MSD

Metropolitan Sewer District

DESIGN MANUAL

LOUISVILLE AND JEFFERSON COUNTY
METROPOLITAN SEWER DISTRICT
700 WEST LIBERTY STREET
LOUISVILLE, KENTUCKY 40203-1911

TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

CHAPTER 1
INTRODUCTION
EXHIBITS

CHAPTER 1
INTRODUCTION

1.1 PURPOSE OF THE MSD DESIGN MANUAL

This MSD Design Manual is a guide for the planning and design of stormwater systems, flood protection works, sanitary sewers, erosion control structures, small sanitary pump stations, small wastewater treatment plants and associated activities for the Louisville and Jefferson County Metropolitan Sewer District. The guidelines and general design procedures in this manual are approved by the MSD Board.

This Manual:

a. Enumerates design standards that have been authorized by the MSD Board and/or KRS 76 to facilitate MSD's compliance with local, state and federal regulations.

b. Identifies submittal requirements and procedures for the review of infrastructure projects within the MSD service area.

c. Serves as a reference document for professional consultants in the design of infrastructure projects within the MSD service area.

1.2 DESCRIPTION AND USE OF THE MSD DESIGN MANUAL

The Manual identifies a single set of standards, submittal requirements and approval procedures to be used in the planning and design of projects within the MSD service area.

This Manual is not intended to serve as a step-by-step design methodology nor can this Manual address every situation, which may arise. The application of sound engineering/surveying principles and judgment combined with the information contained herein are necessary to complete the planning, design, and preparation of related construction documents for stormwater, sanitary sewer, and/or wastewater projects.

Approval of plans by MSD shall not relieve the designer or developer from required compliance with the provisions of this manual unless a written variance is received from MSD.

1.3 STRUCTURE OF THE MSD DESIGN MANUAL

The Manual contains 18 chapters. A general table of contents is found at the beginning of the Manual. To facilitate use of the Manual, a detailed table of contents can be found at the beginning of each chapter for text and exhibits.

The Manual is structured as follows:

a. Chapters 2 and 3 describe MSD's general planning and design approach, required submittals and approval procedures.

b. Chapters 4 through 7 detail MSD standards regarding drafting (manual and computer-aided), construction drawings, record drawings, surveying and easement documents.

c. Chapters 8 through 14 relate to the specific design of sanitary sewers, stormwater systems, erosion control structures, native revegetation, and tree preservation.

d. Chapters 15 and 18 relate to small pump stations, small wastewater treatment plants, odor control, and geotechnical procedures.

1.4 MSD Web Page

The MSD Web Page can be accessed at http://www.msdlouky.org. **The Design Manual is available under the "Reports and Documents" → "Design and Construction Documents" path.**

MSD **no longer distributes hardcopy versions of the manual. Printable PDF versions of the respective chapters are available for download.**

1.5 UPDATES TO THE MSD DESIGN MANUAL

The Manual is intended to be a dynamic document. As design criteria and technology evolve, the Manual will require revisions and improvements. As changes are made, **updates will be posted to the website version. MSD no longer maintains a registered holder list where updates are mailed to manual owners.** . It will be **the designer's** responsibility to **stay updated on the manual.**.

Comments and suggestions concerning the content and format are welcomed from the users of the Manual. Exhibit 1-1 may be used for this purpose.

MSD DESIGN MANUAL
COMMENT FORM

FROM: Name: ______________________________ Date: __________

Company: ____

Street: ____

City: ____________________ State: ________ Zip: __________

The Louisville and Jefferson County Metropolitan Sewer District is most interested in your comments regarding this MSD Design Manual. Please indicate your responses below and return this form to us.

1. List any specific errors detected (with page numbers): ______________

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2. List any recommended revisions for future editions: ______________

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3. List any general comments: ______________________________

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Return to: Louisville and Jefferson County
Metropolitan Sewer District
700 West Liberty Street
Louisville, KY 40203–1911
Attn: Design Manual Comments

TABLE OF CONTENTS

CHAPTER 2
GENERAL INFORMATION

CHAPTER 2
GENERAL INFORMATION
EXHIBITS

CHAPTER 2
GENERAL INFORMATION

2.1 PURPOSE

This chapter:

a. Provides an overview of the Louisville and Jefferson County Metropolitan Sewer District's planning and design approach relating to sanitary and stormwater sewers and their appurtenant facilities.

b. Defines MSD's process for submittal, review and approval of construction documents for sanitary sewer facilities and stormwater facilities.

c. Provides information relating to area utility and public works agency coordination.

d. Provides direction relating to the preparation of opinions of capital, operation, and maintenance costs.

2.2 DESIGN APPROACH

Proposed construction or expansion of sanitary sewer or stormwater facilities within Jefferson County shall be in compliance with MSD's approved countywide 201 Facilities Plan, **approved** action plans, the Sanitary and the Stormwater Drainage Master Plan, **MSD's Wastewater/Stormwater Discharge Regulations**, and guidelines defined in the MSD Design Manual. Additionally, plan development will need to conform to the Louisville and Jefferson County Erosion Prevention and Sediment Control (EPSC) and Floodplain Ordinances and the **other applicable land use planning documents**. Any person, company, corporation, or other entity proposing to develop land or to install new or replacement sanitary sewer or stormwater facilities in Jefferson County must prepare planning and design documents in accordance with the standards and requirements of this Manual for review and approval by MSD. Planning and Construction Documents must be prepared and signed by both a Professional Engineer and Land Surveyor, currently licensed in the Commonwealth of Kentucky. The service level of proposed facilities should be in accordance with standards referenced in these documents. Design standards shall also be those referenced herein.

2.3 SUBMITTAL REQUIREMENTS

The Design Engineer shall submit to MSD for their review and approval, a concept plan and design documents as specified in subsequent chapters of this Manual. Design documents may include, but are not limited to, calculations, plans and specifications. Approval by MSD will be required prior to authorization of any succeeding phase.

Submittal of concept plans shall be prepared in report format (8.5" x 11") and shall be spiral bound, three-ring bound or bound in some other permanent manner. Appended to or included in the submittals shall be maps, figures, and drawings as necessary.

2.4 SUBMITTAL REVIEW AND APPROVAL

The design of new sanitary sewer facilities or an expansion to existing facilities in Jefferson County, whether privately owned or MSD-owned, requires the approval of:

a. MSD
b. Kentucky Division of Water
c. **Louisville-**Jefferson County Health Department

The design of new stormwater facilities or an expansion to existing facilities in Jefferson County, that will become a part of or impact the MSD stormwater infrastructure or other public entity, requires the approval of MSD. Construction within blue-line streams and regulatory floodplains also requires the approval of and permit by the Kentucky Division of Water. The U.S. Army Corps of Engineers approval may also be required. Work within federal and state highway rights-of-way requires approval and/or a permit by the Kentucky Transportation Cabinet. Cities not within the MSD service area are to be informed of improvements by MSD.

Sanitary sewer and stormwater facilities shall be designed according to the appropriate sections of this Manual. Construction documents (plans and specifications) shall be reviewed by MSD prior to submittal to other review agencies.

2.5 UTILITIES/AGENCIES COORDINATION

The Design Engineer shall coordinate the design of all sanitary sewers and of all stormwater facilities improvements with all utilities and/or appropriate public works agencies actively involved in the provision of service in Jefferson County. Contact shall be made with such agencies and preliminary plans provided no later than the initial design submittal to MSD. MSD should be given a copy of all correspondence with utilities and public works agencies. A listing of contact persons, their respective agencies, and the number of plan sets required is included in Exhibit 2-1.

2.6 OPINIONS OF COST

Opinions of probable cost shall be based on the best professional judgement of the Design Engineer. The Design Engineer should use recent bid tabulations, and information from suppliers and contractors in formulating opinions of cost.

Opinions of capital cost shall be in the Construction Specification Institute (CSI) format and shall be grouped by category. Opinions of capital cost should include a construction contingency, allocations for planning and design, and a cost for necessary land, easement, or right-of-way acquisition. The amount or percentage of these contingencies and allocations are dependent upon project specifics and the stage of project development. Opinions of operation and maintenance cost shall include costs for labor, utilities, maintenance and repair.

2.7 PERMIT REQUIREMENTS

A summary of requirements for permits is shown as Exhibit 2-2. The Exhibit contains individual lists for drainage projects, pump station/structural projects, and pipeline projects. The list should not be considered all-inclusive, and the designer will need to confirm all permit requirements as a part of the preliminary scope of the project. The following is a brief summary and the applicability of the three major permits that impact projects in the MSD service area.

a. **Section 404 - Nationwide Permit No. 12 of 33 CFR Part 330** from the U.S. Army Corps of Engineers. Conditions of this permit may require Item b. A permit is required for discharges of soil, sand, gravel or dredged material into a blueline stream if the Average Annual Flow of the stream is greater than 5 CFS. In Jefferson County, this usually requires a drainage area of about 3.5 acres but Design Engineers must inquire from the U.S. Army Corps of Engineers if a certain stream requires this permit.

b. **Section 401 - Application for Water Quality Certification** from the Commonwealth of Kentucky, Natural Resources & Environmental Protection Cabinet, Department for Environmental Protection, Division of Water - Water Quality Branch. This application is required when more than 200 lineal feet of blueline stream is impacted.

c. **Application for Permit to Construct Across or Along a Stream** from the Commonwealth of Kentucky, Natural Resources & Environmental Protection Cabinet, Department for Environmental Protection, Division of Water - Floodplain Management Section - Water Resources Branch. This application is required if the drainage area for the impacted stream is one square mile or greater.

Electrical Service Department
Louisville Gas & Electric Company
820 West Broadway
Louisville, KY 40202
Phone: 627-3162
FAX: 627-2650
2 sets

Gas Department
Louisville Gas & Electric Company
820 West Broadway
Louisville, KY 40202
Phone: 627-3019
FAX: 627-3789
2 sets

ATT
3719 Barddstown Rd.
Louisville, KY 40218
Phone: 454-9854
Fax: 454-2320
2 sets

Relocations Process Owner
Louisville Water Company
550 South Third Street
Louisville, KY 40202
Phone: 569-3600
2 sets

Louisville - Metro Department of Public Works
444 S. Fifth Street suite 400
Louisville, KY 40202
Phone: 574-5810
2 sets

Texas Gas Transmission Corp.
10327 Gas Light Way
Louisville, KY 40299
Phone: 491-0251
FAX: 491-0251
(call prior to transmitting)
2 sets

Insight Communications
11505 Electron Drive
Louisville, KY 40299
Phone: 357-4376
2 sets

Kentucky Transportation Cabinet
District 5
8310 Westport Road
Louisville, KY 40202
Phone: 210-5400
FAX: 210-5494
2 sets

Jefferson County Public Schools
P.O. Box 34020
Louisville, KY 40232-4020
Phone: 473-3011
FAX: 473-3976
2 sets

MSD Stormwater Department or
Planning Department (Sanitary)
700 West Liberty Street
Louisville, KY 40203-1913

REQUIRED PERMITS FOR DRAINAGE PROJECTS

SUBMITTED	APPROVED	PERMIT	REQUIRED SUBMITTALS	AGENCY	WHEN REQUIRED
		1. Construction Along a Stream	Application, HEC2 analysis or floodplain verification	Kentucky Division of Water	For any construction along or across a blueline stream, in a floodplain, or when impounding water.
		2. Section 404 – Nationwide Permit No. 12 of 33 CFR Part 330	Letter and Locations of Crossings	Corps of Engineers	For discharges of soil, sand, gravel or dredged material into a blueline stream. Also when constructing on a stream with a flow >= 5 cfs. May require DOW Water Quality Certification.
		3. Section 401, Clean Water Act – Water Quality Certification	Application / Erosion Control Plans	Kentucky Division of Water	When impacting more than 200 linear feet of a regulated stream and/or; impacting one acre or more of regulated wetlands area. Necessary only at the direction of Corps of Engineers.
		4. Stormwater Discharge Permit	Application/ **NOI (Notice of Intent)**	Kentucky Division of Water	For all projects disturbing >**1 acre**
		5. Water withdrawal Permit	Application/ Letter	Kentucky Division of Water	When necessary to withdraw more than 10,000 gpd of water from a blueline stream
		6. Encroachment Permit	Application	Kentucky Transportation Cabinet	When encroaching on state right-of-way: to be submitted at 80% design stage.
		7. Encroachment Permit	Application	Louisville Metro – Dept. of Public Works	When encroaching on county right-of-way: To be submitted at 80% design stage.
		8. Encroachment Permit	Application	Appropriate city	When encroaching on city right-of-way.
		9. Building Permit for Temporary Office	Site Plan	Louisville Metro – Code Enforcement or City of Louisville Public Works	For any temporary office/trailer.
		10. Lane Closure Permit	Application	Louisville Metro – Dept. of Public Works	When necessary to close lanes of traffic.
		11. Planning Commission Approval	Site Plan(s)	Louisville Metro – Planning Commission	For all projects.
		12. MSD Water Management Approval	Plans/Plan Review Application	MSD	Reviewed internally for all projects.
		13. Traffic Control Plan Approval	Plans/Plan Review Application	Louisville Metro – Dept of Public Works	For any project which requires obstruction of a roadway.
		14. Floodwall Encroachment Permit	Application/Plans	MSD Infrastructure Dept. and Corps of Engineers	When encroaching on the floodwall right-of-way.

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Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502–587–0603 – WWW.MSDLOUKY.ORG

REQUIRED PERMITS FOR PUMP STATION/STRUCTURES PROJECTS

SUBMITTED	APPROVED	PERMIT	REQUIRED SUBMITTALS	AGENCY	WHEN REQUIRED
		1. Construction Along a Stream	Application, HEC2 analysis or floodplain verification	Kentucky Division of Water	For any construction along or across a blueline stream, in a floodplain, or when impounding water.
		2. Section 404 – Nationwide Permit No. 12 of 33 CFR Part 330	Letter and Locations of Crossings	Corps of Engineers	For discharges of soil, sand, gravel or dredged material into a blueline stream. Also when constructing on a stream with a flow >= 5 cfs. May require DOW Water Quality Certification.
		3. Section 401, Clean Water Act – Water Quality Certification	Application / Erosion Control Plans	Kentucky Division of Water	Any activity that requires a Section 404 permit from the Army Corps of Engineers will require a Water Quality Certification from the DOW, if a total of 200 linear feet of impact is proposed.
		4. Water Withdrawal Permit	Application/Letter	Kentucky Div. of Water	
		5. Temporary Discharge Permit	Letter detailing source, treatment analysis, location of discharge	Kentucky Division of Water	For WTP Eliminations, UST dewatering, pump tests, etc.
		6. Encroachment Permit	Application	Kentucky Transportation Cabinet	When encroaching on state right-of-way: to be submitted at 80% design stage.
		7. Encroachment Permit	Application	Louisville Metro – Dept. of Public Works	When encroaching on county right-of-way: To be submitted at 80% design stage.
		8. Encroachment Permit	Application	Appropriate city	When encroaching on city right-of-way.
		9. Building Permit for Temporary Office	Site Plan	Louisville Metro – Dept. of Public Works	For any temporary office/trailer.
		10. Lane Closure Permit	Application	Louisville Metro – Dept. of Public Works	When necessary to close lanes of traffic.
		11. Health Dept. Approval	Plans	Louisville / Jefferson Co. Health Department	For all projects.
		12. Planning Commission Approval	Site Plan(s)	Louisville / Jefferson Co. Planning Com.	For all projects.
		13. MSD Water Management Approval	Plans/Plan Review Application	MSD	Reviewed internally for all projects.
		14. Traffic Control Plan Approval	Plans/Plan Review Application	Louisville Metro – Dept. of Public Works	For any project which requires obstruction of a roadway.
		15. Building Permit	Application/Plan/ Specs	Louisville Metro - Code Enforcement Board	Necessary for all pump stations and waste treatment plants.
		16. Certificate of Occupancy	Plans/Specs	Louisville Metro - Code Enforcement Board	For any project with a building.
		17. Community Facilities Review	Plans/Letter	Louisville Metro Planning Commission	For waste treatment plants.
		18. Air Contaminant Source Permit	Application and Location/Details	Air Pollution Control District	For any fuel tanks.
		19. Fire Marshall Approval	Site Plan(s)	State Fire Marshall	For any enclosed buildings.

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EXHIBIT 2-2
REQUIRED PERMITS

EFFECTIVE DATE: JUNE 30, 2009

REQUIRED PERMITS FOR PIPELINE PROJECTS

SUBMITTED	APPROVED	PERMIT	REQUIRED SUBMITTALS	AGENCY	WHEN REQUIRED
		1. Construction Along a stream	Application, HEC2 analysis or floodplain verification	Kentucky Division of Water	For any construction along or across a blueline stream or in a floodplain.
		2. Section 404 - Nationwide Permit No. 12 of 33 CFR Part 330	Letter and Locations of Crossings	Corps of Engineers	For discharges of soil, sand, gravel or dredged material into a blueline stream. Also when constructing on a stream with a flow >= 5 cfs. May require DOW Water Quality Certification.
		3. Section 401 – Clean Water Act, Water Quality Certification	Application/ Erosion Control Plans	Kentucky Division of Water	When impacting more than 200 linear feet of a regulated stream and/or; impacting one acre or more of regulated wetlands area. Necessary only at the direction of Corps of Engineers.
		4. Storm water Discharge Permit	Application/ Site Plan(s)	Kentucky Division of Water	For all projects
		5. Water Withdrawal Permit	Application/Letter	Kentucky Division of Water	When necessary to withdraw more than 10,000 GPD of water from a blueline stream.
		6. Temporary Discharge Permit	Letter detailing source, treatment, analysis, location of discharge	Kentucky Division of Water	For WTP eliminations, UST dewatering, pump tests, etc.
		7. Construction Permit	Plans/Specs	Kentucky Division of Water	For all projects
		8. Encroachment Permit	Application	Kentucky Transportation Cabinet	When encroaching on state right-of-way: to be submitted at 80% design stage.
		9. Encroachment Permit	Application	Louisville Metro – Dept of Public Works	When encroaching on county right-of-way.
		10. Encroachment Permit	Application	Appropriate city	When encroaching on city right-of-way.
		11. Building Permit for Temporary Office	Site Plan	Louisville Metro - Code Enforcement Board	For any temporary office/trailer.
		12. Parking Meter Permit	Application	Louisville Metro	When necessary to remove meters from service
		13. Lane Closure Permit	Application	Louisville Metro	When necessary to close lanes of traffic.
		14. Health Dept. Approval	Plans	Louisville / Jefferson Co. Health Dept.	For all projects
		15. Traffic Control Plan Approval	Plans/Plan Review Application	Louisville Metro – Dept of Public Works	For any project which requires obstruction of a roadway.
		16. Floodwall Encroachment Permit	Application/Plans	MSD Infrastructure Dept. and Corps of Engineers	When encroaching on the floodwall right-of-way.

TABLE OF CONTENTS

CHAPTER 3
GENERAL PLANNING INFORMATION

CHAPTER 3
GENERAL PLANNING INFORMATION

3.1 PURPOSE

This chapter:

a. Documents Louisville and Jefferson County Metropolitan Sewer District’s philosophy for a regional (watershed) approach for the provision of sanitary sewer and stormwater service in the MSD service area.

b. Identifies the sources of planning and design information for development of sanitary sewer and stormwater drainage infrastructure in the MSD service area.

c. Identifies the goals of the Facilities Plan, Area Action Plans and the Stormwater Drainage Master Plan.

3.2 PLANNING APPROACH

MSD's regional approach for the planning, design, construction, operation and maintenance of sanitary sewer and stormwater facilities is structured to ensure a level of service that protects the general health, safety, and welfare of the citizens of the MSD service area. This approach will also further MSD's efforts to satisfy local, state and federal regulations as they relate to water quality.

MSD's 201 Facilities Plan and approved Area Action Plans provide the framework for planning and design of sanitary sewer facilities in the MSD service area. The Sanitary Master Plan, the Stormwater Drainage Master Plan, **MSD’s Wastewater and Stormwater Discharge Regulations,** and the Watershed Master Plan provide the required technical information necessary for the regional planning and design of sanitary and stormwater facilities in the MSD service area. The Design Engineer should use these documents for planning and as reference documents for the development of sanitary and stormwater facilities in the respective MSD service areas.

3.3 FACILITIES PLAN/AREA ACTION PLANS (SANITARY)

The original master plan prepared for MSD for sewering portions of Jefferson County, Kentucky outside the City of Louisville dates back to 1964. In 1973 and 1974, updates of that plan and the area's 201 Facilities Plan were prepared to conform to the requirements of the Federal Water Pollution Control Act Amendments of 1972. The 201 Facilities Plan was deemed by EPA to be substantially complete in May 1975. The 201 Facilities Plan designated MSD as the local agency to implement the approved program, which became known as the Master Plan Expansion Program.

The goal of the Master Plan Expansion Program was to provide the best solutions, both cost-effectively and environmentally, to the problems of wastewater collection and treatment in Jefferson County. The Master Plan Expansion Program covers a 300-square mile portion of Jefferson County.

Since the 201 Facilities Plan was approved, MSD has initiated and completed the development of the watershed area action plans to address the problems in areas without sanitary sewer service and to facilitate growth in the MSD service area. Action plans are considered to be updates to the 201 Facilities Plan. **The MSD/OCSD Regional Wastewater Facilities Plan 2000 – 2020, dated January 2002 now overrides the original North County Action Plan, dated February 1987.** A list of the remaining area action plans and the date they were adopted by the MSD Board is as follows:

Action Plan	Adopted
Upper Pond Creek	November 1989 (Updated 1998)
Cedar Creek	May 1990 **(Updated July 2000)**
Mill Creek	May 1993
Floyds Fork	July 1993
Regional WCWTP	**Updated March 2002**

3.4 STORMWATER DRAINAGE MASTER PLAN

In order to improve and enhance stormwater drainage services to the City of Louisville and Jefferson County, Agreements of Interlocal Cooperation between MSD, the City of Louisville, and Jefferson County were signed to clearly identify MSD as the responsible agency for providing flood and stormwater services. These agreements became effective January 1, 1987, and supplemented where needed, the powers MSD already possessed pursuant to the Kentucky Revised Statutes, Chapter 76. To facilitate this transition and provide regional guidelines for management of the overall program, the Stormwater Drainage Master Plan (SWDMP) was prepared.

The goal of the SWDMP is to provide a regional approach to develop a consistent level of drainage service and maintain or improve water quality across the County. The Watershed Plan Report of the SWDMP includes the technical information and recommendations to manage the 11 designated watersheds both area-wide and on a local level to meet this goal.

3.5 REGIONAL FACILITIES

In June of 1996 the MSD Board adopted a revised policy for regional wastewater and stormwater facilities serving more than a single development. MSD realized that in some cases regional facilities are more appropriate, cost effective, and assure proper operation and maintenance compared to on-site detention facilities.

The requirement to build or participate in the cost of regional facilities shall be determined concurrently with the review by MSD of the developer's proposed development plans and by an analysis of the development's impact on the general community. This impact includes watershed, other development, existing service facilities, and its conformance with MSD's master plans.

3.6 FLOODPLAIN ORDINANCE

With the issuance of **Louisville Metro's** Floodplain Ordinance, it is important that before planning/design begins on any lot with possible floodplain or minimum opening impacts, the builder must obtain a determination from MSD on the need for a floodplain permit and clarification on exactly what restrictions apply. Construction in the local regulatory floodplain without a valid permit is a violation of the ordinance and is subject to possible fines. Per the ordinance, **"No Development"** is permitted in the local conveyance zone. The conveyance zone is further defined in Section 10.4.

TABLE OF CONTENTS

CHAPTER 4
CADD STANDARDS

TABLE OF CONTENTS (cont.)

CHAPTER 4
CADD STANDARDS
EXHIBITS

CHAPTER 4
CADD STANDARDS

4.1 GENERAL

MSD has adopted CADD standards to provide consistency with respect to plan and document development and for compatibility with respect to the sharing of data and document storage. MSD operates in the AutoCAD environment. Emphasis has been placed on developing standards that are in line with current industry procedures, but can be easily adapted to change with industry advancements.

Development plans for sanitary sewer and stormwater construction shall be prepared in a neat and professional manner **and shall conform to the standards detailed in this chapter.** It is very important that information be presented in such a manner that it will be legible when the plans are scanned, reproduced, or reduced. The following section presents the standards that shall be adhered to on all MSD and Private Development plans. **Private Development Plans, with the exception of lateral extensions, do not have to comply with the final plan submittal requirements of section 4.2.2.** The standard **Layer Names, Colors, Text Heights,** Line Weights, Standard Symbols, and Standard Abbreviations are shown in **Exhibits 4-1 through 4-7** at the end of this chapter**, and will be available on MSD's website at some point in the future.**

It should be noted that the sample sheets shown in Exhibits 4-8 thru 4-17 have not been updated to incorporate the new standards. This will be done in conjunction with making the drawing template, standards and exhibits available in digital form on MSD's website. As previously mentioned, this will be done at some point in the future.

4.2 CADD Structure

4.2.1 CADD Environment

<u>**General**</u>

- **The electronic files will be shared and referenced by many different individuals. Therefore, this chapter outlines the minimum standards, conventions, and formats necessary to ensure a usable electronic file data set to all users.**

- **It must be stressed that while the CADD Standards are to be applied to the deliverable files for design plans, they should not be used to restrict the user's options or workflows during plan development. Interim drawings for public meetings, reviews, etc. may deviate from**

the suggested workflows and standards if needed for particular display or presentation requirements.

- **All drawings shall be in AutoCAD format, compatible with the current version that MSD is running. The project manager should check with MSD for version information before any CADD work begins.**

- **In addition to hard copy drawings, , all final drawings are to be submitted in digital format per the requirements of this chapter.**

- **Model space shall be used for all drafting. Paper space shall be used for borders, viewports, and plotting. Modelspace contains the model at "real life" size. Printing is from paperspace at 1:1 scale for full-size prints**.

Scales

The appropriate scales for original plans are 1" = 50' horizontal with vertical scale of 1" = 5' and 1" = 20' horizontal with vertical scale of 1" = 2'. Other scales may be allowed with prior approval of MSD for the purpose of clarity. A graphic scale is required. In addition, crossings of state highways may require additional sheets at differenct scales. Coordination between MSD project manager and KYTC – District 5 will be necessary.

AutoCAD Template File

An AutoCad template will be created to incorporate the standards as described in this chapter. This file will contain the standard layers, linetypes, fonts, symbols (blocks), and sheets and can be downloaded from the MSD website at some point in the future.

Standard Layers and Line Types

The standard MSD layers are presented in Exhibit 4-1. All drawing elements shall be placed on one of these layers. The color and line style attributes for all drawing elements shall be set to "By Layer". Custom Linestyles are also shown in exhibit 4-1.

Standard Symbols

The standard symbols presented in Exhibit 4-3. These symbols will be pre-loaded as blocks in the future MSD standard template file.

Standard Sheets

The standard sheet size is 24" x 36" for all sanitary and stormwater projects. The sheets are presented in Exhibit 4-4 and will also be pre-loaded as blocks into the future MSD standard template file.

Pen Size Assignments

The chart in exhibit 4-5 shows the relationship between colors and pen sizes (weights). The corresponding ctb file will be made available through MSD's website at some point in the future.

Screening

For screening options - See Exhibit 4-4. The intent is for existing features (topography) to be screened.

Text Fonts, Sizes, and Weights

All fonts, sizes, and weights will be preset attributes in the future MSD template drawing file. The standard font style on MSD projects is "simplex.shx".

The text heights used are synonymous with the Leroy Scale of hand drafting. The following chart shows the height for each text style used. In general, Upper and Lower Case shall be used to denote existing text and UPPER case shall be used to denote proposed text.

TEXT STYLE	HEIGHT (inches)	Notes
L60	0.06	For existing text on plats where space is limited. (Upper & Lower Case)
L80	0.08	All existing text. (Upper & Lower Case)
L100	0.10	For Proposed Item Annotation where space is limited (UPPER CASE)
L120	0.12	For Proposed Item Annotation / Construction Notes. (UPPER CASE)

L140	**0.14**	**For Note Titles & Other Misc. Labels (UPPER CASE)**
L175	**0.175**	**Misc. Titles / Labels (UPPER CASE)**
L200	**0.20**	**Misc. Titles / Labels (UPPER CASE)**

4.2.2 Submittal of Final Plans

General

- **Every sheet in the final plan set shall have a corresponding AutoCAD file. That is, one AutoCAD file per plan sheet. A one to one relationship between the design file content and the plotted sheets shall be maintained.**

- **No external references shall be allowed for the final submittal. Paper space shall be used to represent the actual sheet at a 1:1 scale. All sanitary and storm projects performed for MSD shall be submitted digitally per the requirements of section 4.2.1.**

- **All mapping features and all design features in plan view located in model space of the CAD drawings shall maintain their true coordinate location values. Please reference Chapter 6, "Surveying" for additional details on coordinate systems. Detail sheets do not have to be shown in true coordinate location.**

- **A one-to-one relationship between the design file content and the plotted sheets shall be maintained. i.e., there is no "hidden" information that is turned "off" or "frozen" to make the final plot.**

- **The AutoCad files are submitted as a supplemental deliverable to the stamped and signed mylars, to be used at MSD's discretion.**

- **An AutoCAD (dwg) version of each sheet is submitted per the requirements of this section. The stamped and signed mylars take precedence over the CAD files should any discrepancies airse between the CAD file and the mylars.**

<u>File Naming</u>

At the completion of the plans, the CADD files are to be delivered with the following naming sequence:

AAAAA-SBBB.dwg

where:

AAAAA = Record Number

BBB = sheet number. Use zeroes as necessary.

The "S" stands for sheet(s) and it is not to be changed.

Example: The digital AutoCAD file for Sheet 47 of Drawing Record Number 12345 would be named as follows: 12345_S047.dwg

The files shall be stored in a parent folder named for the Record Number and name of the project and be delivered to MSD on a CD or DVD media format.

A final set of plans shall be printed on 24"x36" paper. This set of plans shall be stamped, signed and dated by the professional engineer of record.

4.3 STANDARD AND TYPICAL DRAWINGS

4.3.1 Definitions

a. Standard Drawings – Details issued by MSD that indicate the acceptable procedure, dimensions, or timetable for a particular facet of construction. The details are not to be modified and can be made a part of the plan set by referencing the respective drawing number on the front Title Sheet. The Standard Drawings are not included in this Design Manual**, but can be found on the MSD webpage under the "Inside MSD" link.** If changes are made to a particular Standard Drawing, the detail ceases to be a Standard Drawing and becomes a Special Detail. The Special Detail will then need to conform to the requirements of Section 4.3.6.

b. Special Details – There are numerous exhibits and design aids found in other chapters of this manual. The details will vary from project to project. Use of the details is encouraged; however, the detail, in its final form, will need to conform to the requirements of Section 4.3.6.

c. Typical Drawings – Examples of typical sheets illustrating the format and information required on MSD contract plans are provided as reference. The respective sheets and exhibit numbers are listed below.

Exhibit	Title
4-8	Sample Title Sheet
4-9	Sample Plan Index Sheet
4-10	Sample Drainage Map (Sanitary Collector System)
4-11	Sample Drainage Map (Storm Collector System)
4-12	Sample Horizontal and Vertical Control Map
4-13	Sample Plan Sheet
4-14	Sample Profile Sheet
4-15	Sample Cross Section Sheet
4-16	Sample Property Acquisition Summary Sheet
4-17	Sample Apportionment Map

4.3.2 Title Sheet Requirements

A MSD Sample Title Sheet can be found on Exhibit 4-7. For each MSD project, t**he title sheet shall have at least the minimum information listed on it:**

a. Contract No., Budget ID No. and Record No.

b. Name of Project -

c. Index of Drawings -

d. Name and Address of Engineer -

e. Design Segment Designation (where applicable)

f. Sheet____of____

g. For sanitary interceptor and major storm sewer contracts, the proposed sewers for which the plans are drawn shall be shown.. The stations at the extremities of the project shall be shown and identified with leaders and arrows. For example: BEGIN PROJECT MC-1, STA. 5+42.00 and END PROJECT MC-1, STA. 10+51.03.

h. To notify the Contractor of the procedure required for the location of utilities prior to construction, the following note should be placed on the Title Sheet.

"NOTE: CAUTION EXISTING UTILITIES"
"THE INFORMATION SHOWN ON THESE DRAWINGS CONCERNING TYPE AND LOCATION OF UNDERGROUND UTILITIES IS NOT GUARANTEED TO BE ACCURATE OR ALL-INCLUSIVE. LOCATION, SIZE, AND MATERIAL SHOWN ON UTILITIES ARE FROM AVAILABLE RECORDS SUPPLIED BY THE RESPECTIVE UTILITY COMPANY. Kentucky 811-Before You Dig (BUD) MUST BE NOTIFIED 2 BUSINESS DAYS PRIOR TO ANY EXCAVATION FOR VERIFICATION OF LOCATION, SIZE AND MATERIAL, Dial 811 or 1-800-752-6007.

i. Other Agency's Standard Drawings pertaining to project (MSD & KYTC) with standard drawing number and description.

j. Revision Block with date & comments

4.3.3 Title Block Requirements

All sheets included in the plans, except the Title Sheet and the MSD Standard Drawings, shall contain a title block, which conforms to the sample shown in the **Exhibit 4-7.**. Information in the Title Block should include the project title indicating sanitary or drainage plans, what type of sheet, and the specific information on the sheet.

4.3.4 Plan Index Sheet Requirements

A Plan Index Sheet shall be prepared to identify the location of the work shown on each Plan Sheet. A Sample Plan Index Sheet is shown on Exhibit 4-8. The Plan Index Sheet shall include a reference to the location of the profile for the sewer lines on each plan sheet if the profile is on a separate sheet. For most projects, the Plan Index Sheet may be shown on the Project Map, which is located on the Title Sheet.

4.3.5 Apportionment Map Requirements

An Apportionment Map shall be prepared for Guaranteed Maximum Assessment apportionment (sanitary collector sewer) projects at a minimum scale of 1" = 100' on a standard size plan sheet. Exhibit 4-16 shows a Sample Apportionment Map. The information shall include, but not be limited to, the following:

a. County Tax Block and Lot Number

b. Property Lines and Dimensions

c. Address of Property

d. Street Names

e. Sewer Sizes

f. Approval and Title Block

g. North Arrow

h. Record Number followed by Letters AM (11732AM)

Those Design Engineers who have sanitary collection system contracts, which contain property that is to be served by a sanitary interceptor, shall include that property on their Apportionment Maps. The property served by the interceptor will be assessed on the collector system.

4.3.6 Special Details

The Design Engineer should show any proposed construction that is not covered by the MSD Standard Drawings as a detail on a Special Detail sheet. The detail should clearly and accurately depict the proposed construction Junction chambers, special pipe bedding, railroad crossings, pump stations, select erosion control measures, and modifications to MSD Standard Drawings are typical examples of items that may require a Special Detail.

Pump station generic details that shall be modified for each project are shown as exhibits in Chapter 15.

4.3.7 Drawing Number Convention (Projects using Multiple Disciplines)

The drawing number shall consist of two parts: The 1st part is the letter corresponding to the discipline. The second part is the numerical page number in that subset.

<u>List of Disciplines</u>
General (G)
Civil/Site (C)
Process (D)
Structure (S)
Architectural (A)
Mechanical/HVAC (M)
Electrical (E)
Instrumentation & Control (I)

Examples: G-1, G-2, S-1, S-2, etc.

4.4 PLAN, PROFILE, AND CROSS-SECTION FORMAT

4.4.1 General Criteria

The plan view of proposed sewer or drainage construction generally should be shown on the same sheet as the profile with the plan view located at the bottom of the sheet and the profile at the top. Samples of the plan and profile sheets can be found in Exhibits 4-12 and 4-13. However, if drafting efficiency can be achieved, the plan view may be shown on a separate sheet from the profile. In this case, the plan sheet and profile sheets shall be cross-referenced. The entire profile for each line shall be shown on one sheet when possible. A profile sheet with profiles for more than one plan sheet can be accepted. Profiles shown on sheets separate from the plan views should follow the plan views in a logical order. The information, which appears, on both the plan and profile views shall, at the minimum, include:

a. The location of all proposed manholes, cleanouts, inlets, catch basins and all associated stations shall be shown.

b. House numbers for all residences and businesses shall be shown and drawn parallel with the streets in the plan view.

c. All existing pipes, culverts and appurtenances shall be hatched.

d. The sizes,locations, and invert elevations, if applicable, of the following items shall be shown:

- Stubs
- Drop Inlets
- Stacks
- Borings and Soundings
- Catch Basin Inlets
- Downspout Connections
- Property Service Connections

e. All existing pipes, culverts, conduits, and utilities of any nature, crossing the proposed improvement location, shall be plotted and labeled in the plan and profile.

f. A beginning and ending contract note and station shall be shown on the Title Sheet and in the plans for all interceptor sewers, major through channels and major storm sewers.

g. **Match lines shall be used for transitioning coverage from one sheet to the next.** A cross-reference shall be shown on each sheet to identify the location of the attendant profile or plan sheet

h. **No overlap of plan coverage from one sheet to the next is permitted.** Match lines are **to be used** in plan view with proper referencing station and attendant sheet number.

i. Title Blocks are required for all sheets except cross-sections. Cross-section information to be used should be similar to that shown in Exhibit 4-14.

j. One-hundred-foot stations shall be shown.

k. Plan sheets must include a north arrow.

4.4.2 Plan View

In addition to those items listed in Section 4.5.1, the information to appear in the plan view shall include, but not be limited to, the following:

a. Locations of future connections (PSC, stubs, etc.).

b. The delta angle of all PI's, except where more than one line intersects at the same manhole or inlet. In those instances, the angles relating all lines shall be shown. When the delta angle is shown, its direction shall be noted (left or right), as the stations increase. All angles shall be shown to the nearest second.

c. The location of the centerline shall be referenced by dimensions to the easement lines and to the appropriate property lines.

d. When it is necessary to orient the alignment to a general locality, indicate the name and direction of the nearest street intersection with a distance to that intersection.

e. Bench marks shall be accurately plotted and labeled on the plans. A description and location of each bench mark, including its station and offset relative to the proposed line, shall be plotted and labeled. When bench marks cannot be plotted with the plan coverage, their location and description should still be shown on the plans where it would have appeared.

f. The precise location of all soundings and borings.

g. Houses, fences and drives shall be shown for a minimum of 50 feet beyond the right-of-way or to the fronts of the houses for lines located in the street or rights-of-way. Trees, steps, walks and other topographic features shall be shown to the extent that they may be pertinent to the improvement location or construction. These items must be field located. LOJIC mapping may be used outside critical areas to supplement the base topography. Trees shall be shown with a designation of size and type **with the dripline depicted graphically**.

h. Property lines, lot lines, easement lines and other boundary lines shall be shown a minimum of 75 feet beyond any proposed or existing right-of-way. In instances where additional information might be required, the limit shall be extended.

i. Property Service Connection symbols for sanitary sewers, as shown in Exhibit 4-2, shall be shown near the lot line where service is expected to be required. For consistency, the symbol should be shown approximately 20 feet behind the property line. If a specific location for the connection needs to be shown, an arrow shall be added to the symbol indicating the desired location of service and a note shall be shown in the area indicating the station of the proposed Property Service Connection.

j. Generally, only the outside lines of a pipe shall be shown on the plans. However, a thin centerline shall be shown within these outside lines where any of the following conditions exist:

1. A distance is shown from a point or line to the centerline of the pipe.

2. The delta angle is shown.

3. The angle of intersection is shown.

Pipes larger than 24 inches in diameter should be drawn to scale to depict the true impact limits.

k. Existing ditches with a bottom width of 4 feet or less should be drawn using the centerline of the ditch. If the ditches and channels have a bottom width greater than 4 feet, each side of the ditch should be drawn and its width be noted. Where ditch paving exists, the width of the paved area shall be shown.

l. Existing and proposed sewers, their direction of flow, size, and MSD Record Number shall be shown. The Deed Book and Page Number shall be shown for existing Sewer or Drainage Easements, which are impacted by sewer construction.

m. All water lines, gas lines, oil lines, electric and telephone conduits, fiber optic cables, and any other underground or overhead utilities shall be shown with the size or primary voltage and ownership identified.

n. All existing or proposed sewers, manholes and catch basins.

o. When sanitary sewers are to be in existing streets, the front dimension and bearing, if possible, of each lot shall be shown. When sanitary sewers are to be placed in easements or rights-of-way, property line dimensions adjacent to the proposed sewer construction shall be shown.

p. Highways, street names, alleys, or major streams and ditches shall be shown. The width and type of all surfaces shall be indicated.

q. Street right-of-way widths shall be shown adjacent to and after the street name. For example: ROBIN ROAD (50' R/W) or ROBIN ROAD (R/W varies) - if the width is not uniform.

r. The name of **all baselines** shall be shown. The pipe size and direction of flow shall be noted **on all pipes**, above the pipe and between all manholes.

s. The general notes and a legend of the standard symbols used throughout the plans shall be shown on the Plan Index Sheet or on the first plan sheet if the plan index is shown on the Title Sheet.

t. Stations shall be shown above each 100-foot station on 50-scale and 20-scale plans and above each 500-foot station on 100-scale plans. For example: 1+00, 5+00, etc. All horizontal curve data shall be shown on the plans, if applicable.

u. The phrase, "Do Not Disturb", shall be used to indicate existing conditions or facilities, which are to remain in place during construction. The phrase or abbreviation, "DND", shall be shown adjacent to all such items on the plans. If used, "DND" must be shown and defined in the legend. Likewise "DNR", "Do Not Remove", may be used to indicate existing conditions or facilities which are to remain in place during construction but which some level of disturbance is anticipated. The size and type of items, which are within the construction area, must be clearly identified. This information is critical to assist in the easement acquisition process.

v. The resurfacing limits will be shown for all projects receiving final resurfacing.

w. Where applicable, add the following: storm sewer pipe and PSC charts

4.4.3 Profile View

In addition to those items listed in Section 4.4.1, the information to appear in the profile view shall include the following as a minimum:

a. Stations and grid elevations shall be shown. . The grid shall be set up on a 2-inch square basis. The vertical scale for 50-scale plans shall be 1" = 5' and for 20-scale plans shall be 1" = 2'.

b. The limits, by station, shall be shown for all concrete caps, cradles and encasements, tunnels, and bored segments.

c. When a line located in an easement crosses a public right-of-way, the limits of that right-of-way, including its width, shall be shown.

d. Information relative to whether the line will be constructed in an easement, right-of-way, or existing MSD property shall be shown. directly above the profile grid.

e. The type of backfill used, when not identified in the general notes, shall be placed directly above the profile grid with a leader and arrow defining the limits of each type of backfill.

f. The ASTM or AASHTO designation (whichever applies) and pipe classification shall be shown below the pipe profile if different from the designation and classification shown in the General Notes or Standard Specifications.

g. The pipe size, grade, and distance between the centerline if the manholes shall be indicated between all manholes. This information shall be parallel to and shown above smaller pipes; however, on pipes of sufficient diameter, this information should be placed inside the pipe. Grades shall be shown as a percent, i.e., 0.50%.

h. Invert elevations shall be shown to the nearest hundredth of a foot and at the following locations:

    1. All breaks in the grade.

    2. Breaks necessary for profile continuation onto another sheet.

    3. Centerline of standard manholes with continuous grade.

4. Other conduits critical to the pipe gradient.

5. Intersecting pipe.

6. All locations necessary to substantiate the profile grade.

7. Both pipe invert edges when there is a drop or slant inlet.

8. Other conditions shown on the typical drawings.

9. Each catch basin or surface inlet connection.

10. Labeled similar to: IE 479.48.

i. Manholes shall be indentified by station, line and manhole number. Proposed manhole rim elevations shall be shown to the nearest tenth (Rim El. 424.9±) in earth areas and to the nearest hundredth in paved areas. Surface inlet grates shall also be shown to the nearest hundredth (Gr. El. 418.76).

j. The water surface elevations of ponding and/or 100-year flooding areas shall be shown.

k. Borings indicating depths and type of soils encountered shall be shown if not shown on a separate soils sheet.

l. The results of all soundings shall be shown using the proper symbol.

m. The vertical height of manhole collars shall be shown.

n. The flow line of all ditches having impact on sewer depth or location which are deeper than one foot shall be plotted and labeled as flowline ditch, left or right. On large channels, it may be necessary to show left and right tops of bank.

o. Existing ground profile including street grades or other improvements shall be shown as dashed lines. Proposed ground profile, including any proposed street grades or improvements, shall be shown as a solid line. See Exhibit 4-2.

p. If basements exist, the basement floor elevation shall be shown for sanitary plans. For houses without basements, the first floor elevations shall be shown. When an existing basement floor elevation absolutely cannot be obtained, a first floor elevation shall be obtained and a basement elevation estimated. When the basement elevation is estimated, this fact shall be duly noted in the profile by using the word "Assumed" adjacent to the elevation. House numbers or lot numbers shall be indicated on the profile along with elevations indicated above.

q. In order to show on which side of the sewer a house is located, houses on the left (when facing up station) shall be drawn using a solid line, and houses on the right (when facing up station) shall be drawn using a dashed line as shown in Exhibit 4-1.

r. Any stacks to be shown on the profile, such as for interceptor sewers, shall be shown solid on the left side and dashed on the right side and should be labeled pipe size stack and left or right.

s. Any underground telephone conduit, water lines, gas lines, etc. shall be shown when crossing proposed MSD facilities.

4.4.4 Cross-Sections

The information to be shown on cross-sections shall be, but not limited to, the following:

a. Horizontal and vertical scales shall be equal. Generally a scale of 1" = 5' shall be used, however, 1" = 10' may be used in special circumstances. Any other scale to be used requires prior approval of the MSD Project Manager.

b. Pre-printed colored grid sheets shall not be used because they cannot be scanned on computer for record.

c. Cross-sections shall be required for all proposed ditch projects as well as roadway or alley construction.

d. Cross-sections should show the existing and proposed ground lines, utilities, fences, structures, property lines, easement lines, and right-of-way lines.

e. Cross-sections shall be shown looking up station and shall be placed on the sheet progressing from bottom of sheet for lower station to top of sheet for higher station and left to right if more than one row of cross-sections is presented on one sheet.

f. Cross-sections shall generally be on even 50-foot stations along the improvement centerline or baseline.

g. If cross-sections are required on a project, pipe crossings may be shown on a cross-section rather than creating a separate profile for each pipe crossing.

h. Half-sections shall be shown for all driveways and a minimum of one half-section between driveways.

i. All water lines, gas lines, telephone conduit, and others shall be shown in the cross-section. .

j. Existing ground shall be shown as dashed lines and proposed grade shall be shown with solid lines.

4.4.5 General Notes

General Notes are notes common to the complete set of plans and shall be shown on the first plan sheet, if space permits, or Title Sheet, if necessary. The type of backfill, pipe material and classification may be shown in the General Notes if the majority of the pipes on a particular project have these items in common. Additionally, a Legend shall be shown on the first plan sheet, which defines the standard symbols used in the plans.

4.4.6 Certification

4.4.6.1 Basement Elevation Certification (Sanitary Projects Only)

The registered Land Surveyor shall place the following certification on the preliminary plan cover sheet, or other appropriate location, prior to the request for a field review. The certification should also be placed on the first plan sheet or other appropriate location in the final plans prior to their submission to MSD for approval.

CERTIFICATION

I hereby certify that the houses shown on these plans, which have basement facilities controlling the elevation of the sanitary sewer, have been entered and controlling elevations determined under my supervision, and that these elevations are correct to the best of my knowledge and belief.

____

Surveyor's Signature, L.S. # and Date

4.4.6.2 Surveyor's Certification

The following certification paragraph and signature is to placed on all sanitary and drainage projects. This note will need to be adjusted if survey procedures deviate from the language as shown.

CERTIFICATION
I hereby certify that the topography for this plan was located under my supervision, and that the property lines shown hereon were obtained from recorded deeds or plats, and that only the property corners noted as monumented were located in the field.
____ Surveyor's Signature, L.S. # and Date

NOTE: ON SANITARY PROJECTS THE CERIFICATIONS CAN BE COMBINED AS A SINGLE NOTE IF APPLICABLE.

Reference is made to Section 6.3.7 of the Manual - Surveying for information on field references.

CERTIFICATION
I hereby certify that the topography for this plan was located under my supervision, and that the property lines shown hereon were obtained from recorded deeds or plats, and that only the property corners noted as monumented were located in the field. ____ Surveyor's Signature, L.S. # and Date

NOTE: ON SANITARY PROJECTS THE CERIFICATIONS CAN BE COMBINED AS A SINGLE NOTE IF APPLICABLE.

Reference is made to Section 6.3.7 of the Manual - Surveying for information on field references.

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502–587–0603 – WWW.MSDLOUKY.ORG

EXHIBIT 4-1 STANDARD LAYERS

EFFECTIVE DATE: JUNE 30, 2009

NAME	DESCRIPTION	COLOR	LINETYPE	LINETYPE EXAMPLES
BM	BENCH MARK	50	CONTINUOUS	
BORDER-0	BASE SHEET LAYER	12	CONTINUOUS	
BORDER-1	BASE SHEET LAYER	20	CONTINUOUS	
BORDER-2	BASE SHEET LAYER	40	CONTINUOUS	
BORDER-3	BASE SHEET LAYER	50	CONTINUOUS	
BORDER-4	BASE SHEET LAYER	150	CONTINUOUS	
BORDER-ROLL	BASE SHEET LAYER	2	CONTINUOUS	
DRNA	DRAINAGE AREA	230	HIDDEN	
E-ASPH	EXISTING ASPHALT	12	HIDDEN	
E-BASE	EXISTING BASELINE	130	CONTINUOUS	
E-BLDG	EXISTING BUILDING	32	CONTINUOUS	
E-CONC	EXISTING CONCRETE	12	HIDDEN	
E-CONT-MJR	EXISTING MAJOR CONTOUR	22	HIDDEN2	
E-CONT-MNR	EXISTING MINOR CONTOUR	12	HIDDEN2	
E-CONT-TXT	EXISTING CONTOUR TEXT (L80)	12	CONTINUOUS	
E-CRST	EXISTING CRUSHED STONE	172	HIDDEN4	
E-DTCH-E	EXISTING EARTH DITCH	102	FLOW LINES	
E-DTCH-P	EXISTING PAVED DITCH	102	DASHED2	
E-ESMNT	EXISTING EASEMENTS	102	PERM ESMT	
E-FENC	EXISTING FENCES	12	FENCE	X X
E-FLTS	EXISTING FAULTS	7	CONTINUOUS	
E-GRND	EXISTING GROUND (TOP OF BANK)	22	EXIST SHOULDER	
E-PL	EXISTING PROPERTY LINES	162	CONTINUOUS	
E-PL-CH	EXISTING PROPERTY LINE CHORD	162	HIDDEN2	
E-ROAD	EXISTING EDGE OF ROAD, PAVEMENT	162	EXIST EDGE PVMT	
E-RR	EXISTING RAILROADS	32	CONTINUOUS	
E-RW	EXISTING RIGHT OF WAY	115	RIGHT OF WAY	
E-SANI *	EXISTING SANITARY SEWERS	102	HIDDEN 2	
E-SPOT	EXISTING SPOT ELEVATION (L80)	195	CONTINUOUS	
E-STRM *	EXISTING STORM SEWERS	102	EXIST PIPE OR STRUCT	
E-STRP	EXISTING PAVEMENT STRIPING	16	CONTINUOUS	
E-TOPO	EXISTING TOPOGRAPHY	12	CONTINUOUS	
E-U-CBTV	EXISTING OVERHEAD CABLE TELEVISION	12	OHC	OHC
E-U-CBTV2	EXISTING UNDERGROUND CABLE TELEVISION	12	CABLETV	CTV
E-U-ELEC	EXISTING OVERHEAD ELECTRIC	22	OHE	OHE
E-U-ELEC2	EXISTING UNDERGROUND ELECTRIC	12	ELEC	UGE
E-U-GAS *	EXISTING GAS	92	GAS	G G
E-U-TELE	EXISTING OVERHEAD TELEPHONE	92	OHT	OHT
E-U-TELE2	EXISTING UNDERGROUND TELEPHONE	92	TELE	UGT
E-U-WATR *	EXISTING WATER	172	WATER	W W
E-VEG	EXISTING VEGETATION, TREES, SHRUBS	12	CONTINUOUS	
FILE-INFO	FILE INFORMATION	7	CONTINUOUS	
GL	GRID LINE	252	CONTINUOUS	
GT	GRID TEXT (L120)	7	CONTINUOUS	
HT	HATCH	92	CONTINUOUS	
P-ASPH	PROPOSED ASPHALT	215	CONTINUOUS	
P-ASPH-HT	PROPOSED ASPHALT HATCH PATTERN	182	CONTINUOUS	
P-BASE	PROPOSED BASELINE	230	CONTINUOUS	
P-BLDG	PROPOSED BUILDING	230	CONTINUOUS	
P-CONC	PROPOSED CONCRETE	214	CONTINUOUS	
P-CONC-HT	PROPOSED CONCRETE HATCH PATTERN	188	CONTINUOUS	

* SEE EXHIBIT 4-2 FOR ADDITIONAL EXPLANATION.

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STANDARD LAYERS

EFFECTIVE DATE: JUNE 30, 2009

NAME	DESCRIPTION	COLOR	LINETYPE	LINETYPE EXAMPLES
P-CONT-MJR	PROPOSED MAJOR CONTOUR	210	CONTINUOUS	
P-CONT-MNR	PROPOSED MINOR CONTOUR	200	CONTINUOUS	
P-CONT-TXT	PROPOSED CONTOUR TEXT (L100)	210	CONTINUOUS	
P-CRST	PROPOSED CRUSHED STONE	213	CONTINUOUS	
P-CURB	PROPOSED CONCRETE CURB	40	CONTINUOUS	
P-DSTB	PROPOSED DISTURB LIMITS	89	DOT2	
P-DTCH-E	PROPOSED EARTH DITCH	210	FLOW LINES	
P-DTCH-P	PROPOSED PAVED DITCH	210	CONTINUOUS	
P-EPSC	PROPOSED SILT CONTROL DEVICES	50	CONTINOUS	
P-FENC	PROPOSED FENCE	210	FENCE	x x x
P-FLOW	PROPOSED DRAINAGE DIRECTIONAL FLOW ARROW	20	CONTINUOUS	
P-GRND	PROPOSED GROUND	210	CONTINUOUS	
P-PERM	PROPOSED PERMANENT EASEMENTS	210	PERM ESMT	
P-PL	PROPOSED PROPERTY LINE	245	CONTINOUS	
P-ROAD	PROPOSED EDGE OF ROAD, PAVEMENT	240	CONTINOUS	
P-RW	PROPOSED RIGHT OF WAY	233	RIGHT OF WAY	
P-SANI *	PROPOSED SANITARY SEWERS	210	CONTINUOUS	
P-SF	PROPOSED SILT FENCE \ TREE PROTECTION FENCE	50	SF	SF
P-SPOT	PROPOSED SPOT ELEVATION (L80 w/o obliquing)	40	CONTINUOUS	
P-STRM *	PROPOSED STORM SEWERS	211	CONTINUOUS	
P-STRP	PROPOSED PAVEMENT STRIPING	52	CONTINUOUS	
P-TEMP	PROPOSED TEMPORARY EASEMENT	190	TEMP ESMT	
P-U-CBTV	PROPOSED OVERHEAD CABLE TELEVISION	200	PROP OHC	OHC
P-U-CBTV2	PROPOSED UNDERGROUND CABLE TELEVISION	200	PROP UGC	UGC
P-U-ELEC	PROPOSED OVERHEAD ELECTRIC	201	PROP OHE	OHE
P-U-ELEC2	PROPOSED UNDERGROUND ELECTRIC	201	PROP UGE	UGE
P-U-GAS *	PROPOSED GAS	205	GAS	G
P-U-TELE	PROPOSED OVERHEAD TELEPHONE	203	PROP OHT	OHT
P-U-TELE2	PROPOSED UNDERGROUND TELEPHONE	203	PROP UGT	UGT
P-U-WATR *	PROPOSED WATER	200	WATER	W
P-VEG	PROPOSED VEGETATION, TREES, SHRUBS, ETC.	205	CONTINUOUS	
PAPER	PAPER	7	CONTINUOUS	
PNTS	POINTS MADE FROM LDD / CIVIL 3D	7	CONTINUOUS	
PRELIM	PRELIMINARY	7	CONTINUOUS	
SL	STATION LABELS (L140)	7	CONTINUOUS	
SNDG	ROCK SOUNDINGS	55	CONTINUOUS	
TX0	TEXT L60	12	CONTINUOUS	
TX1	TEXT L80	20	CONTINUOUS	
TX2	TEXT L100	40	CONTINUOUS	
TX3	TEXT L120	50	CONTINUOUS	
TX4	TEXT L140	70	CONTINUOUS	
TX5	TEXT L175 AND ABOVE	80	CONTINUOUS	
XREF	EXTERNAL REFERENCE	7	CONTINUOUS	

* SEE EXHIBIT 4-2 FOR ADDITIONAL EXPLANATION.

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EXHIBIT 4-2

STANDARD LINETYPE EXHIBITS AND MISCELLANEOUS FEATURES

EFFECTIVE DATE: JUNE 30, 2009

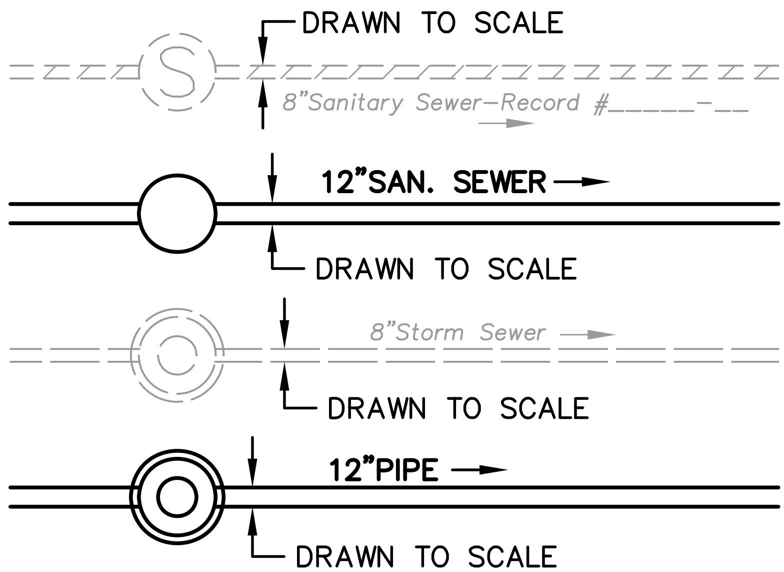
LINETYPES

EXISTING SANITARY SEWER

PROPOSED SANITARY SEWER

EXISTING STORM SEWER

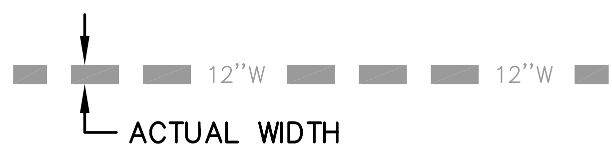
PROPOSED STORM SEWER



APPLIES TO GAS AND WATER

EXISTING UTILITY UP TO 10"

EXISTING UTILITY 12"AND LARGER SHOWN WITH ACTUAL WIDTH ASSIGNED TO LINE,



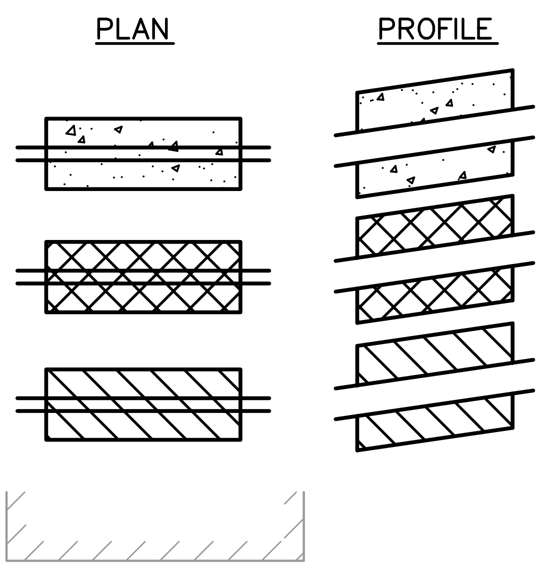
MISCELLANEOUS FEATURES

CONCRETE ENCASEMENT

TUNNELING OR PIPE JACKING

BORE & JACK OR DIRECTIONAL DRILLING

EXISTING BUILDINGS IN PLAN (FIELD LOCATED)



EX BUILDINGS IN PROFILE LEFT AND RIGHT OF BASELINE

SYMBOLS	DESCRIPTION	FILE NAME (.dwg)
	*Existing Tree (with size, type & drip line diameter)** * When locating tree sizes for plan views, measure diameter of trunk at breast height (in inches) and measure actual diameter of Drip line to the nearest foot.	MSDATREE.dwg
	Existing Pine or Spruce W/Size	MSDPINE.dwg
	Existing Bush W/Size	MSDSHRUB.dwg
Wooded Area	*Edge of Woods*	
	Existing Traffic Sign	MSDSIGN.dwg
MB	*Existing Mailbox*	MSDMB.dwg
PB	*Existing Paperbox*	MSDPB.dwg
	Contract Bench Mark	MSDBM.dwg
	Existing Guy Anchor	MSDANCHOR.dwg
	Existing Power Pole	MSDPP.dwg
	Existing Pole W/Light	MSDLS.dwg
	Existing Light Post	MSDLTSTD.dwg
EPED	*Existing Electrical Pedestal*	MSDELECPED.dwg
E	*Existing Electrical Manhole*	MSDEMH.dwg
T	*Existing Telecommunications Manhole*	MSDTMH.dwg
TPed	*Existing Telecommunications Pedestal*	MSDTPED.dwg
CATV–PED	*Existing Cable T.V. Pedestal*	MSDCPED.dwg
437.2±	*Overhead Power Lines (Profile)*	
GM	*Existing Gas Meter*	MSDGM.dwg
GV	*Existing Gas Valve*	MSDGV.dwg
GLM	*Existing Gas Line Marker*	MSDGLM.dwg
	Existing Fire Hydrant	MSDFH.dwg
WM	*Existing Water Meter*	MSDWM.dwg
WV	*Existing Water Valve*	MSDWV.dwg
W	*Existing Water Manhole*	MSDWMH.dwg
WLM	*Existing Water Line Marker*	MSDWML.dwg

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STANDARD SYMBOLS

EFFECTIVE DATE: JUNE 30, 2009

SYMBOLS	DESCRIPTION	FILE NAME (.dwg)
CO	*Existing Sewer Clean–out*	MSDCO.dwg
S	*Existing Sanitary Manhole*	MSDSMH.dwg
M.H.	*Existing Storm Manhole*	MSDSTMH.dwg
	Existing Catch Basin (Single)	MSDCB.dwg
	Existing Catch Basin (Double)	MSDCBD.dwg
	Existing Catch Basin (Round)	MSDCBR.dwg
Steel	*Bridge (type of bridge shall be noted)*	MSDBRDG.dwg
R.P.	*Railway Pole*	MSDRP.dwg
	Railroad Rails (Profile)	MSDRR.dwg
P.L. (PIPE)	*Existing Property Line Pipe (TYPE)*	MSDPLP.dwg
	Right Of Way Marker	MSDRWM.dwg
3	*Parcel Number*	MSCPN.dwg
C–3	*Consent and Release Parcel Number*	MSDCRN.dwg
S	*Sounding Location (Plan)*	MSDSND.dwg
	Sounding To Rock or Refusal (Profile)	MSDSNDRK.dwg
	Sounding No Rock (Profile)	MSDSNDNRK.dwg
B–0	*Boring Location And Number.* *Geotechnical borings were drilled utilizing a truck–mounted drill rig. Borings were taken to a depth of one foot below flow line or until refusal.*	
	PROPOSED EMBANKMENT OR EXCAVATION SLOPE	
	PROPOSED STORM MANHOLE	MSDPSTMH.dwg
	PROPOSED DOUBLE CURB INLET	MSDPDCI.dwg
	PROPOSED CATCH BASIN DOUBLE	MSDPCBD.dwg
	PROPOSED SANITARY MANHOLE	MSDPSMH.dwg

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EXHIBIT 4-3 PAGE 3
STANDARD SYMBOLS

EFFECTIVE DATE: JUNE 30, 2009

SYMBOLS	DESCRIPTION
$\oslash$	*Denotes 4" property service connection to be constructed to property or easement line as directed.*
$\otimes$	*Denotes 4" Y or T branch with stopper. Property service connection is not to be constructed.*
$\oslash$▬	*Denotes 4" property service connection to be constructed from stack at sewer to property or easement line as directed. (See note below)*
$\otimes$▬	*Denotes 4" Y or T branch with stopper to be constructed from stack at sewer. Property service connection is not to be constructed. (See note below)*
$\boxed{\oslash}$	*Denotes a 4" property service connection (PSC) to be constructed. The PSC is <u>not</u> available for connection until the capacity charge, applicable at the time, is paid.*

Note: ***The following must be added to the general*** **notes:**

All stacks must conform to the requirements of section 8.14 of the MSD Design Manual.

4" connections are for single family only all others are 6".

SYMBOLS	DESCRIPTION
	*Denotes 6" property service connection to be constructed to property or easement line as directed.*
	*Denotes 6" Y or T branch with stopper. Property service connection is not to be constructed.*
	*Denotes 6" siamese property service connection to be constructed to property or easement line as directed.*
	*Denotes 6" property service connection to be constructed from stack at sewer to property or easement line as directed. (See note below)*
	*Denotes 6" Y or T branch with stopper to be constructed from stack at sewer. Property service connection is not to be constructed. (See note below)*
	*Denotes a 6" property service connection (PSC) to be constructed. The PSC is <u>not</u> available for connection until the capacity charge, applicable at the time, is paid.*

Note: **The following must be added to the general notes:**

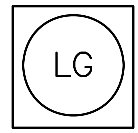
All stacks must conform to the requirements of section 8.14 of the MSD Design Manual.

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES

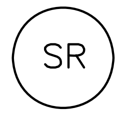
DESCRIPTION — SYMBOL

SITE PREPARATION:

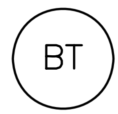
LAND GRADING:



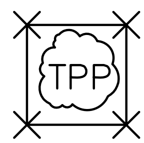
SURFACE ROUGHENING:



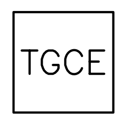
BULLDOZER TRACKED:



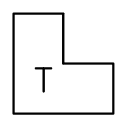
TREE PRESERVATION AND PROTECTION:



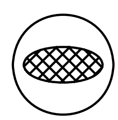
TEMPORARY GRAVEL CONSTRUCTION ENTRANCE/EXIT:



BENCH TERRACING:



TOPSOILLING:



MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

DESCRIPTION	SYMBOL
SURFACE STABILILIZATION:	
TEMPORARY SEEDING:	TS
PERMANENT SEEDING:	PS
SODDING:	SO
MULCHING:	M
DUST CONTROL:	DC
EROSION CONTROL BLANKET:	ECB
TURF REINFORCEMENT MAT:	TRM

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MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

DESCRIPTION	SYMBOL
OUTLET PROTECTION:	
OUTLET STABILIZATION STRUCTURE:	OS
INLET PROTECTION:	IP
GRAVEL AND WIRE MESH INLET SEDIMENT FILTER:	GWI
FILTER FABRIC DROP INLET PROTECTION (TEMPORARY):	FDI
BLOCK AND GRAVEL INLET PROTECTION (TEMPORARY):	BGDI
STONE BAG INLET PROTECTION:	SIP
SEDIMENT TRAPS AND BARRIERS:	
TEMPORARY SEDIMENT TRAP:	TS

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

DESCRIPTION	SYMBOL
SEDIMENT TRAPS AND BARRIERS (CONT):	
SEDIMENT BASIN:	SB
SILT FENCE (SEDIMENT FENCE):	SF SF
DITCH CHECK:	DC DC DC
TEMPORARY SEDIMENT BASIN:	
REINFORCED SILT FENCE:	RSF RSF
STREAM PROTECTION:	
TEMPORARY STREAM CROSSING:	TSC
RIPRAP:	RR
VEGETATED FILTER STRIPS:	VFS VFS VFS

MAPPING SYMBOLS AND NOMENCLATURE FOR EROSION AND SEDIMENT CONTROL PLANS FOR LAND DISTURBING ACTIVITIES (CONT.)

DESCRIPTION	SYMBOL
RUNOFF CONTROL MEASURES:	
PERMANENT CLEAN WATER:	→ PCW →
TEMPORARY CLEAN WATER:	→ TCW →
TEMPORARY SEDIMENT LADEN:	→ TSL →
ROCKFILL:	RF
RUNOFF CONVEYANCE MEASURES:	RCM ➡ RCM ➡ RCM ➡
GRASS–LINED CHANNELS:	GC ➡ GC ➡ GC ➡
SOD LINED CHANNELS:	SC ➡ SC ➡ SC ➡
RIPRAP–LINED CHANNELS:	RRC ➡ RRC ➡ RRC ➡
TURF REINFORCED CHANNELS:	TRC ➡ TRC ➡ TRC ➡
PAVED CHANNELS:	PC ➡ PC ➡ PC ➡
TEMPORARY SLOPE DRAINS:	TSD ➡ TSD ➡ TSD ➡
PIPE SLOPE DRAINS:	PSD ➡ PSD ➡ PSD ➡
RUNOFF CONVEYANCE MEASURES (CONT):	
STONE BAG CHECK DAM:	SBCD ▶ SBCD ▶ SBCD
OTHER RELATED PRACTICES:	
SUBSURFACE DRAIN:	SSD SSD
CONSTRUCTION DEWATERING:	

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EXHIBIT 4-4
PEN SIZE ASSIGNMENTS

EFFECTIVE DATE: JUNE 30, 2009

STANDARD ASSIGNMENTS

PEN SIZE	*COLOR*	*COLOR RANGE 1*	*COLOR RANGE 2*	*COLOR RANGE 3*	*COLOR RANGE 4*
0.18mm	1, 9, 250	10-19	90-99	170-179	
0.25mm	2, 251	20-29	100-109	180-189	
0.30mm	3, 252	30-39	110-119	190-199	
0.35mm	4, 253	40-49	120-129	200-209	160-169
0.50mm	5, 254	50-59	130-139	210-219	
0.60mm	6, 255	60-69	140-149	220-229	
0.70mm	7	70-79	150-159	230-239	
0.90mm	8	80-89		240-249	

SHADING

All pens in the following ranges ending with the number 2 except "2" will plot shaded as follow

COLOR			**PLOTS**		
12-172			40% of black		
182			6% of black		
192-242			40% of black		
188			2% of black		
16			30% of black		

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EXHIBIT 4-5
STANDARD ABBREVIATIONS

EFFECTIVE DATE: JUNE 30, 2009

DESCRIPTION

LG&E	Louisville Gas & Electric Company
PUE	Public Utility Easement
ATT	AT&T
Conc	Concrete
Asph	Asphalt
Culv	Culvert
Hdwl	Headwall
Hdw	Headwater
RCP	Reinforced Concrete Pipe
CMP	Corrugated Metal Pipe
CIP	Cast Iron Pipe
VCP	Vitrified Clay Pipe
PE	Polyethylene
DIP	Ductile Iron Pipe
PVC	Polyvinylchloride
HERCP	Horizontal Eliptical Reinforced Concrete Pipe
HDPE	High Density Polyethylene
HP	High Pressure
MH	Manhole
CB	Catch Basin
CI	Curb Inlet
TG	Top Of Gratr Elevation
I.E.	Invert Elevation
BM	Bench Mark
TBM	Temporary Bench Mark
CSB	Crushed Stone Base
R.R.	Railroad
R/W	Right-of-Way
DND	Do Not Disturb
DNR	Do Not Remove
TBR	To Be Removed
TYP.	Typical

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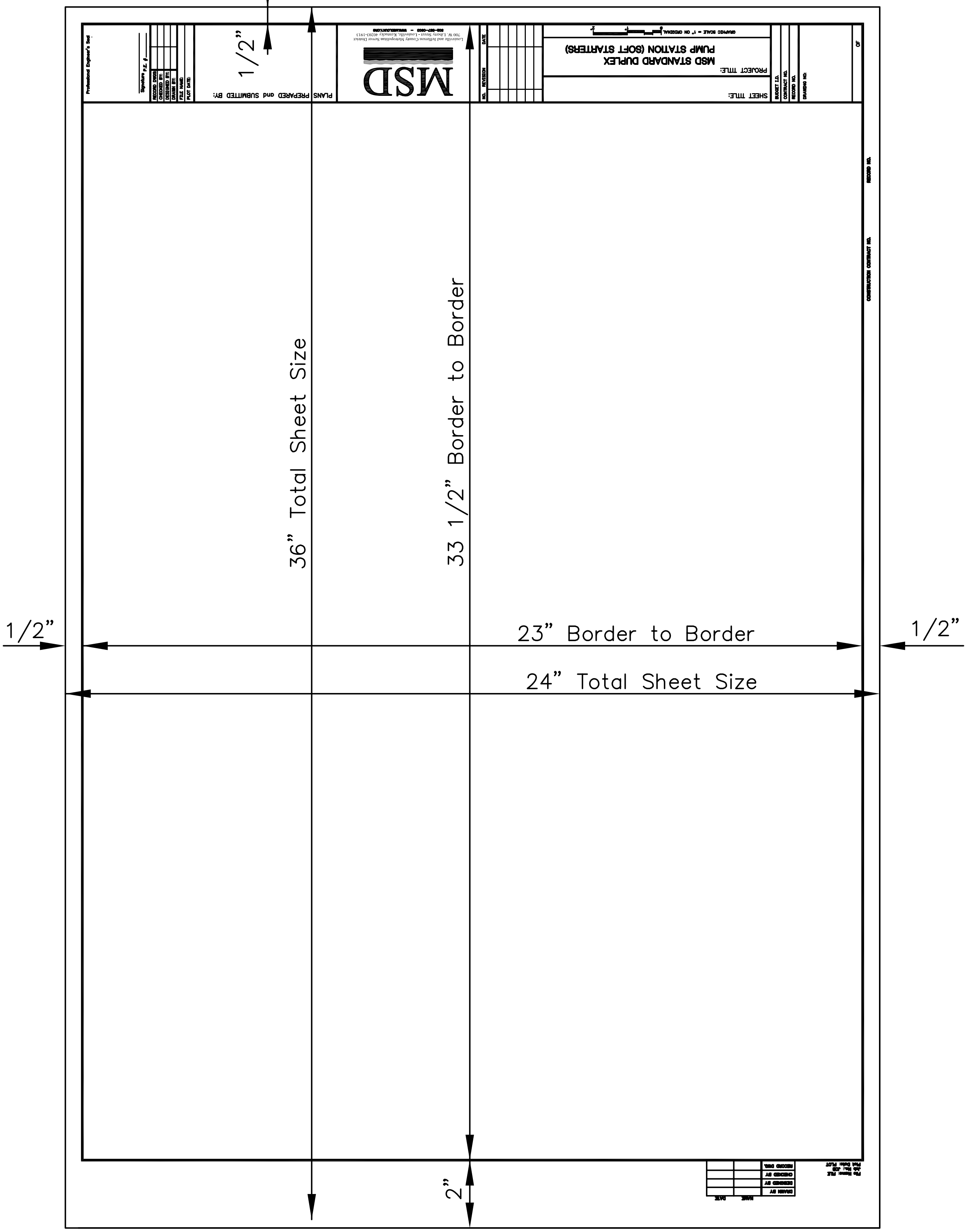
EXHIBIT 4-6
STANDARD BORDER
MSD PROJECTS

EFFECTIVE DATE: JUNE 30, 2009



SHEET TITLE:
MSD STANDARD TITLE BLOCK

PROJECT TITLE:
MSD STANDARDS
SAMPLE DRAWINGS

GRAPHIC SCALE = 1" ON ORIGINAL 0 1" 2"

TITLE BLOCK

LOUISVILLE AND JEFFERSON COUNTY
METROPOLITAN SEWER DISTRICT

DESIGN
APPROVED: ______________________

APPROVED FOR
CONSTRUCTION: ______________________
DIRECTOR OF ENGINEERING DATE

MSD APPROVAL BLOCK

NO.	REVISION	DATE

REVISION BLOCK

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EXHIBIT 4-8
STANDARD TITLE SHEET

EFFECTIVE DATE: JUNE 30, 2009

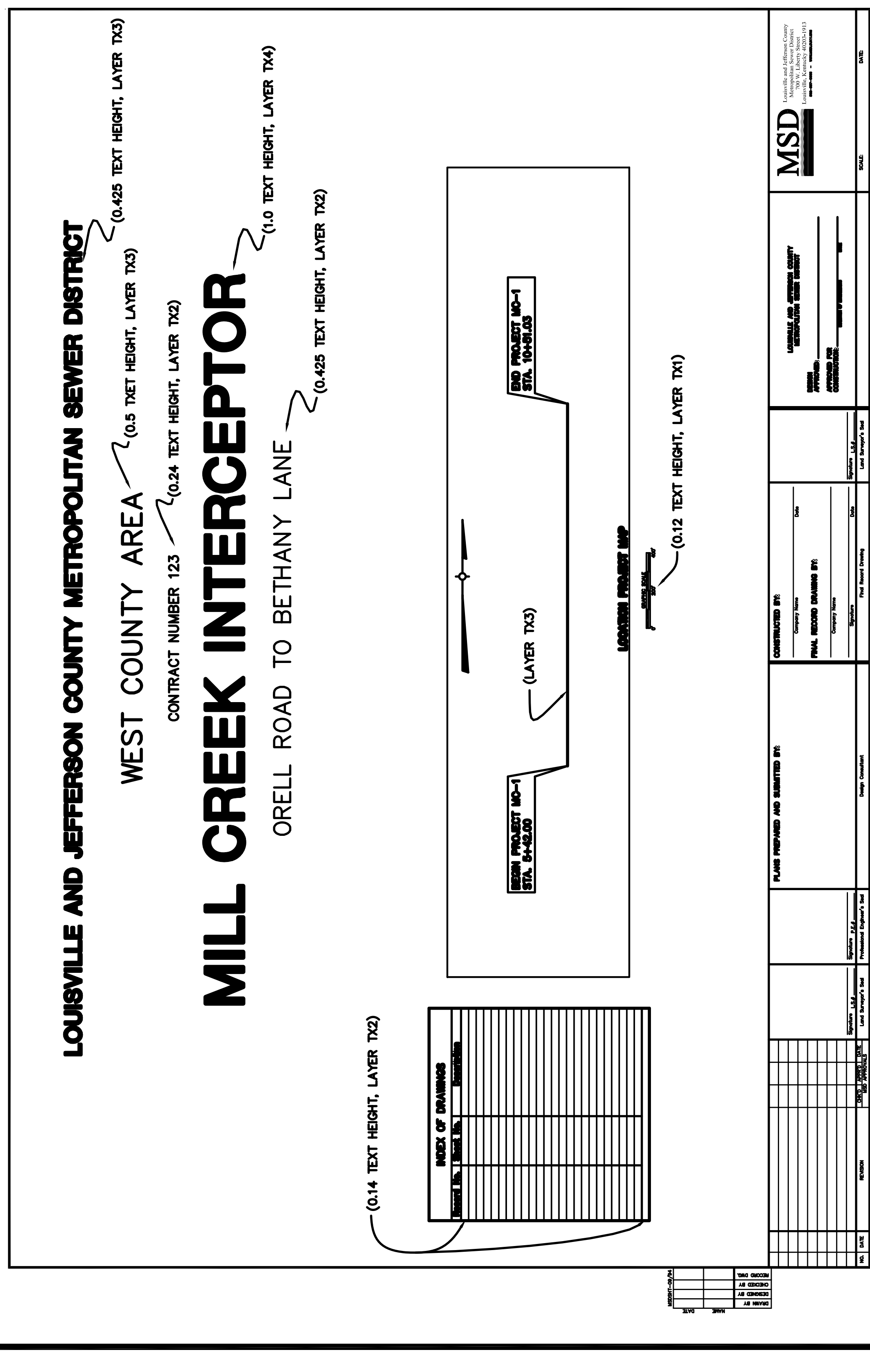

EXHIBIT 4-9
SAMPLE PLAN INDEX SHEET

EFFECTIVE DATE: JUNE 30, 2009

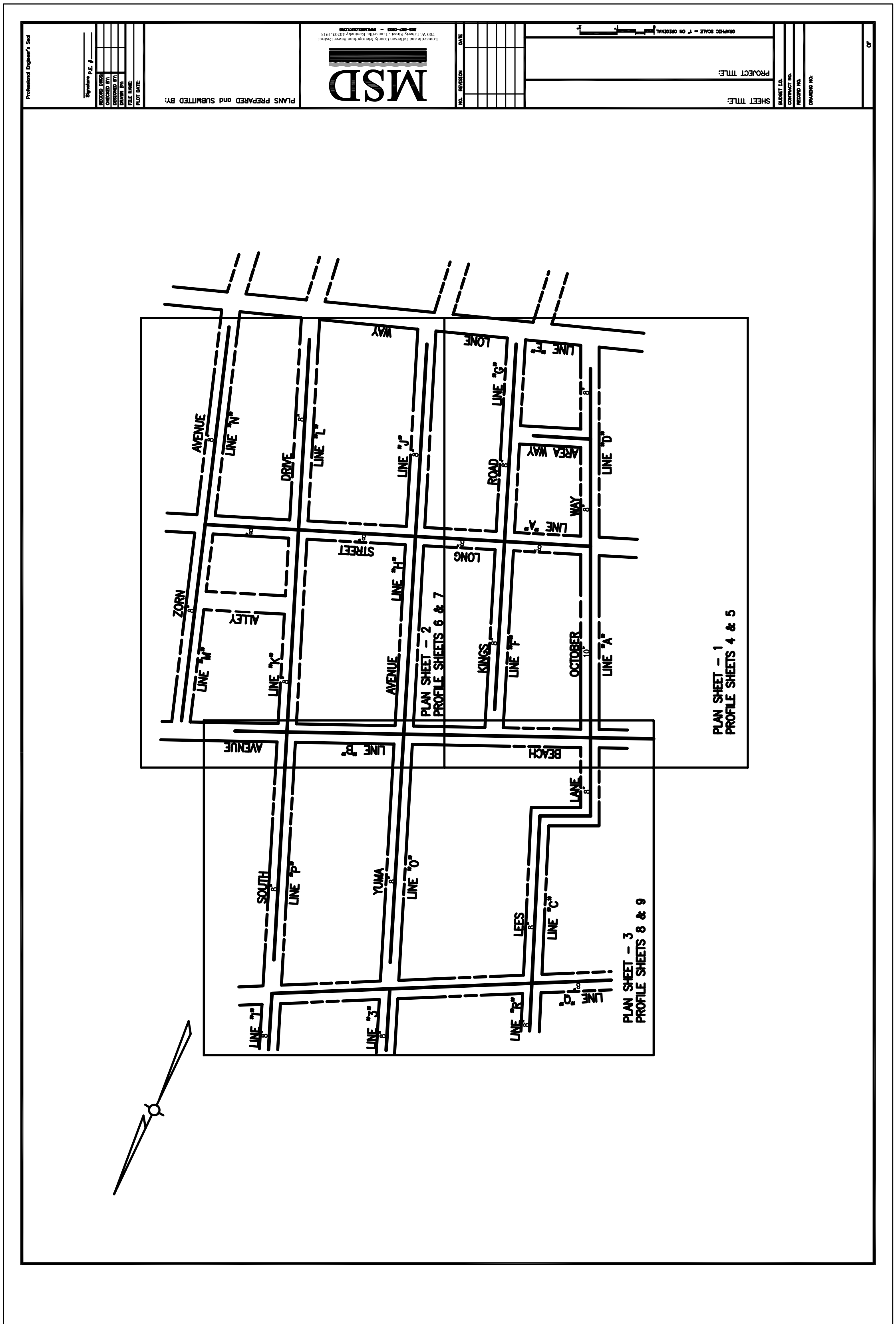

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EXHIBIT 4-10
SAMPLE DRAINAGE MAP
(SANITARY COLLECTOR SYSTEM)

EFFECTIVE DATE: JUNE 30, 2009

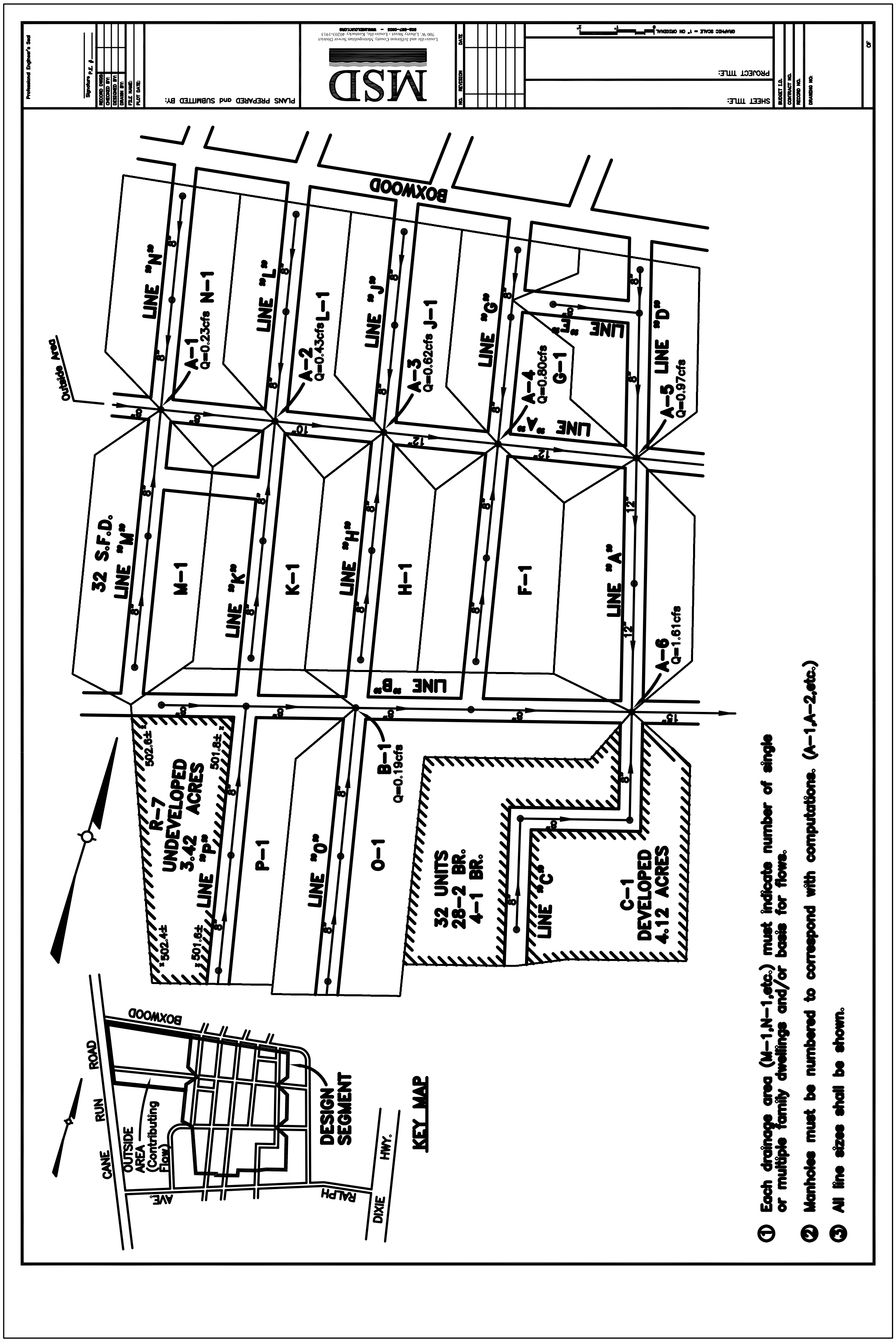

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EXHIBIT 4-11
SAMPLE DRAINAGE MAP
(STORM COLLECTOR SYSTEM)

EFFECTIVE DATE: JUNE 30, 2009

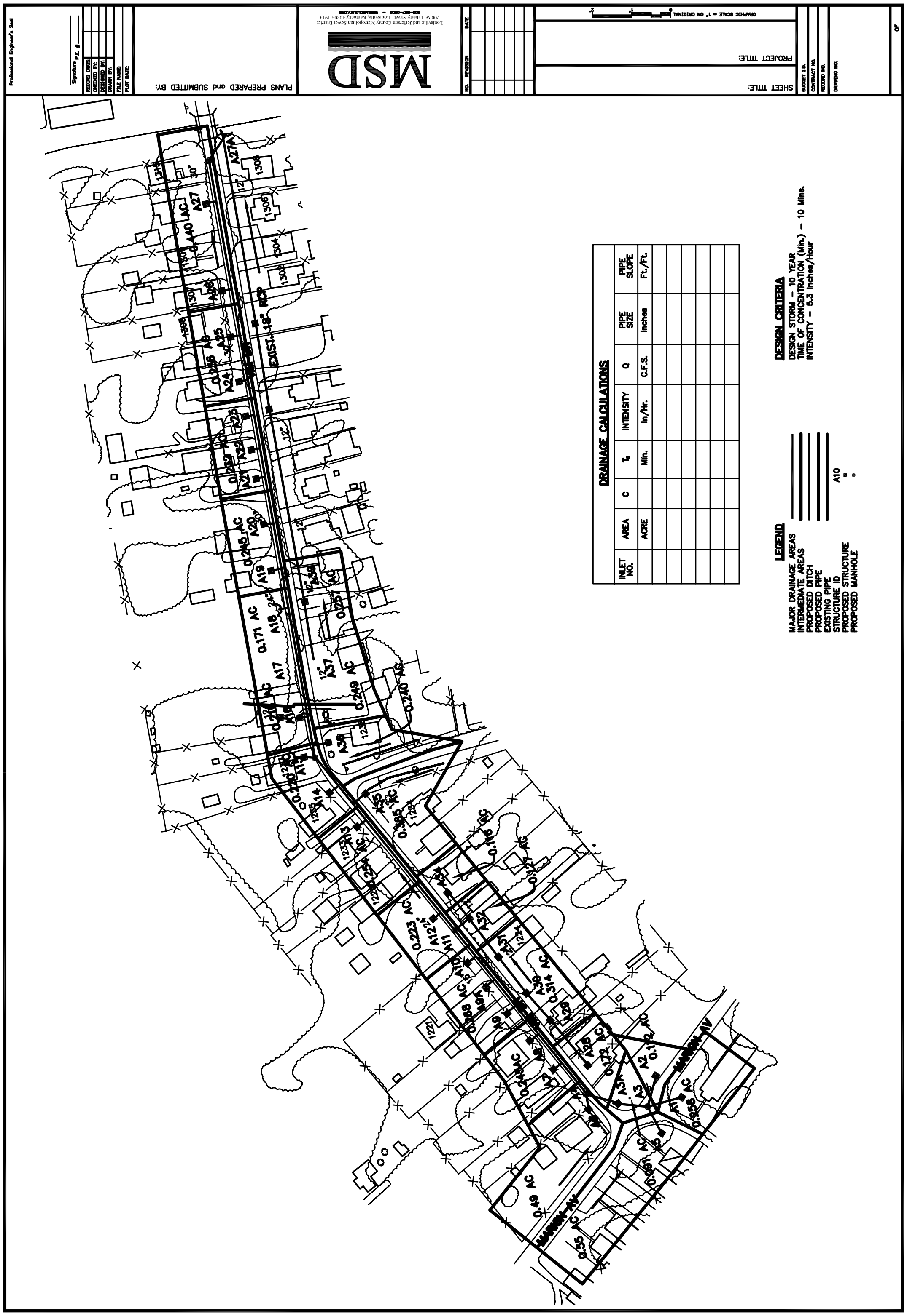

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EXHIBIT 4-12
HORIZONTAL & VERTICAL CONTROL MAP

EFFECTIVE DATE: JUNE 30, 2009

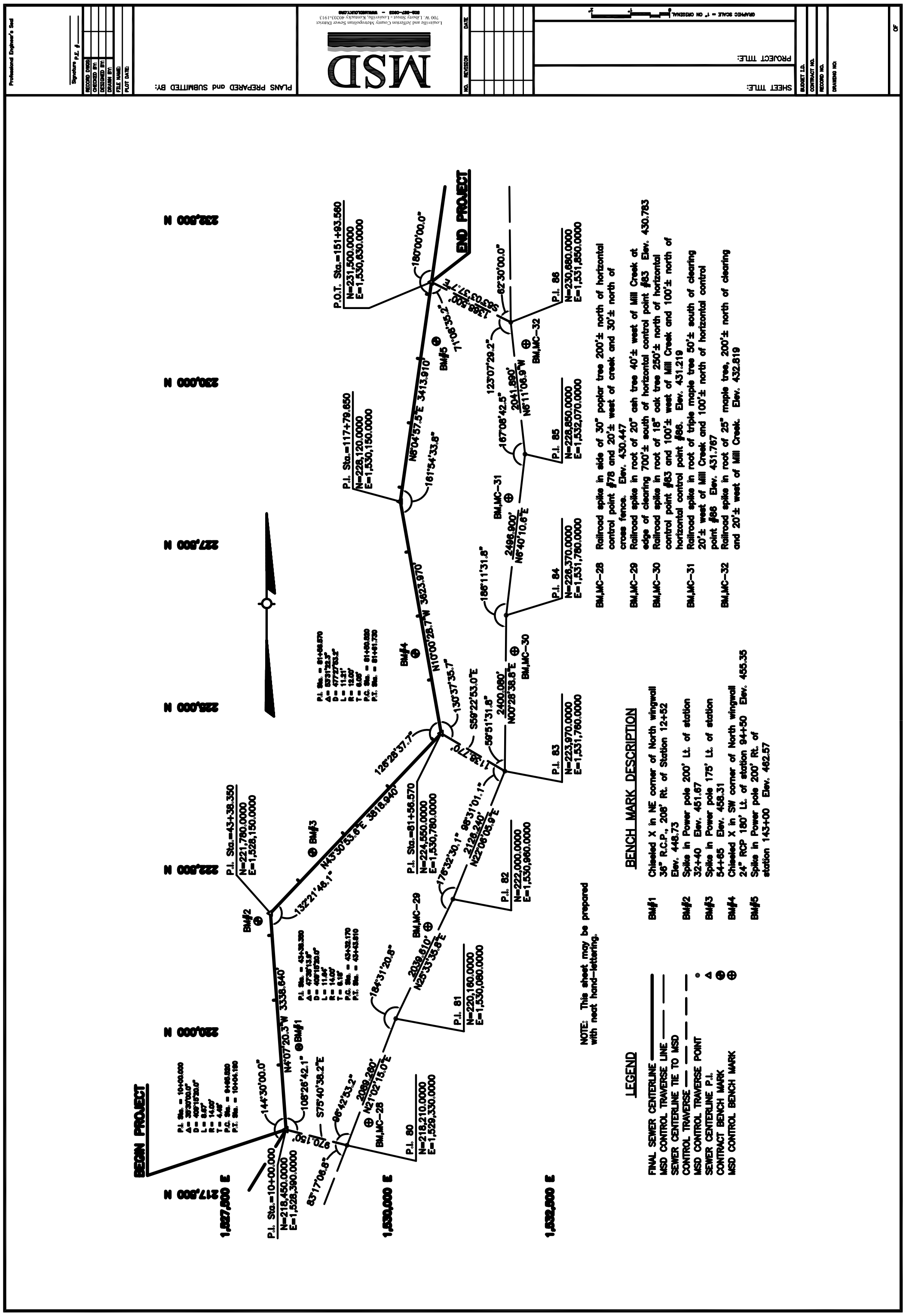

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EXHIBIT 4-13
SAMPLE PLAN SHEET

EFFECTIVE DATE: JUNE 30, 2009

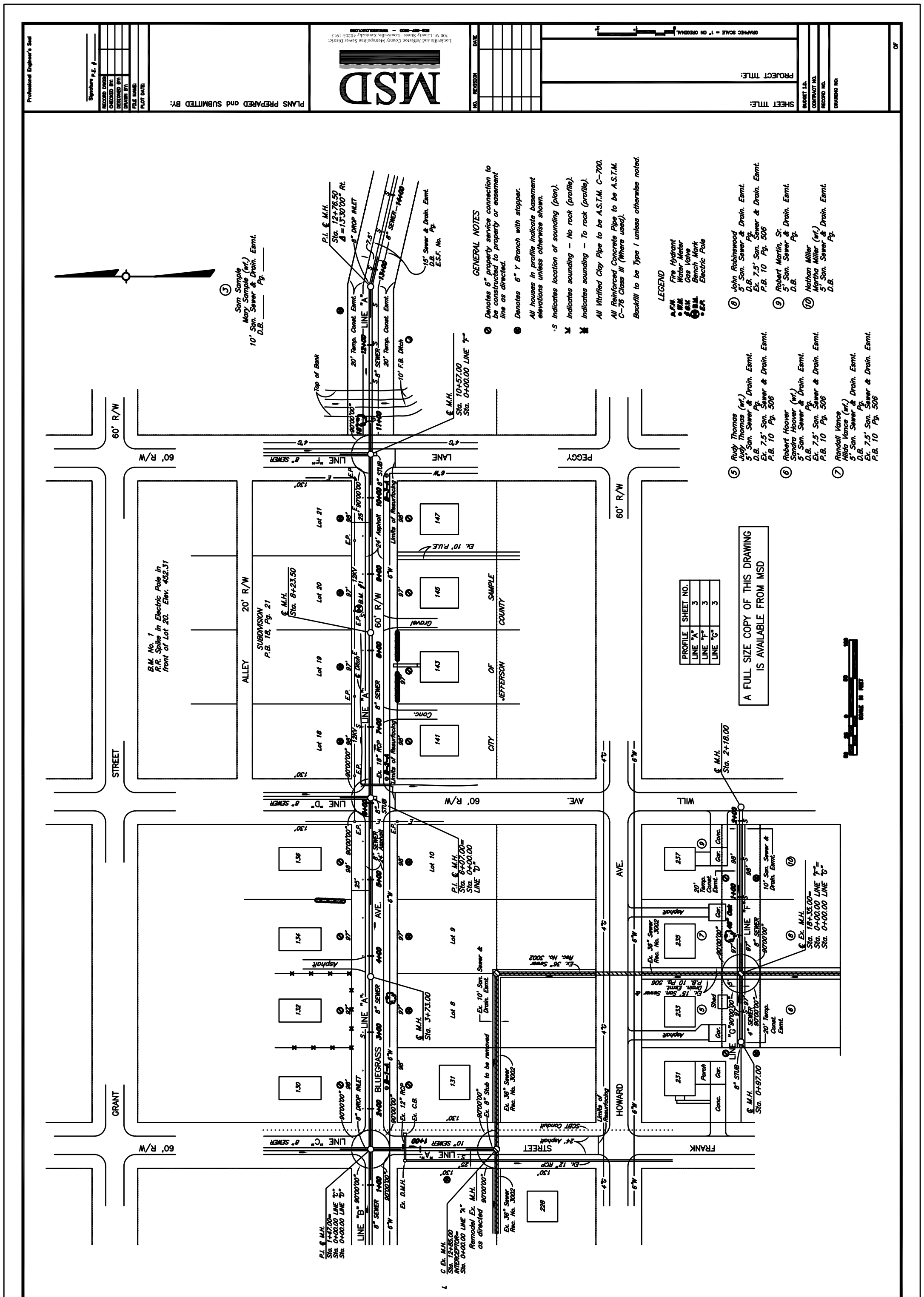

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EXHIBIT 4-14
SAMPLE PROFILE SHEET

EFFECTIVE DATE: JUNE 30, 2009

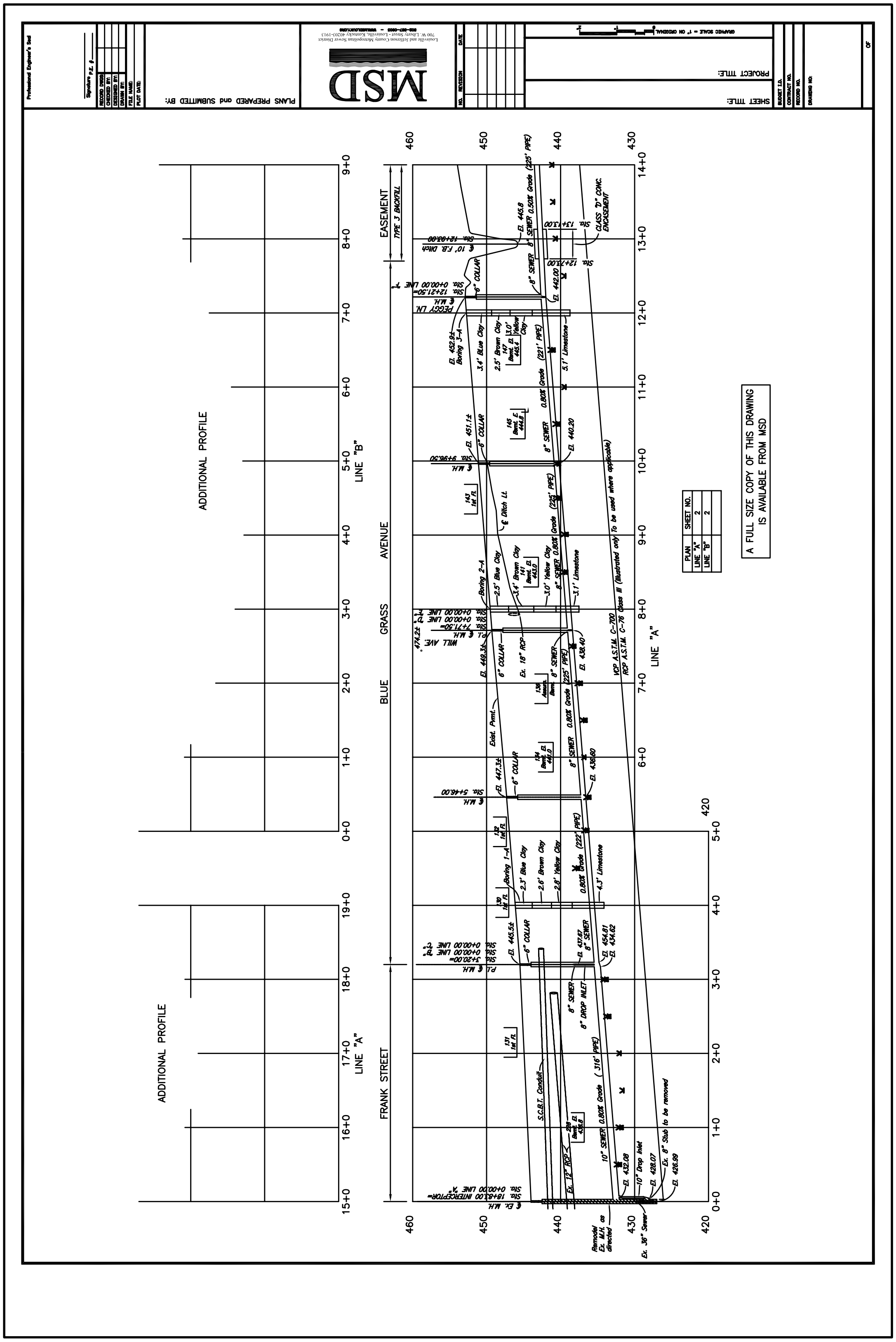

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EXHIBIT 4-15
SAMPLE CROSS SECTION

EFFECTIVE DATE: JUNE 30, 2009

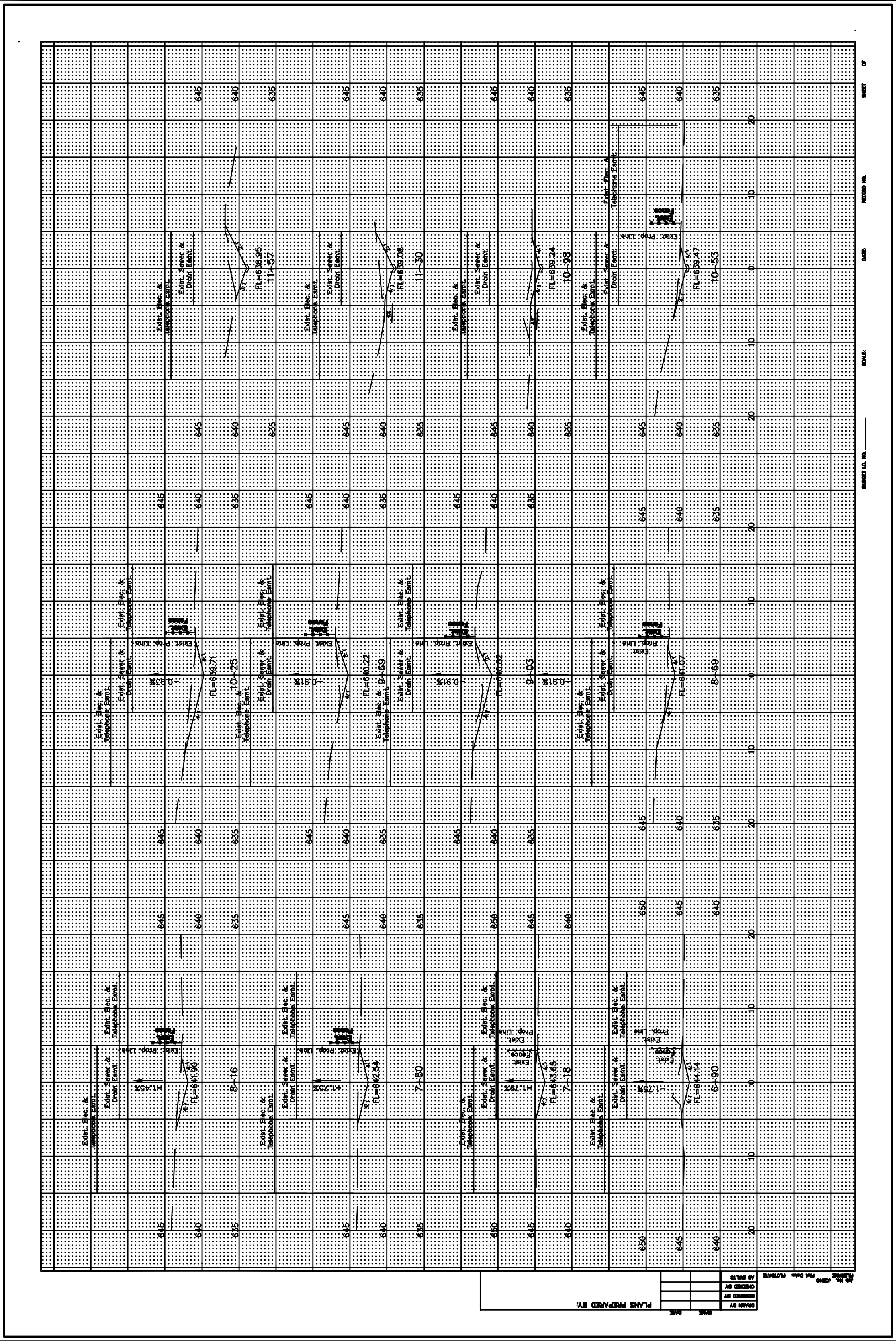

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EXHIBIT 4-16
PROPERTY ACQUISITION SUMMARY SHEET

EFFECTIVE DATE: JUNE 30, 2009

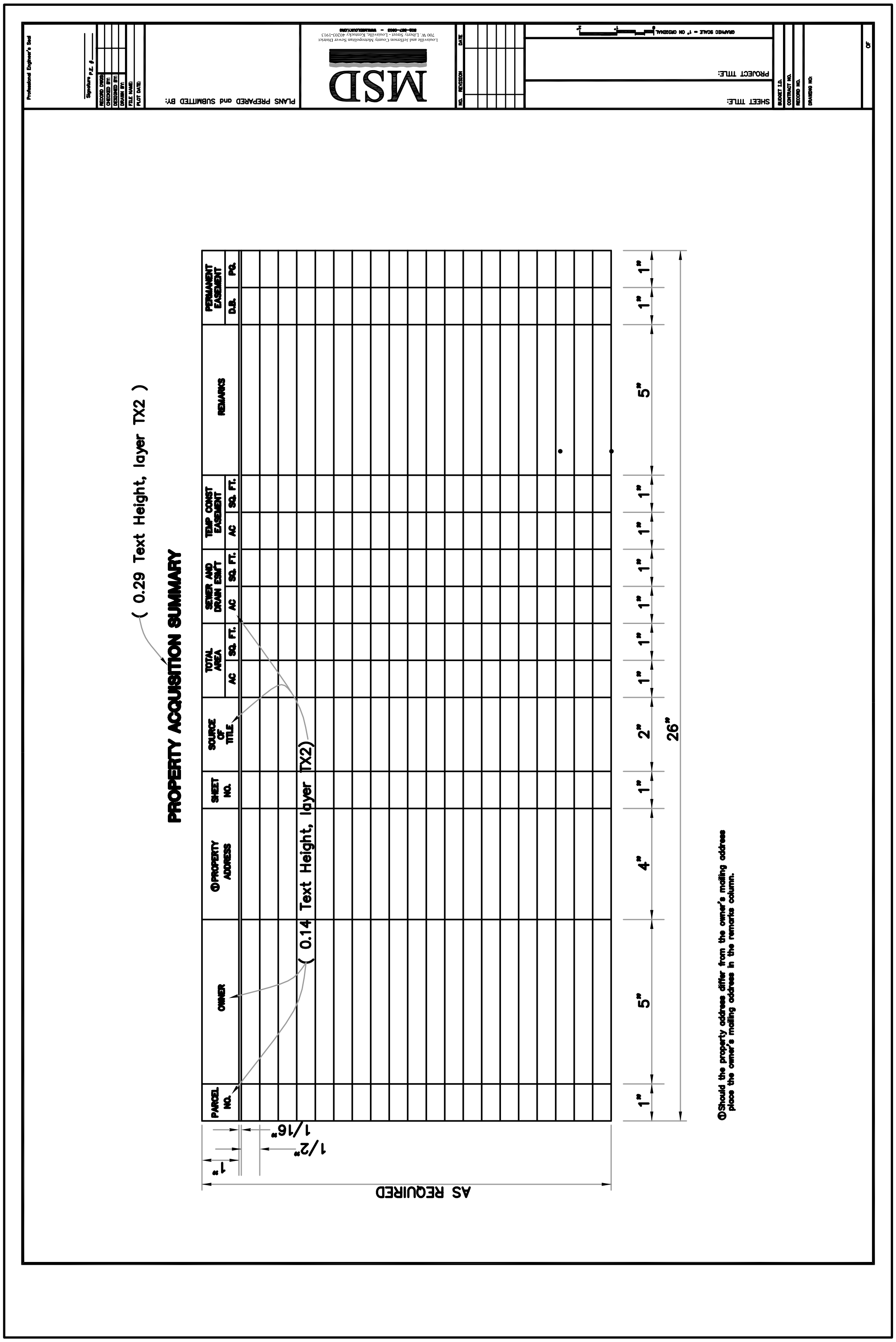

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EXHIBIT 4-17
SAMPLE APPORTIONMENT MAP

EFFECTIVE DATE: JUNE 30, 2009

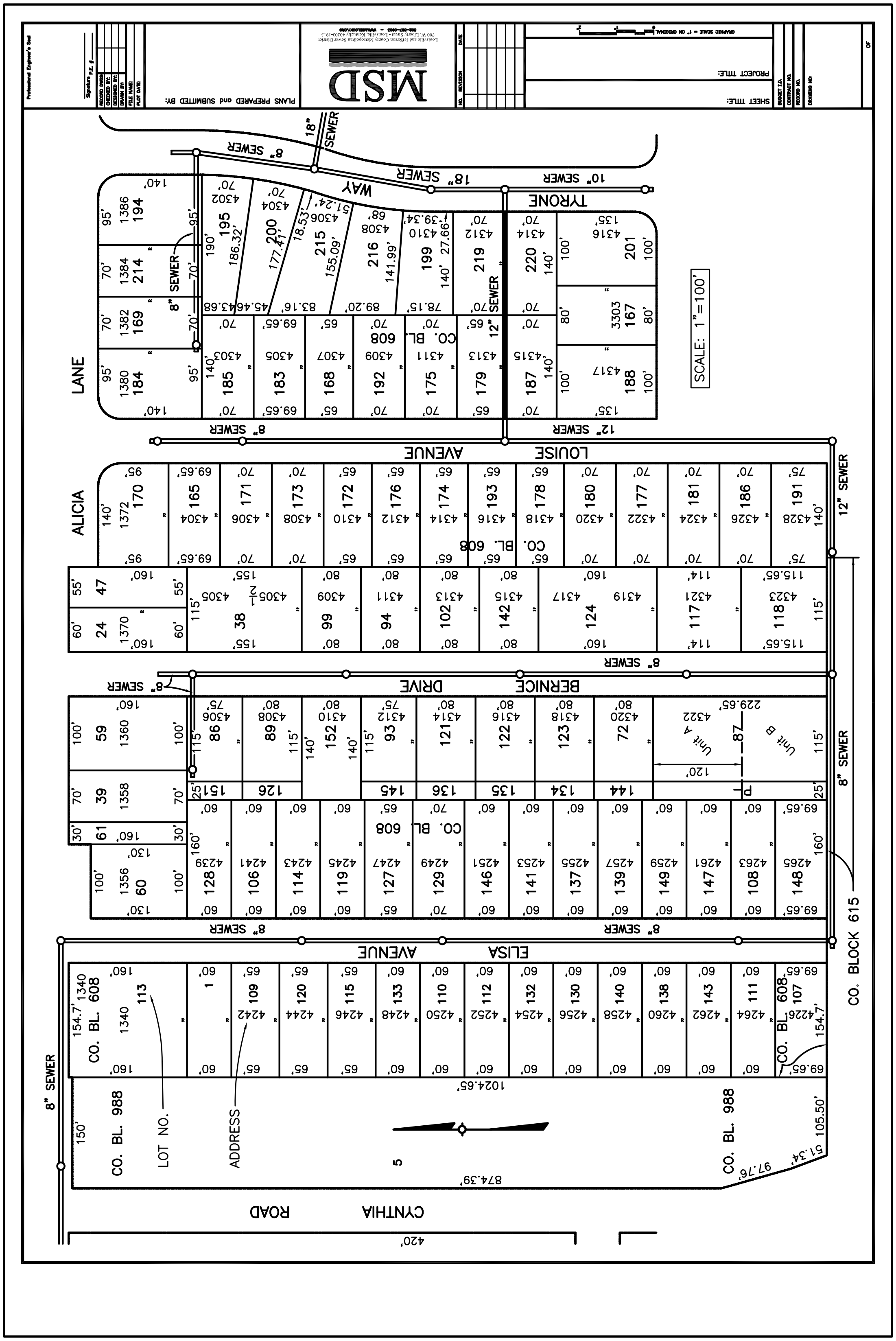


TABLE OF CONTENTS

CHAPTER 5
FINAL RECORD DRAWINGS

CHAPTER 5
FINAL RECORD DRAWINGS

5.1 PURPOSE

This chapter establishes the procedures that must be followed by Design Engineers, Land Surveyors, Contractors, Developers, and MSD concerning Final Record Drawings to ensure that all proposed **wastewater treatment and conveyance** plans correctly depict the facilities as constructed. **The final record drawings are the "Bid Plans" that have been revised to identify changes that occurred during construction.** This chapter also applies to MSD drainage projects, but not privately developed drainage plans.

5.2 GENERAL

On MSD projects, the Final Record Drawings will be prepared by MSD, or the project design engineer/consultant, based on record information provided to MSD by the contractor. At the completion of the project, the contractor will be responsible for providing MSD a set of "Red Line Drawings" and "As-Built Survey Information". The information will be incorporated into the "Bid Plans" design AutoCAD files to become the "Final Record Drawings" file. The Final Record Drawings are then saved in PDF format, with the file name format in accordance with the requirements of Chapter 4. The file will contain a "FRD" reference, differentiating it from the original "bid plans" file.

Note - On private development projects, the project owner will be responsible for preparing the Final Record Drawings, subject to the same requirements as a MSD project.

Red Line Drawings

As the project progresses, the Contractor shall maintain a record of all deviations in location or elevation of any installation from that shown on the Plans. The information will be compiled in a red-lined format on a copy of the Bid Plans. At the completion of the project the information is submitted to MSD. The information should be recorded in a clear and concise format, allowing for an easy transfer of information. For development projects four copies of proposed red line changes on the plans must be submitted for review and approval prior to execution of the changes. Approved changes will be shown on the as-builts.

As-Built Survey Information

The Contractor's Licensed Professional Land Surveyor-will be responsible for "as-builting" the items listed below. The survey information will be compiled in an

electronic fashion, compatible with the .dwg format, and submitted to MSD. Location and elevations shall be tied to the project survey control.

5.3 PROCESS

On MSD projects, the noted as-built information will be provided to MSD as soon as possible after completion of the project. Final payment to the contractor will not occur until the as-built information is provided.

On private development projects, final project acceptance will not occur until the completed Final Record Drawings are reviewed by MSD's Inspection Department for verification of information. Once verified, the plans are returned to Engineering Records for final review and acceptance. If the plans are accepted they become Final Record Drawings. If they are rejected the above process is repeated until accepted.

Reference is made to Chapter 4 for a detailed explanation of the documentation requirements. The as-built information is assigned to a specific layer within the drawing file. Predetermined font and pen sizes have also been established. The parameters are preset if the MSD standard drawing template file was used to generate the base drawing file.

5.4 DRAWING INFORMATION

Where constructed information differs from the **bid** information, the **plans will reflect** a line through the **bid** information and **show** the corrected information near the crossed-out original data. Original information shall under no circumstances be **removed** from the original plans. No red line markings will be accepted. A check mark should be placed beside the original plan information, which has been verified to be correct as constructed. **MSD will not accept Final Record Drawing that have color ink other than black or have plan information overlayed on aerial photos.**

5.5 AS-BUILT ITEMS

The following construction items, at a minimum, should be reviewed and verified to produce the Final Record Drawings:

5.5.1 Alignment Changes

5.5.1.1 Changes in Location

a. Manholes
b. Catch Basins or Surface Inlets
c. Headwalls
d. Retaining Walls
e. Slope Protection
f. Channel Linings

g. Pump Station Wet Wells
h. Pump Station Valve Vaults
i. Air Release Valves
j. Property Service Cleanouts

5.5.1.2 Changes in Elevation

To the nearest hundredth
a. Inverts
b. Rims
c. Surface Inlet Grates
d. Paved Ditches

To the nearest tenth
e. Turf Ditches
f. Miscellaneous Structures

5.5.2 Structure Changes

5.5.2.1 General

a. Manhole collar sizes
b. All revisions in pipe sizes, lengths, slopes, and angles
c. Identify pipe material if different from the plans

5.5.2.2 Pump Stations and Wastewater Treatment Plants

a. All revisions in pipe sizes
b. All revisions to electrical controls
c. All revisions to exhaust and ventilation systems
d. Pump modifications
e. Changes in elevation for inverts and level controls
f. Equipment layout modifications
g. Building modifications

5.5.3 Miscellaneous Changes

5.5.3.1 Property Service Connections

a. Size
b. Length
c. Depth at R/W or Property Line
d. Sewer Station
e. End Location, if the PSC is not perpendicular to the sewer

5.5.3.2 Changes in Lot or Unit Designations

a. Lot Numbers
b. Tract Numbers
c. Apartment Unit Designations
d. Condominium Unit Designations
e. Patio Home Designations

5.5.4 General

a. Any unverified data shall show +/- thereby indicating that information has not been verified.

b. The following stamp will be inserted into each plan sheet after all as-built information has been added.

c. For Private Development see the Record Drawings section of the Lateral Extension Procedures on the MSD Web site.

Final Record Drawing

By______________________Date_____________________

Contractor____

Record Drawings have been prepared based on information provided by the Contractor in accordance with the specifications.

TABLE OF CONTENTS

CHAPTER 6
SURVEYING

TABLE OF CONTENTS (cont.)

CHAPTER 6
SURVEYING

TABLE OF CONTENTS (cont.)

CHAPTER 6
SURVEYING
EXHIBITS

CHAPTER 6
SURVEYING

6.1 PURPOSE

This chapter describes the various field surveys for design, construction and approvals required for MSD projects. Private development requiring MSD approval and/or acceptance of constructed facilities shall also follow these guidelines. Project engineers and field survey crew chiefs should familiarize themselves with this and all other chapters of this Design Manual prior to the start-up of any field survey effort. Familiarity with this Manual will enable the field survey crew to obtain the necessary field information for design and construction and also minimize the occurrence of improper activities.

6.2 GENERAL

6.2.1 Conduct

The members of the survey crew are normally the first representatives of a firm or organization to come in contact with the property owners or residents along the route of the proposed improvement. It is imperative, therefore, that the survey crews conduct themselves properly, both on the project and in the surrounding community. **Survey vehicles should be adequately identified with their corresponding firm name. All survey crew members shall obtain an identification badge from MSD, and wear the badge at all times and be visible to the public.**

Their work should be explained to the property owners and to the public, as necessary, but the survey crew should carefully refrain from outlining any plans or policies, which might be misconstrued. If approached, the survey crew should <u>not</u> convey any project specific information to the property owners. The property owner should be referred to the respective MSD **Project Manager** if he/she has project specific questions. The crew must be courteous at all times when talking with the public and the crew members must maintain a **written** record of the names of owners or residents with whom they converse. During these conversations, **the survey crews should inquire about** the location of survey corners or monuments located on the owner's property.

6.2.2 Right of Entry

When it is obvious that the survey work will require entry onto private property, the owner shall be contacted, the survey work described, and permission to enter obtained. No project specific information should be conveyed to the property owner. Efforts to contact property owners shall include telephone calls and the leaving of letters and a door hanger for those who are not at home. A sample copy of the current MSD Insert Card as shown on Exhibit 6-1 shall also be presented to the property owner. Copies of these may be obtained from the MSD **Project Manager**. It should be explained in the notice that field inspection and soils investigation personnel might require entry from time to time during the course of the project. In the event that the owner does not grant permission and it is evident that the survey work will be delayed, MSD should be notified, in writing, immediately. It is the responsibility of MSD to take whatever course of action deemed necessary to obtain legal right of entry in accordance with state statutes.

6.3 HORIZONTAL AND VERTICAL CONTROL

6.3.1 General

When required, centerline and/or baselines shall be established using acceptable survey procedures. These survey lines shall be established in the general vicinity of the anticipated sanitary sewer or storm drainage system location, within the public right-of-way or easement limits and parallel to the expected location of the improvements. **When horizontal and vertical control monuments have been established in the area of the survey, all centerlines, and/or baselines, and level circuits shall be referenced to these monuments.** These monuments or coordinated positions and/or benchmarks **published by NGS or Louisville/Jefferson County Information Consortium (LOJIC) Geodetic Control Network** shall be shown and identified on the plans.

Trees are not to be used for surveying purposes except in remote areas where there is no other practical alternative. No spikes or nails are to be driven into a tree as described previously. Trees shall not be "blazed" under any circumstances, and only water-based paint may be used if it is necessary to mark a tree.

6.3.2 Guidelines

Horizontal and vertical control shall be established according to the guidelines defined by these publications:

a. **Federal Geodetic Data Committee (FGDC) endorsed standards FGDC-STD-003, FGDC-STD-007.1 through FGDC-STD-007.5 or the current** Federal Geodetic **Data Committee standards.**

b. All pertinent statute laws and regulations.

6.3.3 Datum

All control shall be related to existing monuments that have been **published by**

NGS or referenced on Louisville/Jefferson County Information Consortium (LOJIC) Geodetic Control Network and must reference the appropriate datum as indicated below:

a. Horizontal control shall be referenced to the Kentucky State Plane Coordinate System, North Zone/NAD **HARN** (1983).

b. Vertical control shall be referenced to the **North American Vertical Datum 1988**

6.3.4 Placement

All horizontal control shall be located within the easement or public right-of-way whenever possible. Each monument should be placed to avoid movement caused by construction or other activities. Every horizontal control marker that is not being specifically set for individual project control points should be set at maximum intervals of one-half mile on all projects.

A vertical control marker that is not being specifically set for individual project control points should be placed similarly to horizontal control marker at maximum intervals of one-quarter mile.

6.3.5 Monuments

All horizontal and vertical control markers shall be MSD approved and be of ferrous materials where applicable.

6.3.6 Project Control and Bench Marks

Project horizontal control shall be as described in this chapter. Project vertical control shall be referred to as bench marks. Bench marks shall be established at a maximum interval of 500 and must maintain a minimum distance of 25 feet from the improvement centerline. Each bench mark should be placed to avoid movement caused by construction or other activities.

All bench marks must conform to specifications for quality as referenced in Federal Geodetic Data Committee (FGDC) endorsed standards FGDC-STD-007.4. Sidewalks, steps (unless massive), small concrete slabs and similar structures are not acceptable. Each project must contain at least one bench mark, which conforms Federal Geodetic Data Committee (FGDC) endorsed standards FGDC-STD-007.4.

6.3.7 Survey Control Point References

With the advent of GPS and the coordinate control capabilities of most survey equipment, field references for horizontal survey control points are no longer required. All control information is identified on the Horizontal and Vertical Control Map, Exhibit 4-14.

All bench marks are to be field located and shall be referenced to the centerline of sewer by line designation, station, and offset. In addition, these other field references, such as addresses, etc., should be referenced the same in field notes, plans, and any other pertinent documents submitted. **If a spike in a power pole is used as a benchmark, the field notes, plan sheets, and the horizontal and vertical control sheet shall list the power pole number.**

6.3.8 Vandalized Survey Project Points and Bench Marks

MSD will not assume the responsibility for any damage done to project centerline control points and bench marks until after the final plans, contract documents, and field notes with proper references have been accepted by MSD. Any damage done to those points up to that time will be repaired or replaced by the Land Surveyor at the Land Surveyor's expense. It is advised that these points are accurately field referenced at the earliest possible time.

6.3.9 Horizontal and Vertical Control Review

MSD retains the right to request any corresponding field notes either digital or hard copies that pertain to the horizontal and vertical control for the project together with horizontal and vertical closure statements for their review.

The control data sheets, as shown in Exhibit 6-2, shall be submitted for each newly set horizontal and vertical control monument.

6.3.10 Horizontal and Vertical Control Map

A horizontal and vertical control map is required for all sanitary sewer surveys and major storm drainage projects as designated by the MSD Project Manager. This map shall be prepared on a standard plan sheet and shall be included in the final plans. The final horizontal and vertical control map, similar to Exhibit 4-14, shall include final stations, station equations, all curve data, and the final location and description of bench marks. In addition, the following information shall be shown.

6.3.10.1 Horizontal Information

a. Coordinate ties with adjacent projects.

b. Final coordinates of all horizontal control points, PI's , beginning and ending stations.

c. All bearings, coordinates, angles and point designations on MSD baselines in the design segment.

d. Source of horizontal datum. **(List the bearing and distance of the control line, and the deflection angle of the proposed centerline.)**

6.3.10.2 Vertical Information

a. New bench marks - their designations, locations, description and elevation.

b. **Existing Vertical Control Monuments as referenced in 6.3.3** - their designations, elevation and location.

c. Source of vertical **datum**. (If a spike in a power pole is used for a bench mark, list the power pole number and the height of the spike above the ground, and house number(s) of adjacent homes.

6.4 DEGREE OF ACCURACY

6.4.1 General

The specified criteria for surveys will vary accordingly to their function. All surveys are subject to the guidelines indicated in Section 6.3, Horizontal and Vertical Control.

The instruments used shall meet the specifications indicated in these guidelines or in following sections. All instruments shall be certified to National Institute of Standards and Technology (NIST) standards and manufacturer's specifications. NIST, the instrument manufacturer, or a certified instrument repairs facility must perform the certification.

All **instruments** should be serviced regularly by a certified repair facility and checked at a National Geodetic Survey baseline. EDM instruments should be calibrated by a certified repair facility annually. Field notes of all calibration checks **can be requested by** MSD's Survey Supervisor.

Instrumentation for second order leveling as defined by the Federal Geodetic Control Subcommittee (FGCS) of the FGDC shall be used for any projects requiring second order, class II specifications.

6.4.2 Accuracy Criteria

6.4.2.1 Sanitary Interceptor or Through Drainage System

Horizontal surveys will adhere to Second Order, Class II specifications, except that the error of closure shall equal or exceed 1:50,000.

Vertical control will adhere to Second Order, Class II specifications.

6.4.2.2 Sanitary Collector or Local Drainage Systems

Horizontal surveys will adhere to Third Order, Class I specifications, except the adjustments being made by either the Least Squares or Compass Rule Method.

Vertical control will adhere to Third Order specifications, except the error of closure will be equal to or exceed Second Order, Class II requirements.

6.5 FIELD PROFILE AND TOPOGRAPHY

6.5.1 Field Profile Requirements

Profile elevations shall be determined along sanitary sewer or through drainage system centerlines at 25-foot intervals, where possible, or at 50-foot intervals on paved streets, and at all necessary intermediate breaks. Profiles shall delineate existing structures, roads, streams, etc. Elevations shall be established to the nearest one-tenth of a foot on natural terrain and to one-hundredth of a foot on artificial surfaces.. Cross-sections shall be taken at critical locations when it is necessary to determine what effect open cuts or trenching might have on other facilities such as structures, utilities, pavements, fences, trees, or landscaping. Sufficient original ground elevations must be determined in order to establish the slopes necessary to adequately serve the property. The MSD Project Manager may modify these requirements to suit specific projects.

Roadside ditches within 30 feet, parallel to the sewer, and greater than 1.5 feet in depth shall be shown in profile with the sewer. These ditches and other elevations critical to design and/or construction must be shown on the plans.

6.5.2 Sanitary Service Connection Survey

A sanitary service connection survey shall be made along each street to properly determine the controlling elevations for design of a particular sanitary sewer line. The form found in Exhibit 6-3 shall be used in accomplishing this survey. The following information shall be shown on the form for each unit surveyed:

a. Type of structure.

b. Basement facilities present.

c. Size, type and location of service line.

d. Elevation of the lowest possible living area floor.

e. Any additional information that may be required for design of the sanitary sewer line.

All elevations should be determined by actual field measurements; however, if a unit cannot be entered, an estimated lowest living area floor elevation shall be made from a known elevation from some other point on the unit. In this case, the elevation must be clearly marked as being estimated. Should an estimated elevation control or have the potential to control the vertical elevation of the sewer, the MSD Project Manager shall arrange provision for entry and actual determination of the service elevation.

The completed forms shall be submitted along with the preliminary plans for review. They need not be included in the final plan submission but shall be included with the original drawings submitted at the conclusion of the project.

6.5.3 Topographic Requirements

In addition to the topographic requirements established in Chapter 4, the following information shall be obtained in the field:

a. All topography critical to the design of the improvement shall be located and recorded in the field notes.

b. Topography generated from aerial photography (including LOJIC planimetric and topographic base mapping) shall be identified and field checked for any errors or omissions. Omitted topography shall be located by field survey and appropriately recorded. This work is the specific responsibility of the Engineer or Land Surveyor, even though the aerial photography may have been provided from other sources. All topography within the project construction limits and/or easements and rights-of-way shall be field located.

6.5.4 Survey Information Needed for Trees

a. Species of Tree (Use the Audubon Society Field Guide to North American Trees, Eastern Region)

b. Size (DBH - Diameter at Breast Height)

e. Dripline (Diameter)

f. Encroachment Allowed within the Dripline

g. Location

1. All trees 6 inches in diameter or greater within the temporary or permanent easement shall be located and the species given within 30-feet of the centerline for pipe projects or 15 feet outside the top of slope for ditches.

2. All trees less than 6 inches in diameter shall be located and species given, when within an existing or proposed sewer and drainage easement.

3. When trees are grouped together, at a very close interval, locate the approximate center of the grouping and list the most dominant species of the group.

6.5.5 Soundings

Soundings shall be taken to a depth of 2 feet below the invert of the proposed improvement or to rock, whichever is encountered first. Soundings shall be taken on 50-foot stations in areas where rock is encountered and 100-foot stations where rock is not encountered. In areas of rapidly changing rock elevation, additional rock soundings will be required to identify the rock surface at a minimum of 25-foot stations. All soundings shall be documented for location, surface elevation, rock elevation (depth), and depth of sounding not encountering rock (no rock).

6.6 SPECIAL SURVEYS

6.6.1 Property Surveys

Where the relationship of the improvement location and adjacent property line is critical, the location of existing property lines and other boundaries shall be established by a property survey sufficient to define the easement. All property surveys shall comply with the "Minimum Standards of Practice for Land Surveying in Kentucky", latest revision, as set forth and enforced by the Kentucky Revised Statutes. Property lines, boundary lines, easements, etc. shall be referenced by stations and offsets from the centerline or baseline to the nearest one-hundredth of one foot, by measurement of the angles at the PI with the centerline, and by other means of comparable accuracy. Surveys shall ascertain the names of owners, lessees or tenants, sources of title and date of acquisition and shall be verified from the appropriate Jefferson County records. Copies of all field notes can be requested to be submitted to MSD.

6.6.2 Utility Surveys

All publicly and privately-owned surface and subsurface utilities affected by the proposed improvement shall be located and identified by field survey and by use of maps supplied by the utilities. Locations, elevations, and other pertinent data as may be required for possible relocation or adjustment shall be secured for all such utilities to the limits of information currently available. Overhead power lines near the intended improvement alignment, or those which may be a construction hazard, should be shown on the plans using the proper symbol and labeled with their primary voltage.

6.6.3 Railroad and Highway Surveys

When the centerline of improvements crosses a railroad or highway, all existing and proposed railroad tracks, roadways, and affected structures shall be tied to the improvement centerline. The topography shall be provided on either side of the proposed crossing to the extent required by the affected reviewing agency. **. An attempt to contact the railroad owners shall be made prior to the survey work in the railroad R/W.** Typical information shall include, but not be limited to, the following sections.

6.6.3.1 Railroads

a. Top of rails - 300 feet minimum in either direction locate horizontally and vertically at 50-foot intervals.

b. Angle between centerline of tracks and centerline of improvement.

c. Name and address of railroad company.

d. Location of railroad right-of-way and easements (source of record where possible).

e. Horizontal and vertical information relative to transmission lines, such as telephone or electric.

f. Stations on the centerline of each track.

g. Mile post locations, measured from centerline crossing.

6.6.3.2 Highways

a. Station on centerline of highway and each edge of pavement, or front face of curb, as may be appropriate.

b. Angle between highway centerline and centerline of improvement.

c. Location of highway rights-of-way and easements (source of record where possible).

d. Location of any crossings, parallel utilities, or drainage structures, which may be in conflict with the improvement construction.

e. Number and width of lanes and the type and condition of the surface.

Additional information relative to requirements in the vicinity of railroads and highways may be found in Chapter 8, Sections 8.18, 8.19 and 8.20.

6.7 STAKING SANITARY SEWER AND THROUGH DRAINAGE SYSTEM CENTERLINES

6.7.1 Preliminary Centerlines

Improvement centerlines shall be staked for a preliminary field review by using highly visible temporary markers. These markers shall be placed on the centerline at convenient locations, such as fence lines, streets, and borders of timber areas. Intermediate markers shall be placed as necessary to maintain continuous visibility. Plastic flagging shall be used on the markers to increase their visibility. Approximate stations and line designation shall be placed on the markers. The method of designating the centerline in urban areas may be modified as required to provide the information previously noted, including the use of paint on streets. Final staking of improvement lines and the assignment of final line designations before a preliminary field review is not encouraged. These requirements are subject to revision by the MSD Project Manager to suit specific projects.

6.7.2 Final Centerlines

6.7.2.1 Staking

Prior to acceptance of the final plans, the centerline shall be staked at PI's and as needed to maintain line of sight for purposes of easement acquisition, bidding, MSD field reviews, etc. Stations and line designation shall be clearly marked with an indelible marker on 1" x 2" x 18" (minimum) flat stake adjacent to the PI. Guard stakes of 1" x 1" x 48" (minimum), marked "Centerline Sewer" shall be provided at all PI's, manholes, structures, and other control points.

Stake markings shall include the designation of the sewer, such as Line "A” and the station of the point for which the guard stake is provided.

Points in pavement areas shall be identified by painting the necessary information adjacent to the permanently located point. PK nails or spikes are to be used for final centerline staking. Where necessary, offset stakes shall be utilized to identify points in streets, highways, and railroads.

6.7.2.2 Monuments

Iron pins shall be placed at all PI's and POT's necessary to establish the centerline, beginning and ending stations of the contract, and at those points specifically requested by MSD. These points shall be field referenced, per MSD specifications, so they may be located or reestablished at a later date. Iron pins shall be placed at all other manhole locations but do not need to be field referenced. Iron pins shall be made of or contain ferrous material and be a minimum of 30 inches in length and 5/8 inches in diameter. . In lieu of iron pins, railroad spikes, 6 inches minimum length, or PK nails shall be used in bituminous pavements and a scribed cross ("X") shall be used on concrete surfaces.

6.7.2.3 Centerline Verification

The Design Consultant shall verify the improvement alignment by obtaining field angles and distances along all segments of the improvement centerline. This shall include tying the final centerline alignment by traverse into the MSD control baseline. The alignment shown on the Horizontal and Vertical Control Map described in Section 6.3.10 shall be the final approved alignment.

6.7.2.4 Acceptance

The Design Consultant shall verify, in writing, that the alignment shown on the final construction plans has been located correctly in the field. This shall include returning to the field and verifying that all permanent points are intact and reestablishing all damaged or missing points. This must be accomplished before MSD will accept the original drawings, contract documents, and authorize final payment to the Design Engineer.

6.8 Certification Notes

Example Surveyor Certification notes can be found in section 4.5.6. A certification note, placed on the project title sheet, is required for all projects and should reflect the specific type of survey performed.

MSD

Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913

502–587–0603 – WWW.MSDLOUKY.ORG

EXHIBIT 6-1
IDENTIFICATION CARD
SUMMARY SHEET

EFFECTIVE DATE: JUNE 30, 2009

MSD
Metropolitan Sewer District

LOOK INSIDE

FOR A MESSAGE FOR YOU

Our representatives were in your neighborhood today. Please look inside this envelope for specific information – perhaps including a special telephone number – that will explain the situation.

If you have any questions about our programs, please contact the MSD Customer Service Department at 587-0603 between 8:15 a.m. and 5 p.m. Monday through Friday (except holidays).

Printed on recycled paper (01/00) 84000

MSD
Metropolitan Sewer District

Survey crews . . .

. . . are working in your neighborhood for MSD.

They are gathering detailed information about the land and its man-made features. This information is vital for many of our programs, ranging from routine maintenance to planning for future projects. Gathering this information is part of our continuing effort to improve our services for you.

If you have questions or concerns about this survey work, please feel free to call our Customer Service Department between 8:15 a.m. and 5:00 p.m. Monday through Friday (except holidays). The number is (502) 587-0603.

Printed on recycled paper (01/00) 8000

MSD
Metropolitan Sewer District

We're sorry we missed you!

One of our representatives was here today to investigate your recent request for service. This visit will help determine what can be done about the situation.

We are continuing to review your request, and we will get back in touch with you soon.

☐ If this box is checked, it means we need to talk to you to obtain more information. Please call:

____

____

at ____________________

Thank you for bringing your concern to our attention!

Printed on recycled paper (03/98) 8000

MSD

Louisville and Jefferson County
Metropolitan Sewer District

CONTROL DATA

JEFFERSON COUNTY, KENTUCKY
KENTUCKY STATE PLANE COORDINATE SYSTEM,
NORTH ZONE

NO. OF STATION 28 X FB
ELEVATION OF STATION 456.244 (NAD 1983)
DATE STATION ESTABLISHED 2–1–93

1983 Horizontal Datum

N–Coordinate	E–Coordinate
1239123.1234	287912.5678

Grid Distance and North Azimuth to Objects Observed

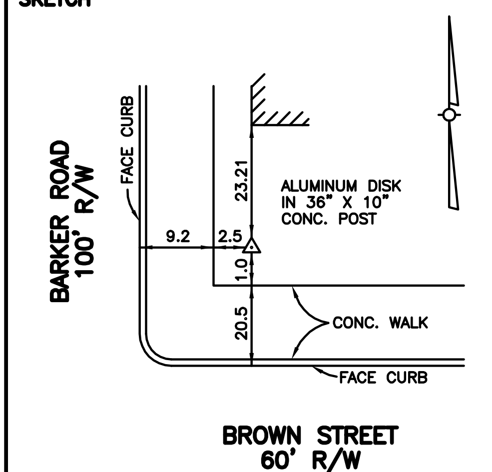
Object	Grid Distance – Ft.	North Azimuth
29 X FB	1321.48	218°15'33"
TRY AND MAKE OBSERVATION >		100'

DESCRIPTION AND REFERENCES:

Monument is aluminum disk set on a concrete post 36" X 10" flush with the ground.

To reach station from intersection Brown Street and Barker Road, City of Louisville, County of Jefferson, proceed 21.5' north of north face curb of Brown Street and 11.7' east of east face curb of Barker Road to aluminum disk set in concrete post.

SKETCH



Control set by: ______________________ **Date** ______________

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 6-3
SERVICE CONNECTION SURVEY FORM

EFFECTIVE DATE: JUNE 30, 2009

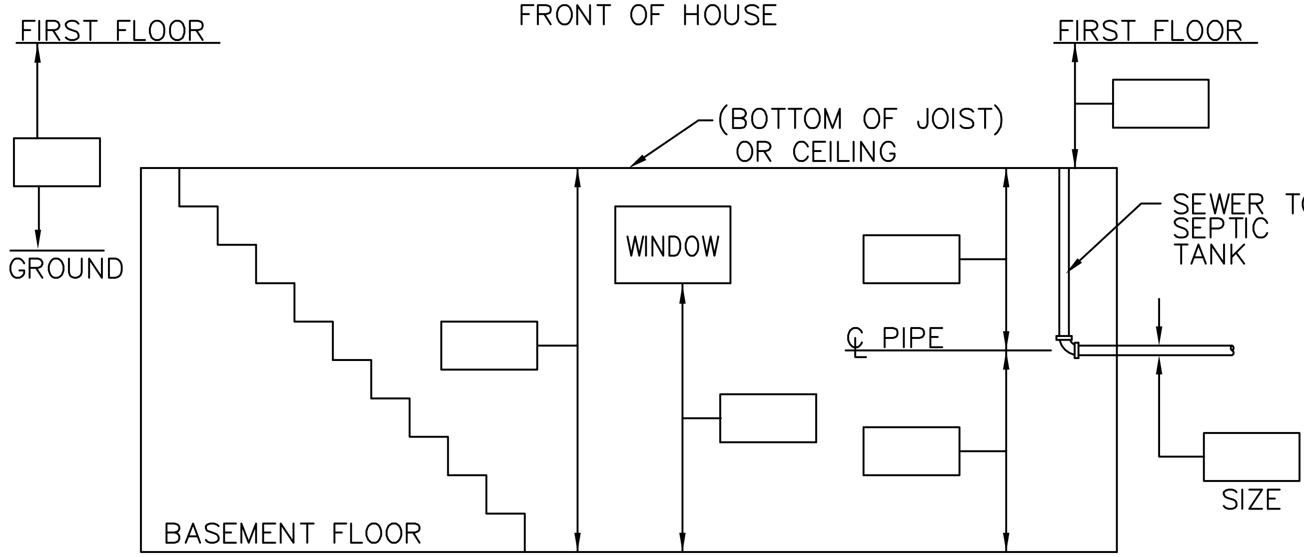
____

PROPERTY OWNER: ______________________________

SHOW LOCATION OF SEWER SERVICE EXITING RESIDENCE:

FRONT OF HOUSE

IF HOUSE SITS ON CORNER, SHOW AND LABEL EACH STREET



TYPE OF STRUCTURE:

Basement ______ BiLevel ______ TriLevel ______ Slab on Grade ______ Crawl Space ______

Other ______________________________

BASEMENT FACILITIES: DISCHARGE TO:

			Septic Tank (Gravity)	Sanitary Pump
Sink	Yes ______	No ______	______	______
Shower	Yes ______	No ______	______	______
Toilet	Yes ______	No ______	______	______
Washer	Yes ______	No ______	______	______
Sump Pump	Yes ______	No ______	______	______
Sanitary Pump	Yes ______	No ______	______	______
Floor Drain	Yes ______	No ______	______	______
Other	Yes ______	No ______	______	______

COMMENTS: ______________________________

____

____

Date: ______________ Survey By: ______________

TABLE OF CONTENTS

CHAPTER 7
EASEMENTS

TABLE OF CONTENTS (cont.)

CHAPTER 7
EASEMENTS

TABLE OF CONTENTS (cont.)

CHAPTER 7
EASEMENTS
EXHIBITS

CHAPTER 7
EASEMENTS

7.1 PURPOSE

All public sanitary sewers, storm drains, and open channels must be constructed in public rights-of-way, easements, publicly owned, or MSD- owned properties. No approval will be given for construction or improvement of any public sewer, storm drain, or channel without provision of suitable permanent easement or right-of-way. MSD will acquire and record all easements for MSD funded projects. The developer on private development projects will be responsible for acquiring all easements. Document recording will be the responsibility of MSD.

7.2 EXISTING EASEMENTS

Each existing easement to be used shall be shown on the plans submitted for review and approval. The information shown on the plans shall include the Deed Book and Page Number of the recorded instrument. All restrictive clauses as to the use of the easements, i.e., for utility purposes, drainage, sanitary sewers, etc., shall be noted on the plan adjacent to the pertinent easement. Construction of sanitary sewers or drainage systems will not be permitted in existing exclusive gas, electric, water, or telephone easements unless a sanitary sewer and Drainage Easement is acquired overlapping the existing easement with prior approval of MSD and the affected agency.

There are existing drainage easements in MSD's service areas. These drainage easements generally do not provide for the construction of sanitary sewers. In order to use these easements for sanitary sewer construction a new easement will be required to convert the existing Drainage Easement into a Sanitary Sewer and Drainage Easement. Construction plans and easement plats shall be prepared accordingly and the proposed new easement should be shown in the same manner as an entirely new easement.

The plats for Drainage Easements, in some cases, were recorded by previously assigned parcel numbers. The new plat converting these parcels will be assigned new parcel numbers. The parcel numbers for the existing Drainage Easements, as well as the Deed Book and Page Number or Plat Book and Page Number, shall be shown in the "remarks" column on the Property Acquisition Summary Sheet when these are available.

7.3 DEFINITIONS

The following terms define the methods under which MSD currently acquires interest in property for the purpose of constructing, operating, and maintaining wastewater treatment, drainage facilities and sanitary sewers:

7.3.1 Fee Simple Title

For the purpose of constructing major aboveground structures, MSD will normally acquire all rights to the required property in fee simple and permanently retain ownership. This generally refers to large pumping stations, wastewater treatment plant sites, and major detention basins.

7.3.2 Sanitary Sewer and Drainage Easement

For the purpose of constructing facilities (sanitary sewers, storm drainage systems, etc.), MSD will acquire the right to construct facilities within the limits of easements. They will have the right to operate and maintain those facilities within the same limits and also have reasonable ingress and egress over each affected property to the easements for construction, operation, maintenance and reconstruction. These easements are permanent in nature and are referred to as Sanitary Sewer and Drainage Easement. See Section 7.6 for the proper terminology to be used on easement plats and acquisition documents.

The limits of Sanitary Sewer and Drainage Easement shall be set for permanent structures. Existing structures shall not be within the easement area, unless the sewer construction actually requires the removal of such buildings or structures.

A property owner generally is restricted from constructing any facility within the limits of the easement that might interfere with the maintenance and operation of the facility.

7.3.3 Temporary Construction Easement

A temporary construction easement will be required adjacent to all new Sanitary Sewer and Drainage Easements when necessary for construction operations. Temporary construction easements shall be required for structure removal, access roads, stockpiling, and other construction activities when necessary. Structure removal includes the removal of treatment plants, pump stations, etc. Sufficient area shall be supplied for movement of equipment and materials to accomplish the intended activity within the Temporary Construction Easement. If at all possible, Temporary Construction Easements will not be acquired on adjacent private property when the proposed facility lies within a dedicated right-of-way or an existing Sanitary Sewer and Drainage Easement. Only under certain unusual conditions will a Temporary Construction Easement be acquired from a parcel if a new permanent easement is not being acquired from that same parcel. Accordingly, no plats shall be prepared showing Temporary Construction Easements only, without the prior approval of MSD. "Consent and Release" may be used in lieu of temporary easement. A "Consent and Release" form is shown on Exhibit 7-4. Temporary Construction Easement lines may be drawn through permanent structures; however, the Contract Documents shall contain language, which clearly indicates that all such permanent structures shall not be disturbed during construction. After the project is completed and the property is restored to its prior condition, all rights to the property are relinquished.

7.4 EASEMENT WIDTHS

Whenever possible, the total easement width, permanent and temporary, should be sufficient to permit the contractor to have flexibility in the method of construction.

Suggested minimum widths of Sanitary Sewer and Drainage Easements and Temporary Construction Easements using trench construction are tabulated below; however, in no case shall these guidelines be a substitute for sound engineering judgement:

Table 1. Minimum Easement Widths

Size of Pipe	Sanitary Sewer and Drainage	Temporary	Total
8" - 12" & Property Service Connections 8" or Less	15'	**20'** on each side	**55'**
15" - 48"	15'	20' on each side	55'
54" - 72"	20'	25' on each side	70'
84" and larger	30'	30' on each side	90'

7.5 CONSTRUCTION PLAN REQUIREMENTS

7.5.1 General

Construction plans shall be prepared in a manner, which will show clearly, and correctly, the information necessary for the acquisition of each parcel of land required. They must accurately show the location of each parcel and its relationship with surrounding areas. The alignment, as shown on the construction plans and easement plats, must agree with the alignment staked in the field. The information shown must be authentic and thoroughly checked since it will become legal evidence regarding the parcels of land required. The plans shall carry appropriate certifications and seals indicating that the surveying has been accomplished under the supervision of a Land Surveyor registered with the Commonwealth of Kentucky. They shall also meet the Minimum Standards of Practice for Land Surveying in Kentucky and the following guidelines:

a. An effort should be made to parallel property lines with the facility when topographic features permit.

b. Easements shall be referenced to property corners and/or known landmarks to the degree that they can be accurately reestablished prior to construction.

c. In residential areas, all topographic features, such as trees, shrubs, sheds, etc., which are located within the easements shall be properly identified on the plans. When undeveloped wooded areas are encountered, only those trees of unusual size or nature need to be specifically identified on the plans. Any items within these easements, which are definitely not to be disturbed during the construction, shall be clearly noted "Do Not Disturb" (DND). Items, which remain, but disturbance is necessary for construction shall be noted "Do Not Remove" (DNR).

7.5.2 Easement Description Criteria

The construction plans shall show the following information for each parcel from which easements are to be acquired:

a. Property owner's name of record, address, and spouse's name, if married. If a Property Acquisition Summary Sheet is included in the plans, this requirement will not apply.

b. Subdivision name, section number and lot number (when a deed has not been recorded) or Deed Book and Page Number.

c. Existing rights-of-way and easements.

d. Existing Sanitary Sewer and Drainage Easements, their Deed Book, Page Number, and MSD Record Number, if available.

e. Property lines with label.

f. Parcel numbers.

In addition, the Deed Book and Page Number for the new easement shall be added to the plans when the information is made available by MSD. Therefore, the abbreviations "D. B. and Pg." shall be added to the plans adjacent to the new easement with enough space to the right of each for this information to be added at a later date.

7.6 EASEMENT PLAT CRITERIA

7.6.1 General

Sanitary Sewer and Drainage Easements

Easement plats shall be prepared for each property having a Sanitary Sewer and Drainage Easement or other type of acquisition. The phrase "Sanitary Sewer and Drainage Easement" shall be used on all plats and acquisition documents. Easement plats, in general, shall be prepared on 8.5" x 14" sheets. A sample plat can be found on Exhibit 7-1.

All plats shall have the title block in the lower right corner of the plat and the Land Surveyor's Certification and Seal in the lower left corner. No other format should be submitted and none will be accepted.

Permanent easement on all plats is to be hatched for clarity. Temporary easements are not to have hatching, cross-hatching, or shading.

Release of Existing Easements

Any release of easement is to have its own plat and the area of easement to be released is to be crosshatched. No plat containing both easement dedication and release of easement will be accepted. The MSD Director of Engineering must approve the release of easement and the applicable fees must be paid. All other requirements of easement plats shall apply to easement release plats. A sample “Release of Easement Plat” is shown on Exhibit 7-2. The easement release (“Quitclaim”) requirements and procedures are found on the MSD web page.

Encroachment Plats

On occasion a permanent structure is found to be, or required to be, encroaching upon an existing easement. In such situations, an easement encroachment plat must be prepared and recorded. A sample plat is shown on Exhibit 7-3.

Easement plats should contain sufficient information to enable a Land Surveyor to locate and stake the easements in the field.

7.6.2 Plat Information

The "Easement Plat Checklist" indicates the plat requirements and should be referenced prior to all submittals to MSD. It is located on the MSD web page.

7.6.3 Property Service Connection Easement

Occasionally, a Sanitary Sewer may be located such that the permanent easement does not extend to the property line of an adjacent property to be served with a proposed property service connection. This occurs due to topographic or geographic considerations such as parallel streams. In these instances, a 15' Sanitary Sewer and Drainage Easement shall be provided from the proposed service facility easement to the property line at the most likely location of the property service connection. Sufficient Temporary Construction Easement shall also be depicted.

7.6.4 Easements on Railroad Rights-of-Way

Sanitary Sewer and Drainage Easements may be acquired on railroad rights-of-way. However, acquisition of easement on a railroad right-of-way does not eliminate the requirement of submitting a Railroad Crossing Conflict Drawing to MSD for approval of conduits crossing under rails of the affected railroad.

7.6.5 Certificates

A Certificate of Easement, Certificate of Easement Release, or Certificate of Encroachment Agreement, as applicable, must be made a part of each easement plat submittal. The certificate forms are available on the MSD web page.

It is the responsibility of the Land Surveyor to attach the proper certificate to each easement plat submitted. No changes in the format of these certificates by the Land Surveyor shall be permitted.

7.6.6 Submission

After the easement requirements have been defined, one set of preliminary plats shall be submitted for review. After incorporating any review comments, the final submittal will be in the following form:

- The original of each plat, signed in ink.
- One copy of each plat.
- One copy of each plat with the appropriate easement certification sheets attached.

Copies of all easement plats submitted shall be clearly legible and shall be made on bond, or better grade, paper using an electrostatic or equivalent copier utilizing a dry process. Plats submitted that are not clearly legible or do not meet the above requirements, will not be accepted.

Easement plats submitted shall contain a Land Surveyor's original stamp, signature and date. If MSD makes any changes or modifications to the final plans after they have been accepted by MSD, the Land Surveyor will receive a copy of the revised sheets. If any changes or revisions are necessary on the easement plats, the Surveyor shall be notified and must make the necessary revisions and resubmit the plats as previously described.

Easement location and requirements shall be determined as early as possible on all projects in order to initiate the acquisition procedures as early as possible. The estimated number of easement plats used in determining easement plat cost during the proposal period shall be given to the Acquisition Department. Adherence to this procedure should minimize the possibilities of project delays due to unavailability of required easements.

7.7 PROPERTY ACQUISITION SUMMARY SHEET

Certain property data shall be shown on the Property Acquisition Summary Sheet, as well as on the construction plan sheet and easement plat. However, a separate Property Acquisition Summary Sheet will not be required if a project has five parcels or less. In such instances, the property acquisition information in the same format may be placed on the Plan Sheet Index, on the first plan sheet if adequate space is available, or be included in the plan index on the cover sheet.

An example of the layout for the Property Acquisition Summary Sheet is shown on Exhibit 4-15. The Property Acquisition Summary Sheet shall show the following data for each parcel required for right-of-way purposes:

7.7.1 Parcel Number

Parcel numbers shall be assigned to each parcel of property to be acquired and shown on the plans. Parcel number 1 shall be assigned to the first parcel, and the remaining parcels shall be numbered consecutively from the beginning to the end of the project. Parcel numbers shall not be assigned to publicly-owned rights-of-way; however, they will be required for privately-owned rights of way, such as Louisville Gas and Electric Company, AT&T, Riverport Authority, railroad companies, private roads, etc.

Parcel numbers assigned to each tract shall not be changed after submission of the final easement plats. If it is then determined that acquisition from any parcel will not be required, that number shall be removed from the plans and the notation "NOT USED" shall be placed in the owner's block on the Property Acquisition Summary Sheet.

7.7.2 Owner's Name

The name of the current owner of the property and address, at the time of the preparation of the plans, shall be shown. These can be obtained from the Louisville and Jefferson County Property Valuation Administration Office. Final changes to the Property Acquisition Summary Sheet will be made when the property is being acquired.

7.7.3 Property Address

The address of the property served shall be shown. Should the owner's mailing address differ from that of the property, the owner's mailing address should be shown in the remark’s column.

7.7.4 Plan Sheet Number

The sheet number is the number assigned to the plan sheet on which the particular parcel is shown. Some parcels, of course, will appear on more than one plan sheet and all sheet numbers must be included.

7.7.5 Source of Title

This column shall show the Deed Book and Page Number of the parcel or the subdivision name, section number and lot number when a deed has not been recorded, or such other evidence of title information as may be available.

7.7.6 Total Area of Tract

The total area of the tract from which an easement is being obtained shall be shown in either acres or square feet in the appropriate column. In general, the area of subdivision tracts shall be shown in square feet, while the area of larger tracts, generally more than an acre, shall be shown in acres.

7.7.7 Area of Easements

The area required for a Sanitary Sewer and Drainage Easement shall be shown in square feet or acres in the appropriate column. The area required for a Temporary Construction Easement shall be shown in square feet or acres in the appropriate column. Areas shall be shown to the nearest square foot or one-thousandth of an acre as appropriate.

The easement areas required on the Property Acquisition Summary Sheet shall generally be shown in square feet for easements of one acre or less and shown in acres for easements of more than one acre.

7.7.8 Permanent Easement

The Deed Book and Page Number of the newly recorded easement will be entered in the appropriate columns by MSD or the Design Engineer if the information is available prior to the submittal of final plans.

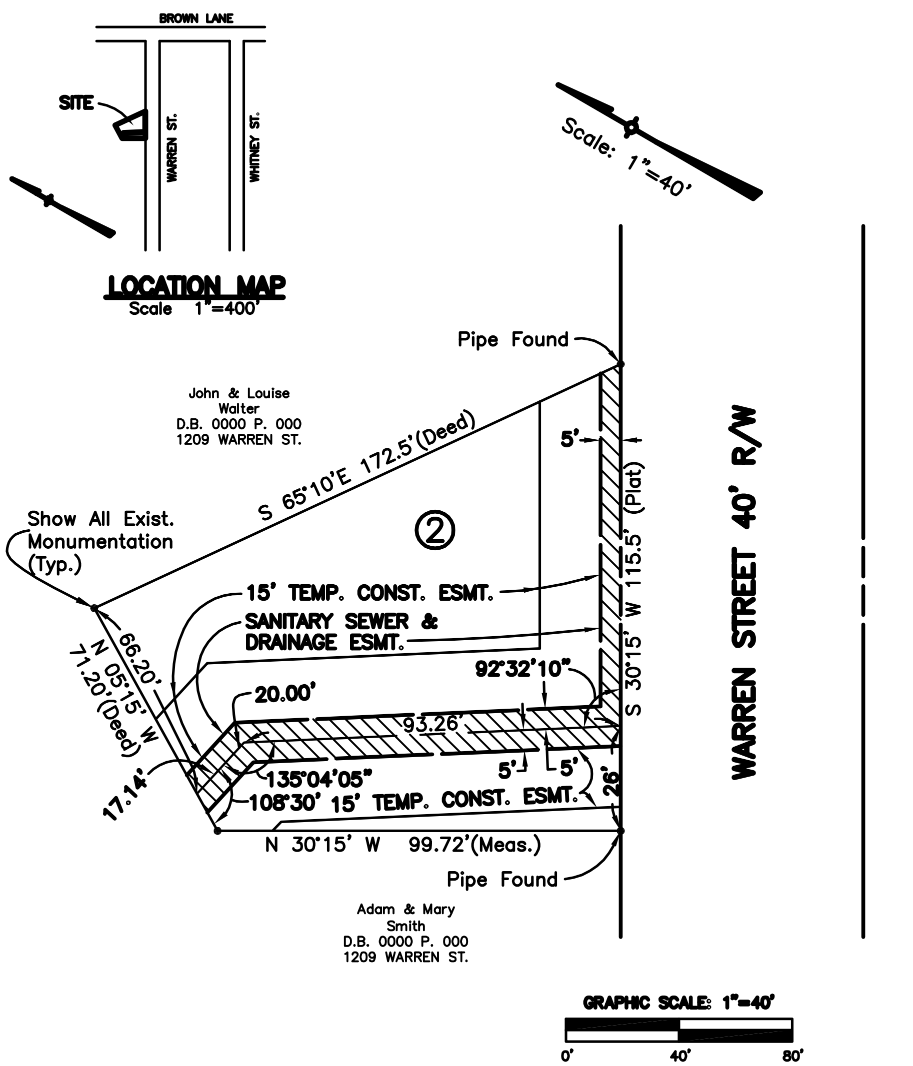
MSD

Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913

502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 7-1
SAMPLE SEWER & DRAINAGE EASEMENT PLAT

EFFECTIVE DATE: JUNE 30, 2009



PERMANENT EASEMENT = 1,502.5 SQ. FT.
TEMPORARY CONSTRUCTION EASEMENT = 4,508 SQ. FT.

The reference meridian used on this plat to determine the directions of survey lines was based on the deed bearing of the NORTH line of the tract.

LAND SURVEYOR'S STAMP

I hereby certify that this plat was made under my supervision and is correct to the best of my knowledge and belief. Distances as shown on this plat have not been adjusted for closure. This easement Plat meets or exceeds the minimum standards of governing authorities.

LAND SURVEYOR'S SIGNATURE Surveyor

Being a part of the same property conveyed to the GRANTOR by deed dated January 1980, recorded in Deed Book 4911, Page 125, in the office of the Clerk of the Jefferson County Court.

Tax Block ________ Lot No. ________

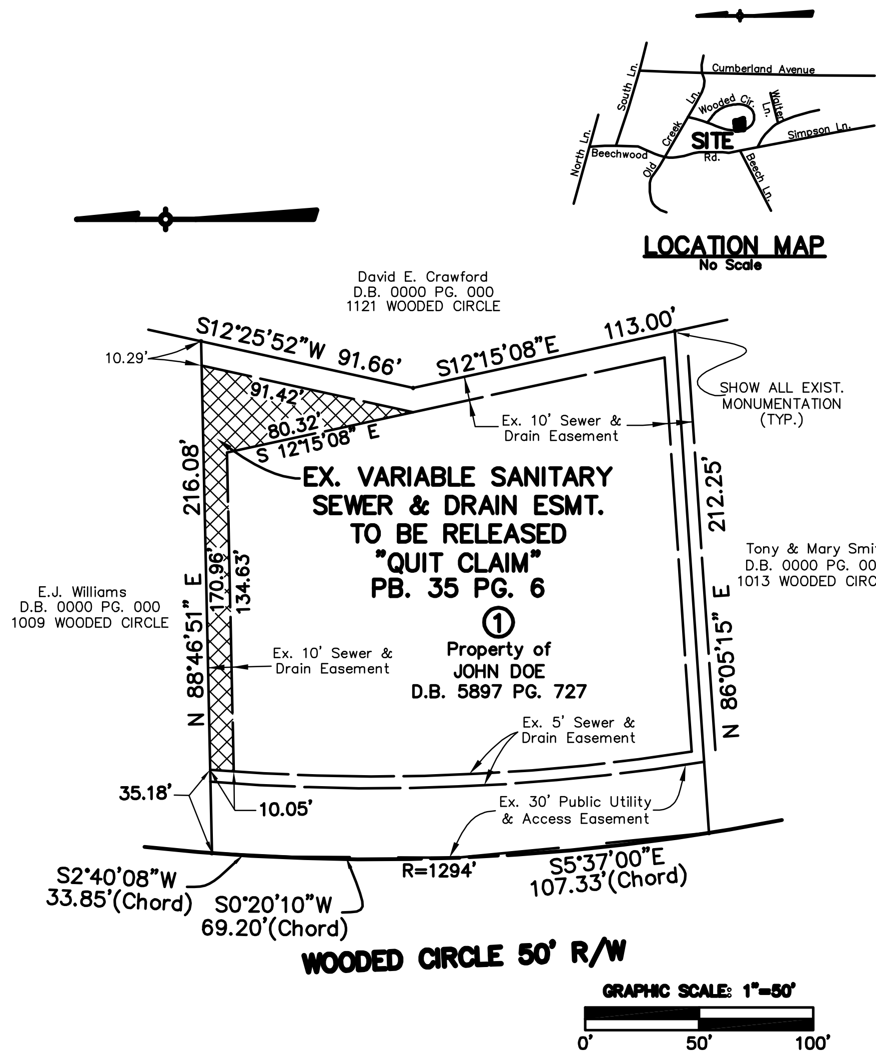
SAMPLE ENGINEERING COMPANY
&
ADDRESS/PHONE NO.

SANITARY SEWER & DRAINAGE EASEMENT

Property of
TOM & JANE POWERS
2001 GREEN CIRCLE WAY
LOUISVILLE, KY. 40218

Property Address
DICK & JANE DOE
1207 WARREN STREET
LOUISVILLE, KY. 40220

Parcel No. 2 Record No. 5199
Date 10-01-00
Sheet 1 of 3



LEGEND

Area to be released = 3,075 Sq.Ft.

All lot dimensions are per deed of record.

The reference meridian used on this plat to determine the directions of survey lines was based on the deed bearing of the NORTH line of the tract.

LAND SURVEYOR'S STAMP

I hereby certify that this plat was made under my supervision and is correct to the best of my knowledge and belief. Distances as shown on this plat have not been adjusted for closure. This easement Plat meets or exceeds the minimum standards of governing authorities.

LAND SURVEYOR'S SIGNATURE ______ Surveyor

Being a part of the same property conveyed to the Grantor by deed dated SEPTEMBER 14, 1989, recorded in Deed Book 5897, Page 727, in the office of the Clerk of the Jefferson County Court.
Tax Block ______ Lot No. ______

SAMPLE ENGINEERING COMPANY
&
ADDRESS\PHONE NO.

RELEASE OF SANITARY SEWER & DRAINAGE EASEMENT

Property of
TOM & JANE POWERS
2001 GREEN CIRCLE WAY
LOUISVILLE, KY. 40218

Property Adress
JOHN DOE
1011 WOODED CIRCLE
LOUISVILLE, KY. 40223

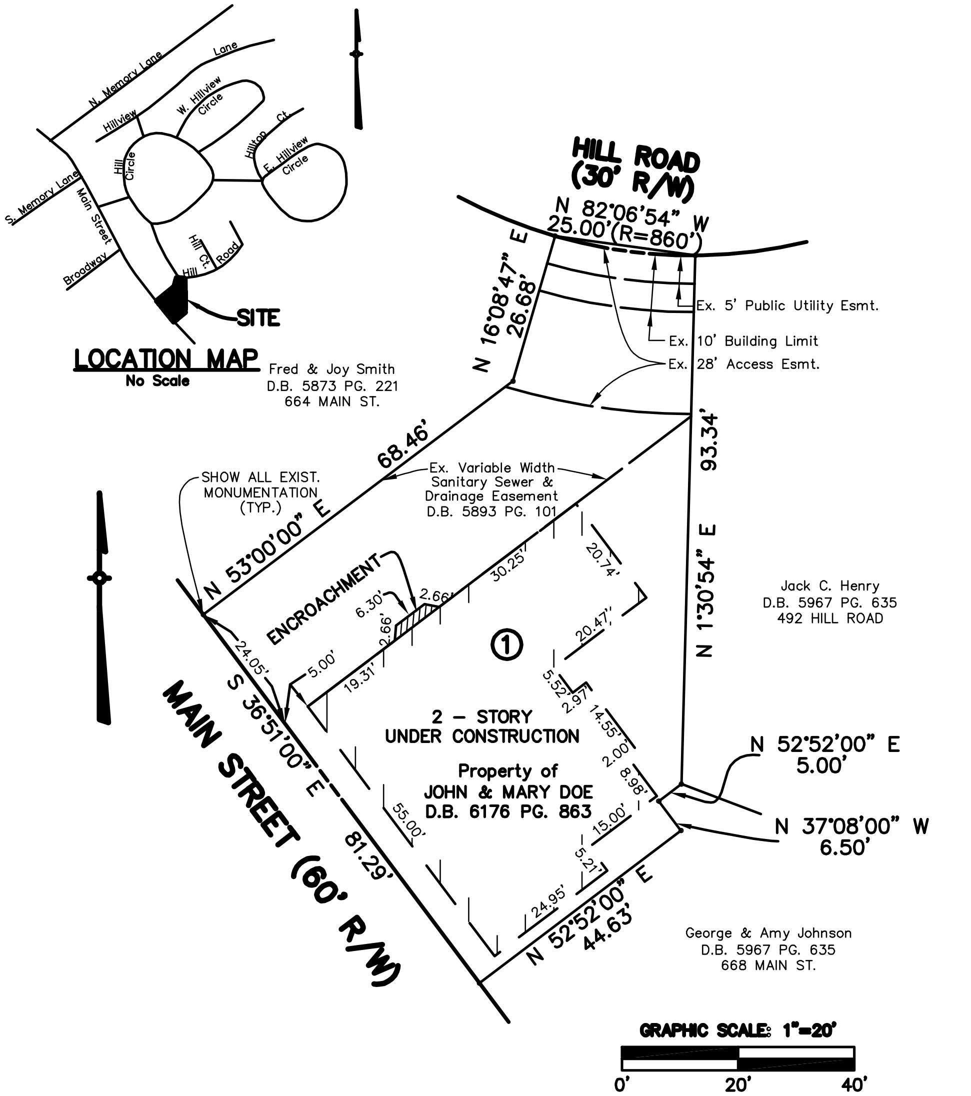
Parcel No. 1 Record No. 11105
Date 10-01-00

Sheet 1 of 3

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 7-3
SAMPLE EASEMENT ENCROACHMENT PLAT

EFFECTIVE DATE: JUNE 30, 2009



LEGEND

Area of Encroachment 16.24 Sq.Ft.

All lot dimensions are per deed of record, unless noted.

The reference meridian used on this plat to determine the directions of survey lines was based on the deed bearing of the NORTH line of the tract.

Being a part of the same property conveyed to the Grantor by deed dated AUGUST 2, 1985, recorded in Deed Book 6176, Page 863, in the office of the Clerk of the Jefferson County Court.
Tax Block ________ Lot No. ________

SAMPLE ENGINEERING COMPANY
&
ADDRESS\PHONE NO.

LAND SURVEYOR'S STAMP

I hereby certify that this plat was made under my supervision and is correct to the best of my knowledge and belief. Distances as shown on this plat have not been adjusted for closure. This easement Plat meets or exceeds the minimum standards of governing authorities.

EASEMENT OF ENCROACHMENT

Property of
TOM & JANE POWERS
2001 GREEN CIRCLE WAY
LOUISVILLE, KY. 40218

Property of
JOHN & MARY DOE
666 MAIN STREET
LOUISVILLE, KY. 40211

LAND SURVEYOR'S SIGNATURE **Surveyor**

Parcel No. 1 **Record No.** 6100
Date 10–01–00
Sheet 1 of 3

CONSENT AND RELEASE

This Consent and release made and entered into this ________ day of ________, 20____, by and between ______________________________, parties of the first part, and

Metropolitan Sewer District

WHEREAS, the Metropolitan Sewer District deems it necessary to perform the following work in order to improve the storm drainage for the following described property, and

WHEREAS, the parties of the first part, being the owners of said property and desirous of having said work performed.

Address of Property: ____
____

Description of Work: ____
____
____

NOW THEREFORE, in consideration of the benefits accruing to said property, the parties of the first part hereby consent and agree that Metropolitan Sewer District. its agents, employees and assigns may enter ant come upon the above described property for the purpose of performing the work as described above and further expressly agree that the parties of the first part will assert no claim whatsoever, of any kind or type, against Metropolitan Sewer District, its agents, employees or assigns by reason of the performing of said work, but by these presents shall be forever barred except that Metropolitan Sewer District shall be liable for any damage to persons or property which results from its acts or omissions during the course of the project as it is performed on party of the first part's property and which occurs during such performance.

IN TESTIMONY WHEREOF, witness the signatures of the parties this _________ day of _______________, 20____.

PROPERTY OWNERS

____
Party of the First Part

____
Party of the First Part

BY: ________________________________
Louisville and Jefferson County..
Metropolitan Sewer District.

(Provide one copy for property
owner and one copy for MSD files

TABLE OF CONTENTS

CHAPTER 8
SANITARY SEWER SYSTEMS

TABLE OF CONTENTS (cont.)

CHAPTER 8
SANITARY SEWER SYSTEMS

TABLE OF CONTENTS (cont.)

CHAPTER 8
SANITARY SEWER SYSTEMS

TABLE OF CONTENTS (cont.)

CHAPTER 8
SANITARY SEWER SYSTEMS
EXHIBITS

CHAPTER 8
SANITARY SEWER SYSTEMS

8.1 PURPOSE

This chapter establishes the minimum standards and technical design criteria for sanitary sewer systems in the MSD service area. Adherence to these will expedite review and approval of plans. Hydraulic design presented herein represents acceptable procedures not necessarily to the exclusion of other sound and technically supported design procedures. Any departure from these design requirements should be brought to the attention of MSD before submission of plans for approval and should be justified and documented. Sanitary sewer plan preparation for private development must conform to Chapter 9 requirements and in all cases plan development shall conform to the Chapter 12 EPSC requirements.

8.2 BASIC ELEMENTS

The design of sanitary sewers basically consists of the determination of the following:

a. The location of the horizontal alignment, which most efficiently provides service to existing and potential users.

b. The vertical restrictions on establishing the sewer alignment including: depths required to serve users, minimum cover, elevations of other sewers in the system, conflicts with other underground facilities, solid rock considerations, and maintaining the required hydraulic gradients.

c. The design flow generated by the existing and future users, which must be transported by the sewer.

d. The size, material, bedding and method of construction required.

e. The necessary appurtenances and special structures required.

8.3 GENERAL LOCATION CRITERIA

Sewers shall be located using sound engineering judgment to determine the most cost-effective and environmentally sensitive alignment that best serves the needs of the entire tributary area. Additionally, it is imperative that all alternatives worthy of consideration receive maximum and equal consideration with regard to environmental impact. The costs and acquisition time for easements can be significant; therefore, sewers should be located within existing easements and rights-of-way whenever feasible and practical. Sewers designed within existing pavements shall be located 5 feet from the edge of pavement on the side opposite the existing water main. Sewers designed within the rights-of-way of proposed streets and highways shall be located in the center of **one of** the proposed **traffic lanes** whenever possible. When the proposed street or highway has a curved alignment, an effort shall be made to locate the sewer a minimum of 5 feet inside the edge of pavement, unless exceptional considerations dictate to the contrary. When selecting the sewer alignment, consideration should be given to the following general location criteria:

a. Elevation requirements necessary to provide appropriate service with due consideration of sanitary facilities in basements.

b. For protection of the environmentally sensitive areas and constraints such as creeks, wetlands, trees, protected habitats, etc.

c. Existing utilities, railroads, highways, and overhead facilities.

d. Location of other existing and proposed sewerage and stormwater facilities.

e. Property values, easement needs and potential damages to the affected properties.

f. Existing and proposed high water elevations, including high water for appropriate design periods.

g. Anticipated extension of existing streets and the potential for the development of contiguous areas.

h. Continuity with adjacent design segments.

i. Maintenance of traffic.

j. Availability of materials.

k. Foundation conditions.

l. Construction cost.

The location of proposed sanitary sewers should also meet the intent of the Kentucky Administrative Regulations, specifically title 401 KAR 5:005 – "Permits to Construct, Modify, or Operate a Facility", Section 7 (Design Considerations), Paragraphs 14 and 15.

8.4 HORIZONTAL ALIGNMENT CRITERIA

8.4.1 General

With the exceptions noted hereafter, all sewers shall be constructed with a straight alignment between manholes. For alignment changes in sewers 36 inches in diameter and larger, curved monolithic sewer sections with a radius equal to four times the diameter of the sewer may be required.

8.4.2 Straight Streets

Generally, sewers shall be located in the traffic lane on the opposite side of the street from the water main and at least 10 feet from the water main; however, the centerline of the sewer should be a minimum of 5 feet from the edge of pavement. Extraordinary circumstances may require placing the sewer closer to the edge of pavement, but every effort shall be made to place the entire manhole frame and cover entirely within the pavement. In areas where this location will conflict with gas and water valves or other utilities, the sewer location shall be adjusted to avoid these conflicts. Consideration of other factors, such as the width of the pavement, depth of rock, and possible conflict with other utilities, will still be required so the sewer can be built without modification during construction. In areas where concrete pavement is encountered, consideration shall be given to placing the sewer in a location whereby one edge of the pavement to be removed would coincide with existing construction joints, which are generally in the centerline of the streets. This procedure would require that only one side of the pavement would have to be sawed for removal. In areas where lots slope abruptly away from the street, consideration shall be given to locating the sewer near the property line on the low side.

8.4.3 Curved Streets

The sewer line may be located outside the pavement if such an alignment proves to be cost-effective. The manholes may be either within the pavement or completely outside the pavement, but shall not be partially in the pavement. The existence of curbs shall be considered in evaluating the benefit of reducing the number of manholes in curved streets. In all cases, the centerline of the manhole shall be a minimum distance of 3 feet from the edge of pavement, and a minimum distance of 5 feet inside the street right-of-way line.

8.4.4 Curve Data

Curve data, based on the arc definition, shall be used for all curved monolithic sewer segments. The curve data shall be shown on the plans near the respective curve (preferably on the inside of the curve) in the following manner:

P.I. Sta. = 10+00.00	(Point of Intersection Station)
Δ = 35° 30' 00" Lt.	(Delta Angle)
D = 409° 15' 20"	(Degree of Curve)
L = 8.67'	(Length of Curve)

R = 14.00'	(Radius)
T = 4.48'	(Tangent Length)
P.C. Sta. = 9+95.52	(Point of Curvature Station)
P.T. Sta. = 10+04.19	(Point of Tangency Station)

8.4.5 Stationing

All sewer stations shall increase upstream. Every effort shall be made to begin the stationing of a sewer with Station 0+00.00 at the downstream end. When an existing sewer is to be extended, the stationing should be continued from the end of the existing sewer whenever possible. For sewers not requiring curved sections, the PI stations and deflection angles or interior angles shall be shown on the plans at all changes in alignment. The arc and tangent lengths of curved sections shall be used in determining the sewer alignment stationing.

8.4.6 Sewer Designations

The designation of the first sewer in a collection system shall be LINE "A". The next sewer upstream contributing to LINE "A" shall be designated LINE "B", and the station of LINE "B" at this point shall be Station 0+00.00. This method shall continue throughout the collection system and subsequent sewers shall be assigned appropriate designations by ascending letters. Lines beyond LINE "Z" shall continue with double letter designations starting with LINE "AA", "AB", etc. For very short segments not extending beyond one manhole, designations such as LINE "B-1" will be allowed.

8.5 VERTICAL ALIGNMENT CRITERIA

8.5.1 Sewer Depths

Sanitary sewers shall have a minimum cover of 4 feet in easements and a minimum cover of 5 feet in rights-of-way. Specific exceptions to these minimum requirements may be made with prior approval by MSD.

In developed areas, the criteria, found in Exhibit 8-2, should be used to establish the flow line of the sewer unless otherwise directed by MSD. The "Service Connection Survey" form, found on Exhibit 6-3, should be used when determining the controlling elevations of a sanitary sewer line. In instances where only a few houses on a sanitary sewer have existing basement facilities, the impact on the entire system shall be considered prior to providing gravity basement service. Additionally, in areas having substantial amounts of solid rock, consideration shall be given to the omission of basement service. This omission must be approved in writing by MSD.

In establishing the elevation of the proposed sanitary sewer, the elevations of existing or proposed interceptor sewers or the elevations of inflow pipes to existing pump stations or wastewater treatment plants and all other utilities shall be considered.

A minimum cover of 2 feet shall generally be maintained when crossing under existing streams, existing ditches, and existing or proposed channel improvements **and storm sewers**, provided the sanitary sewer line is encased in concrete **(or capped if approved by MSD)**. With respect to streams, restoration of the channel invert will conform to the applicable standard drawings (EC-01-01, EC-02-01, or EC-03-01).

The sanitary sewer elevation necessary to serve the entire tributary area shall be considered in establishing the upstream flow line of any sanitary sewer segment including the area beyond the boundary of a design section.

A separate parallel sanitary collector sewer shall be considered in lieu of individual property service connections into the interceptor sewer in areas where the sanitary interceptor sewer reaches excessive depths. The collector sewer, at a higher elevation, should end in a drop manhole or vertical stacks into the interceptor sewer. A cost-effectiveness study shall be submitted to MSD for review and approval.

8.5.2 Sewer Gradients

All sewer gradients shall be referenced to the **North American** Vertical Datum of 19**88**. When connecting into or extending existing sewer facilities that were constructed using another datum, an elevation equation should be shown on the plans. The hydraulic criteria, established in Section 8.9, should be used to determine sewer flow line elevations in manhole structures and curved segments of the sewer.

8.5.3 Flooding and Ponding Areas

In general, the top of sanitary manhole elevations shall be a minimum of 2 feet above existing, proposed, or projected 100-year high water elevations. However, when this minimum elevation causes the manhole to be above the natural ground creating obstructive mounds, the top of the manhole elevation shall be lowered to the natural ground elevation and a watertight manhole lid and frame shall be specified.

8.5.4 Minimum Water Main Clearances

The following minimum clearances between the sewer and existing or proposed water mains shall be used in establishing the sewer alignment:

8.5.4.1 Horizontal Clearance

The horizontal clearance shall be 10 feet minimum. Where this is not possible, the Design Engineer should reference the "Ten State Standards" Section 38.31 **(2004 Edition).**

8.5.4.2 Vertical Clearance

The vertical clearance shall be at least 18 inches. If at all possible, the sewer shall be located below the water main. Should it become necessary for the sewer to cross over the water main, special precautions and exfiltration testing of the sewer will be required. Such cases shall require written approval by MSD.

8.6 GENERAL PROCEDURES

The design flow for each segment of the sewer system shall be determined as the following:

a. Prepare a Drainage Map, which defines the area's tributary to each element of the sewer.

b. Examine each area to determine its potential land use and equivalent population.

c. Determine the average daily flow based upon the equivalent population.

d. Determine the design or peak flow based upon the average daily flow and the appropriate peaking factor.

8.7 DRAINAGE MAP REQUIREMENTS

A Drainage Map shall be prepared showing the actual area to be served by the proposed project, the location of the sewers, the portion of the project area tributary to each individual sewer element, and any points of inflow which contribute additional flow from adjacent areas. The Drainage Map shall be prepared on a standard size sheet at an appropriate scale to show the entire project and adjacent future contributing areas. Two or more sheets may be used for large-scale projects. A sample Drainage Map is shown on Exhibit 4-13. The purpose of the Drainage Map is to graphically depict the basis for the design flow calculations. The Drainage Map and design calculations shall be presented for review with submittal of the preliminary and construction plans. The minimum specific information required includes the following:

a. A key map showing the general location of the project area, including any areas not within the project area that contributes to the proposed system.

b. A general layout of the proposed system with the drainage area tributary to each major element of the system defined.

c. The basis for determining the number of existing and future users and the equivalent population for each drainage area: i.e., the number of single-family or multi-family dwelling units; type and size of existing commercial, industrial and institutional users; and the number of acres of undeveloped land by zoning classification.

d. A zoning designation, such as M-1, for each drainage area.

e. A designation for each sewer line.

f. A numbering system for manholes, which shall be added to the computation sheets.

g. All proposed sewer sizes.

h. The location of estimated or actual flow entering the proposed system from outside areas, developed or undeveloped. These areas are to be shown in entirety on the Drainage Map and shall include the same types of information required for the proposed service area.

i. An adequate number of spot elevations must be obtained in areas of undeveloped land to show the natural drainage of the area if necessary.

j. LOJIC maps may be used to prepare the Drainage Map.

k. An indication of the existing system's ability to receive the proposed flow with sufficient capacity.

8.8 DESIGN FLOW

8.8.1 Collector Sewers

Collector sewers are primarily installed to receive wastewater directly from property service connections. A major change in land use within a tributary area can have a significant impact on the collector system's ability to transport the necessary flow. Collector sewers should be designed to transport the saturation population flow, which might be expected during their service life (flowing full). The appropriate equivalent population and design flows should be calculated as described in Sections 8.8.3 and 8.8.4.

8.8.2 Interceptor Sewers

An interceptor sewer is a principal sewer to which collector sewers are tributary. All interceptor sewers should be designed for saturation population (flowing full) unless otherwise directed by MSD.

For a major industrial water user or for undeveloped industrial land in the tributary area, MSD will generally specify the estimated average daily flows in determining the equivalent population (refer to Exhibits 8-2 and 8-3). Otherwise, a flow of 10 persons per acre shall be assumed for all industrially zoned land, except in areas where specific reliable information is available to more correctly analyze the anticipated flows.

8.8.3 Equivalent Population Sewer Design

8.8.3.1 Current Equivalent Population

A current equivalent population estimate shall be made using the most current aerial photographs or LOJIC maps, a field inventory, or other data sources. The equivalent population per unit factors, as shown in Exhibit 8-2, shall be combined with the land use categories of the tributary area. The factors are then multiplied by the unit count of each land use category to determine the equivalent population.

8.8.3.2 Future Equivalent Population

An estimate of the equivalent population for future development, which can reasonably be expected, shall be made and added to the current equivalent population for each drainage area (see appropriate Action Plan provided by MSD). The equivalent population for the remaining developable land shall be determined by multiplying the number of acres of land in each zoning category by the equivalent population per acre factors given in Exhibit 8-3. Design recommendations should be made relative to the land's potential development if a variance from the standards established in Exhibit 8-3 is suggested.

8.8.4 Design Flows

a. **Design** Average Daily Flow =
100 Gallons/person/day x Total Equivalent Population

b. Design Peak Design Flow =

Design Average Daily Flow x Peaking Factor (Exhibit 8-4)

8.9 HYDRAULIC DESIGN CRITERIA

8.9.1 General

Manning's Equation shall be used to determine proper pipe size and slope to transport the design flow. Design shall be for full flow at saturation conditions with the following characteristics:

a.	Roughness coefficient – n	= 0.013 (Sanitary Sewers Only – Ten State Standards)
b.	Minimum velocity – v	= 2 feet/second
c.	Minimum pipe size – D	= 8 inches
d.	Minimum allowable slopes	= (See Exhibit 8-5)

8.9.2 Hydraulic Grade Line

The hydraulic grade line should not rise above the crown of the sewer pipe. When critical, the hydraulic grade line shall be computed to show its elevation at manholes, transition structures, and junction points of flow in pipes and provide for the losses and the differences in elevation. If velocity entering a manhole is above critical, the hydraulic grade line must be computed to ensure that no service connections are surcharged. The pipe exiting the manhole must be adjusted in elevation to ensure that the energy gradient remains level across the manhole.

8.9.3 Velocity

All sanitary sewers shall be designed to carry the design flow at a minimum velocity of 2.0 ft/s (Reference paragraph 8.9.4 for exceptions). The maximum allowable design velocity shall be 15 ft/s based on the design flow. When severe topographic or unusual conditions require a design velocity greater than 15 ft/s, the hydraulic design and pipe material must be approved in writing by MSD.

8.9.4 Minimum Slopes

The minimum allowable slopes will be as required to obtain the minimum velocity as required in Section 8.9.3 above. In no case shall the slopes be less than those identified in Exhibit 8-5 (stubs shall have a minimum slope of 0.005 ft/ft). Note – For 8" pipe the minimum slope is 0.007 ft/ft (based upon pipe at one-fourth full depth) in cases where the minimum required velocity, at design flow, cannot be achieved at a lesser slope.

8.9.5 Sewer Size Changes

Sewer size changes shall only take place within a manhole or junction box structure. To ensure that the energy gradient is maintained, use the following:

a. Pipes 24" in Diameter or Smaller

1. When increasing the sewer size by 6 inches or less, crown elevations shall match at the centerline of the manhole.

2. When increasing the sewer size by more than 6 inches, the springlines of the smaller and larger sewer shall match at the centerline of the manhole. However, **if** the hydraulic design calculations **show unacceptable losses resulting in a surcharge condition**, the Design Engineer **may** match crown elevations at the centerline of the manhole by raising the elevation of the smaller sewer.

b. Pipes 27" in Diameter or Larger

Manholes or junctions involving sewers 27 inches or larger shall first be designed by matching the crown elevation at the centerline of the structure. The **hydraulic grade line shall then be determined. If the HGL shows a surcharging condition, the downstream pipe may be lowered as needed.**

8.10 HYDRAULIC COMPUTATIONS

Exhibit 8-1 is a sample computation sheet for designing interceptor and collector sewers. The procedure used in completing this form can be found at the bottom of the Exhibit. Blank computation sheets are available on the MSD web page and may be used for the computations. This computation sheet, or similar form, shall be submitted with the plans for review.

8.11 SEWER PIPE

a. The minimum allowable inside diameter for sewer pipe, other than property service connections, shall be 8 inches. All property service connections shall have a minimum inside diameter of 4 inches; however, commercial or industrial connections shall be individually considered with the minimum size of 6 inches.

b. **Pipe material will be selected from the products identified in the MSD Standard Specifications. Alternate products can be specified by the designer, but prior approval from MSD will be required. Designers will indicate "pipe" on the plan unless a particular product or group of products has been**

identified and the decision can be justified. Approved products from the specifications that are not advantageous for a particular project and <u>not allowed</u> will need to be identified in the Contract (must be approved by MSD).

c. Pipe testing and bedding requirements shall be in accordance with the MSD Standard Specifications, except for unusual conditions requiring special design and specifications.

d. Backfill classifications, materials, and methods of compaction shall be in accordance with MSD Standard Specifications, except in unusual conditions requiring special design and specifications.

e. All sewers shall be designed to prevent damage from superimposed loads during and after construction. Proper allowance for loads on sewers shall be made, based on trench width and depth. When standard strength sewer pipe is not sufficient, extra strength pipe or special construction methods shall be specified. Live and dead loads shall be determined for all sewers and calculations submitted to MSD for review. Dead load, live load and impact loading requirements must be met in the selection of pipe materials and installation methods.

f. Sewers 60 inches in diameter and larger shall be designed using the "D" loading method as specified in the "Concrete Pipe Design Manual" published by the American Concrete Pipe Association, latest revision. The cost savings using the actual "D" loading is required to meet the structural requirements, rather than standard class pipe and should be examined. If substantial cost savings can be realized, the actual "D" loading of the pipe required shall be specified and shown on the plans. However, the "D" load design shall be limited to increments of 200 feet or more, and should not vary between manholes unless unusual conditions exist. The "D" load design shall be based on a trench width approved by MSD prior to the actual design.

8.12 MANHOLES

8.12.1 Manhole Locations

Manholes shall be required at the following locations:

a. Changes in sewer grades or alignment (except approved curvilinear alignments)

b. Sewer junctions.

c. Where required, not to exceed the maximum manhole spacing.

d. Changes in sewer diameters

e. The location of the terminal manhole in each sewer line should be based on many factors including manhole spacing, driveway locations, the position of improvements on the lots being served, and the location of temporary sanitary facilities, such as septic tanks. A definitive single policy cannot be established for all circumstances, although the sewer line would normally terminate in the vicinity of the downstream property line.

f. Where vertical stacks connect to large (>48 inches) sewers an additional manhole or cleanout (if connecting sewer is 6 inches) shall be required approximately 5 feet from the stack.

8.12.2 Maximum Manhole Spacing

Size of Sewer	Distance
8" to 15" diameter	400'
18" to 30" diameter	500'
Over 30" diameter	600'

When certain conditions warrant, such as the elimination of a manhole, the manhole spacing can be exceeded with the approval of MSD and DOW.

8.12.3 Diameter

The minimum diameter of manholes shall be 48 inches, although larger diameters are necessary in special instances, such as acute angle considerations with pipe diameters greater than 24 inches. **The minimum elevation drop across new manholes and larger diameter manholes shall be 0.1 feet for changes in pipe direction greater than 45 degrees.** All manholes must be checked to ensure that sufficient wall is supplied between pipe openings to meet all precast manhole criteria. See Appendix G.

8.12.4 Watertight

Watertight manholes and covers are to be used **everywhere unless a waiver is granted by MSD**.

8.12.5 Drop Inlets

A vertical or slanting drop inlet shall be provided for a sewer entering a manhole at an elevation higher than the sewer leaving the manhole. A drop inlet will not be allowed for elevation differences less than 2 feet.

8.12.6 Manhole Collars

A 6-inch collar shall be used when it is certain the manhole rim will not be lowered in the future and a 12-inch or greater collar when lowering is anticipated.

8.12.7 Manhole Numbering

All newly constructed public or private manholes will be assigned identification numbers. It is the designer's responsibility to contact MSD to obtain the required sequence of numbers for the proposed project. The assigned number for the respective manhole will be shown on both the plan and profile sheets as part of the structure note. During construction it is the responsibility of the contractor to stamp the number into the structure rim.

8.12.8 Chimney Seals

Internal, mechanical chimney seals are required on all new MSD manholes. Chemical chimney seals are to be used only for rehabilitation and only in non-paved areas.

8.12.9 Manhole Barrel Joints

See Specification section 5.3.4 for information on the two-way sealing system required for all sanitary manhole sections.

8.12.10 Manhole Frame and Collar Connections

All standard manhole frames shall be bolted to the collar with two 1-inch diameter anchor bolts positioned 180 degrees apart and all watertight manhole frames shall be bolted to the collar with four 1-inch diameter anchor bolts positioned 90 degrees apart.

8.12.11 Manhole Personnel and Equipment Access

Personnel access is required at manholes sufficient for MSD maintenance crews to enter the area. A waiver is required in the event access cannot be provided.

8.13 STUBS

Generally, stubs shall be provided in cul-de-sacs, at points of possible future extension, and at the terminus of the sewer line, unless otherwise directed by MSD. Stubs shall be one foot long measured from outside of manhole barrel for PVC or PE pipe or one pipe length for concrete pipe. The allowable length for cul-de-sac stubs is 20 feet without specific approval from MSD.

8.14 PROPERTY SERVICE CONNECTIONS

a. The property service connection (PSC) is the section of pipe between the R/W or easement line and the mainline sewer. Standard symbols and general notes pertaining to the size, type and length of "Y" or "T" branches and property service connections are shown on Exhibit 4-2 and shall be used on the plans. The standard connection for single-family residences will be 4 inches; however, commercial or industrial connections shall be individually considered with the minimum size being 6 inches. Green metallic “locater” tape labeled “SEWER” must be installed above the PSC at a depth of not more than 30 inches. Each PSC must have a Two–Way Cleanout conforming to MSD Standard Drawing SC-02-01 installed just inside the R/W or easement line.

b. A minimum slope of 2.00% (1/4” /ft.) for property service connections shall be used for determining design elevations. However, in all cases, the invert elevation of the property service connection at the easement or property line shall be equal to or higher than the crown of the sewer. The depth of the property service connection at the R/W line will conform to Exhibit 8-8. The minimum slope for the house connection will be 1.0% (1/8”/ft.).

b. Stacks shall be used when they are more economical than the typical property service connection. Stacks shall also be used in areas where the depths of the mainline sewer, existing utilities, or other obstructions are located at elevations that prevent the use of the typical property service connections. As a rule of thumb, two guidelines must be satisfied for a stack to be used. The receiving sewer must have a minimum cover of 12 feet and the length of stack (measured vertically) must be at least 3 feet. An additional requirement is to provide the minimum 3 feet of fall between the top of stack and house discharge point as indicated on Exhibit 8-8. Example (Assume level ground) - if a receiving sewer has 12 feet of cover and the discharge point at the house is 7 feet below ground, a stack would not be used; however, if the discharge depth was 6 feet or less, a stack would be required. Obviously field conditions may dictate deviations.

c. Property service connections 6 inches in diameter and smaller may be jacked without a casing.

d. Jointless pipe shall be used for new or rehabilitated PSCs. VCP shall not be used for new or rehabilitated PSCs.

8.15 FLOATATION

All sewers and sewer structures to be constructed where high groundwater conditions exist or where flooding of the trench is anticipated shall be designed to prevent floatation or excessive pipe flexing.

8.16 ANCHORS

When sewer slopes of 20 percent or greater are encountered, the sewer shall be securely anchored by using concrete anchors or other specially designed anchoring devices to prevent slippage. The design and method used should be approved by MSD.

8.17 CONCRETE ENCASEMENTS

Concrete encasement shall extend a minimum length of 2 feet beyond the point where a 4-foot depth of cover is reached or to a point 5 feet beyond the tops of banks when crossing a ditch or stream. Concrete encasements shall be used when it is necessary to prevent floatation, when crossing streams, ditches or existing storm drains. They shall also be used where soil conditions may indicate the possibility of heavy erosion, where crossing over utilities with less than 2-feet of clearance, or in areas where the sewer has less than the required cover. The minimum length of the concrete encasement shall be 2 feet beyond the outside diameter of the storm drain or utility conduit.

8.18 TRENCHLESS PIPE INSTALLATION - DESIGN AND CONSTRUCTION REQUIREMENTS

When open cutting is not permitted, the design plans will identify an appropriate pipe installation method and required information for the contractor to bid the project. The engineer will design the trenchless pipe installation using one of the following methods:

- **Tunneling**
- **Boring and Jacking**
- **Horizontal Directional Drilling**
- **Pipe Bursting**

The contractor will have the option to offer a different method of trenchless pipe installation than the one proposed on the plans, subject to approval and acceptance by MSD. When an alternate method is proposed by the contractor he will be responsible for the final design calculations. A plan of operation and list of proposed materials will be submitted for MSD approval. Structural calculations will be required for all components. Items include: casing and carrier pipe, tunnel liner plates, the working pits, sheeting and shoring, electrical facilities, ventilation, and communications. All design calculations and plans must be signed and sealed

and submitted by a professional engineer licensed in the Commonwealth of Kentucky. The contractor will also need to coordinate their excavations beforehand with Kentucky 811- Before you Dig (BUD).

The following criteria shall be followed whenever a trenchless pipe installation is used. Any deviation from this criterion will require prior approval from MSD: Additional reference is made to the MSD Standard Specifications.

Tunneling

- Tunnels shall be constructed using steel liner plates.
- The tunnel liner shall have a minimum outside diameter of 48 inches.
- The carrier pipe shall be installed at least 4 inches above the invert of the liner, and there shall be a minimum distance of 8 inches between the top of the carrier pipe and the top of the tunnel liner.
- Tunnel liner plates and joints shall be of leak proof construction, capable of withstanding E80 loading for railroads and H25 loading for roadways.
- Liner plates shall have minimum yield strength of 28,000 psi.
- It will not be necessary to use a protective coating or cathodic protection on tunnel liners, casing or sewer pipes.
- The space between tunnel liner plates and carrier pipe shall be filled with grout or with pneumatic backstowed pea gravel or No. 9 crushed stone.

Boring/Jacking

- Steel casing pipe shall either be a minimum of 30 inches in diameter or 12 inches greater than the largest outside diameter of the carrier pipe.
- All casing pipe must have a minimum thickness of 3/8-inch unless otherwise determined by designer.
- Steel casing pipe shall have minimum yield strength of 35,000 psi.
- In boring excavation, the carrier pipe shall be encased in a ductile steel casing pipe of sufficient size to provide clearance for the proper installation of the sewer pipe. The inside diameter of the casing pipe shall be at least 12 inches greater than the largest outside diameter of the carrier pipe, joints or couplings, thus providing

a clearance of at least 8 inches between the casing pipe and the carrier pipe. The entire void between the carrier pipe and the casing pipe shall be filled with grout or with pneumatic backstowed pea gravel or No. 9 crushed stone. Any void space outside the casing pipe shall be pressure-filled with cement grout. The cement grout mixture and method of grouting is called for in the MSD Standard Specifications.

Horizontal Directional Drilling

- **Horizontal Drilling is used to install 2 inch to 30 inch diameter pipes in segments up to 1,000 feet.**

- **Completed in three phases: boring of pilot hole, enlarging of hole by reaming, and pulling of pipe through enlarged hole.**

Pipe Bursting

- **Pipe Bursting is used is used to replace existing lines that have defects that cannot be rehabilitated by normal rehabilitation methods.**

- **A static, hydraulic, or pneumatic pipe bursting tool with an expander is launched through the old pipe, fragmenting it and compacting the old pipe fragment into the surrounding soil, creating a path for the new pipe.**

Refer to Section 7 of the MSD Standard Specifications applicable specifications for the performance of trenchless pipe installation.

8.19 RAILROAD CROSSINGS

8.19.1 Criteria

The following criteria shall be strictly adhered to when the planning for sewer construction affects railroad rights-of-way and facilities (railroad companies may specify more stringent requirements):

a. Sewers shall cross tracks at an angle as close to 90 degrees as practical, but preferably never less than 45 degrees. Sewers shall not be placed under railroad bridges where there is a likelihood of restricting the required waterway area of the bridge or where there is a possibility of endangering the foundations.

b. Sewer lines crossing under railroad tracks and rights-of-way shall be constructed **using one of the trenchless methods outlined above and as** permitted by the railroad company.

c. **Sewers** under railroad tracks and across railroad rights-of-way shall extend to a point, a minimum distance of 25 feet from the centerline of the outside track or the right-of-way line, whichever occurs first.

d. Sewer lines laid longitudinally along railroad rights-of-way shall be located as far as practical from any tracks or other important structures. If located within 25 feet of the centerline of any track or should there be danger of damage from leakage to any bridge, building, or other important structure, the sewer shall be encased or shall be of a special design as approved by MSD and the affected railroad.

e. When placed along railroad rights-of-way, the top of the pipe shall have a minimum cover of 4 feet.

g. **Trenchless sewer installations** under railroad tracks and across railroad rights-of-way shall be no less than 4 feet deep measured from the bottom of the rail to the top of the **sewer installation** at its nearest point. The top of the **installation** shall not be above the invert of existing or proposed ditches.

8.19.2 Railroad Conflict Drawings

Railroad conflict drawings shall conform to the following criteria:

a. Railroad conflict drawings, as shown in Exhibit 8-9, shall be prepared on 8.5" x 11" sheets. The plan and profile may be placed on one or more sheets as dictated by the scale. The record number of the plan and/or profile sheet that shows the conflict shall be added to the conflict drawing.

b. Drawings shall be prepared to scale showing the relationship between the proposed sewer and the railroad, angle of crossing, location of utilities, original survey station of the railroad (when available), right-of-way lines, topography, and general layout. The profile established from a field survey shall show the sewer in relation to the actual ground and tracks. The limits of **installation** by station, sewer line soundings and borings, and all other pertinent information shall be shown on the drawing.

c. MSD will furnish any necessary General Notes to be placed on the plans or included in the Special Provisions.

d. Railroad conflict drawings shall be submitted along with a complete questionnaire, which shall be furnished by the railroad company.

8.20 HIGHWAY CROSSING

Sewer pipe installations constructed under State, County, or City maintained roadways, will need to confirm to the design requirements of the respective governing agency. One of the designer's first tasks will be to determine if open cutting will be allowed. Construction shall meet the following requirements (more stringent criteria may be required on a project specific basis):

a. Sewers shall cross the roadways at an angle as close to 90 degrees as practical, but preferably never less than 45 degrees. Sewers shall not be placed under roadway bridges where there is a likelihood of restricting the required area of the bridge or where there is a possibility of endangering the foundations.

b. **Sewer lines crossing under highways and rights-of-way shall be constructed using one of the trenchless methods outlined above and as permitted by the governing agency.**

c. **Sewer installations** under roadways shall have a minimum depth of 3 feet from the surface elevation to the top of the **installation**. The top of the **installation** shall not be above the invert of existing or proposed ditches.

d. **Sewer installations** under roadways shall extend a minimum of 10 feet outside the existing paving, as measured at right angles to the roadway, or to the toe of the slope when the roadway is on fill and the toe of slope exceeds 10 feet outside the existing paving. **Installations** should likewise extend to the top of slope furthest from the roadway on ditches if the top of slope is greater than 10 feet from the edge of pavement.

e. Sewer lines laid in a longitudinal direction on highway rights-of-way shall be located a sufficient distance from the edge of the pavement to allow adequate working room and to provide maximum safety to the motorist when the roadway is to remain open to traffic. Those sewer lines within the roadway right-of-way, but not located under paved areas, shall have no less than 5 feet of cover.

f. Metallic tape shall be laid in the trench above the pipe from the edge of pavement to the right-of-way line or from the end of the tunnel to the right-of-way line on all crossings of State highways.

8.21 CREEK, STREAM OR DITCH CROSSINGS

Sanitary sewer pipes for crossing a creek, stream or ditch shall be a jointless pipe and shall be encased in concrete as required in Section 8.17 Concrete Encasements.

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Louisville, Kentucky
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EXHIBIT 8-1
COMPUTATIONS FOR SANITARY SEWER DESIGN

EFFECTIVE DATE: JUNE 30, 2009

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

COMPUTATIONS FOR SANITARY SEWER DESIGN

ENGINEER ____________________

Project Name ____________________

Record No. ____________________

Sheet ____ of ____

Computed By ____________________

Checked By ____________________

Date ____________________

1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
LOCATION																				Invert Elev. of Sewer		
Drain. Area Designation	Sewer Line Designation	Manhole Designation From	Manhole Designation To	Increment Total Eq. Pop.	Accumulated Total Eq. Pop.	Average Daily Flow	Peak Factor	Total Sewage Flow	Design Flow "Q"	Length	Slope	Size	"Q" Full	"V" Full	Design "Q" / "Q" Full	Design Flow Depth Ratio	Design "V" / "V" Full	Design "V"	Drop	Upper End	Lower End	REMARKS
		Sta.	Sta.			GPD		MGD	c.f.s.	L.F.	ft/ft	In.	c.f.s.	f.p.s.	Ratio	d/D	Ratio	f.p.s.				

Col. 1 Drainage Area Designation
Col. 2 Sewer Line Designation
Col. 3 Manhole Designation by Station
Col. 4 Total Equivalent Population obtained from each individual drainage area analysis
Col. 5 Total Equivalent Population accumulated to this point (Col. 4 + previous Col. 5)
Col. 6 Average Daily Flow (Col. 5 x 100 Gallons per person per day)
Col. 7 Peak Factor from Exhibit 8–4
Col. 8 Total Sewage Flow (Col. 6 x Col. 7 divided by 1,000,000)
Col. 9 Design Flow (Col. 8 x 1.5472 cfs/MGD)
Col. 10 Length of Pipe measured from centerline of Manhole to centerline of Manhole
Col. 11 Design Slope
Col. 12 Pipe Size
Col. 13 "Q" Full
Col. 14 "V" Full
Col. 15 Design "Q" to "Q" Full ratio (Col. 9 divided by Col. 13)
Col. 16 Ratio of Pipe Diameter (D) to Design Flow Depth (d) in feet (Exhibit 8–6)
Col. 17 Design "V" Full to "V" Full Ratio (Exhibit 8–6)
Col. 18 Design Velocity (Col. 14 x Col. 17)
Col. 19 Difference in Invert Elevations

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EXHIBIT 8-2
DEVELOPED AREA WASTEWATER FLOWS

EFFECTIVE DATE: JUNE 30, 2009

DEVELOPMENT	POPULATION PER UNIT	AVERAGE GAL/UNIT/DAY
Single Family Dwelling	4	400
Two Family Dwelling	8	800
Apartments		
1 Bedroom	2	200
2 Bedroom	3	300
3 Bedroom	4	400
Motel Rooms	1	100

DEVELOPMENT	UNIT	EQUIVALENT POPULATION PER UNIT	AVERAGE GAL/UNIT/DAY
Schools *	Students	0.15	15
Mobile Homes	Persons	2.0	200
Nursing Homes	Bed	1.0	100
Offices	Employee	0.15	15
Laundromats	Washer	4.0	400
Non-developable Land	Acres	1.0	100
Commercial *	Acres	20.0	2000
Industrial *	Acres	10.0	1000

* Actual measured wastewater flows should be used when available – with allowance for future expansion.

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EXHIBIT 8-3
UNDEVELOPED AREA WASTEWATER FLOWS

EFFECTIVE DATE: JUNE 30, 2009

ZONING DISTRICT	DWELLING UNITS/ACRE	POPULATION PER UNIT	POPULATION PER ACRE	AVERAGE GAL/ CAP/DAY	AVERAGE GAL/ ACRE/DAY
R-E & R-1	1	4	4	100	400
R-2 *	2	4	8	100	800
R-3 *	3.5	4	14	100	1400
R-4 **	3.75	4	15	100	1500
R-5	6	4	24	100	2400
R-6	15	3	45	100	4500
R-7	30	3	90	100	9000
R-8 & R-8A	50	3	150	100	15000

ZONING DISTRICT	EQUIVALENT POP/ACRE	AVERAGE GAL/ CAP/DAY	AVERAGE GAL/ ACRE/DAY
R-9	150	100	15000
R-10	150	100	15000
Commercial	20	100	2000
Industrial ***	10	100	1000
Non-developable Land	1	100	100

* Saturation standards applicable to the design of collector or interceptor systems.

** In general, for undeveloped areas, the R-4 density is to be considered as a minimum for collection system design unless present development in the vicinity indicates that design for the actual zoning, with MSD approval, would be more prudent.

*** This figure may be adjusted by MSD if a major industrial user is anticipated.

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EXHIBIT 8-4
PEAK FACTOR CURVE

EFFECTIVE DATE: JUNE 30, 2009

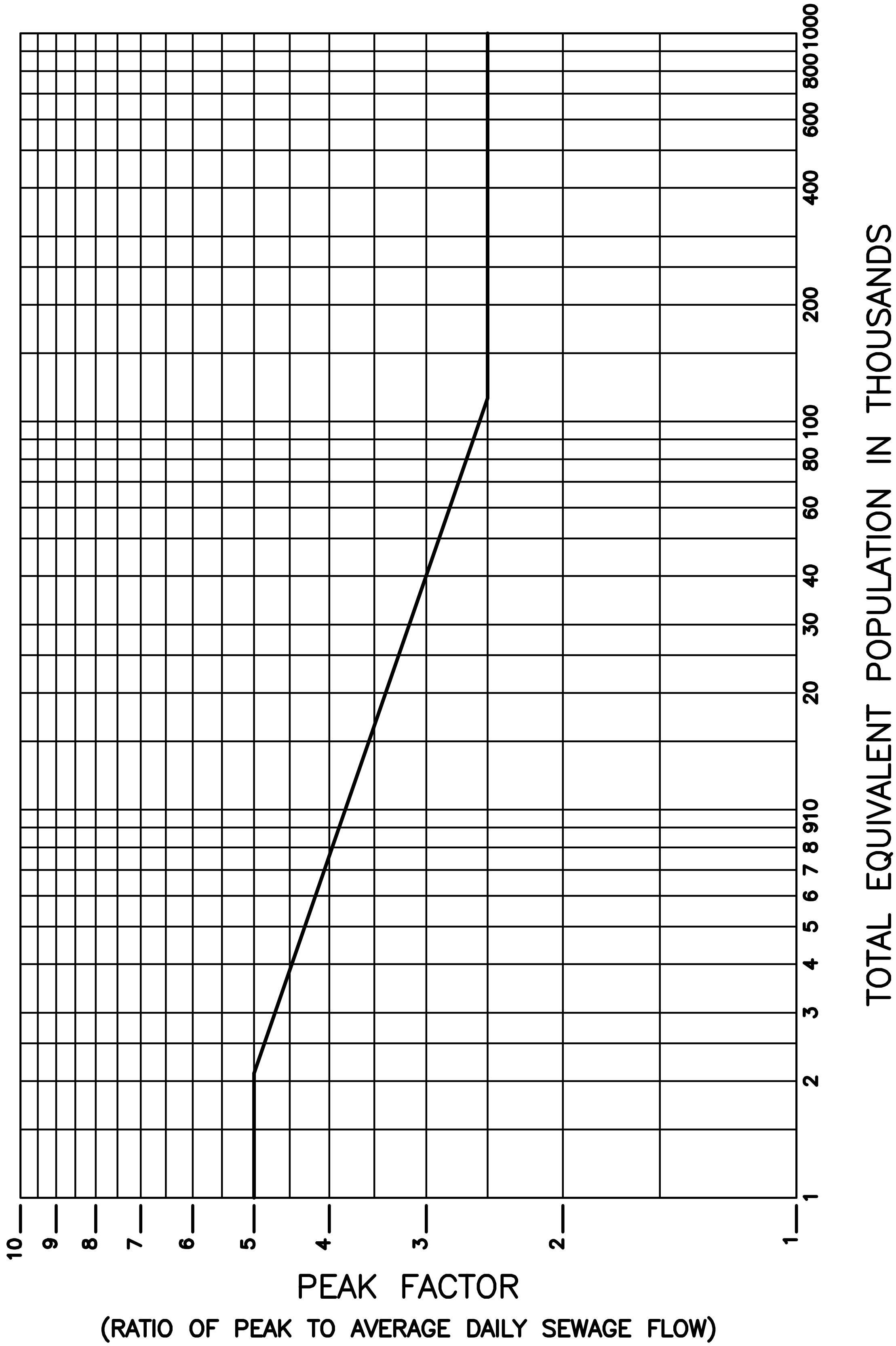

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EXHIBIT 8-5
MINIMUM ALLOWABLE SLOPES

EFFECTIVE DATE: JUNE 30, 2009

Manning's "n" = 0.013

PIPE DIA. (inches)	SLOPE (ft/ft)	VELOCITY FULL (ft/sec)
8	0.0040*	2.2
10	0.0028	2.1
12	0.0022	2.1
15	0.0015	2.0
18	0.0012	2.0
21	0.0010	2.1
24	0.0008	2.0
27	0.00067	2.0
30	0.00058	2.0
36	0.00046	2.0
42	0.00037	2.0
48	0.00030	2.0
54	0.00026	2.0
60	0.00026	2.0
66	0.00026	2.3
72	0.00026	2.4
78	0.00026	2.6
84	0.00026	2.7
96	0.00026	3.0
108	0.00026	3.2
120	0.00026	3.4
132	0.00026	3.6
144	0.00026	3.8

* If 2.0fps can not be achived with the design flow, the minimum slope will be 0.0070. ft/ft

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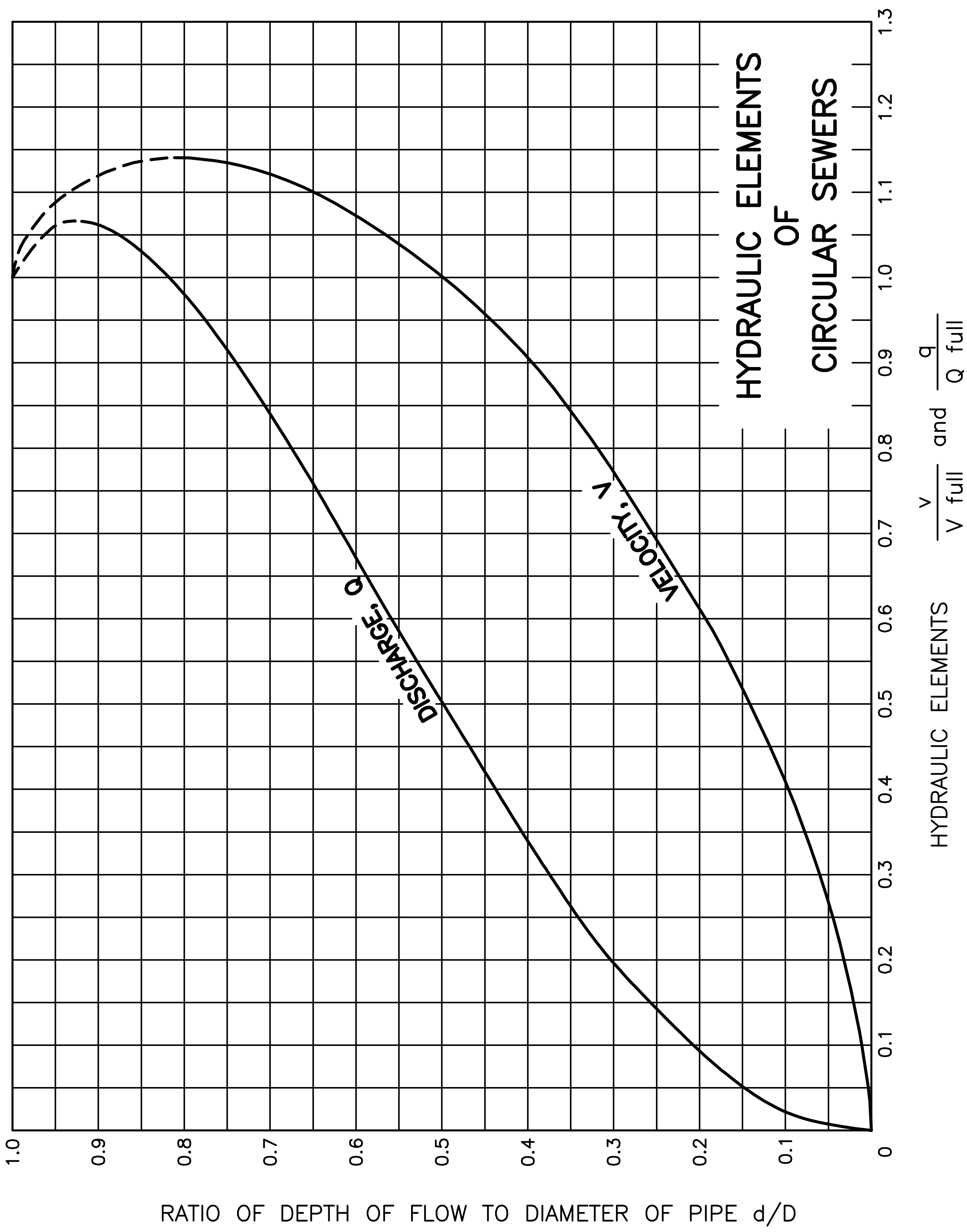
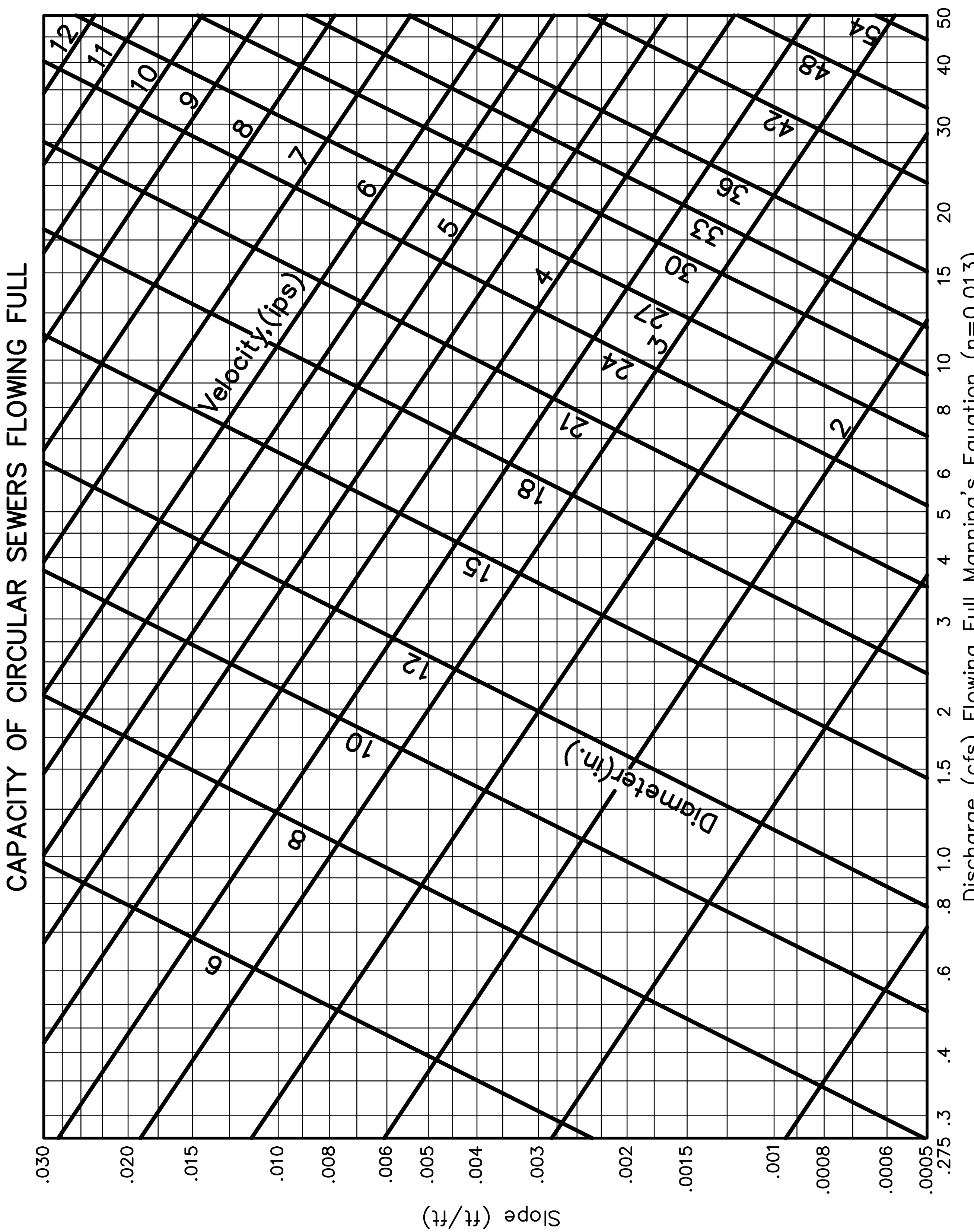
EXHIBIT 8-6
HYDRAULIC ELEMENTS OF
CIRCULAR SEWERS

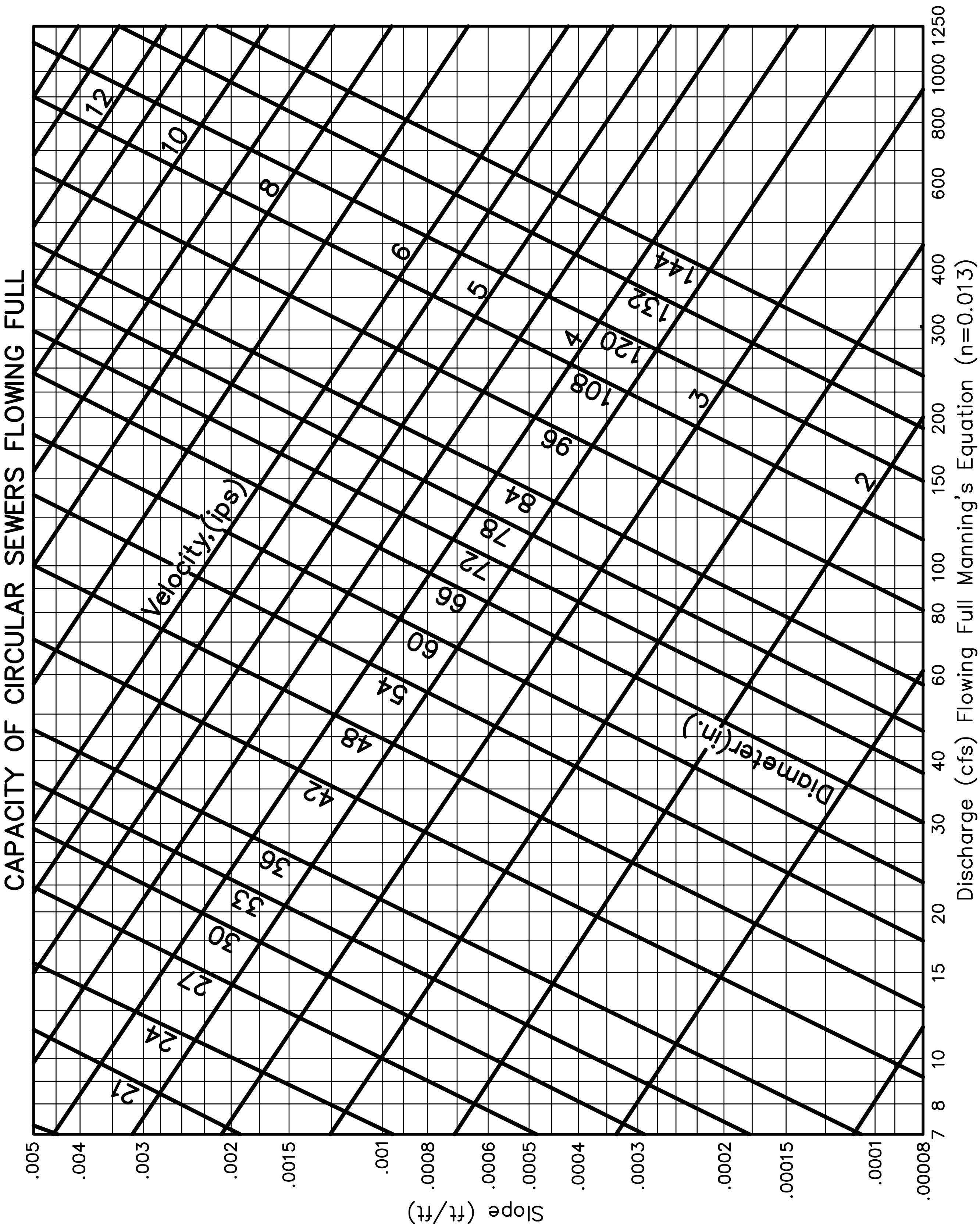
EFFECTIVE DATE: JUNE 30, 2009

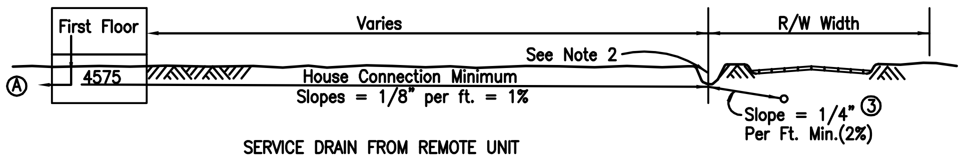


MSD Louisville and Jefferson County Metropolitan Sewer District 700 W. Liberty Street Louisville, Kentucky 40203-1913 502-587-0603 – WWW.MSDLOUKY.ORG	EXHIBIT 8-7 PIPE FLOW CHART FULL (6" - 54") PAGE 1
	EFFECTIVE DATE: JUNE 30, 2009



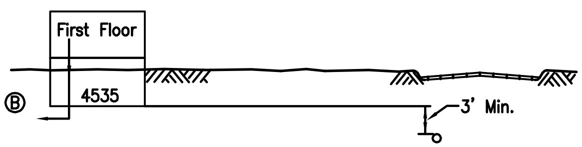
MSD Louisville and Jefferson County Metropolitan Sewer District, 700 W. Liberty Street, Louisville, Kentucky 40203-1913, 502-587-0603 – WWW.MSDLOUKY.ORG	EXHIBIT 8-7 PAGE 2 PIPE FLOW CHART FULL (21"-144") EFFECTIVE DATE: JUNE 30, 2009





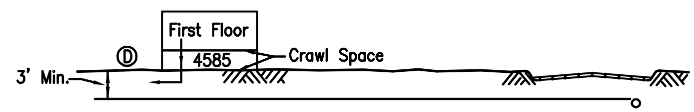
SERVICE DRAIN FROM REMOTE UNIT

When houses or other units are remotely located, consideration must be given to the amount of drop from the point of service to the sewer. The following slopes are considered minimum when not controlled by terrain, low areas, etc.



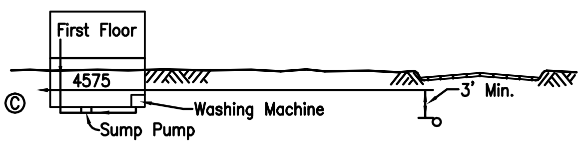
HOUSE DRAIN THROUGH BASEMENT FLOOR

When this condition controls the upper end of a sewer and no sanitary or laundry facilities exist in the basement, consideration should be given to a control depth less than 3' below the basement floor elevation.



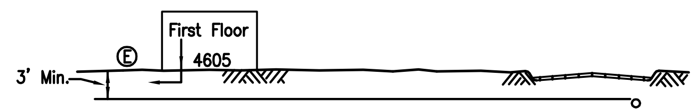
HOUSE DRAIN THROUGH FIRST FLOOR WITH CRAWL SPACE

The crown of the sewer shall be a minimum of 3' below the ground at the point of service outlet.



HOUSE DRAIN THROUGH BASEMENT WALL

Service elevation outlets for sump pumps which do not discharge shower, laundry or sanitary facilities shall not control the sewer depth.



HOUSE DRAIN THROUGH FIRST FLOOR WITH SLAB TYPE FOUNDATION

The crown of sewer shall be a minimum of 3' below the first floor elevation

LEGEND

Ⓐ 4575 Denotes elevation and service line that drains thru basement wall with no sump pump.

Ⓑ 4535 Denotes elevation and service line that drains thru the basement floor.

Ⓒ 4575 Denotes elevation and service line in basement with a sump pump raising wastewater from basement floor.

Ⓓ 4585 Denotes elevation of ground at the point of service line outlet when house has crawl space.

Ⓔ 4605 Denotes first floor elevation.

This legend shall be used in preparation of preliminary plans. The final plans and profiles shall indicate the proper symbol and elevation for only those houses controlling the sewer.

GENERAL NOTES:

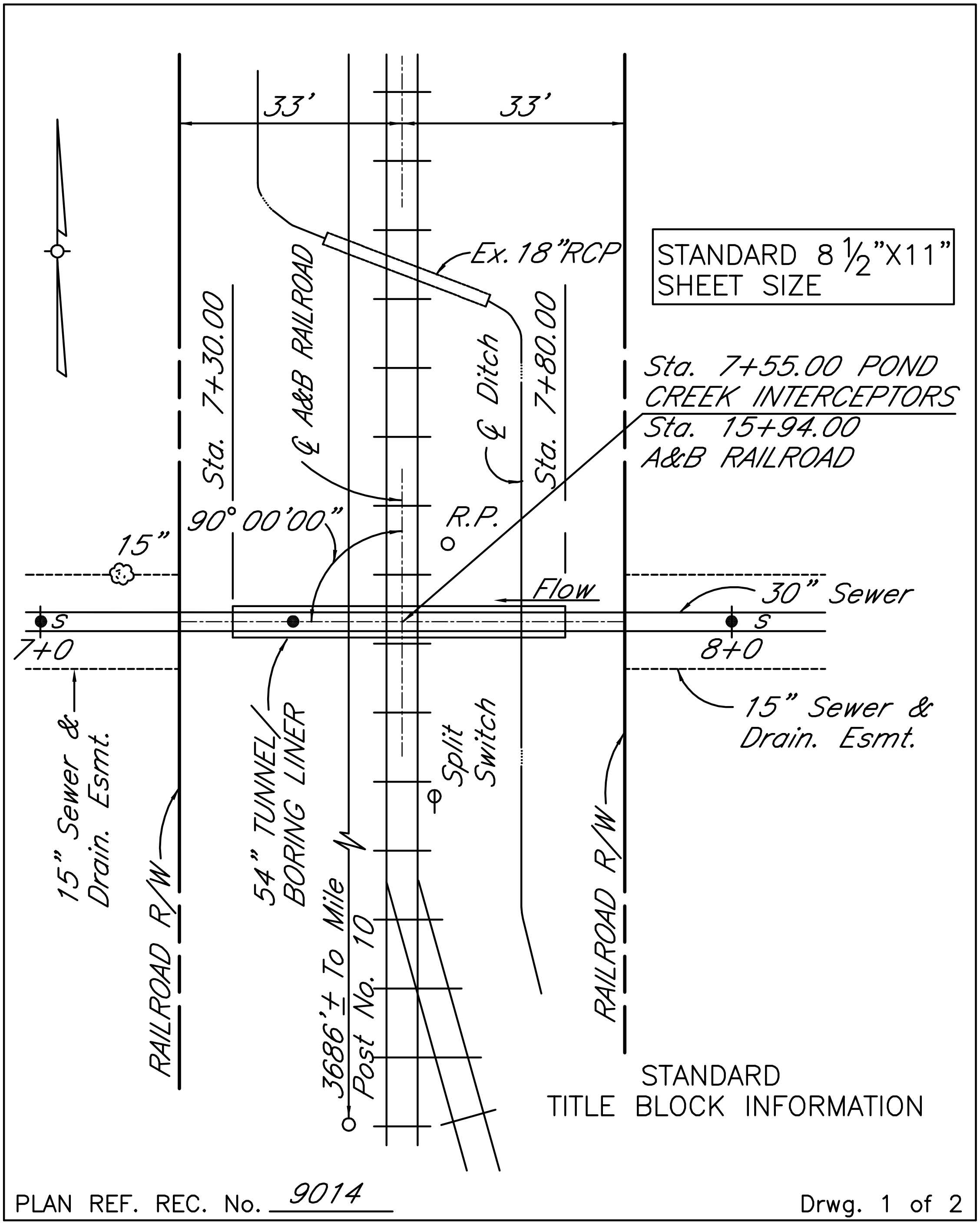
1. The intent of the sewer program is to serve only sanitary facilities in basements and not floor drains, foundation drains, window wells or other such facilities.
2. Where roadside ditches occur, the sewer must be placed at an elevation such that the property service connection at the ditch will have a minimum cover of 1' from the flow line of the ditch to top of encasement or cap.
3. Reference Section 8.14.b of the Design Manual.

TYPICAL SERVICE CONDITIONS

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

RAILROAD CONFLICT DRAWING

EFFECTIVE DATE: JUNE 30, 2009



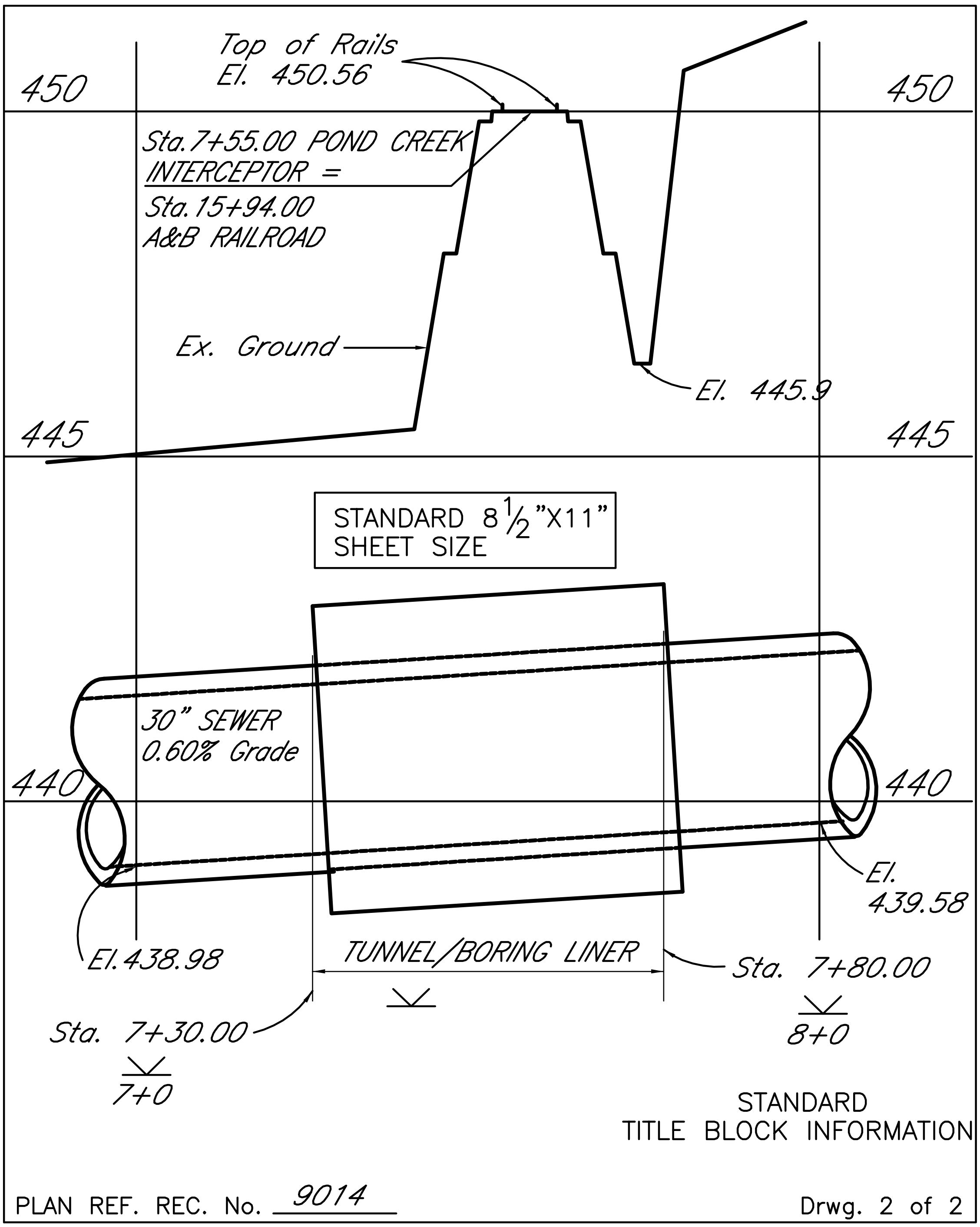

Top of Rails
El. 450.56
450
450
Sta.7+55.00 POND CREEK INTERCEPTOR =
Sta.15+94.00
A&B RAILROAD
Ex. Ground
El. 445.9
445
445
STANDARD 8½"X11"
SHEET SIZE
30" SEWER
0.60% Grade
440
440
El.
439.58
El.438.98
TUNNEL/BORING LINER
Sta. 7+80.00
8+0
Sta. 7+30.00
7+0
STANDARD
TITLE BLOCK INFORMATION
PLAN REF. REC. No. 9014
Drwg. 2 of 2

TABLE OF CONTENTS

CHAPTER 9
DEVELOPMENT SANITARY SEWER CONSTRUCTION

CHAPTER 9
DEVELOPMENT SANITARY SEWER CONSTRUCTION

9.1 PURPOSE

This chapter establishes the minimum sanitary sewer construction plan submittal requirements and MSD procedures for submittal, construction inspection, and final approval of construction for private development **sanitary sewer** projects. Sanitary sewer systems should be designed in accordance with the applicable provisions of this and other chapters of the MSD Design Manual. Particular attention is directed to the EPSC requirements of Chapter 12. Adherence to these procedures will facilitate timely review and approval for construction.

Additional guidance and applicable forms may be retrieved from:

http://www.msdlouky.org/insidemsd/formssanitary.htm

9.2 GENERAL PROCEDURES

a. A meeting should be arranged to discuss a proposed sewer plan. The plan submittal should generally show the lot layout, sewer alignment, and drainage areas in each segment.

b. MSD will review this plan and advise as to which of the three sewer classifications will control the submittal route.

   1. **Lateral Extension (LE)**
      A MSD sanitary sewer system in which the sewer system and the treatment facility is owned and operated by MSD once constructed and approved.

   2. **Private Sewer - MSD System (PS)**
      A sanitary sewer flowing from a private property to an MSD sewer system and is treated at an MSD-owned facility.

   3. **Non-MSD System (NLE)**
      A sanitary sewer system and treatment facility owned and operated by another city, as a private individual, corporation, or agency.

c. If MSD determines that the situation is a LE or PS served by one of MSD’s wastewater treatment plants, the development of design plans may proceed.

d. If MSD determines that the sewers are NLE and they are not served by a MSD owned wastewater treatment plant, a preliminary plan must also be submitted to the Jefferson County Health Department. This is to determine if the wastewater treatment plant has adequate capacity to allow for the proposed sewer expansion.

1. If the plant does not have sufficient capacity, the plant owner must apply for Waste Load Allocation (WLA) determination from the Kentucky Department for Environmental Protection, Facilities Construction Branch. Design drawings can proceed simultaneously with the treatment plant expansion plan once the WLA approval has been issued.

2. If the plant has sufficient capacity, design plans may proceed.

9.3 SUBMITTALS

Submittal requirements for construction plans are listed on the **Sanitary Sewer Document Review Checklist** on (http://www.msdlouky.org/insidemsd/formssanitary.htm). Submittal packages will be addressed to MSD's Development Plan Review Section and must include a completed copy of the checklist. Variations from the checklist will require prior approval from MSD. Any conditions of the Approved Preliminary Plan must be addressed at the time of construction plan submittal.

9.4 PLANS

Plan requirements for the respective sheets are identified on the **Minimum Requirements Checklist for Sanitary Sewer Construction Plans** (Same web address as above).

9.4.1 Standard Drawings / Nonstandard Details

The use of MSD's Standard Drawings is highly encouraged. When a particular drawing is utilized, a copy of the drawing is not required to be shown on the plan set. Reference can be made to the drawing by identifying the drawing number on the plan set "Title Sheet".

Nonstandard details or deviations from MSD's Standard Drawing will need to be shown within the plan set.

9.4.2 Property Service Connection Inlet Sheets

The information for all connections must be shown on a Property Service Connection Inlet Sheet. An example sheet can be found on the MSD web page. A copy of the sheet should be placed on the plans for construction and as-built reference.

9.5 PROPOSED PROJECT PLAN

An 8 ½ x 11 inch drawing identifying the limits of the proposed project must be submitted to MSD for all public and private sewer projects. In order to provide consistency of the Proposed Project Plan (PPP), the use of the template provided on the web page should be used. The PPP should be submitted with the original submission.

9.6 MSD DESIGN APPROVAL

After all MSD concerns are satisfied, a letter **certifying compliance with KAR 5:005 will be sent to the KYDOW along with copies of the approved plans. The Louisville and Jefferson County Health Department will be sent copies of the certification letter and plans.**

9.7 LATERAL EXTENSION OF BOUNDARIES AGREEMENT

For LE projects, the applicant shall submit to MSD's Development Plan Review, a "Lateral Extension **of Boundaries Agreement**". This document is a legal agreement, **required by the State**, between the developer and MSD regarding the construction of the sanitary sewerage facilities. The contract conveys the sewerage facilities to MSD, upon completion and acceptance by MSD.

9.8 NOTICE-TO-PROCEED

A formal Notice-To-Proceed letter will be issued when the following conditions are met.

a. **LE Project**

- All MSD fees are paid pertaining to the sanitary sewer project
- The "**Lateral Extension of Boundaries Agreement**" has been executed
- The "Performance Bond" has been received and accepted
- The "Maintenance Bond" has been received and accepted
- The "Certificate of **Liability** Insurance" has been received and accepted
- The "Accepted Bid Proposal" has been received and accepted
- **The KYDOW construction permit has been received**
- Easement plats have been received and are easily recorded by MSD
- Permits have been issued for work within the right-of-way
- A MSD inspector has been assigned
- Notice of Construction has been received
- Site Disturbance Permit from MSD has been issued

b. **Private Sewer Project**

- All MSD fees are paid pertaining to the sanitary sewer project

- **The KYDOW construction permit has been received**
- A MSD inspector has been assigned
- Notice of Construction has been received
- Site Disturbance Permit from MSD has been issued

9.9 INSPECTION OF CONSTRUCTION

9.9.1 General

MSD has a program of on-site inspection for the construction of all sanitary sewer systems within **District Boundaries**.

9.9.2 Inspector Assignment

Construction of sewers shall not begin in a development until an MSD inspector has been assigned to the construction site. In certain situations, which will be identified during construction plan review, full-time inspection may be required. A MSD inspector shall be present during all testing. MSD requires a 48-hour advance notice to schedule an inspector for a project.

9.10 CONSTRUCTION FIELD CHANGES

Deviations from approved construction plans as a result of unexpected field conditions will require documentation and approval by MSD. To obtain this approval, the developer's engineer shall submit four (4) copies of the marked-up (REDLINE) plans showing the proposed revisions wanting to be made. Upon acceptance of the changes, MSD will mark the REDLINE drawings approved, sign and date the approval and send the REDLINES to the construction site via the inspector. One copy will be for the contractor, two copies for the inspector and one copy for MSD's reviewer file.

9.11 RECORD PLANS

At the completion of construction, a final record (As-Built) **drawings** of the construction plans (including inlet sheet information) bearing the Land Surveyor's original seal, signature, and date, and incorporating <u>all</u> approved changes shall be submitted to MSD. Final Record Drawings shall be prepared in accordance with Chapter 5. MSD's inspector will coordinate and check the work prior to submittal to MSD. The as-builts must be completed and approved before MSD will make the sewers available for connection.

TABLE OF CONTENTS

CHAPTER 10
STORMWATER FACILITIES DESIGN

TABLE OF CONTENTS (cont.)

CHAPTER 10
STORMWATER FACILITIES DESIGN

TABLE OF CONTENTS (cont.)

CHAPTER 10
STORMWATER FACILITIES DESIGN

TABLE OF CONTENTS (cont.)

CHAPTER 10
STORMWATER FACILITIES DESIGN

TABLE OF CONTENTS (cont.)

CHAPTER 10
STORMWATER FACILITIES DESIGN
EXHIBITS

CHAPTER 10
STORMWATER FACILITIES DESIGN

10.1 PURPOSE

This chapter establishes the minimum standards for the planning and design of drainage systems and stormwater management facilities within Jefferson County. The guidelines presented must be used in connection with the Watershed Plans contained in the Stormwater Drainage Master Plan (SWDMP), the EPSC requirements of Chapter 12, and the Jefferson County Floodplain Ordinance.

The criteria in this section shall apply to all drainage facility design in both the local and through drainage systems except where facilities have significant and immediate impact upon State or Federal property or highways. In those cases, the most restrictive of State, Federal or MSD standards shall govern.

Additional stormwater design information may be retrieved from MSD's web page. The path is as follows:

http://www.msdlouky.org/insidemsd/stormwater.htm

10.2 HYDROLOGY FOR STORMWATER FACILITIES DESIGN

10.2.1 General

This section describes the recommended procedures for calculating the runoff generated from a project site. Correct utilization of these procedures should result in the best available estimation of existing and projected runoff. The procedure will also provide the consistency of results necessary when applied to project sites throughout Louisville Metro and Jefferson County.

It is assumed that practicing Engineers involved with preparing drainage plans have adequate knowledge of the recommended procedures. There is, therefore, no attempt in this Design Manual to provide step-by-step calculation methodologies. The information provided in this chapter is geared toward assimilating the runoff calculation process with the regional planning aspects of the SWDMP. Contact MSD if there is reason to believe that these procedures are not applicable in particular project areas.

The runoff calculation procedures to be utilized depend upon the size of the proposed development or project as follows:

a. If the total tributary area to an existing or proposed stormwater facility on the project site is 50 acres or less, and no storage design is required, , the method of runoff calculation shall be the Rational Method as described in Section 10.2.3.1.

b. If the total project drainage area is greater than 50 acres, or storage design is required, a discharge hydrograph must be calculated using the **NRCS** method or another method that has been approved by MSD.

c. The Rational Method may be used to design through drainage channels if the drainage area of the channel is 50 acres or less; otherwise, the channel shall be designed by **NRCS** runoff calculation methodology or another method that has been approved by MSD.

Note: See Exhibit 10-1 for guidance in selecting the appropriate method.

10.2.2 Design Storm

10.2.2.1 Frequency/Return Period

The selection of a design storm is the basis for all runoff calculations and facility design for a project site. The facility specific requirements and associated check frequencies are found in Section 10.3. **The table below summarizes the associated Return Interval for various types of analyses.**

Design Storm Return Interval								
Situation		**Return Interval (years)**						
Type of Analysis	**Limiting Values**	**2**	**5**	**10**	**25**	**50**	**100**	**500**
Bridge	**ADT< 400**			●			●	
	400<ADT<1,500				●		●	
	ADT>1,500					●	●	
Culvert Capacity	**ADT< 400**			●			●	
	400<ADT<1,500				●		●	
	ADT>1,500				●		●	
Bridge Scour Analysis							●	●
Storm Sewer				●			●	
Channel Change		●		●			●	
Roadway Ditch				●			●	
Drop Inlets				●			●	
Detention or Retention Basin		●		●			●	

Note: ADT=Average Daily Traffic

Localized restrictions may be placed on some areas, based upon the hydrologic and hydraulic models developed for the area. Design criteria in such cases shall be established by MSD during the Preliminary Plan Review Process. The elevation of the 100-year pre- and post-development discharge shall be checked for all drainage system designs to assure conformance with the guidelines of the FEMA Program. In areas of the County not covered by a Flood Insurance Study, the Design Engineer must determine the pre-development 100-year Flood Elevation. The elevation for the 100-year post-development discharge shall be conveyed within the limits of the proposed easement.

10.2.3 Runoff Calculation Methods (Design Flow)

10.2.3.1 Rational Method

10.2.3.1.1 General

The Rational Method is the recommended runoff calculation procedure for project sites where:

a. The total drainage area is 50 acres or less.

b. **Detention/**Storage design is **not required.**

10.2.3.1.2 Calculation

a. The Rational Method shall be performed as follows:

$$Q = C \times I \times A$$

Where:

Q = Peak runoff (cu. ft. per sec.)
C = Runoff coefficient
I = Rainfall intensity (inches/hour)
A = Contributing area (acres)

b. **Rainfall Intensity-Duration Curves, Exhibit 10-2, shall be utilized in the Rational Method to determine rainfall depths and storm intensities for Louisville and Jefferson County. Rainfall intensity may also be computed as described in the Kentucky Transportation Cabinet**

Drainage Guidance Manual, most current edition.

c. The time of concentration (duration), Tc, shall be determined by calculating the time for a particle of water to travel from the most hydrological remote point of the project area to the point of interest. Acceptable methods to derive time of concentration are the TR-55 (Technical Release - 55, available from the **NRCS)** and the Kinematic Wave method. The minimum Tc shall not be less than 10 minutes **to any given inlet or analysis point**. Manning's Equation should be used to estimate any in-pipe or channel travel.

d. The runoff coefficient, C, must represent a composite of the surface condition tributary to the point under consideration.

To determine the appropriate C-Factor, the hydrologic soil group, described in Exhibit 10-4, and land use for each surface condition must be obtained. Exhibit 10-5 then combines this information with surface slope to provide the correct C-Factor for that area. The C-Factors given may be used directly when the **drainage area is homogeneous. When it is not,** an appropriately weighted C-Factor must be determined and reviewed by MSD.

For areas where no hydrologic soil group **information can be obtained**, the C-Factor should be the values for soil group C.

If the project site conditions differ significantly from those used as the basis for the C-Factor figures, the Design Engineer must develop a specific composite C-Factor for the area. To determine the composite C-Factor for the entire project site, a weighted average must be calculated based upon the percentages of the areas with different C-Factors. (**NOTE**: Land use regulations in Jefferson County permit the use of higher percentages of impervious surface than may be reflected in the coefficients from Exhibit 10-5. The Design Engineer should select or calculate runoff coefficients, which reflect actual proposed designs. For subdivisions, the Design Engineer should accommodate the maximum imperviousness permitted under land use guidelines.)

e. To calculate flowrates in series, ie in ditch or storm sewer design, the C*A term shall be summed for all contributing drainage areas. The intensity shall be selected from the time of concentration to that point. The Tc selected shall be the larger of these two: 1) Tc for the subject inlet or analysis point based on overland flow to said inlet/anaylsis point and 2) the Tc from the previous in-line inlet or analysis point plus the travel time from the previous inlet or analysis point.

10.2.3.2 Natural Resource Conservation Service (NRCS) Methods

10.2.3.2.1 General

The NRCS Methods are required for runoff calculation procedures for project sites where:

a. The total project drainage area is greater than 50 acres or

b. **Detention/**Storage design is required.

When these project conditions exist, the Design Engineer should confer with MSD to determine if there is a hydrologic or hydraulic model available for the area. If a model exists, site calculations must be performed and correlated with this data.

If models do not exist, the Design Engineer must use the **NRCS** Methodology in model preparation.

10.2.3.2.2 Methods

The **NRCS** Methods also include the TR-20 and TR-55 Methods. Detailed descriptions, example calculations, and worksheets for these methods are available in:

a. Project Formulation - Hydrology, Technical Release No. 20 User's Manual;

b. Urban Hydrology for Small Watersheds, Technical Release No. 55; and

c. A Guide to Hydrologic Analysis Using **NRCS** Methods.

10.2.3.2.3 Curve Number

The curve number is similar to the Rational Method C-Factor in that it is based on the surface conditions of the project site.

The appropriate figures and hydrologs in the Watershed Plans should be utilized to determine the hydrologic soil group and land use definition for the particular area. The correct CN can be determined from Exhibit 10-6.

For through drainage systems, post developed curve numbers shall be based on a fully developed watershed as zoned at the time of design.

Maps depicting the NRCS Hydrologic Soil Groups, Existing Land Use, and Projected Land Use for each watershed in Jefferson County are included in the Watershed Plans available through MSD's Stormwater Department and ERSI coverages provided by LOJIC. This information may be used to determine the appropriate surface condition factors for use in runoff calculation as described in Section 10.2.3.

Contact MSD regarding any discrepancies between the maps and the proposed project site.

10.2.3.2.4 Antecedent Runoff Condition

The index of runoff potential before a storm event is termed the Antecedent Runoff Condition (ARC). The ARC is an attempt to account for the variation in CN at a particular site for various storm conditions. The CNs in Exhibit 10-6 are for average ARC, which are used primarily for design applications. Please refer to the **NRCS** National Engineering Handbook, Section 4 - Hydrology (NEH-4, **NRCS**) for a detailed discussion of storm-to-storm variations and upper and lower CN limits. ARC will normally be involved only in calibration.

10.2.3.2.5 Directly Connected Impervious Areas

Directly connected impervious areas should be considered where applicable in **NRCS** runoff calculations.

NOTE: Land use regulations in Jefferson County permit the use of higher percentages of impervious surface than may be reflected in the coefficients from Exhibit 10-6. The Design Engineer should select or calculate runoff coefficients, which reflect actual proposed designs. For subdivisions, the Design Engineer should accommodate the maximum imperviousness permitted under land use guidelines.

10.2.3.2.6 Rainfall Duration

The minimum design storm duration for planning and design is dependent upon the runoff method used.

a. **The NRCS Method will utilize the NRCS Type II 24-hour rainfall distribution.**

Critical storm analysis shall be performed when warranted as determined by MSD.

10.2.3.2.7 Rainfall Depth

Exhibit 10-3, shall be utilized to determine total rainfall depths for Jefferson County for use by the NRCS methods. These values are derived from Engineering Memorandum No. 2, Revised June 1, 1979, published by the Commonwealth of Kentucky, Division of Water Resources - Department for Natural Resources and Environmental Protection. MSD may require use of local rain gage data where available. The Design Engineer should inquire if MSD has such data available.

10.2.3.2.8 Rainfall Distribution

Synthetic rainfall distributions shall be used for design storm generation. When critical storm analyses are not required, the distributions shall match the NRCS Type II curve as published in NRCS Technical Report 55, with 5-minute time steps.

In some cases MSD may require a critical storm analysis to determine the rainfall duration and distribution that produces the worst runoff conditions for a specific site. Since the NRCS Type II distribution represents a 24-hour duration storm only, it is not applicable to the critical storm analysis. This analysis will be based on dimensionless Huff Distributions as presented in *Rainfall Frequency Atlas of the Midwest* by Floyd Huff and James Angel, Midwestern Climate Center, NOAA, and the Illinois State Water Survey, A Division of the Illinois Department of Energy and Natural Resources.

10.2.3.2.9 Surface Condition Data

Maps depicting the NRCS Hydrologic Soil Groups, Existing Land Use, and Projected Land Use for each watershed in Jefferson County are included in the Watershed Plans available through MSD's Stormwater Department and ERSI coverages provided by LOJIC. This information may be used to determine the appropriate surface condition factors for use in runoff calculation as described in Section 10.2.3. Contact MSD regarding any discrepancies between the maps and the proposed project site.

10.3 HYDRAULICS FOR STORMWATER FACILITIES DESIGN

This section contains the technical criteria required for the design of stormwater facilities. The Design Engineer must make adequate reference to other chapters of this manual and the MSD web page for additional design guidelines.

10.3.1 General Guidelines

10.3.1.1 Design Flows

1. Design flows must be calculated by the appropriate method described in Section 10.2. At a minimum, the facility must have the capacity to transport the 10-year post-development discharge except in unusual cases, such as retrofit projects. MSD will determine design criteria for retrofit projects or other unusual cases. The water surface profile and through system capacity shall be checked for the 100-year post-development discharge. All systems must be capable of passing the 100-year design flow within the drainage easement. Additional facility-specific requirements are found in following portions of this Section.

10.3.1.2 Allowable Pipe Materials

a. Pipe material will be selected from the products identified in the MSD Standard Specifications. Alternate products can be specified by the designer, but prior approval from MSD will be required. Designers will indicate "pipe" on the plan unless a particular

product or group of products has been identified and the decision can be justified. Approved products from the specifications that are not advantageous for a particular project and <u>not allowed</u> will need to be identified in the Contract.

10.3.1.3 Roughness Coefficients "n" (See Exhibit 10-7)

a.	Concrete (Pipe or Finished):	0.012
b.	Plastic (Smooth Interior Wall):	0.011
c.	Corrugated Metal Pipe:	0.024
d.	Sod:	0.030
e.	Placed Riprap:	0.030
f.	Dumped Riprap:	0.035
g.	Gabions:	0.028

h. Coefficients for other approved materials shall be source documented for review.

10.3.1.4 General Pipe Design Requirements

a. Minimum velocity shall be 2 feet per second at design flow or 3 feet per second at full flow; whichever requires the greater slope.

b. Minimum pipe size shall be 12 inches except that driveway entrance pipe may be 10 inches with prior approval by MSD. Smaller pipe sizes may be approved by MSD for detention basin outlets on a case-by-case basis. Such pipes shall not be smaller than 6 inches.

c. Maximum manhole spacing

1.	Less than 18" diameter-	400'
2.	18" to 30" diameter-	500'
3.	33" and greater diameter-	600'

d. All pipes are to have end treatments. Design of end treatments shall consider traffic safety.

e. Stubs for storm sewers when required shall be 1 foot long measured from the outside of the manhole or surface inlet for PVC and PE pipe or one length of pipe for concrete pipe.

f. Submerged pipes are not desirable, but may be approved by MSD on a case-by-case basis.

g. When a drainage system is designed to enter a combined sewer, the last manhole or catch basin should be trapped to prevent the possible release of harmful gases and odors.

10.3.2 Storm Sewers

10.3.2.1 Design Methodology/Design Storm

The Design Engineer may refer to the Kentucky Transportation Cabinet <u>Drainage Guidance Manual</u> for design methodology for storm sewers. The exception being that all storm sewer systems will be designed for the 10-year event. The 100-year discharge elevation must be checked **to ensure the system does not surcharge out of any inlets and/or manholes.** . Manning's Equation is recommended to calculate pipe flow and velocity. The storm sewer hydraulic grade line shall be at least 1.0 foot below the ground surface or building drain elevation**, whichever is lower**, at all points for the design event. **For the 100-year event, the hydraulic grade line may not rise higher than the ground line or building drain elevation, whichever is lower.** Where the storm sewer hydraulic grade line **exceeds** the pipe crown, it must be shown on the Profile Drawing. Losses at all inlets, junction structures and bends are to be considered. Refer to MSD Standard Casting Details for all surface inlets and manhole castings. Pipes on grades greater than or equal to 20% shall have anchors at each pipe joint. The Design Engineer shall check to ensure that all pipes have sufficient cover and that all structures, inlets and manholes have sufficient dimension to receive pipes, bells, frames, and grates.

10.3.3. Culverts

10.3.3.1 Design Methodology/Design Storm

A method as described in the Kentucky Transportation Cabinet <u>Drainage Guidance Manual</u> should be used. The design methodology utilized must be submitted for review.

10.3.3.2 Maximum Allowable Headwater

The most stringent requirement of the following will apply:

a. Cul-de-sacs, alleys, local streets, and collectors: Use the subgrade elevation of the adjacent roadway for the 10-year discharge.

b. Major and minor arterials: Use 12 inches below the **shoulder** elevation of the adjacent roadway for the 100-year discharge.

d. Headwater for the 10-year discharge should not exceed 1.2 times the structure rise except as specifically approved by MSD on a case-by-case basis. **For pipes 30" in diameter and larger, the headwater should not exceed 1.0 times the structure rise except as specifically approved by MSD on a case-by-case basis.**

e. If a culvert has a drainage area greater than one square mile or is in a regulated floodplain the 100-year storm headwater depth shall not be greater than 1.0 times the structure rise except as specifically approved by MSD on a case-by-case basis.

10.3.3.3 General

a. Downstream channel must receive appropriate protection or energy dissipation if the design outlet discharge would cause erosive conditions.

b. Traffic safety must be considered in the design of culvert end treatments. This may include extending the culvert beyond the right-of-way limits, installing catch basins to intercept roadside swales, and installing guardrails. Designs must conform to meet the requirements of the agency responsible for road maintenance and safety.

10.3.4 Trenchless Pipe Installation

Trenchless pipe installation for storm sewers and culverts is described in **Chapter 8 of this manual**.

10.3.5 Conventional Channels and Ditches

This section describes the technical criteria necessary to design stormwater channels and ditches using conventional design procedures. These procedures shall be applied to roadside and rear yard ditches and highly urbanized channels. Where possible, all blueline streams (especially in undisturbed areas) shall be designed using Natural Channel Design techniques as described in Section 10.3.6. This criterion represents minimum requirements. Justification should be submitted to MSD for review and approval in cases where different slopes or other protective measures are recommended.

10.3.5.1 Design Methodology/Design Storm

Manning's Equation is recommended, except in cases where backwater conditions are significant. All calculations must be submitted for review. **Software programs utilized must be approved by MSD.**

a. Design Storm

1. Channels and ditches should be capable of conveying the 10-year storm flow within their banks. Through drainage systems shall generally be designed to collect and transport the post-development rate of runoff for the 100-year design storm. In all cases, the 100-year discharge elevation must be checked to ensure that adjacent structures do not suffer flood damage.

2. All systems must be capable of passing the 100-year design flow within the drainage easement.

b. Channel Criteria

Minimum Channel Slope - 0.5%, except in special cases such as retrofit projects or major channels.

c. Maximum Side Slope

1. Earth 3:1 (when depth < 8.0 feet)
4:1 (when depth > 8.0 feet)
2:1 (may be allowed on case-by-case basis)

2. Riprap and Aggregate 1.5:1
3. Concrete 1:1
4. No maintenance ground cover 2:1
5. Bioengineered systems on various slopes

d. Channel Depth

Channels created for new residential subdivisions shall not have a design depth of greater than 2.0', unless otherwise approved by MSD.

e. Channel Lining

1. Channel slope 0.5% or less – Concrete. Evaluate the use of a low flow channel. As-builts may be required.

2. Channel Slope between 0.5% and **2**.0% - Concrete low flow channel with durable lining for the remainder of the protected section.

3. Channel Slope greater than **2**.0% - Natural vegetation and geosynthetic turf reinforcement.

4. If the design parameters are beyond the limits of natural vegetation, then a non-degradable durable material must be used. Durable channel lining is required to the depth of the **10-year** storm as outlined in Section 10.3.5.3. Durable channel lining may be low maintenance ground cover, sod, soil bioengineered systems, turf reinforcement mats or concrete. **Rip-Rap, Aggregate Channel Lining and Gabion Baskets are to be limited to areas immediately downstream of an outlet pipe to reduce velocities and erosion potential. The use of these materials shall be a last alternative and approved on a case by case basis.** All linings must be approved by MSD on a case-by-case basis.

5. Trapezoidal or rectangular paved channels shall have bottom slopes no less than 1:12 sloping either to the center or to one side of the channel to provide self cleaning.

6. Channel and channel lining design should consider the effects of open channel junctions, curved alignment, obstructions, transitions, constrictions, changes in slope and other characteristics including the effects of subcritical and supercritical flow.

10.3.5.2 General

a. Roadside ditches on retrofit projects, which have less than a 4-foot shoulder, shall not exceed 1'-6" in depth, measured from the edge of pavement.

b. Roadside ditches and channels must have a minimum 4-foot shoulder from the edge of the pavement to the top of the bank.

c. Roadside ditches and channels in through systems must have a minimum 8-foot shoulder from the edge of the pavement to the top of the bank.

d. In areas where new sidewalks are proposed to cross-swales, ditches, or channels, a culvert meeting design storm requirements must be installed extending past the sidewalk sufficiently to allow a maximum 4:1 slope.

e. Ditches and channels adjacent to state highways may require more stringent criteria. The Design Engineer must obtain the criteria from the **KYTC**.

f. Cutoff walls shall be placed at the beginning and end of all paved channels.

g. Utilities and their facilities should not be located within or interfere with swales, ditches, **detention/retention facilities, stormwater quality treatment devices and facilities, manholes**, pipes or landscaping such as trees and bushes.

10.3.5.3 Channel Design Procedure

a. The method of designing channels and ditches as presented agrees with Hydraulic Engineering Circular HEC-15 that is based on the tractive force theory. The calculated shear stress resulting from flow in a channel is compared to the maximum permissible shear stress for the channel lining selected. If the shear force induced by the flowing water equals or exceeds the permissible shear stress of the lining, failure may occur and a more resilient lining must be proposed. This concept allows for calculation of the maximum discharge a channel can carry by equating the calculated and permissible shear[1]. The procedure is applicable to channels of uniform cross section and constant bottom slope.

The suggested step-by-step design procedure shown below is taken from the Kentucky Transportation Cabinet's Drainage Design Manual. Additional information is taken from the Federal Highway Administration's HYDRAIN software documentation manual. Obviously additional procedures and references are available and they should be utilized as designer preference dictates. However, it will be the designer's responsibility to satisfy all MSD reviews.

b. The design procedure as shown assumes steady uniform flow with the energy slope equal to the bed slope and flow calculated using Manning's equation. For conditions other than these, the designer should consult other references; one of which is HEC-11, which focuses on natural channels with irregular cross sections, varying bottom slopes, and flows exceeding 50 cfs.

The maximum shear stress on the side slopes is always less than or equal to that on the channel bottom and does not limit the design of a single, rigid, vegetative, gabion, or temporary lining, but may affect the design of composite linings[1]. The designer is alerted to this situation and should consult the previously noted references.

c. Design Procedure

1. Determine Drainage Area Contributing to the Channel.

2. Select Channel Cross Section- Side Slopes & Bottom Width

[1] Federal Highway Administration's HYDRAIN Software Documentation (GKY and Associates, Inc.).

3. Determine Channel Longitudinal Grade

4. Calculate Design Flow - Adjust channel cross-section and grade as necessary for capacity. (Reference Section 10.3.1.2)

5. Select Channel Lining

   a. Determine maximum permissible shear stress (τ_p) for the selected lining. See Table 5-3 in the **KYTC** Drainage Manual for a summary list of various protection measures or the manufacturer's recommendations for specific Turf Reinforcement products.

   b. Estimate flow depth in the channel.

   c. Determine Manning "n" for selected lining and depth of flow.

   d. Calculate flow using Manning's equation and the estimated flow depth.

   e. If calculated flow varies from design flow, repeat steps (b) and (d) until flows agree.

   f. Calculate actual shear stress(τ_d)

   $$\tau_d = \gamma\, d_n\, s,$$

   Where: τ_d = actual shear stress 1b/ft^2
   γ = specific weight of water 62.4 lbf/ft^3
   d_n = flow depth in ft.
   s = energy slope (bed slope); ft/ft

   g. If $\tau_d < \tau_{p,}$ the lining selected is acceptable

   If $\tau_d > \tau_{p,}$ consider the following:
   - Select a lining with a higher permissible shear stress
   - Decrease slope

- Increase the channel width and/or flatten side slopes

10.3.6 Natural Channel Design Procedures

This section describes Natural Channel Design procedures to be utilized where possible for the design of streams especially along blueline streams and in undisturbed areas. It should be noted that Natural Channel Design techniques promote enhanced stormwater quality and aquatic habitat over conventionally designed channels and ditches and is the preferred method for the design of streams.

10.3.6.1 Design Methodology

Streams designed using natural channel design techniques shall emulate naturally formed streams. The design shall be based upon measurements from reference reaches in similar physiographical regions exhibiting similar characteristics to the desired stream. The designed stream shall exhibit characteristics consistent with stream types expected to occur within the given valley type. Both the pre-existing stream type and the designed stream shall be classified in accordance with the Rosgen Stream Classification system[2].

10.3.6.2 Design Discharge

Streams designed using Natural Channel Design techniques shall include a bankfull channel design based on the bankfull discharge (also commonly referred to as the channel forming discharge). On average, the bankfull discharge approximates a 1.5-year storm event and can range between a 0.8 to 2.0-year storm event. The bankfull discharge used for design shall be determined based on field bankfull indicators and shall be checked against regional curves developed from gauged streams within the same physiographical region as the stream to be designed. Where flooding of nearby structures may occur, the floodplain area adjacent to the bankfull channel shall be designed to convey a 100-year storm event.

10.3.6.3 Design Submittals

All parameters/information used for the basis of design shall be submitted for review. Where an existing stream is present, the design submittal should include calculations for the proposed

[2] Applied River Morphology (Dave Rosgen, 1994)

channel as well as measurements from the existing channel. Information submitted should include reference reach data and location of reference reaches.

As a minimum, the following design parameters/information shall be included in the design submittal: longitudinal profile; cross sectional geometry for pool, riffle and cross-over reaches; stream type; drainage area; bankfull width; mean bankfull depth; bankfull cross sectional area; bankfull discharge; mean bankfull velocity; maximum bankfull depth; width to depth ratio; width of flood prone area; entrenchment ratio; ratio of pool depth to mean bankfull depth; ratio of pool width to mean bankfull width; average riffle, pool, run and glide slope; average water surface slope; valley slope; meander length; belt width; radius of curvature; ratio of meander length to bankfull width; ratio of radius of curvature to bankfull width; meander width ratio; sinuosity; pool to pool spacing; ratio of pool to pool spacing to bankfull width; D50 of bed materials; D84 of material which will be transported during a bankfull event; critical dimensionless shear stresses; minimum mean bankfull depth calculated using dimensionless shear stress equations.

10.3.6.4 Channel Stabilization Methods

Methods to be utilized to stabilize channel banks below the bankfull depth should be included within the design submittal. The use of rock should be limited to areas exhibiting shear stresses above allowable shear stresses for vegetation. The use of native vegetation and soil bioengineering treatments is the preferred method to stabilize channel banks.

10.3.6.5 Aquatic Habitat Enhancements

The use of aquatic habitat enhancements should be included where possible and consistent with stream types. Enhancements may include a variety of structures consistent with stream types such as woody material, rock or wood overhangs, rock vanes, cross vanes, W-weirs, J-hook weirs, stream gravel/boulders, etc. Details for all structures shall be included with the design submittal. In most instances, it is not necessary to extend any in-stream structures or bank revetments above the bankfull depth.

10.3.6.6 Riparian Corridor Enhancements

Where practical, the design shall include enhancements to the riparian corridor on either side of the reconstructed stream. Riparian corridor enhancements shall include native plantings consistent with anticipated inundation periods. Submittals shall include a description of existing vegetation within the riparian corridor as well as proposed plantings and frequency schedules.

10.3.7 Surface Inlets and Gutter Spreads

This section describes the technical criteria necessary to design surface inlets/catch basins. **Please reference HEC -12, Drainage of Highway Pavements for a more in-depth discussions and procedures.**

10.3.7.1 Design Storm

Curb inlets and gutter spreads shall be designed for a storm intensity of 4 inches per hour. All other stormwater inlets shall be designed for the 10-year storm return period.

10.3.7.2 Design Methodology

The design methodology utilized should be similar to those presented in **HEC-12, Drainage of Highway Pavements** or the **KYTC**, where applicable.

10.3.7.3 Maximum Flow Spread on Pavement

Maximum flow spreads on pavement should be set by MSD in the preliminary stages of all projects.

a. Cul-de-sacs, Alleys, and Local Streets - 6 feet; 8 feet with 2 foot wide concrete curb and gutter

b. County Through Roads - 4 feet; 6 feet with 2 foot wide concrete curb and gutter.

Flow spread is measured from the face of curb. Gutter grades of less than 0.50% should be avoided, if possible. **In addition, the flow depth at any location along the curb shall not exceed 4 inches.**

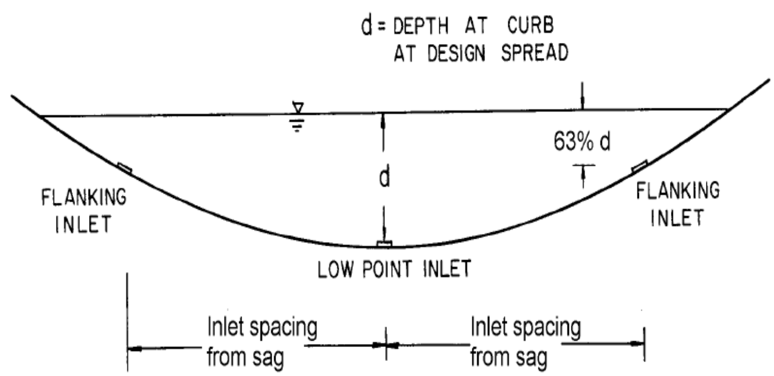
10.3.7.4 General

a. Inlets shall be placed immediately upstream of pedestrian walkways and intersections and designed to intercept as close to 100% of the flow as possible

b. Inlets placed at locations other than that described in Section 10.3.7.4a shall be **placed at locations that prevent the allowable spread or depth at curb criteria from being exceeded. Vane grates shall be used at all inlet locations.**

c. Inlets for drains connected to the combined sewer system shall be trapped and may be designed with flow-throttling capabilities if required by MSD.

d. Inlets at sags in curb and gutter applications shall receive careful design to prevent violation of the gutter spread requirements of Section 10.3.7.3. **In addition, it is good engineering practice to place flanking inlets on each side of the low point inlet when in a depressed area that has no outlet except through the system. This is illustrated in figure below.**



The purpose of the flanking inlets is to act in relief of the inlet at the low point if it should become clogged or if the design spread is exceeded. Flanking inlets can be located so they will function before water spread exceeds the allowable spread at the sump location. The flanking inlets should be located so that they will receive all of the flow when the primary inlet at the bottom of the sag is clogged. They should do this without exceeding the allowable spread at the bottom of the sag. If the flanking inlets are the same dimension as the primary inlet, they will each intercept one-half the design flow when they are located so that the depth of

ponding at the flanking inlets is 63 percent of the depth of ponding at the low point. If the flanker inlets are not the same size as the primary inlet, it will be necessary to either develop a new factor or do a trial and error solution using assumed depths with the weir equation to determine the capacity of the flanker inlet at the given depths.

10.3.8 Detention Basins

This section describes the technical criteria necessary to design stormwater detention basins. Detention basins are typically designed to remain empty during dry weather and to backup or detain excessive runoff generated during a storm. The designer is directed to the **Detention Analysis Checklist** located in the stormwater-sanitary section of MSD's web page.

10.3.8.1 Detention Basin Design

a. A minimum basin volume shall be the difference in runoff volume discharged from the project area to the basin site between the pre-development and post-development 100-year storm, or such volume to sufficiently reduce post-development discharges to pre-development rates whichever is greater. Reference Section 10.2.2.2b for the rainfall duration unique to Detention Basin Design. In cases where the volume requirement governs, the design calculations must not only show that the required volume has been created, but that the basin functions to detain the volume difference. Basin volume may also be dictated by limitations of downstream conditions or other requirements on a case-by-case basis as decided by MSD.

   In many areas of the county the increased runoff volumes can be as critical, if not more critical, than the rate of discharge. MSD will address this issue on a site-specific basis. All development submittals will be evaluated for the impacts of increased runoff and volume control. Satisfying the volume requirement may be met onsite, at approved off-site locations, or by purchase of volume in a Flood Compensation Bank if one is available in the watershed.

   In the Pond Creek watershed, the volume of increased runoff must be mitigated at a ratio of 1.5:1. The ratio may be increased on a site-specific basis as determined by MSD. See section 10.4.2 for other areas that have been identified with the 1.5:1 mitigation ratio. Check with MSD before during work in an area to find out the correct mitigation factor.

If the basin is to be located directly on a portion of the through drainage system, volume calculations must also consider the total system flow reaching the basin. The Design Engineer must contact MSD for direction in these cases. If the basin is to be constructed on a solid or intermittent blue line stream, it must be beneficial to the stream corridor or the public.

b. Maximum basin side slopes shall be 3:1, unless **retaining walls are provided.**

c. Low flow channels may be grass if the channel grade is greater than **2**.0%.

d. Basin design must include maintenance accessibility and responsibility.

e. Requirements of the Dam Safety Law shall be observed.

f. The Design Engineer shall address provisions for anti-seep collars, extended detention basins, wet ponds, soil bioengineering, baffles, outlet protection and length to width ratios.

g. No sanitary sewer manholes shall be placed within the detention basin.

h. Detention basins **in Single Family Developments are to be placed in recorded "Open Spaces". All other detention basins** must be completely within a recorded Permanent Detention Basin Easement.

i. **All detention basins shall include a pretreatment forebay. Forebays shall be designed with volume for the first 1" of runoff. Outlet of the forebay shall be a V-notch weir.**

j. **Retention basins (permanent pools basins or wet basins) shall have a minimum depth of 5'.**

10.3.8.2 Basin Discharge

a. Discharge control structures shall be multi-stage and capable of limiting 2, 10, and 100-year post-development discharges to pre-development peak discharge rates or downstream system capacity and shall be constructed of concrete or approved alternate.

b. The emergency spillway shall be sized to accommodate a flow equal to the design overflow of the 100-year storm post-development discharge**, assuming all other outlets are completely blocked,** without overtopping the dam. **Discharge must be conveyed to a public outlet of sufficient capacity.** Erosion protection must be provided for the spillway and receiving stream **and energy dissipation must be employed**.

c. The dam elevation shall not be less than one foot above the 100-year storm storage and overflow elevation.

d. Appropriate downstream channel protection must be installed **and the basin outlet pipe must be placed no closer than 15' from an adjacent property line**.

e. Storage, discharge, and routing calculations for the 2, 10, and 100-year discharges must be submitted for review and have a Professional Engineer's stamp and signature.

f. **The top of dam shall be at least one foot below the lowest opening of any structure adjacent to and upstream of the dam.**

g. Detention basins shall be fully discharged, **or return to normal pool elevation in the case of wet basins,** within 36 hours after the storm event unless specifically approved by MSD on a case-by-case basis.

h. The detention basin shall be the first item of construction and must be designed to function as a sediment basin through the construction period. The basin design must be checked for capacity due to additional runoff generated by disturbed site conditions. **The detention basin may be designed with over-excavation to account for planned sedimentation during construction. Excess sedimentation shall be removed and disposed of properly to establish design capacity of the detention basin.**

10.3.8.3 Parking Lot Storage

a. Parking lot storage involves shallow ponding in a specifically graded area of a parking lot.

The major disadvantage is the inconvenience to users during the ponding function. Clogging of the flow control device and icy conditions can be maintenance and safety problems. This method is intended to control the runoff directly from the parking area and is not appropriate for storing large volumes.

Parking lot storage shall generally be limited to those areas served by combined sewers, primarily in the central business district of Louisville. Parking lot storage may be approved in separate sewer areas on a case-by-case basis.

b. The general design requirements are:

1. Maximum water depth: 8 inches
2. Minimum ponding area distance from buildings: 10 feet
3. Maximum surface grade: 5.0%
4. Minimum surface grade: 1.0%
5. Maximum discharge to combined sewer system: 10-year pre-development discharge unless otherwise determined by MSD

10.3.8.4 Other Alternatives

a. Other detention designs may be approved by MSD on a case-by-case basis in the combined sewer system. **Basins in the combined sewer system may require backflow devices.**
b. Underground Detention and oversized piping shall be bonded, have a pre-treatment device and be tele-inspected before bond release. Acceptable materials are concrete

vault and concrete construction. All other materials will be considered on a case by case basis.

c. **Vegetated recessed islands, bio-swales or micro-detention are acceptable alternatives in appropriate soil conditions and will be approved by MSD on a case-by-case basis.**

10.3.9 Sinkholes

10.3.9.1 General

A sinkhole is any closed depression in a limestone region formed by the removal of water, surfacial soil, rock or other material that is connected to a cavern or underground passage. The sinkhole drainage area shall include any area that contributes surface water directly to the sinkhole.

The use of sinkholes as stormwater management facilities is not permitted, unless there are no other cost-effective alternatives. Then a submittal must be sent to MSD for approval.

10.3.9.2 Design

Specific design considerations for the use of sinkholes, when permitted, include but are not limited to:

a. The sinkhole shall have the volume to store a 100-year, 24-hour **NRCS** storm with a no outlet condition.

b. Capacity of the sinkhole, including a hydrogeologic study along with dye test results.

c. Protection measures for the sinkhole inlet.

d. Trash barriers.

e. Detention requirements.

f. An alternate means of surface water disposal in the event of sinkhole failure.

g. Restriction of development in floodplain areas adjacent to the sinkhole.

h. Review of construction methods and staging.

i. The design of sinkhole structures must be supervised by a Geotechnical Engineer, licensed in the Commonwealth of Kentucky. The engineer shall also inspect and certify the construction of the sinkhole structure and certify the ability of the sinkhole to accept anticipated flows without flooding or causing property damage in the case of failure.

j. A member of MSD's Maintenance Division must be present on all final inspections for bond release for new subdivisions.

k. Any structural failures must be fully documented and a Geotechnical Engineer, licensed in the Commonwealth of Kentucky, must supervise design of, inspect and certify construction of repairs prior to bond release.

10.4 LOCAL REGULATORY FLOODPLAIN AND CONVEYANCE ZONE

For background information on the Louisville and Jefferson County Floodplain Ordinance and the associated restrictions, refer to section 3.7. It is suggested that MSD be contacted in the early stages of any project if clarification is needed concerning requirements and restrictions. This section defines Floodplain Compensation and describes the methodologies to be used when determining the Local Regulatory Floodplain (LRFP) and Local Regulatory Conveyance Zone (LRCZ).

10.4.1 Definitions:

"Local Regulatory Flood" means the flood having a one-percent (1%) probability of being equaled or exceeded in any given year based on a fully developed watershed.

"Local Regulatory Floodplain" means any stream course or normally dry land area susceptible to being partially or completely inundated by the overflow of water from sources of public water or by the unusual and rapid accumulation or runoff of public surface waters and subject to a local regulatory flood.

"The Local Regulatory Conveyance Zone" is the channel of a river or a solid blue line stream and the land adjacent to that river or stream which, if unobstructed, will discharge a local regulatory flood without cumulatively increasing the water surface elevation more than one tenth of one foot. The conveyance zone is determined by an equal loss of conveyance (at higher elevation) occurring on each side of the channel.

"Floodplain Storage Compensation" means an artificially excavated, hydraulically equivalent volume of floodplain storage sufficient to offset a reduction in floodplain storage resulting from filling or construction within the local regulatory floodplain.

10.4.2 Floodplain Compensation

Floodplain compensation at a ratio of 1:1 is required throughout Jefferson County as part of the Floodplain Ordinance. Due to the severe flooding problems in the lower portion of the Pond Creek watershed, the required ratio is 1.5:1 for any fill placed in the fully developed local regulatory floodplain. The 1.5:1 ratio also applies in Chenoweth Run of the Floyds Fork watershed and Big Run of the Mill Creek watershed. These ratios may be increased on a site-specific basis as determined by MSD.

10.4.3 Determinations

a. MSD has approximate elevations for the LRFP in many locations. Additionally, hydraulic modeling currently exists for many streams in Jefferson County; these models may be utilized to determine the LRFP and LRCZ. If information is not available from MSD, then it will need to be defined as a part of the project.

b. **Natural Resource Conservation Service** Methodology (**NRCS**) shall be used for runoff calculation. A 24-hour Type II storm distribution with five-minute increments is required. Other distribution methods may be approved by MSD on a case-by-case basis.

c. Curve numbers (CN) and time of concentrations (T_c) shall be based on a fully developed watershed as zoned at the time of design.

d. Hydrology information may be computed using HEC-1, HEC-HMS, or POND PACK. Hydraulic modeling should be based on HEC-2 or HEC-RAS. In each case, other software can be utilized if approved by MSD.

10.5 HYDROLOGIC AND HYDRAULIC MODELING STANDARDS

Development of uniform modeling standards is a means by which MSD can regulate the quality of the floodplain models in Jefferson County. Successful floodplain management requires that the hydrologic and hydraulic floodplain models be updated as changes in watersheds occur. These changes include those resulting from continued development in the watershed, as well as from physical changes in the drainage system. As the watersheds evolve over time, the modeling standards provide guidance on how changes should be incorporated into the models. The implementation of a comprehensive set of modeling standards promotes consistency in floodplain modeling, standardizes MSD review effort, and provides a means to educate the engineering/development community.

Hydrologic and hydraulic modeling criteria have been established in Jefferson County through the combined efforts of MSD, U of L, the Kentucky Division of Water, KYTC, the Louisville District Army Corps of Engineers and local engineering consultants.

The following modeling guidelines are consistent with current engineering standards of practice not necessarily to the exclusion of other sound and technically supported procedures. A licensed professional engineer should justify the use of methods other than those described below in writing prior to the model submittal and review process.

10.5.1. Software Selection

HEC-1 and HEC-HMS are the recommended programs for rainfall/runoff hydrologic simulations requiring hydrograph analysis at one or more points along a stream. HEC-2 and HEC-RAS are the recommended programs for open channel flow or floodplain calculations excluding streams with extremely low or high gradient. The most current versions of these software packages are available from the Hydrologic Engineering Center's website at www.hec.usace.army.mil. Caution should be used when converting from one version to another (for example HEC-2 to HEC-RAS) to make sure that the original intent of the model is understood. Changes to be made for the newer model should work properly and should be fully documented. The HEC manuals offer guidance for conversions to the newer versions of their software. Other software may be accepted for floodplain analysis in Jefferson County if approved by FEMA for NFIP usage. A list of accepted models may be found at www.fema.gov. Civil site analysis, local detention basin design, water quality analysis, natural channel design, and interior drainage system design may be performed with models not on FEMA's approved NFIP list if approved by MSD prior to use on a case by case basis.

10.5.2. Hydrologic Modeling

The following methods and/or parameters should be used for single event hydrologic analyses for streams and/or detention basin calculations.

10.5.2.1. Basin Parameters

a. Subbasin Delineation. Depending on the size and location of the watershed being analyzed, and the extents of previous modeling attempts, tributary boundaries may need to be redefined or subdivided. Drainage areas must be delineated using LOJIC mapping with 2-ft contours in Jefferson County. In areas where watersheds extend into other counties and LOJIC data is not available, supplement the topographic data with 7-1/2 Minute USGS Topographic Quadrangles. Subbasin size in developable watershed areas should be 50 to 200 acres. Areas that are not expected to develop due to land use or zoning criteria, such as the Jefferson Memorial Forest, can have larger subbasin areas based on natural drainage patterns.

b. Loss Rate. The **NRCS** Runoff Curve Number (CN) Method, as described in TR-55 (**NRCS** 1986) and NEH-4 (**NRCS** 1985), shall be used to estimate runoff from design storms. Continuous simulations, if necessary, may use other loss rate methodology where applicable.

c. Transform. Rainfall excess shall be transformed into runoff using the **NRCS** Unit Hydrograph approach.

d. Base Flow. Unless modeling the Ohio River, base flow may be ignored during floodplain analyses.

e. Time of Concentration (T_c). The time of concentration shall be calculated for each subbasin using the combined travel times for sheet flow, shallow concentrated flow, and open channel flow in accordance with TR-55 (**NRCS** 1986).

f. Antecedent Runoff Conditions (ARC). Average ARC shall be used in all cases except for model calibration.

g. Infiltration. Runoff infiltration will be calculated using the **NRCS** Runoff Curve Number Method, as discussed above. CN's should be developed for both the "existing watershed conditions" (EX) and the "fully developed watershed conditions" (FD) and analyzed separately. EX CN's shall be estimated using LOJIC data for hydrologic soil groups, land cover type and treatment, hydrologic condition, and percentage of impervious area (connected or unconnected). Impervious area calculations should include LOJIC data sources for buildings, roads, and miscellaneous transportation such as sidewalks and driveways. FD CN's shall be estimated using soils data, existing zoning regulations, and lookup tables relating zoning designations with maximum impervious area limitations to CN values.

h. Channel Routing. Hydrograph routing through a subbasin or along a reach of stream shall use either the Modified Puls (low gradient) or Muskingum-Cunge (moderate to high gradient) routing techniques. Muskingum-Cunge 8-point cross sections are recommended for natural channels. Routing results in the hydrologic model must correlate with the hydraulic model for the same reach.

i. Reservoir Routing. Reservoir routing may be used for modeling storage effects at bridges or culverts, or may be used for detention facility analysis. In either case, the routing method shall use an elevation-volume-outflow relationship developed by the engineer with consideration of backwater effects on the outlet hydraulics. The initial conditions of reservoir elements shall be controlled by normal dry-weather water surface elevations. Documentation of methods used to derive the hydraulic response and storage capacity of structures associated with reservoir routing should accompany the submittal.

10.5.2.2. Meteorological Parameters

a. Rainfall Duration. All models used for hydraulics analysis shall use 24-hour duration design storms.

b. Total Rainfall Depth. Rainfall depths associated with various annual exceedence probabilities are referenced from *Rainfall Frequency Atlas of the United States*, U.S. Department of Commerce, Weather Bureau, 1961 (also known as TP-40). The 24-hour duration rainfall values used for analysis in Jefferson County are as follows (also see Exhibit 10-3):

- 2-year 3.2 inches
- 10-year 4.5 inches
- 100-year 6.2 inches

c. Temporal Distribution. The **NRCS** Type II rainfall distribution (5-minute increment) will be used for design storm definition in Jefferson County.

d. Spatial Distribution. Design storms shall be applied uniformly and simultaneously to subbasins of the hydrologic simulation.

10.5.2.3. Control Specifications

a. Calculation Time Step. There are five-minute (or less) calculation steps required for hydrologic modeling.

b. Simulation Length. Hydrologic models must simulate the 24-hour design storm and describe watershed response until all elements are within 5% of their initial discharge conditions.

10.5.3. Hydraulic Modeling

Water surface profile modeling is required for analyzing impacts to blue line and intermittent blue line streams in Jefferson County. The one-dimensional, steady flow calculations performed by HEC-RAS are suitable for most watershed conditions. HEC-RAS also has the ability to calculate LRCZ boundaries.

10.5.3.1. Study Limits

The hydraulic study should extend upstream and downstream of the impacted reach to a point that the modified profile converges with the existing condition profile for the same event. When creating new models, verify modeling extents with MSD prior to the project.

GIS coverage of watershed boundaries, floodplains and conveyance zones are available with existing H-H models on the MSD web page. Changes to models typically require modification to the existing subbasins and/or cross section coverage.

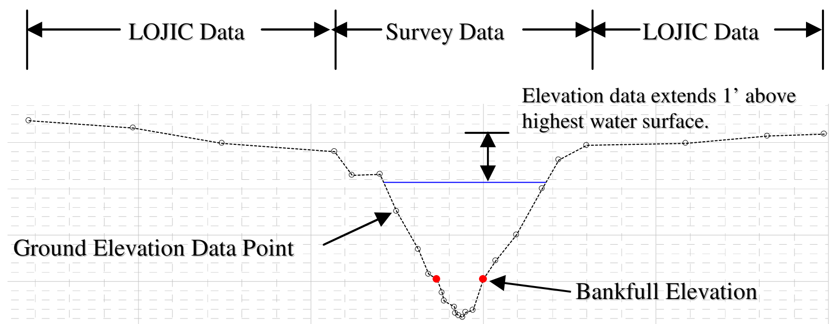
10.5.3.2. Cross Sectional Geometry

a. Width. The minimum width is set by extending the left and right ends of the cross section to one foot above the LRFP elevation.

b. Spacing. Cross section locations should be based on sound engineering judgment. Higher density is required at tributary locations, slope changes, roughness changes, valley morphology changes, and at bridges or other structures. In general, cross section locations should be based on the riffle spacing of the stream being studied. Pool cross sections may be necessary for geomorphic channel design, but are not required for floodplain determination. Cross section spacing on any stream in Jefferson County should not exceed 500 feet (excluding the Ohio River).

c. Number of Data Points. A minimum of seven data points is required to describe each cross section. The maximum number of data points is limited by software constraints.

d. Source of Geometry Data. Elevation data in the active channel shall be collected with field survey and tied to the **North American Vertical Datum of 1988 (NAVD 88)** . The cross section geometry should have the density of points necessary to accurately quantify the area under bankfull elevation and the location of the stream thawleg. LOJIC 2-ft contour mapping may be used to supplement cross section data in the floodplain (overbanks). A licensed Land Surveyor or Professional Engineer must document the accuracy of survey information at cross sections and structures. An example of a suitable cross section is as follows:



e. Bank Stations. Bank stations in natural cross sections should be placed at the geomorphic bankfull elevation. Variations in roughness values should be included for the channel bed, left and right banks, and left and right floodplains.

f. Reach Lengths. The distances measured between cross sections at similar points are called reach lengths. HEC-RAS uses this information to compute discharge-weighted reach overbank segments. Floodplain models should use the distance measured along the stream thawleg for the centerline reach length. Left and right overbank reach lengths should be estimated as the center of mass of the floodplain discharge.

g. Roughness Values. Channel and floodplain roughness values significantly influence model accuracy. Roughness values should be reflective of the natural variations in the bed materials and overbank vegetation. Consistent with models developed in the past, Manning's n should be used to describe frictional energy losses. There are a variety of methods available for calculating

Manning's n from particle size distributions of channel materials (USDA, Rosgen, and others). Listed below are some additional references available that have photographs of reaches with measured values. A listing and description of roughness values with photographs should be included in the documentation of the model development.

References:
Open-Channel Hydraulics, Chow, 1959
Roughness Characteristics of Natural Channels, Barnes, Harry H., USGS, 1967
Roughness Characteristics of New Zealand Rivers, Hicks and Mason, 1991
Stream Corridor Restoration Principles, Practices, and Processes, USDA, 1998
The Reference Reach Field Book, Rosgen, 1998

h. Expansion and Contraction Coefficients. Subcritical flow contraction and expansion coefficients are used to estimate energy losses caused by abrupt changes in the flowing cross sectional area. Typical losses occur upstream and downstream of bridge or culvert crossings and flow through a narrower portion of the valley. Where contraction and expansion losses are expected to occur, contraction coefficients should vary between 0.1 and 0.3, expansion coefficients should vary between 0.3 and 0.5. FEMA requires documentation of loss coefficients higher than these ranges.

i. Ineffective Flow Areas. Effective flow, in one-dimensional modeling, is the portion of the flow traveling in the downstream direction. Portions of the cross section that are occupied by water but not flowing in the downstream direction are described as ineffective flow areas and should be specified. A definition of ineffective flow areas should be justified in the report. Ineffective flow areas in urban watersheds must reflect current development. **It is typical to have ineffective flow areas upstream and downstream of bridges.**

j. Levees. The use of the levee option in HEC-RAS must be used to describe a levee in accordance with FEMA regulations and justified for NFIP use. Use of the levee option in the hydraulic model for other reasons than the description of a legitimate flood control measure must be approved by MSD in advance.

10.5.3.3. Structures

a. <u>Required Structures</u>. Bridges, culverts, significant pedways and other stream crossings should be included in the hydraulic model. The geometry of the obstruction should be surveyed and related to **NAVD 88**. Normal stream debris should be reflected in the reach's roughness values.

b. <u>Analysis Methods</u>. Refer to *Hydraulic Reference Manual* Version 2.0 or higher (HEC). The selected method is at the discretion of the engineer but must be documented in the report.

10.5.3.4. Steady Flow and Boundary Conditions

a. <u>Frequency of Flow Data</u>. The hydrologic model must be sufficiently subdivided to provide flow change locations along the study reach. New flow data should be added to the hydraulic model when the flow rate changes by $\pm$10%.

b. <u>Upstream or Downstream Boundary Conditions</u>. Within each of the eleven major watersheds of Jefferson County, hydraulic models should be connected by junctions or downstream boundary conditions representing larger streams. Normal depth is used to represent the upstream or downstream boundary condition, or starting water surface, when the study reach is sufficiently remote from streams with existing models. If the study reach can be extended to a modeled reach then either a junction should be used or the downstream boundary of the new reach should be set at the water surface elevation of the larger tributary modeled with the same storm event. This conservative "simultaneous peak" approach is used for regulatory models to define the worst possible case of floodplain inundation. A minimum of ten cross sections should be placed between the boundary conditions and the study reach. LRCZ boundary conditions are set at the LRFP elevation plus 0.1 feet.

c. <u>Internal Boundaries (Junctions)</u>. Where possible, newly modeled tributaries will be connected to larger streams with junctions. Under most floodplain modeling conditions in Jefferson County the energy losses occurring at locations where streams come together can be calculated with the Energy Equation option in HEC-RAS. The reach distance across junctions should be minimized to reduce errors when using this option.

10.5.3.5. HEC-RAS Methodology

a. Friction Slope. Use the HEC-RAS Average Conveyance Method.

b. Calculation Tolerances. Use the HEC-RAS Defaults.

c. Conveyance Method. The suggested method, for consistency, is to use the HEC-RAS default, which calculates conveyance in areas defined by changes in Manning's "n" values only.

d. Floodway Methodology. Floodway determinations are required for blue line or intermittent blue line streams in Jefferson County. The LRCZ is determined by using the encroachment options available in HEC-RAS. LRCZ boundaries are established by encroaching into the LRFP, producing equal loss in conveyance from both sides of the channel until the water surface has risen 0.1 feet. Floodway determination should include consideration of expansion and contraction losses at bridges and valley nick points. For additional guidelines refer to HEC-RAS and *Floodway Determination Using Computer Program HEC-2*, TD-5, USACE, 1988.

10.5.4. Submittals

10.5.4.1. The LRFP/LRCZ Report Details

The report should include the following:

a. Discussion of the reasons for development or modifications of floodplain models and the standards or assumptions made. The report should be a bound document including a cover letter signed by a licensed professional engineer.

b. Include a table defining the changes to LRFP and LRCZ limits containing the information provided in HEC-RAS with the standard table "Encroachment 1". HEC-RAS results should be submitted for the existing, or effective model, if available, the corrected effective model showing additional geometry information from the study reach, and the proposed model.

c. Tables of the watershed and basin parameters, i.e. time of concentrations, curve numbers for existing and fully developed conditions and watershed areas.

d. Photographs of representative reaches and all bridges or culverts in the hydraulic model.

e. A table of HEC-HMS elements that correspond to flow change locations in HEC-RAS including junction name, cross section name, and LRFP discharge.

f. Water surface profiles for all events modeled.

g. Typical cross sections showing water surface elevations and encroachment limits.

h. Hardcopies of existing HEC data files used to generate the updated models.

i. A hardcopy summary of HEC-HMS results (standard output table).

j. Digital versions of models prepared for the analysis.

10.5.4.2. Watershed Analysis Mapping

a. Mapping shall include soils, land use, zoning, streams, buildings, roads, existing and proposed LRFP/LRCZ boundaries, hydraulic cross sections and study reach limits, at a minimum. The standard scale for paper maps is 1" = 400' or less using 2-ft contours. **Contact LOJIC for digital or paper mapping.** Contact MSD for guidance and methodology for mapping the LRCZ from model results. Encroachment stations shown on final mapping shall be represented in the final model runs.

b. Digital copies of cross section or subbasin modifications are required. Submittals may be as ESRI shapefiles or *.DXF files referenced to LOJIC coordinate systems.

10.5.4.3. Transmittal Medium

All digital materials, including HEC models, ESRI shapefiles, DXF files, digital photographs, H-H modeling parameters, etc. should accompany submittals on a CD bound into the report.

MSD Louisville and Jefferson County Metropolitan Sewer District 700 W. Liberty Street Louisville, Kentucky 40203-1913 502-587-0603 – WWW.MSDLOUKY.ORG	EXHIBIT 10-1 HYDROLOGIC METHOD SELECTION FLOWCHART
	EFFECTIVE DATE: JUNE 30, 2009

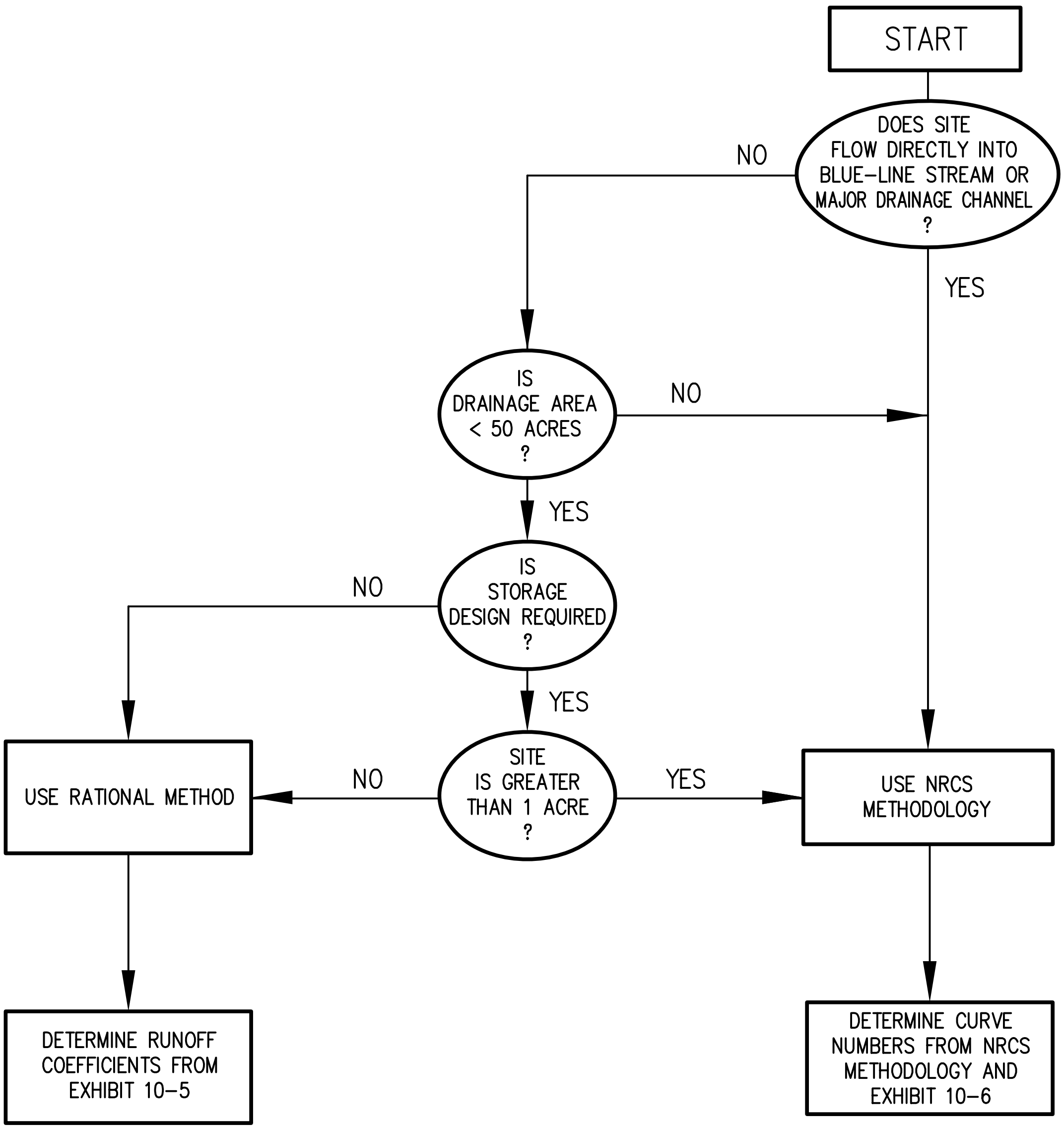


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EXHIBIT 10-2
RAINFALL INTENSITY-
DURATION CURVES

EFFECTIVE DATE: JUNE 30, 2009

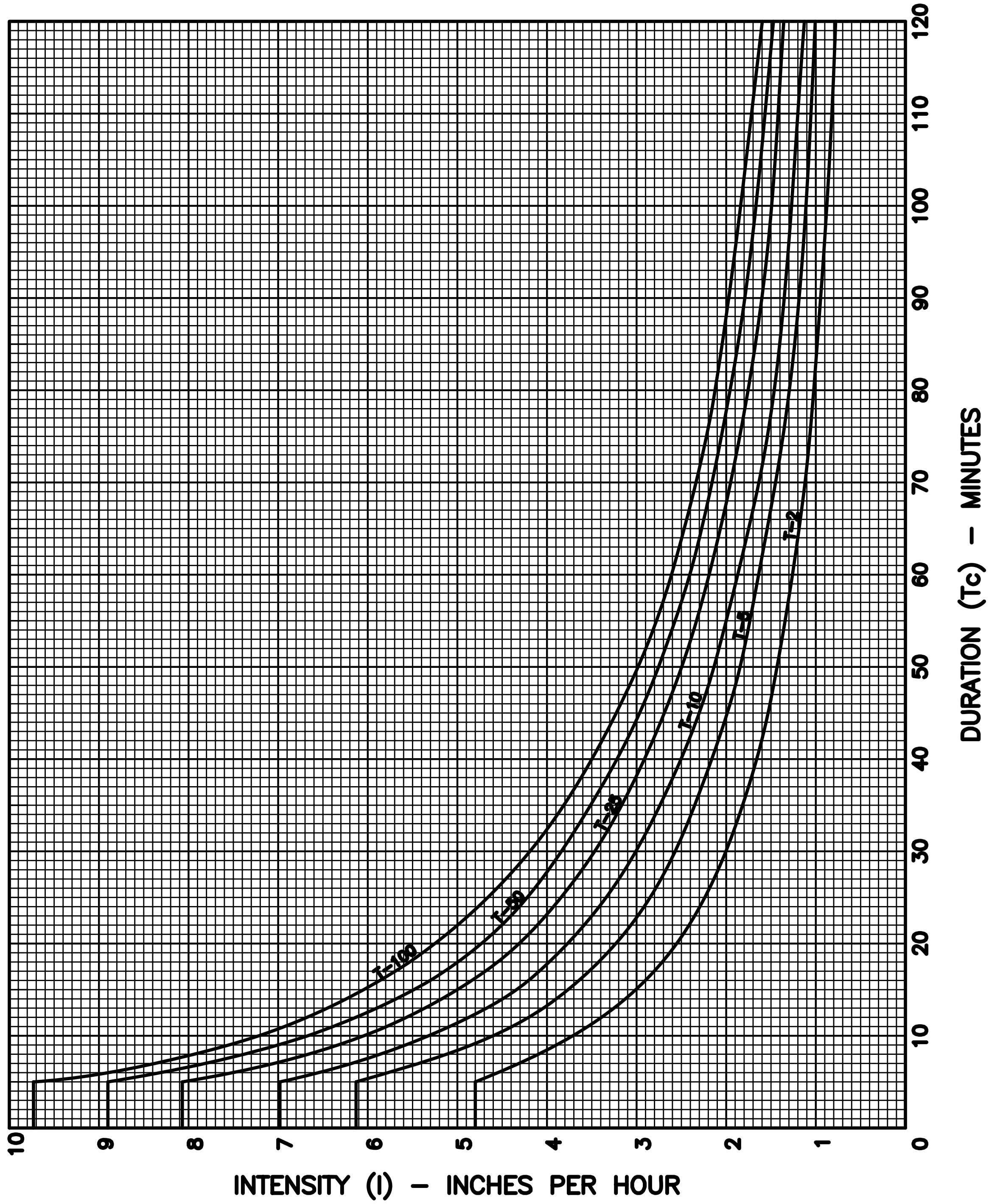

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EXHIBIT 10-3
RAINFALL FOR JEFFERSON
COUNTY * (INCHES)

EFFECTIVE DATE: JUNE 30, 2009

FREQUENCY (YEARS)

DURATION	1	2	5	10	25	50	100	PMP
30 min.	1.0	1.1	1.4	1.6	1.9	2.0	2.3	
1 hour	1.2	1.4	1.8	2.0	2.3	2.6	2.8	
2 hour	1.5	1.7	2.2	2.5	2.8	3.2	3.5	
3 hour	1.6	1.9	2.4	2.7	3.2	3.4	3.8	
6 hour	2.0	2.3	2.8	3.3	3.7	4.2	4.5	28.0
12 hour	2.4	2.8	3.4	3.9	4.4	4.9	5.4	33.0
24 hour	2.7	3.2	4.0	4.5	5.2	5.7	6.2 **	35.0
2 day	0.0	3.6	4.4	5.1	6.1	6.4	7.3	38.5
4 day		4.3	5.3	6.0	6.9	7.6	8.4	
7 day		5.0	6.1	6.8	8.0	8.8	9.6	

* SOURCE:
DIVISION OF WATER RESOURCES
DEPARTMENT FOR NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION
ENGINEERING MEMORANDUM NO. 2 (4–30–71), REVISED (6–1–79)

** NOTE:
RAINFALL RANGED FROM 7.5 TO 12.5 INCHES DURING THE FEBRUARY 28/ MARCH 1, 1997 EVENT.

Hydrologic Soil Group *(HSG)* is NRCS's way of summarizing soil's hydrologic effects. This classification, with land use, is one of the determinants of NRCS's Curve Number. NRCS has categorized every soil in the country into four groups, lettered A to D. Group A is the lease likely to create runoff; group D is the most likely.

The four groups are defined by NRCS soil scientists as follows:

- **Group A** soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/hr). This group also includes sand, loamy sand and sandy loam that have experienced urbanization but not been significantly compacted.
- **Group B** soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15 to 0.30 in/hr). This group also includes silt loam and loam that have experienced urbanization but not been significanly compacted.
- **Group C** soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05 to 0.15 in/hr). This group also includes sandy clay loam that has experienced urbanization but not been significantly compacted.
- **Group D** soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0 to 0.05 in/hr). This group also includes clay loam, silty clay loam, sandy clay, silty clay and clay that have experienced urbanization but not been significantly compacted.

Compound classification A/D indicates that the natural soil is in group D because of a high water table which impedes infiltration and transmission, but following artificial drainage using such methods as perforated pipe underdrains, the soil's classification is changed to A.

For a specific site, *HSG* designations can be obtained by refering to a local NRCS soil survey where one is available. If the survey does not specify *HSG*s, you can look up the soil names in the complete national listing given in NRCS's *Technical Release 55.* If there is no NRCS survey at all, you can make an on-site investigation of soil charateristics, and compare them with the above definitions.

Information about HSG on this page is from page A-1 of U.S. Soil Conservation Service, 1986, *Urban Hydrology for Small Watersheds,* Technical Release 55.

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RUNOFF COEFFICIENTS BASED ON LAND USE, SOIL GROUP AND SLOPE RANGE

LAND USE	%Imp	A 0–2	A 2–7	A 7+	B 0–2	B 2–7	B 7+	C 0–2	C 2–7	C 7+	D 0–2	D 2–7	D 7+
Residential													
RE, R–1, R–2	25	.31	.35	.39	.33	.38	.43	.37	.41	.48	.40	.44	.52
R–3, R–4, R–5	38	.42	.45	.49	.44	.48	.52	.47	.50	.56	.50	.53	.59
R–5A, R–6, R–7, CN, OR–1	65	.65	.67	.69	.66	.68	.71	.68	.70	.73	.69	.71	.75
R8A OR–2, OR–3, OFT	75	.73	.75	.77	.75	.76	.78	.76	.77	.79	.77	.78	.80
Commercial Business C–M, C–1 thru C–5	85	.82	.83	.84	.83	.84	.85	.84	.85	.86	.84	.85	.86
Industrial RT, M–1, M–2, M–3	72	.71	.73	.74	.72	.74	.76	.73	.75	.77	.75	.76	.79
Roofs, Driveways Streets, Etc.	100	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95	.95
Open Spaces, Lawns, Parks, Etc.	0	.09	.15	.21	.13	.19	.26	.18	.23	.32	.22	.27	.37
Woodlands,	0	.09	.15	.20	.13	.18	.23	.17	.22	.26	.20	.25	.30
Pasture, Grass, and Farmland	0	.15	.20	.25	.18	.23	.30	.22	.26	.35	.25	.30	.40
Newly Graded/Disturbed,		.65	.67	.69	.66	.68	.71	.68	.70	.73	.69	.71	.75

Unclassified Areas – These are areas where the Natural Resources Conservation Service has not identified any hydrologic soil groups

		0-2	2-7	7+
Residential	%Imp			
RE, R-1, R-2	25	.37	.41	.48
R-3, R-4, R-5	38	.47	.50	.56
R-5A, R-6, R-7, CN, OR-1	65	.68	.70	.73
R8A OR-2, OR-3, OFT	75	.76	.77	.79
Commercial Business C-M, C-1 thru C-5	85	.84	.85	.86
Industrial RT, M-1, M-2, M-3	72	.73	.75	.77

Notes:

1. Where the imperviousness is significantly different from the assumed values, a weighted coefficient should be computed using the actual percent impervious.
2. Consideration should be given to whether the soil group has been changed due to soil compaction by heavy equipment or mixing of the surfaces and subsurface soils

References:

1. Rossmiller, Ronald L., The Rational Formula Revisited, Proceedings International Symposium on Urban Storm Runoff, University of Kentucky, Lexington, Kentucky, July 28 – 31, 1980.

Runoff Curve Numbers for Urban Areas
(See Section 10.2.3.2)

Cover Description		Curve Numbers for Hydrologic Soil Group			
Cover Type and Hydrologic Condition	Average Percent Impervious Area	A	B	C	D
Fully Developed Urban Areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Poor Condition (grass cover < 50%)		68	79	86	89
Fair Condition (grass cover 50% to 75%)		49	69	79	84
Good Condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right–of–way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right of way)		98	98	98	98
Paved; open ditches (including right–of–way)		83	89	92	93
Gravel (including right–of–way)		76	85	89	91
Dirt (including right–of–way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (previous areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1 to 2 inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2–2c)					

Reference Table 2–2a. pg.2–5 of 210–VI–TR–55, Second Ed., June 1986

Runoff Curve Numbers for Cultivated Agricultural Lands

Cover Description			Curve Numbers for Hydrologic Soil Group			
Cover Type	Treatment	Hydrologic Condition	A	B	C	D
Fallow	Bare Soil	–	77	86	91	94
	Crop Residue Cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight Row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR and CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured and Terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T and CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR and CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C and CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T and CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

Table 2-2b. pg. 2-6 of 210-VI-TR-55, Second Ed., June 1986

Runoff Curve Numbers for Other Agricultural Lands

Cover Description		Curve Numbers for Hydrologic Soil Group			
Cover Type	Hydrologic Condition	A	B	C	D
Pasture, grassland, or range – continous forage for grazing.	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow – continous grass, protected from grazing and generally mowed for hay.	–	30	58	71	78
Brush – brush–weed–grass mixture with brush the major element.	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods – grass combination (orchard or tree farm).	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods.	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads – buildings, lanes, driveways, and surrounding lots.	–	59	74	82	86

Table 2-2c. pg. 2-7 of 210-VI-TR-55, Second Ed., June 1986

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Land Use Definition	Soil Group A	Soil Group B	Soil Group C	Soil Group D	Unclassified
High Density	89	92	94	95	93
Medium Density	77	85	90	92	87
Low Density	61	75	83	87	79
Open/Undisturbed	49	69	79	84	74

The Land Use Definitions are based upon the following conditions:

- High Density – 85% Impervious – Commercial
- Medium Density – 65% Impervious – 1/8 Acre lots
- Low Density – 38% Impervious – 1/4 Acre lots
- Open/Undisturbed – Grass cover on 50% to 75% of the area

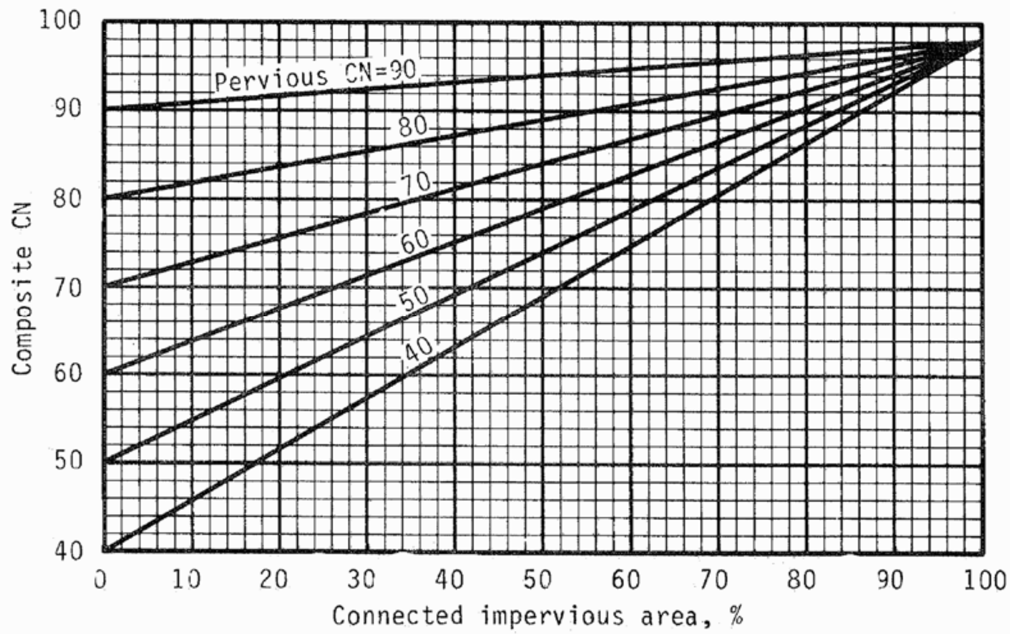


Figure 4-5 - NRCS Composite CN with connected impervious area

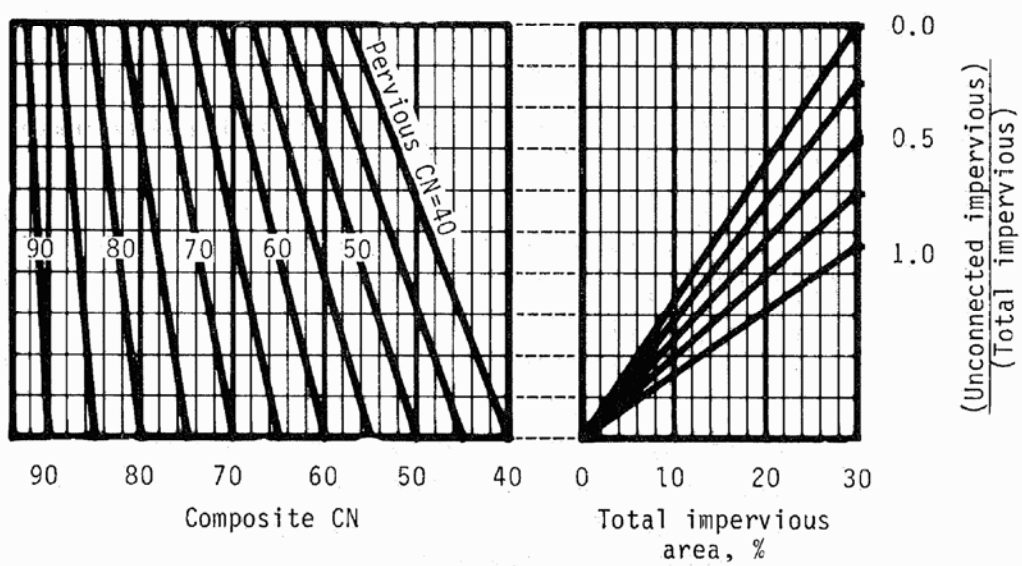


Figure 4-6 - NRCS Composite NC with connected impervious area and total impervious area less than 30%

EXHIBIT 10-7 PAGE 1
MANNING ROUGHNESS COEFFICIENTS, (n)

EFFECTIVE DATE: JUNE 30, 2009

	Manning's n Range
I. CLOSED CONDUITS: *	
A. Concrete pipe	0.012
B. Smooth wall PVC	0.011
C. Corrugated–metal pipe or pipe–arch:	
1. 2–2/3 by 1/2 in. corrugation (riveted pipe):	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved:	
(1) Flowing full under pressure . . .	0.021–0.018
(2) Flowing part full, depth 0.8D . .	0.021–0.016
2. 6 by 2 in. corrugation (field bolted) . . .	0.030
D. Vitrified clay pipe	0.012–0.014
E. Cast–iron pipe, uncoated	0.013
F. Steel Pipe	0.009–0.011
G. Brick	0.014–0.017
H. Monolithic Concrete:	
1. Wood forms, rough	0.015–0.017
2. Wood forms, smooth	0.012–0.014
3. Steel forms	0.012–0.013
I. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017–0.022
2. Natural floor	0.019–0.025
J. Laminated treated wood.	0.015–0.017
K. Vitrified clay liner plates	0.015
II. OPEN CHANNELS, NONVEGETATED LINING, (Straight Alignment): *	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013–0.017
2. Trowel finish	0.012–0.014
3. Float finish	0.013–0.015
4. Float finish, some gravel on bottom. . . .	0.015–0.017
5. Gunite, good section	0.016–0.019
6. Gunite, wavy section	0.018–0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015–0.017
2. Random stone in mortar	0.017–0.020
3. Cement rubble masonry	0.020–0.025
4. Cement rubble masonry, plastered	0.016–0.020
5. Dry rubble (riprap)	0.020–0.030

		Manning's n Range
II.	(CONTINUED)	
	C. Gravel bottom, sides as indicated:	
	1. Formed concrete	0.017–0.020
	2. Random stone in mortar	0.020–0.023
	3. Dry rubble (riprap)	0.023–0.033
	D. Brick	0.014–0.017
	E. Asphalt:	
	1. Smooth	0.013
	2. Rough	0.016
	F. Wood, planed, clean	0.011–0.013
	G. Concrete–lined excavated rock:	
	1. Good section	0.017–0.020
	2. Irregular section	0.022–0.027
III.	HIGHWAY CHANNELS AND SWALES WITH MAINTAINED VEGETATION (Values shown are for Velocities of 2 and 6 f.p.s.): *	
	A. Depth of flow up to 0.7 foot:	
	1. Bermudagrass, Kentucky bluegrass, buffalograss:	
	a. Mowed to 2 inches	0.070–0.045
	b. Length 4–6 inches	0.090–0.050
	2. Good stand, any grass:	
	a. Length about 12 inches	0.180–0.090
	b. Length about 24 inches	0.200–0.100
	3. Fair stand, any grass:	
	a. Length about 12 inches	0.140–0.080
	b. Length about 24 inches	0.250–0.130
	B. Depth of flow 0.7–1.5 feet:	
	1. Bermudagrass, Kentucky bluegrass, buffalograss:	
	a. Mowed to 2 inches	0.050–0.035
	b. Length 4–6 inches	0.060–0.040
	2. Good stand, any grass:	
	a. Length about 12 inches	0.120–0.070
	b. Length about 24 inches	0.200–0.100
	3. Fair stand, any grass:	
	a. Length about 12 inches	0.100–0.060
	b. Length about 24 inches	0.170–0.090

IV. STREET AND EXPRESSWAY GUTTERS: *

	Manning's n Range
A. Concrete gutter, troweled finish.	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture.	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of n by	0.002

V. OPEN CHANNELS, EXCAVATED OR DREDGED **

	Minimum	Normal	Maximum
A. Earth, straight and uniform	0.016	0.018	0.020
1. Clean, recently completed	0.018	0.022	0.025
2. Clean, after weathering	0.022	0.025	0.030
3. Gravel, uniform section, clean. .	0.022	0.027	0.033
B. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides .	0.025	0.030	0.035
5. Stony bottom and weedy sides .	0.025	0.035	0.045
6. Cobble bottom and clean sides .	0.030	0.040	0.050
C. Dragline–excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
D. Rock cuts			
1. Smooth and uniform.	0.025	0.035	0.040
2. Jagged and irregular.	0.035	0.040	0.050
E. Channels not maintained, weeds and brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides .	0.040	0.050	0.080
3. Same, highest stage of flow . .	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140

VI. NATURAL STREAM CHANNELS: **

	Minimum	Normal	Maximum
A. Minor streams (top width at flood stage < 100 ft)			
1. Streams on Plain			
a. Clean, straight, full stage, no rifts or deep pools. . .	0.025	0.030	0.033
b. Same as above, but more stones and weeds	0.030	0.035	0.040
c. Clean, winding, some pools and shoals	0.033	0.040	0.045
d. Same as above, but some weeds and stones	0.035	0.045	0.050
e. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
f. Same as 4, more stones .	0.045	0.050	0.060
g. Sluggish reaches, winding, deep pools	0.050	0.070	0.080
h. Very winding reaches, deep pools, floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
2. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stages			
a. Bottom: gravels, cobbles, few boulders	0.030	0.040	0.050
b. Bottom: cobbles with large boulders	0.040	0.050	0.070
B. Flood Plains			
1. Pasture, no brush			
a. Short grass	0.025	0.030	0.035
b. High grass	0.030	0.035	0.050
2. Cultivated area			
a. No crop	0.020	0.030	0.040
b. Mature row crops.	0.025	0.035	0.045
c. Mature field crops	0.030	0.040	0.050
3. Brush			
a. Scattered brush, heavy weeds	0.035	0.050	0.070
b. Light brush and trees in winter.	0.035	0.050	0.060
c. Light brush and trees in summer.	0.040	0.060	0.080
d. Med. to dense brush, in winter.	0.045	0.070	0.110
e. Medium to dense brush, in summer	0.070	0.100	0.160

VI. (CONTINUED)

4. Trees	Minimum	Normal	Maximum
A. Dense Willows, summer, straight	0.110	0.150	0.200
B. Cleared land w/ stumps, no sprouts	0.030	0.040	0.050
C. Same as b., with heavy growth of spouts	0.050	0.060	0.080
D. Heavy timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
E. Same as d., with flood stage reaching branches .	0.100	0.120	0.160

C. Major Streams (top width at flood stage > 100 ft). The n value is less than that for minor streams of similar description, because banks offer less effective resistance.

1. Regular section with no boulders or brush	0.025	*****	0.060
2. Irregular and rough section . . .	0.035	*****	0.100

* SOURCE:
KENTUCKY DEPARTMENT OF HIGHWAYS DESIGN MANUAL
EFFECTIVE DATE 3–77, EXHIBIT 2–507.1
MANNING ROUGHNESS COEFFICIENTS, n

** SOURCE:
KENTUCKY DEPARTMENT OF HIGHWAYS DESIGN MANUAL
EFFECTIVE DATE 01–01–93, EXHIBIT DR–05.901
MANNING ROUGHNESS COEFFICIENTS, n

TABLE OF CONTENTS

CHAPTER 11
PRIVATE DEVELOPMENT DRAINAGE
PLAN SUBMITTAL REQUIREMENTS

TABLE OF CONTENTS (cont.)

CHAPTER 11
PRIVATE DEVELOPMENT DRAINAGE
PLAN SUBMITTAL REQUIREMENTS

CHAPTER 11
PRIVATE DEVELOPMENT DRAINAGE
PLAN SUBMITTAL REQUIREMENTS

11.1 PURPOSE

This chapter delineates the purpose and legal responsibility through KRS Chapter 76 and the Louisville-Jefferson County Planning Commission Development Code whereby MSD reviews and approves private development plans. Drainage systems should be designed in accordance with the applicable provisions of this and other chapters of this Design Manual and the requirements of the Floodplain and Erosion Prevention and Sediment Control (EPSC) Ordinances. Plans and specifications submitted for review should meet or exceed the minimum construction plan standards as outlined in Section 11.4. Procedures and applicable forms may be retrieved from http://www.msdlouky.org/.

The review primarily examines the development for the following:

a. Potential impacts to upstream, downstream, and adjacent properties.

b. Adequacy of drainage system outlet.

c. Public or "defined" outlet for drainage.

d. Floodplain impact.

e. Erosion Prevention and Sediment Control

f. Adherence to any applicable composite drainage master plan criteria.

11.2 PLANS SUBJECT TO REVIEW AND APPROVAL

MSD has developed checklists to assist in the submittal process. The checklist forms, which are updated periodically, can be downloaded from the MSD web page. For each situation shown below, the applicable checklist is listed. In all cases, an initial “Plan Review Application” will be submitted.

11.2.1 Preliminary Plans for the Louisville-Jefferson County Planning Commission and Board of Zoning Adjustment

a. Request for change of zoning plans.

b. Conditional use permit plans.

c. General district development plans.

d. Detailed district development plans.

e. Preliminary subdivision plans (major subdivision).

f. Board of Zoning Adjustment plans.

g. Submit **Preliminary Plan Checklist**

11.2.2 Technical Review Committee

Reviews preliminary subdivision plans that require no zoning changes.

11.2.3 Minor Subdivision Plats

Subdivision plats dividing tracts of land into two (2) or more lots not designated by the Planning Commission as a major subdivision.

11.2.4 Site Construction Plans

a. Commercial Tracts

b. Industrial Tracts

c. Fills and/or excavations not related to building construction

d. Floodplain Encroachments

e. Stream Crossings

f. Roadway Projects

g. Submit **Site Plan Review Checklist**

11.2.5 Subdivision Construction Plans (Major Subdivision)

Subdivision construction plans shall be reviewed and approved in accordance with the Louisville and Jefferson County Development Code, Metropolitan Subdivision Regulations. Submit **Subdivision Review Checklist**.

11.2.6 Record Plats

Submit in accordance with Metropolitan Subdivision Regulations.

11.2.7 Single Family Construction Plans

a. Lots located in the 100-year F.E.M.A. or Local Regulatory floodplain.

b. Lots not in a recorded subdivision or lots with sensitive features.

c. Lots in a recorded subdivision with **construction** restrictions (i.e. minimum opening elevations, lowest finished floor elevations, **steep slopes and geotechnical evaluations,** etc.) on the recorded plat.

11.2.8 Industrial Waste/Hazardous Materials Spill Prevention and Control Plans

Submit an information checklist available by contacting MSD.

11.3 LEVELS OF REVIEW

11.3.1 Preliminary Plan Approval

Plans specifically prepared for the Planning Commission or the Board of Zoning Adjustment (BOZA) showing conceptual drainage conditions which identify and address potential impacts on public sewer and drainage facilities shall be submitted for MSD review. If significant or sensitive features exist on a site, see Chapter 12, a conceptual EPSC plan will also be required. Plans must receive MSD's stamp of approval in order to be placed on the Planning Commission Land Development and Transportation Committee or BOZA docket. The **Preliminary Plan Checklist** must be submitted before MSD will review the plans.

11.3.2 Construction Plan Approval

Plans for which building or construction permits are being sought must be reviewed and approved by MSD prior to obtaining these permits. Either the MSD **Subdivision Review Checklist** or the **Site Plan Review Checklist** must be submitted**, as well as Detention Checklist and EPSC Checklist**.

11.4 MINIMUM CONSTRUCTION PLAN SUBMITTAL STANDARDS

11.4.1 Major Subdivision Plans

All correspondence and plan submittals should reference the Water

Management Number as assigned by MSD’s **Development Plan Review Team**.

Major Subdivision Plans for the development of more than four (4) lots require dedication of roadways for access.

All plans must be submitted on 24 x 36 inch sheets.

Submit “Extension of Stormwater Boundary Agreement” **with Corporate Resolution and plat showing development boundaries (**if applicable).

11.4.1.1 Cover Sheet

a. Location Map with the site outlined.

b. Title Block: Title of Subdivision, name and address of developer, name address and email address of Engineer, date of preparation, revision dates.

c. Index of Sheets and Legend

d. Engineer's and Land Surveyor's seals, signatures, and dates

e. Water Management Number: As assigned by MSD’s **Development Plan Review Team**

f. Utility Notes

11.4.1.2 Composite Drainage Plan

a. Topography: Minimum Scale 1" = 100' with existing contours at 2-foot intervals, **NAVD 88** datum. Contours to extend a minimum of 50 feet beyond property lines.

b. Proposed Development: Street rights-of-way, street names, street centerline stationing, lot lines, lot numbers, property boundary, existing drainage structures, proposed drainage structures (labeled by number or other designation) and easements with widths shown.

c. Hydrologic Designate drainage areas

Data: (in acres) to individual inlets, and off-site drainage areas (acres), which generate through drainage.

d. Pipe Chart: Pipe number, drainage area, coefficient of runoff (c), time of concentration, intensity, discharge (Q), size, length, slope, capacity, velocity, and headwater depth for both the 10-year and 100-year Qs.

e. 100-year FEMA and Local Regulatory floodplain and conveyance zone, if applicable, with flood elevations noted.

g. Identification of outlet system.

11.4.1.3 Grading and Erosion Prevention and Sediment Control Plan

a. Existing and Proposed Contours

b. Erosion Prevention and Sediment Measures (Reference Chapter 12 and **EPSC Checklist**).

c. Proposed Development: Street rights-of-way, street names, street centerline stationing, lot lines, lot numbers, property boundary, existing drainage structures, proposed drainage structures (labeled by number or other designation) and easements.

d. Grading Plan may be combined with Composite Drainage Plan provided the plan remains legible.

e. Areas of slope greater than or equal to 20% shall be identified.

f. Stream Buffers if applicable.

g. **Limits of disturbance and number of acres disturbed.**

11.4.1.4 Plan and Profile (Road) Sheets

Plan View

a. Catch Basins: Line and station number (structure number), grate type and elevation, and invert elevation.

b.	Pipes:	Length, size, type, slope, pipe number or designation.
c.	Headwalls:	Type, invert elevation.
d.	Ditches and Swales:	Number or designation, type, stations
e.	Easements:	Type, size, existing with deed book and page numbers, proposed.
f.	Utilities:	Existing and proposed (including sanitary sewers).

g. Other drainage structures to be labeled accordingly.

Profile View

a. Storm lines and structures to be shown on road profiles.

b. Utility and sanitary sewer crossings.

11.4.1.5 Storm Drainage Profiles (pipes, ditches, box culverts)

a.	Catch Basins:	Station or number, type, grate type and elevation, invert elevation, and headwater elevation (10 and 100 year).
b.	Pipes:	Length, size, type, class, grade, line number if applicable, HGL (10 and 100 year).

c. Ditches:

- Type
- Grade
- Flow line elevation at grade changes (P.V.I)
- Design Depth
- Mannings "n"
- Slope
- 10 and 100 year discharge depths
- **Channel Shear Stress**

d. Headwalls: Type and invert elevation.

e. Existing and proposed ground surfaces.

11.4.1.6 Standard Detail Sheet

Reference sections 4.4.1 and 4.4.6 for the incorporation of MSD Standard Drawings and Special Details unique to the project. If pre-cast structures are used from sources not on the current MSD Pre-approved source list, then shop drawings of the structures must be approved by MSD prior to construction.

11.4.1.7 Additional Submittal Items

a. **Specifications – All storm drainage construction is expected to conform to MSD Standard Specifications. Any deviations from the specifications must be noted on the plans and be approved by MSD.**

b. **Quantities** - Detailed breakdown of all items, related to storm drainage construction needed by MSD to determine the amount of the subdivision bond.

c. **Approved Preliminary Plan -** including sanitary sewer layout.

d. **Clearing and Grading Plan** - required if site clearing and grading is to precede approval.

e. **Detention Basin Calculations** - if applicable and in accordance with the provisions of Chapters 10 and 12.

f. **Highway Encroachment Permit** - (if applicable).
All construction plans for major subdivisions shall conform to Article 6 of the Louisville and Jefferson County Planning Commission Subdivision Regulations.

g. **Section 404 Permit -** (if applicable) from the U.S. Army Corps of Engineers.

h. **Application for Water Quality Certification** - (if applicable) from the Commonwealth of Kentucky, Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water - Water Quality Branch.

i. **Application for Permit to Construct Across or Along a Stream** - (if applicable) from the Commonwealth of Kentucky, Natural Resources and Environmental Protection Cabinet, Department for Environmental Protection, Division of Water - Floodplain Management Section - Water Resources Branch.

j. Copy of Demolition Permit or General Permit (if applicable).

k. Copy of Approval Letter for private WWTP (if applicable).

i Request for sanitary sewer capacity.

11.4.1.8 Submittal

Two sets of construction plans and specifications are to be submitted for initial review by MSD. Variations from the Minimum Construction Plan Submittal Standards will require prior approval from MSD. Any conditions of the Approved Preliminary Plan (such as geotechnical report, state approvals, etc.) must be addressed at the time of construction plan submittal to MSD.

11.4.2 All Other Development Plans (Site, etc.)

Submit "Extension of Stormwater Boundary Agreement" with Corporate Resolution and plat showing development boundaries (if applicable).

11.4.2.1 Existing Topography Plan

This plan shall conform to Development Code Section 8.1.B.4 requirements with the following additional data:

a. Spot elevations at critical points.

b. 100-year FEMA **Floodway** and Local Regulatory floodplain and conveyance zone, if applicable, with flood elevations noted.

c. Off-site drainage area in acres, which generate through drainage.

11.4.2.2 Proposed Development and Grading Plan

This plan may be combined with the plan described in paragraph 11.4.2.1 if existing features can still be discerned. This plan shall also conform to the requirements of Section 8.1.B.4 of the Development Code with the following additional data:

a. Revised hydrologic data, runoff calculations, and detention basin design, if applicable.

b. Hydraulic data, such as pipe charts and ditch data on profiles, showing quantity of flow, velocities, and degree of protection.

c. Erosion prevention and sediment control measures and details.

d. Show public outlet and evaluate capacity of downstream facilities.

e. Proposed easements for through drainage, detention facilities, and/or offsite increase in runoff.

f. Note specific conflicts with other utilities.

g. Written explanation of any proposed deviation from Planning & Design or MSD policies, standards, or design criteria and any supplemental data that would aid the understanding of the proposed plan work.

h. The stamp of a professional engineer licensed in Kentucky shall be affixed to the plan when the proposed facilities affect public drainage, downstream properties**, Regulatory Floodplain or detention**.

11.5 INSPECTION OF MAJOR SUBDIVISION CONSTRUCTION

11.5.1 General

MSD has a program of on-site inspection for the construction of **public** drainage systems in public rights-of-way or public easements. Drainage construction may begin following MSD approval of the construction plans and issuance of a **Site Disturbance Permit.**

11.5.2 Inspector Assignment

Construction of drainage structures and pipes shall not begin in a development until a MSD inspector has been assigned to the construction site. In certain situations, which will be identified during construction plan review, full-time inspection may be required. In the event that MSD personnel are not available to provide the level of inspection necessitated by a contractor's schedule, the owner may retain (at the owner's expense) an independent inspector working under the direct supervision of a professional engineer approved by MSD. The independent inspector will be required to certify to MSD that the materials and methods of construction are in compliance with the approved plans and specifications. Arrangements for owner-provided inspection including schedule and level of effort must be approved by MSD in advance. MSD inspector shall be present during testing.

MSD requires three (3) working days advance notice to schedule an inspector for a project. To schedule an inspector, please fax the "Notice of Construction Form" to MSD.

11.5.3 Construction Plan Revisions

MSD will require the final approved construction plans bearing the Engineer's original seal, signature, and date prior to beginning storm drainage construction. Deviations from approved construction plans as a result of unexpected field conditions will require documentation and approval by MSD. To obtain this approval, the developer's engineer should submit a marked print of the plans showing the proposed revisions to MSD for review.

11.5.4 Subdivision Bond

In accordance with the Metropolitan Subdivision Regulations, MSD sets the drainage portion of the subdivision bond at 100% of the estimated construction cost consistent with past practice. When projects constructed under MSD drainage inspection are completed, they may have the drainage bond reduced to 20% of the estimated construction cost. When a subdivision is finished and at least 80% of the lots have been developed, the subdivision bond may be released following satisfactory inspections by the Board of Health, the local Fire Department, MSD and the Public Works Department.

11.5.5 Construction Initiation

Recognizing the developer's need to initiate construction in a timely fashion, MSD will allow certain construction activities to proceed prior to the approval of the entire set of construction plans. General clearing and site grading, <u>not</u> involving construction of drainage structures, roadway grading, nor significantly affecting existing drainage in the area, may be performed following approval of a Grading and EPSC Plan by MSD, Jefferson County Department of Public Works and the Planning Commission and the issuance of the necessary work order. A Grading Plan, prepared by a licensed engineer, must be submitted if site clearing and grading is to proceed prior to construction plan approval. The three working days notice of construction form must also be submitted before clearing and grading can begin. Erosion prevention and sediment control measures in accordance with Chapter 12 of this design manual must be clearly described on the plan and must be installed prior to initiating any construction at the project site. Application for approval of a Clearing and Grading Plan may be made at the time of construction plan submittal to MSD. A notice of violation and stop-work order may be issued for failure to implement proper EPSC measures.

11.6 FEES

11.6.1 Plan Review Fees

Only applicable to development outside MSD stormwater service area including the Cities of Anchorage, Jeffersontown, Prospect, Shively, and St. Matthews. These fees must be paid prior to MSD's approval of the plans. Additionally, fees may be required for sites with extensive review of hydrologic and hydraulic modeling.

11.6.2 Stormwater Fees

11.6.2.1 Regional Facility Fee

This is a stormwater impact fee, paid by the developer on sites where MSD has determined on-site detention will not be required. This fee allows the developer to pay a proportionate share of MSD's cost of constructing Regional Stormwater Detention Facilities. For development outside MSD's drainage service area, a twenty percent (20%) surcharge will be added to the regional facility fee.

11.6.3 Compensation Fees

Fees are applicable to sites in floodprone watersheds where runoff volume compensation is required.

TABLE OF CONTENTS
CHAPTER 12
EROSION PREVENTION AND SEDIMENT CONTROL

TABLE OF CONTENTS (cont.)

CHAPTER 12
EROSION PREVENTION AND SEDIMENT CONTROL

TABLE OF CONTENTS (cont.)

CHAPTER 12
EROSION PREVENTION AND SEDIMENT CONTROL

CHAPTER 12

EROSION PREVENTION AND SEDIMENT CONTROL
SUPPLEMENTAL SECTION D
EXHIBITS

CHAPTER 12
EROSION PREVENTION AND SEDIMENT CONTROL

12.1 PURPOSE OF THIS CHAPTER

This chapter of the MSD Design Manual provides the user with the tools to meet the requirements of the Jefferson County Erosion Prevention and Sediment Control (EPSC) Ordinance. Some of the information contained in this chapter, such as the application forms, and checklists are available in digital format and can be downloaded from www.msdlouky.org. Sensitive Features information can be obtained by consulting the LOJIC Standard Information Map at www.lojic.org.

This chapter also establishes requirements to be used when preparing plans for minimizing soil erosion and sedimentation during and after construction of any land development, improvement or retrofit project. Guidelines on how to select and design EPSC Best Management Practices (BMPs) for specific construction activities have been developed in accordance with several references from across the country. **Sections 12.5, 12.6, and 12.7 are organized as collections of BMP sheets. Each sheet describes a particular BMP, appropriate applications, design and implementation measures, and maintenance requirements.**

12.2 OVERVIEW OF EPSC ORDINANCE AND REQUIREMENTS

The EPSC Ordinance requires that an EPSC plan be developed and be approved by MSD. A Site Disturbance Permit should also be obtained from MSD prior to initiating construction on land disturbing activities that are in excess of 2,000 square feet and are situated closer than 50 feet to a Sensitive Feature, or require a building permit as directed by a General Permit.

The Ordinance also establishes standards for the design of EPSC plans to minimize the adverse impact and offsite degradation that may result from construction site runoff.

There are two types of EPSC plans that may be required as part of an application for approval of a land disturbing activity: Concept EPSC plans and Detailed EPSC plans.

- Concept EPSC plans are required only for those land disturbing activities subject to a Type I review and containing sensitive features as identified by the permittee after a site visit. The concept EPSC plan shall contain the information required by the MSD Preliminary Plan Checklist, including a narrative description of how the delineated Sensitive Features will be protected when conducting the proposed land-disturbing activity. Submit the Checklist with the conceptual EPSC plans for review and approval.

- Detailed EPSC plans are required at the construction plan stage for all land disturbing activities subject to both Type I and Type II review. The detailed EPSC plan shall contain the information required by the MSD **EPSC Detailed Construction Plan**

Checklist, and if Sensitive Features are identified, a narrative description of how the delineated Sensitive Features will be protected when conducting the proposed land-disturbing activity must be included on the plans. Submit the MSD **EPSC Detailed Construction Plan Checklist** with the detailed EPSC plans for review and approval.

12.3 SENSITIVE FEATURE IDENTIFICATION

Sensitive Features include land containing any one the following features:

- Local Regulatory Floodplain and Conveyance Zone as defined by local ordinance (Reference Section 10.4 for more details).
- Stream corridors (including blue line and intermittent) as mapped by United States Geological Survey.
- Karst features with a well-defined surface opening (such as a cave, sinkhole, vadose shaft, or other karst anomaly).
- Lakes and impoundments.
- Jurisdictional wetlands as determined by the US Army Corps of Engineers.
- Slopes greater than 20%.
- "Erodible" and "severely erodible" soils as determined by the Natural Resources Conservation Service.
- Sites with the potential to drain stormwater directly into a sensitive feature listed above (including any designated buffer area for that feature) or into a designated greenway.

12.4 EPSC PLAN DEVELOPMENT STANDARDS

EPSC plans shall be developed to achieve an 80% design removal efficiency goal. When a site is completely denuded of vegetation, the structural and nonstructural EPSC measures are designed to trap 80% of the total suspended solids (TSS) that are generated by the site. The design storm event associated with this level of control is the ***10-year 24-hour SCS Type II storm event***. SCS procedures should be used to determine runoff amounts. It is important to note that when a BMP is designed for this event, it will have a greater trapping efficiency for more frequent events (i.e., 2-year storm).

Each EPSC Plan must delineate the following elements:

- All Sensitive Features
- Potential sources of sediment that may potentially leave the site
- The location and depth of all structural and non-structural BMPs necessary to achieve the 80% design removal efficiency goal and protect the Sensitive Features
- Installation and maintenance of required BMPs
- The sequencing of construction activities to be utilized on the project

The following non-structural site management practices shall be utilized on the plans when feasible:

- Minimize site disturbance to preserve and maintain existing vegetative cover;
- Limit the number of temporary access points to the site for land disturbing activities;
- Phase and sequence construction activities;
- Locate temporary and permanent soil disposal areas, haul roads, and construction staging areas to minimize erosion, sediment transport, and disturbance to existing vegetation.

Detailed EPSC plans shall comply with the following standards and review criteria:

- Sediment Tracking Control. Stabilized construction entrances shall be located and utilized at all points of ingress/egress on a construction site. The transfer of soil, mud and dust onto public rights-of-ways shall be prevented.
- Construction Dewatering Operations. Whenever construction dewatering operations are required on a site, they shall be conducted according to the specifications set forth in this Manual, the Standard Specifications and Drawings.
- Crossings of waterways during construction shall be minimized and approved by MSD. Encroachment into stream buffers, riparian areas, and wetlands shall be avoided.
- Topsoil shall be stockpiled and preserved from erosion or dispersal both during and after site grading operations.
- Temporary Stabilization Measures. Where construction or land disturbance activity will or has temporarily ceased on any portion of a site, temporary site stabilization measures shall be required as soon as practicable, but no later than 14 calendar days after the activity has ceased.
- Final Stabilization. Final Stabilization of the site shall be required within 14 calendar days of construction completion.
- Temporary Structural Controls installed during construction shall be designed to accomplish maximum stabilization and control of erosion and sedimentation, and shall be installed, maintained, and removed according to the specifications set forth in the MSD Design Manual, Standard Specifications and Standard Drawings. All temporary structural controls shall function as designed when controlling the peak runoff resulting from the storm event identified in the MSD Design Manual, Standard Specifications and Standard Drawings.
- All Permanent Structural Controls, including drainage facilities such as channels, storm sewer inlets, and detention basins, shall be designed according to the standards set forth in the this Manual, the Standard Specifications and Drawings.

To encourage the development and testing of alternative EPSC BMPs, alternative management practices that are not included in the MSD Design Manual, Standard Specifications and Standard Drawings may be allowed upon review and approval. To use an alternative BMP, submit substantial evidence that the proposed measure will perform at least equivalent to a currently approved control contained in the MSD Design Manual, Standard Specifications and Standard Drawings. Evidence may include, but is not limited to, peer-review by a panel of licensed professional engineers and research results as reported in professional journals or other literature.

If MSD finds the alternative BMP has failed or is inadequate to contain sediment onsite, the alternative BMP shall be removed and replaced with a BMP approved by MSD and found in the MSD Design Manual, Standard Specifications and Standard Drawings.

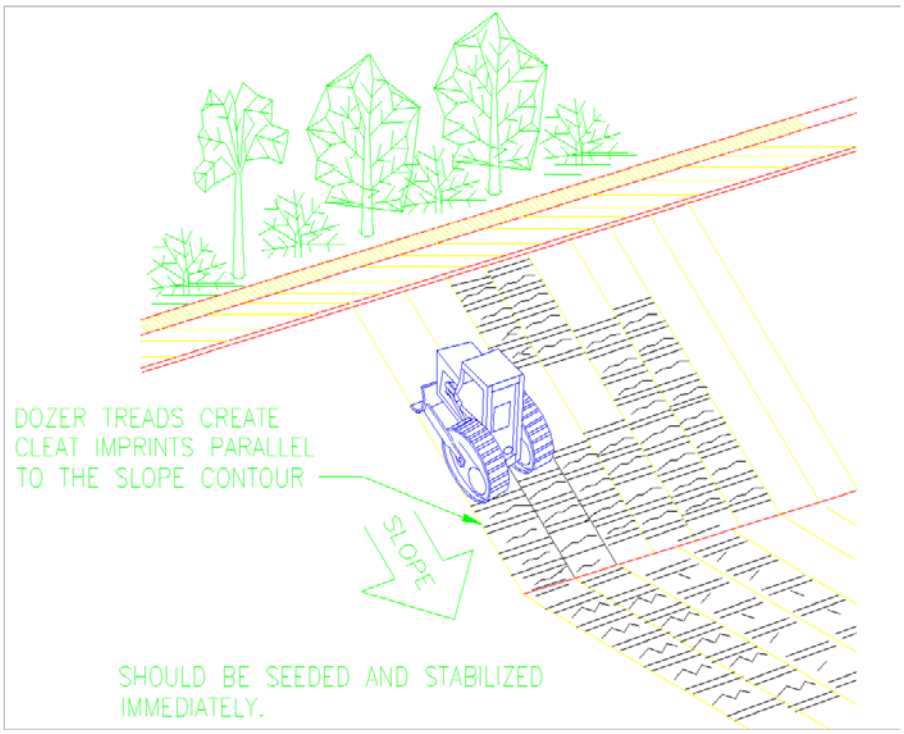
12.5 EROSION PREVENTION MEASURES

Erosion prevention measures shall be used during and after construction site preparation in order to safely convey clean water to storm drains or adequate watercourses. One or more measures should be utilized as appropriate during the project's construction phase. Such measures may include but are not limited to: phasing and construction sequencing, surface roughening, temporary seeding, mulching, matting, and geotextile blankets. Each of these measures is discussed in the sections to follow.

In addition to site-specific erosion control measures, the grading plan should include the following general measures as a minimum:

- The finished cut and fill slopes to be vegetated should not be steeper 3H:1V.
- Cuts or fills should not be so close to property lines as to endanger adjoining property without adequately protecting such properties against erosion, sedimentation, slippage, settlement, subsidence, or other damages.
- Subsurface drainage should be provided in areas having a high water table to intercept seepage that would affect slope stability, bearing strength or create undesirable wetness.
- No fill shall be placed where it can slide or wash onto another property.
- Fill shall not be placed adjacent to channel banks where it can create bank failure, reduce the capacity of the stream, or result in downstream sediment deposition.
- All borrow and disposal areas should be included as part of the grading plan.
- Adequate channels and floodways should be provided to safely convey increased runoff from the developed area to an adequate outlet without causing significant channel aggradation, degradation, or increased off-site flooding.
- The site should be graded to direct flows to appropriate controls.

12.5.1 Surface Roughening EPM-1: SR



Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913

MSD

502-587-0603 – WWW.MSDLOUKY.ORG

SR

Slope Protection	Waterway Protection	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties

DESCRIPTION

Surface roughening is the creation of horizontal grooves, depressions, or steps that run parallel to the contour of the land. **The purpose is to aid in the establishment of vegetation cover from seed, reduce runoff velocity, increase infiltration, reduce erosion, and provide sediment trapping.**

The following surface roughening measures are approved for use: tracking (driving a crawler tractor up and down a slope, leaving the cleat imprints parallel to the slope contour) as shown in Standard Drawing EC-04-**01**; stair-step grading as shown in Standard Drawing EC-05-**01**; and slope grooving (using disks, spring harrows, or teeth on the bucket of a front-end loader) as shown in Standard Drawing EC-06-**01**.

APPLICATION

- **Construction slopes where seeding, planting, and mulching to stabilize soils.**
- **Graded areas with smooth, hard surfaces, and the potential for erosion.**

APPROACH

Cut slopes with a gradient steeper than 3H:1V but less than 2H:1V should be stair-step graded or groove cut. Stair-step grading works well with soils containing large amounts of small rock. Stairs should be wide enough to work with standard earth moving equipment. Grooving can be done by any implement that can be safely operated on the slope, including those described above. Grooves should not be less than 3 inches deep or more than 15 inches apart.

Fill slopes with a gradient steeper than 3H:1V but less than 2H:1V should be compacted every 9 inches of depth. The face of the slope should consist of loose, uncompacted fill 4 to 6 inches deep that can be left rough or can be grooved as described above, if necessary.

12.5.1 Surface Roughening EPM-1: SR

Any cut or filled slope that will be maintained should have a gradient less than 3H:1V and in no case greater than 2H:1V. Such a slope can be roughened with shallow grooves parallel to the slope contour by using normal tilling. Grooves should be close together (less than 10 inches) and not less than 1 inch deep.

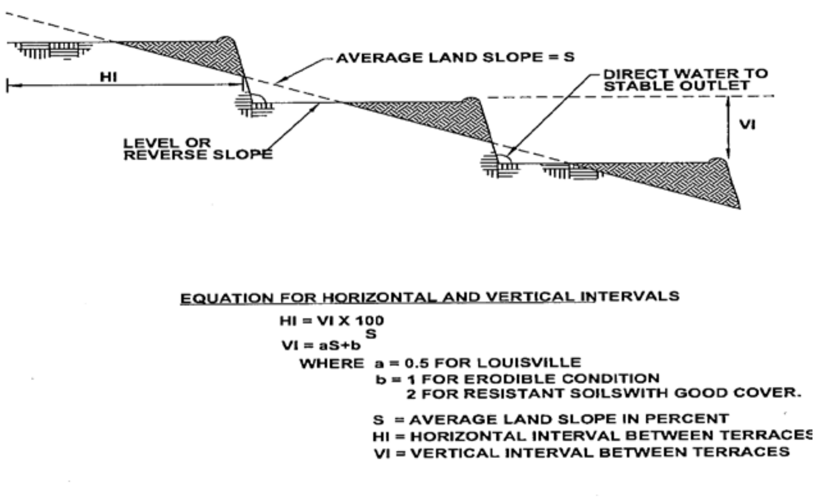
Immediately seed and mulch roughened areas to obtain optimum seed germination and growth. Use erosion control blankets or turf reinforcement mats on long (>50 feet) steep (>2H:1V) slopes as necessary, or hydroseed.

MAINTENANCE

- **Inspect roughened surfaces every seven days and within 24 hours after each rain event that produces 0.5 inches or more of precipitation for rills and washes. Fill these areas slightly above the original grade, then reseed and mulch or cover with blanket or mat as soon as possible.**

LIMITATIONS

- **Surface roughening may not be appropriate for certain soil types including sandy, steep, or shallow soils.**
- **Surface roughening, seeding, and mulching may need to be repeated after significant rain events.**
- **Excessive surface roughening may be undesirable when area is to be mowed.**



BENCH TERRACES

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Slope Protection	Waterway Protection	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties

DESCRIPTION

Bench terraces are permanent earth embankments or ridges constructed along the face of a slope at regular intervals creating a stair-step effect. Bench terraces reduce slope lengths and direct surface **runoff** to stable outlets. **The stair-stepping effect will help vegetation establish and also trap eroding soil from the above slope.** The proper orientation of a bench terrace is shown in Exhibit 12-1 in Supplemental Section D.

APPLICATION

- **Construction slopes steeper than 3:1.**
- **Graded areas where the length of slopes needs to be reduced by terracing.**

APPROACH

Bench terraces are designed for highly erodible, steep slopes ranging from 3:1 to 1.5:1, and should not be constructed on slopes with sandy or rocky soils. They are effective only where there are suitable runoff outlets such as grassed waterways, or piped outlets.

The design of a bench terrace system involves proper spacing and location. Terrace spacing is expressed as the vertical distance between the channels of successive terraces. For each terrace, the spacing is the vertical distance from the top of the hill to the bottom of the channel, commonly known as the vertical interval or VI. Although the horizontal spacing is useful in determining row arrangement, the VI is more convenient for terrace layout and construction.

Terrace spacing is expressed by the empirical formula:

$$VI = aS + b$$

Where:

VI = vertical interval between consecutive terraces in ft.,
a = constant for geographical location (**0.5 for Louisville**),
b = constant for soil erodibility (**1 for erodible conditions, 2 for resistant soils with good ground cover**), and
S = average land slope in **percent**

The horizontal interval HI or bench width can be calculated by the formula:

$$HI = VI \times 100/S$$

Where:

HI = horizontal interval of each terrace in ft.,
VI = vertical interval between consecutive terraces in ft., and
S = average land slope in **percent**.

MAINTENANCE

- Periodically inspect seeded areas, particularly after rain events, for rills and washes.
- Remove debris from outlets and excessive silt from terraces.
- Inspect benches for **destabilizing gully** formation. Gullies may require rock placement to stabilize the area.
- Reseed and mulch as necessary.

LIMITATIONS

- Bench terracing is not applicable for sandy or rocky soils.
- Must only be used when adequate drainage channels and runoff diversions are provided.

12.5.3 TEMPORARY SEEDING EPM-3: TS

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TS

Slope Protection	Waterway Protection	**Surface Protection**	Enclosed Drainage	**Large Flat Areas**	**Borrow Areas**	**Adjacent Properties**

DESCRIPTION

The purpose of temporary seeding is to reduce erosion and sedimentation by stabilizing disturbed areas that would otherwise lay bare for long periods of time **(>14 days)** before they are worked or stabilized. Temporary seeding is also used where permanent vegetation growth is not necessary or appropriate.

APPLICATION

- **Apply to areas left in rough grade condition that will not be disturbed for 14 days or more.**

APPROACH

Any disturbed areas that will not be worked for 14 days or more <u>must</u> have temporary cover applied by the 14th day. Seeded areas should be covered with mulch to provide protection from the weather. If the vegetation does not grow quickly or thick enough to prevent erosion, the area should be re-seeded as soon as possible. Seeded areas should be kept adequately moist. Irrigate the seeded area if normal rainfall is not adequate for the germination and growth of seedlings. Water seeded areas at controlled rates that are less than the rate at which the soil can absorb water to prevent runoff. Runoff of irrigation water, waste water, and fuel can cause **or worsen** erosion. Seed selection should be based on the requirements of the MSD Standard Specifications **and applied at recommended rates.**

MAINTENANCE

- **Inspect frequently for the first six weeks following planting to assure seed is adequately moist and to determine if vegetation is uniform and dense.**
- **Damaged areas should be repaired, fertilized, seeded, and mulched where appropriate.**

LIMITATIONS	• **Some types of grasses (e.g. annual rye) may outcompete desirable permanent vegetation.** • **Uneven application may cause patchy growth and erosion. Overapplication of fertilizer or lime causes stormwater runoff pollution.** • **Areas to be seeded may require compaction, disking, or other activity to prepare the seedbed.**

12.5.4 MULCHING — EPM-4: M

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Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	**Large Flat Areas**	**Borrow Areas**	Adjacent Properties

DESCRIPTION

Mulching is a temporary soil stabilization erosion control method where materials such as grass, **straw, cellulose,** wood chips, wood fibers, **or other suitable materials** are placed on the soil surface. In addition to stabilizing soils, mulching can enhance the absorption of water by the soil, reduce evaporation losses, regulate soil temperatures and reduce the speed of **stormwater** runoff over an area. **Mulching is used in conjunction with seeding and hydroseeding of critical areas for the establishment of temporary or permanent vegetation.**

APPLICATION

- **Temporary stabilization of freshly seeded and planted areas, or during periods unsuitable for growing permanent vegetation.**
- **Short-term ground cover on steep slopes to reduce rainfall impact, decrease the velocity of sheet flow, and trap sediment.**

APPROACH	Erosion control mulching may be used on level areas, slopes up to 50%, and in waterways with caution. Where soil is highly erodible, nets should only be used in connection with organic mulch, such as straw and wood fiber. Mulch is an effective **temporary** ground cover when the establishment of vegetation is improbable due to severe weather conditions (winter conditions), poor soil, or steep slopes. **If using mulch for temporary ground covers without seeding, the mulch should be applied to an appropriate depth for the material used and should have greater than 95% coverage of the soil surface. On steep slopes (>2.5H:1V), or where the mulch is susceptible to movement by wind or water, the mulch should be hydraulically applied or the mulch should be anchored appropriately (e.g. covered by degradable netting).**
MAINTENANCE	• **Avoid traveling on mulched and seeded areas.** • **Periodically inspect mulched and seeded areas, particularly after rainfall events, for damage or deterioration. Replace as necessary.** • **Continue inspections until vegetation is established.**
LIMITATIONS	• **Organic mulches tend to lower the soil surface temperature, and may delay germination of some seeds.** • **Organic mulches may also affect the pH of the soil.** • **Mulching of waterways may cause flow impediments at water inlets and is not appropriate for areas that receive high stream flows.**

12.5.5 EROSION CONTROL BLANKETS AND TURF REINFORCEMENT MATS

EPM-5: ECB/TRM

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ECB

TRM

Slope Protection	**Waterway Protection**	**Surface Protection**	Enclosed Drainage	Large Flat Areas	**Borrow Areas**	Adjacent Properties

DESCRIPTION

A variety of Rolled Erosion Control Products (RECPs) are available for the stabilization of seeded slopes and channel banks. MSD distinguishes between the different types of products using two categories: Erosion Control Blankets (ECBs) and Turf Reinforcement Mats (TRMs).

ECBs and TRMs are preferred alternatives to traditional hard channel protection such as concrete, riprap, gabions and revetment mattresses. These products improve the quality of stormwater discharges by creating a stronger, vegetated **armament** that filters the flow, allows infiltration, and **protects and encourages the establishment of** wildlife habitat. **This BMP prevents soil erosion, promotes seed germination, protects young vegetation and prevents seed or mulch from washing away.** The proper orientation of netting and matting is shown in Standard Drawing EC-07-**01**.

ECBs are used for the temporary stabilization of soil immediately following seeding until the vegetative cover has grown and become well established. They provide temporary protection because they degrade over time as the vegetation becomes established. Some products are effective for a few months while others degrade slowly and are effective for a few years.

TRMs are nondegradable products that enhance the ability of living plants to stabilize soils. They bind with roots to reinforce the soil matrix. TRMs are used in situations where vegetation alone will not hold a slope or stream bank. TRMs **provide potential** “green” solutions in many areas where only “hard” solutions such as riprap or concrete linings were viable in the past.

APPLICATION

- **Any area subject to erosive action particularly where permanent vegetation has been planted.**
- **Graded slopes, stormwater channels, detention structures, stream banks or swales.**

APPROACH

When designing a permanent conveyance (as described in Chapter 10) with a grassed or vegetative lining, the design should address the bare condition prior to vegetation being established. A geotextile lining may be applied to protect the conveyance during this period. It is important to use both the tractive force and the permissible velocity methods to determine the level of protection that is required.

The design of ECBs and TRMs is based on the anticipated shear stresses and maximum flow velocities the fabric will encounter. Once the design shear stresses and maximum flow velocities are known, a corresponding ECB or TRM that meets the conditions may be selected from the list of approved ECB and TRM products. This list can be found on the MSD web page.

The following variables are required to determine the maximum velocity in a channel for a 10-year 24-hour storm event.

- Design peak flow rate value in cubic feet per second (cfs) for the 10-year 24-hour storm,
- Channel dimensions designed to carry the peak flow rate. For simplicity, all channels will be assumed to be trapezoidal in shape,
- Channel bed slope,
- Manning’s channel roughness coefficient (n) of the TRM or ECB or final vegetation, and

Normal channel flow depth (d_n) based on peak flow rate and channel dimensions.

The governing equation for maximum velocity is Manning’s Equation:

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

Where:

V = maximum velocity (ft/sec)
n = Manning’s channel roughness coefficient
R = Hydraulic radius of the flow based on d_n (ft)
S = Channel bed slope (ft/ft)

The governing equation for maximum channel shear stress is:

$$\tau = \gamma\, d_n\, S$$

Where:

τ = maximum shear stress (lbs/ft^2)
γ = unit weight of water = 62.4 lbs/ft^3
d_n = normal channel flow depth (ft)
S = channel bed slope (ft/ft)

MAINTENANCE

- **Inspect ECBs and TRMs periodically and especially after rain events to check for movement of blanket/mat, topsoil, or mulch and any significant erosion.**
- **Continue inspections until vegetation is firmly established.**
- **Repair or replace ECBs or TRMs that have been washed out, broken, or eroded. Repair ground surface with topsoil, re-seed, re-mulch and fertilize where necessary prior to installing new ECBs or TRMs.**

LIMITATIONS

- **Inadequate coverage or anchoring will result in erosion, washout, and poor vegetation establishment.**
- **Do not install within the wetted perimeter of a stream or drainage channel that carries water continuously.**
- **The type of ECB or TRM chosen must be appropriate for the specific project needs.**

12.5.6 FINAL STABILIZATION — EPM-6: FS

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Slope Protection	Waterway Protection	**Surface Protection**	Enclosed Drainage	**Large Flat Areas**	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Final stabilization measures include topsoiling, permanent seeding and planting of grasses, and sodding. Implementation of these items will occur after all construction activities on site have been completed.

These measures reduce stormwater runoff velocity, maintain sheet flow, protect soil surface from erosion, promotes infiltration of runoff into the soil and can improve wildlife habitat.

APPLICATION

- **Any area where soil disturbance activities have taken place.**

12.5.6 FINAL STABILIZATION EPM-6: FS

APPROACH

12.5.6.1 Topsoiling

When and Where to Use It

Topsoil should be used when vegetative stabilization is used, where soils are dense or impermeable, or where mulching and fertilizers alone cannot improve soil quality.

Design Criteria

Stockpiling of topsoil onsite requires good construction sequencing and planning so the stockpiles will not obstruct other operations. If topsoil is to be stockpiled, the use of temporary seeding, mulching, or silt fence to control erosion should be considered.

12.5.6.2 Permanent Seeding and Planting of Grasses

Design Criteria

The use of native species is preferred when selecting vegetation. Seedbed preparation, seed type, application rate, fertilizer rate and planting windows should be designed according to the MSD Standard Specifications.

12.5.6.3 Sodding

When and Where to Use It

Sodding is appropriate for any graded or cleared area that may erode, and where a permanent, long-lived plant cover is immediately needed. Examples of where sodding can be used are yards, buffer zones, stream banks, dikes, swales, slopes, outlets, and filter strips.

Design Criteria

Sodding should be installed per MSD Standard Specifications as shown in Standard Drawing EC-08-**01**. Sodding should not be used on slopes steeper than 2H:1V, unless the sodding is to be mowed, then it should not be placed on slopes greater than 3H:1V

MAINTENANCE

- **Inspect areas where topsoiling, permanent seeding and planting of grasses, and sodding measures have been implemented at a minimum of every seven days and within 24 hours after each storm event that produce 0.5 inches or more of precipitation.**

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Slope Protection	**Waterway Protection**	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties

DESCRIPTION

Riprap is a permanent, erosion-resistant channel lining aggregate consisting of large, loose, angular stone with a filter fabric or granular underlining. The purpose of riprap is to:

- Protect the soil from the erosive force of concentrated runoff; and
- Slow runoff velocities while enhancing the potential for infiltration.

The purpose of filter fabric or granular underlining is to prevent undermining the riprap layer by migration of soil particles under seepage forces through the riprap.

APPLICATION

- **Along streams or within drainage channels as a stable lining resistant to erosion.**
- **On lakefronts and riverfronts, or any other area subject to wave action.**
- **Protection of culvert inlets and outlets to prevent scour and undercutting.**
- **In channels to reduce velocities, dissipate hydraulic energy and promote infiltration and settle sediment.**

APPROACH

The preferred method of slope and channel protection is the use of vegetation. If vegetation cannot withstand the design flows, ECBs and TRMs (see Section 12.5.5) are the preferred and suggested method of protection. When conditions are too severe for vegetation and TRMs, riprap may be used for erosion control and protection. Riprap may be used, as appropriate, at storm drain outlets, on channel banks and/or bottoms, drop structures, at the toe of slopes, and in transitions from concrete channels to vegetated channels. Table 12-1 lists several KTC sizes of coarse aggregates along with the corresponding stone diameter.

Table 12-1. Coarse Aggregates

Aggregate Size (KTC Size No.)	Mean Spherical Diameter (d_{50}) (inches)
1	3.5
2	2.5
23	2.5
3	2.0
357	2.0
4	1.5
467	1.5
5	1.0
57	1.0
610	1.0
67	0.75
68	0.75
710	0.75
78	0.50
8	0.375

Riprap sizes can be designed by the diameter or by the weight of the stones. It is often misleading to think of riprap in terms of diameter, since the stones should be angular instead of spherical. Table 12-2 lists some typical riprap classes and the corresponding dimensions.

Table 12-2. Weight and Size of Riprap Stones

Channel Lining Riprap Class	**Corresponding Size**
IA	Limestone with 100% passing a 5-inch sieve, and no more than 20% passing though square openings 1.5” by 1.5”
II	Limestone with 100% passing a 9-inch sieve, and no more than 20% passing though square openings 5” by 5”
III (Cyclopean Riprap)	> 80% by volume of individual stones ranging from ¼ to 1-½ cubic feet

General

<u>Geotextile Underlining</u>: Place a lining of geotextile filter fabric or granular filter material between the riprap and the underlying soil surface to prevent soil movement into or through the riprap.

<u>Riprap at Outlets:</u> Design criteria for sizing the stone and determining the dimensions of riprap pads used at the outlet of drainage structure are given in Section 12.5.8 of this chapter; Outlet Stabilization**.**

Riprap for Channel Stabilization: Riprap for channel stabilization should be designed to be stable for the condition of bank-full flow in the reach of channel being stabilized. The Federal Highway Administration (FHWA) design procedure as presented in this section should be used. This method establishes the stability of the rock material relative to the forces exerted upon it.

Riprap should extend up the banks of the channel to a height equal to the maximum 10-year flow depth, or to a point where vegetation can be established to adequately protect the channel.

Riprap placed in channel bends should extend upstream and downstream from the point of curvature at least 5 times the channel bottom width. The riprap should extend across the bottom and up both sides of the channel.

Freeboard and Height of Bank: For riprap and other lined channels, the height of channel lining above the water surface should be based on the size of the channel, the flow velocity, the curvature, inflows, wind action, flow regulation, etc.

The designer shall obtain a minimum freeboard for placement of riprap relative to the top of bank from Chapter 10.

Design of Riprap Channel Linings

Design of erosion protection within the channel should be accomplished using the FHWA Tangent Flow Method presented below. This method is applicable to both straight and curved channel sections where flows are tangent to channel bank. The Tangent Flow Method determines a stable rock size for straight and curved channel sections using known shape, flow depth, and channel slope dimensions. A stone size is chosen for the maximum depth of flow. If the sides of the channel are steeper than 3H:1V, the stone size must be modified. The final design size will be stable on both the sides and bottom of the channel.

For Straight Channel Sections:

The Exhibits used in this section are found in Supplemental Section D of this chapter.

1. Enter the graph of Exhibit 12-2 with the maximum flow depth (feet) and channel slope (ft/ft). Where the two lines intersect, choose the d_{50} stone size. (Select d_{50} for diagonal line above the point of intersection.)

2. If the channel side slopes are steeper than 3H:1V, continue with Step 3; if not, the procedure is complete.

3. Enter the graph in Exhibit 12-3 with the side slope and the base width to maximum depth ratio (B/d). Where the two lines intersect, move horizontally left to read K_1.

4. Determine from the graph in Exhibit 12-4 the angle of repose for the d_{50} stone size and the channel side slope. (Use an angle of 42^o for d_{50} >10 inches. Do not use riprap on slopes steeper than the angle of repose for the

stone size.)

5. Enter graph in Exhibit 12-5 with the side slope of the channel and the angle of repose for the d_{50} stone size. Where the two lines intersect, move vertically down to read K_2.

6. Compute d_{50} x $K_1/K_2 = d_{50}$ to determine the correct size stone for the bottom and side slopes of straight sections of channel.

MAINTENANCE

- **Check riprap and channel linings after rain events that produce greater than 0.5 inches of precipitation for slumping, displacement, scour and undermining of riprap. Replace or reposition as necessary.**
- **Remove excessive vegetative growth if stability of area is compromised.**

LIMITATIONS

- **Displacement of riprap or channel lining may occur if the slope is too steep or if riprap is improperly sized or installed.**
- **Weeds may be difficult to control.**
- **Riprap placement in waterways may require permitting with the U.S. Army Corps of Engineers and the Kentucky Division of Water.**

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Slope Protection	**Waterway Protection**	Surface Protection	**Enclosed Drainage**	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Outlet **stabilization** dissipates the energy of concentrated **stormwater** flows thereby reducing erosion or scouring at **stormwater** outlets and paved channel sections. In addition, outlet **stabilization** lowers the potential for downstream erosion. This type of protection can be achieved through a variety of techniques, including permanent turf reinforcement mats (TRMs), stone or riprap, concrete aprons, and paved sections.

APPLICATION

- **Wherever discharge velocities and energies at the outlets of culverts, pipes, conduits, channels or ditches are sufficient to erode the immediate downstream reach.**

APPROACH

The design of lined aprons at the outlets of pipes and paved channel sections applies to the immediate area or reach below the pipe or channel and does not apply to continuous rock linings of channels or streams. Notably, pipe or channel outlets at the top of cut slopes or on slopes steeper than 10% should not be protected using just outlet protection. This causes re-concentration of the flow **which** results in large velocities when the flow leaves the apron. Outlet protection should be designed according to the following criteria:

Round Pipe Flowing Full:

1. Tailwater Depth: The tailwater depth immediately below the pipe outlet must be determined for the design capacity of the pipe. The depth may be determined using Manning's Equation. If the tailwater depth is less than ½ the diameter of the outlet pipe, it should be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than ½ the pipe

diameter, it should be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

2. Apron Length: The required apron length, L_a, according to the tailwater condition, should be determined from the appropriate graphs provided in the following exhibits found in Supplemental Section D of this chapter:

   Minimum Tailwater Condition - Use Exhibit 12-6
   Maximum Tailwater Condition - Use Exhibit 12-7

3. Apron Width: When the pipe discharges directly into a well-defined channel, the apron should extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank (whichever is less). If the pipe discharges onto a flat area with no defined channel, the width of the apron should be determined as follows:

   - The upstream end of the apron, adjacent to the pipe, should have a width three times the diameter of the outlet pipe (3D).
   - For a Minimum Tailwater Condition, the downstream end of the apron should have a width equal to the pipe diameter plus the length of the apron ($D + L_a$).
   - For a Maximum Tailwater Condition, the downstream end should have a width equal to the pipe diameter plus 0.4 times the length of the apron ($D + 0.4 * L_a$).

4. Bottom Grade: The apron shall be constructed with no slope along its length (0% grade). The downstream invert elevation of the apron should be equal to the elevation of the invert of the receiving channel. There shall be no overfall at the end of the apron.

5. Side Slopes: If the pipe discharges into a well-defined channel, the receiving side slopes of the channel should not be steeper than 3H: 1V.

6. Alignment: The apron should be located so there are no bends in the horizontal alignment.

7. Materials:

   - The preferred apron lining shall be with an appropriate permanent turf reinforcement matting (TRM). The shear stress and maximum velocity should be calculated to determine which type of TRM is applicable for the situation (see Section 12.5.5).
   - When conditions are too severe for TRMs the apron may be lined with riprap, grouted riprap, concrete, or gabion baskets. The median-sized stone for riprap should be determined from the curves in Exhibit 12-6 and 12-7 according to the tailwater condition. The gradation, quality, and placement of riprap should conform to the requirements presented in Section 12.5.7.

8. Filter Cloth: In all cases, filter cloth should be placed between the riprap and the underlying soil to prevent soil movement into and through the

riprap. The material must meet or exceed the physical properties for filter cloth found in the requirements presented in Section 12.5.7.

Paved Channel Outlets (Standard Drawing DD-05-**01**):

1. The flow velocity at the outlet of paved channels flowing at design capacity **must not** exceed the permissible velocity of receiving unprotected grass-lined channels as provided in Table 12-3.

2. The paved channel end should merge smoothly with the receiving channel section with no overfall at the end of the paved section. When the bottom width of the paved channel is narrower than the bottom width of the receiving channel, a transition section should be provided with a maximum side divergence of 1 in 3F with;

$$F = \frac{V}{(gd)^{0.5}}$$

Where:
F = Froude number
V = Velocity at beginning of transition (ft./sec.)
d = Depth of flow at beginning of transition (ft.)
g = Acceleration due to gravity (32.2 ft./sec.^{2})

3. Bends or curves in the horizontal alignment at the transition are not allowed unless the Froude number (F) is 1.0 or less, or the section is specifically designed for turbulent flow.

Table 12-3. Maximum Permissible Velocities For Unprotected Grass Lined Channels

Channel Slope	Lining	Velocity (ft./sec.)**
0 – 5 %	Bermuda Grass	8
	KY-31 Tall Fescue	7
	Kentucky Bluegrass	7
	Grass-legume Mixture	5
	Small Grains	3.5
	Temporary Vegetation	3.5
5- 10 %	Bermuda Grass	7
	KY-31 Tall Fescue	6
	Kentucky Bluegrass	6
	Grass-legume mixture	4
	Small Grains	Not Recommended
	Temporary Vegetation	Not Recommended
Greater than 10%	Bermuda Grass	6
	KY-31 Tall Fescue	5
	Kentucky Bluegrass	5
	Grass-legume mixture	Not Recommended
	Small Grains	Not Recommended
	Temporary Vegetation	Not Recommended

***Allow velocities over 5 ft/sec only where good cover and maintenance will be provided.**
****For highly erodible soils, decrease permissible velocities by 25%.**
Source: Elementary Soil and Water Engineering, Shwab et. al. 1971

MAINTENANCE

- **Inspect outlet stabilization periodically, particularly after rain events, for**

erosion, sedimentation, scour or undercutting.
- Repair or replace riprap, TRM, or concrete structures as necessary.
- Remove trash, debris, vegetation, and sediment as necessary.

LIMITATIONS

- An easement may be necessary to maintain riprap outlet protection given that outlet protection is usually at or near the project boundary.

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Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	**Large Flat Areas**	**Borrow Areas**	**Adjacent Properties**

DESCRIPTION

Wind erosion can occur when the surface soil is loose and dry, vegetation is sparse or absent, the wind is sufficiently strong, and when construction traffic disturbs the soil. Wind erodes soils and transports the sediment offsite in the form of fugitive dust, where it may be washed into receiving water bodies by the next **rain event**.

Fugitive dust is a nuisance for neighbors. It settles on automobiles, structures and windows and finds its way into homes. It also can make breathing difficult (for those with respiratory problems) and becomes a safety problem when it blinds motorists, equipment operators and laborers.

Dust control methods should be utilized whenever there are offsite impacts, such as periods of drought, and implemented until final stabilization is reached. **Selection of particular dust control techniques depends primarily on cost and potential environmental hazards (particularly near Sensitive Features). The effectiveness of each technique will depend on soil type, properties of chemical agent, traffic volume, climate, environmental requirements, and frequency of application.**

APPLICATION

- **Clearing and grading activities.**
- **Construction vehicle traffic on temporary or unpaved roads or construction site access paths.**
- **Sediment tracking on paved roads.**
- **Soil and debris storage piles.**
- **Areas with unstabilized soil.**

12.5.9 DUST CONTROL EPM-9: DC

APPROACH

There are many methods to control dust on construction sites including:

- Vegetative Cover - For disturbed areas not subject to traffic, vegetation provides the most practical method of dust control.
- Mulch - Offers a fast, effective means of controlling dust.
- Sprinkling Water – Used on haul roads and other traffic routes as dust control.
- Spray-on-Adhesive - Latex emulsions, or resin in water can be sprayed onto mineral soils to prevent their blowing away and reduce dust caused by traffic.
- Calcium Chloride - May be applied by mechanical spreaders as loose, dry granules or flakes at a rate that keeps the surface moist but not so high as to cause water pollution or plant damage.
- Barriers - Broad, wind, or sediment fences can control air currents and blowing soil. These fences prevent erosion by obstructing the wind near the ground, stopping the soil from blowing offsite. Barriers are not a substitute for permanent stabilization. Perennial grass and **stands** of existing trees may also serve as wind barriers.

Spray exposed soil areas only with approved dust control agents as indicated in the MSD Standard Specifications

MAINTENANCE

- **Reapplication of dust control agents must be appropriate to the agent type and intensity of traffic areas.**

LIMITATIONS

- **Watering prevents dust only for a short period and should be applied daily (or more often) to be effective.**
- **Overwatering may cause erosion.**

12.6 TEMPORARY SEDIMENT CONTROL MEASURES

MSD emphasizes erosion prevention in EPSC plans. However, there are always instances where erosion cannot be prevented. For these situations, temporary sediment controls must be implemented to control the migration of eroded sediment off site. The following sediment control measures are applicable as temporary practices for use during construction. One or more of the measures should be utilized as appropriate during the project's construction phase. A discussion of the planned measures will be required during the Preliminary Plan Review phase for sites containing sensitive features.

12.6.1 STORAGE VOLUMES AND MAINTENANCE SCHEDULES

SCM-1: SV

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Slope Protection	**Waterway Protection**	Surface Protection	**Enclosed Drainage**	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

This section provides the basic formulas needed for temporary sediment basin and sediment trap design.

APPROACH

Calculating the appropriate sediment storage volume is very important in sediment basin and sediment trap design. This volume is the storage occupied by the sediment deposited over the given design period. Design periods may be the life of the basin, or the time between scheduled clean outs. Using computed sediment yields from the Universal Soil Loss Equation (USLE) found in Supplemental Section B, along with the sediment bulk density, the sediment storage volume can be calculated by

$$V_S = \frac{Y_D}{W * 43{,}560}$$

Where: $\mathbf{V_S}$ is the sediment storage volume (acre-feet), $\mathbf{Y_D}$ is the sediment deposited over the design period (pounds), and **W** is the weight density (bulk density) of the deposited sediment (lbs./ft^3). **W** can be found from soil survey data (usually given in grams/cm^3) or by the equation:

$$W = W_c P_c + W_m P_m + W_s P_s$$

Where: W_c, W_m, and W_s are unit weights of clay, silt, and sand in (lbs./ft^3) taken from Table 12-4, and P_c, P_m, and P_s are the primary soil matrix percent clay, silt, and sand as listed in soil survey (used as a decimal).

Table 12-4. Unit Weight Values of Basin Sediment

Type of Basin Operation	Wc (#/ft^3)	Wm (#/ft^3)	Ws (#/ft^3)
Sediment always submerged (Wet Pond)	26	70	97
Basin normally empty (Dry Pond)	40	72	97

R Factors and EI Values

When designing for sediment storage volume, the sediment deposited over the design period Y_D, must be calculated. This value can be obtained by converting the sediment yield calculated by the Universal Soil Loss Equation (USLE) into pounds of sediment. One of the variables used in the USLE is the R factor. R is the factor in the USLE that accounts for the damaging effects of rainfall. The R factor indicates the erosivity of the rainfall, not the average annual precipitation in a locality. The R factor is defined as the number of erosion index (EI) values in a normal year's rain. The EI index value of a given storm is equal to the kinetic energy of the storm (hundreds of foot-tons per acre) times its maximum 30-minute intensity (inches/hour). The EI values of individual storms may be summed to get an EI value for a month, six months, or for any period of time. When EI values are summed and averaged over a period of years, they become R factors.

The distribution of EI values become important when soil losses need to be calculated for a period of time less than one year, such as a construction season. The distribution of the EI values over a known period of time is used to calculate an R factor for that time period. Table 1 in Supplemental Section B of this chapter shows the distribution of EI values for Jefferson County as a percentage of the R factor for Jefferson County. MSD requires a minimum EI value of 50 for any construction period.

The following steps are used to determine the storage volume for a sediment trapping structure. All **USLE** input values are found in Supplemental Sections B and C of this chapter.

1. Determine the site sediment yield using the Universal Soil Loss Equation

$$A = R \bullet K \bullet LS \bullet CP$$

Where:
A = Average soil loss per unit area(tons/acre/specified design period)
R = Rainfall erosive index (100-ft-tons/acre x in/hr)
(EI Value for given design period * average annual R Value)
K = Soil erodibility factor (tons/acre per unit R)
LS = Length-slope steepness factor where length is the slope distance from the point of origin of overland flow to the point of concentrated flow or until deposition occurs (dimensionless)
CP = Control practice factor (dimensionless).

2. Determine the weight density **(W)** of the specific soil.

    - The Jefferson County Soil Survey gives a soil bulk density in grams/cm^3
    - Convert (grams/cm^3) to (lbs/ ft^3) by multiplying by 62.43

    W = (bulk density in grams/cm^3) x (62.43) = lbs/ft^3

3. Convert sediment yield from (tons/acre) to acre-feet of sediment storage.

    - Determine the total disturbed area **DA** (acres)
    - Determine the sediment yield in tons

Multiply **A** from step 1. * **DA** from step 3. (tons/acre * Acres = tons)

- Convert tons to pounds to get $\mathbf{Y_D}$

$\mathbf{Y_D}$ = (tons) * (2000 lbs/ ton) = pounds

$$V_S = \frac{Y_D}{W * 43{,}560} \quad = \textit{acre} - \textit{feet}$$

4. The designer can now determine what level the required sediment storage corresponds to, and require a clean out marking stake to be installed at this elevation. The contractor shall be required to clean out the basin or trap when this level is reached. Or the designer can simply state that based on the calculations, the basin or trap will be required to be cleaned out on a time period basis such as weeks, months or years.

12.6.2 TEMPORARY SEDIMENT BASIN SCM-2: TSB

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Slope Protection	**Waterway Protection**	**Surface Protection**	**Enclosed Drainage**	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

A sediment basin is an impoundment for the purpose of detaining runoff to allow excessive sediment to settle.

Temporary sediment basins should be used on sites where 5 or more acres are disturbed. A temporary sediment basin shall not be built in wetlands, any active or live streams, or in Waters of **the** Commonwealth. Temporary sediment basins shall be utilized until the contributing flow areas to the basin have undergone final stabilization.

Basins shall be designed to have an 80% design removal efficiency goal for total suspended solids (TSS) in the inflow. Drop inlet spillways, pipe spillways, rock fill outlets and weir spillways may be used for the design of the principal spillway. Typical sediment basin schematics are Exhibits 12-8A and 12-8B in Supplemental Section D of this chapter.

APPLICATION

- **Used for retaining stormwater from disturbed areas where 5 to 150 acres are disturbed.**
- **At locations with steep slopes, sloughing or severely eroded soils, or industrial activities that generate sediment and soil particles.**

APPROACH

- Dam Safety –Design criteria such as those used by the USDA Soil Conservation Service (previously the Natural Resources Conservation Service), U.S. Army Corps of Engineers and the Dam Safety and Floodplain Compliance Section of the Kentucky Division of Water must be followed.

- Safety, Signage, and Fencing - Ponds, which are readily accessible to populated areas, should incorporate all possible safety precautions. The inside pond slopes shall be no steeper than 3H:1V.

- General Design Criteria -The design aids located in Section 12.8.2 of this chapter shall be used to properly size the sediment basin. Sedimot III, SEDCAD and other computer models may also be utilized.

- Riser Structure Design- The outlet riser shall be properly designed to meet the discharge capacity of the 10-year 24-hour storm.

Flow control devices can operate as either open channel flow, in which the flow has a free water surface, or pipe flow in which the flow is in a closed conduit. In either situation, an increase in head on a structure increases the discharge flow rate through the structure.

The stage discharge relationship for basin outlet structures is controlled by weir, orifice or pipe flow. A given riser spillway can have a variety of stage discharge relationships depending on the head. When the water level is just above a riser crest (a very low head on the riser), the riser crest acts like a weir, and flow is weir controlled. As the water level in the basin increases, water begins flowing in from all sides including directly above the inlet, and the inlet begins to act like an orifice. As the head continues to increase, the outlet eventually begins to flow full, and pipe flow dictates. To determine which of the three flow mechanisms is controlling at a particular water level in the basin, all three equations should be utilized at each level. The minimum flow for a given stage indicates the actual discharge from the basin and the flow mechanism that is controlling at that water level.

Weir Flow:

$$Q = C\,L\,H^{\frac{3}{2}}$$

Where: Q is the discharge (cfs), C is the weir coefficient (dependent upon units and weir shape but C is typically between 3.0 and 3.2), L is the weir length (feet), which is the total length over which flow crosses the weir (L = circumference of a pipe for circular drop inlets), and H is the water head (feet).

Orifice Flow:

$$Q = C' a \left(2gH\right)^{\frac{1}{2}}$$

Where: Q is the discharge (cfs), C’ is the orifice coefficient (C’ = 0.6 for sharp-edged orifices), a is the cross sectional area of the orifice (ft^2), g = 32.2 ft/sec^2, and H is the head on the orifice (feet).

Pipe Flow:

$$Q = \frac{a\left(2gH'\right)^{\frac{1}{2}}}{\left(1 + K_e + K_b + K_c L\right)^{\frac{1}{2}}}$$

Where: Q is the discharge (cfs), a is the cross sectional area of the pipe (ft^2), g = 32.2 ft/sec^2, H' is the head (feet) defined as the distance from the water surface in the basin to a point 0.6 D above the invert of the outlet barrel where D is the outlet barrel diameter in feet, K_e and K_b depend on the configuration of the pipe entrance and bend (typical values are K_e = 1.0 and K_b = 0.5), K_c is the head loss coefficient due to friction ($K_c = 5087*n^2 / D^{4/3}$, where: n = Manning's roughness coefficient of the barrel and D is the barrel diameter in inches), and L is the total length of the pipe (feet).

Other required design criteria are as follows:

a. Minimum Drainage Area - 5 acres
b. Maximum Drainage Area - 150 acres
c. 80% design removal efficiency goal for TSS.
d. The required draw down time of the basin will be the time to detain flows to meet the 80% design removal efficiency. In many cases this will result in a draw down time longer than 36-hours.
e. Basin Shape - the effective flow length should be at least twice the effective flow width (L=2W minimum).
f. Sediment Volume Storage Accounted For In Design Volume
g. Outlet Riser and Barrel Requirements
    1. Discharge Capacity - 10-year 24-hour storm.
    2. Minimum Outlet Pipe Diameter of 8-inches.
    3. Required 6-inch low flow orifice at bottom of riser structure.
    4. Perforations and orifices shall be designed to keep the 2-year and 10-year 24-hour storm disturbed-state peak flow rates from the basin less than or equal to the pre-disturbance peak flow rates.
    5. Anti-Vortex Device / Trash Rack Required.
    6. Minimum one-foot elevation difference from top of riser to crest of the emergency spillway.
    7. Sediment Volume Storage Accounted For In Design Volume.

h. Embankment Requirements
    1. Maximum Upstream Slope – 3H:1V.
    2. Maximum Downstream Slope – 3H:1V.
    3. Freeboard - 12-inch minimum.
    4. Antiseep collars are required on all penetrations through the dam.
    5. Typical dam height to top width dimensions are provided below in Table 12-5.

Table 12-5. Sediment Basin Width/Height Relationship

Dam Height (Ft)	Top Width (Ft)
< 10	8
11-14	9
15-19	10
20-25	12

i. Emergency Spillway Requirements
   1. Shall be designed to discharge a flow equal to the design overflow of the 100-year 6-hour storm post-development discharge.
   2. Shall have a minimum one-foot of freeboard from the 100-year 6-hour storm water surface elevation to the top of the dam.

MAINTENANCE

- **Inspect temporary sediment basins periodically and after each rainfall event for excessive sediment buildup, undercutting flows or seepage, slope failure, settlement and structural soundness.**
- **Regularly inspect water quality being discharged for suspended sediment and color and perform necessary repairs when appropriate.**
- **Inspect downstream channel for erosion or sedimentation.**
- **Remove accumulated sediment whenever it reaches the designated cleanout level and dispose of sediment at a protected location onsite to prevent resuspension of sediment.**

LIMITATIONS

- **Sediment basins may kill nearby vegetation by excessive sediment or by long periods of submergence.**
- **May not be effective for fine-grained soils such as silt or clay. Additional upstream controls may be necessary.**
- **Can be attractive and dangerous to children. Protective fencing or other access control measures are highly recommended.**

12.6.3 MULTIPURPOSE BASINS SCM-3: MB

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Slope Protection	**Waterway Protection**	**Surface Protection**	**Enclosed Drainage**	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Multipurpose basins are permanent detention basins that are designed for use as temporary sediment basins during the construction phase of a project.

APPLICATION

- **Modification of a permanent detention basin for the purpose of handling large amounts of silt and eroded soil.**

APPROACH

Two spillway configurations are commonly used in the life of a multipurpose basin. The first configuration is the sediment basin spillway, which is typically a CMP riser and RCP barrel configuration. When conversion of the spillway is required, this configuration makes the most sense because the riser section can be removed and the barrel section can be utilized as part of the spillway for the detention basin.

For steps on the design of the principal and emergency spillways for multipurpose basins, refer to Chapter 10. Design the sediment basin principal spillway to reduce the construction-phase conditions to pre-development levels for the 2 and 10-year 24-hour storm events. Design the emergency spillway to pass and provide flow reduction for the 100-year 6-hour storm permanent detention basin using post-development conditions.

Design the principal spillway for the permanent detention basin to reduce post-development flows to pre-development flows for the 2 and 10-year 6-hour storm events as described in Chapter 10. Design the emergency spillway to pass and provide flow reduction for the 100-year detention basin using post-development conditions.

When the sediment pond phase has expired, the temporary riser structure shall be removed and the permanent structure shall be installed. The basin shall be cleaned of deposited sediment and re-graded to meet the permanent basin contours if necessary.

General Design Criteria

a. Minimum Freeboard for both basin phases is 1 ft.
b. Design must include maintenance accessibility and responsibility.
c. Provide erosion protection for the emergency spillway and channel protection for the receiving channel.
d. Storage, discharge, and routing calculations for the 2, 10, and 100-year storm events must be submitted for review.
e. Multipurpose basins shall be fully discharged within 36 hours after the storm event unless specifically approved by MSD.
f. Multipurpose basins shall be the first item of construction.

MAINTENANCE

- **Inspect temporary sediment basins periodically and after each rainfall event for excessive sediment buildup, undercutting flows or seepage, slope failure, settlement and structural soundness.**
- **Regularly inspect water quality being discharged for suspended sediment and color and perform necessary repairs when appropriate.**
- **Inspect downstream channel for erosion or sedimentation.**
- **Remove accumulated sediment whenever it reaches the designated cleanout level and dispose of sediment at a protected location onsite to prevent resuspension of sediment.**

LIMITATIONS

- **Sediment basins may kill nearby vegetation by excessive sediment or by long periods of submergence.**
- **May not be effective for fine-grained soils such as silt or clay. Additional upstream controls may be necessary.**
- **Can be attractive and dangerous to children. Protective fencing or other access control measures are highly recommended.**

12.6.4 TEMPORARY SEDIMENT TRAP SCM-4: TST

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TS

Slope Protection	**Waterway Protection**	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Temporary sediment traps are small temporary ponds that detain sediment-laden runoff from disturbed areas allowing sediment to settle out. A temporary sediment trap is formed by excavating a pond or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is constructed using stones or aggregate to slow the release of runoff. The trap retains the runoff long enough to allow most of the silt to settle out. Sediment traps shall be designed to have an 80% design removal efficiency goal of the total suspended solids (TSS) in the inflow. Temporary sediment trap details are Exhibits 12-9A and 12-9B in Supplemental Section D.

APPLICATION

- **Any disturbed area which is less than 5 acres.**
- **Along the perimeter of a project site to prevent sediment-laden runoff from being discharged off-site or areas where runoff can enter stabilized areas or waterways.**
- **Immediately upstream from temporary storm drain inlet protection measures.**

APPROACH

A sediment trap may be formed completely by excavation or by constructing a compacted embankment. The outlet should be a rock fill weir/spillway section, with the area below the weir acting as a filter for sediment and the upper area as the overflow spillway depth.

To complete the design of the temporary sediment trap:

- Determine the required sediment storage volume.

- Determine the bottom and top surface area of the sediment storage volume using 3H:1V side slope from the bottom of the trap.

- Determine the total trap dimensions by adding the depth required for the 10-year, 24-hour design storm above the surface of the sediment storage volume, while not exceeding 3H:1V side slopes.

- General Design Criteria – the design aids located in Section 12.8.5 shall be used to properly size the sediment trap. Sedimot III, SEDCAD and other computer models may also be utilized.

- Other design requirements are as follows:
  a. Maximum Drainage Area - 5 acres
  b. Maximum Design Life - 18 months
  c. 80% design removal efficiency goal for TSS
  d. Basin Shape - The flow length should be 2 times the flow width.
  e. Embankment Requirements:
     1. Maximum Dam Height - 5 feet.
     2. Maximum Stone Height – 3.5 feet.
     3. Minimum Rock Bottom Width – 3 feet.
     4. Discharge and treatment capacity for the 10-yr. 24-hr. storm event.

MAINTENANCE

- **Inspect traps periodically and after each rain event for excessive sediment buildup, undercutting flows or seepage, slope failure, settlement and structural soundness.**
- **Regularly inspect water quality being discharged for suspended sediment and color; identify and perform repairs to improve water quality.**
- **Inspect downstream channel for erosion or sedimentation.**
- **Remove accumulated sediment whenever it reaches the designated cleanout level.**

LIMITATIONS

- **Sediment traps can kill nearby vegetation by excessive sediment or by long periods of submergence.**
- **Temporary sediment traps only remove coarse particles which settle quickly. They are not effective for fine-grained soils such as silt or clay. Additional upstream erosion control measures are necessary.**
- **Can be attractive and dangerous to children. Protective fencing or other access control measures are highly recommended.**

12.6.5 SILT FENCE

SCM-5: SF

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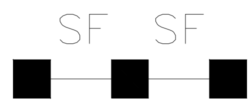

Slope Protection	**Waterway Protection**	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

A silt fence is a temporary measure for sediment control. It shall be designed to have an 80% design removal efficiency goal of the TSS in the inflow. Silt fence consists of posts with **a synthetic** filter fabric stretched across the posts and a wire support fence. The lower edge of the fence is vertically trenched and covered by compacted backfill. Typical silt fence details, with and without reinforcement, are shown in Standard Drawings EF-09-**02** and EF-10-**02**.

APPLICATION

- **Any disturbed area accepting sediment-laden sheet flow conditions.**
- **Along the downstream perimeter of a disturbed site, below the toe of a cleared slope, upstream of sediment traps or basins, along streams and channels and around temporary spoil areas.**

APPROACH

- Maximum sheet or overland flow path length to the fence is 100 feet.
- Maximum slope steepness (normal [perpendicular] to fence line) 2H:1V.
- No concentrated flows greater than 0.5 cfs and not placed across channels.
- General Design Criteria - The design aids located in Section 12.8.4 shall be used to properly design silt fence.
- Standard non-reinforced silt fence shall be used when the contributing slope is less than or equal to 3% and the design life of silt fence is less than 6 months.

- Reinforced silt fence shall be required when the contributing slope is greater than 3% and the design life of the silt fence is greater than 6 months.

Land Slope	Max. Slope Distance
< 5%	100 ft.
5% - 10%	50 ft.
10% - 20%	25 ft.
20% - 50%	15 ft.

- Other design requirements are as follows:
  a. 80% design removal efficiency goal for TSS
  b. Maximum Slope Length - 100 feet
  c. Maximum Slope Gradient – 2H:1V
  d. Minimum Installed Fence Height - 18 inches
  e. Maximum Installed Fence Height - 24 inches
  f. Minimum Post Bury Depth – 18 inches
  g. Maximum Reinforced Fence Post Spacing - 6 feet
  h. Maximum Non-reinforced Post Spacing - 6 feet

MAINTENANCE

- **Inspect silt fence periodically and after each rainfall event for damage or loosened fabric, excessive sediment buildup, undercutting flows or flows around end of silt fence. Repair or replace as necessary.**
- **Remove sediment whenever it reaches one-third of the silt fence height.**
- **Maintain silt fence until disturbed areas have been properly stabilized.**
- **Silt fence should be removed within 30 days after final site stabilization is achieved or after temporary BMPs are no longer needed.**

LIMITATIONS

- **Can not be used in continuously-flowing streams.**
- **Installation and removal may damage vegetation and channel grades.**
- **May kill vegetation by excessive sediment or by long periods of submergence.**
- **Should not be installed along the slope contour and not up or down the slope.**

12.6.6 ROCK DITCH CHECK

SCM-6: RDC

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DC ▶ DC ▶ DC

Slope Protection	Waterway Protection	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

A rock ditch check is a small, temporary or permanent rock fill dam constructed across a drainage ditch, swale, or channel to lower the speed of concentrated flows. Rock ditch checks shall be designed to have an 80% design removal efficiency goal of the TSS in the inflow. A typical rock ditch check section is shown in Standard Drawing EB-03-**01**.

APPLICATION

- **Sediment and erosion control in small open channels (<5-acre drainages).**
- **Flow velocity reduction.**

APPROACH

- Rock ditch checks should be used only in small open channels. The checks should not be placed in Waters of the Commonwealth, unless approved by the State. The center section of a rock ditch check should be lower than the edges.

- Spacing varies with the bed slope of the ditch. The maximum spacing between the rock checks should be such that the toe of the upstream check is at the same elevation as the top of the downstream check.

- In the case of grass-lined ditches and swales, ditch checks should be removed when the grass has matured sufficiently to protect the ditch or swale unless the slope of the swale is greater than 4%. The area beneath the ditch checks should be seeded and mulched immediately after dam removal. Geotextile filter fabric shall be installed under all rock fill.

- General Design Criteria - The Design Aids located in Section 12.8.3 shall be used to properly design rock ditch checks.

- Other design requirements are as follows:
  a. 80% design removal efficiency goal for TSS
  b. Maximum Drainage Area – 5 acres
  c. Maximum Height - 2 feet

- If the rock ditch check is not properly sized, the flow will overtop the structure and the Trapping Efficiency is assumed 0% when this takes place.

MAINTENANCE

- **Inspect every seven days and within 24 hours after each rain event that produces 0.5 inches or more of precipitation to check for excessive sedimentation or instability.**
- **Sediment must be removed before it reaches one-half of the device's original height.**

LIMITATIONS

- **Not for use in continuously-flowing streams.**
- **May damage vegetation and channel grades.**

12.6.7 STABILIZED CONSTRUCTION ENTRANCES

SCM-7: SCE

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TGCE

Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	**Large Flat Areas**	Borrow Areas	**Adjacent Properties**

DESCRIPTION

A stabilized construction entrance is a temporary stone-stabilized pad located at points of vehicular ingress and egress on a construction site to reduce the amount of mud, dirt, rocks, etc. transported onto public roads by motor vehicles equipment and runoff. A diagram of a typical temporary gravel construction entrance is shown in Standard Drawing ER-01-02.

Stabilized construction entrances should be used whenever repetitive traffic will be leaving a construction site and be moving directly onto a public road. Construction entrances provide an area where mud can be removed from vehicle tires before entering a public road.

APPLICATION

- **All points of construction ingress and egress.**

APPROACH

If the action of the vehicle traveling over the gravel pad is not sufficient to remove the majority of the mud, then the tires must be washed before the vehicle enters a public road. If washing is used, provisions must be made to intercept the wash water and trap the sediment before it is carried offsite. Washdown facilities shall be required as directed by MSD. Washdown areas, in general, must be established with crushed gravel and drain into a sediment trap or sediment basin. Construction entrances should be used in conjunction with the stabilization of construction roads to reduce the amount of mud picked up by vehicles. Limiting traffic from the site in wet conditions is a means of controlling mud on streets.

The General Design Criteria **are:**

a. Minimum Entrance Dimensions

1. Thickness - 6 inches
2. Width of entrance area - 24 feet
3. Length – 100 feet or required length for 10 tire revolutions

b. Material - **#57** stone size or larger. Non-woven geotextile fabric is required to underlie the stone.

MAINTENANCE

- **Maintain entrance area to ensure mud, dirt, rocks, etc. are not tracked onto roadways. Remove all mud or sediment deposited on paved roadways as necessary.**
- **Remove gravel material and filter fabric at completion of construction, or as paved surfaces are finished.**
- **Periodic top dressing of the area may be required.**

LIMITATIONS

- **Construction entrances on slopes may require diversions to prevent stormwater from leaving the site.**

12.6.8 STORM DRAIN INLET PROTECTION SCM-8: SIP

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SIP

Slope Protection	**Waterway Protection**	Surface Protection	**Enclosed Drainage**	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Storm drain inlet protection allows sediment to settle prior to entering into a stormwater catch basin or inlet. Storm drain inlet protection can be achieved by placing a temporary filtering device around any inlet to trap sediment. This mechanism prevents sediment from entering inlet structures. Additionally, it serves to prevent the silting-in of inlets, storm drainage systems, or receiving channels.

Four different materials/methods that can be used to provide inlet protection are: filter fabric, block and gravel, gravel and stone with a wire mesh filter, and stone bags. **Straw bales are not permitted for this purpose because of plugging.** In addition, excavating immediately around the drop inlet and using gravel to restrict sediment flow can also be used to protect the inlet. Typical diagrams for each of these filter types are: Filter Fabric Inlet Protection Standard Drawing EF-01-**02**, Block and Gravel Drop Inlet Protection Standard Drawing EF-13-**01**, Gravel and Wire Mesh Inlet Sediment Filter Standard Drawing EF-14-**01**, and Stone Bag Inlet Protection Standard Drawing EF-03-**02**.

APPLICATION

- **Every storm drain inlet, catch basin, curb inlet, culvert or similar drainage structure that receives sediment-laden runoff.**
- Storm drain inlet protection is not meant for use in drainage areas exceeding one (1) acre or for large concentrated **stormwater** flows. <u>Inlet protection is to be used as a last resort for sediment control when no other means are practical.</u>

12.6.8 STORM DRAIN INLET PROTECTION SCM-8: SIP

APPROACH

Inlet protection shall be avoided on roadways due to the potential of ponding and street flooding. Inlet protection may be installed prior to the construction of roads however, once the sub base is laid, the inlet protection shall be removed.

Inlet protection is required on all inlets that have outfalls that bypass sediment trapping structures and directly discharge off-site. General design criteria for each of the materials/methods of inlet protection are provided below.

- Filter Fabric is used for inlet protection when **stormwater** flows are relatively small (0.5 cfs or less) with low velocities and where the inlet drains a relatively flat area (slopes no greater than 5%). This practice cannot be used where inlets are paved or where inlets receive concentrated flows, such as in streets or highway medians.

- Filter Fabric Inlet Protection shall be designed to have an 80% design removal efficiency goal of the total suspended solids (TSS) in the inflow. The design aids located in Section 12.8.4 shall be used to properly design silt fence.

- Block and Gravel filters can be used where heavy flows and higher velocities are expected and where an overflow capacity is necessary to prevent excessive ponding around the structure.

- Block and Gravel Inlet Protection shall be designed to have an 80% design removal efficiency goal of the total suspended solids (TSS) in the inflow. The design aids located in Section 12.8.3 shall be used to properly design rock ditch checks.

- Gravel and Mesh filters can be used where heavy concentrated flows are expected and subject to disturbance by site traffic. Gravel and Mesh filters should not be used where ponding around the structure might cause excessive inconvenience or damage to adjacent structures and unprotected areas. Gravel and Mesh filters have no overflow mechanism; therefore ponding is likely, especially if sediment is not removed regularly. Gravel and Mesh filters must never be used where overflow may endanger an exposed fill slope.

- Gravel and Mesh filters shall be designed to have an 80% design removal efficiency goal of the total suspended solids (TSS) in the inflow. The design aids located in Section 12.8.4 shall be used to properly design silt fence.

- Stone Bag Inlet Protection is used when **stormwater** flows are relatively small (0.5 cfs or less) with low velocities and where the inlet drains a relatively flat area (slopes no greater than 5%). The immediate land area around the inlet should be relatively flat (less than 1% slope).

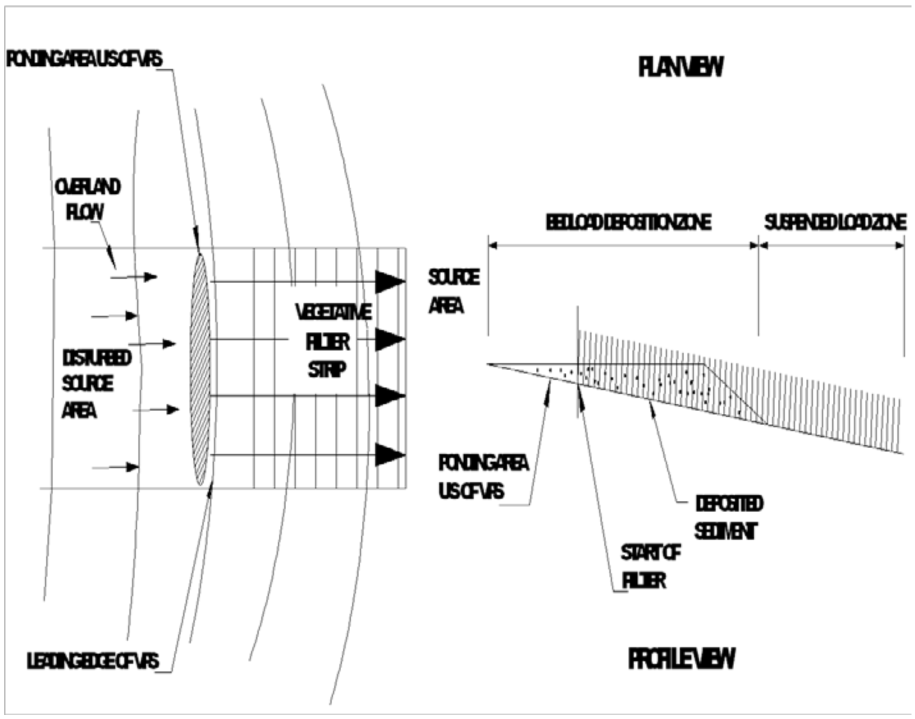
- Stone Bag Inlet Protection shall be designed to have an 80% design removal efficiency goal of the total suspended solids (TSS) in the inflow. The design aids located in Section 12.8.4 shall be used to properly design silt fence.

MAINTENANCE

- **Inspect storm drain inlet protections periodically and after every rain event to check for damage caused by large flows and clogged fabric. Repair or replace as necessary.**
- **Remove sediment when depth exceeds one-third the height of the filter or half the depth of the sediment trap.**

	• **Inlet protection should be removed and the area restored once the contributing watershed has been permanently stabilized.**
LIMITATIONS	• **Some types of inlet protection may cause ponding that could encroach onto access roads, streets, parking lots, driveways or highway traffic.**

12.6.9 VEGETATED FILTER STRIPS SCM-9: VFS



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VFS VFS

Slope Protection	**Waterway Protection**	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Vegetated **f**ilter **s**trips (VFS) are zones of vegetation through which sediment and pollutant-laden runoff are directed before being discharged to a concentrated flow channel. Proper orientation of VFS is shown in Exhibit 12-10 in Supplemental Section D.

APPLICATION

- **Often used in conjunction with other stormwater management practices to reduce the amount of sediment and treat runoff from impervious surfaces.**

APPROACH

In the design of VFS, the designer must select a vegetation type, a ground slope, filter strip width, and strip length. To be effective, VFS should be located on the contour perpendicular to the general direction of flow. Vegetation should be selected to be dense, turf-forming grass in order to minimize water channelization. The designer should never assume that natural vegetation is adequate for VFS. A ponding area shall be constructed at the leading edge of the VFS for bedload deposition.

The design process for VFS requires a series of detailed equations found in Design Hydrology and Sedimentology for Small Catchments, Hann et. al. 1994: pages 359-375. Software packages such as SEDIMOTII, or SEDCAD should be utilized to determine trapping efficiencies for VFS.

- The General Design Criteria to Design Filter Length are:
  a) Select a vegetation type.
  b) Select the design life and maximum allowable sediment deposition. A

design life of 10 years and deposition of 0.5 feet is recommended.

c) Estimate the long-term sediment yield entering the filter strip and a 10-year 24-hour design single-storm sediment yield.

d) Determine desired Trapping Efficiency- 80% design removal efficiency is the goal of the total suspended solids (TSS) in the inflow.

e) Estimate the filter length necessary to prevent deposition within the filter greater than 0.5 feet. (Assume filter width is equal to disturbed area width but no smaller than 15 ft.)

f) Use the filter length to calculate Trapping Efficiency for the design storm.

g) Repeat (d) and (e) until **the filter length achieves appropriate removal efficiency.**

- Minimum Ground Slope = 1%
- Maximum Ground Slope =10%

MAINTENANCE

- **Inspect periodically and after significant rain events until vegetation is established. Repair or replace damaged vegetation or eroded areas.**
- **Vegetation should not be mowed shorter than three inches.**

LIMITATIONS

- **Vegetated filter strips only treat sheet flow and are effective only on gentle slopes.**
- **Proper maintenance is required to maintain the health and density of vegetation.**
- **Filter strips typically require a large amount of space.**

12.7 RUNOFF CONTROL AND CONVEYANCE MEASURES

The following flow control measures are applicable as temporary and/or permanent practices for use during construction.

12.7.1 PIPE SLOPE DRAINS RC&CM-1: PSD

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PSD PSD PSD

Slope Protection	Waterway Protection	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties

DESCRIPTION

Pipe slope drains reduce the risk of erosion by discharging concentrated runoff from the top to the bottom of slopes. Pipe slope drains can be temporary or permanent depending on installation and material used. A typical pipe slope drain layout is shown in Exhibit 12-11 in Supplemental Section D of this chapter.

Temporary pipe slope drains, usually flexible tubing or conduit, may be installed prior to construction of permanent drainage structures. Permanent slope drains shall be buried beneath the ground surface. The inlets and outlets of a pipe slope drain shall be stabilized with flared end sections, Erosion Control Blankets (ECBs), Turf Reinforcement Mats (TRMs) or riprap. The soil around the pipe entrance should be fully compacted to prevent bypassing and undercutting of the structure. The soil at the discharge end of the pipe should be stabilized along the bottom of any swales that lead to sediment trapping structures or other stabilized areas.

APPLICATION

- Pipe slope drains are used when it is necessary for water to flow down a slope without causing erosion, especially before a slope has been stabilized or before permanent drainage structures are installed.

APPROACH

- The capacity should handle a 10-year, 24-hour storm peak flow.
- The maximum drainage area allowed per pipe is 2 acres.

- The inlet section should be securely connected to the slope drain and have watertight connecting bands.
- Slope drains sections should be securely fastened together, have **watertight** gasket fittings, and be securely anchored properly into the soil.
- Diversion channels should direct runoff to slope drains. The height of the dike should be at least 1-foot higher than the top of the inlet pipe and be compacted around the pipe with an anti-seep device.
- The area below the outlet must be properly stabilized with ECBs, TRMs, riprap or other applicable stabilization technique.
- If the pipe slope drain is conveying sediment-laden water, direct all flows into the sediment trapping facility.

Permanent slope drains should be buried beneath the soil surface a minimum 1.5 feet.

MAINTENANCE

- **Inspect periodically and after each rain event. Remove sediment buildup and debris from inlets and outlets as necessary.**
- **Inspect outlet for erosion and downstream scour. Repair damage as necessary.**
- **Install energy dissipaters if appropriate.**

LIMITATIONS

- **Severe erosion may result when downdrains fail.**
- **Should not be used in drainages exceeding 2 acres.**

12.7.2 TEMPORARY STREAM CROSSING RC&CM-2: TSC

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TSC

Slope Protection	**Waterway Protection**	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

A temporary stream crossing is a bridge or culvert across a stream or watercourse for short-term use by construction vehicles and heavy equipment. A stream crossing provides a means for construction vehicles to cross streams or watercourses without moving sediment to streams, damaging the streambed or channel, or causing flooding. A typical layout for a temporary stream low water crossing is shown in Standard Drawing ER-02-**02**.

APPLICATION

- **Any area where construction vehicles must cross a stream or watercourse.**

APPROACH

Prior to constructing a temporary stream crossing, the owner/person financially responsible for the project must submit an Application for Permit to Construct Across or Along a Stream to the Kentucky Division of Water (KDOW). Temporary stream crossings require a Section 404 Permit from the Army Corps of Engineers that is subject to Section 401 Water Quality Certification from KDOW. If the crossing creates more than 200 linear feet of fill or more than 1/3 acre of fill, an Individual Permit may be necessary instead of a Nationwide Permit. A copy of **the Army Corps of Engineers** permit needs to be submitted with the proposed construction plans prior to receiving construction approval.

When feasible, one should always attempt to minimize or eliminate the need to cross streams. Temporary stream crossings are a direct source of pollution; therefore, every effort should be made to use an alternate method (e.g., longer detour), when feasible. When it becomes necessary to cross a stream, a well-planned approach will minimize the damage to the stream bank and reduce erosion. The design of temporary stream crossings requires knowledge of the design flows and other information; therefore, the services of a professional engineer to deal with specific state and local requirements should be considered. The specific loads and the stream conditions will dictate what types of stream crossing to employ.

Design Criteria

Temporary Bridge Crossing

- Structures may be designed in various configurations. However, the materials used to construct the bridge must be able to withstand the anticipated heavy loading of the construction traffic.

- Crossing Alignment - The temporary waterway crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15^{o} from a line drawn perpendicular to the centerline of the stream at the intended crossing location. However, every effort shall be taken to install the crossing perpendicular to the stream. All fill materials associated with the roadway approach shall be limited to a maximum height of two feet above the existing **floodplain** elevation.

- A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. The flow captured in these dikes and swales shall be directed to a sediment trapping structure. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

- Appropriate perimeter controls such as silt fences, must be employed when necessary along banks of stream parallel to the same.

- All crossings shall have one traffic lane. The minimum width shall be 12 feet with a maximum width of 20 feet.

Temporary Culvert Crossing

- Limit the width of fill to that only necessary for the actual crossing.

- Where culverts are installed, coarse aggregate of clean shot limestone rock, riprap, and/or concrete with **#57** stone or greater will be used to form the crossing.

- Clean shot rock and/or riprap may be used as fill for crossings that will be in place for 6 to 12 months. A concrete cap shall be constructed over the rock for crossings that will be in place for more than 12 months.

- The depth of stone cover over the culvert shall be equal to ½ the diameter of the culvert or 12 inches; whichever is greater, but no greater than 18 inches. To protect the sides of the stone from erosion, riprap shall be used.

- The culvert crossing shall be large enough to convey the flow from a two-year frequency storm without appreciably altering the stream flow characteristics. A qualified professional must design the structure.

- The maximum number of pipes as possible should be placed within the stream banks with a maximum spacing of 12 inches between pipes.

- The minimum-sized pipe culvert that may be used is 24 inches.

- All culverts shall be strong enough to support their cross-sectional area under the maximum expected heavy equipment loads.

- The length of the culvert shall be adequate to extend the full width of the crossing, including side slopes.

- The slope of the culvert shall be at least 0.25 feet per foot.

- Crossing Alignment – A temporary culvert crossing shall be at right angles to the stream. Where approach conditions dictate, the crossing may vary 15^{o} from a line drawn perpendicular to the centerline of the stream at the intended crossing location. However every effort shall be taken to install the crossing perpendicular to the stream. All fill materials associated with the roadway approach shall be limited to a maximum height of two feet above the existing **floodplain** elevation.

- The approaches to the structure shall consist of stone pads meeting the following specifications:

    1. Clean stone or concrete fill only
    2. Minimum thickness: 6-inches
    3. Minimum width: equal to the width of the structure
    4. 20-foot minimum approach length

- A water diverting structure such as a dike or swale shall be constructed (across the roadway on both roadway approaches) 50 feet (maximum) on either side of the waterway crossing. This will prevent roadway surface runoff from directly entering the waterway. The 50 feet is measured from the top of the waterway bank. The flow captured in these dikes and swales shall be directed to a sediment trapping structure. If the roadway approach is constructed with a reverse grade away from the waterway, a separate diverting structure is not required.

A temporary culvert crossing should be in place no longer than 24 months.

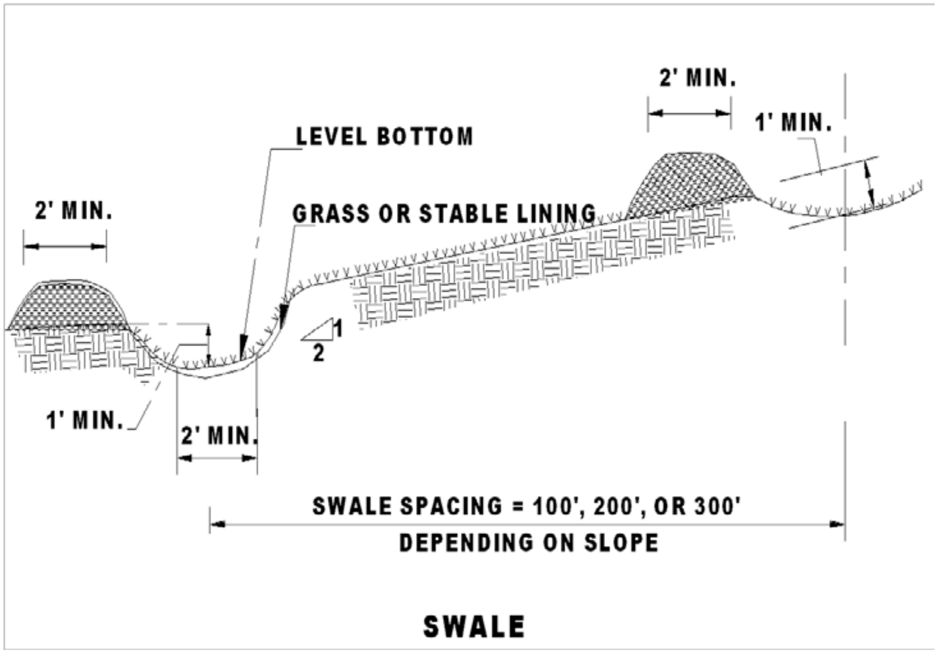
MAINTENANCE

- **Inspect every seven days and after each rain event that produces 0.5 inches or more precipitation and repair any eroded areas immediately.**
- **The crossing should be removed immediately after construction. The stream bed and banks must be stabilized and restored to pre-construction conditions.**

12.7.2 TEMPORARY STREAM CROSSING RC&CM-2: TSC

LIMITATIONS	• **Temporary stream crossings may increase velocity of flows within the channel in excess of those normally encountered, resulting in stream bed and bank scour.** • **Crossings require coordination with the U.S. Army Corps of Engineers and the Kentucky Division of Water.**

12.7.3 RUNOFF CONVEYANCE MEASURES RC&CM-3: RCM



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RCM RCM RCM

Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	Large Flat Areas	**Borrow Areas**	**Adjacent Properties**

DESCRIPTION

Dikes and berms and swales are used to divert upslope runoff from crossing areas where there is a high risk of erosion. Runoff conveyance structures may be used as temporary clean water diversions, temporary sediment-laden **water** diversions, or permanent clean water diversions. Runoff conveyance measures can be either temporary or permanent **stormwater** control structures. Typical cross sections for dikes and swales are shown in Exhibit 12-12 in Supplemental Section D.

When constructed along the upslope perimeter of a disturbed or high-risk area (though not necessarily all the way around it), clean water diversions prevent clear water runoff from flowing over unprotected **downslope** areas. Sediment-laden diversions located on the downslope side of a disturbed or high-risk area will prevent sediment-laden runoff from leaving the site before sediment is properly removed. For short slopes, runoff conveyance measures at the top of the slope reduce the amount of runoff reaching the disturbed area. For longer slopes, several dikes or swales are placed across the slope at intervals. This practice reduces the amount of runoff that accumulates on the face of the slope and carries the runoff safely down the slope. In all cases, runoff is guided to sediment trapping areas or a stabilized outfall before release.

APPLICATION

- Runoff conveyance measures are generally built around the perimeter of a construction site before any major disturbing activity takes place.
- Runoff conveyance measures are used in areas of overland flow.
- Convey stormwater to sediment trapping area.
- Convey clean stormwater around construction areas.

- Convey clean stormwater around construction areas.

APPROACH

Runoff channeled by dikes or swales should be directed to an adequate sediment trapping structure or stabilized outfall. Care should be taken to provide enough channel slope for drainage but not too much slope to cause erosion due to high runoff flow speed. Temporary runoff conveyance measures may remain in place as long as 12 to 18 months (with proper stabilization). Dikes or swales should remain in place until the area they were built to protect is permanently stabilized.

Permanent controls should be designed to handle runoff after construction is complete; should be permanently stabilized; and should be inspected and maintained on a regular basis. Refer to Chapter 10 for temporary and permanent diversion channel stabilization requirements. **Examples of runoff conveyance measures include: grass-lined channels, sod-lined channels, riprap-lined channels, turf reinforced channels, paved channels, and temporary slope drains.**

Dikes and Berms

- Top Width - 2 foot minimum
- Height - 18” minimum measured from upslope toe.
- Side Slopes - 2H:1V or flatter
- Grade - Limited to grades between 0.5% and 1.0%.
- Spacing

Percent Slope	< 5%	5% - 10%	10% - 40%
Horizontal Spacing (ft)	300	200	100

- Stabilization - Slopes shall be stabilized immediately using vegetation, sod, erosion control blankets, or turf reinforcement mats to prevent erosion.
- Outlet - The upslope side of the dike should provide positive drainage so no erosion occurs at the outlet. Provide energy dissipation measures as necessary. Sediment-laden runoff must be released through a sediment trapping facility.
- Other - Minimize construction traffic over temporary dikes.

Swales

- Bottom Width - 2 feet minimum, the bottom should be level.
- Depth - 1-foot minimum.
- Side Slope - 2H:1V or flatter.
- Grade - Maximum 5%, with positive drainage to a suitable outlet.
- Stabilization - Stabilize with erosion control blankets or turf reinforcement mats immediately.

- Spacing

Percent Slope	< 5%	5% - 10%	10% - 40%
Horizontal Spacing (ft)	300	200	100

- Outlet - riprap to stabilize outlet/sedimentation pond.

MAINTENANCE

- **Inspect periodically and after every rain event to check for erosion and accumulation of debris and sediment. Remove debris and sediment buildup as necessary.**
- **Any decrease in the berm height due to settling or erosion should be repaired immediately.**

LIMITATIONS

- **Severe erosion may result when dikes, berms or swales become unstable or or not installed properly.**
- **Concentrated flow within conveyance increases the potential for erosion.**
- **Conveyance should be designed to avoid vehicular crossings.**

12.7.4 CONSTRUCTION DEWATERING RC&CM-4: CD

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Slope Protection	**Waterway Protection**	Surface Protection	**Enclosed Drainage**	**Large Flat Areas**	**Borrow Areas**	Adjacent Properties

DESCRIPTION

Construction dewatering involves removing stormwater or groundwater from bore pits, trenches, and other excavations on the construction site. Usually this removal involves the pumping of this water to an appropriate receiving area. Direct pumping to lakes and streams **is illegal** and must be avoided.

APPLICATION

- **Removal of stormwater or groundwater from bore pits, trenches, and other excavations on the construction site.**

APPROACH

The pump utilized for dewatering purposes must be properly sized. Each pump has its own unique rating curve; therefore it is not feasible to list them in this chapter. The pump rating curve is used to calculate pump design flows based on head loss through the pump system.

The sediment-laden groundwater should be pumped directly to:

- A sediment control structure (i.e., sediment basin or sediment trap);
- An infiltration trench; or
- A vegetated buffer strip or zone.

Pumping to a Sediment Control Structure:

- It is recommended that sediment basins or temporary sediment traps receive sediment-laden water from bore pits and trenches. This will ensure that the 80% trapping efficiency goal will be upheld. Special care should be taken to ensure that the pumping of this water does not cause the sediment control structure to fail. Also, care should be taken at the outlet of the hose from the pump to ensure that erosion does not occur due to high concentrated flows.

Pumping to an Infiltration Trench:

- An infiltration trench is a shallow, excavated trench back-filled with stone to form a reservoir. This reservoir may contain a subsurface drainage pipe or just stone. This trench allows water to filter through the stone and then be diverted to a suitable discharge point. The soils and the depth to the water table must be suitable for this sort of **dewatering.** Typical trench depths range from 2 to 8 feet. The stone fill material consists of washed aggregate 1.5 to 3 inches in diameter.

Pumping to a Vegetated Buffer Strip or Zone:

- Buffer zones are capable of filtering sediment-laden water. One option is to pump the water to a discharge device that will evenly spread the water over a wooded or vegetated buffer zone. An appropriate buffer zone can be determined from Section 12.6.9.

- A plan and profile for dewatering operations with pumping to a vegetated buffer zone is provided in Exhibit 12-13 in Supplemental Section D.

A detail for an outlet structure to the buffer zone is provided in Exhibit 12-14 in Supplemental Section D. This discharge device uses Schedule 40 PVC pipes. The discharge hose from the pump is connected to a flow diffuser constructed using PVC pipe. The diffuser pipes are capped at the ends and the water is discharged through evenly spaced holes drilled into the diffuser. The size and length of the diffuser and the size and spacing of the holes are dependent upon the flow capacity of the pump being used for the **dewatering** process. The **Exhibit provides** recommended pipe sizes, pipe lengths, hole sizes, and hole spacing are based on pump discharge rates for pumps of 5 HP and less.

MAINTENANCE

- **Inspect receiving area frequently to ensure capacity is not exceeded.**

LIMITATIONS

- **If the presence of polluted water is identified, the contractor shall implement appropriate dewatering pollution controls.**

12.7.5 STONE BAG CHECK DAM IN SMALL DITCH — RC&CM-6: SBCD

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Slope Protection	**Waterway Protection**	**Surface Protection**	Enclosed Drainage	Large Flat Areas	Borrow Areas	**Adjacent Properties**

DESCRIPTION

Stone **b**ag **c**heck **d**ams can reduce flow velocities in small man-made swales and ditches, which reduces the erosive potential of the flow and also promotes sediment deposition. A typical layout for a **s**tone **b**ag **c**heck **d**am in a small ditch is shown in Standard Drawing EF-12-**02**.

APPLICATION

- Stone **b**ag **c**heck **d**ams are to be placed in front and rear yard swales only. Stone bag check dams should not be built in wetlands, any active or live streams, and in Waters of the Commonwealth.
- Stone bag check dams are applicable in situations where flow velocities are too high **and are causing** channel scour. They should not be used as a primary sediment-trapping device. They should be used as velocity checks only as a short-term temporary solution.
- Specific conditions for use include new diversion ditches that will not or cannot be stabilized for several days, and temporary diversion channels that are eroding due to high flow rates or steep slopes.

APPROACH

The bags shall be filled with KTC No. 57 stone. The dam shall span the banks of the ditch or swale. The height of the dam on the stream centerline should equal the height of flow for the 2-year 24-hour storm event. Bags should be placed on the bank to a height at least 6 inches higher than the center of the dam.

12.7.5 STONE BAG CHECK DAM IN SMALL DITCH — RC&CM-6: SBCD

Space **s**tone **b**ag **c**heck **d**ams such that the crest of the downstream dam is at the same elevation of the toe of the dam located immediately upstream. Show the designed spacing on the EPSC plans.

MAINTENANCE

- **Inspect every 7 days and after each rain event that produces 0.5 inch or more precipitation to check for excessive sedimentation or debris and trash buildup.**
- **Remove sediment, debris and trash before it reaches one-half of the device's original height.**
- **Loose or displaced stone bags should be repaired to the original specifications or replaced.**

LIMITATIONS

- **Not to be used in streams or rivers.**

12.8 ENGINEERING AIDS AND DESIGN GUIDELINES FOR SEDIMENT CONTROLS

This section presents design aids that were developed for use in designing four types of sediment control structures; temporary sediment basins (Section 12.6.2), temporary sediment traps (Section 12.6.4), silt fences (Section 12.6.5), and rock ditch checks (Section 12.6.6) for Jefferson County, Kentucky. These design aids will each be briefly described and then examples will be used to demonstrate their use in realistic problems. Settling velocity will be discussed to begin.

12.8.1 Characteristic Settling Velocity and Eroded Particle Size

A common feature of each of the design aids is that a characteristic settling velocity for the eroded soil must be obtained. For Jefferson County conditions, this velocity corresponds to an eroded size such that 15% of the sediment has particles smaller than the size specified. The procedure for empirically estimating eroded size distributions is best described by Hayes et.al (1996). Characteristic settling velocity corresponds to an eroded particle diameter that is referred to as D_{15}. This diameter represents the point on the eroded particle size distribution curve where 15% of the particles (by weight) are equal to or smaller than this size. Estimated eroded size distributions for Jefferson County soils using an adaptation of the method described by Foster et al. (1985) were developed. The procedure uses the primary particle size information reported by SCS as part of county soil surveys. This procedure may be used with USDA Soil Survey Data or site specific soil boring data. Other procedures are given by Haan et.al. (1994) for physically based estimating procedures. If D_{15} is less than 0.01 mm, then settling velocity based upon a simplified form of Stokes Law is:

$$\mathbf{V_s = 2.81d^2} \qquad (1)$$

Where: V_s is settling velocity in ft/sec and d is diameter in mm. If D_{15} is greater than or equal to 0.01 mm, then settling velocity should be found using

$$\mathbf{\log_{10}V_s = -0.34246\,(\log_{10}d)^2 + 0.98912\,(\log_{10}d) - 0.33801} \qquad (2)$$

Where: V_s, is settling velocity in ft/sec and d is particle diameter in mm (Wilson et al., 1982). The characteristic settling velocity can be obtained using Figure 12.1 and the eroded particle size (D_{15}) for soils found in Jefferson County, which is provided in Supplemental Section D.

It is important to remember that the eroded size distribution is the most critical parameter in sizing sediment controls. The eroded size distributions vary greatly from primary particle size distributions that are often determined as a result of soil strength investigations for construction purposes. Primary particle sizes will yield erroneous results and should not be used. The user should note that D_{15} is often smaller for coarse textured (more sandy soils) because of the reduced clay content and the lack of aggregation.

Table 12-7. Soil Classification by Texture

Jefferson County Soil Classification by General Texture			
Texture	Coarse	Medium	Fine
Soil Type	Sandy Loam	Silt Loam	Clay Loam

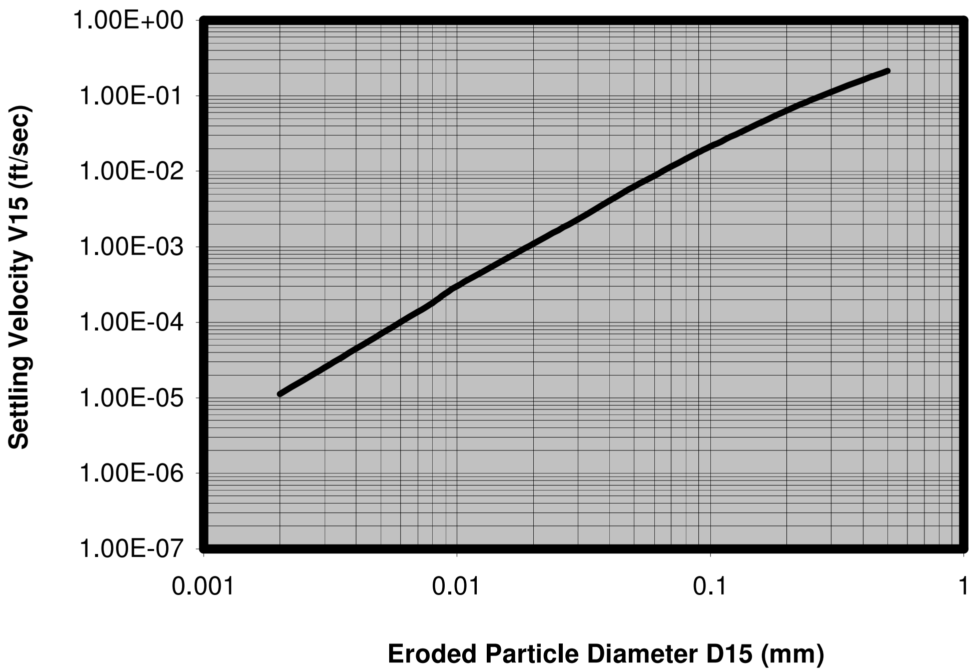


Figure 12.1. Characteristic Settling Velocity as a Function of Eroded Particle Diameter

12.8.2 Sediment Basin Design Aids

Figure 12.2 plots the basin ratio (qpo/AV_{15}) versus percentage of trapping efficiency. For basins, the ratio is defined by:

$$\textbf{Basin Ratio} = q_{po}/AV_{15} \qquad (3)$$

Where: q_{po} = peak outflow rate from the basin (cfs), A =surface area of the pond at riser crest (acres), V_{15} = (from Figure 12.1) characteristic settling velocity (fps), of the characteristic D_{15} eroded particle (mm).

Figure 12.2 is for soils classed as either coarse (sandy loam), medium (silt loam), or fine (clay loam) as shown in Table 12-8. The ratio should be less than or equal to the curve value at any given trapping efficiency. For example, at 80% trapping efficiency, the basin ratio equals 2.0E**+0**5 as shown in Figure 12.2. If the basin ratio q_{po}/AV_{15} intersects the curve at a point having a trapping efficiency less than the desired value, the design is inadequate and must be revised.

Basin Ratios above the design curves are not recommended for any application of the design aids. Constraints for use of Figure 12.2 are:

- Watershed area less than or equal to 30 acres
- Overland slope less than or equal to 20 %
- Outlet diameter less than or equal to 6 feet

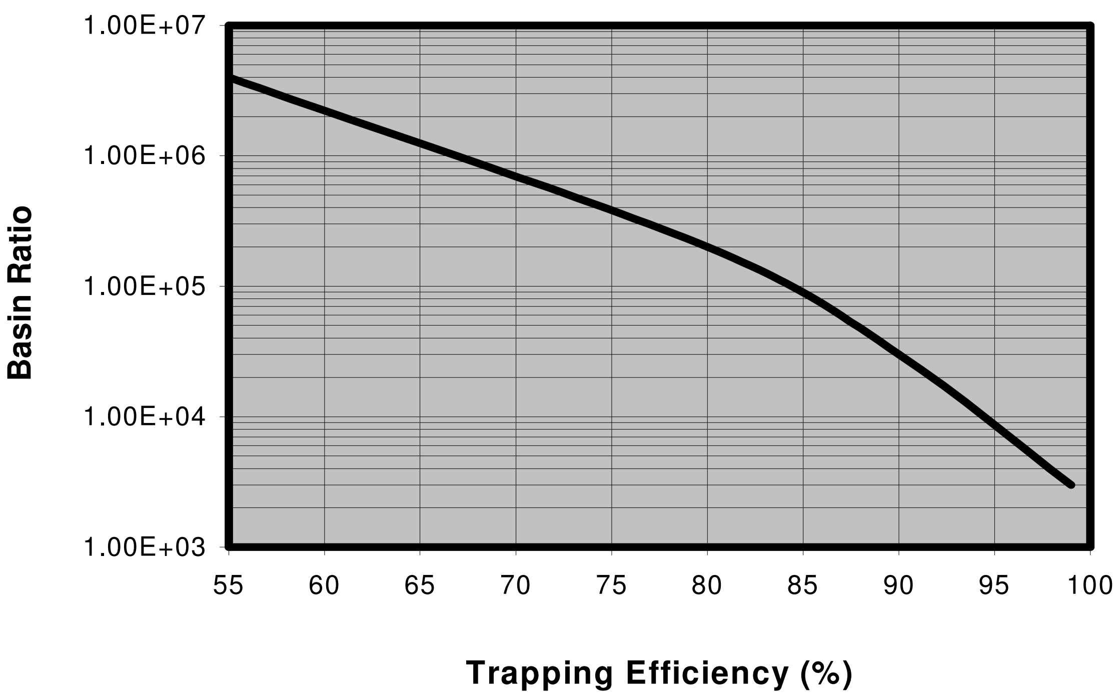


Figure 12.2. Design Aid for Estimating Trapping Efficiency of Sediment Basins.

12.8.3 Rock Ditch Check Design Aids

Design aids for rock ditch checks were developed similarly to those for **basins.** Again, the D_{15} eroded particle size is used for the calculation of the characteristic settling velocity. The ratio for ditch checks is defined by:

$$\textbf{Ditch Check Ratio} = Sq^{(1-b)}/aV_{15} \qquad (4)$$

Where: S = channel slope (%),
q = flow through the check (cfs/ft),
V_{15} = (from Figure 12.1) characteristic settling velocity (fps), of the characteristic D_{15} eroded particle (mm).

Table 12-8. Stone Flow Coefficient a and Exponent b

Stone D_{50} (m)	Exponent b	dl= 1m Coefficient a	dl = 2m Coefficient a	dl = 3m Coefficient a
0.01	0.6371	9.40	6.05	4.60
0.02	0.6540	7.40	4.65	3.55
0.03	0.6589	6.40	4.08	3.08
0.04	0.6609	5.85	3.65	2.80
0.05	0.6624	5.40	3.35	2.60
0.06	0.6635	5.05	3.15	2.40
0.08	0.6644	4.50	2.85	2.20
0.09	0.6648	4.28	2.70	2.10
0.10	0.6651	4.13	2.60	2.05
0.20	0.6662	3.20	2.05	1.57
0.30	0.6664	2.80	1.75	1.30
0.40	0.6665	2.50	1.55	1.16
0.50	0.6666	2.30	1.40	1.08

Coefficients *a* and Exponent *b* can be interpolated from Table 12-8 (Haan et.al. (1994) pg. 151).
D_{50} = rock ditch check average stone diameter in **meters**.
dl = average flow length through the rock ditch check in **meters**.

If the check overtops, the trapping efficiency is assumed to be zero. Figures 12.3a, 12.3b, and 12.3c can be used for estimating trapping efficiency of rock ditch checks. Table 12-8 provides guidance to determine which plot is appropriate.

Ditch Check Ratios above the design curves are not recommended for any application of the design aids. Constraints for the use of Figures 12.3a, 12.3b, and 12.3c are:

- Watershed area is less than or equal to 5 acres
- Overland flow length is less than or equal to 500 feet
- Overland slope is less than or equal to 15 %

Figure 12.3a. **Design Aid for Estimating Trapping Efficiency of Rock Ditch Checks with Fine Texture Soils.**

Figure 12.3b. Design Aid for Estimating Trapping Efficiency of Rock Ditch Checks with Medium Texture Soils.

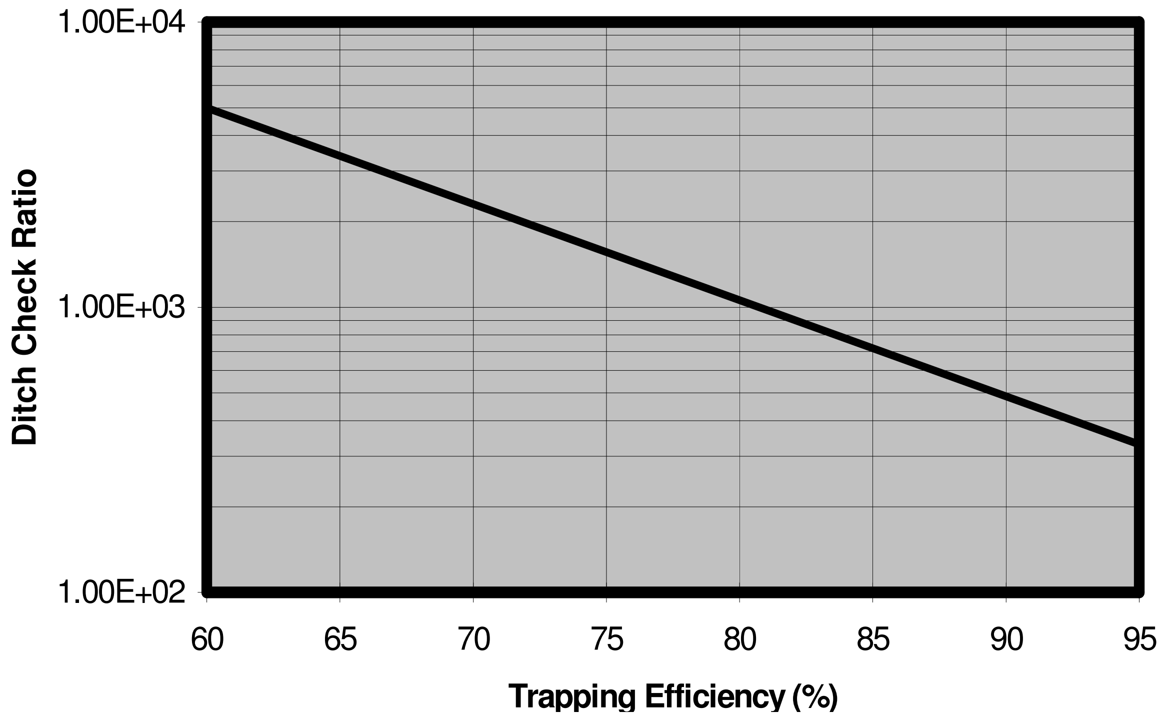


Figure 12.3c. Design Aid for Estimating Trapping Efficiency of Rock Ditch Checks with Coarse Texture Soils.

12.8.4 Silt Fence Design Aids

The design aid for silt fences applies to silt fence placed in areas down slope from a disturbed area where it serves to retard flow and cause settling. Two conditions must be met for a satisfactory design.

- Trapping efficiency must meet the desired level of control.
- Overtopping of the fence must not occur.

One of the most important considerations in silt fence design is to specify regular maintenance. The silt fence design aid is a single line grouping all soil textures together. A similar procedure was used for development of the ratio as used for the **basins** and rock checks. For the silt fence, the ratio is:

$$\textit{Silt Fence Ratio} = q_{po}/V_{15}P_{area} \qquad (5)$$

Where:

q_{po} = peak outflow through the fence (cfs),
V_{15} = (from Figure 12.1) characteristic settling velocity (fps), of the characteristic D_{15} eroded particle (mm),
P_{area} = potential ponding area up slope of the fence (ft^2).

The ponded area can be estimated by using the height of the fence available for flow through and extending a horizontal line from the fence to an intersection with the ground surface upslope of the fence. This is described by the available fence height times the ground slope. Multiply this distance by the available length of fence for ponding to obtain the potential ponding area. Then calculate the ratio and enter the value to Figure 12.4 to determine the efficiency. Once an acceptable trapping efficiency is determined, a calculation for overtopping must be done. The overtopping calculation must be done using the slurry flow rate through the fence. This rate must be checked against the incoming flow to determine if enough storage exists behind the fence to prevent overtopping.

Silt Fence Ratios above the design curves are not recommended for any application of the design aids. Constraints for the use of Figure 12.4 are:

- Watershed area is less than or equal 5 acres
- Overland flow length is less than or equal to 500 feet
- Overland slope is less than or equal to 6 %
- Slurry flow rate through the fence is less than or equal to 10 gpm / ft
- Maximum height of the silt fence is less than or equal to 3 feet

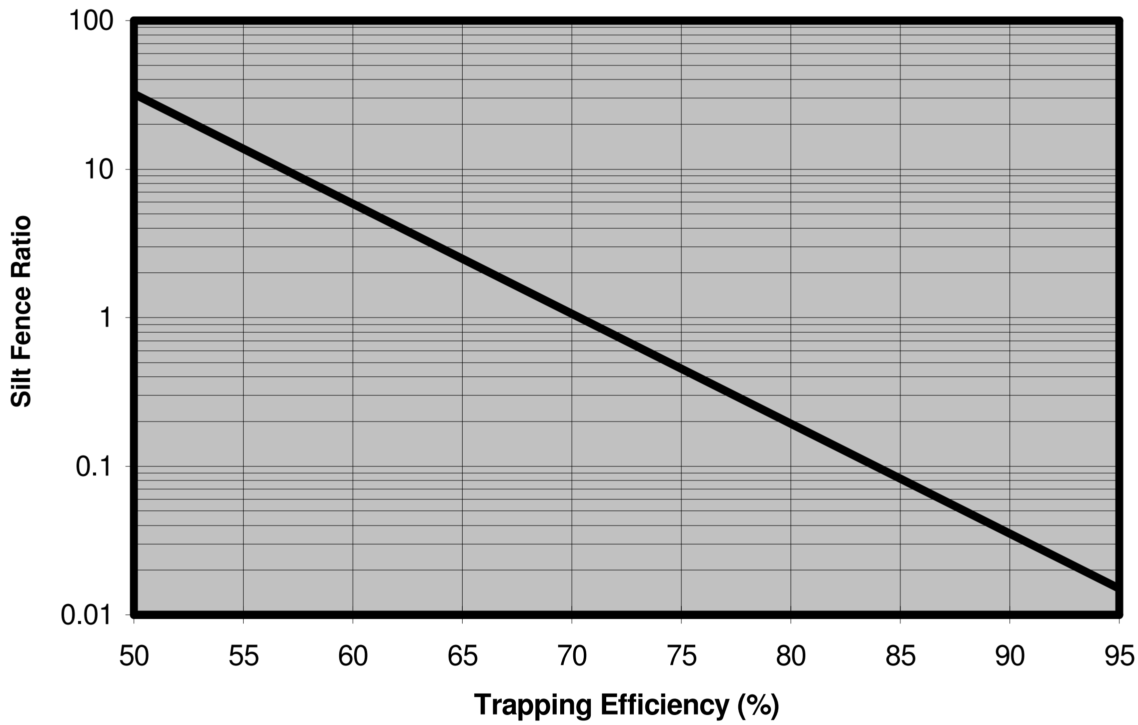


Figure 12.4. Design Aid for Estimating Trapping Efficiency of Silt Fence

12.8.5 Sediment Trap Design Aids

Sediment traps, for the purposes of this document, are small excavated **basins** with rock fill outlets. Their outlet hydraulics are different from a drop inlet structure, thus the design aid is slightly different. Trapping efficiencies for sediment traps are plotted in Figure 12.5 as a function of the sediment trap ratio:

$$Sediment\ Trap\ Ratio = q_{po}/A/V_{15} \qquad (6)$$

Where:

q_{po} = peak outflow (cfs),
A = surface area at the elevation equal to the bottom of the rock fill outlet (acres),
V_{15} = (from Figure 12.1) characteristic settling velocity (fps), of the characteristic D_{15} eroded particle (mm).

Figure 12.5 is for soils classed as either coarse (sandy loam), medium (silt loam), or fine (clay loam) as shown in Table 12-8. The ratio should be less than or equal to the curve value at any desired trapping efficiency.

Sediment Trap Ratios above the design curves are not recommended for any application of the design aids. Constraints for the use of Figure 12.5 are:

- Watershed area less than or equal to 5 acres
- Overland slope less than or equal to 20%
- Rock fill diameter greater than 0.2 ft and less than 0.6 ft.
- Rock fill height less than 5 ft.
- Top width of rock fill between 2 and 4 ft.
- Maximum Side slopes 1:1 to 1.5:1.

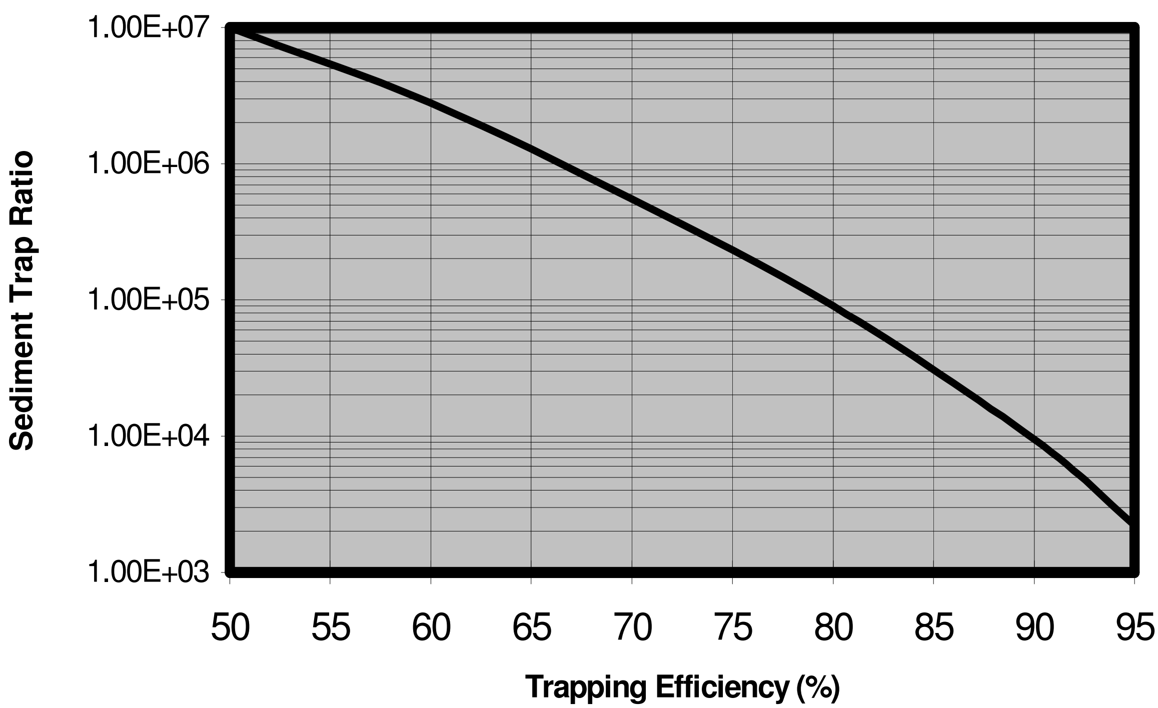


Figure 12.5. Design Aid for Estimating Trapping Efficiency of Sediment Traps.

DESIGN MANUAL CHAPTER 12

SUPPLEMENTAL SECTION A

EROSION PREVENTION & SEDIMENT CONTROL BMP SELECTION PROCESSES, SUGGESTED USES, & GUIDELINES

BMP Suggested Uses

Erosion Prevention Measures

BMP	Design Manual Section	Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties
Erosion Prevention Measures	12.5	X	*X*	X	X	X	X	X
Surface Roughening	12.5.1	X		X				
Bench Terracing	12.5.2	X		X				
Temporary Seeding	12.5.3	X		X		X	X	X
Mulching	12.5.4	X				X	X	
Erosion Control Blankets and Turf Reinforcement Mats	12.5.5	X	X	X			X	
Final Stabilization	12.5.6	X		X		X		X
Topsoiling	12.5.6.1			X		X		
Permanent Seeding and Planting of Grasses	12.5.6.2	X		X		X		X
Sodding	12.5.6.3	X		X		X		X
Riprap or Aggregate	12.5.7	X	X	X				
Outlet **Stabilization**	12.5.8		X		X			X
Dust Control	12.5.9					X	X	X

BMP SUGGESTED USES

Temporary Sediment Control Measures

BMP	Design Manual Section	Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties
Temporary Sediment Control Measures	12.6	X	X	X	X	X	X	X
Storage Volumes and Maintenance Schedules	12.6.1		X		X			X
Temporary Sediment Basin	12.6.2		X	X	X			X
Multipurpose Basin	12.6.3		X	X	.X			X
Temporary Sediment Trap	12.6.4		X	X				X
Silt Fence	12.6.5	X	X					X
Rock Ditch Check	12.6.6			X				X
Stabilized Construction Entrance	12.6.7					X		X
Storm Drain Inlet Protection	12.6.8		X		X			X
Vegetated Filter Strips	12.6.9		X					X

BMP SUGGESTED USES

Runoff Control and Conveyance Measures

BMP	Design Manual Section	Slope Protection	Waterway Protection	Surface Protection	Enclosed Drainage	Large Flat Areas	Borrow Areas	Adjacent Properties
Pipe Slope Drains	12.7.1	X		X				
Temporary Stream Crossing	12.7.2		X	X				X
Runoff Conveyance Measures	12.7.3	X					X	X
Construction Dewatering	12.7.4		X		X	X	X	
Stone Bag Check Dam in Small Ditch	12.7.**5**		X	X				X

DESIGN MANUAL CHAPTER 12

SUPPLEMENTAL SECTION B

JEFFERSON COUNTY RAINFALL & UNIVERSAL SOIL LOSS EQUATION INFORMATION

Rainfall Data

Table 1. Distribution of Rainfall Erosion Index (EI Curves) for Jefferson County

Date	EI Curve Number
January 1	0.0
January 15	1.0
February 1	3.0
February 15	6.0
March 1	9.0
March 15	12.0
April 1	16.0
April 15	21.0
May 1	26.0
May 15	31.0
June 1	37.0
June 15	43.0
July 1	50.0
July 15	57.0
August 1	64.0
August 15	71.0
September 1	77.0
September 15	81.0
October 1	85.0
October 15	88.0
November 1	91.0
November 15	93.0
December 1	95.0
December 15	97.0
January 1	100.0

Minimum Value to be used is 50
Average Annual R Factor = 175

Table 2. Universal Soil Loss Equation CP Factors

Condition	CP Factor
Bare Soil	1.0
Compacted Root Raked Soil	1.2
Compacted Bulldozer Scraped Soil	1.2
Fresh Unprepared Seedbed	0.64
Temporary Seeding 0-60 Days	0.40
Temporary Seeding After 60 Days	0.05
Permanent Seeding 2-12 Months	0.05
Brush	0.35
Erosion Control Blankets	0.01-0.10

Table 3. Universal Soil Loss Equation LS Factors

% Slope	Slope Length in Feet																	
	20	50	75	100	120	150	200	250	300	350	400	450	500	600	700	800	900	1000
0.5	0.1	0.1	0.1	0.1	0.1	0.1	0.11	0.114	0.12	0.12	0.13	0.13	0.13	0.137	0.141	0.145	0.148	0.152
1.0	0.1	0.11	0.12	0.13	0.14	0.14	0.15	0.15	0.17	0.18	0.19	0.20	0.20	0.22	0.23	0.24	0.25	0.25
2.0	0.12	0.16	0.18	0.20	0.21	0.22	0.24	0.26	0.27	0.29	0.0	0.31	0.32	0.34	0.36	0.37	0.38	0.40
3.0	0.17	0.23	0.26	0.28	0.30	0.32	0.35	0.37	0.38	0.41	0.43	0.45	0.46	0.49	0.51	0.53	0.55	0.57
4.0	0.21	0.30	0.35	0.40	0.43	0.47	0.52	0.57	0.62	0.66	0.69	0.73	0.76	0.81	0.87	0.91	0.96	1.00
5.0	0.23	0.37	0.46	0.53	0.58	0.65	0.75	0.84	0.92	1.00	1.07	1.13	1.19	1.31	1.41	1.51	1.60	1.69
6.0	0.30	0.47	0.58	0.67	0.73	0.82	0.95	1.06	1.16	1.25	1.34	1.42	1.50	1.64	1.78	1.90	2.01	2.12
7.0	0.36	0.58	0.71	0.82	0.90	1.01	1.16	1.30	1.42	1.54	1.65	1.75	1.84	2.02	2.18	2.33	2.47	2.60
8.0	0.44	0.70	0.85	0.99	1.08	1.21	1.40	1.56	1.71	1.85	1.98	2.10	2.21	2.42	2.62	2.80	2.97	3.13
9.0	0.52	0.82	1.01	1.17	1.28	1.43	1.65	1.85	2.03	2.19	2.34	2.48	2.62	2.87	3.10	3.31	3.52	3.71
10.0	0.61	0.96	1.18	1.36	1.50	1.67	1.93	2.16	2.37	2.56	2.74	2.90	3.06	3.35	3.62	3.87	4.10	4.33
11.0	0.70	1.11	1.36	1.58	1.73	1.93	2.23	2.49	2.73	2.95	3.16	3.35	3.53	3.87	4.18	4.46	4.74	4.99
12.0	0.80	1.27	1.56	1.80	1.97	2.21	2.55	2.65	3.12	3.37	3.60	3.82	4.03	4.42	4.77	5.10	5.41	5.70
13.0	0.91	1.44	1.76	2.04	2.23	2.50	2.88	3.23	3.53	3.82	4.08	4.33	4.56	5.00	5.40	5.77	6.12	6.46
14.0	1.02	1.62	1.98	2.29	2.51	2.81	3.24	3.62	3.97	4.29	4.58	4.86	5.13	5.62	6.07	6.49	6.88	7.25
15.0	1.14	1.81	2.21	2.56	2.80	3.13	3.62	4.04	4.43	4.79	5.12	5.43	5.72	6.27	6.77	7.24	7.68	8.09
16.0	1.26	2.00	2.45	2.83	3.11	3.47	4.01	4.48	4.91	5.31	5.67	6.02	6.34	6.95	7.51	8.02	8.51	8.97
17.0	1.40	2.21	2.71	3.13	3.42	3.83	4.42	4.94	5.42	5.85	6.26	6.64	7.00	7.66	8.28	8.85	9.39	9.89
18.0	1.53	2.42	2.97	3.43	3.76	4.20	4.85	5.43	5.94	6.42	6.86	7.28	7.68	8.41	9.08	9.71	10.3	10.9
19.0	1.67	2.65	3.24	3.75	4.10	4.59	5.30	5.93	6.49	7.01	7.50	7.95	8.38	9.18	9.92	10.6	11.3	11.9
20.0	1.82	2.88	3.53	4.07	4.46	4.99	5.76	6.45	7.06	7.63	8.15	8.65	9.12	10.0	10.7	11.5	12.2	12.9
25.0	2.63	4.16	5.1	5.89	6.45	7.21	8.33	9.31	10.2	11.0	11.8	12.5	13.2	14.4	15.6	16.7	17.7	18.6
33.3	4.22	6.67	8.17	9.44	10.3	11.6	13.4	14.9	16.4	17.7	18.9	20.0	21.1	23.1	25.0	26.7	28.3	29.9
40.0	5.65	8.94	8.94	12.7	13.9	15.5	17.9	20	21.9	23.7	25.3	26.8	28.3	31.0	33.5	35.8	38.0	40.0
50.0	7.97	12.6	12.6	17.8	19.5	21.8	25.2	28.2	30.9	33.3	35.6	37.8	39.9	43.7	47.2	50.4	53.5	56.4
66.6	11.9	18.9	18.9	26.7	29.2	32.7	37.7	42.2	46.2	49.9	53.3	56.6	59.6	65.3	70.5	75.4	80.0	84.3
100.0	18.9	29.9	29.9	42.2	46.3	51.7	59.7	66.8	73.2	79.0	84.5	89.6	94.5	103.	112	120	126	134

DESIGN MANUAL CHAPTER 12

SUPPLEMENTAL SECTION C

JEFFERSON COUNTY SOIL INFORMATION

Soils Information and Eroded Size Distributions for Jefferson County, Kentucky.

PERCENT FINER FOR SPECIFIED PARTICLE DIAMETERS

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
ASHTON -HSG B										
0-9	0.32	0.0063	100.0	91.9	73.5	56.0	53.1	5.5	3.4	0.0
9-44		0.0053	100.0	91.9	73.4	64.9	62.9	8.0	5.1	0.0
44-80		0.0065	100.0	85.2	51.5	42.5	42.5	7.5	4.9	0.0
BEASLEY -HSG C										
0-7	0.43	0.0048	100.0	87.4	58.6	53.8	52.7	11.7	8.0	0.0
7-29		0.0043	100.0	85.3	51.6	48.2	47.5	13.9	9.8	0.0
29-50		0.0046	100.0	80.9	37.3	35.5	35.5	13.7	9.8	0.0
CAPTINA -HSG C										
0-9	0.43	0.0066	100.0	93.3	78.0	55.6	51.8	4.4	2.7	0.0
9-25		0.0055	100.0	89.1	64.2	57.0	56.1	8.4	5.4	0.0
25-39		0.0063	100.0	83.9	47.2	39.7	39.7	8.7	5.8	0.0
39-58		0.0079	100.0	81.5	39.1	30.3	30.3	8.5	5.8	0.0
58-80		0.0754	100.0	72.9	11.0	8.0	8.0	12.9	9.8	0.0
CORYDON -HSG D										
0-9	0.43	0.0052	100.0	87.3	58.4	53.2	52.6	9.9	6.5	0.0
9-15		0.0048	100.0	84.9	50.5	47.6	47.4	12.1	8.3	0.0
CRIDER -HSG B										
0-12	0.32	0.0054	100.0	93.1	77.4	67.1	64.4	7.3	4.6	0.0
12-38		0.0052	100.0	91.5	72.0	64.2	62.1	9.0	5.8	0.0
38-50		0.0239	100.0	75.1	18.1	15.5	15.5	13.1	9.8	0.0
50-96		0.0037	100.0	80.7	36.7	35.6	35.6	16.2	11.7	0.0
DICKSON -HSG C										
0- 7	0.43	0.0058	100.0	92.4	74.9	61.5	58.8	6.4	4.0	0.0
7-25		0.0054	100.0	92.4	75.1	65.4	63.1	7.5	4.7	0.0
25-45		0.0054	100.0	91.3	71.4	63.1	61.4	8.0	5.1	0.0
45-65		0.0052	100.0	82.1	41.3	38.6	38.6	11.8	8.3	0.0
DUNNING -HSG D										
0-15	0.37	0.0050	100.0	89.3	64.9	58.7	57.1	10.5	7.0	0.0
15-72		0.0045	100.0	83.7	46.4	44.5	44.5	13.3	9.3	0.0
ELK -HSG B										
0-9	0.37	0.0053	100.0	88.8	63.3	56.8	55.8	9.1	5.9	0.0
9-42		0.0054	100.0	91.3	71.4	63.1	61.4	8.0	5.1	0.0
42-69		0.0061	100.0	85.4	51.9	44.7	44.7	8.2	5.4	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP										
			Percent Finer Than							
DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038 (mm)	0.004	0.003	0.001
ENNIS -HSG B										
0-10	0.24	0.0083	100.0	85.6	52.7	34.7	34.6	5.7	3.6	0.0
10-60		0.0080	100.0	83.3	45.3	32.6	32.6	7.3	4.9	0.0
FAIRMOUNT -HSG D										
0-11	0.24	0.0044	100.0	83.1	44.4	43.0	43.0	13.9	9.8	0.0
11-17		0.0045	100.0	83.7	46.4	44.5	44.5	13.3	9.3	0.0
GINAT -HSG D										
0-9	0.43	0.0058	100.0	89.4	65.2	54.8	53.7	7.2	4.5	0.0
9-23		0.0054	100.0	88.3	61.7	55.4	54.6	9.0	5.8	0.0
23-48		0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
48-74		0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
74-80		0.0056	100.0	90.9	70.1	60.1	58.4	7.3	4.6	0.0
GUTHRIE -HSG D										
0-8	0.43	0.0059	100.0	94.3	81.1	64.8	60.6	5.5	3.4	0.0
8-32		0.0054	100.0	92.4	75.1	65.4	63.1	7.5	4.7	0.0
32-53		0.0055	100.0	90.4	68.6	60.2	59.0	7.8	4.9	0.0
53-68		0.0055	100.0	89.5	65.6	57.9	56.9	8.2	5.2	0.0
HOLSTON -HSG B										
0-8	0.28	0.0079	100.0	87.1	57.5	37.7	37.3	5.4	3.4	0.0
8-44		0.0071	100.0	83.7	46.3	35.9	35.9	7.7	5.2	0.0
44-75		0.0073	100.0	81.2	38.1	31.0	31.0	9.1	6.3	0.0
HUNTINGTON -HSG B										
0-11	0.32	0.0057	100.0	89.6	65.9	56.6	55.6	7.5	4.7	0.0
11-64		0.0057	100.0	89.6	65.9	56.6	55.6	7.5	4.7	0.0
64-74		0.0079	100.0	84.2	48.0	34.0	34.0	6.7	4.4	0.0
LAKIN -HSG A										
0-11	0.17	0.0379	100.0	94.8	83.0	16.1	15.0	1.2	0.8	0.0
11-60		0.0441	100.0	92.9	76.6	14.5	14.1	1.7	1.1	0.0
60-80		0.0449	100.0	97.1	90.5	10.7	9.8	0.6	0.4	0.0
LAWRENCE -HSG C										
0-10	0.43	0.0057	100.0	93.7	79.2	65.0	61.4	6.1	3.8	0.0
10-25		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
25-50		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
50-75		0.0049	100.0	87.9	60.3	55.1	53.9	11.2	7.6	0.0
LINDSIDE -HSG C										
0-8	0.32	0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
8-44		0.0054	100.0	90.0	67.1	59.3	58.1	8.2	5.2	0.0
44-60		0.0065	100.0	84.7	49.7	41.0	41.0	7.9	5.2	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
LITZ -HSG C										
0-12	0.32	0.0093	100.0	84.9	50.5	30.9	30.9	5.6	3.6	0.0
12-24		0.0461	100.0	79.7	33.1	12.4	12.4	6.0	4.4	0.0
LORING -HSG C										
0-7	0.49	0.0061	100.0	96.4	88.0	67.8	61.9	4.1	2.5	0.0
7-28		0.0053	100.0	93.3	78.0	69.0	66.5	7.8	4.9	0.0
28-50		0.0054	100.0	93.9	80.0	68.8	65.5	7.0	4.4	0.0
50-65		0.0060	100.0	93.3	78.1	61.2	57.6	5.5	3.4	0.0
LOWELL -HSG B										
0-11	0.37	0.0050	100.0	90.6	69.1	62.0	60.1	9.9	6.5	0.0
11-23		0.0044	100.0	87.3	58.2	53.3	52.0	13.3	9.3	0.0
23-53		0.0043	100.0	85.3	51.6	48.2	47.5	13.9	9.8	0.0
MARKLAND -HSG C										
0- 7	0.43	0.0051	100.0	89.8	66.6	59.9	58.3	10.0	6.6	0.0
7-28		0.0044	100.0	87.3	58.2	53.3	52.0	13.3	9.3	0.0
28-60		0.0048	100.0	86.3	55.1	51.1	50.4	12.1	8.3	0.0
MCGARY -HSG C										
0-11	0.43	0.0052	100.0	87.9	60.1	54.7	53.8	10.0	6.6	0.0
11-39		0.0046	100.0	89.2	64.4	58.1	56.4	12.1	8.3	0.0
39-60		0.0047	100.0	88.5	62.1	56.4	54.9	12.1	8.3	0.0
MELVIN -HSG D										
0-9	0.43	0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
9-30		0.0055	100.0	92.3	74.8	64.7	62.3	7.3	4.6	0.0
30-62		0.0057	100.0	90.1	67.6	57.7	56.3	7.3	4.6	0.0
MEMPHIS -HSG B										
0-9	0.49	0.0060	100.0	95.8	86.3	68.0	62.7	4.7	2.9	0.0
9-23		0.0052	100.0	92.7	76.0	67.5	65.0	8.4	5.4	0.0
23-77		0.0057	100.0	94.9	83.3	68.3	64.0	5.8	3.6	0.0
MUSKINGUM -HSG C										
0-5	0.28	0.0072	100.0	88.3	61.6	42.0	41.4	5.5	3.4	0.0
5-26		0.0074	100.0	84.7	49.8	37.2	37.2	6.8	4.4	0.0
NEWARK -HSG C										
0-7	0.43	0.0059	100.0	89.6	65.8	54.8	53.6	7.0	4.4	0.0
7-38		0.0054	100.0	90.0	67.1	59.3	58.1	8.2	5.2	0.0
38-60		0.0053	100.0	90.5	68.8	61.5	60.8	8.3	5.2	0.0
OTWAY -HSG D										
0-18	0.43	0.0046	100.0	87.9	60.1	54.9	53.4	12.7	8.8	0.0
18-36		0.0052	100.0	90.0	67.0	60.7	60.1	9.0	5.7	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
PURDY -HSG D										
0-9	0.43	0.0052	100.0	92.9	76.8	68.1	65.6	8.2	5.2	0.0
9-42		0.0048	100.0	84.9	50.5	47.6	47.4	12.1	8.3	0.0
42-60		0.0048	100.0	85.6	52.8	49.4	48.9	12.1	8.3	0.0
ROBERTSVILLE -HSG D										
0-6	0.43	0.0058	100.0	93.2	77.6	63.2	59.9	6.1	3.8	0.0
6-21		0.0054	100.0	92.2	74.2	65.5	63.5	7.8	4.9	0.0
21-45		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
45-65		0.0054	100.0	88.3	61.7	55.4	54.6	9.0	5.8	0.0
ROCKCASTLE -HSG D										
0-6	0.43	0.0044	100.0	83.1	44.4	43.0	43.0	13.9	9.8	0.0
6-28		0.0045	100.0	83.7	46.4	44.5	44.5	13.3	9.3	0.0
SCIOTOVILLE -HSG C										
0-13	0.37	0.0059	100.0	91.2	71.0	58.1	56.0	6.6	4.1	0.0
13-34		0.0055	100.0	89.6	65.7	57.9	56.9	8.0	5.1	0.0
34-59		0.0053	100.0	90.6	69.2	61.6	60.9	8.2	5.1	0.0
59-69		0.0071	100.0	84.2	48.2	37.4	37.4	7.4	4.9	0.0
SEQUATCHIE -HSG B										
0-12	0.24	0.0087	100.0	85.9	53.5	33.5	33.4	5.4	3.4	0.0
12-46		0.0060	100.0	87.4	58.5	49.5	49.2	7.4	4.7	0.0
46-72		0.0098	100.0	84.7	49.9	29.4	29.4	5.5	3.6	0.0
SHELBYVILLE -HSG B										
0-9	0.32	0.0058	100.0	94.5	81.8	66.6	62.5	5.8	3.6	0.0
9-38		0.0053	100.0	92.3	74.9	66.3	64.1	8.2	5.2	0.0
38-65		0.0043	100.0	83.8	46.8	44.8	44.5	13.9	9.8	0.0
TAFT -HSG C										
0-9	0.43	0.0060	100.0	93.3	78.1	61.2	57.6	5.5	3.4	0.0
9-24		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
24-64		0.0054	100.0	91.6	72.4	63.8	62.0	7.8	4.9	0.0
64-80		0.0066	100.0	84.4	48.8	39.6	39.6	7.8	5.2	0.0
TYLER -HSG C										
0-14	0.43	0.0058	100.0	92.5	75.5	61.5	58.6	6.2	3.9	0.0
14-18		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
18-59		0.0055	100.0	89.7	66.2	58.2	57.2	7.9	5.0	0.0
59-70		0.0061	100.0	89.6	65.9	52.9	51.5	6.6	4.1	0.0
WEINBACH -HSG C										
0-15	0.43	0.0059	100.0	89.6	65.8	54.8	53.6	7.0	4.4	0.0
15-23		0.0055	100.0	89.9	66.7	58.5	57.5	7.8	4.9	0.0
23-40		0.0055	100.0	89.9	66.7	58.5	57.5	7.8	4.9	0.0
40-52		0.0053	100.0	90.6	69.2	61.6	60.0	8.7	5.6	0.0
52-65		0.0071	100.0	84.2	48.2	37.4	37.4	7.4	4.9	0.0

SOIL SERIES -HYDROLOGIC SOIL GROUP

DEPTH (in)	K	D15 (mm)	1.4	1.0	0.063	0.044	0.038	0.004	0.003	0.001
			Percent Finer Than (mm)							
WESTMORELAND -HSG ZZ										
0-7	0.99	0.0058	100.0	90.1	67.6	56.5	55.1	7.0	4.4	0.0
7-36		0.0062	100.0	85.0	50.6	42.9	42.9	8.2	5.4	0.0
36-49		0.0081	100.0	82.7	43.3	31.2	31.2	7.6	5.2	0.0
WHEELING -HSG B										
0-14	0.37	0.0069	100.0	90.8	69.7	48.9	46.6	5.0	3.1	0.0
14-60		0.0067	100.0	85.1	50.9	40.7	40.7	7.2	4.7	0.0
60-72		0.0255	100.0	87.5	59.1	17.5	17.5	3.4	2.2	0.0
WOOLPER -HSG C										
0-6	0.37	0.0052	100.0	90.0	67.0	60.0	58.5	9.3	6.0	0.0
6-15		0.0047	100.0	86.9	57.0	52.6	51.6	12.2	8.4	0.0
15-65		0.0043	100.0	85.3	51.6	48.2	47.5	13.9	9.8	0.0
ZANESVILLE -HSG C										
0-7	0.43	0.0052	100.0	90.6	69.1	61.8	60.0	9.3	6.0	0.0
7-28		0.0053	100.0	91.8	72.9	64.6	62.6	8.2	5.2	0.0
28-39		0.0055	100.0	89.7	66.2	58.2	57.2	7.9	5.0	0.0
39-60		0.0079	100.0	81.5	39.1	30.3	30.3	8.5	5.8	0.0
ZIPP -HSG D										
0-6	0.28	0.0047	100.0	88.5	62.1	56.4	54.9	12.1	8.3	0.0
6-36		0.0044	100.0	87.3	58.2	53.3	52.0	13.3	9.3	0.0
36-60		0.0046	100.0	85.7	53.1	49.6	48.9	12.7	8.8	0.0

DESIGN MANUAL CHAPTER 12

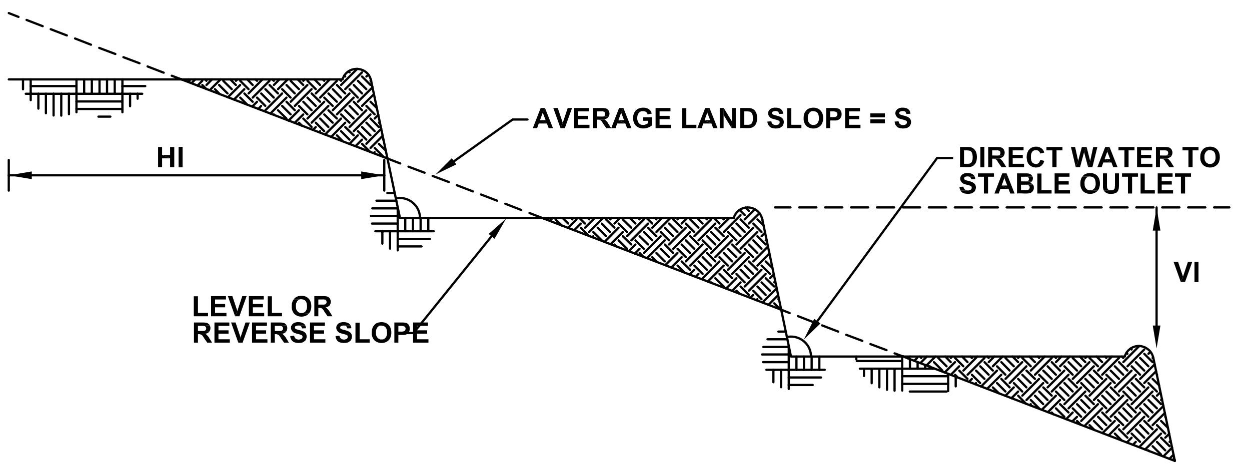
SUPPLEMENTAL SECTION D

EXHIBITS

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 12-1
BENCH TERRACES
FOR URBAN AREAS

EFFECTIVE DATE: JUNE 30, 2009



EQUATION FOR HORIZONTAL AND VERTICAL INTERVALS

$$HI = VI \times \frac{100}{S}$$

$$VI = aS+b$$

WHERE a = 0.5 FOR LOUISVILLE
b = 1 FOR ERODIBLE CONDITION
2 FOR RESISTANT SOILS WITH GOOD COVER.

S = AVERAGE LAND SLOPE IN PERCENT
HI = HORIZONTAL INTERVAL BETWEEN TERRACES
VI = VERTICAL INTERVAL BETWEEN TERRACES

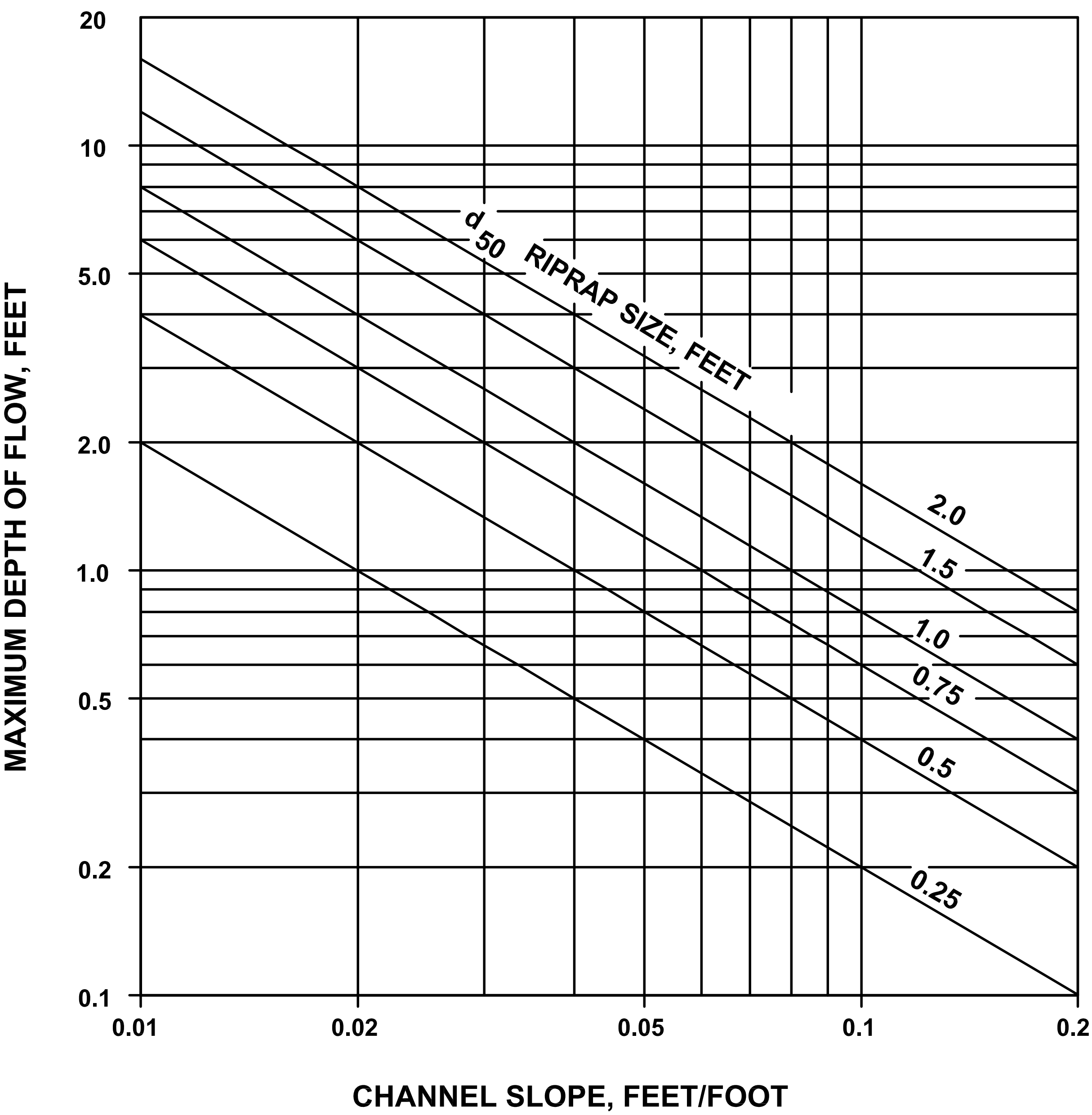
BENCH TERRACES

Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913

502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 12-2
MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

EFFECTIVE DATE: JUNE 30, 2009



MAXIMUM DEPTH OF FLOW FOR RIPRAP LINED CHANNELS

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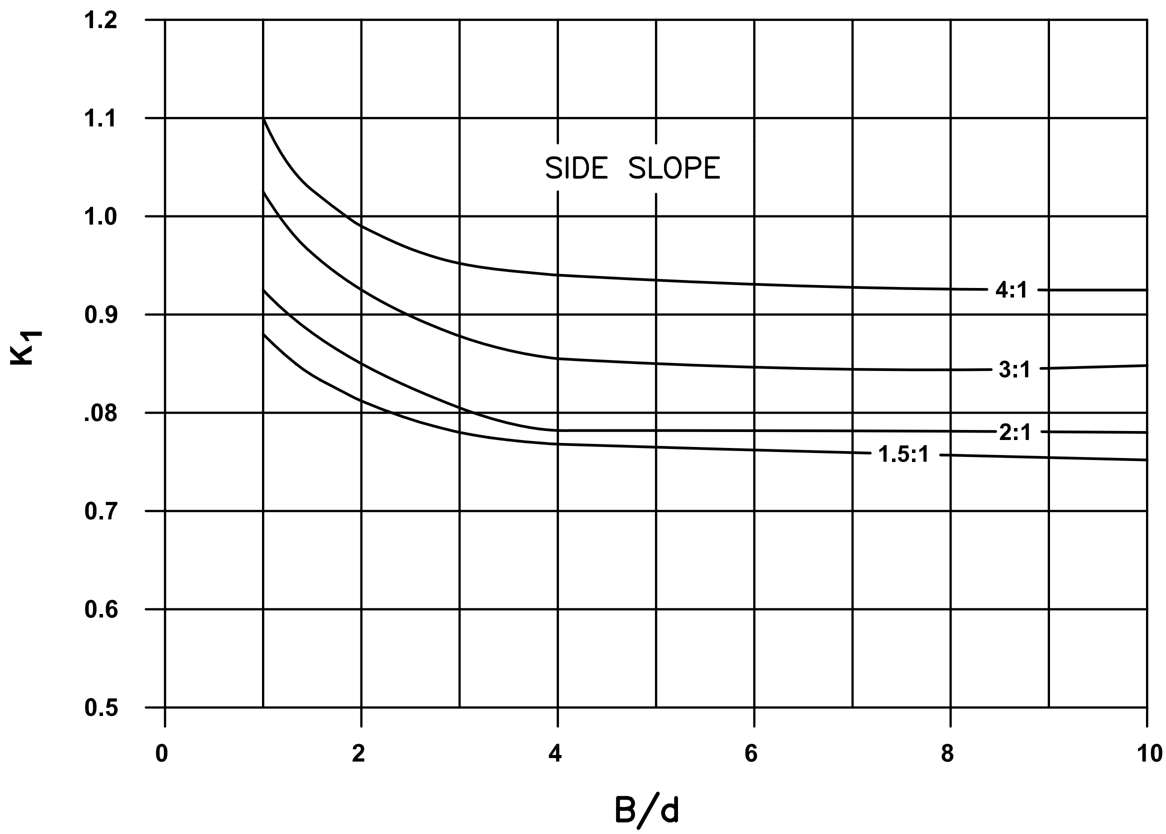

DISTRIBUTION OF BOUNDARY SHEAR AROUND WETTED PERIMETER OF TRAPAZOIDAL CHANNEL

MSD
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Louisville, Kentucky
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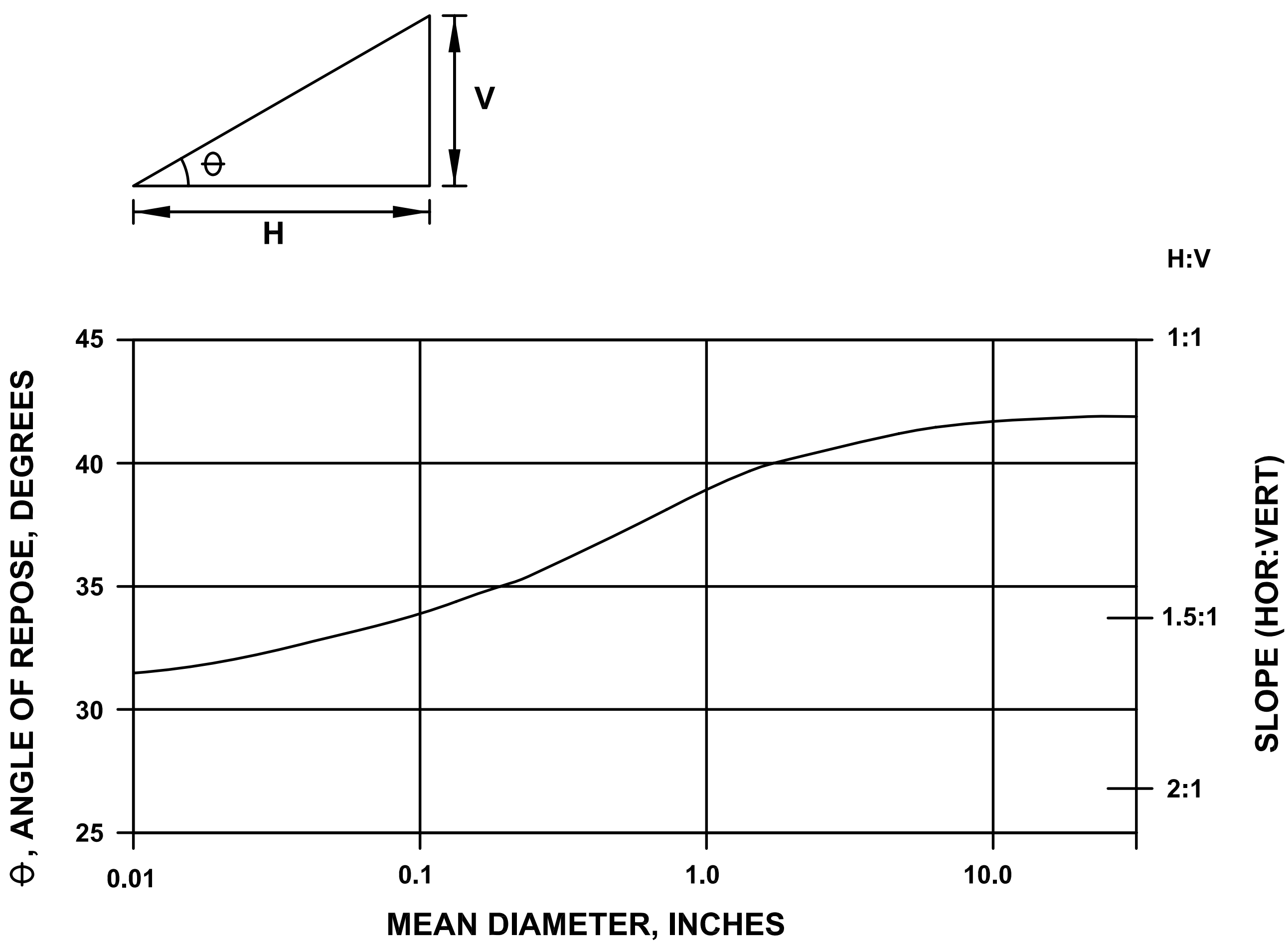
EXHIBIT 12-4
ANGLE OF REPOSE FOR RIPRAP STONES

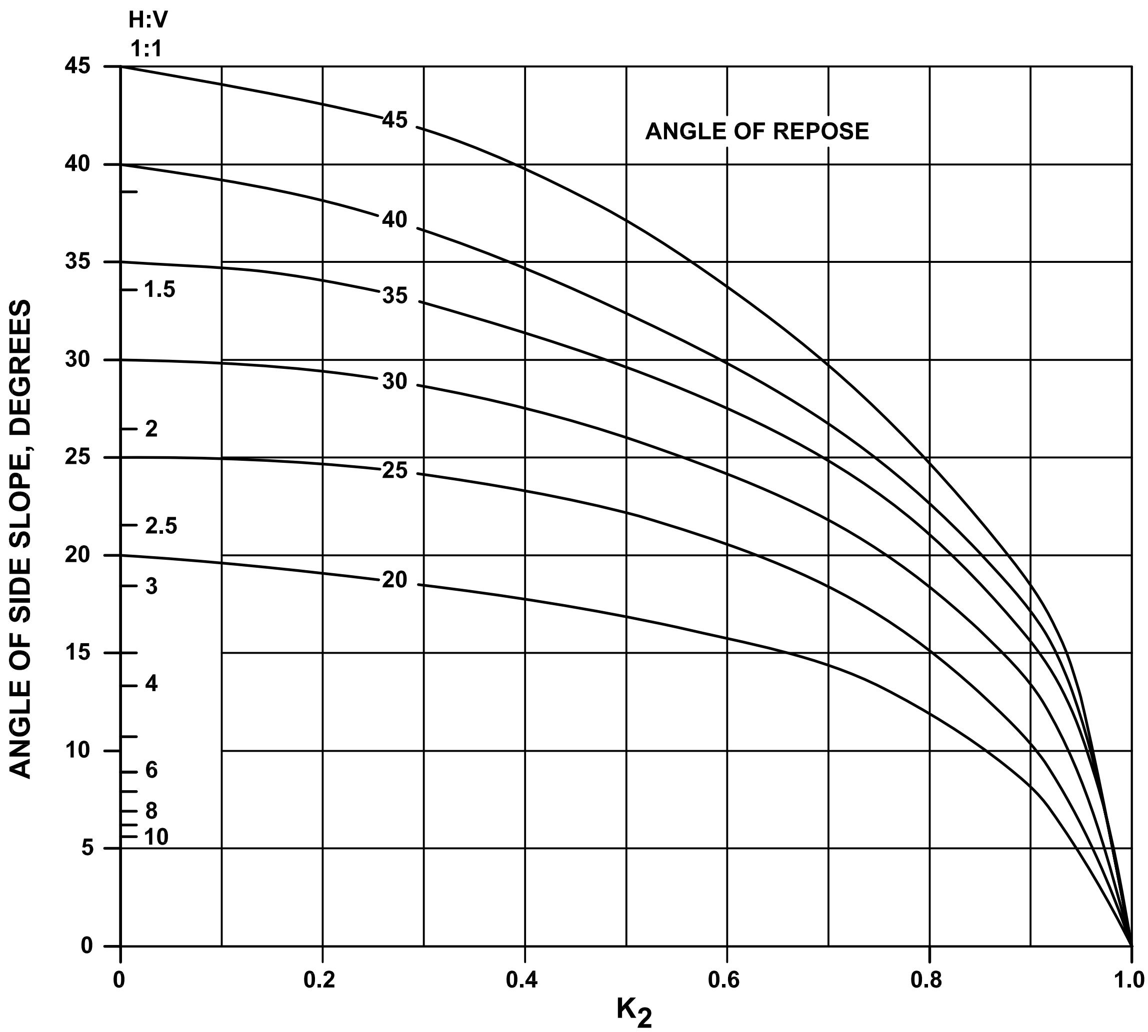
EFFECTIVE DATE: JUNE 30, 2009



ANGLE OF REPOSE FOR RIPRAP STONES

EXHIBIT 12-5
RATIO OF CRITICAL SHEAR STRESS ON SIDES
TO CRITICAL SHEAR STRESS ON BOTTOM

EFFECTIVE DATE: JUNE 30, 2009



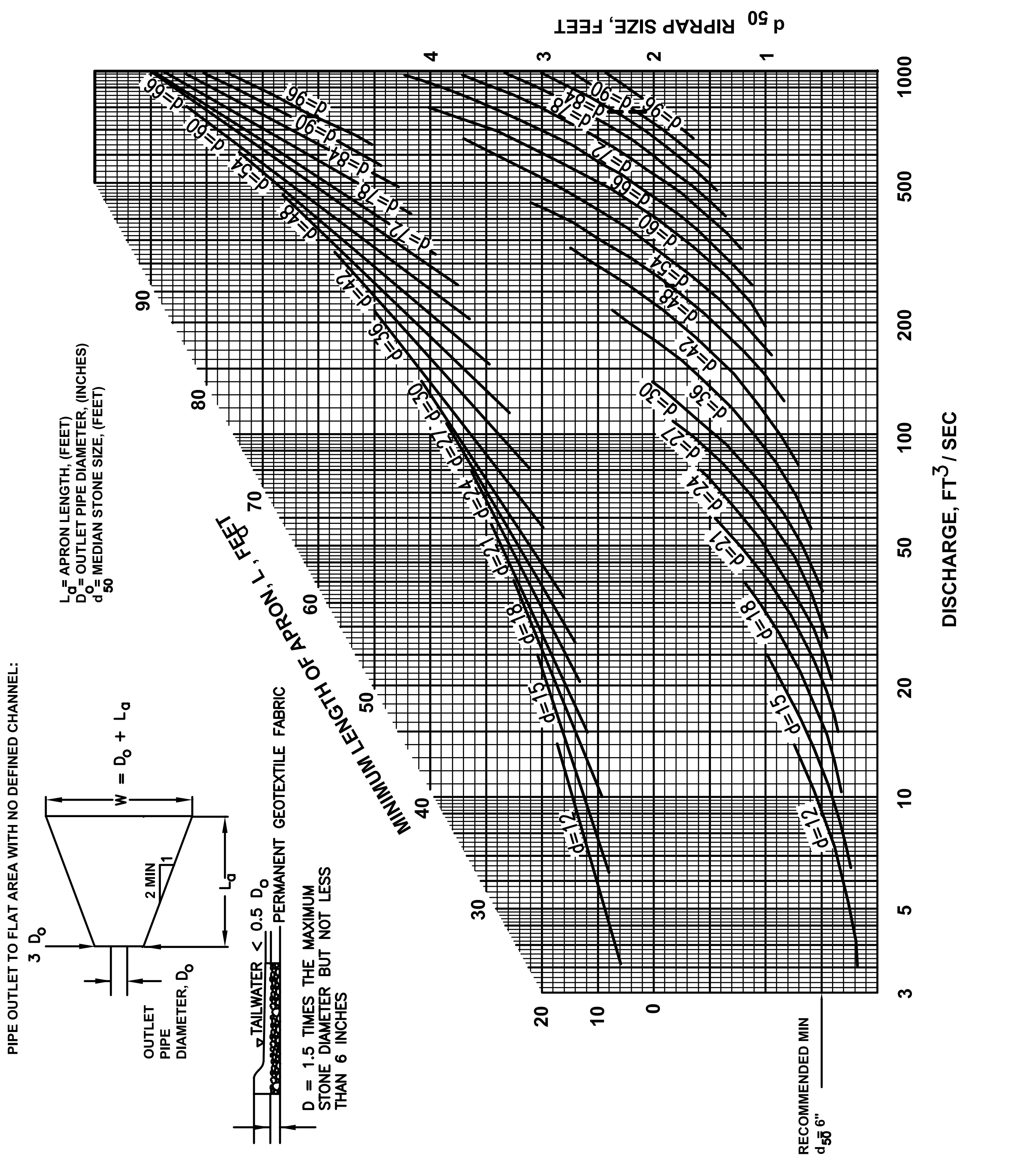
RATIO OF CRITICAL SHEAR ON SIDES TO CRITICAL SHEAR ON BOTTOM

MSD Louisville and Jefferson County Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913

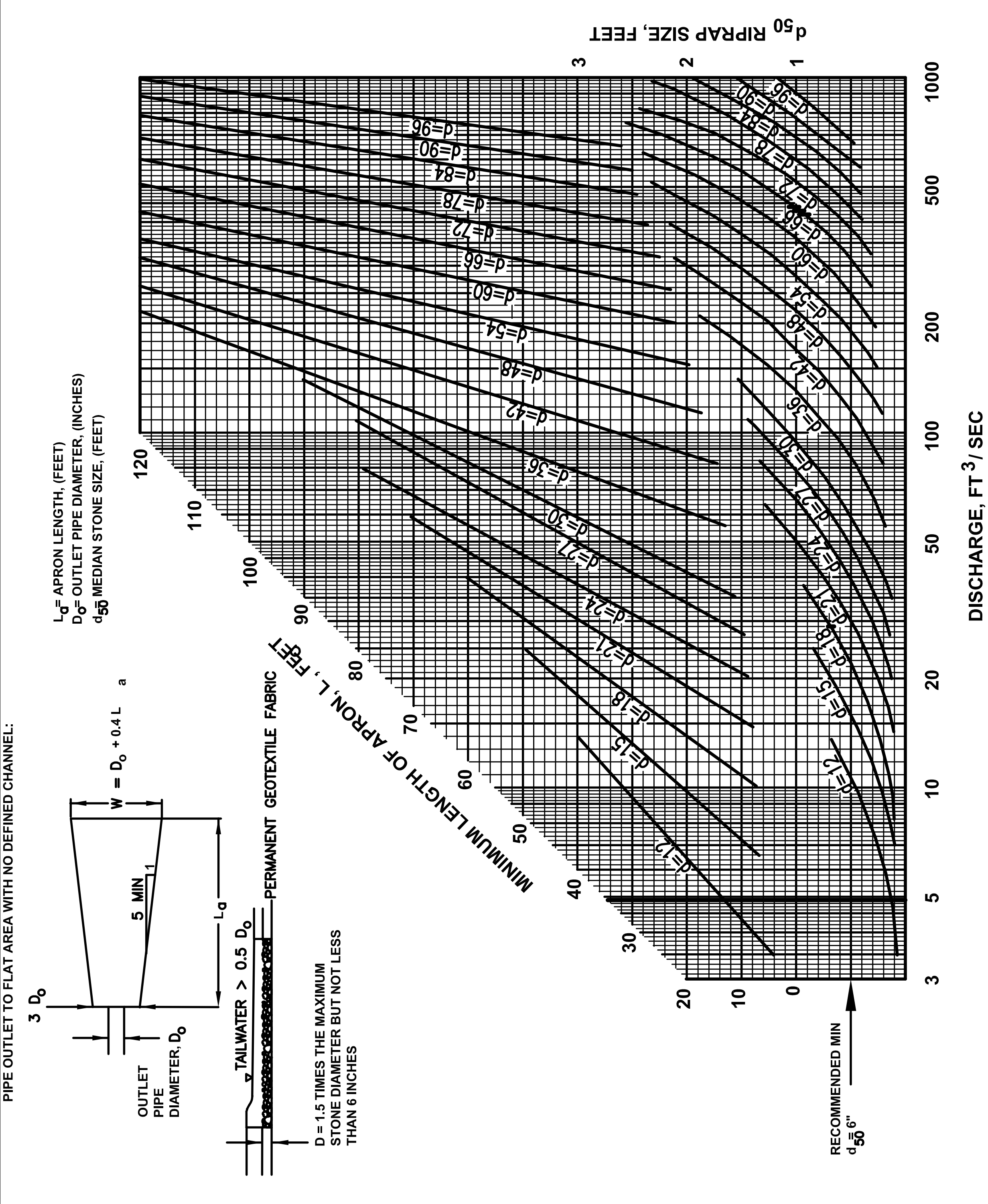
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 12-6
MINIMUM TAIL WATER CONDITION

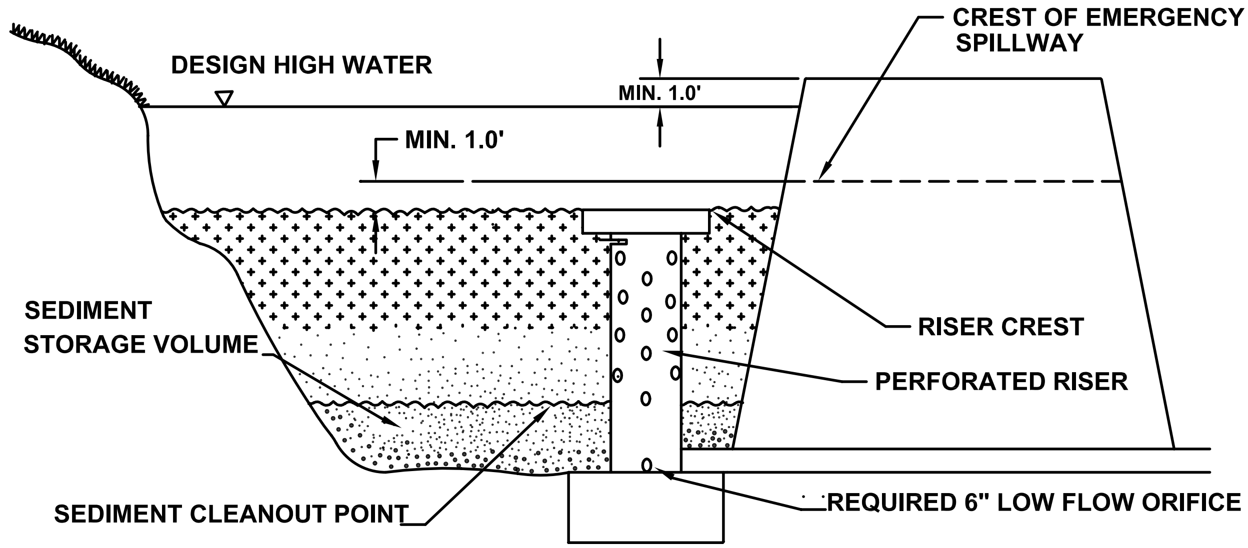
EFFECTIVE DATE: JUNE 30, 2009



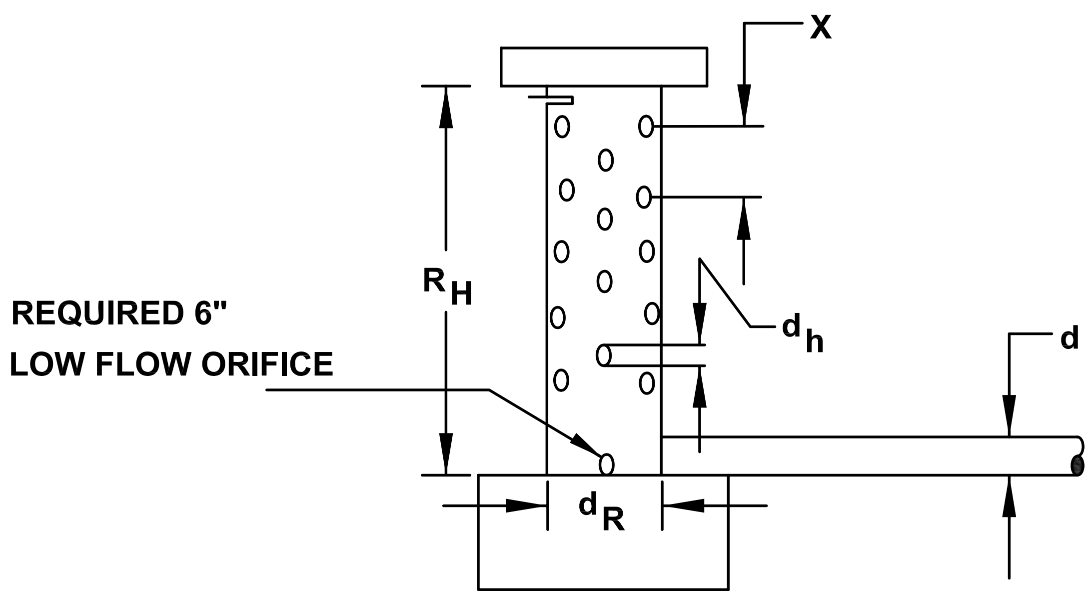
DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL
MINIMUM TAILWATER CONDITION (T < 0.5 DIAMETER)



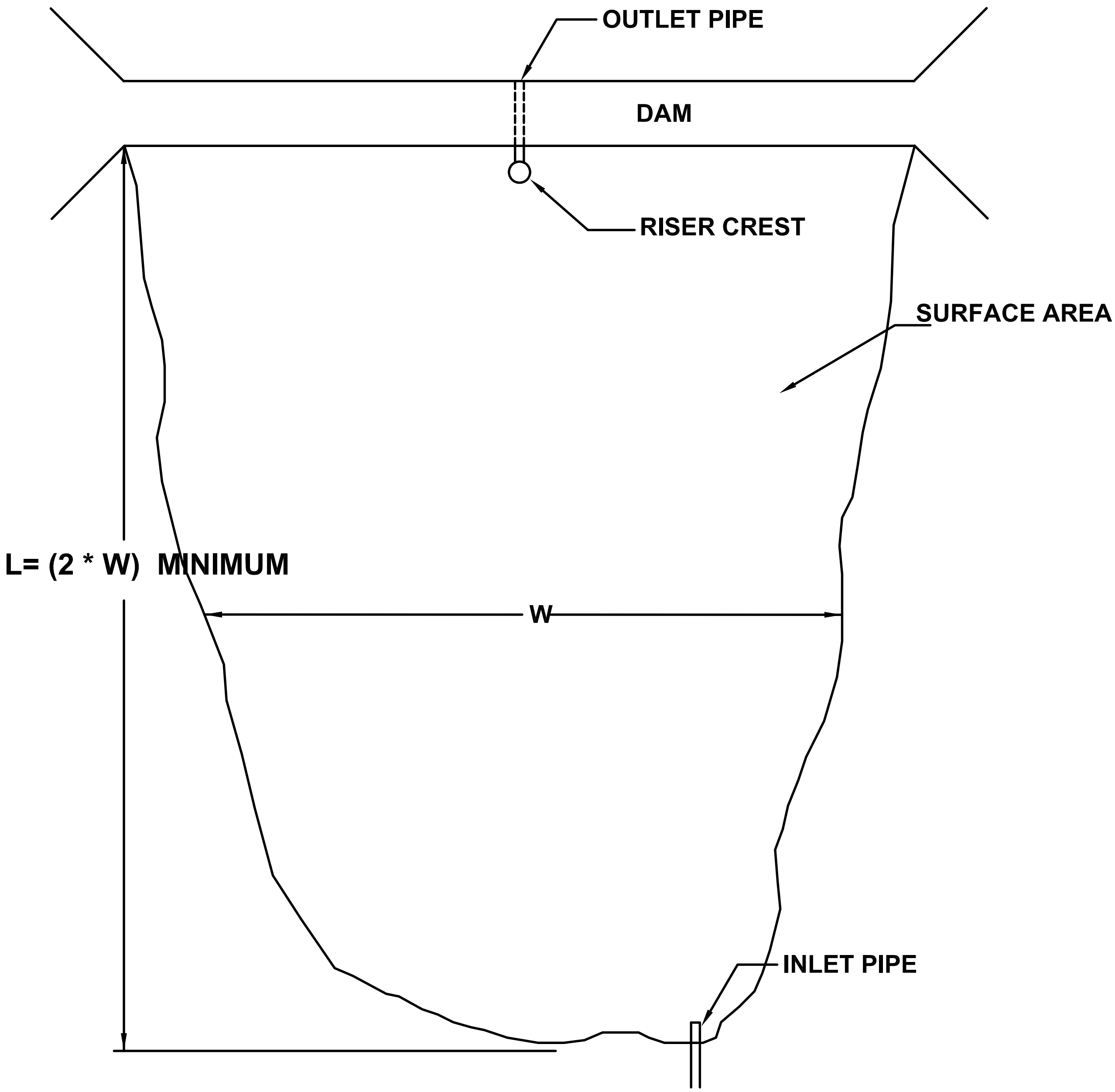
DESIGN OF OUTLET PROTECTION FROM A ROUND PIPE FLOWING FULL MAXIMUM TAILWATER CONDITION (T_w < 0.5 DIAMETER)



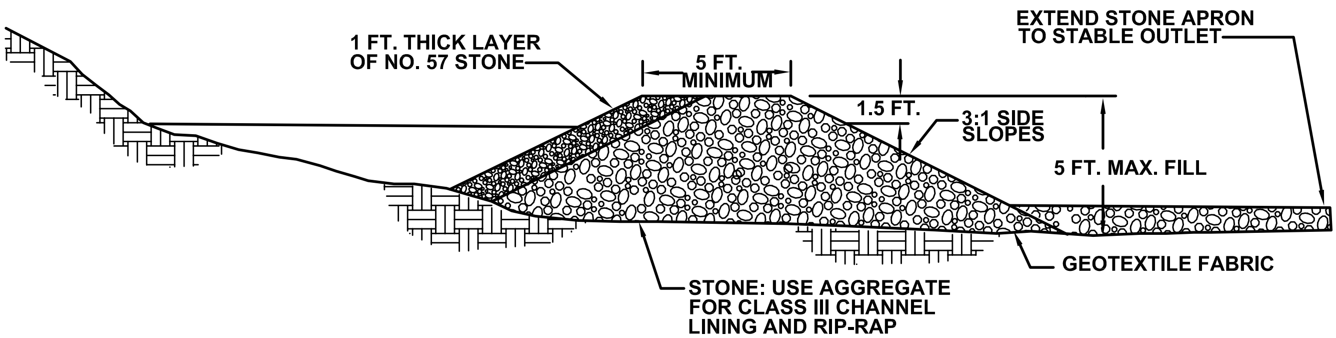
DESIGN ELEVATIONS WITH REQUIRED EMERGENCY SPILLWAY



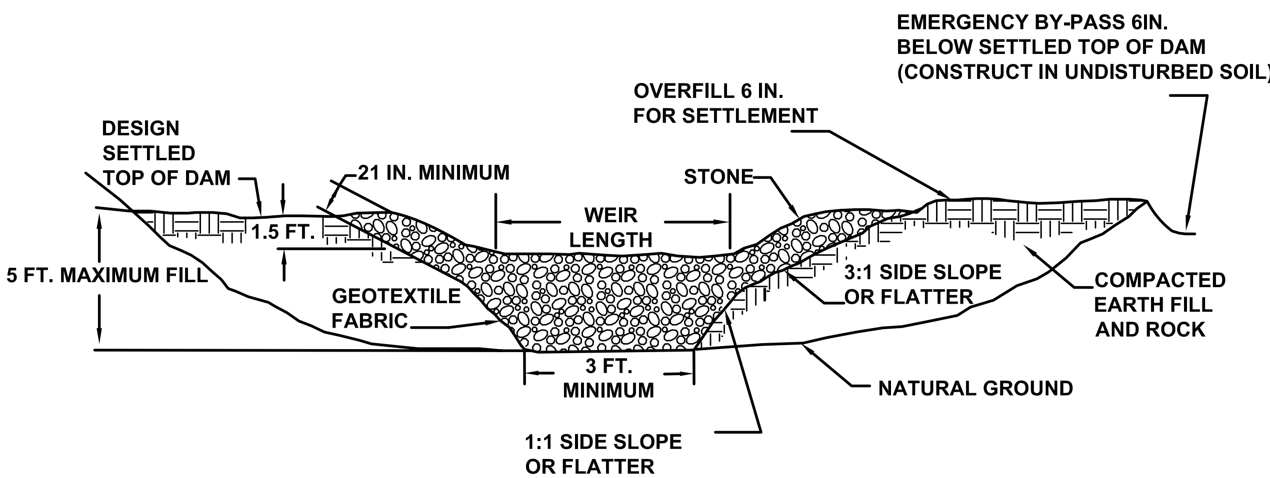
RISER PIPE DETAIL


OUTLET PIPE
DAM
RISER CREST
SURFACE AREA
L= (2 * W) MINIMUM
W
INLET PIPE

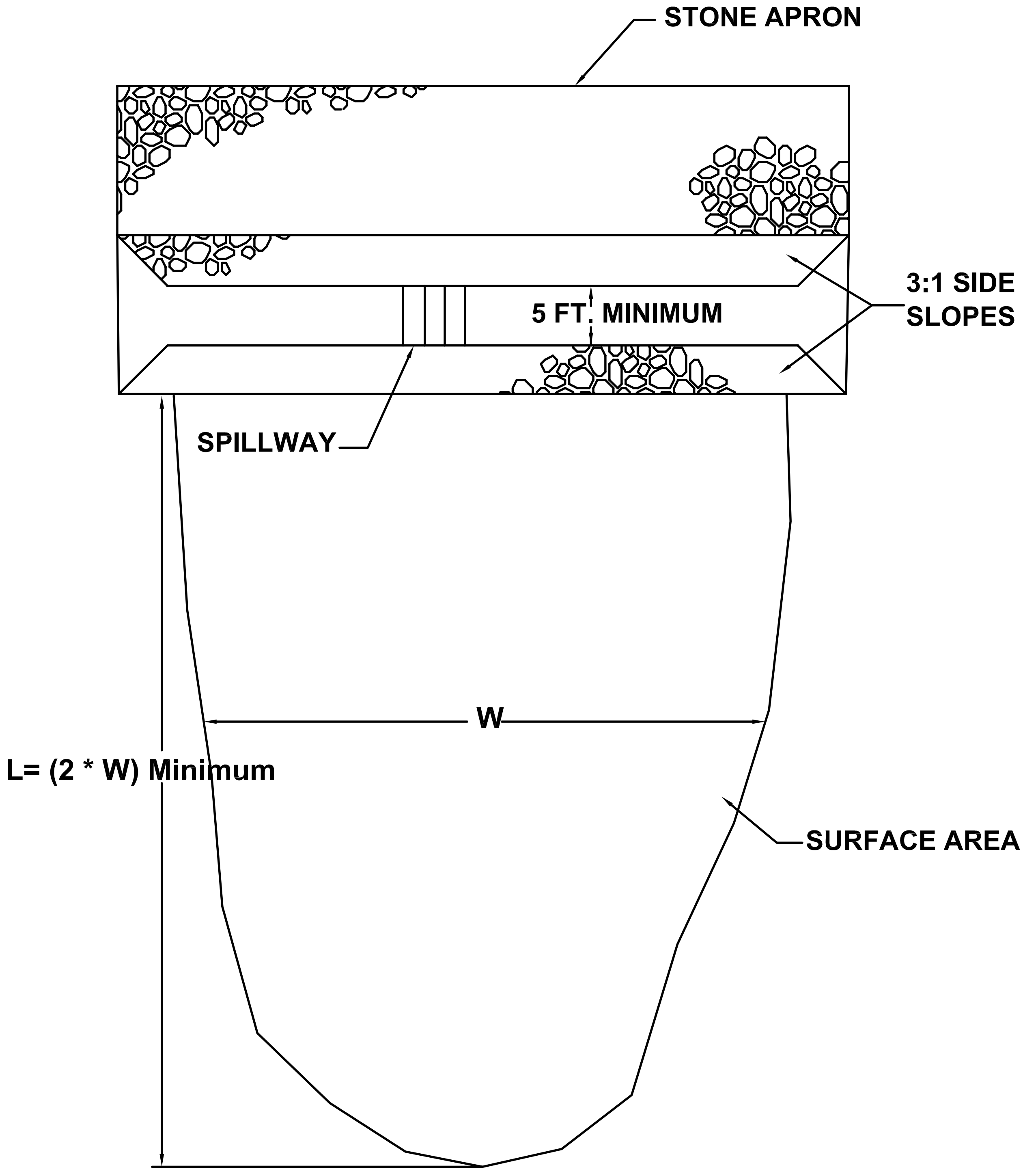
PLAN VIEW



STONE SECTION



EMBANKMENT AND SPILLWAY ELEVATION


STONE APRON
3:1 SIDE SLOPES
5 FT. MINIMUM
SPILLWAY
W
L= (2 * W) Minimum
SURFACE AREA

PLAN VIEW

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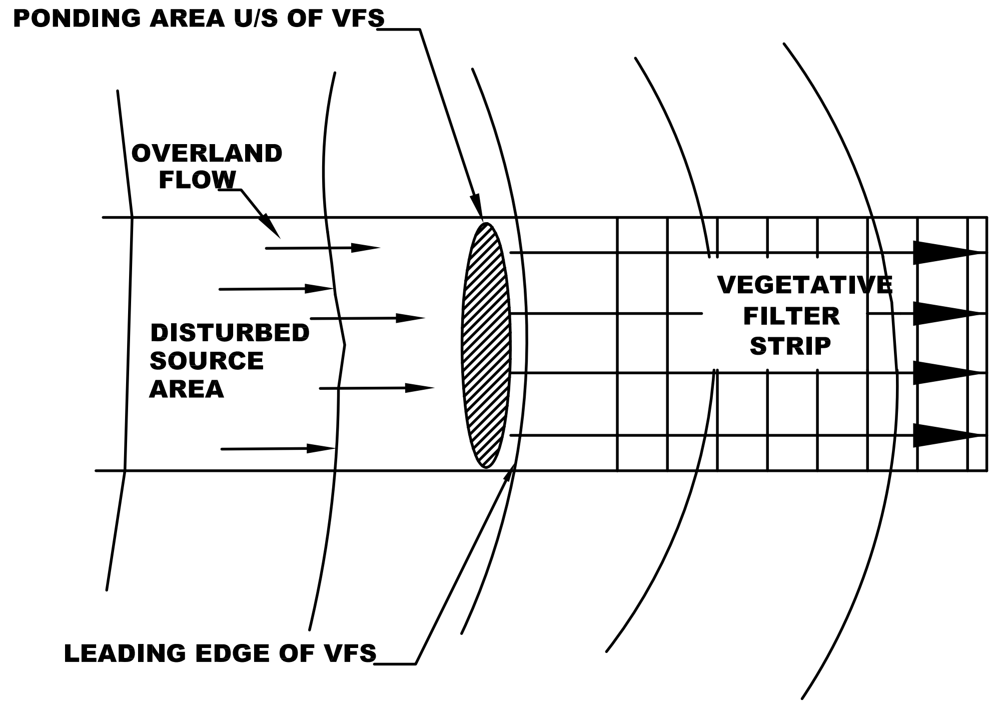
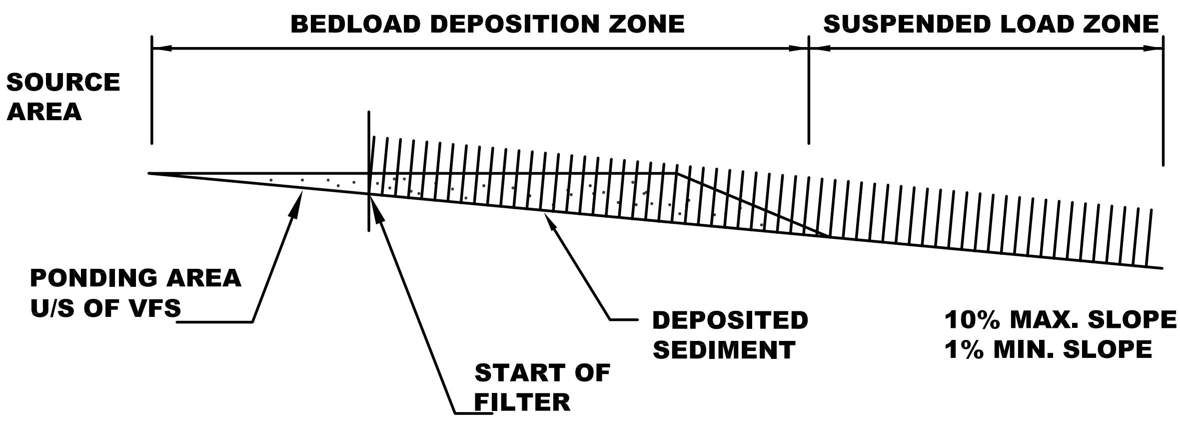
EXHIBIT 12-10
VEGETATED FILTER STRIPS

EFFECTIVE DATE: JUNE 30, 2009



PLAN VIEW



PROFILE VIEW

SCHEMATIC OF A TYPICAL VEGETATIVE FILTER STRIP

MSD

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Metropolitan Sewer District
700 W. Liberty Street
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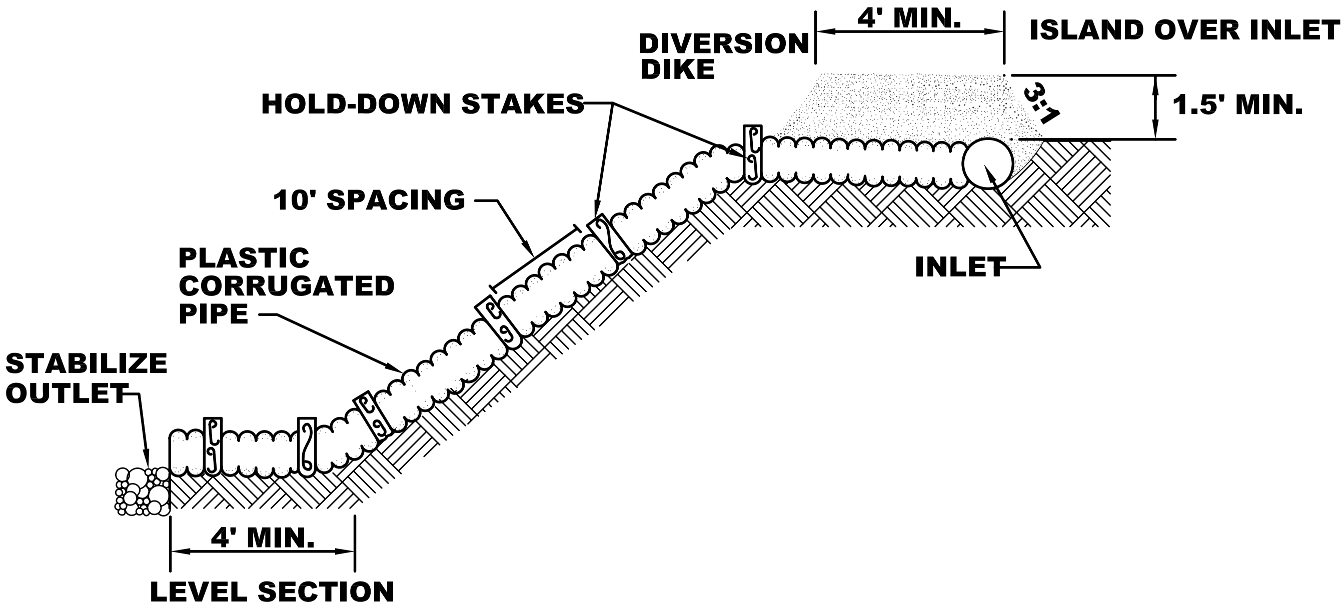
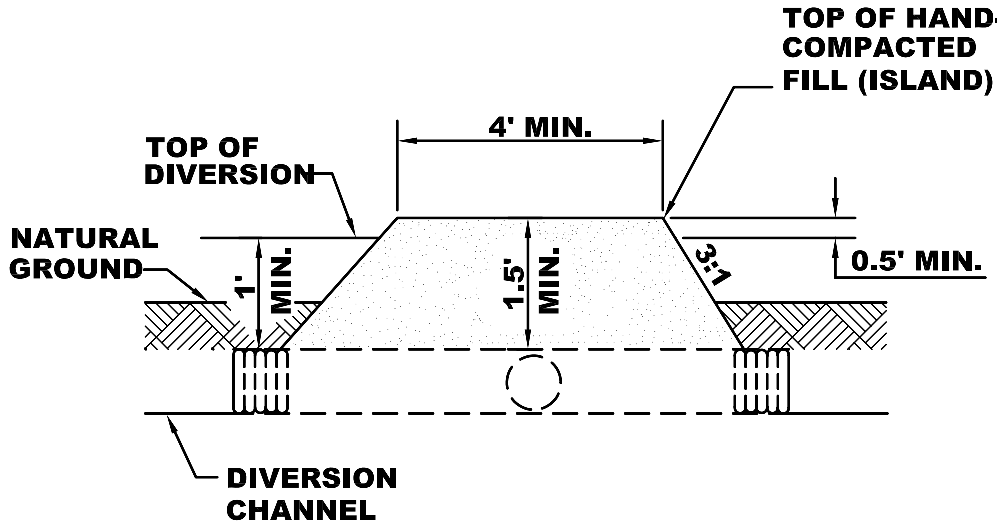
EXHIBIT 12-11
PIPE SLOPE DRAIN

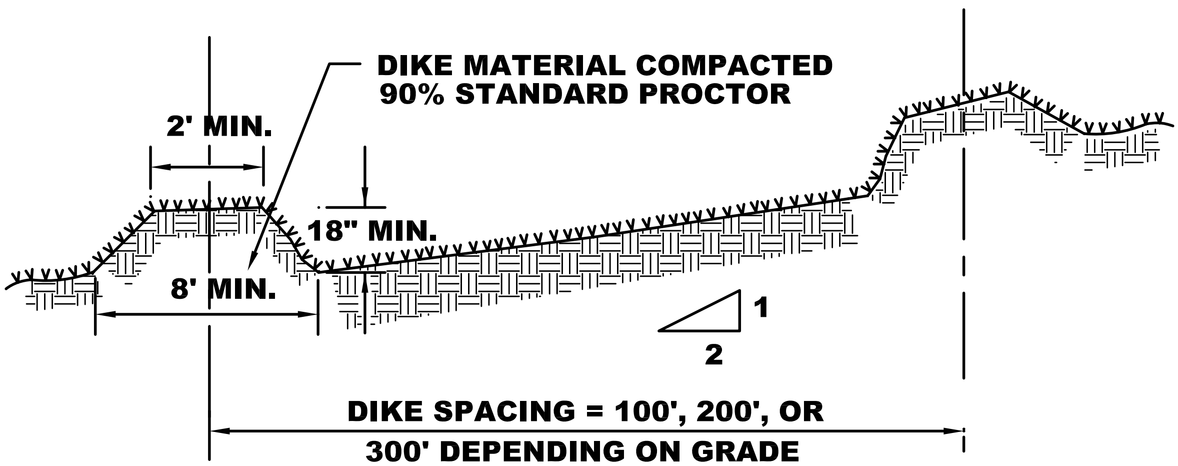
EFFECTIVE DATE: JUNE 30, 2009



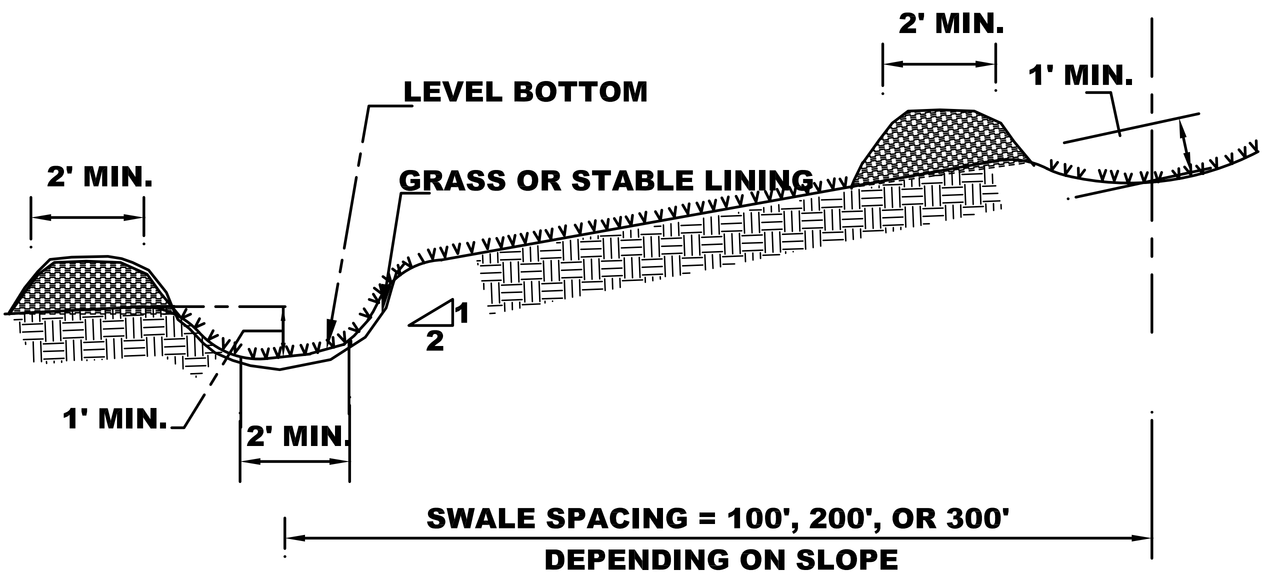


TYPICAL PIPE SLOPE DRAIN LAYOUT

MSD Louisville and Jefferson County Metropolitan Sewer District 700 W. Liberty Street Louisville, Kentucky 40203-1913 502–587–0603 – WWW.MSDLOUKY.ORG	EXHIBIT 12-12 DIKES AND SWALES EFFECTIVE DATE: JUNE 30, 2009



DIKE



SWALE

MSD
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Metropolitan Sewer District
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Louisville, Kentucky
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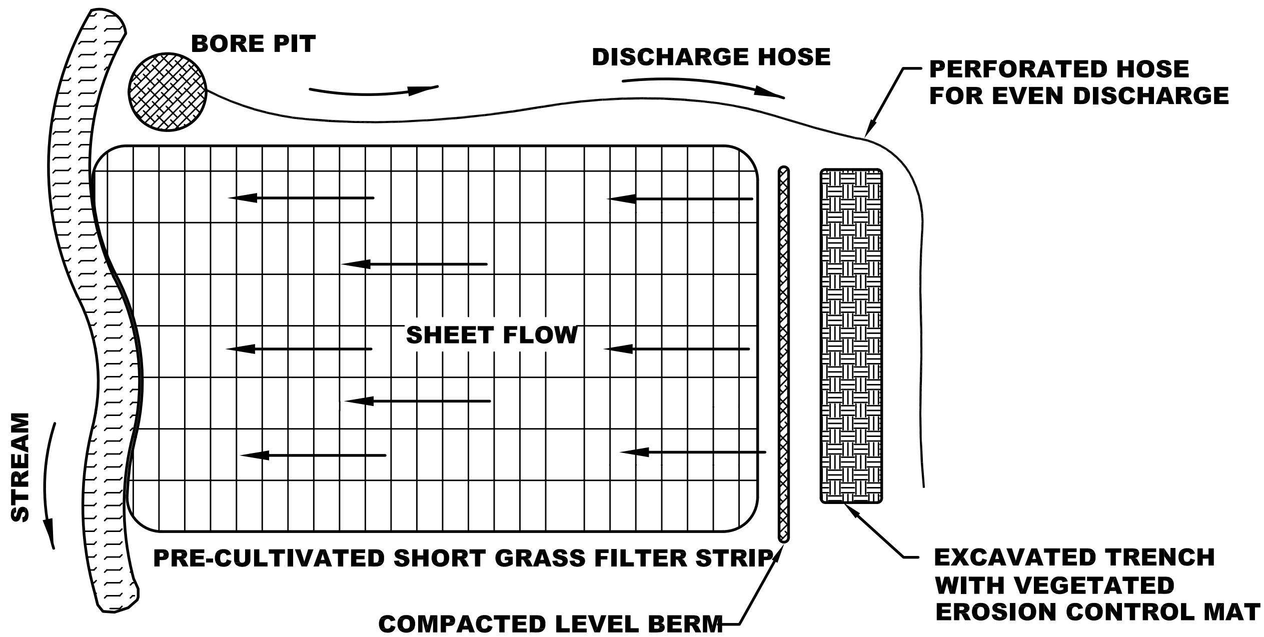
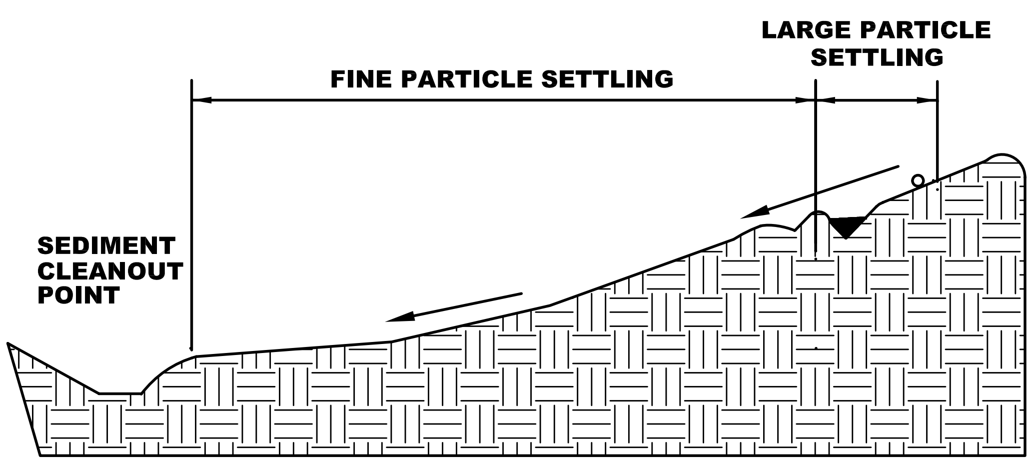
EXHIBIT 12-13
DEWATERING OPERATIONS FOR PUMPING TO A VEGETATED BUFFER ZONE

EFFECTIVE DATE: JUNE 30, 2009



PLAN VIEW



PROFILE VIEW

MSD

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Metropolitan Sewer District
700 W. Liberty Street
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40203-1913

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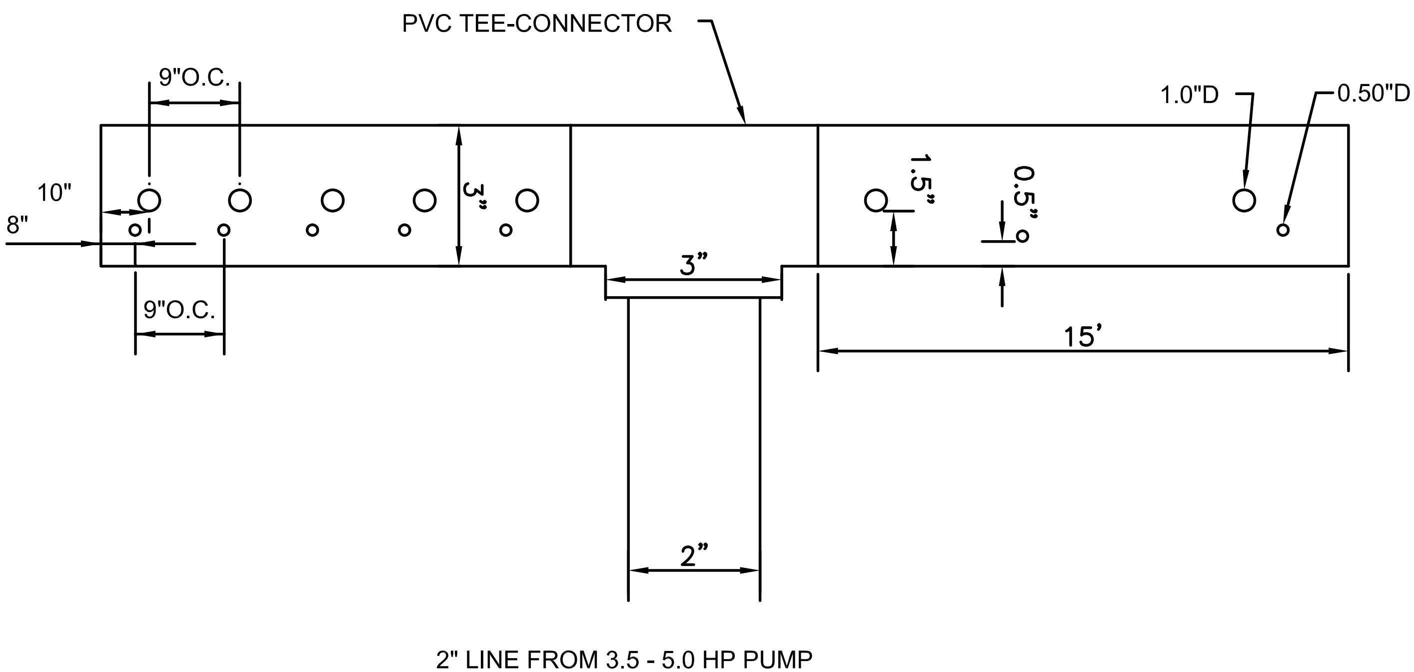
EXHIBIT 12-14
DETAIL FOR DEWATERING OUTLET STRUCTURE

EFFECTIVE DATE: JUNE 30, 2009

- TWO 15-FT. SECTIONS OF 3-INCH DIAMETER SCHEDULE 40 PVC PIPE ATTACHED TO 3" PVC TEE SECTION. EACH OPEN PIPE END SHALL BE CAPPED.
- EACH 15-FT. SECTION HAS 20, 0.50-INCH DIAMETER HOLES LOCATED 0.5 INCHES FROM THE BOTTOM OF THE PIPE LINEARLY SPACED 9 INCHES ON CENTER, WITH THE FIRST HOLE STARTING 8 INCHES FROM THE EXTREME END OF THE PIPE.
- EACH 15-FT. SECTION HAS 18, 1.00-INCH DIAMETER HOLES LOCATED 1.5 INCHES FROM THE BOTTOM OF THE PIPE LINEARLY SPACED 9 INCHES ON CENTER, WITH THE FIRST HOLE STARTING 10 INCHES FROM THE EXTREME END OF THE PIPE.



DEWATERING OUTLET STRUCTURE TO VEGETATED BUFFER ZONE

DESIGN MANUAL CHAPTER 12

SUPPLEMENTAL SECTION E

EROSION CONTROL BLANKETS
&
TURF REINFORCEMENT MATS

Erosion Control Blankets

A list of ECB products for each of the following classes and types is given in the MSD Standard Specifications.

Temporary Erosion Control Blanket (ECB) -Class I & II

For any ECB that has netting attached, the netting shall be photodegradable and/or biodegradable as specified for that Class and type of ECB. The weight of the netting shall not exceed 15% of the total blanket weight.

- **Class I:** Short-term Degradable Products – Defined as products composed primarily of biologically, photochemically or otherwise degradable constituents with longevity of approximately 1 year. Non-organic, photodegradable or biodegradable netting is allowed.

  Urban- Either netted with biodegradable material or non-netted, used in urban and residential areas where the slopes do not exceed 4H:1V. No minimum shear stress required, but the minimum mat thickness allowed is 9mm (3/8 inch). The product should be capable of withstanding moderate foot traffic without tearing or puncturing. Not to be used in channels.

  Type A- Maximum Product Permissible Shear Stress (0 - 1.0 lb/ft^2): A netted product for use on slopes 2.5H:1V and flatter where the calculated design shear stress is 1.0 lb/ft^2 or less. Not to be used in channels.

  Type B- Maximum Product Permissible Shear Stress (1.0 - 2.0 lb/ft^2): Double netted, used on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 2.0 lb/ft^2 or less.

- **Class II:** Long-term Degradable Products- defined as products composed primarily of biologically, photochemically or otherwise degradable constituents with a longevity of up to 5 years.

  Type A-Maximum Product Permissible Shear Stress (0 - 1.0 lb/ft^2): For use on slopes 3H:1V or, in channels where the calculated design shear stress is 1.0 lb/ft^2 or less flatter Jute fabric used for erosion mats shall be a woven fabric of a uniform open weave of single jute yarn.

  Type B- Maximum Product Permissible Shear Stress (0 - 2.0 lb/ft^2): For use on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 2.0 lb/ft^2 or less. Non-organic, photodegradable or biodegradable netting is allowed.

Type C- Maximum Product Permissible Shear Stress (0 - 2.0 lb/ft^2):
For use in environmentally sensitive areas on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 2.0 lb/ft^2 or less. Only organic fiber woven mats are allowed with a maximum opening of 12 mm (1/2 inch).

Turf Reinforcement Mats

MSD Class III TRM physical properties are identified in the MSD Standard Specifications.

- **Class III:** Non-degradable Products- defined as products composed of non-degradable constituents with an unlimited longevity.

  Type A- Maximum Product Permissible Shear Stress (0 – 6.0 lb/ft^2):
  A TRM mat for use on slopes 2H:1V or flatter or, in channels where the calculated design shear stress is 6.0 lb/ft^2 or less.

  Type B- Maximum Product Permissible Shear Stress (6.0 - 8.0 lb/ft^2):
  A TRM mat for use on slopes 1H:1V or flatter or, in channels where the calculated design shear stress is 8.0 lb/ft^2 or less.

  Type C- Maximum Product Permissible Shear Stress (8.0 - 10.0 lb/ft^2):
  A TRM mat for use on slopes 1H:1V or steeper or, in channels where the calculated design shear stress is 10.0 lb/ft^2 or less.

TABLE OF CONTENTS

CHAPTER 13
NATIVE REVEGETATION

TABLE OF CONTENTS (cont.)

CHAPTER 13
NATIVE REVEGETATION
EXHIBITS

CHAPTER 13
NATIVE REVEGETATION

13.1 PURPOSE

This chapter establishes guidelines to be used when preparing planting plans for permanent revegetation of Natural Areas using native plants after construction of any development, improvement, or retrofit project. Loss of habitat including deforestation, forest fragmentation, and wetland impacts have resulted in the need **to revegetate** Natural Areas , **which should be addressed during project** planning, design, and construction. MSD has taken the position of using native plants to restore or enhance Natural Areas whenever possible and practical. By definition Natural Areas generally include plant communities/habitats indigenous to the region including such types as upland forests, forested wetlands, stream bank buffers/riparian corridors, dry-upland or moist meadows, and non-tidal scrub-shrub and/or emergent wetlands, among others.

13.2 GENERAL

The guidelines presented here are intended to provide:

a. An understanding of the approach to Native Revegetation and contributing factors.

b. An understanding of MSD's goals and objectives for Native Revegetation.

c. Familiarization with the basic revegetation planting plan procedures and elements.

13.3 PRINCIPLES OF NATIVE REVEGETATION PLANNING

a. Relate plans proposed for the Native Revegetation of Natural Areas to existing site conditions and surrounding or adjacent natural habitats.

b. Provide restoration or buffering of environmental features such as stream corridors, wetlands, steep slopes, erodible soils, and critical habitats.

c. Always emphasize the use of native plants which are indigenous to the State of Kentucky and the distribution of which occurs within the regional area of Louisville and Jefferson County.

d. Plan for the connection of proposed native revegetation areas to other areas of existing habitat, **and** the revegetation of **areas causing** forest fragmentation.

e. Native Revegetation should be self-sufficient, low-maintenance natural plantings that require minimal watering, weeding, pest and disease control, fertilization, and pruning.

f. Specify a diversity of native plant species representative of natural communities of Kentucky on planting plans to establish various planting zones.

g. Specify the required materials including plant form and size, soil amendments, seeding, protective devices, and erosion control materials.

h. Establish required planting densities and spacing. Develop any necessary Special Provisions including specific requirements for monitoring, inspection, and warranty.

13.4 PLANNING APPROACH

The success and long-term effectiveness of native revegetation depends upon careful planning. Design within the limitations of a given site to capitalize on opportunities presented by existing conditions. Ultimately, the revegetation plans need to identify proper vegetation community types and plant species appropriate to the site and situation. The designer should also factor in changes to the tree canopy that may change the types of plants and seeds selected for the site.

13.4.1 Site Constraints

Proper design of native revegetation areas must take into account site-specific constraints. The project area and the easement or right-of-way boundary must be identified. The location of existing and proposed features within the project area such as buildings, roads, bridges, culverts, head walls, outfalls, fences, sewer lines, buried and above-ground utilities, etc. must also be considered. Vegetation patterns including trees to be retained, existing wetlands, **forested** areas, and other natural community types adjacent to, or within the project site, must be evaluated.

13.4.2 Revegetation Area Extent

The primary factor that determines the extent of native revegetation is the size of the disturbed area and any additional areas within the easement or right-of-way that are conducive to the continuation of revegetation zones. The total area for planting zones may be limited by the physical features identified in subsection 13.4.1.

Project goals and objectives should also be used to determine the type(s) and extent of natural revegetation areas. These may include water quality protection, shading, erosion control, wildlife habitat, buffering and screening, and greenway corridor establishment.

If an area has significant native species, then a protection zone is required. In any case, the goals of the project guide the width of the required protection zone.

Some suggested minimum buffer or corridor widths for certain goals include:

Resource Protection Goal	Minimum Width
Water quality protection and Stream bank stabilization	35 feet*
General Riparian Corridor or Greenway	50 feet*
Corridor Connections for General Wildlife Habitat **and/or** Sensitive Forest Interior Dwelling Wildlife Habitat	300 feet **

*On each side of a centerline or stream bank edge
** Total for both sides of a stream channel or the entire width for a terrestrial corridor

As a general rule the revegetation area should be maximized to the extent possible, given the site and situation constraints previously described, and should always take into account cost considerations.

Distinct planting zones can be as small as several hundred square feet for intentional micro-habitats such as wetland depressions and can be as large as several acres or more for reforestation areas and large corridors. In general the size and layout of planting zones should be clear and straightforward. Plans should be easy to read and understand and practical for a Contractor to implement.

13.5 DESIGN APPROACH

The specific landform and features of the project site will govern the kinds of vegetative restoration or enhancement that can occur onsite. Design considerations should include aspect and orientation, degree of shading or openness (existing and proposed), slope, soil fertility, pH, drainage and moisture, hydrologic regime (flooding, inundation), vegetation cover and propagule source (seed bank, root and rhizome distribution, and re-colonization sources).

13.5.1 Plant Community Types

General types of habitat that can be planned and designed **consist of** both uplands and wetlands including forested and non-forested assemblages. Plant communities can range from forested wetlands, mesic or floodplain forests, xeric ridge or slope forests, to herbaceous habitats including emergent wetlands and native grass and wildflower meadows. It is not the intent of this manual to identify exact plant composition lists for all potential habitats, but rather to provide a general framework and lists of plant species suitable for a variety of conditions.

Plant species selection should be native to the local area and consistent with associated species of recognized natural communities of Kentucky. This includes those communities identified by the Kentucky State Nature Preserves Commission (**http://www.naturepreserves.ky.gov**), and other generally accepted sources on the subject.

a. Suggested Plant Species for Native Seeding

Sun-Dry Grasses (Xeric)

Andropogon virginicus	Broomsedge[ws]
Andropogon elliotti	Elliott's beardgrass[ws]
Andropogon ***ternarius***	Silver beard sedge[ws]
Schizacrium scoparium	Little bluestem[ws]
Sporobolus asper	Dropseed
Sporobolus vaginiflorus	Poverty grass
Sorgastrum nutans	Indian grass[ws]

Sun-Dry Forbs/Flowers (Xeric)

Aster ***(azureus) oolentangiense***	Sky blue aster
Aster oblongifolius	Late lavender aster
Aster pilosus	Frost aster
Asclepias tuberosa	Orange butterfly weed
Cassia fasciculata	Partridge pea
Echinacea pallida	Pale purple coneflower
Echinacea purpurea	Purple coneflower
Hypericum sphearocarpum	St. John's wort
Helianthus mollis	Downy sunflower
Lespedeza capitata	Round headed lespedeza
Lespedeza virginica	Slender lespedeza
Liatris aspera	Rough blazing star
Monarda fistulosa	Wild bergamot
Oenothera biennis	Evening primrose
Ratibida pinnata	Gray headed coneflower
Rudbeckia hirta	Black eyed Susan
Rudbeckia fulgida	Orange coneflower
Solidago canadensis	Canada goldenrod

Sun-Wet Grasses, Sedges, and Rushes (Mesic to Wetland)

Andropogon gerardii	Big bluestem[ws]
Andropogon virginicus	**Broomsedge[ws]**
Chasmanthium latifolium	River oats
Carex frankii	**Frank's sedge**
Carex lurida	Shallow sedge
Carex lupulina	Hop sedge
Carex vulpinoidea	Fox sedge
Juncus effusus	**Soft rush**
Panicum rigidulum	**Redtop panic grass**
Panicum virgatum	Switch grass[ws]
Scirpus cyperinus	Woolgrass
Scirpus validus	Giant bulrush
Spartina pectinata	**Prairie cordgrass[ws]**
Tripsacum dactyloides	**Gama-grass[ws]**

Sun-Wet Forbs/Flowers (Mesic to Wetland)

Agrimonia parviflora	**Small flowered agrimony**
Asclepias incarnata	Swamp milkweed
Aster novae-angliae	New England aster
Aster puniceus	**Purple stemmed aster**
Bidens aristosa	**Tickseed sunflower**
Eupatorium coelestinum	Blue mist plant
Eupatorium perfoliatum	Boneset
Helenium autumnale	Sneezeweed
Helianthus angustifolius	**Swamp sunflower**
Hibiscus moscheutos	Rose-mallow
Lobelia cardinalis	Cardinal flower
Lobelia siphilitica	Great blue lobelia
Mimulus ringens	Monkey flower
Solidago (Euthamia) graminifolia	Grass-leaved goldenrod
Penstemon digitalis	Smooth penstemon
Rudbeckia hirta	**Black eyed Susan**

Shade-Dry Grasses (Xeric)

Chasmanthium latifolium	River oats
Diarrhena americana	American beak grass
Elymus canadensis	Canada wild rye
Elymus hystrix	**Bottle brush grass**
Elymus villosus	**Downy wild rye**

Shade-Dry Forbs/Flowers (Xeric)

Aquilegia canadensis	Columbine
Aster (Eurybia) divaricata	**White wood aster**
Aster ***(Eurybia)*** *shortii*	Short's aster
Campanula americana	Tall blue bell flower
Eupatorium rugosum	White snake root
Geum canadense	**White avens**
Helianthus divaricatus	**Woodland sunflower**
Heuchera americana	Downy alum root
Heuchera villosa	Hairy heuchera
Penstemon hirsutus	Hairy beard tongue
Potentilla simplex	**Common cinquefoil**
Salvia lyrata	**Lyreleaf sage**
Solidago bicolor	**Silverrod**

Shade-Wet Grasses, Sedges, and Rushes (Mesic toWetland)

Carex grayii	**Gray's sedge**
Carex scoparia	**Blunt broomsedge**
Carex vulpinoidea	**Fox sedge**
Chasamanthium latifolium	River oats
Cinna arundinacea	**Sweet wood reed**
Elymus riparius	**Streambank wild rye**
Elymus virginicus	Virginia wild rye
Glyceria striata	**Fowl manna grass**
Panicum clandestinum	Deertongue^{ws}

Shade-Wet Forbs/Flowers (Mesic to Wetland)

Caltha palustris	**Marsh marigold**
Eupatorium coelestinum	**Blue mist plant**
Impatiens capensis	**Spotted jewelweed**
Lobelia cardinalis	Cardinal flower
Lobelia silphilitica	Great blue lobelia
Mimulus ringens	Monkey flower
Penstemon digitalis	**Smooth penstemon**
Phlox divaricata	Blue phlox
Polemonium reptans	**Jacob's ladder**
Senecio aureus	Golden ragwort

NOTE: (^{WS} Warm Season Grasses)

General seed application rates shall correspond to 10-15 lbs of seed per acre consisting of 9-14 lbs of native grass seed and one-half to one pound (½ to1 lb) of forb/flower seed. This shall consist of various mixtures of no less than five (5) species of native grasses, sedges, and rushes and four (4) species of native forbs/flowers as prescribed for the site and situation.

b. Suggested Species for Native Tree **and** Shrub Planting

<u>Native Trees - Mesic to Wet</u>

Betula nigra	River birch
Carpinus caroliniana	Ironwood
Carya laciniosa	**Shellbark hickory**
Celtis occidentalis	Hackberry
Liquidambar styraciflua	Sweet gum
Nyssa sylvatica	Black gum
Platanus occidentalis	American sycamore
Quercus bicolor	Swamp white oak
Quercus palustris	Pin oak
Quercus phellos	Willow oak

<u>Native Trees – Well-drained to Dry (Xeric)</u>

Acer saccharum	Sugar maple
Carya ovata	**Shagbark hickory**
Cercis canadensis	Eastern redbud
Cornus florida	Flowering dogwood
Fagus grandifolia	American beech
Fraxinus americana	White ash
Liriodendron tulipifera	Tulip poplar
Prunus serotina	Black cherry
Quercus alba	White oak
Quercus prinus	Chestnut oak
Quercus rubra	Northern red oak
Sassafras albidum	Sassafras

<u>Native Shrubs – Mesic to Wet</u>

Alnus serrulata	Smooth alder
Aronia arbutifolia	Red chokeberry
Asimina triloba	**Pawpaw**
Cephalanthus occidentalis	Buttonbush
Cornus amomum	Silky dogwood
Ilex verticillata	Winterberry
Lindera benzoin	Spicebush
Physocarpus opulifolius	Common ninebark
Rosa palustris	Swamp rose

Sambucus canadensis	Common elderberry
Viburnum dentatum	Southern arrowwood

Native Shrubs – Well-drained to Dry (Xeric)

Amelanchier arborea	Shadbush
Corylus americana	Hazelnut
Hamamelis virginiana	Witch hazel
Rosa serotina	Pasture rose
Symphoricarpos orbiculatus	**Coralberry**
Viburnum lentago	Nannyberry
Viburnum prunifolium	Black haw
Viburnum rufidulum	Southern blackhaw

A recommended minimum of 4 to 5 species of trees and a minimum of 3 to 4 species of shrubs should be specified for each forested zone to be established. If a shrub community is desired, a minimum of 4 species of shrubs should be selected. Final species selection should take into account the flood or saturation tolerance, the shade tolerance of the species, and adaptability to projected site conditions.

Herbaceous plants, including forbs, wildflowers, grasses, and emergents, that are intended to be planted as live plants can be selected as a subset of the suggested native seeding list indicated above (Subsection 13.5.1 a.). Their selection is based on site conditions, proposed habitats, goals, and general availability.

A plant ecologist, a landscape architect, a landscape restoration specialist, or other qualified professional familiar with **local** natural communities should determine vegetation communities, the plant composition of each, and the size and spacing of plants for native revegetation plans.

The designer should review and incorporate the Native Revegetation Design Checklist, Exhibit 13-1, items when creating plans for Natural Area revegetation including Native Seeding; and Native Tree, Shrub and Herbaceous Planting.

13.5.2 General Guidelines for Planting Plan Development

All planting plans should specify common and scientific names, spacing, quantity, size, form, and any special characteristics of the plants to be established. Spacing of woody plants should include the overall spacing (e.g., the minimum distance between any two trees). Individual species spacing should also be specified as the minimum planting distance between any two individuals of the same species. In proposed natural revegetation areas, a random planting pattern is generally recommended; however, regular, row, or cluster planting may be used if required by site conditions or project objectives. Row or cluster planting is most often used when planting an emergent wetland area or where a grove or grouping of a single species is desired (e.g., an evergreen tree copse). Example plant spacing details are provided in Exhibits 13-2, 13-3, and 13-4.

The actual spacing distances are highly variable and are subject to site conditions, overall goals, and professional judgement. There are times when planting an early successional woodland community where **a** high density of tree saplings is desired and lower density of shrubs is proposed. A corresponding planting density may then be on the order of 435 trees per acre corresponding to an overall on center spacing of approximately 10 feet. For the lower density of shrubs a corresponding density may be 222 shrubs per acre corresponding to an overall on center spacing of approximately 14 feet. Another approach may be to emulate a later stage of succession by planting larger trees in a less dense fashion. This may correspond to trees of a 25-30 foot on-center spacing or greater. The spacing selected should take into account the size of the plants specified.

In some situations the proposed revegetation may constitute supplementing existing vegetation. Examples of this include planting shrubs and small trees in the understory of existing canopy trees to be retained. Another situation encountered is where existing seedlings/saplings are retained and supplemental species of trees and shrubs are specified.

Herbaceous plant densities can result in a spacing as close as 1 foot on-center in order to achieve more rapid and dense coverage, or conversely, they may be planted further apart where supplementation, or initially sparse coverage, is the objective. A summary of several typical on-center plant spacing distances and their respective planting densities **is** provided below.

Typical Plant Spacing and Density Summary

Spacing (feet)	Plants Per Acre	Spacing (feet)	Plants Per Acre
1x1	43,560	10x10	435
2x2	10,890	12x12	302
4x4	2,722	15x15	194
5x5	1,742	18x18	134
7x7	889	20x20	109

Example formats of Plant Composition Table and a Planting Table are provided in Exhibits 13-5 and 13-6.

a. Plant Size Selection

The size of plants selected is important to the success of the revegetation plan and to the overall cost of construction. There are many sizes and forms available for plants. Below is a summary of some of the commonly available plant units from native plant nurseries and seed suppliers.

Trees come in the form of container grown, balled and burlapped, and bare root stock/whips. The size of trees varies from less than a foot tall for bare root stock (seedlings) to 10-12 feet tall or more for balled and burlapped plants and larger bare root tree saplings. Balled and burlapped trees of several caliper inches (e.g., 2-4+ inches) are even taller. Container grown plants are often two to six foot (2'-6') tall for one gallon to three-gallon containers and eight to ten foot (8'-10') or taller for five-gallon containers. Shrubs can be obtained as small as one foot or less up to four to five foot (4'-5') tall for **larger** container grown plants. Shrubs may also be obtained as bare root plants or live cuttings.

Herbaceous plants can be purchased as bare root stock, peat pots/plugs or container grown in typical sizes of pint, quart, and gallon(s) container size. Other typical units include multiple plant flats, two-inch (2") plugs, and four to six-inch (4"-6") peat pots. The height of these plants is usually highly variable; however, certain plants such as grasses can be specified as single or multi-stem units. The seeding of herbaceous plants (grasses, forbs/wildflowers) occurs using live seed usually purchased by the pound or increment of a pound. Native Seed shall be specified in the form of Pure Live Seed (P.L.S) as per MSD Standard Specifications. Seeding is specified on planting plans by percent frequency of overall seeding rate, resulting in a corresponding application rate of pounds per acre (or square footage) for that particular species.

b. Specifying Soil Conditions and Amendments

The project designer shall specify the soil salvaging, furnishing, and amendment parameters for the Natural Areas to be planted and/or seeded. The designer shall determine the existing depth of topsoil onsite, the soil's suitability for salvaging and re-use, and the total depth for topsoil placement (salvaged and/or furnished). The designer shall evaluate the existing soil by having analytical tests performed to determine if the existing topsoil meets MSD Standard Specifications in Section 2.2.1. If the topsoil is deemed to be deficient, the designer must identify in the project's Special Provisions the specific amendments required (e.g., fertilizer, organic matter, lime, etc.) or the volume and depth of suitable furnished topsoil to be provided by the Contractor.

The Designer shall also specify areas where the existing soil is, or may be, infested with noxious weeds, other invasive plants, or any parts (seeds, rhizomes, roots, etc.) of these plants. Specification of the treatment for the infested area(s) should also be identified. This shall include infested soil removal and disposal requirements or specific treatments required for noxious weed and/or invasive species control. The specific measures shall be specified in Special Provisions created for the project.

c. Specifying Protective Devices

There are certain situations where protective devices are required for plant survival and vigor. These include the use of staking and guying or tree shelters. Staking and guying is recommended for all trees greater than 1-inch caliper and is particularly crucial for open areas where trees may be subject to high winds and windfall. Tree shelters are recommended in situations where seedlings or very small saplings are specified. They are also recommended where there is evidence of possible heavy browsing by herbivores (e.g., deer) or where poor soils may contribute to desiccation and plant withering. When specified, either of these protective devices should be incorporated onto the planting plans in the form of notes or symbols around individual trees. Many wetland plants, particularly emergent grasses, must be protected from predation by waterfowl. This may include the use of traditionally named “Goose” or waterfowl exclusion fencing. The materials and execution of protective device placement shall be in accordance with MSD Standard Specifications Section 13. Planting details for these devices are included in MSD Standard Drawings.

d. Creating Special Provisions

Whenever new planting techniques or processes are proposed for a project or there is the need for deviation from standard specifications, a Special Provision is necessary. This is a text document that describes the purpose and required items for implementation of the provision. Development of these Special Provisions should follow the standard outline for MSD Standard Specifications including sections for Description of Work, Materials, and Execution. The execution of these items should also include a description of the appropriate Warranty and Maintenance.

e. Identifying Maintenance and Monitoring Protocols

Maintenance can be specified in Special Provisions and/or in a Maintenance Schedule containing a description of activities required, the methods required, the frequency, and the time of year. (See example in Exhibit 13-7). Maintenance protocols may be identified according to specific plant warranty standard specifications, MSD specifications, and/or the landowner stipulations. Similarly, a derivation of the Maintenance Schedule can be used to identify a monitoring protocol schedule in order to address the execution of specific regulatory and permit condition requirements.

When feasible, management of exotic species should be specified in Special Provisions. Examples of exotic species to be managed include: burning bush, English ivy, periwinkle, Japanese honeysuckle, and garlic mustard.

Maintenance concerns: 1) staking or surveying trees requires follow-up to remove these devices, often several years later; and 2) maintenance or planting plans may need to be bilingual or use symbols when necessary.

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EXHIBIT 13-1
NATIVE REVEGETATION PLAN DESIGN CHECKLIST

EFFECTIVE DATE: AUGUST 31, 2009

NOTE: REFERENCE WEBSITE FOR POSSIBLE UPDATES TO THIS CHECKLIST

NATIVE REVEGETATION PLAN DESIGN CHECKLIST

The Designer should review the project site including determining/accomplishing the following:

_____ Aspect, orientation, slope/topography
_____ Drainage, soil wetness/dryness
_____ Existing shading/tree cover
_____ Likely post-construction shading
_____ Existing native vegetation composition
_____ Evidence of noxious weed infested topsoil
_____ Site constraints and infrastructure features
_____ Depth of existing topsoil
_____ Take soil samples for analytical testing
_____ Invasive plant species for removal

Determine Native Revegetation Planting Plan needs and approach including the following:

_____ MSD project requirements
_____ Permit conditions/mitigation requirements
_____ Determine project area (sq. footage/acreage)
_____ Minimum planting widths for project goals

Determine plant establishment techniques to be used:

_____ Tree and shrub planting
_____ Herbaceous planting
_____Native seeding

Designate and develop planting zones including:

_____ Zone name and number
_____ Making necessary grading changes
_____ Definition of habitat type(s)
_____ Draw plan view of zones

Create Planting Tables and Composition Tables including:

_____ Plant species by zone and strata
_____ Specify quantity per acre
_____ Seeding rate (per acre) and by species
_____ Plant spacing (overall and by species)
_____ Calculate area and required plant quantities
_____Identify plants sizes and plant stock form

Identify and incorporate Planting Details from:

_____ MSD Standard Drawings (Native Revegetation section)

Review MSD Standard Specifications for applicability and project specific modification including:

SECTION 12 NATIVE SEEDING --
MATERIALS

_____ Seed (Section 12.2.1)
_____ Topsoil (Section 12.2.2)
_____ Organic Fertilizers (Section 12.2.3)
_____ Mulch (Section 12.2.4)
_____ Tackifier (Section 12.2.5)
_____ Anchors for Erosion (Section 12.2.6)
_____ Erosion Control Blankets (Section 12.2.7)
_____ Water (Section 12.2.8)

EXECUTION

_____ Schedule (Section 12.3.1)
_____ Transporting Material (Section 12.3.2)
_____ Clearing and Grubbing (Section 12.3.3)
_____ Topsoil Salvaging, Storing (Section 12.3.5)
_____ Seeding (Section 12.3.6)
_____ Fertilization (Section 12.3.7)
_____ Mulch Stabilization (Section 12.3.8)
_____ Watering (Section 12.3.9)
_____ Clean-Up (Section 12.3.10)
_____ Maintenance (Section 12.3.11)
_____ Warranty (Section 12.3.12)

SECTION 13 NATIVE TREE, SHRUB, AND HERBACEOUS PLANTING
MATERIALS

_____ Native Plant Material (Section 13.2.1)
_____ Mulch (Section 13.2.2)
_____ Stakes and Wire (Section 13.2.3)
_____ Tree Shelters (Section 13.2.4)
_____ Waterfowl Exclusion Fencing (Section 13.2.5)
_____ Soil Amendments (Section 13.2.6)
_____ Root gel (Section 13.2.7)
_____ Water (Section 13.2.8)

EXECUTION

_____ General (Section 13.3.1)
_____ Planting (Section 13.3.2)
_____ Maintenance (Section 13.3.3)
_____ Warranty (Section 13.3.4)

Evaluate any additional needs and items for preparation including:

_____ Special Provisions (when necessary)
_____ Maintenance Schedule (Exhibit 17-7)
_____ Monitoring Schedule (e.g. permit conditions)
_____ Support documents (e.g. monitoring plan)

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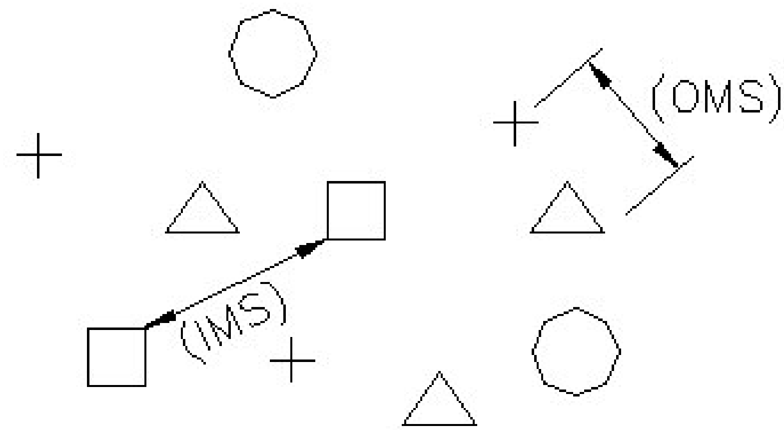
EXHIBIT 13-2
PLANT SPACING - RANDOM

EFFECTIVE DATE: AUGUST 31, 2009



OMS—AN OVERALL MINIMUM SPACING DISTANCE (OMS) IS ASSIGNED TO THE PLANTING CONFIGURATION (SEE PLANT SCHEDULE).

IMS—AN INDIVIDUAL MINIMUM SPACING DISTANCE (IMS) IS ASSIGNED TO EACH INDIVIDUAL SPECIES (SEE PLANT SCHEDULE).

PLANT SPACING—RANDOM

PLAN VIEW **Not to Scale**

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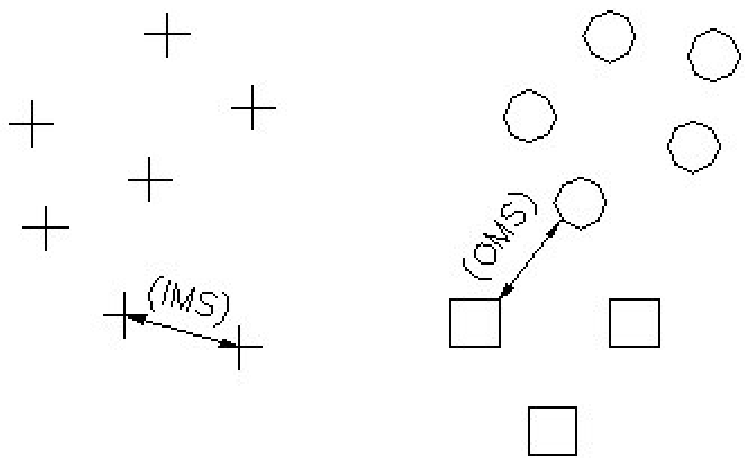
EXHIBIT 13-3
PLANT SPACING - CLUSTER

EFFECTIVE DATE: AUGUST 31, 2009



1. PLANTS ARE ARRANGED IN CLUSTERS CONSISTING OF THE SAME SPECIES.
2. SPACING BETWEEN EACH CLUSTER IS DETERMINED BY THE OVERALL MINIMUM SPACING DISTANCE (OMS).
3. SPACING BETWEEN EACH SPECIES WITHIN EACH CLUSTER IS DETERMINED BY THE INDIVIDUAL MINIMUM SPACING DISTANCE (IMS).
4. CLUSTERS, WHENEVER POSSIBLE, SHALL CONSIST OF ODD NUMBERS WITH NO LESS THAN 3 AND NO MORE THAN 11 INDIVIDUALS OF ONE SPECIES.

PLANT SPACING—CLUSTER

PLAN VIEW **Not to Scale**

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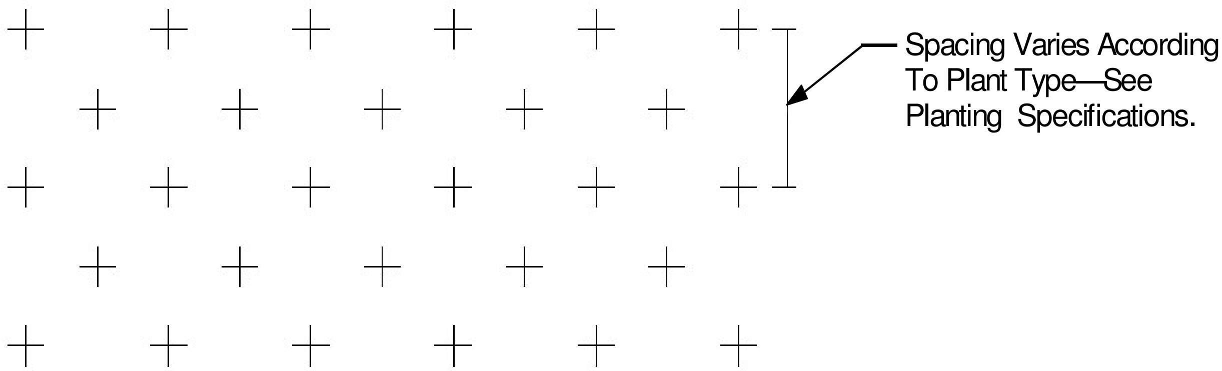
EXHIBIT 13-4
PLANT SPACING - ROW

EFFECTIVE DATE:AUGUST 31, 2009



1. SPACE PLANTS AT EVEN INTERVALS—ALTERNATING ROWS.
2. SEE PLANT SCHEDULE FOR SPECIFIC PLANT SPACING DISTANCES.

COMPOSITION TABLE

Planting Area: Anywhere, Kentucky Zone: 2 Habitat: Floodplain Forest

% Comp. per Strata (per acre)	Overall Min. Spacing (feet)	Total (per acre)	Vegetation Strata/ Species Name	Frequency (%)	Quantity (per acre)	Spacing Type	Individual Min.Spacing (feet)
100	12	435	TREES				
			tree name 1	15	65	RANDOM	26
			tree name 2	25	109	RANDOM	20
			tree name 3	20	87	RANDOM	22
			tree name 4	25	109	RANDOM	20
			tree name 5	15	65	RANDOM	26
100	15 ft.	194	SHRUBS				
			shrub name 1	30	58	RANDOM	27
			shrub name 2	35	68	RANDOM	25
			shrub name 3	35	68	RANDOM	25
100	N/A	40	HERBACEOUS*				
			herb name 1	20	8	SEED	N/A
			herb name 2	15	6	SEED	N/A
			herb name 3	35	14	SEED	N/A
			herb name 4	15	6	SEED	N/A
			herb name 5	15	6	SEED	N/A

*Herbaceous
unit of measure
is lbs

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EXHIBIT 13-5
PLANT COMPOSTION TABLE EXAMPLE

EFFECTIVE DATE: AUGUST 31, 2009

PLANTING TABLE

Size (acres):1.5

Planting Area: Anywhere, Kentucky Zone: 2 Habitat: Floodplain Forest

Quantity	Botanical Name	Common Name	Unit	Size
TREES				
98	tree species 1	tree name 1	balled in burlap	1 1/2 inch caliper
164	tree species 2	tree name 2	container grown	4 - 5 ft.
131	tree species 3	tree name 3	container grown	4 - 5 ft.
164	tree species 4	tree name 4	container grown	4 - 5 ft.
98	tree species 5	tree name 5	container grown	4 - 5 ft.
SHRUBS				
87	shrub species 1	shrub name 1	container grown	2 - 3 ft.
102	shrub species 2	shrub name 2	container grown	2 - 3 ft.
102	shrub species 3	shrub name 3	container grown	2 - 3 ft.
HERBACEOUS				
12	herb species 1	herb name 1	LBS	SEED P.L.S. 75%
9	herb species 2	herb name 2	LBS	SEED P.L.S. 75%
21	herb species 3	herb name 3	LBS	SEED P.L.S. 75%
9	herb species 4	herb name 4	LBS	SEED P.L.S. 75%
9	herb species 5	herb name 5	LBS	SEED P.L.S. 75%

P.L.S. = Minimum
Pure Live Seed
Percentage

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EXHIBIT 13-6
PLANTING TABLE EXAMPLE

EFFECTIVE DATE: AUGUST 31, 2009

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MAINTENANCE SCHEDULE

DESCRIPTION	METHOD	FREQUENCY*	TIME OF YEAR
1. Inspect & replace dead or diseased plants	Follow MSD Specifications	1	March 15 to June 15 & Sept. 15 to Nov. 15
2. Prune all woody plants (corrective pruning only)	Hand tools	1	November 15 to March 1
3. Watering of plants	Water truck/ hand hose	4	June, July, Aug., & Sept.
4. Mowing of permanent seed areas (As required by Special Provisions)	Hand mower or tractor	1	March 1 to May 1 or October 1 to December 1

*Per Year

TABLE OF CONTENTS

CHAPTER 14
TREE PRESERVATION

TABLE OF CONTENTS (cont.)

CHAPTER 14
TREE PRESERVATION
EXHIBITS

CHAPTER 14
TREE PRESERVATION

14.1 PURPOSE

MSD's objective is to preserve as many trees as possible during design and construction of facilities. Trees are beneficial to a community and provide an aesthetically pleasing environment. Trees reduce noise, purify the air, modify the climate, in most cases increase property values and provide wildlife habitats.

To meet these objectives, during the planning and design stages, the proposed routing of the facility must be carefully reviewed. The routing should avoid trees when possible and stay outside of the tree's dripline.

The Louisville and Jefferson County Planning Commission is further developing the following guidelines. The contents of this chapter are intended to be interim guidelines pending completion of the final document.

14.2 GUIDELINES AND GENERAL INFORMATION

14.2.1 General

Generally, cutting the root of a tree within the dripline will reduce the tree's life support system by as much as 25%, outside the dripline only 5%. These percentages can vary with different species of trees.

Exhibit 14-1 shows the common root structure of trees. Exhibit 14-2 shows the dripline and root zones for trees.

14.2.2 Survey Information Needed

a. Species of Tree (Use the Audubon Society Field Guide to North American Trees, Eastern Region).

b. Size (DBH - Diameter at Breast Height). **DBH is measured at approximately 4.5 feet above ground.**

c. Value of the Tree ("Valuation of Trees in Kentucky" - **Kentucky** Arborist **Association**, Inc.).

d. Dripline (Diameter).

e. Encroachment Allowed within the Dripline.

f. Location

1. All trees, **4**-inches in diameter or greater, shall be located and the species given within 30-feet of the centerline of the pipe or 14-feet outside the top of slope of ditches.
2. All trees less than **4**-inches in diameter shall be located and species given, when within an existing or proposed sewer and drainage easement.
3. When trees are grouped together, at a very close interval, locate the approximate center of the grouping and list the most dominant species of the group.

g. Condition (healthy, dead or dying).

14.2.3 Alignment

Pipelines and ditches shall be designed to meander around trees when possible, but necessary measures shall be taken to reinforce ditches in these meandering bends to prevent erosion. The use of the "Green Approach" to reinforce these bends is preferred. The "Green Approach" refers to the use of vegetative solutions to erosion rather than hard liners such as concrete, riprap or gabion, and **revetment** mattresses.

14.2.4 Tunneling or Boring

a. When within a dripline of a tree, consider boring or tunneling. A minimum of 2 feet to the top of the bore or tunnel is recommended. A distance of 3 feet to the top of the tunnel or bore for trees under 12 inches in diameter and 4 feet to the top of the tunnel or bore for trees 12 inches in diameter or more is preferred.

b. For trees 6 inches in diameter and smaller at the DBH, the work pits wall for tunneling or boring should come no closer than the dripline of the tree or as shown on Exhibit 14-3.

c. The side of the tunnel or bore shall be at least 2 feet from the outside of the tree.

d. Most roots live in the top 18 inches of soil. However, root patterns vary depending on the species, size of the tree and the kind of soil. A test pit should be dug to determine if the tunnel or bore should be lowered or could be raised.

14.2.5 Selection & Location

For the answer to "What tree to plant and where to plant it?" contact the City of Louisville's Arborist or Forester or another qualified Arborist.

14.2.6 Arborist

A qualified Arborist shall review all plans, where construction is to take place in a treed area. This plan review and a site visit should determine the effect of the project on the trees that are present. The Arborist should make recommendations on how to prevent or minimize tree damage.

14.2.7 Utility Easements

Do not replant trees within the utility or sewer and drainage easement without written permission from the utility for which the easement was granted.

14.2.8 Root Barrier

Use a root barrier device where necessary to prevent roots from causing damage to pavement or structures.

14.2.9 Replacement

Where removing a tree of significant size and if the property owner agrees, a note shall be placed on the plans stating that a replacement tree, 3-inch caliper, will be planted within the same property and outside the permanent easement. **The replacement tree will be selected from the general guidelines of Chapter 13 of this manual.**

14.2.10 Relocation

Where it is not possible to leave a tree in a permanent easement undisturbed, investigate the possibility of moving the tree outside the permanent easement upon agreement of the property owner.

14.2.11 Construction

a. Protection of the bark of trees shall be prescribed by specifying a method of protection in the specifications or the special provisions.

b. Protection of the tree's root system from compaction by construction equipment, vehicular parking, or excessive foot traffic shall be specified in the specifications or the special provisions.

c. Design facilities to reduce the operating of vehicles, equipment, or parking within the dripline of all trees.

EXHIBIT 14-1
COMMON ROOT STRUCTURE

EFFECTIVE DATE: JUNE 30, 2009

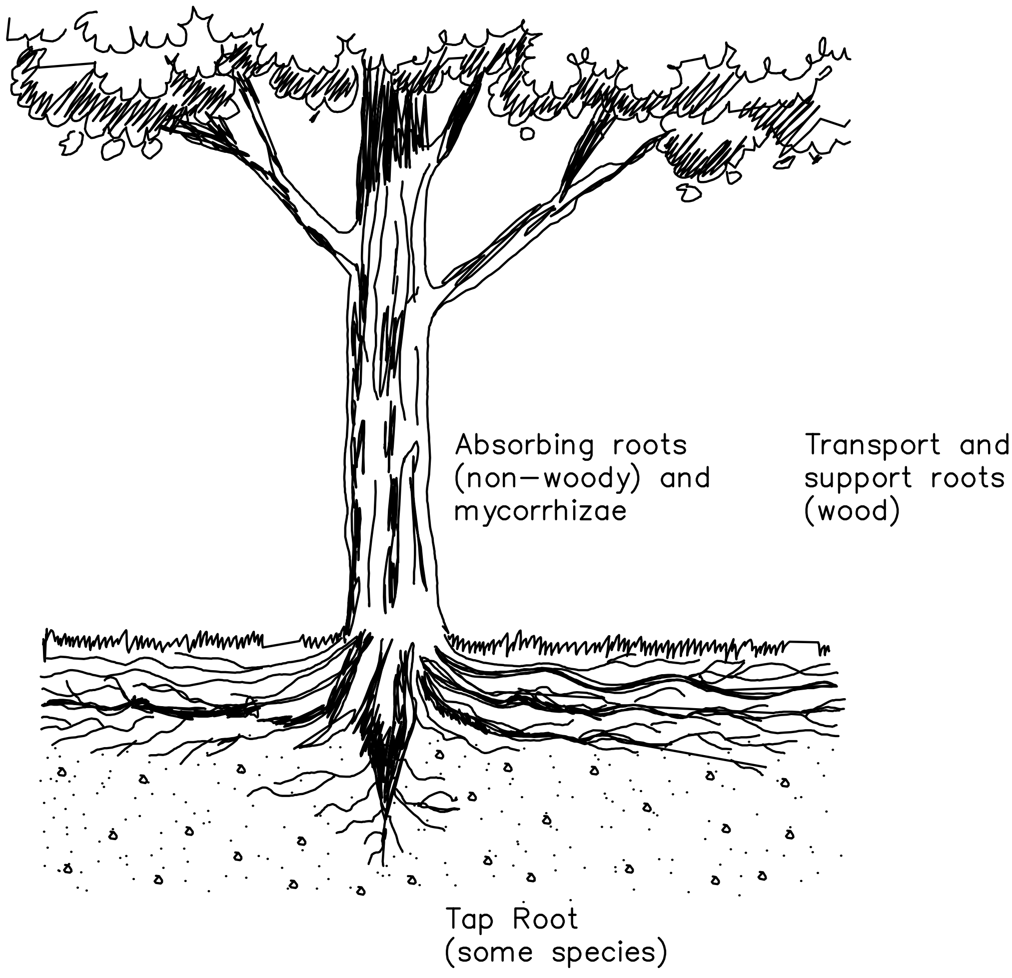

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EXHIBIT 14-2
DRIPLINE

EFFECTIVE DATE: JUNE 30, 2009

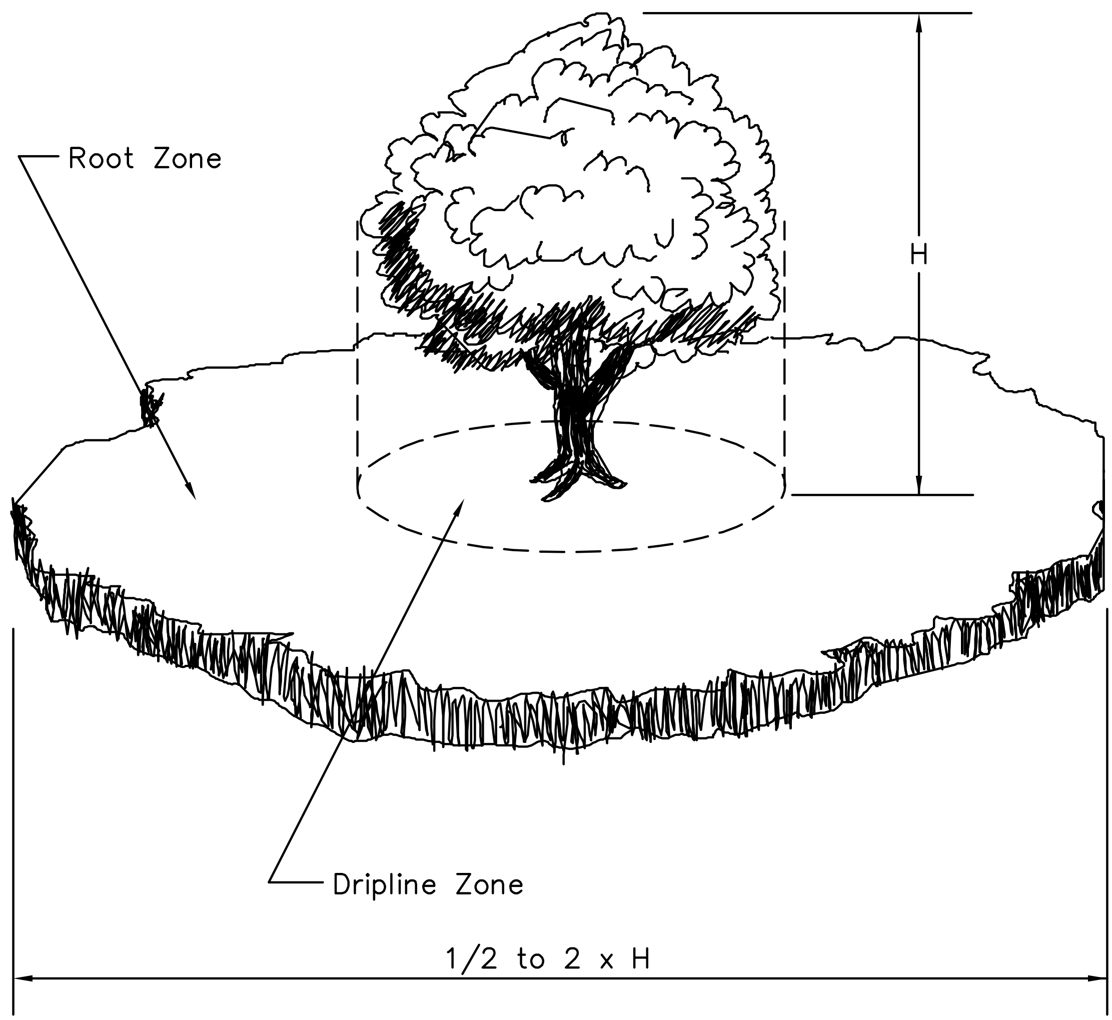

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EXHIBIT 14-3
TUNNEL OR BORE LENGTHS FOR TREE PROTECTION

EFFECTIVE DATE: JUNE 30, 2009

Diameter	Distance "X"
6"–9"	5–Feet
10"–14"	10–Feet
15"–19"	12–Feet
over 19"	15–Feet

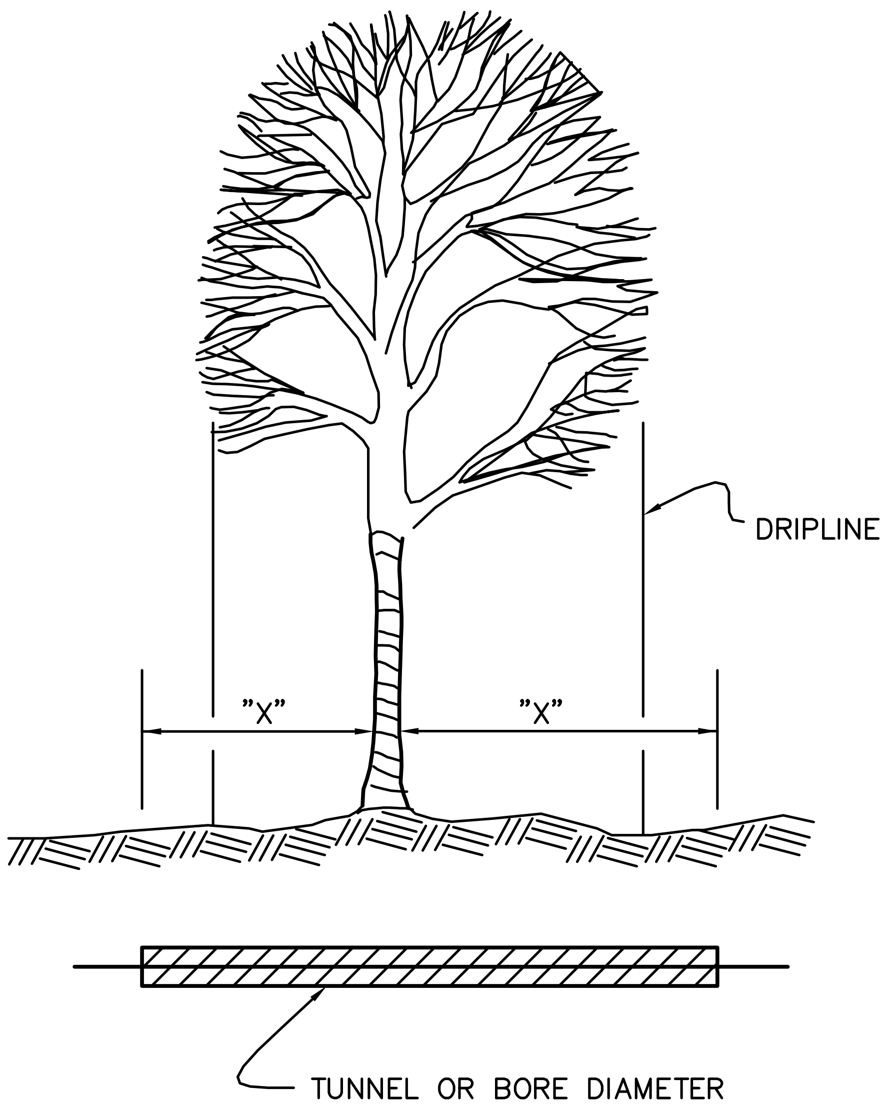

TABLE OF CONTENTS

CHAPTER 15
SMALL PUMP STATIONS

TABLE OF CONTENTS (cont.)

CHAPTER 15
SMALL PUMP STATIONS

TABLE OF CONTENTS (cont.)

CHAPTER 15
SMALL PUMP STATIONS
EXHIBITS

CHAPTER 15
SMALL PUMP STATIONS

15.1 PURPOSE

This chapter:

a. Identifies the planning and design approach to be used for small pump stations.

b. Defines specific criteria for the design of small, sanitary pump stations **and their associated force mains**.

c. Delineates submittal requirements required by MSD for review and approval of small pump stations.

d. Delineates requirements for opinions of construction and operating costs.

e. Pump stations must satisfy the regulations of agencies having jurisdiction. Pump stations, at a minimum, shall conform to this document, MSD's Miscellaneous Electrical, Instrumentation & Control Design Standards, and to the Recommended Standards for Wastewater Facilities, 2004 Edition (Ten State Standards).

15.2 SUBMITTAL REQUIREMENTS

The Design Engineer shall submit the Concept Plan and Final Design submittals to MSD for review and approval. Approval by MSD will be required prior to authorization of any succeeding design phase.

15.2.1 Concept Plan Submittals

The purpose of a Concept Plan is to provide MSD with preliminary design data for proposed facilities (sanitary sewers, pump stations, force main sewers). The Concept Plan is used to determine the compatibility of proposed facilities with the approved countywide 201 Plan and Area Action Plans and to justify alternatives recommended for providing sanitary sewer service.

Developers and engineers submitting Concept Plans should reference previous Area Action Plans and the countywide 201 Plan for information on the existing environment and collection system and on estimated future conditions. Concept Plan submittals relating to pump stations shall include the following elements.

a. Project Background

1. Narrative description of the proposed service and drainage areas that can be served by the proposed facility.
2. Description and reference to any Action Plan requirements that relate to the proposed service area (on-site area to which service will be provided) and drainage areas (off-site areas that can be served with the proposed facilities).
3. Topographic map showing the boundaries of the proposed service and drainage areas.

b. Existing Environment

1. Existing land use for the proposed service area, adjacent areas, and drainage areas, delineating project area or development site.
2. Existing hydrology, land features, floodplains, geological characteristics, surface conditions, subsoil conditions, and water table details.

c. Existing Collection System

1. Current sanitary sewer and stormwater collection system maps for the proposed service area, drainage area, and surrounding area.
2. Details of existing system to which a proposed sewer or force main may connect. Capacity of existing sewer system to receive flow from force main or future gravity sewer if temporary pump station is installed.
3. Locations of streets, alleys, unusual obstructions, required rights-of-ways, and all similar data that may help to define the physical features of a proposed sewer project.

d. Future Conditions

1. Designated land use for the proposed service area, drainage area, and surrounding area.
2. Population and flow projections for the proposed service area and drainage areas as called out in the Area Action Plans.
3. Types of development, i.e., residential, commercial, or industrial.
4. Area Action Plan forecasts for the proposed service area, drainage area, and surrounding area.
5. Location of future roads, parks, industrial areas, etc., which may affect the routing and location of sewers and force mains.
6. Construction phasing to accommodate proposed development.

e. Pump Station Justification

In many cases, pump stations are unavoidable and necessary to provide service to a new area. The need for a sanitary pump station must be justified according to one or more of the following criteria. Compliance with one or more of the following criteria does not relieve the designer from the requirement to evaluate alternatives if portions of the service area do not satisfy these conditions:

1. The pump station is recommended in an approved Area Action Plan; or
2. The elevation of a proposed service area is too low to be served by existing or future on-site or off-site gravity sewers; or
3. Interceptor sewers, planned by MSD, are not in place; or
4. The proposed sanitary pump station has been determined to be a cost-effective alternative to an on-site or off-site gravity sewer. To justify a pump station using these criteria, alternatives must be developed and evaluated as described in the following two sections.

f. Development of Alternatives

The following are minimum alternatives to be considered when a cost-effectiveness study is required as part of the pump station justification.

1. Gravity Sewer to Existing Collection System:
   Provide description and preliminary drawings to illustrate existing facilities, proposed facilities, and connection.
2. Interim Solutions:
   Temporary pump stations that provide service until permanent interceptors or other facilities are constructed.
3. Other Possible Solutions:
   a. Consolidation with other pump stations.
   b. Address sewer connections that are not cost-effective due to site conditions or not possible due to elevation differences, individually.
   c. Grinder pumps for individual homes or small clusters of homes.
4. Pump Station Construction:
   Provide description and preliminary drawings to illustrate existing facilities, proposed facilities, and connection.

g. Evaluation of Alternatives

The alternatives shall be evaluated based on a cost-effectiveness analysis outlined in Section 15.3.4. The analysis shall be performed on each alternative and include both economic and non-economic factors.

15.2.2 Final Design Submittals

Design submittals relating to pump stations shall include the following elements:

a. MSD plans and standard specifications modified to specific project needs with additional diagrams and technical data as necessary to construct the proposed installation.

b. Population and flow projections and calculations.

c. Wetwell calculations.

d. Force main calculations.

e. Pump curve/system curves in feet of total dynamic head versus flow in gallons per minute with the following labels: Pump Curve; Single Pump Operation Curve; Two-Pump Operation Curve; Three-Pump Operation Curve (if applicable); Design Point(s); and Operating Point(s) and Operating Envelope. Shut-off head should be included where it will be a controlling point.

f. Total hydraulic efficiency at operating point(s).

g. Pump cycle time.

h. Valve configuration.

i. Float setting calculations.

j. Buoyancy calculations.

k. Force main pressure and water hammer calculations.

l. Determinations for air release, air/vacuum, and/or sewage combination air valves.

m. Odor control calculations and/or assumptions.

n. Electrical calculations and/or power requirements (refer to Section 15.5.5.1 for specific requirements).

o. Opinions of capital and operation and maintenance costs. **Energy efficiency is to be considered in the design.**

p. Site plans showing details of site access, landscaping (if applicable), and electrical utility pole or service rack location.

15.3 DESIGN APPROACH

15.3.1 Compliance with Area Sanitary Plans

Proposed construction or expansion of small sanitary pump stations shall be in compliance with the approved countywide wastewater 201 Plan and approved Area Action Plans.

15.3.2 Approvals

Prior to construction or expansion of a small sanitary pump station, the design documents must receive the approval of the following agencies and be signed and sealed by a Professional Engineer currently registered in the Commonwealth of Kentucky:

a. MSD

b. Kentucky Division of Water

c. Jefferson County Health Department

15.3.3 Service Level

Guidelines presented in this Design Manual govern the planning and design of small pump stations defined as follows:

a. Range in size up to 700 gallons per minute (peak flow) and/or up to 80 feet of total dynamic head.

b. Proposed construction or expansion of sanitary pump stations exceeding the stated ranges will be considered by MSD on an individual basis.

15.3.4 Cost-Effectiveness Analysis

The cost-effectiveness comparison analysis between a pump station and gravity sewer shall include both economic and non-economic factors.

a. Economic Factors

The economic portion of the cost-effectiveness analysis shall use a present worth calculation that considers capital costs, operation and maintenance costs, and salvage values.

Capital costs shall include opinions of construction cost as outlined in Section 15.6, engineering costs based on recognized fee curves and costs for acquisition of properties, easements and rights-of-way, including legal costs. Operation and maintenance costs shall include opinions of cost for labor, utilities, maintenance and repair of facilities. Salvage values shall be developed on straight-line depreciation.

Life cycle costs should be considered over a 20-year period. Unless otherwise directed by MSD, a discount rate equal to that required by the Division of Water should be used to calculate the present worth value of each alternative.

b. Non-Economic Factors

Non-economic factors to be addressed in narrative form, as a part of the cost-effectiveness analysis, should include:

1. Environmental Impact: The short-term and long-term impacts of the alternative on the environment.
2. Reliability: A measure of how dependable the alternative performs over time.
3. Operability: The ease with which the alternative operates over time.
4. Constructability: The ease with which an alternative can be constructed and phased into operation.
5. Resistance to vandalism.
6. Aesthetics and comments on neighborhood/property owner acceptance.

15.4 DESIGN CRITERIA

15.4.1 Definitions

a. Residential Equivalent Population: Refer to Exhibits 8-2 and 8-3.

b. **Design** Average Daily Flow: Residential equivalent population x 100 gallons per capita per day (gpcd). **This term is also referred to as Average Flow.**

c. Peak Flow: **Design** Average **Daily** Flow x peaking factor.

Peaking factor = $\dfrac{18 + (P)^{1/2}}{4 + (P)^{1/2}}$; Where P = population in thousands

d. Initial Average Flow: Initial residential equivalent population x 100 gpcd.

e. Initial Peak Flow: Initial average flow x peaking factor.

f. 20-Yr. Average Flow: 20-yr. residential equivalent population x 100 gpcd.

g. 20-Yr. Peak Flow: 20-yr. average flow x peaking factor.

h. Ultimate Average Flow: Ultimate residential equivalent population x 100 gpcd.

Ultimate residential equivalent population is defined as the population halfway between 20-year population and watershed saturation population.

i. Ultimate Peak Flow: Ultimate average flow x peaking factor.

j. Watershed Saturation Population: The maximum projected population for the watershed based on present zoning that is equated to equivalent residential units.

k. Emergency Response Storage Volume: Ultimate average flow x 120 min.

15.4.2 General

Population and flow projections for developed and undeveloped areas that are used to design pump stations shall be as defined in Chapter 8. Saturation and 20-year population projections shall be those as used in approved Area Action Plans.

For instances where an Action Plan is unavailable, population projections should be prepared by the Design Engineer and be submitted to MSD for approval.

When designing a new pump station to serve an existing collection system, an infiltration and inflow (I&I) study which considers the effects of wet weather flow shall be performed. The I&I study shall be based on peak flow data

provided by MSD based upon available computer model simulations for the area.

Pump station peaking factors should be the same as sanitary sewer peaking factor, which includes anticipated wet-weather flows.

Pump stations shall be of the wetwell type utilizing submersible pumps. They shall operate automatically under normal conditions but be capable of manual control. Pump stations shall be planned and designed to include provisions for ease of future elimination. Precast concrete or cast-in place concrete wetwells are acceptable.

The pump station top shall be designed to an elevation at least 2 feet above the 100-year flood elevation or the pump station shall be flood proofed to provide maximum protection against flooding while still permitting operation.

Pumps shall be sized such that the pumping capacity, with the largest pump out of service, will handle the peak design flow condition.

All gate and check valves shall be installed horizontally in shallow concrete valve vaults next to the wetwells. The arrangement shall provide for easy access to the equipment to facilitate maintenance. Valve vaults are confined spaces; therefore, they require adequate means for ingress and egress, including OSHA approved ladders and access hatches of sufficient size.

If the pump station is provided with potable water service, the service line shall have a backflow preventer and/or a pressure vacuum breaker ASSE #1020 or a reduced pressure zone ASSE #1013 installed to prevent possible cross connections to the potable water supply. The service line shall be installed in compliance with Louisville Water Company regulations.

Each pump station shall be accessible via an access road with a minimum width of 12 feet and a turn-around to accommodate an AASHTO SU design vehicle at the pump station site. The access road shall be paved with bituminous concrete with a pavement design appropriate to the vehicle and shall be designed to an elevation at least 2 feet above the 100-year flood elevation and maximum grade of 7 percent.

Fencing of the pump station site shall be reviewed on a case-by-case basis by MSD. Landscaping shall comply with buffer requirements of the Louisville and Jefferson County Planning Commission. Any deviations from the above criteria shall be submitted to MSD for review and approval.

To ensure uniformity and MSD system compatibility, MSD has prepared Standard Drawings and Specifications for a typical duplex pump station and its electrical system (see Exhibits 15-1 **through 15-4**). **The DWG files can be found on MSD's web site.** The Design Engineer should use the information that is provided herein to customize these documents in order for the installation to meet the specific project needs. The Design Engineer shall be responsible for the design of the system.

15.4.3 Process

15.4.3.1 Wetwell

Wetwells shall be designed for the ultimate peak flow. The cycle of operation for each pump shall not be less than 15 minutes and the maximum detention time in the wetwell shall average no more than 30 minutes.

The wetwell volume for optimum operation shall be computed as follows:

$$V = (\phi q)/4\ ;$$

Where:

V = Required operating capacity in gallons

ϕ = Minimum time of one pumping cycle in minutes, from start to start. Ideally ϕ = 15 minutes (maximum 30 minutes; minimum 12 minutes)

q = Pump capacity in gallons per minute (use ultimate peak flow)

Detention times for both initial average flow and ultimate average flow conditions shall be computed.

Wetwell volume shall be based on a maximum draw down depth of 4 feet between the lead pump on elevation and the pumps off elevation.

The design of the pump station shall incorporate a minimum two-hour emergency response storage volume based on ultimate average flow conditions as stipulated under Section 15.4.1. The required volume must be provided in the wetwell and/or a separate, self-draining surge tank between the high wetwell alarm elevation and the invert elevation of the lowest influent gravity sewer. The two-hour emergency response storage volume may be waived by MSD if two sources of electric service are provided or there is an emergency generator permanently installed at the pump station. Unless specifically prevented by site conditions, the Design Engineer shall layout the collection system and pump station such that the top of the wetwell or nearest upstream manhole is at least two feet below the lowest building floor elevation receiving sewer service. In the event that emergency response measures are overburdened, this will provide a point of relief to prevent backups into homes and the adverse impacts on public health and property damage. The Design Engineer shall identify the location and characteristics of the overflow relief point on the Drawings.

Avoid dropping influent flows into wetwells **by installing a drop pipe connection on the wetwell interior or exterior** to eliminate air entrainment. **The wetwell shall be considered as a Class 1, Division 1 hazardous location. Rail packages shall be non-sparking.** Further wetwell sizing constraints are detailed in Section 15.5.3, Pump Control.

15.4.3.2 Force Main

Force mains shall be designed for ultimate peak flow conditions and checked for initial and ultimate peak flow conditions to insure the velocity ranges.

Sewage combination air valves shall be provided at all high points in the force main. Long horizontal runs and increases in slope may require air/vacuum and/or air release valves, realizing that air release valves are for pockets of air accumulated during operation and air/vacuum valves are to exhaust or admit air during filling or draining the force main. Cleanouts shall be provided at all low points and at additional critical locations. The Design Engineer shall consider and review with MSD the location of all air release valves, air/vacuum valves, sewage combination air valves and cleanouts.

The Engineer shall provide an economic analysis comparing the installation of air release and air/vacuum release valves against the installation of deeper force main piping. The economic analysis shall take into account the installation and maintenance costs associate with the air release and air/vacuum release valves. Air release and air/vacuum release valves shall be specifically designed for wastewater service and be sized per the manufacturer's recommendations.

The air and vacuum release valves will be contained in a vault and vented above ground. A manually controlled isolation valve shall be installed between the force main and the air release or air/vacuum release valves.

Joint restraints **or concrete thrust** blocks shall be **installed** at bends**. An analysis must be made to determine if a joint restraint is required either upstream or downstream of the bend.**. For slopes of 20 percent and greater, anchors shall be provided at each joint (at a minimum). A flexible through-wall connector shall be used at pipe penetrations through structures to allow for differential settlement.

Force main design criteria shall be as follows:

a. Minimum Pipe Size

1. 4-inch I.D. for wastewater pumps
2. 2-inch I.D. for grinder pumps

b. Design Pipe Roughness Coefficient (C)

1.	PVC	C = 120 **and 150**
2.	Polyethylene	C = 120
3.	Lined Ductile Iron	C = 120
4.	Steel or Unlined Iron	C = 100

c. Velocity (V) Range

1. V = 2.0 to 5.0 feet per second (fps) for wastewater pumps
2. V = 3.0 to 5.0 fps for grinder pumps

Note: A maximum velocity of 6.0 fps is allowable with a present worth economic calculation that considers capital and operating costs in order to justify any increase above 5.0 fps.

15.4.3.3 System Head Curve

The pump/system curve calculation may be performed utilizing any acceptable hydraulic equation.

The system head curve is a plot of the discharge through a pipe system given the size against the head losses as a result of friction in that pipe system. Selection of pump size shall be based on static head and total dynamic head. The design operating point is at the intersection of the pump curve and the system curve. Also, the pump should have an impeller size such that the shut-off head exceeds the pumping head at peak Q.

Static head or static pressure (h_s) shall be based on the average elevation of lead pump on/off:

h_s = (Elevation of highest point in force main) - (Average elevation of lead pump on/off)

Fittings and valves **can** be converted to an equivalent length of force main to compute station losses.

Friction losses (h_f) in the force main **can** be computed according to the Hazen-Williams formula as follows:

$$H_f = (10.44)\,(L)\,\frac{(q)^{1.85}}{(C)^{1.85}\,(d)^{4.8655}}\ ;$$

Where:

- L = Length of pipe (feet)
- q = Flow rate (gallons per minute)
- C = Hazen-Williams friction loss coefficient
- d = Pipe diameter (inches)

Compute total dynamic head as follows:

$$\begin{aligned} TDH &= \text{Static Lift} + \text{Friction Loss} \\ &= h_s + h_f \end{aligned}$$

The TDH shall be calculated for the design roughness coefficient as stated in Section 15.4.3.2 and per the pipe manufacturer's **and pump supplier** recommended roughness coefficient. **All applicable** system curves shall be plotted on the pump curve submitted.

The operating point for the selected pump shall be in the range of initial peak flow to ultimate peak flow as determined by MSD. The pump efficiency at the operating point should be within the acceptable operating range of 60 to 120% of the capacity at the best efficiency point. The selected pump must be approved by MSD.

The pump efficiency shall be included in the final design submittal. Grinder pump efficiencies may be obtained from the manufacturer. Following pump selection, the system should be checked for low static head conditions (i.e., full wetwell condition). The minimum head curve shall be plotted on the pump curve. This check is performed to insure that in no case will the pump be required to operate outside its normal operating range. Such an occurrence could result in overloading of the motor and eventual pump failure. **The motors shall be sized to be non-overloading over the entire pump curve.**

When pump stations are proposed to discharge into gravity sewers, the capacity of the gravity sewer receiving the discharge shall be checked to determine the impact on the sewer capacity.

When pump stations are proposed to discharge into force main sewers, an analysis of the existing pump station shall be performed to evaluate the impact of the additional flow in the existing force main and its effect on the existing pump(s) performance. The Design Engineer should check initial and ultimate flow conditions to see if the existing pump capacity is compromised. Conditions should be verified when the existing pump station is pumping and when it is not pumping (on and off). An analysis of the potential for reverse flow through the existing pumps shall be included. If the capacity is reduced, a recommended upgrade to this station should also be presented in conjunction with the proposed pump station design. Approval of systems that discharge into force mains will be evaluated on a case-by-case basis.

15.4.3.4 Buoyancy

Buoyancy shall be analyzed on the wetwell to determine whether additional methods of restraint are necessary. Mechanical equipment, water weight, and other temporary loads shall not be included in the analysis. A safety factor of 1.5 (minimum) is required.

Buoyancy Force shall be computed as follows:

Buoyancy Force = (Displaced Volume) x (Unit Weight of Water)

Opposing Force shall be computed as follows:

Opposing Force = Weight of Barrel + Weight of Bottom Slab + Weight of Top Slab + Net Weight of Saturated Soil over Bottom Slab Extension + Any Additional Restraints (Do not include electrical/mechanical components).

Factor of Safety is computed as follows:

$$\text{Factor of Safety} = \frac{\text{Opposing Force}}{\text{Buoyant Force}} \geq 1.5$$

15.4.3.5 Force Main Pressure and Water Hammer Calculations

From the Uni-Bell Handbook of PVC Pipe, Design and Construction, 1986, water hammer is an increase in pressure in a pipe caused by a sudden change in velocity. The velocity change usually results from the closing of a valve. The maximum surge pressure encountered is a function of wave velocity (a) as follows:

$$a = 4660/(1 + (kd/Et))^{1/2};$$

Where:

- a = Wave velocity
- k = Fluid bulk modulus, 300,000 pounds per square inch (psi) for water
- d = Pipe ID, (inches)
- E = Modulus of elasticity of pipe
  400,000 psi for PVC pipe
  24,000,000 psi for ductile iron pipe
  110,000 psi for polyethylene
- t = Wall thickness (inches)

OR

$$a = 4660/((1 + (k/E)(DR-2))^{1/2};$$

Where:

- DR = (O.D. (inches)) ÷ (wall thickness (inches))
- DR = Dimension Ratio

The maximum surge pressure (P) is computed as follows:

$$P = \frac{aV}{2.31\ g};$$

Where:

- V = Maximum change in velocity (velocity goes to 0 feet per second)

g = Acceleration due to gravity (32.2 feet per second-squared)
P = Pressure surge (pounds per square inch)

Total pressure is computed as:

Total Pressure = Maximum Surge Pressure + Static Pressure = $P + h_S$

Total pressure must be less than the rated pressure of the pipe (rated pressure including surge allowance).

Cyclic Surge (Fatigue) Analysis is determined (for PVC force mains only) as follows:

a. Estimate the number of pump cycles for the proposed system using a design life of 80 years (use 4 cycles per hour and a safety factor of 2.5).

b. Calculate the peak hoop stress (S) using Vinson's formula.

$$C = (5.05 \times 10^{21})\, S^{-4.906};$$

Where:

C = Average number of cycles to failure
S = Peak hoop stress (pounds per square inch)

c. Determine Total System Pressure (P_T)

$$P_T = \text{Maximum Surge Pressure} + \text{Static Pressure}$$

d. Use International Standards Organization (ISO) formula to determine minimum dimension ratio.

$$DR_{required} = (2S/P_T) + 1\ ;$$

Where:

DR = Dimension Ratio
S = Peak Hoop Stress
P_T = Total System Pressure

The calculated DR value must be greater than the DR of the selected pipe.

Force main pressure and water hammer calculations for ductile iron pipe shall be based upon AWWA Standards

C150/A21.15-91, "American National Standard for the Thickness Design of Ductile Iron Pipe." Calculations for polyethylene pipe shall be based upon AWWA Standards C906-90 "Standard for Polyethylene (PE) Pressure Pipe and Fittings."

15.4.3.6 Odor Control

The Design Engineer shall consider the need for odor control if detention time in either the wetwell or the force main, based on the average flow, exceeds 30 minutes.

Refer to Chapter 17, Odor Control, for specific requirements.

15.5 ELECTRICAL

15.5.1 General

This section provides guidelines for the design and preparation of plans and specifications as related to small sanitary pump station power, control, and telemetry. All electrical documents must be signed and sealed by a Professional Electrical Engineer currently registered in the Commonwealth of Kentucky.

All concepts and designs are to strike a balance between function, initial cost, operational cost, and ease of maintenance. Generally accepted designs, materials, and methods are to be used throughout the project. **MSD provides sample design documents that balance these issues. Drawings and specifications for full-voltage started 3-phase and single-phase, and soft started 3-phase, duplex pump stations are available for downloading from MSD's website. The Design Engineer shall utilize these as a template for completing design.** If, however, the Design Engineer identifies an opportunity to take advantage of an innovative design approach, the Design Engineer is to present the proposal in writing to MSD for evaluation.

15.5.2 Applicable Standards or Codes

All systems, designs and procedures are to meet or exceed the requirements of the latest issue of the following codes or standards:

- Kentucky Building Code: KBC
- National Electrical Code: NEC
- Underwriters Laboratories, Inc.: UL
- Factory Mutual: FM
- National Fire Protection Association: NFPA

- National Electrical Manufacturers Association: NEMA
- Occupational Safety and Health Administration: OSHA
- Kentucky Occupational Safety and Health Administration: KYOSHA

Designs should relate to the following specific requirements:

- NFPA 37 Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines
- NFPA 110 Standard for Emergency and Standby Power Systems
  NFPA 820 Recommended Practice for Fire Protection in Wastewater Treatment and Collection Facilities

15.5.3 Pump Control

15.5.3.1 Automatic Operational Sequence

Programmable logic controller (PLC) based primary controls shall operate the pumps and shall perform automatic alternation and duplexing for two pumps or triplexing for three pumps. The **PLC** shall alternate the lead pump once the wetwell level has been pumped down to the stop elevation. The **PLC** shall also provide for energizing the other pump as a backup or lag pump if needed. Provisions shall also be made for overriding the alternator by manually selecting the pump sequence.

A float switch-based back up control system shall be included that will sequentially start and stop all pumps via time delay relay(s). The back up control system shall function independently of the PLC controls. Upon actuation of a backup float switch, both pumps will be started sequentially with the use of time delay relays. As the level in the pump station falls below the backup stop float switch, the pumps will be stopped in sequential fashion with time delay relays.

A step control or variable level scheme shall be used for the pump control. These schemes shall establish the following sequence of operations:

a. Constant Speed Pumps - The lead pump shall start when the wetwell volume from the pumps "off elevation" to the lead pump "start elevation" is equal to the volume derived in Section 15.4.3.1. The minimum separation between these elevations shall be 12 inches.

If the influent sewage flow into the wetwell is greater than the capacity of one pump, the second and, if applicable, third pumps shall start at ascending, separate levels (start elevations). They then continue to run until the liquid level in the wetwell is pumped down to a predetermined level (stop elevation) for all pumps.

b. Variable speed pumps will be considered on a case-by-case basis.

A PLC program shall be provided and downloaded by MSD based on the sample pump station designs identified earlier. Elevations (in feet above the wet well floor) shall be provided by the Design Engineer to MSD for pump controls. Deviation from the sample pump station designs may render incompatible the associated PLC program developed by MSD for the Developer's use. At MSD's discretion, responsibility for PLC program development for non-standard pump stations may be transferred to the Developer.

15.5.3.2 Control Settings

PLC-based primary controls shall stop all pumps at the wetwell level equal to the minimum level recommended by the manufacturer of the proposed pumps **plus 24 inches and a minimum of 12 inches below the PLC controls lead start elevation**. The increment in levels between the **PLC control** multi-pump start points shall be a minimum of 12 inches.

The elevation for actuation of the back up stop float switch shall be 12 inches below the PLC controls stop elevation. The back up start float switch shall be 12 inches above the last lag pump PLC controls start elevation.

The **SCADA** high water alarm level shall be at or lower than the invert of the influent pipe and at least 12 inches above the **back up start float switch** elevation. **The local high water alarm level shall be a minimum of 12 inches above the high water SCADA alarm.**

15.5.3.3 Level Detection

A hydrostatic level transmitter shall be the preferred method of level detection and shall be incorporated into the pumping station operation. **Float switches shall provide back up pump control and high level alarm signaling. The level transmitter shall be installed in a stainless steel stilling well**. The float switches shall be **free hanging and** suspended by weighted cables, which contain the wiring. The cables shall be of sufficient length to be installed without splicing. Level detection systems that require maintenance personnel to enter the wetwell to repair or replace components are unacceptable. Intrinsically safe relays must be used in conjunction with float switches**, and intrinsically-safe signal repeater used with the level transmitter,** in order to meet the requirements of Class 1, Division I, Group D hazardous locations.

15.5.3.4 Operator Interface

A graphic touch screen "human-machine interface" terminal (HMI) shall be provided for indicating status and alarms, and for input from the operator for various control functions. Two exceptions are the inclusion of a hardwired Hand-Off-Auto switch and a reset pushbutton for each pump to allow manual operation of pumps and resetting of motor starter faults without the HMI or PLC. MSD shall provide and download graphics programming for the operator interface for the sample duplex pump stations designs identified earlier. Deviation from the sample pump station designs may render incompatible the associated HMI graphics developed by MSD for the Developer's use. At MSD's discretion, responsibility for HMI program development for non-standard pump stations may be transferred to the Developer.

15.5.3.5 Pump Interlock

Sensors and control hardware shall be provided to monitor the following conditions:

a. Motor stator over-temperature.
b. Seal leakage.
c. Loss-of-phase, phase reversal, or under voltage.
d. Electrical overload (solid-state, temperature compensated **overload relay for full-voltage started pumps**).
e. **Starter fault (from reduced voltage solid-state starter on soft started pumps).**
f. Short circuit.

All of these conditions shall de-energize the appropriate pump(s). Seal leakage **and over-temperature** shall be **latched in the PLC program until** manually reset **via either "soft buttons" on the** the **HMI on the** control panel inner door **or remotely via the MSD SCADA system**. **When the back up level control mode is engaged,** motor stator over-temperature **and seal failure** shall de-energize the pump**, however, the pump will be re-enabled upon if either interlock self-resets e.g. the motor cools down**. **Electrical overload relays and soft starters shall be provided with a reset pushbutton on the inner door of the control panel, independent of PLC or HMI controls.**

Loss-of-phase, phase reversal or under voltage condition shall de-energize all pumps **in any mode of control**. The monitor for these conditions shall reset automatically once the problem parameter falls within its appropriate range. If, **upon** reset **of the monitor**, the control system calls for more than one pump, the additional pump(s) shall be energized after a time delay(s) **in both the PLC logic or the backup control system to reduce motor inrush current on the electrical service or the generator.**

15.5.4 Alarm System

15.5.4.1 Station Local Alarms

The station shall be provided with a local alarm system **powered from the main control panel and powered via an uninterruptible power supply (UPS). The following shall initiate the local alarm.**

a. High wetwell level.
b. Power failure.

These alarms should annunciate locally via a red flashing light and a horn. The horn shall have a silence button accessible to the general public. The light shall remain on during alarm condition. The horn and light will de-energize automatically **once** the listed alarm conditions **have reset**.

15.5.4.2 Telemetry

The following alarm signals shall be provided **as inputs to the PLC for transmission via MSDs county-wide SCADA system:**

a. Power failure.
b. High wetwell level.
c. Pump on (1 per pump).
d. Pump overload **or starter fault** (1 per pump).
e. Pump seal leak **(1 per pump)**
f. **Pump high** temperature **(1 per pump)**
g. Pump circuit **breaker tripped** (1 per pump).
h. Pump **circuit breaker off** (1 per pump).
i. Pump in Hand (1 per pump)
j. Pump in Auto (1 per pump)
k. Pump in Off (1 per pump)
l. Failure of UPS or DC power supply
m. Main circuit breaker tripped.
n. Transfer switch in normal position.
o. Transfer switch in emergency position.
p. Normal source available.
q. Emergency source available.
r. Generator failure.
s. Generator running.
t. **Generator control in Auto.**

All alarms shall be implemented via 120 VAC dry contacts.

The control panel shall include a blank space on the subpanel for mounting of a modem. MSD shall provide and field install the modem upon notification of control panel installation. MSD shall also provide cabling and antenna as necessary to deliver the SCADA signal from the PLC modem port to its host SCADA site.

15.5.5 Pump Station Electrical Criteria

15.5.5.1 General

All pumping stations shall be wired in strict accordance with the latest edition of the National Electric Code. Pumps and equipment shall normally be designed to operate from a 230/460 volt, three-phase power source. No single-phase to three-phase converters will be allowed. Single-phase service will be considered by MSD on a case-by-case basis. Single-phase pump stations shall have capacitor start motors. A control power transformer will not be required to facilitate auxiliary equipment when **240/**120 volts are available from the utility. All motor starters and controls shall be located in a shop-assembled control cabinet, located above ground level.

All conductors shall be insulated, stranded, copper wire, rated at 600 volts.

An enclosed circuit breaker shall be provided and rated for use as service entrance equipment and shall be housed in a stainless steel, NEMA 4X enclosure. **It shall include an auxiliary contact for indicating a tripped condition to the PLC.**

Pump control cabinets shall be stainless steel, NEMA 3R enclosures suitable for outdoor installation. Each cabinet shall be equipped with a hasp, staple, and three-point latching handle to provide watertight and tamper-proof service and shall be mounted on **a wet well electrical rack.** Each cabinet shall have a hinged inner door, containing all operator control devices, and must be appropriately sized for the application.

Motor starters shall be enclosed in separate enclosures with interface wiring to pumps and control panel as indicated on the sample duplex pump station drawings. Reduced-voltage starting, if required, shall utilize solid-state motor starters with bypass contactors. The solid-state starters shall be used to start and stop the pumps with the bypass contactor utilized for full speed operation. Consult with LG&E for motor starting requirements.

Separate pedestal mounted stainless steel enclosures shall be provided to facilitate the junction of cords from Class I, Division 1 wet well components with permanent wiring to non-hazardous starters and control panel. Cable hangers shall be used to suspend wet well component cables and facilitate easy access for component removal from the wet well top slab. Conduit seal-offs shall be provided between the cord junction box and the respective starter or control panel to isolate them from hazardous and corrosive wet well gases.

At a minimum, the following key issues must be addressed in the design with calculations and/or NEC references to verify such:

a. Service size
b. Feeder/service conductor size
c. Ground conductor size
d. Feeder/service disconnect size

e. Branch circuit conductor size
f. Branch circuit type of protection
g. Branch circuit over-current protection rating
h. Motor controllers size and overload protection rating
i. Pump control system transformer over-current protection
j. Available fault current
k. Feeder/service over-current protection
l. Ground fault protection if required

The sample electrical design drawings available on MSD's website identify conduit and conductor connections with "fill-in-the-blank" provisions for number and size of wires, and conduit sizes.

The **service conductors,** main **circuit breaker, transfer switch, and starter** branch **circuit conductors**, must be sized so that the full capacity of the motor starters may be utilized in the future.

15.5.5.2 Emergency Power

An on-site internal combustion engine-powered generator shall be provided. MSD prefers the use of natural gas. However, MSD will consider economic factors presented by the Engineer regarding generator and gas service costs vs. the use of diesel generators. These stations shall be totally automatic and shall include all necessary transfer switches and other components. The electrical generators shall be housed in weatherproof enclosures. A critical silencer must be provided to minimize noise from the engine-powered generator.

For those generators with a control panel higher than 6 feet above finished grade, an aluminum or stainless steel platform shall be provided around the perimeter of the generator to facilitate access to the control panel as well as routine maintenance points on the generator.

Generator output circuit breakers shall be equipped with an auxiliary contact to indicate the breaker is tripped. This signal contact shall be combined with other signals in the generation of a common failure alarm SCADA signal. Other SCADA signals as identified above shall be provided.

Transfer switches shall be provided with a time-delayed neutral position and shall be mounted in a stainless steel, NEMA 3R enclosure with three-point latching handle **on an deadfront outer**

door. An inner door shall be provided behind the deadfront door for the mounting of operator interface devices. Accessories shall be provided to meet the SCADA requirements mentioned above.

When two independent public electrical utility sources are available, the requirements for in-place generators may be waived by MSD in favor of the dual utility feed.

15.6 OPINIONS OF COST

Opinions of probable cost shall be based on the best professional opinions of the Design Engineer. The Design Engineer should use recent bid tabulations, and information from suppliers and contractors in formulating the opinions of cost.

15.6.1 Opinions of Capital Cost

Opinions of capital cost shall be in Construction Specification Institute (CSI) formatting and shall be grouped by category.

Opinions of capital cost shall include a construction contingency of 3% and should include a cost for necessary land, easement, or right-of-way acquisition.

15.6.2 Opinions of Operation and Maintenance Cost

Opinions of operation and maintenance cost shall include costs for labor, utilities, maintenance and repair. **Energy efficiency is to be considered in the design.**

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EXHIBIT 15-1 PAGE 1
STANDARD DUPLEX PUMP STATION DETAILS

EFFECTIVE DATE: JUNE 30, 2009

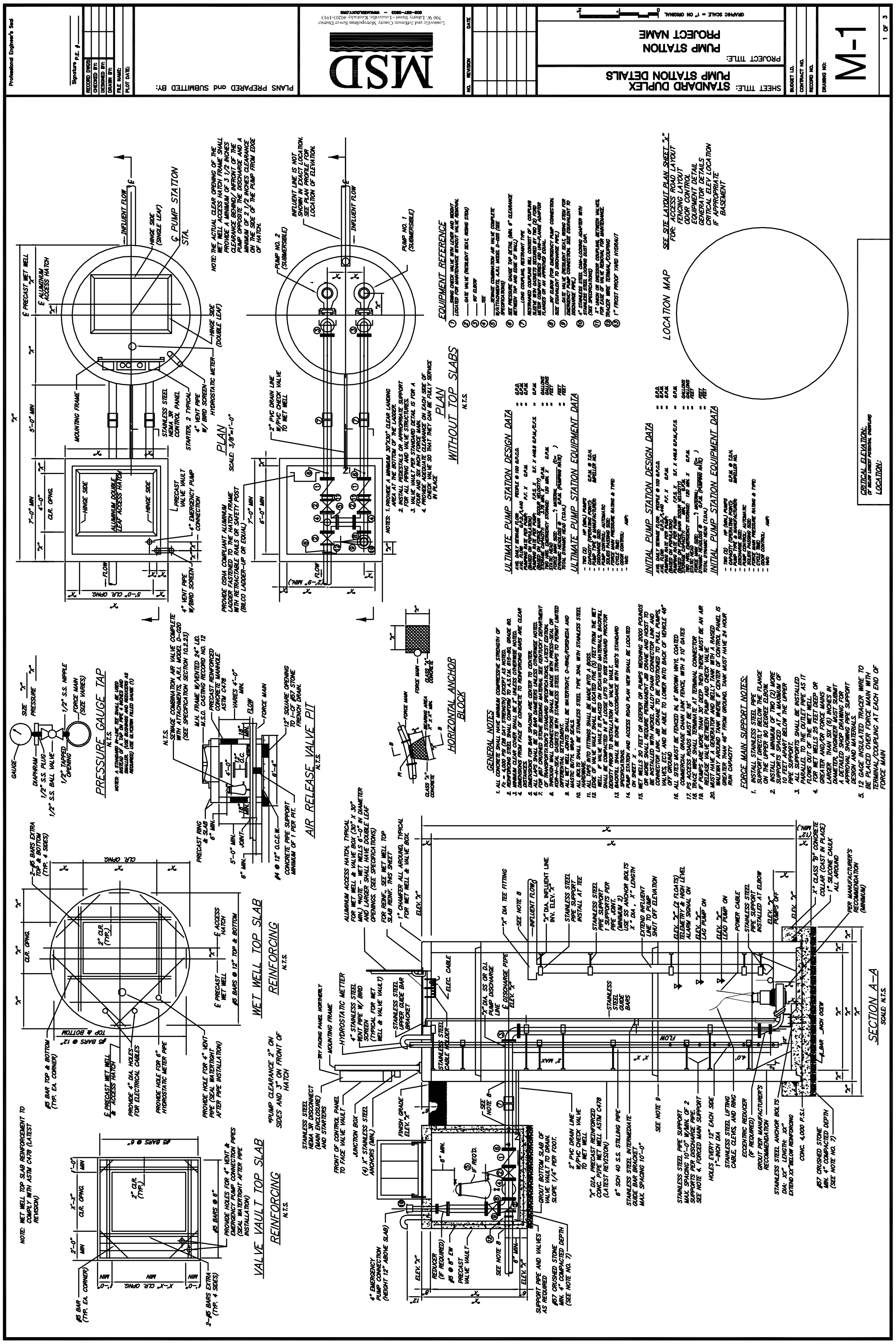

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EXHIBIT 15-1 PAGE 2

STANDARD DUPLEX PUMP STATION DETAILS

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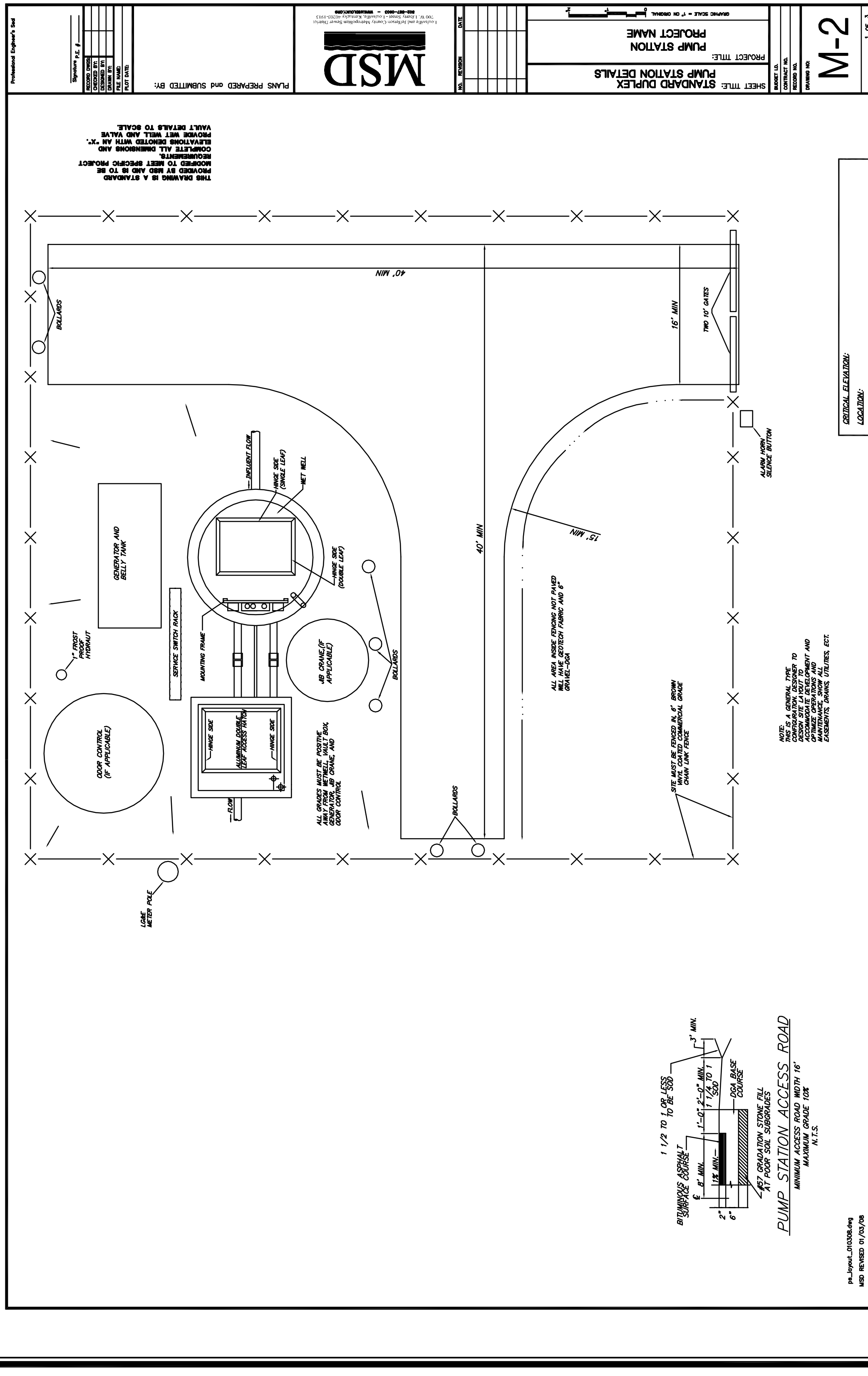

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EXHIBIT 15-2

STANDARD DUPLEX PUMP STATION (THREE PHASE)

EFFECTIVE DATE: JUNE 30, 2009

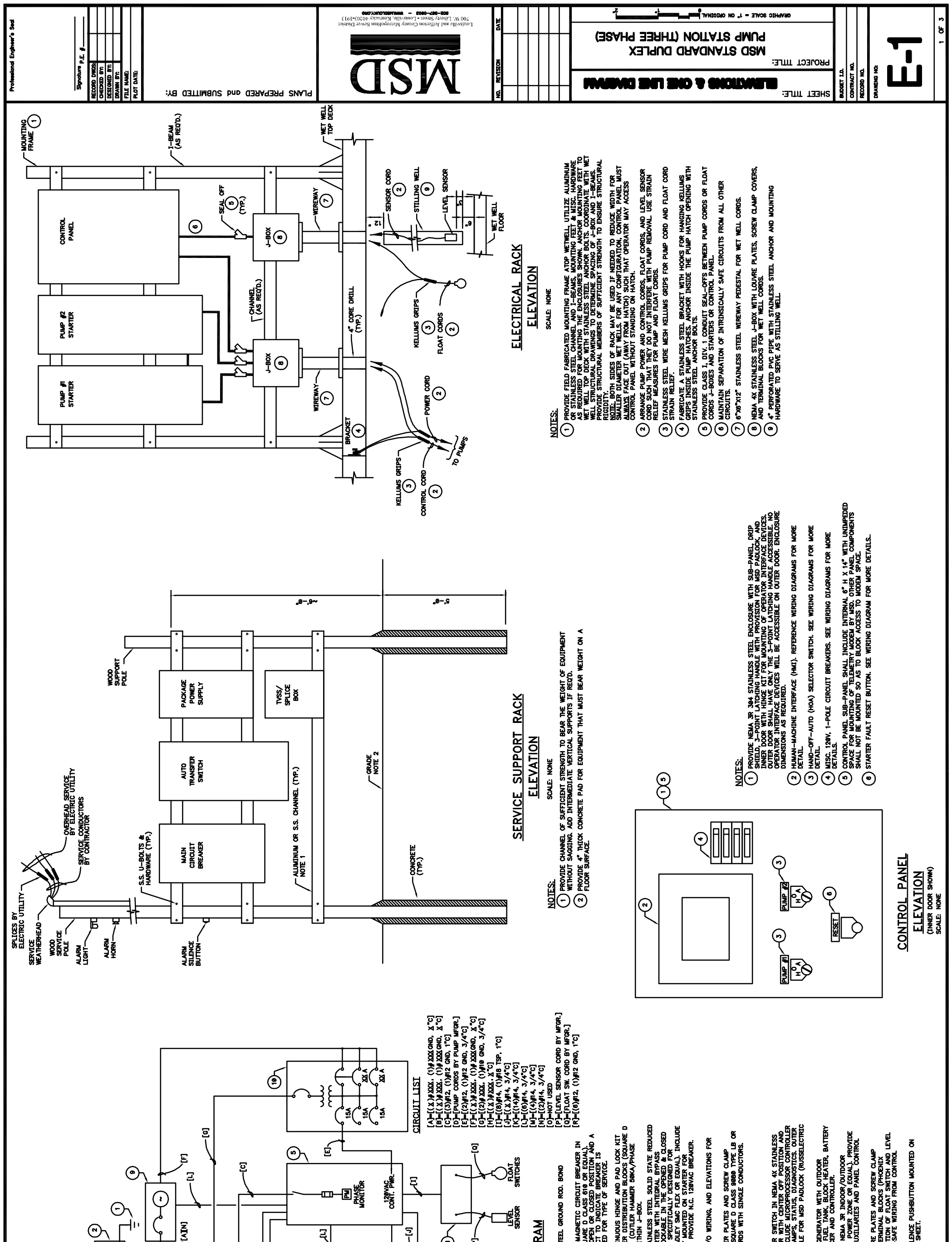

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EXHIBIT 15-2

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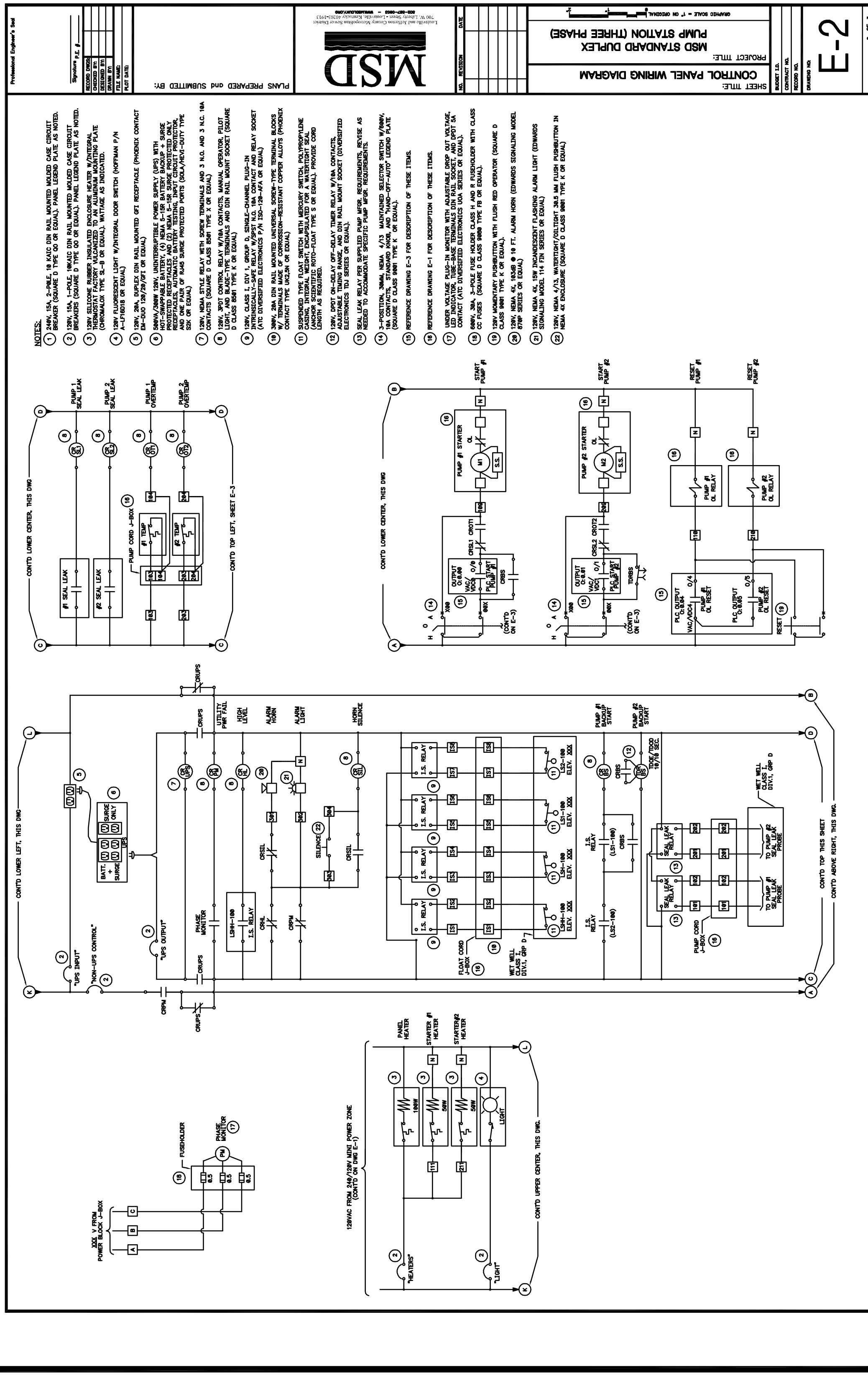

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EXHIBIT 15-2 PAGE 3

STANDARD DUPLEX PUMP STATION
(THREE PHASE)

EFFECTIVE DATE: JUNE 30, 2009

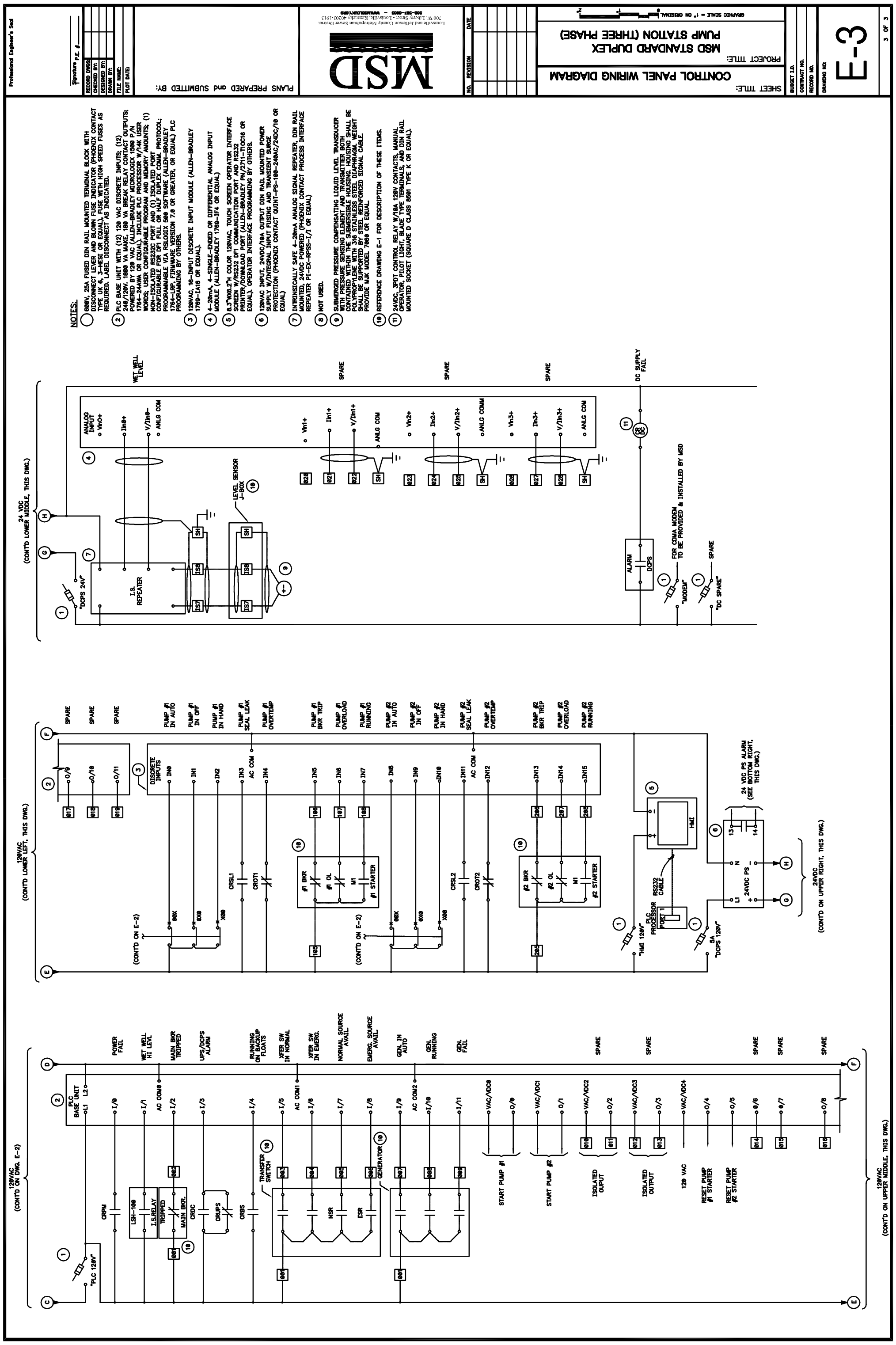

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EXHIBIT 15-3 STANDARD DUPLEX PUMP STATION (SINGLE PHASE)

EFFECTIVE DATE: JUNE 30, 2009

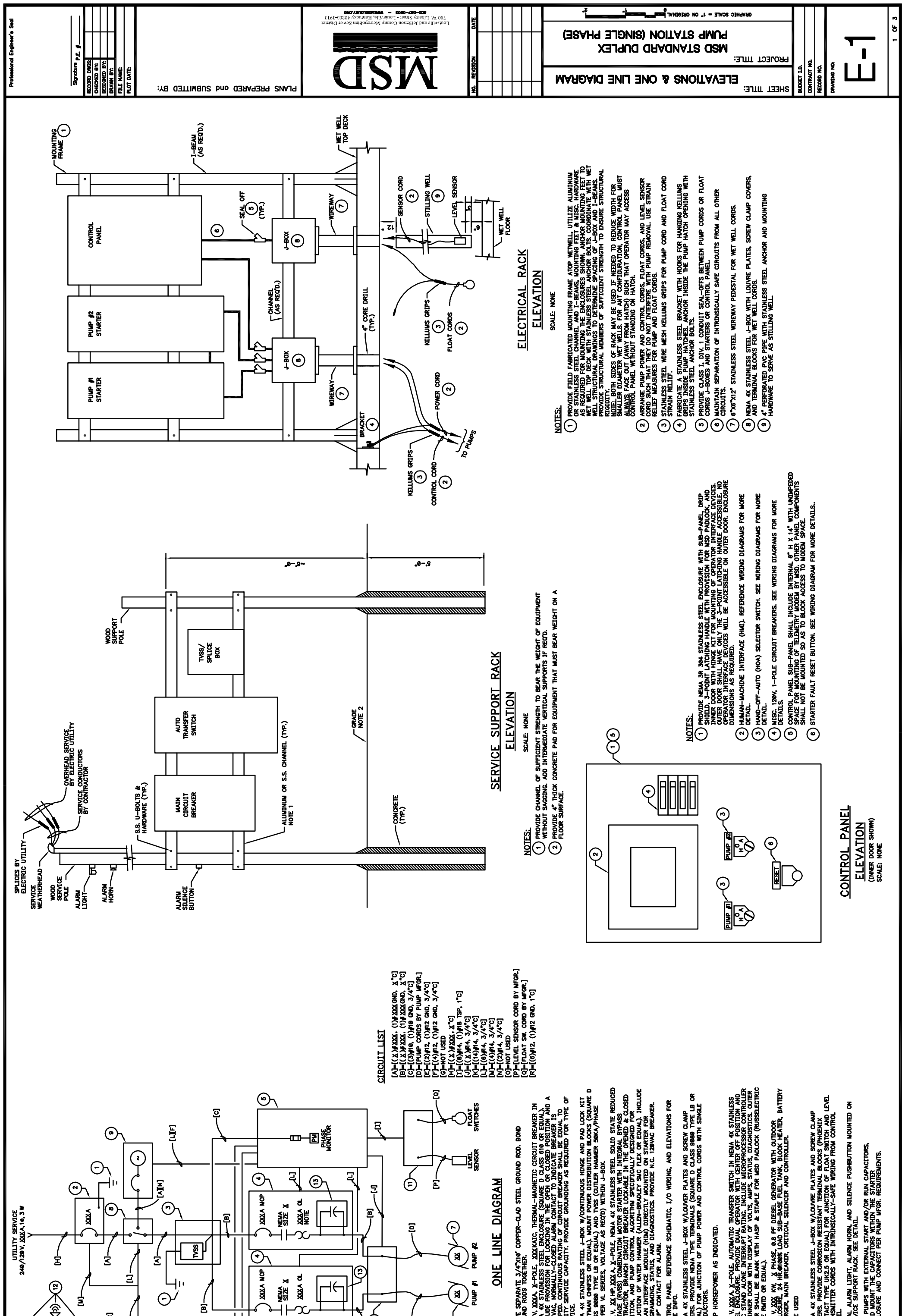

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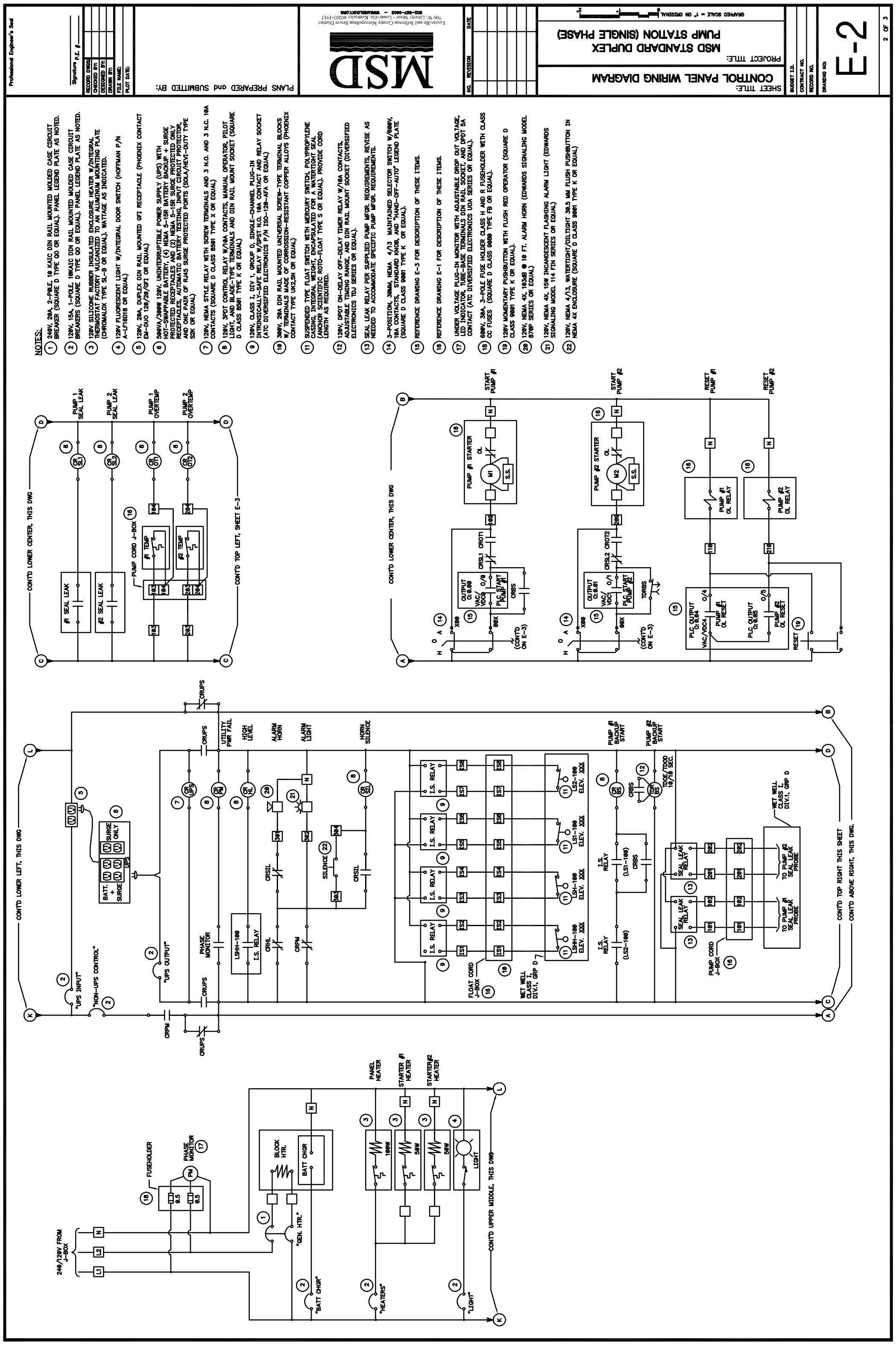
EXHIBIT 15-3 PAGE 2
STANDARD DUPLEX PUMP STATION (SINGLE PHASE)

EFFECTIVE DATE: JUNE 30, 2009



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STANDARD DUPLEX PUMP STATION (SINGLE PHASE)

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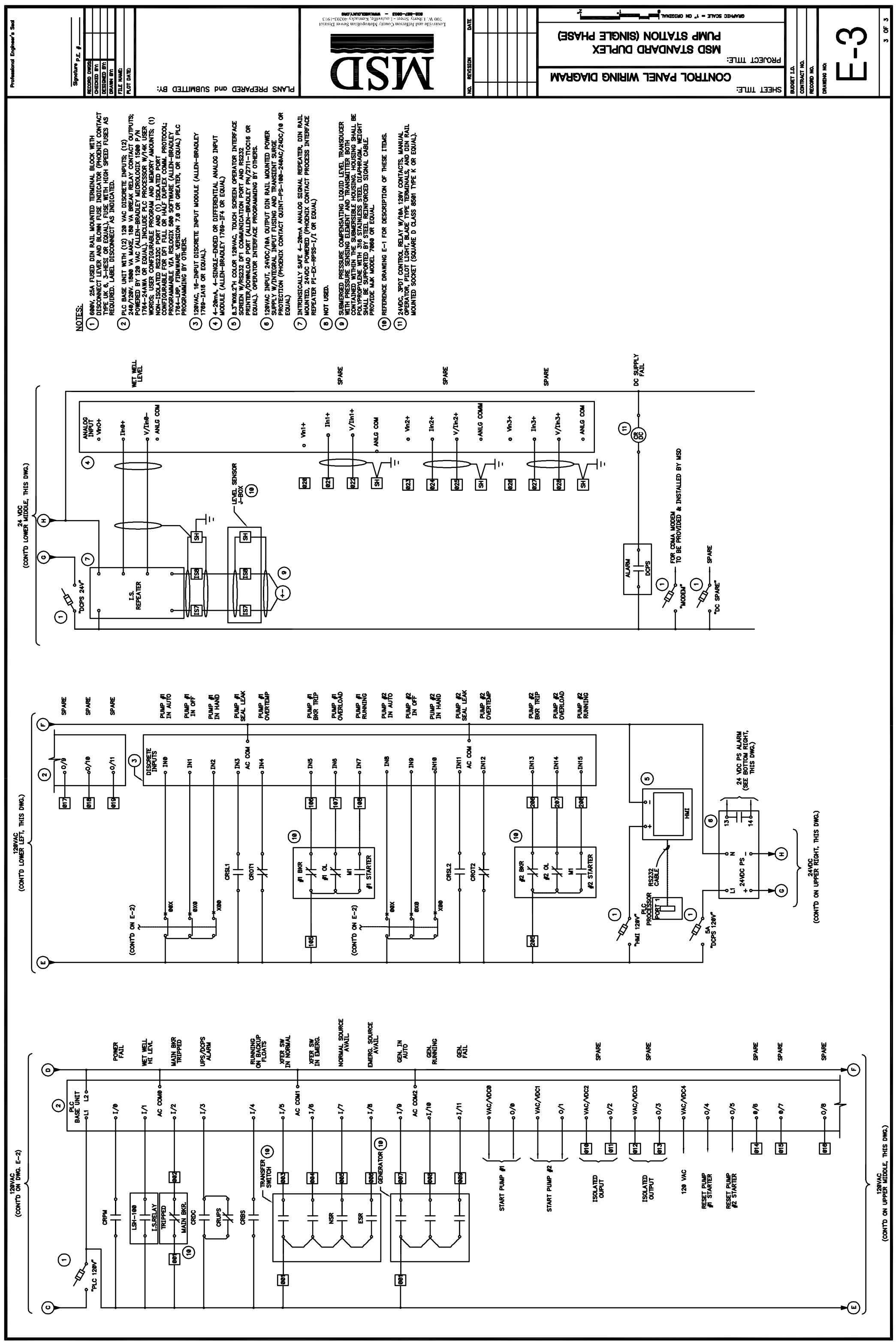

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STANDARD DUPLEX PUMP STATION
(SOFT STARTERS)

EFFECTIVE DATE: JUNE 30, 2009

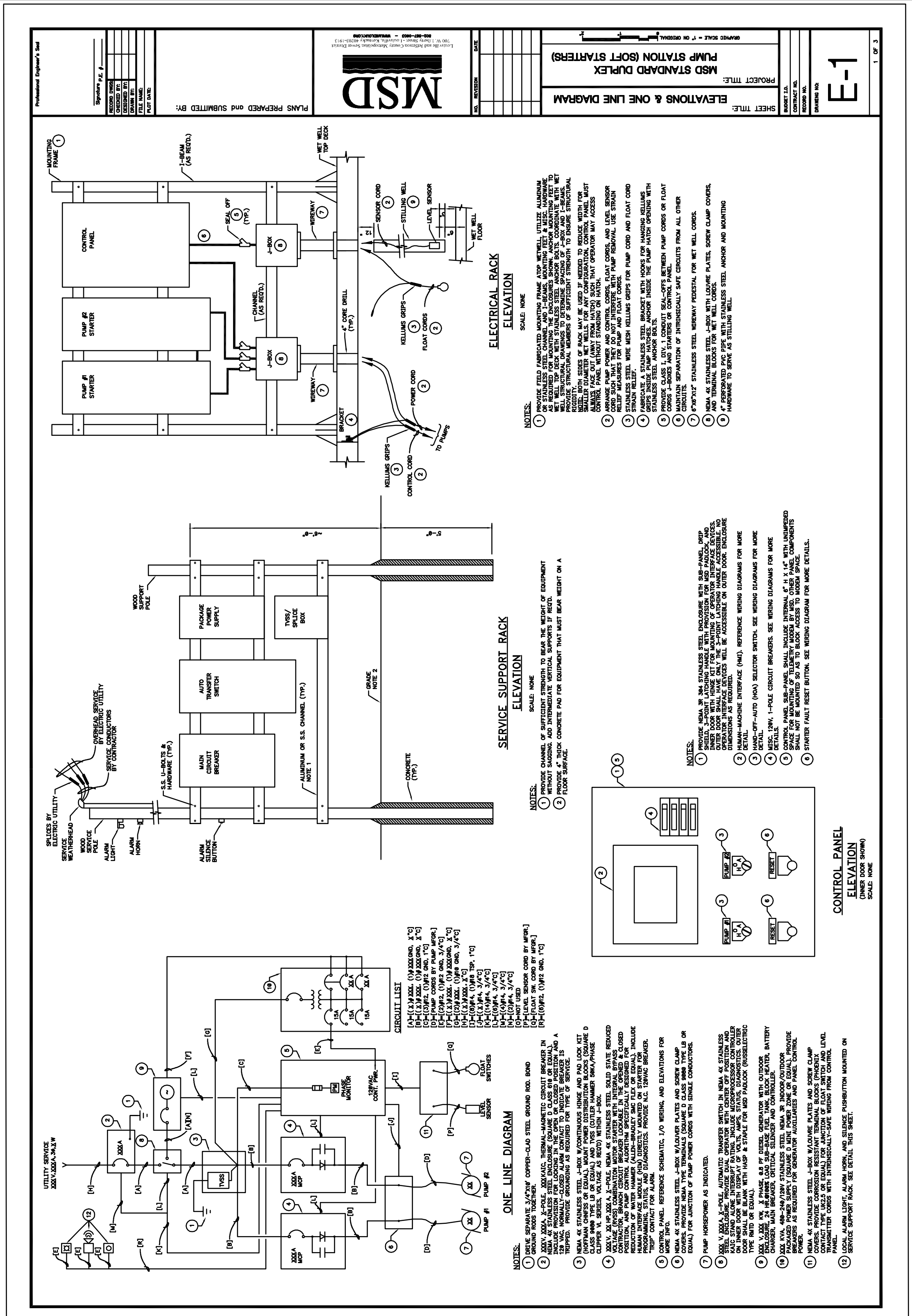

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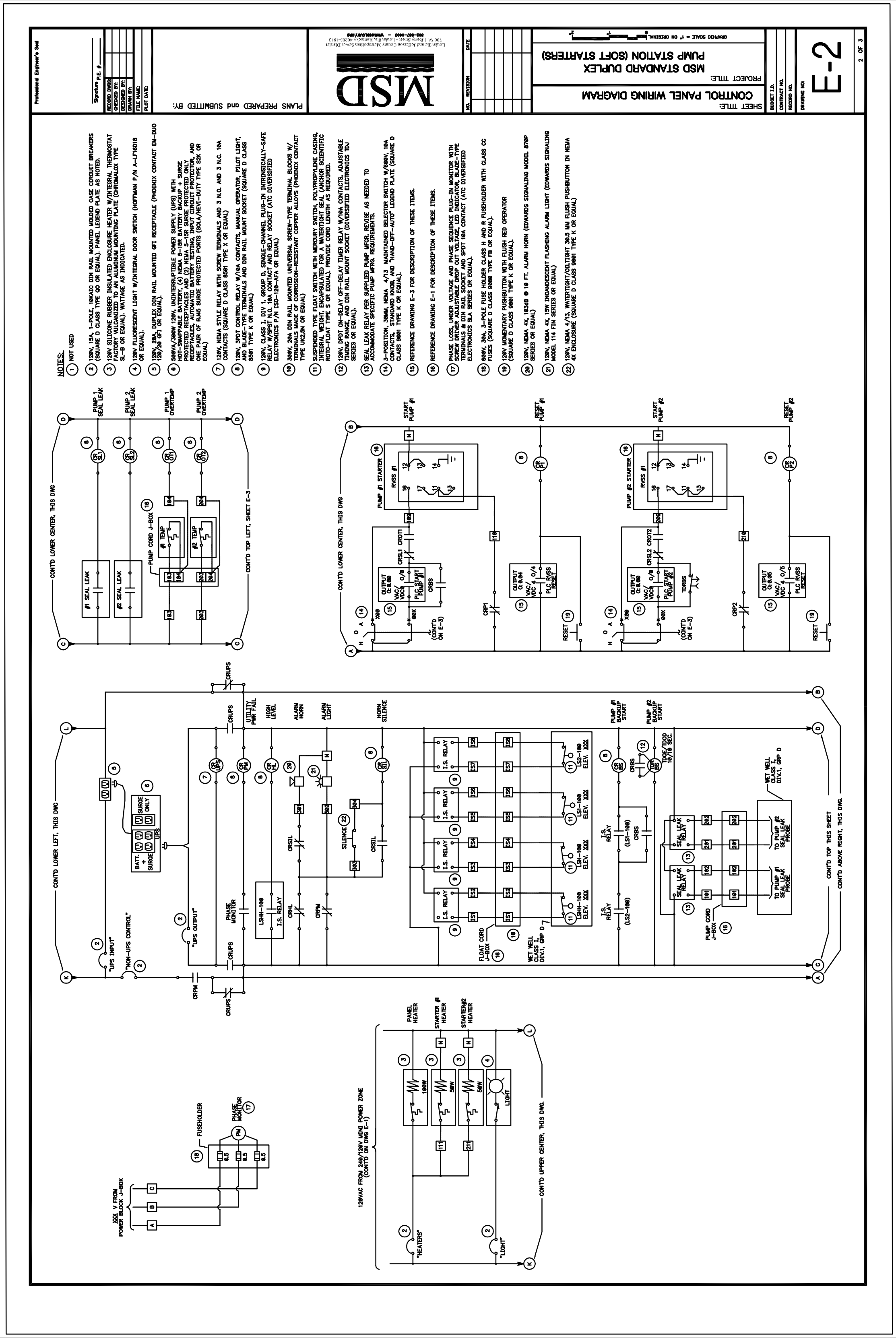
EXHIBIT 15-4

STANDARD DUPLEX PUMP STATION (SOFT STARTERS)

EFFECTIVE DATE: JUNE 30, 2009



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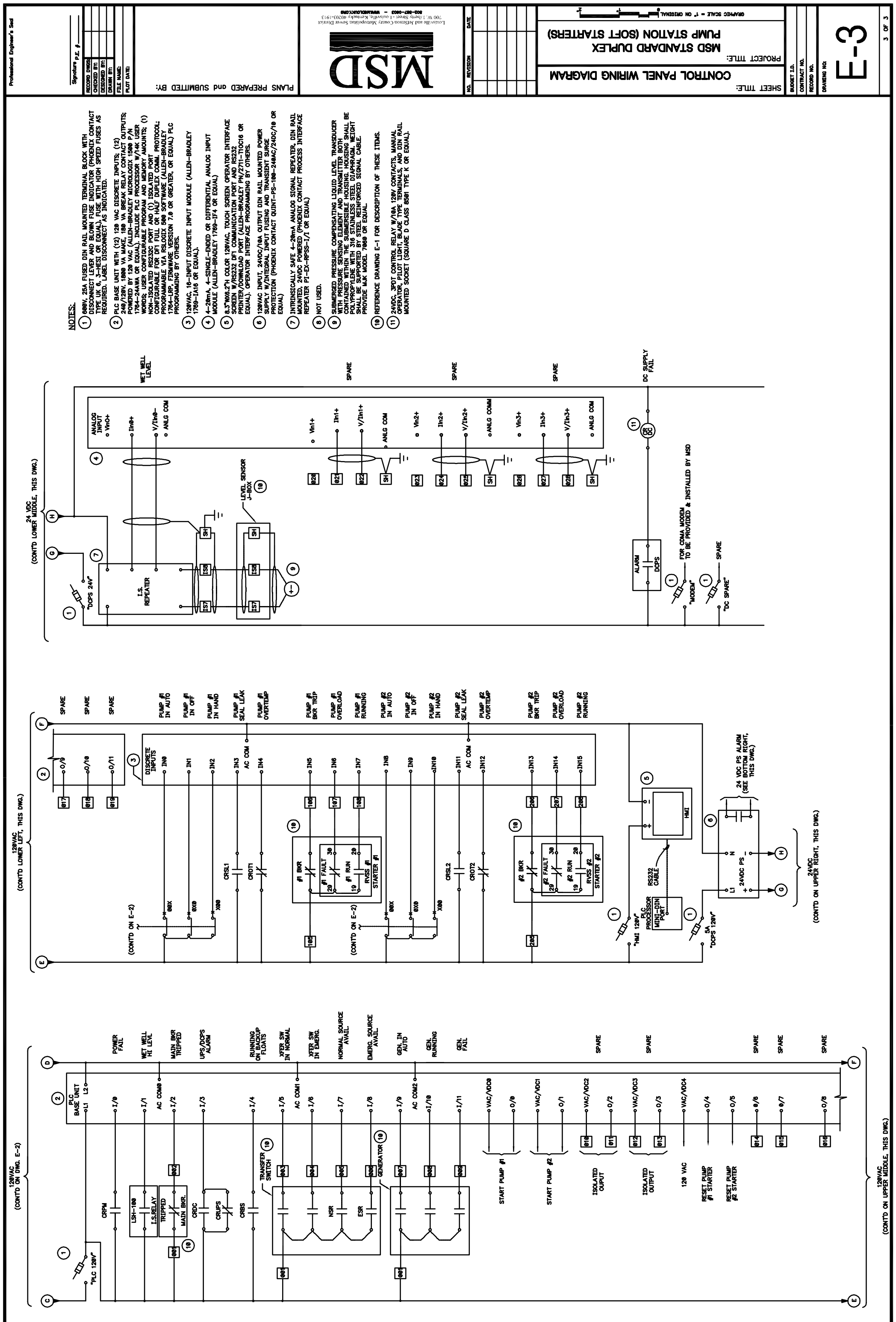

TABLE OF CONTENTS

CHAPTER 16
ODOR CONTROL

TABLE OF CONTENTS (cont.)

CHAPTER 16
ODOR CONTROL
EXHIBITS

CHAPTER 16
ODOR CONTROL

16.1 PURPOSE

The purpose of this chapter is to:

a. Identify the planning and design approach to be used for controlling odors from pumping stations, force mains, sanitary sewers and small wastewater treatment plants.

b. Define specific criteria by which odor control systems will be designed.

c. Identify submittal requirements required by MSD for review and approval of odor control systems.

d. Outline the requirements for opinions of construction and operating costs.

16.2 SUBMITTAL REQUIREMENTS

The Design Engineer shall submit to MSD for review and approval, the Concept Plan, Preliminary Design and Final Design. If the odor control systems are being designed as part of a larger project then the odor control submittals shall be made a part of the submittals for the larger project. Approval by MSD will be required prior to authorization of any succeeding design phase.

Submittals shall be prepared in report format (8.5-inch x 11-inch) and shall be spiral bound, three-ring bound or bound in some other permanent manner. Appended to or included in the bound submittal shall be maps, figures, and drawings as necessary. Sections are to be organized and tabbed according to the requirements of this section.

16.2.1 Concept Plan Submittal

The purpose of a Concept Plan is to provide MSD with preliminary design data for proposed odor control facilities to determine the compatibility of proposed facilities with the design manual and to justify recommended alternatives.

Concept Plan submittals relating to odor control shall be submitted in accordance with Chapter 2, Section 2.3 and include the following elements:

a. A narrative description of the proposed system.

b. Justification of the need for the system and of the type of system proposed. Identification of potential odor producing conditions.

c. Odor control system design criteria form. (Exhibit 16-1).

d. Location of the facility for which odor control is being provided and proximity to potentially sensitive odor receptors.

e. Description of the potential odor control alternatives and rationale used to select the proposed system.

f. Discussion on availability of utilities required to service system.

g. Identification of duties required of operating and maintaining personnel and listing of potential hazards of handling proposed chemicals (if applicable).

h. Cost effective analysis as described in Section 16.3.4.

16.2.2 Preliminary Design and Final Design Submittals

Preliminary Design and Final Design submittals relating to odor control facilities shall be prepared in accordance with Chapter 4 – Drafting Standards and include the following elements:

a. Design Documentation - Preliminary and Final Design submittal shall include all design requirements, assumptions, background data, design calculations and references. Submittals shall include, but not be limited to, those elements outlined in Section 16.4.1.

b. Plans - Show the project name, sheet title and submittal date on all sheets. Plans must be legible and uncluttered. Final documents shall include Professional Engineer stamp and signature on each sheet.

c. Specifications - Prepare specifications consistent with the MSD Contract Documents Manual.

16.3 DESIGN APPROACH

16.3.1 Approvals

Prior to construction or enhancement of odor control facilities, the design documents must receive the written approval of MSD. The Design Engineer shall consult the **Louisville Metro** Air Pollution Control District (**LM**APCD) to determine if a permit to construct and/or operate an air treatment system is required for the project.

16.3.2 Service Level

Guidelines presented in this Design Manual govern the planning and design of odor control systems defined as follows:

a. Chemical feed systems designed to control the formation and release of odorous compounds from wastewater pumping stations, force mains, sanitary sewers and small treatment plants.

b. Air treatment systems for pump stations, force mains and small treatment plants, which capture the odorous air and treat it by means of absorption, adsorption, oxidation or chemical biological stabilization.

16.3.3 Justification

MSD will determine the need for odor control system(s), based on information provided by the design engineer, on a case-by-case basis according to the following criteria:

a. The history of odor complaints in the vicinity. If the MSD has received odor complaints from residents within 100 yards of the proposed facility within the previous year, odor control will be required.

b. The potential that the facility has to create an off-site odor nuisance. If the facility is fed by upstream pumping stations, if it has collection sewers that have low velocities (<2 ft/sec) and/or long detention times (>6 hours) or if it is expected to receive heavy industrial flow, odor control will be required. On-site odor control will also be required if the wetwell has an average detention time in excess of 45 minutes and may be required with lesser detention times if other conditions warrant it.

c. The proximity of proposed facilities to existing and future homes, businesses and roads. If a home or business is located within 150 feet of the facility, or is expected to be within this distance, odor control facilities will be required.

d. Design calculations provided by the design engineer. Refer to Exhibit 16.1.

16.3.4 Cost Effective Analysis

The cost effective comparison analysis between odor control alternatives shall include both economic and non-economic factors.

The economic portion of the cost-effectiveness analysis shall use a present worth calculation that considers capital costs, operation and maintenance costs, and salvage values.

Capital costs shall include opinions of construction cost as outlined in Section 16.5, engineering costs based on recognized fee curves and costs for acquisition of properties, easements and rights-of-way, including legal costs. Operation and maintenance costs shall include opinions of cost for labor, utilities, maintenance and repair of facilities. Salvage values shall be developed on straight-line depreciation.

Life cycle costs should be considered over a 20-year period. Unless otherwise directed by MSD, a discount rate equal to that required by the Division of Water should be used to calculate the present worth value of each alternative.

Non-economic factors to be addressed in narrative form, as a part of the cost-effectiveness analysis, should include:

1. **Environmental Impact:** **The short-term and long-term impacts of the alternative on the environment.**
2. **Reliability:** **A measure of how dependable the alternative performs over time.**
3. **Operability:** **The ease with which the alternative operates over time.**

16.4 DESIGN CRITERIA

16.4.1 General

Design requirements, assumptions, background data, design calculations and references must be documented and submitted to MSD. If it is determined that an odor control system is required based on the preliminary information and the design calculations submitted on Exhibit 16-1, the following information shall be submitted to MSD for review, as a minimum:

a. Air Treatment Systems

   1. Description of source
   2. Air flow rate
   3. Actual or anticipated odorous compounds and projected concentrations. Include mass loadings data and calculations to support projections.
   4. Number of air changes per hour

5. Headloss calculations and duct sizes
6. Exhaust fan sizing
7. Treatment system description, size, dimensions and space requirements
8. Media replacement projections

b. Chemical Addition Systems

1. Pump cycle times
2. Force main velocities and flow rates
3. Chemical feed dosages
4. Bench scale and/or demonstration test results
5. Air relief valve and force main discharge locations and their relationship to nearby homes and businesses.
6. Chemical storage tank sizing and safety requirements
7. Actual or anticipated sulfide levels in wastewater
8. Chemical feed equipment

16.4.2 Odor Production

Odor complaints from collection systems, pump stations, force mains and small wastewater treatment plants are generally caused by the release of hydrogen sulfide (H_2S) gas. Therefore, the chemical feed and air treatment systems described herein are primarily designed to control H_2S. The following is a description of the sulfide generation process in wastewater systems:

- A slime layer will develop on the submerged walls of gravity sewers and force mains if the velocity of the wastewater through the pipe is too low to scour the sides.

- In aquatic environments lacking dissolved oxygen only anaerobic bacteria attach to the slime layer. These bacteria reduce sulfate (SO_4^{2-}), one of the most common anions in water and wastewater to sulfide (S^{2-}).

- The sulfide ions combine with hydrogen ions in the wastewater to form hydrogen sulfide. Depending on pH, the hydrogen sulfide dissociates to dissolved hydrogen sulfide gas (H_2S), hydrosulfide ion (HS^{1-}), and sulfide ion (S^{2-}). At neutral pH of 7, the distribution is approximately 50% H_2S and 50% HS^{1-}. At pH 6, the distribution is approximately 90% dissolved hydrogen sulfide gas and 10% hydrosulfide ion.

- Dissolved hydrogen sulfide gas is the only form of dissolved sulfide which can be released from wastewater to the atmosphere. H_2S produces the "rotten egg" odor characteristic of septic sewage. The release of H_2S from solution is accelerated under turbulent conditions.

Gravity sewers are generally designed to accommodate population growth well into the future. Often, designers will utilize larger pipe at shallower slopes to allow for future flows, minimize the sewer depth, and reduce construction cost. This practice often results in lower wastewater velocities during the initial years when the sewer carries substantially lesser volumes.

Wastewater velocity directly impacts wastewater detention time within the sewer, the amount of grit and organic solids deposition (both of which tend to further reduce wastewater velocity and increase depth of flow), and the extent of slime layer buildup within the submerged portion of the sewer. Velocity thus affects formation of dissolved sulfide and also the release of hydrogen sulfide gas into the sewer atmosphere.

As with sewers, pump station wet wells are normally designed for future flows. While this practice makes economic sense, it does allow for excessive detention times during the initial years of operation. The longer the detention time, the greater the likelihood that the wastewater will become septic. Unless the pump suction pipes and wetwell geometry are appropriately designed, the accumulation of organic matter will promote the generation of dissolved sulfide and hydrogen sulfide gas.

Force mains, inverted siphons and other surcharged pipes are normally completely full of wastewater, and because this condition does not allow reaeration from the sewer atmosphere, dissolved oxygen levels in the wastewater become depleted, and significant quantities of dissolved sulfide can be generated. These conditions should be avoided when possible.

16.4.3 Odor Control Design Guidelines

16.4.3.1 Pipeline Design

Good design and maintenance practices will reduce sulfide problems in collection systems without the use of chemical addition or air treatment. In general, pipeline design should adhere to the following;

a. Limit the use of closed conduit systems (force mains, siphons, and surcharged sewers). If a closed conduit system must be used, limit its length and provide adequate velocity to scour the pipe. Limiting the use and length of force mains in raw wastewater conveyance systems is probably the single most important factor in minimizing sulfide release from collection systems.

b. Wastewater velocities in both gravity and pressure pipes must be adequate to prevent deposition and accumulation of solids, especially during periods of low flow.

c. Maintain gravity trunk sewer and interceptor velocities to the point where wastewater surface reaeration is adequate to prevent sulfide build-up. Maintain dissolved oxygen levels above 0.5 mg/L.

The minimum acceptable velocity for small sewers (less than 18 in. diameter) is two (2.0) feet per second (fps) at initial peak flow conditions as defined in Chapter 8 Section 8.9**.3 and 8.9.4**. Velocities as low as 1.0 fps may be acceptable during low-flow periods and during the early years of development of an area if it is adequately justified. Otherwise, the minimum design velocity shall never be less than 2.0 fps and may need to be higher if a significant sediment load is anticipated. Further information on the design of large diameter systems with regard to sulfide control can be found in ASCE-Manuals and Reports on Engineering Practice-No. 69- "Sulfide in Wastewater Collection and Treatment Systems."

The minimum allowable slopes for sanitary sewer systems are shown on Exhibit 8-5 Chapter 8 – Sanitary Sewer Systems.

The oxygen content of the sewer atmosphere should be maintained close to the 21% found in clean air. Suppression of oxygen content occurs where there are few, if any, connections to an interceptor and/or there is a siphon, pumping station or surcharged section which is blocking the movement of air through the interceptor.

16.4.3.2 Pump Station and Force Main Design

The primary means of minimizing sulfide formation in force mains is maintenance of scouring velocities. It is recommended in Chapter 15 that force mains be designed with a velocity between 2 and 5 fps. A velocity of 2 fps is acceptable with regard to odor control on short force mains (less than 1,000 ft.), but on longer force mains the minimum velocity should be as follows:

MINIMUM SCOUR VELOCITY FOR FORCE MAINS		
Force Main Size (in.)	Minimum Velocity (fps)	
	Typical (1)	Heavy Grit Load (2)
$\leq$10	3.2	3.9
12-30	3.5	4.3
32-60	4.1	5.0
(1) Average or typical wastewater where scour velocity is achieved frequently. (2) Heavy grit load or substantial time between scouring velocity events.		

The wastewater discharged from the force main should enter the receiving manhole at the invert or below the water level to reduce turbulence. Interior drop pipes shall be used to lower forcemain discharge elevation to manhole invert.
Pump station wet wells should be designed to limit detention time and prevent the deposition of solids in order to minimize sulfide production. New pump station and force main designs shall be modeled to predict H_2S production and release. If the station and force main has the potential to be an odor source, then the designer should take the appropriate actions which may include reducing the pump cycle times using dual force mains, using variable speed pumps or decreasing detention time by adjusting the pump level switches.

The bottom of the wet well shall be sloped to match the requirements of the pumps being installed based on pump/wet well modeling. Pump suction should generate enough velocity at its floor to move solids and eliminate dead spots. Influent drop pipes should be used to bring wastewater in below the wet well water level to reduce turbulence.

All wetwells shall have a 6-inch diameter corrosion resistant fiberglass, aluminum or stainless steel vent pipe with two flanged 90º elbows, which will allow connection to odor control device.

16.4.3.3 Chemical Feed Systems

Chemicals may be added to the wastewater to prevent the formation of sulfides through oxidation or precipitation of sulfides that are already in solution. Certain chemicals, such as calcium nitrate (Bioxide) prevent the formation of sulfides because bacteria use nitrates, if no dissolved oxygen (DO) is present, preferentially over sulfates, which prevents the sulfates from being reduced to sulfides. Hydrogen peroxide, potassium permanganate, hypochlorite and chlorine will oxidize sulfides after their formation in the wastewater. Iron salts, such as ferrous chloride, react with the sulfides to produce an insoluble precipitate and prevent the release of H_2S. In addition, caustic (sodium hydroxide) has been used in slug doses to inactivate slime layers in pipes.

MSD currently uses calcium nitrate for purposes of odor control through chemical addition. Hydrogen peroxide, ferrous chloride, potassium permanganate, hypochlorite and chlorine are not used at pumping stations due to poor performance, excessive cost and/or safety concerns.

MSD has found calcium nitrate and ferrous chloride to be effective in controlling H_2S. Calcium nitrate is also easy to handle by operating personnel. An important difference between these two chemicals is that nitrate solutions are less effective at preventing the release of H_2S if sulfides are already in solution. $FeCl_2$, on the other hand, will precipitate the sulfides after they are formed and prevent further formation. This means nitrates should be added upstream of sulfide formation where possible.

Another product used by MSD is a mixture of calcium nitrate and anthraquinone (marketed as Bioxide AQ). This product is often used in situations where existing sulfides have to be removed and where the formation of dissolved sulfides (DS) need to be prevented. This product is non-hazardous and is handled like calcium nitrate except a mixer is required in the storage tank to prevent settling.

The first step in designing a chemical feed system is to conduct laboratory tests on the wastewater to determine sulfide levels under various conditions. For existing pump stations, these tests should be performed on the wastewater as it exits the force main because the sulfide levels will be highest at this point.

The following design criteria shall be used as a guide in designing systems to feed nitrates at pump stations.

CHEMICAL FEED SYSTEM DESIGN CRITERIA	
Criterium	Nitrates
Method of Delivery	Bulk Liquid
Design Dosage Range (1)	1.5 gallons/lb DS
Minimum Reaction Time (mins.)	30
Maximum Allowable DS at Discharge (mg/l)	0.3-0.5
Storage Tank Capacity (days)	90
Storage Tank Material	See Note (2)
Secondary Containment	Secondary containment berm may be required depending on threat to nearby water supplies
Number of Chemical Feed Pumps	2
Chemical Feed Point (Discharge point must be visible from above)	Entrance to P.S. Wetwell above High Water Level

Notes:

1. Design dosages shall be used to size equipment on systems where field tests cannot be performed. Actual dosages will be determined via field tests when system is on-line.
2. Cross-linked High Density Polyethylene or Fiberglass Reinforced Plastic (FRP).

The liquid chemical feed system equipment shall consist of a chemical storage tank (or drums), chemical metering pump(s), pump calibration tube and control panel. Nitrate storage tanks shall be enclosed unless a variance is allowed by MSD and the tank shall include flanges for a fill pipe, pump suction line and vent.

If the chemical is being stored in drums as shown on Exhibit 16-2 the pumping system shall consist of a single diaphragm-type electronic metering pump with spare parts, a calibration cylinder and a pump stand. Pump materials shall be compatible with the chemical being pumped.

The pump and control unit that shall be used with the tank shown in Exhibit 16-3 shall include two metering pumps (with spare parts), pump calibration tube, pump timer, heaters, thermostat, on/off/auto switches, GFI outlet, in a stainless steel NEMA 3R enclosure suitable for outdoor installation. Refer to Exhibit 16-4.

16.4.3.4 Air Treatment Systems

Unlike chemical feed systems, which are designed to prevent the formation of odorous compounds, air treatment systems are designed to capture and treat the odors after they are produced.

Air treatment systems may include the air collection ductwork, an exhaust fan and a means of removing the odorous compounds from the air. System components shall be designed using the following criteria:

a. Ductwork

- Ductwork shall be designed based on the following criteria:

Materials of Construction	Below Grade: • SCH40 or SDR35 PVC Pipe • DR 32.5 high density polyethylene Above Grade: • Fiberglass reinforced plastic coated for UV protection • 304 stainless steel
• Air Velocity in Duct	1500 - 2500 ft/min

- Duct size shall be computed using the following equations:

$$Q = (V)(AC/hr)(1\ hr/60\ min)$$
$$A = Q/v$$
$$D = (4A/\pi)^{0.5}$$

Where:

A = Duct cross-sectional area (ft^2)
D = Duct diameter (ft)
V = Volume of structure from which air is to be drawn (ft^3)
v = Velocity of air through duct (ft/min) - (2500 ft/min)
AC/hr = Air changes per hour from area being ventilated
Q = Air flow rate (ft^3/min)

The ventilation rate (air changes per hour) shall be based on NFPA 820-Fire Protection in Wastewater Treatment Plants (latest edition) issued by the National Fire Protection Association.

b. Exhaust Fan

Exhaust fans shall be corrosion resistant and constructed of fiberglass reinforced plastic or 304L stainless steel materials with sliding motor mounts to allow sheave replacement.

Fans shall be located indoors if possible and if not then noise suppression devices may be required. Constant speed motors will be acceptable in most applications and timers should be considered if intermittent operation may be required. Flexible connectors shall be mounted on the inlet and outlet flanges of the fan and the volute of the fan shall be equipped with a drain to remove condensate.

c. Air Treatment

1. Modular Biofilters

Biofiltration uses naturally occurring microbes to biologically break down odors in waste air streams into carbon dioxide and water. Typically, air is drawn through a humidification chamber through a media bed, which provides a surface on which the microbes can flourish and then discharged through a stack after treatment. The biofilters shall be a modular design which are essentially fully assembled in the factory and delivered to the site ready for connection of ducts and utilities.

Use the following criteria when designing biofilters. Note these design criteria are applicable for installations with H_2S concentrations of 50 parts per million (ppm) or less. Installations with higher expected H_2S concentrations will require lower loading rates and special design considerations.

TYPICAL BIOFILTER DESIGN CRITERIA	
Media Type	Inorganic Media
Air Plenum Depth (inches)	12-18
Media Depth (feet)	4-6
Loading Rate (cfm/ft^2)	12-18
Empty Bed Residence Time (EBRT) (seconds)	20-30
Maximum H_2S concentration (ppm)	50
Maximum Pressure Drop through Media (inches w.c./ft media depth)	0.25-0.33
Initial Media pH Range	7-8.5
Media Moisture Content (% by weight)	40-60
Media Porosity %	40-50

Water Usage (gallons/ 100,000 ft^3 of air)	10
Maximum Air Temperature (°F)	105
Anticipated Media Life (years)	10-12

There are two primary types of biofilter media. Organic media consists of wood chips, bark nuggets, compost and other organic materials or a combination of these locally available materials. It typically has a lower initial cost than inorganic media but it has to be replaced every 2-3 years and has a higher pressure drop resulting in higher power costs.

Inorganic media is typically a nutrient rich mixture of organic and inorganic material that has an expected life of 10 years or more, has lower pressure drop and power costs and is less susceptible to compaction and drying out. Inorganic media shall be used in MSD biofilters.

2. Carbon Canisters

Activated carbon is an effective method of treating a variety of organic contaminants and odor causing compounds. Carbon canisters are vessels, which allow the odorous air to pass through a bed of odor adsorbing carbon-based media. Carbon canisters are available in many shapes and sizes including preassembled, skid-mounted units. Integrally mounted fans are also available. Refer to Exhibit 16-5 for a detail of a typical skid-mounted carbon canister. The size of the canister will be based on the air flow rate, the estimated contaminant loadings and the type of carbon used. The typical velocity through the bed is 50 - 75 feet per minute.

Small carbon canisters are also available for installation on the vent pipes of wetwells. These vent canisters are passive (no fan) and are bolted to a standard 6" diameter vent flange as shown on Exhibit 16-6.

Carbon adsorbs and captures volatile organics and will adsorb hydrogen sulfide if the carbon is impregnated with caustic or if specifically formulated for H_2S removal. MSD will not regenerate carbon on-site therefore the carbon must be replaced as its adsorption capacity is reached. Carbon is not suitable for high concentrations of H_2S (i.e. greater then 5 ppm) due to its limited adsorption capacity. Carbon must be periodically replaced. Most adsorbers located at pumping stations and wastewater treatment plants should use caustic impregnated carbon.

3. Packed Bed Scrubbers

   Scrubbers are used to absorb and oxidize H_2S and other organic compounds in a packed bed of randomly dumped media. Water is recirculated to the top of the media from a collection sump. Caustic chemicals are added to adjust the pH to about 9.5-10, and hypochlorite or potassium hydroxide is dosed to oxidize the absorbed odorants. Typical design criteria are as follows:

Media height -	6 - 10 ft.
Velocity -	350 - 450 ft/min
Recirculation flow rates -	12 - 14 gpm/1,000 cfm
Water blowdown rate -	1 – 3 gpm
Headloss -	2 - 4 inches w.c.

   Other requirements for a scrubber installation shall include a demister, automatic control of pH and oxidation reduction potential (ORP), freeze protection and sump high and low level switches. Scrubbers are well suited for high H_2S loadings, and should be installed where close monitoring and control is available from operating personnel. Scrubbers typically are not used at MSD pumping stations and other small facilities due to the chemical storage and handling requirements and their need for operator attention.

4. Odor Counteractants

   Odor counteractants, or odor neutralizers, can reduce odor intensity by interacting two specific compounds in certain proportions. In most cases, the odor counteractant is sprayed into the foul air stream using an atomizer. The atomizer divides the counteractant into tiny particles, which improves surface contact between the odorous compounds and the counteractant.

   MSD will not accept odor counteractants as a permanent odor control system but may consider it as a temporary solution while a permanent system is installed.

16.4.4 Applications

Selecting the best means of controlling odors requires an understanding of the cause of the odors, the compounds present, the duration and frequency of the odor, site conditions, utilities available and ultimately the overall cost effectiveness. MSD will evaluate each situation and determine the level of odor control required at each site on a case-by-case basis but the following guidelines may be used to predict odor control requirements.

Summary of MSD Collection System Odor Control Guidelines

1. Pipeline Design

   a. Minimize use of force mains and siphons

   b. Maintain dissolved oxygen levels above 0.5 mg/L

   c. Minimum allowable velocity for gravity sewers 2 feet per second unless waiver is received

   d. Minimum allowable velocity for force mains is 2 feet per second for force mains less than 1000 feet long. Refer to 16.4.3.2 for minimum velocities on longer mains.

   e. Minimize use of air release valves on force mains

   f. Air release valves shall be PVC coated for corrosion protection

   g. Force mains shall discharge to receiving manhole at manhole invert via internal drop pipes if necessary. Internal drop pipes shall have open tee connection for clean out purposes.

   h. Chemical feed system shall be designed in basic conformance with Exhibit 16-2.

   i. Calcium nitrate shall be used in the chemical feed systems unless conditions favor using a different chemical.

   j. The need for a chemical feed system at the pump station will be based on:

      - Predicted total sulfide production in the force main (Exhibit 16-1)
      - History of odor complaints in area
      - Density of population along force main route
      - Number of air release valves

- Potential for downstream corrosion

2. Pump Station Wetwell Design

   a. Gravity sewers discharging to a wetwell shall discharge below low water level to minimize turbulence. Interior drop pipes shall be used.

   b. The wetwell bottom shall be designed to prevent the deposition of solids.

   c. Wetwell detention times shall be less than 45 minutes whenever possible.

   d. All wetwells shall be equipped with a 6-inch diameter flanged corrosion-resistant vent pipe and a carbon canister (Exhibit 16-5) shall be attached to the vent to treat the air prior to exhausting. A larger carbon canister with exhaust fan (Exhibit 16-4) may be required if deemed necessary by MSD.

   e. Access hatches to wetwells shall be sealed with weather stripping to prevent fugitive emissions.

   f. Drain lines from valve vaults to the wetwell shall be trapped to prevent odor emissions from valve vault vent.

   g. Packed bed scrubbers, biofilters and other air treatment systems will only be used at pump station sites when abnormal situations exist and when specifically requested by MSD.

Design engineer shall review potential need for odor control, evaluate odor control options and make recommendations in the Concept Plan submittal. Submittal shall include the information outlined in Section 16.2.1. MSD will review the information and determine need for odor control.

16.5 OPINIONS OF COST

Opinions of probable cost shall be prepared in accordance with Chapter 2, Section 2.6.

16.6 REFERENCES

(1) Bowker, R.P.G., J.M. Smith, N.A. Webster, Odor and Corrosion Control in Sanitary Sewerage Systems and Treatment Plants, Design Manual, U.S. Environmental Protection Agency, Center for Environmental Research, Cincinnati, Ohio, 1985.

(2) Sulfide in Wastewater Collection and Treatment Systems, American Society of Civil Engineers, New York, NY, 1982.

(3) Bowker, R.P.G., N.A. Webster, Detection, Control, and Correction of Hydrogen Sulfide Corrosion in Existing Wastewater Systems, U.S. EPA, Office of Wastewater Enforcement and Compliance, Washington, D.C., 1992.

LOUISVILLE AND JEFFERSON COUNTY
METROPOLITAN SEWER DISTRICT
RESIDENTIAL AND LIGHT COMMERCIAL DEVELOPMENT PUMP STATIONS
WETWELL DETENTION TIMES AND PROJECTED SULFIDES

Development: ____________________
Developer: ____________________
Engineer: ____________________

Pump Station:			
(a)	Initial Average Daily Flow Rate (gpm)		Data Input
(b)	Wetwell Diameter (ft):		Data Input
(c)	Depth from All Pumps Off to Lead Pump On (ft):		Data Input
(d)	Will Pumps Have VFDs:	Yes/No	Data Input
(e)	One Pump Flow Rate (gpm):		Data Input
(f)	Number of Pumps:		Data Input
(g)	Distance from Wetwell to Nearest Current or Future Residence (ft):		Data Input
(h)	Distance from Wetwell to Nearest Body of Water (ft):		Data Input
(i)	Does Station Receive Flow from Any Other Pump Station?	Yes/No	Data Input
(j)	Name of Upstream Station:		Data Input
(k)	Volume in Wetwell with Pumps Off (gallons): $V = [3.14*(b)^2/4]*(c)*7.48\ gal/ft^3$	0	Formula
(l)	Wetwell Detention Time(DT) (min): DT = (k)/(a)	#DIV/0!	Formula
Force Main:			
(m)	Force Main Length (ft):		Data Input
(n)	Force Main Inside Diameter (ft):		Data Input
(o)	Number of Air Release Valves (ARV):		Data Input
(p)	Closest Distance from ARV to Residence (ft):		Data Input
(q)	Distance from Discharge Manhole to Nearest Residence (ft):		Data Input
(r)	Force Main Cross Sectional Area (ft^2): $A = 3.14*(n)^2/4$	0.00	Formula
(s)	Force Main Velocity With One Pump Running (ft/s): V = (e)/(r)/7.48/60	#DIV/0!	Formula
(t)	Force Main Volume (Ft^3): V = (m)*(r)	0.00	Formula
(u)	Force Main Detention Time at Avg.Daily Flow (min): DT = (t)*7.48/(a)	#DIV/0!	Formula
(v)	Sulfide Flux Coefficient (ft/hr):	0.001	Given
(w)	Effective Biological Oxygen Demand of Wastewater (mg/L):	280	Given
(x)	Hydraulic Radius of Full Pipe (ft): HR = (n)/4	0	Formula
(y)	**Predicted Total Sulfide Production (mg/L):** $S_c = [3.28*(v)*(w)*[(1+0.48*(x)](x)^{-1}]*(u)/60$	**#DIV/0!**	Formula
(z)	Predicted Total Sulfide Mass (lbs/day): $S_m = (y)*(a)*60*24/1000000*8.34$	#DIV/0!	Formula
	Predicted Bioxide Usage (gals/day): B = (z)*1.0	**#DIV/0!**	Formula

MSD

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40203-1913

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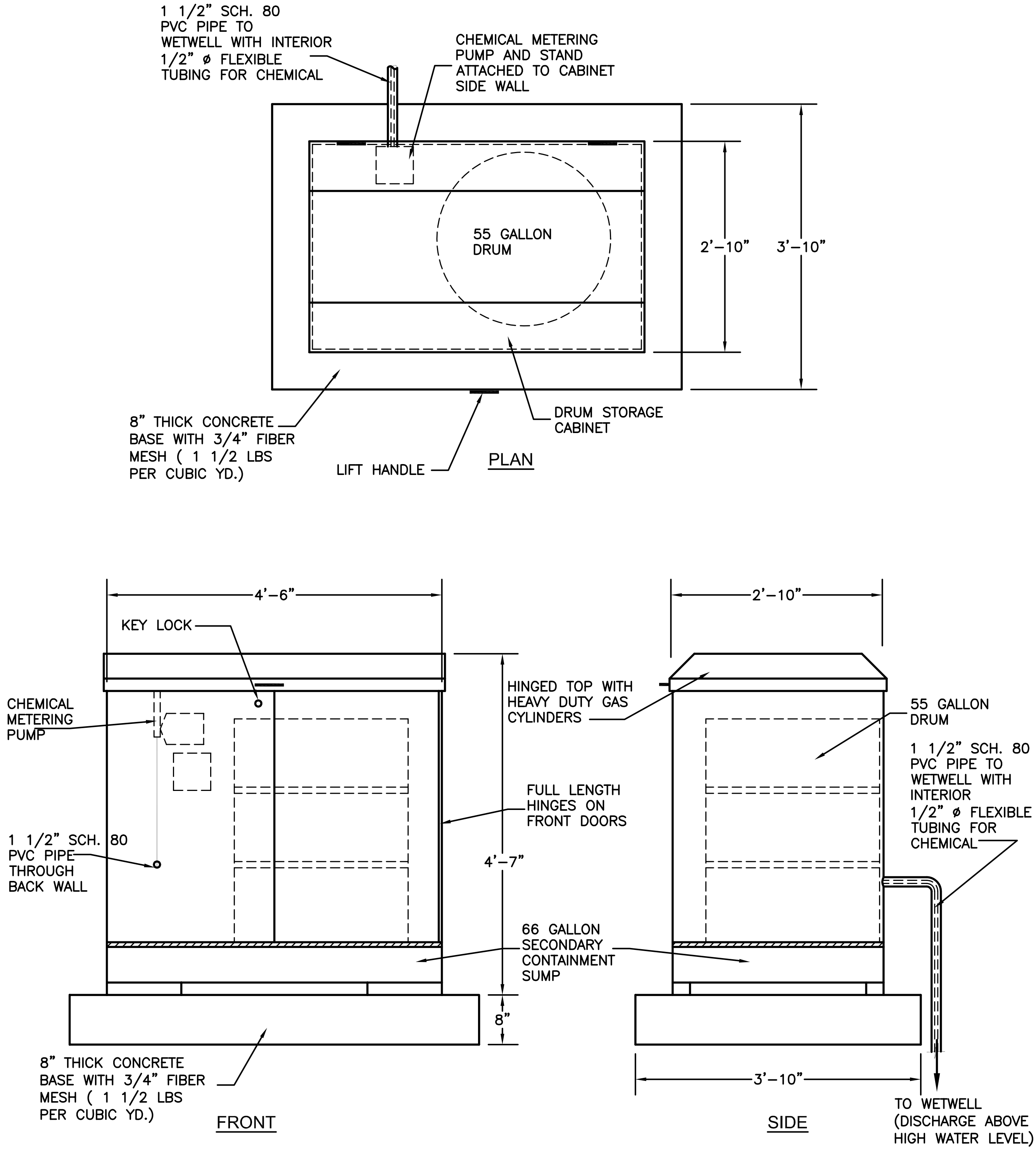
EXHIBIT 16-2
ODOR CONTROL CHEMICAL DRUM STORAGE CABINET DETAIL

EFFECTIVE DATE: JUNE 30, 2009



NOTE:
DRUM STORAGE CABINET SHALL BE DENIOS ENCLOSED 2-DRUM HAZMAT STATION OR EQUAL. CABINET SHALL BE CONSTRUCTED OF WELDED STEEL WITH CORROSION AND WEATHER RESISTANT FINISH.

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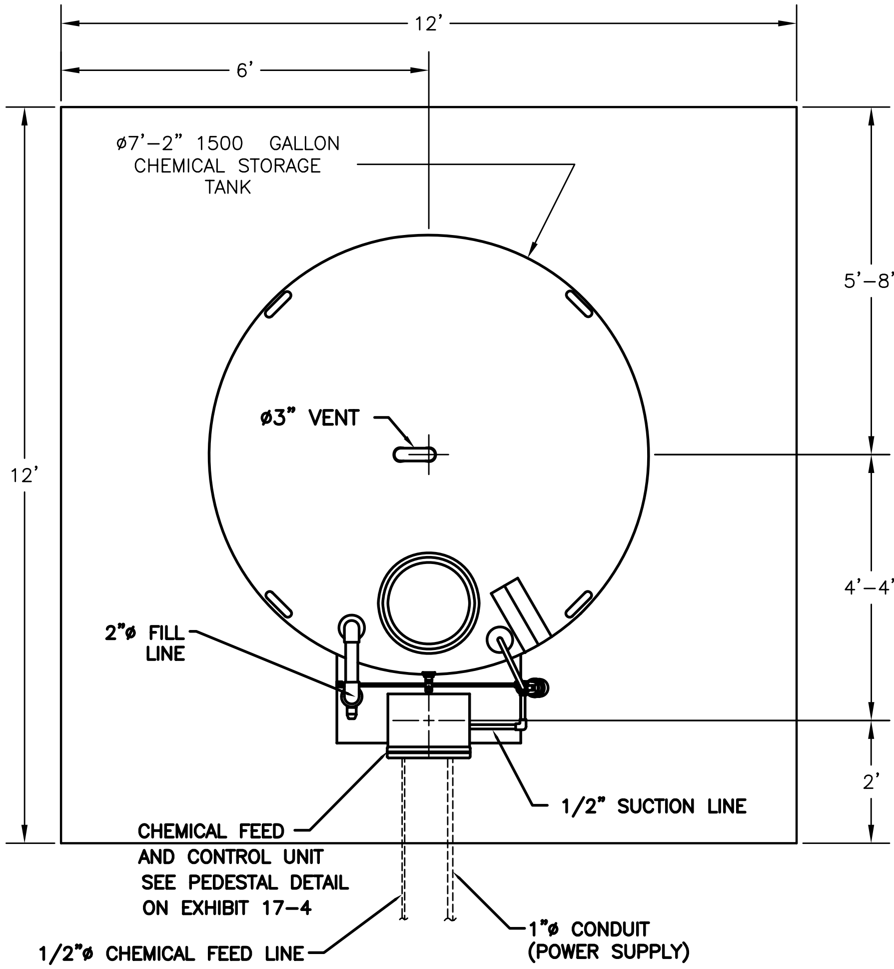
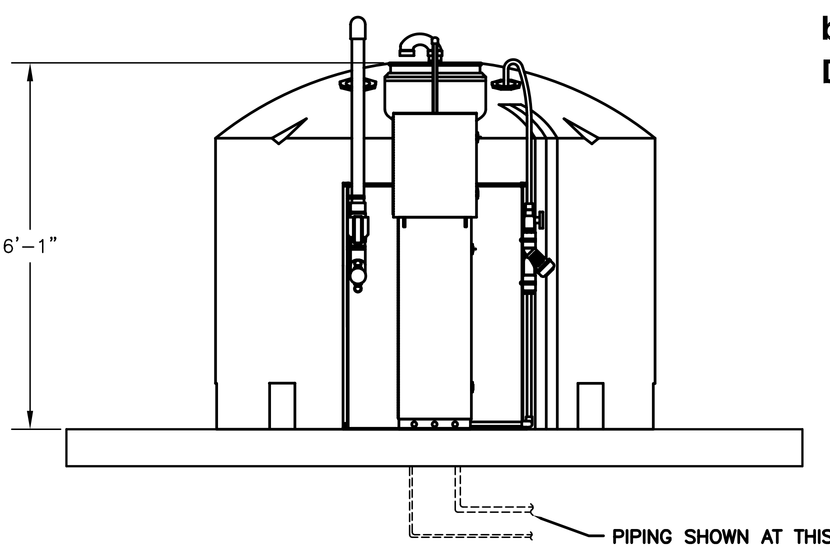
EXHIBIT 16-3
CHEMICAL FEED SYSTEM WITH
1500 GALLON ICT TANK

EFFECTIVE DATE: JUNE 30, 2009



PLAN VIEW

Drawing prepared by US Filter / Davis Process.



ELEVATION VIEW

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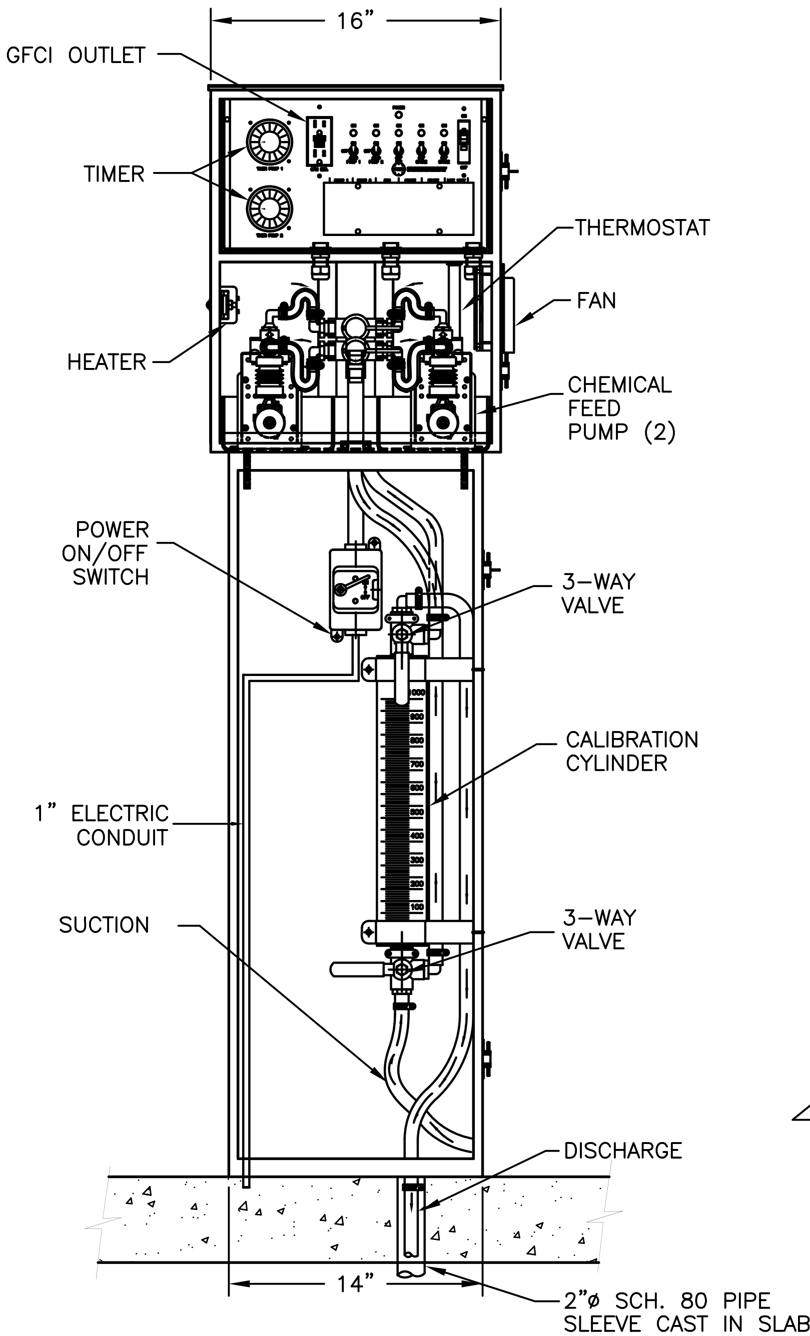
EXHIBIT 16-4
CHEMICAL FEED SYSTEM
CONTROL PANEL DETAIL

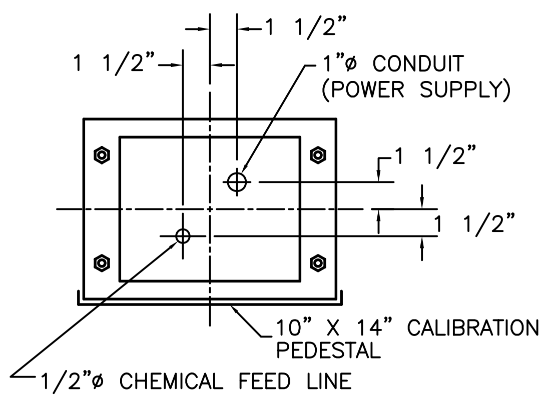
EFFECTIVE DATE: JUNE 30, 2009

NOTES

1. ALL PIPING AND APPURTENANCES , SCH 80 PVC
2. ALL HARDWARE REQUIRED FOR INSTALLATION SHALL BE STAINLESS STEEL.



Drawing prepared by US Filter / Davis Process.



PEDESTAL DETAIL

CHEMICAL FEED AND CONTROL UNIT

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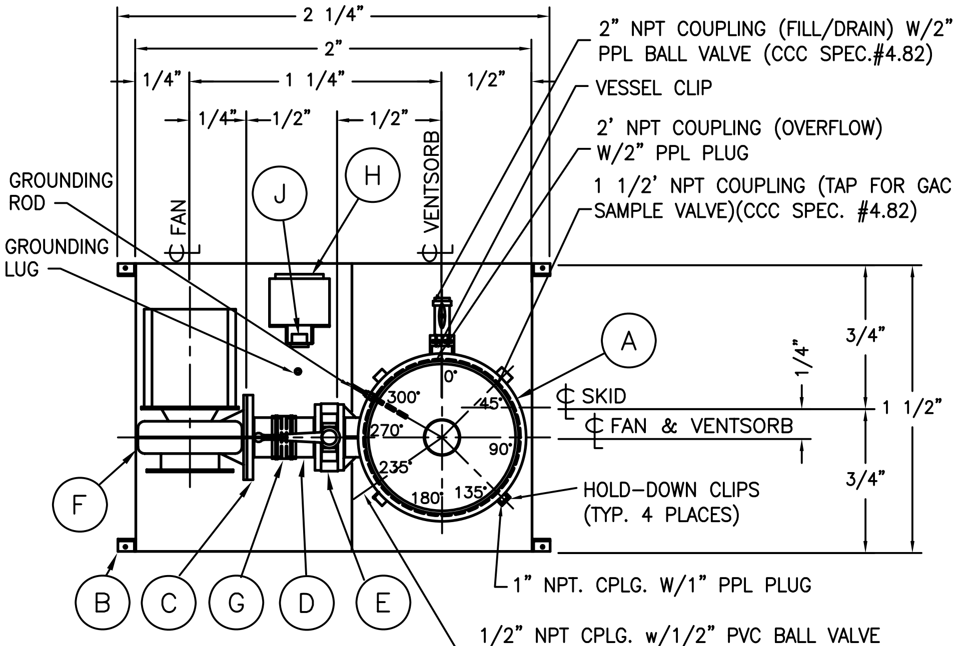
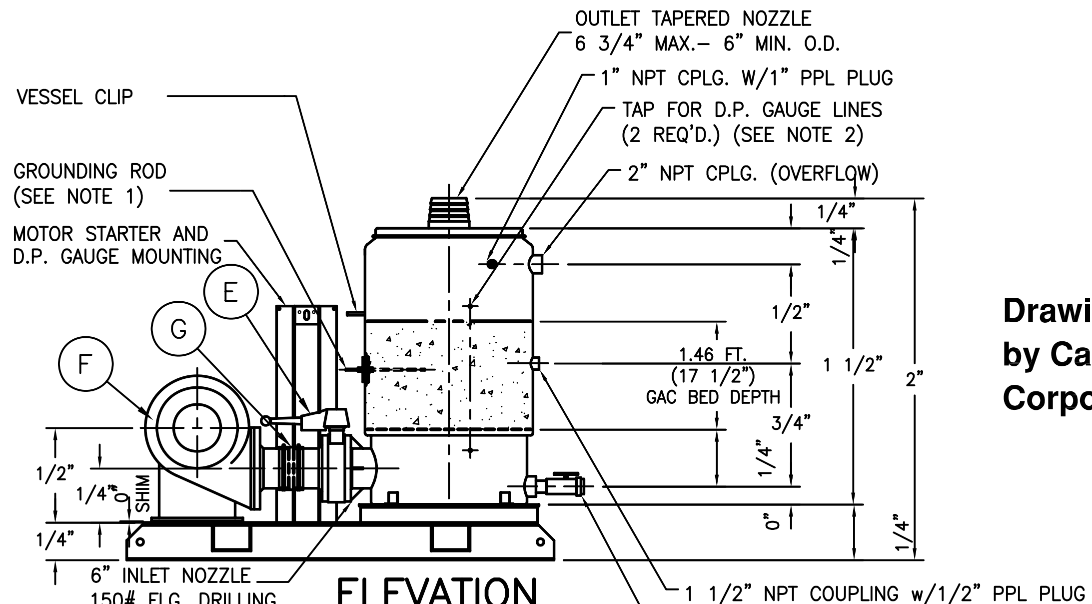
EXHIBIT 16-5
TYPICAL SKID MOUNTED CARBON ADSORBER DETAIL

EFFECTIVE DATE: JUNE 30, 2009



PLAN VIEW



ELEVATION
(APPURTENANCES ROTATED FOR CLARITY)
(SEE PLAN VIEW FOR PROPER ORIENTATION)

1. 3/8" THK. x 4 1/4" O.D. WALL REINFORCEMENT BOSS (1) INSIDE & (1) OUTSIDE. HOLE THRU VESSEL TO BE DRILLED CLOSE TO THE MIDDLE OF THE GAC BED. ROD TO EXTEND APPROX. 10" INTO GAC BED. GROUNDING ROD (316 STN STL.)

2. INSTALL 1/2" HALF–COUPLING OUTSIDE. THREAD 1/2" NPT PIPE NIPPLE INTO COUPLING. ATTACH 1/2" PVC ISOLATION VALVE. (CCC SPEC. #4.50) ATTACH 1/2" NPT X 1/4" TUBE SWAGELOCK S.S. MALE ELBOW. ATTACH LINES FROM DP GAUGE. (2 REQD–(1)ABOVE THE GAC BED AND (1)BELOW GAC BED)

Drawing prepared by Calgon Carbon Corporation

BILL OF MATERIAL

MK#	REQD.	MAT'L.	DESCRIPTION
A	1	PE.	CANNISTER, 28" DIA. x 51" HIGH W/ 6" NOZZLES
B	1	C. STL.	MOUNTING SKID, 48" x 71 1/4" x 6 1/4" THK.
C	1	PPL.	FLANGED SPOOL (BLOWER SIDE)
D	1	PPL.	FLANGED SPOOL (VESSEL SIDE)
E	1	PVC	6" BUTTERFLY VALVE W/LEVER OPERATOR (3.16)
F	1	FRP	FRP FAN (SEE FAN DATA)(RFE–200)
G	1	SILICONE	6" FLEX BOOT W/2– STN. STL. CLAMPS
H	1	FRP	COMBINATION MOTOR STARTER
J	1	–	D.P. GAUGE (DWYER MINIHELIC – MODEL #5020)

ESTIMATED ASSEMBLED WEIGHTS:
EMPTY: 1,163#
OPERATING: 1,388#
FLOODED: 2,303#
CARBON CAPACITY: 225#

FAN DATA

CAPACITY:400 CFM@4553 RPM	RPM: 3600
PRESSURE: 10" SP	TYPE: TEXP
ARRG'T: 10	
ROTATION: CW–BH	S.F.: 1.15
ISOLATORS: YES	REMARKS: GRAPHITE
WEATHER GUARD: YES	IMPREGNATED

MSD

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EXHIBIT 16-6
WETWELL VENT CARBON CANISTER DETAIL

EFFECTIVE DATE: JUNE 30, 2009

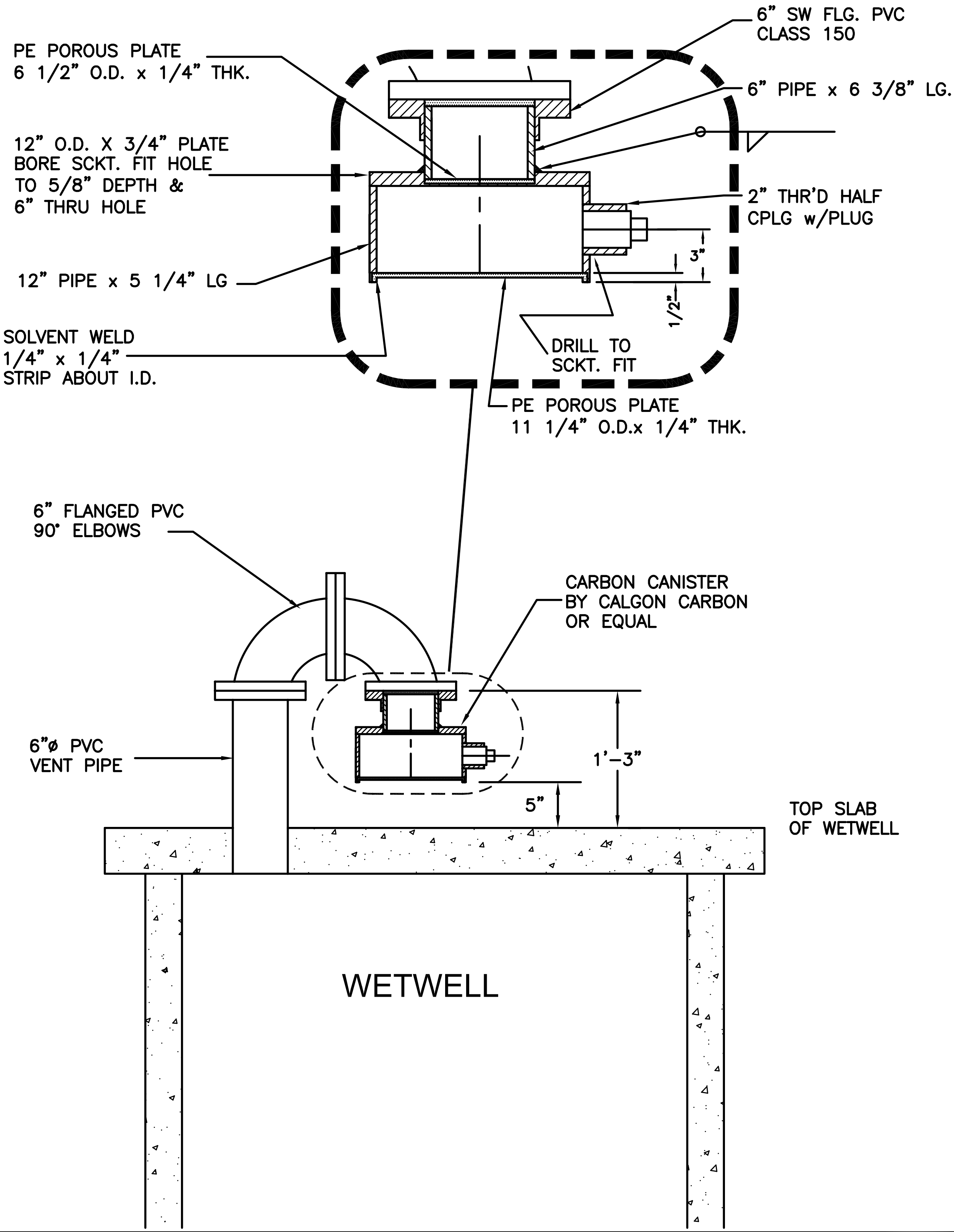

TABLE OF CONTENTS

CHAPTER 17
GEOTECHNICAL

CHAPTER 17
GEOTECHNICAL
EXHIBITS

CHAPTER 17
GEOTECHNICAL

17.1 PURPOSE

This section establishes the minimum standards for performing geotechnical explorations on MSD projects. Geotechnical explorations are required on all MSD projects, unless otherwise directed by MSD. Reasons for performing geotechnical explorations include, but are not limited to, the following:

a. To establish the bedrock depth along the alignment of proposed sewers or at the location of proposed structures.

b. To determine the subsurface profile and properties (texture, moisture content, density, shear strength, compressibility, etc.) of soil and bedrock materials. This information is needed for the design of below grade structures, (wetwells, junction structures, tanks, etc.) building foundations, sheeting and bracing systems, retaining walls, stable channel slopes, pavements, and embankments. Additionally, this information is necessary when unsuitable foundation conditions are at the trench subgrade level or when unstable trench wall conditions are anticipated.

c. To investigate the subsurface conditions at tunnel or boring and jacking sites. The composition and nature of materials at underground crossings is needed to establish the conditions to be encountered (soft ground, hard ground, or mixed face tunneling) and the appropriate construction method.

d. To provide information regarding groundwater so that the contractor can plan for an adequate dewatering system.

e. To determine pavement section makeup, layer thickness and condition.

17.2 GENERAL

17.2.1 Right of Entry

When the geotechnical exploration work will require entry onto private property, the property owner shall be contacted, the work described, and permission to enter obtained. Efforts to contact property owners shall include telephone calls and the leaving of letters for those who are not at home. In some instances, MSD may deem it necessary to issue a letter of introduction and identification (on MSD's letterhead), which the geotechnical field party will provide to the owner. In the event that the owner does not grant permission, and it is evident that the geotechnical work will be delayed, MSD should be notified, in writing, immediately. It is the responsibility of MSD to take whatever course of action is deemed necessary to obtain the legal right of entry in accordance with state statutes.

17.2.2 Protection of Underground Structures and Utilities

Prior to drilling and sampling in public rights-of-way and easements, the Kentucky Underground Utility Protection Center (BUD) shall be called at 1-800-752-6007 and requested to mark the locations of existing underground facilities. At least 2-business days notice is required for service. BUD confirmation numbers should be documented so that a record for the request is available. Drilling should not begin until clearance has been provided or notification that all underground utility lines are marked has been received.

On private property, the BUD does not normally maintain records. It then becomes necessary to employ the property owner's assistance and knowledge of service lines, underground storage tanks, septic tank facilities and/or use visible surface features, such as meter vaults, shut-off valves, etc., to estimate the locations of underground facilities. Borings should be offset accordingly, if necessary, to avoid any conflicting utilities.

If there is any reason to believe that an underground facility exists in an area to be drilled, and its location cannot be determined with reasonable accuracy, then that boring should not be advanced.

17.2.3 Erosion Prevention and Sediment Control/Ground Restoration

All efforts should be extended to avoid rutting, especially in residential areas. Ruts should be repaired with leveling the area with topsoil and seeding or sodding as required by MSD or as agreed upon with the property owner.

When using a truck-mounted drill rig, efforts should be made to access boring locations without crossing streams. In the event that crossing a stream is necessary to access a critical boring location, a ford in the stream, which is regularly used by the property owner, should be used after receiving approval from the property owner and MSD. Any rutting should be repaired with seeding and sodding as described above.

Dozer roads cut to permit access to boring and sounding locations should be leveled and seeded and strawed immediately following completion of the work.

Upon completion, borings should be completely backfilled from the bottom to the ground surface, using excavated cuttings. Reversed auger rotation or down pressure on the drill tools should be used to achieve compaction. In sodded areas, the sod should first be carefully cut, lifted from the boring site, and set aside. After backfilling, the sod should be replaced over the boring and tamped. Asphalt cold patch or concrete should be used to repair borings in pavements.

When drilling around sinkholes or at a site with the potential to drain storm water directly into a water feature (including streams, lakes or impoundments, or along steep slopes), special care should be taken to place all auger cuttings back into the hole. If excess cuttings remain, they should be removed from the site.

17.3 DRILLING AND SAMPLING

17.3.1 Methods and Equipment

Unless otherwise authorized by MSD, power equipment shall be utilized to obtain geotechnical data. In most cases, this will involve a truck or skid-mounted soils drilling rig equipped with continuous flight mechanical augers. In some instances it may be advantageous to use an air track rock drill if only rock soundings are being performed. In areas where drilling rig access is restricted with steep slopes, heavy woods, soft ground, or where the rock surface is known to be shallow with reasonable assurance (for example, next to a rock bottom stream), MSD may permit the use of manually driven sounding rods or hand augers.

In general, all soil test borings shall be performed in accordance with ASTM D 1586 "Standard Method for Penetration Test and Split Barrel Sampling of Soils". Split-barrel samples shall be taken at five-foot depth intervals and at changes in strata. When undisturbed samples in clay soils are required (for example, when shear strength determinations are needed), samples should be obtained in accordance with ASTM D 1587 "Standard Practice for Thin-Walled Tube Sampling of Soils".

Observation wells should be installed in completed soil borings whenever groundwater is encountered during the drilling process. Casing should be of 1-inch diameter field slotted PVC pipe. Water table readings should be obtained from observation wells no sooner than seven days from completion of the boring.

Rock core drilling shall be performed in accordance with ASTM D 2113 "Standard Practice for Diamond Core Drilling for Site Investigation", except when wire line drilling is permitted. The diameter of the rock core shall not be less than 2-1/8 inches.

Limestone formations are prevalent across much of Jefferson County. Rock remnants and hard clay soils are sometimes encountered above the top of rock in these formations. Accordingly, when performing rock line soundings with mechanical augers, the field crew should note the depth intervals of any rock remnants or hard clay soils encountered above the top of rock.

17.3.2 Location, Frequency and Depth Requirements for Soundings and Borings

When required, rock soundings should be performed at intervals of 50 feet where rock is encountered and 100 feet where rock is not encountered along the proposed alignment of collector and interceptor sewers, manholes, pump stations, and underground structures. The soundings should be advanced to a maximum depth, which corresponds to one foot below the invert elevation or to auger refusal, whichever occurs first. The requirements for rock soundings may be waived by MSD in areas of the Jefferson County where the bedrock surface is known to be deeper than excavation depths.

The requirements for soil test borings will be evaluated by MSD on a project-by-project basis. In general, soil test borings will be required for sewers located in areas with deep, potentially unstable soils or where high groundwater may be expected. When required, soil test borings should be drilled at approximate intervals of 500 feet and should be terminated 4 feet below the invert elevation or at auger refusal, whichever occurs first. If bedrock occurs higher than the invert elevation, then rock core drilling should extend the boring to 2 feet below the invert elevation.

Whenever possible, the boring plan should be developed to position test borings at locations of special interest. For example, test borings should be sited at the deepest excavation or where the open trench may affect existing buildings or major utilities. Borings should be drilled at the access pits or shafts of tunnels. If access is available, intermediate borings along the tunnel alignment should be advanced at 100-foot intervals. For large pump station and wastewater treatment plants, the number of borings needed may vary based on the number and layout of the individual facilities.

17.4 LABORATORY ANALYSES

Representative split-barrel samples should be analyzed for Atterberg limits, (ASTM D 4318) particle size distribution (ASTM D 422), specific gravity (ASTM D 854) and moisture content (ASTM D 2216). The samples should then be classified in accordance with ASTM D 2487 "Test Method for Classification of Soils for Engineering Purposes". Representative samples of soil materials, which are to be placed and compacted to controlled moisture-density conditions, should be subjected to Standard Proctor moisture-density tests (ASTM D 698) to determine the maximum dry density and optimum moisture content. Additionally, for any projects requiring pavement design, representative samples of proposed subgrade soils should be subjected to laboratory California Bearing Ratio tests (ASTM D 1883) to provide design CBR values.

When shear strength parameters are required for geotechnical analyses, these parameters should be determined as follows. The shear strength for non-cohesive materials (sand and sand-gravel mixtures) should be measured in accordance with ASTM D 3080 "Standard Test Method for Direct Shear Test of Soils under Consolidated-Drained Conditions". The undrained shear strength for cohesive soils (clays) should be measured in accordance with ASTM D 2166 "Standard Test Method for Unconfined Compressive Strength of Cohesive Soil". The drained shear strength for cohesive soils should be measured in accordance with ASTM D 4767 "Standard Test Method for Consolidated-Undrained Triaxial Compression Test on Cohesive Soils."

17.5 REPORT DEVELOPMENT AND DRAFTING

Reports of geotechnical explorations should include discussions on the project, general site conditions, site geology, scope of work, results of the exploration, and conclusions and recommendations relative to the proposed design and construction. More specifically, the site description should include discussions of the site topography, site drainage characteristics, any existing improvements, etc. Descriptions of the site geology should include underlying soil types and rock formations. Other geologic features such as faults or susceptibility to sinkholes should also be included. A description of the scope of work should also be provided and should include a complete description of the drilling, sampling, and laboratory analysis programs. The results of the exploration should include descriptions of soil types, depths, the presence of any groundwater, etc. Descriptions of rock cores should note the presence of joints, voids, mudseams, recovery ratios and rock quality designation values. References to site locations should also be included. In addition, any engineering analysis performed (slope stability, settlement, etc.) should be discussed. Finally, the conclusions and recommendations relative to design and construction from a geotechnical standpoint should be included.

When submitting the results of rock line soundings, the depth intervals of any rock remnants or hard clay soils encountered above the top of rock should be reported.

Geotechnical exploration data, including boring locations, graphical boring logs, sounding symbols, penetration test blowcounts, unconfined compressive strengths, natural moisture contents, groundwater elevations, top of rock elevations, etc., should be placed on the plan and profile drawings by the Design Engineer. The drawings should reflect the difference between soundings performed with mechanical augers and soundings performed with manually driven sounding rods. For intervals that have been sounded by mechanical augers and by manually driven soundings rods, report both sets of data. The elevations of any rock remnants or hard clay soils encountered above the top of rock should also be noted on the drawings. Refer to the MSD Geotechnical Legend Sheet, Exhibit 17-1, for the appropriate symbols. MSD's drafting standards as outlined before should be followed.

MSD
Louisville and Jefferson County
Metropolitan Sewer District
700 W. Liberty Street
Louisville, Kentucky
40203-1913
502-587-0603 – WWW.MSDLOUKY.ORG

EXHIBIT 17-1
GEOTECHNICAL LEGEND SHEET

EFFECTIVE DATE: JUNE 30, 2009

RQD (%)	Rock Quality
90–100	Excellent
75–90	Good
50–75	Fair
25–50	Poor
0–25	Very Poor

LIMESTONE

SANDSTONE

NONDURABLE SHALE (SDI≤89)

DURABLE SHALE (SDI≥90)

Description of Soil Relative Density or Consistency

SOIL TYPE	RELATIVE DENSITY OR CONSISTENCY	RANGE OF PENETRATION RESISTANCE	RANGE OF UNCONFINED COMPRESSIVE STRENGTH
Fine grained soils (More than half of material is smaller than No. 200 sieve size)	Very Soft Soft Medium Stiff Very Stiff Hard	Less than 2 blows per foot 2 – 4 4 – 8 8 – 15 15 – 30 >30	Less than 0.25 tsf 0.25 – 0.50 0.5 – 1.0 1.0 – 2.0 2.0 – 4.0 >4.0 tsf
Coarse grained soils (More than half of material is larger than No. 200 sieve size)	Very loose Loose Medium Dense Very Dense	Less than 4 blows per foot 4 – 10 10 – 30 30 – 50 >50	Not Applicable

Unified Soil Classifications

MAJOR DIVISIONS		SYMBOL	NAME
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty Sands, sand-silt mixture
		SC	Clayey sands, sand-clay mixture
FINE GRAINED SOILS	SILTS AND CLAYS LL IS LESS THAN 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
	SILTS AND CLAYS LL IS GREATER THAN 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
UNCLASSIFIED MATERIAL		NONE	Non-classified material (i.e. concrete, asphalt, crushed stone, cinders, slag, rubble, talus, etc.) Include visual description

AI	Activity Index
LI	Liquidity Index
N	Penetration Resistance
S+C(%)	Material finer than No. 200 sieve
•S	Location of Sounding
•SB	Location of Soil Boring
◉	Location of Soil Boring and Rock Core
▽	Water Elevation
▮	Thin-walled Tube Sample
<	Standard Penetration Test Sample
Qu	Unconfined Compressive Strength
w(%)	Moisture Content
RQD(%)	Rock Quality Designation
SDI(%)	Slake Durability Index
Rec.(%)	Core Recovery
ø	Angle of Internal Friction
$\bar{ø}$	Effective Angle of Internal Friction
c	Cohesion
$\bar{c}$	Effective Cohesion
γ	Total Unit Weight
⊻ M	Manual Rod Sounding – No Rock Encountered
⊻ M	Manual Rod Sounding to Rock
⊻ A	Auger Sounding – No Rock Encountered
⊻ A	Auger Sounding to Rock

NO. DATE REVISION CHK'D APPR'D DATE MSD APPROVALS
Signature L.S.# Land Surveyor's Seal
Signature P.E.# Professional Engineer's Seal
PLANS PREPARED AND SUBMITTED BY:
Design Consultant
CONSTRUCTED BY:
Company Name Date
FINAL RECORD DRAWING BY:
Company Name
Signature Date
Final Record Drawing
Signature L.S.# Land Surveyor's Seal
MSD Louisville and Jefferson County Metropolitan Sewer District 700 W. Liberty Street Louisville, Kentucky 40203-1913
GEOTECHNICAL LEGEND
PROJECT NAME
PROJECT DESCRIPTION
SCALE: As Shown DATE: MM-DD-YY
CONSTRUCTION CONTRACT NO. ______ RECORD NO. ______ SHEET OF
DRAWN BY / DESIGNED BY / CHECKED BY / RECORD DWG. NAME DATE

APPENDIX A
SELECTED DEFINITIONS

AASHTO - American Association of State Highway Transportation Officials.

ASTM - An abbreviation for American Society for Testing and Materials.

Abandoned - To remove from service for all functional use.

Activated Sludge Process - The process of using biologically active sewage sludge to hasten breakdown of organic matter in sewage during secondary waste treatment.

Acute Toxicity - Any poisonous effect produced within a short period of time, usually within 24-96 hours, resulting in severe biological harm and often death of test organisms.

Aeration - The process of being supplied or impregnated with air. Aeration is used in wastewater treatment to foster biological and chemical oxidation.

Aerobic - This refers to life or processes that can occur only in the presence of oxygen.

Ammonia - One of the seven forms that nitrogen can exist in nature (NH_3-N). It is used as an indicator of water quality because nitrogen is one of the fertilizing elements necessary for algal growth.

Anaerobic - Refers to life or processes that occur in the absence of oxygen.

Arch - The curved top of a structure, usually referred to as being from the springline to the top.

Assimilation - Conversion or incorporation of absorbed nutrients into protoplasm. Also refers to the ability of a body of water to purify itself of organic pollution.

Auger - A boring instrument used for subsurface exploration.

Available Chlorine - A measure of total oxidizing power.

Available Oxygen - The quantity of dissolved oxygen available for oxidation of organic matter in a body of water.

Average Daily Flow - That flow occurring in the sewers as a 24-hour dry weather average, including a nominal amount of infiltration, otherwise described as the total quantity of flow tributary to a point divided by the number of days of flow measurement.

Backfill - (a) The refilling of an excavation after a structure has been placed therein.

(b) The material placed in an excavation in process of backfilling.

Bacteria - Single-celled microorganisms that lack chlorophyll. Some bacteria are capable of causing human, animal, or plant diseases; others are essential in pollution control because they break down organic matter in the air and in the water.

Baffle - Any deflecting device used to change the direction of flow or the velocity of water.

Bar Screen - A preliminary treatment process that removes oversize solids in order to protect downstream treatment processes. Bar screens normally consist of vertical or inclined steel bars spaced at equal intervals across a channel of wastewater.

Barrel, Manhole - The vertical portion of a manhole used to gain access to a sewer or sewer structure.

Base, Manhole - The bottom or supporting structure on which the manhole barrel rests.

Bedding - The earth or other materials on which a sewer or other structure is supported.

Bell - The recessed, over enlarged, female end of a pipe into which the male or spigot end fits.

Biodegradable - The process of decomposing quickly as a result of the action of microorganisms.

Biological Oxidation - The process by which bacterial and other microorganisms feed on complex organic materials and decompose them. Self-purifications of waterways and activated sludge wastewater treatment processes depend on this process. The process is also called biochemical oxidation.

Biosolids - Settleable solids separated from the water during processing of wastewater.

Blazed - The act of removing a portion of bark from a tree for surveying purposes.

Blow Off - A waste gate or device for discharging accumulated solids or for emptying a depressed sewer.

Blueline Stream - Natural surface drainage structure shown on USGS topographic maps as a solid blueline. Also, classified by Kentucky Division of Water as a natural drainage structure having continuous flow during normal weather conditions.

Borings - Subsurface investigations performed to classify the types of soils.

Branch, Y (Wye) - A pipe joined to another pipe (usually at 60 degrees with alignment of the other) molded together and manufactured as a whole unit.

Bulkhead - A partition closing off an opening, usually constructed of timber, brick, or concrete.

Five-Day Carbonaceous Biochemical Oxygen Demand (CBOD5) - A measure of the amount of oxygen consumed in five days by the biological processes that break down organic carbonaceous matter in water. Large amounts of organic waste use up large amounts of dissolved oxygen; thus the greater the degree of pollution, the greater the BOD.

Capacity - The amount of flow in terms of cubic feet per second that a conduit can or will discharge. Capacity depends on factors such as velocity, coefficient of roughness, size, shape, and slope of conduit.

Carbon Dioxide - A colorless gas heavier than air, which is poisonous if inhaled. Its presence can be detected with proper equipment. Common in sewers that are not properly ventilated.

Castings - Metallic objects (normally cast iron) formed in a mold. Examples are: manhole lids; manhole rims; catch basin grates; and frames; etc.

cfs - Cubic feet per second - A unit of measure of the volume of liquid flow past a given point in one second.

Chamber, Chlorine Contract - A structure in which water and chlorine is mixed and then detained in order to achieve disinfection.

Chamber, Diversion - A chamber which contains a device for drawing off all or part of the flow.

Chamber, Junction - A converging section of a conduit used to facilitate the flow from one or more conduits into the main conduit.

Chamber - A general term applied to a space enclosed by walls or to a compartment often prefixed by a descriptive word, such as "junction chamber", "grit chamber", etc.

Chamfer - A flat surface created by slicing off a square edge or corner.

Chemical Oxygen Demand (COD) - A measure of the amount of oxygen required to oxidize organic and oxidizable inorganic compounds in water. The COD test, like the biochemical oxygen demand test, is used to determine the degree of pollution in an effluent.

Chlorination - The application of chlorine to drinking water or sewage for disinfection or the oxidation of undesirable compounds or micro-organisms.

Chlorinator - A device for adding a chlorine in the form of a gas or liquid to water.

Chlorine - An element ordinarily existing as a greenish-yellow gas about 2.5 times as heavy as air. At atmospheric pressure and a temperature of -30.1 degrees Fahrenheit, the gas becomes an amber liquid about 1.5 times as heavy as water. The chemical symbol of chlorine is Cl, its atomic weight is 35.457, and its molecular weight is 70.914.

Clarification - The removal of suspended solids by means of gravity settling, which can be aided by chemically-induced coagulation.

Clarifier - A settling tank which allows solids to separate out by gravity and contains a method to mechanically remove solids from the bottom of the tank.

Coagulant Agent - Chemical(s) that cause very fine particles to clump together into larger particles.

Coagulation - The clumping of very fine particles into larger particles induced by chemicals such as lime or alum. The larger particles allow separation of the solids from the water by settling, skimming, draining or filtering.

Coefficient - A numerical quantity interposed in a formula which expresses the relationship between two or more variables, which may be derived by theoretical or experimental methods.

Coefficient, Roughness - A factor, "n", in the Kutter, Manning, Hazen-Williams, and other formulae, which represents the effect of roughness of the confining channel or conduit material upon the energy losses in the flowing water.

Collar - (a) A cylindrical ring of either brick or precast concrete, secured upon the cone or barrel of a manhole upon which the frame will rest.

(b) A cylindrical monolithic concrete encasement for securing a joint and preventing shear by movement.

Collector System - A network of lateral and branch sewers in a defined area, which collects and transports sewage to a larger sewer.

Comminutor - A device that shreds solids in the wastewater in order to make them easier to treat and transport.

Composite Sample - A combination of individual samples of water or wastewater taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability of individual samples. Periodic samples may have equal volume or may be roughly proportioned to the flow at the time each sample is taken.

Conduit - A continuous piping or passage system for transporting water or sewage underground. Also, used for containing wires and cables of other utilities.

Connection, House - See Property Service Connection.

Contract Documents - The Agreement, Addenda (which pertain to the Contract Documents), Bid Proposal (including documentation accompanying the bid and any post-bid documentation submitted prior to the Notice of Award) when attached as an exhibit the Agreement, the Bonds, the General Conditions, the Special Provisions, the Specifications and the Drawings as the same or more specifically identified in the Agreement, together with all amendments, modifications and supplements issued on or after the effective date of the Agreement.

Cradle - Type of bedding, usually of gravel or concrete, being laid upwards from the trench bottom to the springline of the pipe.

Crown - The highest inside part of a conduit; the inner top of a conduit.

Cubic Feet per Second - (Abbreviated c.f.s.) A unit of measure of the volume of liquid flow past a given point in one second.

Cul-de-sac - An alley or street having no outlet at one end, usually having an area at its dead end for turning around.

Culvert - A closed conduit typically of precast or monolithic structure of sufficient length for the passage of water.

Datum - An agreed standard point or plane of stated elevation. Any position or element in relation to which others are determined, for example, the horizontal control system used in map making.

Dead Man - A post put in solid ground for furnishing and fastening or anchoring guy wires.

Dechlorination - Removal of residual chlorine in water by a chemical or physical processes.

Delta - Used as a symbol, this indicates the angle of deflection from the forward tangent either left or right to the centerline of the sewer.

Detention Tank - A tank used to provide adequate storage time for chemical or physical reactions to occur.

Digestion - The biochemical decomposition of organic matter. Digestion of biosolids takes place in tanks where the biosolids decompose, resulting in partial gasification, liquefaction, and mineralization of pollutants.

Discharge -
(a) As applied to a sewer or stream; the rate of flow, or volume of water flowing therein at a given place and within a given period of time.
(b) The act, in water or other liquid, of passing through an opening or along a conduit or channel.
(c) The water or other liquid which emerges from an opening or passes along a conduit or channel.

Disinfection - Effective killing by chemical or physical processes of organisms capable of causing infectious disease. Chlorination is currently the most common method in wastewater treatment processes.

Diversion - An arrangement of pipes, conduits, gates and/or valves that allows flow to be passed around a hydraulic structure or appurtenance.

Double System - Usually two conduits laid in parallel -- one conduit laid in the trench being used for a drain, and the other as a sewer or sewers laid on either side of a street.

Drainage Area - A tributary area which is generally limited by a topographic area, but may be also limited by political boundary or economic factors.

Drop Inlet - A contrivance of pipe fittings which is utilized when an incoming sewer is considerably higher than the outgoing sewer.

Dynamic Head - In pumping water, a head usually expressed in pounds per square inch (p.s.i.) representing both the pressure due to the elevation to which the water is pumped and that due to friction of the water in the pipe; the head against which a pump works.

Effluent - The water or wastewater that flows from a basin, treatment process or treatment plant.

Encasement - Usually monolithic concrete that is used to enclose the periphery of a conduit.

Engineer - A consultant or in-house designer who is in responsible design and who is a registered Professional Engineer in the Commonwealth of Kentucky.

Equivalent - Being equal in measure.

Extended Aeration - Treatment process similar to conventional activated sludge with the exception that the wastewater is retained in the aeration tank longer (18-24 hours).

Fascines - A long bundle of sticks of wood bound together and used for such purposes as filling ditches and making revetments for riverbanks.

Fecal Coliform Bacteria - A group of organisms indigenous to the intestinal tracts of humans and other mammals. The presence of fecal coliform in water is an indicator of pollution and of potentially dangerous bacterial contamination.

Filtration - The process of passing water through material such as a bed of sand, coal or other granular substance to remove impurities such as suspended particles and bacteria.

Final Effluent - The effluent from the final treatment unit of a wastewater treatment plant.

Flap Gate - A gate that opens and closes by rotation around a hinge or hinges at the top of the gate, permitting the fluid to pass only in one direction.

Floc - A clump of solids formed in sewage by biological or chemical action.

Flocculation - The process of gathering fine particles to form larger particles after coagulation by the use of gentle mixing.

Flood Level - The stage of a stream at the time of a flood.

Flood Plain - The land contained within the perimeter of the probable limiting flood.

Flood Frequency - The frequency with which the maximum flood may be expected to occur at a site in any average interval of years. Frequency analysis defines the "N-year flood" as being the flood which will, over a long period of time, be equaled or exceeded on the average once every N years.

Flow, Dry-Weather (Sanitary) - The flow of wastewater in a sewer during dry weather. Such flow consists mainly of sewage and wastes with no stormwater or groundwater included.

Flow Meter - A device that measures the rate at which water is flowing through the conduit or channel.

Force Main - A pipe under internal pressure created by being on the discharge side of a pump station.

fps - Feet per second.

Gate, Sluice - A gate constructed to slide vertically, or nearly so, and fasten into or against a permanent structure.

Grade -

(a) The inclination or slope of a stream channel, conduit or natural ground surface, usually expressed in terms of the ratio or percentage of vertical rise or fall per 100 feet of horizontal distance. See Slope.

(b) The elevation of the invert of the bottom of a pipe line, canal, culvert, sewer, etc.

Grade, Hydraulic - In a closed conduit under pressure, a line joining the elevations to which water would rise in pipes freely vented and under atmospheric pressure. See Gradient, Hydraulic; also, Line, Hydraulic Grade.

Gradient - The rate of change of any characteristic per unit of length, or slope. The term is usually applied to such things as elevation, velocity, pressure, etc. See Slope.

Gradient, Hydraulic - The slope of the hydraulic grade line, the rate of change of pressure head, the ratio of the loss in the sum of the pressure head, and positive head to the flow distance.

Grit - The heavy material present in wastewater, such as sand, gravel, and cinders.

Groundwater - Subsurface water occupying the zone of saturation. In a strict sense, the term applies only to water below the water table.

Head - The height of the free surface of fluid above any point in a hydraulic system; a measure of the pressure or force exerted by the fluid.

Head, Friction - The head lost by water flowing in a conduit as the result of intermolecular friction or disturbances setup by the contract between the moving water and its containing conduit.

Head, Loss of - The vertical distance or height through which a body must fall freely under the force of gravity to acquire the velocity which it possesses. It is equal to the square of the velocity divided by twice the acceleration of gravity.

Heavy Metals - Metallic elements with high molecular weights, generally toxic in low concentrations to plant and animal life. Such metals often reside in the environment and accumulate biologically. Examples include mercury, chromium, cadmium, arsenic, and lead.

Hydraulic Grade Line - A hydraulic profile of the piezometric level of water at all points along the line. The term is usually applied to water moving in a conduit, open channel, stream, etc. In an open channel it is the free water surface.

Hydrogen Sulfide (H_2S) - A malodorous gas made up of hydrogen and sulfur with the characteristic odor of rotten eggs. It can be emitted in the natural decomposition of organic matter if it becomes anaerobic. In heavy concentrations, it can cause illness or death.

I/I - Refers to infiltration and/or inflow.

Increment, Area - A precise part of an area or one of a series of areas.

Industrial Waste - That waste from the processes of manufacturing discharge in water, as distinguished from the normal sanitary waste contributed by employees.

Infiltration - Refers to groundwater that enters a sewer system through such sources as defective pipes, pipe joints, connections, or manholes.

Infiltration, Groundwater - That part of sanitary sewage flow derived from groundwater sources and passing into public sewers through defects or faulty construction.

Inflow - Refers to water discharged into service connections and sewer pipes from foundations and roof drains, paved surfaces and sump pumps.

Inorganic Matter - Chemical substances of mineral origin, or more correctly not of basic carbon structure.

Interceptor - See Sewer Interceptor.

Interceptor Sewer - A sewer which receives flow from a number of collector sewers or outlets and, frequently, additional predetermined quantities of stormwater (if from a combined system), and transports such water to a point for treatment or disposal.

Invert - The floor, bottom or lowest portion of the internal cross-section of a sewer or other conduit.

Joint, Bell-and-Spigot - A form of joint used on pipes which have an enlarged diameter or bell at one end, and a spigot at the other which fits into and is laid in the bell. The joint is then made tight by cement, lead, a rubber "O" ring, or other jointing compounds or materials.

Lamp Hole - 8" diameter cleanout on the end of a long 8" sanitary stub.

Lathes - Wooden 1" x 2" survey stakes.

Local Drainage System - A drainage system that does not receive or transport runoff from an adjoining property.

Manhole - An opening by which a man may enter or leave a sewer, conduit, or other closed structure for inspection, cleaning, and other maintenance operations, closed by a removable cover.

MGD - Millions of gallons per day.

Microbes - Minute life form or micro-organisms, especially one that causes disease.

Milligrams per liter (mg/L) - A measure of the concentration by weight of a substance per unit volume. One mg/L is equivalent to one part per million (ppm).

Monolithic - Cast-in-place, rather than precast.

MSD - Louisville and Jefferson County Metropolitan Sewer District.

Neutralization - Addition of an acid or alkali to a liquid to cause the pH of the liquid to move towards a neutral pH of 7.0.

Nutrients - Elements or compounds essential as raw materials for organism growth and development. Common nutrients are carbon, oxygen, hydrogen, nitrogen, sulfur and phosphorus.

Organism - Living organisms common to the intestinal tract of man and other mammals whose presence in wastewater is an indicator of pollution and of potentially dangerous bacterial contamination.

Outcrop, Rock - The appearance at the earth surface of a rock strata.

Outfall - The conduit leading to the discharge stream through which the effluent flows.

Oxygen Demand - The quantity of oxygen utilized in the biochemical oxidation of organic matter.

Package Wastewater Treatment Plant - A prefabricated wastewater treatment plant that is hauled to the plant site and installed as the only facility.

Peak - A maximum quantity which occurs over a relatively short period of time, such as an hour or day.

Peak Demand - The maximum, momentary load placed on a wastewater plant or pumping station.

Peak, Instantaneous - The maximum rate which ever occurs, possibly for only a moment.

pH - A measure of the acidity or alkalinity of a material, liquid, or solid. pH is represented on a scale of 0 to 14, with 7 representing a neutral state, 0 representing the most acid, and 14 representing the most alkaline.

Pipe, Vitrified Clay - A pipe made of clay burned in a kiln with surfaces glazed for water tightness. It is used for carrying sewage and sometimes for carrying water. It is seldom used under pressure.

Pollutant - Any gas, liquid, or solid that makes a resource unfit for a specific purpose.

Population, Equivalent - A hypothetical number of persons representing flow. The equivalent population of an existing industry or a school, for example, is determined from the normal flow of sewage divided by the average contribution of wastewater per person.

Population, Saturation - The actual or equivalent population of a given area that exists or would occur when the area is completely developed according to its present use for developed areas, and its present zoning for undeveloped areas.

Population, Total Equivalent - The sum of the residential population in a given area, and its equivalent population.

Potable Water - Water suitable for drinking or cooking purposes from health and aesthetic considerations.

ppm - Part per million. A measure of the concentration by weight of a substance per unit volume. One ppm is equal to one mg/L.

Precast - That which is formed in a mold or form and distributed by the manufacturer as a complete unit.

Precipitate –

(a) Noun: An insoluble, finely-divided substance which is a product of a chemical reaction within a liquid.

(b) Verb: Separation from solution of an insoluble substance.

Pretreatment - Any process used to reduce pollution before the wastewater is introduced into a sewer system for further treatment.

Primary Treatment - An early stage process in wastewater treatment in which floating and settleable solids are mechanically separated from the water being treated.

Private Drainage System - See Local Drainage System

Property Service Connection - That portion of a sewer system located within an easement or right-of-way which transports sewage from private property to the main sewer.

Proposed - That which is to have immediate consideration for construction.

Pump Station - A station at which sewage is pumped to a higher elevation.

Receiving Waters - A stream, river, lake, ocean, or other surface or groundwaters into which treated or untreated wastewater is discharged.

Sanitary Sewers - Sewers intended to carry wastewater from residences, businesses and industries. Stormwater runoff is carried in a separate system.

Screen - A device with openings used to retain or remove suspended or floating solids in flowing water or sewage.

Secondary Treatment - Wastewater treatment process used to convert dissolved or suspended materials into a form more easily separated from the water being treated. The most common form of secondary treatment is a biological treatment process that is followed by secondary clarifiers.

Sedimentation Tanks - Tanks where the solids are allowed to settle or to float. Settled solids are pumped to thickeners or digesters. Scum that floats in a sedimentation tank is either skimmed off or recycled through the wastewater treatment plant.

Sedimentation - The separation of solids by means of gravity.

Service Area - A geographic area serviced by a public utility or served by a sewage collection system.

Settleable Solids - Bits of debris and fine matter heavy enough to settle out of wastewater.

Sewage - Largely, the water supply of a community after it has been fouled by various uses. From the standpoint of source, it may be a combination of the liquid or water carried wastes from residences, businesses and institutions, together with those from industrial establishments, and with such groundwater, surface water, and stormwater as may be present.

Sewage, Combined - Sewage containing both sanitary sewage and surface or stormwater.

Sewage, Domestic - Sewage derived principally from dwellings, businesses, institutions, and the like. It may or may not contain groundwater, surface water, or stormwater.

Sewage, Industrial - Sewage in which industrial wastes pre-dominates.

Sewage, Sanitary -
(a) Domestic sewage with storm and surface water excluded.

(b) Sewage discharging from the sanitary conveniences of dwellings (including apartment complexes and hotels), office buildings, factories, or institutions.

(c) The water supply of a community after it has been used and discharged into a sewer.

Sewer - A pipe or conduit that carries waste, storm or surface water.

Sewer, Branch - A sewer which receives sewage from lateral sewers and discharges into a larger sewer.

Sewer, Collector - A sewer which receives flow directly from property service connections. Collector sewers are tributaries to interceptor sewers.

Sewer, Combined - A sewer intended to receive both wastewater and storm or surface water.

Sewer, Interceptor - A sewer which receives flow from a number of collector sewers or outlets and, frequently, additional predetermined quantities of stormwater (if from a combined system), and transports such water to a point for treatment or disposal.

Sewer, Inverted Siphon - A section of sewer constructed lower than adjacent sections to pass beneath a watercourse or other obstruction. It runs full or at greater than atmospheric pressure because its crown is depressed below the hydraulic grade line.

Sewer, Lateral - A sewer which receives sewage from a relatively small area which discharges into a branch or other sewer and has few others sewers tributary to it.

Sewer, Main - The principal sewer to which branch sewers and submains are tributary, also called trunk sewer.

Sewer, Outfall - A sewer that receives wastewater and/or stormwater and carries it to a point of final discharge.

Sewer, Relief - A sewer built to carry the flows in excess of the capacity of an existing sewer.

Sewer, Sanitary - A sewer which primarily carries sewage, and to which storm surface, and ground waters are not intentionally admitted.

Sewer, Submain - An arbitrary term used for relatively large branch sewers.

Slope - The inclination of the invert of a conduit expressed as a decimal or as feet per stated length measured horizontally in feet.

Soundings - Method used to ascertain the depth of rock strata.

Springline - The inner edge of the inclined or horizontal base where the arch begins.

Stabilization - The process of converting active organic matter into inert, harmless material.

Stacks – A vertical connection to a collector sewer. Used when more economical than a typical property service connection.

Storm Sewer - A separate sewer that carries runoff from storms, surface drainage and street, and does not include domestic or industrial wastes.

Subgrade - The bottom of a trench or other excavation that is somewhat below the predetermined elevation of the bottom of the final excavation or structure, the intervening space being backfilled with some special material such as sand, gravel, broken stone, or tamped earth, or impervious lining. The term is also applied to the elevation of such bottom.

Submain - See Sewer, Submain.

Sump - A depression that serves as a receptacle for liquids to be pumped.

Surcharge - A condition where a sewer is inadequate to discharge the total amount of flow when it is just filled or flowing at the planned depth or head. The amount of surcharge is measured by the volume or rate of excess flow or by the excess height of the hydraulic grade line.

Surface Water - Water on the earth's surface open to the atmosphere, such as rivers, streams, and oceans.

Swale - A shallow ditch which does not exceed 6" in depth from the top of bank.

"Ten-States Standards" - "Recommended Standards for Wastewater Facilities of the Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers." 1990 Edition.

Through Drainage System – A drainage system that collects or transports runoff from more than one property.

Topography - The configuration of a surface area including its relief, or relative elevations, and the location of its natural and constructed features.

Total Dissolved Solids (TDS) - The total amount of dissolved materials, organic and inorganic, contained in water and wastes. Excessive dissolved solids make water unpalatable for drinking water and unsuitable for some industrial uses.

Transition - A short section of a conduit used as a conversion section to unite two conduits having different hydraulic elements.

Trunk - See Trunk Sewer.

Trunk Sewer - A sewer which receives many tributary branches and which serves a large area.

USGS - Abbreviation for United States Geological Survey.

Velocity, Self-Cleaning - The minimum velocity in sewers necessary to keep solids in suspension and prevent their deposition and the subsequent nuisances from stoppages and odors on decomposition.

Wastewater - See Sewage.

Water Quality Criteria - The maximum levels of pollutants that can be reached prior to impacting the suitability of water for a given water use classification. Generally, water use classification includes: public water supply; recreation; propagation of fish and other aquatic life; agricultural use and industrial use.

Water Quality Standard - A plan for water quality management containing four major elements: the use (recreation, drinking water, fish and wildlife propagation, industrial or agricultural) to be made of the water; criteria to protect those uses; implementation plans (for needed industrial municipal waste treatment improvements) and enforcement plans; and an anti-degradation station to protect existing high quality waters.

Watershed - The area drained by a given stream or segment of a stream.

APPENDIX B
SYSTEMS INTERNATIONAL CONVERSIONS

Alphabetical List of Units

To Convert From	To	Multiply By
acre-foot	meter^3 (m^3)	1.233 482 E+03
acre	meter^2 (m^2)	4.046 856 E+03
astronomical unit	meter (m)	1.495 98 E+11
atmosphere (normal)	pascal (Pa)	1.013.25 E+05
bar	pascal (Pa)	1.000 000 E-05
barrel (for petroleum, 42 gal)	meter^3 (m^3)	1.589 873 E-01
British thermal unit (International Table)	joule (J)	1.055 056 E+03
bushel (U.S.)	meter (m^3)	3.523 907 E-02
caliber (inch)	meter (m)	2.540 000 E-02
calorie (International Table)	joule (J)	4.186 800 E+00
cal/g	joule/kilogram (J/kg)	4.186 800 E+03
calorie (thermochemical)/minute	watt (W)	6.973 333 E-02
carat (metric)	kilogram (kg)	2.000 000 E-04
centimeter of mercury (0°)	pascal (Pa)	1.333 22 E+03
centimeter of water (4°C)	pascal (Pa)	9.806 38 E+01
circular mil	meter^2 (m^2)	5.067 075 E-10
cup	meter^3 (m^3)	2.365 882 E-04
day (mean solar)	second (s)	8.640 000 E+04
degree (angle)	radian (rad)	1.745 329 E-02
degree Celsius	Kelvin (K)	$t_K = t_{°C} + 273.15$
degree Fahrenheit	degree Celsius	$t_C = (t_F - 32)/1.8$
degree Fahrenheit	Kelvin (K)	$t_K = (t_F + 459.67)/1.8$
degree Rankine	Kelvin (K)	$t_K = t_R/1.8$
dyne	newton (N)	1.000 000 E-05
dyne-centimeter	newton-meter (Nm)	1.000 000 E-07
dyne/centimeter	pascal (Pa)	1.000 000 E-01
electron volt	joule (J)	1.602 19 E-19
erg	joule (J)	1.000 000 E-07
faraday (chemical)	coulomb ©	9.649 57 E+04
fluid ounce (U.S.)	meter^3 (m^3)	2.957 353 E-05
foot	meter (m)	3.048 000 E-01
foot^3/minute	meter^3/second)m^3/s)	4.719 474 E-04
foot/second	meter^3/second (m^3/s)	2.831 685 E-02
foot^3	meter^3 (m^3)	2.831 685 E-02
foot^3	gallons (gal)	7.48052 E+00
foot^2	meter^2 (m^2)	9.290 304 E-02
foot/hour	meter/second (m/s)	8.466 667 E-05
foot/minute	meter/second (m/s)	5.080 000 E-03
foot/second	meter/second (m/s)	3.048 000 E-01
foot^2/second	meter^2/second (m^2/s)	9.290 304 E-02
foot of water (39.2°F)	pascal (Pa)	2.988 98 E+03
footcandle	lumen/meter^2 (lm/m^2)	1.076 391 E+01
footcandle	lux (lx)	1.076 391 E+01
foot-pound-force	joule (J)	1.355 818 E+00

To Convert From	To	Multiply By
foot-pound-force/hour	watt (W)	3.766 161 E-04
foot-pound-force/minute	watt (W)	2.259 697 E-02
foot-pound-force/second	watt (W)	1.355 818 E+00
foot-second^2	meter/second^2 (m/s^2)	3.048 000 E-01
gallon (U.S. dry)	meter^3 (m^3)	4.404 884 E-03
gallon (U.S. liquid)	meter^3 (m^3)	3.785 412 E-03
gallon (U.S. liquid)/day	meter^3/second (m^3/s)	4.381 264 E-08
gallon (U.S. liquid)/minute	meter^3/second (m^3/s)	6.309 020 E-05
gallon/minute	foot^3/hr	8.020800 E+00
gamma	tesla (T)	1.000 000 E-09
gill (U.S.)	meter^3 (m^3)	1.182 941 E-04
grad	degree (angular)	9.000 000 E-01
grad	radian (rad)	1.570 796 E-02
gram	kilogram (kg)	1.000 000 E-03
gram/centimeter^3	kilogram/meter^3 (kg/m^3)	1.000 000 E+03
gram-force/centimeter^2	pascal (Pa)	9.806 650 E+01
horsepower (electric)	watt (W)	7.460 000 E+01
horsepower (metric)	watt (W)	7.354 99 E+02
inch	meter (m)	2.540 000 E-02
inch^2	meter^2 (m^2)	6.451 600 E-04
inch^3	meter^3 (m^3)	1.638 706 E-05
inch^3/minute	meter^3/second (m^3/s)	2.731 177 E-07
inch of mercury (32°F)	pascal (Pa)	3.386 389 E+03
inch of water (39.2° F)	pascal (Pa)	2.490 82 E+02
kilocalorie (International Table)	joule (J)	4.186 800 E+03
kilocalorie (thermochemical)	joule (J)	4.184 000 E+03
kilocalorie (thermochemical)/minute	watt (W)	6.973 333 E+01
kilocalorie (thermochemical)/second	watt (W)	4.184 000 E+03
kilogram-force (kgf)	newton (N)	9.806 650 E+00
kilogram-force-meter	Newton-meter (N m)	9.806 650 E+00
kilogram-force-second^2/meter (mass)	kilogram (kg)	9.806 650 E+00
kilogram-force/centimeter^2	pascal (Pa)	9.806 650 E+04
kilogram-force/meter^2	pascal (Pa)	9.806 650 E+00
kilogram-force/millimeter^2	pascal (Pa)	9.806 650 E+06
kilogram-mass	kilogram (kg)	1.000 000 E+00
kilometer/hour	meter/second (m/s)	2.777 778 E_01
kilowatt-hour	joule (J)	3.600 000 E+06
kip (1000 lbf)	newton	4.448 222 E+03
kip/inch^2 (ksi)	pascal (Pa)	6.894 757 E+06
knot (International)	meter/second (m/s)	5.144 444 E-01
liter (L)	feet^3 (ft^3)	3.53000 E+02
liter (L)	gallons(gal)	0.264000 E+00
liter (L)	meter^3 (m^3)	1.000 000 E-03
lux	lumen/meter^2 (lm/m^2)	1.000 000 E+00
maxwell	weber (Wb)	1.000 000 E-08
mil	meter (m)	2.540 000 E-08
mile (International Nautical)	meter (m)	1.852 000 E+03
mile (U.S. nautical)	meter (m)	1.852 000 E+03
mile (U.S. statue)	meter (m)	1.609 344 E+03

To Convert From	To	Multiply By
$mile^2$ (U.S. statue)	$meter^2$ (m^2)	2.589 988 E+06
mile/hour (U.S. statue)	meter/second (m/s)	4.470 400 E-01
mile/hour (U.S. statue)	kilometer/hour	1.609 344 E+00
minute (angle)	radian (rad)	2.908 882 E-04
moment of inertia ($lbm \cdot ft^2$)	kilogram-$meter^2$ ($kg \cdot m^2$)	4.214 011 E-02
moment of inertia ($lbm \cdot in^2$)	kilogram-$meter^2$ ($kg\ m^2$)	2.926 397 E-04
ounce (U.S. fluid)	$meter^3$ (m^3)	2.957 353 E-05
peck (U.S)	$meter^3$ (m^3)	8.809 768 E-03
pennyweight	kilogram (kg)	1.555 174 E-03
pint (U.S. dry)	$meter^3$ (m^3)	5.506 105 E-04
pint (U.S. liquid)	$meter^3$ (m^3)	4.731 765 E-04
poise (absolute viscosity)	pascal-second (Pa·s)	1.000 000 E-01
pound-force-foot/inch	newton-meter/meter (N·m/m)	5.337 866 E+01
pound-force-foot/inch	newton-meter/meter (N·m/m)	4.448 222 E+00
pound-force/inch	newton/meter (N/m)	1.751 268 E+02
pound-force/foot	newton/meter (N/m)	1.459 390 E+01
pound-force/$foot^2$	pascal (Pa)	4.788 026 E+01
pound-force/$inch^2$ (psi)	pascal (Pa)	6.894 757 E+03
pound-force-second/$foot^2$	pascal-second (Pa·s)	4.788 026 E+01
pound-mass (lbm avoirdupois)	kilogram (kg)	4.535 924 E-01
pound-mass (troy or apothecary)	kilogram (kg)	3.732 417 E-01
pound-mass/$foot^2$	kilogram/$meter^2$ (kg/m^2)	4.882 428 E+00
pound-mass/second	kilogram/second (kg/s)	4.535 924 E-01
pound-mass/$foot^3$	kilogram/$meter^3$ (kg/m^3)	1.601 846 E+01
pound-mass/$inch^3$	kilogram/$meter^3$ (kg/m^3)	2.767 990 E+04
pound-mass/gallon (U.S. liquid)	kilogram/$meter^3$ (kg/m^3)	1.198 264 E+02
pound-mass/foot – second	pascal – second (Pa·s)	1.488 164 E+00
quart (U.S. dry)	$meter^3$ $(m)^3$	1.101 221 E-03
quart (U.S. liquid)	kilogram/$meter^3$ (kg/m^3)	9.463 529 E-04
rod	meter (m)	1.101 221 E-03
roentgen	coulomb/kilogram (C/kg)	2.579 760 E-04
second (angle)	radian (rad)	4.848 137 E-06
slug	kilogram (kg)	1.459 390 E+01
slug/$foot^2$	kilogram/$meter^3$ (kg/m^3)	5.153 788 E+02
slug/foot-second	pascal-second (Pa·s)	4.788 026 E+01
statute mile (U.S.)	meter (m)	1.609 344 E+03
stere	$meter^3$ (m^3)	1.000 000 E+00
tablespoon	$meter^3$ (m^3)	1.478 676 E-05
teaspoon	$meter^3$ (m^3)	4.928 922 E-06
tex	kilogram/meter (kg/m)	1.000 000 E-06
ton (assay)	kilogram (kg)	2.916 667 E-02
ton (long, 2240 ibm)	kilogram (kg)	1.016 047 E+03
ton (metric)	kilogram (kg)	1.000 000 E+03
ton (nuclear equivalent of TNT)	joule (J)	4.200000 E+09
ton (register)	$meter^3$ (m^3)	2.831 685 E+00
ton (short, 2000 ibm)	kilogram (kg)	9.071 847 E+02
ton (short, mass)/hour	kilogram (kg)	2.519 958 E-01
ton (long, mass)/$yard^3$	kilogram/$meter^3$ (kg/m^3)	1.328 939 E+03
watt-hour	joule (J)	3.600 000 E+03

To Convert From	To	Multiply By
watt-second	joule (J)	1.000 000 E+00
yard	meter (m)	9.144 000 E-01
$yard^2$	$meter^2$ (m^2)	8.361 274 E-01
$yard^3$	$meter^3$ (m^3)	7.645 549 E-01
$yard^3$/minute	$meter^3$/second (m^3/s)	1.274 258 E-02
year (calendar)	second (s)	3.153 600 E+07

APPENDIX C
FLEXIBLE PIPE
UTILIZATION IN MSD SYSTEM

For many years pipe materials installed into MSD's gravity sewer system were rigid pipe products comprised predominantly of two types. These were vitrified clay pipe (VCP), which was installed for small and intermediate size sewers, and reinforced concrete pipe (RCP) which was typically laid for larger diameter sewers. While each of these traditional products has some limitations, in general they have proven to b very durable and strong and they have served well in the MSD system.

In the early 1980's, solid wall polyvinyl chloride pipe (PVC) was introduced into MSD's sanitary system. PVC pipe has now replaced clay pipe as the preferred product for small to intermediate size sanitary sewers. Since PVC pipe diameters were limited to 18 inches and below, and these pipe materials exhibit relatively high stiffness values, MSD's standard crushed stone encasement (based on the industry standard ASTM D2321) has proven to be adequate for the necessary structural support.

In recent years, manufacturers have developed a number of new flexible pipe products with increasing diameters and some with lower stiffness values. These have included corrugated polyethylene (PE) pipe, high-density polyethylene (HDPE) profile-wall pipe, corrugated PVC pipe, PVC profile wall pipe, and steel spiral rib pipe. Many of these products have been reviewed and approved for use, because MSD recognizes that in certain situations the benefits of lighter weights and fewer joints may be greater than the structural disadvantages associated with flexible pipe.

However, MSD also recognizes that the use of flexible pipe products may not be appropriate in every situation. Accordingly, MSD's Director of Engineering has issued Guidelines for Use of Flexible Pipe for Drainage Facilities. These guidelines were developed after evaluating flexible pipe materials and seeking input from local engineers, developers and contractors. A copy of the guidelines, which have been in effect since February, 1991, is attached.

MSD considers the use of flexible pipe in drainage applications more critical than in sanitary facilities for several reasons. First, drainage facilities often include pipes installed at shallow depths. This makes the pipe more susceptible to damage caused by construction equipment, traffic loads, utility cuts, etc. Second, the flexible pipes products that are approved for sanitary applications tend to exhibit high stiffness values compared with flexible pipe products approved for drainage applications. Last, drainage pipes are typically of larger diameter. This means that larger loads must be supported by the pipe/soil structure. Consequently, more care must be exercised during installation to ensure that the crushed stone is properly worked into the haunching and initial backfill zones to provide the required lateral support.

It is for these reasons that rigid pipes are the preferred product in MSD's drainage system. MSD's policy requires that the Engineer justify the use of flexible pipe on drainage projects. The following is an application form and checklist which should be completed when an Engineer decides to use flexible pipe in the MSD drainage system.

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APPLICATION FOR USE OF FLEXIBLE PIPE IN DRAINAGE FACILITIES WITHIN MSD DRAINAGE SERVICE AREA

General Data

Date:____________________

Project Name:____

Owner/Developer:____

Engineer:____

MSD Reviewer:____

Decision: ____________ Accepted ____________ Rejected

____________ Revise and Resubmit

Flexible Pipe Data

Type of Pipe Proposed:____

Manufacturer/Trade Name:____

Diameter:______________________ in. Min./Max. Cover:_________ ft./ _________ ft.

Justification Data

It is the responsibility of the Engineer submitting plans for approval to request and justify the use of flexible pipe materials. As a minimum, the Engineer must address the following items. Attach written responses to this application and reference MSD's Design Manual whenever applicable. Include responses as notes on plans when response requires Contractor's attention.

Item 1. Outline procedures to protect flexible pipe from excessive construction loadings (both equipment and backfill material). If conditions are outside of those used in the Min./Max. Burial Depths Chart for Flexible Pipe, (for example, if backfill weights or construction loads are greater) provide design calculations in accordance with 1) AASHTO Design Procedures Section 12 or Section 18 (as appropriate) and 2) the Modified Iowa Equations to demonstrate a maximum deflection of 5 percent. Design calculations must also show maximum allowable loads, maximum construction loads and maximum in-service loads.

Item 2. Provide information which demonstrates the proposed flexible pipe has adequate hydraulic capacity (If “n” value is higher than a previously approved product).

Item 3. Provide geotechnical data to support design assumptions concerning soil stiffness in haunching and initial backfill zones. Refer to MSD’s trench Details for trench widths and crushed stone encasement dimensions, and reference the required trench width and encasement information on plans.

Item 4. Does the groundwater condition or provisions where long runs of concrete encasement indicate that the pipe will be subjected floatation? If yes, discuss measures to prevent occurrence and reference on plans.

Item 5. Discuss the potential for post-installation damage by subsequent construction of other utilities, service connections, fence posts, structure excavation, etc. Flexible pipe shall not be allowed within road right of ways and other locations where potential for damage exists.

Item 6. If steep slopes exist, discuss methods to be employed that will prevent creep or downslope slippage.

Item 7. Discuss the need to provide end treatments to protect inlet/outlet end of flexible pipes from damage.

Item 8. Flexible pipe generally requires more inspection to ensure proper bedding, haunching, backfilling, etc. Outline a plan for the owner/developer to provide the construction inspection of flexible pipe, if MSD inspection forces are not available for full-time inspection during pipe installation. The plan should include the inspector’s qualifications and procedures that will be followed to provide complete inspection of installation procedures. Note that supervision must be provided by a registered professional engineer.

MSD Review Comments: ____

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____

____

APPENDIX D
MINIMUM AND MAXIMUM BURIAL DEPTHS FOR FLEXIBLE PIPE

The attached table outlines minimum and maximum burial depths for the flexible pipe products that are currently approved for use on MSD projects. It was developed using the design procedures contained in the AASHTO Standard Specifications – Division I, Section 12 for aluminized steel pipe and Section 18 for thermoplastic pipe. It also considers a limiting deflection of 5 percent, using the Modified Iowa Method. This table should be used as a reference when standard conditions apply.

Standard conditions assume that the pipe is installed in a trench conforming with the details shown in Appendix F. Backfill is assumed to be 120 pounds per cubic foot. This corresponds to normal soil receiving moderate compaction, or sand which has been flushed and jetted. If the backfill is expected to contain significant quantities of rock fragments, then a higher unit weight should be used and project specific calculations should be performed when unusual (greater than AASHTO H-20) live loadings are expected or the loading does not represent a true negative projecting installation. This could occur in situations containing fill embankments.

MSD

Louisville and Jefferson County
Metropolitan Sewer District

EXHIBIT D-1
MINIMUM AND MAXIMUM BURIAL DEPTHS FOR FLEXIBLE PIPE

EFFECTIVE DATE: APRIL 1, 1995

MINIMUM AND MAXIMUM BURIAL DEPTHS FOR FLEXIBLE PIPE

Pipe Type	Applicable Standard	Diameter (inches)	Stiffness (psi)	Minimum / Maximum Burial Depth (feet)
ETI Ultra-Rib Pipe Ribbed PVC Sewer Pipe	ASTM D-794	8" through18"	60 PSI	1.0 / 25.0'
		21" through 30"	46 PSI	1.0 / 25.0'
Perma-Loc Corrugated PVC Sewer Pipe	ASTM F-794	18" - 36"	46 PSI	1.0 / 25.0'
Contech A 2000 PVC Sewer Pipe	ASTM F-949	4" - 18"	55 PSI	1.0 / 25.0'
Carlon Vylon H. C. Profile PVC Sewer Pipe	ASTM F-794	21" - 48"	46 PSI	1.0 / 25.0'
ADS - N12 HDPE Corrugated Pipe	AASHTO M252	4" - 8"	50 PSI	1.0 / 20.0'
	AASHTO M252	10"	50 PSI	1.0 / 17.0'
	AASHTO M294	12"	50 PSI	1.0 / 17.0'
	AASHTO M294	15"	42 PSI	1.0 / 17.0'
	AASHTO M294	18"	40 PSI	1.0 / 17.0'
	AASHTO M294	24"	34 PSI	1.0 / 17.0'
	AASHTO M294	30"	28 PSI	1.0 / 14.0'
	AASHTO M294	36"	22 PSI	1.0 / 12.0'
Hancor Hi-Q HDPE Corrugated Pipe	AASHTO M252	4" - 6"	50 PSI	1.0 / 23.0'
	AASHTO M252	8"	50 PSI	1.0 / 20.0'
	AASHTO M252	10" - 12"	50 PSI	1.0 / 16.0'
	AASHTO M294	15"	42 PSI	1.0 / 16.0'
	AASHTO M294	18"	40 PSI	1.0 / 16.0'
	AASHTO M294	24"	34 PSI	1.0 / 16.0'
	AASHTO M294	30"	28 PSI	1.0 / 15.0'
	AASHTO M294	36"	22 PSI	1.0 / 12.0'
Driscopipe Permacore HDPE Profile Pipe	ASTM F-894	18" through 48"	RSC 160	1.0 / 25.0'
Solid Wall PVC Pipe				
SDR 35	ASTM D-3034	4" through 27"	46 PSI	1.0 / 25.0'
SDR 26	ASTM D-2241	1-1/2" through 12"	115 PSI	1.0 / 25.0'
SDR 21	ASTM D-2241	1-1/2" through 12"	234 PSI	1.0 / 25.0'
CONTECH Aluminized Steel ULTRA-FLO	AASHTO M36	18" through 48"	16 gauge	1.0 / 25.0'
	AASHTO M36	54"	16 gauge	1.25 / 22.0'
	AASHTO M36	60"	16 gauge	1.25 / 20.0'
	AASHTO M36	18" through 48"	14 gauge	1.0 / 25.0'
	AASHTO M36	54" through 60"	14 gauge	1.25 / 25.0'
	AASHTO M36	66"	14 gauge	1.5 / 25.0'
	AASHTO M36	72"	14 gauge	1.5 / 24.0'
	AASHTO M36	78"	14 gauge	1.75 / 22.0'
	AASHTO M36	18" through 60"	12 gauge	1.0 / 25.0'
	AASHTO M36	66" through 72"	12 gauge	1.25 / 25.0'
	AASHTO M36	78"	12 gauge	1.5 / 25.0'
	AASHTO M36	84"	12 gauge	1.75 / 25.0'
	AASHTO M36	90" through 96"	12 gauge	2.0 / 25.0'
	AASHTO M36	102"	12 gauge	2.5/ 25.0'

NOTE: Based on H-20 loading, 100% pavement transference, AASHTO impact factors, prism load with soil unit weight of 120 pcf, and soil modulus of 1000 psi. Refer to installation details for trench width and installation specifications.

APPENDIX E
REQUIRED PIPE CLASS FOR
REINFORCED CONCRETE PIPE

The attached chart contains the required pipe class for reinforced concrete pipe. It was developed using the revised bedding factors outlined in ACPA publication Design Data 40. This chart should be used as a reference when standard conditions apply.

Standard conditions assume that the pipe is installed in a trench conforming with the details shown in Appendix F. Backfill is assumed to be 120 pounds per cubic foot. This corresponds to normal soil receiving moderate compaction, or sand which has been flushed and jetted. If the backfill is expected to contain significant quantities of rock fragments, then a higher unit weight should be used and project specific calculations should be performed. Furthermore, project specific calculations should be preformed when unusual (greater than AASHTO H-20) live loadings are expected or the loading does not represent a true negative projecting installation. This could occur in situations containing fill embankments.

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REQUIRED PIPE CLASS FOR CIRCULAR REINFORCED CONCRETE PIPE IN TRENCH INSTALLATION WITH #57 CRUSHED STONE PIPE CRADLE

Height of Cover (feet)

Pipe Inner Diameter (in)	0.5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
12	4	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4	4
15	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4	4
18	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4	4	4
21	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	4
24	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4
27	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4
30	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
33	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
36	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
39	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
42	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
48	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
54	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4
60	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4
66	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4
72	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
78	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
84	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
90	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
96	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4
102	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
108	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
114	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
120	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
126	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
132	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
138	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4
144	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4

Notes: (1) Based on H - 20 loading, 100% pavement transference, AASHTO impact factors, soil unit weight of 120 pcf with Marston Equation, maximum allowable MSD trench widths, and bedding factor = 2.4. Refer to installation details for trench width and installation specifications.

(2) For pipe sizes 12-inch through 24-inch diameter, non-reinforced concrete pipe meeting ASTM C14 Class III, can be used where reinforced concrete pipe Class III is allowed.

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Metropolitan Sewer District

EXHIBIT E-1
CIRCULAR RCP CLASS AND DEPTH CHART

EFFECTIVE DATE: JANUARY 1, 2001

APPENDIX F
TRENCH DETAILS

An evaluation of standard installation procedures and specifications which are referenced by pipe product manufacturers has resulted in revisions to MSD's trench details. Installation specifications which were reviewed in developing the revised details include manufacturer's specific recommended trench width and the following ASTM specifications.

1.) ASTM D 2321: Standard Practice for Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.

2.) ASTM A 798: Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications.

The revised details are illustrated in the following exhibits. In certain installations conformance with manufacturers recommended procedures will result in wider trench widths and more crushed stone encasement than MSD has previously required. This is especially the case for large diameter flexible pipes, and in situations where flexible pipe is used and poor soil conditions exist.

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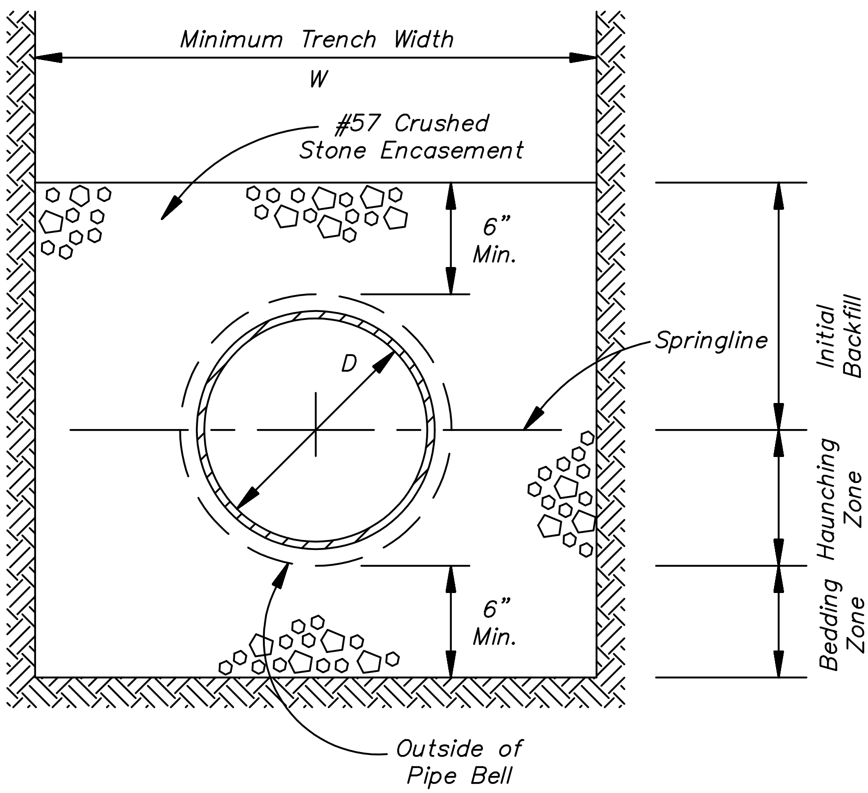
EXHIBIT F-1
CRUSHED STONE ENCASEMENT FOR THERMOPLASTIC PIPE 4" - 12" DIA.

EFFECTIVE DATE: JANUARY 1, 2001



Nominal Pipe Dia. (D)	W	
	Good Soil or Rock	Poor Soil*
4"	1'–9"	2'–0"
6"	1'–11"	3'–0"
8"	2'–1"	4'–0"
10"	2'–3"	5'–0"
12"	2'–6"	6'–0"

*See Note 6

NOTES

1. Place #57 crushed stone in 6" maximum layers and work in around pipe by hand within the haunching zone.

2. Provide bell holes in pipe bedding, no larger than necessary, to ensure uniform pipe support. Fill all voids under bell by hand with bedding material.

3. Check grade of the pipe after placement of crushed stone up to springline to insure the desired flow line alignment has not changed.

4. Any trench bracing used below the top of pipe shall be left in place.

5. For installations where significant groundwater flow is anticipated, such as if pumping methods are required to dewater the trench excavation below the water table, or if after construction, the permeable encasement will act as a "french drain" under high ground water levels, the entire perimeter of the crushed stone encasement shall be wrapped with an approved geotextile fabric to prevent the migration of fines and loss of pipe support.

6. For installations in poor native soils where in–situ lateral soil resistance is negligible, such as soft clay with unconfined compressive strengths less than 0.5 tsf or loose sands with standard penetration test N–values less than 10, the minimum trench width shall be expanded by increasing the distance between the side of the pipe and the line of actual excavation or trench bracing to a minimum of 2.5 pipe diameters (2.5 x D).

7. Deflection tests shall be performed as per MSD specifications.

8. For installations where the trench bottom consists of soft clay or very loose sands, undercut to a depth as required by the Engineer, and replace with a foundation of #57 crushed stone compacted in maximum six inch layers. Class "B" concrete shall be used to backfill the undercut zones in ditches and streams.

9. To prevent damage to the pipe and disturbance of the pipe encasement, provide a minimum depth of cover of 24" above the top of pipe before allowing vehicles or construction equipment to traffic the trench surface. Where construction loads may be excessive, the minimum cover shall be increased.

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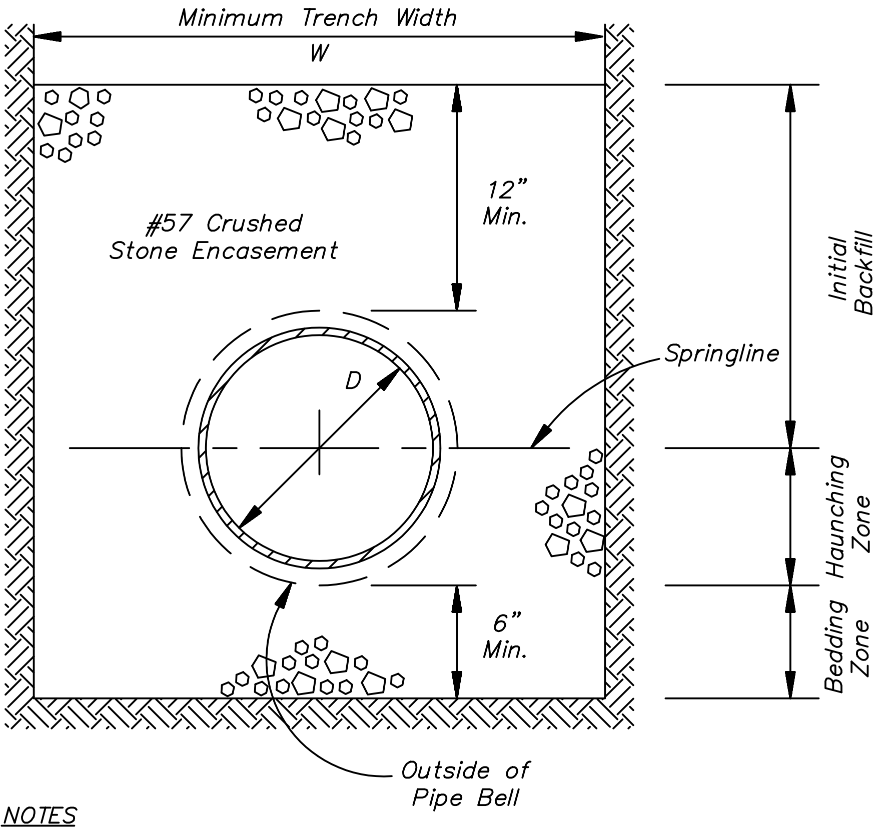
EXHIBIT F-2
CRUSHED STONE ENCASEMENT FOR THERMOPLASTIC PIPE 15" - 48" DIA.

EFFECTIVE DATE JANUARY 1, 2001



Nominal Pipe Dia. (D)	W	
	Good Soil or Rock	Poor Soil*
15"	2'–10"	6'–3"
18"	3'–3"	6'–6"
24"	4'–4"	7'–0"
30"	5'–6"	7'–6"
36"	6'–6"	9'–0"
42"	7'–11"	10'–6"
48"	8'–4"	12'–0"

*See Note 6

NOTES

1. Place #57 crushed stone in 6" maximum layers and work in around pipe by hand within the haunching zone.

2. Provide bell holes in pipe bedding, no larger than necessary to ensure uniform pipe support. Fill all voids under bell by hand with bedding material.

3. Check grade of the pipe after placement of crushed stone up to springline to insure the desired flow line alignment has not changed.

4. Any trench bracing used below the top of pipe shall be left in place.

5. For installations where significant groundwater flow is anticipated, such as if pumping methods are required to dewater the trench excavation below the water table, or if after construction, the permeable encasement will act as a "french drain" under high ground water levels, the entire perimeter of the crushed stone encasement shall be wrapped with an approved geotextile fabric to prevent the migration of fines and loss of pipe support.

6. For installations in poor native soils where in–situ lateral soil resistance is negligible, such as soft clay with unconfined compressive strengths less than 0.5 tsf or loose sands with standard penetration test N–values less than 10, the minimum trench width shall be expanded by increasing the the distance between the side of the pipe and the line of actual excavation or trench bracing to a minimum of 30" or one pipe diameter (D) whichever is greater.

7. Deflection tests shall be performed as per MSD specifications.

8. For installations where the trench bottom consists of soft clay or loose sands, undercut to a depth as required by the Engineer, and replace with a foundation of #57 crushed stone compacted in maximum six inch layers. Class "B" concrete shall be used to backfill the undercut zones in ditches and streams.

9. To prevent damage to the pipe and disturbance of the pipe encasement, provide a minimum depth of cover of 24" above the top of pipe before allowing vehicles or construction equipment to traffic the trench surface. Where construction loads may be excessive, the minimum cover shall be increased.

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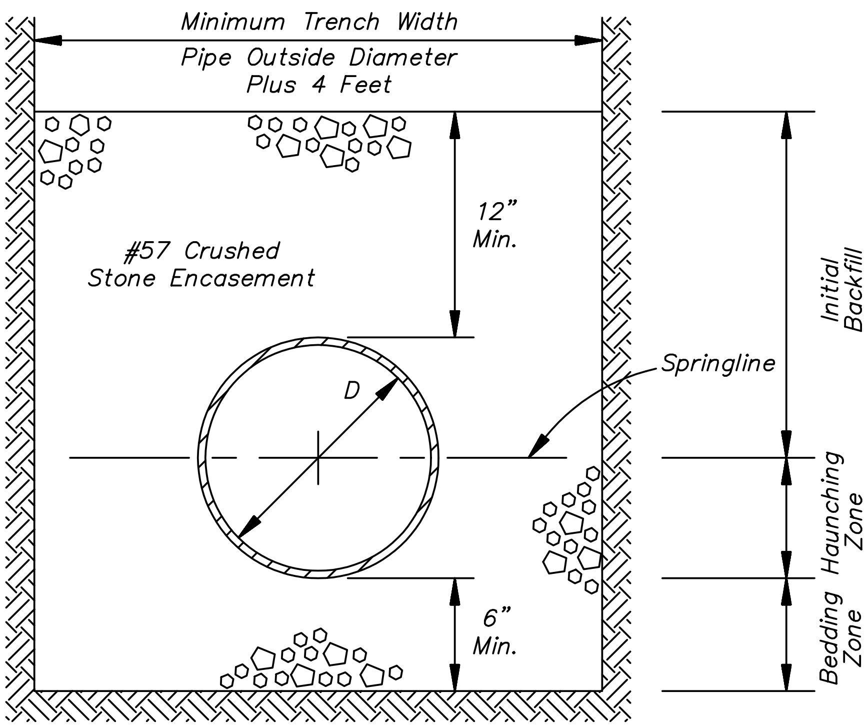
EXHIBIT F-3
CRUSHED STONE ENCASEMENT FOR CORRUGATED/SPIRAL RIB METAL PIPE

EFFECTIVE DATE: JANUARY 1, 2001



Nominal Pipe Dia. (D)	W	
	Good Soil or Rock	Poor Soil*
18"	3'–3"	6'–6"
21"	3'–10"	6'–9"
24"	4'–4"	7'–0"
30"	5'–6"	7'–6"
36"	6'–6"	9'–0"
Larger Than 42"	Pipe O.D. Plus 48"	

*See Note 6

NOTES

1. Place #57 crushed stone in 6" maximum layers and work in around pipe by hand within the haunching zone.

2. Check grade of the pipe after placement of crushed stone up to springline to insure the desired flow line alignment has not changed.

3. Any trench bracing used below the top of pipe shall be left in place.

4. For installations where significant groundwater flow is anticipated, such as if pumping methods are required to dewater, the trench excavation below the water table, or if after construction, the permeable encasement will act as a "french drain" under high ground water levels, the entire perimeter of the crushed stone encasement shall be wrapped with an approved geotextile fabric to prevent the migration of fines and loss of pipe support.

5. For installations in poor native soils where in–situ lateral soil resistance is negligible, such as soft clay with unconfined compressive strengths less than 0.5 tsf or loose sands with standard penetration test N–values less than 10, the minimum trench width shall be expanded by increasing the distance between the side of the pipe and the line of actual excavation or trench bracing to a minimum of 30" or one pipe diameter (D) whichever is greater.

6. Deflection tests shall be performed as per MSD specifications.

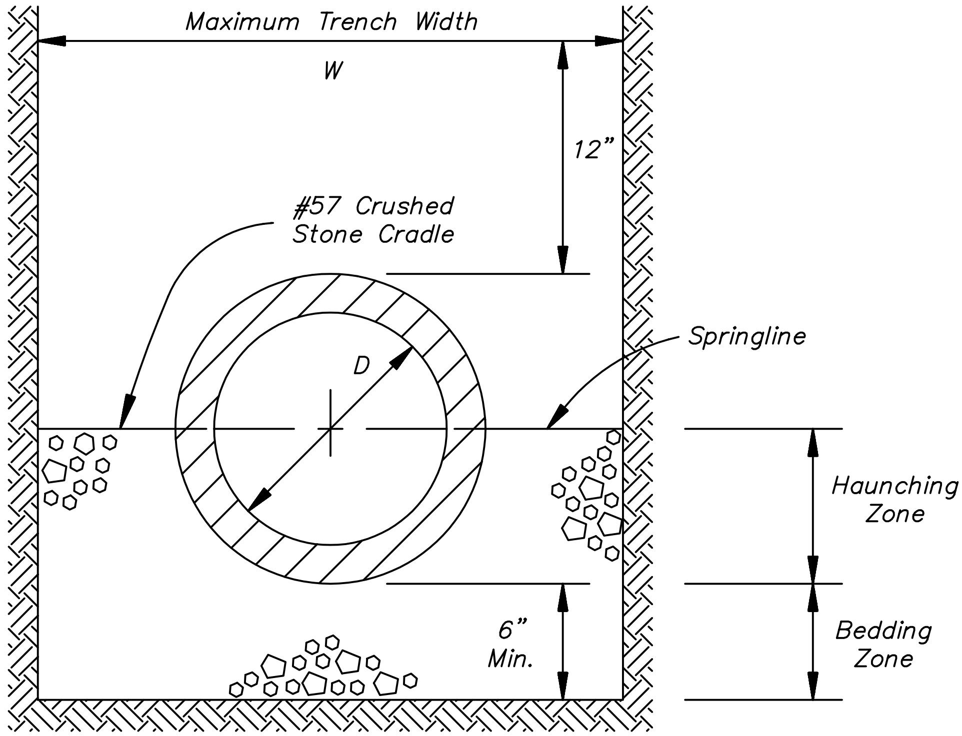
7. For installations where the trench bottom consists of soft clay or loose sands, undercut to a depth as required by the Engineer, and replace with a foundation of #57 crushed stone compacted in maximum six inch layers. Class "B" concrete shall be used to backfill the undercut zones in ditches and streams.

8. To prevent damage to the pipe and disturbance of the pipe encasement, provide a minimum depth of cover of 24" above the top of pipe before allowing vehicles or construction equipment to traffic the trench surface. Where construction loads may be excessive, the minimum cover shall be increased.

Louisville and Jefferson County
Metropolitan Sewer District

EXHIBIT F-4
CRUSHED STONE CRADLE FOR REINFORCED CONCRETE PIPE

EFFECTIVE DATE: JANUARY 1, 2001



NOTES

1. Place #57 crushed stone in 6" maximum layers and work under pipe by hand within the haunching zone.

2. Check grade of the pipe after placement of crushed stone up to springline to insure the desired flow line alignment has not changed.

3. Any trench bracing used below the top of pipe shall be left in place.

4. For installations where the trench bottom consists of soft clay or loose sands, undercut to a depth as required by the Engineer, and replace with a foundation of #57 crushed stone compacted in maximum six inch layers. Class "B" concrete shall be used to backfill the undercut zones in ditches and streams.

5. To prevent damage to the pipe and disturbance of the pipe encasement, provide a minimum depth of cover of 24" above the top of pipe before allowing vehicles or construction equipment to traffic the trench surface. Where construction loads may be excessive, the minimum cover shall be increased.

6. The maximum allowable trench width shall apply to a height of 12" above the outside top of the pipe.

Nominal Pipe Dia. (D)	W
12"	3'–5"
15"	3'–9"
18"	4'–1"
21"	4'–4"
24"	4'–8"
27"	5'–1"
30"	5'–5"
33"	5'–10"
36"	6'–2"
39"	6'–8"
42"	6'–11"
48"	7'–6"
Larger Than 48"	Pipe O.D. Plus 2'–8"

APPENDIX G

MSD CRITERIA FOR PRECAST STRUCTURES

Effective October 1, 1990

1. Any use of precast structures must be so noted on the plans, including a typical detail for each type of structure for the project.

2. Structures which require specially designed footings, cut-off walls, etc., will not be allowed as precast.

3. Openings in precast structures for pipes shall be the outside diameter of the pipe plus maximum of 6 inches. In order to use non-shrink grout, the opening shall be the outside diameter of pipe plus 3 inches. (Outside diameter of pipe plus 4 ½ inches is permissible when tapered hole forms are utilized.)

4. For precast structures (other than those with knockout panels), the opening around the pipe shall either be filled with non-shrink grout for the wall thickness of the structure or the pipe shall be encased with a minimum 6-inch collar of concrete from the inside face of the wall to 1'-0" outside the outer face of the wall. The pipe shall be adequately supported to prevent settling while the grout or the concrete encasement is setting up. The inside face of the structure walls shall be finished with a trowel and wet brush finish.

5. For circular structures, the following applies as to the maximum inside diameter (or horizontal dimension) of pipe to be used with a given size of manhole.

Diameter of Structure	Maximum Size of Pipe*
4'-0"	24 inches
5'-0"	36 inches
6'-0"	48 inches

*Outside diameter may be considered on a case-by-case basis for flexible pipe.

6. For circular structures, the minimum distance allowed between precast holes for the pipes shall be 12 inches.

7. For circular structures and rectangular structures (other than those with knockout panels), the minimum vertical distance from the holes for the pipes to the top of the structure wall shall be 4 inches. If this vertical distance is less than 12 inches, then additional reinforcing steel shall be furnished for this section. The top slab must be designed for HS-20 loading.

8. For precast structures with knockout panels, holes for the pipe shall <u>not</u> be cut into the structural members (i.e., top beams and corner columns) and non-shrink grout shall <u>not</u> be allowed to be placed around the pipes. The pipes shall be encased with concrete a minimum 6-inch collar around the outside of pipe or a minimum of 3 inches beyond the hole knocked in the wall, whichever is greater. Also, the concrete encasement shall extend from the inside face of the wall to 1'-0" outside the outer face of the wall.

9. Precast structures with knockout panels shall not be used with more than 2 feet of earth cover unless load calculations are supplied.

10. For rectangular structures where pipe will be installed in adjacent walls (other than those with knockout panels), at least 6 inches of wall (measured from the interior corner)is required on each side of the pipe beyond the precast opening for the pipe. This rule is not applicable for structures which have pipe installed in opposite walls or where one outlet pipe is utilized.

11. A wash is required in the bottom of catch basins to provide positive drainage (sloped toward outlet).

APPENDIX H

POLICY ON DESIGN OF STORMWATER CAPITAL PROJECTS
ADOPTED BY MSD BOARD JULY 11, 1994

Policy Statements

a. General

Flood reduction solution alternatives shall be evaluated primarily based upon relative cost. MSD shall implement the most cost-effective solution whenever feasible. In addition to standard and traditional alternatives, such as modifying or replacing downstream structures and improving stream conveyance, floodproofing of affected structures shall be routinely considered in evaluating solution alternatives. If acquisition and relocation of demolition of affected structures is identified as the most cost-effective solution alternative for a drainage problem, then the Board shall consider the specific situation and decide on the alternative to be used.

Solution alternatives should be evaluated secondarily on the opportunity to use Best Management Practice (BMPs) to improve water quality and maintain natural habitat. Of alternatives with similar estimated costs, the alternative with the highest potential to improve water quality and maintain habitat shall be chosen.

b. Priorities for Project Evaluation

Projects should address drainage requests in the following order of priority:

1. Eliminate or reduce flowing with risk of personal injury.
2. Eliminate first floor flooding.
3. Eliminate or reduce basement flooding.
4. Provide an outlet for drainage from a critical upstream project or area.
5. Eliminate or reduce flooding which interferes with transportation of priority access roads to neighborhoods.
6. Control erosion in situations where structures or property are being damaged or erosion is occurring outside of defined easements.
7. Eliminate long-term standing water of “yard flooding” which occurs outside a defined easement.
8. Control erosion within a defined easement.
9. Eliminate long-term standing water due to the lack of an outlet within an easement.

The final solution to the problems within a project area should address as many as possible of the above-listed items that exist, while remaining cost-effective.

c. Definition of Project Scope

Improvement projects fall into the three categories, depending upon the numbers and locations of affected buildings and residents and the scope of construction effort required: mini-project, neighborhood project, and regional project.

Mini-projects shall meet the following criteria. If one or more of the listed criteria are not met, the project is beyond the scope of a mini-project and is either a neighborhood or regional project.

1. Project addresses a problem located within a single defined subdivision or group of structures.

2. Project does not involve construction of, or improvement to, a regional detention facility.

3. Project does not involve improvement of conveyance within a defined blueline stream.

Neighborhood projects shall meet the following criteria. If one or both of the listed criteria are not met, the project is beyond the scope of a neighborhood project and is a regional project.

1. Project addresses a problem located in one or more subdivisions or groups of structures in a centralized area.

2. Project does not involve construction of a regional detention facility.

Regional projects shall meet the following criteria:

1. Project addresses problems of multiple subdivision, developments, or groups of structures; at least some of the problems are independent and could be solved by separate neighborhood projects.

2. Project influences extend downstream and upstream in the watershed, beyond the typical reach of a neighborhood project.

3. Project involves construction or modification of a regional detention facility or improvement to conveyance of a blueline stream.

d. Design Criteria and Guidelines

Specific design criteria for drainage projects are found in this Design Manual. General guidance for all drainage design and particular guidance of various project categories follows.

For all projects, the guidelines of the Stream Corridors/Greenways Multi-Objective Plan shall be followed. The disturbance of natural stream corridors should be minimized, the preservation of natural streams and habitat should be emphasized, and the use of the piped systems and lined channels should be discouraged. In addition, designs should incorporate BMP's for water quality control.

Structural improvements, such as downstream culvert replacements or upstream detention ponds, shall be designed to mitigate existing flooding problems and provide one foot of freeboard for the 100-year event. If improvements require phasing of funding and/or construction, phasing should be done beginning from the downstream improvements and proceeding upstream. An exception to this general phasing rule is a detention facility, which should be constructed in the early phases of overall project construction. All projects shall be constructed in conformance with the Soil Erosion and Sediment Control Ordinance.

Mini-projects will be designed to establish adequate conveyance capacity of improve the conveyance capacity of the existing drainage system to control frequent storm events. Drainage systems shall be designed so that no flooding of habitable structures occurs during a 100-year event. Neighborhood projects shall be designed similarly so that drainage systems do not allow flooding of habitable structures for the 100-year event. Regional projects shall be designed to reduce or eliminate flooding of habitable structures and property. Regional facilities should also be evaluated for their impacts on base flow, since maintenance of adequate base flow in receiving waters is essential to watershed-wide water quantity and quality management.

e. Non-structural Solution Alternative Design Criteria

e.1. Floodproofing

Floodproofing is the term for procedure which eliminate or reduce flood damage by protecting or modifying buildings instead of preventing flood waters from reaching them. Dry floodproofing seals the exterior of the home and protects the interior. Wet floodproofing involves designing or retrofitting a building's electrical systems, utilities, and valuable items so that they are located above the predicted flood stage and allowing flood water to pass into or through the structure. Both types of floodproofing shall be routinely considered among possible alternatives for solving drainage and flooding problems. If floodproofing alone, or in combination with other measures, provides the lease expensive solution to a problem, it should be utilized.

Floodproofing has limitations; it protects to a specific elevation and does not guarantee a structure will not be damaged by flood waters. Floods exceeding the design event could still damage the structure. Also, some means of floodproofing requires human intervention (e.g., blocking openings and entryways). Education of the owners or residents of floodproofed structures, in terms of their responsibilities and expectations, is essential to the success of floodproofing operations.

Floodproofing designs shall be based upon the 100-year storm event and provide one foot of freeboard. Designs should conform to the guidelines listed in the Kentucky Flood Protection Manual and/or the appropriate Federal Emergency Management Agency (FEMA) Publication.

FEMA 15 – Design Guidelines for Flood Damage Reduction
FEMA 54 – Elevated Residential Structures
FEMA 85 – Manufactured Home Installation in Flood Hazard Areas
FEMA 102 – Floodproofing Non-residential Structures
FEMA 114 – Retrofitting Flood-prone Residential Structures

e.2 Acquisition and Relocation

The cost of acquiring flood-prone properties for relocation or demolition as a solution alternative for flooding problems shall be determined routinely and compared to the costs of other alternatives. For such a property, the total acquisition cost will include the following component costs: for demolition candidates, buying the property, razing the building, disposing of waste materials, and restoring the site; for relocation candidates, buying the old property, buying and preparing the new site, moving and installing the building on the new site, and restoring the old site.

In a case where acquisition appears to be the lowest cost alternative, the MSD Board will receive a summary of alternatives, costs, and supporting arguments. The Board will then decide whether to select acquisition of another alternative to address the specific case. For any property from which a flood-prone building is moved or demolished, redevelopment shall meet the criteria of the floodplain management ordinance.

f. Conformance with Watershed Master Plans

Projects shall be designed and constructed in a manner consistent with the Watershed Master Plan for the area. If a project is proposed that does not conform to the Watershed Master Plan, the impact of the project on the entire drainage basin shall be evaluated prior to final design and construction. The completed project shall be represented in future updates of the Watershed Master Plan model.

g. Public Involvement

g.1. Public Meetings

Public involvement shall be mandatory for all drainage projects. Complaint files and resident interviews shall be the basis for assessing the need for a project and developing its scope. Public meetings will be held for at least three stages of each project: pre-design, presentation of alternatives, and pre-construction. Additional public meetings may be scheduled as needed to inform residents further and to build support for a project.

g.2. Consensus Building

Through the public involvement process, MSD will describe the goals, approach, and anticipated benefits of a proposed project to the affected parties and will evaluate their level of support. A strong majority of affected individuals must support a project for it to proceed. If support is weak, there will be not project. If support is moderate, MSD will approach the local elected official to explain the need for strong support and to enlist the official's help in increasing the local approval. If a strong majority support the project, it will go forward, utilizing condemnation if necessary to assure the project's progress.

h. Easements

Residents who will benefit from a project are expected to provide easements needed for the project at no cost to the project. Residents whose property is affected but not benefited by a project may be asked to donate easements. Easement acquisition must be timely; attempts to obtain easements at no cost must not slow a project's schedule. If a project has strong consensus support and benefits but necessary easements cannot be obtained rapidly, MSD will pursue condemnation after obtaining specific Board approval.

i. Project Funding

In general, MSD will fund the assessment of problems related to public drainage facilities and the design and construction of projects to solve the problems. Projects which provide greater benefits should receive higher priority in the process of scheduling work. During project planning, issues outside MSD's responsibility may be added into a project if the requesting owner or owners are willing to fund the difference in project costs.

Flooding due to existing, approved development shall be addressed by MSD. Alternative solutions shall be evaluated and presented to the affected parties. MSD will fund the most cost-effective feasible solution. If the parties involved prefer an alternative solution and are willing to fund the difference in cost, MSD may consider implementing the alternative.

Flooding resulting from the unapproved actions or development by a citizen, group or company shall be mitigated by that individual. Solution alternatives developed by the responsible party will be subject to review and comment by MSD and the public.

Inter-agency projects for infrastructure improvement are encouraged. MSD will coordinate with other government agencies to review planned projects in areas for which mini-projects are planned. Lead agency approaches, with a single contractor performing all proposed improvements, are encouraged. Costs of the drainage improvements will be prorated to the costs of the other improvements.