85-03

Carmen Johnson
Fac/Perm/Co ID# 85-03 | Date 5/14/12 | Doc ID# | DIN

DUKE ENERGY

Belews Creek Steam Station
Stokes County, NC

Landfill Permit Application – Design Package

APPROVED
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION
DATE 12-20-07 BY EL

Prepared By:

SHIELD ENGINEERING, INC.
4301 Taggart Creek Road
Charlotte, North Carolina 28208
(800) 395-5220

DUKE ENERGY
BELEWS CREEK STEAM STATION
STOKES COUNTY, NORTH CAROLINA
LANDFILL PERMIT APPLICATION - DESIGN PACKAGE

Prepared by:

Shield Engineering, Inc.
4301 Taggart Creek Road
Charlotte, North Carolina 28208

Shield Project No. 1020062

October 2002

SHIELD
ENGINEERING, INC.

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Drawings

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.0503 SITING AND DESIGN REQUIREMENTS FOR DISPOSAL SITES

Disposal sites shall comply with the following requirements in order for a permit to be issued:

(1) A site shall meet the following siting requirements:

Response

Items identified under this section were addressed in the Site Permit Application submitted by Duke Power Company. Appendix I includes a copy of the August 2, 2002 approval letter for the Site Permit Application received by Duke Power Company from your office.

(2) A site shall meet the following design requirements:

(a) The concentration of explosive gases generated by the site shall not exceed:

(i) twenty-five percent of the limit for the gases in site structures (excluding gas control or recovery system components); and

(ii) the lower explosive limit for the gases at the property boundary.

Response

Only coal ash will be disposed in this facility. No putrescible, cellulose or organic material which would produce methane will be disposed at this facility.

(b) A site shall not allow uncontrolled public access so as to expose the public to potential health and safety hazards at the disposal site;

Response

Site access is controlled by fencing located at the two potential access points along Pine Hall Road. Gates at these access points are locked during non-operating hours.

(c) A site shall meet the following surface water requirements:

(i) A site shall not cause a discharge of pollutants into waters of the state that is in violation of the requirements of the National Pollutant Discharge Elimination System (NPDES), under Section 402 of the Clean Water Act, as amended, or that is in violation of standards promulgated under G.S. 143-214.1 and G.S. 143-215;

(ii) A site shall not cause a discharge of dredged material or fill material into waters of the state that is in violation of the requirements under Section 404 of the Clean Water Act, as amended, or that is in violation of any state requirements regulating the discharge of dredged or fill material into waters of the state, including wetlands; and

(iii) A site shall not cause non-point source pollution of waters of the state that violates assigned water quality standards.

Response

Project discharges are controlled through the use of either a sediment basin or a sediment trap. Both the sediment basin and the sediment trap discharge to the Belews Creek Ash Basin. The Ash Basin discharge is monitored under the NPDES Permit #NC0024406.

The project has an Erosion and Sediment Control Plan which was submitted to the Land Quality Section on August 26, 2002. A copy of the Erosion and Sediment Control Plan approval letter is pending and will be transmitted to the Division of Waste Management upon receipt.

(d) A site shall meet the following ground water requirements:

(i) A site, except for land clearing and inert debris landfills subject to Rule .0564(8)(e) of this Section, shall be designed so that the bottom elevation of solid waste will be a minimum of four feet above the seasonal high water table;

(ii) Operators of new industrial solid waste landfills, lateral expansions of existing industrial solid waste landfills, and industrial solid waste landfills receiving solid waste on or after January 1, 1998 shall submit to the Division a design which satisfies one of the following criteria;

(A) a design that will ensure that the groundwater standards established under 15A NCAC 2L will not be exceeded in the uppermost aquifer at the compliance boundary established by the Division in accordance with 15A NCAC 2L. The design shall be based upon modeling methods acceptable to the Division, which shall include, at a minimum, the following factors:

I. the hydrogeologic characteristics of the facility and surrounding lands;

II. the climatic factors of the area; and

III. the volume and physical and chemical characteristics of the leachate; or

(B) A design with a leachate collection system, a closure cap system, and a composite liner system consisting of two components; the upper component shall consists of a minimum 30-ml flexible membrane (FML) and the lower components shall consist of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec. FML components consisting of high density polyethylene (HDPE) shall be at least 60-ml thick. The FML component shall be installed in direct and uniform contact with the compacted soil component.

(iii) The division reserves the right to require an applicant to submit a liner design if the groundwater protection demonstration in sub-item (ii) of this paragraph is not satisfactory.

(iv) Industrial solid waste landfills shall comply with groundwater standards established under 15A NCAC 2L at the compliance boundary.

Response

(i) The depth of the allowable cut was determined by evaluating ground water data for the landfill site. To determine the fluctuation (range) of groundwater elevation over time, only the data from the older wells (MW-2, MW-3, MW-4, and MW-5) that go back to 1989 were used, the more recent data has been collected during the present, on-going drought. Using this data from the older wells, the ground water range was plotted versus ground elevation and a regression line was fitted. It was assumed that the 13 years of data overlaps both the high and low groundwater levels. From the regression line, the range of groundwater levels versus ground elevation was estimated. This information is shown on the Table below. The lowest groundwater levels in the data have occurred within the last couple of years and is represented by the groundwater contours on Drawing 2. The bottom of the proposed excavation was kept above this groundwater level by the amounts shown on the Table.

Ground Elevation (Feet)	**Estimated Range of Groundwater Fluctuations (Feet)**	**Recommended distance above Groundwater Contours on Drawing 2 for bottom of cut (feet)**
775	3.6	8
780	3.9	8
785	4.1	9
790	4.4	9
795	4.7	9
800	5.0	10
805	5.3	10
810	5.6	10
815	5.8	10
820	6.1	11
825	6.4	11
830	6.7	11
835	7.0	11
840	7.3	12
845	7.6	12

(ii) A report titled Duke Energy Belews Creek Steam Station, Stokes County, NC, Landfill Permit Application .0503(2)(d)(ii)(A) Compliance Demonstration Report, dated January 18, 2002, was submitted to demonstrate that the conceptual design submitted in the Duke Energy Belews Creek Steam Station Landfill Permit Application – Siting Package, October 2, 2001 will ensure that the ground water standards established under 15A NCAC 2L will not be exceeded in the uppermost aquifer at the compliance boundary established by the Division in accordance with 15A NCAC 2L. This report demonstrated compliance with15A NCAC 2L by groundwater modeling methods as described in 0504(2)(d)(ii)(A).

A subsequent report was submitted to address questions raised by the Solid Waste Section after review of the initial modeling. This subsequent report was titled, Duke Energy Belews Creek Steam Station, Stokes County, NC, Landfill Permit Application .0503(2)(d)(ii)(A) Compliance Demonstration Report, Addendum 1, dated May 31, 2002. This report presented the results of additional groundwater modeling and found that the conceptual design included in the October 2, 2001 submittal will not exceed the ground water standards established under 15A NCAC 2L.

(iii) Submittals referenced in (ii) above included an engineered cap design comprised of a geomembrane, geonet and vegetative layer with the following specifications:

- Geomembrane - 40 mil textured HDPE with a hydraulic conductivity of 2×10^{-13} cm/sec.
- Geonet - composite drainage net with a hydraulic conductivity of 1 X 10 cm/sec.
- Vegetative layer - 2 foot thick, stabilized and seeded

(iv) Submittals referenced in (ii) above demonstrate that the landfill will comply with groundwater standards established under 15A NCAC 2L at the compliance boundary.

(e) A site shall not engage in open burning of solid waste;

Response

There will be no burning of solid waste at this facility. The only waste being disposed at the facility is coal ash.

(f) A site, except a land clearing and inert debris landfill, shall meet the following buffer requirements;

(i) A 50-foot minimum buffer between all property lines and disposal areas;

(ii) A 500-foot minimum buffer between private dwellings and wells and disposal areas; and

(iii) A 50-foot minimum buffer between streams and rivers and disposal areas; and

Response

A site map identifying the required buffers was included in the Site Permit Application on Figure .0504-1.

(g) Requirements of the Sedimentation Pollution Control Law (15A NCAC 4) shall be met.

Response

An Erosion and Sediment Control Plan has been prepared for this project. The plan was submitted to the Land Quality Section on August 26, 2002. A copy of the Erosion and Sediment Control Plan approval letter will be transmitted to the Division of Waste Management upon receipt.

.0504 APPLICATION REQUIREMENTS FOR SANITARY LANDFILLS

A permit for a sanitary landfill shall be based upon a particular stream of identified waste, as set forth in Rule .0504 (g)(i) and (ii) of this Section. Any substantial change in the population or area to be served, or in the type, quantity or source of waste shall require a new permit and operation plan, including waste determination procedures where appropriate. Five sets of plans shall be required with each application.

(1) The following information shall be required for reviewing a site application for a proposed sanitary landfill:

Response

Items identified under this section were addressed in the Site Permit Application submitted by Duke Power Company. Appendix I includes a copy of the August 2, 2002 approval letter for the Site Permit Application received by Duke Power Company from your office.

(2) The following information shall be required for reviewing a construction plan application for a proposed sanitary landfill:

(a) A map showing existing features to include:
- (i) existing topography of the site on a scale of at least 1 inch equals 200 feet with five foot contours;
- (ii) bench marks;
- (iii) springs;
- (iv) streams;
- (v) potential groundwater monitoring sites;
- (vi) pertinent geological features; and
- (vii) soil boring locations

Response

Attached to this application is Drawing 1 – Existing Topography which shows the requested features.

(b) A grading plan that provides:
- (i) proposed excavated contours;
- (ii) soil boring locations;
- (iii) locations and elevations of dikes or trenches;
- (iv) designated buffer zones;
- (v) diversion and controlled removal of surface water from the work areas; and
- (vi) proposed utilities and structures

Response

Attached to this Application is Drawing 2 – Grading Plan which shows the requested information. The diversion and controlled removal of surface water from the work areas is shown on Drawing 4 - Erosion Control Plan.

(c) A construction plan that provides:
  (i) engineering design for liners, leachate collection systems;
  (ii) proposed final contours showing removal of surface water runoff; and
  (iii) locations of slope drains or other drop structures.

Response

Attached to this Application is Drawing 3 – Construction Plan which shows the requested information. This design does not call for a liner or leachate collection system, instead an engineered cap has been designed which is comprised of a geomembrane, geonet, and vegetative layer with the following specifications:

- Geomembrane - 40 mil textured HDPE with a hydraulic conductivity of 2×10^{-13} cm/sec.
- Geonet - composite drainage net with a hydraulic conductivity of 1 X 10 cm/sec.
- Vegetative layer - 2 foot thick, stabilized and seeded

(d) An erosion control plan that identifies the following:
   (i) locations of temporary erosion control measures (sediment basins, stone filters, terraces, silt fences,e tc.);
   (ii) locations of permanent erosion control measures (rip-rap, energy dissipators, ditch stabilization, pipe drains, etc.); and
   (iii) seeding specifications and schedules.

Response

Attached to this Application is Drawing 4 – Erosion Control Plan which shows the requested features. This drawing was part of the entire Sediment and Erosion Control Permit Application included in Appendix IV. The seeding specification is included in Appendix V.

(e) Detailed diagrams showing typical sections of:
- (i) dikes,
- (ii) trenches;
- (iii) diversions;
- (iv) sediment basins, and
- (v) other pertinent details.

Response

Attached to this Application is Drawing 5 – Details which shows the requested information.

(f) A minimum of two cross sections per operational area showing:
- (i) original elevations
- (ii) proposed excavated depths
- (iii) proposed final elevations
- (iv) groundwater elevation and
- (v) soil borings

Response

Attached to this Application is Drawing 6 – Cross Sections which shows the requested information.

(g) Site development showing phases or progression of operation

Response

Attached to this Application is Drawing 7 – Site Development Plan which shows the progression of the landfilling activity.

(h) A written report that contains the following:

(i) a copy of the deed or other legal description of the landfill site that would be sufficient as a description in an instrument of conveyance and property owner's name;

(ii) Name of individual responsible for operation and maintenance of the site;

(iii) Projected use of land after completion of the sanitary landfill;

(iv) Anticipated lifetime of the project;

(v) Description of systematic usage of area, operation, orderly development and completion of the sanitary landfill;

(vi) Earthwork calculations;

(vii) Seeding specifications and schedules;

(viii) Calculations for temporary and permanent erosion control measures;

(ix) Any narrative necessary to describe compliance with the Sedimentation Pollution Control Act of 1973 (15A NCAC 4);

(x) A discussion of compliance with design requirements in Rule .0503 (2) of this Section; and

(xi) Any other information pertinent to the proposed construction plan.

Response

(i) A copy of the deed or other legal description of the landfill site that would be sufficient as a description in an instrument of conveyance and property owner's name.

A copy of the deed and legal description is included in Appendix II.

Property Owner's name is Duke Power Company, a subsidiary of Duke Energy Corporation.

(ii) Name of individual responsible for operation and maintenance of the landfill.

- Randy Price, Environmental Coordinator, Belews Creek Steam Station
- Larry Harper, Contract Administrator, Duke Energy, Charlotte, NC
- David Tucker, Boral Material Technologies, Inc. current site contractor to Duke Energy.

(iii) Projected use of land after completion of the sanitary landfill.

No post use of the closed ash landfill is currently planned at this time. However, Duke Energy would like to retain the option of re-excavating any or all of the landfill should a future approved beneficial use be identified. Any future use desired by the station will be communicated to NCDENR.

(iv) Anticipated lifetime of project.

The production of salable and landfilled ash at the Belews Creek Steam Station is a continuous process. The anticipated lifetime of this landfill project is five (5) years as projected on drawings.

(v) Description of systematic usage of area, operation, orderly development and completion of the sanitary landfill;

Duke's ash placement Contractor typically cycles 4 trucks daily to the landfill from the ash collection facility. This varies depending on volume of ash sold on a daily basis. Ash is placed in 12 inch lifts and compacted to a minimum 90% Standard Proctor density. A water truck is used for dust control. An engineered cap is placed over the top of ash as final cover. Site design directs drainage to sediment ponds which discharge clean water to the ash basin. Soil cover is applied to the top elevations and slopes, then seeded to establish vegetation in order to minimize erosion. The Contractor follows provisions of a NCDENR approved Sediment and Erosion Plan.

(vi) Earthwork calculations
Earthwork calculations are included in Appendix III. The total ash volume for Area 1 is 1,130,000 cubic yards. The Belews Creek Steam Station produces approximately 70,000 cubic yards of ash per month.

(vii) Seeding specifications and schedules

Seeding specifications are included in Appendix V.

(viii) Calculations for temporary and permanent erosion control measures

A copy of the entire Sediment and Erosion Control Plan, and amendments is included in Appendix IV.

(ix) Any narrative necessary to describe compliance with the Sedimentation Pollution Control Act of 1973 (15A NCAC 4)

A copy of the entire Sediment and Erosion Control Plan, and amendments is included in Appendix IV.

A copy of the Sediment and Erosion Control Plan approval letter will be transmitted to the Division of Waste Management upon receipt.

(x) A discussion of compliance with design requirements in Rule .0503(2) of this Section.

A discussion of the design requirements of Rule .0503(2)(a) through (g) were presented in *Duke Energy Belews Creek Steam Station Landfill Permit Application – Siting Package, October 2, 2001*.

Compliance with Rule .0503(2)(d) was demonstrated by groundwater modeling, submitted in the reports *Duke Energy Belews Creek Steam Station, Stokes County, NC, Landfill Permit Application .0503(2)(d)(ii)(A) Compliance Demonstration Report, dated January 18, 2002* and *Duke Energy Belews Creek Steam Station, Stokes County, NC, Landfill Permit Application .0503(2)(d)(ii)(A) Compliance Demonstration Report, Addendum1 dated May 31, 2002*.

The modeling performed in these reports found that the design presented for the Belews Creek ash landfill will ensure that 2L groundwater standards are not exceeded. This conclusion was reached by review of the site-specific conditions and by the use of groundwater modeling that included site-specific adsorptive properties. The design provided ensures that the ground water standards established under 15A NCAC 2L will not be exceeded.

This design proposed in this demonstration calls for:

1. the active landfill to receive ash for a 5 year period.
2. an engineered cover to be placed on the completed landfill at the end of the 5 year period.

(xi) Any other information pertinent to the proposed construction plan

It is Duke Energy's intent to submit a Site Suitability and Design Permit Applications for Areas 2 and 3. The subsequent Design Application package will address the entire landfill comprised of Areas 1, 2 and 3.

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Drawings Under Seperate Cover

APPENDIX I

August 2, 2002 Site Permit Approval Letter

North Carolina
Department of Environment and Natural Resources

Division of Waste Management

Michael F. Easley, Governor
William G. Ross Jr., Secretary
William L. Meyer, Director

August 2, 2002

Allen Stowe
Duke Energy
PO Box 1006
Charlotte, NC 28201-1006

RE: Site Suitability for an Industrial Landfill, Duke Energy
Belews Creek Steam Station, Stokes County, NC

Dear Mr. Stowe;

The Solid Waste Section of the Division of Waste Management (Division), has completed its review of the site application and facility plan study for the proposed Belews Creek Steam Station, Industrial Landfill. The proposed site is located on NC SR 1908 in Stokes County, near Walnut Cove, North Carolina.

The application was prepared by Duke Power, Group Environment, Health and Safety, Huntersville, NC and is referenced as follows: *Duke Energy, Belews Creek Steam Station, Stokes County, N.C., Landfill Permit Application – Siting Package,* dated October 2, 2001. Also referenced are the *Duke Energy Belews Creek Steam Station Stokes County, NC Landfill Permit Application .0503(2)(d)(ii)(A) Compliance Demonstration Report* dated January 18, 2002 and the *Duke Energy Belews Creek Steam Station Stokes County, NC Landfill Permit Application .0503(2)(d)(ii)(A) Compliance Demonstration Report Addendum 1* dated May 31,2002.

Pursuant to Rule .0504, the Division is notifying Duke Energy that the site is considered suitable, and you are authorized to prepare and submit an application for a permit to construct.

Section .0201 of the Solid Waste Management Rules (15A NCAC 13B) requires the Division to issue a solid waste permit in two parts. The first part is a Permit to Construct and the second part is a Permit to Operate. The Division may only issue a Permit to Operate after it determines that the facility has been constructed in accordance with the construction permit and that all pre-operative conditions have been met. The final action the Division may take on a permit application is the issuance or denial of a permit.

APPROVED DISPOSAL AREA

Based upon information submitted and revised through July 30, 2002, the Division has determined that the Area 1, as proposed in the conceptual design plan, is suitable for development of a solid waste management facility subject to the terms and conditions specified below. This statement of suitability does not predetermine that all portions of this property are deemed appropriate for landfilling activities. Each phase will be evaluated during the design process as to whether or not landfilling can be performed and what, if any, engineering is deemed appropriate to achieve that purpose.

Disposal of waste, or any portion of the waste disposal unit is not permitted in the 100-year flood plain. This includes the containment berm or any leachate storage or treatment facilities.

GENERAL CONDITIONS AND SITE-SPECIFIC DESIGN REQUIREMENTS

The Division requires the submittal of a construction plan application for the first five-year development phase, as identified in the conceptual design plan, which is consistent with the requirements of 15A NCAC 13B .0503, .0504, and .0505, including, but not limited to, the site specific criteria set forth in this letter. Development of subsequent phases of the landfill will be in accordance with rule .0201(e).

Buffers

Horizontal buffers shall be as described in the conceptual design and as designated in Rule .0503(2)(f), and shall also include the following buffer criteria:

a) A 100-foot minimum buffer shall be maintained between facility boundaries and borrow areas, unless otherwise approved by the Division.
b) A minimum 50-foot buffer shall be maintained between borrow areas and delineated wetlands.
c) A minimum 50-foot buffer shall be maintained between disposal areas and the delineated wetlands.
d) A minimum 200-foot buffer shall be established between the waste boundary and the property line, unless otherwise approved by the Division.

Duke Energy may utilize all remaining areas of the site, except buffer areas, for other solid waste management activities (such as composting or recycling) or for landfill support activities (such as leachate management and/or stockpiling of cover material) upon approval by the Division.

Design and Construction Standards

An engineering evaluation and design report shall be prepared. The division strongly encourages Duke Energy and their consultant to schedule a pre-design meeting with the division to discuss a strategy for preparing a permit to construct that will meet the goals and objectives of Duke Energy, be permittable, and be protective of public health and the environment. The permit to construct should consider the following:

1. Use of any composite liner system other than that specified in .0503(d)(2)(ii)(B) will require groundwater modeling to demonstrate compliance with ground water standards established under 15A NCAC 2L.

Additional Subsurface Investigation

A geologic and hydrogeologic report shall be submitted as a component of the construction plan application. The report shall present the results of additional subsurface investigations at the site and shall be consistent with the requirements of Section .0503(d)(ii) and .0504(1)(c) of the Solid Waste Management Rules.

1. Further investigative hydrogeological work may be necessary to delineate the rock surface and potentiometric surface in order to ensure that a 4 foot vertical separation is achieved.
2. The presence of springs to the east of the landfill may need to be investigated further in order to ensure proper monitoring of the landfill.

The Permit to Construct and the Permit to Operate will be issued to Duke Energy, Belews Creek Steam Station. If you have any questions, or would like to schedule a meeting to discuss this letter, please contact our office at (919)733-0692.

Sincerely,

James C Coffey

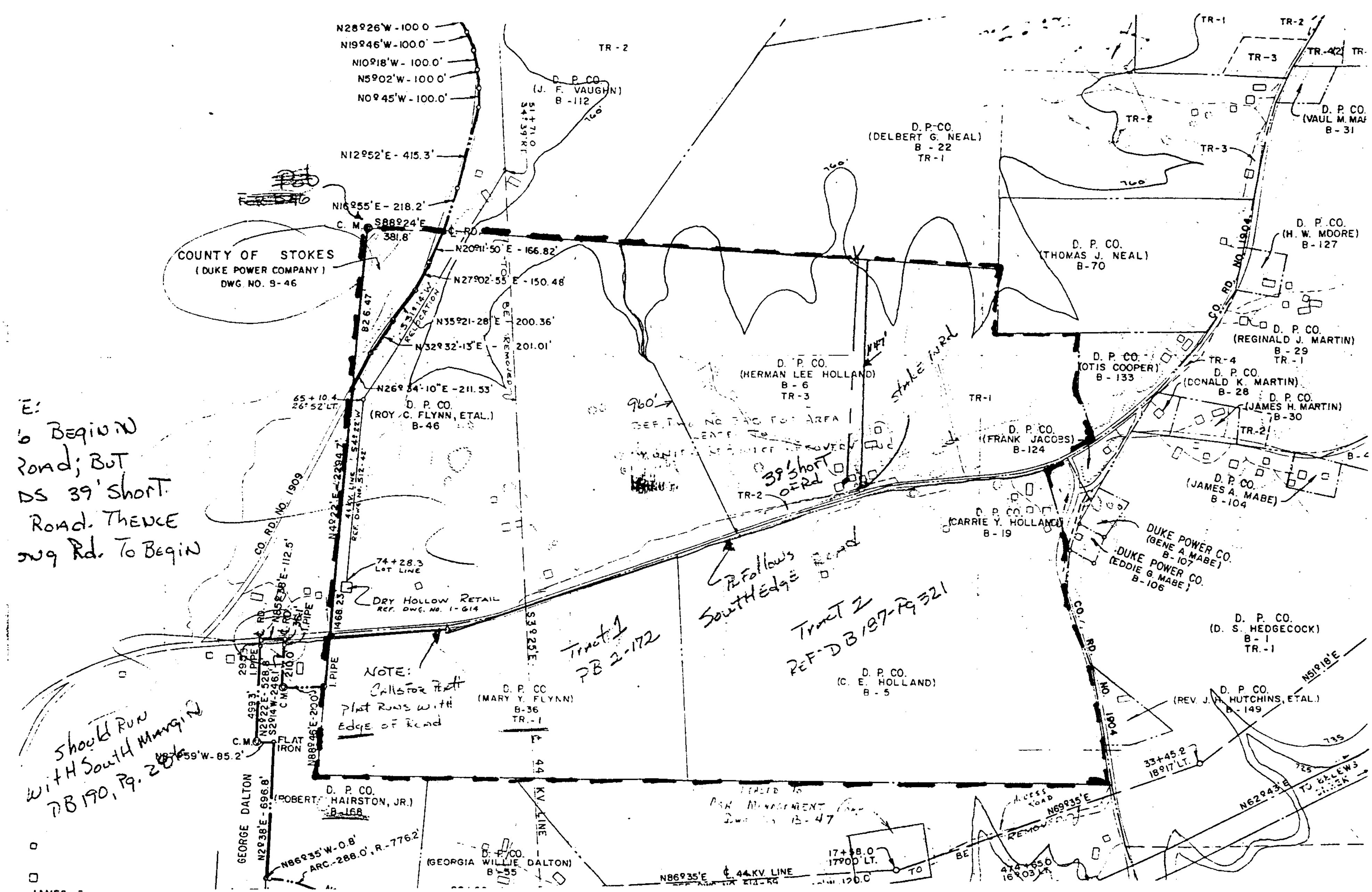
James C. Coffey, Chief
Solid Waste Section

cc: Ellen Lorscheider, SWS
Brent Rockett, SWS
Tim Jewett, SWS
Hugh Jernigan, SWS

C:\TEMP\Site Suitability Letter1.wpd

APPENDIX II

Deed and Legal Description of Property


COUNTY OF STOKES
(DUKE POWER COMPANY)
DWG. NO. 9-46
N28°26'W-100.0
N19°46'W-100.0'
N10°18'W-100.0'
N5°02'W-100.0'
N0°45'W-100.0'
N12°52'E-415.3'
N16°55'E-218.2'
C. M.
S88°24'E
381.8'
N20°11'50"E-166.82'
N27°02'55"E-150.48'
N35°21'28"E-200.36'
N32°32'13"E-201.01'
N26°34'10"E-211.53'
RELOCATION
TO BE REMOVED
826.47
65+10.4
26°52'LT.
N49°22'E-2294.7'
1468.23
CO. RD. NO. 1909
74+28.3
LOT LINE
DRY HOLLOW RETAIL
REF. DWG. NO. 1-614
D. P. CO.
(ROY C. FLYNN, ETAL.)
B-46
D. P. CO.
(J. F. VAUGHN)
B-112
TR-2
51+71.0
34°39'RT.
D. P. CO.
(DELBERT G. NEAL)
B-22
TR-1
D. P. CO.
(THOMAS J. NEAL)
B-70
D. P. CO.
(VAUL M. MA
B-31
TR-3
TR-4
D. P. CO.
(H. W. MOORE)
B-127
D. P. CO.
(REGINALD J. MARTIN)
B-29
TR-1
D. P. CO.
(OTIS COOPER)
B-133
D. P. CO.
(DONALD K. MARTIN)
B-28
D. P. CO.
(JAMES H. MARTIN)
B-30
D. P. CO.
(FRANK JACOBS)
B-124
D. P. CO.
(JAMES A. MABE)
B-104
D. P. CO.
(CARRIE Y. HOLLAND)
B-19
DUKE POWER CO.
(GENE A MABE)
B-107
DUKE POWER CO.
(EDDIE G. MABE)
B-106
D. P. CO.
(HERMAN LEE HOLLAND)
B-6
TR-3
D. P. CO.
(D. S. HEDGECOCK)
B-1
TR.-1
D. P. CO.
(REV. J. H. HUTCHINS, ETAL.)
B-149
N51°18'E
33+45.2
189°17'LT.
N62°43'E
TO BELEWS CREEK
CO. RD. NO. 1904
D. P. CO.
(C. E. HOLLAND)
B-5
D. P. CC
(MARY Y. FLYNN)
B-36
TR.-1
S3°25'E
44 KV. LINE
N86°35'E
44 KV. LINE
ACCESS ROAD
N69°35'E
REMOVED
17+58.0
179°00'LT.
TO BE
47+165.0
169°03'LT.
D. P. CO.
(GEORGIA WILLIE DALTON)
B-55
D. P. CO.
(ROBERT HAIRSTON, JR.)
B-168
GEORGE DALTON
N2°38'E-696.8'
N86°35'W-0.8'
ARC.-288.0', R.-776.2'
N88°46'E-210.0
I. PIPE
C. M.
FLAT IRON
N2°22'E-528.8
S2°14'W-246.1
N65°28'E-112.5'
210.0
36.1
499.3'
299.3'
N87°59'W-85.2'
960'
39' short of Rd
147'
stake in Rd
R Follows SouthEdge Road
Tract 1
PB 2-172
Tract 2
REF-DB 197-Pg 321
NOTE:
Calls for Ptt
Plat Runs with
Edge of Road
E:
Begin
Road; But
DS 39' Short
Road. Thence
Rd. To Begin
Should Run
with South Margin
PB 190, Pg. 286

FINAL CERTIFICATE 0 3 8 0 0 9 0 4 File No. B - 6

ATTORNEYS REAL ESTATE TITLE OPINION
(Fee Simple Purchase)

The undersigned hereby certifies to DUKE POWER COMPANY that, based on a personal examination of all public records which do or may disclose information affecting the title to the property described in Schedule A hereof and which sources of title information cover a period of not less than sixty years last past, it is the opinion of the undersigned that, subject only to the liens, encumbrances, and other objections noted under Schedule B hereof, the marketable fee simple title to the property in the deed shown in Schedule A hereof is as of the date of this report vested in Duke Power Company, originally having been conveyed to Wocasar, Inc. by the source cited hereinafter.

SCHEDULE A

Name of Grantor (s) Herman Lee Holland and wife, Anna Mae N. Holland

dated March 25, 1969 and recorded in Book 187, page 367, on April 2, 1969.

SCHEDULE B

1. TAXES AND SPECIAL ASSESSMENTS:
   (a) County, City and School taxes have been paid through and including those for the year 19 68.
   (b) There are no special levies, assessments, estate and inheritance taxes or other taxes due except 1969 taxes are a lien

2. MORTGAGES, DEEDS OF TRUST, AND VENDOR'S LIENS (Give parties, amount, date and recording data.)

None

3. RESTRICTIVE COVENANTS AND CONDITIONS: Are there any? No
   If so, give recording data for these restrictions.

4. ARE THERE OTHER LIENS, OBJECTIONS, ZONING REGULATIONS, OR OTHER DEFECTS? (Except other easements to Duke Power Company) No. (Answer "yes" or "no" and, if any, describe below)

This title is certified down to April 2, 19 69.

WOMBLE, CARLYLE, SANDRIDGE & RICE

By: Clyde C. Bowden
Attorney

Deed File No. B-6

B-6

THIS DEED DRAWN BY Lyle T. Crawley BOOK 187 PAGE 367

Mail to Leslie E. Bowden P. O. Drawer 84 Winston-Salem, North Carolina
(Name) (Street and Number) (City) (State)

THIS DEED, Made this the 25 day of March, 1969

by Herman Lee Holland and wife, Anna Mae N. Holland

part ies of the first part, to WOCASAR, Inc., a North Carolina corporation of Forsyth County, North Carolina,

part y of the second part;

Witnesseth That the said parties of the first part, in consideration of ($100.00 & OVC) One hundred dollars and other valuable considerations to them paid by the said party of the second part, the receipt of which is hereby acknowledged, have bargained and sold, and by these presents do bargain, sell and convey unto the said party of the second part and its successors and assigns a tract or parcel of land in the County of Stokes and State of North Carolina, in Sauratown Township, and bounded as follows:

TRACT NO. ONE: Beginning at a stake in the Walnut Cove Road, corner of the school house lot, running thence North on the school house line 21 1/4 chains to a stake; thence South 78° West on that line 3 1/2 chains to a stake in Young's line; thence North on Young's line 15 chains to a stake in Taylor's line; thence East on Taylor's line (now Tom Neal) line 11 1/2 chains to a stone and pointers; thence South on Moody's line 5 chains to a stone; thence East on Moody's line (now Tom Neal) 16 chains to a stake in said Walnut Cove Road; thence Southwest along said road at it meanders to the Beginning, same containing 36 1/2 acres, more or less.

TRACT NO. TWO: All of the Thornton A. Freeman Estate lands which lie on the North side of the present State Highway (old No. 77) and between the present State Highway, and the old State Highway and which portion of the Thornton A. Freeman Estate lands which lie to the East of an iron stake, Flynn's new corner; which corner is directly across the highway from the corner between Farm Tracts 1 and 2 of the Freeman Estate and Freeman Survey.

TRACT NO. THREE: Beginning at a rock on the North side of the public road, runs North 17° West to the branch, and down the branch as it meanders 23 3/4 chains to Taylor's line; thence East on Taylor's line 18 1/2 chains to a rock; thence South on Linville's line 17 chains and 38 links to a stake in the road; thence West along said road as it meanders 10 chains and 12 links to the Beginning, containing 28 acres, more or less.

SAVE AND EXCEPT that 2.32 acre tract conveyed to Otis Cooper and wife, Mary Alice Cooper by deed recorded in Deed Book 175, at page 77, in the office of the Register of Deeds, Stokes County, North Carolina.

[redacted]

Deed No. B-6
Book 187 Page 367

The above land was conveyed to grantor by _____, See Book No. _____ Page _____

B-6

TO HAVE AND TO HOLD the aforesaid tract or parcel of land all privileges and appurtenances thereunto belonging to the said party of the second part and its successors and assigns forever.

And the said parties of the first part do covenant that they are seized of said premises in fee and have the right to convey the same in fee simple; that the same are free from encumbrances; and that they will warrant and defend the said title to the same against the claims of all persons whatsoever.

IN TESTIMONY WHEREOF the said parties of the first part have hereunto set their hands and seals.

(Seal) Herman Lee Holland (Seal)

(Seal) Anna Mae N. Holland (Seal)

(Seal) (Seal)

(Seal) (Seal)

(Seal) (Seal)

STATE OF NORTH CAROLINA, Stokes County

I, Georgia E Cooke (Ward), a Notary Public of Buncombe Stokes County, North Carolina, do hereby certify that Herman Lee Holland and wife, Anna Mae N. Holland

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the 27 day of March, 19 69

My commission expires Sept. 21, 1969 Georgia E Cooke (Ward), Notary Public

STATE OF NORTH CAROLINA, _____ County

I, _____, a Notary Public of _____ County, North Carolina, do hereby certify that _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the _____ day of _____, 19____

My commission expires _____, 19____ _____, Notary Public

STATE OF NORTH CAROLINA—Forsyth County

I, _____, a Notary Public of Forsyth County, North Carolina, do hereby certify that _____ and his wife _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial Seal). Witness my hand and notarial seal this the _____ day of _____, 19____

My commission expires _____, 19____ _____, Notary Public

STATE OF NORTH CAROLINA—Stokes County

The foregoing (or annexed) certificate of Georgia E. Cooke (Ward) Notary Public Buncombe County (there give name and official title of the officer signing the certificate proved upon).

is (are) certified to be correct. This the 1 day of April A.D., 1969

Probate fee 25c paid.

Filing fee $ _____ paid

Register of Deeds

By Dona M. Mack Deputy-Assistant

Filed for Registration at 1:15 o'clock P M

April 1 1969 and registered in Book 187

Page 367

Dona M. Mack, Deputy

Register of Deeds, Stokes Co. N. C.

Deed

Herman Lee Holland and wife

Anna Mae N. Holland

TO

WOCASAR, Inc.

Insert brief description here to go on Register of Deeds Index

FINAL CERTIFICATE 0 3 8 0 1 0 2 4 File No. B - 36

ATTORNEYS REAL ESTATE TITLE OPINION

(Fee Simple Purchase)

The undersigned hereby certifies to DUKE POWER COMPANY that, based on a personal examination of all public records which do or may disclose information affecting the title to the property described in Schedule A hereof and which sources of title information cover a period of not less than sixty years last past, it is the opinion of the undersigned that, subject only to the liens, encumbrances, and other objections noted under Schedule B hereof, the marketable fee simple title to the property in the deed shown in Schedule A hereof is as of the date of this report vested in Duke Power Company, originally having been conveyed to Wocasar, Inc. by the source cited hereinafter.

SCHEDULE A

Name of Grantor (s) Mary Y. Flynn, widow

dated March 20, 1969 and recorded in Book 187, page 319, on March 25, 1969.

SCHEDULE B

1. TAXES AND SPECIAL ASSESSMENTS:
   (a) County, City and School taxes have been paid through and including those for the year 19 68.
   (b) There are no special levies, assessments, estate and inheritance taxes or other taxes due except 1969 taxes are a lien

2. MORTGAGES, DEEDS OF TRUST, AND VENDOR'S LIENS (Give parties, amount, date and recording data.)

None

3. RESTRICTIVE COVENANTS AND CONDITIONS: Are there any? No
   If so, give recording data for these restrictions.

4. ARE THERE OTHER LIENS, OBJECTIONS, ZONING REGULATIONS, OR OTHER DEFECTS? (Except other easements to Duke Power Company) No (Answer "yes" or "no" and, if any, describe below)

This title is certified down to March 25, 69

WOMBLE, CARLYLE, SANDRIDGE & RICE

By: Lyle T. Bowlder

Attorney

Deed File No. B-36

B-36

BOOK 187 PAGE 319

THIS DEED DRAWN BY Lyle E. Browder

Mail to L. E. Browder, UP 308 Drawer 84, Winston-Salem, North Carolina 27108
(Name) (Street and Number) (City) (State)

THIS DEED, Made this the 20 day of March, 1969,

by Mary Y. Flynn, widow

part Y of the first part, to WOCASAR, Inc., a North Carolina corporation of Forsyth County, North Carolina,

part Y of the second part;

Witnesseth That the said part Y of the first part, in consideration of ($100.00 & OVC) One hundred dollars and other valuable considerations to her paid by the said part Y of the second part, the receipt of which is hereby acknowledged, has bargained and sold, and by these presents do grant bargain, sell and convey unto the said part Y of the second part and its successors and assigns a tract or parcel of land in the County of Stokes and State of North Carolina, in Sauratown Township, and bounded as follows:

Tract No. One: Farm Tract No. 1, in the subidivion of the lands of Thornton A. Freeman Estate, according to a map or plat made of same in December, 1947, by F. O. Jones, Surveyor, which said plat is recorded in Stokes County Registry, in Deed Book 108, at page 206, and Plat Book 2, at page 172, to which reference is hereunto made. Said Farm Tract contains 40.28 acres, more or less.

Also all of the Thornton A. Freeman Estate lands which lie on the North side of the present state highway (old No. 77) and between the present state highway, and the old state highway, and which portion of the Thornton A. Freeman Estate lands lie to the West of an iron stake, Holland's new corner, which corner is directly across the highway from the corner between Farm Tracts One and Two, of the Freeman Estate and Freeman Survey.

Tract No. Two: Beginning in the center of Belews Creek, runs South 58 poles to a stone; thence East 29½ poles to a stone; thence North 20 poles to a stone; thence East 63 poles to a stone; thence South 31 poles to a maple; thence East 31 poles to a hickory and stone; thence North 31 poles to a stake and pointers; thence North 7° West 153 poles to a stone; thence North 47° West 9 poles to the center of the creek; thence South 20° West 16 poles, North 28° West 7 poles and 18 links, North 53° West 13½ poles South 78° West 12 poles and 14 links; South 44° West 6 poles and 8 links; thence 75° West 15 poles and 18 links; South 35° West 34 poles, South 66° East 7½ poles, South 43½° East 8 poles and 50 links, South 40° East 22 poles and 16 links, South 47° West 13½ poles; North 54° West 27½ poles, South 4° West 50 poles, South 57° West 10 poles, North 81° West 5 poles to the beginning in the center of the creek; containing 98 3/4 acres, more or less.

[redacted]

The above land was conveyed to grantor by _____, See Book No. _____ Page _____

Deed No. B-36

Book 187 Page 319

Deed File No. B-36

TO HAVE AND TO HOLD the aforesaid tract or parcel of land all privileges and appurtenances thereunto belonging to the said party of the second part and its successors and assigns forever.

And the said party of the first part do ~~xxx~~ covenant that they are seized of said premises in fee and has the right to convey the same in fee simple; that the same are free from encumbrances; and that she will warrant and defend the said title to the same against the claims of all persons whatsoever.

IN TESTIMONY WHEREOF the said party of the first part has hereunto set her hand and seal.

(Seal) Mary Y Flynn (Seal)

(Seal) (Seal)

(Seal) (Seal)

(Seal) (Seal)

(Seal) (Seal)

STATE OF NORTH CAROLINA, Stokes County

I, Georgia E Cooke (Wood), a Notary Public of Rockingham County, North Carolina, do hereby certify that Mary Y. Flynn, widow

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the 21 day of March 1969

My commission expires Sept 21 1969 Georgia E. Cooke (Wood) Notary Public

STATE OF NORTH CAROLINA, _____ County

I, _____, a Notary Public of _____ County, North Carolina, do hereby certify that _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the _____ day of _____ 19__

My commission expires _____ 19__ _____ Notary Public

STATE OF NORTH CAROLINA—Forsyth County

I, _____, a Notary Public of Forsyth County, North Carolina, do hereby certify that _____ and his wife _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial Seal). Witness my hand and notarial seal this the _____ day of _____ 19__

My commission expires _____ 19__ _____ Notary Public

STATE OF NORTH CAROLINA—~~xxxxxxxxxx~~ Stokes County

The foregoing (or annexed) certificate of Georgia E. Cooke (Wood) notary public (Here give name and official title of the officer signing the certificate passed upon)

is (are) certified to be correct. This the 25 day of March A.D. 1969

Probate fee 25c paid.

Filing fee $_____ paid.

~~xxxxxxxxxx~~ Register of Deeds

By Doris M Make Deputy-~~Assistant~~

Filed for Registration at 10:15 o'clock A M
March 25 1969 and registered in Book 187
Page 319

Doris M. Make, Deputy
Register of Deeds, Stokes Co. N. C.

Deed

Mary Y. Flynn

TO

WOCASAR, Inc.

Insert brief description here to be used on Register of Deeds Index

FINAL CERTIFICATE 38 01072 File No. B - 46

ATTORNEYS REAL ESTATE TITLE OPINION
(Fee Simple Purchase)

The undersigned hereby certifies to DUKE POWER COMPANY that, based on a personal examination of all public records which do or may disclose information affecting the title to the property described in Schedule A hereof and which sources of title information cover a period of not less than sixty years last past, it is the opinion of the undersigned that, subject only to the liens, encumbrances, and other objections noted under Schedule B hereof, the marketable fee simple title to the property in the deed shown in Schedule A hereof is as of the date of this report vested in Duke Power Company, originally having been conveyed to Wocasar, Inc. by the source cited hereinafter.

SCHEDULE A

Name of Grantor (s) Roy C. Flynn and wife Peggy F. Flynn and Mary F. Flynn, widow

dated March 20, 1969 and recorded in Book 187, page 340, on March 28, 1969.

SCHEDULE B

1. TAXES AND SPECIAL ASSESSMENTS:
   (a) County, City and School taxes have been paid through and including those for the year 19 68.
   (b) There are no special levies, assessments, estate and inheritance taxes or other taxes due except 1969 taxes are a lien

2. MORTGAGES, DEEDS OF TRUST, AND VENDOR'S LIENS (Give parties, amount, date and recording data.)

None

3. RESTRICTIVE COVENANTS AND CONDITIONS: Are there any? No
   If so, give recording data for these restrictions.

4. ARE THERE OTHER LIENS, OBJECTIONS, ZONING REGULATIONS, OR OTHER DEFECTS? (Except other easements to Duke Power Company) No (Answer "yes" or "no" and, if any, describe below)

This title is certified down to March 28, 1969.

WOMBLE, CARLYLE, SANDRIDGE & RICE

By: Lyle T. Bowlin
Attorney

B-46

THIS DEED DRAWN BY Lewis E. Browder, Atty. BOOK 187 PAGE 240

Mail to L. E. Browder, P. O. Drawer 84, Winston-Salem, North Carolina
(Name) (Street and Number) (City) (State)

THIS DEED, Made this the 20th day of March, 19 69

by Roy C. Flynn and wife, Peggy F. Flynn and Mary Y. Flynn, Widow,

part ies of the first part, to WOCASAR, Inc., a North Carolina corporation of Forsyth County, North Carolina,

part Y of the second part;

Witnesseth That the said part ies of the first part, in consideration of ($ 100.00 & OVC), One hundred dollars and other valuable considerations to them paid by the said part Y of the second part, the receipt of which is hereby acknowledged, ~~his~~/have bargained and sold, and by these presents do bargain, sell and convey unto the said part Y of the second part and its successors and assigns ~~his~~ a tract or parcel of land in the County of ~~Forsyth~~ Stokes and State of North Carolina, in Sauratown Township, and bounded as follows:

Beginning at a stake in the center of the public road, runs on Goolsby's line 125 poles to two white oaks, marker ("B" on the West side of a branch, in G. B. Taylor's (now Johnnie Vaughn) line; thence East on said Taylor's line 146 poles to a stone in said Taylor's line; thence South on a new line 70 poles less 39 feet to the aforesaid public road; thence along said road as it meanders 160 poles to the Beginning, containing 89-1/2 acres, more or less.

SAVE AND EXCEPT from the above described property the following: Beginning at a rock on the North side of the public road runs North 17° West to the branch and down the branch as it meanders 23-3/4 chains to Taylor's line; thence East on Taylor's line 18-1/2 chains to a rock; thence South on Linville's line 17 chains and 38 links to a stake in the road; thence West along said road as it meanders 10 chains and 12 links to the Beginning, containing 28 acres, more or less, same being that property described in Deed Book 43, at page 436, in the office of the Register of Deeds, For Stokes County, North Carolina.

[redacted]

The above land was conveyed to grantor by _____. See Book No. _____ Page _____

Deed File No. B-46

BOOK 187 PAGE 341

TO HAVE AND TO HOLD the aforesaid tract or parcel of land all privileges and appurtenances thereunto belonging to the said part y of the first part and its successors and assigns forever.

And the said part ies of the first part do covenant that they are seized of said premises in fee and have the right to convey the same in fee simple; that the same are free from encumbrances; and that they will warrant and defend the said title to the same against the claims of all persons whatsoever.

IN TESTIMONY WHEREOF the said part ies of the first part have hereunto set their hand s and seal s

Roy C. Flynn (Seal)

Peggy F. Flynn (Seal)

Mary Y. Flynn (Seal)

STATE OF NORTH CAROLINA, Stokes County

I, W. Thurman Tilley, a Notary Public of Stokes County, North Carolina, do hereby certify that Roy C. Flynn and wife, Peggy F. Flynn and Mary Y. Flynn, Widow

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the 21 day of March 19 69

My commission expires Jan 31 1970 W. Thurman Tilley Notary Public

STATE OF NORTH CAROLINA, _____ County

I, _____, a Notary Public of _____ County, North Carolina, do hereby certify that _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the _____ day of _____ 19__

My commission expires _____ 19__ _____ Notary Public

STATE OF NORTH CAROLINA—Forsyth County

I, _____, a Notary Public of Forsyth County, North Carolina, do hereby certify that _____ and his wife _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial Seal). Witness my hand and notarial seal this the _____ day of _____ 19__

My commission expires _____ 19__ _____ Notary Public

STATE OF NORTH CAROLINA—~~FORSYTH~~ Stokes County

The foregoing (or annexed) certificate of W. Thurman Tilley, Notary Public of Stokes County (here give name and official title of the officer signing the certificate passed upon)

is (are) certified to be correct. This the 21 day of March A.D., 1969

Probate fee 25c paid.

Filing fee $ _____ paid.

~~REGISTER~~ Register of Deeds

By Drew M. Mark Deputy-Assistant

Filed for Registration at 11:45 o'clock A M

March 28 1969 and registered in Book 187

Page 341

Drew M. Mark, Asst.

Register of Deeds, Stokes Co. N. C.

Appd

ROY C. FLYNN, et al

TO

WOCASAR, INC.

Insert brief description here to be used on Register of Deeds Index

FINAL CERTIFICATE 0 3 8 0 0 9 0 1 File No. B - 5

ATTORNEYS REAL ESTATE TITLE OPINION
(Fee Simple Purchase)

The undersigned hereby certifies to DUKE POWER COMPANY that, based on a personal examination of all public records which do or may disclose information affecting the title to the property described in Schedule A hereof and which sources of title information cover a period of not less than sixty years last past, it is the opinion of the undersigned that, subject only to the liens, encumbrances, and other objections noted under Schedule B hereof, the marketable fee simple title to the property in the deed shown in Schedule A hereof is as of the date of this report vested in Duke Power Company, originally having been conveyed to Wocasar, Inc. by the source cited hereinafter.

SCHEDULE A

Name of Grantor (s) C. E. Holland, and wife, Carrie Y. Holland

dated March 12, 1969 and recorded in Book 187, page 321, on March 25, 1969.

SCHEDULE B

1. TAXES AND SPECIAL ASSESSMENTS:
   (a) County, City and School taxes have been paid through and including those for the year 19 68.
   (b) There are no special levies, assessments, estate and inheritance taxes or other taxes due except 1969 taxes are a lien

2. MORTGAGES, DEEDS OF TRUST, AND VENDOR'S LIENS (Give parties, amount, date and recording data.)

None

3. RESTRICTIVE COVENANTS AND CONDITIONS: Are there any? No
   If so, give recording data for these restrictions.

4. ARE THERE OTHER LIENS, OBJECTIONS, ZONING REGULATIONS, OR OTHER DEFECTS? (Except other easements to Duke Power Company) No. (Answer "yes" or "no" and, if any, describe below)

This title is certified down to March 25, 19 69.

WOMBLE, CARLYLE, SANDRIDGE & RICE

Doyle F. Rowder

Attorney

Deed File No. B-5

THIS DEED DRAWN BY (Lois G. Crowder) BOOK 187 PAGE 321

Mail to LE Crowder, P.O. Drawer 84, Winston Salem, NC
(Name) (Street and Number) (City) (State)

THIS DEED Made this the 28 day of March, 19 69,

C. E. Holland and his wife Carrie Y. Holland

of the State of North Carolin

part ies of the first part, to WOCASAR, Inc., a North Carolina corporation

of Forsyth County, State of North Carolina, part y of the second par

Witnesseth That the said part ies of the first part, in consideration of ($100.00 & OVC) One hundred dollar and other valuable considerations to them paid by the said part y of the secon part, the receipt of which is hereby acknowledged, have bargained and sold, and by these presents do bargain, sell and convey unto the said part y of the second part and its successors and assigns a tract or parcel o land in the County of Stokes and State of North Carolina, in Sauratown Township, and bounded as follows

Being known and designated as Lot Nos. 15, through 21, inclusive, and a farm Tract No. 2 as set out upon the Subdivision of the lands of the Thornton A. Freeman Estate, recorded in Deed Book 108, at pages 205, and 206, in the office of the Register of Deeds, Stokes County, North Carolina.

[redacted]

The above land was conveyed to grantor by ____ See Book No. ____ Page ____

TO HAVE AND TO HOLD the aforesaid tract or parcel of land all privileges and appurtenances thereunto belonging to the said part y of the second part and its successors and assigns forever.

And the said part ies of the first part do covenant that they are seized of said premises in fee and have the right to convey the same in fee simple that the same are free from encumbrances; and that they will warrant and defend the said title to the same against the claims of all persons whatsoever.

IN TESTIMONY WHEREOF the said part ies of the first part have hereunto set their hand s and seal s

(Seal) C. E. Holland (Seal)

(Seal) X Carrie Y. Holland (Seal)

STATE OF NORTH CAROLINA Stokes County

I, Georgia P. Cooke (wmd), a Notary Public of Buncombe County, North Carolina, do hereby certify that C. E. Holland and his wife Carrie Y. Holland grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial Stamp or Seal) Witness my hand and notarial seal this the 24 day of March, 19 69

My Commission expires Sept 21, 19 69 Georgia P. Cooke (Wmd) Notary Public

STATE OF NORTH CAROLINA—Forsyth County

I, ____, a Notary Public of Forsyth County, North Carolina, do hereby certify that ____ and his wife ____ grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial Seal) Witness my hand and notarial seal this the ____ day of ____, 19____

My commission expires ____, 19____, Notary Public

STATE OF NORTH CAROLINA Stokes County

The foregoing (or annexed) certificate of Georgia P. Cooke (wmd) notary public (there give name and official title of the officer signing the certificate passed upon) is (are) certified to be correct. This the 25 day of March A.D. 19 69

Register of Deeds

By Doris M Nicks Deputy-Assistant

Filed for Registration at 10:15 o'block A M
March 25 1969 and registered in Book 187
Page 321.

Doris M Nicks, Deputy
Register of Deeds, Stokes Co. N. C.

Deed No. B-5
Book 187 Page 321

Probate fee 25c paid.

Filing fee $ ____ paid.

Deed File No. R-5

FINAL CERTIFICATE 0 3 8 0 0 9 6 2 File No. B - 22

ATTORNEYS REAL ESTATE TITLE OPINION
(Fee Simple Purchase)

The undersigned hereby certifies to DUKE POWER COMPANY that, based on a personal examination of all public records which do or may disclose information affecting the title to the property described in Schedule A hereof and which sources of title information cover a period of not less than sixty years last past, it is the opinion of the undersigned that, subject only to the liens, encumbrances, and other objections noted under Schedule B hereof, the marketable fee simple title to the property in the deed shown in Schedule A hereof is as of the date of this report vested in Duke Power Company, originally having been conveyed to Wocasar, Inc. by the source cited hereinafter.

SCHEDULE A

Name of Grantor (s) Delbert G. Neal and wife, Stella Calhoun Neal

dated April 24, 1969 and recorded in Book 187, page 492, on April 25, 1969.

SCHEDULE B

1. TAXES AND SPECIAL ASSESSMENTS:
   (a) County, City and School taxes have been paid through and including those for the year 19 68.
   (b) There are no special levies, assessments, estate and inheritance taxes or other taxes due except 1969 taxes are a lien

2. MORTGAGES, DEEDS OF TRUST, AND VENDOR'S LIENS (Give parties, amount, date and recording data.)

None

3. RESTRICTIVE COVENANTS AND CONDITIONS: Are there any? No
   If so, give recording data for these restrictions.

4. ARE THERE OTHER LIENS, OBJECTIONS, ZONING REGULATIONS, OR OTHER DEFECTS? (Except other easements to Duke Power Company) No (Answer "yes" or "no" and, if any, describe below)

This title is certified down to April 25, 19 69.

WOMBLE, CARLYLE, SANDRIDGE & RICE

By [signature]
Attorney

Deed File No. B-22

B-22

THIS DEED DRAWN BY Lyle G. Browder BOOK 187 PAGE 492

Mail to L. E. Browder, P. O. Drawer 84, Winston-Salem, North Carolina
(Name) (Street and Number) (City) (State)

THIS DEED, Made this the 24 day of April, 19 69,

by Delbert G. Neal and wife, Stella Calhoun Neal

part ies of the first part, to WOCASAR, Inc., a North Carolina Corporation, of Forsyth County, North Carolina,

part y of the second part;

Witnesseth That the said part ies of the first part, in consideration of ($100.00 & OVC) One hundred dollars and other valuable considerations to them paid by the said part y of the second part, the receipt of which is hereby acknowledged, ~~has~~/have bargained and sold, and by these presents do bargain, sell and convey unto the said part y of the second part and its successors and assigns ~~heirs~~ tract or parcel of land in the County of ~~Forsyth~~ Stokes and State of North Carolina, in Sauratown Township, and bounded as follows:

TRACT NO. ONE: Beginning at a stone said stone being the southwest corner of Lot No. 1 as set out upon the hereinafter referred to map and running thence along the west boundary line of Lot No. 1, North 5 deg. 30' East 305 feet to a stone; thence along the southern boundary line of Lot No. 2, as set out upon the hereinafter referred to map, North 85 deg. 30' West 3450 feet to an iron stake in the eastern right of way line of Dan River Road; thence along the Eastern right of way line of Dan River Road Southwardly as it meanders 1387 feet to a pine knot; thence along the northern boundary line of P. L. Young South 35 deg. 30' East 2810 feet to a stone; thence along the western boundary line of R. N. Taylor, North 5 deg. 30' East 1008 feet to a stone; thence South 86 deg. West 500 feet to a point, the place of beginning, same containined 88.50 acres, and being Lot No. 3 as set out upon the Map of the R. H. Taylor farm as surveyed by F. O. Jones, in April, 1920.

TRACT NO. TWO: Beginning at a stake in the Walnut Cove Road in Taylor line and running west on his line 19 1/2 chains to a stake; thence South on Taylor's line 20 3/4 chains to a stone and pointers, thence east on a new line 16 chains to the center of the said road; thence Northeast along said road as it meanders to the Beginning, containing 36 1/2 acres, more or less. SAVE AND EXCEPT from the two hereinabove described tracts that 21.83 acre tract described in Deed Book 113, at page 395, and that 25 acre tract, recorded in Deed Book 126, at page 144, both of which are recorded in the office of the Register of Deeds, Stokes County, North Carolina.

TRACT NO. THREE: Beginning atan iron stake in the West right of way line of Old N. C. Route 77 (Pine Hali Road) 30 feet west of the center thereof at Tom Neal's corner; running thence West with the South line of the Tom Neal property 200 feet to an iron stake; thence South 11 deg. 45 ' West 200 feet to an iron stake; thence East 200 feet to an iron stake in the West right of way line of Old N. C. Route 77; thence with the West line of said highway North 11 deg. 45' East 200 feet to the point of Beginning.

Deed No. B-22
Book 187 Page 492

47.53

Deed File No. B-22

TO HAVE AND TO HOLD the aforesaid tract or parcel of land all privileges and appurtenances thereunto belonging to the said party of the second part and its successors and assigns forever.

And the said parties of the first part do covenant that they are seized of said premises in fee and have the right to convey the same in fee simple; that the same are free from encumbrances; and that they will warrant and defend the said title to the same against the claims of all persons whatsoever.

IN TESTIMONY WHEREOF the said parties of the first part have hereunto set their hands and seals

Delbert G. Neal (Seal) Stella Calhoun Neal (Seal)

(Seal) (Seal)

(Seal) (Seal)

(Seal) (Seal)

STATE OF NORTH CAROLINA, Stokes County

I, Virginia F. Williams a Notary Public of Stokes County, North Carolina, do hereby certify that Delbert G. Neal and wife, Stella Calhoun Neal

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the 25th day of April 19 69

My commission expires February 12 19 71 Virginia F. Williams Notary Public

STATE OF NORTH CAROLINA, _____ County

I, _____, a Notary Public of _____ County, North Carolina, do hereby certify that _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial stamp or seal). Witness my hand and notarial seal this the _____ day of _____ 19_____

My commission expires _____, 19____ _____ Notary Public

STATE OF NORTH CAROLINA—Forsyth County

I, _____, a Notary Public of Forsyth County, North Carolina, do hereby certify that _____ and his wife _____

grantors, each personally appeared before me this day and acknowledged the execution of the foregoing deed of conveyance.

(Notarial Seal). Witness my hand and notarial seal this the _____ day of _____ 19_____

My commission expires _____, 19____ _____, Notary Public

STATE OF NORTH CAROLINA—Forsyth Stokes County

The foregoing (or annexed) certificate of Virginia F. Williams, a notary public of Stokes County (here give name and official title of the officer signing the certificate passed upon)

is (are) certified to be correct. This the 25 day of April A.D., 1969

Probate fee 25c paid.

Filing fee $_____ paid.

_____ Register of Deeds

By Doris M. Mabe Deputy-Assistant

Filed for registration at 1 o'clock P M

April 25 1969 and registered in Book 187

Page 492

Doris M. Mabe, Deputy

Register of Deeds, Stokes Co. N. C.

Insert brief description here to be used on Register of Deeds Index

Delbert G. Neal et ux

TO

WOCASAR, Inc.

Rec'd

APPENDIX III
Calculations

KAH
9/3/02

Duke Energy
Belews Creek Ash Landfill Design
Area 1 ash quantity

EXISTING VOLUME IN AREA #1

Area #	Area (sq. ft.)	Average ash elevation	Baseline elevation	Depth	Volume present
1	38,226	775	775	0	0
2	115,860	777.5	775	2.5	10,728
3	123,387	782.5	775	7.5	34,274
4	64,543	787.5	775	12.5	29,881
5	24,397	792.5	775	17.5	15,813
6	22,961	797.5	775	22.5	19,134
7	22,654	802.5	775	27.5	23,074
8	22,505	807.5	775	32.5	27,089
9	21,587	812.5	775	37.5	29,982
10	23,341	817.5	775	42.5	36,740
11	22,954	822.5	775	47.5	40,382
12	24,305	827.5	775	52.5	47,260
13	27,244	832.5	775	57.5	58,020
14	30,855	837.5	775	62.5	71,424
15	10,683	835	775	60	23,740
16	101,589	842.5	775	67.5	253,973
17	22,732	847.5	775	72.5	61,040
18	20,956	852.5	775	77.5	60,151
19	18,678	857.5	775	82.5	57,072
.20	15,156	862.5	775	87.5	49,117
21	14,059	867.5	775	92.5	48,165
22	13,120	872.5	775	97.5	47,378
23	12,247	877.5	775	102.5	46,493
24	11,627	882.5	775	107.5	46,293
25	10,881	887.5	775	112.5	45,338
			Total Volume existing in Area 1		**1,182,559**

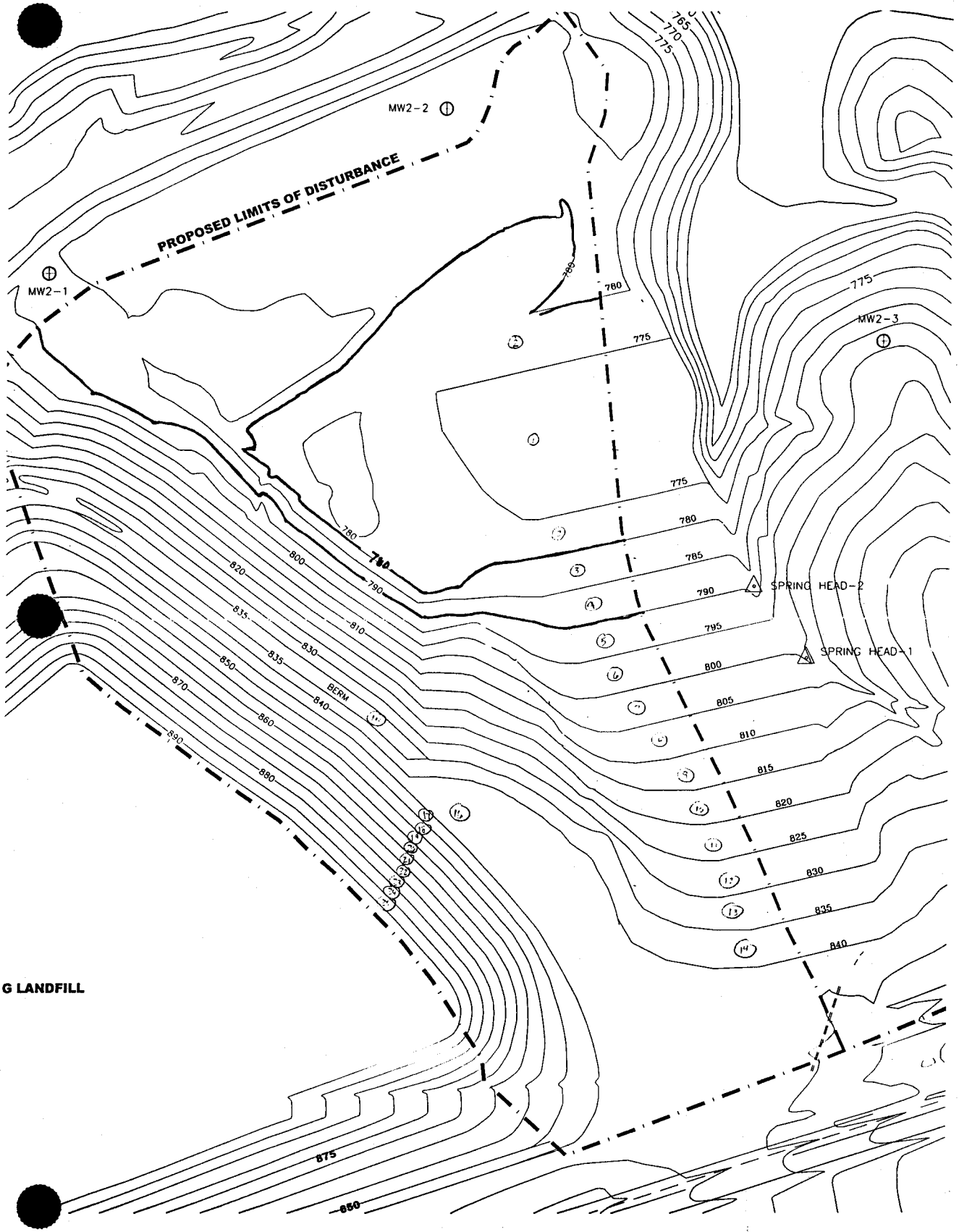
Duke Energy
Belews Creek Ash Landfill Design
Area 1 ash quantity

Area #	Area (sq. ft.)	Average ash elevation	Baseline elevation	Depth	Volume present
1	15,898	780	775	5	2,944
2	22,495	782.5	775	7.5	6,249
3	24,227	787.5	775	12.5	11,216
4	24,297	792.5	775	17.5	15,748
5	25,213	797.5	775	22.5	21,011
6	25,215	802.5	775	27.5	25,682
7	26,197	807.5	775	32.5	31,533
8	26,596	812.5	775	37.5	36,939
9	26,149	817.5	775	42.5	41,160
10	26,149	822.5	775	47.5	46,003
11	26,054	827.5	775	52.5	50,661
12	25,855	832.5	775	57.5	55,062
13	30,351	835	775	60	67,447
14	25,156	837.5	775	62.5	58,231
15	32,618	842.5	775	67.5	81,545
16	35,733	847.5	775	72.5	95,950
17	38,803	852.5	775	77.5	111,379
18	35,963	857.5	775	82.5	109,887
19	36,527	862.5	775	87.5	118,375
20	34,759	867.5	775	92.5	119,082
21	33,534	872.5	775	97.5	121,095
22	32,670	877.5	775	102.5	124,025
23	30,703	882.5	775	107.5	122,243
24	29,914	887.5	775	112.5	124,642
25	192,340	890	775	115	819,226
			Total Volume existing in Area 1		2,417,334

→ DROPPING THIS COLUMN BY 3' FOR SOIL COVER
→ 2,319,176
(THIS IS THE VOLUME @ FINAL ELEVATIONS)

2,319,176 (TOTAL VOLUME)
− 1,182,559 (EXISTING VOLUME)
1,136,617 ASH VOLUME FOR AREA #1

249
9/3/02


MW2-2
PROPOSED LIMITS OF DISTURBANCE
MW2-1
MW2-3
SPRING HEAD-2
SPRING HEAD-1
BERM
765
770
775
780
785
790
795
800
805
810
815
820
825
830
835
840
820
800
790
810
830
850
870
890
880
860
875
850

G LANDFILL


TYPE 2 OUTLET STABILIZATION APRON
MW2-1
24" CMP (S=31%)
TYPE 1 OUTLET STABILIZATION APRON
Berm
24" CMP (S=33%)
24" CMP (S=33%)
24" CMP (S=33%)
EXISTING ROAD
SLOPE DOWN 0.5%
SLOPE DOWN 0.5%
TYPE 3 BERM DITCH
11% SLOPE ON ROAD
(S.R. 1908)
752
755
775
780
785
790
795
800
805
810
815
820
825
830
835
840
845
850
855
860
865
870
875
880
885
890
(800)
(825)

7<Q0
10/8/02

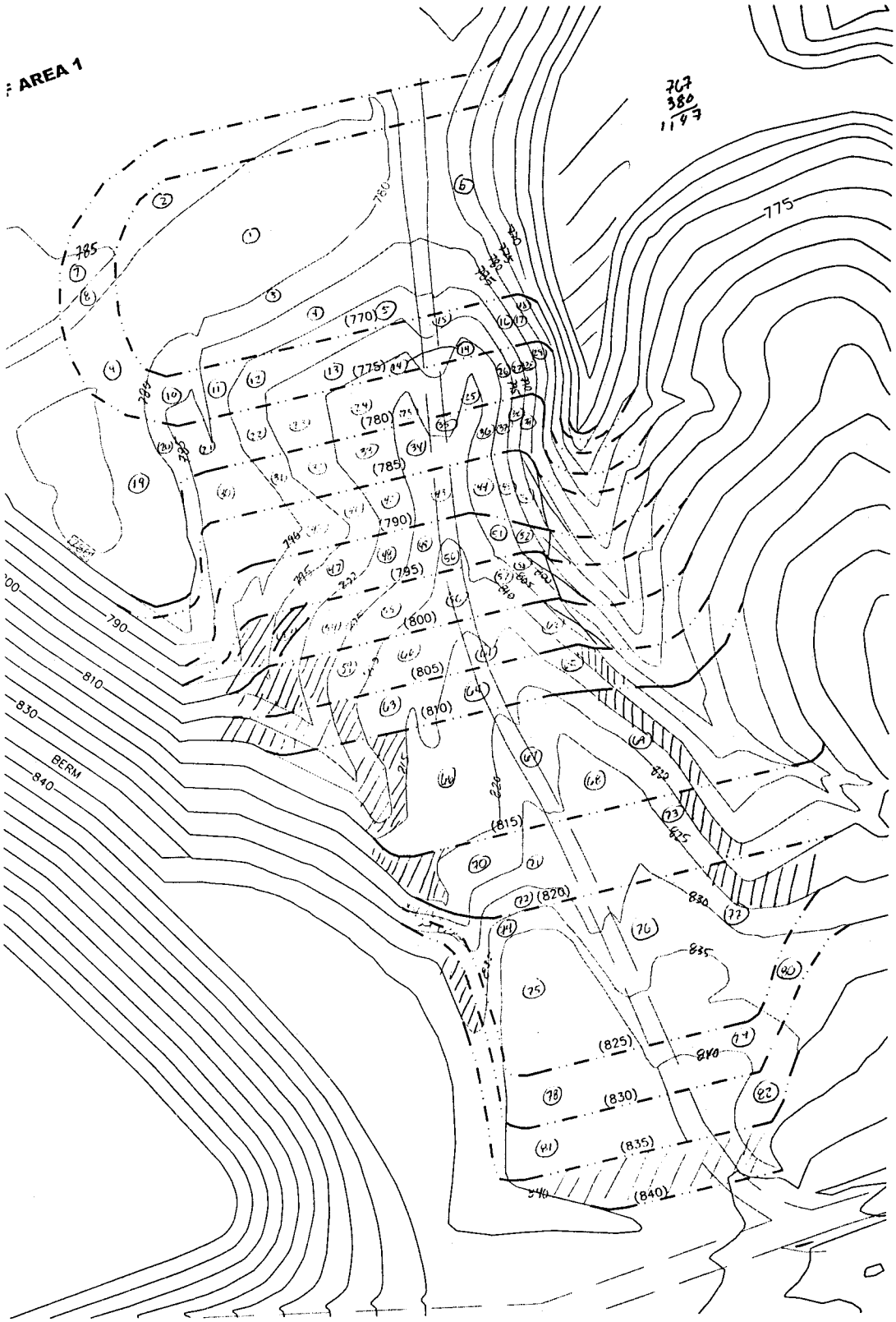
Duke Energy
Belews Creek Ash Landfill Design
Area 1 grading soil quantity - Revised 10-02

Area #	Area (sq. ft.)	Average existing elevation	Average proposed elevation	Depth	Volume of soil removed
1	29,034	780	770	10	10,753
2	4,139	782.5	770	12.5	1,916
3	17,032	782.5	770	12.5	7,885
4	9,978	787.5	770	17.5	6,467
5	4,038	792.5	770	22.5	3,365
6	3,567	777.5	770	7.5	991
7	1,680	785	772.5	12.5	778
8	1,278	782.5	772.5	10	473
9	5,949	780	772.5	7.5	1,653
10	2,839	782.5	772.5	10	1,051
11	1,545	787.5	772.5	15	858
12	3,772	792.5	772.5	20	2,794
13	4,594	797.5	772.5	25	4,254
14	1,147	800	772.5	27.5	1,168
15	1,607	795	772.5	22.5	1,339
16	749	787.5	772.5	15	416
17	647	782.5	772.5	10	240
18	492	777.5	772.5	5	91
19	12,126	780	777.5	2.5	1,123
20	1,190	782.5	777.5	5	220
21	2,958	787.5	777.5	10	1,096
22	1,629	792.5	777.5	15	905
23	2,891	797.5	777.5	20	2,141
24	7,488	802.5	777.5	25	6,933
25	914	805	777.5	27.5	931
26	620	797.5	777.5	20	459
27	633	792.5	777.5	15	352
28	637	787.5	777.5	10	236
29	616	782.5	777.5	5	114
30	3,619	787.5	782.5	5	670
31	1,396	792.5	782.5	10	517
32	2,255	797.5	782.5	15	1,253
33	2,792	802.5	782.5	20	2,068
34	3,297	805	782.5	22.5	2,748
35	598	802.5	782.5	20	443
36	1,008	802.5	782.5	20	747
37	705	797.5	782.5	15	392
38	639	792.5	782.5	10	237
39	663	787.5	782.5	5	123
40	2,239	792.5	787.5	5	415
41	1,734	797.5	787.5	10	642
42	1,955	802.5	787.5	15	1,086
43	2,932	807.5	787.5	20	2,172

RAG
10/8/02

44	1,724	802.5	787.5	15	958
45	1,022	797.5	787.5	10	379
46	1,099	792.5	787.5	5	204
47	2,779	797.5	792.5	5	515
48	2,237	802.5	792.5	10	829
49	3,375	807.5	792.5	15	1,875
50	637	810	792.5	17.5	413
51	1,056	802.5	792.5	10	391
52	600	797.5	792.5	5	111
53		797.5	797.5	0	0
54	2,675	802.5	797.5	5	495
55	2,875	807.5	797.5	10	1,065
56	3,810	810	797.5	12.5	1,764
57	1,400	807.5	797.5	10	519
58	1,054	802.5	797.5	5	195
59	2,084	807.5	802.5	5	386
60	6,516	812.5	802.5	10	2,413
61	1,931	815	802.5	12.5	894
62	1,174	807.5	802.5	5	217
63	3,377	812.5	807.5	5	625
64	5,467	817.5	807.5	10	2,025
65	1,332	812.5	807.5	5	247
66	11,798	817.5	812.5	5	2,185
67	10,680	822.5	812.5	10	3,956
68	4,572	827.5	812.5	15	2,540
69	3,002	817.5	812.5	5	556
70	3,664	822.5	817.5	5	679
71	12,096	827.5	817.5	10	4,480
72	1,227	832.5	817.5	15	682
73	1,914	822.5	817.5	5	354
74	10,931	837.5	822.5	15	6,073
75	13,242	840	822.5	17.5	8,583
76	12,771	832.5	822.5	10	4,730
77	3,753	827.5	822.5	5	695
78	9,463	840	827.5	12.5	4,381
79	3,796	837.5	827.5	10	1,406
80	2,729	832.5	827.5	5	505
81	11,437	840	832.5	7.5	3,177
82	2,926	837.5	832.5	5	542
		Total Soil Cover Available from Area 1			**59,986**

SOIL CODE (PHYSICAL ANALYSIS SAMPLES)



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BELEWS CREEK
EROSION AND SEDIMENT CONTROL PLAN
TYPE "A"-2 PERIMETER DITCH DESIGN

STEP 1: DETERMINE THE REQUIRED FLOW CAPACITY

DRAINAGE AREA: USE ONLY SOUTHERN FACE (SLOPED) AREA
159,526 SQUARE FEET
3.7 ACRES (SEE FIGURES)

DETERMINE THE RUNOFF COEFFICIENT

DRAINAGE AREA	159,526 SQUARE FEET
MAXIMUM SLOPE LENGTH	1,075 FEET
ELEVATION DROP	70 FEET
SLOPE	6.5 %
LOCATION	STOKES COUNTY (USE GREENSBORO MAP)

FROM TABLE 8.03A
LAND USE: BARE PACKED SOIL - TEMPORARY COVER (0.30 - 0.60) ✓
USE C = 0.45

DETERMINE THE TIME OF CONCENTRATION
FROM FIGURE 8.03A
Tc= 5 MIN ✓

DETERMINE THE RAINFALL INTENSITY, FREQUENCY, AND DURATION
FROM FIGURE 8.03D (GREENSBORO)
10-YEAR INTENSITY 6.5 inches/hour ✓

DETERMINE THE PEAK DISCHARGE, Q
Q = CiA
Q= 10.71 cfs

STEP 2: DETERMINE THE SLOPE AND SELECT CHANNEL GEOMETRY AND LINING
STEP 3: DETERMINE THE PERMISSIBLE VELOCITY
DESIGN OF GRASS LINED CHANNEL

GRADE OF CHANNEL:	790-750	40 FT
LENGTH OF CHANNEL:	1070 FT	
SLOPE:	3.74%	
VEGETATION: TALL FESCUE		
SOIL: EROSION RESISTANT		
PERMISSIBLE VELOCITY (TABLE 8.05A)		5.5 ft/sec ✓

STEP 4: MAKE AN INITIAL ESTIMATE OF CHANNEL SIZE
PEAK DISCHARGE / PERMISSIBLE VELOCITY = REQUIRED AREA
10.71 cfs / 5.0 ft/sec = 1.95 sq. ft.

TRAPEZOIDAL CHANNEL	
BOTTOM WIDTH	3 ft
DEPTH	2 ft
SIDE WIDTH	4 ft
CROSS SECTIONAL AREA	14 sq ft

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STEP 5: CALCULATE THE HYDRAULIC RADIUS

HYDRAULIC RADIUS 1.17

STEP 6: DETERMINE THE ROUGHNESS COEFFICIENT, n

FROM TABLE 8.05E, MANNINGS n = 0.025

DETERMINING SHEAR STRESS

PERMISSIBLE SHEAR STRESS
= 2.00 lbs / sq ft for a synthetic mat (Table 8.05g)

SHEAR STRESS = T = yds Unit weight of water x flow depth x slope (ft/ft)
= (62.4 lbs/cu ft)*(0.39 ft)*(.0374) (0.39 ft depth based on Figure 8.05d)
= 0.91 lb/sq ft
The use of a synthetic mat (2.0 lb/sq. ft) is capable of providing the shear stress necessary.

STEP 7: CALCULATE THE ACTUAL CHANNEL VELOCITY

$V = 1.49/n*R^{2/3}*S^{1/2}$
V = 12.81 ft/sec

CALCULATE THE CHANNEL CAPACITY, Q
Q= AV
Q= 179.35 cu ft/sec

STEP 8: CHECK AGAINST RESULTS FOR PERMISSIBLE VELOCITY AND REQUIRED DESIGN CAPACITY

PERMISSIBLE VELOCITY = 5.5 ft/sec
ACTUAL VELOCITY= 12.81 ft/sec

* The channel shall be lined with a synthetic mat increasing the shear stress to permissible levels

MAXIMUM CHANNEL CAPACITY= 179.35 cu ft/sec
ACTUAL CHANNEL FLOW= 10.71 cu ft/sec

STEP 9: IF DESIGN IS NOT ACCEPTIBLE, ALTER CHANNEL DIMENSIONS.

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave., 2-7%	0.10-0.15
Sandy soil, steep, 7%	0.15-0.20
Heavy soil, flat, 2%	0.13-0.17
Heavy soil, ave., 2-7%	0.18-0.22
Heavy soil, steep, 7%	0.25-0.35
Agricultural land:	
Bare packed soil	
Smooth	0.30-0.60
Rough	0.20-0.50
Cultivated rows	
Heavy soil no crop	0.30-0.60
Heavy soil with crop	0.20-0.50
Sandy soil no crop	0.20-0.40
Sandy soil with crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

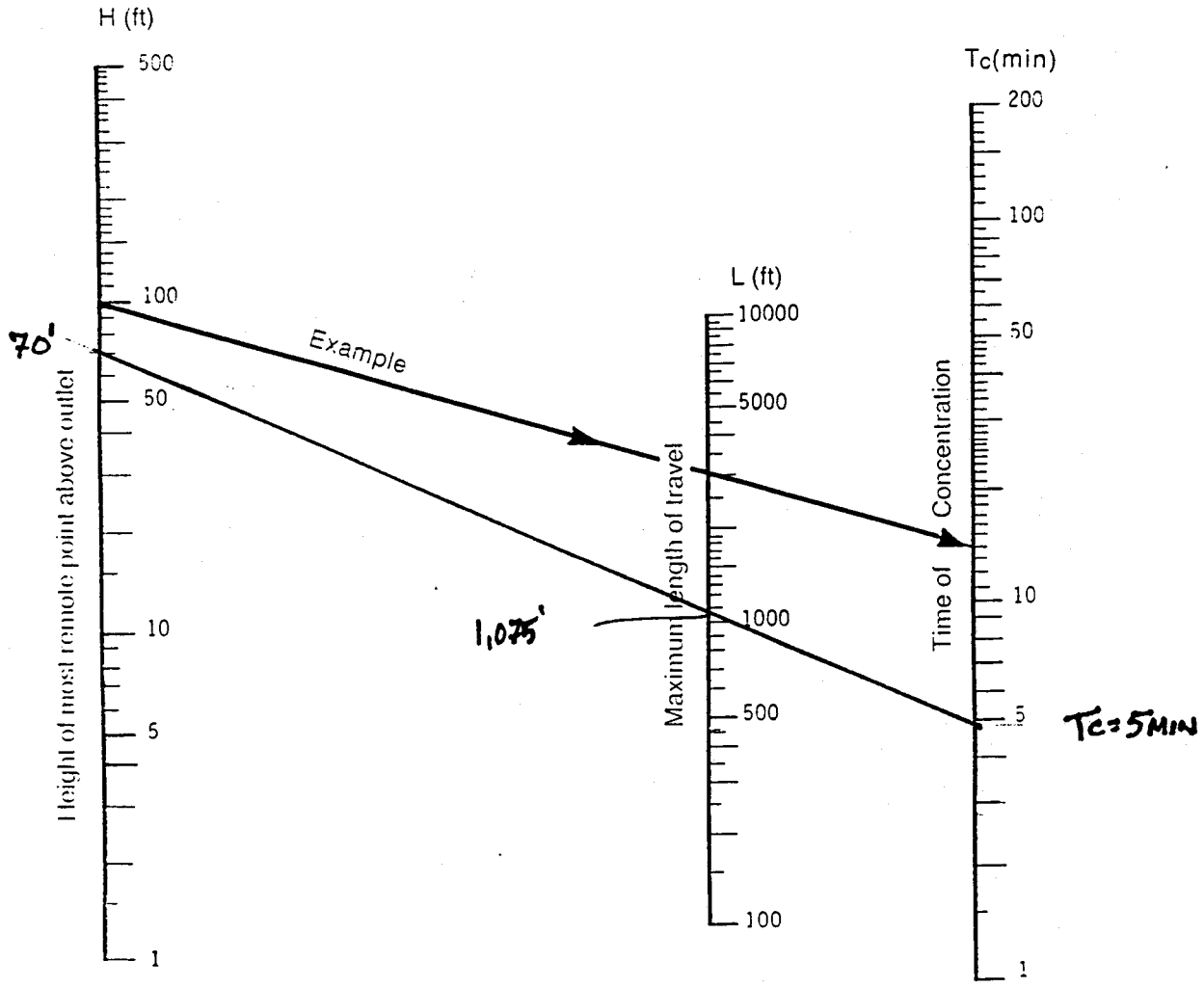
NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, Tc. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).



Note:
Use nomograph Tc for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply Tc by 2.

For overland flow, concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Figure 6.03a Time of concentration of small drainage basins.

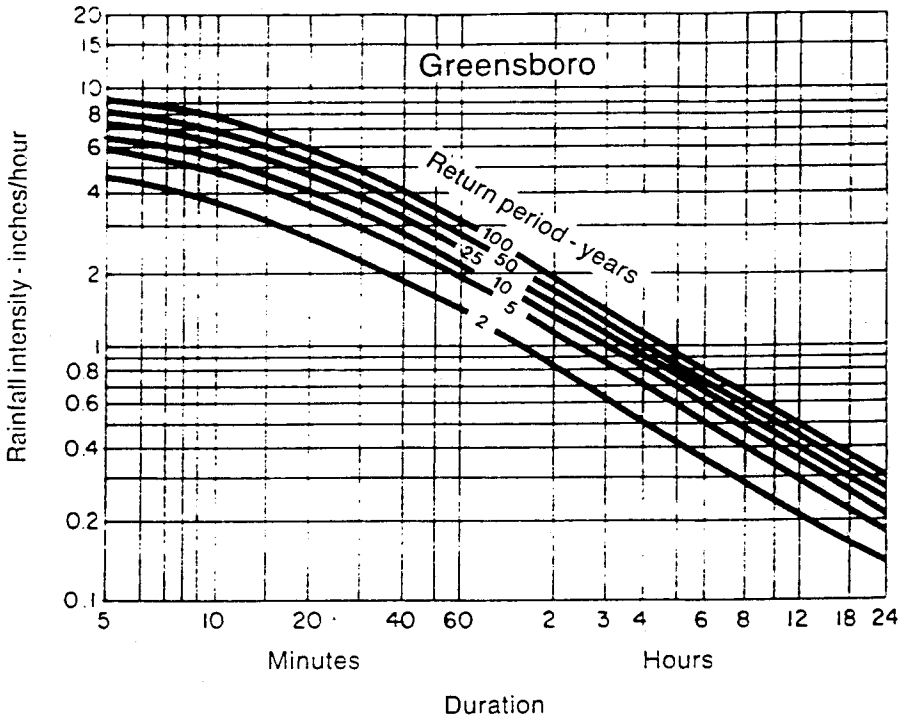


Figure 8.03d Rainfall intensity duration curves—Greensboro.

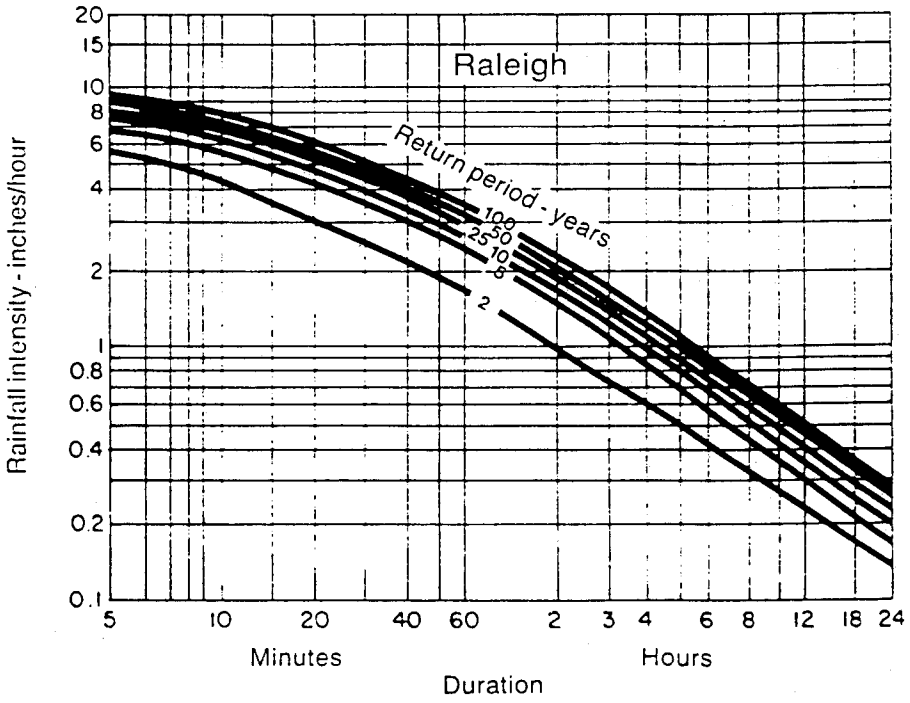


Figure 8.03e Rainfall intensity duration curves—Raleigh.

Table 8.05a
Maximum Allowable Design Velocities[1]
for Vegetated Channels

Typical Channel Slope Application	Soil Characteristics[2]	Grass Lining	Permissible Velocity[3] for Established Grass Lining (ft/sec)
0-5%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	5.0
		Tall fescue	4.5
		Bahiagrass	4.5
		Kentucky bluegrass	4.5
		Grass-legume mixture	3.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	6.0
		Tall fescue	5.5
		Bahiagrass	5.5
		Kentucky bluegrass	5.5
		Grass-legume mixture	4.5
5-10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	4.5
		Tall fescue	4.0
		Bahiagrass	4.0
		Kentucky bluegrass	4.0
		Grass-legume mixture	3.0
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	5.5
		Tall fescue	5.0
		Bahiagrass	5.0
		Kentucky bluegrass	5.0
		Grass-legume mixture	3.5
>10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	3.5
		Tall fescue	2.5
		Bahiagrass	2.5
		Kentucky bluegrass	2.5
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	4.5
		Tall fescue	3.5
		Bahiagrass	3.5
		Kentucky bluegrass	3.5

Source: USDA-SCS Modified

NOTE: [1]Permissible Velocity based on 10-yr storm peak runoff
[2]Soil erodibility based on resistance to soil movement from concentrated flowing water.
[3]Before grass is established, permissible velocity is determined by the type of temporary liner used.

Selecting Channel Cross-Section Geometry

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change throughout the length of a channel, subdivide the channel into design reaches, and design each reach to carry the appropriate capacity.

The three most commonly used channel cross-sections are "V"-shaped, parabolic, and trapezoidal. Figure 8.05b gives mathematical formulas for the area, hydraulic radius and top width of each of these shapes.

(continued)
Sample Problem 8.05a
Design of a
grass-lined channel.

Channel summary:
Trapezoidal shape. Z=3, b=3 ft, d=1.5 ft, grade = 2%

Note: In Sample Problem 8.05a the "n-value" is first choosen based on a permissible velocity and not a design velocity criteria. Therefore the use of table 8.05c may not be as accurate as individual retardance class charts when a design velocity is the determining factor.

Tractive Force Procedure

The design of riprap-lined channels and temporary channel linings is based on analysis of tractive force.

NOTE: This procedure is for uniform flow in channels and is *not* to be used for design of deenergizing devices and may not be valid for larger channels

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change through the length of a channel, subdivide the channel into design reaches as appropriate.

PERMISSIBLE SHEAR STRESS

The permissible shear stress, T_e, is the force required to initiate movement of the lining material. Permissible shear stress for the liner is not related to the erodibility of the underlying soil. However, if the lining is eroded or broken, the bed material will be exposed to the erosive force of the flow.

COMPUTING NORMAL DEPTH

The first step in selecting an appropriate lining is to compute the design flow depth (the normal depth) and determine the shear stress.

Normal depths can be calculated by Manning's equation as shown for trapezoidal channels in Figure 8.05d. Values of the Manning's roughness coefficient for different ranges of depth are provided in Table 8.05e for temporary linings and Table 8.05f for riprap. The coefficient of roughness generally decreases with increasing flow depth.

Table 8.05e
Manning's Roughness
Coefficients for Temporary
Lining Materials

	n value for Depth Ranges*		
	0-0.5 ft	0.5-2.0 ft	>2.0 ft
Lining Type			
Woven Paper Net	0.016	0.015	0.015
Jute Net	0.028	0.022	0.019
Fiberglass Roving	0.028	0.021	0.019
Straw with Net	0.065	0.033	0.025
Curled Wood Mat	0.066	0.035	0.028
Synthetic Mat	0.036	0.025	0.021

* Adapted from: FHWA-HEC 15, Pg. 37 - April 1988

Table 8.05g
Permissible Shear Stresses for Riprap and Temporary Liners

Lining Category	Permissible Unit Shear Stress, T_d Lining Type	(lb/ft^2)
Temporary	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	
	Single	0.60
	Double	0.85
	Straw with Net	1.45
	Curled Wood mat	1.55
	Synthetic Mat	2.00
	d_{50} Stone Size (inches)	
Gravel Riprap	1	0.33
	2	0.67
Rock Riprap	6	2.00
	9	3.00
	12	4.00
	15	5.00
	18	6.00
	21	7.00
	24	8.00

Adapted From: FHWA, HEC-15, April 1988, pgs. 17 & 37.

Design Procedure-Temporary Liners

The following is a step-by-step procedure for designing a temporary liner for a channel. Because temporary liners have a short period of service, the design Q may be reduced. For liners that are needed for six months or less, the 2-yr frequency storm is recommended.

Step 1. Select a liner material suitable for site conditions and application. Determine roughness coefficient from manufacturer's specifications or Table 8.05e, pg. 8.05.10.

Step 2. Calculate the normal flow depth using Manning's equation (Figure 8.05d). Check to see that depth is consistent with that assumed for selection of Manning's n in Figure 8.05d, pg. 8.05.11. For smaller runoffs Figure 8.05d is not as clearly defined. Recommended solutions can be determined by using the Manning equation.

Step 3. Calculate shear stress at normal depth.

Step 4. Compare computed shear stress with the permissible shear stress for the liner.

Step 5. If computed shear is greater than permissible shear, adjust channel dimensions to reduce shear or select a more resistant lining and repeat steps 1 through 4.

Design of a channel with temporary lining is illustrated in Sample Problem 8.05b, pg. 8.05.14.

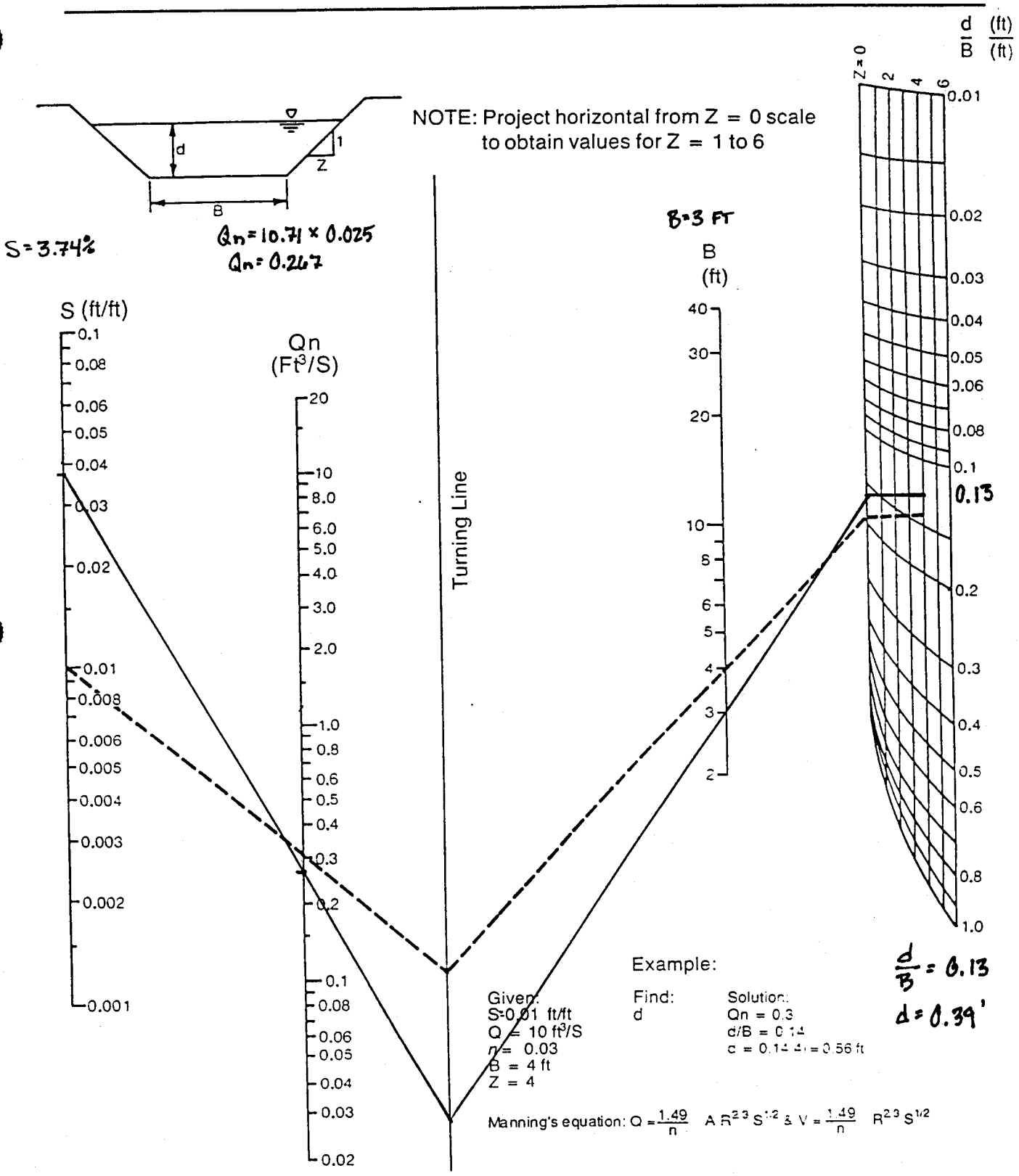
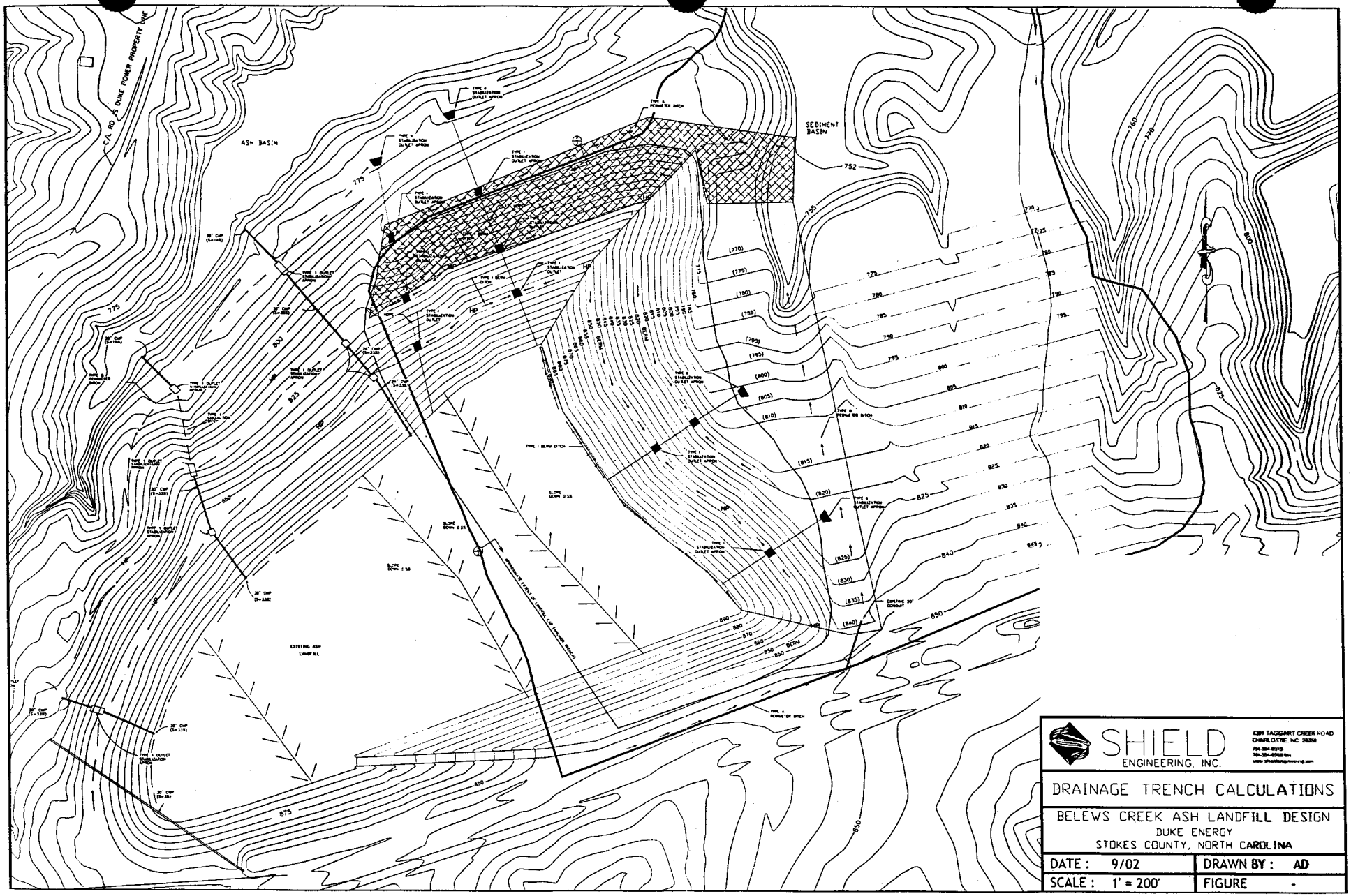


Figure 8.05d Solution of Manning's equation for trapezoidal channels of various side slopes.
Adapted from: FHWA-HEC. 15, Pg 40 - April 1988



SHIELD ENGINEERING, INC.

4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28269

DRAINAGE TRENCH CALCULATIONS

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 9/02	DRAWN BY : AD
SCALE : 1" = 200'	FIGURE -

RAG
10/9/02

BELEWS CREEK
EROSION AND SEDIMENT CONTROL PLAN
TYPE "A" PERIMETER DITCH DESIGN

STEP 1: DETERMINE THE REQUIRED FLOW CAPACITY

DRAINAGE AREA: USE ONLY SOUTHERN FACE (SLOPED) AREA
297,900 SQUARE FEET
6.8 ACRES (SEE FIGURES)

DETERMINE THE RUNOFF COEFFICIENT

DRAINAGE AREA	297,900 SQUARE FEET
MAXIMUM SLOPE LENGTH	1,500 FEET
ELEVATION DROP	50 FEET
SLOPE	3.3 %
LOCATION	STOKES COUNTY (USE GREENSBORO MAP)

FROM TABLE 8.03A
LAND USE: BARE PACKED SOIL - TEMPORARY COVER (0.30 - 0.60) ✓
USE C = 0.45

DETERMINE THE TIME OF CONCENTRATION
FROM FIGURE 8.03A
Tc= 8 MIN ✓

DETERMINE THE RAINFALL INTENSITY, FREQUENCY, AND DURATION
FROM FIGURE 8.03D (GREENSBORO)
10-YEAR INTENSITY 5.9 inches/hour ✓

DETERMINE THE PEAK DISCHARGE, Q
Q = CiA
Q= 18.16 cfs ✓

STEP 2: DETERMINE THE SLOPE AND SELECT CHANNEL GEOMETRY AND LINING
STEP 3: DETERMINE THE PERMISSIBLE VELOCITY
DESIGN OF GRASS LINED CHANNEL

GRADE OF CHANNEL:	750-740= 10 FT
LENGTH OF CHANNEL:	1500 FT
SLOPE:	0.67%
VEGETATION: TALL FESCUE	
SOIL: EROSION RESISTANT	
PERMISSIBLE VELOCITY (TABLE 8.05A)	5.5 ft/sec ✓

STEP 4: MAKE AN INITIAL ESTIMATE OF CHANNEL SIZE
PEAK DISCHARGE / PERMISSIBLE VELOCITY = REQUIRED AREA
18.16 cfs / 5.0 ft/sec = 3.30 sq. ft.

TRAPEZOIDAL CHANNEL	
BOTTOM WIDTH	3 ft
DEPTH	2 ft
SIDE WIDTH	4 ft
CROSS SECTIONAL AREA	14 sq ft

RAY
10/9/02

STEP 5: CALCULATE THE HYDRAULIC RADIUS

HYDRAULIC RADIUS 1.17 ✓

STEP 6: DETERMINE THE ROUGHNESS COEFFICIENT, n

FOR A SYNTHETIC MAT LINER:

FROM TABLE 8.05E, MANNINGS n = 0.025 ✓

DETERMINING SHEAR STRESS

PERMISSIBLE SHEAR STRESS

= 2.0 lbs / sq ft for a synthetic mat ✓

SHEAR STRESS = T = yds Unit weight of water x flow depth x slope (ft/ft)

= (62.4 lbs/cu ft)*(0.87 ft)*(.0067) (0.87 ft depth based on Figure 8.05d)

= 0.36 lb/sq ft

The use of a synthetic mat will provide the shear stress (2.0 lb/sq. ft.) necessary. ✓

STEP 7: CALCULATE THE ACTUAL CHANNEL VELOCITY

$V = 1.49/n*R^{2/3}*S^{1/2}$

V = 5.41 ft/sec ✓

CALCULATE THE CHANNEL CAPACITY, Q

Q= AV

Q= 75.74 cu ft/sec ✓

STEP 8: CHECK AGAINST RESULTS FOR PERMISSIBLE VELOCITY AND REQUIRED DESIGN CAPACITY ✓

PERMISSIBLE VELOCITY = 5.5 ft/sec

ACTUAL VELOCITY= 5.41 ft/sec

* The channel shall be lined with a synthetic mat liner increasing the shear stress to permissible levels

MAXIMUM CHANNEL CAPACITY= 75.74 cu ft/sec ✓

ACTUAL CHANNEL FLOW= 18.16 cu ft/sec

STEP 9: IF DESIGN IS NOT ACCEPTIBLE, ALTER CHANNEL DIMENSIONS.

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave., 2-7%	0.10-0.15
Sandy soil, steep, 7%	0.15-0.20
Heavy soil, flat, 2%	0.13-0.17
Heavy soil, ave., 2-7%	0.18-0.22
Heavy soil, steep, 7%	0.25-0.35
Agricultural land:	
Bare packed soil	
Smooth	0.30-0.60
Rough	0.20-0.50
Cultivated rows	
Heavy soil no crop	0.30-0.60
Heavy soil with crop	0.20-0.50
Sandy soil no crop	0.20-0.40
Sandy soil with crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

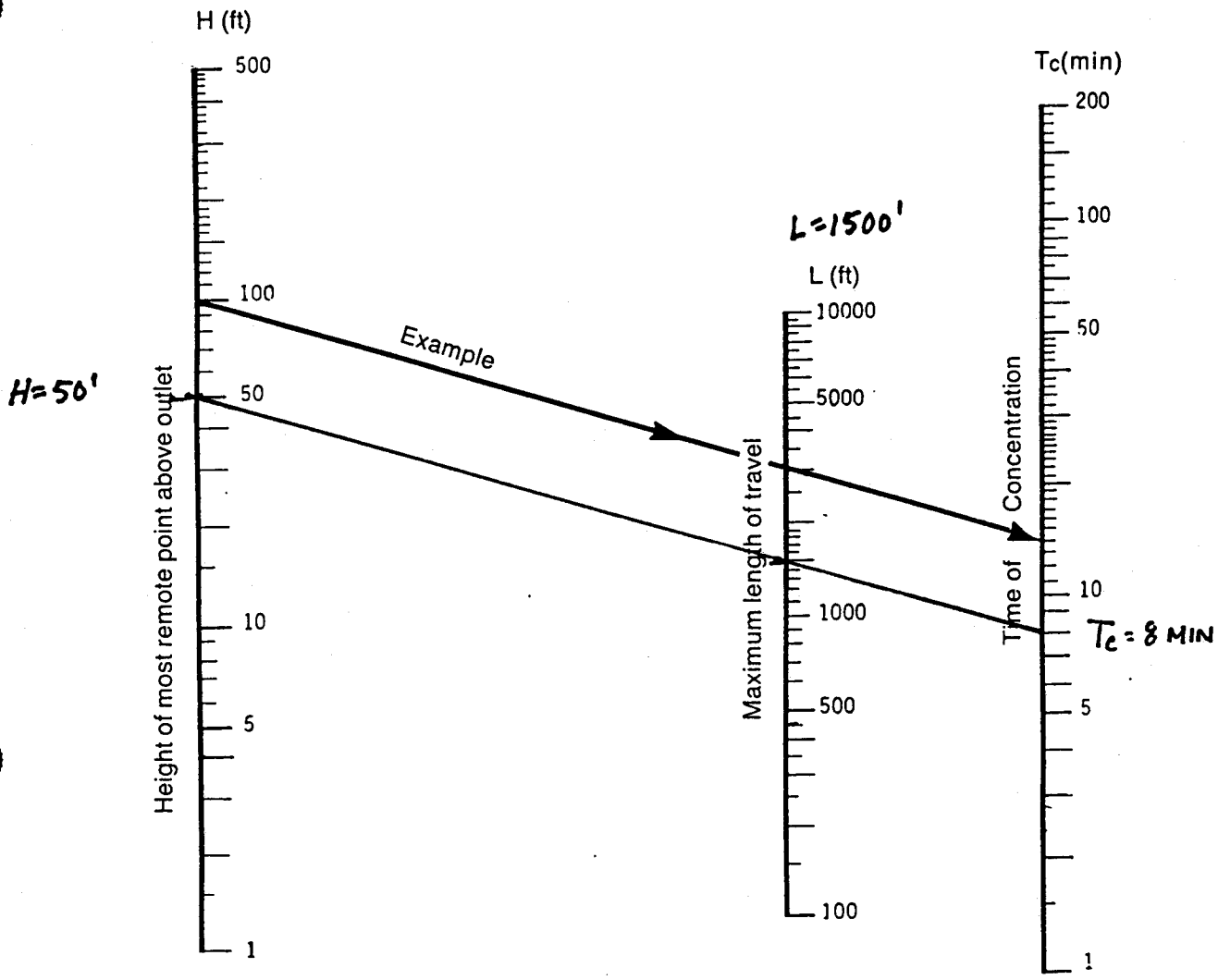
Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, Tc. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).

TYPE A PERIMETER DITCH



Note:
Use nomograph Tc for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply Tc by 2.

For overland flow, concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Figure 8.03a Time of concentration of small drainage basins.

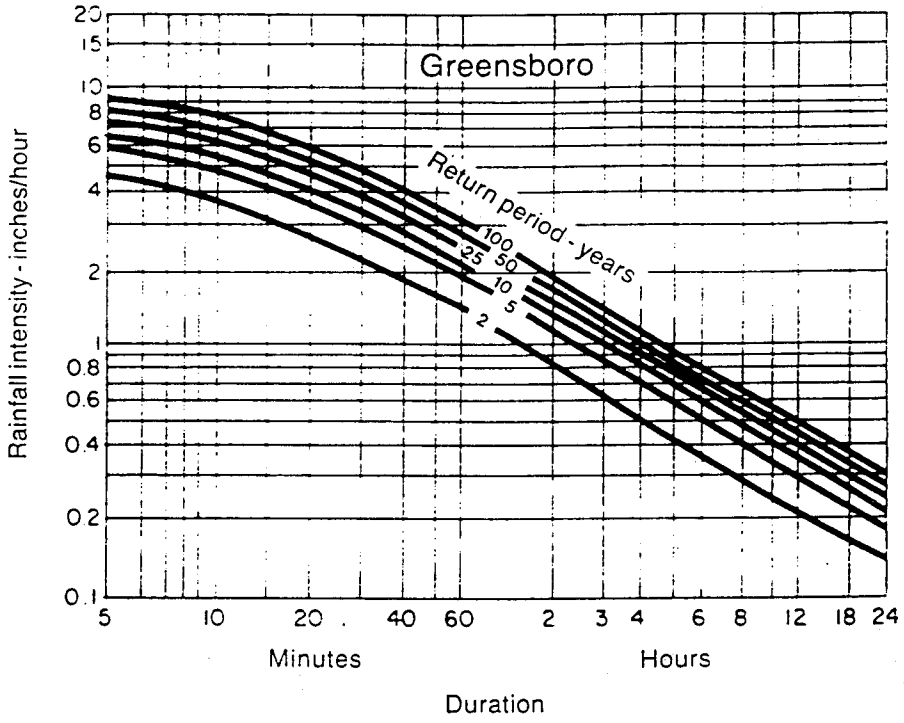


Figure 8.03d Rainfall intensity duration curves—Greensboro.

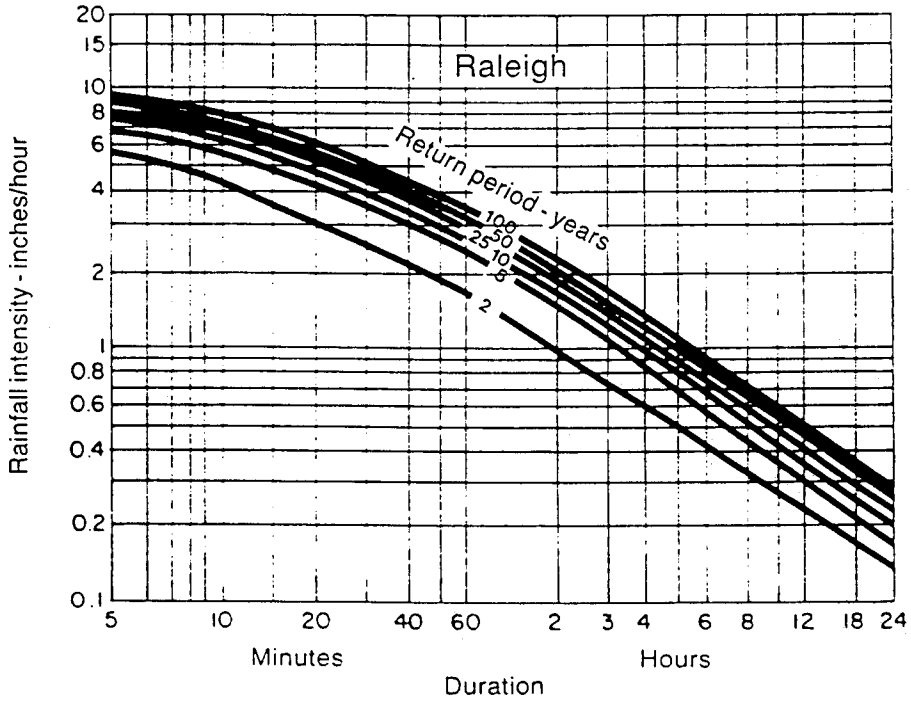


Figure 8.03e Rainfall intensity duration curves—Raleigh.

Table 8.05a
Maximum Allowable Design Velocities[1]
for Vegetated Channels

Typical Channel Slope Application	Soil Characteristics[2]	Grass Lining	Permissible Velocity[3] for Established Grass Lining (ft/sec)
0-5%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	5.0
		Tall fescue	4.5
		Bahiagrass	4.5
		Kentucky bluegrass	4.5
		Grass-legume mixture	3.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	6.0
		Tall fescue	5.5
		Bahiagrass	5.5
		Kentucky bluegrass	5.5
		Grass-legume mixture	4.5
5-10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	4.5
		Tall fescue	4.0
		Bahiagrass	4.0
		Kentucky bluegrass	4.0
		Grass-legume mixture	3.0
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	5.5
		Tall fescue	5.0
		Bahiagrass	5.0
		Kentucky bluegrass	5.0
		Grass-legume mixture	3.5
>10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	3.5
		Tall fescue	2.5
		Bahiagrass	2.5
		Kentucky bluegrass	2.5
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	4.5
		Tall fescue	3.5
		Bahiagrass	3.5
		Kentucky bluegrass	3.5

Source: USDA-SCS Modified

NOTE: [1]Permissible Velocity based on 10-yr storm peak runoff
[2]Soil erodibility based on resistance to soil movement from concentrated flowing water.
[3]Before grass is established, permissible velocity is determined by the type of temporary liner used.

Selecting Channel Cross-Section Geometry

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change throughout the length of a channel, subdivide the channel into design reaches, and design each reach to carry the appropriate capacity.

The three most commonly used channel cross-sections are "V"-shaped, parabolic, and trapezoidal. Figure 8.05b gives mathematical formulas for the area, hydraulic radius and top width of each of these shapes.

(continued)
Sample Problem 8.05a
Design of a
grass-lined channel.

Channel summary:
Trapezoidal shape, Z=3, b=3 ft, d=1.5 ft, grade = 2%

Note: In Sample Problem 8.05a the "n-value" is first choosen based on a permissible velocity and not a design velocity criteria. Therefore the use of table 8.05c may not be as accurate as individual retardance class charts when a design velocity is the determining factor.

Tractive Force Procedure

The design of riprap-lined channels and temporary channel linings is based on analysis of tractive force.

NOTE: **This procedure is for uniform flow in channels and is *not* to be used for design of deenergizing devices and may not be valid for larger channels**

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change through the length of a channel, subdivide the channel into design reaches as appropriate.

PERMISSIBLE SHEAR STRESS

The permissible shear stress, T_d, is the force required to initiate movement of the lining material. Permissible shear stress for the liner is not related to the erodibility of the underlying soil. However, if the lining is eroded or broken, the bed material will be exposed to the erosive force of the flow.

COMPUTING NORMAL DEPTH

The first step in selecting an appropriate lining is to compute the design flow depth (the normal depth) and determine the shear stress.

Normal depths can be calculated by Manning's equation as shown for trapezoidal channels in Figure 8.05d. Values of the Manning's roughness coefficient for different ranges of depth are provided in Table 8.05e for temporary linings and Table 8.05f for riprap. The coefficient of roughness generally decreases with increasing flow depth.

Table 8.05e
Manning's Roughness
Coefficients for Temporary
Lining Materials

	n value for Depth Ranges*		
	0-0.5 ft	0.5-2.0 ft	>2.0 ft
Lining Type			
Woven Paper Net	0.016	0.015	0.015
Jute Net	0.028	0.022	0.019
Fiberglass Roving	0.028	0.021	0.019
Straw with Net	0.065	0.033	0.025
Curled Wood Mat	0.066	0.035	0.028
Synthetic Mat	0.036	0.025	0.021

* Adapted from: FHWA-HEC 15, Pg. 37 - April 1988

Table 8.05g
Permissible Shear Stresses for Riprap and Temporary Liners

Lining Category	Lining Type	Permissible Unit Shear Stress, T_d (lb/ft^2)
Temporary	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	
	Single	0.60
	Double	0.85
	Straw with Net	1.45
	Curled Wood mat	1.55
	Synthetic Mat	2.00
	C_{50} Stone Size (inches)	
Gravel Riprap	1	0.33
	2	0.67
Rock Riprap	6	2.00
	9	3.00
	12	4.00
	15	5.00
	18	6.00
	21	7.00
	24	8.00

Adapted From: FHWA, HEC-15, April 1988, pgs. 17 & 37.

Design Procedure-Temporary Liners

The following is a step-by-step procedure for designing a temporary liner for a channel. Because temporary liners have a short period of service, the design Q may be reduced. For liners that are needed for six months or less, the 2-yr frequency storm is recommended.

Step 1. Select a liner material suitable for site conditions and application. Determine roughness coefficient from manufacturer's specifications or Table 8.05e, pg. 8.05.10.

Step 2. Calculate the normal flow depth using Manning's equation (Figure 8.05d). Check to see that depth is consistent with that assumed for selection of Manning's n in Figure 8.05d, pg. 8.05.11. For smaller runoffs Figure 8.05d is not as clearly defined. Recommended solutions can be determined by using the Manning equation.

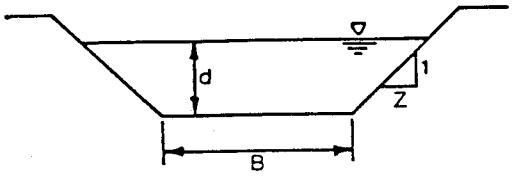
Step 3. Calculate shear stress at normal depth.

Step 4. Compare computed shear stress with the permissible shear stress for the liner.

Step 5. If computed shear is greater than permissible shear, adjust channel dimensions to reduce shear or select a more resistant lining and repeat steps 1 through 4.

Design of a channel with temporary lining is illustrated in Sample Problem 8.05b, pg. 8.05.14.

TYPE "A"



NOTE: Project horizontal from Z = 0 scale to obtain values for Z = 1 to 6

$Q_n = 18.16 \times 0.025$
$= 0.454$

S = .67%

B = 3

S (ft/ft)

Qn (Ft^3/S)

Turning Line

B (ft)

d/B (ft/ft)

Z = 0, 2, 4, 6

= 0.29

Example:

Given:
S = 0.01 ft/ft
Q = 10 ft^3/S
n = 0.03
B = 4 ft
Z = 4

Find:
d

Solution:
Qn = 0.3
d/B = 0.14
d = 0.14(4) = 0.56 ft

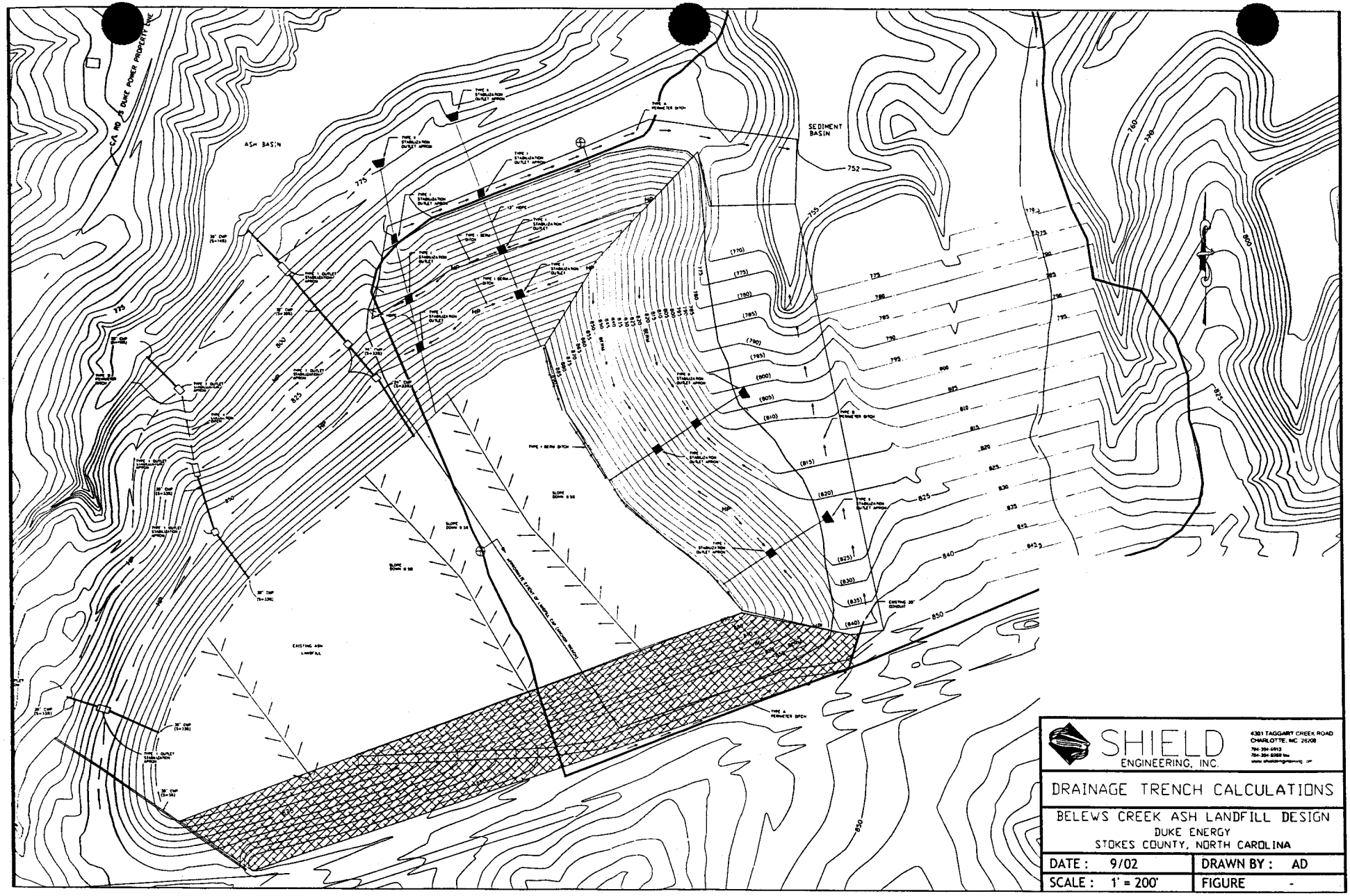
Manning's equation: $Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$ & $V = \frac{1.49}{n} R^{2/3} S^{1/2}$

$\frac{d}{B} = 0.29$

$d = 3 \cdot 0.29$

$d = 0.87$ FT

Figure 8.05d Solution of Manning's equation for trapezoidal channels of various side slopes.
Adapted from: FHWA-HEC. 15, Pg 40 - April 1988



SHIELD ENGINEERING, INC.

4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28208
704-394-6913
704-394-6982 fax
www.shieldengineering.com

DRAINAGE TRENCH CALCULATIONS

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 9/02	DRAWN BY : AD
SCALE : 1" = 200'	FIGURE -

KAO
10/9/02

BELEWS CREEK
EROSION AND SEDIMENT CONTROL PLAN
TYPE "B" PERIMETER DITCH DESIGN

STEP 1: DETERMINE THE REQUIRED FLOW CAPACITY

DRAINAGE AREA: USE ONLY SOUTHERN FACE (SLOPED) AREA
514,564 SQUARE FEET
11.8 ACRES (SEE FIGURES)

DETERMINE THE RUNOFF COEFFICIENT

DRAINAGE AREA	514,564 SQUARE FEET
MAXIMUM SLOPE LENGTH	1,350 FEET
ELEVATION DROP	140 FEET
SLOPE	10.4 %
LOCATION	STOKES COUNTY (USE GREENSBORO MAP)

FROM TABLE 8.03A
LAND USE: BARE PACKED SOIL - TEMPORARY COVER (0.30 - 0.60) ✓
USE C = 0.45

DETERMINE THE TIME OF CONCENTRATION
FROM FIGURE 8.03A
Tc= 15.5 MIN ✓

DETERMINE THE RAINFALL INTENSITY, FREQUENCY, AND DURATION
FROM FIGURE 8.03D (GREENSBORO)
10-YEAR INTENSITY 4.8 inches/hour ✓

DETERMINE THE PEAK DISCHARGE, Q
Q = CiA
Q= 25.52 cfs ✓ must add flow from Type A perimeter ditch (18.16 cfs)
43.68 cfs ✓

STEP 2: DETERMINE THE SLOPE AND SELECT CHANNEL GEOMETRY AND LINING
STEP 3: DETERMINE THE PERMISSIBLE VELOCITY
DESIGN OF CHANNEL
GRADE OF CHANNEL: 840-750 90 FT ✓
LENGTH OF CHANNEL: 1315 FT
SLOPE: 6.84%
PERMISSIBLE VELOCITY : Not necessary, shear stresses in channel to be analyzed

STEP 4: MAKE AN INITIAL ESTIMATE OF CHANNEL SIZE

TRAPEZOIDAL CHANNEL	
BOTTOM WIDTH	5 ft
DEPTH	2 ft
SIDE WIDTH	4 ft
CROSS SECTIONAL AREA	18 sq ft

SRA
10/9/02

STEP 5: CALCULATE THE HYDRAULIC RADIUS

HYDRAULIC RADIUS 1.29 ✓

STEP 6: DETERMINE THE ROUGHNESS COEFFICIENT, n

FROM TABLE 8.05F, MANNINGS n = 0.078 Rock rip-rap 0.5-2.0 depth ✓

DETERMINING SHEAR STRESS

PERMISSIBLE SHEAR STRESS (Table 8.05g) ✓
= 5.00 lbs / sq ft for 15 inch rock rip-rap

SHEAR STRESS = T = yds Unit weight of water x flow depth x slope (ft/ft) ✓
= (62.4 lbs/cu ft)*(1.05 ft)*(.0684) (1.05 ft depth based on Figure 8.05d)
= 4.48 lb/sq ft

The use of 15" rip-rap is capable of providing the shear stress necessary (Table 8.05g).

STEP 7: CALCULATE THE ACTUAL CHANNEL VELOCITY

$V = 1.49/n*R^{2/3}*S^{1/2}$

V = 5.92 ft/sec

CALCULATE THE CHANNEL CAPACITY, Q

Q= AV

Q= 106.64 cu ft/sec

STEP 8: CHECK AGAINST RESULTS FOR PERMISSIBLE VELOCITY AND REQUIRED DESIGN CAPACITY

PERMISSIBLE VELOCITY = NA ft/sec

ACTUAL VELOCITY= 5.92 ft/sec

* The channel shall be lined with 15" rip-rap increasing the shear stress to permissible levels

MAXIMUM CHANNEL CAPACITY= 106.64 cu ft/sec ✓

ACTUAL CHANNEL FLOW= 43.68 cu ft/sec

STEP 9: IF DESIGN IS NOT ACCEPTIBLE, ALTER CHANNEL DIMENSIONS.

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C	Land Use	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighborhood areas	0.50-0.70	Sandy soil, ave., 2-7%	0.10-0.15
		Sandy soil, steep, 7%	0.15-0.20
Residential:		Heavy soil, flat, 2%	0.13-0.17
Single-family areas	0.30-0.50	Heavy soil, ave., 2-7%	0.18-0.22
Multi units, detached	0.40-0.60	Heavy soil, steep, 7%	0.25-0.35
Multi units, attached	0.60-0.75		
Suburban	0.25-0.40	Agricultural land:	
		Bare packed soil	
Industrial:		Smooth	0.30-0.60
Light areas	0.50-0.80	Rough	0.20-0.50
Heavy areas	0.60-0.90	Cultivated rows	
		Heavy soil no crop	0.30-0.60
Parks, cemeteries	0.10-0.25	Heavy soil with crop	0.20-0.50
		Sandy soil no crop	0.20-0.40
Playgrounds	0.20-0.35	Sandy soil with crop	0.10-0.25
		Pasture	
Railroad yard areas	0.20-0.40	Heavy soil	0.15-0.45
		Sandy soil	0.05-0.25
Unimproved areas	0.10-0.30	Woodlands	0.05-0.25
Streets:			
Asphalt	0.70-0.95		
Concrete	0.80-0.95		
Brick	0.70-0.85		
Drives and walks	0.75-0.85		
Roofs	0.75-0.85		

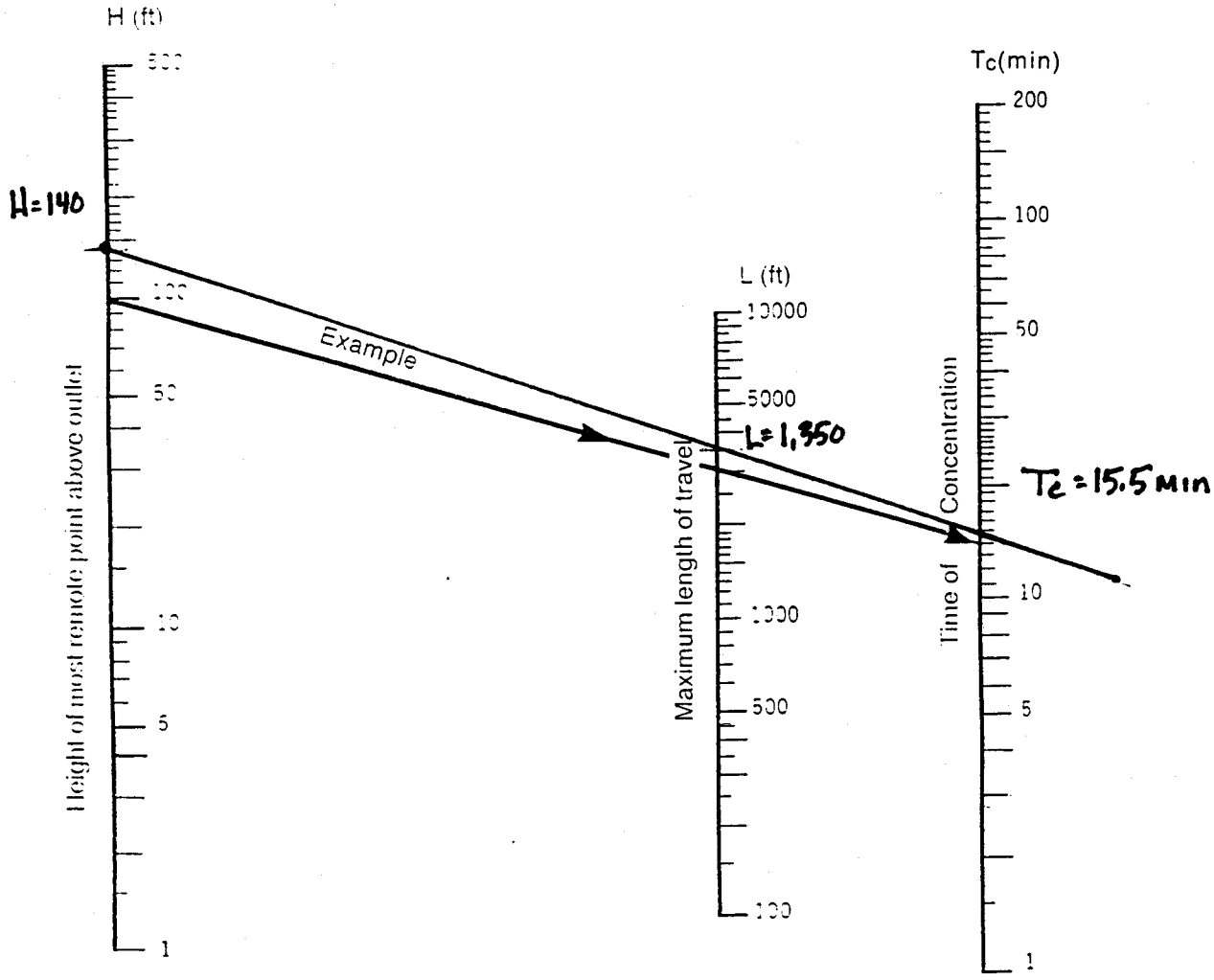
NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, T_C. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).



Note:
Use nomograph Tc for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels

For overland flow, grassed surfaces, multiply Tc by 2.

For overland flow, concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Figure 8.03a Time of concentration of small drainage basins.

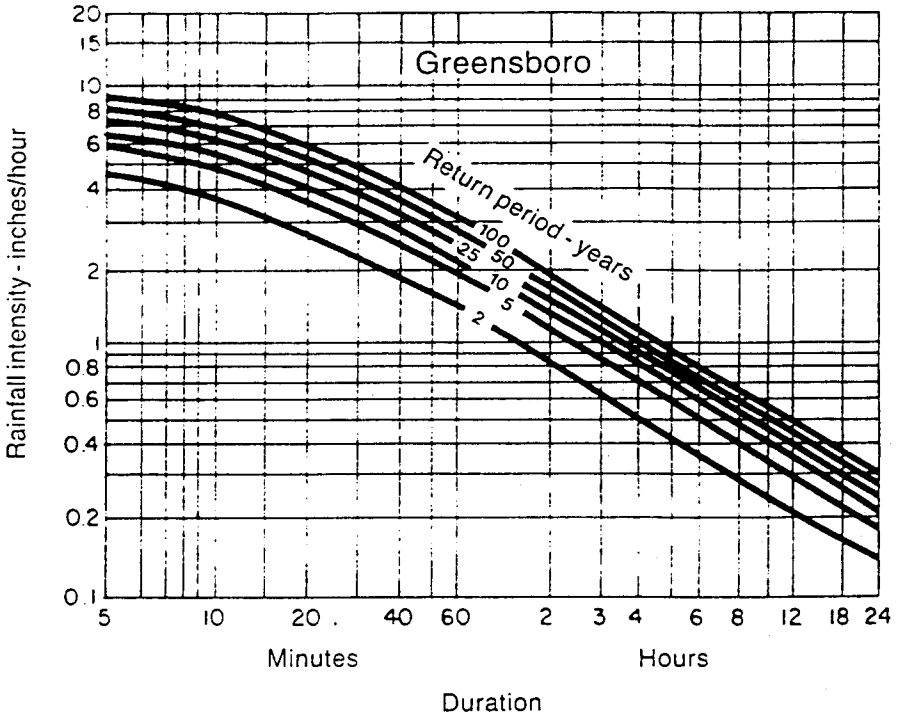


Figure 8.03d Rainfall intensity duration curves—Greensboro.

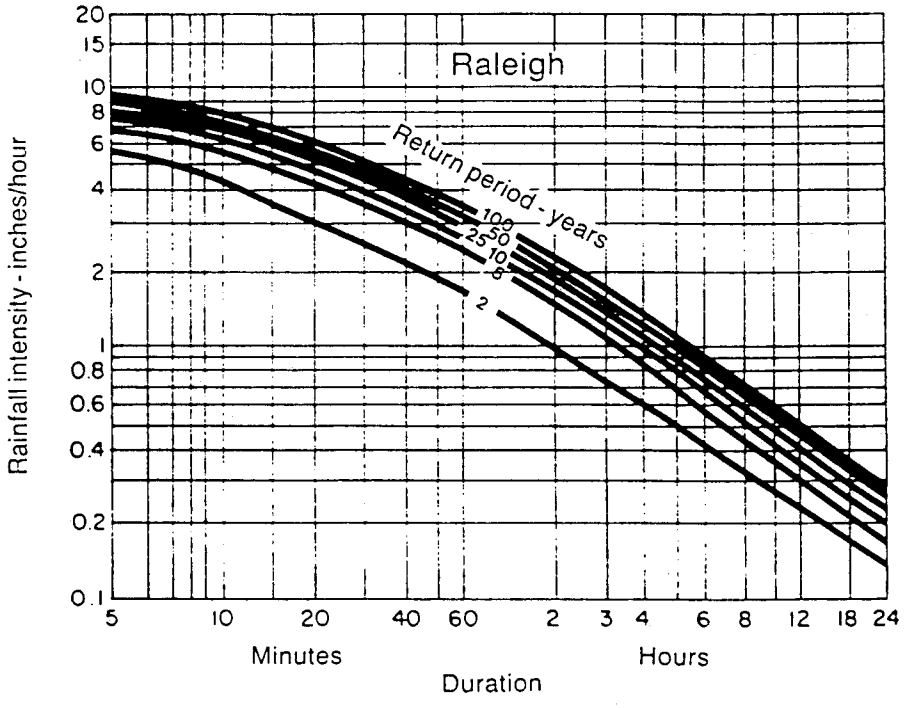


Figure 8.03e Rainfall intensity duration curves—Raleigh.

Table 8.05f Manning's Roughness Coefficient

Lining Category	Lining Type	*n* - value: *n* value for Depth Ranges 0-0.5 ft (0-15 cm)	0.5-2.0 ft (15-60 cm)	2.0 ft (> 60 cm)
Rigid	Concrete	0.015	0.013	0.013
	Grouted Riprap	0.040	0.030	0.028
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.023	0.020	0.020
	Rock Cut	0.045	0.035	0.025
Gravel Riprap	1-inch (2.5-cm) D_{50}	0.044	0.033	0.030
	2-inch (5-cm) D_{50}	0.066	0.041	0.034
Rock Riprap	6-inch (15-cm) D_{50}	0.104	0.069	0.035
	12-inch (30-cm) D_{50}	--	0.078	0.040

Note: Values listed are representative values for the respective depth ranges. Manning's roughness coefficients, *n*, vary with the flow depth.

DETERMINING SHEAR STRESS

Shear stress, T, at normal depth is computed for the lining by the following equation:

$$T = yds$$

Td = Permissible shear stress

where:

T = shear stress in lb/ft^2
y = unit weight of water, 62.4 lb/ft^3
d = flow depth in ft
s = channel gradient in ft/ft.

If the permissible shear stress, T_d, given in Table 8.05g is greater than the computed shear stress, the riprap or temporary lining is considered acceptable. If a lining is unacceptable, select a lining with a higher permissible shear stress and repeat the calculations for normal depth and shear stress. In some cases it may be necessary to alter channel dimensions to reduce the shear stress.

Computing tractive force around a channel bend requires special considerations because the change in flow direction imposes higher shear stress on the channel bottom and banks. The maximum shear stress in a bend, T_b, is given by the following equation:

$$T_b = K_b T$$

where:

T_b = bend shear stress in lb/ft^2
K_b = bend factor
T = computed stress for straight channel in lb/ft^2

The value of K_b is related to the radius of curvature of the channel at its center line, R_c, and the bottom width of the channel, B, Figure 8.05e. The length of channel requiring protection downstream from a bend, L_p, is a function of the roughness of the lining material and the hydraulic radius as shown in Figure 8.05f.

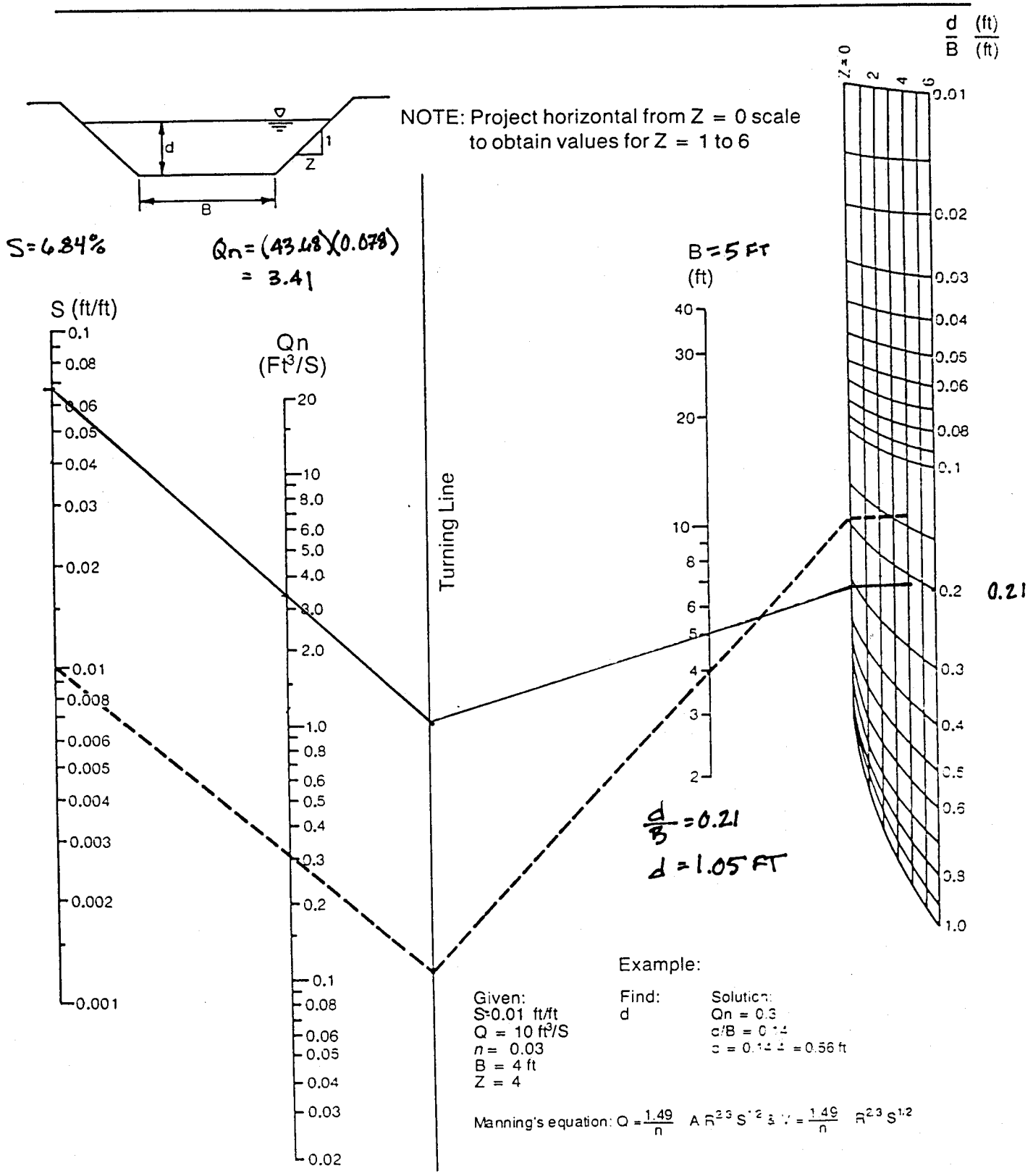


Figure 8.05d Solution of Manning's equation for trapezoidal channels of various side slopes.
Adapted from: FHWA-HEC. 15, Pg 40 - April 1988

Table 8.05g
Permissible Shear Stresses for Riprap and Temporary Liners

Lining Category	Permissible Unit Shear Stress, T_d Lining Type	(lb/ft^2)
Temporary	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	
	Single	0.60
	Double	0.85
	Straw with Net	1.45
	Curled Wood mat	1.55
	Synthetic Mat	2.00
	d_{50} **Stone Size** (inches)	
Gravel Riprap	1	0.33
	2	0.67
Rock Riprap	6	2.00
	9	3.00
	12	4.00
	15	5.00
	18	6.00
	21	7.50
	24	8.00

Adapted From: FHWA, HEC-15, April 1988, pgs. 17 & 37.

Design Procedure-Temporary Liners

The following is a step-by-step procedure for designing a temporary liner for a channel. Because temporary liners have a short period of service, the design Q may be reduced. For liners that are needed for six months or less, the 2-yr frequency storm is recommended.

Step 1. Select a liner material suitable for site conditions and application. Determine roughness coefficient from manufacturer's specifications or Table 8.05e, pg. 8.05.10.

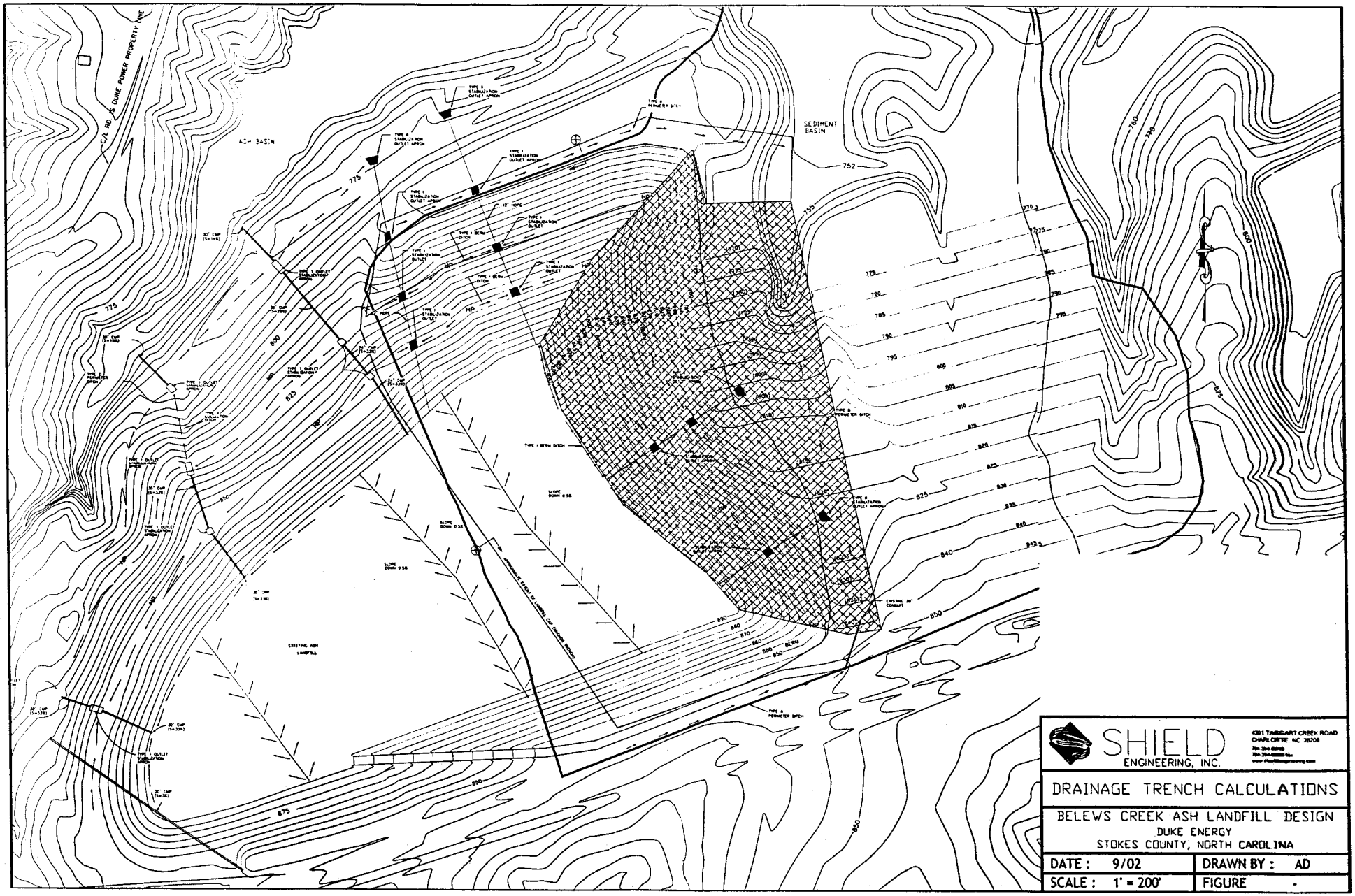
Step 2. Calculate the normal flow depth using Manning's equation (Figure 8.05d). Check to see that depth is consistent with that assumed for selection of Manning's n in Figure 8.05d, pg. 8.05.11. For smaller runoffs Figure 8.05d is not as clearly defined. Recommended solutions can be determined by using the Manning equation.

Step 3. Calculate shear stress at normal depth.

Step 4. Compare computed shear stress with the permissible shear stress for the liner.

Step 5. If computed shear is greater than permissible shear, adjust channel dimensions to reduce shear or select a more resistant lining and repeat steps 1 through 4.

Design of a channel with temporary lining is illustrated in Sample Problem 8.05b, pg. 8.05.14.



SHIELD ENGINEERING, INC.

4301 TARGART CREEK ROAD
CHARLOTTE, NC 28208

DRAINAGE TRENCH CALCULATIONS

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 9/02	DRAWN BY : AD
SCALE : 1" = 200'	FIGURE -

TRD
10/9/02

Duke Energy
Belews Creek Ash Landfill
Drainage pipe - 12 inch diameter, Area #1

Area #2:	166,072 square feet 3.81 acres
Runoff (25-year storm) Area: Maximum Slope Length: Elevation Drop: Slope: Location:	 3.81 acres 400 feet 3 feet 0.75% Winston-Salem, NC ✓
From Table 8.03A	Use agricultural land (will be cover & temporary seeding) Smooth packed surface --> c = 0.30 - 0.60 Use c = 0.45 ✓
From Figure 8.03A:	With height of 5 feet Maximum length of travel: 210 ✓ Time of Concentration: 4.0 min
From Figure 8.03D:	Using Greensboro Data Intensity = 6.2 in/hr ✓
Calculate Flow	Q = cia Q= 10.64 cfs ✓

Based on spreadsheet calculations:
Theta = 255 degrees
Depth of flow in 12" pipe = 9.65 inches ✓

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C	Land Use	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighborhood areas	0.50-0.70	Sandy soil, ave., 2-7%	0.10-0.15
		Sandy soil, steep, 7%	0.15-0.20
Residential:		Heavy soil, flat, 2%	0.13-0.17
Single-family areas	0.30-0.50	Heavy soil, ave., 2-7%	0.18-0.22
Multi units, detached	0.40-0.60	Heavy soil, steep, 7%	0.25-0.35
Multi units, attached	0.60-0.75		
Suburban	0.25-0.40	Agricultural land:	
		Bare packed soil	
Industrial:		Smooth	0.30-0.60
Light areas	0.50-0.80	Rough	0.20-0.50
Heavy areas	0.60-0.90	Cultivated rows	
		Heavy soil no crop	0.30-0.60
Parks, cemeteries	0.10-0.25	Heavy soil with crop	0.20-0.50
		Sandy soil no crop	0.20-0.40
Playgrounds	0.20-0.35	Sandy soil with crop	0.10-0.25
		Pasture	
Railroad yard areas	0.20-0.40	Heavy soil	0.15-0.45
		Sandy soil	0.05-0.25
Unimproved areas	0.10-0.30	Woodlands	0.05-0.25
Streets:			
Asphalt	0.70-0.95		
Concrete	0.80-0.95		
Brick	0.70-0.85		
Drives and walks	0.75-0.85		
Roofs	0.75-0.85		

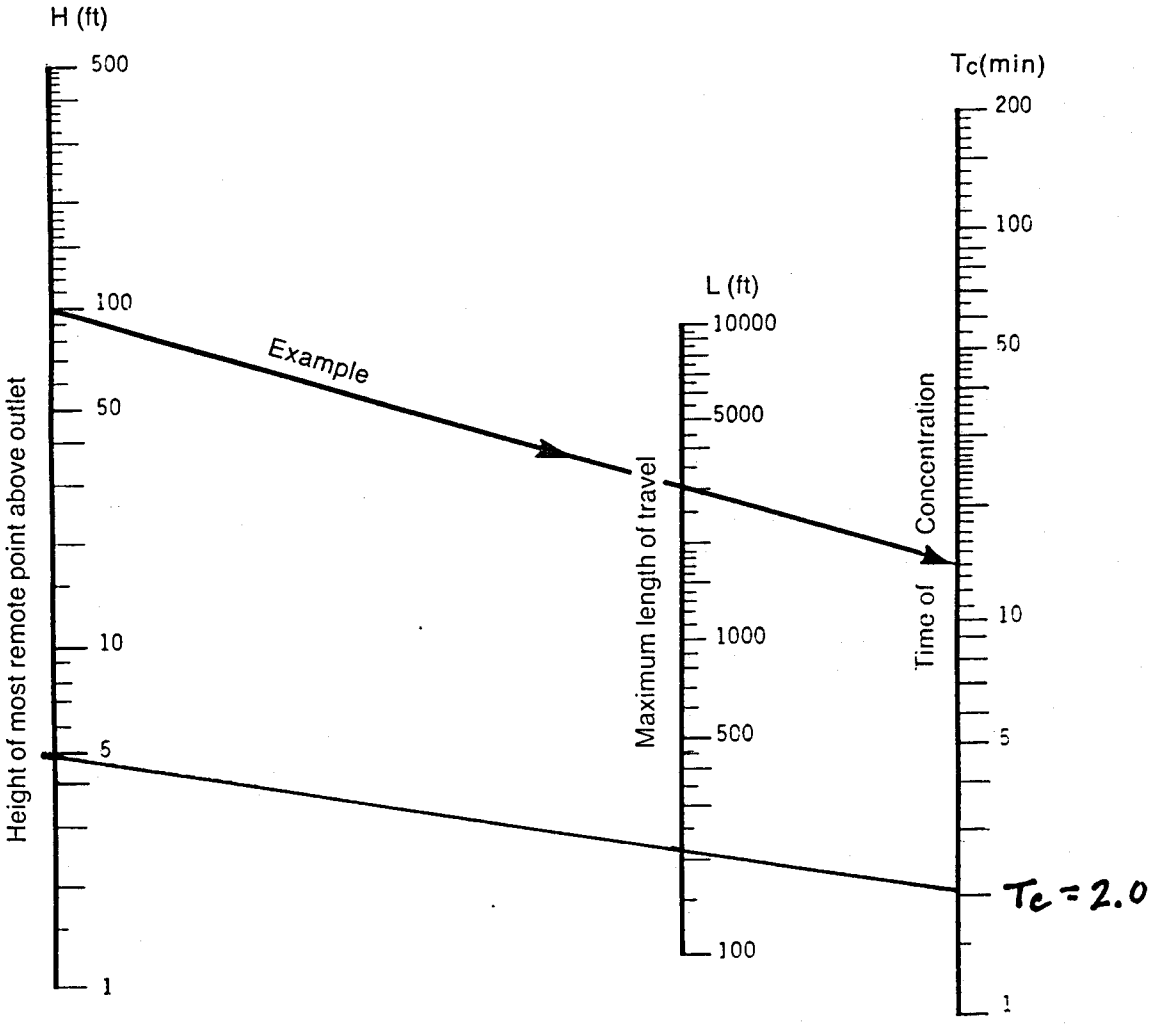
NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, Tc. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).



Note:
Use nomograph T_c for natural basins with well-defined channels, for overlanc flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply T_c by 2. ← = 4.0

For overland flow, concrete or asphalt surfaces, multiply T_c by 0.4.

For concrete channels, multiply T_c by 0.2.

Figure 8.03a Time of concentration of small drainage basins.

i = 6.2

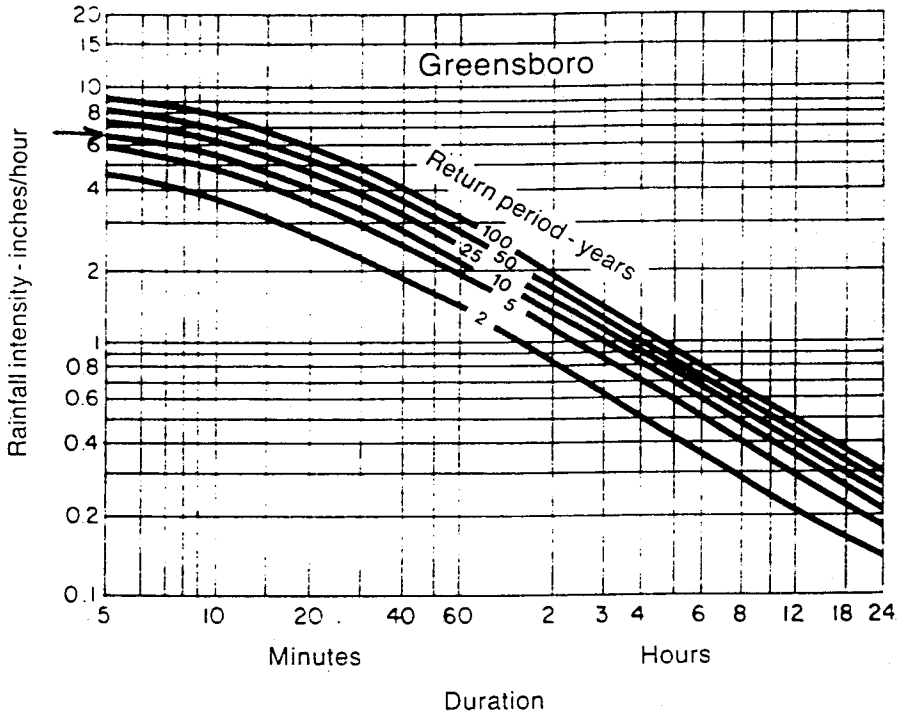


Figure 8.03d Rainfall intensity duration curves—Greensboro.

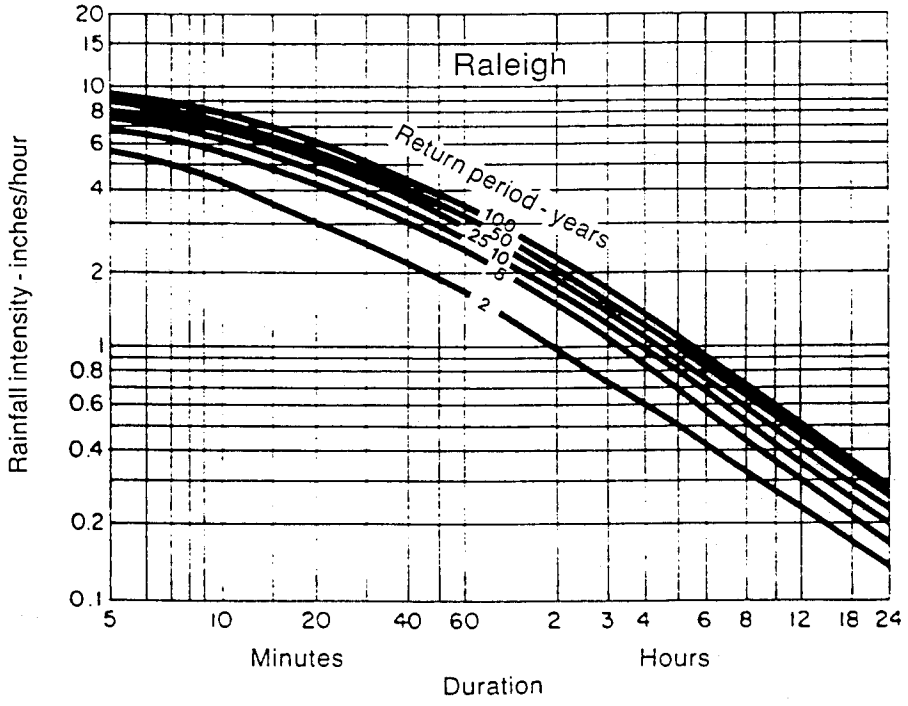


Figure 8.03e Rainfall intensity duration curves—Raleigh.

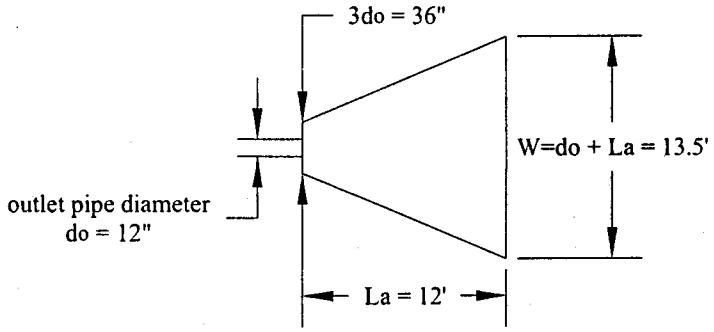
10/9/02

Duke Energy
Belews Creek Ash Landfill
Type II - Stabilization Outlet Protection Design

Area #1 - Pipe #1 (12" diameter)
Flow = 10.64 cfs

1. Determine Tailwater Depth
$\Rightarrow$ Tailwater < 0.5 do

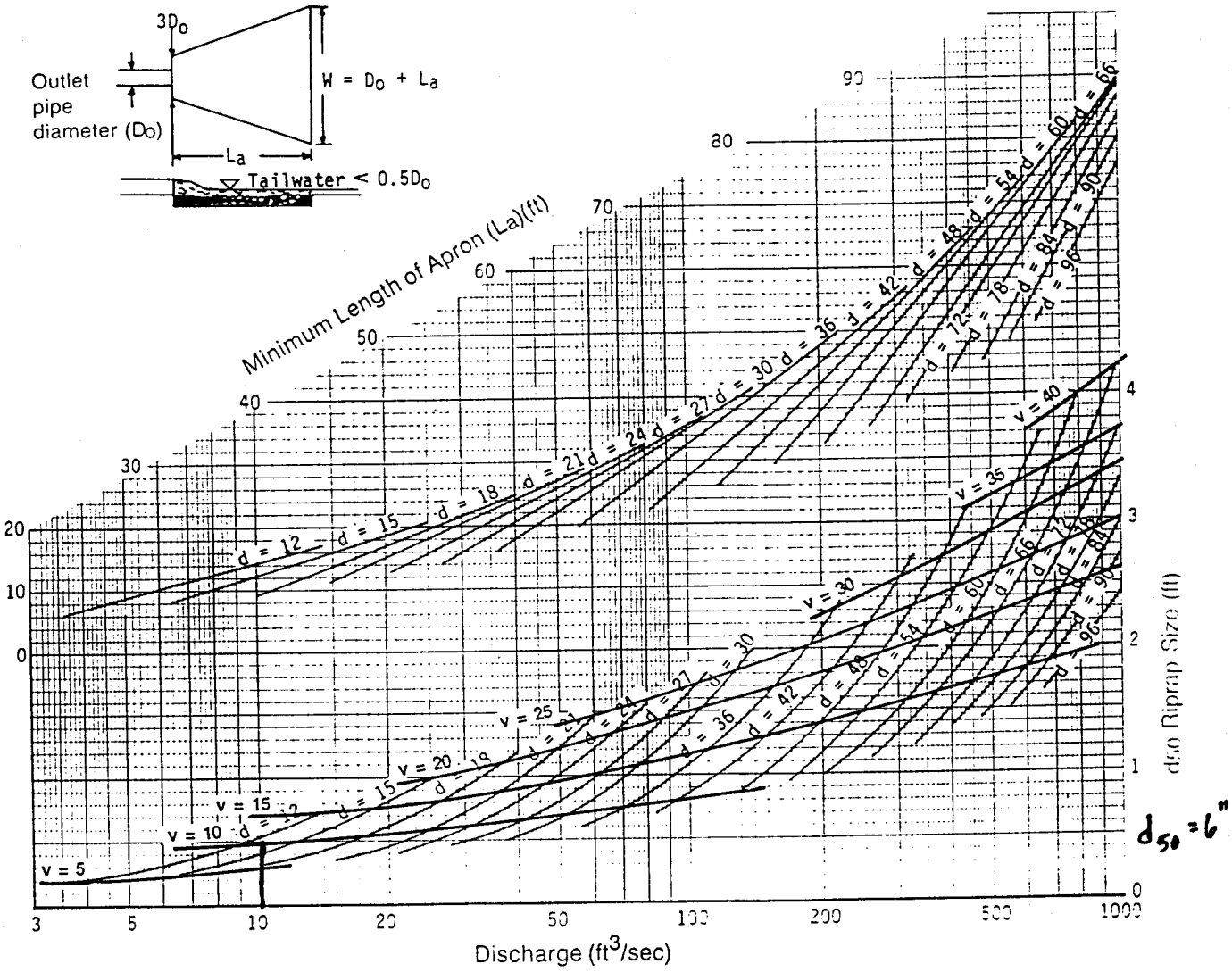
2. From Figure 8.06A
d_{50} = Rip-rap size @ Q = 10.64 cfs
d_{50} = 6"
Minimum length of apron = 12'



3. Determine the apron width at pipe outlet
= 3do
= 36"

4. Determine the maximum stone diameter
$d_{max} = 1.5 * d_{50}$
d_{max} = 9"

5. Determine the apron thickness
= 1.5*d_{max}
= 13.5"



Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).

12 inch diameter corrugated pipe

theta (deg)	(rad)	sin theta	1 49/.024	Area			1/49/n*A*R$^{2/3}$*S$^{1/2}$
0	0.000	0.000	62.08333	1/8*(theta-sin theta)*do)	hyd. Rad.	Slope $^{1/2}$	Q (flow)
1	0.017	0.017	62.1	0.0000	0.000	0.560	0.00
2	0.035	0.035	62.1	0.0000	0.000	0.560	0.00
3	0.052	0.052	62.1	0.0000	0.000	0.560	0.00
4	0.070	0.070	62.1	0.0000	0.000	0.560	0.00
5	0.087	0.087	62.1	0.0000	0.000	0.560	0.00
6	0.105	0.105	62.1	0.0000	0.000	0.560	0.00
7	0.122	0.122	62.1	0.0000	0.001	0.560	0.00
8	0.140	0.139	62.1	0.0001	0.001	0.560	0.00
9	0.157	0.156	62.1	0.0001	0.001	0.560	0.00
10	0.175	0.174	62.1	0.0001	0.001	0.560	0.00
11	0.192	0.191	62.1	0.0001	0.002	0.560	0.00
12	0.209	0.208	62.1	0.0002	0.002	0.560	0.00
13	0.227	0.225	62.1	0.0002	0.002	0.560	0.00
14	0.244	0.242	62.1	0.0003	0.002	0.560	0.00
15	0.262	0.259	62.1	0.0004	0.003	0.560	0.00
16	0.279	0.276	62.1	0.0005	0.003	0.560	0.00
17	0.297	0.292	62.1	0.0005	0.004	0.560	0.00
18	0.314	0.309	62.1	0.0006	0.004	0.560	0.00
19	0.332	0.326	62.1	0.0008	0.005	0.560	0.00
20	0.349	0.342	62.1	0.0009	0.005	0.560	0.00
21	0.367	0.358	62.1	0.0010	0.006	0.560	0.00
22	0.384	0.375	62.1	0.0012	0.006	0.560	0.00
23	0.401	0.391	62.1	0.0013	0.007	0.560	0.00
24	0.419	0.407	62.1	0.0015	0.007	0.560	0.00
25	0.436	0.423	62.1	0.0017	0.008	0.560	0.00
26	0.454	0.438	62.1	0.0019	0.008	0.560	0.00
27	0.471	0.454	62.1	0.0022	0.009	0.560	0.00
28	0.489	0.470	62.1	0.0024	0.010	0.560	0.00
29	0.506	0.485	62.1	0.0027	0.011	0.560	0.00
30	0.524	0.500	62.1	0.0030	0.011	0.560	0.01
31	0.541	0.515	62.1	0.0033	0.012	0.560	0.01
32	0.559	0.530	62.1	0.0036	0.013	0.560	0.01
33	0.576	0.545	62.1	0.0039	0.014	0.560	0.01
34	0.593	0.559	62.1	0.0043	0.014	0.560	0.01
35	0.611	0.574	62.1	0.0047	0.015	0.560	0.01
36	0.628	0.588	62.1	0.0051	0.016	0.560	0.01
37	0.646	0.602	62.1	0.0055	0.017	0.560	0.01
38	0.663	0.616	62.1	0.0059	0.018	0.560	0.01
39	0.681	0.629	62.1	0.0064	0.019	0.560	0.02
40	0.698	0.643	62.1	0.0069	0.020	0.560	0.02
41	0.716	0.656	62.1	0.0074	0.021	0.560	0.02
42	0.733	0.669	62.1	0.0080	0.022	0.560	0.02
43	0.751	0.682	62.1	0.0086	0.023	0.560	0.02
44	0.768	0.695	62.1	0.0092	0.024	0.560	0.03
45	0.785	0.707	62.1	0.0098	0.025	0.560	0.03
46	0.803	0.719	62.1	0.0104	0.026	0.560	0.03
47	0.820	0.731	62.1	0.0111	0.027	0.560	0.03
48	0.838	0.743	62.1	0.0118	0.028	0.560	0.04
49	0.855	0.755	62.1	0.0126	0.029	0.560	0.04
50	0.873	0.766	62.1	0.0133	0.031	0.560	0.05
51	0.890	0.777	62.1	0.0141	0.032	0.560	0.05
52	0.908	0.788	62.1	0.0149	0.033	0.560	0.05
53	0.925	0.799	62.1	0.0158	0.034	0.560	0.06
54	0.943	0.809	62.1	0.0167	0.035	0.560	0.06
55	0.960	0.819	62.1	0.0176	0.037	0.560	0.07
56	0.977	0.829	62.1	0.0185	0.038	0.560	0.07
57	0.995	0.839	62.1	0.0195	0.039	0.560	0.08
58	1.012	0.848	62.1	0.0205	0.041	0.560	0.08
59	1.030	0.857	62.1	0.0216	0.042	0.560	0.09
60	1.047	0.866	62.1	0.0227	0.043	0.560	0.10
61	1.065	0.875	62.1	0.0238	0.045	0.560	0.10
62	1.082	0.883	62.1	0.0249	0.046	0.560	0.11
63	1.100	0.891	62.1	0.0261	0.047	0.560	0.12
64	1.117	0.899	62.1	0.0273	0.049	0.560	0.13
65	1.135	0.906	62.1	0.0285	0.050	0.560	0.14
66	1.152	0.914	62.1	0.0298	0.052	0.560	0.14
67	1.169	0.921	62.1	0.0311	0.053	0.560	0.15
68	1.187	0.927	62.1	0.0325	0.055	0.560	0.16
69	1.204	0.934	62.1	0.0338	0.056	0.560	0.17
70	1.222	0.940	62.1	0.0353	0.058	0.560	0.18
71	1.239	0.946	62.1	0.0367	0.059	0.560	0.19
72	1.257	0.951	62.1	0.0382	0.061	0.560	0.21
73	1.274	0.956	62.1	0.0397	0.062	0.560	0.22
74	1.292	0.961	62.1	0.0413	0.064	0.560	0.23
75	1.309	0.966	62.1	0.0429	0.066	0.560	0.24
76	1.327	0.970	62.1	0.0445	0.067	0.560	0.26
77	1.344	0.974	62.1	0.0462	0.069	0.560	0.27
78	1.361	0.978	62.1	0.0479	0.070	0.560	0.28
79	1.379	0.982	62.1	0.0497	0.072	0.560	0.30
80	1.396	0.985	62.1	0.0514	0.074	0.560	0.31
81	1.414	0.988	62.1	0.0533	0.075	0.560	0.33
82	1.431	0.990	62.1	0.0551	0.077	0.560	0.35
83	1.449	0.993	62.1	0.0570	0.079	0.560	0.36
84	1.466	0.995	62.1	0.0590	0.080	0.560	0.38
85	1.484	0.996	62.1	0.0609	0.082	0.560	0.40
86	1.501	0.998	62.1	0.0629	0.084	0.560	0.42
87	1.519	0.999	62.1	0.0650	0.086	0.560	0.44
88	1.536	0.999	62.1	0.0671	0.087	0.560	0.46
89	1.553	1.000	62.1	0.0692	0.089	0.560	0.48
90	1.571	1.000	62.1	0.0714	0.091	0.560	0.50
91	1.588	1.000	62.1	0.0736	0.093	0.560	0.52
92	1.606	0.999	62.1	0.0758	0.094	0.560	0.55
93	1.623	0.999	62.1	0.0781	0.096	0.560	0.57
94	1.641	0.998	62.1	0.0804	0.098	0.560	0.59
95	1.658	0.996	62.1	0.0828	0.100	0.560	0.62

12 inch diameter corrugated pipe

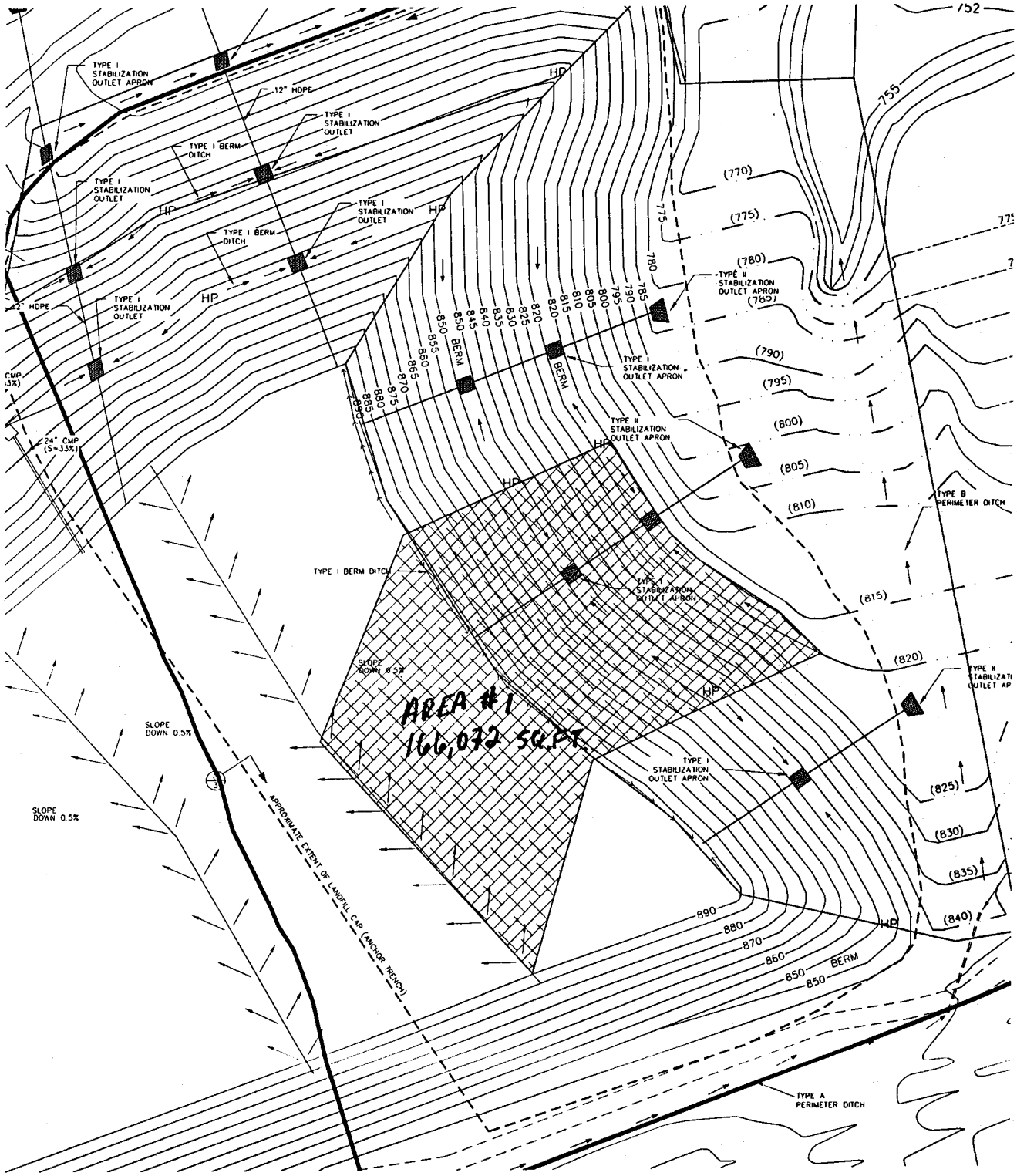
theta (deg)	(rad)	sin theta	1.49/.024	Area			1/49/n*A*R$^{2/3}$*g$^{1/2}$
0	0.000	0.000	62.08333	1/8*(theta-sin theta)*do)	hyd. Rad.	Slope $^{1/2}$	Q (flow)
96	1.676	0.995	62.1	0.0851	0.102	0.560	0.64
97	1.693	0.993	62.1	0.0876	0.103	0.560	0.67
98	1.711	0.990	62.1	0.0900	0.105	0.560	0.70
99	1.728	0.988	62.1	0.0925	0.107	0.560	0.73
100	1.746	0.985	62.1	0.0951	0.109	0.560	0.75
101	1.763	0.982	62.1	0.0977	0.111	0.560	0.78
102	1.780	0.978	62.1	0.1003	0.113	0.560	0.81
103	1.798	0.974	62.1	0.1029	0.115	0.560	0.84
104	1.815	0.970	62.1	0.1056	0.116	0.560	0.88
105	1.833	0.966	62.1	0.1084	0.118	0.560	0.91
106	1.850	0.961	62.1	0.1111	0.120	0.560	0.94
107	1.868	0.956	62.1	0.1139	0.122	0.560	0.97
108	1.885	0.951	62.1	0.1168	0.124	0.560	1.01
109	1.903	0.945	62.1	0.1196	0.126	0.560	1.04
110	1.920	0.940	62.1	0.1226	0.128	0.560	1.08
111	1.938	0.934	62.1	0.1255	0.130	0.560	1.12
112	1.955	0.927	62.1	0.1285	0.131	0.560	1.15
113	1.972	0.920	62.1	0.1315	0.133	0.560	1.19
114	1.990	0.913	62.1	0.1346	0.135	0.560	1.23
115	2.007	0.906	62.1	0.1376	0.137	0.560	1.27
116	2.025	0.899	62.1	0.1408	0.139	0.560	1.31
117	2.042	0.891	62.1	0.1439	0.141	0.560	1.35
118	2.060	0.883	62.1	0.1471	0.143	0.560	1.40
119	2.077	0.875	62.1	0.1503	0.145	0.560	1.44
120	2.095	0.866	62.1	0.1536	0.147	0.560	1.48
121	2.112	0.857	62.1	0.1569	0.149	0.560	1.53
122	2.130	0.848	62.1	0.1602	0.150	0.560	1.58
123	2.147	0.839	62.1	0.1636	0.152	0.560	1.62
124	2.164	0.829	62.1	0.1669	0.154	0.560	1.67
125	2.182	0.819	62.1	0.1704	0.156	0.560	1.72
126	2.199	0.809	62.1	0.1738	0.158	0.560	1.77
127	2.217	0.799	62.1	0.1773	0.160	0.560	1.82
128	2.234	0.788	62.1	0.1808	0.162	0.560	1.87
129	2.252	0.777	62.1	0.1843	0.164	0.560	1.92
130	2.269	0.766	62.1	0.1879	0.166	0.560	1.97
131	2.287	0.755	62.1	0.1915	0.168	0.560	2.02
132	2.304	0.743	62.1	0.1951	0.169	0.560	2.08
133	2.322	0.731	62.1	0.1988	0.171	0.560	2.13
134	2.339	0.719	62.1	0.2025	0.173	0.560	2.19
135	2.356	0.707	62.1	0.2062	0.175	0.560	2.24
136	2.374	0.694	62.1	0.2099	0.177	0.560	2.30
137	2.391	0.682	62.1	0.2137	0.179	0.560	2.36
138	2.409	0.669	62.1	0.2175	0.181	0.560	2.42
139	2.426	0.656	62.1	0.2213	0.182	0.560	2.47
140	2.444	0.643	62.1	0.2251	0.184	0.560	2.53
141	2.461	0.629	62.1	0.2290	0.186	0.560	2.60
142	2.479	0.615	62.1	0.2329	0.188	0.560	2.66
143	2.496	0.602	62.1	0.2368	0.190	0.560	2.72
144	2.514	0.588	62.1	0.2407	0.192	0.560	2.78
145	2.531	0.573	62.1	0.2447	0.193	0.560	2.84
146	2.548	0.559	62.1	0.2487	0.195	0.560	2.91
147	2.566	0.544	62.1	0.2527	0.197	0.560	2.97
148	2.583	0.530	62.1	0.2567	0.199	0.560	3.04
149	2.601	0.515	62.1	0.2607	0.201	0.560	3.11
150	2.618	0.500	62.1	0.2648	0.202	0.560	3.17
151	2.636	0.485	62.1	0.2689	0.204	0.560	3.24
152	2.653	0.469	62.1	0.2730	0.206	0.560	3.31
153	2.671	0.454	62.1	0.2771	0.208	0.560	3.38
154	2.688	0.438	62.1	0.2812	0.209	0.560	3.45
155	2.706	0.422	62.1	0.2854	0.211	0.560	3.52
156	2.723	0.406	62.1	0.2896	0.213	0.560	3.59
157	2.740	0.390	62.1	0.2937	0.214	0.560	3.66
158	2.758	0.374	62.1	0.2979	0.216	0.560	3.73
159	2.775	0.358	62.1	0.3022	0.218	0.560	3.80
160	2.793	0.342	62.1	0.3064	0.219	0.560	3.87
161	2.810	0.325	62.1	0.3106	0.221	0.560	3.95
162	2.828	0.309	62.1	0.3149	0.223	0.560	4.02
163	2.845	0.292	62.1	0.3191	0.224	0.560	4.10
164	2.863	0.275	62.1	0.3234	0.226	0.560	4.17
165	2.880	0.259	62.1	0.3277	0.228	0.560	4.25
166	2.898	0.242	62.1	0.3320	0.229	0.560	4.32
167	2.915	0.225	62.1	0.3363	0.231	0.560	4.40
168	2.932	0.208	62.1	0.3406	0.232	0.560	4.47
169	2.950	0.191	62.1	0.3449	0.234	0.560	4.55
170	2.967	0.173	62.1	0.3493	0.235	0.560	4.63
171	2.985	0.156	62.1	0.3536	0.237	0.560	4.71
172	3.002	0.139	62.1	0.3579	0.238	0.560	4.78
173	3.020	0.122	62.1	0.3623	0.240	0.560	4.86
174	3.037	0.104	62.1	0.3666	0.241	0.560	4.94
175	3.055	0.087	62.1	0.3710	0.243	0.560	5.02
176	3.072	0.069	62.1	0.3753	0.244	0.560	5.10
177	3.090	0.052	62.1	0.3797	0.246	0.560	5.18
178	3.107	0.035	62.1	0.3841	0.247	0.560	5.26
179	3.124	0.017	62.1	0.3884	0.249	0.560	5.34
180	3.142	0.000	62.1	0.3928	0.250	0.560	5.42
181	3.159	-0.018	62.1	0.3971	0.251	0.560	5.50
182	3.177	-0.035	62.1	0.4015	0.253	0.560	5.58
183	3.194	-0.053	62.1	0.4059	0.254	0.560	5.66
184	3.212	-0.070	62.1	0.4102	0.255	0.560	5.74
185	3.229	-0.087	62.1	0.4146	0.257	0.560	5.82
186	3.247	-0.105	62.1	0.4189	0.258	0.560	5.90
187	3.264	-0.122	62.1	0.4233	0.259	0.560	5.98
188	3.282	-0.140	62.1	0.4276	0.261	0.560	6.07
189	3.299	-0.157	62.1	0.4320	0.262	0.560	6.15
190	3.316	-0.174	62.1	0.4363	0.263	0.560	6.23

12 inch diameter corrugated pipe

theta (deg)	(rad)	sin theta	1.49/.024	Area			$1/49/n^*A^*R^{2/3}*S^{1/2}$	
0	0.000	0.000	62.08333	1/8*(theta-sin theta)*do)	hyd. Rad.	Slope $^{1/2}$	Q (flow)	
191	3.334	-0.191	62.1	0.4406	0.264	0.560	6.31	
192	3.351	-0.208	62.1	0.4450	0.266	0.560	6.39	
193	3.369	-0.225	62.1	0.4493	0.267	0.560	6.47	
194	3.386	-0.242	62.1	0.4536	0.268	0.560	6.55	
195	3.404	-0.259	62.1	0.4579	0.269	0.560	6.63	
196	3.421	-0.276	62.1	0.4621	0.270	0.560	6.71	
197	3.439	-0.293	62.1	0.4664	0.271	0.560	6.80	
198	3.456	-0.309	62.1	0.4707	0.272	0.560	6.88	
199	3.474	-0.326	62.1	0.4749	0.273	0.560	6.96	
200	3.491	-0.342	62.1	0.4792	0.275	0.560	7.04	
201	3.508	-0.359	62.1	0.4834	0.276	0.560	7.12	
202	3.526	-0.375	62.1	0.4876	0.277	0.560	7.20	
203	3.543	-0.391	62.1	0.4918	0.278	0.560	7.28	
204	3.561	-0.407	62.1	0.4960	0.279	0.560	7.35	
205	3.578	-0.423	62.1	0.5002	0.280	0.560	7.43	
206	3.596	-0.439	62.1	0.5043	0.281	0.560	7.51	
207	3.613	-0.454	62.1	0.5084	0.281	0.560	7.59	
208	3.631	-0.470	62.1	0.5126	0.282	0.560	7.67	
209	3.648	-0.485	62.1	0.5167	0.283	0.560	7.75	
210	3.666	-0.500	62.1	0.5207	0.284	0.560	7.82	
211	3.683	-0.515	62.1	0.5248	0.285	0.560	7.90	
212	3.700	-0.530	62.1	0.5288	0.286	0.560	7.98	
213	3.718	-0.545	62.1	0.5329	0.287	0.560	8.05	
214	3.735	-0.560	62.1	0.5369	0.287	0.560	8.13	
215	3.753	-0.574	62.1	0.5408	0.288	0.560	8.20	6.805449
216	3.770	-0.588	62.1	0.5448	0.289	0.560	8.28	
217	3.788	-0.602	62.1	0.5487	0.290	0.560	8.35	
218	3.805	-0.616	62.1	0.5526	0.290	0.560	8.43	
219	3.823	-0.630	62.1	0.5565	0.291	0.560	8.50	
220	3.840	-0.643	62.1	0.5604	0.292	0.560	8.57	
221	3.858	-0.656	62.1	0.5642	0.293	0.560	8.64	
222	3.875	-0.669	62.1	0.5681	0.293	0.560	8.72	
223	3.892	-0.682	62.1	0.5718	0.294	0.560	8.79	
224	3.910	-0.695	62.1	0.5756	0.294	0.560	8.86	
225	3.927	-0.707	62.1	0.5793	0.295	0.560	8.93	
226	3.945	-0.720	62.1	0.5831	0.296	0.560	8.99	
227	3.962	-0.732	62.1	0.5867	0.296	0.560	9.06	
228	3.980	-0.743	62.1	0.5904	0.297	0.560	9.13	
229	3.997	-0.755	62.1	0.5940	0.297	0.560	9.20	
230	4.015	-0.766	62.1	0.5976	0.298	0.560	9.26	
231	4.032	-0.777	62.1	0.6012	0.298	0.560	9.33	
232	4.050	-0.788	62.1	0.6047	0.299	0.560	9.39	
233	4.067	-0.799	62.1	0.6082	0.299	0.560	9.46	
234	4.084	-0.809	62.1	0.6117	0.300	0.560	9.52	
235	4.102	-0.819	62.1	0.6152	0.300	0.560	9.58	
236	4.119	-0.829	62.1	0.6186	0.300	0.560	9.64	
237	4.137	-0.839	62.1	0.6220	0.301	0.560	9.70	
238	4.154	-0.848	62.1	0.6253	0.301	0.560	9.76	
239	4.172	-0.857	62.1	0.6286	0.301	0.560	9.82	
240	4.189	-0.866	62.1	0.6319	0.302	0.560	9.88	
241	4.207	-0.875	62.1	0.6352	0.302	0.560	9.94	
242	4.224	-0.883	62.1	0.6384	0.302	0.560	10.00	
243	4.242	-0.891	62.1	0.6416	0.303	0.560	10.05	
244	4.259	-0.899	62.1	0.6448	0.303	0.560	10.11	
245	4.276	-0.906	62.1	0.6479	0.303	0.560	10.16	
246	4.294	-0.914	62.1	0.6510	0.303	0.560	10.21	
247	4.311	-0.921	62.1	0.6540	0.303	0.560	10.27	
248	4.329	-0.927	62.1	0.6570	0.304	0.560	10.32	
249	4.346	-0.934	62.1	0.6600	0.304	0.560	10.37	
250	4.364	-0.940	62.1	0.6630	0.304	0.560	10.42	
251	4.381	-0.946	62.1	0.6659	0.304	0.560	10.46	
252	4.399	-0.951	62.1	0.6687	0.304	0.560	10.51	
253	4.416	-0.956	62.1	0.6716	0.304	0.560	10.56	
254	4.434	-0.961	62.1	0.6744	0.304	0.560	10.60	
255	4.451	-0.966	62.1	0.6771	0.304	0.560	10.65	←
256	4.468	-0.970	62.1	0.6799	0.304	0.560	10.69	
257	4.486	-0.974	62.1	0.6826	0.304	0.560	10.74	
258	4.503	-0.978	62.1	0.6852	0.304	0.560	10.78	
259	4.521	-0.982	62.1	0.6878	0.304	0.560	10.82	
260	4.538	-0.985	62.1	0.6904	0.304	0.560	10.86	
261	4.556	-0.988	62.1	0.6929	0.304	0.560	10.90	
262	4.573	-0.990	62.1	0.6954	0.304	0.560	10.93	
263	4.591	-0.993	62.1	0.6979	0.304	0.560	10.97	
264	4.608	-0.995	62.1	0.7003	0.304	0.560	11.01	
265	4.626	-0.996	62.1	0.7027	0.304	0.560	11.04	
266	4.643	-0.998	62.1	0.7051	0.304	0.560	11.08	
267	4.660	-0.999	62.1	0.7074	0.304	0.560	11.11	
268	4.678	-0.999	62.1	0.7097	0.303	0.560	11.14	
269	4.695	-1.000	62.1	0.7119	0.303	0.560	11.17	
270	4.713	-1.000	62.1	0.7141	0.303	0.560	11.20	
271	4.730	-1.000	62.1	0.7163	0.303	0.560	11.23	
272	4.748	-0.999	62.1	0.7184	0.303	0.560	11.26	
273	4.765	-0.999	62.1	0.7205	0.302	0.560	11.28	
274	4.783	-0.998	62.1	0.7225	0.302	0.560	11.31	
275	4.800	-0.996	62.1	0.7245	0.302	0.560	11.34	
276	4.818	-0.994	62.1	0.7265	0.302	0.560	11.36	
277	4.835	-0.992	62.1	0.7284	0.301	0.560	11.38	
278	4.853	-0.990	62.1	0.7303	0.301	0.560	11.40	
279	4.870	-0.988	62.1	0.7322	0.301	0.560	11.43	
280	4.887	-0.985	62.1	0.7340	0.300	0.560	11.45	
281	4.905	-0.982	62.1	0.7358	0.300	0.560	11.46	
282	4.922	-0.978	62.1	0.7375	0.300	0.560	11.48	
283	4.940	-0.974	62.1	0.7393	0.299	0.560	11.50	
284	4.957	-0.970	62.1	0.7409	0.299	0.560	11.52	
285	4.975	-0.966	62.1	0.7426	0.299	0.560	11.53	

12 inch diameter corrugated pipe

theta (deg)	(rad)	sin theta	1.49/.024	Area			1/49/n*A*R$^{2/3}$*S$^{1/2}$
0	0.000	0.000	62.08333	1/8*(theta-sin theta)*do)	hyd. Rad.	Slope $^{1/2}$	Q (flow)
286	4.992	-0.961	62.1	0.7442	0.298	0.560	11.55
287	5.010	-0.956	62.1	0.7457	0.298	0.560	11.56
288	5.027	-0.951	62.1	0.7472	0.297	0.560	11.57
289	5.045	-0.945	62.1	0.7487	0.297	0.560	11.58
290	5.062	-0.940	62.1	0.7502	0.296	0.560	11.59
291	5.079	-0.933	62.1	0.7516	0.296	0.560	11.60
292	5.097	-0.927	62.1	0.7530	0.295	0.560	11.61
293	5.114	-0.920	62.1	0.7543	0.295	0.560	11.62
294	5.132	-0.913	62.1	0.7556	0.294	0.560	11.63
295	5.149	-0.906	62.1	0.7569	0.294	0.560	11.63
296	5.167	-0.899	62.1	0.7582	0.293	0.560	11.64
297	5.184	-0.891	62.1	0.7594	0.293	0.560	11.64
298	5.202	-0.883	62.1	0.7605	0.292	0.560	11.65
299	5.219	-0.874	62.1	0.7617	0.292	0.560	11.65
300	5.237	-0.866	62.1	0.7628	0.291	0.560	11.65
301	5.254	-0.857	62.1	0.7639	0.291	0.560	11.66
302	5.271	-0.848	62.1	0.7649	0.290	0.560	11.66
303	5.289	-0.838	62.1	0.7659	0.290	0.560	11.66
304	5.306	-0.829	62.1	0.7669	0.289	0.560	11.66
305	5.324	-0.819	62.1	0.7678	0.288	0.560	11.65
306	5.341	-0.809	62.1	0.7687	0.288	0.560	11.65
307	5.359	-0.798	62.1	0.7696	0.287	0.560	11.65
308	5.376	-0.788	62.1	0.7705	0.287	0.560	11.64
309	5.394	-0.777	62.1	0.7713	0.286	0.560	11.64
310	5.411	-0.766	62.1	0.7721	0.285	0.560	11.63
311	5.429	-0.754	62.1	0.7729	0.285	0.560	11.63
312	5.446	-0.743	62.1	0.7736	0.284	0.560	11.62
313	5.463	-0.731	62.1	0.7743	0.283	0.560	11.62
314	5.481	-0.719	62.1	0.7750	0.283	0.560	11.61
315	5.498	-0.707	62.1	0.7756	0.282	0.560	11.60
316	5.516	-0.694	62.1	0.7763	0.281	0.560	11.59
317	5.533	-0.682	62.1	0.7769	0.281	0.560	11.58
318	5.551	-0.669	62.1	0.7774	0.280	0.560	11.57
319	5.568	-0.656	62.1	0.7780	0.279	0.560	11.56
320	5.586	-0.642	62.1	0.7785	0.279	0.560	11.55
321	5.603	-0.629	62.1	0.7790	0.278	0.560	11.54
322	5.621	-0.615	62.1	0.7795	0.277	0.560	11.52
323	5.638	-0.601	62.1	0.7799	0.277	0.560	11.51
324	5.655	-0.587	62.1	0.7803	0.276	0.560	11.50
325	5.673	-0.573	62.1	0.7807	0.275	0.560	11.49
326	5.690	-0.559	62.1	0.7811	0.275	0.560	11.47
327	5.708	-0.544	62.1	0.7815	0.274	0.560	11.46
328	5.725	-0.529	62.1	0.7818	0.273	0.560	11.44
329	5.743	-0.515	62.1	0.7822	0.272	0.560	11.43
330	5.760	-0.499	62.1	0.7825	0.272	0.560	11.41
331	5.778	-0.484	62.1	0.7827	0.271	0.560	11.39
332	5.795	-0.469	62.1	0.7830	0.270	0.560	11.38
333	5.813	-0.453	62.1	0.7833	0.270	0.560	11.36
334	5.830	-0.438	62.1	0.7835	0.269	0.560	11.34
335	5.847	-0.422	62.1	0.7837	0.268	0.560	11.33
336	5.865	-0.406	62.1	0.7839	0.267	0.560	11.31
337	5.882	-0.390	62.1	0.7841	0.267	0.560	11.29
338	5.900	-0.374	62.1	0.7842	0.266	0.560	11.27
339	5.917	-0.358	62.1	0.7844	0.265	0.560	11.25
340	5.935	-0.341	62.1	0.7845	0.264	0.560	11.23
341	5.952	-0.325	62.1	0.7846	0.264	0.560	11.22
342	5.970	-0.308	62.1	0.7848	0.263	0.560	11.20
343	5.987	-0.292	62.1	0.7849	0.262	0.560	11.18
344	6.005	-0.275	62.1	0.7849	0.261	0.560	11.16
345	6.022	-0.258	62.1	0.7850	0.261	0.560	11.14
346	6.039	-0.241	62.1	0.7851	0.260	0.560	11.12
347	6.057	-0.224	62.1	0.7852	0.259	0.560	11.10
348	6.074	-0.207	62.1	0.7852	0.259	0.560	11.08
349	6.092	-0.190	62.1	0.7853	0.258	0.560	11.06
350	6.109	-0.173	62.1	0.7853	0.257	0.560	11.04
351	6.127	-0.156	62.1	0.7853	0.256	0.560	11.02
352	6.144	-0.139	62.1	0.7853	0.256	0.560	11.00
353	6.162	-0.121	62.1	0.7854	0.255	0.560	10.98
354	6.179	-0.104	62.1	0.7854	0.254	0.560	10.96
355	6.197	-0.087	62.1	0.7854	0.253	0.560	10.94
356	6.214	-0.069	62.1	0.7854	0.253	0.560	10.92
357	6.231	-0.052	62.1	0.7854	0.252	0.560	10.90
358	6.249	-0.034	62.1	0.7854	0.251	0.560	10.88
359	6.266	-0.017	62.1	0.7854	0.251	0.560	10.86
360	6.284	0.001	62.1	0.7854	0.250	0.560	10.83


TYPE I STABILIZATION OUTLET APRON
12" HDPE
TYPE I STABILIZATION OUTLET
TYPE I BERM DITCH
HP
TYPE II STABILIZATION OUTLET APRON
BERM
24" CMP (S=33%)
TYPE B PERIMETER DITCH
SLOPE DOWN 0.5%
AREA #1
166,072 SQ.FT.
APPROXIMATE EXTENT OF LANDFILL CAP (ANCHOR TRENCH)
TYPE A PERIMETER DITCH

SHIELD ENVIRONMENTAL ASSOCIATES, INC.

BY RAU DATE 10/9/02
CHKD. BY AAD DATE 10/9/02

CLIENT	DUKE ENERGY	SHEET	1 OF 9
PROJECT	BELEWS CREEK ASH LANDFILL	PROJECT NO.	1020062
SUBJECT	GEONET DRAINAGE DESIGN	TASK NO.	

PROBLEM : DESIGN GEONET DRAINAGE COLLECTOR PIPE

ASSUMPTIONS:
- CONSERVATIVLY ASSUME ENTIRE GEONET DRAINAGE CARRIED BY ONE PIPE OUTFALL
- USE HELP MODEL RESULTS FOR POST-OPERATIONAL PERIOD

DESIGN :

FROM HELP MODEL - HIGHEST AVERAGE MONTHLY VALVE COLLECTED IN DRAINAGE LAYER (LAYER 3) IS DURING THE MONTH OF JANUARY = 1.8437 INCHES

$$1.8437 \frac{IN}{MONTH} \times \frac{MONTH}{30\ DAYS} \times \frac{DAY}{24\ HR} \times \frac{HR}{3600\ SEC} = 7.113 \times 10^{-7} \frac{IN}{SEC}$$

$$7.113 \times 10^{-7}\ IN/SEC \times \frac{FT}{12\ IN} = 5.9275 \times 10^{-8}\ FT/SEC$$

$$5.9275 \times 10^{-8}\ FT/SEC \times 43{,}560\ FT^2/ACRE \times 19\ ACRES = 4.9058 \times 10^{-2}\ CFS$$

$$4.9058 \times 10^{-2}\ FT^3/SEC \times \frac{448\ GPM}{CFS} = \underline{21.978\ gpm}$$

FROM ADVANCED DRAINAGE SYSTEMS (ADS)
6" DIAMETER PIPE $n = 0.015$

FROM ADS TABLE 6
6" DIAMETER PIPE, 0.5% SLOPE = 0.3415 CFS

$$0.3415\ CFS \times \frac{448\ GPM}{CFS} = \underline{153.0\ gpm}$$

CONCLUSION : 6" DIAMETE ADS PIPE CAPACLE OF CARRYING ENTIRE FLOW FROM GEONET

```
**********************************************************************************
**********************************************************************************
**                                                                              **
**                                                                              **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                 HELP MODEL VERSION 3.04   (10 APRIL 1995)                    **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                     USAE WATERWAYS EXPERIMENT STATION                        **
**                FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                              **
**                                                                              **
**********************************************************************************
**********************************************************************************

PRECIPITATION DATA FILE:     C:\HELP3\P100.D4
TEMPERATURE DATA FILE:       C:\HELP3\T100.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\S100.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\ET100.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\AREA1PO.D10
OUTPUT DATA FILE:            C:\HELP3\AREA1PO.OUT

TIME:   9:23     DATE:  12/10/2001

**********************************************************************************

     TITLE:  BCS Landfill - Area 1 - Post Operational Period

**********************************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  96
          THICKNESS                      =      9.00   INCHES
          POROSITY                       =      0.4300 VOL/VOL
          FIELD CAPACITY                 =      0.2060 VOL/VOL
          WILTING POINT                  =      0.0980 VOL/VOL
          INITIAL SOIL WATER CONTENT     =      0.1720 VOL/VOL
          EFFECTIVE SAT. HYD. COND.      =  0.345999986000E-03 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	15.00	INCHES
POROSITY	=	0.4300	VOL/VOL
FIELD CAPACITY	=	0.2060	VOL/VOL
WILTING POINT	=	0.0980	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1720	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.115000003000E-03	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.0100	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	21.00	PERCENT
DRAINAGE LENGTH	=	800.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	4.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 99

THICKNESS	=	806.00	INCHES
POROSITY	=	0.4500	VOL/VOL
FIELD CAPACITY	=	0.2150	VOL/VOL
WILTING POINT	=	0.0570	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1640	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.104999999000E-03	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 97

THICKNESS	=	48.00	INCHES
POROSITY	=	0.5200	VOL/VOL
FIELD CAPACITY	=	0.1960	VOL/VOL
WILTING POINT	=	0.0610	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2280	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.153000001000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	72.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	19.600	ACRES
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.096	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	7.740	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	1.764	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	147.256	INCHES
TOTAL INITIAL WATER	=	147.256	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
GREENSBORO NORTH CAROLINA

STATION LATITUDE	=	35.13	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	90	
END OF GROWING SEASON (JULIAN DATE)	=	305	
EVAPORATIVE ZONE DEPTH	=	18.0	INCHES

AVERAGE ANNUAL WIND SPEED = 7.60 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 74.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 70.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GREENSBORO NORTH CAROLINA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
3.51	3.37	3.88	3.16	3.37	3.93
4.27	4.19	3.64	3.18	2.59	3.38

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GREENSBORO NORTH CAROLINA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
37.50	39.90	48.00	58.30	66.50	73.50
77.20	76.30	69.90	58.40	48.50	40.20

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR GREENSBORO NORTH CAROLINA
AND STATION LATITUDE = 35.13 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.47	3.45	4.14	3.02	3.20	3.83
	4.43	4.33	3.83	3.11	2.68	3.18
STD. DEVIATIONS	1.75	1.75	1.93	1.43	1.66	2.04
	2.01	2.19	2.50	2.02	1.61	1.98
RUNOFF						

TOTALS	0.044	0.128	0.038	0.002	0.016	0.020
	0.009	0.026	0.072	0.033	0.011	0.053
STD. DEVIATIONS	0.198	0.441	0.136	0.007	0.063	0.092
	0.044	0.085	0.186	0.094	0.046	0.174

EVAPOTRANSPIRATION

TOTALS	1.287	1.641	2.785	3.048	3.653	3.827
	4.108	3.209	2.673	2.630	1.186	1.079
STD. DEVIATIONS	0.245	0.280	0.461	0.776	0.945	1.503
	1.498	1.072	0.805	0.832	0.332	0.225

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	1.8437	1.8335	1.7233	0.7521	0.4829	0.2482
	0.2288	0.3687	0.8211	0.7268	0.6894	1.3581
STD. DEVIATIONS	1.4833	1.4138	1.3396	0.6966	0.6865	0.3102
	0.4795	0.7278	1.1392	0.8922	1.1041	1.5043

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002
STD. DEVIATIONS	0.0002	0.0001	0.0002	0.0001	0.0001	0.0000
	0.0001	0.0001	0.0002	0.0001	0.0001	0.0003

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0015	0.0014	0.0020	0.0025	0.0022	0.0017
	0.0016	0.0016	0.0008	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0154	0.0141	0.0204	0.0246	0.0220	0.0174
	0.0159	0.0158	0.0080	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0042	0.0047	0.0046	0.0018	0.0012	0.0006
	0.0006	0.0009	0.0031	0.0016	0.0017	0.0060
STD. DEVIATIONS	0.0036	0.0041	0.0082	0.0016	0.0021	0.0007
	0.0017	0.0021	0.0117	0.0020	0.0031	0.0251

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	42.67 (6.674)	3035871.2	100.00
RUNOFF	0.451 (0.5527)	32099.13	1.057
EVAPOTRANSPIRATION	31.127 (3.1654)	2214618.00	72.948
LATERAL DRAINAGE COLLECTED FROM LAYER 3	11.07664 (4.38230)	788080.875	25.95897
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00159 (0.00058)	113.100	0.00373
AVERAGE HEAD ON TOP OF LAYER 4	0.003 (0.002)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.01536 (0.15360)	1092.833	0.03600
CHANGE IN WATER STORAGE	-0.001 (1.2527)	-73.00	-0.002

Technical Notes

Technical Note 2.109
Re: Flow Capacity
Date: June, 2001

It is the intent of this Technical Note to provide current hydraulic performance data for use by the engineering community. A bibliography is included for the engineer's use if further information or guidance is needed.

Manning's "n" values, or roughness coefficient, are offered for design purposes based on the best available data assembled from a variety of sources as indicated. Table 1 presents the Manning's "n" values recommended by the ADS Engineering Department for use in design.

Table 1
Manning's "n" Value for Design
(Storm & Sanitary Sewer and Culverts)

Pipe Description	"n"
ADS Corrugated Polyethylene Pipe	
3"-6" (75 mm-150 mm)	0.015
8" (200 mm)	0.016
10" (250 mm)	0.017
12"-15" (300 mm - 375 mm)	0.018
18"-24" (450 mm - 600 mm)	0.020
ADS N-12	0.012
Concrete Pipe	0.013
Corrugated Metal Pipe (2⅔" x ½" (67.7mm x 12.7mm) corrugation)	
Annular	
Plain	0.024
Paved Invert	0.020
Fully Paved (smooth lined)	0.013
Helical	
Plain 15" (375 mm)	0.013
Plain 18" (450 mm)	0.015
Plain 24" (600 mm)	0.018
Plain 36" (900 mm)	0.021
Spiral Rib	0.012
Plastic Pipe (SDR, S&D, Etc.)	0.011
Vitrified Clay	0.013

Table 6

CIRCULAR PIPE FLOW CAPACITY

Full Flow (cubic feet per second)

Full Flow (cubic meters per second)

*Conv. Factor = $(1.486xR^{2/3}xA)/n$ (English)

*Conv. Factor = $(1.0xR^{2/3}xA)/n$ (Metric)

Manning's "n" =		0.015															
Diameter		*Conv	(% Slope) ft/100ft, m/100m														
(in.)	(mm.)	Factor	0.02	0.05	0.10	0.20	0.35	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.50	5.00	10.00	20.00
4		1.64	0.0231	0.0366	0.0517	0.0732	0.0968	0.1157	0.1417	0.1636	0.1829	0.2003	0.2164	0.2313	0.2586	0.3658	0.5173	0.7315
	100	0.04	0.0006	0.0010	0.0014	0.0020	0.0026	0.0031	0.0038	0.0044	0.0049	0.0054	0.0058	0.0063	0.0070	0.0099	0.0140	0.0198
6		4.83	0.0683	0.1080	0.1527	0.2160	0.2857	0.3415	0.4182	0.4829	0.5399	0.5915	0.6389	0.6830	0.7636	1.0799	1.5272	2.1597
	150	0.13	0.0018	0.0029	0.0041	0.0058	0.0077	0.0092	0.0113	0.0131	0.0146	0.0160	0.0173	0.0185	0.0206	0.0292	0.0413	0.0584
8		10.41	0.1472	0.2328	0.3292	0.4656	0.6159	0.7361	0.9016	1.0411	1.1639	1.2750	1.3772	1.4723	1.6461	2.3279	3.2921	4.6557
	200	0.28	0.0040	0.0063	0.0089	0.0126	0.0166	0.0199	0.0244	0.0281	0.0315	0.0345	0.0372	0.0398	0.0445	0.0629	0.0890	0.1259
10		18.89	0.2671	0.4224	0.5973	0.8448	1.1175	1.3357	1.6359	1.8890	2.1119	2.3135	2.4989	2.6714	2.9867	4.2238	5.9734	8.4477
	250	0.51	0.0072	0.0114	0.0161	0.0228	0.0302	0.0361	0.0442	0.0511	0.0571	0.0625	0.0676	0.0722	0.0807	0.1142	0.1615	0.2284
12		30.74	0.4347	0.6873	0.9719	1.3745	1.8183	2.1733	2.6618	3.0735	3.4363	3.7643	4.0659	4.3466	4.8597	6.8726	9.7194	13.7452
	300	0.83	0.0118	0.0186	0.0263	0.0372	0.0492	0.0588	0.0720	0.0831	0.0929	0.1018	0.1099	0.1175	0.1314	0.1858	0.2627	0.3716
15		55.77	0.789	1.247	1.764	2.494	3.299	3.943	4.830	5.577	6.235	6.830	7.377	7.887	8.818	12.470	17.635	24.940
	375	1.51	0.021	0.034	0.048	0.067	0.089	0.107	0.131	0.151	0.169	0.185	0.199	0.213	0.238	0.337	0.477	0.674
18		90.74	1.283	2.029	2.869	4.058	5.368	6.416	7.858	9.074	10.145	11.113	12.004	12.833	14.347	20.290	28.695	40.580
	450	2.45	0.035	0.055	0.078	0.110	0.145	0.173	0.212	0.245	0.274	0.300	0.325	0.347	0.388	0.549	0.776	1.097
21		136.95	1.937	3.062	4.331	6.124	8.102	9.684	11.860	13.695	15.311	16.772	18.116	19.367	21.653	30.622	43.306	61.244
	530	3.80	0.054	0.085	0.120	0.170	0.225	0.268	0.329	0.380	0.425	0.465	0.502	0.537	0.600	0.849	1.201	1.698
24		195.61	2.766	4.374	6.186	8.748	11.572	13.832	16.940	19.561	21.870	23.957	25.877	27.663	30.928	43.739	61.857	87.479
	600	5.29	0.075	0.118	0.167	0.236	0.313	0.374	0.458	0.529	0.591	0.648	0.700	0.748	0.836	1.182	1.672	2.365
27		267.89	3.789	5.990	8.472	11.981	15.849	18.943	23.200	26.789	29.952	32.810	35.439	37.886	42.358	59.903	84.716	119.806
	680	7.39	0.104	0.165	0.234	0.330	0.437	0.522	0.640	0.739	0.826	0.905	0.977	1.045	1.168	1.652	2.336	3.303
30		354.93	5.02	7.94	11.22	15.87	21.00	25.10	30.74	35.49	39.68	43.47	46.95	50.19	56.12	79.36	112.24	158.73
	760	9.94	0.14	0.22	0.31	0.44	0.59	0.70	0.86	0.99	1.11	1.22	1.31	1.41	1.57	2.22	3.14	4.45
36		577.50	8.17	12.91	18.26	25.83	34.17	40.84	50.01	57.75	64.57	70.73	76.40	81.67	91.31	129.13	182.62	258.27
	900	15.61	0.22	0.35	0.49	0.70	0.92	1.10	1.35	1.56	1.75	1.91	2.07	2.21	2.47	3.49	4.91	6.98
42		871.56	12.33	19.49	27.56	38.98	51.56	61.63	75.48	87.16	97.44	106.74	115.30	123.26	137.81	194.89	275.61	389.77
	1050	23.58	0.33	0.53	0.75	1.05	1.39	1.67	2.04	2.36	2.63	2.89	3.12	3.33	3.73	5.27	7.45	10.54
48		1244.91	17.61	27.84	39.37	55.67	73.65	88.03	107.81	124.49	139.18	152.47	164.69	176.06	196.84	278.37	393.67	556.74
	1200	33.65	0.48	0.75	1.06	1.51	1.99	2.38	2.91	3.37	3.76	4.12	4.45	4.76	5.32	7.53	10.64	15.05
60		2258.85	31.94	50.51	71.43	101.02	133.64	159.72	195.62	225.88	252.55	276.65	298.82	319.45	357.16	505.09	714.31	1010.19
	1500	61.06	0.86	1.37	1.93	2.73	3.61	4.32	5.29	6.11	6.83	7.48	8.08	8.64	9.65	13.65	19.31	27.31

APPENDIX IV
Erosion Control Plan

Duke Power
A Duke Energy Company

Duke Power
Power Generation Department
P.O. Box 1006
Charlotte, NC 28201-1006

August 29, 2002

Mr. Steve Booe
North Carolina Department of Environment
and Natural Resources
Winston-Salem Regional Office
Land Quality Section
585 Waughtown Street
Winston-Salem, North Carolina 27107

Subject: Belews Creek Steam Station
Ash Landfill
Erosion Control Plan

Dear Mr. Booe:

Belews Creek Steam Station is in the process of applying for an expansion of the existing ash landfill. Attached for your review is associated the erosion control plan that includes: two sets of drawings, calculations, a completed Financial Responsibility Ownership form and also check for $ 2,450.00.

Your review and approval of this erosion control plan is requested. Upon approval the erosion control measures will be put in place and the land disturbing activity will begin. If you need additional information or have any questions please call me at (704) 382-4669.

Sincerely,

Robert R. Wylie

Robert Wylie, Engineer
Duke Energy Corporation

R. R. Wylie

bc:	Allen Stowe	EC11E
	Bill Miller	EC12ZB
	Jeff Newell	EC01U
	Larry Harper	EC01U
	Mike Ruhe	EC11E
:	Randy Price	Belews Creek Steam Station
	Ron Lewis	EC12A
	Tim Ervine	EC11E
	Tony Mathis	EC01U

File Number: 404.110.06 (Belews Creek Steam Station)

DUKE ENERGY NAME AND LOGO ARE ON BACK. HOLD AT AN ANGLE TO VIEW. VOID IF ABSENT.

DUKE ENERGY CORPORATION

P.O. BOX 1015
CHARLOTTE, NORTH CAROLINA 28201-1015

WACHOVIA BANK OF SOUTH CAROLINA, NA
COLUMBIA, S.C.

67-1
532

CHECK NO
633626

DATE AUGUST 29, 2002

Amount
$*********2,450.00

PAY

TO THE ORDER OF
00000009024117
NC DENR
585 WAUGHTOWN STREET
WINSTON-SALEM NC 27107

Authorized Signature

PRINTED WITH BLUE BACKGROUND ON WHITE PAPER. VOID IF ABSENT.

"633626" :053200191: 3206 89557"

EROSION AND SEDIMENTATION CONTROL PLAN

BELEWS CREEK ASH LANDFILL
STOKES COUNTY, NORTH CAROLINA

PREPARED FOR:

DUKE ENERGY COMPANY
CHARLOTTE, NORTH CAROLINA

PREPARED BY:

SHIELD ENGINEERING, INC.
4301 TAGGART CREEK ROAD
CHARLOTTE, NORTH CAROLINA 28208

SHIELD PROJECT NO. 1020062-01

AUGUST 2002

SHIELD ENGINEERING, INC.

LIMITATIONS

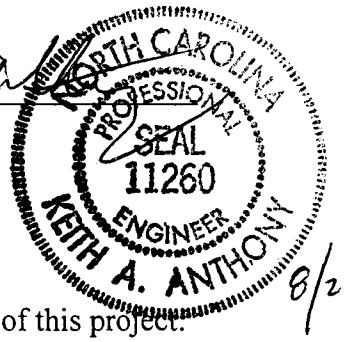
This report has been prepared in accordance with generally accepted civil and environmental engineering practices for the exclusive use of Duke Energy Company, its agents, and/or clients. This report may not be reproduced, in whole or in part, without the permission of Duke Energy Company.

Our conclusions and recommendations are based upon our site observations, provided survey and guidelines from the North Carolina Erosion and Sediment Control Planning and Design Manual. We have assumed that information provided to us by others is correct and true, unless otherwise noted. If additional information or changes in information is available in the future, we request the chance to review and change our recommendations, if necessary.

The Erosion and Sedimentation Control Plan was prepared under my direct supervision:

By: _____

Keith A.Anthony, P.E.
Principal Engineer



8/28/02

I assisted with the preparation of this project.

By: _____

Andrew A. Davis, P.E.
Project Manager

TABLE OF CONTENTS

1.0 NARRATIVE

1.1 Project Description:

The scope of the project is the construction / continuation of an ash landfill. The new landfilling activities will include a 2,108,300 square foot (48.4 acres) tract of land to be cleared, graded, and/or used as a future ash landfill (activities to be conducted through 2007). The site is a tract located in Stokes County near Winston Salem, North Carolina off Pine Hall Road (See Figure 1 - Vicinity Map). The Erosion and Sedimentation Control Plan is based upon approximately 48.4 acres of watershed.

1.2 Site Description:

The site is currently a wooded area with the active face of an existing ash landfill on the western edge of the project site. This active face is to be closed prior to new landfilling activities. Site topography, in general, slopes toward an existing sediment basin located at the northern end of the property and ultimately, all drainage will flow into the existing ash basin. The proposed location of the project is entirely on property owned by Duke Energy (Duke). This site is part of a proposed expansion to an existing ash landfill. An access road is presently located on the site along with an existing sediment basin. The proposed area for fill is shown on Figure 4 – Erosion and Sediment Control Plan.

1.3 Adjacent Property:

The site is located entirely within Duke's property at the Belews Creek Power Plant. The ash landfill property is located off of Pine Hall Road . The tract of land to the west of the property in question is currently an existing ash landfill.

1.4 Soils:

The top layer of soils in the subject area consist primarily of sandy silts (ML) and silty sands (SM) with a Standard Penetration Resistance of N <30. The layer ranges in thickness from 10.6 to 43.3 feet. The underlying layer of soil consists of saprolite and weathered rock consisting of sandy silts (ML) and silty sands with layers of moderately to very severely weathered rock.

Surface and subsurface drainage patterns provide an indication of the direction in which groundwater would flow. The movement of groundwater through soil and rock is dependent upon the effects of geological features, such as bedding, faults, folds or foliation planes on groundwater flow. Groundwater recharge within the region occurs mostly from precipitation on upland areas above flood plains. The residual soils and saprolite act as an infiltration medium for precipitation to seep into the fractures and joints of the underlying bedrock. Discharge from the system occurs as seepage springs that are common near the bases of slopes and at the intersection with surface water features such as streams and lakes. Three spring heads can be seen on Figure 2 – Site Topographic Map.

1.5 Planned Erosion and Sedimentation Control Practices:

1.5.1 Temporary Gravel Construction Entrance:

A gravel roadway is currently in use at the site for access to the present landfilling operations. Additional gravel will be placed on the existing gravel road near the entrance to the fill site. The entrance will be graded so that runoff water will be directed to the grass-lined channels and sediment basin.

1.5.2 Land Grading

Grading will be required on approximately 16.6 acres. The flatter slope after grading will reduce the overall erosion potential of the site. Grading activities will be conducted based on the location of the landfilling activities.

Slopes will be fine graded immediately after rough grading; the surface will be disked and vegetated according to the Vegetation Plan.

1.5.3 Sediment Control Basin

An existing sediment basin will be utilized at the northern end of the proposed site. The entire 48.4 acre area of the project site will drain through this basin. The only modification to the existing basin will be the raising of the berm on the northern end of the basin to an elevation of 758.0'. See Appendix B for the Sediment Basin Calculations.

1.5.4 Sediment Trap

A sediment trap will be constructed on the eastern side of the project site. The containment volume of the sediment trap will consist of the area defined by the trap and the existing contours. The trap will receive water from a portion of Area #3 (approximately 3.6 acres). Details of the sediment trap design can be seen in Appendix B.

1.5.5 Sediment Fence

A Sediment fence will be constructed below small denuded areas and as necessary to prevent sediment from entering drainage channels. A sediment fence will be placed along the grass lined channels to prevent sediment from leaving the site.

1.5.6 Grass-Lined Channel

Two (2) Grass-lined channels with temporary straw-net liners will be constructed to collect and convey site water to the project's sediment basin. See Appendix B for Channel calculations and Figure 4 for the location of the channels.

Should the disturbed areas adjoining the channels not be stabilized at the time the channels are vegetated, a sediment fence will be installed adjacent to the channel to prevent channel siltation.

1.5.7 Surface Stabilization

Surface stabilization will be accomplished with vegetation and mulch as specified in the vegetation plan. Vegetation will be planted immediately upon the grading completion.

1.5.8 Dust Control

Dust control is not expected to be a problem due to the distance from the site to the nearest area of concern. Should excessive dust be generated, it will be controlled by sprinkling with water.

2.0 CONSTRUCTION SCHEDULE

1. Obtain plan approval and other applicable permit approval.
2. Flag the work limits and mark the buffer area for protection.
3. Hold preconstruction conference at least one week prior to beginning construction.
4. Add gravel to the construction entrance if necessary.
5. Install sediment basin modifications as the first construction activity.
6. Rough grade site, compact fill areas, construct channels and sediment trap, and install sediment fence as needed.
7. Transport ash fill to site, spread, compact, and treat.
8. Complete final grading for cover soils.
9. Complete final grading for grounds and permanently vegetate, landscape, and mulch.
10. All erosion and sediment control practices will be inspected weekly and after rainfall events. Needed repairs will be made immediately.
11. After site is stabilized, remove all temporary measures and install permanent vegetation on the disturbed areas.

3.0 MAINTENANCE PLAN

The Contractor will be responsible for maintenance of the erosion control measures during the construction of the project. Once the project has been completed, the owner of the facility will become responsible for maintaining the permanent measures. Typical maintenance issues include the following:

1. All erosion and sediment control practices will be checked for stability and operation following every runoff-producing rainfall but in no case less than once every month. Any needed repairs will be made immediately to maintain all practices as designed.

2. Sediment will be removed from the sediment basin when the level of sediment reaches 2.0 feet below top of the riser. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.

3. Sediment will be removed from behind the sediment fence when it becomes approximately 0.5 feet in depth at the fence. The sediment fence will be repaired as necessary to maintain a barrier.

4. All seeded areas will be fertilized, reseeded as necessary, and mulched according to specifications in the vegetative plan to maintain a vigorous, dense vegetative cover.

4.0 SPECIFICATIONS

4.1 Temporary Gravel Construction Entrance

1. Clear the existing roadway and shoulders of the roadway of all vegetation, roots, and other objectionable material.

2. Grade the existing access road foundation so that the entrance will drain to the drainage channels and sediment basin.

3. Place stone to the grade, elevation, and dimensions shown on the Plans.

4. Use crushed stone 2" – 3" in size.

5. The gravel roadway shall be maintained in a condition to prevent mud or sediment from leaving the site. Should mud be tracked or washed onto public roads, it must be removed immediately.

4.2 Land Grading

1. Finished land surfaces will be graded as shown on the Site Grading Plan.

2. Cut slopes will be 3:1 or flatter for maintenance by mowing and roughened for vegetative establishment.

3. Areas to be filled will be cleared and grubbed (with the exception of the areas already cleared).

4. Fill will be placed in layers not to exceed 6" and compacted as required.

5. Frozen material or soft, highly compressive material will not be used as fill.

6. Fill is not to be placed on a frozen surface.

7. The gravel road and construction entrance will be sloped to control runoff.

8. As soon as final grades are reached, the graded areas will be stabilized in accordance with the vegetative plan.

9. An undisturbed area will be left as a buffer around the entire graded area.

10. When the ash fill area has been properly stabilized all the temporary sediment and erosion control measures will be removed and the disturbed area graded to blend with the surrounding area and vegetated.

4.3 Sediment Basin

1. Clear and grub foundation for embankment and excavate the area for the riprap outlet pad. Area pad to be 10.0' long, 11.5' wide and a minimum of 13.5 inches deep.

2. Excavate cutoff trench along embankment centerline and up abutments. Keep trench dry when backfilling and compacting.

3. Use excess material from grading as source of fill material for raising the embankment. Material should be clean soil, free of roots, woody material, rock's or other objectionable material. Scarify foundation and place fill in layers not to exceed 8" over the entire length of the embankment. Compact by heavy wheel equipment. The entire surface of each layer must be traversed by at least one wheel of the compaction equipment. The fill material must be moist but not so wet that water can be squeezed from it.

4. Perforate 24" CMP riser with 1/2" holes spaced 3" apart in each outside valley. Rows of holes shall be vertically spaced 6" apart and have a minimum 15 holes each. Secure trash rack to riser top. Maximum opening between bars of rack not to exceed 3".

5. Securely attach the riser to the barrel and all other pipe joints with rod and lug connector bands with rubber gaskets to assure water tightness. Place the barrel and riser on a smooth, firm foundation. Place fill around the pipe in 4" layers and hand compact. Take care not to raise the pipe from firm contact with its foundation when compacting under pipe haunches.

6. Secure one standard corrugated metal anti-seep collar around barrel. Make sure connection is watertight. Hand compact around anti-seep collar.

7. Place a minimum of 2 ft. of hand compacted backfill over pipe before crossing it with construction equipment.

8. Anchor riser in place with 1/3 yd^3 (3'x3'x1') concrete pad poured around riser.

9. Place 3/4" gravel (D.O.T. #5 washed stone) over the perforated holes approximately 2" thick.

10. Install emergency spillway in undisturbed soil to the lines and grades shown in drawings.

11. Place Class A erosion control stone over filter fabric on level grade for riprap apron at pipe outlet. Top of riprap to be same elevation as outlet channel bottom. No overfall.

12. Clear sediment basin area to elevations shown on the Erosion and Sediment Control Plan after the embankment is complete.

13. Vegetate all disturbed areas (except the sediment pool) in accordance with the vegetative plan.

14. Sediment to be removed from basin when the level is within 2.0' of the top of the riser. (Same level as top of gravel).

4.4 Sediment Trap

1. Clear, grub, and strip the area under the embankment of all vegetation and root mat.

2. Clear pond area below elevation of 765'

3. Construct dam and stone spillway to dimensions, slopes, and elevations shown on Figure 6.

4. Ensure that the spillway crest is level and at least 1.5 feet below the top of dam at all points.

5. Use Class "B" erosion control stone for the spillway section.

6. Use D.O.T. #57 washed stone for inside spillway face.

7. Ensure that the top of the dam at all points is 0.5' above natural surrounding ground.

8. Stabilize the embankment and all disturbed area above the sediment pool as shown in the vegetation plan.

4.5 Sediment Fence

1. Construct the sediment fence at the locations shown.

2. Locate posts downslope of fabric to hold fencing.

3. Bury toe of fence approximately 8" deep to prevent undercutting.

4. When joints area necessary, securely fasten the fabric at a support post with overlap to the next post.

5. Filter fabric is to be of nylon, polyester, propylene, or ethylene yarn with extra strength – 50 lb/ linear inch (minimum), and with a flow rate of at least 0.3 gal./ft^2/minute. Fabric should contain ultraviolet inhibitors and stabilizers.

6. Post to be 4" diameter pine with a minimum length of 4 feet.

4.6 Grass Lined Channels

1. Excavate the channels and shape it to an even cross section as shown on the plans. When staking, indicate a 0.2' overcut around the channel perimeter for silting and bulking.

2. Remove excess soil away from channel so that surface water may enter freely.

3. Apply lime, fertilizer, and seed to the channel and adjoining areas.

4. Hold mulch in place immediately after spreading with a net until grass becomes established.

5.0 VEGETATIVE PLAN

The site is located in the Piedmont Region and because of the frequent mowing which will be performed at this site, the grass cover is considered as high maintenance. Referencing the attached Table 6.11b of the North Carolina Erosion and Sediment Control Design Manual the appropriate Seeding Number of 7CP, which is shown on the attached Table 6.11v (See Appendix D), should be used for seeding at this site.

Ground cover shall be placed on exposed slopes within 30 working days following completion of any phase of grading, permanent ground cover for all disturbed areas within 30 working days or 120 calender days (whichever is shorter) following completion of construction or development.

Seedbed Preparation

1. Remove rocks and debris that could interfere with tillage and the production of a uniform seedbed.
2. Apply lime and fertilizer at rates recommended; spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller.
3. Break up large clods and rake into a loose, uniform seedbed.
4. Rake to loosen surface just prior to applying seed.

Seeding Methods

1. Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.
2. Rake seed into the soil and lightly pack to establish good contact.

Mulch

Apply grain straw and tack as recommended.

Maintenance

Reseed, fertilize and mulch as necessary.

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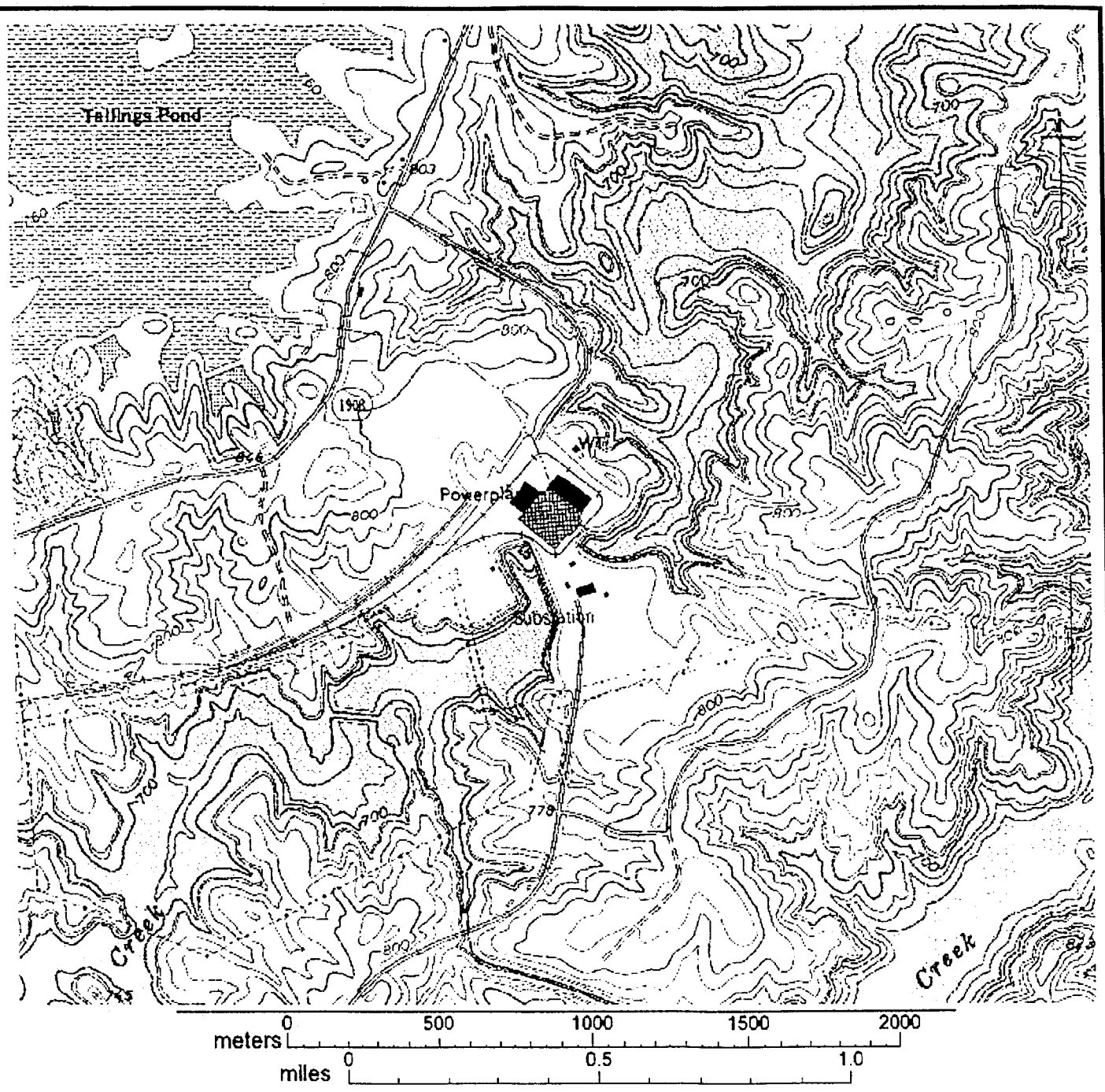


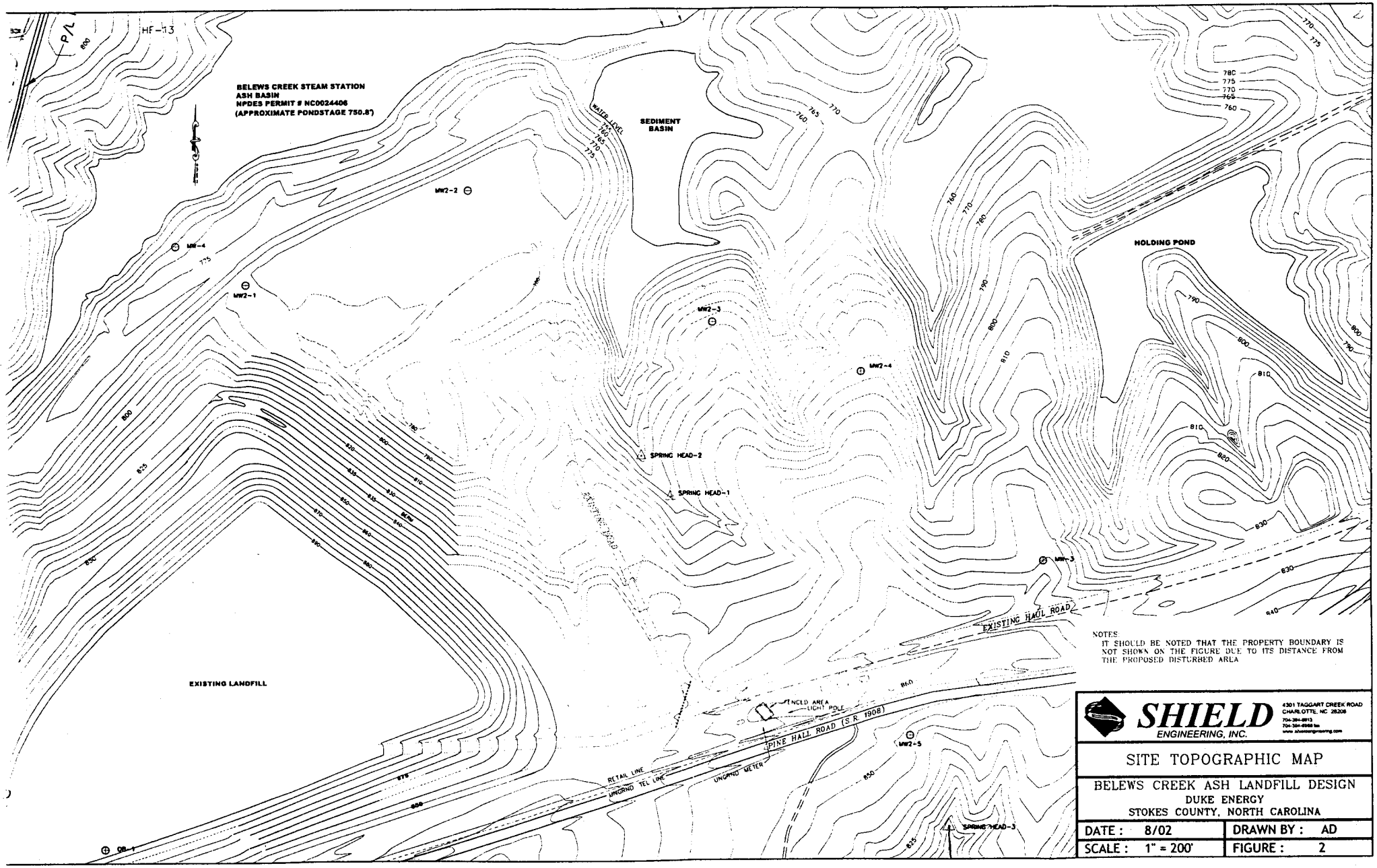
QUADRANGLE LOCATION

BELEWS LAKE, NC

SHIELD
ENGINEERING, INC.
4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28208
704-394-6913
704-394-6968 FAX
www.shieldengineering.com

PROJECT#: 1020062	BELEWS CREEK ASH LANDFILL DESIGN
DATE: 07/26/02	DUKE ENERGY
PROJECT MGR: KAA	STOKES COUNTY, NORTH CAROLINA
DESIGNED BY: AAD	
DRAWN BY: AAD	SITE LOCATION MAP — FIGURE: 1
SCALE: AS SHOWN	

H:\ENGINEERING\2002\1020062\LOCATION MAP



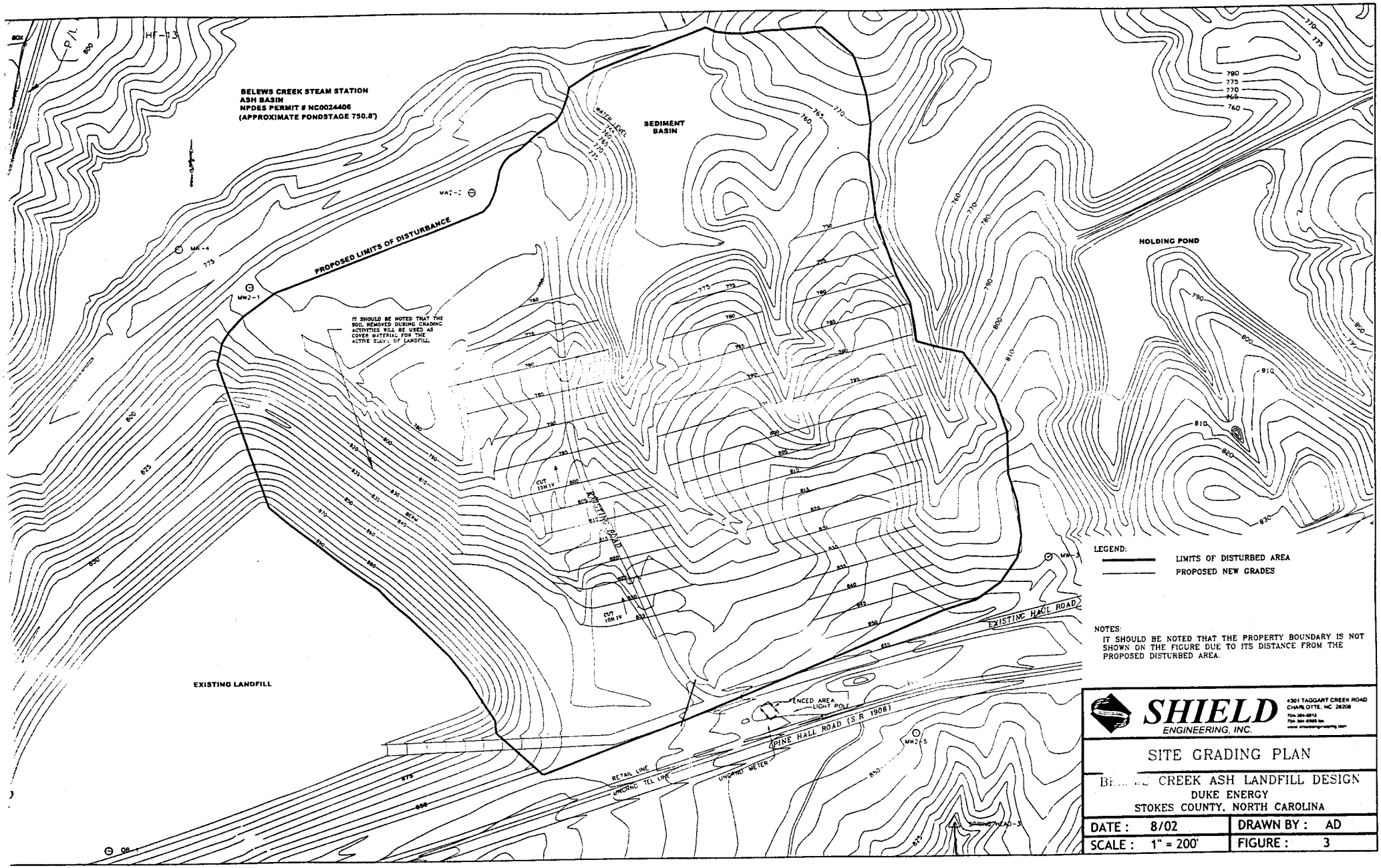
NOTES:
IT SHOULD BE NOTED THAT THE PROPERTY BOUNDARY IS NOT SHOWN ON THE FIGURE DUE TO ITS DISTANCE FROM THE PROPOSED DISTURBED AREA

SHIELD ENGINEERING, INC.
4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28208
704-391-8813
704-391-8968 fax
www.shieldengineering.com

SITE TOPOGRAPHIC MAP

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 8/02	DRAWN BY : AD
SCALE : 1" = 200'	FIGURE : 2

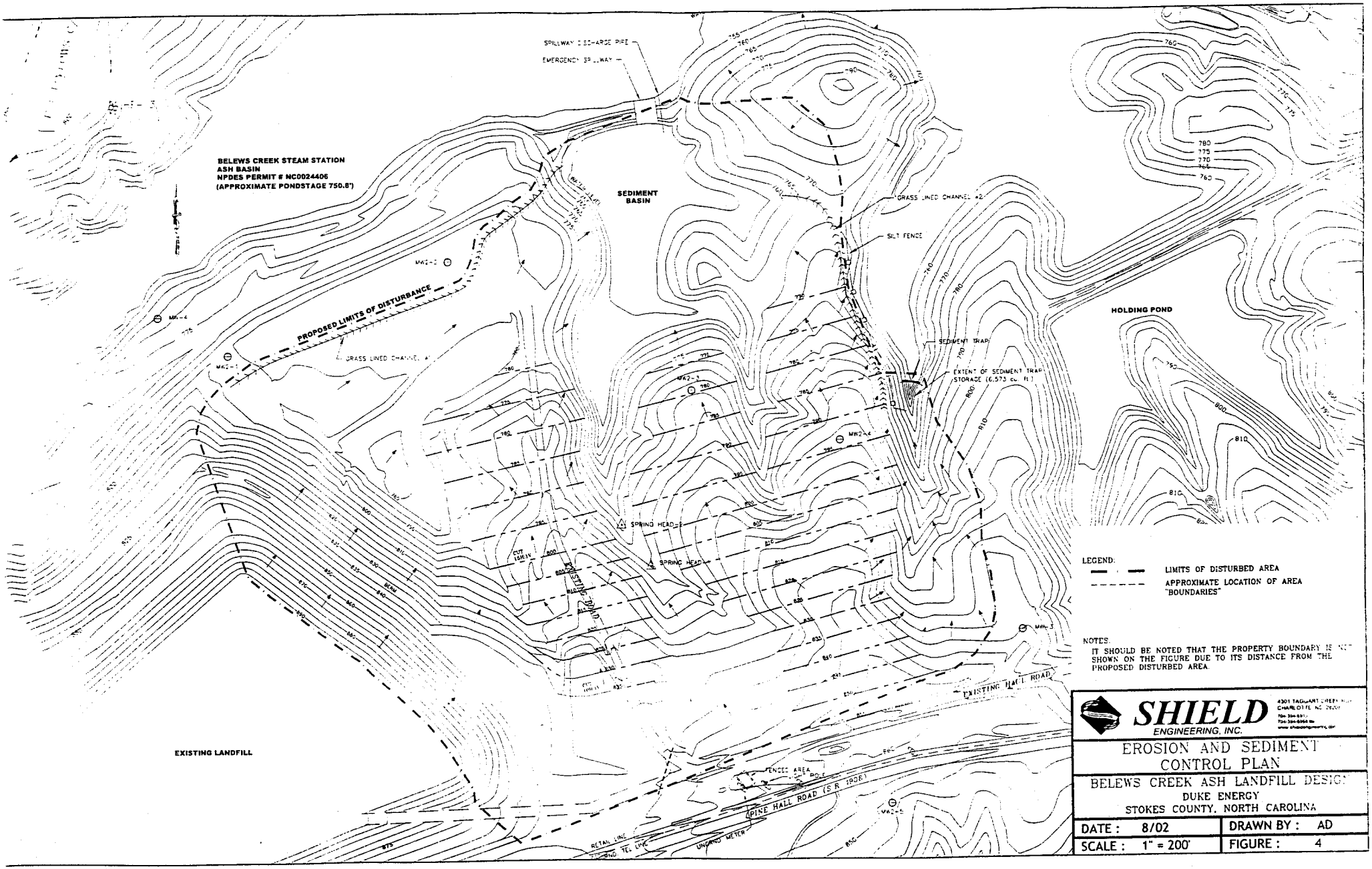


SHIELD ENGINEERING, INC.
4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28208
704-394-8913
Fax 394-4569 fax

SITE GRADING PLAN

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 8/02	DRAWN BY : AD
SCALE : 1" = 200'	FIGURE : 3



LEGEND:

- LIMITS OF DISTURBED AREA
- APPROXIMATE LOCATION OF AREA "BOUNDARIES"

NOTES:

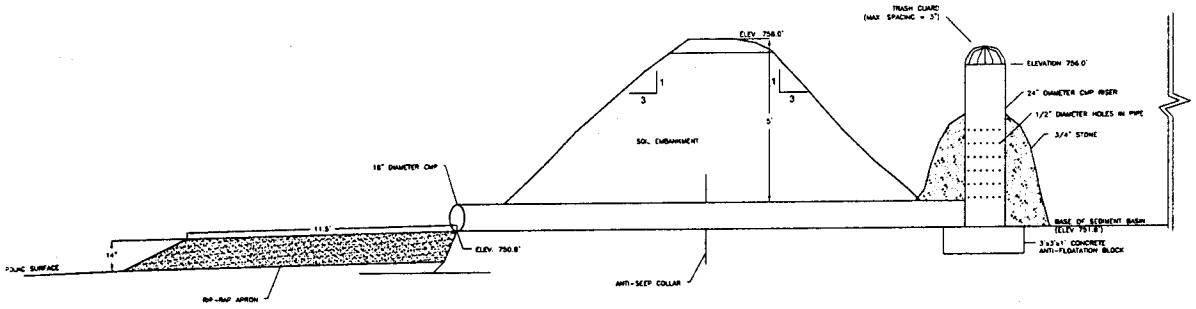
IT SHOULD BE NOTED THAT THE PROPERTY BOUNDARY IS NOT SHOWN ON THE FIGURE DUE TO ITS DISTANCE FROM THE PROPOSED DISTURBED AREA.

SHIELD ENGINEERING, INC.
4301 TAGUART CREEK
CHARLOTTE, NC 28217
704-364-6911
704-364-6966 fax
www.shieldengineering.com

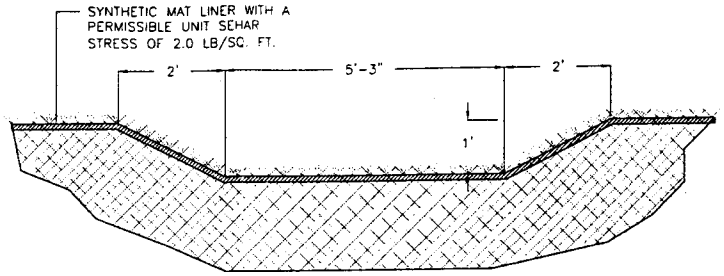
EROSION AND SEDIMENT CONTROL PLAN

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

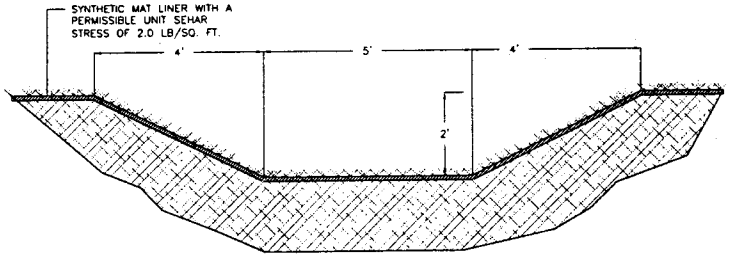
DATE : 8/02	DRAWN BY : AD
SCALE : 1" = 200'	FIGURE : 4



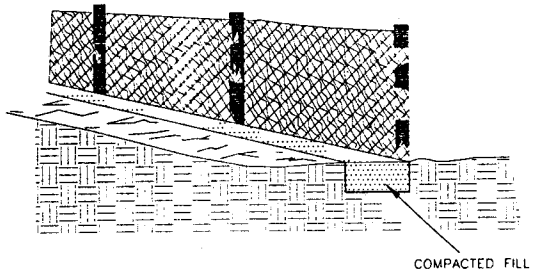
DISCHARGE PIPE/EMBANKMENT DETAIL
NOT TO SCALE



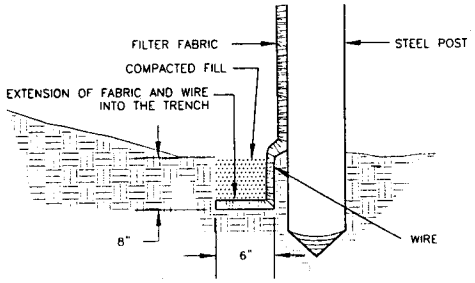
CROSS SECTION DETAIL - CHANNEL #2
NOT TO SCALE



CROSS SECTION DETAIL - CHANNEL #1
NOT TO SCALE



TEMPORARY SILT FENCE DETAIL
NOT TO SCALE



TEMPORARY SILT FENCE DETAIL
NOT TO SCALE

SHIELD ENGINEERING, INC.
4301 TAGGART CREEK ROAD
CHARLOTTE NC 28208

SITE DETAILS

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 8/02	DRAWN BY : AD
SCALE : NA	FIGURE : 5

2.0 CONSTRUCTION SCHEDULE

Obtain plan approval and other applicable permit approval

Flag the work limits and mark the buffer area for protection

Hold preconstruction conference at least one week prior to beginning construction.

Add gravel to the construction entrance if necessary

Install sediment basin modifications as the first construction activity

Rough grade site, compact fill areas, construct channels and sediment trap, and install sediment fence as needed.

Transport ash fill to site, spread, compact, and treat

Complete final grading for cover soils.

Complete final grading for grounds and permanently vegetate, landscape, and mulch

All erosion and sediment control practices will be inspected weekly and after rainfall events Needed repairs will be made immediately

After site is stabilized, remove all temporary measures and install permanent vegetation on the disturbed areas.

3.0 MAINTENANCE PLAN

The Contractor will be responsible for maintenance of the erosion control measures during the construction of the project. Once the project has been completed, the owner of the facility will become responsible for maintaining the permanent measures. Typical maintenance issues include the following:

All erosion and sediment control practices will be checked for stability and operation following every runoff-producing rainfall but in no case less than once every month. Any needed repairs will be made immediately to maintain all practices as designed.

Sediment will be removed from the sediment basin when the level of sediment reaches 2.0 feet below top of the riser. Gravel will be cleaned or replaced when the sediment pool no longer drains properly.

Sediment will be removed from behind the sediment fence when it becomes approximately 0.5 feet in depth at the fence. The sediment fence will be repaired as necessary to maintain a barrier.

All seeded areas will be fertilized, reseeded as necessary, and mulched according to specifications in the vegetative plan to maintain a vigorous, dense vegetative cover.

5.0 VEGETATIVE PLAN

The site is located in the Piedmont Region and because of the frequent mowing which will be performed at this site, the grass cover is considered as high maintenance. Referencing the attached Table 6.11b of the North Carolina Erosion and Sediment Control Design Manual the appropriate Seeding Number of 7CP, which is shown on the attached Table 6.11v (See Appendix D), should be used for seeding at this site.

Ground cover shall be placed on exposed slopes within 30 working days following completion of any phase of grading, permanent ground cover for all disturbed areas within 30 working days or 120 calender days (whichever is shorter) following completion of construction or development.

Seedbed Preparation

1. Remove rocks and debris that could interfere with tillage and the production of a uniform seedbed
2. Apply lime and fertilizer at rates recommended, spread evenly and incorporate into the top 6" with a disk, chisel plow, or rotary tiller
3. Break up large clods and rake into a loose, uniform seedbed
4. Rake to loosen surface just prior to applying seed

Seeding Methods

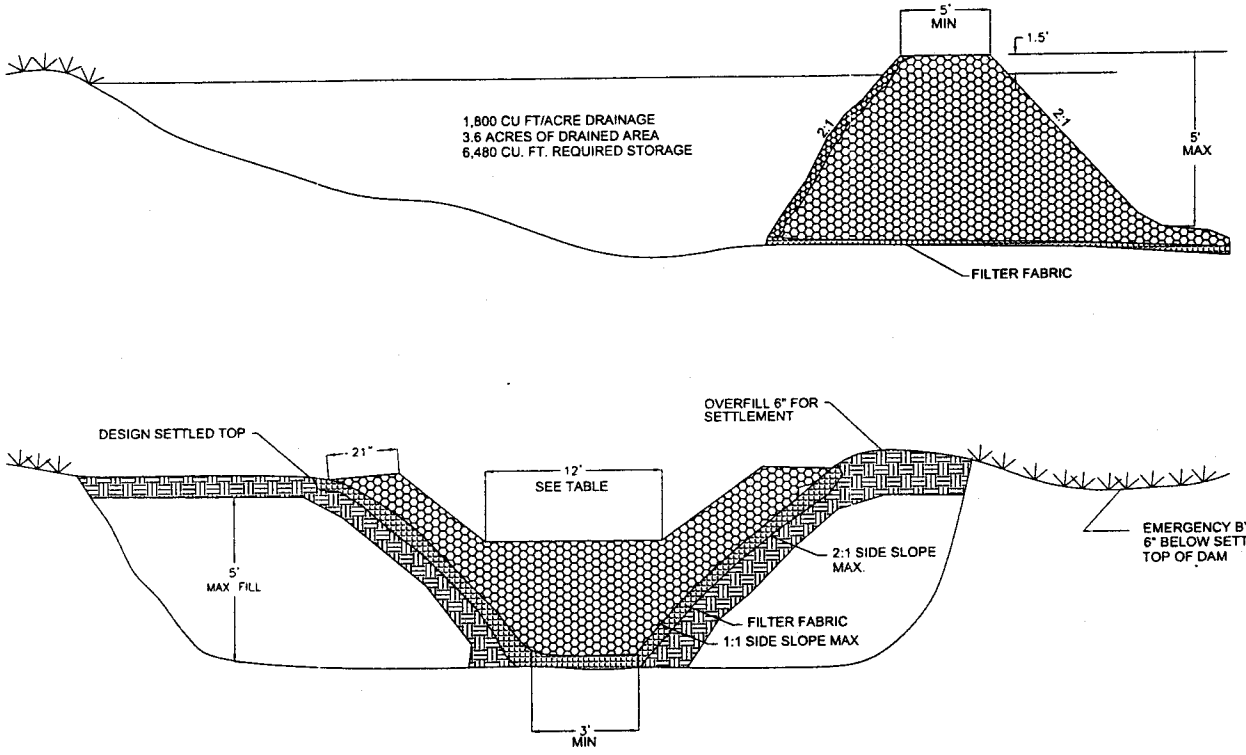
Broadcast seed at the recommended rate with a cyclone seeder, drop spreader, or cultipacker seeder.
Rake seed into the soil and lightly pack to establish good contact

Mulch

Apply grain straw and tack as recommended

Maintenance

Reseed, fertilize and mulch as necessary



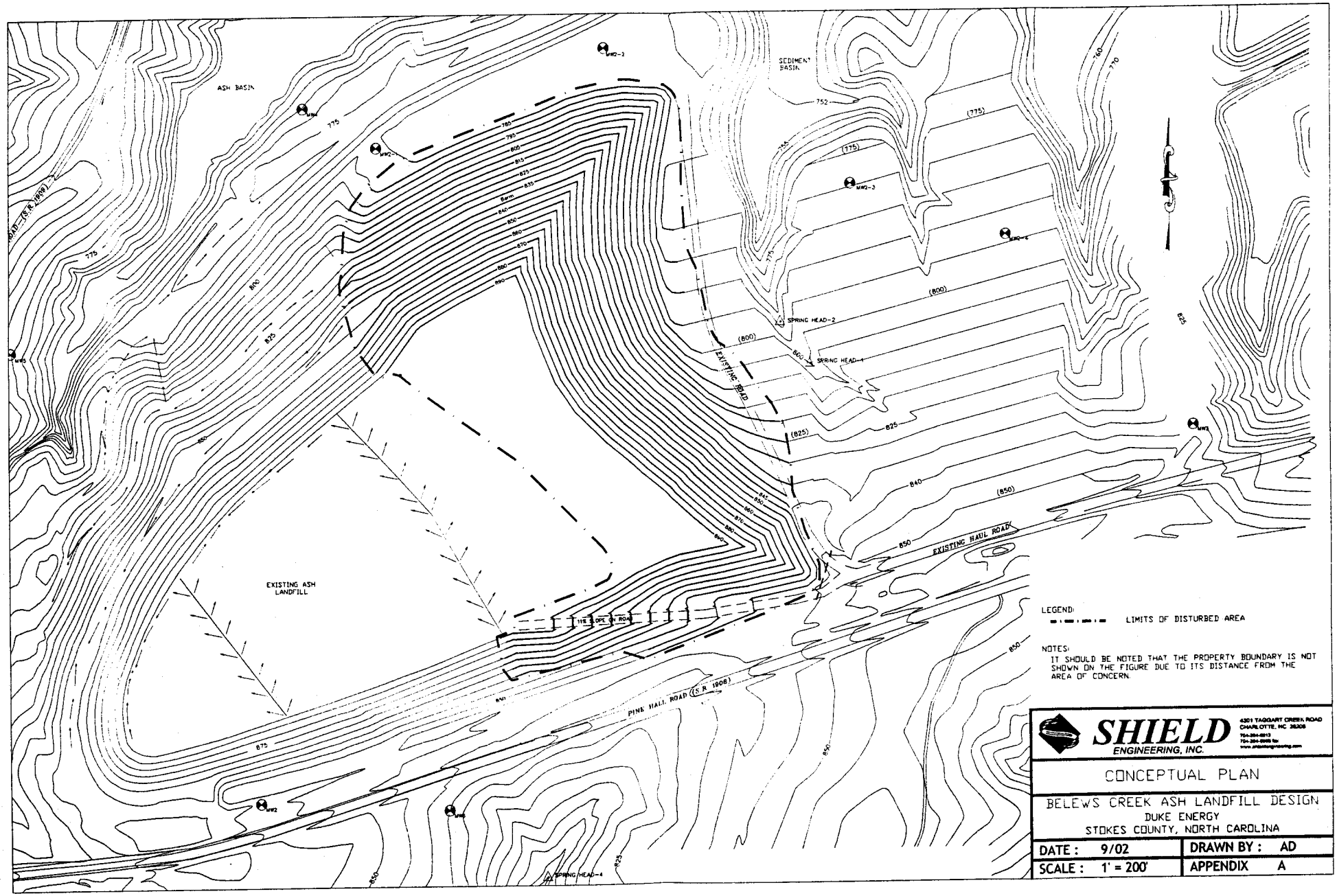
TEMPORARY SEDIMENT TRAP
NOT TO SCALE

SHIELD ENGINEERING, INC.
4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28208
704-364-6913
704-364-9668 fax
www.shieldengineering.com

SEDIMENT TRAP DETAIL

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 8/02	DRAWN BY : AD
SCALE : NA	FIGURE : 6



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4301 TAGGART CREEK ROAD
CHARLOTTE, NC 28208

CONCEPTUAL PLAN

BELEWS CREEK ASH LANDFILL DESIGN
DUKE ENERGY
STOKES COUNTY, NORTH CAROLINA

DATE : 9/02	DRAWN BY : AD
SCALE : 1" = 200'	APPENDIX A

APPENDIX A
Erosion and Sediment Control
Financial Responsibility / Ownership Form

FINANCIAL RESPONSIBILITY /OWNERSHIP FORM
SEDIMENTATION POLLUTION CONTROL ACT

No person may initiate a land-disturbing activity on one or more acres as covered by the Act before this form and an acceptable erosion and sedimentation control plan have been completed and approved by the Land Quality Section, NC Department of Environment, and Natural Resources. (Please type or print and, if question is not applicable, place N/ A in the blank).

Part A.

1. Project Name: Belews Creek Steam Station Ash Landfill
2. Location of land-disturbing activity: County : Stokes County

   City or Township: Belews Creek and Highway/Street: Pine Hall Road
3. Approximate date land-disturbing activity will be commenced: October 1, 2002
4. Purpose of development (residential, commercial, industrial, etc.): Industrial
5. Total acreage disturbed or uncovered (including off-site borrow and waste areas):

   48.4 acres
6. Amount of fee enclosed $ 2,450.00
7. Has an erosion and sedimentation control plan been filed? Yes _____ No _____

   Enclosed: X
8. Person to contact should sediment control issues arise during land-disturbing activity.

   Name: Randy Price Telephone: (336) 445-0324
9. Landowner(s) of Record (Use blank page to list additional owners):

   Duke Energy Corporation
   Name(s)

   P.O. Box 1006 — Current Mailing Address
   Charlotte, North Carolina 28201 — City State Zip

   526 South Church Street — Current Street Address
   Charlotte, North Carolina 28201 — City State Zip
10. Recorded in Deed Book No.: 187 Page No.: 319, 321, 340, 367 and 492

Part B.

Person(s) or firm(s) who are financially responsible for this land-disturbing activity (Use a blank page to list additional persons or firms):

Duke Energy Corporation
Name of Person(s) or Firm(s)

P.O. Box 1006 — Current Mailing Address
Charlotte, North Carolina 28201 — City State Zip

Telephone: (704) 373-3231

526 South Church Street — Current Street Address
Charlotte, North Carolina 28201 — City State Zip

Telephone: (704) 382-3231 MAR 373

2. (a) If the Financially Responsible Party is not a resident of North Carolina give name and street address of a North Carolina Agent.

Name

Mailing Address

City State Zip

Telephone

Street Address

City State Zip

Telephone

(b) If the Financially Responsible Party is a Partnership or other person engaging in business under an assumed name, attach a copy of the certificate of assumed name. If the Financially Responsible Party is a Corporation give name and street address of the Registered Agent.

Name of Registered Agent

Mailing Address

City State Zip

Telephone

Street Address

City State Zip

Telephone

The above information is true and correct to the best of my knowledge and belief and was provided by me under oath. (This form must be signed by the financially responsible person if an individual or his attorney-in-fact or if not an individual by an officer, director, partner, or registered agent with authority to execute instruments for the financially responsible person). I agree to provide corrected information should there be any change in the information provided herein.

Michael A. Ruhe
Type or print name

Michael A Ruhe
Signature

Manager, Environmental Health and Safety
Title or Authority

8/29/02
Date

I, Evia J. Woolard, a Notary Public of the County of Mecklenburg State of North Carolina, hereby certify that Michael A. Ruhe appeared personally before me this day and being duly sworn acknowledged that the above form was executed by him.

Witness my hand and notarial seal, this 29th day of August, 2002

Seal

Evia J. Woolard
Notary

My commission expires August 14, 2006

APPENDIX B
Supporting Calculations

BELEWS CREEK
EROSION AND SEDIMENT CONTROL PLAN
SEDIMENT POND DESIGN

STEP 1: **PEAK FLOW FOR DRAINAGE AREA** (25 YEAR STORM)

A = 48.4 acres (SEE FIGURES)
I = 7 in/hr (FROM FIGURE 8.03D)
C = FROM TABLE 8.03A
LAND USE: USE AGRICULTURAL LAND, BARE PACKED SOIL
USE C = 0.50
FROM FIGURE 8.03A
Tc= 5 MIN
Q = CiA
169.4 cfs

STEP 2: **SITE LIMITATIONS** -->

SEDIMENT BASIN DISCHARGE PIPE OUTLET ELEVATION IS LIMITED BY THE ELEVATION OF THE WATER IN THE ASH BASIN

STEP 3: **BASIN VOLUMES**

MINIMUM VOLUME REQUIRED IS 1,800 CUBIC FEET PER ACRE

48.4 ACRES X 1,800 CUBIC FEET PER ACRE = 87,120 CUBIC FEET OF STORAGE **REQUIRED**

SURFACE AREAS DETERMINED USING CONTOURS ON AUTOCAD
AVAILABLE SURFACE AREA OF SEDIMENT POND @ ELEV. 750.8 = 87,077 SQUARE FEET
AVAILABLE SURFACE AREA OF SEDIMENT POND @ ELEV. 756.0 = 153,800 SQUARE FEET

VOLUMES TO BE DETERMINED
SEDIMENT POND WITH 1 FOOT OF WATER (1' x 87,077 sq ft)) 87,077 CUBIC FEET
SEDIMENT POND WITH 4.2 FEET OF WATER - TO THE 756 CONTOUR
4.2 ft x (153,800 sq ft + 87,077 sq ft)/2 505,842 CUBIC FEET

STEP 4: **AREA AND SHAPE OF BASIN**

THE AREA AND SHAPE OF THE BASIN WILL BE DEPENDANT ON THE SIZE AND SHAPE OF THE EXISTING CONTOURS (SEE GRADING PLAN). A MODIFICATION PLANNED WILL BE THE RAISING OF THE BERM LOCATED ON THE NORTHERN SIDE OF THE EXISTING SEDIMENT POND. THE BERM WILL BE RAISED TO AN APPROXIMATE ELEVATION OF 758.

CHECK LENGTH TO WIDTH RATIO: NA - EXISTING CONTOURS DETERMINE
COMPUTE THE BASIN SURFACE AREA AT PRINCIPAL SPILLWAY ELEVATION:

CHECK THE RATIO OF BASIN SURFACE AREA TO PEAK INFLOW RATE (SHOULD BE GREATER THAN OR EQUAL TO 0.01 ACRES/CFS):
(153,800 sq ft / 43, 560 sq ft / acre) / 169.4 cfs = 0.020843 acres / cfs

STEP 5: DETERMINE THE SIZE OF THE PRINCIPAL SPILLWAY

MINIMUM CAPACITY OF 0.2 cfs/acre (as referenced in NC Erosion and Sediment Control Planning and Design Manual, Section 8.07)

Qp = 0.2xacreage
Qp = 9.68 cfs

FROM TABLE 8.07A: USE A 18" DIA. CORRUGATED METAL OUTLET CONDUIT
ASSUMED ELEVATION OF INLET: 756 (4.2' HEAD AT FULL CAPACITY)

FROM TABLE 8.07A, WITH A 4.2' HEAD, 18" DIAMETER PIPE, AND ADJUSTED FOR A 100' LENGTH OF DISCHARGE PIPE:
FOR AN 18" PIPE AND 4.2' OF HEAD, Q = 11.198
Qp = 11.198*0.88 (FOR PIPE LENGTH ADJUSTMENT)
Qp= 9.85 cfs

RISER:
FROM FIGURE 8.07B: PIPE RISER HAS 24" DIAMETER
AREA OF HOLES FOR DEWATERING:

$$Ao = \frac{As(2h)^{1/2}}{T*Cd*20{,}428}$$

WHERE As= SURFACE AREA OF BASIN
h= MAX. ELEVATION ABOVE HOLES (756-751.8)
T= DETENTION TIME (48 hrs)
Cd= COEFFICIENT OF CONTRACTION (0.6)

Ao= 0.76 SQUARE FEET
109.10 SQUARE INCHES

Area of a 1/2 inch diameter hole = 0.001364 sq ft per hole
0.19635 sq in per hole
Number of holes required: 555.6601

It should be noted that 1/2 inch diameter holes will be spaced 3 inches on center around the perimeter of the riser. Approximately 25 holes per row. Rows will be separated by 6 inches vertically. Rows will be placed at the elevations of 753', 753.5', 754.0', 754.5', 755.0', and 755.5'.

It should be noted that the volume of water required to raise the water level in the sediment basin to the top of the riser will require a volume (505,842 cu. ft) nearly six (6) times the required volume (87,077 cu. ft.) for the sediment basin

Based on these numbers. it is anticipated that the number (150) and rows (6) of holes present in the riser will be sufficient for drainage.

STEP 6: DESIGN ANTI-SEEP COLLAR

AT LEAST 2 FEET FROM A PIPE JOINT
COLLAR MUST PROTECT AT LEAST 1.5 FEET FROM THE PIPE
WATERTIGHT CONNECTIONS

STEP 7: DESIGN ANTI-FLOATATION BLOCK

WEIGHT OF WATER DISPLACED BY PIPE

DIAMETER = 24 INCHES
HEIGHT = 4.2 FEET

VOLUME = 13.19 CUBIC FEET

WEIGHT OF WATER = 823 POUNDS

SAFETY FACTOR = 1.1 906 POUNDS

UNIT WEIGHT OF CONCRETE = 150 POUNDS PER CUBIC FOOT
CUBIC FEET ON CONCRETE NECESSARY 6.04 CUBIC FEET

USE A 3' x 3' x 1' ANTI FLOATATION BLOCK

STEP 8: DESIGN OUTLET

DETERMINE DISCHARGE VELOCITY FROM THE BARREL:

ASSUME THAT THERE IS MINIMUM TAILWATER CONDITIONS DUE TO FLAT, WIDE DISCHARGE AREA
18 INCH DIAMETER DISCHARGE PIPE (BARREL)
DETERMINE d_{50} RIP-RAP SIZE: (USING FIGURE 8.06A) d_{50}= 6 INCHES
MAXIMUM STONE DIAMETER 9 INCHES
DETERMINE THE APRON THICKNESS 14 INCHES
APRON WIDTH AT PIPE OUTLET = 3 x PIPE DIAMETER = 54 "
APRON WIDTH AT OUTLET END = Do + La 11.5'

STEP 9: DESIGN EMERGENCY SPILLWAY

DETERMINE REQUIRED CAPACITY FOR THE EMERGENCY SPILLWAY:

$Qe = Q_{10} - Qp$ Qp = 9.68 cfs
Q_{10} = 169.4 cfs

Qe= 159.7 cfs

FROM TABLE 8.07c - DESIGN FOR VEGETATED SPILLWAYS EXCAVATED IN EROSION RESISTANT SOILS (SIDE SLOPES - 3 HORIZONTAL,: 1 VERTICAL)

USING A DISCHARGE OF 160 cfs:

SLOPE RANGE = 2.5 - 2.7 %
BOTTOM WIDTH = 28 FEET
STAGE FEET = 1.7 FEET

STPE 10: SPILLWAY DETAILS

CONSTRUCTION SHALL FOLLOW ALL RECOMMENDATIONS LISTED IN THE NORTH CAROLINA EROSION AND SEDIMENT CONTROL PLANNING AND DESIGN MANUAL UNLESS OTHERWISE SPECIFIED BY THE ENGINEER.

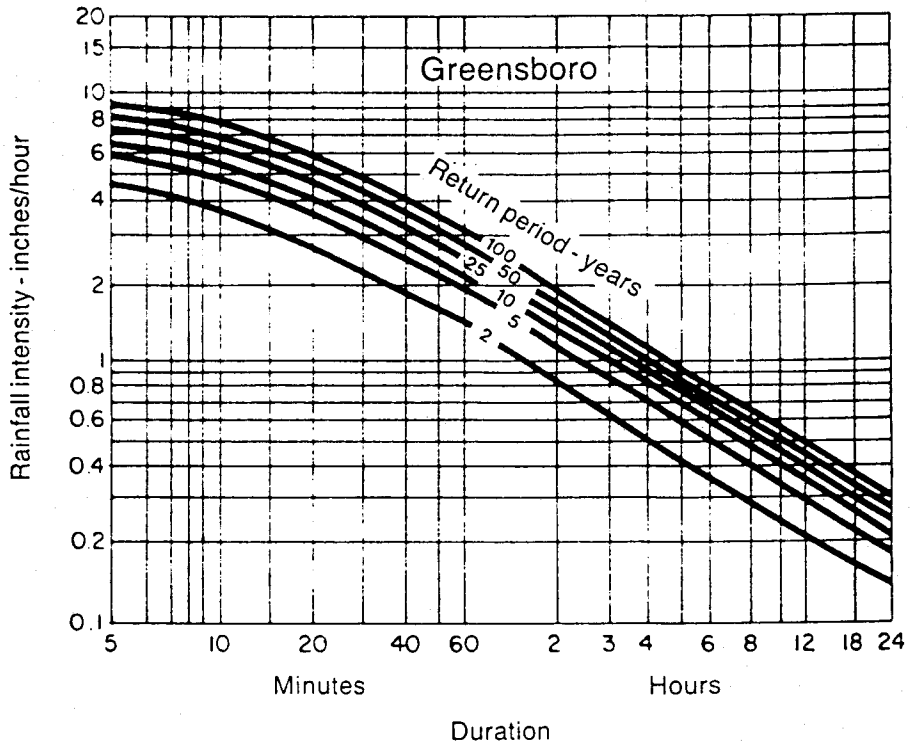


Figure 8.03d Rainfall intensity duration curves—Greensboro.

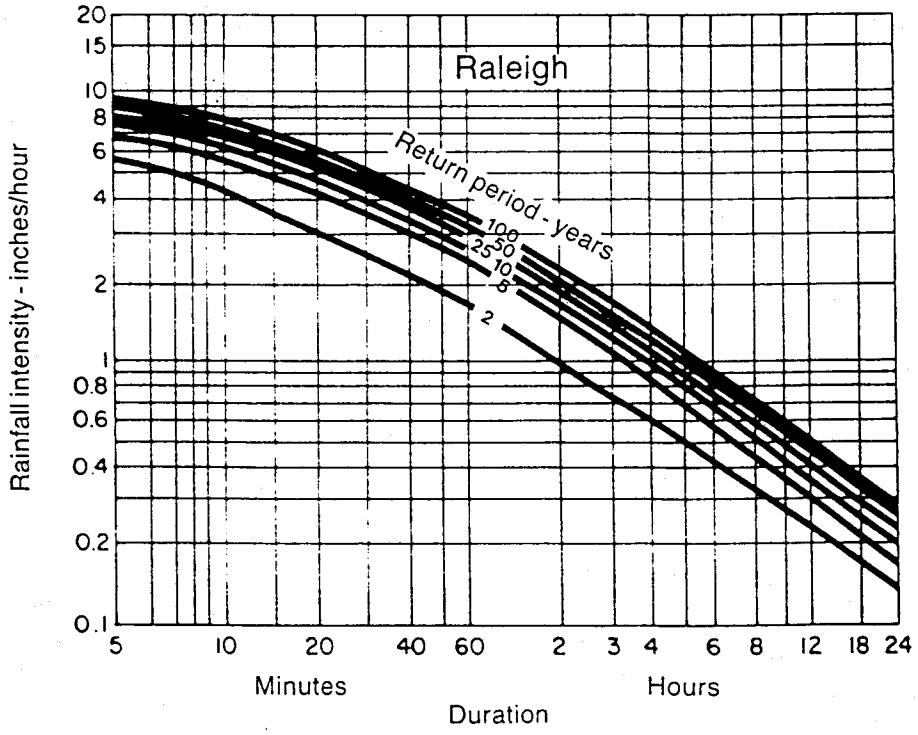


Figure 8.03e Rainfall intensity duration curves—Raleigh.

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C	Land Use	C
Business:		Lawns:	
Downtown areas	0.70-0.95	Sandy soil, flat, 2%	0.05-0.10
Neighborhood areas	0.50-0.70	Sandy soil, ave., 2-7%	0.10-0.15
		Sandy soil, steep, 7%	0.15-0.20
Residential:		Heavy soil, flat, 2%	0.13-0.17
Single-family areas	0.30-0.50	Heavy soil, ave., 2-7%	0.18-0.22
Multi units, detached	0.40-0.60	Heavy soil, steep, 7%	0.25-0.35
Multi units, attached	0.60-0.75		
Suburban	0.25-0.40	Agricultural land:	
		Bare packed soil	
Industrial:		Smooth	0.30-0.60
Light areas	0.50-0.80	Rough	0.20-0.50
Heavy areas	0.60-0.90	Cultivated rows	
		Heavy soil no crop	0.30-0.60
Parks, cemeteries	0.10-0.25	Heavy soil with crop	0.20-0.50
		Sandy soil no crop	0.20-0.40
Playgrounds	0.20-0.35	Sandy soil with crop	0.10-0.25
		Pasture	
Railroad yard areas	0.20-0.40	Heavy soil	0.15-0.45
		Sandy soil	0.05-0.25
Unimproved areas	0.10-0.30	Woodlands	0.05-0.25
Streets:			
Asphalt	0.70-0.95		
Concrete	0.80-0.95		
Brick	0.70-0.85		
Drives and walks	0.75-0.85		
Roofs	0.75-0.85		

NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

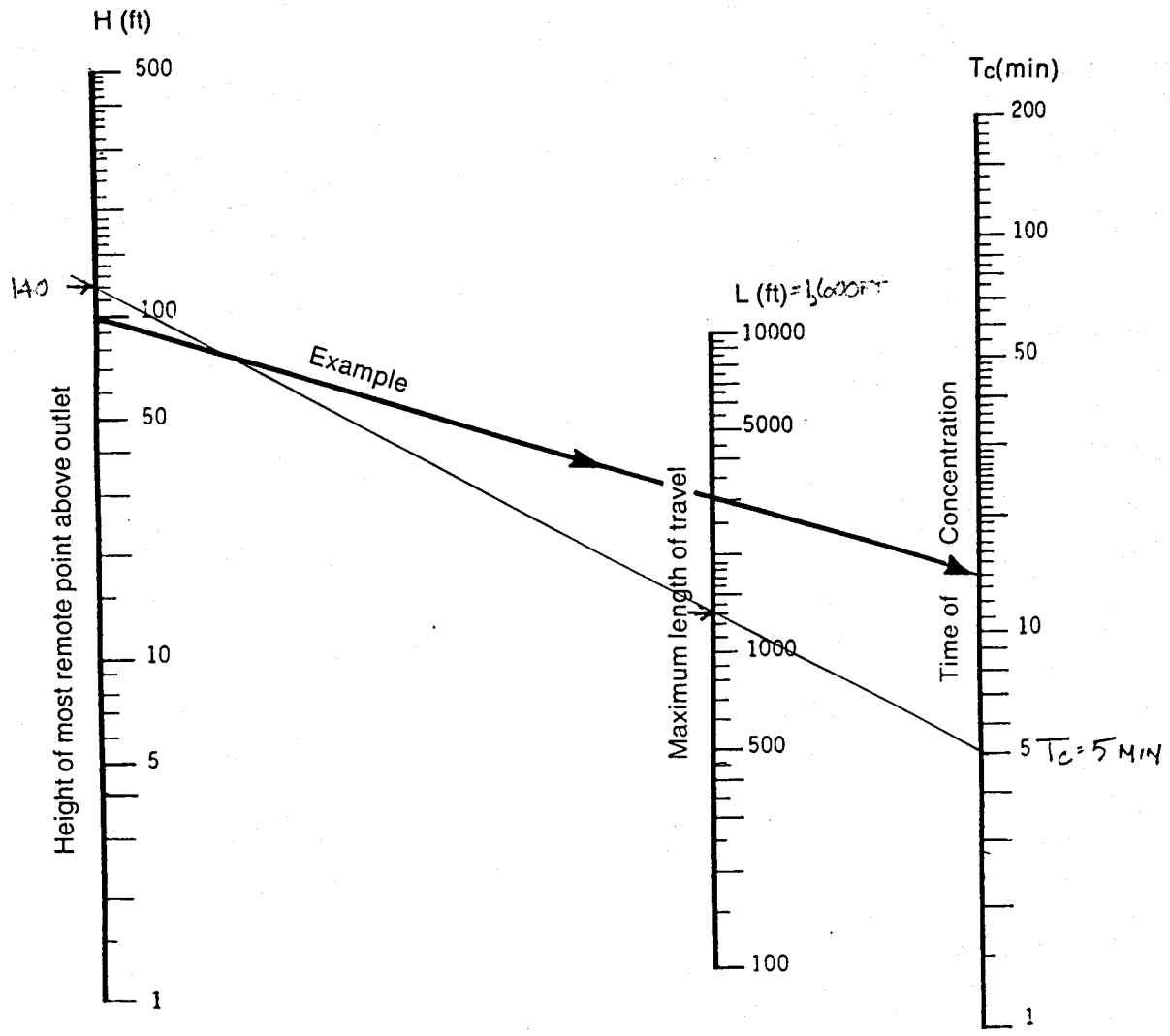
Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, Tc. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).

890-750



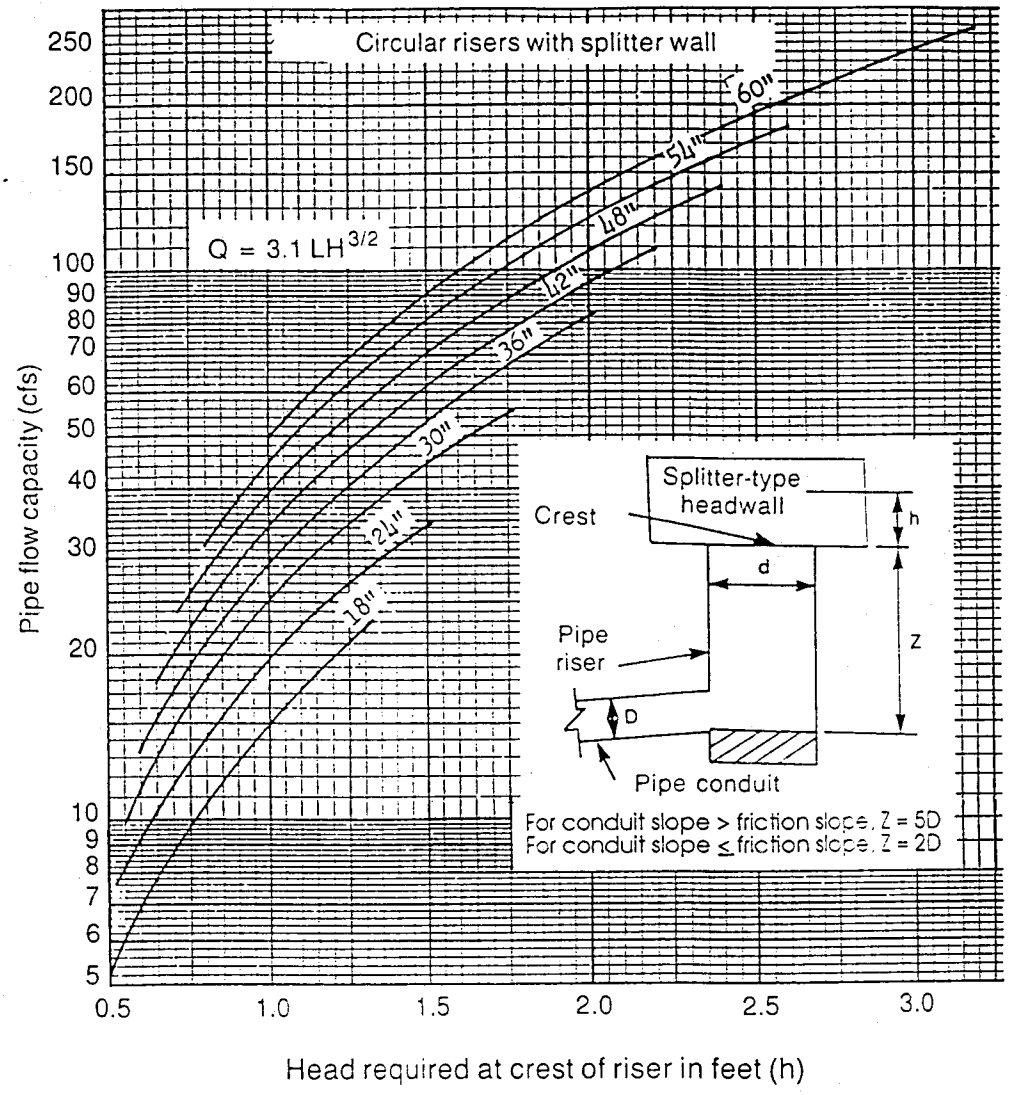
Note:
Use nomograph Tc for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply Tc by 2.

For overland flow, concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Figure 8.03a Time of concentration of small drainage basins.



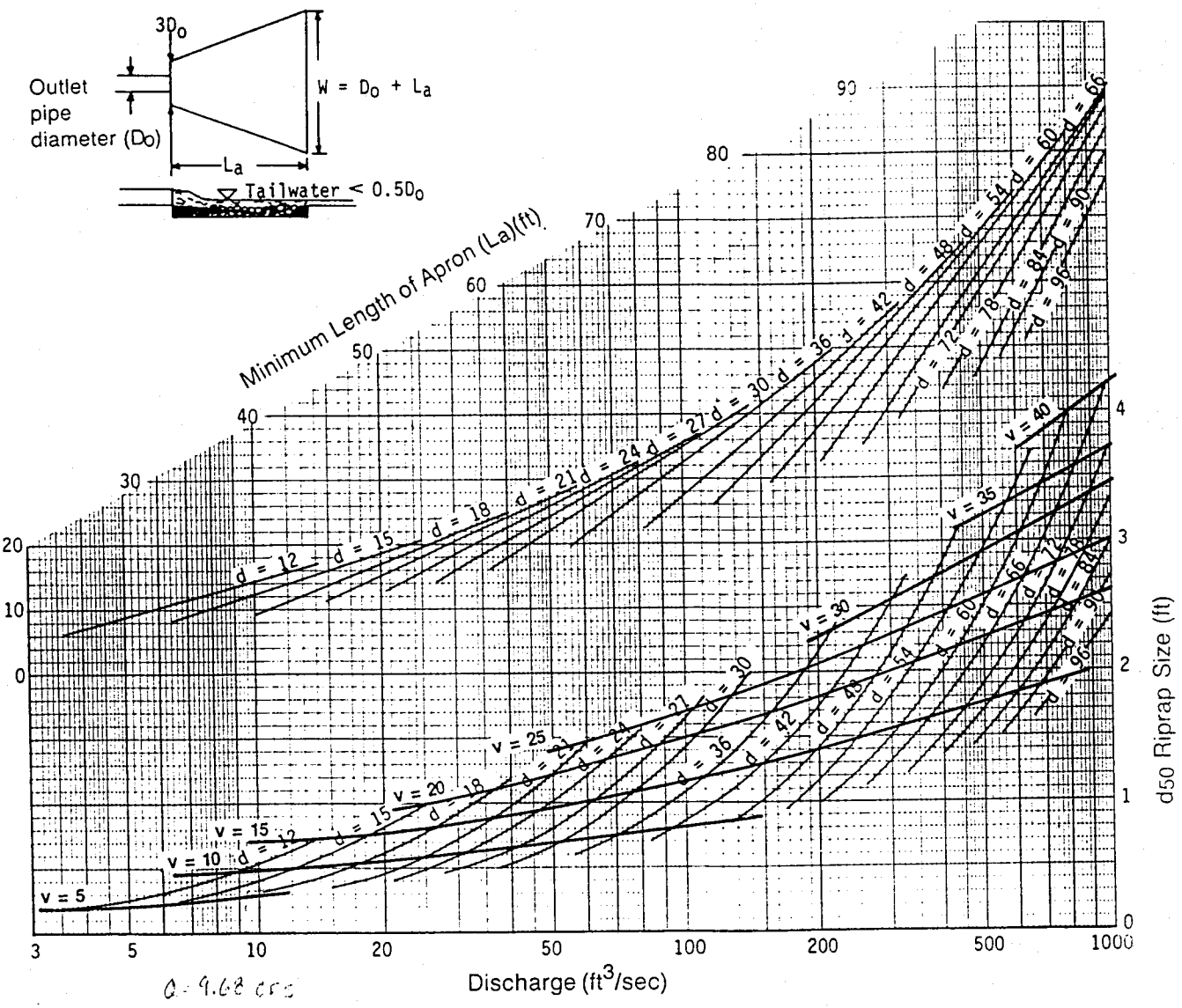
Inlet Proportions	
Pipe Conduit (D) - in	Pipe Riser (d) - in
8-12	18
15	21
18	24
21	30
24	30
30	36
36	48
42	54
48	60

Pipe drop inlet spillway design:

For a given Q and H, refer to Table 8.07a or 8.07b for conduit size. Then determine the riser diameter (d) from the Inlet Proportions Table on this figure. Next, refer to the above curves, using the conduit capacity and riser diameter, and find the head (h) required above the crest of the riser. The height of the riser should not be less than 5D - h, except as noted in the above sketch.

Example - Given: CMP; Q = 20 cfs; H = 14 ft. h max. 1.0 ft; L = 70 ft. From Table 8.07a find conduit size (D) = 18 inches. From Inlet Proportions Table, riser size = 24 inches. Head (h) required for Q = 20 and d = 24 is 1.0 ft.

Figure 8.07b Design chart for riser outlet.



Curves may not be extrapolated.

Figure 8.06a Design of outlet protection protection from a round pipe flowing full, minimum tailwater condition (T_w < 0.5 diameter).

Table 8.07c
Design Table for Vegetated Spillways Excavated in Erosion Resistant Soils
(side slopes–3 horizontal:1 vertical)

Discharge Q CFS	Slope Range Minimum Percent	Slope Range Maximum Percent	Bottom Width Feet	Stage Feet
15	3.3	12.2	8	.83
	3.5	18.2	12	.69
20	3.1	8.9	8	.97
	3.2	13.0	12	.81
	3.3	17.3	16	.70
25	2.9	7.1	8	1.09
	3.2	9.9	12	.91
	3.3	13.2	16	.79
	3.3	17.2	20	.70
30	2.9	6.0	8	1.20
	3.0	8.2	12	1.01
	3.0	10.7	16	.88
	3.3	13.8	20	.78
35	2.8	5.1	8	1.30
	2.9	6.9	12	1.10
	3.1	9.0	16	.94
	3.1	11.3	20	.85
	3.2	14.1	24	.77
40	2.7	4.5	8	1.40
	2.9	6.0	12	1.18
	2.9	7.6	16	1.03
	3.1	9.7	20	.91
	3.1	11.9	24	.83
45	2.6	4.1	8	1.49
	2.8	5.3	12	1.25
	2.9	6.7	16	1.09
	3.0	8.4	20	.98
	3.0	10.4	24	.89
50	2.7	3.7	8	1.57
	2.8	4.7	12	1.33
	2.8	6.0	16	1.16
	2.9	7.3	20	1.03
	3.1	9.0	24	.94
60	2.6	3.1	8	1.73
	2.7	3.9	12	1.47
	2.7	4.8	16	1.28
	2.9	5.9	20	1.15
	2.9	7.3	24	1.05
	3.0	8.6	28	.97
70	2.5	2.8	8	1.88
	2.6	3.3	12	1.60
	2.6	4.1	16	1.40
	2.7	5.0	20	1.26
	2.8	6.1	24	1.15
	2.9	7.0	28	1.05
80	2.5	2.9	12	1.72
	2.6	3.6	16	1.51
	2.7	4.3	20	1.35

Discharge Q CFS	Slope Range Minimum Percent	Slope Range Maximum Percent	Bottom Width Feet	Stage Feet
80	2.8	5.2	24	1.24
	2.8	5.9	28	1.14
	2.9	7.0	32	1.06
90	2.5	2.6	12	1.84
	2.5	3.1	16	1.61
	2.6	3.8	20	1.45
	2.7	4.5	24	1.32
	2.8	5.3	28	1.22
	2.8	6.1	32	1.14
100	2.5	2.8	16	1.71
	2.6	3.3	20	1.54
	2.6	4.0	24	1.41
	2.7	4.8	28	1.30
	2.7	5.3	32	1.21
	2.8	6.1	36	1.13
120	2.5	2.8	20	1.71
	2.6	3.2	24	1.56
	2.7	3.8	28	1.44
	2.7	4.2	32	1.34
	2.7	4.8	36	1.28
140	2.5	2.7	24	1.71
	2.5	3.2	28	1.58
	2.6	3.6	32	1.47
	2.6	4.0	36	1.38
	2.7	4.5	40	1.30
160	2.5	2.7	28	1.70
	2.5	3.1	32	1.58
	2.6	3.4	36	1.49
	2.6	3.8	40	1.40
	2.7	4.3	44	1.33
180	2.4	2.7	32	1.72
	2.4	3.0	36	1.60
	2.5	3.4	40	1.51
	2.6	3.7	44	1.43
200	2.5	2.7	36	1.70
	2.5	2.9	40	1.60
	2.5	3.3	44	1.52
	2.6	3.6	48	1.45
220	2.4	2.6	40	1.70
	2.5	2.9	44	1.61
	2.5	3.2	48	1.53
240	2.5	2.6	44	1.70
	2.5	2.9	48	1.62
	2.6	3.2	52	1.54
260	2.4	2.6	48	1.70
	2.5	2.9	52	1.62
280	2.4	2.6	52	1.70
300	2.5	2.6	56	1.69

Example of Use

Given: Discharge, Q = 87 c.f.s. Spillway slope, Exit section (from profile) = 4%.

Find: Bottom width and Stage in Spillway.

Procedure: Enter table from left at 90 c.f.s. Note that Spillway slope (4%) falls within slope ranges corresponding to bottom widths of 24, 28, and 32 ft. Use bottom width, 32 ft., to minimize velocity. Stage in Spillway will be 1.14 ft.

Note: Computations based on: Roughness coefficient, n = .040. Maximum velocity = 5.50 ft. per sec.

5249

BELEWS CREEK
EROSION AND SEDIMENT CONTROL PLAN
CHANNEL #1 DESIGN

STEP 1: DETERMINE THE REQUIRED FLOW CAPACITY

DRAINAGE AREA: USE APPROXIMATE FOOTPRINT OF LANDFILL - AREA 1
845,275 SQUARE FEET
19.4 ACRES (SEE FIGURES)

DETERMINE THE RUNOFF COEFFICIENT

DRAINAGE AREA	845,275 SQUARE FEET
MAXIMUM SLOPE LENGTH	1,800 FEET
ELEVATION DROP	135 FEET
SLOPE	7.5 %
LOCATION	STOKES COUNTY (USE GREENSBORO MAP)

FROM TABLE 8.03A
LAND USE: BARE PACKED SOIL (0.30 - 0.60)
USE C = 0.30

DETERMINE THE TIME OF CONCENTRATION
FROM FIGURE 8.03A
Tc= 5.5 MIN

DETERMINE THE RAINFALL INTENSITY, FREQUENCY, AND DURATION
FROM FIGURE 8.03D (GREENSBORO)
10-YEAR INTENSITY 6.5 inches/hour

DETERMINE THE PEAK DISCHARGE, Q
Q = CiA
Q= 37.84 cfs

STEP 2: DETERMINE THE SLOPE AND SELECT CHANNEL GEOMETRY AND LINING
STEP 3: DETERMINE THE PERMISSIBLE VELOCITY
DESIGN OF GRASS LINED CHANNEL

GRADE OF CHANNEL:	790-755=	35 FT
LENGTH OF CHANNEL:	1000 FT	
SLOPE:	3.50%	
VEGETATION: TALL FESCUE		
SOIL: EROSION RESISTANT		
PERMISSIBLE VELOCITY (TABLE 8.05A)		5.0 ft/sec

STEP 4: MAKE AN INITIAL ESTIMATE OF CHANNEL SIZE
PEAK DISCHARGE / PERMISSIBLE VELOCITY = REQUIRED AREA
37.84 cfs / 5.0 ft/sec = 7.57 sq. ft.

TRAPEZOIDAL CHANNEL	
BOTTOM WIDTH	5 ft
DEPTH	2 ft
SIDE WIDTH	4 ft
CROSS SECTIONAL AREA	12 sq ft

STEP 5: CALCULATE THE HYDRAULIC RADIUS

HYDRAULIC RADIUS 0.86

STEP 6: DETERMINE THE ROUGHNESS COEFFICIENT, n

MULTIPLY THE PERMISSIBLE VELOCITY BY HYDRAULIC RADIUS

4.30 =VR

FROM FIGURE 8.05C, MANNINGS n = 0.038

DETERMINING SHEAR STRESS

PERMISSIBLE SHEAR STRESS

= 2.00 lbs / sq ft for a synthetic mat

SHEAR STRESS = T = yds Unit weight of water x flow depth x slope (ft/ft)

= (62.4 lbs/cu ft)*(0.7 ft)*(.035) (0.7 ft depth based on Figure 8.05d)

= 1.5288 lb/sq ft

The use of a synthetic map is capable of providing the shear stress necessary.

STEP 7: CALCULATE THE ACTUAL CHANNEL VELOCITY

$V = 1.49/n*R^{2/3}*S^{1/2}$

V = 6.64 ft/sec

CALCULATE THE CHANNEL CAPACITY, Q

Q= AV

Q= 79.64 cu ft/sec

STEP 8: CHECK AGAINST RESULTS FOR PERMISSIBLE VELOCITY AND REQUIRED DESIGN CAPACITY

PERMISSIBLE VELOCITY = 5.0 ft/sec

ACTUAL VELOCITY= 6.64 ft/sec * The channel shall be lined with a synthetic mat liner increasing the shear stress to permissible levels

MAXIMUM CHANNEL CAPACITY= 79.64 cu ft/sec

ACTUAL CHANNEL FLOW= 37.84 cu ft/sec

STEP 9: IF DESIGN IS NOT ACCEPTIBLE, ALTER CHANNEL DIMENSIONS.

Table 8.03a
Value of Runoff Coefficient (C) for Rational Formula

Land Use	C
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.50-0.70
Residential:	
Single-family areas	0.30-0.50
Multi units, detached	0.40-0.60
Multi units, attached	0.60-0.75
Suburban	0.25-0.40
Industrial:	
Light areas	0.50-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets:	
Asphalt	0.70-0.95
Concrete	0.80-0.95
Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.85

Land Use	C
Lawns:	
Sandy soil, flat, 2%	0.05-0.10
Sandy soil, ave., 2-7%	0.10-0.15
Sandy soil, steep, 7%	0.15-0.20
Heavy soil, flat, 2%	0.13-0.17
Heavy soil, ave., 2-7%	0.18-0.22
Heavy soil, steep, 7%	0.25-0.35
Agricultural land:	
Bare packed soil	
Smooth	0.30-0.60
Rough	0.20-0.50
Cultivated rows	
Heavy soil no crop	0.30-0.60
Heavy soil with crop	0.20-0.50
Sandy soil no crop	0.20-0.40
Sandy soil with crop	0.10-0.25
Pasture	
Heavy soil	0.15-0.45
Sandy soil	0.05-0.25
Woodlands	0.05-0.25

NOTE: The designer must use judgment to select the appropriate C value within the range for the appropriate land use. Generally, larger areas with permeable soils, flat slopes, and dense vegetation should have lowest C values. Smaller areas with slowly permeable soils, steep slopes, and sparse vegetation should be assigned highest C values.

Source: American Society of Civil Engineers

The overland flow portion of flow time may be determined from Figure 8.03a. The flow time (in minutes) in the channel can be estimated by calculating the average velocity in feet per minute and dividing the length (in feet) by the average velocity.

Step 4. Determine the rainfall intensity, frequency, and duration (Figures 8.03b through 8.03g—source: North Carolina State Highway Commission; Jan. 1973). Select the chart for the locality closest to your location. Enter the "duration" axis of the chart with the calculated time of concentration, T_C. Move vertically until you intersect the curve of the appropriate design storm, then move horizontally to read the rainfall intensity factor, i, in inches per hour.

Step 5. Determine peak discharge, Q (ft^3/sec), by multiplying the previously determined factors using the rational formula (Sample Problem 8.03a).

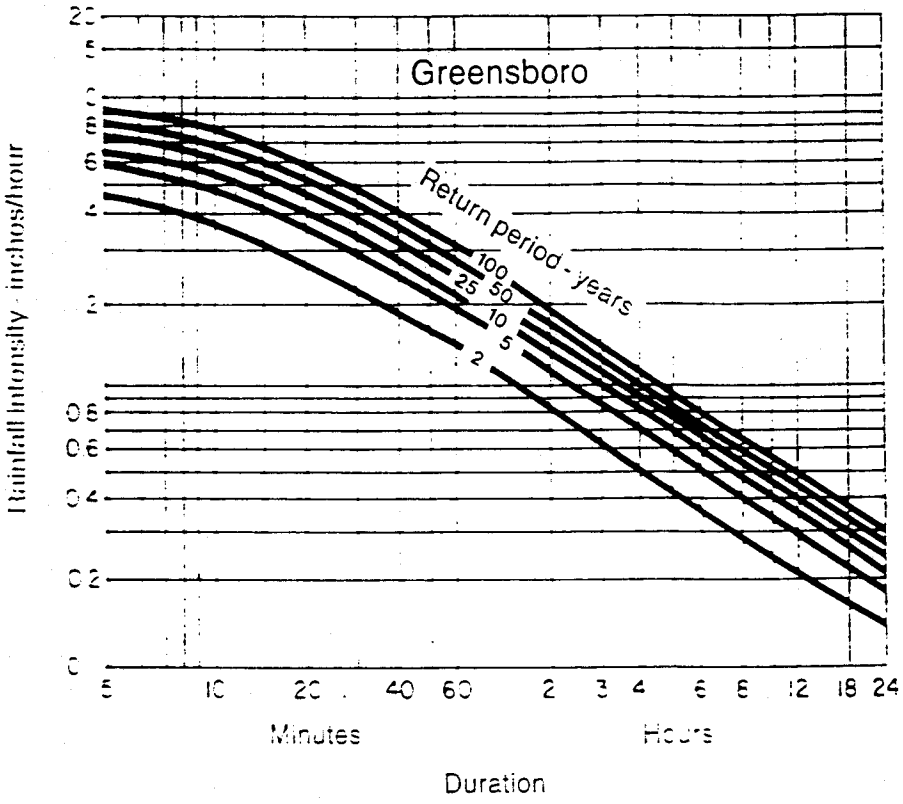


Figure 8.03d Rainfall intensity duration curves—Greensboro.

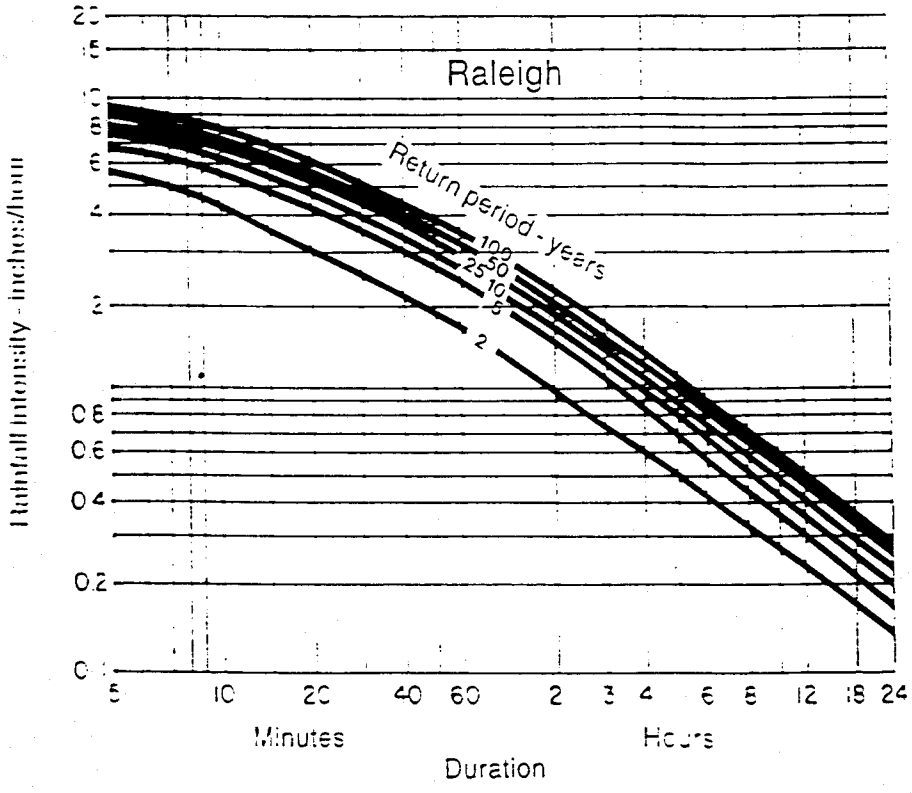
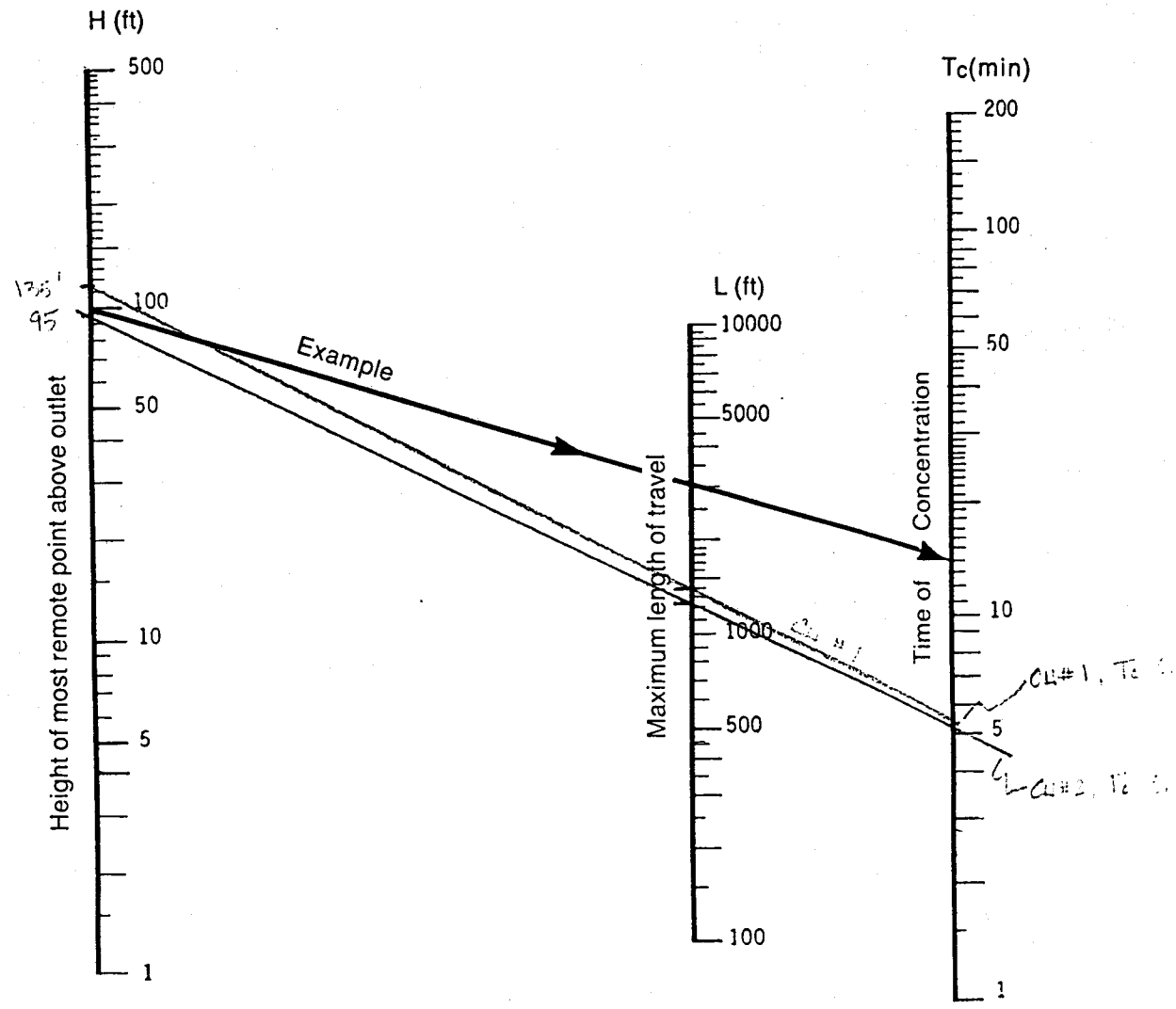


Figure 8.03e Rainfall intensity duration curves—Raleigh.



Note:
Use nomograph Tc for natural basins with well-defined channels, for overland flow on bare earth, and for mowed-grass roadside channels.

For overland flow, grassed surfaces, multiply Tc by 2.

For overland flow, concrete or asphalt surfaces, multiply Tc by 0.4.

For concrete channels, multiply Tc by 0.2.

Figure 8.03a Time of concentration of small drainage basins.

Table 8.05a
Maximum Allowable Design Velocities[1] for Vegetated Channels

Typical Channel Slope Application	Soil Characteristics[2]	Grass Lining	Permissible Velocity[3] for Established Grass Lining (ft/sec)
0-5%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	5.0
		Tall fescue	4.5
		Bahiagrass	4.5
		Kentucky bluegrass	4.5
		Grass-legume mixture	3.5
	Erosion Resistant Plastic (Clay mixes)	Bermudagrass	6.0
		Tall fescue	5.5
		Bahiagrass	5.5
		Kentucky bluegrass	5.5
		Grass-legume mixture	4.5
5-10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	4.5
		Tall fescue	4.0
		Bahiagrass	4.0
		Kentucky bluegrass	4.0
		Grass-legume mixture	3.0
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	5.5
		Tall fescue	5.0
		Bahiagrass	5.0
		Kentucky bluegrass	5.0
		Grass-legume mixture	3.5
>10%	Easily Erodible Non-plastic (Sands & Silts)	Bermudagrass	3.5
		Tall fescue	2.5
		Bahiagrass	2.5
		Kentucky bluegrass	2.5
	Erosion Resistant Plastic (Clay Mixes)	Bermudagrass	4.5
		Tall fescue	3.5
		Bahiagrass	3.5
		Kentucky bluegrass	3.5

Source: USDA-SCS Modified

NOTE: [1]Permissible Velocity based on 10-yr storm peak runoff
[2]Soil erodibility based on resistance to soil movement from concentrated flowing water.
[3]Before grass is established, permissible velocity is determined by the type of temporary liner used.

Selecting Channel Cross-Section Geometry

To calculate the required size of an open channel, assume the design flow is uniform and does not vary with time. Since actual flow conditions change throughout the length of a channel, subdivide the channel into design reaches, and design each reach to carry the appropriate capacity.

The three most commonly used channel cross-sections are "V"-shaped, parabolic, and trapezoidal. Figure 8.05b gives mathematical formulas for the area, hydraulic radius and top width of each of these shapes.

Step 10. For grass-lined channels once the appropriate channel dimensions have been selected for low retardance conditions, repeat steps 6 through 8 using a higher retardance class, corresponding to tall grass. Adjust capacity of the channel by varying depth where site conditions permit.

NOTE 1: If design velocity is greater than 2.0 ft/sec., a temporary lining may be required to stabilize the channel until vegetation is established. The temporary liner may be designed for peak flow from the 2-yr storm. If a channel requires temporary lining, the designer should analyze shear stresses in the channel to select the liner that provides protection and promotes establishment of vegetation. For the design of temporary liners, use tractive force procedure.

NOTE 2: Design Tables—Vegetated Channels and Diversions at the end of this section may be used to design grass-lined channels with parabolic cross-sections.

Step 11. Check outlet for carrying capacity and stability. If discharge velocities exceed allowable velocities for the receiving stream, an outlet protection structure will be required (Table 8.05d, pg. 8.05.9).

Sample Problem 8.05a illustrates the design of a grass-lined channel.

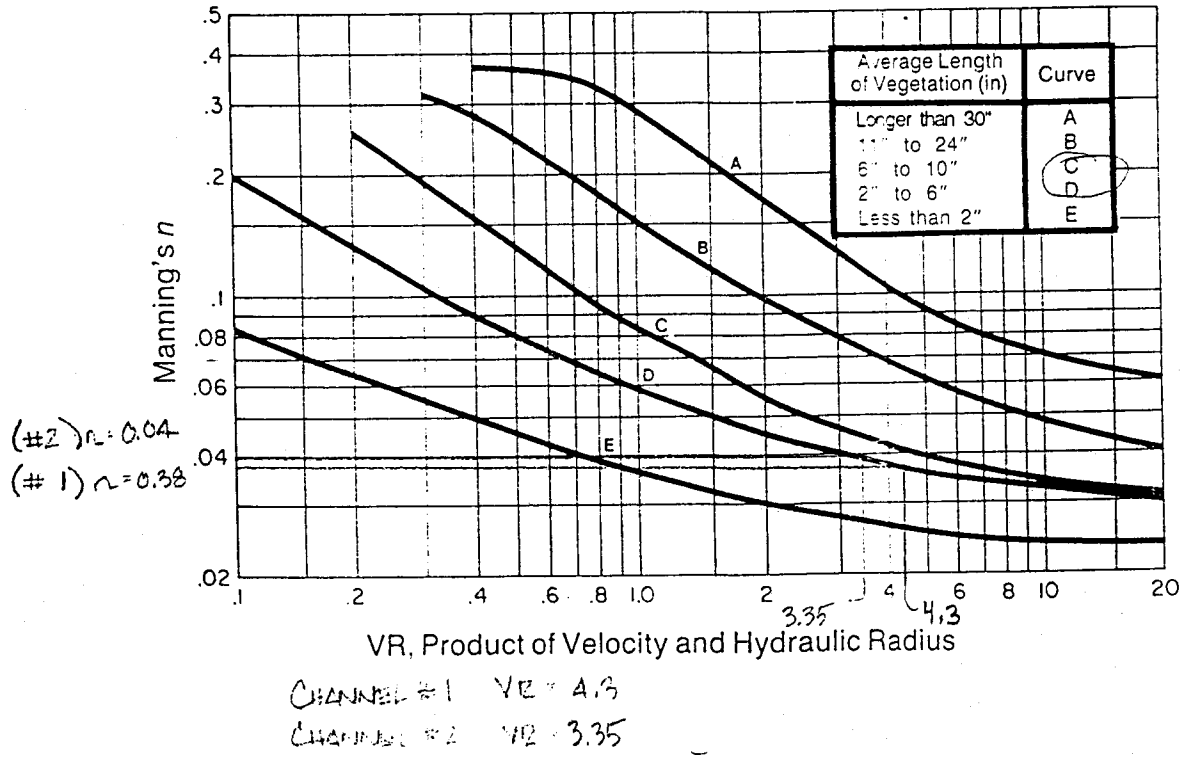


Figure 8.05c Manning's *n* related to velocity, hydraulic radius, and vegetal retardance.
Note: From Sample Problem 8.05a multiply Vp x Hydralulic Radius (4.5x0.54=2.43), then enter the product of VR and extend a straight line up to Retardance class "D", next project a straight line to the left to determine a trial manning's *n*.

Table 8.07a
Pipe Flow Chart for Design of Corrugated Metal Outlet Conduit
(Q in cubic ft/sec)

For Corrugated Metal Pipe Inlet $K_e + K_b = 1.0$ and 70 feet of Corrugated Metal Pipe Conduit n = 0.025. Note correction factors for other pipe lengths.

Dia. / H	12"	15"	18"	21"	24"	30"	36"	42"
2	2.84	4.92	7.73	11.30	15.60	26.60	40.77	58.12
3	3.48	6.03	9.47	13.84	19.10	32.58	49.93	71.19
4	4.02	6.96	10.94	15.98	22.06	37.62	57.66	82.20
5	4.49	7.78	12.23	17.87	24.66	42.06	64.46	91.90
6	4.92	8.52	13.40	19.57	27.01	46.07	70.60	100.65
7	5.32	9.21	14.47	21.14	29.19	49.77	76.28	108.75
8	5.68	9.84	15.47	22.60	31.19	53.19	81.53	116.23
9	6.03	10.44	16.41	23.97	33.09	56.43	86.49	123.30
10	6.36	11.00	17.30	25.26	34.88	59.48	91.16	129.96
11	6.67	11.54	18.14	26.50	36.59	62.39	95.63	136.33
12	6.96	12.05	18.95	27.68	38.21	65.16	99.87	142.37
13	7.25	12.55	19.72	28.81	39.77	67.83	103.96	148.21
14	7.52	13.02	20.47	29.90	41.27	70.39	107.88	153.80
15	7.78	13.48	21.19	30.95	42.72	72.85	111.66	159.18
16	8.04	13.92	21.88	31.96	44.12	75.24	115.32	164.40
17	8.29	14.35	22.55	32.94	45.48	77.55	118.87	169.46
18	8.53	14.77	23.21	33.90	46.80	79.81	122.33	174.39
19	8.76	15.17	23.84	34.83	48.08	81.99	125.67	179.15
20	8.99	15.56	24.46	35.73	49.33	84.12	128.93	183.80
21	9.21	15.95	25.07	36.62	50.55	86.21	132.13	188.36
22	9.43	16.32	25.65	37.47	51.73	88.22	135.21	192.76
23	9.64	16.69	26.23	38.32	52.90	90.21	138.27	197.12
24	9.85	17.05	26.80	39.14	54.04	92.15	141.24	201.35
25	10.05	17.40	27.35	39.95	55.15	94.05	144.15	205.50
L	Correction Factors For Other Pipe Lengths							
40	1.23	1.22	1.20	1.19	1.16	1.14	1.13	1.11
50	1.14	1.13	1.12	1.11	1.10	1.09	1.08	1.07
60	1.07	1.06	1.06	1.05	1.05	1.04	1.04	1.03
70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
80	0.95	0.95	0.95	0.96	0.96	0.96	0.97	0.97
90	0.90	0.91	0.91	0.92	0.92	0.93	0.94	0.94
100	0.86	0.87	0.88	0.89	0.89	0.90	0.91	0.92

CHANNEL #1

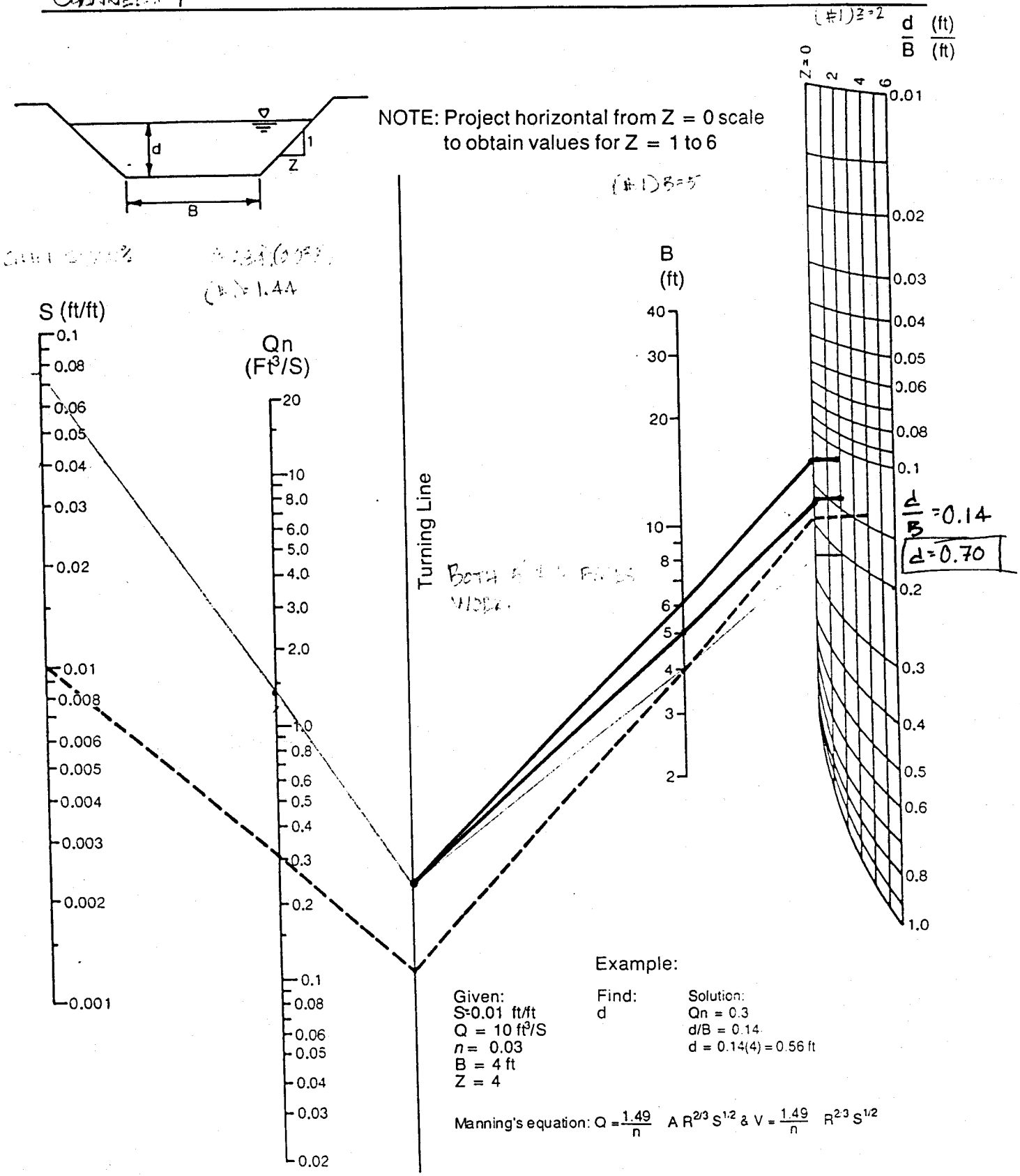


Figure 8.05d Solution of Manning's equation for trapezoidal channels of various side slopes.
Adapted from: FHWA-HEC. 15, Pg 40 - April 1988

BELEWS CREEK
EROSION AND SEDIMENT CONTROL PLAN
CHANNEL #2 DESIGN

STEP 1: DETERMINE THE REQUIRED FLOW CAPACITY

DRAINAGE AREA: USE APPROXIMATE FOOTPRINT OF LANDFILL (AREA #3)
218,125 SQUARE FEET
5.0 ACRES (SEE FIGURES)

DETERMINE THE RUNOFF COEFFICIENT

DRAINAGE AREA	218,125 SQUARE FEET
MAXIMUM SLOPE LENGTH	1,425 FEET
ELEVATION DROP	95 FEET
SLOPE	6.7 %
LOCATION	STOKES COUNTY (USE GREENSBORO MAP)

FROM TABLE 8.03A
LAND USE: BARE PACKED SOIL (0.30 - 0.60)
USE C = 0.30

DETERMINE THE TIME OF CONCENTRATION
FROM FIGURE 8.03A
Tc= 5 MIN

DETERMINE THE RAINFALL INTENSITY, FREQUENCY, AND DURATION
FROM FIGURE 8.03D (GREENSBORO)
10-YEAR INTENSITY 6.5 inches/hour

DETERMINE THE PEAK DISCHARGE, Q
Q = CiA
Q= 9.76 cfs

STEP 2: DETERMINE THE SLOPE AND SELECT CHANNEL GEOMETRY AND LINING
STEP 3: DETERMINE THE PERMISSIBLE VELOCITY
DESIGN OF GRASS LINED CHANNEL

GRADE OF CHANNEL:	790-760=	30 FT
LENGTH OF CHANNEL:	510 FT	
SLOPE:	5.88%	
VEGETATION: TALL FESCUE		
SOIL: EROSION RESISTANT		
PERMISSIBLE VELOCITY (TABLE 8.05A)		5.0 ft/sec

STEP 4: MAKE AN INITIAL ESTIMATE OF CHANNEL SIZE
PEAK DISCHARGE / PERMISSIBLE VELOCITY = REQUIRED AREA
9.76 cfs / 5.0 ft/sec = 1.95 sq. ft.

TRAPEZOIDAL CHANNEL	
BOTTOM WIDTH	5.25 ft
DEPTH	1 ft
SIDE WIDTH	2 ft
CROSS SECTIONAL AREA	7.25 sq ft

STEP 5: CALCULATE THE HYDRAULIC RADIUS

HYDRAULIC RADIUS 0.75

STEP 6: DETERMINE THE ROUGHNESS COEFFICIENT, n

MULTIPLY THE PERMISSIBLE VELOCITY BY HYDRAULIC RADIUS

3.73 =VR

FROM FIGURE 8.05C, MANNINGS n = 0.04

STEP 7: CALCULATE THE ACTUAL CHANNEL VELOCITY

$V = 1.49/n*R^{2/3}*S^{1/2}$

V = 7.43 ft/sec

DETERMINING SHEAR STRESS

PERMISSIBLE SHEAR STRESS

= 2.00 lbs / sq ft for a synthetic mat

SHEAR STRESS = T = yds Unit weight of water x flow depth x slope (ft/ft)

= (62.4 lbs/cu ft)*(0.525 ft)*(.058)

= 1.90008 lb/sq ft

The use of a synthetic map is capable of providing the shear stress necessary.

CALCULATE THE CHANNEL CAPACITY, Q

Q= AV

Q= 53.86 cu ft/sec

STEP 8: CHECK AGAINST RESULTS FOR PERMISSIBLE VELOCITY AND REQUIRED DESIGN CAPACITY

PERMISSIBLE VELOCITY = 5.0 ft/sec

ACTUAL VELOCITY= 7.43 ft/sec

* The channel shall be lined with a synthetic mat liner increasing the shear stress to permissible levels

MAXIMUM CHANNEL CAPACITY= 53.86 cu ft/sec

ACTUAL CHANNEL FLOW= 9.76 cu ft/sec

STEP 9: IF DESIGN IS NOT ACCEPTIBLE, ALTER CHANNEL DIMENSIONS.

CHANNEL #2

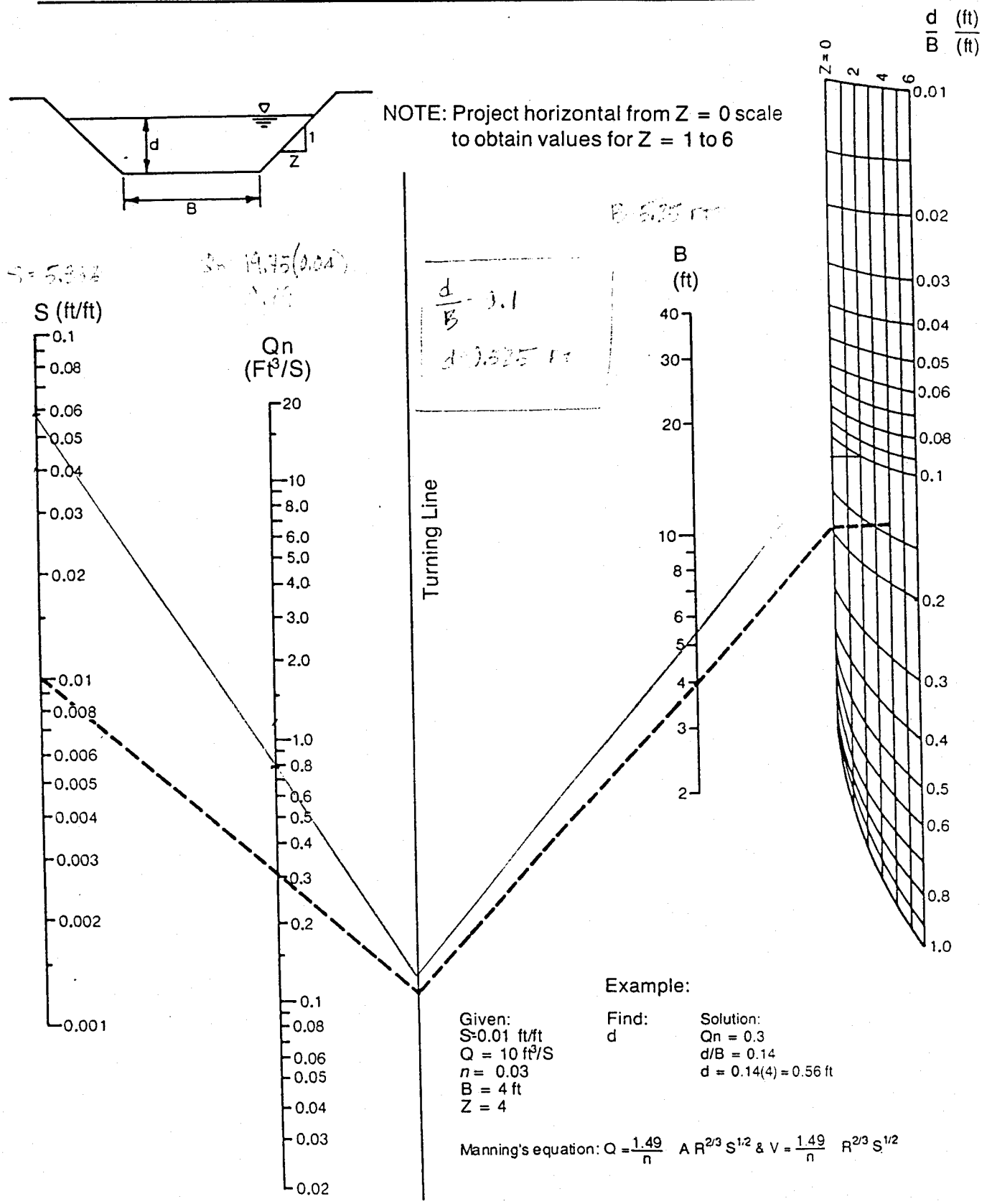


Figure 8.05d Solution of Manning's equation for trapezoidal channels of various side slopes.
Adapted from: FHWA-HEC. 15, Pg 40 - April 1988

KCG

Sediment Trap Design

Design for Area #3 –> 3.6 acres

Minimum volume for sediment trap is 1,800 cu. ft. per acre

1,800 cu. ft./ acre * 3.6 acres = 6,480 cu. ft.

(3.6 acres based on drainage patterns on site plan)

Elevation	Area	Average area	Water Elevation	Vol using avg. Area
756	100	100	756	0 cu. ft.
756-758	195	147.5	758	295 cu. ft.
758-760	320	257.5	760	1105 cu. ft.
760-762.5	480	400	762.5	2915 cu. ft.
762.5-765	675	577.5	765	6573.75 cu. ft.

Area: based on contours drawn on site maps
Average area: based on average area for elevation section

Sediment trap to be raised to an elevation of 765. See Figure 6 for sediment trap details.

APPENDIX C
Checklist

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT,
AND NATURAL RESOURCES
LAND QUALITY SECTION

EROSION AND SEDIMENTATION CONTROL PLAN CHECKLIST

The following items shall be incorporated with respect to specific site conditions, in an erosion and sedimentation control plan

LOCATION INFORMATION

- ✓ Project location
- ✓ Roads, street
- ✓ North arrow
- ✓ Scale
- ✓ Adjoining lakes, streams or other major drainage ways

GENERAL SITE FEATURES

- ✓ North arrow
- ✓ Scale-
- ✓ Property line
- ✓ Legend
- ✓ Existing contours
- ✓ Proposed contours
- ✓ Limit and acreage of disturbed area
- NA Planned and existing building locations and elevations
- ✓ Planned and existing road locations and elevations
- NA Lot and/or building numbers
- ✓ Land use of surrounding areas
- NA Rock outcrops
- ✓ Seeps or springs
- NA Wetland limits
- NA Easements
- ✓ Streams, lakes, ponds, drainage ways, dams
- ✓ Boundaries of the total tract
- ✓ If the same person conducts the land-disturbing activity and any related borrow or waste activity, the related borrow or waste activity shall constitute part of the land-disturbing activity unless the borrow or waste activity is regulated under the Mining Act of 1971, or is a landfill regulated by the Division of Solid Waste Management. If the land-disturbing activity and any related borrow or waste activity are not conducted by the same person, they shall be considered separate land-disturbing activities
- _____ Stockpiled topsoil or subsoil location
- NA Street profiles

SITE DRAINAGE FEATURES

- ✓ Existing and planned drainage patterns (include off-site areas that drain through project)
- ✓ Size of Areas to be disturbed (Acreage)
- ✓ Size and location of culverts and sewers
- ✓ Soils information (type, special characteristics)
- ✓ Design calculations for peak discharges of runoff (including the construction phase and final runoff coefficients of the site)
- ✓ Design calculations and construction details for culverts and storm sewers
- ✓ Design calculations cross sections and method of stabilization of existing and planned channels (include temporary linings)
- ✓ Design calculations and construction details of energy dissipators below culvert and storm sewer outlets (for rip-rap aprons, include stone sizes (diameters and apron dimensions)
- ✓ Soil information below culvert storm outlets
- NA Design calculations and construction details to control ground-water, i.e., seeps, high water table, etc.
- ✓ Names of receiving watercourse or name of municipal operator (only where stormwater discharges are to occur)

EROSION CONTROL MEASURES

- ✓ Legend
- ✓ Location of temporary and permanent measures
- ✓ Construction drawings and details for temporary and permanent measures
- ✓ Design calculations for sediment basin and other measures
- ✓ Maintenance requirements during construction
- ✓ Person responsible for maintenance during construction
- ✓ Maintenance requirements and responsible person(s) of permanent measures

VEGETATIVE STABILIZATION

- ✓ Areas and acreage to be vegetatively stabilized
- ✓ Planned vegetation with details of plants, seed, mulch and fertilizer
- ✓ Specifications for permanent and temporary vegetation
- ✓ Method of soil preparation

NOTE: Should include provision for ground cover on exposed slopes within 30 working days following completion of any phase of grading, permanent ground cover for all disturbed areas within 30 working days or 120 calendar days (which- ever is shorter) following completion of construction or development.

OTHER REQUIREMENTS

- ✓ Narrative describing construction sequence (as needed)
- ✓ Narrative describing the nature and purpose of the construction activity
- ✓ Completed Financial Responsibility/Ownership Form (to be signed by person financially responsible for project
- ✓ Bid specifications regarding erosion control
- ✓ Construction sequence related to sedimentation and erosion control (include installation of critical measures prior to initiation of the land-disturbing activity and removal of measures after areas they serve have been permanently stabilized)

APPENDIX D
Vegetative Plan Specifications

Table 6.11b
Key to Permanent Seeding Mixtures Based on Site Characteristics

Region and Site Characteristics[1]	Seeding Number	Table (6.11)
I. Mountains		
A. Steep slopes (steeper than 3:1); low maintenance		
1. Average soils	1M	c
2. Cold sites or rocky, rough, dry soils	2M or	d
	7M (trees)	i
B. Gentle slopes (3:1 or less)		
1. Low maintenance		
a. Average soil	3M	e
b. Rough, rocky, dry soil	2M or	d
	7M (trees)	i
2. High maintenance		
a. Full sun, soils with good moisture retention	4M	f
b. Full sun, drought-prone soils	5M	g
c. Sun or semi-shade, minimum-care lawns	6M	h
C. Grass-lined channels	8M	j
II. Piedmont		
A. Low maintenance		
1. Steep slopes or stony, shallow or dry soils	1P	k
2. Gentle slopes with average or better soils	2P	l
B. High maintenance (slopes less than 3:1)		
1. Cool sites: soils with average or better moisture retention	3P	m
2. Warm sites; dry, poor soils[1]	4P or 3CP	n, r
C. Grass-lined channels		
1. Soils with average or better moisture retention.	5P or 8M	o, j
2. Full sun, drought-prone soils	7CP	v
III. Coastal Plain		
A. Well- to poorly-drained soils with good water-holding capacities		
1. Low maintenance	1CP	p
2. High maintenance	2CP	q
B. Well-drained sandy loams to excessively well-drained sands		
1. High maintenance, fine turf	3CP	r
2. Low- to medium-care lawns	4CP	s
3. Low maintenance	5CP	t
C. Intertidal zones of estuarine shorelines, dredged material, and graded areas in salt water	6CP	u
D. Grass-lined channels	7CP	v
E. Coastal sands exposed to salt spray and/or wind erosion	see Table 6.16a	

[1]Refer to Table 6.11a for soil suitability limitations.

Table 6.11v
Seeding No. 7CP for: Grass-lined Channels; Coastal Plain, Lower Piedmont, and Dry Soils in the Central Piedmont

Seeding Mixture

Species[1]	Rate (lb/acre)
Common Bermudagrass	40-80 (1-2 lb/1,000 ft^2)

Seeding dates

Coastal Plain: Apr. - July

Piedmont: Apr. 15 - June 30

Soil amendments

Apply lime and fertilizer according to soil tests, or apply 3,000 lb/acre ground agricultural limestone and 500 lb/acre 10-10-10 fertilizer.

Mulch

Use jute, excelsior matting, or other effective channel lining material to cover the bottom of channels and ditches. The lining should extend above the highest calculated depth of flow. On channel side slopes above this height, and in drainages not requiring temporary linings, apply 4,000 lb/acre grain straw and anchor straw by stapling netting over the top.

Mulch and anchoring materials must not be allowed to wash down slopes where they can clog drainage devices.

Maintenance

A minimum of 3 weeks is required for establishment. Inspect and repair mulch frequently. Refertilize the following Apr. with 50 lb/acre nitrogen.

[1]Refer to *Appendix 8.02* for botanical names.

APPENDIX V
Seeding Specifications

SECTION 02936

SEEDING

PART I GENERAL

1.01 WORK INCLUDED

A. Preparation of topsoil

B. Fertilizing

C. Seeding

D. Mulching

1.02 REGULATORY REQUIREMENTS

A. Comply with applicable North Carolina State laws for fertilizer composition.

1.03 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.04 DELIVERY, STORAGE AND HANDLING

A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging will not be acceptable.

B. Delivery fertilizer in waterproof bags showing weight, chemical analysis and name of manufacturer.

PART 2 PRODUCTS

2.01 SEED MIXTURE

A. Seed Mixture: Sericia Lespedeza and Rye

2.02 SOIL MATERIALS

A. Topsoil: Excavated from site and placed according to Section 02227 Vegetative Soil Layer.

2.03 ACCESSORIES

A. Mulching Material: Wood cellulose pulp (Conwed, Spra-Mulch or equal). Plain straw with tack coat is an acceptable substitute for wood cellulose pulp.

B. Lime: Lime shall comply with applicable North Carolina state laws and shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the manufacturer's guaranteed analysis. Lime shall be ground limestone containing not less than 88 percent total carbonates and shall be ground to such fineness that 90 percent by weight will pass through a No. 100 mesh sieve and 50 percent by weight will pass through a No. 200 mesh sieve.

C. Fertilizer: Fertilizer shall comply with applicable North Carolina state laws and shall be delivered in unopened bags or other convenient standard container, each fully labeled with the manufacturer's guaranteed analysis. Fertilizer shall contain not less than ten percent nitrogen, ten percent available phosphoric acid and ten percent water soluble potash (N-P-K, 10-10-10). Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable and shall be immediately removed from the job site.

PART 3 EXECUTION

3.01 INSPECTION

A. Verify that prepared soil base is ready to receive the work of this Section.

3.02 PREPARATION OF TOPSOIL

A. Prepare subsoil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

B. Remove foreign materials, weeds and undesirable plants and their roots.

C. Scarify topsoil to a depth of 3 inches where seeding is to be placed.

3.03 APPLICATION OF LIMESTONE

A. Apply lime in accordance with manufacturer's instructions.

B. Apply after raking of topsoil.

C. Do not apply lime at same time or with same machine as will be used to apply seed.

D. Mix thoroughly into upper 4 inches of topsoil.

3.04 SEEDING AND FERTILIZING

		Per Acre	Planting Date
A.	Fertilizer	300 lbs	1-1 to 12-31
	Sericia Lespedeza (Scarified)	25 lbs	1-1 to 8-15
	Sericia Lespedeza (Unhulled – Unscarified)	50 lbs	8-15 to 12-31
	Wood Cellulose Pulp (Conwed, Spra-Mulch or equal)	500 lbs	1-1 to 12-31
	Accompanying Seed Rye	25 lbs	11-1 to 2-1

Load all materials into water filled tank, agitate until a smooth slurry is formed, then spray on slope.

B. Do not seed an area in excess of that which can be mulched on the same day.

C. Do not sow immediately following rain, when ground is too dry or during windy periods.

3.05 MULCHING

A. Immediately following seeding, apply mulch to a thickness of 1/8 inches.

B. Apply water with a fine spray immediately after each area has been mulched. Saturate to 4 inches of soil.

END OF SECTION