

CITY OF BROKEN ARROW
RETAINING STRUCTURE INSPECTIONS PROGRAM
GUIDANCE MANUAL
DECEMBER 14, 2017

PREPARED BY:

CITY OF BROKEN ARROW
ENGINEERING AND CONSTRUCTION DEPARTMENT

INTEROFFICE MEMO

To: Mr. Michael L. Spurgeon, City Manager

From: Mr. Kenneth D. Schwab, P.E., CFM, Assistant City Manager – Operations

Copied: Mr. Alex Mills, P.E., CFM, Director of Engineering and Construction

Date: December 14, 2017

Re: Retaining Structure Inspections Program

KDS
12-14-17

In an effort to enhance public protection and improve the overall life of any specific publicly-owned retaining structures constructed in the public right of way or upon City owned property, the City of Broken Arrow has developed a unique Program to inspect these retaining structures which include: (1) earth retaining walls, (2) flood control and protection structures, as well as (3) sound or noise barrier walls. Presently, the State of Oklahoma does not require any “on-going” structural inspections of a publicly-owned retaining structure once it has been constructed and is effectively placed in operations or service, unless the structure specifically serves as a dam. Local and state building code do in fact require these structures to be inspected during the construction, but not legislation currently exists that requires continual observation to be performed once the structure is erected. The burden to prepare and develop an “on-going” inspections program is truly left up to the owner of the structures. A few municipalities across the nation have recognized a need to develop a program to better ensure properly maintained and operator structures, but very few have established a formal program.

Based upon the fact that the city has grown significantly over the past several decades and several retaining structures are continuing to age, much like other public infrastructure, the City of Broken Arrow developed an unprecedented Retaining Structures Inspections Program in order to conduct visual observations and investigations of the condition of specified structures in an effort to gauge the anticipated predicted continued performance of these structures. Using some of the requirements established by state statutes for the continued inspections of specific dams, Staff has developed a policy to govern the administration and oversight of the Retaining Structure Inspections Program, as well as establish a certification and training aspect to effectively ensure qualified inspectors conduct these investigations.

The policy identifies the risk assessment criteria and classification for structures as well as the individual responsibilities and duties of special personnel. In addition, a current Retaining Structure Inventory is included to document which structures meet with the policy requirements. As additional structures are identified that meet with the requirements of the policy, they will be added to an updated Inventory record.

The above identified information has been compiled in a Program Guidance Manual and is attached for your information. Thank you for supporting this initiative.

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SECTION ONE:

POLICY

**CITY OF BROKEN ARROW
RETAINING STRUCTURE INSPECTIONS PROGRAM
BASIC GUIDELINES AND STANDARD OPERATING PROCEDURES
REVISION 0 – DECEMBER 12, 2017**

City Manager

Effective Date

- 1.0 Overview.** This document is intended to provide the basic guidelines and standard operating procedures required to implement the City of Broken Arrow’s Retaining Structure Inspections Program for publicly-owned facilities. This Program is hereby established solely for publicly-owned structural retaining features, such as earth retaining wall and flood walls or water retaining structures, and is not intended for landscaping or no risk retaining features.
- 2.0 Definitions.** The following definitions are intended to provide clarity and to assist in the implementation of this Program:
- 2.1 Clear Height. The vertical distance measured from the surface, whether it is ground, pavement or water, of the non-retained side of the structure to the top of the retaining structure.
 - 2.2 Retained Height. The vertical distance measured from the surface, whether it is ground, pavement or water, of the non-retained side of the structure to the top of the retaining material.
 - 2.3 Retaining Structure. A vertical structure intended to retain a specific material, generally soil or water, on one side of the structure, but has a different height between the surface of the retained material, commonly referred to as backfill material, and the surface of the non-retained material on the opposite side.
 - 2.4 Retaining Structure Material. The actual physical material used to form the retaining structure. Material is commonly reinforced concrete or a concrete segmental block unit, but could be another material such as steel or wood planks.
 - 2.5 Risk Assessment. For the purposes of this Program, risk is assessed solely as a function of the structures clear height defined below, unless otherwise deemed necessary by the Retaining Structures Engineer:
 - 2.5.1 Low Risk – Retaining structures that are 4-feet in clear height or less;
 - 2.5.2 Limited Risk – Retaining structures that a greater than 4-feet in clear height up to a clear height of 12-feet;
 - 2.5.3 Moderate Risk – retaining structures that are greater than 12-feet in clear height up to a clear height of 20-feet; and
 - 2.5.4 High Risk – Retaining structures that are greater than 20-feet in clear height.
 - 2.6 Seismic Activity. Seismic activity with respect to this policy that constitutes a special inspection is a 5.0 magnitude earthquake that occurs within a 50-mile radius of the individual retaining structure.

3.0 Statutes and Regulations. There are presently no known state statutes and/or state regulations that govern protocols, processes and procedures with respect to operational and performance-based inspections regarding publicly-owned retaining structure systems. If state statutes and/or regulations become available and are subsequently adopted, then the City will incorporate the appropriate and applicable laws and/or rules to the City of Broken Arrow's Retaining Structure Inspections Program basic guidelines and standard operating procedures. Design of a retaining structure shall comply with the following standards:

- 3.1 International Code Council (ICC), International Building Code (IBC), latest edition adopted by city ordinance.
- 3.2 City of Broken Arrow, Engineering Design Criteria Manual (EDC Manual), latest revision.

4.0 Roles. The following section identifies the City of Broken Arrow's representative responsible for the duties associated with each specific role:

- 4.1 Retaining Structure Owner – The City of Broken Arrow shall serve as the retaining structure owner for each individual publicly-owned retaining structure located within public right-of-way or on public property, unless specifically exempted from the Program;
- 4.2 Retaining Structure Owner Representative – The City Manager or his/her designee shall serve as the Retaining Structure Owner's Representative and perform the duties thereof;
- 4.3 Retaining Structure Inspections Program Coordinator – The Planning Division Manager in the Engineering and Construction Department shall serve as the Retaining Structure Inspections Program Coordinator and perform the duties thereof;
- 4.4 Retaining Structure Engineer – The Director of Engineering and Construction or his designee shall serve as the Retaining Structure Engineer and perform the duties thereof; and
- 4.5 Retaining Structure Operator – The Streets and Stormwater Department Director in the Streets and Stormwater Department shall serve as the Retaining Structure Operator for all publicly-owned retaining structures; however, the daily operations and maintenance responsibilities shall be administered based upon the type of structure as defined below:
 - 4.5.1 Treatment Plant Retaining Structure – Any water or wastewater treatment plant process facility identified as a retaining structure in accordance with this document and/or city policies shall be operated by the specific Plant Manager;
 - 4.5.2 Park Retaining Structures - Any city park, golf course or recreational facility identified as a retaining structure in accordance with this document and/or city policies shall be operated by the Director of Parks and Recreation or his/her designee;
 - 4.5.3 Other Special Retaining Structures – All other facilities identified as a retaining structure in accordance with the state statutes shall be operated by the Assistant Director of Streets and Stormwater in the Street and Stormwater Department, unless specifically identified otherwise.

- 5.0 Duties.** The following general duties shall be the responsibility of each specific role identified in Section 4.0:
- 5.1 Retaining Structure Owner Representative – shall make all administrative decisions associated with ownership of the publicly-owned retaining structure;
 - 5.2 Retaining Structure Inspections Program Coordinator – shall coordinate all aspects of the Program both internally between other departments, as well as externally with other agencies, such as the Oklahoma Department of Transportation, Tulsa County, Wagoner County, and other agencies, if applicable;
 - 5.3 Retaining Structure Engineer – shall make or cause to make all technical decisions associated with the ownership of the publicly-owned retaining structures;
 - 5.4 Retaining Structure Operator – shall make or cause to make all daily operational and maintenance decisions associated with ownership of the publicly-owned retaining structure.
- 6.0 Reporting.** Retaining Structure Operators shall conduct both routine and special inspections associated with the specific structure under their supervisory oversight. These reports shall be examined and summarized in the Inspections Report as specified by this document and defined below.
- 6.1 Routine Inspections – shall be performed in accordance with the structure’s individual classification as established by the City of Broken Arrow:
 - 6.1.1 Low Risk – are not required to be inspected in accordance with the requirements specified in this policy, but should be examined by the individual operator in accordance to a routine maintenance schedule established by the operator;
 - 6.1.2 Limited Risk – shall be inspected once in a five (5) year period and the Routine Inspection Report (RIR) turned into the Retaining Structure Program Coordinator;
 - 6.1.3 Moderate Risk – shall be inspected once in a three (3) year period and the Routine Inspection Report (RIR) turned into the Retaining Structure Program Coordinator; and
 - 6.1.4 High Risk – shall be inspected annually and the Routine Inspection Report (RIR) turned into the Retaining Structure Program Coordinator.
 - 6.2 Special Inspections – shall be performed immediately after a natural disaster event, such as a flood or seismic activity, which may have impacted the integrity of the structure. Special Inspections shall be performed on High Risk Classification structures.
 - 6.3 Professional Structural Engineer Inspections – shall be performed on any structure that the Retaining Structure Engineer deems critical and/or essential to the public health and safety and that a failure either structurally or hydraulically cause damage if not averted or repaired. The Inspection shall be performed by a licensed professional engineer in the State of Oklahoma qualified in structural design, construction and behavioral analysis of retaining structures.

6.4 Report Format – attached to this document is a Standard Retaining Structure Report format intended to be used for both Routine Inspections and Special Inspections.

7.0 Action Plans. If a severe structural distress or hydraulic deficiency is observed during an Inspection, whether it is a Routine Inspection or a Special Inspection, then the Retaining Structure Engineer shall implement a pre-determined Action Plan defined as follows:

7.1 Preventive Action Plan. The retaining Structure Engineer shall perform or cause to be performed a Professional Structural Engineer Inspection on any structure deemed necessary. One copy of the subsequent professional engineering report shall be submitted to the Retaining Structure Program Coordinator to serve as a record while another copy shall be submitted to the Retaining Structure Owner's Representative for administrative purposes.

7.2 Emergency Action Plan. If the structure show signs of imminent failure, then the City's Emergency Action Plan shall be implemented.

SECTION TWO:
REPORT FORM

CITY OF BROKEN ARROW
RETAINING STRUCTURE INSPECTION REPORT (RSIR)

Inspection Date: _____ Structure Name: _____
Inspector Name: _____ Structure ID No.: _____
Inspection Type: _____ Structure Type: _____

Section (I) - Retaining Structure Foundation Observations:

Is there any heaving, cracking, bludging, depression, settlement or distress of non-retained material in front of the retaining feature? If so, where along the base of the structure is the disturbance located.

Section (II) - Retaining Structure Facing Observations:

Is there any heaving, cracking, bludging, splading, splitting or distress of retaining feature material? If so, where along the face of the retaining structure is the disturbance located.

Section (III) - Retaining Structure Backfill Observations:

Is there any heaving, cracking, bludging, depression, distress, ponding of retained material behind the retaining feataure; weep holes clogged? If so, where along the retaining structure is the disturbance.

Section (IV) - Action Plan Implementation Measures:

Is there a need to implement the Action Plan with respect to this structure? If so, which plan?

Inspector Signature Date Retaining Structure Engineer Date

SECTION THREE:

APPLICATION

CITY OF BROKEN ARROW

RETAINING STRUCTURE INSPECTION APPLICATION (RSIA)

Name: _____
Department: _____
Supervisor: _____

Date: _____
Position: _____

Section (I) - Education Background:

High School Education: _____
Baccalaureate Degree(s): _____

Graduate Degree(s): _____

Section (II) - Specialized Training or Certifications with Retaining Structures:

Section (III) - Experience with Retaining Structures:

Section (IV) - Additional Information:

Inspector Signature Date

SECTION FOUR:
TRAINING GUIDE

**CITY OF BROKEN ARROW
RETAINING STRUCTURES INSPECTIONS PROGRAM
TRAINING MATERIAL**

1.0 General Categories of Retaining Structures

- 1.1 Retaining Walls
- 1.2 Flood Walls
- 1.3 Sound (Noise) Barrier Walls
- 1.4 Dams (Not a part of this Program – See Dam Safety Program)

2.0 Types of Retaining Structures

- 2.1 Traditional Retaining Walls
 - 2.1.1 Concrete Retaining Walls
 - A. Gravity Retaining Walls
 - B. Cantilevered Retaining Walls
 - C. Tied-Back Retaining Walls
 - D. Solider Retaining Walls
 - E. Masonry Block Retaining Walls
 - 2.1.2 Steel Retaining Walls
 - A. Sheet Pile Walls
 - B. Anchored Sheet Pile Walls
 - 2.1.3 Timber Retaining Walls
 - A. Railroad Tie Retaining Walls
 - 2.1.4 Hybrid
 - A. Modified Solider Pile Walls
- 2.2 Non-Traditional Retaining Walls
 - 2.2.1 Soil Stabilized Retaining Walls
 - A. Reinforced Soil Retaining Walls
 - B. Soil-Nailed Retaining Walls
 - 2.2.2 Stone Retaining Walls
 - A. Stepped Gabion Basket Retaining Walls
 - B. Anchored Gabion Basket Retaining Walls
 - C. Grouted Laid-Up Rip Rap Walls
- 2.3 Mechanically-Stabilized Earth Retaining Walls
 - 2.3.1 Modular (Segmental) Block Retaining Walls
 - A. Anchored Pinned (Small Block) Retaining Walls
 - B. Anchored Gravity (Large Block) Retaining Walls

3.0 Geotechnical Properties

- 3.1 Soil Characteristics
 - 3.1.1 Types of Soils
 - A. Cohesionless Soils
 - 1. Sands (S)
 - 2. Gravels (G)
 - B. Cohesive Soils
 - 1. Clays (C)
 - 2. Silts (M)

- C. Sedimentary Rocks
 - 1. Claystone (Shale)
 - 2. Sandstone
 - 3. Limestone
- C. Metamorphic Rocks
- D. Igneous Rocks
- 3.1.2 Soil Densities (Unit Weight)
 - A. Dry Soil Density (γ_d) – Water Content Ratio (ω): $\omega \leq 5\%$
 - B. Moist Soil Density (γ_m) – WCR (ω): $10\% \leq \omega \leq 70\%$
 - C. Saturated Soil Density (γ_{sat}) – WCR (ω): $\omega \geq 80\%$
- 3.1.3 Soil Description Parameters
 - A. Gradation
 - 1. Well Graded
 - 2. Poorly Graded
 - B. Stiffness
 - 1. Very Soft
 - 2. Soft
 - 3. Medium Stiff
 - 4. Stiff
 - 5. Very Stiff
 - C. Drainability
 - 1. Drained
 - 2. Undrained
- 3.1.4 Internal Angle of Friction (ϕ)
 - A. Clays (Low Plasticity)
 - 1. Drained: $24^\circ \leq \phi \leq 28^\circ$
 - 2. Undrained: $\phi = 0^\circ$
 - B. Silts (Low Plasticity)
 - 1. Drained: $26^\circ \leq \phi \leq 30^\circ$
 - 2. Undrained: $\phi = 0^\circ$
 - C. Sands (Poorly Graded to Well Graded)
 - 1. Drained: $28^\circ \leq \phi \leq 36^\circ$
 - 2. Undrained: Sands drain, thus ϕ same as above
 - D. Gravels (Poorly Graded to Well Graded)
 - 1. Drained: $32^\circ \leq \phi \leq 40^\circ$
 - 2. Undrained: Gravels drain, thus ϕ same as above
- 3.1.5 Ultimate Cohesion (C_u)
 - A. Normally Consolidated Soils
 - 1. Very Soft: $0 \text{ psf} \leq c_u \leq 250 \text{ psf}$
 - 2. Soft: $251 \text{ psf} \leq c_u \leq 500 \text{ psf}$
 - 3. Medium Stiff: $501 \text{ psf} \leq c_u \leq 1,000 \text{ psf}$
 - 4. Stiff: $1,001 \text{ psf} \leq c_u \leq 2,000 \text{ psf}$
 - 5. Very Stiff: $2,001 \text{ psf} \leq c_u \leq 4,000 \text{ psf}$
 - B. Overconsolidated Soils
 - 1. Very Soft: $c_u = 0 \text{ psf}$
 - 2. Soft: $1 \text{ psf} \leq c_u \leq 250 \text{ psf}$

3. Medium Stiff: $251 \text{ psf} \leq c_u \leq 500 \text{ psf}$
4. Stiff: $501 \text{ psf} \leq c_u \leq 1,000 \text{ psf}$
5. Very Stiff: $1,001 \text{ psf} \leq c_u \leq 1,500 \text{ psf}$

3.2 Soil Mechanics

3.2.1 Stress Relationships

- A. Normal (Vertical) Stress (σ_v)

$$\sigma_v = \gamma h$$

- B. Lateral (Horizontal) Stress (σ_h)

$$\sigma_h = K\sigma_v = K\gamma h$$

- C. Shear Stress (τ)

$$\tau = c_u + R\mu_{sl}$$

3.2.2 Stress Concepts

- A. Total Stress Concept

- B. Effective Stress Concept

$$\sigma' = K(\gamma_{\text{sat}} - \gamma)h + \gamma_w h$$

3.2.3 Lateral (Horizontal) Earth Stress Ratio (K)

- A. Active Lateral Earth Stress Ratio (K_a)

1. Rankine Concept ($\beta = 0^\circ$)

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

2. Coulomb Concept ($\beta \geq 0^\circ$)

$$K_a = \cos^2(\phi + \theta) / (\cos^2 \theta \cos(\theta - \delta) [1 + \{\sin(\phi + \delta) \sin(\phi - \beta) / \cos(\theta - \delta) \cos(\theta + \beta)\}^{1/2}]^2)$$

where: $\delta \leq \theta$ and

$$\beta \leq \phi$$

- B. "At-Rest" Lateral Earth Stress Ratio (K_o)

1. Jaky Concept

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

2. Others

- C. Passive Lateral Earth Stress Ratio (K_p)

1. Rankine Concept ($\beta = 0^\circ$)

$$K_p = (1 + \sin \phi) / (1 - \sin \phi)$$

2. Coulomb Concept (Do Not Use)

3.2.4 Friction or Adhesion Concepts

- A. Grain Particle to Grain Particle Friction

1. Cohesionless Soils

$$\mu_{sl} = \tan \delta$$

where δ is between $2/3 \phi$ to $3/4 \phi$

2. Drained Cohesive Soils

Same as above

- B. Soil to Material Surface Contact Adhesion

1. Cohesionless Soils

$$c_a = 0$$

2. Cohesive Soils

$$c_a = v c_u$$

where v is between $2/3$ to $3/4$

3.2.5 Soil Plasticity Concepts for Cohesive Soils

- A. General Concepts (Atterberg Limits)
 - 1. Liquid Limit
 - 2. Plastic Limit
 - 3. Shrinkage Limit
- B. Plastic Index ($PI = LL - PL$)
 - 1. Trace amount of Plasticity: $0 \leq PI \leq 4$
 - 2. Low Plasticity Material: $5 \leq PI \leq 12$
 - 3. Slightly Plastic Material: $13 \leq PI \leq 17$
 - 4. Moderately Plastic Material: $18 \leq PI \leq 24$
 - 5. Highly Plastic Material: $PI \geq 25$

4.0 Design Parameters

4.1 External Stability Design

- A. Traditional and Non-Traditional Retaining Wall Modes of Failure
 - 1. Overturning Failure
 - 2. Sliding Failure
 - 3. Bearing Failure
 - 4. Buoyancy Failure
 - 5. Global Stability Failure
- B. Mechanically Stabilized Earth Retaining Wall Modes of Failure
 - 1. Overall External Unit Stability
 - a. Overturning Failure
 - b. Sliding Failure
 - c. Bearing Failure
 - d. Buoyancy Failure
 - e. Global Stability Failure
 - 2. Localized Block Stability
 - a. Block Sliding Failure
 - b. Crest Toppling Failure
 - c. Facing Connection Failure
 - d. Compound Stability Failure

4.2 Internal Stability Design

- A. Reinforced Concrete Structures (Unified Design Approach)
 - 1. Shear Capacity
 - 2. Flexural Bending Capacity
 - 3. Torsional Bending Capacity
- B. Steel Structures (ASD or LRFD)
 - 1. Axial Tension/Compression Capacity
 - 2. Shear Capacity
 - 3. Flexural Bending Capacity
 - 4. Torsional Bending Capacity
 - 5. Flange Buckling
 - 6. Web Crippling
 - 7. Others
- C. Timber Structures
- D. Anchored Systems
 - 1. Steel Anchors

- 2. Deadman
- 3. Geosynthetics
- 4. Others
- E. Mechanically Stabilized Earth Retaining Wall Modes of Failure
 - 1. Block Shear Capacity
 - 2. Block Axial Compression Capacity
 - 3. Anchorage Pullout Failure
 - 4. Anchor Tensile Overstress Failure
- 4.3 Serviceability Design
 - A. Stormwater Runoff (Drainage) Design
 - B. Hydrostatic Relief Design
 - C. Deflection Considerations
 - D. Public Safety Considerations
- 5.0 Inspection Considerations**
 - 5.1 General Considerations
 - 5.2 Overall Site Conditions
 - A. Vegetation
 - B. Drainage
 - 1. Global
 - 2. Localized
 - 5.3 Foundation System Soil Distress
 - A. Heaving (Pushing)
 - B. Swelling
 - C. Depression
 - D. Cracking
 - 5.4 Structure System Distress
 - A. Facing
 - B. Spalding
 - C. Cracking
 - D. Bulging
 - E. Buckling
 - F. Fatigue
 - 5.5 Anchorage System Distress
 - A. Fasteners
 - B. Brittleness/Ductility
 - 5.6 Backfill Material Soil Distress
 - A. Cracking
 - 1. Tension (Sliding)
 - 2. Shear (Settlement)
 - B. Depression (Ponding)
 - C. Swelling
 - D. Internal Drainage
- 6.0 Inspection Procedure (Recommended Methodology)**
 - 6.1 Document General Information
 - 6.2 Document Overall/Global Observations
 - 6.3 Document Foundation Observations

- 6.4 Document Structure System Observations
- 6.5 Document Anchorage System Observations
- 6.6 Document Backfill Material Observations

7.0 Reporting

- 7.1 Inspector Complete Report
 - A. Inspection Date
 - B. Structure Identification Number
 - C. Identify Structure Type
 - D. Identify Structure Operator
 - E. Document Observations
 - F. Review Report
 - G. Executed Signature
- 7.2 Submit Report to Program Coordinator
- 7.3 Program Coordinator Action Plan Steps
 - A. If operations or maintenance is required as identified by the Inspection Report, then the Project Coordinator shall contact Retaining Structure Operator to implement a Maintenance Action Plan. Retaining Structure Operator shall document the action taken.
 - B. If preventive action is required as identified by the Inspection Report, then Project Coordinator shall contact the Retaining Structure Engineer to implement the Preventive Action Plan. The Retaining Structure Program Coordinator shall document the action taken.
 - C. If the Inspection Report identifies an emergency situation, then the Inspector shall contact Retaining Structure Engineer directly and the Retaining Structure Engineer shall deem whether it is necessary to implement the Emergency Action Plan or the Preventive Action Plan. The Retaining Program Coordinator shall document the steps taken.

SECTION FIVE:
TRAINING RECORD

SECTION SIX:
CERTIFICATION FORM

CITY OF BROKEN ARROW

DEPARTMENT OF ENGINEERING AND CONSTRUCTION RETAINING STRUCTURE INSPECTION PROGRAM

KENNETH D. SCHWAB, P.E., MSCE

CERTIFIED INSTRUCTOR

This document certifies that the individual identified above has satisfied all requirements necessary to be considered a Certified Instructor for the City of Broken Arrow Retaining Structure Inspection Program and is, therefore, considered qualified to train potential candidates seeking the classification of a Certified Inspector. The above individual through education, training and practice in the specified area of science and engineering is hereby certified to serve as an instructor on behalf of the City of Broken Arrow as of this date **December 12, 2017**.

Courses Completed:

- (1) Bachelor of Science in Civil Engineering, Oklahoma State University, 1988;
- (2) Master of Science in Civil Engineering (Geotechnical Emphasis), Oklahoma State University, 1995;
- (3) Design of Segmental Retaining Walls, National Concrete Masonry Institute, June 28, 2008, 4 hours;
- (4) Advanced Topics in Slope Stability Analysis, Dr. Garry Gregory, Ph.D., P.E., April 3, 2009, 6 hours;
- (5) Design of Small Dams and Dam Stability Analysis, ASCE, 2011, 2 hours;
- (6) Shallow Foundation Design, Construction and Repair, R. Michael Bivens, March 2, 2012, 6 hours;
- (7) Design Modifications to the Wind Load Analysis in ASCE 7-10, April 2012, 4 hours;
- (8) Retaining Wall Design and Slope Stabilization Techniques, Rajendra Meruva, P.E., Sept. 15, 2017, 6 hours.

CITY OF BROKEN ARROW

DEPARTMENT OF ENGINEERING AND CONSTRUCTION
RETAINING STRUCTURE INSPECTION PROGRAM

NAME

CERTIFIED INSPECTOR

This document certifies that the individual identified below completed the City of Broken Arrow Retaining Structure Inspection Program training requirements. This program equates to 2.0 professional development hours (PDH's) on the following date(s) Date.

Instructor

Program Coordinator

SECTION SEVEN:
INVENTORY

**CITY OF BROKEN ARROW
RETAINING STRUCTURE INSPECTIONS PROGRAM
RETAINING STRUCTURES INVENTORY
DECEMBER 13, 2017**

BA ID NO.	Publically-Owned Structure	General Location	Operator	Height (ft)	Length	Year Const.	Type	Risk	Des.	Latitude	Longitude	Purpose	Inspected
	Tiger Hill Retaining Wall	Kenosha St. and 9th Street	Streets	28.00	1,000	2012	Segmental	High	Yes	36.06020	-95.78155	Commercial	NA
	Hillside Drive Retaining Wall	Hillside Drive east of Charleston	Streets	22.00	645	2012	Segmental	High	Yes	36.75142	-95.78564	Roadway	NA
	Albany Retaining Wall	Albany Street at Hillside Drive	Streets	15.42	1,120	2000	Segmental	Moderate	No	36.07336	-95.78962	Roadway	NA
	Liberty Park Trail - North	Trail east of Elm Place	Parks	22.00	274	2017	Segmental	High	Yes	35.99227	-95.78354	Pedestrian	12/15/2010
	Liberty Park Trail - South	Trail east of Elm Place	Parks	22.00	277	2017	Segmental	High	Yes	36.02690	-95.81050	Pedestrian	12/15/2010
	Bass Pro Pond Wall	Los Cabos and Charleston	Streets	12.50	75	2013	Cantilevered	Moderate	Yes	36.06963	-95.78988	Parking	NA
	Inverness Retaining Wall	Inverness Apartments	Streets	8.00	203	NA	Segmental	Limited	No	35.99947	-95.79756	Pedestrian	NA
	Timber Ridge Wall West	Kenosha Street at 33rd Street	Streets	4.00	1,020	NA	Segmental	Low	No	36.06103	-95.75042	Pedestrian	NA
	Timber Ridge Wall East	Kenosha Street at 33rd Street	Streets	4.00	520	NA	Segmental	Limited	No	36.06103	-95.74721	Pedestrian	NA
	Castlegate Detention Pond	Jackson Park	Stormwater	6.00	600	2010	Segmental	Limited	No	36.03468	-95.84772	Pedestrian	NA
	Cantaberry Duck Pond	Aspen Ave. 2200 S. of New Orleans	Streets	4.00	208	2010	Segmental	Low	Yes	36.01137	-95.81542	Pedestrian	NA