

Survey Quality Levels

Abstract:

The following quality levels will be used to qualify potential accuracies of a survey and credibility of underground infrastructure. A combination of control quality, mapping criteria, and locate grade will determine the means and methods required to meet the desired quality level.

Definitions

Primary Control Network – A control network defined and published by the Denver Water Survey Section that forms the basis for all other control (Project Control Network, Project Control, Secondary Control, Tertiary Control, etc.). The Primary Control Network is made up of a collection of physical markers with geodetic and grid values meeting or exceeding the minimum requirements of Control Quality Level 1.

Project Control Network – A network of control points delivered to a Contractor to be used as primary control for a given Denver Water engineering project that meets the minimum requirements of Control Quality Level 1. A Project Control Network will include or reference at least one Primary Control Network point when available.

Project Control – A group of control points for internal or external use that meet the minimum requirements of Control Quality Level 2. Project control will include or reference at least one Primary Control Network point when available.

Secondary Control – Control set from the Primary Control Network or a Project Control Network meant to supplement higher order control when necessary. Secondary control should be considered temporary and must meet the minimum requirements of Control Quality Level 2.

Tertiary Control – Control set that meets the minimum requirements of Control Quality Level 3.

See the “Survey Control” Types exhibit for a visual breakdown of the 4 control classifications.

Control Quality Level 1 (CQL1)– Primary Control Network, Project Control Network

Geospatial Accuracy: $\pm 0.10'$ H – $0.20'$ V

Relative Accuracy: $\pm 0.04'$ H – $0.02'$ V*

Network Precision: < 10 ppm

Minimum Requirements:

- Redundant 4-hour static GNSS observations
- Closed traverse, if feasible
- Digital Leveled Elevations with a minimum precision of 1:300,000, if feasible
- Network adjustment with a minimum precision of 1:100,000

** Vertical Relative Accuracy is a direct result of digitally leveled elevations.*

Control Quality Level 2 (CQL2)– Project Control, Secondary Control

Geospatial Accuracy: $\pm 0.10'$ H – $0.20'$ V

Relative Accuracy: $\pm 0.10'$ H – $0.02'$ V*

Minimum Requirements:

- 180 epoch GNSS observation or closed traverse from a CQL 1 control station (VRS does not meet the accuracy requirements of Project Control)
- Digital Level Loop with a minimum precision of 1:300,000

** Vertical Relative Accuracy is a direct result of digitally leveled elevations.*

Control Quality Level 3 (CQL3) – Tertiary Control

Geospatial Accuracy: $\pm 0.10'$ H – $0.20'$ V

Relative Accuracy: $\pm 0.10'$ H – $0.20'$ V*

Minimum Requirements:

- 180 epoch GNSS observation or three measured rounds from a CQL 1 or CQL 2 control station (VRS does not meet the accuracy requirements of Secondary Control)

** Vertical Relative Accuracy is a direct result of digitally leveled elevations.*

Deformation Quality (DQ) – Deformation Surveys

Geospatial Accuracy: $\pm 0.10'$ H – $0.20'$ V

Relative Accuracy: $\pm 0.02'$ H – $0.02'$ V

Minimum Requirements:

- 3 measured rounds from Project Control Network (CQL 1)
- LiDAR Collection from Project Control Network (CQL 1)
- Digital Level Loop with a minimum precision of 1:300,000

Mapping Quality Level 1 (MQL1) – Terrestrial LiDAR

Relative Accuracy: $\pm 0.04'$ H – $0.04'$ V

Minimum Requirements:

- Terrestrial LiDAR collection within 400'

Mapping Quality Level 2 (MQL2) – GNSS and Conventional Collection

Relative Accuracy: +\ - 0.10' H – 0.10' V

Minimum Requirements:

- 6 epoch GNSS observation or conventional measurement using averaged EDM collection

Mapping Quality Level 3 (MQL3) – VRS

Relative Accuracy: +\ - 0.10' H – 0.20' V

Minimum Requirements:

- 6 epoch GNSS observation from VRS

Mapping Quality Level 4 (MQL4) – DRCOG extracted features, ground realized remote Sensing

Relative Accuracy: +\ - 0.30' H – 0.20' V

Minimum Requirements:

- Field verification

Sub-Surface Utility Quality Levels

Abstract:

The following quality level standards are designed to follow the American Society of Civil Engineers (ASCE) “Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data,” also known as ASCE 38. It is the purpose of this document to normalize the available resources and technologies that Denver Water Survey or any Contractor that works for Denver Water Survey has to the ASCE 38 standard for each Utility Quality Level, A through D. All definitions in the ASCE 38 standard will be used throughout this document.

General Notes:

Quality levels can only be assigned based on the information available for each segment of an individual utility. Blanket statements about quality levels for a mapped area are not acceptable. Evidence must be provided for each segment per utility to qualify the quality level of that utility. Sources of evidence utilized by Denver Water Survey include eMap records, secretary files, CAD files from past projects, survey data from past projects, visual surface features, externally sourced GIS data, geophysical evidence (e.g., radio detection or pipe scopes), the GNSS database, pothole data, and data collected during excavation.

Utility Quality Level D (UQLD)

Evidence to Qualify: eMap Records, Secretary Files, As-Built Drawings, External GIS Data, Old CAD Files, Old Survey Data

Discussion: Underground facilities depicted in GIS records, CAD files, or old As-Built plan sets can be assumed to be at minimum a UQLD. Resources such as eMap, secretary files, past projects, and other external authoritative data sources from Tier 1 utility members are great places to start understanding what current subsurface conditions will be like in a given area. The surveyor or engineer should not consider the historic record as “current conditions” or elevate the quality level of such facilities without gathering further evidence.

Utility Quality Level C (UQLC)

Evidence to Qualify: Record Data from UQLD plus Current Visual Features from Imagery, Street View, or Field Visits

Discussion: After preliminary research has been completed and an underground facility has been identified, additional current evidence should be gathered to qualify for UQLC. To move the underground facility from UQLD to UQLC, the historic record must be confirmed by current visual evidence. The term “current visual evidence” is defined as remotely sensed data from street view cameras or aerial imagery that is less than five years old and has visible features such as manholes, valve cases, pull boxes, etc., that can be clearly identified in the imagery. An in-person visible inspection also qualifies assuming the visit is within one year of the qualification process and the technician can confirm the surface feature is related to the subsurface utility alignment trying to be identified.

Utility Quality Level B (UQLB)

Evidence to Qualify: Record Data from UQLD, Visual References from UQLC, and Geophysical Methods such as Radio Detection and Pipe Scoping with Sonder; CAD/GEO Files (e.g., DXF, CSV, SHP) that have been loaded into high-precision survey equipment (GNSS or Conventional); observed deltas from record to ground measurements on visible surface evidence that are within Mapping Quality Level 3.

Discussion: Any standard geophysical process that is conducted by a trained and confident technician that confirms the location of an underground facility and then is mapped using precise GNSS or Conventional survey equipment can be qualified as UQLB. In addition to mapping the 2D geometry of the facility, additional information such as geophysical methods used to locate the facility and the date of location should be associated with the digital record.

Utility Quality Level A (UQLA)

Evidence to Qualify: Confirmed record evidence from the UQLB process and precise vertical information recorded to confirm elevation and measured to Mapping Quality Level 2. As-Built data stored in the GNSS survey database (the GNSS database is a living record of Denver Water Facilities that were surveyed during install and open trench; all measurements taken from top of pipe/conduit to Mapping Quality Level 2).

Discussion: To qualify a facility to UQLA, precise horizontal and vertical measurements must be made to the top of pipe (TOP) of the facility. This can only be achieved if the facility was surveyed with precise GNSS or Conventional survey equipment at the time of installation or if the buried facility is excavated using minimally intrusive excavation techniques (i.e., potholes) and measurements are taken at a determined interval to confidently confirm the depth of the facility.