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DESIGN MANUAL

SANITARY SEWER

BALTIMORE COUNTY
DEPARTMENT OF PUBLIC WORKS DESIGN MANUAL

WASTEWATER COLLECTION AND PUMPING

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Baltimore County Department of Public Works
Design Manual

WASTEWATER COLLECTION AND PUMPING

I. GENERAL

A. Purpose and Scope

This document contains the minimum design criteria, information and guidance to properly design the components of the Baltimore County sanitary sewer system. This information outlines the approach, requirements, considerations and hydraulic calculations used in the design of the components of the gravity sewers and pumping stations. The Baltimore County Department of Public Works has the complete authority for the design, construction, operation, and maintenance of the public sewer collection system within its political boundaries.

B. Applicability

While the requirements described for the various components of sewer design will include and cover the majority of the conditions encountered, there is no intention to relieve the Engineer of responsibility to recognize when conditions are not favorable for the application of standards. In the preparation of the contract documents, the Engineer shall take into account such matters as constructability, system maintenance, and environmental impacts. The Engineer shall be continually alert to conditions that cannot be satisfied by the application of the standard criteria.

C. References

All construction plans and specifications for the extension or rehabilitation of the sanitary sewer system within the State of Maryland are subject to the guidelines contained in the latest edition of the *Maryland Department of the Environment's Design Guidelines for Sewerage Facilities*. It is the responsibility of the Engineer to refer to this document.

D. Glossary

The following abbreviations and definitions are beneficial in the reading and understanding of this design section.

Abbreviations

ACI	American Concrete Institute
ACP	Asbestos Cement Pipe
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials

BGE	Baltimore Gas and Electric Company
CAD	Computer-aided Drafting
CIP	Cast Iron Pipe
COMAR	Code of Maryland Regulations
DIP	Ductile Iron Pipe
GIS	Geographic Information System
GPAD	Gallons Per Acre Per Day
GPCD	Gallons Per Capita Per Day
GPM	Gallons Per Minute
HDD	Horizontal Directional Drilling
HDPE	High Density Polyethylene
HS-20, H-20	Truck Loading Designations
LPSS	Low Pressure Sewer System
MCC	Motor Control Center
MDE	Maryland Department of the Environment
MGD	Million Gallons Per Day
MOSH	Maryland Occupational Safety and Health
NSF	National Sanitation Foundation
NPSHR	Net Positive Suction Head Required
OSHA	Occupational Safety and Health Administration
PCCP	Prestressed Concrete Cylinder Pipe
PLC	Programmable Logic Controller
PRV	Pressure Reducing Valve
PSI	Pounds Per Square Inch
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
SCADA	Supervisory Control and Data Acquisition
SDR	Standard Dimension Ratio
SHA	State Highway Administration
SHC	Sewer House Connection
USGS	United States Geological Survey
VCP	Vitrified Clay Pipe
VFD	Variable Frequency Drive
WWTP	Waste Water Treatment Plant

Definitions

Engineer: A professional engineer, registered in the State of Maryland, who is responsible for the design of the project.

E. Design Objectives

The objective of these design standards is to provide a sanitary sewer system that safely collects and transports wastewater without harm to human health or environment; requires a minimal amount of maintenance; provides reliable service; and is cost effective.

F. Special Wastes

The Baltimore County sanitary sewer system is designed to collect and transport domestic wastewater. Any waste that differs in physical, biological, or chemical composition from normal domestic wastewater will not be allowed to be discharged into the sanitary sewer without written approval from the Department of Public Works, Bureau of Utilities, Engineering and Regulation Division.

G. Limitations

It is not possible to include in these guidelines all features of design that are necessary to accomplish the development of construction documents for all projects. The topics addressed are limited to those that will help the Engineer perform most tasks in an efficient manner while complying with County practice.

H. Alternative to Gravity Systems

It is the policy of the Department of Public Works to promote the use of gravity sewer systems to the extent possible due to the reliability and low maintenance associated with gravity sewer systems. All proposals to use grinder pumps/low pressure sewer systems shall be approved by the Director of Public Works in accordance with approved policies.

II. PRELIMINARY DESIGN CONSIDERATIONS

A. Existing Conditions

An important initial step in the design process is to obtain all existing maps, drawings, surveys, boring logs, and other data containing pertinent information on existing conditions in the area being served. Possible sources of such information include the following:

- Baltimore County Department of Public Works
- Local, State, and Federal Agencies, such as: Soil Conservation Service and USGS
- Public Utilities
- Commercial Businesses and Private Companies
- Planning Board

B. Field Investigations

1. Field Surveys*:* Field surveys shall be performed. Depending on the magnitude and complexity of the project, subsurface information, such as soil borings, may be required. Topographic information shall show locations of all streets, buildings, pavements, sidewalks, vegetation, drainage channels, and other land surface features, such as utility manholes or structures, which may influence the design and layout of the collection or conveyance system. Information on existing utilities shall include the location of underground water lines, sanitary sewers, storm drains, gas mains, electric conduit, and similar facilities.

    a. Items to Include in Topographic Surveys:
        1) All buildings and other structures, within and immediately adjacent to the project limits, together with all improvements including wells, springs, septic tanks, drain fields, dry wells, etc.
        2) Property and right-of-way lines (proposed and existing) including right-of-way widths and identifying road names.
        3) Property information:
            - owner name(s)
            - deed and recording references including parcel number, lot number, subdivision name and record plat reference(s)
            - property pipes, monuments or markers
            - street address
        4) Roadway pavements, curb lines, driveway entrances, walkways, fences, walls, etc., including types of materials, widths, heights, and all other descriptive data.
        5) Guardrails, sign posts, retaining walls, traffic lights, and other features related to the roadway safety.
        6) Horizontal and vertical location of existing utilities, including but not limited to, water mains, valves, cap and blow-offs, vaults, fire

hydrants, water meters, cub stops, sewer mains, manholes, cleanouts, storm drains, storm drain inlets, culverts, gas mains, utility poles, telecommunication utilities, and other located utilities. These utilities shall include those that are overhead, surface and subsurface.

7) Trees:
   - Trees, 12-inches in diameter and larger within proposed rights-of-way, shall be individually located and identified by type.
   - For existing developed properties, all trees, regardless of size, shall be located and identified by size and type that exist on the landscaped area of the property including hedges, shrubs, flower beds, gardens, planting boxes, etc.
   - For trees whose foliage overhangs the right-of-way or construction strip, the extent and diameter of the foliage (fall line) shall also be shown.
   - The tree line shall be located, and general characteristics of the wooden area shall be given including approximate average size of the trees, density, and general type of trees represented.
8) Water courses, such as streams, springs, swales and ditch areas shall be shown and located including edge of water and bottom of stream/ditch elevations at the deepest section.
9) Vehicular access routes for off-road or undeveloped areas shall be identified for use during construction.
10) Mail boxes.
11) Curb cuts.
12) Railroad tracks, bridges and ballast.
13) In addition to the above items, the following shall also be shown in conjunction with the topography:
   - 100-year floodplain
   - Natural Resources District Boundary
   - wetlands
   - 25-foot wetland buffer
   - traverse points and references (capital projects)
   - existing and proposed drainage and utility easements
   - Chesapeake Bay Critical Area Boundary
14) Identify and reference construction drawing numbers of all existing and proposed water and sewer utilities within and adjacent to the project limits.
15) On projects requiring permanent structures (i.e., pumping stations, water booster stations, etc.), the extent of the area shown outside of the anticipated property or right-of-way shall be determined by the Engineer on a case-by-case basis but shall not be less than 100 feet.
16) In new developments, where the terrain is being transformed, most of the information shall be obtained directly from approved plans prepared to satisfy proposed improvements including curbs, storm drains, street rights of-way and lots, as taken from the record plat and

construction plans and shall show all existing features that are to remain undisturbed.

b. Method of Locating Topography:
   1) The method of locating topography shall be by field surveys utilizing the radial survey method, the GPS Real-Time Kinematic (RTK) method or the cross-section method.
   2) Aerial photogrammetry may not be used for the preparation of construction plans. The Baltimore County topographic information shown on the County geographical information system (GIS) shall not be utilized as topography for contract drawings.
   3) Surveys may not be performed while snow cover is present on the ground.

c. Existing and Proposed Contour Lines:
   For capital projects, existing and proposed contour lines shall be shown on the plans. Sufficient information shall be obtained in order to allow the contours to be shown at 2-foot intervals or less. In areas of steep slopes (greater than 20%), contours may be shown at 5-foot intervals with the approval of the Sewer Design Section. For developer projects, contours do not need to be shown within the proposed road right-of-way; however, the above requirements for capital projects apply to all other areas.

2. Survey Controls:

   a. All surveys shall be in accordance with *The Maryland Standards of Practice for Professional Land Surveyors and Property Line Surveyors,* as adopted March 3, 1995 and as amended.

   b. Control points shall be referenced to the Maryland Coordinate System (NAD83/1991) horizontally and based on the County's survey control system. All other control points, whether National Geodetic Survey or State Highway Administration, shall be permitted as long as they are in the National Geodetic Survey database and are either first or second order points. All control loops to sites shall have a minimum closure of 1:15,000. For capital projects, all control points shall be referenced in the field to three (3) fixed objects that will not be disturbed during the construction of the project. These objects shall be well identifiable points (such as a tack in a 36" *oak* tree in lieu of a 36" tree). Also, it is desirable that these reference points be within 100 feet of the control station where possible. All control points, with their corresponding coordinate values, shall be shown upon the plan sheets in their relative position to the project by scale. Values may be shown at the corresponding location of the point or in tabular form

   c. Vertical control shall be referred to the National Geodetic Vertical Datum of 1988 (NGVD '88) with local reference to the County's survey control

system or other designated bench marks available in the National Geodetic Survey database. A closed level loop shall be used to establish benchmarks on the site using a minimum of two known benchmarks to verify the elevations clearly shown and referenced in detail on the plans. For capital projects, a minimum of two (2) benchmarks shall be shown on each plan sheet. As the vertical datum has changed over the years, the Engineer shall not use elevations from as-built plans without field verification.

d. Survey baselines shall be extended for the full length of the project and a minimum of 200-linear feet beyond anticipated limits of work. Station equalities shall be shown for all common intersecting control points. Bearings and distances between control points shall be shown. Coordinates of all control points shall be either shown at the control point in a neat manner or in tabulation form on each plan sheet for which the control points occur.

3. Soil Conditions: For larger projects, the character of the soil in which sewers or pumping stations will be constructed should be determined. The presence of rock, unfavorable soil conditions, or high groundwater table should be clearly established. The soil bearing capacity should be determined as needed for designing footings. Soil tests used to determine the need for corrosion control include earth resistivity, ph, oxidation-reduction potential, and relative moisture content and shall be completed if required.

4. Corrosion: If metal pipe, structures, or appurtenances are to be buried, the need for corrosion control must be assessed. The need for corrosion control should be based on data obtained from corrosion surveys, operating records, visual observations, inspections, and tests of existing facilities in the area and from manufacturers recommendations.

5. Construction Survey:

   a. General: The County shall provide the necessary stakeout controls on the plans for setting the alignment, both horizontally and vertically, to construct the proposed public utility. The Developer shall provide the necessary stakeout controls on the plans for setting the alignment, both horizontally and vertically, to construct the proposed private utility.

   b. Sewer Mains: Dimensioning shall be shown for gravity sewers by providing a table listing the manholes with their respective numbers and coordinate values. Dimensioning shall be shown for sewer force mains and appurtenances in the same manner as for water mains.

C. Layout

1. Service Area: The requirement that an area be served by a gravity collection, conveyance system, or a pumping system will, in most cases, be determined by topography. Building and grade elevations shall be evaluated for gravity drainage to an existing or proposed sewer collection system. In addition to topographic considerations, natural boundaries (like waterways, rivers, streams, etc.), and property lines of Federal, State, and local property also play a role in determining the size and limits of service areas.

2. Sewer System: The development of final sewer plans must await a final site plan, the completion of field surveys, and, to some extent, the establishment of floor grades. However, the development of economical site plans often requires concurrent preliminary planning of the sewer system. The location of building and lateral sewers will depend not only upon topography, but also upon the type and layout of the buildings to be served. Main, trunk, and interceptor sewers will follow the most feasible route to the point of discharge. The following general criteria will be used where possible to provide a layout that is practical, economical, and meets hydraulic requirements:

    - follow slopes of natural topography for gravity sewers
    - check existing maps or field surveys along prospective sewer routes to assure that adequate slopes are available
    - avoid routing sewers through heavily wooded areas and areas which require extensive restoration after construction and which limit access for future maintenance
    - check subsurface investigations for groundwater levels and types of subsoil encountered; if possible, avoid areas of high groundwater and the placement of sewers below the groundwater table
    - locate manholes at changes in direction, size, or slope of gravity sewers
    - sewer sections between manholes should be straight; the use of curved sewer alignments are not recommended
    - manholes should be located at intersections of streets when possible
    - avoid placing manholes adjacent to watercourses and in locations where the tops will be submerged or subject to surface water inflow
    - designer shall evaluate alternative sewer routes where applicable
    - verify that final routing selected is the most cost effective alternative that meets service requirements

3. Geographic Information System: Information on existing utilities may be available on the County's GIS system; and the new design and the as-built drawings must be incorporated into the GIS system. A CAD/GIS standard has been adopted and shall be used for all designs.

D. Summary of Procedure

1. The person desiring to provide sewer facilities shall engage the services of a Registered Professional Engineer in the State of Maryland skilled in designing sewer facilities.

2. The Engineer should evaluate the situation and shall prepare a preliminary report and design. The design shall conform to the standards herein.

3. The Engineer shall hold a preliminary engineering conference with representatives of the Bureau of Engineering and Construction to insure that the proposed design will conform to the requirements of the Bureau.

4. Based upon the results of the conference, the Engineer may proceed to the preparation of a final report, plans, and specifications.

E. Preliminary Engineering Conference

1. When Conference is Necessary: A preliminary conference with the Engineer will, in general, be required for the more important projects. A conference will not be required in cases of minor extensions to existing sewer systems or where prior provision has been made for such extension when conditions have not materially changed since such approval. The County will decide when a preliminary engineering conference or preliminary report will or will not be required. It is important that proper consideration of comprehensive planning be given to a project early in the development stages. The aspects of a project should be discussed with the County to assure that all Department planning requirements will be met.

2. Project Proposal: At the preliminary engineering conference, the Engineer is expected to set forth the sewerage problem and the proposed solution in such a manner as to support the recommendations made and the conclusions reached.

3. Plans: Location maps, layout sketches, and other illustrative material shall be presented. A summary of the major topics for discussion is given below:
    - locations, origin, and purpose and scope of the project
    - existing project conditions
    - County population projections
    - design analysis, including all design criteria employed
    - design computations
    - function, layout and siting requirements of the proposed facilities
    - evaluation of alternatives (feasibility, construction restraints, project costs, environmental constraints, non-economic factors, ease of operation and maintenance and maintenance costs)

- cost estimates and comparison of alternatives, including rights-of-way requirements
- if required, present worth cost determination and comparison based on engineering economics methods
- required permits and approvals of other agencies
- conclusions and recommendations
- schedule for implementation
- project illustrations
- additional subject matter, as required by DPW, whenever the specifics of each project dictates

A more detailed list of important design criteria is given in other chapters of this document. A review of the criteria outlined in this document as they relate to the particular project will be done. It is understood that at the time of this preliminary engineering conference, many of the criteria may not have been determined for a particular project.

4. Scope of Conference: Subjects appropriate to the project should be covered in the conference.

5. Preliminary Report: Copies of sketches, computations, and other written notes referred to by the Engineer at a preliminary conference shall be provided to the County. Supplementing the conference in cases of larger and more complicated works, the County may require submission of a written preliminary report detailing the agreement reached or elaborating on any of the subjects or design criteria discussed.

6. Scope of Advice From the County: Advice provided by the County is advisory only and does not constitute final approval by DPW. Favorable consideration of design data submitted at a preliminary engineering conference or in a preliminary report in no manner waives the legal requirement for the submission of final plans and an Engineer's report. DPW reserves the right to require modifications to the plans that do not conform to good engineering practice.

F. Designer's Report

The purpose of the report is to record for permanent reference the controlling assumptions made and factors used in the functional design of the sewerage works. Two copies of the report shall be submitted.

G. Drainage and Utility Easements

1. Legal Depictions:

a. New Subdivisions: Sewer mains within new subdivisions are typically located within the proposed County road right-of-way within the subdivision. When sewer mains within new subdivisions must be extended outside of the proposed County road right-of-way, the utility shall be placed within a drainage and utility easement. These easement areas shall be shown on the record plat for the proposed subdivision. The Bureau of Development Plans Review in the Department of Permits and Development Management will review and approve the proposed record plat after the contract drawings have been approved. The record plat shall meet the requirements of the Department of Permits and Development Management. Record plats shall be prepared on mylar.

b. SHA Road Right-of-Way: Longitudinal alignments and perpendicular crossings within the State Highway Administration road right-of-way are discussed in Chapter V.

c. Existing Subdivision: Sewer mains traversing property within the area of an existing recorded record plat which require new easements or modification of existing easements will require a revised record plat. The Bureau of Engineering & Construction will not approve sewer contract drawings until the revised record plat has been recorded and a copy is submitted to the Sewer Design Section. Temporary construction easements shall not be shown on a revised record plat but, instead, shall require the preparation of a standard drainage and utility easement plat. Revised record plats shall be prepared on mylar.

d. Private Property: Sewer mains traversing private property that is not recorded by record plat nor within any road right of way shall be placed within drainage and utility easements. Information depicting the exact location of the easement shall be presented on an 8½" x 14" standard drainage and utility easement plat or mylar. A written deed of easement shall accompany the plat for submission to the Bureau of Engineering & Construction for review and comment prior to the property owner signing the easement documents. For developers' projects, a deed of easement shall be prepared by an attorney. For a developer's project, once the plat and deed have been reviewed and approved, they will be returned to the developer's engineer for acquiring the necessary signatures. It will be the developer's responsibility to obtain the necessary signatures on the easement documents and to record them. Construction drawings for developer projects will not be approved until all necessary easement documents have been recorded and copies have been submitted to the Bureau of Engineering & Construction. For capital projects, once the drainage utility easement plat has been reviewed and approved, the Bureau of Land Acquisition will prepare the deed of easement and will be responsible for obtaining the necessary signatures and subsequent recordation.

In all cases, the deed of easement shall state the grantor as the property owner and the grantee as Baltimore County, Maryland.

Standard drainage and utility easement plats shall be prepared in accordance with the Bureau of Land Acquisition standards and will be subject to the review and approval of the Bureau of Land Acquisition.

2. Purpose: The legal depiction of drainage and utility easements and the documents associated with them provide permission for the construction, reconstruction, maintenance, repair and ownership of the proposed utility within the area designated on the plat. The property owner retains ownership of the land in all cases; however, the placement of landscaping and permanent structures within the easement areas is restricted.

3. Location:

   a. The location of drainage and utility easements shall be determined, in general, by the location and depth of the sewer main to be placed within the easement. Before establishing the location of the easement and associated sewer, the Engineer shall consider the property owner's interests in positioning the easement within the property. Easements which split or angle across the property's building envelope shall be avoided. Easement locations shall be fixed by surveys.

   b. Drainage and utility easements may not be located within landscape buffer areas, forest retention areas, forest mitigation areas, stormwater management areas including, but not limited to, stormwater management ponds, water quality traps, water quality swales, rain gardens, recharge areas, embankments, riprap areas, spillway, outfall channel or fenced-in areas, or ingress/egress easements unless prior approval is obtained by the Bureau of Engineering & Construction.

4. Width: The width of drainage and utility easements shall be large enough to ensure that they are adequate to construct, access, repair and/or replace the sewer. The topography of the sewer alignment, anticipated soil conditions, and required excavation depths shall be taken into consideration when easements are required. Additionally, other considerations include size of equipment and material required for the excavation and repair of the sewer. Consideration also shall be given to the requirement of future pipeline installations within the same easement.

   The following minimum easement widths shall be provided:

   a. Sanitary sewers and force mains shall be centered within a minimum twenty-foot (20') wide easement. For any larger pipe sizes and special

circumstances (such as depth nearing 20'), the width shall be determined on a case-by-case basis by the Bureau of Engineering & Construction. Sewers located adjacent and parallel to lot lines shall be centered within a thirty-foot (30') wide easement.

b. For longitudinal alignments along, but outside of, the SHA and County road rights-of-way, generally the centerline of sewers shall be no less than five feet (5') from the edge of a road right-of-way. The easement boundary line opposite of the road right-of-way shall be no less than ten feet (10') from the utility centerline. In all cases, the easement shall extend to the edge of the right-of-way for access.

c. Centerline of sewers shall be no closer than fifteen feet (15') from the edge of easements that are within the building envelope.

d. For utilities over ten feet (10') in depth, the easement width shall be equal to twice the depth of the sewer with the sewer centered within the easement.

5. Access: Adequate access shall be provided to the easement for both construction and maintenance purposes. In determining adequate access, the Engineer shall evaluate the contractor's and the County's abilities to deliver the required materials and equipment to every location along the pipeline alignment without traversing through private properties. The maximum distance between access points shall be 1,500 feet unless otherwise directed by the Bureau of Engineering & Construction. In selecting points of access, the Engineer shall avoid environmentally sensitive areas such as: wetlands, slopes over 10%, and heavily wooded areas. Access shall be provided by means of a drainage and utility easement no less than twenty feet (20') wide. For developer projects, if the contractor requires access through private property during construction, the developer shall be required to obtain – in writing – all rights of entry for temporary access.

III. ENGINEERING REPORTS AND FACILITY PLANS

A. General

The Engineering Report or Facility Plan

- identifies and evaluates wastewater related problems
- assembles basic information
- presents criteria and assumptions
- examines alternate projects with preliminary layouts and cost estimates
- describes financing methods
- sets forth anticipated charges for users
- offers a conclusion with a proposed project for consideration
- outlines official actions and procedures to implement the project

The planning document must include sufficient detail to demonstrate that the proposed project meets the applicable criteria.

The concept, factual data, and controlling assumptions and considerations for the functional planning of facilities are presented. These data form the continuing technical basis for the detailed design and preparation of construction plans and specifications.

Sketches may be provided to aid in presentation of a project. Outline specifications of special materials or equipment are occasionally included.

Engineering Reports must be completed for collection system, pump station, and interceptor projects. Comprehensive Facility Plans must be completed or have been completed for projects involving new, expanded, upgraded, or rehabilitated wastewater treatment facilities and major collection, interceptor, and pump station projects. The determination of classification as major or minor collection, interceptor, and pump station projects will be made by DPW.

B. Engineering Reports

Engineering Reports for minor sewer extension and pumping stations shall contain the following and other pertinent information as required by DPW:

1. Problem Definition: The description of the existing system should include an evaluation of the conditions and problems requiring correction.

2. Design Flow: The anticipated design average and design peak flows for the existing and ultimate conditions must be established. The basis of the projection of initial and future flows must be included, and must reflect, the existing or initial service area and the anticipated future service area. Flow data needed for design of new facilities is included in Chapter V.

3. Impact on Existing Wastewater Facilities: The impact of the proposed project on all existing wastewater facilities, including gravity sewers, left stations, and treatment facilities must be evaluated.

4. Project Description: A written description of the project is required.

5. Drawings: Drawings identifying the site of the project and anticipated location and alignment of all the proposed facilities are required.

6. Engineering Criteria: Engineering criteria to be used in design of the project shall be included.

7. Site Information: Project site information should include topography, soils, geologic conditions, depth to bedrock, groundwater level, floodplain considerations, and other pertinent site information.

8. Alternative Selection: The reasons for selection of the proposed alternative, including any lift station sites, feasibility, and how the project fits into a long-term plan, shall be discussed.

C. Facility Plans

1. General: Facility plans must be completed for wastewater treatment facilities, major collection systems, and those interceptor sewers and pumping stations serving major areas. Facility Plans shall contain the following and other pertinent information as required by DPW:

   a. Problem Evaluation and Existing Facility Review
      - descriptions of existing system, including condition and evaluation of problems requiring correction
      - summary of existing and previous local and regional wastewater facility and related planning documents

   b. Planning and Service Area: Planning area and existing and potential future service area.

   c. Population Projection and Planning Period: Present and predicted population shall be based on a 20-year planning period. Phased construction of wastewater facilities shall be considered in rapid growth areas. Sewers, and other facilities, with a design life in excess of 20 years shall be designed for the extended period.

   d. Hydraulic Capacity: The flows for the design year shall be identified and used as a basis for design of sewers, pumping stations, wastewater treatment plants, treatment units, and other wastewater handling facilities. The various design flows have been defined in Chapter V.

e. Hydraulic Capacity to Serve Existing Collection Systems:

1) Projections shall be made from actual flow data to the extent possible.

2) The accuracy of data and projections shall be evaluated. This reliability estimation shall include an evaluation of the accuracy of existing data as well as an evaluation of the reliability of estimates of flow reduction anticipated due to infiltration/inflow reduction or flow increases due to elimination of sewer bypasses and backups.

3) Critical data and methodology used shall be included. It is recommended that graphical displays of critical peak wet weather flow data be included for a wet weather flow period of significance to the project.

f. Hydraulic Capacity to Serve New Collection Systems:

1) The sizing of wastewater facilities receiving flows from new wastewater collection systems shall be based on an average daily flow of ninety (90) gallons per capita per day (gpcd) plus wastewater from industrial plants and institutional and commercial facilities, as outlined in Chapter V, unless water use data or other justification upon which to better estimate flow is provided.

2) The 90 gpcd figure shall be used which, in conjunction with the peaking factor from the Maryland Department of the Environment (MDE) curves shown in the Appendix, is intended to include infiltration for systems built with modern construction techniques.

3) If the new collection system is to serve existing development, the likelihood of infiltration/inflow contributions from existing service lines, and non-wastewater connections to those service lines, shall be evaluated; and wastewater facilities designed accordingly.

g. Initial Alternative Development: The process of selection of wastewater collection system alternatives for detailed evaluation shall be discussed. All alternatives, including no action, and the basis for the engineering judgement for selection of the alternatives chosen for detailed evaluation, shall be included.

h. Detailed Alternative Evaluation: The following shall be included for the alternatives to be evaluated in detail:

1) Sewer System Revisions: Proposed revisions to the existing sewer system, including the adequacy of portions of the system not being changed by the project, must be provided.

2) Wet Weather Flows: Facilities to transport and treat wet weather flows in a manner that complies with Local, State, and Federal regulations must be provided.

i. Final Project Section: The project selected from the alternatives considered under "h," shall be set forth in the final facility plan document to be forwarded to DPW for review and approval including the financing considerations and recommendations for implementation of the plan.

IV. ENGINEERING PLANS AND SPECIFICATIONS

A. Plans and Supporting Documents

Submissions to DPW shall include sealed plans, design criteria, the appropriate construction permit applications, review forms, and permit fees, if required.

1. General

   a. Plan Title: All plans for wastewater facilities shall bear a suitable title showing the name of the project. They shall show the scale in feet, a graphical scale, the North arrow, State plane grids, date, name of the Engineer with the certificate number and imprint of the registration seal. A space should be provided for signature by the appropriate County agencies. The County standard title block for all drawings is available electronically or from the Engineering Records Office.

   b. Plan Format: The plans shall be clear and legible (suitable for scanning). They shall be drawn to scale that will permit all necessary information to be plainly shown. The size of plans should be 24” x 36”. The datum used shall be indicated. Locations and logs of test borings, when required, shall be shown on the plans.

   c. Plan Contents: Detail plans shall consist of: plan views, profiles, elevations, sections, and supplementary views which, together with the specifications and general layouts, provide the working information for the Contract and construction of the facilities. They also shall include: dimensions and relative elevations of structures, the location and outline of equipment, location and size of piping, water levels, and ground elevations.

   d. Design Criteria: Design criteria shall be included with all plans and specifications, and a hydraulic profile shall be provided for force mains and all wastewater treatment facilities.

   e. Operation During Construction: Project construction documents shall specify the procedure for operation during construction.

2. Plans of Sewers

   a. General Plan: A comprehensive plan of existing and proposed sewers shall be submitted for projects involving new sewer systems and substantial additions to existing systems. This plan shall show the following:

      1) Geographical Features:

a) Topography and elevations – existing or proposed streets and all streams or water surfaces shall be clearly shown. Contour lines, at suitable intervals, should be included.

b) Streams – the direction of flow in all streams and high and low water elevations of all water surfaces shall be shown.

c) Boundaries – the boundary lines of the County and the area to be sewered shall be shown.

2. Sewers: The plan shall show the location, size, and direction of flow of all existing and proposed sanitary sewers.

b. Detailed Plans: Detailed plans shall be submitted. Profiles shall have a horizontal scale of not more than 50 feet to the inch, and a vertical scale of not more than 5 feet to one inch. Plan views shall be drawn to a corresponding horizontal scale and must be shown on the same sheet. Plans and profiles shall show:

- location of streets and sewers
- line of ground surface, size, material, and type of pipe
- length between manholes
- invert and surface elevation at each manhole
- grade of sewer between each two adjacent manholes (all manholes shall be numbered on the profile)
- elevation and location of the basement floor shall be plotted on the profile of the sewer which is to serve the house in question; the Engineer shall state that all sewers are sufficiently deep to serve adjacent basements except where otherwise noted on the plans
- locations of all special features, such as inverted siphons, concrete encasements, elevated sewers, etc.
- all known existing structures and utilities (above and below ground) which might interfere with the proposed construction or require isolation setback, particularly water mains and water supply structures (wells), gas mains, storm drains, and telephone and power conduits
- special detail drawings, made to scale to clearly show the nature of the design, shall be furnished to show the following:
  - all stream crossings and sewer outfalls with elevations of the streambed and normal and extreme high and low water levels
  - details of all special sewer joints and cross sections
  - details of all sewer appurtenances, such as manholes, inspection chambers, vaults, inverted siphons, and elevated sewers

3. Plans of Pumping Stations

a. Location Plan: A location plan shall be submitted for projects involving construction or revision of pumping stations. This plan shall show the following:
   - the location and extent of the tributary area
   - any boundaries within the tributary area
   - the location of the pumping station and force main and pertinent elevations

b. Detailed Plans: Detailed plans shall show the following, where applicable:
   - topography of the site
   - existing pumping station
   - proposed pumping station, including provisions for installation of future pumps
   - elevation of high water at the site and maximum elevation of wastewater in the collection system upon occasion of a power failure
   - maximum hydraulic gradient in downstream gravity sewers when all installed pumps are in operation
   - test borings and groundwater elevations

B. Specifications

Complete, sealed, technical specifications shall be submitted for the construction of sewers, wastewater pumping station, and all other appurtenances and shall accompany the plans.

The Specifications accompanying construction drawings shall include, but not be limited to:

- specifications for the approved procedures for operation during construction in accordance with this Chapter
- all construction information not shown on the drawings which are necessary to inform the builder in detail of the design requirements for the quality of materials, workmanship, and fabrication of the project.

The Specifications shall also include:

- the type, size, strength of operating characteristics and rating of equipment
- the complete requirements for all mechanical and electrical equipment, including machinery, valves, piping, and jointing of pipe
- electrical apparatus, wiring, instrumentation and meters
- laboratory fixtures and equipment, operating tools, construction materials
- special filter materials, such as: stone, sand, gravel, or slag
- miscellaneous appurtenances
- chemicals when used
- instructions for testing materials and equipment, as necessary, to meet the design standards

- performance tests for the completed works and component units (it is suggested that these performance tests be conducted at design load conditions wherever practical)

C. Revisions to Approved Plans

Any deviations from approved plans or specifications affecting capacity, flow, operation of units, or point-of-discharge shall be approved, in writing, before such changes are made. Plans or specifications so revised should, therefore, be submitted well in advance of any construction work that will be affected by such changes to permit sufficient time for review and approval. Structural revisions or other minor changes not affecting capacities, flows, or operation will be permitted during construction without written approval. “As Built” plans, clearly showing such alterations, shall be submitted to the reviewing agency at the completion of the work.

D. Standard Details

All work shall be completed in accordance with the *Standard Details for Construction*, latest revision. The Engineer shall refer to these details during the design of the project and during the preparation of the construction drawings.

V. DESIGN OF SEWERS

A. Approval of Sewers

In general, the Bureau of Engineering and Construction will approve construction plans for new sewer systems, extensions to new areas or replacement sewers. Separate systems are required for sanitary sewers and storm drains. Storm water runoff from roofs, streets, and other areas, including groundwater drains and foundation drains, must be excluded from sanitary sewers.

Constructed overflows shall not be permitted at any time.

B. Design Capacity and Design Flow

1. General

   a. The sizing of major components of the County's collection, conveyance, and pumping systems, such as major pumping stations, force mains, and interceptor sewers, are generally the responsibility of the Bureau of Engineering and Construction.

   b. The Master Plan generally shows the major existing and planned wastewater collection, conveyance, and pumping system components. The Engineer shall be familiar with design facilities in accordance with the Master Plan.

   c. The sewer design guidelines presented herein shall apply to Developer and Capital Projects.

   d. In general, sewer capacities shall be designed for the estimated ultimate tributary population except in considering parts of systems that may be readily increased in capacity. Consideration shall be given to the maximum anticipated capacity of institutions, industrial parks, etc. Where future relief sewers are planned, economic analysis of alternatives must accompany designs.

2. Design Period

   In general, sewer systems shall be designed for the design life of the pipeline material.

3. Design Factors and Design Flow

   a. General: The anticipated design average and design peak flows for the existing and ultimate conditions must be established. The basis of the

projection of initial and future flows must be provided and must reflect the existing or initial service area and the anticipated future service area.

b. Flow Definitions and Identification*:* The following flows for the design year shall be identified and used as a basis for design of sewers, pumping stations, lift stations, wastewater treatment plants, treatment units, and other wastewater handling facilities.

   Where any of the terms defined in this section are used in these design standards, the definition contained in this section applies.

   1) Design Average Flow*:* The design average flow is the average of the daily volumes to be received for a continuous 12-month period expressed as a volume per unit time. However, the design average flow for facilities having critical seasonal high hydraulic loading periods (eg, recreational areas, campuses, industrial facilities) shall be based on the daily average flow during the seasonal period.

   2) Design Maximum Day Flow: The design maximum day flow is the largest volume of flow to be received during a continuous 24-hour period expressed as a volume per unit time.

   3) Design Peak Hourly Flow*:* The design peak hourly flow is the largest volume of flow to be received during a one-hour period expressed as a volume per unit time.

   4) Design Peak Instantaneous Flow: The design peak instantaneous flow is the instantaneous maximum flow to be received.

c. Quantity of Wastewater: For any segment of the proposed sewer system the design wastewater flow must be determined. Sanitary or domestic wastes based on the population served by a given sewer segment, extraneous infiltration/inflow, and contributing commercial and industrial flows must be added to produce the design flow. The design flow rate shall be the sum of the peaked residential, peaked institutional, peaked commercial and industrial flow rates for the service area plus the corresponding infiltration and inflow components within the service area. The methods and criteria outlined below shall be used to develop design flows:

   1) Tributary Area: This is the area contributing wastewater to a particular sewer segment.

   2) Sanitary or Domestic Wastes:

a) Contributing Population: Domestic wastewater quantities normally are to be computed on a contributing population basis except as noted in the subparagraphs below. The population to be used in design depends upon the zoning of the area that the sewer serves. If the area contains residential zoning, the design population is based on full occupancy of all housing to be served at the population density shown on the following table. If the area contains non-residential zoning, the design contributing population for non-residential areas is based on the population per acre and dwelling units per acre densities in the following table:

Zoning Classification	Dwelling Units per Acre	Population per Acre
RC 2		
RC 5	0.667	2.33
DR 1	1.0	3.5
DR 2	2.0	7.0
DR 3.5	3.5	12.25
DR 5.5	5.5	19.25
DR 10.5	10.5	36.75
DR 16	16.0	56.0
R 0	5.5	19.25
BL	--	12.0
BM	--	10.0
BR	--	12.0
MR	--	10.0
ML	--	10.0
MLR	--	10.0
MH	--	16.0

b) Average Daily Flow:

1. Residential: The average daily per capita wastewater quantity for residential areas shall be 90 gallons per capita per day. The average daily residential flow rate shall be determined by multiplying the applicable population densities by the average daily per capita wastewater quantity of 90 gpcd.

2. Commercial and Institutional: The average daily wastewater quantities for commercial and institutional areas are given in the following table. The average daily commercial and institutional flow rate shall be determined by multiplying the applicable annual water use shown in the table by the selected parameter for the particular type of establishment.

Type of Establishment or Institution	Selected Parameter	Annual Water Use (gpd/unit)
Apartments		
High Rise	Gpd/occupied unit	218
Garden Type	Gpd/occupied unit	213
Banks	Gpd/gross sq. foot	0.04
Barber Shops	Gpd/chair	54.6
Beauty Salons	Gpd/station	269
Boarding Houses	Gpd/person	40
Car Washes	Gpd/sq. foot	4.78
Churches	Gpd/member	0.138
Clubs		
Golf Clubs	Gpd/membership	66.1
Swimming Clubs	Gpd/membership	16.5
Boating Clubs	Gpd/membership	10.5
Colleges		
Students in residence	Gpd/student	106
Non-resident students	Gpd/student	15.2
Department Stores	Gpd/sq. foot of total sales area	0.216
Shopping Centers	Gpd/sq. foot of total sales area	0.16
Drug Stores	Gpd/gross sq. foot	0.13
Hospitals	Gpd/bed	346
Hotels	Gpd/sq.foot	0.256
Laundries		
Commercial Laundries and Dry Cleaners	Gpd/sq. foot	0.253
Laundromats	Gpd/sq.foot	2.17
Motels	Gpd/sq. foot	0.224
Movie Theaters	Gpd/seat	5
Nursing Homes and Institutions	Gpd/bed	133
Office Buildings		
General Office	Gpd/gross sq. foot	0.093
Medical Office	Gpd/gross sq. foot	0.62
Primary and Secondary Schools		
Public Elementary	Gpd/student	5.38
Public Junior High	Gpd/student	5.64
Public Senior High	Gpd/student	6.63
Private Elementary	Gpd/student	2.27
Private Senior High	Gpd/student	10.4
Combined (grades 1-12)	Gpd/student	8.49
Restaurants		
Drive Ins (parking only)	Gpd/car space	109
Drive Ins (seating and parking)	Gpd/seat	40.6
Conventional Restaurants	Gpd/seat	24.2
Retail Stores	Gpd/gross sq. foot	0.16
Rooming Houses	Gpd/person	40
Service Stations	Gpd/sq.foot of garage and office space	0.251
Supermarkets	Gpd/gross sq. foot	0.20
Warehouses	Gpd/gross sq. foot	0.03

3. Industrial: The average daily wastewater quantities for industrial steady flow are given in the following table. The average daily flow rate shall be determined by multiplying the applicable gallons/acre per day by the total acres of industrially zoned area. This flow represents the design contributing population that includes the population employed at any time. Industrial flow cannot be computed on a population basis. Flows from industrial facilities depend upon the type and extent of the activities. Industrial waste sewers and sanitary sewers will be designed for the peak industrial flow as determined for the particular industrial process or activity involved.

Acres	Gallons per Acre
0-25	4,000
26-100	3,000
101-200	2,000
201-500	1,500
Over 500	1,000

c) Average Hourly Flow: When designing sewers to serve small areas and where the majority of wastewater is generated by commercial, institutional, or industrial users or other short term wastewater generators, the average hourly flow rate shall be used. The average hourly flow rate shall be computed based on the actual period of waste generation.

d) Peak Diurnal Flow Rate: The normal daily range of flow, or the diurnal pattern, is from approximately 40% to 250% of the average daily flow. The peak daily, or diurnal, flow rate is an important factor in sewer design especially when minimum velocities are to be provided on a daily basis. The peak diurnal flow rate shall be one half of the extreme peak flow rate.

e) Peak Residential Flow: The peak residential wastewater flow is determined by the peaking factor as shown in the empirical curves published by the Maryland Department of the Environment (MDE) formerly the Maryland State Department of Health and Mental Hygiene.

4. Infiltration and Inflow

a. General: Extraneous flows from groundwater infiltration enter the sewer system through defective pipe, joints, fittings, and manhole walls. Sources of inflow include connections from roof leaders, yard drains,

storm drains, cooling water discharges and foundation drains in addition to submerged manhole covers.

b. Design Allowance for New Sewers*:* Where infiltration and inflow must be calculated for an area that is currently served by a collection system, the allowance for infiltration and inflow will be provided by the Bureau of Engineering and Construction and is based on flow records.

C. Hydraulic Design of Sewers

1. General

a. Hydraulic Design: As discussed in previous sections, the Bureau of Engineering and Construction reserves the right to determine the size of major wastewater conveyance and pumping facilities. Sewers shall be designed to discharge the wastewater flows as required by Section V,B. Generally, it is desirable to design sewers for full flow, even at the peak rates. Flows above 90-95% of full depth are considered unstable and may result in a sudden loss of carrying capacity with surcharging at manholes. In addition, large trunk and interceptor sewers laid at flat grades are less subject to wide fluctuations in flow; and if designed to flow full, may lack sufficient air space above the liquid to assure proper ventilation. Adequate sewer ventilation is a desirable method of preventing the accumulation of explosive, corrosive, or odorous gasses, and of reducing the generation of hydrogen sulfide. Therefore, trunk and interceptor sewers shall be designed to flow at depths not exceeding 90% of full depth; laterals and main sewers, 80%; and building connections, 70%. However, regardless of flow and depth, the minimum sizes to be used are 6-inch for building connections and 8-inch for all other sewers. Industrial applications shall use the same design criteria as sanitary sewers, except pipe material that is resistant to the waste, shall be specified. The following formula, charts, procedures and criteria shall be used for design.

b. Design Formula and Charts:

1) The Manning Formula shall be used for design of gravity flow sewers.

2) Roughness: In all cases, Manning's "n" shall be 0.013. Due to uncertainties in design and construction and a desire to provide a margin of safety, "n" values smaller than 0.013 will not permitted. Variation of "n" with depth may be considered in designing sewers to flow partially full.

3) Velocity: Sewers will be designed to provide a minimum velocity of 2.0 feet per second at the average daily flow, or average hourly flow rate, and a minimum velocity of 2.5 – 3.5 feet per second at the peak

diurnal flow rate. When velocities drop below 1.0 foot per second during periods of low flow, organic solids suspended in the wastewater can be expected to settle out in the sewer. Sufficient velocity (2.5 – 3.5 feet per second) must be developed regularly, once or twice daily as a minimum, to re-suspend and flush out solids that may have been deposited during low flows. A velocity of 2.5 feet per second is required to keep grit and sand suspended. However, new sewers that are properly designed and constructed should contain only minor quantities of grit or sand. Maximum velocity is set at 10.0 feet per second in the event that grit becomes a problem.

4) Slope: The minimum slopes for sewers of various sizes shall be as follows:

Pipe Size (inches)	*Minimum Slope (feet per 100 feet)*
8	0.60
12	0.40
15	0.25
18	0.18
21	0.12
24	0.10
36	0.10

Assuming uniform flow, the value of "S" in the Manning Formula is equivalent to the sewer invert slope. Pipe slopes must be sufficient to provide required minimum velocities and depths of cover on the pipe. Although it is desirable to install large trunk and interceptor sewers on flat slopes to reduce excavation and construction costs, the resulting low velocities may cause objectionable solids to be deposited in the pipe creating a buildup of hydrogen sulfide.

Laying pipes on slopes that provide minimum velocities shall be avoided whenever possible. Minimum velocities have been outlined in Section C.

Pipeline slopes exceeding 20% are permitted only with the approval of the Bureau of Engineering and Construction. Special anchor requirements for steep slope pipelines are required, and these requirements are outlined in other sections of these guidelines.

If practical, suitable drop manholes or other structures or methods to dissipate energy and reducing erosive velocities shall be provided as approved by the Bureau of Engineering and Construction.

In instances where the Bureau of Engineering and Construction approves slopes less than the allowed minimum slopes, the Engineer

shall add the following notes to the respective profile(s) in **bold** lettering:

"NOTE: The Contractor shall assure that the minimum slope of the sewer main shown on the above profile to be no less than designed. The slope shall be computed by using the actual constructed distances between manholes and elevation differences of the manhole inverts. The survey rod must be completely plumb during readings.

If the manhole cone section prevents a plumb reading of each pipe invert, then a level must be used within the manhole to project the invert for a plumb rod reading. The Contractor shall have each manhole run surveyed by a Maryland Registered Land Surveyor, and the results shall be submitted in writing to the County Inspector. A second copy shall be submitted to the Sewer Design Section for verification. The Sewer Design Section shall approve the information submitted by the Contractor's surveyor prior to constructing any subsequent manhole runs. Constructed slopes, which result in a pipe capacity less than the design flow rate or result in velocities less than scouring velocity to naturally cleanse the sewer, shall be reconstructed to the proper slope before constructing any subsequent manhole runs."

5) Cover: Adequate cover must be provided for frost protection. Generally, a minimum of three and one-half feet (3.5') of earth will be required to protect the sewer against freezing. Where frost penetrates to a considerably greater depth and lasts for an appreciable period of time, the waste may not contain sufficient heat to prevent the gradual cooling of surrounding earth and the buildup of an ice film inside the pipe. Under these conditions, greater cover shall be required. Sufficient cover also must be provided to protect the pipe against structural damage due to superimposed surface loadings. Concentrated and uniformly distributed loads are discussed in this chapter.

c. Design Procedure: After a preliminary layout has been made, a tabulation will be prepared, in convenient form, setting forth the following information for each sewer section:
   - designation of manhole by numerals
   - contributing populations – residential and non-residential
   - design flows – average, daily peak, and extreme peak
   - length of sewer
   - invert elevations
   - invert slope or gradient

- pipe diameter and roughness coefficient
- flow depths at design flows
- velocities at design flows
- depths of cover on the pipe – maximum and minimum

d. Hydraulic Profile: In most situations where small or medium-sized gravity sewers are installed in long runs, it will be safe to assume uniform flow throughout the entire length of conduit. However, in cases where larger sewers (24-inch diameter and above) are constructed in runs of less than 100 feet and with a number of control sections where non-uniform flow may occur, a plot of the hydraulic profile is recommended. Methods used to calculate and plot hydraulic profiles, including backwater curves, drawdown curves, and hydraulic jumps, will conform to those presented in standard textbooks.

e. Critical Flow: Gravity sewers ordinarily will be designed to maintain subcritical flow conditions in the pipe throughout the normal range of design flows. However, there are exceptions in which supercritical flow may be required and will be justified. Minimum sized sewers, 6 and 8-inch designed to discharge very low flows, must occasionally be placed on slopes steeper than critical in order to provide minimum velocities. In addition, small to medium sized sewers, when required to discharge unusually large flows, may necessitate super-critical slopes. Finally, steep slopes may be unavoidable due to natural topography and ground conditions. Where super-critical flow will occur, care must be taken in the design to insure that downstream pipe conditions do not induce a hydraulic jump or other flow disturbance. Depths of flow within 10-15% of critical are likely to be unstable and will be avoided where pipes will flow from 50-90% full. Critical depths for various flows and pipe diameters may be obtained from standard hydraulic textbooks.

f. Computer Programs: Numerous commercial computer programs are available for modeling, data management (such as location, diameter, depth, slope, and capacity of each component), design, and analysis of sewer systems. As well as being used to design new collection systems, these programs are able to assist with assessing the impacts of changes and additions to existing collection systems thus helping to optimize designs.

D. Details of Design and Construction

1. Gravity Sewer Design

a. General: The layout of a gravity sewer system of collectors and interceptors is a function of the topography. Collector and interceptor sewers shall be designed to serve all areas up to the drainage area limits

within the current development envelope. The plan and profile alignments of the sewer system shall provide for future connections within the drainage area limits while minimizing both expense and modifications to the existing system.

Consideration shall be given to space requirements for future utilities, particularly water and storm drains. In the absence of water and storm drain design, the Engineer shall recommend the space requirements for future water or drainage facilities and shall provide the necessary clearances. This requirement is particularly important at roadway intersections. When plans of existing facilities are insufficient to accurately locate existing underground obstructions that may alter the final design, the Engineer shall perform test pit excavations during the design to uncover the subject facilities so that horizontal and vertical positions of existing utilities may be accurately determined. During test pitting, the Engineer shall be responsible for providing all traffic control and public safety measures necessary to locate the utilities and shall be responsible for restoring the surface. The Engineer shall coordinate the test pit operations and shall provide a field survey crew to physically locate the subject facility.

In general, sewers 24-inches in diameter or less shall be laid with straight alignment between manholes. Use a laser beam to check for straight alignment.

Curvilinear alignment of sewers larger than 24 inches may be considered on a case-by-case basis, provided compression joints are specified and ASTM or specific pipe manufacturer's maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves that start and end at manholes. When curvilinear sewers are proposed, minimum slopes indicated in Section V-C-4 must be increased accordingly to provide a recommended minimum velocity of 2.0 feet per second when flowing full.

b. Horizontal Alignment – Location: The horizontal alignment shall take into account the following general alignment guidelines. Pipelines greater than 12 inches in diameter may have other limitations and requirements that alter these general alignment guidelines.

    1) Due to the greater depth of the sewer in relation to most other utilities, the location for the sewer main shall be given first priority.

    2) Sanitary sewer shall be designed with a straight horizontal alignment between manholes.

3) For Developer's projects, the design of the public water, sewer force mains, and storm drain utilities within proposed developments, shall be prepared concurrently to ensure compatibility of the utilities.

4) In new developments where sewers are constructed in advance of the road pavements, the sewer shall be placed on the lower side of the street, seven feet (7') from the street centerline. On curved streets, this location must be compromised since straight horizontal alignments are required between manholes.

   For road widths 24 feet or less, sewer mains shall be designed five feet (5') from the road right-of-way centerline in lieu of the seven feet (7') stated above.

   In all cases, manholes must be placed within the pavement area wherever possible. Within closed section roadways, manholes shall not be closer than three feet (3') from the face of the curb; the manhole cone section shall be rotated away from the face of the curb. Manholes shall not be located within designated parking areas within townhouse and condominium subdivisions.

5) If public water and sewer mains cannot be located within the paved roadway section, the Engineer shall request a waiver of these design standards from the Bureau of Engineering and Construction, providing reasons why the standards cannot be met.

6) For developer projects, whenever the system is planned to be extended by either future phases within the subdivision or by other parties, the sewer main shall be extended beyond the edge of paving by means of a manhole to avoid future cutting of the pavement.

7) In existing development with curbs, the sewer mains shall be generally located as in new subdivisions.

8) Where sewers in residential developments are constructed between or across lot lines, the centerline of the pipe shall be constructed on the lot line between lots or along the rear property line. Generally, the sewers or required easements shall not cut across building envelopes. In cases where sewer mains are between or behind lots where access from public roads is limited, access easements from the nearest public roadway shall be provided between lots. All such easements shall allow adequate access to the seer by maintenance personnel and equipment. See the section entitled, *Rights-of-Way, Easements and Construction Strips,* within this design manual for additional information regarding easement and access requirements.

9) In proposed subdivisions where easements are required between two adjacent lots for the extension of the sewer system, a sewer main shall be provided within the easement between the adjacent lots. The sewer main shall extend the full length of the easement between the lots.

   In cases where a utility easement is required to be extended to the limits of the property being developed through a lot or open space to provide future service to an adjacent property, that easement shall be cleared of trees and otherwise shall be prepared for the future extension of the main. For Developer Projects, whenever the proposed sewer system is planned to also serve an adjoining future service area, drainage and utility easements shall be provided to enable the future sewer extension.

10) Within private roads, public sewer mains shall be located within the paved roadway sections. When a sewer main cannot be located within the private road, the Engineer shall obtain prior approval by the Sewer Design Section for its location.

11) When sewer mains are proposed for locations adjacent to existing buildings, the minimum distance away from the building foundation shall be fifteen feet (15') as long as the sewer depth is not greater than the bottom of the building foundation. The horizontal distance to the building shall be no greater than the depth of sewer.

12) Generally, all sewers crossing waterways shall be encased in concrete, a minimum of six inches (6") thick. Limits of concrete encasement shall extend from top of bank to top of bank. The entire manhole run, which encompasses the encasement, shall consist of ductile iron pipe. The design shall incorporate restoration with riprap placed from bottom of stream to top of bank. Although in many cases MDE guidelines require Class I riprap, Baltimore County has found this size of riprap to be insufficient to withstand the stream velocities encountered during rainfall events. Therefore, the minimum size riprap shall be Class II.

13) Sewer mains shall not be located within stormwater management facilities. Likewise, any drainage and utility easement for a sewer main shall not be located within stormwater management facilities. These areas include, but are not limited to, stormwater management ponds, water quality traps, swales, rain gardens, and recharge areas and the associated embankments, riprap areas, spillway outfall channel, fenced-in areas or other features associated with the stormwater management facility.

14) When a sewer main is proposed parallel to or adjacent to a stream or other waterway, it shall be located so that future movement of the waterway due to streambank erosion will not encroach upon the sewer main. Generally, this shall be accomplished by locating the sewer main away from the outside meander bend of the stream. If it is not possible to locate the sewer main away from the outside meander bend, the Sewer Design Section will only reconsider the sewer main location if the Engineer incorporates permanent streambank stabilization measures which satisfies the Sewer Design Section.

15) The alignment within existing roadways shall avoid high traffic volume roads if other options are available. The alignment shall be designed to allow the construction of the pipeline without the need to have road closings. When a sewer main is required to cross a Baltimore County road right-of-way, after considering the type and condition of the road, traffic volumes, disruption to traffic and possible conflicts with existing utilities, the Engineer shall recommend to open cut, tunnel, or jack and bore the utility across the roadway on a case-by-case basis. Baltimore County DPW's Bureau of Engineering and Construction shall make the final decision as to the method used. The approval method shall be noted on the plans and profile.

16) Longitudinal alignments within the State Highway Administration road right-of-way shall be avoided. Approval on such longitudinal alignments must receive prior written approval from the Sewer Design Section and the State Highway Administration.

17) In existing road rights-of-way, the alignment shall try to avoid the removal of trees or landscaped areas. In parks and public rights-of-way where the alignment will require the removal of trees, the Engineer shall obtain the approval of the appropriate agency or agencies for tree removal. When the alignment is located outside of rights-of-way, it shall minimize disturbance to environmental features. In addition to trees, the alignment shall attempt to avoid wetlands, steep slopes, and other sensitive/difficult areas to work within. The alignment shall follow property lines to the extent practical and feasible.

18) When existing roadways are involved with the alignment, the horizontal alignment of the road must be evaluated for acceptable geometry; and the sewer main must be designed with respect to possible roadway improvements to avoid costly relocations. The Engineer shall evaluate the plane geometry of the road with respect to movement of traffic and available right-of-way width for the accommodation of the sewer main.

19) Sewer mains proposed to cross State Highway Administration or County road rights-of-way must be placed within a tunnel or sleeve if required by the appropriate agencies. DIP shall be used for the entire manhole run in applications where a tunnel or sleeve is required. The design and construction of the carrier pipe and casing pipe within railroad rights-of-way shall be designed in accordance with the requirements of the railroad being crossed. Manholes shall be no closer than ten feet (10') from both ends of the sleeve.

20) Sewer mains may not be located within existing or proposed wetland mitigation areas, forest retention areas, or reforestation areas.

21) If the Master Water and Sewer Plan identifies a proposed interceptor or collector sewer within a proposed subdivision, the Developer shall construct the proposed sewer as part of the onsite utility construction. If the sewer main must be increased in size to accommodate the remaining drainage area above and beyond that required for the subdivison, the larger size sewer main shall be constructed. If a larger size sewer main is constructed, the PWUA will discuss potential recoupments to recover the cost of the pipe size increase.

22) Sewers on twenty percent (20%) slopes or greater, if permitted, shall be anchored in accordance with the following schedule and in accordance with the Standard Specifications. Drop manholes are not allowed. The Engineer shall ensure that an inflatable plug can be fully inserted within the pipe.

- Grades 20% - 35%
  20 ft. length pipe – anchor at each joint
  13 ft. length pipe – anchor at every other joint
  Anchor spacing shall not exceed 36 feet.

- Grades 35% - 50%
  20 ft. length pipe – anchor at each joint
  13 ft. length pipe – anchor at each joint
  Anchor spacing shall not exceed 24 feet.

- Grades >50%
  Custom Design
  Anchor spacing shall not exceed 16 feet.

23) The Engineer shall show a detail on how the pipe will enter manholes for sewer slopes twenty percent (20%) or greater. The detail shall demonstrate that an inflatable plug will be capable of being inserted into the sewer with the brick channel in place. The length of sewer plugs is as follows:

6 –10-inch diameter plug: 24-inch length
8 –12-inch diameter plug: 25.5-inch length
12 –18-inch diameter plug: 27-inch length

24) If locating sewers in roadways is deemed impractical by Baltimore County, the following criteria will be met:

a. Maximum Slope above the pipe is 15%
b. Cross slope is to be a minimum of 2% and a maximum of 5%

c. Vertical Alignment – Location

Grades: The vertical position of gravity sewers is determined by the rate of fall between the unit to be served and the collector sewer, by the rate of fall of the ground along the course of the pipeline, and by the existence of obstructions that cannot be economically relocated. All sewer grades shall be established to require the least excavation while satisfying minimum and maximum velocity requirements, design flow conditions, clearances, and depth requirements. All sanitary sewers shall be designed on a continuous grade between manholes.

The minimum slopes are presented in Section V-C-4 herein.

Sewer house connections (SHCs) shall have the minimum slopes as discussed in Section VI-C, *Building Connections*, in these design guidelines.

For gravity systems, the pipeline layout is directly affected by the minimum acceptable fluid velocities as determined by the design flow, pipe size, slope and Manning roughness “n” coefficients. (See Section V-C, Hydraulic Design of Sewers.)

Where different diameter pipes meet at manholes, the crown of all upstream pipes shall be set at the same elevation as the crown of the downstream pipe unless hydraulic gradient computations require a higher setting.

d. Sewer Depths – General*:* The collector sewer shall be designed at a sufficient depth to provide gravity sewer service to the basement or lowest floor level of all buildings and to cross streams and waterways with a minimum 3.5-feet depth of cover unless otherwise directed by the Sewer Design Section. The minimum cover over any sewer shall be three and one-half feet (3.5’). Sewers greater than twenty feet (20’) deep will require written approval from the Sewer Design Section.

1) Sewer Depths at Stream Crossings: Where a sewer parallels a water course, the Designer shall ensure that the proposed sewer depth will

be adequate to facilitate future crossings of the stream while maintaining a minimum 3.5-feet of cover over any future stream crossings. Where sewer mains cross streams, the crossing angle shall be as close to ninety degrees (90°) as possible, and the crossing pipe shall be set at an elevation to provide a minimum of 3.5 feet of cover over the pipe measured from the bottom of the deepest section of the stream channel to the top of the pipe.

2) Sewer Depths Adjacent to Buildings: As previously noted, if sewers are parallel to an existing building, they shall be located no closer than fifteen feet (15') from an existing building foundation. This distance must increase if the building has a basement and the sewer depth is beneath the basement foundation. The horizontal distance to the building shall be no greater than the depth of the sewer.

e. Buoyancy: Buoyancy of sewers shall be considered, and flotation of the pipe shall be prevented where high groundwater conditions are expected.

f. Flow Depth-Minimum: Slopes slightly less than those required in Section V.C.1.b.4 may be permitted when approved by DPW. Such decreased slopes only will be considered when the depth of flow will be 0.3 of the diameter, or greater, for design average flow.

g. Minimize Solids Deposition: The pipe diameter and slope shall be selected to obtain the greatest practical velocities to minimize settling problems. Oversized sewers will not be approved to justify using flatter slopes. If the proposed slope is less than the minimum slope of the smallest pipe which can accommodate the design peak hourly flow, the actual depths and velocities at minimum, average, and design maximum day and peak hourly flow for each design section of the sewer shall be calculated by the Design Engineer to be included with the information submitted with the preliminary report at the preliminary engineering conference or shall be included with the plans if a conference is not required.

h. High Velocity Protection: Where velocities greater than fifteen feet (15') per second are attained, special provision shall be made to protect against displacement by erosion and impact.

2. Sewer Mains – Plan:

a. Sewer main plans shall be drawn to a scale of 1" = 50' or 1" = 30'.

b. All proposed pipes shall be shown and symbolized as noted in the Standard Details. More specifically, the pipe is to be identified by two (2) parallel lines with shading in between. Pipe lines 24 inches in diameter

and smaller shall be shown symbolically as two feet (2') wide as a minimum based on a scale of 1" – 50'. Pipe lines over 24 inches in diameter shall be shown to scale.

c. The plan location of the pipeline and appurtenances shall be carefully dimensioned so that its route is clearly identified. Dimensioning of the proposed pipeline, including appurtenances, shall be as noted in *Control, Topographic and Construction Surveys.* Appurtenances shall be called by symbols and notes and dimensioned both in respect to pipeline arrangements and in respect to required positions in relation to surface features.

d. Manholes shall not be shaded. Manholes shall be numbered in consecutive order with the numbers placed within a standard circle. The numbering shall start with the connection to existing sewer. The slope of frames and covers that are proposed to be flush with grade shall conform to the proposed finished grade. The type of manhole shall conform to the Standard Details.

e. All pipe sizes shall be clearly identified together with flow directional arrows.

f. The 100-year floodplain NRD, wetlands, and the 25-foot wetland buffer shall clearly be shown on the plans.

g. Sewer Service Chart: The following tabulated data shall be shown for all house and building connections:

SEWER SERVICE
(Example Only)

Lot No.	Sewer Main Station (EX MH1-MH2)	Invert at Main	Drop House Connec-tion	Length of Service	Slope of Service	Inv. @ RW Line	Prop. Fin. Grade @ RW Line	Depth of Service @ RW Line
79	0+23	267.98	--	20	2%	268.38	275.00	7.0
78	0+27	268.41	--	11	2%	268.63	274.13	5.5
77	1+01	276.38	--	42	2%	277.22	288.75	11.5
76	1+10	277.35	287.96	51	2%	288.68	292.68	4.0
75	@ MH2	278.47	--	53	2%	279.53	284.53	5.0

3. Sewer Mains: Profile

a. Profiles shall be drawn for all public sewer mains at a scale of 1" = 50' horizontal and a scale of 1" = 5' vertical.

b. Profiles shall be shown below the sewer plan view.

c. Manholes in profile shall be numbered to correspond to the manhole numbering on the plan. The numbers shall be within a standard circle together with the manhole top elevation. The type of manhole with a reference to the Standard Detail shall be called out. The type of frame and cover also shall be called out. The top of manhole elevation and ground elevation also shall be called out. Manholes shall be numbered in consecutive order and shall start with the connection to existing sewer and shall be oriented in the same direction as the plan.

d. Profile match lines shall correspond to centerline of manhole locations.

e. When a proposed sewer is located on a lot line between two lots, the limits and lot numbers shall be designated in the profile along with the street name to which the lot fronts.

f. Profiles Not Within Proposed Roads*:* In developing the profile information within or outside existing roads, the centerline of the sewer main in plan shall be used for the profile stationing which will provide true length profiles.

g. For minimum vertical clearances, see Section V-D-8-a-*4*, *Crossings* on page 44*.*

h. Utilities that cross sewer mains with the minimum vertical clearance shall be plotted to horizontal and vertical scale and identified in order to advise the contractor of their specific locations. For these utilities, stations and invert elevations shall be provided at every pipeline crossing for each pipe shown. If the elevation of the existing pipeline to be crossed is unknown or when the proposed clearance between an existing utility and the proposed utility is one foot (1') or less, the Engineer shall arrange to have a test pit excavated to determine the exact horizontal and vertical location of the existing utility or utilities prior to submission of preliminary construction drawings.

i. When a proposed or existing storm drain parallels a proposed sewer main, the storm drain shall be shown dashed in the background of the profile.

j. For existing developed properties, the finished floor or basement elevation of the dwelling to be served shall be projected on the profile along with the elevation relative to the house connection and to the correct vertical scale.

k. Sewer house connections into manholes shall only be permitted for terminal manholes. The connections to terminal manholes will be shown with the appropriate invert and lot number shown. All services within terminal manholes shall have the invert match top of bench.

l. The following information as minimum requirements shall be shown on the profile:
   - first floor and basement elevations for existing developed properties
   - road names
   - existing and proposed utilities, including storm drains
   - existing ground elevation line
   - proposed ground elevation line
   - bottom of stream or swale that parallels proposed sewer
   - 100-year flood elevation line with elevations
   - relocations of conflicting utilities
   - proposed finished road grade line
   - centerline of existing and proposed road crossings
   - date of topographical survey
   - centerline and name of intersecting street
   - limits of proposed fill and certified compaction

   The Engineer shall clearly note that the construction of the proposed sewer may not occur until the grade is within ± 0.2 feet of finished grade.

4. Pipeline Materials

   a. General: Pipeline design practices and materials used in the Baltimore County Sewer System are employed to ensure maximum service capacity with the least costs of installation and maintenance.

      The Engineer must be aware of the particular properties of each type of pipe so as to include or exclude the possibility of its employment under the greatest range of applications, leaving the construction contractor as many options as possible for the selection of the type of pipe to be installed. Any special design features and/or special materials required due to the specific nature of the project shall be submitted for approval to the Sewer Design Section.

      The following table presents the pipe materials that are acceptable to Baltimore County for interceptor and collector sewer construction. These materials are acceptable when supplied in conformance with the material and installation requirements of the Standard Specifications and this Design Manual.

PIPE TYPE MATERIAL	SPECIFICATION	SIZE ALLOWED
Polyvinyl Chloride (PVC) SDR35	ASTM D 3034 ASTM F 1336	6 thru 15-inch
Polyvinyl Chloride (PVC)	ASTM F 679 T-1 wall thickness ASTM 1336	18 thru 24-inch
Ductile Iron Class 52	AWWA C151	6 inches and larger
Reinforced Concrete Pipe (RCP)	ASTM C76	24 inches and larger
Prestressed Concrete Cylinder Pipe	AWWA C301	24 inches and larger

b. Special Circumstances

1) In addition to the types of pipe shown above, other pipe materials may be considered on a case-by-case basis when recommended by the Engineer and approved in writing by the Sewer Design Section.

2) The Sewer Design Section will require the use of DIP under the following circumstances:
   - for all open cut stream crossings (see *Pipeline Design in Wetlands, Stream Crossings and Tree Protection* for additional considerations for stream crossings)
   - sewers within casing pipes or tunnels shall be DIP
   - sewers greater than eighteen feet (18') deep
   - sewers proposed in fill areas

3) In areas where significant hydrogen sulfide concentrations are expected to exist, such as downstream from a pumping station or pressure sewer discharge, hydrogen sulfide resistant pipe materials, such as PVC, shall be used if available in the required diameter. If PVC is not an option in the required diameter, the Engineer shall investigate other solutions, such as special protective linings.

c. Underdrains: If groundwater conditions exist at the site which will be above the sewer main, the Engineer shall incorporate underdrains into the design if opportunities exist to drain the groundwater to storm drains, stormwater management ponds, or existing grades.

5. Change in Pipe Size

a. When a smaller sewer joins a larger one, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient.

b. Sewer extensions shall be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole constructed in accordance with Section VI – A, *Manholes*, with special consideration of an appropriate flow channel to minimize turbulence when there is a change in sewer size. A schedule for construction of future downstream sewer relief must be provided.

6. Installation

a. Standards: Installation specifications shall contain appropriate requirements based on the criteria, standards, and the requirements established by industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints, impeded cleaning operations and future connections, nor create excessive side fill pressures and ovulation of the pipe nor seriously impair flow capacity.

b. Trenching: The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the bedding and hunching to be placed and compacted to adequately support the pipe. Appropriate trench widths are shown in the Baltimore County Standard Details. The trench sides shall be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength shall be used.

   In unsupported unstable soil, the size and stiffness of the pipe, the stiffness of the embedment and insitu soil, and the depth of cover shall be considered in determining the minimum trench width necessary to adequately support the pipe.

   Ledge rock, boulders, and large stones shall be removed to provide a minimum clearance of four inches (4”) below and on each side of the pipe(s).

c. Bedding, Haunching and Initial Backfill: Bedding classes A, B, C, or crushed stone, as described in ASTM C12, shall be used and carefully compacted for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load based on the type of soil encountered and potential groundwater conditions.

   Embedment materials for bedding, haunching, and initial backfill, Classes I, II, or III, as described in ASTM D2321, shall be used and carefully compacted for all flexible pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load based on the type of soil encountered and potential groundwater conditions.

   All water entering the excavations or other parts of the work shall be removed until all the work has been completed. No sanitary sewer shall be used for the disposal of trench water unless specifically approved by the Engineer, and then only if the trench water does not ultimately arrive at existing pumping or wastewater treatment facilities.

d. Final Backfill: Final backfill shall be of a suitable material removed from the excavation except where other material is specified. Debris, frozen material, large clods or stones, organic matter, or other unstable materials shall not be used for final backfill with two feet (2') of the top of the pipe. Final backfill shall be placed in such a manner as not to disturb the alignment of the pipe.

e. CCTV Inspection: CCTV inspection must be performed in accordance with the Standard Specifications and *Specification Guidelines: Wastewater Collection Systems Maintenance and Rehabilitation* prepared by the National Association of Sewer Service Companies (NASSCO) and the *Handbook: Sewer Infrastructure Analysis and Rehabilitation,* EPA/625/6-91/030, October 1991.

7. Joints and Infiltration

a. Joints: The installation of joints and the materials used shall be included in the Specifications. Sewer joints shall be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.

b. Leakage Tests: Leakage tests shall be specified. This may include appropriate water or low pressure air testing. The testing methods selected should take into consideration the range in groundwater elevations during the test and anticipated during the design life of the sewer.

c. Water (Hydrostatic) Test: The leakage exfiltration or infiltration shall not exceed 200-gallons per inch of pipe diameter per mile per day for any section of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of two feet (2').

d. Air Test: The air test shall, as a minimum, conform to the test procedure described in ASTM C924 for concrete pipe; and for other materials, procedures approved by DPW.

8. Protection of Water Supplies

General: When wastewater systems are proposed in the vicinity of any water supply facilities, requirements of these design guidelines shall be used to maintain acceptable isolation distances. The following requirements shall also be followed:

a. Cross Connections Are Prohibited: There shall be no physical connections between a public or private potable water supply system and a sewer or appurtenance thereto which would permit the passage

of any wastewater or polluted water into the potable supply. No water pipe shall pass through or come into contact with any part of a sewer manhole.

b. Relation to Water Works Structures: While no general statement can be made to cover all conditions, it is generally recognized that sewers shall meet the requirements of these guidelines and the Maryland Department of the Environment (MDE) *Design Guidelines for Sewerage Facilities* with respect to the minimum distances from public water supply wells or other water supply sources and structures.

c. Relation to Water Mains: Sewers shall be laid at least ten feet (10') horizontally from any existing or proposed water main. The distance shall be measured from the outside diameter of each pipeline. In cases where it is not practical to maintain a 10' separation, DPW may allow deviation on a case-by-case basis if supported by data from the Design Engineer. Such deviation may allow installation of the sewer closer to the water main provided that the water main is in a separate trench and at an elevation so that the bottom of the water main is at least eighteen inches (18") above the top of the sewer measured from the outside diameter of both pipelines.

   If it is impossible to obtain proper horizontal and vertical separation, as described above, both the water main and the sewer must be constructed of mechanical joint pipe complying with the Standard Specifications; pipe must be pressure tested to 150 psi to assure watertightness before backfilling.

d. Crossings: Sewers crossing water mains shall be laid to provide a minimum vertical distance of 18" between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. The crossing shall be arranged so that the sewer joints shall be equidistant and as far as possible from the water main joints and will not be closer horizontally than 3' to the crossing, unless the joints are fully encased in concrete as required below. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to maintain line and grade.

   When it is impossible to obtain proper horizontal and vertical separation as stipulated above, one of the following methods must be specified:

   1) The sewer shall be designed and constructed equal to the water pipe and shall be pressure tested at 150 psi to assure watertightness prior to backfilling.

2) Either the water main or the sewer line may be encased in a watertight carrier pipe that extends 10' on both sides of the crossing, measured perpendicular to the water main. The carrier pipe shall be of materials approved by DPW for use in water main construction.

e. Relation to Wells and Reservoirs: Sewers shall be located no closer than 50' horizontally to water wells or reservoirs to be used for potable water supply.

f. Relation to Force Mains: Force mains will have no joint closer horizontally than 3' to the crossing, unless the joint is encased in concrete. The thickness of the concrete encasement will be a minimum of 4" at pipe joints.

g. Relation to Depressed Sewers: Depressed sewers crossing potable water lines must be installed below the water line with a minimum vertical clearance of 2'. .

E. Hydrogen Sulfide in Sewers

The corrosion of sewers and appurtenances and the impacts of odor and toxic gases are two important problems occurring in wastewater collection systems. Both of these problems can be attributed in large part to the generation of hydrogen sulfide (H_2S) in sewers. The EPA publication, *Process Design Manual for Sulfide Control in Sanitary Sewerage Systems*, contains a complete discussion of this topic.

Sewers shall be designed hydraulically to prevent excessive generations of H_2S. In general, small diameter sewers designed to maintain velocities greater than two feet (2') per second providing sufficient air-to-wastewater contact, normally do not experience a significant buildup of H_2S. Larger sized sewers may be susceptible to H_2S formation, but rates of generation can be reduced through proper design with concentrations limited to less than one (1) milligram per liter.

1. Corrosion Control: Where it is determined that the potential exists for damaging H_2S concentrations that will cause microbiologically induced corrosion, pipe materials must be selected to resist the microbiological corrosion and attack from sulfuric acid. Locations of concern may be where new sewer connections are made to older systems with a history of H_2S problems and deteriorating sewers and outfalls from pressure sewers and force mains. Chapter V lists various pipe materials and applications suitable for sewer use. As indicated, PVC and ABS, fiberglass, and vitrified clay are best suited for corrosive environments whereas concrete, ductile iron, and

cast iron soil pipe should be avoided unless special protective linings, coatings, or treatment are provided.

2. Sewer Gases: In designing the sewer system, consideration shall be given to the possibility of objectionable odors being emitted from manholes and sewers. As noted above, new sewer connections to older systems with a history of H_2S problems will very likely experience similar difficulties. In these cases, sewers and manholes will be located such that emissions of odorous sewer gases, and in particular H_2S, do not create a nuisance or hazard for nearby building occupants.

F. Low Pressure Sanitary Sewer Design

1. Policy
    a. It is the policy of DPW to promote the use of gravity sewer systems to the extent practical and feasible due to the reliability and low maintenance associated with gravity sewer systems. LPSS systems will not be considered as a method of providing sewer service that could otherwise be furnished by conventional gravity sewer systems.
    b. The grinder pump/low pressure sewer system shall be considered as a supplemental method for wastewater collection and not as a replacement for conventional gravity collection systems.
    c. Where the design of the low-pressure sewer system requires the use of pumping stations, the number of pumping stations and linear feet of force mains should be minimized.
    d. Grinder pumps on private property and connecting to County maintained gravity service connections to gravity sewers are privately owned and maintained and are subject to review and approval under the plumbing permit process.
    e. Grinder pump/pressure sewer systems are not to be used on an interim or temporary basis in anticipation of conventional gravity systems being installed in the future except under extraordinary circumstances.

2. Approval Required
    a. Submission to the Department – Requests for grinder pump/low pressure sewer systems must be submitted in writing to the Director of the Department of Public Works.
    b. Requirements for Approval – To receive approval from the Department of Public Works for the installation of a grinder pump/low pressure sewer system, the area to be served must have environmental, topographic or subsurface conditions which make it very difficult for potential users to be served by a gravity collection system or such conditions that make it very difficult or impractical to construct and maintain a gravity system.

c. Evidence Required –When submitting the request to the Department of Public Works, the applicant shall provide overwhelming evidence that gravity sewer installation is not feasible.
d. Review by Director
    1) Requests for grinder pump/low pressure sewer systems will be reviewed on a case-by-case basis and must be approved by the Director.
    2) Determinations of feasibility, difficulty or practicality shall be made by the Director based on the facts of each particular situation and the design of sewer systems must meet the needs of a particular situation.
    3) See Baltimore County Code Title 4, Subtitle 1 for additional information.

3. Design
   Hydraulic Calculation
    a. The design of the low-pressure sewer system shall be based on the probability method using HDPE Pipe (SDR-11) and Progressive Cavity Type Grinder Pump only.
    b. Minimum velocity shall be 2.0 feet per second
    c. Minimum size of pipe is one and one-half inches (1.5”)
    d. The Hazen-Williams friction coefficient (C Factor) shall be 150

4. Low Pressure Sewer Pipe Installation
   The method of pressure sewer pipe installation is the option of the Contractor unless otherwise stated in the Special Provisions or on the plans. Methods of installation allowed are:
    a. Open Cut
    b. Directional Drilling

5. Pipe Material
    a. For low-pressure lines, open trench construction, the material shall be Schedule 40, Schedule 80, SDR-21 polyvinyl chloride (PVC) pipe or high density polyethylene (HDPE) pipe, ASTM D1248, SDR 11.
    b. For low-pressure lines, directional drilling, the materials shall be high density polyethylene (HDPE) pipe, ASTM D1248, SDR-11.

6. Construction Drawings
   Construction drawings shall be drawn at a horizontal scale of 1” = 50’

    a. Grinder Pump
        1) In selecting a suitable location for our grinder pump on an owner’s property, Baltimore County requires that the grinder pump be:
            a) located as close to the road as possible

b) at least eight feet (8') away from any permanent structures
c) not located in the drip line of large trees or where tree roots may be damaged
d) within depth limitations to serve all existing plumbing, including the basement
e) not located in owner's sidewalks, access or driveways
f) if lot size limits grinder pump location to driveways, the grinder pump must be protected by railroad ties or concrete curb stops to prevent damage from vehicles

2) Grinder pumps shall be shown on the drawings and located with coordinates and labeled as simplex or duplex.
3) For each grinder pump, provide existing ground elevation at the grinder pump location and invert of the proposed inlet pipe.
4) The maximum depth of the inlet pipe is ten feet (10') from the existing/proposed ground.
5) All service lines between the grinder pump and low-pressure sewer shall be one and one half inches (1 ½").
6) Duplex grinder pumps, if used, must be located on or near the property line dividing two properties. Two (2), four-inch (4") inlets are required – one for each property.
7) Simplex grinder pumps, if used, must be located a minimum of seven and one half feet (7.5') from the property lines. One (1), four-inch (4") inlet is required.
8) Commercial property shall require a larger duplex grinder pump and must be located a minimum of seven and one half feet (7.5') from the property lines. One (1), six-inch (6") inlet is required.
9) Show the proposed electrical cable between the BGE meter and the grinder pump.
10) The disconnect panel is connected directly to the BGE meter.
11) On all plans in large bold lettering add either:
    - "**COUNTY MAINTAINED GRINDER PUMP**" or
    - "**PRIVATELY MAINTAINED GRINDER PUMP**"
12) The service valve assembly shall be located on the property line between the low-pressure pipe in the road and the grinder pump.
13) Electrical service between the house and the grinder pump shall not exceed two hundred feet (200').
14) All applicable Baltimore County standard grinder pump/low pressure sewer details shall be included on the Construction Drawings.
15) Record Plats
    For Developer projects, the record plat for the subdivision shall clearly and **boldly** identify all lots that will be served by a grinder

pump and shall note that these grinder pumps will be privately owned and maintained by the property owner.

b. Low Pressure Pipes
    1) Proposed low-pressure sewer pipe shall be located a minimum of ten feet (10') horizontally from water lines.
    2) Proposed low-pressure sewer pipe shall be a minimum of six feet (6') from all other utilities.

c. Manholes
    1) Show all manholes on drawings and locate with coordinates.
    2) Label all manholes as one of the following:
        a) Inline Cleanout/Flushing Connection Manhole
        b) Combination Flushing Connection and Air/Vacuum Release Valve Manhole
        c) Terminal Combination Flushing Connection and Air/ Vacuum Release Valve Manhole
        d) Intersection Flushing Connection Manhole

7. Profiles
   Profiles will be drawn with a horizontal scale of 1" = 50' and a vertical scale of 1" = 5'.

    a. Show proposed low-pressure sewer pipe in profile.
    b. Show stations for the low-pressure sewer every fifty feet (50') starting at a manhole with 0+00.
    c. At each fifty-foot (50') station, show the invert of the proposed low-pressure sewer pipe.
    d. Show all manholes, with station, inverts, type and coordinates.
    e. Manholes shall be located as follows:
        1) All high points shall have air/vacuum release valve manhole.
        2) All low points shall have inline cleanout manhole.
        3) All intersections shall intersection flushing connection manhole.
        4) All ends of pipe shall have terminal flushing connection manhole or, if required, a terminal air/vacuum release valve.
        5) At the end of County maintenance and beginning of private maintenance, an inline cleanout shall be required.
    f. The maximum horizontal distance between low-pressure sewer manholes hall be eight hundred feet (800').
    g. All utility crossings must be shown.
    h. All utility crossings shall have a minimum one-foot (1') vertical clearance.
    i. All existing or proposed utilities that parallel the proposed sewer shall be shown.
    j. The depth of proposed low pressure sewers shall be at least:

1) A minimum of six inches (6”) below any parallel water lines and
2) A minimum of four and one half feet (4.5’) below existing or proposed grade.

8. Maintenance of Grinder Pumps
   See Baltimore County Code Title 4, Subtitle 1

9. The Engineer/Designer shall become familiar with Baltimore County Special Provisions Part-B Specifications for the Pressure Sewer System.

VI. SEWER SYSTEM LAYOUT AND APPURTENANCES

A. Manholes

1. General

   a. Manhole Details are shown in the *Standard Details for Construction*. The Engineer shall use these standards as required to meet the design situation and shall designate the type on the profiles.

   b. When the pipe size entering and exiting manholes are the same, a minimum drop between invert in and invert out shall be one tenth of a foot (0.1'), and the maximum drop shall be one foot-eight inches (1'8"). For pipelines of different sizes, the pipeline crowns shall be matched. For interceptor sewers, the invert elevation of collector sewers and services shall match the crown elevation of the interceptor sewer. For manholes where vertical drops are required, see Section VI.A.12, Drop Manholes.

   c. The centerline of the manhole shall be located a minimum of three feet (3') from face of curb.

   d. Generally, manholes located within paved and mowed areas shall be constructed to proposed finished grade. Generally, manholes located within open space areas shall be a minimum of one foot (1') above existing ground.

   e. Manholes shall be placed where waterways are not likely to change direction or erode the area around the manhole, and locating manholes within streams shall be avoided. Manholes located within a floodplain shall be constructed with a watertight frame and cover.

   f. The crown of the outlet pipe from a manhole will be on line with or below the crown of the inlet pipe.

2. Locations

   Manholes shall be constructed at the following locations:
   - changes in alignment
   - changes in grade
   - change in pipe size
   - change in pipe material
   - pipeline junctions or intersections
   - at distances not to exceed 400 feet for sewer 15 inches or less and at distances 500 feet for sewers 18 inches to 30 inches except that distances up to 600 feet may be approved; greater spacing may be

approved in larger sewers provided the velocity is sufficient to prevent solids deposition
- at the terminal end of all sewers
- at locations along the sewer where future extensions are planned
- at locations where there is a change from public to private maintenance

3. Materials of Construction

   Manholes shall be pre-cast or poured-in-place concrete type. Manhole lift holes and grade adjustment rings shall be sealed with non-shrinking mortar or other approved material.

4. Size

   The minimum inside diameter of manholes shall be 48 inches for sewers less than 24 inches in diameter. For sewers 24 inches in diameter and larger, the minimum inside diameter shall be 60 inches. Larger diameter manholes may be required depending upon the locations of the sewers entering and exiting the manhole. A minimum one foot (1') of manhole wall is required between the outside diameters of pipelines where entering or existing the manhole. A minimum access diameter of 24 inches shall be provided as shown on the standard details.

5. Channel and Bench

   a. Typical manhole channels are shown in the standard details. If channeling for standard manholes that differs from what is shown in the standard details is required, the Engineer shall detail the channel on the plans, showing curve data, invert and bench elevations, and bench slopes, etc. This detailed information also shall be provided for all manholes over five feet (5') in diameter, bend structures, and junction chambers.

   b. Manhole channels shall not have a centerline radius of less than 2.5 times the pipe diameter.

   c. A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter.

   d. The diameter of the manhole installed must be large enough to accommodate a 12-inch wide bench on either side of the channel.

   e. The bench shall be sloped no less than one-half inch (½ ") per foot (4%). No lateral sewer, service connection, or drop manhole pipe shall discharge onto the surface of the bench.

f. The channel straight through a manhole shall be made to conform as closely as possible in shape and slope to that of the connecting sewers. The channel walls should be formed or shaped to the full height of the crown of the outlet sewer in such a manner to not obstruct maintenance, inspection, or flow in the sewers.

g. When curved flow channels are required or specified in manholes, including branch inlets, minimum pipe slopes shall be increased to maintain acceptable velocities.

6. Corrosion Protection

Where corrosive conditions exist or are anticipated, corrosion protection on the interior of manholes will be required. When corrosion protection is required by the Bureau of Engineering & Construction, the Engineer shall identify on the sewer profile where special manhole coating materials are to be used. One location where corrosion protection will be required is the discharge manhole for sewage force mains and pressure sewers. For new manholes, the coating shall consist of a minimum 16-mil factory-applied coal tar polyamide epoxy on all interior surfaces. For existing manholes, the manhole shall first be thoroughly cleaned by high-pressure washing (2000 psi minimum). The manhole walls shall then be lined pneumatically with Permacast by APM Permaform, high performance mix by Stron Seal, Sewper Coat by Lafarge Calcium Aluminates, or approved equal.

7. Watertightness

a. Watertight manhole covers are to be used whenever the manhole covers may be flooded by surface water runoff, ponding, or high water to prevent storm water inflow. Manhole top elevations will be set to avoid submergence of the cover.

b. Manholes located within the 100-year floodplain shall extend above existing ground or proposed grade and shall be constructed with a watertight frame and cover as indicated in the Standard Details.

c. A stainless steel insert dish shall be installed within all manholes when the edge of the cover is five feet (5') or less to the face of the curb or center of the gutter flow line. A stainless steel insert dish also shall be installed in all manholes within the vertical sump of roadways, when the manhole is within a swale or ditch, and when the manhole is located between homes on a side lot line. The Engineer shall identify on the construction drawings which manholes will receive an insert dish. A stainless steel insert dish also may be required at other locations that may be determined as necessary by the Bureau of Engineering & Construction

on a case-by-case basis. If an insert dish is installed, then a watertight frame and cover is not required.

d. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to occur.

e. In areas subject to high groundwater tables, manholes will be constructed of materials resistant to groundwater infiltration.

8. Deep Manholes

The manhole depth is defined from the lowest invert to the top of the frame and cover. Approval of the Bureau of Engineering & Construction is required for manhole depths exceeding thirty feet (30'). If the manhole depth exceeds thirty feet (30'), the Engineer shall take into consideration the following design requirements:

- provide computations from a Professional Engineer indicating that flotation will not occur
- verify that the groundwater pressure on the pre-cast concrete manhole section joints will not exceed the requirements of ASTM C443 latest revision and the standard specifications
- verify that the groundwater pressure on the pipe to manhole connections will not exceed the requirements of ASTM C923 latest revision and the standard specifications
- identify any modifications necessary to the standard manhole details as a result of the manhole depth and groundwater pressure
- where deep manholes are approved by the Bureau of Engineering & Construction, manholes over thirty feet (30') deep shall have a minimum five-foot (5') inside diameter, from invert to the cone section (the inside diameter from the invert to the cone section may be larger depending upon the pipe sizes entering and exiting the manhole as outlined in Section VI.A.4, Size)
- an intermediate landing or platform is required to be installed in all manholes exceeding twenty feet (20') deep; a landing or platform shall be provided for each ten feet (10') of height or fraction thereof

9. Terminal Manholes

a. Terminal manholes shall be constructed at the end of a sewer that will not be extended in the future. Terminal manholes shall meet the requirements of the standard details.

b. A maximum of three (3) sewer service connections shall enter a terminal manhole. A minimum of thirty degrees (30º) shall be provided between each service. The connections shall not spill over the bench.

10. Doghouse Manholes

    Doghouse manholes will be approved by the Bureau of Engineering & Construction only on a case-by-case basis. Doghouse manholes shall meet all requirements of the Standard Details.

11. Drop Manholes

    a. Design details, as well as maximum and minimum allowable drops, are indicated for drop manholes in the Standard Details for various sewer sizes. When the drop required is less than the minimum indicated on the Standard Details, no drop manhole is required. In lieu of a drop manhole, the slopes of the connecting pipelines and manhole channel shall be adjusted and sloped to limit the difference between the invert in and invert out of the manhole to less than one foot eight inches (1' 8").

    b. The channel shall be shaped to prevent solids deposition.

12. Inspection and Testing

    The standard specifications include a requirement for inspection and testing for watertightness and damage to the manhole prior to being placed in service.

B. Siphons

1. General

   Inverted siphons should have not less than two (2) barrels with a minimum size of six inches (6"). They shall be provided with the necessary appurtenances for maintenance, convenient flushing, and cleaning equipment. The inlet and discharge structures shall have adequate clearances for cleaning equipment, inspection, and flushing.

2. Design

   a. Design shall provide sufficient head and appropriate pipe sizes to provide velocities of at least three feet per second (3 fps) for average design flows.

   b. The inlet and outlet details shall be so arranged that the design average flow is diverted to one (1) barrel and so that either barrel may be removed from service for cleaning.

   c. The vertical alignment should permit cleaning and maintenance.

C. Building Connections

1. General

   a. Building connections are to be provided to connect individual buildings to the collector sewer main. Unless otherwise approved, one (1) building connection shall be allowed per lot. Building connections shall be shown on the plan and profile as described in Section V-D, *Details of Design and Construction,* page 29.

   b. Building connections shall be planned to eliminate as many bends are practical and to provide convenience in cleaning. Bends greater than forty-five degrees (45º) made with one (1) fitting should be avoided. Combinations of elbows, such as 45º-45º or 30º-60º, should be used with a cleanout provided. Generally, connections to other sewers will be made directly to the pipe with standard fittings rather than through manholes. However, a manhole must be used if the connection is more than 100 feet from the building cleanout. Normally, the cleanout inside the building will not be adequate for cleaning; thus, outside cleanouts will be provided. Installation of a two-way cleanout at the building connection five feet (5') from the footing is recommended. Manholes will be installed where cleanouts are not feasible.

2. Location

   a. The County-owned and maintained portion of the sanitary sewer building connection shall be built to the property line or edge of the drainage and utility easement, whichever applies.

   b. For Capital Projects, all building connections for improved lots shall be located so as to readily serve the basement or lowest floor of the existing dwellings or buildings in a cost effective manner. If it is not feasible, practical or economical, the Engineer shall propose first floor service in lieu of basement service. Where the location or depth of the sewer main is established by a crucial building house connection, this connection shall be located by the Engineer in the most advantageous position to minimize costs while providing basement service to the lot. In non-critical areas, the actual location of the building connection shall be determined after discussion with the property owner in the field prior to construction as long as the location is compatible with the collection system as designed. However, it shall be the responsibility of the Engineer to propose a feasible location for the building connection based on the location of existing wells, septic tank facilities, topography, and other features.

c. For developer projects, all building connections shall be designed to provide basement service. If it is not feasible or practical, or the building connection will drive the sewer main excessively deep, the Engineer shall propose first floor service in lieu of basement service. All improved properties having frontage on the collector sewer that are not a part of the proposed subdivision, but which may be served by the sewer main, shall be shown on the Contract Drawings. Connections to these lots, whether negotiated by the developer or required by the Bureau Engineering & Construction, shall be installed on the Contract Drawings.

d. Cleanouts are required to be installed on all building connections and must be located and constructed in accordance with the Standard Details.

e. When adjacent to a building connection, the entire stormwater management facility shall be shown on the plan view of the Construction Drawing. The location of the building connection shall not cause the private on-site service to pass through stormwater management facilities.

f. For residentially zoned properties, if the type of dwelling unit changes after design approval, then the building connection shall be revised on the Construction Drawings to meet the configuration of the proposed developments.

g. If a sewer main traverses between two adjacent lots, the building connection shall not be located adjacent to the building.

h. For new subdivisions, all proposed driveways shall be shown in plan view on the Construction Drawings.

i. Connections shall be located on the downstream side of the property.

3. Size

The size of all building connections shall be six inch (6”) or eight inch (8”) in diameter depending on the proposed use and type and the discharge flow requirements established by the Engineer. The size of the building connection for condominiums or apartments shall be no less than eight inches (8”).

4. Grades

Building connections shall be designed for a two percent (2%) minimum grade. The maximum allowable grade for a building connection shall be ten percent (10%). Drop connections shall be laid on a fixed grade of two percent (2%).

5. Depth

   Minimum cover over the building connection at the property line or easement shall be three and one-half feet (3½'). Where storm drains have not been proposed or installed, building connections shall have a minimum cover within the street right-of-way of six and one-half feet (6½'). The maximum depth at the property line shall not exceed twelve feet (12').

6. Type

   Connections for the various types of development shall be as follows:
   - single-family detached and attached – individual sewer services
   - townhouse condominium – individual sewer service
   - multi-family (apartments) – sewer service to the property line with private on-site sewers unless public sewers are required to traverse the property to serve other properties
   - multi-family (apartment style condominiums) – one sewer service to each building; on-site sewers shall be publicly owned only if the sewer mains will provide service to adjoining properties
   - single-family – panhandle lots – individual sewer service connections shall extend to the edge if the road right-of-way unless otherwise approved by the Bureau of Engineering & Construction. Publicly owned sewer mains shall extend within the panhandle lots if the sewer is required to be extended to adjoining properties.
   - boat pump-out facilities – boat pump-out facilities at marinas shall include semi-positive displacement pumps equipped with hour meters. The grinder pump shall be owned and maintained by the property owner. A meter agreement shall be prepared and executed by both Baltimore County and the property owner.

7. Materials

   Building connection materials shall meet the requirements of the Standard Specifications and the approved source of supply.

8. Alignment

   Service connections shall be perpendicular to mains and have no change in direction between the main or manhole and the cleanout at the property line. Services can only be connected to manhole if the structure is a terminal manhole. Services entering a terminal manhole must be placed at an angle ninety degrees (90º) or greater than the outgoing sewer main alignment. In general, services entering a manhole shall be designed so that the crown of the service main matches the crown of the incoming main.

9. Clearance

    a. Crossing Water Main: Clearance shall be measured between outside of pipes. Sewer house and building connections crossing water mains (existing or future) shall have a minimum of twelve inches (12") clearance below water mains. Sewer house and building connections crossing above water mains shall have a minimum of twelve inches (12") clearance and be encased in concrete ten feet (10') each side of water main.

    b. Parallel to Water House Service: Sewer house and building connections shall ordinarily be not less than seven feet (7') horizontally from water house services and a minimum of twelve inches (12") clear below water house services.

    c. Crossing Storm Drains and Other Utilities: Sewer house and building connections crossing storm drains and other utilities (existing or future) shall have a minimum clearance of twelve inches (12") from these utilities.

10. Abandonment

    When a property is developed, all unused service connections shall be abandoned at the property line. Cleanouts shall be removed and watertight caps shall be installed on the service.

D. Cleanouts

1. Cleanouts must be installed on all sewer building connections to provide a means for cleaning the connection. An acceptable cleanout is shown in Standard Detail S-12A.

2. Cleanouts shall not be located within sidewalks, driveways, or steps. If allowed, sewer services placed within a paved area for non-residential properties shall have a frame and cover placed over the cleanout in accordance with the Standard Details.

3. Cleanouts shall not be located any closer to a building than the depth of the building connection at the cleanout. In no case shall the cleanout be closer than fifteen feet (15') from the structure.

E. Sewers in Relation to Streams

1. Cover Depth

    a. The top of all sewers entering or crossing steams shall be at a sufficient depth below the natural bottom of the streambed to protect the sewer line. In general, the following cover requirements must be met:

- Two feet (2') of cover where the sewer is located in rock.
- Three and one-half feet (3½') of cover in other material. In major streams, more than 3½' of cover may be required.
- In paved steam channels, the top of the sewer line should be placed below the bottom of the channel pavement.

b. Less cover may be approved only if the proposed sewer crossing will not interfere with the future improvements to the stream channel. Reasons for requesting less cover shall be provided in any request for deviation from these guidelines.

2. Horizontal Location

Sewers located along streams shall be located outside of the streambed and sufficiently removed to provide for future possible stream widening and to prevent pollution by siltation during construction.

3. Structures

The sewer outfalls, headwalls, manholes, gate boxes, or other structures shall be located so that they do not interfere with the free discharge of flood flows of the stream.

4. Alignment

Sewers crossing streams shall be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade. Sewer systems shall be designed to minimize the number of stream crossings.

5. Construction

a. Materials

Sewers entering or crossing streams shall be constructed of ductile iron pipe with mechanical joints; otherwise, they shall be constructed so that they will remain watertight and free from changes in alignment or grade. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials that will not readily erode, cause siltation damage to the pipe during placement, or corrode the pipe.

b. Siltation and Erosion

Construction methods that will minimize siltation and erosion shall be employed. The design Engineer shall include in the project specifications the method(s) to be employed in the construction of sewers in or near

streams. Such methods shall provide adequate control of siltation and erosion by limiting unnecessary excavation, disturbing or uprooting trees and vegetation, dumping of soil or debris, or pumping silt-laden water into the stream. Specifications shall require that cleanup, grading, seeding, and planting or restoration of all work areas shall begin immediately. Exposed areas shall not remain unprotected for more than seven (7) days.

F. Aerial Crossings

1. General

   Approval from the Bureau of Engineering & Construction is required for the use of aerial crossings.

2. Support

   Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave overturning and settlement.

3. Freezing

   Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above and below ground sewers. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize frost heaving.

4. Impact of Flood Waters

   For aerial stream crossings, the impact of floodwaters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the 100-year flood elevation. Ductile iron pipe with mechanical joints is required.

VII. PIPING - Pipe Materials, Fittings, and Joints

A. Factors to be considered in the selection of pipe materials and piping systems for sewers or force mains are:

- flow characteristics or friction coefficient,
- life expectancy and history of use,
- resistance to scour and abrasion,
- resistance to acids, alkalis, high temperature, corrosive wastes and soils,
- ease of handling and installation,
- physical strength and pressure ratings,
- joint water tightness and ease of installation,
- availability of pipe in required sizes, strengths, etc.,
- availability of fittings, connections, and adapters.

Pipe, fittings, and joints serving as part of force mains will be selected to withstand the maximum internal operating pressures, including transient surges. The project specifications will indicate the appropriate pressure class and rating for each pipe application. No pipe manufactured is suitable for all installation requirements and conditions. Each type of pipe will be evaluated to determine its suitability for the particular design. Pipe materials that are determined to be inappropriate for use will be deleted from the project specifications.

B. Where iron or concrete pipe are to be considered, special attention will be paid to subsurface and soil conditions. The characteristics of the soil in which a pipe is placed affect the rates of corrosion, with the most corrosive soils being those having poor aeration and high values of acidity, electrical conductivity, dissolved salts, and moisture content.

C. In areas where problems with root penetration are anticipated, pipe with a joint that will successfully resist root penetration shall be specified. Generally speaking, the more watertight the joint, the greater will be the resistance to root penetration. Rubber-gasketed and compression-type joints are considered to provide the tightest joints. Also, pipe that comes in longer lengths are preferred.

VIII. FORCE MAINS

A. General

The pipeline, which receives wastewater from a pumping station and conveys it to the point of discharge, is called a force main. The design of the force main must be coordinated with the pumping station design. Force mains will be designed as pressure pipe and must be adequate in strength to withstand an internal operating pressure equal to the pump discharge head plus an allowance for transient pressures caused by water hammer. The internal operating pressure is maximum at the pumping station and is reduced by friction to atmospheric pressure, or near atmospheric pressure, at the point of force main discharge. The primary consideration in the hydraulic design of force mains is to select a pipe size that will provide the required minimum velocities without creating excessive energy losses due to pipe friction. The most economical size of force main should be determined on the basis of power costs required for pumping and capital investment costs for piping and equipment. In practice, however, the size usually is governed by the need to maintain minimum velocities at low flows to prevent deposition of solids and to develop sufficient velocity at least once a day to re-suspend any solids that may have settled in the line. Regardless of pipe sizes required for minimum velocities, the minimum diameters to be used are 1½ inches for pressure sewers at grinder pump installations, 4 inches for force mains serving small pump stations and pneumatic ejectors, and 6 inches for all other force mains.

B. Hydraulic Calculations

The system curve for the force main, showing the total energy losses associated with the range of possible pumping rates, shall be developed and shall be shown on the plans. Design velocities in force mains shall generally be between 2 and 6 feet per second. The maximum velocity shall be based on the ultimate design pumping rate.

C. Plan View

1. When installed parallel to a water main, the force main shall be designed per the horizontal and vertical clearances indicated between water and sewer mains in Chapter V.

2. When installed parallel to an existing sewer pipeline, provide 5 feet minimum horizontal clearance as measured from the outside edges of the pipes.

D. Profile

1. The Engineer shall strive to achieve a vertical profile that rises continuously from the pumping station toward the discharge manhole.

2. Ideally, the force main shall be designed without intermediate high points and with the top of the force main below the hydraulic grade line at the minimum pumping rate so that air release valves will not be needed. If the elimination of high points is not feasible, or if the design requires long, relatively flat vertical alignments, the design may require air release and air and vacuum valves.

3. Continuous uphill pumping shall be achieved in order to keep the force main full.

4. Force mains, with intermediate high points above the gravity sewer discharge point, can create partial vacuum conditions in the force main under circumstance such as draining conditions that occur due to intermittent pumping or when the HGL profile drops below the pipeline profile. The Engineer shall provide appropriate air release and air vacuum valves to protect the force main against damage under these conditions.

5. Downhill pumping is prohibited.

6. All force mains shall have a minimum of 3.5 feet of cover. In street rights-of-way, cover shall be measured from the top of the force main to the proposed grade; or in cases when the proposed grade is above the existing ground surface, the depth of cover shall be measured from the existing ground line. In easements across private property, future development in the area shall be given consideration when developing the force main profile and possible future development grades shall be evaluated to ensure that the minimum depth of cover is met. In situations where the force main parallels a water main, the force main depth shall be no less than 4.5 feet to avoid conflicts with water services.

7. The top of the force main and its appurtenances shall generally be designed to be lower than the HGL.

8. The following minimum information shall be shown on the profile:
   - existing and proposed utilities (longitudinal parallel utilities shall be “ghosted” in profile) including storm drains
   - road names
   - existing ground elevation line
   - proposed ground elevation line
   - existing and proposed road grade profile
   - areas requiring fill with certified compaction

- centerline and name of intersecting streets
- limits of restrained joint pipe

E. Appurtenances

1. Air Release and Air and Vacuum Valves: Force mains shall ideally be designed to rise continuously in profile from the pumping station to the point of discharge. To minimize installation and maintenance costs, the Designer shall evaluate the feasibility of eliminating intermediate high points by installing the main deeper below grade. Where this is not practical, the Designer shall include an automatic combination of air and vacuum valves at the intermediate high points to expel accumulated air under pressure to allow air into the force mains to prevent vacuum conditions and to expel larger quantities of air when the mains are filled. Air release and vacuum valves on wastewater force mains shall be specifically manufactured for wastewater service, be sized according to manufacturer's recommendations, and shall be placed in pre-cast manholes per the Standard Details.

2. Discharge Manholes: The connection between the force main and gravity sewer shall be designed with a discharge manhole. The termination of the force main in the discharge manhole shall be designed so that the force main will be flowing full at all times. See the Standard Details for discharge manhole details.

    a. For new manholes, the interior of the discharge manhole shall receive two coats of a factory-applied polyamide coal tar epoxy for a total dry film thickness of 16-mils. Existing manholes shall be lined in accordance with the Sewer Design Section manhole-lining specifications. Additional manholes further downstream also may require coatings. This determination will be made based on pipe slopes, flow and manhole spacing.

    b. Odor control may need to be provided at every discharge manhole.

    c. There shall be no branch laterals or SHCs at a discharge manhole.

F. Pipeline Materials

Force Mains, 6-inches in diameter and larger, shall be DIP, minimum Class 54, or PCCP in accordance with the Standard Specifications.

G. Pipe Restraint

1. Thrust Restraint Design for Buried Pipelines

Force mains shall be restrained to resist thrusts that develop at bends, tees, wye connections, reducers, and plugs in the pipe. The magnitude of such forces can be calculated with the use of formulas found in standard hydraulic textbooks. Required methods of restraint will consist of mechanical joint restraints or concrete thrust blocks and anchors.

Buttresses are shown in the Standard Details and are to be used in all cases compatible with design conditions. The Engineer shall verify that the standard buttresses, shown in the Standard Details, apply to the specific conditions of each particular design. If required, the Designer shall prepare and submit thrust restraint calculations based on internal hydraulic surge pressures and soil bearing capacities as determined by field measurements.

2. Alternate Buttress/Restrained Joint Design

   a. Special or Modified Thrust Blocks: Special or modified thrust block details are to be employed for conditions not covered by the Standard Details. All buttresses shall be designed based on actual soil conditions, groundwater depths, and design pressures.

      Horizontal bends, reducers, tees, tapping sleeves and valves (TS&V), plugs and caps shall be designed using one of the appropriate earth pressure theories available. *Design Method for Vertical Anchor Slabs in Sand* by N. Krebs Oversen and Helle Stormann is recommended. (See Pages 1481 to 1500, *Performance of Earth and Earth-Supported Structures*, Volume 1, Part 2, ASCE, 1972.) A design concept based on bearing capacity shall not be used. For blocks in cohesive soils, the soil resistance shall be evaluated in terms of short and long-term shear strengths. The lowest resistance between the two shall be used for the design. The calculated net soil resistance for the block to be used shall be at least 1.5 times the design thrust force. Design criteria for pipe anchors for vertical bends shall neglect the weight of the earth over the pipe. The weight of the pipe, and water in the pipe, also shall be considered negligible for pipe 16 inches in diameter and smaller.

   b. Restrained Joints: In lieu of special or modified thrust blocks, restrained joint pipe may be allowed in conjunction with the standard thrust blocks.

      All design of restrained joint systems shall be in accordance with the Ductile Iron Pipe Research Association (DIPRA) Thrust Restraint Design for Ductile Iron Pipe (1997) or Concrete Pressure Pipe Manual of Water Supply Practices M9. All restrained joint designs shall have a factor of safety of 1.5. All design parameters for restrained joint designs shall be based on actual field conditions, including soil types, groundwater conditions, design depths, and pipeline pressures.

Computations must be submitted for all restrained joint conditions. The limits of restrained joint pipe shall clearly be shown on the profile. The actual length of restrained joint pipe limits shall be rounded up to the next standard length of pipe or to the nearest fitting, whichever is greater.

H. Water Hammer

1. When the velocity of a fluid is changed, a phenomenon known a water hammer may result leading to fractures of the pipe and fittings and other damage.

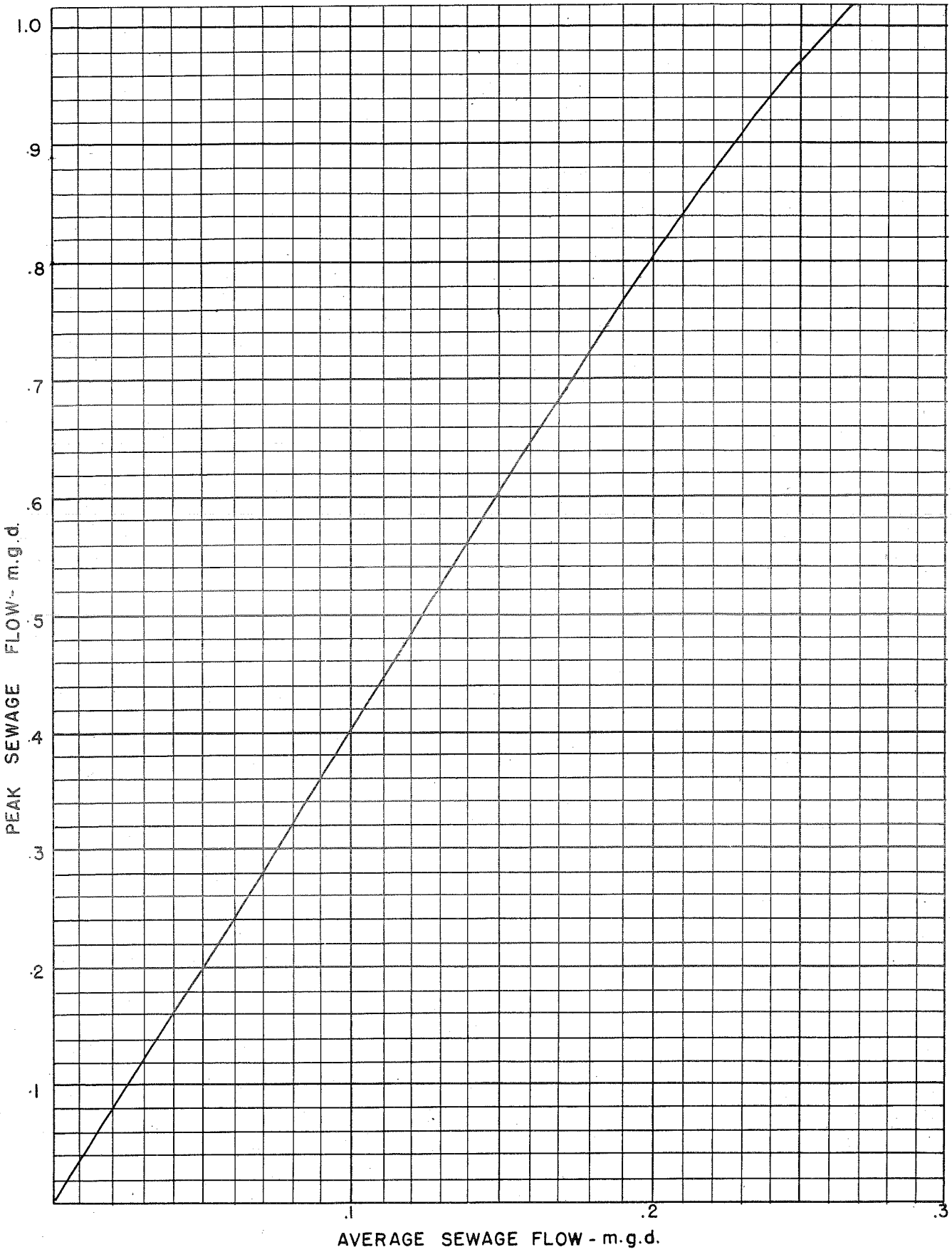
2. The Engineer shall prepare a complete study of each force main design in conjunction with related pumping station. A written detailed analysis, along with supporting calculations, shall be submitted to the Sewer Design Section for approval during the engineering report phase of the project. This analysis shall include, and is not necessarily limited to, the following:
   - transient pressures due to water hammer and the effect of these pressures on the entire system
   - investigation of the pipeline profile to determine the possibility of water column separation
   - reverse rotation characteristics of the pumps
   - shut-off characteristics of the proposed pump control valves
   - a computer analysis of the transient pressures combined with the total system characteristics
   - substantiation for the use of surge valves, extraordinary pipe supports and bracing, when necessary, listing recommended size and computed discharge pressures

I. Identification

When force mains are constructed of material that might cause the force main to be confused with potable water mains, the force main shall be appropriately identified.

APPENDIX

Maryland Department of the Environment Peaking Curves



DEPARTMENT OF PUBLIC WORKS

SANITARY SEWER DESIGN STANDARDS

PEAK FLOW CURVE

0 TO 0.3 mgd

Maryland State Department of Health

ISSUED: AUGUST 22, 1955

REVISED: JANUARY 7, 2010

REVISED:

PLATE

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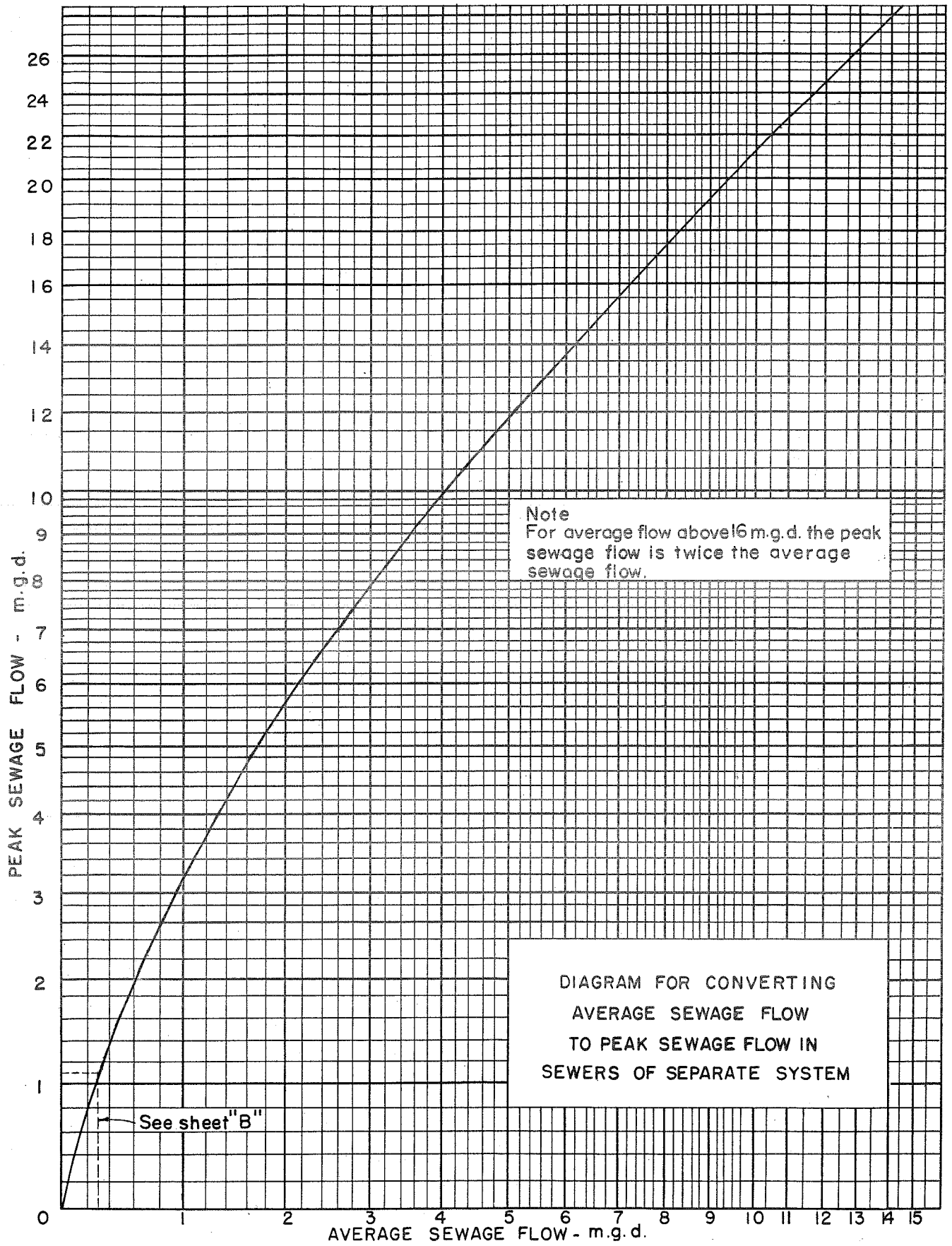

DEPARTMENT OF PUBLIC WORKS

SANITARY SEWER DESIGN STANDARDS

PEAK FLOW CURVE

0 TO 14 mgd

Maryland State Department of Health

ISSUED: AUGUST 22, 1955

REVISED: JANUARY 7, 2010

REVISED:

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