APPENDIX 1:

DESIGN STANDARDS

STREETS

All street improvements proposed for any subdivision to be developed under the jurisdiction of these ordinances shall be furnished and installed by the subdivider in accordance with the "*Standard Specifications for Public Works Construction*", published by the North Central Texas Council of Governments (NCTCOG), latest edition.

The purpose of this section is to provide a set of minimum design standards to be used in the designing of roadway facilities in the City of Alvarado. These guidelines will be used by consultanting engineers employed by the City and engineers for private developments in the City. Each sheet of the plans and profiles will bear the seal and signature of the registered professional civil engineer who prepared them. These guidelines should result in the construction of safe, economical streets and thoroughfares. The Director of Public Works may approve unusual circumstances or special designs requiring a variance from the standards in this manual.

Classification of Roadways
There are four (4) basic classifications of streets in the City of Alvarado. The classifications are as follows:

Principal Arterial seven (7) lane divided and undivided

This classification is designed to handle large volumes of intra- and inter-city travel through Alvarado. No direct residential driveway access should be allowed (at least on new sections where driveways do not presently exist).

Minor Arterial five (5) lane divided and undivided and Minor Arterial four (4) lane undivided

This classification is designed to feed traffic from collectors and minor residential streets the Principal Arterial. Direct residential driveway access should not be allowed on new sections of arterial except where existing driveways are present.

Collector two (2) lane undivided

Collector streets should direct residential and local traffic onto the nearest arterial to avoid carrying volumes of through-traffic across residential neighborhoods and other sensitive areas. Direct residential driveway access is permitted. The Collector street shall be the minimum street class serving commercial, industrial or multifamily areas.

Residential two (2) lane undivided

The minor residential is to provide access to the various residential classifications in the City of Alvarado.

Each roadway is made up of elements that are related to the use of that particular facility. These elements include right-of-way, pavement width, median width if required, arrangement of traffic lanterns and parking tones, curb radii at intersections and other characteristics, Table No. 1 is to be used in the design of the various classifications of roadways in Alvarado.

Table No. 1
STREET CLASSIFICATIONS AND CHARACTERISTICS

TYPE	CLASSIFICATION	FACE TO FACE PAVEMENT WIDTH (FT)	FACE TO FACE MEDIAN WIDTH (FT)	PARKWAY WIDTH (FT)	RECOMMENDED MINIMUM ROW WIDTH (FT)
A7D	Principal Arterial divided- 7 lane	2 - 38	24	15	130
A7U	Principal Arterial undivided- 7 lane	88	---	15	118
A5D	Minor Arterial divided- 5 lane	2 - 26	18	15	100
A5U	Minor Arterial undivided- 5 lane	64	---	15	94
A4U	Minor Arterial undivided- 4 lane	50	---	15	80
C2U	Collector undivided- 2 lane	38	---	11	60
R2U	Residential undivided	30	---	10	50
R2D	Residential divided at entrance only	2 - 18	varies	10	varies

Geometric Design

General

Geometrics of city streets may be defined as the geometry of the curbs or pavement areas, which governs the movement of traffic within the confines of the rights-of-way. Included in the geometrics are the pavement, width, radius of curvature, width of traffic lanes, parking lanes, or turning lanes, median width separating opposing traffic lanes, median nose radii, curb radii at street intersections, crown height, cross slope, geometric shapes of islands separating traffic movements and other features. Since city streets are differentiated by their functions and location, there is also a variance in the geometry which describes the path vehicular traffic should follow.

Design Speed

The design speed is a primary factor in the horizontal and vertical alignment on city streets and thoroughfares. Design features such as curvature, radii for turning movements and sight distances are directly related to the design speed. The design speed also affects features such as lane widths, pavement width, pavement cross-fall, pavement crown, and clearances.

The design speed is defined as the approximate speed that can be maintained safely by a vehicle over a given section of road when conditions are so favorable that the design features of the roadway govern. The speed limit or posted speed is the maximum legal speed set by local authorities for a certain roadway or area. The design speed should never be less than the likely legal speed limit.

The various street and thoroughfare classifications that make up the system within the City require different design speeds according to their use and location. Table No. 2 indicates the allowable design speeds for the various classifications within the City. Lower design speeds (and speed limits) may be permitted for all classifications for unusual conditions, terrain, or alignment.

Table No. 2
DESIGN SPEED (MPH)

Type	Classification	Design Speed A
A7D	Principal Arterial- divided	40
A7U	Principal Arterial- undivided	40
A5D	Minor Arterial- divided	35
A5U	Minor Arterial- undivided	35
A4U	Minor Arterial- undivided	35
C2U	Collector	30
R2U	Residential	30

Horizontal Alignment

The horizontal geometrics of the streets and thoroughfares include the segment of geometric design associated with the alignment, inter-sections, pavement widths, and related geometric elements. The various classifications, utilizing the design speed as a control, must have certain horizontal and vertical geometrics to provide a safe economical facility for use by the public.

Horizontal Curves

The alignment of the streets and thoroughfares is usually determined by the alignment of the existing right-of-way or structures which cannot be relocated. Changes in the direction of a street or thoroughfare are minimized by constructing a simple curve having a radius that is compatible with the speed of vehicular traffic.

Curvature in the alignment of arterials is allowed under certain conditions, but the greater traffic volume and the higher vehicle speeds which accompany these thoroughfares tend to increase the number of accidents when curving of alignment occurs. Curves in the alignment of residential streets usually provide aesthetic value to residential neighborhoods without affecting the orderly flow of traffic or safety. Minimum permitted radii of curvature are shown in Table No. 3. These are based on traffic consisting of typical present day automobiles operating under optimum weather conditions. There are other important considerations in the design of curves on thoroughfares including the location of intersecting streets, drives, bridges, and other topographic features.

Table No. 3
MINIMUM CENTERLINE RADIUS FOR ROADWAYS

Street Classification	**Minimum Radius (FT)**
Arterial-- 40 mph	700
Collector—35 mph	500
Residential—30 mph	300

Residential streets intersecting a collector street or arterial street will have a tangent section of centerline at least fifty feet (50') in length measured from the right-of-way line of the collector or arterial street. No such tangent is required when the residential street curve has a centerline radius greater than four hundred feet (400') with the center located on the collector street or major street right-of-way line.

Reverse circular curves shall be separated by a straight tangent section not less than one hundred feet (100') long.

Turning Lanes

Turning lanes are provided at intersections to accommodate left-turning vehicles. The primary purpose of these turning lanes is to provide storage for the turning vehicles. The secondary purpose is to provide space to decelerate from the normal speed to a stopped position in advance of the intersection or to a safe speed for the turn in case a stop is necessary. Left turn lanes at intersections shall be twelve feet (12') in width (minimum). Turn lanes shall have a width transition of not less than one hundred fifty feet (150') in length and a storage lane of not less than one hundred fifty feet (150') in length.

Street Intersections

The intersection at grade of all thoroughfares will be at or near an angle of ninety degrees (90°). At the intersection of these thoroughfare types, the various geometrics including pavement widths, lane widths, curb radii, median widths, turning lane data, crossfall, crown height, and other features differ. Streets often intersect at angles less than ninety degrees (90°); however, no street will be allowed to intersect at less than seventy degrees (70°). Table No. 4 shows the curb radii required for intersections at ninety degrees.

Table No. 4
CURB RADII (90°) INTERSECTION

Intersecting Streets	Radius (FT)
Arterial/Arterial	30
All others	20

The location of any median nose will be so located that traffic will clear it while making a left turn. Other considerations include adequate clearance between the median nose and through traffic on the intersecting thoroughfare and location of the median nose to properly clear the pedestrian crosswalks.

Sidewalks

The purpose of the public sidewalk is to provide a safe area for pedestrians. The City of Alvarado requires that sidewalks be constructed with the paving of streets or when building construction occurs and that all sidewalks conform to state laws for barrier free construction.

Concrete sidewalks on residential streets will have a width of not less than four feet (4') and thickness of not less than four inches (4") and will be constructed of three thousand pounds per square inch (3,000 psi) concrete on both sides of all streets. Sidewalks will be constructed not less than one foot (1') from the street right-of-way line and will extend along the street frontage including the side lot corner lots and block ends.

Sidewalks on arterial streets and non-residential collectors shall be five feet (5') wide.

All concrete for sidewalks will be placed on a two-inch (2") sand cushion and will be reinforced with 6 X 6 No. 6 gauge welded wire fabric or number three (3) reinforcing steel bars spaced at eighteen inches (18") on center each way.

The subdivider may petition for a determination by the City that sidewalk construction is either not feasible or inappropriate at the time of subdivision construction. If determined to by inappropriate at the time of construction by the City, funds for such construction shall be placed in escrow with the City by the subdivider. The sidewalk escrow rate will be approved by resolution by the City Council.

Vertical Alignment

The vertical alignment of all thoroughfares should be designed to insure the safe operation of vehicles by the traveling public and should allow easy access to adjacent property. A travel-way, which is safe for vehicles, is dependent on criteria which considers operating speeds, maximum grades, vertical curves, and sight distance. In addition to these considerations, other factors related to vertical alignment include storm drainage inlet may also be required in the median.

Street Grades

The intersection design of two (2) thoroughfares will include grades which will result in a plane surface or at least a surface which approximates a plane surface. A vehicle traveling on either thoroughfare should be able to traverse the intersection at the design speed without discomfort. To accomplish a smooth transition, slope toward the median of one lane thoroughfare may be required. In this case, a storm drainage inlet may also be required in the median.

In presenting the grades of intersecting thoroughfares in the paving plans, profiles of all four (4) curbs of a thoroughfare will be shown as a continuous grade through the intersection of the other thoroughfare.

Minimum Grades

Minimum longitudinal grades for streets and thoroughfares are required to insure proper flow of surface drainage toward inlets. Minimum grades are five-tenths percent (.5%) for portland cement and asphaltic concrete pavement. The minimum grades for cul-de-sacs will be six-tenths percent (0.6%). All valley gutters should be a minimum of eight feet (8') wide and constructed of reinforced concrete and will have minimum grades of five-tenths percent (0.5%).

Maximum Grades

Maximum longitudinal grades will be compatible with the type of facility and the accompanying characteristics including the design speed, traffic conditions and sight distance.

Arterials must move large volumes of traffic at faster speeds, and flatter grades will better accommodate these characteristics. Truck and bus traffic on these type facilities often control traffic movement, particularly if steep grades prevent normal speeds. The normal maximum street grades allowed for Alvarado streets are shown in Table No. 5. Steeper grades may be permitted for short lengths where required by topographical features or restricted alignment.

Table No. 5

MAXIMUM STREET GRADES

STREET CLASSIFICATION	MAXIMUM GRADE
Arterial	6%
Collector	8%
Minor Residential	10%

Pavement Slope

On undivided streets, the maximum difference in curb elevations will not exceed five-tenths foot (0.5').

Vertical Curves

When two (2) longitudinal street grades intersect at a point of vertical intersection (PVI) and the algebraic difference in the grades is one percent (1.0%) or greater, a vertical curve is required. Vertical curves are utilized in roadway design to affect a gradual change between tangent grades and should result in a design which is safe, comfortable in operation, pleasing in appearance, and adequate for drainage. The vertical curve will be formed by a simple parabola and may be a crest vertical curve or a sag vertical curve.

Stopping Sight Distance

Crest Vertical Curve

When a vertical curve is required, it must not interfere with the ability of drivers to see a length of street ahead, should they be required to suddenly stop. This length of street, called the stopping sight distance, should be sufficient length to enable a person in a vehicle having an eye height of three and three quarters feet (3.75') above the pavement and traveling at or near design speed to stop before reaching an object in his path five tenths foot (0.5') in height.

The minimum stopping sight distance is the sum of two distances: 1) The distance traversed by a vehicle from the instant the driver sights an object for which a stop is necessary to the instant the brakes are applied; and 2) The distance required to stop the vehicle after the brake application begins.

The minimum safe stopping sight distances for the City of Alvarado street types are shown in Table No. 6. These sight distances are based on each design speed shown and on wet pavement. The minimum length of crest vertical curve required for the safe stopping sight distance of each street type may be calculated using the formula L = KA. The values of K for a crest vertical curve are also shown in Table No. 6.

Table No. 6
MINIMUM LENGTH OF A VERTICAL CURVE

CREST VERTICAL CURVE	SAG VERTICAL CURVE
L = KA where L = minimum length vertical curve required for safe stopping sight distance; K = horizontal distance in feet required to effect a one percent change in gradient; and, A = algebraic difference in grade.	L = KA where L = minimum length vertical curve required for safe stopping sight distance; K = horizontal distance in feet required to effect a one percent change in gradient; and, A = algebraic difference in grade.

Type	Street Classification	Design Speed (MPH)	Safe Stopping Distance (FT)	Normal Crest Vertical Curve K(FT)	Normal Sag Vertical Curve K (FT)
A7D	Principal Arterial divided- 7 lane	40	325	80	70
A7U	Principal Arterial undivided- 7 lane	40	325	80	70
A5D	Minor Arterial divided- 5 lane	35	250	50	50
A5U	Minor Arterial Undivided- 5 lane	35	250	50	50
A4U	Minor Arterial undivided- 4 lane	35	250	50	30
C2U	Collector undivided- 2 lane	30	200	30	40
R2U	Residential undivided	30	150	30	40

Sag Vertical Curve

When a sag vertical curve is required, the vertical curve will be of sufficient length to provide a comfortable ride and safe stopping sight distance during the change in vertical direction. The minimum length of sag vertical curve required shall be calculated using the formula L = KA and the values of K for a sag vertical curve are shown in Table No. 6.

Intersection Grades

The grade of an intersecting street with the principal street gutter should not be generally more than four percent (4%) either up or down within the first twenty feet (20') beyond the curb line of the principal street except that in very hilly terrain a maximum intersecting grade of six percent (6%) can be considered. Grade changes of one percent (1%) or more require vertical curves.

Median Openings

The following standards for median openings are established to facilitate traffic movement and promote traffic safety.

Median openings will normally be permitted at all intersections with dedicated City of Alvarado Streets. Exceptions would be at certain minor streets where, due to unusual conditions, a hazardous situation would result. Normal spacing between median openings should be no more than twelve hundred feet (1,200').

Mid-block median openings or other openings with left turns permitted into adjacent property will not normally be permitted unless all the following conditions exist:

- The property to be served is a significant traffic generator with demonstrated or projected trip generation of not less than two hundred fifty (250) vehicles in a twelve (12)-hour period.
- The median opening is not less than four hundred feet (400') from an intersection with an arterial thoroughfare.
- The median opening is not less than two hundred sixty feet (260') from an intersection with a collector thoroughfare.
- The median opening is not less than three hundred feet (300') from any other existing or proposed median opening.
- The median width is sufficient to permit the construction of a left turn storage lane.
- Median openings will not be permitted in left turn storage lanes. Wherever possible, median openings should serve both sides of a thoroughfare.

Driveway and Curb Openings

The minimum distance between driveways is normally twenty feet (20'). The distance between one-way, ninety-degree (90°) drives can vary between four feet (4') and twenty feet (20'). The island between angle drives should equal or exceed fifty square feet (50 S.F.) in area.

In all cases, driveway locations must conform to minimum safe sight distance and stopping sight distance standards.

Driveway Grades

The normal driveway grade within the street right-of-way is one-quarter inch per foot rise above the top of curb at the property line. The minimum elevation of a driveway at the right-of-way is two inches (2") above the top of the curb. Barrier free sidewalk construction requires a maximum driveway grade as measured from the gutter of eight percent (8%).

Where driveway construction or reconstruction must occur off the street right-of-way, the usual maximum grade is fourteen percent (14%). The maximum change in grade without vertical curve is twelve percent (12%) for any ten feet (10') in distance. Driveways should be profiled for a distance of at least twenty-five feet (25') outside the right-of-way to ensure adequate replacement design.

Due to state laws requiring barrier free construction of sidewalks, steps or other abrupt changes in sidewalk grades are prohibited at driveways.

Alley Grades

Alleys are constructed with a 5-inch inverted crown for drainage. The maximum grades for alleys are eight percent (8%) within thirty feet (30') of an intersection with a street and fourteen percent (14%) elsewhere, unless otherwise approved by the City, and the minimum grade is four tenths percent (0.4%). Changes in grade, including intersections with streets, may not exceed three percent (3%) without providing vertical curves.

Pavement Design

Factors which influence the performance of thoroughfare pavement include the subgrade upon which the pavement structure rests, the quality of materials used to construct the pavement, and the type and amount of traffic using the facility. In designing a pavement that will provide a reasonable degree of performance during an expected life, certain factors can be predetermined. The load bearing capacity of the subgrade will be determined by making a soils engineering investigation of the site. The strength of the pavement can also be established by specifications and quality control during construction.

Standard pavement sections are established in Table No. 10A, "Minimum Standard Concrete Street Pavement Design" and Table 10B "Minimum Standard Asphalt Street Pavement Design". Unusual design conditions may be encountered that will preclude the use of Table No. 10A or 10B. The proposed pavement will be designed in accordance with the geotechnical investigation or Table No. 10A or 10B, whichever is more restrictive.

Table No. 10A
MINIMUM STANDARD CONCRETE STREET PAVEMENT DESIGN

TYPE OF STREET	MINIMUM SUBGRADE TREATMENT	CONCRETE THICKNESS (IN)	PAVEMENT STRENGTH (PSI)	REBAR SIZE AND SPACING
Driveway Residential	2" cushion sand	5	3,000	No. 3 24" longitudinal 24" traverse
Driveway Commercial	2" cushion sand	6	3,000	No. 3 24" longitudinal 24" traverse
Alley	6" lime or cement treated material	6	3,000	No. 3 22" longitudinal 24" traverse
Residential	6" lime or cement treated material	6	3,000	No. 3 22" longitudinal 24" traverse
Collector	6" lime or cement treated material	6	3,000	No. 3 22" longitudinal 24" traverse
Arterial	6" lime or cement treated material	7	3,000	No. 3 22" longitudinal 24" traverse

Table No. 10B

MINIMUM STANDARD ASPHALT STREET PAVEMENT DESIGN

TYPE OF STREET	MINIMUM SUBGRADE TREATMENT	HMAC BASE COURSE TYPE 'A' OR 'B' THICKNESS (IN)	HMAC SURFACE COURSE TYPE 'D' THICKNESS (IN)
Alley	6" lime or cement treated material	4	2
Residential	6" lime or cement treated material	4	2
Collector	6" lime or cement treated material	4	2
Arterial	8" lime or cement treated material	8	2

The subdivider or contractor will be required to furnish soil tests on the subgrade soils at four hundred foot (400') intervals, or more frequently if material changes are encountered. Such data will include, but is not necessarily limited to Liquid Limit, Plasticity Index (P.I.), and Percent Passing No. 200 sieve. An independent testing laboratory approved by the City of Alvarado, at the subdivider or contractor's expense, will perform tests.

All subgrades will be stabilized with lime or cement depending on the type of soil encountered. The amount and type of stabilization will be in accordance with the geotechnical investigation recommendation or as shown in Table No. 10A and 10B, whichever is more restrictive.

Curbs will not be more than six inches (6") wide at the top an seven and one half inches (7½") wide at the base and not more than seven inches (7") or less than six inches (6") high. Gutter will be a minimum of twenty-four inches (24") wide. Curb and gutter shall be reinforced with three number 4 (3- #4) bars, two (2) in the base and one (1) in the roll.

The method of design for all paving will be in accordance with the latest practices of the American Association of State Highway and Transportation Officials, the Texas Department of Transportation or the Portland Cement Association. The materials used in the construction of concrete pavements will conform to the requirements of the latest edition of the Texas Department of Transportation's Standard Specification for the Construction of Highways, Streets, and Bridges.

WATER AND SANITARY SEWER

All water and sanitary sewer improvements proposed for any subdivision to be developed under the jurisdiction of this ordinance shall be furnished and installed by the subdivider in accordance with the "*Standard Specifications for Public Works Construction*", published by the North Central Texas Council of Governments (NCTCOG), latest edition.

The purpose of this section is to provide a set of minimum design standards to be used in the design of water and sanitary sewer facilities in the City of Alvarado. These guidelines will be used by consulting engineers employed by the city and engineers for private developments in the city. Each sheet of the plans and profiles will bear the seal and signature of the registered professional civil engineer who prepared them. The Director of Public Works may approve unusual circumstances or special designs requiring a variance from the design standards.

1. Approved fire hydrants shall be provided at locations such that all areas of single family residential development are located within a five hundred (500) feet radius from a fire hydrant and the hose line route to each building will not be more than six hundred (600) feet by public right-of-way. In areas other than single family residential development the radius shall be not less than three hundred (300) feet and the hose line route shall not be less than three hundred (300) feet. In locating fire hydrants, preferences shall be given to street intersections;

2. Valves of approved design shall be located such that the distance between valves is a maximum of six hundred feet (600') on 12" and smaller lines. On larger lines spacing shall be subject to approval of the City's consulting engineer. Valves shall be furnished with extensions such that the working nut is a maximum of 48" below grade. A minimum

of two (2) valves shall be placed at each water main tee and a minimum of three (3) valves shall be placed at each water main cross. Each fire hydrant shall be provided with a valve on its lead pipe;

3. Adequate air and vacuum relief, draining and flushing valves must be providing for flushing, disinfecting, daily operations requirements and repairs of the water system;

4. Sanitary sewer manholes will be located at intersections of other sewers and at intermediate spacing along the line. Generally, the maximum spacing should not exceed five hundred (500) feet. Manholes are required for any six (6) inch connection or greater. Manholes will be located at all changes in grade or alignment and at the ends of all sewers that will be extended;

5. Water services for each lot shall be a minimum of 1" type K copper tubing. Sanitary sewer service to each lot shall be a minimum of four (4) inch ASTM D3034 DR-35 PVC pipe;

6. Manholes shall be constructed water-tight with water-tight lids;

7. No connection will be made to any sanitary sewerage system within the City which will permit the entrance of surface water or waste of other than domestic sewage characteristics without specific authorization by the City Council;

8. The provisions for lift stations or separate treatment facilities will not be permitted unless approved by the City Council;

9. The specifications for materials and workmanship shall conform to *The Standard Specifications for Public Works Construction*, published by the North Central Texas Council of Governments, latest edition.