

ELECTRONIC ACCEPTANCE STANDARDS

10.00 DRAFTING STANDARDS

This section covers formatting and structuring of electronic as-built files necessary to process information from electronic as-builts directly into the City's electronic infrastructure inventories. Compliance leads to timely updates, complete inventories and ensures that precise engineering and survey information is used to update the City's infrastructure inventories.

10.01 PURPOSE

These standards are required so that the City can collect and maintain accurate and reliable infrastructure information for the planning, design, construction and operation of public facilities; so that the City can meet obligations to maintain accurate records of public assets, and be able to serve the complex needs of diverse users of public information.

Please read through this section, referenced exhibits and supplemental information prior to setting up a drawing environment. Although these standards have been designed to accommodate various automated design packages, the handling of certain features requires special attention. Please see the City web page for current versions of this document and all referenced material.

The following Exhibits apply to this chapter:

- A. As-Built Layering protocols ([Exhibit 1](#)).
- B. List of Required Layers for Infrastructure Components ([Exhibit 2](#)).
- C. City Inventory Information ([Exhibit 3](#)).

The following Supplements apply to this chapter:

- A. As-Built Check List ([Supplement 1](#)).
- B. Typical As-built Drawing ([Supplement 2](#)).
- C. Internet Links Electronic Acceptance Standards ([Supplement 3](#)).

Other helpful information:

- A. See the City's web page for an [Overview of City's GIS](#).
- B. Sections 10.01.8 City Inventory Information and Definitions (found in this chapter) provides definitions for all *italicized* terms, e.g., [valid object/entities](#), [drawing objects](#), [associative annotation](#), etc. Please refer to this section for clarification.
- C. Template drawing file (DWT and DWG) containing standard layers, blocks, and text styles used by the City of Springfield.
- D. Set of standard blocks used by the City of Springfield.

All electronic as-built construction drawings shall be submitted in accordance with other sections of this design manual. As-built drawings shall be submitted in both hard copy and electronic form. See other sections of this manual for acceptance requirements for hard copy plan sets. This section, Sections 10, outlines electronic standards for layering conventions and [valid object/entities](#) requirements. Submitted electronic file format shall be compatible with the AutoCAD version currently in use by the City. Please contact the City to determine [AutoCAD® version](#) currently in use.

Files submitted shall adhere to the following minimum standards.

10.01.1 Accuracy

- A. All as-built drawing information shall accurately represent as-built construction and shall be graphically and mathematically correct, i.e. [drawing objects](#) shall represent changes in dimensioning as a result of construction. Drawings shall also adhere to requirements in Section 9.00 of this Design Manual.
- B. If actual construction varies from proposed construction, changes to proposed construction should be crossed out, but remain in the drawing on a separate layer. As-constructed information, i.e., [infrastructure components](#), shall then be placed on a new layer with new line work and reflect the changes accurately. See attached [Exhibit 2: List of Required Layers for Infrastructure Components](#).

10.01.2 Consistency Between Electronic Copy and Hard Copy

Submit all information required to reproduce a hard copy from the electronic file. The electronic copy and hard copy shall be identical with the exception of the original signature on the engineer's stamp.

All line types, fonts, and shapes shall be reproducible by the City in the AutoCAD environment to support hard copy reproduction. If the City encounters significant problems during reproduction, the drawing will not be accepted.

10.01.3 Electronic As-built Drawing Set

Submit a complete electronic as-built drawing set. This drawing set shall include, but not be limited to, a **continuous** design drawing model where all [infrastructure components](#) are either drawn in the same drawing model or where each drawing model contains sufficient survey control (as defined in Section 11.08) to tie separate drawing models together. Individual drawing files typically contain one drawing model. The drawing set must also contain all contract drawing sheets. The electronic as-built drawing set shall conform to the minimum standards specified in this section, Section 9.00, and where appropriate other sections of this Design Manual.

- A. Plan and Profile:
 - 1. All [infrastructure components](#) shall be placed on the appropriate layers as described in the layering conventions. See [Exhibit 2: List of Required Layers for Infrastructure Components](#).
 - 2. In the plan section of the drawing, submit all [infrastructure components](#) and [associated annotation](#) in model space, see Section 10.01.08.E. [Drawing objects](#) not directly tied to the model and/or sheet specific information may be placed in model space or paper space.
 - 3. In the profile, detail, and cross-section, all [infrastructure components](#) not directly tied to the model may be placed in model space or paper space, but shall be placed on the appropriate layers as described in the layering conventions. See [Exhibit 2: List of Required Layers for Infrastructure Components](#).
 - 4. All [specific construction notes](#) shall be in model space. [General construction notes](#) may be located in either model space or paper space.
 - 5. [Non-referenced images](#), standard drawings, specifications, and/or blocks shall be bound in the drawing and not attached as an external reference.
 - 6. Registered [orthophotography](#) shall not be used as a backdrop in the plan view to

- represent existing topography, neither in the submitted electronic files nor on the hardcopy files.
7. Transportation plans for Signal or Detection systems, Street Lighting, or Roadway Striping/Signaling shall each be submitted in individual AutoCAD drawing (.dwg) files.

B. Plot Layout, Plot Settings and Line Types:

1. Submit all information required to reproduce a hard copy from the submitted electronic file. If custom plot styles are used then the appropriate support files (e.g. plot style table (STB), color based plot style table (CTB), etc.) must be provided with the drawing set. If the City encounters significant problems reproducing an exact copy of the submitted hard copy plans, the drawing will not be accepted.
2. Standard AutoCAD font and line types shall be used. If custom fonts and line types are used all support files (e.g. SHX, LIN, etc.) must be provided with the drawing set. If the City encounters significant problems handling fonts and line types, the drawing will not be accepted.

10.01.4 Referenced Information

- A. Include and attach all detail information generated by automated design software that describes [infrastructure components](#).
- B. If Xrefs are used with a drawing, bind all Xrefs before submission. The City will not accept drawing with Xrefs.
- C. Purge all invisible [drawing objects](#) before submission.

10.01.5 Drawing Objects (Entities)

- A. All [infrastructure components](#) shall be sorted onto layers and shall conform to the City's layering conventions. See [Exhibit 2: List of Required Layers for Infrastructure Components](#).
- B. Purge all drawings of empty layers and unused blocks, line types, dimension styles, plot styles, text styles, shapes, etc. and make sure all [infrastructure components](#) are clean, that is:
 1. Linear [infrastructures components](#) shall continue as single non-broken lines or plines between nodal [infrastructure components](#), e.g. sewer pipe lines shall continue from the one MH to another without breaks for annotation. Linear [infrastructure components](#) shall snap to the center of the nodal [infrastructure components](#), e.g., pipe lines shall snap to the center of MH symbols.
 2. If annotation placement is required over linear [infrastructure components](#), masking can be used to provide the same visual effect without breaking up the geometry of the linear features (see AutoCAD "Wipeout" Command). If dashed or broken linetypes are required to properly display linear [infrastructure components](#), special line types can be used. All custom linetype definition files (SHX files) shall accompany the drawing file(s).
 3. Ends of arcs, lines and plines shall be snapped end-point to end-point.

4. No duplicate objects shall remain on the [infrastructure component](#) layers.
 5. [Infrastructure component](#) features representing areas (such as detention ponds, etc.) shall be composed of joined polylines where possible and at a minimum shall consist of a series of [valid objects](#) snapped end-to-end with no gaps (see AutoCAD Pedit and Join commands).
- C. All [drawing objects](#) required for updating City inventories shall be easily accessible for extraction.
- D. All [infrastructure components](#) shall be composed of the following [valid object types](#) in order to be accepted by the City (see the Definition List, Valid Objects, for object type definitions and related AutoCAD commands):
1. Arc
 2. Circle
 3. Dimension
 4. Ellipse (including elliptical arcs)
 5. Image
 6. Insert (also known as a Block Reference)
 7. Leader
 8. Line
 9. Multiline Text
 10. Point
 11. Polyline
 12. Text
- E. All [infrastructure components](#) shall be drawn as 2D objects.

10.01.6 Layering Conventions

All [infrastructure components](#) shall be placed on the correct layer as described in the layering protocols and conventions. See [Exhibit 1: As-Built Layering Protocols](#) and [Exhibit 2: List of Required Layers for Infrastructure Components](#).

- A. The layering protocols are provided to assist users with correctly developing layer names that will consistently meet the City's layering convention standards. All [infrastructure components](#) shall comply with these conventions.

Layer names shall consist of the following groups separated by “_”. In some cases, feature name will have “-“ to describe the compound feature names. These protocols allow layer names to be identified and sorted correctly. The protocol is as follows: 1) status→ 2) feature group → 3) feature name→ 4) feature class. See [Exhibit 1: As-Built Layering Protocols](#) and [Exhibit 2: List of Required Layers for Infrastructure Components](#).

- B. [Exhibit 2: List of Required Layers for Infrastructure Components](#) provides a list of layer name examples that shall be used when creating electronic as-builts.

10.01.7 Media

Files submitted shall be on Compact Disk. Clearly label all CD ROM's with City project number, project name, company name, file name(s) and extension(s), AutoCAD version, and date. Contact the City for current version information.

Acceptable media: Compact Disc (CD). CD's shall be "locked" (where write session have been closed out) to ensure that data cannot be changed after submittal.

10.01.8 City Inventory Information and Definitions

Below please find definitions for terms used in Section 10 and descriptions of information needed to update City inventories and databases. When new [infrastructure components](#) are added, removed or modified as a result of construction, electronic as-built drawing content shall include these components and their [associated annotation](#).

Each [infrastructure component](#) and piece of [associated annotation](#) shall be placed on the appropriate layer as defined in this section. See Exhibits [1](#), [2](#) and [3](#) for layering protocols, layering conventions and example lists of infrastructure components,

List of Terms included in Section 10.01.8:

- A. [General Construction Notes](#)
 - B. [Specific Construction Notes](#)
 - C. [AutoCAD version accepted by City](#)
 - D. [Infrastructure Components](#)
 - E. [Associated Annotation](#)
 - F. [Features \(linear features and nodal features\)](#)
 - G. [Drawing Objects](#)
 - H. [Valid AutoCAD Object \(types\)](#)
 - I. [Registered orthophotography/registration file](#)
 - J. [Non-referenced images](#)
- A. **General Construction notes:**
General construction notes pertain to the overall project and not to specific [infrastructure components](#) or groups of components. Refer to SECTION II – DRAFTING STANDARDS, Sub-Section 9.00 DRAFTING STANDARDS for the submission of items and requirements of the project Cover Sheet. As such, most *general construction notes* are not required to be on any specific layer. The exception being that vertical and horizontal projection information shall be placed on survey layers identified in [Exhibit 1](#).
- Submitters shall indicate which vertical datum is used to express elevation values.
- B. **Specific Construction notes:**
Specific construction notes usually pertain to individual or small groups of infrastructure components. See [associated annotation](#) for examples of *specific construction notes*. Refer to SECTION II – DRAFTING STANDARDS, Sub-Section 9.00 DRAFTING STANDARDS for the submittal of items and requirements of project construction notes, plan views, and profiles.
- C. **AutoCAD® version accepted by City:**

All as-built files shall be compatible with the current version of AutoCAD® the City uses and accepts. Check with the City of Springfield Public Works Engineering Division for the latest version requirements.

D. Infrastructure Components:

Features depicting quantifiable pieces of infrastructure required to update the City's digitally mapped infrastructure inventories include but are not limited to new infrastructure and infrastructure that has changed as a result of construction.

There are two basic types of *Infrastructure Components*:

1. As-Built Infrastructure Components (AS); new components added as a result of the construction project and modified system components that were changed as a result of the construction project. Both of these types of features shall be placed on layers prefixed with “AS.”
2. Retired Infrastructure Components (AR) are underground, partially underground or otherwise specified *infrastructure components* that have been removed or abandoned as a result of construction. Example features include maintenance holes, sewer main lines, etc. Associated annotation shall clearly identify whether the feature is abandoned or removed.

Otherwise specified retired *infrastructure components* that may not be underground include:

- a. Traffic Conduit.
- b. Traffic Signal Bases.

Describe all infrastructure components on AR layers with text specifying whether component is abandoned or removed. Please note, AR *infrastructure components* are identified with an asterisk in the List of Required Layers for Infrastructure Components.

E. Associated Annotation:

In addition to requirements described elsewhere in this manual, annotation describing the material, size (length and/or area), horizontal and vertical location and dimensions of infrastructure components shall be provided in the plan view of the drawing model. *Associated annotation* shall be placed on the correct layer and include but not be limited to the following:

1. Sanitary and Storm drainage linear infrastructure components shall be annotated with:
 - a. Pipe Diameter
 - b. Pipe Material
 - c. Pipe Invert Elevation placed at both ends of each pipe
 - d. Surface waterway thalweg (center line of deepest channel-water course) flow elevations placed at both ends of each channel, canal, ditch, stream, etc.
 - e. Surface waterway “common name” (contact the City’s Engineering Division if unsure)
 - f. Length (stationed horizontal distance – not flow distance)

2. Sanitary and Storm drainage nodal [infrastructure components](#) shall be annotated with:
 - a. RIM Elevation (or surface elevation)
 - b. Depth (depth from RIM/surface elevation to bottom of MH/structure)
 - c. Barrel Diameter (or box size)
 - d. Material Type (if other than concrete)

3. Storm drainage polygonal [infrastructure components](#) shall be annotated with:
 - a. Surface water body average area (based on projected average water level)
 - b. Surface water body top of bank area
 - c. Surface water body maximum water level area (based on relevant year events, e.g. 25 year event)

* Note: Bathymetric data shall include contours, spot elevations and elevation stationing along thalweg of linear surface waterway features according to other sections of the design manual (see sections 4.03) and shall conform to the electronic acceptance standards specified in this section.

4. Street [infrastructure components](#) shall be annotated with:
 - a. Street name
 - b. Street width (between front face of curbs or edges of pavement for street with no curbs)
 - c. Sidewalk width and setback from front face of curb

* Surface and subsurface properties (such as material, depth, etc.) can appear in detail and/or profile views and shall be clearly annotated.

5. Survey Control (see Section 11.08: Survey Control)
 - a. Horizontal and vertical coordinate values at each control point, i.e., benchmarks and significant points used in the control survey. Symbols shall be used to clearly mark each control point (insertion point of block shall be set to the center of the symbol and all symbols shall be snapped to the control points).
 - b. Bearings (in degrees, minutes and seconds), distances, and curves where appropriate on each control line
 - c. Stationing along center line

F. Features (linear features and nodal features):

Geographic features are usually a collection of drawing objects assembled to illustrate features found in the field. These complex features include buildings, streets, maintenance holes, clean outs, etc. Some features can be drawn with a single object. Examples of simple features include pipe segments and sewer taps. In As-Built drawings, map features commonly depict infrastructure components and topography.

Nodal features are best represented as points or blocks and can include [infrastructure components](#) such as Maintenance Holes (MH), Catch Basins (CB), Clean Outs (CO), etc. Linear [infrastructure components](#) are represented with lines, polylines, arcs, etc. Examples of linear features include pipes, curb lines, etc.

G. Drawing Objects:

Each geometric shape is a distinct object. It often takes more than one AutoCAD object to adequately draw a feature. All AutoCAD objects are classified into object types. Similar to features, there are simple and complex object types. Complex object types include cubes, cones, and spheres. Simple object types include lines, points, and polylines.

H. Valid Drawing Object (types):

Although many other object types are found in current versions of AutoCAD, only the following types are accepted for mapping [infrastructure components](#):

Valid Drawing Objects	
Object Type*	Description*
Arc	A circular arc Related command: ARC
Circle	A full circle. Related command: CIRCLE
Dimension	An object that can be composed of a dimension line, extension lines, arrowheads, a leader, an annotative text including alphanumeric characters and tolerances. Dimensions are measurements of a particular type, which include Aligned, Rotated, Radial, Diametric, 2LineAngular, 3PointAngular, and Ordinate. Related commands: DIMALIGNED, DIMANGULAR, DIMBASELINE, DIMCENTER, DIMCONTINUE, DIMDIAMETER, DIMLINEAR, DIMORDINATE, DIMRADIUS
Ellipse (including elliptical arcs)	A full ellipse. Related command: ELLIPSE
Image	An object that contains and displays a raster or bit-mapped bitonal, 8-bit gray, 8-bit color, or 24-bit color image file. Valid file types include TIFF and JPG. Related commands: IMAGE, IMAGEATTACH
Insert (also known as a Block Reference)	An object that references and displays an external reference or a block (this includes both single block instances inserted with INSERT and multiple block instances inserted in a rectangular array with MINSERT). Related commands: INSERT, MINSERT, XATTACH, XREF
Leader	A polyline with or without an arrow at one end and annotative text at the other. Related command: LEADER
Line	A single line segment. Related command: LINE
Multiline Text	A paragraph of alphanumeric characters. Related command: MTEXT
Point	A point marker that can appear as a dot, square, circle, X, tick, or plus sign (+), or as a combination of these figures. Related commands: POINT, DIVIDE, MEASURE
Polyline	A 2D line or mesh of adjustable width or a 3D line or mesh of non-adjustable width composed of line and arc segments. The decision to use a polyline or a lightweight polyline is controlled by the PLINETYPE system variable. Related commands: 3DMESH, 3DPOLY, BOUNDARY, DONUT, EDGESURF, ELLIPSE, PFACE, PLINE, POLYGON, RECTANG, REVSURF,

	RULESURF, TABSURF
Text	A single line of alphanumeric characters. Related commands: STYLE, TEXT

*Table above contains standard Autodesk descriptions from AutoDesk help documentation.

I. Registered Orthophotography/registration file:

Herein orthophotography is defined as aerial photography (pictures taken from the air) registered to mapped features in the plan view. Orthophotography shall not be used to map [Infrastructure Components](#). The City prefers vector based topography as it consumes much less disk space and is capable of higher precision. Furthermore, scanning plans with this aerial imagery produces poor electronic archives as [Infrastructure Components](#) are difficult to read.

Acceptable image formats include TIFF and JPEG. Registration files shall accompany orthophotography, as they are required to restore the image's orientation in the drawing. These files contain coordinates for the image's insertion point and values for scale and rotation. Acceptable formats include TIFF world files (TFW) and JPEG registration files (JGW).

For each orthophotography image used in a drawing the following information shall be provided:

1. Image file name and path.
2. Registration file name and path.

J. Non-referenced images:

Miscellaneous images (typically snap shots or scanned illustrations) inserted into a drawing to provide further detail, show stages of construction or other information regarding construction.

Non-referenced images shall be imbedded in the drawing and shall not have registration files.