STORMWATER DRAINAGE DESIGN MANUAL

CITY OF JONESBORO
CRAIGHEAD COUNTY COUNTY
ARKANSAS

September 2008

Revised February 2009
STORMWATER MANAGEMENT REGULATIONS

REGULATIONS DESIGNED TO LESSEN AND AVOID HAZARDS TO PERSONS AND PROPERTY CAUSED BY OBSTRUCTION TO DRAINAGE, AND TO OTHERWISE PROMOTE THE PUBLIC HEALTH, SAFETY AND GENERAL WELFARE.

ARTICLE 1

1.1 Title – These regulations shall hereafter be known, cited and referred to as the “Stormwater Management Regulations” of the City of Jonesboro, Arkansas.

1.2 Authority – These regulations are adopted pursuant to the power and authority vested through the applicable laws and statutes of the State of Arkansas.

1.3 Applicability – The provisions of this regulation are applicable to all persons, firms, corporations, business, or other legal entity proposing to develop land in the City of Jonesboro Planning jurisdiction.

1.4 Purpose – In order to promote the public health, safety, and general welfare of the citizens of Jonesboro, the provisions of these regulations are intended to: (1) reduce property damage and human suffering, (2) minimize the hazards of personal injury and loss of life due to flooding, and (3) protect water quality and the environment.

1.5 Definitions – For the purpose of these regulations, certain terms and words shall be used, interpreted, and defined as set forth in this section. Unless the context clearly indicates to the contrary, words used in the present tense include the future tense; words used in the singular shall include the plural, and vice-versa; and the word, “shall,” is always mandatory.

A. Base Flood – The flood that has a one (1) percent chance of being equaled or exceeded in any given year, i.e., the 100-Year Flood.

B. Bond – The form of security for the completion or maintenance of drainage improvements.

C. Building – Any structure built for the support, shelter, or enclosures of persons, animals, chattels, or movable property of any kind.

D. Channel – Course of perceptible extent which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water, and which has a definite bed and banks.

E. Compliance Letter – An acceptance letter issued by the City Engineer based upon the review of the Stormwater Management plan or construction plans as prepared and certified by the Engineer of Record for a project.

F. Conduit – Any open or closed device for conveying flowing water.

G. Critical Facilities – Include: Governmental facilities that are considered essential for the delivery of critical services and crisis management (such as data and
communication centers and key governmental complexes); facilities that are essential for the health and welfare of the whole population (such as hospitals, prisons, police and fire stations, emergency operations centers, evacuation shelters and schools); mass transportation facilities (such as airports, bus terminals, train terminals); lifeline utility systems (including potable water, wastewater, oil, natural gas, electric power and communications systems); high potential loss facilities (such as nuclear power plants or military installations); hazardous material facilities (such as industrial facilities housing or manufacturing or disposing or corrosives, explosives, flammable materials, radioactive materials and toxins).

H. Detention – The temporary detaining or storage of floodwater in reservoirs, on parking lots, on rooftops, and other areas under predetermined and controlled conditions accompanied by controlled release of the stored water.

I. Detention Basins – Any man-made area which serves as a means of controlling and temporarily storing stormwater runoff. The facility normally drains completely between spaced runoff events, e.g., parking lots, rooftops, athletic fields, dry wells, oversized storm drain pipes.

J. Developer – A person, legal entity, or its representative that improves unimproved land or rehabilitates or adds improvements to an existing improvement on previously improved land.

K. Development – Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations or storage of equipment or materials.

L. Differential Runoff – The volume and rate of flow of stormwater runoff discharged from a parcel of land or drainage area which is or will be greater than the volume and rate which existed prior to the development.

M. Drainage Easement – Authorization by a property owner for use by another party or parties for all or any portion of his, her, or its land for drainage purposes.

N. Engineer of Record – A professional engineer registered in the State of Arkansas who is responsible for the design and construction administration, observation, and inspection of the stormwater facilities proposed for specific development or redevelopment projects of all facilities to be dedicated to the City of Jonesboro.

O. Flooding – An overflowing of water resulting in the inundation or submergence of normally dry land.

P. Floodplain – A land area adjoining a watercourse which is likely to be flooded.

Q. Floodway – The channel of a watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without a cumulative increase of the water surface elevation more than a designated height.
R. **Freeboard** – A factor of safety expressed as the difference in elevation between the top of the detention basin dam, levees, culvert entrances and other hydraulic structures, and the design flow elevation.

S. **Grading Permit** – A permit issued by the City Engineer which allows land disturbance activities (e.g., clearing, grading, excavation, etc.) on a specific development.

T. **Lowest Floor** – Refers to the lowest floor of the lowest enclosed area (including basement). For a typical **slab-on-grade construction**, the elevation of the lowest floor is the top of the first floor of the house. For a typical **basement foundation construction**, the elevation of the lowest floor is the top of the basement floor. For a typical **crawl space foundation construction**, the elevation of the lowest floor is the top of the first floor of the house. For typical **split-level constructions**, the elevation of the lowest floor is the top of the first living floor – the **garage floor** is not the lowest floor as long as there are no living areas in the garage and it is used solely for storage, parking vehicles and entry to the house. The elevation of the lowest floor of a **manufactured home**, however, is the bottom surface of the lowest floor joist.

U. **Maintenance**:

**Short-term Maintenance** – General upkeep of the site and facilities, specifically the mowing or trimming of grasses or other vegetative cover and the removal of litter and other minor debris that could impact the functionality of the facilities or that would otherwise be considered unsightly or a nuisance.

**Long-term Maintenance** – Removal of sediment deposits, re-grading or shaping of embankments, drainage channels, and detention areas, and repair or replacement of piping networks, and other drainage structures.

V. **NRCS (SCS) Method** – A methodology developed by the Natural Resources Conservation Service (formerly the Soil Conservation Service) for obtaining a design hydrograph to simulate the discharge from a watercourse over a specific time period.

W. **On-site Detention** – Temporary storage of runoff on the same land or development site where the runoff is generated.

X. **Peak Flow** – The peak rate of flow of water at a given point in a watercourse or conduit.

Y. **Plat** – A legally recorded plat of a parcel of land subdivided into lots with streets, alleys, easements, and other land lines drawn to scale.

Z. **Project** – Any development involving the construction, reconstruction, or improvement of structures or grounds, or both.

AA. **Retention Basin** – A stormwater detention facility which maintains a fixed minimum water elevation between runoff events except for the lowering resulting from losses of water to infiltration or evaporation.
BB. Special Flood Hazard Area (SFHA) – The land area covered by the floodwaters of the base flood.

CC. Stormwater Drainage Design Manual – The set of drainage policies, analysis methods, design charts, stormwater runoff methods, and design standards used by the City of Jonesboro as the official design guidelines for drainage improvements consistent with the regulations.

DD. Stormwater Management System – The collection of open channels, drainage swales, detention facilities, retention facilities, and enclosed conduits that comprise the overall drainage system for an area or region.

EE. Stormwater Runoff – Water that results from precipitation which is not absorbed by the soil, evaporated into the atmosphere, or entrapped by ground surface depressions and vegetation, which flows over the ground surface.

FF. Stormwater Runoff Management Facility – Any facility constructed to manage or otherwise control the flow of stormwater runoff from a site including but not limited to open channels, drainage swales, detention facilities, retention facilities, or enclosed stormwater conveyance systems.

GG. Structure – Any object constructed above or below ground. Pipes, manholes, and certain other utility structures which exist underground may be excluded from the definition.

HH. Sub-basin – The area that contributes stormwater runoff to a given point in the overall stormwater management system.

II. Substantial Damage – Damage of any origin where the cost to restore a structure to its original undamaged state would equal or exceed 50% of the market value of the structure before any damage occurred. In determining whether substantial damage has occurred, estimators must use standard contractor and materials costs. There are no exceptions for homeowners who make their own repairs or for discounted or free raw materials.

JJ. Substantial Improvement – Any reconstruction, remodeling, addition or improvement to a structure with a cost equaling or exceeding 50% of the market value of the structure before any improvement. Improvements to correct identified violations of local health, sanitary or safety Codes are not substantial improvements, regardless of the cost, as long as they are the minimum improvement necessary to bring the structure up to Code. Alterations to historical structures are also exempted, as long as the improvement does not affect the structure’s official status of “historical structure.”

KK. Swale – A ditch or depression that is cut into the soil that allows the flow of water to pass.

LL. Watercourse – Any surface stream, creek, brook, branch, depression, reservoir, lake, pond, river, ditch, wetland, swamp area, or drainage way in or into which stormwater runoff flows.
ARTICLE 2
STANDARD PROVISIONS

2.1 General This article establishes the standard provisions of the City of Jonesboro Stormwater Management Regulations.

2.2 Stormwater Management Plan (SWMP) Required - Any person, firm, corporation, business, or legal entity proposing to develop land within the City of Jonesboro Planning jurisdiction shall prepare and submit a SWMP to the City Engineer for review and be issued a Compliance Letter prior to commencement of construction of the improvements, except for the following:

- One new or existing single-family structure;
- One new or existing duplex family structure;
- One existing commercial or industrial structure where additional structural and site improvements are less than 2000 square feet.

2.3 Stormwater Pollution Prevention Plan (SWPPP) Required – Any person, firm, corporation, business, or legal entity proposing to disturb for construction purposes (e.g., clear, grade, excavate, etc.) one (1) acre or more of total land area, or less than one (1) acre of total land area that is part of a larger common development or sale if the larger common plan will ultimately disturb one (1) acre or more, shall prepare and submit a SWPPP to the City Engineer for review and be issued a Grading Permit prior to commencement of the proposed land disturbance activities.

2.4 Drainage Alterations or Modifications Permit Required - No person, firm, corporation or business shall alter or modify any open channel, drainage swale, detention facility, enclosed stormwater conveyance system, or other watercourse either natural or artificial where any of said facility is part of the City of Jonesboro Stormwater Management System, without first submitting construction plans and supporting documentation to the City Engineer for review and being issued a Compliance Letter.

2.5 Floodplain Development Permit Required – A permit is required for all structural development, placement of manufactured structures, clearing, grading, mining, drilling, dredging, placement of fill, excavating, watercourse alteration, drainage improvements, roadway or bridge construction, individual water or sewer installation or any other development in a Special Flood Hazard Area.

2.6 Public and Private Responsibilities

A. Public Responsibilities:

1. Administration – Administration of these regulations shall be the responsibility of the City Engineer.

2. Operation and Maintenance of Publicly Owned Facilities – The City of Jonesboro Public Works Department shall be responsible, after construction, for the operation and long-term maintenance of all drainage structures and improved watercourses which are part of the City of
Jonesboro Stormwater Management System and which are not constructed and maintained by or under the jurisdiction of any State or Federal agency.

B. Private Responsibilities:

1. Each developer of land has responsibility to provide on the developer's property Stormwater Runoff Management Facilities to ensure proper drainage and control of stormwater on and from the developer's property;

2. Each developer of land has a responsibility to properly maintain any on-site Stormwater Runoff Management Facility. Such responsibility is to be transmitted to subsequent owners through appropriate covenants to be recorded with or in the deed, and;

3. Each developer of land has a responsibility both during and after construction to provide, install, and maintain appropriate erosion control measures and other stormwater Best Management Practices (BMPs) as needed to minimize any adverse impact to water quality or the local environment.

ARTICLE 3
APPLICATION FOR PERMITS

3.1 General - This article establishes plan preparation and submittal requirements for development projects within the Jonesboro Planning jurisdiction.

3.2 Stormwater Management Plans (SWMP)

3.2.1 Preparation – The SWMP shall be prepared in accordance with the provisions set forth in these regulations and shall be sealed by the Engineer of Record for the project.

3.2.2 Submission – The Developer shall submit two (2) copies of the SWMP and all supporting documentation to the City Planning Office along with the review fee as established by the City Council. Upon receipt, the Planning Office will forward the submittals to the City Engineer for review.

3.2.3 Plan Review – The City Engineer or his designated representative shall review the submittals for conformance to the City of Jonesboro minimum design standards as established in these regulations and in the Stormwater Drainage Design Manual.

The City Engineer will review and comment or approve the project submittals within fifteen (15) business days upon receipt. Failure of the City Engineer to meet this timeline shall not be considered approval of the proposed work.

3.2.4 Rejection – If it is determined that the proposed development will not control stormwater runoff in accordance with these regulations, a comment letter listing the deficiencies shall be issued to the Developer for response. Re-submittals shall be made to the City Planning Office.
If needed, an informal meeting between the Developer and the City Engineer or his designee may be scheduled by either party to review the overall concepts included in the plan. The purpose of this meeting may vary, but generally shall be to jointly agree upon an overall stormwater management concept for the proposed development and to review criteria and design parameters which shall apply to the project.

3.2.5 Acceptance – If it is determined that the proposed development will control stormwater runoff in accordance with these regulations, a Compliance Letter shall be issued to the Developer stipulating the conditions of approval which are:

1. The Engineering Department relied upon statements and representations made in the engineer’s report, plans, and specification. In case any statement or representation in the aforementioned documents is found to be incorrect, then the approval may be revoked;

2. There shall be no deviations from the approved plans and specifications unless revised plans and specifications have been first submitted for review and written consent given amending the Compliance Letter;

3. The review of the plans and specifications are for conformance to City of Jonesboro minimum design standards and in no way constitute an analysis of the hydraulic or structural design;

4. If construction of this project is not started within one-year from the date of approval, then the approval is terminated, and;

5. Construction inspection for the work related to the Stormwater Management plan shall be the responsibility of the Engineer of Record.

Other conditions of approval may be added by the City Engineer as needed, as long as the added conditions are consistent with these regulations.

Should the original Engineer of Record be prevented from completing the project, the Developer shall employ another qualified engineer and immediately notify the City Engineer. The Developer shall also provide the name, address and telephone number of the new Engineer of Record.

3.3 Stormwater Pollution Prevention Plan (SWPPP)

3.3.1 Preparation – The SWPPP shall be prepared in accordance with the provisions set forth in these regulations. All SWPPPs shall be prepared and sealed by the Engineer of Record for the project except those for:

- One new or existing single-family structure that is part of a larger common development;
- One new or existing duplex family structure that is part of a larger common development, or;
- One existing commercial or industrial structure where additional structural or site improvements are less than 2000 square feet and that is part of a larger common development.
SWPPPs for the above exempt sites can be prepared by the Developer, provided that the Developer is knowledgeable with the applicable local, state, and federal requirements for SWPPP preparation.

3.3.2 Submission – The Developer shall submit two (2) signed copies of the SWPPP to the City Planning Office along with the review fee as established by the City Council. Upon receipt, the Planning Office will forward the submittals to the City Engineer for review.

3.3.3 Plan Review – The City Engineer or his designated representative shall review the submittals for conformance to the City of Jonesboro minimum design standards as established herein.

The City Engineer will review and comment or approve the project submittals within fifteen (15) business days upon receipt. Failure of the City Engineer to meet this timeline shall not be considered approval of the proposed work.

3.3.4 Rejection – If it is determined that the proposed development will not control stormwater runoff in accordance with these regulations, a comment letter listing the deficiencies shall be issued to the Developer for response. Re-submittals shall be made to the City Planning Office.

If needed, an informal meeting between the Developer and the City Engineer or his designee may be scheduled by either party to review the overall concepts included in the plan. The purpose of this meeting may vary, but generally shall be to jointly agree upon an overall stormwater management concept for the proposed development and to review criteria and design parameters which shall apply to the project.

3.3.5 Acceptance – If it is determined that the proposed development will control stormwater runoff in accordance with these regulations, a Grading Permit shall be issued to the Developer.

3.4 Drainage Alterations/Modifications

3.4.1 Preparation – Construction plans for alterations or modifications to the City of Jonesboro Stormwater Management System shall be prepared in accordance with the provisions set forth in these regulations and shall be sealed by the Engineer of Record for the project.

3.4.2 Submission – The Developer shall submit two (2) copies of the construction plans and all supporting documentation to the City Planning Office along with the review fee as established by City Council. Upon receipt, the Planning Office will forward the submittals to the City Engineer for review.

3.4.3 Plan Review – The City Engineer or his designated representative shall review the submittals for conformance to the City of Jonesboro minimum design standards as established by these regulations and the Stormwater Drainage Design Manual.

The City Engineer will review and comment or approve the project submittals within fifteen (15) business days upon receipt. Failure of the City Engineer to meet this timeline shall not be considered approval of the proposed work.
3.4.4 Rejection – If it is determined that the construction plans do not comply with these regulations, a comment letter listing the deficiencies shall be issued to the Developer for response. Re-submittals shall be made to the City Planning Office.

If needed, an informal meeting between the Developer and the City Engineer or his designee may be scheduled by either party to review the overall concepts included in the plan. The purpose of this meeting may vary, but generally shall be to jointly agree upon an overall stormwater management concept for the proposed development and to review criteria and design parameters which shall apply to the project.

3.4.5 Acceptance – If it is determined that the proposal complies with these regulations, a Compliance Letter shall be issued to the Engineer of Record stipulating the conditions of approval which are:

1. The Engineering Department relied upon statements and representations made in the engineer’s report, plans, and specification. In case any statement or representation in the aforementioned documents is found to be incorrect, then this approval may be revoked;

2. There shall be no deviations from the approved plans and specifications unless revised plans and specifications have been first submitted for review and written consent given amending the Compliance Letter;

3. The review of the plans and specifications are for conformance to City of Jonesboro minimum design standards and in no way constitute an analysis of the hydraulic or structural design;

4. If construction of this project is not started within one-year from the date of approval, then the approval is terminated, and;

5. Construction inspection for the work related to the alterations or modifications to the City of Jonesboro Stormwater Management System is the responsibility of the Engineer of Record.

Other conditions of approval may be added by the City Engineer as needed, as long as the added conditions are consistent with these regulations.

Should the original Engineer of Record be prevented from completing the project, the Developer shall employ another qualified engineer, and immediately notify the City Engineer. The Developer shall also provide the name, address and telephone number of the new Engineer of Record.

3.5 Floodplain Development Permit

3.5.1 Preparation – Application for a Floodplain Development Permit shall be made by the Developer on forms prescribed by the City Engineer and made available through the City Planning Office.

3.5.2 Submission – The Developer shall submit two (2) copies of the application and all supporting documentation to the City Planning Office along with the review fee as
established by the City Council. Upon receipt, the Planning Office will forward the submittals to the City Engineer for review.

3.5.3 Plan Review – The City Engineer or his designated representative shall review the submittals for conformance to the City of Jonesboro minimum design standards as established in these regulations and in the Stormwater Drainage Design Manual.

The City Engineer will review and comment or approve the project submittals within fifteen (15) business days upon receipt. Failure of the City Engineer to meet this timeline shall not be considered approval of the proposed work.

3.5.4 Rejection – If it is determined that the proposed development is not in accordance with these regulations, a comment letter listing the deficiencies shall be issued to the Developer for response. Re-submittals shall be made to the City Planning Office.

If needed, an informal meeting between the Developer and the City Engineer or his designee may be scheduled by either party to review the overall concepts included in the plan. The purpose of this meeting may vary, but generally shall be to jointly agree upon an overall stormwater management concept for the proposed development and to review criteria and design parameters which shall apply to the project.

3.5.5 Acceptance – If it is determined that the proposed development is in accordance with these regulations, a Compliance Letter shall be issued to the Developer stipulating the conditions of approval which are:

1. The Engineering Department relied upon statements and representations made in the Floodplain Development Application. In case any statement or representation in the aforementioned documents is found to be incorrect, then the approval may be revoked;

2. There shall be no deviations from the approved plans and specifications unless revised plans and specifications have been first submitted for review and written consent given amending the Compliance Letter;

3. The review of the plans and specifications are for conformance to City of Jonesboro minimum design standards and in no way constitute an analysis of the hydraulic or structural design, and;

4. If construction of this project is not started within one-year from the date of approval, then the approval is terminated.

Other conditions of approval may be added by the City Engineer as needed, as long as the added conditions are consistent with these regulations.

ARTICLE 4
DESIGN CRITERIA AND PERFORMANCE STANDARDS

4.1 Design Criteria – The City of Jonesboro’s Stormwater Drainage Design Manual (Drainage Manual) latest version shall be the accepted design document. It is the responsibility of the
Developer and the Engineer of Record to verify that they are using the latest version of the Drainage Manual in the design of their proposed development. Unless otherwise provided, the following rules shall govern the design and improvements with respect to managing stormwater runoff:

A. Method of Determining Stormwater Runoff – Developments where the upstream drainage area contributing runoff is less than 100 acres should be designed using the SCS, Type II 24-hour distribution, TR-55 Hydrograph Method for calculating runoff. Developments where the area contributing runoff is greater than 100 acres shall use the City of Jonesboro basin analysis for calculating runoff. If not available, the FEMA Data shall be used for calculating runoff. If neither the basin analysis nor the FEMA Data is available, the SCS TR-55 Hydrograph Method for calculating runoff shall be used.

B. Differential Runoff – The total volume, peak flow rate, and velocity of stormwater runoff from a site, post-development, should to the extent practicable approximate that of the site prior to the development.

C. Development Design – Developments shall be located and laid out in such a manner as to minimize the velocity of overland flow, allow maximum opportunity for infiltration of stormwater into the ground, preserve and utilize existing and planned streams, channels, detention basins, retention basins, and include wherever possible, streams and floodplains within parks and other public grounds.

Streets, curbs and gutters, parking areas, enclosed conveyance systems, detention basins, retention basins, and other generally accepted practices and methods for stormwater control may be a part of the overall stormwater runoff management systems for a particular site. To the maximum extent possible, these facilities shall be concurrently designed to effectively manage stormwater runoff in accordance with these regulations.

D. Enclosed Systems and Open Channels – Enclosed systems and open channels shall be designed in accordance with the Drainage Manual.

E. Evaluation of Downstream Flooding – The Engineer of Record shall evaluate whether the proposed plan will cause or increase downstream flooding conditions within the drainage sub-basin in which the project is located or if it will otherwise increase peak flows from the drainage sub-basin. This evaluation shall be made on the basis of existing downstream development and an analysis of stormwater runoff with and without the proposed development. When it is determined that the proposed development will cause or increase downstream flooding conditions, provisions to correct such cause or increase shall be included in the overall design of the stormwater management system improvements. Such provisions may include downstream improvements or detention of stormwater runoff and its regulated discharge to the downstream storm drainage system, or both.

When it is determined that a localized flooding condition exist downstream of a proposed development, the Engineer of Record for the project shall notify the City Engineer of this discovery and include sufficient documentation in the project
submittals to assist in the delineation of the identified Special Flood Hazard Area (SFHA).

F. Detention – The following design criteria shall govern the design of detention facilities:

1. **Release Rate** – The release rate from any detention facility shall be equal to or less than that of the site prior to the proposed development.

2. **Freeboard** – Detention storage areas shall have adequate capacity to contain the storage volume of tributary stormwater runoff with freeboard in accordance with the Drainage Manual.

3. **Outlet Control Works**
   
   (a.) Outlet works shall not include any mechanical components or devices and shall function without requiring attendance or control during operation.

   (b.) Size and hydraulic characteristics shall be such that all water and detention storage is released to the downstream stormwater conveyance systems within 24 hours after the end of the design rainfall. Normal time for discharge ranges from 3 to 24 hours.

4. **Spillway** – Emergency spillways shall be provided in accordance with the Drainage Manual.

5. **Design Data Submittal** – In addition to complete plans, all design data shall be submitted as required in the detention design data submittal section of the Drainage Manual.

6. **Detention Methods** – Depending upon the detention alternative or alternatives selected by the Engineer of Record, the design criteria for detention shall follow those given in the Drainage Manual.

G. **Alternatives to On-site Detention**

1. **Alternative Methods** – Where on-site detention is deemed inappropriate, alternatives to on-site detention shall be permitted. The methods may include off-site detention or improvements.

   Determinations regarding the appropriateness of on-site detention shall be made by the City Engineer based upon the impact of the proposed development on existing drainage networks and the location of the project in relation to existing floodplains, regional detention facilities, and other planned drainage or channel improvements. Disputes, if any, shall be resolved by the Stormwater Management Board.

   Determinations regarding the appropriateness of off-site detention or comparable improvements shall be made by the City Engineer
based upon the impact of the proposed development on existing drainage networks and the location of the project in relation to existing floodplains, regional detention facilities, and other planned drainage or channel improvements. Disputes, if any, shall be resolved by the Stormwater Management Board.

2. **Excess Stormwater Storage Credit** – A Developer may receive credit for excess stormwater storage (in acre-ft) created on one site that may be applied to another site within the same watershed. The transfer of storage volume credit (in acre-ft) shall not be allowed when the site where credited storage is proposed to be transferred has an existing flooding condition downstream or the proposed development will cause downstream flooding.

### 4.2 Performance Standards

A. **Stormwater Channel Location** – Generally acceptable locations of stormwater runoff channels may include but not be limited to the following:

1. In a depressed median of a double roadway, street or parkway provided the median is wide enough to permit maximum three (3) to one (1) side slopes;

2. Along the roadway, street, or parking; or,

3. Located along lot lines within the rear yards of lots or parcels. Stormwater runoff channels located along front and side lot lines shall be enclosed with conduits sized in accordance with the Drainage Manual. Channels along rear lot lines can be open ditch. In all cases, provisions (site grading, berms, dikes, swales, etc.) shall be provided for the safe containment or conveyance of the base flood along these routes.

B. **Easements** – Drainage easements for access, maintenance, detention and conveyance of stormwater shall be provided and shown on the final plat. Easements shall be required for all drainage ways serving two or more lots or parcels and shall be designated for drainage only. Minimum required dimensions for drainage easements are included in the Drainage Manual (Figures 1 and 2; Appendix 2), but in no case shall the prescribed easements be less than that required to convey or detain the 100-yr runoff. All drainage easements shall have a maintenance agreement approved before final acceptance of the improvements.

C. **Storm Sewer Outfall** – The storm sewer outfall shall be designed in accordance with the Drainage Manual so as to provide adequate protection against downstream erosion and scouring.

D. **Lot Lines** – Whenever the plans call for the passage or storage of floodwater, surface runoff, or stormwater along lot lines, grading of all such lots shall be prescribed and established for the safe passage or storage of the waters, and no structures including fences may be erected, shrubbery or trees planted, or
changes made to the prescribed grades and contours of the specified floodways which will obstruct the flow of stormwater.

E. **Manholes** – All sanitary sewer manholes constructed in a floodplain or in an area designed for the storage or passage of flood or stormwater, shall be provided with either a watertight manhole cover or be constructed with a rim elevation of a minimum one (1) foot above the high water elevation of the base flood, whichever is applicable to the specific area. The Engineer of Record shall identify which sanitary sewer manholes within the project limits are subject to this requirement, and coordinate with City Water and Light regarding the appropriate remedy.

F. **Floor Elevations** – The lowest floor of any occupied residence or commercial building in a local or FEMA designated Special Flood Hazard Area (SFHA) shall be established by a licensed Professional Engineer registered in the State of Arkansas, using good engineering practices. Any proposed lot or lots located in a local or FEMA Special Flood Hazard Area (SFHA) shall be identified and the Finished Floor Elevation (FFE) shown on the record plat. Finished Floor Elevations shall be referenced to the applicable engineering study.

ARTICLE 5
BONDS, MAINTENANCE ASSURANCE, CERTIFICATIONS, NOTIFICATIONS AND FINAL ACCEPTANCE

5.0 **Maintenance Agreement** – A maintenance agreement assuring perpetual maintenance of stormwater management improvements and drainage easements to be dedicated to the City shall be agreed upon by the City and the Developer prior to final acceptance of the improvements. The maintenance agreement shall be the responsibility of the Developer and shall be in a form acceptable to the City Engineer and the City Attorney.

5.1 **Performance Bond** – The Developer shall, before the sale of any lot or lots, either complete the improvements or provide a Performance Bond to guarantee the completion of the improvements in a timely manner. The bond shall be in a form and in an amount acceptable to the City Engineer and the City Attorney, and shall assure that the prescribed work will be well and truly performed and complete in good, sufficient, and workmanlike manner within an agreed time period, not to exceed six (6) months, and shall indemnify and hold harmless the City of Jonesboro from and against all claims, loss, damages, injury or death, court costs, litigation expense, reasonable attorneys’ fees, and expenses whatsoever which may arise because of or resulting from the Developer’s operation.

All companies furnishing bonds shall be on the U.S. Treasury Department’s most current list of approved surety companies (Circular 570, as amended) and be authorized to transact business in the State of Arkansas.

5.2 **Maintenance Bond** – A one-year maintenance bond against defects in workmanship shall be required for any portions of the stormwater management improvements proposed to be dedicated to the City of Jonesboro. The maintenance bond shall be in a form acceptable to the City Engineer and the City Attorney, and shall indemnify and hold harmless the City from and against all claims, loss, costs, damages, injury or death, court costs, litigation expense, reasonable attorneys’ fees, and expenses whatsoever which it may suffer or be compelled to
suffer to pay by reason of failure of the Developer to keep said work in repair or against any and all defects of workmanship or materials. No maintenance bond shall be required for improvements located on private property which is not to be dedicated to the City.

All companies furnishing bonds shall be on the U.S. Treasury Department’s most current list of approved surety companies (Circular 570, as amended) and be authorized to transact business in the State of Arkansas.

5.3 Certifications – Prior to issuance of any occupancy permit or entrance into the one-year probationary period for subdivision acceptance, the Engineer of Record shall submit to the City Engineer certification that the stormwater management system is complete and functional in accordance with the plans approved by the City Engineer. Any deviations from the approved plans shall be noted. To insure the adequacy of stormwater quantity detention facilities and stormwater management practices, this certification shall, at a minimum include “record drawings” showing final topographic features of all facilities and updated hydrologic and hydraulic computations for the as-built conditions.

Prior to the issuance of any occupancy permit subject to minimum floor elevation requirements, a registered engineer or registered land surveyor, shall submit to the City Engineer certification of the elevation of the lowest floor (including basement); or if the structure has been flood proofed, the elevation to which the structure is flood proofed. This information must be provided on a FEMA Elevation Certificate.

5.4 Notifications – Developers having been issued a Grading Permit shall notify the City Engineer upon final stabilization of the disturbed lands and request that the grading permit be terminated.

5.5 Final Acceptance – Upon expiration of the approved one-year maintenance bond and correction of all deficiencies noted in the eleventh month anniversary inspection report prepared by the City Engineer or his designated representative and presented to the Developer, the City Engineer shall issue or cause to be issued a letter to the Engineer of Record for the project accepting the improvements into the City’s long-term maintenance program.

As-builts of the project shall be provided to the City of Jonesboro in ESRI shapefile and PDF formats in conformance with provisions of this manual.

For all shapefiles, a separate spatial data file should be used for each structure and specific attributes should be recorded on site at the time of collection. The fields that should be used for recording these attributes along with all feature attribute input criteria are located in Appendix 6-“GIS Database Submittals” of the Stormwater Drainage Design Manual.

Final Acceptance by the City of Jonesboro will not be given until as-builts are provided to the City.

ARTICLE 6
ENFORCEMENT

6.1 General – It shall be the duty of the City Engineer to bring to the attention of the City Attorney any violation or lack of compliance of these regulations.
6.2 Violations and Penalties – Any person, firm, corporation, or other legal entity who fails to comply with or violates these regulations shall be guilty of a misdemeanor and upon conviction thereof shall be fined not less than $100 per day and not more than $500 per day for so long as the violation or violations exist. Each day shall constitute a separate offense.

6.3 Inspection – The City Engineer may make or cause to be made the inspection of any tract of land for each of the following:

   A. Permit – Before a Compliance Letter or Grading Permit is issued, the City Engineer may examine or cause to examine any tract of land for which an application has been received.

   B. Construction – The City Engineer may inspect or cause to be inspected at various intervals during the course of construction including but not limited to:

      1. Prior to the initiation of the project after temporary or permanent erosion prevention and sediment control practices have been installed;

      2. After the completion of rough grading and installation of stormwater management structures, and;

      3. Upon completion of the project.

   The City Engineer shall issue or cause to be issued a Notice of Violation (NOV) to the Developer of the project where the violations are observed. The NOV shall identify the violation or violations found and request that a Corrective Action Plan (CAP) with timeline be developed, submitted to the City Engineer for approval, and implemented to ensure future compliance with these regulations. Failure to respond to the NOV within 30 calendar days from the date shown shall result in the NOV and all supporting documents being forwarded to the City Attorney for appropriate enforcement action and may result in the issuance of a Stop Work Order.

6.4 Revocation; Stop Work Orders – The City Engineer may revoke any permit issued under the provisions of these regulations when informed of any false statement misrepresentation of facts in the application or plans. Any non-permitted stormwater management system, or construction, or fill located within a floodplain shall, upon written notice, be removed at the expense of the Developer.

   When it is found that any provisions of these regulations are being violated, the City Engineer may issue a stop work order. The stop work order shall be served upon the Developer and the Engineer of Record for the project, and by posting of the stop work order at the site of the violation.

   A hearing to appeal the stop work order may be requested by the Developer upon whom an order has been served. An appeal must be requested in writing to the Secretary of the Stormwater Management Board or his or her designee within 30 days after service of the stop work order. The Stormwater Management Board shall hold an appeal hearing within 31 days after receipt of appeal. If no appeal is requested within 30 days after service of the stop work order, the stop work order shall remain in effect until compliance with the appropriate regulations can be demonstrated to the reasonable satisfaction of the City Engineer.
ARTICLE 7
GENERAL PROVISIONS

7.1 Interpretation, Conflict and Severability Interpretations

A. Interpretation – In their interpretation and application, the provisions of these regulations shall be held to be the minimum requirements for the promotion of the public health, safety and general welfare.

B. Conflict with Public and Private Provisions – These regulations are not intended to interfere with, abrogate, or annul any other ordinance, rule or regulation statute or other provision of law. Where any provision of these regulations imposes restrictions different from those imposed by any other provision of any other ordinance, rule or regulation, or other provision or law, whichever provisions are more restrictive or impose higher standards, shall control.

C. Private Provisions – These regulations are not intended to abrogate any easement, covenant or any other private agreement or restriction, provided that where the provision of these regulations are more restrictive or impose highest standards or regulations that such easement, covenant or other private agreement or restriction, the requirements of these regulations shall govern. Where the provisions of easement, covenant or private agreement or restriction imposed duties and obligations more restrictive, or higher standards than the requirements of these regulations, and regulations or determinations there under, then such private provisions shall be operative and supplemental to these regulations and determinations made hereunder.

D. Severability – If any part of provision of these regulations or application thereof to any person of circumstances is adjudged invalid by any court or competent jurisdiction, such judgment shall be confined in its operation to that part, provision, or application directly involved in the controversy in which such judgment shall have rendered and shall not affect or impair the validity of the remainder of these regulations or the application to other persons or circumstances. The governing body hereby declares that it would be enacted the remainder of these regulations even without any such part, provision or application found to be unlawful or invalid.

7.2 Saving Provision – These regulations shall not be construed as abating any action now pending under, or by virtue of, prior existing regulations, or as discontinuing, abating, modifying, or altering any penalty accruing or about to accrue, or as effecting the liability of any person, firm or corporation, or as waiving any right to the City of Jonesboro under any section or provision existing at the time of adoption of these regulations, or as vacating or annulling any rights obtained by any person, firm, or corporation by lawful action of the City, except as shall be expressly provided for in these regulations.

7.3 Amendments – For the purpose of providing for the public health, safety and general welfare, the governing body may, from time to time, amend the provisions of these regulations. The Public Works Department has the responsibility for updating, on a continuing basis, the Stormwater Drainage Manual.
7.4 Appeals

Only the Developer may appeal an adverse decision of the City of Jonesboro regarding stormwater development issues, including, but not limited to, stormwater runoff quantity and quality, floodplain impact, stop work orders, and impact to neighboring properties, to the Stormwater Management Board.

All appeals and variance requests must be complete and filed on the form provided by the Secretary of the Board and shall include:

1. The name of the Developer;
2. The name of the Developer’s representative, if any;
3. The case number, map number, and parcel number, if any;
4. The interpretation that is claimed;
5. The decision of the City Engineer or his agent;
6. The location of the property;
7. The stormwater drainage plans which were accepted, and the deviation from the stormwater drainage plan that is being requested;
8. The specific action requested of the Board, and;
9. The reasons justifying such action.

All appeals and variance requests must be filed within thirty (30) days after an adverse decision of the office of the City Engineer for the City of Jonesboro regarding stormwater development issues, including, but not limited to, stormwater runoff quantity or quality, or both, floodplain impact, stop work orders and impact to neighboring properties. The required items must be submitted ten (10) business days prior to the regular monthly Stormwater Management Board meeting for the appeal or variance to be heard at that meeting. A filing fee as established by the City Council shall be charged to each appellant and shall be payable to the City of Jonesboro. Appellant shall also be responsible for any and all publication fees.

All appeals and variance requests will be filed with the Secretary of the Board. The Secretary of the Board shall:

1. Accept all appeals and variance requests on behalf of the Board;
2. Assign each appeal or variance request a number;
3. Number each appeal or variance request consecutively in order of receipt (beginning on January 1 of each year), preceded by a hyphen and the year of filing;
4. Ensure that appeals or variance requests are heard in the order that they appear
on the calendar;

5. Prepare an agenda and distribute it to each Board member at least five (5) business days before each meeting;

6. Send a copy of the agenda to the City of Jonesboro Public Works Committee, the Metropolitan Area Planning Commission, the Mayor, the City Clerk, the City Attorney, the Public Works Director, the City Engineer, and the City Floodplain Administrator, and;

7. Include on the agenda each appeal or variance request to be heard.

Variance Considerations

1. In passing variances for applications, the Stormwater Management Board shall consider all technical evaluations, all relevant factors, all applicable local ordinances and regulations, and:
   a. The danger that materials may be swept onto other lands to the injury of others;
   b. The danger to life and property due to flooding or erosion damage;
   c. The susceptibility of the proposed facility and its contents to flood damage and the effect of such damage on the individual owner;
   d. The importance of the services provided by the proposed facility to the community;
   e. The necessity of the ancillary facility;
   f. The availability of alternative locations that is for the proposed facility, not subject to flooding or erosion damage;
   g. The relationship of the proposed development or improvement plan to the master drainage plans for that area;
   h. The safety of access to the property in times of flood for ordinary and emergency vehicles;
   i. The expected heights, velocity, duration, rate of rise, and sediment transport of the floodwaters expected at the site;
   j. The costs of providing governmental services during and after flood conditions including maintenance and repair of public utilities and facilities such as sewer, gas, electrical, water systems, streets, and bridges, and;
   k. Any other relevant facts that pertain to compliance with City Ordinances and Regulations or are mandated by Federal or State laws, rules, or regulations.

2. Upon consideration of the factors listed above, and the objectives of these regulations, the Stormwater Management Board may attach such conditions to the granting of
variances as it deems necessary to further the objectives of these regulations.

3. Conditions for variances:

   a. Variances shall only be issued upon a determination that the variance is the minimum necessary, considering the flood hazard, to afford relief; and in the instance of a historical building, a determination that the variance is the minimum necessary so as not to destroy the historic character and design of the building;

   b. Variances shall only be issued upon (i) a showing of good and sufficient cause, (ii) a determination that failure to grant the variance would result in exceptional hardship, and (iii) a determination that the granting of a variance will not result in any of the following: (a) increased flood heights; (b) additional threats to public safety or extraordinary public expense; (c) create a public or private nuisance; (d) cause fraud on or victimization of the public; (e) or conflict with existing Federal or State laws, rules, regulations;

   c. The Secretary of the Stormwater Management Board shall maintain the records of all appeal actions, and;

   d. The City Floodplain Administrator shall report any variances to the Federal Emergency Management Agency upon request.

4. Variances may be issued for the reconstruction, rehabilitation, or restoration of structures listed on the National Register of Historic Places or the State Inventory of Historic Places without regard to the procedures set forth in this section, except for Items 3a, 3c, and 3d above, and provided the proposed reconstruction, rehabilitation, or restoration will not result in the structure losing its historical designation.

Open Meetings

All meetings of the Board shall be open to the public. The Board shall meet at regular monthly intervals with the day and time to be determined by the chairman.

Notice of such regular or special meetings shall be provided to the media as required by the Arkansas Freedom of Information Act by the Secretary of the Board who shall notify the City Clerk and all notices of meetings shall be posted on the City of Jonesboro web site.

The Board shall provide fifteen (15) minutes at the conclusion of each regular Board meeting for public comment on non-agenda items. Each individual is required to limit his or her comments to five (5) minutes. The Board reserves the right to suspend the rules and allow additional time if necessary.

Hearing Procedure

1. Members and alternates of the Board shall receive applicant’s documents from the Secretary no less than five (5) business days before the appeal hearing date;

2. Following the introduction of the case, the Board will be given two (2) minutes to review documents pertinent to the appeal hearing;
3.  The Developer or Developer’s agent will be allowed ten (10) minutes to present the case to the Board;

4.  City of Jonesboro technical staff shall be given ten (10) minutes for questions and comments. Technical staff shall include, but not be limited to, the City Engineer, the Assistant City Engineer, the City Floodplain Administrator, the City Public Works Director, or any designated city staff with pertinent technical information related to the appeal;

5.  The Mayor or City Council member(s), or both, shall be given two (2) minutes to speak if he or she requests time to comment;

6.  A public representative, for or against the requested variance, may have two (2) minutes to comment, with a maximum of three persons representing each side. Persons wishing to address the Board shall register with the Secretary of the Board or his/her designee, including their name, address and a brief description of their concern, prior to the beginning of the appeal hearing;

7.  Rebuttal will be limited to five (5) minutes per each public representative;

8.  The Developer, City of Jonesboro technical staff, or others present will then respond to questions from the Board;

9.  Upon a motion by any Board member specifically stating the amount of additional time requested and approval by five (5) members of the Board, additional time may be granted to a speaker, and;

10. Once a motion and a second to the motion are made, further discussion is limited to members of the Board unless they have additional questions for the applicant or others. In the absence of procedures included in the Board’s enabling legislation or this document, the most recent edition of the Robert’s Rules of Order shall apply.

Conduct During Appeal Hearing

Any person other than a Board member shall only address their comments to the Board, shall respond to the questions asked, and shall accord the utmost courtesy to the Board and the other participants. The chairman reserves the right to remove any participant from the hearing upon repeated rude or derogatory remarks, abusive comments and unsubstantiated statements as to motives or personalities, or both.

Decision of the Board

At the conclusion of all of the evidence in all cases heard at that hearing session, the Board shall discuss the cases and render decisions on that date or defer decisions for no longer than thirty-one (31) days thereafter. The Board shall have the authority to table, approve or deny a variance or appeal.

The Developer may withdraw his/her appeal one time. The appeal shall be heard at the next regularly scheduled Board meeting. If applicant withdraws an appeal a second time, the Developer must wait 180 days before requesting that the appeal be heard by the Board.
Any action taken by the Board shall be by motion which shall state the reason or reasons for the action taken with particularity. All the decisions of the Board shall be in writing and must indicate the vote of the Board upon the decision.

A quorum of the Board must be present to render any decisions. Five (5) Board members are considered a quorum and there must be five (5) votes to take any affirmative action.

The vote of an alternate member of the Board shall be counted in the tabulation of the result only if she or he is substituting for a regular member. If the alternate member is not substituting for a regular member, the vote shall be recorded but not counted in the decision of the Board.

The decision of the Board on each appeal shall be promptly entered on the minutes of the meeting of the Board by the Secretary and filed in the City Clerk’s office.

Re-hearings

No re-hearing of a decision by the Board shall be held except on motion to reconsider that vote by a member of the majority of the Board on the preceding vote, or on a motion or written request to reconsider a prior decision receiving five (5) votes of a quorum of the Board.

If the request for a re-hearing is granted, the case shall be put on the calendar for a re-hearing. In all cases, the request for a re-hearing shall be by the Developer in writing, reciting the reasons for the request, and shall be duly verified and accompanied by the necessary data and diagrams. The Developer requesting the re-hearing shall be notified to appear before the Board on a date to be set by the Board. The notification shall be by the secretary.

7.5 Conflict of Interest

No member of the Board shall act on any case in which he/she has a personal interest, whether it is a direct or indirect financial interest in the property itself, or by virtue of family relationship with the Developer pursuant to the City of Jonesboro’s Code of Ethics (Code Section 2.20.14).

Any person who has a conflict shall notify the chairman or secretary immediately upon realizing a conflict may exist. A Board member who has a conflict may not participate as a Board member on the item in which he or she has a conflict of interest.

An alternate member shall replace any member who has a conflict of interest or who is unable to attend due to an illness or an extended absence from the metropolitan area. The Secretary of the Board shall be responsible for contacting the Board members prior to the meeting to determine the need for alternate members. If an alternate member is needed, the secretary shall be responsible for contacting the alternate member.

7.6 Special Meetings

The Chairman or Vice-Chairman may call special meetings at a time and place of their choosing. Whenever such a special meeting is called, the public shall be notified by appropriate means in accordance with the Arkansas Freedom of Information Act.
7.7 Board Announcements

Public announcements including, but not limited to, Board decisions, Board recommendations or other Board actions shall be released to the public upon approval by the Board or in the interim upon approval by the Chair, or in his absence, the Vice-Chair.

7.8 Appeals from Decisions of the Board

Any aggrieved party may appeal any decision of the Board to the Craighead County Circuit Court as provided in ARK. CODE ANN. §14-56-425.

ARTICLE 8
LIABILITY

8.1 Disclaimer of Liability – The performance standards and design criteria set forth herein and in the Drainage Manual establish minimum requirements which must be implemented with good engineering practice and workmanship. Use of the requirements contained herein shall not constitute a representation, guarantee, or warranty of any kind by the City of Jonesboro, or its officers and employees of the adequacy or safety of any Stormwater Management plan imply that the land uses permitted will be free from damages caused by stormwater runoff. The degree of protection required by these regulations is considered reasonable for regulatory purposes and is based on historical records, engineering and scientific methods of study. Larger storms may occur or stormwater runoff heights may be increased by man-made or natural causes. These regulations, therefore, shall not create liability on the part of the City of Jonesboro or any officer or employee with respect to any legislative or administrative decision lawfully made hereunder.
# Table of Contents

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE OF CONTENTS</td>
<td>i</td>
</tr>
<tr>
<td>1.0 INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1 Purpose</td>
<td></td>
</tr>
<tr>
<td>1.2 Scope</td>
<td></td>
</tr>
<tr>
<td>1.3 Drainage Policy</td>
<td></td>
</tr>
<tr>
<td>2.0 CONSTRUCTION PLANS PREPARATION</td>
<td>3</td>
</tr>
<tr>
<td>2.1 General</td>
<td></td>
</tr>
<tr>
<td>2.2 Design Phase</td>
<td></td>
</tr>
<tr>
<td>2.3 Miscellaneous</td>
<td></td>
</tr>
<tr>
<td>2.4 Design Guidelines and Checklists for Storm Drainage Plans</td>
<td></td>
</tr>
<tr>
<td>2.4.1 Drainage Area Map</td>
<td></td>
</tr>
<tr>
<td>2.4.2 Storm Sewer Design Guidelines</td>
<td></td>
</tr>
<tr>
<td>2.4.3 Laterals</td>
<td></td>
</tr>
<tr>
<td>2.4.4 Inlets and Intakes</td>
<td></td>
</tr>
<tr>
<td>2.4.5 Plan and Profile Sheets</td>
<td></td>
</tr>
<tr>
<td>2.4.6 Detention</td>
<td></td>
</tr>
<tr>
<td>2.4.7 Bridges</td>
<td></td>
</tr>
<tr>
<td>2.4.8 Open Channels</td>
<td></td>
</tr>
<tr>
<td>3.0 HYDROLOGY</td>
<td>11</td>
</tr>
<tr>
<td>3.1 General</td>
<td></td>
</tr>
<tr>
<td>3.2 Intentionally Deleted</td>
<td></td>
</tr>
<tr>
<td>3.3 SCS, Type II 24-hour Distribution, TR-55 Hydrograph Method</td>
<td></td>
</tr>
<tr>
<td>3.3.1 Accumulated Rainfall (p) and Rainfall Distribution</td>
<td></td>
</tr>
<tr>
<td>3.3.2 Curve Number (CN) Factors</td>
<td></td>
</tr>
<tr>
<td>3.3.3 Hydrologic Soil Groups</td>
<td></td>
</tr>
<tr>
<td>3.3.4 Cover Type</td>
<td></td>
</tr>
<tr>
<td>3.3.5 Treatment</td>
<td></td>
</tr>
<tr>
<td>3.3.6 Hydrologic Condition</td>
<td></td>
</tr>
<tr>
<td>3.3.7 Antecedent runoff condition (ARC)</td>
<td></td>
</tr>
<tr>
<td>3.3.8 Ponding and Swamp Adjustment Factor (Fp)</td>
<td></td>
</tr>
<tr>
<td>3.4 Computer Hydrograph Methods</td>
<td></td>
</tr>
<tr>
<td>4.0 STORM DRAINAGE APPURTENANCES</td>
<td>18</td>
</tr>
<tr>
<td>4.1 General</td>
<td></td>
</tr>
<tr>
<td>4.2 Design Frequencies</td>
<td></td>
</tr>
<tr>
<td>4.3 Runoff Calculations</td>
<td></td>
</tr>
<tr>
<td>4.4 Street Flow</td>
<td></td>
</tr>
<tr>
<td>4.4.1 Definitions</td>
<td></td>
</tr>
<tr>
<td>4.4.2 Calculation of Flow in Streets</td>
<td></td>
</tr>
<tr>
<td>4.4.3 Uniform Gutter Sections</td>
<td></td>
</tr>
</tbody>
</table>
4.4.4 Composite Gutter Sections
4.4.5 Parabolic Street Sections

4.5 Drainage Inlet Design
4.5.1 Inlet Types
4.5.2 Interception Capacity of Inlets on Grade
   4.5.2.1 Grate Inlets
   4.5.2.2 Curb-opening Inlets
   4.5.2.3 Combination Inlets
4.5.3 Interception Capacity of Inlets in Sag Locations
   4.5.3.1 Grate Inlets in Sags
   4.5.3.2 Curb-Opening Inlets
   4.5.3.3 Combination Inlets
4.5.4 Inlet Locations
   4.5.4.1 Geometric Controls
   4.5.4.2 Inlet Spacing on Continuous Grades

4.6 Hydraulic Design of Closed Conduits
4.6.1 Velocity in Closed Conduits
4.6.2 Roughness Coefficients for Closed Conduits
4.6.3 Minor Head Losses in Closed Conduits

5.0 OPEN CHANNELS ........................................................................................................36

5.1 General
5.2 Cross Sections
5.3 Roughness Coefficients
5.4 Velocity Requirements
5.5 Channel Drop Structures
   5.5.1 Vertical Drop Structures
   5.5.2 Sloping Drop Structures

6.0 CULVERTS .................................................................................................................38

6.1 General
6.2 Culverts Flowing with Inlet Control
6.3 Culverts Flowing with Outlet Control

7.0 BRIDGES .....................................................................................................................41

8.0 DETENTION POND DESIGN .....................................................................................42

8.1 General
8.2 No Adverse Impact Policy
8.3 Detention Reservoir Routing
   8.3.1 Inflow Hydrograph
   8.3.2 Stage-Storage Curve
      8.3.2.1 Stage-Storage Calculations
   8.3.3 Stage-Discharge Curve
      8.3.3.1 Stage-Discharge Calculations
   8.3.4 Dry Reservoirs (Ponds)
   8.3.5 Open Channels
   8.3.6 Wet Reservoirs (Ponds)
   8.3.7 Parking Lots
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.3.8</td>
<td>Control Structures</td>
</tr>
<tr>
<td>8.3.9</td>
<td>Emergency Spillways</td>
</tr>
<tr>
<td>9.0</td>
<td>FLOODPLAIN GUIDELINES</td>
</tr>
<tr>
<td>9.1</td>
<td>General Standards</td>
</tr>
<tr>
<td>9.2</td>
<td>Risk Zone Specific Standards</td>
</tr>
<tr>
<td>9.3</td>
<td>Hydrology</td>
</tr>
<tr>
<td>9.4</td>
<td>Hydraulics</td>
</tr>
<tr>
<td>9.5</td>
<td>SFHA Submittals</td>
</tr>
<tr>
<td>10.0</td>
<td>EROSION CONTROL</td>
</tr>
<tr>
<td>10.1</td>
<td>General</td>
</tr>
<tr>
<td>10.2</td>
<td>Environment Protection Agency BMP’S</td>
</tr>
</tbody>
</table>
APPENDIX 1 ........................................................................................................ List of Tables
APPENDIX 2 ........................................................................................................ Figures
APPENDIX 3 ........................................................................................................ Intentionally Deleted
APPENDIX 4 ........................................................................................................ Street Capacity Nomographs
APPENDIX 5 ........................................................................................................ Culvert Nomographs
APPENDIX 6 ........................................................................................................ GIS Database Submittals
APPENDIX 7 ........................................................................................................ ADEQ Permit No. ARR150000
APPENDIX 8 ........................................................................................................ Bibliography
1.0 INTRODUCTION

1.1 Purpose

The purpose of this manual is to establish standard principles and practices for the design and construction of storm water drainage facilities within Jonesboro, Arkansas. In addition floodplain compliance guidelines will be presented to insure base flood elevations will not rise because of the construction or modification of structures or land alteration within the floodplain. The design factors, formula, graphs, and procedures are intended for use as engineering guides in the solution of drainage problems involving determination of the quantity, rate of flow, and conveyance of storm water. The procedures defined herein shall be applied by experienced professional engineers licensed to practice in the State of Arkansas. Also, ultimate responsibility for the design of storm drainage structures lies with the engineer of record. As such, prudent engineering judgment should be used in the design of any facility within Jonesboro.

Methods of design other than those indicated herein may be considered in difficult cases where experience clearly indicates they are preferable. However, there should be no extensive variations from the practices established herein without express approval from the City of Jonesboro.

1.2 Scope

This manual presents various applications of accepted principles of surface drainage engineering and is a working supplement to the information obtained from standard drainage handbooks and other publications on drainage. It is presented in a format that gives logical development of solutions to problems of storm water drainage design and floodplain management.

This manual is intended to be used by the City of Jonesboro, consulting engineers contracted with the City, and for private development within the planning jurisdiction of the City. This manual applies to storm drainage conditions, which are generally relative to the City of Jonesboro and the immediate geographical area. Accepted engineering principles, applied to the City of Jonesboro’s storm drainage requirements, are detailed within this manual.

1.3 Drainage Policy

The basic objective of the City of Jonesboro is to construct and maintain facilities intended to minimize the threat of flooding to all areas of the City and comply with the requirements of the National Flood Insurance Program. Drainage facilities are defined as all channels, pipes or other structures which handle public water. Additionally, it is the City’s intent to insure that adequate facilities are constructed to accommodate new development such that existing property will not be subjected to additional flooding and so as not to increase the limits of the floodplains as shown on the flood insurance rate maps (FIRM’s) for the City of Jonesboro and other entities (County, Levee Improvement Districts, and Municipal Utility Districts).

It is not economically feasible to construct storm sewer facilities, which are large enough to keep the street systems from becoming inundated during severe storm events. City policies as defined in the governing drainage ordinance and standards in this manual are
designed to minimize the impacts (depth and duration) of storm events and insure that
the lowest floor elevation of any structures not used exclusively for storage, access, or
parking are, at a minimum, twelve (12) inches above the 100-year flood elevation. The
intent of this policy is that there should not be any street ponding for minor storm events,
minor street ponding for larger events, and major ponding for the 100-year event storms
but without water inundating building structures. Every attempt will be made to design
major thoroughfares so that they are passable during severe storm events.

The City of Jonesboro has included in this manual criteria covering the design of storm
water systems to serve both existing and new developments.

The criterion is considered a minimum for the City of Jonesboro. Approval from other
applicable agencies may be required. Ultimate approval for any variance of the criteria
contained in this manual must be given by the City of Jonesboro.
2.0 CONSTRUCTION PLAN PREPARATION

2.1 General

This section covers the preparation of drainage construction plans for the City of Jonesboro.

2.2 Design Phase

Plans shall be submitted in accordance with the City of Jonesboro’s Checklist for Storm Drainage Plans. The first engineering plan set submission shall be complete, and in sufficient detail to allow review by the City of Jonesboro. All topographic surveys should be furnished to allow establishment of alignment, grades, and rights-of-way requirements.

The hydraulic design of the proposed facilities shall be accomplished based on the procedures and criteria outlined in this manual. Calculations shall be submitted as part of the plan set. These plans shall show the alignment, drainage areas, size of facilities, and grades.

Storm drainage plans shall include at a minimum, a drainage area map, plan-profile sheets, and channel cross-sections, if applicable.

Survey control performed for the project shall reference two reference marks established by the City of Jonesboro. A copy of the reference marks can be obtained from the City Engineer.

Survey control for the project shall conform to the following requirements:

- Vertical control will be NAVD 88, Third Order Vertical
- Horizontal control will be NAD 83, Third Order Class 1, Arkansas State Plane North Zone

2.3 Miscellaneous

All drawings shall be prepared on bond paper with a minimum sheet size of 24” x 36”, to a standard engineering scale, and shall be clearly legible when sheets are reduced to half scale. All drawings shall be signed and sealed by a Professional Engineer registered in the State of Arkansas. After each review, all review comments shall be addressed, additional data incorporated, and drafting of plans completed. Each plan-profile sheet shall have a benchmark shown.

2.4 Design Guidelines and Checklists for Storm Drainage Plans

2.4.1 Drainage Area Map

The drainage area map shall be to a standard engineering scale, and show the street rights-of-way. Scale shall be selected to adequately depict drainage areas, flow paths, etc.
When calculating runoff, the drainage area map shall show the boundary of the drainage area contributing runoff into the proposed system. The area shall be further divided into sub-areas, sequentially numbered, to determine flow concentration points or inlet locations. The centerline of all streets will normally be a boundary of a drainage area, to insure that inlets are sized and positioned to fill the need without depending on storm water crossing over the street crown for proper drainage.

Direction of flow within streets, alleys, natural and man-made drainage ways, and at all system intersections, shall be clearly shown on the drainage area map and/or paving plans. Existing and proposed drainage inlets, storm sewer pipe systems, and drainage channels shall also be clearly shown and identified.

The following items/information shall be included:

1. Use design criteria as outlined in drainage regulations and prescribed in this manual;

2. Standard Engineering Scale. Show match lines between any two (2) or more maps. Show graphic bar scale;

3. Show drainage areas including acres, land use description, hydrologic soil group, and inlet time for each area;

4. Show existing sub-areas for alley, street, and off-site areas;

5. Indicate contours on map for on- and off-site, not to exceed two (2) foot contour. For large drainage areas show contours at intervals appropriate to indicate drainage patterns;

6. Location of all existing and proposed drainage structures on the project site;

7. Show local and FEMA designated SFHA and floodways if they exist. If not, note that none exists;

8. Indicate city zoning on drainage area. Identify land use for adjacent properties;

9. Show points of concentration and their designations;

10. Inlets, their size and location, the bypass flow for each, the direction of flow as indicated by flow arrows, the station for the centerline;

11. Indicate runoff at all inlets, dead-end streets and alleys, or to and from adjacent additions or acreage;

12. For cumulative runoff, show calculations;

13. Show north arrow. Orient sheet such that the direction of north is to top page or to the left;

14. Location of existing and proposed drainage structures;
(15) A table depicting runoff computations;
(16) Flow arrows to indicate all crests, sags, and street and alley intersections; and,
(17) Street names shall be indicated.

2.4.2 Storm Sewer Design Guidelines

General guidelines for the design of closed conduit systems, storm sewers, are outlined below.

(1) Diversion of flow from one natural drainage area to another will not be allowed;
(2) Show plan and profile of all storm sewers;
(3) Pipe Material in City rights-of-way or easements shall conform to the following minimum requirements:
   - Roadway Crossings
     RCP Class III or Class IV
     ASTM C-76
     ASTM C-506
     ASTM C-507
     Box Culverts and Small Bridges
     ASTM C-1433
     ASTM C-507
   - Mains and Laterals
     Aluminized Steel Type 2 Corrugated Steel Pipe
     ASTM A-929
     ASTM A-760
     RCP Class III or Class IV
     ASTM C-76
     ASTM C-506
     ASTM C-507
     Box Culverts and Small Bridges
     ASTM C-1433
     ASTM C-507

Alternative pipe materials for use outside City rights-of-way or easements shall be approved by the City Engineer.

(4) In areas where pipes cross beneath railroads, areas of deep fill and areas subjected to heavy loads the engineer shall select the pipe material that is adequate for the design load and provide documentation of such analysis;
(5) The minimum allowable concrete strength for concrete pipe is 3,500 psi. Specify concrete strength for all structures;
(6) Provide inlets where street capacity is exceeded. Provide inlets where addition of alley runoff to street exceeds intersecting street capacity;
(7) Storm water flow from streets into alleys is to be avoided. The City Engineer may approve this type of drainage flow when it is not possible to direct flow anywhere else;

(8) Maximum discharge velocity of eight (8) feet per second (fps) is allowed at the pipe outfall. Velocities that exceed 8 fps must be approved by the City Engineer and must include adequate provisions for erosion control considering the soil conditions at the outfall;

(9) As it relates to erosion control, discharge flow lines of storm sewers shall be a maximum of two (2) feet above the natural flow line of the channel, unless channel lining is present. Energy dissipation shall be provided when specified by the City Engineer;

(10) Where fill is proposed for trench cuts in creeks or outfall ditches, compaction shall be 95% of the maximum density as determined by ASTM D 698; and,

(11) Any off-site drainage work or discharge to downstream property will require an easement. Easement shall be sized such that the developed flows can be conveyed within the easement.

2.4.3 Laterals

Laterals are defined as minor storm sewer lines that serve the purpose of connecting a single inlet to a larger storm sewer main line. The following is a list of requirements that apply to laterals.

(1) Show laterals on trunk profile with stations;

(2) Provide lateral profiles for laterals exceeding thirty (30) feet in length. Potential conflicts with existing utilities (i.e. sanitary sewer, etc.) should be shown in profile;

(3) Laterals shall be placed in profile such that the hydraulic grade line is not less than one foot from the curb flow line, unless utilities or storm sewer depth requires otherwise;

(4) Laterals shall not enter the corners or bottoms of inlets;

(5) In general, the angle of confluence between main line and lateral shall not exceed ninety (90) degrees. Situations where angles exceed this requirement must be supported by calculations that show that the connection will not create adverse flow conditions in the connecting pipe;

(6) Longitudinal centers should intersect;

(7) At junction structures, downstream pipe crown elevations should not be above upstream pipe crown elevations; and,

(8) Minimum pipe diameter within City rights-of-way or easements shall be eighteen (18) inches unless otherwise approved by the City Engineer.
2.4.4 Inlets and Intakes

Inlets shall be provided at the following locations as a minimum:

- At locations on grade where the design flows exceeds the depth and spread criteria;
- At all low points (sag points) in gutters;
- Immediately upgrade of median breaks and street intersections;
- Immediately upgrade of roadway cross slope reversals;
- Upstream and downstream of bridge locations where applicable; and,
- Behind curbs and sidewalks as necessary to drain low areas.

Inlets shall be given the same number designation as the area or sub-area contributing runoff to the inlet. The inlet number designation shall be shown opposite the inlet. At intersections, where possible, the end of the inlet shall be ten (10) feet from the curb return or Point of Tangency, and the inlet location shall also provide minimum interference with the use of adjacent property. Inlets in residential areas should be located in streets and alleys so that driveway access is not prohibited to the lots. Drainage from abutting properties shall not be impaired, and shall be designed into the storm drainage system.

Data opposite each inlet shall include paving or storm sewer stationing at centerline of inlet, size and type of inlet, number or designation, top of curb elevation and flow line of inlet as shown on the construction plans.

1. Indicate direction of flow and the design flow (Q) entering the inlet. Identify capacity of inlet and any bypass flow that may result;
2. On plan view, indicate inlet designation number, location of inlet (station and offset), size of inlet, sizes of pipes entering and exiting the inlet with associated flow lines, and top-of-curb elevations; and,
3. Use standard curb inlets in City rights-of-way or easements as presented in the City of Jonesboro Street Improvement Program Manual, latest edition.

2.4.5 Plan and Profile Sheets

In the plan view, the storm sewer designation, size of pipe, and length of each size pipe shall be shown adjacent to the storm sewer. The main line sewer plan shall be stationed at one hundred (100) feet intervals.

This data shall consist of pipe diameter in inches, the design storm discharge in cubic feet per second, slope of hydraulic gradient in percent, Manning capacity of the pipe flowing full in cubic feet per second, velocity in feet per second, and \( \frac{V^2}{2g} \). Also, the head loss at each interception point shall be shown.
Stationing and flow line elevations shall also be shown at all pipe grade changes, pipe size changes, lateral connections, manholes, and wye connections. Crown elevations should conform to 2.4.3(7).

1. The recommended scale for storm sewer plan and profile sheets is 1" = 50' minimum and 1" = 100' maximum;

2. Indicate property lines and lot lines along storm sewers, and show easements with dimensions;

3. Provide separate plan and profile of storm sewers. The storm drain lines should also be shown on paving plans with a dashed line. Full pipe sections should be shown on sanitary sewer profiles at crossings;

4. Show pipe sizes in plan and profile;

5. Show hydraulics on each segment of pipe profile to include: Q (Design Flow), C (Manning full flow capacity); S (Slope), V (Velocity), V^2/2g (Velocity Head);

6. Show all existing utilities in plan and profile. Show sanitary sewer profiles at all crossings of storm drain profiles;

7. Indicate existing and proposed ground line on all street, alley, and storm sewer profiles;

8. Show future streets and grades where applicable;

9. When connections are made to existing systems, computations must be provided to show the capacity of the existing system to accept flows. Hydrologic Grade Line (HGL) will be calculated from the outfall to the connection point including the designed flows of the added system;

10. Indicate flow line elevations of storm sewers on profile, show pipe slope (percent grade). Match pipe soffits at all junction boxes or inlets;

11. In general, the angle of confluence between main line and lateral shall not exceed ninety (90) degrees;

12. Show details of all non-standard structures such as junction boxes, headwalls, storm sewers, flumes, and manholes;

13. Pipe deflections for directional changes shall be placed at the manufacturers recommendations. Deflections exceeding the manufacturer’s recommendation will not be tolerated;

14. Bends in pipes may be used in unusual circumstances with approval by the City. No bend at one location may exceed thirty (30) degrees;

15. Show water surface elevation of the outfall for design year event (i.e. Q_{25});
(16) On all dead-end streets and alleys where water exits at the dead-end, show grade out to “daylight” for drainage on the profiles and provide erosion control when necessary. Show typical section and slope of “daylight” drainage;

(17) At sags in pavement, provide a positive overflow (swale) to act as a safety path for failure of the storm drain system. Also, provide minimum lowest floor elevations along this overflow rout; and,

(18) Provide sections for road, railroad, and other ditches with profiles. Show design water surface on profile.

The profile portion of the storm sewer plan-profile sheet shall include:

(1) The existing and proposed ground profile along the centerline of the proposed sewer;

(2) The hydraulic gradient of the sewer;

(3) The profile of the proposed storm sewer line;

(4) Profile view of utilities that cross the proposed sewer alignment;

(5) Locations where laterals intersect the main line;

(6) Text identifying the pipe size, elevations at 50’ intervals, physical grade in percent, stations where laterals intersect main line; and,

(7) Hydraulic data for each length of storm sewer between interception points shall be shown on the profile.

2.4.6 Detention

(1) Provide drainage area map and show all computations for runoff affecting the detention basin;

(2) Provide a plot plan with existing and proposed contours for the detention basin and plan for structural measures;

(3) Where earth embankment is proposed for impoundment, furnish a typical embankment section and specifications for fill including profile for the structural outflow structure and Geotechnical report;

(4) Provide structural details and calculations for any item that is not a standard detail;

(5) Provide detention basin volume calculations and elevation versus storage curve;

(6) Provide detention calculations for volume by elevation-area, outflow using orifice and/or weir, and reservoir routing; and,
(7) Provide SCS, Type II 24-hour distribution, determination of storage requirements, (permitted for areas of 100 acres or less). Areas greater than 100 acres shall use City of Jonesboro FEMA data (if available).

2.4.7 Bridges

(1) Show Geotechnical soil boring information on plans;

(2) Provide channel cross sections of the water surface elevations for the design storm immediately upstream and downstream of the structure;

(3) Provide hydraulic calculations on all sections;

(4) Provide structural/standard details and calculations;

(5) Provide vertical and horizontal alignment;

(6) Show soil erosion protection measures;

(7) The pre- and post- construction SFHA and regulatory floodway if defined shall be delineated on the plans; and,

(8) Additional requirements for Bridges may be found in Section 7.0 and Section 9.0.

2.4.8 Open Channels

(1) Plan view of channel showing existing and proposed alignment including creek centerline stationing, north arrow, and scale;

(2) Profile of existing and proposed creek centerline;

(3) Profile of the 25-year and 100-year water surface elevation;

(4) Typical cross sections showing dimensions, and the station limits for which they apply;

(5) Velocities and discharges for the 25-year and 100-year storms;

(6) Limits of temporary erosion protection associated with the construction of the channel needs to be indicated in plan view;

(7) Indicate property lines and lot lines along with existing utilities and show easements with dimensions; and,

(8) Include on the construction plans or as in a separate report, the computations performed in developing the water surface profile.
3.0 HYDROLOGY

3.1 General

The planning, design, and construction of drainage facilities are based on the determination of one or more aspects of storm runoff.

Continuous long-term records of rainfall and resulting storm runoff in an area provide the best data source from which to base the design of storm drainage and flood control systems in that area. However, it is not possible to obtain such records in sufficient quantities for all locations requiring storm runoff computations. Therefore, the accepted practice is to relate storm runoff to rainfall, thereby providing a means of estimating the rates, timing and volume of runoff expected within local watersheds at various recurrence intervals.

It is generally accepted that urban development has a pronounced effect on the rate and volume of runoff from a given rainfall. Urbanization generally alters the hydrology of a watershed by improving its hydraulic efficiency, reducing its surface infiltration, and reducing its storage capacity.

For certain small drainage areas (generally less than 100 acres in size), the widely used NRCS (formerly SCS) graphical peak discharge (TR55) provides a useful means of determining peak discharges. If the engineer wishes to use an alternative design technique, it is recommended that the City Engineer be consulted prior to design. If the area is larger than 100 acres and has FEMA hydrology determined for it, the FEMA hydrology model shall be used.

3.2 (Intentionally Deleted)

3.3 SCS, Type II 24-hour Distribution, TR-55 Hydrograph Method

The Soil Conservation Service (SCS now Natural Resources Conservation Service – NRCS) hydrologic method has been widely used by engineers and hydrologists for analyses of small urban watersheds.

This method results from extensive analytical work using a wide range of statistical data concerning storm patterns, rainfall-runoff characteristics and many hydrologic observations in the United States. The SCS method can be applied to urban drainage areas of any size. Major parameters required to calculate the hydrograph include the rainfall distribution, runoff curve numbers, time of concentration, and drainage area.

The runoff equation used by the SCS is a relationship between accumulated rainfall and accumulated runoff derived from experimental plots for numerous soils and vegetation. The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is:

\[
Q = \frac{(P - I_c)^2}{(P - I_c) + S}
\]  

(3.2)
Where

- \( Q \) = accumulated direct runoff, (in)
- \( P \) = accumulated rainfall (potential maximum runoff), (in)
- \( S \) = potential maximum retention after runoff begins, (in)
- \( I_a \) = initial abstraction (including surface storage, interception, and infiltration prior to runoff), (in)

Initial abstraction \((I_a)\) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. \( I_a \) is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, \( I_a \) was found to be approximated by the following empirical equation:

\[
I_a = 0.2S
\]  
(3.3)

By removing \( I_a \) as an independent parameter, this approximation allows use of a combination of \( S \) and \( P \) to produce a unique runoff amount. Substituting equation (3.3) into equation (3.2) gives:

\[
Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}
\]  
(3.4)

\( S \) is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and \( S \) is related to CN by:

\[
S = \frac{1000}{CN} - 10
\]  
(3.5)

Graphical peak discharge was developed from TR-20. The peak discharge equation is

\[
q_p = q_uA_mQF_p
\]  
(3.6)

- \( q_p \) = peak discharge, (cfs)
- \( q_u \) = unit peak discharge, (cfs/sq mi/in)
- \( A_m \) = drainage area, (mi²)
- \( Q \) = runoff, (in)
- \( F_p \) = pond and swamp adjustment factor (necessary if spread throughout the watershed and not considered in \( T_c \) computation)

The following are the steps necessary to use the SCS Method for peak discharge computations:

1. Determine the drainage area;
2. Determine the soil classification based on runoff potential (Group A, B, C, or D). See Section 3.3.3 for detailed information. One approach for a general classification is to determine the soil name and type from SCS (NRCS) soils map or report for Craighead County;
3. Determine the antecedent soil moisture conditions (AMC). For design purposes, the AMC will be “average” or II;
4. Classify cover type and hydrologic condition of the soil-cover complex as good, fair, or poor. For additional information see Tables 2-2a, b, and c in Appendix 1;
5. Determine the Curve Number (CN) for the AMC II soil classification. If necessary, determine a weighted value by dividing the sum of the products of the subarea sizes and CNs by the total area. (See Section 3.3.2 for details about CN);

6. Estimate the watershed time of concentration in hours (Tc) using TR-55 with max sheet flow of 100 ft.;

7. Determine the potential maximum storage (S). Use Equation 3.5 to calculate the potential maximum storage;

8. Determine the initial abstraction (Ia). Use CN to determine Ia using Table 4-1 from TR-55, as shown below. See if Ia is greater than P;

<table>
<thead>
<tr>
<th>Curve number</th>
<th>Ia  (in)</th>
<th>Curve number</th>
<th>Ia  (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>3.000</td>
<td>70</td>
<td>0.857</td>
</tr>
<tr>
<td>41</td>
<td>2.878</td>
<td>71</td>
<td>0.817</td>
</tr>
<tr>
<td>42</td>
<td>2.762</td>
<td>72</td>
<td>0.778</td>
</tr>
<tr>
<td>43</td>
<td>2.651</td>
<td>73</td>
<td>0.740</td>
</tr>
<tr>
<td>44</td>
<td>2.545</td>
<td>74</td>
<td>0.703</td>
</tr>
<tr>
<td>45</td>
<td>2.444</td>
<td>75</td>
<td>0.667</td>
</tr>
<tr>
<td>46</td>
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<td>76</td>
<td>0.632</td>
</tr>
<tr>
<td>47</td>
<td>2.255</td>
<td>77</td>
<td>0.597</td>
</tr>
<tr>
<td>48</td>
<td>2.167</td>
<td>78</td>
<td>0.564</td>
</tr>
<tr>
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<td>79</td>
<td>0.532</td>
</tr>
<tr>
<td>50</td>
<td>2.000</td>
<td>80</td>
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<tr>
<td>51</td>
<td>1.922</td>
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<tr>
<td>52</td>
<td>1.846</td>
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<td>53</td>
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<td>54</td>
<td>1.704</td>
<td>84</td>
<td>0.381</td>
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<td>55</td>
<td>1.636</td>
<td>85</td>
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</tr>
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<td>56</td>
<td>1.571</td>
<td>86</td>
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<td>87</td>
<td>0.299</td>
</tr>
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<td>60</td>
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<td>62</td>
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<td>93</td>
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<td>64</td>
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<td>65</td>
<td>1.077</td>
<td>95</td>
<td>0.105</td>
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<td>66</td>
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<td>68</td>
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<tr>
<td>69</td>
<td>0.899</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. Use information in Section 3.3.1 to determine the total rainfall for watershed for the design frequency;
10. Determine the accumulated direct runoff (Q) using equation 3.4 (or solution of runoff equation TR-55 Figure 3.1);

11. Determine $I_a/P$ ratio;
12. Using $I_a/P$ ratio and $T_c$ determine unit peak discharge ($q_u$).
   Use TR-55 Exhibit 4-II Unit peak discharge ($q_u$) for NRCS (SCS) type II rainfall distribution;

13. Determine the unit peak discharge using graphical methods of the $I_a/P$ ratio and the $T_c$ (hours) and using Worksheet 4 in Appendix 1;
14. Determine the pond and swamp adjustment factor ($F_p$); and,
15. Compute peak discharge using equation 3.6
Appendix 1 has worksheets from the TR-55 manual to determine peak discharge.

### 3.3.1 Accumulated Rainfall (P) and Rainfall Distribution

Jonesboro is located in the SCS Type II hypothetical storm area. The design storm duration for drainage work is the 24-hour duration at the relevant frequency. The rainfall depth vs. frequency is shown in Table 3-1.

#### Table 3-1. Rainfall Depth vs. Frequency for Jonesboro, AR
from TP-40 and HYDRO-35

<table>
<thead>
<tr>
<th>Frequency</th>
<th>24-hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Year</td>
<td>3.88</td>
</tr>
<tr>
<td>10-Year</td>
<td>5.58</td>
</tr>
<tr>
<td>25-Year</td>
<td>6.35</td>
</tr>
<tr>
<td>50-Year</td>
<td>6.99</td>
</tr>
<tr>
<td>100-Year</td>
<td>7.70</td>
</tr>
<tr>
<td>500-Year</td>
<td>9.25</td>
</tr>
</tbody>
</table>

### 3.3.2 Curve Number (CN) Factors

The major factors affecting CN determination are hydrologic soil groups (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). The CN varies according to the factors below. Tables 2-2a, b and c in Appendix 1 provide details for CN selection. If a watershed subarea has multiple land uses, the CN can be weighted for the subarea.

### 3.3.3 Hydrologic Soil Groups

Soil properties influence the relationship between rainfall and runoff by affecting the rate of infiltration. NRCS divides soils into four hydrologic soil groups based on infiltration rates (Groups A-D). Urbanization also impacts soil groups as well.

**Group A** - Group A soils have low runoff potential due to high infiltration rates even when saturated. These soils primarily consist of deep sands, deep loess, and aggregated silts.

**Group B** - Group B soils have moderate infiltration rates when saturated. These soils primarily consist of moderately deep to deep, moderately well-drained to well-drained soils with moderately fine to moderately coarse textures (shallow loess, sandy loam).

**Group C** - Group C soils have slow infiltration rates and a moderately high runoff potential. These soils when saturated usually have a layer near the surface that impedes downward movement of water. These soils are moderately fine to fine in texture and examples include clay loams, shallow sandy loams, soils low in organic content, and soils usually high in clay.

**Group D** - Group D soils have high runoff potential (very slow infiltration rates) when saturated. These soils are predominantly clay soils with a high swelling potential, soils
with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material.

The SCS has published a county soil survey book for Craighead County. Use of the soil survey book and TR-55 table of soils and their hydrologic soil group is necessary to determine the Curve Number (CN).

### 3.3.4 Cover Type

Cover types can include vegetation, bare soil, and impervious surfaces. Cover type can be determined by reconnaissance, aerial photography, and land use maps. Tables 2-2a, b and c in Appendix 1, addresses most cover types.

### 3.3.5 Treatment

Treatment is a cover modifier that describes management of cultivated agricultural lands. Table 2-2b in Appendix 1 is used with agricultural areas that are cultivated.

### 3.3.6 Hydrologic Condition

Hydrologic condition is generally estimated from plant density and residue cover to account for the effects of cover and treatment in infiltration and runoff. Hydrologic condition only is a factor in CN for agricultural lands. Details about good, fair, and poor conditions are found in Table 2-2b and Table 2-2c in Appendix 1.

### 3.3.7 Antecedent Runoff Condition (ARC)

For design purposes, the antecedent runoff conditions (ARC) will be average, or Type II. The CN values assume medium ARC (or Type II) conditions.

### 3.3.8 Ponding and Swamp Adjustment Factor ($F_p$)

If ponds and swamp areas are spread throughout the watershed and not considered in the Tc computation, an adjustment is needed. Table 4-2 includes the adjustment factor for percent of area of the subbasin that is pond or swamp.

<table>
<thead>
<tr>
<th>Percentage of pond and swamp areas</th>
<th>$F_p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
</tr>
<tr>
<td>0.2</td>
<td>0.97</td>
</tr>
<tr>
<td>1.0</td>
<td>0.87</td>
</tr>
<tr>
<td>3.0</td>
<td>0.75</td>
</tr>
<tr>
<td>5.0</td>
<td>0.72</td>
</tr>
</tbody>
</table>
3.4 Computer Hydrograph Methods

The Corps of Engineers have developed HEC-HMS for determining hydrology. For large areas, HEC-HMS provides flow estimates that can account for valley storage and routing which SCS methods do not. HEC-HMS can be obtained from the Corps of Engineers. It can be downloaded from their website at http://www.hec.usace.army.mil/. For a Conditional Letter of Map Revision (CLOMR) or Letter of Map Revision (LOMR), a FEMA approved hydrology model must be used. Currently (May 2006), HEC-HMS is approved by FEMA.

NRCS has also developed a computer version of TR-55. It can be downloaded from their website at http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html or http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-wintr55.html.
4.0 STORM DRAIN AND DRAINAGE APPURTENANCES

4.1 General

This section contains storm drainage design criteria and demonstrates the design procedures to be employed on drainage projects within the City of Jonesboro. All drainage design calculations and assumptions shall be submitted with permit applications.

4.2 Design Frequencies

Table 7 in Appendix 1 shows the appropriate design frequencies to be used for storm drain designs in the City of Jonesboro.

4.3 Runoff Calculations

To begin design of a storm drainage system, it is necessary to compute the amount of runoff that accumulates upstream of the intake structures. For basins less than 100 acres, the SCS Method should be used for computing runoff. The equation is:

\[
Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}
\]  

(4.1)

where

\[
\begin{align*}
Q & = \text{runoff, (in)} \\
P & = \text{rainfall, (in)} \\
S & = \text{potential maximum retention after runoff begins, (in)}
\end{align*}
\]

\(S\) is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and \(S\) is related to CN by:

\[
S = \frac{1000}{CN} - 10
\]  

(4.2)

4.4 Street Flow

The next step in the design of the storm drain system is to calculate the flow within the streets.

4.4.1 Definitions

The following street classifications will provide clarity in discussing the requirements and methodology to calculate the flow in streets:

- **Principal Arterials**: Serve the major centers of activity
- **Minor Arterials**: Intended to provide land access
- **Collectors**: Connect local streets in residential neighborhoods
Locals: Provide access to various public and private properties

The following descriptions relate to the shape of the cross section of the roadway:

Straight Crown - A constant slope from one gutter flow line across the street to the other gutter flow line.

Parabolic Crown - A pavement surface shaped in a parabolic from one gutter flow line to the other.

Vertical Displacement Between Gutter Flow Line - Due to topography, it will be necessary at times that the curbs on a street be placed at different elevations.

4.4.2 Calculation of Flow in Streets

The calculation of flow in streets is dependent on street width and shape. Generally, there are two shapes for streets: straight crown and parabolic crown. The straight crowned street can be further subdivided into two types of gutters: uniform and composite. The following discussion covers the methodology used to compute the flow in the street.

Table 7 in Appendix 1 shows the requirements for the design of the roadway drainage.

4.4.3 Uniform Gutter Sections

\[ Q = \frac{K_c}{n} S_x^{1.67} S_l^{0.5} T^{2.67} \]  

Uniform Road Section

The runoff in the gutter is generally treated as open channel flow. Therefore, Manning’s Equation can be used to calculate the flow or spread in the road section. The following formula is a modified version of the Manning’s Equation. It incorporates the geometry of the uniform roadway section.

\[ Q = \frac{K_c}{n} S_x^{1.67} S_l^{0.5} T^{2.67} \]  

(4.3)
Where:

\[ K_C = 0.56 \]
\[ n = \text{Manning’s roughness coefficient (0.013 for concrete)} \]
\[ S_L = \text{Longitudinal slope of road, (ft/ft)} \]
\[ S_X = \text{Pavement (road) cross-slope, (ft/ft)} = \frac{d}{T} \]
\[ T = \text{Total width of flow or spread} \]
\[ Q = \text{Total discharge, (cfs)} \]
\[ S_L = \text{Longitudinal slope of road} \]

This equation assumes that the depth of flow, \( d \), is small when compared to the overall spread and therefore the spread is assumed to be equal to the wetted perimeter. Also, the friction along the curb height is assumed to be negligible when compared to the friction along the spread.

The roadway should be designed such that the spread will be maximized just upstream of the inlet. See design spread criteria in Table 7 in Appendix 1.

**4.4.4 Composite Gutter Sections**

![Composite Road Section Diagram]

Where:

\[ Q_W = \text{Flow in depressed section, (ft}^3/\text{s)} \]
\[ Q_S = \text{Side flow, (cfs)} \]
\[ S_W = \text{Gutter Cross Slope, (ft/ft)} \]
\[ S_X = \text{Pavement (road) cross-slope, (ft/ft)} \]
\[ W = \text{Width of depressed gutter, (ft)} \]
\[ T_S = \text{Width of side flow, (ft)} \]
\[ T = \text{Total width of flow, (ft)} \]
\[ a = \text{Continuous gutter depression, (in)} \]

In order to calculate the flow in a composite section the ratio of frontal flow to total gutter flow, \( E_o \), can be calculated using Formula (4.4) in conjunction with Formula (4.3).
4.4.5 Parabolic Street Sections

For residential streets, parabolic sections are often used because they provide a flatter driving surface than uniform sections. However, the flow capacity is less for the parabolic section than the uniform section. The following formulas can be used to calculate the flows and associated spread in a parabolic section.

\[
y = ((Q/S^{0.5})C^2) /C1 \quad (4.5)
\]

\[
Q = (y^*C1)^{(1/C2)}*S^{0.5} \quad (4.6)
\]

\[
T = B – (C3-C4y)^{0.5} \quad (4.7)
\]

\[
A = (T x y) / 3 \quad (4.8)
\]

\[
V = Q/A \quad (4.9)
\]

Where:

- \( y \) = Flow depth in gutter for one side of street, (ft)
- \( Q \) = Gutter discharge for one side of the street, (cfs)
- \( T \) = Spread for one side of the street, (ft)
- \( A \) = Cross sectional area of flow, (ft²)
- \( V \) = Velocity of flow, (ft/s)
- \( B \) = 1/2 of the street width

\[
E_o = \frac{1}{\left\{1 + \frac{S_w}{S_x} \left[1 + \left(\frac{S_w}{(T/W)-1}\right)^{2.67} - 1\right]\right\}^{-1}} = \frac{Q_w}{Q_{TOTAL}} \quad (4.4)
\]
### Table 4.1: Parabolic Roadway Coefficients

<table>
<thead>
<tr>
<th>CROWN</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot;</td>
<td>9.2180</td>
<td>0.3405</td>
<td>169</td>
<td>338</td>
</tr>
<tr>
<td>26' * 5&quot;</td>
<td>9.9714</td>
<td>0.3404</td>
<td>169</td>
<td>405.6</td>
</tr>
<tr>
<td>4&quot;</td>
<td>10.9821</td>
<td>0.3404</td>
<td>169</td>
<td>507</td>
</tr>
<tr>
<td>7&quot;</td>
<td>9.1145</td>
<td>0.3418</td>
<td>225</td>
<td>385.7143</td>
</tr>
<tr>
<td>31' * 6&quot;</td>
<td>9.7396</td>
<td>0.3418</td>
<td>225</td>
<td>450</td>
</tr>
<tr>
<td>* 5&quot;</td>
<td>10.5346</td>
<td>0.3418</td>
<td>225</td>
<td>540</td>
</tr>
<tr>
<td>8&quot;</td>
<td>9.1888</td>
<td>0.3421</td>
<td>324</td>
<td>486</td>
</tr>
<tr>
<td>36' * 7&quot;</td>
<td>9.7317</td>
<td>0.3421</td>
<td>324</td>
<td>555.4286</td>
</tr>
<tr>
<td>* 6&quot;</td>
<td>10.4020</td>
<td>0.3422</td>
<td>324</td>
<td>648</td>
</tr>
<tr>
<td>44' * 8&quot;</td>
<td>9.9146</td>
<td>0.3433</td>
<td>484</td>
<td>726</td>
</tr>
<tr>
<td>7&quot;</td>
<td>10.4975</td>
<td>0.3433</td>
<td>484</td>
<td>829.7143</td>
</tr>
<tr>
<td>6&quot;</td>
<td>11.2173</td>
<td>0.3433</td>
<td>484</td>
<td>968</td>
</tr>
</tbody>
</table>

* These crown heights shall be used for new developments

**Note:** These constants were derived for a Manning’s n of 0.016.

Alternatively, the nomographs included in Appendix 4 can be used as aids in designing parabolic roadway drainage.

### 4.5 Drainage Inlet Design

The hydraulic capacity of a storm drain inlet depends upon its geometry as well as the characteristics of the gutter flow. Inlet capacity governs both the rate of water removal from the gutter and the amount of water that can enter the storm drainage system. Inadequate inlet capacity or poor inlet location may cause flooding on the roadway resulting in a hazard to the traveling public.

In general inlets should be placed to meet the spread requirements summarized in Table 7 in Appendix 1. In addition, inlets should be spaced at a maximum distance of 600 feet apart or before intersecting street.

#### 4.5.1 Inlet Types

Storm drain inlets are used to collect runoff and discharge it to an underground storm drainage system. Inlets are typically located in gutter sections, paved medians, and roadside and median ditches. Inlets used for the drainage of highway surfaces can be divided into the following three classes:

1. Grate inlets;
2. Curb-opening inlets; and,
3. Combination inlets
Grate inlets consist of an opening in the gutter or ditch covered by a grate. Curb-opening inlets are vertical openings in the curb covered by a top slab. Combination inlets consist of both a curb-opening inlet and a grate inlet placed in a side-by-side configuration, but the curb opening may be located in part upstream of the grate.

4.5.2 Interception Capacity of Inlets on Grade

Inlet interception capacity, $Q_j$, is the flow intercepted by an inlet under a given set of conditions. The efficiency of an inlet, $E$, is the percent of total flow that the inlet will intercept for those conditions. The efficiency of an inlet changes with changes in cross slope, longitudinal slope, total gutter flow, and, to a lesser extent, pavement roughness. In mathematical form, efficiency, $E$, is defined by the following equation:

$$ E = \frac{Q_j}{Q} $$

(4.10)

Where:

- $E$ = Inlet Efficiency (ft³/s)
- $Q$ = Total Gutter Flow
- $Q_j$ = Intercepted Flow, (ft³/s)

Flow that is not intercepted by an inlet is termed carryover or bypass and is defined as follows:

$$ Q_b = Q - Q_j $$

(4.11)

Where:

- $Q_b$ = bypass flow, (ft³/s)

In Appendix 4, design charts for inlets on grade and procedures for using the charts are presented for the various inlet configurations. Remember that for locally depressed inlets, the quantity of flow reaching the inlet would be dependent on the upstream gutter section geometry and not the depressed section geometry.

Charts for grate inlet interception have been made and are applicable to all grate inlets tested for the Federal Highway Administration. The chart for frontal flow interception is based on test results which show that grates intercept all of the frontal flow until a velocity is reached at which water begins to splash over the grate. At velocities greater than “Splash-over” velocity, grate efficiency in intercepting frontal flow is diminished. Grates also intercept a portion of the flow along the length of the grate, or the side flow. A chart in Appendix 4 is provided to determine side-flow interception. Chart 5B in Appendix 4 determines the “splash-over” velocity.
A procedure for determining the interception capacity of combination inlets is also presented.

4.5.2.1 Grate Inlets

Grate inlets perform satisfactory over a wide range of gutter grades. The capacity of an inlet depends on its geometry and the cross slope, longitudinal slope, total gutter flow, depth of flow and pavement roughness. The depth of water next to the curb is a major factor in the interception capacity of both gutter inlets and grate inlets. At low velocities all the water flowing in the gutter adjacent to a grate is intercepted. On steep slopes only a portion of the frontal flow will be intercepted if the velocity is high or the grate is short and splash over occurs. For grates less than two (2) feet long intercepted flow is small.

A parallel bar grate inlet is the most efficient type of curb inlet; however when crossbars are added for bicycle safety the efficiency is greatly reduced. Where bicycle traffic is a design consideration, the curved vane grate and tilt bar grate are recommended for both hydraulic features and safety.

Where debris is a problem, consideration should be given to debris handling efficiency rankings. Table 4-2 presents the results of tests for debris handling efficiency. This table should be used for relative comparisons only.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Grate</th>
<th>Longitudinal Slope</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>1</td>
<td>Curved Vane</td>
<td>46</td>
</tr>
<tr>
<td>2</td>
<td>30º - 85 Tilt Bar</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>45º - 85 Tilt Bar</td>
<td>43</td>
</tr>
<tr>
<td>4</td>
<td>P – 50</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>P – 50x100</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>45º - 60 Tilt Bar</td>
<td>16</td>
</tr>
<tr>
<td>7</td>
<td>Reticuline</td>
<td>12</td>
</tr>
<tr>
<td>8</td>
<td>P-30</td>
<td>9</td>
</tr>
</tbody>
</table>

When the velocity approaching the grate is less than the “splash-over” velocity, the grate will intercept essentially all of the frontal flow. Conversely, when the gutter flow velocity exceeds the “splash-over” velocity for the grate, only part of the flow will be intercepted. A part of the flow along the side of the grate will be intercepted, dependent on the cross slope of the pavement, the length of the grate, and flow velocity.

The ratio of frontal flow to total gutter flow, $E_o$ for a uniform cross slope is expressed by equation 4.12:

$$E_o = \frac{Q_w}{Q} = 1 - \left(1 - \frac{W}{T}\right)^{2.67}$$

(4.12)
Where:

\[ Q = \text{total gutter flow, (ft}^3/\text{s}) \]
\[ Q_w = \text{flow in width } W, \text{ (ft}^3/\text{s}) \]
\[ W = \text{width of depressed gutter or grate, (ft)} \]
\[ T = \text{total spread of water, (ft)} \]

Chart 2B in Appendix 4 provides solutions of \( E_o \) for either uniform cross slopes or composite gutter sections.

The ratio of side flow, \( Q_s \), to total gutter flow is:

\[
\frac{Q_s}{Q} = 1 - \frac{Q_w}{Q} = 1 - E_o \quad (4.13)
\]

The ratio of frontal flow intercepted to total frontal flow, \( R_f \), is expressed by equation 4.14:

\[
R_f = 1 - K_u (V - V_o) \quad (4.14)
\]

Where:

\[ K_u = 0.09 \text{ in English Units} \]
\[ V = \text{velocity of flow in the gutter, (ft/s)} \]
\[ V_o = \text{gutter velocity where “splash-over” first occurs, (ft/s)} \]

(Note: \( R_f \) cannot exceed 1.0)

This ratio is equivalent to frontal flow interception efficiency. Chart 5B in Appendix 4 provides a solution for equation 4.14 which takes into account grate length, bar configuration, and gutter velocity at which splash-over occurs. The average gutter velocity (total gutter flow divided by the area of flow) is needed to use Chart 5B in Appendix 4. This velocity can also be obtained from Chart 4B in Appendix 4.

The ratio of side flow intercepted to total side flow, \( R_s \), is side flow interception efficiency, is expressed by equation 4.15. Chart 6B in Appendix 4 provides a solution to equation 4.15.

\[
R_s = \frac{1}{1 + \left( \frac{K_u L^{1.8}}{S_x L^{2.5}} \right)} \quad (4.15)
\]

Where:

\[ K_u = 0.15 \text{ in English Units} \]
\[ L = \text{length of grate along gutter, (ft)} \]
\[ S_x = \text{roadway cross slope} \]
\[ V = \text{velocity, (ft/s)} \]
The efficiency, \( E \), of a grate is expressed as provided in equation 4.16:

\[
E = R_f E_o + R_s (1 - E_o)
\]  

(4.16)

The first term on the right side of equation 4.16 is the ratio of intercepted frontal flow to total gutter flow, and the second term is the ratio of intercepted side flow to total side flow. The second term is insignificant with high velocities and short grates.

The interception capacity of a grate inlet on grade is equal to the efficiency of the grate multiplied by the total gutter flow as represented in equation 4.17.

\[
Q_i = E Q = Q \left[ R_f E_o + R_s (1 - E_o) \right]
\]  

(4.17)

**4.5.2.2. Curb-opening Inlets**

Curb-opening inlets are most effective on flatter slopes, in sags, and with flows which typically carry significant amounts of floating debris. The interception capacity of curb-opening inlets decreases as the gutter grade increases. Consequently, the use of curb-opening inlets is recommended in sags and on grades less than 3%.

Curb-opening inlets are effective in the drainage of pavements where flow depth at the curb is sufficient for the inlet to perform efficiently. Curb openings are less susceptible to clogging and offer little interference to traffic operation. They are a viable alternative to grates on flatter grades where grates would be in traffic lanes or would be hazardous for pedestrians or bicyclists.

Curb opening heights vary in dimension; however, a typical maximum height is approximately 4 to 6 inches. The length of the curb-opening inlet required for total interception of gutter flow on a pavement section with a uniform cross slope is expressed by equation 4.18:

\[
L_T = K_u Q^{0.42} S_x^{0.3} \left( \frac{1}{nS_x} \right)^{0.6}
\]  

(4.18)

Where:

- \( K_u = 0.6 \) in English Units
- \( n = \) Manning’s Coefficient
- \( S_x = \) roadway cross slope
- \( L_T = \) curb opening length required to intercept 100 percent of the gutter flow, (ft)
- \( S_l = \) longitudinal slope
- \( Q = \) gutter flow, (ft³/s)

The efficiency of curb-opening inlets shorter than the length required for total interception is expressed by equation 4.19:
\[ E = 1 - \left(1 - \frac{L}{L_T}\right)^{1.8} \]  

(4.19)

Where:

- \( L \) = curb-opening length, (ft);
- \( L_T \) = curb opening length at 100% efficiency, (ft)

Chart 7B in Appendix 4 is a nomograph for the solution of equation 4.18 and Chart 8B in Appendix 4 provides a solution of equation 4.19.

The length of inlet required for total interception by depressed curb-opening inlets or curb-openings in depressed gutter sections can be found by the use of an equivalent cross slope, \( S_e \), in equation 4.18 in place of \( S_x \). \( S_e \) can be computed using equation 4.20.

\[ S_e = S_x + S'_w E_o \]  

(4.20)

Where:

- \( S_x \) = roadway cross slope, (ft/ft);
- \( S'_w \) = cross slope of the gutter measured from the cross slope of the pavement, \( S_x \), (ft/ft), \( S'_w = (a/[12 W], \text{for } W \text{ in ft}) \) or \( = S_w - S_x \);
- \( a \) = gutter depression, (in);
- \( E_o \) = ratio of flow in the depressed section to total gutter flow determined by the gutter configuration upstream of the inlet.

The following diagram shows the depressed curb inlet for equation 4.26, \( E_o \) is the same ratio as used to compute the frontal flow interception of a grate inlet.

As seen from Chart 7B in Appendix 4, the length of curb opening required for total interception can be significantly reduced by increasing the cross slope or the equivalent cross slope. The equivalent cross slope can be increased by use of a continuously depressed gutter section or a locally depressed gutter section.
Using the equivalent cross slope, $S_e$, equation 4.18 becomes:

$$L_T = K_T Q^{0.42} S_L^{0.3} \left( \frac{1}{nS_e} \right)^{0.6}$$  \hspace{1cm} (4.21)

Where:

- $K_T = 0.6$ in English Units
- $n = $ Manning’s Coefficient
- $S_e =$ equivalent cross slope
- $L_T =$ curb opening length required to intercept 100 percent of the gutter flow, (ft)
- $S_L =$ longitudinal slope
- $Q =$ gutter flow, (ft$^3$/s)

Equation 4.19 is applicable with either straight cross slopes or composite cross slopes. Charts 7B and 8B in Appendix 4 are applicable to depressed curb-opening inlets using $S_e$.

### 4.5.2.3. Combination Inlets

Combination inlets provide the advantages of both curb opening and grate inlets. This combination results in a high capacity inlet which offers the advantages of both grate and curb-opening inlets. When the curb opening extends upstream of the grate in a “sweeper” configuration, the interception capacity can be computed as the sum of the capacity of the curb opening upstream of the grate and the grate capacity. Used in a sag configuration, the “sweeper” inlet can have a curb opening on both sides of the grate.

The interception capacity of a combination inlet consisting of a curb opening and grate placed side-by-side is no greater than that of the grate alone. Capacity is computed by neglecting the curb opening. A combination inlet is sometimes used with a part of the curb opening placed upstream of the grate. The curb opening in such an installation intercepts debris which might otherwise clog the grate and is called a “sweeper” inlet. A sweeper combination inlet has an interception capacity equal to the sum of the curb opening upstream of the grate plus the grate capacity, except that the frontal flow and thus the interception capacity of the grate is reduced by interception by the curb opening.

### 4.5.3 Interception Capacity of Inlets in Sag Locations

Inlets in sag locations operate as weirs under low head conditions and as orifices at greater depths. Orifice flow begins at depths dependent on the grate size, the curb opening height, or the slot width of the inlet. At depths between those at which weir flow definitely prevails and those at which orifice flow prevails, flow is in a transition stage. At
these depths, control is ill-defined and flow may fluctuate between weir and orifice control. Design procedures presented here are based on a conservation approach to estimating the capacity of inlets in sump locations.

The efficiency of inlets in passing debris is critical in sag locations because all runoff which enters the sag must be passed through the inlet. Total or partial clogging of inlets in these locations can result in hazardous ponded conditions. Grate inlets alone are not recommended for use in sag locations because of the tendencies of grates to become clogged. Combination inlets or curb-opening inlets are recommended for use in these locations.

**4.5.3.1 Grate Inlets in Sags**

A grate inlet in a sag location operates as a weir to depths dependent on the size of the grate and as an orifice at greater depths. Grates of larger dimension will operate as weirs to greater depths than smaller grates.

![Diagram of grate inlet in sag](image)

The capacity of grate inlets operating as weirs is:

\[ Q_j = C_w \cdot P \cdot d^{1.5} \]  

(4.22)

Where:

- \( P \) = perimeter of the grate in (ft) disregarding the side against the curb
- \( C_w = 3.0 \) in English Units
- \( d \) = average depth across the grate; \( 0.5 \cdot (d_1 + d_2) \), (ft)

The capacity of a grate inlet operating as an orifice is:

\[ Q_j = C_o \cdot A_g \cdot (2 \cdot g \cdot d)^{0.5} \]  

(4.23)

Where:

- \( C_o \) = orifice coefficient = 0.67
- \( A_g \) = clear opening area of the grate, (ft\(^2\))
- \( g = 32.2 \) ft/s\(^2\)

Use of equation 4.23 required the clear area of opening of the grate. Opening ratios for the grates are given on Chart 9B in Appendix 4.
Chart 9B in Appendix 4 is a plot of equation 4.22 and 4.23 for various grate sizes. The chart indicates the effect of the grate size on the depth at which it operates as an orifice. The transition from weir to orifice flow results in an interception capacity less than that computed by either the weir or the orifice equation. This capacity can be approximated by drawing in a curve between the lines representing the perimeter and net area of the grate to be used.

4.5.3.2 Curb-Opening Inlets

The capacity of a curb-opening inlet in a sag depends on water depth at the curb, the curb opening length, and the height of the curb opening. The inlet operates as a weir to depths equal to the curb opening height and as an orifice at depths greater than 1.4 times the opening height. At depths between 1.0 and 1.4 times the opening height, flow is in a transition stage.

Spread on the pavement is the usual criterion for judging the adequacy of a pavement drainage inlet design. It is also convenient and practical in the laboratory to measure depth at the curb upstream of the inlet at the point of maximum spread on the pavement. Therefore, depths at the curb measurements from experiments coincide with the depth at curb of interest to designers. The weir coefficient for a curb-opening inlet is less than the usual weir coefficient for several reasons. The most obvious of which is that depth measurements from experimental tests were not taken at the weir, and drawdown occurs between the point where measurements were made and the weir.

The weir location for a depressed curb-opening inlet is at the edge of the gutter, and the effective weir length is dependent on the width of the depressed gutter and the length of the curb opening. The weir location for a curb-opening inlet that is not depressed is at the lip of the curb opening, and its length is equal to that of the inlet, as shown in Chart 10B in Appendix 4.

The equation for the interception capacity of a depressed curb-opening inlet operating as a weir as:

\[ Q_j = (L + 1.8W)d^{0.5} \]  

(4.24)

Where:

- \( C_w = 2.3 \)
- \( L = \) length of curb opening, (ft)
- \( W = \) lateral width of depression, (ft)
- \( d = \) depth at curb measured from the normal cross slope, (ft), i.e., \( d = T S_x \)

The weir equation is applicable to depths at the curb approximately equal to the height of the opening plus the depth of the depression. Thus, the limitation on the use of equation 4.24 for a depressed curb-opening inlet is:

\[ d \leq h + a/12, \text{ in English Units} \]  

(4.25)
The weir equation for curb-opening inlets without depression becomes:

$$Q_j = C_w L d^{1.5}$$  \hspace{1cm} (4.26)$$

Without depression of the gutter section, the weir coefficient, $C_w$, becomes 3.0, English system. The depth limitation for operation as a weir becomes $d \leq h$.

At curb-opening lengths greater than 12 feet, equation 4.26 for non-depressed inlet produces intercepted flows which exceed the values for depressed inlets computed using equation 4.25. Since depressed inlets will perform at least as well as non-depressed inlets of the same length, equation 4.26 should be used for all curb-opening inlets having lengths greater than 12 feet.

Curb-opening inlets operate as orifices at depths greater than approximately 1.4 times the opening height. The interception capacity can be computed by equation 4.27a and equation 4.27b. These equations are applicable to depressed and undepressed curb-opening inlets. The depth at the inlet includes any gutter depression.

$$Q_j = C_o h L \left(2 g d_o\right)^{0.5}$$  \hspace{1cm} (4.27a)$$

Or

$$Q_j = C_o A_d \left[2g \left(d_i - \frac{h}{2}\right)\right]^{0.5}$$  \hspace{1cm} (4.27b)$$

Where:

- $C_o = \text{orifice coefficient (0.67)}$
- $d_o = \text{effective head on the center of the orifice throat, (ft)}$
- $L = \text{length of orifice opening, (ft)}$
- $A_d = \text{clear area of opening, (ft}^2\text{)}$
- $d_i = \text{depth at lip of curb-opening, (ft)}$
- $h = \text{height of curb-opening orifice, (ft)}$
- $g = \text{gravitational constant (32.2 ft/s}^2\text{)}$
The height of the orifice in equations 4.27a and 4.27b assumes a vertical orifice opening. As illustrated in the adjacent figure, other orifice throat locations can change the effective depth on the orifice and the dimension \((d_1 - h/2)\). A limited throat width could reduce the capacity of the curb-opening inlet by causing the inlet to go into orifice flow at depths less than the height of the opening.

For curb-opening inlets with other than vertical faces, equation 4.27a can be used with:

\[
\begin{align*}
  h &= \text{orifice throat width, (ft)} \\
  d_0 &= \text{effective head on the center of the orifice throat, (ft)}
\end{align*}
\]

Chart 10B in Appendix 4 provides solutions for equations 4.24 and 4.27 for depressed curb-opening inlets, and Chart 11B in Appendix 4 provides solutions for equations 4.26 and 4.27 for curb-opening inlets without depression. Chart 12B in Appendix 4 is provided for use for curb-openings with other than vertical orifice openings.

### 4.5.3.3 Combination Inlets

Combination inlets consisting of a grate and a curb opening are considered advisable for use in sags where hazardous ponding can occur. Equal length inlets refer to a grate inlet placed along side a curb-opening inlet, both of which have the same length. A “sweeper” inlet refers to a grate inlet placed at the downstream end of a curb-opening inlet. The curb-opening inlet is longer than the grate inlet and intercepts the flow before the flow reaches the grate. The “sweeper” inlet is more efficient than the equal length combination inlet and the curb-opening has the ability to intercept any debris which may clog the grate inlet. The interception capacity of the equal length combination inlet is essentially equal to that of a grate alone in weir flow. In orifice flow, the capacity of the equal combination inlet is equal to the capacity of the grate plus the capacity of the curb-opening.

Equation 4.22 and Chart 9B in Appendix 4 can be used for grates in weir flow or combination inlets in sag locations. Equations 4.24, 4.25, and 4.26 as well as Charts 10B, 11B, and 12B in Appendix 4 for curb-opening inlets are applicable assuming that the grate is completely clogged.

Where depth at the curb is such that orifice flow occurs, the interception capacity of the inlet is computed by adding equations 4.23 and 4.27 are as follows:

\[
Q_j = 0.67 A_g (2 g d)^{0.5} + 0.67 h L (2 g d_0)^{0.5} \quad (4.28)
\]

Where:

- \(A_g\) = clear area of the grate, \((\text{ft}^2)\)
- \(g\) = gravitational constant \((\text{ft/s}^2)\)
- \(d\) = average depth over the grate, \((\text{ft})\)
- \(h\) = height of curb-opening orifice \((\text{ft})\)
- \(L\) = length of curb-opening, \((\text{ft})\)
- \(d_0\) = effective depth at the center of the curb opening orifice, \((\text{ft})\)
Trial and error solutions are necessary for determining the depth at the curb for a given flow rate using Charts 9B, 10B, and 11B in Appendix 4 for orifice flow. Different assumptions for clogging of the grate can also be examined using these charts.

4.5.4 Inlet Locations

4.5.4.1 Geometric Controls

There are a number of locations where inlets may be necessary with little regard to contributing drainage area. These locations should be marked on the plans prior to any computations regarding discharge, water spread, inlet capacity, or flow bypass. Examples of such locations as follows:

- At locations on grade where the design flows exceeds the depth and spread criteria;
- At all low points (sag points) in gutters;
- Immediately upgrade of median breaks and street intersections;
- Immediately upgrade of roadway cross slope reversals;
- Upstream and downstream of bridge locations, where applicable;
- Behind curbs and sidewalks as necessary to drain low areas; and,
- At the end of channels in cut sections.

In addition to the areas identified above, runoff from areas draining towards the highway pavement should be intercepted by roadside channels or inlets before it reaches the roadway. This applies to drainage from cut slopes, side streets, and other areas alongside the pavement. Curbed pavement sections and pavement drainage inlets are inefficient means for handling extraneous drainage.

4.5.4.2 Inlet Spacing on Continuous Grades

Design spread is the criterion used for locating storm drain inlets between those required by geometric or other controls. Design spread criteria is presented in Table 7 in Appendix 1. The interception capacity of the upstream inlet will define the initial spread. As flow is contributed to the gutter section in the downstream direction, spread increases. The next downstream inlet is located at the point where the spread in the gutter reaches the design spread. Therefore, the spacing of inlets on a continuous grade is a function of the amount of upstream bypass flow, the tributary drainage area, and the gutter geometry. However, the inlets shall not be spaced any more than 600 feet apart.

For a continuous slope, the designer may establish the uniform design spacing between inlets of a given design if the drainage area consists of pavement only or has reasonably uniform runoff characteristics and is rectangular in shape. In this case, the time of concentration is assumed to be the same for all inlets.
4.6 HYDRAULIC DESIGN OF CLOSED CONDUITS

All closed conduits shall be hydraulically designed through the application of Manning’s Equation, (non critical flows) expressed as follows:

\[ Q = A \frac{V}{n} \]  
\[ Q = \frac{1.486}{n} AR^{2/3} S_f^{1/2} \]  
\[ R = \frac{A}{P} \]

Where:
- \( Q \) = flow (ft\(^3\)/s)
- \( A \) = cross sectional area, (ft\(^2\))
- \( V \) = velocity of flow in the conduit, (ft/s)
- \( n \) = roughness coefficient of the conduit
- \( R \) = hydraulic radius which is the area of flow divided by the wetted perimeter, (ft)
- \( S_f \) = channel slope of the conduit in (ft/ft)
- \( P \) = wetted perimeter, (ft)

4.6.1 Velocity in Closed Conduits

Storm sewers should operate within certain velocity limits to prevent excessive deposition of solids due to low velocities, and to prevent invert erosion and undesirable and hazardous outlet conditions due to excessively high velocity. Minimum and maximum velocities for closed conduits are provided in Table 6 in Appendix 1. In extreme conditions where the maximum velocity must be exceeded, prior approval must be obtained from the City Engineer.

4.6.2 Roughness Coefficients for Closed Conduits

Roughness coefficients are directly related to construction procedures. When alignment is poor and joints have not been properly assembled, extreme head losses will occur. Coefficients used in this matter are related to construction procedures, and assume that the pipe will be manufactured with a consistently smooth surface. Recommended roughness coefficients are provided in Table 2 in Appendix 1.

4.6.3 Minor Head Losses in Closed Conduits

Head losses at structures shall be determined for manholes, junction boxes, wye branches, bends, curves, and changes in pipe sizes in the design of closed conduits. Minimum head loss used at any structure shall be 0.10 feet. Properly designed curves may have zero losses.
A. Head losses and gains for wyes and pipe size changes will be calculated by the following formulas:

Where \( V_1 < V_2 \):

\[
\frac{V_2^2}{2g} - \frac{V_1^2}{2g} = HL
\]

Where \( V_1 > V_2 \):

\[
\frac{V_2^2}{4g} - \frac{V_1^2}{4g} = HL
\]

and \( V_1 \) is upstream velocity and \( V_2 \) is downstream velocity. It should be noted that new storm sewer design shall be designed where the receiving pipe velocity increases going downstream. Otherwise, a hydraulic jump may occur. Deviations to this requirement shall be handled on a case by case basis by the City Engineer.

B. Head losses and gains for manholes, bends, curves and junction boxes will be calculated as shown in Table 5A and Table 5B in Appendix 1.

1) The basic equation for most cases where there is both upstream and downstream velocity, takes the form as set forth below with the various conditions of the coefficient “\( K_j \)” shown in Table 5A in Appendix 1.

\[
h_j = \frac{V_2^2}{2g} - K_j \frac{V_1^2}{2g}
\]  \hspace{1cm} (4.33)

Where:

- \( H_j \) = junction or structure head loss, (ft)
- \( V_1 \) = velocity in upstream pipe, (ft/s)
- \( V_2 \) = velocity in downstream pipe, (ft/s)
- \( K \) = junction or structure coefficient of loss

2) In the case where the inlet is at the very beginning of a line, or the line is laid with bends or obstructions, the equation is revised as follows, without any approach velocity.

\[
h_j = K_j \frac{V_2^2}{2g}
\]  \hspace{1cm} (4.34)
5.0 OPEN CHANNELS

5.1 General

This section describes the criteria for the design of drainage channels. The minimum slope for all proposed channels shall be 0.25%, unless otherwise approved by the City Engineer.

The hydraulic characteristics of improved channels are to be determined through the application of Manning’s Equation. In lieu of Manning’s Equation, HEC-RAS can be used to determine the water surface profile. According to the complexity of the system, the City Engineer may require the use of the HEC-RAS Computer Program.

5.2 Cross Sections

Figure 2 in Appendix 2, contains typical sections that are to be used in the design of open channels.

All improved channels shall be designed to carry the 25-year flow plus one foot of freeboard. Adjacent building structures finish floor elevations shall be at least one foot above the 100-year water surface elevation.

A dedicated drainage easement shall be provided to the City of Jonesboro for open channels. The easement width shall be no less than the minimum width required to convey the 100-year frequency runoff or 15 feet, whichever the greater.

Unlined improved channels that contain bends shall be designed such that erosion at the bends is minimized. Erosion protection at bends shall be determined based on the velocity along the outside of the channel bend. Unlined improved channels shall have side slopes no steeper than 3:1 and lined channels shall have side slopes no steeper than 2:1, unless authorized by the City Engineer. A soil analysis shall be performed to determine the maximum slope that the soil, at the channel improvement site, can sustain without failure.

5.3 Roughness Coefficients

The roughness coefficients that are to be used are shown in Table 4 in Appendix 1. Variations from that which is shown must be approved by the City Engineer.

5.4 Velocity Requirements

The velocity limits for open-channel flow are given in Table 4 in Appendix 1. The channels for which the velocity exceeds these limits shall be protected by appropriate erosion protection or energy dissipater or both.
5.5 Channel Drop Structures

The function of a drop structure is to reduce channel velocities by allowing flatter upstream and downstream channel slopes. Sloping channel drops and vertical channel drops are two commonly used drop structures.

The flow velocities in the channel upstream and downstream of the drop structure need to satisfy the permissible velocities allowed for channels in Table 4 in Appendix 1. The velocities shall be checked for flows produced by the 10-, 50- and 100-year frequency events.

An apron shall be constructed immediately upstream of the chute to protect against the increasing velocities and turbulence which result as the water approaches the drop structure. The apron shall extend at least five (5) feet upstream of the point where flow becomes supercritical. In no case shall the length of the upstream apron be less than ten (10) feet.

An apron shall be constructed immediately downstream of the chute or stilling basin to protect against erosion due to the occurrence of the hydraulic jump. The apron shall extend a minimum of ten (10) feet beyond the anticipated location of the hydraulic jump.

The design of drop structures is based on the height of the drop, the normal depths upstream and downstream of the drop structure and discharge.

5.5.1 Vertical Drop Structures

The approximate height of the drop required to stabilize the hydraulic jump should be determined.

The drop length and the hydraulic jump length of the drop structure should be calculated to determine the length of the downstream apron required to prevent erosion.

5.5.2 Sloping Drop Structures

The location of the hydraulic jump should be determined based on the upstream and downstream flow depths and channel slopes.

The length of the hydraulic jump should be calculated to determine the length of the downstream apron required to prevent erosion.
6.0 CULVERTS

6.1 General

The design theory outlined herein is a modification of the method used in the hydraulic design of concrete box and pipe culverts, as discussed in the Federal Highway Administration’s Hydraulic Design Series Number 5 entitled “Hydraulic Design of Highway Culverts”.

The hydraulic capacity of culverts is computed using various factors and formulas. Laboratory tests and field observations indicate that culvert flow may be controlled either at the inlet or outlet. Inlet control involves the culvert cross-sectional area, the ponding of headwater at the entrance, and the inlet geometry. Outlet control involves the tailwater elevation in the outlet channel, the slope of the culvert, the roughness of the surface and length of the culvert barrel.

6.2 Culverts Flowing with Inlet Control

Inlet control means that the discharge capacity of a culvert is controlled at the culvert entrance by the depth of the headwater and entrance geometry, including the barrel shape and cross-sectional area, and the type of inlet edge.

Nomographs for determining culvert capacity for inlet control are shown in Appendix 5. These nomographs were developed by the Division of Hydraulic Research, Bureau of Public Roads, from analysis of laboratory research reported in the National Bureau of Standards Report No. 444, entitled “Hydraulic Characteristics of Commonly Used Pipe Entrances”, by John L. French, and “Hydraulics of Conventional Highway Culverts” by H. G. Bossy. Experimental data for box culverts with headwalls and wingwalls were obtained from an unpublished report of the U.S. Geological Survey.

6.3 Culverts Flowing with Outlet Control

The culvert is designed so that the depth of headwater, which is the vertical distance from the upstream culvert flow line to the elevation of the ponded water surface, does not encroach on the allowable freeboard during the design storm.

Headwater depth, HW, can be expressed by a common equation for all outlet control conditions:

\[ HW = H + h_O - L \cdot (S_O) \]  \hspace{1cm} (6.1)

HW = headwater depth in feet from the flow line of the culvert, (ft)
H = head or energy required to pass a given discharge through a culvert, (ft)
hO = vertical distance from the downstream culvert flow line to the elevation from which H is measured, (ft)
L = length of culvert, (ft)
S_O = culvert barrel slope, (ft)

The head, H, is made up of three parts: including the velocity head, exist loss (H_v) and entrance loss (H_e), and a friction loss (H_f). This energy is obtained from the ponding of water at the entrance and is expressed as:
$H = H_V + H_e + H_f \quad (6.2)$

$H$ = head or energy in feet of water
$H_V = \frac{V^2}{2g}$ where $V$ is average velocity in culvert or \( \frac{Q}{A} \)
$H_e = K_e \frac{V^2}{2g}$ where $K_e$ is the entrance loss coefficient Table 8 in Appendix 1
$H_f = \text{the energy required to overcome the friction of the culvert barrel and expressed as:}$

$$H_f = \frac{29.2n^2L}{R^{1.33}} \times \frac{V^2}{2g} \quad (6.3)$$

Where:

- $n$ = coefficient of roughness
- $L$ = length of culvert barrel, (ft)
- $V$ = average velocity in the culvert, (ft/s)
- $g$ = gravitational acceleration (32.2 ft/s$^2$)
- $R$ = hydraulic radius (Area / Wetted Perimeter, ft)

Substituting into the previous equation:

$$H = \frac{V^2}{2g} + K_e \frac{V^2}{2g} + \left[ \frac{29.2n^2L}{R^{1.33}} \right] \frac{V^2}{2g} \quad (6.4)$$

and simplifying:

$$H - \left[ 1 + K_e + \frac{29.2n^2L}{R^{1.33}} \right] \frac{V^2}{2g} \quad \text{for full flow} \quad (6.5)$$

For various conditions of outlet control flow, $h_O$ is calculated differently. When the elevation of the water surface in the outlet channel is equal to or above the elevation of the top of the culvert opening at the outlet, $h_O$ is equal to the tailwater depth or:

$$h_O \text{ re} = TW$$

If the tailwater elevation is below the top of the culvert opening at the outlet, $h_O$ is the greater of two values: (1) Tailwater, TW, as defined above, or (2) $(d_c + D)/2$, where $d_c$ = critical depth. The critical depth, $d_c$, for box culverts may be obtained from Appendix 5 or may be calculated from the formula:

$$d_c = 0.315 \left( \frac{Q}{B} \right)^{2/3} \quad (6.6)$$
Where:

\[ dc = \text{critical depth for box culvert}, \ (\text{ft}) \]
\[ Q = \text{discharge}, \ (\text{ft}^3/\text{s}) \]
\[ B = \text{bottom width of box culvert}, \ (\text{ft}) \]

The critical depth for circular pipes may be obtained from Appendix 5, or may be calculated by trial and error. Charts developed by the Bureau of Public Roads may be used for determining the critical depth. Utilize values of \( D, A \) and \( d_c \), which will satisfy the equation:

\[
\frac{Q^2}{g} = \frac{A^3}{D}
\]  

(6.7)

Where:

\[ d_c = \text{critical depth for culvert}, \ (\text{ft}) \]
\[ Q = \text{discharge}, \ (\text{ft}^3/\text{s}) \]
\[ g = \text{gravitational constant} \ (32.2 \text{ ft/s}^2) \]
\[ A = \text{cross-sectional area}, \ (\text{ft}^2) \]

The equation is also applicable for trapezoidal or irregular channels, in which instances "\( D \)" becomes the channel top width in feet.
7.0 BRIDGES

Once a design discharge and depth of flow have been established, the size of the bridge opening may be determined. The bridge opening shall be designed so that it is in compliance with Section 5.0 and Section 9.0 of this manual and meets all FEMA requirements.

The bridge opening shall be designed utilizing the latest version of HEC-RAS computer software.

Input and output data from the software shall be included within the storm drainage calculations as required by Section 2.0 of this manual.
8.0 DETENTION POND DESIGN

8.1 General

The purpose of stormwater detention is to protect downstream properties from flood increases due to upstream development. Stormwater detention is required to control peak flow at the outlet of a site such that post-development peak flows are equal to or less than pre-development peak flows for the 2-year through 100-year design storms.

8.2 No Adverse Impact Policy

The City of Jonesboro has adopted the policy that runoff from new development will not adversely affect downstream properties.

The City of Jonesboro retains the right to require detention in areas of known flooding when detention will not exacerbate downstream flooding. Detention systems must be constructed during the first phase of major developments to eliminate damage to adjacent properties during construction. In this regard, the detention systems shall be designed to function as sediment traps and cleaned out to proper volumes before completion. If siltation has occurred, detention systems must be restored to their design dimensions after construction is complete and certified as part of the as-built submittal.

8.3 Detention Reservoir Routing

The peak flow reduction obtained by a stormwater detention system can be evaluated by performing reservoir routing calculations, usually as a trial and error process. The use of the Storage Indication Method relationship is as follows:

   a. Inflow Hydrograph
   b. Stage-storage curve
   c. Stage-discharge curve

Development of each of these relationships should be based on site-specific data.

8.3.1 Inflow Hydrograph

Fundamentals for the development of an inflow hydrograph for design flood conditions presented in Section 3.
8.3.2 Stage-Storage Curve

A stage-storage curve defines the relationship between the depth of water and storage volume in a reservoir. An example of a stage-storage curve is shown below.

![Stage-storage curve graph]

8.3.2.1 Stage-Storage Calculations

**Bottom Area**

The volume is computed by treating it as a trapezoidal basin where:

\[ V = LWD + (L+W)Z \frac{D^2}{3} + \frac{4}{3} Z^2 D^3 \]  

(8.1)

Where:

- \( V \) = Storage at stage \( D \) (cu-ft)
- \( D \) = Stage or depth (ft)
- \( L \) = Bottom length (ft)
- \( W \) = Bottom width (ft)
- \( Z \) = Side slope, (Z:1) (H:V)

**Pipe Storage**

\[ V = \frac{L}{6} \left( A_1 + 4M + A_2 \right) \]  

(8.2)

Where:

- \( V \) = Storage (cu-ft)
- \( L \) = Pipe length (ft)
- \( A_1 \) = Cross-sectional area of depth at downstream end
- \( A_2 \) = Cross-sectional area of depth at upstream end
- \( M \) = Cross-sectional area of depth at midsection

When the pipe slope is zero, Volume = \( LA_1 \)
Contours

The average-end-area method may be applied vertically or the Conic method. The conic method uses the following equation:

\[ V = d \left( \frac{A_1 + \sqrt{A_1 A_2} + A_2}{3} \right) \]  \hspace{1cm} (8.3)

Where:

- \( V \) = Storage (cu-ft)
- \( d \) = Change in elevation between points 1 and 2
- \( A_1 \) = Surface area at elevation 1 (sq-ft)
- \( A_2 \) = Surface area at elevation 2 (sq-ft)

8.3.3 Stage-Discharge Curve

A stage-discharge curve defines the relationship between the depth of water and the discharge or outflow from a storage basin. An example of a stage-discharge curve is shown below.

A typical stormwater storage basin has two spillways: principal and emergency. The principal spillway is usually designed with a capacity sufficient to convey the design storm without allowing flow to enter the emergency spillway. The emergency spillway is sized to provide a bypass for stormwater during a storm that exceeds the design capacity of the principal spillway.
8.3.3.1 Stage-Discharge Calculations

**Culverts/Orifices**

The equation used for culvert/orifice structures is:

\[ Q = C_o A \sqrt{\frac{2gh}{k}} \times Nb \]  \hspace{1cm} (8.4)

**Under Inlet Control**

Q = Discharge, (cfs)
A = Culvert area, (sq-ft)
h = Distance between the water surface and the centroid of the culvert barrel (1/2 flow depth during partial flow), (ft)
Nb = Number of barrels
C_o = Orifice coefficient
k = 1

**Under Outlet Control**

Q = Discharge, (cfs)
A = Culvert area, (sq-ft)
h = Distance between the upstream and downstream water surface
Nb = Number of barrels
C_o = 1
k = 1.5 + [(20n^2L)/R^{1.33}]
n = Manning's n-value
L = Culvert length, (ft)
R = Area/wetted perimeter, (ft)

Profile of typical culvert

h(i) is the head under inlet control. H(o) under outlet control.
Weirs

The basic equations used to calculate weir flow are:

Rectangular, Cipoletti, Broad Crested & Riser

\[ Q = C_w L H^{1.5} \]  \hspace{1cm} (8.5)

Where:

- \( Q \) = Discharge over weir, (cfs)
- \( L \) = Length of the weir crest, (ft)
- \( H \) = Distance between water surface and the crest, (ft)
- \( C_w \) = Weir coefficient, typically 3.33

V-notch

\[ Q = 1.38 Tan \left( \frac{\theta}{2} \right) H^{2.5} \]  \hspace{1cm} (8.6)

Where:

- \( Q \) = Discharge over weir, (cfs)
- \( \theta \) = Angle of v-notch, (deg)
- \( H \) = Head on apex of v-notch, (ft)

Adjustment for Submerged Weirs

Rectangular, V-notch, and Cipoletti weirs are affected by submergence when the tailwater rises above the crest, as shown below. The result will be that the discharge over the weir will be reduced.
The equation for the reduction in flow is:

\[
Q_s = Q_r \left( 1 - \left( \frac{H_2}{H_1} \right)^{1.5} \right)^{0.385}
\]

(8.7)

Where:

- \(Q_s\) = Submerged flow, (cfs)
- \(Q_r\) = Unsubmerged flow from standard weir equations
- \(H_1\) = Upstream head above crest, (ft)
- \(H_2\) = Downstream head above crest, (ft)

**Routing fundamentals**

Reservoir routing is the process of passing a flood hydrograph through a storage reservoir or detention pond. This process changes the pattern of flow with respect to time but conserves volume. The purpose of reservoir routing is usually to reduce the peak flow to a predetermined level or to delay the peak. The routing procedure is known as the Storage Indication Method and begins with a stage/storage/discharge relationship, an inflow hydrograph and is based entirely on the continuity equation.

\[
I - O = \frac{ds}{dt}
\]

(8.8)

Where:

- \(I\) = Inflow;
- \(O\) = Outflow;
- \(ds/dt\) = change in storage

**Limitations**

The most common type of detention routing problem requires knowing the design storm period or inflow hydrograph and peak outflow or allowable discharge from the detention basin. A trial and error procedure is used to calculate the storage volume required.

A less common routing problem involves preventing storage basin overflow during the design for a given basin size and return period. In such a case, the magnitude of the peak flow reduction is fixed. A trial and error procedure will be required to find a solution, as only the stage-storage curve is known explicitly.
8.3.4 Dry Reservoirs (Ponds)

Wet weather ponds or dry reservoirs shall be designed with proper safety, stability, and ease of maintenance. Maximum side slopes for grass reservoirs shall not exceed one (1) foot vertical for three (3) feet horizontal (3:1) unless adequate measures are included to provide for the above noted features. In no case shall the limits of the maximum water surface elevation be less than one (1) foot vertically below the lowest floor elevation of any adjacent structure.

The entire reservoir area shall be seeded, fertilized, mulched, sodded or paved as required for acceptance by the City Engineer. Overflow areas shall be protected against erosive velocities.

8.3.5 Open Channels

Normally permitted open channels may be used as detention areas provided that the limits of the maximum design water surface elevation are not less than one (1) foot below the lowest floor elevation of any adjacent structure. No detention will be permitted within public road rights-of-way unless approval is given by the City of Jonesboro.

8.3.6 Wet Reservoirs (Ponds)

Permanent lakes with fluctuating volume controls may be used as retention areas provided that the limits of the maximum water surface elevation are not less than one (1) foot below the lowest floor elevation of any adjacent structure.

Maximum side slopes for the fluctuating area of permanent lakes shall be one (1) foot vertical to three (3) feet horizontal (3:1) unless provisions are included for safety, stability, and ease of maintenance.

Special consideration shall be given to safety and accessibility in design of permanent lakes in residential areas. Typical items to be considered are: tops with grate openings on riser structures, 6’ to 10’ wide safety ledges at no greater than 2’-3’ below normal pool elevation, trash and/or safety racks on pipe inlets and outlets, danger/warning signs, fencing, etc.

An analysis shall be furnished of any proposed earthen dam construction soil. A boring of the foundation for the earthen dam may be requested by the City Engineer. Earthen dam structures shall be designed by a licensed Professional Engineer in the State of Arkansas.

8.3.7 Parking Lots

Detention in parking lots is not permitted except in those instances where the parking serves lot serves as overflow storage for those storms above the 10-year storm event. In this instance detention is permitted to a maximum depth of six (6) inches. In no case should the maximum limits or storage be designed closer than ten (10) feet from a building unless waterproofing of the building and pedestrian accessibility are properly documented and approved. The maximum design water surface elevation should be no less than one (1) foot below the lowest floor of any adjacent structure.
8.3.8 Control Structures

The 100-year frequency storm is to be used to determine the volume of detention storage required. In addition, the outlet structure shall be designed such that peak discharges for the fully urbanized development are not increased for the pre-developed storm frequencies of the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year storm events.

Detention facilities shall be provided with obvious and effective control structures. Plan view and sections of the structure with adequate details shall be included in plans.

The maximum discharge shall be designed to take place under total anticipated design-head conditions.

Sizing of the low-flow pipe shall be by inlet control, hydrologic control, and hydrologic gradient requirements. Low-flow pipes shall not be smaller than twelve (12) inches in diameter to minimize maintenance and operating problems except in parking lot and roof retention where minimum size of openings shall be designed specifically for each condition. A bar-screen on a minimum (3:1) slope to reduce blockage by debris is suggested on the flow-pipe.

Where the outflow structure conveys flow through the embankment in a conduit, the conduit shall be reinforced concrete or an approved alternate designed to withstand external loads. The conduit is to withstand the internal hydraulic pressure without leakage under full external load or settlement, and must convey water at the design velocity without damage to the interior surface of the conduit.

The outflow structure shall discharge flows into the natural stream or unlined channels at a non-erosive rate in accordance with the requirements of this design manual.

Earth embankments used to impound required detention volume shall be constructed according to specifications for fill based on a Geotechnical Investigation of the site. The Geotechnical investigation shall be performed by a registered Professional Engineer in the State of Arkansas, who has an emphasis in geotechnical analysis and shall include, as a minimum, the type of material to be used, water content, liquid limit, plasticity index, and desired compaction.

8.3.9 Emergency Spillways

An emergency spillway or overflow area shall be provided at the maximum 100-year pool level. Spillways shall be designed for the 500-year design storm. This design criteria shall apply to all dams with normal storage greater than or equal to one (1) acre-foot or have a dam height of five (5) feet of greater, that are exempt from Title VII “Rules Governing Design and Operation of Dams” that are regulated by the Arkansas Natural Resource Commission.
9.0 FLOODPLAIN GUIDELINES

9.1 General Standards

The following standards apply to all developments in Special Flood Hazard Areas, regardless of the type of proposed development or the Risk Zone of the proposed site:

(1) All new and substantial construction or substantial improvements shall be designed (or modified) and adequately anchored to prevent flotation, collapse or lateral movement of the structure resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy;

(2) All new construction or substantial improvements shall be constructed by methods and practices that minimize flood damage;

(3) All new construction or substantial improvements shall be constructed with materials resistant to flood damage;

(4) All critical facilities constructed or substantially improved in Special Flood Hazard Areas (SFHA) must be constructed or modified to exceed 500-year flood protection standards or located outside the SFHA;

(5) The placement or construction of all new structures must be in full compliance with the provisions of this Code;

(6) For the purposes of this Code, all mixed-use structures are subject to the more stringent requirements of residential structures;

(7) A substantial improvement or substantial damage to an existing structure triggers a requirement to bring the entire structure into full compliance with the provisions of this Code. The existing structure, as well as any reconstruction, rehabilitation, addition, or other improvement, must meet the standards of new construction in this Code;

(8) Any improvement to an existing structure that is less than a substantial improvement requires the improvement, but not the existing structure, to be in full compliance with the provisions of this Code;

(9) All manufactured homes to be placed within a Special Flood Hazard Area on a community's FIRM shall be installed using methods and practices which minimize flood damage. For the purposes of this requirement, manufactured homes must be elevated and anchored to resist flotation, collapse, or lateral movement. Methods of anchoring may include, but are not limited to, use of over-the-top or frame ties to ground anchors. This requirement is in addition to applicable State and local anchoring requirements for resisting wind forces. Screw augers or expanding anchors will not satisfy the requirement of this provision;

(10) The design or location of electrical, heating, ventilation, plumbing, and air conditioning equipment for new structures, or for any improvements to an
existing structure, must prevent water from entering or accumulating within the components during base flood events;

(11) The design of all new and replacement water supply systems must minimize or eliminate infiltration of floodwaters into the system during base flood events;

(12) The design of all new and replacement sanitary sewage systems must minimize or eliminate infiltration of floodwaters into the system during flooding events, and must prevent sewage discharge from the systems into floodwaters;

(13) The placement of on-site waste disposal systems must avoid impairment to, or contamination from, the disposal system during base flood events;

(14) Construction of basement foundations in any Special Flood Hazard Area is prohibited;

(15) New construction and substantial improvements, with fully enclosed areas (such as garages and crawlspaces) below the lowest floor that are usable solely for parking of vehicles, building access or storage in an area other than a basement and which are below the base flood elevation shall be designed to automatically equalize hydrostatic flood forces on exterior walls by allowing for the entry and exit of floodwaters. Designs for meeting this requirement must either be certified by a registered professional engineer or architect or meet or exceed the following minimum criteria:

(a) A minimum of two (2) openings on separate walls having a total net area of not less than one (1) square inch for every square foot of enclosed area subject to flooding shall be provided;

(b) The bottom of all openings shall be no higher than one (1) foot above grade;

(c) Openings may be equipped with screens, louvers, valves, or other coverings or devices provided that they permit the automatic entry and exit of floodwaters.

(16) The placement of recreational vehicles (RV) in Special Flood Hazard Areas must either:

(a) Be temporary, as demonstrated by the RV being fully licensed, being on wheels or a jacking system, attached to the site only by quick disconnect type utilities and security devices, having no permanently attached additions, and being immobile for no more than 180 consecutive days; or else

(b) Meet all provisions of this Code applicable to manufactured home structures.

(17) All proposals for the development of a residential subdivision, commercial business park or manufactured home park/subdivision must have public utilities
and facilities such as sewer, gas, electrical and water systems located and constructed to minimize or eliminate flood damage;

(18) All proposals for the development of a residential subdivision, commercial business park or a manufactured home park/subdivision must include an adequate drainage plan to reduce exposure to flood hazards; and,

(19) All proposals for the development of a commercial business park or a manufactured home park/subdivision must include an adequate evacuation plan for the escape of citizens from affected nonresidential structures during flooding events.

(20) A minimum of a ten (10) foot buffer shall be placed between any structure and the floodway.

9.2 RISK ZONE SPECIFIC STANDARDS

In addition to the General Standards, the following standards apply to specific development types in specific Risk Zones. Risk Zones listed in this Code that do not appear on the current FIRM are not applicable.

(1) **In AE Risk Zones:** Special Flood Hazard Areas with base floods determined

(a) For Residential Structures in Zone AE:

1. For all new residential structures, the top surface of the lowest floor must have an elevation (1 foot or more) above the published BFE. This elevation must be documented on an Elevation Certificate properly completed by a Professional Engineer, Surveyor, or Architect licensed to practice in the State of Arkansas.

2. For all substantial improvements or substantial damage to existing residential structures, the entire structure becomes subject to the requirements of a new residential structure.

3. For any reconstruction, rehabilitation, addition, or other improvement to an existing residential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new residential structure.

(b) For Nonresidential Structures in Zone AE:

1. All new commercial, industrial or other nonresidential structures must either:
Floodplain Guidelines

1. Have the lowest floor (including basement) elevated (1 feet or more) above the base flood level or

2. Be floodproofed such that, together with attendant utility and sanitary facilities, be designed so that below (an elevation of 3 feet above) the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

3. A registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify on a Floodproofing Certificate that the design and methods of construction are in accordance with accepted standards of practice as outlined in this subsection. A record of such certification which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained by the Floodplain Administrator.

2. For all substantial improvements or substantial damage to existing commercial, industrial or other nonresidential structures the entire structure becomes subject to the requirements of a new nonresidential structure.

3. For any reconstruction, rehabilitation, addition, or other improvement to an existing nonresidential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new nonresidential structure.

(c) For Manufactured Homes in Zone AE:

1. All manufactured homes that are placed or substantially improved on sites:

   a. outside of a manufactured home park or subdivision,
   b. in a new manufactured home park or subdivision,
   c. in an expansion to an existing manufactured home park or subdivision, or
   d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated (1 feet or more) above the base flood elevation and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.
2. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision on the community's FIRM that are not subject to the provisions of paragraph (1.) of this section be elevated so that either:

   a. the lowest floor of the manufactured home is (1 feet or more) above the base flood elevation, or
   b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

3. For all substantial improvements or substantial damage to existing manufactured home, the entire structure becomes subject to the requirements of a new manufactured home.

4. For any reconstruction, rehabilitation, addition, or other improvement to an existing manufactured home that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new manufactured home.

(d) Where FEMA has not established a regulatory floodway in Zone AE, no Floodplain Development Permit may be issued unless a detailed engineering analysis is submitted along with the application that demonstrates the increase in base floodwater elevation due to the proposed development and all cumulative developments since the publication of the current FIRM will be less than 1 foot.

(2) **Floodways** - High risk areas of stream channel and adjacent floodplain

a) Developments in regulatory floodways are prohibited, unless:

1. A No-Rise Certificate, signed and stamped by a Professional Engineer licensed to practice in the State of Arkansas, is submitted to demonstrate through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that the proposed development would not result in any increase in flood levels within the community during the occurrence of a base flood event; or

2. All requirements of 44 CFR §65.12 are first met.

b) No Manufactured Home may be placed in a regulatory floodway, regardless of elevation height, anchoring methods, or No-Rise Certification.
(3) **In AH or AO Risk Zones:** Special Flood Hazard Areas of shallow flooding

(a) For Residential Structures in Zones AH or AO:

1. All new residential structures must be constructed with the top surface of the lowest floor elevated (1 feet or more) above the published BFE, or (2 feet or more) above the highest adjacent grade in addition to the depth number specified (at least 2 feet if no depth number is specified) on the community's FIRM. This elevation must be documented on an Elevation Certificate properly completed by a Professional Engineer, Surveyor or Architect licensed to practice in the State of Arkansas.

2. For all substantial improvements or substantial damage to existing residential structures the entire structure becomes subject to the requirements of a new residential structure.

3. For any reconstruction, rehabilitation, addition, or other improvement to an existing residential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new residential structure.

(b) For Nonresidential Structures in Zones AH or AO:

1. All new commercial, industrial or other nonresidential structure must either:
   
   a. have the top surface of the lowest floor elevated (1 feet or more) above the published BFE, or (2 feet or more) above the highest adjacent grade in addition to the depth number specified (at least 2 feet if no depth number is specified) on the community's FIRM, with documentation on an Elevation Certificate properly completed by a Professional Engineer, Surveyor or Architect licensed to practice in the State of Arkansas; or
   
   b. be floodproofed such that the structure, together with attendant utility and sanitary facilities be designed so that below (3 feet or more) above the published BFE in Zone AH, or (3 feet or more) above the base specified flood depth in an AO Zone, the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads of effects of buoyancy.

2. For all substantial improvements or substantial damage to existing commercial, industrial or other nonresidential structures the entire structure becomes subject to the requirements of a new nonresidential structure.
3. For any reconstruction, rehabilitation, addition, or other improvement to an existing nonresidential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new nonresidential structure.

(c) For Manufactured Homes in Zones AH or AO:

1. All manufactured homes that are placed or substantially improved on sites:
   a. outside of a manufactured home park or subdivision,
   b. in a new manufactured home park or subdivision,
   c. in an expansion to an existing manufactured home park or subdivision, or
   d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated (1 feet or more) above the published BFE, or (2 feet or more) above the highest adjacent grade in addition to the depth number specified (at least 2 feet if no depth number is specified) on the community's FIRM, and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

2. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision on the community's FIRM that are not subject to the provisions of paragraph 1. of this section be elevated so that either:
   a. the lowest floor of the manufactured home meets the elevation standard of paragraph 1., or
   b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

3. For all substantial improvements or substantial damage to existing manufactured home, the entire structure becomes subject to the requirements of a new manufactured home.

4. For any reconstruction, rehabilitation, addition, or other improvement to an existing manufactured home that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new manufactured home.
(d) Where FEMA has not established a regulatory floodway in Zones AH or AO, no Floodplain Development Permit may be issued unless a detailed engineering analysis is submitted along with the application that demonstrates the increase in base floodwater elevation due to the proposed development and all cumulative developments since the publication of the current FIRM will be less than 1 foot.

(e) Require adequate drainage paths around structures on slopes, to guide flood waters around and away from proposed structures.

(4) **In “A” Risk Zones:** Special Flood Hazard Areas with no base flood elevations determined

(a) In Zone A, The applicant or the applicant’s agent must determine a base flood elevation prior to construction. The BFE will be based on a source or method approved by the local Floodplain Administrator.

(b) For Residential Structures in Zone A:

1. For all new residential structures, the top surface of the lowest floor must have an elevation (1 feet or more) above the BFE. This elevation must be documented on an Elevation Certificate properly completed by a Professional Engineer, Surveyor or Architect licensed to practice in the State of Arkansas.

2. For all substantial improvements or substantial damage to existing residential structures, the entire structure becomes subject to the requirements of a new residential structure.

3. For any reconstruction, rehabilitation, addition, or other improvement to an existing residential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new residential structure.

(c) For Nonresidential Structures in Zone A:

1. All new commercial, industrial or other nonresidential structures must either:
   
   a. have the lowest floor (including basement) elevated (1 feet or more) above the base flood level or
   
   b. be floodproofed such that, together with attendant utility and sanitary facilities, be designed so that below (an elevation of 3 feet above) the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.
c. A registered professional engineer or architect shall develop and/or review structural design, specifications, and plans for the construction, and shall certify on a Floodproofing Certificate that the design and methods of construction are in accordance with accepted standards of practice as outlined in this subsection. A record of such certification which includes the specific elevation (in relation to mean sea level) to which such structures are floodproofed shall be maintained by the Floodplain Administrator.

2. For all substantial improvements or substantial damage to existing commercial, industrial or other nonresidential structures the entire structure becomes subject to the requirements of a new nonresidential structure.

3. For any reconstruction, rehabilitation, addition, or other improvement to an existing nonresidential structure that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new nonresidential structure.

(d) For Manufactured Homes in Zone A:

1. All manufactured homes that are placed or substantially improved on sites:

   a. outside of a manufactured home park or subdivision,
   b. in a new manufactured home park or subdivision,
   c. in an expansion to an existing manufactured home park or subdivision, or
   d. in an existing manufactured home park or subdivision on which a manufactured home has incurred "substantial damage" as a result of a flood, be elevated on a permanent foundation such that the lowest floor of the manufactured home is elevated (1 feet or more) above the base flood elevation and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

2. Require that manufactured homes be placed or substantially improved on sites in an existing manufactured home park or subdivision on the community's FIRM that are not subject to the provisions of paragraph (1.) of this section be elevated so that either:

   a. the lowest floor of the manufactured home is (1 feet or more) above the base flood elevation, or
   b. the manufactured home chassis is supported by reinforced piers or other foundation elements of at least equivalent strength that are no less than 36 inches in height above
grade and be securely anchored to an adequately anchored foundation system to resist flotation, collapse, and lateral movement.

3. For all substantial improvements or substantial damage to existing manufactured home, the entire structure becomes subject to the requirements of a new manufactured home.

4. For any reconstruction, rehabilitation, addition, or other improvement to an existing manufactured home that is less than a substantial improvement, only the improved area, but not the entire structure, becomes subject to the requirements of a new manufactured home.

(e) Base flood elevation data and a regulatory floodway, utilizing accepted engineering practices, shall be generated for subdivision proposals and other proposed development including the placement of manufactured home parks and subdivisions which is greater than 50 lots or 5 acres, whichever is lesser, if not otherwise provided.

9.3 Hydrology

Any hydrologic study performed within the City of Jonesboro must comply with the guidelines set forth in this manual. This includes submitting a hydrologic work map that includes watershed boundaries, and all other hydrologic parameters. If the Design Engineer wishes to use an alternative hydrologic analysis methodology, the City Engineer shall be consulted prior to the start of the analysis. In locations where FEMA hydrology exists, the FEMA hydrology model shall be used. FEMA models shall be updated, as deemed necessary, by the City Engineer to simulate current development within the drainage basin.

9.4 Hydraulics

Any modification to a floodway or floodplain where no floodway has been determined within the City of Jonesboro requires a hydraulic study, performed by a Professional Engineer licensed in the State of Arkansas. All hydraulic studies along water courses must comply with FEMA’s guidelines.

The Corps of Engineers HEC-RAS computer program shall be used to compute the water surface elevation. To do so, cross sections along the watercourse must be no greater than 400 ft. apart for tangent sections of channel and no greater than 200 ft. apart for curvilinear sections of channel unless otherwise approved by the City Engineer. Roughness values shall be determined based on values in Table 4 in Appendix 1. A printout of the computer model as well as an electronic copy of the HEC-RAS files shall be submitted with the Hydraulic Report for any work proposed in the floodplain. All hydraulic models shall conform to survey control requirement of Section 2.2.

Table 4 in Appendix 1, shows the maximum permissible velocities that are to be allowed in the channel. Velocities above that which are shown in this table, must be reduced or approved by the City Engineer.
9.5 SFHA Submittals

(1) Elevation Certificates

(a) Minimum requirements for all elevation certificate submittals are as follows:

1. Submit two original copies of all elevation certificates with permit applications;

2. The basis for all base flood elevations in Zone AE areas shall be determined using the FIS Profiles, not scaled off the FIRM;

3. Provide at least two site pictures and a vicinity map with all submittals (includes pre-construction elevation certificates). The vicinity map shall depict, at a minimum, the following:

   a. Location of floodplain and floodway (where floodway is applicable);
   b. Property Lines (Plat of Survey);
   c. Spot elevation for all pertinent data to include all utilities servicing the building;
   d. Adjacent waterway name;
   e. Surrounding street names;
   f. Location of utilized benchmark;
   g. Dimensioned location of building on property;
   h. North arrow; and,
   i. Scale

(2) Letter of Map Change

(a) For letters of map change, submit all FEMA requirements and forms requested included in the MT-1, MT-2, and MT-EZ standard application packs;

(b) As-built or topographic surveys are required for all LOMR-F submittals. These surveys shall depict, at a minimum, the following:

1. Location of floodplain and floodway (where floodway is applicable),
2. Adjacent waterway name;
3. Surrounding street names;
4. Location of utilized benchmark;
5. Location of property and buildings;
6. Spot elevations;
7. Natural ground contours (maximum one foot contour interval);
8. North arrow; and,
9. Scale

All SFHA submittals must comply with all guidelines set forth in this manual and all utilized survey control must be based on state or federal published benchmarks.
10.0 EROSION CONTROL

10.1 General

Any development within the City of Jonesboro Planning jurisdiction must comply with the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended, Ark. Code Ann. 8-4-101 et seq.) and the Clean Water Act (33 U.S.C. 1251 et seq.), and shall obtain authorization to discharge storm water associated with construction activity under the National Pollutant Discharge Elimination System (NPDES) permit program administered by the Arkansas Department of Environmental Quality (ADEQ). Eligibility and permit requirements for this program are provided in Appendix 7.

In addition to the Federal and State requirements, any development within the City of Jonesboro Planning jurisdiction shall comply with the provisions of Section 2.3, 2.6 (B)(3), and Section 3.3 of the Stormwater Management Regulations.

10.2 Environmental Protection Agency BMP’s

In 1996, under a cooperative agreement between the American Society of Civil Engineers (ASCE) and the U.S. Environmental Protection Agency (USEPA) the International Stormwater Best Management Practices (BMP) Database was developed monitoring the performance of BMP techniques. All BMP studies, performance analysis results, tools for use in BMP performance studies, monitoring guidance and other study-related publications can be found at www.bmpdatabase.org. This website provides scientifically sound information to improve the design, selection and performance of BMPs. Designers shall utilize appropriate BMP’s as they relate to each specific project.
APPENDIX 1
LIST OF TABLES
## Appendix 1

### Table of Contents

<table>
<thead>
<tr>
<th>Table Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Intentionally Deleted)</td>
</tr>
<tr>
<td>2</td>
<td>Roughness Coefficients for Closed Conduits</td>
</tr>
<tr>
<td>2-1</td>
<td>TR-55 Runoff Depth for Selected CN's and Rainfall Amounts</td>
</tr>
<tr>
<td>2-2a</td>
<td>TR-55 Runoff Curve Numbers for Urban Areas</td>
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<td>TR-55 Runoff Curve Numbers for Cultivated Agricultural Lands</td>
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<td>TR-55 Graphical Peak Discharge method</td>
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<td>4</td>
<td>Roughness Coefficients for Open Channels</td>
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<td>Velocity Head Loss Coefficients for Closed Conduits</td>
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<td>Head Loss Coefficients Due to Sudden Enlargements and Contractions</td>
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<td>6</td>
<td>Velocity Requirements for Closed Conduits</td>
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<tr>
<td>7</td>
<td>Design Criteria for the Design of Roads, Culverts, and Channels</td>
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<tr>
<td>8</td>
<td>Entrance Loss Coefficients for Culverts</td>
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**TABLE 2**
Roughness Coefficients for Closed Conduits*

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<th>Material of New Construction</th>
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<td>Corrugated Metal Pipe Culverts</td>
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*Note: For materials other than those listed here, use manufacturer's suggestion and/or City Engineers recommendations.
### Table 2-1 Runoff depth for selected CN’s and rainfall amounts

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<td>8.98</td>
<td>9.71</td>
<td>10.42</td>
<td>11.10</td>
<td>11.76</td>
<td>12.39</td>
<td>12.76</td>
</tr>
</tbody>
</table>

1/ Interpolate the values shown to obtain runoff depths for CN’s or rainfall amounts not shown.
Table 2-2a  Runoff curve numbers for urban areas 1/

<table>
<thead>
<tr>
<th>Cover type and hydrologic condition</th>
<th>Average percent impervious area (I_a)</th>
<th>Curve numbers for hydrologic soil group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\text{Cover description})</td>
<td>A</td>
</tr>
<tr>
<td>Fully developed urban areas (vegetation established)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open space (lawns, parks, golf courses, cemeteries, etc.) 2/</td>
<td>Poor condition (grass cover &lt; 50%)</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Fair condition (grass cover 50% to 75%)</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Good condition (grass cover &gt; 75%)</td>
<td>39</td>
</tr>
<tr>
<td>Impervious areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paved parking lots, roofs, driveways, etc. (excluding right-of-way)</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Streets and roads:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paved; curbs and storm sewers (excluding right-of-way)</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Paved; open ditches (including right-of-way)</td>
<td>83</td>
<td>89</td>
</tr>
<tr>
<td>Gravel (including right-of-way)</td>
<td>76</td>
<td>85</td>
</tr>
<tr>
<td>Dirt (including right-of-way)</td>
<td>72</td>
<td>82</td>
</tr>
<tr>
<td>Western desert urban areas:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural desert landscaping (pervious areas only) 4/</td>
<td>63</td>
<td>77</td>
</tr>
<tr>
<td>Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td>Urban districts:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial and business</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td>Industrial</td>
<td>72</td>
<td>81</td>
</tr>
<tr>
<td>Residential districts by average lot size:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/8 acre or less (town houses)</td>
<td>65</td>
<td>77</td>
</tr>
<tr>
<td>1/4 acre</td>
<td>38</td>
<td>61</td>
</tr>
<tr>
<td>1/3 acre</td>
<td>30</td>
<td>57</td>
</tr>
<tr>
<td>1/2 acre</td>
<td>25</td>
<td>54</td>
</tr>
<tr>
<td>1 acre</td>
<td>20</td>
<td>51</td>
</tr>
<tr>
<td>2 acres</td>
<td>12</td>
<td>46</td>
</tr>
<tr>
<td>Developing urban areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newly graded areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(pervious areas only, no vegetation)</td>
<td>77</td>
<td>86</td>
</tr>
<tr>
<td>Idle lands (CN’s are determined using cover types similar to those in table 2-2c)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Average runoff condition, and \(I_a = 0.2S\).
2. The average percent impervious area shown was used to develop the composite CN’s. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN’s for other combinations of conditions may be computed using figure 2-3 or 2-4.
3. CN’s shown are equivalent to those of pasture. Composite CN’s may be computed for other combinations of open space cover type.
4. Composite CN’s for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN’s are assumed equivalent to desert shrub in poor hydrologic condition.
5. Composite CN’s to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN’s for the newly graded pervious areas.
<table>
<thead>
<tr>
<th>Cover type</th>
<th>Treatment</th>
<th>Hydrologic condition</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<td>Bare soil</td>
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<td>86</td>
<td>91</td>
<td>94</td>
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<tr>
<td></td>
<td>Crop residue cover (CR)</td>
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<td>85</td>
<td>90</td>
<td>93</td>
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<td>88</td>
<td>90</td>
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<tr>
<td>Row crops</td>
<td>Straight row (SR)</td>
<td>Poor</td>
<td>72</td>
<td>81</td>
<td>88</td>
<td>91</td>
</tr>
<tr>
<td></td>
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<td>Good</td>
<td>67</td>
<td>78</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>SR + CR</td>
<td>Poor</td>
<td>71</td>
<td>80</td>
<td>87</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
<td>64</td>
<td>75</td>
<td>82</td>
<td>85</td>
</tr>
<tr>
<td></td>
<td>Contoured (C)</td>
<td>Poor</td>
<td>70</td>
<td>79</td>
<td>84</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
<td>65</td>
<td>75</td>
<td>82</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>C + CR</td>
<td>Poor</td>
<td>69</td>
<td>78</td>
<td>83</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
<td>64</td>
<td>74</td>
<td>81</td>
<td>85</td>
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<tr>
<td></td>
<td>Contoured &amp; terraced (C&amp;T)</td>
<td>Poor</td>
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<td>74</td>
<td>80</td>
<td>82</td>
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<tr>
<td></td>
<td></td>
<td>Good</td>
<td>62</td>
<td>71</td>
<td>78</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td>C&amp;T + CR</td>
<td>Poor</td>
<td>65</td>
<td>73</td>
<td>79</td>
<td>81</td>
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<tr>
<td></td>
<td></td>
<td>Good</td>
<td>61</td>
<td>70</td>
<td>77</td>
<td>80</td>
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<tr>
<td>Small grain</td>
<td>SR</td>
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<td>76</td>
<td>84</td>
<td>88</td>
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<td>75</td>
<td>83</td>
<td>87</td>
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<tr>
<td></td>
<td>SR + CR</td>
<td>Poor</td>
<td>64</td>
<td>75</td>
<td>83</td>
<td>86</td>
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<tr>
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<td>60</td>
<td>72</td>
<td>80</td>
<td>84</td>
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<td></td>
<td>C</td>
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<td>73</td>
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<td>C + CR</td>
<td>Poor</td>
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<td>73</td>
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<td>72</td>
<td>80</td>
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<td>72</td>
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<td>59</td>
<td>70</td>
<td>78</td>
<td>81</td>
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<tr>
<td></td>
<td>C&amp;T + CR</td>
<td>Poor</td>
<td>60</td>
<td>71</td>
<td>78</td>
<td>81</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
<td>58</td>
<td>69</td>
<td>77</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Close-seeded legumes or broadcast legumes</td>
<td>Poor</td>
<td>66</td>
<td>77</td>
<td>85</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Good</td>
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<td>85</td>
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<td>C</td>
<td>Poor</td>
<td>64</td>
<td>75</td>
<td>83</td>
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<td>55</td>
<td>69</td>
<td>78</td>
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<td>C&amp;T</td>
<td>Poor</td>
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<td>73</td>
<td>80</td>
<td>83</td>
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<td></td>
<td>Good</td>
<td>51</td>
<td>67</td>
<td>76</td>
<td>80</td>
</tr>
</tbody>
</table>

1 Average runoff condition, and \(I_e=0.2S\)
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good \(\geq 20\%\)), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.
### Table 2-2c  Runoff curve numbers for other agricultural lands 1/

<table>
<thead>
<tr>
<th>Cover type</th>
<th>Hydrologic condition</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture, grassland, or range—continuous forage for grazing. 2/</td>
<td>Poor</td>
<td>68</td>
<td>79</td>
<td>86</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>49</td>
<td>69</td>
<td>79</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>39</td>
<td>61</td>
<td>74</td>
<td>80</td>
</tr>
<tr>
<td>Meadow—continuous grass, protected from grazing and generally mowed for hay.</td>
<td>—</td>
<td>30</td>
<td>58</td>
<td>71</td>
<td>78</td>
</tr>
<tr>
<td>Brush—brush-weed-grass mixture with brush the major element. 2/</td>
<td>Poor</td>
<td>48</td>
<td>67</td>
<td>77</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>35</td>
<td>56</td>
<td>70</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>30 4/</td>
<td>48</td>
<td>65</td>
<td>73</td>
</tr>
<tr>
<td>Woods—grass combination (orchard or tree farm). 2/</td>
<td>Poor</td>
<td>57</td>
<td>73</td>
<td>82</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>43</td>
<td>65</td>
<td>76</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>32</td>
<td>58</td>
<td>72</td>
<td>79</td>
</tr>
<tr>
<td>Woods. 2/</td>
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<td>77</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>Fair</td>
<td>36</td>
<td>60</td>
<td>73</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td>30 4/</td>
<td>55</td>
<td>70</td>
<td>77</td>
</tr>
<tr>
<td>Farmsteads—buildings, lanes, driveways, and surrounding lots.</td>
<td>—</td>
<td>50</td>
<td>74</td>
<td>82</td>
<td>86</td>
</tr>
</tbody>
</table>

1 Average runoff condition, and I_a = 0.2S.
2 Poor: <50% ground cover or heavily grazed with no mulch.
   Fair: 50 to 75% ground cover and not heavily grazed.
   Good: >75% ground cover and lightly or only occasionally grazed.
3 Poor: <50% ground cover.
   Fair: 50 to 75% ground cover.
   Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN’s shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN’s for woods and pasture.
6 Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
   Fair: Woods are grazed but not burned, and some forest litter covers the soil.
   Good: Woods are protected from grazing, and litter and brush adequately cover the soil.
### Worksheet 2: Runoff curve number and runoff

<table>
<thead>
<tr>
<th>Project</th>
<th>By</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Checked</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Check one: [ ] Present  [ ] Developed

### 1. Runoff curve number

<table>
<thead>
<tr>
<th>Soil name and hydrologic group (appendix A)</th>
<th>Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)</th>
<th>CN</th>
<th>Area</th>
<th>Product of CN x area</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ CN_{(weighted)} = \frac{\text{total product}}{\text{total area}} = \_ \_ \_ \_ \_ = \_ \_ \_ \_ \_ \_ ; \]

Use only one CN source per line

**Totals**

### 2. Runoff

<table>
<thead>
<tr>
<th>Frequency (yr)</th>
<th>Rainfall, P (24-hour) (in)</th>
<th>Runoff, Q (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Use P and CN with table 2-1, figure 2-1, or equations 2-3 and 2-4)</td>
<td></td>
</tr>
</tbody>
</table>
Worksheet 4: Graphical Peak Discharge method

<table>
<thead>
<tr>
<th>Project</th>
<th>By</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Checked</td>
<td>Date</td>
</tr>
</tbody>
</table>

Check one:  
- Present
- Developed

1. Data

Drainage area ........................................... \( A_m \) = ______________ mi\(^2\) (acres/640)

Runoff curve number ................................. \( CN \) = ______________ (From worksheet 2)

Time of concentration ................................. \( T_c \) = ______________ hr (From worksheet 3)

Rainfall distribution ................................. = ______________ (I, IA, II III)

Pond and swamp areas spread throughout watershed ................................... = ____________ percent of \( A_m \) ( ________ acres or mi\(^2\) covered)

2. Frequency ......................................................... yr

3. Rainfall, \( P \) (24-hour) ............................................ in

4. Initial abstraction, \( I_a \) ............................................. in
   (Use \( CN \) with table 4-1)

5. Compute \( I_a / P \) ..................................................

6. Unit peak discharge, \( q_u \) .................................... csm/in
   (Use \( T_c \) and \( I_a / P \) with exhibit 4–______)

7. Runoff, \( Q \) ....................................................... in
   (From worksheet 2)  Figure 2-6

8. Pond and swamp adjustment factor, \( F_p \) ..................................
   (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond ans swamp area.)

9. Peak discharge, \( q_p \) .............................................. ft\(^3\)/s
   (Where \( q_p = q_u A_m Q F_p \))

<table>
<thead>
<tr>
<th>Storm #1</th>
<th>Storm #2</th>
<th>Storm #3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 4
Roughness Coefficients for Open Channels*

<table>
<thead>
<tr>
<th>Channel Description</th>
<th>Recommended Roughness Coefficients</th>
<th>Maximum Velocity (ft/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Normal</td>
</tr>
<tr>
<td><strong>Minor Natural Streams</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately Well Defined Channel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass and Weeds, Little Brush</td>
<td>0.025</td>
<td>0.030</td>
</tr>
<tr>
<td>Dense Weeds, Little Brush</td>
<td>0.030</td>
<td>0.035</td>
</tr>
<tr>
<td>Weeds, Light Brush on Banks</td>
<td>0.030</td>
<td>0.035</td>
</tr>
<tr>
<td>Weeds, Heavy Brush on Banks</td>
<td>0.035</td>
<td>0.050</td>
</tr>
<tr>
<td>Weeds, Dense Willow on Banks</td>
<td>0.040</td>
<td>0.060</td>
</tr>
<tr>
<td>Irregular Channel With Pools and Meanders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass and Weeds, Little Brush</td>
<td>0.030</td>
<td>0.036</td>
</tr>
<tr>
<td>Dense Weeds, Little Brush</td>
<td>0.036</td>
<td>0.042</td>
</tr>
<tr>
<td>Weeds, Light Brush on Banks</td>
<td>0.036</td>
<td>0.042</td>
</tr>
<tr>
<td>Weeds, Heavy Brush on Banks</td>
<td>0.042</td>
<td>0.060</td>
</tr>
<tr>
<td>Weeds, Dense Willow on Banks</td>
<td>0.048</td>
<td>0.072</td>
</tr>
<tr>
<td>Floodplain, Pasture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short Grass, No Brush</td>
<td>0.030</td>
<td>0.035</td>
</tr>
<tr>
<td>Tall Grass, No Brush</td>
<td>0.035</td>
<td>0.040</td>
</tr>
<tr>
<td>Floodplain, Cultivated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Crops</td>
<td>0.030</td>
<td>0.035</td>
</tr>
<tr>
<td>Mature Crops</td>
<td>0.035</td>
<td>0.045</td>
</tr>
<tr>
<td>Floodplain, Uncleared</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy Weeds, Light Brush</td>
<td>0.050</td>
<td>0.060</td>
</tr>
<tr>
<td>Medium to Dense Brush</td>
<td>0.070</td>
<td>0.100</td>
</tr>
<tr>
<td>Trees with Flood Stage below Branches</td>
<td>0.080</td>
<td>0.100</td>
</tr>
</tbody>
</table>
### TABLE 4
Roughness Coefficients for Open Channels*

<table>
<thead>
<tr>
<th>Channel Description</th>
<th>Recommended Roughness Coefficients</th>
<th>Maximum Velocity (ft/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Normal</td>
</tr>
<tr>
<td>Major Natural Streams</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>The roughness coefficient is less than that for minor streams of similar description because banks offer less effective resistance.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderately Well Defined Channel</td>
<td>0.025</td>
<td>0.060</td>
</tr>
<tr>
<td>Irregular Channel</td>
<td>0.035</td>
<td>0.100</td>
</tr>
<tr>
<td>Unlined Vegetated Channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mowed Grass, Clay Soil</td>
<td>0.025</td>
<td>0.030</td>
</tr>
<tr>
<td>Mowed Grass, Sandy Soil</td>
<td>0.025</td>
<td>0.030</td>
</tr>
<tr>
<td>Unlined Non-Vegetated Channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean Gravel Section</td>
<td>0.022</td>
<td>0.025</td>
</tr>
<tr>
<td>Shale</td>
<td>0.025</td>
<td>0.030</td>
</tr>
<tr>
<td>Smooth Rock</td>
<td>0.025</td>
<td>0.030</td>
</tr>
<tr>
<td>Earth Lined, Sandy</td>
<td>0.028</td>
<td>0.035</td>
</tr>
<tr>
<td>Earth Lined, Clay</td>
<td>0.028</td>
<td>0.035</td>
</tr>
<tr>
<td>Lined Channels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smooth Finished Concrete</td>
<td>0.013</td>
<td>0.015</td>
</tr>
<tr>
<td>Riprap (rubble)</td>
<td>0.030</td>
<td>0.040</td>
</tr>
<tr>
<td>Gabion</td>
<td>0.028</td>
<td>0.032</td>
</tr>
<tr>
<td>Pavement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td>-</td>
<td>0.015</td>
</tr>
<tr>
<td>Asphalt</td>
<td>-</td>
<td>0.017</td>
</tr>
</tbody>
</table>

*Note: Deviations from these values must be approved by the City Engineer for Jonesboro.*
### TABLE 5A
Velocity Head Loss Coefficients for Closed Conduits

<table>
<thead>
<tr>
<th>Description of Conditions</th>
<th>Kj</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inlet on Main Line</td>
<td>0.5</td>
</tr>
<tr>
<td>Inlet on Main Line with Branch Lateral</td>
<td>0.25</td>
</tr>
<tr>
<td>Manhole on Main Line with bend at:</td>
<td></td>
</tr>
<tr>
<td>90 degrees</td>
<td>0.25</td>
</tr>
<tr>
<td>60 degrees</td>
<td>0.35</td>
</tr>
<tr>
<td>45 degrees</td>
<td>0.5</td>
</tr>
<tr>
<td>22.5 degrees</td>
<td>0.95</td>
</tr>
<tr>
<td>Wye Connection or Cut In</td>
<td></td>
</tr>
<tr>
<td>60 degrees</td>
<td>0.6</td>
</tr>
<tr>
<td>45 degrees</td>
<td>0.75</td>
</tr>
<tr>
<td>22.5 degrees</td>
<td>0.95</td>
</tr>
<tr>
<td>Inlet or Manhole at the Beginning of Line</td>
<td>1.25</td>
</tr>
<tr>
<td>Conduit Curves for 90 degrees*</td>
<td></td>
</tr>
<tr>
<td>Curve Radius</td>
<td></td>
</tr>
<tr>
<td>2 to 8 times the diameter **</td>
<td>0.4</td>
</tr>
<tr>
<td>8 to 20 times the diameter</td>
<td>0.25</td>
</tr>
<tr>
<td>Greater than 20 times the diameter</td>
<td>0</td>
</tr>
<tr>
<td>Bends where the radius is equal to the Diameter</td>
<td></td>
</tr>
<tr>
<td>90 degree bend</td>
<td>0.05</td>
</tr>
<tr>
<td>60 degree bend</td>
<td>0.43</td>
</tr>
<tr>
<td>45 degree bend</td>
<td>0.35</td>
</tr>
<tr>
<td>22.5 degree bend</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The values of the coefficient "Kj" for determining the loss of head due to obstructions in pipes are shown in Table 6-B and the coefficients are used in the following equation to calculate the head loss at the obstruction:

\[ H_j = K_j \left( \frac{V^2}{2g} \right) \]

* Where deflection other than 90 degrees are used, the 90 degree deflection coefficient can be used with the following percentage factors:
  - 60 degree bend = 0.85
  - 45 degree bend = 0.70
  - 22.5 degree bend = 0.40

**The diameter is the inside diameter of the pipe.**
TABLE 5B
Head Loss Coefficients Due to
Sudden Enlargements and
Contractions

<table>
<thead>
<tr>
<th>$\frac{D2}{D1}$*</th>
<th>Sudden Enlargements, $K_j$</th>
<th>Sudden Contractions, $K_j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>0.1</td>
<td>0.08</td>
</tr>
<tr>
<td>1.4</td>
<td>0.23</td>
<td>0.18</td>
</tr>
<tr>
<td>1.6</td>
<td>0.35</td>
<td>0.25</td>
</tr>
<tr>
<td>1.8</td>
<td>0.44</td>
<td>0.33</td>
</tr>
<tr>
<td>2</td>
<td>0.52</td>
<td>0.36</td>
</tr>
<tr>
<td>2.5</td>
<td>0.65</td>
<td>0.4</td>
</tr>
<tr>
<td>3</td>
<td>0.72</td>
<td>0.42</td>
</tr>
<tr>
<td>4</td>
<td>0.8</td>
<td>0.44</td>
</tr>
<tr>
<td>5</td>
<td>0.84</td>
<td>0.45</td>
</tr>
<tr>
<td>10</td>
<td>0.89</td>
<td>0.46</td>
</tr>
<tr>
<td>&gt; then 10</td>
<td>0.91</td>
<td>0.47</td>
</tr>
</tbody>
</table>

*D2/D1 = Ratio of larger to smaller diameter
# TABLE 6
Velocity Requirements for Closed Conduits*

<table>
<thead>
<tr>
<th>Material of New Construction</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Sewers</td>
<td>2.000</td>
<td>8</td>
</tr>
<tr>
<td>Inlet Laterals</td>
<td>2.000</td>
<td>8</td>
</tr>
<tr>
<td>Culverts</td>
<td>2.000</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: Velocities that exceed 8 fps must be approved by the City Engineer.

For velocity requirements in Open Channels see Table 4. Storm Sewers shall discharge into open channels at a maximum velocity of 8 feet per second.
### TABLE 7
**Design Criteria for the Design of Roads, Culverts, and Channels***

<table>
<thead>
<tr>
<th>Road Classification</th>
<th>Design Return Period</th>
<th>Design Spreads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Thoroughfare</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Lane Divided</td>
<td>10-Year</td>
<td>Two Lanes Open Ea. Direction</td>
</tr>
<tr>
<td></td>
<td>100-Year</td>
<td>Top of Curb</td>
</tr>
<tr>
<td>4 Lane Divided</td>
<td>10-Year</td>
<td>One Lane Open Ea. Direction</td>
</tr>
<tr>
<td></td>
<td>100-Year</td>
<td>Top of Curb</td>
</tr>
<tr>
<td>4 Lane Undivided</td>
<td>10-Year</td>
<td>One Lane Open Ea. Direction</td>
</tr>
<tr>
<td></td>
<td>100-Year</td>
<td>Top of Curb</td>
</tr>
<tr>
<td>Collector</td>
<td>10-Year</td>
<td>Allow 1 Lane Open</td>
</tr>
<tr>
<td></td>
<td>100-Year</td>
<td>Top of Curb</td>
</tr>
<tr>
<td>Residential Streets</td>
<td>10-Year</td>
<td>Top of Curb</td>
</tr>
<tr>
<td></td>
<td>100-Year</td>
<td>Contained within the Right of Way</td>
</tr>
<tr>
<td>Rural Road w/ Bar Ditches</td>
<td>10-Year</td>
<td>One Foot Below Pavement</td>
</tr>
<tr>
<td></td>
<td>100-Year</td>
<td>Contained within the Right of Way</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Drainage Structures***</th>
<th>Design Return Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosed Storm Sewer System</td>
<td>10-Year</td>
</tr>
<tr>
<td>Culvert or Bridge Along a Creek, River, or other Watercourse</td>
<td>25-Year</td>
</tr>
<tr>
<td>Culvert or Bridge not Located on a Creek River or other Watercourse</td>
<td>10-Year</td>
</tr>
<tr>
<td>Channel Improvements</td>
<td>25-Year**</td>
</tr>
</tbody>
</table>

*Note: The City Engineer may reserve the right to require more stringent requirements depending on the location of a specific project. All deviations from what is shown must be approved by the City Engineer.

**Note: For Channel Improvements the 25-year storm should be contained within the channel. Adjacent structures and lots must be a minimum of one foot above the 100-year water surface elevation.

***Note: All improvements in SFMA shall meet requirements of Section 9 in this manual
APPENDIX 2
FIGURES
# Appendix 2

## Table of Contents

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Piped Flow Types</td>
</tr>
<tr>
<td>2</td>
<td>Open Channel Types</td>
</tr>
</tbody>
</table>

*Table of Contents*  
*Appendix 2*
Figure 1. Piped Flow Types

Typical Drainage Pipe/Swale Section
Figure 2. Open Channel Types

TYPICAL CHANNEL IMPROVEMENT
W/ GABION LINING

TYPICAL IMPROVED CHANNEL IMPROVEMENT
W/ ROCK CHANNEL LINING

TYPICAL IMPROVED UNLINED CHANNEL SECTION
APPENDIX 3
INTENTIONALLY DELETED
APPENDIX 4
STREET CAPACITY NOMOGRAPHS
# Appendix 4

## Table of Contents

<table>
<thead>
<tr>
<th>Chart Number</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>Flow in Triangular Gutter Sections</td>
</tr>
<tr>
<td>2B</td>
<td>Ratio of Frontal Flow to Total Gutter Flow</td>
</tr>
<tr>
<td>3B</td>
<td>Conveyance in Circular Channels</td>
</tr>
<tr>
<td>4B</td>
<td>Velocity in Triangular Gutter Sections</td>
</tr>
<tr>
<td>5B</td>
<td>Grate Inlet Frontal Flow Interception Efficiency</td>
</tr>
<tr>
<td>6B</td>
<td>Grate Inlet Side Flow Intercept Efficiency</td>
</tr>
<tr>
<td>7B</td>
<td>Curb-opening and Slotted Drain Inlet Length for Total Interception</td>
</tr>
<tr>
<td>8B</td>
<td>Curb-opening and Slotted Drain Inlet Interception Efficiency</td>
</tr>
<tr>
<td>9B</td>
<td>Grate Inlet Capacity in Sump Conditions</td>
</tr>
<tr>
<td>10B</td>
<td>Depressed Curb-opening Inlet Capacity in Sump Locations</td>
</tr>
<tr>
<td>11B</td>
<td>Undepressed Curb-opening Inlet Capacity in Sump Locations</td>
</tr>
<tr>
<td>12B</td>
<td>Curb-opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats</td>
</tr>
</tbody>
</table>
CHART 1B

\[ Q = \frac{0.56}{n} S_{x}^{1.67} S^{0.05} T^{2.67} \]

**EXAMPLE:**

**GIVEN:**
- \( n = 0.016 \)
- \( S_{x} = 0.03 \)
- \( S = 0.04 \)
- \( T = 6 \) FT

**FIND:**
- \( Q = 2.4 \) FT³/S
- \( Q_n = 0.038 \) FT³/S

**Flow in Triangular Gutter Sections - English Units**

1. For V-Shape, use the nomograph with:
   \[ S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2}) \]

2. To determine discharge in gutter with composite cross slopes, find \( Q_3 \) using:
   \( T_3 \) and \( S_x \). Then, use CHART 4 to find \( Q_o \). The total discharge is:
   \[ Q = Q_3 / (1 - Q_o) \]
   and \( Q_w = Q - Q_3 \).
Ratio of Frontal Flow to Total Gutter Flow
Velocity in Triangular Gutter Sections - English Units

**CHART 4B**

\[ V = \frac{0.12}{n} S^{0.5} S_x^{0.67} T^{-0.67} \]

**EXAMPLE**

**GIVEN**

- \( S = 0.02 \)
- \( S_x = 0.015 \)
- \( T = 6 \text{ FT} \)
- \( n = 0.016 \)

**FIND**

- \( V_n = 0.32 \text{ FT/S} \)
- \( V = 1.95 \text{ FT/S} \)
EXAMPLE:

GIVEN:
RETICULINE GRATE
L = 3 FT
V = 8 FT/S

FIND: 
Rf = 0.81

- Grate inlet frontal flow interception efficiency chart
- Length of grate L (FT)
- Splash-over velocity V (FT/S)
- Curve for different types of grates
- Example calculation for given length and velocity
Floodplain Compliance Guidelines

CHART 6B

Grate Inlet Side Flow Intercept Efficiency

EXAMPLE:
GIVEN:
\( S_x = 0.025 \)
L = 2 FT
V = 4 FT/SEC
FIND: \( R_s = 0.063 \)
CHART 7B

\[ L_T = 0.6Q^{0.42}S^{0.3}(1/nS_x)^{0.6} \]

For composite cross slopes, use \( S_b \) for \( S_x \).
\[ S_b = S_x + S_wE_o \quad ; \quad S_w = Q/W \]

Example:

Given: \( n = 0.016 \); \( S = 0.01 \)
\( S_x = 0.02 \); \( Q = 4 \text{ FT}^3/\text{s} \)

Find: \( L_T = 34 \text{ FT} \)

Curb-opening & Slotted Drain Inlet Length for Total Interception - English Units

Chart 7B
Curb-opening and Slotted Drain Inlet Interception Efficiency.

\[ E = 1 - (1 - \frac{L}{L_T})^{1.8} \]
Grate Inlet Capacity in Sump Conditions - English Units

**CHART 9B**

- **A = CLEAR OPENING AREA**
- **P = 2W + L (WITH CURB)**
- **P = 2(W + L) (WITHOUT CURB)**

### Grate Opening Ratio

- P-1/78-4: 0.8
- P-1/78: 0.9
- P-1/1/8: 0.6
- Reticulate: 0.8
- Curved vane: 0.35
- 30° tilt-bar: 0.34
- Tested

**DISCHARGE Q (FT³/S)**

**DEPTH OF WATER d (FT)**

**Curb**

**W**

**L**

**A**

*Floodplain Compliance Guidelines*
Depressed Curb-opening Inlet Capacity in Sump Locations - English Units

Chart 10B
Undepressed Curb-opening Inlet Capacity in Sump Locations - English Units

L = LENGTH OF CURB OPENING
A = L \times h

DISCHARGE Q (FT³/S)

DEPTH OF WATER d (FT)
Curb-opening Inlet Orifice Capacity for Inclined and Vertical Orifice Throats - English Units

\[ Q = 0.67 \left( \frac{hL}{d_o} \right)^{5/3} \]

- \( h \): WIDTH OF ORIFICE
- \( L \): LENGTH OF ORIFICE
- \( d_o \): WATER DEPTH TO THE CENTER OF ORIFICE

WATER DEPTH \( d_o \) (FT)

DISCHARGE \( Q \) (FT^3/S)

<table>
<thead>
<tr>
<th>( d_o ) (FT)</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
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<tr>
<td>2</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

\( hL = 1 \) FT^2

Chart 12B
## Appendix 5

### Table of Contents

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1B</td>
<td>Headwater Depth for Concrete Pipe Culverts with Inlet Control</td>
</tr>
<tr>
<td>2B</td>
<td>Headwater Depth for C. M. Pipe with Inlet Control</td>
</tr>
<tr>
<td>3B</td>
<td>Headwater Depth for Circular Pipe Culverts with Beveled Ring Control</td>
</tr>
<tr>
<td>4B</td>
<td>Critical Depth - Circular Pipe</td>
</tr>
<tr>
<td>5B</td>
<td>Head for Concrete Pipe Culverts Flowing Full, ( n = 0.012 )</td>
</tr>
<tr>
<td>6B</td>
<td>Head for Standard C.M. Pipe Culverts Flowing Full, ( n = 0.0245 )</td>
</tr>
<tr>
<td>7B</td>
<td>Head for Structural Plate Corrugated Metal Pipe Culverts Flowing Full, ( n = 0.0328 ) to 0.302</td>
</tr>
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</table>

#### Circular Culverts

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>8B</td>
<td>Headwater Depth for Box Culverts with Inlet Control</td>
</tr>
<tr>
<td>9B – 27B</td>
<td>Headwater Depth for Inlet Control Rectangular Box Culverts, Flared Wingwalls 18° to 33.7° and 45°</td>
</tr>
<tr>
<td>28B</td>
<td>Head for Corrugated Metal Box Culverts Flowing Full with Corrugated Bottom Rise/Span &gt; 0.5</td>
</tr>
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#### Concrete Box Culverts

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>29B</td>
<td>Headwater for Oval Concrete Pipe Culverts Long Axis Horizontal with Inlet Control</td>
</tr>
<tr>
<td>30B</td>
<td>Headwater Depth for Oval Concrete Pipe Culverts Long Axis Vertical with Inlet Control</td>
</tr>
<tr>
<td>31B</td>
<td>Critical Depth - Oval Concrete Pipe Long Axis Horizontal</td>
</tr>
<tr>
<td>32B</td>
<td>Critical Depth - Oval Concrete Pipe Long Axis Vertical</td>
</tr>
<tr>
<td>33B</td>
<td>Head for Oval Concrete Pipe Culverts Long Axis Horizontal or Vertical Flowing Full, ( n = 0.012 )</td>
</tr>
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#### Elliptical Culverts

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>34B</td>
<td>Headwater Depth for C.M. Pipe-Arch Culverts with Inlet Control</td>
</tr>
<tr>
<td>35B</td>
<td>Headwater Depth for Inlet Control Structural Plate Pipe-Arch Culverts, 35A - 457 mm (18-inch - 35B) Radius Corner Plate, Projecting or Headwall Inlet, Headwall with or without Edge Bevel</td>
</tr>
<tr>
<td>36B</td>
<td>Headwater Depth for Inlet Control Structural Plate Pipe-Arch Culverts, 787 mm (Chart 36A (31-inch - Chart 36B)) Radius Corner Plate, Projecting or Headwall Inlet, Headwall with or without Edge Bevel</td>
</tr>
<tr>
<td>37B</td>
<td>Critical Depth - Standard Corrugated Metal Pipe-Arch</td>
</tr>
<tr>
<td>38B</td>
<td>Critical Depth - Structural Plate Corrugated Metal Pipe-Arch</td>
</tr>
<tr>
<td>39B</td>
<td>Head for Standard C.M. Pipe-Arch Culverts Flowing Full, ( n = 0.024 )</td>
</tr>
<tr>
<td>40B – 54B</td>
<td>Head for Structural Plate Corrugated Metal Pipe-Arch Culverts, 457 mm - 40A (18-inch - 40B) Corner Radius Flowing Full, ( n = 0.0327 ) - 0.0306</td>
</tr>
</tbody>
</table>

#### Pipe/Arch Culverts

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>55B</td>
<td>Throat Control for Side-Tapered Inlets to Pipe Culvert (Circular Section Only)</td>
</tr>
<tr>
<td>56B</td>
<td>Face Control for Side-Tapered Inlets to Pipe Culverts (Non-Rectangular Section Only)</td>
</tr>
</tbody>
</table>

#### Circular Tapered Inlet

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>57B</td>
<td>Throat Control for Box Culverts with Tapered Inlets</td>
</tr>
<tr>
<td>58B</td>
<td>Face Control for Box Culverts with Side-Tapered Inlets</td>
</tr>
<tr>
<td>59B</td>
<td>Face Control for Box Culverts with Slope-Tapered Inlets</td>
</tr>
</tbody>
</table>

#### Rectangular Tapered Inlets

<table>
<thead>
<tr>
<th>Chart</th>
<th>Description</th>
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<tbody>
<tr>
<td>57B</td>
<td>Throat Control for Box Culverts with Tapered Inlets</td>
</tr>
<tr>
<td>58B</td>
<td>Face Control for Box Culverts with Side-Tapered Inlets</td>
</tr>
<tr>
<td>59B</td>
<td>Face Control for Box Culverts with Slope-Tapered Inlets</td>
</tr>
</tbody>
</table>
CHART 1B

EXAMPLE

Examples:

Headwater Scales 2 & 3
Concrete Pipe Culverts
With Inlet Control

Bureau of Public Roads Jan. 1963
Revised May 1964

Chart 1B
Appendix 5
CHART 2B

HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

To use scale (2) or (3) project horizontally to scale (1), then use straight inclined line through C and Q scales, or reverse as illustrated.

BUREAU OF PUBLIC ROADS JAN. 1963

Chart 2B
Appendix 5
CHART 3B

<table>
<thead>
<tr>
<th>DIAMETER</th>
<th>ENTRANCE TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.63</td>
<td>0.063</td>
</tr>
<tr>
<td>2.73</td>
<td>0.085</td>
</tr>
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</table>

HEADWATER DEPTH FOR CIRCULAR PIPE CULVERTS WITH BEVELED RING INLET CONTROL

Chart 3B
Appendix 5
CHART 4B

Critical depth for circular pipe drainage design. The charts show the relationship between discharge (Q) and critical depth (D) for different pipe diameters (D). The discharge is measured in cubic feet per second (CFS), and the critical depth is measured in feet. The charts are divided into three sections, each covering a different range of discharge values (0-100, 0-1000, and 0-4000 CFS). The critical depth cannot exceed the top of the pipe (Dc cannot exceed top of pipe). BUREAU OF PUBLIC ROADS, JAN. 1964.
Chart 5B

HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN 1963

Chart 5B
Appendix 5
CHART 6B

For outlet crest not submerged, compute HW by methods described in the design procedures.

HEAD FOR
STANDARD
C. M. PIPE CULVERTS
FLOWING FULL
n = 0.024

Chart 6B
Appendix 5
CHART 7B

For outlet crown not submerged, compute HW by methods described in the design precedents.

HEAD FOR
STRUCTURAL PLATE
CORR. METAL PIPE CULVERTS
FLOWING FULL
n = 0.0328 TO 0.0302

Chart 7B
Appendix 5
HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS 18° TO 33.7° & 45°
WITH BEVELED EDGE AT TOP OF INLET

Chart 9B
Appendix 5
CHART 10B

EXAMPLE

8 X FT. 1.0 X FT. 0.8 X CUBIC FT. Q/NS - 7.1

HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
90° HEADWALL
CHAMFERED OR BEVELED INLET EDGES

HEADWATER DEPTH IN TERMS OF HEIGHT (CENTS)
2.0
1.5
1.0
0.5
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

HEADWATER DEPTH IN FEET
12
10
8
6
4
2

DISCHARGE PER FOOT OF BARREL WIDTH (Q/NS FT. X CUBIC FT. PER FOOT)
200
100
50
20
10
5
2
1

HEIGHT OF BARREL (D) IN FEET
3
2
1

INLET FACE-ALL EDGES:
1/8 IN. BEVELS 33.7° (1:1)
1/16 IN. BEVELS 45° (1:1)
3/4 INCH CHAMFERS

HEADWATER DEPTH IN FEET
2
1
0.5
0.25
0

NOTE ON BEVELS:
FACE DIMENSION OF ALL SIDE AND TOP BEVELS SHALL NOT BE LESS THAN SHOWN TO OBTAIN BEVEL TERMINATION IN ONE PLANE IN A RECTANGULAR BOX, EITHER INCREASE G OR Δ OR DECREASE THE BEVEL ANGLE.

FEDERAL HIGHWAY ADMINISTRATION
MAY 1973

Chart 10B
Appendix 5
EXAMPLE

\[ D \times B \times T \times O \times W \times O \times C \times D \times C \times G \times S \times T \]

CHART 11B

BEVELED EDGES - TOP AND SIDES

\[ \frac{1}{8} \text{ INCH CHAMFER ALL EDGES} \]

FLOW

\[ \text{Skew Angle} \]

\[ \text{Flow} \]

\[ \text{Skew Angle} \]

\[ \text{Skew Headwall Inlet} \]

HEADWATER DEPTH FOR INLET CONTROL

SINGLE BARREL BOX CULVERTS

SKEWED HEADWALLS

CHAMFERED OR BEVELED INLET EDGES

FEDERAL HIGHWAY ADMINISTRATION

MAY 1973

Chart 11B

Appendix 5
Example

B = 7 FT. D = 5 FT. Q = 500 CFS
Q = 71.5

INLET 8 45° WW HW HW NORMAL
D FT
45° WW 2.18 10.9
18.4° WW 2.27 11.4

SKewed 15°-45°
18.4° or more

W W

2.20 11.0

Discharge per foot of barrel width (Q/B) in CFS

600
500
400
300
200
100
50
20
10
5

Height of barrel (D) in feet

Chart 12B

3° Skew
NORMAL INLETS
WINGWALL FLARE

45°

18.4°

18.4°

2

3° Skew
NORMAL INLETS

WINGWALL NOT OFFSET

18.4°

45°

HEADWATER DEPTH IN TERMS OF HEIGHT (H/W)

HEADWATER DEPTH FOR INLET CONTROL
RECTANGULAR BOX CULVERTS
FLARED WINGWALLS
NORMAL AND SKewed INLETS

3/4" CHAMFER AT TOP OF OPENING

BUREAU OF PUBLIC ROADS
OFFICE OF R & D
AUGUST 1968

NOTE:
HEADWATER SCALE FOR SKewed
INLETS IS CONSTRUCTED FOR 3°
SKEW AND 3:1 WINGWALL FLARE
(18.4°)
ALSO A GOOD APPROXIMATION
FOR ANY SKEW ANGLE FROM 15°
TO 45° AND FOR GREATER SKEW
ANGLES OF WINGWALLS.
EXAMPLE

\( Q = 7 \text{ ft} \), \( D = 5 \text{ ft} \), \( Q = 600 \text{ CFS} \)

\( Q = 71.3 \)

WINGWALL TOP EDGE HW HW FLARE ANGLE BEVEL \( \theta \) FT

<table>
<thead>
<tr>
<th>( \theta )</th>
<th>( \text{IN./FT.} )</th>
<th>( \text{IN./FT.} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>45°</td>
<td>1/2</td>
<td>2.06</td>
</tr>
<tr>
<td>33.7°</td>
<td>1</td>
<td>1.50</td>
</tr>
<tr>
<td>18.4°</td>
<td>1/2</td>
<td>1.52</td>
</tr>
</tbody>
</table>

CHART 13B

13.4° WW & \( d = 0.083 \)D

33.7° WW & \( d = 0.083 \)D

45° WW & \( d = 0.042 \)D

0.042 45° 0.083 33.7°

TOP EDGE BEVEL ANGLE REQUIRED

WINGWALLS

FLARE ANGLE MIN. OFFSET

1:1 45° 3/4 x B (FT)

1:1.5 33.7° 1 x B

1:2 28.6° 1-1/4 x B

1:3 18.4° 1-1/2 x B

= USE 33.7° 0.0083D TOP EDGE BEVEL AND READ HW ON SCALE FOR 18.4° WW

HEADWATER DEPTH IN TERMS OF HEIGHT (HW/HD)

HEADWATER DEPTH FOR INLET CONTROL

RECTANGULAR BOX CULVERTS

OFFSET FLARED WINGWALLS AND BEVELED EDGE AT TOP OF INLET

BUREAU OF PUBLIC ROADS
OFFICE OF RD D AUGUST 1960

Chart 13B
Appendix 5
CHART 16B

Entrance Condition
(1) 90° headwall.
(2) 80° headwall.
(3) Thick wall projecting.
(4) Thin wall projecting.
(5) Thin wall projecting.

Discharge (Q) in cfs

Ratio of Headwater Depth to Rise (HW/D)

Example

Q = 494 cfs

Headwater Depth

For C.M. Box Culverts

RISE / SPAN < 0.3

WITH INLET CONTROL

Nomenclature adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Chart 16B
Appendix 5
CHART 17B

Entrance Condition
(2) 90° headwall.
(3) Thick wall projecting.
(5) Thin wall projecting.

Discharge (Q) in cfs.

Ratio of Headwater Depth to Rise (H/W / D)

Example:
D = 8.0 ft
Q = 950 cfs

Entrance Type

HW

D

ft

ft

Headwater Depth

FOR C.M. BOX CULVERTS

0.3 ≤ RISE / SPAN ≤ 0.4

WITH INLET CONTROL

Chart 17B
Appendix 5
CHART 18B

Example:
D = 9.87 ft
Q = 1520 cfs

Entrance Type
(2) 0.88 8.51
(3) 0.90 8.70
(5) 0.97 9.36

Discharge (Q) in cfs

Range of Headwater Depth to Rise (H W / D)

HEADWATER DEPTH FOR C.M. BOX CULVERTS
0.4 ≤ RISE / SPAN < 0.5
WITH INLET CONTROL

Dilution of this nomograph may distort scale
Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Chart 18B
Appendix 5
Chart 19B

Entrance Conditions
(2) 90° headwall.
(3) Thick wall projecting.
(4) Thin wall projecting.

Headwater Depth
For C.M. Box Culverts
0.5 x Rise / Span
With Inlet Control

Nomographs adapted from material furnished by
Kaiser Aluminum and Chemical Corporation
**EXAMPLE:**

RISE (D) = 6 ft 6 in
SPAN (B) = 22 ft 1 in
AREA (A) = 116.4 ft²
FLOW (Q) = 1050 ft³/s

RISE / SPAN = 6.6 / 22.08 = 0.29

\[
\frac{Q}{AD} = \frac{1050}{(116.4)(6.6)^{0.5}} \\
3.49
\]

\[
\frac{d_c}{D} = 0.63 \\
d_e = 0.63(6.6) = 4.1 \text{ ft}
\]
CHART 21B

CULVERT AREA

Discharge (Q) in cfs.

3000
2000
1500
1000
900
800
700
600
500
400
300
200
100
50

Area (ft²) = \frac{Q}{A}

Discharge (Q) in cfs.

3000
2000
1500
1000
900
800
700
600
500
400
300
200
100
50

Area (ft²) = \frac{Q}{A}


distance (R) in feet

Length (L) in feet

RISE / SPAN = 0.3

HEAD FOR C.M. BOX CULVERTS
FLOWING FULL
CONCRETE BOTTOM
Rise/Spans < 0.3

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

Chart 21B
Appendix 5
STORM WATER DRAINAGE DESIGN MANUAL AND FLOODPLAIN COMPLIANCE GUIDELINES

CHART 22B

HEAD FOR
C.M. BOX CULVERTS
FLOWING FULL
CONCRETE BOTTOM
0.3 ≤ RISE/SPAN ≤ 0.4

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

Chart 22B
Appendix 5
## Chart 23B

### Head for C.M. Box Culverts Flowing Full

- **Concrete Bottom**
  - $0.4 \leq \text{RISE/SPAN} < 0.5$

### Nomograph Description

- Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation.
- Displacement of this nomograph may distort shape.

### Table: Area (ft²) vs. Discharge (MCF)

<table>
<thead>
<tr>
<th>Area (ft²)</th>
<th>Discharge (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 57</td>
<td>0.026</td>
</tr>
<tr>
<td>58 - 142</td>
<td>0.025</td>
</tr>
<tr>
<td>143 - 220</td>
<td>0.024</td>
</tr>
</tbody>
</table>

### Diagram

- **CULVERT AREA**
  - Discharge (MCF) vs. Area (ft²)
  - Length (L) in feet vs. Rise
  - Head (H) in feet

- **SUBMERGED OUTLET CULVERT FLOWING FULL**
  - Slope $S_o$ and $H_w$

- **Legend**
  - Span vs. Rise
  - Concrete warrior flowing full

### Notes

- CHART 23B
- Appendix 5
Storm Water Drainage Design Manual and Floodplain Compliance Guidelines

CHART 24B

Discharge (Q) in cfs. vs. Area

<table>
<thead>
<tr>
<th>Area (ft²)</th>
<th>( \bar{h} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 - 65</td>
<td>0.026</td>
</tr>
<tr>
<td>66 - 120</td>
<td>0.025</td>
</tr>
</tbody>
</table>

HEAD FOR C. M. BOX CULVERTS
FLOWING FULL
CONCRETE BOTTOM

0.5 \( \leq \) RISE/SPAN

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may be unlawful.
CHART 25B

CULVERT AREA

Discharge (q) in cfs.

<table>
<thead>
<tr>
<th>Area (ft²)</th>
<th>( \bar{a} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 - 28</td>
<td>0.035</td>
</tr>
<tr>
<td>29 - 63</td>
<td>0.034</td>
</tr>
<tr>
<td>64 - 150</td>
<td>0.033</td>
</tr>
</tbody>
</table>

HEADING FOR C.M. BOX CULVERTS

FLOWING FULL

CORRUGATED METAL BOTTOM

RISE / SPAN < 0.3

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

Chart 25B
Appendix 5
CULVERT AREA

Discharge (Q) in cfs:

Area (ft²)   H

20 - 30   0.035
31 - 63   0.036
64 - 154  0.033
155 - 200 0.032

HEAD FOR
C.M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM

0.3 ≤ RISE/SPAN ≤ 0.4

Chart 26B
Appendix 5
Sewer Wafer Drainage Design Manual and Floodplain Compliance Guidelines

CHART 28B

Discharge (cfs) vs. Culvert Area

Area (ft²) | H
---|---
40 - 56 | 0.034
57 - 120 | 0.033

HEADING FOR C. M. BOX CULVERTS
FLOWING FULL
CORRUGATED METAL BOTTOM
0.5 ≤ RISE / SPAN

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Dilution of this nomograph may distort scale

Chart 28B
Appendix 5
Chart 29B

Headwater Depth for Oval Concrete Pipe Culverts
Long Axis Horizontal
With Inlet Control

To use scale (2) or (3), draw a straight line through known values of size and discharge to intersect scale (1). From point on scale (1) project horizontally to solution on either scale (2) or (3).

Example:
Size: 76" x 46" 0.300 cfs
HW/D = HW (feet)
Slope = 0

<table>
<thead>
<tr>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.8</td>
<td>11.2</td>
<td>4.0</td>
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<tr>
<td>2.2</td>
<td>6.8</td>
<td>3.0</td>
</tr>
<tr>
<td>2.5</td>
<td>9.2</td>
<td>4.0</td>
</tr>
</tbody>
</table>

HW/D Entrance Type
(1) Square edges with headwall
(2) Groove and with headwall
(3) Groove and projecting

Chart 29B
Appendix 5
CHART 30B

HEADWATER DEPTH FOR
OVAL CONCRETE PIPE CULVERTS
LONG AXIS VERTICAL
WITH INLET CONTROL

EXAMPLE
Size: 30° x 60°
0.200 cfs

HW / D (feet)

(1) 1.6 12.0
(2) 0.0 10.0
(3) 2.1 10.0

D in feet

To use scales (2) or (3), draw a straight line
through known values
of size and discharge
to intersect scale (1).
From point on scale (1)
project horizontally to
solution on either scale
(2) or (3).

HEADWATER DEPTH IN TERMS OF RISE (HW / D)

SQUARE ENTRANCE WITH HEADWALL

SQUARE ENTRANCE WITH HEADWALL

GROOVED ENTRANCE WITH HEADWALL

GROOVED ENTRANCE WITH HEADWALL

BUREAU OF PUBLIC ROADS JAN. 1963

Chart 30B
Appendix 5
CHART 31B

BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
OVAL CONCRETE PIPE
LONG AXIS HORIZONTAL

DISCHARGE - Q - CFS

0 20 40 60 80 100 120 140 160 180 200

0 1.0 2.0 3.0 3.4

CRITICAL DEPTH - D - FEET

0 1 2 3 4 5 6 7

DISCHARGE - Q - CFS

0 100 200 300 400 500 600 700 800 900 1000

Chart 31B
Appendix 5
CHART 32B

Critical Depth, $d_c$, versus Discharge, $Q$, for Oval Concrete Pipe with Long Axis Vertical.

$\delta_c$ cannot exceed top of pipe.

BUREAU OF PUBLIC ROADS
JAN. 1964

Chart 32B
Appendix 5
Head for Oval Concrete Pipe Culverts
Long Axis Horizontal or Vertical Flowing Full
n = 0.012

NOTE
Dimensions on size scale are ordered for long and horizontal installations. They should be reversed for long axis vertical.
**Storm Water Drainage Design Manual and Floodplain Compliance Guidelines**

**CHART 34B**

*Example:*
- Size: 36' x 28'
- 0.20 VSF

<table>
<thead>
<tr>
<th>Size (Span x Rise of Pipe Arch)</th>
<th>Discharge (Q) in GFS</th>
<th>HW D Scale</th>
<th>Entrance Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>16' x 7' x 10'-1''</td>
<td>5,000</td>
<td>(1) 1.00</td>
<td>Headwall</td>
</tr>
<tr>
<td>15'-4'' x 9'-3''</td>
<td>4,000</td>
<td>(2) 1.10</td>
<td>Raised to conform to slope</td>
</tr>
<tr>
<td>12'-10'' x 6'-4''</td>
<td>3,000</td>
<td>(3) 1.20</td>
<td>Projecting</td>
</tr>
<tr>
<td>11'-8'' x 7'-3''</td>
<td>2,000</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>9'-6'' x 6'-6''</td>
<td>1,000</td>
<td>1.40</td>
<td></td>
</tr>
<tr>
<td>6'-2'' x 5'-6''</td>
<td>800</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>7'-0'' x 5'-1''</td>
<td>600</td>
<td>1.60</td>
<td></td>
</tr>
<tr>
<td>6'-1'' x 4'-7''</td>
<td>500</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>72'' x 44''</td>
<td>400</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>65'' x 40''</td>
<td>300</td>
<td>1.90</td>
<td></td>
</tr>
<tr>
<td>58'' x 36''</td>
<td>200</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>50'' x 31''</td>
<td>100</td>
<td>2.10</td>
<td></td>
</tr>
<tr>
<td>43'' x 27''</td>
<td>50</td>
<td>2.20</td>
<td></td>
</tr>
<tr>
<td>36'' x 22''</td>
<td>20</td>
<td>2.30</td>
<td></td>
</tr>
<tr>
<td>29'' x 18''</td>
<td>10</td>
<td>2.40</td>
<td></td>
</tr>
<tr>
<td>25'' x 16''</td>
<td>5</td>
<td>2.50</td>
<td></td>
</tr>
<tr>
<td>22'' x 13''</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18'' x 11''</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To use scale (2) or (3) project horizontally to scale (1), then use straight lines through D and Q scales, or reverse as illustrated.

**Headwater Depth for C.M. Pipe-Arch Culverts with inlet control**

**Chart 34B**

Appendix 5
CHART 35B

Storm Water Drainage Design Manual and Floodplain Compliance Guidelines

HEADWATER DEPTH FOR INLET CONTROL
STRUCTURAL PLATE PIPE-ARCH CULVERTS
18-IN. RADIUS CORNER PLATE
PROJECTING OR HEADWALL INLET
HEADWALL WITH OR WITHOUT EDGE BEVEL

Chart 35B
Appendix 5
Example

Size: 17.4' x 11.5' Q = 2500 CFS

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>HEADWALL</th>
<th>NO BEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW / D</td>
<td>6.4</td>
<td>4.6</td>
</tr>
<tr>
<td>HW FL</td>
<td>18.9</td>
<td>16.7</td>
</tr>
</tbody>
</table>

Type of inlet

90° Headwall
33.7° x 0.10D Bevel
No Bevel
Projecting

Headwater depth in terms of arch rise HW / D

Discharge CFs

Pipe Arch Size - Span x Rise (H) ft. Additional sizes indicated are listed in manufacturer's catalogs.

Headwater depth for inlet control:

Structural Plate Pipe - Arch Culverts
31-in. radius corner plate
Projecting or Headwall inlet
Headwall with or without edge bevel

Chart 36B
Appendix 5
CHART 37B

BUREAU OF PUBLIC ROADS
JAN. 1964

CRITICAL DEPTH
STANDARD C.M. PIPE-ARCH

Chart 37B
Appendix 5
For outlet crown not submerged, compute HW by methods described in the design procedure.
CHART 40B

SUBMERGED OUTLET CULVERT FLOWING FULL

For outlet crown not submerged, compute HN by methods described in the design procedure.

LENGTH-L-IN FEET
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0
8.2
8.4
8.6
8.8
9.0
9.2
9.4
9.6
9.8
10.0
10.2
10.4
10.6
10.8
11.0
11.2
11.4
11.6
11.8
12.0
12.2
12.4
12.6
12.8
13.0
13.2
13.4
13.6
13.8
14.0
14.2
14.4
14.6
14.8
15.0
15.2
15.4
15.6
15.8
16.0
16.2
16.4
16.6
16.8
17.0
17.2
17.4
17.6
17.8
18.0
18.2
18.4
18.6
18.8
19.0
19.2
19.4
19.6
19.8
20.0

HEAD FOR STRUCTURAL PLATE CORRUGATED METAL PIPE ARCH CULVERTS 18 IN. CORNER RADIUS FLOWING FULL
n = 0.0327 to 0.0306

Chart 40B
Appendix 5
Chart 41B

Appendix 5
CHART 42B

Entrance Conditions

(2) 60" headwall.
(4) Mitered to embankment.
(5) Thin wall projecting corrugated metal.

<table>
<thead>
<tr>
<th>Arch Area in square feet</th>
<th>Discharge (Q) in cfs</th>
<th>Headwater Depth to Rise (H W / D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
<td>0.5</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
<td>1.0</td>
</tr>
<tr>
<td>300</td>
<td>300</td>
<td>1.5</td>
</tr>
<tr>
<td>400</td>
<td>400</td>
<td>2.0</td>
</tr>
<tr>
<td>500</td>
<td>500</td>
<td>2.5</td>
</tr>
<tr>
<td>600</td>
<td>600</td>
<td>3.0</td>
</tr>
<tr>
<td>700</td>
<td>700</td>
<td>3.5</td>
</tr>
<tr>
<td>800</td>
<td>800</td>
<td>4.0</td>
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<td>900</td>
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<td>4.5</td>
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<td>1000</td>
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<td>5.0</td>
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<tr>
<td>1100</td>
<td>1100</td>
<td>5.5</td>
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<td>1200</td>
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<td>6.0</td>
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<tr>
<td>1300</td>
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<tr>
<td>1400</td>
<td>1400</td>
<td>7.0</td>
</tr>
<tr>
<td>1500</td>
<td>1500</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Example

\[ A = \frac{277.5 \pi}{2} \]
\[ Q = 8000 \text{ cfs} \]

Entrance Type: HW, WW

<table>
<thead>
<tr>
<th>Entrance Type</th>
<th>HW</th>
<th>WW</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2)</td>
<td>2.03</td>
<td>26.74</td>
</tr>
<tr>
<td>(4)</td>
<td>2.40</td>
<td>31.64</td>
</tr>
<tr>
<td>(5)</td>
<td>2.33</td>
<td>30.69</td>
</tr>
</tbody>
</table>

Homographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Chart 42B

Appendix 5

0.4 ≤ RISE / SPAN < 0.5
WITH INLET CONTROL
Chart 43B

Entrance Conditions
(2) 90° headwall,
(4) Mitered to embankment,
(5) Thin wall projecting corrugated metal.

Example
A = 1.05 ft²
Q = 1400 cfs

Discharge (Q) in cfs

Headwater Depth to Rise (H/W)

Headwater Depth

For C. M. Arch Culverts
0.5 ≤ Rise/Span
With Inlet Control
Chart 44B

EXAMPLE:
RISE (D) = 5 ft 9 in
SPAN (B) = 16 ft
AREA (A) = 66.6 ft²
FLOW (Q) = 400 ft³/s
RISE/SPAN = 5.75/16 = .36
Q/AD² = 400/(66.6)(5.75)² = 2.6
D/ds = .47
ds = (.47)(5.75) = 2.7 ft

Chart 44B
Appendix 5
Storm Water Drainage Design Manual and Floodplain Compliance Guidelines

CHART 458

Area of Culvert

Discharge (Q) in cfs.

5000
4000
3000
2000
1000
500
100

Area (ft²)

5000
4000
3000
2000
1000
500
100

Turning Line

0.3 ≤ RISE/SPAN < 0.4

SUBMERGED OUTLET CULVERT FLOWING FULL

HEAD FOR
C.M. ARCH CULVERTS
FLOWING FULL
CONCRETE BOTTOM

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Dilution of this nomograph may distort scale

Chart 45B
Appendix 5
Storm Water Drainage Design Manual and Floodplain Compliance Guidelines

CHART 46B

HEAD FOR
C.M. ARCH CULVERTS
FLOWING FULL
CONCRETE BOTTOM
0.4 ≤ RISE / SPAN ≤ 0.5

Discharge (Q) in cfs.

Area of Culvert

Length (L) in feet

Head (H) in feet

Area (ft²)

\( \bar{R} \)

Example

\( 0.25 \times 50 = 12.5 \)

Example

\( 0.50 \times 100 = 50 \)

Example

\( 0.75 \times 200 = 150 \)

Example

\( 1.00 \times 300 = 300 \)

Example

\( 1.25 \times 400 = 500 \)

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may result in error

Chart 46B
Appendix 5
CHART 47B

HEAD FOR C.M. ARCH CULVERTS FLOWING FULL CONCRETE BOTTOM 0.5 ≤ RISE / SPAN

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Chart 47B
Appendix 5
CHART 48B

Discharge (Q) in cfs.

Area of Culvert

Length (L) in feet

Head (H) in feet

Area (ft²)  R

20 - 60  0.029
61 - 260  0.028

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

HEAD FOR
C. M. ARCH CULVERTS
FLOWING FULL
EARTH BOTTOM (n_b = 0.022)

0.3 ≤ RISE / SPAN ≤ 0.4

Chart 48B
Appendix 5
Area of Culvert

Discharge (Q) in cfs

Length (L) in feet

Head (H) in feet

Area (ft²)

<table>
<thead>
<tr>
<th>Area (ft²)</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-90</td>
<td>0.029</td>
</tr>
<tr>
<td>91-360</td>
<td>0.028</td>
</tr>
</tbody>
</table>

HEAD FOR
C. M. ARCH CULVERTS
FLOWING FULL
EARTH BOTTOM (nᵢ = 0.022)
0.4 ≤ RISE/SPAN < 0.5

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph may distort scale

Appendix 5
Chart 50B

Area of Culvert

Discharge (Q) in cfs

Length (L) in feet

Head (H) in feet

Flowing Full

C.M. Arch Culverts

Earth Bottom (n_b = 0.022)

0.5 ≤ Rise / Span

Chart 50B

Appendix 5

Storm Water Drainage Design Manual and Floodplain Compliance Guidelines

Area (ft²)

0.025

0.029

0.030

Swollen Outlet Culvert Flowing Full

Nomographs adapted from material furnished by Kaiser Aluminum and Chemical Corporation

Duplication of this nomograph not designed for

Appendix 5
CHART 51B
(English Units)
CHART 52B
(English Units)
EXAMPLE:
RISE (D) = 13 ft
SPAN (S) = 20 ft 1 in
AREA (A) = 201.8 ft²
FLOW (Q) = 2100 ft³/s

\[ \frac{Q}{AD^{0.5}} = \frac{2100}{(201.8)(15.0)}^{0.5} \]
= 2.9

\[ \frac{d_c}{D} = 0.65 \]

\[ d_c = (0.65)(13) = 8.5 \text{ ft} \]
EXAMPLE:

RISE (D) = 13 ft 3 in
SPAN (B) = 26 ft
AREA (A) = 294 ft²
FLOW (Q) = 2000 ft³/s
RISE/SPAN = 13.25/26 = .50
Q/AD = 2000/(294.0)(13.25)
  = 1.9

$\frac{SL}{D} = .45$

d_c = (.45)(13.25) = 6.0 ft
**CHART 55B**

**THROAT CONTROL**

**FOR SIDE-TAPERED INLETS TO PIPE CULVERT**

(CIRCULAR SECTION ONLY)

**SCALE ENTRANCE**

1. SMOOTH INLETS (CONCRETE)
2. ROUGH INLETS (CMIP)

**EXAMPLE**

\[ D = 72 \text{ INCHES} \quad \text{60 FEET} \]

\[ Q = 800 \text{ CFS} \]

**ENTRANCE**

\[ H_{W2} \quad H_{W1} \quad \text{D}\]

\[ (1) \quad 2.36 \quad 1.2 \]

\[ (2) \quad 2.42 \quad 1.5 \]

**HEADWATER DEPTH AT THROAT IN TERMS OF DIAMETERS (H_{W2}/D) IN FT.**

**DIAmeter OF Culvert Throat (D) IN INCHES**

**DISCHARGE PER BARREL (Q/N) IN CFS**

**EXAMPLE**

The chart provides a visual representation of the relationship between the diameter of the culvert throat, the discharge per barrel, and the headwater depth at the throat. It includes examples for smooth and rough inlets, with specific values for discharge and headwater depth for different diameters.
CHART 56B

Scale

Entrance Type

(1) Beveled Edge

(2) Square Edge

(3) Thin Edge Projecting

0.0428 OR 0.0538

Chart 56B
Appendix 5
THROAT CONTROL FOR BOX CULVERTS WITH TAPERED INLETS

Chart 57B
Appendix 5
CHART 59B

EXAMPLE

<table>
<thead>
<tr>
<th>D x 0 FEET</th>
<th>200 CFS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>INLET H W</td>
<td>Q B f</td>
</tr>
<tr>
<td>TYPE</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>(1) 1.41 61 13.1</td>
</tr>
<tr>
<td></td>
<td>(2) 1.38 61 13.1</td>
</tr>
</tbody>
</table>

SCALE ENTRANCE TYPE

(1) 15° TO 25° WING WALL FLARES WITH TOP EDGE BEVELED OR 28° TO 80° WING WALL FLARES WITH NO BEVELS

(2) 28° TO 45° WING WALL FLARES WITH TOP EDGE BEVELED OR 45° TO 90° WING WALL FLURES WITH BEVELS ON TOP AND SIDES

VERTICAL FACE

MITERED FACE

FACE CONTROL FOR BOX CULVERTS WITH SLOPE TAPERED INLETS
Chart 60B

A) Discharge Coefficient for

\[ \frac{H_{Wf}}{L_f} > 0.15 \]

B) Discharge Coefficient for

\[ \frac{H_{Wf}}{L_f} \leq 0.15 \]

C) Submergence Factor

\[ Q_r = C_d L H_{Wf}^{1.5} \]

\[ C_d = k_1 c_r \]

English Discharge Coefficients
for Roadway Overtopping
Appendix 6

GIS Database Submittals

All storm drainage infrastructures in any dedicated easement or street rights of way shall be submitted in accordance with all provisions herein. This includes all vertical and horizontal alignments for all constructed street centerlines and detention/retention pond finished contours, outlet structures, and emergency spillways. Survey control shall conform to Section 2.2 of this manual.

All data shall be provided to the City of Jonesboro in ESRI shapefile and PDF formats.

For all shapefiles, a separate spatial data file should be used for each structure and specific attributes should be recorded on site at the time of collection. The following table should be used for recording these attributes along with all feature attribute input criteria.

Table 1. Attribute Fields

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
<th>Length</th>
<th>Precision</th>
<th>Scale</th>
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<tbody>
<tr>
<td><strong>Inlet</strong></td>
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<tr>
<td>COMMENT</td>
<td>Text</td>
<td>80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Circular Pipe** |           |        |           |       |
| DATE              | Date      |        |           |       |
| BASIN             | Text      | 1      |           |       |
| NUMBER            | Long Integer | 6    |           |       |
| SIZE              | Short Integer | 2   |           |       |
| MATERIAL          | Text      | 20     |           |       |
| PROTECTION        | Text      | 21     |           |       |
| COMMENT           | Text      | 80     |           |       |
| INVERT            | Float     | 6      | 2         |       |

<p>| <strong>Elliptical Pipe</strong> |           |        |           |       |
| DATE               | Date      |        |           |       |
| BASIN              | Text      | 1      |           |       |
| NUMBER             | Long Integer | 6    |           |       |
| DIMENSION          | Text      | 5      |           |       |
| MATERIAL           | Text      | 20     |           |       |
| PROTECTION         | Text      | 21     |           |       |
| COMMENT            | Text      | 80     |           |       |
| INVERT             | Float     | 6      | 2         |       |</p>
<table>
<thead>
<tr>
<th>Field Name</th>
<th>Data Type</th>
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<tbody>
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<td>Arch Pipe</td>
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<td>Box Culvert</td>
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<td>DATE</td>
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<td>BASIN</td>
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</tr>
<tr>
<td>NUMBER</td>
<td>Long Integer</td>
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ANY FEATURE WITH THESE ATTRIBUTES

BASIN:  C = Cache
      L = Languille
      S = St Francis

MATERIAL:  Concrete
           Corrugated metal
           Non corrugated metal
           Plastic
           Clay

PROTECTION:  None
         Flared end section
         Headwall
         Headwall and Wingwall

INVERT:  2 decimal places in the measurement

ARCH PIPE

DIMENSION:  11x18
            14x22
            18x29
            23x36
            27x44
            31x51
            36x59
            40x65
            45x73
            54x88

BOX CULVERT

WIDTH & HEIGHT:  1, 2, 3, 4, 5, 6, 7, 8, 9, 10

BRIDGE

PIERSHAPE:  Circular
           Square

PIERSIZE:  12, 18, 24, 30, 36, 42, 48

DECKTOBEAM:  one decimal place in the measurement
CIRCULAR PIPE

SIZE:  12, 15, 18, 24, 30, 36, 42, 48, 54, 60, 72

ELLiptical PIPE

DIMENSION:  12x18
            14x23
            19x30
            22x34
            24x38
            29x45
            34x53
            38x60
            43x68
            48x76
            53x83

INLET

TYPE:  Area
       Combination
       Curb
       Grate
       Junction box
       Other

WIDTH & LENGTH: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

DEPTH:  one decimal place in the measurement

OUTFALL

SIZE:  12, 15, 18, 24, 30, 36, 42, 48, 54, 60, 72

FLOWDIRECT: N, S, E, W

FLOWQUANT: 0, 25, 50, 75, 100

COLOR:  Clear
        Black
        Dark brown
        Light brown
        Red
        Other
For each structure, a digital photograph shall be taken and submitted, providing visual documentation of the structure’s condition. Each image file shall be named to identify it based on drainage area, structure type, and number.

As a post processing step, all appropriate drainage structure location points shall be connected to create line work representing the storm drainage network. Care should be taken to tie the new drainage structures to the existing structures or to the appropriate drainage channel. At a minimum, structure diameter and length (in feet) should be added to the attribute table at the time of creation.

POLLUTANT:  None
Oil
Oil sheen
AUTHORIZATION TO DISCHARGE STORMWATER UNDER
THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM AND THE
ARKANSAS WATER AND AIR POLLUTION CONTROL ACT

In accordance with the provisions of the Arkansas Water and Air Pollution Control Act (Act 472 of
seq.),

Operator of Facilities with Stormwater Discharges Associated With Construction Activity

is authorized to discharge to all receiving waters except as stated in Part 1.B.11 (Exclusions).

For facilities that are eligible for coverage under this General Permit (GP), the Department sends a
cover letter (Notice of Coverage with tracking permit number which starts with ARR15) and a copy
of the permit to the facility. The cover letter includes the Department's determination that a facility
is covered under the GP and may specify alternate requirements outlined in the permit.

The responses to comments related to this permit are available as a separate document on the
Department's website.

Issue Date: October 31, 2008

Effective Date: November 1, 2008

Expiration Date: October 31, 2011

Steven L. Drown
Chief, Water Division
Arkansas Department of Environmental Quality
PART I
PERMIT REQUIREMENTS

Information in Part I is organized as follows:

Section A: Definitions
Section B: Coverage Under this Permit:
  1. Permitted Area
  2. Eligibility
  3. Responsibilities of the Operator
  4. Where to submit
  5. Requirements for Qualifying Local Program (QLP)
  6. Requirements for Coverage
  7. Notice of Intent (NOI) Requirements
  8. Posting Notice of Coverage (NOC)
  9. Applicable Federal, State or Local Requirements
 10. Allowable Non-Stormwater Discharges
 11. Limitations on Coverage (Exclusions)
 12. Trench and Ground Water Control
 13. Buffer Zones
 14. Waivers from Permit Coverage
 15. Continuation of the Expired General Permit
 16. Notice of Termination (NOT)
 17. Responsibilities of the Operator of a Larger Common Plan of Development for a Subdivision
 18. Change in Operator
 19. Late Notifications
 20. Failure to Notify
 21. Maintenance
 22. Releases in Excess of Reportable Quantities
 23. Attainment of Water Quality Standards
SECTION A: DEFINITIONS

1. "ADEQ" or "Department" is referencing the Arkansas Department of Environmental Quality. The Department is the governing authority for the National Pollutant Discharge Elimination System program in the state of Arkansas.

2. "Arkansas Pollution Control and Ecology Commission" shall be referred to as APCEC throughout this permit.

3. "Automatic Coverage" indicates those sites that are defined as a small construction site or a site that is less than five (5) acres but part of a larger common plan.

4. "Best Management Practices (BMPs)" schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage. According to the EPA BMP manual the use of hay-bales in concentrated flow areas is not recommended as a best management practice.

5. "Commencement of Construction" the initial disturbance of soils associated with clearing, grading, or excavating activities or other construction activities.

6. "Contaminated" means a substance the entry of which into the MS4, Waters of the State, or Waters of the United States may cause or contribute to a violation of Arkansas water quality standards.

7. "Control Measure" as used in this permit, refers to any Best Management Practice or other method used to prevent or reduce the discharge of pollutants to waters of the State.

8. "Construction Site" an area upon which one or more land disturbing construction activities occur that in total will disturb one acre or more of land, including areas that are part of a larger common plan of development or sale where multiple separate and distinct land disturbing construction activities may be taking place at different times on different schedules but under one plan such that the total disturbed area is one acre or more.

9. "CWA" the Clean Water Act or the Federal Water Pollution Control Act.

10. "Dedicated Portable Asphalt Plant" a portable asphalt plant that is located on or contiguous to a construction site that provides asphalt only to the construction site on which the plant is located or adjacent to. The term does not include facilities that are subject to the asphalt emulsion effluent guideline limitations at 40 CFR Part 443.

11. "Dedicated Portable Concrete Plant" a portable concrete plant that is located on or contiguous to a construction site and that provides concrete only to the construction site on which the plant is located on or adjacent to.

12. "Detention Basin" a detention basin is an area where excess stormwater is stored or held temporarily and then slowly drains when water levels in the receiving channel recede. In essence, the water in a detention basin is temporarily detained until additional room becomes available in the receiving channel.

13. "Director" the Director, Arkansas Department of Environmental Quality, or a designated representative.

14. "Discharge" when used without qualification means the "discharge of a pollutant".

15. "Discharge of Stormwater Associated with Construction Activity" as used in this permit, refers to a discharge of
pollutants in stormwater runoff from areas where soil disturbing activities (e.g., clearing, grading, or excavation), construction materials or equipment storage or maintenance (e.g., fill piles, borrow area, concrete truck washout, fueling), or other industrial stormwater directly related to the construction process (e.g., concrete or asphalt batch plants) are located.

16. "Discharge-Related Activities" as used in this permit, include: activities that cause, contribute to, or result in stormwater point source pollutant discharges, including but not limited to: excavation, site development, grading and other surface disturbance activities; management of solid waste and debris; and measures to control stormwater including the construction and operation of BMPs to control, reduce or prevent stormwater pollution.

17. "Disturbed area" the total area of the site where any construction activity is expected to disturb the ground surface. This includes any activity that could increase the rate of erosion, including, but not limited to, clearing, grubbing, grading, excavation, demolition activities, haul roads, and areas used for staging. Also included, are stockpiles of topsoil, fill material and any other stockpiles with a potential to create additional runoff.

18. "Eligible" qualified for authorization to discharge stormwater under this general permit.

19. "Erosion" the process by which the land's surface is worn away by the action of wind, water, ice or gravity.

20. "Facility" or "Activity" any NPDES "point source" or any other facility or activity (including land or appurtenances thereto) that is subject to regulation under the NPDES program.

21. "Final Stabilization":

A. All soil disturbing activities at the site have been completed and either of the two following criteria are met:

   1) A uniform (e.g., evenly distributed, without large bare areas) perennial vegetative cover with a density of 80% of the native background vegetative cover for the area has been established on all unpaved areas and areas not covered by permanent structures, or

   2) Equivalent permanent stabilization measures (such as the use of riprap, gabions, or geotextiles) have been employed.

B. When background native vegetation will cover less than 100% of the ground (e.g., arid areas, beaches), the 80% coverage criteria is adjusted as follows: if the native vegetation covers 50% of the ground, 80% of 50% (0.80 x 0.50 = 0.40) would require 40% total cover for final stabilization. On a beach with no natural vegetation, no stabilization is required.

C. For individual lots in residential construction, final stabilization means that either:

   1) The homebuilder has completed final stabilization as specified above, or

   2) The homebuilder has established temporary stabilization including perimeter controls for an individual lot prior to occupation of the home by the homeowner and informing the homeowner of the need for, and benefits of, final stabilization.

D. For construction projects on land used for agricultural purposes (e.g., pipelines across crop or range land, staging areas for highway construction, etc.), final stabilization may be accomplished by returning the disturbed land to its pre-construction agricultural use. Areas disturbed that were not previously used for agricultural activities, such as buffer
strips immediately adjacent to “water of the United States”, and areas which are not being returned to their pre-construction agricultural use must meet the final stabilization criteria in A, B, or C above.

22. “Infrastructure” streets, drainage, curbs, utilities, etc.

23. “Impaired Water” a water body listed in the current, approved Arkansas 303(d) list.

24. “Lanscaping” improving the natural beauty of a piece of land (i.e. entrance of subdivision) through plantings or altering the contours of the ground.

25. “Large and Medium Municipal Separate Storm Sewer System” all municipal separate storm sewer systems that are either:
   
   A. Located in an incorporated place with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census; or
   
   B. Located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal, separate storm sewers that are located in the incorporated places, townships or towns within such counties; or
   
   C. Owned or operated by a municipality other than those described in paragraphs (i) or (ii) and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

26. “Large Construction Site” Construction activity including clearing, grading and excavation, except operations that result in the disturbance of less than five acres of total land area. Construction activity also includes the disturbance of less than five acres of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb five acres. (Please see Part I.B.14 for partial waivers.)

27. “Larger Common Plan of Development” a contiguous (sharing a boundary or edge; adjacent; touching) area where multiple and distinct construction activities may be taking place at different times on different schedules under one plan. Such a plan might consist of many small projects (e.g., a common plan of development for a residential subdivision might lay out the streets, house lots, and areas for parks, schools and commercial development that the developer plans to build or sell to others for development.) All these areas would remain part of the common plan of development or sale. The following items can be used as guidance for deciding what might or might not be considered a “Common Plan of Development or Sale.” The “plan” in a common plan of development or sale is broadly defined as any announcement or piece of documentation (including a sign, public notice or hearing, sales pitch, advertisement, drawing, permit application, zoning request, computer design, etc.) or physical demarcation (including boundary signs, lot stakes, surveyor markings, etc.) indicating construction activities may occur on a specific plot. You must still meet the definition of operator in order to be required to get permit coverage, regardless of the acreage you personally disturb.

If a smaller project (i.e., less than 1 acre) is part of a large common plan of development or sale (e.g., you are building a residential home on a ½ acre lot in a 40 acre subdivision or are putting in a fast food restaurant on a ¼ acre pad that is part of a 20 acre retail center) permit coverage is required. Under 40 CFR 122.26(b)(2)(vi), smaller parts of a larger common plan of development are automatically authorized under this general permit and should follow the conditions of a site with automatic coverage set forth in this permit (see Part I.B.6.A).

28. “NOC” Notice of Coverage

29. “NOI” Notice of Intent to be covered by this permit.
30. "NOT" Notice of Termination.

31. "Operator" for the purpose of this permit and in the context of stormwater associated with construction activity, means any person (an individual, association, partnership, corporation, municipality, state or federal agency) who has the primary management and ultimate decision-making responsibility over the operation of a facility or activity. The operator is responsible for ensuring compliance with all applicable environmental regulations and conditions.

In addition, for purposes of this permit and determining who is an operator, “owner” refers to the party that owns the structure being built. Ownership of the land where construction is occurring does not necessarily imply the property owner is an operator (e.g., a landowner whose property is being disturbed by construction of a gas pipeline or a landowner who allows a mining company to remove dirt, shale, clay, sand, gravel, etc. from a portion of his property). Likewise, if the erection of a structure has been contracted for, but possession of the title or lease to the land or structure is not to occur until after construction, the would-be owner may not be considered an operator (e.g., having a house built by a residential homebuilder).

32. "Outfall" a point source where stormwater leaves the construction site.

33. "Owner" the owner or operator of any “facility or activity” subject to regulation under the NPDES program. In addition, for purposes of this permit and determining who is an operator, “owner” refers to the party that owns the structure being built. Ownership of the land where construction is occurring does not necessarily imply the property owner is an operator (e.g., a landowner whose property is being disturbed by construction of a gas pipeline). Likewise, if the erection of a structure has been contracted for, but possession of the title or lease to the land or structure is not to occur until after construction, the would-be owner may not be considered an operator (e.g., having a house built by a residential homebuilder).

34. "Physically Interconnected" that one municipal separate storm sewer system is connected to a second municipal separate storm sewer system in such a way that it allows for direct discharges into the second system.

35. "Point Source" any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff.

36. "Qualified Local Program" is a municipal program for stormwater discharges associated with construction sites that has been formally approved by the Department.

37. "Qualified personnel" a person knowledgeable in the principles and practice of erosion and sediment controls who possesses the skills to assess conditions at the construction site that could impact stormwater quality and to assess the effectiveness of any sediment and erosion control measures selected to control the quality of stormwater discharges from the construction activity.

38. "Regulated Small Municipal Separate Storm Sewer System" all municipal separate storm sewer systems that are either:

   A. Located within the boundaries of an “urbanized area” with a population of 50,000 or more as determined by the latest Decennial Census by the Bureau of Census; or
   B. Owned or operated by a municipality other than those described in paragraph A and that serve a jurisdiction with a population of at least 10,000 and a population density of at least 1,000 people per square mile; or
   C. Owned or operated by a municipality other than those described in paragraphs A and B and that contributes substantially to the pollutant loadings of a “physically interconnected” municipal separate storm sewer system.
39. "Retention Basin" a basin that is designed to hold the stormwater from a rain event and allow the water to infiltrate through the bottom of the basin. A retention basin also stores stormwater, but the storage of the stormwater would be on a more permanent basis. In fact, water often remains in a retention basin indefinitely, with the exception of the volume lost to evaporation and the volume absorbed into the soils. This differs greatly from a detention basin, which typically drains after the peak of the storm flow has passed, sometimes while it is still raining.

40. "Runoff Coefficient" the fraction of total rainfall that will appear at the conveyance as runoff.

41. "Sediment" material that settles to the bottom of a liquid.

42. "Sediment Basin" a basin that is designed to maintain a 10 year-24 hour storm event for a minimum of 24-hours in order to allow sediment to settle out of the water.

43. "Small Construction Site" Construction activities including clearing, grading, and excavating that result in land disturbance of equal to or greater than one acre and less than five acres. Small construction activity also includes the disturbance of less than one acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than one and less than five acres. Small construction activity does not include routine maintenance.

44. "Stormwater" stormwater runoff from rainfall, snow melt runoff, and surface runoff and drainage.

45. "Stormwater Associated with Construction Activity" the discharge from any conveyance which is used for collecting and conveying stormwater and which is directly related to construction activity.

46. "Stormwater Pollution Prevention Plan (SWPPP or SWP3)" a plan that includes site map(s), an identification of construction/contractor, activities that could cause pollutants in the stormwater, and a description of measures or practices to control these pollutants (BMPs).

47. "Temporary Sediment Controls" controls that are installed to control sediment runoff from the site. These could be silt fencing, rock check dams, etc.

48. "Total Maximum Daily Load" or "TMDL" the sum of the individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for non-point sources and natural background. If receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any non-point sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure.

49. "Uncontaminated" can not exceed the water quality standards as set forth in APCEC Regulation 2.

50. "Urbanized Area" the areas of urban population density delineated by the Bureau of the Census for statistical purposes and generally consisting of the land area comprising one or more central place(s) and the adjacent densely settled surrounding area that together have a residential population of at least 50,000 and an overall population density of at least 1,000 people per square mile as determined by the latest Decennial Census by the Bureau of Census.
SECTION B: COVERAGE UNDER THIS PERMIT

Introduction

This Construction General Permit (CGP) authorizes stormwater discharges from large and small construction activities that result in a total land disturbance of equal to or greater than one acre, where those discharges enter surface waters of the State or a municipal separate storm sewer system (MS4) leading to surface waters of the State subject to the conditions set forth in this permit. This permit also authorizes stormwater discharges from any other construction activity designated by ADEQ where ADEQ makes that designation based on the potential for contribution to an excursion of a water quality standard or for significant contribution of pollutants to waters of the State. This permit replaces the permit issued in 2003. The goal of this permit is to minimize the discharge of stormwater pollutants from construction activity. The Operator should make sure to read and understand the conditions of the permit. A copy of the General Stormwater Construction Permit is available on the ADEQ web site at http://www.adeg.state.ar.us/water/branch_npdess/stormwater/construction/construction.htm. You may also obtain a hard copy by contacting the ADEQ’s General Permits Section at (501) 682-0623.

1. Permitted Area. If a large or small construction activity is located within the State of Arkansas, the operator may be eligible to obtain coverage under this permit.

2. Eligibility. Permit eligibility is limited to discharges from “large” and “small” construction activity, or as otherwise designated by ADEQ. This general permit contains eligibility restrictions, as well as permit conditions and requirements. You may have to take certain actions to be eligible for coverage under this permit. In such cases, you must continue to satisfy those eligibility provisions to maintain permit authorization. If you do not meet the requirements that are a precondition to eligibility, then resulting discharges constitute unpermitted discharges. By contrast, if you eligible for coverage under this permit and do not comply with the requirements of the general permit, you may be in violation of the general permit for your otherwise eligible discharges.

A. This general permit authorizes discharges from construction activities as defined in 40 CFR 122.26(a), 40 CFR 122.26(b)(14)(x), and 40 CFR 122.26(b)(15)(i).

B. This permit also authorizes stormwater discharges from support activities (e.g., concrete or asphalt batch plants, equipment staging yards, materials storage areas, excavated material disposal areas, borrow areas) provided:

1) The support activity is directly related to a specific construction site that is required to have NPDES permit coverage for discharges of stormwater associated with the construction activity;
2) The support activity is not a commercial operation serving multiple unrelated construction projects by different operators, and does not operate beyond the completion of the construction activity at the last construction project it supports;
3) Pollutant discharges from support activity areas are minimized in compliance with conditions of this permit; and
4) Discharges from the support activity areas must be identified in a stormwater pollution prevention plan stating appropriate controls and measures for the area.

C. Other activities may be considered for this permit at the discretion of the Director as defined in 40 CFR 122.26(b)(15)(ii).

3. Responsibilities of the Operator. Permittees with operational control are responsible for compliance with all applicable terms and conditions of this permit as it relates to their activities on the construction site, including protection of endangered species and implementation of BMPs and other controls required by the SWPPP. Receipt of this general
permit does not relieve any operator of the responsibility to comply with any other applicable federal, state or local statute, ordinance or regulation.

4. **Where to submit.** The operator shall submit a complete and signed NOI and SWPPP to the Department at the following address:

   Arkansas Department of Environmental Quality  
   Discharge Permits Section  
   5301 Northshore Drive  
   North Little Rock, AR 72118-5317

   Or by electronic mail (Complete documents (NOI and SWPPP) must be submitted in PDF format) to:

   Water-permit-application@adeq.state.ar.us;

   NOTE: Notice of Coverage (NOC) will NOT be issued until payment has been received by ADEQ.

5. **Requirements for Qualifying Local Program (QLP).** The Department reviews and approves the QLP programs to ensure that they meet or supersede both state and federal requirements outlined in this permit and 40 CFR 122.44(s). ADEQ will review the QLP program at least every 5 years for recertification. If the Department approves a QLP, then the QLP requirements must at the minimum meet the Department's requirements. This would include all templates and forms.

   If the small construction site is within the jurisdiction of a QLP, the operator of the small construction site is authorized to discharge stormwater associated with construction activity under QLP permit requirements only.

List of Qualifying Local Programs: A list of municipalities with Qualifying Local Programs is available at [http://www.adeq.state.ar.us/water/branch_npdes/stormwater/ms4.htm](http://www.adeq.state.ar.us/water/branch_npdes/stormwater/ms4.htm). At this time only the City of Hot Springs is meeting the ADEQ minimum requirements.

6. **Requirements for Coverage.**

   A. **Automatic Coverage.** An operator of each site with automatic coverage may discharge under this general permit without submitting a NOI, SWPPP and fee. Please note that all the permit conditions set forth must be followed. The Operator is responsible for ensuring that the site is in compliance with any changes or updates of this general permit, by either contacting ADEQ or reviewing the ADEQ website [http://www.adeq.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm](http://www.adeq.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm)

   B. **Large Construction Sites.** An operator of a large construction site discharging under this general permit must submit the following items at least two weeks prior to commencement of construction:

   1) A Notice of Intent (NOI) in accordance with the requirements of Part 1.B.7 of this permit.

   2) A complete Stormwater Pollution Prevention Plan (SWPPP) in accordance with the requirements of Part II.A of this permit.

   3) An initial permit fee must accompany the NOI under the provisions of APCEC Regulation No. 9. Subsequent annual fees will be billed by the Department until the operator has requested a termination of coverage by submitting a Notice of Termination (NOT). Failure to remit the required permit fee may be grounds for the Director to deny coverage under this general permit.

   4) Per Part 1.B.14 of the permit, any single lot that are less than five (5) acres but part of a larger common plan
greater than five (5) acres, are waived from the requirements of a large site and may be permitted under automatic coverage.

Permitted Ongoing Project:

If you previously did receive authorization to discharge for your project under the 2003 CGP and you wish to obtain coverage under this permit, you must submit only an NOI within 60 days of the issuance date of this permit and update the existing SWPPP in accordance with Part II of this permit.

C. Coverage within a QLP

An operator of a site with automatic coverage, as defined in this permit, shall comply with the requirements of the QLP which has jurisdiction over the site.

7. Notice of Intent (NOI) Requirements

A. NOI Form. Large Construction site operators who intend to seek coverage for stormwater discharge under this general permit must submit a complete and accurate ADEQ NOI form to the Department at least two weeks prior to coverage under this permit. The NOI form must be the current version obtained from the stormwater webpage indicated above in Part I.B.

If the NOI is deemed incomplete, the Department will notify the applicant with regard to the deficiencies by a letter, email, or phone within ten (10) business days of receipt of NOI. If the operator does not receive a notification of deficiencies from ADEQ's receipt of the NOI, the NOI is deemed complete. If the applicant does not provide the Department with the requested deficiencies within the deadline set by the Department, then the Department will return the NOI, fee and SWPPP back to the applicant.

B. Contents of the NOI. The NOI form contains, at a minimum, the following information:

1) Operator (Permittee) information (name, address, telephone and fax numbers, E-mail address)
2) Whether the operator is a federal, state, private, public, corporation, or other entity
3) Application Type: New or renewal
4) Invoice mailing information (name, address, and telephone and fax numbers)
5) Project Construction site information (name, county, address, contact person, direction to site, latitude and longitude for the entrance of the site or the endpoints for linear project (in degrees, minutes, and seconds), estimated construction start date and completion date through site final stabilization, estimate of the total project acreage and the acreage to be disturbed by the operator submitting the NOI, type of the project (subdivision, school, etc), whether the project is part of a larger common plan of development.)
6) Discharge information (name of the receiving stream, ultimate receiving stream, name of municipal storm sewer system)
7) Endangered Species information
8) Previous/Current permit information
9) The Certification statement and signature of a qualified signatory person in accordance with 40 CFR 122.22, as adopted by reference in APCEC Regulation No. 6
10) The certification of the facility corporation
11) Other information (location of the SWPPP).
C. **Notice of Coverage (NOC).** Unless notified by the Director to the contrary, dischargers who submit a NOI in accordance with the requirements of this permit are authorized to discharge stormwater from construction sites under the terms and conditions of this permit two weeks after the date the NOI is deemed complete by ADEQ. If the NOC has not been received by the permittee two weeks after the date the NOI is deemed complete by ADEQ, the NOI should be posted until the NOC is received. Upon review of the NOI and other available information, the Director may deny coverage under this permit and require submittal of an application for an individual NPDES permit.

8. **Posting Notice of Coverage (NOC).**

A. **Large Sites:** NOC Posting for Large Construction Sites. The posting for large construction sites shall be obtained from the Department only after the permittee has met the NOI, permit fee and complete SWPPP submittal to the Department for the coverage.

B. **Automatic Coverage Sites.** The Automatic Coverage NOC for small sites and a single site less than five (5) acres but part of a larger common plan, as defined in Part I.A, can be obtained from the Water Division’s Construction Stormwater webpage. Posting a NOC without a SWPPP is a violation of this permit.

C. **Linear Projects.** If the construction project is a linear construction project (e.g., pipeline, highway, etc.), the notice must be placed in a publicly accessible location near where construction is actively underway and moved as necessary.

Please note, this permit does not provide the public with any right to trespass on a construction site for any reason, including inspection of a site; nor does this permit require that the permittee allow members of the public access to a construction site.

9. **Applicable Federal, State or Local Requirements.** The operator must ensure that the stormwater controls implemented at the site are consistent with all applicable federal, state, or local requirements. Additionally, an operator who is operating under approved local erosion and sediment plans, grading plans, local stormwater permits, or stormwater management plans shall submit signed copies of the Notice of Intent to the local agency (or authority) upon the local agency’s request.

10. **Allowable Non-Stormwater Discharges.**

A. The following non-stormwater discharges that are combined with stormwater during construction may be authorized by this permit. Non-stormwater discharges must be addressed in the stormwater pollution prevention plan.

1) Fire fighting activities;
2) Fire hydrant flushings;
3) Water used to wash vehicles (where detergents or other chemicals are not used) or control dust in accordance with Part II.A.4.1.2;
4) Potable water sources including uncontaminated waterline flushings;
5) Landscape irrigation;
6) Routine external building wash down which does not use detergents or other chemicals;
7) Pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled materials have been removed) and where detergents or other chemicals are not used;
8) Uncontaminated air conditioning, compressor condensate (See Part I.B.12 of this permit);
9) Uncontaminated springs, excavation dewatering and groundwater (See Part I.B.12 of this permit);
10) Foundation or footing drains where flows are not contaminated with process materials such as solvents (See Part I.B.12 of this permit);
11. Limitations on Coverage (Exclusions). The following stormwater discharges associated with construction activity are not covered by this permit:

A. **Post Construction Discharge.** Stormwater discharges associated with construction activities that originate from the site after construction activities have been completed, the site has undergone final stabilization, and the permit has been terminated.

B. **Discharges Mixed with Non-Stormwater.** Stormwater discharges that are mixed with sources of non-stormwater other than those identified in Part I.B.10.

C. **Discharges Covered by another Permit.** Stormwater discharges associated with construction activity that are covered under an individual or an alternative general permit may be authorized by this permit after an existing permit expires provided the expired permit did not establish numeric effluent limitations for such discharges.

D. **Discharges into Receiving Waters with an Approved TMDL.** Discharges from a site into receiving waters for which there is an established total maximum daily load (TMDL) allocation (www.adeg.state.ar.us/water/branch_planning/default.htm) for Turbidity, Oil & Grease, and/or other pollutants at the discretion of the Director are not eligible for coverage under this permit unless the permittee develops and certifies a stormwater pollution prevention plan (SWPPP) that is consistent with the assumptions and requirements in the approved TMDL. To be eligible for coverage under this general permit, operators must incorporate into their SWPPP any conditions applicable to their discharges necessary for consistency with the assumptions and requirements of the TMDL within any timeframes established in the TMDL. If a specific numeric wasteload allocation has been established that would apply to the project’s discharges, the operator must incorporate that allocation into its SWPPP and implement necessary steps to meet that allocation. Please note that the Department will be reviewing this information. If it is determined that the project will discharge to a TMDL, then the Department may require additional BMPs.

E. **Discharges into Impaired Receiving Waters (303(d) List).** Discharges from a site into a receiving waters listed as impaired under Section 303(d) of the Clean Water Act (www.adeg.state.ar.us/water/branch_planning/default.htm) for Turbidity, Oil & Grease and/or other pollutants at the discretion of the Director, should incorporate into the SWPPP any additional BMPs needed to sufficiently protect water quality. The SWPPP should include a proposal for monitoring to determine if the BMPs and controls are effective. Please note that the Department will be reviewing this information. If it is determined that the project will discharge to an impaired water body, then the Department may require additional BMPs.

F. **Endangered and Threatened Species and Critical Habitat Protection.** Stormwater discharges from construction sites that are likely to adversely affect a listed endangered or threatened species or its critical habitat must contact the U.S. Fish and Wildlife Service (USFWS) at (501) 513-4470 or www.fws.gov/arkansas-es. Discharges which are not in compliance with the Endangered Species Act (ESA) can not be covered under this permit.

In order to obtain coverage, the applicant must follow the process required by the USFWS in order to determine the project’s compliance with the ESA. This automatic process can be found on the USFWS website at the following address: www.fws.gov/arkansas-es. The certification provided by the process must be included in the project’s Stormwater Pollution Prevention Plan. If at some point during the process, the submittal of information to the USFWS is required, then the incomplete checklist should be submitted to the Department along with the letter of correspondence that was submitted to the USFWS.
12. **Trench and Ground Water Control.** There shall be no turbid discharges to surface waters of the state resulting from dewatering activities. If trench or ground waters contain sediment, it must pass through a sediment settling pond or other equally effective sediment control device, prior to being discharged from the construction site. Alternatively, sediment may be removed by settling in place or by dewatering into a sump pit, filter bag, or comparable practice. Ground water dewatering which does not contain sediment or other pollutants is not required to be treated prior to discharge. However, care must be taken when discharging ground water to ensure that it does not become pollutant-laden by traversing over disturbed soils or other pollutant sources.

13. **Buffer Zones.**

An undisturbed buffer zone as stated below shall be maintained at all times. Exceptions from this requirement for areas, such as water crossings, limited water access, and restoration of the buffer are allowed if the permittee fully documents in the SWPPP the circumstances and reasons for the buffer zone encroachment. Additionally, this requirement is not intended to interfere with any other ordinance, rule or regulation, statute or other provision of law.

A. For construction projects where clearing and grading activities will occur, the SWPPP must provide at least twenty-five (25) feet of buffer zone, as measured horizontally from the top of the bank to the disturbed area, from any named or unnamed streams, creeks, rivers, lakes or other water bodies.

B. The Department may also require up to fifty (50) feet of buffer zone, as measured from the top of the bank to the disturbed area, from established TMDL water bodies, streams listed on the 303(d)-list, an Extraordinary Resource Water (ERW), Ecologically Sensitive Waterbody (ESW), Natural and Scenic Waterway (NSW), and/or any other uses at the discretion of the Director.

C. Linear projects will be evaluated individually by the Department to determine buffer zone setbacks.

14. **Waivers from Permit Coverage.** The Director may waive the otherwise applicable requirements of this general permit for stormwater discharges from construction activities under the terms and conditions described in this section.

A. **Waiver Applicability and Coverage.** Based upon 40 CFR Part 122.26.b.15.i.A, operators of small construction activities may apply for and receive a waiver from the requirements to obtain this permit.

B. **No Stormwater Leaving the Site.** If all of the stormwater from the construction activity is captured on-site under any size storm event and allowed to evaporate, soak into the ground on-site, or is used for irrigation, a permit is not needed.

C. **TMDL Waivers.** This waiver is available for sites with automatic coverage if the ADEQ has established or approved a TMDL that addresses the pollutant(s) of concern and has determined that controls on stormwater discharges from small construction activity are not needed to protect water quality. The pollutant(s) of concern include sediment (such as total suspended solids, turbidity or siltation) and any other pollutant that has been identified as a cause of impairment of any water body that will receive a discharge from the construction activity. Information on TMDLs that have been established or approved by ADEQ is available from ADEQ online at www.adeq.state.ar.us/water/branch_planning/default.htm.

D. **Discharges into Impaired Receiving Waters (303(d) List).** This waiver is available for sites with automatic coverage if the ADEQ has listed the waters in 303(d) list that addresses the pollutant(s) of concern and has determined that controls on stormwater discharges from small construction activity are not needed to protect water quality. The pollutant(s) of concern include sediment (such as total suspended solids, turbidity or siltation) and any other pollutant.
that has been identified as a cause of impairment of any water body that will receive a discharge from the construction activity. Information on 303(d) that have been established by ADEQ is available from ADEQ online at www.adeg.state.ar.us/water/branch_planning/default.htm

E. Sites part of the Larger Common Plan. Any single lot less than 5 acres that is part of larger common plan may be considered as a small construction site. As long as the operator has complied with all conditions of this permit without submitting an NOI in accordance with 40 CFR 122.28(b)(2)(v). This waiver is applicable if the operator has only one lot in the larger common plan or multiple lots in which construction will not begin within 24 months of the prior construction.

15. Continuation of the Expired General Permit. If this permit is not reissued or replaced prior to the expiration date, it will be administratively continued in accordance with the Administrative Procedure Act and remain in force and effect. If you were granted permit coverage prior to the expiration date, you will automatically remain covered by the continued permit until the earliest of:

- Reissuance or replacement of this permit, at which time the operator must comply with the conditions of the new permit to maintain authorization to discharge and, the operator is required to notify the Department of his/her intent to be covered under this permit within 60 days after the effective date of the renewal permit; or
- Submittal of a Notice of Termination; or
- Issuance of an individual permit for the project’s discharges; or
- A formal permit decision by ADEQ to not reissue this general permit, at which time you must seek coverage under an alternative general permit or an individual permit.

Small site Operators are responsible for ensuring that the site is in compliance with any changes or updates of this general permit, by reviewing the ADEQ website at: http://www.adeg.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm.

16. Notice of Termination (NOT). All construction activities that disturbed soil are complete, the site has reached final effective stabilization (100% stabilization with 80% density), all stormwater discharges from construction activities authorized by this permit are eliminated and all temporary sediment controls are removed and properly disposed, the operator of the facility may submit a complete Notice of Termination (NOT) to the Director. Along with the NOT, pictures that represent the entire site should be submitted for review. Final stabilization is not required if the land is returned to its pre-construction agriculture use. Operators of small construction sites are not required to submit NOTs for their construction sites. However, final stabilization is required on all sites. If a Notice of Termination is not submitted when the project is completed, the operator will be responsible for annual fees.


A. The operator is ultimately responsible for the runoff from the perimeter of the entire development. Regardless for the reason of the runoff, the operator is responsible for ensuring sufficient overall controls of the development.

B. The operator shall not terminate the permit coverage until the following conditions have been met:

1) After all construction including landscaping and lot development has been completed; and

2) All lots are sold and developed.

The following exceptions to this requirement can apply:
a. less than 100% sold and developed at the discretion of the Director, or
b. Separation of the larger common plan if twenty-four (24) months have passed with no construction activity.
c. All lots are developed and there are no temporary common controls for subdivision outfalls, i.e. sediment basins, large sediment traps, check dams, etc.

3) If lots are sold then re-sold to a third party then permit coverage needs to be obtained by each of the operators while they have ownership of the lots. The second owner is responsible to obtain the same certification from the third owner, i.e. the certification must pass from owner to owner.

C. The operator shall not terminate permit coverage until the operators of all the individual lots within the larger common plan are notified of their permitting requirements under this general permit. In this case, the signed certification statements from each operator of individual lots must be maintained in the stormwater pollution prevention plan for the large common plan. A copy of the signed certifications must be submitted to ADEQ with the NOT. The certification shall be as follows:

"I, ____________________________, operator of an individual lot #_____, block #_____ of _________ subdivision, certify under penalty of law that I was notified by the operator of the larger common plan of the stormwater permitting requirements for my construction site(s). I understand prior to commencement of any construction activity I have to prepare and comply with a SWPPP and post the Construction Site Notice. I understand that prior to the sale of this lot to another party, I must notify the new owner of ADEQ requirements and obtain this certification from the new owner."

Signature ____________________________

D. The following examples are provided as clarification:

1) If a small portion of the original common plan of development remains undeveloped and there has been a period of time (i.e., more than 24 months) where there are no ongoing construction activities (i.e., all areas are either undisturbed or have been finally stabilized), you may re-evaluate the original project based on the acreage remaining from the original “common plan.” If less than five but more than one acre remains to build out the original “common plan”, coverage under the large permit may not be required. However, you will need to comply with the terms and conditions for Small Construction Sites in the Construction General Permit. If less than one acre remains of the original common plan, your individual project may be treated as a part of a less than one acre development and no permit would be required.

2) If you have a long-range master plan of development where some portions of the master plan are conceptual rather than a specific plan of future development and the future construction activities would, if they occur at all, happen over an extended period of time (i.e., more than 24 months), you may consider the “conceptual” phases of development to be separate “common plans” provided the periods of construction for the physically interconnected phases will not overlap.

3) Where discrete construction projects within a larger common plan of development or sale are located ¼ mile or more apart and the area between the projects is not being disturbed, each individual project can be treated as a separate plan of development or sale provided any interconnecting road, pipeline or utility project that is part of the same “common plan” is not concurrently being disturbed. For example, an interconnecting access road or pipeline were under construction at the same time, they would generally be considered as a part of a single “common plan” for permitting purposes.

4) If the operator sells all the lots in the subdivision to one or more multi-lot homebuilder(s), provisions must be made to obtain stormwater permit coverage by one of the following options:
   a. The permit may be transferred from the first “operator” to the new/second “operator”.

b. A new, separate permit may be obtained by the second "operator".
   NOTE: If a new permit is to be obtained, then it must be obtained before the first/original permit is terminated.

5) If the operator retains ownership of any lots in the subdivision, the operator shall maintain permit coverage for those lots under the original permit. The operator shall modify the Storm water Pollution Prevention Plan (SWPPP) by stating which lots are owned and marking the lots on the site map. If there are one (1) or two (2) lots remaining and the total acreage is less than five (5) acres, the original permit could be terminated and those lots could be covered as a small site.

18. **Change in Operator.** For stormwater discharges from large construction sites where the operator changes, including instances where an operator is added after the initial NOI has been submitted, the new operator must ensure that a permit transfer form is received by the Department at least two (2) weeks prior to the operator beginning work at the site.

19. **Late Notifications.** A discharger is not precluded from submitting an NOI in accordance with the requirements of this part after the dates provided in Part I.B.6 of this permit. In such instances, the Director may bring an enforcement action for failure to submit an NOI in a timely manner or for any unauthorized discharges of stormwater associated with construction activity that have occurred on or after the dates specified in this permit.

20. **Failure to Notify.** The operator of a construction site who fails to notify the Director of their intent to be covered under this permit, and who potentially discharges pollutants (sediment, debris, etc.) to waters of the State without an NPDES permit, is in violation of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended).

21. **Maintenance.** Determination of the acreage of disturbance does not typically include disturbance for routine maintenance activities on existing roads where the line and grade of the road is not being altered, nor does it include the paving of existing roads. Maintenance activities (returning to original conditions) are not regulated under this permit unless one or more acres of underlying and/or surrounding soil are cleared, graded, or excavated as part of the operation.

22. **Releases in Excess of Reportable Quantities.**

   A. The discharge of hazardous substances or oil in the stormwater discharge(s) from a facility shall be prevented or minimized in accordance with the applicable stormwater pollution prevention plan for the facility. This permit does not relieve the operator of the reporting requirements of 40 CFR Parts 110, 117 and 302. Where a release containing a hazardous substance or oil in an amount equal to or in excess of a reporting quantity established under either 40 CFR 110, 40 CFR 117, or 40 CFR 302, occurs during a 24-hour period, the following action shall be taken:

   1) Any person in charge of the facility is required to notify the National Response Center (NRC) (800-424-8802) in accordance with the requirements of 40 CFR 110, 40 CFR 117, or 40 CFR 302 as soon as he/she has knowledge of the discharge;

   2) The operator shall submit within five (5) calendar days of knowledge of the release a written description of the release (including the type and estimate of the amount of material released), the date that such release occurred, and the circumstances leading to the release, and steps to be taken in accordance with Part II.B.13 of this permit to the ADEQ.

   3) The stormwater pollution prevention plan described in Part II.A of this permit must be modified within fourteen (14) calendar days of knowledge of the release to:

      a. Provide a description of the release and the circumstances leading to the release; and
b. The date of the release;

2. Additionally, the plan must be reviewed to identify measures to prevent the reoccurrence of such releases and to respond to such releases, and the plan must be modified where appropriate.

B. Spills. This permit does not authorize the discharge of hazardous substances or oil resulting from an on-site spill.

23. Attainment of Water Quality Standards

The operator must select, install, implement and maintain control measures at the construction site that minimize the discharge of turbidity and/or oil and grease and/or other pollutants at the discretion of the Director as necessary to protect water quality. In general, except in situations explained in below, the stormwater controls developed, implemented, and updated to be considered stringent enough to ensure that your discharges do not cause or contribute to an excursion above any applicable water quality standard.

At any time after authorization, the ADEQ may determine that the stormwater discharges may cause, have reasonable potential to cause, or contribute to an excursion above any applicable water quality standard. If such a determination is made, ADEQ will require the permittee to:

A. Develop a supplemental BMP action plan describing SWPPP modifications to address adequately the identified water quality concerns and submit valid and verifiable data and information that are representative of ambient conditions and indicate that the receiving water is attaining water quality standards; or

B. Cease discharges of pollutants from construction activity and submit an individual permit application.

All written responses required under this part must include a signed certification consistent with Part II.B.9.
PART II
STANDARD CONDITIONS

Information in Part II is organized as follows:

Section A: Stormwater Pollution Prevention Plans:
1. Deadlines for Plan Preparation and Compliance
2. Signature, Plan Review, Plan Availability, and NOC
3. Keeping Plans Current
4. Contents of Stormwater Pollution Prevention Plan
5. Contractors
6. Inspectors
7. Plan Certification

Section B: Standard Permit Conditions:
1. Retention of Records
2. Duty to Comply
3. Penalties for Violations of Permit Conditions
4. Continuance of Expired General Permit
5. Need to Halt or Reduce Activity Not a Defense
6. Duty to Mitigate
7. Duty to Provide Information
8. Other Information
9. Signatory Requirements
10. Certification
11. Penalties for Falsification of Reports
12. Penalties for Tampering
13. Oil and Hazardous Substance Liability
14. Property Rights
15. Severability
16. Transfers
17. Proper Operation and Maintenance
18. Inspection and Entry
19. Permit Actions
20. Re-Opener Clause
21. Local Requirements
SECTION A: STORMWATER POLLUTION PREVENTION PLANS (SWPPP).

The operator must prepare a stormwater pollution prevention plan (the plan/SWPPP) before permit coverage. At least one SWPPP must be developed for each construction project or site covered by this permit. The SWPPP must follow the order outlined in Part II.A.4-7 below. This basic ADEQ format is available through the Department's website http://www.adeg.state.ar.us/water/branch_npdes/stormwater/construction/construction.htm. Other formats may be used at the discretion of the Director if the format has been approved by the Department prior to use. The operator must implement the SWPPP as written from initial commencement of construction activity until final stabilization is complete, with changes being made as deemed necessary by the permittee, local, state or federal officials. The plan shall be prepared in accordance with good engineering practices, by qualified personnel and must:

- Identify potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges from the construction;
- Identify, describe and ensure the implementation of Best Management Practices (BMPs), with emphasis on initial site stabilization, which are to be used to reduce pollutants in stormwater discharges from the construction site;
- Be site specific to what is taking place on a particular construction site;
- Ensure compliance with the terms and conditions of this permit; and
- Identify the responsible party for on-site SWPPP implementation.

1. Deadlines for Plan Preparation and Compliance.

   A. Large Construction Sites

   The plan shall be completed and submitted for review, along with a NOI and initial permit fee 2 weeks prior to commencement of construction activities. Submittals of updates to the plan during the construction process are required only if requested by the Director.

   B. Automatic Coverage Sites

   The plan shall be completed prior to the commencement of construction activities and updated as appropriate. Submittal of NOI, permit fee and SWPPP is not required.

   C. Existing Permittees

   Existing permittees, that were permitted prior to the issuance of this renewal permit, are required to update their plan as appropriate to come into compliance with the requirements contained in Part II.A.4 within sixty (60) days from the effective date of this permit.

2. Signature, Plan Review, Plan Availability and NOC.

   A. The plan shall be signed by the operator in accordance with Part II.B.9 and be retained on-site at the construction site during normal business hours (8:00 A.M. - 5:00 P.M.). The operator shall keep the complete updated SWPPP on-site.

   B. The operator shall make plans available, upon request, to the Director, the EPA, or a State or local agency reviewing sediment and erosion plans, grading plans, or stormwater management plans, or, in the case of a stormwater discharge associated with construction activity which discharges through a municipal separate storm sewer system with an NPDES permit, to the municipal operator of the system.
C. The Director, or authorized representative, may notify the operator at any time that the plan does not meet one or more of the minimum requirements of this Part. Within seven (7) business days of such notification from the Director, or as otherwise provided by the Director, or authorized representative, the operator shall make the required changes to the plan and submit to the Director a written certification that the requested changes have been made. The Department may request re-submittal of the SWPPP to confirm that all deficiencies have been adequately addressed. The Department may also take appropriate enforcement action for the period of time the operator was operating under a plan that did not meet the minimum requirements of this permit.

D. The operator must post the NOC near the main entrance of the construction site and visible to the public. The NOC will indicate the location of the SWPPP.

3. **Keeping Plans Current.** The operator shall amend the plan within seven (7) business days or whenever there is a change in design, construction, operation, or maintenance at the construction site which has a significant effect on the potential for the discharge of pollutants to the Waters of the State that has not been previously addressed in the SWPPP. The plan should also be modified if a determination has been made through inspections, monitoring (if required), or investigation by the operator, local, state, or federal officials that the discharges are causing or contributing to water quality violation or the plan proves to be ineffective in eliminating or significantly minimizing pollutants from sources identified in stormwater discharges from the construction site.

4. **Contents of the Stormwater Pollution Prevention Plan.** The stormwater pollution prevention plan shall include the following items:

   A. **Site Description.** Each plan shall provide a description of the following:

      1) Pre-construction topographic view;
      2) A description of the nature of the construction activity and its intended use after the NOT is filed (i.e., residential subdivision, shopping mall, etc.);
      3) A description of the intended sequence of major activities which disturb soils for major portions of the site (e.g. grubbing, excavation, grading, infrastructure installation, etc.);
      4) Estimates of the total area of the site (including off-site borrow and fill areas) and the total area of the site that is expected to be disturbed by excavation, grading or other activities; and
      5) An estimate of the runoff coefficient of the site for pre- and post-construction activities and existing data describing the soil or the quality of any discharge from the site.

   B. **Responsible Parties.** The SWPPP must identify (as soon as this information is known) all parties (i.e., General Contractors, Landscapers, Project Designers, and Inspectors) responsible for particular services they provide to the operator to comply with the requirements of the SWPPP for the project site, and areas over which each party has control. If these parties change over the life of the permit, or new parties are added, then the SWPPP should be updated to reflect these changes.

   C. **Receiving Waters.** The SWPPP must identify the nearest receiving water(s), or if the discharge is to a municipal separate storm sewer, the name of the operator of the municipal system, the ultimate receiving water(s)

   D. **Documentation of Permit Eligibility Related to the 303 (d) list and Total Maximum Daily Loads (TMDL).** The SWPPP should include information on whether or not the stormwater discharges from the site enter a water body that is on the most recent 303 (d) list or with an approved TMDL. If the stormwater discharge does enter a water body that is on the most recent 303(d) list or with an approved TMDL, then the SWPPP should address the following items:

      1) Identification of the pollutants that the 303 (d) list or TMDL addresses, specifically whether the 303 (d) list or
TMDL addresses sediment or a parameter that addresses sediment (such as total suspended solids, turbidity, or siltation);

2) Identification of whether the operator’s discharge is identified, either specifically or generally, on the 303 (d) list or any associated assumptions and allocations identified in the TMDL for the discharge; and

3) Measures taken by the operator to ensure that its discharge of pollutants from the site is consistent with the assumptions and allocations of the TMDL.

If the Department determines during the review process that the proposed project will be discharging to a receiving water that is on the most recent 303 (d) list or with an approved TMDL, then the Department will notify the applicant to include additional Best Management Practices in the SWPPP.

E. **Attainment of Water Quality Standards After Authorization.**

1) The permittee must select, install, implement, and maintain BMPs at the construction site that minimize pollutants in the discharge as necessary to meet applicable water quality standards. In general, except in situations explained below, the SWPPP developed, implemented, and updated to be considered as stringent as necessary to ensure that the discharges do not cause or contribute to an excursion above any applicable water quality standard.

2) At any time after authorization, the Department may determine that the storm water discharges may cause, have reasonable potential to cause, or contribute to an excursion above any applicable water quality standard. If such a determination is made, the Department will require the permittee to:

   a. Develop a supplemental BMP action plan describing SWPPP modifications to address adequately the identified water quality concerns and submit valid and verifiable data and information that are representative of ambient conditions and indicate that the receiving water is attaining water quality standards; or

   b. Cease discharges of pollutants from construction activity and submit an individual permit application.

3) All written responses required under this part must include a signed certification (Part II.B.10)

F. **Endangered Species.** The SWPPP must contain information on endangered and threatened species, including whether any endangered species are in proximity of the stormwater discharge and BMP’s to be constructed to control stormwater runoff. The letter of consent from the USF&W, as stated in Part I.B.11.F must be included with the SWPPP along with the name and telephone number of the person or agency which was contacted to obtain the information.

G. **Site Map.** The SWPPP must contain a legible site map complete to scale, showing the entire site, that identifies, at a minimum, the following:

1) Direction of stormwater flow (i.e., use arrows to show which direction stormwater will flow) and approximate slopes anticipated after major grading activities;

2) Delineate on the site map areas of soil disturbance and areas that will not be disturbed under the coverage of this permit;

3) Location of major structural and nonstructural controls identified in the plan;

4) Location of main construction entrance and exit;

5) Location where stabilization practices are expected to occur;

6) Locations of off-site materials, waste, borrow area, or equipment storage area;

7) Location of areas used for concrete wash-out;

8) Location of all surface water bodies (including wetlands);
9) Locations where stormwater is discharged to a surface water and/or municipal separate storm sewer system if applicable.

10) Locations where stormwater is discharged off-site (should be continuously updated);

11) Areas where final stabilization has been accomplished and no further construction phase permit requirements apply.

H. Stormwater Controls. Each plan shall include a description of appropriate controls and measures that will be implemented at the construction site. The plan will clearly describe for each major activity identified in the project description control measures associated with the activity and the schedule during the construction process that the measures will be implemented. Perimeter controls for the site must be installed after the clearing and grubbing necessary for installation of the measure, but before the clearing and grubbing for the remaining portions of the site. Perimeter controls must be actively maintained until final stabilization of those portions of the site upward of the perimeter control. Temporary perimeter controls must be removed after final stabilization and properly disposed. The description and implementation of controls shall address the following minimum components:

1) Initial Site Stabilization, Erosion, and Sediment Controls. The SWPPP must address, at a minimum, the following:

   a. For larger common plans, only streets, drainage, utility areas, areas needed for initial construction of streets (e.g., borrow pits, parking areas, etc.) and areas needed for stormwater structures may be disturbed initially. Upon stabilization of the initial areas, additional areas may be disturbed.

   b. The construction-phase erosion (such as site stabilization) and sediment controls (such as check dams) should be designed to retain sediment on-site to the extent practicable.

   c. All control measures must be properly selected, installed, and maintained in accordance with the manufacturer’s specifications, good engineering, and construction practices. If periodic inspections or other information indicates a control has been used inappropriately or incorrectly, the permittee must replace or modify the control for site situations.

   d. If sediment escapes the construction site, off-site accumulations of sediment must be removed at a frequency sufficient to minimize off-site impacts (e.g., fugitive sediment in street could be washed into storm sewers by the next rain and/or pose a safety hazard to users of public streets). This permit does not give the authority to trespass onto other property; therefore this condition should be carried out along with the permission of neighboring land owners to remove sediment.

   e. Sediment must be removed from sediment traps (if used please specify what type) or sedimentation ponds when design capacity has been reduced by 50%.

   f. Litter, construction debris, and construction chemicals exposed to stormwater shall be prevented from becoming a pollutant source for stormwater discharges (e.g., screening outfalls picked up daily).

   g. Off-site material storage areas (also including overburden and stockpiles of dirt, borrow areas, etc.) used solely by the permitted project are considered a part of the project and shall be addressed in the SWPPP.

2) Stabilization Practices. The SWPPP must include, at a minimum, the following information:

   a. Description and Schedule: A description of initial, interim, and permanent stabilization practices, including site-specific scheduling of the implementation of the practices. Site plans should ensure that existing vegetation is preserved where attainable and that disturbed areas are stabilized. Stabilization practices may include: mulching, temporary seeding, permanent seeding, geotextiles, sod stabilization, vegetative buffer strips, protection of trees, and preservation of mature vegetation and other appropriate measures.

   b. Description of buffer areas: The Department requires that a buffer zone be established between the top of stream bank and the disturbed area. The SWPPP must contain a description of how the site will maintain
buffer zones. For construction projects where clearing and grading activities will occur, SWPPP must provide at least twenty-five (25) feet of buffer zone from any named or unnamed streams, creeks, rivers, lakes or other water bodies. The plan must also provide at least fifty (50) feet of buffer zone from established TMDL water bodies, streams listed on the 303 (d)-list, an Extraordinary Resource Water (ERW), Ecologically Sensitive Waterbody (ESW), Natural and Scenic Waterway (NSW), and/or other uses at the discretion of the Director. If the site will be disturbed within the recommended buffer zone, then the buffer zone area must be stabilized as soon as possible. Exceptions from this requirement for areas, such as water crossings, limited water access, and restoration of the buffer are allowed if the permittee fully documents in the SWPPP the circumstances and reasons for the buffer zone encroachment. Additionally, this requirement is not intended to interfere with any other ordinance, rule or regulation, statute or other provision of law. Please note that above-grade clearing that does not disturb the soil in the buffer zone area does not have to comply with buffer zone requirements.

c. Records of Stabilization: A record of the dates when major grading activities occur, when construction activities temporarily or permanently cease on a portion of the site, and when stabilization measures are initiated shall be included in the plan.

d. Deadlines for Stabilization: Stabilization measures shall be initiated as soon as practicable in portions of the site where construction activities have temporarily or permanently ceased, but in no case more than fourteen (14) days after the construction activity in that portion of the site has temporarily or permanently ceased, except:

1) Where the initiation of stabilization measures by the fourteenth (14th) day after construction activity temporarily or permanently ceases is precluded by snow cover, stabilization measures shall be initiated as soon as practicable.

2) Where construction activity will resume on a portion of the site within twenty-one (21) days from when activities ceased (e.g. the total time period that construction activity is temporarily ceased is less than twenty-one (21) days), then stabilization measures do not have to be initiated on that portion of the site by the fourteenth (14th) day after construction activity temporarily ceased.

3) Structural Practices. A description of structural practices to divert flows from exposed soils, store flows, or otherwise limit runoff and the discharge of pollutants from exposed areas of the site to the degree attainable. Structural practices should be placed on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 of the Clean Water Act. Such practices may include but are not limited to:

- silt fences (installed and maintained)
- earthen dikes to prevent run-on
- drainage swales to prevent run-on
- check dams
- subsurface drains
- pipe slope drains
- storm drain inlet protection
- rock outlet protection
- sediment traps
- reinforced soil retaining systems
- gabions
- temporary or permanent sediment basins.

A combination of erosion and sediment control measures is encouraged to achieve maximum pollutant removal. Adequate spillway cross-sectional area and re-enforcement must be provided for check dams, sediment traps, and sediment basins.
a. Sediment Basins.

(1) For common drainage locations that serve an area with ten (10) or more acres (including run-on from other areas) draining to a common point, a temporary or permanent sediment basin that provides storage based on either the smaller of 3600 cubic feet per acre, or a size based on the runoff volume of a 10 year, 24 hour storm, shall be provided where attainable (so as not to adversely impact water quality) until final stabilization of the site. In determining whether installing a sediment basin is attainable, the operator may consider factors such as site soils, slope, available area on site, etc. Proper hydraulic design of the outlet is critical to achieving the desired performance of the basin. The outlet should be designed to drain the basin within twenty-four (24) to seventy-two (72) hours. (A rule of thumb is one square foot per acre for a spillway design.) The 24-hour limit is specified to provide adequate settling time; the seventy-two (72)-hour limit is specified to mitigate vector control concerns. If a pipe outlet design is chosen for the outfall, then an emergency spillway is required. If “non-attainability” is claimed, then an explanation of non-attainability shall be included in the SWPPP. Where a sediment basin is not attainable, smaller sediment basins and/or sediment traps shall be used. Where a sediment basin is un-attainable, vegetative buffer strips or other suitable controls which are effective are required for all side slopes and down slope boundaries of the construction area. The plans for removal of the sediment basin should also be included with the description of the basin in the SWPPP.

(2) For drainage locations serving an area less than ten (10) acres, sediment traps, silt fences, or equivalent sediment controls are required for all side slope and down slope boundaries of the construction area unless a sediment basin providing storage based on either the smaller of 3600 cubic feet per acre, or a size based on the runoff volume of a 10 year, 24 hour storm is provided. (A rule of thumb is one square foot per acre for a spillway.) However, in order to protect the waters of the state, the Director, at their discretion, may require a sediment basin for any drainage areas draining to a common point.

b. Velocity Dissipation Devices.

Velocity dissipation devices must be placed at discharge locations, within concentrated flow areas serving two or more acres, and along the length of any outfall channel to provide a non-erosive flow velocity from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected (i.e., no significant changes in the hydrological regime of the receiving water). Please note that the use of hay-bales is not recommended in areas of concentrated flow.

I. Other Controls.

1) No solid materials, including building materials, shall be discharged to waters of the State.
2) Off-site vehicle tracking of sediments and the generation of dust shall be minimized through the use of a stabilized construction entrance and exit and/or vehicle tire washing.
3) For lots that are less than one (1) acre in size an alternative method may be used in addition to a stabilized construction entrance. An example of an alternative method could be daily street sweeping. This could allow for the shortening of the construction entrance.
4) The plan shall ensure and demonstrate compliance with applicable State or local waste disposal, temporary and permanent sanitary sewer or septic system regulations.
5) No liquid concrete waste shall be discharged to waters of the State. Appropriate controls to prevent the discharge of concrete washout waters must be implemented if concrete washout will occur on-site.
6) No contaminants from fuel storage areas, hazardous waste storage and truck wash areas shall be discharged to
waters of the State. Methods for protecting these areas shall be identified and implemented. These areas should not be located near a water body, if there is a water body on or near the project.

J. Non-stormwater discharges. Sources of non-stormwater listed in Part 1.B.10 of this permit that are combined with stormwater discharges associated with construction activity must be identified in the plan. This list should be site specific non-stormwater discharges.

K. Post-Construction Stormwater Management. The operator is required to provide a description of measures that will be installed during the construction process to control pollutants in stormwater discharges that will occur after construction operations have been completed. Structural measures should be placed on upland soils to the degree attainable. The installation of these devices may be subject to Section 404 (Corps of Engineers) of the Clean Water Act. This permit only addresses the installation of stormwater management measures, and not the ultimate operation and maintenance of such structures after the construction activities have been completed and the site has undergone final stabilization. However, post-construction stormwater BMPs that discharge pollutants from a point source once construction is completed may need authorization under a separate ADEQ NPDES permit. Such practices may include but are not limited to:

- infiltration of runoff onsite
- flow attenuation by use of open vegetated swales and natural depressions
- stormwater retention structures
- stormwater detention structures (including wet ponds)
- sequential systems, which combine several practices

A goal of at least 80% removal of total suspended solids from these flows which exceed predevelopment levels should be used in designing and installing stormwater management controls (where practicable). Where this goal is not met, the operator shall provide justification for rejecting each practice listed above based on site conditions.

L. Applicable State or Local Programs. The SWPPP must be updated as necessary to reflect any revisions to applicable federal, state, or local requirements that affect the stormwater controls you implement at your site.

M. Inspections.

Inspections should conducted by qualified personnel (provided by the operator). Inspections must include all areas of the site disturbed by construction activity and areas used for storage of materials that are exposed to precipitation. Inspectors must look for evidence of, or the potential for, pollutants entering the stormwater conveyance system. Erosion and sedimentation control measures must be observed to ensure proper operation. Discharge locations must be inspected to determine whether erosion control measures are effective in preventing significant impacts to waters of the State, where accessible. Where discharge locations are inaccessible, nearby downstream locations must be inspected to the extent that such inspections are practicable. Locations where vehicles enter or exit the site must be inspected for evidence of off-site sediment tracking. Inspections may not be required if the lot(s) within a larger common plan is/are sufficiently stabilized. The operator must ensure that no sediment will leave the lot(s) that are stabilized. These lots must be identified within the SWPPP and show what date they were stabilized. If the operator is unable to ensure this, then inspections must continue.

1) Inspection Frequency. Inspections must be conduct in accordance with one of the following schedules listed below. The schedule must be specified in the Stormwater Pollution Prevention Plan (SWPPP).

a. At least once every 7 calendar days,

b. At least once every 14 calendar days and within 24 hours of the end of a storm event of 0.5 inches or greater (a
rain gauge must be maintained on-site).

2) **Inspection Form.** The ADEQ inspection form should be used for all inspections. The inspection form should include any erosion/sediment controls that are being used on the site. The form is available on the Department's website [www.adep.state.ar.us](http://www.adep.state.ar.us). If a different form is used, it must at a minimum contain the following information:

   a. Inspector Name and Title
   b. Date of Inspection
   c. Amount of Rainfall and Days Since Last Rain Event (only applicable to Part II.A.4.M.1.b)
   d. BMPs used on-site
   e. If the BMPs are in working order and if Maintenance is required (when scheduled and completed)
   f. Location and Dates When Major Construction Activities Begin, Occur or Cease
   g. Report Signature of Inspector

   Additional information may be added to the inspection report at the permittee's discretion.

3) **Inspection Records.** The report shall be retained as part of the stormwater pollution prevention plan for at least three (3) years from the date the site is finally stabilized. The report shall be signed and have a certification statement in accordance with the requirements of this permit.

4) **Winter Conditions.** Inspections will not be required at construction sites where snow cover exists over the entire site for an extended period, and melting conditions do not exist. Regular inspections, as required by this permit, are required at all other times as specified in this permit.

N. **Maintenance.** A description of procedures to maintain vegetation, erosion and sediment control measures and other protective measures in good, effective operating condition shall be outlined in the plan. Any repairs that are needed based on an inspection shall be completed within three (3) business days of discovery or as otherwise directed by state or local officials. However, if conditions do not permit large equipment to be used, a longer time frame is allowed if the condition is thoroughly documented on the inspection form. Maintenance for manufactured controls must be done at a minimum of the manufacturer's specifications. Maintenance for non-manufactured controls, i.e. check dams, sediment traps, must be done upon 50% capacity.

5. **Contractors.**

   For each measure identified in the plan, the stormwater pollution prevention plan must clearly identify the contractor(s) that will implement the measure. If additional contractors are added to the project, then the list of contractors should be updated accordingly in the SWPPP.

6. **Inspectors.**

   The stormwater pollution prevention plan must clearly identify the person or persons that will be conducting the inspections of all stormwater controls. If additional inspectors are added to the project, then the list of inspectors should be updated accordingly in the SWPPP.

7. **Plan Certification.**

   The Stormwater Pollution Prevention Plan (SWPPP) Certification must be signed by either the operator or the cognizant official identified on the Notice of Intent. All documents required by the permit and other information requested by the Director shall be signed by operator or by a duly authorized representative of the operator (Please see Part II.B.10 below
for certification).
SECTION B: STANDARD PERMIT CONDITIONS

1. **Retention of Records.**

   A. The operator shall retain records of all stormwater pollution prevention plans, all inspection reports required by this permit, and records of all data used to complete the Notice of Intent to be covered by this permit for a period of at least three years from the date the Notice of Termination letter is signed by the Department. This period may be extended by request of the Director at any time.

   B. The operator shall retain a signed copy of the stormwater pollution prevention plan required by this permit at the construction site from the date of project initiation to the date of final stabilization.

2. **Duty to Comply.** The operator must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the federal Clean Water Act and the Arkansas Water and Air Pollution Control Act and is grounds for: enforcement action; permit termination, revocation and re-issuance, or modification; or denial of a permit renewal application.

3. **Penalties for Violations of Permit Conditions.** The Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended) provides that any person who violates any provisions of a permit issued under the Act shall be guilty of a misdemeanor and upon conviction thereof shall be subject to imprisonment for not more than one (1) year, or a criminal penalty of not more than twenty five thousand dollars ($25,000) or by both such fine and imprisonment for each day of such violation. Any person who violates any provision of a permit issued under the Act may also be subject to civil penalty in such amount as the court shall find appropriate, not to exceed ten thousand dollars ($10,000) for each day of such violation. The fact that any such violation may constitute a misdemeanor shall not be a bar to the maintenance of such civil action.

4. **Continuance of the Expired General Permit.** An expired general permit continues in force and effect until a new general permit is issued. If this permit is not re-issued or replaced prior to the expiration date, it will be administratively continued in accordance with the Administrative Procedure Act and remain in force and effect. If you were granted permit coverage prior to the expiration date, you will automatically remain covered by the continued permit until the earliest of:

   A. Re-issuance or replacement of this permit, at which time you must comply with the conditions of the new permit, within 60 days after issuance, to maintain authorization to discharge; or

   B. Your submittal of a Notice of Termination; or

   C. Issuance of an individual permit for the project's discharges; or

   D. A formal permit decision by the ADEQ to not re-issue this general permit, at which time you must seek coverage under an individual permit.

5. **Need to Halt or Reduce Activity Not a Defense.** It shall not be a defense for an operator in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

6. **Duty to Mitigate.** The operator shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has reasonable likelihood of adversely affecting human health or the environment.

7. **Duty to Provide Information.** The operator shall furnish to the Director, an authorized representative of the Director, the
EPA, a State or local agency reviewing sediment and erosion plans, grading plans, or stormwater management plans, or in the case of a stormwater discharge associated with industrial activity which discharges through a municipal separate storm sewer system with an NPDES permit, to the municipal operator of the system, within a reasonable time, any information which is requested to determine compliance with this permit.

8. **Other Information.** When the operator becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in the Notice of Intent or in any other report to the Director, he or she shall promptly submit such facts or information.

9. **Signatory Requirements.** All Notices of Intent, reports, or information submitted to the Director or the operator of a regulated small, medium, or large municipal separate storm sewer system shall be signed and certified.

A. All Notices of Intent shall be signed as follows:

1) For a corporation: by a responsible corporate officer. For purposes of this section, a responsible corporate officer means:

   a. A president, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy or decision-making functions for the corporation; or

   b. The manager of one or more manufacturing, production, or operating facilities, provided, the manager is authorized to make management decisions which govern the operation of the regulated facility including having the explicit or implicit duty of making major capital investment recommendations, and initiating and directing other comprehensive measures to assure long term environmental compliance with environmental laws and regulations; the manager can ensure that the necessary systems are established or actions taken to gather complete and accurate information for permit application requirements; and where authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.

2) For a partnership or sole proprietorship: by a general partner or the proprietor, respectively;

3) For a municipality, State, Federal or other public agency: By either a principal executive or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes:

   a. The chief executive officer of the agency; or

   b. A senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency.

B. All reports required by the permit and other information requested by the Director shall be signed by a person described above or by a duly authorized representative of that person. A person is a duly authorized representative only if:

1) The authorization is made in writing by a person described above and submitted to the Director;

2) The authorization specifies either an individual or a person having responsibility for the overall operation of the regulated facility or activity, such as the position of plant manager, operator of a well or a well field, superintendent, or position of equivalent responsibility, or position of equivalent responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position); and
3) Changes to authorization. If an authorization under this Part is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the above requirements must be submitted to the Director prior to or together with any reports, information, or applications to be signed by an authorized representative.

10. Certification. Any person signing a document under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments such as Inspection Form were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Note: For this permit only, "this document" refers to the Stormwater Pollution Prevention Plan, "attachments" refers to the site map and inspection forms, and "system" is referencing the project site.

11. Penalties for Falsification of Reports. The Arkansas Water and Air Pollution Control Act provides that any person who knowingly makes any false statement, representation, or certification in any application, record, report, plan or other document filed or required to be maintained under this permit shall be subject to civil penalties specified in Part II.B.3 of this permit and/or criminal penalties under the authority of the Arkansas Water and Air Pollution Control Act (Act 472 of 1949, as amended).

12. Penalties for Tampering. The Arkansas Water and Air Pollution Control act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under the Act shall be guilty of a misdemeanor and upon conviction thereof shall be subject to imprisonment for not more than one (1) year or a fine of not more than twenty five thousand dollars ($25,000) or by both such fine and imprisonment.

13. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the operator from any responsibilities, liabilities, or penalties to which the operator is or may be subject under Section 311 of the Clean Water Act or Section 106 of CERCLA.

14. Property Rights. The issuance of this permit does not convey any property rights of any sort or any exclusive privileges, nor does it authorize any injury to private property, any invasion of personal rights, or any infringement of Federal, State, or local laws or regulations.

15. Severability. The provisions of this permit are severable. If any provisions of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provisions to other circumstances and the remainder of this permit shall not be affected thereby.

16. Transfers. This permit is not transferable to any person except after notice to the Director. A transfer form must be submitted to the ADEQ as required by this permit.

17. Proper Operation and Maintenance. The operator shall at all times:

A. Properly operate and maintain all control (and related appurtenances) which are installed or used by the operator to achieve compliance with the conditions of this permit. This provision requires the operation of backup or auxiliary facilities or similar systems which are installed by an operator only when the operation is necessary to achieve compliance with the conditions of the permit.
B. Provide an adequate operating staff which is duly qualified to carry out operation, inspection, maintenance, and testing functions required to insure compliance with the conditions of this permit.

18. **Inspection and Entry.** The operator shall allow the Director, the EPA, or an authorized representative, or, in the case of a construction site which discharges to a municipal separate storm sewer, an authorized representative of the municipal operator of the separate sewer system receiving the discharge, upon the presentation of credentials and other documents as may be required by law, to:

A. Enter upon the operator’s premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;
B. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
C. Inspect at reasonable times any facilities or equipment (including monitoring and control equipment);

19. **Permit Actions.** This permit may be modified, revoked and reissued, or terminated for cause including, but not limited to, the following;

A. Violation of any terms or conditions of this permit;
B. Obtaining this permit by misrepresentation or failure to fully disclose all relevant facts;
C. A change in any conditions that requires either a temporary or permanent reduction or elimination of the authorized discharge;
D. A determination that the permitted activity endangers human health or the environment and can only be regulated to acceptable levels by permit modification or termination; or
E. Failure of the operator to comply with the provisions of ADEQ Regulation No. 9 (Fee Regulation). Failure to promptly remit all required fees shall be grounds for the Director to initiate action to terminate this permit under the provisions of 40 CFR 122.64 and 124.5(d), as adopted by reference in ADEQ Regulation No. 6, and the provisions of ADEQ Regulation No. 8.

20. **Re-Opener Clause.**

A. If there is evidence indicating potential or realized impacts on water quality due to any stormwater discharge associated with industrial activity covered by this permit, the operator of such discharge may be required to obtain an individual permit or an alternative general permit in accordance with Part 1.B.22 of this permit, or the permit may be modified to include different limitations and/or requirements.

B. Permit modification or revocation will be conducted in accordance with the provisions of 40 CFR 122.62, 122.63, 122.64 and 124.5, as adopted by reference in ADEQ Regulation No. 6.

21. **Local Requirements.** All dischargers must comply with the lawful requirements of municipalities, counties, drainage districts, and other local agencies regarding any discharges of stormwater to storm drain systems or other water sources under their jurisdiction, including applicable requirements in municipal stormwater management programs developed to comply with the ADEQ permits. Dischargers must comply with local stormwater management requirements, policies, or guidelines including erosion and sediment control.
Appendix 8

Bibliography


