CHAPTER 9

RIGHT-OF-WAY, SURVEYING AND MAPPING

A. RIGHT-OF-WAY (ROW)

The phrase “right-of-way” generally refers to an easement, but railroads adopted this phrase to describe their property.

Caltrain right-of-way is made up of lengths of land of varying widths that usually increase at stations and yards to accommodate the increased real estate that these facilities require. The uniformity of the right of way is sometimes interrupted by the acquisition of private or public parcels of land that adjoin the original right-of-way.

1.0 CALTRAIN POLICY

The intent of Caltrain policy on right-of-way is to acquire and maintain the minimum right-of-way required consistent with the safety, maintenance, and operating requirements. The policy eliminates or reduces unnecessary property dispositions for proposed corridor improvements.

Caltrain general policy on right-of-way is as follows:

a. Preserve the existing right-of-way

b. Renew all existing leases only with the approval of the Caltrain Deputy Director of Engineering

c. Execute any new leases only with the approval of the Caltrain Deputy Director of Engineering

d. Acquire additional right-of-way for current and potential uses in the future

Caltrain may work, on a partnership basis, with local land use authorities in early corridor planning phases to identify properties adjacent to Caltrain corridor and to explore all appropriate means for acquisition and preservation of those properties.

2.0 PROPERTY TRANSFERS

Land can be acquired by actual purchase (Fee Simple), or an Easement or right of use. An Easement may come in the form of an agreement with a local municipality such a Franchise Right. Land can also be acquired when railroad exercises its right of eminent domain.

2.1 Fee Simple

Fee simple or fee simple absolute is an estate where a right or rights to land exist without duration or limitations. This method of acquisition shall be proposed for the purchase of right-of-way for the construction of permanent surface facilities.

2.2 Fee Simple Determinable

Fee simple determinable is an estate where the creator or grantor retains a right or reversion such that should the subsequent owner violate the condition set out in the instrument that created it, the estate can be terminated and recovered.

2.3 Easement

An easement is the right of use over the property of another for a special purpose. Literally, portions of the railroad property that were acquired through an easement are right-of-way.

An easement may be acquired as a permanent or temporary easement. Permanent easements shall be proposed for utilities, maintenance accesses, and train control facilities. Temporary easement shall be proposed for construction accesses.

2.4 Franchise Right

A franchise right is a non-transferable privilege to use the property of another. The grantee of the franchise right does not hold any interest or ownership to the property. When the real property is no longer in the use of the grantee, the owner will presume sole right and ownership to the property. The grantee may extend the right to the property with a fee.

3.0 RIGHT-OF-WAY REQUIREMENTS

Because right-of-way plans approved by Caltrain are used as a basis for acquisition of property, all interests and uses required shall be shown on the ROW drawings together with the detailed property dispositions.

The proposed right-of-way takes shall be based on the project footprint and are influenced by the track alignment, site topography, drainage improvements, structural improvements, service/access roads, utilities, and other required related Caltrain facilities.

3.1 Preliminary Right-of-Way Assessment

A Preliminary Right-of-Way Assessment is meant to be a tool for assessing property issues during the conceptual stage of proposed improvements. A Preliminary Right-of-Way Assessment process is not a boundary survey and is not designed to be used in replacement of, or in conflict with, state law and local law regarding boundary surveying. Detailed requirements for the Preliminary ROW Assessment are provided in the Reference at the end of the Chapter.

3.2 Right-of-Way Boundary Resolution

Right-of-way boundary resolution shall be performed at the final design stage for projects with definite right-of-way takes and permanent easements. Detailed requirements for the ROW Boundary Resolution are provided in the Reference at the end of the Chapter.

3.2.1 Legal Descriptions

Prior to the preparation of legals and plat maps, all proposed parcels for right-of-way takes shall be clearly identified in the right-of-way exhibit maps for the approval of the Caltrain Deputy Director of Engineering. The following documents shall be included in the maps.

a. Right-of-way base maps of resolved right-of-way.

b. Right-of-way exhibits clearly define areas of right-of-way takes.

c. Right-of-way appraisal maps and record maps.

A complete legal description shall consist of two (2) parts, the legal description in writing and the plat map showing the area being described.

3.2.2 Plat Maps

A plat map is a map or drawing of the land being described in the legal description. It shall be drawn to scale. Detailed requirements for the Plat Maps are provided in the Reference at the end of the Chapter.

B. SURVEYING

Most of Caltrain improvements involve rehabilitation and improvement of existing facilities.

Supplemental surveys shall be provided for planning and engineering when detail topographic features are not available through aerial maps. The products resulting from supplemental surveys are generally topographic maps and digital terrain models (DTMs). Conventional (on the ground) surveying method shall be used to gather data for supplemental surveys.

1.0 SURVEY CONTROL

Survey control establishes a common, consistent network of physical points for controlling the horizontal and vertical positions. The survey control network ensures that adjacent projects have compatible control, hence it provides consistent and accurate horizontal and vertical control for all subsequent project surveys including photogrammetric, mapping, etc.

The following policies, standards, and procedures are applicable to all survey control work for all Caltrain improvement projects.

1.1 Geodetic Surveying

Surveys employing the principals of geodesy are of high precision and generally extend over large areas, such as Caltrain's corridor. Surveyors must understand the elements that comprise geodetic surveys in order to perform geodetic surveys along Caltrain corridor.

1.1.1 Horizontal Datums

The Caltrain corridor control network is based upon NAD 83 (North American Datum of 1983), and all geodetic surveying work performed for Caltrain shall adhere to this datum. State Code of the State of California requires surveyors to utilize NAD 83 as the reference frame for geodetic surveys.

Caltrain allows GPS software utilizing the WGS 84 system because the WGS 84 (World Geodetic System of 1984) and GRS 80 (Geodetic Reference System of 1980) ellipsoids are so close, that the resulting computed data is correct.

Relative positioning data collected by surveyors can be tied to the NAD 83 datum using a State HARN (High Accuracy Reference Network), the national CORS (Continually Operating Referencing Stations) network or calculated from either a HARN or CORS. HARN's and CORS are from different adjustments and should not be utilized together in the same survey.

After 2007 the National Geodetic Survey (NGS) will put all control under a new national control system known as the NAD 83 National Spatial Reference System (NSRS). The NGS will be combining all control points, both HARN and CORS points under this one system. At that time, Caltrain will begin to utilize this new system.

1.1.2 Epochs

The NGS has planned to publish a 2007.0 epoch. Caltrain will be specifying this epoch, the 2007.0 epoch, as the basis for all geodetic surveying performed on the ROW.

1.1.3 The Geoid

Caltrain currently specifies the use of the current geoid (Geoid 03) to be used in the processing and adjusting of geodetic survey data.

1.1.4 Vertical Datums

Elevations for engineering projects must be referenced to a single vertical datum so various phases of a project, and contiguous projects, will conform.

The vertical datum for Caltrain shall be the North American Vertical Datum of 1988 (NAVD 88) as established by the NGS.

Control surveys shall utilize new or adjusted NGS NAVD 88 bench marks only. NAVD 88 bench marks whose elevations have been derived from a vertcon shift of an NGVD 29 bench mark shall not be used in Primary and Secondary Vertical Control Networks as constraining elevation points but may be used as a general vertical check. Caltrain will not accept control point data utilizing RTK (Real Time Kinematic) or GPS (Global Positioning Systems) derived elevation data.

A full report of the vertical control used to vertically constrain a control network is to be included in the deliverables of any control project performed for Caltrain.

Local cities or agencies may use still different vertical datums that may be some variation from mean sea level or differ from that of the NGVD 29 or NAVD 88 vertical datums and these differences have to be taken into consideration when trying to utilize as-built plans on work performed by others on adjacent projects or on projects that are dated.

1.1.5 Least Square Adjustment

Baselines generated during geodetic surveys will be adjusted using a minimally constrained adjustment to check the measurement data and insure that the survey meets FGCS (Federal Geodetic Control Subcommittee) criteria and Caltrain's specification for Primary and Secondary Control Networks. A full report of this minimally constrained adjustment will be included in the deliverables of any geodetic control project performed for Caltrain.

Minimally adjusted baselines meeting Caltrain standards will be subsequently adjusted using fully constrained adjustments in the current epoch to check the validity of the control work

These baselines will then be adjusted using fully constrained adjustments in the correct epoch, if different from Caltrain epoch and in the units required by Caltrain.

2.0 CALIFORNIA STATE PLANE COORDINATES

Surveys shall be performed on the California Coordinate System (CCS) in conformance with the California Public Resources Code. Surveyors shall be familiar with these codes because they define the CCS and provide for its use.

The State of California is comprised of five (5) zones. Zone III covers 15 counties including San Francisco, San Mateo, Santa Clara. All survey work performed for Caltrain shall be based upon the California State Plane Coordinate System, Zone III.

3.0 TOPOGRAPHIC SURVEYS

Topographic surveys are used to determine the configuration of the ground surface and the locations of all natural and manmade objects and features. The resulting surveys include digital terrain models (DTMs) and topographic maps are the basis for planning and engineering.

Elevations of existing topographic features including top of rail, top of pavement, and utilities are often required to develop accurate plans, specifications, and estimates. Surveyors need to carefully select methods and procedures for conducting the survey work to obtain accurate data.

The topographic surveys shall include the following items:

a. Track centerline and profile extending at least 200 feet beyond project limits.

b. Roadway surveys extending at least 200 feet on each side of the proposed roadway right of way lines.

c. Switch points, point of frogs, joints at project limits, joints at control points, signal facilities, communication line locations, etc.

C. MAPPING

Caltrain does not have specific requirements in aerial mapping and photography except that any mapping shall adhere to the NMAS, and that these accuracies are map sheet based.

The most commonly used data accuracy standards for municipal mapping applications are the American Society of Photogrammetry and Remote Sensing (ASPRS) Class I and II. Caltrain, and more and more municipalities, requests mapping projects to be compliant with the NMAS (National Map Accuracy Standards) for large-scale mapping.

1.0 ACCURACIES

1.1 Horizontal Accuracy

The **TABLE 9-1** below shows the standard for some common map scales. Note that the conversion of paper maps into digital data usually creates additional error.

1.2 Vertical Accuracy

Vertical accuracy as applied to contour maps, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. The designer shall perform testing to determine which of the maps are to be tested, and the extent of the testing.

TABLE 9 -1 MAP SCALES

HORIZONTAL ACCURACY EXAMPLES		
Scale	**Engineering Scale**	**National Map Accuracy Standard**
1:480	1”=40’	+/- 1.33 feet
1:600	1”=50’	+/- 1.67 feet
1:1,200	1"=100'	+/- 3.33 feet
1:2,400	1"=200'	+/- 6.67 feet
1:4,800	1"=400'	+/- 13.33 feet
1:9,600	1"=800'	+/- 26.67 feet
1:12,000	1"=1000'	+/- 33.33 feet
1:24,000	1"=2000'	+/- 40.00 feet

Only published maps meeting these accuracy requirements shall note this fact on their legends: "This map complies with National Map Accuracy Standards (NMAS)"

When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be so stated in the legend.

2.0 MAPPING SCALE AND APPLICATION

The following **TABLE 9 -2** depicts various mapping scales and their applications.

TABLE 9 - 2 MAPPING APPLICATIONS

MAP SCALE	CONTOUR INTERVAL	MAPPING APPLICATION
1”= 20’	1 foot	Grade Crossing, Bridge, and Station Sites for Final Design
1”= 40’	2 foot	Standard Maps for Engineering Design (Preliminary Engineering and Plans, Specifications and Estimates)
1”= 100’	5 foot	Standard Maps for Environmental Studies, Feasibility Studies, Planning, and Conceptual Engineering
1”= 200’	10 foot	Corridor Studies

3.0 ORTHOPHOTOGRAPHY

In digital orthophotography, pixel resolution correlates with map scale. The **TABLE 9 - 3** below provides typical correlations between pixel resolution and various map scales. The needs for the required output pixel resolution shall be established in the beginning.

TABLE 9 – 3 PIXEL RESOLUTION

TARGET MAP SCALE		ORTHOPHOTO
1 in = x ft	Ratio, ft/ft	Pixel Resolution (ft)
40	1:480	0.20
50	1:600	0.25
100	1:1,200	0.5
200	1:2,400	1.0
400	1:4,800	2.0

REFERENCE FOLLOWS

CHAPTER 9 REFERENCE

A. RIGHT-OF-WAY

1.0 GENERAL

The phrase “right-of-way” as it pertains to a railroad, whether passenger or freight system, refers to the real estate or land on which the roadbed, track structure and facilities are built.

The width of a railroad right-of-way (ROW) is dependent on many variables, and the determination of the right-of-way width at particular locations along a rail corridor can only occur after research into the history and chain of title that shaped that corridor. For example, a double track railroad’s written acquisition deeds may be written in such a way that its right-of-way width is to be measured at right angles from a line running midway between the two tracks. But what if that same railroad was originally a single track system and the written acquisition deeds are written in such a way that its right-of-way width is to be measured at right angles from the centerline of the original track. Which track? And what if that original track location had undergone two or three line changes and curve revisions through its history, some of which are documented? And what if routine railroad maintenance has thrown the track centerline from its original or relocated position? These are the questions that any ROW Engineer working on a railroad right-of-way has to answer.

1.1 Caltrain Right-of-way

The Caltrain corridor is a right-of-way that was purchased largely from the Southern Pacific Railroad (SP), a double track system. Before the SP came along, a large part of what is now Caltrain's main line right-of-way was owned by the San Francisco and San Jose Railroad, a single track system. Several line changes and curve revisions have occurred along the right-of-way throughout its history, some of which have been documented, others that were not, and routine maintenance over the years has also worked to change the original geometry.

The Caltrain right-of-way is made up of lengths of land of varying widths that usually increase at stations and yards to accommodate the increased real estate that these facilities require. The uniformity of the right-of-way is sometimes interrupted by the acquisition of private or public parcels of land that adjoin the original right-of-way. Land can be acquired by actual purchase, in which the purchaser can acquire land in fee simple or they can acquire an easement or right of use. A right of use may come in the form of an agreement with a local municipality such a Franchise Right. Land can also be acquired when the railroad exercises its right of eminent domain if it can be shown that it is in the public’s interest.

Right-of-way engineers work in conjunction with the Caltrain Real Estate Department and the Caltrain Engineering Department to determine existing right-of-way conditions and assess right-of-way needs. There is further discussion of this issue in sections below.

2.0 REAL PROPERTY DEFINED

2.1 Types of Real Property Transfer

Real property is the interest that a man has in lands, tenements, or hereditaments, and also things that are permanent, fixed, and immovable and which cannot be carried out of their places, as land or tenements. This definition pertains to the land but it also pertains to the rights arising out of or connected to the land.

The transfer of real property or conveyance of private lands between individuals, corporations, or other entities or, to or from city or county entities is accomplished by a document known as a deed. There are many different kinds of deeds such as grant deeds, quitclaim deeds, corporation deeds, warranty deeds, statutory deeds, etc. These deeds are made public by the filing of such instruments at the county recorders office. The kinds of instruments used to convey real property to the Caltrain corridor are of the grant deed or quitclaim variety.

2.1.1 Fee Simple

Fee simple or fee simple absolute is an estate where a right or rights to land exist without duration or limitations. This method of acquisition shall be proposed for the purchase of right-of-way for the construction of permanent surface facilities.

2.1.2 Fee Simple Determinable

Fee simple determinable is an estate where the creator or grantor retains a right or reversion such that should the subsequent owner violate the condition set out in the instrument that created it, the estate could be terminated and recovered.

2.1.3 Easement

An easement is the right of use over the real property of another. The right is often described as the right to use the land of another for a special purpose. The phrase “right-of-way” is generally referring to an easement, but the railroad’s adopted this phrase to describe their property. So those portions of the railroad property that were acquired through an easement are quite literally, right-of-way.

An easement may be acquired as a permanent or temporary easement. Permanent easements shall be proposed for utilities, maintenance accesses, and railroad signal facilities. Temporary easement shall be proposed for construction accesses.

2.1.4 Franchise Right

A franchise right is a non-transferable privilege to use the real property of another. The grantee of the franchise right does not hold any interest or ownership to the real property. When the real property is no longer in the use of the grantee, the original owner will presume sole right and ownership to the property. The grantee may extend the right to the property with a fee. A franchise right does not require a conveyance to be created. For example, a municipal agency may grant a “franchise” to a railroad that will give them sole authority to cross a street.

2.2 Right-of-Way Requirements

Right-of-way is the composite total requirement of all interests and uses of real property needed to construct, maintain, protect, and operate the commuter rail system. Some right-of-way requirements are temporary, while other right-of-way requirements are permanent as dictated by operating and maintenance needs. The intent is to acquire and maintain the minimum right-of-way required consistent with the operating requirements of the Caltrain system. Because right-of-way plans approved by the agency are used as a basis for acquisition of property, all interests and uses required shall be shown on the right-of-way plans together with the detailed property dispositions.

The proposed right-of-way takes shall be based on the project footprint and are influenced by the track alignment, site topography, drainage improvements, structural improvements, service/access roads, utilities, and other required related railroad facilities.

The existing right-of-way shall be preserved, and additional right-of-way acquired for potential uses in the future. All existing leases for renewal shall only be renewed after consultation with Caltrain Engineering. New leases shall not be executed without prior approval by Caltrain Deputy Director of Engineering.

It is the responsibility of the ROW Engineer to coordinate ownership boundaries with new right-of-way requirements and to calculate areas of ownerships, right-of-way requirements, excesses, and remainders as a basis for all R/W maps and descriptions. Since Caltrain's survey control network and its railroad design criteria are based on the California Coordinate System, right-of-way calculations must also be based on the California Coordinate System. Products, deliverables and calculations having to do with right-of-way engineering will be based on the California Coordinate System, the NAD 83 horizontal datum and the NAVD 88 vertical datum as is Caltrain specification. These datum specifications are described and discussed in detail in the Geodetic Surveying Section below.

a. Boundary Determination

Property boundaries are to be established on the same grid system as new right-of-way requirements (California Coordinate System) for:

i. Partial acquisition parcels.
ii. Total acquisitions with a boundary line coincident with the right-of-way line.
iii. Total acquisitions which include excess.
iv. Ownership boundaries shall be located from field survey data and record information in accordance with established legal principles.
v. The underlying fee in an abutting public road will be mapped as part of an ownership as defined above only when it is specifically included in the record description of the property.

b. Minor Design Changes

When minor design adjustments are required, a meeting should occur between the Project Manager and the Right-of-way Engineer.

2.2.1 Preliminary Right-of-Way Assessment

A Preliminary Right-of-way Assessment is an elective in-house Caltrain process of examining available record property information and mapping in the area of a proposed improvement project. It is designed to produce an early assessment of the potential for property conflicts and the need for property acquisition in order to accommodate the needs of the proposed improvements. A Preliminary Right-of-way Assessment, if requested by the Caltrain, shall be performed at the preliminary engineering stage of all projects to identify right-of-way impacts. The preliminary right-of-way assessment shall include the following tasks.

a. Secure any Title information and Title reports as might be available in-house with the Caltrain on the subject property.

b. Determine from available in-house recorded or unrecorded deed information, agreements, franchise rights, other rights, easements, or title that the Caltrain has along that portion of the railroad corridor adjacent to or within the area of the proposed improvement project.

c. Secure all recorded or unrecorded deeds, rights or agreements inherited by the Caltrain as part of the purchase and sale agreement with the SP.

d. Secure all recorded or unrecorded deeds, rights or agreements inherited by the Caltrain as part of the purchase and sale agreement with the State of California.

e. Trace record property transfers to the Union Pacific Railroad as part of the merger with SP. This will require the assistance of a Title Company.

f. Research public's records at the County of the subject property for recorded Parcel Maps, Subdivision Maps, Records of Survey, Monumentation Maps and Right-of-Way Mapping that may have been prepared in and around subject property, which may influence the location of subject property.

g. Gather all SP Right-of-Way and Track Mapping, Valuation Maps, and Station Maps, available within the Caltrain's in-house mapping records for original track alignment and parcel configuration information.

h. Research the Caltrain records for all right-of-way work previously performed in the area of the subject property.

i. Review available in-house Caltrain documentation on lease agreements.

j. Prepare a base map from all of the record information, topographic information and right-of-way mapping gathered and prepare an electronic file of this record right-of-way.

k. The base map and resulting ROW will be prepared from available record deeds and record mapping and available topographic information.

A Preliminary Right-of-way Assessment is meant to be a tool for assessing property issues during the conceptual stage of an improvement project. A Preliminary Right-of-way Assessment process is not a boundary survey and is not designed to be used in replacement of, or in conflict with, state law and local law regarding boundary surveying.

2.2.2 Right-of-Way Boundary Resolution

Right-of-way boundary resolution shall be performed at the final design stage for projects with definite right-of-way takes and permanent easements. The right-of-way boundary resolution shall include the following tasks.

a. Perform field boundary evidence search and topographic survey of existing possession lines to determine location of written title documents and recorded maps of adjacent subdivisions and properties in the field.

b. Research available documentation including recorded maps, assessor's information and maps, available title information, recorded deeds, SP valuation maps, San Francisco and San Jose Railroad Route Maps, and Caltrain conveyance maps to formulate a boundary evidence search plan and subsequent boundary resolution and ROW check.

c. Review Preliminary Record of Survey Map of the Caltrain right-of-way, if available.

d. Review Preliminary Record of Survey Maps, if available.

e. Resolve geometry of original single track and/or subsequent double track alignments to reconcile calls to “centerline of track” in recorded deed documents and title reports.

f. Prepare right-of-way base maps.

g. Prepare land information packages to assist the Title Company on searching the Caltrain’s ownership rights and on any adjoining properties deemed necessary to assist in the resolution of the Caltrain right-of-way lines. This procedure assists the Title Company greatly and minimizes the cost of Preliminary Title Report preparation.

h. Field verification of records

2.2.3 Legal Descriptions

The preparation of legal descriptions and plat maps for right-of-way acquisitions shall be coordinated closely with the project team and the Caltrain Real Estate Department. Prior to the preparation of legals and plat maps, all parcels for right-of-way takes shall be clearly identified in the right-of-way exhibit maps with approval from the Project Manager and the Caltrain Real Estate Department. The following documents shall be submitted to Caltrain Real Estate Department for approval.

a. Right-of-way base maps of resolved right-of-way.

b. Right-of-way exhibits clearly define areas of right-of-way takes.

c. Right-of-way appraisal maps and record maps.

A legal description prepared for the Caltrain will consist of two (2) parts, the legal description in writing and the plat map showing the area being described. A legal description submitted without both parts will be considered incomplete unless otherwise agreed upon by the Caltrain.

Describing Land

Metes Descriptions are perimeter descriptions described by measurement and direction of travel only and they have no bounds calls or calls to an adjoiner.

Bounds descriptions are perimeter descriptions based upon bounds calls only and have no measurement or direction of travel calls included.

Metes and bounds descriptions are perimeter descriptions that are described by measurements, direction of travel and by calls to adjoiners.

Strip descriptions are descriptions of property whose perimeter is described by widths from a given base line or centerline, say the centerline of a track, such as “30 feet on each side of the following described centerline”.

Descriptions by reference are descriptions of property by reference to some map or plat, such as “Lot 1, Block 49 of the University Subdivision”.

Descriptions by exception are descriptions of property which except out certain areas as a reservation from the conveyance such as “Lot 1, Block 49 of the University Subdivision, except the northerly 50 feet”.

There are many other ways to describe land but the type of legal description that one is likely to encounter on the Caltrain corridor will be of the Quasi-Metes and Bounds type. This is a description that utilizes both written instructions: measurements and direction of travel, and a call for a map. The other type of descriptions that one would encounter on this corridor is a combination bounds and strip description. When writing legal descriptions for the Caltrain, the use of bounds only descriptions is discouraged.

Plat Maps

A plat map as defined by the Caltrain is a map or drawing of the land being described in the legal description. The plat map is attached to, and made a part of, the legal description.

A plat map prepared for the Caltrain, shall be drawn to scale, and shall include, at a minimum, the following information:

i. North arrow
ii. Legend
iii. Point of beginning
iv. Point of commencement if applicable
v. Thicker line indicating the land being described
vi. Adjoiner record deed or map information
vii. Relevant record deed or map data on the subject parcel of land
viii. Adjacent street names, right-of-way lines and right-of-way widths
ix. Distances and bearings of all lines along the land being described
x. Relevant bearings or distances to adjoiners
xi. Area of described land
xii. Stamp and signature of the licensed California land surveyor responsible for the map
xiii. Title block
xiv. Date
xv. Scale
xvi. Title or name of the land being described
xvii. Assigned Caltrain Real Estate Department Parcel Number
xviii. Plat Map prepared on an 8.5 x 11 or 8.5 x 14 format sheet of paper.

2.3 Right-of-Way Preservation

Caltrain may work, on a partnership basis, with local land use authorities in early corridor planning phases to identify under utilized existing rail corridors or properties and to explore all appropriate means for acquisition and preservation of those corridors or properties. Preserving right-of-way for commuter rail use can be accomplished through various methods including:

a. Donations

b. Dedications

c. Transportation Impact Mitigations

d. Advance Right-of-way Purchase

B. SURVEYING AND MAPPING

1.0 SURVEY CONTROL

Survey control establishes a common, consistent network of physical points that are the basis for controlling the horizontal and vertical positions of rail transportation improvement projects and facilities. The survey control network ensures that adjacent projects have compatible control. Furthermore, a precise control network provides consistent and accurate horizontal and vertical control for all subsequent project surveys including photogrammetric, mapping, planning, design, construction, and right-of-way.

The following policies, standards, and procedures are applicable to all survey control work for all Caltrain improvement projects. This includes surveys performed by Caltrain in-house survey staff, Consultants, local agencies, private developers and others.

1.1 Geodetic Surveying

Surveys employing the principals of geodesy are of high precision and generally extend over large areas, such as Caltrain railroad corridor which runs from the City of San Francisco to the City of Gilroy and runs approximately 77 miles. It is important to understand the elements that comprise geodetic surveys in order to understand the Caltrain requirements for Geodetic Surveys along their corridor.

1.1.1 Horizontal Datums

A Horizontal Datum is generally defined by three basic requirements:

a. An ellipsoid

b. An origin

c. An orientation

The shape of the earth, although generally thought of as a sphere is really a sphere but with flattening at the poles. This flattening at the poles creates what is known as an oblate spheroid. Geodetic Surveyors must take into account this true shape of the earth. Geodetic surveys establish control networks on a mathematical surface that most closely approximates the shape of the earth. This mathematical surface is known as the ellipsoid.

Although there are several mathematical surfaces or ellipsoids that have been developed over the years, the first reference spheroid used in North America was Clarke's Spheroid of 1866. Much of the California Department of Transportation's (Caltrans) mapping is based upon this spheroid.

A Horizontal Datum is dependent upon the ellipsoid that is chosen to define its surface. For example, the North American Datum of 1927, or NAD 27, is based upon Clarke's Spheroid of 1866. The origin of this datum is the triangulation station at Meade's Ranch in Kansas. The orientation was the geodetic azimuth from the Station at Meade's Ranch Kansas to the Station at Waldo in the town of Waldo, Kansas.

With the launching of satellites, the NAD 27 horizontal datum was rendered unusable. All near-earth satellites orbit around the center of the earth's mass, so an ellipsoid for satellite positioning had to have its origin at the center of mass. The Clarke Spheroid of 1866 had its center roughly 300 meters away from the center of the earths mass.

In recent years, better mathematical models have been developed by the National Geodetic Survey (NGS) and the U.S. Department of Defense (DoD) and new reference spheroids have been developed that better approximate the actual shape of the earth. The latest ellipsoid developed by the DoD is the WGS84. The DoD uses an earth-centered, earth-referenced coordinate system or horizontal datum also called the WGS 84 that is based upon this ellipsoid. The latest ellipsoid developed by the NGS for civilian users is the Geodetic Reference System of 1980 (GRS 80) which has its origin positioned to be earth-centered and the orientation is that of the Bureau International de l'Heuer (BIH) terrestrial system of 1984 (BTS-84).

The NGS or National Geodetic Survey developed the North American Datum of 1983 (NAD 83) to provide the survey community and other users with a reference system that was earth-centered, earth-fixed system, orientated to the BTS-84 system and based upon the GRS 80 ellipsoid.

Caltrain corridor control network is based upon this NAD 83 or North American Datum of 1983, and all geodetic surveying work performed for Caltrain shall adhere to this datum. State Code of the State of California requires surveyors to utilize NAD 83 as the reference frame for geodetic surveys. In addition, all Plane Surveying performed on the PCJPB's rail corridor should be tied to this reference frame.

GPS software utilizing the WGS 84 system is permitted by Caltrain because the WGS 84 and GRS 80 ellipsoids are so close, that the resulting computed data is correct.

Relative positioning data collected by surveyors performing work along the corridor can be tied to the NAD 83 datum using a State HARN, the national CORS network, or calculated from either a HARN or CORS. HARN's and CORS are from different adjustments and should not be utilized together in the same survey.

After 2007 the NGS will put all control under a new national control system known as the NAD 83 National Spatial Reference System (NSRS). The NGS will be combining all control points, both HARN and CORS points under this one system. At that time, Caltrain will begin to utilize this new system.

1.1.2 Epochs

California survey control points, because of crustal motion between the Pacific and North American Plates, are subject to "shifting" positions on a constant basis. Depending on the type of seismic activity, great horizontal and vertical deformation can occur in monument positions. The published positions of points must be continually updated to account for these shifts or deformations. Depending on the kind of survey being performed and the time frame that it is performed within, some thought should be given to the epoch to use for the survey.

An epoch can be calculated for any given moment in time and is a "snapshot" in time of the positions of all the positions of the included monumentation. The first statewide epoch was the High Precision Geodetic Network that was published as the 1991.35 epoch. Later after the Northridge earthquake, a statewide epoch was re-calculated and became know as the 1998.5 epoch. Much of the geodetic survey work completed in southern California is on this epoch. In northern California we are presently using the 2002 epoch. After the 2004 San Simeon earthquake, the NGS and the California Spatial Reference Center (CSRC) published a new epoch known as the 2004.0 epoch.

Currently there are plans by the NGS to publish a 2007.0 epoch and the CSRC would be moving all of it data from the 2004.0 epoch to this new 2007.0 epoch. Caltrain will be

specifying this epoch, the 2007.0 epoch, as the basis for all geodetic surveying performed on its rail corridor.

1.1.3 The Geoid

Measurements are made on the apparent or topographic surface of the earth and computations are performed on an ellipsoid. One other surface is involved in geodetic measurement and that is known as the geoid. In geodetic surveying, the computations of the geodetic coordinates of points are performed on an ellipsoid which closely approximates the size and shape of the earth in the area of the survey. The actual measurements made on the surface of the earth with certain instruments are referred to as the geoid. The ellipsoid is the mathematically defined surface with specific dimensions but the geoid, coincides with that surface to which the oceans could conform over the entire earth if free to adjust to the combined effect of the earth's mass attraction and the centrifugal force of the earth's rotation.

The geoid is a surface along which the gravitational potential is everywhere equal and to which the direction of gravity is always perpendicular. This is significant because optical survey instruments containing leveling devices are commonly used to make geodetic measurements. When properly adjusted, the vertical axis of the instrument coincides with the direction of gravity and is therefore, perpendicular to the geoid.

Just as with ellipsoids, there are many definitions for the geoid that have been used over time in geodetic surveying. Currently Caltrain is specifying the use of the current geoid (Geoid 03) be used in the processing and adjusting of geodetic survey data while performing geodetic surveys along its rail corridor. This geoid is available to users to download on the NGS website.

1.1.4 Vertical Datums

Elevations for engineering projects must be referenced to a single vertical datum so various phases of a project, and contiguous projects, will conform. Various organizations use datums that best serve their needs but these many different datums can cause confusion when trying to compare vertical data between projects performed by different agencies or private entities.

The North American Vertical Datum of 1988 (NAVD 88) is a vertical network defined by one (1) station, Father Point/Rimouski, which is an International Great Lakes Datum (IGLD) water-level station located at the mouth of the St. Lawrence River in Quebec, Canada. This one (1) station mean sea level elevation was held fixed in a minimally constrained least-squares adjustment performed by the NGS. Because only one (1) station was held fixed, the network was not distorted due to constraints of different mean sea level elevations, unlike the National Geodetic Vertical Datum of 1929 (NGVD 29).

Both datum's, NGVD 29 and NAVD 88 are orthometric elevations. An orthometric elevation or height of a point on the earth's surface is the distance from the reference surface (geoid) to the point, measured along the plumb line, normal to the geoid.

Local cities or agencies may use still different vertical datums that may be some variation from mean sea level or differ from that of the NGVD 29 or NAVD 88 vertical datums and these differences have to be taken into consideration when trying to utilize as-built plans on work performed by others on adjacent projects or on projects that are dated.

The vertical datum for Caltrain shall be the North American Vertical Datum of 1988 or NAVD 88 as established by the National Geodetic Survey. All scope of services developed for Caltrain shall be specified as NAVD 88 vertical datum based projects.

Control surveys performed for Caltrain will utilize new or adjusted NGS NAVD 88 bench marks only, as the basis for their survey work. NAVD 88 bench marks whose elevations have been derived from a vertcon shift of an NGVD 29 bench mark shall not be used in Primary and Secondary Vertical Control Networks as constraining elevation points but may be used as a general vertical check. These vertcon elevations are generally only published to the tenth of a foot accuracy. Caltrain will not except control point data utilizing RTK or GPS derived elevation data.

A full report of the vertical control used to vertically constrain a control network is to be included in the deliverables of any control project performed for Caltrain.

Baseline Adjustment using Least Square Adjustment

Baselines generated during geodetic surveys will be adjusted using a minimally constrained adjustment to check the measurement data and insure that the survey meets FGCS criteria and Caltrain specification for Primary and Secondary Control Networks. A full report of this minimally constrained adjustment will be included in the deliverables of any geodetic control project performed for Caltrain.

Minimally adjusted baselines meeting Caltrain standards will be subsequently adjusted using fully constrained adjustments in the current epoch to check the validity of the control work

These baselines will then be adjusted using fully constrained adjustments in the correct epoch, if different from the Caltrain epoch and in the units required by Caltrain.

2.0 CALIFORNIA STATE PLANE COORDINATES

The State Plane Coordinate System is a coordinate system that divides the United States into over 120 numbered zones. Three (3) conformal projections were chosen:

a. Lambert Conformal Conic

b. Transverse Mercator

c. Oblique Mercator

To maintain an accuracy of one part in 10,000, it was necessary to divide many states into zones. Each zone has its own central meridian or standard parallels to maintain the desired level of accuracy. Zone boundaries follow county boundaries.

Surveys performed for Caltrain shall be on the California Coordinate System (CCS) in conformance with the California Public Resources Code. Surveyors working on Caltrain corridor shall be familiar with these codes because they define the CCS and provide for its use.

A plane survey coordinate system is on a flat surface and therefore the geodetic positions of points must be projected from the curved surface of the spheroid to the flat surface to create flat plane coordinate positions. This is accomplished using a “projection”. The CCS system is based upon the Lambert Conformal Conic Projection.

The State of California is comprised of five zones, all utilizing the Lambert Conformal Conic Projection. Zone III covers the counties of Alameda Calaveras, Contra Costa, Madera, Marin, Mariposa, Merced, Mono, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Stanislaus, and Tuolumne. The Caltrain railroad corridor lies entirely within San Francisco, San Mateo and Santa Clara counties, all lying within CCS, Zone III.

All survey work performed for Caltrain shall be based upon the California State Plane Coordinate System, Zone III.

3.0 AERIAL MAPPING AND PHOTOGRAMMETRY

Mapping prepared for Caltrain shall be in conformance with the National Map Accuracy Standards. Caltrain may require a report of the checks that were made to insure that the mapping is in compliance with these standards and this report may be requested at any time including as part of the deliverables.

3.1 Horizontal Accuracy

For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch. These limits of accuracy shall apply in all cases to positions of well-defined points only. Well-defined points are those that are easily visible or recoverable on the ground, such as the following: monuments or markers, such as bench marks, property boundary monuments; intersections of roads, railroads, etc.; corners of large buildings or structures (or center points of small buildings); etc.

In general what is well defined will be determined by what is plottable on the scale of the map within 1/100 inch. Thus while the intersection of two road or property lines meeting at right angles would come within a sensible interpretation, identification of the intersection of such lines meeting at an acute angle would obviously not be practicable within 1/100 inch.

Similarly, features not identifiable upon the ground within close limits are not to be considered as test points within the limits quoted, even though their positions may be scaled closely upon the map. In this class would come timber lines, soil boundaries, etc.

The table below shows the standard for some common map scales. Note that the conversion of paper maps into digital data usually creates additional error.

HORIZONTAL ACCURACY EXAMPLES		
Scale	Engineering Scale	National Map Accuracy Standard
1:480	1”=40’	+/- 1.33 feet
1:600	1”=50’	+/- 1.67 feet
1:1,200	1"=100'	+/- 3.33 feet
1:2,400	1"=200'	+/- 6.67 feet
1:4,800	1"=400'	+/- 13.33 feet
1:9,600	1"=800'	+/- 26.67 feet
1:12,000	1"=1000'	+/- 33.33 feet
1:24,000	1"=2000'	+/- 40.00 feet

3.2 Vertical Accuracy

Vertical accuracy as applied to contour maps on all publication scales, shall be such that not more than 10 percent of the elevations tested shall be in error more than one-half the contour interval. In checking elevations taken from the map, the apparent vertical error may be

decreased by assuming a horizontal displacement within the permissible horizontal error for a map of that scale.

The accuracy of any map may be tested by comparing the positions of points whose locations or elevations are shown upon it with corresponding positions as determined by surveys of a higher accuracy. Tests shall be made by the producing consultant or by the Caltrain. Caltrain shall also determine which of the maps are to be tested, and the extent of the testing.

Published maps meeting these accuracy requirements shall note this fact on their legends, as follows: "This map complies with National Map accuracy Standards."

Published maps whose errors exceed those aforestated shall omit from their legends all mention of standard accuracy.

When a published map is a considerable enlargement of a map drawing (manuscript) or of a published map, that fact shall be stated in the legend. For example, "This map is an enlargement of a 1:20,000-scale map drawing," or "This map is an enlargement of a 1:24,000-scale published map."

3.3 Aerial Mapping and Photography

Caltrain does not have specific requirements in aerial mapping and photography except that any mapping adhere to the National Map Accuracy Standards, shown in detail above, but it understands that these accuracies are map sheet based. Caltrain understands that while it asks for adherence to these NMAS standards, often, the interpretations of these standards are misunderstood and that the project manager should examine each potential consultant photogrammetrist' interpretation of the NMAS standards so that the expectations of the final mapping product are met. Also, accuracy standards vary in complexity and usability, and it is best that a discussion with the photogrammetrist take place regarding accuracy specification that would best suit the needs and budget of the project.

The most commonly used data accuracy standards for county and municipal mapping applications are the American Society of Photogrammetry and Remote Sensing (ASPRS) Class I and II. Additionally, more and more counties and municipalities, just as the PCJPB does, are requesting their mapping projects to be compliant with the National Map Accuracy Standards (NMAS) for large-scale mapping.

The American Society of Photogrammetry and Remote Sensing (ASPRS) developed a new set of accuracy evaluation criteria. These accuracy standards for large-scale maps (generally 1"=1000' and larger {i.e. 1"=200', 1"=100', etc.}) look at continuous datasets (not map sheet based) from a statistical perspective (the root mean square error or RMSE) and therefore are considered more stringent. In terms of RMSE (like the ASPRS standards), NMAS generally equates to ASPRS Class 1.5.

3.4 Mapping Scale and Application

The following chart depicts various mapping scales and their applications.

MAP SCALE	CONTOUR INTERVAL	MAPPING APPLICATION
1"= 20'	1 foot	Grade Crossing, Bridge, and Station Sites for Final Design
1"= 40'	2 foot	Standard Maps for Engineering Design (PE and PS&E)
1"= 100'	5 foot	Standard Maps for Environmental Studies, Feasibility Studies, Planning, and Conceptual Engineering
1"= 200'	10 foot	Corridor Studies

3.5 Orthophotography

In digital orthophotography, pixel resolution correlates with map scale. The table below is designed to give a general idea of the pixel resolution as it correlates with various map scales. These correlations are typical and the needs of the project may dictate a higher or lower level of output pixel resolution.

TARGET MAP SCALE		ORTHOPHOTO
1 in = x ft	Ratio, ft/ft	Pixel Res. (ft)
40	1:480	0.20
50	1:600	0.25
100	1:1,200	0.5
200	1:2,400	1.0
400	1:4,800	2.0

4.0 SUPPLEMENTAL ENGINEERING SURVEYS

Supplemental engineering surveys shall be provided for planning and engineering design when detail topographic features are not available through aerial maps. The products resulting from supplemental engineering surveys are generally topographic maps and digital terrain models (DTMs). Conventional (on the ground) surveying method shall be used to gather data for supplemental engineering surveys. This section provides standards, procedures, and general information for performing conventional engineering surveys using the Total Station Survey System (TSSS), GPS, and differential leveling.

4.1 Planning

Planning begins with the meeting between the Project Surveyor and the Project Manager to discuss the proposed survey request. From a planning perspective, an important part of this meeting is obtaining information about anticipated future related survey requests for the project. Consideration of future right-of-way surveys and construction surveys should be part of the planning process so that the most efficient survey work plan for the overall project can be formulated.

A work plan for supplemental engineering surveys shall be prepared by the Project Surveyor. This work plan shall contain:

a. A survey request prepared by the Project Manager

b. A list of the required deliverables

c. A schedule for the requested project surveys, including critical milestones

4.2 Topographic Surveys

Topographic surveys are used to determine the configuration of the surface of the project site and the locations of all natural and manmade objects and features. The deliverables of topographic surveys including DTMs and topographic maps are the basis for planning studies and engineering designs.

A DTM is a representation of the surface of the project site using a triangulated irregular network (TIN). The TIN models the surface with a series of triangular planes. Each of the vertices of an individual triangle is a coordinated (x,y,z) topographic data point. The triangles are formed from the data points by a computer program, which creates a seamless, triangulated surface without gaps or overlaps between triangles. The standard program for generating the DTM shall be AutoCAD Land Development Desktop Civil Design.

The topographic surveys shall include the following items along the railroad corridor:

a. Track centerline and profile shall include at least 200 feet beyond project limits.

b. Roadway surveys shall include at least 200 feet on each side of the proposed roadway right-of-way lines.

c. Switch points, point of frogs, joints at project limits, joints at control points, signal facilities, communication line locations, etc.

Most of Caltrain's projects involve rehabilitation and major improvements of existing facilities. For these projects, elevations of existing topgraphic features including top of rail, top of pavement, and utilities are often required to develop accurate plans, specifications, and estimates. As a result, surveyors need to carefully select methods and procedures for conducting the survey work to obtain accurate data.

4.3 Utility Surveys

Utility surveys are used to locate existing utilities for the following purposes:

a. Basis for planning and design

b. Relocations of impacted utilities

c. Acquisition for utility easements and/or right-of-way

d. Information for coordination and negotiation with utility companies

Survey limits and types of utilities to be located should be shown on the Survey Request and/or its attachments. The field survey file should include all utility maps and drawings and descriptions of easements.

It is important to locate all significant utility facilities. The following are lists of facilities and critical points to be located for various utilities. Potholing shall be considered to verify locations of critical utilities.

a. Oil and Gas Pipelines

i. Intersection point with centerlines and/or right-of-way lines
ii. For lines parallel to right-of-way: location ties necessary to show relationship to the right-of-way lines
iii. Vents
iv. Angle points
v. Meter vaults, valve pits, etc.

b. Water and Sewer Lines

i. Intersection point with centerlines and/or right-of-way lines
ii. For lines parallel to right-of-way: location ties necessary to show relationship to the right-of-way lines
iii. Manholes, valve boxes, meter pits, crosses, tees, bends, etc.
iv. Elevation on waterlines, sewer inverts, and manhole rings
v. Fire hydrants
vi. Curb stops

c. Overhead Lines

i. Supporting structures on each side of roadway with elevation of neutral or lowest conductor at each centerline crossing point
ii. On lines parallel to roadway, supporting structures that may require relocation, including overhead guys, stubs, and anchors

d. Underground Lines

i. Cables/lines (denote direct burial or conduit, if known), etc.
ii. Manholes, pull boxes, and transformer pads
iii. Crossing at centerline or right-of-way lines
iv. For lines parallel to right-of-way: location ties as necessary to show relationship to the right-of-way lines

END OF REFERENCE
END OF CHAPTER