

CITY OF BROKEN ARROW

ENGINEERING DESIGN CRITERIA

MANUAL

ADOPTED BY CITY COUNCIL ON JUNE 21, 2010
REVISION NO. 1 APPROVED JANUARY 28, 2011

BROKEN ARROW CITY COUNCIL

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REVISION STATUS

<u>Revision</u>	<u>Date</u>	<u>Description</u>
0	06-21-10	Adopted by Council
1	01-28-11	Added Sections 4.9, 4.10 and 6.4.9 Revised Sections 4.6.6, 6.4.2, 6.4.5, 6.4.7, 6.4.8, 6.5.2, 6.6 and 9.2

Engineering Design Criteria Manual
Revision No. 1 Errata Summary

1. Page 4-2, Section 4.6.1 – Deleted extra space between Section 4.6 and title line of 4.6.1.
2. Page 4-10, Section 4.9 – Addition of Slope Protection (Revetment) Design criteria.
3. Page 4-10, Section 4.10 – Addition of Subgrade Modification Parameters criteria.
4. Page 6-2, Section 6.4.2 – Addition of restriction on rights-of-way variances.
5. Page 6-5, Section 6.4.7 – Addition of Section C, intersection and driveway offsets.
6. Page 6-5 and 6-6, Section 6.4.8 – Addition of minimum tangent segment criteria for both horizontal and vertical curves.
7. Pages 6-7 through 6-8, Section 6.5.2 – Addition of 8” Aggregate Base and Subgrade Modification criteria.
8. Page 6-9, Section 6.6 – Addition of ODOT Superpave identification call out.
9. Page 9-1, Section 9.2.1 – Revision of pipe material criteria and depth restrictions.

PREFACE

The City of Broken Arrow intends for the criteria set forth herein to serve as the requirements for the engineering and design of all public improvements and private development improvements which shall be donated to the City unless otherwise noted, that occurs within the jurisdiction specified within this manual. In addition, these requirements are to supplement all local, state, and federal building codes and regulations with respect to the engineering and design aspect associated with said development.

By setting forth these minimum standards, neither the City as an entity nor any of its staff members is making any representations, warranties or assurances that these minimum engineering design criteria are sufficient to ensure the proper design and subsequent construction of the proposed improvements. To the contrary, the City of Broken Arrow is merely setting forth certain minimum engineering design standards necessary to promote the proper construction of the proposed improvements. Any person or entity owning land within the jurisdiction specified herein and developing improvements upon said land shall be solely responsible to rely upon their own properly licensed and/or certified design professionals to accurately engineer and design the proposed improvements, whether public or private, which are capable of providing the services required of said improvements and which are adequate under all reasonably foreseeable circumstances for the purposes intended.

When the City, as represented by its staff, reviews and examines proposed improvement documents, including but not limited to design calculations and construction plans, for conformity to these criteria, such action is conducted and performed by the City merely to determine whether or not the minimum requirements set forth will be met. The acceptance of said documents does not imply, represent, warrant, or assure any person that the proposed improvements are adequate for the intended purposes nor does it alleviate, relieve, or reduce the responsibility and/or liability of the required design professional.

ACKNOWLEDGEMENTS

The following City personnel served as instrumental Engineering Design Criteria Members responsible in the creation and development of this manual:

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REFERENCE LIST

City of Broken Arrow Plans and/or Documents:

Comprehensive Plan;

Master Park Plan;

Standard Construction Specifications

Transportation Planning and Policy Review and Recommendations Report, December 2008

Codes, Regulations, Standards, other: (most current edition)

American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Streets, 2004 Edition

American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures, 1993 Edition

American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, 1999, 3rd Edition or later edition

American Association of State Highway and Transportation Officials (AASHTO) Bridge Design Specifications Manual, or latest edition

American Association of State Highway and Transportation Officials (AASHTO) LRFD Guide Specification for Design of Pedestrian Bridges, latest edition

American Association of State Highway and Transportation Officials (AASHTO) M294, Material Specification

American Concrete Institute ACI 318-08: Building Code and Commentary, latest edition

American Concrete Institute ACI 332-08: Code Requirements for Residential Concrete and Commentary, latest edition

American Concrete Institute ACI 350-06: Environmental Structures Code Requirements, latest edition

American Concrete Institute ACI 530-08: Building Code Requirement for Masonry Structures, latest edition

American Society of Civil Engineers ASCE 7-08: Minimum Design Loads for Buildings and Other Structures, latest edition

American Institute of Steel Construction AISC Manual of Steel Construction, LRFD

American Institute of Steel Construction AISC 2008 Cold-Formed Steel Design Manual, latest edition

American Institute of Steel Construction AISC Manual of Steel Construction, ALLOWABLE STRESS DESIGN

American Institute of Steel Construction AISC Manual of Steel Construction

American Institute of Timber Construction AITC Timber Construction Manual, 4th edition

American Land Title Association ALTA and the American Congress on Surveying and Mapping ACSM standards, latest edition

American Water Works Association AWWA D100-05: Welded Carbon Steel Tanks for Water Storage, latest edition

American Water Works Association AWWA D103-09: Factory-Coated Bolted Carbon Steel Tanks for Water Storage, latest edition

American Water Works Association AWWA D110-04: Wire- and Strand-Wound, Circular Prestressed Concrete Water Tanks, latest edition

American Water Works Association AWWA D115-06: Tendon Prestressed Concrete Water Tanks, latest edition

American Water Works Association AWWA M31: Manual of Water Supply Practices, Distribution System Requirements for Fire Protection

Aluminum Association AA, Aluminum Design Manual 2005, latest edition

Crane Manufacturers Association of America CMAA, Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Under Running Trolley Hoist, Publication No. 74, 2004

Institute of Traffic Engineers ITE Trip Generation Manual 2003 edition

International Building Code (IBC) as identified City of Broken Arrow, Code of Ordinances, Chapter 6: Buildings and Building Regulations, Article II, Section 6-16: Adoption

National Concrete Masonry Association NCMA: Design Manual for Segmental Retaining Walls, 3rd edition, latest edition

Occupational Safety and Health Act, Standards for Construction Industry, 2010

Oklahoma Department of Transportation ODOT Policy on Driveway Regulations for Oklahoma Highways 1996 edition

Open Channel Hydraulics by Ven te Chow, published by McGraw-Hill Book Company, 1959 or an approved equivalent

Telecommunications Industry Association and Electronic Industries of America TIA/EIA-222-G, latest edition

Transportation Research Board TRB Highway Capacity Manual HCM 2003 edition

United States Access Board (USAB), Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, July 23, 2004 or latest edition

United State Department of Transportation (USDOT) Federal Highway Administration (FHWA) Manual of Uniform Traffic Control and Devices (MUTCD)

United State Department of Transportation (USDOT) Federal Highway Administration (FHWA) Hydraulic Series No. 5: Hydraulic Design of Highway Culverts, revised May 2005

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1.0 GENERAL PROVISIONS

1.1 TITLE:

This Manual shall hereafter be known, cited and referred to as the Engineering Design Criteria Manual (EDCM) for the City of Broken Arrow, Oklahoma.

1.2 SCOPE:

The criteria established and set forth in this manual are the minimum acceptable standards of engineering and design for any and all public and/or private (unless otherwise noted) development that occurs within the City of Broken Arrow. All parties developing and constructing improvements within the City shall meet these minimum standards and are encouraged to exceed them where it is considered to be in the best interest of all parties.

1.3 AUTHORITY:

This Manual is hereby adopted under the authority granted by Oklahoma State Statutes.

1.4 JURISDICTION:

This Manual shall apply to all development and construction activity that occurs within the corporate limits of the City of Broken Arrow, Oklahoma.

1.5 IMPLEMENTATION:

The City shall prepare engineering and design criteria for the implementation in the course of the design of a construction improvement project. These criteria shall apply to all construction, whether public improvements and private improvements that will be donated to the public, started within the jurisdiction.

1.6 AMENDMENTS:

For the purpose of providing to the public improved health, safety and general welfare requirements, the Director of Engineering and Construction may make a recommendation to the Office of the City Manager, and the City Manager may from time to time amend the provisions imposed by these criteria without public hearings or notices being made. Amendments shall be effective as of the date of publication for its insertion into this manual.

1.7 VARIANCES:

Whenever the application of one of these criteria results in an unusual hardship or creates an unordinary conflict with the application of one or more criterion, the Director of Engineering and Construction may present a grant variance request to the City Manager or designee. The City Manager or designee may at his/her discretion grant a variance or waive all or part of said criterion in order to produce a sound and reasonable design that is consistent with standard practice within the engineering and construction profession. The developer shall prepare a Variance of Waiver Request Form provided in Appendix A - Use Variance Request and submit the document to the Director of Engineering and Construction for appropriate action.

2.0 SURVEYING AND RIGHT OF WAY ACQUISITIONS

2.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited, and referred to as the Surveying and Rights of Way Acquisition section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

This section shall reflect the most recent adoption of the State of Oklahoma criteria and requirements identified in the Oklahoma Administrative Code Title 59, Section 475; Title 65, Section 3; Title 245: Section 15, specifically Chapter 13 – Minimum Standards for Land Surveying and the Rules of Procedure. In case of conflict or contradiction, the most stringent criterion shall govern the design.

2.2 SURVEY CLASSIFICATION SYSTEM:

Surveying requirements defined as follows are for public properties and public projects. Requirements for private properties and projects remain the responsibility of the owner.

2.2.1 Class 1: ALTA/ACSM Survey

- A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the American Land Title Association (ALTA) and the American Congress on Surveying and Mapping (ACSM) standards, latest edition.
- B. The general purpose of this survey is associated with the purchase of real property to be owned by the City or one of its entities.

2.2.2 Class 2: Boundary Survey

- A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the State of Oklahoma Administrative Code statutes, latest codification, and corresponding amendments.
- B. The general purpose of this survey is associated with the acquisition of real property to be owned by the City or one of its entities or to obtain certain access, use and service rights as defined by the owner thereof.

2.2.3 Class 3: Topographical Survey

- A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the State of Oklahoma Administrative Code statutes, latest codification, and corresponding amendments or by standard of professional surveying practice, whichever is defined by the City on a case-by-case basis.
- B. The general purpose of this survey is associated with the collection of existing physical features, both at-grade and below-grade features, as well as existing contour grades. Elevation Certificates for floodplain management purposes are included in this classification.

- 2.2.4 Class 4: Positional Survey
 - A. This class of survey shall meet the standard of professional surveying practice or that standard as defined by the City on a case-by-case basis.
 - B. The general purpose of this survey is associated with the collection of existing, at-grade physical features.
- 2.2.5 Class 5: Control Survey
 - A. This class of survey shall meet the minimum requirements for accuracy and criteria as established and set forth by the State of Oklahoma Administrative Code statutes, latest codification, and corresponding amendments.
 - B. The general purpose of this survey is to establish a horizontal and vertical control system for additional survey work.

2.3 SURVEY CONTROL SYSTEMS:

- 2.3.1 Horizontal Control System: All horizontal control points for any survey classification identified in Section 2.2 shall be tied to the Oklahoma Coordinate System, Oklahoma North Zone, Lambert Projection as defined in Oklahoma Administrative Code, Title 19, Section 60.
- 2.3.2 Vertical Control System: All vertical control points shall be tied to the North American Vertical Datum 1988 (NAVD 88) and indicate the corresponding 1929 National Geodetic Vertical Datum (NGVD).
- 2.3.3 Control Monuments:
 - A. Materials: Monuments shall be constructed of material capable of being detected with conventional instruments for finding ferrous or magnetic objects;
 - B. Size: Monuments of suitable size and depth shall be used;
 - C. Information: All monuments shall have affixed thereto a durable marker or cap bearing, at a minimum, the license number of the professional land surveyor in responsible charge for the placement of the monument.
 - D. Placement: Monuments shall be placed at all of the following platted subdivision locations:
 - 1. Boundary corners;
 - 2. Lot corners;
 - 3. Block corners;
 - 4. Angle points;
 - 5. Street centerline points of intersection; and
 - 6. Street centerline points of curvature.

2.4 REAL PROPERTY ACQUISITION DOCUMENTS:

- 2.4.1 Conveyance Document: The Conveyance Document shall be prepared in accordance with the standard verbiage approved by the City for said type of acquisition.
- 2.4.2 Legal Description: The written Legal Description of said property shall be prepared in accordance with the format shown in Appendix B – Survey Documentation, Exhibit A. This document shall be signed, sealed, and dated by a licensed Professional Land Surveyor registered in the state of Oklahoma.

- 2.4.3 Plat of Survey Drawing: The Plat of Survey drawing of said property shall be prepared in accordance with the format shown in Appendix B – Survey Documentation, Exhibit B. This document shall be signed, sealed, and dated by a licensed Professional Land Surveyor registered in the state of Oklahoma.
- 2.4.4 Closure Certification Statement: The Closure Certification Statement for said property shall be prepared in accordance with the format shown in Appendix B – Survey Documentation, Exhibit B. This document shall be signed, sealed, and dated by a licensed Professional Land Surveyor registered in the state of Oklahoma.
- 2.4.5 Certified Property Ownership Report: This document certifies the record owner, property address, and all encumbrances, such as liens and judgments of record on said property, and all easements and rights-of-way of record on and along a specific parcel of land as of the date of the report. The report shall be prepared by a licensed and bonded Abstractor in the County wherein the property is situated.

2.5 REAL PROPERTY ACQUISITION TYPES AND REQUIREMENTS:

2.5.1 Fee Simple:

- A. Appraisal or Appraisal Waiver, if deemed necessary by the Director of Engineering and Construction;
- B. Conveyance Documents;
- C. ALTA/ACSM Survey or Boundary Survey;
- D. Certified Property Report;
- E. Legal Description;
- F. Plat of Survey;
- G. Closure Certified Statement;
- H. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.

2.5.2 Permanent Easements:

- A. Appraisal, if deemed necessary by the Director of Engineering and Construction;
- B. Conveyance Documents;
- C. Boundary Survey, if deemed necessary by the Director of Engineering and Construction;
- D. Legal Description;
- E. Plat of Survey;
- F. Certified Property Report, if deemed necessary by the Director of Engineering and Construction;
- G. Closure Certified Statement;
- H. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.

- 2.5.3 Temporary Easements:
 - A. Conveyance Documents;
 - B. Legal Description;
 - C. Plat of Survey;
 - D. Closure Certified Statement;
 - E. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.
- 2.5.4. Deeds of Dedication:
 - A. Conveyance Documents;
 - B. Legal Description;
 - C. Plat of Survey;
 - D. Closure Certified Statement;
 - E. Special Conditions Documents, if deemed necessary by the Director of Engineering and Construction.

2.6 TYPES OF CONVEYANCE DOCUMENTS:

- 2.6.1 Fee Simple Types:
 - A. General Warranty Deeds;
 - B. Special Warranty Deeds;
 - C. Deed of Dedications;
 - D. Trustee Deeds;
 - E. Quit Claim Deeds;
 - F. Others as approved by the City Legal Department.
- 2.6.2 Permanent Easement Types:
 - A. Utility Easements;
 - B. Overland Drainage Easements;
 - C. Mutual Access Easements;
 - D. Others as approved by the City Legal Department.
- 2.6.3 Temporary Easement Types:
 - A. Construction Easements;
 - B. Access Easements;
 - C. Others as approved by the City Legal Department.
- 2.6.4. Rights of Entry

3.0 EARTH CHANGE OPERATIONS AND POLLUTION PREVENTION MEASURES

3.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Earth Change Operations and Pollution Prevention Measures section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

3.2 DEFINITIONS:

- 3.2.1 EPA – Environmental Protection Agency
- 3.2.2 ODEQ – Oklahoma Department of Environmental Quality
- 3.2.3 USACE – United States Army Corps of Engineers

3.3 PERMIT REQUIREMENTS:

- 3.3.1 All Earth Change Operations shall comply with the requirements of the City of Broken Arrow Earth Change Permit Ordinance.
- 3.3.2 All Earth Change Operations shall comply with the State of Oklahoma General Permit OKR10 for Storm Water Discharges from Construction Activities within the State of Oklahoma, effective date September 13, 2007 and any subsequent supplements. Any Storm Water Pollution Prevention Plan and subsequent Report shall be submitted to the City for review and acceptance prior to submittal to ODEQ.
- 3.3.3 All Earth Change Operations along the waterways of the United States shall comply with the federal regulations as set forth in the Clean Water Act, Section 401. The documents necessary to obtain said 401-permit and subsequent mitigation measures and the approved permit shall be submitted for information purposes to the Department of Engineering and Construction, Stormwater Division Manager.
- 3.3.4 All Earth Change Operations along the waterways of the State of Oklahoma shall comply with the federal regulations as set forth in the Clean Water Act, Section 404. The documents necessary to obtain said 404-permit and subsequent mitigation measures and the approved permit shall be submitted for information purposes to the Department of Engineering and Construction, Stormwater Division Manager.

3.4 TYPES OF EARTH CHANGE OPERATIONS GOVERNED:

- 3.4.1 Clearing and grubbing operations;
- 3.4.2 Top soil removal and replacement operations;
- 3.4.3 Grading operations;
- 3.4.4 Excavation operations;
- 3.4.5 Embankment and fill operations;
- 3.4.6 Trenching and backfilling operations;
- 3.4.7 Stream bank stabilization;
- 3.4.8 Berming or diking;
- 3.4.9 Tree removal of certain caliper; and
- 3.4.10 Other similar operations.

3.5 EARTH CHANGE CRITERIA:

- 3.5.1 Earth Change Volume – calculation shall be based upon neat-line cross-sections of the earth change operations limits less the top soil removal volume. The following methods of calculation shall be considered acceptable:
 - A. Average End Area Method – maximum cross-section spacing of 100 feet.
 - B. Prismoidal Method – maximum cross-section spacing of 200 feet.
 - C. Other methods must be approved by the Director of Engineering and Construction.
- 3.5.2 Compaction Considerations – volume calculations shall consider a minimum of 12% and a maximum of 15% compaction increases in all embankment and fill placement operations otherwise approved by the Director of Engineering and Construction.
- 3.5.3 Top Soil Operations - volume calculations shall consider the minimum removal of the top five (5) inches of soil and subsequent replacement of the same soil, otherwise approved by the Director of Engineering and Construction.
- 3.5.4 Excavations – all excavations shall comply with the requirements of Occupational Safety and Health (OSHA) Standards for the Construction Industry defined in 29 Code of Federal Regulations (CFR) Part 1926, Subpart P.

3.6 STORMWATER POLLUTION PREVENTION CONTROL MEASURES:

The following Best Management Practices (BMP) shall comply with the minimum standards as described in the United States Environmental Protection Agency, National Pollutant Discharge Elimination System (NPDES), Best Management Practice (BMP) Manual

- 3.6.1 Stormwater Runoff Control Measures:
 - A. Land Grading
 - B. Permanent Diversions
 - C. Preservation of Natural Vegetation
 - D. Temporary Stabilized Construction Entrance
 - E. Check Dams
 - F. Filter Berms
 - G. Grass-Lined Swales/Channels
 - H. Other Measures as approved by the Director of Engineering and Construction
- 3.6.2 Erosion Control Measures:
 - A. Chemical Stabilization
 - B. Mulching
 - C. Permanent Seeding
 - D. Sodding
 - E. Soil Retention
 - F. Dust Control
 - G. Soil Roughening
 - H. Geotextiles
 - I. Gradient Terraces
 - J. Temporary Slope Drains
 - K. Other Measures as approved by the Director of Engineering and Construction

3.6.3 Sediment Control Measures:

- A. Temporary Diversion Dikes
- B. Wind Fences and Sand Fences
- C. Brush Barrier
- D. Silt Fences
- E. Storm Drain Inlet Protection
- F. Sediment Basins and Rock Dams
- G. Sediment Traps
- H. Construction Entrances
- I. Other Measures as approved by the Director of Engineering and Construction

3.7 **STORMWATER POLLUTION PREVENTION PLAN CRITERIA:**

A Stormwater Pollution Prevention Plan (SWP3) is required by all developers on any parcel of land that equals or exceeds one (1) acre of disturbed area in size. The following requirements shall be addressed in the plan. An example plan is provided for individual use in Appendix C.

3.7.1 Introduction:

- A. Project Name
- B. Location
- C. Street Address
- D. Owner Information

3.7.2 Site and Activity Description (OKR10, Section 4.5.1):

- A. Pollutant Description
- B. Construction Activity Description
- C. Intended Sequence of Construction
 1. Install Stabilized Construction Entrance;
 2. Install Silt Fencing and Hay Bales;
 3. Clearing and Grubbing;
 4. Stripping and Stockpile of Topsoil;
 5. Rough Grading for Paved Areas;
 6. Install Inlet Protection;
 7. Construct Drainage Ditches and Underground Utilities;
 8. Finished Grading for Paved Areas and Drainage Ditch;
 9. Construct Paved Areas Complete with Curb and Gutter if required;
 10. Sod, Seed and Re-vegetate Disturbed Areas;
 11. Remove Accumulated Silt and Excess Earth;
 12. Remove all remaining Temporary Controls;
 13. Perform Final Pavement Wash Down.
- D. Total Site Area
- E. Runoff Coefficient
- F. Pre-Developed Runoff Coefficient
- G. Post-Developed Runoff Coefficient
- H. General Location Map

- I. Construction Drawings
 - 1. Site Map
 - 2. Drainage Maps
 - 3. Grading and Paving Plans
 - 4. Erosion and Sediment Control Plans
- J. Industrial Discharge Description
- K. Receiving Waters
- 3.7.3 Permit Requirements (OKR10, Section 4.5.2):
 - A. Copy of OKR10, effective date of September 13, 2007, or latest revision
 - B. Copy of the signed Notice of Intent (NOI)
- 3.7.4 Measures to Protect Endangered or Threatened Species (OKR10, Section 4.5.3):
 - A. Identification of Endangered or Threatened Species
 - B. Identification of Critical Habitats
 - C. Implementation of Best Management Practice to reduce danger
 - D. Copy of Correspondence to USF&WS and ODC
- 3.7.5 Affect on Historic Preservation Laws of Federal, State and Local (OKR10, Section 4.5.4)
- 3.7.6 Affect on Water Quality-Impaired Waters (OKR10, Section 4.5.5)
- 3.7.7 Controls to Reduce Pollutants (OKR10, Section 4.5.6)
 - A. Erosion and Sediment Controls (OKR10, Section 4.5.6.A)
 - B. Storm Water Management (OKR10, Section 4.5.6.B)
 - C. Other Controls (OKR10, Section 4.5.6.C)
 - D. Approved State or Local Plans (OKR10, Section 4.5.6.D)
- 3.7.8 Maintenance (OKR10, Section 4.5.7)
- 3.7.9 Inspections (OKR10, Section 4.5.8)
- 3.7.10 Non-Storm Water Discharges (OKR10, Section 4.5.9, Section 1.3.1.C):

The following non-storm water discharge activities are authorized under the OKR10 General Discharge Permit for Construction Activities:

 - A. Fire Hydrant flushings;
 - B. Waters used to wash vehicles where detergents are not used;
 - C. Water used to control dust in accordance with OKR10 Part 4.5.2.C.2;
 - D. Potable water, including waterline flushing and initial pressure tests of newly constructed piping where piping is clean and chemical agents have not been added to the test water or applied to the pipes;
 - E. Routine external building wash down which does not use detergents;
 - F. Pavement wash waters where spills or leaks of toxic or hazardous materials have occurred (unless all spilled material has been removed) and where detergents are not used;
 - G. Uncontaminated air conditioning or compressor condensate;
 - H. Uncontaminated ground water or spring water;
 - I. Foundation or footing drains where flows are not contaminated with process materials such as solvents;
 - J. Landscape irrigation;
 - K. Discharge or flows from emergency fire fighting activities;
 - L. Uncontaminated flows from excavation dewatering activities will be allowed if operational and structural controls are used to reduce any pollutant releases in order to avoid or minimize the impacts on water quality.

- 3.7.11 Authorized Construction Support Activities (OKR10, Section 1.3.1.B):
The following specified construction support activities are allowed by the General Permit for construction activity provided that the activity is: (A) directly related to the construction activities; (B) that the support activity is not a commercial operation serving multiple unrelated construction projects by different operators; (C) appropriate control measures for the support activities are identified in the Storm Water Pollution Prevention Plan; and (D) the support activities are not located within the watershed of an Outstanding Resource Water.
- A. Concrete Batch Plants;
 - B. Asphalt Batch Plants;
 - C. Equipment Staging Yards;
 - D. Material Storage Areas;
 - E. Excavated Material Disposal Areas;
 - F. Borrow Pit Areas.
- 3.7.12 Limitations on Coverage (OKR10, Section 1.3.2):
The following items are activities are not authorized under the OKR10 General Discharge Permit for Construction Activities:
- A. Post Construction Discharges (OKR10, Section 1.3.2.A);
 - B. Discharges Mixed with Non-Storm Water (OKR10, Section 4.5.6.B);
 - C. Discharges Covered by Another Permit (OKR10, Section 4.5.6.C);
 - D. Discharges Threatening Water Quality (OKR10, Section 4.5.6.D);
 - E. Discharges Not Protective of Listed Endangered Species (OKR10, Section 4.5.6.E);
 - F. Construction Activity on Native American (Indian) Country Land (OKR10, Section 4.5.6.F);
 - G. Construction Activity for Oil and Gas Operations and Pipelines (OKR10, Section 4.5.6.G);
 - H. Construction Activities Related to Agriculture (OKR10, Section 4.5.6.H);
 - I. New Sources or New Discharges of Constituents of Concern to Impaired Waters (OKR10, Section 4.5.6.I).
- 3.7.13 Modifications/Alterations
- 3.7.14 Certifications (OKR10, Section 4.6):
- A. Permittee Certification;
 - B. Preparer Certification;
 - C. Contractor Certification.

4.0 GEOTECHNICAL

4.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Geotechnical section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

4.2 DEFINITIONS:

- 4.2.1 Adhesion (C_a) – is the natural physical attractive force between soil particles and a physical feature or object, such as a concrete foundation.
- 4.2.2 Cohesion (C) – is the natural chemical attractive force between soil particle to soil particle due to the chemical composition of the soil and the presence of moisture in the soil.
- 4.2.3 Liquid Limit (LL) – is the measure of the water content of a soil at which point the soil passes from a liquid state to a plastic state.
- 4.2.4 Moisture Content (w) – is the measure of the weight of the water for a given soil sample expressed as a ratio to the total weight of the solid particles.
- 4.2.5 Plastic Limit (PL) – is the measure of the water content of a soil at which point the soil passes from a plastic state to a semi-solid state.
- 4.2.6 Plasticity Index (PI) – is the measure of the difference between the Liquid Limit of a soil and Plastic Limit of the same soil sample.
- 4.2.7 Shrinkage Limit (SL) - The moisture content of a soil below in which a decrease in moisture will not result in a decrease in volume.

4.3 FIELD INVESTIGATION PROCEDURES:

- 4.3.1 Equipment: Equipment shall be determined by a Geotechnical Engineer.
- 4.3.2 Subsurface Exploration: The Geotechnical Engineer shall conduct all subsurface exploration in order to obtain soil samples from the site using the split-barrel or thin-walled tube sampling procedures as detailed in ASTM specification D 1586 and ASTM specification D 1587, latest editions respectively. All bore holes shall be grouted or backfilled in accordance with the Oklahoma Water Resources Board requirements or Oklahoma Department of Transportation

4.4 LABORATORY EXAMINATION PROCEDURES:

- 4.4.1 In-Situ Moisture Content Testing: The Geotechnical Engineer shall conduct all in-situ moisture content testing of the samples in accordance with ASTM specification D 2216, latest edition.
- 4.4.2 Plastic Limits Testing: The Geotechnical Engineer shall conduct all plastic limits testing on the samples in accordance with ASTM specification D 4318, latest edition.

- 4.4.3 Grain Size Distribution Analysis: The Geotechnical Engineer shall conduct all grain size distribution analyses in accordance with ASTM specifications D 421 and D 1140, latest editions. All soil samples shall be classified in accordance with the Unified Soil Classification System (USCS) as well as the American Association of State Highway and Transportation Officials (AASHTO) Classification System.
- 4.4.4 One-Dimensional Consolidation Testing: The Geotechnical Engineer shall conduct one-dimensional consolidation testing in accordance with ASTM specification D 4546, latest edition.
- 4.4.5 Dry Density Testing: The Geotechnical Engineer shall conduct the maximum dry density of a soil sample in accordance with ASTM specification D 698, latest edition.

4.5 GEOTECHNICAL PROPERTIES:

4.5.1 Plasticity Index Parameters – (PI = LL – PL)

<u>Description</u>	<u>PI Range</u>
Trace amount of Plasticity	0 – 4
Low Plasticity Material	5 – 12
Slightly Plastic Material	13 – 17
Moderately Plastic Material	18 – 24
Highly Plastic	25 Plus

4.5.2 Soil Stiffness Parameters

<u>Description</u>	<u>Void Ratio (e) Range</u>
Very Soft Soils	e >2.5
Soft Soil Material	1.5 < e <= 2.5
Medium Soil Material	0.5 < e <= 1.5
Stiff/Hard Soil Material	e <= 0.5

4.6 DESIGN PARAMETERS:

If particular design values are not provided through laboratory testing methods, then the following design parameters shall be utilized unless other data is approved by the Director of Engineering and Construction.

4.6.1 Internal Angle of Friction

A. Cohesionless Soils

1. Drained Soil Condition (ϕ')

<u>Soil Description</u>	<u>Range (Loose – Dense)</u>
Well Graded Gravel (GW)	32°- 40°
Poorly Graded Gravel (GP)	32°- 38°
Well Graded Sand (SW)	30°- 37°
Poorly Graded Sand (SP)	29°- 36°
Silty Sand (SM)	29°- 35°
Low Plasticity Silt (ML)	27°- 33°

2. Undrained Soil Condition (φ)
Cohesionless soil will drain; therefore, this condition will be identical to the condition noted above.

B. Cohesive Soils

1. Drained Soil Condition (φ')

<u>Soil Description</u>	Range (Loose – Dense)
Normally Consolidated Clays	$10^\circ - 22^\circ$
Overconsolidated Clays	$27^\circ - 35^\circ$

2. Undrained Soil Condition (φ)

<u>Soil Description</u>	Range (Soft – Stiff)
Normally Consolidated Clays	0°
Overconsolidated Clays	0°

4.6.2 Ultimate Cohesion Value

A. Cohesionless Soils

Cohesionless Soils by definition contain no cohesive properties and thereby they exhibit no cohesive characteristics; therefore, ultimate cohesion value is zero:

$$C' = C_u = 0$$

B. Cohesive Soils

1. Drained Soil Condition (C')

<u>Soil Description</u>	Range (Soft – Stiff)
Normally Consolidated Clays	0 psf
Overconsolidated Clays	
Very Soft	0 psf
Soft	0 – 250 psf
Medium Stiff	251 – 500 psf
Stiff	501 – 1000 psf
Very Stiff	1001 – 1500 psf

2. Undrained Soil Condition (C_u)

<u>Soil Description</u>	<u>Range (Soft – Stiff)</u>
Normally Consolidated Clays	
Very Soft	0 – 250 psf
Soft	251 – 500 psf
Medium Stiff	501 – 1000 psf
Stiff	1001 – 2000 psf
Very Stiff	2001 – 4000 psf
Overconsolidated Clays	
Very Soft	0 psf
Soft	0 – 250 psf
Medium Stiff	251 – 500 psf
Stiff	501 – 1000 psf
Very Stiff	1001 – 1500 psf

4.6.3 Adhesion Values

A. Cohesionless Soils

Cohesionless Soils by definition contain no cohesive properties and thereby they exhibit no cohesive characteristics. Therefore, ultimate cohesion value is zero which implies that the corresponding adhesion value is likewise zero:

$$C_a' = C_a = 0$$

B. Cohesive Soils

1. Drained Soil Condition (C_a')

$$2/3 C' \leq C_a' \leq 3/4 C'$$

2. Undrained Soil Condition (C_a)

$$1/2 C_u \leq C_a \leq 2/3 C_u$$

4.6.4 Horizontal Earth Stress Relationships

A. Cohesionless Soils

1. Drained Soil Condition

a. Active Horizontal Earth Stress (K_a') –

$$\sigma_h = K_a' \sigma_v$$

where:

$$K_a' = (1 - \sin \phi') / (1 + \sin \phi') \text{ for level backfills}$$

b. “At-Rest” Horizontal Earth Stress (K_o') -

$$\sigma_h = K_o' \sigma_v$$

where:

$$K_o' = (1 - \sin \varphi')$$

c. Passive Horizontal Earth Stress (K_p') -

$$\sigma_h = K_p' \sigma_v$$

where:

$$K_p' = (1 + \sin \varphi') / (1 - \sin \varphi') \text{ for level backfills}$$

2. Undrained Soil Condition

a. Active Horizontal Earth Stress (K_a) -

$$\sigma_h = K_a \sigma_v$$

where:

$$K_a = (1 - \sin \varphi) / (1 + \sin \varphi) \text{ for level backfills}$$

b. “At-Rest” Horizontal Earth Stress (K_o) -

$$\sigma_h = K_o \sigma_v$$

where:

$$K_o = (1 - \sin \varphi)$$

c. Passive Horizontal Earth Stress (K_p) -

$$\sigma_h = K_p \sigma_v$$

where:

$$K_p = (1 + \sin \varphi) / (1 - \sin \varphi) \text{ for level backfills}$$

B. Cohesive Soils (Not Allowed for Backfill Material)

1. Drained Soil Condition

a. Active Horizontal Earth Stress (K_a') –

$$\sigma_h = K_a' \sigma_v - 2C'(K_a')^{1/2}$$

where:

$K_a' = (1 - \sin \phi') / (1 + \sin \phi')$ for level backfills

C' = drained cohesion value

b. “At-Rest” Horizontal Earth Stress (K_o') -

$$\sigma_h = K_o' \sigma_v - 2C'(K_o')^{1/2}$$

where:

$K_o' = (1 - \sin \phi')$

C' = drained cohesion value

c. Passive Horizontal Earth Stress (K_p') -

$$\sigma_h = K_p' \sigma_v + 2C'(K_p')^{1/2}$$

where:

$K_p' = (1 + \sin \phi') / (1 - \sin \phi')$ for level backfills

C' = drained cohesion value

2. Undrained Soil Condition (Considered as a temporary condition)

a. Active Horizontal Earth Stress (K_a) –

$$\sigma_h = K_a \sigma_v - 2C_u (K_a')^{1/2}$$

where:

$K_a = (1 - \sin \phi) / (1 + \sin \phi)$ for level backfills

C_u = undrained cohesion value

b. “At-Rest” Horizontal Earth Stress (K_o) -

$$\sigma_h = K_o \sigma_v - 2C_u (K_o')^{1/2}$$

where:

$K_o = (1 - \sin \phi)$

C_u = undrained cohesion value

c. Passive Horizontal Earth Stress (K_p) -

$$\sigma_h = K_p' \sigma_v + 2C_u(K_p')^{1/2}$$

where:

$K_p = (1 + \sin \phi') / (1 - \sin \phi')$ for level backfills

C_u = undrained cohesion value

4.6.5 Minimum Surcharge Loading

A. Active Loading Condition

$$\sigma_s = K_a q_s$$

where:

$q_s = 100$ psf for general live loading and operation conditions;

$q_s = 200$ psf for general construction conditions;

$q_s = 300$ psf for heavy construction conditions.

B. “At-Rest” Loading Condition

$$\sigma_s = K_o q_s$$

where:

$q_s = 100$ psf for general live loading and operation conditions;

$q_s = 200$ psf for general construction conditions;

$q_s = 300$ psf for heavy construction conditions.

4.6.6 Recommended Minimum Equivalent Lateral Fluid Pressure
(Refer to Appendix D - Geotechnical Relationships Documents)

A. Active Loading Condition

$$\sigma_a = K_a \sigma_v = (40 \text{ psf/ft})h$$

C. “At-Rest” Loading Condition

$$\sigma_o = K_o \sigma_v = (60 \text{ psf/ft})h$$

D. Saturated Loading Condition

$$\sigma'_{\text{sat}} = K_a \sigma'_v = (90 \text{ psf/ft})h$$

E. Passive Loading Condition

$$\sigma_p = K_p \sigma_v = (360 \text{ psf/ft})h$$

- Notes: (1) The above minimum equivalent pressures are recommended for use in the absence of geotechnical data.
 (2) Ignore the depth of the soil above the frost line;
 (3) Use a soil mobilization reduction factor for passive resistance of 2/3 to 3/4.

4.6.7 Passive Pressure Resistance Mobilization Factor

A. Cohesionless Soils

$$2/3 \leq F_m \leq 3/4 \quad (\text{Loose to Dense})$$

B. Cohesive Soils

$$1/2 \leq F_m \leq 3/4 \quad (\text{Soft to Stiff})$$

4.6.8 Soil to Foundation/Wall Friction Angle

A. Cohesionless Soils

1. Drained Condition (δ')

$$\tan^{-1}[2/3(\tan \varphi)] \leq \delta' \leq \tan^{-1}[3/4(\tan \varphi)]$$

2. Undrained Condition (δ)

Cohesionless soil will drain; therefore, this condition will be identical to the condition noted above.

B. Cohesive Soils

1. Drained Condition (δ')

$$\tan^{-1}[1/2(\tan \varphi)] \leq \delta' \leq \tan^{-1}[2/3(\tan \varphi)]$$

2. Undrained Condition (δ)

Undrained Cohesive soils do not exhibit particle to particle friction characteristics; therefore, this condition will not exist in practice.

4.6.9 Shear Strength

A. Cohesionless Soil Conditions

1. Drained Condition (S')

$$S' = R_v (\tan \delta') + F_m P_p'$$

Where:

R_v = Total Resultant of Vertical Load;

P_p' = Total Horizontal Passive Resistance Force Capacity (Drained);

F_m = Passive Pressure Resistance Mobilization Factor (see Sect. 4.5.7).

δ' = Soil to Foundation/Wall Friction Angle (Drained).

2. Undrained Condition (S_u)

$$S_u = R_v (\tan \delta) + F_m P_p$$

Where:

R_v = Total Resultant of Vertical Load;

P_p = Total Horizontal Passive Resistance Force Capacity (Undrained);

F_m = Passive Pressure Resistance Mobilization Factor (see Sect. 4.5.7).

δ = Soil to Foundation/Wall Friction Angle (Undrained).

B. Cohesive Soil Conditions

1. Drained Condition

$$S' = R_v \tan \delta' + F_m P_p'$$

Where:

R_v = Total vertical load;

P_p' = Total horizontal Passive Resistance Force Capacity;

F_m = Passive Pressure Resistance Mobilization Factor (see Sect. 4.5.7);

δ' = Soil to Foundation Friction Angle.

2. Undrained Condition

$$S_u = C_a A + F_m P_p$$

C_a = Soil Particle to Foundation Particle Adhesion.

4.7 STABILITY RATIOS FOR DESIGN:

4.7.1 Stability Against Overturning

A. Dense Sand, Stiff Clay or Rock Foundation Soil

$$F.S._{ot} \geq 1.5$$

B. Loose Sand or Soft Clay Foundation Soil

$$F.S._{ot} \geq 2.0$$

4.7.2 Stability Against Sliding

A. Dense Sand, Stiff Clay or Rock Foundation Soil

$$F.S._{sl} \geq 1.5$$

B. Loose Sand or Soft Clay Foundation Soil

$$F.S._{sl} \geq 2.0$$

4.7.3 Stability Against Bearing

- A. Dense Sand, Stiff Clay or Rock Foundation Soil
 - 1. Bearing Pressure Distribution Trapezoidal
 $F.S._b \geq 2.0$
 - 2. Bearing Pressure Distribution Triangular
 $F.S._b \geq 3.0$
- B. Loose Sand or Soft Clay Foundation Soil
 - 1. Bearing Pressure Distribution Trapezoidal
 $F.S._b \geq 3.0$
 - 2. Bearing Pressure Distribution Triangular
 $F.S._b \geq 4.0$

4.7.4 Stability Against Buoyancy (Floatation/Uplift)

- A. Normal Saturated Soil Condition
 $F.S._{up} \geq 1.33$
- B. Extreme Flood Condition
 $F.S._{up} \geq 1.25$

4.8 SLOPE STABILITY:

Stability of slopes shall be performed by a registered geotechnical engineer using industry standard slope stability methods unless directed otherwise by the Director of Engineering and Construction.

4.9 SLOPE PROTECTION (REVTMENT) DESIGN:

Slope protection or revetment design shall comply with the United States Department of Transportation, Federal Highway Administration Hydraulic Engineering Circular No. 11 – Design of Riprap Revetment where applicable. Other methods of slope protection shall be considered on a case by case scenario.

4.10 SUBGRADE MODIFICATION PARAMETERS:

The following subgrade modification parameters refer to fine-grained materials that possess swell potential. A professional geotechnical engineer registered in the State of Oklahoma shall test the subgrade material, classify the soil in accordance with standard industry

classification indexes and provide requirements to reduce the swell potential of the subgrade soil in accordance with the following guidelines:

- 4.10.1 Subgrade Modification for Paving Facilities – Fine-grained subgrade materials shall be considered expansive when the material’s plasticity index (PI) is greater than 13. In the above identified case, the subgrade material shall be chemically modified with lime treated stabilization material in order to reduce the plasticity index (PI) to 13 or less.
- 4.10.2 Subgrade Modification for Building Facilities – Fine-grained subgrade materials shall be considered expansive when the material’s plasticity index (PI) is greater than 10. In the above identified case, the subgrade material shall be chemically modified with lime treated stabilization material in order to reduce the plasticity index (PI) to 10 or less.

5.0 STRUCTURAL

5.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Structural section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

5.2 DEFINITIONS:

- 5.2.1 AA – Aluminum Association
- 5.2.2 AASHTO – American Association of State Highway and Transportation Officials
- 5.2.3 ACI – American Concrete Institute
- 5.2.4 AISC – American Institute of Steel Construction
- 5.2.5 AISI – American Iron and Steel Institute
- 5.2.6 ASCE – American Society of Civil Engineers
- 5.2.7 ASD – Allowable Stress Design Method for steel structures or structural elements
- 5.2.8 AITC – American Institute of Timber Construction
- 5.2.9 AWWA – American Water Works Association
- 5.2.10 CMAA – Crane Manufacturers Association of America
- 5.2.11 IBC – International Building Code
- 5.2.12 ICC – International Code Council
- 5.2.13 IRC - International Residential Code
- 5.2.14 LRFD – Load Resistance Factor Design Method for steel structures or structural elements
- 5.2.15 NCMA – National Concrete Masonry Association
- 5.2.16 TIA/EIA – Telecommunication Industry Association and Electronic Industries of America
- 5.2.17 UDA – Unified Design Approach for concrete structures or structural elements
- 5.2.18 USD – Ultimate Strength Design Method for concrete structures or structural elements
- 5.2.19 WSD – Working Stress Design Method for concrete structures or structural elements

5.3 STRUCTURE CLASSIFICATION:

- 5.3.1 Building Structure – Any structure, enclosed or non-enclosed, that may be occupied at any time by people.
- 5.3.2 Bridge Structure – Any structure, which is not a part of a building element, that has a total span length, either due to a single span or the combination of multiple spans, of 20-feet or greater.
- 5.3.3 Non-Building/Bridge Structure – All other types of structures including, but not limited to, the following:
 - A. Elevated towers and tanks;
 - B. In-ground tanks, boxes, sumps;
 - C. Earth retaining structures;
 - D. Independent slab on-grade foundations not associated with buildings or bridges;

- E. Cranes, hoists, trolleys and monorails.

5.4 TYPES OF ACCEPTABLE CONSTRUCTION MATERIALS AND PROCESSES:

- 5.4.1 Concrete Material
 - A. Cast-in-Place
 - B. Pre-Cast
 - C. Tilt-Up Panel
- 5.4.2 Structural Steel Material
 - A. Hot Rolled
 - B. Cold Formed
- 5.4.3 Timber/Wood Material
- 5.4.4 Aluminum Material
- 5.4.5 Masonry Block
 - A. Non-Mechanically Stabilized Earth Retaining Structures
 - B. Mechanically Stabilized Earth Retaining Structures
- 5.4.6 Others – Must be approved by the Director of Engineering and Construction

5.5 ACCEPTABLE DESIGN METHODS:

- 5.5.1 Building Structures
 - A. Structural Steel - LRFD method of design shall be used.
 - B. Concrete – UDA or USD methods shall be used.
- 5.5.2 Bridge Structures
 - A. Structural Steel – LRFD method of design shall be used.
 - B. Concrete – UDA or USD methods of design shall be used.
- 5.5.3 Non-Building/Bridge Structures
 - A. Structural Steel - LRFD or ASD methods of design may be used.
 - B. Concrete – UDA, USD or WSD methods may be used.

5.6 PRIMARY LOAD AND LOAD COMBINATION CRITERIA:

The following paragraph identifies the applicable design criteria that govern the determination of primary loads and appropriate load combinations for the specific type of structure identified in the above paragraph. The appropriate load combinations shall be determined based upon the specific design method used. In case of conflict or contradiction, the most stringent criterion shall govern the design.

- 5.6.1 Building Structures – All building type structures shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method specified in the current effective adoption of the International Building Code as identified City of Broken Arrow, Code of Ordinances, Chapter 6: Buildings and Building Regulations, Article II, Section 6-16: Adoption.
- 5.6.2 Bridge Structures – Bridge structures shall be categorized as vehicular type bridges and non-vehicular type bridges. Non-vehicular type bridges shall be design for and intended to carry pedestrian, bicyclists, equestrian riders, and light maintenance vehicles, but not designed and intended to carry typical roadway vehicles.

- A. Vehicular Type Bridge Structures - All vehicular bridge type structures shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in the AASHTO Bridge Design Specifications Manual, or latest edition as approved by the Director of Engineering and Construction.
 - B. Non-Vehicular Type Bridge Structures - All non-vehicular (pedestrian traffic only) shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in the AASHTO LRFD Guide Specification for Design of Pedestrian Bridges, latest edition as approved by the Director of Engineering and Construction.
- 5.6.3 Non-Building/Bridge Structures - All building type structures shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method specified in ASCE 7-08: Minimum Design Loads for Buildings and Other Structures, or latest edition as approved by the Director of Engineering and Construction, unless considered as a specialized structure. Specialized structures shall be designed in accordance with the appropriate design code as defined by the industry.
- A. Water Storage Tanks:
 - 1. Steel Storage Tanks – shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in AWWA D100-05: Welded Carbon Steel Tanks for Water Storage, or latest edition, and AWWA D103-09: Factory-Coated Bolted Carbon Steel Tanks for Water Storage, or latest edition.
 - 2. Prestressed Concrete Storage Tanks - shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in AWWA D110-04: Wire- and Strand-Wound, Circular Prestressed Concrete Water Tanks, or latest edition, and AWWA D115-06: Tendon Prestressed Concrete Water Tanks, or latest edition.
 - B. Broadcast Structures – shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in TIA/EIA-222-G, or latest edition.
 - C. Crane/Trolley/Hoist/Monorail Support Structure - shall comply with the design criteria for primary load generation and appropriate load combinations corresponding to the design method(s) specified in CMAA: Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Running Trolley Hoist, Publication No. 74, latest edition.

5.7 STRUCTURAL ELEMENT DESIGN CRITERIA:

The following paragraph identifies the applicable design criteria that govern the design of the specific structural elements that collectively or individually function to serve as the load resistant structure or structures to transmit the primary loads and the corresponding load combinations to the ground.

5.7.1 Concrete Structures

- A. Building Structures
 - 1. Non-Residential – shall comply with the requirements specified in ACI 318-08: Building Code and Commentary, latest edition.
 - 2. Residential - shall comply with the requirements specified in ACI 332-08: Code Requirements for Residential Concrete and Commentary, or latest edition.
- B. Bridge Structures - shall comply with the requirements specified in either ACI 318-08: Building Code and Commentary, or latest edition or the AASHTO Bridge Design Specifications, latest edition, whichever is more stringent.
- C. Non-Building/Bridge Structures
 - 1. Non-Environmental Structures – shall comply with the requirements specified in ACI 318-08: Building Code and Commentary, or latest edition.
 - 2. Environmental Structures – shall comply with the requirements specified in ACI 350-06: Environmental Structures Code Requirements, or latest edition.
 - 3. Prestressed Concrete Water Storage Tanks – shall comply with the requirements specified in AWWA D110-04: Wire- and Strand-Wound, Circular Prestressed Concrete Water Tanks, or latest edition, and AWWA D115-06: Tendon Prestressed Concrete Water Tanks, or latest edition.

5.7.2 Steel Structures

- A. Hot Rolled Steel:
 - 1. Building - shall comply with the requirements specified in the AISC Manual of Steel Construction, LRFD, latest edition.
 - 2. Bridge Structures - shall comply with the requirements specified in the AISC Manual of Steel Construction, LRFD, latest edition or the AASHTO Bridge Design Specifications for vehicular type bridges and LRFD Guide Specification for Design of Pedestrian Bridges, latest edition, whichever is more stringent.
 - 3. Non-Building/Bridge Structures – shall comply with the requirements specified in either the AISC Manual of Steel Construction, LRFD, latest edition or the AISC Manual of Steel Construction, ASD, 9th edition, dependent upon the design method of choice.
 - 4. Carbon Steel Water Storage Tanks - shall comply with the requirements specified in AWWA D100-05: Welded Carbon Steel Tanks for Water Storage, or latest edition, and AWWA D103-09: Factory-Coated Bolted Carbon Steel Tanks for Water Storage, or latest edition.
 - 5. Broadcast Steel Structures - shall comply with the requirements specified in TIA/EIA-222-G, or latest revision.
 - 6. Crane/Hoist/Trolley/Monorail Support Structures – shall comply with the requirements specified in CMAA: Specifications for Top Running and Under Running Single Girder Electric Traveling Cranes Utilizing Running Trolley Hoist, Publication No. 74, latest edition.

- B. Cold Formed Steel – shall comply with the requirements specified in the AISI 2008 Cold-Formed Steel Design Manual, or latest edition.
- 5.7.3 Timber/Wood Structures
All timber/wood structures shall comply with the AITC Timber Construction Manual, 4th edition or later.
- 5.7.4 Aluminum Structures – shall comply with the AA Aluminum Design Manual, 2005, or latest edition.
- 5.7.5 Masonry Structures
 1. Building Structure- shall comply with the ACI 530-08: Building Code Requirement for Masonry Structures, or latest edition.
 2. Mechanically Stabilized or Segmental Earth Retaining Structures – shall comply with the NCMA: Design Manual for Segmental Retaining Walls, 3rd edition, or latest edition.

6.0 TRANSPORTATION FACILITIES

6.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Transportation Facilities section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

6.2 DEFINITIONS:

- 6.2.1 AASHTO – American Association of State Highway and Transportation Officials
- 6.2.2 FHWA – Federal Highway Administration
- 6.2.3 ODOT – Oklahoma Department of Transportation
- 6.2.4 SN – Structural Number for Pavement Design
- 6.2.5 AC – Asphaltic Concrete
- 6.2.6 PCC – Portland Cement Concrete

6.3 STREET CLASSIFICATIONS:

- 6.3.1 Arterial Streets
 - A. Primary
 - B. Secondary
- 6.3.2 Commercial Streets
 - A. Minor
 - B. Collector
- 6.3.3 Industrial Streets
 - A. Minor
 - B. Collector
- 6.3.4 Residential Streets
 - A. Minor - A residential street that has unlimited driveway access and that connects to major residential streets. Minor residential streets are limited to 900 linear feet in length before they must connect to a major street.
 - B. Major – A residential street that has unlimited driveway access and connects to either an arterial or a residential collector street.
 - C. Collector – A residential street that has limited driveway and residential major street access and that connects to arterial streets.

6.4 STREET DESIGN PARAMETERS:

- 6.4.1 Design Speed (Not necessarily the posted speed)
 - A. Arterial
 - 1. Primary – 50 mph
 - 2. Secondary – 45 mph
 - B. Commercial
 - 1. Minor – 35 mph
 - 2. Collector – 40 mph

- C. Industrial
 - 1. Minor – 35 mph
 - 2. Collector – 40 mph
 - D. Residential
 - 1. Minor – 25 mph
 - 2. Major – 30 mph
 - 3. Collector – 30 mph
- 6.4.2 Rights of Way – (Not subject to the provisions of Section 1.7)
- A. Arterial
 - 1. Primary – 120 feet
 - 2. Secondary – 100 feet
 - 3. Intersection – 130 feet with an additional 5 feet of utility easement along the perimeter of a property for a distance of 350 feet as measured from the section lines. In addition, a 25-foot by 25-foot corner clip shall be required at the intersection of the north/south right of way boundary with the east/west right of way boundary. Rights of ways shall transition at the end of the 350-foot distance back to existing right of way boundary along a 30 degree angle.
 - B. Commercial – 80 feet
 - C. Industrial
 - 1. Minor – 60 feet
 - 2. Collector – 80 feet
 - D. Residential
 - 1. RE Zoning – 60 feet
 - 2. All other – 50 feet
- 6.4.3 Number of Lanes
- A. Arterial
 - 1. Two-lanes in undeveloped area or where turning movements are limited;
 - 2. Three-lanes on arterials where turning movements are not restricted;
 - 3. Four-lanes on arterials where turning movements are limited;
 - 4. Five-lanes on arterials where turning movements are not restricted;
 - 5. Six-lanes on arterials where turning movements are limited;
 - 6. Seven-lanes on arterials where turning movements are not restricted.
 - B. Commercial and Industrial
 - 1. Two-lanes where no turning movements are allowed;
 - 2. Three-lanes at intersection of two-lane with arterial;
 - 3. Three-lanes where turning movements are allowed;
 - 4. Three- or four-lanes at intersection of three-lane with arterial.
 - C. Residential
 - 1. Two-lanes;
 - 2. Three-lanes at intersection with arterial.

6.4.4 Longitudinal Grades

- A. Arterial
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 4.0%
- B. Industrial
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 4.0%
- C. Commercial and Residential Collector
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 6.0%
- D. Residential Major and Minor
 - 1. Minimum Grade - 0.4%
 - 2. Maximum Grade - 8.0%

6.4.5 Curbs and Gutters

- A. Arterial
 - 1. No curb and gutter on two-lane arterial. Use 4-foot paved shoulder.
 - 2. No curb and gutter on three-lane arterial. Use 4-foot paved shoulder.
 - 3. 6-inch barrier curb and gutter on four-lane arterial.
 - 4. 6-inch barrier curb and gutter on median and outside lanes of five-lane arterial.
 - 5. 8-inch barrier curb and gutter on six-lane arterial.
 - 6. 8-inch barrier curb on outside lanes of seven-lane arterial, 6-inch barrier curb on raised median.
- B. Commercial and Industrial
 - 1. 6-inch barrier curb and gutter on two-lane street;
 - 2. 6-inch barrier curb and gutter at intersection with four- or five-lane arterial;
 - 3. 8-inch barrier curb at intersection with six- or seven-lane arterial, transition to 6-inch from end of radius.
- C. Residential – (Not required in RE zoned subdivisions)
 - 1. 6-inch barrier curb or mountable curb and gutter on two-lane street;
 - 2. 6-inch barrier curb and gutter at intersection with four- or five-lane arterial;
 - 3. 8-inch barrier curb at intersection with six or seven lane arterial, transition to 6-inch from end of radius.

6.4.6 Pavement Medians

- A. Striped median on three-lane arterial where turning movements are allowed.
- B. No median on four-lane transitional arterial.
- C. Raised (6-inch) grass median on three-lane arterial where no turning movements are allowed.
- D. Raised (6-inch) grass median on five-lane arterial where no turning movements are allowed.

- E. Raised (6-inch) landscaped median on six-lane arterial where no turning movements are allowed.
 - F. Raised (6-inch) landscaped median on seven-lane arterial where no turning movements are allowed.
- 6.4.7 Intersections and Driveways
- A. Intersections:
 - 1. Arterial to Arterial
 - a. Curb Radius – 45 feet minimum
 - b. Delta Angle – 87.5 degrees to 92.5 degrees
 - 2. Commercial to Commercial/Industrial
 - a. Curb Radius – 40 feet minimum
 - b. Delta Angle – 80 degrees to 100 degrees
 - 3. Commercial to Arterial
 - a. Curb Radius – 40 feet minimum
 - b. Delta Angle – 85 degrees to 95 degrees
 - 4. Industrial to Industrial/Commercial
 - a. Curb Radius – 40 feet minimum
 - b. Delta Angle – 80 degrees to 100 degrees
 - 5. Industrial to Arterial
 - a. Curb Radius – 45 feet minimum
 - b. Delta Angle – 85 degrees to 95 degrees
 - 6. Residential Major to Residential Collector
 - a. Curb Radius – 25 feet minimum
 - b. Delta Angle – 80 degrees to 100 degrees
 - 7. Residential Major/Collector to Arterial
 - a. Curb Radius – 35 feet minimum
 - b. Delta Angle – 85 degrees to 95 degrees
 - 8. Residential Minor to Residential Minor/Major
 - a. Curb Radius – 25 feet minimum
 - b. Delta Angle – 75 degrees to 105 degrees
 - B. Driveways: (Within public Right-of-Way)
 - 1. Industrial Driveways
 - a. Width:
 - 1. Minimum – 24 feet
 - 2. Maximum – 36 feet
 - b. Curb Radius:
 - 1. Minimum – 15 feet
 - 2. Maximum – 35 feet
 - c. Pavement Minimum Thickness:
 - 1. Asphaltic Concrete – 9.5 inches
 - 2. Portland Concrete – 8 inches
 - 2. Commercial Driveways
 - a. Width:
 - 1. Minimum – 24 feet
 - 2. Maximum – 36 feet

- b. Curb Radius:
 - 1. Minimum – 5 feet
 - 2. Maximum – 15 feet
 - c. Pavement Thickness:
 - 1. Asphaltic Concrete – 7.5 inch
 - 2. Portland Cement Concrete – 6 inch
 - 3. Residential Driveways
 - a. Width:
 - 1. Minimum – 12 feet
 - 2. Maximum – 25 feet
 - b. Curb Radius
 - 1. Abutting Residential – 5 feet
 - 2. Abutting Arterial – 10 feet
 - c. Pavement Thickness:
 - 1. Asphaltic Concrete – 7.5 inches
 - 2. Portland Concrete – 6 inches
- C. Offsets - (Not subject to the provisions of Section 1.7)
 - 1. Intersections
 - a. Residential Minor street jogs shall avoid centerline to centerline offsets of less than 125 feet.
 - b. All other street classifications shall avoid centerline to centerline offsets of less than 150 feet.
 - 2. Driveways
 - a. All driveways along an arterial or collector street shall be offset at least 250 feet from the centerline of an arterial or collector street intersection of the centerline of the driveway.
 - b. For non-residential or multi-family developments, the centerline of all driveways along an arterial or collector street shall align with the access point or be offset at least 200 feet from any access point on the opposite side of the street.

6.4.8 Geometrics

- A. Horizontal – Horizontal geometrics shall comply with American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Street, 2004 Edition or later edition as approved by Director of Engineering and Construction.
 - 1. Minimum Tangent Segment at Intersections – A minimum tangent segment of 50 feet is required at streets intersecting an Arterial street and is recommended at all other intersections.
 - 2. Minimum Tangent Segment between Curves – A minimum tangent segment of 50 feet is required between reverse curves and is recommended between other horizontal curves.
- B. Vertical – Vertical geometrics shall comply with American Association of State Highway and Transportation Officials (AASHTO) A Policy on Geometric Design of Highways and Street, 2004 Edition or later edition as approved by Director of Engineering and Construction.

1. Minimum Tangent Segment at Intersections - A minimum tangent segment of 50 feet is required between the edge of an intersection, the curb line or travel way, and either the beginning or the end of a vertical curve for streets intersecting with an arterial street and is recommended for all other intersections.

6.4.9 Traffic Control Measures

- A. T-Intersections – To the maximum extent possible, residential minor street intersection with either residential major or collector streets shall be three (3) way or “T” intersections. Four (4) way intersections involving residential minor streets and either residential major or collector streets shall be avoided unless dictated by design principles and standards.
- B. Four Way Intersections – All collector streets and residential major streets that intersect with an arterial street shall match the location of existing or proposed future collector and major streets of the adjoining subdivisions to provide a four (4) way intersection, unless topography or other limiting factors prohibit such an intersection.
- C. Non-Linear Curvature – All non-arterial streets shall limit tangent segments of a roadway to 900 feet or less before employing a reasonable, gradual curvilinear segment that meets the requirements identified in the Horizontal Geometrics section.

6.5 TYPICAL ROADWAY SECTIONS:

6.5.1 Lane Widths:

- A. Arterial Streets
 1. 3-Lane Arterial – 37 feet (12, 13, 12)
 2. 4-Lane Arterial – 48 feet (12, 12, 12, 12)
 3. 5-Lane Arterial – 61 feet (12, 12, 13, 12, 12)
 4. 6-Lane Arterial – 72 feet (12, 12, 12, 12, 12, 12)
 5. 7-Lane Arterial – 85 feet (12, 12, 12, 13, 12, 12, 12)
- B. Commercial Streets
 1. Minor – 30 feet (15, 15)
 2. Collector – 36 feet (18, 18)
- C. Industrial Streets
 1. Minor – 32 feet (16, 16)
 2. Collector – 38 feet (19, 19)
- D. Residential Streets
 1. Minor – 24 feet (12, 12)
 2. Major – 26 feet (13, 13)
 3. Collector – 30 feet (15, 15)

6.5.2 Pavement Thicknesses: Pavement thicknesses shall be in accordance with the AASHTO Guide for Design of Pavement Structures, 1993 Edition. Asphalt pavement section Structural Numbers (SN) shall comply with the Flexible Pavement Method and Concrete pavement section Structural Numbers (SN) shall comply with the Rigid Pavement Method. Refer to Section 4.10 for Subgrade Modification Parameters.

- A. Arterials

1. Primary – SN shall equal 5.0 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 8" Asphalt Type A Base Course
 - 8" Aggregate Base
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 - b. Concrete Paving Section:
 - 9" PCC
 - 8" Aggregate Base
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 2. Secondary – SN shall equal 5.0 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 8" Asphalt Type A Base Course
 - 8" Aggregate Base
 - 8" Recompacted Subgrade or 8" Modified Subgrade
(may substitute ¾" AC Type A for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 9" PCC
 - 8" Aggregate Base
 - 8" Recompacted Subgrade or 8" Modified Subgrade
- B. Commercial
1. Minor – SN shall equal 4.4 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 6 ¾" Asphalt Type A
 - 8" Recompacted Subgrade or 8" Modified Subgrade
(may substitute ¾" AC Type A for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 2. Collector – SN shall equal 4.8 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 6 ¾" Asphalt Type A
 - 8" Recompacted Subgrade or 8" Modified Subgrade
(may substitute ¾" AC Type A for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC
 - 8" Recompacted Subgrade or 8" Modified Subgrade

C. Industrial

1. Minor – SN shall equal 4.4 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 6 ¾" Asphalt Type A Base Course
 - 8" Recompacted Sub-grade
 - (may substitute ¾" AC Type A for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC
 - 8" Recompacted Subgrade or 8" Modified Subgrade
2. Collector – SN shall equal 4.4 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 6 ¾" Asphalt Type A
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 - (may substitute ¾" AC Type A for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC
 - 8" Recompacted Subgrade or 8" Modified Subgrade

D. Residential:

1. Minor/Major – SN shall equal 3.9 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 1 ½" Type B Asphalt Wearing Course
 - 6" Type A Asphalt Base Course
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 - (may substitute 1" AC Type A for Equivalent Aggregate, approx 3")
 - b. Concrete Paving Section:
 - 6" PCC
 - 8" Recompacted Subgrade or 8" Modified Subgrade
2. Collector – SN shall equal 4.4 or greater with a minimum typical section as follows:
 - a. Asphalt Paving Section:
 - 2" Asphalt Type B Wearing Course
 - 6 ¾" Asphalt Type A
 - 8" Recompacted Subgrade or 8" Modified Subgrade
 - (may substitute ¾" AC Type A for Equivalent Aggregate, approx 2 ½")
 - b. Concrete Paving Section:
 - 7" PCC
 - 8" Recompacted Subgrade or 8" Modified Subgrade

6.5.3 Cross Slope:

- A. Arterial – 3/8 inch per foot
- B. Commercial:
 - 1. Minor – minimum 3/8 inch per foot
 - 2. Collector – minimum 3/8 inch per foot
- C. Industrial:
 - 1. Minor – minimum 1/4 inch per foot
 - 2. Collector – minimum 3/8 inch per foot
- D. Residential:
 - 1. Minor – minimum 1/4 inch per foot
 - 2. Major/Collector – minimum 1/4 inch per foot

6.6 PAVEMENT MATERIALS:

- 6.6.1 Arterial:
 - A. Asphaltic Concrete:
 - 1. Base Course – Type A (or S4) PG64-22
 - 2. Wearing Course – Type B (or S3) PG70-28 (Insoluble)
 - B. Portland Concrete - Class BA1
- 6.6.2 Commercial:
 - A. Asphaltic Concrete:
 - 1. Base Course – Type A (or S4) PG64-22
 - 2. Wearing Course – Type B (or S3) PG64-22 (Insoluble)
 - B. Portland Concrete - Class BA1
- 6.6.3 Industrial:
 - A. Asphaltic Concrete:
 - 1. Base Course – Type A (or S4) PG64-22
 - 2. Wearing Course – Type B (or S3) PG64-22 (Insoluble)
 - B. Portland Concrete - Class BA1
- 6.6.4 Residential:
 - A. Asphaltic Concrete:
 - 1. Base Course – Type A (or S4) PG64-22
 - 2. Wearing Course – Type B (or S3) PG64-22 (Insoluble)
 - B. Portland Concrete - Class BA1

6.7 SIDEWALKS AND TRAILS:

- 6.7.1 Geometrics – all sidewalk and/or trail geometric design shall comply with the American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, 1999, 3rd Edition or later edition as approved by the Director of Engineering and Construction and the United States Access Board (USAB), Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, July 23, 2004 or latest edition.
- 6.7.2 Access Way Standard Widths
 - A. Sidewalk
 - 1. Residential Streets – 4 feet
 - 2. Industrial Streets – not required
 - 3. Commercial Streets – not required

4. Arterial Streets – 5 feet
- B. Trails
1. Locally Funded Projects – 8 feet
 2. Federally Funded Projects – 10 feet or as dictated by funding source.

7.0 TRAFFIC OPERATIONS

7.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Traffic Operations section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

7.2 DEFINITIONS:

- 7.2.1 AASHTO – American Association of State Highway and Transportation Officials
- 7.2.2 FHWA – Federal Highway Administration
- 7.2.3 HCM – Highway Capacity Manual
- 7.2.4 ITE – Institute of Traffic Engineers
- 7.2.5 MUTCD – Manual of Uniform Traffic Control and Devices
- 7.2.6 ODOT – Oklahoma Department of Transportation
- 7.2.7 TRB – Transportation Research Board

7.3 TRAFFIC SIGNALIZATION WARRANTS:

The following traffic signalization warrants required for the signalization of an arterial intersection shall comply with those warrants as depicted in the Federal Highway Administration MUTCD 2009 edition, or later edition as approved by the Director of Engineering and Construction.

- 7.3.1 Eight-Hour Vehicular Volume
- 7.3.2 Four-Hour Vehicular Volume
- 7.3.3 One-Hour Peak Vehicular Volume
- 7.3.4 Pedestrian Volume
- 7.3.5 School Crossing
- 7.3.6 Coordinated Signal System
- 7.3.7 Crash Experience
- 7.3.8 Roadway Network
- 7.3.9 Intersection near a Grade Crossing

7.4 TRAFFIC SIGNALIZATION REQUIRED WARRANT RATIOS:

- 7.4.1 Arterial and Arterial Intersection Requirements – The Director of Engineering and Construction may require the signalization of an intersection if any of the warrants above are met.
- 7.4.2 Arterial and Non-Arterial Intersection Requirements – Each individual warrant identified above shall equal or exceed 125% of the minimum criteria in order to require a signalized intersection unless otherwise determined by City Administration.

7.5 TRAFFIC IMPACT ANALYSIS:

A Traffic Impact Analysis (TIA) shall be performed by a proposed development if the development meets the criteria established in the Oklahoma Department of Transportation Policy on Driveway Regulations for Oklahoma Highways 1996 edition, or later as approved by the Director of Engineering and Construction.

7.6 LEVEL OF SERVICE CRITERIA:

- 7.6.1 Intersections Analysis – The Level of Service (LOS) analysis for existing intersections shall comply with the processes and procedures identified in Chapter 16 of the Transportation Research Board Highway Capacity Manual 2000 edition, or later edition as approved by the Director of Engineering and Construction.
- 7.6.2 Arterial Analysis - The Level of Service (LOS) analysis for existing arterial roadways shall comply with the processes and procedures identified in Chapter 15 of the Transportation Research Board Highway Capacity Manual 2000 edition or later edition as approved by the Director of Engineering and Construction.
 - A. Arterial roadways shall be classified as urban arterials.
 - B. Other roads shall be classified in accordance with their specific use.

7.7 TRAFFIC COUNT DATA:

- 7.7.1 Arterial Traffic Count Data:
 - A. Annual Average Daily Traffic (AADT) Volume – Arterial AADT may be used from the City of Broken Arrow traffic count data performed for the appropriate intersection. This data is generally conducted around November of each year.
 - B. Peak Hour (PH) Volume – Arterial PH volume shall be either:
 - 1. Calculated from generally accepted relations between peak hour volumes for an arterial and AADT, or
 - 2. Statistically determined from field collected data.
- 7.7.2 Intersection Traffic Count Data:
 - A. Annual Average Daily Traffic Volume – AADT shall include the appropriate turning movements and be statistically generated from field collected data.
 - B. Peak Hour Traffic Volume – PHV shall include the appropriate turning movements and be statistically generated from field collected data.

7.8 TRIP GENERATION PROJECTIONS:

Trip generation for the specific type of development as well as the peak time, weekday versus weekend and morning versus evening, if appropriate, shall be estimated using the statistical data generated in the Institute of Traffic Engineers Trip Generation Manual 2003 edition, or later as approved by the Director of Engineering and Construction.

7.9 AUXILIARY LANE CRITERIA:

- 7.9.1 Auxiliary Acceleration Lanes – Auxiliary acceleration lanes for developments shall not be constructed.
- 7.9.2 Auxiliary Deceleration Lanes – Auxiliary deceleration lanes may be required dependent upon the anticipated proposed turning movements for the development as estimated in accordance with the trip generation projections section.

7.10 INTERSECTION CONSTRUCTION GUIDE:

- 7.10.1 Detection – All intersections shall use video detection unless otherwise approved by the Director of General Services.
- 7.10.2 Wiring – All intersections shall locate the service wiring overhead unless otherwise approved by the Director of General Services.
- 7.10.3 Stacking Distance – Minimum approved stacking distance for a dedicated turning movement shall be 125 feet unless otherwise approved by the Director of Engineering and Construction.
- 7.10.4 Taper Runout Ratio – Minimum taper runout ratio required at an intersection in addition to the stacking distance shall AASHTO minimum criteria for the proposed design speed of the arterial or 10:1, whichever criteria produces the greater distance.

7.11 TRAFFIC SIGNAGE:

All traffic signage shall comply with the Federal Highway Administration MUTCD 2009 edition or later edition as approved by the Director of Engineering and Construction.

7.12 TRAFFIC STRIPING:

All traffic striping shall comply with the Federal Highway Administration MUTCD 2009 edition or later edition as approved by the Director of Engineering and Construction or the Oklahoma Department of Transportation striping standards, whichever is more stringent.

7.13 TRAFFIC CALMING DEVICES:

All traffic calming device requests shall be submitted to the Department of Engineering and Construction prior to design. Upon approval of the Director of Engineering and Construction, traffic calming devices may be designed in accordance with federal, state and local standards and acceptable practices. Proposed design must be submitted to Department of Engineering and Construction for approval from the Director prior to implementation.

Devices may include, but not be limited to, the following:

- 7.13.1 Traffic Circles;
- 7.13.2 Traffic Roundabouts;
- 7.13.3 Traffic Speed Humps (Bumps, etc.)
- 7.13.4 Other Devices

8.0 WATER DISTRIBUTION

8.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Water Distribution section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

This section shall reflect the most recent adoption of the State of Oklahoma criteria identified in Oklahoma Administrative Code Title 252: Oklahoma Department of Environmental Quality; Chapter 626: Public Water Supply Construction Standards; Subchapter 15: Pump Facilities, Subchapter 17: Finished Water Storage and Subchapter 19: Distribution System. In case of conflict or contradiction, the more stringent criterion shall govern the design.

8.2 DISTRIBUTION LINE TYPES:

- 8.2.1 Transmission Lines – They generally are 24-inch diameter and larger in size:
 - A. Raw Water Transmission Lines – Lines from raw water source to Treatment Plant. No domestic taps are allowed on this type of line.
 - B. Treated Water Transmission Lines – Lines from Treatment Plant to Water Storage Tanks. No domestic taps are allowed on this type of line;
- 8.2.2 Feeder Lines – Connect Transmission Lines and Storage Tanks to Trunk Lines. They generally range from 12-inch diameter to 24-inch diameter in size and run along section line roads.
- 8.2.3 Trunk Lines – Connect Feeder Lines to Branch Lines. They generally range from 8-inch diameter to 12-inch diameter in size and run down collector and main residential entryway streets.
- 8.2.4 Branch Lines – Connect Trunk Lines and Branch Lines to one another. They generally range from 4-inch in diameter to 8-inch in diameter.
- 8.2.5 Fire Suppression Lines – Separate water mains that provide water for fire suppression demand for individual industrial or commercial entities. These lines are generally privately owned.
- 8.2.6 Water Service Lines – Connects City water main to water meter or public line.
- 8.2.7 Customer Service Lines – Connect individual water meters to specific facilities. These lines are generally privately owned.

8.3 MATERIAL REQUIREMENTS:

(Refer to City of Broken Arrow Standard Construction Specifications, latest edition)

- 8.3.1 Trunk and Branch Lines: Use AWWA C-900, DR-14 material or an approved equal.
- 8.3.2 Transmission and Feeder Lines: Use AWWA C-905, DR-18 material or an approved equal for 24 inch diameter lines or less. Use concrete or steel pipe in accordance with standard construction specifications for lines greater than 24 inches in diameter.

8.4 DISTRIBUTION SYSTEM DESIGN CRITERIA:

- 8.4.1 Hydraulic Model. All distribution lines shall be designed utilizing a hydraulic analysis based upon known or expected demand and minimum pressure requirements for normal operating condition.
- 8.4.2 Minimum Pressure Requirement. Any point along and/or within the distribution system shall maintain a minimum of thirty-five (35) pounds per square inch (psi) of working pressure under normal operating condition, unless approved by the Director of Engineering and Construction.
- 8.4.3 Normal Operating Condition. Normal Operating Condition shall be defined as any flow condition through the distribution system including peak demand and fire flow, where fire suppression protection is provided.
- 8.4.4 Minimum Hydraulic Model Flow Rate. A minimum flow rate for a distribution system or segment of the system shall be calculated at not less than one (1) gallon per minute (gpm) per service connection.
- 8.4.5 Minimum Cover. Provide a minimum of 36 inches of soil cover over the water distribution line unless otherwise approved by the Director of Engineering and Construction or designee.
- 8.4.6 Looped Lines. All water mains shall be looped within a domestic distribution system. At the discretion of the Director of Engineering and Construction or designee, line may be installed as dead end lines only if they include an automatic flushing device or other devices approved by the Director of Engineering and Construction or designee.
 - A. All lines in a cul-de-sac arrangement shall be looped with a minimum 4 inch line.
 - B. Water mains that terminate at locations which will be extended through anticipated phased construction in the future may have a fire hydrant positioned at the end of the line as opposed to an automatic flushing device.
- 8.4.7 Air Release Apparatuses:
 - A. Air Relief Valve and Vaults. Install air relief valve and vaults at high points along distribution system where air can accumulate within a line that is 12 inches or greater in diameter. Do not use automatic release system where flooding of the valve exhaust may occur.
 - B. Blow Off Valve. Install blow off valves at low points along distribution system to effectively remove accumulated sediments within a line that is 12 inches or greater in diameter. Extend the open end of the exhaust line from automatic valves to at least 1-foot above grade and terminate with a screened, downward-facing elbow.
 - C. Do not cross connect air release systems with any sewer collection system line.
- 8.4.8 Fire Hydrants:
 - A. Hydrants shall not be installed on lines less than 6-inch in diameter.
 - B. A valve shall be installed between the water main and the fire hydrant.
 - C. Hydrants shall be spaced as follows:
 - 1. Maximum spacing in residentially zoned areas shall be 600 feet;
 - 2. Maximum spacing in commercially and industrially zoned areas shall be 300 feet.

8.4.9 Water Valves:

- A. Minimum spacing of valves along the distribution system shall be as follows:
 - 1. At locations not more than one mile intervals on lines greater than 24 inches in diameter;
 - 2. At locations not more than one-half mile intervals on 12 inch to 24 inch diameter lines;
 - 3. At locations not more than one-quarter mile intervals on lines less than 12 inches in diameter.
- B. Additional valve locations along the distribution system shall be as follows:
 - 1. Valves shall be arranged such that each block within a subdivision can be isolated;
 - 2. Valves shall be positioned at all intersections in readily accessible locations;
 - 3. Valves shall be located at all changes of distribution system line type;
 - 4. Valve locations shall be marked on curbs.

8.4.10 Service Connections:

- A. Service connections shall be installed by the developer and located at the lot lines;
- B. Minimum service connection size:
 - 1. Single resident service connection shall be $\frac{3}{4}$ inch or greater;
 - 2. Dual service connection shall be 1 inch or greater.

8.5 WATER STORAGE SYSTEM DESIGN CRITERIA:

Water storage requirements shall comply with the criteria specified in the American Water Works Association (AWWA) Manual of Water Supply Practices M31: Distribution System Requirements for Fire Protection, fourth edition or latest edition as approved by the Director of Engineering and Construction or designee.

8.6 FIRE SUPPRESSION SYSTEM DESIGN CRITERIA:

Fire suppression requirements shall comply with the criteria specified in the American Water Works Association (AWWA) Manual of Water Supply Practices M31: Distribution System Requirements for Fire Protection, fourth edition or latest edition as approved by the Director of Engineering and Construction or designee.

8.7 CONSTRUCTION PARAMETERS:

8.7.1 Installation Conditions:

- A. Pipe shall be laid straight with respect to its horizontal alignment except for the use of standard bends or for allowable deflection in accordance with manufacturer's recommendations as approved by the Director of Engineering and Construction or designee;
- B. Metal tracer wire shall be placed above the pipe material in accordance to construction standard details.

8.7.2 Trench Conditions:

- A. Trench width shall be in accordance to approved construction standard details;
 - B. All pipe must be bedded in accordance with approved construction standard details.
- 8.7.3 Separation Conditions:
- A. Horizontal Separation:
 - 1. 5 feet from electrical and petroleum lines;
 - 2. 10 feet from existing sanitary sewer lines;
 - 3. 50 feet from private water wells and petroleum product tanks; and
 - 4. 15 feet from all septic tanks.
 - B. Vertical Separation: Water mains must cross at least two feet above or below sanitary sewers.
 - C. Exceptions: If proper separation cannot be obtain, then construct sanitary sewer of same material as the water main. Pressure test the section in question.
- 8.7.4 Stream Crossing Conditions
- A. Aerial – Are discouraged and must be approved by the Director of Engineering and Construction or designee;
 - B. Below Grade – Are preferred and must have 4-foot of cover.
- 8.7.5 Blocking – All fittings including tees, bends, plugs and hydrants shall be provided with a thrust reaction blocking device or joint restraints to prevent movement.
- 8.7.6 Conduits – All water mains that are placed within a conduit shall require restrained joints.

9.0 WASTEWATER COLLECTION

9.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Wastewater Collection section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma.

This section shall reflect the most recent adoption of the State of Oklahoma criteria identified in Oklahoma Administrative Code Title 252: Oklahoma Department of Environmental Quality; Chapter 656: Water Pollution Control Facility Construction Standards; Subchapter 5: Sanitary Sewer Standards and Subchapter 7: Pump Station Standards. In case of conflict or contradiction, the more stringent criterion shall govern the design.

9.2 MATERIAL REQUIREMENTS:

(Refer to City of Broken Arrow Standard Construction Specifications, latest edition)

9.2.1 Gravity Sewer Collection System:

- A. Collection systems 2.5 feet deep or less – C-900 PVC, DR 18 or an approved equivalent material. Must be concrete encased.
- B. Collection systems greater than 2.5 feet to 16 feet deep - PVC, SDR 35 or an approved equivalent material for all pipe diameters.
- C. Collection systems greater than 16 feet to 25 feet deep:
 1. Diameters 15 inches or less - PVC, SDR 26 or an approved equivalent material;
 2. Diameters greater than 15 inches – C-905 PVC, DR 18 or an approved equivalent material.
- D. Collection systems greater than 25 feet deep:
 1. Diameters 15 inches or less - C-900 PVC, DR 18 or an approved equivalent material;
 2. Diameters greater than 15 inches – C-905 PVC, DR 18 or an approved equivalent material.

9.2.2 Force Main System:

- A. Force mains with diameter of 12-inches or less – PVC, AWWA C-900, DR-18 or an approved equivalent material;
- B. Force mains with diameters greater than 12-inches – PVC, AWWA C-905, DR-25 or an approved equivalent material.

9.2.3 Lift Station: Shall be made of cast-in-place or pre-cast concrete sections in accordance with American Concrete Institute (ACI) 350-current edition or an approved equivalent material.

9.3 DESIGN CAPACITY:

Design sanitary sewer capacity for the ultimate future population that may be served by the individual line by using either of the following methods but not less than the minimum capacity requirements in Section 9.2.3:

9.3.1 Peak Hourly Flow (PHF) – use data for the given service area that considers:

- A. Domestic usage;
- B. Commercial and industrial usage;
- C. Acceptable Peaking Factor for inflow and infiltration; plus
- D. Known pumping needs.

9.3.2 Average Daily Flow (ADF) per Capita – 100 gallons per day per person (gpdpp).

9.3.3 Minimum Required Capacity:

<u>Drainage Area</u>	<u>Line Size</u>	<u>Firm Capacity</u>
Less than 154 Acres	8"	0.49 mgd
155 to 238 Acres	10"	0.76 mgd
239 to 540 Acres	12"	1.08 mgd
541 to 807 Acres	15"	1.62 mgd
808 to 1,174 Acres	18"	2.35 mgd
1,175 to 1,617 Acres	21"	3.24 mgd
1,618 to 2,065 Acres	24"	4.13 mgd
2,066 to 2,828 Acres	27"	5.65 mgd
2,829 to 3,745 Acres	30"	7.49 mgd
3,746 to 6,090 Acres	36"	12.18 mgd
6,091 to 9,189 Acres	42"	18.38 mgd
9,190 to 13,118 Acres	48"	26.24 mgd
13,119 to 17,962 Acres	54"	35.92 mgd
17,963 to 23,790 Acres	60"	47.58 mgd
23,791 to 30,675 Acres	66"	61.35 mgd

9.4 PEAKING FACTOR (PF):

9.4.1 Use field data gathered during peak usage times, generally early spring months of mid-February to mid-May; otherwise

9.4.2 Use 3.5 – 4.0 for older, clay-tile pipe material;

9.4.3 Use 3.0 – 3.5 for newer, PVC pipe material.

9.5 DESIGN CRITERIA:

9.5.1 Gravity Collection System:

- A. Minimum Pipe Diameter (d_{min}) – 8-inch;
- B. Minimum Velocity (v_{min}) – 2 feet per second (fps);
- C. Minimum Manning's Roughness Coefficient (n_{min}) – 0.013;
- D. Minimum Pipe Slope (s_{min}):
 - 1. 6" diameter – 0.50%;
 - 2. 8" diameter – 0.40%;
 - 3. 10" diameter – 0.29%;

4. 12" diameter – 0.22%;
 5. 14" diameter – 0.17%;
 6. 15" diameter – 0.15%;
 7. 16" diameter – 0.14%;
 8. 18" diameter – 0.12%;
 9. 21" diameter – 0.10%;
 10. 24" diameter – 0.08%.
- E. Maximum Velocity (v_{max}) – Unless otherwise approved by the Director of Engineering and Construction, maximum conveyance velocities in the gravity collection system shall not exceed 8 feet per second. This velocity shall be determined under average dry weather flow conditions.
 - F. Maximum Depth – All sanitary sewers shall be laid at depths to flowlines of 15 feet or less, unless otherwise approved by the Director of Engineering and Construction or designee.
 - G. Maximum Manhole Spacing (s_{max}):
 1. Diameters of 12" or less – 300 feet;
 2. Diameters greater than 12" but less than 18" – 400 feet;
 3. Diameters of 18" or greater – 500 feet.
- 9.5.2 Pressurized Conveyance System (includes Force Main and Lift Station):
- A. Minimum Pipe Diameter (d_{min}) – 4-inch;
 - B. Minimum Velocity (v_{min}) – 2 feet per second (fps) for low flow operating condition;
 - C. Maximum Velocity (v_{max}) – 8 feet per second (fps) for maximum (peak hour) operating condition;
 - D. Maximum Operating Pressure (Design Working Pressure) – 2/3 Rated pressure of the pipe material;
 - E. Design Hazen and Williams Friction Roughness Values for Pipe Material:
 1. PVC Material – 130;
 2. Lined Iron or Steel – 120;
 3. Unlined Iron or Steel – 100.
 - F. Air-Relief and Blow-Off Valves – Install at high points and low points as directed by the City.

9.6 CONSTRUCTION PARAMETERS:

9.6.1 Laying Conditions:

- A. Gravity pipe shall be laid straight with respect to horizontal alignment between manholes;
- B. Pipe shall be laid at a constant slope with respect to vertical alignment between manholes;
- C. Metal tracer wire shall be placed above the force main pipe material in accordance to construction standard details.
- D. Minimum depth at the tap shall be 4.5 feet below the finish floor elevation.

9.6.2 Trench Conditions:

- A. Trench width shall be in accordance to approved construction standard details;

- B. All pipe must be bedded in accordance with approved construction standard details;
 - C. Minimum cover shall be 36-inches, unless approved by the Director of Engineering and Construction or designee.
- 9.6.3 Separation Conditions:
- A. Horizontal Separation:
 1. 5 feet from electrical, gas and petroleum lines;
 2. 10 feet from existing water mains;
 3. 50 feet from private water wells and petroleum product tanks; and
 4. 300 feet from public water supply well.
 - B. Vertical Separation: Sanitary sewers must cross at least two feet above or below water mains.
 - C. Exceptions: If proper separation cannot be obtained, then construct sanitary sewer of same material as the water main. Pressure test the section in question.
- 9.6.4 Stream Crossing Conditions
- A. Aerial – Are discouraged and must be approved by the Director of Engineering and Construction;
 - B. Below Grade – Are preferred and must have 4-foot of cover.
 1. Gravity Sewer must be sleeved.
 2. Force Mains must be sleeved.
- 9.6.5 Manhole Conditions
- A. Minimum Inside Diameter – 4 feet;
 - B. Minimum Vertical Depth – 4 feet;
 - C. Flow Channel Slope – 0.10 foot;
 - D. Drop Manholes – required for any gravity sewer entering the manhole 24-inches or more above the manhole bottom;
 - E. Force Main Termination – Must be 24-inches or less above the manhole bottom.
- 9.6.6 Lift Stations
- A. Type – Must be Suction Lift with pumps located in a ventilated compartment placed above grade over the wet well area;
 - B. Style – Triplex System with one pump serving as a back-up pump;
 - C. Firm Capacity – Equivalent to two pumps in operation at one time capable of meeting the maximum operating condition;
 - D. Minimum Suction Opening – 4 inches in diameter;
 - E. Clog Protection – Pump intake must have screening devices to protect against clogging;
 - F. Priming – Pump intake must operate under positive suction head;
 - G. Controls – Provide control system that alternates operation of each individual pump with maximum of two operating to meet maximum demand;
 - H. Wet Well Volume – Effective wet well volume shall be sized based on the design average flow in order to adequately fill in 30 minutes or less;
 - I. Pump Start Frequency – Each pump shall be sized adequately to start and stop less than 6 times per hour as a maximum. The longest duration between any pump stopping to the next pump starting must be 30 minutes or less;

- J. Security – Provide secure site around lift station;
- K. Alarm System – Provide an automatic alarm system capable of altering appropriate personnel of an equipment failure before an overflow occurs;
- L. Emergency Operations – One of the following must be met:
 - 1. On-site standby generator or engine-driven pump that has automatic means of activation during equipment or power failure – one hour of minimum storage at design flow above the alarm level is required;
 - 2. Portable engine-driven pump with a quick connect to the force main – four hours of minimum storage at design flow above the alarm level is required; or
 - 3. 24 hours of storage at design flow above the alarm level with visual/audio alarm system as a minimum.
- M. No emergency overflow basin shall be permitted within the City, unless approved by the Director of Engineering and Construction.
- N. Flood Protection – Pumps, mechanical and electrical equipment shall be protected from physical damage by the 1% chance (100-year return event) storm. Access to the station shall be maintained up to and including the 4% chance (25-year return event) storm;
- O. Buoyancy – Lift station shall remain stable against buoyancy for extreme groundwater and flood conditions.

10.0 STORMWATER MANAGEMENT

10.1 INTRODUCTION:

This section of the Manual shall hereafter be known, cited and referred to as the Stormwater Management section of the Engineering Design Criteria Manual for the City of Broken Arrow, Oklahoma. In addition, this section was formerly known, cited and referred to as the Stormwater Criteria Manual.

This section shall comply with the most recent adoption of the City of Broken Arrow, Oklahoma, Code of Ordinances, Chapter 25: Stormwater Management.

10.2 RAINFALL DATA:

Total rainfall depths shall be specific to the City of Broken Arrow based upon the general site location.

10.2.1 Rainfall intensity values for durations greater than one (1) hour shall be developed in accordance with the procedures identified and the rainfall frequency atlases provided in the United States Department of Commerce (USDOC) and National Weather Bureau (NWS) Technical Publication No. 40 (TP-40), May 1961 edition.

10.2.2 Rainfall intensity values for durations of one (1) hour or less shall be developed in accordance with the procedures identified the National Oceanic and Atmospheric Administration (NOAA) and National Weather Service (NWS) Technical Memorandum entitled Hydro-35, June 1977 edition.

10.2.3 The totalized rainfall depth with respect to a specific time duration event for a given return frequency shall be equal to or greater than the minimum rainfall values provided in Appendix F, Exhibit A.

10.3 STORMWATER RUNOFF:

10.3.1 The approved stormwater runoff methods that shall be used to determine total and/or peak stormwater runoff rates, which subsequently may be used for the design of the individual components of the stormwater drainage system, are provided in Appendix F, Exhibit B. All other methods for determining peak runoff and corresponding storage volume must be approved in advance by the Local Administrator. These approved methods include the following:

- A. The Rational Method;
- B. The SCS Method;
- C. The Snyder's Method with Tulsa Modifiers; and
- D. Unit Volume Method.

- 10.3.2 Rational Method. The Rational Method may be used to determine peak flows for design of the stormwater drainage system in accordance with the limitations prescribed herein. However, the Rational Method shall not be allowed for detention storage volume calculations. Determination of the Rational Method runoff coefficient (C) requires the professional to exercise good engineering judgment. In an effort to facilitate good judgment, Appendix F, Exhibit D presents the recommended range of C values for specific land uses and surface characteristics that should be used. The principles detailed in the United States Department of Transportation, Federal Highway Administration Hydraulic Engineering Circular Number 22 (HEC-22): Urban Drainage Manual, second edition, dated August 2001 shall govern with respect to the application of the Rational Method, except where specifically modified herein.
- 10.3.3 Soil Conservation Service (SCS) Method. The SCS Method may be used to determine peak flows for design of the stormwater drainage system in accordance with the limitations prescribed herein. In addition, the SCS Method shall be allowed for detention storage volume calculations as prescribed herein as well. Determination of the SCS curve number (CN) requires the professional to exercise good engineering judgment. County soil maps shall be used in the determination of the corresponding curve number values in association with the specific land uses and surface characteristics that exist or that are proposed. The principles detailed in the United States Department of Transportation, Federal Highway Administration Hydraulic Engineering Circular Number 22 (HEC-22): Urban Drainage Manual, second edition, dated August 2001 shall govern with respect to the application of the SCS Method, except where specifically modified herein.

10.4 TIME OF CONCENTRATION:

Appendix F, Exhibit E presents the overland flow velocities for various ground covers to determine the sheet flow and shallow concentrated flow portions of travel time calculations. Manning's Formula shall be used to determine the velocity for travel time calculations for concentrated flow within swales, ditches, channels, and storm sewers.

10.5 STORMWATER DRAINAGE SYSTEM:

The stormwater drainage system shall individually or collectively include: the stormwater collection system, the stormwater conveyance system, the stormwater storage system, and the stormwater discharge system.

10.5.1 Stormwater Transmission System – shall include the individual elements that transmit stormwater runoff to a collection point. These elements shall generally be privately owned and shall include, but not be limited to, the following:

- A. Overland and sheet surface stormwater flow areas from both private and/or public property;
- B. Below land groundwater flow areas from both private and/or public property;
- C. Upstream water ways.

- 10.5.2 Stormwater Collection System – shall include the individual elements that accept and collect stormwater from both private and public property. These elements shall include, but not be limited to, the following items:
- A. Street inlets
 - B. Area inlets;
 - C. Median drains;
 - D. Pipe inlets.
- 10.5.3 Stormwater Conveyance System – shall include the individual elements that convey stormwater to a discharge point or a storage facility. These elements shall include, but not be limited to, the following items:
- A. Roadway surface drainage system;
 - B. Underground pipe network;
 - C. Extended box structure network;
 - D. Open channel systems:
 - 1. Improved channels;
 - 2. Natural drainage ways;
 - 3. Borrow ditches;
 - E. Connection network:
 - 1. Junction boxes;
 - 2. Manholes.
- 10.5.4 Stormwater Storage System – shall include all on-line and/or off-line at-grade or below grade detention facilities as well as retention facilities.
- A. Dry detention facilities. Dry detention facilities shall be provided with underground drainage or a concrete trickle channel to eliminate standing water after storm periods. These types of facilities may be used for recreational purposes and other approved uses to the maximum extent possible when not functioning as a detention facility.
 - B. Wet detention facilities. Wet detention facilities may be used on a limited basis and shall be approved only when the pond inflow is sufficient to maintain pond water surface levels and to preclude the water from stagnating.
 - C. Underground detention facilities. Underground detention facilities may consist of basins, tanks, and/or oversized piping networks.
 - D. Parking lot detention. Parking lot detention may be used provided the maximum 1% chance (100-year) stormwater depth is twelve (12) inches or less. Any repaving of the parking lot shall be evaluated for impact on volume and release rates and are subject to approval by the Local Administrator. All parking lot detention areas shall have a minimum of two signs posted identifying the detention pond area. The signs shall have a minimum of 1.5 square feet and contain the following message:

WARNING
 This area is a Stormwater
 Detention Facility and is subject to
 periodic flooding to a depth of
(provide 1% chance storm design depth).

Any suitable materials and geometry of the sign is permissible, subject to approval by the Local Administrator.

- E. Retention facilities: Retention facilities may be used when the existing conditions runoff from a watershed would exceed the capacities of downstream facilities. The retention facility shall contain the 1% chance (100-year) stormwater runoff and release shall be by evaporation, infiltration or slow release at outflow rates less than existing levels.
- 10.5.5 Stormwater Discharge System – shall include all outfall control structures as well as the corresponding energy dissipators.
- A. Outfall control structures shall include, but not be limited to, the following items:
 - 1. Weir structures;
 - 2. Orifice flow device structures;
 - 3. Flume structures;
 - 4. Open channel flow structures;
 - 5. Pressurized flow structures;
 - 6. Spillway structures.
 - B. Energy dissipaters shall include, but not be limited to, the following items:
 - 1. Riprap;
 - 2. Pre-manufactured revetment;
 - 3. Concrete stilling and energy dissipation structures.

10.6 STORMWATER DRAINAGE SYSTEM GENERAL REQUIREMENTS:

- 10.6.1 The stormwater drainage system shall be designed to receive and pass the runoff from a 1% chance (100-year) storm under ultimate urbanization. In areas covered by the Regulatory Flood Area, that data shall govern. In areas not covered by the Regulatory Flood Area, the owner shall have a professional engineer prepare and submit a study area. The ultimate urbanized flow shall be confined within the said stormwater drainage system.
- 10.6.2 A minimum of the 1% chance (100-year) and the 20% chance (5-year) storm events shall be evaluated when designing the individual elements of the stormwater collection and conveyance systems and their subsequent stormwater discharge system.
- 10.6.3 A minimum of the 1% chance (100-year), 2% chance (50-year), 4% chance (25-year), 10% chance (10-year) and the 20% chance (5-year) storm events shall be evaluated when designing the individual elements of the stormwater storage system and its subsequent stormwater discharge system. Appendix F, Exhibit F presents storm frequency terminology for better clarification.
- 10.6.4 Site grading shall provide surface water drainage directly into a storm sewer, natural drainage course, improved channel, or paved street without crossing more than four (4) adjacent lots.
- 10.6.5 No inlets shall be designed for placement within driveways or entries unless individually approved by the Local Administrator.

- 10.6.6 Driveway approaches shall be designed and constructed so that the runoff from the 1% chance (100-year) storm shall not leave the roadway except in locations where the driveway is designed as part of the drainage system.
- 10.6.7 Submittals for Streets and Drainage Systems shall include the following required items for approval of street and drainage plans:
 - A. Subgrade plasticity test results
 - B. Geotechnical engineers report
 - C. Pavement design report
 - D. Hydrology and Hydraulics report (drainage)
 - E. Storm sewer and drainage plans including as a minimum, tabulation sheet, plan sheets, profile sheets, drainage structure summary sheets, and standard details.
 - F. Street plans including as a minimum, plan sheets, profile sheets, cross-sections, and standard details.

10.7 STORMWATER TRANSMISSION SYSTEM DESIGN REQUIREMENTS:

- 10.7.1 The overland flow portion of the drainage system shall be confined to dedicated rights-of-way, or drainage easements to assure the stormwater can pass through the development without inundating the lowest level of any building, dwelling, or structure.
- 10.7.2 An overland drainage easement shall be required for overland flows that immediately drain to a collection point and that are located outside of public right-of-way. No overland flows shall be allowed to adversely affect other private or public structures.
- 10.7.3 No overland or sheet flow transmission system, such as a side yard or backyard swale shall be grading in such a manner as to trap stormwater which in turn may potentially damage a building, dwelling, or structure.

10.8 STORMWATER COLLECTION SYSTEM DESIGN REQUIREMENTS:

- 10.8.1 The stormwater collection system shall be designed either:
 - A. To pass a minimum of the runoff from a 20% chance (5-year) storm in a pipe network together with an overland flow path with capacities so that the combination of the two will pass the runoff from a 1% chance (100-year) storm under ultimate urbanized conditions; or
 - B. To pass the entire runoff from 1% chance (100-year) storm in the pipe network. Should the entire runoff from a 1% chance (100-year) storm be conveyed in an enclosed drainage network, grading shall be designed to convey the runoff from the 1% chance (100-year) storm overland in the event of inlet or storm sewer blockage or bypass.
- 10.8.2 In either case, an overland drainage easement shall be required for overland flows that immediately drain to a collection point and that are located outside of public right-of-way. No overland flows shall be allowed to adversely affect other private or public structures.

- 10.8.3 In areas where ultimate flows are not planned for conveyance to a regional detention facility, the Local Administrator may reduce the capacity requirement to the existing condition flows.
- 10.8.4 The distance between inlets, as well as the distance to the first inlet on a street shall be determined by the lesser of the following:
- A. Water depth due to runoff shall not exceed the top of the curb for the 1% chance storm (100-year); or
 - B. 600 feet.
- 10.8.5 At sump locations, the water depth shall not exceed six (6) inches above the top of curb, or twelve (12) inches above the top of grate, whichever is less, for the 1% chance (100-year) storm. Where sump collection systems are used, an overflow route shall be provided in the event of a complete blockage of the inlet of pipe. If the inlets and pipe are sized for the 1% chance (100-year) storm, a sod overflow can be used. If a 20% chance (5-year) storm inlet and pipe system is designed, the overflow area shall be concrete lined. When a sod overflow structure is constructed, it shall be lined with Bermuda grass or approved equal and shall contain energy dissipators, if required at the outflow point.
- 10.8.6 Stormwater runoff from areas greater than one half (1/2) acre outside the roadway of arterial and collector streets shall be collected before it reaches the roadway. In no circumstance shall concentrated flows be allowed to discharge into arterial streets. Parking lots shall have internal drainage systems so as to reduce concentrated flow onto public streets. This requirement shall not apply to residential lots used as single-family residences. The Local Administrator may approve sheet flows to the subject streets when connecting to an underground storm sewer system is not economical. In sheet flow instances, the developer must prove no adverse impact to the traveling public, and that the street drainage system is capable of conveying the increased flows.

10.9 STORMWATER CONVEYANCE SYSTEM DESIGN REQUIREMENTS:

- 10.9.1 Open channel and/or ditch elements shall comply with the following requirements:
- A. In areas where overland flows may cause problems, the Local Administrator may require that the entire runoff from the 1% chance (100-year) storm shall be conveyed through an enclosed drainage network.
 - B. Trapezoidal channels shall be designed with a hard lined flow channel, such as concrete or rock. The low flow channel shall branch off to pick up any storm sewers discharging into the channel. The top of the sides of the low flow channel shall be a minimum of six (6) inches lower than the adjacent main channel bottom, to ensure that the drainage runs over and into the low flow channel and does not erode around it. The minimum cross slope on the bottom of the trapezoidal channel shall be 2%. The easement for the trapezoidal channel shall include a ten (10) foot width on the top of one bank for an access road.

- C. Borrow ditches, when allowed, shall not exceed four (4) feet in depth. Culverts shall be sized to adequately convey the borrow ditch flow. Borrow ditches shall be designed to convey the runoff from the 10% chance (10-year) storm as a minimum. The ditch side slopes shall be three (3) feet horizontal to one (1) foot vertical or flatter.
- D. Side slopes for grass-lined channels shall be 3:1 or flatter. Side slopes for concrete lined channels shall be 1:1 or flatter for concrete placed against an existing slope or vertical or flatter where the side wall is formed.
- E. Culverts in borrow ditches shall be sized to pass the 10% chance (10-year) storm. The minimum culvert size shall be no less than fifteen (15) inches in diameter.
- F. The street side of a culvert will be no closer than four (4) feet from the edge of pavement or back of curb, closest to the culvert.
- G. A storm sewer discharging into or collecting water from a borrow ditch shall be no closer than four (4) feet from the edge of pavement or back of curb, closest to the culvert.
- H. Roughness coefficients for channel design shall be as listed as in Tables 5-5 and 5-6, Figure 5-5, pages 109 through 123, of Open Channel Hydraulics by Ven te Chow, published by McGraw-Hill Book Company, 1959 edition or an approved equivalent.
- I. The maximum velocity in an unlined ditch or grass-lined improved channel shall be six (6) feet per second (fps) for the 1% chance (100-year) storm event. When the 1% chance (100-year) storm velocity in a drainage channel/ditch exceeds six (6) fps, erosion control measures such as energy dissipators and/or channel lining shall be placed in the area where the velocity exceeds six (6) fps.
- J. Concrete lined drainage channels shall include the entire channel flow depth and one (1) foot above the peak 1% chance (100-year) storm water surface. When the lining is designed to be constructed with separate sides and bottom, the design shall include the requirement for the bottom to be placed last and it shall cover a minimum of four (4) inches of the sides.
- K. The centerline radius of a curve on an improved channel shall be a minimum of three (3) times the top width at the design flow or 100 feet, whichever is greater.
- L. All improved channels shall be provided with a minimum of one (1) foot of freeboard above peak 1% chance (100-year) storm water surface.
- M. At all bends in improved channels, the amount of freeboard on the outside wall shall be increased by the following equation:

$$H = V^2(b)/64.4r$$

where:

H is height of freeboard in feet;

V is the average velocity in feet per second;

b is the width of the channel at the design water surface in feet; and

r is the radius of curvature of the channel centerline in feet.

- N. The increased freeboard height shall be maintained a minimum of one (1) channel width upstream and downstream of the bend.
- 10.9.2 Closed conduit system elements shall comply with the following requirements:
- A. Storm sewer piping shall be constructed of reinforced concrete pipe (RCP), high density polyethylene pipe (HDPE), coated steel pipe, or double wall polyethylene corrugated pipe dependent upon the corresponding soil and loading conditions, unless otherwise approved in writing by the Director of Engineering and Construction. Minimum pipe size shall be 15" diameter.
 - B. When RCP is specified, it shall be furnished with omni-flex joints or equivalent. When RCP is specified in a non-cohesive soil, such as sugar sand, and the storm drain is within fifteen (15) feet of a structure that would sustain damage from sinkholes, the City may require wrapping of joints with a non-woven geotextile 6-ounce fabric.
 - E. Where RCP storm sewers cross streets, they shall be backfilled with either Oklahoma Department of Transportation, Type A, aggregate base or flowable fill. Where metal or polyethylene storm sewers cross streets, they shall be backfilled with flowable fill.
 - F. Pipe and box culverts shall comply with the design requirements established in the United States Department of Transportation, Federal Highway Administration's Hydraulic Design Series Publication Number 5: Hydraulic Design of Highway Culverts. Culverts shall be examined for both inlet controlled and outlet controlled conditions for the design flows. The slope used for the design shall be the slope of the invert of the culvert.
 - G. The Manning's Roughness Coefficient (n) value shall be 0.013 for reinforced concrete pipe (RCP) and 0.012 for smooth wall corrugated polyethylene pipe and high density polyethylene pipe (HDPE). Manning's Roughness Coefficient (n) value for coated steel or metal pipe shall be approved by the Local Administrator.
 - H. No pipe shall be installed downstream having a diameter smaller than the pipe from which it is receiving flow unless otherwise approved by the Local Administrator for detention facility purposes.
 - I. Capacity of stormwater conveyance systems located downstream from any proposed development that produces a measurable increase in stormwater runoff shall be thoroughly investigated. Replacement, modifications or adjustments of the existing downstream conveyance system may be required by the City in order to convey the increased flow from the proposed development.
 - J. Junctions between different pipe sizes shall be made with the top inside of the downstream pipe no higher than the top inside of the upstream pipe.
 - K. A manhole or junction box shall be required at all changes of grade, changes in alignment, and junction between two (2) or more different pipe sizes.
 - L. The horizontal distance between pipes being placed in the same trench shall be a minimum of $2T + 6'$. This would include multiple pipe crossings for culvert purposes.

- M. Radius pipes may be used only on locations within conveyance systems that have a diameter of 36 inches or larger. The radius of the curve shall be no less than five (5) times the diameter of the pipe. The degree of deflection shall be no greater than 7 ½ degrees per joint of radius pipe, or the pipe manufacturer's recommendation, whichever is less. The City may require radius pipe as a requirement to these provisions should the energy loss within the system become excessive and, thereby, considered to be detrimental to the system.
 - N. A minimum of six (6) inches cover shall be provided over conveyance system pipes and box culverts to the bottom of the subgrade, except when the box culvert structure is designed to transmit vehicular loading with the top at grade.
 - P. Maximum spacing between manholes or junction boxes shall not exceed 400 feet for pipes of fifteen (15) inches in diameter and shall not exceed 500 feet for pipe sizes over fifteen (15) inches in diameter.
 - R. All junction boxes and manholes shall be designed with the standard manhole ring and cover at grade in pavement areas and at least a minimum of 2" above grade outside of pavement areas.
 - S. A manhole or junction box shall be constructed at the Point of Curvature or Point of Tangency for all curves in conveyance systems.
 - T. All storm sewers shall be shown in profile, showing, size, type, grade, and 1% chance (100-year) storm flow rates and velocities. Profiles shall show the natural and proposed ground line at the center of the storm sewer. Energy grade line and hydraulic grade line shall be calculated and clearly shown. Stationing shall start at 0+00.00 and shall be continuous through manholes, along the main (trunk) line, to the top of the system. Branch lines shall be stationed starting from X0+00.00 from their connection with the main line. Lines shall be stationed on the profile drawing from left to right increasing upstream.
 - U. The radius of curve for a box structure shall be a minimum of three (3) times the maximum width of the box structure, but not less than 50 feet.
- 10.9.3 Cross street conveyance system structures shall comply with the following requirements:
- A. Bridges - New span bridges shall have adequate capacity to pass the 1% chance (100-year) storm ultimate urbanized flows with one (1) foot of freeboard under the low chord. A backwater analysis shall be provided to illustrate compliance with this requirement and to insure there are no adverse downstream or upstream impacts.
 - B. Culverts - New culverts under public roads shall have adequate capacity to pass the 1% chance (100-year) storm ultimate urbanized flows with a maximum water surface elevation not exceeding 6 inches below the lowest pavement (or gutter) elevation in the roadway sump. A backwater analysis shall be provided to illustrate compliance with this requirement and ensure there are no adverse downstream or upstream impacts.

- C. Reinforced concrete pipe (RCP) located under streets shall not be less than C-76 Class III. For back and side yard installations of RCP, Class II may be used. Corrugated metal pipes shall meet Oklahoma Department of Transportation gauge requirements in accordance with the subsequent fill height, and shall be bituminous-coated and lined. Polyethylene corrugated pipe placed under streets shall meet the requirements of AASHTO M294.
- 10.9.4 Stub street conveyance systems shall comply with the following requirements: When a stub street is included in a subdivision design, it shall include provisions for drainage of the stub street until such time as the stub street is connected to the extended street system. Design of stub streets will contain the following minimum provisions for drainage:
- A. Stub streets which drain into the development under design will not require special drainage structures.
 - B. Stub streets which drain away from the development will require a drainage easement on the adjoining property with a 1% chance (100-year) storm flow capacity ditch to a point of natural drainage or concrete curb and gutter across the end of the street, with storm inlets tied to an operational storm sewer system.

10.10 STORMWATER STORAGE SYSTEM DESIGN REQUIREMENTS:

10.10.1 General Storage requirements shall comply with the following:

- A. Detention storage shall be required to accommodate excess runoff from all storms from the 20% chance (5-year) storm up to the 1% chance (100-year) storm. Excess runoff is that runoff generated due to urbanization which is greater than the runoff historically generated under existing conditions, for a given frequency storm. Detention facilities shall be designed so that the peak rate of discharge does not exceed that of the existing conditions.
- B. Peak release rates from private developments shall not exceed the existing runoff that occurred before private development for all storm frequencies up to and including the 1% chance (100-year) storm. The 20% chance (5-year), 10% chance (10-year), 4% (25-year), 2% chance (50-year), and 1% chance (100-year) storms shall be investigated at a minimum. Appendix F, Exhibit F presents storm frequency terminology for better clarification.
- C. Public regional detention facilities may be designed with 1% chance (100-year) storm outflow rates equal to or lower than pre-development values with possible increased flow rates for the 20% chance (5-year), 10% chance (10-year), and 2% chance (50-year) storms from pre-development flow rates under those conditions where downstream areas are not adversely impacted.
- D. If the development is situated in such a manner that the stormwater is discharged into a stormwater system which the Local Administrator determines will not be adversely affected, the developer may make a monetary payment or some other form of valuable consideration to the City in accordance with Section 25-207 of the Stormwater Management Ordinance, in lieu of constructing an onsite detention facility.

- E. Changes may be made to streams or channels within the Regulatory Flood Fringe Area; subject to approval of the Local Administrator, provided that:
 1. The volume of floodwater storage is not reduced;
 2. Neither downstream or upstream water surface elevations are adversely increased; and
 3. All required permits are obtained prior to starting work
- 10.10.2 Detention Facility design shall comply with the following criteria:
- A. The design storm for detention facilities shall be a 24-hour storm.
 - B. The three allowed methods for detention facility design are SCS Method, Snyder's Method with Tulsa Modifiers and Unit Volume Relationship Method. See Appendix F, Exhibit B to determine applicability of each method.
 - C. The time increment used in developing the rainfall distribution shall be rounded off to the nearest whole time interval or to the nearest time increment. For the 24-hour storm, the maximum time increment shall be 5 minutes.
 - D. The rainfall patterns shall be used in accordance with the modeling technique selected.
 - E. For Snyder's Method with Tulsa Modifiers, the loss rates in determining the runoff/hydrograph shall be an initial loss of 0.5 inches and a uniform loss of 0.08 inches per hour for the subsequent hours once the initial losses are satisfied.
 - F. All calculations for detention facilities shall be submitted for review by the City. The submittal shall include:
 1. The 20% chance, 10% chance, 2% chance, and 1% chance storm hydrographs for the proposed development and all upstream areas draining through the proposed development for existing and post-project conditions shall be determined. The detention facility and stormwater drainage system shall be designed to convey any offsite runoff that drains to it.
 2. Detention facility stage/area/outflow or stage/volume/outflow relationships.
 3. A stage versus time analysis through the facility.
 4. Outlet structure details.
 5. Applicable orifice or weir flow calculations for outlet structure and overflow spillway.
 6. Existing conditions and post-project conditions drainage area maps.
 7. For SCS Method, list soil classifications, curve number assumptions, and time of concentration/lag time calculations.
 8. For Snyder's Method, list time to peak (TL), peaking coefficient (Cp), and peak of unit hydrograph flow rate (qp) calculations.
 9. Supporting documentation to include HEC runs, a list of assumptions, and other data required to validate the information provided.
 10. All dikes and spillways on detention facilities shall have typical cross sections shown on the plans.
 11. Side slopes on detention facilities shall not be steeper than 3:1 (Horizontal:Vertical).

12. Detention facilities shall be provided with a concrete trickle channel from the inlet(s) to the outlet structure to transmit low flows. The minimum slope of the bottom of the pond and trickle channel shall be 0.50%.
13. The detention area shall be identified as a separate platted area; as appropriate, it may consist of one or more platted lots, a separate block, a reserve area, or it may be dedicated by separate instrument. No detention facilities will be allowed in off-tract areas without written agreement between affected property owners and said agreement must be filed and recorded in County land records.
14. Provision for the maintenance responsibility of private detention facilities shall appear among the plat's restrictive covenants, or applicable law.
15. In the event a detention facility, as a result of drainage improvements, becomes unnecessary, the facility by action of the City Council may be vacated as provided for in the covenants or under applicable law.
16. An access way at least twenty (20) feet wide shall be provided to any detention area. Access may be provided by frontage on a dedicated public street or by an access easement from a public street to the detention area. The access road shall have a maximum grade of twelve percent (12%).
17. If a detention facility is approved by the City to serve areas outside the development in which it is located, such additional areas shall be specifically identified in the provision for detention.
18. Any dam or berm constructed shall be designed by an Oklahoma Registered Professional Engineer.
19. Any dam constructed for the purpose of storing water and under the jurisdiction of the Oklahoma Water Resources Board shall be designed in accordance with the State of Oklahoma Administrative Code, Section 785.
20. All detention dams or dikes shall be constructed as earth filled and non-overflow type dams. Embankment slopes shall not be steeper than 3:1. Earthen portions of the dam structure shall have a minimum of one foot of freeboard above the 0.2% chance storm event. Flows above the 1% chance storm event are not required to be detained. Freeboard requirements may be adjusted for detention facilities not utilizing earthen berm dams by the Director of Engineering.
21. All detention facilities shall be constructed with an emergency spillway structure designed to pass the flow from the 1% chance flood event in the event of blockage of the outlet structure. Erosion control in the form of concrete lining, rip-rap, dissipator blocks, etc. shall be provided where deemed necessary by the Local Administrator.

22. All earth slopes and areas subject to erosion, such as, adjacent to trickle channels, inlet structures, and outlet structures, shall be slab sodded with Bermuda sod or protected with other erosion control measures. All other earth surfaces, within the designated detention area, shall have an established growth of Bermuda grass. All grass covered areas shall be fertilized, watered and in an established growing condition prior to completion and approval of the detention facility.
23. Construction of the detention facility shall occur before or in concurrence with construction of other proposed impervious areas onsite including buildings and parking lots.
24. Appendix F, Exhibit C presents a simplified unit volume detention curve that may be used to size the detention storage volume required for developments two (2) acres or smaller.

10.11 STORMWATER DISCHARGE SYSTEM DESIGN REQUIREMENTS:

10.11.1 Outfall/Discharge structures shall comply with the following design requirements:

- A. All drainage structures that discharge directly into a waterway shall have a concrete headwall/wingwall and apron. Precast concrete end treatments may be used with approval of the Local Administrator.
- B. All hydraulic control devices, such as weirs, orifices, and flumes shall comply with the design requirements identified in the United States Department of the Interior, Bureau of Reclamation Water Measurement Manual, 2001 revised reprint edition.

10.11.2 Permanent erosion control measures for discharge structures shall comply with the following requirements:

- A. When the 1% chance (100-year) storm outfall velocity at the discharge structure exceeds six (6) fps, permanent erosion control measures shall be installed.
- B. Riprap design shall comply with the requirements of United States Department of Transportation, Hydraulic Engineering Circular Number 14 (HEC-14): Hydraulic Design of Energy Dissipators for Culverts and Channels, third edition, dated July 2006.

10.12 MISCELLANEOUS STORMWATER REQUIREMENTS:

The following section of the Manual covers fee in lieu of detention, stormwater development permits, floodplain development permits, floodplain development permit certificates of compliance, earth change permits, and state or federal stormwater related permits.

10.12.1 Fee in-lieu of detention requirements:

When approved by the Local Administrator, a developer may make a monetary payment or some other form of valuable consideration in lieu of building a detention facility. The developer or engineer shall fill out and turn in a "Fee In Lieu of Detention Determination Form" as included in Appendix F, Exhibit H to the Local Administrator. The Local Administrator shall make the determination of whether fee

in-lieu of detention will be allowed based upon the capacity of the receiving stormwater drainage system and whether regional detention facilities are either proposed or in place. The amount of the fee shall be based on the number of square feet of impervious area added to the property. The developer shall provide the Local Administrator calculations of the number of square feet of increased impervious area and the Local Administrator shall prepare a bill for payment in-lieu of detention. For increased impervious area calculations, existing impervious area shall be defined per conditions on the site dated March 4, 1999. The square footage of increased impervious areas for proposed residential developments shall be determined from the “Residential Housing Density vs. Impervious Area” graph shown in Appendix F, Exhibit I. To determine the impervious area, obtain the total platted area minus open space areas or reserve areas greater than 0.5 acres divided by the total number of residential units to determine the units per acre. Use the units per acre along with the graph to determine the impervious area percentage. Multiply the impervious area percentage by the total platted area minus applicable reserve or open space areas to obtain the proposed impervious area. The square footage of increased impervious area shall be shown immediately above the title block in the lower right hand corner of both the site plan and engineering plan cover sheet for both residential and non-residential projects. The fee shall be paid at the time the final plat is released for residential developments. The fee shall be paid prior to issuance of building permit for non-residential developments. When these fees are collected, they shall be deposited into a Stormwater Capital Improvements Fund, which will be used for future or ongoing stormwater improvement and regional detention projects.

10.12.2 Permit Requirements:

- A. Stormwater Development Permit – A Stormwater Development Permit shall be obtained prior to any development on projects that require platting, site plan approval or alterations to existing public stormwater drainage systems. The Stormwater Development Permit fee set by ordinance shall be submitted with the permit application. A copy of the “Stormwater Development Permit” form is included in Appendix F, Exhibit J. The minimum submittal requirements are as follows:
1. Name and address of legal owner.
 2. Legal description of property.
 3. Boundary line survey.
 4. A location map at 1” = 2000’ scale shown on plans.
 5. Title of project or property shown on plans.
 6. Existing and proposed contours at 1’ or 2’ intervals or spot elevations with drainage arrows.
 7. Existing storm sewer and natural features on site and on adjacent properties within (50) fifty feet of the site boundary line.
 8. Manhole top of rim elevations to be shown on plans. If needed, show manhole adjusted to grade with proposed elevation.
 9. Silt fence, hay bales, ditch checks, and any necessary erosion control shall be shown on plans with details and notes.
 10. Permanent erosion control on the plans in areas of concentrated flows.

11. Plans to show no increase of runoff unless development is within a subdivision with an approved detention facility or fee in-lieu of detention has been approved. A table comparing existing conditions to proposed conditions with drainage areas clearly labeled shall be included.
 12. Runoff will be conveyed to a storm sewer system before entering public streets per section 10.8.6. Profiles of storm pipe with 1% chance peak flow rates and velocities shall be included.
 13. Three sets of the grading, drainage, and storm sewer design plans will be signed and sealed by an Oklahoma Registered Professional Engineer and submitted to the Broken Arrow Development Services Department.
 14. The Local Administrator shall have the right to waive sections of the permit requirements, subject to the developer providing adequate proof, to the Local Administrator, the development does not cause adverse impact to the community.
- B. Floodplain Development Permit – A Floodplain Development Permit shall be required to assure conformity with the provisions of the Stormwater Management Ordinance and to insure that new development is constructed in a manner that minimizes exposure to flooding. A Floodplain Development Permit shall be obtained before construction or development begins in any area in the Regulatory flood Area established in Section 25-304 of the Stormwater Management Ordinance. Application for a Floodplain Development Permit shall be made on forms furnished by the Local Administrator. Application for a “Floodplain Development Permit” shall be made on the form included in Appendix F, Exhibit K. The Floodplain Development Permit fee and submittal requirements set by ordinance shall be submitted to the Local Administrator with the permit application.
- C. Floodplain Development Permit Certificate of Compliance – A copy of the “Certificate of Compliance” is included in Appendix F, Exhibit L.
1. In the Regulatory Flood Area, as determined by documents enumerated in Section 25-304 of the Broken Arrow Stormwater Management Ordinance, it shall be unlawful to occupy or permit the use or occupancy of any building or premises, or both, or part thereof hereafter created, erected, changed, converted, or wholly or partly altered or enlarged in its use or structure until a Certificate of Compliance has been issued by the Local Administrator stating that the building or land conforms to the requirements of the Stormwater Management Ordinance.
 2. A Certificate of Compliance shall be issued by the Local Administrator upon satisfactory completion of all development in the Regulatory Flood Area.
 3. Issuance of the certificate shall be based upon the inspections conducted as prescribed in Section 25-507 of the Stormwater Management Ordinance, and/or any certified elevations, hydraulic

data, flood-proofing, anchoring requirements or encroachment analysis which may have been required as a condition of the approved permit.

- D. State or Federal Permits/Approvals – Any projects requiring stormwater related state or national permits, approvals or certifications, including but not limited to FEMA CLOMR/LOMRs, U.S. Army Corps of Engineers 404 Permits, ODEQ 401 Certifications, ODEQ OPDES Permits, OWRB Dam Permits, and OWRB Stream Water Use Permits shall forward copies of those permit applications to the City of Broken Arrow Stormwater Manager at time of application to the state or federal agency.

**APPENDIX A:
VARIANCE REQUEST**

**CITY OF BROKEN ARROW
ENGINEERING DESIGN CRITERIA
VARIANCE REQUEST**

Date: _____
Applicant: _____
Project Title: _____

1.0 Engineering Design Criteria Regulation Section(s)/Number(s) -

2.0 Specific Reason(s) for Request of Variance -

3.0 Design Recommendation to Resolve Conflict -

Applicant Signature

Date

Engineering and Construction Department Recommendation

Administration

Approval

Denial

**APPENDIX B:
SURVEY AND RIGHTS OF WAY DOCUMENTS**

GENERAL WARRANTY DEED

This Indenture: Made this ____ day of _____ 20__, between _____, of Tulsa/Wagoner County, in the State of Oklahoma, party(ies) of the first part, hereinafter called Grantor(s) and CITY OF BROKEN ARROW, County of Tulsa/Wagoner, State of Oklahoma, party of the second part, hereinafter called Grantee.

WITNESSETH: That in consideration of the sum of Ten Dollars (\$10.00) and other goods and considerations, receipt of which is hereby acknowledged, said party grantor does, by these presents, grant, bargain, sell and convey unto Grantee, their heirs and assigns, all of the following described real estate, situated in the County of Tulsa/Wagoner, State of Oklahoma, to wit:

SEE EXHIBIT "A"

TO HAVE AND TO HOLD THE SAME, together with all and singular the tenements and appurtenances thereto belong or in any wise appertaining forever. And Grantor, their heirs, executors and administrators does hereby covenant, promise and agree to and with Grantee, at the delivery of these presents that they lawfully seized in their own right of an absolute and indefeasible estate of inheritance in fee simple, of and in all and singular the above granted and described premises, with the appurtenances; that the same are free, clear, and discharged and unencumbered of and from all former and other grants, titles, charges, estates, judgments, taxes, assessments and encumbrances of whatsoever nature and kind, EXCEPT: Easements and buildings, restrictions of record and special assessments not yet due, the grantor, _____ will WARRANT AND FOREVER DEFEND the same unto the Grantee, its heirs and assigns, against grantor, their heirs or assigns and all and every person or persons whomsoever lawfully claiming or to claim the same.

IN WITNESS WHEREOF, the Grantor, has hereunto set _____ hand the day and year above written.

State of Oklahoma)
)§.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this ____ day of _____, 20__, personally appeared _____, known to me to be the identical person(s) who executed the within and foregoing instrument in writing and acknowledged to me that he/she executed the same as his/her and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last written above.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked: _____
Project: _____

GENERAL WARRANTY DEED
(Oklahoma Statutory Form)

THIS INDENTURE, Made this ____ day of _____, 20__, between _____, Grantor, and the CITY OF BROKEN ARROW, OKLAHOMA, a municipal corporation, Grantee.

WITNESSETH, that in consideration of the sum of TEN AND NO/100 (\$10.00) DOLLARS, receipt of which is hereby acknowledged, said Grantor do(es), by these presents, grant, bargain, sell and convey unto said Grantee, its successors or assigns, all of the following described real estate, situated in the County of Tulsa/Wagoner, State of Oklahoma, to-wit:

SEE EXHIBIT "A"

EXEMPT FROM DOCUMENTARY STAMPS PURSUANT TO 68 O.S. 3202 (11).

TO HAVE AND TO HOLD THE SAME, together with all and singular the tenements, hereditaments and appurtenances thereto belonging or in any wise appertaining forever.

And said Grantor, for themselves and their heirs, executors, and administrators, does hereby covenant, promise and agree to and with said Grantee, at the delivery of these presents that he(he) is lawfully seized in his(her) own right of an absolute and indefeasible estate of inheritance in fee simple, of and in all and singular the above granted and described premises, with the appurtenances; that the same are free, clear, and discharged and unencumbered of and from all former and other grants, titles, charges, estates, judgments, taxes, assessments and encumbrances, of whatsoever nature and kind, EXCEPT: Easements, building restrictions of record and special assessments not yet due; and that Grantor will WARRANT AND FOREVER DEFEND the same unto the said Grantee, its successors or assigns, against said Grantor, his(her) heirs and assigns and every person or persons whomsoever lawfully claiming or to claim the same.

IN WITNESS WHEREOF, the said Grantor, has hereunto set his hand the day and year above written.

By: _____
Name:

By: _____
Name:

STATE OF OKLAHOMA)
)
COUNTY OF _____) §.

Before me, the undersigned, a Notary Public, in and for said County and State, on this ____ day of _____, 20__, personally appeared _____, to me known to be the identical person(s) who executed the within and foregoing instrument, and acknowledged to me that he/she executed the same as his/her free and voluntary act and deed for the purposes therein set forth.

GIVEN under my hand and seal the day and year last above written.

My Commission Expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ Checked: _____
Project: _____

DEED OF DEDICATION

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, the owner(s) of the legal and equitable title to the following described real estate situated in the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, for and in consideration of the sum of One Dollar (\$1.00), cash in hand, paid by the City of Broken Arrow, Oklahoma and other good and valuable considerations, receipt of which are hereby acknowledged, do(es) hereby dedicate to the City of Broken Arrow for the benefit of the public, forever, the following described property, to wit:

SEE EXHIBIT "A"

for the purpose of permitting the City to construct a _____ thereon, through, over, under and across said property, together with all necessary and convenient appurtenances thereto, which may include, but not necessarily be limited to franchised public utilities and telecommunication services; and to use and maintain the same, and of affording the City, its officers, agents, employees, and/or all persons under contract with it, the right to enter upon said premises and strip of land for the purpose of surveying, excavating for, constructing, operating, repairing and maintaining of such construction.

TO HAVE TO HOLD such property unto the City of Broken Arrow, its successors and assigns, forever.

DATED this ___ day of _____ 20___.

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on ___ day of _____, 20___, personally appeared _____, to me known to be the identical person(s) who executed the within and foregoing instrument in writing and acknowledged to me that he/she/they executed the same as his/her/their free and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission Expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

City Attorney

City Manager

Engineer _____ Checked: _____
Project: _____

QUIT CLAIM DEED

This Indenture: made this ____, day of _____, 20__, between _____ ("Grantor"), of Tulsa/Wagoner County, State of Oklahoma, party of the first part, for and in consideration of the Grantor's interest and support for the future growth and improvements to the City of Broken Arrow, Oklahoma and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, does hereby quit claim, grant, bargain, sell and convey unto the City of Broken Arrow, a municipal corporation, Tulsa County ("Grantee") all of ____ rights, title, interest and estate, both at law and in equity, of, in and to, the following described real property located in Tulsa/Wagoner County, State of Oklahoma, to-wit:

SEE EXHIBIT "A"

To have and to hold the described premises unto grantee, his heirs, successors and assigns forever.

Executed this _____ day of _____, 2010.

State of Oklahoma)
) §.
County of Tulsa)

Before me, the undersigned, a Notary Public in and for said County and State on this _____ day of _____, 20__, personally appeared _____, to me known to be the identical person who executed the within and foregoing instrument and acknowledged to me that he/she executed the same as his/her free and voluntary act and deed for the uses and purposes therein set forth.

Given under my hand and seal of office the day and year above.

My Commission Expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked _____
Project: _____

QUIT-CLAIM DEED

(Statutory)

THIS INDENTURE, made this ___ day of _____, 2010, between _____, husband and wife, Grantors, and _____, husband and wife, Grantees.

WITNESSETH, That Grantors, in consideration of the sum of TEN AND NO/100 (\$10.00) Dollars, and other good and valuable considerations, receipt of which is hereby acknowledged, do hereby quit-claim, grant, bargain, sell, and convey unto Grantees, their successors and assigns, forever, all their right, title, interest, and estate, both at law and in equity, of, in and to the following described real estate, situated in the County of _Tulsa/Wagoner, State of Oklahoma, to-wit:

SEE EXHIBIT "A"

EXEMPT FROM DOCUMENTARY STAMPS PURSUANT 68 O.S. 3202 (3).

Together with all and singular the hereditaments and appurtenances thereunto belonging. TO HAVE AND TO HOLD the above granted premises unto the said Grantees, their successors and assigns forever.

IN WITNESS WHEREOF, Grantors have hereunto set their hand the day and year first above written.

By: _____

By: _____

STATE OF OKLAHOMA)
) §:
COUNTY OF _____)

Before me, the undersigned, a Notary Public in and for said County and State, on the ___ day of _____, 2010, personally appeared _____, husband and wife, to me known to be the identical persons who executed the within and foregoing instrument and acknowledged to me that he/she/they executed the same as his/her/their free and voluntary act and deed for the uses and purposes therein set forth.

Given under my hand and seal the day and year last above written.

My Commission Expires: _____
Notary Public

Approved as to Form: _____ Approved as to Substance: _____

Asst. City Attorney City Manager

Engineer _____ checked _____
Project: _____

UTILITY EASEMENT

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, the owner(s), of the legal and equitable title to the following described real estate, "Grantor," in consideration of the sum of One Dollar (\$1.00), cash in hand paid by the City of Broken Arrow, Oklahoma and other good and valuable considerations, receipt of which is hereby acknowledged, do(es) hereby assign(s), grant(s) and convey(s) to the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a municipal corporation, its successors and assigns, "Grantee," an easement and right of way over and across the following described real property and premises, situated in Tulsa/Wagoner County, State of Oklahoma to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, operating, and replacing utility lines and appurtenances.

Grantor agrees not to build or construct any building or buildings upon the permanent easement area. However, Grantor expressly reserves the right to build and construct sidewalks, streets and driveways, water mains, gas lines, electrical lines and other public service facilities across said premises herein described.

There is further granted the right to remove any tree or parts of trees, which in the judgment of the City may interfere with the construction of the applicable utilities.

PROVIDED, that the said Grantor, his/her heirs, executors, administrators and assigns, shall fully use and enjoy the said premises except as may be necessary for the purposes herein granted to the City, its successors or assigns.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

IN WITNESS WHEREOF, the parties hereto have caused this instrument to be executed this ____ day of _____, 2010.

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____, 20____, personally appeared _____ to me known to be the identical person(s) who executed the within and foregoing instrument and acknowledged to me that he/she/they executed the same as his/her/their free and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer: _____ checked: _____
Project: _____

DRAINAGE EASEMENT

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, the owner(s) of the legal and equitable title to the following described real estate situated in the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, for and in consideration of the sum of One Dollar, cash in hand, paid by the City of Broken Arrow, Oklahoma and other good and valuable considerations, receipt of which are hereby acknowledged, do(es) hereby dedicate to the public, forever, the following described property, to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, maintaining, operating, and replacing drainage facilities and appurtenances.

The City is hereby given and granted the exclusive possession of said above described premises for the purposes aforesaid, and grantor(s), for him/her and their heirs, administrators, successors and assigns, covenant(s) and agree(s) that no building, structure, wall or other above ground obstruction will be placed, erected, installed or permitted upon the above described land; and further covenant(s) and agree(s) that in the event the terms of this paragraph are violated by the grantor(s) or any person in privy with them, such violation will be promptly corrected and eliminated immediately upon receipt of notice from City or City shall have right to remove or otherwise eliminate such violation, and grantor(s), his/her heirs, administrators, successors and assigns, shall promptly pay the actual cost thereof.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

DATED this ___ day of _____ 20____.

State of Oklahoma)
)§.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this _____ day of _____, 20____, personally appeared _____, known to me to be the identical person(s) who executed the within and foregoing instrument in writing and acknowledged to me that he/she executed the same as his/her and voluntary act and deed for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last written above.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked: _____
Project: _____

**DRAINAGE AND UTILITY
EASEMENT**

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____ the owner(s), of the legal and equitable title to the following described real estate, "owner(s)" in consideration of the sum of One Dollar (\$1.00), cash in hand paid and other good and valuable considerations, receipt of which is hereby acknowledged, do(es) hereby assign(s), grant(s) and convey(s) to the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a municipal corporation, its successors and assigns, "City", an easement and right of way over and across the following described real property and premises, situated in Tulsa/Wagoner County, State of Oklahoma to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, maintaining, operating, and replacing drainage facilities and appurtenances and any other utility lines and appurtenances at the City's sole discretion.

and granting this right of way to utilities that have right of way franchises with the City of Broken Arrow.

The City is hereby given and granted the exclusive possession of said above described premises for the purposes aforesaid, and owner(s), for him/her and their heirs, administrators, successors and assigns, covenant(s) and agree(s) that no building, structure, wall or other above ground obstruction will be placed, erected, installed or permitted upon the above described land; and further covenant(s) and agree(s) that in the event the terms of this paragraph are violated by the owner(s) or any person in privy with them, such violation will be promptly corrected and eliminated immediately upon receipt of notice from City or City shall have right to remove or otherwise eliminate such violation, and owner(s), his/her heirs, administrators, successors and assigns, shall promptly pay the actual cost thereof.

However, owner expressly reserves the right to build and construct sidewalks, streets and driveways, water mains, gas lines, electrical lines and other public service facilities across said premises herein described.

There is further granted the right to remove any tree or parts of trees, which in the judgment of the City may interfere with the construction of the applicable utilities.

PROVIDED, that the said owner(s), his/her heirs, executors, administrators and assigns, shall fully use and enjoy the said premises except as may be necessary for the purposes herein granted to the City, its successors or assigns.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

DATED this __ day of _____, 20__.

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____ 20____, personally appeared _____ to me known to be the identical person(s) who executed the within and foregoing instrument as the free and voluntary act and deed of such person for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer: _____ checked: _____
Project: _____

**DRAINAGE EASEMENT
CORPORATE or PARTNERSHIP**

KNOW ALL MEN BY THESE PRESENTS:

That "Corporate name" by "signatory name", its "corporate officer" of Tulsa/Wagoner County, State of Oklahoma, the owner of the legal and equitable title to the following described real estate, party of the first part, in consideration of the sum of One Dollar, cash in hand paid, receipt of which is hereby acknowledged, do(es) hereby assign, grant and convey to the City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a municipal corporation, party of the second part, its successors and assigns, an easement and right of way over and across the following described real property and premises, situated in Tulsa/Wagoner County, State of Oklahoma, to wit:

SEE EXHIBIT "A"

with right of ingress and egress to and from the same, for the purpose of constructing, maintaining, operating, and replacing drainage facilities and appurtenances.

The City is hereby given and granted the exclusive possession of said above described premises for the purposes aforesaid, and grantor(s), for him/her and their heirs, administrators, successors and assigns, covenant(s) and agree(s) that no building, structure, wall or other above ground obstruction will be placed, erected, installed or permitted upon the above described land; and further covenant(s) and agree(s) that in the event the terms of this paragraph are violated by the grantor(s) or any person in privy with them, such violation will be promptly corrected and eliminated immediately upon receipt of notice from City or City shall have right to remove or otherwise eliminate such violation, and grantor(s), his/her heirs, administrators, successors and assigns, shall promptly pay the actual cost thereof.

TO HAVE AND TO HOLD such easement and right of way unto the City of Broken Arrow, Oklahoma, its successors and assigns forever.

DATED this ___ day of _____ 20____. _____ (Corporate name)

By _____

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned Notary Public, in and for said County and State, on this _____ day of _____, 20____, personally appeared _____ for (Corp. Name) known to me to be the identical person(s) who subscribed the name of the maker thereof to the foregoing instrument as its (signatory officer or general partner) and as the free and voluntary act and deed of such corporation for the uses and purposes therein set forth.

My Commission Expires: _____

Notary Public
Approved as to Substance:

Approved as to Form:

Asst. City Attorney

City Manager

Engineer _____ checked: _____
Project: _____

TEMPORARY CONSTRUCTION EASEMENT

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, (marital status), the owner(s), of the legal and equitable title to the following described real estate situated in Tulsa/Wagoner County, State of Oklahoma, for and in consideration of the sum of One Dollar, cash in hand paid by the City of Broken Arrow, Oklahoma, and other good and valuable considerations, receipt of which are hereby acknowledged, does hereby grant and convey unto the said City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a temporary easement, through, over and under and across the following described property, situated in Tulsa/Wagoner County, to wit:

SEE EXHIBIT "A"

for a period of **not more than 10 months from the date of the start of construction**. This grant of temporary right to use and occupy is given for the purpose of permitting the City of Broken Arrow, its employees, representatives, agents, and/or persons under contract with it, to use said described property in connection with **the construction of**

IN WITNESS WHEREOF, the parties have caused this instrument to be executed this _____ day of _____
_____ 2010.

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____, 20____, personally appeared _____, marital status, to me known to be the identical person(s) who executed the within and foregoing instrument as his/her/their free and voluntary act and deed of such person(s) for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer _____ checked: _____

Project: _____

**TEMPORARY CONSTRUCTION EASEMENT
CORPORATE or PARTNERSHIP**

KNOW ALL MEN BY THESE PRESENTS:

That the undersigned, _____, by "signatory name", _____, its "corporate officer", the owner(s), of the legal and equitable title to the following described real estate situated in Tulsa/Wagoner County, State of Oklahoma, for and in consideration of the sum of One Dollar, cash in hand paid by the City of Broken Arrow, Oklahoma, a municipal corporation, and other good and valuable considerations, receipt of which are hereby acknowledged, does hereby grant and convey unto the said City of Broken Arrow, Tulsa/Wagoner County, Oklahoma, a temporary easement, through, over and under and across the following described property, situated in Tulsa/Wagoner County, to wit:

SEE EXHIBIT "A"

for a period of not more than ___ months from the date of this instrument. This grant of temporary right to use and occupy is given for the purpose of permitting the City of Broken Arrow, its employees, representatives, agents, and/or persons under contract with it, to use said described property in connection with the construction of _____

IN WITNESS WHEREOF, the parties have caused this instrument to be executed this ___ day of _____, 20___.

(Corporate name) _____
By _____
TITLE

State of Oklahoma)
) §.
County of _____)

Before me, the undersigned, a Notary Public within and for said County and State, on this _____ day of _____, 20___, personally appeared for _____ for (Corp. Name) to me known to be the identical person(s) who executed the within and foregoing instrument as its (signatory officer or general partner) and as the free and voluntary act and deed of such corporation for the uses and purposes therein set forth.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal the day and year last above written.

My Commission expires: _____

Notary Public

Approved as to Form:

Approved as to Substance:

Asst. City Attorney

City Manager

Engineer: _____ checked: _____
Project: _____

**APPENDIX C:
EARTH CHANGE OPERATIONS AND POLLUTION
PREVENTION CONTROLS DOCUMENTS**

**Storm Water
Pollution Prevention Plan
(SWP3)**

for

Project Name

City of Broken Arrow

***Tulsa/Wagoner* County, Oklahoma**

Owner:

NAME OF OWNER

Date Issued:

Date SP3 Signed By Owner

Prepared by:

Name of Entity preparing

SP3

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1.0 Introduction:

Project Name:	_____
Location:	Section, Township, Range, County, State
Street Address:	_____
Owner:	Owner information Address City, State, Zip Phone Fax / E-mail

2.0 Site and Activity Description (OKR10, Section 4.5.1):

Description:	_____
Construction Activity Description:	_____
Intended Sequence of Construction:	(TO BE REVISED ACCORDINGLY TO SPECIFIC PROJECT BY PREPARER)
	<ul style="list-style-type: none">• Install Stabilized Construction Entrance• Install Silt Fencing and Hay Bales• Clearing and Grubing• Stripping and Stockpile of Topsoil• Rough Grading for Paved Areas• Install Inlet Protection• Construct Drainage Ditches and Underground Utilities• Finished Grading for Paved Areas and Drainage Ditch• Construct Paved Areas Complete with Curb and Gutter if required• Sod, Seed and Revegetate Disturbed Areas• Remove Accumulated Silt and Excess Earth• Remove all remaining Temporary Controls• Perform Final Pavement Wash Down
Total Site Area:	_____
Runoff Coefficient:	
Pre-Developed Runoff Coefficient:	Existing runoff coefficients have been estimated at _____
Post-Developed Runoff Coefficient:	Developed runoff coefficients have been estimated at _____ this is an estimated increase of _____
Industrial Discharge Description:	The entire site is _____ acres, and _____ acres of the site will be disturbed by the drainage ditches, paving, grading, and utility construction.
Receiving Waters:	This project drains into _____

3.0 Measures to Protect Endangered or Threatened Species (OKR10, Section 4.5.3):

Identification of Endangered or Threatened Species:	Examined the Aquatic Resources of concern to stormwater construction as shown U.S.Fish and wildlife 303(d) list and found no Endangered or Threatened Species listed for the area of concern
Identification of Critical Habitats:	Examined the Aquatic Resources of concern to stormwater construction as shown U.S. Fish and wildlife 303(d) list and found identify type/state no Critical Habitats listed for the area of concern
Implementation of Best Management Practice to reduce danger:	Finding no Identification of any Endangered or Threatened Species as well as no Identification of any Critical Habitats, there should be no danger in proceeding with the site development

4.0 Affect on Historic Preservation Laws of Federal, State, and Local (OKR10, Section 4.5.4):

Historical Preservation: None of the joining or adjacent properties to the proposed construction are preserved by the State Historical Society, therefore this construction will have no adverse effects

5.0 Affect on Water Quality-Impaired Waters (OKR10, Section 4.5.5):

Wetlands: Owner reviewed the appropriate Map as provided by the U.S. Fish and Wildlife Service for Broken Arrow, Oklahoma, and it appears that there are no designated Wetlands within the project area

6.0 Controls to Reduce Pollutants (OKR10, Section 4.5.6): Erosion and Sediment Controls (OKR10, Section 4.5.6.A):

Temporary Stabilization Practices:
Topsoil stockpiles and disturbed portions of the site where construction activity temporarily ceases for at least 21 days will be stabilized with temporary seed and mulch no later than 14 days from the last construction activity in the area. The temporary seed shall be **identify type** applied at the rate of **identify amount** pounds per acre. Prior to seeding, **identify amount** pounds of ground agricultural limestone and **identify amount** pounds of **identify type** fertilizer shall be applied to each acre to be stabilized. After seeding, each area shall be mulched with **identify amount** pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight.

Permanent Stabilization Practices:
Disturbed portions of the site where construction activities permanently cease shall be stabilized with permanent seed no later than 14 days after the last construction activity. The permanent seed mix shall consist of **identify amount** pounds per acre of **identify type** and **identify amount** pounds per acre of common **identify type**. Prior to seeding, **identify amount** pounds of ground agricultural limestone and **identify amount** pounds of **identify type** fertilizer shall be applied to each acre to be stabilized. After seeding, each area shall be mulched with **identify amount** pounds per acre of straw. The straw mulch is to be tacked into place by a disk with blades set nearly straight.

7.0 Storm Water Management (OKR10, Section 4.5.6.B)

Provide description.

8.0 Other Controls (OKR10, Section 4.5.6.C):

Waste Disposal:

Concrete should be disposed of in a manner that prevents contact between the concrete or wash water and storm water, which will discharge from the site. Dispose of concrete and wash water in a diked area and allow to harden prior to removal. All waste materials will be collected and stored in securely lidded metal dumpsters rented from local waste management services, licensed to operate solid waste disposal sites. [redacted] construction waste will be buried on site. No burning of solid waste is allowed. [redacted] on-site concrete batch plant shall be allowed.

Hazardous Waste:

All hazardous waste materials will be disposed of in the manner specified by local or State regulation. Site personnel will be instructed in these practices and the superintendent for the general contractor will be responsible for seeing that these practices are followed.

Sanitary Waste:

All sanitary waste will be collected from portable units as required by local regulations.

Offsite Vehicle Tracking:

A stabilized construction entrance will be constructed and maintained to reduce tracking of sediments onto public streets. Excess material tracked onto public streets will be removed as necessary. Dump trucks hauling material from the site will be covered with tarpaulin.

Discharge Associated with Industrial Activity:

There is [redacted] discharge associated with industrial activity.

9.0 Approved State or Local Plans (OKR10, Section 4.5.6.D):

The storm water pollution prevention plan meets the requirements of the City of Broken Arrow and the State of Oklahoma Department of Environmental Quality (DEQ) and the Environmental Protection Agency (EPA) with respect to storm water management and erosion and sediment control. To ensure compliance, this plan was prepared in accordance with the EPA Storm Water Management for Construction Activities Developing Pollution Prevention Plans and Best Management Practices and in accordance to the State of Oklahoma, General Permit OKR10, dated September 13, 2007. There are [redacted] other State or Federal requirements for sediment and erosion plans (or permits), or storm water management site plans (or permits).

10.0 Maintenance (OKR10, Section 4.5.7)/ Inspection (OKR10, Section 4.5.8):

Erosion and Sediment Control Inspection and Maintenance Practices:

These are inspection and maintenance practices that will be used to maintain the erosion and sediment control:

- All control measures will be inspected at least once each week and following any rainfall of 0.5 inches or greater.
- All measures will be maintained in good working order. If a repair is necessary, it will be initiated within 24 hours of report.
- Built up sediment will be removed from silt fence when it has reached one-third the height of the fence.
- Silt fence will be inspected for depth of sediment, tears, to see if the fabric is securely attached to the fence posts, and to see that the fence posts are firmly in the ground.
- Temporary and permanent seeding and planting will be inspected for bare spots, washouts and healthy growth.
- A maintenance inspection report will be made after each inspection. A copy of the report form to be completed by the inspector is attached.
- The general contractor will select individuals responsible for inspections, maintenance and repair activities and filling out the inspection and maintenance report. Personnel selected for inspection and maintenance responsibilities will receive training from the general contractor. They will be trained in inspection and maintenance practices necessary for keeping the erosion and sedimentation controls in good working order.

11.0 Non-Storm Water Authorized Discharges (OKR10, Section 4.5.9, Section 1.3.1.C):

The following non-storm water discharge activities are authorized under the OKR10 General Discharge Permit for Construction Activities:

- Fire hydrant flushings.
- Waters used to wash vehicles where detergents are not used.
- Waters used to control dust in accordance with Part 4.5.2.C.2.
- Potable water, including waterline flushing and initial pressure tests of newly constructed piping where the piping is clean and chemical agents have not been added to the test water or applied to the pipes.
- Routine external building wash down which does not use detergents.
- Pavement wash waters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used.
- Uncontaminated air conditioning or compressor condensate.
- Uncontaminated ground water or spring water.
- Foundation or footing drains where flows are not contaminated with process materials such as solvents.
- Landscape irrigation.
- Discharge or flows from emergency fire fighting activities.
- Uncontaminated flows from excavation dewatering activities will be allowed if operational and structural controls are used to reduce any pollutant releases in order to avoid or minimize the impacts on water quality. These controls must be included in your SWP3.

12.0 Limitations on Coverage (OKR10, Section 1.3.2)

The following items activities are not authorized under the OKR10 General Discharge Permit for Construction Activities:

- Post Construction Discharges (OKR10, Section 1.3.2.A)
- Discharges Mixed with Non-Storm Water (OKR10, Section 4.5.6.B)
- Discharges Covered by Another Permit (OKR10, Section 4.5.6.C)
- Discharges Threatening Water Quality (OKR10, Section 4.5.6.D)
- Discharges Not Protective of Listed Endangered Species (OKR10, Section 4.5.6.E)
- Construction Activity on Native American (Indian) Country Land (OKR10, Section 4.5.6.F)
- Construction Activity for Oil and Gas Operations and Pipelines (OKR10, Section 4.5.6.G)
- Construction Activities Related to Agriculture (OKR10, Section 4.5.6.H)
- New Sources or New Discharges of Constituents of Concern to Impaired Waters (OKR10, Section 4.5.6.I)

13.0 Authorized Construction Support Activities (OKR10, Section 1.3.1.B):

The following Specified construction support activities are allowed by the General Permit for construction activity provided that the activity is:

(A) Directly related to the construction activities.

(B) That the support activity **is / is not** a commercial operation serving multiple unrelated construction projects by different operators.

(C) Appropriate control measures for the support activities are identified in the Storm Water Pollution Prevention Plan.

(D) The support activities **are /are not** located within the watershed of an Outstanding Resource Water.

- Concrete Batch Plants
- Asphalt Batch Plants
- Equipment Staging Areas
- Material Storage Areas
- Excavated Material Disposal Areas
- Borrow Pit Areas

14.0 Alterations / Modifications

If Contractor or Owner is required to alter or modify any provision identified on this SWP3 during the course of construction, then the party who desires the alteration or modification must resubmit the revised SWP3 to the proper governing authorities and receive authorization from such authority prior to the commencement of said construction activity that precipitated the alteration / modification.

Certification of Compliance by Engineer

I hereby certify that this report for the erosion and sedimentation control design for **PROJECT DESCRIPTION**, Broken Arrow, Oklahoma was prepared by me or under my direct supervision, in accordance within the provisions of City of Broken Arrow for the owner's thereof.

NAME
Title

DATE

Owner Certification

I, owner of said property, certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to ensure that qualified personnel properly gathered and evaluated 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 or imprisonment for knowing violations.

For **OWNER'S Name**

Signature _____ Date _____

Contractor's Certification

I certify under penalty of law that I understand the terms and conditions of the general National Pollutant Discharge Elimination System (NPDES) permit that authorizes the storm water discharges associated with industrial activity from the construction site identified as part of this certification.

Contractor is responsible for general construction activities related to the construction, temporary and permanent stabilization, construction entrances, and sedimentation control.

For **Contractor's Entity**

Signature _____ Date _____



City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches

Stabilization Measures

Project: _____

Street Address _____

Inspector: _____ Date: _____

Project Engineer: _____ Contract Administrator: _____

Project Description: _____

Date since last rainfall: Amount of rainfall: inches

Notes:

Stabilization Measures				
Area:	Date since last disturbance	Date of next disturbance	Stabilized with	Condition
Roadway				
Parking				
Graded area				
Other				

Stabilization Required:

Findings and Recommendation on BMP:

Work to be performed by: _____ On of before: _____



City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches

Structural Controls- Construction Entrance

Project: _____

Street Address _____

Inspector: _____ Date: _____

Project Engineer: _____ Contract Administrator _____

Project Description: _____

Date since last rainfall: _____ Amount of rainfall: _____ inches

Notes: _____

Notes on BMP: _____

Construction Entrance:

Does sediment track to road:
Is the gravel clean or filled with sediment:
Does traffic use the entrance:

Findings and Recommendations on BMP:

Work to be performed by: _____ On of before: _____



City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches

Structural Controls-Silt Fence, Haybales, Overland Swales

Project: _____
 Street Address _____
 Inspector: _____ Date: _____
 Project Engineer: _____ Contract Administrator _____
 Project Description: _____

Date since last rainfall: _____ Amount of rainfall: _____ inches

Notes: _____

Notes on BMP: _____

Silt Fence, Hay Bales, Swales

Location	Is BMP adequate?	Is there evidence of washout, overtopping, bypassing?
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----

Findings and Recommendations on BMP: _____

Work to be performed by: _____ On of before: _____



City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches

Structural Controls-Inlet Protection

Project: _____

Street Address _____

Inspector: _____ Date: _____

Project Engineer: _____ Contract Administrator _____

Project Description: _____

Date since last rainfall: _____ Amount of rainfall: _____ inches

Notes: _____

Notes on BMP: _____

Inlet Protection

Location	Is BMP adequate?	Is there evidence of washout, overtopping, bypassing?
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Effectiveness and Recommendations of BMP:

Work to be performed by: _____ On of before: _____



City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches

Trash Containment

Project: _____

Street Address _____

Inspector: _____ Date: _____

Project Engineer: _____ Contract Administrator _____

Project Description: _____

Date since last rainfall: _____ Amount of rainfall: _____ inches

Notes: _____

Notes on BMP: _____

Trash Containment

Location	Is BMP adequate?
-----	-----
-----	-----
-----	-----
-----	-----

Effectiveness and Recommendations:

Work to be performed by: _____ On of before: _____

City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches



Structural Controls-Sedimentation Basin

Project: _____

Street Address _____

Inspector: _____ Date: _____

Project Engineer: _____ Contract Administrator _____

Project Description: _____

Date since last rainfall: _____ Amount of rainfall: _____ inches

Notes: _____

Notes on BMP: _____

Sedimentation Basin

Location	Is BMP adequate?	Measured Ntu
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----

Effectiveness and Recommendations on BMP: _____

Work to be performed by: _____ On of before: _____



City of Broken Arrow

Inspection and Maintenance Report Form

to be completed every 14 days and within 24 hours of a rainfall event greater than 0.5 inches

Structural Controls-Re-establishment of Vegetation

Project: _____

Street Address _____

Inspector: _____ Date: _____

Project Engineer: _____ Contract Administrator _____

Project Description: _____

Date since last rainfall: _____ Amount of rainfall: _____ inches

Notes: _____

Notes on BMP: _____

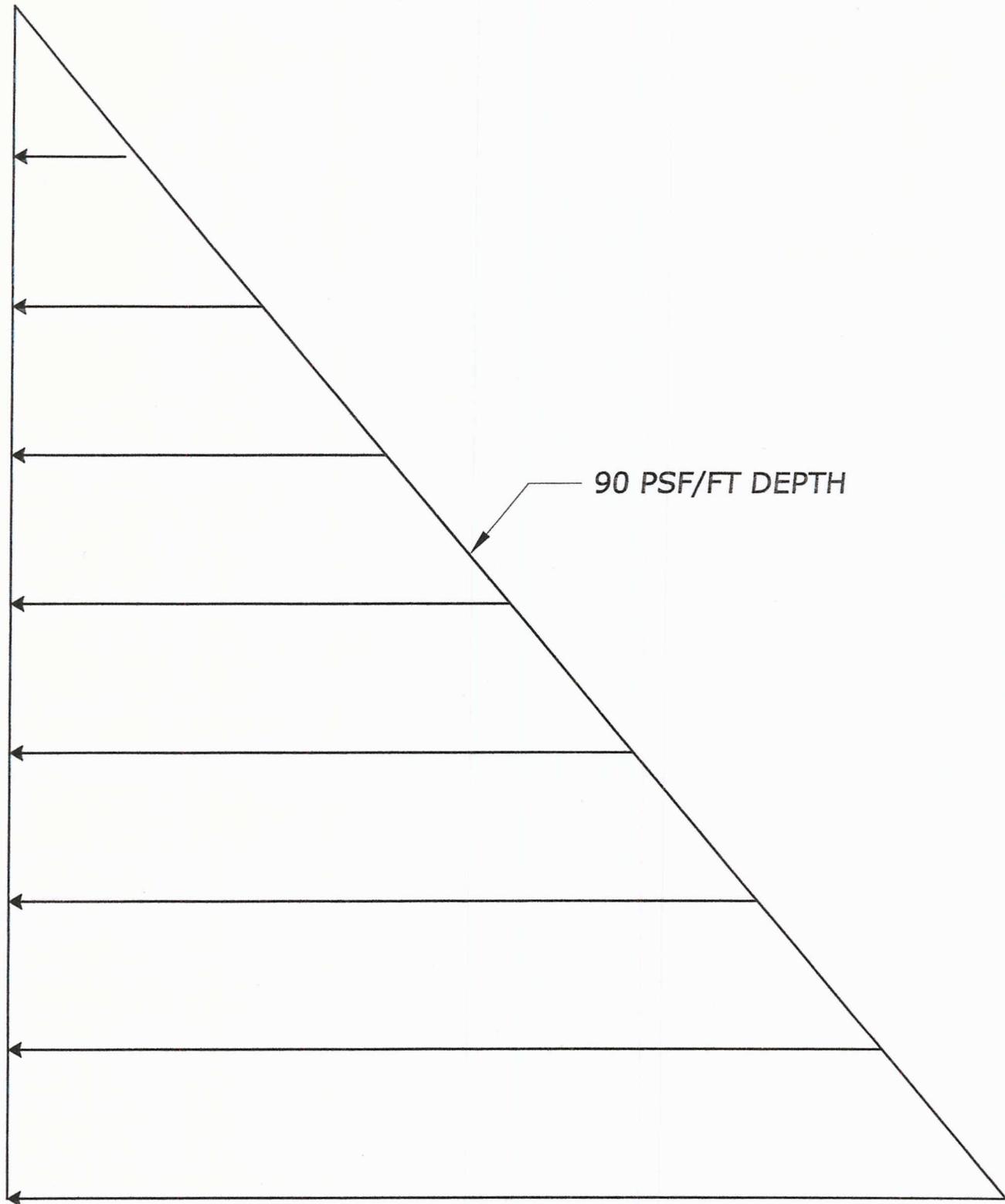
Re-vegetation

Location	Is BMP adequate?	is the plant material established?
-----	-----	-----
-----	-----	-----
-----	-----	-----
-----	-----	-----

Effectiveness and Recommendations on BMP:

**APPENDIX D:
GEOTECHNICAL RELATIONSHIPS DOCUMENTS**

Equivalent Fluid Pressure Diagram



Recommend Minimum Saturated Lateral Earth Pressure

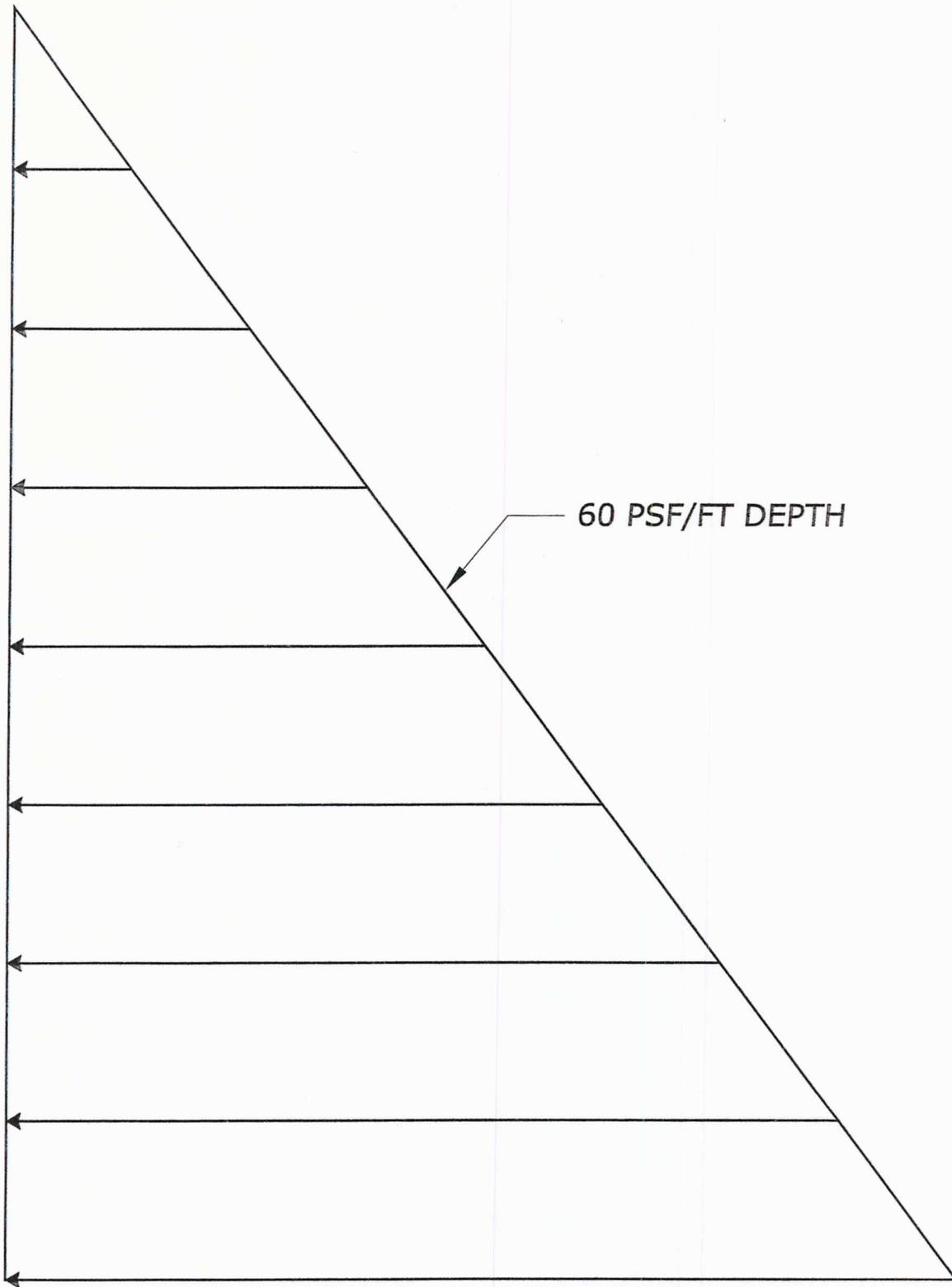


CITY OF
BROKEN ARROW
Where opportunity lives

Engineering & Construction Department
Equivalent Fluid Pressure Diagram
Exhibit C-3

02/15/10

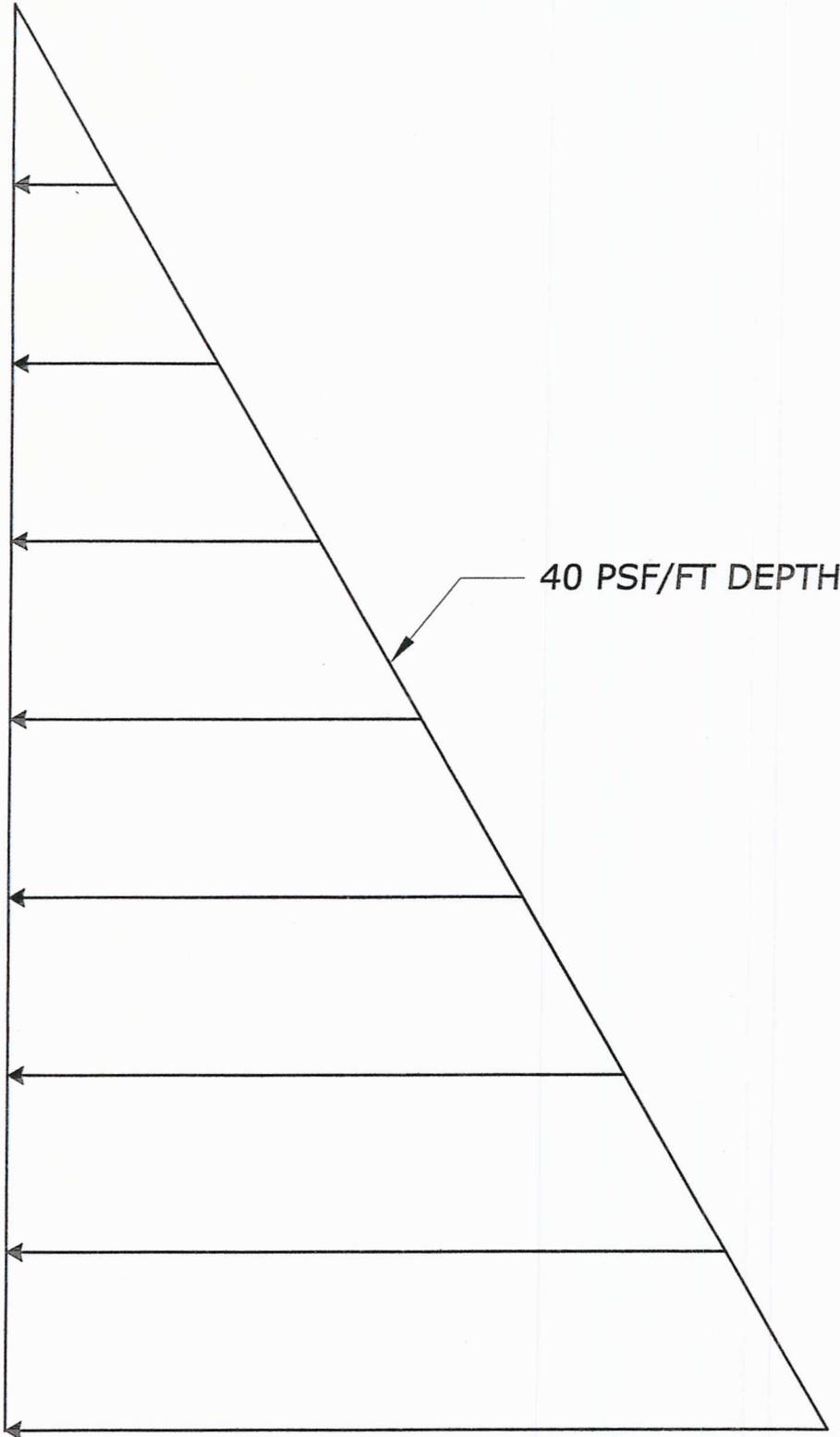
Equivalent Fluid Pressure Diagram



Recommend Minimum "At-Rest" Lateral Earth Pressure



Equivalent Fluid Pressure Diagram



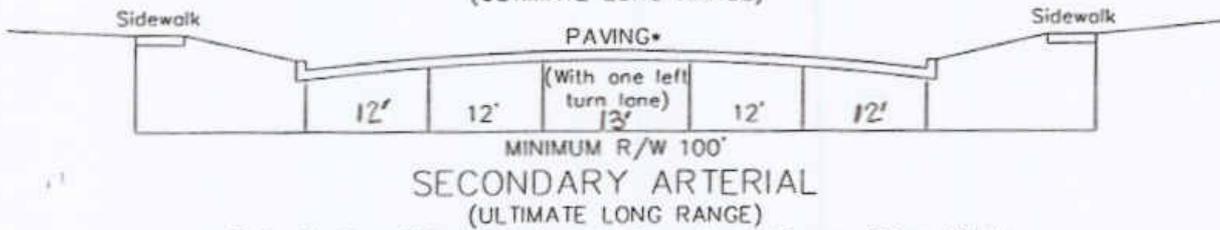
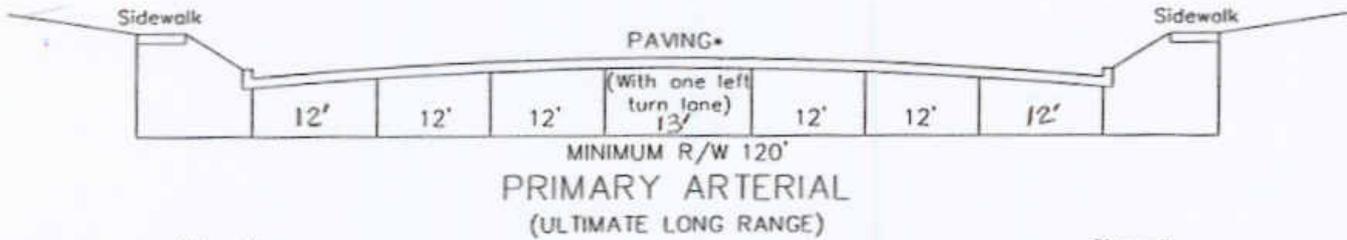
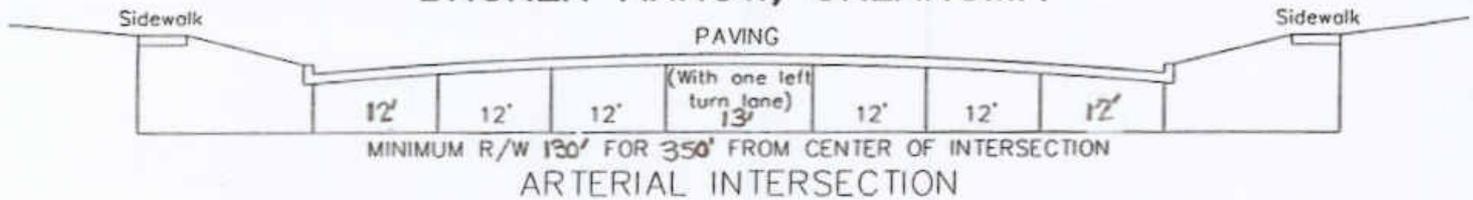
Recommend Minimum Active Lateral Earth Pressure



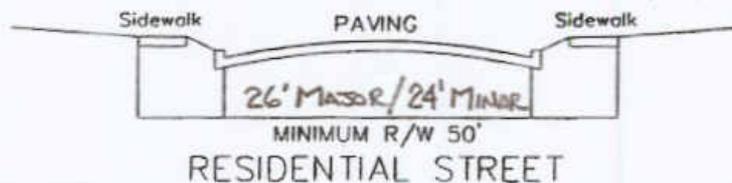
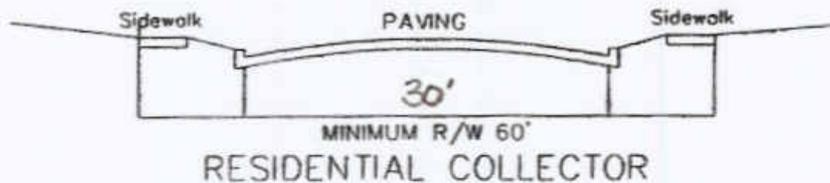
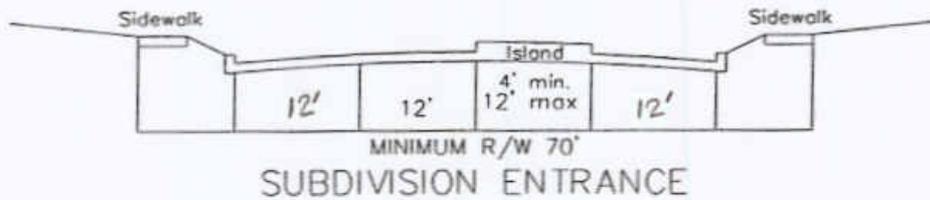
**APPENDIX C:
GEOTECHNICAL RELATIONSHIPS DOCUMENTS**

**APPENDIX E:
TRANSPORTATION FACILITIES DOCUMENTS**

STREET AND ROADWAY STANDARDS BROKEN ARROW, OKLAHOMA



* Center Median will be used where design and operating conditions dictate.



CROSS SECTIONS
NOT TO SCALE

NOTES:

1. FOR ROADWAY DETAILS REFER TO STANDARD CONSTRUCTION SPECIFICATIONS.
2. ALL ARTERIAL UTILITIES EXCEPT STORMWATER AND SIGNALS ARE TO BE PLACED IN UTILITY EASEMENTS.
3. STREET DESIGN STANDARDS ARE IN THE BROKEN ARROW ENGINEERING DESIGN CRITERIA MANUAL

TABLE 6.1 - STREET DESIGN STANDARDS

Roadway Design Item	Notes	Arterial		Commercial		Industrial		Residential			Section
		Primary	Secondary	Collector	Standard	Collector	Standard	Collector	Major	Minor	Reference
Right-of-Way											
Widths	1, 2	120'	100'	80'	60'	80'	60'	60'	50'	50'	6.4.2.
Pavement Width											
7-Lane Section		85'	NA	NA	NA	NA	NA	NA	NA	NA	6.5.1.
6-Lane Section		72'	NA	NA	NA	NA	NA	NA	NA	NA	6.5.1.
5-Lane Section		61'	61'	NA	NA	NA	NA	NA	NA	NA	6.5.1.
4-Lane Section		48'	48'	NA	NA	NA	NA	NA	NA	NA	6.5.1.
3-Lane Section	3	37'	37'	40'	40'	40'	40'	40'	40'	NA	6.5.1.
2-Lane Section		26'	26'	36'	30'	38'	32'	30'	26'	24'	6.5.1.
Pavement Design											
Assumed Tandem Axle Load		65 kips	65 kips	56 kips	56 kips	65 kips	65 kips	56 kips	36 kips	36 kips	
Assumed Single Axle Load		40 kips	40 kips	30 kips	30 kips	40 kips	40 kips	30 kips	20 kips	20 kips	
Assumed Average Daily Traffic	4	Traffic	Traffic	2000-6000	2000-6000	2000-6000	2000-6000	2000-6000	300-700	200	
Design Speed		50 mph	45 mph	40 mph	35 mph	40 mph	35 mph	30 mph	30 mph	30 mph	6.4.1.
Concrete Design											
Min PCC Pavement Thickness	5	9"	9"	7"	7"	7"	7"	7"	6"	6"	6.5.2.
Min Subgrade Modification		8"	8"	8"	8"	8"	8"	8"	8"	8"	6.5.2.
Asphalt Design											
Min AC Wearing Course		2"	2"	2"	2"	2"	2"	2"	1.5"	1.5"	6.5.2.
Min AC Base Thickness		8"	8"	6.75"	6.75"	6.75"	6.75"	6.75"	6"	6"	6.5.2.
Min Aggregate Base Thickness		8"	8"	NA	NA	NA	NA	NA	NA	NA	6.5.2.
Substitute AC for Equiv Aggr	6	NA	NA	(0.75")2.5"	(0.75")2.5"	(0.75")2.5"	(0.75")2.5"	(0.75")2.5"	(1") 3"	(1") 3"	6.5.2.
Min Subgrade Modification		8"	8"	8"	8"	8"	8"	8"	8"	8"	6.5.2.
Geometric Design											
Min Grade		0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%	6.4.4.
Max Grade		4.0%	4.0%	6.0%	6.0%	4.0%	4.0%	8.0%	8.0%	8.0%	6.4.4.
Min Centerline Radius		1125'	1125'	821'	544'	821'	544'	208'	208'	208'	
Min Stopping Sight Distance		425'	360'	305'	250'	305'	250'	200'	200'	200'	

Notes

1. Right of Way at Arterial/Arterial Intersections is 130' for the first 350', measured from section line.
2. Right of Way at all street intersections to include corner clip of 25' by 25'.
3. Three lane section for Commercial, Industrial and Residential are at intersections with Arterial. Width Includes 4' median.
4. Average Daily Traffic for Arterials is determine from actual traffic counts.
5. Dowel Jointed PC Pavement
6. May substitute AC thickness for equivalent structural thickness of aggregate base.

**APPENDIX F:
STORMWATER MANAGEMENT DOCUMENTS**

EXHIBIT A

RAINFALL DEPTHS AND INTENSITIES RATIONAL METHOD

RAINFALL DEPTHS						
Rainfall Duration	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-Minute	0.492	0.575	0.637	0.729	0.802	0.875
10-Minute	0.821	0.960	1.064	1.220	1.342	1.464
15-Minute	1.050	1.228	1.362	1.560	1.717	1.873
30-Minute	1.440	1.747	1.969	2.292	2.544	2.795
60-Minute	1.845	2.287	2.601	3.053	3.405	3.755

Source: National Weather Service Hydro 35 and Department of Commerce and National Weather Bureau Technical Publication No. 40.

RAINFALL INTENSITIES						
Rainfall Duration	Return Period					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5-Minute	5.900	6.896	7.641	8.753	9.629	10.500
10-Minute	4.927	5.762	6.386	7.318	8.052	8.781
15-Minute	4.200	4.913	5.446	6.241	6.867	7.490
30-Minute	2.879	3.494	3.938	4.583	5.088	5.590
60-Minute	1.845	2.287	2.601	3.053	3.405	3.755

Source: National Weather Service Hydro 35 and Department of Commerce and National Weather Bureau Technical Publication No. 40.

RAINFALL DEPTHS SCS METHOD

24-Hr Duration						
Location	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr
Broken Arrow	4.02	5.22	6.15	7.14	8.05	9.00

Sources: Soil Conservation Service Technical Release No. 55 and U.S. Weather Bureau Rainfall Atlas of the United States.

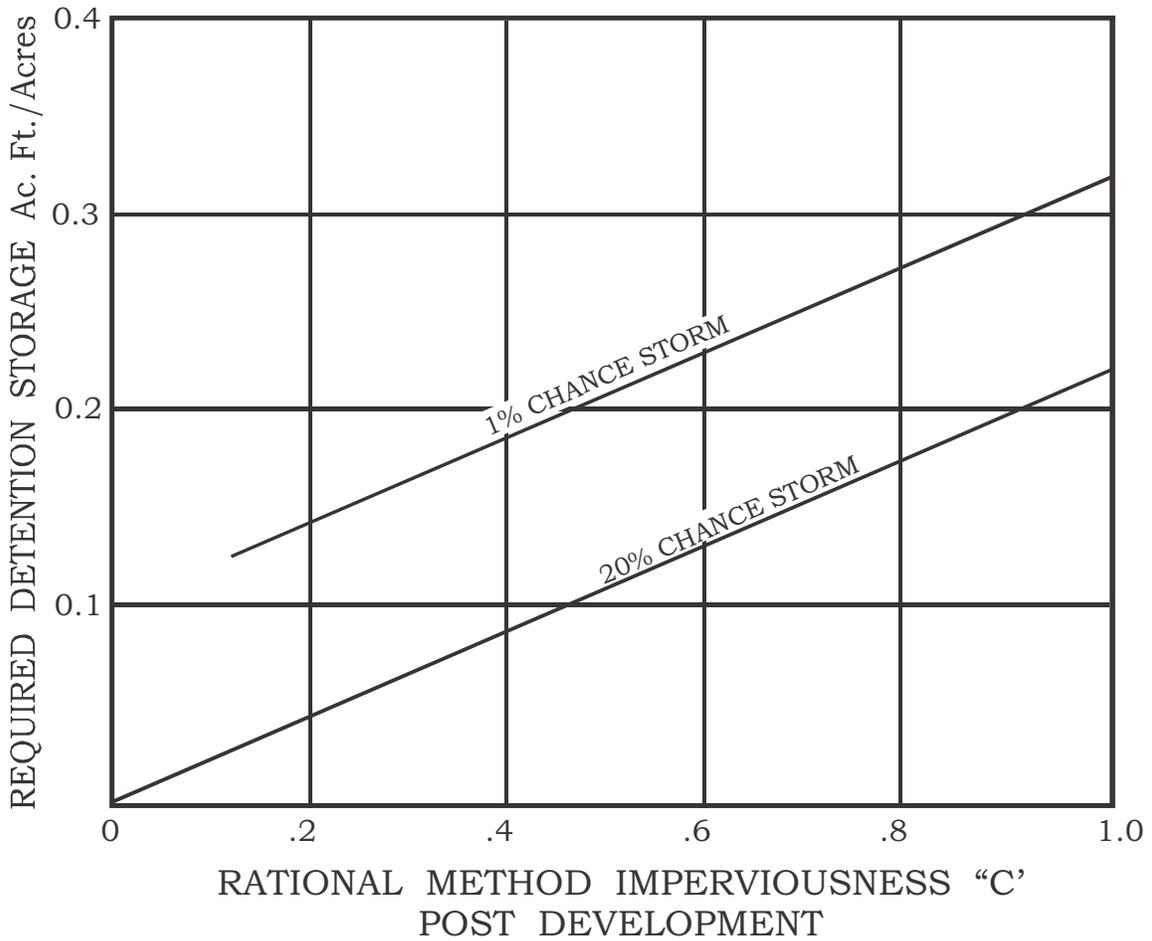
EXHIBIT "B"

APPROVED RUNOFF METHODS

Method	Applicable For		Min. Drainage Area (Acres)	Max. Drainage Area (Acres)
	Peak Flow Calcs	Volume Calcs		
Rational Method	Yes	No	0	200
SCS Method	Yes	Yes	0	2000
Snyder's Method With Tulsa Modifiers	Yes	Yes	10	None
Unit Volume Table	No	Yes	0	2

EXHIBIT "C"

UNIT VOLUME DETENTION CURVES



REFERENCE: CITY OF TULSA STORMWATER MANAGEMENT
CRITERIA MANUAL, March 1994

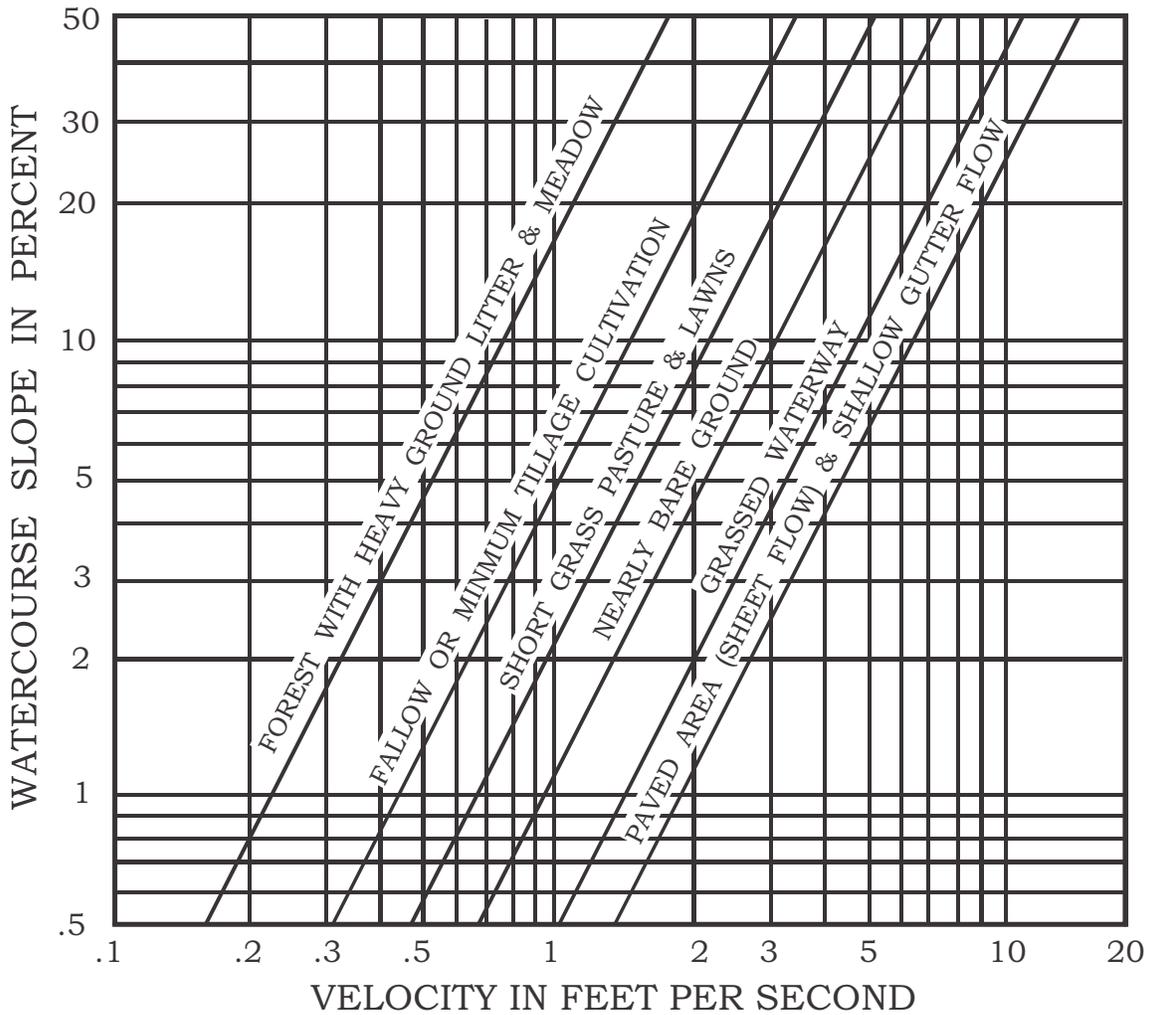
EXHIBIT “D”

RUNOFF COEFFICIENTS AND PERCENT IMPERVIOUSNESS		
Land Use Or Surface Characteristic	Percent Imperviousness	Runoff Coefficients
BUSINESS: Commercial Areas Neighborhood Areas	70 to 95 60 to 80	0.70 to 0.95 0.50 to 0.70
RESIDENTIAL Single Family Multi-unit (detached) Multi-unit (attached) ½ acre lot or larger Apartments	30 to 60 45 to 55 65 to 75 25 to 40 65 to 75	0.30 to 0.60 0.40 to 0.60 0.60 to 0.75 0.25 to 0.40 0.50 to 0.70
INDUSTRIAL Light uses Heavy Uses	70 to 80 80 to 90	0.50 to 0.80 0.60 to 0.90
PARKS, CEMETERIES	4 to 8	0.10 to 0.25
PLAYGROUNDS	10 to 20	0.20 to 0.35
SCHOOLS	40 to 60	0.50 to 0.60
RAILROAD YARDS	35 to 45	0.20 to 0.35
UNDEVELOPED AREAS Cultivated Pasture Woodland Offsite flow analysis (land use not defined)	30 to 70 20 to 60 5 to 40 35 to 55	0.35 to 0.60 0.25 to 0.50 0.10 to 0.40 0.45 to 0.65
STREETS Paved Gravel	90 to 100 50 to 70	0.80 to 0.90 0.55 to 0.65
DRIVES AND WALKS	90 to 100	0.80 to 0.90
ROOFS	85 to 95	0.80 to 0.90
LAWNS Sandy soils Clayey soils	5 to 10 10 to 30	0.10 to 0.20 0.13 to 0.35

EXHIBIT "E"

TRAVEL TIME VELOCITIES FOR OVERLAND FLOW

FOR TC - RATIONAL METHOD
FOR T1 - SCS METHOD



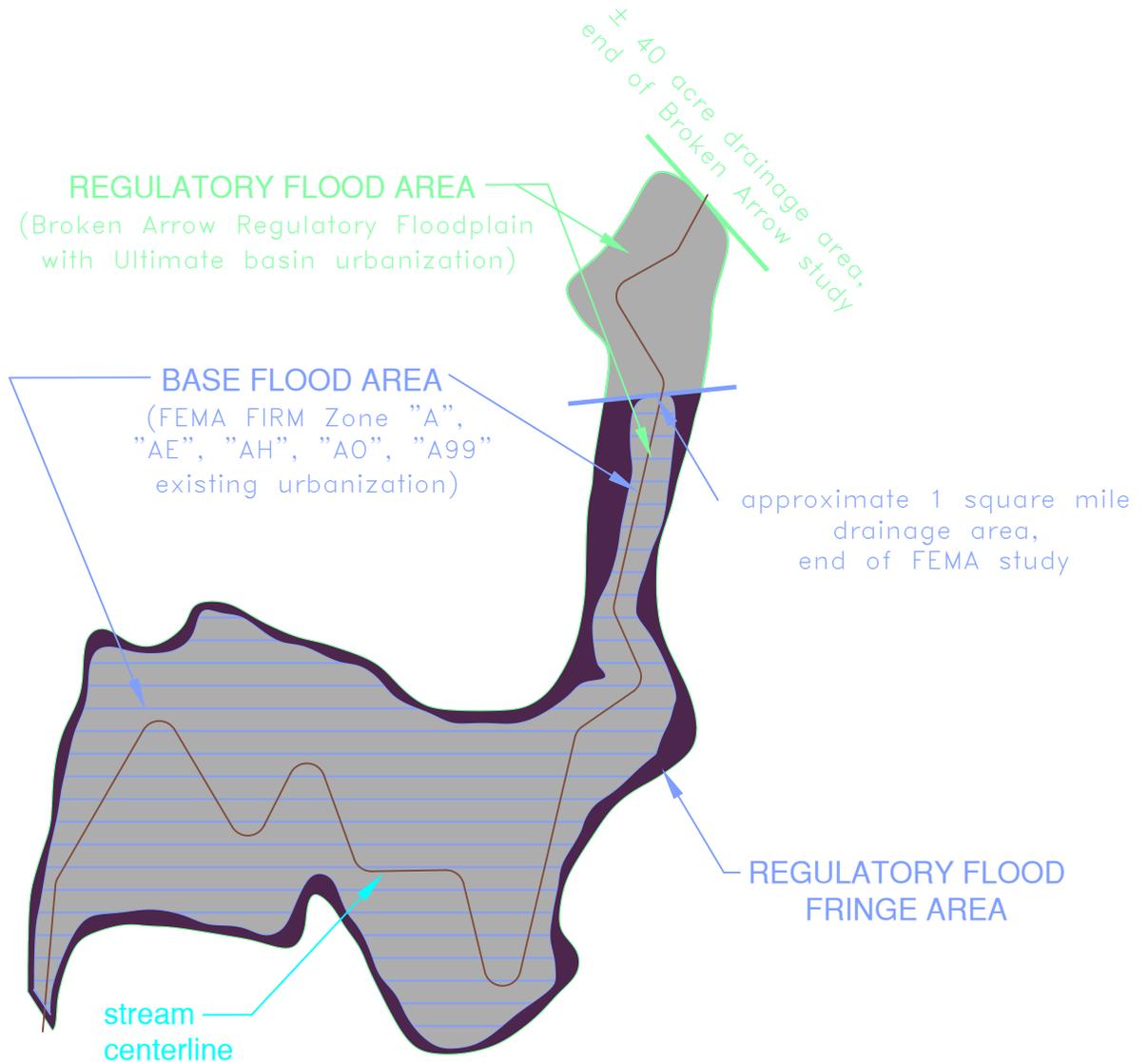
REFERENCE: URBAN HYDROLOGY FOR SMALL WATERSHEDS
TECHNICAL RELEASE Number 55, SCS - January 1975

EXHIBIT “F”

STORM FREQUENCY TERMINOLOGY TABLE

Modern Terminology	Past Terminology
0.2% Chance Storm	500 – Year Storm
1% Chance Storm	100 – Year Storm
2% Chance Storm	50 – Year Storm
10% Chance Storm	10 – Year Storm
20% Chance Storm	5 – Year Storm

City of Broken Arrow Example Regulatory Floodplain



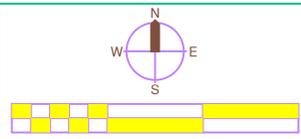
LEGEND

- BASE FLOOD AREA
- REGULATORY FLOOD FRINGE AREA



**CITY OF BROKEN ARROW, OKLAHOMA
ENGINEERING DEPARTMENT**

City of Broken Arrow
Example Regulatory Floodplain



DRAFTER
ADN
DATE
08/01
DRAWING
regfloodplain



City Staff to complete this section
Determination Number: _____

FEE-IN-LIEU OF DETENTION DETERMINATION FORM

EXHIBIT "H"

Project Name: _____

Project Contact: _____ Phone Number: _____

Mailing Address: _____

Legal Description of Property: _____

Section/Township/Range	Legal Description (Attach Legal and Vicinity Map if Required)
------------------------	---

County Parcel Number: _____

Is this property part of a P.U.D. or Plat? Yes No

If yes, provide name and number: _____

Nature of Proposed Project: (Check All That Apply)

- Residential Plat
- Commercial/Industrial Plat
- Commercial/Industrial Site Plan
- Other (describe) _____

Approximate area of site: _____ acres.

Approximate area of proposed development: _____ acres.

THE LOCAL ADMINISTRATOR IS TO COMPLETE THE BELOW SECTION:

- Drainage Basin: Haikey Creek Broken Arrow Creek Adams Creek
 Elm Creek Aspen Creek

Is there a constructed facility affecting this project? Yes No

Is there a planned facility affecting this project? Yes No

- Fee-In-Lieu of Detention will be required on this project.*
- Fee-In-Lieu of Detention will be allowed on this project. *
- On Site Detention will be required on this project.

LOCAL ADMINISTRATOR

DATE

An approved fee-in-lieu of detention determination form is valid for one year after the date signed. If no development plans are submitted within that time frame, a new determination will be required.

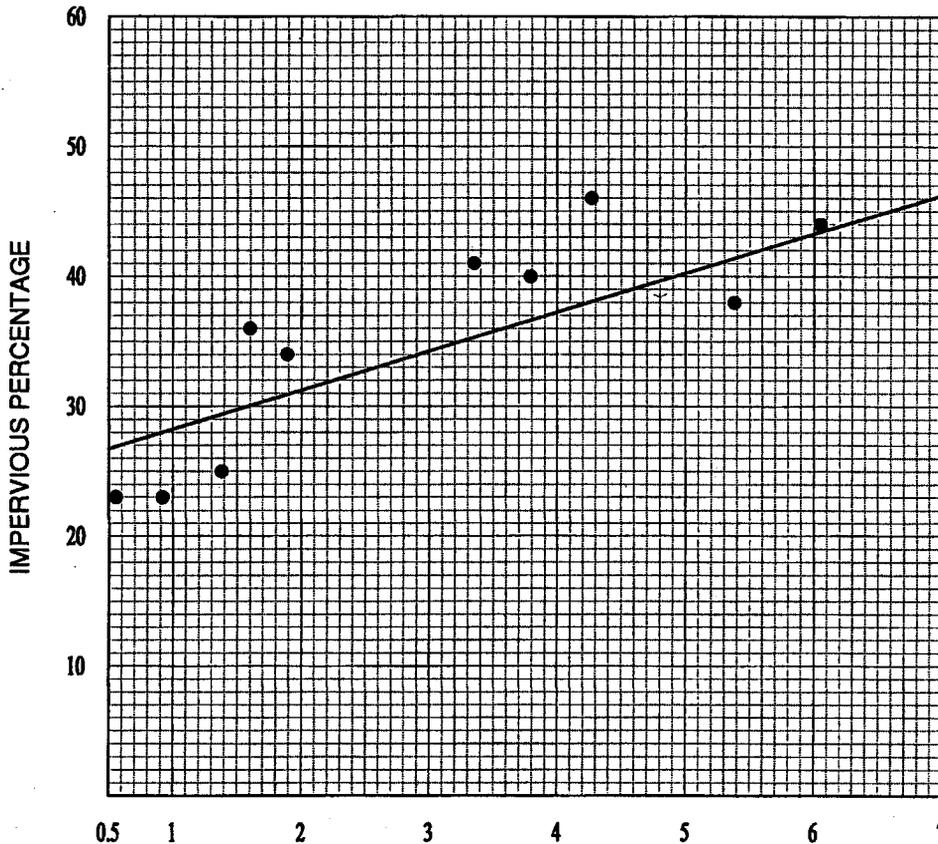
*Developments designated fee-in-lieu of detention must show that stormwater can be conveyed to downstream stormwater drainage systems without adversely impacting offsite properties or creating a public safety hazard.

FIGURE "I"

RESIDENTIAL HOUSING DENSITY AND IMPERVIOUS AREA

RAW DATA	
UNITS PER ACRE	IMPERVIOUS %
4.27	46
1.38	25
1.60	36
1.89	34
3.79	40
5.38	28
3.35	41
6.05	44
0.55	23
0.92	23

LINEAR REGRESSION MODEL	
UNITS PER ACRE	IMPERVIOUS %
0.0	25.24
1.00	28.24
2.00	31.24
3.00	34.25
4.00	37.25
5.00	40.25
6.00	43.25

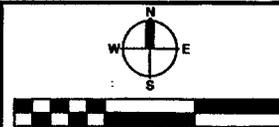


* BASED ON 10 SINGLE-FAMILY HOUSING UNITS PER ACRE
SUBDIVISIONS WITHIN CITY
OF BROKEN ARROW



CITY OF BROKEN ARROW, OKLAHOMA
ENGINEERING DEPARTMENT

Figure "I"
City of Broken Arrow



DRAFTER
TN
DATE
05/12/08
DRAWING



STORMWATER DEVELOPMENT PERMIT APPLICATION

EXHIBIT "J"

This application is in conformance with provisions of Ordinance No. 2443. The fee for a Stormwater Development Permit Application is \$25.00.

Proposed Subdivision Name: _____ Legal Property Owner or Applicant: _____ Mailing Address: _____ Phone Number: _____ Fax Number: _____

Tract Acreage: _____ County Parcel Number: _____

Legal Description of Property: _____
Section/Township/Range Subdivision Block No. Lot No.

If Property Not located in a Platted Subdivision: (Attach legal description)

Nature of Proposed Construction: (Check All That Apply)

- Residential Commercial Industrial Placement of Fill
- Alteration of Existing Public Stormwater Drainage System Other

Description of Proposed Construction:

Permit Certification:

I Certify that I am one of the following:

- Owner or lessee of the property on which permit work is to be performed.
- Agent of the property owner or lessee for which permit work is to be performed.
(Please attach notarized agreement.)
- Licensed Engineer or Architect employed in connection with the work.

Signature of Applicant: _____

Date: _____

Affidavit as to easements, dedications and rights-of-way

I _____ being duly sworn upon oath, state that I have researched and examined or caused to be researched and examined all recorded documents and instruments relating to said real property, and that all recorded easements, dedications and rights-of-way are known to me and are delineated on the plot plan which is a part of the application for Stormwater Development Permit.

It is understood that issuance of such Stormwater Development Permit does not authorize or permit construction of a permanent structure over or upon any easement, dedication or right-of-way.

Applicant will provide the minimum submittal requirements as follows:

- 1. Boundary Line Survey With All Easements and Floodplain Shown on Plans. () YES () NO
- 2. 1"= 2000' Scale Map Shown On Plans. () YES () NO
- 3. Project Title or Property Name Shown On Plans. () YES () NO
- 4. Existing and Proposed Contours or Spot Elevations Are Shown. () YES () NO
- 5. Existing Storm Sewer and Natural Features within 50' of Boundary Shown . () YES () NO
- 6. Manhole Top of Rim Elevations and Adjustments Shown. () YES () NO
- 7. Erosion Control Plan, Notes, and Details Provided. () YES () NO
- 8. Permanent Erosion Control Shown in Areas of Concentrated Flows. () YES () NO
- 9. Existing vs proposed Runoff Comparison Table Provided (If Applicable). () YES () NO
- 10. Runoff Conveyed to Storm Sewer System Before Entering Public Streets () YES () NO
Per Stormwater Management Ordinance No. 2443 Section 25-202(f)
- 11. 20% and 1% chance Storm Flows Shown. () YES () NO
- 12. 3 sets of Grading, Drainage, & Storm Plans Signed & Sealed by () YES () NO
a Professional Engineer.

FOR SMALL PROJECTS WITH MINIMAL IMPACTS TO THE STORMWATER SYSTEM, PORTIONS OF THE SUBMITTAL REQUIREMENTS MAY NOT BE REQUIRED. CONTACT THE LOCAL ADMINISTRATOR TO REQUEST VARIANCES TO THE SUBMITTAL REQUIREMENTS.

ANY PROJECT WITHIN THE CITY OF BROKEN ARROW REGULATORY FLOODPLAIN MUST ALSO HAVE A FLOODPLAIN DEVELOPMENT PERMIT

PERMIT ISSUED:

LOCAL ADMINISTRATOR

DATE

City Staff to complete this section Permit Number: _____ Dev. Number: _____



<p>City Staff to complete this section</p> <p>Permit Number: _____</p> <p>Dev. Number: _____</p>
--

**FLOODPLAIN DEVELOPMENT
PERMIT APPLICATION**

EXHIBIT "K"

This application is in conformance with provisions of Ordinance No. 2443. The fee for a Floodplain Development Permit Application fee is \$25.00.

Signature required in SECTION 1. Complete this form through SECTION 2.

Proposed Subdivision Name (if applicable): _____

SECTION 1: GENERAL PROVISIONS (Applicant to read and sign):

1. No work may start until a permit is issued.
2. The permit may be revoked if any false statements are made herein.
3. If revoked, all work must cease until permit is re-issued.
4. Development shall not be used or occupied until a Certificate of Compliance is issued.
5. The permit will expire if no work is commenced within one year of issuance.
6. Applicant is hereby informed that other permits may be required to fulfill local, state and federal regulatory requirements.
7. Applicant hereby gives consent to the Local Administrator or his/her representative to make reasonable inspections required to verify compliance.
8. I, THE APPLICANT, CERTIFY THAT ALL STATEMENTS HEREIN AND IN ATTACHMENTS TO THIS APPLICATION ARE, TO THE BEST OF MY KNOWLEDGE, TRUE AND ACCURATE.

_____ DATE: _____
(APPLICANTS SIGNATURE)

SECTION 2: PROPOSED DEVELOPMENT (To be completed by Applicant)

	<u>NAME</u>	<u>ADDRESS</u>	<u>TELEPHONE</u>
APPLICANT:	_____	_____	_____
CONTRACTOR:	_____	_____	_____
ENGINEER:	_____	_____	_____

PROJECT LOCATION: _____
ADDRESS AND LEGAL DESCRIPTION – AS ATTACHMENT IF NEEDED

Note: To avoid delay in processing the application, please provide enough information to easily identify the project location. Provide the street address, lot & block number or legal (attach) and, outside urban areas, the distance to the nearest intersecting road or well-known landmark. A sketch attached to this application showing the project location would be helpful.

DESCRIPTION OF WORK (Check all applicable boxes):

A. STRUCTURAL DEVELOPMENT:

ACTIVITY STRUCTURE TYPE ESTIMATED COST OF PROJECT \$ _____

- New Structure
- Addition
- Alteration
- Relocation
- Demolition
- Replacement
- Residential (1-4 Family)
- Residential (More than 4 Family)
- Non-residential (Flood proofing? Yes)
- Combined Use (Residential & Commercial)
- Manufactured (Mobile) Home (In Manufactured Home Park? Yes)

B. OTHER DEVELOPMENT ACTIVITIES:

- Clearing Fill Grading
- Excavation (Except for Structural Development Checked Above)
- Watercourse Alteration (Including Dredging and Channel Modifications)
- Drainage Improvements (Including Culvert Work)
- Road, Street or Bridge Construction
- Subdivision (New or Expansion)
- Individual Water or Sewer System
- Utility Construction

After completing SECTION 2, APPLICANT should submit form to Local Administrator

SECTION 3: FLOODPLAIN DETERMINATION (To be completed by Local Administrator)

The proposed development is located on FIRM Panel No. _____, Dated _____.

The Proposed Development:

- (Is Is Not) Located in the Broken Arrow Regulatory Floodplain
- (Is Is Not) Located in the FEMA Special Flood Hazard Area
FIRM zone designation is _____
100-Year flood elevation at the site is _____
- (Is Is Not) Located in the FEMA Floodway
- (Is Is Not) Located an Unnumbered "A" zone
 See Section 4 for additional instructions

SIGNED _____ DATE _____

Local Administrator

SECTION 4: ADDITIONAL INFORMATION REQUIRED (To be completed by Local Administrator)

The applicant must submit the documents *checked* below before the application can be processed:

- A site plan showing the location of all existing structures, water bodies, adjacent roads, lot dimensions and proposed development.
- Development plans, drawn to scale, and specifications, including where applicable; details for anchoring structures, proposed elevation of lowest floor (including basement), types of water resistant materials used below the first floor, details of flood proofing of utilities located below first floor and details of enclosures below the first floor.
- Subdivision or other development plans.
- Plans showing the extent of watercourse relocation and/or landform alterations.
- Top of new fill elevation _____ ft. NGVD
- Flood proofing protection level (non-residential only) _____ ft. NGVD. For flood proofed structures, applicant must attach certification from registered engineer or architect.
- Certification from a registered engineer that the proposed activity in the regulatory floodplain will not result in any adverse hydrological impact to the site, upstream, or downstream properties which includes but is not limited to

SECTION 5: PERMIT DETERMINATION (To be completed by Local Administrator)

I have determined that the proposed activity: Is Is Not in conformance with provisions of the City

of Broken Arrow Ordinance No. 2443, the permit is issued subject to the conditions attached to and made part of this permit.

SIGNED _____ DATE _____

If the Local Administrator found the permit application was not in conformance with the provisions of the City of Broken Arrow Ordinance No. 2443 he will provide a written summary of deficiencies. Applicant may revise and resubmit an application to the Local Administrator or may request a hearing from the Floodplain Appeals Board.

SECTION 6: AS-BUILT ELEVATIONS (To be submitted by Applicant before Certificate of Compliance is issued)

The following must be provided for project structures and grading. This section must be completed by a registered professional engineer or a licensed land surveyor (attach certification).

Complete 1 or 2 below.

1. Actual (As-Built) Elevation of the top of the lowest floor, including basement, bottom of lowest structural member of the lowest floor, excluding piling and columns) is: _____ft. NGVD.
2. Actual (As-Built) Elevation of flood proofing protection is: _____ft. NGVD

NOTE: Any work performed prior to submittal of the above information is at risk of the applicant.

SECTION 7: COMPLIANCE ACTION (To be completed by the Local Administrator)

The Local Administrator will complete this section as applicable based on inspection of the project to ensure compliance with the City of Broken Arrow's Stormwater Ordinance for flood damage prevention.

INSPECTIONS: DATE _____ BY _____ DEFICIENCIES? YES NO
DATE _____ BY _____ DEFICIENCIES? YES NO
DATE _____ BY _____ DEFICIENCIES? YES NO

SECTION 8: CERTIFICATE OF COMPLIANCE (To be completed by Local Administrator)

Certificate of Compliance issued by: _____ Date: _____

EXHIBIT "L"

CERTIFICATE OF COMPLIANCE
FOR DEVELOPMENT IN THE REGULATORY FLOOD AREA
(OWNER MUST RETAIN THIS CERTIFICATE)

FLOODPLAIN DEVELOPMENT PERMIT NO. _____
PERMIT DATE _____

PREMISES LOCATED AT:

OWNERS NAME AND ADDRESS:

CHECK ONE:

- NEW STRUCTURE
- EXISTING STRUCTURE
- FLOOD TOLERANT LAND USE
- CHANNEL IMPROVEMENT
- OTHER- Describe: _____

THE LOCAL ADMINISTRATOR IS TO COMPLETE THE SECTION BELOW.

A. COMPLIANCE IS HEREBY CERTIFIED WITH THE REQUIREMENTS OF LOCAL
STORMWATER MANAGEMENT ORDINANCE NO. 2443

SIGNED: _____ DATED: _____