Chapter 14 Location Survey Procedures

Location surveys gather data for use by planners and engineers. The products resulting from location surveys are generally topographic maps and/or a digital terrain model (DTM). Both conventional (on the ground) and photogrammetric methods are used to gather data for location surveys. This chapter provides standards, procedures, and general information for performing conventional location surveys using the WSDOT Total Station System (TSS), GPS, and differential leveling. For a discussion of photogrammetric surveys, see Chapter 12, "Photogrammetry." For a discussion on preparing a Record of Survey or Monumentation Map, see Chapter16, "MONUMENTATION AND SURVEY RECORDS".

14-01 Responsibilities

Successful location surveys require close cooperation between Planning/Design and Surveys.

Project Manager

The Project Manager is an engineer who leads the Project Development Team and is responsible for overall project planning and completion.

It is the responsibility of the Project Manager to:

- Meet with the Project Surveyor to review the scope and future needs of the project.
- Ensure that all survey requests are accurate and specific.
- Obtain right of entry, as needed, for surveys outside existing WSDOT right of way.

Project Surveyor

The Project Surveyor is appointed by the Project Engineer to:

- Participate as a member of the Project Development Team.
- Coordinate with other functional areas.
- Review and schedule each location survey request.
- Determine the appropriate method to accomplish the requested surveys in cooperation with the project manager.
- Create and maintain a survey project file.

14-02 Preliminary Survey Meeting

As soon as a project is known, e.g., appears on a Status of Projects Report or an initial survey request is received, the Project Surveyor will schedule a meeting with the Project Manager to discuss anticipated survey requests. The meeting with the Project Manager covers:

- Project Schedule
- Acquisition of any critical information not included in the initial survey request such as as-builts, alignments, etc.
- Overall project survey needs
- Alternative survey methods

- Safety considerations
- Recommendations for survey methods
- Appointment of Project Surveyor to the Project Development Team
- Review of existing Records of Surveys for relevant information.
- Accuracy requirements for the survey
- Determine survey products (See Chapter 16 "MONUMENTATION AND SURVEY RECORDS" for the section on "When a Survey Document is Prepared".
- Additional survey needs (right of way, construction, etc.)

14-03 Location Survey Request

All location surveys are initiated by a written request from the Project Manager or designee. Requests are directed to the Project Engineer or the Project Surveyor if one has been appointed.

Survey requests should contain the following information:

- Requestor's name, phone number, and functional area
- Date of request
- County, Route, and milepost of beginning and end of project
- Job Number; work order and group
- Specific date needed (ASAP is not acceptable)
- Description of work requested
- Expected work product
- Sketch of the area to be surveyed showing lateral limits for the survey and beginning and end of work area
- Signature of the Project Engineer or Project Manager (senior level or above)

See Figure 14-1, for sample Survey Services Request form.

Survey requests should be date stamped and then reviewed by the Region Project Survey Manager, Chief of Parties or Party Chief with the Project Engineer or his designee
The purpose of the form is to confirm survey needs: control network, topographic, photogrammetric, crew size, deadlines, construction, mapping, etc.

Washington State Department of Transportation

Survey Request Form

Design Office

PE/Manager	Org. Number	Date Requested	Date Needed
Team Leader / Contact Name	Contact Phone	Survey Request No.	

Project ID	Project Name	State Route
Project Limits MP to MP	Project Scope	

Purpose/Scope of Survey Request

◉ General Topo ◯ Control ◯ Boundary ◯ Construct. Layout/Staking ◯ As-Built

Description:

....

(Continue on next sheet if necessary)

Additional Special Features Requested

- ☐ 2D/3D survey points and survey chains
- ☐ Monuments found/Specified
- ☐ Utility Features
- ☐ Traffic/Electrical features
- ☐ Wetlands/other environmental features
- ☐ Other

List other special features:

....

Survey Request SR Limits MP to MP — or — SR Alignment Limits STA to STA	Offset Limits (Left) From to	Project Combined Factor (CF) (if provided by design)
	Offset Limits (Right) From to	Start survey at: Point # / range Segment #

Supporting files location
(CD, floppy, or network/web location)

In this location, find these supporting files:

Known project control point documentation

State Plane to Project conversion report

Other supporting documentation

Work Map

Survey Crew

To be filled out by survey crew only

Survey Crew Party Chief	Org. Number	Date Received	Date Completed
CAiCE Operator/Secondary Contact	Contact Phone	Combined Factor (CF)	

Survey data has been: ☐ Not Collected ☐ Collected ☐ Downloaded ☐ Processed/Adjusted ☐ Checked ☐ DTM developed

Survey files location
(CD, floppy, or network/web location)

In this location, find these survey files:

Survey files (KCM,XLM,SDR, etc.)

Monument documentation

State Plane to Project Datum report

Traverse document(s)

Non-Std Feature codes used

Survey Feature Code Tables

WSDOT Std

Project Specific

Survey Party Chief Comments:

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SAMPLE SURVEY REQUEST FORM
Figure 14-1

14-04 Planning

Planning begins with the meeting between the Project Surveyor and the Project Manager to discuss the proposed survey request. See 14-02, "Preliminary Meeting." 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 are considerations of the planning process so that the most efficient survey work plan for the overall project can be formulated.

A work plan for location surveys is prepared by the Project Surveyor. This work plan contains:

A list of the required location survey products

- A schedule for the requested project surveys, including critical milestones
- Resource needs (personnel, equipment, overtime, travel expense)

14-04.1 Safety Planning

Safety is a prime consideration in all survey planning and especially with location surveys, which often require work in and around traffic. A key planning consideration is to reduce (minimize) the overall exposure of surveyors to traffic. Carefully selecting the survey method, choosing the time to perform the survey, and employing special survey techniques can accomplish this in part.

14-05 Research

Make research for the location surveys part of the research for the overall project. Research for location surveys and control surveys can be undertaken at the same time.

Identify existing survey control in the area. When necessary, plan a control survey that will meet the requirements of the initial survey request as well as anticipated future project surveying needs. See Chapter 13, "Control Survey Procedures."

Research information in WSDOT files so that all existing aerial photos, topographic mapping, monumentation maps, USGS maps, and as-built plans are identified. This will ensure that work accomplished on a previous project or survey request will not be duplicated.

Search the records and files of other government agencies, utility companies, and railroads for information on facilities located in the project area. Potential agencies include:

- Federal agencies: Bureau of Land Management, Bureau of Reclamation, Army Corps of Engineers, National Oceanic Atmospheric Administration, National Geodetic Survey and U.S. Forest Service.
- State agencies: Department of Parks and Recreation and Department of Natural Resources.
- Local public agencies: County and city public works departments, transit districts, reclamation districts, flood control districts, public utility districts, park districts, water districts, and community service districts.
- Private utility companies: Railroad, electrical power, telephone, cable TV, natural gas, pipeline companies, and water companies.

Obtain vesting documents for all recorded easements.

A data base of local contacts for survey research efforts should be maintained by each Surveys office. A simple, searchable, digital data base can be used for this purpose. Each record should contain the name of the agency or company, address, phone numbers, and the name of contacts. Special care should be taken to keep contacts friendly. Prompt payment for information that is purchased and letters thanking cooperative staff go a long way to improving research efforts.

14-06 Office Preparation

The Project Surveyor and party chief are responsible for the development of the necessary instructions and information (field package) for performing the requested location surveys. Surveys office staff, under the direction of the Project Surveyor, generally prepare the field package using information obtained from the research, together with other compiled and computed data. The field package contains all the necessary information and data to efficiently complete the field work required by the survey request. Typical information and data include:

- Copy of survey request (always included)
- Special instructions including safety and hazardous waste considerations (always included)
- Control diagram and station listing
- As-built plans
- Monumentation and right of way maps and monument listing
- Maps of record
- Utility maps
- Utility easement descriptions
- Data in digital format
    - Control data: descriptions, coordinates, elevations
    - Monumentation data: descriptions, coordinates
    - Topo data: descriptions, coordinates, elevations
    - Alignment data

14-07 Field Work

Field work should not be initiated without a completed field package, including survey request form and written instructions designating any special survey needs.

14-07.1 General

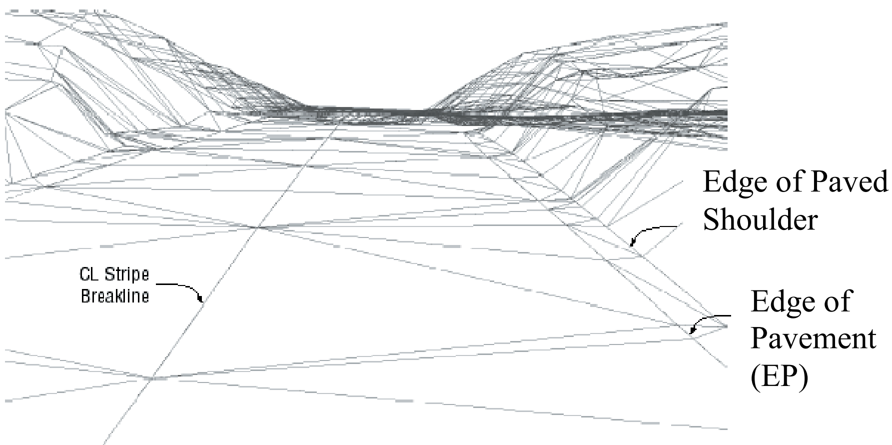
Download data collectors daily. Transfer files to a laptop computer hard drive or server and then back up on an approved storage medium disk. File naming conventions must be used to keep track of raw data files for each day of work for large survey requests. Locate data files, for each job, in a job directory. Store any comments, descriptions of special circumstances, and narratives of the work in a read.me subdirectory of the job directory.

Field crews must check their own work before sending it to the office. Field crews located in remote areas must check their work before returning to their area office. All work by field crews must be independently checked in the area office. Responsibility for final checking of all survey products, including DTMs, rests with the area office data processing staff.

14-07.2 Topographic Survey

Topographic surveys are undertaken to determine the configuration of the earth's surface and the locations of natural and manmade objects and features. The resulting products of topographic surveys, digital terrain models (DTMs) and topographic maps are the basis for planning studies and engineering designs.

A DTM is a representation of the surface of the earth 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 that creates a seamless, triangulated surface without gaps or overlaps between triangles. Triangles are created so that their sides do not cross breaklines. Triangles on either side of breaklines have common sides along the break line. (See Figure 14-2.)



A DTM MODEL USING THE TIN METHOD
Figure 14-2

Breaklines define the points where slopes change in grade (the intersection of two planes). Examples of Breaklines are the crown of pavement, edge of pavement, edge of shoulder, flow line, top of curb, back of sidewalk, toe of slope, top of cut, and top of bank. Breaklines within existing highway rights of way are clearly defined, while breaklines on natural ground are more difficult to determine.

Locating topographic data points that define breaklines and random spot elevation points creates DTMs. The data points are collected at random intervals along longitudinal breaklines with observations spaced sufficiently close together to accurately define the profile of the break line. Like contours, breaklines do not cross themselves or other breaklines.

Add structure section.

Cross-sections can be generated from the finished DTM for any given alignments.

Method: When creating field-generated DTMs, data points are gathered along DTM breaklines, and randomly at spot elevation points, using the TSS radial survey method. This method is called a DTM break line survey.

The number of breaklines actually surveyed can be reduced for objects of a constant shape such as curbs. To do this, a standard cross section for such objects is sketched and made part of the field notes. Field-collected breaklines are identified by line numbers and type on the sketch along with distances and changes in elevation between the breaklines. With this information in the field notes, only selected breaklines need to be located in the field, while others are generated in the office based on the standard cross section.

Advantages of DTM break line surveys:

- Safety of field crews is increased because the need to continually cross traffic is eliminated.
- Observations at specific intervals (stations) are not required.
- New sets of cross sections can be easily created for each alignment change.

DTM survey guidelines:

- Remember to visualize the DTM that will be created to model the ground surface and how breaklines control placement of triangles.
- Use proper and up to date, feature topographic codes, and point numbering.
- Collect extra ground shots for critical points between breaklines, around drop inlets and culverts, and on natural ground in relatively level areas.
- Make a sketch of the area to be surveyed identifying breaklines by name.
- Do not change break line codes without creating a new line.
- Take shots on breaklines at approximately 50 foot intervals and at changes in grade.
- Locate topography points/shots at high points and low points and on a grid of approximately 50 foot centers when the terrain cannot be defined by breaklines.
- Keep sight distances to a length that will ensure that data point elevations meet desired accuracies, especially in steep terrain.
- Gather one extra line of terrain points 20 to 30 feet outside the work limits.
- Locate major features outside of work area that will be impacted by project.

Accuracy Standard: Topography points/shots located on paved surfaces or any engineering works are located within ±0.06 ft horizontally and ±0.05 ft vertically. Topography points/shots on original ground are located within ±0.15 ft horizontally and vertically.

Checking: Check topography points/shots by various means including reviewing the resultant DTM, reviewing breaklines in profile, and locating some data points from more than one setup.

Products: The Surveys group is responsible for developing and delivering final, checked location survey products, including DTMs, to the Project Manager. Products can be tailored to the needs of the requestor whenever feasible, but normally should be kept in digital form and include the following items:

- Converted and adjusted existing recorded alignments, if requested. (CAiCE or similar design software project subdirectory)
- CAiCE KCM file or similar design software files of survey chains and points. (CAiCE project subdirectory)
- CAiCE or similar design software segment name and description.
- CAiCE or similar design software DTM surface files. (CAiCE project subdirectory)

- Hard copy topographic map with border, title block, labeled contours, and planimetry.
- File of all surveyed points with coordinates and descriptions.
- Project Datum information.

14-07.3 Pavement Elevation Surveys

A significant portion of today's transportation program consists of rehabilitation and other improvements of existing facilities. For these projects, elevations of existing pavements are often required to develop accurate plans, specifications, and estimates. Because of safety considerations, surveyors need to carefully select methods and procedures for conducting pavement elevation surveys.

Until recently, the only practical method to acquire pavement elevation data was through conventional leveling or TSS methods. Both of these methods require surveys to be performed in, or adjacent to, moving vehicular traffic and can necessitate the use of temporary traffic controls including lane closures.

Alternate methods for determining pavement elevations, such as remote observations and photogrammetry, are now available and should always be considered. It is the responsibility of the Project Surveyor, in cooperation with the field supervisor, the requesting Project Manager, and with the assistance of Safety, Traffic Operations, Maintenance, and Permits functions, to determine the survey method or system that is most appropriate for a project.

When a request for a pavement elevation survey is received, the Project Surveyor will cooperate with staff from the following functional areas:

- Requesting Project Engineer: Determine (a) the overall objectives of the survey, (b) possible areas that can be eliminated to reduce the amount of data collection required, (c) realistic delivery times, and (d) the pavement elevation accuracy requirements. Key objective: determine, in cooperation with the Project Engineer, what is the minimal amount of data, if any, that is necessary to obtain a quality design.
- Permit Engineer: Determine if consultants, contractors, or others are, or will be, working near the project location.
- Traffic Operations: Obtain information on average daily traffic, peak hour traffic, and feasibility of traffic controls, including lane and shoulder closures.
- Maintenance: Coordinate survey activities with the maintenance engineer and area superintendent. Determine if maintenance activities that will require lane closures are planned for the survey area. Possibly, a maintenance lane closure can be jointly used for the survey effort.
- Safety: Solicit comments and advice from the Region Safety Office whenever safety issues arise that are not routine.

Note:
Remember, the need for a pavement elevation survey should always be questioned. The use of as-built information, existing survey data, or other record data must be considered before performing a pavement elevation survey. Request the Project Engineer to consider alternate design methods or procedures that do not require pavement elevations or require less accurate pavement elevations.

For instance, if concrete barriers are to be installed for construction, discuss with the Project Engineer the feasibility of collecting accurate pavement elevations after the barriers are installed, but before establishing (staking) the final grade. With this method, the design is based on available data and then refined based on accurate pavement elevations collected during construction.

Safety

Pavement elevation surveys are one of the most hazardous surveys performed by WSDOT surveyors. It is imperative that safe surveying practices be employed for such surveys.

For pavement elevation surveys, a key planning consideration is to reduce (minimize) the overall exposure of surveyors to traffic. Carefully selecting the survey method, choosing the time to perform the survey, and employing special survey techniques can accomplish this, in part. In addition, when planning pavement elevation surveys, safety of the traveling public must be a priority consideration.

Prior to commencing each pavement elevation survey, a tailgate safety meeting shall be conducted. All those involved in the pavement elevation survey must participate in the meeting and discuss all safety aspects of the survey. The meeting must be documented.

Close coordination between the Surveys Office and the Region Safety Office must be maintained.

Method: WSDOT and others have developed innovative methods for pavement elevation surveys. Whenever appropriate, employ new surveying technologies to reduce exposure of surveyors to traffic hazards. See Section 11.7-4, “Pavement Elevation Survey Methods.”

Accuracy Standard: Data points should be located within ± 0.05 ft horizontally and ±0.03 ft vertically.

Checking: Data points are checked by various means including reviewing breaklines in profile and locating some data points from more than one setup.

Products: The Survey Group is responsible for developing and delivering final, checked location survey products, including DTMs, to the survey requestors. Products can be tailored to the needs of the requestor whenever feasible, but normally should be in digital form and include the following items:

- CAiCE KCM file or similar design software files of survey chains and points.
- CAiCE or similar design software segment name and description.
- CAiCE DTM or similar design software surface files. (CAiCE project subdirectory)
- Files of all surveyed points with coordinates and descriptions.
- Project Datum information.

14-07.4 Pavement Elevation Survey Methods

Various pavement survey methods are discussed in detail below to aid in the selection of the best method for a given survey.

14-07.4(a) Conventional (TSS) Survey:

Description: Locate data points on pavement breaklines using the TSS radial survey method. Accuracy of survey data points are within 0.02 ft.

Several methods have been used successfully to aid the surveyor to continually monitor traffic while making observations at the edge of a roadway. Two of these methods are:

- Stand to the side of the pavement break line and hold the prism rod inverted, at an angle, with the prism directly on the observation point. The instrument operator sights the intersection of the prism and pavement (zero height of target).
- Utilize an expendable prism (sign reflector) mounted in a small (2.5" diameter) piece of material from a cone base. The expendable prism is placed directly on the point of observation, and the instrument operator sights as noted above.

The main disadvantage to the DTM break line method is that it normally cannot be used to obtain interior break line elevations (e.g., crown lines) without lane closures.

Production: Production varies depending on traffic, road profile, and number of breaklines. A four-person survey party is recommended. In light-to-moderate traffic, 200 to 250 observations per day can be expected. This equates to 4000 to 5000 feet per day of roadway, with four to five pavement breaklines. Production is reduced significantly by heavy traffic conditions and complexity of highway cross sections. Additional breaklines significantly reduce production. Survey costs increase significantly if lane closures are necessary.

14-07.4(b) Trigonometric Surveys:

Description: WSDOT has devised trigonometric methods to determine pavement elevations using the TSS without the use of a prism. These methods have been used successfully to supplement conventional pavement elevation surveys. Accuracy of survey data points are within 0.02 feet.

Following are such methods:

- Prismless /TSS: This method utililizes the technology of prismless EDM's in a Total Station. In the field a TSS is used to observe paint markings or pavement markers at ground level (typically at 40' intervals). Care must be exercised to take shot within the instruments range to maintain desired accuracy tolerances. Use standard feature codes for all shots. When changing instrument positions, turn to the last point collected to determine location to start collection of data.
- Defined Line/TSS: This method requires a known roadway (as-built) alignment that is consistent with (a) existing, well-defined, as-built roadway features (e.g., edge of pavement, edge of gutter) and (b) existing project control. Station/offset coordinates are pre-calculated for each required pavement elevation location. Direction and distance are then calculated from a specific, known control point to each pavement elevation location. In the field, a TSS is used to observe the known direction and to measure the unknown vertical angle to each pavement elevation location from a known control point. The predetermined distance, observed direction, and measured vertical angle are used to create a data file from which pavement elevations are calculated. Pre-determined distances and directions can be calculated.
- Two TSS/Laser Dot: Another similar method employs two TSS and a low-power laser. With this method, simultaneous horizontal and vertical TSS measurements are made from two known control points to a random pavement point defined by directing a laser beam onto the pavement surface at the location desired. The laser beam provides a sight point for the simultaneous TSS observations. (Prior to using this method, review the latest safety regulations concerning the operation of laser devices.)

Note:
The advantage of trigonometric methods over the conventional method is that surveyors

are not required to work adjacent to traffic. Additional costs are incurred because of the need for very accurate alignment data for the Defined Line/TSS method and the need for larger survey crews for the Two TSS/Laser Dot method. Both methods require an expanded control network and more time for computations.

Production: Varies depending on number of breaklines. Generally, less production than the normal DTM break line method.

14-07.5 Utility Surveys

Utility surveys are undertaken to locate existing utilities for (a) consideration in engineering design, (b) purposes of utility relocation, and (c) right-of-way acquisition and negotiation.

Show survey limits and types of utilities to be located on the Survey Request and/or its attachments. Include all utility maps and drawings and descriptions of easements in the field survey file.

It is important to locate all significant utility facilities. The following are lists of facilities and critical points to be located for various utilities. Be sure to check the field package for any required special facilities not listed. Pothole underground utilities only if specifically requested on the Survey Request. Potholing is to be undertaken by the utility company.

Oil and Gas Pipelines

- Intersection point with center lines and/or right of way lines
- For lines parallel to right of way – location ties necessary to show relationship to the right of way lines
- Vents
- Angle points
- Meter vaults, valve pits, etc.

Water and Sewer Lines

- Intersection point with center lines and/or right of way lines
- For lines parallel to right of way – location ties necessary to show relationship to the right of way lines
- Manholes, valve boxes, meter pits, crosses, tees, bends, etc.
- Elevation on waterlines, sewer inverts, and manhole rings
- When appropriate, or when requested, draw a sketch of storm and sewer manholes identifying the type and size of pipes and the direction of flow. Also, indicate which structure the pipelines flow to or from.
- Fire hydrants
- Curb stops

Overhead Lines

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

Underground Lines

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

Railroads

- Profile and locate 500 ft each side of the proposed roadway right of way lines. (See Design Manual Chapter 930.03.)
- Switch points, signal, railroad facilities, communication line locations, etc.

Method: TSS radial survey, GPS fast static, kinematic or RTK.

Accuracy Standard: Data points located on paved surfaces or any engineering works are located within ±0.10 ft horizontally and ±0.10 ft vertically. Data points on original ground will be located within ±0.30 ft horizontally and vertically. Be certain to review the purpose and type of the utility location with the Project Engineer. Some utility locations may require more stringent accuracies than above due to possible conflicts with other utilities, topographic features or design limitations. Adjust the method and accuracies expected to the purpose of the survey.

Checking: Utility data should be checked by the following means:

- Compare field collected data with existing utility maps
- Compare field collected data with the project topo map/DTM
- Review profiles of field collected data
- Include field collected data that have elevations in project DTM
- Locate some data points from more than one setup

Product: The Survey Group is responsible for developing and delivering final, checked location survey products, including DTMs, to the survey requestors. Products can be tailored to the needs of the requestor whenever feasible, but normally should be in digital form and include the following items:

- CAiCE KCM or similar design software files file of survey chains and points
- CAiCE or similar design software segment name and description
- CAiCE or similar design software DTM surface files (CAiCE project subdirectory)
- Hard copy topographic map with border, title block, labeled contours, and planimetry
- File of all surveyed points with coordinates and descriptions

14-07.6 Archaeological Site/Environmentally Sensitive Area Survey

Archaeological and environmental site surveys are performed for planning and engineering studies. Surveys staff must work closely with the appropriate specialists and the survey requestor to correctly identify archeological and environmentally sensitive data points.

Method: TSS radial survey, GPS fast-static, kinematic or RTK

Accuracy Standard: Data points located on paved surfaces or engineering works are located within ±0.50 ft horizontally and ±0.50 ft vertically. Data points on original grounds are located within ±0.50 ft horizontally and vertically. Review field survey package for possible higher required accuracy.

Checking: Check data points by various means including, reviewing the resultant DTM, reviewing breaklines in profile, and locating some data points from more the one setup.

Product: The Survey Group is responsible for developing and delivering final, checked location survey products, including DTMs, to the survey requestors. Products can be tailored to the needs of the requestor whenever feasible, but normally should be in digital form and include the following items:

- 3-D digital graphic file of mapped area (Intergraph, .dgn, format)
- Hard copy topographic map with border, title block, and planimetry (contours and elevations only if specifically requested)
- File of all surveyed points with coordinates and descriptions

14-07.7 Spot Location or Monitoring Surveys

Monitoring surveys are undertaken for monitoring wells, bore hole sites, and other needs.

Method: TSS radial survey, GPS fast static or kinematic

Accuracy Standard: Data points located on paved surfaces or any engineering works are located within ±0.08 ft horizontally and ±0.05 ft vertically. Data points on original ground are located within ±0.15 ft horizontally and vertically. Be certain to review the purpose of the spot location and monitoring surveys with the Project Engineer. Some spot checking and monitoring may require more stringent accuracies than above. Adjust the method and accuracies expected to the purpose of the survey.

Checking: Observe data points with multiple ties. See Chapter 9-4.2 “TSS Specifications - Methods.”

Product: The Survey Group is responsible for developing and delivering final, checked location survey products, including DTMs, to the survey requestors. Products can be tailored to the needs of the requestor whenever feasible, but normally should be in digital form and include the following items:

- File of all surveyed points with coordinates and descriptions
- Sketch or map showing locations of data points

14-07.8 Vertical Clearance Surveys

Vertical clearance surveys are undertaken to measure vertical clearances for signs, overhead wires and bridges.

Method: TSS radial method.

Accuracy Standard: Data points located on paved surfaces or any engineering works are located within ±0.10 ft horizontally and ±0.10 ft vertically. Data points on original ground should be located within ±0.10 ft horizontally and vertically.

Checking: Observe data points with multiple ties. See Chapter 9-4.2 “TSS Specifications Methods.”

Product: The Survey Group is responsible for developing and delivering final, checked location survey products, including DTMs, to the survey requestors. Products can be tailored to the needs of the requestor whenever feasible, but normally should be in digital form and include the following items:

- File of all surveyed points with coordinates and descriptions
- Sketch or map showing vertical clearances
- Project Datum information.

14-08 Office Data Processing

Data processing includes preparing and checking survey products for delivery to the survey requestor. Processing, editing, and transferring data is all done using CAiCE software. Supplemental control established during the location survey must be adjusted by appropriate method, least squares, compass or transit rule, constrained to existing project control before calculating coordinates for topographic data points.

14-08.1 DTM Processing

The primary steps in processing a DTM are:

1. Use CAiCE or similar design software to create a survey database file, adjust control network, compute adjusted coordinates (x,y,z) for all DTM data points, edit known coding problems.
2. Review file to verify checks shots and validate field procedures such as proper entry of instrument and prism height.
3. Check the survey chains (DTM breaklines) in plan and profile for errors: incorrect positions, points skipped, crossing breaklines, and mislabeled data.
4. Create DTM surface database, calculate DTM triangles, and compute DTM contours.
5. Check the DTM by creating “freehand” cross sections from the DTM contours.
6. Return to step 1 and make corrections to database noted from steps 3-7. Repeat steps 3-5 as necessary.