00	94.00	2
14	1854.00	94.00	2000.00	84.00	2
15	958.00	68.00	1206.00	105.00	2
16	1206.00	105.00	1290.00	105.00	2
17	1290.00	105.00	1446.00	83.00	2
18	1446.00	83.00	1553.00	82.00	3
19	1553.00	82.00	1712.00	87.00	2
20	1712.00	87.00	1784.00	102.00	2
21	.00	20.00	696.00	24.00	3

22	696.00	24.00	958.00	33.00	3
23	958.00	33.00	1115.00	47.00	3
24	1115.00	47.00	1381.00	76.00	3
25	1381.00	76.00	1446.00	83.00	3
26	1553.00	82.00	1646.00	78.00	3
27	1646.00	78.00	2000.00	73.00	3
28	.00	13.00	696.00	13.00	4
29	696.00	13.00	958.00	7.00	4
30	958.00	7.00	1115.00	40.00	4
31	1115.00	40.00	1486.00	77.00	4
32	1486.00	77.00	1668.00	58.00	4
33	1668.00	58.00	2000.00	52.00	4

1

ISOTROPIC SOIL PARAMETERS

4 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	45.0	60.0	20.0	45.0	.30	.0	1
2	115.0	125.0	400.0	34.0	.30	.0	1
3	125.0	135.0	800.0	35.0	.30	.0	1
4	145.0	150.0	1000.0	45.0	.30	.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 14 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	35.00
2	84.00	36.00
3	194.00	37.00
4	500.00	49.00
5	696.00	54.00
6	958.00	59.00
7	1115.00	61.00
8	1174.00	63.00
9	1245.00	68.00
10	1328.00	73.00
11	1375.00	74.00
12	1486.00	77.00

13	1668.00	78.00
14	2000.00	75.00

A Horizontal Earthquake Loading Coefficient
Of .030 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

1

A Critical Failure Surface Searching Method, Using A Random
Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 696.00 ft.
and X =1000.00 ft.

Each Surface Terminates Between X =1174.00 ft.
and X =1424.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = .00 ft.

10.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial
Failure Surfaces Examined. They Are Ordered - Most Critical
First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	898.67	58.45
2	907.98	54.81

3	917.44	51.57
4	927.03	48.72
5	936.73	46.29
6	946.52	44.26
7	956.39	42.65
8	966.32	41.46
9	976.29	40.69
10	986.28	40.33
11	996.28	40.40
12	1006.27	40.89
13	1016.23	41.81
14	1026.14	43.14
15	1035.98	44.89
16	1045.75	47.05
17	1055.41	49.62
18	1064.96	52.60
19	1074.37	55.97
20	1083.63	59.74
21	1092.73	63.90
22	1101.64	68.44
23	1110.35	73.35
24	1118.85	78.62
25	1127.11	84.25
26	1135.14	90.22
27	1142.90	96.52
28	1150.39	103.14
29	1157.60	110.08
30	1164.50	117.31
31	1171.10	124.83
32	1177.37	132.61
33	1183.15	140.44

*** 1.808 ***

Individual data on the 37 slices

Slice No.	Width Ft(m)	Weight Lbs(kg)	Water Force Top Lbs(kg)	Water Force Bot Lbs(kg)	Tie Force Norm Lbs(kg)	Tie Force Tan Lbs(kg)	Earthquake Force Hor Lbs(kg)	Earthquake Force Ver Lbs(kg)	Surcharge Load Lbs(kg)
1	1.4	44.9	.0	14.5	.0	.0	1.3	.0	.0
2	7.9	1994.4	.0	1496.7	.0	.0	59.8	.0	.0
3	9.5	6076.7	.0	5013.8	.0	.0	182.3	.0	.0
4	9.6	9740.3	26.6	8147.3	.0	.0	292.2	.0	.0
5	9.7	12964.6	182.8	10871.7	.0	.0	388.9	.0	.0
6	9.8	15730.1	343.7	13188.5	.0	.0	471.9	.0	.0
7	9.9	18003.3	508.1	15093.4	.0	.0	540.1	.0	.0
8	1.6	3113.9	98.4	2605.7	.0	.0	93.4	.0	.0
9	8.3	23537.0	.0	16046.8	.0	.0	706.1	.0	.0
10	10.0	31842.8	.0	20874.3	.0	.0	955.3	.0	.0
11	10.0	35379.9	.0	22343.7	.0	.0	1061.4	.0	.0
12	10.0	38342.0	.0	23393.6	.0	.0	1150.3	.0	.0

13	10.0	40706.7	.0	24021.8	.0	.0	1221.2	.0	.0
14	10.0	42459.1	.0	24227.5	.0	.0	1273.8	.0	.0
15	9.9	43590.7	.0	24010.2	.0	.0	1307.7	.0	.0
16	9.8	44100.0	.0	23370.2	.0	.0	1323.0	.0	.0
17	9.8	43992.0	.0	22308.6	.0	.0	1319.8	.0	.0
18	9.7	43279.3	.0	20827.6	.0	.0	1298.4	.0	.0
19	9.5	41981.0	.0	18929.7	.0	.0	1259.4	.0	.0
20	9.4	40121.7	.0	16618.1	.0	.0	1203.7	.0	.0
21	9.3	37733.4	.0	13896.9	.0	.0	1132.0	.0	.0
22	1.9	7600.5	.0	2563.9	.0	.0	228.0	.0	.0
23	7.2	27367.5	.0	9027.5	.0	.0	821.0	.0	.0
24	8.9	32007.4	.0	10775.4	.0	.0	960.2	.0	.0
25	8.7	28672.8	.0	9873.6	.0	.0	860.2	.0	.0
26	8.5	25003.7	.0	8827.7	.0	.0	750.1	.0	.0
27	8.3	21054.2	.0	7640.0	.0	.0	631.6	.0	.0
28	8.0	16880.9	.0	6312.4	.0	.0	506.4	.0	.0
29	6.4	10567.5	.0	4083.3	.0	.0	317.0	.0	.0
30	1.4	2023.0	.0	781.7	.0	.0	60.7	.0	.0
31	7.5	10041.1	.0	4021.1	.0	.0	301.2	.0	.0
32	7.2	8364.1	.0	3482.5	.0	.0	250.9	.0	.0
33	6.9	6648.3	.0	2887.9	.0	.0	199.4	.0	.0
34	6.6	4920.8	.0	2238.3	.0	.0	147.6	.0	.0
35	2.9	1674.0	.0	800.6	.0	.0	50.2	.0	.0
36	3.4	1450.5	.0	693.8	.0	.0	43.5	.0	.0
37	5.8	981.0	.0	495.6	.0	.0	29.4	.0	.0

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	898.67	58.45
2	907.00	52.92
3	915.61	47.84
4	924.48	43.23
5	933.59	39.09
6	942.90	35.45
7	952.39	32.30
8	962.04	29.67
9	971.81	27.55
10	981.68	25.95
11	991.63	24.88
12	1001.61	24.34
13	1011.61	24.34
14	1021.60	24.86
15	1031.54	25.92
16	1041.42	27.50
17	1051.19	29.61
18	1060.84	32.23
19	1070.34	35.37
20	1079.65	39.00
21	1088.76	43.13
22	1097.64	47.73
23	1106.26	52.80
24	1114.60	58.32
25	1122.63	64.28

26	1130.34	70.65
27	1137.69	77.43
28	1144.67	84.58
29	1151.27	92.10
30	1157.45	99.96
31	1163.21	108.14
32	1168.52	116.61
33	1173.38	125.35
34	1177.76	134.34
35	1180.28	140.30

*** 1.842 ***

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Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	932.44	58.20
2	941.07	53.13
3	949.94	48.51
4	959.03	44.35
5	968.32	40.66
6	977.79	37.45
7	987.42	34.73
8	997.17	32.50
9	1007.02	30.77
10	1016.94	29.55
11	1026.91	28.84
12	1036.91	28.64
13	1046.91	28.95
14	1056.87	29.77
15	1066.79	31.10
16	1076.62	32.93
17	1086.34	35.26
18	1095.93	38.09
19	1105.37	41.40
20	1114.62	45.19
21	1123.67	49.45
22	1132.49	54.17
23	1141.05	59.33
24	1149.35	64.92
25	1157.34	70.92
26	1165.02	77.33
27	1172.36	84.12
28	1179.34	91.28
29	1185.95	98.79
30	1192.17	106.62
31	1197.97	114.76
32	1203.36	123.19
33	1208.31	131.88

34	1212.80	140.81
35	1213.28	141.89

*** 1.897 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	898.67	58.45
2	907.83	54.45
3	917.14	50.80
4	926.57	47.48
5	936.13	44.52
6	945.78	41.91
7	955.52	39.65
8	965.34	37.76
9	975.22	36.23
10	985.15	35.06
11	995.12	34.26
12	1005.11	33.82
13	1015.11	33.76
14	1025.11	34.06
15	1035.08	34.73
16	1045.03	35.76
17	1054.93	37.16
18	1064.78	38.92
19	1074.55	41.05
20	1084.23	43.53
21	1093.82	46.37
22	1103.30	49.56
23	1112.66	53.09
24	1121.87	56.97
25	1130.94	61.18
26	1139.85	65.72
27	1148.59	70.59
28	1157.14	75.77
29	1165.49	81.27
30	1173.64	87.07
31	1181.57	93.17
32	1189.26	99.55
33	1196.72	106.21
34	1203.93	113.14
35	1210.88	120.33
36	1217.56	127.78
37	1223.96	135.46
38	1229.52	142.67

*** 1.914 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	864.89	58.71
2	873.93	54.44
3	883.11	50.46
4	892.41	46.78
5	901.82	43.41
6	911.33	40.33
7	920.94	37.57
8	930.64	35.12
9	940.41	32.98
10	950.24	31.16
11	960.13	29.65
12	970.06	28.47
13	980.02	27.60
14	990.00	27.06
15	1000.00	26.84
16	1010.00	26.94
17	1019.99	27.36
18	1029.96	28.11
19	1039.91	29.17
20	1049.81	30.56
21	1059.66	32.27
22	1069.46	34.29
23	1079.18	36.62
24	1088.82	39.27
25	1098.38	42.23
26	1107.83	45.49
27	1117.17	49.06
28	1126.39	52.93
29	1135.49	57.09
30	1144.44	61.54
31	1153.24	66.28
32	1161.89	71.30
33	1170.37	76.60
34	1178.68	82.17
35	1186.80	88.00
36	1194.74	94.09
37	1202.47	100.44
38	1209.99	107.03
39	1217.29	113.85
40	1224.37	120.91
41	1231.22	128.20
42	1237.84	135.70
43	1244.17	143.37

*** 1.964 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	898.67	58.45
2	907.02	52.96
3	915.64	47.88
4	924.49	43.22
5	933.55	38.99
6	942.80	35.21
7	952.23	31.88
8	961.81	29.00
9	971.52	26.60
10	981.33	24.66
11	991.22	23.20
12	1001.17	22.22
13	1011.16	21.72
14	1021.16	21.70
15	1031.15	22.17
16	1041.10	23.12
17	1051.00	24.55
18	1060.82	26.45
19	1070.53	28.83
20	1080.12	31.67
21	1089.56	34.98
22	1098.83	38.73
23	1107.90	42.93
24	1116.77	47.56
25	1125.39	52.61
26	1133.77	58.08
27	1141.87	63.94
28	1149.68	70.19
29	1157.18	76.80
30	1164.35	83.77
31	1171.17	91.08
32	1177.64	98.71
33	1183.72	106.65
34	1189.42	114.87
35	1194.71	123.35
36	1199.59	132.08
37	1204.04	141.03
38	1204.23	141.45

*** 2.003 ***

1

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	898.67	58.45
2	908.45	56.40
3	918.29	54.59
4	928.16	53.02
5	938.08	51.70
6	948.02	50.63
7	957.99	49.81
8	967.97	49.23
9	977.96	48.90
10	987.96	48.82
11	997.96	49.00
12	1007.95	49.42
13	1017.93	50.08
14	1027.89	51.00
15	1037.82	52.17
16	1047.72	53.58
17	1057.58	55.23
18	1067.40	57.14
19	1077.17	59.28
20	1086.88	61.67
21	1096.53	64.30
22	1106.10	67.17
23	1115.61	70.28
24	1125.03	73.62
25	1134.37	77.20
26	1143.62	81.01
27	1152.77	85.04
28	1161.81	89.31
29	1170.75	93.79
30	1179.57	98.50
31	1188.28	103.43
32	1196.85	108.57
33	1205.30	113.92
34	1213.61	119.49
35	1221.78	125.25
36	1229.80	131.22
37	1237.67	137.39
38	1244.97	143.41

*** 2.101 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1000.00	73.94
2	1009.77	76.08

3	1019.52	78.30
4	1029.26	80.58
5	1038.98	82.93
6	1048.68	85.35
7	1058.36	87.85
8	1068.03	90.41
9	1077.67	93.05
10	1087.30	95.75
11	1096.91	98.53
12	1106.50	101.37
13	1116.06	104.29
14	1125.61	107.27
15	1135.13	110.33
16	1144.63	113.45
17	1154.10	116.64
18	1163.56	119.90
19	1172.99	123.23
20	1182.39	126.63
21	1191.77	130.10
22	1201.13	133.63
23	1210.45	137.24
24	1219.76	140.91
25	1223.39	142.37

*** 2.105 ***

1

Failure Surface Specified By 41 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	831.11	58.97
2	840.66	55.99
3	850.28	53.27
4	859.98	50.82
5	869.73	48.63
6	879.55	46.72
7	889.41	45.07
8	899.32	43.69
9	909.26	42.59
10	919.22	41.76
11	929.21	41.21
12	939.20	40.93
13	949.20	40.92
14	959.20	41.19
15	969.18	41.73
16	979.15	42.55
17	989.09	43.64
18	999.00	45.00
19	1008.86	46.63
20	1018.68	48.54

21	1028.44	50.71
22	1038.14	53.15
23	1047.77	55.85
24	1057.32	58.82
25	1066.78	62.05
26	1076.15	65.54
27	1085.42	69.28
28	1094.59	73.28
29	1103.64	77.53
30	1112.58	82.02
31	1121.38	86.76
32	1130.06	91.74
33	1138.59	96.95
34	1146.98	102.40
35	1155.21	108.07
36	1163.29	113.97
37	1171.20	120.09
38	1178.94	126.42
39	1186.50	132.97
40	1193.88	139.71
41	1195.23	141.02

*** 2.127 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	864.89	58.71
2	872.77	52.56
3	880.95	46.81
4	889.41	41.47
5	898.12	36.56
6	907.06	32.08
7	916.22	28.06
8	925.56	24.49
9	935.07	21.39
10	944.72	18.76
11	954.48	16.62
12	964.34	14.96
13	974.28	13.80
14	984.25	13.13
15	994.25	12.95
16	1004.25	13.27
17	1014.21	14.09
18	1024.13	15.39
19	1033.97	17.19
20	1043.70	19.48
21	1053.31	22.24
22	1062.77	25.48
23	1072.06	29.18

24	1081.16	33.34
25	1090.03	37.94
26	1098.67	42.98
27	1107.05	48.44
28	1115.15	54.31
29	1122.94	60.57
30	1130.42	67.21
31	1137.56	74.22
32	1144.34	81.57
33	1150.74	89.24
34	1156.76	97.23
35	1162.38	105.50
36	1167.58	114.05
37	1172.35	122.84
38	1176.68	131.85
39	1180.23	140.30

*** 2.131 ***

1

```
                Y            A     X     I     S            F     T


                .00    250.00    500.00    750.00   1000.00   1250.00

X          .00 +*--------+---------+---------+---------+---------+
               -
               -W*
               -
               -
               -W*
        250.00 +
               - *
               -
               - *
               -
               -
A       500.00 + *
               -
               -
               -
               -
               -**
X       750.00 +..
               -..
               ..9
               ..5
               .51
               ****
I      1000.00 .218
               .2188
               .2118
               ..*118
               ...W11*
               -...*33
S      1250.00 +..W.54
               -...*..
               - .W...
               -  *...
               -    .*
               -  *
       1500.00 +  *
               -  *
               -
               -
               - **  *
               -  *
F      1750.00 +
               -   *
               -   *
               -
               -
               -
T      2000.00 + **
```

Calculation of Veneer Stability for Static and Seismic Conditions
Saturated and Unsaturated Cases

Project: WCA Material Recovery CDLF, Phase 2 3H:1V slope ratio

Reference: **Geotechnical and Stability Analyses for Ohio Waste Containment Facilitie**
Ohio EPA Geotechnical Resource Group, Guidance Document 660, September 2004
http://www.epa.state.oh.us/dsiwm/document/guidance/gd_660.pdf

The described method calculates the factor of safety against final cover sliding with varying depths of water (head) above barrier layer, e.g., an upper vegetation-support layer above a synthetic membrane or compacted soil; precipitation depth can be specified (design storm), or for a given desired factor of safety, the minimum required friction angle can be determined (after Matasovic, 1991)

For saturated conditions, assume a minimum 10-year, 60-min design storm impinges on surface soils at field capacity

The following assumes a 3H:1V slope ratio, with 18 inches of vegetative cover soil above a compacted soil barrier (10^-5 cm/sec)

A mimimal amount of cohesion may be assumed for a soil-to-soil interface - if a flexible membrane barrier is to be used, no cohesion is assumed and a synthetic drain layer or free draining sand must be used!

The assumed design condition places a bench or diversion berm every 25 to 30 vertical feet, thus the slope length of interest is 75 feet

The basic equation for the safety factor is:

FS = {c/Gam-c*Zc*Cos^2Beta + tanPhi[1 - Gam-w(Zc - Dw)/(Gam-c*Zc)] - Ng*tanBeta*tanPhi } / Ng+tanBeta Eq. 9.1

where:	Fs	=	1.5	=	Factor of Safety (for static case use 1.5, for seismic use 1.1)	
	Ng	=	0	=	peak horizontal acceleration, %g (specific to region)	
	Gam-c	=	120	=	unit weight of cover material, pcf (assume saturated)	
	Gam-w	=	62.4	=	unit weight of water, pcf	
	c	=	0	=	cohesion along failure surface, psf	
	Phi	=		=	internal angle of friction, degrees	
	Beta	=	18.43	=	angle of slope (degrees), for 3H:1V slopes =	18.43
	Zc	=	1.5	=	depth of cover soil, ft.	
	Dw	=		=	depth of water (assume parallel to slope), see Eq. 9.2 below	

Turned around, the equation becomes:

Phi = tan^-1 {Fs*(Ng + tanBeta) - (c/Gam-c*Zc*Cos^2Beta) / [1 - (Gam-w*(Zc-Dw)/(Gam-c*Zc)] - Ng*tanBeta]} = 30.50 degrees
See Summary

The calculation of head follows:

Havg = P(1-RC)*(L*cosBeta) / Kd*sinBeta = 13.3 cm = 0.44 feet Eq. 9.2

where:	Havg	=	average head on failure surface				
	P	=	precipitation, in/hr =	2.75	=	1.94E-03	(cm/sec)
	L	=	slope length, ft =	75	=	2286	(cm)
	RC	=	runoff coefficient =	0			
	Kd	=	permeability of drainage layer		=	1	(cm/sec)

thus, Dw = Zc - Havg = 1.06 feet Eq. 9.4

SUMMARY OF REQUIRED DESIGN PARAMETERS

THE FOLLOWING ANALYSES ASSUME NO INTERFACE COHESION

For unsaturated, static conditions, required minimum friction angle for a safety factor of 1.5 is	26.56	degrees	
For unsaturated, seismic conditions, required min. friction angle for a safety factor of 1.1 is	21.23	degrees	
For saturated, static conditions, required minimum friction angle for a safety factor of 1.5 is	30.50	degrees	CRITICAL
For saturated, seismic conditions, required minimum friction angle for a safety factor of 1.1 is	24.60	degrees	

INTERFACE TESING SHALL BE PERFORMED AS A CQA REQUIREMENT FOR ACTUAL FIELD CONDITIONS

Calculations based on Hough's method for sand (corrected SPT values) and consolidation theory for clays (using lab data)
These preliminary calculations assume no soil surcharge (preloading) to establish baseline settlement for planning purposes

Assume soil surcharge height =	0	feet	x	soil unit weight =	100	pcf =	0	psf		
				Soil surcharge pressure increase =			0	psf	* Soils data for G-13 (24-25 ft.) represent worst conditions in Phase 2 footprint	
Max. final waste height =	123	feet	x	unit weight =	50	pcf =	6150	psf	** Past consolidation pressure (Pc) in psf -- see laboratory consolidation curves	
Est'd base soil thickness =	0	feet	x	soil unit weight =	100	pcf =	0	psf		
				Final vertical pressure increase =			6150	psf	ALL STRESSES USED IN THE CALCULATIONS ARE EFFECTIVE STRESS	

Soil Profile for Boring G-4 (worst case) **Grd. Elev.** **259.09** **Water table depth (ft) * =** **46**

Water Table Elevation = 213.09

initial vertical stress condition	surcharge preload, if any	final vertical stress

The ground surface will be excavated here **Grade El.** **226**

Cut Depth **33**

Layer	Original Depth (ft)	Depth After Cut (ft)	Base Elev.	Unit Wt. (pcf) - wet	Po (psf)	u (psf)	Po' (psf)	After Cut Thickness (ft)	Soil Type	N (bpf)	Zave (ft)	I	Average Po'	Past Pc**	Pi	Surcharge Ps	Pp=Pi+Ps	del-P	Pf
					0		0				0								
1	12		247.09	92	1104.00	-2121.60	3225.60	0	SM-ML	8	0	1	1613		1613	0	1613	6150	7763
2	48	15	211.09	96	4560.00	124.80	4435.20	15	SM	12	7.455	0.97	3830	4560	4560	0	4560	5966	9796
3	59	26	200.09	120	5880.00	811.20	5068.80	11	SM	25	20.41	0.9	4752	5880	5880	0	5880	5535	10287
4	92	59	167.09	120	9840.00	2870.40	6969.60	33	SM	100	42.41	0.78	6019	9840	9840	0	9840	4797	10816
5	100	67	159.09	135	10920.00	3369.60	7550.40	8	Rock	100	62.91	0.63	7260	10920	10920	0	10920	3875	11135

Reference: Cheney, R.S., and R.G. Hassie, Soils and Foundations Workshop Manual, US Federal Highway Administration, November 1982

RR = Recompression ratio (staged loading/unloading)

CR = Consolidation ratio (virgin compression curve)

Use consolidation data, considering maximum past pressure for peat & clay layers:

for log Pc/Po < Pc: **del-H = Ho * RR * log(Pc/Po)**

for log Pf/Pc > Pc: **del-H = Ho * CR * log(Pf/Pc)**

add the two:

Use corrected spf, without past pressure, for sands:

del-H = Ho * 1/C' * log(pf/Po)

Layer	Ref. Consol Data	RR Cr/1+eo	CR Cc/1+eo	log Pp/Po	del-H (ft)	log Pf/Pp	del-H (ft)	del-H clay (ft)	N'/N	N'	C'	log Po/Pf	del-H sand (ft)	TOTAL SETTLEMENT
1														
2	G-13, 24 - 25 ft	0.018	0.180	0.08	0.02	0.33	0.89	0.91						0.91
3									1.7	43	85	0.34	0.04	0.04
4									1.4	140	25	0.25	0.34	0.34
5									1.3	130	55	0.19	0.03	0.03
					Consolidation Settlement - Clay Layers			**0.91**	**Elastic Settlement - Sand Layers**				**0.41**	**1.32**

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

North Carolina 35.702 N 78.484 W 200 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004

Extracted: Thu Mar 20 2008

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Help | Docs | U.S. Map

Precipitation Intensity Estimates (in/hr)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	4.91	3.92	3.27	2.24	1.40	0.82	0.58	0.35	0.20	0.12	0.07	0.04	0.03	0.02	0.01	0.01	0.01	0.01
2	5.71	4.57	3.83	2.64	1.66	0.98	0.69	0.41	0.24	0.15	0.08	0.05	0.03	0.02	0.02	0.01	0.01	0.01
5	6.53	5.23	4.41	3.13	2.01	1.20	0.85	0.51	0.30	0.18	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
10	7.32	5.86	4.94	3.58	2.33	1.40	1.00	0.60	0.36	0.22	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01
25	8.12	6.47	5.47	4.05	2.70	1.65	1.19	0.72	0.43	0.26	0.15	0.08	0.05	0.04	0.03	0.02	0.02	0.01
50	8.76	6.98	5.89	4.43	3.00	1.87	1.36	0.83	0.49	0.29	0.17	0.09	0.06	0.04	0.03	0.02	0.02	0.02
100	9.34	7.42	6.25	4.78	3.29	2.08	1.53	0.93	0.56	0.33	0.19	0.10	0.06	0.05	0.03	0.02	0.02	0.02
200	9.84	7.80	6.56	5.11	3.58	2.29	1.70	1.04	0.63	0.37	0.21	0.11	0.07	0.05	0.03	0.03	0.02	0.02
500	10.40	8.23	6.91	5.50	3.94	2.58	1.94	1.20	0.73	0.42	0.24	0.13	0.08	0.06	0.04	0.03	0.02	0.02
1000	10.92	8.60	7.19	5.82	4.25	2.82	2.16	1.33	0.82	0.47	0.26	0.14	0.09	0.06	0.04	0.03	0.02	0.02

Text version of table

* These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval. Please refer to the documentation for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval**
Precipitation Intensity Estimates (in/hr)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	5.38	4.30	3.58	2.45	1.53	0.91	0.64	0.38	0.22	0.13	0.08	0.04	0.03	0.02	0.01	0.01	0.01	0.01
2	6.25	5.00	4.19	2.89	1.81	1.07	0.76	0.46	0.27	0.16	0.09	0.05	0.03	0.03	0.02	0.01	0.01	0.01
5	7.13	5.71	4.81	3.42	2.19	1.32	0.94	0.56	0.33	0.20	0.12	0.06	0.04	0.03	0.02	0.02	0.01	0.01
10	7.99	6.39	5.39	3.90	2.54	1.54	1.10	0.66	0.39	0.24	0.13	0.07	0.05	0.04	0.02	0.02	0.02	0.01
25	8.86	7.06	5.96	4.42	2.94	1.81	1.31	0.79	0.47	0.28	0.16	0.09	0.06	0.04	0.03	0.02	0.02	0.02
50	9.55	7.60	6.42	4.83	3.27	2.05	1.49	0.90	0.54	0.32	0.18	0.10	0.06	0.05	0.03	0.02	0.02	0.02
100	10.16	8.08	6.80	5.21	3.59	2.28	1.68	1.02	0.61	0.36	0.20	0.11	0.07	0.05	0.03	0.03	0.02	0.02
200	10.73	8.50	7.15	5.57	3.90	2.51	1.87	1.14	0.69	0.40	0.23	0.12	0.08	0.06	0.04	0.03	0.02	0.02
500	11.35	8.98	7.54	6.00	4.30	2.82	2.13	1.30	0.80	0.46	0.26	0.14	0.09	0.06	0.04	0.03	0.02	0.02
1000	11.93	9.40	7.86	6.37	4.65	3.10	2.37	1.46	0.90	0.51	0.29	0.15	0.09	0.07	0.04	0.03	0.02	0.02

* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

*** Lower bound of the 90% confidence interval**
Precipitation Intensity Estimates (in/hr)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	4.49	3.59	2.99	2.05	1.28	0.74	0.53	0.32	0.19	0.11	0.06	0.04	0.02	0.02	0.01	0.01	0.01	0.01
2	5.23	4.19	3.51	2.42	1.52	0.89	0.63	0.38	0.22	0.13	0.08	0.04	0.03	0.02	0.02	0.01	0.01	0.01
5	5.98	4.79	4.04	2.87	1.84	1.09	0.77	0.47	0.27	0.17	0.10	0.05	0.04	0.03	0.02	0.01	0.01	0.01
10	6.70	5.35	4.51	3.27	2.13	1.27	0.91	0.55	0.32	0.20	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
25	7.39	5.89	4.98	3.69	2.46	1.49	1.07	0.65	0.39	0.24	0.13	0.07	0.05	0.04	0.02	0.02	0.02	0.01
50	7.94	6.32	5.34	4.02	2.72	1.68	1.22	0.74	0.44	0.27	0.15	0.08	0.05	0.04	0.03	0.02	0.02	0.01
100	8.41	6.68	5.63	4.31	2.97	1.85	1.36	0.83	0.50	0.30	0.17	0.09	0.06	0.04	0.03	0.02	0.02	0.02
200	8.82	6.99	5.88	4.58	3.21	2.03	1.50	0.92	0.56	0.33	0.19	0.10	0.06	0.05	0.03	0.02	0.02	0.02
500	9.25	7.31	6.14	4.88	3.50	2.26	1.70	1.04	0.63	0.38	0.21	0.11	0.07	0.05	0.03	0.03	0.02	0.02
1000	9.62	7.58	6.34	5.13	3.75	2.45	1.86	1.15	0.70	0.42	0.23	0.13	0.08	0.06	0.04	0.03	0.02	0.02

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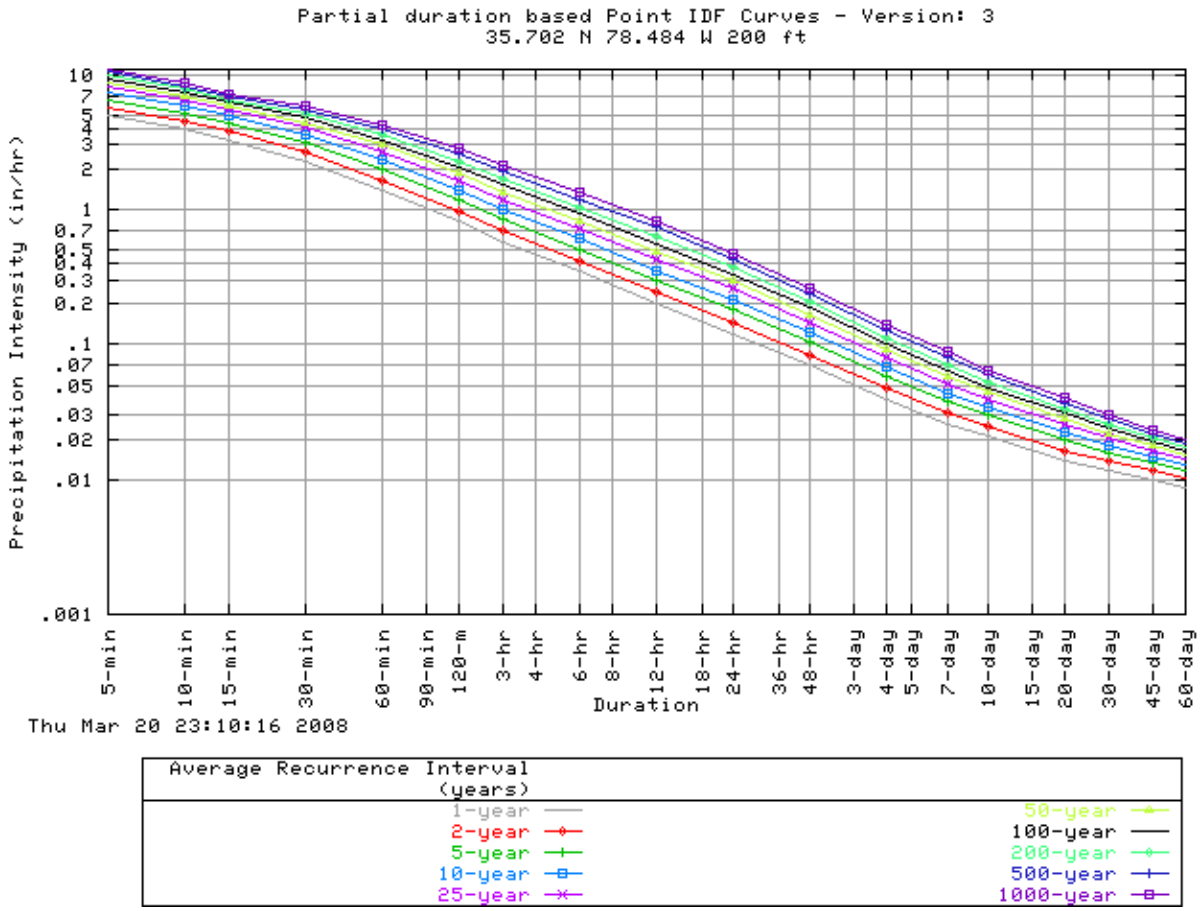
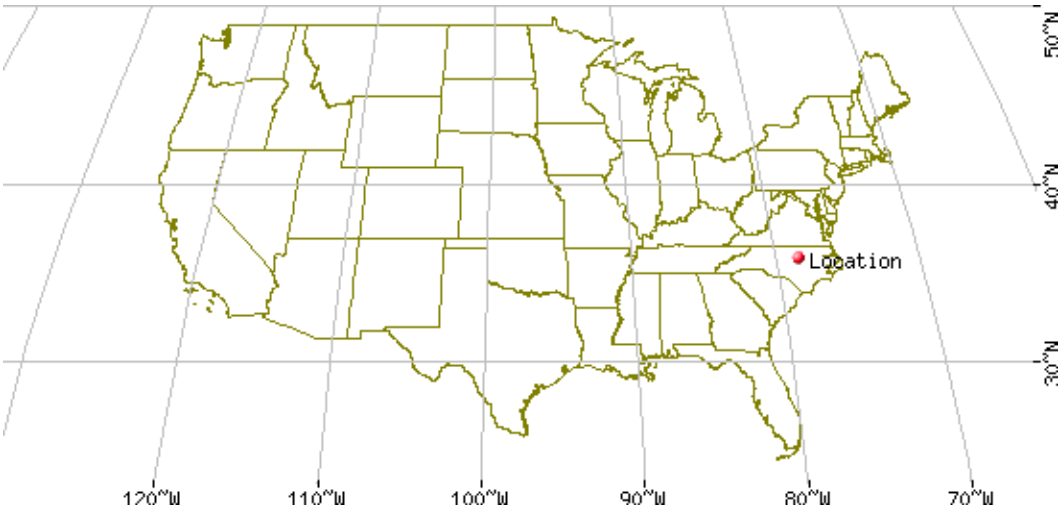
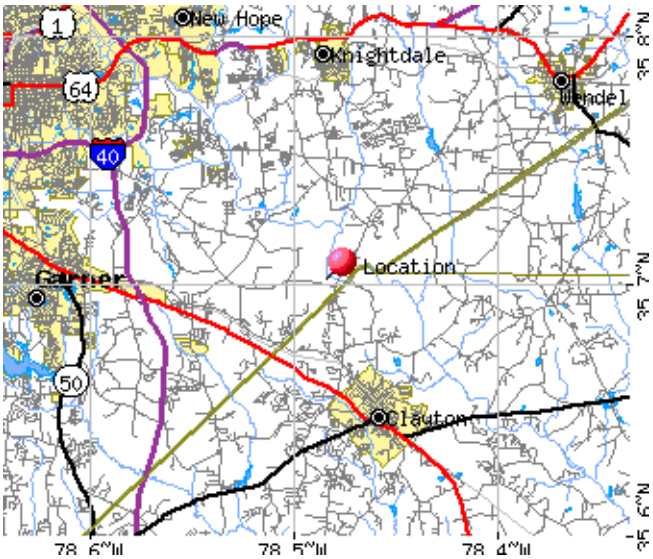
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.



Maps -





These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server.

Please read disclaimer for more information.

LEGEND

State
County
Indian Resv
Lake/Pond/Ocean
Street
Expressway
Highway
Connector
Stream
Military Area
National Park
Other Park
City
County

Scale 1:228583
0 2 4 6 8 mi
0 2 4 6 8 10 km
*average--true scale depends on monitor resolution

Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information
about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study,
please refer to our documentation.

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:
+/-30 minutes ...OR... +/-1 degree of this location (35.702/-78.484). Digital ASCII data can be obtained directly from

NCDC.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910
(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Disclaimer

POINT PRECIPITATION FREQUENCY ESTIMATES FROM NOAA ATLAS 14

North Carolina 35.702 N 78.484 W 200 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004

Extracted: Thu Mar 20 2008

Confidence Limits | Seasonality | Location Maps | Other Info. | GIS data | Maps | Help | Docs | U.S. Map

Precipitation Frequency Estimates (inches)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.41	0.65	0.82	1.12	1.40	1.64	1.73	2.08	2.45	2.89	3.34	3.75	4.35	4.97	6.66	8.28	10.54	12.63
2	0.48	0.76	0.96	1.32	1.66	1.95	2.07	2.48	2.92	3.50	4.04	4.51	5.21	5.93	7.89	9.77	12.38	14.80
5	0.54	0.87	1.10	1.56	2.01	2.39	2.54	3.05	3.61	4.44	5.08	5.62	6.41	7.18	9.41	11.45	14.28	16.89
10	0.61	0.98	1.23	1.79	2.33	2.81	3.01	3.61	4.29	5.19	5.91	6.50	7.36	8.16	10.60	12.74	15.73	18.49
25	0.68	1.08	1.37	2.02	2.70	3.30	3.58	4.31	5.16	6.23	7.06	7.71	8.67	9.49	12.20	14.45	17.61	20.54
50	0.73	1.16	1.47	2.22	3.00	3.74	4.08	4.94	5.96	7.08	7.99	8.69	9.71	10.54	13.47	15.77	19.05	22.09
100	0.78	1.24	1.56	2.39	3.29	4.15	4.59	5.58	6.76	7.95	8.95	9.69	10.79	11.61	14.74	17.08	20.46	23.59
200	0.82	1.30	1.64	2.55	3.58	4.59	5.12	6.25	7.63	8.87	9.96	10.74	11.91	12.70	16.05	18.39	21.85	25.06
500	0.87	1.37	1.73	2.75	3.94	5.15	5.83	7.16	8.83	10.16	11.36	12.20	13.45	14.19	17.81	20.15	23.68	26.98
1000	0.91	1.43	1.80	2.91	4.25	5.65	6.48	7.99	9.94	11.20	12.49	13.37	14.68	15.35	19.19	21.49	25.07	28.42

Text version of table

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*** Upper bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

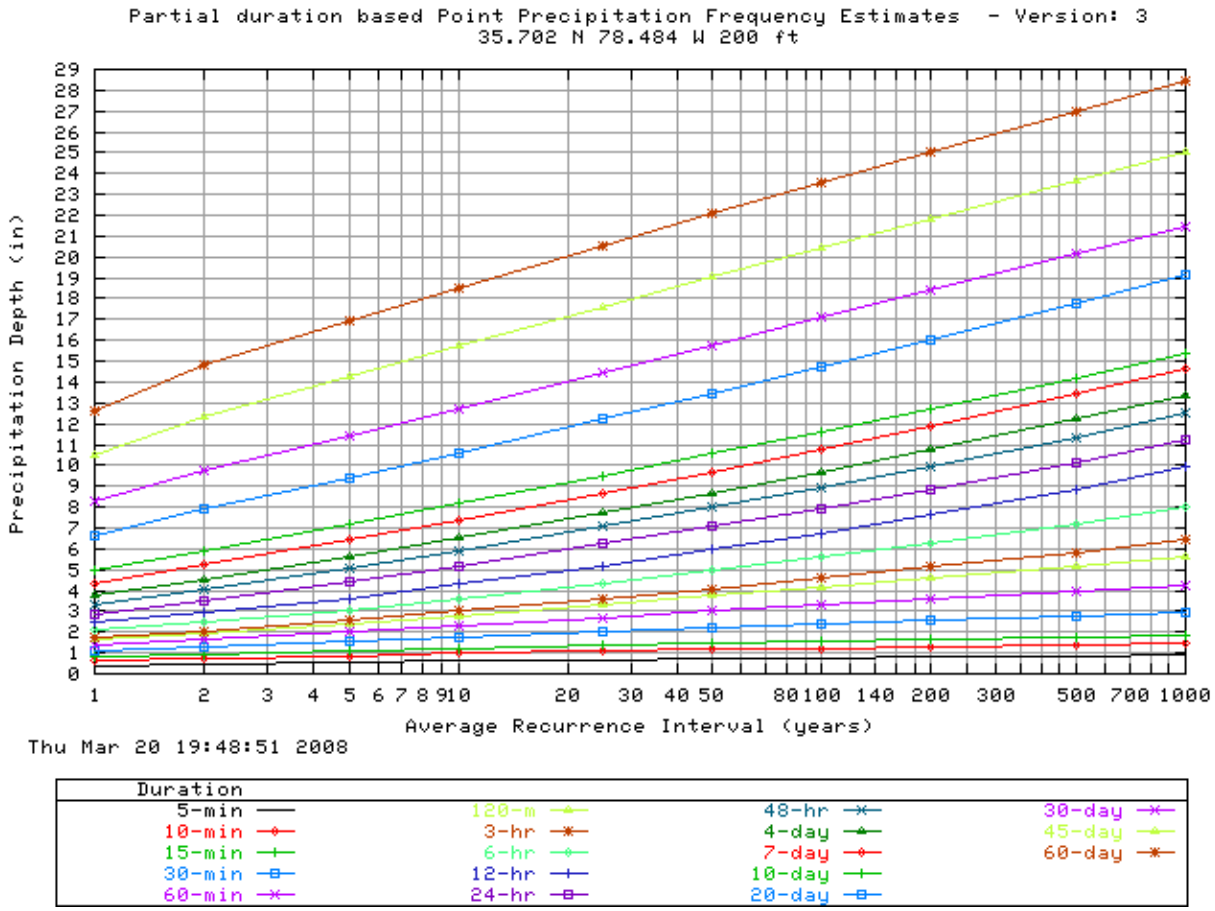
ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.45	0.72	0.90	1.23	1.53	1.81	1.92	2.29	2.70	3.16	3.64	4.05	4.68	5.32	7.12	8.84	11.16	13.35
2	0.52	0.83	1.05	1.45	1.81	2.15	2.29	2.73	3.21	3.83	4.40	4.87	5.60	6.34	8.43	10.43	13.11	15.63
5	0.59	0.95	1.20	1.71	2.19	2.63	2.81	3.35	3.97	4.85	5.54	6.06	6.89	7.69	10.05	12.21	15.13	17.85
10	0.67	1.06	1.35	1.95	2.54	3.08	3.31	3.96	4.71	5.67	6.44	7.00	7.91	8.73	11.31	13.60	16.66	19.55
25	0.74	1.18	1.49	2.21	2.94	3.63	3.93	4.72	5.65	6.81	7.70	8.32	9.32	10.16	13.03	15.42	18.67	21.74
50	0.80	1.27	1.60	2.42	3.27	4.10	4.49	5.41	6.49	7.72	8.71	9.38	10.44	11.29	14.39	16.83	20.19	23.40
100	0.85	1.35	1.70	2.60	3.59	4.56	5.04	6.09	7.37	8.68	9.76	10.48	11.61	12.44	15.76	18.24	21.70	25.00
200	0.89	1.42	1.79	2.78	3.90	5.03	5.62	6.81	8.30	9.69	10.88	11.63	12.85	13.63	17.17	19.67	23.21	26.58
500	0.95	1.50	1.88	3.00	4.30	5.64	6.40	7.81	9.61	11.12	12.45	13.23	14.55	15.25	19.09	21.57	25.19	28.68
1000	0.99	1.57	1.97	3.18	4.65	6.20	7.12	8.73	10.82	12.29	13.71	14.53	15.90	16.53	20.61	23.05	26.70	30.23

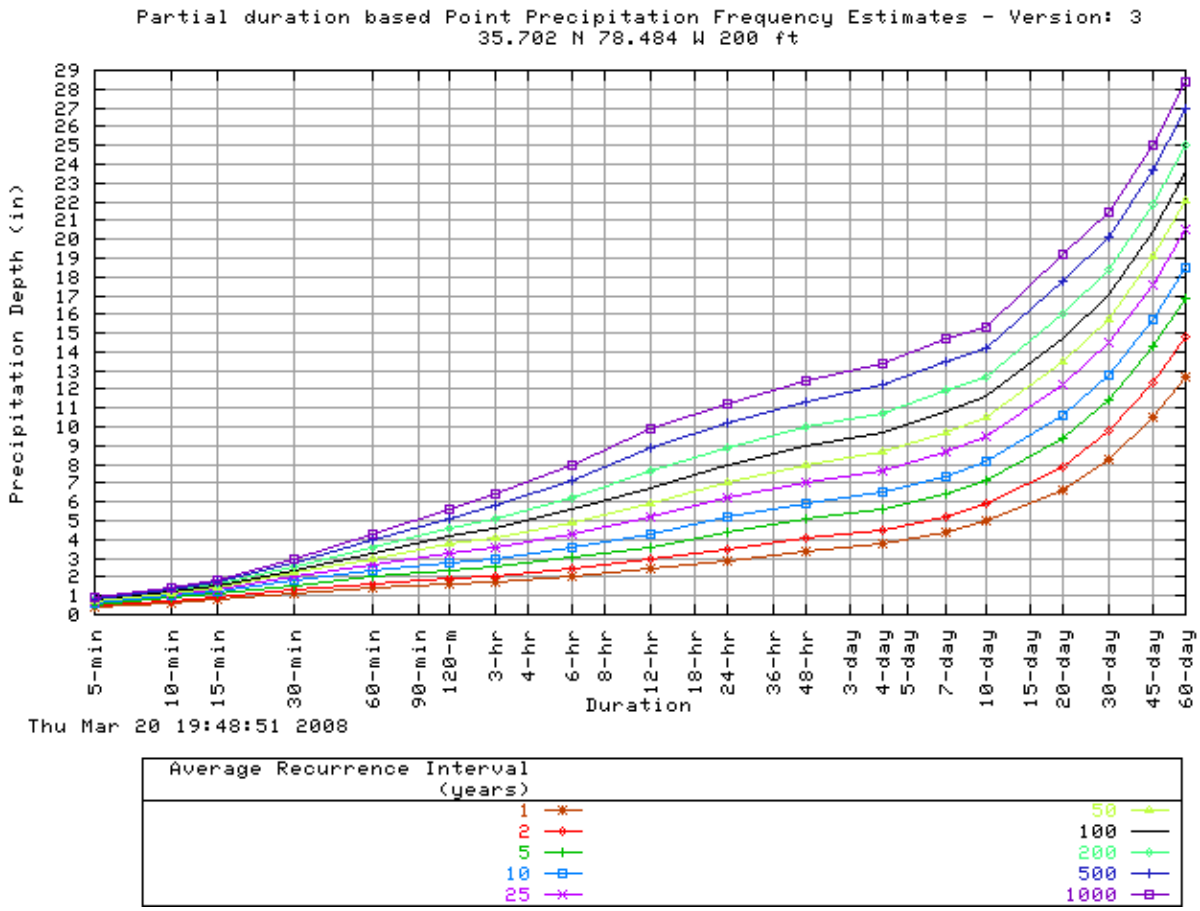
* The upper bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are greater than.
** These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.

*** Lower bound of the 90% confidence interval**
Precipitation Frequency Estimates (inches)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	0.37	0.60	0.75	1.02	1.28	1.49	1.58	1.90	2.24	2.65	3.08	3.48	4.05	4.64	6.24	7.77	9.97	11.95
2	0.44	0.70	0.88	1.21	1.52	1.78	1.89	2.27	2.67	3.21	3.72	4.18	4.84	5.54	7.39	9.16	11.70	13.98
5	0.50	0.80	1.01	1.43	1.84	2.17	2.32	2.79	3.30	4.07	4.67	5.20	5.95	6.70	8.79	10.72	13.47	15.94
10	0.56	0.89	1.13	1.64	2.13	2.54	2.73	3.29	3.90	4.75	5.42	6.00	6.82	7.60	9.89	11.91	14.83	17.43
25	0.62	0.98	1.25	1.84	2.46	2.98	3.23	3.90	4.66	5.68	6.45	7.09	8.01	8.81	11.37	13.47	16.57	19.34
50	0.66	1.05	1.33	2.01	2.72	3.35	3.66	4.44	5.34	6.42	7.27	7.96	8.94	9.76	12.51	14.68	17.90	20.77
100	0.70	1.11	1.41	2.15	2.97	3.70	4.08	4.97	6.00	7.19	8.11	8.85	9.89	10.72	13.65	15.87	19.18	22.15
200	0.73	1.17	1.47	2.29	3.21	4.06	4.52	5.51	6.69	7.99	8.98	9.76	10.88	11.69	14.81	17.05	20.44	23.47
500	0.77	1.22	1.53	2.44	3.50	4.52	5.09	6.24	7.63	9.09	10.18	11.02	12.20	12.99	16.37	18.60	22.06	25.19
1000	0.80	1.26	1.58	2.57	3.75	4.91	5.59	6.87	8.45	9.96	11.12	12.00	13.26	14.00	17.57	19.77	23.30	26.46

* The lower bound of the confidence interval at 90% confidence level is the value which 5% of the simulated quantile values for a given frequency are less than.
** These precipitation frequency estimates are based on a partial duration maxima series. ARI is the Average Recurrence Interval.
Please refer to the documentation for more information. NOTE: Formatting prevents estimates near zero to appear as zero.




Partial duration based Point Precipitation Frequency Estimates - Version: 3
35.702 N 78.484 W 200 ft
Precipitation Depth (in)
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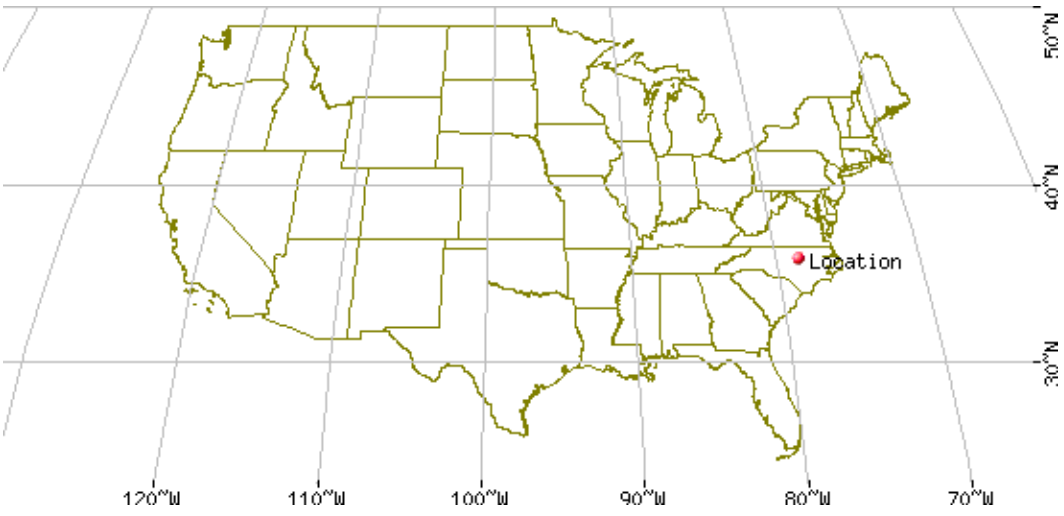
10-min
15-min
30-min
60-min
90-min
120-m
3-hr
4-hr
6-hr
8-hr
12-hr
18-hr
24-hr
36-hr
48-hr
3-day
4-day
5-day
7-day
10-day
15-day
20-day
30-day
45-day
60-day
Thu Mar 20 19:48:51 2008
Average Recurrence Interval (years)
1
2
5
10
25
50
100
200
500
1000

Maps -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110°W
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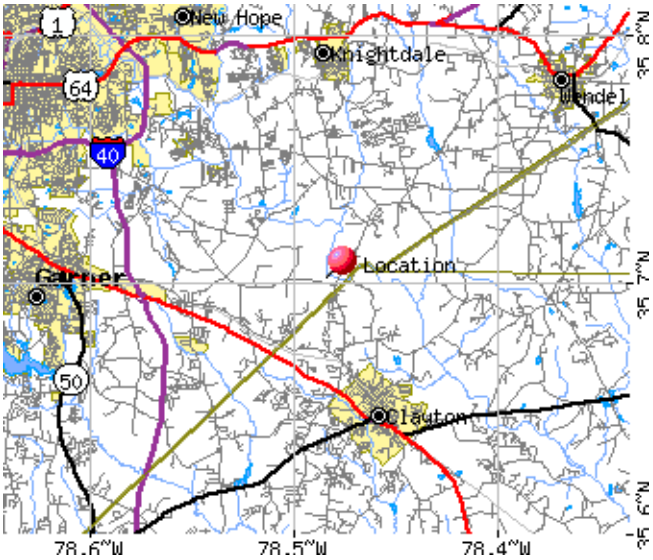
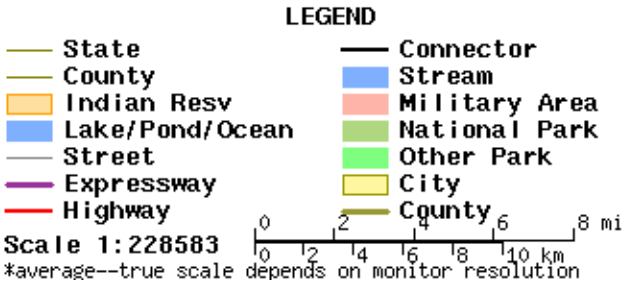
80°W
70°W



These maps were produced using a direct map request from the U.S. Census Bureau Mapping and Cartographic Resources Tiger Map Server.

Please read disclaimer for more information.



Other Maps/Photographs -

View USGS digital orthophoto quadrangle (DOQ) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
from this site. A DOQ is a computer-generated image of an aerial photograph in which image displacement caused by terrain relief and camera tilts has been removed. It combines the image characteristics of a photograph with the geometric qualities of a map. Visit the USGS for more information.

Watershed/Stream Flow Information -

Find the Watershed for this location using the U.S. Environmental Protection Agency's site.

Climate Data Sources -

Precipitation frequency results are based on data from a variety of sources, but largely NCDC. The following links provide general information
about observing sites in the area, regardless of if their data was used in this study. For detailed information about the stations used in this study,
please refer to our documentation.

Using the **National Climatic Data Center's (NCDC)** station search engine, locate other climate stations within:
+/-30 minutes ...OR... +/-1 degree of this location (35.702/-78.484). Digital ASCII data can be obtained directly from **NCDC**.

Hydrometeorological Design Studies Center
DOC/NOAA/National Weather Service
1325 East-West Highway
Silver Spring, MD 20910
(301) 713-1669
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Project: Brownfield Road C&D Landfill Phase 2 Final Cover & Perimeter Channels

Problem Statement:

Design permanent runoff system to meet NCDENR runoff management requirements

Use Small Watershed Method, based on Rational Equation for Q100 peak flow runoff determination (post-closure conditions apply) and Manning's Equation for determining channel and pipe sections

Design Assumptions:

The subject watershed includes all of CDLF Units 1 and 1A, designed for the final closure configuration. Perimeter channels will convey runoff from side slopes and cap to two sedimentation basins.

The design watershed covers 19.97 acres, plus or minus, composed of 3H:1V grassy slopes and a grassy upper cap with 2 to 5% slopes, all draining by gravity via pipes, berms, and channels toward the perimeter, where it will be conveyed by lined channels (the subject of this design) to the ponds

The channels are typically trapezoidal profile ditches, with 3H:1V side slopes and a depth of 2 feet.

Methodology:

Divide the site plan into small drainage areas serving specific features, i.e., slope berms leading to HDPEslope drains (buried in the slope cover with stone protection at the inlet/outlets)

Determine drainage for design storm using the Rational Method (ref. Malcom) and regional rainfall intensity data from NOAA (see reference literature section)

Assume a trial width and channel liner (e.g., vegetation, turf reinforcement mat, rip-rap) and an appropriate Manning's friction coefficient; iterate to determine the optimum channel width using the Normal Depth Procedure (with Manning's Equation for open channels)

Adjust design flow in some downstream sections for additive drainage areas (others are not additive)

The design will make use of natural stone rip-rap and (in some cases) existing stone outcrops for liners

References:

Malcom, H.R., Elements of Urban Stormwater Design, © NCSU, Raleigh, NC, 1989

Malcom, H.R., Stormwater Design Fundamentals, © HRM, Raleigh, NC, 2003

North Carolina Erosion and Sedimentation Control Planning and Design Manual, 1988, 2006

Bonnin, G.M., et. al., Precipitation-Frequency Atlas of the United States, NOAA Atlas 14, Volume 2, Version 2, National Oceanic and Atmospheric Adminitration, June 2004
current information available on-line at http://hdsc.nws.noaa.gov

Design Calculations for Channel No. **1** Page 2

Description: South side of CDLF phase 2 channel #1 drains into Down Pipe #1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.14	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0.00	0%	0.90	0.00
	Summation	0.14	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.14 acres

Maximum Relief, H 8 feet (height above outlet within drainage area)

Hydraulic Length, L 468 feet (distance along main drainage feature)

Channel Slope, S 0.017 Maximum slope Length = 468 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 4 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.14 = 0.45 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 1 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 3

Channel No. **1** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.017	
Channel Side Slope, m		3	
Calculated Flow for	Q100	1	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.17 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.30	0.87	3.90	0.22	0.32		Deep
2	0.28	0.80	3.77	0.21	0.28		Deep
2	0.26	0.72	3.64	0.20	0.25		Deep
2	0.24	0.65	3.52	0.19	0.21		Deep
2	0.22	0.59	3.39	0.17	0.18	√	Deep

Normal flow for design condition: 0.22 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.7 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.2 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **2** Page 4

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #2
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.55	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.55	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.55 acres

Maximum Relief, H 14 feet (height above outlet within drainage area)

Hydraulic Length, L 410 feet (distance along main drainage feature)

Channel Slope, S 0.034 Maximum slope Length = 410 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.55 = 1.78 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 2 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 5

Channel No. **2** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.034	
Channel Side Slope, m		3	
Calculated Flow for	Q100	2	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.24 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.34	1.03	4.15	0.25	0.40		Deep
2	0.32	0.95	4.02	0.24	0.36		Deep
2	0.30	0.87	3.90	0.22	0.32		Deep
2	0.28	0.80	3.77	0.21	0.28		Deep
2	0.26	0.72	3.64	0.20	0.25	√	Deep

Normal flow for design condition: 0.26 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.8 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.6 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.6 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 3

Description: West side of CDLF Phase 2 drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.59	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.59	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.59 acres

Maximum Relief, H 6.5 feet (height above outlet within drainage area)

Hydraulic Length, L 355 feet (distance along main drainage feature)

Channel Slope, S 0.018 Maximum slope Length = 355 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.59 = 1.91 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Estimate Flow Depth by Normal Depth Procedure Page 7

Channel No. **3** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.018	
Channel Side Slope, m		3	
Calculated Flow for	Q100	2	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.33 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.39	1.24	4.47	0.28	0.52		Deep
2	0.37	1.15	4.34	0.27	0.47		Deep
2	0.35	1.07	4.21	0.25	0.43		Deep
2	0.33	0.99	4.09	0.24	0.38		Deep
2	0.31	0.91	3.96	0.23	0.34	√	Deep

Normal flow for design condition: 0.31 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.2 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.4 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **4** Page 8

Description: North Side of CDLF Phase 2 drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.9	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.90	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.90 acres

Maximum Relief, H 20.5 feet (height above outlet within drainage area)

Hydraulic Length, L 655 feet (distance along main drainage feature)

Channel Slope, S 0.031 Maximum slope Length = 655 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 4 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.9 = 2.92 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 3 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 9

Channel No. **4** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.031	
Channel Side Slope, m		3	
Calculated Flow for	Q100	3	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.38 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.41	1.32	4.59	0.29	0.58		Deep
2	0.39	1.24	4.47	0.28	0.52		Deep
2	0.37	1.15	4.34	0.27	0.47		Deep
2	0.35	1.07	4.21	0.25	0.43		Deep
2	0.33	0.99	4.09	0.24	0.38	√	Deep

Normal flow for design condition: 0.33 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.0 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.6 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.7 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 5

Description: East side of CDLF Phase 2 drains into Down Pipe #4
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.14	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.14	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.14 acres

Maximum Relief, H 8 feet (height above outlet within drainage area)

Hydraulic Length, L 380 feet (distance along main drainage feature)

Channel Slope, S 0.021 Maximum slope Length = 380 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.14 = 0.45 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 1 cfs

Estimate Flow Depth by Normal Depth Procedure Page 11

Channel No. **5** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.021	
Channel Side Slope, m		3	
Calculated Flow for	Q100	1	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.15 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.29	0.83	3.83	0.22	0.30		Deep
2	0.27	0.76	3.71	0.20	0.26		Deep
2	0.25	0.69	3.58	0.19	0.23		Deep
2	0.23	0.62	3.45	0.18	0.20		Deep
2	0.21	0.55	3.33	0.17	0.17	√	Deep

Normal flow for design condition: 0.21 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.8 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.3 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 6

Description: South side of CDLF Phase 2 Channel #6 and drains into DP#1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.73	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.73	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.73 acres

Maximum Relief, H 18 feet (height above outlet within drainage area)

Hydraulic Length, L 686 feet (distance along main drainage feature)

Channel Slope, S 0.026 Maximum slope Length = 686 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.73 = 5.61 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 6 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **6** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.026	
Channel Side Slope, m		3	
Calculated Flow for	Q100	6	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.82 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.58	2.17	5.67	0.38	1.14		Deep
2	0.56	2.06	5.54	0.37	1.07		Deep
2	0.54	1.95	5.42	0.36	0.99		Deep
2	0.52	1.85	5.29	0.35	0.92		Deep
2	0.50	1.75	5.16	0.34	0.85	√	Deep

Normal flow for design condition: 0.5 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.4 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.8 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.9 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 7

Description: South West side of CDLF Phase 2 drains into Down Pipe #2
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.51	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0.00	0%	0.30	0.00
Roadway	packed gravel	0.00	0%	0.90	0.00
	Summation	1.51	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.51 acres

Maximum Relief, H 10 feet (height above outlet within drainage area)

Hydraulic Length, L 513 feet (distance along main drainage feature)

Channel Slope, S 0.019 Maximum slope Length = 513 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 4 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.51 = 4.90 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 5 cfs

Estimate Flow Depth by Normal Depth Procedure Page 15

Channel No. **7** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.019	
Channel Side Slope, m		3	
Calculated Flow for	Q100	5	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.80 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.57	2.11	5.60	0.38	1.10		Deep
2	0.55	2.01	5.48	0.37	1.03		Deep
2	0.53	1.90	5.35	0.36	0.95		Deep
2	0.51	1.80	5.23	0.34	0.88		Deep
2	0.49	1.70	5.10	0.33	0.82	√	Deep

Normal flow for design condition: 0.49 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.9 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.6 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.6 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 8

Description: West side of CDLF Phase 2 drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.44	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.44	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.44 acres

Maximum Relief, H 8 feet (height above outlet within drainage area)

Hydraulic Length, L 588 feet (distance along main drainage feature)

Channel Slope, S 0.014 Maximum slope Length = 588 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.44 = 4.67 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 5 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **8** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.014	
Channel Side Slope, m		3	
Calculated Flow for	Q100	5	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.94 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.61	2.34	5.86	0.40	1.27		Deep
2	0.59	2.22	5.73	0.39	1.18		Deep
2	0.57	2.11	5.60	0.38	1.10		Deep
2	0.55	2.01	5.48	0.37	1.03		Deep
2	0.53	1.90	5.35	0.36	0.95	√	Deep

Normal flow for design condition: 0.53 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.6 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.5 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.5 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 9

Description: North side of CDLF Phase 2 drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.1	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.10	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.10 acres

Maximum Relief, H 12 feet (height above outlet within drainage area)

Hydraulic Length, L 735 feet (distance along main drainage feature)

Channel Slope, S 0.016 Maximum slope Length = 735 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2.1 = 6.81 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **9** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.016	
Channel Side Slope, m		3	
Calculated Flow for	Q100	7	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.23 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.69	2.81	6.36	0.44	1.63		Deep
2	0.67	2.69	6.24	0.43	1.53		Deep
2	0.65	2.57	6.11	0.42	1.44		Deep
2	0.63	2.45	5.98	0.41	1.35		Deep
2	0.61	2.34	5.86	0.40	1.27	√	Deep

Normal flow for design condition: 0.61 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.0 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.6 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.6 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 10

Description: North East side of CDLF Phase 2 drains into Down Pipe #4
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.76	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.76	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.76 acres

Maximum Relief, H 22 feet (height above outlet within drainage area)

Hydraulic Length, L 692 feet (distance along main drainage feature)

Channel Slope, S 0.032 Maximum slope Length = 692 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.76 = 5.71 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 6 cfs

Estimate Flow Depth by Normal Depth Procedure Page 21

Channel No. **10** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.032	
Channel Side Slope, m		3	
Calculated Flow for	Q100	6	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.74 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.55	2.01	5.48	0.37	1.03		Deep
2	0.53	1.90	5.35	0.36	0.95		Deep
2	0.51	1.80	5.23	0.34	0.88		Deep
2	0.49	1.70	5.10	0.33	0.82		Deep
2	0.47	1.60	4.97	0.32	0.75	√	Deep

Normal flow for design condition: 0.47 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.7 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 11

Description: South side of CDLF Phase 2 drains into Down Pipe #1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.01	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.01	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.01 acres

Maximum Relief, H 22 feet (height above outlet within drainage area)

Hydraulic Length, L 823 feet (distance along main drainage feature)

Channel Slope, S 0.027 Maximum slope Length = 823 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2.01 = 6.52 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Estimate Flow Depth by Normal Depth Procedure Page 23

Channel No. **11** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	7	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.94 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.61	2.34	5.86	0.40	1.27		Deep
2	0.59	2.22	5.73	0.39	1.18		Deep
2	0.57	2.11	5.60	0.38	1.10		Deep
2	0.55	2.01	5.48	0.37	1.03		Deep
2	0.53	1.90	5.35	0.36	0.95	√	Deep

Normal flow for design condition: 0.53 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.7 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.9 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 12

Description: South West side of CDLF Phase 2 drains into Down Pipe #9
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.54	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.54	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.54 acres

Maximum Relief, H 10 feet (height above outlet within drainage area)

Hydraulic Length, L 607 feet (distance along main drainage feature)

Channel Slope, S 0.016 Maximum slope Length = 607 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.54 = 5.00 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 5 cfs

Estimate Flow Depth by Normal Depth Procedure Page 25

Channel No. **12** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	5	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.67 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.53	1.90	5.35	0.36	0.95		Deep
2	0.51	1.80	5.23	0.34	0.88		Deep
2	0.49	1.70	5.10	0.33	0.82		Deep
2	0.47	1.60	4.97	0.32	0.75		Deep
2	0.45	1.51	4.85	0.31	0.69	√	Deep

Normal flow for design condition: 0.45 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.3 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.8 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.8 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 13

Description: West side of CDLF Phase 1 drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.35	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.35	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.35 acres

Maximum Relief, H 14 feet (height above outlet within drainage area)

Hydraulic Length, L 800 feet (distance along main drainage feature)

Channel Slope, S 0.018 Maximum slope Length = 800 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2.35 = 7.62 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 8 cfs

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Channel No. **13** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	8	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.08 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.65	2.57	6.11	0.42	1.44		Deep
2	0.63	2.45	5.98	0.41	1.35		Deep
2	0.61	2.34	5.86	0.40	1.27		Deep
2	0.59	2.22	5.73	0.39	1.18		Deep
2	0.57	2.11	5.60	0.38	1.10	√	Deep

Normal flow for design condition: 0.57 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.8 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.0 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 14

Description: North side of CDLF Phases 1 & 2 drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	3	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	3.00	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 3.00 acres

Maximum Relief, H 13 feet (height above outlet within drainage area)

Hydraulic Length, L 986 feet (distance along main drainage feature)

Channel Slope, S	0.013	Maximum slope	Length	=	986	feet
	0.000	Minimum slope	Length	=	0	feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 8 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute:	I =	7.25	in/hr	
25-year, 5-minute:	I =	8.08	in/hr	
100-year, 5-minute:	I =	9.27	in/hr	Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 3 = 9.73 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 10 cfs

Estimate Flow Depth by Normal Depth Procedure Page 29

Channel No. **14** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	10	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.35 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	0.63	3.08	6.98	0.44	1.78		Deep
3	0.61	2.95	6.86	0.43	1.68		Deep
3	0.59	2.81	6.73	0.42	1.57		Deep
3	0.57	2.68	6.60	0.41	1.47		Deep
3	0.55	2.56	6.48	0.39	1.38	√	Deep

Normal flow for design condition: 0.55 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**9**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.9 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 15

Description: North East side of CDLF Phase 2 drains into Down Pipe #4
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.82	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.82	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.82 acres

Maximum Relief, H 31 feet (height above outlet within drainage area)

Hydraulic Length, L 931 feet (distance along main drainage feature)

Channel Slope, S 0.033 Maximum slope Length = 931 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2.82 = 9.15 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 10 cfs

Estimate Flow Depth by Normal Depth Procedure Page 31

Channel No. **15** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	10	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.35 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	0.63	3.08	6.98	0.44	1.78		Deep
3	0.61	2.95	6.86	0.43	1.68		Deep
3	0.59	2.81	6.73	0.42	1.57		Deep
3	0.57	2.68	6.60	0.41	1.47		Deep
3	0.55	2.56	6.48	0.39	1.38	√	Deep

Normal flow for design condition: 0.55 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**9**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.9 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 16

Description: South side of CDLF Phase 2 drains into Down Pipe #1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.51	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.51	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.51 acres

Maximum Relief, H 20 feet (height above outlet within drainage area)

Hydraulic Length, L 939 feet (distance along main drainage feature)

Channel Slope, S 0.021 Maximum slope Length = 939 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 7 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2.51 = 8.14 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 9 cfs

Estimate Flow Depth by Normal Depth Procedure Page 33

Channel No. **16** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	9	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.21 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.68	2.75	6.30	0.44	1.58		Deep
2	0.66	2.63	6.17	0.43	1.49		Deep
2	0.64	2.51	6.05	0.41	1.40		Deep
2	0.62	2.39	5.92	0.40	1.31		Deep
2	0.60	2.28	5.79	0.39	1.22	√	Deep

Normal flow for design condition: 0.6 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.9 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.0 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.1 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 17

Description: South West side of CDLF Phases 1 & 2 drains into Down Pipe #2
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.9	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.90	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.90 acres

Maximum Relief, H 12 feet (height above outlet within drainage area)

Hydraulic Length, L 710 feet (distance along main drainage feature)

Channel Slope, S 0.017 Maximum slope Length = 710 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.9 = 6.16 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Estimate Flow Depth by Normal Depth Procedure Page 35

Channel No. **17** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.027	
Channel Side Slope, m		3	
Calculated Flow for	Q100	7	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.94 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.61	2.34	5.86	0.40	1.27		Deep
2	0.59	2.22	5.73	0.39	1.18		Deep
2	0.57	2.11	5.60	0.38	1.10		Deep
2	0.55	2.01	5.48	0.37	1.03		Deep
2	0.53	1.90	5.35	0.36	0.95	√	Deep

Normal flow for design condition: 0.53 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.7 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.9 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 18

Description: West side of CDLF Phase 1 drains into Down Pipe #6
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.85	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.85	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 1.85 acres

Maximum Relief, H 10 feet (height above outlet within drainage area)

Hydraulic Length, L 633 feet (distance along main drainage feature)

Channel Slope, S	0.016	Maximum slope	Length	=	633	feet
	0.000	Minimum slope	Length	=	0	feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute:	I =	7.25	in/hr	
25-year, 5-minute:	I =	8.08	in/hr	
100-year, 5-minute:	I =	9.27	in/hr	Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 1.85 = 6.00 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Estimate Flow Depth by Normal Depth Procedure Page 37

Channel No. **18** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.016	
Channel Side Slope, m		3	
Calculated Flow for	Q100	7	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.23 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.69	2.81	6.36	0.44	1.63		Deep
2	0.67	2.69	6.24	0.43	1.53		Deep
2	0.65	2.57	6.11	0.42	1.44		Deep
2	0.63	2.45	5.98	0.41	1.35		Deep
2	0.61	2.34	5.86	0.40	1.27	√	Deep

Normal flow for design condition: 0.61 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.0 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.6 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.6 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 19

Description: West side of CDLF Phase 1(ex. Channel) drains into Down Pipe #6
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.61	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.61	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.61 acres

Maximum Relief, H 2 feet (height above outlet within drainage area)

Hydraulic Length, L 175 feet (distance along main drainage feature)

Channel Slope, S 0.011 Maximum slope Length = 175 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.61 = 1.98 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **19** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.011	
Channel Side Slope, m		3	
Calculated Flow for	Q100	2	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.42 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.43	1.41	4.72	0.30	0.63		Deep
2	0.41	1.32	4.59	0.29	0.58		Deep
2	0.39	1.24	4.47	0.28	0.52		Deep
2	0.37	1.15	4.34	0.27	0.47		Deep
2	0.35	1.07	4.21	0.25	0.43	√	Deep

Normal flow for design condition: 0.35 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.9 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.3 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 20

Description: West side of CDLF Phase 1(ex. Channel) drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.34	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.34	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.34 acres

Maximum Relief, H 2 feet (height above outlet within drainage area)

Hydraulic Length, L 175 feet (distance along main drainage feature)

Channel Slope, S 0.011 Maximum slope Length = 175 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.34 = 1.10 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **20** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.011	
Channel Side Slope, m		3	
Calculated Flow for	Q100	2	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.42 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.43	1.41	4.72	0.30	0.63		Deep
2	0.41	1.32	4.59	0.29	0.58		Deep
2	0.39	1.24	4.47	0.28	0.52		Deep
2	0.37	1.15	4.34	0.27	0.47		Deep
2	0.35	1.07	4.21	0.25	0.43	√	Deep

Normal flow for design condition: 0.35 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.9 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.3 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 21

Description: North side of CDLF Phase 1 (ex. Channel) drains into Down Pipe #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.67	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.67	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.67 acres

Maximum Relief, H 5 feet (height above outlet within drainage area)

Hydraulic Length, L 280 feet (distance along main drainage feature)

Channel Slope, S 0.018 Maximum slope Length = 280 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.67 = 2.17 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 3 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **21** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.018	
Channel Side Slope, m		3	
Calculated Flow for	Q100	3	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.50 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.46	1.55	4.91	0.32	0.72		Deep
2	0.44	1.46	4.78	0.31	0.66		Deep
2	0.42	1.37	4.66	0.29	0.61		Deep
2	0.40	1.28	4.53	0.28	0.55		Deep
2	0.38	1.19	4.40	0.27	0.50	√	Deep

Normal flow for design condition: 0.38 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.5 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.4 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.4 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 22

Description: North side of CDLF Phase 1 (ex. Channel) drains into Down Pipe #5
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.95	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.95	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.95 acres

Maximum Relief, H 5 feet (height above outlet within drainage area)

Hydraulic Length, L 340 feet (distance along main drainage feature)

Channel Slope, S 0.015 Maximum slope Length = 340 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 4 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.95 = 3.08 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 4 cfs

Estimate Flow Depth by Normal Depth Procedure Page 45

Channel No. **22** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.015	
Channel Side Slope, m		3	
Calculated Flow for	Q100	4	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.72 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.55	2.01	5.48	0.37	1.03		Deep
2	0.53	1.90	5.35	0.36	0.95		Deep
2	0.51	1.80	5.23	0.34	0.88		Deep
2	0.49	1.70	5.10	0.33	0.82		Deep
2	0.47	1.60	4.97	0.32	0.75	√	Deep

Normal flow for design condition: 0.47 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.5 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.4 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.5 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 23

Description: North side of CDLF Phase 2 drains into Down Pipe #5
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.00	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.00 acres

Maximum Relief, H 11 feet (height above outlet within drainage area)

Hydraulic Length, L 566 feet (distance along main drainage feature)

Channel Slope, S	0.019	Maximum slope	Length	=	566	feet
	0.000	Minimum slope	Length	=	0	feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute:	I =	7.25	in/hr	
25-year, 5-minute:	I =	8.08	in/hr	
100-year, 5-minute:	I =	9.27	in/hr	Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2 = 6.49 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **23** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.019	
Channel Side Slope, m		3	
Calculated Flow for	Q100	7	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.12 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.66	2.63	6.17	0.43	1.49		Deep
2	0.64	2.51	6.05	0.41	1.40		Deep
2	0.62	2.39	5.92	0.40	1.31		Deep
2	0.60	2.28	5.79	0.39	1.22		Deep
2	0.58	2.17	5.67	0.38	1.14	√	Deep

Normal flow for design condition: 0.58 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.2 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.7 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.7 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 24

Description: North East side of CDLF Phase 2 drains into Down Pipe #4
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	3.61	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	3.61	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 3.61 acres

Maximum Relief, H 36 feet (height above outlet within drainage area)

Hydraulic Length, L 1189 feet (distance along main drainage feature)

Channel Slope, S 0.030 Maximum slope Length = 1189 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 7 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 3.61 = 11.71 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 12 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **24** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.030	
Channel Side Slope, m		3	
Calculated Flow for	Q100	12	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.16 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 2 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
2	0.67	2.69	6.24	0.43	1.53		Deep
2	0.65	2.57	6.11	0.42	1.44		Deep
2	0.63	2.45	5.98	0.41	1.35		Deep
2	0.61	2.34	5.86	0.40	1.27		Deep
2	0.59	2.22	5.73	0.39	1.18	√	Deep

Normal flow for design condition: 0.59 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**2**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**8**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 5.4 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.1 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.2 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 25

Description: South side of CDLF Phase 2 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.4	65%	0.35	22.58
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0.77	35%	0.90	31.94
	Summation	2.17	100%		54.52

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.55

Design Conditions:

Drainage Area, A 2.17 acres

Maximum Relief, H 18 feet (height above outlet within drainage area)

Hydraulic Length, L 945 feet (distance along main drainage feature)

Channel Slope, S 0.019 Maximum slope Length = 945 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 7 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.55 * 9.27 * 2.17 = 10.97 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 11 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **25** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.019	
Channel Side Slope, m		3	
Calculated Flow for	Q100	11	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.77 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	0.71	3.64	7.49	0.49	2.25		Deep
3	0.69	3.50	7.36	0.48	2.13		Deep
3	0.67	3.36	7.24	0.46	2.01		Deep
3	0.65	3.22	7.11	0.45	1.90		Deep
3	0.63	3.08	6.98	0.44	1.78	√	Deep

Normal flow for design condition: 0.63 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**9**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.6 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.7 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.8 (for bend in channel) Kb min = 1.05
Rc = 300 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 26

Description: South side of CDLF Phase 2 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	9	78%	0.35	27.20
Cap areas	good grass (2 - 5%)	1.21	10%	0.30	3.13
Roadway	packed gravel	1.37	12%	0.90	10.65
	Summation	11.58	100%		40.98

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.41

Design Conditions:

Drainage Area, A 11.58 acres

Maximum Relief, H 20 feet (height above outlet within drainage area)

Hydraulic Length, L 770 feet (distance along main drainage feature)

Channel Slope, S 0.026 Maximum slope Length = 770 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.41 * 9.27 * 11.58 = 44.00 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 44 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **26** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.026	
Channel Side Slope, m		3	
Calculated Flow for	Q100	44	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 4.58 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	1.10	6.93	9.96	0.70	5.44		Deep
3	1.08	6.74	9.83	0.69	5.24		Deep
3	1.06	6.55	9.70	0.68	5.04		Deep
3	1.04	6.36	9.58	0.66	4.85		Deep
3	1.02	6.18	9.45	0.65	4.66	√	Deep

Normal flow for design condition: 1.02 feet

COMMENT: Flow < max. allowable depth of 2 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**2**	**feet**
Top width = 2m*y + B =	**15**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 7.1 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.7 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.7 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 27

Description: West side of CDLF Phase 1 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	16.95	82%	0.35	28.65
Cap areas	good grass (2 - 5%)	1.91	9%	0.30	2.77
Roadway	packed gravel	1.85	9%	0.90	8.04
	Summation	20.71	100%		39.45

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.39

Design Conditions:

Drainage Area, A 20.71 acres

Maximum Relief, H 12 feet (height above outlet within drainage area)

Hydraulic Length, L 655 feet (distance along main drainage feature)

Channel Slope, S 0.018 Maximum slope Length = 655 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.39 * 9.27 * 20.71 = 75.74 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 76 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **27** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.018	
Channel Side Slope, m		3	
Calculated Flow for	Q100	76	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 9.50 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	1.52	11.49	12.61	0.91	10.80		Deep
3	1.50	11.25	12.49	0.90	10.49		Deep
3	1.48	11.01	12.36	0.89	10.19		Deep
3	1.46	10.77	12.23	0.88	9.90		Deep
3	1.44	10.54	12.11	0.87	9.61	√	Deep

Normal flow for design condition: 1.44 feet

COMMENT: Flow < max. allowable depth of 2 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**2**	**feet**
Top width = 2m*y + B =	**15**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 7.2 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.6 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.7 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 28

Description: West side of CDLF Phase 1 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	19.82	84%	0.35	29.25
Cap areas	good grass (2 - 5%)	1.91	8%	0.30	2.42
Roadway	packed gravel	1.99	8%	0.90	7.55
	Summation	23.72	100%		39.21

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.39

Design Conditions:

Drainage Area, A 23.72 acres

Maximum Relief, H 2 feet (height above outlet within drainage area)

Hydraulic Length, L 170 feet (distance along main drainage feature)

Channel Slope, S 0.012 Maximum slope Length = 170 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.39 * 9.27 * 23.72 = 86.22 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 87 cfs

Estimate Flow Depth by Normal Depth Procedure Page57

Channel No. **28** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.012	
Channel Side Slope, m		3	
Calculated Flow for	Q100	87	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 13.33 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	1.76	14.57	14.13	1.03	14.87		Deep
3	1.74	14.30	14.00	1.02	14.51		Deep
3	1.72	14.04	13.88	1.01	14.14		Deep
3	1.70	13.77	13.75	1.00	13.78		Deep
3	1.68	13.51	13.63	0.99	13.43	√	Deep

Normal flow for design condition: 1.68 feet

COMMENT: Flow < max. allowable depth of 2 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**2**	**feet**
Top width = 2m*y + B =	**15**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 6.4 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.3 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 29

Description: North West corner of CDLF Phase 1 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	30.24	87%	0.35	30.47
Cap areas	good grass (2 - 5%)	2.05	6%	0.30	1.77
Roadway	packed gravel	2.45	7%	0.90	6.35
	Summation	34.74	100%		38.58

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.39

Design Conditions:

Drainage Area, A 34.74 acres

Maximum Relief, H 4 feet (height above outlet within drainage area)

Hydraulic Length, L 264 feet (distance along main drainage feature)

Channel Slope, S 0.015 Maximum slope Length = 264 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.39 * 9.27 * 34.74 = 124.26 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 125 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **29** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.015	
Channel Side Slope, m		3	
Calculated Flow for	Q100	125	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 17.12 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	1.96	17.40	15.40	1.13	18.89		Deep
3	1.94	17.11	15.27	1.12	18.46		Deep
3	1.92	16.82	15.14	1.11	18.04		Deep
3	1.90	16.53	15.02	1.10	17.62		Deep
3	1.88	16.24	14.89	1.09	17.21	√	Deep

Normal flow for design condition: 1.88 feet

COMMENT: Flow < max. allowable depth of 2 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**2**	**feet**
Top width = 2m*y + B =	**15**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 7.7 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.8 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.8 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 30

Description: North side of CDLF Phase 1 Perimeter berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	15.75	82%	0.35	28.77
Cap areas	good grass (2 - 5%)	1.22	6%	0.30	1.91
Roadway	packed gravel	2.19	11%	0.90	10.29
	Summation	19.16	100%		40.97

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.41

Design Conditions:

Drainage Area, A 19.16 acres

Maximum Relief, H 5 feet (height above outlet within drainage area)

Hydraulic Length, L 768 feet (distance along main drainage feature)

Channel Slope, S 0.007 Maximum slope Length = 768 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 9 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.41 * 9.27 * 19.16 = 72.76 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 73 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **30** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.007	
Channel Side Slope, m		3	
Calculated Flow for	Q100	73	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 14.64 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	1.83	15.54	14.57	1.07	16.21		Deep
3	1.81	15.26	14.45	1.06	15.82		Deep
3	1.79	14.98	14.32	1.05	15.44		Deep
3	1.77	14.71	14.19	1.04	15.06		Deep
3	1.75	14.44	14.07	1.03	14.69	√	Deep

Normal flow for design condition: 1.75 feet

COMMENT: Flow < max. allowable depth of 2 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**2**	**feet**
Top width = 2m*y + B =	**15**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 5.1 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.8 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.8 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 31

Description: North East side of CDLF Phase 2 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	11.3	80%	0.35	28.07
Cap areas	good grass (2 - 5%)	1.22	9%	0.30	2.60
Roadway	packed gravel	1.57	11%	0.90	10.03
	Summation	14.09	100%		40.70

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.41

Design Conditions:

Drainage Area, A 14.09 acres

Maximum Relief, H 11 feet (height above outlet within drainage area)

Hydraulic Length, L 575 feet (distance along main drainage feature)

Channel Slope, S 0.019 Maximum slope Length = 575 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.41 * 9.27 * 14.09 = 53.15 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 54 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **31** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.019	
Channel Side Slope, m		3	
Calculated Flow for	Q100	54	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 6.57 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	1.29	8.86	11.16	0.79	7.60		Deep
3	1.27	8.65	11.03	0.78	7.35		Deep
3	1.25	8.44	10.91	0.77	7.11		Deep
3	1.23	8.23	10.78	0.76	6.87		Deep
3	1.21	8.02	10.65	0.75	6.64	√	Deep

Normal flow for design condition: 1.21 feet

COMMENT: Flow < max. allowable depth of 2 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**2**	**feet**
Top width = 2m*y + B =	**15**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 6.7 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.4 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.5 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 32

Description: North East side of CDLF Phase 2 Perimeter Berm Channel
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.11	66%	0.35	23.08
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	1.09	34%	0.90	30.66
	Summation	3.20	100%		53.73

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.54

Design Conditions:

Drainage Area, A 3.20 acres

Maximum Relief, H 34 feet (height above outlet within drainage area)

Hydraulic Length, L 1341 feet (distance along main drainage feature)

Channel Slope, S 0.025 Maximum slope Length = 1341 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 8 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.54 * 9.27 * 3.2 = 15.94 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 16 cfs

Estimate Flow Depth by Normal Depth Procedure Page 65

Channel No. **32** **Maximum slope**

Assumed channel lining		Vegetated TRM	
Manning's coefficient, n		0.025	(NCESC, Table 8.05e)
Channel Gradient, S		0.025	
Channel Side Slope, m		3	
Calculated Flow for	Q100	16	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 1.70 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 3 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
3	0.70	3.57	7.43	0.48	2.19		Deep
3	0.68	3.43	7.30	0.47	2.07		Deep
3	0.66	3.29	7.17	0.46	1.95		Deep
3	0.64	3.15	7.05	0.45	1.84		Deep
3	0.62	3.01	6.92	0.44	1.73	√	Deep

Normal flow for design condition: 0.62 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**3**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**9**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 5.3 > 4 fps
Requires permanent channel liner

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.0 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 300 feet

TRM liner meets max. tractive force = 2.0 psf (USE STONE CHECK DAMS)

Design Calculations for Channel No. 33

Description: North East side of Perimeter Berm drains into Basin #1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.05	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.05	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 2.05 acres

Maximum Relief, H 61 feet (height above outlet within drainage area)

Hydraulic Length, L 1895 feet (distance along main drainage feature)

Channel Slope, S 0.032 Maximum slope Length = 1895 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 10 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 2.05 = 6.65 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Estimate Flow Depth by Normal Depth Procedure Page 67

Channel No. **33** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.032	
Channel Side Slope, m		3	
Calculated Flow for	Q100	7	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.87 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.70	2.17	5.43	0.40	1.18		Deep
1	0.68	2.07	5.30	0.39	1.10		Deep
1	0.66	1.97	5.17	0.38	1.03		Deep
1	0.64	1.87	5.05	0.37	0.96		Deep
1	0.62	1.77	4.92	0.36	0.90	√	Deep

Normal flow for design condition: 0.62 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**1**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.9 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.3 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 34

Description: South side of Perimeter Berm slope drains into Existing Basin
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.87	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.87	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.87 acres

Maximum Relief, H 36 feet (height above outlet within drainage area)

Hydraulic Length, L 962 feet (distance along main drainage feature)

Channel Slope, S 0.037 Maximum slope Length = 962 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.87 = 2.82 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 3 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **34** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.037	
Channel Side Slope, m		3	
Calculated Flow for	Q100	3	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.35 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.48	1.17	4.04	0.29	0.51		Deep
1	0.46	1.09	3.91	0.28	0.47		Deep
1	0.44	1.02	3.78	0.27	0.43		Deep
1	0.42	0.95	3.66	0.26	0.39		Deep
1	0.40	0.88	3.53	0.25	0.35	√	Deep

Normal flow for design condition: 0.4 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**1**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.4 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 35

Description: North East side of Perimeter Berm drains into Basin #3
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.61	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.61	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.61 acres

Maximum Relief, H 18 feet (height above outlet within drainage area)

Hydraulic Length, L 418 feet (distance along main drainage feature)

Channel Slope, S 0.043 Maximum slope Length = 418 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.61 = 1.98 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Estimate Flow Depth by Normal Depth Procedure Page 71

Channel No. **35** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.043	
Channel Side Slope, m		3	
Calculated Flow for	Q100	2	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.21 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.40	0.88	3.53	0.25	0.35		Deep
1	0.38	0.81	3.40	0.24	0.31		Deep
1	0.36	0.75	3.28	0.23	0.28		Deep
1	0.34	0.69	3.15	0.22	0.25		Deep
1	0.32	0.63	3.02	0.21	0.22	√	Deep

Normal flow for design condition: 0.32 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**1**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.2 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.9 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.9 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. 36

Description: North East side of Perimeter Berm drains into Basin #4
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.66	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.66	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Design Conditions:

Drainage Area, A 0.66 acres

Maximum Relief, H 31 feet (height above outlet within drainage area)

Hydraulic Length, L 794 feet (distance along main drainage feature)

Channel Slope, S 0.039 Maximum slope Length = 794 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.35 * 9.27 * 0.66 = 2.14 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 3 cfs

Estimate Flow Depth by Normal Depth Procedure

Channel No. **36** **Maximum slope**

Assumed channel lining		Grass w/ straw and net	
Manning's coefficient, n		0.033	(NCESC, Table 8.05e)
Channel Gradient, S		0.039	
Channel Side Slope, m		3	
Calculated Flow for	Q100	3	cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.34 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.48	1.17	4.04	0.29	0.51		Deep
1	0.46	1.09	3.91	0.28	0.47		Deep
1	0.44	1.02	3.78	0.27	0.43		Deep
1	0.42	0.95	3.66	0.26	0.39		Deep
1	0.40	0.88	3.53	0.25	0.35	√	Deep

Normal flow for design condition: 0.4 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:

Bottom width, B =	**1**	**feet**
Minimum depth =	**1**	**feet**
Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 3.4 < 4 fps OK
Below permissible velocity for vegetation

> 2.5 fps
Requires temporary liner

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 1.0 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 1.0 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB1**

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.65	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.65	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.65 acres

Maximum Relief, H 1 feet (height above outlet within drainage area)

Hydraulic Length, L 306 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 794 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 6 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.65 = 1.81 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 2 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 75

Channel No.	**DB1**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	2 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.44 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.53	1.37	4.35	0.32	0.64		Deep
1	0.51	1.29	4.23	0.31	0.58		Deep
1	0.49	1.21	4.10	0.30	0.54		Deep
1	0.47	1.13	3.97	0.29	0.49		Deep
1	0.45	1.06	3.85	0.27	0.45	√	Deep

Normal flow for design condition: 0.45 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.9 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.3 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB2** Page 76

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.07	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.07	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.07 acres

Maximum Relief, H 1 feet (height above outlet within drainage area)

Hydraulic Length, L 126 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 126 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.07 = 0.19 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 1 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 77

Channel No.	**DB2**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	1 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.22 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.41	0.91	3.59	0.25	0.37		Deep
1	0.39	0.85	3.47	0.24	0.33		Deep
1	0.37	0.78	3.34	0.23	0.30		Deep
1	0.35	0.72	3.21	0.22	0.26		Deep
1	0.33	0.66	3.09	0.21	0.23	√	Deep

Normal flow for design condition: 0.33 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.5 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.2 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB3** Page 78

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.11	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.11	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.11 acres

Maximum Relief, H 1 feet (height above outlet within drainage area)

Hydraulic Length, L 117 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 117 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.11 = 0.31 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 1 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 79

Channel No.	**DB3**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	1 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.22 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.41	0.91	3.59	0.25	0.37		Deep
1	0.39	0.85	3.47	0.24	0.33		Deep
1	0.37	0.78	3.34	0.23	0.30		Deep
1	0.35	0.72	3.21	0.22	0.26		Deep
1	0.33	0.66	3.09	0.21	0.23	√	Deep

Normal flow for design condition: 0.33 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.5 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.2 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB4** Page 80

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.56	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.56	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.56 acres

Maximum Relief, H 2 feet (height above outlet within drainage area)

Hydraulic Length, L 234 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 234 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 3 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.56 = 1.56 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 2 cfs**

Estimate Flow Depth by Normal Depth Procedure

Channel No.	**DB4**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	2 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.44 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.53	1.37	4.35	0.32	0.64		Deep
1	0.51	1.29	4.23	0.31	0.58		Deep
1	0.49	1.21	4.10	0.30	0.54		Deep
1	0.47	1.13	3.97	0.29	0.49		Deep
1	0.45	1.06	3.85	0.27	0.45	√	Deep

Normal flow for design condition: 0.45 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.9 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.3 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB5** Page 82

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.4	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.40	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.40 acres

Maximum Relief, H 1 feet (height above outlet within drainage area)

Hydraulic Length, L 134 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 134 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.4 = 1.11 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 2 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 83

Channel No.	**DB5**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	2 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.44 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.53	1.37	4.35	0.32	0.64		Deep
1	0.51	1.29	4.23	0.31	0.58		Deep
1	0.49	1.21	4.10	0.30	0.54		Deep
1	0.47	1.13	3.97	0.29	0.49		Deep
1	0.45	1.06	3.85	0.27	0.45	√	Deep

Normal flow for design condition: 0.45 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.9 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.3 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB6** Page 84

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.81	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.81	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.81 acres

Maximum Relief, H 5 feet (height above outlet within drainage area)

Hydraulic Length, L 468 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 468 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.81 = 2.25 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 3 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 85

Channel No.	**DB6**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	3 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.66 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.63	1.82	4.98	0.37	0.93		Deep
1	0.61	1.73	4.86	0.36	0.87		Deep
1	0.59	1.63	4.73	0.35	0.80		Deep
1	0.57	1.54	4.60	0.34	0.75		Deep
1	0.55	1.46	4.48	0.33	0.69	√	Deep

Normal flow for design condition: 0.55 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.1 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.4 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB7** Page 86

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.87	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.87	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.87 acres

Maximum Relief, H 5 feet (height above outlet within drainage area)

Hydraulic Length, L 471 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 471 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 5 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.87 = 2.42 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 3 cfs**

Estimate Flow Depth by Normal Depth Procedure

Channel No.	**DB7**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	3 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.66 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.63	1.82	4.98	0.37	0.93		Deep
1	0.61	1.73	4.86	0.36	0.87		Deep
1	0.59	1.63	4.73	0.35	0.80		Deep
1	0.57	1.54	4.60	0.34	0.75		Deep
1	0.55	1.46	4.48	0.33	0.69	√	Deep

Normal flow for design condition: 0.55 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 2.1 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.3 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.4 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Calculations for Channel No. **DB8** Page 88

Description: South West side of CDLF phase 2 channel #2 drains into Down Pipe #7
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.35	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.35	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Design Conditions:

Drainage Area, A 0.35 acres

Maximum Relief, H 1 feet (height above outlet within drainage area)

Hydraulic Length, L 121 feet (distance along main drainage feature)

Channel Slope, S 0.010 Maximum slope Length = 121 feet
0.000 Minimum slope Length = 0 feet

Trapezoidal channel:
Max. flow depth 1 feet (based on site geometry)
Side slope, m 3

Time of Concentration: (Reference Malcom Exhibit 2)

Kirpich's Equation, Tc = [L^3/H]^0.385/128 = 2 minutes, use 5 minutes

Runoff Intensity: (Reference NOAA Atlas-14)

10-year, 5-minute: I = 7.25 in/hr
25-year, 5-minute: I = 8.08 in/hr
100-year, 5-minute: I = 9.27 in/hr Use this

Determine Discharge, Q: (Reference Malcolm Eq. II-1)

Rational Eq'n , Q = CIA = 0.30 * 9.27 * 0.35 = 0.97 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: **Q100 = 1 cfs**

Estimate Flow Depth by Normal Depth Procedure Page 89

Channel No.	**DB8**		**Maximum slope**
	Assumed channel lining		Grass w/ straw and net
	Manning's coefficient, n		0.033 (NCESC, Table 8.05e)
	Channel Gradient, S		0.010
	Channel Side Slope, m		3
	Calculated Flow for	Q100	1 cfs

Rearrange Manning's Equation: (Reference Malcom Eq. II-16)

Zreq = A*R^.0667 = Q*n/1.49*S^0.5 = 0.22 use for comparison (see below)

Calculate Zavg = A * R^0.667 for various flow depths by iterative procedure
(find "normal" flow for design width, B = 1 feet):

B, ft.	y, ft.	A, s.f.	P, ft.	R, ft.	Zavg		Comment
1	0.41	0.91	3.59	0.25	0.37		Deep
1	0.39	0.85	3.47	0.24	0.33		Deep
1	0.37	0.78	3.34	0.23	0.30		Deep
1	0.35	0.72	3.21	0.22	0.26		Deep
1	0.33	0.66	3.09	0.21	0.23	√	Deep

Normal flow for design condition: 0.33 feet

COMMENT: Flow < max. allowable depth of 1 feet

Recalculate:	**Bottom width, B =**	**1**	**feet**
	Minimum depth =	**1**	**feet**
	Top width = 2m*y + B =	**7**	**feet**

Check Velocity: (Reference Malcom Eq. II-11)

V = Q/A = Q/(B*y + M*y^2) = 1.5 < 4 fps OK
Below permissible velocity for vegetation

< 2.5 fps OK
Below permissible velocity for bare soil

Tractive Force Procedure: (Reference NCESC, App. 8.05)

T = y * d * s = 0.2 psf (for straight channel) where y = 62.4 pcf

Tb = Kb * T = 0.2 (for bend in channel) Kb min = 1.05
Rc = 75 feet

Straw w/net liner meets max. tractive force = 1.45 psf

Design Flow Calculations for **DPIPE #1** Page 90

Description: Cumulative flow from Subareas 2 - 5 in CDLF Unit 1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	6.37	84%	0.35	29.41
Cap areas	good grass (2 - 5%)	1.21	16%	0.30	4.79
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	7.58	100%		34.20

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.34

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 9.27 in/hr

Determine Discharge, Q = CIA = 0.34 * 9.27 * 7.58 = 24.03 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 25 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 25 cfs

Pipe diameter, d, ft = 1.5 = 18 inches

Pipe length, L, ft = 514 Determine from site geometry

Pipe slope, S = 0.29 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 57 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 1.77 s.f.
R = hydraulic radius = A / P = 0.375 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 32.0 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #2**

Description: Cumulative flow from Subareas 4 - 5 in CDLF Unit 1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	5.48	87%	0.35	30.49
Cap areas	good grass (2 - 5%)	0.81	13%	0.30	3.86
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	6.29	100%		34.36

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.34

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 9.27 in/hr

Determine Discharge, Q = CIA = 0.34 * 9.27 * 6.29 = 20.03 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 21 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 21 cfs

Pipe diameter, d, ft = 1.5 = 18 inches

Pipe length, L, ft = 646 Determine from site geometry

Pipe slope, S = 0.26 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 54 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 1.77 s.f.
R = hydraulic radius = A / P = 0.375 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 30.3 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #3**

Description: Cumulative flow from Subarea 5 in CDLF Unit 1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	11.42	93%	0.35	32.66
Cap areas	good grass (2 - 5%)	0.82	7%	0.30	2.01
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	12.24	100%		34.67

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 9.27 in/hr

Determine Discharge, Q = CIA = 0.35 * 9.27 * 12.24 = 39.33 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 40 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 40 cfs

Pipe diameter, d, ft = 1.5 = 18 inches

Pipe length, L, ft = 876 Determine from site geometry

Pipe slope, S = 0.26 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 54 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 1.77 s.f.
R = hydraulic radius = A / P = 0.375 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 30.3 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #4**

Description: Cumulative flow from Subarea 7 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	8.16	87%	0.35	30.45
Cap areas	good grass (2 - 5%)	1.22	13%	0.30	3.90
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	9.38	100%		34.35

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.34

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 9.27 in/hr

Determine Discharge, Q = CIA = 0.34 * 9.27 * 9.38 = 29.87 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 30 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 30 cfs

Pipe diameter, d, ft = 1.5 = 18 inches

Pipe length, L, ft = 566 Determine from site geometry

Pipe slope, S = 0.29 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 57 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 1.77 s.f.
R = hydraulic radius = A / P = 0.375 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 32.0 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #5**

Description: Cumulative flow from Subareas 6, 10 - 12 and 18 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.85	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.85	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 9.27 in/hr

Determine Discharge, Q = CIA = 0.35 * 9.27 * 2.85 = 9.25 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 10 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 10 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 62 Determine from site geometry

Pipe slope, S = 0.31 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 20 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 25.2 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #6**

Description: Cumulative flow from Subareas 6, 11 - 12 and 18 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	2.67	100%	0.35	35.00
Cap areas	good grass (2 - 5%)	0	0%	0.30	0.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	2.67	100%		35.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.35

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 9.27 in/hr

Determine Discharge, Q = CIA = 0.35 * 9.27 * 2.67 = 8.66 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 9 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 9 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 107 Determine from site geometry

Pipe slope, S = 0.24 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 17 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 22.2 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #7**

Description: Cumulative flow from Subarea 18 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.47	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.47	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.30 * 10.00 * 0.47 = 1.41 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 2 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 120 Determine from site geometry

Pipe slope, S = 0.27 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 19 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 23.6 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #8**

Description: Cumulative flow from Subareas 14 - 19 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0.94	47%	0.35	16.53
Cap areas	good grass (2 - 5%)	1.05	53%	0.30	15.83
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.99	100%		32.36

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.32

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.32 * 10.00 * 1.99 = 6.44 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 7 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 7 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 120 Determine from site geometry

Pipe slope, S = 0.27 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 19 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 23.6 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #9**

Description: Cumulative flow from Subareas 17 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.43	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.43	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.30 * 10.00 * 0.43 = 1.29 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 2 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 90 Determine from site geometry

Pipe slope, S = 0.22 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 17 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 21.3 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #10**

Description: Cumulative flow from Subareas 19 and 19 in CDLF Unit 1A
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	1.05	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	1.05	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.30 * 10.00 * 1.05 = 3.15 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 4 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 4 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 80 Determine from site geometry

Pipe slope, S = 0.15 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 14 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 17.6 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #11**

Description: Cumulative flow from Subarea 21 in CDLF Unit 1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.65	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.65	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.30 * 10.00 * 0.65 = 1.95 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 2 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 70 Determine from site geometry

Pipe slope, S = 0.28 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 19 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 24.0 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #12**

Description: Cumulative flow from Subarea 20 in CDLF Unit 1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.67	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.67	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.30 * 10.00 * 0.67 = 2.01 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 3 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 3 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 110 Determine from site geometry

Pipe slope, S = 0.27 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 19 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 23.6 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **DPIPE #13**

Description: Cumulative flow from Subarea 25 in CDLF Unit 1
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	0	0%	0.35	0.00
Cap areas	good grass (2 - 5%)	0.46	100%	0.30	30.00
Roadway	packed gravel	0	0%	0.90	0.00
	Summation	0.46	100%		30.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.30

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.30 * 10.00 * 0.46 = 1.38 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 2 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 2 cfs

Pipe diameter, d, ft = 1 = 12 inches

Pipe length, L, ft = 80 Determine from site geometry

Pipe slope, S = 0.31 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 20 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 0.79 s.f.
R = hydraulic radius = A / P = 0.25 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 25.2 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **CPIPE #1**

Description: Cumulative flow from Channel #5 and DPIPE #8
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	good grass (3H:1V)	1.1	50%	0.35	17.42
Cap areas	good grass (2 - 5%)	1.05	48%	0.30	14.25
Roadway	packed gravel	0.06	3%	0.90	2.44
	Summation	2.21	100%		34.12

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.34

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.34 * 10.00 * 2.21 = 7.54 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 8 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 8 cfs

Pipe diameter, d, ft = 1.5 = 18 inches

Pipe length, L, ft = 30 Determine from site geometry

Pipe slope, S = 0.02 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 15 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 1.77 s.f.
R = hydraulic radius = A / P = 0.375 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 8.4 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **CPIPE #2**

Description: Cumulative flow from buildings, driveways, metals stockpiles
Designed for post-closure conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Weighted	"urban" runoff	2.05	48%	0.90	42.91
Yard area	good grass (2 - 5%)	0.25	6%	0.30	1.74
Stockpiles	packed gravel	2	47%	0.90	41.86
	Summation	4.30	100%		86.51

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.87

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.87 * 10.00 * 4.30 = 37.20 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 38 cfs

Design Conditions: **Smooth-wall HDPE**

Number of pipes, N = 1 So each pipe carries 38 cfs

Pipe diameter, d, ft = 1.5 = 18 inches

Pipe length, L, ft = 60 Determine from site geometry

Pipe slope, S = 0.16 Determine from site geometry

Manning's n = 0.013 Reference Hancor Drainage Handbook

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 42 cfs

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 1.77 s.f.
R = hydraulic radius = A / P = 0.375 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 23.8 fps

NOTE: **Velocity is OK, between 3 fps and 12 fps (ref. Hancor Design Manual)**

Use stone inlet and outlet protection (unless catch basin is specified)

Design Flow Calculations for **CPIPE #3 Revised**

Description: Culvert beneath perimeter road to New Sed Basin
Designed for bare-earth construction conditions (anticipated max. flow)

Slope Conditions:		**Drainage Area, ac.**	**Percent Area, Ai**	**Ci, Runoff Coefficient**	**Product (Ai x Ci)**
Side slopes	(bare earth)	6.5	100%	0.60	60.00
Cap areas		0	0%	0.30	0.00
Ex. Roadway		0	0%	0.90	0.00
	Summation	6.50	100%		60.00

Composite Runoff Coefficient, C = Σ (Ai x Ci) / Σ Ai = 0.60

Assume 5-minute time of concentration for NOAA Atlas-14

Use 100-year design storm intensity, I = 10.00 in/hr

Determine Discharge, Q = CIA = 0.60 * 10.00 * 6.50 = 39.00 cfs

DESIGN IS BASED ON 100-YEAR STORM INTENSITY: Q100 = 39 cfs

Design Conditions: **Corrugated Metal Pipe - Use Aluminum (CAP)**

Number of pipes, N = 2 So each pipe carries 20 cfs

Pipe diameter, d, ft = 2 = 24 inches (set to control discharge)

Pipe length, L, ft = 50 Determine from site geometry

Pipe slope, S = 0.02 Determine from site geometry

Manning's n = 0.025 Ref. NCESC Design Manual, Table 8.07a

Q allowable, per Manning's equation: 1.486 / n*A*R^2/3*s^1/2 = 17 cfs
OK

Where: Q = theoretical flow at "just full" conditions in cfs
A = area of pipe = pd^2/4 = 3.14 s.f.
R = hydraulic radius = A / P = 0.5 ft
P = wetted perimeter, circumference of a round pipe flowing just full
S = longitudinal slope, defined above (neglects friction losses)

Check Velocity for "just full" conditions: V = s^1/2 * d^2/3 / 8.9*n = 5.3 fps

NOTE: Use stone inlet and outlet protection (SEE PIPE DESIGN SCHEDULE)

Description: Pipe Inlet on Channel #4 to DPIPE #5 (see channel calculations)

Proceedures and Assumptions:

Assume a four-side weir inlet with rectangular openings above a fabricated sump

Use runoff calculations developed for channels to obtain peak flow

Determine Flow Capacity:

Drainage Areas:	Subarea 10, plus adjacent road	totalling =	0.24	acres
	Peak channel flow for design storm,	Q100 =	3	cfs
	Maximum Flow Depth (normal depth method) =		0.23	feet

Basic Weir Equation: (Reference Malcom, Eq. I-6)

Q allowable = Cw*L*H^3/2 = 5 cfs OK for design runoff

Where Q =	Discharge from drainage area, cfs			
Cw =	Weir Coefficient for free overfall value	=	3	
L =	Length of weir at crest, trial value, feet	=	8	User input
H =	Driving head (approaching flow), feet	=	0.37	User input

Use a square weir with rectangular side openings, length	=	24	inches
height	=	5	inches

INSTALLATION NOTES:

ASSUME DEPTH OF CATCH BASIN IS 5 FEET, USE MASONRY OR PRECAST UNIT (PROVIDE MINIMUM 2 FEET ROAD COVER ABOVE EXIT PIPE)

PROVIDE A SOLID TOP COVER TO PREVENT ENTRY BY PERSONS AND/OR DEBRIS

OTHER DESIGNS MAY BE CONSIDERED SUBJECT TO ENGINEER'S APPROVAL; I.E., AN OPEN-TOP SQUARE OR RECTANGULAR DESIGN WITH A GRATE, A ROUND DESIGN, OR USE A STONE-PROTECTED PIPE INLET OR FLAIRED-END SECTION

PROTECT INLET FROM SEDIMENT ENTRY WITH A STONE FILTER AND WIRE FENCE

Design Flow Calculations for **Catch Basin CB #2**

Description: Pipe Inlet on Channel #5 to CPIPE #1 (see channel calculations)

Proceedures and Assumptions:

Assume a four-side weir inlet with rectangular openings above a fabricated sump

Use runoff calculations developed for channels to obtain peak flow

Determine Flow Capacity:

Drainage Areas:	Subarea 13, plus adjacent road	totalling =	0.22	acres
	Peak channel flow for design storm,	Q100 =	2	cfs
	Maximum Flow Depth (normal depth method) =		0.15	feet

Basic Weir Equation: (Reference Malcom, Eq. I-6)

Q allowable = Cw*L*H^3/2 = 5 cfs OK for design runoff

Where Q =	Discharge from drainage area, cfs			
Cw =	Weir Coefficient for free overfall value	=	3	
L =	Length of weir at crest, trial value, feet	=	8	User input
H =	Driving head (approaching flow), feet	=	0.37	User input

Use a square weir with rectangular side openings, length = 24 inches
height = 5 inches

INSTALLATION NOTES:

ASSUME DEPTH OF CATCH BASIN IS 5 FEET, USE MASONRY OR PRECAST UNIT
(PROVIDE MINIMUM 2 FEET ROAD COVER ABOVE EXIT PIPE)

PROVIDE A SOLID TOP COVER TO PREVENT ENTRY BY PERSONS AND/OR DEBRIS

OTHER DESIGNS MAY BE CONSIDERED SUBJECT TO ENGINEER'S APPROVAL;
I.E., AN OPEN-TOP SQUARE OR RECTANGULAR DESIGN WITH A GRATE, A ROUND
DESIGN, OR USE A STONE-PROTECTED PIPE INLET OR FLAIRED-END SECTION

PROTECT INLET FROM SEDIMENT ENTRY WITH A STONE FILTER AND WIRE FENCE

Description: Pipe Inlet on Channel #6 to DPIPE #8 (see channel calculations)

Proceedures and Assumptions:

Assume a four-side weir inlet with rectangular openings above a fabricated sump

Use runoff calculations developed for channels to obtain peak flow

Determine Flow Capacity:

Drainage Areas:	Subareas 14 - 19, plus adjacent road	totalling =	2.93	acres
	Peak channel flow for design storm,	Q100 =	12	cfs
	Maximum Flow Depth (normal depth method) =		0.59	feet

Basic Weir Equation: (Reference Malcom, Eq. I-6)

Q allowable = Cw*L*H^3/2 = 13 cfs OK for design runoff

Where Q =	Discharge from drainage area, cfs			
Cw =	Weir Coefficient for free overfall value	=	3	
L =	Length of weir at crest, trial value, feet	=	12	User input
H =	Driving head (approaching flow), feet	=	0.5	User input

Use a square weir with rectangular side openings, length	=	36	inches
height	=	6	inches

INSTALLATION NOTES:

ASSUME DEPTH OF CATCH BASIN IS 5 FEET, USE MASONRY OR PRECAST UNIT (PROVIDE MINIMUM 2 FEET ROAD COVER ABOVE EXIT PIPE)

PROVIDE A SOLID TOP COVER TO PREVENT ENTRY BY PERSONS AND/OR DEBRIS

OTHER DESIGNS MAY BE CONSIDERED SUBJECT TO ENGINEER'S APPROVAL; I.E., AN OPEN-TOP SQUARE OR RECTANGULAR DESIGN WITH A GRATE, A ROUND DESIGN, OR USE A STONE-PROTECTED PIPE INLET OR FLAIRED-END SECTION

PROTECT INLET FROM SEDIMENT ENTRY WITH A STONE FILTER AND WIRE FENCE

Design Flow Calculations for **Catch Basin CB #4**

Description: Pipe Inlet to CPIPE #2 at access drive (see channel calculations)

Proceedures and Assumptions:

Assume a four-side weir inlet with rectangular openings above a fabricated sump

Use runoff calculations developed for channels to obtain peak flow

Determine Flow Capacity:

Drainage Areas:	Subareas 14 - 19, plus adjacent road	totalling =	4.3	acres
	Peak channel flow for design storm,	Q100 =	38	cfs
	Maximum Flow Depth (assumed backwater) =		0.9	feet

Basic Weir Equation: (Reference Malcom, Eq. I-6)

Q allowable = Cw*L*H^3/2 = 41 cfs OK for design runoff

Where Q =	Discharge from drainage area, cfs			
Cw =	Weir Coefficient for free overfall value	=	3	
L =	Length of weir at crest, trial value, feet	=	16	User input
H =	Driving head (approaching flow), feet	=	0.9	User input

Use a square weir with rectangular side openings, length = 48 inches
height = 11 inches*

INSTALLATION NOTES: *Requires vertical bar grate!

ASSUME DEPTH OF CATCH BASIN IS 5 FEET, USE MASONRY OR PRECAST UNIT
(PROVIDE MINIMUM 2 FEET ROAD COVER ABOVE EXIT PIPE)

PROVIDE A SOLID TOP COVER TO PREVENT ENTRY BY PERSONS AND/OR DEBRIS

OTHER DESIGNS MAY BE CONSIDERED SUBJECT TO ENGINEER'S APPROVAL;
I.E., AN OPEN-TOP SQUARE OR RECTANGULAR DESIGN WITH A GRATE, A ROUND
DESIGN, OR USE A STONE-PROTECTED PIPE INLET OR FLAIRED-END SECTION

PROTECT INLET FROM SEDIMENT ENTRY WITH A STONE FILTER AND WIRE FENCE

CUSTOM BASIN SCHEDULE

These take the place of temporary sediment traps per Wake County requirements

Design Storm Event	Q25	25-Year, 5-Minute Storm
Peak Runoff Intensity, I, in/hr	8.12	NOAA Atlas 14
Design Runoff Coefficient, C	0.35	Cleared, unimproved area (for traps only)

Basin No.	**CB-1**
Disturbed Area, acres	3.60
* Required Volume (1800 f^3 / ac), cf	6,480
Peak Runoff Flow, Qp, cfs	10.2
* Required Area (0.01 *Qp), sq. ft. with 2:1 length to width ratio	4456
Min. Basin Dimensions: Length, ft	60
(measured at bottom) Width, ft	30
** Effective Depth, ft	4
Required Filter Weir Length, ft	10
Required Filter Weir Crest Width, ft	5
Resulting Dimensions: Length, ft	84
(measured at top) Width, ft	34
Resulting Storage Volume, cf	9360
Resulting Surface Area, sf	4536

Use 4-inch diameter PVC pipe drain (see details) with 4 drilled half-inch diameter holes placed in rings spaced 3 inches vertically

The design is OK if the resulting volume and area are larger than the required quantities

* Design criteria per NC Sedimentation and Erosion Control Design Manual guidelines - the basins are purposefully shallow and have large surface areas

** Vertical distance from top or weir to bottom of excavation, considered here to be the minimum desired depth of the sediment trap

The perimeter berm should be level and the height should be at least 1.5 feet higher than the top of the weir

Use 3H:1V side slopes inside and outside basin for berm and weir, vegetate slopes as soon as practical - within 20 days per NC S&EC Rules and Guidelines

Compact all soil per Technical Specifications, if provided, or as directed by the Engineer

Cover weir with UV-resistant silver tarp, per Wake County specifications

Direct discharge away from water bodies and/or riparian buffer zones

Construct diversion ditches toward basin, as shown on plans, and stabilize with rip-rap or vegetation as directed by the Engineer

WASTE SCREENING FORM

Facility I.D. _____
Permit No. _____

Day / Date: _____ Time Weighed in: _____
Truck Owner: _____ Driver Name: _____
Truck Type: _____ Vehicle ID/Tag No: _____
Weight: _____ Tare: _____

Waste Generator / Source: _____

Inspection Location: _____

Reason Load Inspected: Random Inspection _____ Staff Initials _____
Detained at Scales _____ Staff Initials _____
Detained by Field Staff _____ Staff Initials _____

Description of Load: _____

_____

Approved Waste Determination Form Present? (Check one) Yes_____ No _____ N/A____

Load Accepted (signature) _____ Date _____

Load Not Accepted (signature) _____ Date _____

Reason Load Not Accepted (complete below only if load not accepted) _____

Description of Suspicious Contents: Color _____ Haz. Waste Markings _____
Texture _____ Odor/Fumes_____
Drums Present _____ Other _____
(describe)_____
Est. Cu. Yds. Present in Load _____
Est. Tons Present in Load _____

Identified Hazardous Materials Present:_____

County Emergency Management Authority Contacted? Yes_____ No _____

Generator Authority Contacted? _____

Hauler Notified (check if waste not accepted)? ____ Phone _____ Time Contacted _____

Final Disposition of Load _____

Signed _____ Date _____
Solid Waste Director

Attach related correspondence to this form. File completed form in Operating Record.

HAZARDOUS WASTE CONTACTS

The following contacts were taken from the NC DENR Division of Waste Management web site in early 2007; the availability and local phone numbers should be verified before a emergency, or modify this list as needed. For more information see http://www.wastenot.org/hwhome.

EMERGENCY RESPONSE

Clean Harbours	Reidsville, NC	336-342-6106
GARCO, Inc.	Asheboro, NC	336-683-0911
Safety-Kleen	Reidsville, NC	800-334-5953

TRANSPORTERS

ECOFLO	Greensboro, NC	336-855-7925
GARCO, Inc.	Asheboro, NC	336-683-0911
Zebra Environmental Services	High Point, NC	336-841-5276

DISPOSAL AND LANDFILLS

ECOFLO	Greensboro, NC	336-855-7925
Safety-Kleen	Reidsville, NC	800-334-5953
Zebra Environmental Services	High Point, NC	336-841-5276

USED OIL AND ANTIFREEZE

3RC Resource Recovery	Winston-Salem, NC	336-784-4300
Carolina Environmental Associates	Burlington, NC	336-299-0058
Environmental Recycling Alternatives	High Point, NC	336-869-8785

FLUORESCENT HANDLERS

3RC Resource Recovery	Winston-Salem, NC	336-784-4300
Carolina Environmental Associates	Burlington, NC	336-299-0058
ECOFLO	Greensboro, NC	336-855-7925
GARCO, Inc.	Asheboro, NC	336-683-0911
Safety-Kleen	Reidsville, NC	800-334-5953

PCB DISPOSAL

ECOFLO	Greensboro, NC	336-855-7925
GARCO, Inc.	Asheboro, NC	336-683-0911
Zebra Environmental Services	High Point, NC	336-841-5276

U S E F U L A G E N C I E S a n d C O N T A C T S

Air Permits NC Div. of Air Quality 919-733-3340	Indoor **Air Quality**, US EPA Info Hotline 1-800-438-4318	**Asbestos** Environmental Epidemiology Mary Giguere 919-707-5950	**Customer Call Center** DENR 1-877-623-6748
Drinking Water Environmental Health Jessica Miles 919-715-3232	Safe **Drinking Water** US EPA 1-800-426-4791	Emergencies 24 hours **Emergency Management** 919-733-3300 919-733-9070 1-800-858-0368	**Energy Division Hotline** NC Commerce Dept. 1-800-662-7131
Environmental Education Office of Env. Education 1-800-482-8724	**Environmental Education** NC Cooperative Ext. Service NCSU 919-515-2770	**Federal Register** RCRA/Superfund/UST 1-800-424-9346	**Fluorescent Lights** Green lights Hotline 202-775-6650 EPA Energy Star 1-888-782-7937
Freon US EPA Region 4 Pam McIlvane 404-562-9197	**Groundwater** Division of Water Quality None Dedicated Soil Disposal Ted Bush 919-733-3221	**Hazardous Waste** Hazardous Waste Section 919-508-8400	**Household Hazardous Waste** Solid Waste Section Bill Patrakis 336-771-5091
Lab Certification Water Quality Jim Meyer 919-733-3908 ext. 207	**Land Farm** Division of Water Quality David Goodrich 919-715-6162	**Landfills** Solid Waste Section Division of Waste Management 919-508-8400	**Lead Abatement** Division of Public Health Jeff Dellinger 919-733-0668
Childhood **Lead Poisoning** Environmental Health Ed Norman 919-715-3293	National **Lead Info. Center** 1-800-LEAD-FYI 1-800-532-3394	**Medical Waste** Solid Waste Section Bill Patrakis 919-508-8512	**Oil Pollution** Aquifer Protection Section Debra Watts 919-715-6699
OSHA-Health Consultations NC Dept of Labor Roedreick Wilce 919-852-4379	**OSHA Training & Outreach** NC Dept. of Labor Joe Bailey 919-807-2891	Stratosphere **Ozone** US EPA Information Hot Line 1-800-296-1996	**PCBs** TSCA, EPA Region 4 Craig Brown 404-562-8980 TSCA Assistance Info. 202-554-1404
Pesticides Disposal Assistance Program NC Dept. of Agriculture Hazardous Waste Royce Batts 919-715-9023	**Pesticide Info. Hotline** 1-800-858-7378	**Petroleum Product** Soil Disposal, UST Scott Ryals 919-733-8486	**Pollution Prevention** & Environmental Assistance 919-715-6500 1-800-763-0136

Public Affairs, DENR Diana Kees Acting Director 919-715-4112	**Public Right to Know** Employee Right to Know OSHA, Dept. of Labor Anthony Bonapart 919-807-2846	**Radiation Materials** Radiation Protection Beverley Hall 919-571-4141	**Recycling Markets Directory** **What Can I do with it?** 919-715-6500
Toxic **Release Reporting** Emergency Planning SARA Title III Richard Berman 919-733-1361 1-800-451-1403 (24 hours)	**Run Off** Water Quality 919-733-5083	**Safety Hotline** NC Dept. Of Labor 1-800-LABOR-NC 919-807-2796	**Septic Tanks**, On-site Treatment System Environmental Health Steven Berkowitz 919-733-2895
Sewer Discharges Pre-Treatment Public Owned Treatment (POTW) 919-733-5083	**Small Business Ombudsman** US EPA 1-800-368-5888	**Spill Reporting** 1-800-858-0368	**State Operator** 919-733-1110
Stormwater, Permits Unit Water Quality 919-733-5083 1-800-858-0368	**Superfund** Federal Sites Dave Lown 919-508-8464 State Inactive Sites Charlotte Jesneck 919-508-8460	**Toxicology** **Env. Epidemiology** Occupational Surveillance 919-707-5900	**Transport Hazardous Waste** Division of Motor Vehicle (NC DOT) Sgt. T.R. Askew 919-715-8683
US DOT Regulations Office of Motor Carriers Chris Hartley 919-856-4378	**Underground Storage Tanks** Grover Nicholson 919-733-1300	**Waste Minimization** Pollution Prevention & Environmental Assistance 919-715-6500 1-800-763-0136	**Wetlands Info Hotline** US EPA 1-800-832-7828
North Carolina Division of Waste Management - 1646 Mail Service Center, Raleigh, NC 27699-1646 - (919) 508-8400			

FIRE OCCURRENCE NOTIFICATION

NC DENR Division of Waste Management
Solid Waste Section

The Solid Waste Rules [15A NCAC 13B, Section 1626(5)(d) and Section .0505(10)(c)] require verbal notification within 24 hours and submission of a written notification within 15 days of the occurrence. The completion of this form shall satisfy that requirement. *(If additional space is needed, use back of this form)*

NAME OF FACILITY: _____ PERMIT #_____

DATE AND TIME OF FIRE _____/_____/_____ @ _____: ____ AM / PM (circle one)

HOW WAS THE FIRE REPORTED AND BY WHOM _____

_____

LIST ACTIONS TAKEN_____

_____

_____

_____

WHAT WAS THE CAUSE OF THE FIRE_____

_____

_____

_____

DESCRIBE AREA, TYPE, AND AMOUNT OF WASTE INVOLVED _____

_____

_____

WHAT COULD HAVE BEEN DONE TO PREVENT THIS FIRE_____

_____

_____

_____

CURRENT STATUS OF FIRE _____

_____

_____

DESCRIBE PLAN OF ACTIONS TO PREVENT FUTURE INCIDENTS: _____

_____

_____

_____

_____

NAME_____TITLE_____DATE_____

THIS SECTION TO BE COMPLETED BY SOLID WASTE SECTION REGIONAL STAFF

DATE RECEIVED_____

List any factors not listed that might have contributed to the fire or that might prevent occurrence of future fires:

_____

_____

FOLLOW-UP REQUIRED:

☐ NO ☐ PHONE CALL ☐ SUBMITTAL ☐ MEETING ☐ RETURN VISIT BY:_____ (DATE)

ACTIONS TAKEN OR REQUIRED:

Revised 6/29/01