AUTODESK **UNIVERSITY** 2014

Follow the GIS Brick Road: Data-Sharing Workflows between GIS and AutoCAD Civil 3D 2015

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Mark Valentino - Freese and Nichols, Inc.
Eddie Johnson – Construction Industry Solutions (COINS)

GS5322-L

Learning Objectives

At the end of this class, you will be able to:

- Access data from a geographic information system database to use for preliminary design in AutoCAD Civil 3D software
- Stylize geographic information system data for use in preliminary design
- Create AutoCAD Civil 3D software surfaces and pipe data from geographic information system data
- Complete the workflow by exporting AutoCAD Civil 3D software data back to geographic information system

About the Speakers

Michael Gardner *is the AutoCAD Coordinator for Freese and Nichols Inc. (FNI), an engineering and architectural firm located in Fort Worth, Texas. Certified in AutoCAD and AutoCAD Civil 3D software, he has over 35 years of drafting and CAD experience. As the CAD manager for various firms, Michael has provided user support, developed corporate CAD standards, and created customized training. He also has offered contract services through his own firm. Michael draws from over 20 years of teaching experience to provide custom material and training through Freese and Nichols University, the training arm of FNI.*

Mark Valentino *is the GIS Coordinator for Freese and Nichols, Inc. Mark is an ESRI Certified ArcGIS Desktop Professional and ESRI Certified Enterprise Administration Associate*

Eddie Johnson *is an ENI Technical Specialist for Construction Industry Solutions (COINS) in Dallas-Fort Worth. He is an Autodesk Certified Instructor, Certified Autodesk Product Support Specialist and Autodesk Infrastructure Design Suite Certified BIM Specialist focusing on the products in the Infrastructure Design Suite. With 25 years of Industry experience, 17 of which was as a designer, CAD Manager and Production Manager, he leverages this knowledge to maximize his clients' productivity and ROI through training/support, consulting and various professional services.*

Eddie was a highly rated speaker at Autodesk University 2009 and AUGI CAD Camp in 2010.

About the Companies

Freese and Nichols, Inc. *is a full-service professional consulting firm and the first engineering/architecture firm to receive the Malcolm Baldrige National Quality Award. The firm was started by John Hawley in 1894, making this year our 120th Anniversary. Hawley was Texas' first independent consulting engineer for water and sewer work.*

With offices in Texas and North Carolina, Freese and Nichols provides services in:

- *Engineering*
- *Architecture*
- *Construction services*
- *Planning*
- *Energy*
- *Program management*

Construction Industry Solutions (COINS) *is a leading provider of Autodesk design and engineering solutions to the building, architecture, mechanical, civil engineering, geospatial, and construction industries. We are also a market-leading, construction-industry software solutions company providing innovative ERP business software and savvy solutions for top construction and service businesses around the world. We are a global company with a strong presence in the USA, UK, Ireland, Australia, and Asia.*

The Disclaimer!

The information included in this document is not intended to be an all-round primer for GIS and coordinate systems. If you would like more information on coordinate systems and GIS then the following sites may be of interest to you:

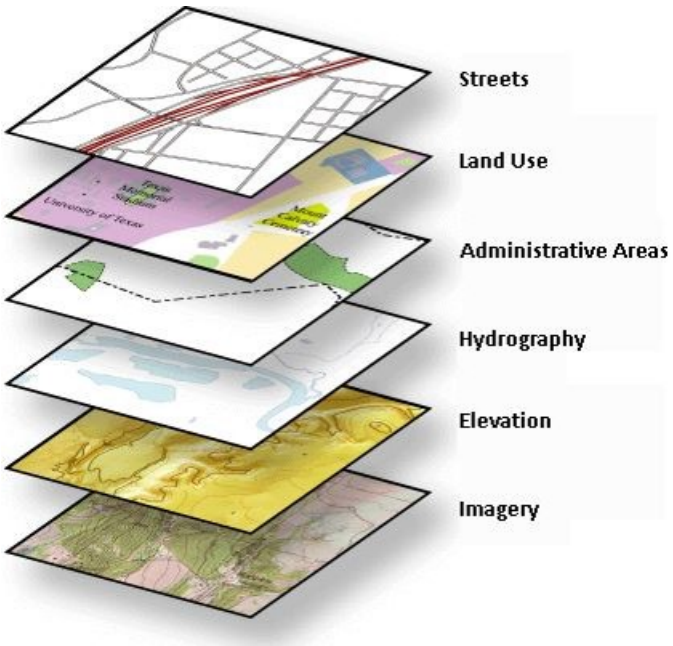
- http://www.esri.com/
- http://www.usgs.gov/
- http://www.webgis.com/usgsseam.html
- http://data.geocomm.com/

GIS Overview

A geographic information system (GIS) captures, stores, analyzes, manages, and presents data that is linked to location. Technically, GIS is geographic information systems which includes mapping software and its application with remote sensing, land surveying, aerial photography, mathematics, photogrammetry, geography, and tools that can be implemented with GIS software. Still, many refer to "geographic information system" as GIS even though it doesn't cover all tools connected to topology. It is a transformational technology and method.

GIS as defined by www.esri.com/what-is-gis:

- GIS lets us visualize, question, analyze, interpret, and understand data to reveal relationships, patterns, and trends
- GIS integrates hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information
- GIS allows us to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts
- GIS helps you answer questions and solve problems by looking at your data in a way that is quickly understood and easily shared.
- GIS technology can be integrated into any enterprise information system framework



CAD/GIS Integration

In many ways CAD and GIS are like oil and water. CAD data is very precise with accurate measurements whereas GIS tends to be neither of these (however it can be as will be discussed later). GIS data is typically worked in very large scale, cartographic in nature and not pure engineering. However it is this magnitude of scale that makes it a valuable tool for CAD users. Although current GIS data may not be accurate to CAD standards, the data is useful in preparing early prototype designs before the effort is expended to retrieve more accurate data.

In short, GIS gives the CAD user access to readily available data that can be used to prepare a design evaluation or begin a preliminary design with little or no extra cost or effort. This early design effort many times will yield information that will aid in collecting more accurate site data and allow the engineer to expend less time and effort getting the data needed for a final design.

Routing a pipeline is a good example of using GIS data for preliminary design. It allows the engineer to use aerial data and topography to identify structures, roads, creeks and other obstacles that may impede the alignment desired. Property line information may be added to help 'fine tune' the alignment for obtaining easement information. Once this preliminary design is complete, then the survey work may begin with a more defined path for collection than might have been available without the GIS information.

Preparing CAD to receive GIS data

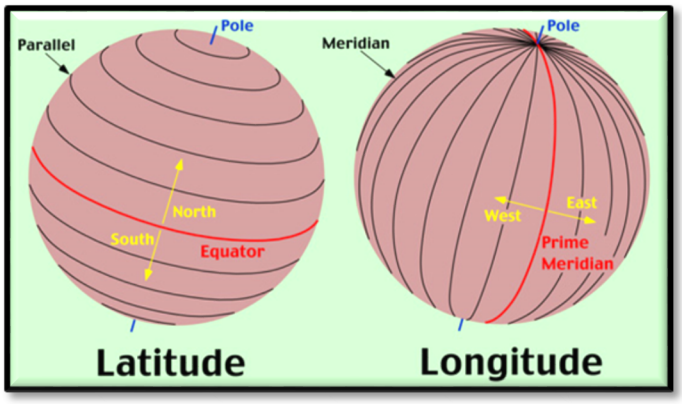
GIS data is *spatial* meaning 'of or related to space.' This means that *where in the world* the data is located is just as important as *what* the data is. In order to prepare CAD to receive GIS data located correctly we need to take a look at Coordinate Systems and what they mean.

Coordinate System Basics

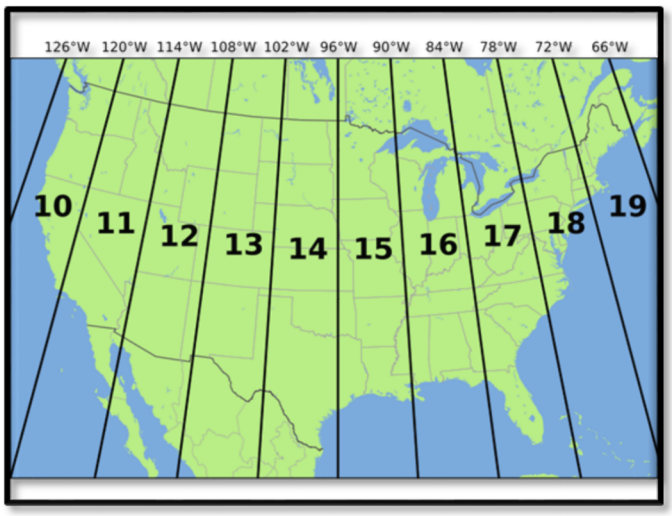
Simply put, a coordinate system is just a reference system with specified *datum* (horizontal and vertical location relative to a specific location) and *projection* (mathematical model used to transform the curved surface of the earth to a planar representation). Standard coordinate systems use particular projections over zones of the earth's surface. Each zone then has a specified origin.

There are three distinct types of coordinate system:

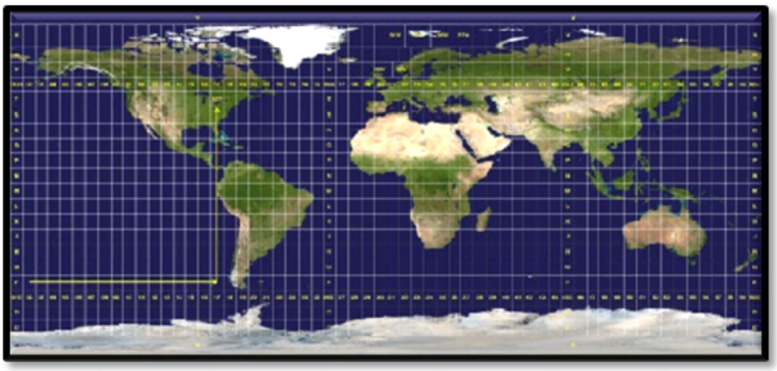
- Geographic – global or spherical system such as Latitude-Longitude



- Projected – Also known as "Grid", utilizes localized zones for higher accuracy on the ground. (State Plane Coordinates fall in to this category.)



- Global Cartesian – Provides coordinates for the whole earth. GPS uses this system

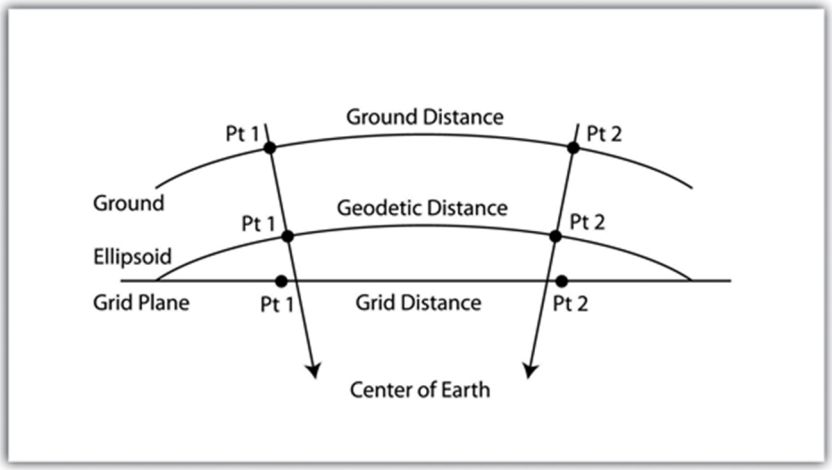


Each Coordinate System is defined by the following:

- Measurement Framework which is *Geographic* (spherical coordinates are measured from the earth's center) or *Planimetric* (earth's coordinates are projected onto a two-dimensional planar surface)
- Unit of Measurement (Feet, Meters or Decimal degrees)
- For Projected Systems, the definition of the map projection
- Other measurement system properties such as a datum or spheroid of reference and projection parameters

Grid to Ground

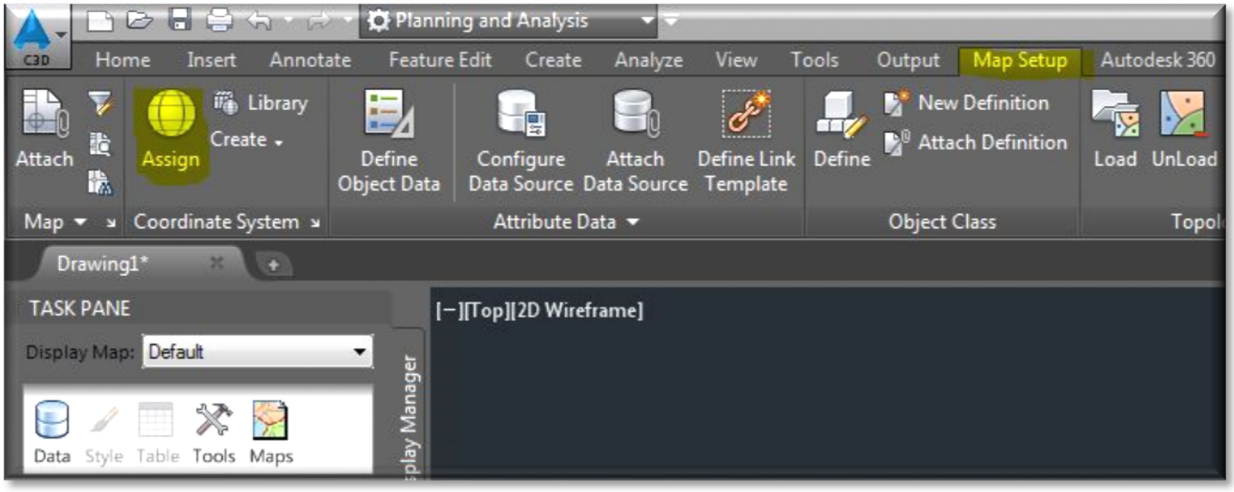
Measuring distances between two points varies dependent upon the coordinate system in use. Typically measurements over short distances (less than a mile) are measured along the ground and are thus understood to be *Ground* measurements. However when dealing with the vast distance inherit in GIS data the accuracy of ground measurements become difficult to maintain. Therefore most GIS data is measured in *Grid*. Let's look at what the difference is between *Ground* and *Grid* using the following diagram:



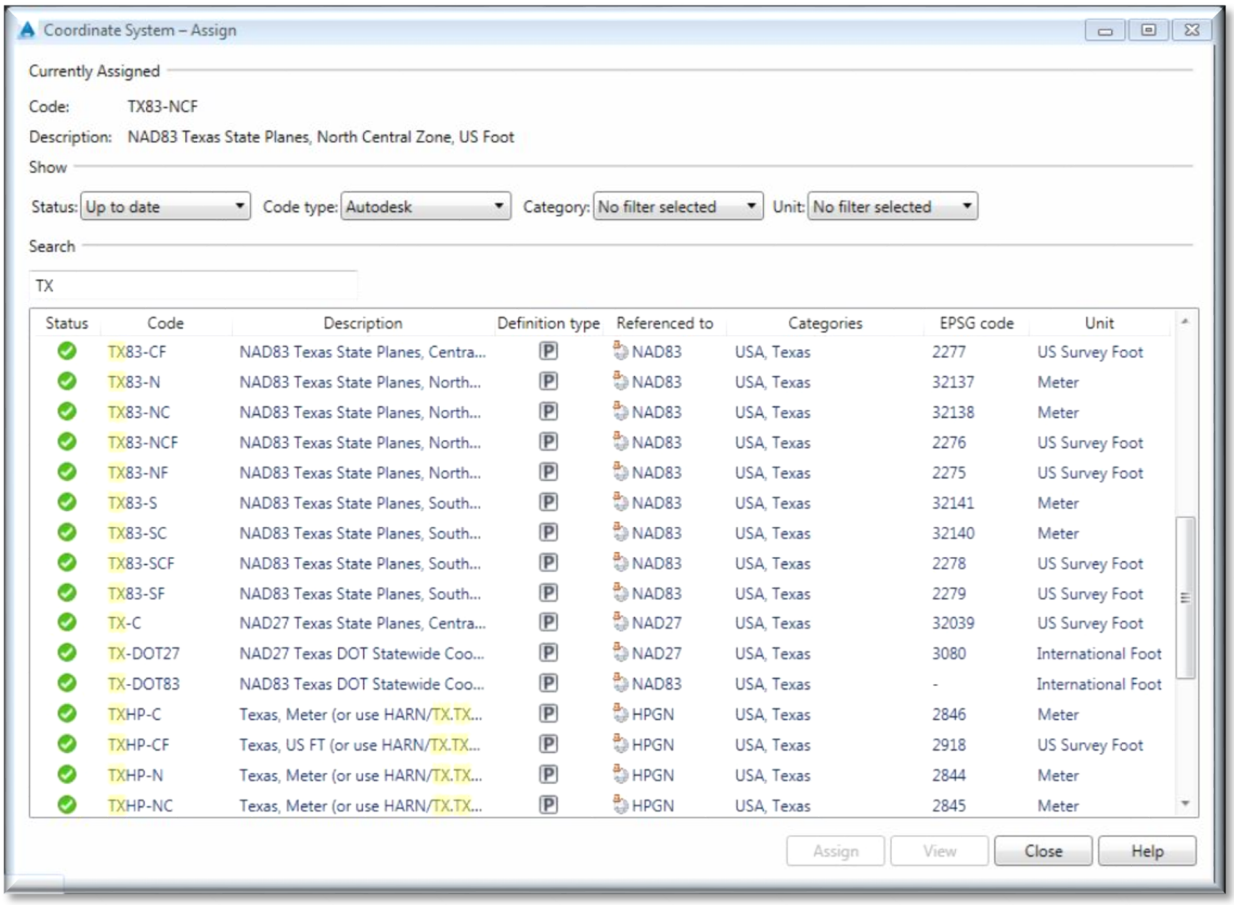
- Ground - Earth Surface consisting of Horizontal distances, elevations and angles
- Ground Distance – Distance (horizontal distance and curvature applied) between two ground points
- Ellipsoid - Mathematically smoothed surface of the earth by averaging the high and low points
- Geodetic Distance – The length of the shortest curve between those two points along the surface of the earth model being used by the spatial reference system
- Grid Plane - A grid is a two-dimensional horizontal rectangular coordinate system
- Grid Distance – The distance between two points that is expressed in mapping projection coordinates

Setting Coordinate System

In order to accurately locate the data coming from GIS it is important to set the desired coordinate system for the working area. Typically the State Plane Coordinates are used in CAD design files. To assign the desired coordinate value set the workspace to Planning and Analysis and select *Assign* from the Map Setup tab in the ribbon menu.

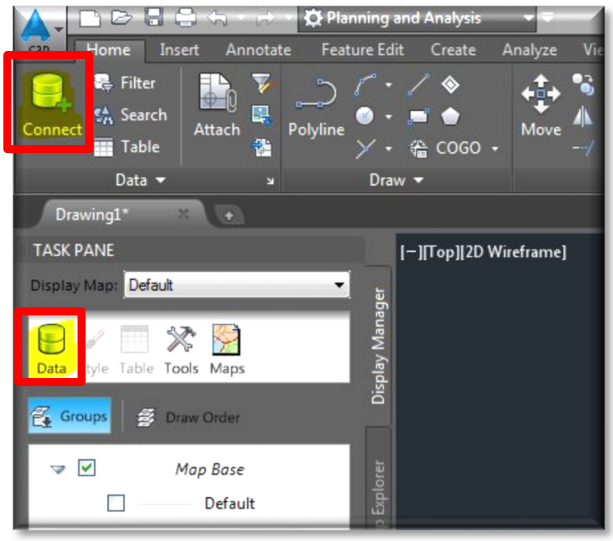


The Coordinate System Assign window gives you access to a vast number of coordinate systems around the world. You may shorten the list by entering some part of the name for the coordinate system you desire in the Search box. Next, scroll to and select the desired coordinate system.



Attaching GIS Data in AutoCAD Civil 3D

Map 3D enables users to not only import from a wide array of data formats but allows connection to data in their original sources and save changes in the native format or convert the data to DWG format, breaking any connection to the original source



With the coordinate system set we are ready to bring GIS data in to our CAD file. You may insert either a data file or raster image into your drawing or create a database connection. The icon for inserting these files is *Connect* located on the Home tab of the ribbon menu on the Planning and Analysis workspace. Alternatively the icon *Data* may be accessed from the top of the TASK PANE.

Data Connect

Following are some of the methods you can use to insert GIS data in to your CAD file.

Add ArcSDE Connection

If you use SQL Server or Oracle you can use either Windows or ArcSDE authentication.

- Select the feature classes to include in your map.
- Style, theme, and edit the features.
- Bring in a static copy of ArcSDE data as drawing objects.

Add Raster Image or Surface Connection

Connecting to raster data as opposed to inserting the image has advantages:

- Faster Performance
- When panning and zooming only the image in current view regens
- Raster formats supported: .DEM, .JPG, .JPG2, .ECW, .SID, .TIF, .PNG
- Raster enablers are not needed to connect to ECW or SID files

Add SDF Connection (Spatial Data File)

A *Spatial Data File* (SDF) is a native Autodesk file-based geospatial format that is optimized for storing large, classified data sets. The SDF format is similar to the SHP format in that if contains both spatial data and attribute data. However it accomplishes this in a single file rather than a set of files.

The SDF file has certain advantages to the SHP in the following ways:

- It stores and manages an order of magnitude more data than DWG
- It is very fast, allowing Autodesk applications, such as AutoCAD Map 3D and Map Server, to read and display tens of thousands of features per second.
- It provides the power of a database without the overhead and cost of a full relational database management system (RDBMS) such as SQL Server or Oracle.
- An SDF file can store a single feature class, or it can store multiple feature classes.
- It is easy to manage, providing access to the database schema.

Add SHP Connection (Shape Files)

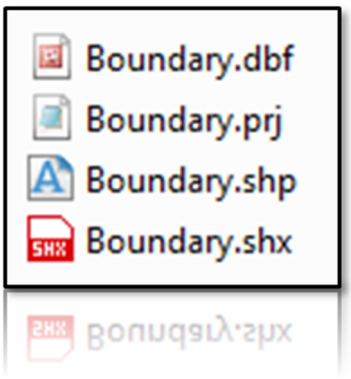
A *Shape File* (SHP) is a digital vector storage format for storing geometric location and associated attribute information. The SHP format was introduced with ArcView GIS version 2 in the beginning of the 1990s. It is now possible to read and write SHP using a variety of free and non-free programs. With MAP 3D you can either insert a SHP into your drawing or create a database connection.

Select the feature classes to include in your map.

- Style, theme, and edit the features.
- Lock the file when you connect to it.

An individual SHP is actually a collection of files as described above that must be moved or distributed as a group otherwise the SHP can be rendered unusable.

- .SHP – Shape format (file that stores the feature geometry)
- .SHX – Shape Index format (file that stores the index of the feature geometry)
- .DBF – dBASE file that stores the attribute information of features
- .PRJ – File that stores the coordinate system
- .SBN and .SBX - files that store the spatial index of the features (optional)
- .FBN and .FBX - files that store the spatial index of the features for SHP that are read-only (optional)
- .AIN and .AIH - files that store the attribute index of the active fields in a table or a theme's attribute table (optional)



Add WFS Data (Web Feature Service - web-based vector features service)
Select the feature classes to include in your map.

- Reproject the data to the coordinate system of your map.
- Style and theme features. You cannot edit features from a WFS data source.

Example WFS Data Sources

WFS Data Source	Description
http://demo.cubewerx.com/demo/cubeserv/cubeserv.cgi?datastore=Foundation	Data layers such as boundaries, terrains, physiography, utilities, and more.
http://regis.intergraph.com/wfs/dcmetro/request.asp?	Virginia, USA Census tracts, Congressional districts, counties, interstates, POI, and places.

Add WMS Data (Web Map Service – web-based raster image data service)
Select the feature classes to include in your map.

Example WMS Image Sources

WMS Image Source	Description
http://maps.customweather.com/image	Weather data
http://wms.jpl.nasa.gov/wms.cgi?	Global SRTM and DTED data
http://globe.digitalearth.gov/viz-bin/wmt.cgi	All types of data for the globe - soils, temperature, land cover, boundaries, etc.
http://terraservice.net/ogccapabilities.ashx	USGS orthographic and topographic maps
http://demo.cubewerx.com/demo/cubeserv/cubeserv.cgi?	Source of different types of data layers, such as boundaries, terrains, physiography, utilities, SRTM, etc.
http://edcw2ks51.cr.usgs.gov/servlet/com.esri.wms.Esrimap?WMTVER=1.1.0&ServiceName=133urban&	Various orthographic images for USA cities, for example, San Francisco, Reno, and Chattanooga.
http://www2.dmsolutions.ca/cgi-bin/mswms_gmap	Various Canadian features - provincial boundaries, lakes, railroads, and more.
http://demo.deegree.org:8080/deegree/wms?	Geospatial data from NGA (U.S.), Intevation (Germany) and OGC (U.S.)
http://www.ga.gov.au/bin/getmap.pl?dataset=national&	Geoscience Australia national geoscience datasets

Stylize GIS Data

When you add GIS data a default set of styles are applied to the objects. You will likely wish to modify or change these styles to fit your standards or specific needs. CAD data is typically modified by changing colors, line types or layers to obtain the desired look. GIS data has a different set of tools for modifying the look and feel. These tools can be found on the TASK PANE in the Planning and Analysis workspace. The TASK PANE may be accessed while in the AutoCAD Civil 3D workspace by using the *MAPWSPACE* command and setting it to *ON*.

TASK PANE

The TASK PANE in the Planning and Analysis workspace serves a similar purpose to the TOOLSPACE in the AutoCAD Civil 3D workspace. From here the user has the ability to modify or Style the various components and control the order of display, moving certain features in front or behind other features.

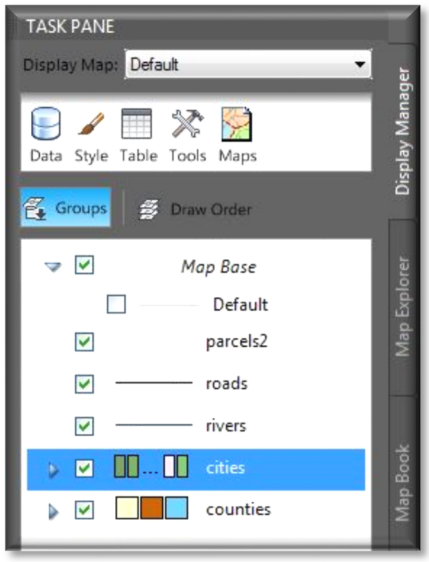
The TASK PANE has a group of icons at the top used to edit and modify the GIS data in addition to four tabs.

- Display Manager – Manage Features stored in data stores, attach drawing files and change the appearance of features. Each feature is a layer and drawing layers can be added as well.
- Map Explorer – View the elements of your Map Project. Such elements include files connected to as sources, queries used and saved and templates for linking drawing objects to data.
- Map Book – Divide a large map into “tiles”. Each tile is rendered on a separate page. Publish in various formats for printing and online display
- Survey – Bring in and work with Survey Point Data

Styling

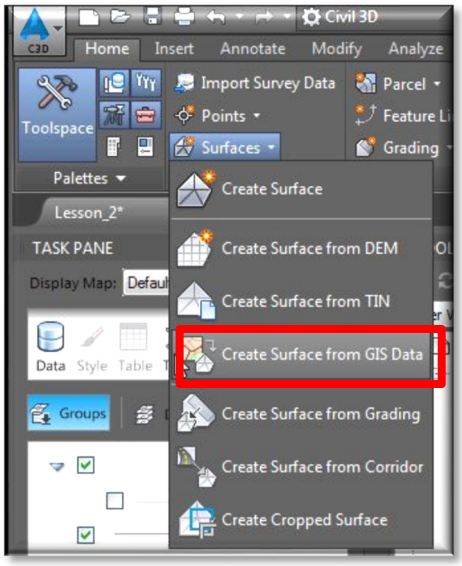
From the Display Manager Tab the user has control of the display order of the items by moving them up or down the list to move the items from front to back (top to the front and bottom to the back) of the CAD file.

To modify the color or line type of the attached GIS data, highlight the item to be modified in the list and select the *Style* icon near the top of the TASK PANE. The Style Editor window will open giving you access to all of the modification and label tools. From here colors, line weights and styles, transparency and labels can be set for each of the GIS data items.



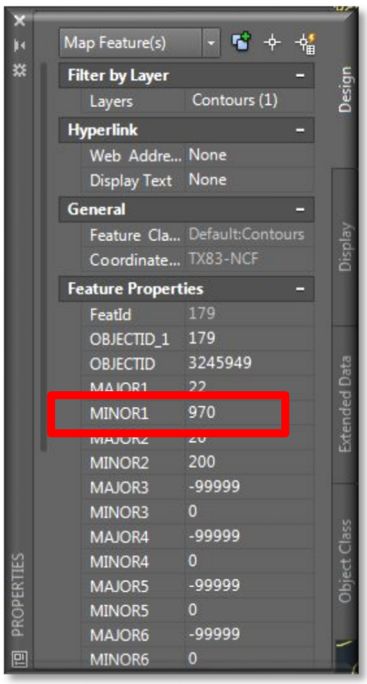
Creating AutoCAD Civil 3D Objects from GIS Data

With the GIS data attached to our CD file, it's time to begin converting that data to be useable as a part of our AutoCAD Civil 3D design set. We will look at two processes, creating a surface and creating pipe networks from existing data.



Create a Surface

One of the more basic uses of GIS data is to bring surface information in to AutoCAD Civil 3D. This may well be the simplest process of all. Data for creating a surface can be obtained either from a live connection such as an ESRI database or from a SHP. The SHP file does not need to be connected to your CAD file to be used for surface creation.



Be certain to determine which property in the SHP contains the elevation data to be used for creating the surface. One simple way is to attach the SHP, highlight one of the contour lines and select Properties. From the Properties window a list of the properties will appear that are a part of the SHP and allow you to determine which one has the needed value for contour elevations.

Create Pipe Networks from Existing Pipe Data

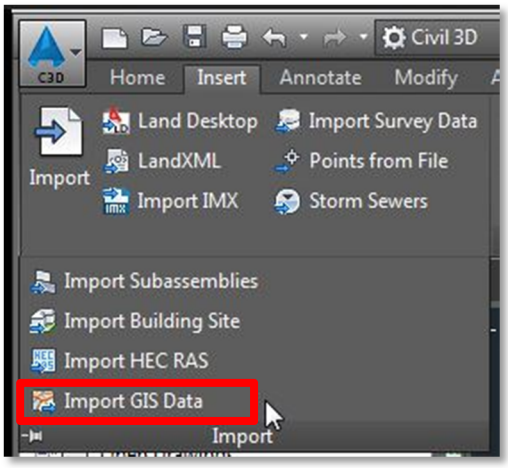
In addition to surface data, Pipe Networks can be created from GIS data, assuming the data contains all the necessary ingredients. Unfortunately not all of the data related to pipes has all the information necessary to create a Pipe Network. Properties that are needed for pipe include:

- Geometry (Created with the SHP)
- Pipe Size (Inner Diameter)
- Starting Elevation (Invert In)

- Ending Elevation (Invert Out)
- Material (PVC, HDPE, etc.)

In like manner, certain properties are needed when defining structures such as manway or junction boxes:

- Geometry (Created with the SHP)
- Rim Elevation
- Sump Elevation



Import GIS Data

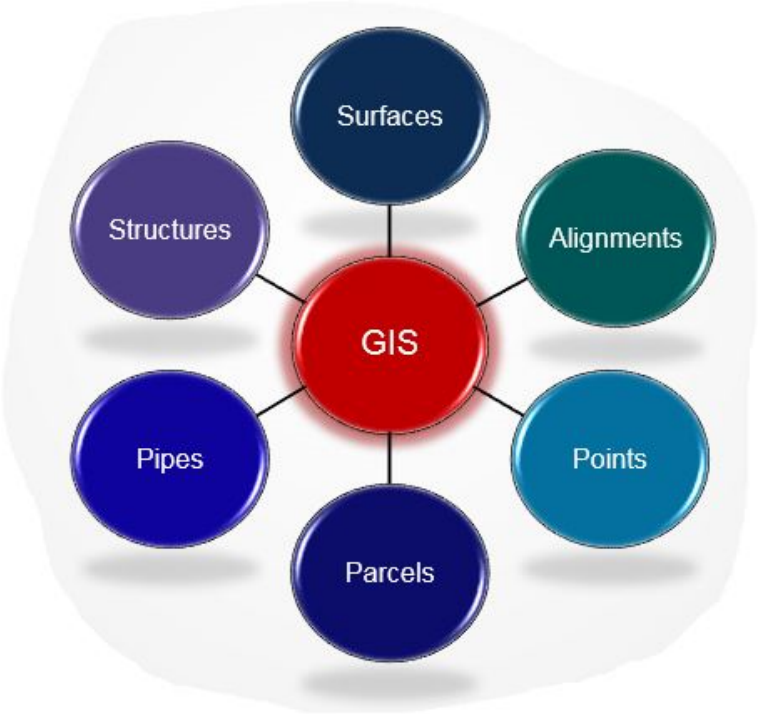
The process of creating a Pipe Network from GIS data starts under the Import section on the Insert tab of the AutoCAD Civil 3D Ribbon menu.

The Import GIS Data window will open allowing you to select a single SHP or a folder containing several SHP. Selecting a folder is convenient for importing both pipe and structures at one time and having them connected once imported. Remember that the SHP can only contain one type of object so at least two SHP are needed to import both pipe and structures. A network name, pipe list, pipe and structure labels are selected through this process.

Once the pipe and structure properties are assigned, the pipe network will be available in the AutoCAD Civil 3D design file.

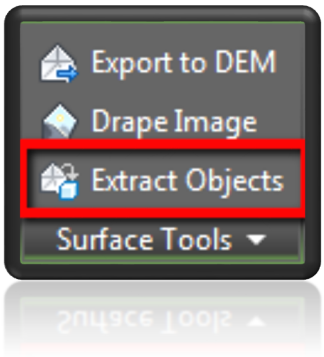
Export AutoCAD Civil 3D Design Data to GIS

Each completed AutoCAD Civil 3D project contains data that can be reused or shared for additional projects. Typically this data is stored as AutoCAD Civil 3D files and then later attempts to extract this information in a newer version of software becomes cumbersome at best. What if that data could be stored in a convenient package that could be extracted and used at a later time without concern over the version or even brand of software being used? GIS gives us that ability to store data that can be readily used regardless of the version or file type needed.



How Do We Share Civil Data

There are a number of ways to transfer AutoCAD C3D data to GIS. First you must determine what information and how detailed that information must be in order to determine the process needed. Following is a list of commands that will allow you to generate GIS friendly data:



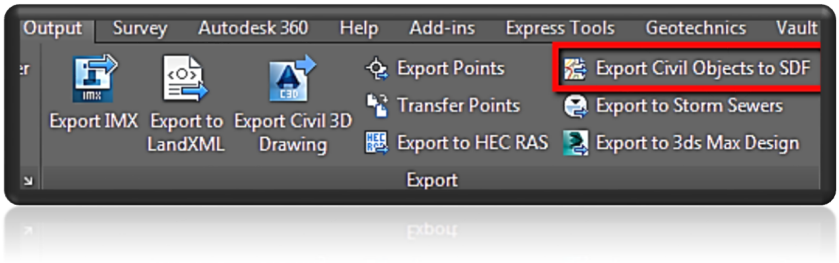
Extract Contour Data

An existing AutoCAD Civil 3D surface may be used to extract data directly to a SHP for use in GIS. The Extract Objects icon is located on the context ribbon menu that appears when the surface is highlighted. Once executed the contours are selected and using MAPEXPORT the appropriate data is selected and a SHP is created.

Export AutoCAD Civil 3D Objects to SDF

Exporting AutoCAD Civil 3D objects to SDF is similar to extracting data for SHP. Advantages of using SDF is that all the data is stored in one file and that multiple data types may be included in the single SDF. The only problem is that GIS will not read an SDF and the data must then be converted to SHP. There are four types of AutoCAD Civil 3D Data that can be exported to SDF:

- Alignments
- Points
- Parcels
- Pipe Network Data



MAPEXPORT

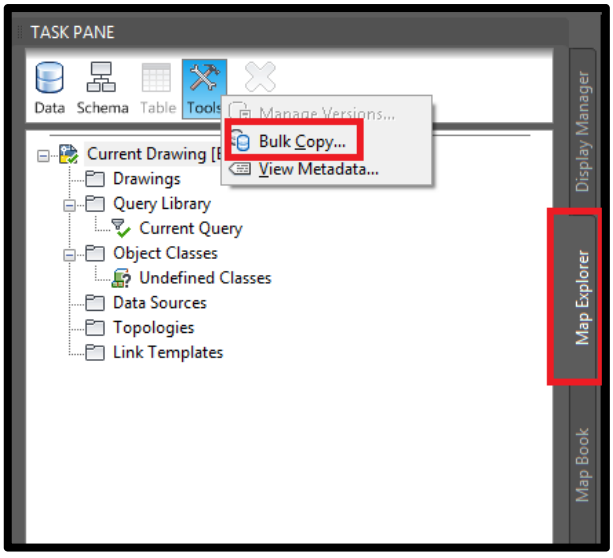
The MAPEXPORT command is used in conjunction with the Extract Objects or the Export Civil Objects to SDF to generate the particular file type containing the desired information.

Bulk Copy

Bulk Copy is available under the Tools icon when the Map Explorer tab is selected in the TASK PANE. It gives you the ability to copy selected feature items from the current drawing to a SHP or SDF.

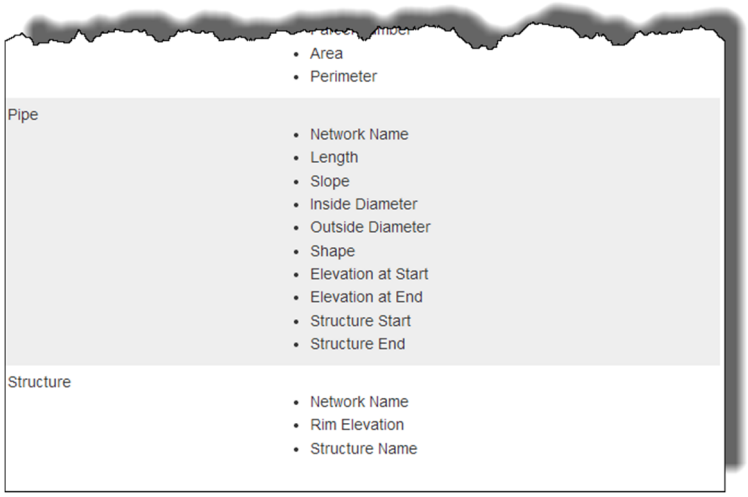
Bulk Copy can also be used to copy SDF data in to a SHP for use by GIS. When selecting items to copy from the source SDF there are some restrictions for the target name:

- SHP will not accept special characters in the name (i.e., \, /, - , _, etc.)
- Name length must be 12 characters or less



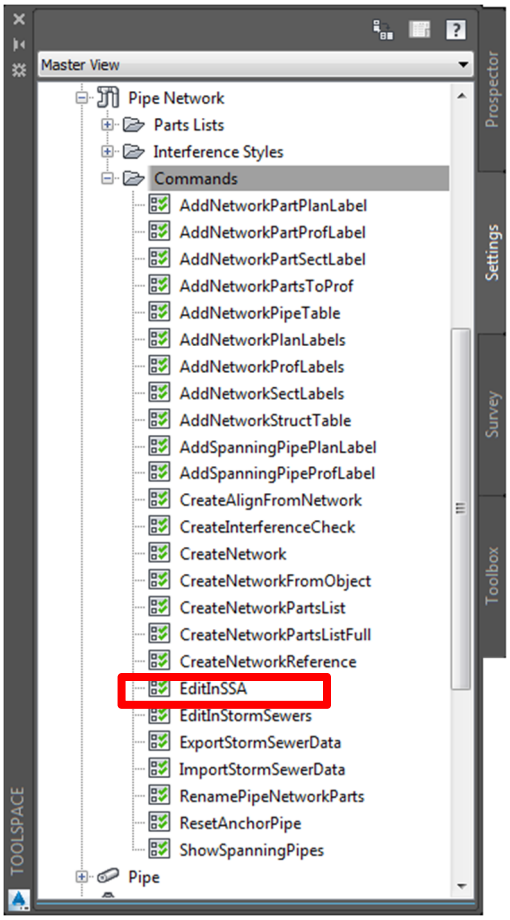
Storm and Sanitary Analysis (SSA)

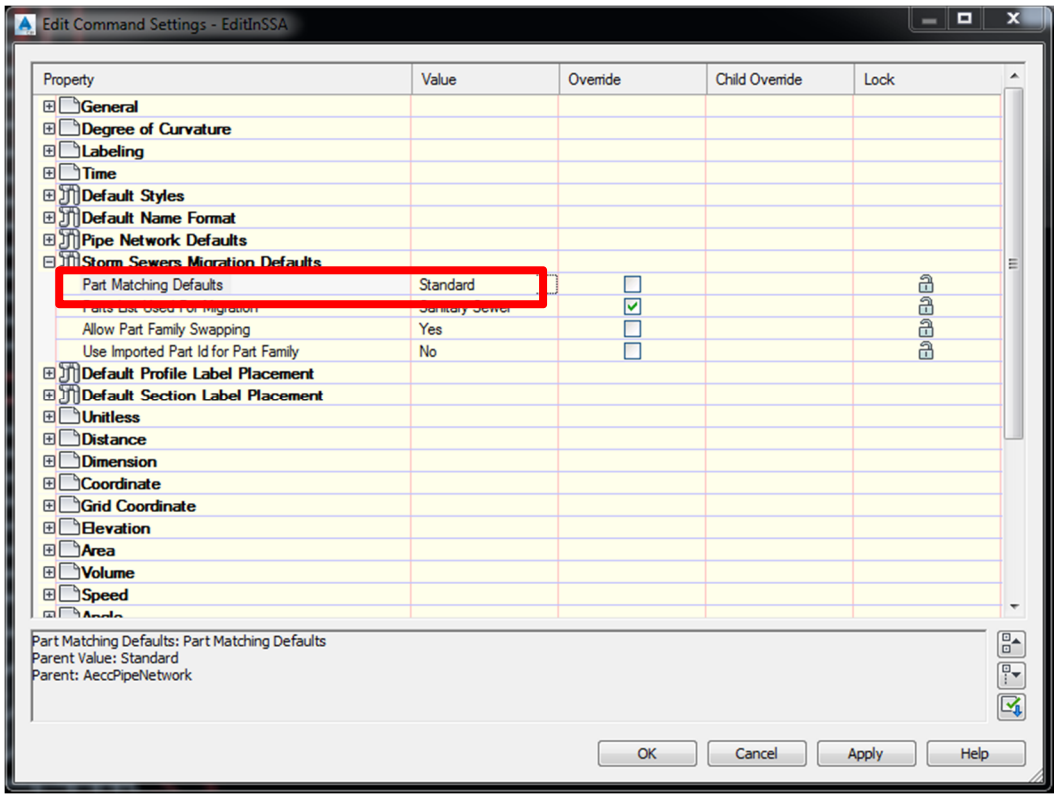
Exporting Pipe Networks from Civil 3D to GIS as an SDF is easy however the exported attributes are limited. This limitation creates the need for another process that allows for additional attributes to be collected and sent to GIS.

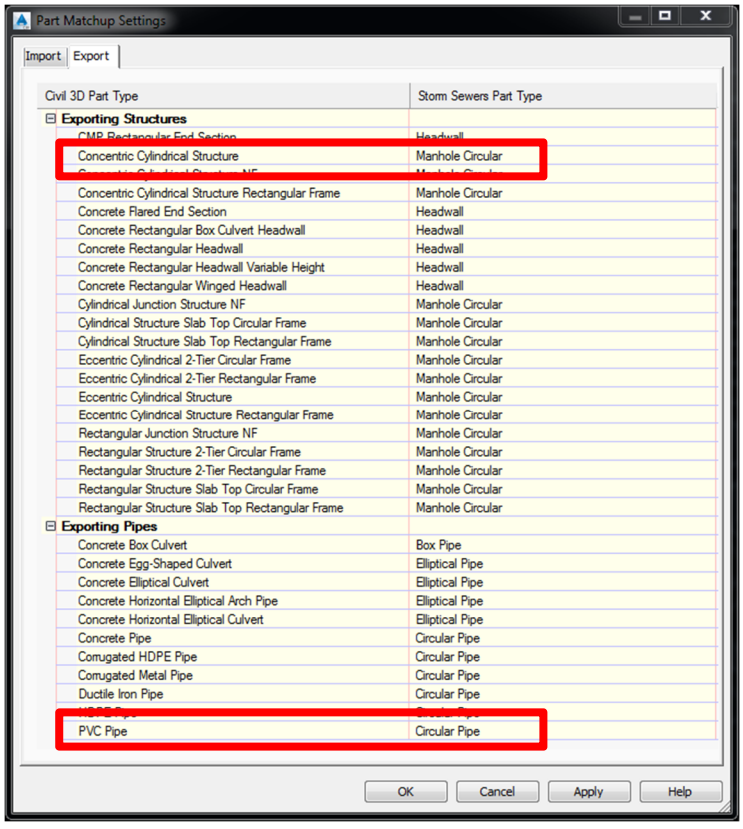


The Storm and Sanitary Analysis program allows the user to extract data from Civil 3D objects (namely pipes and structures) and export them to GIS with more attribute information than a simple SDF. Interoperability with AutoCAD Civil 3D makes it a simple process to export your Pipe Network data to SSA.

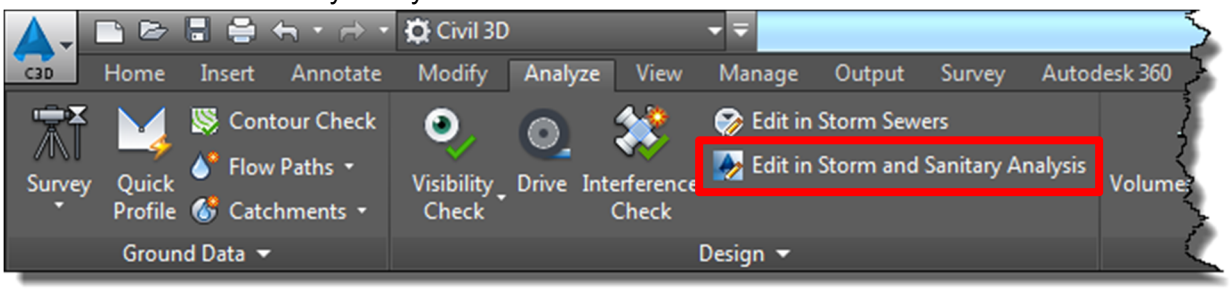
Begin the process by verifying the Part Matching defaults. This is found on the Tool Space Settings tab. Expand Pipe Network > Commands > EditInSSA




Edit Command Settings - EditInSSA
Property
Value
Override
Child Override
Lock
General
Degree of Curvature
Labeling
Time
Default Styles
Default Name Format
Pipe Network Defaults
Storm Sewers Migration Defaults
Part Matching Defaults
Standard
Allow Part Family Swapping
Yes
Use Imported Part Id for Part Family
No
Default Profile Label Placement
Default Section Label Placement
Unitless
Distance
Dimension
Coordinate
Grid Coordinate
Elevation
Area
Volume
Speed
Part Matching Defaults: Part Matching Defaults
Parent Value: Standard
Parent: AeccPipeNetwork
OK
Cancel
Apply
Help

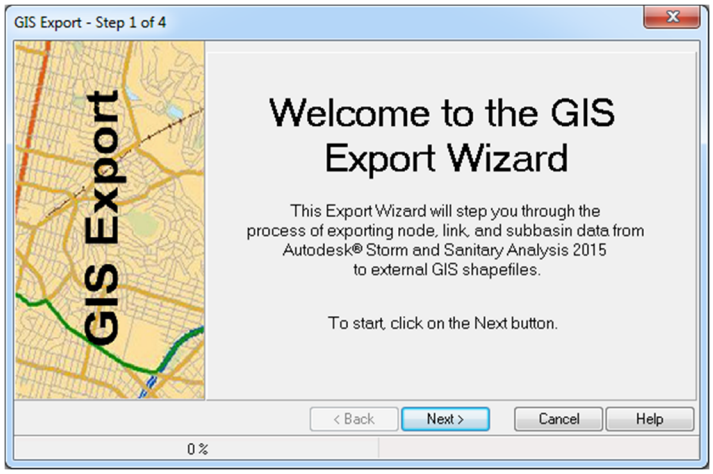

Part Matchup Settings
Import
Export
Civil 3D Part Type
Storm Sewers Part Type
Exporting Structures
Concentric Cylindrical Structure
Manhole Circular
Concentric Cylindrical Structure Rectangular Frame
Manhole Circular
Concrete Flared End Section
Headwall
Concrete Rectangular Box Culvert Headwall
Headwall
Concrete Rectangular Headwall
Headwall
Concrete Rectangular Headwall Variable Height
Headwall
Concrete Rectangular Winged Headwall
Headwall
Cylindrical Junction Structure NF
Manhole Circular
Cylindrical Structure Slab Top Circular Frame
Manhole Circular
Cylindrical Structure Slab Top Rectangular Frame
Manhole Circular
Eccentric Cylindrical 2-Tier Circular Frame
Manhole Circular
Eccentric Cylindrical 2-Tier Rectangular Frame
Manhole Circular
Eccentric Cylindrical Structure
Manhole Circular
Eccentric Cylindrical Structure Rectangular Frame
Manhole Circular
Rectangular Junction Structure NF
Manhole Circular
Rectangular Structure 2-Tier Circular Frame
Manhole Circular
Rectangular Structure 2-Tier Rectangular Frame
Manhole Circular
Rectangular Structure Slab Top Circular Frame
Manhole Circular
Rectangular Structure Slab Top Rectangular Frame
Manhole Circular
Exporting Pipes
Concrete Box Culvert
Box Pipe
Concrete Egg-Shaped Culvert
Elliptical Pipe
Concrete Elliptical Culvert
Elliptical Pipe
Concrete Horizontal Elliptical Arch Pipe
Elliptical Pipe
Concrete Horizontal Elliptical Culvert
Elliptical Pipe
Concrete Pipe
Circular Pipe
Corrugated HDPE Pipe
Circular Pipe
Corrugated Metal Pipe
Circular Pipe
Ductile Iron Pipe
Circular Pipe
PVC Pipe
Circular Pipe
OK
Cancel
Apply
Help

Exporting the Pipe Network is handled from the Analyze tab in the ribbon menu and selecting Edit in Storm and Sanitary Analysis.

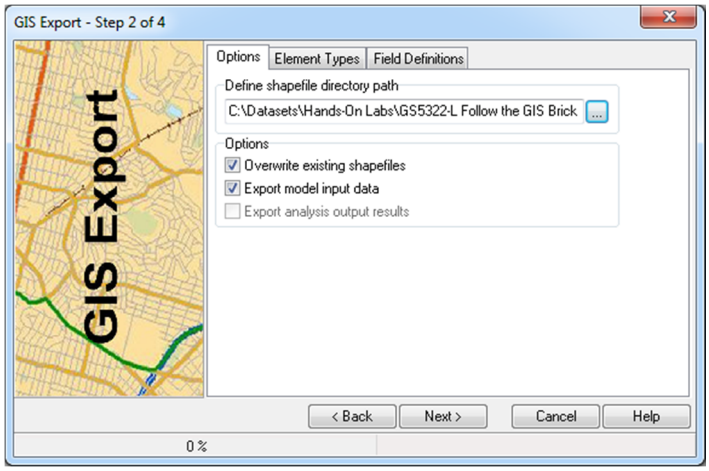


Select the Pipe Networks to be included and create a New Project when SSA launches.

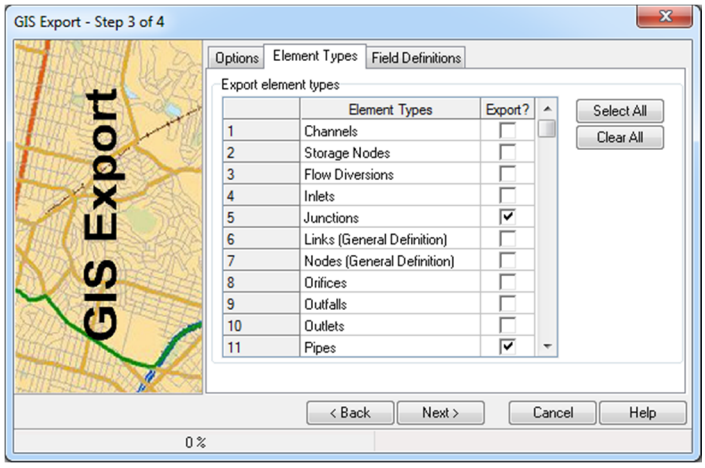
Inspect the imported pipes and structures and make ant necessary adjustments. When satisfied that Pipe Network is ready for export select File > Export > GIS Export.



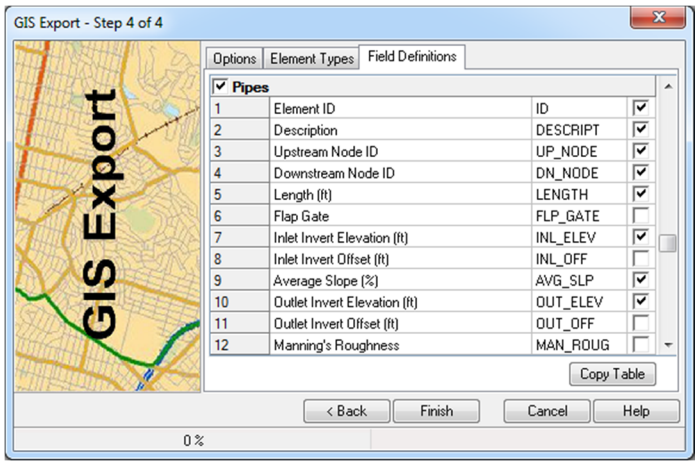
Select Next and define the SHP directory path

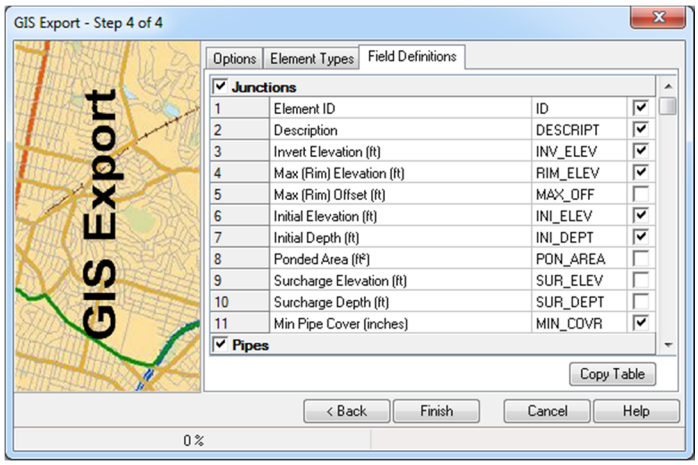


Select Element Types, pipes and junctions (structures)

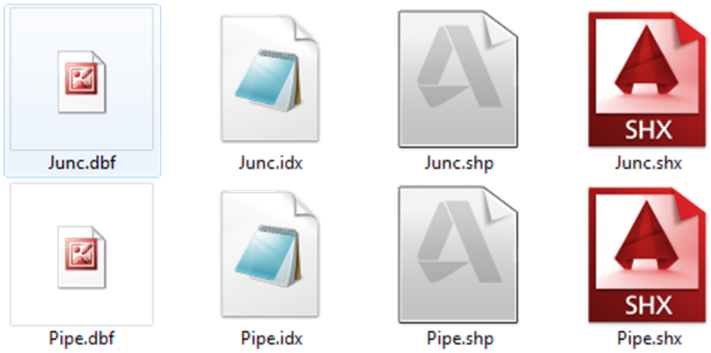


Next select the Field Definitions to be exported to the SHP. The information available will vary depending on the type of Element(s) selected.





Click finish and the data will be exported to the SHP and the folder designated.



The created SHP are now available to be imported to GIS and return to the beginning!