3.6 Roadway Design

A) Introduction

Civil 3D is the roadway design software used for surveying and roadway design work at Caltrans. It is the Department's policy that all new projects that require earthwork to be performed shall be designed using Civil 3D (RDS) starting July 1, 2014. MicroStation remains the standard drafting software and has been used by all functional units since 1995.

Caltrans has developed custom resource files for all these applications to maximize the efficiency of the CADD System. These resource files are based on information from the various guidance and policy documents such as the *Highway Design Manual*, *CADD Users Manual*, and the *Plans Preparation Manual*. The purpose of this section is to provide requirements and guidance to the engineer and surveyor in the use of these CADD tools as they relate to the roadway design process.

It is recommended that RDS users document their work. The suggested method of documentation is to create a text file named "Readme.txt" and saving it in the project directory under the appropriate functional sub-directory e.g. Design, Survey, Traffic, etc. This file is known as a "read me" file. During the design processes many files are created at different times representing different things. A "Readme" file documents the points, alignments, surfaces, cross-sections, etc. along with when they were created, by whom, and what they represent. The documentation becomes an invaluable source of information for the users of the project data. Caltrans projects can be active for several years. How the project is organized must be clear for a long period, even after the original operators are no longer available. This problem is minimized when a "Readme" file is maintained in the project directory.

B) Project and Data Management

Data management is a very important consideration when working with large and complex datasets. Decisions regarding data storage can have a significant impact on the drawing performance during the Plan Production process.

Referencing External Data

It is possible to use or display data from other files without storing the information in the current drawing. This is accomplished using external references (XREF) for dwg, dgn, and pdf files, and data references for RDS object data. Referencing, rather than inserting data reduces the amount of data in a drawing file and enables sharing of project data amongst different users.

XREFs

XREFs display an AutoCAD drawing (dwg or dxf) file, a MicroStation design (DGN) file, PDF's and non-georeferenced images in the current drawing as a block. The display of the XREF appears "transparent" (i.e. greyscale, or halftone) to indicate the data being displayed from that file does not actually reside in the current file. The location, scale and rotation can be set when attaching the XREF. XREF [Enter] at the command line launches the dialog box used to load a reference file.

The two main ways to share data between drawings is Data References and External References. Starting 2013, polylines, survey figures and feature lines can be targeted in a corridor from an externally referenced file. This eliminates most of the need to copy elements from a referenced file into the active file. There are still some situations where it is desirable to copy objects from externally referenced files. Usually this can be done using the "NCOPY" command in the RDS. With Data References, only some of the RDS objects can be shared (alignments, profiles, surfaces, pipe networks and view frames). Quite often that is sufficient, however, if the user needs to reference photo or survey data objects, an AutoCAD element, or a DGN element the user must use an external reference to see the object. Using RDS the user can apply labels to the elements through the XREF or use object snaps to select key points along the XREF'ed line.

Although Caltrans will be changing the way it processes data in RDS and will eventually abandon the use of the survey database, there are still projects that contain elements in a survey database. Certain objects like survey figures and survey points, cannot be data referenced or NCOPY'ed into a drawing. In this situation the objects must be inserted from the Survey Database. For example, the designer needs to use the existing EP for rehab work. In this situation they must open the Survey Database to insert the survey figure into the active drawing. However, if they only wish to visually see where the data lies, they can use XREFs to see the graphics.

Data Shortcuts

A data shortcut is an instrument that allows sharing an object from a source file, where the object resides to another file(s). Data shortcuts can be created from the following objects; surfaces, alignments, profiles, pipe networks, corridors and view frame groups. The creator of the object establishes a data shortcut for other users to use via a data reference.

The advantage of using data shortcuts is that these objects can be shared with other team members which reduces duplicate data and allows the workload to be divided into more manageable segments. Data shortcuts also allow the design to be synchronized across a set of drawings. If any of the source objects are edited or updated, all drawings that reference these objects will be synchronized and thus contain the latest changes. Caltrans frequently uses data shortcuts for surfaces, alignment, and profiles.

Data References

To use the Source object in another drawing, the user needs to create a Data Reference to the object. The data reference maintains an active link to the source object. The referenced objects have read-only geometry but provide the user with the ability to apply a local objects style and annotation, perform analysis and access to the source object's properties. The referenced object takes up less file space when the drawing is saved. A single design object can be referenced into all drawings which require that object. If the source object is edited, the synchronization process ensures that changes are reflected in the referenced object. Synchronization occurs when the consumer drawing is opened and can also be done manually by a user.

Data references are essential when working with large datasets. In general, data references offer the following benefits:

- Each drawing only needs to reference the object(s) pertinent to the drawing.
- A referenced object consumes very little space in its host drawing.
- Each data reference is automatically updated when the source object changes.
- The data reference is a read-only copy and is protected from unintentional changes.
- The source object in the data reference is available for analysis. For example, you can reference a surface and then create a profile based on that surface in the host drawing.

Data File Structure

At Caltrans all data associated with a project is kept on a server under a common directory. This directory name is usually called “projects” or proj1, proj2, proj3, etc. Under the “projects” directory there are directories usually named by the expenditure authorization (EA) of the project or the project EFIS number.

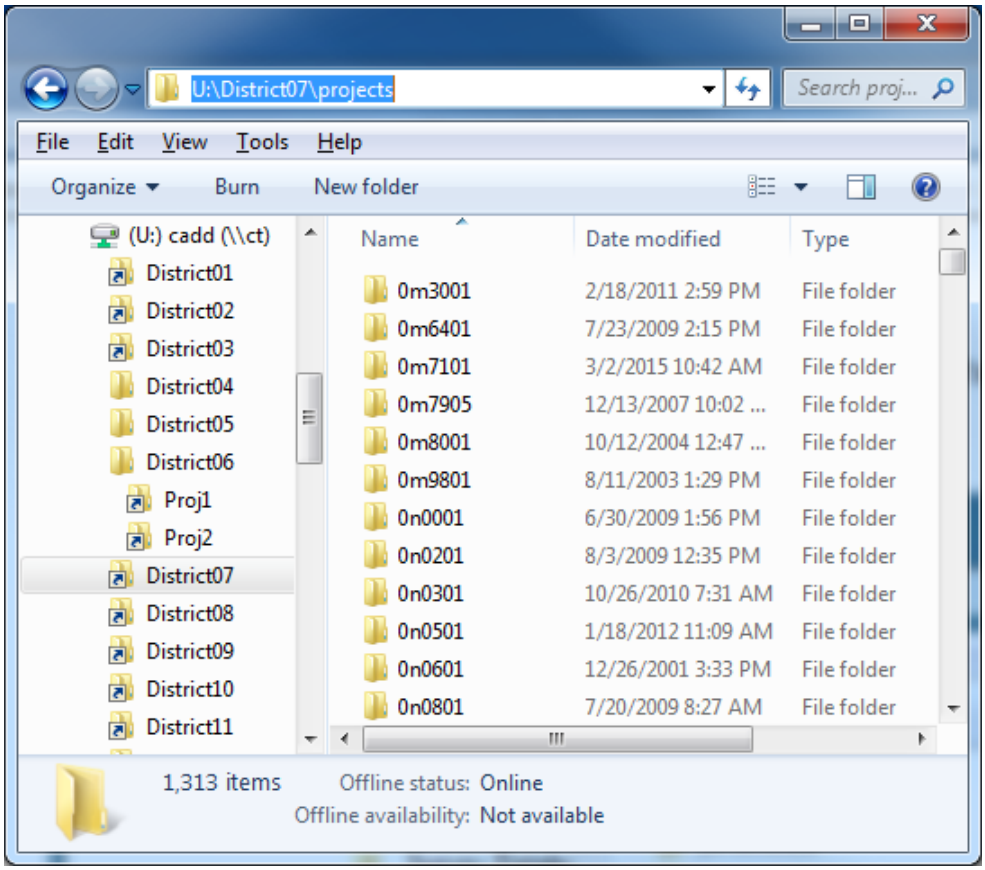


Figure 1 – Typical District projects directory

Working Folder

The working folder is the folder where all the projects for a district are stored. The image above shows the district 7 projects U:\District07\projects.

The Data Shortcuts Project Folder

The data shortcut projects folder is the sub-folder of the projects data folder. For example any of the sub-directories0m3001, 0m6401,… , 0n0801 could be data shortcut project folders where Civil 3D files for that project reside.

Data Shortcut Environment Variable DSSYSVAR

There is an environment variable on the computer that is used by the RDS to help determine the location of the Working Folder. This folder is used when making or reading data shortcuts. The name of this variable is DSSYSVAR.

To prevent problems created by differently mapped-drives across multiple functional groups, a Windows system environmental variable representing the Working Folder should be used. When data shortcuts are written to an XML file, the path includes the variable %DSSysVar% as part of the project path.

Without the use of this variable, when a user attempts to load a shortcut on a computer that has a different Working Folder than was used to create a data shortcut, the data shortcut would not resolve. As soon as the Windows Environmental variable is set the data shortcuts will resolve, as long as the folder structure is similar on both computer workstations below the %DSSysVar% path.

District Project Servers, Data Shortcut System Variables and Working Directories

For District Projects use the following table to set up project directories and folders.

The following table identifies all the mapped locations of the Project directories on the District servers. The drive that is mapped to this location is the drive that the DSSysVar should be set to when working with data shortcuts and references on the server.

District Project Servers, Data Shortcut System Variables & Working Directories

This information changes often. HQ Office of CADD and Engineering GIS Support recommends checking with the local district CADD and/or IT support staff to make sure that the latest information is being used.

This information is also available on the Caltrans internal website at the following location:

https://cadd.onramp.dot.ca.gov/node/438

C) Caltrans MicroStation Standard Resource Files

The MicroStation resource files are discussed in Chapter 2 of this manual.

D) Existing Topography

Overview

Topographic (topo) survey products are the basis for planning studies and engineering design. Existing topography data can be collected using different methods with distinct accuracies. Data types include photogrammetric data, aerial Light Detection and Ranging (LiDAR) scanned data, bathymetric data, and field collected survey data. Field collected data may be surveyed with conventional methods, a total station, as well as Mobile Terrestrial Laser Scanning (MTLS). The standard topographic products in a roadway design project are topographic data, surface(s), and topographic mapping drawings.

The Office of Photogrammetry administers and processes photogrammetric, aerial LiDAR and bathymetric data. The resulting topographic maps conform to the standards outlined in Standards and Symbols for Photogrammetric Mapping (SSPM) and “Standard Plan A10D”. The standards of the resulting roadway design projects are provided in this section.

Field collected survey data is gathered in accordance with Chapter 11 and Chapter 15 of the “Surveys Manual.” The deliverables for the resulting topo maps and Civil 3D roadway design products are provided in this document.

Existing topo data is provided in Civil 3D as Points, Linework, and Surfaces in a collection of drawings and databases. The data is delivered as outlined in this document to improve performance, while providing the necessary information for all functional units to design and deliver a project.

For a complete listing of the standard layers, styles, and tools used in the delivery of topo data, see Appendix A7 in this manual.

Drawing Templates

Two templates contain all the layers, styles, and page setups required to create drawings for processing and delivering different types of topo data, ***Ct_2016_Topo_Surveys_MTLS.dwt*** and ***Ct_2016_Topo_Aerial_Photo.dwt***.

- ***Ct_2016_Topo_Surveys_MTLS.dwt*** – used to create drawings containing survey and MTLS data.
- ***Ct_2016_Topo_Aerial_Photo.dwt*** - used to create drawings containing aerial LiDAR, bathymetric and photo data.

Either template can be used to create the final *EG_Surface* and *EG_Linework_Points* drawings.

When saving drawings, file names can be alphanumeric with underscores or dashes. They should not include spaces or special characters to prevent unforeseen program errors.

Civil 3D Project Folders for topo data

The Caltrans Civil 3D project folder structure supports dynamic data sharing of many Civil 3D objects. The following is a brief overview of the folder structure as it pertains to topo deliverables.

Data in the Caltrans project folder structure is protected with an organized system of access permissions. Typically *Read/Write* access is assigned to all project members at the project level, and then restrictions are applied to project sub-folders based on functional unit.

- Engineers have *Read*-only access to the Surveys folders and files including Drawings and Survey Databases. They have *Write* access to the Design folders and files.
- Surveyors have *Read*-only access to the Design folders and files. They have *Write* access to the Survey folders and files including Drawings and Survey Databases.

The Civil 3D Project Folder structure must be in place on the server before the topo data can be delivered and shared. The folders are created by the appropriate District IT or CADD Support personnel at the request of the Project Engineer. The District Surveyors and HQ Photogrammetry DTM processors must be given permission to *Read* and *Write* to the appropriate folders.

Ideally, all the drawings and Survey Database(s) are prepared directly on the server within the Civil 3D Project Folder structure; however, this may not always be possible. If the project folders are not available on the server or access to the server is limited, a project folder structure can be created locally on the user's computer. The data can then be prepared locally and later copied to the server. When working locally, only the drawings and database folders should be copied to the project folders on the server. The Data Shortcuts MUST be recreated directly on the server.

- All the drawings and database files in the <Project name>\Surveys\ folder are accessible as *Read*-only for the functional units outside of the Surveys functions.

Multi-tiered Data Shortcut Levels

Caltrans utilizes two multi-tiered shortcut levels within a project folder; a lower-tiered Surveys level and an upper-tiered Project level. This gives Surveyors the ability to compartmentalize individual topo data Surfaces at the lower-tiered Surveys level,

allowing them to be merged into a single existing ground Surface. The merged Surface is shared at the upper-tiered Project level for all project users. This ensures that all users will be working with the same exact Surface and will only be working with the Surface that the Surveyors consider complete.

- The upper-tiered ***Project*** Data Shortcut level is for use by everyone working on the project. This is where the merged existing ground Surface Data Shortcut is set, as well as Data Shortcuts to the existing and new roadway alignments and profiles.
- The lower-tiered ***Surveys*** Data Shortcut level is for use by Photogrammetry and Survey users only. This is where the individual Surface Data Shortcuts are set. These Surfaces are not to be used directly in the design process.

The Data Shortcut System Variable (DSSYSVAR)

The Windows System Environmental Variable representing the Working Folder, DSSysVar, will be used to prevent problems created by differently mapped-drives across multiple functional groups. This variable must be set to the appropriate location prior to creating a Data Shortcut and prior to creating a Data Reference. When a Data Shortcut is created, the path includes the variable DSSysVar instead of the entire path up to the Working Folder. Subsequent Data References will resolve if the folder structure for all users is the same below the DSSysVar path. Without this variable the reference will not resolve when a user attempts to load a Data Reference on a computer having a different path or mapped drive than what was used to create the Data Shortcut.

Survey Data Collection

Caltrans Data Collection (CTDC)

During the 80s and 90s, Caltrans worked with the California State University Fresno to create a DOS based data collection system, **Caltrans Data Collection (CTDC)**, and a data processing system, **Caltrans Data Processing (CTDAP)**. At the time, data was collected in the field using standard numeric Topo codes with CTDC and processed using the CTDAP. When the data was processed, the final values were recorded in a column delimited text file formatted in a **Total Station Survey (TSS)** file format. When using the Caltrans standard resource files, the Caltrans CADD standards are adhered to while the TSS file is imported and translated into Points and Lines with specific attributes within the roadway design software. As survey field equipment and roadway design software evolved, there became a need to develop new routines to continue using the TSS file format.

CTDC data is collected today using Trimble Access on Trimble data collectors. Once collected, the data is transferred to **Trimble Business Center (TBC)** where it is processed and exported to a TSS file. The resulting TSS files are imported into a Civil 3D Survey Database, creating Survey Points and Survey Figures. All corrections and edits to the topo data are typically made within Civil 3D.

The CTDC data collection was a robust method for collecting data when it was developed but it has its limitations with newer equipment and software. Some of the limitations of CTDC include:

- Requires numeric coding instead of the industry standard alpha coding.
- Descriptive information is included in the Description field of the Survey Points, providing pertinent information to the design process. However, this attribute coding is limited to two entry fields and is only displayed in the Point Descriptions. Therefore, the Points used to generate the linework must be displayed to see the information about the Survey Figure.

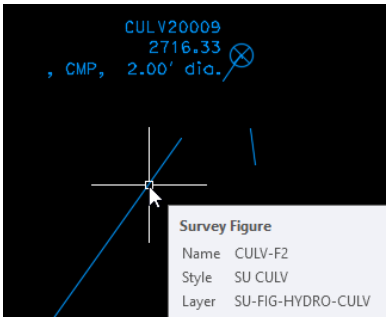


Figure 2 - Information about the culvert Survey Figure (diameter and material) are only displayed in the Point's Description

- Coding for Surface type is limited to *ground* or *feature*.
- Doesn't support Trimble Line Control codes on the data collector, preventing real-time display of linework in the field.
- Symbology of the features in TBC do not reflect the same symbology in Civil 3D, making it difficult to identify errors.

CTDC data is used today but it is being phased out with a new method of data collection. This document focuses on working with the new **Caltrans Survey Asset Collection (CSAC)** data. For information regarding the use of TSS files, Survey Databases, Survey Points, and Survey Figures, see the Caltrans internal training manual "*Civil 3D 2016 Survey Data Processing and DTM*" found on the OLS FTP site,

ftp://cadd.dot.ca.gov/OLS_FTP/Software/Civil3D/Training/Survey_Data_Processing_DTM/Civil_3D_2016/Civil_3D_2016-Survey_Data_Processing_and_DTM.pdf

Caltrans Survey Asset Collection (CSAC)

In January 2014, Caltrans began work with Autodesk and Trimble representatives to establish a different method to collect data, a method that would leverage the strengths of both applications. The goal was to improve data collection methods in the field while providing attribute-rich features that transfer smoothly into Civil 3D and other asset management systems. The result of these efforts culminated in the creation of Caltrans Survey Asset Collection (CSAC).

CSAC data is collected using Trimble Access on Trimble data collectors with the Caltrans **Feature Code Library (FCL)**. Once collected, the data is transferred to TBC where it is processed, edited, and exported to Shape files (.shp). The resulting Shape files are imported into a Civil 3D drawing, creating AutoCAD Points, COGO Points, Feature Lines, and Polylines.

All corrections and edits to the data are made within TBC, new Shape files are exported, and the data is re-imported and updated in Civil 3D.

Some key aspects of the CSAC data collection include:

- Alpha coding
- Robust variable attribute coding that provides more information with all features, including Point and Line Features

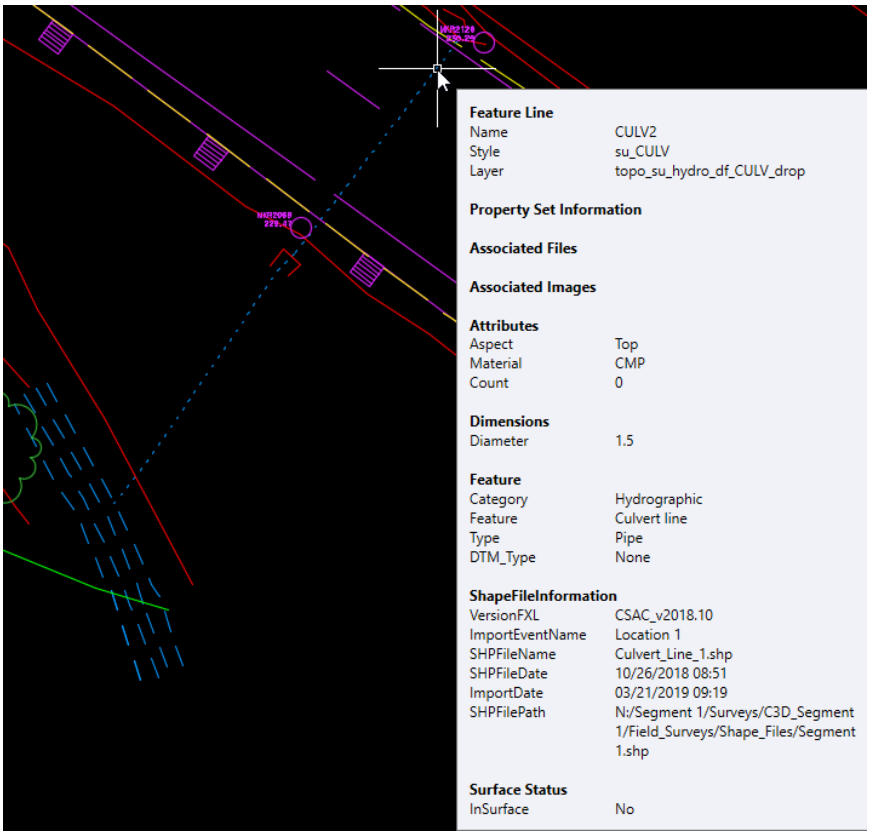


Figure 3 - Information about the culvert Feature Line (aspect, material, diameter, and type) are displayed directly with the Line

- Coding for Surface type is variable, including *Ground*, *Bridge deck*, *Bridge underside*, and *Ground underside* - with the potential for more options
- Supports Trimble Line Control codes that enable real-time visualization on the data collector
- Photos and documents can be associated to all features and the association is transferred to Civil 3D for use in the design process
- Supports the ability to use multiple codes at the same location, “stacking codes,” where multiple features converge at the same Point
- Symbology of the features in TBC reflect the same symbology in Civil 3D, making it easier to identify errors
- TBC is used to make all corrections and edits to the data
- TBC is used to export the CSAC data in Shape files

  Note: Shape files do not support curved linework, they only contain one type of geometric data: Lines or Points. This is discussed in more detail later in this document.

- Civil 3D is used to create and share Surfaces, as well as deliver the topo and attribute information

The CSAC workflow relies on tools that are only available in Civil 3D 2016 or more recent versions. CSAC objects cannot be delivered in Civil 3D 2012.

Data should only be collected with the CSAC FCL when a NEW Civil 3D 2016 project is being prepared for and delivered to Design. An exception may be made to the direction above if an existing Civil 3D 2016 project has less than 30% of the design work performed and the Survey Figures are NOT referenced to a Corridor or in Cross Sections. If the Project Engineer approves, additional topo data can be collected with the CSAC FCL and existing Civil 3D 2016 Survey Databases and their associated drawings can be converted for use with the Civil 3D Shape Tools. DO NOT collect additional topo data with the CSAC FCL for an existing project or convert existing Civil 3D 2016 projects without the Project Engineer's approval. See the rollout memo on the following page for more information about the rollout of the CSAC FCL.

The CSAC process introduces significant changes to the deliverables and tasks performed in TBC and Civil 3D. This section provides an overview of the deliverables, project organization, tasks, and tools.

TBC Project Details

ALL processing and corrections to the topo data are performed in TBC. This ensures that the TBC project is complete for the location of data collected. Multiple TBC projects may be created for a single Civil 3D project to accommodate different site locations and the involvement of different crews during the data collection process.

Surfaces are created in TBC for review QA/QC purposes only. Transferring a Surface from TBC to Civil 3D should not be done because of potential translation issues and other issues that are caused when merging multiple data sets.

Shape files

A set of Shape files are exported from every TBC project containing CSAC data for a Civil 3D project. The TBC project Shape files represent the final edited TBC project dataset and are stored in the TBC project's *.shp* folder within the *Field Surveys* folder of the Civil 3D project folders.

These files are typically only used by the Surveyor who loads the CSAC data into the Civil 3D drawing. However, these files can be used by others using GIS applications for asset management systems, such as the utility database.

A collection of at least four or five files are created for each CSAC FCL Feature Code that is used within the data set selected in the TBC project. The extensions of the three required files are DBF, SHP, and SHX. A file with the extension PRJ is included if a coordinate system is assigned to the data. If 50 different features codes in a TBC project are selected, then 50 collections of Shape files will be exported. Each

collection of Shape files contains one or more Points or Lines for each Feature Code. For example, if 12 lines in the TBC project use the Feature Code named *Curb_Lip_1* (code LIP1), then the Shape file collection named *Curb_Lip_1** will create 12 *su_CURB_LIP* Feature Lines when imported into Civil 3D.

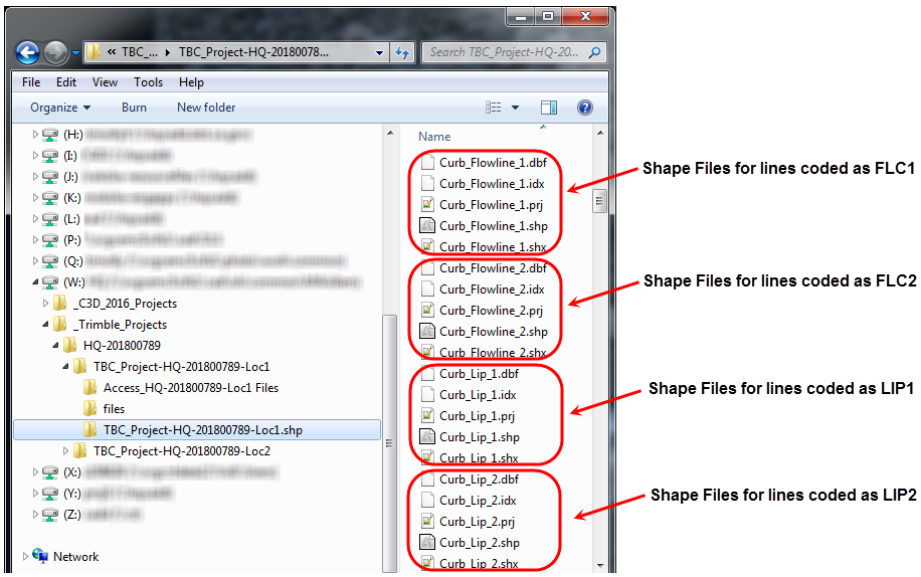


Figure 4 - A collection of 5 files represent a Shape file per each CSAC FCL Feature exported from a TBC project. Each Shape file can contain one or more Point or Line Features, but not Curve Features.

When more than one TBC project is used for a Civil 3D project, multiple sets of TBC project Shape files are created and delivered in separate TBC project *.shp* folders. These project *.shp* folders are delivered in the Civil 3D project's *Shape_Files* folder. The TBC project's *.shp* folder creates a unique location to contain the different TBC project Shape files. This ensures that Shape files with the same name are stored separately and cannot be overwritten while allowing them to be imported into the same Civil 3D drawing.

Images and Documents

Images captured in the field and supporting documents including DOCX, PDF, and XLSX, can be associated to CSAC data in TBC. The images and documents are stored in folder(s) within the TBC project *.shp* folder in the Civil 3D project folders.

The images and documents can be viewed by any user working on the Civil 3D project through nested XREF's with tools provided in the Civil 3D Shape tools.

KML/KMZ Files

A KML or KMZ file can be used to digitally represent the project location and CSAC features in GIS environments or within Internet-based, two-dimensional maps and three-dimensional Earth browsers. A KML file is an XML file with specific notation for

expressing geographical information such as annotation and visualization in 2D and 3D geographical models available online (Google Earth). A KMZ file consists of a main KML file and zero or more supporting files that are packaged using a Zip utility into a single unit, called an Archive. Since a KMZ file contains the supporting files in its zipped file structure, photos or documents that are stored in that structure can be seen by other Earth browser users. A KML file does not offer this standalone file imbedding option.

KML/KMZ file(s) are exported from every TBC project containing CSAC data for a Civil 3D project. The TBC project KML/KMZ file(s) represent the final edited TBC project dataset and are stored in the *Deliverables* folder of the Civil 3D project folders.

- If images are associated to the CSAC data, a KMZ file must be delivered.
- If images are not associated to the CSAC data, a KML file can be delivered.

The KML/KMZ file(s) can be viewed by any user working on the Civil 3D project, even those who DO NOT work in Civil 3D. This makes the attribute information accessible by ALL users working on the Civil 3D project.

Civil 3D Drawing Details

The CSAC data is stored in a Civil 3D drawing as COGO Points, Feature Lines, AutoCAD Points, Polylines, and associated Surfaces. The drawing(s) is shared for use in the design process as a nested XREF in the project's *EG_Linework_Points* drawing. The Surface is shared for use in the design process as a Data Shortcut in the *EG_Surface* drawing. The *EG_Linework_Points* and *EG_Surface* drawings will be discussed in more detail later in this document.

The only edits to CSAC data that are performed in Civil 3D is the trimming and clipping of overlapping data from multiple data sets in the same drawing. Two tools are included in the Civil 3D Shape tools to trim CSAC lines, **Trim Feature Lines** and **Trim Features at Boundary**.

Note: These tools can also be used to trim aerial LiDAR, photo, and MTLS topo data.

Drawing Requirements

The CSAC import process relies on drawings that contain the appropriate Property Sets, Point Groups, Object Styles, and Import Settings. The CSAC Styles, Property Sets, Point Groups, and Import Settings were added to the *Ct_2016_Topo_Surveys_MTLS*.dwt template which was included in the *Ct Resource 18.8.16.6* update for Civil 3D. Drawings created from the correct template contain the Custom Drawing Property ***Topographic Data*** that contains the value of ***Surveys & MTLS data v11*** or higher.

To verify that the correct *Topographic Data* version is being used, in **Civil3D** click the **Application Menu** button ➢ **Drawing Utilities** ➢ **Drawing Properties** ➢ in the **Custom** tab ➢ verify that **Topographic Data** is ***Surveys & MTLS data v11*** or higher.

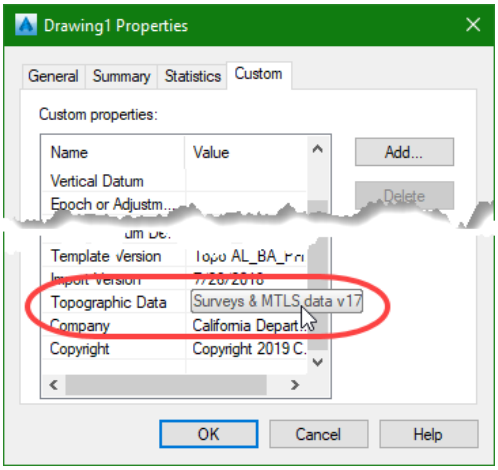


Figure 5 Template versions in the Drawing Properties

Property Sets

A **Property Set** is a custom attribute that can be attached to AutoCAD elements and Civil 3D objects. The Property Set values can be geometry related such as the length of a Polyline or they can be user-defined Feature related attributes providing detailed information about the object, such as the asset ID of a power pole.

The descriptive information input in the Feature Code attributes is directly associated to the CSAC data in Property Sets. The Property Sets are used to display the CSAC FCL Attribute information associated to the objects. While working in the drawing containing the objects, the information can be displayed in the Properties Palette when the object is selected or with tools provided in the Civil 3D Shape tools. The information can also be viewed by any user working on the Civil 3D project through nested XREF's with tools provided in the Civil 3D Shape tools. The Property Set data is also used in **SHP Palette** queries and the **SHP tool's Point Table** provided in the Civil 3D Shape tools described in the next section.

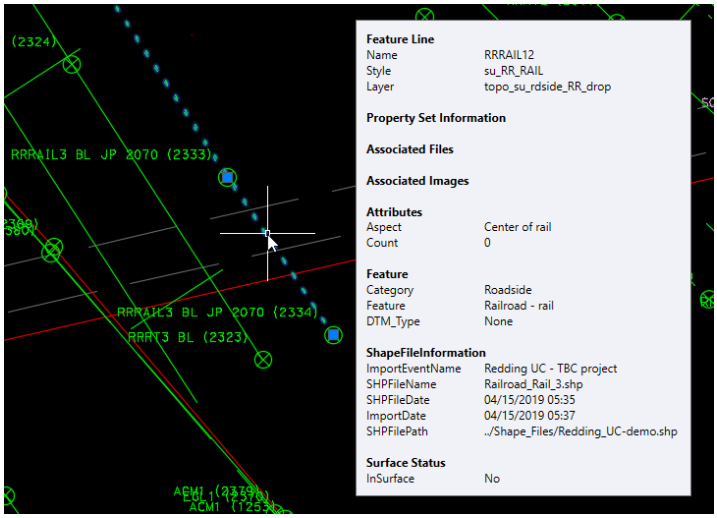


Figure 6 Feature Code Attributes stored in Property Sets of the Civil 3D objects

The Points used to create the linework in TBC, ***Line Points***, contain attributes that specify the Feature Code and the data collector's Point number. These points can be imported into Civil 3D for field notes review purposes, however, they don't contain any other feature attributes useful for design and must be hidden when the project is delivered.

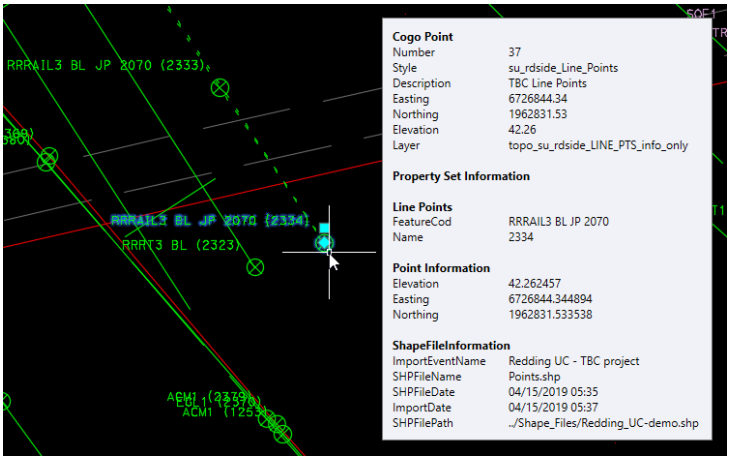


Figure 7 Property Sets of the CSAC Line Points include the Feature Code and data collector's Point number

CSAC Property Set Definitions

A Property Set Definition specifies the characteristics of a group of Property Sets that can be associated with an object, e.g., the Property Set Definition named ***Feature*** includes the object's attributes for ***Category***, ***Desc_1***, ***DTM_Type***, etc. See Appendix A7 in this manual for a complete listing of the Property Set Definitions included in the *Ct_2016_Topo_Surveys_MTLS*.dwt template.

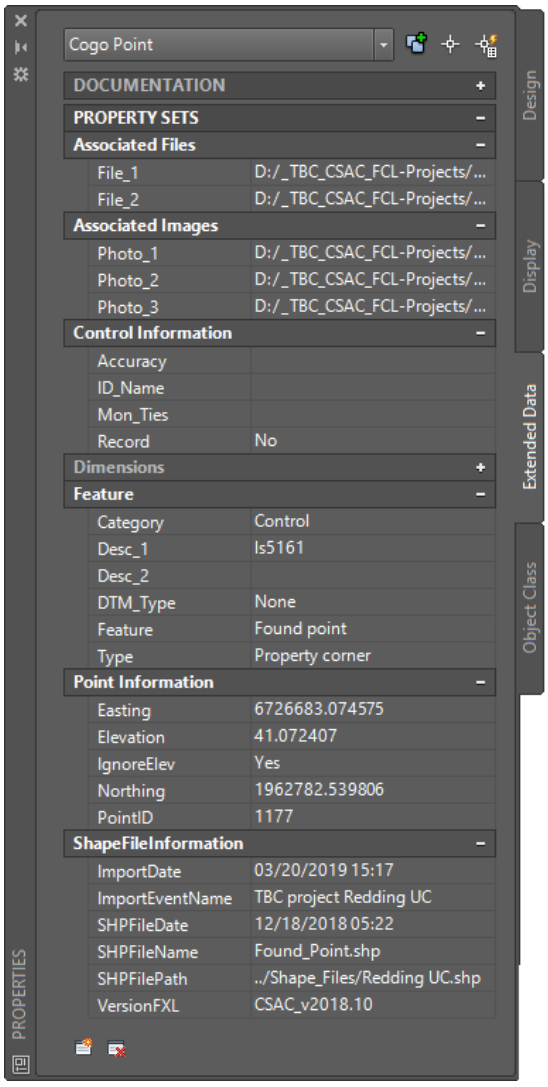


Figure 8 Property Set Definitions and Property Sets assigned to a COGO Point

Point Groups

A **Point Group** is a named collection of Points that organizes and controls Point appearance in a drawing. Point Groups provide a flexible and convenient way to work with Points that share common characteristics or are used to perform a task, such as creating a Surface.

Pre-defined Topo Point Groups

The Civil 3D 2016 template, *Ct_2016_Topo_Surveys_MTLS.dwt*, contains Point Groups that are used by COGO Points created with the CSAC workflow and Survey Points created with the CTDC workflow. See Appendix A7 in this manual for a complete listing of the Point Groups included in the *Ct_2016_Topo_Surveys_MTLS*.dwt template.

Display Order

The Point Group display order in a drawing determines the order in which Points belonging to multiple groups are drawn when the drawing is opened or when graphics are regenerated. This is a quick and easy way to set the display of Points when working with drawings. The display order is accessed through the properties of the Point Group collection in the **Prospector** tab. The first (highest) Point Group in the list is used when the graphics are regenerated. A Point that belongs to more than one Point Group is drawn by the Point Group that is highest in the display order, it is unaffected by the Point Groups that are lower in the display order.

Properties

CTDC Point Groups

The **Point Group Properties** are used to determine how Points are added to a Point Group. The properties can be pre-defined in queries where the properties describe the criteria that a Point must match to belong to the Point Group. This is the case of the Point Groups for CTDC Points. First the user-defined Point property identifying the DTM type, DTMAttribute, is used as the criteria for grouping the Points and then all the Points matching the specified criteria are added to the Point Group's Point list. If a Point's criteria in the drawing is changed, the Point Group will indicate the change.

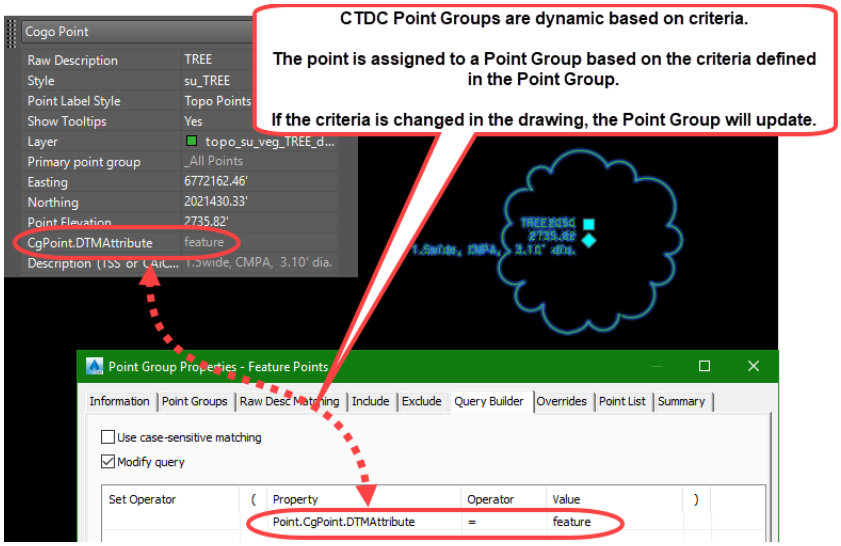


Figure 9 CTDC Point Group with criteria that a Point must meet to be included in the group

CSAC Point Groups

Point Groups can also be populated manually when the Point Group Properties are not pre-defined. This is the case of Point Groups for CSAC Points. The Points are

added to the Point Group during the import process and only the Point's Number is added to the Point Group Property.

The significant difference with these Point Groups is that the criteria determining if a Point belongs in the group is managed only when the Points are imported into the drawing. If the Point's DTM_Type is changed in the drawing, the Point Group will NOT indicate the change. This Point Group will only indicate a change if the Point is removed from the drawing.

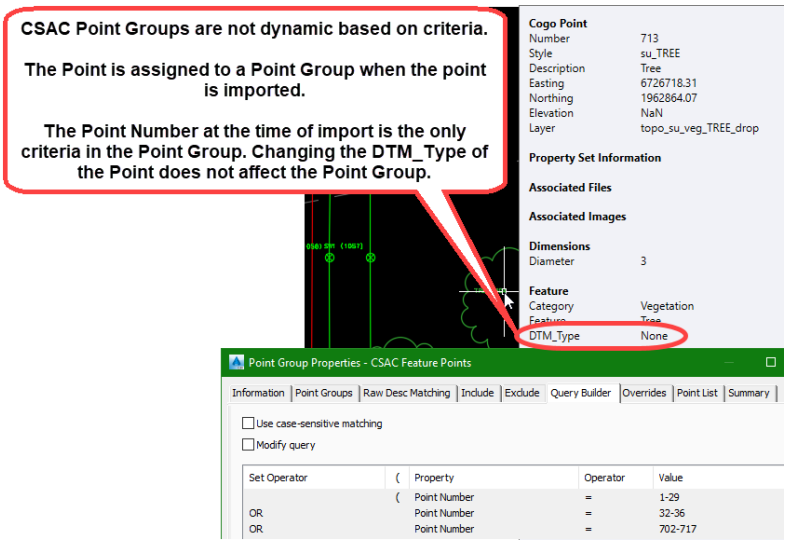


Figure 10 CSAC Point Group

Point List

The Point Group's Point List is maintained dynamically, which means that an out-of-date notification, , appears whenever a change occurs that affects the Point List. When a Point Group is out-of- date, one or more Points in the Point List no longer match the criteria specified on the tabs in the Point Group Properties.

A Point Group's Point List may be out-of-date when one or more of the following occurs:

- Points that belonged to the Point Group were deleted from the drawing.
- The property of a Point belonging to a Point Group was changed so that the Point no longer meets the criteria for being included in the Point Group.
- New Points were created that match the Point Group's criteria in the Properties.

Point Group's role with topo data

Point Groups provide two fundamental roles when working with topo data:

- Point Groups are used to add COGO Points or Survey Points to a Surface

- Point Groups can be used to control how Points are displayed in the drawing

The **Point Group Overrides** are a quick way change the display of all Points in the Point Group, instead of changing each Point's style individually. For example, the **CSAC Line Points – display OFF** Point Group is set up to quickly hide the Points used to create the CSAC linework.

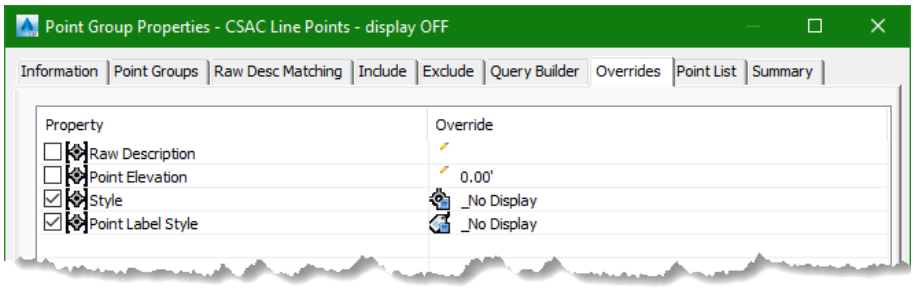


Figure 11 Point Group Properties Overrides control the display of the Points in the Point Group

Drawing Objects

The CTDC workflow results in a Civil 3D Survey Database and a drawing containing Survey Figures and Survey Points. The Survey Points at each vertex of the Survey Figures, referred to as Survey Figure Points, contain additional metadata about the linework that is important in the design process, e.g., fence height or culvert material. However, working with Survey Figures and Survey Points can be cumbersome, create larger drawings, and are different objects than those created with the photo, aerial LiDAR, bathymetric, and MTLS topo workflows.

The CSAC workflow creates objects consistent with the photo, aerial LiDAR, bathymetric, and MTLS topo workflows; which is a combination of Civil 3D objects and AutoCAD elements. Topo features such as asphalt edges, fences, and trees are stored as Civil 3D Objects, COGO Points, and Feature Lines. Random breaklines and spot elevations are stored as AutoCAD Elements, AutoCAD Points, and Polylines.

Below is a table showing the Pros and Cons of using Civil 3D Objects and AutoCAD Elements:

Civil 3D Objects vs. AutoCAD Elements

Civil 3D Objects	AutoCAD Elements
Pro Are given unique names	Con Cannot be named
Pro Use Styles to control the display attributes and symbology	Con Use layers to control the display attributes
Pro Display symbology based on the style • Feature Lines display custom linestyles • COGO Points display custom symbols and blocks	Con Do not display symbology • 3D Polylines do not display custom linestyles • AutoCAD Points do not display custom symbols or blocks
Pro Feature Lines and COGO Points are listed in the Prospector	Con 3D Polylines and AutoCAD Points are not listed in the Prospector

Civil 3D Objects	AutoCAD Elements
Pro More commands are available for Feature Lines • The Offset command can be performed on Feature Lines • The Elevation Editor displays the elevation, length, and grade of each segment of a Feature Line	Con Some commands cannot be performed on 3D Polylines • The Offset command does not work with Polylines • The Elevation Editor does not work with Polylines
Con The objects increase the drawing file size • Feature Lines increase the drawing size by a factor of 2.3 when compared with 3D Polylines • COGO Points increase the drawing size by a factor of 9.4 when compared with AutoCAD Points	Pro The elements make the drawing simpler and lighter

Civil 3D Objects

Each Civil 3D object has a base layer on which the object physically resides, the Object Layer, and has Component Layers that control the display of object components, such as Surface triangles, linework, or symbols. The Object Layer is defined in the Drawing Settings or when the object is imported into a drawing. The Component Layers are defined in the Object Styles. Objects are physically created on the Object Layer, but the display of components is governed by the associated Component Layers defined in the Object's Style.

The appearance of Civil 3D Objects is controlled by their style. A style is defined by subcomponents used for different viewing angles, such as 3D perspectives (Model), top-down Plan view, Profile view, or Section view. A style defines the component's color, line weight, symbol, and layer. The appearance can also be set to invisible (No Display). The ability to set a Civil3D object to an invisible state is helpful; the data does not need to be removed from the drawing if a temporary change of the display in a drawing is needed.

Feature Lines

CSAC, photo, aerial LiDAR, and MTLS linear topo features are stored as Feature Lines.

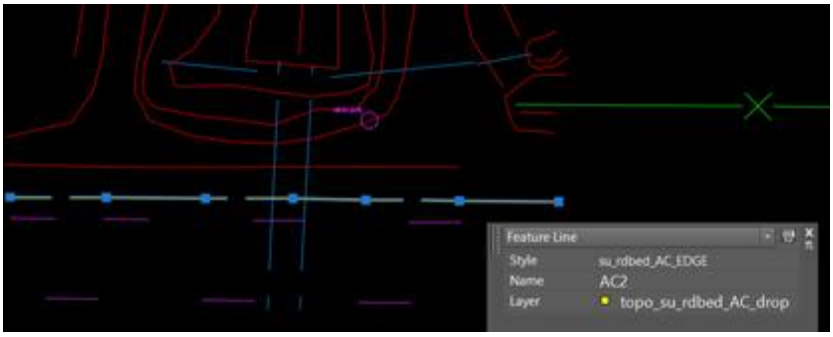


Figure 12 Civil 3D Feature Line

A Feature Line is a 3D linear object that Surface and grading commands recognize and use as breaklines. Feature Lines can be drawn, created from existing objects, exported from Corridors, or created when importing a Shape file.

An option to store Feature Lines in a Site is available. However, if two Feature Lines in the same Site cross each other, they are forced to be at the same elevation at the intersection. The ability to control how the crossing is resolved is controlled by the Feature Line Styles and the order that they are created. Because of this, all topo linework stored as Feature Lines should not be stored in a Site. The Site must be designated as *None* to prevent any undesired crossing resolutions.

Unlike Survey Figures, Feature Lines do not require a Survey Database to be created, stored, or shared in other drawings.

1) Feature Line Style

The **Feature Line Style** contains a component that controls the visual display of the linework including color, line style, weight, etc. Another component is available to control the placement of markers at the vertices of the linework when a Feature Line is displayed in a profile or a cross section.

Feature Line Styles are stored within the drawing templates. This ensures that all styles are available in every new drawing created from the templates. The styles are configured for final plan production and should not be modified.

Points

There are two types of Civil 3D Points; COGO Points and Survey Points. CSAC, photo, aerial LiDAR, bathymetric, and MTLS point topo features are stored as COGO Points.

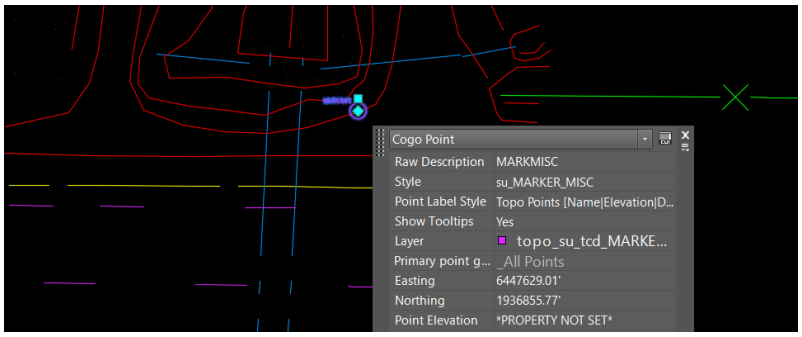


Figure 13 Civil 3D COGO Point

A **COGO Point** is a 3D Point object that has coordinate data and a variety of properties including name, description, and style. COGO Points are included in Surfaces as DTM Points where appropriate through Point Groups. **Survey Points** are like COGO Points, except that they require a Survey Database to be created. The Survey Database prevents Survey Points from being edited in a drawing.

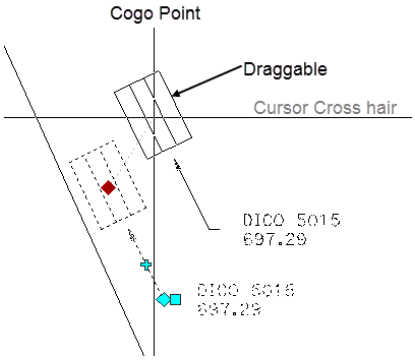


Figure 14: COGO Point Dragged

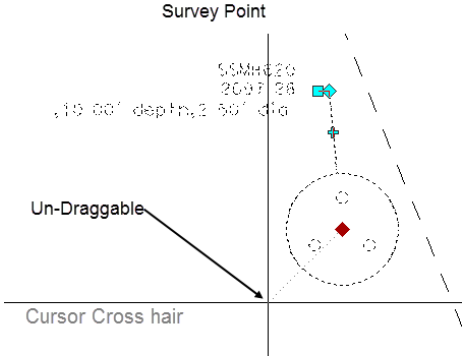


Figure 15: Survey Point Dragged State

The two forms of Points can be visually identified by the icon that appears in the Prospector's list view or in any list view panorama.

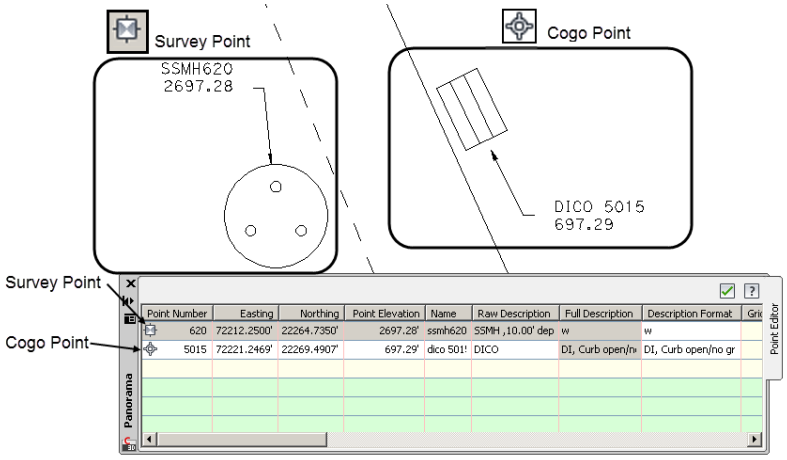


Figure 16: Survey Points vs. COGO Points

2) Point Style

A **Point Style** contains two components; a Marker and a Label. **Markers** can be a simple symbol such as an X or a custom block. The Marker is integral to the Point. If a Point's location changes, the symbol will always be synchronized. **Labels** can be a simple display of a COGO Point's information. Point Styles are stored within the drawing templates to ensure that all styles are available in every new drawing created from the templates. The styles are configured for final plan production and should not be modified.

CSAC Point Styles have been developed for the following types of Points:

- Individual Points
  - Such as manholes or utility poles. These are assigned a Point Style with a corresponding block as the Point Marker and a Label Style that includes the Point name and elevation.
- Line Points
  - The Points used to create the linework in TBC do not need unique symbols, so the Point Marker is a simple circle with an X in the middle. The Label Style includes the Feature Code input in the field and the data collector's Point number.

3) Label Styles

When a label is needed for a Point, whether in the analysis mode or for final plan production, a Point Label Style is used together with a Point Style.

A **Point Label Style** can be used to label standard Point information including:

- Point ID (Point Number or Point Name)
- Coordinates
- Elevation
- Description

Several Point Label Styles have been preconfigured and included in the templates. If needed, an existing Point Label Style can be copied and edited, or a new one can be created. Updated or new Point Label Styles that would be beneficial to all users should be provided to the Office of Land Surveys for inclusion into the template.

Note: Only the Point Markers of individual Points are plotted in the final design contract plans. The Point Markers of the Line Points and all Point Labels, except for control Point Labels, are not.

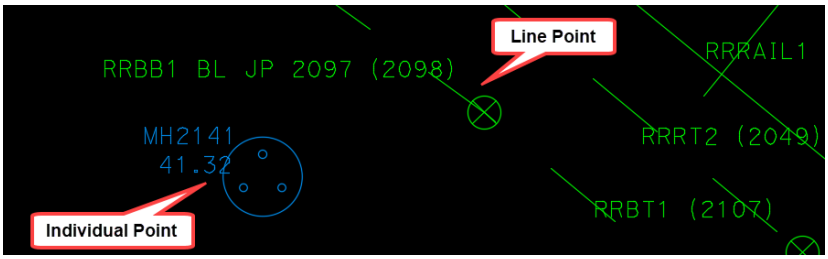
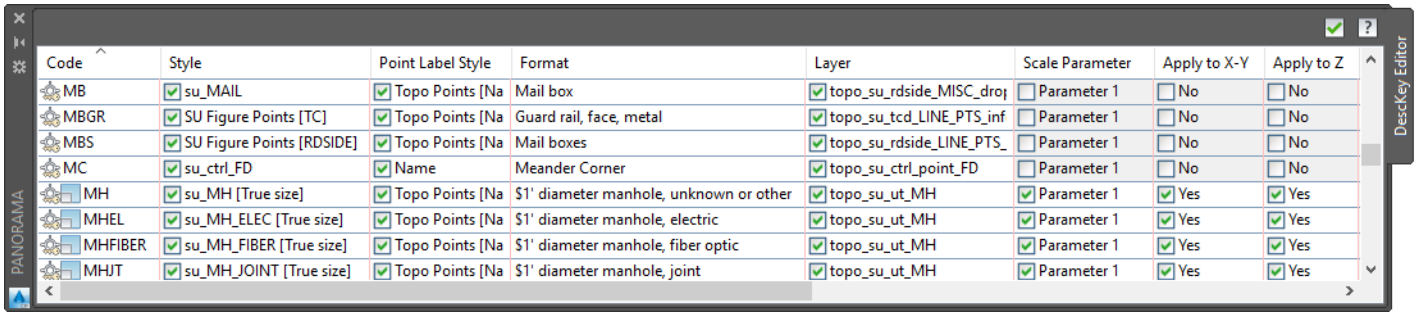


Figure 17 CSAC Individual Point and Line Point Styles and Labels

4) Description Keys

Civil 3D can assign the Style and Layer of a Point object based on the Point's raw description. A Description Key Set is list of predefined properties that control certain properties of a Point when applied. When a Point or Points are inserted into a drawing, the raw description of each Point is evaluated by the Description Key Sets. When a Point has a raw description that matches a Description Key, the properties defined in the key are assigned to that Point. If a raw description doesn't match a Description Key, or it contains a null or empty value, the drawing's default setting is applied.

Each Description key contains a Code, Style, Point Label Style, Format, Layer, and other fields that control the scale and rotation of the Point Style's marker. The entire list of Caltrans Description Keys can be found in Appendix A7 in this manual.



Code	Style	Point Label Style	Format	Layer	Scale Parameter	Apply to X-Y	Apply to Z
MB	su_MAIL	Topo Points [Na	Mail box	topo_su_rdside_MISC_dro	Parameter 1	No	No
MBGR	SU Figure Points [TC]	Topo Points [Na	Guard rail, face, metal	topo_su_tcd_LINE_PTS_inf	Parameter 1	No	No
MBS	SU Figure Points [RDSIDE]	Topo Points [Na	Mail boxes	topo_su_rdside_LINE_PTS_	Parameter 1	No	No
MC	su_ctrl_FD	Name	Meander Corner	topo_su_ctrl_point_FD	Parameter 1	No	No
MH	su_MH [True size]	Topo Points [Na	$1' diameter manhole, unknown or other	topo_su_ut_MH	Parameter 1	Yes	Yes
MHEL	su_MH_ELEC [True size]	Topo Points [Na	$1' diameter manhole, electric	topo_su_ut_MH	Parameter 1	Yes	Yes
MHFIBER	su_MH_FIBER [True size]	Topo Points [Na	$1' diameter manhole, fiber optic	topo_su_ut_MH	Parameter 1	Yes	Yes
MHJT	su_MH_JOINT [True size]	Topo Points [Na	$1' diameter manhole, joint	topo_su_ut_MH	Parameter 1	Yes	Yes

Figure 18: Description Keys

The order in which Description Key Sets are processed or searched is significant. The Key Set at the top of the **Description Key Sets Search Order** dialog box is searched first. Consider the Points filtering through the Description Key Sets as if the sets were sieves. As soon as a Point's raw description has been *caught* by an upper sieve, its properties will be set. If all the Description Keys are unique, re-ordering the sets is not necessary, as Points will be able to pass through all the sieves until a corresponding Key is matched without the concern of a mismatch. If more than one Description Key Set includes an identical Key, the sets will need to be re-ordered, such that the Key Set containing the preferred Key is at the top of the list before inserting Points into the drawing.

To set the order of Description Key Sets, go to **Toolspace** ➢ **Settings** ➢ <drawing name> ➢ **Point** ➢ right-click **Description Key Sets** ➢ **Properties**. In the **Description Key Sets Search Order** dialog box, select a Key Set and use the arrows to move the set up or down the list as necessary.

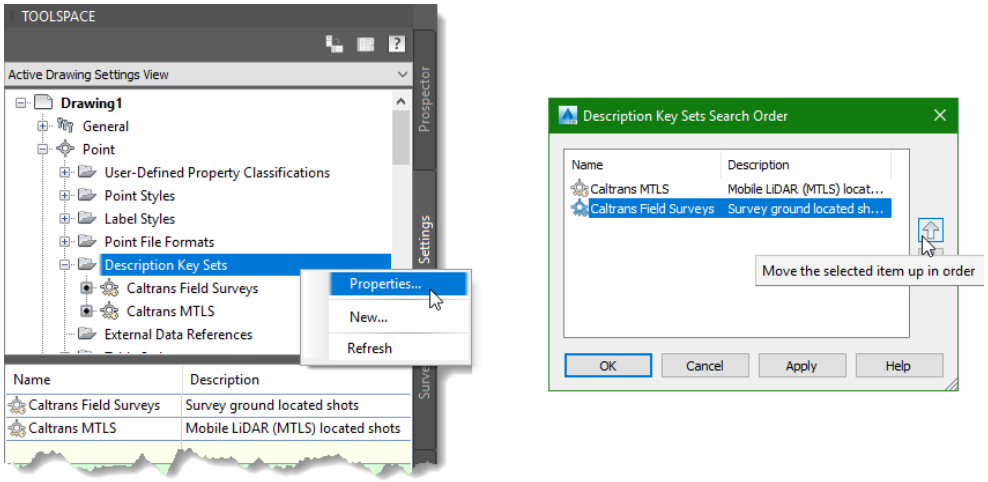


Figure 19: The Description Key Sets Search Order dialog box

The following table lists the key properties of a Description Key that are used with CSAC Points.

<table>
<tr><th>Property</th><th colspan="3">Description</th></tr>
<tr><td>Code</td><td colspan="3">Used during description key matching. The characters in the Code column act as a raw description prefix. Asterisks (*) may be used for wildcard raw description matching.
When the raw description of a Point matches the Code, the associated Styles and Layer are assigned to the resulting Point object.</td></tr>
<tr><td>Style</td><td colspan="3">The Style assigned to the Point.</td></tr>
<tr><td>Point Label Style</td><td colspan="3">The Point Label Style assigned to the Point.</td></tr>
<tr><td>Layer</td><td colspan="3">Designates the Object Layer that will be assigned to the Point.</td></tr>
<tr><td rowspan="5">Format</td><td colspan="3">Used to translate parameters in the raw description into a full description. Parameters are elements that are included in the raw description of a Point. For example, the raw description MH 3 consists of a leading element, MH, followed by one parameter, 3, separated by a space. Up to nine space-delimited parameters can be incorporated into the full description. The parameters are preceded by a $ symbol in the Format field. The numeric value indicates the matching Parameter in the Description Key row. If parameters are not included in the Format field, only the text specified in the Format field will be included in the Point’s full description.
Examples:</td></tr>
<tr><td>Format</td><td>Point’s Raw Description</td><td>Resulting Point’s Full Description</td></tr>
<tr><td>$*</td><td>MH 3</td><td>MH 3</td></tr>
<tr><td>$1’ diameter manhole</td><td>MH 3</td><td>3’ diameter manhole</td></tr>
<tr><td>Manhole</td><td>MH 3</td><td>Manhole</td></tr>
<tr><td>Scale Parameter</td><td colspan="3">When checked ON, the parameter specified in the field must be included in Format and the Point’s raw description.</td></tr>
</table>

Apply to X-Y	When checked ON, the parameter entered in the Point's raw description will be applied to the Point Style's Marker in the X and Y directions.
Apply to Z	When checked ON, the parameter entered in the Point's raw description will be applied to the Point Style's Marker in the Z direction.

Figure 20 Example of Description Keys and Parameters in the Point's Raw Description

5) Object Styles, Layers, and Naming Conventions

The COGO Point and Feature Line Object Layers and Component Layers defined in the styles are based on common Feature Groups, e.g., Hydrographic Features, Roadbed Features, etc. This allows the user to quickly freeze or turn *OFF* the Layers of an entire Feature Group using the **Layer Filters**. Users can quickly manage a drawing and reduce the drawing's displayed objects without removing them from the drawing.

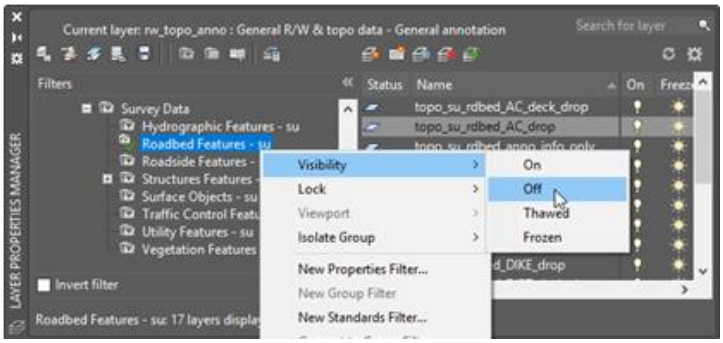


Figure 21 Changing the visibility of Layers in a Layer filter

The name of the Style specifies the method of data collection and specific details about the Feature. The names of the Civil 3D objects are shorter and more general because it will be used to label the Feature in drawings, cross sections, or profiles.

For example;

Style Name	Feature Line Name	Component Layer	Object Layer
Face of thrie-beam, cable, or other rail barriers			
su_BARR_FACE_RAIL	FRAIL	topo_su_tcd_BARRIER_drop	topo_su_tcd_BARRIER_drop
Bottom of concrete barriers			
su_BARR_BOT_CONC	BBAR	topo_su_tcd_BARRIER_drop	topo_su_tcd_BARRIER_drop
Asphalt edges in the roadbed on bridge deck			
su_rdbed_AC_EDGE_deck	AC	topo_su_rdbed_AC_deck_drop	topo_su_rdbed_AC_deck_drop

Style Name	COGO Point Name	Component Layers Marker Layer Label Layer	Object Layer
Center of a rectangular electric Pullbox			
su_PB_RECT_ELEC	PB	topo_su_ut_PB topo_su_ut_anno_info_only	topo_su_ut_PB
Center of a round drainage inlet on bridge deck			
su_DI_RND_deck	DI	topo_su_hydro_df_STR_deck_drop topo_su_str_anno_deck_info_only	topo_su_ut_DI_deck_drop
Cantilever Sign at post location			
su_SIGN_CANT	SIGN	topo_su_tcd_SIGN_drop topo_su_tcd_anno_info_only	topo_su_tcd_SIGN_drop

Object Layers and Surface Type

The CSAC Feature Line and COGO Point Object Layer assignments are different than those assigned to photo, aerial LiDAR, bathymetric, and MTLS data.

The Surface type of CSAC data is determined by the value of the object's Feature Code Attribute **DTM_Type.** For example, if the value of the object's DTM_Type is ***Ground***, then the object will be included in ground Surfaces. The Object Layer assigned when Shape files are imported match the layer defined in the Feature Line or COGO Point Styles.

The Object Layers of photo, aerial LiDAR, bathymetric, and MTLS data are used to identify the type of Surface that the object should be included in. Feature Lines placed

on Object Layer **topo_ml_FEATURE_LINE_DTM_Ground** will be included in ground Surfaces. COGO Points placed on Object Layer **topo_ml_POINT_DTM_None** will be excluded from all Surfaces. The Object Layer for this data is assigned when DWG files are imported into the Civil 3D drawing and can be changed afterwards if required.

For example,

Style Name	Feature Line Name	Component Layer	Object Layer
Face of thrie-beam, cable or other rail barriers			
ml_BARR_FACE_RAIL	FRAIL	topo_ml_tcd_BARRIER_drop	topo_ml_FEATURE_LINE_DTM_None
Bottom of concrete barriers			
ml_BARR_BOT_CONC	BBAR	topo_ml_tcd_BARRIER_drop	topo_ml_FEATURE_LINE_DTM_Ground
Asphalt edges in the roadbed on bridge deck			
ml_rdbed_AC_EDGE_deck	AC	topo_ml_rdbed_AC_deck_drop	topo_ml_FEATURE_LINE_DTM_Deck

Style Name	COGO Point Name	Component Layers Marker Layer Label Layer	Object Layer
Center of a rectangular electric Pullbox			
ml_PB_RECT_ELEC	PB	topo_ml_ut_PB topo_ml_ut_anno_info_only	topo_ml_POINT_DTM_None
Center of a round drainage inlet on bridge deck			
ml_DI_RND_deck	DI	topo_ml_hydro_df_STR_deck_drop topo_ml_str_anno_deck_info_only	topo_ml_POINT_DTM_None
Cantilever Sign at post location			
ml_SIGN_CANT	SIGN	topo_ml_tcd_SIGN_drop topo_ml_tcd_anno_info_only	topo_ml_POINT_DTM_None

AutoCAD Elements

Polylines

CSAC, photo, aerial LiDAR, bathymetric, and MTLS miscellaneous linear features are collected to enhance a Surface, e.g., random Breaklines, are stored as 3D Polylines.

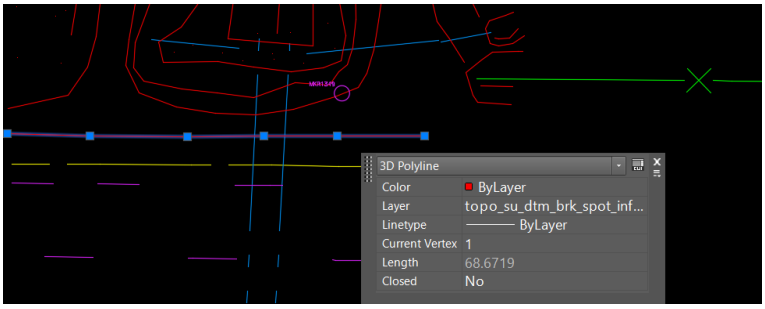


Figure 22 Random Breakline stored as a 3D Polyline

There are 2 types of Polylines; 2D and 3D Polylines. A 3D Polyline is a 3D Line Element that Surface and grading commands recognize and use as Breaklines; however, they do not have a Name or Style. Polylines can be drawn, created from existing objects, or created when importing a Shape file.

AutoCAD Points

CSAC, photo, aerial LiDAR, bathymetric, and MTLS miscellaneous Point features collected to enhance a Surface, e.g., spot elevation Points, are stored as AutoCAD Points.

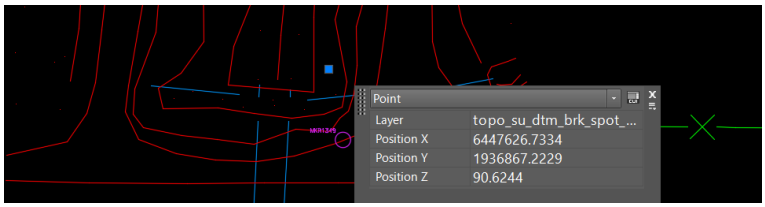


Figure 23 Spot elevation Point stored as an AutoCAD Point

An AutoCAD Point is a simple 3D Point Element that Surface commands recognize and use as DTM Points; however, they do not have a Name or Style. AutoCAD Points can be can be drawn, created from existing objects, or created when importing a Shape file.

Layers and Surface Type

The CSAC Polyline and AutoCAD Point Layer assignments are like those assigned to photo, aerial LiDAR, bathymetric, and MTLS data; the Layer that the Polylines and AutoCAD Points are placed on indicates the Surface type and the feature type. Only random Breaklines and spot elevation Points are assigned to these Layers. The

Layers are assigned when Shape files containing CSAC data or DWG files containing photo, aerial LiDAR, bathymetric, and MTLS data are imported.

Note: All elements on these Layers are NOT plotted in the final design contract plans.

- topo_su_dtm_brk_spot_info_only – random Breaklines and spot Points in ground Surface areas
- topo_su_dtm_brk_spot_deck_info_only – random Breaklines and spot Points in bridge deck Surface areas
- topo_su_dtm_brk_spot_underside_info_only – random Breaklines and spot Points in bridge underside Surface areas
- topo_su_dtm_brk_spot_subterranean_info_only – random Breaklines and spot Points in subterranean Surface areas

6) Civil 3D 2016 Shape Tools

The CSAC workflow relies on the **Civil 3D SHP and Table Tools** available in Civil 3D 2016 or newer releases of Civil 3D. These tools are used to import the TBC Shape files into a Civil 3D drawing, display the object attributes, display images and/or files associated to the objects, query objects based on the attributes, navigate to and/or select objects, trim lines, copy objects with attributes through an XREF, and create Point Tables with the Point Attributes.

The **Civil 3D SHP and Table Tools** can be accessed on the **Toolbox** tab of the **Toolspace** Palette. Some of the more commonly used tools are in the **Caltrans** tab of the **Ribbon** and in the **Surveys** palette group of the **Ct Topo** tool palette.

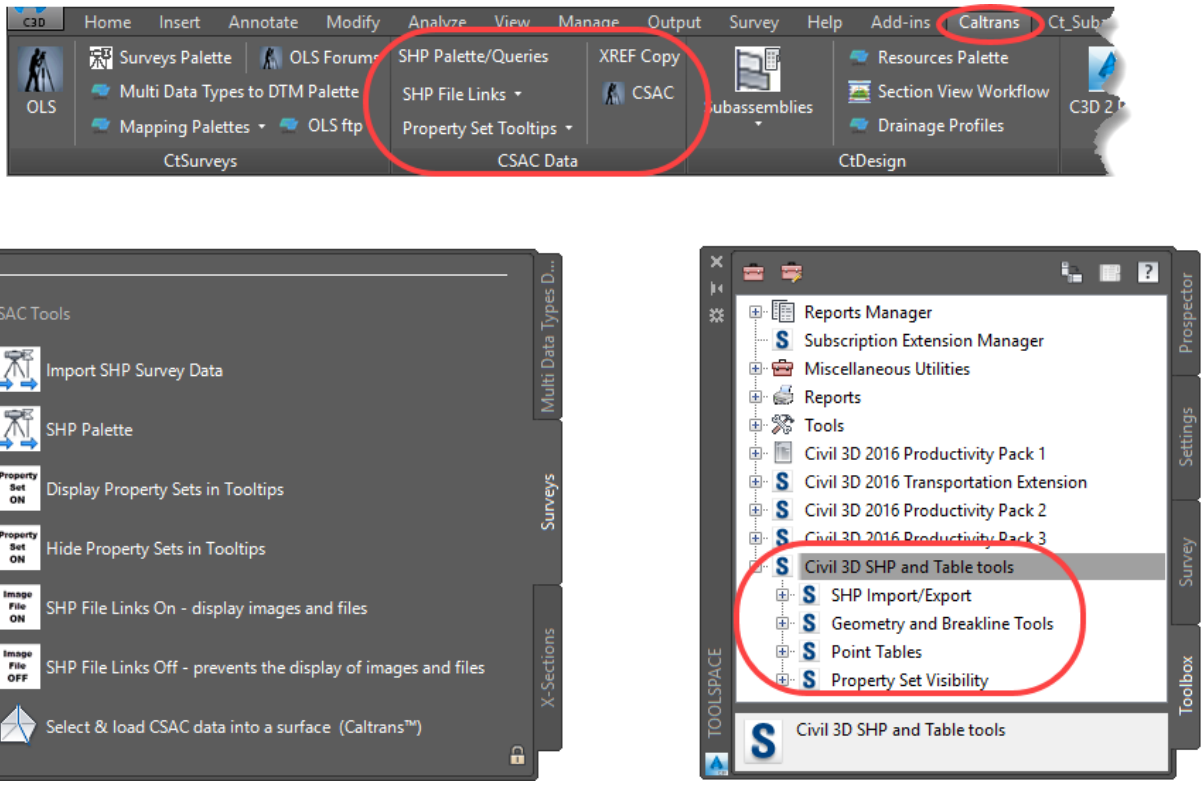


Figure 24 Civil 3D SHP and Table Tools

The primary tools that will be used in the CSAC topo delivery process include:

- Import SHP Survey Data
- SHP Palette
- SHP File Links ON/OFF
- Trim Feature Lines & Features at Boundary
- Display/Hide Property Sets in Tooltips

- Point Tables

SHP Import/Export Tools

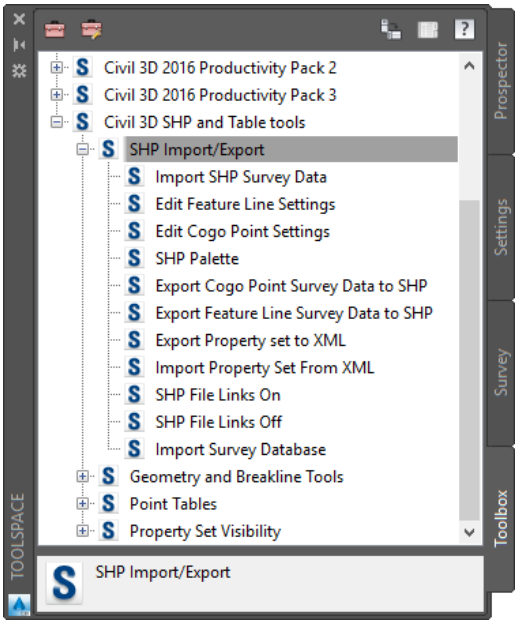


Figure 25 SHP Import/Export Tools

Import SHP Survey Data

The **Import SHP Survey Data** tool (IMPORTSHPSURVEYDATA command) is used to import data from Shape files into a Civil 3D drawing. The **Import SHP Survey Data** dialog box contains options to define import events, spatial filters, query filters, and import settings. Before importing the data, the import options are specified (SHP settings, data filters, queries, etc.), the import event is named, and the Shape files are selected. During the import into the active Civil 3D drawing, the settings will apply to the selected Shape files.

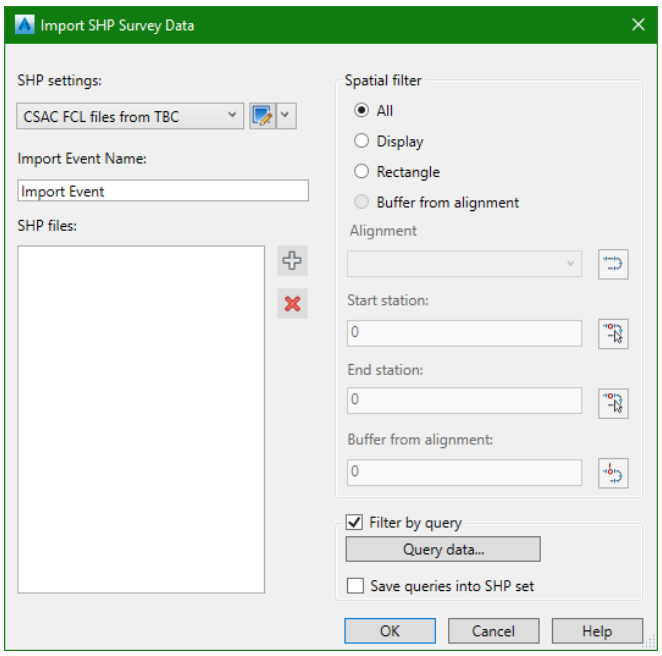


Figure 26 Import SHP Survey Data

CSAC Import SHP Survey Data Settings

The Shape file data is imported and stored in the drawing based on the settings defined in the **Import SHP Survey Data Settings**. The settings contain instructions to interpret the Shape file attributes and control how the COGO Points, AutoCAD Points, Feature Lines, Polylines, and 3D Polylines will be configured during the import process.

The ***CSAC FCL files from TBC*** settings option is pre-defined for the CSAC Shape files and is stored in the Civil 3D 2016 template: *Ct_2016_Topo_Surveys_MTLS.dwt*. The Caltrans SSHPI settings files, *Ct-Survey_Data-Feature_Lines.XML* and *Ct-Survey_Data-Points.XML*, determine how the Lines and Points in the CSAC Shape files will be stored when they are imported into a Civil 3D drawing. Additional configuration of the settings is NOT required when the Caltrans CSAC FCL is used.

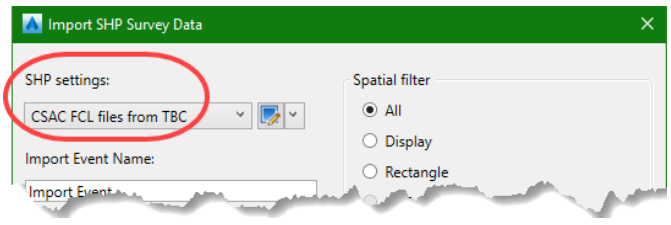


Figure 27 Preconfigured Settings in the Import SHP Survey Data Tool

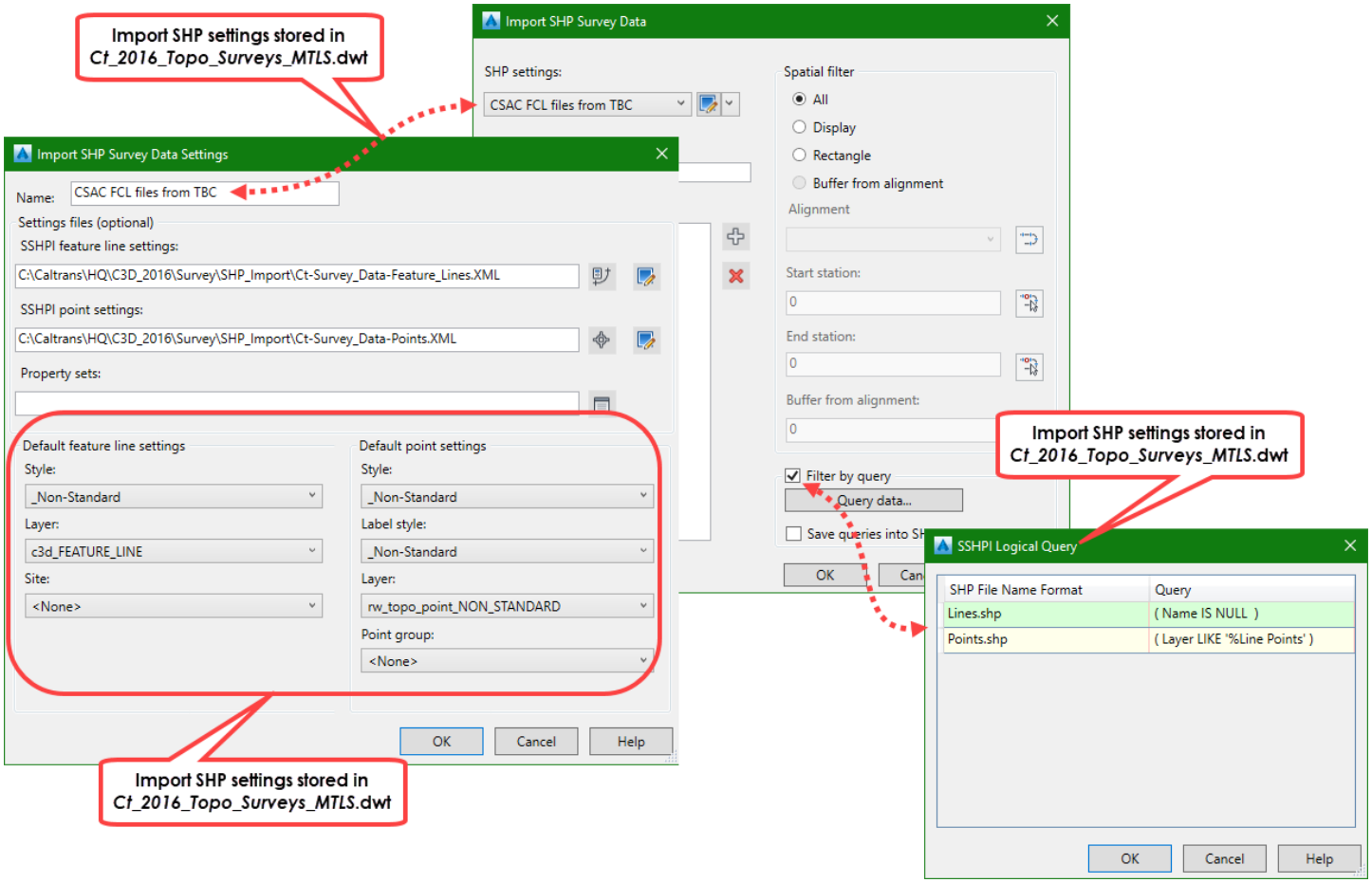


Figure 28 Import SHP Survey Data Settings

7) Non-standard objects

The ***CSAC FCL Survey Data*** settings also includes options for Feature Lines and COGO Points that do not match any of the instructions provided in the Caltrans settings files.

For example, if a CSAC FCL Attribute field is *Required*, such as **DTM_Type**, and the field is blank then the data will be imported with a non-standard style.

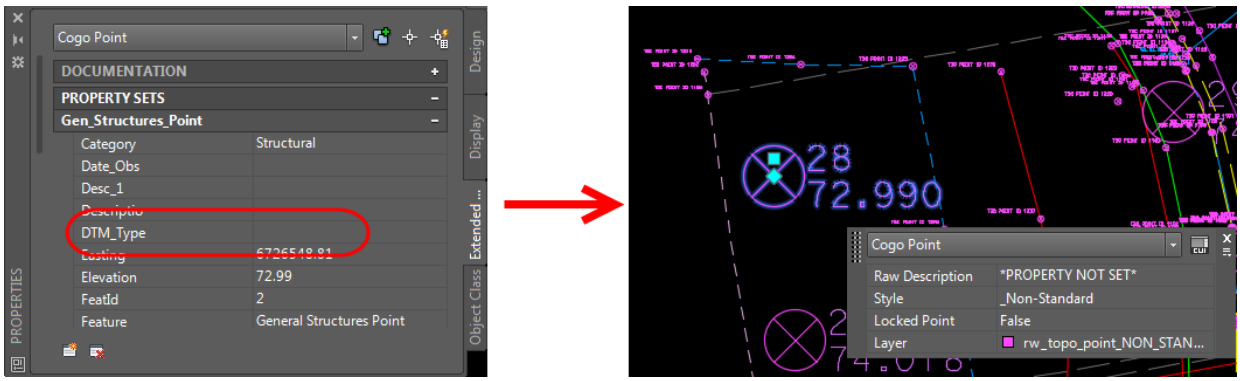


Figure 29 Non-standard COGO Point because a required Feature Code Attribute is blank

Blank Required Attribute Fields

Required Attribute fields must be populated at the time of data collection when using the CSAC FCL with Trimble Access. However, if the data is processed in TBC using a different version of the CSAC FCL containing different Attributes, it is possible for required Attribute fields to be blank. Special attention must be made to ensure all required Attribute fields are populated when the data is edited in TBC.

Another situation where the data may not match the instructions provided in the Caltrans settings files is when a user creates their own Feature Code and an unexpected Shape file is imported.

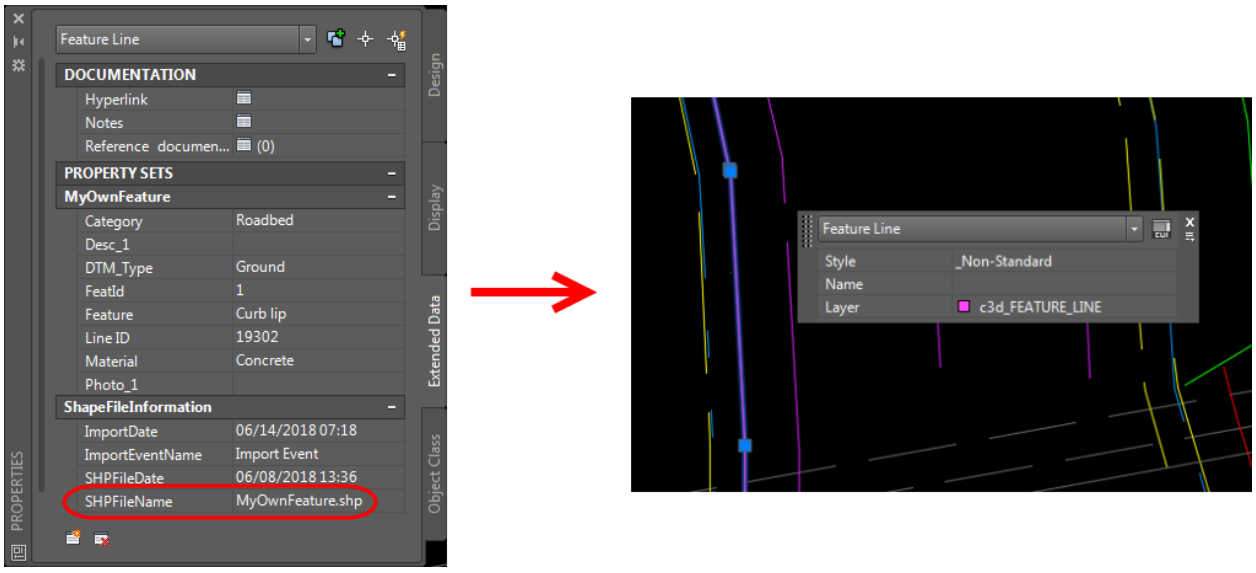


Figure 30 Non-standard Feature Line because the Shape file name is not a standard Feature Code

8) Spatial Filter

The **Spatial Filter** can be used to import only those features in the Shape files that fall within a boundary or within a buffer based on an Alignment.

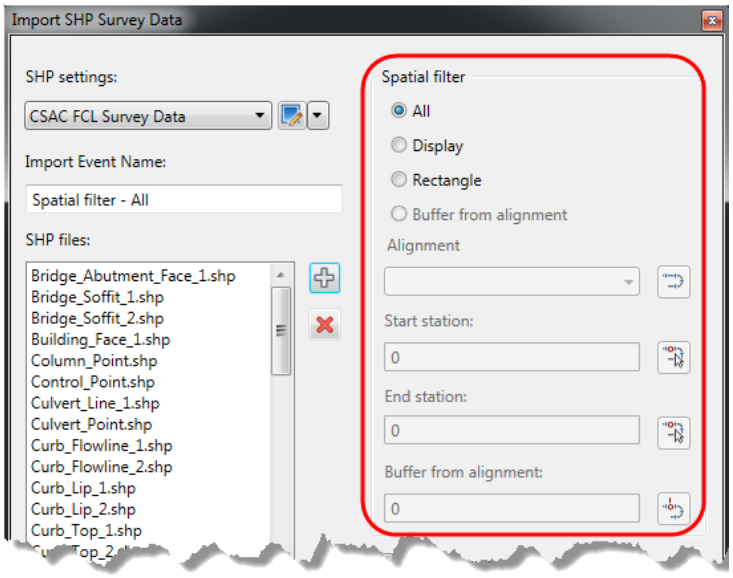


Figure 31 Spatial Filter controls the area that CSAC objects will be imported

9) Filter by query

The **Filter by query** can be used to include or exclude features from specific Shape files based on queries during import.

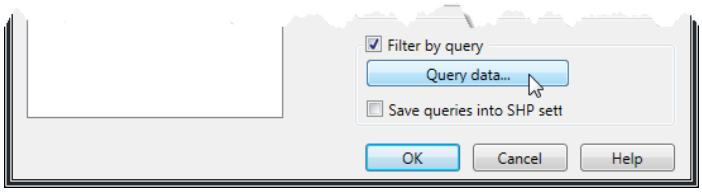


Figure 32 Filter by query helps to include or exclude features

TBC creates two separate project Shape files (Lines.shp & Points.shp) that would create duplicate features if imported into Civil 3D without queries. Queries are used to exclude some of these duplicate objects during import. One query is used to exclude all features in the ***Lines.shp*** file, to avoid duplications with the other linear Shape files. Another query is included to only import the Points used to create linework in TBC, *Line Points*, in the ***Points.shp*** file. These queries are pre-defined for the CSAC Shape files and are stored in the Civil 3D 2016 template, *Ct_2016_Topo_Surveys_MTLS.dwt*, as shown in the Figure below.

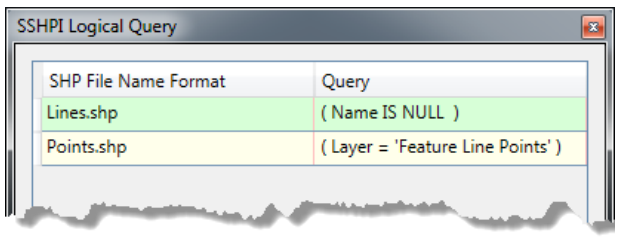


Figure 33 Queries to exclude all lines in Lines.shp and only include a selection of Points in Points.shp

CSAC SSHPI Line and Point Settings

The SSHPI Line and Point settings files, *Ct-Survey_Data-Feature_Lines.XML* and *Ct-Survey_Data-Points.XML*, contain queries to parse the attributes of the data in the TBC Shape files. Based on the query results, the data is assigned a Civil 3D or AutoCAD object type (COGO Point, Feature Line, AutoCAD Point, Polyline, or 3D Polyline) with the specified Name, Style, Object Layer, and Point Group, if applicable.

For a complete listing of the standard layers and styles, see Appendix A7 in this manual.

Different Features created from the same Shape (.SHP) file

In many cases, different features can be created based on the attributes in the Shape file that were assigned in the field.

For example, when **Asphalt_Breakline_*.shp** files are imported, 6 different Line features can be created as shown in the table below:

Civil 3D Object	DTM_Type	Aspect	Description
Feature Line	Ground or None	Grade break	Asphalt roadbed grade breaks – ground
Feature Line	Bridge deck	Grade break	Asphalt roadbed grade breaks - bridge deck
Feature Line	Ground or None	Flowline	Flowlines, roadbed - except curb flowlines - ground
Feature Line	Bridge deck	Flowline	Flowlines, roadbed - except curb flowlines - bridge deck
3D Polyline	Ground or None	Random breakline	Random breaklines in ground DTM areas
3D Polyline	Bridge deck	Random breakline	Random breaklines in bridge deck DTM areas

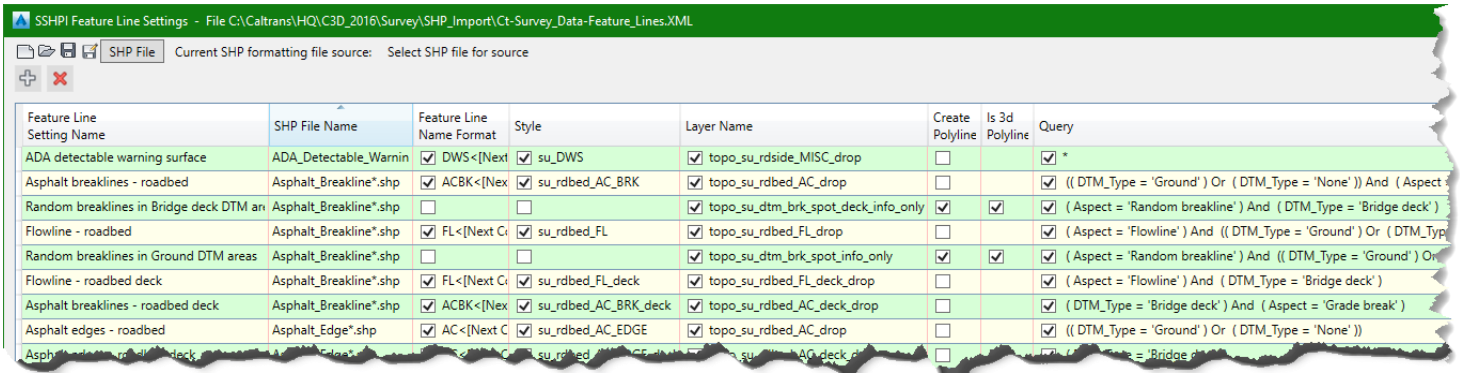


Figure 34 SSHPI Feature Line settings file used when importing CSAC data

When **Gen_Roadbed_Point.shp** files are imported, 4 different Point features can be created as shown in the table below:

Civil 3D Object	DTM_Type	Type	Point Group	Description
COGO Point	Ground or None	Other	CSAC Ground Points	Miscellaneous roadbed point features - ground
COGO Point	Bridge deck	Other	CSAC Bridge Deck Points	Miscellaneous roadbed point features - bridge deck
AutoCAD Point	Ground or None	Spot	n/a	Spot elevations & mass points in ground DTM areas
AutoCAD Point	Bridge deck	Spot	n/a	Spot elevations & mass points in bridge deck DTM areas

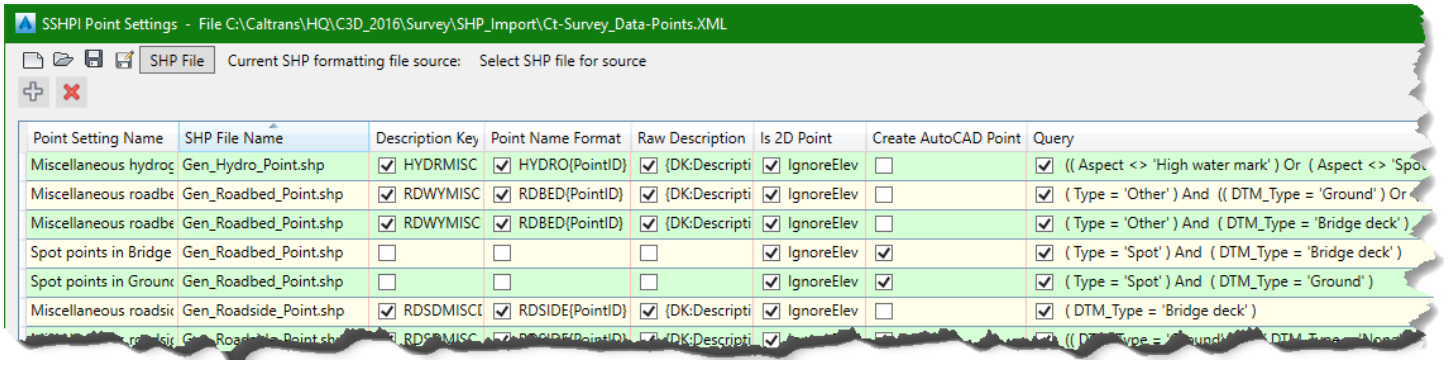


Figure 35 SSHPI Point settings file used when importing CSAC data

2D Points are created when "IgnoreElev" is set to Yes

Points with the attribute **IgnoreElev** set to **Yes** are stored as 2D COGO Points where the elevation of the Point is not set.

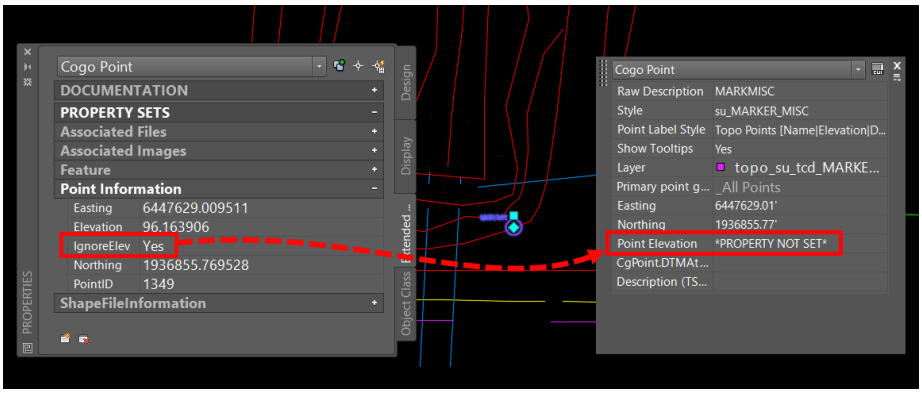


Figure 36 COGO Point elevation is not set when IgnoreElev = Yes

COGO Points are added to Point Groups

COGO Points are added to one of the CSAC Point Groups based on the attribute **DTM_Type**.

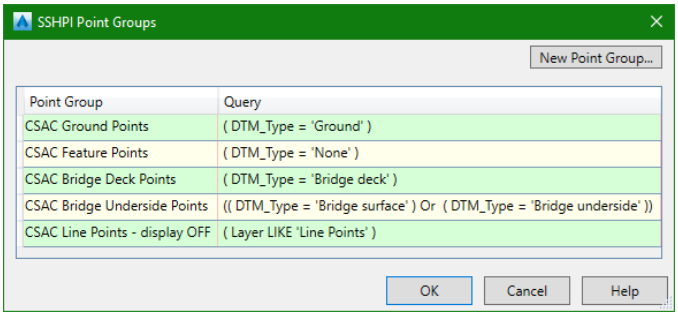


Figure 37 Queries to determine the CSAC Point Group that COGO Points are added to during import

SHP Palette

The **SHP Palette** is used to query, locate, and select the CSAC Points and Lines. The palette displays a list of the imported data in an expandable, hierarchical tree structure.

- When an import event is selected, the list of imported data is displayed in the lower window pane.
- When an import event is expanded, the list of the import Shape files is displayed.
- When an imported Shape file is selected, the list of Feature Lines or COGO Points is displayed in the lower window pane.

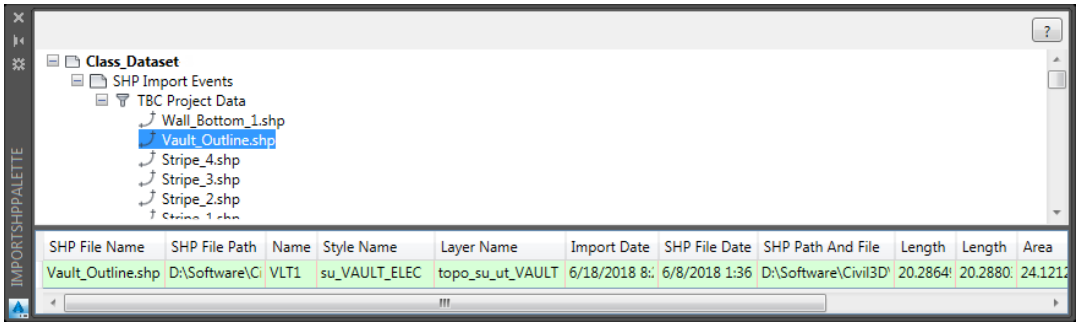


Figure 38 Import SHP Palette with imported data

SHP Palette Context Menus

A context menu is displayed when imported data or an import event is right-clicked, presenting commands for working with the selected import event or data contained in the event.

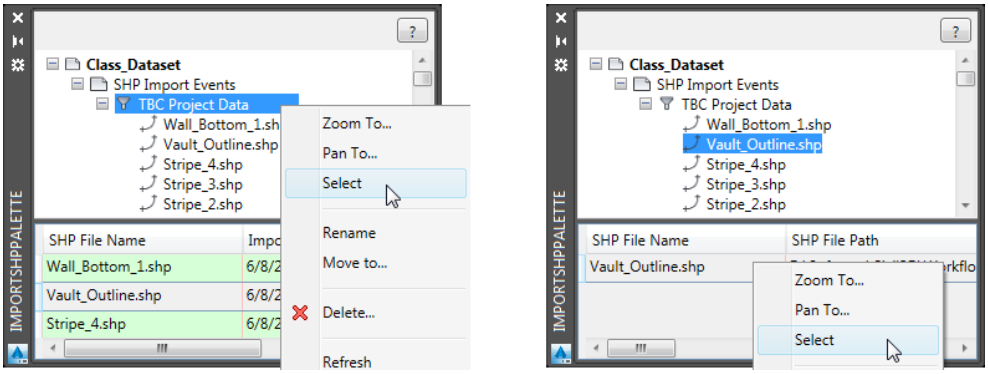


Figure 39 Context menu access when right-clicking an import event or imported data

10) SHP Palette Queries

The **SHP Palette** contains a tool, **SSHPI Drawing Query**, to define queries using COGO Point Properties, Feature Line Properties, Point UDP's, and/or Property Sets. The queries filter all objects in the active drawing or in an XREF, creating a list of the objects meeting the criteria in the SHP Palette.

The queries can be predefined in a template or created by the users.

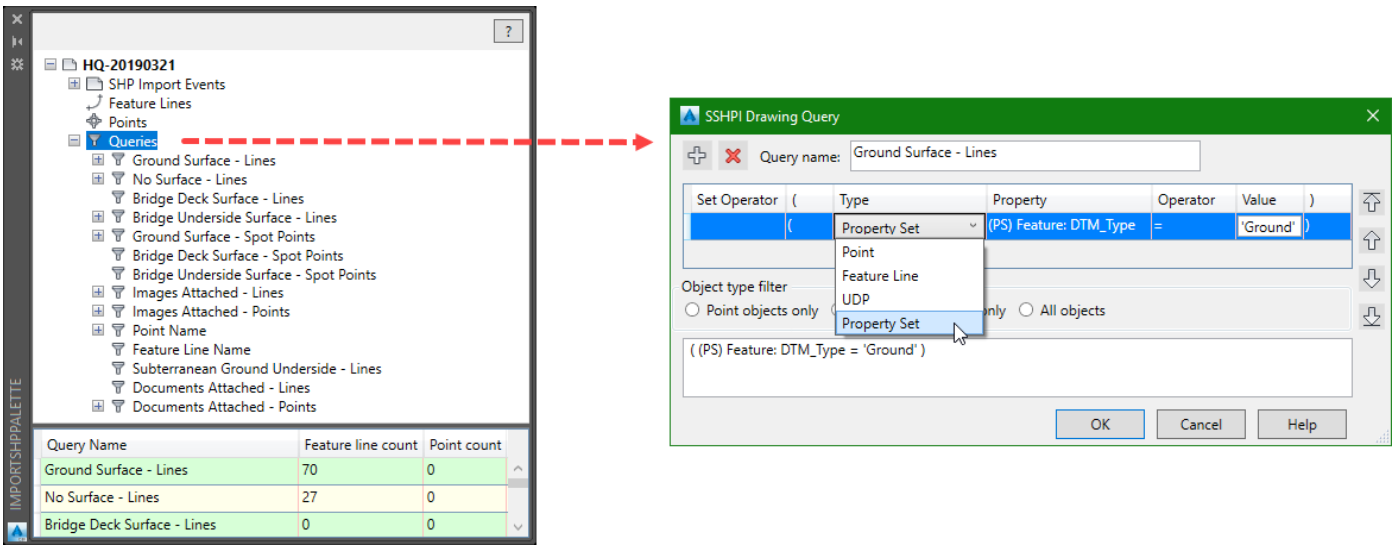


Figure 40 Import SHP Palette and SSHPI Drawing Queries

11) Query Context Menus

A context menu is displayed when a query or an object within the query is right-clicked, presenting commands for working with the selected query or data contained in the query.

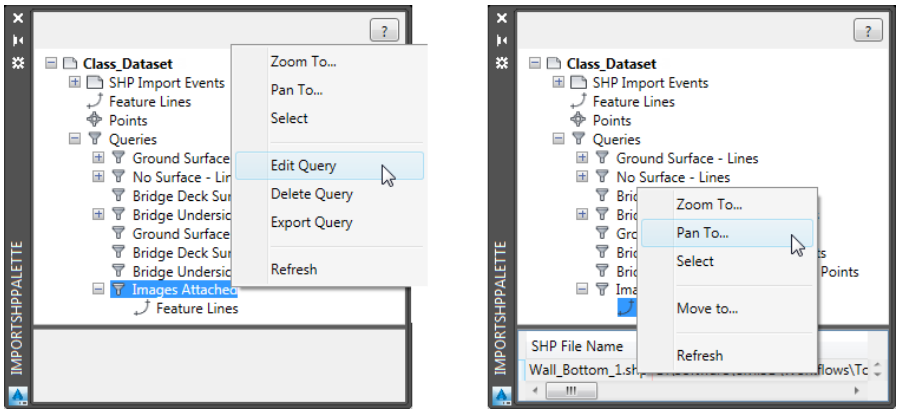


Figure 41 Context menu access when right-clicking an import event or imported data

12) CSAC SHP Palette Queries

The Civil 3D 2016 template, *Ct_2016_Topo_Surveys_MTLS.dwt*, contains pre-defined queries to filter objects based on the value assigned to DTM_Type to assist with Surface creation. For example, in the previous CTDC workflow, Survey Figures were added to a Surface directly from the Database as Breaklines. This isn't the case for Surface creation with CSAC. The Query function allows the user to select and add Feature Lines, 3D Polylines, and AutoCAD Points to a Surface. There are also queries pre-defined to filter objects that have images and/or documents attached.

The pre-defined queries include:

- Ground Surface – Lines
- No Surface – Lines
- Bridge Deck Surface – Lines
- Bridge Underside Surface – Lines
- Subterranean Ground Underside – Lines
- Ground Surface – Spot Points
- Bridge Deck Surface – Spot Points
- Bridge Underside Surface – Spot Points
- Images Attached – Lines
- Images Attached – Points
- Documents Attached – Lines
- Documents Attached – Points
- Point Name
- Feature Line Name

Note

COGO Points cannot be loaded into a Surface from a selection set, they must be loaded into a Surface with a Point Group.

SHP File Links On/Off

The **SHP File Links ON** command (SSHPFILELINKSON) is used to indicate that an object in the active drawing or in an XREF contains a referenced image or document. To access currently referenced File Links for the selected object, or, to save a new Link, **SHP File Links** must be turned ON.

When the **SHP File Links** is ON, the File Link icon  displays as the cursor hovers over the object. To open a referenced Link, press **[Ctrl]** + left-click when the File Link icon is displayed.

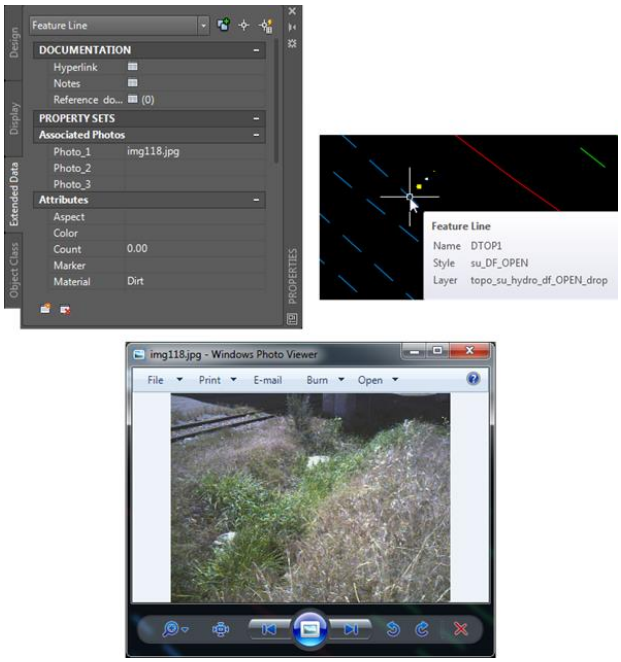


Figure 42 Using SHP File Links to view linked images or documents

Property Set Visibility

Display/Hide Property Sets in Tooltips

The **Display Property Sets in Tooltips** tool (SSHPTOOLTIPSON command) is used to display the Property Set data in the tooltips when hovering over a CSAC object in the active drawing or in an XREF.

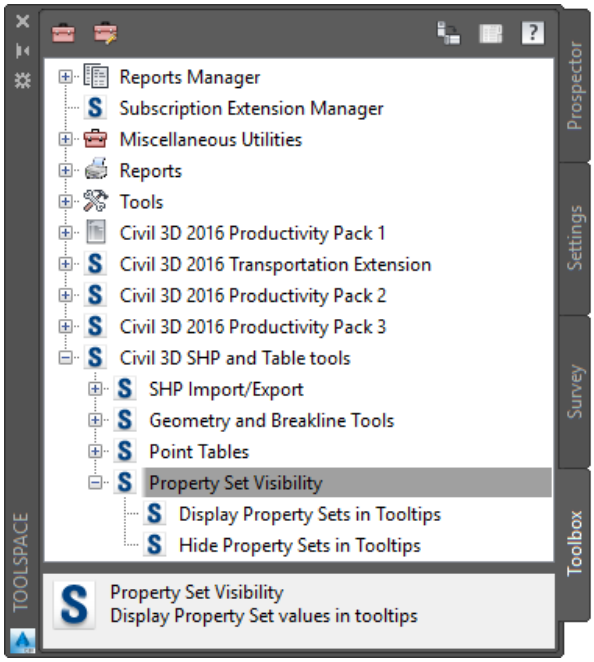


Figure 43 Property Set Visibility

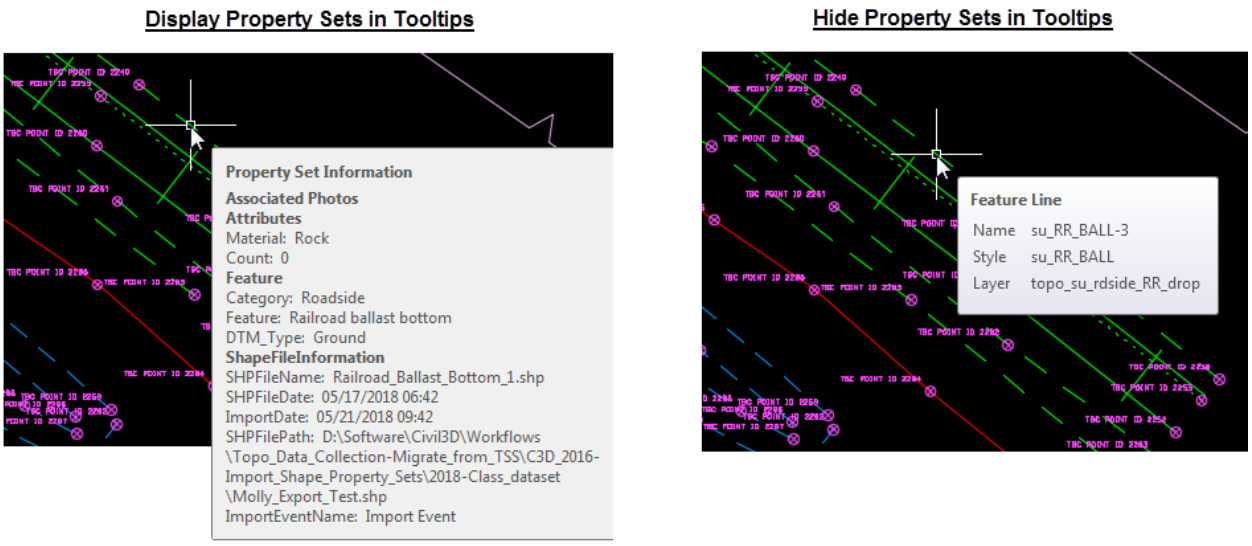


Figure 44 Display/Hide Property Sets of CSAC objects in the active drawing

Geometry and Breakline Tools

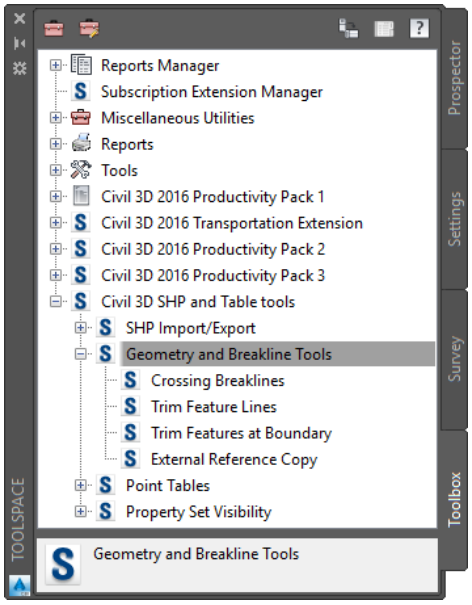


Figure 45 Geometry & Breakline Tools

Crossing Breaklines

The **Crossing Breaklines** tool (CROSSINGBREAKLINES command) is used to identify intersecting lines in the active drawing. If crossing Breaklines are identified in Civil 3D they must be resolved in TBC and then re-imported into Civil 3D. This tool is like the **Resolve Crossing Breaklines** command found on the **Ribbon** ➢ **Analyze** tab ➢ **Ground Data** drop-down.

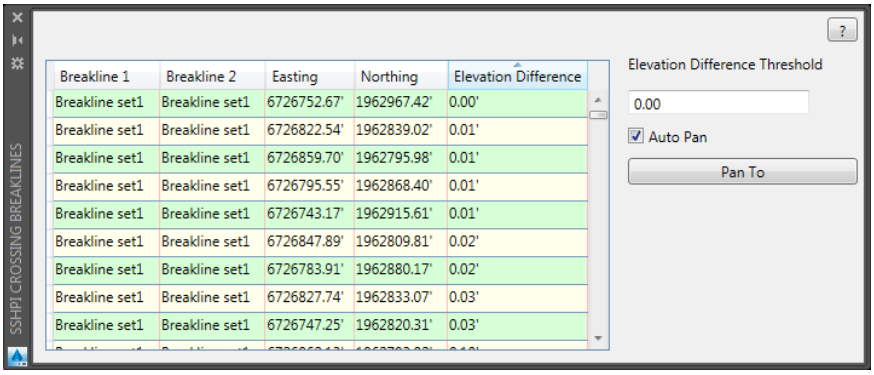


Figure 46 Crossing Breaklines tool for Feature Lines & Polylines

Trim Feature Lines

The **Trim Feature Lines** tool (SSHPITRIM command) is used to trim Feature Lines and Polylines along one or more cutting edges defined by other objects. This tool is like the **Trim** command found on the **Ribbon** ➢ **Home** tab ➢ **Modify** panel.

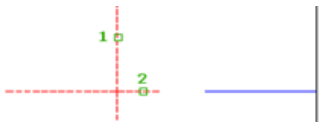


Figure 47 Trim Feature Lines command

Trim Features at Boundary

The **Trim Feature at Boundary** tool (SSHPIBOUNDARYTRIM command) is like the **Trim Feature Lines** tool except more options are provided to trim Feature Lines and Polylines inside or outside of a closed boundary.

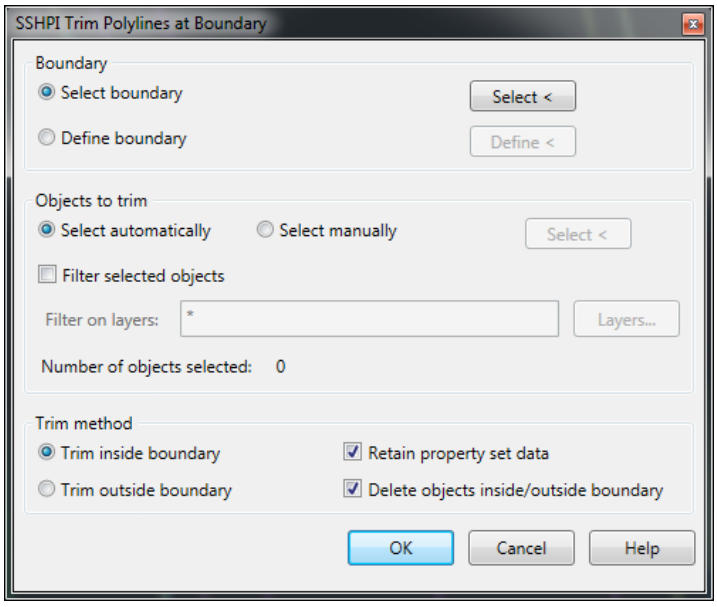


Figure 48 Trim Objects by Boundary

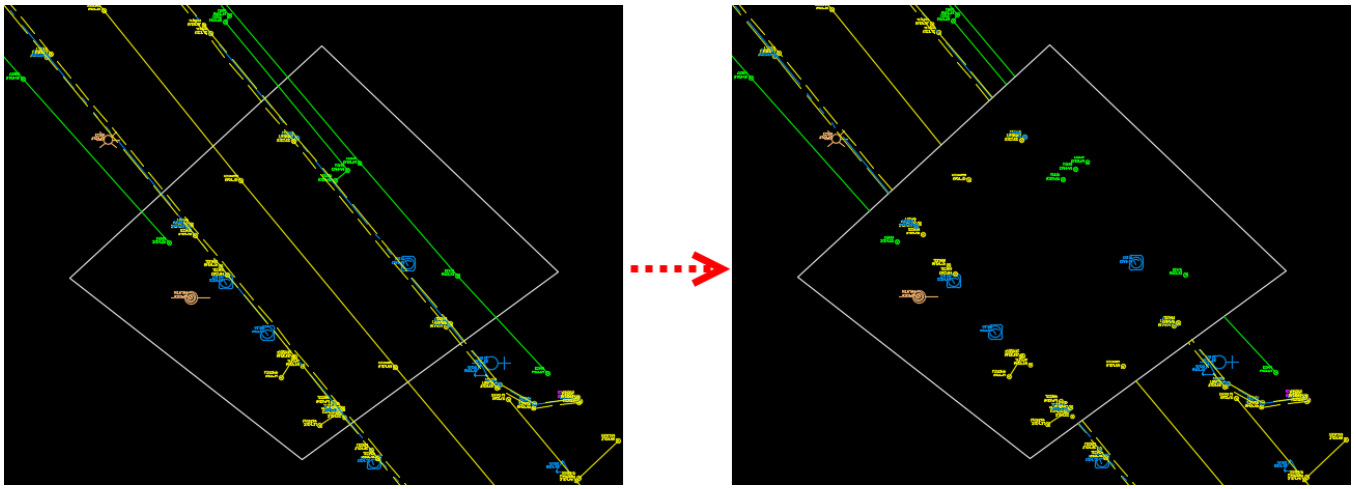


Figure 49 Trimmed Feature Lines & Polylines by Boundary

External Reference Copy

The **External Reference Copy** tool (XREFCOPY command) is used to copy objects from an XREF into the active drawing when the object is required in a Design Drawing. A few examples of this would be to project and label the object in a cross section or to link to the object in a corridor. The Property Set data associated to the objects in the XREF is included with the copied data.

Point Table Tools

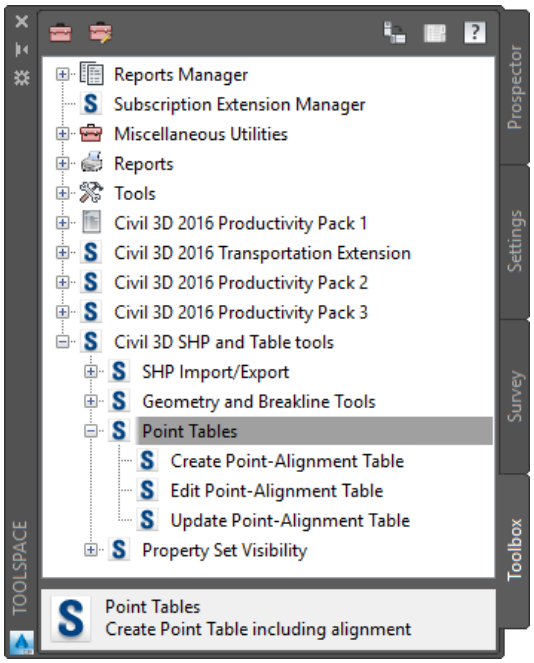


Figure 50 Point Tables Tools

The **Point Tables** tools consist of three commands to create (CREATEPOINTALIGNTABLE command), edit (EDITPOINTALIGNTABLE command), and update (UPDATEPOINTALIGNTABLES command) Point and Alignment Tables.

The table is customizable and can include CSAC Property Set information.

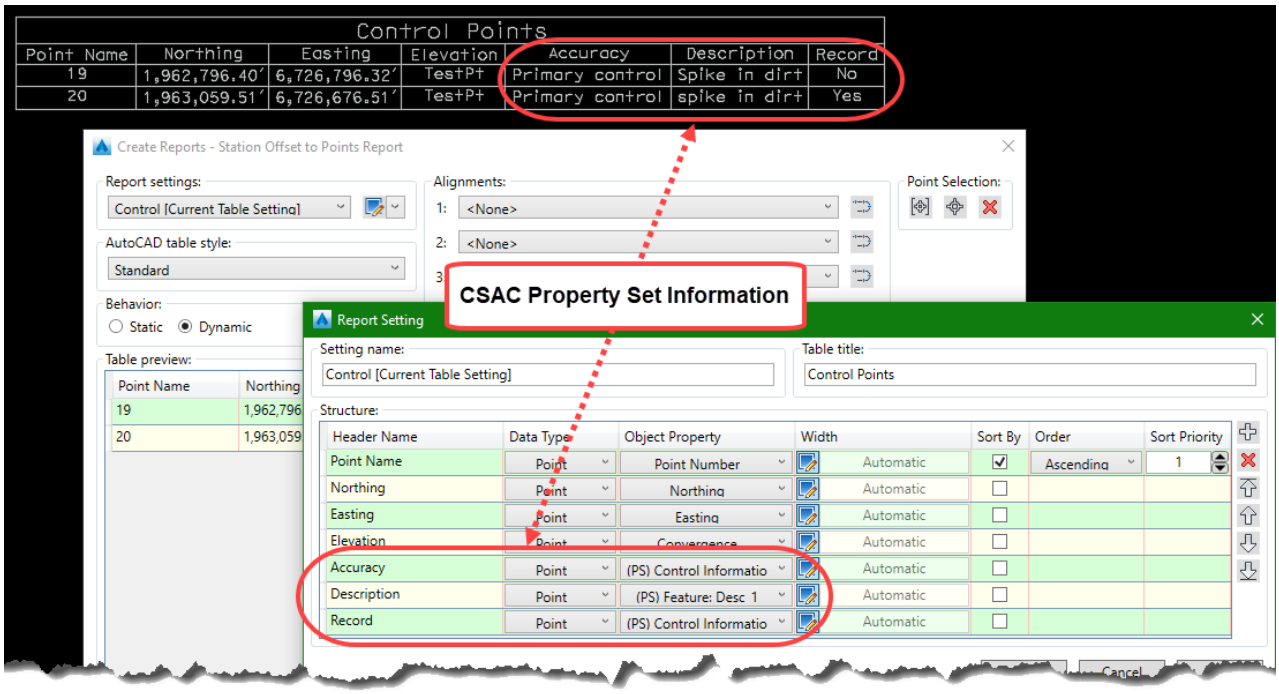


Figure 51 Point Table displaying CSAC Property Set Information

The tables can also include station and offsets to one or more Alignments with a variety of table sorting options.

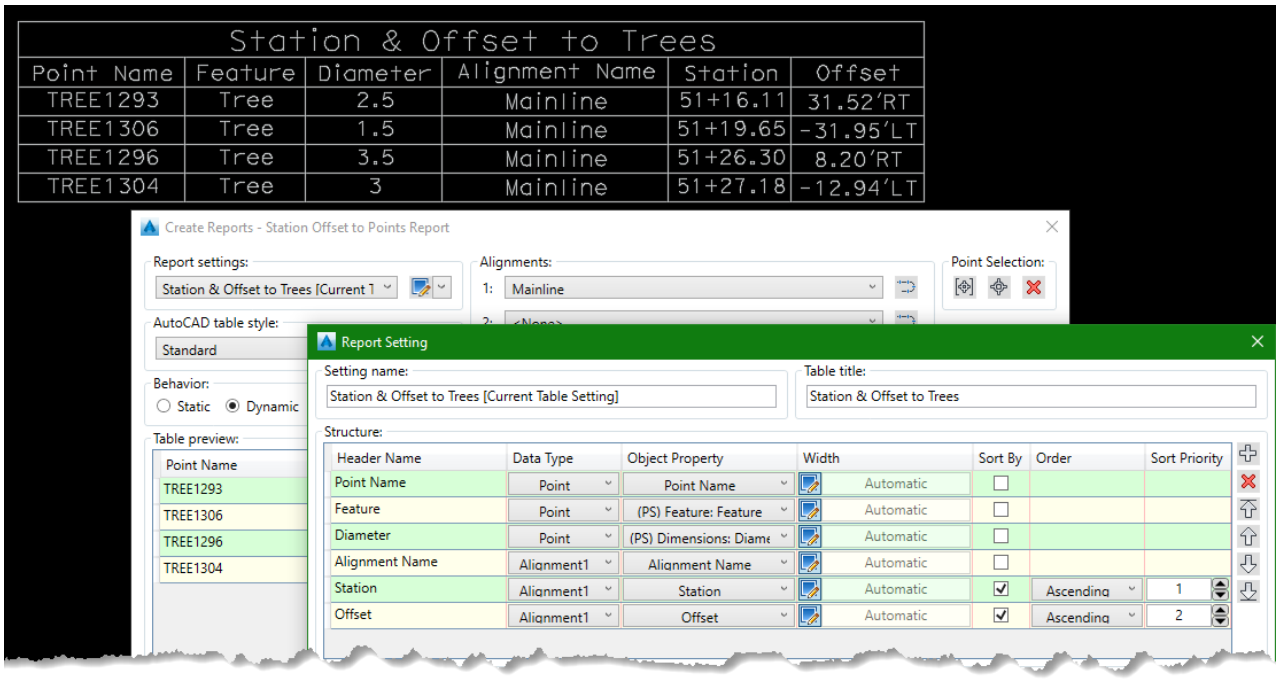


Figure 52 Point Table displaying CSAC Property Set Information and Station & Offsets to an Alignment

CSAC Project Organization & Deliverables

Trimble Project Files and Folders

A Trimble project folder will contain one or more TBC projects. An example project folder structure is shown below. The sub-folders are created by TBC when data is imported or exported.

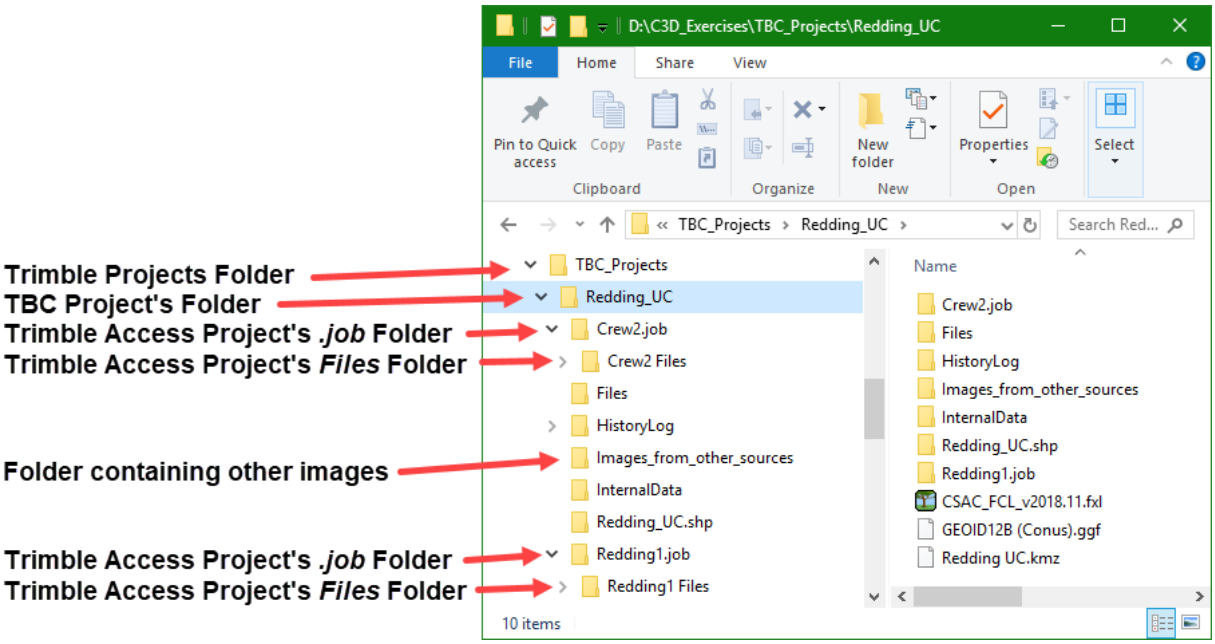


Figure 53 Example of a Trimble Project Folder

<table>
<tr><th>Folder</th><th colspan="3">Description</th></tr>
<tr><td>Trimble Projects Folder</td><td colspan="3">This is the top-level folder containing the TBC projects; a TBC project file (*.VCE) for each project and a TBC project folder for each TBC project.</td></tr>
<tr><td></td><td>TBC Project's Folder</td><td colspan="2">Contains the TBC project's supporting files including the attached FXL, the imported Access project folders, the exported TBC Shape files folder, images associated to data that are not transferred with .job files, and KML/KMZ files exported from the TBC project.
If images are associated to the data, a KMZ file should be created for delivery.
If images are not associated to the data, a KML file can be created for delivery.</td></tr>
<tr><td></td><td></td><td>Trimble Access Project's .job Folder</td><td>Contains the imported .job file and the Access Project's Files folder.
When a Trimble Access .job file, or any JobXML (.jxl) file, is imported, a project subfolder is created in the project folder to contain the imported data file along with any referenced image files. This ensures that when multiple files of the same type are imported, any referenced image files with the same name are stored separately and cannot be overwritten.</td></tr>
<tr><td></td><td></td><td></td><td>Trimble Access Project's Files Folder</td><td>Contains the images associated to data in the imported .job file. Images taken from other sources should be copied to this location or to another folder in the TBC project's folder.</td></tr>
<tr><td></td><td></td><td>TBC Project's .shp Folder</td><td colspan="2">Contains the Shape files of the features exported from a single TBC project. A collection of 5 files are created for every CSAC FCL Feature Code exported from the TBC project.</td></tr>
</table>

Civil 3D 2016 Project Files and Folders

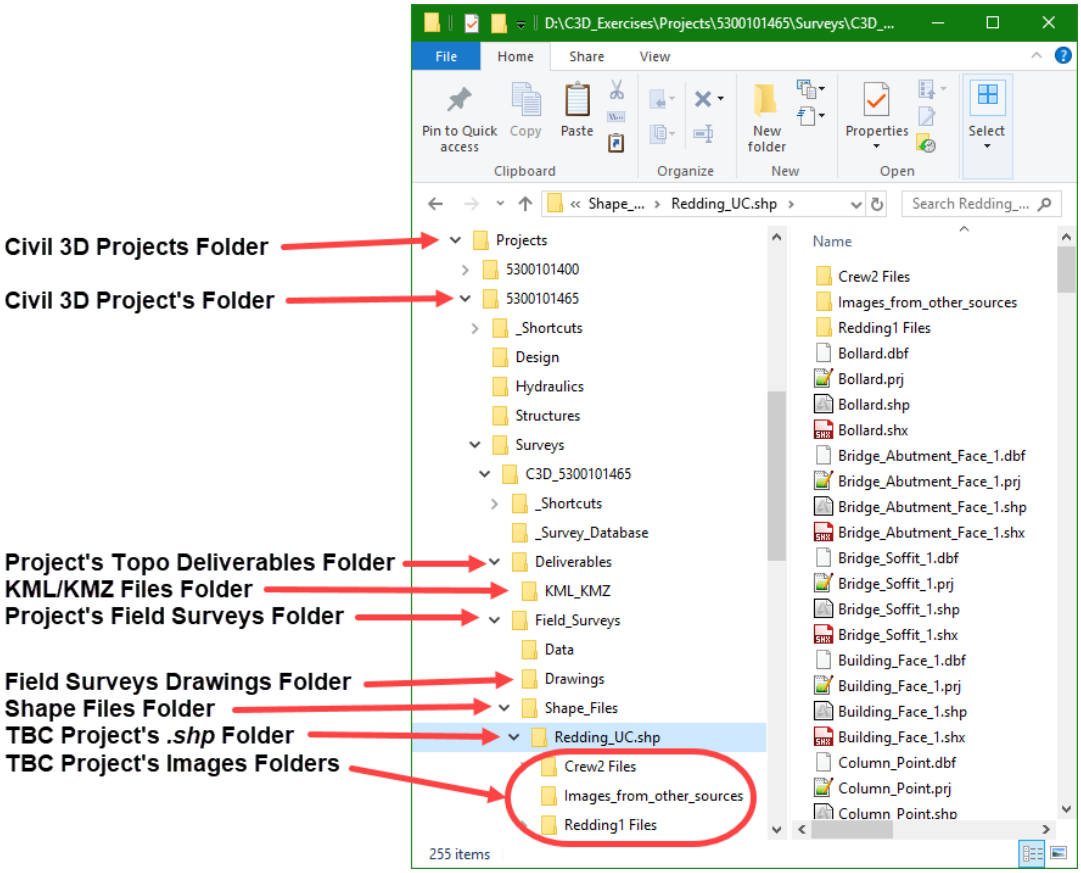


Figure 54 Example of a Civil 3D Project Folder containing CSAC Files

Folder	Description				
Civil 3D Project's Folder	This is the top-level folder containing the Civil 3D project's files and folders.				
	Project's Topo Deliverables Folder	Contains the final merged topo data drawings for use in the design process including *EG_Surface* and *EG_Linework_Points* drawings, topo data DGN files, and a folder containing the KML/KMZ files.			
		KML/KMZ Files Folder	Contains the KML or KMZ files exported from one or more TBC project.		
	Project's Field Surveys Folder	Contains folders for Civil 3D CSAC, CTDC or MTLS topo drawings, files imported into the drawings, and supporting documentation.			
		Field Surveys Drawings Folder	Contains the individual CSAC, CTDC or MTLS topo drawings containing COGO Points, Feature Lines, AutoCAD Points, Polylines, and associated Surfaces.		
		Shape Files Folder	Contains folders for TBC project Shape files, associated images, and documents.		
			TBC Project's *.shp* Files Folder	Contains the Shape files of the features exported from a single TBC project. When more than one TBC project is imported into a Civil 3D project, multiple TBC project .shp folders are delivered.	
				TBC Project's Images Folders	Contains images and documents associated to data in the TBC project's Shape files.

Topo Data Deliverables

Reasons for Delivery Methods

The reasons for delivering topo data in Civil 3D as described in this section were determined based on a variety of factors:

- Improves the performance of Civil 3D
- Provides a consistent standard deliverable for all users, even if there is only a single topo data drawing
  - All users can view the topo lines and Points by XREF'ing the *EG_Linework_Points* drawing
  - All users can work with the merged Surface by data referencing the *Existing_Ground* Surface stored in the *EG_Surface* drawing
- Makes it easier to add additional topo data if the project scope changes in the future
  - All users will automatically see the changes
- Minimizes the number of drawings that other users need to manually XREF
- Provides a single merged Surface for all users
  - Ensures that all users are working with the same Surface
  - Ensures that overlapping and abutting Surfaces are managed properly

The active drawing's file size seriously impacts the performance of Civil 3D. For example, the process of viewing and exporting contours to a DGN file can take an extremely long time when the active drawing contains the Surface and possibly the topo data. However, the time to work with the same Surface can be reduced by over 90% when the Surface is data referenced in the active drawing.

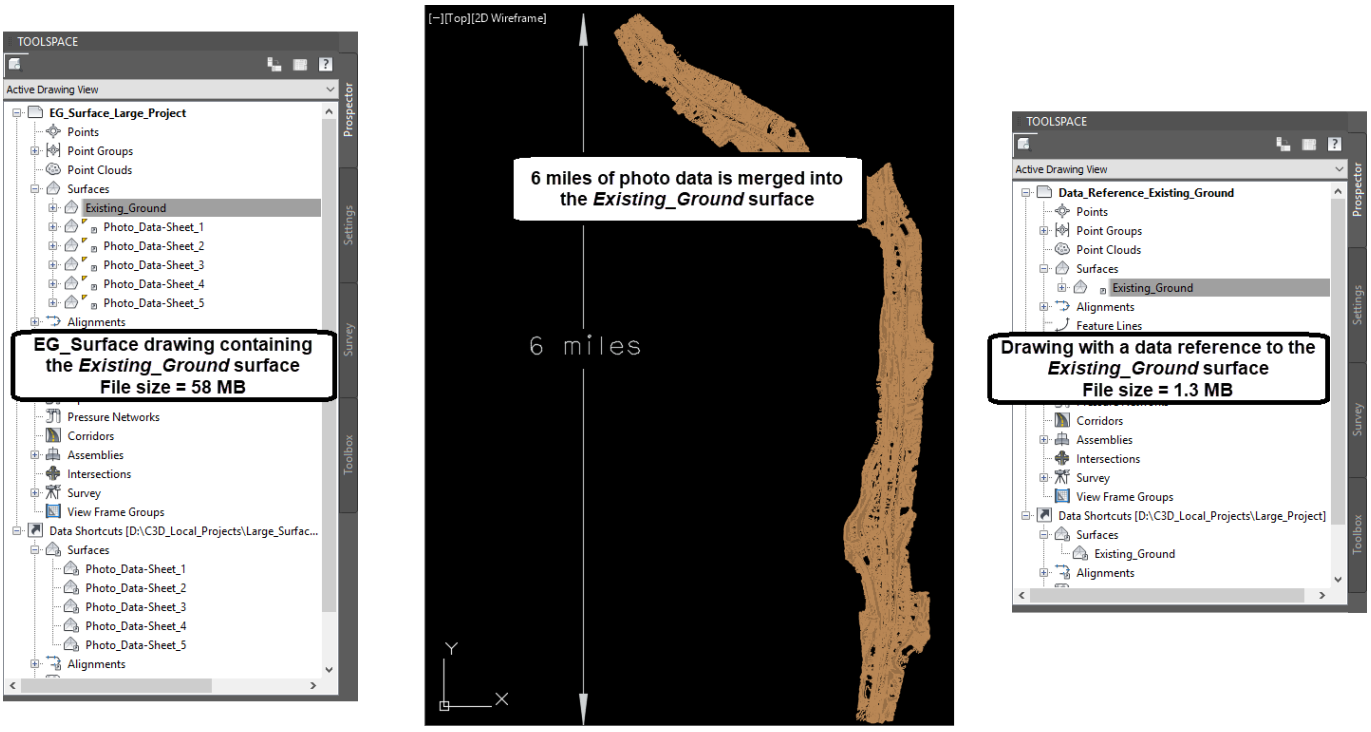


Figure 55 File size comparison – EG_Surface drawing vs. a drawing containing a data reference to the Surface

Standard Topo Deliverables

The standard topo deliverables are a collection of drawings containing Civil 3D objects that are shared as XREF's or Data Shortcuts. The data is delivered this way to improve performance, while also providing the necessary information for all functional units to design and deliver a project.

Throughout most of the design process, the XREF and Data Shortcut deliverables are enough. However, when a cross section needs to refer to a topo feature, e.g., to project and label a feature in a cross section, the user must copy the object(s) into the drawing that contains the cross section. All topo data objects, except for Survey Figures, can be copied from a nested XREF with the Shape Tools **External Reference Copy** tool. Survey Figures are inserted into the drawing containing the cross sections from the Survey Database. In either situation, the design team must be informed if changes are made to the data because they need to reinsert the affected objects into their drawings.

13) Topo Data Drawings - <topo data>.dwg

One or more Civil 3D drawings containing Points, Lines, and their associated Surface(s). Data from different data types, including photogrammetric, aerial LiDAR, bathymetric, MTLS, and survey topo data, are stored in different drawings. These drawings and Surfaces ARE NOT directly referenced by other functional users.

Different types of topo data, including photo, aerial LiDAR, bathymetric, MTLS, and survey data are typically stored in different files to keep the Civil 3D drawings easier to manage. The data may also be divided further into different drawings to make the file sizes smaller.

These drawings are not directly referenced by other functional units, instead they are displayed as **Nested References** through the *<project name>-EG_Linework_Points.dwg*.

The Surfaces in these drawings are not directly visible to the functional units outside of the Surveys functions, instead they are data referenced into the *EG_Surface.dwg* and then merged into the *Existing_Ground*, *Existing_Bridge_Deck*, or *Existing_Bridge_Underside* Surfaces that are shared at the project shortcuts level.

Drawing Management

One of two Civil 3D drawing templates should be used when creating a topo data drawing. Each template contains layers and styles identifying different data types and topo features. The styles ensure that the data and Surfaces are displayed with the appropriate properties to visually distinguish the features and the data types. For a complete listing of the layers, styles, and tools used in the delivery of topo data, see Appendix A7 in this manual.

- *Ct_2016_Topo_Surveys_MTLS.dwt* – used for Survey & MTLS data
  - The CSAC Shape file workflow creates a mixture of Civil 3D objects and AutoCAD elements based on the Feature Codes and Feature Code Attributes. For this to occur, templates with the *Topographic Data* version, ***Surveys & MTLS data v11*** or higher, must be used when working with CSAC Shape file data.
  - Do not mix CTDC and CSAC data in the same Civil 3D project.
- *Ct_2016_Topo_Aerial_Photo.dwt* – used for photo, aerial LiDAR, and bathymetric data
- When working with a new data set, it's best to check the data in a separate TBC project for CSAC data or working drawing for CTDC data. If everything checks out and all edits have been applied in the TBC project or Survey Database then the data can be added to an existing drawing or a new drawing can be created for the final *<topo data>.dwg*. This is especially important with CTDC data because inserting and removing Survey Points and Survey Figures over and over can lead to potential drawing corruption.
- Surfaces in the *<topo data>.dwg*:
  - Surfaces are created from the topo data drawing objects contained in the drawing.

        - Surfaces should not be created from external files i.e., XML or point cloud files, when the topo data resides in the drawing.
    - Surfaces for ground data and bridge data should be created as separate Surfaces.
    - Use Surface names and descriptions to identify the data type such as *Survey_Data_Ground* or *Photo_Data_Bridge_Deck*.
    - Data Shortcuts are made to the individual Surfaces at the lower-tiered *Surveys* shortcut level.

      Data references will be made to these Surfaces in the *<project name>_EG_Surface.dwg*. The individual Surfaces will be merged into the *Existing_Ground*, *Existing_Bridge_Deck,* or *Existing_Bridge_Underside* Surfaces that exist in the *<project name>_EG_Surface.dwg*.

- When new data is added to a drawing and the new data overlaps other data in the drawing, the underlying older data must be trimmed and deleted from the drawing or moved to an unused frozen layer to ensure that it is not displayed nor used in the Surface.
- Different types of data such as, photo, aerial LiDAR, bathymetric, MTLS, or survey data, and their associated Surfaces are typically stored in different individual drawings. Survey data is not typically included in a drawing containing photo or aerial LiDAR data.
    - Projects are active for several years. Efficient data storage, archiving, and retrieval is facilitated by grouping data into import events and documenting the process in the **ReadMe** file. The ReadMe file is described in further detail later in this document.
    - In the following situations, different types of data, such as, photo, aerial LiDAR, bathymetric, MTLS, or survey data, can be stored in the same drawing to create a single Surface:
        - When data of one type is interspersed in the middle of a different data type, e.g., when survey data is collected to supplement areas not included with MTLS data.
        - When there are many regions of abutting data. This removes the need to clean the Surface triangles at those edges that would have been required when pasting the Surfaces.
- Resolve crossing breaklines to the following elevation differences:
    - Survey Data
        - 0.00’
    - Photogrammetric Data

    - 0.50’ – within the highway right of way and on any hard Surfaces
    - 1.00’ – all other areas
- Prior to creating Data Shortcuts, verify that the DSSysVar is set appropriately.
- To improve the performance of Civil 3D, when possible, keep drawing file sizes from exceeding **9 MB**.
    - An exception to this is photo and aerial LiDAR data drawings. These drawings are large even when tiled into smaller sections. When possible, keep these drawing file sizes from exceeding **30 MB**.

Folder Path

The folder path is based on the type of data:

- <project name>\Surveys\C3D_<project name>**Field_Surveys**\Drawings\
- <project name>\Surveys\C3D_<project name>**Photogrammetry**\Drawings\

File Name

The file name varies based on the type of data.

Note: Once references are made to the drawing and/or Surface, the drawing and/or Surface name must not be changed.

Suggested file names:

- Drawings containing CSAC data should include the TBC project name and the survey request #, or other descriptive information about the data
    - *<TBC project name>_SR08-22263.dwg*
- Drawings containing data originating in a DGN file (photo, bathymetric, aerial LiDAR or MTLS data) should include the topo data type and the source DGN file name
    - *<data type>_<source DGN name>.dwg*
- Drawings containing CTDC data should include the Survey Database name and the name of the Import Event, survey request #, or other descriptive information about the data
    - *<survey database name>_SR08-22263.dwg*

Drawing Objects

The topo data drawings contain a variety of objects based on the data type.

For information regarding the use of TSS files, Survey Databases, Survey Points, and Survey Figures, see the Caltrans internal training manual “*Civil 3D 2016 Survey Data Processing and DTM”* found on the OLS FTP site:

ftp://cadd.dot.ca.gov/OLS_FTP/Software/Civil3D/Training/Survey_Data_Processing_DTM/Civil_3D_2016/Civil_3D_2016-Survey_Data_Processing_and_DTM.pdf

- All topo data drawings contain a Surface created from the topo data contained in the drawing
  - Style = _No Display
  - Do not create Surfaces from external files, e.g., XML or point cloud files, when the topo data resides in the drawing.

CSAC, MTLS, Photo, and Aerial LiDAR data

- Drawing objects
  - Topo features
    - COGO Points
    - Feature Lines
  - Miscellaneous features collected to enhance a Surface
    - AutoCAD Points
    - 3D Polylines
- Drawing DOES NOT contain
  - Survey Points
  - Survey Figures

CTDC data

- Drawing objects
  - Survey Points
  - Survey Figures
- Drawing DOES NOT contain
  - Survey Figure Points

When data edits are required

- If errors are found with the CSAC objects, ALL EDITS should be performed in TBC. When the edits are complete, the affected data is exported from TBC and re-imported into Civil 3D.
  - Edit the affected data in TBC.
  - Export new Shape files of the affected features.
  - Copy and replace the shape files in the Civil 3D project folder.
  - Re-import and replace the objects in the drawing.

- If errors are found with the CTDC objects, all edits should be reflected in the Survey Database. When the edits are complete, insert or remove the affected data from the topo data drawing.
- After edits are made, save and close the topo data drawing.
  - Open the *<project name>_EG_Surface.dwg*, **Synchronize** the Data Referenced Surfaces, rebuild the impacted ground and bridge Surface(s), save and close the drawing.
  - Edits are automatically reflected in the *<project name>-EG_Linework_Points.dwg* when the drawings are saved.

Data Sharing

- Data Shortcuts to the individual topo data Surfaces are made in the lower-tiered *Surveys* shortcut level to prevent them from being referenced directly by other users.
- XREF the individual topo data drawings to the *<project name>-EG_Linework_Points.dwg* using **Relative Path** and the **Attachment Reference** type to ensure the references are nested.

14) Surface Drawing - <project name>_EG_Surface.dwg

A Civil 3D drawing containing the merged *Existing_Ground* Surface(s) created from data references to the Surfaces in the topo data drawing(s). The *Existing_Ground* Surface is data referenced by all users in need of the Surface data throughout the design process.

Instead of delivering multiple Surfaces for project design work, Caltrans typically delivers one merged Surface for ground data and separate Surfaces for bridge data. The merged ground Surface combines the ground Surfaces that are created from the different topo data Surfaces. The same is done for the bridge Surfaces. To keep the file size manageable, only the merged ground and bridge Surfaces are created and stored in the *<project name>_EG_Surface.dwg*. The topo data Surfaces are data refenced into this drawing.

This drawing is not directly referenced by other functional units, instead the Surfaces are shared through **Data Shortcuts**.

Only the merged *Existing_Ground*, *Existing_Bridge_Deck,* and/or *Existing_Bridge_Underside* Surface is visible to the other functional units for use in the design process. Modifications made to the topo data Surfaces will automatically be reflected in the *Existing_Ground*, *Existing_Bridge_Deck,* or *Existing_Bridge_Underside* Surface when the drawings are saved and synchronized.

Drawing Management

- The *<project name>_EG_Surface.dwg* contains:
  - A Surface named *Existing_Ground*, *Existing_Bridge_Deck,* and/or *Existing_Bridge_Underside*
  - Data references are made to the topo data ground and/or bridge Surfaces from the lower-tiered *Surveys* shortcut level
  - The topo data Surfaces are merged into the appropriate *Existing_Ground*, *Existing_Bridge_Deck,* or *Existing_Bridge_Underside* Surface
  - A Data Shortcut to the *Existing_Ground*, *Existing_Bridge_Deck,* and/or *Existing_Bridge_Underside* Surface is made in the upper-tiered *Project* shortcut level
- To provide a consistent standard deliverable for all users, the process above must be done, even if there is only a single topo data drawing.
- Managing Surfaces from data in adjoining drawings is important when creating a merged Surface. The methods used when Surfaces overlap are different than when Surfaces abut.
  - Overlapping Surfaces
    - When Surfaces are pasted into the merged *Existing Ground* Surface and one Surface overlaps another, the border of the last pasted Surface will clip

the data in the underlying pasted Surface. Extraneous triangle legs along the border must be deleted from the topmost Surface(s).

In some situations, overlapping Surfaces create a pocket or hole in an overlying Surface that needs to be filled-in with data from the underlying Surface.

- Abutting Surfaces
  - When Surfaces are pasted into the merged *Existing Ground* Surface and one Surface abuts another, the Surfaces must have a common breakline along the abutting edge to force the triangle vertices to match in that location. Extraneous triangle legs along the border must be deleted from one of the abutting Surfaces. The border is then added to the other Surface as a breakline.

- Prior to creating Data Shortcuts, verify that the DSSysVar is set appropriately.
- The *Existing_Ground* Surface in this drawing is shared for use by others with Data Shortcuts. Since this drawing is not intended to be XREF'd, the file size should not cause any delays with users working through data references. However, if the response time becomes a serious issue, an additional drawing can be created where the *Existing_Ground* Surface would be divided into multiple Surfaces.
  - For example,
    - *<project name>_EG_Surface-North.dwg* containing Surface *Existing_Ground-North*
    - *<project name>_EG_Surface-South.dwg* containing Surface *Existing_Ground-South*

Folder Path

- <project name>\Surveys\C3D_<project name>\Deliverables\

File Name

- The name should contain the project name and *EG_Surface*
  - *<project name>_EG_Surface.dwg*

Drawing Objects

- Data References to the individual topo data ground and bridge Surfaces from the lower-tiered *Surveys* shortcut level
  - Surface Style = _No Display
- An Existing Ground Surface
  - A Surface named *Existing_Ground*
  - Surface Style = _Border Only

  - The lower-tiered Data Referenced ground Surfaces are merged into this Surface
- A Bridge Surface(s) - deck and/or underside Surface(s)
  - A Surface named *Existing_Bridge_Deck* and/or *Existing_Bridge_Underside*
  - Surface Style = _Border Only
  - The lower-tiered Data Referenced bridge Surfaces are merged into this Surface
- Drawing DOES NOT contain
  - Points
  - Survey Figures
  - Feature Lines

When edits are required

- DO NOT delete or rename the drawing if there are Data Shortcuts in the upper-tiered *Project* shortcut level to any of the Surfaces in the drawing.
- DO NOT delete or rename the *Existing_Ground*, *Existing_Bridge_Deck*, or *Existing_Bridge_Underside* Surfaces if there are Data Shortcuts in the upper-tiered *Project* shortcut level to any of these Surfaces.
  - If the one of the Surfaces must be edited, keep the original Surface as is and edit the Surface definitions to reflect the desired changes.
- If the individual topo data Surfaces are edited, the Data References to the Surfaces in the <*project name*>*_EG_Surface.dwg* must be **Synchronized** and the impacted Surface must be rebuilt.

Data sharing

- Data Shortcuts to the *Existing_Ground*, *Existing_Bridge_Deck*, and *Existing_Bridge_Underside* Surfaces are made in the upper-tiered *Project* shortcut level.
- The Surfaces are Data Referenced as needed by other users from the upper-tiered *Project* shortcut level for corridor design and cross sections. The data referenced Surfaces:
  - Are a read-only copy and can be displayed with any style by any user without concern of unintentional changes to the Surfaces.
  - Can be used for any type of analysis and reporting.
  - Can be masked by the user to block out areas of a Surface to prevent them from being displayed, enhancing the performance of Civil 3D.
- This drawing should NOT be directly XREF'd by any user.

15) Linework & Points Drawing - <project name>-EG_Linework_Points.dwg

A Civil 3D drawing containing nested External References (XREF's) to the individual topo data drawing(s). This drawing is XREF'd by all functional users in need of displaying the topo Points and Lines in the nested topo data drawings throughout the design process.

The topo Points and Linework need to be viewed during project design work. This is done by referencing the drawings containing the topo data. To minimize the number of files that the user needs to manually XREF, all the topo data drawings containing Point and Line topo features are referenced into a single drawing, *<project name>-EG_Linework_Points.dwg*, using the **Attachment** option. When this drawing is XREF'd, the other drawings will automatically be displayed as nested references. If modifications are made or additional topo data is added, anyone referencing this drawing will automatically see the changes.

Drawing Management

- XREF the topo data drawings displaying only the Point and Line topo features. The following settings must be used when attaching the drawings:
  - **Reference Type** = *Attachment*
  - **Path type** = *Relative path*
- To provide a consistent standard deliverable for all users, this must be done even if there is only a single topo data drawing.
- If data in one drawing overlaps the data in another drawing, use **XCLIP** to mask the underlying data.
- If drawing response times become a serious issue or when the file size exceeds **9 MB**, additional drawings can be created.
  - For example,
    - *<project name>-EG_Linework_Points-North.dwg*
    - *<project name>-EG_Linework_Points-South.dwg*
- When XREF'ing drawings on the project server, set the path to Relative Path.
  - If Relative Path is not allowed, save the active drawing and re-attempt XREF'ing the drawings.

Folder Path

- <project name>\Surveys\C3D_<project name>\Deliverables\

File Name

- The name should contain the project name and *EG_Linework_Points*
  - *<project name>-EG_Linework_Points.dwg*

Drawing Objects

- XREF's to the topo data drawings displaying the Point and Line topo features
  - DO NOT XREF drawings containing Survey Figure Points to this drawing
- A closed Polyline that is used to XCLIP overlapping XREF's, if necessary.
- Drawing DOES NOT contain ANY topo data

When edits are required

- Insert or remove affected data in the individual topo data drawings. The changes are automatically reflected in this drawing.

Data sharing

- The *<project name>-EG_Linework_Points.dwg* is XREF'd by other users as needed to display the topo Points & Linework.
- Topo data in the XREF drawings is displayed exactly as seen in the nested drawings.
  - Set the style of the Surfaces in the topo data drawings to *_No Display*.
- The attribute information and associated images of CSAC data in the XREF'd drawings can be displayed by all users using the Civil 3D SHP and Table Tools, **Display Property Sets in Tooltips** (SSHPTOOLTIPSON), and **SHP File Links ON** (SSHPFILELINKSON).
- The attribute information of CSAC data in the XREF'd drawings can be queried using the Civil 3D SHP and Table Tools, **SHP Palette** (IMPORTSHPPALETTE).
- Information about all topo data in the XREF'd drawings can be seen in tool tips using the Caltrans developed tool **Ct Enable XREF Data Tips** (CTSTARTXRPROPS).
- Object snaps can be used on the topo data in the XREF'd drawings.

16) Topo Basemaps - <topo data>.dgn

One or more MicroStation DGN files containing the survey and MTLS topo data and the labeled contours of the *Existing_Ground* Surface. These drawings are used as a basemap for the final design contract plans.

MicroStation DGN files of the Topo Basemaps are required for the final contract plan preparation and submittal for PS&E.

Civil 3D is used to export topo DGN files of the survey and MTLS topo features, and the *Existing_Ground* Surface contours. Photo and aerial LiDAR data originate in DGN files, and do not need to be exported from Civil 3D. The original DGN files for the data described above should be available for use in the topo basemap instead. See *Standards and Symbols for Photogrammetric Mapping* (SSPM) and *2015 Standard Plans* for the required standards of photogrammetric and aerial LiDAR data in DGN files.

Caltrans Civil 3D resource files ensure that survey and MTLS topo features will display properly in Civil 3D and will export appropriately to MicroStation, i.e., they will export on the correct level, color, and line weight.

Drawing Management

- In general, Caltrans contract plans are printed at a scale of 1" = 50'. When creating the topo map in Civil 3D, display the data with the annotation scale set to 1” = 50’. This will scale the Linetypes, Blocks, and Annotation appropriately.
  - A larger scale may be requested by the engineer for smaller projects such as ADA ramp projects.
- When exporting to a DGN file from Civil 3D, the following Export Settings for MicroStation DGN must be used:
  - Use one of the appropriate Caltrans MicroStation seed files based on Zones 1 through 6, located in C:\Caltrans\HQ\MSV8i\seedV8_zones\, to ensure that the coordinate system is imbedded in the DGN file.
  - Remapping Options
    - Turn ON **Use remapping file**
    - Use the *50_Scale-Remap_C3D_to_MSta.csv* for 1” = 50’ mapping
      - This file sets all linestyles to a scale of 3.937 in the DGN file
      - This file maps the Civil 3D Blocks, Fonts, Linestyles, and Layers to the appropriate MicroStation Cells, Fonts, Linestyles, and Levels
    - Turn ON **Remap AutoCAD color book to color index**
      - Use **Ct Export**
      - This file maps the Civil 3D color book color to the appropriate MicroStation color index

    - Use the *CT_DwgSettingsInV8i.dws*
        - This file maps the Civil 3D Lineweight in inches to the appropriate MicroStation Lineweight index
        - This file specifies the required advanced settings when opening a DWG file in MicroStation
    - Turn ON **Replace ByLayer properties with layer properties**
        - This setting ensures that the elements in MicroStation will change the element's properties to the actual value instead of *ByLevel*
- When multiple data sets are used to create different topo maps, for example photo and survey data, older less accurate data underlying the newer more accurate data should be trimmed and removed.
- The drawing file size can cause problems during export. If problems are experienced when exporting the *Existing_Ground* contours from the *EG_Surface* drawing to a DGN file, create a data reference to the *Existing_Ground* Surface in another drawing, display and label the contours, and export the labelled contours to a DGN file.

Folder Path

- <project name>\Surveys\C3D_<project name>\Deliverables\

File Name

- Topo features - the name should be the same as the topo data drawing(s) used to export the data
    - *<topo data>.dgn*
- Surface contours - the name should contain the project name, Surface Name, and *Contours*
    - *<project name>_<Surface_name>-Contours.dgn*

Objects Exported from Civil 3D

Survey and MTLS Data

- Point & Line topo features
    - Exported from the survey and MTLS topo data Civil 3D drawings
- CTDC Figure Points

Surface Contours

- Labeled contours of the *Existing_Ground* Surface
    - Use the Caltrans tool to Label Contours (CTLABLCONTOUR)

Objects NOT Exported from Civil 3D

- Photo and aerial LiDAR topo data
  - The original DGN file is the topo DGN basemap deliverable for these data types because some of the data from the original DGN file is not loaded into Civil 3D. The original DGN files contain more information that is required in the topo basemap.

When edits are required

- The impacted DGN files must be recreated
- If the Surface is impacted, the Surface contours DGN file must be recreated

Data Sharing

- The topo basemap DGN files can be provided as separate files. The end user can merge these files into the final DGN files for PS&E submittal.
- The topo basemap DGN files may be referenced by other users during the design process in MicroStation when other applications outside of Civil 3D are used, e.g., for hydraulics or landscape design work.
- The topo basemap DGN files are required for the plan preparation and PS&E submittal.

CSAC Specific Deliverables

17) TBC Shape Files

When the edits to the CSAC data in TBC are complete, Shape files are exported from every TBC project containing topo data for a Civil 3D project. The TBC project Shape files represent the final edited TBC project dataset. These files are typically only used by the Surveyor who loads the CSAC data into the Civil 3D drawing. However, these files can be used by others using GIS applications for asset management systems, such as the utility database.

File Management

- Shape files are exported from a TBC project when all the edits to the data are complete.
- If modifications are made to the TBC project, new Shape files must be exported and copied to the Civil 3D project folders.

Folder Path

- <project name>\Surveys\C3D_<project name>\Field_Surveys\Shape_Files\<TBC project name>.shp\

File Name

- Shape file names
  - Shape files generated by TBC are automatically named using the Feature Code name. For example,
    - *Curb_Lip_1.**
    - *Curb_Lip_2.**
    - *Sign_Line.**
    - *Sign_Point.**

When Edits are required

- Edit the affected data in TBC. Do not edit the data in Civil 3D.
- Since the exported Shape files are a collection of 5 files for every CSAC FCL Feature Code, the "affected data" that must be exported from TBC includes the edited object(s), as well as, all the other objects in the project that have the same Feature Code as the edited object(s). For example, if the project contains 50 lines that use the Feature Code ***TOC1*** and only one ***TOC1*** line is edited in TBC, all 50 ***TOC1*** lines must be exported to ensure they are all included in the same Shape file that will be copied to the Civil 3D project.
  - Use the **Advanced Selection** tool to select all the features that use the same Feature Code as the edited object(s).
    - This ensures that the Shape files contain all the objects that are in the TBC projects.

- Transfer the new Shape files to the Civil 3D project folders and re-import into Civil 3D.
    - Copy the new Shape files from the TBC project.
    - Paste the new Shape files into the TBC project's *.shp* folder within the Civil 3D project folder.
    - Overwrite the existing shape files.
    - Re-import the new Shape files into the Civil 3D drawing.

Data Sharing

- These files can be used by others using GIS applications for asset management systems such as the utility database.

18) Images and Documents

Images captured in the field and supporting documents including DOCX, PDF, and XLSX, can be associated to CSAC data in TBC. The images and documents are stored in folder(s) in the TBC project's *.shp* folder within the Civil 3D project folders. The images and documents can be viewed by any user working on the Civil 3D project with tools provided in the Civil 3D 2016 Shape tools.

File Management

- Images and documents associated to CSAC data are copied to a folder in the TBC project's *.shp* folder within the Civil 3D project folders.
    - If images were collected with the data collector, a folder containing the images is placed in the TBC project folder when the Trimble Access JOB file is loaded into the TBC project.
        - The folder named, *<Access JOB name> Files*, is copied to the TBC project's *.shp* folder within the Civil 3D project.
    - When an image from other camera sources or a document is associated to a feature in a TBC project, a copy of the file is placed in the TBC project folder.
        - A folder named *Files* is created in the TBC project's *.shp* folder within the Civil 3D project and these images and documents are copied to this folder.
- This gives all users the ability to view images and documents associated to CSAC objects in Civil 3D.

Folder Path

- <project name>\Surveys\C3D_<project name>\Field_Surveys\Shape_Files\<TBC project name>.shp\ <Access JOB name> Files\
- <project name>\Surveys\C3D_<project name>\Field_Surveys\Shape_Files\<TBC project name>.shp\ Files\

File Name

- Images are automatically named by the data collector or camera.
  - The data collectors and cameras can be setup with a unique prefix or numbering sequence to minimize duplicate file names.

When modifications are required

- If the association to images or documents changes in TBC, copy new files or remove unused files from the Civil 3D project folders.

Data Sharing

- The associated images of CSAC data in the XREF'd drawings can be displayed by all users using the Civil 3D SHP and Table Tools, **Display Property Sets in Tooltips** (SSHPTOOLTIPSON), and **SHP File Links ON** (SSHPFILELINKSON).
- These files can be used by others using GIS applications for asset management systems such as the utility database.

19) KML/KMZ Files

The KML/KMZ file(s) exported from the TBC project represents the final edited TBC project dataset and are stored in the *Deliverables* folder of the Civil 3D project folders. This makes the attribute information accessible by ALL users working on the Civil 3D project, even those who DO NOT work in Civil 3D.

- If images are associated to the CSAC data, a KMZ file must be delivered.
- If images are not associated to the CSAC data, a KMZ or KML file can be delivered.

When more than one TBC project is used for a Civil 3D project, multiple KML/KMZ files are created and delivered.

File Management

- A KML/KMZ file is exported from a TBC project when all edits to the data are complete.
- If edits are made to the TBC project, a new KML/KMZ file must be exported and copied to the Civil 3D project folders.
  - This ensures that the KML/KMZ files contain all CSAC objects that are in the TBC projects.

Folder Path

- <project name>\Surveys\C3D_<project name>\Deliverables\KML\

File Name

- The name should contain the TBC project name.

When Edits are required

- Edit the affected data in TBC. Do not edit the affected data in Civil 3D.
- Export and copy the new KML/KMZ file from the TBC project into the *Deliverables* folder within the Civil 3D project folder, replacing the existing file.

Data Sharing

- These files can be used by others using GIS applications or Google Earth to see all the CSAC objects, feature attributes, and associated images and documents for the project.

CTDC Specific Deliverables

The CTDC specific deliverables are being replaced by CSAC deliverables in newer Civil 3D 2016 drawings. For more information regarding the use of TSS files, Survey Databases, Survey Points, and Survey Figures, see the Caltrans internal training manual "*Civil 3D 2016 Survey Data Processing and DTM*" found on the OLS FTP site,

ftp://cadd.dot.ca.gov/OLS_FTP/Software/Civil3D/Training/Survey_Data_Processing_DTM/Civil_3D_2016/Civil_3D_2016-Survey_Data_Processing_and_DTM.pdf

20) Survey Databases

During the design process, topo data may need to be projected into a cross section. The Survey Database must be available as read-only for the data to be projected in a cross section.

Survey Database Management

The Survey Databases can be managed two different ways

- One database per project
  - Each Import Event represents a different set of survey or LiDAR topo data generated from TSS or XML files exported from CAiCE.
    - Additional databases may need to be created if the file size becomes unmanageable. When possible, keep the Survey Database (*.sdbx) file sizes from exceeding **30 MB**.
  - All the required data can be inserted into a single topo data drawing or into multiple drawings.
- Multiple databases per project
  - Each database represents a different set of survey or LiDAR topo data generated from TSS or XML files exported from CAiCE.
  - In this situation it is not recommended that data from different databases be inserted into a common drawing because it would make it difficult to determine which database maintains the data. It is suggested to create a separate drawing for each separate database.

Folder Path

- <project name>\Surveys\C3D_<project name>_Survey_Database\

Database Name

- The database name shall contain the project name.

- Try to have a common name for the database and all associated drawings, especially when working with multiple databases per project. This makes it easier to determine which database contains the data in a specific drawing.
  - For example,
    - Database name: *0c180_PM14-19*
    - Associated drawings:
      - *0c180_PM14-19_SR0053888-Survey_Ground.dwg*
      - *0c180_PM14-19_SR0053888-Survey_Bridge.dwg*.

When edits are required

- Make sure all changes are reflected in the survey database.
- Insert or remove data affected in all drawings.

This process must be followed for the following reasons:

- To use a Survey Database object in a cross section, the object MUST reside in the drawing containing the cross section.
  - A Surface does not contain breaklines that can be used in a cross section.
  - Survey Figures cannot be copied from one drawing to another.

Data Sharing

- The survey database is created and stored in the project folders on the server.
- If a survey database must be moved or copied from a local drive
  - The ENTIRE folder and its contents should be copied to the project's _Survey_Database\ folder.
  - Copying just the folder contents will not work for users who have read-only access.

21) CTDC Figure Points Drawing - <survey_database_name>-EG_Figure_Points.dwg

The CTDC *<topo data>.dwg(s)* and *<project name>-EG_Linework_Points.dwg* do not contain Survey Figure Points because they can cause network issues including longer file open and save times, and slow functions. These Points carry important descriptive information about the associated Survey Figures, therefore these Points are provided in a separate drawing to be displayed when needed.

Note: Only CTDC topo data stored in a Survey Database will need a *<survey_database_name>-EG_Figure_Points.dwg*.

Drawing Management

- The Survey Figure Points from each Survey Database(s) can be inserted directly into this drawing.
- If response times become a serious problem or when the file size exceeds **9 MB** additional drawings can be created.

Folder Path

- <project name>\Surveys\C3D_<project name>\Deliverables\

File Name

- The name should contain the Survey Database name and *EG_Figure_Points*
  - *<survey_database_name>-EG_Figure_Points.dwg*

Drawing Objects

- Survey Figure Points inserted from Survey Database(s)
- Drawing **DOES NOT** contain
  - Individual Survey Points
  - Survey Figures
  - Surfaces

When edits are required

- Insert or remove affected data.

This process must be followed for the following reasons:

- Survey Figure Points are extraneous and are not required in the *<topo data>.dwg(s)*. However, the information they contain may be needed during the design process e.g., to see the descriptive information about Survey Figure such as the height of a fence.
- XREF'd drawings containing large numbers of Survey Figure Points cause slow response times in Civil 3D and can prevent the export to DGN command from succeeding.
- Keeping this data in a separate drawing gives user the ability to XREF the drawing only when needed.

Data sharing

- Information about the topo data in the XREF'd drawings can be seen in tool tips using the Caltrans developed tool **Ct Enable XREF Data Tips** (CTSTARTXRPROPS)
- The *<survey_database_name>-EG_Figure_Points.dwg* is XREF'd by other users ONLY when the descriptive information associated to the Figure Points is required.

ReadMe File

- Prepare a project ReadMe document
  - Deliver the ReadMe document to Design providing necessary project information including:
    - Project Units
    - Horizontal and Vertical Datums
    - Data Quality
      - Design quality
      - Study quality
    - Civil 3D Settings
      - DSSysVar
      - Working Folder
      - Data Shortcuts Project Folder
      - Survey Database name, if any
    - A brief explanation of data including:
      - Data type – CSAC, CTDC, MTLS, aerial LiDAR, or photo data
      - Final Surface name(s)
      - *EG_Linework_Points* drawing name that should be used by the design team
    - A listing with paths to additional delivered files including:
      - Shape files
      - KML/KMZ files
      - Attached images/documents
    - Links to videos showing how design can use CSAC data, if applicable
      - http://cadd.dot.ca.gov/manuals/civil3d/videos/CSAC_New%20SurveyDeliverable.mp4
      - http://cadd.dot.ca.gov/manuals/civil3d/videos/CSAC_PhotoQuery.mp4
    - Tables listing the features and the associated Civil 3D Styles can be found in Appendix A7 in this manual.
  - Retain a copy of the ReadMe for Surveys
    - Additionally, note the Field Survey data files' names and directory folder paths

Workflow Checklist

The following is a general workflow outline for creating and delivering topo data. Exercises demonstrating the general workflows described in this section can be

found in the in the Caltrans internal training manual "*CSAC Data and Surface Processing*" found on the OLS FTP site:

ftp://cadd.dot.ca.gov/OLS_FTP/Software/Civil3D/Training/Survey_Data_Processing_DTM/Civil_3D_2016/CSAC_Data_and_Surface_Processing_C3D-2016.pdf

Determine where the project will be prepared

22) Does the Civil 3D project folder structure exist on the server?

- **Yes** - Create all the drawings, and Survey Database if working with TSS data, in the project folder structure on the server.
- **No** - Create a local project folder structure. Save all the drawings, and Survey Database if working with TSS data, in the local project folder structure and copy the drawings to the server when the project folder structure is available.

Create the Individual Topo Data Drawings and Surfaces

23) Survey Data from CSAC Shape files

Copy the Trimble files to the Civil 3D project folder

- Copy the TBC project's *.shp* folder, the images captured in the field, and the TBC project's KML/KMZ file from the TBC Project folder into the Civil 3D project folders.

  For detailed instructions refer to Exercise 5-1 in Chapter 5.

Does the CSAC project data exist in a Civil 3D drawing?

- **Yes** – Edits were made to the CSAC data in TBC. The data was re-imported into an existing Civil 3D topo data drawing.
  - Copy the modified Trimble files to the existing TBC project's *.shp* folder in the Civil 3D project folders.
- **No** – The CSAC data is new. The data needs to be imported into a new Civil 3D topo data drawing.
  - Copy the new TBC project's *.shp* folder and associated files to the Civil 3D project folders.

In Civil 3D

- Create a new survey data Civil 3D drawing
  - Use the Ct_2016_Topo_Surveys_MTLS template with *Topographic Data* version, ***Surveys & MTLS data v11*** or higher
- Import the Shape Files
  - **Toolspace** ➢ **Toolbox** tab ➢ **Civil 3D SHP and Table Tools** ➢ **SHP Import/Export** ➢ **Import SHP Survey Data** (IMPORTSHPSURVEYDATA)

-OR-

- **Ribbon** ➢ **Home** tab ➢ **Palettes** panel ➢ **Tool Palettes** button ➢ **CT Topo** palette ➢ **Surveys** tab ➢ **Import SHP Survey Data** (IMPORTSHPSURVEYDATA)
  - **SHP settings**: *CSAC FCL files from TBC*
  - **Import Event Name**: <*TBC Project name*> or <*TBC Project name – modified data*>

☐ Turn On/Off Line Points

- **Toolspace** ➢ **Prospector** tab ➢ right-click **Point Groups** ➢ **Properties**
- Move **CSAC Line Points - display OFF** or **Line Points – display OFF** to the top of the list

☐ View object attributes

- **Toolspace** ➢ **Toolbox** tab ➢ **Civil 3D SHP and Table Tools** ➢ **Property Set Visibility** ➢ **Display Property Sets in Tooltips** ➢ hover over the object to see attribute information

-OR-

- Select the object ➢ right-click ➢ **Properties** ➢ to see attribute information

☐ Check for non-standard objects

- **Toolspace** ➢ **Prospector** tab ➢ **Feature Lines** or **Points**➢ click on the column header **Style** to sort the list in alphabetical order, placing **_Non-Standard** at the top of the list

☐ View associated images and documents

- **Toolspace** ➢ **Toolbox** tab ➢ **Civil 3D SHP and Table Tools** ➢ **SHP Import/Export** ➢ **SHP File Links On** ➢ the file link icon  is displayed as the cursor hovers over an object that has an attached image ➢ press **[Ctrl]** and click on the object ➢ to view the associated image or document

☐ Query objects

- **Toolspace** ➢ **Toolbox** tab ➢ **Civil 3D SHP and Table Tools** ➢ **SHP Import/Export** ➢ **SHP Palette**
  - In **IMPORTSHPPALETTE** palette,
    - <*drawing name*> ➢ **Queries** ➢ right-click the desired object(s) in the appropriate query ➢ select the desired action - **Zoom to…**, **Pan To…**, **Select**, or **Refresh**

    -OR-

    - <*drawing name*> ➢ right-click **Queries** ➢ **New Query**, **Import Queries**, or **Export Queries**

-OR-

- <*drawing name*> ➢ **Queries** ➢ right-click ➢ **Edit Query** or **Export Query**

- Lock objects
  - **Toolspace** ➢ **Prospector** tab ➢ *Drawing name* ➢ **Points** ➢ **Point Groups** ➢ right-click the Point Group to be locked ➢ **Lock Points**

  -OR-

  - Select one or more COGO Points ➢ right-click ➢ **Lock Points**

  -OR-

  - **Ribbon** ➢ **Home** tab ➢ **Layers** panel ➢ **Layer Properties** button (LAYER) ➢ select the layer(s) to be locked ➢ click in the **Lock** column to toggle the icon from unlocked  to locked 
- Create the survey data Surface
- Load the Breaklines and spot elevation Points manually (there is also a macro available to do these steps)
  - Add the Breaklines to the Surface
    - Select the Feature Lines & Polylines for the desired Surface type ➢ **Toolspace** ➢ **Toolbox** tab ➢ **Civil 3D SHP and Table Tools** ➢ **SHP Import/Export** ➢ **SHP Palette**
      - In the **IMPORTSHPPALETTE** palette ➢ <*drawing name*> ➢ **Queries** ➢ right-click <*the Surface type*> **- Lines** ➢ **Select**
    - Add the lines to the Surface ➢ **Toolspace** ➢ **Prospector** tab ➢ <*drawing name*> ➢ **Surfaces** ➢ <*Surface name*> ➢ **Definition** ➢ right-click **Breaklines** ➢ **Add…**
  - Add the AutoCAD Points (spot Points) to the Surface
    - Select the AutoCAD Points for the desired Surface type ➢ **Toolspace** ➢ **Toolbox** tab ➢ **Civil 3D SHP and Table Tools** ➢ **SHP Import/Export** ➢ **SHP Palette**
      - In the **IMPORTSHPPALETTE** palette ➢ <*drawing name*> ➢ **Queries** ➢ right-click <*the Surface type*> **- Spot Points** ➢ **Select**
    - Group the selected points ➢ key-in **GROUP** ➢ press **[Enter]**
    - Add the points to the Surface ➢ **Toolspace** ➢ **Prospector** tab ➢ <*drawing name*> ➢ **Surfaces** ➢ <*Surface name*> ➢ **Definition** ➢ right-click **Drawing Objects** ➢ **Add…**
      - In the **Add Points From Drawing Objects** dialog box,

- **Object type**: *Points*
- Select one of the grouped Points in the drawing and press **[Enter]**

- End the Point grouping ➢ select one of the grouped Points ➢ key-in **UNGROUP** ➢ press **[Enter]**

-OR-

- Load the Breaklines and spot elevation Points using the macro
  - Launch the macro
    - **Ribbon** ➢ **Home** tab ➢ **Palettes** panel ➢ **Tool Palettes** button ➢ **CT Topo** palette ➢ **Surveys** tab ➢ **Select & load CSAC data into a Surface**
- Add the COGO Points to the Surface
  - Update the Point Groups
  - Add the desired Point Group to the Surface ➢ **Toolspace** ➢ **Prospector** tab ➢ <*drawing name*> ➢ **Surfaces** ➢ <*Surface name*> ➢ **Definition** ➢ right-click **Point Groups** ➢ **Add…**
    - Select ***CSAC <Surface type> Points*** or ***<Surface type> Points*** if the CSAC Point Group doesn't exist
- Check the Surface
- Turn Off the CSAC Line Points
- Delete extraneous triangles
- Set the Surface style to *_No Display*
- Set the Data Shortcuts Working Folder for the *Surveys* lower- tiered shortcut level
  - Select the *Surveys* folder within the project folder structure
  - Confirm that the Data Shortcuts Project Folder is set to *C3D_<project name>*
- Save the drawing
- Create a Data Shortcut to the Surface

24) Survey Data from a TSS file

The TSS specific deliverables are being replaced by CSAC deliverables in newer Civil 3D 2016 drawings. For more information regarding the use of TSS files, Survey Databases, Survey Points, and Survey Figures, see the Caltrans internal training manual "*Civil 3D 2016 Survey Data Processing and DTM*" found on the OLS FTP site,

ftp://cadd.dot.ca.gov/OLS_FTP/Software/Civil3D/Training/Survey_Data_Processing_DTM/Civil_3D_2016/Civil_3D_2016-Survey_Data_Processing_and_DTM.pdf

In Civil 3D

- ☐ Create a new survey data Civil 3D drawing
  - Set the Ct Launcher Profile to Ct_Topography_Surveys_MTLS
  - Use the Ct_2016_Topo_Surveys_MTLS template
  - Save drawing as *<survey database name>_<import event name or SR#>.dwg*
- ☐ Create a Survey Database
  - Set the Survey Database Working Folder
  - Select the *_Survey_Database* folder within the project folder structure
  - Create a new Survey Database
  - Set the database units & coordinate system
- ☐ Import the TSS file
- ☐ Insert the survey data into the drawing
  - Insert the Survey Points and Survey Figures into the drawing
  - Remove the Survey Figure Points from the drawing
- ☐ Create the survey data Surface
- ☐ Add the Breaklines to the Surface
  - Create Breaklines from the Survey Figures in the database
- ☐ Add the Points to the Surface
  - Update the Point Groups
  - Add the *Ground Points*, Point Groups to the Surface
- ☐ Check & correct any errors with the survey data and the Surface
- ☐ Delete extraneous triangles
- ☐ Set the Surface style to *_No Display*
- ☐ Set the Data Shortcuts Working Folder for the *Surveys* lower- tiered shortcut level
  - Select the *Surveys* folder within the project folder structure

- Confirm that the Data Shortcuts Project Folder is set to *C3D_<project name>*

☐ Save the drawing

☐ Create a Data Shortcut to the Surface

Create the EG_Surface Drawing and Existing_Ground Surface

25) EG_Surface.dwg & Existing_Ground Surface

In Civil 3D

☐ Create the Civil 3D drawing, <project name>_EG_Surface.dwg

☐ Create the Surface, *Existing_Ground*

☐ Set the Data Shortcuts Working Folder for the *Surveys* lower- tiered shortcut level

- Select the *Surveys* folder within the project folder structure
- Confirm that the Data Shortcuts Project Folder is set to *C3D_<project name>*

☐ Create a Data Reference to all the individual Surfaces

- Set the Surface styles to *_Border Only*

☐ Paste the data referenced Surfaces into the *Existing_Ground* Surface in the following order:

- Older &/or less accurate Surface(s)
- Newer &/or more accurate Surface(s)

☐ Check & correct any errors with the *Existing_Ground* Surface

- Add underlying data in hole areas created with certain types of overlapping Surfaces.
- When adjoining Surfaces do not overlap, add a breakline to the less accurate or older Surface that is created from the boundary of the more accurate or newer Surface

☐ Set the Surface styles

- All the individual Surface styles should be *_No Display*
- The *Existing_Ground* Surface should be *_Border Only*

☐ Set the Data Shortcuts Working Folder for the *Projects* upper- tiered shortcut level

- Select the *Projects* folder that the project folder structure resides in
- Confirm that the Data Shortcuts Project Folder is set to *<project name>*

☐ Associate the current Data Shortcuts Project Folder to the drawing

☐ Save the drawing

☐ Create a Data Shortcut to the *Existing_Ground* Surface

Create the EG_Linework_Points Drawing

26) EG_Linework_Points.dwg

In Civil 3D

- Create the <project name>-***EG_Linework_Points.dwg*** drawing in the *Deliverables*\ folder
- XREF all the photo & survey data drawing(s)
  - Attach the drawings with the following settings:
    - **Reference Type**: *Attachment*
    - **Path type**: *Relative path*
  - Attach the drawings in the following order:
    - Older &/or less accurate Surface(s)
    - Newer &/or more accurate Surface(s)
- Use the border(s) of the Surface(s) in the overlying referenced drawing to mask the underlying referenced drawing(s)
  - For a single masking per XREF use XCLIP
    - Set the Data Shortcuts Working Folder for the *Surveys* lower- tiered shortcut level
      - Select the *Surveys* folder within the project folder structure
      - Confirm that the Data Shortcuts Project Folder is set to *C3D_<project name>*
    - Create a Data Reference to the overlying Surface using the *_Border* style
    - Extract the Surface border
    - Delete the data referenced Surface from the drawing. Do NOT delete/remove the Surface from the Data Shortcuts node of the Prospector.
    - Convert the Surface border 3D Polylines to closed 2D Polylines
    - Key-in XCLIP
    - Select the underlying XREF and press **[Enter]**
    - Key-in **N [Enter]** for New boundary
    - Key-in **I [Enter]** for Invert, a hole boundary
    - Key-in **S [Enter]** for Select polyline
    - Select the closed 2D Polyline
    - Press **[Enter]** to exit the command
  - If multiple border areas need to be masked in the same XREF, merge the multiple areas into a single shape to be used with XCLIP

Create the Topo DGN File(s)

- Open each of the survey data drawing(s)
  - Export Civil 3D Drawing to a DGN file of each drawing
- Open the *EG_Surface.dwg.* To display the *Existing_Ground* Surface contours
  - Style = <the appropriate contour style based on the data requirements>
  - Use the Caltrans tool to Label Contours (CTLABLCONTOUR)
  - Export Civil 3D Drawing to a DGN file

Note

If problems are experienced when exporting the *Existing_Ground* contours from the *EG_Surface* drawing to a DGN file, create a data reference to the *Existing_Ground* Surface in another drawing.

Deliver the data

27) Were the drawings and Survey Database created within the project folder structure on the server?

- **Yes**
  - Go to ***Wrap up the project***
- **No**
  - Go to ***Transfer the project to the server***

Transfer the project to the server

28) Copy all the local drawings to the project folder structure on the server

- Save and close all the local drawings and database(s)
- Close Civil 3D
- Copy the photo & survey data drawing(s) to the appropriate folders on the server
- Copy the topo DGN files to the *Deliverables*\ folder on the server
- Copy the ***EG_Surface*** drawing and the ***EG_Linework_Points*** drawing to the *Deliverables*\ folder on the server

29) Re-create the Data Shortcuts on the server

- Set the *DSSysVar*
- Open each of the photo & survey data drawing(s) and do the following:
  - Rebuild the Surface if necessary

- Set the Data Shortcuts Working Folder for the *Surveys* lower-tiered shortcut level
  - Select the *Surveys* folder within the project folder structure on the server
  - Confirm that the Data Shortcuts Project Folder is set to *C3D_<project name>*
  - Associate the drawing to the lower-tiered *Surveys* shortcut level project
- Save the drawing
- Create a Data Shortcut to the Surface

☐ Open the ***EG_Surface*** drawing and do the following:

- Set the Data Shortcuts Working Folder for the *Surveys* lower- tiered shortcut level
  - Select the *Surveys* folder within the project folder structure on the server
  - Confirm that the Data Shortcuts Project Folder is set to *C3D_<project name>*
  - Associate the drawing to the lower-tiered *Surveys* shortcut level project
- Synchronize all the previously data referenced Surface(s)
  - In the **Toolspace** ➢ **Prospector** tab ➢ ***EG_Surface*** ➢ **Surfaces** ➢ right-click each data referenced Surface(s) ➢ **Synchronize**
- Rebuild the ***Existing_Ground*** Surface
- Save the drawing
- Set the Data Shortcuts Working Folder for the *Projects* upper- tiered shortcut level
  - Select the *Projects* folder that the project folder structure resides in on the server
  - Confirm that the Data Shortcuts Project Folder is set to *<project name>*
  - Associate the current Data Shortcuts Project Folder to the drawing
- Save the drawing
- Create a Data Shortcut to the *Existing_Ground* Surface

30) Copy the local database(s) to the project folder structure on the server

☐ Copy the Survey Database folder(s) and all files in the folder to the _*Survey_Database*\ folder on the server

Wrap up the project

31) Verify that all the Data Shortcuts work properly

☐ Save and close each of the individual topo data drawing(s)

- In the ***EG_Surface*** drawing do the following:
  - If necessary, synchronize all the data referenced Surface(s)
    - In the **Toolspace** ➢ **Prospector** tab ➢ ***EG_Surface*** ➢ **Surfaces** ➢ right-click each data referenced Surface(s) ➢ **Synchronize**
  - Rebuild the ***Existing_Ground*** Surface
  - Save and close the drawing
- On a different computer that was not used to deliver the project
  - Verify that a data reference to the ***Existing_Ground*** Surface can be made

32) Verify that all the XREFs work properly

- In the ***EG_Linework_Points*** drawing do the following:
  - If necessary, reload each of the photo & survey data drawing(s)
  - In the **External References** palette,
    - Verify that the **Saved Path** for all referenced drawings is a relative path and does not reference a drive letter
  - Save and close the drawing

33) Prepare and send the Readme document for the Design Group

Identify the following:

Project information

- Project Units
- Horizontal and Vertical Datums
- Data Quality
  - Design quality
  - Study quality
- Data Type
  - CSAC
  - CTDC
  - MTLS
  - Aerial LiDAR
  - Photo

Civil 3D Settings

- The location that the *DSSysVar* should be set to, i.e.
  - *\\st01caddm02\CADD*
- The Project's Working Folder, i.e.

- *%DSSysVar%\PROJ\01*

- The Data Shortcut's Project Folder, i.e.
  - *<project name>*

Civil 3D Deliverables

- Data Shortcuts:
  - **Surfaces**: include all the Surface names, i.e.
    - *<project name>_Existing_Ground*
    - *<project name>_Bridge_Decks*
  - **Alignments**: include all the Alignment names if the district Surveys office provides the project's existing alignments
- Linework & Points drawing(s):
  - **File Location:** \<project folder name>***Surveys\C3D_**<project folder>***Deliverables**
  - **File name:** include the linework and point DWG name(s), i.e.
    - <project_name>*_EG_Linework_Points.dwg*
    - *<survey_database_name>-EG_Figure_Points.dwg*
- Topo Basemap drawings:
  - **File Location:** \<project folder name>***Surveys\C3D_**<project folder>***Deliverables**
  - **File name:** include the topo DGN file name(s), i.e.
    - *<topo data>.dgn*
    - *1220-06_Topo_Sheet_01.dgn*
    - *<project name>_<Surface_name>-Contours.dgn*
- KML/KMZ Files:
  - **File Location:** \<project folder name>***Surveys\C3D_**<project folder>***Deliverables\KML***
  - **File name:** include the TBC project named KML/KMZ file(s), i.e.
    - *<TBC project name>.KMZ*
- Shape Files:
  - **File Location:** \<project folder name>***Surveys\C3D_**<project folder>***Field_Surveys\Shape_Files***
  - **Sub-folder name:** include the TBC project named Shape file folder(s), i.e.
    - \<*TBC project name*>***.shp***
- Images and Documents
  - **File Location:** \<project folder name>**\Surveys\C3D_**<project folder>**\Field_Surveys\Shape_Files**<TBC project name>**.shp**

- **Sub-folder(s) name:** include the names of the Access project named image folder(s) and other images and documents folder, i.e.
  - \<Access JOB name> **Files**
  - **\Files**

- Survey Databases:
  - **Database Location:** \<project folder name>***Surveys\C3D_**<project folder>***_Survey Databases**\
  - **Database name(s):** include the survey database name(s)

CSAC Videos

- Links to videos showing how design can use CSAC data
  - http://cadd.dot.ca.gov/manuals/civil3d/videos/CSAC_New%20SurveyDeliverable.mp4
  - http://cadd.dot.ca.gov/manuals/civil3d/videos/CSAC_PhotoQuery.mp4

CSAC Features & Styles Documentation

- Listings of the features and the associated Civil 3D Styles are found in Appendix A7 in this manual.

E) Horizontal Alignments

Horizontal alignments can be simple graphical elements depicting the approximate location of an object or they can tightly control the location of an object, i.e. the layout line of a retaining wall. When a horizontal element is a constraint in the design of a facility and will be used in the construction stakeout process, it should be developed within the roadway design software with the appropriate state plane coordinate system. This ensures the ability to generate traverse reports and the ability to transfer the data electronically.

This section distinguishes between two different types of horizontal alignments, roadway alignments and other alignments, in order to address specific concerns related to each.

1) Roadway Alignments

A horizontal alignment is the mathematical definition of the horizontal path of a highway or roadway. For most roadway alignments at Caltrans this consists of straight-line sections that connect tangentially to circular curve sections. The roadway alignment is directional in that a stationing or length is recorded from the beginning of the alignment to the end. Surveyors and engineers build the roadway using these alignments. Further discussion and Caltrans design policy on horizontal alignments can be found in Chapter 200 of the *Highway Design Manual* (HDM) https://dot.ca.gov/-/media/dot-media/programs/design/documents/hdm-complete-14dec2018.pdf#page=143

a) Best Practices & things to think about

i) Existing and New Alignments

- Alignments are the backbone of contract plans as well as other record maps, i.e. Records of Surveys that are recorded at the County Offices. For this reason, it is important to make sure that the alignments are as accurate as possible and meet the following minimum criteria:
  - Tangency at least to the nearest tenth of a second, 00.0”
  - Coincidence between compound and reversing curves to the nearest hundredth of a foot, 0.01’
- When you are creating the alignment in Civil 3D, the software will flag elements of your alignment and profile that do not meet requirements. Whether the alignment is new or existing, make sure to set the following items in the Design Criteria tab in Civil 3D.

(a) Design speed (HDM section 101.1,2).
(b) Highway type (HDM section 60.3) and turn on the design checksets.
(c) Set the design criteria file for Civil 3D.
(d) Select the maximum superelevation rate for the highway.

ii) Existing Alignments

- Consult with the District Surveys office for existing alignments in electronic format.
- Research as-builts for existing alignments. If conversion is needed for units or datum, seek assistance from the District Survey office.
- Develop alignment from a combination of as-builts and project control.
- Priority of project control:
  (a) Original project control, documented and archived in the District Survey office
  (b) Centerline monuments, documented and archived in the District Surveys office (lead and tacks or tags, chiseled crosses, etc.)
  (c) Reference ties to centerline
  (d) Right of way monuments and found points with ties to centerline
  (e) Field collected survey data
- Priority of field collected survey data:
  (a) Concrete features (edge of PCC, back of sidewalk, lip, etc.)
  (b) Asphalt features (edge of pavement)
  (c) Dirt or stripe features – data of this type should only be used when project control and other field survey data is unavailable.

iii) New Alignments

i) Follow requirements as specified in *Highway Design Manual*, Chapter 200, Topic 203 – Horizontal Alignment

iv) Naming Convention Recommendations

- The alignment name should include the type of roadway, interstate, state route, county route, etc., and the route number. For example, I15 for Interstate 15 and SR20 for state route 20
- At intersections,
  (a) The alignment name of the street should include the entire street name, if possible, or use the first three or more letters followed by 1. For example, MAPLE1 for Maple Street.
  (b) The alignment name of the ramps should include the first two letters of the street name and the quadrant number, as shown in the diagram.

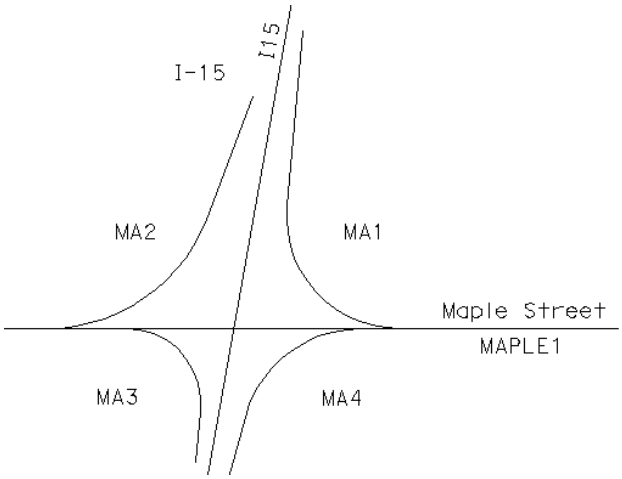


Figure 56 Multiple ramp alignments with names

Format & Attributes

Make sure to use the alignment styles from the Caltrans template file along with the corresponding alignment labels so the program will automatically be assigning the correct graphics attributes to your alignment and stationing. There are two styles for each type of alignment style Production and [Analysis]. Production style is a style to use when the design is finished, and you are ready to print the plans. Analysis styles include design checks, use different colors for different parts of the alignment and show more information about the alignment not needed on the plans.

Linear Feature Attributes Table

Alignment Type	Linestyle	Weight	Color	Level
MAIN	0	3	0	align_MAIN
FRONTAGE	0	2	14	align_FRONTAGE
LOCAL-ST	0	2	10	align_LOCAL-ST
RAMP	0	2	13	align_RAMP
ROUNDABOUT	0	2	14	align_ROUNDABOUT
SECONDARY-HWY	0	2	8	align_SECONDARY-HWY
TEMP	0	2	12	align_TEMP

Stationing and Annotation Attributes Table

The text and tic sizes are based on a plotting scale of 1” = 50’ (Caltrans Base Scale). It is important to place text at the appropriate CADD size within the drawing based on the intended scale of the plotted plan sheet. For any plot scale, the text will appear 0.14 inches when plotted on a 22” x 34” plan sheet.

All text annotation for alignments will use the font CTFont1 with a text size of 7’ and the tic size shall be 7’ for a 1” = 50’ scale drawing.

The tic intervals for stationing will be every 100’. The whole number value of the station will be annotated without the “+00” portion of the station every 500’. The annotated value of the other 100’ intervals will be the single hundred value for that station.

For example, with a station range of 265+00 to 271+00 the annotation would be as follows:

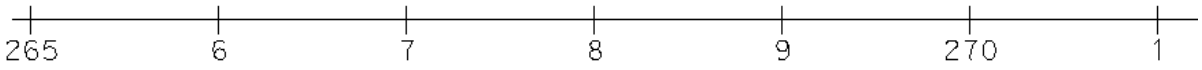


Figure 57 Alignment annotation

Alignment TICS and Annotation Attributes Table

Feature	Weight	Color	Level
MAIN	1	0	align_MAIN-anno
FRONTAGE	1	14	align_FRONTAGE-anno
LOCAL-ST	1	10	align_LOCAL-ST-anno
RAMP	1	13	align_RAMP-anno
ROUNDABOUT	1	14	align_ROUNDABOUT-anno
SECONDARY-HWY	1	8	align_SECONDARY-HWY-anno
TEMP	1	12	align_TEMP-anno

2) Other Alignments

Other alignments represent all other linear elements that are an integral part of the design and construction stakeout processes. Typical elements include, but are not limited to:

- Flow line of curb returns and islands
- Pullouts that are not parallel with roadway alignments
- Fence lines not controlled by right of way
- Right of Way

Right of way requirements are initially developed early in the design process and are further refined by the surveyor performing the right of way engineering. These elements are used to acquire and document property; the roadway design software should therefore be used for the development and subsequent electronic transfer of this data.

- Structural Systems

Retaining walls and sound walls are typical structural systems. It is best to develop the layout lines of these systems in the roadway design software rather than creating a simple graphic element. These designed objects are needed during the design and construction stakeout processes.

- Bridge Systems

Bridge foundation plans typically include layout lines of wing walls, abutments, and bents. These plans, in a geographically correct DGN file, are useful during the design and construction stakeout processes.

- Drainage Systems

Typical drainage systems are pipes, culverts, and in-stream and channel facilities. It is best to develop the layout lines of these systems in the roadway design software rather than creating a simple graphic element. These designed objects are needed during the design and construction stakeout processes.

Develop plan views for drainage systems showing drainage features, manholes and drainage inlets.

a) Best Practices & things to think about
   i) The roadway design software should be used for the development and subsequent electronic transfer of this data when the alignment is not parallel with or controlled by a roadway alignment.
   ii) When the alignment is parallel with and/or concentric to a roadway alignment, the same concerns about tangency and coincidence should be respected.
      - Tangency to the nearest tenth of a second, 00.0”
      - Coincidence between compound and reversing curves to the nearest hundredth of a foot, 0.01’
   iii) If it is not feasible to develop the alignment with the roadway design software, then a layout of the graphical elements must be provided in a geographically correct DGN file.
   iv) When stationing is applied to an alignment of a structural system, the stationing pattern should reflect the structures numbering system, i.e. Retaining Wall 7 starts at 70+00.

b) Format & Attributes.

Always try to apply the appropriate style to any other alignment you may have. Some of these styles may also have Label styles as well, like retaining walls and drainage systems and others may have no labels, like edge of travelled way, edge of pavement, etc.

See Sections 2.4, 2.6, 2.7, and 2.8 for information about the attributes and annotation associated with linear elements.

F) Vertical Alignments

The vertical alignment is the mathematical definition of the vertical path of a horizontal alignment of the highway or roadway. The vertical alignment is always associated with a horizontal alignment and consists of tangent sections (grades) that connect tangentially to parabolic vertical curve sections. It is defined by vertical points of intersection (VPI's) that are in turn defined by the horizontal alignment stationing and elevation. The vertical alignment is drawn in profile view. Requirements for vertical curves are given in terms of minimum curve length and are based on design speed, difference in grade, and adequate sight distance. The vertical alignment is needed by surveyors to set the elevation of the roadway. Further discussion and Caltrans design policy on vertical alignments can be found in Chapter 200 of the *Highway Design Manual*,

https://dot.ca.gov/-/media/dot-media/programs/design/documents/hdm-complete-14dec2018.pdf#page=143

1) Roadway Vertical Alignments (Profile)

   a) Best Practices & things to think about

- Naming Convention Recommendations
  - i) Each vertical alignment is intrinsically tied to a horizontal alignment through assigned stationing. The name of the vertical alignment should be the same as the name of the alignment to which it is associated. For example, SR20 for the name of the vertical alignment to match the horizontal alignment name of SR20.
- Existing Vertical Alignments (Terrain Profiles)
  - i) In certain rehabilitation projects it is acceptable to use existing ground elevations as the points of intersection (PI's) for the vertical alignment when no vertical curve correction is needed. In this case it is best to use the original ground elevation from each cross section and station where a template is to be applied.
  - ii) When using existing ground data as the vertical alignment make sure to check the profiles of the finished grade at the centerline and edge of traveled way to assure a smooth profile for traffic. Avoid small series of dips by adding a leveling course.
- New Vertical Alignments (Design Profiles)
  - i) Follow requirements as specified in *Highway Design Manual*, Chapter 200, Topic 204 – Grade
  - ii) When you are creating the alignment in Civil 3D, the software will flag elements of your alignment and profile that do not meet requirements.

Whether the alignment is new or existing, make sure to set the following items in the Design Criteria tab in Civil 3D.
(a) Design speed (HDM section 101.1,2).
(b) Highway type (HDM section 60.3) and turn on the design checksets.
(c) Set the design criteria file for Civil 3D.
(d) Select the maximum superelevation rate for the highway.

iii) Use customized tables developed from the HDM with roadway design software to assist in determining minimum vertical curve lengths.
iv) When the alignment is complete make sure to check that the alignment is, at least, within minimum and maximum sustained grades and using the minimum curve length specified for the design speed.
v) Offset alignments are not stationed, nor are they typically shown on the profile sheet. However, if it were a split roadway, the left and right profiles would use the centerline stationing with a callout, i.e. 30' left of SR20.

2) Other Vertical Alignments

Other vertical alignments represent all other vertical elements that are an integral part of the design and construction stakeout processes. Typical elements include, but are not limited to:

- Drainage Systems

Typical drainage systems are pipes, culverts, and in-stream and channel facilities.

- Barriers

a) Best Practices & things to think about

- Drainage Profiles
  i) Develop profiles for all drainage systems that will be modified or added showing existing ground, proposed ground and the drainage feature.
  ii) Profile annotation includes the roadway profile grade station, skew angle, if any, station and offset to end points, bends, risers, drain inlets, and wing walls. For larger lengths of pipe a centerline bearing is beneficial.
- Barrier Profiles
  i) It is recommended that a profile of the grade at the base of the barrier be created and reviewed to ensure that the top of the barrier is consistent with the edge of traveled way and will be constructed without dips. If necessary, i.e. at drainage swales, corrections should be made on the grade.

Format & Attributes

As with alignments, use the appropriate profile style for your design and original ground profiles and profile label sets. There are only two styles for design profiles; Finish Grade [Production] and Finish Grade [Analysis]

Roadway Profile Attributes and Annotation Table

Object type	Linestyle	Weight	Color	Level
PROFILE-FINISH	0	1	0	rd_PROFILE-FINISH
PROFILE-FINISH-ANNO	0	1	0	rd_PROFILE-FINISH-anno
PROFILE-OG	3	1	12	rd_PROFILE-OG
PROFILE-OG-ANNO	0	1	12	rd_PROFILE-OG-anno

Drainage System Profile Attributes Table

Object type	Linestyle	Weight	Color	Level
DRAINAGE PROFILE	0	1	1	df_PROFILE
DRAINAGE PROFILE-ANNO				df_PROFILE-anno
EXIST DR PROFILE	3	1	1	df_PROFILE-dither
EXIST DR PROFILE-ANNO	0	1	1	df_PROFILE-dither

Stationing and Annotation Attributes Table For Profiles

The text is based on a plotting scale of 1” = 50’ (Caltrans Base Scale). It is important to place text at the appropriate CADD size within the drawing based on the intended scale of the plotted plan sheet. For any plot scale, the text will appear 0.14 inches when plotted on a 22” x 34” plan sheet.

All text annotation for vertical alignments will use the font CTFont1 and have a text size of 7’ for a 1” = 50’ scale drawing.

G) Superelevation and Cross Slope

Through horizontal curved sections, the cross slope of the roadbed is sloped to counter the effects of radial forces developed as the vehicle travels through the curve. The cross slope of the roadbed through curved sections is referred to as a "superelevated" sections. The superelevation diagram is necessary for the construction engineers and surveyors to set the cross slope of the roadbed.

Caltrans has developed a table that prescribes the superelevation rates based on roadway type (design speed) and horizontal curve radius. This table is found in the HDM, Superelevation Rates Table 202.2.

Along tangent sections, the roadway cross section is sloped at 2% away from the centerline to provide for drainage of the surface water. This is called a normal crown section. The change from a cross slope of the roadbed in a tangent section to a superelevated section in a curve requires a transition length. The rates at which the cross slopes can change per distance along the roadway can be found in the HDM. Factors determining the transition lengths are the total change in cross slope and the width of the roadway, The Superelevation Transition and Runoff Lengths is found in the HDM, Figure 202.5A. Caltrans has developed superlevation roadway design standards based on HDM, Topic 202 that can aid in the development of superelevation definitions meeting department standards.

1) Best Practices & things to think about

   a) Existing Cross Slopes

      i) Roadway design software allows the engineer to sample existing cross slopes and build new roadway elements, such as lanes and shoulders, to match existing cross slopes. In these cases, it is important for the engineer to consider the following:
         - Monitor the longitudinal profile of the outside edge of that element to make sure it remains smooth and that the cross slopes fluctuate at a constant rate of change between stations.
         - Make sure that the slope of the roadbed is within allowable limits as found in the HDM.
         - Keep in mind where drainage inlets and low spots will be located.

   b) New or Corrected Cross Slope and Superelevation

      i) Use the roadway design software to generate superelevation definitions based on tables defined in the HDM.
         - When you are creating the alignment in Civil 3D, make sure to set the design speed and the maximum super elevation rate for the highway in

the Design Criteria tab in Civil 3D. The software has features that will help the engineer design a superelevation table for a given alignment.

ii) Take the time to carefully review the superelevation definitions, transition values, and cross slope standards against HDM Topic 202 – Superelevation, Topic 301 – Traveled Way standards and Topic 302 – Shoulder Standards.

iii) In cases where the roadway consists of three or more lanes sloped in the same direction, refer to the HDM Topic 833 – Roadway Cross Sections.

2) Format & Attributes for Superelevation Diagram

The superelevation diagram is drawn on the profile sheet above the profile or separately on a superelevation sheet.

Superelevation Attributes Table

Object	Linestyle	Weight	Color	Level
LEFT ES	0	1	2	rd_SUPERELEVATION
RIGHT ES	0	1	3	rd_SUPERELEVATION
LEFT ETW	0	1	10	rd_SUPERELEVATION
RIGHT ETW	0	1	11	rd_SUPERELEVATION
AXIS/ROTATION	pp-axis	3	0	rd_SUPERELEVATION
SUPER-ANNO	0	1	0	rd_SUPERELEVATION-ANNO

Annotation Attributes Table

The text is based on a plotting scale of 1” = 50’ (Caltrans Base Scale). It is important to place text at the appropriate CADD size within the drawing based on the intended scale of the plotted plan sheet. For any plot scale, the text will appear 0.14 inches when plotted on a 22” x 34” plan sheet.

All text annotation for superelevation diagram will use the font CTFont1 and have a text size of 7’ for a 1” = 50’ scale drawing.

H) Alternate Design Techniques

While cross section design methods lend themselves well for roadway design, site design or three-dimensional (3D) design techniques may be useful for other types of civil facilities. Site design techniques are available that will let the user define the elevation along the path of a shape, specify parameters of cut/fill slopes, and work with existing terrain surfaces to extend slopes from the path of the shape. The result is a set of points and breaklines that are used to create a proposed surface. A combination of cross sections, alignments, and profiles can be created from the resulting surface for construction staking purposes. Examples of facilities that can be designed with these techniques include:

- Bridge fill cone areas
- Intersections with multiple layout lines that require more detailed information than slope stake listings
- Building pads
- Retention ponds
- Berms, dikes & levees
- Stockpiles & borrow pits
- General landscaping and contour grading
- Parks
- Parking lots
- Pedestrian Ramps

1) Best Practices & things to think about

- When designing a facility with site design techniques the engineer is better able to visualize the finished product, generate accurate quantities, and produce contour grading plans.
- Site design techniques involve the creation of breaklines and points from a alignment with an associated profile or fixed elevation, from survey figures or feature lines using specified slopes that extend to an existing surface or a defined elevation.

I) Digital Design Model (DDM) and Design Contours

Engineers are familiar with digital terrain models (DTM's) that are used to define existing topography and three-dimensional mapping of existing terrain. There is now the capability to construct, from design cross sections and site design tools, digital design models (DDM) that represent a proposed construction model of the design project. In addition to creating design contours, DDM's can be used to view the design for completeness and accuracy; it can also be used for "stakeless construction".

1) Best Practices & things to think about

- Check the catch lines carefully as this represents the point where the DDM and DTM surfaces elevations are the same. If they are not, there may be a "bust" in the design or original ground.
- Use only the finished surfaces from your design cross sections for creating your DDM.
- At-grade intersections will require that the design surface for the main line serve as the original ground for the crossing road. Manual edits to the DDM will be necessary to add profiles of the returns in order to accurately represent the proposed surface at the intersection.
- Have one DDM for the project that was created from the same design files that were used for the final cross section plots, slope stake listings, and earthwork volumes.
- Do not create DDM's from extraneous or alternate alignments and design information.

2) Format & Attributes

Digital Design Model Attributes Table

Feature	Linestyle	Weight	Color	Level
DESIGN BREAKLINES	0	1	3	c3d_GRADING
DESIGN MINOR CONTOUR	0	0	5	rd_CONTOUR_MINOR
DESIGN MAJOR CONTOUR	0	2	5	rd_CONTOUR_MAJOR

Annotation Attributes Table

The text is based on a plotting scale of 1” = 50’ (Caltrans Base Scale). It is important to place text at the appropriate CADD size within the drawing based on the intended scale of the plotted plan sheet. For any plot scale, the text will appear 0.14 inches when plotted on a 22” x 34” plan sheet.

All text annotation for DDM’s and contours will use the font CTFont1 and have a text size of 7’ for a 1” = 50’ scale drawing.

Digital Design Annotation Attributes Table

Object type	Linestyle	Weight	Color	Level
DESIGN CONTOURS-ANNO	0	1	3	c3d_GRADING-anno
DESIGN BREAKLINES-ANNO	0	0	5	rd_CONTOUR-anno

J) Design Cross Sections

Design cross sections are developed from the roadway design software as it applies typical sections at specific station intervals within given station limits. The cut/fill and roadbed slopes will change as the horizontal and vertical alignment, super elevation, and existing ground changes from station to station.

Cross sections are an integral part of the design and construction staking processes. They are needed by the engineer to help determine quantities of earthwork, structural roadway material, and right of way impacts or requirements. Surveyors and construction engineers utilize the cross sections and resulting slope stake listings throughout the construction of the project.

In Civil 3D the design cross sections come from the corridor models. Engineers should build sample lines for cross sections only at stations where there is a cross section in the corridor model.

1) Best Practices & things to think about

- Cross sections, slope stake listings and earthwork quantities should be produced concurrently and based on identical design data depicted on the contract plans.
- Slope stake listings and earthwork quantities are a direct result of the design cross sections.
- Cross sections should be available for use by others as noted in Appendix QQ of the *Project Development Procedures Manual* (PDPM).
- A typical cross section shows the pavement structure within a specified station limit range whereas a design cross section shows the cross-slope and earthwork at a specific station.
- Design cross sections will show finished grades, sub grades, original ground, existing and proposed edge of traveled way, existing and proposed edge of pavement, hinge point and catch point. Include offsets to right of way if the slope catch point is within 15’ of the right of way.
- Provide cross sections for interim construction phases when projects with stage construction require partial fills, cuts, or detour work.
- Refrain from the use of “Pavement Plane Projection” or “Match Existing Cross Slope” when topographic data is available unless approved by the Project Surveyor.
- When two alignments are converging or diverging, develop a match line between slopes until the catch lines become completely separated.

See images below.

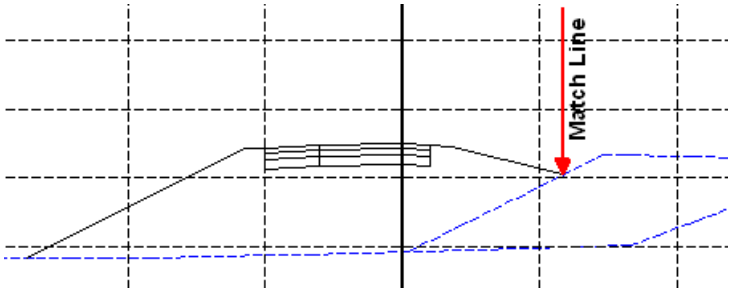


Figure 58 Cross-section showing match line

Section A-A

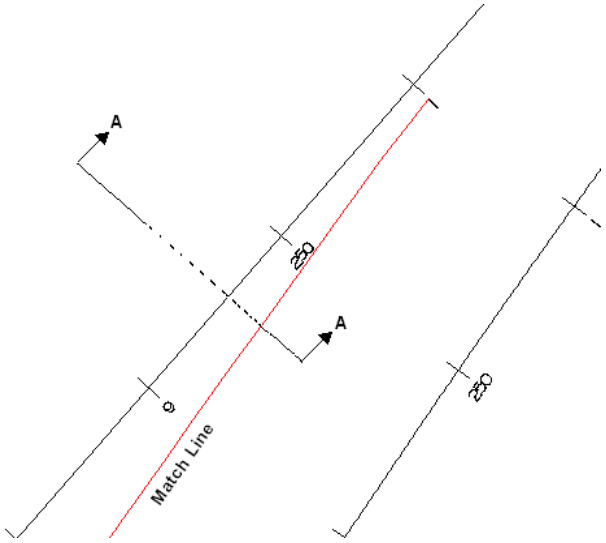


Figure 59 Alignment with match line

- Identify shear key location and final grades for rock slope protection (RSP) areas other than culverts. The typical below depicts an RSP area that should be identified on the cross sections.

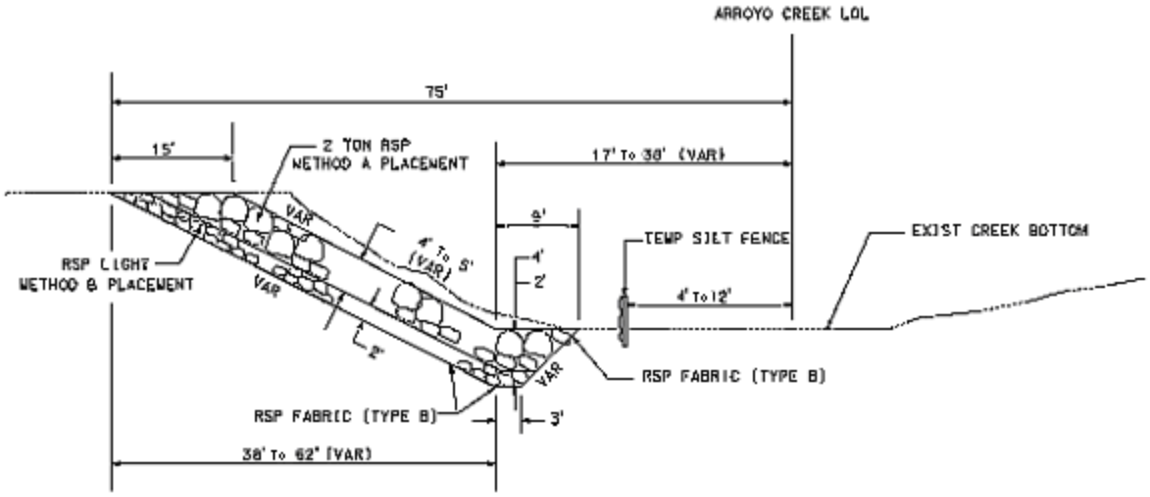


Figure 60 Typical Cross section showing Rock Slope Protection

2) Format & Attributes

- The recommended scale for cross sections is 1” = 10’ for rural areas and 1” = 5’ for Urban areas or depending on the cross section width along the project. The scale will be consistent for a given alignment. The vertical and horizontal

scales should be the same. The sheet may be oriented in either landscape or portrait views but must remain consistent throughout the job.

- The cross-section sheets must include the alignment name and stationing, sheet number and total number of sheets, District-County-Route, Expenditure Authorization (EA), vertical and horizontal scale, date of cross section plots, and the statement “Design Study Only” or “For Earthwork Calculations Only”. The alignment name and stationing must be shown for each cross section and sheets must be arranged in order of increasing station.

Cross Section Linear Feature Attributes Table

Feature	Linestyle	Weight	Color	Level
DESIGN SECTION ELEMENTS	0	1	0	rd_DESIGN-X-SECTION
EXISTING GROUND	4	1	4	c3d_SECTION
MAJOR GRID	1	2	2	border_GRID-MAJOR-dither
MINOR GRID	1	0	3	border_GRID-MINOR-dither
FRAME	0	0	0	border_SHEET
BORDER	0	3	0	border_SHEET
LEADERS	0	1	0	c3d_SECTION

Cross Section Annotation Attributes Table

Feature	Wt.	Color	Level	Font	Text Size *	Text
DIST-CO-RTE	1	0	border_WITHIN-Border-anno	CTFONT1	1.75	0.175
EA	1	0	border_WITHIN-Border-anno	CTFONT1	1.75	0.175
Post Mile	1	0	border_WITHIN-Border-anno	CTFONT1	1.75	0.175
Sheet No.	1	0	border_WITHIN-Border-anno	CTFONT1	1.4	0.14
Scale	1	0	border_WITHIN-Border-anno	CTFONT1	1.4	0.14
Sheet Title	1	0		BOLD	6.0	0.60
Date	1	0	border_WITHIN-Border-anno	CTFONT1	1.4	0.14
Labels	1	0	c3d_SECTION-VIEW-anno	CTFONT1	1.4	0.14
Station	1	0	border_SHEET	CTFONT1	2.0	0.20
Grid Labels	1	0	c3d_SECTION-VIEW-anno	CTFONT1	1.4	0.14
Alignment	1	0	border_WITHIN-Border-anno	BOLD	2.4	0.24

* The text size is relative to the border sizing.

** For any plot scale, the plotted text will appear as noted above on a 22” x 34” cross section sheet. The default text sizes in the macro will use these recommended text sizes.

3) Intervals

- Must not be greater than 50’ station intervals.
- Must not be greater than 25’ station intervals when conditions noted below require additional attention, or when required by the engineer and surveyor.
    - On curves with a radius equal to or less than 1000’
    - When the profile grade is less than 0.3%
    - When the project is flagged for machine guidance
    - When the cross sections will be used to create a DDM
- Cross section shall be created at the following key stations:
    - Begin and end of curves
    - Begin and end of roadway tapers, including parabolic increments
    - Roadway pullouts, including all corners
    - Angle point locations
    - High and Low points on a vertical alignment
    - Drainage structures
    - Begin and end of super transitions
    - Guardrail flares at the end of flare
    - Begin and end of curb returns
    - Begin and end of approach slabs to bridges
    - Begin and end of bridge
    - Major sign locations
- Tapered sections at on/off ramp connections shall be included in the main line cross sections up to and including the gore point (23’). The remaining portion of each ramp is to be listed separately.
- Depending upon the project, additional cross sections may be required. The Project Surveyor and Engineer shall determine the need when the Survey File Checklist, Appendix QQ of the *Project Development Procedures Manual* (PDPM), is reviewed.

4) Key Points

- Grade breaks necessary for staking or for creating the finish roadbed surfaces shall be annotated with offset from the mainline and elevation. See the following table for a listing of point codes.

Point Code	Description
BARR	Barrier – used for both faces.
BBARR	Bottom of Barrier – Used for both faces. If point is coincidental with ES then use BBARR or BARR.
BEN	Bench – Can be used for both edges
TOE	Bench – Toe of the slope
BKWALL	Back of wall
BKCURB *	Back of curb – typically not staked by Surveys but this provides clarifying information for Construction
BKSW	Back of sidewalk
CL	Centerline
CONFM	Conform
CONT	Contour grading lines
CP	Catch point – intersection of design surface with existing surface
CPC	Cath point in cut condition.
CPF	Catch point in fill condition.
EP	Edge of pavement – only for use with miscellaneous roadway sections including bike paths, rest stops, dike pads, etc.
ES	Edge of shoulder
ETW	Edge of traveled way
FL	Paved or unpaved flow line
FSW	Front of sidewalk
FWALL	Face of wall

Point Code	Description
HP	Hinge point – top of slopes within the design surface
LIP	Lip of the gutter
LL *	Lane line – also used for Pavement Structure change
LOL	Layout line for retaining, sound, or wing walls
ML	Match line
PG	Profile grade
R/W	Right of way
RSP	Rock Slope Protection
S/C	Saw cut line
SL *	String line – the plane of the traveled way
TBAR	Top of the Barrier – Used for both faces
TBERM	Top of berm
TCURB *	Top of curb – typically not staked by Surveys but this provides clarifying information for Construction
TDIKE *	Top of dike – typically not staked by Surveys but this provides clarifying information for Construction
TDITCH	Top of ditch
TOE	Toe – bottom of slopes within the design surface, not the catch point
TWALL	Top of wall

*** On** request only

See Chapter 2 of the *Plans Preparation Manual* for acceptable format examples