ENGINEERING AND DESIGN REPORT

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

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

Received
JUN 2008
Waste
Management

Prepared for:

Material Recovery, LLC
421 Raleighview Road
Raleigh, North Carolina 27610

To the Attention of:

Mr. Nick Marotta
Regional Engineer

G. David Garrett, P.G., P.E.
Principal Engineer/Geologist

NORTH CAROLINA LICENSED GEOLOGIST SEAL DAVID GARRETT

6-10-2008

June 2008

David Garrett & Associates

Engineering and Geology

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Signature page of Applicant –

Name of facility MATERIAL RECOVERY, LLC

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision and that the information provided in this application is true, accurate, and complete to the best of my knowledge.

I understand that North Carolina General Statute 130A-22 provides for administrative penalties of up to fifteen thousand dollars ($15,000.00) per day per each violation of the Solid Waste Management Rules. I further understand that the Solid Waste Management Rules may be revised or amended in the future and that the facility siting and operations of this solid waste management facility will be required to comply with all such revisions or amendments.

Signature	Print Name	Date
[signature]	VERNON SMITH	6/26/08

REGIONAL VICE PRESIDENT
Title

MATERIAL RECOVERY, LLC AND WCA WASTE SYSTEMS, INC
Business or organization name

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DRAWINGS *Refer to the folded drawing set that accompanies this report – a subset of drawings pertaining to this report are identified below*

APPENDICES – VOLUME 2

INTRODUCTION

WCA Waste Corporation and subsidiary Material Recovery, LLC, intend to build the previously approved Phase 2 of their Construction and Demolition debris landfill (CDLF), located at 2600 Brownfield Road (S.R. 2553) in Wake County, North Carolina. This expansion and future operations at this facility will be conducted in accordance with **Solid Waste Rules 15A NCAC 13B .0531** *et seq.*, which became 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 2 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 2 and beyond – these soil types are present 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 included two disposal areas, the currently active "northern" area (45 acres, 20 acres of which are developed as Phase 1) and the "southern" area (24 acres, future development). Phase 2 includes the remaining 25 acres of the "northern" area, matching the originally planned footprint and final grades. Earlier site investigations include the December 2001 Site Suitability Application (presented in two sections, including 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.

Current plans include closing portions of Phase 1 that will reach final by June 30, 2008 under the old **".0500 Rules"**, which required 24 inches of soil cover. The remaining portions of Phase 1 and all of Phase 2 will be permitted and operated under the 2006 C&D rules, including operations, closure and post-closure, monitoring, and financial assurance. 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. 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. An Sedimentation and Erosion Control (S&EC) Plan 2 will be submitted to Wake County as a separate document. ***This application requests a Permit to Construct from the Division for the entire Phase 2 footprint, with the understanding that the 5-year Permit to Operate will include the southern portion of the footprint.***

1.0 BACKGROUND INFORMATION

1.1 Existing Facilities and Development History

WCA Material Recovery, LLC, Phases 1 and 2 encompass a 45-acre contiguous footprint within the "northern" disposal area, contained within a 210-acre permitted facility boundary. Phase 2 is located to the east (uphill) of Phase 1 and will share the storm water management facilities. The facility has scales and office/scale house building, an inert debris stockpile (used for making and storing beneficial fill), and a Land Clearing Inert Debris (LCID) stockpile. 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 (see **Drawings S-1** through **S4**).

Originally permitted in 2002 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 cells (Cells A, B, and C), now operating in Cells B and C. Portions of Cell A and Cell B have reached final grades along the outer slopes (north and west sides). Based on the 2001 Joyce Engineering report, **Phase 1 will contain approximately 1,429,000 cubic yards (964,000 tons)** of C&D. Based on recent volume calculations, there is approximately **762,000 cubic yards (514,000 tons) remaining** to reach the permitted interim grades in Phase 1.

The Service Area includes all or parts of Wake, Johnston, Durham, Orange, and Chatham 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 **650 tons per day** in accordance with the Wake County Franchise and the NC DENR permit. In early 2008 the facility received a 5-year permit to operate renewal for Phase 1.

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 S-1** through **S4**).

1.3 Phase 2 Expansion

Phase 2 will encompass a 25-acre footprint – contiguous with Phase 1 – within the original permitted boundary and grades. A planned vertical expansion over Phase 1 (included in the Operations Plan for Phase 2) will bring the final elevations to approximately El. 400 (MSL) – consistent with the original permitted final grades. Based on recent volume calculations, Phase 2 and the vertical expansion will add an estimated **4.2M cubic yards (2.8M tons)** of C&D debris, relative to elevations established in a February 2008 aerial survey, allowing for 0.7M cubic yards remaining in Phase 1. The total waste volume will be 1.4M + 4.2M = **5.6M 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, representing three 5-year permitting cycles (including the current cycle just started this year). Phase 2 will be constructed and operated as three cells, beginning in the southeast (Cell 2A) and working toward the northwest (Cell 2B), culminating in a vertical expansion over Phases 1 and 2 (Cells 2C).

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).

Design capacity in Phase 1 will not be reached by June 30, 2008. Portions of the 3H:1V side slopes that will have reached final grades by June 30, 2008 will be clearly delineated and, thus, will be closed under the old Rule .0510, under which Phase 1 was permitted and previously operated. Plans are to close the remaining portions of Phase 1 (not already at grade on June 30, 2008) under the Rule .0547, hence making those portions subject to the financial assurance requirements, but not to include the previously closed portions of Phase 1 in the financial assurance calculations. A survey of Phase 1 will be completed close to June 30, 2008 to verify the remaining portions of that unit that will remain open and be subject to Rule .0547.

(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 that will have not receive solid waste after June 30, 2008 and, thus, are subject to the final closure requirements of Rule .0510 are depicted in **Drawing E1**. Regulatory final cover requirements for these areas include 24 inches of final cover soil, with the upper 6 inches capable of supporting vegetation. Slope ratios shall be 3H:1V along side slopes and 5% minimum on upper cap surfaces (post-settlement). Although no specific permeability is required under Rule .0510, nor is a CQA plan required, efforts will be made to compact the soils as densely as practical to assure long-term cover performance, and the final cover thickness will be slightly overbuilt. The slopes will utilize “tack-on” side slope benches (soil berms or terraces incorporated into the final cover) to facilitate erosion control, in keeping with the original construction plans. Typically, slope stability is not an issue for these slope ratios. 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 should 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 "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 **E2** are the base grades and final grades for Phase 2. 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. Also shown in the Facility Plan (**Drawing S4**) are 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 "cells," 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 – Cell 2A (south side) will be filled first, during which time Cell 2B (north) side will be built then filled. Finally, Cell 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. Subcells within the Phase 2 footprint may be constructed incrementally, as needed to manage surface runoff. Interior slopes will be maintained at 3H:1V, in accordance with Division requirements, while upper surfaces shall be graded to promote positive drainage, ideally at a 5% slope.

Upon reaching final grades (**Drawing E2**), exterior slopes will be covered with an interim cover soil with vegetation or mulch and allowed to settle for up to 6 months; then the final cover section will be placed. 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**).

3.3 Facility Report

3.3.1 Waste Stream

The CDLF was originally permitted for 650 tons per day. The facility operates 6 days per week (300 days per year) – this equates to 195,000 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 Pop[1]	2007 Pop	% Growth[2]	2009 Pop	% Growth	2019 Pop	% Growth	2029 Pop	% Growth
CHATHAM	49,820	58,309	17%	60,711	22%	72,612	46%	84,861	70%
DURHAM	224,567	248,516	11%	255,680	14%	291,390	30%	328,327	46%
JOHNSTON	123,113	155,874	27%	165,471	34%	214,626	74%	268,223	118%
ORANGE	115,938	125,436	8%	128,985	11%	145,051	25%	159,816	38%
WAKE	633,852	807,934	27%	857,678	35%	1,111,606	75%	1,382,214	118%
MULTI-COUNTY SERVICE AREA	1,147,290	1,396,069	22%	1,468,525	28%	1,835,285	60%	2,223,441	94%
STATE OF NORTH CAROLINA	8,046,813	8,860,341	10.1%	9,348,744	16.2%	10,744,214	33.5%	12,167,409	51.2%

[1]Source data: 2006 Certified County Population Estimates, North Carolina State Demographics, North Carolina State Data Center, 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/

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 indicates 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) indicates 762,442 cubic yards remaining in Phase 1 – this subtracted from the total airspace yields approximately 4,218,215 cubic yards contributed by Phase 2 (Cells 2A, 2B, and 2C).

A volume analysis comparing the February 2008 surface model to waste contours in Cells 1A and 1C in March 2005 (at the completion of Cell '1C') determined that approximately 880,000 cubic yards of airspace were consumed during the 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 in the airspace (748,000 cubic yards of the consumed airspace was actual waste, or 21,370 cubic yards per month), yields an estimated in-place waste density of 0.66 tons per cubic yard – the earlier calculations by Joyce Engineering were based on 0.5 tons per cubic yard.

Projecting the monthly airspace consumption (25,142 cubic yards) to the total airspace for the "North" disposal area (Phase 1 and Phase 2), the remaining life relative to the February 2008 survey is 195 months, or approximately 16 years, which represents three 5-year permitting cycles including the current cycle just began earlier this year. These projections assume even waste intake (regional growth factors are not factored in).

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 blasting plan will be 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.

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**). Soil properties testing used to facilitate these evaluations included grain size analysis, shear strength, consolidation, and compaction characteristics (see **Appendix 5**). 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.

4.1.3 Technical References

Calculations found in **Appendices 1 and 2** 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 Application (**refer to **Volume 1, Section 1)**.

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 should 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 should 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 **Drawing E1** – while this rule requirement pertains to separation of stormwater runoff from leachate (i.e., a lined landfill), in order to reduce generated leachate volumes, good practices for water management include diverting water 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

See **Drawing E2** for final contours and **Drawing EC2** for final cover cross-section and details.

4.4.5 Temporary and Permanent S&EC

See **Drawing E1** for temporary sedimentation and erosion control (S&EC) measures and **Drawing EC1** for final measures. A separate S&EC plan submittal to NC DENR Division of Land Quality has been made. Minor design revisions to the S&EC plan, if any, resulting from the Wake County Environmental Services review will be incorporated during construction and shown on "as-built" drawings for the Permit to Operate application.

4.4.6 Vertical Separation

See **Drawing E1** for base grades relative to ground water; 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).

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, S5 and E1**).

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, S5 and E1**).

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. The grading plan (**Drawing E1)** indicates vertical separation to ground water on the order of 10 feet near G-4. 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 benchmark is tied into the North Carolina State Plan (NCSP) coordinate system. The NCSP coordinates of the benchmark are as follows:

BM-1	N 713,853.47	E 2,148,693.87	El. 268.75
BM-2	N 711,371.57	E 2,147,318.46	El. 278.32

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

5.5 Landfill Subgrade

5.5.1 Subgrade Inspection Requirement

The Owner/Operator shall have the Phase 1A subgrade inspected by a qualified engineer or geologist upon completion of the excavation (as part of the CQA in accordance with **Rule .0534 (b)** and **Rule .0539**), 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**). A separate plan has been prepared and submitted to the Wake County Department of Environmental Services, and is depicted in the construction plan set (see **Drawings E1 and EC3**). 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).

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.

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 State Solid Waste Regulators (SC DHEC). 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, paper mill residuals, 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 with input from all parties, if so warranted based on project specific conditions. No modifications will be made without the Engineer’s approval.

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. **Appendix A** (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, 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. High Density Polyethylene (HDPE) Pipe

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

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

B. Corrugated Polyethylene (CPE) Pipe

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

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

C. Aggregates (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 should 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 should 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 should 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 should 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 should 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

At the completion of each major construction activity at the landfill unit, or at periodic intervals, the CQA Testing Firm will provide final copies of all required forms, observation logs, field and laboratory testing data sheets, sample location plans, etc., in a certified report. Said report shall include summaries of all the data listed above. 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 (FINAL COVER SYSTEM)

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.

TABLE 6A

CQA TESTING SCHEDULE FOR GENERAL EARTHWORK

PROPERTY	**TEST METHOD**	**MINIMUM TEST FREQUENCY**
CONTROL TESTS:		
Consistency Evaluation	Visual[1]	Each Material
RECORD TESTS:		
Lift Thickness	Direct Measure	Each compacted lift
In-Place Density	ASTM D 2922[2]	2 per acre per lift
Moisture Content	ASTM D 3017[3]	2 per acre per lift

Notes:

1. To be performed by Contractor Superintendent, Engineer, or CQA Testing Firm.
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.
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.

TABLE 6B
CQA TESTING SCHEDULE FOR DRAINAGE AND FINAL COVER

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	1 per acre

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.

TABLE 6C
CQA TESTING SCHEDULE FOR COMPACTED SOIL BARRIER

PROPERTY	TEST METHOD	MINIMUM TEST FREQUENCY
RECORD TESTS:		
Lift Thickness	Direct measure	4 per acre per lift
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.
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.
3. Optionally use ASTM D 2216, ASTM D 4643, or ASTM D 4959. For each 10 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.

APPENDIX A:
REFERENCE LIST OF TEST METHODS

<u>American Society American Society of Testing and Materials (ASTM):</u>

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 D 5084	Standard Test Method for Measuring Hydraulic Conductivity of Soils using Flexible Wall Permeameter.

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

7.1 General Conditions

This Operations Plan was prepared for Material Recovery, LLC, to provide landfill personnel with an understanding of relevant rules and how the Design Engineer assumed that the facility would be operated. While deviations from the operation plan outlined here may be acceptable, significant changes should 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 the stockpile area (inert debris) or to the working face of the C&D disposal unit. Tires and LCID are not currently 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 should 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

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Division of Land Resources - Land Quality Section

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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

C&D Landfill, Inc., 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

C&D Landfill, Inc., 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 .0102, 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 7.6.3** 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) will inevitably wind up in the C&D waste stream from job sites. These may be disposed with the C&D wastes as long as the materials are non-liquid and non-hazardous. If large quantities of garbage, "black bags" or any prohibited wastes are detected, the Operator shall be responsible for removing these materials at the earliest practical time.

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 consist of ground LCID, WWTP sludge (with permission from the Division) and/or other non-C&D waste materials.

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 12 inches before 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 should 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 operator shall ensure that all protective measures are functioning prior to placing soil 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

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 7.9.2**), 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 should 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 should 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 should 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 should 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 should be mostly inert and not attractive to animals, but care should be taken to bury animal carcasses or other putrescible wastes that are admitted to the landfill (subject to the waste screening procedures). Operations should 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.

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 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 9.0). 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, should 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 should 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)

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 7.13**). The reporting requirements include a map prepared by a licensed surveyor.

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 Phase 2 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 E2** 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 6.7** and **Appendix 8**). 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 25% (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 deep 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 should 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 12 inches and 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 two loose lifts no thicker than 12 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. These surface materials are not subject to a permeability requirement, thus no testing will be specified. Care should 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 should follow immediately. The work should be scheduled to optimize weather conditions, if possible.

Inspection and Testing – Soils for the barrier layer are subject to the testing schedule outlined in the Construction Quality Assurance plan (see **Section 7.0**). 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 accordance the specifications provided in the Construction Plans (see **Drawing EC2**), unless approved otherwise (in advance) by the Engineer). In areas to be seeded, fertilizer and lime typically should 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 **Drawings**). Alternative erosion control products may be substituted with the project engineer's prior consent. All rolled erosion control materials should 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 should 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 **19 acres**. 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 7**), the planned volume of Phase 2 is 4.2M cubic yards. Please note that some of Phase 1 shall be closed under **Solid Waste Rule 0.510**.

8.2.3 Closure Schedule

Refer to the requirements outlined in **Section 9.1.5** (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 in Section

TABLE 8A
ESTIMATED FINAL CLOSURE COSTS FOR PHASE 2 (in 2008 dollars)

1) Regulatory Minimum Cover with Compacted Soil Barrier

Topsoil (18" over 43 ac)	104,060 c.y.	@	\$3.25 / cubic yard	\$338,195
Compacted Soil Barrier*	119,670 c.y.	@	\$8 / cubic yard	\$1,196,700
Seed and Mulch	43 acres	@	\$1,300 per acre	\$ 55,900
Storm Water Piping**	2500 LF	@	\$10.00 / LF	\$ 25,000
CQA	43 acres	@	\$4,500 per acre	\$ 193,500
Total Construction Cost (if contracted out)				**\$1,809,295**

2) Alternative Final Cover with Flexible Membrane Barrier

Topsoil (24" over 43 ac)	138,750 c.y.	@	\$3.25 / cubic yard	\$450,938
Single-bond Geocomposite Drainage Layer	1,873,080 s.f.	@	\$0.45 / s.f.	\$ 842,886
40-mil HDPE flexible Membrane	1,873,080 s.f.	@	\$0.35 / s.f.	\$ 655,578
Seed and Mulch	43 acres	@	\$1,300 per acre	\$ 55,900
Storm Water Piping**	2500 LF	@	\$10.00 / LF	\$ 25,000
CQA	43 acres	@	\$2,500 per acre	\$ 107,500
Total Construction Cost (if contracted out)				**\$2,137,802**

3) Alternative Final Cover with Flexible Membrane Barrier (Largest Open Area)

Topsoil (24" over 19 ac)	61,306.7 c.y.	@	\$3.25 / cubic yard	\$199,247
Single-bond Geocomposite Drainage Layer	827,640 s.f.	@	\$0.45 / s.f.	\$ 372,438
40-mil HDPE flexible Membrane	827,640 s.f.	@	\$0.35 / s.f.	\$ 289,674
Seed and Mulch	19 acres	@	\$1,300 per acre	\$ 24,700
Storm Water Piping**	2500 LF	@	\$10.00 / LF	\$ 25,000
CQA	19 acres	@	\$2,500 per acre	\$ 47,500
Bonded Construction Cost (if contracted out)				**\$958,559**

*Maximum permeability of 1×10^{-5} cm/sec, use a shrinkage factor of 15%.

**Preliminary estimates, subject to verification.

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, thus the Financial Assurance calculations (**Section 9.0**) are based on a maximum open area of 19 acres at any given time (Part 3 above). Likewise, the cost for 19 acres of the Regulatory Minimum Cover is $813,405.

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.

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 10.2**). 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.

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	Semi-Annually	None (3)	None (3)
Ground Water Monitoring System - Check well head security, visibility (4)	Semi-Annually	Semi-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. Discontinue 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

WCA Waste Corporation
Mr. Vernon Smith, Regional VP
421 Raleighview Road
Raleigh, North Carolina 27604
Tel 919-838-6973

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.

8.3.4 Post-Closure Cost Estimate

The following cost estimate 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 1A (in 2008 dollars)

Annual Events	Units		Unit Cost	Cost/ Event	Annual Costs
Reseeding/mulching and erosion repair (Assume 10% cap, once per year)	5	ac.	$600	$3,000.00	$3,000.00
Mow final cap (twice per year)	43	ac.	$25	$1,087.00	$2,175.00
Ground Water Monitoring and Reporting	2	ea.	$7,500	$7,500.00	$15,000.00
Methane Monitoring and Reporting	1	ea.	$1,500	$1,500.00	$1,500.00
Maintain storm water conveyances	1	ea.	$3,000	$3,000.00	$3,000.00
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
	Total Cost for One Year				**$29,775.00**

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 1A 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 2008 dollars) projected over 30 years of post-closure care.

The bond should 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 should be reduced over time. Once into the post-closure period, the financial assurance instrument should be recalculated periodically, ideally on an annual basis, and the posted amount (bond, insurance, etc.) should be adjusted accordingly on a periodic basis.

SUMMARY OF CLOSURE AND POST-CLOSURE COST

1.	Final Closure Construction (see **Table 8A, Part 3**)	$ 958,559
2.	Projected Post-Closure Costs (see **Table 8C * 30 years)**	$ 893,250
	TOTAL CLOSURE/POST-CLOSURE COST	**$1,851,809**

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 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 (24-26 ft.) represent worst soil conditions within Phase 2
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 B--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

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)

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**
G-4, 24 - 25 ft	0.018	0.180	0.08	0.02	0.33	0.89	0.91						0.91
								1.7	43	85	0.34	0.04	0.04
								1.4	140	25	0.25	0.34	0.34
								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.
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*** 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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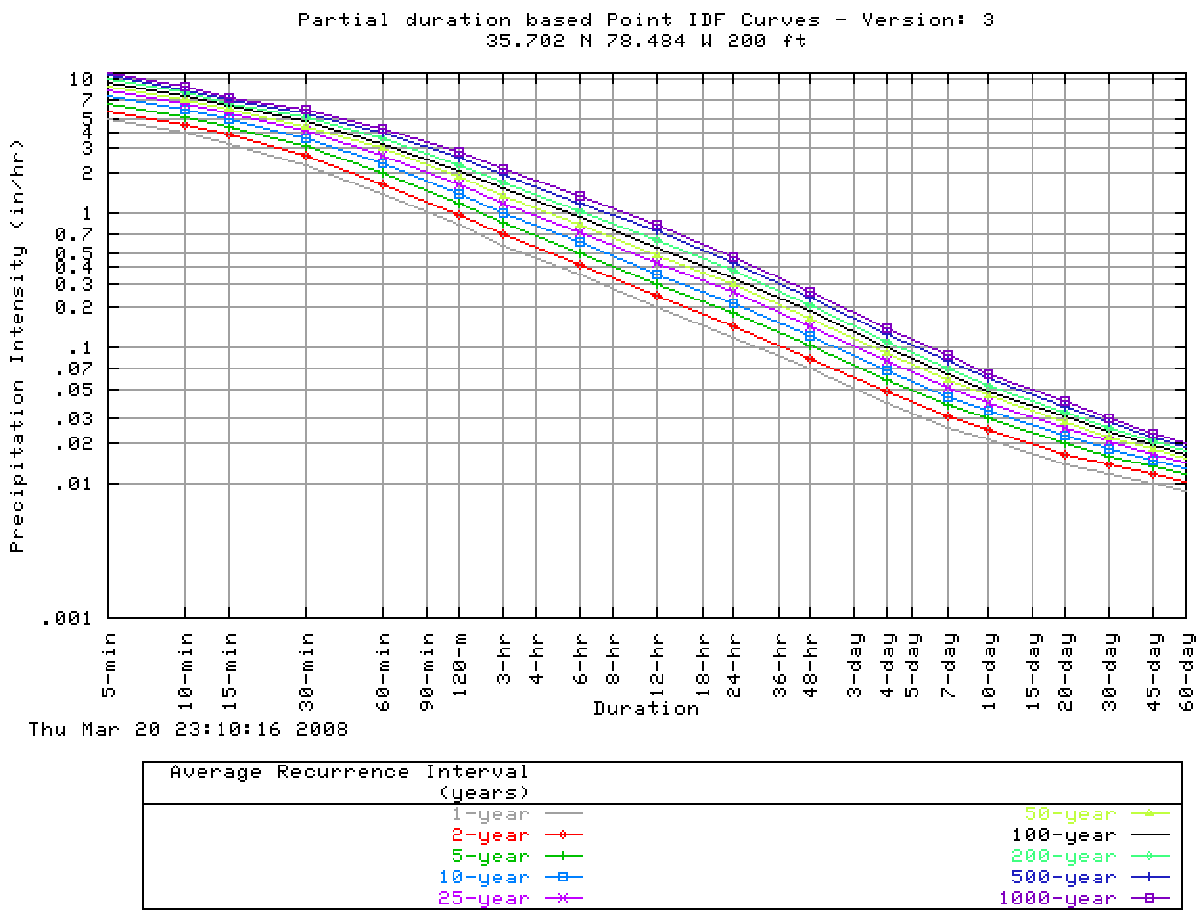
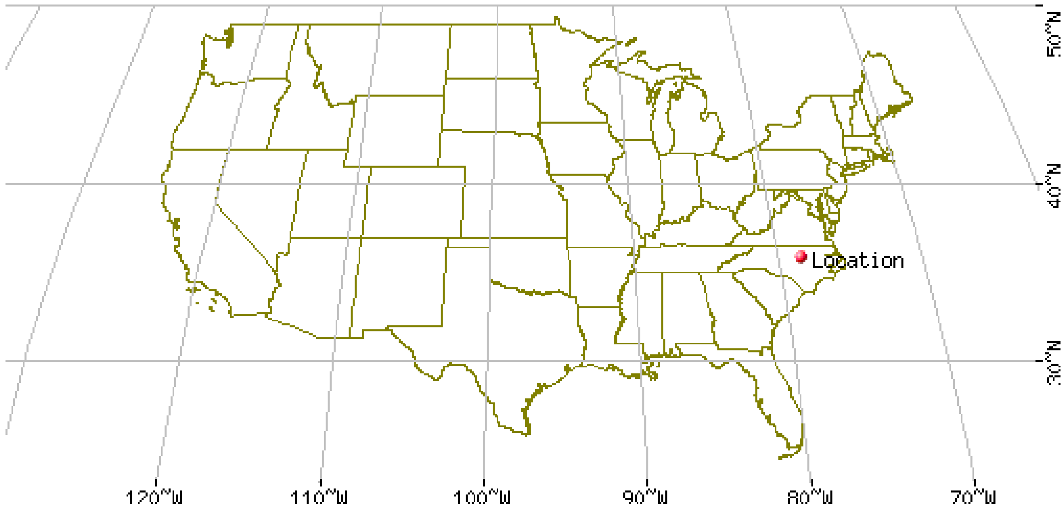
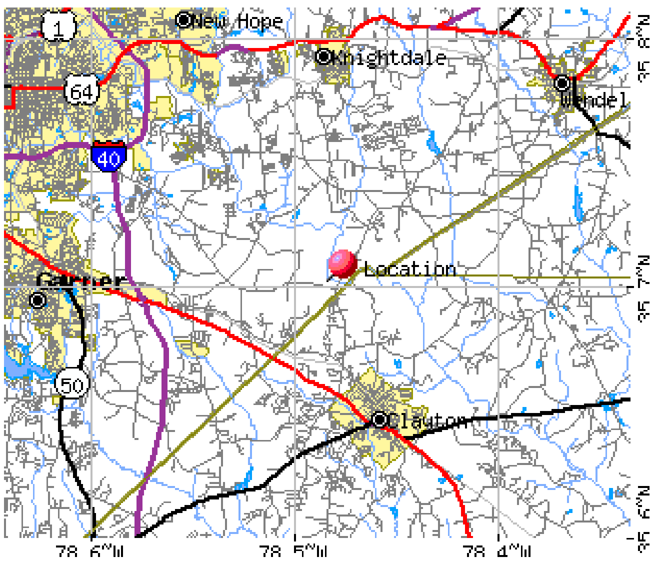


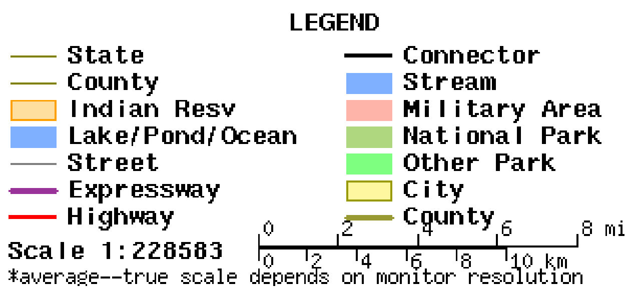
Maps -





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.



Other Maps/Photographs -

[View USGS digital orthophoto quadrangle (DOQ)](#) covering this location from TerraServer; **USGS Aerial Photograph** may also be available
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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

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

* 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 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

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* 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

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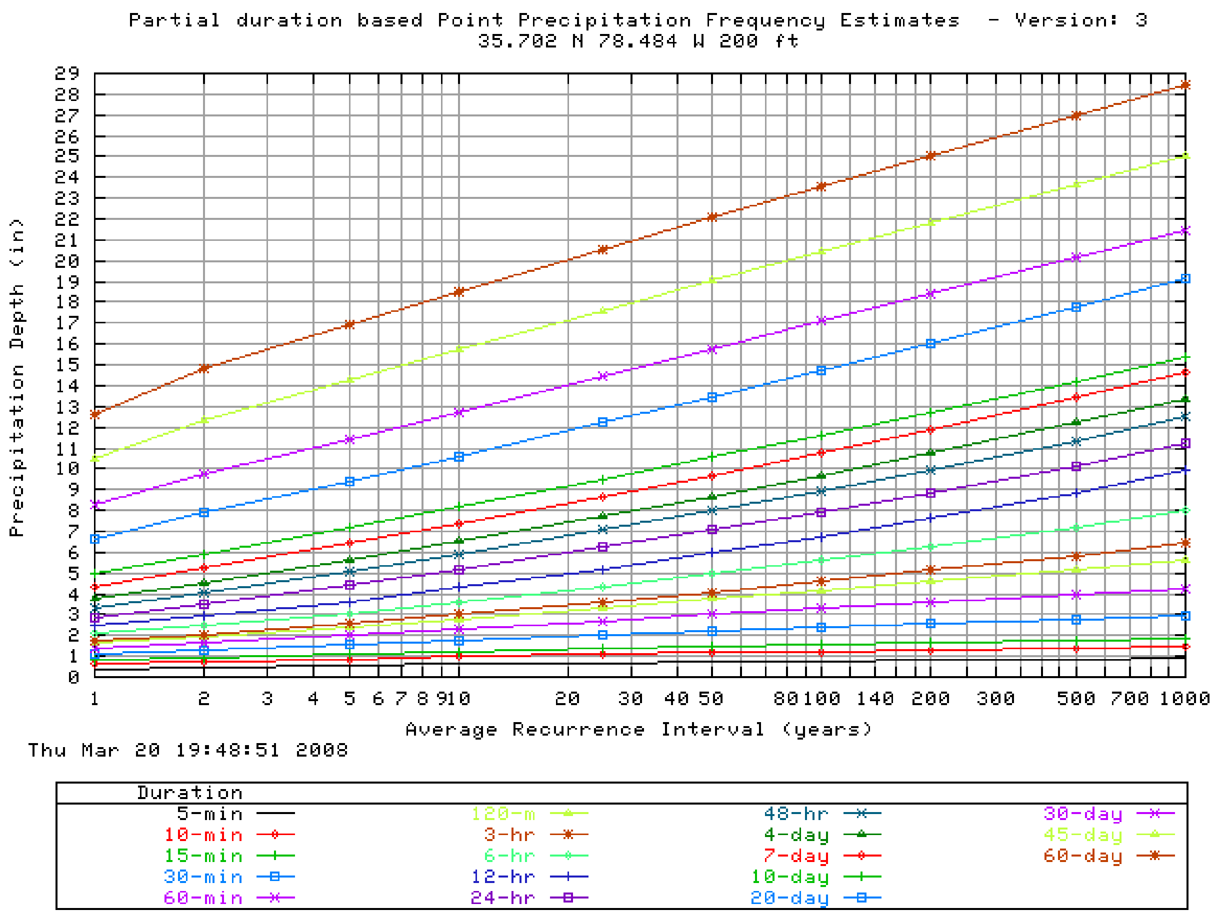
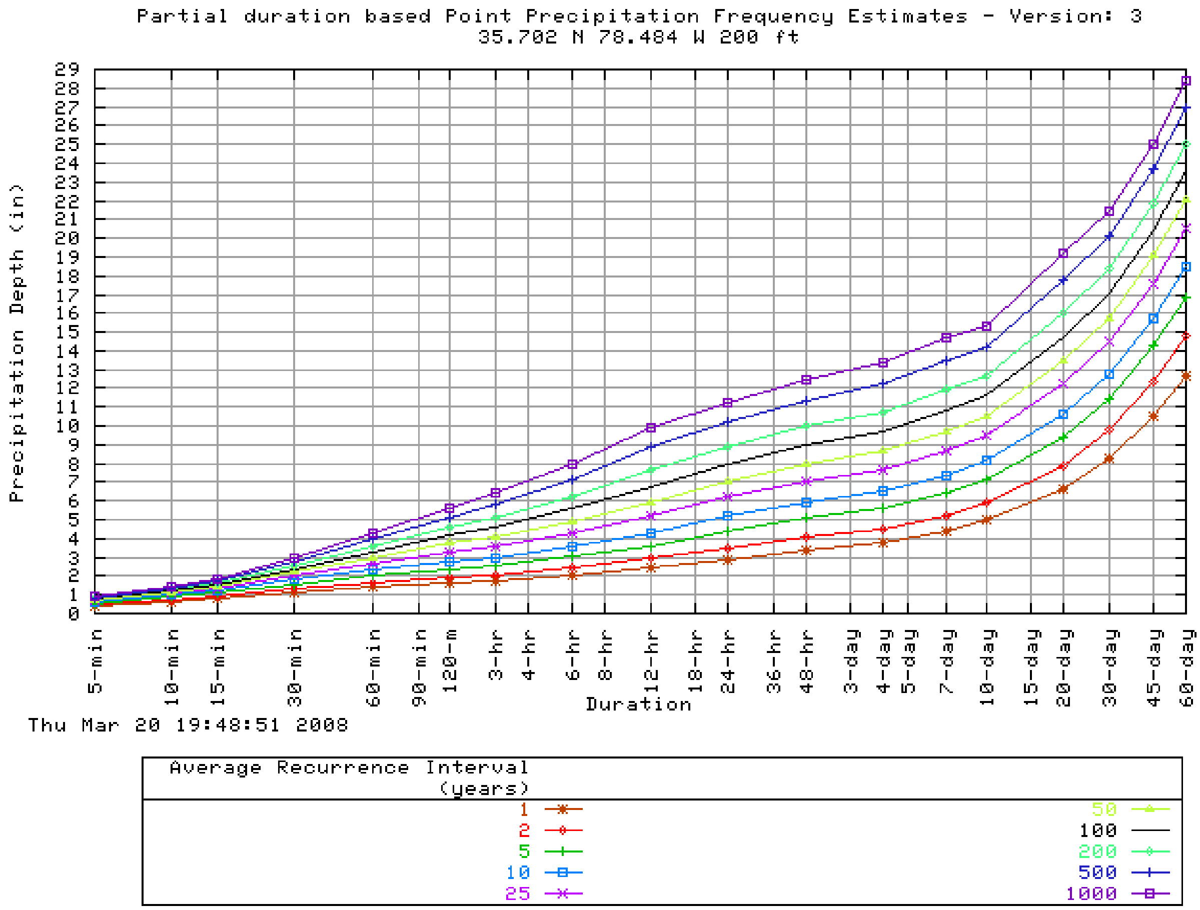
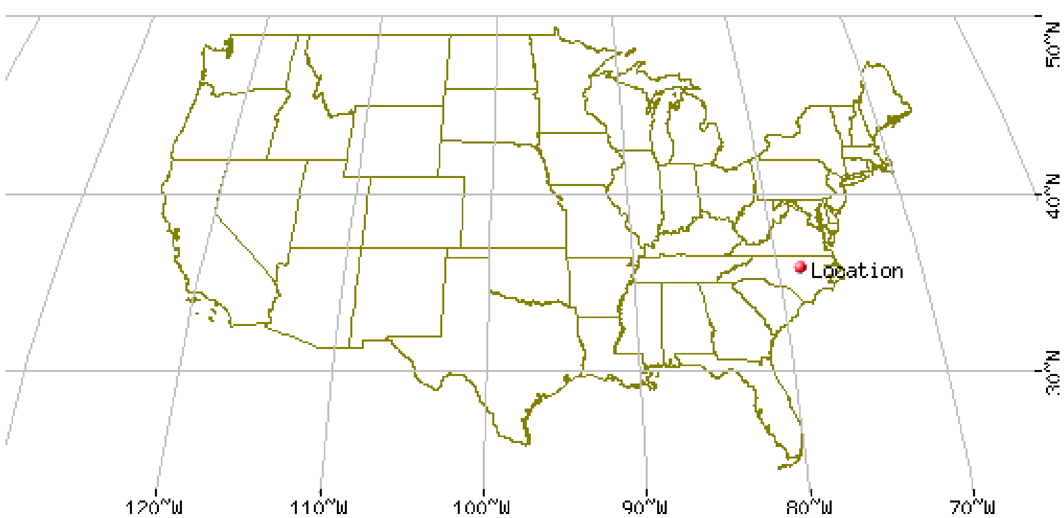


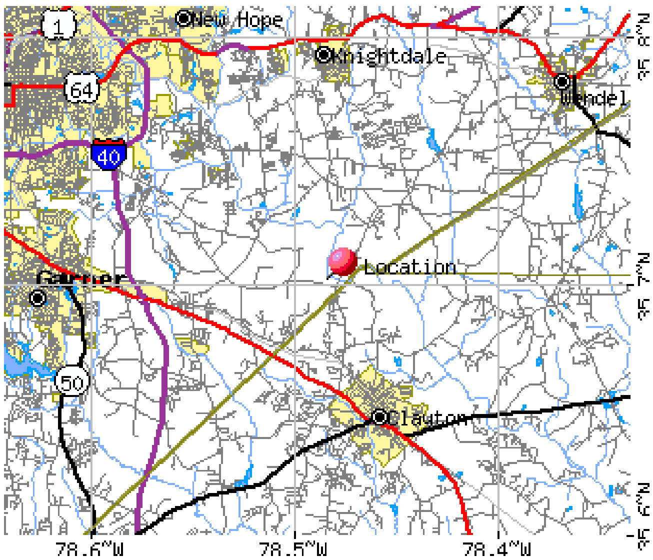


Partial duration based Point Precipitation Frequency Estimates - Version: 3
35.702 N 78.484 W 200 ft
Precipitation Depth (in)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
5-min 10-min 15-min 30-min 60-min 90-min 120-m 3-hr 4-hr 6-hr 8-hr 12-hr 18-hr 24-hr 36-hr 48-hr 3-day 4-day 5-day 7-day 10-day 15-day 20-day 30-day 45-day 60-day
Duration
Thu Mar 20 19:48:51 2008
Average Recurrence Interval
(years)
1
2
5
10
25
50
100
200
500
1000

Maps -



Location
50°N
40°N
30°N
120°W
110°W
100°W
90°W
80°W
70°W



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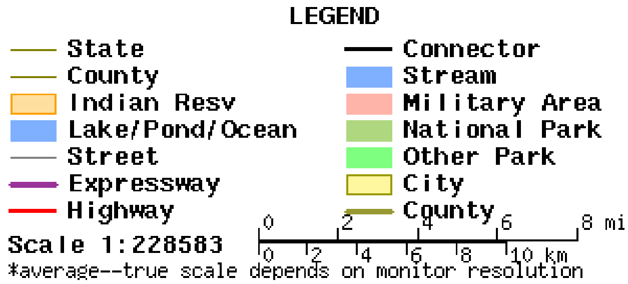

Other Maps/Photographs -

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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

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

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**

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

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

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**

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

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

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

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

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

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

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

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

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

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

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

Estimate Flow Depth by Normal Depth Procedure

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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)

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

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

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)

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

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

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)

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)

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

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)

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

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

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

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

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

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

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**

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**

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

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

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**

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**

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

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

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

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

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

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**

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)

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

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

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

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

USEFUL AGENCIES and CONTACTS			
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

NCDENR
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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