CERTIFICATE OF AUTHENTICITY

THIS IS TO CERTIFY THAT THE FOLLOWING ELECTRONIC RECORDS ARE TRUE AND ACCURATE REPRODUCTIONS OF THE ORIGINAL RECORDS OF JAMES CITY COUNTY GENERAL SERVICES DEPARTMENT- STORMWATER DIVISION; WERE SCANNED IN THE REGULAR COURSE OF BUSINESS PURSUANT TO GUIDELINES ESTABLISHED BY THE LIBRARY OF VIRGINIA AND ARCHIVES; AND HAVE BEEN VERIFIED IN THE CUSTODY OF THE INDIVIDUAL LISTED BELOW.

BMP NUMBER: **PC138**

DATE VERIFIED: **November 2, 2012**

QUALITY ASSURANCE TECHNICIAN: **Leah Hardenbergh**

Leah Hardenbergh

LOCATION: WILLIAMSBURG, VIRGINIA

Stormwater Division

MEMORANDUM

DATE: March 13, 2010

TO: Michael J. Gillis, Virginia Correctional Enterprises Document Management Services

FROM: Jo Anna Ripley, Stormwater

PO: 270712

RE: Files Approved for Scanning

General File ID or BMP ID: PC138

PIN: 3840100055

Subdivision, Tract, Business or Owner Name (if known): Langley Federal Credit Union

Property Description: 2

Site Address: 5220 Monticello Ave

(For internal use only) **Box** 124 **Drawer:** 2

Agreements: (in file as of scan date) **Y** **Book or Doc#:** 060011427 **Page:**

050020281

Comments

COUNTY OF JAMES CITY, VIRGIN

COPY

DECLARATION OF COVENANTS

INSPECTION/MAINTENANCE OF DRAINAGE SYSTEM

THIS DECLARATION, made this 5th day of May, 20 06, between Langley Federal Credit Union, and all successors in interest, ("COVENANTOR(S),") owner(s) of the following property:

Street Address: 5220 Monticello Avenue, Williamsburg, VA 23188

Legal Description: Tax Map Parcel # (38-4)(01-0-0055)

Project Name: Langley Federal Credit Union

Document No._____, Deed Book _____, Page No. _____;

Instrument No. 050020281 TH, and the County of James City, Virginia ("COUNTY.")

TDP 5-8-06

WITNESSETH:

We, the COVENANTOR(S), with full authority to execute deeds, mortgages, other covenants, and all rights, titles and interests in the property described above, do hereby covenant with the COUNTY as follows:

1. The COVENANTOR(S) shall provide maintenance for the drainage system including any runoff control facilities, conveyance systems and associated easements, hereinafter referred to as the "SYSTEM," located on and serving the above-described property to ensure that the SYSTEM is and remains in proper working condition in accordance with approved design standards, and with the law and applicable executive regulations. The SYSTEM shall not include any elements located within any Virginia Department of Transportation rights-of-way.

2. If necessary, the COVENANTOR(S) shall levy regular or special assessments against all present or subsequent owners of property served by the SYSTEM to ensure that the SYSTEM is properly maintained.

3. The COVENANTOR(S) shall provide and maintain perpetual access from public right-of-ways to the SYSTEM for the COUNTY, its agent and its contractor.

4. The COVENANTOR(S) shall grant the COUNTY, its agent and its contractor a right of entry to the SYSTEM for the purpose of inspecting, monitoring, operating, installing, constructing, reconstructing, maintaining or repairing the SYSTEM.

5. If, after reasonable notice by the COUNTY, the COVENANTOR(S) shall fail to maintain the SYSTEM in accordance with the approved design standards and with the law and applicable executive regulations, the COUNTY may perform all necessary repair or maintenance work, and the COUNTY may assess the COVENANTOR(S) and/or all property served by the SYSTEM for the cost of the work and any applicable penalties.

Revised 01/05

Instrument # 060011427

Recorded on May 15, 2006

6. The COVENANTOR(S) shall indemnify and save the COUNTY harmless from any and all claims for damages to persons or property arising from the installation, construction, maintenance, repair, operation or use of the SYSTEM.

7. The COVENANTOR(s) shall promptly notify the COUNTY when the COVENANTOR(S) legally transfers any of the COVENANTOR(S)' responsibilities for the SYSTEM. The COVENANTOR(S)' shall supply the COUNTY with a copy of any document of transfer, executed by both parties.

8. The covenants contained herein shall run with the land and shall bind the COVENANTOR(S) and the COVENANTOR(S)' heirs, executors, administrators, successors and assignees, and shall bind all present and subsequent owners of property served by the SYSTEM.

9. This COVENANT shall be recorded in the County Land Records.

IN WITNESS WHEREOF, the COVENANTOR(S) have executed this DECLARATION OF COVENANTS as of the date first above written.

COVENANTOR(S)

Print Name/Title Thomas K. Hornor
Vice President
Facilities Management

ATTEST:

COVENANTOR(S)

Print Name/Title _____

ATTEST:

_____

COMMONWEALTH OF VIRGINIA

~~CITY~~/COUNTY OF James City, Virginia

I hereby certify that on this 5th day of May, 20 06, before the subscribed, a Notary Public for the Commonwealth of Virginia, personally appeared Thomas K Homer and did acknowledge the aforegoing instrument to be their Act.

IN WITNESS WHEREOF, I have hereunto set my hand and official seal this 5th day of May, 20 06.

Notary Public Amy M. Kessler

My Commission expires: November 30, 2009

Approved as to form:

Asst County Attorney

This Declaration of Covenants prepared by:

Stacy P. Anderson
(Print Name)

Executive Assistant/Contract Administrator
(Title)

4571 Ware Creek Road
(Address)

Williamsburg, VA 23188
(City) (State) (Zip)

(757) 566-3032
(Phone Number)

drainage1.pre

James City County Environmental Division
Stormwater Management/BMP Record Drawing & Construction Certification Review
Tracking Form

Project Name: New Town Langley Federal Credit Union
County Plan No.: SP-145-05
Stormwater Management Facility: Underground detention
BMP Phase #: ☐ I ☐ II ☒ III
☒ Information Package Received. Date/By: 10/1/07
☒ Completeness Check:
- ☒ Record Drawing — Date/By: 10/1/07 Nicholas Botta, P.E., AES
- ☒ Construction Certification — Date/By: 10/1/07 " " "
- ☒ RD/CC Standard Forms — (Required for all BMPs after Feb 1st 2001Only)
- ☒ Insp/Maint Agreement # / Date: 5/15/06 #06001427
- ☒ BMP Maintenance Plan Location: ON Record Drawing / and Sheet 5 of site plan
- ☐ Other:

☒ Standard E&SC Note on Approved Plan Requiring RD/CC or County comment in plan review
- ☒ Yes ☐ No — Location: Sheet 6 note #20 & noted on sheet 5

☒ Assign **County BMP ID Code #**: Code: PC138
☒ Preliminary Input/Log into Division's "As-Built Tracking Log"
☒ Add Location to GIS Map. Obtain basic site information (GPIN, Owner, Address, etc.)
☒ Preliminary Log into Access Database (BMP ID #, Plan No., GPIN, Project Name, etc.)
☒ Active Project File Review (correspondence, H&H, design computations, etc.).
☒ Initial As-Built File setup (File label, folder, copy plan/details/design information, etc.).
☒ Inspector Check of RD/CC (forward to Inspector using transmittal for cursory review).
☒ Pre-Inspection Drawing Review of Approved Plan (Quick look prior to Field Inspection).
☒ Final Inspection (FI) Performed — Date: 10/4/07
☒ Record Drawing (RD) Review — Date: 10/4/07
☒ Construction Certification (CC) Review — Date: 10/4/07
☒ Actions:
- ☐ No comments.
- ☐ Comments. Letter Forwarded. Date:
- ☒ Record Drawing (RD)
- ☐ Construction Certification (CC)
- ☐ Construction-Related (CR)
- ☐ Site Issues (SI)
- ☒ Other: Phone 10/8/07 Nick Botta - Mylar Copy - Recieved 10/8/07

☐ Second Submission:
☐ Reinspection (if necessary):
☒ Acceptable for SWM Purposes (RD/CC/CR/Other). Ok to proceed with bond release.
☒ Complete "Surety Request Form".
☒ Check/Clean active file of any remaining material and finish "As-Built" file.
☒ Add to County BMP Inventory/Inspection schedule (Phase I, II or III).
☒ Copy Final Inspection Report into County BMP Inspection Program file.
☒ Obtain Digital Photographs of BMP and save into County BMP Inventory.
☒ Request mylar/reproducible from As-Built plan preparer.
☒ Complete "As-built Tracking Log".
☒ Last check of BMP Access Database (County BMP Inventory).
☐ Add BMP to JCC Hydrology & Hydraulic database (optional).
☐ Add BMP to Municipal BMP list (if a County-owned facility)
☒ Add BMP to PRIDE BMP ratings database.

Final Sign-Off

Plan Reviewer: Jason Beck Date: 10/9/07

*** See separate checklist, if needed.

James City County, Virginia
Environmental Division

Stormwater Management / BMP Facilities
Record Drawing and Construction Certification Forms

(Note: In accordance with the requirements of the Chesapeake Bay Preservation Ordinance, Chapter 23, Section 23-10(4), BMP's shall be designed and constructed in accordance with the manual entitled James City County Guidelines for Design and Construction of Stormwater Management BMP's. Erosion and sediment control policy and approved plans generally require that at the completion of the project and prior to release of surety, an "as-built" plan prepared by a registered Professional Engineer or Certified Land Surveyor must be provided for the drainage system for the project, including any Best Management Practice (BMP) facilities. In addition, for BMP facilities involving the construction of an impounding structure or dam embankment, certification is required by a Professional Engineer who has inspected the structure during its construction. Currently there are over 20 water quality type BMP's accepted by the County.)

Section 1 – Site Information:

Project Name: Langley Federal Credit Union
Structure/BMP Name: On-site Underground Detention
Project Location: Monticello Avenue and New Town Avenue
BMP Location: Parking Lot
County Plan No.: SP - 145 - 05

Project Type:
- ☐ Residential
- ☒ Commercial
- ☐ Institutional
- ☐ Public
- ☐ Other
- ☐ Business
- ☐ Office
- ☐ Industrial
- ☐ Roadway

Tax Map/Parcel No.: (38-4)(01-0-0055)
BMP ID Code (if known):
Zoning District: MU with land designation E & G
Land Use: Commercial and Offices
Site Area (sf or acres): 2.00 Acres (Project Area)

Brief Description of Stormwater Management/BMP Facility: 350 LF of 48" underground pipe in the parking lot is used for stormwater conveyance and detention.

Nearest Visible Landmark to SWM/BMP Facility: All storm inlets in parking lot.

Nearest Vertical Ground Control (if known):
☒ JCC Geodetic Ground Control ☐ USGS ☐ Temporary ☐ Arbitrary ☐ Other
Station Number or Name: JCC Station No. 325
Datum or Reference Elevation: Elevation 110.67 NGVD 29
Control Description:
Control Location from Subject Facility: _____

Section 2 – Stormwater Management / BMP Facility Construction Information:

PreConstruction Meeting Held for Construction of SWM/BMP Facility: ☒ Yes ☐ No ☐ Unknown
Approx. Construction Start Date for SWM/BMP Facility: December, 2006
Facility Monitored by County Representative during Construction: ☒ Yes ☐ No ☐ Unknown
Name of Site Work Contractor Who Constructed Facility: David A. Nice Builders
Name of Professional Firm Who Routinely Monitored Construction: AES Consulting Engineers
Date of Completion for SWM/BMP Facility: May, 2007
Date of Record Drawing/Construction Certification Submittal: September 25, 2007

(Note: Record Drawing and Construction Certifications are required within thirty (30) days of the completion of Stormwater Management and/or BMP facility construction. Record Drawings and Construction Certifications must be reviewed and approved by the James City County Environmental Division prior to final inspection, acceptance and bond or surety release.)

Section 3 – Owner / Designer / Contractor Information:

Owner/Developer: *(Note: Site Owner or Applicant responsible for development of the project.)*

Name: Langley Federal Credit Union
Mailing Address: 1055 West Mercury Blvd.
Hampton, Va 23661
Business Phone: 757-827-7200 Fax:757-896-9205
Contact Person: Tom Hornor Title:V.P. of Facilities Management

Design Professional: *(Note: Professional Engineer or Certified Land Surveyor responsible for the design and preparation of plans and specifications for the Stormwater Management / BMP facility.)*

Firm Name: AES Consulting Engineers
Mailing Address: 5248 Olde Towne Road, Suite 1
Williamsburg, VA 23188
Business Phone: 757-253-0040
Fax: 757-220-8994
Responsible Plan Preparer: Mark A. Richardson, P.E.
Title: Project Manager
Plan Name: Site Plan for Langley Federal Credit Union
Firm's Project No. 9529-01
Plan Date: November 16, 2005
Sheet No.'s Applicable to SWM/BMP Facility: 5 / 10 / ____ / ____ / ____

BMP Contractor: *(Note: Site Work Contractor directly responsible for construction of the Stormwater Management / BMP facility.)*

Name: David A. Nice Builders, Inc.
Mailing Address: 4571 Ware Creek Road
Williamsburg, VA 23188
Business Phone: 757-566-3032
Fax: 757-566-4686
Contact Person: Andy McKown
Site Foreman/Supervisor: Kevin Hockaday
Specialty Subcontractors & Purpose (for BMP Construction Only):
N/A

Section 4 – Professional Certifications:

Certifying Professionals: *(Note: A Registered Professional Engineer of Certified Land Surveyor is responsible for preparation of a Record Drawing, sometimes referred to as an As-Built plan, for the drainage system for the project including any Stormwater Management/BMP Facilities. A Registered Professional Engineer is responsible for the inspection, monitoring and certification of Stormwater Management / BMP facilities during its construction.)*

Record Drawing and Construction Certifications for Stormwater Management / BMP Facilities

Record Drawing Certification

Firm Name: AES Consulting Engineers
Mailing Address: 5248 Olde Towne Road, Suite 1
Williamsburg, VA 23188
Business Phone: 757-253-0040
Fax: 757-220-8994

Name: Nicholas Botta, P.E.
Title: Project Engineer

Signature: Nicholas Botta
Date: 10-1-07

I hereby certify to the best of my knowledge and belief that this record drawing represents the actual condition of the Stormwater Management / BMP facility. The facility appears to conform with the provisions of the approved design plan, specifications and stormwater management plan, except as specifically noted.

COMMONWEALTH OF VIRGINIA
NICHOLAS BOTTA
Lic. No. 024730
10-1-07
PROFESSIONAL ENGINEER

_____ (Seal)

Virginia Registered Professional Engineer
Or Certified Land Surveyor

Construction Certification

Firm Name: AES Consulting Engineers
Mailing Address: 5248 Olde Towne Road, Suite 1
Williamsburg, VA 23188
Business Phone: 757-253-0040
Fax: 757-220-8994

Name: Nicholas Botta, P.E.
Title: Project Engineer

Signature: Nicholas Botta
Date: 10-1-07

I hereby certify to the best of my knowledge and belief that this Stormwater Management / BMP facility was monitored and constructed in accordance with the provisions of the approved design plan, specifications and stormwater management plan, except as specifically noted.

COMMONWEALTH OF VIRGINIA
NICHOLAS BOTTA
Lic. No. 024730
10-1-07
PROFESSIONAL ENGINEER

_____ (Seal)

Virginia Registered
Professional Engineer

Section 5 – Record Drawing and Construction Certification Requirements and Instructions:

- ❑ PreConstruction Meeting – Provides an opportunity to review SWM / BMP facility construction, maintenance and operation plans and address any questions regarding construction and/or monitoring of the structure. The design engineer, certifying professionals (if different), Owner/Applicant, Contractor and County representative(s) are encouraged to attend the preconstruction meeting. Advanced notice to the Environmental Division is requested. Usually, this requirement can be met simultaneously with Erosion and Sediment Control preconstruction meetings held for the project.

- ❑ A fully completed ***STORMWATER MANAGEMENT / BMP FACILITIES, RECORD DRAWING and CONSTRUCTION CERTIFICATION FORM*** **and** ***RECORD DRAWING CHECKLIST***. All applicable sections shall be completed in their entirety and certification statements signed and sealed by the registered professional responsible for individual record drawing and/or construction certification.

- ❑ The Record Drawing shall be prepared by a Registered Professional Engineer or Certified Land Surveyor for the drainage system of the project including any Best Management Practices.

- ❑ Construction Certification. Construction of Stormwater Management / BMP facilities which contain impoundments, embankments and related engineered appurtenances including subgrade preparation, compacted soils, structural fills, liners, geosynthetics, filters, seepage controls, cutoffs, toe drains, hydraulic flow control structures, etc. shall be visually observed and monitored by a Registered Professional Engineer or his/her authorized representative. The Engineer must certify that the structure, embankment and associated appurtenances were built in accordance with the approved design plan, specifications and stormwater management plan and standard accepted construction practice and shall submit a written certification and/or drawings to the Environmental Division as required. Soil and compaction test reports, concrete test reports, inspection reports, logs and other required construction material or installation documentation may be required by the Environmental Division to substantiate the certification, if specifically requested. The Engineer shall have the authority and responsibility to make minor changes to the approved plan, in coordination with the assigned County inspector, in order to compensate for unsafe or unusual conditions encountered during construction such as those related to bedrock, soils, groundwater, topography, etc. as long as changes do not adversely affect the integrity of the structure(s). Major changes to the approved design plan or structure must be reviewed and approved by the original design professional and the James City County Environmental Division.

- ❑ Record Drawing and Construction Certifications are required within **thirty (30) days** of the completion of Stormwater Management / BMP facility construction. Submittals must be reviewed and accepted by James City County Environmental Division prior to final inspection, acceptance and bond/surety release.

  Dual Purpose Facilities – Completion of construction also includes an interim stage for Stormwater Management / BMP facilities which serve dual purpose as temporary sediment basins during construction and as permanent stormwater management / BMP facilities following construction, once development and stabilization are substantially complete. For these dual purpose facilities, construction certification is required once the temporary sediment basin phase of construction is complete. Final record drawing and construction certification of additional permanent components is required once permanent facility construction is complete.

  Interim Construction Certification is required for those dual purpose embankment-type facilities that are generally ten (10) feet or greater in dam height (*) and may not be converted, modified or begin function as a permanent SWM / BMP structure for a period generally ranging from six (6) to eighteen (18) months or more from issuance of a Land Disturbance permit for construction.

Interim or final record drawing and construction certifications are not required for temporary sediment basins which are designed and constructed in accordance with current minimum standards and specifications for temporary sediment basins per the Virginia Erosion and Sediment Control Handbook (VESCH); have a temporary service life of less than eighteen (18) months; and will be removed completely once associated disturbed areas are stabilized, unless a distinct hazard to the public's health, safety and welfare is determined by the Environmental Division due to the size or presence of the structure or due to evidence of improper construction.

(*Note: Dam Height as referenced above is generally defined as the vertical distance from the natural bed of the stream or waterway at the downstream toe of the embankment to the top of the embankment structure in accordance with 4VAC50-20-30, Virginia Impoundment Structure Regulations and the Virginia Dam Safety Program.)

- ❑ Record Drawings shall provide, at a minimum, all information as shown within these requirements and the attached **RECORD DRAWING CHECKLIST** specific to the type of SWM/BMP facility being constructed. Other additional record data may be formally requested by the James City County Environmental Division. *(Note: Refer to the current edition of the James City County Guidelines for Design and Construction of Stormwater Management BMP's manual for a complete list of acceptable BMP's. Currently there are over 20 acceptable water quality type BMP's accepted by the County.)*

- ❑ Record Drawings shall consist of blue/black line prints and a reproducible (mylar, sepia, diazo, etc.) set of the approved stormwater management plan including applicable plan views, profiles, sections, details, maintenance plans, etc. as related to the subject SWM / BMP facility. The set shall indicate "**RECORD DRAWING**" in large text in the lower right hand corner of each sheet with record elevations, dimensions and data drawn in a clearly annotated format and/or boxed beside design values. Approved design plan values, dimensions and data shall not be removed or erased. Drawing sheet revision blocks shall be modified as required to indicate record drawing status. Elevations to the nearest 0.1' are sufficiently accurate except where higher accuracy is needed to show positive drainage. Certification statements as shown in Section 4 of the Record Drawing and Construction Certification Form, ***or similar forms thereof***, and professional signatures and seals, with dates matching that of the record drawing status in the revision or title block, are also required on all associated record drawing plans, prints or reproducibles.

- ❑ Submission Requirements. Initial and subsequent submissions for review shall consist of a minimum of one (1) blue/black line set for record drawings and one copy of the construction certification documents with appropriate transmittal. Under certain circumstances, it is understood that the record drawing and construction certification submissions may be performed by different professional firms. Therefore, record drawing submission may be in advance of construction certification or vice versa. Upon approval and prior to release of bond/surety, final submission shall include one (1) reproducible set of the record drawings, one (1) blue/black line set of the record drawings and one (1) copy of the construction certification. Also for current and/or future incorporation into the County BMP database and GIS system, it is requested that the record drawings also be submitted to the Environmental Division on a diskette or CD-ROM in an acceptable electronic file format such as *.dxf, *.dwg, etc. or in a standard scanned and readable format. The electronic file requirement can be discussed and coordinated with Environmental Division staff at the time of final submission.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

I. Methods and Presentation: *(Required for all Stormwater Management / BMP facilities.)*

XX 1. All constructed facilities meet approved design plans, unless otherwise shown. Record information or deviations from approved design plan shown in clearly annotated format and/or boxed beside design values.

XX 2. Elevations to the nearest 0.1' unless higher accuracy is needed to show positive drainage.

XX 3. All plan sheets labeled with "RECORD DRAWING" in large text in lower right hand corner (Approved County Plan Number and BMP ID Code can be included if known).

XX 4. All plans sheet revision blocks modified to indicate date and record drawing status.

XX 5. All plan sheets have certification statements and certifying professional's signature and seal.

II. Minimum Standards: *(Required for all Stormwater Management / BMP facilities, as applicable.)*

XX 1. All requirements of Section I (Methods and Presentation) apply to this section.

XX 2. Plan Views: Show general location, arrangement and dimensions. Location and alignment shall generally match approved design plans.

N/A 3. Profile or elevations along top or berm of the facility. At a minimum, elevations are required at each end, at intervals not to exceed 50 feet and where low spots may be present. Top of embankment or berm elevations must be no less than design elevation plus any settlement allowances.

N/A 4. Top widths, berm widths and embankment side slopes.

XX 5. Show length, width and depth of facility or grading, contours or spot elevations as required to verify permanent pool and design storage volumes were met or were reasonably close to the approved design. Evaluation of as-built grading, contours, spot elevations, or cross-sections, may be necessary by the professional to ensure approved design configurations, depths and volumes were closely maintained. If grading or elevations are significantly different from the approved plan, the Environmental Division shall be contacted immediately to determine whether the variation is acceptable or whether further evidence will be required. Facilities which do not closely resemble approved plan grades, elevations or configurations may require regrading by the Contractor; check volumetric computations; and/or a check hydraulic routing to ensure approved design water surface elevations, discharges or freeboard were closely maintained.

N/A 6. Cross-section of the embankment through the principal spillway or outlet barrel. Must extend at least 100 ft. downstream of the pipe outlet or to recorded site property line, whichever is closer. Proper correlation is required between principal spillway (control structure) crest, emergency spillway crest, orifice and weirs and the top of the dam or facility. All elevations and dimensions must reasonably match the design plan or be sequentially relative to each other and the facility must reflect the required design storage volume(s) and/or design depth.

N/A 7. Profile or elevations along the entire centerline of the emergency spillway. Emergency spillway may be steeper, but no flatter or narrower than design.

XX 8. Elevation of the principal spillway crest or outlet crest of the structure.

XX	9.	Primary control structure (riser) diameter or dimensions, height, type of material and base size. Indicate provisions for access that are present such as steps, ladders, etc.
XX	10.	Dimensions, locations and elevations of outlet orifices, weirs, slots and drains.
N/A	11.	Type and size of anti-vortex and trash rack device. Height, diameter, dimensions, bar spacings (if applicable) and elevations relative to the principal spillway crest. Indicate if lockable hatch is present or not.
N/A	12.	Type, location, size and number of anti-seep collars or documentation of other methods utilized for seepage control. **May need to obtain this information during construction.**
N/A	13.	Top of impervious core embankment, core trench limits and elevation of cut-off trench bottom. **May need to obtain this information during construction.**
XX	14.	Elevation of the principal spillway barrel (outlet pipe) inlet and outlet invert.
XX	15.	Outlet barrel diameter, length, slope, type and thickness class of material and type of flared end sections, headwall or endwall.
N/A	16.	Outfall protection dimension, type and depth of rock and if underlain filter fabric is present.
N/A	17.	BMP interior and periphery landscaping zones conform with arrangements and requirements of the approved design plan.
XX	18.	Maintenance plan taken from approved design plan transposed onto record drawing set.
N/A	19.	Fencing location and type, if applicable to facility.
XX	20.	BMP vicinity properly cleaned of stockpiles and construction debris.
XX	21.	No visual signs of erosion or channel degradation immediately downstream of facility.
N/A	22.	Any other information formally requested by the Environmental Division specific to the constructed SWM/BMP facility.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

III. Group A – Wet Ponds *(Includes A-1 Small Wet Ponds; A-2 Wet Ponds; A-3 Wet Ext Det Ponds.)*

N/A A1. All requirements of Section II, Minimum Standards, apply to Group A facilities.

N/A A2. Principal spillway consists of reinforced concrete pipe with O-Ring gaskets for watertight joint construction.

N/A A3. Sediment forebays or pretreatment devices provided at inlets to pond. Generally 4 to 6 ft. deep.

N/A A4. Access for maintenance and equipment is provided to the forebay(s). Access corridors are at least 12 ft. wide, have a maximum slope of 15 percent and are adequately stabilized to withstand heavy equipment or vehicle use.

N/A A5. Adequate fixed vertical sediment depth markers installed in the forebay(s) for future sediment monitoring purposes.

N/A A6. Pond liner (if required) provided. Either clay liners, polyliners, bentonite liners or use of chemical soil additives based on requirements of the approved plan.

N/A A7. Minimum 6 percent slope safety bench extending a minimum of 15 feet outward from normal pool edge and/or an aquatic bench extending a minimum of 10 feet inward from the normal shoreline with a maximum depth of 12 inches below the normal pool elevation, if applicable, per the approved design plans. (Note: Safety benches may be waived if pond side slopes are no steeper than 4H:1V).

N/A A8. No trees are present within a zone 15 feet around the embankment toe and 25 feet from the principal spillway structure.

N/A A9. Wet permanent pool, typically 3 to 6 feet deep, is provided and maintains level within facility.

N/A A10. Low flow orifice has a non-clogging mechanism.

N/A A11. A pond drain pipe with valve was provided.

N/A A12. Pond side slopes are not steeper than 3H:1V, unless approved plan allowed for steeper slope.

N/A A13. End walls above barrels (outlet pipe) greater than 48 inch in diameter are fenced to prevent a fall hazard.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

IV. Group B – Wetlands: *(Includes B-1 Shallow Marsh; B-2 Ext Det Shallow Wetlands; B-3 Pond Wetland System and B-4 Pocket Wetland).*

N/A B1. Same requirements as Group A Wet Ponds.

N/A B2. Minimum 2:1 length to width flow path provided across the facility.

N/A B3. Micropool provided at or around outlet from BMP (generally 3 to 6 ft. deep).

N/A B4. Wetland type landscaping provided in accordance with approved plan. Includes correct pondscaping zones, plant species, planting arrangements, wetland beds, etc. Wetland plants include 5 to 7 emergent wetland species. Individual plants at 18 inches on center in clumps.

N/A B5. Adequate wetland buffer provided (Typically 25 ft. outward from maximum design water surface elevation and 15 ft. setback to structures).

N/A B6. No more than one-half (½) of the wetland surface area is planted.

N/A B7. Topsoil or wetland mulch provided to support vigorous growth of wetland plants.

N/A B8. Planting zones staked or flagged in field and locations subsequently established by appropriate field surveying methods for record drawing presentation.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

V. Group C – Infiltration Practices *(Includes C-1 Infiltration Trench; C-2 Infiltration Trench; C-3 Infiltration Basin; and C-4 Infiltration Basin)*

N/A C1. All requirements of Section II, Minimum Standards, apply to Group C facilities as applicable.

N/A C2. Facility is not located on fill slopes or on natural ground in excess of six (6) percent.

N/A C3. Pretreatment devices provided prior to entry into the infiltration facility. Acceptable pretreatment devices include sediment forebays, sediment basins, sediment traps, sump pits or inlets, grass channels, plunge pools or other acceptable measures.

N/A C4. Three (3) or more of the following pretreatment devices provided to protect long term integrity of structure: grass channel; grass filter strip; bottom sand layer; upper filter fabric layer; use of washed bank run gravel aggregate.

N/A C5. Sides of infiltration practice lined with filter fabric.

N/A C6. Facility was not used for erosion and sediment control purposes and sediment was prevented from entering the facility to the greatest extent possible during construction.

N/A C7. Stabilization and acceptable vegetative cover established over contributing drainage area prior to conveyance of stormwater to the facility.

N/A C8. Minimum one hundred (100) foot separation horizontally from any known water supply well and minimum one hundred (100) foot separation upslope from any building.

N/A C9. Minimum twenty-five (25) foot separation down gradient from any structure.

N/A C10. Stormwater outfalls provided for overflow associated with larger design storms.

N/A C11. No visual signs of erosion or channel degradation immediately downstream of facility.

N/A C12. Facility does not currently cause any apparent surface or subsurface water problems to downgrade properties.

N/A C13. Observation well provided.

N/A C14. Adequate, direct access provided to the facility for future maintenance, operation and inspection.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

VI. Group D – Filtering Systems *Includes D-1 Bioretention Cells; D-2 Surface Sand Filters; D-3 Underground Sand Filters; D-4 Perimeter Sand Filters; D-5 Organic Filters; and D-6 Pocket Sand Filters)*

N/A D1. All requirements of Section II, Minimum Standards, apply to Group D facilities.

N/A D2. Sediment pretreatment devices provided.

N/A D3. For D-1 BMPs (Bioretention Cells), pretreatment consisting of a grass filter strip below level spreader (deflector); a gravel diaphragm; and mulch and planting soil layers were provided.

N/A D4. For D-1 BMPs (Bioretention Cells), plantings consist of native plant species; vegetation provided was based on zones of hydric tolerances; trees and understory of shrubs and herbaceous materials were provided; woody vegetation is absent from inflow locations; and trees are located around facility perimeter.

N/A D5. Facility was not used for erosion and sediment control purposes and sediment was prevented from entering the facility to the greatest extent possible during construction.

N/A D6. No visible signs of accumulated silt/sediment were present in the facility following construction or alternately, accumulated silt/sediment was properly removed.

N/A D7. Filtering system is off-line from storm drainage conveyance system.

N/A D8. Overflow outlet has adequate erosion protection.

N/A D9. Deflector, diversion, flow splitter or regulator structure provided to divert the water quality volume to the filtering structure.

N/A D10. Minimum four (4) inch perforated underdrain provided in a clean aggregate envelope layer beneath the facility.

N/A D11. Minimum fifty (50) foot separation from any slope fifteen (15) percent or greater. Minimum one hundred (100) foot separation horizontally from any known water supply well. Minimum one hundred (100) foot separation upslope and twenty-five (25) foot separation downslope from any building.

N/A D12. Stabilization and acceptable vegetative cover established over contributing drainage area prior to conveyance of stormwater to the facility.

N/A D13. No visual signs of erosion or channel degradation immediately downstream of facility.

N/A D14. Adequate, direct access provided to the pretreatment area and/or filter bed for future maintenance.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

VII. Group E – Open Channel Systems *(Includes E-1 Wet Swales (Check Dams);E-2 Dry Swales; and E-3 Biofilters)*

N/A E1. All requirements of Section II, Minimum Standards, apply to Group E facilities as applicable.

N/A E2. Open channel system has constructed longitudinal slope of less than four (4) percent.

N/A E3. No visual signs of erosion in the open channel system's soil and/or vegetative cover.

N/A E4. Open channel side slopes are no steeper than 2H:1V at any location. Preferred channel sideslope is 3H:1V or flatter.

N/A E5. No visual signs of ponding are present at any location in the open channel system, except at rock check dam locations for E-1 systems (Wet Swales).

N/A E6. For E-2 BMPs (Dry Swales), an underdrain system was provided.

N/A E7. Treated timber or rock check dams provided as pretreatment devices for the open channel system.

N/A E8. Gravel diaphrahm provided in areas where lateral sheet flow from impervious surgaces are directly connected to the open channel system.

N/A E9. Grass cover/stabilization in the open channel system appears adaptable to the specific soils and hydric conditions for the site and along the channel system.

N/A E10. Open channel system areas with grass covers higher than four (4) to six (6) inches were properly mowed.

N/A E11. Facility was not used for erosion and sediment control purposes and sediment was prevented from entering the facility to the greatest extent possible during construction.

N/A E12. No visible signs of accumulated silt/sediment were present in the facility following construction or alternately, accumulated silt/sediment was properly removed and no adverse affects to the function of the facility are anticipated.

N/A E13. For E-3 BMPs (Biofilters), the bottom width is six (6) feet maximum at any location.

N/A E14. For E-3 BMPs (Biofilters), sideslopes are 3H:1V maximum at any location.

N/A E15. For E-3 BMPs (Biofilters), the constructed channel slope is less than or equal to three (3) percent at any location.

N/A E16. For E-3 BMPs (Biofilters), the constructed grass channel is approximately equivalent to the constructed roadway length.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

VIII. Group F – Extended Dry Detention *(Includes F-1 Timber Walls; and F-2 Dry Extended Detention with Forebay)*

N/A F1. All requirements of Section II, Minimum Standards, apply to Group F facilities.

N/A F2. Basin bottom has positive slope and drainage from all basin inflow points to the riser (or outflow) location.

N/A F3. Timber wall BMP used in intermittent stream only. (ie. Prohibited in perennial streams.)

N/A F4. Forebay provided approximately 20 ft. upstream of the facility. Forebays generally 4 to 6 feet in depth.

N/A F5. A reverse slope pipe, vertical stand pipe or mini-barrel and riser was provided to prevent clogging

N/A F6. Principal spillway and outlet barrel provided consisting of reinforced concrete pipe with O-Ring gaskets for watertight joint construction.

N/A F7. Mini-barrel and riser, if used, contains a removable trash rack to reduce clogging.

N/A F8. Low flow orifice, if used, has a minimum diameter of three (3) inches or two (2) inches if internal orifice control was utilized and a small, cage type external trash rack.

N/A F9. Timbers properly reinforced or concrete footing provided if soil conditions were prohibitive.

N/A F10. Timber wall cross members extended to a minimum depth of two (2) feet below ground elevation.

N/A F11. Protection against erosion and scour from the low flow orifice and weir-flow trajectory provided.

N/A F12. Stilling basin or standard outlet protection provided at principal spillway outlet.

N/A F13. Adequate, direct access provided to the facility. Access corridor to facility is at least ten (10) feet wide, slope is less than twenty (20) percent and appropriate stabilization provided for equipment and vehicle use. Access extends to forebay, standpipe and timber wall, as applicable.

N/A F14. No visual signs of undercutting of timber walls or clogging of the low orifice were present.

N/A F15. No visual signs of erosion or channel degradation immediately downstream of facility.

N/A F16. No visible signs of accumulated silt/sediment were present in the facility following construction or alternately, accumulated silt/sediment was properly removed and no adverse affects to the function of the facility are anticipated.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

IX. Group G – Open Spaces *(Includes All Open Space Types G-1; G-2; and G-3)*

N/A G1. All requirements of Section II, Minimum Standards, apply to Group G facilities as applicable.

N/A G2. Constructed impervious areas appear to conform with locations indicated on the approved plan and appear less than sixty (60) percent impervious in accordance with the requirements of the James City County Chesapeake Bay Preservation Ordinance.

N/A G3. Dedicated open space areas are in undisturbed common areas, conservation easements or are protected by other enforceable instruments that ensures perpetual protection.

N/A G4. Provisions included to clearly specify how the natural vegetated areas utilized as dedicated open space will be managed and field identified (marked).

N/A G5. Adequate protection measures were implemented during construction to protect the defined dedicated open space areas.

N/A G6. Dedicated open space areas were not disturbed during construction (ie. cleared, grubbed or graded).

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

(Key for Checklist is as follows: XX Acceptable N/A Not Applicable Inc Incomplete)

X. Storm Drainage Systems (Associated with BMP's Only)

(Includes all incidental stormwater drainage conveyance systems associated with SWM/BMP facilities such as onsite or offsite storm drains, open channels, inlets, manholes, junctions, outlet protections, deflectors, etc. These facilities are external to the treatment function of, but are directly associated with drainage to and/or from a constructed SWM/BMP facility. The intent of this portion of the certification is to accurately identify the type and quantity of inflow or outflow points associated with the facility for future reference. The Professional may use his/her own discretion to determine inclusive facilities to meet the intent of this section. As a general rule, storm drainage systems would include incidental facilities to the nearest access structure upslope or downslope from the normal physical limits of the facility or 800 feet of storm drainage conveyance system length, whichever is less.)

XX SD1. All requirements of Section II, Minimum Standards, apply to Storm Drainage Systems.

XX SD2. Horizontal location of all pipe and structures relative to the SWM/BMP facility.

XX SD3. Type, top elevation and invert elevation of all access type structures (inlets, manholes, etc.).

XX SD4. Material type, size or diameter, class, invert elevations, lengths and slopes for all pipe segments.

N/A SD5. Class, length, width and depth of riprap and outlet protections or dimensions of special energy dissipation structures.

XII. Other Systems

(Includes any non-typical, specialty, manufactured or innovative stormwater management/BMP practices or systems generally accepted for use as or in conjunction with other acceptable stormwater management / BMP practices. Requires evidence of prior satisfactory industry use and prior Environmental Division approval, waiver or exception.)

N/A O1. All requirements of Section II, Minimum Standards, apply to this section.

N/A O2. Certification criteria to be determined on a case-by-case basis by the Environmental Division specific to the proposed SWM/BMP facility.

STORMWATER MANAGEMENT / BMP FACILITIES
RECORD DRAWING CHECKLIST

XIII. References *(The James City County Record Drawing and Construction Certification Forms and Checklists for Stormwater Management / BMP facilities were developed using the following sources and references.)*

- ☐ Baltimore County, Maryland Soil Conservation District, As-Built Stormwater Management Pond Checklist.
- ☐ James City County, Virginia, Guidelines for Design and Construction of Stormwater Management BMP's (October 1999.)
- ☐ James City County, Virginia, Stormwater Detention/Retention Basin Design Checklist and Erosion and Sediment Control and Stormwater Management Design Plan Checklists.
- ☐ James City County Stormwater Policy Framework, Final Report of the James City County BMP Policy Project, October 1998, The Center for Watershed Protection.
- ☐ Prince Georges County, Maryland, As-Built Requirements Retention or Detention Pond/Basin.
- ☐ Prince William County, Virginia, Stormwater Management Fact Sheet.
- ☐ Stafford County, Virginia As-Built Plan Checklist.
- ☐ Stormwater Management Design Manual, NRCS Maryland Code No. 378, Pond Standards and Specifications.
- ☐ USEPA/Watershed Management Institute, Stormwater Management Inspection Forms.
- ☐ Virginia Impounding Structure Regulations (Dam Safety), Department of Conservation & Recreation, 1997.
- ☐ Virginia Erosion and Sediment Control Handbook, Third Edition 1992, Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation.
- ☐ Virginia Stormwater Management Handbook, 1999 edition, Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation.

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DIVISION

James City County, Virginia
Environmental Division

Stormwater Management / BMP Facilities Record Drawing and Construction Certification

Standard Forms & Instructions

Contents | Page

Record Drawing and Construction Certification Forms

Section 1 – Site Information		1
Section 2 – Construction Information		2
Section 3 – Owner / Designer / Contractor Information		2
Section 4 – Professional Certifications		3
Section 5 – Certification Requirements and Instructions		4

Record Drawing Checklist

I.	Methods and Presentation	(Required for All Facilities)	6
II.	Minimum Standards	(Required for All Facilities)	6
III.	Group A – Wet Ponds		8
IV.	Group B – Wetlands		9
V.	Group C – Infiltration Practices		10
VI.	Group D – Filtering Systems		11
VII.	Group E – Open Channel Systems		12
VIII.	Group F – Extended Dry Detention		13
IX.	Group G – Open Spaces		14
X.	Storm Drainage Systems	(Associated with BMP's Only)	15
XII.	Other Systems		15
XIII.	References		16

Issue Date
February 1, 2001

STORMWATER MANAGEMENT/ BMP FACILITY MAINTENANCE PLAN

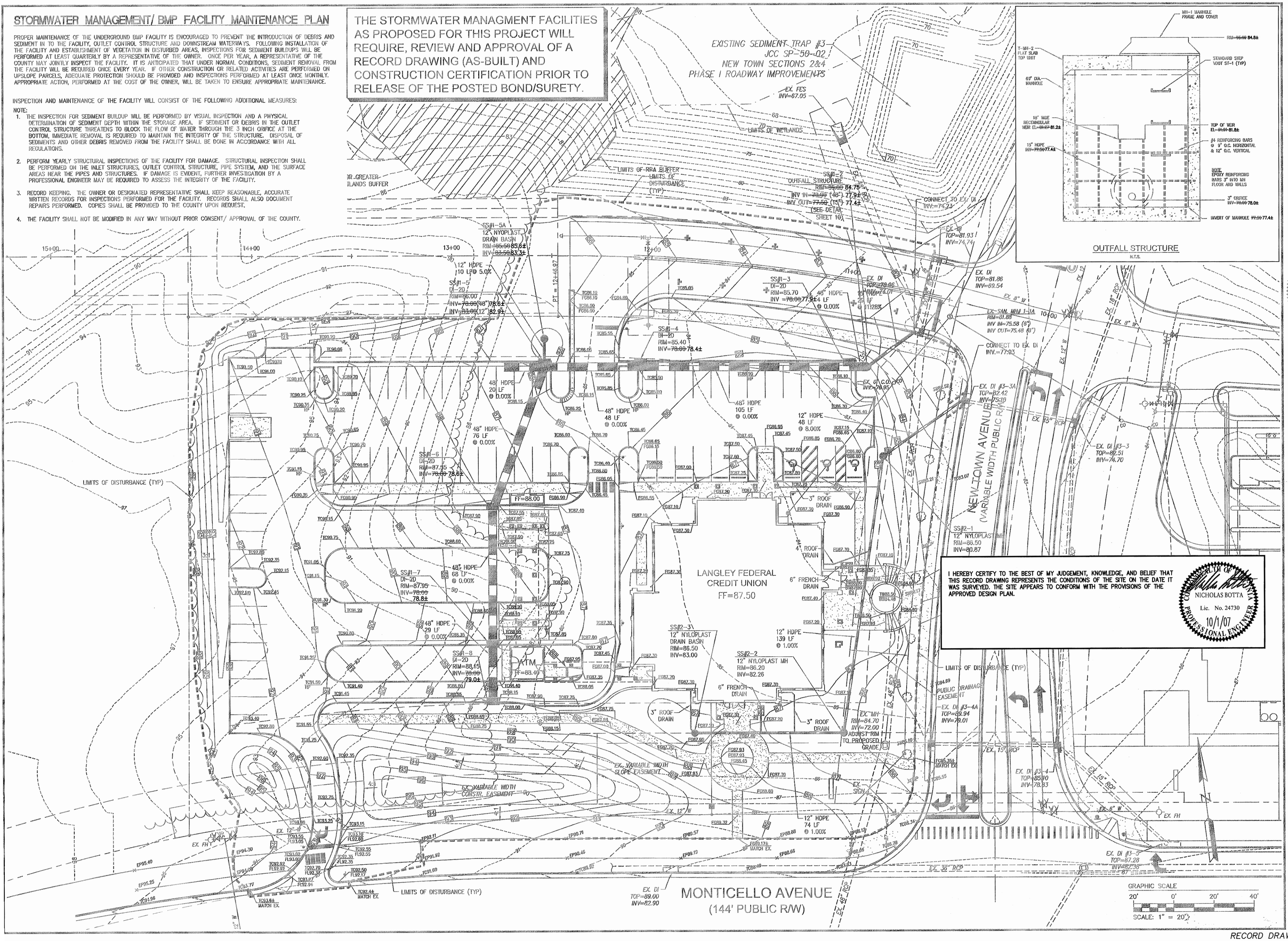
PROPER MAINTENANCE OF THE UNDERGROUND BMP FACILITY IS ENCOURAGED TO PREVENT THE INTRODUCTION OF DEBRIS AND SEDIMENT IN TO THE FACILITY, OUTLET CONTROL STRUCTURE AND DOWNSTREAM WATERWAYS. FOLLOWING INSTALLATION OF THE FACILITY AND ESTABLISHMENT OF VEGETATION IN DISTURBED AREAS, INSPECTIONS FOR SEDIMENT BUILDUPS WILL BE PERFORMED AT LEAST QUARTERLY BY A REPRESENTATIVE OF THE OWNER. ONCE PER YEAR, A REPRESENTATIVE OF THE COUNTY MAY JOINTLY INSPECT THE FACILITY. IT IS ANTICIPATED THAT UNDER NORMAL CONDITIONS, SEDIMENT REMOVAL FROM THE FACILITY WILL BE REQUIRED ONCE EVERY YEAR. IF OTHER CONSTRUCTION OR RELATED ACTIVITIES ARE PERFORMED ON UPSLOPE PARCELS, ADEQUATE PROTECTION SHOULD BE PROVIDED AND INSPECTIONS PERFORMED AT LEAST ONCE MONTHLY. APPROPRIATE ACTION, PERFORMED AT THE COST OF THE OWNER, WILL BE TAKEN TO ENSURE APPROPRIATE MAINTENANCE.

INSPECTION AND MAINTENANCE OF THE FACILITY WILL CONSIST OF THE FOLLOWING ADDITIONAL MEASURES:

NOTE:

1. THE INSPECTION FOR SEDIMENT BUILDUP WILL BE PERFORMED BY VISUAL INSPECTION AND A PHYSICAL DETERMINATION OF SEDIMENT DEPTH WITHIN THE STORAGE AREA. IF SEDIMENT OR DEBRIS IN THE OUTLET CONTROL STRUCTURE THREATENS TO BLOCK THE FLOW OF WATER THROUGH THE 3 INCH ORIFICE AT THE BOTTOM, IMMEDIATE REMOVAL IS REQUIRED TO MAINTAIN THE INTEGRITY OF THE STRUCTURE. DISPOSAL OF SEDIMENTS AND OTHER DEBRIS REMOVED FROM THE FACILITY SHALL BE DONE IN ACCORDANCE WITH ALL REGULATIONS.
2. PERFORM YEARLY STRUCTURAL INSPECTIONS OF THE FACILITY FOR DAMAGE. STRUCTURAL INSPECTION SHALL BE PERFORMED ON THE INLET STRUCTURES, OUTLET CONTROL STRUCTURE, PIPE SYSTEM, AND THE SURFACE AREAS NEAR THE PIPES AND STRUCTURES. IF DAMAGE IS EVIDENT, FURTHER INVESTIGATION BY A PROFESSIONAL ENGINEER MAY BE REQUIRED TO ASSESS THE INTEGRITY OF THE FACILITY.
3. RECORD KEEPING. THE OWNER OR DESIGNATED REPRESENTATIVE SHALL KEEP REASONABLE, ACCURATE WRITTEN RECORDS FOR INSPECTIONS PERFORMED FOR THE FACILITY. RECORDS SHALL ALSO DOCUMENT REPAIRS PERFORMED. COPIES SHALL BE PROVIDED TO THE COUNTY UPON REQUEST.
4. THE FACILITY SHALL NOT BE MODIFIED IN ANY WAY WITHOUT PRIOR CONSENT/ APPROVAL OF THE COUNTY.

THE STORMWATER MANAGMENT FACILITIES AS PROPOSED FOR THIS PROJECT WILL REQUIRE, REVIEW AND APPROVAL OF A RECORD DRAWING (AS-BUILT) AND CONSTRUCTION CERTIFICATION PRIOR TO RELEASE OF THE POSTED BOND/SURETY.



OUTFALL STRUCTURE
N.T.S.

I HEREBY CERTIFY TO THE BEST OF MY JUDGEMENT, KNOWLEDGE, AND BELIEF THAT THIS RECORD DRAWING REPRESENTS THE CONDITIONS OF THE SITE ON THE DATE IT WAS SURVEYED. THE SITE APPEARS TO CONFORM WITH THE PROVISIONS OF THE APPROVED DESIGN PLAN.

COMMONWEALTH OF VIRGINIA
NICHOLAS BOTTA
Lic. No. 24730
10/1/07
PROFESSIONAL ENGINEER

No.	DATE	REVISION / COMMENT / NOTE	REVISED BY	REVIEWED BY
4	2/16/07	ROOF DRAIN REVISIONS	BBS	NB
3	6/30/06	REVISED PER JCC COMMENTS	BBS	NB
2	5/09/06	REVISED PER JCC COMMENTS 3/13/06 & 4/13/06	BBS	NB
1	12/22/06	REVISED PER JCC COMMENTS 12/06	BBS	NB

COMMONWEALTH OF VIRGINIA
MARK A. RICHARDSON
No. 035306
2/16/07
PROFESSIONAL ENGINEER

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(757) 253-0040
Fax (757) 220-8994

AES CONSULTING ENGINEERS
WILLIAMSBURG • RICHMOND • GLOUCESTER

GRADING AND DRAINAGE PLAN

Langley Federal Credit Union
BERKELEY DISTRICT JAMES CITY COUNTY VIRGINIA

Designed	Drawn
AES	RMK
Scale	Date
1"=20'	11/16/05
Project No.	
9529-1	
Drawing No.	
5	

RECORD DRAWING–10/1/2007

PC138_NEW_TOWN_LANGLEY_FEDERAL - 024

DRAINAGE CALCULATIONS

FOR

LANGLEY FEDERAL CREDIT UNION

MAY 2006
RECEIVED
PLANNING DEPARTMENT

Prepared By:

AES Consulting Engineers
5248 Olde Towne Road, Suite 1
Williamsburg, Virginia 23188

May 5, 2006
AES Project No. 9529-01

COMMONWEALTH OF VIRGINIA
MARK A. RICHARDSON
No. 035306
5/5/06
PROFESSIONAL ENGINEER

SP-145-05
3rd Sub

AES
CONSULTING ENGINEERS

TABLE OF CONTENTS

I INTRODUCTION

II EXISTING SITE CONDITIONS

III PROPOSED SITE CONDITIONS

APPENDICES

SEDIMENT TRAP
STORM SEWER – Calculations
STORMWATER DETENTION SYSTEM
- UNDERGROUND STORAGE

CONSULTING ENGINEERS

I INTRODUCTION

The proposed project represents the development of a 2.0 acre site adjacent to New Town for the Langley Federal Credit Union. The site is located at the northwest corner of the intersection of Monticello Avenue and New Town Avenue. The site is bounded to the west by Tax Parcel (38-4)(1-3) which is currently wooded, and to the north by a future road that will connect that property with New Town Avenue. The project consists of the construction of a 16,000 s.f., 2 story building and a parking lot that includes 64 parking spaces and 5 drive-thru lanes. The layout of the drive-thru lanes includes space for the future development of 2 additional drive-thru lanes. This space was assumed to be impervious for all stormwater calculations. The primary ingress to the site will be from the future road along the north side of the site. Approximately 200 feet of this road will be constructed to the entrance of the site.

II EXISTING SITE CONDITIONS

Approximately 43% of the site is currently wooded. The remaining portion of the site was previously cleared and filled as part of the New Town Avenue construction. Slopes on the wooded portion of the site range from 3-14%, and average approximately 2% on the filled portion of the site. The site primarily drains towards the northeast corner of the site where an existing inlet collects most of the runoff. The stormwater enters an existing 48" storm sewer and eventually drains to an outfall located next to an existing sediment trap on the north side of the 60 foot wide right-of-way that connects to New Town Avenue.

III PROPOSED SITE CONDITIONS

During the initial stages of construction, a sediment trap will be installed at the northeast corner of the property. This sediment trap will serve 2.6 acres.

Water quality for the post-development stormwater runoff from this site is addressed in the New Town Master Stormwater Management Plan. Water quantity will be managed in the following manner:

- 1.28 acres of the site will drain to a 48" diameter underground pipe system that will serve as storage. The stormwater will be controlled prior to leaving the site using an outlet control device constructed inside a manhole. The underground pipe system consists of 350 linear feet of 48" diameter HDPE pipe.

- 0.24 acres of the site will be collected in a 12" pipe that will connect to the existing New Town Avenue storm drainage system at the northeast corner of the site. The New Town Avenue storm drainage system drains to BMP #53 (JCC Pond #PC-173) which has the capacity to receive this runoff.

CONSULTING ENGINEERS

means nothing. Does it detain the 1-year, 24hr. storm for 24 hours

The 48" diameter underground pipe system and outlet control structure has been designed to attenuate the 1 year storm using the SCS Method, and the 2 & 10 year storms using the Modified Rational Method. The Critical Storm Duration was calculated using the method outlined in Chapter 5 of the Virginia Stormwater Management Handbook.

The following results were achieved from the underground 48" diameter system:

	Pre-Dev Runoff (2.35 AC)	Post-Dev Runoff To 48" Pipe System	Outflow from 48" Pipe System
1 Yr.		3.17 CFS	0.40 CFS
2 Yr.	2.21 CFS ✓	2.75 CFS	0.39 CFS ✓
10 Yr.	3.02 CFS ✓	3.86 CFS	2.86 CFS ✓
100 Yr.	4.11 CFS	5.41 CFS	5.82 CFS

Drainage calculations are included in this report to show that the New Town Avenue storm drainage system has adequate capacity to accept the runoff from the 0.24 acres of the site. These calculations were performed based on as-built information for drainage areas, runoff coefficients, and pipe lengths and slopes.

- Meets pre 2, pre 10 criteria
- SCPV CRITERIA ~ 6 hr. det time. Probably impossible to meet using 48" system. would need larger pipe or "bed" type system.

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SEDIMENT TRAP

CONSULTING ENGINEERS

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Williamsburg (757) 253-0040
Gloucester (804) 693-4450
Richmond (804) 330-8040

Project	Langley Federal C. U.
Project No.	9529-01
Subject	Sediment Trap #
Sheet No.	1 Of 1
Calculated By	NB Date 2/22/06

Drainage Area to Sediment Trap = 2.6 Acres

Required Wet Storage = 67 cy/acre * (Drainage Area) = 174 cubic yards, or 4,703 cubic feet

Required Dry Storage = 67 cy/acre * (Drainage Area) = 174 cubic yards, or 4,703 cubic feet

Determine Volume of Sediment Trap by Contour:

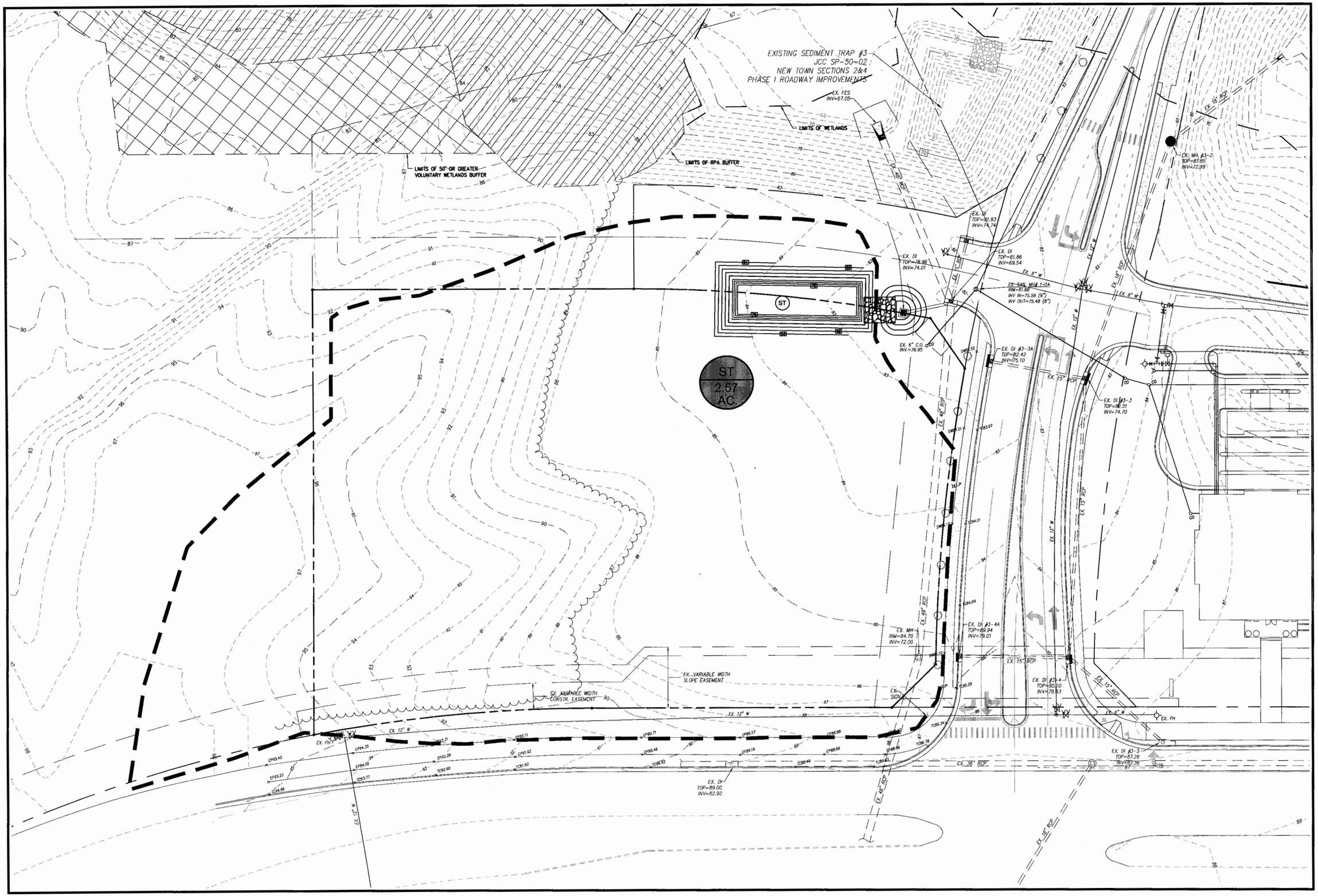
Elevation	Depth	Area (sq. ft.)	Volume (cu. ft.)	Volume (cu. yd.)	Sum Volume (cu. ft.)	Sum Volume (cu. yd.)
76	0	1158	0	0	0	0
77	1	1332	1245	46	1245	46
78	1	1514	1423	53	2668	99
79	1	1705	1609.5	60	4278	158
80	1	2109	1907	71	6185	229
81	1	2236	2172.5	80	8357	310
82	1	3014	2625	97	10982	407

Width of Aggregate Outlet Weir = 6 ft./acre & (Drainage Area) = **15.6** feet

Elevation of Wet Storage Volume = **79.22**

Elevation of Dry Storage Volume = **81.40**

Elevation of accumulated sediment when sediment removed is required (1/2 wet storage volume) = **77.78**



No.	DATE	REVISION / COMMENT / NOTE	REVISED BY	REVIEWED BY

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WILLIAMSBURG • RICHMOND • GLOUCESTER

SEDIMENT TRAP DRAINAGE AREA MAP

Langley Federal Credit Union

BERKELEY DISTRICT JAMES CITY COUNTY VIRGINIA

Designed	Drawn
NB	NB
Scale 1"=50'	Date 5/5/06
Project No. 9529-01	
Drawing No. 1	

STORM SEWER

Calculations

CONSULTING ENGINEERS

AES CONSULTING ENGINEERS

Williamsburg (757) 253-0040
Gloucester (804) 693-4450
Richmond (804) 330-8040

Project:	Williamsburg Landing
Project No.:	8162-05
Subject:	Runoff Coefficients & Curve Numbers
Date:	May 5, 2006
Calculated By:	N. Botta

Subject Area: Drainage System #1 - To 48" Underground Pipe

Area Description	Area	C	Impervious 0.90	Grass 0.20				Area
Inlet #1-3	0.09	0.82	0.08	0.01				0.09
Inlet #1-4	0.57	0.84	0.52	0.05				0.57
Inlet #1-5	0.20	0.90	0.20					0.20
Inlet #1-5A	0.07	0.20		0.07				0.07
Inlet #1-6	0.10	0.83	0.09	0.01				0.10
Inlet #1-7	0.09	0.74	0.07	0.02				0.09
Inlet #1-8	0.16	0.46	0.06	0.10				0.16
TOTAL	1.28	0.76	1.02	0.26	0	0	0	1.28
					1.28			

Subject Area: Drainage System #2 - To New Town Avenue Storm System

Area Description	Area	C	Impervious 0.90	Grass 0.20				Area
Inlet #2-2	0.08	0.90	0.08					0.08
Inlet #2-3	0.16	0.46	0.06	0.10				0.16
TOTAL	0.24	0.61	0.14	0.1	0	0	0	0.24
					0.24			

Subject Area: Existing New Town Avenue Storm System (As-built)

Area Description	Area	C	Impervious 0.90	Grass 0.20				Area
Inlet #3-3A	0.41	0.49	0.17	0.24				0.41
Inlet #3-4A	0.28	0.73	0.21	0.07				0.28
Inlet #3-4	0.21	0.80	0.18	0.03				0.21
Inlet #3-5	0.34	0.78	0.28	0.06				0.34
Inlet #3-3	0.88	0.60	0.50	0.38				0.88
TOTAL	2.12	0.64	1.34	0.78	0	0	0	2.12
					2.12			

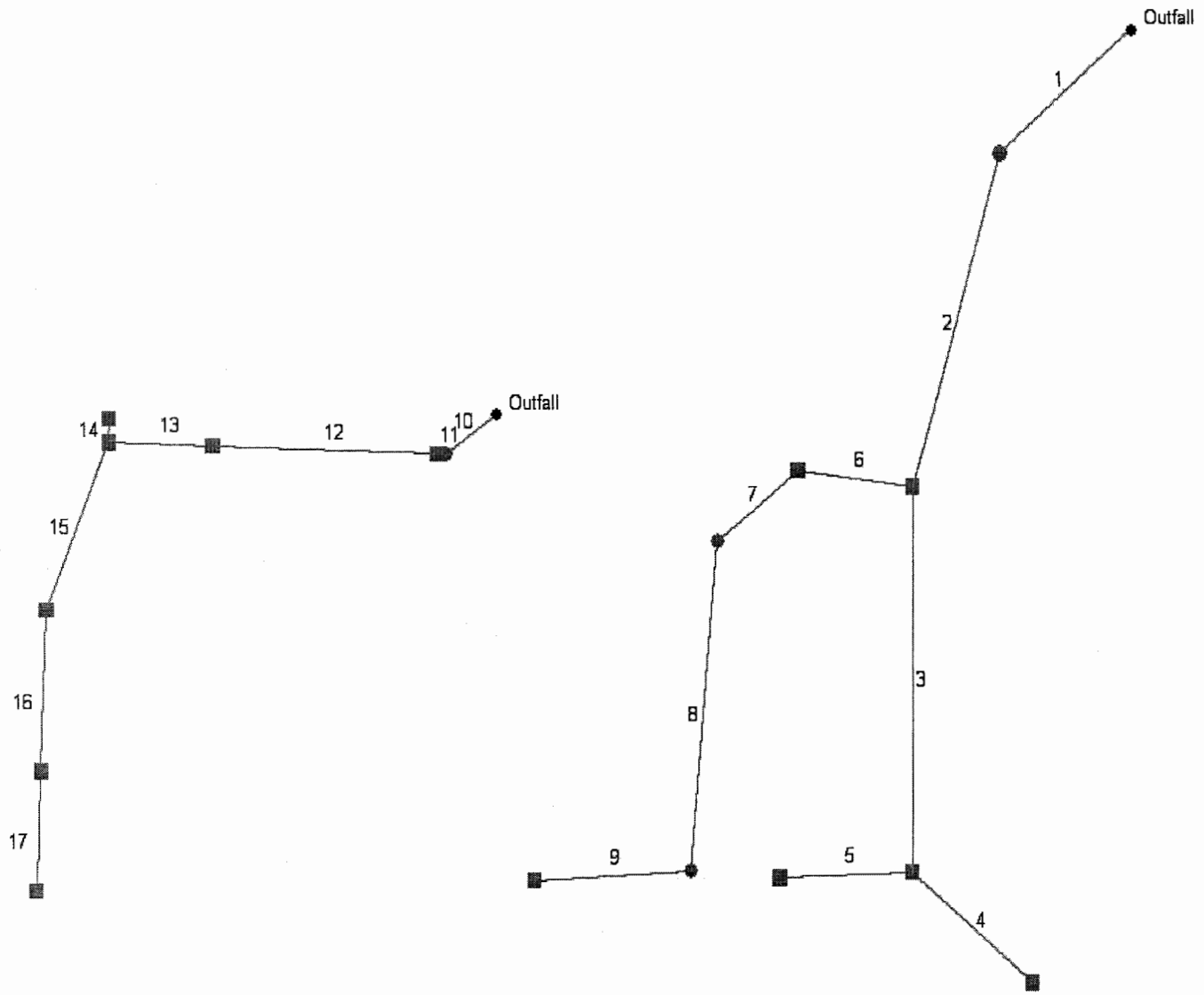
Subject Area: Pre-Development Drainage Area to Existing Inlet at Northwest Corner of Property

Area Description	Area	C	Impervious 0.90	Grass 0.20	Woods 0.30			Area
Pre-Dev Area	2.35	0.25		1.27	1.08			2.35
TOTAL	2.35	0.25	0	1.27	1.08	0	0	2.35
					2.35			

Subject Area: Drainage System #1 - To 48" Underground Pipe

Area Description	Area	C	Impervious 98	Grass 68				Area
Inlet #1-3	0.09	95	0.08	0.01				0.09
Inlet #1-4	0.57	95	0.52	0.05				0.57
Inlet #1-5	0.20	98	0.20					0.20
Inlet #1-5A	0.07	68		0.07				0.07
Inlet #1-6	0.10	95	0.09	0.01				0.10
Inlet #1-7	0.09	91	0.07	0.02				0.09
Inlet #1-8	0.16	79	0.06	0.10				0.16
TOTAL	1.28	92	1.02	0.26	0	0	0	1.28
					1.28			

Hydraflow Plan View



9529-01 LFCU	No. Lines: 17	05-05-2006

Hydraflow Storm Sewers 2005

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line type	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
1	End	81.0	140.0	MH	0.00	0.00	0.00	0.0	65.00	8.46	71.85	18	Cir	0.013	0.60	81.85	Ex. 3-2 - 3-1
2	1	146.0	-33.0	Curb	0.00	0.88	0.60	5.0	71.85	1.16	73.55	18	Cir	0.013	1.48	82.51	Ex. 3-3 - 3-2
3	2	162.0	-17.0	Curb	0.00	0.21	0.80	5.0	75.00	1.85	77.99	15	Cir	0.013	1.50	85.10	Ex. 3-4 - 3-3
4	3	73.0	-51.0	Curb	0.00	0.34	0.78	5.0	80.40	1.96	81.83	15	Cir	0.013	1.00	87.28	Ex. 3-5 - 3-4
5	3	62.0	88.0	Curb	0.00	0.28	0.73	5.0	77.99	0.89	78.54	15	Cir	0.013	1.00	84.94	Ex. 3-4A - 3-4
6	2	54.0	80.0	Curb	0.00	0.41	0.49	5.0	73.55	2.87	75.10	15	Cir	0.013	1.13	82.42	Ex. 3-3A - 3-3
7	6	48.0	-45.0	MH	0.00	0.00	0.00	0.0	77.03	8.00	80.87	12	Cir	0.012	0.77	86.50	2-1 - Ex. 3-3A
8	7	139.0	-47.0	MH	0.00	0.08	0.90	5.0	80.87	1.00	82.26	12	Cir	0.012	0.99	86.20	2-2 - 2-1
9	8	74.0	82.0	Grate	0.00	0.16	0.46	5.0	82.26	1.00	83.00	12	Cir	0.012	1.00	86.50	2-3 - 2-2
10	End	29.0	145.0	MH	0.00	0.00	0.00	0.0	74.23	11.28	77.50	15	Cir	0.013	0.65	85.00	1-2 - Ex. 1-1
11	10	4.0	37.0	Curb	0.00	0.09	0.82	5.0	78.00	0.00	78.00	48	Cir	0.013	0.50	85.70	1-3 -1-2
12	11	105.0	0.0	Curb	0.00	0.57	0.84	5.0	78.00	0.00	78.00	48	Cir	0.013	0.50	85.40	1-4 - 1-3
13	12	48.0	0.0	Curb	0.00	0.20	0.90	5.0	78.00	0.00	78.00	48	Cir	0.013	2.14	86.00	1-5 - 1-4
14	13	10.0	90.0	Grate	0.00	0.07	0.20	5.0	83.00	5.00	83.50	12	Cir	0.013	1.00	85.50	1-5A - 1-5
15	13	76.0	-70.0	Curb	0.00	0.10	0.83	5.0	78.00	0.00	78.00	48	Cir	0.013	0.59	87.55	1-6 - 1-5
16	15	68.0	-20.0	Curb	0.00	0.09	0.74	5.0	78.00	0.00	78.00	48	Cir	0.013	0.50	87.95	1-7 - 1-6
17	16	50.0	0.0	Curb	0.00	0.16	0.46	5.0	78.00	0.00	78.00	48	Cir	0.013	1.00	88.15	1-8 - 1-7

9529-01 LFCU | Number of lines: 17 | Date: 05-05-2006

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line		Incr	Total		Incr	Total	Inlet	Syst					Size	Slope	Up	Dn	Up	Dn	Up	Dn	
		(ft)	(ac)	(ac)	(C)			(min)	(min)	(in/hr)	(cfs)	(cfs)	(ft/s)	(in)	(%)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
1	End	81.0	0.00	2.36	0.00	0.00	1.51	0.0	10.2	5.9	8.97	30.54	5.64	18	8.46	71.85	65.00	72.99	66.50	81.85	72.78	Ex. 3-2 - 3-1
2	1	146.0	0.88	2.36	0.60	0.53	1.51	5.0	9.8	6.0	9.10	11.33	5.87	18	1.16	73.55	71.85	74.70	73.18	82.51	81.85	Ex. 3-3 - 3-2
3	2	162.0	0.21	0.83	0.80	0.17	0.64	5.0	5.9	6.9	4.39	8.77	5.02	15	1.85	77.99	75.00	78.83	75.84	85.10	82.51	Ex. 3-4 - 3-3
4	3	73.0	0.34	0.34	0.78	0.27	0.27	5.0	5.0	7.1	1.89	9.04	3.63	15	1.96	81.83	80.40	82.38	80.95	87.28	85.10	Ex. 3-5 - 3-4
5	3	62.0	0.28	0.28	0.73	0.20	0.20	5.0	5.0	7.1	1.46	6.08	2.00	15	0.89	78.54	77.99	79.01	79.09	84.94	85.10	Ex. 3-4A - 3-4
6	2	54.0	0.41	0.65	0.49	0.20	0.35	5.0	9.3	6.1	2.12	10.94	2.75	15	2.87	75.10	73.55	75.68	75.26	82.42	82.51	Ex. 3-3A - 3-3
7	6	48.0	0.00	0.24	0.00	0.00	0.15	0.0	8.6	6.2	0.91	10.91	3.05	12	8.00	80.87	77.03	81.27	77.43	86.50	82.42	2-1 - Ex. 3-3A
8	7	139.0	0.08	0.24	0.90	0.07	0.15	5.0	6.8	6.6	0.97	3.86	2.72	12	1.00	82.26	80.87	82.68	81.40	86.20	86.50	2-2 - 2-1
9	8	74.0	0.16	0.16	0.46	0.07	0.07	5.0	5.0	7.1	0.52	3.86	1.86	12	1.00	83.00	82.26	83.31	82.82	86.50	86.20	2-3 - 2-2
10	End	29.0	0.00	1.28	0.00	0.00	0.97	0.0	57.1	2.4	2.34	21.68	2.91	15	11.28	77.50	74.23	78.11	75.48	85.00	81.86	1-2 - Ex. 1-1
11	10	4.0	0.09	1.28	0.82	0.07	0.97	5.0	56.9	2.4	2.35	0.00	2.79	48	0.00	78.00	78.00	78.42	78.45	85.70	85.00	1-3 -1-2
12	11	105.0	0.57	1.19	0.84	0.48	0.90	5.0	53.3	2.5	2.27	0.00	1.95	48	0.00	78.00	78.00	78.70	78.52	85.40	85.70	1-4 - 1-3
13	12	48.0	0.20	0.62	0.90	0.18	0.42	5.0	49.7	2.7	1.11	0.00	0.68	48	0.00	78.00	78.00	78.75	78.74	86.00	85.40	1-5 - 1-4
14	13	10.0	0.07	0.07	0.20	0.01	0.01	5.0	5.0	7.1	0.10	7.96	1.59	12	5.00	83.50	83.00	83.63	83.13	85.50	86.00	1-5A - 1-5
15	13	76.0	0.10	0.35	0.83	0.08	0.22	5.0	39.4	3.1	0.69	0.00	0.41	48	0.00	78.00	78.00	78.77	78.77	87.55	86.00	1-6 - 1-5
16	15	68.0	0.09	0.25	0.74	0.07	0.14	5.0	25.0	4.0	0.57	0.00	0.34	48	0.00	78.00	78.00	78.77	78.77	87.95	87.55	1-7 - 1-6
17	16	50.0	0.16	0.16	0.46	0.07	0.07	5.0	5.0	7.1	0.52	0.00	0.31	48	0.00	78.00	78.00	78.77	78.77	88.15	87.95	1-8 - 1-7

9529-01 LFCU

Number of lines: 17

Run Date: 05-05-2006

NOTES: Intensity = 143.72 / (Inlet time + 19.20) ^ 0.94; Return period = 10 Yrs.

Hydraflow Storm Sewers 2005

CONSULTING ENGINEERS
Williamsburg (757) 253-0040
Gloucester (804) 693-4450
Richmond (804) 330-8040

Project:	Langley Federal Credit Union
Project No.:	9529-01
Subject:	Channel Design
Date:	May 5, 2006
Calculated By:	N. Botta

Design Point: Inlet 1-5A

Drainage Area	=	0.21	Acres	(Area draining to Design Point)
C	=	0.25		(Runoff Coefficient)
I	=	7.13	in/hr	(Design Rainfall Intensity) 10 year storm - Tc = 5 min.

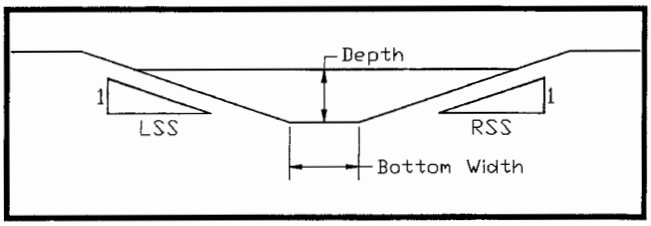
Q = C I A (Peak Flow)

= 0.25 x 7.13 x 0.21

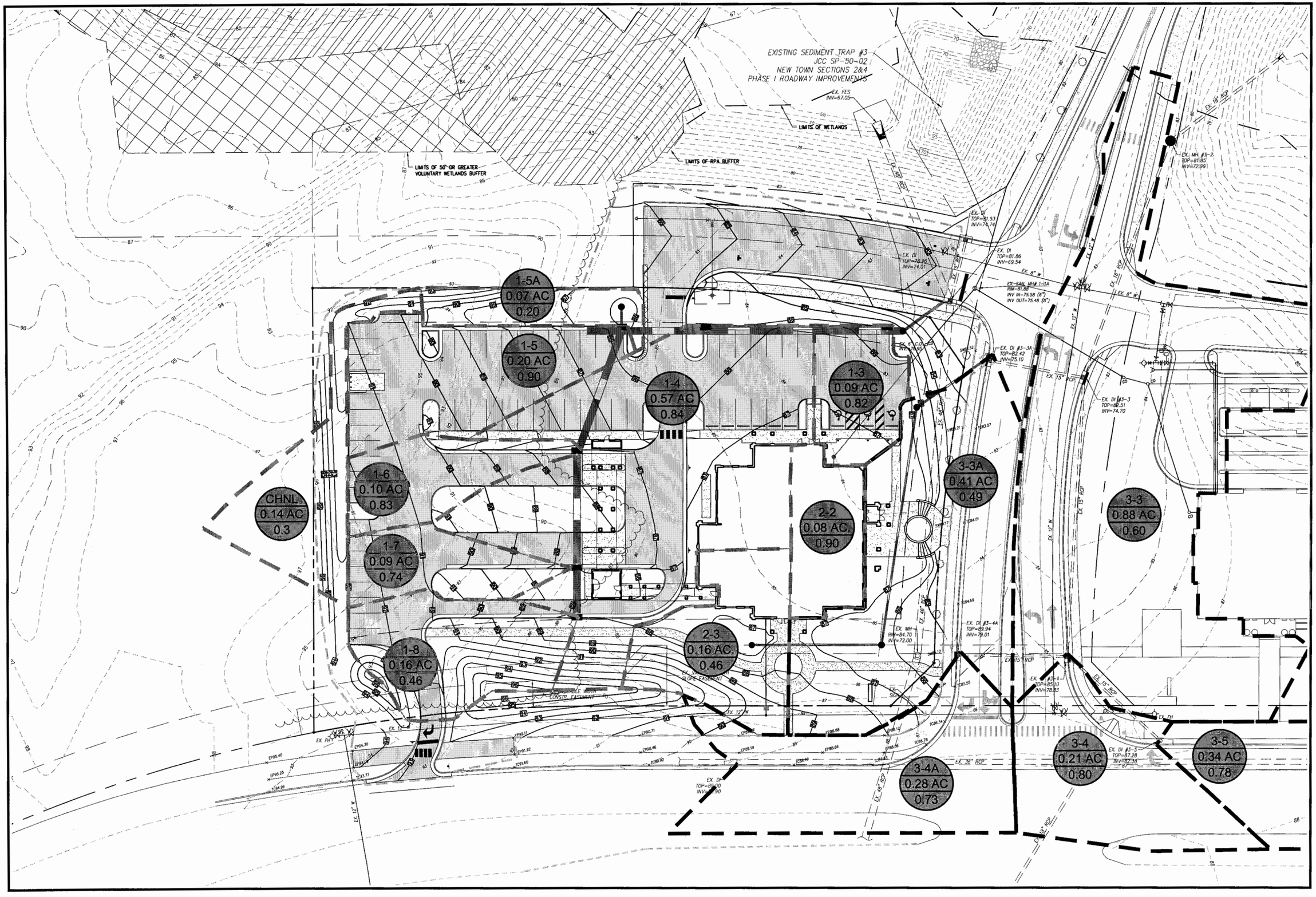
= 0.37 CFS

Channel Characteristics

Rt. Sideslope	=	3.00	:1
Lt. Sideslope	=	3.00	:1
Base Width	=	2.00	Ft.
Max. Depth	=	0.50	Ft.
Channel Slope	=	1.30	%
Mannings (n)	=	0.200	



Depth of Flow	=	0.36	Ft.	
Area	=	1.09	SF	Wetted Perimeter = 4.25 Ft.
Hydraulic Radius	=	0.26	Ft.	
Velocity (V)	=	0.34	Ft./sec.	(From Manning's Equation)
Flow (Q)	=	0.37	CFS	(From Continuity Equation Q=AV)



No.	DATE	REVISION / COMMENT / NOTE	REVISED BY	REVIEWED BY

5248 Olde Towne Road, Suite 1
Williamsburg, Virginia 23188
(757) 253-0040
Fax (757) 220-8994

CONSULTING ENGINEERS
WILLIAMSBURG • RICHMOND • GLOUCESTER

INLET DRAINAGE AREA MAP

Langley Federal Credit Union

BERKELEY DISTRICT JAMES CITY COUNTY VIRGINIA

Designed	Drawn
NB	NB
Scale	Date
1"=50'	5/5/06

Project No. 9529-01

Drawing No. 1

STORMWATER DETENTION SYSTEM

CONSULTING ENGINEERS

CONSULTING ENGINEERS

Williamsburg (757) 253-0040
Gloucester (804) 693-4450
Richmond (804) 330-8040

Project:	Langley Federal Credit Union
Project No.:	9529-01
Subject:	Critical Storm Duration
Date:	Modified Rational Method
Calculated By:	May 2, 2006
	N. Botta

Equation 5-5 - Virginia Stormwater Management Handbook

$$T_d = \sqrt{\frac{2\,C\,A\,a\,(b - t_c/4)}{q_o}} - b$$

C =	0.76	Post-Development Runoff Coefficient
A =	1.28	Drainage Area (Acres)
t_c =	10	Post Development Time of Concentration (Minutes)
a =	185.06	From Table 5-5 for James City County (10 year storm)
b =	20.81	

Equation 5-2 - Virginia Stormwater Management Handbook

$$I_{post} = \frac{a}{b + T_d}$$ Rainfall Intensity where $T_d = t_c$

I_{post} = 6.01 in/hr

$q_o = (C_{pre\text{-}dev})\,(I)\,(A)$ Allowable Peak Outflow (10 year storm)

C =	0.25	Pre-Development Runoff Coefficient
A_{pre} =	2.35	Pre-Development Drainage Area (Acres)
t_c =	15	Pre-Development Time of Concentration (Minutes)
I_{pre} =	5.17	in/hr

q_o = 3.04 CFS Pre-Development Peak Flow (10 year storm)

Using Equation 5-5

T_d = 25.79 Minutes

Storm Duration Factor = T_d/t_c = 2.58 x t_c

Hydrograph Return Period Recap

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Mod. Rational	-------	1.86	2.21	-------	-------	3.02	-------	-------	4.11	LFCU Pre-Dev 2.35 AC
2	Mod. Rational	-------	2.28	2.75	-------	-------	3.86	-------	-------	5.41	LFCU Post-Dev 1.28 AC
3	SCS Runoff	-------	3.13	4.12	-------	-------	7.37	-------	-------	10.43	SCS 1 yr storm
4	Reservoir	3	0.40	2.52	-------	-------	9.87	-------	-------	10.17	Routed 1 yr SCS
5	Reservoir	2	0.36	0.39	-------	-------	2.86	-------	-------	5.82	Routed Peak Storm

Does 350' of 45" provide 24 hr det of 1-YEAR POST-DEV STORM VOL.

Det time 1-YEAR? STORM

8594 CF Thru 3"

1-YEAR out 0.40 CFS

8594 CF / 0.40 CFS

21485 s × 1 m / 60 s × 1 hr. / 60 min

5.96 hrs. DET

meets 2-YEAR PRE

Hydrograph Plot

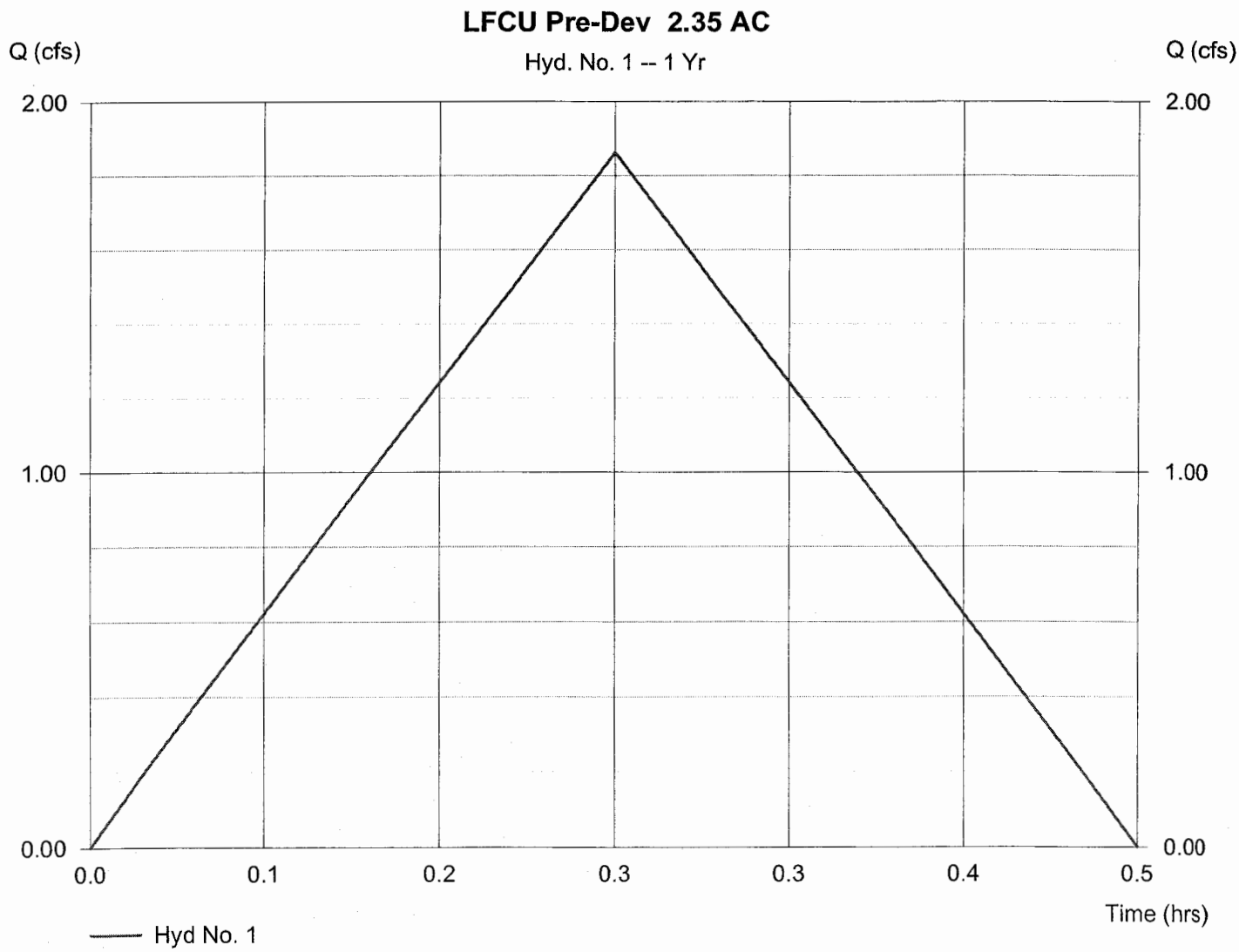
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:5 PM

Hyd. No. 1

LFCU Pre-Dev 2.35 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 1.86 cfs
Storm frequency	= 1 yrs	Time interval	= 1 min
Drainage area	= 2.4 ac	Runoff coeff.	= 0.25
Intensity	= 3.170 in/hr	Tc by User	= 15 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 1 x Tc

Hydrograph Volume = 1,676 cuft



Hydrograph Plot

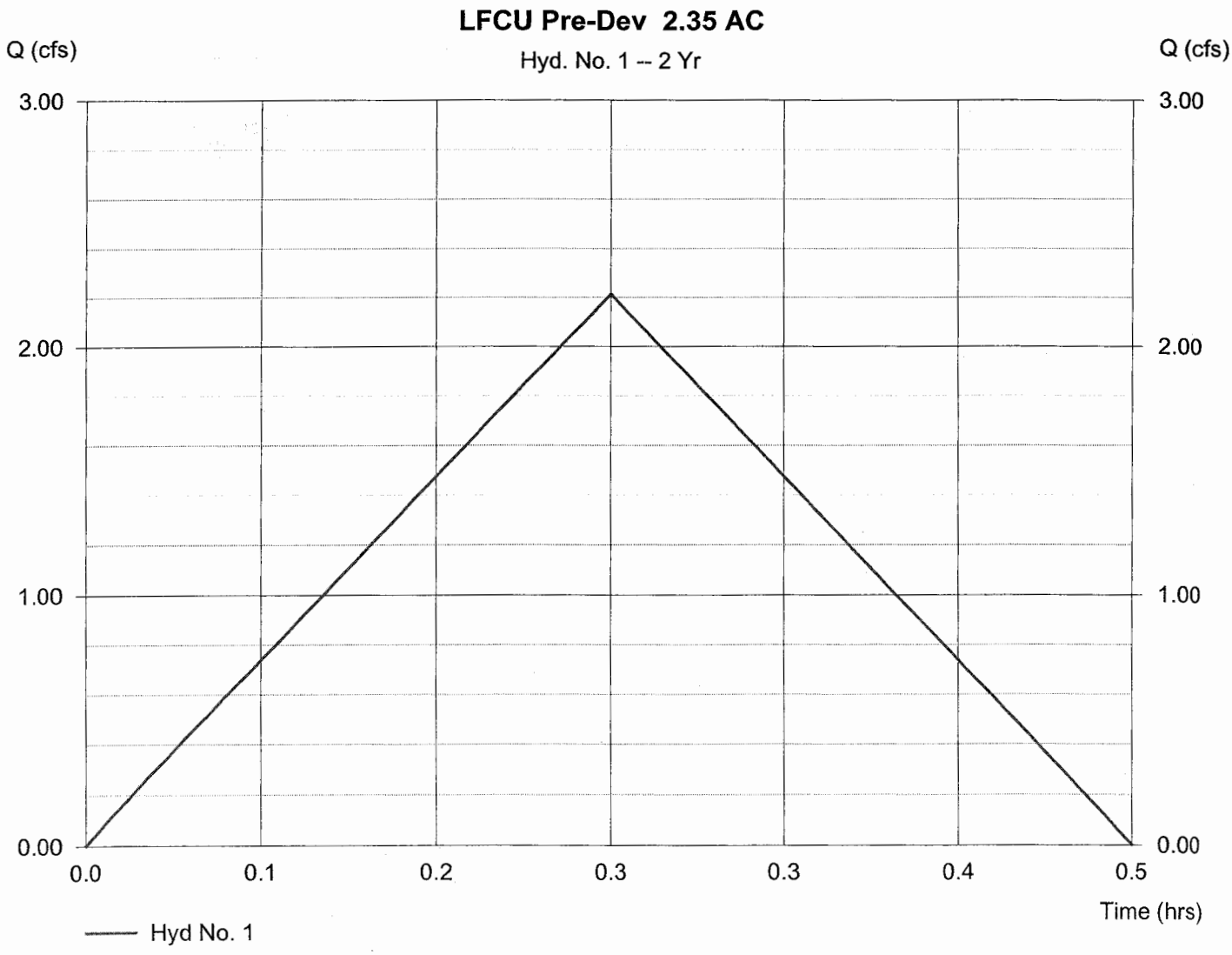
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 1

LFCU Pre-Dev 2.35 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 2.21 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 2.4 ac	Runoff coeff.	= 0.25
Intensity	= 3.766 in/hr	Tc by User	= 15 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 1 x Tc

Hydrograph Volume = 1,991 cuft



Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

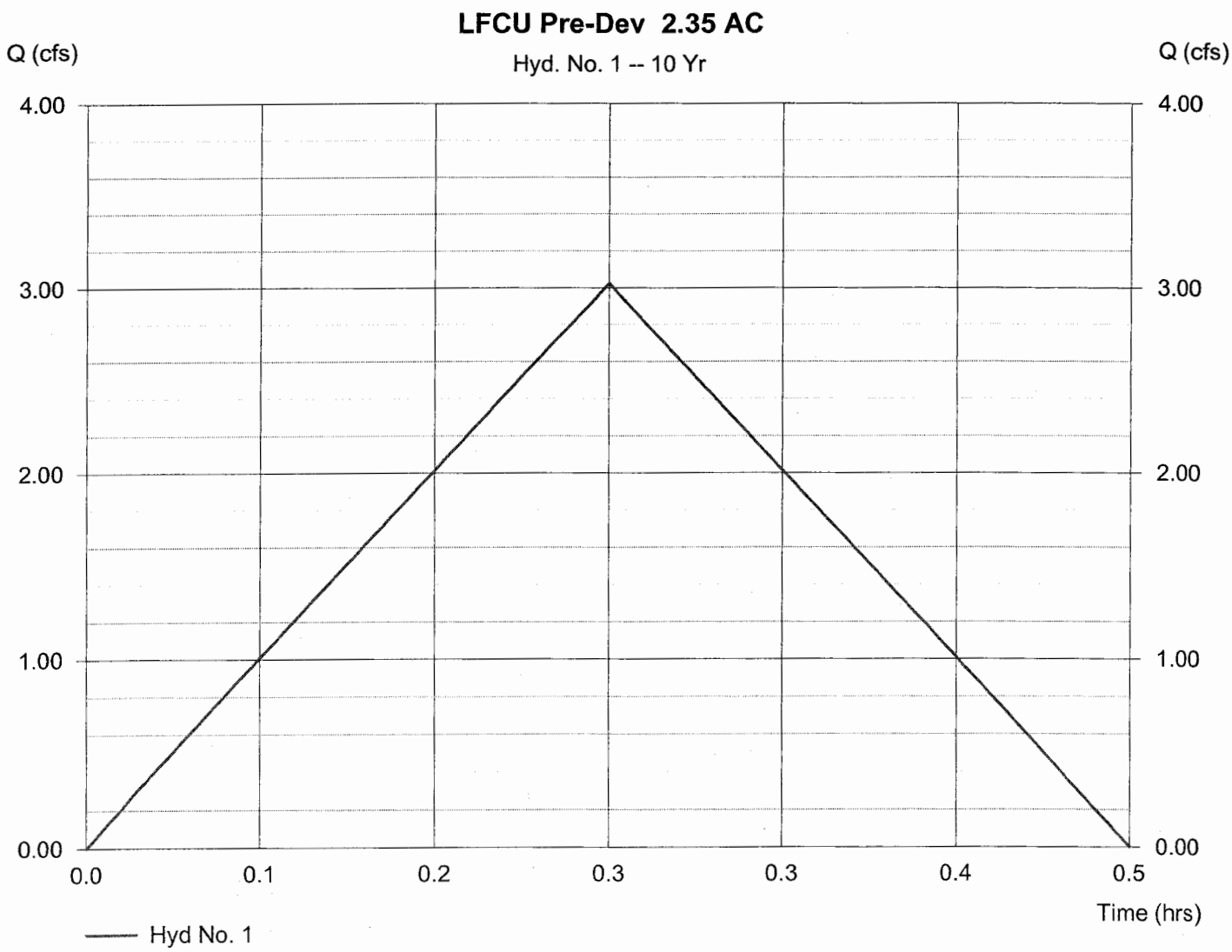
Friday, May 5 2006, 12:6 PM

Hyd. No. 1

LFCU Pre-Dev 2.35 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 3.02 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 2.4 ac	Runoff coeff.	= 0.25
Intensity	= 5.143 in/hr	Tc by User	= 15 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 1 x Tc

Hydrograph Volume = 2,719 cuft



Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

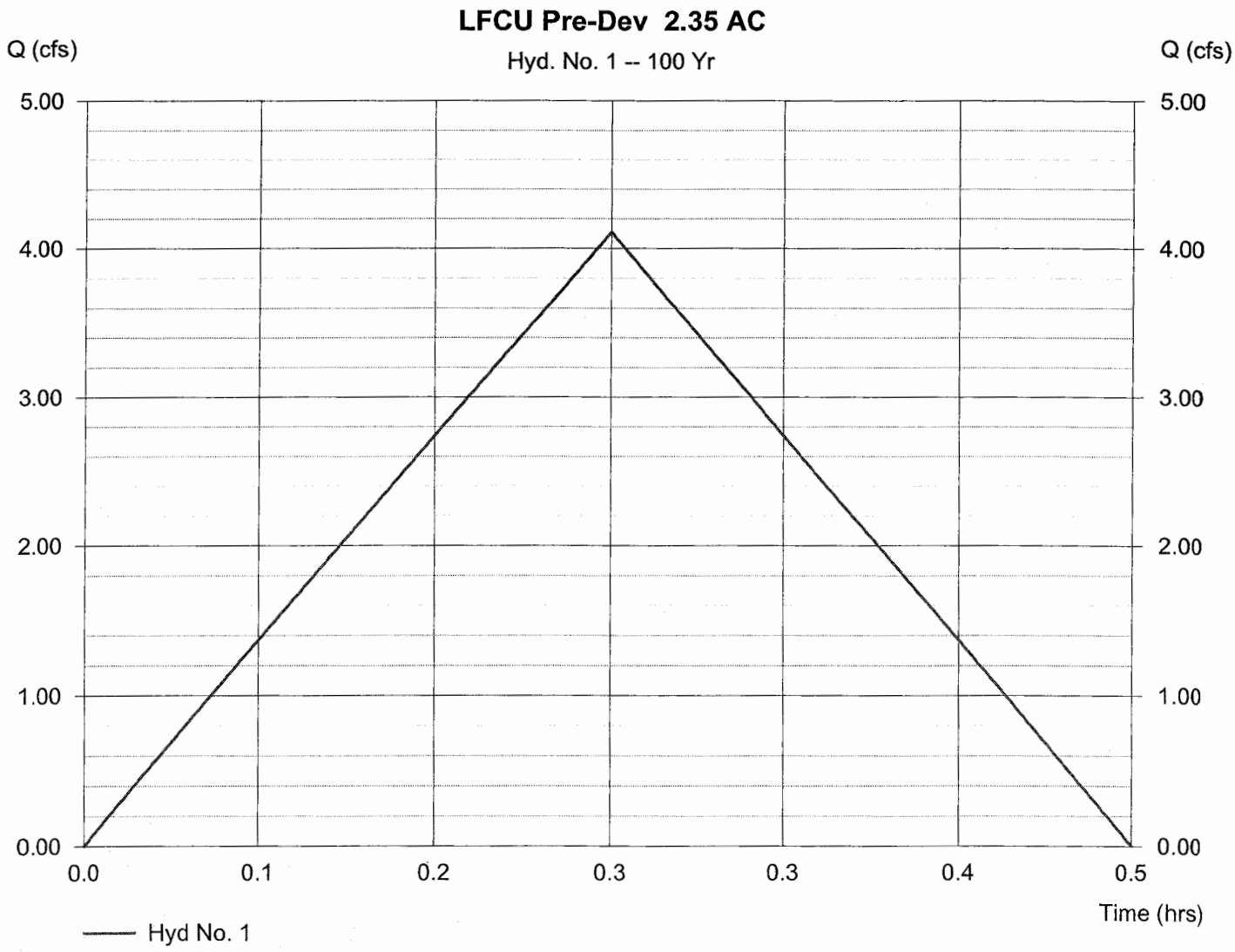
Friday, May 5 2006, 12:6 PM

Hyd. No. 1

LFCU Pre-Dev 2.35 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 4.11 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 2.4 ac	Runoff coeff.	= 0.25
Intensity	= 6.990 in/hr	Tc by User	= 15 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 1 x Tc

Hydrograph Volume = 3,696 cuft



Hydrograph Plot

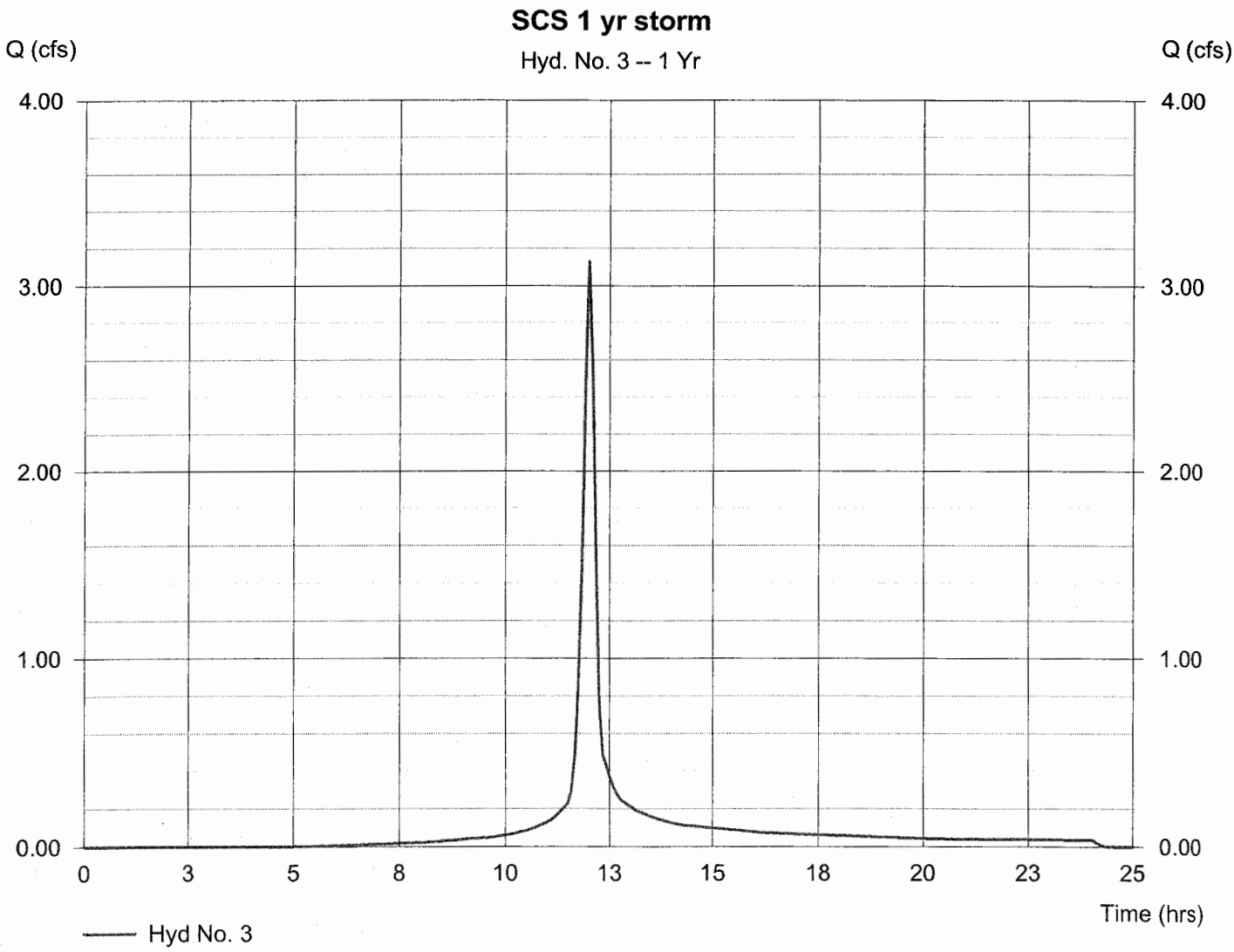
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 3

SCS 1 yr storm

Hydrograph type	= SCS Runoff	Peak discharge	= 3.13 cfs
Storm frequency	= 1 yrs	Time interval	= 5 min
Drainage area	= 1.28 ac	Curve number	= 92
Basin Slope	= 0.0 %	Hydraulic length	= 0 ft
Tc method	= USER	Time of conc. (Tc)	= 10 min
Total precip.	= 2.80 in	Distribution	= Type II
Storm duration	= 24 hrs	Shape factor	= 484

Hydrograph Volume = 8,594 cuft



Hydrograph Plot

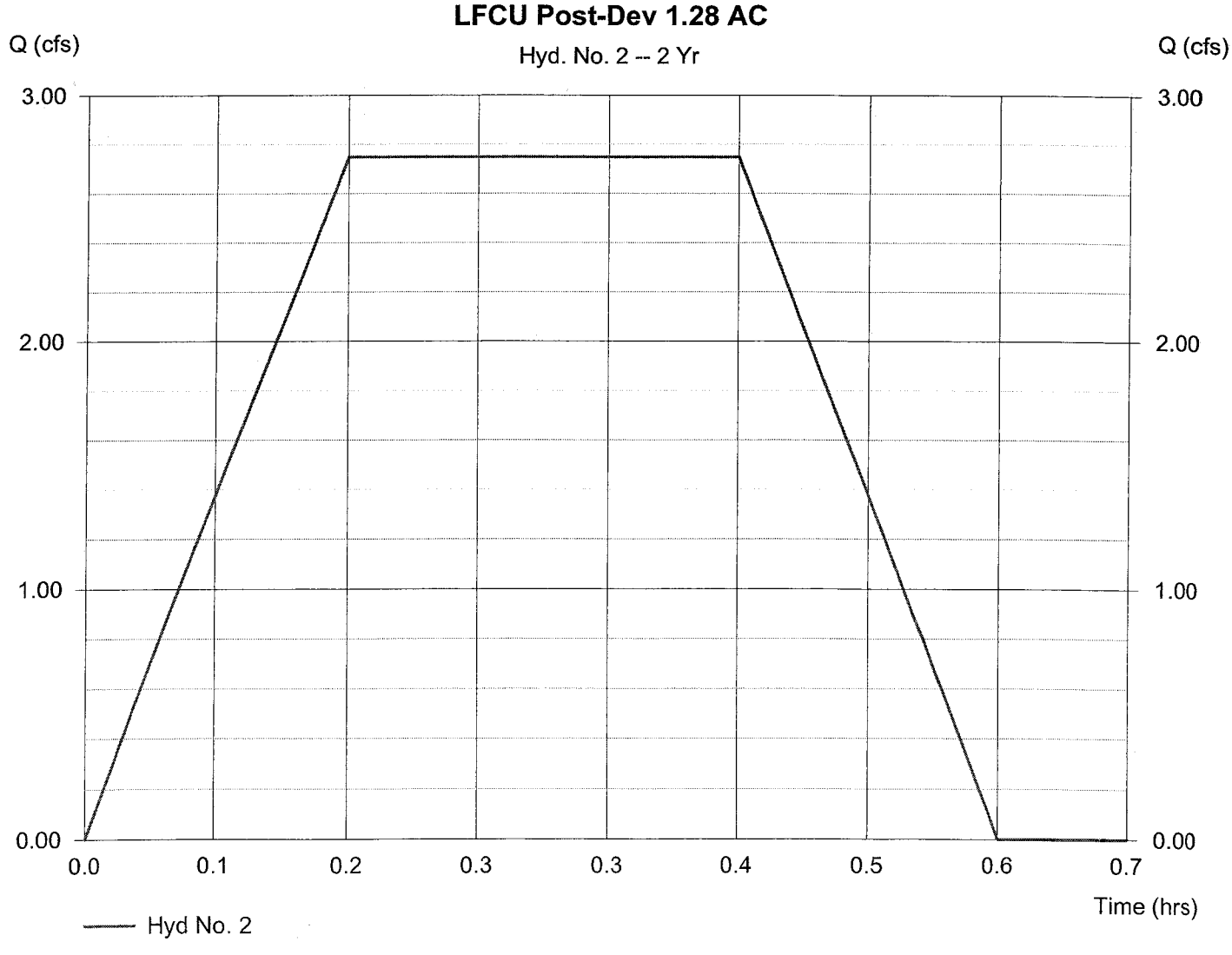
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 2

LFCU Post-Dev 1.28 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 2.75 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Drainage area	= 1.3 ac	Runoff coeff.	= 0.76
Intensity	= 2.826 in/hr	Tc by User	= 10 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 2.58 x Tc

Hydrograph Volume = 4,255 cuft



Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

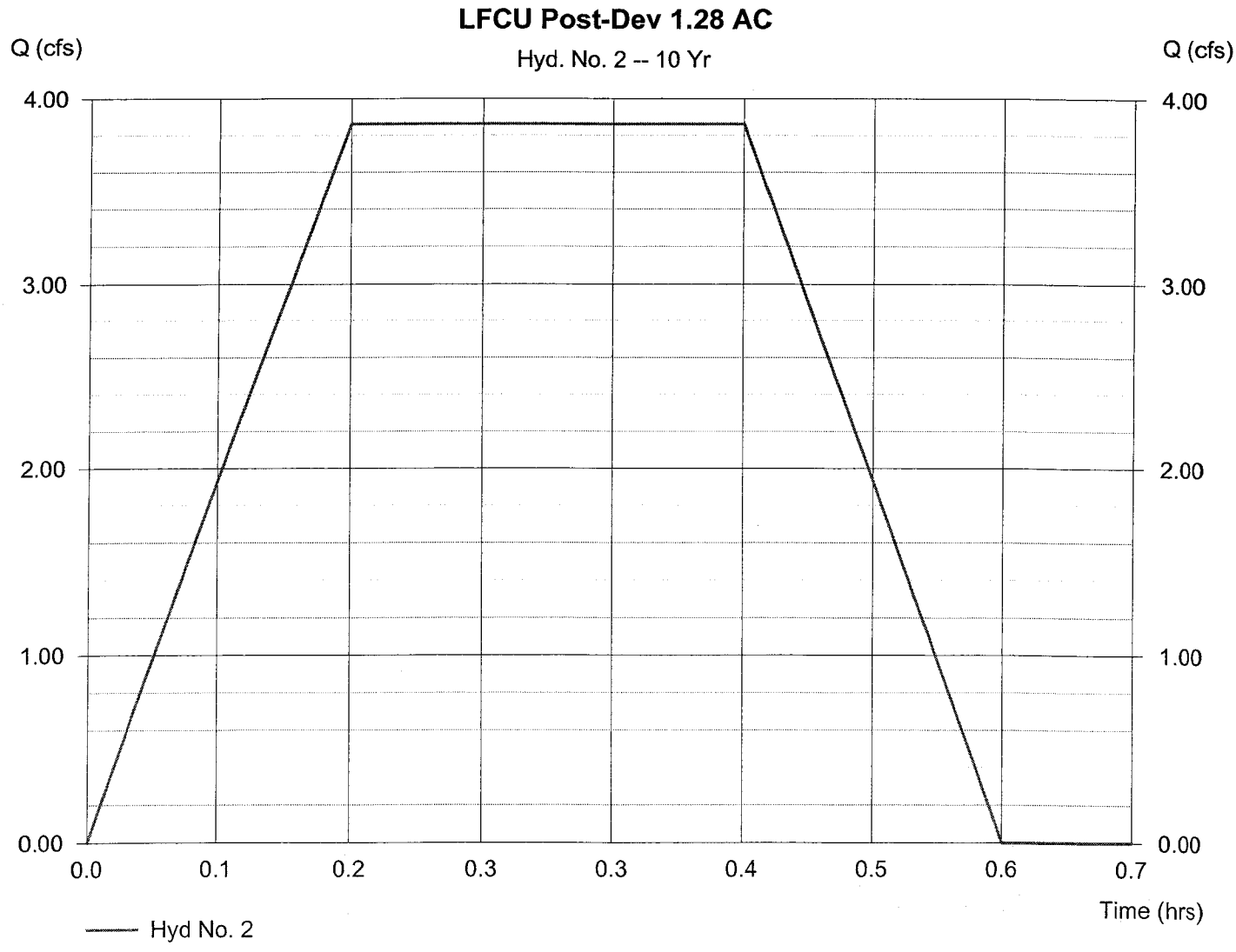
Friday, May 5 2006, 12:6 PM

Hyd. No. 2

LFCU Post-Dev 1.28 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 3.86 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Drainage area	= 1.3 ac	Runoff coeff.	= 0.76
Intensity	= 3.970 in/hr	Tc by User	= 10 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 2.58 x Tc

Hydrograph Volume = 5,979 cuft



Hydrograph Plot

Hydraflow Hydrographs by Intelisolve

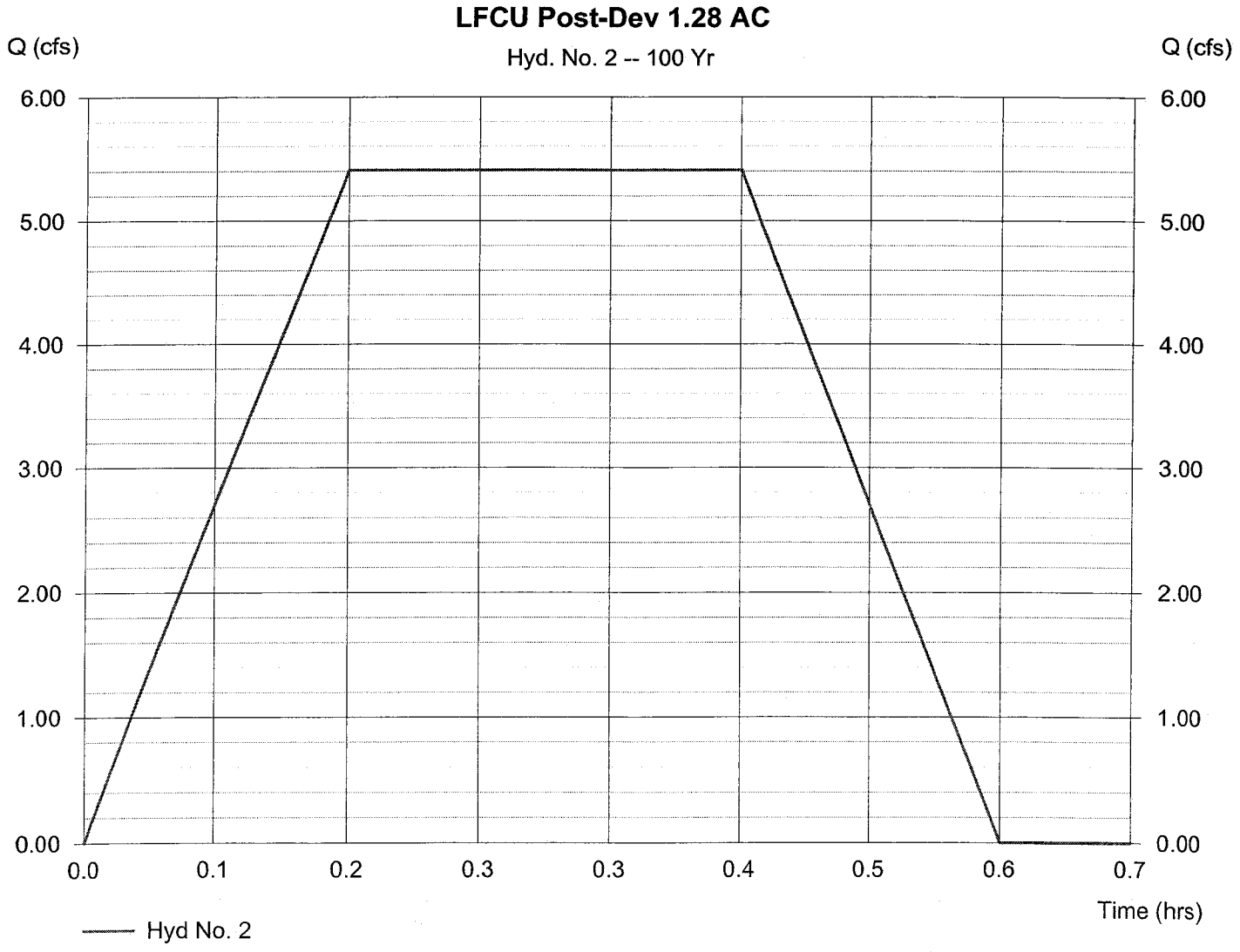
Friday, May 5 2006, 12:6 PM

Hyd. No. 2

LFCU Post-Dev 1.28 AC

Hydrograph type	= Mod. Rational	Peak discharge	= 5.41 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Drainage area	= 1.3 ac	Runoff coeff.	= 0.76
Intensity	= 5.559 in/hr	Tc by User	= 10 min
IDF Curve	= JCCstormsewer.IDF	Storm duration	= 2.58 x Tc

Hydrograph Volume = 8,371 cuft



Pond Report

Hydraflow Hydrographs by Intelisolve

Friday, May 5 2006, 12:6 PM

Pond No. 3 - 350 LF-48 in

Pond Data

Pond storage is based on known values

48" pipes

Stage / Storage Table

Stage (ft)	Elevation (ft)	Contour area (sqft)	Incr. Storage (cuft)	Total storage (cuft)
0.00	78.00	00	0	0
0.50	78.50	00	319	319
1.00	79.00	00	542	861
1.50	79.50	00	648	1,509
2.00	80.00	00	693	2,202
2.50	80.50	00	693	2,895
3.00	81.00	00	647	3,542
3.50	81.50	00	543	4,085
4.00	82.00	00	318	4,403
4.50	82.50	00	93	4,496
5.00	83.00	00	93	4,589

Culvert / Orifice Structures

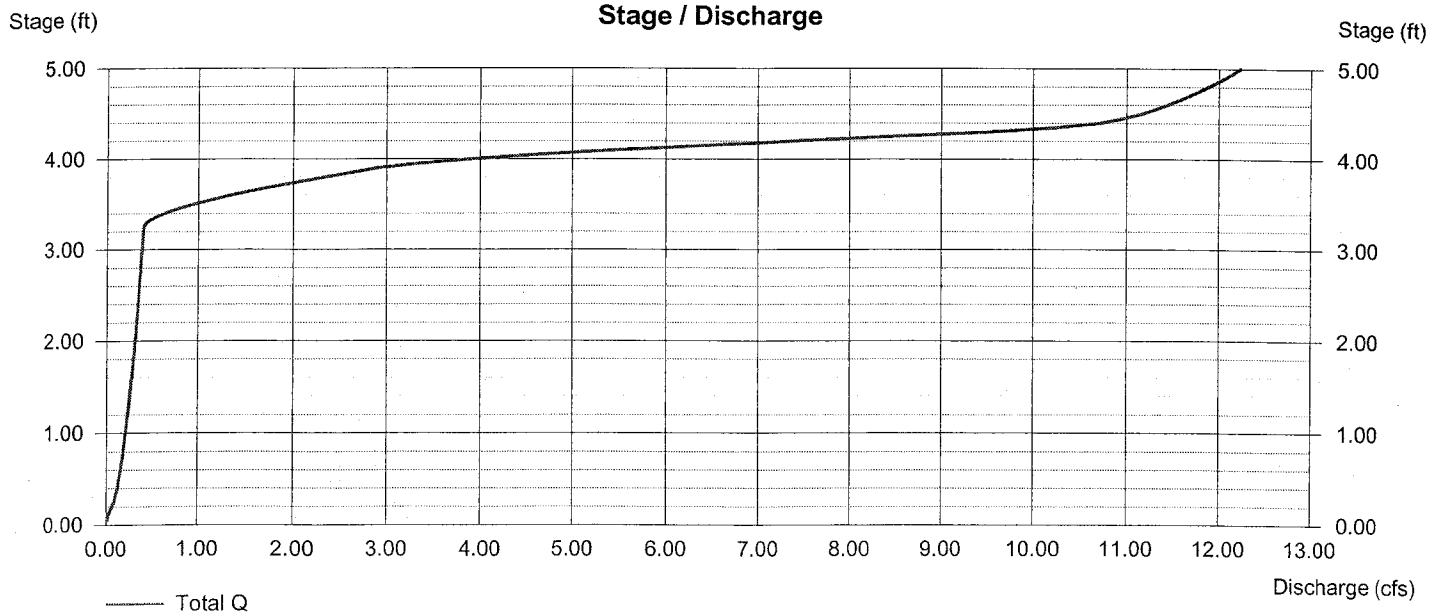
	[A]	[B]	[C]	[D]
Rise (in)	= 15.00	3.00	0.00	0.00
Span (in)	= 15.00	3.00	0.00	0.00
No. Barrels	= 1	1	0	0
Invert El. (ft)	= 78.00	78.00	0.00	0.00
Length (ft)	= 29.00	0.00	0.00	0.00
Slope (%)	= 11.28	0.00	0.00	0.00
N-Value	= .013	.013	.013	.013
Orif. Coeff.	= 0.60	0.60	0.60	0.60
Multi-Stage	= n/a	Yes	No	No

Weir Structures

	[A]	[B]	[C]	[D]
Crest Len (ft)	= 1.50	5.00	0.00	0.00
Crest El. (ft)	= 81.27	81.91	0.00	0.00
Weir Coeff.	= 3.33	3.33	0.00	0.00
Weir Type	= Rect	Rect	---	---
Multi-Stage	= Yes	Yes	No	No

Exfiltration = 0.000 in/hr (Wet area) Tailwater Elev. = 0.00 ft

Note: Culvert/Orifice outflows have been analyzed under inlet and outlet control.



Hydrograph Plot

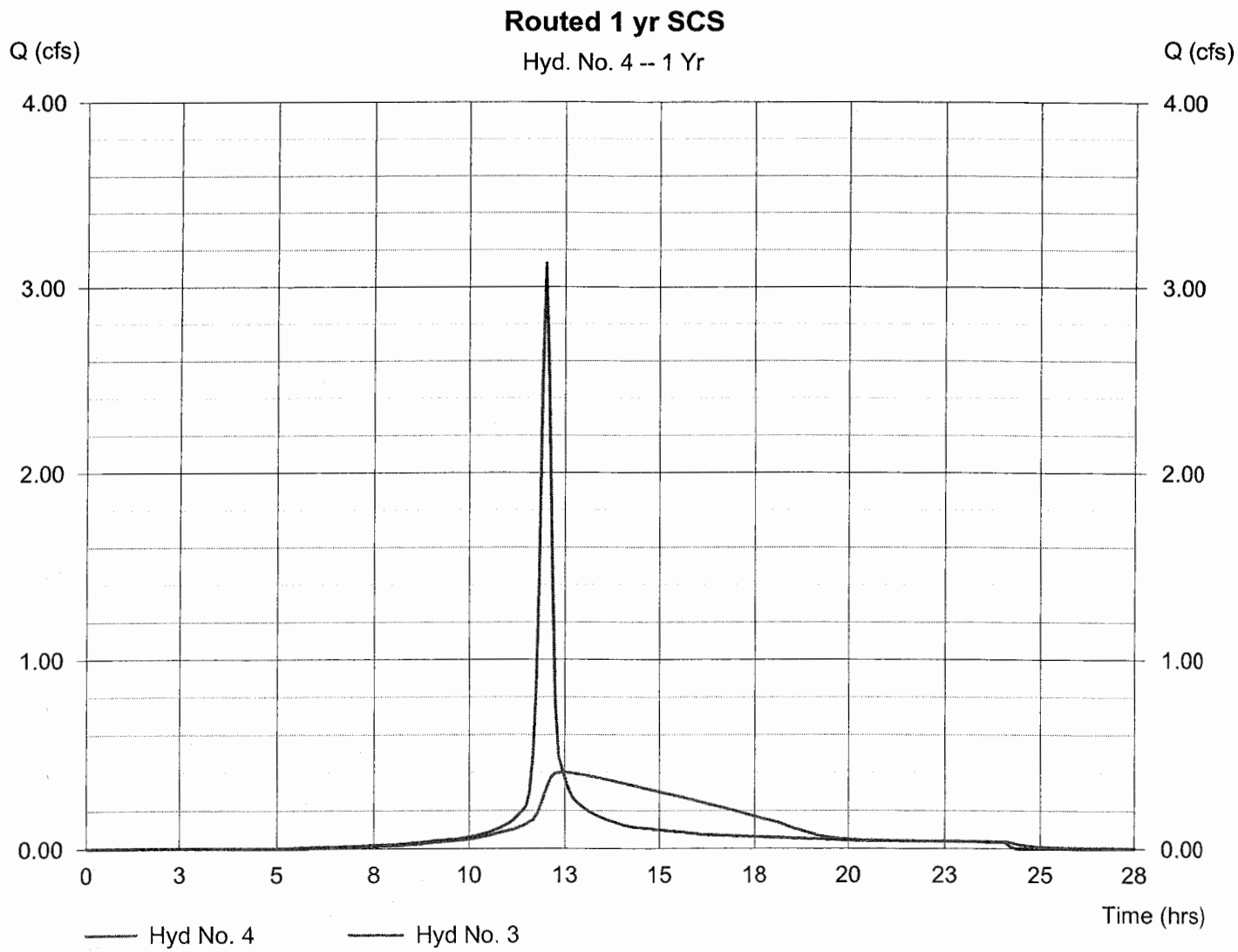
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 4

Routed 1 yr SCS

Hydrograph type	= Reservoir	Peak discharge	= 0.40 cfs
Storm frequency	= 1 yrs	Time interval	= 5 min
Inflow hyd. No.	= 3	Max. Elevation	= 81.15 ft
Reservoir name	= 350 LF-48 in	Max. Storage	= 3,708 cuft

Storage Indication method used. | Hydrograph Volume = 8,587 cuft



Hydrograph Plot

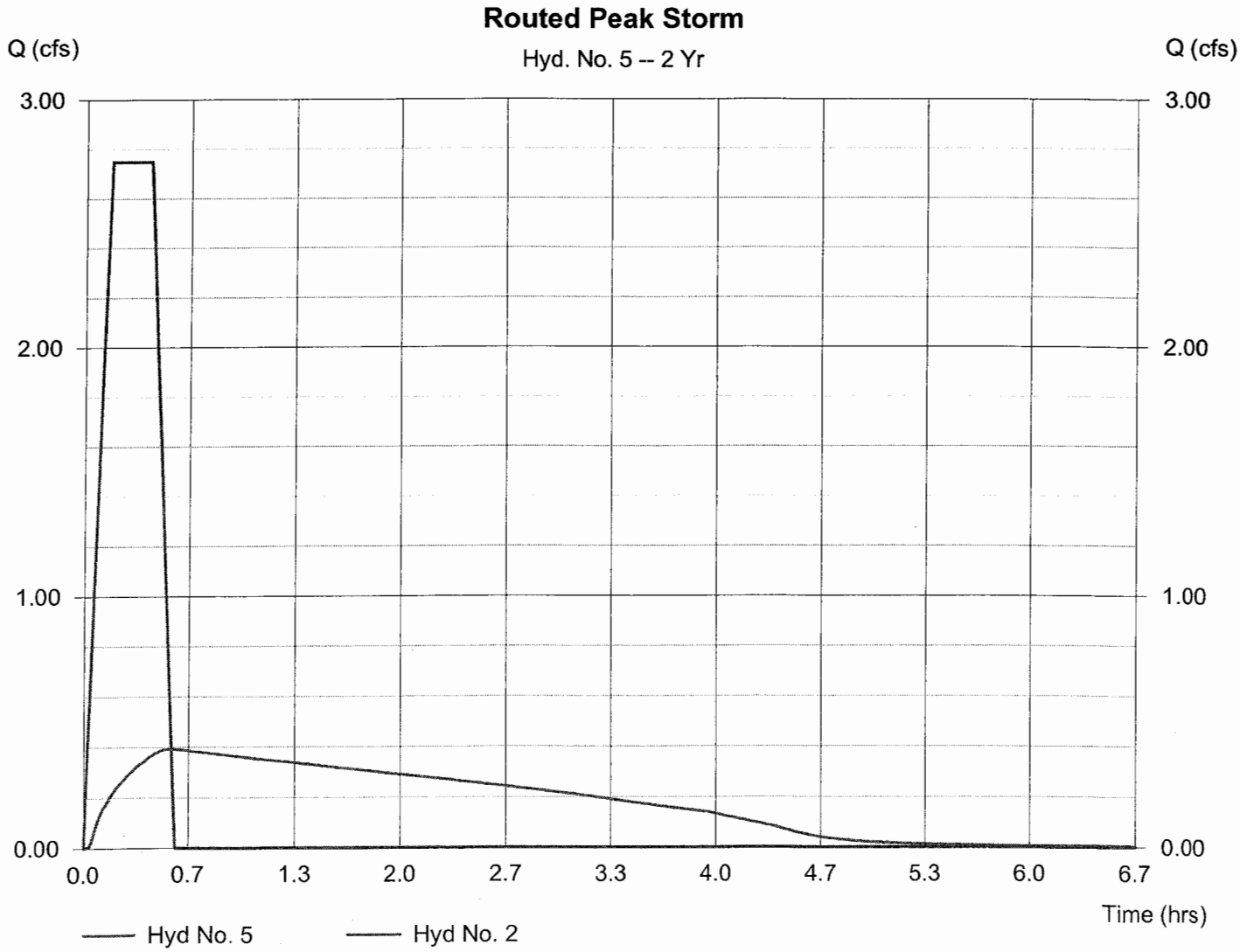
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 5

Routed Peak Storm

Hydrograph type	= Reservoir	Peak discharge	= 0.39 cfs
Storm frequency	= 2 yrs	Time interval	= 1 min
Inflow hyd. No.	= 2	Max. Elevation	= 81.05 ft
Reservoir name	= 350 LF-48 in	Max. Storage	= 3,595 cuft

Storage Indication method used. | Hydrograph Volume = 4,117 cuft



Hydrograph Plot

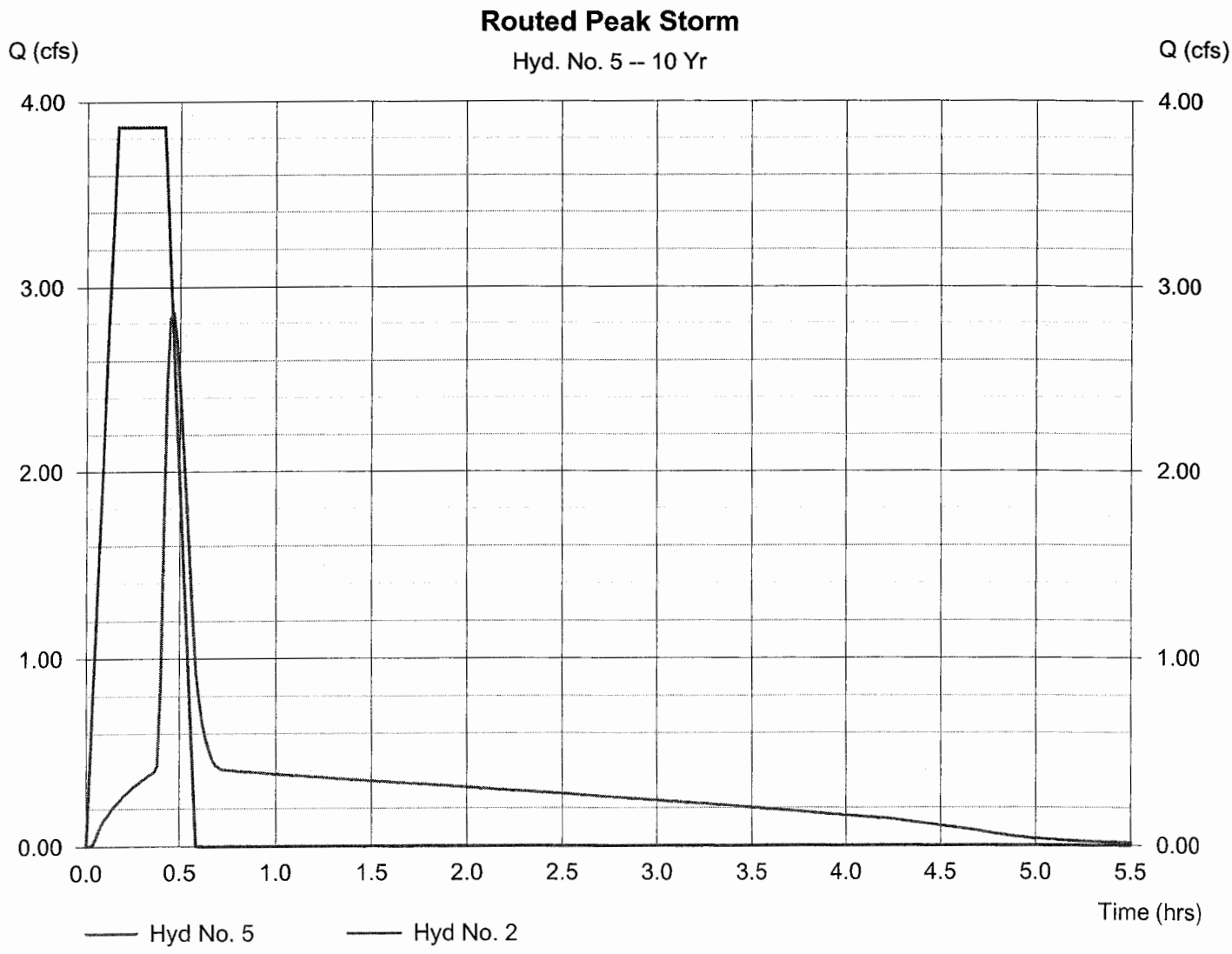
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 5

Routed Peak Storm

Hydrograph type	= Reservoir	Peak discharge	= 2.86 cfs
Storm frequency	= 10 yrs	Time interval	= 1 min
Inflow hyd. No.	= 2	Max. Elevation	= 81.89 ft
Reservoir name	= 350 LF-48 in	Max. Storage	= 4,334 cuft

Storage Indication method used. | Hydrograph Volume = 5,787 cuft



Hydrograph Plot

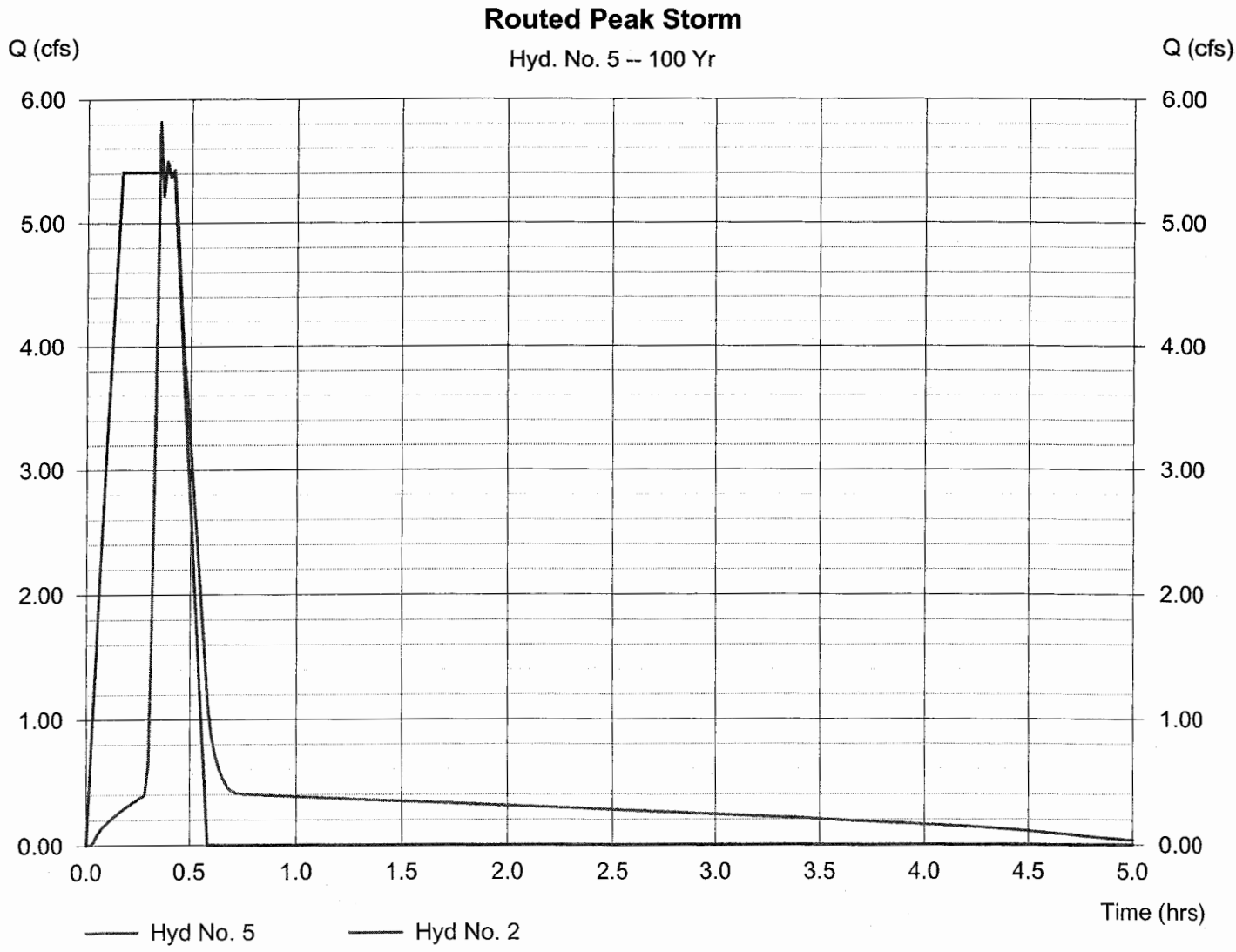
Hydraflow Hydrographs by Intelisolve | Friday, May 5 2006, 12:6 PM

Hyd. No. 5

Routed Peak Storm

Hydrograph type	= Reservoir	Peak discharge	= 5.82 cfs
Storm frequency	= 100 yrs	Time interval	= 1 min
Inflow hyd. No.	= 2	Max. Elevation	= 82.12 ft
Reservoir name	= 350 LF-48 in	Max. Storage	= 4,424 cuft

Storage Indication method used. | Hydrograph Volume = 8,105 cuft



EXISTING SEDIMENT TRAP #3
JCC SP-50-02
NEW TOWN SECTIONS 2&4
PHASE I ROADWAY IMPROVEMENTS

LIMITS OF 50' OR GREATER VOLUNTARY WETLANDS BUFFER

LIMITS OF WETLANDS

LIMITS OF RPA BUFFER

DESIGN POINT

Tc = 15 Min.
Q1 = 1.86 CFS
Q2 = 2.21 CFS
Q10 = 3.02 CFS
Q100 = 4.11 CFS

PRE
2.35 AC
0.24

EX. VARIABLE WIDTH SLOPE EASEMENT

EX. VARIABLE WIDTH CONSTR. EASEMENT

GRAPHIC SCALE
50' 0' 50' 100'
SCALE: 1" = 50'

No.	DATE	REVISION / COMMENT / NOTE	REVISED BY	REVIEWED BY

5248 Olde Towne Road, Suite 1
Williamsburg, Virginia 23188
(757) 253-0040
Fax (757) 220-8994

CONSULTING ENGINEERS
WILLIAMSBURG • RICHMOND • GLOUCESTER

PRE DEVELOPMENT DRAINAGE AREA MAP

Langley Federal Credit Union

BERKELEY DISTRICT JAMES CITY COUNTY VIRGINIA

Designed	Drawn
NB	NB
Scale	Date
1"=50'	5/5/06

Project No.
9529-01

Drawing No.
1

EXISTING SEDIMENT TRAP #3
JCC SP-50-02
NEW TOWN SECTIONS 2&4
PHASE I ROADWAY IMPROVEMENTS

LIMITS OF 50' OR GREATER VOLUNTARY WETLANDS BUFFER

LIMITS OF WETLANDS

LIMITS OF RPA BUFFER

POST
1.28 AC
0.76

EX. FES INV=67.05

EX. MH #3-2 TOP=81.85 INV=72.99

EX. DI TOP=81.93 INV=74.74

EX. DI TOP=78.96 INV=74.01

EX. DI TOP=81.86 INV=69.54

EX. SAN. MH # 1-1A RIM=81.88 INV IN=75.58 (6") INV OUT=75.48 (8")

EX. DI #3-3A TOP=82.42 INV=75.10

EX. DI #3-3 TOP=82.51 INV=74.70

EX. MH RIM=84.70 INV=72.00

EX. DI #3-4A TOP=89.94 INV=79.01

EX. DI #3-4 TOP=85.10 INV=78.83

EX. DI #3-5 TOP=87.28 INV=82.38

EX. DI TOP=89.00 INV=82.90

EX. VARIABLE WIDTH SLOPE EASEMENT

EX. VARIABLE WIDTH CONSTR. EASEMENT

EX. 8" W

EX. 12" W

EX. 15" RCP

EX. 36" RCP

EX. 48" RCP

EX. 18" RCP

EX. FH

No.	DATE	REVISION / COMMENT / NOTE	REVISED BY	REVIEWED BY

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CONSULTING ENGINEERS
WILLIAMSBURG • RICHMOND • GLOUCESTER

POST DEVELOPMENT DRAINAGE AREA MAP

Langley Federal Credit Union

BERKELEY DISTRICT JAMES CITY COUNTY VIRGINIA

Designed	Drawn
NB	NB
Scale	Date
1"=50'	5/5/06

Project No.
9529-01

Drawing No.
1

HDPE/CPP STRUCTURAL

HDPE | CPP

STORM DRAINAGE PIPE DESIGN

FOR

LANGLEY FEDERAL CREDIT UNION

MAY 2006
RECEIVED
PLANNING DEPARTMENT

RECEIVED
ENVIRONMENTAL
DIVISION

SP-145-05
3RD SUB

Prepared By:

AES Consulting Engineers
5248 Olde Towne Road, Suite 1
Williamsburg, Virginia 23188

May 12, 2006
AES Project No. 9529-01

ADDRESSED
COMM 9B
4/13/06

AES
CONSULTING ENGINEERS

Design information for the 48-inch HDPE storm drainage pipe proposed for the Langley Federal Credit Union site was compiled from the following publications by Advanced Drainage Systems, Inc.:

- Technical Notes 2.130 – Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution.
- Product Notes 3.107 – Specifications for Smooth Interior Corrugated Polyethylene Pipe
- Product Notes 3.115 – Installing N-12 Storm, Sanitary Sewer, and Culvert Pipe
- Technical Report 4.103 – Plastic Pipe Design

In addition, deflection calculations were performed using the calculator provided on the Advanced Drainage Systems, Inc. website. Two calculations were made based on the minimum and maximum design covers over the pipe in the areas of proposed pavement, as measured from the top of the pipe to the bottom of the base material in the pavement section. These calculations were performed using the following assumptions:

- Dry Density of 130 lbs/cf (This is the most conservative choice in the list provided)
- Additional Surface Load of 800 lbs/cf (This was based on the value 5.56 lbs/in^2 listed in Table 5 of Technical Report 4.103 for H20 loading and 2 feet of cover. This value was converted to 800 lbs/cf.)
- Density of Backfill Material of 85% (This is the most conservative choice in the list provided)
- Deflection Lag Factor of 1.0 (This value is suggested in section 1.A on page 4 of Technical Report 4.103)

The results were deflections of 1.57% with 2.5 feet of cover (minimum cover as designed) and 1.479% with 5.3 feet of cover (maximum cover as designed). These results are less than the maximum allowable deflection of 5%.

These results are consistent with the PC-1 Standard on page 107.20 of the Virginia Department of Transportation Road and Bridge Standards which calls for a minimum cover during construction to be 2 feet (diameter/2) and minimum finished cover of 1 foot.

CONSULTING ENGINEERS

PIPE DEFLECTION CALCULATIONS

CONSULTING ENGINEERS

ADS
THE MOST ADVANCED NAME IN DRAINAGE SYSTEMS®

N-12 Deflection Calculation

Estimate deflection of ADS N-12 pipe using Spangler's Modified Iowa Equation by filling out the fields below and clicking "Calculate."

1. What is the height of cover, H (ft) over top of pipe? 2.5

2. Select the unit weight of cover, δ(lbs/ft^3) from the table below.

	Dry Density, pcf	Class Group Symbol	Description
◉	130	GW	well-graded, clean gravels, gravel-sand mixtures
○	120	GP	poorly-graded clean gravels, gravel-sand mixtures
○	130	GM	silty gravels, poorly graded gravel-sand silt
○	125	GC	clayey gravels, poorly graded gravel-sand-clay
○	120	SW	well-graded clean sands, gravely sands
○	110	SP	poorly-graded clean sands, sand-gravel mix
○	110	SM	silty sands, poorly-graded sand-silt mix
○	120	SM-SC	sand-silt-clay mix with slightly plastic fines
○	115	SC	clayey sands, poorly-graded sand-clay mix
○	110	ML	inorganic silts and clayey silts
○	110	ML-CL	mixture of organic silt and clay
○	110	CL	inorganic clays of low-to-medium plasticity

3. Enter any additional surface loads (in lbs/ft^2): 800

4. Select the density of the backfill material:

◉ 85% ○ 90% ○ 95% ○ 100%

Modulus of soil reaction, E' : 700

Use the automatically calculated result or enter another value.

5. Enter nominal pipe diameter (in). Pipe stiffness is automatically set as shown below.

Nominal Pipe Nominal Pipe

Search
CLICK HERE EPA Stor Phase II
How Does Pipe Measur
N-12 Pipe vs

PC138 NEW TOWN LANGLEY FEDERAL 1061

Diameter	Stiffness	Diameter	Stiffness
○ 4	50	○ 18	40
○ 6	50	○ 24	34
○ 8	50	○ 30	28
○ 10	50	○ 36	22
○ 12	50	○ 42	19
○ 15	42	◉ 48	17

6. Enter the deflection lag factor: 1.0

* Note: Spangler's Modified Iowa Equation, as used herein, is applicable only to installations where pipe is buried at depths of 25' or less. Calculated pipe deflections at depths greater than 25' can be taken as estimates of the pipe's performance and should be verified by a local engineer.

Calculate Reset

Result:

The N-12 deflection is 1.570%.

4640 Trueman Boulevard, Hilliard, OH 43026 Tel: 800-821-6710
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PC138 NEW TOWN LANGLEY FEDERAL 062

ADS
THE MOST ADVANCED NAME IN DRAINAGE SYSTEMS®

N-12 Deflection Calculation

Estimate deflection of ADS N-12 pipe using Spangler's Modified Iowa Equation by filling out the fields below and clicking "Calculate."

1. What is the height of cover, H (ft) over top of pipe? 5.3

2. Select the unit weight of cover, δ(lbs/ft^3) from the table below.

	Dry Density, pcf	Class Group Symbol	Description
◉	130	GW	well-graded, clean gravels, gravel-sand mixtures
○	120	GP	poorly-graded clean gravels, gravel-sand mixtures
○	130	GM	silty gravels, poorly graded gravel-sand silt
○	125	GC	clayey gravels, poorly graded gravel-sand-clay
○	120	SW	well-graded clean sands, gravely sands
○	110	SP	poorly-graded clean sands, sand-gravel mix
○	110	SM	silty sands, poorly-graded sand-silt mix
○	120	SM-SC	sand-silt-clay mix with slightly plastic fines
○	115	SC	clayey sands, poorly-graded sand-clay mix
○	110	ML	inorganic silts and clayey silts
○	110	ML-CL	mixture of organic silt and clay
○	110	CL	inorganic clays of low-to-medium plasticity

3. Enter any additional surface loads (in lbs/ft^2): 800

4. Select the density of the backfill material:

◉ 85% ○ 90% ○ 95% ○ 100%

Modulus of soil reaction, E' : 1000

Use the automatically calculated result or enter another value.

5. Enter nominal pipe diameter (in). Pipe stiffness is automatically set as shown below.

Nominal Pipe Nominal Pipe

Diameter	Stiffness	Diameter	Stiffness
○ 4	50	○ 18	40
○ 6	50	○ 24	34
○ 8	50	○ 30	28
○ 10	50	○ 36	22
○ 12	50	○ 42	19
○ 15	42	◉ 48	17

6. Enter the deflection lag factor: 1.0

* Note: Spangler's Modified Iowa Equation, as used herein, is applicable only to installations where pipe is buried at depths of 25' or less. Calculated pipe deflections at depths greater than 25' can be taken as estimates of the pipe's performance and should be verified by a local engineer.

Calculate Reset

Result:

The N-12 deflection is 1.479%.

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PC138-NEW TOWN-LANGLEY/FEDERAL-106%

REFERENCE MATERIAL

CONSULTING ENGINEERS

REVISED 7/01

PC-1

EXTRA STRENGTH CLAY PIPE		
Diameter (IN.)	Area (SQ. FT.)	Allowable Maximum Cover (FT.)
12	0.8	15
15	1.2	15
18	1.8	15
21	2.4	15
24	3.1	15
30	4.9	13
36	7.1	13

Notes:

All Vitrified Clay Pipe is to be Extra Strength.

Maximum heights of cover shown in table are for finished construction.

To protect pipe during construction minimum height of cover prior to allowing construction traffic to cross installation is to be 3.0'. This cover is to extend the full length of the pipe culvert. The approach fill ramp is to extend a minimum of 10 (Dia. + 3') on each side of the culvert, or to the intersection with a cut.

Minimum finished height of cover to be 2.0', except pipe under entrances and median crossovers where a 9" minimum will be permitted.

Method "A" bedding is to be used for all installations unless otherwise designated on plans.

VITRIFIED CLAY

POLYETHYLENE DOUBLE WALL CORRUGATED PIPE CULVERT		
Diameter (IN.)	Area (SQ. FT.)	Allowable Maximum Cover (FT.)
12	0.8	21
15	1.2	21
18	1.8	20
24	3.1	20
30	4.9	19
36	7.1	18

Note: For details of bedding for Polyethylene Pipe Culvert see Standard PB-1.

POLYVINYLCHLORIDE RIBBED PIPE CULVERT		
Diameter (IN.)	Area (SQ. FT.)	Allowable Maximum Cover (FT.)
18	1.7	20
21	2.3	19
24	3.0	19
30	4.7	18
36	6.9	18
48	12.3	18

Notes:

Cover heights indicated in tables are for finished construction.

To protect pipe during construction, minimum height of cover to be as follows prior to allowing construction traffic to cross installation.

Pipe Diameter	** Minimum cover Height During Construction
12" to 30"	1'-6"
36" and above	$\frac{\text{Diameter}}{2}$

Minimum finished height of cover to be 1/8 Diameter or 1'-0" whichever is greater, except pipe under entrances and median crossovers where a 9" minimum will be permitted for pipe up to 24" diameter.

** The cover shall extend the full length of the pipe. The approach fill is to extend a minimum of (10)(Diameter + 1/2 Diameter) on each side of the structure, or to the intersection with a cut.

The allowable cover tables shown are based on a soil modulus of 700 PSI. All other design criteria are in accordance with the AASHTO Specifications and VDOT Modifications for Soil Thermoplastic Pipe Interaction Systems.

PLASTIC PIPE

Sheet 16 of 17

VITRIFIED CLAY AND PLASTIC PIPE MAXIMUM COVER TABLE FOR H-20 LIVE LOAD

VIRGINIA DEPARTMENT OF TRANSPORTATION

SPECIFICATION REFERENCE

232
302

107.20

Technical Notes

Technical Note 2.130

Re: Structural Performance of Corrugated PE Pipe Using the Burns and Richard Solution

Date: Updated October, 2003

By: James B. Goddard, Norman E. Kampbell, & David P. Kozman

INTRODUCTION

In 1964, Jerome Burns and Ralph Richard presented a break-through paper on the "Attenuation of Stresses for Buried Cylinders" which provided an improved understanding of the stresses around a buried pipe. The analysis is applicable to deeply buried structures where the structure is made from an elastic material and the soil is assumed to be an elastic medium. The circumferential stiffness of the pipe, the bending stiffness of the pipe, and the load transfer between the soil and pipe all influence the loads, in both magnitude and direction (tensile or compression loads). The solution is applicable to any pipe buried in a linearly elastic medium.

The elastic medium parameters are the modulus of elasticity (E′), Poisson's ratio of the soil (μ), the constrained modulus (M′), and the lateral stress ratio (K). These parameters are related by the following equations:

$$M' = \frac{E'(1-\mu)}{(1+\mu)(1-2\mu)} \tag{1}$$

$$K = \frac{\mu}{(1-\mu)} \tag{2}$$

Two additional constants relate to the lateral stress ratio:

$$B = \frac{1}{2}(1+K) = \frac{1}{2}\left(\frac{1}{1-\mu}\right) = \text{symmetrical lateral stress ratio} \tag{3}$$

and

$$C = \frac{1}{2}(1-K) = \frac{1}{2}\left(\frac{1-2\mu}{1-\mu}\right) = \text{antisymmetrical lateral stress ratio} \tag{4}$$

The pipe parameters are the mean radius of the pipe, the circumferential stiffness, and the pipe stiffness (bending stiffness). The circumferential stiffness (or ring compression stiffness) is given by the equation:

$$K_{rc} = \frac{E_{rc} A}{R} \tag{5}$$

where:

E_{rc} = the compression modulus of the pipe material (psi)
A = the unit area of the pipe wall (in^2/in)
R = the mean radius (in.)

The pipe stiffness (or ring bending stiffness or flexural stiffness) is given by the equation:

$$K_f = \frac{6E_f I}{R^3} \tag{6}$$

where:

E_f = the flexural modulus (psi)
I = the moment of inertia of the pipe wall (in^4/in)
R = the mean radius (in)

Soil-structure interaction parameters are defined as the ring flexibility ratio, UF, where:

$$UF = \frac{2BM'R}{EA} = \frac{(1+K)M'R}{EA} \tag{7}$$

and the bending flexibility ratio, VF, where:

$$VF = \frac{2CM'R^3}{6EI} = \frac{(1-K)M'R^3}{6EI} \tag{8}$$

UF is a measure of the relative flexibility of the pipe and the soil under uniform interaction loads. VF is a measure of the relative flexibility of the pipe and soil under varying radial and tangential interaction loads.

FILE INPUTS

The accompanying file, Burns and Richard Solution.xls*, requires the input of the pipe and soil properties and dimensions.

The pipe inputs are:

outside diameter (D) in inches
thickness (t) in inches — this is the total wall thickness
unit wall area (A) in in^2/in
moment of inertia (I) in in^4/in
flexural modulus (E′) in psi — for the resin; typically 110,000 psi for HDPE
compressive modulus (E_{rc}) — for HDPE; typically >110,000 psi

The spreadsheet can be downloaded from the ADS website: www.ads-pipe.com

distance from inner diameter to neutral axis (c) in inches

The soil inputs are:

soil modulus of elasticity in psi: typically based on E'_5 values from the CANDE program and work by Duncan and Hartley. The soil modulus values are shown in Table 1 from the CANDE program.

Poisson's ratio, (μ): typically ranging from 0.30 to 0.35 for good granular soil, to 0.30 to 0.40 for mixed soils, to 0.35 to 0.40 for cohesive soils. For highly compacted dense graded aggregates, the Poisson's ratio may be as low as 0.2, but these should be special cases. CLSM or CDF may provide values as low as 0.15.

unit weight of soil (density): ranging from 100 to 150 lb/ ft^3, depending on soil type and compaction effort (special cases, such as landfills can vary widely, as low as 40 lb/ft^3)

height of cover in feet above the pipe crown for the installation.

OUTPUTS

After feeding the spreadsheet** with the above inputs, the outputs are provided from horizontal springline (0°) to crown (90°) to horizontal springline (180°). The radial soil pressure (P_r), radial deflection (w) (doubled to provide total deflection), tangential deflection (v), circumferential wall thrust (N), and wall bending moment (M) are calculated using the Burns and Richard analysis (see Figure 1). From these outputs, ring compressive stress, inner wall bending stress, outer wall bending stress, total stress (inner wall and outer wall; see Figure 2), wall compressive strain, ring shortening, total vertical deflection, total horizontal deflection, and circumferential shortening are generated.

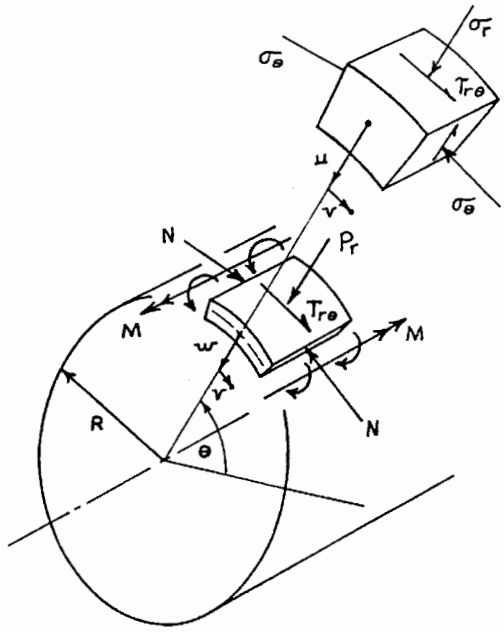


Figure 1: Free-body diagram of pipe profile.

The spreadsheet can be downloaded from the ADS website: www.ads-pipe.com

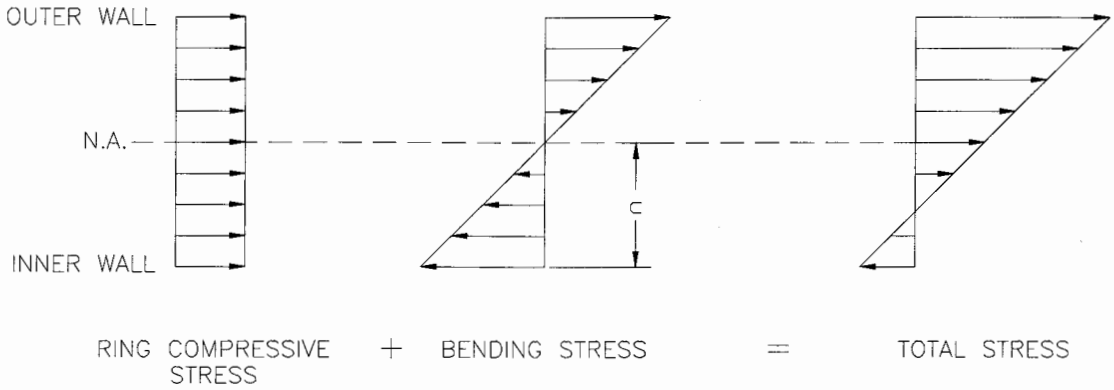


Figure 2: Stress distribution of pipe profile

A great deal can be learned from plots of pipe deflection versus pipe stiffness; moment versus pipe stiffness; thrust versus pipe stiffness; tension versus pipe stiffness; and compression versus pipe stiffness. As pipe stiffness increases so does the moment, thrust, tension and compression in the pipe wall. All other things remaining constant, as pipe stiffness increases deflection changes very little; it is the soil stiffness that defines deflection performance. Thus it can be said a pipe that is more compliant is a more structurally capable pipe.

For the design engineer, vertical deflection limits typically will determine the design limits, however, other parameters should also be checked. Circumferential shortening should be limited to less than 2%. Under total stress, inner and outer wall stress should be limited to less than 1,000 psi tensile stress and/or 3,000 psi compressive stress.

SUMMARY

This spreadsheet* provides a powerful tool for the design engineer. Installation limits based on deflection, buckling, and circumferential shortening can be selected by the designer, based on his or her experience with pipe installations. It will provide more accurate predictions of pipe performance than the traditional approaches, particularly the "Iowa Formula" for thermoplastic pipes.

The problems with the Iowa Formula:

$$\Delta Y = \frac{W}{\left(EI/R^3 + E'\right)}$$

are: 1. It is assumed that the total stiffness (resistance to deformation) of the soil-pipe interaction system can be estimated by adding the separate stiffnesses of the pipe and the soil. It is far more complicated.

2. The pipe stiffness is a composite of a material stiffness (E) and a geometric stiffness (I/R^3). The soil stiffness (E′) is only a material stiffness.

The spreadsheet can be downloaded from the ADS website: www.ads-pipe.com

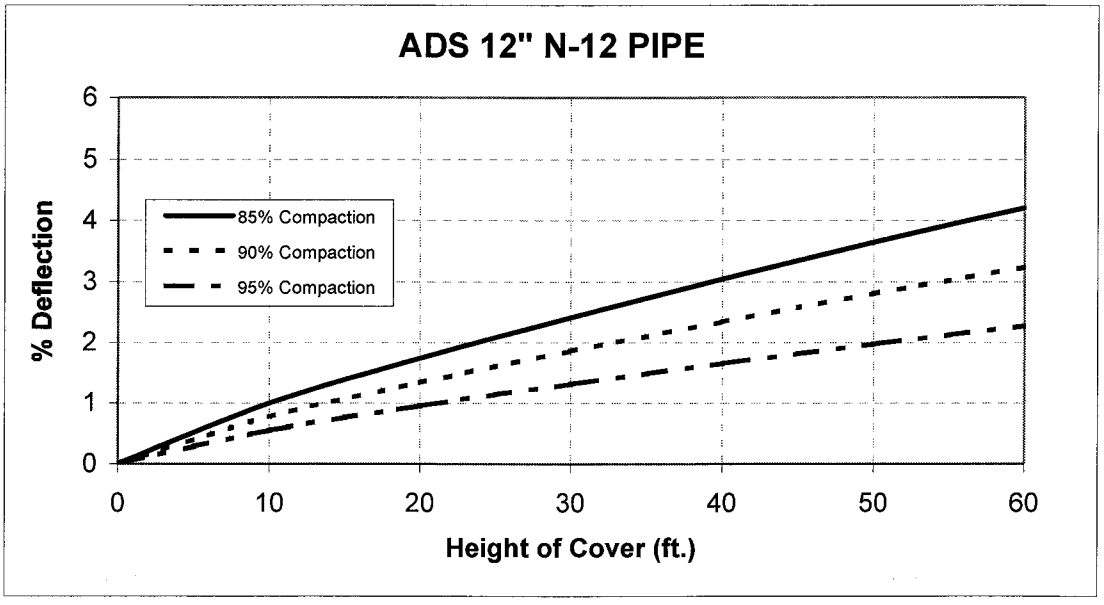
3. The soil stiffness (E′) is empirically arrived at by back calculation of existing installations. This data is from installations with limited cover; typical 25' or less. This makes extrapolations above and beyond the pipes studied vulnerable to error. A single E′ is typically used for a given backfill material and compaction level regardless of depth, which is clearly in error.
4. The load (W) is not truly known. For flexible pipes it is often taken as the Marston load; $W = c_d \gamma B_c B_d$ where c_d is a coefficient dependent upon the depth of burial in the trench, the type of backfill soil, and the nature and extent of a soil arch; typically read from prepared charts. B_c is the OD of the pipe and B_d is the trench width.
5. For viscoelastic materials, like HDPE, the modulus value (E) typically used is based on a test specimen in bending only. There is no consideration of the effect of hoop compression and circumferential shortening; which do effect soil arching and, therefore, soil pressure on the pipe.

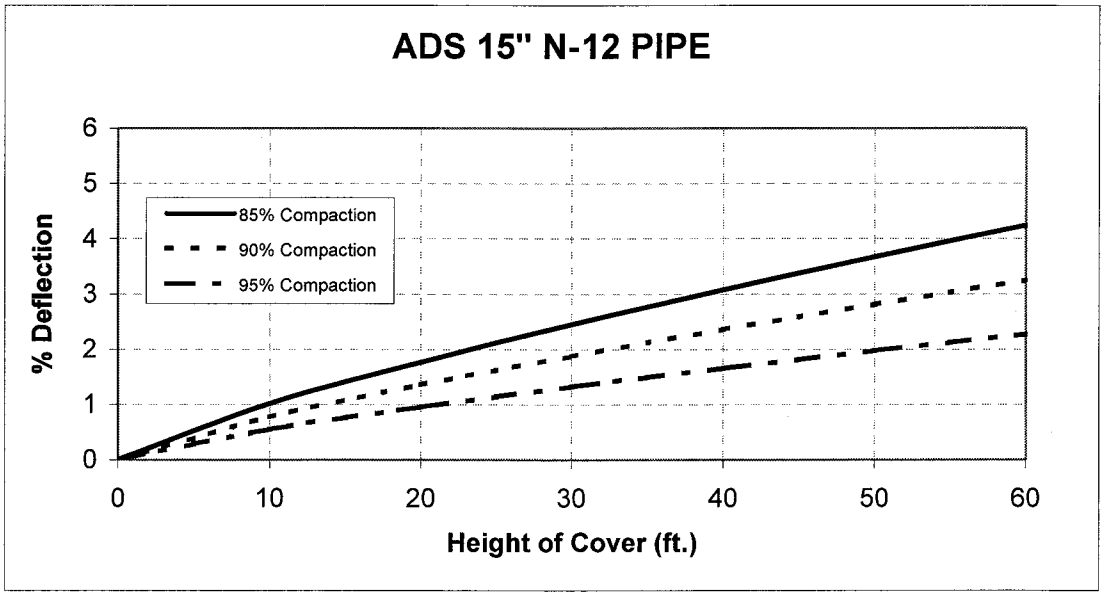
The Burns and Richard solution deals with these issues and provides a much more thorough analysis of the pipe response.

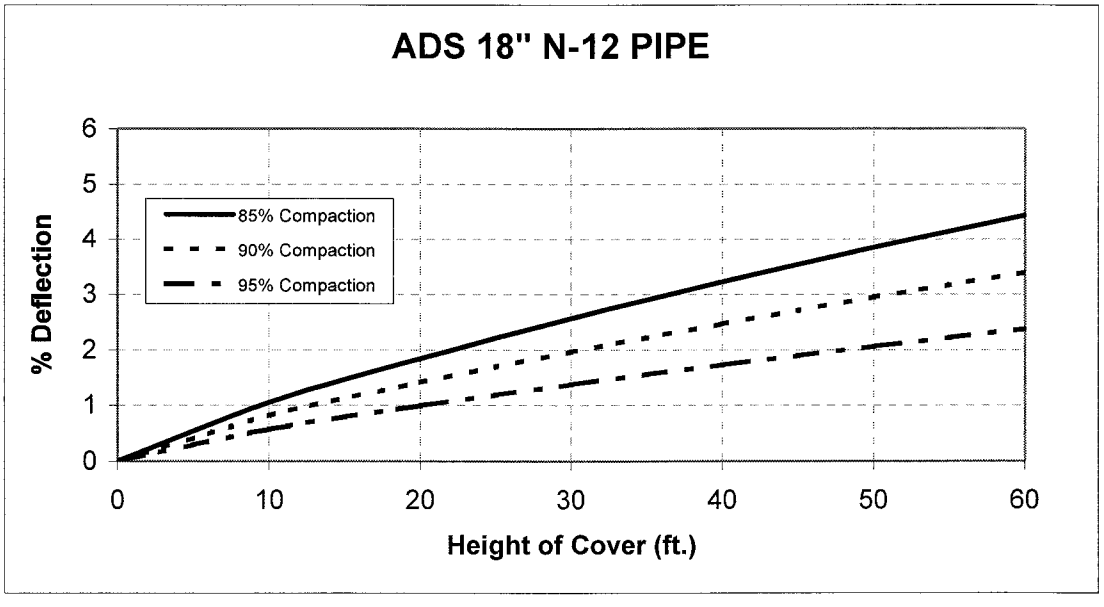
Table 1. Predefined MATNAM values and associated soil classes for the overburden dependent model

Young's Modulus (psi) for Overburden Pressures

Soil	MATNAM	5 psi	10 psi	15 psi	20 psi	25 psi	30 psi	40 psi	50 psi	Poisson's Ratio	Density (lb/ft^3)
Granular											
Good	G.GOOD	1,100	1,300	1,500	1,650	1,800	1,900	2,100	2,250	0.30-0.35	110-150
Fair	G.FAIR	550	750	850	1,000	1,100	1,150	1,300	1,400		
Mixed											
Good	M.GOOD	600	850	1,000	1,100	1,200	1,250	1,350	1,450	0.30-0.40	100-140
Fair	M.FAIR	400	550	600	700	750	800	900	900		
Cohesive											
Good	C.GOOD	250	325	375	375	400	400	400	400	0.35-0.40	100-130
Fair	C.FAIR	150	200	225	250	250	250	250	250		


ADS 12" N-12 PIPE
% Deflection
Height of Cover (ft.)
85% Compaction
90% Compaction
95% Compaction
0
1
2
3
4
5
6
0
10
20
30
40
50
60


ADS 15" N-12 PIPE
% Deflection
Height of Cover (ft.)
85% Compaction
90% Compaction
95% Compaction
0
1
2
3
4
5
6
0
10
20
30
40
50
60


ADS 18" N-12 PIPE
% Deflection
Height of Cover (ft.)
85% Compaction
90% Compaction
95% Compaction
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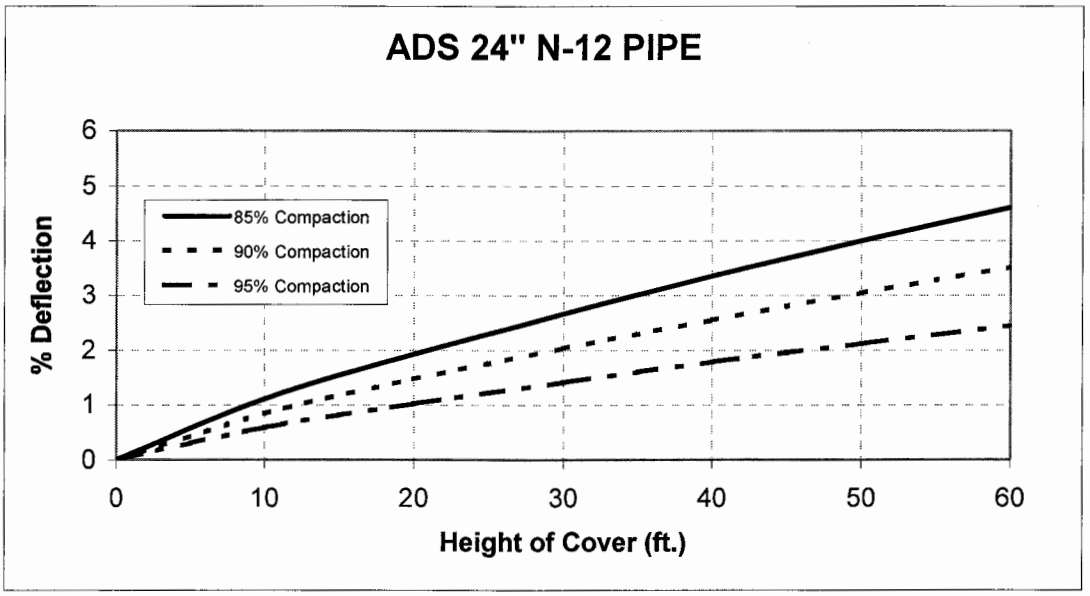
ADS 24" N-12 PIPE
% Deflection
Height of Cover (ft.)
85% Compaction
90% Compaction
95% Compaction
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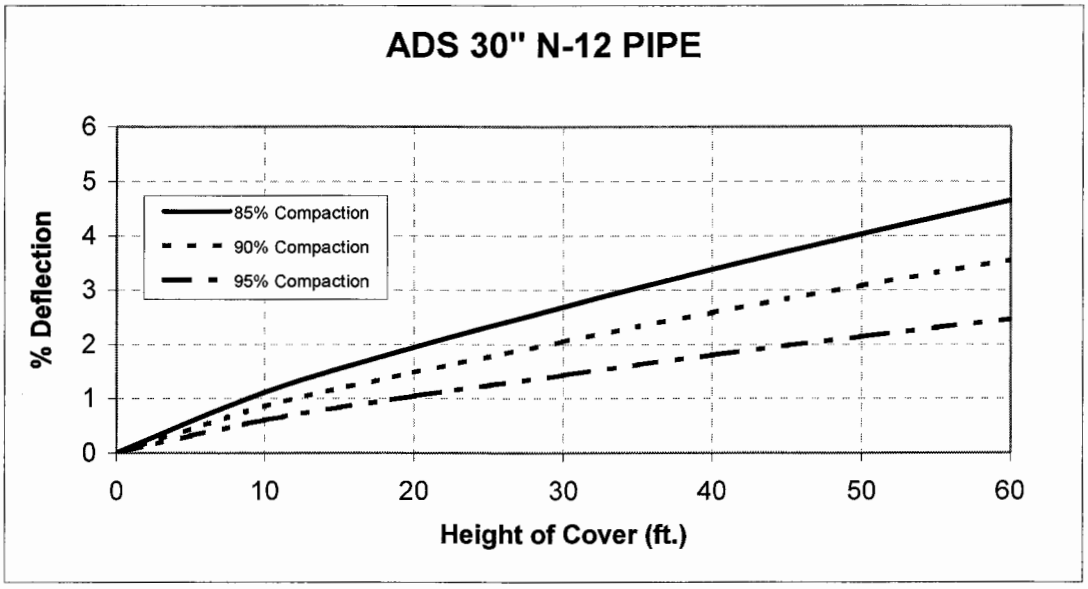
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% Deflection
Height of Cover (ft.)
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90% Compaction
95% Compaction
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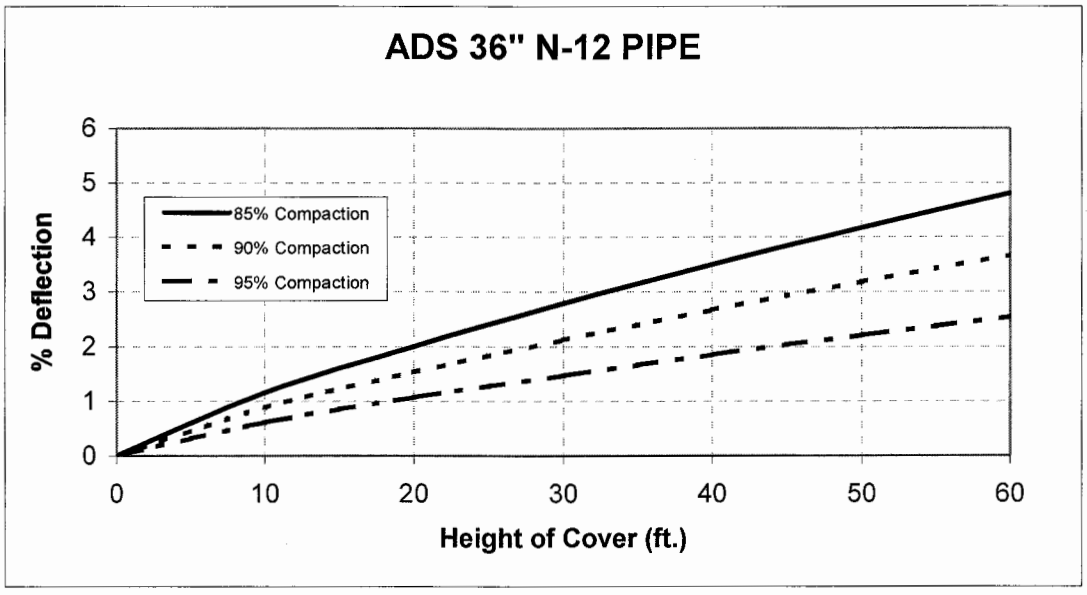
ADS 36" N-12 PIPE
% Deflection
Height of Cover (ft.)
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90% Compaction
95% Compaction
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30
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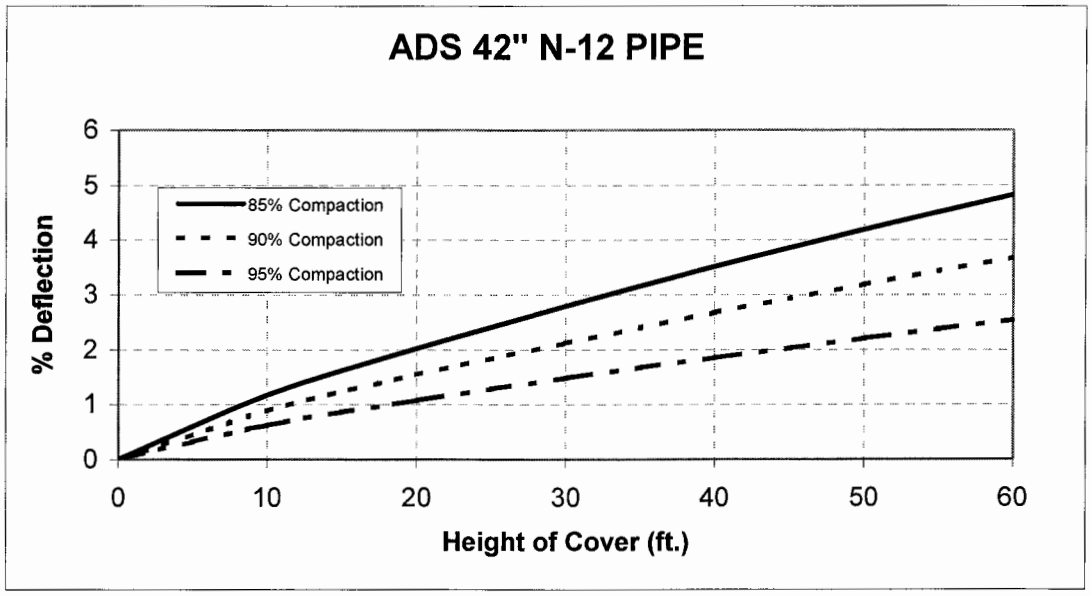
50
60


ADS 42" N-12 PIPE
% Deflection
Height of Cover (ft.)
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90% Compaction
95% Compaction
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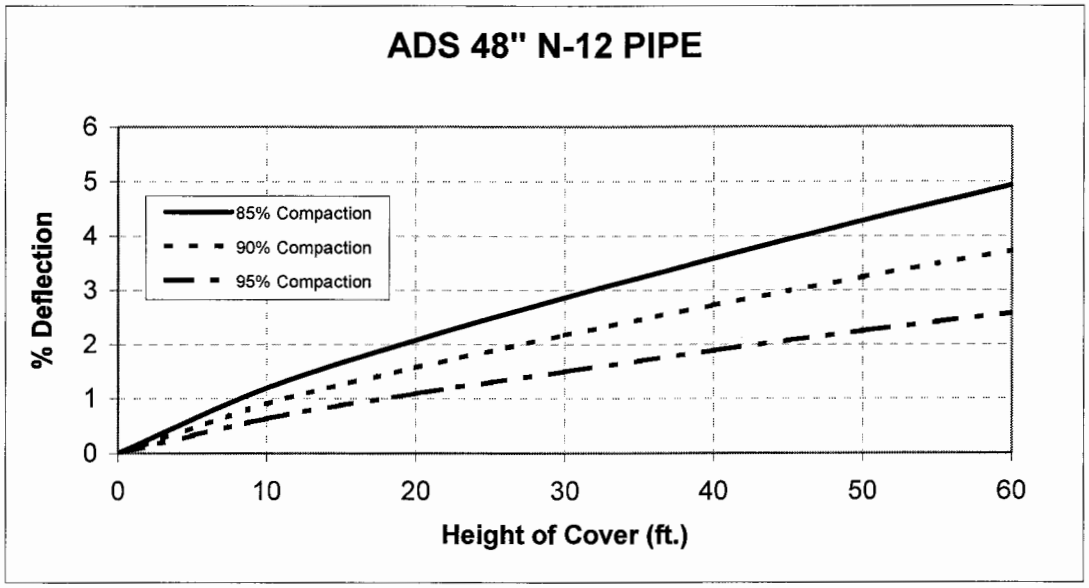
ADS 48" N-12 PIPE
% Deflection
Height of Cover (ft.)
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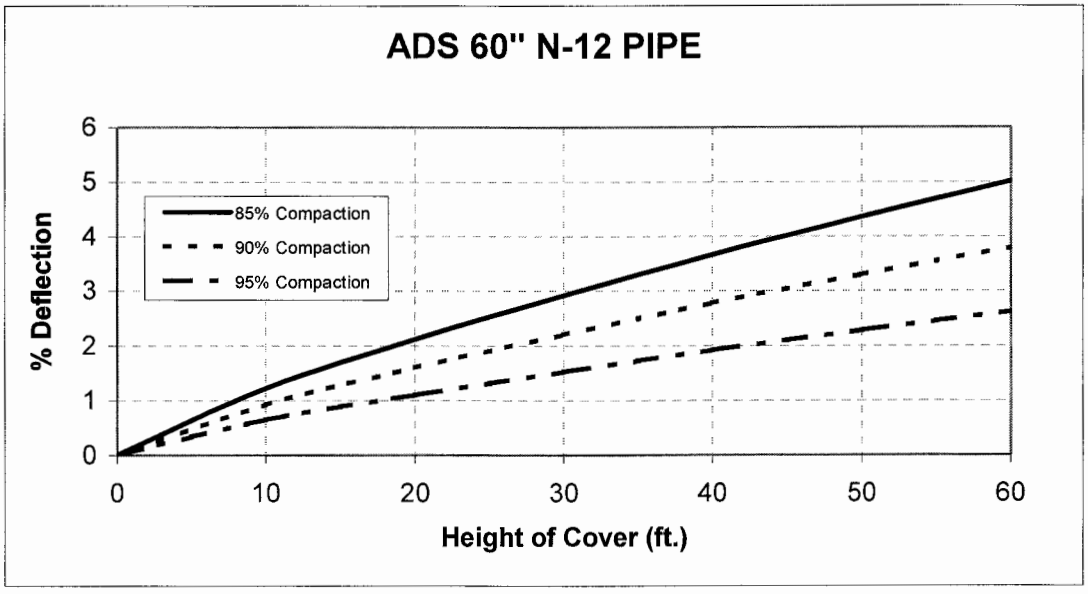
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% Deflection
Height of Cover (ft.)
85% Compaction
90% Compaction
95% Compaction
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Product Notes

Product Note 3.107

Re: Specification for Smooth Interior Corrugated Polyethylene Pipe

Date: January 2005

This specification applies to high density polyethylene corrugated pipe with an integrally formed smooth waterway. Nominal sizes for which this specification is acceptable are 100 – 1500 mm (4 - 60 inch) diameters. Sizes 100 – 1500 mm (4 - 60 inch) shall be either AASHTO Type 'S' or Type 'D' as follows. Sizes 100 – 1500 mm (4 - 60 inch) designated as AASHTO Type 'S' (N-12) shall have a full circular cross-section, with an outer corrugated pipe wall and an essentially smooth inner wall (waterway). Corrugations for Type 'S' sizes 100 – 1500 mm (4 - 60 inch) shall be annular (N-12). Sizes 1050 – 1500 mm (42 thru 60 inch) designated as AASHTO Type 'D' (N-12HC) shall consist of an essentially smooth waterway braced circumferentially with circular ribs which are formed simultaneously with an essentially smooth outer wall. The 1050 – 1500 mm (42 thru 60 inch) (N-12HC) sizes shall conform to AASHTO Type 'D' (which describes dual wall pipe with a smooth waterway).

Pipe manufactured for this specification shall comply with the requirements for test methods, dimensions and markings found in AASHTO Designations M252, and M294. Pipe and fittings shall be made from virgin PE compounds which conform with the applicable current edition of the AASHTO Material Specifications for cell classification as defined and described in ASTM D3350.

The minimum parallel plate stiffness values when tested in accordance with ASTM D2412 shall be as follows:

Diameter (nominal)	Pipe Stiffness (minimum)	Diameter (nominal)	Pipe Stiffness (minimum)
100 mm (4")	340 kN/m^2 (50 pii)	600 mm (24")	235 kN/m^2 (34 pii)
150 mm (6")	340 kN/m^2 (50 pii)	750 mm (30")	195 kN/m^2 (28 pii)
200 mm (8")	340 kN/m^2 (50 pii)	900 mm (36")	150 kN/m^2 (22 pii)
250 mm (10")	340 kN/m^2 (50 pii)	1050 mm (42")	140 kN/m^2 (20 pii)
300 mm (12")	345 kN/m^2 (50 pii)	1200 mm (48")	125 kN/m^2 (18 pii)
375 mm (15")	290 kN/m^2 (42 pii)	1500 mm (60")	95 kN/m^2 (14 pii)
450 mm (18")	275 kN/m^2 (40 pii)		

The fittings shall not reduce or impair the overall integrity or function of the pipeline. Fittings may be either molded or fabricated. Common corrugated fittings include in-line joint fittings, such as couplers and reducers, and branch or complimentary assembly fittings such as tees, wyes and end caps. These fittings may be installed by various methods such as snap-on, bell and spigot, bell – bell and wrap around couplers. Couplers shall provide sufficient longitudinal strength to preserve pipe alignment and prevent separation at the joints. Only fittings supplied or recommended by the manufacturer shall be used. Where designated on the plans or project specifications, an elastomeric gasket meeting the requirements of ASTM F477 shall be supplied.

Installation of the pipe specified above shall be in accordance with either AASHTO Section 30 or ASTM Recommended Practice D2321 as described elsewhere in these specifications and as recommended by the manufacturer.

ADS N-12 PRODUCT INFORMATION SHEET

Nominal Diameter	Inside Diameter, Average	Outside Diameter, Average	Inner Liner Thickness, Minimum	Minimum Pipe Stiffness @ 5% Deflection	Weight kg./6m (lbs./20 ft.)	Area mm^2/mm	"I" cm^4/cm	"C" mm
100 mm (4")	104 mm (4.10")	120 mm (4.78")	0.5 mm (0.020")	340 kN/m^2 50 psi	4.08 kg (9.00 lbs)	1.59 (0.063 in^2/in)	0.010 (0.0006 in^4/in)	3.06 (0.12 in)
150 mm (6")	152 mm (6.00")	176 mm (6.92")	0.5 mm (0.020")	340 kN/m^2 50 psi	7.71 kg (17.00 lbs)	2.15 (0.085 in^2/in)	0.035 (0.0021 in^4/in)	4.94 (0.19 in)
200 mm (8")	200 mm (7.90")	233 mm (9.11")	0.6 mm (0.024")	340 kN/m^2 50 psi	13.97 kg (30.80 lbs)	2.75 (0.108 in^2/in)	0.078 (0.005 in^4/in)	6.36 (0.25 in)
250 mm (10")	251 mm (9.90")	287 mm (11.36")	0.6 mm (0.024")	340 kN/m^2 50 psi	20.96 kg (46.20 lbs)	3.48 (0.137 in^2/in)	0.134 (0.008 in^4/in)	7.58 (0.30 in)
300 mm (12")	308 mm (12.15")	367 mm (14.45")	0.9 mm (0.035")	345 kN/m^2 50 psi	29.60 kg (65.20 lbs)	5.50 (0.217 in^2/in)	0.574 (0.035 in^4/in)	10.92 (0.43 in)
375 mm (15")	380 mm (14.98")	448 mm (17.57")	1.0 mm (0.039")	290 kN/m^2 42 psi	42.00 kg (92.50 lbs)	6.91 (0.272 in^2/in)	0.901 (0.055 in^4/in)	13.21 (0.52 in)
450 mm (18")	459 mm (18.07")	536 mm (21.20")	1.3 mm (0.051")	275 kN/m^2 40 psi	58.38 kg (128.60 lbs)	6.93 (0.273 in^2/in)	1.327 (0.081 in^4/in)	14.48 (0.57 in)
600 mm (24")	612 mm (24.08")	719 mm (27.80")	1.5 mm (0.059")	235 kN/m^2 34 psi	99.93 kg (220.30 lbs)	8.23 (0.324 in^2/in)	2.245 (0.137 in^4/in)	18.80 (0.74 in)
750 mm (30")	762 mm (30.00")	892 mm (35.10")	1.5 mm (0.059")	195 kN/m^2 28 psi	140.00 kg (308.6 lbs)	9.60 (0.378 in^2/in)	4.539 (0.277 in^4/in)	21.84 (0.86 in)
900 mm (36")	914 mm (36.00")	1059 mm (41.70")	1.7 mm (0.067")	150 kN/m^2 22 psi	180.00 kg (396.8 lbs)	10.19 (0.401 in^2/in)	6.555 (0.400 in^4/in)	25.40 (1.00 in)
1050 mm (42") Type S	1054 mm (41.40")	1212 mm (47.70")	1.8 mm (0.070")	140 kN/m^2 20 psi	230.00 kg (570.10 lbs)	11.64 (0.458 in^2/in)	9.373 (0.572 in^4/in)	30.73 (1.21 in)
1050 mm (42") Type D	1054 mm (41.50")	1187 mm (46.75")	1.8 mm (0.070")	140 kN/m^2 20 psi	269.76 kg (594.70 lbs)	14.86 (0.585 in^2/in)	9.685 (0.591 in^4/in)	35.31 (1.39 in)
1200 mm (48") Type S	1209 mm (47.60")	1361 mm (53.60")	1.8 mm (0.070")	125 kN/m^2 18 psi	283.50 kg (625.00 lbs)	12.58 (0.495 in^2/in)	9.341 (0.570 in^4/in)	29.72 (1.17 in)
1200 mm (48") Type D	1208 mm (47.55")	1339 mm (52.70")	1.8 mm (0.070")	125 kN/m^2 18 psi	309.72 kg (682.80 lbs)	14.76 (0.581 in^2/in)	10.090 (0.616 in^4/in)	33.02 (1.30 in)
1500 mm (60") Type S	1512 mm (59.5")	1684 mm (66.3")	1.8 mm (0.070")	95 kN/m^2 14 psi	410.00 kg (903.90 lbs)	14.68 (0.578 in^2/in)	14.09 (0.860 in^4/in)	33.66 (1.32 in)
1500 mm (60") Type D	1514 mm (59.6")	1664 mm (65.5")	1.8 mm (0.070")	95 kN/m^2 14 psi	509.53 kg (1123.30 lbs)	17.15 (0.675 in^2/in)	13.305 (0.812 in^4/in)	36.32 (1.43 in)

Date: January 20, 2005

Product Notes

Product Note 3.115

Re: Installing N-12 Storm, Sanitary Sewer and Culvert Pipe

Date: Revised November 5, 2003

1. Introduction
2. Warranty
3. Pre-construction
   - 3.1 Precautions
   - 3.2 Ordering
   - 3.3 Receiving and Unloading
   - 3.4 Stockpiling
4. Installation
   - 4.1 Line and Grade
   - 4.2 Trench Widths
   - 4.3 Dewatering
   - 4.4 Joints
     - 4.4.1 Soil Tight
     - 4.4.2 Silt Tight
     - 4.4.3 Water Tight
   - 4.5 Joint Assembly
5. Embedment Material
   - 5.1 Foundation
   - 5.2 Bedding
   - 5.3 Haunching
   - 5.4 Initial Backfill
   - 5.5 Final Backfill
6. Vehicular and Construction Loads
7. Manhole Connections
8. Tap Connections
9. Fittings
10. Field Connections
    - 10.1 Soil Tight Systems
    - 10.2 Water Tight Systems
11. Curvilinear Installations
12. Post-Construction
    - 12.1 Visual Inspection
    - 12.2 Infiltration/ Exfiltration
    - 12.3 Air Testing
13. Specifications
14. Appendix

1. INTRODUCTION

This handbook is intended to provide guidance for the proper installation of Advanced Drainage Systems (ADS) high density polyethylene (HDPE) pipe used in storm drain applications. This handbook is not intended to replace standard industry or project specifications, but to provide guidance based on our experience, research and recommendations for proper product performance.

It is recognized that installation practices vary from region to region, however, the following recommended guidelines are generally applicable to most installations.

2. WARRANTY

Advanced Drainage Systems, Inc. warranties its products as described in the Terms and Conditions of Sale that are provided on the back of each invoice and bill of lading.

3. PRE-CONSTRUCTION

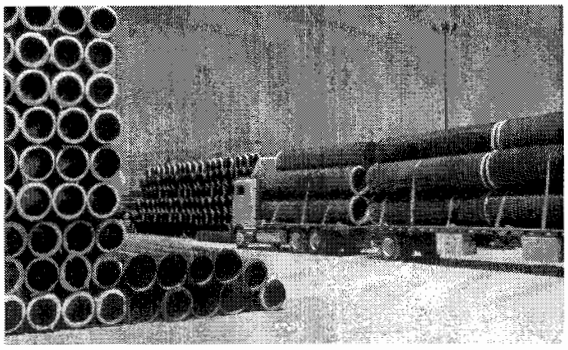
3.1. Precautions

Federal regulations covering safety for construction are published in the Safety and Health Regulations for Construction under the Department of Labor, Occupational Safety and Health Administration (OSHA). These regulations define practices which must be followed.

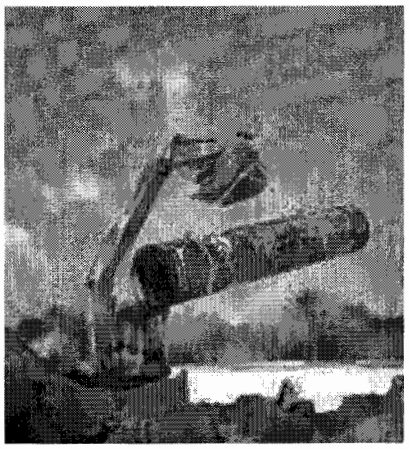
3.2. Ordering

Pipe should be ordered from an ADS sales representative or authorized distributor. ADS representatives can assist in placing an order by reviewing project plans and specifications to insure proper quantities and components are ordered. Any certification which may be required should be noted at the time of order so the ADS representative can arrange for proper certifications to be supplied with pipe deliveries.

3.3. Receiving and Unloading



ADS pipe is shipped to the job site on dropside or flat bed trailers. Upon arrival at the jobsite, the pipe should be inspected for quantity and shipping damage. Any discrepancies or damage should be noted on the delivery receipt and the supplier notified. Most deliveries arrive on self



unloading ADS dropside trailers. However, for 1500 mm (60" pipe) and some flatbed deliveries, the contractor may be required to unload the pipe.

The pipe is designed to withstand normal field handling and can be easily unloaded by hand or with equipment. To avoid damage, the pipe should not be dropped. Additionally, tie down straps or bands should not be removed until the pipe has been secured, to prevent rolling or dropping the pipe.

Handling should be accomplished by hand, lifting tongs or nylon slings. When using slings, two pick points are recommended.

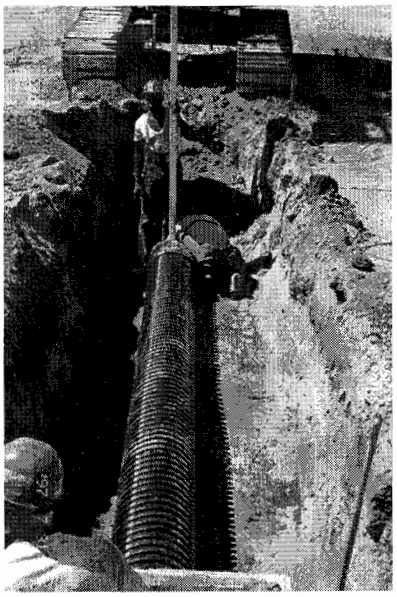
3.4. Stockpiling

Stockpile pipe as close as possible to its final location but away from construction traffic and activities. Pipe should be stockpiled on level ground. If stacked, blocking should be provided to prevent rolling. Stacked pipe should be placed with bells alternated on successive layers and the bells should overhang the layer below to prevent deforming and damaging the bell.

The protective wrap on the gaskets of the spigot end should be left on the pipe until it is ready for installation. Lube, couplers and fittings should be stored with the pipe. Couplers and fittings should be stored flat to prevent damage and misshape.

4. INSTALLATION

4.1. Line and Grade



Storm drain pipe systems are designed to provide hydraulic capacity based on pipe size and slope. The alignment or line of the pipe is the horizontal location of the pipe, while the grade is the vertical slope of the pipe. In order for a storm drain system to function as designed, it is important to install the pipe to the proper line and grade.

Generally, no special practices are required to maintain line and grade; however, certain installation techniques can greatly increase the system performance and rate of installation.

Alignment is established by a field survey. Once the trench is excavated on line, the pipe bedding should be placed to proper thickness. The top of the bedding should be adjusted to allow for the difference between the plan invert (flowline) and pipe profile wall thickness. The following table gives the dimension to be subtracted from the pipe inverts indicated on the plans when checking bedding elevations.

Table 1 – Invert Adjustment for Wall Thickness

Pipe Diameter in. (mm)	Wall Thickness		
	Inches	feet	mm
12" (300 mm)	1.15"	0.10'	29 mm
15" (375 mm)	1.30"	0.11"	33 mm
18" (450 mm)	1.57"	0.13'	40 mm
24" (525 mm)	1.86"	0.16'	47 mm
30" (600 mm)	2.55"	0.21'	65 mm
36" (750 mm)	2.85"	0.24'	72 mm
42" (1050 mm)	3.15"	0.26'	80 mm
48" (1200 mm)	3.00"	0.25'	79 mm
60" (1500 mm)	3.40"	0.28'	86 mm

4.2. Trench Widths

References for trenching practice are in AASHTO Section 30 and ASTM D2321. Both of these specifications provide guidelines for trench widths applicable to a variety of installation conditions. Trench widths may be varied based on the competency of the in-situ soil, backfill materials, compaction levels and loads. In general, the following table provides recommended trench widths for most installations, to permit proper placement and compaction of backfill material in the haunches and around the pipe. However, the design engineer may modify the trench widths based on an evaluation of the competency of the in-situ materials, the quality and compaction level of the backfill, the design loads and the compaction equipment to be used. In lieu of the engineer's recommendations or governing agency specifications, the following trench widths are suggested.

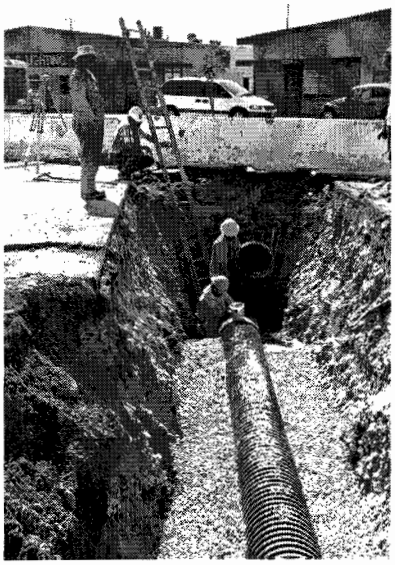


Table 2 – Suggested Minimum Trench Widths

Nominal Pipe Diameter, inches (mm)	Pipe OD, inches (mm)	Minimum Trench Width, inches (mm)
4" (100 mm)	4.78" (120 mm)	21" (530 mm)
6" (150 mm)	6.92" (176 mm)	23" (580 mm)
8" (200 mm)	9.11" (233 mm)	25" (630 mm)
10" (250 mm)	11.36" (287 mm)	28" (710 mm)
12" (300 mm)	14.45" (367 mm)	31" (790 mm)
15" (375 mm)	17.57" (448 mm)	34" (860 mm)
18" (450 mm)	21.2" (536 mm)	39" (990 mm)
24" (600 mm)	27.8" (719 mm)	48" (1220 mm)
30" (750 mm)	35.1" (892 mm)	66" (1680 mm)
36" (900 mm)	41.7" (1059 mm)	78" (1980 mm)
42" (1050 mm)	47.7" (1212 mm)	83" (2110 mm)
48" (1200 mm)	53.6" (1361 mm)	89" (2260 mm)
60" (1500 mm)	66.3" (1684 mm)	102" (2590 mm)

Trenching should be completed in existing soils with sidewalls reasonably vertical to the top of the pipe. For positive projection embankment installations, the embankment material should be placed and compacted to a minimum of one (1') foot above the pipe and the trench excavated into the embankment. When excavation depths or soil conditions require shoring or use of a trench box, the bottom of the shoring or trench box should be placed no lower than the top of the pipe. This prevents disruption of the backfill envelope when removing the shoring or trench box. If this practice cannot be followed, consideration should be given to leaving the shoring in place.

4.3. Dewatering

Excessive groundwater hinders proper placement and compaction of bedding and backfill. ADS N-12 pipe will float in standing water, therefore, it is imperative that a dry trench be provided. It may be necessary to provide sump pumps, well points, deep wells, geofabrics, underdrains or a diversion ditch to insure a dry trench. A qualified engineer should be consulted to determine dewatering methods.

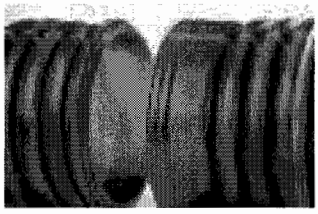
4.4. Joints

ADS offers a variety of joint options to satisfy specific project requirements. Three performance levels are commonly required for storm drain applications.

4.4.1. Soil Tight Joints

Soil tight joints are specified as a function of opening size, coupler length and backfill particle size. Split couplers may be used for pipe sizes up to 60" to provide a soil tight connection. The sides of the split couplers are "hinged" so they easily open to accept each end of the adjacent pipe sections. There are matching holes at the ends of the split coupler which allow securing the coupler with nylon ties.

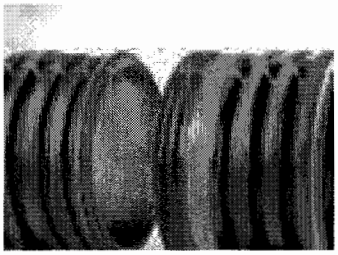
4.4.2. Silt Tight Joints



Silt tight joints are specified where there is a high percentage of fines and groundwater potential. These joints are designed to guard against infiltration of soil at the joint. A bell and spigot design with an elastomeric rubber gasket meeting ASTM F-477 is generally specified for silt tight applications. The ADS N-12 ST IB pipe joint is designed to meet the silt tight requirements.

4.4.3. Water Tight Joints

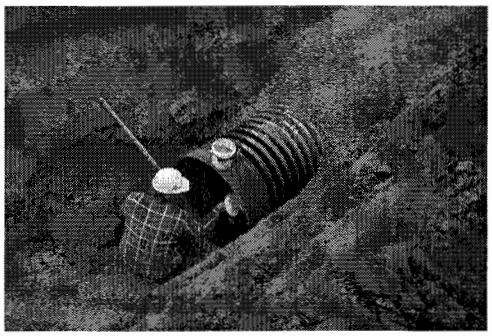
Watertight joints are specified to meet a laboratory pressure test of 10.8 psi per ASTM D-3212. These joints are designed to prevent infiltration of soil and exfiltration of storm water. The joints have a bell and spigot or bell–bell design and incorporate an ASTM F-477 elastomeric rubber gasket. ADS Pro-Link WT and ADS N-12 WT IB pipe joints satisfy the requirements of watertight installations.



4.5. Joint Assembly

Split couplers are easily installed by laying the adjoining sections of pipe in the open split coupler and wrapping the coupler around the pipe. Nylon ties may then be fed through the holes in the end of the coupler to secure the coupler to the pipe. The pipe and the inside of the coupler should be clean and free of dirt prior to securing the coupler.

Bell and spigot or bell – bell couplers incorporating an elastomeric rubber gasket are either an in-line bell (N-12 ST or WT IB), a welded bell (Pro-Link ST or WT) or a bell-bell (Pro-Link WT). These couplers are easily installed by the following procedure which will insure the specified performance:



1. Thoroughly clean the bell and spigot ends, making sure they are free of mud and grit. Remove the protective shrink-wrap from the gasket. If the gasket has been removed, make sure the gasket seat is clean and reinstall the gasket by stretching it over the pipe and nesting it in the seat. Gaskets should be installed with the marking facing the coupler.
2. Remove shipping collars (where provided) prior to lowering the pipe in the trench. Properly dispose of shipping collars outside the pipe trench. Do not install pipe with shipping collars on the pipe and do not dispose of shipping collars in the trench.
3. Lubricant is supplied for gasketed joint installation in the form of tubs. The lubricant should be liberally applied to both the bell and spigot ends of the pipe. Care should be taken to insure lubricant is applied to the chamfered leading edge of the bell.
4. Align the pipe and push the spigot home on grade. Joints should be installed with bells facing upstream for proper installation. Generally, pipes should be laid starting at the downstream end and working upstream. Small diameter pipe (below 24") can usually be installed by pushing the joint home by hand. Larger diameters may necessitate using a bar or equipment to push home. If a bar or equipment is utilized, a wood block should be used to prevent damage to the bell. When pushing the joint home, make sure bedding material is not pulled into the bell by the spigot. Material such as small stones and sand pulled into the bell as the pipe is joined can cause leaks.

5. EMBEDMENT MATERIALS

Embedment materials are those used for bedding, haunching and initial backfill as illustrated in Figure 1. AASHTO Section 30 and ASTM D-2321 classify soils using AASHTO and Unified soil classification, respectively. The following will describe soils using the ASTM D-2321 nomenclature with AASHTO designations noted.

Class I – Angular crushed stone or rock, dense or open graded with little or no fines (¼ inch to 1½ inches in size)

Class II – (GW, GP, SW, SP, GW-GC, SP-SM) Clean, coarse grained materials, such as gravel, coarse sands and gravel/sand mixtures (1 ½ inches in size). (AASHTO classifications A1 & A3).

Class III – (GM, GC, SM, SC) Coarse grained materials with fines including silty or clayey gravels or sands. Gravel or sand must comprise more than 50 percent of Class III materials (1½ inches maximum size). (AASHTO classifications A-2-4 & A-2-5).

Class IV – (ML, CL, MH, CH) Fine grained materials, such as fine sand and soils containing 50 percent or more clay or silt. Soils classified as Class IVa (ML or CL) have medium to low plasticity and are not recommended in the embedment zone. Soils classified as Class IVb (MH or CH) have high plasticity and are not recommended for embedment materials.

Class V – (OL, OH, PT) These materials include organic silts and clays, peat and other organic materials. They are not recommended for embedment materials.

Note: All embedment materials should be free from lumps of frozen soil or ice when placed. Additionally, embedment materials should be placed and compacted at optimum moisture content.

AASHTO SECTION 30 *

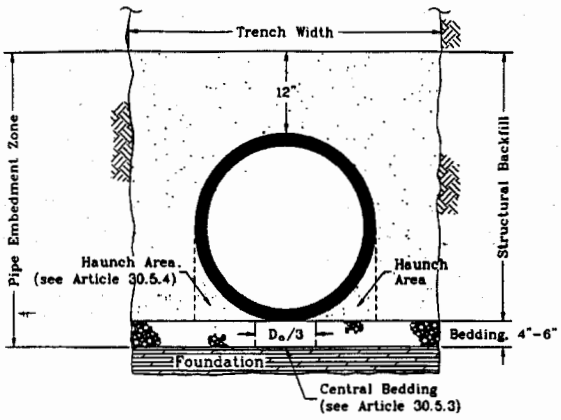


FIGURE 30.5.1

ASTM D-2321 *

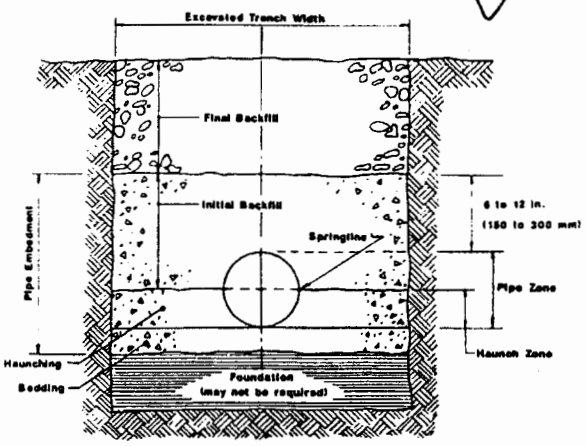


FIG. 1 Trench Cross Section Showing Terminology

These specifications are presented as a guide and are not a substitute for local agency/designer standards. Both specifications are illustrated to show similarities and ADS's recommendations are presented in the text. Embedment materials should be specified with consideration given to design loads and the classification and suitability of native soils. For normal installations without live loads or deep cover heights, many native soils will be applicable. Also, using native soils minimizes the potential for migration of fines into the embedment material. Where native soils are not appropriate for embedment materials or the loading conditions, an imported material should be considered.

5.1. Foundation

A stable foundation must be provided to insure proper line and grade is maintained. Unsuitable foundations must be stabilized at the engineer's direction. Unsuitable or unstable foundations may be undercut and replaced with a suitable bedding material, placed in 6" lifts. Other methods of stabilization, such as geotextiles may be appropriate based on the engineer's judgement.

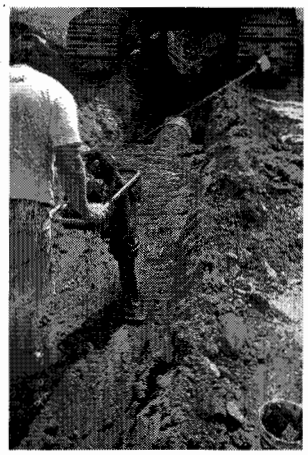
5.2. Bedding

A stable and uniform bedding shall be provided for the pipe and any protruding features of its joints and/or fittings. The middle of the bedding equal to 1/3 of the pipe OD should be loosely placed, with the remainder compacted to a minimum of 90 percent standard proctor density. Class I, II and III materials are suitable for use as bedding.

5.3. Haunching

Proper haunching provides a major portion of the pipe's strength and stability. Care must be exercised to insure placement and compaction of the embedment material in the haunches. For larger diameter pipes (> 30"), embedment materials should be worked under the haunches by hand. Haunching materials may be Class I, II or III and must be placed and compacted in 8 inch maximum lifts, compacted to 90 percent standard proctor density.

5.4. Initial Backfill



Initial backfill materials are required to a minimum of ¾ of the pipe diameter for proper structural performance of the pipe. The AASHTO and ASTM specifications extend the initial backfill from the springline to 6 inches to 12 inches above the pipe to provide protection for the pipe from construction operations during placement of the final backfill, and to protect the pipe from stones or cobbles in the final backfill. For proper structural performance of the pipe, the initial backfill need only extend to ¾ of the pipe diameter. Class I, II, III or low plasticity Class IV materials may be used as initial backfill. However:

Class I materials must be used in wet trenches if Class I bedding and haunching materials are used.

Class II materials must be compacted in 6 inch lifts to 90 percent standard proctor density.

Class III materials must be compacted in 6 inch lifts to 90 percent standard proctor density. See note.

Class IVa low plasticity materials (CL-ML) are not recommended since they must be compacted in thin lifts while at or near optimum moisture content to provide proper pipe support. These materials may only be used under the direction of the Engineer.

Class IVb high plasticity clays and silts and all Class V materials are not recommended for initial backfill.

Note: Flooding or jetting as a procedure for compaction should only be used with the Engineer's approval and never with initial backfill material such as aggregate base or Class IV materials.

Controlled Low Strength Materials (CLSM) or flowable fills are acceptable backfill materials. Several considerations should be accounted for when using CLSM backfill. Provisions to prevent floatation of the pipe during placement of the CLSM must be used. This can include anchoring the pipe by placing flowable fill at each joint and allowing the fill to partially cure prior to placing the flowable fill along the entire length of the pipe. Also, mechanical anchors such as bent rebar driven into competent soil or precast weights, may be used at each joint to prevent floatation. When using CLSM, the fill should always be placed to completely encase the pipe.

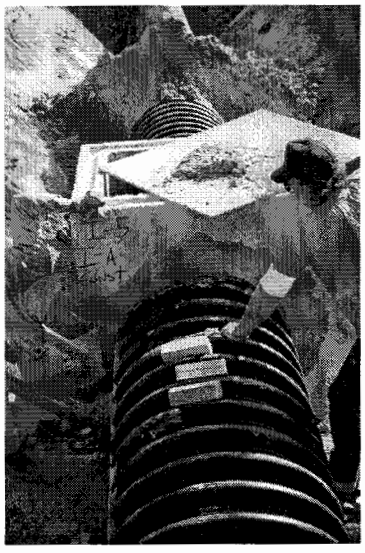
5.5. Final Backfill

The final backfill should be the same material as the proposed embankment. Generally, the excavated material may be used as final backfill. Placement should be as specified for the embankment. In lieu of a specification, the final backfill should be placed in 12 inch maximum lifts and compacted to a minimum 85 percent standard proctor density to prevent excessive settlement at the surface. Compaction should be performed at optimum moisture content.

6. VEHICULAR AND CONSTRUCTION LOADS

ADS N-12 pipes are designed to carry H-25 live loads (40,000 lbs. Axle – legal load) with 12 inches of cover. This assumes a well compacted embedment and includes the subbase material for installations under pavement. For 60" N-12 the minimum cover for H-25 loads is 2'-0".

During construction, avoid heavy equipment loads (> 40,000 lbs. per axle) over the pipe. An additional 12 inches of temporary cover should be placed over the pipe for heavy construction load crossings. Hydrohammers or hoe-pak compactors may not be used over the pipe until at least 48 inches of cover have been provided.



7. MANHOLE CONNECTIONS

Consideration should be given to the project performance specified when selecting manhole connections. When connecting to concrete manholes or inlets, grouting the pipe to the manhole or inlet using non-shrink grout provides a soil tight installation. A gasket placed in a pipe corrugation at the approximate center of the manhole or inlet wall will act as a water barrier. This water barrier should provide a silt tight installation. An ADS WaterStop™ Gasket can be used in a similar way to achieve a water tight installation. Other water tight installations may require flexible rubber connections such as rubber boots, "A-Loks", etc. ADS N-12/SDR- 35 adapters or the smooth exterior ADS manhole adapter pipe should be used with flexible rubber connections. Insert the ADS N-12/SDR-35 or ADS manhole adapter into the flexible connector using a lubricant as recommended by the manufacturer of the flexible connector. The flexible connector should be sized to the OD of SDR-35 PVC pipe. When connecting to manholes, insure backfill is placed under the pipe adjacent to the manhole to prevent differential settlement.

8. TAP CONNECTIONS

Tap connections may be accomplished using fabricated reducing fittings, saddle tees or "Insert-A-Tees". Fabricated reducing fittings are installed using normal installation procedures for the joints specified. Saddle tees are split couplers with an N-12 stub welded onto the center of the coupler. A half circle approximately 1" larger than the nominal stub diameter should be cut into each pipe end of the main line. The pipes should be aligned with the saddle tee wrapped around the pipe and secured with nylon ties. "Insert-A-Tee" connections may be made at locations along the length of the pipe. Installation of an "Insert-A-Tee" should follow the manufacturer's recommendations. In general, the installation involves marking the location of the tap. A hole is cored using a core drill sized for the "Insert-A-Tee". Then, a neoprene boot and PVC stub are inserted in the hole and a gasketed ADS N-12 pipe is inserted.

9. FITTINGS

ADS offers a full complement of fittings. ADS standard fittings include tees, bends, wyes, reducers and end caps. Additionally, a full line of manifold fittings and components are available for underground storm

water management systems. All fittings are available with joints which are compatible with the pipe used on the project, to provide a complete system. For a complete list of ADS standard fittings, contact your ADS representative for a fittings manual.

Special fittings not included in ADS's fittings manual may be made by special order and an ADS representative should be contacted for details.

10. FIELD CONNECTIONS

Field connections may be necessary to complete pipe runs for short pipe lengths or for repairs to pipe damaged during construction. Field connections and repairs should be performed with couplers compatible to the overall system. The following methods are applicable to both field connections and repairs. See Product Note 3.105 for more details on field cuts and connections.

10.1 Soil Tight Systems

If the damage is a hole or crack in the corrugation wall only and is less than one-quarter of the pipe diameter in area, and the pipe is not under pavement, clean the pipe, center a split coupler over the damaged area and secure snugly with nylon ties.

If the damage exceeds the above criteria or if the pipe is under pavement, cut out the damaged pipe, cut a replacement piece to fit, lay a split coupler under each exposed end, place the new pipe section in the trench and secure the coupling with nylon ties.

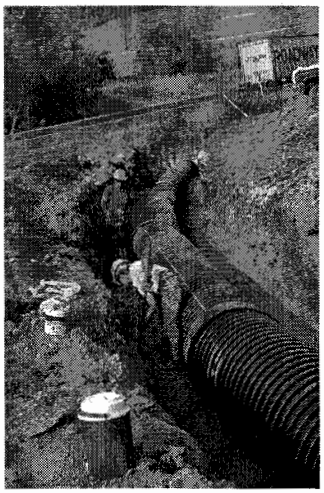
10.2 Water Tight Systems

For watertight systems, any damaged pipe should be removed and repaired using an ADS field repair coupler. The vent tubes should be sealed appropriately. The pipe should be cut beyond the damaged area and removed. A new section of pipe, cut to fit should be inserted with a field repair coupler placed beneath each cut end of the pipe. The ends of the pipe should be clean and free of debris. The protective film over the field coupler may then be peeled back while adhering the coupler to the pipe. Once the coupler is in place, the tie-down bands may be ratcheted tight to provide a watertight seal. The protective film on the overlap seal can then be removed to complete the installation.

NOTE: The above are guidelines. The final repair decision should be reviewed and determined by the project engineer.

11. CURVILINEAR INSTALLATIONS

ADS N-12 pipe can be laid on a curved alignment as a series of tangent (straight sections) deflected horizontally at each joint. However, the amount of deflection is dependent on the type of joint selected. Typically, ADS N-12 ST and WT IB (in-line bell) pipe joints can only accommodate small deflection angles (< 1°) and maintain the silt-tight or water tight joint performance for which they are designed. Split couplers will also permit small deflection angles (approximately 1° to 3°). The ADS Pro-Link WT and ST joints (welded bells or bell-bell couplers) can accommodate deflection angles (approximately 3°), however; water-tightness may be affected at larger deflection angles. The following table may be used as a guide in determining the radius of ADS pipe with a given joint type. The designer should contact an ADS representative before using any ADS pipe for curvilinear installations to insure proper joint selection and performance.



*Limited availability.

Diameter	Joint Type	Max. D @ joint	Radius (ft) per pipe length (ft)		
			*10' Pipe	13' Pipe	20' Pipe
4"-36"	Pro-link ST or WT (Welded Bells or Bell-Bell Couplers)	3 degree	197 ft	257 ft	395 ft
42"-60"	Pro-link ST (Welded Bells or Bell-Bell Couplers)	3 degree	197 ft	257 ft	395 ft
4"-60"	N-12 ST & WT IB	1 degree	X	753 ft	1159 ft

12. POST –CONSTRUCTION

Generally, no post construction is necessary for ADS pipe installations; however it is good practice to perform a visual inspection to insure proper line and grade have been achieved. It is important to understand that under normal conditions, any deflection will be realized within the first thirty (30) days after installation and generally within 2-3 days most deflection (approximately 90-95%) will be realized. This affords the inspector the opportunity to inspect the pipe shortly after installation, with the ability to note deficiencies before the project is complete. The inspection should be performed after the pipe has been laid and backfilled, but may be before final paving has been placed.

The following outlines various inspection methods commonly specified for flexible pipes (plastic and metal).

12.1. Visual Inspection

A visual inspection will usually reveal improper line and grade as well as excessive deflection. For most projects, which specify a soil tight or silt tight joint performance, a visual inspection is sufficient to insure a successful installation. Caution is advised when inspecting pipe or entering manhole or inlet structures to insure compliance with all OSHA regulations.

12.2. Infiltration/Exfiltration

For systems designed for watertight applications without specifying any ASTM specification for testing, an infiltration/exfiltration test is a simple and easy method of insuring proper joint performance. For an infiltration/exfiltration test, a run of piping is tested by filling the system with water from structure to structure (manhole or inlets) and measuring the water level immediately after filling and at a later period of time (generally 24 hours). The drop in water level can then be converted to gallons/ inch diameter/ mile /day and compared to the permissible level established for the project. In the absence of a specified level, 200-gal/ in. dia./ mi./ day may be considered watertight. An acceptable ASTM specification for testing infiltration/exfiltration is ASTM C969.

12.3. Air Testing

After the pipe has been laid and backfilled, each section of pipeline between manholes may be tested by a low pressure air test. Individual joints may also be tested with appropriate equipment. This test is usually for systems where performance standards require watertight joints. ASTM F-1417 may be used for air testing these systems and should be completed from structure to structure or for individual joints. Fabricated structures and fittings should not be tested to avoid damaging these components.

ASTM F-1417 specifies a 3.5 psi air pressure be held for a specified length of time based on the pipe diameter with a maximum 0.5 psi pressure drop. Although the diameters listed in ASTM F-1417 only include up to 36", linear interpolation for larger diameters is generally acceptable.

13. SPECIFICATIONS

The following is a list of common material, design and performance specifications for ADS N-12 pipe. This list is not all inclusive, but does include the most common applicable specifications.

AASHTO M-252	Standard Specification for Corrugated Polyethylene Drainage Tubing
AASHTO M-294	Standard Specification for Corrugated Polyethylene Pipe, 300 to 1500-mm Diameter
AASHTO Section 18	Soil-Thermoplastic Pipe Interaction Systems
AASHTO Section 12	LRFD Specifications – Buried Structures and Tunnel Liners
AASHTO Section 30	Thermoplastic Pipe
ASTM F 405	Standard Specification for Corrugated Polyethylene (PE) Tubing and Fittings
ASTM F 667	Standard Specification for Large diameter corrugated Polyethylene Tubing and Fittings
ASTM D 2321	Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
ASTM F 477	Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F 1417	Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
ASTM C 969	Standard Practice for Infiltration and Exfiltration Acceptance Testing of installed Precast Concrete Pipe Sewer Lines

14. APPENDIX

The following related documents should be consulted for additional information regarding the use of ADS N-12. These documents may be obtained from your ADS representative or by viewing our Web Site: www.ads-pipe.com.

ADS Technical Notes

Technical Note 2.107 – Pipe Floatation

Technical Note 2.108 – Chemical Resistivity

Technical Note 2.109 – Flow Capacity

Technical Note 2.115 – Comparative Pipe Stiffness

Technical Note 2.116 – Abrasion Resistance

Technical Note 2.120 – Storm Water Detention/Retention System Design

Technical Note 2.130 – Structural Performance of Corrugated PE Pipe using the Burns & Richard Solution

Technical Note 2.160 – Installation of ADS N-12 Pipe In Flowable Fill

Technical Report 4.103 – Plastic Pipe Design

Product Notes

Product Note 3.105 – Integral Bell Transition

Product Note 3.106 – Standard Pipe Perforations, N-12

Product Note 3.107 – N-12 Specification and Product Information

Technical Report

Technical Report 4.103
Re: Plastic Pipe Design
Date: November 1, 1994
Revised: April, 2004
By: J. B. Goddard

INTRODUCTION

Profile wall HDPE pipe has been produced in the United States since the 1960's. This process began with single wall small diameter pipe and has grown over time to dual wall pipe in large diameters. At the original publication of this report, the work relating to the design of plastic pipe was somewhat limited. This was especially true of profile wall HDPE pipe used in storm drain applications. The introduction of smooth interior corrugated HDPE in 1987 created significant new applications for plastic pipe. However the research and development of technical information for design purposes was obviously slower in catching up. Although HDPE pipe is now used extensively and has been the subject of numerous research projects, little time is spent instructing undergraduates on the design and construction of plastic pipe soil structure interaction.

In fact little time is spent on underground structures at all in undergraduate studies. The majority of time is spent instead on bridges, large buildings, and pavement design, despite the fact that nearly 10% of transportation construction dollars are spend on drainage structures. The small amount of time spent in undergraduate studies on underground structures is generally limited to rigid and elastic materials. Viscoelastic materials are largely ignored.

In considering pipe design, generally, pipes are divided into two categories, rigid and flexible. Rigid pipes are defined as those that will not accept deflection without structural distress. Flexible pipes are defined as those that will deflect at least 2% without structural distress. Concrete, clay, and cast iron pipe are examples of rigid pipes. Steel, aluminum and plastic pipes are usually considered flexible. Within the flexible family, metal pipes such as steel and aluminum would be considered elastic. The thermoplastic pipes such as HDPE and PVC would be considered viscoelastic or viscoplastic.

This is broken down even further as other factors influence pipe performance beyond the type and material behavior. Individual pipe types may have different performance limits based on type, material, and wall design. The strength to resist wall stresses due to external load is critical for rigid pipe and in fact is what the design method for rigid pipe is based on. In contrast for flexible pipe, stiffness is important in resisting deflection and possible buckling. Equally important in the consideration of flexible pipe design is wall area and wall profile.

For all buried pipe, rigid or flexible, the structural performance is dependent on soil structure interaction. AASHTO recognizes the significance of the soil in the buried drainage performance in the titles of the bridge pipe sections. Sections 12, 17, and 18 dealing with CMP, RCP, and Thermoplastic pipes all use the term "soil-structure interaction." AASHTO goes further to define the importance of soil in this system:

"The type and anticipated behavior of the material beneath the structure, adjacent to the structure, and over the structure must be considered." (From paragraph 17.1.6, AASHTO "Standard Specifications for Highway Bridges").

Also: "It must be recognized that a buried plastic pipe is a composite structure made up of the plastic ring and soil envelope, and that both materials play a vital part in the structural design of plastic pipe".(From paragraph 18.1.1, AASHTO "Standard Specifications for Highway Bridges").

Both of these statements apply to rigid and flexible pipe.

To put the differences between rigid, elastic, and viscoelastic materials in the simplest possible terms consider the following: the hard candy stick, a Hershey™ bar, and licorice. The hard candy (rigid) shatters if you attempt to bend it beyond its resistance, regardless of loading rate. The Hershey™ bar (elastic) flexes under load but returns to shape unless that load exceeds the yield point. Beyond the yield point, the material takes a permanent set or deformation. At some point of strain, the elastic material fails. The licorice (viscoelastic) responds differently depending on the rate at which the load is applied. If the load is applied very rapidly, the strength of the material is quite high. If a much lower load is placed on the licorice it will slowly elongate. If the elongation is fixed at some constant strain, the licorice will relieve itself of stress.

Although helpful in visualizing the differences in these materials, this perspective is inaccurate in that the pipe wall in non-pressure pipe is normally in compression, not tension. Because of that, the tendency is for the pipe wall to compress and thicken under load rather than stretching and thinning (or necking down). The impact of that is to increase cross sectional or wall area while, at the same time, stress relaxation is taking place. The impact of this is discussed later in the design section.

DESIGN THEORY

The proof of any design theory should be how accurately it predicts the point and mode of failure in the product under the anticipated loading conditions. Unfortunately, current non-pressure pipe design procedures do not pass this test. Rigid pipe practice tends to predict quartering of the pipe as a failure mode when in fact wall shear is more common. Metal pipe design predicts circumferential wall crushing as the failure mode, a phenomenon which is rarely seen in the field; localized buckling is a much more common failure mechanism. In defense of both theories, however, they appear to be generally conservative in that there are few structural failures of standard production pipe supplied by either industry, unless blatantly abused in installation and handling.

The same can generally be said for standard production thermoplastic pipe supplied by the major producers in that there have been few structural failures of these products. Design theory for these products is considerably more confusing, in part because the products represented are only about 40 years old and in part because of the variation in wall design and materials (primarily PVC and HDPE).

Prior to developing a design procedure, performance limits must be established. Deflection, wall buckling, stress, and strain are normally considered performance limits for flexible pipes.

The most obvious concern in the design and installation of flexible pipe is deflection (Illustrations 1 and 2). In general, most agencies try to control the quality of their flexible pipe installations with deflection limitations. Deflection control plays an important roll in the determination of the quality of an installation and can be an indication of long-term performance. Deflection limits are set to avoid reversal of curvature, to limit bending stress and strain, and to avoid pipe flattening. Excessive deflection may reduce the flow capacity of the pipe and may cause joint leakage. Deflection of flexible pipe is primarily controlled by the method of installation, backfill, and *in situ* soil properties. Deflection does not however, determine the ability of the pipe to perform its intended function in the field.

Wall buckling (Illustration 3) should be considered. Large diameter flexible pipe design may be governed by buckling, particularly when subjected to high soil pressures in low stiffness soils. This is not very common in the smaller diameters. However, as diameter increases, buckling can become a factor in flexible pipe.

Wall stress (Illustration 4) in compression can theoretically lead to wall crushing, if excessive. If the ring compressive stress is greater that then compressive strength of the wall of the pipe, wall crushing may occur. The viscoelastic properties of thermoplastic material make this mode of failure very unlikely and field and lab tests tend to confirm that view.

Generally, pipe wall strain, in bending, should be checked. Typically, these are outer wall fiber strains brought about by excessive deflection or localized deformations. Strain limits for thermoplastic pipe materials are generally assumed to be from 3.5 to 8% depending on wall design and resin used. Note that this is fiber strain, not deflection.

The equations to determine deflection, wall buckling, wall stress, and wall strain were developed primarily for evaluating flexible pipes manufactured from elastic materials and do not adequately reflect the effect of viscoelastic properties; in some cases treating a positive attribute as a negative. Again, using an analogy, the viscoelastic material is treated as a spring and dash pot (or shock absorber) connected in parallel, with the spring handling sudden or short term loads and the dash pot responding to long term loads. The effect of this combined response is significant on the soil structure interaction system. (Figure 1.)

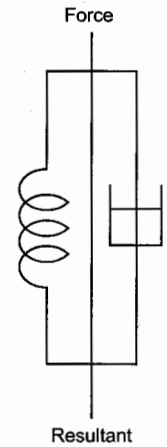


Figure 1.

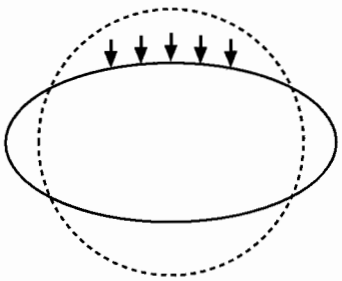


Illustration 1.
Ring deflection in a flexible pipe

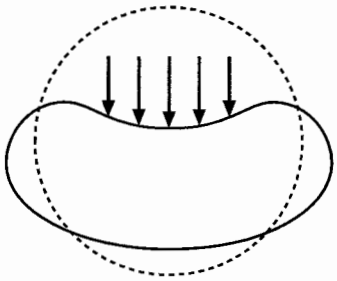


Illustration 2.
Reversal of curvature due to over-deflection

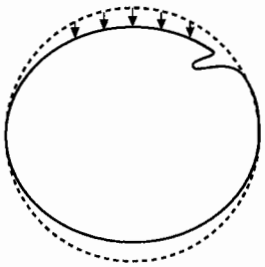


Illustration 3.
Localized wall buckling

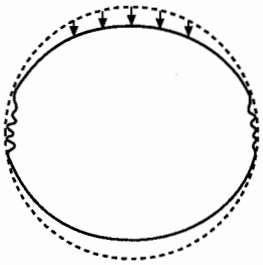


Illustration 4.
Wall crushing at the 3 and 9 o'clock positions

DESIGN PRACTICE

1. Deflection

Probably the most commonly used formula in plastic pipe design is Spangler's Iowa Deflection Formula. It is referenced or utilized, at least in some form, in the ASCE *Plastic Design Manual*; by Moser in his textbook, *Buried Pipe Design*; by Koerner in his textbook, *Designing with Geosynthetics*; by the Bureau of Reclamation; and by the Environmental Protection Agency. The most common form of the equation is:

$$\Delta x = \frac{D_L(kwr^3)}{(EI + 0.061E'r^3)}$$

Where:
- Δx = Horizontal deflection of the pipe in inches
- D_L = Deflection Lag Factor (usually 1.5)
- k = Bedding Constant
- w = Load per unit length of pipe in lbs / linear in.
- r = Pipe radius in inches
- E = Modulus of elasticity of material in lbs / in^2
- I = Moment of Inertia of pipe wall in in^4/in.
- E′ = Modulus of soil reactions in lbs / in^2

Developed by Dr. Merlin G. Spangler based on work begun in 1927 with rigid and flexible pipes, this built on previous work by Dr. Marston which predicted loads on culverts. The form above is the modified formula developed by Dr. Reynold Watkins based on his work in 1958.

It should be noted that this equation was developed largely from test installations using 15 to 25 feet of cover.

A number of factors in the equation are contentious and deserve explanation:

A. The deflection lag factor (D_L) was included in the equation because Spangler believed that deflections could increase as much as 30% over a period of 40 years. He recommended a D_L of 1.5 to be conservative. We now know virtually all of the deflection occurs during the first year, therefore a D_L of 1.0 may be used.

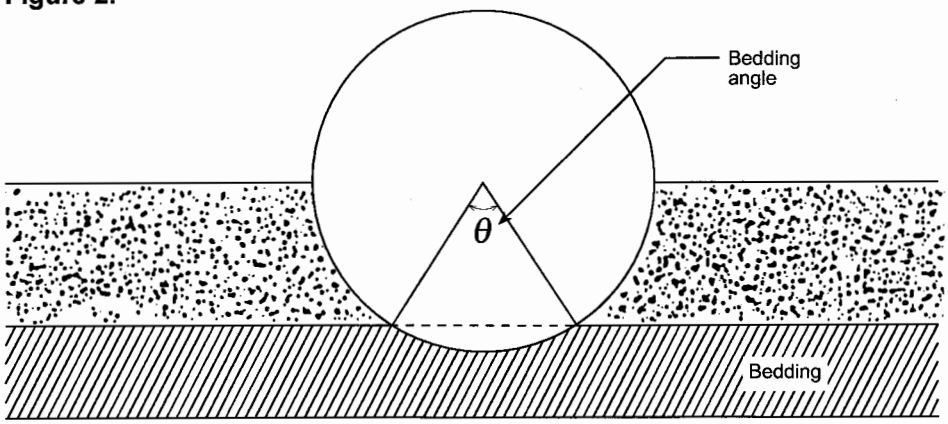
B. The bedding constant (k) is usually assumed to equal 0.1, although, as shown in Table 1, other values may be appropriate for specific installation conditions. A bedding angle (see Figure 2) of 0 degrees would indicate a very firm foundation which would not be recommended for any pipe type.

Table 1.

Values of Bedding Constant, K

Bedding angle, degrees	K
0	0.110
30	0.108
45	0.105
60	0.102
90	0.096
120	0.090
180	0.083

Figure 2.



C. The load per unit length of pipe (W) is Marston's prism load, which assumes that the entire weight of the vertical prism of soil over the pipe is pressing down on the pipe. For very deep fills, this is probably very conservative in that it assumes no soil arching. This may be unconservative for very shallow cover.

D. The modulus of soil reaction (E') has been studied extensively and continues to be a point of contention between rigid and flexible pipe manufacturers. Probably the most used values are those developed by Amster Howard of the U.S. Bureau of Reclamation and shown in Table 2. These values are based on field measurements of flexible pipe installations whose installation conditions were known and then back calculating to find the E' values.

Recent work by Dr. Mike Duncan at V.P.I. indicates that E' varies with depth. When looked upon as a confining pressure, this seems logical. Amster Howard's work limits his E' values to 50 feet or less. Richard Chamber's work published in 1980 showed that E' can be replaced by M_s (constrained soil modulus) in the Iowa Formula. M_s does vary with depth. Dr. Duncan's values are shown in Table 3. These values may be more appropriate than those shown in Table 2.

Values of E' have been given as high as 8,000 psi in very high fills.

Selection of the appropriate E' value is up to the design engineer who must make that decision based on experience and knowledge of the project conditions. Clearly, values less than 400 psi would indicate backfill conditions inappropriate for pipe installation.

Table 2.

Average Values of Modulus of Soil Reaction, E′
(For Initial Flexible Pipe Deflection)

Soil type-pipe bedding material (Unified Classification System)*	E′ for degree of compaction of bedding, lb/in^2			
	Dumped	Slight, < 85% proctor, < 40% relative density	Moderate, 85%-95% proctor, 40%-70% relative density	High > 95% proctor > 70% relative density
Fine-grained soils (LL > 50) † Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; Otherwise use E′ = 0			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse-grained particles	50	200	400	1000
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse-grained particles Coarse-grained soils with fines GM, GC, SM, SC contains more than 12% fines	100	400	1000	2000
Coarse-grained soils with little or no fines GW, GP, SW, SP‡ contains less than 12% fines	200	1000	2000	3000
Crushed rock	1000	3000	3000	3000
Accuracy in terms of percentage deflection§	± 2	± 2	± 1	± 0.5

* ASTM Designation D2487, USBR Designation E-3
† LL - liquid limit
‡ Or any borderline soil beginning with one of these symbols (i.e., GM-GC, GC-SC)
§ For ± 1% accuracy and predicted deflection of 3%, actual deflection would be between 2 and 4%

NOTE: Values applicable only for fills less than 50 ft (15 m). Table does not include any safety factor. For use in predicting initial deflections only, appropriate deflection lag factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower E′ value or average the two values. Percentage proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/ft^3 (598,000 J/m^1) (ASTM D698, AASHTO T-99, USBR Designation E-11). 1 lb/in^2 = 6.9 kN/m^2.

SOURCE: Amster K. Howard, "Soil Reaction for Buried Flexible Pipe", U.S. Bureau of Reclamation, Denver, Colorado. Reprinted with permission from American Society of Civil Engineers J. Geotech Eng. Div., January 1977, pp. 33-43.

Table 3.

Design Values of E' (psi)

Type of soil (1)	Depth of Cover (ft) (2)	Standard AASHTO Relative Compaction			
		85% (3)	90% (4)	95% (5)	100% (6)
Fine-grained soils with less than 25% sand content (CL, ML, DL-ML)	0-5	500	700	1,000	1,500
	5-10	600	1,000	1,400	2,000
	10-15	700	1,200	1,600	2,300
	15-20	800	1,300	1,800	2,600
Coarse-grained soils with fines (SM,SC)	0-5	600	1,000	1,200	1,900
	5-10	900	1,400	1,800	2,700
	10-15	1,000	1,500	2,100	3,200
	15-20	1,100	1,600	2,400	3,700
Coarse-grained soils with little or no fines (SP, SW, GP, GW)	0-5	700	1,000	1,600	2,500
	5-10	1,000	1,500	2,200	3,300
	10-15	1,050	1,600	2,400	3,600
	15-20	1,100	1,700	2,500	3,800

One variation to the Modified Iowa Formula that can simplify its use is replacing the pipe *EI* values with a minimum pipe stiffness value as shown below:

$$\Delta x = D_L \frac{kWr^3}{\frac{D^3 PS}{53.77} + 0.061E'r^3}$$

Minimum pipe stiffness values are provided in the pipe specification in ASTM and AASHTO.

PS = Pipe stiffness on #/in./in.
D = Pipe diameter in inches.

One additional design approach intended in part to limit installation deflections and insure construction survivability is the use of flexibility factor in the AASHTO design procedure. Based on earlier experience with corrugated steel and corrugated aluminum pipe, AASHTO has set a minimum flexibility factor for thermoplastic pipes of 0.095, based on the following formula:

$$FF = \frac{D^2}{EI}$$

Where: D = Pipe diameter in inches
E = Modulus of Elasticity
I = Moment of Inertia of pipe wall in $in^4/in.$

To utilize minimum specified pipe stiffness (PS), this equation becomes:

$$FF = \frac{53.77}{PS * D}$$

From this, Table 4 can be generated:

Table 4

Pipe Stiffness for FF = 0.095

Pipe Diameter (in)	Pipe Stiffness (#/in/in)	Pipe Diameter (in)	Pipe Stiffness (#/in/in)
12	47.17	36	15.72
15	37.73	42	13.48
18	31.44	48	11.79
24	23.58	54	10.48
30	18.87	60	9.43

Considerable experience with pipe sizes 48″ and smaller and with stiffness values equal to or greater than those given has shown that these products perform well with good installation procedures. More flexible structures can be successfully installed if special care is exercised.

2. Wall Buckling

Wall buckling can govern design of flexible pipes subjected to high soil pressures, external hydrostatic pressure, or internal vacuum. The more flexible the pipe, the lower the resistance to buckling. Caution should be exercised when considering large diameter pipes or pipes in shallow burial. Buckling equations assume the external pressure is reasonably uniform around the pipe. From Dr. Moser's textbook, the following equation offers a relatively simple solution that has been shown to be conservative for thermoplastic pipe.

$$P_{cr} = 2\sqrt{\frac{E'}{1-\upsilon^2}\left(\frac{EI}{R^3}\right)}$$

Where: P_{cr} = Critical Buckling Pressure (psi)
E' = Soil Modulus (psi)
υ = Poisson's Ration
E = Modulus of Elasticity (Pipe Material) (psi)
I = Moment of Inertia (in^4/in)
R = Pipe Radius (in)

AASHTO and ASCE use a somewhat different approach relying on variations of the AWWA equation. The current AASHTO version is as follows:

$$P_{CR} = 9.24\left(\frac{R}{A_P}\right)\sqrt{\frac{C_W M_S EI}{0.149R^3}}$$

Where: R = Pipe Radius (in)
M_S = Soil Modulus (psi)
C_W = Water Buoyancy Factor = $(1-0.33h_W/h)$
Where: h_W = Height of water above the top of pipe
h = Height of ground surface above pipe
A_P = Pipe wall area. (in^2/in)

For viscoelastic materials, the *E* value in this equation is normally the long-term *E* value, either 10yr. or 50 yr.

3. Wall Crushing

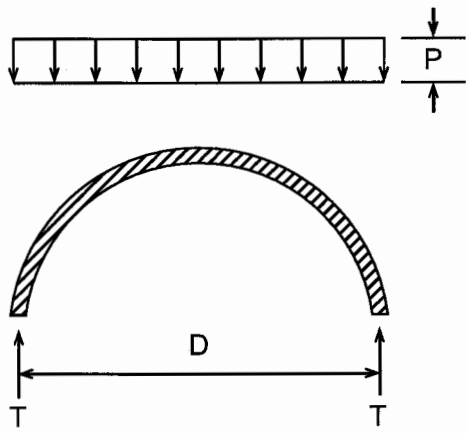
Based on ring compression theory developed for metal pipe, the potential for wall crushing under load is checked in the AASHTO design procedure. According to the AASHTO procedure, this can be addressed in two ways, using service load design or load factor design. Both start by calculating the thrust in the wall as follows:

$$T = P * D/2$$

Where: T = Thrust in lbs/ft.
P = Design Load in psi
D = Diameter in feet.

This is represented by the free body diagram in Figure 3.

Figure 3



The design load is generally assumed to be the weight of the soil load above the pipe, calculated by multiplying the soil density times the height of cover. Any anticipated live load must be added to this dead load. Live loads are given in Table 5 and shown on Figure 4, 5, and 6.

Table 5.

Live Loads on Flexible Pipe
(Live Load Transferred to Pipe, lb/in^2)

Height of Cover (FT)	Highway H20	Railway E80	Airports
1	12.50	N.R.	N.R.
2	5.56	26.39	13.14
3	4.17	23.61	12.28
4	2.78	18.40	11.27
5	1.74	16.67	10.09
6	1.39	15.63	8.79
7	1.22	12.15	7.85
8	0.69	11.11	6.93
10	N.S.	7.64	6.08
12	—	5.56	4.76
14	—	4.17	3.06
16	—	3.47	2.29
18	—	2.78	1.91
20	—	2.08	1.53
22	—	1.91	1.14
24	—	1.74	1.05
26	—	1.39	N.S.
28	—	1.04	—
30	—	0.69	—
35	—	N.S.	—
40	—	—	—

Notes: H2O load simulates 20 ton truck traffic and impact.
E80 load simulates 80,000 lb./ft. railway load and impact. Airport load simulates 180,000 lb. dual tandem gear, 26 inch spacing between tires and 66 inch center-to-center spacing between fore and aft tires under rigid pavement 12" thick plus impact.
N.S.= Not Significant
N.R.= Not Recommended

Figure 4.

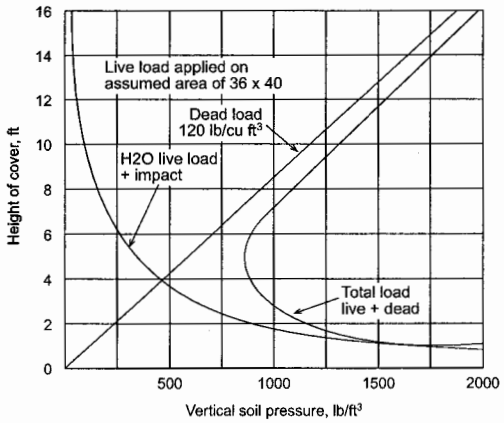


Figure 5.

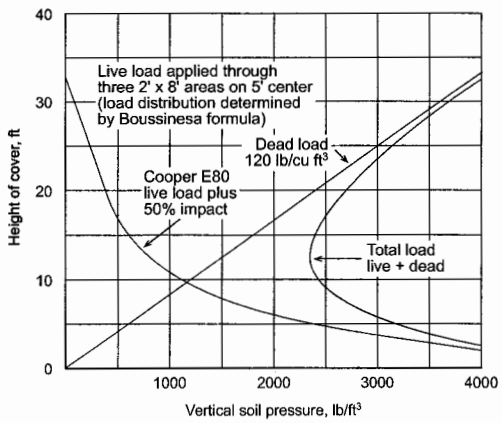
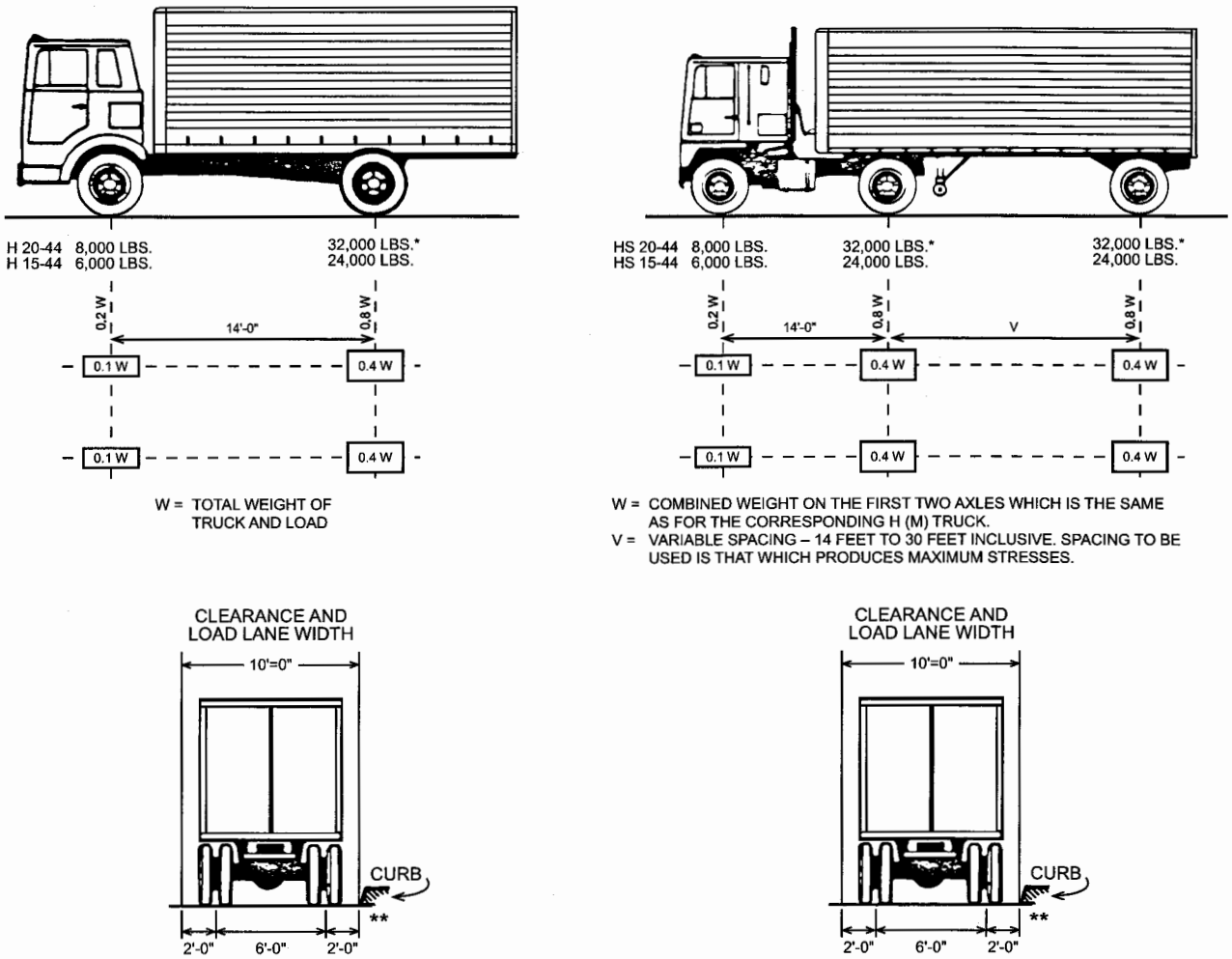


Figure 6.



With the wall thrust determined, the required pipe wall area can then be calculated. AASHTO provides two approaches to this: Service Load Design and Load Factor Design. Service Load design is a working stress method, while Load Factor Design is based on ultimate strength principles. Using Service Load Design, the following equation is used to determine required wall area:

$$A = \frac{T}{f_A}$$

Where: A = Required wall area in in^2/ft.
T = Thrust in #/ft.
f_A = Allowable minimum tensile strength in psi divided by a S.F. of 2

This approach has been used successfully with metal pipe, and more recently plastic pipe, for many years. For the plastic pipe (viscoelastic) model, there are a couple of fundamental errors that lead the designer to very conservative designs. The most obvious error is the use of tensile strength values in calculating wall area compression. With the principle resins used in the manufacture of thermoplastic pipe the allowable values should be higher in compression.

The second error is that the calculated soil load is still based on the weight of the soil prism over the pipe without any consideration of soil arching, which has been proven in a number of research studies to reduce the load considerably in very deep fills.

The third error is the use of long term material properties rather than initial strength in these calculations. When backfilled with Type I, Type II, or compacted Type III soils, it is appropriate to assume the pipe is subjected to repeated dynamic loads from successive settling of the soil. Because stresses in the pipe wall relax, design should be based on the instantaneous modulus of elasticity and compressive strength.

4. Wall Strain

Pipe wall strain is mostly a post-construction concern. Within the normally specified deflection limitations, allowable outer fiber tensile strains are not a concern. If, however, due to poor installation, localized deformations occur, wall strain should be checked. Allowable strains for the resins used for thermoplastic pipe are 3.5 to 5% for PVC and 4 to 8% for HDPE. To check bending strain,

$$E_b = 6\left(\frac{t}{D}\right)\left(\frac{\Delta Y}{D}\right)$$

Where: E_b = Bending Strain
t = Wall thickness
D = Diameter
ΔY = Vertical Deflection

Total circumferential strain may also include (in addition to bending strain) ring compression strain and strain due to Poisson's effect. Ring compression strain is:

$$E_c = \frac{P_v D}{2tE}$$

Where: E_c = Ring Compression Strain
D = Diameter
P_v = Vertical soil pressure
E = Modulus of elasticity

The contribution to circumferential strain due to the Poisson effect caused by longitudinal strain is:

$$E = -vxL_s$$

Where: E = Circumferential Poisson's strain
v = Poisson's ratio
L_s = Longitudinal strain

As noted, these strains are additive. Compressive strains reduce tensile strains.

In order to properly design any plastic pipe, it is necessary to know the section properties of the pipe, including: inside and outside diameter; pipe wall area; wall centroid; and moment of inertia. Also, the minimum resin properties including short and long term tensile strength, modulus of elasticity, compression strength and allowable long term strain. These values will be available in the referenced specifications or from the manufacturers.

OTHER DESIGN PRACTICES

During the last few years, AASHTO has been in the process of converting the structural design methods to the LRFD method from the working stress or ultimate stress methods. This has resulted in NCHRP Project 04-26, the "Proposed Design Thermoplastic Culvert Pipe" which will provide modifications to AASHTO Design Specifications Sections 3 and 12. Although not yet published, this method for determining the performance of thermoplastic pipe is being used by different DOT's and agencies around the United States. It is beyond the scope of this paper to go into a full discussion of the LRFD method but the basic premise of method will be discussed.

The LRFD method is intended to provide safety factors in the course of the design of the structural components. Hence the name Load Resistance Factor Design. Both the load and the resistance of the material being designed have factors applied to provide for safety factors in the design. In the case of the loads, the factors applied are greater than one and result in an increased load. In the case of the load resistance, the factors are less then one and the load resistance of the material is decreased. The primary purpose of the method is to allow the actual material properties of a product to be used and the safety factor gained from the factors applied.

1. Load Determination

   The proposed LRFD guidelines require that the pipe be investigated at the strength limit state for thrust, general and local buckling, and combined strain. In order for these to be checked it is necessary to find some loading conditions. The first is factored load and is given by the following equation:

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$$P_u = \eta_{EV}(\gamma_{EV} K_2 VAF P_{sp} + \gamma_{WA} P_W) + \eta_{LL}\gamma_{LL} P_L C_L$$

Where: η_{EV} = load modifier for vertical earth loads
γ_{EV} = load factor for vertical pressure of dead load
VAF = vertical arching factor found as follows:

$$VAF = 0.76 - 0.71\left[\frac{S_H - 1.17}{S_H + 2.92}\right]$$

$$S_H = \frac{\varphi_S M_S R}{E_P A_g}$$

P_{SP} = soil prism pressure at pipe spring line
γ_{WA} = load factor for hydrostatic pressure
P_W = hydrostatic pressure
η_{LL} = load modifier for vertical live load
γ_{LL} = load factor for vertical pressure of live load
S_H = hoop stiffness factor
ϕ_S = resistance factor for soil stiffness
M_s = secant constrained soil modulus
A_g = area of pipe wall per unit length

The service load is the same equation with the load factors and load modifiers removed. This reduces the equation to the following:

$$P_S = K_2 VAF P_{SP} + P_L C_L + P_W$$

In general, the factored load adds a safety factor of 1.75 when used in accordance with the guidelines for LRFD. This is the prescribed method for determining load in the LRFD guidelines. The determination of P_{SP}, P_W, and P_L should be determined as shown in the Section 12 guidelines. Once the load is determined, the safety of the system against structural failure must be determined. This includes resistance to thrust, compressive strain, buckling, combined bending and thrust, and combined strain. All of these conditions are outlined in Section 12.

2. Thrust

The other required loading condition which is included in the pipe calculation is thrust. This will be used in several of the calculations to determine the ability of the pipe to carry the loads applied.

The factored thrust is found as follows:

$$T_u = P_u\left(\frac{D_o}{2}\right)$$

Where: T_u = factored thrust per unit length
P_u = design factored load per equation no. 1

The factor on this equation varies between 1.35 and 1.75 depending on whether the load used is dead or live load.

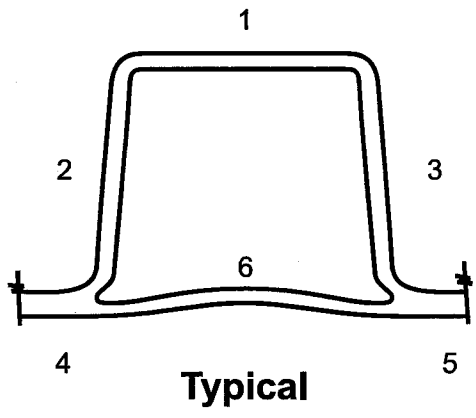
3. Effective Area and the Idealized Section

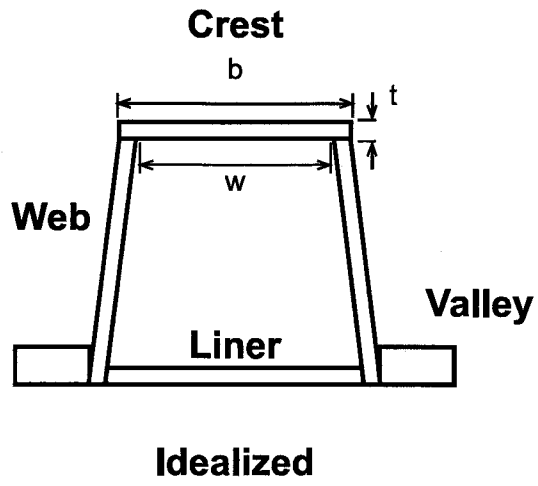
Ultimately, the main difference between the LRFD and Section 18 is related to the effective area and its impact on the resistance of the section to load and strain. At this time, effective area is computed using the concept of the idealized profile. Ultimately, it will probably be replaced with some quality test method.

In order to determine the ability of a profile to resist axial thrust, strain, and flexure, LRFD requires that the section be reduced to an idealized profile. The profile removes most of the geometry of the profile and reduces it to a box-like structure consisting of the following:

Crest: top of corrugation running from sidewall to sidewall
Web: sidewall of corrugation
Liner: interior wall of pipe running from sidewall to sidewall
Valley: area between two corrugations

There are inherent problems with this methodology. The idealized section does not provide a section that gives any credit to the profile of the corrugation or the stability of that profile. In addition, the box structure that is produced is not a profile that is in current production and several assumptions must be made in the conversion of the profile. Nevertheless, the current standard requires the use of the Idealized Section.





A. Factored Strain in the Element

The first step in computing the effective area of the element is the determination of the factored strain in the element. This is given by the following equation:

$$\varepsilon = \left[\frac{\gamma_E * VAF * (P_{SP}) + \gamma_h * P_W}{E_{pl}} + \frac{\gamma_L * C_L * P_L}{E_{ps}} \right] * \frac{D_o}{2 * A_g}$$

Where: E_{pl} = Long term pipe modulus of elasticity = 22ksi
E_{ps} = Short term pipe modulus of elasticity = 110ksi

This equation is basically the factored load applied to the pipe from the LRFD with the modulus of elasticity of the pipe applied to the equation and a term on the right side of the equation to take into account the pipe corrugation. These terms are added to provide for the strain in the pipe. The modulus of elasticity used varies, depending on the properties being used. Long term modulus is used for dead load and short term is used for live load. The factors of safety used in this equation are the same used in the load equation and essentially equate to an increase in the load and corresponding strain of 1.75.

B. Slenderness Factor

The LRFD method borrows from column design and includes a slenderness factor. This is intended to be a term which accounts for long slender sections which are more prone to buckling. The slenderness factor is obtained from the following equation:

$$\lambda_i := \max\left[\left(\frac{w_i}{t_i}\right)\cdot\sqrt{\frac{\varepsilon}{k}}, 0.673\right]$$

Where: λ_i = slenderness factor
w_i = unsupported length of the element
t_t = thickness of the element
k = plate buckling coefficient = 4.0

This factor is found for each element in the idealized section including the crest, web, liner, and valley. The difficult part in this equation is the determination of the unsupported length. Creation of the idealized section is a very subjective process which must be completed for each profile. The unsupported length is therefore subject to interpretation and a wide range of results are possible, depending on the interpretation of this section. In addition, the profile section is taken out of the equation and the geometry is given no credit for its ability to resist load and strain. Also, because the factored strain is used in this equation it has a built-in factor of 1.75 which will carry through the rest of the calculations, causing the effective area to decrease significantly. After the slenderness factor is found, the effective width factor is computed.

C. Effective Width Factor

The effective width factor is computed as follows:

$$\rho_i := \frac{\left(1 - \frac{0.22}{\lambda_i}\right)}{\lambda_i}$$

The effective width factor will be less than one. Again, the load factor used in the strain equation carries through to the slenderness factor and because the slenderness factor is used in the effective width factor calculation, the result is a larger decrease in the effective width factor. This factor is multiplied by the unsupported length mentioned earlier and results in a further reduction of the unsupported length by the following equation:

D. Effective Element Width

$$w_{e_i} := \rho_i \cdot w_i$$

The result of all these equations is to get an effective width to be used in the effective area equation, which will provide an area less then the gross area of the cross section. In addition to this, the effective area has included in it, because of the calculation method, the same load factor used to find the load on the pipe. This means that the effective area will become even more conservative.

The effective area of the profile is taken as the following:

$$A_{eff} = \frac{A_g - \sum(1-\rho_i)w_i t_i}{\omega}$$

Where: ω = distance to the next corrugation

The effective area is the gross area of the pipe minus the areas which are not considered effective in resisting forces applied to the pip. The effective area can be generally 30% - 50% less then the gross area of the profile, depending on the methodology used to determine the idealized section.

4. Factored Compressive Strain

Once the effective area of the profile is determined it will be used in every other calculation for the LRFD method, which is why it is necessary to find it early in the calculations. Eventually this method of idealizing the section and finding an effective area should be replaced with a quality control test value which has not been finalized at this point. From the values collected so far, the factored compressive strain that the pipe theoretically must resist is found. This value is given by the following equation:

$$\varepsilon_{c.u} = \varepsilon * \frac{A_g}{A_{eff}}$$

The factored compressive strain that the pipe must resist is increased by the ratio of the gross area to the effective area. This value will always be greater then 1. In some cases it can be as high as 1.5. Considering that the value for strain includes a factor of 1.75 for dead load, and the effective area included this safety factor in the reduction of effective width, the factored compressive strain could have a safety factor in the range of 2 to 5 depending on the designer's interpretation. This strain will be used to compare the capacity of the pipe to carry load and strain, and will therefore affect the outcome of every other component of the design.

5. Factored Capacity

The factored capacity is given by the following equation:

$$\phi T * \varepsilon_{yc} = 0.90 * 0.04 = 0.036$$

Where: ϕT = Resistance factor for Thrust and is equal to 0.90
ε_{yc} = compressive limiting strain = 0.04 for HDPE

This represents the compressive strain that the pipe is capable of resisting for localized buckling. Please note that it is factored as part of the LRFD method and the compressive strain capacity is therefore reduced by 10%. This is compared to the factored compressive strain from step 3. If the factored compressive strain is less than the factored capacity, then the design is good. So ε_{cu} must be $\leq \phi T * \varepsilon_{yc}$ for the design to be good. There are factors on both sides of the equation. The compressive strain is increased and resistance capacity of the pipe is decreased.

6. Global Buckling

The global buckling equation is used to look at the occurrence of a large scale buckling event as opposed to a localized concern. The global buckling resistance of the pipe is give by the following equation:

$$\varepsilon_{bck} := \frac{1.2 \cdot C_n \left(E_{pl} \cdot I_p\right)^{\frac{1}{3}}}{A_{eff} \cdot E_{pl}} \cdot \left[\frac{\phi_s \cdot M_s \cdot (1 - 2 \cdot \upsilon)}{(1 - \upsilon)^2}\right]^{\frac{2}{3}} \cdot R_h$$

Where: ε_{bck} = Global buckling resistance
Cn = calibration factor for non linear effects
I_p = Moment of Inertia of the corrugation
ϕ_s = soil stiffness factor = 0.90
ν = poisons ratio
R_h = correction factor for soil backfill geometry

This is the amount of buckling the pipe is capable of resisting, based on an installation in a specific soil. This equation uses the effective area found previously and adds a safety factor to the Soil Modulus which decreases it by 10%. In addition, the global buckling resistance capacity is multiplied by a resistance factor to give the following equation:

$$\phi_{bck} * \varepsilon_{bck} = 0.70 * \varepsilon_{bck}$$

The global buckling resistance capacity is reduced by 30% with the resistance factor multiplied through. This is then compared to the overall compressive strain on the pipe, which has been increased with its own load factors as mentioned before. In order for the check to be valid $\varepsilon_{c.u} \leq \varepsilon_{bck} * \phi_{bck}$.

7. Flexure

The flexure capacity of the pipe is checked assuming that the pipe is deflected to the service limit. You must find the factored bending tension strain in order to do this check. The factored bending tension strain is found from the following equation:

$$\varepsilon_f := \gamma_E \cdot D_f \cdot \left(\frac{c}{R}\right) \cdot \left(\frac{\Delta f}{D}\right)$$

Where: ε_f = factored bending strain
γ_E = earth load factor = 1.75
D_f = shape factor for PE pipe
c = distance from neutral axis to extreme fiber
Δf = reduction of vertical diameter due to bending

The factored tension strain is increased by a factor 1.75. This provides the bending strain, which is due to deflection in the pipe in the tensile direction. The tensile strain is then found by subtracting the factored compression strain from the factored tension strain as follows:

$$\varepsilon_f - \varepsilon_{c.u,}$$

Once this value is found it is compared with the limiting strain, which is reduced by the flexure resistance factor. This is found from the equation:

$$\phi_f * \varepsilon_{yt}$$

Where: ϕ_f = 0.90 and is the flexure resistance factor
ε_{yt} = -0.075 and is the tensile limiting strain.

The resistance factor here reduces the tensile limiting strain by 10%. Once again, these values are compared and $\varepsilon_f - \varepsilon_{c.u,} \leq \phi_f * \varepsilon_{cu}$ for the design to be good.

8. Compression

For compression, the factored tension strain is added to the factored compression strain and compared to the compressive resistance strain with the associated resistance factor. This assumes that the strains occur in the same direction and become an additive force in compression as follows:

$$\varepsilon_f + \varepsilon_{c.u,}$$

This is then compared to the flexural compression resistance which is given by the following:

$$\phi_f * 1.5 * \varepsilon_{yc}$$

All of these factors are given earlier in this description. Once again, the flexure compression strain must be less then the flexure compression resistance strain in order for the design to be adequate.

9. Deflection

The last check in Section 12 is for deflection and is given by the following equation:

$$\Delta t = \frac{(D_L K P_{SP} + C_L P_L) D_0}{\frac{E_P I_P}{R^3} + 0.061 M_S} + \varepsilon_{SC} D_i$$

Where:
Δt = total deflection of the pipe
D_L = Deflection lag Factor
K = bedding coefficient
P_{SP} = Soil Prism pressure, evaluated at spring line
C_L = live load distribution coefficient
P_L = live load pressure
D_0 = Original Pipe Diameter
E_p = Short or long term modulus of pipe
I_P = Moment of inertia of pipe per unit length
R = radius to centroid of pipe profile
M_s = secant constrained soil modulus
ε_{SC} = service compressive strain from thrust

The deflection given by the equation for Δt should be less then the allowable deflection set by the Engineer. In general, this is either 5% or 7.5%. The equation as shown is basically the Iowa formula with the extra term added at the end for circumferential shortening. This addition of the last term is a little misleading and probably not a good representation of the actual conditions. Circumferential shortening is generally considered to be a good thing in that it provides the pipe with a method for shrinking from long term loads and transferring the load to the surrounding soil. It is also a compressive strain. The primary cause of concern from deflection would be a tensile strain which would be located at the spring lines and at the outer fiber of the pipe, in most instances. Tensile strain is obviously checked elsewhere in the method as is compressive strain. Therefore, it may be more appropriate in terms of strain for the circumferential strain to be removed, although it does contribute to the overall deflection of the pipe.

INSTALLATION

As noted in the introduction, design of any buried structure, be it rigid or flexible, depends on the interaction of the pipe structure with the surrounding soil (or backfill). Sound installation practice assures satisfactory structural performance. Fortunately, for thermoplastic pipe there is an excellent installation specification in ASTM D2321, "Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications." This specification is particularly helpful in its classification of embedment and backfill materials and its recommendations for their use. It also includes guidance on the compatibility of backfill materials with various soil types, particularly in

terms of migration of fines. Minimum compaction levels for different backfill classes are provided and should be followed. These are based on providing an E' (modulus of soil reaction) value of 1,000 psi, as used in the deflection formula (1).

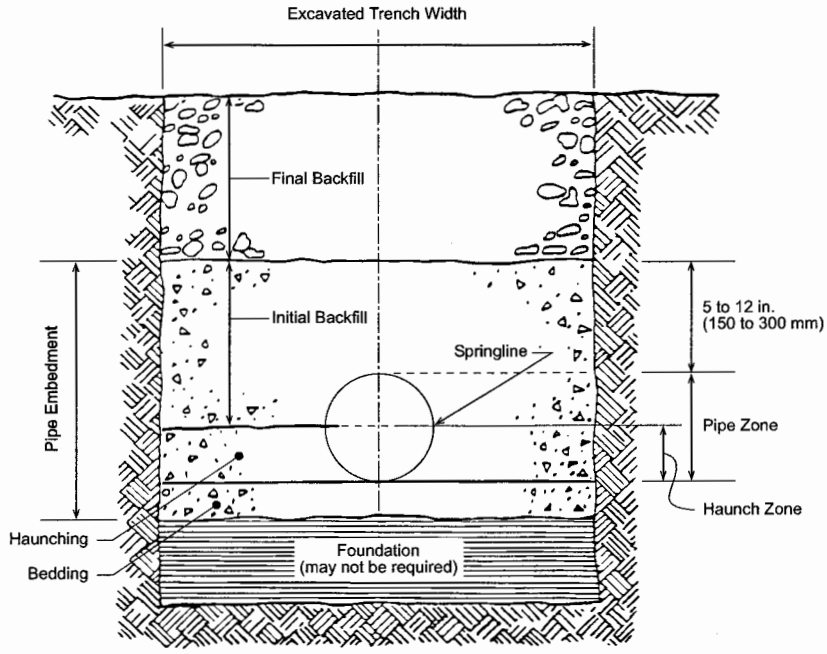
In typical conditions, the minimum trench width is determined by the size of the pipe and the ability to get compaction equipment between the pipe and the trench walls. The minimum trench width should not be less than the outside diameter plus 16 inches or the pipe outside diameter times 1.25 plus 12 inches; whichever is greater. High speed trenches may enable satisfactory installation of pipe in narrower trenches. Poor *in situ* soil conditions such as peat, muck, running sands, or expansive clays will require substantially wider backfill, as well as deeper foundation and bedding. Trench width and foundation depth should be based on a thorough site investigation.

Other means of trench control through poor *in situ* soils include wrapping the backfill and bedding material with a geotextile. Particularly severe conditions may require a geonet or geogrid, often in combination with a geotextile.

Bedding, to provide a stable and uniform base for the pipe, should be 3 to 4 inches thick. Over rock or unyielding foundations, a minimum of 6″ of bedding should be provided.

Backfill in the area up to the spring line should be carefully placed and compacted to achieve a minimum E' value of 1,000 psi as detailed in ASTM D2321. A minimum of 12″ of backfill should be placed and compacted above the crown of the pipe. It is typical for trenches to be backfilled entirely with Type I or Type II materials when under pavement. (Figure 7)

Figure 7.



Trench Cross Section

For pipe up to 48″ diameter, and with pipe stiffness equal to or in excess of those required in AASHTO Section 18 (Table 4), a minimum of 12″ of compacted cover is required prior to vehicle loadings. For larger or less stiff pipe, additional cover is recommended. Recent development of flowable, low strength cement or fly ash backfill provides the ability to reduce trench widths and still get adequate backfill support. This can be particularly helpful in municipal street installations. Manufacturer's recommendations should be closely followed. More information is available in the ADS "Technical Note 2.160, Installation of ADS N-12® Pipe in Flowable Fill."

Flexible pipe should never be installed in a concrete cradle, as done for rigid pipe in a Class A installation. This type of installation could create concentrated forces at the ends of the cradle when the pipe has deformed.

RESEARCH

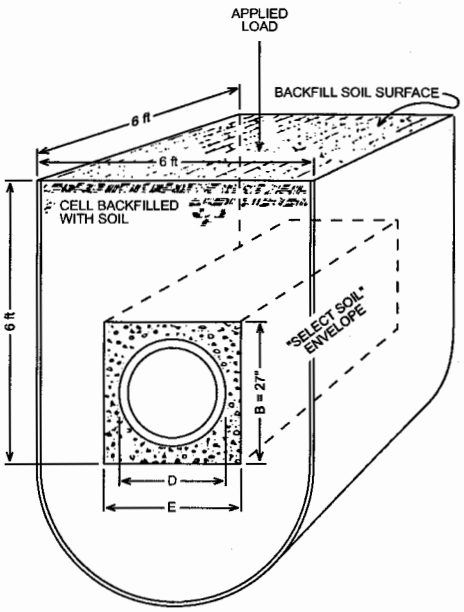
One way to verify design and installation procedures for any product is to compare research findings with predicted performance. Over the past twenty years, there has been a substantial amount of research done by the plastic pipe industry or by users of plastic pipe to verify the existing design procedures or to improve upon them.

A considerable amount of research has been conducted at Utah State University by Dr. Reynold Watkins and/or Dr. Al Moser. Much of Dr. Watkins' work has involved the use of a soil pressure test cell at U.S.U, to attempt to simulate very large soil pressures on buried pipe. Depending on the specific test, different backfill material and installation practices have been used as well. Based on work done in 1982 (TRR 903) (Figures 8 and 9) and 1990 on corrugated polyethylene pipe, the measured deflections were 1/2 to 2/3 those predicted by the Modified Iowa Formula (1) (Figure 10).

Figure 8.

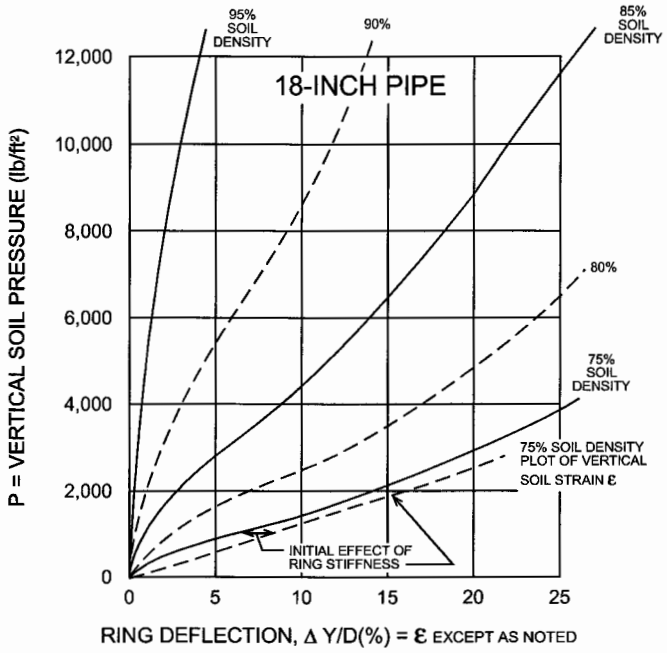
H-20 (32 kip axle load) being applied on 24-inch pipe with cover removed

Figure 9.



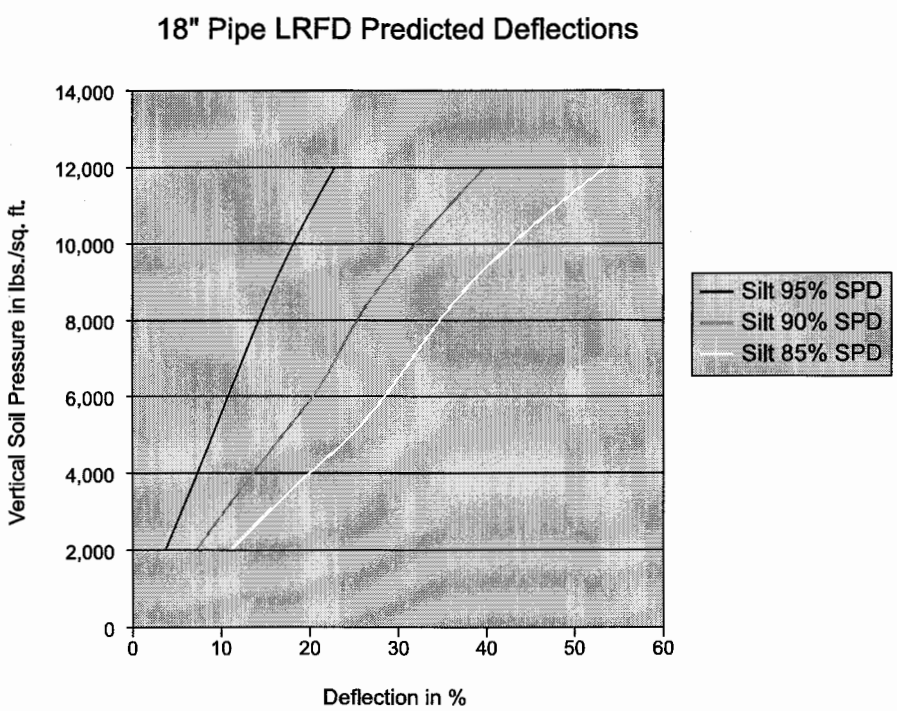
Sketch of the small Utah State University high vertical soil pressure test cell, showing the setup for testing corrugated plastic pipe. The test can be conducted with or without the "select soil" envelope (gravel)

Figure 10.



The LRFD formula for deflection would have predicted the deflections shown in Figure 10A. The LRFD formula over-predicts deflections in well-compacted soil by a factor of 4. This is consistent with the overly conservative design method. At the soil pressures in the test cells in both tests, the resultant wall thrust exceeded that predicted by the AASHTO equations (8&9) by a factor of 2 using short-term material values, and by a factor of 10 using long term (50 year) material values. In these tests however, no wall thrust failure occurred. So, ultimate wall thrust loads must be greater than those in these tests. These tests also exceeded the predicted wall buckling pressures by approximately 50%. With deflections less than 5% in these tests, wall strain was about 1%, well under the strain limit for HDPE.

Figure 10A.



In 1987, under the direction of Dr. Ernest Selig, a 24″ diameter corrugated polyethylene pipe was installed in a 100′ highway fill under I-279 North of Pittsburgh, PA as a test of the pipe's performance under high soil pressures in a realistic installation. Pipe shape and circumference have been monitored, along with soil pressure at crown and spring line, free field soil strain, and trench strain (pipe and backfill). Under 100 feet of fill, this pipe has shortened vertically 4.43%, with 1.6% represented in circumferential shortening. The actual deflection is therefore only 2.8%. The free field soil strain is 4.8%. Because of the combination of circumferential shortening and deflection, a soil arch has developed over pipe in the fill, reducing the vertical soil pressure at the crown to only 22% of the predicted (by Marsten) soil pressure and 27% of that predicted by the LRFD method for factored load. Total vertical shortening is 55% of that predicted by the Iowa Formula (1) and 65% of that predicted by LRFD. Actual deflection (out of roundness) is only 35% of that predicted by the Iowa formula. In the case of LRFD, the total deflection includes a circumferential shortening term. LRFD does, however, predict that the pipe would fail under the installed conditions at 36 feet from flexural compression. If the resistance factors were removed and load factors remained, LRFD would predict a failure point at 60 feet of depth in compression. Using the AASHTO design calculations by either method indicates that the pipe would have failed in wall crushing at between 36 feet and 60 feet. Dr. Selig has shown that finite element analysis programs, specifically CANDE and SOILCON, can predict the kind of results found in this study.

In 1989, Dr. Lester Gabriel conducted a series of tests in a soil cell at California State University on 4″, 6″, 8″ & 12″ corrugate polyethylene pipe. The backfill was Class 1, Type A aggregate as defined by CALTRANS. This material was dumped into place to model poor quality backfill placement. Deflections in this test were approximately ½ of those predicted by the Iowa Fomula (1), using E' of 1,000 psi for dumped gravel.

Dr. Michael Katona has published two papers - one on minimum cover, one on maximum cover - on corrugated polyethylene pipe using finite element analysis (CANDE). The minimum cover analysis had excellent correlation with Dr. Watkins' work discussed earlier. The maximum cover analysis, which based its input on the AASHTO design procedure, has been shown to be very conservative, based on Dr. Selig's work in Pennsylvania.

In July of 2002, the Ohio Research Institute for Transportation and the Environment published their final report on deep burial of thermoplastic pipe. The pipe was buried from 20 feet to 40 feet and measurements were taken for deflection, circumferential shortening, profile changes, strains, and soil pressures against the pipe walls. The study concluded that thermoplastic pipe field response stabilizes within a three month time period. In addition, the pipe will work to shed load, and sand backfill properly utilized is nearly as effective as stone backfill.

In one additional study of note, Mr. R.W. Culley of the Saskatchewan Department of Highways and Transportation conducted a test where 25,000 cycles of load were passed over a 600mm (24 inch) diameter corrugated polyethylene pipe with no increase in deflection. Backfill was gravel compacted to 85% to 90% AASHTO T-99 density.

Research done by Dr. Al. Moser (on PVC) and Dr. Lans-Eric Janson (on PE) has shown that the strain limits of 3.5% and 8% respectively for these materials are conservative and in typical installation should not be a failure mode.

Dr. Watkins and Dr. Janson both provide guidance on the use of short- and long-term modulus and tensile values in the design equation, with Dr. Watkins stating: "Because stresses in the pipe relax, design should be based on quick modulus of elasticity and early strength – not 50 or 100 year

strength under persistent stresses." Dr. Janson states, "For each new short-term change of deflection, whenever it comes up, the pipe materials has a stiffness corresponding to the short term loading conditions." Further, "It should be the long-term creep modulus which shall be used in determining the ring stiffness from a pipe classification point of view." The exception to this may be the Buckling Equation, particularly in poor soils.

REAL WORLD INSTALLATIONS

The performance of the plastic pipe in "real world" installations is the more telling proof of whether the design calculations and the research projects truly represent the type of results found in the field. With a performance history of only 40 years of less, it is prudent for the Engineer to familiarize himself with actual installation investigations. Hundreds of these now exist for PE pipe.

In 1985, John Hurd completed a study of nearly 200 cross drain installations of corrugated polyethylene pipes (T.R.R. 1087). Pipe performance was most affected by installation quality, and problems were largely confined to smaller (12″ and 15″) sizes. Deflection appeared to be built into the culverts instead of caused by highway loadings.

One particular installation covered in John Hurd's report, a 24″ cross drain in Noble County, Ohio, has now been studied for 20 years. This site is particularly aggressive, with low pH flows, highly abrasive flows, and a minimum cover (15″-18″). The pipe is still in excellent condition and deflection has not changed since six months after installation, despite heavy truck loads.

Another D.O.T. study, this one by L. John Fleckenstein and David L. Allen of the Kentucky Transportation Center, investigated the condition of 14,195 feet of smooth interior corrugated polyethylene pipe. Deflections were found to be small in the storm sewer installations. Driveway culverts tended to be shallower and more poorly backfilled and exhibited greater deflections, although largely localized. Some of the driveway culverts had as little as 2 –3 inches of cover.

A 1986 review by the Pennsylvania D.O.T. of culvert installations in western Pennsylvania, where pH of flows tends to be low, led to the recommendation that corrugated polyethylene pipe be used for maintenance and included on new design projects. One pipe, in Venango County, had been installed in 1984 in a site where corrugated steel pipe was replaced every six months. The corrugated PE pipe was in excellent condition in 1986, and the pipe is still performing well in 2004. Cover on these pipes ranged from 2″ to 4′.

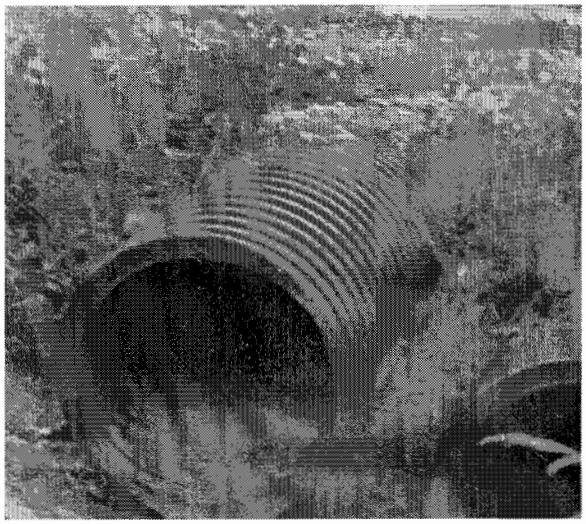
The South Carolina D.O.T. completed a 3 year study of corrugated polyethylene pipe in 1989. Deflections were reported as minimal in all test installations. Smooth interior pipe was favored over corrugated interior pipe for most installations. Cover on these pipes fanged from 2″ to 3′. Recommendations included increased use of both types of pipe, with cross drains limited to smooth interior.

In 1990, based on an evaluation of 6,400 feet of 30 and 36 inch diameter smooth interior corrugated polyethylene pipe, the New York D.O.T. approved the use of this pipe for culverts and storm sewers. Minimum cover was set at 12″ and maximum at 15′. Anticipated service life is given as 70 years.

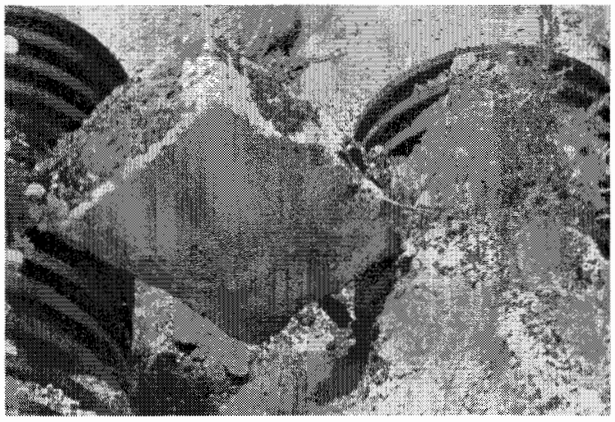
A review of these user reports supplies some guidance on how plastic pipe performs under typical highway installation conditions. An inspection of installations made with disregard for good practice provides additional information regarding the performance limits of these products. A

number of installations in Ohio provide an interesting look at installation abuses and the ability or inability of plastic pipe to survive and continue to perform its intended function.

In Noble County, Ohio, under S.R. 564, there are two multiple pipe installation worth review. Both are extreme examples of inappropriate practices, for different reasons, yet both are performing quite well. The northern of the two installations consists of two parallel, 24″ diameter, Type C corrugated polyethylene pipes installed with minimum cover. The upstream ends are approximately 9″ apart, while the downstream ends are touching. Standard recommendations require a minimum of 12″ of separation in order to assure adequate backfill placement between the pipes. At the downstream end, there is little backfill below the spring line of the pipes and some soil movement from the surface to the void area has occurred. The pipes are in good shape are performing their intended function.

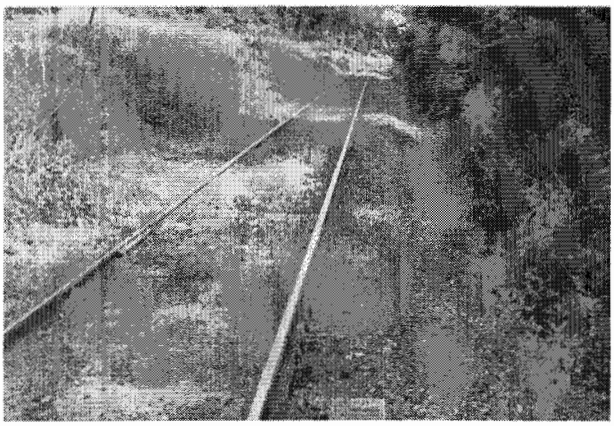


The other installation is just north of Middleburg, OH, where three, 24″ diameter, Type S pipes are installed in parallel. In this case, spacing is only a little closer than appropriate, but the backfill includes large concrete rubble. These pipes are performing well, are round and straight.

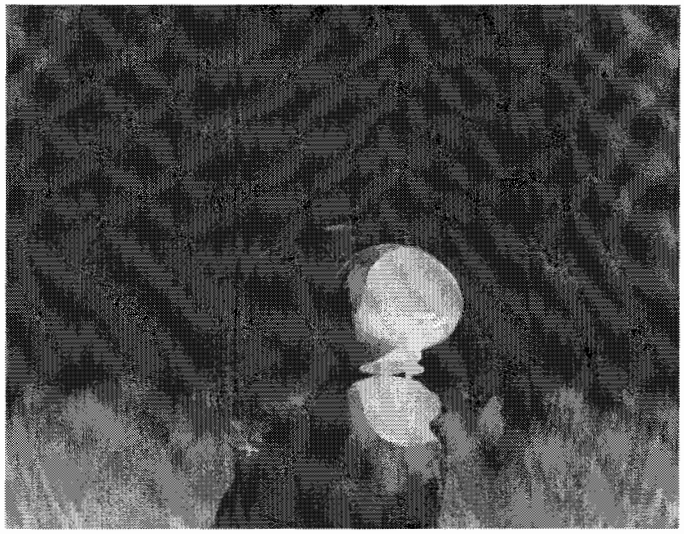


In Muskingum OH, where a county road intersects a state road, a 12″ corrugated polyethylene pipe was installed across the gravel road in such a way that the corrugations stuck up through the surface of the road. In the winter of 1983-84 a snow plow cut the tops off the corrugations. The pipe, backfilled with gravel, is still functioning (17 years later) as intended. Traffic, including a school bus, runs over the cut end regularly. The 12″ minimum cover requirement certainly was not followed.

One installation we discovered involved a 12″ diameter corrugated polyethylene pipe installed under a railroad track outside Peninsula, Ohio. This pipe was installed to replace a failed steel pipe, which has not been removed; in fact, the polyethylene pipe was placed on top of the steel pipe. Cover, below the ties, is 6″ or less and backfill is railroad ballast rock. The pipe is in good shape and is performing well. Recommended minimum cover under railroad loading is 24″ from the bottom of the ties.



One project of particular interest was a private shopping complex with both corrugated polyethylene pipe and a reinforced concrete pipe installed by the same contractor with the same backfill; in this case large lumps of blue clay, pushed into place with a dozer. The 36″ diameter corrugated polyethylene pipe is slightly misaligned, although the joints are intact and secure. Maximum deflection is 7%. The 42″ concrete pipe is misaligned at the joints, with the gasket hanging out of one joint and the bell broken on another joint. The lesson here is that poor construction practice will affect any pipe type in a negative manner regardless of pipe type.



SUMMARY

1. The current traditional design procedures, although intended for flexible (elastic) pipes, appear to offer a conservative design approach for currently manufactured thermoplastic pipe.

2. Existing state reports on thermoplastic pipe in actual service indicated good performance, particularly when installed with reasonable care.

3. Performance of thermoplastic pipe, when poorly installed, is comparable with more traditional products, when poorly installed.

4. Design procedures will continue to evolve as additional research is completed. Simplified, user-friendly, finite element analysis programs based on research findings will be used more in special project design.

5. The LRFD method specifically designed for thermoplastic pipe is overly conservative in comparison to other methods, and under-predicts the performance of plastic pipe by up to a factor of 5.

REFERENCE SPECIFICATIONS

Polyethylene (PE)

AASHTO M252	Corrugated Polyethylene Drainage Tubing
AASHTO M294	Corrugated Polyethylene Pipe, 12 to 36 in. Diameter
ASTM D1248	Polyethylene Plastics Molding and Extrusion Materials
ASTM D2104	Polyethylene (PE) Plastic Pipe, Schedule 40
ASTM D2239	Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D2447	Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter
ASTM D3035	Polyethylene (PE) Plastic Pipe, (DR-PR) Based on Controlled Outside Diameter
ASTM D3350	Polyethylene Plastics Pipe and Fittings Materials
ASTM F405	Corrugated Polyethylene (PE) Tubing and Fittings
ASTM F449	Subsurface Installation of Corrugated Polyethylene Pipe for Agricultural Drainage or Water Table Control
ASTM F481	Installation of Thermoplastic Pipe and Corrugated Pipe in Septic Tank Leach Fields
ASTM F585	Insertion of Flexible Polyethylene Pipe into Existing Sewers
ASTM F667	Large Diameter Corrugated Polyethylene Pipe and Fittings
ASTM F714	Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
ASTM F810	Smoothwall Polyethylene (PE) Pipe for Use in Drainage and Waste Disposal Absorption Fields
ASTM F894	Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe

Poly Vinyl Chloride (PVC)

AASHTO M264	Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping
AASHTO M278	PS46 Poly Vinyl Chloride (PVC) Pipe

AASHTO M304	Poly (Vinyl Chloride) (PVC) Ribbed Drain Pipe and Fittings Based on Controlled Inside Diameter
ASTM D2672	Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement
ASTM D3915	Rigid Poly (Vinyl Chloride) (PVC) and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds for Plastic Pipe and Fittings
ASTM F679	Poly (Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings
ASTM F794	Poly (Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter
ASTM D2665	Poly (Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings
ASTM D1785	Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
ASTM D2241	Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
ASTM D2729	Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings

Applicable General Specifications

AASHTO R6	Standard Recommended Practice for Plastic Pipe and Tubing
AASHTO Section 12	
AASHTO Section 18	Soil Thermoplastic Pipe Interaction Systems
ASTM D883	Standard Terminology Relating to Plastics
ASTM D2321	Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity Flow Applications
ASTM F412	Definitions of Terms Relating to Plastic Piping Systems

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TRANSMITTAL

DATE: May 17, 2006

TO: Environmental

FROM: Jason Purse, Planner

SUBJECT: **SP-145-05, Langley Federal Credit Union (Resubmittal)**

ITEMS ATTACHED: Storm Drainage Pipe Design

ACTION: Please review and return comments by May 31, 2006

RECEIVED
MAY 17 2006
ENVIRONMENTAL DIVISION

This was a supplemental report provided to address comment #9b as issued by the Environmental Division on April 13, 2006. It is part of the May 10, 2006 plan of development resubmittal from Planning. It is a structural analyses report for the oversized 48-inch corrugated polyethylene pipe system being used for underground detention (quantity control.) The report has been reviewed and approved by our Division.

Scott J Thorne 5-26-06

JCSA:

General Comments:

1. Per the proffers, the Applicant shall be responsible for developing water conservation standards to be submitted to and approved by the James City Service Authority prior to final plan approval. Please contact Mrs. Beth Davis, JCSA Environmental Education Coordinator at (757)253-6859 for coordination as early in the design process as possible. The standards must be approved prior the plan.
   Response: Water Conservation Standards dated March 14, 2006 have been included with this submittal for your review.

2. Reference the County monumentation used and any temporary bench mark established on site.
   Response: The monumentation used (Sta. 325) has been added to Note #16 on the Cover Sheet.

3. Provide a recordable easement plat for the required JCSA Urban Easements at the fire hydrant and exiting sewer clean out.
   Response: The easement plat is enclosed with this submittal.

Sheet 4:

1. Label details W13.0 and W15.0 as JCSA.
   Response: The details have been labeled as "JCSA" on Sheet 4.

2. Remove the extra valve by the fire hydrant.
   Response: The valve has been removed.

3. Show the segmental block wall or remove the call out.
   Response: The call-out for the wall has been removed.

Environmental:

General:

1. The existing sediment trap to the north of the site was not labeled as requested in previous comment # 7. Label the existing sediment trap as existing temporary sediment trap # 3 per approved County Plan No. SP-50-02 (New Town Section 2 & 4, Phase I roadway improvements).
   Response: The existing sediment trap has been labeled on all applicable sheets.

Chesapeake Bay Preservation:

2. The variable width RPA buffer was not shown on Environmental Inventory Sheet 3 as requested in previous comment # 8c. It cannot be determined if the limit of work for the project encroaches into the variable width RPA buffer.

Response: The RPA buffer and Voluntary Wetlands Buffer limits have been added to the plans.

3. The limit of RPA wetlands was not shown on Environmental Inventory Sheet 3 as requested in previous comment # 8d.
Response: The Wetlands limits have been added to the plans.

Erosion & Sediment Control Plan:

4. Phase I E&SC. The Phase I erosion and sediment control plan was reconfigured considerably since the last submission. The following comments pertain to the revised Phase I E&S plan on Sheet 3.

4a. Diversion dikes which convey disturbed area runoff to the onsite temporary sediment trap must be shown going into the trap - not the trap's stone overflow outlet structure. Also, provide matting or stone reinforcement within the trap's side slopes where diversion dikes enter the basin. Interior side slopes of the trap must not erode due to incoming runoff from the diversions.
Response: Sheet 3 has been revised to direct runoff from the diversion dikes directly into the trap. Riprap was added.

4b. Label the silt fence on the north side of the 60 ft. public (road) right-of-way with standard VESCH keys (SF).
Response: The silt fence has been labeled on Sheet 3.

4c. Response to previous comment # 15 is noted; however, standard keys and symbols for dust control, in accordance with VESCH requirements, must be shown on Phase I E&SC plan Sheet 3. Dust control will be important during initial site clearing, grubbing and initial grading operations.
Response: Dust Control symbols have been added to Sheet 3. In addition, Dust Control measures have been added to the E&S Narrative on Sheet 6.

5. Slope Labels. Label all graded cut and fill slopes with slope indicators as intended (i.e. 4H:1V, 3H:1V, etc.). This is mainly for the graded berm along the Monticello side, the cut slope along the west side of the project and the fill slope to the east of the parking area to the north of the building. Slopes steeper than 3H:1V require matting.
Response: Slope labels have been added to Sheet 5.

Stormwater Management / Drainage:

6. General note # 14 was added to the cover sheet of the plans to address previous comment # 16. Add a second line (sentence) to that note to state that the "onsite

stormwater management facility (oversized underground detention pipe) is for quantity control purposes only."
Response: The additional language has been added to Note #15 on the Cover Sheet.

7. Existing Storm System. The existing invert elevation is not indicated for the "EX. MH" structure (Rim 84.70) as situated in the southeast corner of the site. This is the first storm drainage structure across (on the north side of) Monticello Avenue. Also, as proposed onsite storm System 2 ties into existing storm drainage piping systems along New Town Avenue, existing pipe and inlet information needs to be shown on Sheet 5 for the existing pipe system below proposed storm structure SS # 2-1. Pipe information for the existing system needs to closely correspond to that shown in the storm sewer computations in the design report.
Response: The invert for the existing manhole situated in the southeast corner of the site was added to the plans. The existing pipe and inlet information for the storm drainage system along New Town Avenue was added to the plans.

8. Drainage Easements. Label the existing drainage easement through the site along the existing 48-inch RCP pipe from south site border (at Monticello Ave.) to the north site border (at the 60 ft. public road R/W). Sheets 3, 4, 5 and 6 appear to have linework for a drainage easement; however, a label is not provided. If not present, a drainage easement (minimum width of 25 feet for 48-inch pipe) would be necessary to ensure offsite drainage can be adequately maintained through the development site.
Response: The drainage easement for the 48" pipe was added to the plans.

9. Underground Detention System. The stormwater management plan for the site was reconfigured since the last submission. The following comments pertain to the oversized pipe - underground stormwater detention system for the site.

   9a. Previous comment # 19d was not addressed in the comment – response letter dated December 7, 2005. No details or sections were found for installation of the 48-inch corrugated polyethylene pipe (HDPE) system under/along the proposed parking lot. Indicate type of pipe to be used (i.e. ASTM AASHTO M294 Type S, etc.) and requirements for bedding, haunching, backfill and final backfill (cover) over the pipe. Minimum cover must also be stated or shown on the details for during construction and final conditions (Note: 2 ft. recommended during construction, 1 ft. for final conditions.) It is recommended that installation follow standard manufacturer recommendations and/or ASTM D2321 requirements as applicable.
   Response: A detail and notes have been added to Sheet 9 of the plans.

9b. Provide polyethylene pipe structural computations to show adequacy of the system for deflection, buckling, bending stress and strain based on dead and live load conditions. Section modulus and minimum pipe stiffness used in computations shall be based on standard values from manufacturer's information or polyethylene pipe association standards.
Response: To be submitted under separate cover.

9c. The pipe slope for the 15-inch HDPE storm pipe segment between storm structures SS # 1-2 (Outlet Structure Weir Manhole) and existing DI Inlet 1-1 is shown as 13 percent on plan Sheet 3; however, storm sewer computations shown in the design report show a pipe slope of 11.28 percent. Ensure a steeper pipe slope does not result in pre-development allowable discharges being exceeded under post development conditions.
Response: Sheet 5 was revised to show the pipe slope to be 11.28%. The steeper slope does not result in a post-development flow that exceeds the pre-development flow due to the control of flow by the outlet structure.

9d. Similar to the above comment, the pond report (Hydraflow hydraulic model) for the weir structure at SS # 1-2 shows a 15-inch outfall pipe at invert elevation 78.0, a length of 5 feet and a slope of 1 percent. This is assumed to be the 15-inch HDPE outfall pipe from SS # 1-2 (weir manhole) to existing structure 1-1. The information in the hydraulic model does not match any of the information in the storm sewer design report or Sheet 5 construction plan information.
Response: The pond report has been revised to include the correct information for the outfall pipe from SS#1-2 to existing structure #1-1.

10. Manhole SS # 1-2. Response to previous comment # 24 "The stormwater management system has been re-designed" is noted; however, it is still unclear how tailwater in the existing storm drainage piping system along New Town Avenue was considered in the design of the onsite stormwater management system. In specific, how was tailwater considered downstream of the new 15-inch HDPE pipe between SS # 1-2 (Weir Manhole) and existing Inlet 1-1 accounted for in the hydraulic model in the design report. The hydraulic grade line at existing inlet 1-1 is shown at El. 75.48.
Response: Elevation 75.48 is the elevation of the crown of the proposed 15" HDPE pipe at Inlet #1-1. This value is considered to be conservative in the design of the proposed storm system.

11. Minimum Standard # 19. The 11 x 17 inch size drainage map and grading plan on Sheet 5 clearly show that runoff from the adjacent parcel to the west (n/f WHS Land Holding LLC) and from the onsite 3H:1V cut-slope area at the west part of the site will be intercepted by a onsite stormwater conveyance channel which runs parallel to the west curb line. This drainage is then brought around the northwest

corner of the site and flows in an east direction (along the curb line) to the 60 ft. public right-of-way. Although in the future the roadway will be extended, in the interim condition, this drainage cannot be discharged in a concentrated manner to a location which is on a uniform slope and does not have any type of natural receiving drainage channel. Furthermore, just downslope of this discharge area is the location of the variable width RPA buffer which is a protected and sensitive area. This scenario raises several issues that must be properly addressed:

11a. Provide computations for the onsite stormwater conveyance channel design consistent with Minimum Standard # 19 of the Virginia Erosion and Sediment Control regulations. No onsite channel design computations were provided nor do the plans indicate channel specifications (width, slope, side slopes, depth, lining, etc.) nor requirements for outlet protection at the end of the channel in accordance with Minimum Standard #11 of the Virginia Erosion and Sediment Control regulations.
Response: Design calculations are included in the Drainage Calculations. A detail was added to Sheet 9 of the plans.

11b. The outfall of the onsite graded channel must discharge to a well-defined, adequate receiving channel, either natural or man-made.
Response: A drainage inlet (SS #1-5A) was added to the plans adjacent to the proposed entrance to the property. This inlet will collect the runoff that is concentrated in the onsite stormwater conveyance channel and will direct the flow into the onsite underground storage system. When the property to the west of the site is developed, and the road extended, the drainage area contributing to this inlet will be significantly reduced. At most, the modification will result in an additional drainage area of 0.07 acres included in the onsite system if a low point at the inlet location remains. If it is decided to create a berm between the parking lot and the road, the inlet will be removed at that time. The calculations for the underground storage system were revised to include the 0.07 acres.

11c. Channel adequacy computations must be provided for the receiving channel in accordance with Minimum Standard # 19 and VESCH procedure.
Response: See response to comment 11b.

11d. As it does not appear an adequate, well-defined natural receiving channel is present at the outfall location of the graded onsite stormwater conveyance channel, resolve of these issues may result in the need to divert the drainage from the west part of the site into the onsite storm system and revise the stormwater management facility (underground detention system) computations accordingly.
Response: See response to comment 11b.

AES CONSULTING ENGINEERS
Engineering, Surveying, and Planning
5248 Olde Towne Road, Suite 1
WILLIAMSBURG, VIRGINIA 23188

Phone: (757) 253-0040
Fax: (757) 220-8994

LETTER OF TRANSMITTAL

RECEIVED
OCT 1 2007
ENVIRONMENTAL DIVISION

ATTN:

CO.: JCC Environmental Division

Address: 101 Mounts Bay Road, Building E
Williamsburg, Va 23185

cc: Alan Robertson, WJCC Schools

DATE	JOB NO.
10/1/07	9529-03

FROM: Nick Botta

RE
Langley Federal Credit Union

WE ARE SENDING YOU THE FOLLOWING ITEMS:

☒ Attached
☐ Under separate cover via

☐ Original(s) ☐ Print(s) ☒ Plan(s) ☐ Specification(s) ☐ Change Order

☐ Copy of letter(s) ☐ Other:

COPIES	DATE	No. of Pages	DESCRIPTION
1	10/1/07	1	BMP Record Drawing
1	10/1/07		BMP Certification

THESE ARE TRANSMITTED as checked below:

☐ For your approval ☐ For your signature ☒ For review and comment

☐ For your use ☐ As you requested ☐ As requested by:

☐ Other:

REMARKS:
A mylar will be submitted after the Record Drawing is found to be acceptable by your review.

If enclosures are not as noted, kindly notify us at once.

File name: S:\Jobs\9529\03- BMP Cert\Admin\Correspondence\Transmittals\952903 LOT 2007-10-01 JCC.doc
Form Rev. 7/02

TRANSMITTAL

RECEIVED
MAY 10 2006
ENVIRONMENTAL DIVISION

DATE: May 10, 2006

TO: Environmental$
JCSA*

FROM: Jason Purse, Planner

SUBJECT: **SP-145-05, Langley Federal Credit Union (Resubmittal)**

ITEMS ATTACHED: Site Plan
Drainage Calculations$
JCSA Water Conservation Standards*
JCSA Recordable Easement Plat*

ACTION: Please review and return comments by May 24, 2006

Plan is Approved.

for DEC
5-26-06

AES CONSULTING ENGINEERS
Engineering, Surveying, and Planning
5248 Olde Towne Road, Suite 1
WILLIAMSBURG, VIRGINIA 23188

Phone: (757) 253-0040
Fax: (757) 220-8994

LETTER OF TRANSMITTAL

ATTN: **Jason Beck**

CO.: JCC Environmental Division

Address: 101 Mounts Bay Road, Building E

Williamsburg, Va 23185

cc: Alan Robertson, WJCC Schools

DATE	JOB NO.
10/8/07	9529-03

FROM: Nick Botta

RE
Langley Federal Credit Union

RECEIVED
OCT 9 2007
ENVIRONMENTAL DIVISION

WE ARE SENDING YOU THE FOLLOWING ITEMS: ☒ Attached ☐ Under separate cover via

☐ Original(s) ☐ Print(s) ☒ Plan(s) ☐ Specification(s) ☐ Change Order

☐ Copy of letter(s) ☐ Other:

COPIES	DATE	No. of Pages	DESCRIPTION
1	10/1/07	1	BMP Record Drawing (Mylar)

THESE ARE TRANSMITTED as checked below:

☐ For your approval ☐ For your signature ☐ For review and comment

☐ For your use ☒ As you requested ☐ As requested by:

☐ Other:

REMARKS:

If enclosures are not as noted, kindly notify us at once.

File name: \\Aeswilss01\jobs\Jobs\9529\03- BMP Cert\Admin\Correspondence\Transmittals\952903 LOT 2007-10-08 JCC.doc
Form Rev. 7/02

James City County Environmental Division
Stormwater Management / BMP Inspection Report
Subsurface - Detention and Infiltration Facilities

County BMP ID Code (if known): PC-138

Name of Facility: Langley Federal Credit Union BMP No.: _____ Date: 10/4/07

Location: Monticello Avenue and New Town Avenue

Name of Owner: Langley Federal Credit Union

Name of Inspector: Jason Beck

Type of Facility: Underground Detention facility

Weather Conditions: Hot - Type: ☒ Final Inspection ☐ County BMP Inspection Program ☐ Owners Inspection

If an inspection item is not applicable, mark NA, otherwise mark the appropriate column.

O.K. - The item checked is in adequate condition and the maintenance program is currently satisfactory. No action required.
Routine - The item checked requires attention, but does not present an immediate threat to the function/integrity of the BMP.
Urgent - The item checked requires immediate attention to keep the BMP operational and prevent damage to the facility.

Provide an explanation and details in the comment column, if routine or urgent are marked.

Facility Item	O.K.	Routine	Urgent	Comments
Accessibility:				
Roads	✓			
Parking Areas	✓			
Gates	N/A			
Locks	N/A			
Safety Fencing	N/A			
Access Points:				
Trap Doors	N/A			
Manholes/ Vaults	✓			
Grates	✓			
Observ Wells	N/A			
Pretreatment Devices: ☒ **Inlet** ☐ **Sump** ☐ **Forebay** ☐ **Other**				
Sediment	✓			
Trash & Debris	✓			
Structure	✓			
Other	✓			

Facility Item	O.K.	Routine	Urgent	Comments
Primary Storage/ Infiltration Area Structure (Pipe, Stone, etc):				
Trash & Debris				
Sediment				
Ponding / Drawdown				
Cracks				
Joints				
Seams				
Coating				
Aesthetics				
Other	✓			48" HDPE
Inlet Structure # 1 (Describe Location):				
Condition of Structure	✓			All curb inlets and the one
Erosion	✓			yard inlet were okay.
Trash and Debris	✓			
Sediment	✓			
Aesthetics	✓			
Other				
Inlet Structure # 2 (Describe Location):				
Condition of Structure				
Erosion				
Trash and Debris				
Sediment				
Aesthetics				
Other				
Inlet Structure # 3 (Describe Location):				
Condition of Structure				
Erosion				
Trash and Debris				
Sediment				
Aesthetics				
Other				
Outlet - Principal Overflow or Bypass Structure (Describe Location):				
Condition of Structure				None shown
Erosion				
Trash and Debris				
Sediment				
Other				

Facility Item	O.K.	Routine	Urgent	Comments
Nusiance Type Conditions:				
Mosquito Breeding	✓			
Animals, Rodents	✓			
Graffiti	✓			
Other	✓			
Perimeter (Contributing Drainage Area) Conditions:				
Stabilization	✓			
Vegetation Condition	✓			
Trash and Debris	✓			
Aesthetics	✓			
Other				

Remarks:

Overall Environmental Division Internal Rating: 3

Signature: [signature] **Date:** 10/4/07

Title: Environmental Inspector

SWMProg\BMP\CoInspProg\SubDetInfil.wpd

Date Record Created:

Created By:

WS_BMPNO: PC138

WATERSHED	PC
BMP ID NO	138
PLAN NO	SP-145-05
TAX PARCEL	(38-4)(1-55)
PIN NO	3840100055
CONSTRUCTION DATE	
PROJECT NAME	Langley Federal Credit Union
FACILITY LOCATION	5220 Monticello Avenue
CITY-STATE	Williamsburg, Va. 23188
CURRENT OWNER	Langley Federal Credit Union
OWNER ADDRESS	1055 West Mercury Blvd
OWNER ADDRESS 2	
CITY-STATE-ZIP CODE	Hampton, VA 23661
OWNER PHONE	827-7200
MAINT AGREEMENT	Yes
EMERG ACTION PLAN	No

Get Last BMP No | Return to Menu | Print Record

MAINTENANCE PLAN	Yes	CTRL STRUC DESC	Underground
SITE AREA acre	2	CTRL STRUC SIZE inches	48
LAND USE	Mixed Use	OTLT BARRL DESC	
old BMP TYP	Dry Pond	OTLT BARRL SIZE inch	
JCC BMP CODE	F2 Dry ED with forebay		
POINT VALUE	0	EMERG SPILLWAY	No
		DESIGN HW ELEV	72.2
		PERM POOL ELEV	na
SVC DRAIN AREA acres	1.28	2-YR OUTFLOW cfs	0.39
		10-YR OUTFLOW cfs	2.86
		REC DRAWING	Yes
SERVICE AREA DESCRI	Building & Parking area		
IMPERV AREA acres	1.02	CONSTR CERTIF	Yes
RECV STREAM	UT of Powhatan Creek		
EXT DET-WQ-CTRL	No	LAST INSP DATE 10/4/2007	Inspected by:
WTR QUAL VOL acre-ft	0	INTERNAL RATING	3
CHAN PROT CTRL	Yes	MISC/COMMENTS	
CHAN PROT VOL acre-ft	0.197	Underground detention storm pipe (quantity control only), 350 ft. of 48-inch	
SW/FLOOD CONTROL	Yes		
GEOTECH REPORT	No		

Additional Comments:

Previous Comments

ENVIRONMENTAL DIVISION REVIEW COMMENTS
NEW TOWN – LANGLEY FEDERAL CREDIT UNION
COUNTY PLAN NO. SP – 145 - 05
April 13, 2006

General:

1. The existing sediment trap to the north of the site was not labeled as requested in previous comment # 7. Label the existing sediment trap as existing temporary sediment trap # 3 per approved County Plan No. SP-50-02 (New Town Section 2 & 4, Phase I roadway improvements).

Chesapeake Bay Preservation:

2. The variable width RPA buffer was not shown on Environmental Inventory Sheet 3 as requested in previous comment # 8c. It cannot be determined if the limit of work for the project encroaches into the variable width RPA buffer. Sheet 3 V.W RPA buffer + Corp. Vol. wetland buffer shown.

3. The limit of RPA wetlands was not shown on Environmental Inventory Sheet 3 as requested in previous comment # 8d.

Erosion & Sediment Control Plan:

4. Phase I E&SC. The Phase I erosion and sediment control plan was reconfigured considerably since the last submission. The following comments pertain to the revised Phase I E&S plan on Sheet 3.

   4a. Diversion dikes which convey disturbed area runoff to the onsite temporary sediment trap must be shown going into the trap - not the trap's stone overflow outlet structure. Also, provide matting or stone reinforcement within the trap's side slopes where diversion dikes enter the basin. Interior side slopes of the trap must not erode due to incoming runoff from the diversions. DD ok. Riprap shown.

   4b. Label the silt fence on the north side of the 60 ft. public (road) right-of-way with standard VESCH keys (SF). Done.

   4c. Response to previous comment # 15 is noted; however, standard keys and symbols for dust control, in accordance with VESCH requirements, must be shown on Phase I E&SC plan Sheet 3. Dust control will be important during initial site clearing, grubbing and initial grading operations. DC symbol shown.

5. Slope Labels. Label all graded cut and fill slopes with slope indicators as intended (i.e. 4H:1V, 3H:1V, etc.). This is mainly for the graded berm along the Monticello side, the cut slope along the west side of the project and the fill slope to the east of the parking area to the north of the building. Slopes steeper than 3H:1V require matting. OK

Stormwater Management / Drainage:

6. General note # 14 was added to the cover sheet of the plans to address previous comment # 16. Add a second line (sentence) to that note to state that the "onsite stormwater management facility (oversized underground detention pipe) is for quantity control purposes only."

7. Existing Storm System. The existing invert elevation is not indicated for the "EX. MH" structure (Rim 84.70) as situated in the southeast corner of the site. This is the first storm drainage structure across (on the north side of) Monticello Avenue. Also, as proposed onsite storm System 2 ties into existing storm drainage piping systems along New Town Avenue, existing pipe and inlet information needs to be shown on Sheet 5 for the existing pipe system below proposed storm structure SS # 2-1. Pipe information for the existing system needs to closely correspond to that shown in the storm sewer computations in the design report.

8. Drainage Easements. Label the existing drainage easement through the site along the existing 48-inch RCP pipe from south site border (at Monticello Ave.) to the north site border (at the 60 ft. public road R/W). Sheets 3, 4, 5 and 6 appear to have linework for a drainage easement; however, a label is not provided. If not present, a drainage easement (minimum width of 25 feet for 48-inch pipe) would be necessary to ensure offsite drainage can be adequately maintained through the development site.

9. Underground Detention System. The stormwater management plan for the site was reconfigured since the last submission. The following comments pertain to the oversized pipe - underground stormwater detention system for the site.

   9a. Previous comment # 19d was not addressed in the comment – response letter dated December 7, 2005. No details or sections were found for installation of the 48-inch corrugated polyethylene pipe (HDPE) system under/along the proposed parking lot. Indicate type of pipe to be used (ie. ASTM AASHTO M294 Type S, etc.) and requirements for bedding, haunching, backfill and final backfill (cover) over the pipe. Minimum cover must also be stated or shown on the details for during construction and final conditions (Note: 2 ft. recommended during construction, 1 ft. for final conditions.) It is recommended that installation follow standard manufacturer recommendations and/or ASTM D2321 requirements as applicable. sheet 9

   9b. Provide polyethylene pipe structural computations to show adequacy of the system for deflection, buckling, bending stress and strain based on dead and live load conditions. Section modulus and minimum pipe stiffness used in computations shall be based on standard values from manufacturer's information or polyethylene pipe association standards. Not provided, under separate cover. Provided May 17 2006

   9c. The pipe slope for the 15-inch HDPE storm pipe segment between storm structures SS # 1-2 (Outlet Structure Weir Manhole) and existing DI Inlet 1-1 is shown as 13 percent on plan Sheet 3; however, storm sewer computations shown in the design report show a pipe slope of 11.28 percent. Ensure a steeper pipe slope does not result in pre-development allowable discharges being exceeded under postdevelopment conditions.

   11.28 shown, no impact on hydraulics.

9d. Similar to the above comment, the pond report (Hydraflow hydraulic model) for the weir structure at SS # 1-2 shows a 15-inch outfall pipe at invert elevation 78.0, a length of 5 feet and a slope of 1 percent. This is assumed to be the 15-inch HDPE outfall pipe from SS # 1-2 (weir manhole) to existing structure 1-1. The information in the hydraulic model does not match any of the information in the storm sewer design report or Sheet 5 construction plan information. now ok

10. Manhole SS # 1-2. Response to previous comment # 24 "The stormwater management system has been re-designed" is noted; however, it is still unclear how tailwater in the existing storm drainage piping system along New Town Avenue was considered in the design of the onsite stormwater management system. In specific, how was tailwater considered downstream of the new 15-inch HDPE pipe between SS # 1-2 (Weir Manhole) and existing Inlet 1-1 accounted for in the hydraulic model in the design report. The hydraulic grade line at existing inlet 1-1 is shown at El. 75.48. USED D/S pipe crown elevation.

11. Minimum Standard # 19. The 11 x 17 inch size drainage map and grading plan on Sheet 5 clearly show that runoff from the adjacent parcel to the west (n/f WHS Land Holding LLC) and from the onsite 3H:1V cut-slope area at the west part of the site will be intercepted by a onsite stormwater conveyance channel which runs parallel to the west curb line. This drainage is then brought around the northwest corner of the site and flows in an east direction (along the curb line) to the 60 ft. public right-of-way. Although in the future the roadway will be extended, in the interim condition, this drainage cannot be discharged in a concentrated manner to a location which is on a uniform slope and does not have any type of natural receiving drainage channel. Furthermore, just downslope of this discharge area is the location of the variable width RPA buffer which is a protected and sensitive area. This scenario raises several issues that must be properly addressed:

11a. Provide computations for the onsite stormwater conveyance channel design consistent with Minimum Standard # 19 of the Virginia Erosion and Sediment Control regulations. No onsite channel design computations were provided nor do the plans indicate channel specifications (width, slope, side slopes, depth, lining, etc.) nor requirements for outlet protection at the end of the channel in accordance with Minimum Standard # 11 of the Virginia Erosion and Sediment Control regulations. 0.34 FOS 0.36' < 0.5'

11b. The outfall of the onsite graded channel must discharge to a well-defined, adequate receiving channel, either natural or man-made. change to underground system 0.07 AC.

11c. Channel adequacy computations must be provided for the receiving channel in accordance with Minimum Standard # 19 and VESCH procedure.
NOT AN ISSUE NOW.

11d. As it does not appear an adequate, well-defined natural receiving channel is present at the outfall location of the graded onsite stormwater conveyance channel, resolve of these issues may result in the need to divert the drainage from the west part of the site into the onsite storm system and revise the stormwater management facility (underground detention system) computations accordingly.
Goes to inlet SS #1-5.